ABSTRACTS

31st IAS Meeting of Sedimentology

held in Kraków on 22nd–25th of June 2015

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Plenary key note lectures

Predicting sedimentary system response to human activities: The future of the Mississippi Delta

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On a global scale, major delta systems aggraded and prograded during the middle to late Holocene when global sea-level rise slowed to rates of < 1mm/yr. However, most major delta systems face considerable uncertainty in the near future due to human activities that have changed inputs of water and sediment, and accelerated rates of global sea-level rise. The Mississippi delta is one such example, and is now in the midst of a profound transformation, where >25% of deltaic wetlands have disappeared during the last 100 yrs, and the region is increasingly vulnerable to storm surge. Land-building diversions of Mississippi River water and sediment are envisioned to achieve sustainability of delta surface area, but present scientific, political, economic, and cultural challenges. This presentation examines technical issues that link future sea-level rise and sediment mass balance, and uses the Mississippi as a case study to address sustainability of deltaic landscapes.

The Holocene Mississippi delta reflects filling of a glacial-period incised valley followed by progradation and construction of an extensive delta-plain topset. Long-term rates of deposition required to fill the valley and construct the delta plain over the past 12,000 yrs are ~230 megatons of sediment per year (Mt/yr), with remaining supply dispersed to the shelf. Prior to the 20th century, >400 Mt/yr of sediment were delivered to the delta plain from a drainage basin of >3,400,000 km^2, then dispersed through crevasse and distributary channel networks to a delta topset that exceeded 20,000 km^2. However, >40,000 dams within the drainage basin now trap ~50% of the natural sediment load, whereas construction of continuous levees have decoupled the delta-plain topset from fluvial sediment input. Hence the delta plain is now both supply- and transport-limited. Moreover, rates of global sea-level rise are now >3 times faster than they were during construction of the delta-plain topset. The unintended but unfortunate convergence of engineering activities with accelerated sea-level rise resulted in the now well-documented rapid 20th century submergence of the Holocene delta plain.

Future delta landscapes cannot resemble the recent past. For the Mississippi case, the present transport-limited condition can be mitigated by land-building and land-sustaining diversions that reintroduce river sediment to delta-plain wetlands. However, the present supply-limited condition ensures insufficient mineral sediment to sustain a large portion of the delta-plain surface. Rrates of global sea-level rise are currently ~3 mm/yr, and expected to accelerate to >4 mm/yr by 2100. Without diversion of sediment to the delta plain, a conservative sea-level rise and subsidence scenario will inundate the ~10,500 sq. km that is now <0.5 m in elevation by the year 2100, whereas a worst-case scenario will inundate >13,500 sq. km. ~18-24 billion tons of sediment will be required to sustain surface area to the year 2100, more than can be delivered from the Mississippi drainage basin in the current supply-limited state. However, even if natural loads were restored, global sea-level rise is >3 times faster than during the 6000 yr period over which the delta plain was constructed, and significant drowning is inevitable.

Mg

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Next to calcium, magnesium (Mg) is the major cation involved in the carbon cycle and the reaction of atmospheric CO_2 with Ca and Mg from silicate minerals is a dominant component of the global climate system. Magnesium is the eight most abundant element in the continental crust and the fourth most abundant species in seawater. Both, the modern Mg concentration in seawater of 53 mmol/l and the isotopic composition of delta26Mg of -0.82 permil are globally rather uniform and the residence time of Mg in seawater is considerable (about 13 Myr). Magnesium is derived from weathering on continents and reaches the oceans via riverine and coastal groundwater. At mid-ocean ridges, Mg is hydrothermally exchanged for Ca forming, in combination with dolomite precipitation and ion-exchange reactions with clay minerals, the main sinks in the global Mg cycle.
With reference to carbonates, Mg is a key element and particularly the fluid Mg/Ca molar ratio in marine and continental carbonate depositional environments represents one of the most important controls on carbonate mineralogy (aragonite, calcite, vaterite, ikaite, Mg-calcite, dolomite, magnesite, amorphous calcium carbonate), petrography and crystallography. Fluctuations of the seawater Mg/Ca molar ratio through Earth history resulted in calcite and aragonite seas, respectively, affecting abiogenic cement precipitation and the evolution of carbonate secreting taxa. In the context of biologically controlled mineralization, high fluid Mg/Ca ratios in vacuoles are used as a strategy to stabilize non-crystalline (amorphous) carbonates for extended periods of time. The Mg concentration of different calcite polymorphs represents the most important factor affecting carbonate diagenetic pathways with increasing calcite Mg contents leading to increasing diagenetic reactivity. The formation of non-stoichiometric and stoichiometric dolomites in the presence of Mg-rich fluids is a field of intensive research in applied and fundamental carbonate geology.
In order to quantitatively explore the significance of parent fluid Mg/Ca molar ratios in carbonate precipitation and alteration environments in a process-oriented manner, a series of field and laboratory experiments have been performed and some of the results are reported here. The applicability of this work and resulting findings to natural settings must be continuously tested. A first set of experiments deals with inorganic laboratory precipitation work with focus on the relation between fluid Mg/Ca molar ratio (and other parameters) and carbonate mineralogy, morphology and crystallography. This work is complemented by cave monitoring experiments documenting the relation between climate, fluid Mg/Ca molar ratios and speleothem mineralogy. Moreover, crystals precipitated on watch glasses are studied geochemically and crystallographically in context to their fluid chemistry. Along similar lines, gel growth experiments using seeds of island spar, calcite and belemnite rostrum fragments shed light on the significance of Mg/Ca molar ratios in the formation of radiaxial fibrous and fascicular-optical calcites. Data obtained represent an important step forward in our understanding of these poorly constrained fabrics. Finally, hydrothermal carbonate replacement experiments provide quantitative data on rates and mechanisms of biogenic and abiogenic aragonites reacting with Mg-bearing solutions during the transforming to dolomite and magnesite and have a direct bearing on processes in the subsurface.

Facies and precipitates associated with carbonate-producing hot-springs

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Hot springs are commonly located in tectonically active areas like those found in the African Rift Valley, Iceland, New Zealand, and in the Yuannan Province of China where subsurface heat can moderate the temperature and geochemistry of the subsurface groundwater. When ejected at the Earth's surface, precipitates that form from these hydrothermal waters are characterized by their mineralogical diversity and morphological complexity. Such variability reflects the fact that precipitation is controlled by the interplay of many different variables including the chemistry of the spring water, the rate at which the water cools, degassing of the spring water, and the activity of the microbial populations that are invariably present. These systems are therefore superb natural laboratories for assessing the factors that control the precipitation of the different polymorphs of calcium carbonate as well as the incredible range of crystal forms that can develop.

Precipitation of calcite and aragonite in hot spring environments is controlled principally by saturation levels that vary at all scales. The microbial mats that thrive in these environments commonly play a critical role in the precipitation of these calcite and aragonite. Theses mats, formed of the microbes and copious amounts of exopolysaccharides, are characterized by numerous microdomains (on micron scale) with each domain having its own geochemical signature. Thus, aragonite may be precipitated in one microdomain whereas amorphous calcium carbonate or calcite may be precipitated in an adjacent microdomain. The morphology of the calcite and aragonite crystals that form in hot spring systems is controlled by many different factors, including supersaturation levels, evaporation, degassing, and supercooling that are collectively constitute the "driving force". As the driving force increases, so the crystal morphology progressively changes skeletal crystals, to dendrite crystals, to spherulitic crystals. Many of these crystals are crystallographically complex with growth patterns that are difficult to determine.

The hallmark of $CaCO_3$ deposits that form in hot spring settings is their mineralogical and crystallographic diversity that commonly reflect subtle, microscale variations in the microenvironments where they formed.

Colluvium – the ugly duckling of clastic sedimentology

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Colluvium (or talus) is a general term for clastic slope-waste sediments, typically coarse grained and immature, deposited in the lower part and foot zone of a mountain slope or other topographic escarpment and brought there chiefly by sediment-gravity processes. Colluvial depositional systems abound in the modern Holocene landscape, but are a little-explored frontier of clastic sedimentology, hardly mentioned in textbooks and virtually ignored in the development of clastic facies models. Colluvial deposits have drawn little sedimentological interest by being generally discarded as nearly intractable 'chaotic slope breccias'. At the lack of criteria for recognition, relatively few ancient cases of colluvium have been reported, albeit ranging from Pleistocene to Precambrian. The interpretive labels used vary from 'basin-margin breccias' and 'proximal fanglomerates' to 'debris slopes', 'slope-waste aprons' and – in connection with fault escarpments – 'footwall fans/aprons'.
The present review of colluvial processes and facies is based on a detailed sedimentological study of modern and older Quaternary colluvial systems in the western Norway, central Greece, south-central Turkey, northern Croatia and north-western Spain. The main processes of colluvial sedimentation are 'avalanches', rapid mass movements including debris falls, various debris flows and debris-bearing snow flows, with a contributing role of debris creep, water sheetwash and minor channelized waterflow. Debris flows may be watery or slushy, typically cohesive, characterized by a low to high apparent viscosity; or may be cohesionless, dry or semi-dry. Common modifying processes include deposition of wind-blown silt or fine sand and the infiltration of gravel frameworks with fine-grained sediment by percolating water (illuviation). The relative role and time incidence of the various processes depend strongly upon the local weather (reflecting regional climate) and slope conditions (lithology and morphology). However, the time-stratigraphic local changes in sedimentation processes appear to be regionally correlative and can be attributed to climatic changes. Colluvial fans/aprons are closed-end systems, with a considerable import and negligible export of sediment and with relatively little contemporaneous reworking of deposits, and hence are capable of recording legible signatures of regional climatic changes. The sedimentation is highly episodic, merely 'probing' the local weather conditions and allowing long-term changes in processes to be recorded within relatively small thicknesses of deposits.
Colluvial systems may not necessarily react to the same main atmospheric factors that tend to be immediately recorded by plant ecosystems or lacustrine hydrological systems. This is because some climatic thresholds have to be reached, in terms of precipitation, runoff and air-temperature conditions, before a recognizable change in sedimentation processes will occur. Colluvial systems are thus more likely to respond to major climatic changes, rather than short-term minor climatic fluctuations. Furthermore, the local slopes – differing in their lithological and morphological conditions – may have different thresholds of response to a particular climatic change, and this variation will inevitably add 'noise' to a regional-scale record. The climate-change resolution of colluvial record may thus not be the same as that of palynological or limnological record, although the latter are prone to other kinds of 'noise' (local response irregularities) and are not necessarily always superior.

Future of sequence stratigraphy

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The Sequence Stratigraphy revolution included Exxon's key claim of a fundamental and repetitive stratigraphic motif, seen on their global seismic data, which was to become the sea-level driven, stratigraphic 'sequence'. This brought huge value to stratigraphy in terms of (1) emphasizing the need to integrate classical stratigraphy with depositional systems, and so highlighting the dynamic character of the new stratigraphy; (2) providing guidelines and a methodology for deciphering stratigraphy in new regions, particularly emphasizing the need to identify the basic regressive and transgressive components of river-delivered, shelf-transiting systems; and (3) providing the framework for a source-to-sink understanding of stratigraphy, and thereby enables a deciphering of provenance as well as sediment-budget and grain size partitioning across alluvial plain to deepwater transects. The sediment-budget volume partitioning is beginning to bring surprises. A component of this source-to-sink understanding is the predictive power that Exxon originally sought.
Sequence stratigraphy has been much less successful in providing an understanding of the sequence-controlling variables, partly because it was initially tied strongly to sea-level change, and stratal patterns were given sea-level terms. Ironically, just as a great number of stratigraphers (including myself) appeared to reach near-consensus on terminology in 2009, Exxon stratigraphers recanted and suggested that it may have been a mistake to link stratal pattern and sea-level condition. Release from this constraint is now allowing great progress in integrating outcrop, subsurface and experimental studies in dynamic stratigraphy. On margins with a large sediment flux, and especially in Greenhouse times, deepwater fans are now as commonly reported at sea-level highstands as at lowstands, autogenic responses in stratigraphy during steady forcing of external variables are being emphasized and the non-uniqueness of stratigraphic changes and key surface generation is being demonstrated, not least because of modeling and experiments in stratigraphy. These approaches are no longer 'threatening' to sequence stratigraphy, but strengthen it.

Carbonates – archive for Carbon Cycle history and for chemostratigraphy

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The discovery of isotope geochemistry as a powerful tool in oceanography and paleoclimatology dates back into middle of the 20th century. Oxygen isotope records stored in carbonate of planktic and benthic foraminifera were recognized by Emiliani as archives of the "orbital pulse", or in other words, of Milankovich cyclicity. Oxygen isotope geochemistry resulted in a new understanding of ice age history and it developed into a powerful instrument in stratigraphy. Even if fundamentals of C-isotope geochemistry also were established in the early years of isotope geochemistry, the importance of C-isotope composition of marine carbonates for geology and oceanography was appreciated only in the 1970ties. Carbonate carbon isotope values were used as a proxy of changes in the marine carbon pool and, in a next step, of variations the global carbon cycle. Changes in the open marine carbon pool are regarded as synchronous on a global scale due to short mixing time of the oceans in the order of thousand years. Based on this, fluctuations in the C-isotope record of marine carbonates can be used as accurate stratigraphic markers. Pelagic carbonates continue to serve as reference archives for C-isotope stratigraphy. Orbital variations (long eccentricity), greenhouse climate conditions triggered by volcanic degassing or by sudden methane release are identified as cause of change in marine C-isotope records. However, also system intrinsic variations in carbonate and organic carbon burial rates can results in C-isotope excursions of global scale as described by Louis-Schmid et al. in 2007. Bulk carbonate records provide reproducible C-isotope signatures far back into earth history. However, poor understanding of source and origin of pelagic micrites in pre-Jurassic oceans complicates interpretations of C-isotope records. Projection of pelagic C-isotope curves into hemipelagic or neritic environments asks for a thorough understanding of environmental conditions during formation of these sediments and of diagenesis affecting the isotopic composition of hemipelagic and neritic sediments.

Session key note lectures

Deciphering Earth's natural hourglasses: Perspectives on source-to-sink analysis

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Production, transport and deposition of sediments takes place across changing altitudes, physical processes, environments and controls en route from source to sink through a downstream narrowing and then broadening fairway of sediment grains, constituting giant “hour-glasses” of nature, a fundamental unit of both geomorphology and sedimentology.
Here we review the status of the rapidly evolving multidisciplinary source-to-sink approach, compare it with the more mature “sink-to-sink” sequence stratigraphic approach, summarize the spatial and temporal variability of source-to-sink systems, and discuss qualitative and semi-quantitative methods for reconstruction of area, relief and sediment supply from source terrains. The variability of source-to-sink systems is viewed in the framework of active margins, passive margins and intra-cratonic basins, of which each is characterized by typical patterns of sediment partitioning and long term preservation. The systems are largely time invariable; modern and sub-modern systems are keys to enhance our understanding of their ancient counterparts. Three different time-framework categories for source-to-sink analysis are presented: modern systems; sub-modern to Quaternary systems; and pre-Quaternary systems, all of which have large differences when it comes to amount and type of data, controlling factors, accuracy in interpretation, and societal applications. Importantly, systems are evolving through time with the effect that estimations of source area parameters for one period of time may change significantly into another when boundary conditions are different.
Sink reconstruction can with variable confidence be established through the use of seismic, well and outcrop data, whereas reconstruction of source relief, drainage and sediment production generally is attached with more uncertainty. Methods like landscape interpolation, sediment volume backfilling, geomorphological scaling relationships, sediment flux estimations from river data and from stratigraphy as well as isotope-based analytical data can, preferentially in combination, be used to unravel past source terrains. Such methods are presented along with a discussion on how they can improve models for basin fill.
Sink and source reconstruction is a two-way process. Source reconstruction sheds light on sink understanding and vice versa. This mutuality is a prerequisite for further advance in source-to sink studies. The prognosis of source area parameters may give additional insight into the complete erosional-depositional system in general and sediment supply in particular, and hence enables us to arrive at more robust models and predictions for the sink were resources commonly are contained.

Mixed energy deltas: The rule rather than the exception

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River deltas are usually interpreted as fluvial-, wave- or tide-dominated based on the process regime dominance and although this classification is logical and extremely useful most of the modern and ancient deltas show a mixture of these processes. The relative influence of processes on the behavior of deltaic shorelines is controlled by unsteady external forcing conditions over long time periods or by autogenic process changes over relatively short temporal and spatial scales (hundreds to thousands of years; km to 10s of km). The modern large Holocene deltas stratigraphic responses were autogenic because late Holocene external forcing was relatively steady (constant rates of relative sea level rise, and sediment supply). Responses over longer time intervals would likely be allogenic due to the increased probability of unsteady external forcing over longer time scales. Such changes are better exemplified in ancient delta deposits.
The dominant depositional process can change down depositional dip as the delta progrades across the shelf and into slightly deeper water, or laterally because of shifting fluvial discharge or because of oceanographic differences between distributaries. The three most common types of process change seen in Holocene deltas are from fluvial- to wave-dominance (Mississipi and Danube deltas) from tide- to wave-dominance (Mekong Delta) or from fluvial- to tide-dominance (Mahakam Delta). Particular segments of large delta complexes can also show these changes. The pervasive and rapid process changes seen in Holocene deltas suggest that process regime variability was also common in ancient deltas, expressed by changes in the character of the deltaic succession, especially on the delta front, the regime-defining segment of the delta. Such changes should be considered more as a rule than an exception. Campanian and Maastrichtian delta deposits from the Western Interior Seaway and Laramide Washakie Basin show clear evidence of such changing process regimes. Maastrichtian Fox Hill deltas in Washakie Basin, Wyoming show facies of variable (fluvial, wave, tide) processes between successive vertically stacked parasequences which were controlled by allogenic forcing and within the same delta sequence that reflects autogenic forcing. A reasonably good time framework in the rock record is needed to aid discussion of whether observed stratigraphic responses are autogenic or allogenic, and it is important to make this distinction because of local or regional implications for stratigraphy. A common theme seen in shelf-delta stratigraphy is the occurrence of spatially extensive flooding surfaces bounding deltaic complexes of 1-300 ky duration, but with great lateral, between-lobe variability within such units. The stratigraphic interval bounded by the flooding-surface, records the overall cross-shelf regression and transgression of the delta complex (allogenic response), whereas the great internal variability reflects autogenic spreading of the lobes during the cross-shelf transits.

Follow the food; the waxing & waning of coral buildups during the Cenozoic

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Evolution of reefs and reef attributes through time has long been the focus of research, with conceptual models deeply influenced by modern Caribbean coral buildups. Though many ecological conditions (e.g., wave action, light, nutrient flux) are recognized as influential parameters, a rationale linking these parameters genetically with reef types, and their boom and bust pattern, is still missing.
Cenozoic coral buildups are abundant and well exposed in the Mediterranean region, allowing nearly complete along-dip observations of the facies. The types of buildups are analyzed through three consecutive steps: 1) on the basis of rock volume, textures, associated sediments, and light-dependent skeletal components, as a proxy for water depth (i.e., light penetration and wave energy); 2) in the context of global environmental conditions (e.g., temperature gradients and carbon cycling as indicated by oxygen and carbon isotope records); and 3) through processes that promoted the waxing and waning of the reef limestones (e.g., relief functionality, nutrient flux and trophic requirements).
Danian to early Ypresian buildups, without a significant break in shallow tropical carbonate sedimentation after the Cretaceous-Paleogene boundary, attest to the rise of modern coralgal communities and the first evolutionary steps of the main lineages of larger benthic foraminifers. The warm Eocene, when temperature gradients were minima, was dominated by LBF, though corals were diverse and occurred in small biostromes and buildups in the mesophotic zone. Coral buildups re-emerged during the Late Eocene cooling; the subsequent Oligocene cooling coincided with the first diversification of the zooxanthellae and coral reorganization, and increase in coral accretion potential. The subsequent late Oligocene-Miocene warming saw the diversification of other groups of LBF, and coralline red algae diversified; corals were subordinated and, along with red algae, formed abundant buildups. Paralleling the second step in zooxanthellae diversification and the progressive increase in global temperature gradients, the Late Miocene saw the onset of modern reefs occupying the shallow euphotic zone and forming a rigid framework up to sea level. The upward migration of the corals is seen as a response to the strengthening of the thermocline.
These trends show that larger coral buildups coincide with strong temperature gradients. Coral reorganization and changes in the building capacity concur with global cooling episodes and diversification of zooxanthellae. In contrast, LBF became the main actors associated with weaker thermal gradients and reduced water-mass stratification, likely resulting in reduced turbulence.

Recent advances in Late Cretaceous geochronology and chronostratigraphy

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The sedimentary record has commonly been interpreted as riddled with hiatuses, perhaps recording as little as a tenth of elapsed geologic time in any given succession. In the past, when radioisotopic dates were widely spaced and their uncertainties large, there was little to challenge such conventional wisdom, save for the ranting of cyclostratigraphers whose ability to distill evidence of Milankovitch periodicities from some successions seemed to suggest a higher level of stratigraphic completeness. Recent advances in the integration of geochronology, astrochronology, biostratigraphy, and chemostratigraphy for Late Cretaceous sections of the Western Interior basin and other areas have made it possible to more rigorously evaluate stratigraphic completeness in the process of refining geologic time scales. The application of independent chronometers (U-Pb, Ar-Ar, and floating astrochronologies) has allowed for significant advances in accuracy, precision and confidence in the resulting time scales, while helping to validate claims for the preservation of orbital signals in hemipelagic strata. New methods developed in the course of this research include not only advances in analytical approaches to geochronologic determinations, but also more comprehensive assessments of total uncertainties associated with time scale development. Lastly, the use of chemostratigraphic frameworks to help export refined temporal control to areas where either biostratigraphy and/or datable horizons are lacking, has enormous potential to extend and refine global Cretaceous chronostratigraphy. The talk will summarize these recent developments.

Western Tethyan rifting: Growth and demise of Lower Jurassic carbonate platforms, and the birth of pelagic carbonate platform/basin systems

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Carbonate platforms across the peri-Mediterranean region were extended in the Early Jurassic, as a result of intracontinental rifting which would lead to seafloor spreading in the western Tethys. The Northern Apennines provide spectacular field evidence enabling researchers to tackle a well known subject in new, stimulating ways, but still using "old" tools.
Initially (late Hettangian) footwall platforms prograded, through the growth of low-angle clinoform slopes, taking advantage of the accommodation space provided by incipient hangingwall subsidence. The clinoforms hosted in-situ subtidal production, largely microbial, with tubular Cyanophyceae, *Thaumatoporella*, and microproblematica (*Lithocodium-Bacinella*) dominating. Tectonic subsidence rates soon exceeded the carbonate growth potential, so hangingwall carbonate factories, including those initial prograding wedges, were drowned and foundered as room was created to host thick pelagic and resedimented successions. Faulting produced a submarine relief of about 1km, locally up to about 2 km. Constraints for computing slip rates come unexpectedly from an hands-on examination of exhumed submarine fault escarpments. As fault activity declined, a thin drape of condensed pelagic epi-escarpment deposits could settle, and locally remain preserved, on the pre-rift peritidal limestone exposed at the footwall. Ammonite biostratigraphy of these condensed deposits, coupled with geological mapping, serves to constrain the minimum rates of footwall unroofing as the beds of the peritidal substrate they overlie unconformably can be traced laterally to reveal how much deep into the footwall stratigraphy had fault-displacement progressed at the times when the pelagic drape was sedimented. Plotting the oldest age of the epi-escarpment deposits against the lowest stratigraphic level in the footwall they rest upon provides the minimum slip rates for the local rift fault. Numerical results are in the order of 100's of metres/million year, but actual rates could have been one order of magnitude higher. In addition, the paleoescarpment dataset reveals that the total displacement along synsedimentary faults was attained in a short burst (late Hettangian-early Sinemurian), so the accommodation space produced by rift faults was essentially filled by a post-rift succession.
The tectonically-driven drowning of hangingwall platforms is documented by a drowning succession, with mixed components of the planktonic (calcareous nannoplankton) and benthic carbonate factories. This is older than that observed on structural highs, where an association with dominant microbial oncoids, crinoids, siliceous and calcareous sponges and benthic foraminifera documents sedimentation on a deeper carbonate bank that persisted for a few million years, until the earliest Pliensbachian. The disappearance of coated grains, and appearance of ammonite-dominated assemblages, marks a super-regional, synchronous drowning event interpreted as unrelated with tectonics, and driven instead by paloceanographic perturbation. Following this, the footwall blocks became Pelagic Carbonate Platforms (PCPs), hosting a condensed succession documenting the Pliensbachian-Tithonian in few tens of metres or less. While the geometry of the PCP-top succession was a wide convex-up lens, with stratigraphic units thinning out towards PCP-edges, scattered condensed deposits are also found along the marginal paleoescarpments, or draping megabreccia piles or house-size olistoliths at basin margins. The basin-fill history ended in the Early Cretaceous as the calpionellid limestone (Maiolica) eventually onlapped the uppermost escarpment and PCP-top succession.

Isotope analysis of fluid inclusion water in non-marine carbonates

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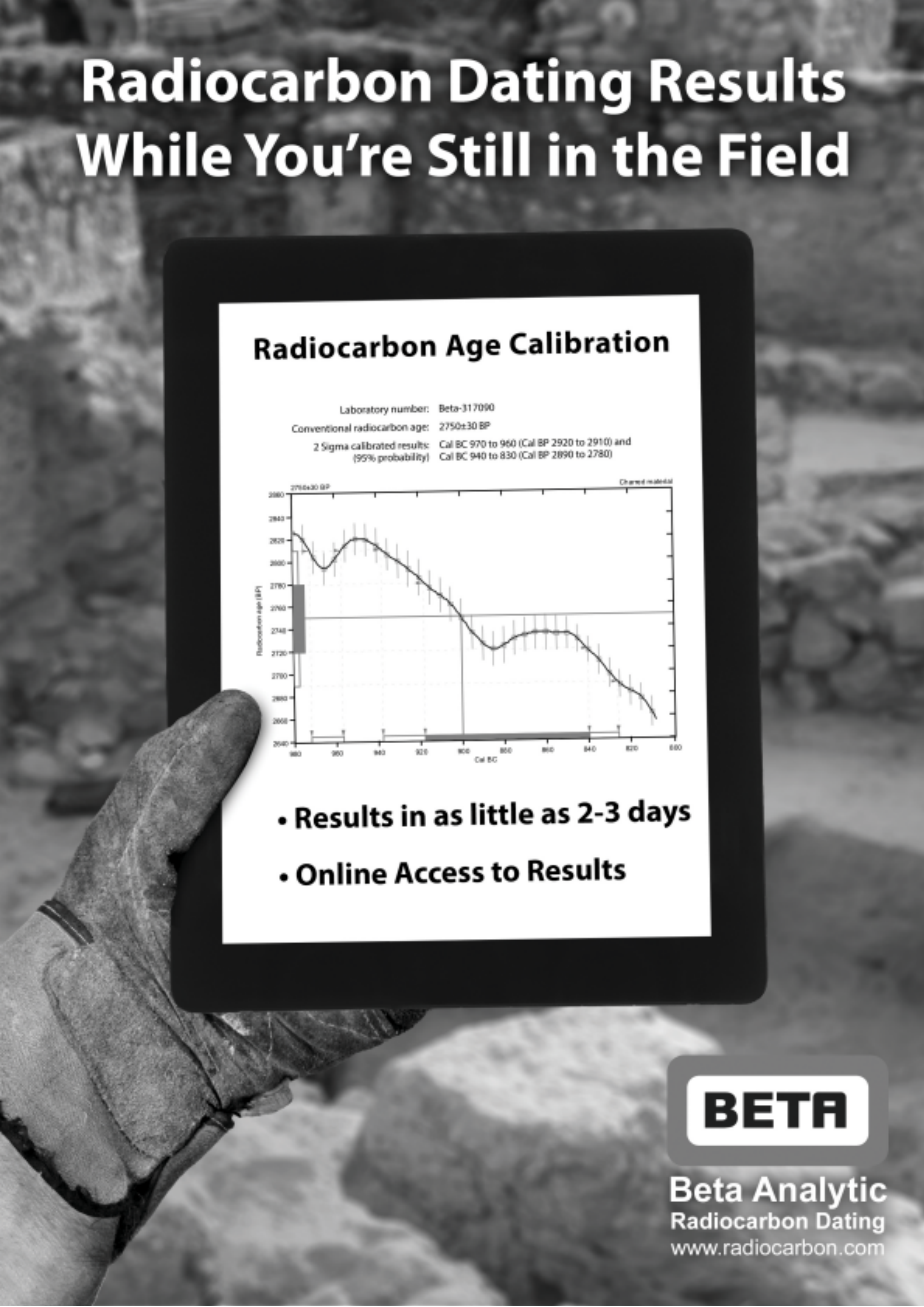
Non-marine carbonates have turned into a hot topic in the geosciences over the past few decades, which is due to several developments in this field of science. First, there is the remarkable increase of studies of speleothem calcite as a climate archive. Owing to the great advances in precision of Uranium series dating of such calcites, speleothem records now form the well-dated backbone of terrestrial climate archives. Their dominantly calcitic mineralogy allows many climate proxy records to be applied that were already developed for marine carbonate studies.
Another reason why non-marine carbonates have moved to the center of attention is that the large oil reserves in the South Atlantic "pre-salt" reservoirs are largely developed in non-marine carbonates (travertines and tufas). Initially, the genesis and architecture of such deposits were poorly understood by, traditionally marine-based, oil company carbonate sedimentologists, which has initiated considerable industry funding for academic groups working on this topic over the past years.
One of the most important limitations for the application of (isotope)-geochemical proxy records on non-marine carbonates is that the chemical composition of the fluid from which the carbonate forms is much more variable than that of marine carbonates. Since most geochemical proxy records depend on reasonably precise knowledge of the composition of the fluid from which the carbonate formed, it is of pivotal importance to beter characterize the fluids (and conditions) in which non-marine carbonates grow. Many researchers have done so by studying and monitoring modern non-marine carbonate deposits, like caves and travertine/tufa systems, carefully linking carbonate structure and composition to fluid chemistry and growth conditions.
Another approach to get information regarding the formation fluids, is the study of water trapped in fluid inclusions in non marine carbonates. In several labs worldwide, analytical procedures have been developed and refined over the past 15 years for the stable isotope ($\delta^{18}O$ and δ2H) analysis of fluid inclusion waters in speleothems and other non-marine carbonates. The lab at VU-University Amsterdam has been one of the pioneering labs in this field.
In speleothem studies, fluid inclusion isotope values provide key paleoclimate parameters. Such data are a direct proxy for the isotopic composition of paleo-rainfall, because cave drip water captured in the fluid inclusions isotopically approximates rainwater recharging the cave. Besides direct paleorainfall isotope records, this technique also allows for the calculation of changing formation temperatures through time, by combining the oxygen isotope data of fluid inclusion water and host calcite.
This ability to measure direct fluid composition and calculate isotope equilibrium temperatures is also of good use when this technique is applied to higher temperature systems, like subsurface reservoir diagenetic systems, or minerals formed at hydrothermal springs.

In this presentation some recent work done in our lab in Amsterdam is lined up to demonstrate the potential and limitations of the fluid inclusion stable isotope technique for the study of non-marine carbonates.

Oral and poster presentations



Radiocarbon Dating Results
While You're Still in the Field
Radiocarbon Age Calibration
Laboratory number: Beta-317090
Conventional radiocarbon age: 2750±30 BP
2 Sigma calibrated results: Cal BC 970 to 960 (Cal BP 2920 to 2910) and
(95% probability) Cal BC 940 to 830 (Cal BP 2890 to 2780)
• Results in as little as 2-3 days
• Online Access to Results
BETA
Beta Analytic
Radiocarbon Dating
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Textural and geochemical variations in a recent laminated carbonate fluvial deposit as environmental and temporal indicators

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The textural and stable-isotope variations in a calcite laminated deposit, formed in a draining pipe in the Monasterio de Piedra Natural Park (NE Spain), were studied to infer the environmental and temporal significance of lamination. The River Piedra stands out by the high deposition rate of tufa (7.86 mm/y, from 1999 to 2012), with marked seasonal variations. Water composition is of HCO_3–SO_4–Ca type, with mean pH= 8.03 and SIc= +0.73.
The pipe (8 m long, 25 cm in diameter, 3-5º of inclination) diverted water from the river to a secondary channel. In the pipe, water depth was 15 to 18 cm and mean velocity was 2 m/s. The pipe was removed during the summer of 2009, and then the inner deposit was retrieved. The deposit coated a bit more than the lower half of the pipe, forming a body (open semi-cylinder) of rather constant thickness (6.5 to 7.1 cm); in cross-section, the deposit sharply ends laterally upward. The laminae mimic the pipewall.
The lamination consists of alternating light and dark laminae (naked-eye observation), which in optical microscope correspond, respectively, to dense and/or dark small-crystal laminae (1 to 2.8 mm thick) and porous and/or light large-crystal laminae (1.3 to 3.8 mm thick). Both types of laminae can consist of several sublaminae. The large-crystal laminae exhibit long crystals (0.5 to 2.5 mm long) grouped in adjacent fan-shaped and parallel bodies, forming palisades. These structures are also present in the small-crystal laminae, but the crystals are shorter. In SEM, the crystals are seen as compact mesocrystals that, in general, cannot be associated with calcite precipitation around filamentous bacteria. However, abundant calcified microbial filaments and EPS, along with rare bacterial calcite tubes, occur on and among the mesocrystals in both types of laminae.
A total of 31 consecutive laminae were sampled in one section for stable-isotope analyses. The $\delta^{13}C$ individual values (mean= -8.22‰ V-PDB) did not show a cyclic pattern, except for a few cases in which the variations were opposite to those of $\delta^{18}O$. The individual $\delta^{18}O$ values (mean= -8.31‰ V-PDB) showed a cyclic pattern that suggests that the small-crystal laminae formed with higher water temperature than the large-crystal laminae. Assuming that those variations were biannual, the studied record represents 15.5 years. Water temperature estimates (using analyzed river-water $\delta^{18}O$ = -8.5‰ V-SMOW) ranged from 17.4 to 11.5 ºC, consistent with seasonally measured water temperatures. The estimated temperatures showed a trend toward cooling (approximately 0.5 ºC) parallel to that of the air temperature through time. Tufa stromatolite sampled biannually in the river within the Park (1999-2009) showed a similar $\delta^{18}O$ pattern, and mean values of $\delta^{18}O$ (-8.27‰) and $\delta^{13}C$ (-8.23‰) very close to those of the pipe deposit during the same period.
Therefore, changes in temperature and temperature-related parameters (e.g., SIc) can explain most textural and stable-isotope cyclic variations of the studied deposit.

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Process stratigraphy – from analog-based to physics-based stratigraphic predictions

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A significant source of uncertainty in geologic prediction resides in the stratigraphic interpretation. Since current stratigraphic interpretation methods are mostly empirical, a step change in prediction can be achieved by quantitatively constraining interpretations and therefore geologic models using the physics of fluid flow (fluid mechanics) and sediment transport. Sedimentary patterns observed in geologic data (facies, facies stacking, seismic maps and cross-sections) contain a record of the sedimentary processes over a wide range of time and length scales.
Process Stratigraphy involves the integration of process sedimentology and sequence stratigraphy in creating a new approach to interpret geologic data. Sequence Stratigraphy combine the analyses of facies stacking, regional surfaces tied to base level changes and extra-basinal controls to create predictive models of lithology distribution and reservoir architecture. Currently, sequence stratigraphy utilizes a somewhat qualitative, analog-based approach to define the stratigraphy in a region of interest. This analyses works well at a more regional scale, but fails in predicting fine scale (sub-seismic) reservoir architecture and lithology distribution. Process sedimentology includes the study and understanding of fluid dynamics, morphodynamics and sedimentary transport mechanisms including deposition and erosion. Recently, full physics computational methods have been created that are capable of modeling geologically plausible scenarios by simulating sediment deposition from turbid flows over basin fill timescales.
In Process Stratigraphy, analog-based stratigraphic concepts are combined with physics-based analytical and numerical modeling to more realistically predict lithology distribution and reservoir architecture. Through this process, it is possible to populate property distributions in reservoir models to more accurately characterize reservoir uncertainty and to enable improved business decision-making, representing a paradigm shift from analog- to physics-based stratigraphic predictions. Without the ability to condition these models to present day observations, the computational methods serve only illustrative rather than practical purposes. However, if conditioning were feasible, these computational models could assist stratigraphers to quantitatively predict geological properties in regions sparsely populated with data.
The work flow in Process Stratigraphy is to (1) interpret sedimentary flow parameters (e.g., flow height, density, velocity, local gradient, Froude number) from the available stratigraphic/sedimentologic information (e.g., sedimentary structures, stratal geometries and stacking, geomorphology from seismic patterns – or “from rock to sedimentary flow”), and (2) use the sedimentary flow regimes (hydraulics + sedimentary transport) interpreted from the geologic record to predict sedimentary facies away from well control; and to create facies volumes (e.g., reservoir property volumes) from resultant flow regimes through inversion using local calibration (seismic, wells, cores) to condition reservoir models (or, “from sedimentary flow to rock”), aiming at generating improved reservoir simulations with multiple scenarios.

Origin of Devonian conical mud mounds of Hamar Lakhdad Ridge, Anti-Atlas, Morocco: Hydrothermal or hydrocarbon venting?

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In the Eastern Anti Atlas desert of Morocco, 15km southeast of Erfoud stands an impressing and unusual East-west oriented geological structure of 6km length for 1.5 km width. Emerging from the surrounding flat Erg, the Hamar Laghdad ridge exposes a Devonian sedimentary succession crossed by important senestral N-E to S-W transforming faults. The western part of the ridge overlies directly the Silurian shales succession, whereas the eastern part spreads over 100 m-thick calco-alcaline basalt of early Devonian age. This particularity produced a significant difference in the sedimentation patterns. The western part of the ridge consists of a normal marine outer shelf sediments dominated by shales and marls intercalated with scarce fossiliferous limestones enriched in cephalopods (orthoceratids and goniatitids) deposited during the Pragian and early Emsian. However, the eastern part experienced shallower deposition characterized by crinoidal limestones. The most interesting feature consists of a constellation of 48 calcareous cones emerging from the sediment surface; there are ca. 10 m in diameter and 30 to 50 m high. These steep, very well preserved slope cones were described as hydrothermal vents by Mounji and Bourque (1998). They correspond to thick limestone layers organized around a central funnel. The mound walls, as the inter mounds layers, are enriched in fossils especially crinoids, but the mounds seem to have been colonized from time to time by communities of organisms such as bivalves. The sediment micrite is characterized by very negative $\delta^{18}O$ values, ranging from -8 to -10‰ V_{PDB} and positive $\delta^{13}C$ values, between 0 and 2‰, which suggest a precipitation from hydrothermal waters derived from underlying volcanic intrusives. They also contain cemented cavities (stromatactis). The latter are filled by three different generations of cement with $\delta^{18}O$ 6-8‰ higher than the host rock, in or near the field of early Devonian seawater. Some fully recrystallized corals have also been observed in the limestones layers and in the mound flanks indicating that at least some of the stromatactis are in fact relicts of dissolved organism fossils recrystallized later in isotopic equilibrium with sea water. A younger mudmounds framework associated with neptunian dykes of middle Devonian age (Peckmann et al., 1999) is present in the west part of the ridge. Both are characterized by very low $\delta^{13}C$ values (-10‰ to -20‰ V_{PDB}) probably deriving from isotopically light hydrocarbon such as methane. These younger mudmounds originated in a medium influenced by a hydrocarbon venting, contrary to the older Kess-Kess which is related to the venting of hydrothermal waters.

Biotic versus abiotic iron: An example of the fault-related ironstone hosted in Eocene carbonates in the Bahariya area, Western Desert, Egypt

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The cherty ironstone deposits of the Bahariya area have been previously interpreted as a microbial mediated iron of primary marine origin. The role of microorganisms in the deposition of metalliferous sediments particularly in banded iron formations has been discussed for many years as they are potential archives of Precambrian environments. The cherty ironstone rocks hosted in the Naqb Formation (Eocene) provides key information about the origin of abiotic iron replacing biotic fabrics and can be considered a recent, well preserved analogue for the process. The Naqb Formation consists of carbonate rocks deposited in shallow marine conditions showing shallow subtidal and oolitic shoal facies that were replaced by quartz and iron-bearing minerals (goethite and hematite) in the vicinity of two major faults in the northern Bahariya Depression. Sedimentological and detailed petrographic and micro-morphologic analyses of this rock unit revealed distinctive diagenetic events (e.g., micritization, karstification, dolomitization, silicification and hematitization). Several stages of micritization have been recognized in the skeletal and non-skeletal particles (nummulites, alveolinids, echinoids, bivalves, algae, ooids and oncoids) preserved in the carbonate rocks. Such a process produced micro-borings, irregular micrite envelopes, cortoids and aggregates with preservation of the clast morphology and formation of cryptocrystalline carbonates. It is commonly accepted that micritization occurs in surface sediments of shallow tropical seas where it is produced by the activity of endolithic cyanobacteria. Further fabric of retentive dolomitization of limestones preserved the micritized features. In the vicinity of the faulted areas, the micritized and dolomitized grains were replaced by iron in micro-globular fabrics with relics of dolomite pseudomorphs. In addition, the micritized nummulitic facies, that passed laterally to micritized oolitic, oncolithic and fossiliferous facies, were replaced by iron after dolomite with the presence of fairly preserved microbial filaments. The preservation of the biotic features in all micritized skeletal and no-skeletal carbonate grains and their replacement by iron may make confusion in the interpretation of the abiotic iron to be described as a microbially-mediated iron. The precipitation of iron took place after the dolomitization process and was related to fluids circulating through major faults in the area. Our proposed model of iron formation can give new insight about abiotic ironstone replacing biotic and abiotic features that contrast to previous interpretations.

Cherty ironstone hosted in Eocene marine carbonates: Tectonic and sedimentological controls on iron and silica formation

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In this paper, we focus on the sedimentology and tectonic controls on the formation of cherty ironstone hosted in the Early Eocene Naqb Formation exposed in the northern part of the Bahariya Depression (Egypt). This rock unit (up to 13 m thick) is composed of two carbonate sequences separated by a paleokarstic surface. The Naqb Formation was deposited on a shallow-water platform with intertidal, shallow subtidal and oolitic shoal facies. Dominant organisms in these environments comprise larger benthic foraminifera (nummulites, alveolinids, miliolids, orbitolites), dasycladacean algae, mollusk shells and some echinoids whereas the non-skeletal grains are mostly of ooids, oncoids and pelloids. The two carbonate sequences have undergone extensive diagenetic processes, the most important of which are the karstification, dolomitization, silicification, barite formation and Fe/Mn accumulation.
The Naqb Formation was totally replaced and/or cemented spatially by iron-bearing minerals and/or silica in the vicinity of major faults affected on the area. In the distal parts, the mineralization is only localized along the major sedimentary discontinuities. Outside the faulted areas by 1 to 2 km, the Naqb Formation was not replaced by iron: Even though, pinkish colored dolostones due to pigmentation and staining by iron were observed. The depositional structures (facies and structures) as well as the karstic features (dissolutions, brecciation, etc.) shown by the host carbonates are preserved by the ore deposits. The iron mineral phases, with the associated silica, manganese, barite and others, represent a replacement and open-space filling products (breccias, concretionary and vein-type). Petrographic and mineralogical observation revealed that the two carbonate sequences experienced fabric retentive dolomitization processes that resulted in the formation of unimodal (rarely polimodal), fine to medium-grained, subhedral to euhedral loosely-packed mosaics of dolomite. Later, the carbonates were silicified and ferruginized where the iron oxides and/or silica occur as pseudomorphs after dolomite crystals. The silica occurred mainly in the dissolved clasts and other associated diagenetic features (e.g., dissolution tubes) as well as in sedimentary discontinuities. Silica occurs mainly as mega-quartz, micro-quartz and chalcedony quartz and sometimes shows banded fabrics alternating with the dolomite and iron bands and laminae. Different textures of iron oxides (e.g., massive amorphous, boxwork brecciated, colloform and alveolar cavity-filling textures) were formed after silicification. In addition, the oolitic and oncolithic fossiliferous as well as the laminated textures of their host carbonate facies were preserved and replaced by iron oxides with relics of dolomites.
According to these features, a new sedimentary and diagenetic model is provided to elucidate the genetic mechanisms for the cherty ironstone hosted in carbonate sediments in the Bahariya area. The ironstone deposits are interpreted as a replacement product formed by dissolution of specialized host rocks (dolomites) and concomitant generation of dolomite pseudomorphs followed by precipitation of iron minerals through structural traps (faults). The formation of these deposits resulted from abundant crustal silica and iron-rich fluids leached from the underlying basement rocks under acidic conditions. This explanation for the formation of cherty ironstone of the Bahariya region is similar to that provided by some previous genetic models for banded iron formation (BIF).

Estimate of sediments, erosion potential and structure discontinuities in Masal basin and sub basins, Anzali, Iran

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To study on such parameters as particle size in Masal Basin Rivers with gravely bed, more than 30 sediment samples were taken from 15 sampling stations. Analysis of the size of particles indicated a clear decrease downward of the Masal River; while, in other branches in spite of remarkable sedimentary disconnections, average of particle size to the end of river shows an increase. Entrance of sediments from side branches and lithological changes in feeder formations are important factors which increase and/or decrease the structure of the sediments in floor of the channel and create disconnections in the channel. Also studies indicate the role of such forces as hydraulic matching, erosion, slope change and lithological changes in the process of making the particles tiny in Masal basin. On the whole, sediments in the understudy basin have poor and to some extent, very poor matching. Sediment estimation of the basin was conducted with the erosion potential model. Based on the total amount of the annual sediment production, the basin was estimated to produce 59787.78 tons per hectare which is highest amount compared to those of other basins.

Sequence stratigraphy, reservoir quality and sedimentary environment of the Upper Dalan and Kangan formations, Persian Gulf Basin, Iran

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Using of the concepts of the sequence stratigraphy at the carbonate sedimentary environments began since 1980s. At the sequence stratigraphy the main emphasis is the role of environmental conditions that control reservoir quality and the requirement conditions for development of reservoir rocks is assessed without any regard to the changes after sedimentation. Accordingly, in the Upper Dalan and Kangan formations existence more energetic, grain dominated facies that was sedimented at time of transgression of Permian sea, cause the development of reservoirs with high reservoir quality at this formations. In This sequence reservoir quality is largely depend on the distribution pattern of sedimentary facies and sedimentary tissues has been created good reservoir units by extension dolograinstone and grainstone at high energy conditions and with good moldic and inter-particle porosity. Mud dominant facies are without or low reservoir quality. This facies in low energy regression conditions cause low accommodation space or at extermly transgressive system tract (TST) and stacking of deep sediments, in fact this facies separate high reservoir quality units from low reservoir quality units. Study of lithology, fossils, sedimentary structures at core samples with mineralogy, texture, diagenetic features at microscopic analysis we distinction 11 facies at Upper Dalan and 12 facies at Kangan formations. Based on microfacies sedimentary environment this formations is homoclinal ramp. Four large third-order sequence were defined on basis of on lithology and type of fossils especially foraminifer. The key challenge in this reservoir analysis was to predict vertical distribution of petrophysical properties to improve reservoir characterization and relationship between sequence stratigraphy, reservoir quality and sedimentary environment.

Sedimentology and geochemistry of the Paleoproterozoic shallow-marine Espanola Formation, Huronian Supergroup, Canada: Implications for deposition in a tectonically-controlled rift basin

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The Paleoproterozoic (2.45–2.2 Ga) Huronian Supergroup is a southward-thickening wedge of mostly siliciclastic sedimentary rocks with subordinate carbonate and volcanic rocks, exposed along the north shore of Lake Huron, Ontario, Canada. The lower part of the Huronian Supergroup is inferred to have been deposited in a restricted, fault-bounded continental rift basin during Early Proterozoic episodes of crustal stretching and contemporaneous faulting along the southern margin of the Archean Superior Province. This study aims at evaluating evidence of syndepositional tectonic instability from the shallow-marine Espanola Formation of the lower Huronian Supergroup based on a thorough sedimentological assessment of Espanola Formation outcrops and drill core north of Elliot Lake, Ontario. Our investigation has revealed the widespread occurrence of tectonically-induced deformation structures within the Espanola Formation, which can be broadly grouped into three main categories: 1) forceful intrusion structures, 2) slope failure structures, and 3) soft-sediment deformation structures. Conspicuous examples of these structures include 10 to 100 cm thick clastic dykes, large-scale slump structures, intraformational breccia, load casts, ball and pillow structures, convolute lamination, and dish-and-pillar structures. All but the slump structures are restricted to discrete stratigraphic horizons, laterally traceable over long distances and confined between undisturbed strata of similar lithology. Such characteristics strongly indicate liquefaction and fluidization mechanisms possibly triggered by rift-related seismic activities during lower Huronian basin subsidence.
In some places, microbial mat structures also appear to have been disrupted by seismic events. Previous observations including restricted lateral distribution of lower Huronian units, significant thickening and facies variations across major normal faults in the area, and widespread continental flood basalts at the base of the Huronian Supergroup further support a tectonically-controlled rift basin interpretation. Geochemically, siltstones of the Espanola Formation plot in the continental arc field on Th-Sc-Zr/10 and La-Th-Sc ternary plots, which probably reflects the tectonic setting of the source rocks, rather than the Huronian basin itself. Geochemical comparisons with modern and Paleozoic continental rift basin sediments indicate similar discrepancies in tectonic setting discrimination.

Sedimentology and sequence stratigraphy of the Early and Middle Jurassic outcrops, Jabal Tuwayq, Saudi Arabia

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A high-resolution sequence stratigraphy study based on outcrops and shallow core of the Jurassic Shaqra group in Jabal Tuwayq, central Arabia, provides a comprehensive reference for the most economically important formations in the Arabian Platform. Moreover, it provides a continuous record of a Jurassic extensive shallow marine intra-cratonic platform. Ten third-order composite-sequences of mixed carbonate-siliciclastics succession from Early-Toarcian to Kimmeridgian were defined along 300 km N-S transect south of Riyadh. The composite-sequence boundaries are marked by regional fluvial erosion unconformities, and exposure and ravinement surfaces. The composite-sequences consist of multiple transgressive asymmetrical high-frequency sequences forming correlatable wedge shaped successions 5-10 m thick. The facies succession is controlled mainly by eustatic sea level change, differential subsidence and siliciclastic influx. The depositional profile is very flat and shows gradual lateral facies changes from fluvial/coastal plain sandstone, inner-platform shale, and lagoonal limestone through back-barrier grainstone.

The Marrat Formation (Early to Middle Toarcian) records the first Jurassic marine transgression at the outcrop and contains five facies-association, including: red fluvial shale and sandstone, mottled shale and microbial-laminated intertidal sandstone, swaley cross-stratified and bioturbated shoreface sandstone, green shale and lagoonal white bioturbated mudstone/wackestone facies and subaqueous evaporites with microbial-laminated structure. The succession makes two transgressive-regressive composite-sequences that both begin with fluvial deposits and grades upward to lagoonal limestone facies, with the MFS at the base of the lagoonal facies. The composite sequences are onlapping and wedging southward. An evaporite unit marks a lowstand wedge in the northern part of the cross-section. A dominantly arid climate during Marrat Formation is suggested by low siliciclastic influx, thick fluvial red shale and evaporite sediments.

The Dhruma Formation (Early Bajocian-Middle Callovian) unconformably overlies the Marrat Formation and consists of five composite-sequences (DCS1-DCS5). DCS1 begins with shallow intertidal mixed carbonate-siliciclastic successions deepening and thickening upward with an increase siliciclastic influx to the platform (D1 unit). DCS2 records the Bajocian MFS with green shale and white oncoidal benthic foraminifera-rich lagoonal wackestone (D2, Dhibi Limestone Member). DCS3 begins with brown transgressive grainstone interbedded with argillaceous mudstone (D3 unit). It grades upward to white benthic foraminifera-rich lagoonal wackestone and back-barrier cross-bedded peloidal grainstone that marks the Early-Bathonian MFS (D4 unit). DCS4 is a transgressive sequence that begins with white pelletal mudstone (D5 unit) that grades upward to reddish-green shale (D6 unit). The red shale grades southward to coastal/intertidal sandstone incised with fluvial deposits with petrified tree-trunks. This marked the middle Bathonian unconformities. DCS5 is begins with transgressive brown wave-dominated cross-bedded ooid grainstone (top D6 unit) onlapping the unconformity. It grades upward to white benthic-foraminifera and coral/stromatoporoid-rich lagoonal wackestone/packstone (D7 Atash Member) overlain by transgressive thick green shale of the Middle Callovian (D7 Hisyan Member).

The best reservoir facies within such a flat, shallow mixed carbonate-siliciclastic platform occur: 1) at the base of transgressive lagoonal cycles marked by scoured-base intraclastic grainstone/rudstone facies, and 2) top of composite sequences during maximum marine flooding and backstepping of the back-barrier grainstone and stromatoporoid/coral buildups.

How fast is the growth of a man-induced travertine? An example from Canary Islands, Spain

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The Calabozo Carbonate Deposit, in northern Gran Canary, Spain is a small travertine building composed of a suite of pools and cascade terraces. At present the building is totally dry and there is no flowing water. The system was active only about forty years when the water was used for irrigation of banana fields, which is an evidence of the rapid growth of travertines in volcanic settings.
The carbonate building is composed of three main elements:
1) Relatively homogeneous slope situated containing the exit of the ancient irrigation plumber and showing an irregular thin coating of carbonate either with some macrophyte framestones and oncoliths.
2) Pools of about 1 to 2 m in diameter and 0.3 to 0.6 m deep. They are partially filled by debris of powdery carbonate, clays and vegetal fragments.
3) Cascade barriers limitate the pools. They are the more visible parts of the building and are the main carbonate constructions and formed by: a) vertical to oblique macrophyte coated stems, b) curtains formed by the coalescence of hanging coated stems,c) peaks (viseras) situated on the curtains and formed by network of thinner vegetation debris incrusted by carbonate.
These architectural elements are formed by: 1) Coarse crystalline coated stems that form the framestone of the cascade barriers. The mean diameter of coated stems is 4 cm and the length is highly variable from 6 to 30 cm. All have an empty nucleus. The crystalline coatings are palisadic and equigranular mosaics. 2) Fine crystalline coated stems/other plant structures. This facies consists on ellipsoidal to irregular pores (up to 1 cm) surrounded by irregularly laminated micrite including palisade-like laminae. Organic filaments and diatoms are very common. 3) Crusts of well defined laminae (up to 0.3 mm thick) of coarse palisade to fan-like calcite crystals alternating with finer (< 0.1 mm) micrite laminae cover the slope surface. 4) Micrite occurs mostly in the spaces left by the calcified stems or as thin laminae between the coarse crystalline bands. It contains diatoms and some microbial structures such as filaments, spheres and EPS. Contrary to the expected in thermal deposits, in the Calabozo travertine the barriers are built by macrophytes incrusted by coarse palisade and laminated calcite. Macrophyte stems created small obstacles and were later coated by coarse crystalline calcite. The coarse size of the crystals probably reflect high precipitation rates under disequilibrium caused by water degasification after it exit from the plumber and also by probably high velocity due to the slope. The rate of calcite precipitation would have been very high, which was necessary to preserve and coat the stems that formed the original obstacle. In these conditions travertine growth on the slope can contribute to a fast change of landscape, whether or not induced by man-activity.

Sand supply from shoreface to foredunes: aeolian transport measurements and morphological evolution of a Tuscany beach stretch (Italy)

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The coastal dunes are a highly dynamic sedimentary environment characterized by a continuous time-space readjustment in terms of morphology, shape and dimension. This is mainly due to the periodic fluctuation of the volume of sand available and by the force of the deflation processes, which are in turn driven by the interplay among pattern of vegetation cover, surface roughness and local-regional wind regime. The aim of our research is to quantify the deflation, transport and deposition of sands in a natural coastal field dune system located in the northern coast of Tuscany, Italy. The northern part of the investigated area is characterized by stable coastline condition while southwards strong erosive processes took place since 1800s. Sedimentological data come from a series of sand trap spaced along transects orthogonal to the coastline from the backshore to the semi stable dune field. The trap were constructed of PVC pipe 100 x 10 cm, with two openings 7 cm wide and 50 cm tall arranged on opposite sides of the tube. An opening is willing windward and works for sand collection. The other is leeward and is covered with a metal wire 60µm opening in order to prevent the passage of sand. Traps were buried along, until the base of the free window coincide with the surface of the ground about 1,5 m. The sand trapped within each collector was sampled every two hours for three consecutive times. In laboratory sand samples were weighed and subject to grain size analysis by means of mechanical sieves. Local wind parameters and their fluctuation with time were acquired through a meteorological mobile station. The station is equipped with three anemometers located at three different heights from ground surface: 40, 120 and 180 cm. A wireless sensor allows the constant output of data (every 5 s) to a device. Temperature and relative humidity values are measured every 30 minutes. Analysis of data has evidenced the time-space fluctuation of sand volume in the two study area (stable area and under erosion). Basing on this methodological approach the time-space fluctuation of sand volume experienced by the two study areas (stable area and under erosion) has been estimated. Basing on this methodological approach the time-space fluctuation of sand volume experienced by the two study areas (stable area and under erosion) has been estimated.

Stratigraphic architecture of deltaic deposits in high-accommodation settings: The case study of the Valimi Formation (Gulf of Corinth, Greece)

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The Gulf of Corinth is an active rift located in the Aegean back-arc region, between the Peloponnesus peninsula and mainland Greece. The syn-rift deposits are traditionally subdivided into three units, that are in stratigraphic order: i) the Lower Group (fluvio-lacustrine deposits); ii) the Middle Group (giant Gilbert-type deltas and associated deep-water deposits), and iii) the Upper Group (slope deposits, perched Gilbert-type fan deltas and stepped marine terraces uplifted along the coastline). Syn-rift deposits have been accumulated in high-accommodation settings, in which the depositional systems record a continuous and rapid increase in accommodation space.
This study focuses on the deltaic deposits of the Lower Group, that is in turn subdivided into three laterally equivalent formations: the Exochi Fm. (alluvial deposits), the Valimi Fm. (fluvio-deltaic deposits) and the Aiges Fm. (turbiditic-lacustrine deposits). More in detail, this study has been carried out on the lacustrine deltaic deposits of the Valimi Fm. exposed in the surroundings of the Valimi village (central part of the southern margin of the Gulf of Corinth). The succession is about 800 m thick and has been investigated through modern facies association concepts to reconstruct the depositional evolution, as well as the stratigraphic architecture of deltaic deposits.
Six different facies associations have been recognized, typically vertically arranged up to form coarsening- and shallowing-upward trends (i.e. open lake deposits at the base, passing upward to prodelta, delta front, mouth-bar, distributary channels and delta plain deposits). This vertical stacking pattern record the deposition of shoal-water deltas prograding into a shallow lacustrine environment. This interpretation is in contrast with previous studies that refer these deposits to Gilbertian-type deltaic settings. Coarsening- and shallowing-upward units (i.e. single shoal-water deltas) are vertically stacked in a parasequence-like arrangement, resulting in an overall aggradational-(slight) retrogradational trend that became aggradational-(slight) progradational in the upper part of the succession.
The rapid creation of accommodation space that typifies high-accommodation settings has an important impact on the stratigraphic features of shoal-water deltas deposits. The most important of them are: i) single story and isolated channels within delta plain fines; ii) uncommon and poorly developed paleosoils in delta plain deposits; iii) thin, discontinuous and sandy matrix-rich lignite layers within delta plain deposits, similar to those classically excepted for transgressive settings; iv) general lack of compensational geometries and lobes avulsion processes within mouth-bar deposits.

Upper Quaternary seismic stratigraphy and sequence development in an ever evolving marginal basin: The North Evoikos Gulf, east-central Aegean Sea

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The North Evoikos Gulf is a deep (460 m) semi enclosed, elongate marginal basin connected to the Aegean Sea via a 45m sill to the north. It is an active extensional basin with high seismic activity and a small Upper Quaternary shoshonitic volcanic center (Likades islands) developed to the north.
A dense grid of high to medium resolution seismic reflection profiles has been used to establish the overall Upper Quaternary seismic stratigraphy of the sedimentary infill and 10 cores were investigated in order to elucidate the most recent sedimentary sequences. Detailed seismic facies analysis allowed defining a series of sedimentary features that can be used as indicators of past sea or lake levels. Notably: 1) buried erosional surfaces forming terraces, 2) delta offlap breaks and coastal or delta clinoform wedges, 3) unconformities and their transition to conformable sequence boundaries, 4) alternation of marine and lacustrine facies.
Along the northern shelf we trace a vertically stacked series of coastal clinoform wedges, that form from 165 to 225 m bsl. These we attribute to MIS 2-MIS 16 low sea level stands. The fact that they are arranged in aggradation manner makes us postulate greater magnitude sea level drops to 165-180 m bpsl during globally synchronous low sea level stands and normal subsidence rates locally. Further upslope, coarse fan delta progradation is observed offshore the Xerias torrent at 75-130m bsl and above the numerous vertically stacked clinoform wedges the fine grained Loggos fan is developed. An extensive abrasion platform is observed in between 75 and 105m bsl and locally form small clinoform wedges at similar depths. Along the southern slope of the gulf the abrasion-erosive unconformity extends deeper and the low stand wedges are not so well developed, due to active sediment gravity flows and tectonic deformation. A small basin is forming behind a structural height at the south quarter of the gul. Within this basin marine-lacustrine cycles can be differentiated on high resolution records.
Sedimentary lithofacies recovered in cores include small scale sequences that comprise of alternations- a few decimeters to meters thick- of mostly chemical carbonates (60-95%) and more marly sediments (around 30-40% $CaCO_3$) richer in siliclastic clays.
In North Evoikos Gulf we present univocal evidence that during major Upper Quaternary low sea levels the sea dropped over 165 m suggesting that during glacial intervals evaporation exceeded precipitation and runoff to varying degrees. This scenario persisted through MIS 4&3 and the MIS 2 erosional unconformity has eroded, to varying degree MIS 3 mostly chemical carbonate rich sediments.

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Raman spectroscopy in heavy-mineral studies

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Raman spectroscopy is an innovative tool with tremendous potential, serving as a fundamental complement to a variety of provenance methods including heavy-mineral analysis. Because of its accuracy, efficiency and versatility, the results of the Raman technique are indispensable for fully reliable identification of heavy minerals in grain mounts or thin sections. Thorny long-standing problems that cannot be solved confidently with a polarizing microscope alone, such as the determination of opaque and altered heavy minerals, of detrital grains as small as a few microns, or of colourless crystals with uncertain orientation and rounded morphology, can finally be addressed. Detrital minerals are determined by comparison of the obtained Raman peaks with reference spectra. Although the method can be highly automatized, the full ability and experience of the operator is required to combine Raman data with the optical information obtained under the microscope on the same grains, which is essential for the efficient application of the method in provenance studies. Raman mineral analysis allows us to confidently identify dubious detrital minerals independently of their size and orientation. During counting of heavy-mineral mounts or thin sections, grain types that cannot be specifically determined are usually assigned to generic groups (i.e. opaques, turbid grains, undetermined rock fragments) and generally neglected in subsequent provenance considerations, which may result in a partial and seriously biased description and interpretation of the detrital assemblage. We can rapidly solve the thorny identification problems routinely encountered in optical heavy-mineral analysis. The Raman mineral analysis (RaMAn) technique allows us to identify various types of opaque and transparent accessory minerals and even to quantitatively or semi-quantitatively analyse the chemistry of solid solutions and isomorphic series (amphiboles, pyroxenes, garnets, olivines, epidotes, spinels). Among opaque accessory minerals, which may be strongly concentrated in placer deposits of economic interest and are particularly relevant for both provenance and settling-equivalence studies, magnetite, ilmenite or chromite can be discriminated with Raman spectroscopy. A new integrated methodology is available to determine the mineralogical composition as small as in silt-sized sediments, reaching the same precision level required to perform quantitative provenance analysis as traditionally done on sand-sized sediments. The user-friendly Raman spectroscopy, can be routinely applied also in mineralogical studies of ancient siltstones. Provenance information can thus be extracted from mudrocks, which represent a very conspicuous part of the stratigraphical record and are prone to preserve original detrital assemblages from diagenetic dissolution better than permeable interlayered sandstones. Quantitative mineralogical analysis of silt-sized sediments by innovative techniques opens up new frontiers in sedimentary petrology and petroleum exploration. Such an effective approach is of crucial importance to make accurate provenance diagnoses and sediment budgets and to correctly unravel the innumerable pieces of geological information stored in sedimentary archives from the alluvial plain to the deep-sea.

Clumped isotopes in tufas: The good, the bad and the ugly

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It is widely agreed that stable oxygen isotope values in riverine carbonates can represent near-equilibrium isotopic conditions once the resurgent spring water has equilibrated with atmospheric carbon dioxide. The concept that these deposits offer an attractive complementary climate archive to speleothems is well established. However, oxygen isotope data suffers from the inherent weakness that, in most paleo-applications, assumptions are required about either the isotopic composition of the fluid or the temperature of the system. The advent of clumped isotope analysis has recently offered the promise of palaeotemperature reconstruction without the need for assumptions or information on the isotopic composition of the parent water, potentially reducing some of the uncertainty.

At the time of writing there has been little published on clumped isotopes in tufa/travertine deposits. Kele et al. (pers. comm. 2015) have work in review that describes equilibrium clumped isotope palaeotemperatures, from a range of tufa and travertine 'vents'. In support of this, our data from the Kamara fissure ridge travertine in SW Turkey gives a mean clumped isotope temperature of 59.8 ˚C (n=15, Std error 3 ˚C). This is within error of the actual temperature a constant 56 ˚C. We discuss here new data from active riverine tufa stromatolites in the European Alps and S. France where tufa clumped isotope temperatures are consistent with near equilibrium conditions, within 0.5 ˚C of the measured value. Another sample of calcified moss tufa has an anomalously low clumped isotope temperature, perhaps because calcification of moss is dominated by thin-film precipitation where rapid carbon dioxide degassing causes disequilibrium. Importantly, the tufa stromatolites are active examples of systems that build annually laminated tufa deposits that have much promise for palaeoenvironmental reconstruction.

We have four pilot data points from a last interglacial laminated tufa stromatolite from Caours NW France where clumped isotopes give a ~15 ˚C differential between maxima (21.9, 21.0 ˚C) and minima (5.1, 3.8 ˚C) values. This compares favourably with a 12 °C differential between summer (April to September) and winter (October to March) in the modern Scardon River at Abbeville, a few kilometres downstream from Caours, and suggests that seasonal temperature variations from tufa stromatolites will be resolvable. The 'surprise' with this data is that the maximum and minimum values are not in the layers we expected! This might suggest that the tufa oxygen isotope record is much more responsive to winter recharge than we envisaged. Further, it appears to support the view that the main control on tufa stromatolite fabric is rate of calcite precipitation and not the cyanobacterial community present. This may mean that in some tufa stromatolites, although the cyanobacterial fabric or framework is a spring-summer one, much of the (mass) calcification is a winter phenomenon related mainly to outgassing of carbon dioxide. As such the temperature of the calcification could be un-coupled from the cyanobacterial growth temperature.

Devonian lacustrine shore zone architecture imaged with ground penetrating radar

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Lake margin sedimentary systems have been the subject of only limited study. The Middle Devonian orbitally controlled cyclic succession of Northern Scotland contains repeated developments of shore zone sandstones and thus provides an ideal location for the study of these units. The cycles are on average 15 m thick and comprise deep lake, perennial lake, playa and shore zone facies (2 to 3.5 m in thickness). High resolution sedimentary logging and the construction of photo-panels were combined with high resolution GPR profiling (250 MHz). To ensure close ties between the sedimentary logs and the GPR data, the cliffs were accessed using rope access techniques while GPR grids were shot directly above. The profiles were shot mainly in the strike direction of what was thought to be the shore elongation every 5-10 m and every 20-30 m in the dip direction. Shore zone systems of 3 different sequences have been imaged for a total of 1155 m of GPR profile collected. This configuration has allowed 3D visualisation of the architecture of the shore zone systems and, in combination with detailed sedimentology, provided insights into the generation of the dynamic shore zone environments. Loading and discrete channel forms are recognised in thin-bedded sandstones within the lower portion of the lake shore zone successions. Radar profiles suggest that sandstone beds towards the base of these units are sharp-based and contain some erosional features. Up-section the sandstone beds appear to become amalgamated forming subtle low angle accretionary bar complexes. These features are imaged well on the radar profiles where successive erosion/accretion can be recognised and their three dimensional form and distribution can be mapped. The orientation of these features is similar to extensive palaeocurrent measurements from oscillation ripples suggesting an alignment of the shore zone bars perpendicular to the prevailing wind direction. Further loaded sandstone beds and sand-filled shallow channel features overlie the bar forms. The channels are well imaged in the radar scans where their wider context can be gained.
The shore zone sandstones overlie playa facies which contain abundant desiccation horizons, reflecting the most arid phase in the climatically controlled lacustrine cycle. As climatic conditions ameliorated the rejuvenation of fluvial systems resulted in the transport of sand out into the basin. Initial deposition was limited to intermittent events where sediment was laid down on a water saturated substrate. Some of these may have occurred subaqueously as small scale turbidity flows. High resolution fluctuations in lake level resulted in periodic short lived reworking events along the lake margin which produced amalgamated sands, forming low relief bars. Shore zone reworking is likely to have occurred over a wide area as the lake margin migrated back and forth, and gradually transgressed. Continued transgression forced fluvial systems back towards the basin margin.

A 2.3 million year lacustrine record of orbital forcing from the Devonian of northern Scotland

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Detailed sedimentological examination of well exposed onshore sections through the continental Middle Devonian succession of northern Scotland have been augmented with offshore well data to allow the construction of a continuous 2.3 million year record of orbital forcing. The Middle Devonian of northern Scotland comprises a succession of cyclic lacustrine deposits. The onshore exposures of this succession, although well exposed, are disrupted by faulting. Hand held gamma logging of onshore exposures has allowed direct ties to be made to adjacent offshore well data which provides a continuous record through the lacustrine succession. Further onshore sections, shown to be representative of those identified in the offshore data, help define the orbital periodicities influencing sedimentation and furthermore, provide insights in to the response of the lacustrine system through time.
Periodicities reflecting the precessional (19 886 years) and eccentricity (100 000 years) cycles are shown to be dominant by the direct measurement and extrapolation of depositional rates in well exposed sections as well as the analysis of ratios between primary and, modulating, secondary cycles. The demonstration of a robust link between gamma log response and lithology in the onshore cycles allows the offshore data to be to be interrogated for evidence of the long term climatic forcing of sedimentation. Fourier analysis has confirmed the presence of regular cycles throughout the succession which vary in thickness similarly to the onshore records. Variations in cycle thickness and symmetry are related to a trend from an underfilled to a balanced fill lacustrine basin. Of further importance is the period of each cycle during which lacustrine conditions, and therefore lake level controlled accommodation, existed.

Oxygen and carbon isotope records of Lower–Middle Jurassic belemnite rostra and marine carbonates from the Pieniny Klippen Belt (Carpathians)

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The reconstruction of Early Jurassic (~201 to 174 Ma ago) environment is of particular interest to palaeoclimatoligsts due to cyclic changes from icehouse to greenhouse or even super greenhouse conditions. It was a time of fundamental environmental changes – a break up of the Pangea supercontinent, the formation of the Central Atlantic Large Igneous Province, the first-order mass extinction at the Triassic–Jurassic boundary and the Toarcian Ocean Anoxic Event (TOAE). In addition, global carbon cycle perturbation such as the TOAE or Sinemurian–Pliensbachian boundary event (S-P) have been described by multiple authors.
This study presents new carbon and oxygen isotope data of bulk rocks and well-preserved belemnite rostra from the Lower Sinemurian–Upper Aalenian of the Pieniny Klippen Belt, Carpathians. Analysed samples are derived from three outcrops in Slovakia and Ukraine. The studied sediments of this region were deposited in the Pieniny Klippen Basin (in the Tethys Ocean), within the Mediterranean ammonite province of Europe.
Belemnite rostra were screened for the state of preservation using cathodoluminescence microscope and analysed for iron, manganese and strontium contents using optical emission spectrometry (ICP OES).
$\delta^{13}C$ temporal trends display prominent negative drops in the Upper Sinemurian (Obtusum?–Oxynotum? Zones), on the Sinemurian–Pliensbachian boundary (S–P event; Raricostatum–Jamesoni Zones) and in the Early Toarcian (TOAE; Tenuicostatum–Serpentinum Zones). A major positive shifts were recorded in the Upper Pliensbachian (Margaritatus Zone) and in the Lower Toarcian (Serpentinum Zone). These events correspond to major perturbations in the global carbon cycle.
Temperatures calculated for the measured range of the $\delta^{18}O$ values of well-preserved belemnite rostra imply cooling of sea water in the Pieniny Klippen Basin of ca. 5 °C in the Late Pliensbachian, which corresponds to previously suggested ‘minor icehouse’ conditions during this time. Another drop of the temperature, of ca. 7.5 °C, was recorded between the Early Toarcian and the Late Aalenian (Serpentinum–Concavum chrons). This cooling event is consistent with previously published data from other Tethyan regions. Described by many authors Early Toarcian warming has not been recorded, since no well-preserved belemnite rostra has been found in the studied sediments of this age.

Origin of travertine lithotypes in Denizli Basin, Western Turkey: Petrographic and geochemical approaches

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In literature often the origin of travertine lithotypes has been attributed to abiotic and biotic processes. To give a more precise interpretation on their origin a more detailed investigation is necessary, including a distinction of travertine lithotypes. This study aims to evaluate travertine lithotypes from different locations in the Denizli Basin (Turkey), in comparison to lithotypes that were previously described from different locations all over the world. This study combines petrographic observations with geochemical results.
Nine lithotypes were differentiated in slope, fissure-ridge and pool facies. These are
(1) crystalline crust lithotype, (2) micrite lithotypes which is divided into green coloured micrite (2i), green coloured micrite with microphyte (2ii), brown coloured micrite (2iii), dark coloured micrite with microphyte (2iv), dark coloured micrite with microphyte and diagenetic formations (2v), (3) bryophyte lithotype which is subdivided into the microphytes and reeds travertine,
(4) shrub, (5) banded, (6) gas bubble, (7) paper-thin rafts, (8) fenestral travertine, and,
(9) monomictic and polymictic dentrital travertine.
The $\delta^{13}C$ and $\delta^{18}O$ signatures of the lithotypes vary from -3.2 to +7.8‰ and -16.4 to -6.6‰ V-PDB, respectively. The crystalline crust lithotype with aphanitic micrite, laminar micrite, dendritic shrub fabrics, typically occurred in the slope facies, has an average $\delta^{13}C$ signature of 5.7‰ (V-PDB). This value is distinctively higher than that of the shrub lithotype with peloidal micrite fabric (average of 4.4‰ V-PDB) in terrace pools, which is closer to average $\delta^{13}C$ value (4.43‰ V-PDB) of the fenestral travertine in the pool facies. On the other hand, the micrite lithotype with microphyte containing radial dendritic spar, peloidal and aphanitic micrite fabrics and the bryophyte lithotype with microphyte that only shows aphanitic micrite fabric, both in the pool facies, have average $\delta^{13}C$ signature of 0.8‰ and -0.48‰ V-PDB, respectively. In addition, average $\delta^{13}C$ signature of bryophyte lithotype with reeds (3.52 V-PDB) is much higher that the bryophyte lithotypes with microphytes. The polymictic travertines composed of aphanitic micrite fabric, that include quartz particles, detrital rock material and clay, have an average $\delta^{13}C$ of -1,25‰ V-PDB, much lower than that of the monomictic travertine (average $\delta^{13}C$ of 5.15 V-PDB). Comparing the crystalline crust lithotypes, it seems that the presence of microbial filaments, such as algaes and diatome, increases with higher $\delta^{13}C$ values. Comparing the micritic lithotypes and associated fabrics to their isotopic signature, an increase in $\delta^{13}C$, ranged from 0.23‰ to 4.6‰ $\delta^{13}C$ (V-PDB), is observed.
Differences in the $\delta^{13}C$ values of all lithotypes studied could be originated from mainly the location of waters precipitating travertine, the variations at the fabric density including diagenetic overprints, the metabolic activities of microbial organisms, the density of organic matter conducted by travertine lithotypes in micro-scale as well as magmatic sources, thermometamorphic decomposition of Mesozoic limestones and Paleozoic marbles and CO_2 degassing interpreting from facies in macro-scale. This study shows that fabric variations can be related to diagenetic overprints changed the $\delta^{13}C$ signatures of lithotypes. These diagenetic overprints consist of dissolution by inorganic or organic acids from microorganisms leading to micritisation and recrystallization inducing to dendritic spar formation.

A quantitative compositional approach to the study of a Miocene carbonate shelf in the northern Apennines

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The petrography of 147 samples of carbonate and mixed siliciclastic-carbonate rocks has been performed on shallow-water carbonates of early-middle Miocene deposited in a wedge-top basin in the northern Apennines. High-frequency sampling of the Torriana log (Val Marecchia valley, Romagna Apennines) covers the entire carbonate succession from the basal unconformity to the terrigenous-rich sediments that mark the demise of the shelf. The modal analysis has been performed by point counting (300 points) in order to quantify the main framework components: an intrabasinal carbonate fraction (biogenic), a terrigenous fraction (largely siliciclastic), and an authigenic intrabasinal component constitued by glauconitic grains.
On the basis of the relative amounts of these framework components, four different petrofacies are distinguished and matched with lithofacies units. From the base to the top they are the following:
- Rudstones and subordinate grainstones, made up almost exclusively of intrabasinal carbonate grains, represented by bryozoans and subordinate echinoid spines and plates. Cement is constituted by scarce sparry calcite.
- Rudstones to grainstones, made up almost exclusively of intrabasinal carbonate grains plus very subordinate amounts of siliciclastic grains (quartz, feldspars). Intrabasinal carbonates consist of shallow-water bioclasts such as bryozoan fragments, echinoid spines and plates, red algae and benthic macroforaminifera (Amphisteginae, Gypsinae). Grains are cemented by sparry calcite. Siliciclastic grains are concentrated in thin laminae; isorientation is also occasionally observable in bioclastic grains (Amphisteginae).
- Hybrid arenites: the intrabasinal carbonate component (biogenic) is associated with variable but subordinate amounts of terrigenous siliciclastic components dominated by quartz and feldspar grains (both plagioclase and k-feldspar). The biogenic component is still represented by bryozoans and echinoids but the bryozoan/echinoid ratio noticeably decreases. The siliciclastic component is mainly concentrated in thin laminae. The interstitial fraction includes pore-filling sparry calcite and micritic matrix.
- Arenites, from medium to fine-grained; the terrigenous input noticeably increases and becomes dominant. It is made up of prevalent quartz and feldspars and few lithics (sedimentary, metamorphic and volcanic). Intrabasinal grains are subordinate, made up of fragments of algae, bryozoans, and planktonic foraminifera. Glauconitic grains are present (up to 7% of the whole rocks); calcite is the dominant pore-filling cement.
The hierarchical cluster analysis of point counting data is in agreement with outcrop-scale facies observations. Our data indicate an almost exclusively intrabasinal supply during deposition of the basal portions. A vertical evolution is documented and it is evidenced by a progressive increase in the terrigenous supply that replaces the bioclastic fraction. The terrigenous input becomes significant in the upper unit marking the crisis of the shelf.

Contrasting carbonate-gypsiferous facies along the lacustrine-playa lake system of the Deza Formation (Upper Eocene, Almazán basin, central Spain)

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Non-marine carbonate-gypsiferous facies are common from arid to subhumid regions within hydrologically closed continental basins. Saline lakes occurrence is controlled by tectonics and climate, and their sedimentation is largely determined by surface and groundwater flows.
The Deza Formation (DF) is an Upper Eocene carbonate lacustrine unit that forms part of the Paleogene continental succession (more than 3500 m thick) of the Almazán basin (north-central Spain). It was deposited in a piggy-back basin related to the main thrust of the Iberian Chain. This work is focused on the southern part of DF that outcrops along 9 km in the SE-NW Cihuela-Embid anticline. Two complete and well exposed sections have been studied together with a small section at the northwestern end of the anticline.
The best southeastern section (AE) is 260 m thick and consists of marly limestones and limestones with dark marly intercalations and dispersed silica nodules in the lower two thirds of the section. Biomicrite facies with gastropods, ostracods and charophytes are commonly present. This section displays sequences around 1 m thick that begin with dark marly facies and end with compact limestones with numerous lenticular submillimetre gypsum moulds filled with sparite. The upper third of section is made up of calcrete-palustrine sequences less than 1 m thick.
The central section (UC) situated 2.9 km northward, is 190 m thick and consists of 5 major sequences; the lowest one is mainly made of dolostones with clayey-marly intercalations, and the other consist of siliciclastic muds and marly muds in their base that gradually change into limestones upward; silica nodules are common from the base to the top of the section. The dolostones of the lowest sequence are dolomicrites -dolomicrosparites with relics of microfossils and/or dolomitized/calcitized lenticular gypsum crystals. The upper four sequences, in their turn, are formed by sequences1-3 m thick that begin with clayey and/or marly levels and end with palustrine limestone characterized by interstitial crowded lenticular calcite pseudomorphs after gypsum crystals and by gastropod protoshells. In contrast with AE section, biomicrite facies are scarce.
The section (Bo) at the northwestern tip of the anticline (3.4 km from UC section) is mainly represented by laminated gypsiferous facies and is correlated with the upper sequence of the UC section.
The areal differentiation of facies indicates a change along the SE-NW trending from lacustrine (AE section) to evaporite playa lake (Bo section) environments through a palustrine fringe represented in the central section (UC section). On the basis of their contrasting types of carbonates and associated facies along this trending, it is important to highlight the total replacement (calcitization or dolomitization) of the interstitial gypsum in the entire DF, but in the north-western tip the interstitial and laminated gypsum is preserved in clayey-marly host rock. It is interpreted that, in the carbonate lacustrine-palustrine environments, the sulphate solutions coming from of the calcitization/dolomitization is reprecipitated in the next sedimentary cycle, and/or in the distal playa lake areas resulting in laminated gypsums.

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Paleoichnology of Middle Carboniferous age anchimetamorphic rocks – a preliminary study

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In the Bükk Mountains (North Hungary), Middle Carboniferous anchimetamorphic dark-grey shales with limestone intercalations are exposed along the railway cuttings between the villages Nagyvisnyó and Nekézseny (railway section number 422). They belong to the Málykinka Formation. According to the published examinations based on the poorly preserved plant and animal fossils, such as *Neuropteris* sp., *Pleurotomaria* sp., *Linoproductus linearis* (WAAGEN), *Spirifer* cf. *zitteli* SCHELLWIEN, *Fenestella* sp., and crinoid stems, the shales were deposited in marine anoxic environment while the intercalating limestones were referred to marine littoral zone.
Examination of polished slabs shows that the shales are strongly bioturbated (ichnofabric index = 4), however the bioturbational structures are poorly visible due to low colour contrast in dark-grey rocks.
The following ichnotaxa have been identified: *Asterosoma* isp., *Chondrites* isp., *Helminthopsis* isp., *Phycosiphon* isp., *Nereites* isp. and *Trichichnus* isp. *Chondrite*s and *Phycosiphon* are the dominant ichnotaxa. The observed trace fossils represent the categories fodinichnia, chemichnia and pascischnia. Their trace makers benefited from high organic matter content in the sediment. They belong to the distal *Cruziana* ichnofacies or to a transition to the *Zoophycos* ichnofacies, which indicate that the shale was deposited in offshore or deeper shelf environment.

Pedogenic calcretes a characteristic feature in the first alluvial deposits of an intraplate extensional basin (Upper Jurassic, North Spain)

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Calcrete deposits are highly abundant in ancient and modern continental basins and given its great importance, they have been thoughtfully studied. Calcretes have become an important tool for the reconstruction of past environments.
This work is focused on the earliest syn-rift sedimentary record (Tithonian) of the W Cameros Basin, which include alluvial fan, fluvial and lacustrine sediments. This sedimentary record is characterized by the abundant presence of calcrete deposits which, despite their age, display a great variety of well-preserved pedogenic facies, microfabrics and features which allow a detailed sedimentological, morphological and petrological analysis. In addition to its great degree of preservation, the interest of these calcrete deposits lays on the fact that they developed on architecturally heterogeneous sedimentary systems. This sedimentary heterogeneity is preserved in the calcrete deposits in the form of a great variability in their morphology, lateral extension, thickness and environmental distribution. This provides a great opportunity to analyze the relative controlling role which local geomorphological factors, such as sedimentation rate and frequency, main transport processes, texture of the host sediment and water-table fluctuations, had over calcrete deposit development.
Therefore, the aim of this work is describing these exceptional calcrete deposits, distinguishing the different calcrete sequences which developed on the different sedimentary environments based on their morphology, lateral extension and thickness, and assessing their genesis and environmental significance. This will allow integrating them within the sedimentary framework, assessing the role that the different geomorphological factors had on calcrete development and finally establishing their relationship and interaction with the main allogenetic factors, such as climate, tectonics and the drainage area. The great development of calcrete profiles in the study area allows inferring a semi-arid climate involving seasonal alternation of wet and dry periods. Also, the variations in calcrete sequence characteristics and distribution can be considered as ultimately caused by tectonic differences between the halfgrabens distinguished. Finally the lithology of the drainage area was also an important factor that controlled the hydrochemistry of both runoff water as groundwater. The water was supplied to the basin came from different carbonate source areas (predominantly marine Jurassic beds of limestone and lesser extent calcareous sandstone) and was much supersaturated with respect to calcium carbonate. This factor in conjunction with climate and tectonics very widely promotes the rapid and significant development of pedogenic calcretes on different temporarily inactive (no sedimentation) alluvial system environments.

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Catchment controls on evolution of dryland alluvial megafans: Quaternary examples from central Iran

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Tectonics, climate, base level and upstream catchment exert primary controls on evolution of alluvial megafans and the relative importance of these controls on fan morphology and sedimentary architecture is still not fully understood. This study examines the role of upstream catchment characteristics on the evolution of alluvial megafans (>30 km in length), by examining four selected megafans along the flanks of the Kohrud Mountain range, central Iran. These fans are cut distally by an axial river and playa lake sediments reflecting seasonal and more regional climatic fluctuations. They formed in a tectonically active basin, with a arid to semiarid climatic setting and associated long-term (Plio-Pleistocene to Recent) change from wetter to drier conditions. However, important key differences between these fans exist in the catchment bedrock, catchment geometry and outlet spacing. Detailed fan surface mapping (based on 1/50000 topographic maps, satellite images, and fieldwork) combined with the collection of geomorphic parameters reveals that the evolution of these megafans responded to key differences in upstream catchment characteristics of the bedrock geology. This paper identifies and explores the main controls on the evolution of megafans along the margin of the Kohrud Mountain range. Catchment lithology, localized tectonism and climatic change have all acted as important drivers in the development and evolution of the Kohrud megafans.

Semi-automatic segmentation of petrographic thin section images using a "seeded-region growing algorithm" with an application to characterize weathering of the Buntsandstein Formation, northern Germany

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Accurate imaging of minerals in petrographic thin sections using (semi) automatic image segmentation techniques remains a challenging task chiefly due to the optical similarity of adjacent grains or grain aggregates rendering definition of grain boundaries difficult. We present a new semiautomatic image segmentation workflow for the quantitative analysis of microscopic grain fabrics. The workflow uses an automated seeded region growing algorithm, which is based on variance analysis of five or more RGB images. The workflow is implemented in the open-source Geographic Information System (GIS) software SAGA (System for Automated Geoscientific Analyses). SAGA provides all required tools for image analysis and geographic referencing. It also features a graphical user interface that allows the user to simultaneously display and link multiple images and, thus, facilitates manual post-processing of the images. SAGA's capabilities for vector data analysis offer instant calculation and visualization of the compiled geometric database within a GIS environment. Specifically, grain contacts are automatically identified by lines of intersection and manually classified by contact type to characterize the mineral fabric of petrographic thin sections. To demonstrate the effectiveness of the workflow, 39 transmitted light images of 13 weathered sandstone samples of the Buntsandstein Formation in northwestern Germany were analyzed. Based on the segmentation results obtained from the samples, a number of parameters, including modal composition, geometry of grain contacts, porosity, and grain size distribution were determined and statistically evaluated. The results of the image analysis are utilized to assess the weathering susceptibility of the sandstone samples and point to the importance of cementation determining the geotechnical properties of a given sandstone sample.

Duricrust origin of South American table mountains (tepuis): Evidence from field and experimental data

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Geoscientific research was performed in the largest sandstone cave systems in Venezuelan table mountains (tepuis). It showed that erosion of non-cemented layers. Softer beds in which the caves were initially formed show a lack of cementation. The hard overlying and underlying beds, as well as the pillars which penetrate the uncemented arenite beds, are cemented by opal and quartz cements. The pillars indicate that the main diagenetic phase was represented by descending silica-bearing fluids. The pillars originated when the fluid flow reached coarse-grained arenitic bed, where the continuous fluid front splited to narrow channels (so-called “finger-flow” pillars). This caused lithification of the arenitic material in the channels and the rest of arenites in these beds escaped from lithification (softer beds) and was easily erodable.
This brought a new view on the origin of whole tepuis. They consist of hard quartzites and sandstones of the Matauí Formation, which are underlain by arkoses of the Uaimapué Formation. These are the uppermost formation of the Roraima Supergroup which is the Paleoproterozoic detritic cover of the Archean Guyana Shield. The main lithification phase of the Matauí Formation deposits, which caused their hardening to quartzites, was represented by descending silica-bearing fluids which did not penetrate to the underlying arkoses which remained almost unlithified. When looking for the best source of fluids, tepuis likely originated in places where there was an intensive descending fluid flow leaking from surface water reservoirs, such as rivers or lakes, This continuous flow carried SiO_2 from the lateritized surface beds and caused strong lithification of the underlying upper part of the Roraima Supergroup. These indurated parts of the formation remained as tepuis, while the remainder of the formation was removed by erosion. The softness of the underlying, non-lithified sediment below the tepuis caused undercutting of their margins thus maintaing steep walls.
To verify the new theory, an experimet was performed, using layered sands and sodium-silicate solution. Fine to medium sand fraction was used (0.08-0.5 mm), along with coarse (0,5-1 mm) to very coarse (1-2,5 mm) fraction. The sands were layered and compacted in a transparent plastic box (14 l volume), with the latter forming the thickest layer (10 cm in the centre). The coarsest layer was limited by two 3 cm thick layers of fine- to medium-grained sand; top and bottom of the layerded packet was formed by 2 cm thick layers of coarse sand. 3 liters of sodium-silicate solution (so-called water glass) were left to drip for several hours to the top of the sediment. Each liter was stained with a different ink to reveal the individual phases of impregnation. The fine-grained layers were perfectly impregnated all through their volume, whereas thedescending fluid flow has split to “fingers” in the very coarse layer, forming thus small “finger-flow” pillars. Results of this experiment, which was designed to mimic as close as possible the real diagenesis by descending silica-bearing fluids, perfectly match the real phenomena observed on the tepuis.

Comparative analysis of high-frequency sequences recorded across different subsident domains of the Sinemurian Iberian carbonate platform (NE Spain)

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We present here the results of a comparative analysis of high-frequency sequences recorded along the shallow carbonate platform developed during the Upper Sinemurian in the Northern Iberian Basin. The facies and sequential analysis was performed into three basin areas with different subsidence areas, which are separated 50-60 km. The Almonacid de la Cuba area includes the thickest succession (up to 38 m) and the largest number of sequences (up to 15). In Calanda, with intermediate thickness (up to 18 m), the maximum number of recorded sequences is 11, whereas in the area with the lowest thickness of Montalbán-Castel de Cabra (7–12 m thick succession), the record of sequences ranges between 6 and 9. Most of the sequences have a shallowing-upward facies evolution trend, are 1 to 3 m thick, and are bounded by flooding surfaces linked to stages of episodic increase of accommodation. The study from continuous outcrops indicates that the lateral continuity of these discontinuities is at least 10 km. This continuity suggests the existence of a regional or global allocyclic factor controlling the origin of the sequences. The successive stages of increasing accommodation affected the studied domain of the basin, but had a variable record depending on the subsidence rates that operated in either sector analysed platform. In areas with low subsidence rates, which are dominated by high-energy grain-supported facies (oolitic, peloidal, intraclastic, bioclastic), the number of sequences identified is lower, since the sequence boundaries tend to be amalgamated. By contrast, in subsiding domains of the platform there is a significant preservation of the low-energy sub-wave base open mud-supported facies, and the record of sequences and sequence boundaries is more complete and continuous.

Sedimentological response and coastal geomorphology of the last 8500 years of Zakynthos Island, Ionian Sea: A history of a segregated Mediterranean Island

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Zakynthos is one of the most seismically active regions in the Mediterranean area It is located very close to the convergent boundary between the African and Eurasian plates and its Holocene evolution has been influenced by tectonic activity, catastrophic events and relative sea level changes.
In the present study detailed sedimentological, palaeontological and ^{14}C dating analyses were used in order to reconstruct the Holocene landscape evolution of Zakynthos Island. Based on four 30 m cores down, one drilled in the northern part and the others in the southern part of the Island, we interpret the depositional environments and we estimate the age depth model based on ^{14}C radiocarbon dating, using the OxCal software. For our interpretation we took into account sedimentological (grain size analysis and moment measures), geochemical (total organic carbon – TOC and total nitrogen - TN) and palaeontological (micro- and macro fauna) proxies while the chronological framework of the present study is based on seventeen (17) ^{14}C dating results of *Cerastoderma* sp. shells.
Based on lithological observations, sedimentological laboratory analyses, micro- and macrofossill analyses, radiocarbon dating and age-depth models we conclude the following remarks:
• Before 6400 yrs BP in the inland research areas of Zakynthos Island marine depositional environments have been recorded.
• Due to the sea level rise until 6000 yrs BP both in the northern and southern part of Zakynthos Island, brackish lagoonal and lagoon / barrier systems had developed.
• In such lagoonal environments, marine influence and water circulation between the lagoon and the open sea has been observed, which could be attributed either to the destruction of the barrier of the lagoon and the development of inlets or to the temporary intrusions of marine water via storms or tsunamogenic events.
• Before 8300 yrs BP the Vasilikos peninsula seems to have consisted an isolated, separated from Zakynthos, small island.
• Various sedimentation rates have been reconstructed with the highest ones observed before 7000 yrs BP (north 39.14 mm/y and south 9.17 mm/y), while a clear decrease in the rate of sedimentation has been recorded from 6000 yr BP to present (north 1.02 mm/y and south 1.14 mm/y).
• The observed high sedimentation rates in Zakynthos Island correspond well to the most widespread Holocene warm and humid phases and to periods of fast sea level rise.
• The fact that the Vasilikos peninsula had been a separate island during most of the prehistory constitutes an important factor for the archaeological research of Zakynthos and the other Ionian Islands as well.

Direct observation of turbidity currents in the Congo Canyon reveals a new flow structure

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Turbidity currents carry sediment from shallow continental shelves towards deep ocean basins. The magnitude of sediment transported by these submarine flows is comparable to those of the world's largest rivers. Given the scale of the flows, surprisingly little direct observations of these flows are available, and most of our knowledge of these flows is generated indirectly through outcrop studies, numerical models and laboratory experiments. Turbidity currents in small-scale laboratory experiments typically have a three-folded structure consisting of: 1) a thick turbulent head, which is being fed by 2) a faster moving thinner body, which is outrunning 3) a dissipating tail. Here we use acoustic Doppler current profiler (ADCP) records of turbidity currents at 2,000 water depth in the Congo Canyon, to investigate if the flows in Congo Canyon are indeed of a similar flow structure to those observed in smaller-scale laboratory experiments.
The measurements from the Congo Canyon show flows with durations of 6-to-10-days. The flows consist of fast frontal cells with velocities of over 2 m/s, followed by much slower moving and thicker trailing bodies. The body switches between fast and thin, and slower and thicker modes. Our calculations of bed shear stresses show the frontal cell is likely to be erosional, whilst the trailing body may only transport sand as bedload.
The velocity difference between the fast moving frontal cell and the slower trailing body suggests that the thin frontal part of the turbidity current drives the flow, and continuously autosuspends and feeds sediment into the ever growing trailing body. That difference in velocity (flow stretching) seems to be the most likely mechanism that is responsible for the long duration of the flow.

The Devonian/Carboniferous interval in a platform-to-basin direction: A geochemical solution of sequence stratigraphy in pelagic settings?

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The Devonian/Carboniferous (D/C) boundary is an important time interval in the Earth´s history, characteried by climatic perturbations and eustatic sea-level fluctuations related to the glaciation of Gondwana. In recent years, it has been widely accepted among the international stratigraphic community that the global stratotype of the D/C boundary was ill-defined as concerns the biostratigraphic criteria for its definition and the LaSerre (Montagne Noire, France) GSSP itself. In the search for a "natural D/C boundary", i.e. one to be defined on event-stratigraphy basis, a lot of effort has been recently put into the study of the uppermost Famennian Hangenberg black-shale interval. In follow-up of this effort, we investigated the sea-level signal at and around the Hangenberg event using the methods of facies and microfacies analysis, element geochemistry and petrophysics with high stratigraphic resolution. We investigated seventeen D/C sections in several regions of Europe constituting the Late Devonian Laurussia (Moravia, Rhenish Slate Mountains, Ardennes), Gondwana (Carnic Alps, Montagne Noire and Pyrenees) and South China. In relativelly shallow-marine carbonate ramp settings (Ardennes) and mixed carbonate-siliciclastic settings (Rhenish Slate Mountains), well-traceable facies tracts indicate a prominent interval of forced regression in the latest Devonian. This interval coincides with significant hiatus in carbonate platform settings (Moravia) and it correlates with the "Hangenberg sandstone" of the Rhenish Slate Mountains – a fining-upward siliciclastic succession directly overlying the Hangenberg black shale. This forced regression is associated with overturns in geochemical composition, in particular the elevated values of zirconium (Zr/Al), which is perceived as an indicator of continental influence in marine settings and a proxy of siliciclastic input. In lithologically monotonous pelagic settings (Carnic Alps, Montagne Noire) and turbidite settings (Moravia), the Zr/Al and other geochemical anomalies are well traceable even without the associated lithological evidence. The Zr/Al anomaly directly overlying the Hangenberg black shale interval (often associated with positive ^{13}C excursion) represents a widely correlatable horizon, which we interpret as a signal of forced regression traceable even in very distal pelagic settings. This suggests that prominent sea-level changes can be traced in monotonous deep-marine facies, far away from the fluctuating base level (sea-level), based on subtle geochemical markers.

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Isotope geology applied to sedimentary successions: the case of the Bambuí Group, São Francisco Basin, Brazil

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Isotope techniques have been widely applied to help understanding the evolution of sedimentary basins, including provenance of the sediments, age of deposition, and timing of post-depositional alterations, as well and to decipher the variations of the seawater chemistry. This is mostly important on Precambrian rocks when fossil record is poor.
Here we present data on the Neoproterozoic São Francisco basin, deposited on the São Francisco Craton, Brazil. This basin contains a basal glacial diamictite which age is still disputable. U-Pb detrital zircons older than 875 Ma suggest a Sturtian age for these sediments and this interpretation is supported by and Pb-Pb isochron age of 740 ± 22 Ma obtained on a cap carbonate of the Bambuí Formation, which overlies the glacial deposits. Based on these data, the rest of the sedimentary succession has been interpreted as Neoproterozoic. In addition, C and Sr isotope ratios determined on the carbonates were used for chemostratigraphy basin global correlations. However, recent U-Pb ages obtained on an expressive detrital zircon population from the lowermost formation of the Bambuí Group indicate that the maximum depositional age is 560 Ma, suggesting an unconformity, which has not been found in the field. Moreover, the index fossil Cloudina was also recently found in the lower part of the succession confirming the U-Pb ages on detrital zircons. The Sr isotopic ratios recorded on the carbonates show large variations, ranging from 0.7074 to 0.7085 and do not follow the pattern defined for the Sr evolution on seawater global curves.
These findings help to reinforce the previous hypothesis that the São Francisco basin was deposited in a restrict environment with intermittent connections with an open sea. Moreover, our results indicate that basin global correlations should be done with caution on sedimentary successions when the geotectonic evolution of the basin in not fully understood.

3D analysis of compaction related tectonic and stratigraphic features of the Late Miocene succession from the Pannonian Basin

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The Pannonian Basin of Central Europe is a classical back-arc basin, surrounded by the Alpine, Carpathian and Dinaric mountain belts. Asymmetric extension created several separate half-grabens in the area during the Neogene. In the Early to Middle Miocene the basin evolved as part of the Central Paratethys. From the beginning of the Late Miocene the uplift of the Carpathians separated the Pannonian Basin from the sea, thus creating Lake Pannon. The lake persisted for ca. 7-8 mys and it was progressively filled up by clastic materials transported into the lake by rivers, like the paleo-Danube and paleo-Tisza from the North and minor sediment input derived from the southern hinterland.
We performed 2D and 3D seismic interpretation in the few-km-thick Late Miocene basin fill in order to understand the evolution of the basin. The palaeo-water depth of the lake was estimated based on the height of the prograding shelf-margin slope clinoforms from different parts of the basin. During our paleobathymetric calculations we performed precise depth conversion of the seismic data and decompaction of the slope clinoforms (Algyő Formation) on tectonically restored sections. Our calculations showed that water depth of Lake Pannon could have reached more than 1000 metres in the deepest basins during early Late Miocene (early Pannonian s.l.) times. Recent height of these clinoforms is only ca. 5-600 metres due to the burial and associated compaction effect of the slope sediments.
Our seismic interpretation also demonstrates the importance of differential compaction induced normal faulting above basement highs. These features have been overlooked in the Pannonian Basin and have been potentially misinterpreted. We analysed the 4D development of such a fault system using 3D seismic data and precise decompaction of the sediments overlying the basement high. We propose a method to differentiate faults with tectonic origin and compaction-induced structures. Differential compaction also plays a major role in the evolution of sediment transport routes at different scales.

Biotic vs. abiotic precipitation in hydrothermal spring systems: Modern examples from Tuscany

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With the recent discovery of giant hydrocarbon reservoirs in the South Atlantic, non-marine carbonate deposits have received significant attention. This has led to the recognition that there is paucity of data regarding the mechanisms and the conditions that lead to the precipitation of continental carbonates relative to the vast information available for marine carbonates. Aiming to improve our understanding of the processes that control calcium carbonate precipitation in hydrothermal springs, a multi-scale study of modern hydrothermal travertine deposits, occurring at Bagni San Filippo (Radicofani Basin) and Bagni di Saturnia (Albegna Valley) in Tuscany, Central Italy, is here presented. Thermal water discharges at Bagni di Saturnia reach a rate of 800 litres per second with a maximum temperature of 37.5 °C and a pH of ca. 6.4. The spring expels water enriched in H_2S-CO_2-$SO_4$2- and HCO_3- and divalent cations (Ca>Mg). The total dissolved solids (TDS) in the water amount to 2.94 g/l. In contrast, Bagni San Filippo thermal water discharges reach rates of 40 kg/s, with a temperature of 50 °C and a pH of ca. 7. TDS are around 4 g/l mainly comprising HCO_3, SO_4, Ca and Mg. Four depositional environments encompass the studied depositional systems and can be differentiated into: 1) hydrothermal vent, 2) self-built channel, 3) waterfall, and 4) terraced slope. The self-built channel consists of a sinuous to sub-horizontal channel (varying in width from 20 cm to more than 1.80 m) and associated hemispherical ponds (up to 50 cm in width). The flowing of water across a sharp break in slope gives rise to waterfall depositional systems from about 2 to 4 m high. Down current from the waterfalls, the gradient reduces and water splashes into the pools of the adjacent terraced slope system. Water flow along the different depositional systems is, in general, fast flowing, but pools and ponds represent the slow-moving portion of the different depositional systems. Carbonate precipitation along the flow path occurs in association with living microbial mats and biofilms, composed of a heterogeneous community of green algae, filamentous cyanobacteria and other types of prokaryotes, and bacteria, with a variable amount of extracellular polymeric substances (EPS). Nine categories of different fabric types, dominantly calcite and aragonite in composition, have been distinguished. High magnification SEM analysis indicates that EPS and often the external surface of cyanobacterial sheaths are the location where the carbonate minerals nucleate and grow. Precipitation begins with organomineral nano-globules (5 to 80 nm diameter) that are organized into triangular-like morphologies and gradually give rise to well-developed carbonate crystals, substituting/replacing the organic matter. These observations suggest that biological activity and degradation of organic matter may play a fundamental role in the travertine formation. We conclude that the individual fabric types reflect the precipitation processes due to interplay between abiotic and biotic and/or a combination of both processes. Fabrics occurring in low energy areas might be more biologically influenced than fabrics occurring in fast flowing dipping surfaces, for which the abiotic processes of physical degassing might prevail.

Late Miocene lacustrine deltaic deposit: Integrated outcrop and well data from the junction of the Danube Basin and Gerecse Hills, Hungary

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Late Miocene deposits in the deep depressions of the Pannonian Basin (i.e. Danube Basin) are profundal marls, turbidites and slope shales, followed by shallow water deltaic bodies and alluvial plain sediments. The huge volume of clastics was sourced from the emerging Alps and Carpathians surrounding the basin. Some elevated basement blocks (i.e. Gerecse Hills) were only flooded by shallow water; therefore the succession is mostly made up of deltaic sequences. This study focuses on the latter. The study area is located in the northern foreground of the Gerecse Hills, near Neszmély. In a deep valley there are 11 outcrops within a 1 km distance. The oldest strata are blue to brown clays with intercalations of very fine cross-laminated sand with lenticular to wavy bedding and coarse mollusc-hash of hummocky cross-lamination and some vertical burrow fills. Shells are of littoral brackish molluscs, mainly bivalves. Clayey strata with in situ mollusc shells also occur. Higher up in the succession cross-laminated very fine and fine grained sandstone becomes dominant. Sand bodies are often cut by erosional surfaces, commonly paved by rip-up mud-clasts or marked by wedge-shaped silty-sandy fills. In these beds tabular and trough cross-bedding is common. The sandy sediments are overlain by mottled, oxidized sandy siltstones with calcareous concretions or by an organic-rich to carbonaceous clay with carbonized wood trunks and numerous gastropod shells. These carbonaceous clays lead correlation of the sections and are overlain by the blue, fossiliferous clays again. The exposed Pannonian succession was deposited in shallow water above storm-wavebase to lower shoreface and in delta plain channels. The sedimentary successions partly reflect cyclic changes of water depth and are interpreted as lacustrine parasequences indicating repeated rises of base level. The littoral shell debris may have been accumulated by storms or as a transgressive lag related to minor oscillations of lake level. Some of the fluvial deposits could be channels on the delta plain, but those of a more complex cut-and-fill structure are interpreted as small incised valleys, therefore may reveal minor drops of base-level. Cyclicity on the same scale can also be deduced from archive boreholes descriptions and well logs. The correlation of the coarsening-upward units (i.e. parasequences) was a challenge. A relation was found between thickness and abundance of various shallow lacustrine facies and locus of basement blocks of the area. Although the regional trend of palaeotransport directions is towards SE-E, unusual directions towards N and NE were measured. The position of these deltaic deposits and palaeotransport directions also indicate that the Gerecse block was not only a passive morphostructural feature flooded and covered by sediments, but its relative vertical motions may have actively influenced the locus of different sedimentary environments, incision of channels in particular, and sediment dispersal directions.

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Gypsum tumuli in the karst areas of western Ukraine

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The specific forms of weathering develop on the surface of the insolated gypsum rocks, in semi-arid environments. The surface layer of gypsum is in places detached from the substrate and forms domal bulges with empty interiors - called the gypsum tumuli. The tumuli are best known from the Mediterranean region where they are commonly a few decimeters in diameter and less than 30 cm in height, although in some places they are larger and attain nearly 15 m in diameter and over 1 m in height. It is thought that the tumuli are the product of a volume increase of the surface layer of gypsum rock, due to multiple wetting and drying cycles, and dissolution and evaporative re-precipitation of gypsum crystals in the pores, closer to the surface of the rock. The tumuli are very common in the karst landscapes of the semi-arid zone. The gypsum tumuli are observed also in the wetter climatic zones, although they are apparently more rare there. For example, in the temperate climatic zone in Poland only 11 forms have been recorded so far. The gypsum tumuli occur in the numerous outcrops of the Badenian (Middle Miocene) gypsum deposits of the Carpathian Foredeep in the west Ukraine. They have been found and documented in the several natural gypsum escarpments (at Havryl'ak – 8 forms, Hlushkiv – at least 18 forms, Pohorilivka – 5 forms, Pylypche – 17 forms, Shishkivtsy – 40 forms, Tovtry – 34 forms) and also noted in several other exposures (Borshchiv, Chortovets', Chun'kiv, Havrylyak, , Ozeriany, Podillia, Ustechko). The gypsum tumuli are also quite commonly observed at the bottom of the abandoned quarries (at Kudryntsi, Nahoriany, Stal'nivtsi, Pisky, Verenchanka, Zavallya). At the Kostryzhivka quarry as many as 32 tumuli structures have been recorded. In all the investigated escarpments, the tumuli are present on the well-insolated slopes exposed to the south and west. Most commonly they occupy the upper best insolated parts of the slope showing the inclination of 20-25° (i.e. oriented perpendicularly to the sun rays in summer middays). The statistic measurements revealed that the investigated tumuli are mostly small and flat (less than 1 m in diameter and less than 20 cm in height). Larger forms are developed in the coarse-crystalline selenitic gypsum (e.g. at Shishkivtsy, Ozeriany), and it appears that they represent exhumed primary selenite domes (i.e. the Badenian sedimentary structures) modified by karst weathering. The occurrence of the tumuli in the apparently more xeric and well-insolated sites supports the view that their origin is related to the specific microclimate. This microclimate probably favored accelerated evaporation of water from the surface of the gypsum rock shortly after rains – the process is considered as the crucial for the growth of these specific and unique forms.

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Rapid growth of hydration caves in the weathering anhydrite rocks, Pisky quarry, Ukraine

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Weathering of the anhydrite rocks is associated with the development of the spectacular deformational structures generated by volume increase during hydration of the mineral anhydrite ($CaSO_4$) and its transformation to gypsum ($CaSO_4$ $2H_2O$) which occupies up to over 60% larger volume than the anhydrite precursor. It is known that in some tunnels excavated in the anhydrite-bearing rocks the hydration can lead to over 5 m large heave of the tunnel bottom, and in places the average heave rate attains 1-2 mm/day, although commonly it is much slower (only a few mm a year). The hydration of anhydrite rocks at the surface is the most spectacular and can lead to the formation of giant domal structures with empty interiors large enough to shelter a group of standing peoples. Such forms, first described from environs of the Harz Mts. in Germany, are known as the hydration caves, or swelling caves (Germ. Quellungshöhlen).
The unique site with actively weathered anhydrite rocks has been recognized at Pisky quarry near Lviv in Ukraine. The quarry was opened in 1940 to exploit the Badenian (Middle Miocene) gypsum deposits. These deposits contain anhydrite layer now exposed at the bottom of the quarry and subjected to intensive hydration. The weathering-induced deformation structures occur within the area 100x150 m large. They enclose fractures, joints, thrust and strike-slip faults, as well as pressure ridges, tepee structures, and bulges or domes with empty interiors, some of them representing the hydration caves. Over ten growing hydration caves have been recognized at Pisky quarry. The largest cave is 9.5 m long and 7.8 wide and attains 1.2 m in height. Since 2008 the place has been systematically monitored, based on network of ca. 200 benchmarks fixed in the rocks to measure the rate (and direction) of the deformation.
The measurements made in the period 2009-2014 revealed that the average rate of displacement equaled 0.5-2.0 cm/year, although both slower and higher values were recorded locally. The higher values, up to 4.0 cm/year, were commonly noted in the period 2012-2014. In one place, unexpectedly, the rapid opening and growth of the new hydration cave was observed, with the rate (estimated mainly from the photographic documentation) of a few tens of cm per year. The height of this cave attained 70-80 cm in July 2013 and enlarged to over 1 m in August 2014. Last year the 3D scanning documentation of the Pisky site was made which will permit more precise evaluation of the deformation rate and recognition of the evolution of these unique structures in the future.

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Permian ikaite in Oman grew in warm-temperate waters on a shallow shelf: Cold shower for glendonite as climatic indicator

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Glendonite – a pseudomorph after ikaite ($CaCO_3.6H_2O$) – occurrences have been used as direct environmental indicators that are then used for wider paleoceanographic reconstructions. The direct link between glendonite occurrence and paleo-ocean temperature however is not well established, nor is the proper documentation of an ikaite precursor in most ancient examples. We here document glendonites from a Middle Permian tropical setting in Oman, demonstrate their affinity with ikaite, and show that they formed in upwelled waters substantially warmer than generally believed necessary for their formation.

Ikaite is undersaturated and metastable across all temperatures (-2 to >30 °C) in the surficial environment. It can be grown in the laboratory at near-freezing temperatures (-1.8 to +4 °C) in a high alkalinity solution that also contains inhibitors, usually dissolved orthophosphates, to supress the growth of anhydrous $CaCO_3$. It is widely accepted that the same conditions are necessary for ikaite to grow in the sedimentary/early diagenetic environment. Once formed, ikaite decays rapidly or morphs to anhydrous $CaCO_3$ which leads to the preservation of its crystal shape as glendonite. The genetic link between ikaite and glendonite was established by E. Suess and colleagues in 1982.

The widely held assumption about the conditions necessary for the growth of ikaite and its early transformation into glendonite is here challenged by the discovery of chrysanthemum glendonites in the Middle Permian Saiq Formation of Oman, a carbonate unit deposited in a tropical setting at the margin of the Neotethys Ocean. Here ikaite grew in response to millennial upwelling events that brought cool (15–20 °C) iron-rich, high pCO_2 and low pH waters onto the otherwise warm and saline Saiq shelf. The interaction of these two water masses caused extensive septarian fissuring and dissolution of aragonite and high-Mg calcite that led to a rapid rise in pH and alkalinity on and beneath the sea floor. Authigenic precipitation of $CaCO_3$ was prevented by cool temperatures in conjunction with the prevailing high Mg/Ca ratio and possibly orthophosphates. This allowed ikaite to grow on the sea floor and within the fissures and burrows, and to morph into a more stable anhydrous form of $CaCO_3$ shortly after. Upwelling persisted for centuries, allowing a cool water carbonate factory to produce a thin blanket of hematite-rich heterozoan sediments that covered the sea floor and infiltrated the fissures, thus entombing the glendonites. Our study demonstrates ikaite does not always form in freezing waters and therefore glendonites cannot always be used as reliable paleoclimatic proxies.

The "Neoproterozoic climatic paradox" revisited: The Ghaub Fm. of the Otavi Mountain Land (northern Namibia)

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According to the Snowball Earth hypothesis, the earth´s surface became entirely frozen during glacial episodes in the late Proterozoic. The mentioned hypothesis is said to best explain diamictite deposits, occurring at tropical paleolatitudes, which are partly interpreted as product of grounding ice, associated with an extreme sea-level fall (range of 1000 m). On top of the diamictites the almost worldwide present fine-grained cap carbonates occur, interpreted as chemical precipitates during a super greenhouse, associated with a strong sea-level rise caused by melting of all ice. Data for the Snowball Earth hypothesis come from the Ghaub Fm. of northwestern Namibia and many other areas.
We investigated the Ghaub Fm. in the northeastern part of this country, and the underlying Auros and overlying Maieberg Fms. in the central Otavi Mountain Land. Here two neighboring areas show a platform and a slope setting. Cap carbonates occur in both areas, diamictites only on the slope, partly on top of shedded oolites. No erosional unconformity was detected on the platform underneath the cap carbonates: different types of stromatolites occur, showing a distinct shallowing trend (metre-high columnar to wavy stromatolites), overlain by tubular features, interpreted as degassing (melting of clathrates?), followed by the cap carbonates. Carbon isotopes show only relatively little fluctuations resp. excursions below the cap carbonates. Only in the slope area, $\delta^{13}C$ values underneath the diamictites are diminished for about -2‰ VPDB. None of the sections exhibit the widely published strongly negative excursion described from elsewhere, used for correlation and as argument for coeval Snowball Earth episodes. After the cap carbonates the $\delta^{13}C$ values are even more negative (often -5‰ VPDB) than underneath the Ghaub Fm., whereas the Ghaub interval itself is less negative or even positive.
The main sea level drop and build-up of ice occurred before the Ghaub time, during deposition of the upper Auros Fm. But the different types of stromatolites indicate shallowing within a photic area, a sea level fall of around ?100 m, certainly not 1000 m, so the amount of ice was limited.
The probably fluvioglacial material of the Ghaub diamictites was shed from highlands in some distance. Strongest warming occurred shortly before the cap carbonates, causing a strong break up of ice that had reached the ocean; sediment-laden icebergs shed their load only locally (e.g. Fransfontein area). This indicates, that glaciations in the hinterland reached the sea not everywhere, a strong counterargument against worldwide glacial cover including the oceans. Another argument against this hypothesis is the continuous record of life. Fluctuations of sea level (changes of microbiota) continue into the cap carbonates, but it was still cold, near freezing (glendonite occurrences) and not at all a super-greenhouse.
Distinct warming in the subsequent Maieberg time caused a strong transgression (cap carbonate sequence). Microbiotic life started to flourish, enhancing in local restricted areas the source rock potential. A new model is needed, to explain low latitude glaciations, probably mostly restricted to highlands, coexisting with oceans widely ice-free from low to higher latitudes, enabling continuous life in the oceans.

The composition of the cement in non-metallic red beds and ore-bearing grey sandstones in Copper Zhezkazgan deposit (central Kazakhstan)

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Zhezkazgan deposits are located in Central Kazakhstan in the basin of the River Kara-Kengir. The total thickness of these deposits is 1,500 m. The Zhezkazgan suite has a Middle-Upper Carboniferous age, and the thickness is about 700 m. This consists of regularly alternating grey-coloured and red-coloured sandstones and siltstones. Zheskazgan ore deposits are found exclusively in the grey-coloured rocks, regardless of lithology. Copper, lead and zinc is found in the grey-coloured rocks on average 4-5 times more often than in the red-coloured. Industrial mineralization of the deposit extends to a depth of about 600 m. The total number of mineralized grey-coloured strata in the field is 26, but commercial mineralization bears only 19 of them. These layers are combined into nine ore-bearing horizons, each of which includes several layers of ore-bearing rocks, separated from each other by red non-ore layers. There are Taskuduksky, Zlatoust, Pokrov, and Raymund (Lower, Middle, Upper) and Krestov, Pokro suites, and Transit zones.
The study of cement and its material composition is important for determining the processes that led to the formation of layers. Cement for all types of clastic rocks is predominantly polymineral. For grey sandstones identified six types of cement: quartz-albite, carbonate-quartz, silica-clay, carbonate-chlorite, clay-sericite and clay impregnated with iron hydroxides. In the red sandstone identified five types of cement: clay impregnated with iron hydroxides, sericite-chlorite, clay-carbonate, feldspar-quartz and iron-quartz-chlorite. In red siltstones and aleuropelites are three types: clay impregnated with glandular compounds, carbonate and quartz.
In sandstones marked following cementation: basal contact, filling the pore, regeneration and corrosion. Basal type of cementation and type of contact occur in siltstones, aleurolites and red sandstone. Secondary cementing types, i.e. type of regeneration and corrosion characterizes grey sandstones. Ore minerals replace the primary cement in grey sandstones. Therefore, the volume of cement in grey sandstones smaller compared with the volume of cement in red beds. Microscopic studies of cement in various rocks show the following content: siltstones and aleurolites - 44-85%, in red sandstone – 28-50%, in grey sandstone - 10-27%. This gives us reason to assume that siltstones and aleurolites were not exposed to strong changes because hydrothermal solutions cannot penetrate into fine-grained rocks. Ore minerals occupied almost all the space between the grains in grey sandstone and replace some of the primary cement. We now intended that the red and grey sandstones formed in different facies conditions, and therefore their permeability to ore-bearing solutions were originally different. The fact that the ore material penetrated in the grey sandstones indicates us that the initially rock had high porosity. Most likely the primary cement in grey sandstone was the composition of the carbonate. Action fluids, except the processes of mineralization, were in the form of sericitization, pelitization, albitization of feldspars and chloritization of mafic minerals.

Life of the dead mounds: an example from the Devonian mud mounds of Hamar Laghdad (Morocco)

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Devonian carbonate buildups exposed in the eastern Anti-Atlas of southern Morocco and widely known as the Kess-Kess mounds constitute a classical example of deep-water mud mounds related to hydrothermal venting. They developed on the Hamar Laghdad elevation, located near Erfoud, which was created by an Early Devonian submarine volcanic eruption. Hydrothermal seepage persisted for a long period of time, from the late Pragian to the early Frasnian. During late Emsian time, reactivation of magmatic processes caused doming of the volcanic complex and the overlying sedimentary strata, and in consequence, a network of faults originated. The faults served subsequently as conduits for hot fluids migrating to the sea floor. Kess-Kess mounds developed preferentially over cross-points of radial and tangential faults. Some individual vent sites were also active during the Eifelian, Givetian and the Frasnian. Geochemical data suggest that mud mound carbonates precipitated from brines comprising a mixture of hydrothermal fluids and seawater. One of the characteristic features of the mud mounds at Hamar Laghdad is the presence of a large number of cavities, which are fragments of larger open spaces. Originally, they constituted a complex system of fissures, chimneys and open spaces, connected to the sea-floor (vent outlets), and now are mostly filled with micritic and fine-grained laminated sediments and calcite cements. Conodont fauna recovered from the infill suggests that the cavities must have formed simultaneously with the formation of mud mounds or immediately after. Their irregular shapes point to chemical corrosion rather than to tectonic control as a mechanism of their origin. It is suggested that the presence of both the dissolution of the carbonate host rock and the precipitation of mud mound carbonates resulted from the mixing of hydrothermal fluids and seawater, and that during the formation of mounds dissolution took place in zones dominated by hydrothermal fluid-rich mixtures, and precipitation occurred where seawater predominated.
Although growth phases of mounds at Hamar Laghdad lasted for a short period of time, mostly during a single conodont zone, the mounds after their "death" remained a place of intense animal activity. The top parts of the dead mounds were colonized by high diverse communities of rugose and tabulate corals, bivalves, crinoids, and brachiopods. The elevated position of mound tops offered a better exposition to water movement and reduced significantly sediment stress on the fauna. Cavities and fissures, the former fluid migration pathways, became the place of development of cryptic biota before they have been completely filed with carbonate sediments and cements. The cryptic biota encrusting the roof of the cavities consisted predominantly of four groups of invertebrates: rugose corals, crinoids, tabulates (?), and sponges. The organisms grew predominantly in an upside-down position, forming spectacular "hanging gardens". In addition, particularly large cavities were periodically visited by hundreds of trilobites (Scutellum, Harpes). The size frequency distribution of their exuviae suggests a mass gathering for molting and mating.

Tracks and sediments: Evolutionary stasis in foot function?

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Walking on a shoreline, or across another soft substrate, can result, given the right geological conditions, in a fossilised record of locomotion being preserved in a track. Fossil tracks have been found from various part of the African Rift made by a range of different human ancestors have the potential to record evolutionary changes hominin locomotion and consequently potential changes in their landscape use. In recent years the study of vertebrate ichnology has been revolutionised by the advent and application of tools for three-dimensional data capture. These tools have driven the demand for more sophisticated analytical tools that draw on such fields as the mathematics of topology and geometric morphometrics. We illustrate some of these tools using a range of animal and human tracks from various parts of African. In particular, we focus on a piece of freeware call MB2 Track Transformer which enables individual tracks within a trail to be co-registered such that a mean track can produced and compared to other track populations. Using these tools we explore how substrate plays an important role in determining individual track morphology and crucially on the relationship between depth and foot pressure vital to the interpretation of foot function and gait. The assumed relationship between foot (plantar) pressures and track depth is explored and found to be dependent on substrate properties, stratigraphy and the overall yield strength of a substrate. This allows a model of how human track morphology varies with substrate strength to be advanced and aids the interpretation of ancient African tracks. Comparing tracks from Latoli (Tanzania, 3.66 Ma) and Ileret (Kenya, 1.5 Ma) with those made by unshod anatomically modern humans in Namibia we can explore how human gait has change over time. Surprisingly the results emphases a lack of evolutionary change in foot function during this time.

Space-time evolution of a hydrothermal system: Dating and stable isotope geochemistry of Quaternary thermogene travertines in Southern Tuscany (Albegna Valley, central Italy)

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This work integrates U-Th geochronological data and stable isotope (delta^{13}C and delta^{18}O) analysis performed on thermogene travertine deposits exposed along the Neogene-Quaternary tectonic depression of the Albegna Valley (Southern Tuscany, Italy). The aim is twofold: (i) to constrain the timing of the travertine deposition related to the Quaternary hydrothermal pulses; and (ii) to investigate the nature and geochemistry of fluids feeding the travertine-depositing springs.
The Albegna Valley is located southward of the Monte Amiata geothermal field developing along a tectonic post-orogenic NE-SW trending depression filled by marine and transitional sediments, deposited from Upper Miocene to Quaternary. These post-orogenic sequences unconformably cover a thrust stack made of Mesozoic-Cenozoic calcareous-marls (Tuscan Domain) and allochtonous flysch-type sequence (Ligurian Domain). The hydrothermal aquifer is hosted by the Mesozoic limestones and is characterized by a general southward drainage direction before feeding the main thermal spring occurring at the Saturnia village. Meteoric water infiltrates from exposed sectors through the fault-fracture permeable network and mixes at depth with magmatic fluids, generating the hydrothermal conditions.
Travertines of the Albegna Valley are exposed at different altitudes along a NNE-SSW transect of about 18 km, with the highest depositional quotes (700 m a.s.l) in the northern part and the active deposition located at the Saturnia spring (140 m a.s.l). Travertine sampling included banded vs. bedded travertines belonging to different morphotypes (fissure ridge and plateau). Based on U-Th dating, the travertine deposition is active at least since the Middle Pleistocene. The results provide temporal constraints about the space-time migration of the hydrothermal fluids feeding the travertine-depositing springs. In particular, they suggest (i) a general rejuvenation of the main travertine bodies moving southwards and from higher to lower altitudes in the study area, and (ii) a recurrence intervals of hydrothermal pulses during Quaternary time.
Delta^{13}C values are positive, ranging from 2.84 ‰ to 10.86‰, for the banded and bedded travertine, showing the thermogene origin of the deposits, with a CO_2 originating from igneous sources mixed with CO_2 deriving from marine limestone dissolution. Delta^{18}O values for both the banded and bedded travertine are negative, with values between -14.57 ‰ and -5.06 ‰. Banded travertines show a more positive delta^{13}C and more negative delta^{18}O value than the associated bedded travertine. Temperatures of the depositing paleofluids, calculated using a non-equilibrium fractionation empirical curve, provided a range comprised between 70 °C and 35 °C for banded travertines and between 45 °C and 22 °C for bedded travertines, with banded travertine depositional temperatures systematically higher than the associated bedded travertine. The hydrothermal circulation in the Albegna Valley shows a decreasing temperature of the travertine-depositing fluids with time, due to a progressive chemical dilution of deep magmatic fluids (probably connected with the Monte Amiata geothermal field) and the increase of meteoric fluids.

The first evidence of trace fossils in Upper Eocene sediments of Tbilisi environs (the Achara-Trialeti fold-thrust belt, Georgia) and their geological significance

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Ichnology as an important tool in solving of fundamental geological problems is still poorly comprehensible field of study in Georgia. Only rare references on findings of trace fossils are found in Georgian geological literature, where they are defined as general characteristic features of flysch sediments (hieroglyphs/bioglyphs or fucoids), and lack any type of precise definition, classification and geological interpretation.

During the last decade based on the authors' rich data from personal field observations, trace fossils were widely recorded in the Mesozoic-Cenozoic sedimentary basins of Georgia, mostly affected by turbiditic sedimentation('flysch' basins). Accordingly establishing of fundamental ichnological research in Georgia has become a matter of great scientific importance.

The present study is one of the first attempts of precise definition, classification and paleoenviromental interpretation of recently found trace fossils in Upper Eocene suites of Tbilisi environs which occupy eastern segment of the Achara-Trialeti fold-thrust belt (one of the major tectonic units of Georgia). During Cretaceous– Paleogene time the Achara-Trialeti was an intra-arc rift basin produced by northward subduction of the Tethys Ocean under Eurasian active margin. Abundant occurrences of trace fossils are related to the arch part of Lisi anticline which is built up by the Upper Eocene "Nummulitic Tbilisi suite" (1000-1500 m). The latter is represented by the alternation of sandstones, siltstones and argillites with rare interlayers of fissile clays and marls comprising carbonized relics of plants and coal lenses. Dominant in section thick bedded sandstones are rich in Upper Eocene nummulitic fauna and microforaminiferas. According to recent observations the sandstones have internal structural features characteristic to medium-grained turbidites of Bouma sequence.

Determined for the first time Lisi ichnocomplex of Tbilisi suite according to Seilacher's scheme of bathymetric zonality of trace fossils, comprises characteristic species for shelfal *Cruziana* (*Rhyzocorallium*), bathial *Nereites* (*Cosmoraphe*, *Paleodictyon*), transitional between them *Zoophycos* (*Zoophycos*) and common for low-oxygen environment *Chondrites* (*Chondrites*) facies. In contrast to Upper Eocene Tbilisi suite, Oligocene sediments of Lisi anticline are free of biogenic sedimentary structures. This fact supports a supposition that during deposition of Maikop series (Oligocene-Lower Miocene) the bottom of the basin was saturated by H_2S and therefore was an unfavorable habitat for benthic communities. As Upper Eocene and Oligocene suites of the Lisi anticline are lithologicaly almost similar, ichnological analysis will be a helpful tool in solving of a boundary problem between them. Apparently the boundary line will pass above the bedding planes of the youngest bioturbated beds. Presence of shallow marine *Rhyzocorallium* in Lisi ichnocomplex refers to existence of terrestrial environment in the central uplifted part of the Lisi anticline. Discovery of the relics of Lower Oligocene terrestrial mammalians here confirms this opinion.

Resolution of Upper Eocene-Oligocene boundary problem and reconstruction of the Upper Eocene sedimentary basin of Tbilisi environs are the main goals of our future research. Further integrated ichnological - sedimentological studies, focused on the precise ethological classification of trace fossils with insight into depositional environment, water depth, stratigraphic markers of environment change, and styles of deposition are required as well.

Changes in architectural character of systems tract within stratigraphic sequences caused by varying sediment supply during a base-level cycle

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Changes in base level heavily control the architecture of sedimentary sequences due to their effects on the distribution of sediments in time along the depositional profile. The classical sequence stratigraphic model predicts that a major role on the final architecture of a stratigraphic sequence is played by the changes in the base level with respect to the changes in the sediment supply, which is assumed generally constant at a fixed point during a complete base-level cycle. Nevertheless, sedimentary successions preserve evidence of rapid changes in the amount and type of sediments delivered in a basin. The detailed stratigraphic reconstruction of a Triassic succession in the Southern Alps of Italy is one of those successions, where major changes in the type and amount of sediment delivered in a sedimentary basin during a base-level cycle are recorded. The stratigraphic evolution and depositional architecture of the studied succession reflect a shift from carbonate to siliciclastic sedimentation, as well as rapid changes in the amount of delivered sediments. The change in the sediment supply is in tune with specific moments of the base level curve, indicating that the sedimentological expression of system tracts can significantly diverge from the classical model if changes in the amount of delivered sediments occur. Thus, different sequence stratigraphic interpretations should be considered (especially in vertical successions, such as wells, well logs, stratigraphic sections) when dealing with important changes in the sediment supply. In detail, sequence stratigraphic surfaces that are related to the interplay between the rates of sedimentation and base level changes (maximum flooding surfaces, and maximum regressive surfaces) can be unidentifiable in terms of sedimentary expression when sedimentation rate overpasses the rate of base level change at a certain position of the sedimentary basin. On the contrary, specific time intervals can be characterized by reduced sediment supply (falling stage system tract and low stand system tract), thus becoming hardly recognizable in vertical sections.

Relationship between cyanobacterial species composition and calcification patterns in a modern tufa-depositing river (River Piedra, NE Spain): A comparison of the populations occurrence and different sedimentary facies

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The River Piedra (northeastern Spain) stands out by the high deposition of tufa. The mean deposition in the area of the Monasterio de Piedra Natural Park was 9.13 mm/y, measured on tablets from 1999 to 2012, and showed marked seasonal variations. The water composition is of HCO_3–SO_4–Ca type, with mean pH= 8.03 and SIc= + 0.73. The bed morphology, water velocity and type of biological substrates defined several depositional subenvironments in which distinct sedimentary facies formed. Bacterial communities of this fluvial system are dominated by cyanobacteria. Because of this, we examined the cyanobacterial populations in different subenvironments in the Park in order to understand the relationship between the cyanobacterial taxa, the environmental conditions that determine the formation of distinct facies, and the differences in their deposition rates. Samples for morphological and phylogenetic analyses of cyanobacteria were taken in different subenvironments in September 2010, and the results were compared with the attributes of the correlative deposits on tablets, and the hydrochemical and physical parameters.
In areas with fast-flowing water *Phormidium incrustatum* was the dominant cyanobacterium. This species was associated with the formation of extensive thick stromatolites, consisting of palisades of calcite tubes (filament encrustations), and showed the highest deposition rates (up to 1.7 cm/year). In contrast, in areas with slow-flowing water, in which deposition rates were lower, *Phormidium aerugineo-caeruleum* was the dominant species, where it formed randomly oriented calcite tubes, both as thin and discontinuous/uneven laminae and scattered bodies within the loose lime mud and sand-sized carbonate sediment. In stepped waterfalls and short falls, with intermediate deposition rates, both species of *Phormidium* were associated with the dominant spongy moss and algal boundstones, i.e., interbedded *P. incrustatum* stromatolite layers and uneven *P. aerugineo-caeruleum* laminae, which is consistent with the varying flow conditions in the waterfalls. These findings suggest that the differences in EPS-producing cyanobacteria and their calcification pattern are dependent on flow conditions. Moreover, the different degrees of calcification (i.e., thickness of encrustations) found in *P. incrustatum* in this study might have resulted, at least partially, from slight differences in any of the parameters (e.g., CO_2 outgassing rate, temperature and calcium concentration) that influence the saturation index of water with respect to calcite at the various sampled sites. In addition, changes in $CaCO_3$ saturation associated with microbially produced EPS around the cells might have also contributed to the varied shape and size of the $CaCO_3$ particles in the encrustations; despite no regular pattern was found, in some coatings, smaller and/or irregular forms dominated inwards, whereas larger and/or well-formed crystals dominated outwards.
Variations in cyanobacterial species composition in the sedimentary facies might be linked to differences in specific ecological adaptive traits of cyanobacteria, which make it possible for the species to occupy distinct niches and thereby to colonize to different extents.

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Great Bahama Bank slope sedimentation patterns: The model of periplatform drifts

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Hydroacoustic and sedimentological data of the western flank of Great Bahama Bank and Cay Sal Bank document how the interplay of offbank sediment export, along-slope transport, and erosion together shape facies and thickness distribution of slope deposits. The integrated data set depicts the combined product of these processes and allows formulating a comprehensive model of a periplatform drift that significantly amends established models of carbonate platform slope facies distribution and geometry. The basinward thinning wedge of the periplatform drift at the foot of the escarpment of Great Bahama Bank displays along- and down-slope variations in sedimentary architecture. Sediments consist of periplatform ooze, i.e. carbonate mud and muddy carbonate sand, coarsening basinward. In zones of lower contour current speed, depth related facies belts develop. In the upper part of the periplatform drift wedge in a water depth of 180 to 300 m and slope angles of 6°–9° the seafloor displays a smooth surface. Parasound data indicate that this facies is characterized by a parallel layering. Basinward, the slope shows a distinct break at which the seafloor inclination diminishes to 1° to 2°. Downslope of this break, the drift wedge has a 3–4 km wide pervasive cover of bedforms down to a water depth of around 500 m. The steep flanks and internal stratification of the wavy bedforms face upslope, indicating upstream migration; the bedforms therefore share all the characteristics of cyclic step sedimentation. This is the first description of cyclic step sedimentation patterns in carbonate slope depositional systems. This new slope sedimentation model aids in understanding the complexity of carbonate slope sedimentation models with facies belts perpendicular and parallel to the platform margin. The new model sharply contrasts with existing slope facies models in which facies belts are solely positioned parallel to the platform margin.

Facies analysis and 3D photogrammetry in Surat Basin (QLD, Australia): New outcrop insights of the Precipice Sandstone (Lower Jurassic)

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The formation of the Precipice Sandstone is well known as one of the most important petroleum reservoir in Australia. It has been recognised as the basal infill of the Surat Basin, which it has been intensively exploited for gas reservoir purposes. Nonetheless its value, only few papers described the depositional history of the formation detected in wells, and studies concerning outcrop data are not published yet.
The Surat Basin covers an area of ~300 000 km^2 in southern Queensland and northern New South Wales. Though commonly considered an intracratonic sag basin, the triggering mechanism for its formation remains unresolved. The Precipice Sandstone (Lower Jurassic) unconformably overlain the sequences of the Bowen Basin (Permo-Triassic) and it is overlaid by the Evergreen Formation (lacustrine environment). By literature the Precipice Sandstone is defined as a fluviatile system from 50 to 150 m thick and crops out along the northern part of the Surat Basin in lateral continuous cliffs. This setting provides the perfect condition for photogrammetry shooting and analyse architectures, bedding and facies. The formation is grouped in two main parts, the lower part dominated by trough cross stratified sand, while the upper part shows a fining-upward sequence of sand and silt with slumps, ripple and plane parallel stratification, where pass gradually into the Evergreen Formation. The deposits belonging to the transition between Precipice and Evergreen are still topic of discussion.
This study aims at investigating the facies association of the Precipice Fm in outcrop to define a depositional setting and identify correlations with well data. This is carried out integrating classical facies analysis with the innovative 3D photogrammetry at outcrop scale to provide a wider and reliable scenario of the system. The technology of the 3D photogrammetry elaborated with Sirovision™ has advanced to investigate at high-resolution bedding and fractures. Sirovision™ is a geology / geotechnical mapping and analysis system that generates accurate, scaled 3D images of rock faces from outcrops or open pit rock walls. With this technique every pixel in the image is a 3D data point, rather than a modelled point cloud draped with an image. Within the Surat Basin, the main structural feature is the Taroom Trough, which is also the approximate depositional axis of the basin and fairly closely corresponds with the Mimosa Syncline, the structural axis recognised in the underlying Bowen Basin sequence. The basin is therefore asymmetrical with the sedimentary sequence thickening gradually from the west to a maximum in the Taroom Trough and then thinning more abruptly towards the eastern margin of the basin. A major, meridional-trending fault system, the Goondiwindi-Moonie-Burunga system is situated on the eastern side of the basin. Changes in thickness from West to East detected in wells and outcrop suggest the action of a syn-depostional tectonics inherited by the tectonic features of the Bowen Basin, unusual scenario in a declared “not-tectonically-influenced” basin. Moreover this coupling of technologies will set up future models for reservoir modelling and flow unit modelling.

Stratigraphic forward modelling on reservoir geometry of the Springbok Formation (Middle Jurassic): Prediction on the unexplored depocenter of Surat Basin (QLD, Australia)

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Attention in studying the sedimentary infill of the Surat Basin has increased in response to the extensive exploration of gas resources. The eastern Surat Basin has settled as an active regional exploration target for Coal Seam Gas, hosting large gas reserves after a long history of conventional gas exploration. Sedimentary successions with high level of geometric complexity characterise the Surat Basin infill. The uncertainty rises up when correlating coal seams and groups from the eastern to the western flanks of the Surat Basin is not calibrated by high-resolution seismic. Further information on reservoir architectures are necessary for a complete depositional model.
The innovation of Stratigraphic Forward Modelling (SFM) has big importance to frameworks where numerical simulation of the depositional processes can be used to predict reservoir properties at appropriate scales, away from wells and below seismic resolution. Such advanced approach now empowers geologists with a way to validate a conceptual sedimentological model and assess the concurrent action of imposed forcings on sedimentary systems.
LECODE (Landscape Evolution Climate Ocean and Dynamic Earth) is a new geomorphic and stratigraphic forward modelling code capable of simulating surface evolution and clastic sedimentary processes in 3D through geological times. This numerical tool can be used to test geological scenarios and to assess and compare existing geological data to simulated one, such as high-resolution stratigraphic record, sediment dispersion and clastic sedimentary system evolution.
This work focuses on a stratigraphic forward model of the Springbok Formation, deposited during the early Late Jurassic (Oxfordian) within the Surat Basin. This formation is ascribed by the literature to an extensive fluvio-alluvial system, which is conformably overlaid to the alluvio-coastal system of Westbourne Fm (Kimmeridgian-Tithonian).
The key-feature of the Springbok Fm is the basal unconformity, which deeply incises the Walloon Coal Measures on the eastern margin of the basin. The stratigraphical relationship between Walloon and Springbok in the western and the central part of the basin is not well documented. Investigating the nature of the unconformity can be useful for the prediction of reservoir connectivity. Several hypotheses could be correlated to the Springbok Fm unconformity, involving climatic changes and tectonics. Although the deposition in the Surat Basin has been generally considered not influenced by active tectonics, the effects of the active margin in the eastern flank of Australia seems to have an important role on Springbok Fm unconformity.

Vertical variability of the chemical composition of swampy, lagoon-like and limnic sediments in the Jamno Lake, N Poland

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The aim of this study was to evaluate the vertical variability of the chemical composition of Jamno lake sediment during its Holocene history. Due to the nature of the environment of coastal lakes, located in the zone of mixing of the marine and terrestrial influences, sediments are characterized by a significant variation in, among others, their chemical composition. This difference, occurring both in the temporal and spatial dimensions, is one of the proxies that allow to reaconstruct the environmental conditions in the past and is widely applied in palaeogeographic studies.
Jamno Lake is situated in the central part of the Polish coast, in the north-eastern part of the West Pomerania region. The results of the geochemical analyses of sediments from three cores: JS-5 located in the west part of the lake, JS-21 located in its middle part and JS-55, located in the south-east part of the lake, are the basis of this study. The cores were taken as a part of the project: "Verification and reinterpretation of results of the studies on lacustrine sediments contaminated by heavy metals, nutrients and organic compounds along with drawing up of the unified methodology within this scope on the basis of sediments analyses of lake and dammed reservoirs which are in need to start their revitalisation based on studies carried out at selected water bodies – a pilot study" implemented in 2009. The obtained sediment was examined for the content of organic and mineral matter, through loss on ignition method, and the share of the elements (Na, K, Ca, Mg, Fe, Mn, Cu, Zn, Pb) by atomic absorption spectrometry (AAS).
Basing on lithological characteristics of the sediments and geochemical analyses results, supported by the statistical methods, several stages of various sedimentation conditions were distinguished. Periods in which there was only a slight change in the measured components reflect the stabilization of the environmental conditions. The significant fluctuations of the studied variables identify the periods characterized by high volatility of environmental conditions resulting, among others, from short-term climate changes. The trends of analyzed components content reflected the pace and direction of the environmental changes. On the contrary, the rapid, short-term changes in the proportion of elements indicate the impact of extreme events.

3D imaging of vents and sand injectites produced by Lower Cretaceous hydrothermal activity in the southern North Sea

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Within the Jurassic Broad Forteen Basin (North Sea), 31 vents built of 58 smaller structures have recently been recognized within a seismic cube thanks to seismic attribute analysis. Near the surveyed volume, well cuttings from Zeichstein salt structures contain nephelinic basalts dating of 100 Ma. Strong amplitude anomalies present within the salt are good indication of the presence of igneous intrusions.
The vents are imaged as sub-transparent agglomeration of sub-vertical pipe structures emanating above the seismic amplitude anomalies. The vents were analyzed through distinct categories: size, shape, upper part shape and source bed. Most of the vents originate from the Lower Germanic Triassic Group (Bundsandstein). They are conical in shape and have an eye-shaped upper dome. At the top, numerous domes have been eroded. A few domes have jacked up the overburden, sometimes including lateral intrusion (sandstone sill). Almost all vents terminate at the Upper Jurassic/Lower Cretaceous unconformity. Based on the relationship with the overlaying deposits, we have constrained the time span of venting to be from pre-Mid Hauterivian times (eroded/partly eroded upper parts of the vents, onlaps on the vents) to Albian times for the latest (bended reflections, igneous intrusion dating from well cutting).
Vents formation and subsequent fluidized sandstone injection and expulsion are interesting from petroleum exploration perspective. Most of the vents punctured through basins primary source rock – the Posidonia shales. The breaching most probably created new pathways for fluid migration, connecting the source with the overlaying sandstone units with sand injectites/fracturation around the pipes. Sand injections in the vents could serve as both migration route and reservoir units, under the condition that fluids did not conceal the pore-space. The occurrence of hydrothermal activity could also create sweet spots where good maturity occurs at shallow depth because of the associated localized heat-flow. In this new play, the seal is similar to the traditional one in the basin, the Vieland Claystone Fm, which drape and onlap on hydrothermal vents domes that are natural stratigraphic traps.
In addition, this discovery illustrates the complexity of transfer of fluids and solids associated with igneous intrusions within sedimentary basins. The zone was not considered particularly volcanic except for the isolated Zuidwal volcano situated onshore (50 km East and older). Besides the economic impact of this discovery, one could ask what is the trigger of this activity? Was it so discreet in the seismic images that it is more widespread than thought in the basin? The relation with the tectonic context is still unclear since, at sedimentary scale, a large time-lag could exist between the disequilibrium of conditions triggering the melting and its actual emplacement within the basins. Nevertheless, early inversion of the Jurassic structures or regional doming are the best candidate at the origin of this discovery.

Paragenetic sequence in seep carbonates records cyclic gas migrations through sandstone dykes – Panoche Hills, California

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The Paleocene Moreno Formation in the Panoche Hills of the Great Valley Forearc Basin in Central California offer a unique opportunity to study authigenic seep carbonate precipitation just below the sea floor and their relation to a dense network of sand injectites which are inferred carrier beds for migrating fluids. While previous publications focused on the large-scale statistical relationship between the density of injectites and the occurrence of seep carbonates over the 20 km-long outcrop, this study focuses on the detailed interaction between the injectites and the origin and nature of the seep carbonates.
Clusters of subspherical to mounded carbonate concretions, which are between 20 cm to 3 m in diameter, are observed in restricted areas directly above the dyke tips. Lucinids clams, a representative chemosynthetic bivalve, has been found in and around the carbonate concretions. The occurrence of clams may extend over ca. 50 m above and below the highest dyke's tips. This indicates that seepage through dykes lasted for a long period, and that the dyke emplacement occurred in several episodes.
The matrix of the carbonate concretions is siliciclastic-rich micrite characterized by vuggy porosity and numerous burrows, indicating the emplacement of the carbonates in uncompacted shallow buried sediments. The voids are filled by peloidal sediments and distinctive cements. The succession of cements is consistent and characterized by respectively dendritic Mg-rich calcite, acicular barite, botryoidal to acicular aragonite and anisopachous laminated meniscus cements
The $\delta^{13}C$ isotopic values of all the authigenic carbonates (matrix and cements) vary around -50 ‰ PDB indicating a methane-derived authigenic origin. The aforementioned paragenetic sequence may repeat up to ten times separated possibly by a corrosive surface.
The repetition of the sequences indicates cyclic fluid circulations in the dykes linked to autocyclic (gas accumulation) or allocyclic phenomenon (f.e. reactivation of overpressure in deep sand reservoir). Mineral successions and subsequent cements may be linked directly to the temporal evolution of fluid fluxes and dynamic changes in depth of the sulfate-methane transition zone.
Late diagenetic phases witness the circulation of marine and finally meteoric fluids. The latter is likely related to the exhumation of the basin. The first marine-related microsparitic cements have $\delta^{13}C$ values around 0 ‰ PDB and are cementing the micritic authigenic carbonate concretions. Later diagenetic phase are found in septarian cracks and constitutes at least seven generations of calcite, hematite, and quartz cements.

Continental-scale paleodrainage and mixed bedrock-alluvial rivers of the Aptian McMurray Formation, eastern margins of the Alberta Foreland-Basin System

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The Aptian McMurray Formation is the primary reservoir interval for the Alberta Oil Sands within the Cretaceous foreland-basin section of the Western Canada Sedimentary Basin. McMurray reservoir strata consist of basal fluvial deposits that are interpreted to become increasingly marine-influenced up through the section, and individual point-bar successions are typically of a scale (30-45 m in thickness) that is comparable to, or larger than, the largest rivers on the planet today. This paper reports on research designed to examine the broader context for McMurray deposition, especially the scale and nature of the McMurray contributing drainage area and sediment-routing system.

Published interpretations of McMurray fluvial deposits of the "Assiniboia paleovalley" in eastern Alberta and western Saskatchewan infer a paleodrainage basin in the southwest US and the Western Cordillera, although significant Canadian shield contributions are known as well. Detrital zircons (DZs) represent a powerful tool for testing these types of interpretations and understanding continental paleodrainage. Recently published and new DZ data indicate instead that the McMurray was the axial stream for a drainage sourced in the Appalachians of the southeastern US through eastern Canada, >3000 km to the SSE, which served as the divide between the Gulf of Mexico-Atlantic and the Boreal Sea. This paleodrainage, the continental-scale drainage of its time, was routed through the US midcontinent to the Assiniboia paleovalley, had numerous shield-derived tributaries from the east, but remained mostly separate from smaller southwest US and cordillera-derived fluvial systems that dominate McMurray-equivalent strata in the foredeep farther west until Albian time. This continental-scale paleodrainage produced the laterally extensive and thick point-bar successions in the Aptian McMurray Formation (and overlying Albian strata) that make the Alberta oil sands technologically and economically viable.

Throughout the Alberta foreland-basin system, and extending south through much of the southern Canadian and US continental interior through the reconstructed drainage basin, Lower McMurray strata most commonly consist of fluvial channel-belt sands that rest on the sub-Cretaceous unconformity, which cuts sedimentary rocks that range from Jurassic to Devonian in age. These relationships are inconsistent with a typical aggrading valley model, and are instead interpreted to indicate the lower McMurray Formation and its correlatives represent what geomorphologists have referred to as mixed bedrock-alluvial valleys. In the modern world, mixed bedrock-alluvial valleys (a) dominate the vast low-relief, erosional continental interiors, (b) occupy regions of net surface uplift, (c) deepen and widen over long periods of time (>>10^6 yrs) by lateral migration and channel-belt deposition, punctuated by periods of bedrock valley incision, (d) are contributory, and (e) leave behind a succession of downward-stepping channel-belt sands as terraces. This alternative interpretation is consistent with basic observations from well logs and other data, and has significantly different implications for (a) understanding long-term basin evolution, ranging from larger plate-scale geodynamic processes vs. the influence of the evolving flexural signal associated with the shorter-wavelength foreland-basin system, and (b) predicting vertical and lateral litho and chronostratigraphic relationships with the McMurray paleovalley system itself.

Contribution to sedimentological and petrographic characteristics of an olistostrome hosted in the Cieszyn Beds at Żywiec (U. Jurassic – L. Cretaceous; Western Outer Carpathians, Poland)

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The Cieszyn Beds form the oldest unit of the Outer Carpathian succession, which marks the opening of a rift (proto-Silesian Basin) that subsequently evolved into the Silesian Basin. Dark grey to black mudstones and marls deposited at the earliest stage of the rift evolution are overlain by a complex of calciturbidites with teschenite sills. A part of this complex is deformed by synsedimentary folds. The folded complex is succeeded by the olistostrome body that consist of olistoliths of shales, dismembered folded limestone beds, and debris-flow layers containing pebbles and olistoliths of earlier olistostrome-type deposits. These are followed by debris-flow layers containing a large variety of olistoliths of intrabasinal and extrabasinal derivation, of both sedimentary and intrusive rocks. The past research led to the indentification of two types of olistostrome facies. Type 1 contains olistoliths of sedimentary rocks only, which occur in moderate proportions ranging from 15% to 25% of the rock volume. Type 2 contains less than 5% olistoliths per volume, and these include also igneous and metamorphic rocks. The olistostrome is overlain by a succession of thin debris-flow conglomerate layers and normally graded siliciclastic turbidites.
Recent observations on this succession provided several details that contribute to our knowledge of the olistostrome components (especially the calciturbidites), the hosting strata, and the onset of olistostrome formation processes in general.
The calciturbidites form a coarsening-upwards sequence in which three facies complexes that mark three stages in facies evolution up the succession can be identified. The lower complex consists of very thin turbidite beds (3-5 cm), very fine and fine-grained, which form Bouma sequences T_{ce} and T_{cde} deposited by strongly diluted turbidity currents. The middle complex is characterized by thin- to medium-bedded, fine grained rhythms T_{ce}, T_{bce} and solitary T_{abce}. The upper complex represents deposition out of normally diluted to concentrated turbidity currents. Here fine-grained T_{ce} beds are associated with up to 30 cm thick coarse-grained, T_{ace} turbidites deposited by rapidly decelerating flows.
Calciturbidites in the lower complex are composed of very well-sorted pelsparite. The coarse-grained beds in the middle complex are represented by biosparite, and intrapelsparite. Composition of turbidites in the syndepositionally folded complex underlying the olistostrome classifies them as biooosparite and biooopelsparite – wackestone after Dunham. These beds, rich in carbonate mud matrix, were deposited by highly concentrated and rapidly decelerating tubidity currents. This further emphasizes the generally coarsening upwards trend associated with increasing volume and energy combined with increased density of the flows directly preceding the onset of the highest energy olistostrome deposition. The detrital carbonate facies present in olistoliths above are laminated biointrasparite and oobiosparite set in rich matrix of mudstone with stringers of carbonate silt.
The above observations suggest that the onset of the olistostrome deposition was preceded by turbidite facies progradation, which may reflect ongoing uplift of the source area. On the other hand, the broad range of grain types characterize complexity of composition of the carbonate platform supplying the deep proto-Silesian basin in detrital materials.

Impact of middle Cretaceous (Albian to Turonian) environmental changes in the eastern sub-equatorial Pacific: New insights from the Andean Basin (northern Peru)

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New Albian-Turonian carbon isotope (carbonate and organic matter) curves from epeiric-neritic carbonate successions from the eastern sub-equatorial Pacific in Peru is reported. The focus was to test the hypothesis that mid-Cretaceous OAEs (OAE1b set, OAE1c, OAE1d and OAE2), which are mostly documented in the Tethys and Atlantic realm are recorded in the Peruvian epeiric-neritic realm. For this purpose, we have combined chemostratigraphical and sedimentological information from expanded and well-exposed sections in NW Peru. The geochemical data indicate presence of the OAE1b set, OAE1c, OAE1d, as well as the Cenomanian-Turonian Boundary Event (OAE2), known as one of the most extreme carbon cycle perturbations of the Mesozoic. The new carbon isotopes record is constrained by biostratigraphic evidence and strontium isotope stratigraphy using well-preserved oyster shells. Facies associations range from shallow subtidal inner ramp to outer ramp settings.
The sedimentological observations, combined with the carbon isotopes record, were used to elucidate the complex interplay of climatic changes, nutrient supply, and platform drowning. These observations show: (1) An upper Aptian-lower Albian lithological change from siliciclastic- to carbonate-dominated sedimentation that is coeval to the unfolding of the Kilian event.
(2) A lower Albian incipient platform drowning linked to the impact of the Paquier event. (3) A lower middle Albian demise in neritic carbonate production that coincides with the Leenhardt Level, followed by middle Albian condensed sedimentation characterized by negative values in carbonate carbon isotopes. (3) Renewed carbonate ramp production during the upper Albian-middle Cenomanian. (4) An upper Cenomanian-middle Turonian transition where the OAE2 is represented by a 44 m thick sedimentary succession characterized by rhythmically bedded marls, marly limestones and limestones. Despite the lack of anoxic facies and organic matter enrichment, the carbon isotopes curve matches with global published high-resolution records for coeval successions in the Pacific realm, European Tethys and Western Atlantic domain, supporting the global nature of the isotope patterns described here.

Multitaxon oncoidal communities: An example from the Liassic of Morocco (Upper Pliensbachian, Central High Atlas Basin)

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A large (6 cm diameter) porostromate marine oncoid from the Upper Pliensbachian of the Aganane Formation (southern Central High Atlas of Morocco) has been investigated for its microfossil content and structure. It was sampled from an oncoid-rich interval, situated 5 m below the Pliensbachian–Toarcian boundary in the Ait Athmane section. The oncoid displays a multitaxon community of cyanobacteria/calcimicrobes and incertae sedis. The laminae-forming microfossils mainly consist of various filamentous cyanobacteria, including *Girvanella*-type tubes and three morphotypes of rivulariacean-type taxa distinguished by filament size, distributional pattern, and thallus shape. They are accompanied by abundant thin-walled and variable shaped thaumatoporellaceans whose role in the oncoidal biotic community is unknown. Filaments of microtubular straight series of concave-upwards chambers/cells can be assigned to the calcimicrobe *Gakhumella* Zaninetti. These biota are accompanied by the cryptobiotic cavity-dwelling calcareous benthic foraminifera *Bullopora*. According to sedimentological, microfacies and micropalaeontological analysis, the depositional setting of the oncoids can be assigned to the inner part of a carbonate platform.

Impact of Early Jurassic environmental perturbations on neritic carbonate factories

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The late Early Jurassic (Pliensbachian–Toarcian) has been a time of recurrent environmental perturbations, whose intensities have reached a climax during the so-called Toarcian oceanic anoxic event (T-OAE, ca. 183 Ma). Although it has long been observed that the Pliensbachian–Toarcian transition correspond to a drastic reduction of peritidal carbonate production leading to a platform drowning event, its exact timing and causes remains so-far elusive. Moreover, due to a strong focus of previous studies toward the T-OAE, the other environmental events and their impact on peritidal carbonate remain so far underexplored.
In order to improve our knowledge about late Early Jurassic neritic environments, we have combined extensive field-work in the Central High Atlas of Morocco (sedimentology, petrography, sequence stratigraphy) with high-resolution chemostratigraphy (coupled carbonate and organic matter carbon isotope) and biostratigraphy (based on ammonites, brachiopods and nannofossils). A total of four successive events of carbonate factory demise can be documented during the Late Pliensbachian - Toarcian time interval. These events are contemporaneous with marine extinction events. They can be linked to environmental deterioration, most probably consecutive to the pulsed activity of the Karoo-Ferrar Large Igneous Province. They all lead to a near shutdown of carbonate accumulation. They however differ in their timing, intensity and unfolding. A first demise event, corresponding to the so-called Late Pliensbachian Margaritatus event, is associated with a severe backstepping of carbonate facies belts. Impact on benthic carbonate producers seems however limited.
Of major interest are the demise events recorded at the Pliensbachian-Toarcian boundary (P-To) and at the onset of the T-OAE. An intense sea-water eutrophication occurs during the P-To event, as documented by phosphorus analyses in deep-water setting, the disappearance of shallow-water oligotrophic hypercalcifiers (corals & lithiotids bivalves) to the benefit of siliciclastic sedimentation, and the swarming of echinoids at the transition between the two sedimentation regimes. A mixed siliciclastic-carbonate factory (dominated by lithiotid bivalves) is however quickly reinstalled in the aftermath of the P-To event. The third demise event, associated with the T-OAE, marks the end of the dominance of lithiotids bivalves on the neritic carbonate factory. Probably related to a post T-OAE calcification overshoot, peritidal carbonate production resumes rapidly as testified by extensive ooidal shoal deposits during the Middle Toarcian. A last demise event occurs during the late Middle Toarcian. It is marked by the shutdown of the ooid-dominated carbonate factory, most likely related to global cooling and enhanced fresh-water influx.
This study demonstrates that late Early Jurassic peritidal carbonates are faithful recorders of global environmental changes, further highlighting the importance of neritic/peritidal carbonates as environmental archive.

NanoSIMS C and O isotope analysis of hydrate-associated Oligocene carbonates: Challenging the conventional approach to authigenic carbonates

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Petrography and stable C and O isotopic compositions of methane-derived carbonates from the Polish Outer Carpathians were analyzed. Two methods were employed in isotopic determinations. Conventional IRMS measurements on powdered bulk samples were performed with high precision (errors ~0.06‰ for $\delta^{13}C$ and ~0.08‰ for $\delta^{18}O$, 1σ), whilst *in situ* measurements were made using NanoSIMS with a high spatial resolution (5 µm), but with low precision (errors ~3.0‰ for $\delta^{13}C$ and ~2.3‰ for $\delta^{18}O$, 2σ). The NanoSIMS study proved very useful in identifying the sources of the fluids precipitating the carbonates. They were formed predominantly by the anaerobic oxidation of biogenic methane (AOM). The very fine spatial resolution of the analyses revealed highly variable $\delta^{13}C$ values, even in individual crystals, from extremely negative (-54‰) related to AOM to positive (7‰) related to methanogenesis (Me). Other methods, including laser ablation and standard SIMS, would fail to detect this variability and would not indicate the true sources of the fluids, because they would show average values. Particular attention should be paid when $\delta^{13}C$ values, obtained by these means and especially by c-IRMS performed on powdered samples from authigenic carbonates, are between -30 and ~3‰, because they may be the result of a mixture of carbonate cements. Therefore, any straightforward interpretation of the sources of authigenic carbonates based on these methods may be attempted only if the $\delta^{13}C$ values are extreme, i.e. resulting either from AOM or Me. Unusual clast-like druses from the carbonates were analyzed in detail with NanoSIMS. They are filled with strongly ^{13}C-depleted (down to -54‰) and ^{18}O-enriched (up to 6‰) fringe calcite which precipitated on the walls of the druses from heavy-oxygen-containing water, released from the dissociation of gas hydrates. The rocks can thus be termed clathrites. The bulk rock isotopic analyses of powdered samples of these druses show no evidence of hydrates and alone would not point to the true origin of these rocks. Precipitation of the carbonate cements started when hydrates were still present, so they are a type of melt-and-seal fabric. The recognition of such features in association with their heavy O isotopic composition may be crucial evidence of the former occurrences of gas hydrates in ancient methane-derived carbonates.
The isotopic results this work demonstrate that NanoSIMS can be very useful in reconstructing the diagenetic evolution of pore water by analyzing the stable isotope compositions of even microcrystalline cements. This provides a basis for the application of NanoSIMS to tracing diagenetic pathways from various, even complexly formed, authigenic precipitates, for instance concretions which grew pervasivel. However, the low precision of the measurements achieved in these preliminary analyses indicates that the application of NanoSIMS to materials having a very low variability of isotope ratios (e.g. paleoenvironmental reconstruction) is currently limited.

Outcrop Gamma Ray of Upper Cretaceous (middle/upper Cenomanian) carbonates from the Apennine Carbonate Platform (Cilento Promontory, southern Italy)

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During the last twenty years, gamma-ray logging of outcrops has been increasingly used as a tool for directly comparing and correlating well data with surface geology. Moreover it has emerged as a rapid and cost-effective method of improved facies characterisation and as a tool helping in the recognition of cycles and their stacking patterns and sequence stratigraphy.
For this study, we logged with a portable gamma ray device (Super Spec RS 125-Radiation Solutions) two coeval sections of middle/upper Cenomanian carbonates, each about 70 meters thick, exposed on the southern slope of Monte Chianello (Cilento Promontory - southern Italy) at about 6 km of distance from each other. Both sections belong to the Apennine Carbonate Platform, representing a nearly 5 km-thick pile of shallow-water carbonates that were deposited during the Late Triassic to Late Cretaceous (with renewed sedimentation in the Eocene and Early Miocene) at the southern margin of the Tethyan ocean and were later incorporated as thrust sheets in the southern Apennine fold-and-thrust belt. Both the studied sections start with dark, finely laminated, thinly bedded and relatively organic-rich calcareous dolomitic facies, deposited in a restricted environment, probably representing a small shallow intra-platform basin. These dark dolomitized limestones evolve upward into more thickly bedded and organic-lean limestones and dolomites which were deposited in a carbonate platform setting.
These sections are of particular interest because they could offer a small scale outcrop analogue for the Basilicata oilfields, where coeval levels of the buried Apulian Platform are represented by organic-rich dolomites acting as the source rock of a thick column of reservoir made of middle to Upper Cretaceous alternating limestones and dolomites. The aim of the work is to use the gamma-ray log to help delineating sedimentary cycles and their stacking pattern in the studied sections and to help the comparison between the outcrop sections and their subsurface equivalent drilled by the wells of the Basilicata oilfields.
Peaks in the U and Th content, revealed by the spectral GR log, were used together with facies analysis (based on field observations and microfacies analysis of thin sections) to help the correlation between the studied sections and to recognize the main sedimentary cycles. The total GR curves show a good match both of the trends and of the main peaks. In terms of cyclicity, a sharp change is observed between the first part of the sections, where the GR logs show cycles on average 5 m thick, and the upper part of the sections, characterized by cycles on average 15-20 m thick.
Changes in the organic matter content are well depicted by the U curve, showing the alternation in the lower part of the studied sections of calcareous organic-lean levels and laminated and dolomitic organic-rich levels. The spectral GR data were analysed for clay mineralogy and geochemical facies. The Th/K diagram point to the presence of illite, smectite and rarely kaolinite. The Th/U diagram gives information on the organic matter content and on the redox conditions of the sedimentary environment.

Sedimentation processes in the region of the Sao Tome seamount (south Atlantic): Bottom current vs. gravity flows

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The main goal of this work is to gain better understanding of interplay between gravity-driven sedimentation processes and those related to bottom currents on the Brazil continental rise during the Late Quaternary.
The study embraces an area close to the Sao Tome seamount (21°-23° S) that is located on the continental rise in the SW Brazil Basin (South Atlantic). Several high resolution acoustic profiles (4 kHz) and four sediment cores were collected in the region during cruises 33, 35, 37, 43 of the RV *Akademik Ioffe* (2010-2014). Additional lithological data (core V14-13) were received from online available database of the NOAA National Geophysical Data Center.
An analysis of acoustic data allowed distinguishing of four major echo-facies. Chaotic echo-facies with a hummocky bottom surface are related to the lower seamount slopes. An area to the north-west of the seamount is characterized by acoustically transparent facies with a high-amplitude sea-floor reflector. South of the mount seismic profiling revealed acoustically stratified deposits with high-amplitude slightly undulated continuous reflectors. At the foot of the north-western mount slope there is an erosion-depositional system consisting of several small mounded drifts oriented roughly parallel to the regional contours and separated from each other by moats (Borisov et al., 2013).
Deposits recovered by core V14-13 (depth 4259 m) correspond to transparent echo-facies. Intercalation of clay and fine sand in the upper part of the core (0-93 cm) is considered to be a result of bottom current activity, while almost 5.5 m of sands below (with several turbidite sequences) were deposited by gravity flows. Acoustically stratified facies correlate with sandy-clay contourites observed in cores AI-2561 and AI-2562 (depth 4053 and 3950 m, respectively). Thin interbeds of fine well-sorted sand in brownish pelagic clay are interpreted as gravitites reworked by bottom currents. Cores AI-2445 and AI-3150 (depth 4108 and 4090 m, respectively) collected from two drift summits recovered alternation of muddy contourites and three turbidite sequences. The thickest sequence consists of almost pure foraminiferal sand with coarse quartz grains and has an evidence of top-truncation by bottom currents.
Bottom-water circulation in the study area is controlled by Antarctic Bottom Waters (Reid, 1996) responsible for contourite deposition. It is suggested that sedimentation processes related to bottom currents were dominant during the late Quaternary. The Sao Tome seamount plays an important role in formation of erosion-depositional system at the foot of its NW slope. As a large topographic obstacle it causes a deflection of bottom waters flow, increase in flow velocity and changes in its structure.

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The Albian-Cenomanian (Cretaceous) transition in NW Germany: High-resolution integrated stratigraphy of the Anderten research cores

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The upper Albian to lower Cenomanian of the central NW German Basin is represented by an expanded offshore succession of basinal marly claystones and marls, comprising the Peine, Herbram and Baddeckenstedt formations. Here we present a new c. 160-m-thick composite record spanning the uppermost Albian to mid-lower Cenomanian based on two cored boreholes that have been drilled at Anderten, east of Hannover (Germany). Both cores have been subject to an integrated study including detailed bed-by-bed and geophysical logging, sedimentological analyses as well as bio-, event and chemostratigraphic calibration.
Correlation of the high-resolution Anderten carbon stable isotope record to European reference sections and to records from the NW German Basin provided the basis for chronostratigraphic dating. Based on the observed pattern, the base of the succession can be placed in the upper Albian Mortoniceras rostratum and the top in the upper lower Cenomanian Mantelliceras dixoni ammonite zone. The carbon stable isotope markers of (1) the OAE 1d, (2) the Albian–Cenomanian Boundary Event (ACBE) and (3) the Lower Cenomanian Event(s) (LCE) can be identified. Right above the LCE, a well developed unconformity has been observed that is succeeded by the common occurrence of rotaliporids and a major increase in inoceramid abundances. The chemostratigraphic age assignments are supported by bio- and event stratigraphic results: calcareous nannofossils indicate an extended CC9 zone up to the lowermost CC10 (UC0–UC3) as indicated by the FAD of Microrhabdulus decoratus at the top, ammonites of the topmost Albian Arrhapoceras briacense Zone occur between the B and C peaks of the ACBE, and the early Cenomanian ultimus/Aucellina and crippsi events have been identified at levels of the isotope curve that strictly correspond to their position elsewhere. The major sea-level fall in the latest Albian, resulting in a hiatus across the Albian–Cenomanian boundary interval in most basin margin section of NW Europe, is represented in the Anderten core by a correlative conformity at the base of the argillaceous Bemerode Member of the Herbram Formation that ranges into the lowermost Cenomanian. Due to the continuous, expanded record and integrated stratigraphic data set, the Anderten succession can be considered as a potential reference section for the Albian–Cenomanian transition in the Boreal Realm.

Holocene lagoonal sedimentation under conditions of constant water level rise of the non-tidal sea as recorded in the deposits from the Szczecin Lagoon, NW Poland

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The Polish part of the Szczecin Lagoon, NW Poland, is a part of the Oder river mouth discharging into the Baltic Sea. It is a large reservoir (ca. 670 km^2) of brackish waters - its environment is conditioned by the cross-influence of fresh and marine waters. However the Baltic Sea is a non-tidal sea, the recurring storms – especially in winter seasons – that push the marine waters ("backwater") into the Szczecin Lagoon, can be considered, to a certain extent, an analogy of the tides. They result in water circulation typical for an estuary. Since the Szczecin Lagoon is sheltered from the immediate influence of the Baltic Sea waters by a land barrier, interrupted only by the narrow rivers' outlets, the whole ecosystem has a range of features characteristic for a separated lagoon.
The outline of the postglacial history of this sedimentary basin is recognized thanks to an extensive drilling campaign. Almost 150 sediment cores revealed the chronostratigraphic sequence of three sediment facies: beginning with alluvial, limnic and swampy deposits accumulated in Late Glacial and Early Holocene, through marine (from 7300 to ca. 3000 years BP), to a recent lagoon-like sedimentation with a significant impact of the Oder river. Since the marine transgression ca. 7300 years BP (a beginning of the Littorina transgression in the area), the hydrological changes has been induced and controlled by the Baltic Sea level rise due to postglacial eustatic sea level changes and isostatic rebound. Macrofossil analyses of the sediment cores allowed to reconstruct the temporal and spatial dynamics of water level rise in the area of the present day Szczecin Lagoon. The palaeoshorelines were recognized on a basis of the presence of reed taxa macroremains (e.g. *Schoenoplectus* spp., *Eleocharis* sp.). Along with taxonomical diversity of macrofossils, the observations of the littoral plants macroremains' state of preservation helped to draw a conclusion of location of the sites with regards to the palaeoshoreline. The results of C^{14} dating allowed to precisely establish the chronostratigraphic succession of palaeohydrological events. Several areas of a different patterns of palaeohydrological development can be distinguished through the Szczecin Lagoon.

Facies architecture and palaeoenvironment implications of the Upper Cretaceous (Santonian) Csehbánya Formation at the Iharkút vertebrate locality (Bakony Mts, Northwestern Hungary)

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Fluvial deposits of the Santonian Csehbánya Formation exposed in the Iharkút open-pit mine (Bakony Mts., Northwestern Hungary) provided rich and diverse continental vertebrate and plant assemblages. Isolated and associated remains of 31 taxa including fish, amphibians, turtles, lizards, pterosaurs, crocodilians, dinosaurs and birds were encountered.
The sedimentological investigation and facies analysis resulted in the identification of eight lithofacies associations: 1) lenticular sandstone, 2) tabular (sheet) sandstone, 3) conglomerates with sandstone, 4) stacked deposits consisting of clayclasts, sandstone and siltstone, 5) dark sandy siltstone, 6) massive claystone, 7) reddish paleosols, 8) yellowish, mottled paleosols. These associations are interpreted as: 1) ribbon-like fluvial channel deposits, 2) crevasse splay deposits, 3) coarse grained channel deposits, 4) high density flash flood deposits, 5) stagnant pool deposits with high organic content, 6) deposits of shallow lakes and ponds, 7) moderately drained paleosols, 8) hydromorphic paleosols. Sedimentological investigations suggest that the terrestrial sediments were deposited in an anastomosing fluvial system because: (i) they include multiple coexistent channel belt deposits, (ii) the ribbon shaped sandstone bodies are predominant, (iii) the cross-bedding structures and the lateral accretion are almost completely absent in the channel fill deposits and (iv) the alluvial architecture is characterized by channel sandstone bodies surrounded by large proportion of overbank deposits.
One particular channel fill deposit (site SZ-6) was examined in special details because of its lithological features and because it is the most important fossiliferous horizon at Iharkút. Thus the interpretation of the sedimentological characteristics of this sequence is particularly important for the vertebrate palaeontology of the locality.
Site SZ-6 is an asymmetrical lenticular channel fill. The erosional base of the channel cuts into the underlying massive bluish-green clay deposit. The thickness of the channel-fill is 3 to 3.5 m and it is ca. 400 m wide. The fining-upward sequence is made up by coarse, pebbly sand and organic-rich silt/clay. It can be divided into three units. Unit 1 is a 10 to 50 cm thick basal breccia layer composed of grey-green sand, siltstone, clayclasts, pebbles, plant debris and bones. It is the richest fossil-bearing horizon in the quarry. The poorly sorted sandstone breccia layer is interrupted by laminated siltstone/claystone horizons in at site SZ-6. Higher up the coarse and fine grained horizons alternate forming a stacked series of fining upward units. Unit 2 represents a grey-green, strongly cemented sandstone bed showing a poorly developed fining-upward trend. Unit 3 is a 30 to 50 cm thick, laminated, greyish, brownish siltstone layer which contains plant debris and a few bones. Based on sedimentological investigations we propose that the fossil-rich site SZ-6 can be interpreted as one of the abandoned channels formed during episodic high density flash flood events.

The Sabiñánigo flood-dominated delta systems revisited (Jaca basin, South-central Pyrenees, Spain)

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The Jaca basin, located in the South-central Pyrenees, is an E-W elongated trough developed in a wedge-top depozone within the South Pyrenean Zone. The Lutetian-Bartonian boundary coincides with the transition from deep-marine clastic systems of the Upper Hecho Group (Rapitán turbidite system), to the first deltas of the Jaca basin. These deltas are represented by the Larrés Marls (prodelta mudstones) and the genetically-related Sabiñánigo Sandstone Fm (delta front to outer shelf sandstones to siltstones). At this phase of basin evolution, tectonics exerted a general strong control on the facies distribution of the different stratigraphic units.
The Sabiñánigo sedimentary systems are flood-dominated deltas. The sedimentary processes and tectonic constraints controlling the architecture of these deltas can be more detailed than before. In this work a new point of view of the Sabiñánigo Sandstone architecture is presented, accounting new detailed data, allowing to improve the paleogeographic framework until now in force. The study is founded on a detailed geological map and integration of detailed stratigraphic sections into a long-distance high-resolution correlation. Both the geological map and the cross-section are covering the region from the limbs of the Basa anticline in the east until the Berdún region in the west.
The correlation shows that distinctive stretches of the Sabiñánigo Sandstone can be ascribed to two different types of sedimentary systems, with each one having a distinctive compositional signature and prevailing more or less if the data analysed is located in the northern or southern limb of the Basa anticline. North-derived sediments are outstanding in the northern limb of the Basa anticline and much less represented in the southern limb. In addition, north-derived sandstones are restricted to the eastern Jaca basin, merging into mudstones to the west, where the east-derived sedimentary input prevails. The E-W trending Basa anticline is passing to the west into the Jaca thrust. Facies associations developed in the hanging wall and footwall of this thrust can be better explained than before, accounting the new insights after the integrated approach based on the new data of this work.
The Sabiñánigo Sandstone can be seen as an exemplary field example of flood-dominated deltas, combining the interplay of two interfingered source areas, with the cyclic staking pattern additionally controlled by tectonic factors.

Spatial heterogeneity in a Pleistocene example of infralittoral coralligenous (*de plateau*?), Le Castella, southern Italy

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Coralligenous (C) is the most volumetrically significant type of autochthonous carbonate build-up in the Mediterranean, currently developing on hard and soft substrates (C"*de plateau*"), at depths ranging from 4 to 120 m water depth (wd). Literature on the C "*de plateau*" is relatively scarce, because of the difficulty in assessing the nature of the substrate of C build-ups by underwater investigation. Rare fossil examples are reported.
In particular, there is a need for establishing and documenting the range of morphological variability of build-up types at the macro-scale, and its potential link with environmental factors such as light, temperature, and sedimentary input. The increase of turbidity, burial and sediment deposition represent a threat to C assemblages as factors influencing the spatial and temporal variability. Beside large-scale morphology, C build-ups are formerly categorized into banks and rims. Nevertheless, scientific literature reports various definitions (e.g. heads, blocks patches, pillar, reefs, mound-shaped bank, minute reef, columns, ridges).
Shallow marine carbonate deposits from the Upper Pleistocene Le Castella marine terrace (Southern Italy) are preserved in spectacular exposures presenting a unique opportunity to explore and understand genesis and morphological development of recent Mediterranean C. The C build-ups occur in the lower transgressive portion of an unconformity-bounded, high-frequency sequence. They show high structural and morphological heterogeneity in terms of framework type and build-up size, over a distance of several hundred meters from the north to the south of the present-day coastline. To the north, C forms banks up to 4 m high, with a dense, coralline-dominated framework, laterally adjacent to paleo-channels devoid of build-ups and filled by coeval infralittoral biogenic packstone. To the south, build-ups are smaller (up to 1.5 m high), with an open algal framework and the coral *Cladocora caespitosa* alternating with or replacing coralline algae. At both locations, the most important framework-building coralline species are *Mesophyllum alternans* and *Titanoderma pustulatum*. The build-ups developed on a mobile substrate of various origin, therefore representing a fossil example of C de plateau.
Analysis of sedimentary structures, paleo-topographic indicators, faunal composition of associated mollusc assemblages, and predominance of M. alternans suggest the algal builds-ups grew between fair-weather base and storm wave base, within an infralittoral setting with a reconstructed 10 to 20 m wd. C in the Le Castella deposits competed for the space with other infralittoral biocoenoses. Suitable substrate availability in the form of hard conglomerate blocks or shell accumulations was the main factor controlling the inception and spatial distribution of C. Differences in size and internal composition between the north and south locations were driven by differences in hydrodynamism and sediment supply. In the south, the presence of abundant sediment input, supplied along shore during high energy events, combined with syn-sedimentary tectonism resulted in smaller build-ups with more open framework, the growth of which was terminated earlier than in the northern location by sediment burial. Eventually, relative sea level fall during regression, locally resulting in the formation of a regressive surface of marine erosion, prevented further growth of the C even in the northern area.

Did high atmospheric pCO_2 cause 50% lower-than-recent calcification rates in Plio-/Pleistocene reef corals (Florida platform, USA)?

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Laboratory experiments have demonstrated a link between skeletal calcification rates in corals and the saturation of seawater with aragonite $CaCO_3$. Decreasing supersaturation of aragonite in seawater in response to ongoing ocean acidification is, therefore, a possible threat to corals and other shallow marine biota. However, the 1:1 application of the laboratory results on predictions of future effects of ocean acidification to natural biological systems, must be treated with care due to complicated interrelations between different factors affecting coral calcification. Here we present the first data of calcification in fossil reef corals. The corals derive from the Florida platform (southeastern USA) and represent interglacial periods in the time interval from the middle Pliocene climatic optimum to the early Pleistocene (3.2–1.2 Ma) when atmospheric CO_2 (pCO_2) was similar to the present-day or even higher, but corresponding saturation with aragonite and its effects on reef health is still unknown. The recorded Plio-/Pleistocene calcification rates range from 0.18 to 0.82 g cm^2/yr (mean 0.38 + 0.16 g cm^2/yr), which is half of that of modern shallow-water reef corals. These low calcification rates are the combined effect of reduced rates of extension and low bulk density. In order to understand the environmental context, we have modeled the fossil calcification data using modern analogue data from the Western Atlantic and Indo-Pacific calibrated against water temperature and found the discrepant calcification in modern and fossil corals to be largely an effect of a non-analogous relationship of density with temperature. Although the slope of the relationship, i.e. the response of density change to temperature change, is the same in the Pliocene model and modern corals, it differs by the lower starting point of absolute density. Stable isotope proxy data from the fossil corals and the overall structure of the ancient shallow marine communities are consistent with a well-mixed, open marine environment alike the present-day reef tract, but the occurrence of highly porous and fragile skeletons notably coincides with the rarity of intra-skeletal, early marine inorganic cement. We therefore conclude that low calcification rates reflect high temperatures and/or low saturation of seawater with aragonite. Although changes in pCO_2 over geological time-scales were likely buffered away by the oceanic carbonate system, aragonite saturation seems to have been lagging behind the glacial–interglacial cycles of pCO_2, causing low calcification rates of z-corals during interglacials.

Channel and sediment dynamics of the Mulde river in historical times (Germany): First results

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The Mulde river is a minor river in eastern Germany and tributary to the Elbe river system. Its headwaters are formed by the Freiberger Mulde and Zwickauer Mulde, both draining the Erzgebirge region which used to be a major mining district in eastern Germany before 1989. For this reason, Mulde sediments have a high level of contamination, both from a generally elevated geogenic background and the episodic draining of ancient mines and industrial wastelands. Discharge by the Mulde is highly seasonal with low water levels during summer and peak flow during winter/early spring associated with snowmelt (bankfull stage). Unusual weather configurations (5B) during the summers of 1954, 2002, and 2013 (and earlier years) have led to catastrophic flood events causing large economic damage and were associated with significant contaminations of the flood plains.
We study changes in the river bed of the Mulde in historical times (after 1870) using ancient maps (scale 1:25 000), aerial photographs and logging of sediments in point-bar deposits. Our study concentrates on separate reaches where the course of the river bed and channel dynamics were not modified through river management. Our data show a sinuosity of the channel of 1.6 (low-sinuosity river) and rates of cutbank retreat/point-bar growth of 4–6 m/yr which fit the global pattern of bank erosion rates for the size of the river catchment. Displacement of the channel seems to result from chute cutoff or minor avulsions, whereas neck-cutoff has not been documented so far. Interestingly, our observations point to a possible change in river dynamics: older flood sediments on point-bars (chute bars from 1954) are well sorted, clean sand, but upper point-bar deposits formed during the 2013 event are gravel dominated, and full of plastic waste. Future work on geochemical contamination will use geochemical marker analysis for fine-scale stratigraphic correlations, and test whether the river system is currently changing its dynamics from sand to gravel dominated associated with a change in discharge pattern.

Frequency analysis of a Lower Jurassic Carbonate Platform: The Calcare Massiccio Formation (Apennines, Italy)

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This paper illustrates the evolution the Lower Jurassic shallow-water carbonates known as the Calcare Massiccio Formation in the Central Apennines (Italy). The Calcare Massiccio is characterized by lateral variability in the facies associations, related to an articulated physiography of the Triassic to Early Jurassic carbonate platform. In this work to document the environmental changes during the platform evolution two stratigraphic sections were studied. The investigated sections are located in the Northern Latium and Umbria area. The sections were sampled bed by bed for thin section analysis. Quantitative analysis were made by point counting using the software JMicroVision 1.2.7. In every slide 500 points were counted. Point counts were analysed statistically by a hierarchical cluster analysis after the Ward method with squared Euclidean distance using the 'SPSS 22.0 for Windows' program. Before the cluster analysis was performed, a factor analysis of the main components was carried out.

Profound climatic perturbations at the Triassic-Jurassic boundary – a clay mineral and geochemical evidence from the continental mudrocks in Poland

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A development of the Central Atlantic Magmatic Province (CAMP) and related processes are commonly inferred as a trigger of biogeochemical cycle destabilization, climatic shifts and other global environmental changes at the Triassic-Jurassic boundary. The bulk-rock mineralogy, clay mineralogy and geochemistry of many continental mudrock samples collected from four borehole cores yield information on Rhaetian - early Hettangian palaeoclimatic and palaeoenvironmental variations in the Polish Basin. During the Rhaetian-earliest Hettangian times, non-marine, alluvial-lacustrine sedimentation prevailed in the area of Poland. Changes in detrital clay mineral composition and in the major element contents were mostly controlled by weathering regime and climate. A diagenetic overprint due to burial is mostly insignificant, but in places hydrothermal activity may have influenced clay mineral composition, e.g. by chloritization of kaolinite. After semi-dry climate conditions in the Norian times (common domination of illite in the Zbąszynek Beds), smectite predominance in most part of the early-middle Rhaetian Wielichowo Beds points to some increase in precipitation and its distinct seasonality. In the topmost part of the Wielichowo Beds and in the Late Rhaetian - earliest Hettangian Zagaje Formation, the kaolinite-illite association prevails. It signifies the general fundamental climate change and predominance of round-year rainfall. Several warming and cooling events are inferred in the late Rhaetian and the earliest Hettangian and are evidenced by changes in kaolinite-illite ratio, other geochemical indices such as major element geochemistry and osmium isotopic system, and palynofloral characteristics. These climate reversal events are also confirmed by $\delta^{13}C$ wood data. It should be noticed that peaks of kaolinite and weathering indices seem to slightly precede negative excursions of the carbon curves. Such rapid and episodic fluctuations point to climate destabilisation and the sequence of frequent and catastrophic climatic reversals, which led to multi-phase extinction.

Peritidal carbonate platform onset and widening: Sedimentological and isotopic evidences (Dolomia Principale, Upper Triassic)

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The Late Triassic Dolomia Principale formation (DP; upper Carnian - Norian - ?Rhaetian) represents the largest epicontinental carbonate platform of the western Tethys, with a size comparable to today´s Great Barrier Reef in Australia. The DP was deposited during a time span of ca 20 Myr, with thicknesses of 500 to 4000 m.
The platform interior facies are represented by a thick succession of peritidal carbonates. Dolomitic beds are organized in meter-scale shallowing-upward cycles, characterized by subtidal facies (rich in marine fauna), grading upward into intertidal–supratidal facies with planar stromatolites.
The platform margin has been documented in the Northern Julian Alps, near Tarvisio, where a prograding upper Carnian platform–basin transition is preserved. The margin mainly consists of serpulids, microbialites and marine phreatic cements and separates the DP platform interior facies from the clinostratified breccia and megabreccia slope facies.
The coastal area at the back of this huge peritidal carbonate platform is recorded by the siliciclastic-carbonate deposits of the Travenanzes Formation (TVZ; upper Carnian p.p.) in the Dolomites, which is about 200 m thick. This coastal system is characterized by dryland river systems, mainly drying out before the shoreline, and by coastal mudflats and sabkhas. Calcic and vertic paleosols indicate an arid/semi-arid climate. Seaward of the shoreline, a carbonate tidal-flat developed. Meter-scale shallowing-upward peritidal cycles are equivalent to those of the adjacent DP, except for thin dark clay intercalations representing sporadic fluvial sediment-supply to the shallow-marine system. The depositional architecture of the TVZ exhibits an overall transgressive pattern, with a strong retrogradation of the shoreline related to the low sediment supply of continental origin to the carbonate lagoon. Equally, the progradation of the platform margin is related to the high carbonate production on the whole carbonate system. The progradational geometry of the platform margin, together with the retrogradational architecture of the coastal area at its back, result in a gradual widening of the platform lagoon system.
The stable isotopic composition of dolomite in the TVZ was analyzed along three stratigraphic sections. Oxygen and carbon isotope values show no correlation ($R2 < 0.001$), and a wide range of $\delta^{13}C$ values (from ca -6‰ to +4‰) is observed, compared with a narrow range in $\delta^{18}O$ (from ca 0‰ to +3‰). $\delta^{13}C$ is strongly facies controlled, suggesting the absence of a burial diagenetic overprint. $\delta^{18}O$ shows a positive upward trend, from 0–1‰ to 2–3‰, in the three sections analyzed. $\delta^{18}O$ values are consistent with dolomite precipitation from Carnian sea-water. The widening of the platform gradually limited the exchange with open-marine waters in the restricted lagoon. The gradual $\delta^{18}O$ enrichment observed up-section could be explained by progressively longer residence times of seawater on the platform and consequent increasing evaporation due to arid climate.

3D internal architecture and morphodynamic evolution of tidal point bars: inferences from the Venice Lagoon (Italy)

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Although meanders are ubiquitous features of the tidal landscape, the description of their hydrodynamics and morphodynamic evolution, as well as the analysis of their planimetric shape and morphometric characteristics, are still in their infancy. Moreover the internal architecture of tidal meanders is relatively unexplored and is commonly investigated on the basis of facies models developed in analogy with their fluvial counterparts.
The present study aims at improving current understanding of these issues by investigating the internal architecture of an abandoned intertidal meander loop, located in the NE sector of the Venice Lagoon (Italy), and by defining high-resolution facies models of related point bar deposits. The meandering channel is 6 m wide, the loop axis is oriented NW-SE, and the radius of curvature is approximately 24 m. The analysis of historical photos reveals that the channel was active until the latest 40's of 20th century.
Using a hand auger core sampler, which minimizes sediment compaction, about one hundred cores were collected in the study site, over an area of about 450 m^2. Coring depth spans from 1 to 3 m, and cores are 3.5 cm in diameter. Core logging was carried out following the basic principles of facies analyses, which allowed us to distinguish five types of deposits, namely: sub-tidal platform, salt marsh, channel lag, point bar, and channel fill. Sub-tidal platform deposits consist of an alternance of sand and muddy sediments. Salt marsh deposits are characterized by brown mud, with a variable amount of fine to very fine sand, which commonly occurs in millimetric sandy laminae. Roots, wood fragments and bioturbation are common. Channel lag deposits consist of massive grey-bluish medium sand, with mud clasts, wood fragments and shells, overlying an erosional surface cut onto the sub-tidal platform deposits and overlain by point bar deposits. This latter shows a clear fining upward trend defined by grey-bluish fine sand sediments grading into sandy mud. Point-bar deposits are commonly bioturbated, although traces of the primary lamination are locally preserved. Channel fill deposits consist of dark grey-bluish, massive, organic-rich mud, grading downward into slightly sandier deposits. Rare shells in life position occur.
Sedimentary logs were spatially correlated to define an high-resolution 3D architectural model using the software Move 2014.2. Four key surfaces were defined: sub-tidal platform /saltmarsh boundary, point bar base, point bar top, and channel base. 3D modelling shows that during meander bend expansion, thalweg migration followed a horizontal trajectory, generating a flat surface in turn floored by channel lag deposits. On the contrary, the trajectory defined by lateral migration of the inner channel bank show a clear rising trajectory, pointing to a progressive increase of channel depth. Such a process reflects meander bend migration under strong aggradation of surrounding overbanks, and appears to be quite a distinctive feature of tidal channels in salt marsh settings.

Travertine fissure-ridges as proxies of tectonically controlled hydrothermal fluids fed by a carbonate reservoir: Special emphasis on Denizli basin of SW Anatolia, Turkey

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Hydrothermal fluids fed by carbonate reservoirs and reaching the surface through structural conduits can deposit travertine. Travertine in fact is the result of carbonate precipitation through loss of carbon dioxide (CO_2) based on the reaction: $H_2O + CO_2 + CaCO_3 = Ca(HCO_3)_2$. Travertine fissure-ridges are the typical morpho-tectonic features that have usually been considered as the main linkage among brittle structures affecting the substratum, hydrothermal fluids circulation, thermal springs location, and travertine deposition.
The analyses of the anatomy of the fissure-ridges, as well as the relationships between bedded and banded travertine could reveal much on: 1) the mechanism promoting hydrothermal fluids upwelling from the carbonate reservoir; 2) the fissure-ridge growth process; 3) the evolution of the fault zone driving fluids circulation. In this presentation, some examples of travertine fissure-ridges developed in different tectonic environments are described, mainly focussing on these main topics.
This contribution aims to characterize the hydrothermal circulation promoting fissure-ridge travertine evolution in the Denizli Basin where the travertine deposition is the prominent in the World. This implies the reconstruction of the origin and physical-chemical nature of fluid that deposited the travertine and the relationships between fluid circulation and tectonic structures. To this purpose, an integration of petrographic, isotopic, sedimentological, fault kinematics and structural data incorporated with geophysics along the northern Denizli Basin is performed. In this view, the reconstruction of fossil hydrothermal circulation through travertine fissure-ridges represents an innovative approach to evaluate the tectonic evolution of travertine fissure-ridge and its influence on the sedimentary architecture. This is the main target of the research proposal in the tectonically active Denizli Basin, in order to characterize the geological structures influencing the development of the basin in relation to the hydrothermal circulation. Specifically the geophysical surveys along the travertine fissure-ridges demonstrate that the banded and bedded travertines are veins is contemporary formations in close relation to the fault activity, therefore highlighting the fundamental role of travertine fissure-ridges in reconstructing palaeotectonic activity in a region.

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Remarks on *Morelletpora turgida* (Radoičić) from the Lower Cretaceous of Iran

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Radoičić (1964) described the species *Pianella turgida* from Cenomanian limestones of the external Dinarids. With the reinstatement of the genus *Salpingoporella*, *P. turgida* has been transferred to this genus and reported as *Salpingoporella turgida* from different parts of the Tethyan realm (see Carras et al., 2006 for most records).
From the Paleocene of India Varma (1950, 1955) described the new genus *Morelletpora* with *M. nammalensis* as type species. Varma considered the new alga as being articulated, with club-shaped segments and only first order branches (= laterals). The branches have a proximal tubular part, enlarging distally to form a barrel-shaped sporangium.
The well founding of the genus *Morelletpora* was questioned for a long time mainly due to the poor material on which the description of Varma was based. However, Parente (1997) described from uppermost Cretaceous limestones of southern Italy a new species attributed to this genus, *Morelletpora dienii*, and resumed the discussion on the genus *Morelletpora* which is characterized, besides the segmented thallus, by laterals more or less differentiated in a "stalk" and a "swollen part".
Barattolo (2002) attributed for the first time the species *Salpingoporella turgida* to the genus *Morelletpora*, as *Morelletpora turgida* nov. comb., and considered the species " structurally similar to *M. dienii*".
Recent studies on the Lower Cretaceous deposits from Iran (e.g. Schlagintweit et al., 2013, and unpublished data of the present authors) revealed the existence of numerous, well preserved specimens of *Morelletpora turgida* distributed along the whole Aptian carbonate succession of the Taft Formation from Ardekan-Hersisht and Anarak areas (central Iran). The identified specimens permit a better morphologic re-description of this alga with clear evidence for both the segmented character of the thallus and the characteristic shape of the laterals. The new data reinforce the attribution of this alga to the genus *Morelletpora* as proposed by Barattolo (2002).
Morelletpora turgida has been identified to date in limestones of Aptian-Cenomanian age from numerous regions of the Tethyan realm: Dinarids (Croatia, Montenegro, Bosnia-Herzegovina), Turkey, Liban, Iran, China, representing (following Carras et al., 2006) the southern and central part of the Tethyan Domain.

Paleoenvironmental reconstruction of a Pannonian (Late Miocene) sedimentary sequence in the Eastern Mecsek Mountains, Southern Hungary

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Late Miocene lacustrine deposits in the vicinity of the Mecsek Mountains, in the southern part of the Pannonian Basin, are relatively poorly known. Various lithological units, their sedimentary and structural features were studied in a sand pit in the Eastern Mecsek. The sandy sequence unconformably overlies Middle Miocene fossiliferous, pebbly limestones and lies next to the Carboniferous Mórágy Granite Formation. This latter was the main sediment source in the lower part of the Upper Miocene succession. The Late Miocene (Pannonian) age and the lacustrine character is confirmed by mollusks recently studied from this locality. The lacustrine sequence can be subdivided into three main facies associations. The lower facies association (ca. 20 m thick) consists of alternating beds of coarse-grained arkosic sand and gravel. Both contain granite derived angular clasts (feldspar, quartz and rock fragments). Rarely limonitic moulds of both littoral and sublittoral lacustrine molluscs were also found in these beds. Clay occurs as continuos beds or as irregular patches in the sand, and its abundance changes systematically, usually increasing upward. In the continuous beds the clay is mixed with very coarse sand to pebble-sized clasts in a matrix-supported fabric. These beds are interpreted as debris flow deposits, while the others as semi-cohesive grain-flows. The beds dip steeply and have opposite dip directions in the two halves of the sand pit. Syndepositional strike-slip faults and deformation bands were also observed in the lowermost unit. The second facies is visible in a 3 metres thick dark grey claymarl, with a rich assemblage of sublittoral molluscs. The third facies association overlies this with a sharp boundary. It is made up of ca. 20 m thick silty sand, without systematic vertical variation of the grain size. Structureless silty sands alternate with cross-laminated and cross-bedded sands. The bottom surface of the structureless sands shows irregular, wide or narrow pockets tapering downwards, indicating bioturbation. This facies association contains littoral lacustrine mollusks. Few centimeter thick gravel beds occur as intercalations, which again consist mainly of granite detritus. In this facies, however, the granite body was not the only source of clasts, as fragments of Middle Miocene limestones, conglomerates and characteristic Middle Miocene fossils like shark teeth are present.
The lowermost arkosic sand and gravel was deposited on a fan delta, which was built mainly by debris and grain-flows coming from islands or inundated structural highs made up of granite. The overlying clayey facies with sublittoral molluscs was deposited in water depths below the storm wave base and thus points to a base-level rise. The sharp boundary with the uppermost sandstone facies association may indicate forced regression, i.e. a rapid drop of the base level. This third facies association is interpreted as deltaic sediments, products of shallow terminal distributary channels and mouth bars. The reduced amount of granite detritus in the middle (clayey) and the uppermost (sandy) facies association points to a temporal cut-off/backstepping of the granitic source area during their deposition.

Small-scale physical simulation of gravity flows in minibasins

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An experimental study was conducted in a small-scale physical model constructed in order to represent an area of Brazil offshore characterized by two minibasins. This study aimed to understand the sediment filling of minibasins and the generation of sand deposits mainly by density currents. For this purpose, a distorted model was constructed using an horizontal scale of 1:3000 and a vertical scale of 1:1000 (dimensions ~ 4 m x 4 m x 1 m) based on Froude densimetric number. Five series of experiments divided into two phases were performed in the model. In the first phase of experiments the continuous flow injection was 2 L/min and in the second phase was 2.5 L/min. The mixture was composed of water and two types of mineral coal (d = 1.19, D50 = 80 microns and D50 = 45 microns used on a ratio of 1:5 to 1:20 in the first phase and in the second, respectively) and the volume concentration was 5%. Approximately 8800 liters of the mixture were injected and the evolution of the flow was evaluated by images every five seconds. The generated deposit was documented (bathymetry and particle-size distribution) using laser scanning as well as a grain-size particle analyzer. The data analysis focused mainly on the interaction of the flow with the seafloor topography and also on the dynamic processes minibasin filling (preferred direction and velocities). The analysis of the dynamics of filling suggests that the deposits are connected by two types of trajectories, the large main one and the small adjacent (also called secondary). Both can present an intermittent behavior along time. During the experiments it was observed the occurrence of fill-and-spill processes: the first minibasin was filled with coarser sediment size (D50 = 35 microns on the model or very fine sand in the prototype), whereas in the distal minibasin occurred only deposition of the finest fraction (D50 = 15 microns on the model or very fine silt in the prototype). In the model, the average velocity of the main trajectory responsible for the filling of the first minibasin was 0.16 m/s, which is feasible equivalent of 15 m/s in the prototype. After this series of experiments, the generated deposit had a total volume around 170 liters, that were located mainly in the proximal minibasin with a depocenter around 40 mm in the model(equivalent to 4 m in the prototype); while the distal mini-basin presented a local thickness around 6 mm along the main trajectory (12 mm max). The results obtained until now suggest that the first minibasin was completely filled and the full bypass of the current for the second minibasin, with coarser sediment, will likely occur in later experiments. The comparison with the natural environment will be further discussed.

Changes in the conditions and directions of the fluvial deposit transport at the turn of the Miocene and Pliocene recorded in the heavy mineral composition (the example of Central Poland)

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The period between the boundary Miocene/Pliocene and the early Pleistocene is one of the least explored geological periods in Central Poland. Most likely, the majority of deposits from that period hadn't been preserved, which resulted in a stratigraphic gap that lasted for ca. 2.5 million years. New information about this period is provided by analysis of heavy minerals (fraction 0.1-0.2 mm) of the sand-silt series of fluvial and fluvial-lacustrine deposits accumulated in a large vanishing lake and drilled in Rożce. Their age was determined based on the results of palynological and paleomagnetic analysis.
The obtained results demonstrated a large variation in the content of heavy minerals in the vertical profile, which contributed to the determination of changes in the directions and conditions of sediment transport.
The determined set of minerals in the deposits proved to be unusual for this period, and so far hasn't been described in the literature. In addition to minerals commonly identified in the deposits of the pre-Pleistocene substratum (garnets, staurolites, disthenes, zircons, rutiles, titanites, tourmalines), a high content of amphiboles was determined in all samples. Furthermore, some of the analysed deposits contain large amounts of minerals not resistant to long-distance transport (siderites, iron carbonates, pyrites, as well as micas in the light fraction). Such a set of minerals may indicate several sources of deposits.
Initially, in the conditions of a relatively humid climate, with a well-developed river network and large drainage basins, deposits rich in amphiboles and garnets were supplied. Sources of these deposits might be located e.g. in the area of the East European Platform (the Volhynian-Ukrainian or the Belarusian-Masurian massifs). They are accompanied by pyrites and micas which possible source are the north-western peripheries of the Holycross Mountains where there are sedimentary rocks dated from the Middle Jurassic with inserts containing siderite, muscovite and pyrite. Pyrite could also be formed in a reducing atmosphere.
This was followed by gradual dehumidification of the climate, and consequently stabilization of dry climate. Consequently, this led to a reduction in the length of rivers and the dynamics of flows. Pyrite disappeared from the sediment. The content of garnets and amphiboles in the composition of heavy minerals became gradually reduced until finally entirely eliminated. They were replaced by siderites and iron carbonates, which accounted for over 90% of heavy minerals.
In the later period, the climate became more humid again. The existing rivers provided sediments which were very rich in resistant minerals, primary iron oxides and amphiboles. It is possible that the minerals were derived from the erosion of older deposits of the Neogene or Paleogene. Probably the sediments came also from the north. After that period, the climate became drier. The water body probably was periodically drying up, and hence the increased content of iron carbonates. Younger Pliocene deposits havn't been preserved. The top layer of deposits has properties of fluvioglacial and ice-marginal sediments, and is associated with the first Scandinavian ice sheets in the area of Poland.

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Physical behaviour of the Cretaceous calcareous nannofossil ooze

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The Upper Cretaceous–Danian Chalk Group is one of the most important, but also challenging, hydrocarbon reservoirs of the North Sea. Exploration and development of this reservoir has led to improved and continuously evolving understanding of chalk deposition and chalk depositional environments. However, current knowledge of the physical behaviour of calcareous nannofossil ooze is very limited and more empirical data on parameters such as erosion thresholds, erosion rates, settling behaviour and aggregation behaviour are needed. Our study focuses on acquisition of this vital information via physical sedimentological experiments using annular laboratory flumes and chalk ooze. The experimental sediment used in our study as representative of Cretaceous age coccolithic ooze was produced by gently disaggregating very fine-grained, non-cemented, highly porous Maastrichtian chalk with < 2 % non-carbonate content. Our previous experiments have studied the behaviour of this ooze after short-term consolidation and subsequent mobility of chalk ooze beds, settled out from 1–2 vol % sediment concentrations. The results from these studies revealed a positive correlation between initial concentration of suspended material and bed consolidation, and between bed consolidation and erosion threshold. Essentially these experiments studied mobility of high porosity beds (~ 80 vol %). More recent experiments examine the mobility of chalk ooze beds with decreasing porosity to < 60 vol %. These experiments show little variation in erosion threshold values in beds with porosities < 75 vol %, but a significant decrease of erosion rates suggesting that erosion rates may be a better indicator of bed erodibility than surface erosion threshold.

Facies variability and depositional setting of pericratonic Silurian shales in Poland based on new cores from the Lublin and southern Podlasie basins

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Siluran mudrock belt along the NW slope of the East European Platform in Poland has been interpreted as deposited in the distal segment of Caledonian foreland basin, whose proximal segment is missing and possibly displaced by a Variscan strike-slip activity. The belt appears to occupy the gently westward sloping forebulge and cratonwards, it interfingers with and onlaps shelf carbonates. Cores from seven well acquired recently by Orlen Upstream from the SE part of the basin allowed for detailed insight into a 300-m thick, Rhuddanian- Ludfordian succession extending for ca 110 km in along strike direction. Sedimentology and regional correlations show that these deposits form a 2nd-order shoaling-up sequence, which was deposited on an outer to mid-shelf ramp at water depths extending up into the storm-wave base and that intermittent periods of sea-floor ventilation superimposed on upward increasing degree of clastic dilution were among the main controls on the preservation of total organic matter in the mudstones.
The succession rests across ravinement surface on either Upper Ordovician platform carbonates, or locally developed Hirnantian diamictites. Llandovery strata reveal (1) black, organic-rich (TOC = 5-8%), banded to plane laminated, argillaceous mudstones that are enveloped by (2) thin interbeds of dark gray, laminated mudstones and greenish grey, bioturbated mudstones (TOC < 0.5%). Facies 2 records mid-Rhuddanian transgression and Telychian highstand, both accompanied by intermittent anoxic and suboxic bottom conditions, whereas facies 1 reflects intervening late Rhuddanian-Aeronian maximum flooding and anoxia, all occurring in a relatively deep-water setting dominated by slow suspension settling. The Sheinwoodian is dominated by (3) dark gray, discontinuously planar laminated, locally microbioturbated, argillaceous to dolomitic mudstones, which abound in pyrite framboids, fecal pellets, fibrous organic matter (TOC = 0.80-2.5%) and reveal good porosities (up to 243 nD). This facies occurs also in in the overlying Homerian, where it is interbedded with (4) dark grey, chiefly calcite-cemented mudstones showing discontinuous, wavy to speckled laminae enriched in commonly piritized organic matter in various stages of degradation (TOC = 0.7-2.2%). Both facies become increasingly intercalated upwards with (5) load-casted, asymmetrical silt micro-ripples, continuous laminae, mm-thick lags of shell detritus and numerous mud-on-mud erosional scours. Facies spectrum 3-5 reflects a gradual upward transition into dysoxic outer shelf below storm-wave base affected by distal storm currents. Evidence for lateral transport, increased clastic dilution and further shallowing into shelf-shoreface transition near storm-wave becomes more conspicuous in overlying Gorstian-Ludfordian strata. Facies 4 forms here pelagic background (TOC = 0.4-1.2%) for event beds, including (7) thin, sharp-based calcareous sandstones and calcarenites, graded-laminated to massive mudstones, and siltstones revealing parallel inclined and hummocky laminasets as well as wave-modified ripple lenses.
The most organic-rich Rhuddanian and Aeronian mudstones tend to pinch out both cratonwards and towards the SE onto the basal unconformity, but their distribution was also controlled by the strongly varying relief of the unconformity itself. The less organic rich Sheinwoodian mudstones forms a 40-75 m-thick layer that is continuous across the entire study area and can be gas prone, albeit probably at depths below 4 km.

Microbial-derived pirite as evidence of early diagenetic processes on a Late Holocene shoreface deposits (Sulcis Iglesiente, West Sardinia, Italy)

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Since Roman time, SW Sardinia was a mine district and its fluorishing industrial activity lasted few decades ago. Mine activity in the district resulted in enhanced amount of sediments transported by rivers to the coast and, one of the major concern is elucidating the mineralogical background before and after industrial activity along the present-day coasts.
A 3-m long core was collected in the shoreface zone, at -13–m depth below sea level and ca. 500 m far from the coastal area located on the southern-western of Sardinia (west Mediterranean, Italy). A multidisciplinary approach was followed to study the core and two samples were collected for dating purpose. ^{14}C analysis revealed a Late Holocene age comprises between 4320 ± 30 BP (base) and 1420 ± 30 yeas BP (close to the top). Preliminary sedimentological data show that the core is composed of medium-fine grained sand, with the presence of aligned pebbles and/or shells at the base of the strata. These strata can be interpreted as the results of major storms occurred in a shoreface setting. Pervasive early diagenetic processes and sub-oxic conditions are observed as well.
The preliminary geochemical results can be summarized as follows: 1) residual metal sulphides are not detected; 2) Zn and Pb carbonates can be found in samples collected close to the beaches, 3) barite and other minerals are often concentrated in the fine fraction (<63 microns). Moreover, the microscopic analysis reveals the presence of secondary pyrite that is interpreted to be of microbial origin. Thus the microbial activity most likely plays a fundamental tool in the pervasive early digenesis of the studied core. Bacterial activity and its effect on biominerals processes and sedimentological features are actually under investigation.

The geology of the Elizabeth Bay aeolian diamond placer in the Sperrgebiet, Namibia

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The aeolian deposit at Elizabeth Bay consists of a sedimentary package that contain diamondiferous grits (coarse sand to granules) that has been laid down, reworked and concentrated to various degrees by dominant southerly winds. The deposit forms part of the diamond mega-placer that developed along the coast of southwestern Africa. The main source of sediment supply was the Orange River that introduced diamonds eroded from inland kimberlites onto the coast where northwards directed longshore drift and a strong southerly wind regime generated several economic placers in a variety of settings.
Elizabeth Bay is situated 230 km north of the Orange River mouth and is the largest south facing embayment on the Sperrgebiet coast. It is therefore a very active location for northwards migrating sediments to be moved from a coastal setting to a terrestrial setting, and it serves as a take-off point for sediments feeding into the Namib sand sea as one of four aeolian transport corridors currently operating.
The deposit was first prospected and mined from 1909 to 1931. The mining operation re-opened in 1991 and continues to this day. The deposit is hosted in a valley cut into the Mesoproterozoic gneisses of the Namaqua Metamorphic Complex during an Oligocene sea-level lowstand. It was then subsequently filled in with a sequence of sediments consisting of clay, sand and diamondiferous grits.
The lowermost clay unit was deposited in a fluvio-lacustrinal environment during a Lower Miocene sea-level high stand. The diamondiferous sedimentary sequence has been divided stratigraphically and chronologically into red, brown and grey beds ranging in age from late Pliocene to Holocene. The sediments consist predominantly of aeolian grits, but also contain fluvial sheetwash gravel. Diagenetic cementation has cemented the diamondiferous aeolian sediments in some localities. Recent prospecting and mining has revealed remnants of a coarser marine gravel unit in the southernmost extent of the deposit overlain by aeolian sediments. It is interpreted to represent an earlier marine to terrestrial transition point when sea-level was between 10 and 15 metres below present sea-level.
The internal structure and texture of the sediments at Elizabeth Bay is highly complex and variable. Grit concentration varies from massive to disseminated grits to sand, as well as variations from coarse to fine grit resulting in a complex deposit with high and often unpredictable variability in diamond concentration. The morphology and orientation of the valley hosting the deposit also had an influence on diamond concentration. In comparison to most other placer deposits along the west coast of southern Africa, Elizabeth Bay has a relatively high concentration of diamonds. Unfortunately, due to a relatively small average stone size of 4-7 stones/carat, the value per carat is low, making Elizabeth Bay a marginal deposit from an economic perspective.

Interplay of tectonics and sedimentation in the Polish Zechstein Basin

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The Polish Zechstein Basin (PZB) developed in an area of long-lasting crustal extension which enabled subsidence and sedimentation since the Permian until the Late Cretaceous, when the Permo-Mesozoic basin became inverted. Basin-wide distribution of Zechstein lithofacies brought previous researchers to the conclusion that tectonics played an insignificant role during Late Permian deposition. Studies carried out in the central part of the basin indicate that this assumption is unjustified.

The central part of the PZB is weakly recognizable due to deep burial of the Zechstein deposits. At present, the only Zechstein rock exposures are in mine excavations in the Kłodawa Salt Structure (KSS), which rises from a depth of ~6 km to the shallow subsurface. The KSS is situated in the axial, deepest part of the PZB, where basinal facies and continuous sedimentation throughout the latest Permian are assumed. All 4 Zechstein cycles, PZ1–PZ4, are preserved in the KSS and the sedimentary record in each of them indicates that basin bathymetry permanently varied in this area.

The Oldest Halite rock salt (PZ1) is built of a range of lithotypes among which speckled salt. This type of salt commonly fills channels, implying that it originated in response to redeposition of salts on a topographic slope. Basin floor relief is also reflected by thickness and facies variation of Stinking Shale–Main Dolomite deposits (PZ2) over a distance of a few kilometres. In the PZ3, over 100 horizons of desiccation polygons are documented. They repetitively developed at the final stage of the upper Younger Halite deposition. The most common desiccation polygons are hexagonal or pentagonal in plan-view, with diagonals ~1 m in length and the depth of desiccation fissures less than 1 m. In some locations, there are also large-scale polygons with diagonals and fissure depth in the range of at least a few metres. Fields of polygons occur over the limited area of the salt structure. This suggests that only part of the basin was drying out and, thus, that islands existed in the axial part of the PZB. Basin bathymetry varied also in the PZ4, as indicated by abundant clayey salts deposits. They consist of redeposited terrigenous-evaporite rocks and contain channels filled with boulder-grade debris.

The structures and textures documented in the KSS imply that redeposition was a common process in the axial part of the PZB, which requires repetitive rejuvenation of the topographic relief. Since redeposited sediments and desiccation polygons are also documented in other salt diapirs in the PZB centre and all those salt structures are located above basement faults, it is concluded that basement fault activity was responsible for diversification of basin bathymetry and facies variation. Uprising fault blocks were the sites of shallow areas or emergence, which promoted erosion and redeposition of sediments downslope fault ramps. Linear arrangement of reef complexes and facies boundaries in other parts of the basin indicate that sedimentation was controlled by basement fault activity throughout the PZB. Pre-Zechstein relief influenced facies distribution only at an early stage of the PZB evolution.

Microstructure of non marine, deep water microbialites in Blue Lake (Maar) of Mount Gambier and in adjacent hypogenic cenotes, south east south Australia

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In south-east South Australia microbialite grow in Blue Lake Maar of the sub-recent Mt Gambier volcano and in the nearby hypogenic cenotes. The association with volcanism and faulting related to extension is analogous to the setting in which Pre-Salt microbialite reservoirs evolved. The latest eruption in the area may have been that of Mt Schank at ~5000 yrs BP. The > 70 m deep Blue Lake fills the crater of the Mount Gambier Volcano possessing microbialites that grow from the walls down to ~40 m. The oldest date for the stromatolites is ~8000 BP. Some are solid towers, but others are "chimneys" around a central vertical channel. They appear to have been related to groundwater resurgence and are interspersed with charophyte meadows. Cross sections from a "chimney" show it is composed of Mg calcite with rather delicate shrub-like textures. Backscatter scanning electron microscopy (SEM) micrographs of polished cross-sections revealed thrombolitic microstructures with microclots of calcified masses accumulated around filaments and patches of angular calcite clasts. These clasts were interpreted as disintegrated material that originally precipitated around bacterial filaments. Circular structures ca. 10 µm in diameter (consistent in size with filamentous cyanobacteria) occurred throughout the sample. The structures represent cross-sections of filamentous bacterial microfossils that were biomineralised within calcified masses. Similar microbialites occur in Black Hole and several other microbialite-bearing cenotes that are aligned along the same fault trend in the vicinity of Mt Gambier. Cenotes are thought to have formed hypogenically, aided by the corrosive exhalation of volcanigenic carbon dioxide. These may have formed the cupola- and wine-glass-shaped cavities characteristic of the limestones of the upper walls of the cenotes. Microbialites in Black Hole are clumped columns growing from the walls. At depth, microbialites appear purple, probably due to the presence of phycoerythrin in response to loss of red light at depth and beneath shaded overhangs. The microbialites have a variety of forms with generally smooth surfaces on the light-facing side and overlapping tongues on the shaded wall-facing side, though converse relationships have also been observed. The internal texture varies from a cabbage-stem like network of mesoclots with large cavities to compact, truly stromatolitic laminations. The primary mineralisation phase likely began with nucleation and growth of acicular aragonite minerals on the cell wall or within extracellular polymeric substances surrounding filamentous bacteria. SEM examination using secondary electron mode of a whole mount sample reveals nanometre-scale, rod-shaped aragonite crystals. The secondary mineralization phase involved infilling by calcite with euhedral crystals.

On the growth, form and ultimate size of ooids

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Up to and including Brückmann's review in 1721 it was generally accepted that oolites were composed of petrified fish roe. In 1879 Sorby showed that oolitic grains were not in fact eggs, but, like De La Beche in1851, suggested that they were the product of minute, prismatic crystals of carbonate "mechanically accumulating around a centre, something like the layers in a large rolled snowball". The term "oolith" was so firmly entrenched in usage that Kalkowsky continued its use, even though he thought it "rather stupid" since the constituent grains were by this time clearly known to not be fossilized eggs. He proposed that the constituent grains be termed "Ooid" and suggested that they were produced by the activities of minute "phytoorganisms". Bucher (1918) compared the origin and structure of ooids to those of urinary calculi such as gallstones that Schade (1908, 1910) formed by the transformation from an emulsion colloid to solid state. If the emulsion was of pure composition the calculi formed with a radial crystalline structure, but if other colloidal impurities were present then co-precipitation gave rise to calculi with a concentric structure. Folk and Lynch (2001) suggested that "nannobacteria", might play a role in ooid formation. Ryall (1908) also found that "nanobacteria" were implicated in the growth of concentric kidney stones in humans. It is now clear that these "nanobes" are not independent organisms, but are nevertheless composed of organic matter fragments. Duguid et al. (2010) concluded that micro-organisms do not play a primary role in ooid genesis. However Diaz et al. (2014) have concluded that carbonate precipitation in marine oolitic biofilms is spatially and temporally controlled by a complex consortium of microbes. We find that there is little evidence in nature for the "snowball model" of accretion forming concentric accumulations that typify ooids. We are examining the relevance of mathematical models of accretion to understanding the possible biotic influence on ooid growth. Ooid size has generally been arbitrarily limited to grains below 2 mm diameter, but many examples of larger "giant" ooids are recorded. Typically these forms do not occur in well-sorted accumulations. We anticipate that our mathematical models will also establish how environmental factors limit the maximum size of ooid growth.

The Ross and Bude Formations – evidence for sub-sea fan deposits in an enclosed Carboniferous Basin

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The sedimentologically comparable Namurian Ross Formation of County Claire, Eire, and the Westphalian Bude Formation of north Cornwall, England were formed in a foreland basin isolated from the world ocean by the Variscan orogeny. The Bude Formation has many features typical of turbidite sequences, but also contains thick, amalagamated sandstones of limited lateral extent and disrupted "slump beds" that can be correlated over large distances. The work of scientists from the Jagiellonian University, Krakow, provided the important clues that permitted an understanding the origin of these enigmatic sediments. Dżułyński, Książkiewicz, Unrug and Leszczyński developed the concept of "fluxoturbidites" that provided clues to the interpretation of the amalgamated Bude sandstones while the experiments of Dżułyński, and Radomski on bedding disturbances produced by the impact of heavy suspensions upon horizontal sedimentary layers provided an explanation for the laterally continuous "slurried" and "slump" beds characteristic of parts of the Bude Formation. These insights led in 1969 to the development of a model of a submarine fan model for the development of the Bude Formation sequence. This, in turn, gave rise to the concept that submarine fans might form attractive hydrocarbon prospects, a suggestion greeted with derision when presented to the International Geological Congress in Sydney in 1976. However, by the 1990s discoveries of large oil reserves in deep-sea fan reservoirs had become commonplace and both the Bude Formation and the comparable Ross Formation were closely studied by petroleum geologists as outcrop analogues for the understanding of sand-body geometry and reservoir architecture in submarine fans. It has been claimed that structures found in the thick sandstones in both the Ross and Bude formations are indicative of wave influence on shelf sediments. Careful considerations of these features show that they are not produced by wave activity in shallow water, but are compatible with processes operating in fan channels. There is little to support the suggestion of Higgs (2004) that these formations are the result of deposition on a shallow-water lake shelf. This and earlier similar suggestions seem to be based on a lack of appreciation of the extensive variety of structures now known to occur in turbidite and sub-sea fan systems. The evidence that these two formations were deposited on a storm-influenced shelf is based on the equivocal evidence of hummocky cross-stratification and quasi-symmetrical ripples, and is neither supported by the facies associations nor by the stratification characteristics of the associated sediments. The problems regarding the depositional environments of these two formations all disappear when it is realized that they contain no other substantial evidence for shallow-water or emergent environments.

Early Permian warm- to cool-water carbonate shift in Arctic Canada caused by global warming-induced upwelling intensification and closure of Uralian seaway

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A major oceanic cooling event took place in the Sverdrup Basin, Arctic Canada, across the Asselian-Sakmarian boundary (Early Permian). Warm-water carbonates dominated the margins of the basin during the Pennsylvanian and Early Permian (Asselian), stretching all along the NW margin of Pangea. In the Sverdrup Basin, these carbonates belong to the Nansen Formation and are dominated by calcareous algae, *Palaeoplysina*, foraminifer and colonial coral – a photozoan biota. This fossil assemblage suggests sedimentation occurred in warm sub-tropical conditions (18-22 °C) based on modern comparisons. It is widely agreed that these unusually warm conditions for the western margin of a continent at sub-tropical latitudes (~25-30° N) were caused by an influx of warm Tethys-derived waters connected to NW Pangea shelves via the open Uralian valve. A seemingly abrupt shift to cooler water in earliest Sakmarian time disrupted these conditions and triggered a change in the biota and sedimentation all along the margins of NW Pangea. As a result, warm-water carbonates shifted to impoverished cool-water carbonates dominated by bryozoan, echinoderm, brachiopod and sponge spicule – a heterozoan biota – now preserved in the Raanes and Great Bear Cape formations of the Sverdrup Basin. The prevailing hypothesis to explain this change in oceanic temperature is the closure of the Uralian connection between the Tethyan Ocean and NW Pangea at about the Asselian-Sakmarian boundary. However, closure of the Uralian valve alone cannot satisfactorily explain the shift in oceanic temperatures and sedimentary regime in the Sverdrup Basin, especially since the cooling started in outer shelf settings prior to the Uralian valve closure, while warm waters persisted in inner shelf settings after the closure.

To elucidate the timing of the cooling event in the Sverdrup Basin, one exceptionally well-preserved section located north of Otto Fiord, NW Ellesmere Island, was analyzed. Ten microfacies were defined and interpreted based on the texture, grain size, sorting and fossil assemblage. We propose that intensified upwelling processes along the NW margin of Pangea started shedding cool water onto the shelf during the Late Asselian. Increasing upwelling brought nutrient-rich cool waters onto the shelf, causing shoaling of the thermocline and forcing warm oligotrophic biota into increasingly shallow water inner shelf areas during the Late Asselian. A more significant landward shift of the cool-water heterozoan biota occurred in the earliest Sakmarian, this time most likely in response to the Uralian valve closure. However, photozoan biota persisted in innermost, and often protected shelf areas, until at least the mid Sakmarian, indicating warm ambient temperatures were still prevailing, in spite of the end of warm water influx from the Tethys Ocean.

Intensification of upwelling along the western margin of Pangea during the Late Asselian may have been caused by the well-documented global warming event at that time, associated with the thawing of Gondwana land glaciers. Early Permian high pCO_2 has been modeled as the cause of rising global atmospheric temperatures. Analogously, modern-day coastal upwelling processes are experiencing an intensification of wind stresses on the ocean surface as a result of ongoing global warming.

Variations of Tortajada fluvial-tufa sub-environments in a tectonically active basin, Teruel semigraben, NE Spain

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Tortajada fluvial-tufa system is a freshwater fluvial carbonate deposit located approximately 6 km NE of Teruel (NE of Spain), in the eastern and tectonically active margin of the Teruel Basin. This margin was active during Neogene and Quaternary because of the movement of Concud and Teruel faults. The preserved deposit is divided in three main zones: upper terrace, lower terrace, and middle cascade-ponds. These terraces, cascades and ponded/shallow lacustrine areas, are composed of six facies: 1) *framestone of stem* facies formed by calcified macrophyte and bryophyte hanging stems, or some macrophytes growing upward, 2) *phytoclastic rudstone* facies consist of calcified macrophyte and bryophyte fragments distributed chaotically in micritic/microsparitic matrix, 3) *framestone of bryophyte (moss)* facies is a phytoherm of calcified bryophytes in living positions, 4) *peloidal and filamentous stromatolite* facies are slightly undulated stromatolite bodies with internal peloidal layers and organic filaments from which stromatolites could have been formed, 5) *mudstone* facies made up of micritic matrix with few grains (fragments of mosses and charophytes, ostracods, intraclasts…) and, 6) *conglomerate and breccia* facies containing stream fluvial polymictic gravels and slope-breccias. Besides, *granular and peloidal* microfacies appear in various facies (mainly in stromatolites) composed of intraclastic grains (previous moss and tufa fragments) and micritic peloids. Identifiable *microbial* microstructures in topmost parts of almost all facies micritized previously existing crystals.

All six facies are organized in three sedimentary sequences, from east to west (downstream): terrace sequence, pond sequence and cascade sequence. All sequences start from fluvial conglomeratic base, with energy of water decreasing towards the top. These sequences were dependent of paleomorphology and, therefore, conditioned by Late Pliocene and Quaternary tectonic activity. Thus, secondary faults linked to the eastern margin of extensional Teruel Basin were, for instance, responsible for the cascade sequence. Also discontinuities made in Mesozoic host-rock allowed the upwelling of groundwater. Thereby, tectonic activity played an important role in diverse episodes of the formation of this fluvial-tufa system, beginning from the initial incision and establishment of fluvial network, and finalizing on tuffaceous ponds/shallow lacustrine and cascade areas. This is reflecting in various described facies and sequences formed along different sub-environments of the system.

Negative isotopic values suggest that the origin of water for the formation of Tortajada fluvial-tufa deposit was both meteoric rainfall and upwelling of shallow-groundwater, consistent with other data of tufas from the NE of Iberian Peninsula. Low ranges in $\delta^{18}O$ indicates and open system with short residence time of water. In contrast, variations in $\delta^{13}C$ values could be related to diverse processes, such as degassing during calcite physicochemical precipitation, photosynthesis or respiration of microbes, or even different residence times of the water.

In conclusion, Tortajada fluvial-tufa deposit provides important information about fluvial sedimentation and tufa development during the evolution and different episodes of the formation of Teruel Basin.

Provenance of the southeastern Paraná Basin, Brazil, based on U-Pb, Lu-Hf and O isotopic study of detrital zircons and whole rock Sm-Nd and Pb-Pb isotopic signatures

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U-Pb, Lu-Hf and O isotope data were obtained on detrital zircons from late Paleozoic-early Mesozoic units from Paraná Basin, southeastern Brazil, in order to constrain the maximum deposition ages and provenance of the sediments, as well as to contribute to the understanding of the tectonic evolution of the basin. Whole rock Sm-Nd and Pb-Pb isotopic signatures were also taken in order to help the interpretation. The studied section includes rocks from 11 stratigraphical units (from base to top), namely Itararé (Rio do Sul Formation), Guatá (Rio Bonito Formation, subdivided into Triunfo, Paraguaçu and Siderópolis members, and Palermo Formation), Passa Dois (Irati, Serra Alta, Teresina, and Rio do Rasto formations, the last one subdivided into Serrinha and Morro Pelado members) and São Bento (Botucatu Formation) groups. The sediments of the Paraná Basin are covered by the Paraná Continental Flood basalts dated at 134 Ma, defining the maximum depositional age of the sedimentary succession.
U-Pb ages were obtained in 1941 detrital zircons and range from 266 Ma to 3.4 Ga. All units show an age-peak (523-653 Ma) from the Brasiliano orogeny (Neoproterozoic to Lower Cambrian), reflecting the importance of adjacent source areas found nearby, such as Dom Feliciano Belt and diverse granitic plutons found in Santa Catarina State. The Pb-Pb data on whole rocks show this similarity with rocks from the Brazilian Shield. Archean age peaks also occur in all units but are not so expressive, and the source areas can be correlated to Setuva Nuclei and Atuba Complex found in Paraná State. Paleoproterozoic age peaks are observed in all units, but the 1.8 Ga peak is very expressive in samples from Rio Bonito Formation until Siderópolis Member. A very important peak of 1.0 Ga occurs in all units. The latter two sources were not yet identified in the area, and O and Hf isotopic signatures suggest a mantle filiation for them. Sm-Nd (TDM) model ages determined on 35 whole rock samples from all units range from 1.1 to 1.9 Ga and the $\varepsilon Nd(0)$ values are all negative (-15 to -6), showing that the sediments were formed mostly by crustal sources. However, TDM model ages are older than 1.4 Ga and more negative (-10 to -15) epsilon values were observed in the lower units (Rio do Sul Formation to Paraguaçu Member). The upper units show $\varepsilon Nd(0)$ values ranging from -6 to -12 and TDM model ages younger than 1.5 Ga. These values are compatible with those determined on granitoids found in Santa Catarina State. Finally from Siderópolis Member until Botucatu Formation, all units show the Permian age peak (266 to 290 Ma), which is interpreted as zircons from volcanic ashes from Choiyoi Volcanic Province located in the Gondwana western margin. The age-peaks become younger towards the top of the section, which reinforces the idea of concomitant sedimentary basin infill with this volcanic event although no ash beds were found in the studied area.

The control of paleogeomorphplogy to sedimentary filling process in Jurassic of the Yabulai Basin, NW China

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The Yabulai Basin is one of the small to medium Meso- Cenozoic faulted basins in Hexi Corridor in NW China. According to the regional tectonic structures and Jurassic sedimentations in northwestern China, the basin can be subdivided into three sub-sags, which are the Yanchang sub- sag, the Xiaohu sub- sag and the Suotuo sub- sag from west to east. The sequence-stratigraphic framework and depositional systems were investigated by using seismic profiles, well logs and cores. Five third- order sequences were interpreted, which are SQJ1j, SQJ2q, SQJ2x1, SQJ2x2 and SQJ3s in Jurassic of Mesozoic in the Yabulai Basin. Six sedimentary facies associations are identified: the shoreland plain, fan delta dominated sedimentary systems, braided river delta dominated sedimentary systems, turbidite deposits, shallow lakes and half-deep lake systems.
Paleogeomorphplogy is the dominated influence factor in the distribution of sedimentary. Controlled by two boundary faults (Yabulai Mountain fault and the Beida Mountain fault), two main sources of sediment supply were around the basin, forming the northern and southern delta systems of the Xinhe Formation (J2x1 and J2x2) in the Yabulai Basin. Supplied by the northern Yabulai Mountain fault source, the Yanchang sub-sag, the Suotuo sub- sag and the southern part of the Xiaohu sub- sag all developed fan delta with coarse clastic deposit. Furthermore, a muti- step Jurassic basement provided a broad and gentle slope background and made it possible to develop braided river delta which need accommodation and a long-distance transportation for sediments at the northern part of the Xiaohu sub- sag. In additional, multiple underwater distributary channels were identified obviously through the interpretation of available cores, corresponding well-logs and 2D, 3D seismic. Based on core description, conventional thin section and general physical analysis, the physical properties of the braided river delta sandstone reservoirs have been summarized. It is inferred that high quality sandstone reservoirs with high natural productivity of oil and gas are widely developed in the braided river delta front, which developed at northern part of the Xiaohu sub- sag, controlled by the muti- step Jurassic basement.

Quantitative heavy mineral analysis in the oil industry

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Fast turnaround time for the oil industry is everything. Producing high quality, reliable and repeatable analysis has been traditionally considered as "time consuming". This problem has been therefore been disregarded in the past in favour of a fast generation of both data and interpretation. However, the amount of literature available today, together with the technological progress, demand for a more comprehensive and consistent analytical service to be provided. The risk of introducing biases in heavy mineral studies is high. The analysis could be strongly affected by the way samples are processed during disaggregation. The use of a jaw crusher or an improper use of a mortar could easily determine the artificial generation of heavy mineral species, particularly for garnet and other coarse-grained mineral species. Further biases are introduced when a proper quantity of separated heavy minerals need to be selected to be mounted on a slide. "Coning and quartering" can only reduce but not avoid the error introduced by different operators. Regardless of the analytical technique used for determining heavy mineral abundances the type of produced data cannot be considered as quantitative. Therefore, the use of commonly used provenance indices should be limited and evaluated with care.
A proper heavy mineral separation, including (i) weighing multiple times during different stages of the separation, (ii) the use of a micro-splitter to avoid preferential selection of certain species of heavy minerals and (iii) precise measurement of the weight % of minerals mounted on a slide allow the calculation of the quantitative indices introduced by Garzanti & Andò (2007). The use of these indices allow to understand the possible effect of density-sorting during transport and consequent concentration according to sub- sedimentary environments and of the depletion of heavy mineral species from diagenetic dissolution.
Traditional optical analysis is inherently open to bias due to the heavy reliance on interpretations made by the microscope user. In a study of a 'synthetic' hand-picked heavy mineral sample, our data shows variances between both different users and the same user with different microscopes, whilst automated Raman spectroscopy provided results closest to the known proportions of the sample. Automated Raman spectroscopy utilises image analysis to rapidly analyse large amounts of grains in a heavy mineral sample. Repeated analysis of the same samples have indicated that results are reliable and consistent. Furthermore, Raman spectroscopy has been demonstrated to reveal chemical and structural differences between single minerals. Two minerals which have received a large amount of attention are garnet and zircon, and therefore it is possible to quantitatively evaluate the geochemistry of garnets analysed using Raman spectroscopy, and qualitatively evaluate the structural damage and trace element geochemistry of zircons analysed.
The contribution will focus on the combination of a rigorous sample preparation and the advantages of automated Raman analysis, which allows for fast analytical turnaround and reliable data, which makes this methodology highly suitable for the oil industry.

Combined chemostratigraphy and high resolution sandstone petrography (HRSP) for enhanced fluvial siliciclastic reservoir quality

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Elemental chemostratigraphy applied to the oil and gas industry has proliferated over the past decade due to its objectivity and independence in modelling changes in geological features such as sediment provenance, simple lithological variations or fluctuations in terrigenous input. This study aims at validating geochemical profiling as a powerful tool in fluvial siliciclastic reservoir quality assessment by coupling chemostratigraphy with a high resolution sandstone petrographic analysis (HRSP), in a well-constrained sedimentological framework. For this study 23 fine to very fine-grained samples from different meandering fluvial depositional facies were analysed by: (i) Gazzi-Dickinson point count to characterise the type and distribution of depositional texture, framework composition and cements precipitation chronology, and (ii) a custom diagenetic point-count for a semi-quantitative description (100 points/thin section) of the primary and secondary pore spaces in the same area of the Gazzi-Dickinson point-count (Henares et al., 31st IAS meeting). Intergranular volume as well as compaction and cementation indexes (IGV, ICOMP, COPL and CEPL) for porosity loss were calculated.
Sandstone composition has been further characterised via inductively coupled plasma optical emission (ICP-OES) and mass spectrometry (MS) to obtain data for 49 elements (ten majors, twenty-five trace and fourteen rare earth elements). Information from HRSP has been integrated into the chemostratigraphic data set by means of multivariate statistical analysis. The latter reveals the link between REE as Cs, Ga, Rb, La, with the presence of mudclasts and high matrix concentrations at the base of the main channel in chute channels and point bars respectively. Ga/Rb vs K2O/Rb were extremely useful in identifying the presence of K-feldspar overgrowth. Not surprisingly, the presence of gypsum is strongly connected to that of S, whereas that of CaO is not fully related to the amount of carbonate cements. A-CN-K, $CaCO_3$-(MnO)$FeCO_3$-$MgCO_3$ plots provide insight on the origin of carbonate cementing phases and diagenetic overprint. Results demonstrate how a combined petrographic-chemical multidisciplinary approach enhances the understanding of the relationships between framework and interstitial component and their impact on reservoir quality.

First seismic stratigraphic analysis of the sedimentary record of the Ria de Ferrol ("Rías Altas", NW Spain)

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The Ria of Ferrol is located in the passive Atlantic margin of western Galicia (NW Spain), placed in the named Artabro Gulf. The Ría de Ferrol is a much closed embayment with a NE to SW orientation that occupies around 21 km^2. Three different geographic areas can be distinguished within the Ría de Ferrol, (1) the outermost part is the mouth of the estuary and has a NE-SW orientation, with a width of 2.2 km and 33 m of average depth; (2) the second area comprises the narrow strait (2 km long and 0.5 km wide with 20 m depht) that connects the external and the internal parts; (3) the third area is the inner part of the estuary, with a E-W orientation in its middle area changing to NE-SW orientation in the innermost part where Xubia and Belelle rivers provide the main fresh water input. The Ria de Ferrol is mesotidal and semidiurnal with amplitudes ranging from 1.5 m during neap tides to 4 m during spring tides.
The coast area is characterized by granites and by Paleozoic sedimentary rocks that were metamorphosed by compression and heating during the Hercynian orogeny. These rocks have been cut by NE-SW, N-S and NW-SW faults.
There are scarce scientific studies in the Ría de Ferrol (mainly concerning with water circulation and sediment contamination) but none of them deal with the sedimentary infill. We present the first detailed study of the stratigraphic record using geophysical and sedimentological data.
Two seismic surveys were carried out in the area recording a total of 90 km of seismic profiles. The seismic data were acquired using a “modified Boomer”, with a single Boomer source (AAE CSP 300) and a sub-bottom profiler receiver (ORE 3.5 kHz). Four gravity cores were also recovered in the inner part to perform sediment characterization.
Three main seismic units have been identified in the inner part of the ria. The oldest one lies directly over granitic and metamorphic basement, and is characterized by channel incisions and low continuity of reflectors. The overlying unit presents well defined channel incisions and infill with vertical aggradation, with an erosive surface at its bottom. The youngest unit is delimited at its base by an erosive horizontal surface, showing an aggrading configuration pattern of very continuous reflectors. In the external part, deeper and older seismic units are identified, but scarcely characterized due to the limitations of the acoustic penetration system.
The identified seismic units are correlated to land outcrops. The younger unit corresponds to Holocene marine sedimentation while the older ones are correlated to late Pleistocene deposits.

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Bottom current-generated bedforms: the action of the MOW (Mediterranean outflow)

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The effects of the Mediterranean Outflow Water (MOW) over a deep seafloor environment have been filmed with an ARGUS ROV system in the Cadiz Contourite Depositional System (Gulf of Cadiz, Spanish Atlantic) during the MOWER Cruise, September, 2014. The new images, obtained in different erosional and depositional features of the system at depths between 500 and 900 m, state the capability of bottom currents to generate bedforms at different scales. The ROV system recorded a great variability of current-induced features, both longitudinal and transverse in different sub-environments dominated by gravel and sand to silty sand sediments: furrows, contouritic channels, terraces, and drift domains.
The longitudinal bedforms are represented by: surface lineations, comet scours, crag and tails, and also scours around rock fragments from gravel to olistolites in scale, and sand and gravel ribbons or irregular patches. The transverse forms are exemplified by large dunes with rectilinear crests, barhan dunes and sinuous to crescent sandwaves. All the transverse bedforms present the superimposition of mostly asymmetric ripples, similar in size but variable crestlines, varying from linguoid, sinuous to rectilinear. Besides these bedforms, a hard substrate similar to autigeneic iron-rich carbonates or soft ground on blue marls are identified with local non cohesive mobile sandy patches metric in scale. In some places, benthic organisms have been used to corroborate the vector of the flow currents. This is the case of sponges which appear associated to tails of clean sand on the lee side of the current flow.
The spatial distribution of the bedforms confirms the general westward decrease in energy of the MOW. But the bedform patterns together with other indicators (e.g., benthos) reflect a great variability in the velocity and direction of the bottom current at local scale. This fact suggests a complex scenario characterized by the combination of different hydrodynamic processes action. This framework also raise questions about part of them are relict or palimpsest bedforms.

Sparse-spike deconvolution promoting frequency dependent seismic stratigraphic analysis and an application

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The term- Seismic Sedimentology is first put forward by Zeng in the article of making stratigraphic section by using seismic data. It is a subject applying advanced geophysical processing and interpretation techniques to study sedimentary rocks and their forming processes. Afterwards, a group of scholars at homeland and abroad has done a lot of research in the theory and application of seismic sedimentology. 90° phase transformation, stratal slice and frequency dependent interpretation, as the three key technologies in seismic sedimentology, have been the valid tools for the study of high frequency sequence and sedimentary system, also functioning well in the application of thin sand body exploration and development.
The low-frequency components of seismic data tend to characterize thicker litho-stratigraphic units, while high-frequency components tend to characterize thinner isochronous-stratigraphic units. Therefore, frequency dependent interpretation technique- as one of the key techniques in seismic sedimentology- can help to achieve fine sedimentary sequence analysis. At present, the main method is to get frequency profile from frequency filtering method, but the dominant frequency of seismic event varies with stratum, so that when selecting a certain narrow frequency profile with frequency filtering, there will be a lot of unexpected stratigraphic information carried by events which are missed in frequency profile, thus affecting sequence analysis. Although spectral decomposition method is superior to frequency filtering method in the time-frequency resolution and reservoir identification, however, in the application of frequency dependent interpretation, there exist the same problems as frequency filtering, loses some stratum reflection information, which is out of the limited frequency band.
To achieve real frequency dependent stratum reflection profiles with whole stratum information, a time-varying sparse-spiking deconvolution based method is proposed in this paper. The method is about seeking stratum reflection coefficient with sparse-spiking deconvolution in the given estimation seismic wavelet and sparse constraint conditions. The convolution of acquired stratum reflection coefficient and expected frequency wavelet contributes to total stratigraphic information reflection profile. By the verification of the veracity of this method with forward modeling data, and selecting delta progradation as the example for effect analysis, we can acquire thin sequence clearly which cannot be seen in original seismic section for fine sequence analysis.
The exploration experience of oil and gas fields in recent decades indicates that a lot of fields are related to delta facies. For this reason, it is critical to identify delta front subfacies with accuracy in oil-gas exploration. The method provides possibilities for identifying typical progradation seismic reflection characteristics in delta front subfacies and dividing sequence stratigraphic framework subtly, which caters for the demand of practical work and make up for the disadvantages of previous work. It uses low and medium frequency mainly when portraying big progradation, or referring to original records directly and employing high frequency section when analyzing thin layer sedimentation. Even though the information in a single section may not be as plentiful as source record, the specific information reflected by each section will lead to more detailed geological information after comprehensive analysis.

Variations in internal textures and formation ages of Fe-Mn nodules from Campbell Plateau and their relationships with sedimentary history

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An extensive ferromanganese nodule field occurs in the east of Campbell Plateau of Southwest Pacific Ocean beneath the Deep Western Boundary Current (DWBC) and Antarctic Circumpolar Current (ACC). Several types of nodule morphology were identified including distinctive discoidal forms with overgrowths resulting possibly from overcrowding and partial sediment burial. Five principal nodule facies were also recognized by location and occurrence (Wright et al., 2005). Nine Fe-Mn nodules from the six dredge sites were analyzed for the mineralogical and chemical compositions as well as $^{10}Be/^{9}Be$ dating.

Fe-Mn nodules show various concentric internal growth textures, such as, cuspates, large parabolic cuspates, pseudo-columnar, columnar, globular, and laminated, which vary even in a nodule with hydrogenetic, early diagenetic, or mixed origin. Each texture shows micro-textural varieties and different mineralogy and/or chemistry. The genesis of each internal texture was indicated by the REE patterns, the mineralogy of Mn-oxides, and the Mn/Fe ratios.

$^{10}Be/^{9}Be$ dating of Fe-Mn nodules indicates total ages from 6 Ma to more than 14 Ma. Data points for individual nodules define line segments on log-linear plots indicating significant changes in growth rate. The changes of growth rate and the internal variations of growth texture are closely related to the paleooceanographic environment during the nodule formation. The ages of the growth changes were calculated from the $^{10}Be/^{9}Be$ dating.

14.2 Ma indicates the age of the initial nodule growth in the region. 10.4 Ma, 8.8 to 8.4 Ma, 6.5 Ma, 5.0 to 4.6 Ma, 2.4 to 1.8 Ma, and 0.8 to 0.4 Ma show the ages of the change in growth rate and formation environment. Several hiatuses in nodule growth were shown between 6.1 Ma and 5.1 Ma as well. The ages and the internal textures of Fe-Mn nodules indicate the environment of nodule growth related to the sedimentary history in the SW Pacific (Carter et al., 2004; Graham et al., 2004).

Sequence stratigraphic framework and develpment model of the Cretaceous in Northeast Block, Oriente Basin, Ecuador

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The Oriente basin of Ecuador has produced a substantial amount of oil over the past years. The Cretaceous is the main explorative target in the Northeastern block of Oriente Basin in Ecuador. But now in the study area, there are certain differences on the understanding of the sequence stratigraphic framework, control factors and sedimentary model with sequence among different scholars. The classification projects of sequence stratigraphy and the determination of facies development model haven't been systematically recognized. It greatly restricts any further exploration of hydrocarbons.Therefore, it has great theoretic and practical significance to carry out thorough researches on sequence stratigraphy and its sedtimentary characteristics of Cretaceous in Northeastern block. Based on the comprehensive analysis of core, well logging and seismic data, sequence boundaries of the Cretaceous in Northeastern block of Oriente Basin are identified according to seismic reflection terminal, the stacking patterns of sequence as well as changes of lithology and isochronous stratigraphic framework of the Cretaceous including Hollin and Napo Formation is established. Hollin and Napo formations are divided into one second order sequence (KSS1), six third order sequences (KSQ1-KSQ6), sixteen fourth order sequences and thirty-four fifth order sequences. The KSQ1-KSQ5 has complete system tract composition which develops SMST, TST and HST system tract. The KSQ6 only develops SMST system tract. According to synthetic records for calibration of the seismic profile and combining with drilling and logging sequence stratigraphic division, seismic as well as drilling and logging data consistency of sequence stratigraphic division of Cretaceous in the study area has been implemented.
Typical mixed clastic and carbonate gentle dipping slope sequence stratigraphy development mode has been identified in the study area. Cretaceous as a relatively complete second order sequence, experienced a complete sedimentary cycle that the relatively down-up-down sea level. Also, the third order sequence has apparent transgression-regression cycle which respond to sedimentary environment that undergo multi-period transitions from tidal flat to restricted platform, to inner shelf subaqueous shoal and to outer shelf mudstone. Then the sea level drops, meanwhile the sedimentary environment evolves into inner shelf limestone bank and restricted platform. The control factors of sequence development are complex. Tectonization and the 2nd relative global sea level control the 2nd sequence boundary; the 3rd relative global sea level and tectonic subsidence contro the 3rd sequence boundary and model; sediment supply rate, climate and hydrodynamic type and intensity control the 4th and 5th sequence, lithology and their distribution.
On the basis of the study on sequence stratigraphy and combined with the characteristics of the core, well logging and seismic facies, we propose the mixed clastic and carbonate deposit model in low energy estuary. Establishment of isochronous stratigraphic framework and sedimentary model of the Cretaceous will provide scientific basis for predicting the distribution of favorable sand body in the Northeast Block, Oriente Basin.

The Röt-type facies of the Western Balkanides revisited: Depositional environments and regional correlation

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In the Alpine West Balkan tectonic zone, i.e., Western Balkanides, the vertical transition from continental red-bed strata of the Petrohan Terrigenous Group (Lower Triassic) to marine deposits of the Iskar Carbonate Group (Lower–Upper Triassic) comprises a 35-40 m thick Röt-type succession of late Olenekian age (Svidol Fm). Two interpretations have been proposed in previous studies to characterize the depositional environment of that unit: coastal fluvial floodplain and tide-dominated delta. However, the lack of diagnostic facies indicating fluvial or delta settings and new sedimentological evidence suggest that the uppermost part of Petrohan Terrigenous Group and the whole Svidol Formation were formed in different environments.
During the first stage predominantly siliciclastic sediments with some intercalated carbonate beds were deposited on a coastal marine sandy-muddy flat which was influenced by fluvial processes, wave activity and tidal currents. Terrigenous supply from the adjacent distal alluvial floodplain produced fine-grained sandstones with low-angle cross bedding and parallel lamination which formed in lower and upper flow regime, respectively, while associated laminated shales reflect settling from fine suspension. The moderately sorted sandstones are dominated by subrounded quartz, muscovite and stable heavy minerals, while rock fragments and gravel-sized clastics are lacking. Normal wave action is indicated by the formation of mostly symmetric wave ripples and wave ripple cross lamination. The occurrence of heterolithic (lenticular, flaser, wavy) bedding reflects the influence of tidal currents. Intermittent marine flooding is inferred from the presence of scarce crinoids and benthic foraminifera, vertical burrows, carbonate intraclasts (including flat pebbles), single ooids and micritic matrix in the sandstones. The generally low hydrodynamics in the shallow water setting was interrupted by high energy events probably related to intermittent storms that produced erosional channels and scour-and-fill structures. Thin carbonate beds were deposited during periods of silicicalstic starvation and were penecontemporaneously dolomitized due to elevated salinity. The sporadic occurrence of mottled pedogenic dolocretes in some sandstone beds suggests episodic subaerial exposure. Common load casts along stratal boundaries between sandstones and shales reflect high sedimentation rate.
During the second stage, deposition occurred in a carbonate tidal flat environment with semiarid to arid climatic regime. Massive and laminated early diagenetic dolomites with desiccation cracks, fenestrae, evaporite crystals and pseudomorphs, scarce ostracods, microbial structures and variable amounts of siliciclastic admixtures were generated in the low-energy intertidal and supratidal zones. Ooidal, intraclastic and bioclastic limestones and dolostones (showing mimetic replacement) with low-diversity fauna (crinoids, bivalves, gastropods) and locally manifested cross bedding were produced in the more agitated subtidal zone. S-shaped vertical joints in some strata of micritic carbonates imply soft deformation due to periodical paleoseismic activity.
The Röt-type succession exposed in the Western Balkanides can be correlated with some parts of the typical Röt facies of the German Basin (France, Switzerland, Netherlands, Great Britain, Denmark, Germany, Poland) as well as the Tethyan Werfen facies (Italy, Austria, Germany, Switzerland, Poland, Hungary, Slovakia, Croatia, Romania). However, greatest similarity is outlined to the Hungarian Röt of Tisza Megaunit, the Spanish Röt, and the Röt-type facies from Central Switzerland and Sardinia Island.

Coralline algal facies and paleoenvironmental interpretation in Gârbova de Sus Formation (Lopadea Veche, Romania)

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Gârbova de Sus Formation is a Middle Miocene carbonate unit developed on the western border of the Transylvanian Basin. From the Lopadea Veche area we analyzed a mixed carbonate-siliciclastic succesion about 30 m thick that transgressively overlies the Mesozoic ophiolites of Trascău Mountains. A distinct rhodolithic level from the upper part was also studied. The coralline algal assemblages from these deposits include non-geniculate genera: *Lithothamnion*, *Mesophyllum*, *Phymatolithon*, *Spongites*, *Neogoniolithon*, *Hydrolithon*, *Lithoporella*, *Lithophyllum* and *Sporolithon*. Based on quantitative estimations and growth forms of coralline algae, bryozoan, large foraminifera and encrusting foraminifera, five facies have been distinguished: large benthic foraminiferal packstone-grainstone, *Acervulina*-rhodolith facies, algal-bryozoan facies, maerl facies and rhodolith pavement.
The main biogenic components of large benthic foraminifera packstone-grainstone are *Amphistegina* and *Heterostegina*. Fragments of corallines and bryozoans are subordonate components and free-living acervulinids, planktonic foraminifera, worm tubes, echinoid plates and spine fragments also occur. This facies is associated with intercalations of sandy marls rich in foraminifera. The lower part of the succesion shows a low-light/high-energy environment in which melobesioids (algal-bryozoan boundstone) and *Acervulina* (*Acervulina*-rhodolith floatstone) are dominant components along with encrusting and free-living bryozoans, worm tubes, rare sporolithaceans and very rare mastophoroids. The *Acervulina*-corallinacean macroids reach up to 6 cm in diameter and their nuclei may consist of bryozoans or microconglomerates derived from the lowest part of the succesion.
Rhodoliths up to 5 cm in diameter, branching and encrusting thalli, bryozoans and large benthic foraminifera predominate in the algal-bryozoan facies from the middle part of the succesion. The algal assemblages from these deposits are represented by abundant melobesioids, common sporolithaceans, very rare lithophylloids and scarced mastophoroids.
Floatstone-rudstone with free-living branching thalli of *Lithothamnion* and *Sporolithon* represent the maerl facies. The free-living branches are associated with encrusting corallines and rhodoliths (2-5 cm in diameter) in the upper part of the mixed carbonate-siliciclastic succesion, forming a rhodolith pavement about 5 m thick. Mastophoroids are important contributors to rhodolith formation, becoming more common than the sporolithaceans.
The distinct rhodolith-bearing level is formed by large (7-14 cm) spheroidal/sub-spheroidal rhodoliths dispersed in a marly-argilleous matrix. The presence of *Hydrolithon* in association with other mastophoroids and melobesioids suggest a shallow water environment and probably a low-light intensity implied by the presence of *Sporolithon*. The rhodoliths are overlain by sandy bioclastic limestones with small nodules and branches of corallines that contain inclusions of Fe oxide-hydroxides and ultimately by a level of planktonic wackestone with fragments of bivalves.

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Seismic sedimentology of sandy debris flow and fan delta system in the Paleogene Dongying Formation of Shanan Depression, Bohai Bay Basin, North China

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The Dongying formation of Bohai Bay Basin were deposited during faulted period, where fan delta facies and shore-shallow lake subfacies are dominated in the study area. E-W-trending en-echelon faults developed in Shanan depression, which controlled sand-dispersal patterns. Sandy debris flow was first recognized in this area on cores, based on characteristics of gravel lithofacies with inverse grading, deformed mudstone clasts, massive sand unit with sharp contact, mudstone clasts with planar fabric and floating quartz pebbles in sandstone, floating mudstone clasts near the top of sandstone bed, internal shear surface, etc. Fan delta system was identified from core analysis and log interpretation. Seismic sedimentology methods are introduced in this study considering the lack of log data, and the high-quality three-dimensional seismic dataset. Stratal slicing was conducted by 90° phase shift technique, frequency division processing and calibration with cores and logs. Meanwhile we extracted seismic attributes between sequence boundaries. Combination of stratal slicing interpretation with attribute-assisted analysis provided a better explanation for the distribution of sandstone bodies and the depositional system interpretation. Consequently, the distribution characteristics of sandy debris flow and fan delta depositional system in study area were determined and favorable sand body distribution were predicted, providing a strong support for exploration.
According to analysis of depositional characteristics, this study established typical sandy debris flow and fan delta depositional system in Shanan depression. Meanwhile, it can be referred for seismic sedimentology study in non-marine basins, especially areas with high-quality 3D seismic dataset but few log data.

Integrated characterization and modelling of the fluvial reservoir architecture, Shihezi Formation, Sulige Gas Field, Ordos Basin, North China

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Extensive researches have been conducted on the geological modeling of fluvial reservoir, but many problems still existed on how to characterize the strong heterogeneity fluvial reservoir architecture. This paper, taking one low permeable fluvial gas field in Ordos Basin as an example, carries out studies on a new geological modeling method to characterize the strong heterogeneity of fluvial reservoirs.
Sulige Gas Field, located in the north of Ordos Basin , has been the largest natural gas field of China up to now with an exploration area of 3.6×104 km^2 and an estimated gas reserve of 3.8×1012 m^3. The main producing horizon of the gas field, Member 8 of Shihezi Formation (H8), is a set of fluvial sandstone-conglomerate deposition characterized by low porosity, low permeability and high heterogeneity. Prediction of the three dimension of reservoir architecture and petrophysical property is critical to the high efficient development of the field. In this paper, an integrated approach was adopted to characterize the fluvial reservoir architecture with core, well logs and 3D seismic data, and subsequently a 3D reservoir model was built to assess and predict reservoir performance quantitatively, which has significant meaning for achieving the goal of optimizing and adjusting development plan and providing guidelines for similar reservoirs.
Firstly, reservoir architecture elements was recognized by core observation and well log interpretation. Point bar of meandering river and channel bar of braided river are the most widespread reservoir microfacies. The thickness of single and superposed point bar, channel bar was determined with wireline logs and the superposition patterns of channel sandstone-conglomerates were grouped into three types. Secondly, 16 horizontal wells was used to interpret the width of sandstone-conglomerate bodies of single and connected channel belts, which then is used as a guide to the correlation of sandstone-conglomerate bodies between wells. Thirdly, strata slices extracted from RMS and other seismic attributes data set are successfully used to interpret the distribution of channels and channel belts. Then the empirical equations relating channel depth, channel width, and channel-belt width was drawn as a result. Finally, the 3D model of sandstone-conglomerate architecture and petrophysical property was built with object-based simulation and sequential Gaussian simulation respectively, which provided basis for preparing development plan of Sulige gas field.

Mineralogical and geochemical expression of the Late Campanian Event in the Aquitaine and Paris Basins (Tercis-les Bains section and Poigny borehole): Palaeoclimatic implications

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The clay mineralogy and stable isotope chemistry (^{13}C and ^{18}O) of Campanian sediments of two French sedimentary basins (Paris and Aquitaine Basins) are investigated. The clay fraction of the Campanian sediments from the Tercis-les-Bains section (Aquitaine Basin) and from the Poigny borehole (Paris Basin) is mainly composed of smectite. The overall monotonous smectitic sedimentation was interrupted in the Upper Campanian of both basins by significant detrital inputs including illite, kaolinite and chlorite at Tercis-les-Bains, and only illite at Poigny. The detrital inputs resulting from the erosion of nearby continental areas, is also recognized in the Tethyan Realm (Gubbio and Furlo sections, Central Italy) and probably in the South Atlantic Ocean. They coincide with a global negative carbon isotope excursion namely the Late Campanian Event (LCE). Carbon isotope signals are used for long-distance correlations between the sections studied here and previously studied sections. Spectral analyses performed on ^{13}C and smectite/illite ratio, suggest an approximate duration of the LCE of 400 kyr. The intensification of the continental erosion during the LCE may result from a climate change under orbital control, and/or from a regression triggering the increase of silicate erosion. Tectonic movements may also be responsible for the erosion of newly exposed continental areas. As this event seems to be recorded at a large geographical scale, the increasing chemical weathering may be responsible for a pCO_2 decrease and may partly explain the Late Cretaceous global cooling, recorded in benthic foraminifera during the Campanian.

Hardground formation through the Phanerozoic: Why is the record of seafloor lithification so scarce during times ruled by aragonite sea chemistry?

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Synsedimentary marine lithification of carbonate seafloors leading to hardground surfaces is well known from present-day and from the fossil record. Carbonate hardgrounds are key stratigraphic surfaces in the geological record used as palaeoenvironmental archives, and in petroleum geology, due to their assumed impact on fluid flow. While early cementation is generally favored in tropical neritic-epeiric settings, hardground formation is not restricted to these warm waters. Indeed, many examples were reported from cool-water temperate latitudes, but also from deeper hemipelagic to bathyal domains, with lithified surfaces mentioned from depths of up to 4000 m. Hardgrounds are abundantly recognized and described from calcite sea intervals, such as Ordovician, Jurassic or Cretaceous periods, albeit their record is relatively poor for aragonite sea intervals, such as Permian or Triassic periods. This temporal distribution is assumed to mirror secular variations in seawater chemistry that was considered ideal during calcite seas for widespread (low-Mg) calcite precipitation of epicontinental seafloors, as well as syndepositional dissolution of aragonite bioclasts promoting local $CaCO_3$ supersaturation and seafloor cementation. Although this argument is well supported by the considerable record of Paleozoic and Mesozoic calcite sea hardgrounds, it has to be contrasted by the numerous hardgrounds reported from recent and modern shallow-water tropical and temperate, as well as deep-water, aragonite seas. The high record of present-day discontinuities is certainly best explained by the nearly pristine condition in which these surfaces are found. Conversely, diagenetic overprint may represents a considerable bias to the preservation and recognition of hardgrounds that developed in past aragonite seas, such as e.g., during the Triassic. Indeed, aragonite (and high-Mg calcite) considered as primary precipitates during those periods are less stable than calcite, and their early dissolution or recrystallization may affect hardground preservation and hinder their recognition. However, it is also noteworthy that hardground description from several calcite sea periods (e.g, Paleocene-Eocene or Devonian) remains relatively scarce. The latter observation is particularly surprising regarding early Cenozoic world that is considered a warm time interval during which epeiric seas were common, two features assumed ideal for widespread hardground development. While it is admittedly true that the chemical state of the oceans greatly accounts for the higher versus lower record of hardgrounds during calcite versus aragonite seas, respectively, other parameters must be taken into consideration. For example, greenhouse/icehouse cycles, epicontinental sea extent, variations in oceanic circulation and atmospheric pCO_2 evolution over time should have also influenced the formation, distribution, preservation and eventually the record of hardgrounds throughout the Phanerozoic, as well as the nature of their early marine precipitates. Diagenesis certainly represents the main bias to hardground preservation, but mechanical erosion, bioerosion and aftermaths of worldwide global crises, such as, e.g. the Permian-Triassic Mass Extinction and the following low biotic recovery, could have temporally affected hardground preservation and record as well.

Geochemical expression of subaerial exposure from the marginal deposits of an ancient closed lacustrine system – the Miocene Ries Crater Lake (Germany)

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Chemostratigraphic studies on lacustrine sedimentary sequences provide essential insights on past cyclic climatic events, on their repetition and prediction through time. Such studies are commonly performed on recent lacustrine systems but are much scarcer on ancient deposits due to the frequent diagenetic overprint of primary depositional features. The aim of the present study is to describe subaerial exposure surfaces within the sedimentary succession of the northern margin of the Miocene Ries Crater Lake, Germany, and to relate these exposure events to successive lacustrine cycles across five closely-spaced, laterally equivalent stratigraphic section. Emersion of this area is evidenced by patchily distributed palustrine deposits. The methodological approach combines lateral and vertical facies changes with high-resolution $\delta^{13}C$ and $\delta^{18}O$ chemostratigraphy from bulk and matrix carbonates. The investigated area is critical as it represents the transition from shoreline to proximal domains of a closed hydrological system that was affected by repetitive phases of emersion due to evaporation. These deposits are principally characterized by a succession of ostracod- and gastropod-dominated packstones to grainstones, algal (Cladophora) boundstones, and the above-mentioned palustrine facies. Optical, cathodoluminescence and back-scatter electron microscopy, as well as EDX analyses were performed on key thin sections to discriminate primary (syn)depositional features from secondary diagenetic overprint. A first-order result is that cycles identified by lateral tracing of facies change are not correlated by isotope chemostratigraphy. Bulk $\delta^{13}C$ and $\delta^{18}O$ values ($n = 195$) are scattered and range from -7.4 to +4.0‰ (mean = +0.1‰) and from -7.7 to +3.9‰ (mean = -0.6‰), respectively. The correlation of both carbon and oxygen isotopic values is positive and nearly linear ($R^2 = 0.94$). This relationship is apparently in agreement with the previous interpretation of the lake as a closed saline system. However, such a correlation between $\delta^{13}C$ and $\delta^{18}O$ here likely reflects a diagenetic signal, as the five individual chemostratigraphic profiles are not correlated between each other. While evidence of emersion horizons is not reflected by any carbon and oxygen isotope shifts, subaerial exposure and meteoric diagenesis is mirrored by the presence of gravitational calcite cements displaying intrinseque luminescence. This luminescent pattern is also observed in phreatic calcite fabrics. The latter pore-filling sparry cements often reveal two intrinseque luminescence phases separated by a thin bright luminescent phase, a feature that may point to successive episodes of meteoric diagenesis interrupted by a shallow ?burial lacustrine episode, i.e. possibly reflecting successive lake level fluctuations. Several terrigeneous particles (quartz, Fe-oxides, clay minerals, etc.) deposited on an erosion surface, likely pointing to clastic accumulation during emersion. One major outcome of the present work is that the chemostratigraphic identification of high-resolution cyclic changes in this transitional setting of the Ries Lake is not straightforward, perhaps due to reduced sediment accumulation combined to frequent lake level oscillations. Hence it is assumed that most of the Ries Lake marginal deposits were affected by meteoric diagenesis due to repetitive exposure, a feature hindering the chemostratigraphic identification of single emersion episodes and cycles.

Baltoscandian trace fossils from the northern Estonia and glacial erratic boulders from SW Poland

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In the northern Estonia deposits (Kohtla Järve; Estonia deposit, Kukruse Regional Stage) *Arachnostega gastrochaenae* on cystoids, brachiopods, nautiloid and bivalve, as well as *Osprioneides kampto* in bryozoans were found. This assemblage occurs in limestone interbedded with oil shale (kukersite), that is the latest Middle Ordovician - Late Ordovician in age (see Hints et al. 2007). *Arachnostega* on cystoids and brachiopods have not been described from the Baltica yet. Mikuláš and Dronov (2005), Vinn et al. 2014a encountered this ichnotaxon on cephalopods, bivalves, gastropods and hyolithids from Russia (St. Petersburg region) and Estonia. *Arachnostega*, excellent indicator of soft substrates, occurred only in the Middle and Upper Ordovician (Darriwilian–Katian) of Baltica. It has been suggested that producers of these traces preferred temperate climates then tropics. *Osprioneides kampto* – rare Palaeozoic boring, in the studied assemblage from Estonia was encountered in bryozoans. Earlier, this ichnotaxon was described for the first time by Vinn et al. 2014b from the Upper Ordovician (Sandbian) bryozoans of Estonia. An interesting, very well preserved assemblage of trace fossils belonging to following ichnogenera: *Arachnostega*, *Balanoglossites*, *Chondrites*, ?*Clionoides*(?*Palaeosabella*), *Diplocraterion*, ?*Gastrochaenolites*, *Maeandropolydora*, *Osprioneides*, *Phycodes*, *Planolites*, *Rosselia*, *Sedilichnus* (*Oichnus*), *Skolithos*, *Talpina* (*Conchotrema*), *Teredolites*, *Trypanites* in the glacial erratic boulders in SW Poland (Fore-Sudetic Block) has been found. The most interesting burrows and borings are *Arachnostega gastrochaenae*, *Balanoglossites* isp., *Osprioneides kampto* and ?*Clionoides* (?*Palaeosabella*) isp. The studied assemblage occurs both in rocks and wood, stromatoporoids, corals, mollusks, trilobites and bryozoans (from Cambrian to Neogene in age). *Arachnostega gastrochaenae* occurs on the pygidium of Ordovician trilobite and cephalopods (Orthoceratite Limestone). It is the first report of this ichnotaxon on trilobite from Baltoscandia. In many blocks of reddish, gray or green Ordovician Orthoceratite Limestone, rich in large nautiloids (mostly endocerids) and trilobites, *Balanoglossites* is very common. Recently, Knaust and Dronov (2013) studied this ichnotaxon from these deposits (St. Petersburg region, Russia). It showed that *Balanoglossites*, known mainly from Triassic, occurs in a great abundance in Ordovician. According to these authors, so common occurrence of *Balanoglossites* in the Orthoceratite Limestone might have been connected with the main diversification of polychaetes (possibly tracemakers of this trace fossil) in the Middle Ordovician. In the ?Ordovician bryozoan and Silurian stromatoporoids from erratic blocks in SW Poland, *Osprioneides kampto* was found. This deep, Palaeozoic boring, was reported only from the Upper Ordovician (Sandbian) and Silurian (Wenlock – Přídolí) of Saaremaa (Estonia) and Gotland (Sweden) by Beuck et al. 2008, Vin and Wilson 2010 and Vinn et al. 2014b. Additionally, from glacial stromatoporoid blocks, ?*Clionoides* (?*Palaeosabella*) isp. and *Trypanites* isp. were described. On the basis of the collected trace fossil assemblage, the possibly directions of source material movement and environments for erratic boulders were suggested. Ordovician Orthoceratite Limestone blocks that contain *Arachnostega gastrochaenae* and *Balanoglossites* isp., could be derived from the St. Petersburg region (Russia), Estonia or Sweden, whereas Silurian stromatoporoids with *Osprioneides kampto*, ?*Clionoides* (?*Palaeosabella*) isp. and *Trypanites* isp., from Gotland (Sweden), Saaremaa (Estonia) or adjacent areas.

Eocene olistostrome in the northern zone of the Magura Nappe in Tokarnia village (West Outer Carpathians, Poland)

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The Magura Nappe is the biggest one of main tectonic units of the West Outer Carpathians. Its deposits were continuously sedimented in the Magura Basin in the time interval from the Late Jurassic up to the Miocene. In the Miocene they were folded, tectonically detached from their substratum, and thrust over the group of the fore-Magura nappes, and together with them thrust over the Silesian Nappe. From the south, it tectonically contacts the Pieniny Klippen Belt and these both units contact the Inner Carpathian terrain. Mainly flysch deposits not older than Albian-Cenomanian were preserved in the Magura Nappe. Four facies-tectonic zones were distinguished within this nappe. From south to north they are Krynica, Bystrica, Rača and Siary zones. Several olistostrome levels have been identified within the sedimentary succession of discussed nappe. Middle Eocene olistostrome from the Rača zone in Tokarnia village and it surroundings belongs to the most interesting chaotic complexes. The Ropianka Formation (Late Cretaceous–Paleocene), variegated Łabowa Shale Formation (Early and Middle Eocene), Pasierbiec Sandstone Formation (Middle Eocene), Beloveža Formation (Middle and Late Eocene) and Magura Formation (Late Eocene–Early Oligocene were distinguished within the lithostratigraphic log of the Rača zone in this area. The discussed olistostrome is developed within the Pasierbiec Sandstone Formation. The formation consists of thick-bedded 0,5–2,0 m sandstone and conglomerate turbidites with occasional interbeddings of thin- and medium-bedded, shaly-sandstone Beloveža-type flysch packages and rare thick-bedded Łącko-type marlstones. The sandstones are usually massive, gradually fractionated, coarse-grained or conglomeratic, but some represent fine- and medium-grained, glauconitic Osielec-type sandstones. Conglomerates are predominantly fine, but in some cases coarse or even very coarse. The sandstones and conglomerates are composed of quartz, feldspars, grains of granitoids, clasts of chlorite, sericite and muscovite schists, amphibole gneisses as well as limestones and rare cherts. In conglomeratic sandstones often occur large foraminifera, mainly nummulites. Measured paleocurrent directions suggest that clastic material of sandstones and conglomerates have been transported to the Magura Basin from the north. The olistostrome is developed as deposit of debris-flow origin. Pebbles and cobbles of exotic rocks stuck in the coarse matrix consisted of sandy-gravel material, often containing abundant mudstone or claystone clasts. Olistoliths of shales, occasionally large, in some cases represented by red shales occur also in this complex. Defragmented and plastically deformed pelitic limestone layers 0,2-07 m in dimension stand out in the Tokarnia olistostrome. Occasional fragments of nummulitic limestones were also noticed there. Part of olistostrome consists of defragmented, chaotically arranged, thick-bedded sandstone layers. Discussed olistostrome could be equivalent of the other complex known form Osielec village, in which large gabbro blocks were found.
Detritic material of the Pasierbiec and Osielec sandstone lithotypes have been derived to the Magura Basin from the ridge bordering the basin from the north. Pebbles and cobbles of pelitic limestones represent basinal slope facies, numulitic limestones shelf facies and gabro from Osielec represents cristaline core of the ridge.

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Eocene deposits with carbonate concretions in the Silesian Nappe in Rożnów Lake surroundings (Outer Carpathians, Poland)

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In the lithostratigraphic section of the Silesian Nappe in Rożnów Lake surroundings crop out pelitic Eocene deposits, so-called "Green Shales". They are underlied by the Middle Eocene Hieroglyphic Beds and overlied by the Late Eocene Globigerina Marls. In their base, within the Hieroglyphic Beds, is developed a large olistostrome (Waśkowska & Cieszkowski, 2014). Foraminiferal assemblages indicate the Bartonian age of the Green Shales. Deposition of these shales took place in the Silesian Basin below the CCD (Waśkowska, 2014). Within Green Shales occure spherical and loaf-like calcareous cobbles and boulders, reaching up to 2 m in diameter. These forms, called "septary concretions", are cut by characteristic radial or polygonal networks of calcite veins. The carbonate cobbles and boulders stuck in the debrit that consists of green mudstone clasts. Discussed spherical and loaf-like forms origin of plastically deformed fragments of allodapic limestones layers and other calcareous rocks, which form olistoliths within the mass-flow origin deposits, that consists mainly of mudstone clasts. These boulders are represented mostly by massive sparitic and micritic limestones, sandy limestones and marls. Within the limestones gradation of grains and Bouma sequences typical for turbidites occasionally were noticed. Between the catbonate grains rare recrystallized bioclasts occur. Paleogene planktic foraminifera (*Subbotina* sp., ?*Catapsydrax* sp.) and calcareous dinoflagellates were found there. The calcareous rocks were probably deposed in the middle or lower part of the southern slope of the Silesian Basin.
The calcareous material of allodapic limestones has been derived there by turbidity currents from the shelf surrounding the Silesian Ridge. Slope mass movements caused that the layers of carbonates slide from slope to the basin. During inducing a mass-flow sliding the limestone layers were defragmented to smaller pieces, turned down the slope and rolled. Still plastic calcareous deposits, being in early stage of diagenesis, were rounding and got their actual spherical shapes. Septaria in limestone cobbles and boulders constitute effect of the postredepositional diagenetic processes. They constitute one of indicators of the submarine mass movements (olistostromes) which were noticed in the section of the Eocene deposits of the Silesian Nappe (Cieszkowski et al., 2012).

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First occurrence of an ophthalmosaurid ichthyosaur in the Upper Jurassic of the Northern Apennines (Marche, Central Italy): Stratigraphic setting

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An ophthalmosaurid ichthyosaur was discovered in Upper Jurassic deposits of the Umbria-Marche sedimentary succession near Genga (Ancona, Marche, Italy). While other Mesozoic marine reptiles have been found at different stratigraphic intervals in Italy, this specimen represents the first ichthyosaur ever recorded from the Upper Jurassic of the Apennines. It consists of an almost complete skeleton preserved on a slab, with an articulated vertebral column, and disarticulated skull and pectoral girdle. This paper describes the stratigraphy of the ichthyosaur-bearing deposits.

The Umbria-Marche sedimentary succession is characterized by Meso-Cenozoic pelagites and hemipelagites overlying Lower Jurassic shallow-water carbonates (Calcare Massiccio Fm.). The rifting stage, which affected the Western Tethys in the Early Jurassic, produced a complex submarine architecture, resulting in a mosaic of variable facies and thickness differences in the syn- and post-rift succession. Extension linked with opening of the Liguria - Piedmont Ocean dismembered and drowned a huge carbonate platform (Calcare Massiccio paleoplatform), and converted it into a system with small horsts-and-grabens/semigrabens, where pelagic deposits capped the shallow-water carbonates. The original Early Jurassic paleobathymetric differences were levelled by Early Cretaceous times. The basin-fill deposits onlapped the (mostly pre-rift) Calcare Massiccio facies, exposed at the footwall of Jurassic faults in the form of paleoescarpments, and buried the structural highs while their margins were largely inactive. The area in which the ichthyosaur was found was characterized by numerous structural highs (Mt. Murano, Mt. Revellone, Mt. Scoccioni and Mt. Valmontagnola), onlapped by the Jurassic - Early Cretaceous basin-fill units. In the Middle Jurassic, a huge block (about 0,7 km longer axis) of Calcare Massiccio - characterizing the Il Sassone sector - collapsed from the western escarpment of the Mt. Scoccioni or from the Mt. Revellone high, due to tectonic/gravitative instability. The olistolith was embedded in the "Calcari e marne a *Posidonia*" Fm. (late Toarcian-?late Bajocian), and subsequently was onlapped by the "Calcari Diasprigni" (?late Bajocian-early Kimmeridgian) and "Calcari ad aptici e *Saccocoma*" (Kimmeridgian p.p.-early Tithonian) Fms. Additional stratigraphic evidence for tectonic instability across the study area is found in the Middle Jurassic with gravity flow deposits, slumps and breccias bearing Calcare Massiccio clasts.

The specimen was discovered in the Upper Jurassic deposits onlapping the Il Sassone mega-olistolith. It was embedded in green and reddish limestones and cherty-limestones referable to the "Calcari ad aptici e *Saccocoma*" Fm. The faunal assemblage includes belemnites (*Duvalia* spp.), aptychi (*Laevaptychus* sp., ?*Laevilamellaptychus* sp.), rhyncholites (*Leptocheilus* sp.), shark teeth (hexanchiforms), trace fossils (*Thalassinoides* sp., *Chondrites* sp.), radiolarians, calcisphaerulids and abundant *Saccocoma tenella*. These elements, coupled with the absence of *S. vernioryi*, *Chitinoidella* spp. and calpionellids, constrain the age of the ichthyosaur to the late Kimmeridgian - earliest Tithonian.

Early Cretaceous vs. Early Jurassic tectonics: Role of inherited structures in the post-rift evolution

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While the subject of Early Jurassic rifting in the Western Tethys, with its accompanying set of variable facies and stratigraphic thickness, has been thoroughly addressed over the last decades, post-rift Mesozoic extension is a far lesser known theme. Stratigraphic and structural evidence document a late Early Cretaceous extensional phase, which can be identified across Italy (outcrop and subsurface), in the form of mega-clastic bodies, neptunian dykes, syn-sedimentary faults and angular unconformities. The pre-rift substrate (Calcare Massiccio Fm., a shallow-water limestone) was exposed at the footwall of Early Jurassic basin-margin rift faults/paleoescarpments as the submarine tectonic topography was draped and eventually levelled by pelagic sediments. Where present, Cretaceous faults reactivated Early Jurassic structures, although not necessarily reutilizing the original fault planes in a strict sense, causing downstepping-rejuvenation of the inherited margins. The “Mt. Cosce Breccia”, outcropping on the eastern slopes of the homonymous hill (Narni-Amelia Range, Central Apennines), is a polygenic breccia with lithoclasts of the Calcare Massiccio Fm. and of Jurassic basinal and condensed units, and rests unconformably on the Jurassic horst-block of Mt. Cosce. This deposit indicates reactivation of an Early Jurassic fault, and exhumation of a paleoescarpment tract that had been buried by the lower part of the Maiolica Fm. Stratigraphic evidence indicates an ? Hauterivian-Barremian age for the breccia. Neptunian dykes made of Maiolica-type facies, referable to the same tectonic event, penetrate a structural-high top condensed succession about 4 km east of Mt. Cosce, in the Sabini Mts. Calcirudites and calcarenites embedded in the upper Maiolica Fm. occur in the Sibillini Mts. and the Umbria-Marche and Marche Ranges (Northern Apennines), also with clasts of the unroofed pre-rift substrate. A comparable situation to Mt. Cosce, albeit at a larger scale, is represented in the Southern Alps by the “Ballino Breccia”, having an Early Cretaceous age and found at the Jurassic western margin of the Trento Plateau. In the subsurface of the Po plain the “Cavone Breccia”, a Lower Cretaceous mega-clastic deposit sealed by the Marne del Cerro Fm. (Aptian-Albian) is related to tectonic rejuvenation of the buried Bagnolo carbonate platform margin. Early Cretaceous paleoescarpments have been described in the Ligurian Briançonnais, as well as in the exposed margins of the Apulia carbonate platform (Maiella Range - a still debated subject - and Gargano peninsula). Syn-sedimentary faults and breccias sealed by the Marne a Fucoidi Fm. (Aptian-Albian), identified in seismic lines, affect the buried eastern and northern margins of the Ombrina-Rospo plateau (Apulia Platform, Adriatic offshore).
These data suggest that evidence for Early Cretaceous extension are more widespread than expected. As plates re-arrangement took place in the Mediterranean region in the “Middle Cretaceous” due to opening of the Southern Atlantic, causing the inception of Alpine compression, an extensional phase is a rather unexpected event that will deserve future investigation.

Preserving and comunicating unique depositional geometries through photogrammetric techniques: The Agolla case study (Umbria-Marche Apennines)

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Conserving geological heritage is pivotal in improving the fruition of geological resources. Preserving significant geological outcrops is even compelling when the site concerned quickly undergoes natural processes of geological and environmental evolution. An efficient and not expensive tool to ward and communicate geological features is represented by photogrammetry and 3D models, with the possibility to create large-shared database.
A paradigmatic case is represented by the Jurassic Agolla outcrop (Umbria-Marche Apennines, Italy). The Umbria-Marche Basin displays a well-known Jurassic stratigraphy, controlled by an Early Jurassic extensional phase, which caused the fragmentation of a huge carbonate platform ("Calcare Massiccio", Hettangian). Tectonics produced the drowning of the benthic factory and a complex submarine paleo-topography characterized by structural highs and lows (with consequent thickness and facies variations of the syn- and post-rift deposits). The pre-rift "Calcare Massiccio" was exposed along the horst-block margins forming morphological escarpments affected by episodic failures. The resulting rock-fall deposits (paleobreccia), topographically higher with respect to the basin floor, could represent preferential sites to host condensed facies (epi-breccia deposits) before being definitively sealed by the basin-fill deposits.
The studied outcrop is a paleobreccia made of markedly angular "Calcare Massiccio" blocks (> 1 m longer axis). The boulders are draped by fossil-rich epi-breccia pelagites belonging to the "Bugarone" Group (late Kimmeridgian in age), in turn covered by the "Calcari a Saccocoma e Aptici" Fm. passing upward to the "Maiolica" Fm (late Tithonian).
Taking into account the uniqueness of such outcrops and their importance in reconstructing the basin architecture, 3D models were performed. In these models, the sedimentological and paleontological details are faithfully reproduced, as well as the stratigraphic relationships between different litostratigraphic units are emphasized.
The obtained model can be used to objectively convey to the scientific community raw data used for inferences and geological reconstructions. A shared database (in which to upload the obtained interactive models) could represents a fundamental tool for communication and exchange of punctual geological information, providing to all users the possibility to analyse the 'digital outcrop' from any perspective or angulation in a three-dimensional space.
In conclusion, 3D photogrammetry proved to be an effective and powerful tool in preserving, fairly and over time, information with regional or global significance.

Tectonic evolution of the Jurassic-Lower Cretaceous magmatic arc from provenance studies in the Eastern region of Atamaca, Chile, between 26° and 27° S

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During the Jurassic-Lower Cretaceous, in the western active margin of South America, a marine basin developed in the Atacama region that has been traditionally classified as a backarc basin. Sedimentary sequences along the eastern edge of the basin (the High Cordillera), between latitudes 26-27°S, are composed of over 1600 m of sedimentary fill of mainly carbonate sediments intercalated with siliciclastic, volcaniclastic, and volcanic rocks.
Provenance studies were performed on outcrops of interleaved sandstones within the carbonate facies along SW-NE transects over a west-east distance of 70 km. Collected samples recorded the formation of the basin (Lower Jurassic) through silting (Cretaceous).
Results of the Gazzi-Dickinson method of point counting were plotted on QFL, QmFLt and QpLvLs ternary diagrams. The QpLvLs diagram results show provenance from an orogenic active arc throughout the basin's evolution. The arc evolved from a transitional arc in the Lower and Middle Jurassic to a dissected arc in the Lower Cretaceous. Moreover, results show a significant tectonic shift in the Upper Jurassic, at the boundary between the non-dissected and transitional arc (diagrams QFL and FQmLt), expressed in the predominance of volcanic arenites on lithic arkose.

Mending the slow varve-clock: Mechanisms and consequences of selective reduction of dark laminae in varved coccolith sediments

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Annual laminae in lacustrine and marine sediments (varves) are used for fine chronological calibration of geological record. A varve-based time scale may be accepted as robust and accurate if annual nature of laminae is well ascertained. This can be done by identifying clear and regular record of seasonal changes in the environment (Thomsen 1989). Anderson (1996) suggested also that long-distance lateral continuity of laminae supports seasonal nature of alternating laminae. Varve chronologies proved robust and reliable in lacustrine sediments, but the prime modern example of seasonally laminated modern marine sediment, the coccolith mud in the deep parts of the Black Sea, shows dramatic discrepancies between chronologies based on varve counts and on isotope dating. A fossil equivalent of the Black Sea coccolith mud is present over a large area in the Carpathians, from the Alpine foreland in Austria to the southern end of the East Carpathians in Romania, as the Oligocene Tylawa Limestones, isochronous microlaminated coccolith limestones laid down in stratified waters with lowered salinity in the upper and anoxia in the lower part of the water column. Unlike in the Black Sea laminated coccolith mud, continuity of individual laminae and their bundles in Tylawa Limestones is lost over a dozen of kilometres. In a younger chronohorizon of Oligocene coccolith limestones in the Carpathians – the Jasło Limestone – laminae have been successfully correlated over 450 kilometers despite the fact that individual laminae in Jasło Limestone are more lenticular and blurred than those in Tylawa Limestones. We studied ulstrastructure of laminae in Tylawa Limestones to find the reason for the puzzling loss of continuity. We found evidence that the coccolith-rich light laminae in the Tylawa Limestones were originally separated by laminae rich in diatom frustules, but the diatom skeletons have been selectively eliminated during early diagenesis, thus obliterating the varved nature of primary sediment. We suggest that elimination of diatom skeletons and obliteration of seasonal record occurred in two main stages. In the first sediment particles were filtered through a fluff layer a couple of centimetres thick, similar to that observed at the deep bottom of the Black Sea, where opaline frustules were largely dissolved. The second stage was early diagenesis in predominantly calcareous coccolith mud soon after deposition. The remaining skeletal debris of diatoms was selectively dissolved and silica precipitated in sites where organic matter decomposed in interiors of coccospheres in adjacent parts of light laminae. As a result, the dark laminae deposited in winter and spring, with a record of spring diatom blooms, where selectively reduced. The light laminae composed mostly of coccolith material from summers blooms, approached one another and often coalesced. Counts of the light laminae give results lower than the number of originally laid down light laminae and the years passed. Lateral continuity of laminae appears to be a important tool for testing the reliability of varves as a chronometer in fossil laminated coccolith limestones.

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Upscaling strategy for porosity networks in complex non-marine carbonate reservoirs

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Heterogeneity is an inherent characteristic of carbonate reservoir rocks, which relates to their geological evolution, e.g. sedimentary origin, diagenetic processes and burial history. Especially in continental carbonates these processes influence the size and shape of pores, resulting in a very complex porosity network. To evaluate the reservoir potential of these continental carbonates, a critical decision has to be made regarding the scale at which petrophysical measurements should be performed in order to be representative and statistically stationary. Different porosity types in sedimentary rocks manifest themselves on a spectrum of different spatial scales. An example of the lower end of the spectrum is very fine micro-porosity in micritic textures, characterized by pore diameters on sub-µm scale. On the other hand karst and shelter porosity forms the largest pores in sedimentary rocks with diameters up to meter scale. In this study a unique dataset comprising several orders of spatial scale (µm←→m) is used to deduce the influence of the sample size on measured porosity.
High-resolution LIDAR data of quarry walls is used to assess the porosity on the upper end of the spatial spectrum, while medical-CT, micro-CT scans and thin-sections are used to cover the middle and lower end of the spectrum. For each spatial scale, the Representative Elementary Volume is calculated (i.e. the smallest value that can be taken as a representation for the entire sample area/volume that does not respond to small changes in volume or location).
In this case study, two approaches to calculate the REV are compared. Both methods are applicable on 2D as well as 3D datasets. The first method uses the chi-square criterion to measure how much a single randomly chosen subsample diverges from the mean value of all realizations. This method is closely related to the original definition proposed by Bear. The second method uses the relationship between the REV and geostatistical interpretations. A volume Vi falls within the REV domain if Y(x,Vi) can be treated as a stationary random function for any x in the domain. The results of both methods are in the same order of magnitude and vary depending on the scale of the sample. Nevertheless, the geostatistical method provides additional information on the shape of the REV based on the spatial distribution of the porosity parameter, i.e. the anisotropy.
In order to link results from LIDAR, medical CT, µCT and thin-sections and to accurately predict adequate REV sizes a workflow derived from multiple point geostatistical studies is applied. This approach combines the strengths of pixel-based and object-based techniques. The quality of the simulated datasets is determined by comparing pore shape distributions and simulated permeability values of a corresponding part of both the original dataset and the simulated dataset.
This study illustrates the complexity of the application of the REV parameter in geological studies. Only by calculating the REV at different scales, reservoir properties in complex carbonate rocks can be evaluated correctly.

Storm flood impacts along the shores of tideless inland seas: A morphological and sedimentological study of the Vesterlyng beach, the Belt Sea, Denmark

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The morphological and sedimentological impacts of the storm flood Bodil (December 2013) were investigated at a tideless beach along the inland Belt Sea, Denmark. Impacts on the beach morphology was measured by Digital Geographic Position System (DGPS), sediment types were studied in the field and the overall characteristics of the storm flood and winds were investigated by data on water level variations, wind strength and directions provided by the Danish Meteorological Institute (DMI). Morphological elements formed by the storm flood includes: Gravelly storm berms, sandy to gravelly wash-over fans, storm scarps and gravel flats. The data indicates that storm berm crest is identical to the still-water level (1.60 m) in the Belt Sea during the storm flood and the wave runup (0.77 m) towards the shore. The crest of 2.37 m is a precise measure of the characteristics of the storm flood and classifies it as a large-scale event. In a Holocene perspective it is suggested that storm berm (beach ridge) heights can be used as a proxy of past flood events and thereby aid in the prediction of future flooding frequency and magnitude along tideless shores.

From build-up to pebbles: Brief history of a crustose coralline build-up of the Upper Eocene of Northwestern Italy

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Fossil crustose coralline framework are known from the Eocene onward, with occurrences in middle Eocene of Spain, the Upper Eocene of Northern Italy, the Miocene of Malta and Poland and the Plio-Pleistocene of the Mediterranean. The studied example presents a coralline algae framework from the Upper Eocene of Northwestern Italy. Although the carbonate platform where the build-up developed is lost, its remains are preserved. Reworked skeletal grains, transported off shore by debris-flow, are preserved in the Ternate Formation, a deep-water sub-marine fan. In the Upper Oligocene conglomerates of the Gonfolite Lombarda Group, biogenic carbonate pebbles of Upper Eocene age are preserved. Textural characteristics, skeletal assemblages, coralline-algae flora and benthic foraminifers composing the pebbles were studied and compared to those of Ternate Fm. The same rhodalgal skeletal-assemblage, the same species of coralline algae and the same association of benthic foraminifers were found in both set of samples, suggesting their common origin. While Ternate Fm. materials were undoubtedly reworked during transport, the limestone pebbles are pristine fragments of the original carbonate platform which was uplifted and eroded between Upper Eocene and Upper Oligocene. They actually have no internal textural features suggesting reworking (common orientation of the grains, high degree of sorting, presence of rip-up clasts, fragmentation of delicate skeletal elements). The remnant of the crustose coralline framework was preserved in these pebbles. *Neogoniolithon* sp. is the most common crust-forming species, this alga has the ability to grow directly over fine grained mobile substrate and thus has a pivotal role in framework formation. Although the preserved framework was only observed in limestone pebbles, fragments of *Neogoniolithon* sp. crusts were commonly observed in all the samples of Ternate Fm., testifying the importance of this framework builder in the carbonate factory. *Sporolithon aschersoni* and the encrusting foraminifer *Acervulina linearis*, together with encrusting bryozoans also contributed to the building of the framework. Compared to other European examples of the same age the studied skeletal association lacks fragments of hermatypic corals. The exclusion of corals may have been caused by the general instability of the environment. Ternate Fm. sub-marine fan was supplied by periodic debris flow, probably started by river floods. These events were able to sweep away the platform with enough energy to carry large boulders and to rip away fragments of the substrate several meters in length. Lumps of sediment, rich in hydrocarbons and pyrite, have been observed in the Ternate Fm., suggesting that bottom waters were occasionally and locally depleted in oxygen. The lack of oxygen was probably caused by recurrent high riverine discharge of organic matter and nutrients. The combined stressful effects of bottom instability and riverine discharge probably excluded corals from the association. The integrated study of the abundant but reworked materials of the Ternate Fm. and of the pristine, but rare, limestone pebbles of the Gonfolite Group allowed the reconstruction of a otherwise lost Eocene carbonate factory.

A model for backwater controls on the architecture of distributary channel fills in coastal plain successions: Preliminary test against field data from the Neslen Formation (Campanian – Utah, USA)

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Backwater hydraulics exert an important control on fluvio-deltaic morphodynamics, but the mechanisms by which this is recorded in preserved stratigraphy are not well understood. It is known that the lowermost portions of modern rivers undergo flow acceleration and become erosional at high discharges due to drawdown of the in-channel water surface near the river mouth in relation to the fixed water surface at the shoreline, and that distributary channels developed in the seaward portions of coastal plains tend to be subject to a reduction in lateral mobility due to diminished sediment flux at low flow.
Consideration of what we know of channel morphodynamics associated with backwater effects as based on observations from numerical models and modern sedimentary systems is here used to make speculative predictions concerning the architecture of distributary channel fills in the rock record. Through analysis of literature-derived datasets, a model is here proposed that predicts distributary channel fills characterized by (i) low width-to-thickness aspect ratios, (ii) internal architectures dominated by multi-storey aggradational infill styles, (iii) a facies organization that relates drawdown-related scour and possible overprint of a tidal signal, and (iv) limited development of co-genetic sand-prone overbank units.
To test these predictions, fieldwork was carried out to examine sedimentological characters of channel bodies from an interval of the Campanian Neslen Formation (eastern Utah, USA), which comprises a succession of sandstone, carbonaceous mudstone, and coal, deposited in a coastal-plain setting, and in which significant evidence of tidal influence is preserved.
Three types of channel bodies are recognized in the studied interval, in terms of lithology and formative-channel behaviour: sand-prone laterally accreting channel elements, heterolithic laterally accreting channel elements, and sand-prone aggradational ribbon channel elements. This study concentrates on the ribbon channel bodies since they possess geometries compatible with laterally stable distributaries developed in the zone of drawdown. The sedimentological and architectural characteristics of these bodies are analysed and compared with the proposed model of distributary channel-fill architecture.
The architecture of the analysed sand-bodies does not entirely and unequivocally conform to the proposed model, but the predicted characters are variably shown. Further work encompassing other depositional systems is required to better test the model, and more generally to better understand the role of backwater processes in controlling the architecture of distributary channel bodies, their down-dip variations, and how these are expressed in the context of the autogenic evolution of prograding coastal plains.

Climate change and geomorphic evolution: Insights from meta-analysis of the sedimentary architecture of fluvial systems across the Paleocene-Eocene boundary

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The Paleocene-Eocene Thermal Maximum (PETM) was a brief episode of extreme global warming that occurred at ca. 56 Ma. As this event is associated with the release of isotopically light carbon into the atmosphere, the PETM is considered as a deep-time analogue for present-day climate change. Stratigraphic architecture of the continental sedimentary record of the PETM preserves a record of the geomorphic impact of hyperthermal events on terrestrial landscapes and sedimentary systems. Although the magnitude and rate of the PETM climate change do not represent the norm in geological history, assessing the effects of the PETM on different fluvial successions is a significant generic test of the sensitivity of fluvial architecture to a climatic driver, as opposed to other controlling factors.
To assess the response of fluvial processes and landforms to the PETM, a meta-analysis has been carried out to compare the sedimentary architecture of continental successions from four different basins (Tremp-Graus Basin, Spain; Uinta Basin, UT, USA; Piceance Basin, CO, USA; Bighorn Basin, WY, USA). The sedimentological data result from both original outcrop studies and published datasets, and were collated into a database of classified fluvial architecture (FAKTS) in standardized and quantified format, in order to facilitate comparisons. The chosen case studies possess good temporal control and constraints on the potential influence of different controlling factors on stratal organization.
Sedimentological characteristics are compared across the PETM, and across the studied successions, with the tentative aim of identifying either common threads or factors associated with particular responses. Features that are compared include the abundance and geometry of fluvial channel complexes, architectural elements and lithofacies: these features can partly be interpreted in terms of geomorphic processes operating at a basin scale and the development of landforms associated with these processes.
Data on the proportion and geometry of channel complexes from the different case studies relate an increase in the abundance and size of channel sandstone bodies for the stratigraphic intervals that embody the PETM. Geometrical characteristics of preserved barforms and channel fills employed as proxies for the hydraulic geometry of their formative channels display contrasting relationships with their stratigraphic position relative to the PETM, although results may reflect variable preservation potential in relation to variations in the degree of amalgamation of these bodies. Variations in the types of lithofacies composing the channel bodies are documented across the PETM in all the case-study successions, but do not appear to relate to common evolutions in the relative dominance of different channel-filling processes.
The common recognition of architectural change at the PETM highlights the widespread influence of this event on many aspects of terrestrial landscapes. Similarities in the sedimentological evolution of the different successions possibly relate to corresponding responses of the catchment and depositional basins to increased seasonality and intensity of precipitation and vegetation turnover. The observed differences may in part be connected to differences in basin setting (e.g. endorheic vs. exorheic drainage), and possibly related to different climatic responses to the PETM (e.g. wetting vs. drying) in different global climatic zones.

Tectonic controls on the distribution of remobilised carbonate facies along the Syrian Arc Fold Belt: Eocene Thebes Formation, Hammam Faraun Fault Block, Sinai Egypt

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Mass transport deposits in deep water basins have been well studied in siliciclastic environments but less so in carbonate basins. In particular, the shape and size of carbonate mass transport deposits, and their relationship to the carbonate factory, relative sea level and tectonism is less well documented. Footwall rotation and uplift during rifting in the Gulf of Suez has exposed a 400 m thick succession of remobilized carbonate bodies in the Hammam Faraun Fault (HFF) Block on the western side of the Sinai Peninsula in the Thebes Formation. The pseudo 3D exposure of the remobilised bodies in the fault block provided an opportunity to better understand the cause of slope instability in the region. The results help to constrain the factors that influence the morphology of carbonate mass transport.

The Thebes Formation in the study area comprises remobilised carbonate facies embedded in slope sediments. In the lower Thebes Formation, matrix supported conglomerates, comprising clasts of a range of shallow water carbonate facies, and upward-fining skeletal grainstone facies are hosted in a background of foraminiferal wacke-packstones interpreted as in situ middle ramp deposits. Remobilised sediment is dominated by a diverse assemblage of large benthic foraminifera, red algal and green algal fragments, echinoid and bryozoan debris. Clast-supported conglomeratic beds and slumped beds also occur in the upper part of the lower Thebes Formation, but are less common. The nature of the remobilised facies implied periods of collapse causing debris flows and grainstone turbidite deposition, with slumping occurring in the uppermost part of the lower Thebes Formation.

Slope instability in carbonate environments is often caused by oversteepening of the platform edge. The lack of large framebuilders after the Palaeoce-Eocene Thermal Maxiumum makes this mechanism an unlikely control on mass transport, as rimmed carbonate platforms were rare at this time. In this region, however, the Syrian Fold Belt (SAFB) created "pseudo" rimmed platforms, as compression reactivated older faults and formeda series of anticlinal ridges. One of the southernmost expressions of the SAFB is the Wadi Araba fault, located northeast of Hammam Faraun on the eastern side of the Gulf of Suez. Thinning of the Thebes Formation to the south, north-to-south paleo-flow indicators and a gradual disappearance of remobilised carbonates southwards suggest that the Wadi Araba fault was responsible for slope instability in the region.

The Upper Thebes Formation is dominated by fine-grained planktonic foraminiferal wackestones representing in situ outer ramp and basinal deposition. Interbedded grainstone turbidite and channelized grainstone beds are characteristic of concentrated flow into the basin from the platform top. This marked decrease in grain size and absence of mass transport deposits suggests that the tectonic control on platform geometry and slope instability had waned prior to deposition of the upper Thebes Formation.

Facies analysis and depositional architecture of the Santo Spirito Formation (Majella, Central Apennine)

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This work focuses on the Bartonian to lower Rupelian interval of the Santo Spirito Formation (Danian-Rupelian) outcropping in the northern sector of the Majella Mountain (Central Apennines).
In this sector the investigated deposits represent the sedimentation in middle to outer ramp environments. The outer ramp consists of marly, highly bioturbated wackestone to packstone with planktonic foraminifers deposited within the aphotic zone and below the storm-weather wave base. The transition between middle and outer ramp is represented by cross-bedded bioclastic packstones that formed three-dimensional submarine dunes migrating basinward. The main components are echinoid fragments, encrusting foraminifers such as *Gypsina*, usually hooked, acervuliniids, *Planorbulina*, *Lobatula lobatula*, both articulated and encrusting red algae fragments and rotaliids. Minor components are bryozoan fragments, deep water small benthic foraminifers such as buliminaceans and frequent planktonic foraminifers. These skeletal assemblages suggest the presence of a carbonate factory associated with a vegetated environment. The middle ramp was characterized by a third lithofacies consisting in a larger benthic foraminifera floatstone. The main components are *Nummulites*, *Discocyclina*, *Assilina*, *Asterocyclina*, alveolinids tests, together with abundant *Gypsina*, rotaliids and coral fragments. This facies is interpreted to represent the sediment filling rip channels, placed perpendicular to coastline, and formed during storm events.
The stratigraphic architecture of the Santo Spirito Formation in the investigated area has been interpreted as a depositional sequence of high rank that can, in turn, be subdivided into 7 low rank depositional sequences, each of which shows preserved deposits attributed to TST and HST.

The Permian–Triassic continental succession at Allan Hills recording a fluvial-reworked fossil forest (Southern Victoria Land, Transantarctic Mountains, Antarctica)

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The Allan Hills are located at the edge of the East Antarctica Ice Plateau in the northern part of the Southern Victoria Land and they show an extensive exposure of several hundreds meters thick siliciclastic continental succession of the Late Permian to Early Jurassic Beacon Supergroup. We present here a preliminary report of the stratigraphic-sedimentological features of these deposits focusing on the Permian-Triassic transition (PTT). We collected several samples of sandstone, mudstone and fossil logs to be examined in the next steps of the research, with specific focus on their paleoclimate, paleoenvironmental and provenance records. The studied portion of the succession is characterized by marked facies changes through the PTT, accompanied by remarkable changes in paleoflora, particularly from *Glossopteris*- to *Dicroidium*-dominated associations. Anyway the exact position of the PTT is not easy to place due to the continental-clastic character of the deposits, even if some constraints could be seen in the occurrence of paleosols, carbon isotope anomalies, trends in organic matter content. The lower part of the succession, Permian in age, is characterized by the alternation of coarse-medium sandstone beds with coal seams, showing the development of floodplain with high-energy meandering streams developing coarse sandstone point bars and wide marshes along the alluvial plain. The high-grade vegetated alluvial plain is documented by the thick coal seams (from some dm to 3 metres), by the abundance of carbonaceous sandstones and vegetal fossils, like leaf impressions, particularly *Glossopteris*, and logs. A sharp but conformable boundary marks the upward transition to about 200 metres thick coarse and gravelly sandstone succession with rare and thin mudstone interlayers containing *Dicroidium* leaf impressions, recording a Triassic age, and red sandstone paleosols. The gravelly sandstones are mainly characterized by fluvial trough-cross stratification, showing dominant palaeocurrents towards the northern sectors, and minor ripple beds with an increasing upward *Skolithos*-type bioturbation containing abundant fragments of fossil logs. About 100 metres above the boundary, a magnificent fluvial-reworked fossil forest occur, with several well-preserved permineralized logs also showing root apparatus, englobed in the coarse sandstones. The silicified trunks, up to 12-15 metres long and up to 40 cm in diameter, have a significant compression-ratio. The logs often have one black-carbonized side-surface, whereas the major portions are silicified and well-preserved primary details and growth-rings are observable. Some of them are oriented according to the fluvial paleocurrents, whereas some are oblique/transversal to them. A few metres above again some reworked charcoalified?/permineralized-peat/wood lenticular levels are interlayered within the trough cross-stratified coarse sandstones, that dominate the upper part of the succession. Our efforts are focused: i) to understand the significance of the dramatic abrupt facies change at the PTT, from meandering stream alluvial plain with marshes, to low-vegetated alluvial plain with sandy-braided streams; ii) to understand the significance of the charcoalified?-wood bearing sandstones, close to the reworked-fossil forest in a high-energy fluvial system, speculating if the overall evidence can be consistent with a post-apocalyptic scenario with the destruction of the forest due to floods or to great paleofires.

Unwrinkling the mats: A reappraisal of the microbial mat subzonal scheme of the Abu Dhabi sabkha

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The northern coast of Abu Dhabi is characterized by an extremely shallow-dipping homoclinal carbonate ramp and exhibits a dominant, well-documented, regressive sabkha environment up to 5 km in width. Though currently threatened by developing coastal industry, the Abu Dhabi sabkha represents a fine example of the complex relationship between supratidal evaporites and intertidal carbonates and organics.
Microbial mats (also variously termed ‘algal mats’, ‘stromatolitic mats’, and ‘cyanobacterial mats’ in the historical literature) are the most eye-catching surface feature of the Abu Dhabi sabkha. Though composed of microorganisms, they are easily visible from satellite imagery as a dark band delineating the upper intertidal zone of the northern coast. Southwest of Abu Dhabi city, where the bands are most pronounced, microbial mats range from 150 m to 700 m in width. The morphology of these microbial mats is directly related to their health which is, in turn, controlled by the regularity and duration of water coverage. As a result of their ‘sweet-spot’ niche and the extremely shallow homoclinal carbonate ramp setting, the sedimentary morphology of microbial mats is strongly controlled by small-scale sea level fluctuations. Historically, the regressive microbial mats have been divided into qualitatively-assigned subzones. Four subzones were initially identified in the 1960s, but this number was later expanded to ten upon further research in the 1970s. However, evidence of a current transgression in the Abu Dhabi sabkha has been identified. This finding may complicate our use of microbial mat morphology as an analogue for the interpretation of ancient microbial systems. As such, historical investigations of the Abu Dhabi microbial mats may be outdated, and our understanding of the current subzones can therefore be enhanced by a fresh investigation that takes the current transgressive regime into account. Thus, we propose an updated subzonal scheme of the Abu Dhabi microbial mats based on quantitative assessment of Recent microbial sedimentary structures.

Depositional architecture and evolution of mixed travertine-siliciclastic succession in a fault controlled continental extensional basin (Messinian, Southern Tuscany, Central Italy)

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The extensional Neogene Albegna Basin (Southern Tuscany, Italy) includes several travertine units from Miocene to Holocene time. During the late Miocene (Messinian), a fault-controlled basin (nearly 500 km^2 wide) was filled by precipitated travertine carbonate and detrital siliciclastic strata, nearly 90 m thick. This continental carbonate succession was investigated to define its geometry, lithofacies types, depositional environments, and to characterize the variety of precipitated carbonate fabrics.

The mixed carbonate-siliciclastic succession has a wedge-shaped geometry thinning northward. Carbonates are in centimetres to a few decimetres thick beds and include nine travertine facies types: F1) clotted peloidal micrite and microsparite boundstone; F2) raft rudstone/floatstone; F3) sub-rounded radial coated grains grainstone; F4) coated gas bubble boundstone; F5) crystalline dendrite cementstone; F6) laminated boundstone; F7) coated reed boundstone; F8) peloidal skeletal grainstone; F9) calci-mudstone and microsparstone. Siliciclastic deposits vary from decimetre to more than 10 m thick beds and include five lithotypes: F10) breccia; F11) conglomerate; F12) massive sandstone; F13) laminated sandstone; F14) claystones. The succession recorded three phases of evolution of the depositional setting. 1) At the base of the succession a northward prograding hydrothermal travertine terraced slope is identified, developed close to the extensional faults placed southward with respect to the travertine deposition. Terrace walls and pool rims are characterized by crystalline dendrites, whereas terrace pools show widespread coated bubble boundstone. Adjacent to the travertine terraced slope, in the eastern part of the studied unit, 3-4 m thick layers of laminated claystone, decimetre thick layers of conglomerate and laminated sandstone accumulated in an alluvial plain environment. 2) The almost continue travertine succession was interrupted by the deposition of several metres thick alluvial fan deposits, consisting of massive breccias, intercalated with channelized conglomerates and laminated sandstone, fluvial deposits that prograded northward and westward. Travertine lenses, 2-3 metre thick, characterized by low-angle terraced systems, occur intermittently alternated with the siliciclastic deposits. 3) In the third phase, the depositional setting evolved into an alluvial plain with ponds rich in coated reed travertines. The thermal water influence on the depositional environment decreased in this final phase and the travertines, more influenced by ambient temperature freshwater, are enriched in faecal pellets, molluscs and phytoclastic remains.

This study shows the stratigraphic architecture and sedimentary evolution of hundred metres scale continental succession in which hydrothermal activity and travertine precipitation were driven by the extensional tectonic regime, with faults acting as fluid paths for the thermal water. Fault activity created the accommodation space for carbonate and alluvial sediment accumulation. Erosion of the uplifted footwall blocks provided the sediment source for the alluvial fan breccias, which alternated with the hydrothermal precipitation. It is supposed that possible humid climate phases, during the post-evaporitic Messinian time, were useful to the recharge of the aquifer that fed the vents and promoted the formation of the detrital alluvial fans.

How to upscale detailed sedimentological analysis for use in static and dynamic modeling: Examples from clastic and mixed carbonate/clastic depositional systems

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The challenge for sedimentological investigations in the modern E&P industry is to produce data that can be used in the static and dynamic model workflows. Therefore, reservoir geologists have to create the appropriate input for static and dynamic modelling by transforming the often very complex sedimentological descriptions. This paper demonstrates an efficient and geologically most realistic approach using gross depositional environment (GDE) maps.
GDE maps are simplified layer-based maps which illustrate only the most common, thus key depositional environments (DE's). They are not strict paleogeographic reconstructions and they do not attempt to represent the myriad of depositional environments present in the subsurface in any given layer. This simplification is crucial for static modelling in order to constrain the 3D DE distribution.
Thus the sedimentological data that forms the basis of these maps must be simplified. Such a task is done using a progressive workflow that becomes ever more simplistic. Initially the core is described in detail in a litho-facies sense. Subsequently sedimentologically related litho-facies are then grouped together into depositional environments. Critically then the DE's are grouped into like-for-like categories such as fluvial, deltaic or shoreface GDE's (for example) at each well whereby the dominant DE is assigned per layer. At this juncture the dominate GDE per layer is posted onto a log motif map. Finally then the core controlled log motif is now used as a guide away from core control with depositional environments allocated to nearby 'like' log motifs. Following this process the GDE map (per layer) is drawn in a geologically realistic manner with geo-bodies scaled using the geometries and juxtapositions from modern analogues and/or out crops. An example of this work flow, from Eastern Europe, is used to illustrate this simplification and the GDE mapping workflow.
Additionally, four depositionally diverse clastic and carbonate examples are given that show how sedimentological data can be up-scaled and incorporated into static and dynamic models using this GDE technique. The first three examples, are from the Murzuq (glacial) and Sirte (volcano-clastic & arid carbonates) Basins of Libya where previously recorded hand drawn core descriptions were simplified, re-interpreted and then used as the key DE control points for subsequent GDE maps. The forth case study example, is a deep water turbidite from Central Europe. Subsequent drilling locations were made based on a GDE controlled dynamic model which when drilled intersected the nominated GDE's as predicted. In fact the dynamic models of all four examples were successfully history matched with little to no refinement to the geological model component indicating the validity of this approach.

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Submarine features formed in the coastal zone as a result of the Hans Glacier recession and the impact of oceanographic conditions (Isbjørnhamna, Hansbukta, Hornsund)

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The studies of a seafloor in the fjords of Spitsbergen are very important to know the past of the tidewater glaciers and the glacial submarine morphology. The modern geophysical equipment such multibeam echosunder can be used to make a precise bathymetry map of the seafloor in the fjords, which can reveal all landforms on the seabed. This study focuses mainly on to identification and description of the glacial submarine morphology of Isbjørnhamna and Hansbukta. The important aim of this study is to attempt to explain the genesis of these forms, too.
The Isbjørnhamna is located in the outer part of Hornsund, on southern Spitsbergen. The location of this bay causes that the Greenland Sea has a big impact on its oceanographic conditions. The Isbjørnhamna is bordered on the north by Hansbukta. Hansbukta is located between Baranowskiodden and Oseanograftangen. The tidewater glacier – Hansbreen is located in the north-east part of Hansbukta. This bay is growing all time, as a result of the Hans Glacier recession. The oceanographic conditions and Hans Glacier recession cause changes in the bottom of the bays. The relief of the bottom of Isbjørnhamna and Hansbukta are very diverse. The first part of the study area has a seafloor mainly formed by the retreated tidewater glacier – Hansbreen. This part includes Hansbukta and Isbjørnhamna (to the terminal moraine). The outer part of the bay is mainly formed by dynamic marine processes, for example: ocean currents and waves. But these processes have impact on the seabed in the inside part of the study area, too. The forms which are mainly in shallow parts of the bays and near the shores are: ripple marks, rocks (skerries), pits and plough marks. In turn, the annual moraines are near the ice cliff of Hans Glacier. In the inner part of bays we can distinguish forms, like: flat areas, pockmarks, mass movement forms (landslides, downhill creep). The biggest submarine form in study area is the end moraine of Hans Glacier from Little Ice Age. This moraine is located in outer part of the Isbjørnhamna. The other forms (like pits and plough marks) are located on the slopes this moraine. The flat areas are divided by the ranges of moraines and the rock sills. The other forms, like pockmarks are located on these flat areas.
The changes of oceanographic conditions and the recession of tidewater glacier are the cause of constant changes of submarine landscape. The landforms of the seabed can be illustrated.

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The Direndall tufa deposit (Luxembourg): A new record of environment and climate evolution during the Holocene based on combined stratigraphical, malacological and geochemical studies

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A new multidisciplinary study is in progress at Direndall in the Mamer Valley in Luxembourg, combining stratigraphy, geochemistry, malacology and palynology. As it covers a wide part of the Holocene (C14 dating between c. 10 000 to 900 ka BP), the 8m-high tufa deposit provides a great opportunity to discuss modalities and timing of the so-called 'late Holocene tufa decline' (Goudies et al., 1993) and the combined controls of climate and human activity on fluvial formations since the Early Holocene. Recent fieldworks at Direndall allowed collection of new stratigraphical data and samples for a geochemical study. We investigate calcite stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) and Mg/Ca and Sr/Ca ratios from Direndall tufa as records of past temperature and humidity conditions. Comparisons with the environmental reconstructions from a previous malacological study (Meyrick, 2000) show strong consistency with the $\delta^{13}C$ record suggesting that humidity might have been the main climatic factor controlling environment evolution at Direndall during the Holocene. Despite the clear climatic variations observed at Direndall, none can explain the environmental change toward open conditions while optimum forest develops as recorded by molluscs at the top of the sequence. This episode is very likely to be linked to local anthropogenic forest clearance during the Roman occupation of Direndall surroundings. However, no clear impact of human activity has been observed in the tufa stratigraphy or precipitation rate. The exceptionally long Direndall tufa sequence thus already provided outstanding palaeoenvironmental and palaeoclimatic data and might become, together with the underlying fluvial and colluvial deposits, a reference site for the Holocene and Tardiglacial in Luxembourg and surrounding areas.

The depositional model for the Late Triassic Maleri Formation, India: A record of sedimentation by an ephemeral fluvial system in a Gondwana rift basin

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The Gondwana succession of the Pranhita-Godavari Basin was deposited in a NW-SE trending linear rift basin. Maleri Formation (400-500 m thick) represents the Late Triassic part of this succession. The basal ~100 m (Unit I) of this fluvial deposit is almost entirely made up of red mudstones and siltstones, devoid of any thick sandbody. The upper part (Unit II, 300-400 m) comprises an alternation of 3-5m thick sheet bodies of medium to fine quartzose sandstone and thicker (5-20 m) mud-rich intervals (similar to those of Unit I). Calcirudites/calcarenites (CRA), made up of intraformational carbonate clasts represent the coarsest sediment of this succession. Small isolated CRA bodies (30-80 cm thick), enclosed within mudstones-siltstones, occur throughout the succession.
Here we propose the depositional model based on the sedimentological evidences from this succession.
The mud-rich intervals of both the Units are composed of: i) Massive pedogenically modified mudstones; ii) Sets of horizontal and down-current accreting inclined strata made up of rippled and parallel laminated siltstones; iii) Sheet/lensoid bodies of cross bedded CRA, encased within fines, and having erosional basal bounding surface; iv) Structureless mudstones with floating, detrital, pedogenic concretions. Desiccation cracks are present all throughout.
These intervals are interpreted to have deposited in wide, flat, low relief plains by weakly channelized to unconfined sluggish ephemeral flows. An admixture of sand-poor detritus and intraformational pedogenic material were distributed through a network of small, ephemeral, discontinuous streams and were deposited either within the channels or in ephemeral floodplain depressions. Large perennial water bodies were absent. The floodplains used to remain exposed to sub-aerial soil forming processes for prolonged periods under a semi-arid climate.
The sheet sandbodies of the Unit II are laterally extensive and are internally constituted of three types of storeys: i) Sheet-like storeys of plane parallel laminated fine sandstone; ii) Lenticular storeys with erosional basal bounding surface, composed of medium to fine grained cross stratified sandstone showing a fining upward grain-size trend, with or without mud clasts in their basal part; iii) Tabular to sheet storeys of scour fills.
These multistoreyed sandbodies were emplaced by very wide, short-lived, shallow sheet floods that repeatedly concentrated into local braid channels. The flow use to fluctuate between upper and lower flow regime conditions. These sandbodies represent brief periods of higher hydraulic efficiency and enhanced supply of coarser-grained extra-basinal detritus.
We conclude that a deeply weathered and highly denuded hinterland straddling, the rift basin used to introduce an overwhelmingly fines-dominant sediment load to the depositional basin during the entire tenure of sedimentation under a condition of low and episodic precipitation. Due to the low hydraulic efficiency of the flow, the sand grade material in the sediment load obtained from the hinterland was retained close to the basin margin. The residual load, enriched in fines used to reach the more distal depositional sites. This condition of low hydraulic efficiency was punctuated by short-lived events of catastrophic rainfall having very high periodicity. The higher hydraulic efficiency during these events allowed the sand-grade material to travel to the distal sites and form the sheet sandbodies.

Fluctuating fluvial-marine influences in a lagoon-barrier system from Ghana

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Lagoon-barrier systems represent a transitory environment between the land and sea and are influenced by both fluvial and marine processes. Their connection to the ocean, and thus the interplay between marine and fluvial processes, is dependent on barrier breaching and fragmentation as well as overwashing and overtopping of the barrier. Fluvial processes dominate most of the time, when the barrier is closed. However, when the barrier is breached an ephemeral connection between the lagoon and the ocean develops, estuarine-like conditions ensue and a transient, perched estuarine system develops. This rapid switch to estuarine conditions provides real time insight into a temporary fluvial-marine transition. The Muni-Pomadze lagoon is located on the central coast of Ghana. Three ephemeral streams forming a small coastal river catchment drain into the lagoon. A beach-barrier separates the lagoon from the ocean with river water and sediment effectively contained behind it. However, at the end of a rainy season, when floodwaters are impounded behind the barrier, the barrier may be breached. Breaching creates an ephemeral opening and short-term connection to the ocean resulting in hydrological and physico-chemical variation in the lagoon. A tidal prism extends into the lagoon and waters become brackish. There is evidence for increased biodiversity levels in the lagoon following breaching - rapid colonisation of the lagoon sediments by marine invertebrates and an increase in fish population have both been observed. Breaching also provides a conduit for sediment transport. Prior to breaching fine-grained alluvial sediment is trapped and deposited in the lagoon behind the barrier. As the lagoon is drained suspended sediment flows through though the breach and out to sea. There is little evidence for transport of beach sand into the lagoon. Once the lagoon is drained the breach is closed by a supra-tidal berm formed by longshore currents that transport sediment from the west. Sediment overwashing and overtopping of the barrier occurs during storm events. Small washover fans, developed at low points along the lagoon side of the barrier have formed indicating some influx of marine water and sediment into the lagoon. However, from aerial photos the locations of these fans have remained stable and their size constant from 1972 (earliest available air photos) to the present. The small size and stability of these fans suggests that overwashing has remained relatively consistent during this time. This is in contrast to the incidence of breaching, which appears to be more frequent due to erosion of the barrier. Digital mapping and GIS analysis has revealed that 36 meters of stable barrier at its breach end was removed by erosion between 2005 and 2014. Unconsolidated sands that currently form a transient, spit-like feature have replaced the stable barrier. Sea level rise creates the potential for further barrier erosion and an increasingly permanent connection between the lagoon and ocean; it might also provide the opportunity to observe the shift to a more marine dominated environment and estuarine conditions.

Impacts of sea level rise at a lagoon-barrier system, Ghana

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Modern lagoon-barrier systems are highly sensitive to changes in sea level. Their formation is associated with sea level rise (SLR) following the end of the Pleistocene glaciation and there is increasing evidence of their susceptibility to erosion and destruction in the face of current rising sea levels. Understanding the response of lagoon barrier systems to rising sea level not only contributes to the knowledge of coastal sedimentary systems but can also assist in predicting and managing coastal hazards. The Muni-Pomadze lagoon (MPL) is located on the erosion-dominated central coast of Ghana. It is a closed lagoon fronted by a beach barrier. The 2 km long barrier prevents connection with the ocean except during rare breaches. The lagoon's status as a Ramsar site has limited the anthropogenic impact on it, making it a good location to consider recent shoreline changes associated with SLR. The influence of SLR on the MPL shoreline was considered from three perspectives: (1) analyzing shoreline imagery for evidence of recent change (2) assessing current shoreline erosion and sedimentation along the barrier and (3) predicting the effects of a one-metre SLR. The barrier beach has undergone recent retreat. GIS analysis comparing the 2014 high-water mark (HWM) along the beach barrier with aerial images from 1972 indicates that approximately 9 metres of shoreline retreat (average rate 0.22 metres per year) has occurred with an areal loss of approximately 22,000 m^2 of shoreline. Although shoreline retreat occurred along the whole barrier, analysis of imagery shows that between 2005 and 2014, 36 metres was eroded from the breach end of the higher, vegetated part of the barrier. The more resilient barrier has been replaced by an unstable sandy spit. Exposed tree roots at the breach end of the barrier indicate that this erosion is ongoing, actively decreasing the length of the stable barrier. The transition from a stable barrier to a more transient spit has increased the potential for barrier breaching and marine flooding of the lagoon. Shortening of the barrier by erosion appears to be more significant than landward migration by overwashing. Although there are a few washover fans, imagery and field observation shows that they are unchanged in size, shape and location during the 42 years of record suggesting that landward migration of the barrier is not keeping pace with SLR. Projections for a one-meter SLR assume that barrier migration does not keep up with rates of erosion and SLR. The one-meter projection reveals fragmentation of the barrier into a number of small islands with an associated increasingly permanent connection to the ocean and shift to estuarine-like conditions. The loss of the barrier and transition to a more open estuarine environment increases the risk of coastal flooding, forces relocation of the local community and alters ecosystem services currently provided by the lagoon system.

Abiotic and biotic opaline speleothems in the Algar do Carvão cave (Terceira, Azores)

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The vertical, volcanic Algar do Carvão cave is located in the central area of Terceira Island (Azores, Portugal) within the Basaltic Fissural Zone. It is the only tourist-visited cave with large siliceous speleothems anywhere in the world. It descends to 80 m and has a large lake at the bottom.
Opaline speleothems are distributed throughout the cave. They appear mainly as stalactites (1m of height and 40-50 cm of diameter), stalagmites (50 cm of height and <1m de diameter) and flowstones covering the ceiling and walls; they are formed by drip and runoff of meteoric water. X-ray diffraction analyses showed them to be formed of opal-A (amorphous silica). Their patterns included a broad scattering band between 15 and 30 2°. The full width at half maximum of the distinctive 22° diffraction band varied from 6 to 7.9 2°, indicating disordered opal. Examination of thin sections by optical microscopy showed an alternation of white and transparent microlaminations (50-700 µm). Scanning electron microscopy (SEM) revealed silica microspheres some 0.3-0.5 µm in diameter forming smooth and lumpy microlaminations. Some of the latter showed places with moulds of filamentous bacteria. The opal-A of the speleothems is mainly formed by inorganic precipitation, although the above filamentous bacterial moulds indicate a local biogenic role in the appearance of some microlaminations.
The δD value for the stalactites and flowstones was -103.7±11.1‰, while that for $\delta^{18}O_{SMOW}$ was 39.4±0.3‰. These values are in agreement with their formation via precipitation from meteoric water.
The quantity of silica in these speleothems cannot come simply from the leaching of the volcanic rocks; nearby geothermal systems are likely involved. The water vapour released by these systems contains acidic gases (CO_2 and H_2S). The resulting acidified water dissolves siliceous minerals from the rocks and sediments over which it flows, leading to the precipitation of opal-A when it reaches the cave.

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Fresh water inflows and eutrophication during the deposition of the Messinian gypsum: Insights from the Piedmont basin (NW Italy)

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Giant evaporite salt basins formed in deep time in response to the onset of extreme arid climate condition and hypersalinity. A celebrated and extensively documented example is the Late Miocene Mediterranean basin in which, during the Messinian salinity crisis (MSC), more than 1 million of km^3 of evaporites (gypsum and halite) were deposited in both deep basinal areas (now buried below the abyssal plains of the Mediterranean sea) and in a mosaic of peripheral sub-basins (which provide most of the present day MSC outcropping successions). The reference sections of these peripheral Messinian evaporites are located in the western, southern and eastern parts of the Mediterranean; conversely, the northernmost sector is much less known. Here we present the results of stratigraphical, sedimentological, paleontological and geochemical studies on the Messinian gypsum deposits formed during the first phase of the MSC in the Piedmont Basin (NW Italy), a land-locked peripheral basin located at the northwestern edge of the Adriatic Gulf. These deposits, referred to as the Primary Lower Gypsum unit (PLG) show a remarkable lithological cyclicity, with the rhythmic repetition of shale/gypsum couplets that are considered to reflect precession-controlled humid-arid climate oscillations. The biotic content of the gypsum layers is unexpectedly very similar to that of the shales and consists of marine and brackish water diatoms, clay-rich aggregates and enigmatic filamentous fossils (the so-called spaghetti-like structures) that are interpreted as fossilized sulfur-cycling megabacteria (like *Beggiatoa* and *Thioploca*). This peculiar fossil assemblage is thought to reflect conditions of increased productivity in the water column, triggered by high fluxes of nutrients in the basin during phases of enhanced riverine runoff and fresh water discharge, rather than being the product of increasing salinity and evaporation rate. These conditions promoted a diffuse eutrophication of the water column, fostering the deposition of thin layers of organic-rich sediments on the growing gypsum crystals; degradation of organic material by sulfate-reducing bacteria provided the elevated levels of hydrogen sulphide necessary for the growth of sulfur-cycling megabacteria which were rapidly entrapped within the gypsum. Other lines of evidence point to the strong influence of fresh water inflow during the first phase of the MSC in the Piedmont Basin, including i) the palaeobotanical content of the PLG unit, which indicates the persistence of moist climate conditions, ii) the very low salinity data (average of 1.6 wt% NaCl equivalent) from gypsum fluid inclusions, and iii) the sharp increase of lipid biomarkers derived from the continent above the MSC onset. These observations pose the crucial question whether other mechanism rather than the sole evaporation of seawater were capable to provide SO_4^{2-} enrichment necessary for gypsum precipitation. The attribution of the studied filaments to fossils of sulfur-cycling megabacteria opens the way to consider the possible role of microbially driven sulfur-redox reactions in sulfate concentration and marginal gypsum precipitation.

Depositional architecture and facies character of the Tivoli Pleistocene travertines (Acque Albule Basin, Central Italy)

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Hydrothermal travertine deposits display a variety of decametre to kilometre-scale geobody geometries, complex internal stratal patterns, millimetre to metre scale vertical alternations and lateral transitions of various precipitated fabric types and associated primary porosities.
Six boreholes were cored in the Upper Pleistocene travertines of the Acque Albule Basin (Tivoli, Central Italy) to investigate the character and spatial distribution of travertine facies along a 3 km long, N-S oriented transect. The studied travertines are wedge-shaped with variable lateral thickness (20-45 m thick), gently dipping and thinning towards the South and East. The travertines overlie a tens-of-metres thick succession of Middle Pleistocene deposits comprising lacustrine siltstone and marls with ostracodes, molluscs and Charophytes, alluvial plain siltstone and sandstone and pyroclastic deposits erupted by the Sabatini Mts. and Albani Hills volcanic districts. In the southernmost distal area, travertines are intercalated with alluvial fluvial siltstone, sandstone and conglomerates of the Aniene river, which borders the southern end of the travertine unit. In most of the analysed cores, the onset of hydrothermal carbonate precipitation followed the deposition of 1-2 m thick organic matter-rich mudstone of marsh environment.
The studied travertine unit is subdivided into three zones (proximal, intermediate and distal) with respect to facies composition and depositional environments. In the northern proximal area, closer to the hydrothermal vent, travertines are characterized by facies types indicative of shallow ponds and pools of terraced slopes, such as clotted peloidal micrite dendrites boundstone, radial spherulite grainstone, coated reeds, rafts and coated gas bubble boundstone. The intermediate depositional zone, nearly 2 km southward, is characterized by 10 m thick, smooth slope facies with crystalline dendrite cementstone, laminated boundstone and radial spherulite grainstone with dips up to 45° towards the E and S. The southernmost distal zone consists of travertine ponds dominated by coated vegetation and Charophytes. Travertine stable isotope data indicate average values of 9.8 ‰ V-PDB for $\delta^{13}C$ (range from 8.5 to 12 ‰) and of - 6.4 ‰ V-PDB for $\delta^{18}O$ (range from -7.5 to -4.8 ‰), confirming the geothermal origin of the precipitating spring water. In the southern distal area, the influence of freshwater due to the proximity of the Aniene river in facies with coated reeds and Charophytes is supported by the decrease of the $\delta^{13}C$ to values of 5 ‰. The travertine succession is marked by numerous centimetre- to metre-thick clayey intraclastic/extraclastic wackestone to floatstone/rudstone indicative of non-deposition and erosion, due to temporary interruption or deviation of thermal water input. Two major unconformities, 0.5-8 m thick, are associated with metres thick beds of coated reed and Charophytes boundstone to packstone, similar to the distal southernmost freshwater-influenced facies.
The complexity of the Tivoli travertine facies architecture results from the interplay between several regional and local factors that control the sedimentary dynamics, such as extensional and strike-slip fault and volcanic activity, humid climatic phases, substrate lithology and topography, and basin hydrology that influence the vent location and discharge rates, flow paths and physico-chemical properties of spring water, and the rates and modes of carbonate precipitation.

Trace fossils from the Malatya basin ramp deposits (Upper Campanian-Maastrichtan), Eastern Turkey

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The uppermost Cretaceous (upper Campanian-Maastrichtian) transgressive ramp deposits of the Malatya Basin (Eastern Turkey) were accumulated in a gradually deepening environment ranging from mid-ramp to outer ramp and basin. Rudist bearing shallow-marine limestones in the basin are overlain by abundant planktonic foraminifera and nannoplankton-bearing mudstone-dominated 'deep' marine strata. Trace fossils of the 'pelagic' deposits were studied in Yeşilyurt and Hekimhan areas.
Rudist-bearing bioclastic limestones are gradually overlain by more than 100 m thick claystone/shale and marl/clayey limestone alternation in Yeşilyurt area. Marls and clayey limestones are dominated by planktonic foraminifera-bearing carbonate mudstone to wackestone depositional texture (autochthonous deposits). The succession includes calcarenite beds dominated by rudstones-floatstones in several stratigraphic levels. These layers are represented by abundance of shallow-water litho-bioclasts embedded within the planktonic foraminifera and calcisphere-bearing micritic matrix (allochthonous deposits). The succession includes sandstone and conglomerate interlayers and levels of slumped beds in the upper parts as well. The trace fossils in the Yeşilyurt area were observed through several stratigraphic levels which consist of *Chondrites* isp., *Palaeophycus* isp., ?*Phycodes* isp., ?*Planolites* isp., *Rhizocorallium* isp., *Taenidium* isp., *Trichichnus* isp., *Zoophycus* isp.
Approximately 1100 m thick pelagic successions in the Hekimhan area gradually overlie the rudist-bearing neritic limestones. The pelagic sequence is dominated by flysch-type sandstone-mudstone alternation with complete and partial Bouma sequences. Carbonate content of abundant planktonic foraminifera and nannoplankton-bearing 980 m thick siliciclastic succession gradually increases upwards and siliciclastics pass into clayey limestones and marls. Trace fossils in the Hekimhan area are observed in boths siliciclastics and carbonate-dominated deposits, which include *Ophiomorpha* isp., *O. annulata*, *O. rudis*, *Palaeophycus* isp., ?*Planolites* isp., *Halimedides* isp., *Cosmorhaphe* isp., *Paleodictyon* isp., *Paleodictyon* cf. *croaticum*, *Paleodictyon majus*, ?*Scolicia* isp., *Trichichnus* isp., *Zoophycu*s isp., and root traces.
Yeşilyurt area has relatively low diversity of ichno-assemblages which are indicated by *Cruziana-Zoophycos* ichnofacies. However, Hekimhan area contains a moderately diverse *Nereites* ichnofacies.

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Ichnological features of prodelta sediments from the Mezardere Formation (Late Eocene - Early Oligocene), Gökçeada Island, Nw Turkey

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The Mezardere Formation (Eocene-Lower Oligocene) in the Gökçeada Island is 400–900 m thick. It is composed mostly of thin-bedded, light grey, calcareous, fissile mudstones and siltstones. They display fine parallel lamination or rarely ripple lamination, and locally contain concretions. These sediments are intercalated with isolated thin beds of very-fine grained or fine-grained slightly muscovitic sandstones. The sandstones display parallel lamination in the lower part and ripple lamination in the upper part, or only ripple lamination. Fine carbonized plant detritus is commonly dispersed in the sandstones. The fine-grained sediments are interpreted as prodelta deposited at the depth of 50–80 m (Hoşgörmez & Yalçın, 2005).
The Mezardere Formation contains local packages of coarsening and thickening upwards sandstones that are interbedded with siltstones and mudstones. The sandstones were deposited in distal mouth bars. In the middle of the formation, lens bodies of thick, thickening up, cross-bedded sandstones are present and are interpretd as proximal mouth bars. Locally, fillings of small channels of delta slope are recorded as packages of lenticular sandstone bed.
The delta front sands do not contain trace fossils or bioturbational structures. The prodelta sediments are poorly bioturbated (ii = 0-1). Only on surfaces of some sandstone beds a low-diverse trace fossil assemblage occur, including *Archaeonassa fossulata*, ?*Arenicolites* isp., *Bichordites kuzunensis*, *Gordia* isp., *Helminthoidichnites tenuis*, cf. *Halimedides* isp., *Haplotichnus* isp., *Palaeophycus tubularis*, *Planolites montanus*, *Planolites* isp., ?*Ptychoplasma* isp., cf. *Treptichnus* isp., ?*Undichna* isp., and some arthropod trackways and resting traces. *Gordia* and *Helminthoidichnites*, produced probably by the same tracemaker, are the most abundant trace fossils. The low diversity of trace fossils is typical of deltaic sediments, but it is distincly lower in the Mezardere Formation and in other deltaic sediments, without contribution of typically marine ichnoataxa. This suggests a stronly brackish waters in the basin, however the occurrence of *Bichordites kuzunensis* Demírcan & Uchman, 2012 in one outcrop (Kuzulimanı), produced by small echinoids, suggests local episodesof normal marine conditions.

Evidence of supercritical flow during deposition in delta front clinothems of the Eocene Sant Llorenç del Munt fan delta, Ebro Basin, Spain

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Crossbedding, paleocurrent and accretion dip directions, and vertical successions within the sandy delta front clinothems of the Eocene Sant Llorenç del Munt fan delta deposits in the Ebro Basin of eastern Spain, record evidence of supercritical flow conditions (densiometric Froude # > 1) during deposition by sediment gravity flows.
The Sant Llorenç del Munt fan delta deposits are comprised of progradational to aggradational sequences of conglomeratic alluvial topset and sandy marine foreset strata. Although the entire succession is made of several composite sequences, this study was focused on the oldest, termed the San Vincenç composite sequence. Delta foreset heights, reflecting water depths, range from 40 - 80 m, while foreset lengths (from brink point rollover to downlap) range from 100's m to ~1 km, resulting in foreset dip angles from 4 - 6 degrees.
Supercritical flow features include sigmoid-like, humpback trough crossbedding, asymptotic and downlapping upstream-dipping foresets, brinkpoint and topset preservation, grain and outsized clast imbrication, and associated scour and fluidization structures. Sigmoid-like humpback crossbedding is interpreted to have formed by the migration of dunes. Upstream-dipping asymptotic foreset strata are interpreted to have formed by upstream migrating, long-wavelength antidunes, while upstream-dipping, downlapping foreset strata are interpreted to have formed by upstream-moving traction carpets encroaching into the scour pit of an upstream-migrating cyclic step.
These features are interpreted to have formed by supercritical bedforms migrating within mouth-bar, delta front, gully, and perched and toe-of-clinothem lobe environments. Mouth bar strata are comprised of multiple successions of sandy and conglomeratic backset (upstream-dipping accretion direction) strata separated by high-relief scour surfaces. Delta front and gully-fill strata (2-6 m thick) also exhibit exhibit backset strata, although within conformable sandy successions interbedded with bioturbated calcareous mudstone. Perched and toe-of-clinothem lobes (1-3 m thick) exhibit low relief scour surfaces, low-angle backset strata, and shallow (< 1 m thick) channel-fills with basal rip-up clast conglomerates.
The supercritical bedforms in the Sant Llorenç del Munt fan delta deposits are interpreted to have formed by sustained sediment gravity flows (possibly hyperpycnal) fed by flood events, and subsequent mass sediment movement in mouth bars formed at the terminal end of fluvial/distributary channels. Cyclic steps and long-wavelength antidunes migrated within channels and gullies in the mouth bar and delta front. The gullies fed lobes both perched on the delta front and at the slope change at the toe-of-clinothem. Similar features are forming in the modern Squamish River delta front in British Columbia, Canada.

Tectonic and sedimentary characteristics of the Cuu Long Basin, south Vietnam

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The Cuu Long Basin, located offshore southeast Vietnam, is a continental rift basin between the Indian plate and Eurasian plate, and deposited 3,000 m to 8,000 m sediments in Cenozoic. Researches indicated that the Cuu Long Basin was formed by the crust extension and magmatic activity in the northern continent margin of the South China Sea. It has experienced 5 stages of tectonic evolution, including formation of basement before late Eocene, initial and continued rifting in late Eocene to Oligocene, thermal subsiding stage I in early Miocene, re-extension in mid-Miocene and compression then thermal subsiding stage II in late Miocene to Quaternary. Influenced by tectonic actions, this basin has experienced 5 major sedimentary periods. In the initial period, the basin was an intracratonic environment before late Eocene, sediment was mainly basement rock predominantly composed of crystalline acid magmatic rocks. Then with initial and continued rifting, the basin turned to terrestrial environment in late Eocene, which lasted until early Miocene. Fluvial deposits, coastal and shallow lacustrine deposits, delta deposits and lagoon deposits dominated the basin in Eocene to Oligocene. Sediments were sandstone, mudstone and conglomerate. During the first stage of thermal subsidence in early Miocene, the Cuu Long basin mainly developed tidal deposits. Sediments were siltstone, sandstone and mudstone. With the re-extension and sea level rise in mid-Miocene, the basin turned to transitional facies. From late Eocene to mid-Miocene, the sediments in basin were more than 2000 m, even more than 5000 m in the sedimentary center of the Bach Ho oil field. Finally, with the second stage of thermal subsidence and continued sea level rise, the basin turned to marine environment in late Miocene to Quaternary, and shelf deposits, slope deposits, bathyal deposits, abysmal deposits and carbonate deposits dominated the basin. Sediments were sandstone, siltstone, turbidite, mudstone and carbonate rock. The marine deposits were about 1500 m, with the thickest up to 3000 m local. The lagoon deposits in Oligocene formed the mainly hydrocarbon source rock of Cuu Long basin. And the adjacent sandstone, carbonate rock and basement rock are the potential reservoir for oil and gas.

Surfacial processes and deep-sea sedimentation: When source-to-sink systems are no more preserved

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Deep-sea sedimentary successions are fine records of surface processes affecting the Earth. In compressional settings, they may result the unique archive of the multiple stages that constitute the growth of a mountain belt, as source-to-sink systems are often completely dismantled by post-depositional tectonics. Indeed, the analysis of facies architectures and sediment compositional trends, which are functions of climate, tectonics and volcanism, has a fundamental role in understanding what and how long geodynamic and climatic processes have contributed to shape the Earth surface.
Here, we take in account the Val d'Aveto Formation (32-29 Ma; Northern Apennies, Italy), a foredeep Formation that has been deposited during the early stages of the subduction of the Adriatic plate beneath the European one. We unravel the significance of its stratigraphic record through facies and petrographic analyes (clast-counts, sandstone point-counts and minero-chemical investigation through X-ray diffraction and SEM-EDS). All of these analyses, carried out in the field and in laboratory, had the aim of define 1) the evolution of the sedimentary architecture of this turbidite system, 2) the compositional trends of the deposits, and 3) the sediment provenance area, in order to unravel the impact of tectonics, volcanism and climate on the sedimentation.
In this way, we documented that:
1) Climate has a primary role on transporting detritus across the source-to-sink, consequently shaping the turbidite system in response to cyclical sea level variations. Minor is its effect on sediment production.
2) Tectonics plays a fundamental role on the production of siliciclastic detritus, promoting also variation in sediment compositions in response to the activation of deformational fronts.
3) Volcanism had a high impact on the environment during eruptive events, both in terms of sediment production and transport, but its effects rapidly disappear as the sedimentary system re-approach to pre-eruptive conditions.

What killed the Tertiary Southalpine carbonate platform?

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The carbonate platforms of the Tertiary Alpine basins (Northalpine Molassa and Southalpine Foredeep basin) are shaped by the different geodynamic settings. According to the classification of Bosence (2005), the Northalpine basin hosted a foreland margin platform (Nummulitic Limestones), whereas the Southalpine basin probably hosted a thurst-top platform that supplied the shallow-water carbonate turbidites of the Ternate Formation. Actually, this latter carbonate platform is no more present, rapidly eroded during the Oligo-Miocene evolution of the Southern Alps, but a paleoecological reconstruction have been provided by Coletti et al. (in prep.) through the analysis of pebbles encountered in the Oligo-Miocene siliciclastic turbidite fan of the Gonfolite Lombarda Group. Here, we first reconstructed the suitable conditions of rise and growth of this narrow platform on top of the active thrusts of the Southern Alps during the Eocene and Early Oligocene, and then investigated the geodynamic processes that have contributed to killing it in the Early Oligocene. We envisaged a top-thrust platform grown up in front of gentle relieves of Jurassic to Cretaceous sedimentary covers, as suggested by the abundant and angular Mesozoic pebbles encountered in the turbidite fan of the Ternate Formation. The large presence of mass flow deposits and marly, often plurimetric soft clasts also suggests that a small, instable delta was frequently discharging terrigenous detritus through flash flood events moving across the platform deep into the basin.
The abrupt disappearance of re-sedimented shallow-water carbonates probably corresponded to the death of the platform soon after the Early Oligocene, but doubts are still present on the causes that triggered it. The temporal gap (at least 5 Ma) that divides the top of the Ternate Formarion and the first clastic inputs of the Gonfolite Lombarda Group (~27 Ma) may indicate that the onset of the major phase of growth of the Alpine belt was not the primary cause of the disappearance of the narrow Tertiary Southalpine platform, but maybe the changed climate conditions exposed it to karsification processes and prevented its survival.

Facies architecture and depositional model for the Coimbra Group, Lusitanian Basin (Portugal)

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A depositional model is proposed for the Lower Jurassic shallow-marine carbonate succession (Coimbra Group) of the Lusitanian Basin, in the Coimbra-Penela region (western-central Portugal). Detailed field information from 21 stratigraphic sections (among several dozens of other observations) and from structural-geology surveys, was mapped and recorded on graphic logs showing the lithological succession, including sedimentological, palaeontological and structural data. Facies determination was based on field observations, petrographic and X-Ray diffraction analysis. Vertical distribution of clay mineral assemblages (especially the relative abundance of illite, kaolinite and smectite) served as paleoclimate indicator. Lateral and vertical facies trends were evaluated.

A formal lithostratigrafic framework is proposed for the Coimbra Group cropping out in the eastern part of the basin (more landward zone of the Lusitanian Basin – i.e. in the proximal domain), ranging in age from the early Sinemurian to the early Pliensbachian and recorded in two distinct subunits: the Coimbra formation, essentially dolomitic; and the overlying S. Miguel formation, essentially dolomitic-limestone and marly-limestone. Locally, the Coimbra formation may be subdivided into 3 subunits, with a thickness in the order of 20±10 m in Coimbra and 45±10 m in the Penela region. In turn, the S. Miguel formation may be subdivided into others 4 subunits, with a thickness in the order of 50±10 m in Coimbra and 60±10 m in the Penela region. The lithostratigraphic boundary between the two formations correspond to a local disconformity with very short-term subaerial exposure evidences (intermittent/ephemeral, with local micropalaeokarstic dissolution) linked to possible synsedimentary intra-Sinemurian tectonic pulses.

The 15 identified facies were subsequently grouped into 4 genetically related facies associations indicative of sedimentation within supra/intertidal, shallow partially restricted subtidal-lagoonal, shoal and more open-marine (sub)environments.

The integration of the results obtained by facies and sequential analysis allow to presenting an evolutionary palaeoenvironmental framework - at local scale. A general long-term transgressive phase is evidenced by the progressive deepening of the carbonate system, with environments ranging from tidal flat-protected lagoon to high-energy and low-energy open-marine, suggesting a general back-stepping of a coastal/peritidal system (during the Hettangian-lower Sinemurian, possibly to the base of the upper Sinemurian) and a very shallow, inner part of a low-gradient, carbonate ramp system that begins to develop in the second half of the upper Sinemurian.

Two types of dolomitization are recognized: one (a) syndepositional (or early diagenetic), massive-stratiform, of "penesaline type", with the concurrent action of microbial activity; another (b) later, localized, common during diagenesis (sometimes with dedolomitization), particularly where fluids followed discontinuities such as joints, faults, bedding planes and, in some cases, pre-existing palaeokarstic features.

Jurassic-Lower Cretaceous facies and biostratigraphy of the Danubian nappes (eastern Serbia)

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In eastern Serbia, the Mesozoic successions are exposed along the valley of the Danube River. They represent the Danubian nappes which belong to a much larger Dacia Mega-Unit. It was a part of the European continent detached from it during Jurassic rifting in the easternmost domain of the Alpine Tethys and docked again to the European foreland during the Miocene. Three sections with Jurassic–Early Cretaceous deposits crop out along the road Dobra – Boljetinsko brdo. In the studied area, Jurassic sedimentation began with clastic deposits that transgressively overlie Permian rocks. Three considerably different successions were studied above the Lower Jurassic quartz sandstone and conglomerate. The first succession, exposed between tunnels no 17 and 21, is over 150 m thick and typical of a deep-water basin. The following units occur in stratigraphic order: red shale with intercalations of thin beds of nodular limestone; white marly limestone that transits upwards into well-bedded limestone with subordinate marly interlayers; thin-bedded green and upsection red calcareous radiolarite; indistinctly bedded grey marly limestone; well-bedded reddish limestone with chert nodules and interlayers of dark red shale. Several breccia and calcarenite beds are interstratified in the last unit.
The second succession (exposed at tunnel no 10) indicates deposition on a pelagic plateau. This section is much more condensed, not exceeding 20 m in total thickness. The predominant facies is red nodular limestone of Rosso Ammonitico type. Rare chert nodules and layers exist only in the middle part of the section. Slumped beds and intraformational conglomerates occur in the upper half. Both sections continue with a thick succession of light grey micrite with chert nodules that closely resembles the Maiolica limestone of the Southern Alps. Up to several meters thick slumped levels are common in this Lower Cretaceous limestone.
The third succession (exposed at tunnel no 13) is also condensed (total thickness 17m) and indicates deposition on a pelagic plateau. This section is characterized by a thin, but rather conspicuous interval of alternating green, violet and red radiolarites.
The first section represents a deeper basin, whereas the other two were deposited on a pelagic plateau. These successions indicate a typical horst-and-graben topography, well known from other domains of the Alpine Tethys. The topographic difference was apparently diminished by the Early Cretaceous, when Maiolica type limestone became ubiquitous as is now confirmed also with radiolarians.

Stratigraphy, fluids and ecology: The genesis of bio-concretionned rocky outcrops (tegnùe) of the northern Adriatic shelf

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The occurrence of localized rocky outcrops up to 2-3 m high, interrupting the otherwise silicoclastic inner shelf of the north-western Adriatic Sea at depths between 15-40 m, is anecdotally known since centuries. Such 'rocks', grouped under the dialectal name of tegnùe, are known by fishermen for their fishing value but also as a threat to trawling. Their ecology is a subtype of coralligenous habitat. Their nature, however, could not be understood by ecology alone since such epifaunal and algal component is mainly a later exploitation rather than a genetic cause of this peculiar habitat. A running hypothesis for years was that these rocks represented Holocene beachrock deposits formed at a very early stage of the post-glacial transgression. However, a better understanding of the processes has been always hampered by the difficulty in getting samples of diagnostic value. More recently, convincing arguments have been put forth supporting that part at least of the northern Adriatic tegnùe are linked to calcium carbonate precipitation by hydrocarbon-imprinted fluids. A project undertaken in 2013 by the municipality of Chioggia has been addressed to study a marine area, where these outcrops are particularly prolific, by means of high-resolution seismic stratigraphy, oceanographic measurements and bottom sampling. A metric stratoid collected at 23 m water depth proved to be an excellent archive registering the various steps that led a shelly sand sediment to turn into a rock first and then a coralligenous habitat at present. The sample embeds a variety of disarticulated and oriented shell remains, mainly bivalves, sourced by lagoonal to shallow marine environments. AMS14C dating of some such bioclasts reveals that they have an age comprised between ca. 7.3 and 9.2 kyrs cal BP. Such ages are consistent with the proposed time when the post-glacial sea level rise reached this depth. The shelly sand is therefore interpreted as a condensed section above the ravinement surface. SEM-EDS, cathodoluminescence and geochemical mapping document that this highly porous sandy deposit got cemented by only one generation of calcium carbonate identified as scalenohedral calcite coating individual clasts. As suggested by the chronology of the fossiliferous calcarenite, this process took place under marine conditions but the marine-vadose typology of the cement suggests the interaction between marine and less saline fluids, likely related to onshore freshwater discharge at sea by a sealed water-table. Our research thus documents a new modality for the formation of at least one typology of these Adriatic outcrops. Calcarenites thus formed may keep buried or get exhumed by oceanographic causes. In this latter case, they can become site of faunal and algal colonization. Although our study does not identify hydrocarbon-seepage as of the main drivers for the genesis of tegnùe here, nevertheless our lastroid contains small pebbles of a dark mudstone whose bulk $\delta^{13}C$ depleted composition is a signature of hydrocarbon seepage. We suggest that hydrocarbon-seepage was conducive to lithification of fine grained (lagoonal?) sediments quickly eroded by the transgression and embedded together with the shells in the chaotic condensed deposit which is core to the tegnùe.

Novel colour characterization of modern marine cores; grain size determination and trace fossils disturbance

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Colour analysis is proved as a very useful proxy in research of deep-sea modern cores. Colour characterization is a highly diagnostic feature of sedimentological, geochemical/mineralogical and paleontological properties (i.e., sediment composition, carbonate content, grain size, etc.). Thus, colour variations have been applied in high resolution climate studies or in chronostratigraphic models. A novel colour characterization has been applied on cores from the IODP Expedition 339 to test its usefulness in colour analysis of deep sea modern materials deposited in the Gulf of Cadiz and western Iberian Margin, where turbidites, contourites and hemipelagic deposits can be found. The method is based on the measurement of pixel values of images that was previously treated by adjustment modifications. The application allows differentiation of colour intervals based on the obtained pixel values. Colour information can be related with lithology, even more precisely that other previous analyses executed on shipboard using the Munsell Colour chart. Obtained colour values were compared with the grain size distribution, showing a clear relationship reflected in a high linear correlation value; darker intervals that are characterized by lower pixel values are related to coarser grained sediments, while, lighter sediments with higher pixel values are associated to finer grained sediments. Additionally, the ichnological analysis was conducted to evaluate the influence of trace fossils on the sediment colour, showing that the obtained colour data are variably determined by sediment mixing. This influence has been proved in different situations, regardless of the type and size of traces and degree of bioturbation. Therefore, the sediment mixing caused by the tracemaker activity can modify the colour and, consequently affect those interpretations that are inferred from the analysed data. Thus, a detailed ichnological study would be conducted in any sedimentological study of deep-sea modern cores that considers colour characterization, in order to avoid misinterpretations of the involved parameters.

Late Quaternary palaeoenvironmental evolution of the southern Evoikos Basin, Aegean Sea as deduced from palaeontological and sedimentological data

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A (micro)-palaeontological and sedimentological investigation was undertaken on several cores recovered by Athens University in the South Evoikos Basin, a down to 145 m deep marginal basin in the Central Aegean Sea, which receives little terrigenous supply and its sedimentation is dominated by hemipelagic processes, elucidated the palaeoenvironmental evolution of the area during the last 90 kyr.
Lithofacies associations display the same cyclic development as recorded along the entire East Mediterranean Sea, centered on organic rich sapropelic sediments. Although lithofacies chromatic variations are not as striking if compared to deeper basins, nevertheless consistently score increased OC contents and securely correlate to the S1-S3 stratigraphic levels. This is further documented by C14 dating. Grain size plots display well established trends of fining silts during MIS 1, MIS 3 and MIS 5 high sea level stages and coarsening median diameters to sands during low sea level MIS 2 and MIS 4 times. Carbonate contents and mineralogy also display comparable cyclic variations with enhanced carbonate contents and minerals during low sea levels and reduced carbonates and enhanced siliclastic silts and clays during high sea levels. Sedimentological and micropaleontological data, especially benthic foraminifera suggest a number of substantial changes in sedimentation and also food/oxygen availability to the benthic ecosystem during the last ~90 ka BP. Cluster analysis (Q-mode) based on the most abundant taxa was used to recognize similarities within the data set. Four main clusters were established by Q-mode cluster analysis. The *Elphidium* spp. – *Haynesina* spp. Assemblage corresponds to a marginal marine environment of low productivity, well oxygenated estuarine waters inflow and vibrant currents referable to transition from MIS 5 to MIS 4. The *Cassidulina carinata* Assemblage corresponds to a transgressive trend from MIS 4 to MIS 3, from a foreshore environment into a marine circalittoral domain with paleontological evidences of water stratification events and sustained eutrophication. The *Bulimina gibba* Assemblage signifies a shallow to very shallow sedimentary basin, possibly part of a coastal lagoon as those developed on the shelf, indicative of the extensive regression that took place in the second half of MIS 3 and during the course of MIS 2.
Finally, the *Bulimina marginata* Assemblage supports open marine sedimentation with high organic productivity and low oxygen concentration. This assemblage prevailed during the transgression of MIS 1 and especially within the time interval of the deposition of the well-established uppermost East Mediterranean Sapropel S1, which is also identified in the South Evoikos Basin.

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Siliciclastic rift sequences in southwestern Tasmania: Identification of Cambrian–Ordovician lacustrine sedimentation?

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Rifting in the Late Cambrian–Early Ordovician of northern and western Tasmania created a complex system of grabens and half-grabens. These provided accommodation space for large volumes of basement-derived sediments, dominated by extensive alluvial fans and braided river facies. Depocentres migrated both spatially and temporally as rifting continued. Thickness variations and dramatic differences in the coarseness of the conglomerates have been used to identify the active basin margin faults of tectonically active troughs.
Regional palaeogeographic reconstructions of the Arenig stage demonstrate that Tasmania was located outboard of the eastern margin of Gondwana, sited north of the palaeoequator between latitudes 10° and 20°. The Late Cambrian through Ordovician tropical climate was dominated by the influence of a strong, extended greenhouse effect. The lack of sediment stabilisation by plants and rootlets in this Early Palaeozoic vegetation-free terrestrial landscape resulted in alluvial and fluvial depositional processes being markedly different than their present-day counterparts. Vegetation typically exerts significant influence on a variety of environmental factors including sediment trapping and stabilisation, decreasing run-off and erosion rates, promotion of soil and regolith development, and impacts on hydraulic processes. In particular, energy levels and run-off rates would have been an order of magnitude greater, fluctuations in energy levels more extreme and high energy events more frequent.
Five broad lithofacies have been recognised in the Late Cambrian–Early Ordovician siliciclastic sequence of northern Tasmania: Three lithofacies are interpreted to represent terrestrial alluvial fan through braided fluvial deposits (displaying debris flow, sheet flow and channel flow geometries), while two represent transitional marine (tidal) to shallow marine environments (dominated by heterolithic bedding and varying degrees and styles of bioturbation). Adjacent lithofacies often have sharp contacts or rapid transition with each other, suggesting accelerated changes in the volume of sediment flux and/or the rate of tectonic subsidence. In addition, sediments within the alluvial fan and braided fluvial settings typically display a strong proximal–distal grain-size relationship.
Surprisingly, there is a paucity of claystone and siltstone within the Late Cambrian–Early Ordovician terrestrial environments of northern and western Tasmania, and this inhibition of lacustrine sedimentation was initially attributed to high sediment flux during the rift event. However, fieldwork conducted in January 2015 in similar-aged, coarse-grained siliciclastic sequences within the remote wilderness area of southwestern Tasmania confirms the presence of two thick fine-grained sequences, totaling at least 200 m. The presence of these units is currently being assessed in terms of the interplay between tectonics and deposition.

Deposition and karstification of Upper Permian Zechstein carbonates on the Utsira High, North Sea

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The Upper Permian Zechstein carbonates on the Southern Utsira High, Norwegian North Sea have been cored in four wells and provide the first detailed information on the Zechstein in the northern most part of the Zechstein Basin at the transition to the Permian successions offshore mid-Norway and onshore East Greenland.
The four cores are all representing the Zechstein 2 unit and consists of interbedded peritidal mud-dominated carbonates and oolitic grainstones, all highly due to later exposure. The carbonates are erosively overlain by Jurassic sandstones, and have most likely been exposed and infiltrated by Jurassic fresh water causing extensive alteration and karstification.
To understand the importance of later fresh water diagenesis on the reservoir properties, we have compared the succession to the time equivalent Zechstein 2 carbonates in the Løgumkloster cores in Southern Denmark. The facies development in the two areas is very similar, suggesting relatively uniform depositional conditions across the northern and southern Permian basin shelf areas. The main differences seem to be the extensive presence of calcite and absence of anhydrite in Utsira High when compared to Løgumkloster.

The first record of *Zoophycos* in the Lusitanian Basin (Portugal): Addressing generalized paleoenvironmental conditions during the lowermost Toarcian

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Trace fossils, as reflecting behavior of tracemakers, have been revealed as very useful in basin analysis, providing valuable information on the depositional and ecological conditions, as reflecting the response of the organisms to the environmental parameters. Particular ichnotaxa and/or concrete records are of especially interest, improving environmental analysis. Lower Toarcian (Polymorphum Zone) sediments from the Lusitanian Basin (Portugal) consist of decimeter- to meter-thick marls and centimeter-thick limestone alternations with abundant benthic and nektonic macrofauna (the Marly limestones with "*Leptaena*" facies of S. Gião Formation; Duarte, 2007). In this facies, the record of *Zoophycos* has been previously indicated, but never studied in detail (i.e., Duarte, 1997; Silva and Duarte, 2012). Preliminary ichnological analysis of the Marly limestones with "*Leptaena*" facies revealed the presence of several beds characterized by dominance of *Zoophycos* being the first record of this ichnotaxon in the Lusitanian Basin. These facies have been interpreted as corresponding to an abrupt flooding event in the whole basin at the base of a second-order depositional sequence. Relationship between *Zoophycos* tracemaker and the marly accumulation agrees with enhancing nutrient flux associated to the flooding event occurring at the early Toarcian. The studied *Zoophycos* could be considered as a stratigraphic interval of reference for correlation through the Lusitanian Basin, reflecting similar palaeoecological conditions affecting macrobenthic tracemaker community.
This singular ichnological event ends at the top of Polymorphum Zone being followed by an abrupt change in ichnofacies, dominated by *Thalassinoides*. This last ichnogenus record that marks the extreme base of Levisoni Zone in eastern part of the basin, is associated with an increase of carbonate deposition in the basin.

New insights into the origin of Mn-rich shrubs in hot-spring travertines using synchrotron analyses

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Travertines are present all over the world, but their conditions of precipitation can be different. Quaternary travertines from the basin of Ouarzazate (Morocco) are classified as thermogenic, because they formed from springs at temperatures between 25-35 °C. Akdim et al. (1991) confirmed the hydrothermal circulation of meteogene water along a network of deep tectonic faults during their formation. Travertines are formed by a succession of various layers, varying in their colour (pink, orange, white, grey) and texture (coarsely to fine-grained). Mn-oxides widely occur in these travertines and can be diffuse or observed as well-developed shrubs. Travertines are well known to be associated with microorganisms, as described by Pentecost and Coletta (2004). Chafetz et al. (1998) investigated Mn-shrubs in Skoura travertines and interpreted them as a result of bacterially-induced precipitation. They used Scanning Electron Microscopy and found rod- and sphere-shaped bodies they assumed to be bacterial fossils. Their interpretation is based on the fact that micro-environments around bacterial bodies induced precipitation due to variations in pH and Eh.
The aim of this contribution is to determine whether the precipitation of Mn and Fe oxides in travertine samples is biologically induced or purely geochemical in origin. A thorough characterization of samples is necessary regarding two major issues: the search of indices associated with biological activity, and the nature of the various mineral phases (which can be compared to physicochemical models). Thin sections have been investigated using optical, cathodoluminescence, and scanning electron microscopes. Minerals were identified using XRD, and oxygen and carbon stable isotopes were used to assess the geochemical conditions of calcium carbonate precipitation (e.g., oxygen stable isotope ratios have been used as a thermometer proxy and points out a range of temperatures between 21–28 °C). In addition, more precise mineralogical analyses and elemental mapping have been performed on microsites of interest, using the synchrotron facilities at the Paul Scherrer Institute (Villigen, Switzerland).
Our results show a fairly complex story of the formation with two main phases. First, aragonite precipitated from warm parent water during intense degasing. Second, partial dissolution occurred, and late calcitic cement precipitated. Cathodoluminescence emphasized what could be interpreted as a partial dissolution of Mn-Rich shrubs. No obvious traces of bacterial activity have been found: under SEM, Mn-oxides appear as needles (max length 1μm), and not as spherical bodies as observed by Chafetz et al. (1998). XRD diffractograms do not show any other mineral than calcite, but new results are expected from synchrotron analyses. Based on the chemical composition obtained with EDS, Mn-rich shrubs are supposed to be pyrolusite in mineralogy, which would be consistent with the geochemical model expressing solid phases in function of partial pressures of O_2 and CO_2 (modified from Garrel and Christ, 1965). Finally, Diffusion Limited Aggregation processes explain the geometry of the shrubs. Our preliminary conclusions are: (i) there is no need for a bacterial mediation to explain the presence of Mn-Rich shrubs; (ii) an abiotic origin of Mn-Rich shrubs remains likely.

The Magdalena Sandstone (Silesian Nappe, Polish Outer Carpathians): Deep-water turbidites or shelf tempestites?

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Palaeobathymetry of the Polish Outer Carpathian 'flysch' basins, now represented by the orogen individual nappes, has long been a central and controversial issue in their analysis. The past 80 years of regional research gave inconsistent bathymetric interpretations, but the vast majority of Carpathian geologists insist that all the Jurassic to Miocene deposits in the Polish Outer Carpathians are of deep-water origin. However, it is likely that in an evolving array of tectonically active thrust wedge-top basins many transient zones of shallow-water sedimentation would form and that their deposits, if not cannibalized by erosion, might locally be preserved within the ultimate nappe stack. This hypothesis is postulated here for the Magdalena Sandstone member at the top of the early Oligocene Menilite Beds formation in the Silesian Nappe.

Recent sedimentological studies of the Menilite Beds in the Gorlice area suggest a shallow-marine origin of this succession, including the Magdalena Sandstone. The occurrence of features interpreted as wave-ripple cross-lamination and hummocky stratification implies deposition above the storm wave base, which means a water depth no greater than 100 m and perhaps less than 50 m on the account of the landlocked nature of the narrow Carpathian Paratethys seaway. The Menilite Beds with Magdalena Sandstone deposits form a 180-m thick succession comprising three coarsening-upwards regressive parasequences. The basal shales of the succession contain sandstone bodies interpreted to be shelf-margin channels or gullies filled by debris flows and high-density turbidity currents, and considered to be a signal of an impending forced regression driven by tectonic uplift. Each of the overlying parasequences commences with heterolithic deposits dominated by grey to black shales and showing lenticular, wavy or flaser bedding as well as graded beds with plane-parallel or hummocky stratification and wave-ripple cross-lamination, interpreted to be outer-shelf tidalites and distal tempestites. The thicker sandstone beds in parasequence middle part, with parallel and apparent hummocky stratification as well as wave-ripple cross-lamination, are considered to be sublittoral prodelta tempestites. The upper part of each parasequence is dominated by coarse-grained quartz-glauconite sandstones and quartz-rich pebble conglomerates, which form broadly convex-upwards packages stacked in an offset 'compensational' manner, interpreted to be shingled distal to proximal mouth bars of an advancing shoal-water deltaic system.

Sedimentation is thought to have occurred on a tectonically-steepened perched narrow shelf, where the accommodation-driven deltaic system was readily reaching the shelf margin. Marine flooding events are attributed to the shelf episodic foundering. The ultimate collapse of the shelf then brought turbiditic sedimentation represented by the overlying succession of late Oligocene–Miocene Krosno Beds.

Stratigraphic architecture of rift-related continental basins at the onset of stretching: Examples from the syn-rift Upper Barremian of the Southwestern Iberian Basin, east-central Spain

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The very onset of stretching during rift basins initiation is not a very well documented process either from the structural and stratigraphic points of view due to: (1) a lack of good geological outcropping examples of ancient rifts, being most of them seriously inverted or buried and (2) the advanced stage of evolution of Present and/or Recent rift systems. For seismically imaged rifts, interpretation of the expected small features representing that early stage of evolution is always challenging.

The characterization of some small and now slightly inverted and outcropping Upper Barremian rift-related basins located at the Serranía de Cuenca (Southwestern Iberian Ranges) has allowed exploring the stratigraphic architectural patterns at the onset of the stretching. The pre-rift carbonate ramps deposited under thermal subsidence conditions underwent a circa 30 M.y. long period of thermal uplift (Oxfordian-Upper Barremian) that led to the development of a prominent regional unconformity.

The low-stretching syn-rift basins developed on an almost flat surface and were filled by the continental carbonate-dominated deposits of La Huerguina Limestones Fm. Basin margin faults lengths range from a few hundred meters to several Km and the thickness of the syn-rift deposits from some meters to a few hundreds.

Then, stretching began with the creation of a few and very small half-graben like basins, isolated and randomly arranged. The sedimentary features of the associated sedimentary wedges were unalike, since they would not be connected. Sedimentation in palustrine environments, and the abundance of paleosols, characterized this phase.

The progression of the stretching led to enlargement of the basins; the hangingwalls of the half-grabens underwent small amounts of rotation in combination with fulcrum displacement outwards from the basin margin faults. Basins were filled by aggrading parallel to subparallel wedge-shaped sedimentary units that progressively onlapped away from the basin margin fault, and thinned out gradually. Development of distal alluvial and palustrine plains, with spotted shallow lakes, was the subsequent sedimentary response due to the creation of slight topographic gradients that allowed drainage.

At the latter stages, the sedimentation tended to expand beyond the basin margin faults, as the whole basin colmatated. The distance between two successive onlap points of the sedimentary wedges increased away from the basin margin fault, resembling "thin wings" in cross section, even with small fault throws. During this final phase, widespread shallow lacustrine and palustrine conditions dominated, accompanying the expansion and leveling of the depositional surface all across the area.

As a whole, this evolution is characterized by a general tendency toward the maintenance of balanced ratios between sedimentation and accommodation rates. In a low stretching area this would contribute to the preservation of the evenly flat landscape

Therefore, the main features of the arising stratigraphic architecture are 1) prevailing of aggradational patterns, 2) progressive increase in the horizontal distance between two successive onlap points away from the basin margin faults, 3) overall stratigraphic architecture dominated by paraconformities and absence of angular unconformities, 4) prevalence of lacustrine and palustrine poorly drained sedimentary environments in the synrift flat landscape.

Structure of the Werra Anhydrite (z1ANa) within the Werra potash deposit

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The Werra potash deposit is located in Central Germany at the border of Hesse and Thuringia. It comprises an area of approx. 900 km² and belongs to the northern part of the South German Block in close spatial association to the Mediterranean-Mjösen-Lineament (Rauche & Franzke, 1990).
Within that area, which was at the southern rim of the Central European basin during the latest Permian, the Werra Formation (z1) has developed as a cyclic succession of clay, carbonate, anhydrite and salt. The Werra salt includes two major potash layers and is generally overlain by clay, anhydrite and carbonates of younger Zechstein cycles. The hanging wall Triassic section consists mainly of sand- and claystone and partly limestone. The precipitation of salts was followed by sedimentation of the reddish, brownish Upper Werra Clay (z1Tb) as salt top. Only minor layers of rock salt were developed in the Werra Formation and in the Staßfurt Formation.
The three-dimensional model of the Werra Anhydrite (z1ANa) representing the salt base was extracted from a 3D geological model for the interval between Permian Rotliegend basement and the Cenozoic cover.
Because of a multitude of geological data including wells, several seismic campaigns of different ages, underground radar measurements as well as isopach and isobaths maps, harmonising the various data sets was an essential first step.
The data were validated and processed with SURFER® to detect input data conflicts with the help of e.g. 2D isopach maps. After this a fault network was created in Paradigm SKUA® based on fault reflection data of seismic and radar profiles including information from underground wells and drifts. SKUA® provides the opportunity to incorporate X-, Y-shaped and dying faults into the model. Considering stratigraphy, the modelled horizons do not overlap within a smaller scale. During this process stress evolution has been taken into consideration. Several observed anhydrite cliffs and walls represent an increased thickness that indicates syn-depositional faulting (Rockel & Ziegenhardt, 1979) and consequently an early segmentation of the Werra Anhydrite can be assumed.
It is important to understand the structural development, thickness distribution and tectonic influences on the Werra Anhydrite to minimize hydrological risks for mining. In addition the facies distribution (Koch & Vogel, 1980) of the potash seams depends on the relief of the basin and the situation of faults.

Brine dilution-concentration cycles in a continental gypsum sequence: Mineralogical and textural results

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Evaporites are natural chemical deposits that have significant economic, scientific and social implications, and are used as indicators of different paleoclimates and sedimentary environments. The chemistry of the brine is controlled by the solutes income and the hydric balance with periods of brine dilution and concentration.
The analysis of outcrop and cores, leads to the establishment of the depositional systems and cyclicity of the Miocene evaporite units found in the "Sinclinal de Villar de Cañas", located within the Loranca Basin (westernmost part of the Tajo Basin, Spain). The evaporitic sequence, with a total thickness of about 120 m, is divided into three subunits. The lower is composed by an alternation of shales, secondary gypsum, and anhydrite deposits with some sodium sulphate minerals. The second subunit is composed mainly of primary gypsum deposits where several brine dilution-concentration sequences occur. Each sequence reveals a basal dilution surface and a marked crystal finning upwards trend produced by the brine progressive concentration. The uppermost evaporitic subunit is characterised by an alternation of shale and primary gypsum beds, and in this case the dilution-concentration cycles start with the entrance into the basin of detritic materials transported by water that produced the dilution of the brine.
This work focuses on the study of the textural features that characterise the dilution-concentration cycles that compose the gypsum middle subunit. The characterisation of these cycles in the geological record appears as a good indicator of shallow water depth and climate control over the geochemical character of the brine.

Salts as cool climate indicators in the geological record: Thenardite after mirabilite deposits from central Spain

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Salt bodies are natural chemical deposits that have significant economic, scientific and social implications, and are, as well, commonly used as indicators of different paleoclimates and sedimentary environments. Most salt deposits are formed under arid environmental conditions, being that most salts are produced in hot arid climates, although there are many examples in current settings where they are precipitating under arid but cool conditions, such as the case of mirabilite deposits formation.
The diagenetic transformation of a mirabilite deposit into thenardite in the upper part of the lower Miocene unit of the Tajo basin (Spain) resulted in the largest reserves of this important industrial mineral in Europe. The unit was formed in a time period (~18.4 Ma) that appears characterised, in other basins of the Iberian Peninsula, by the existence of particular mammal assemblages appropriate to a relatively cool and arid climate. This time interval is as well coincident with the Mi-1a cooling event that is well documented at a worldwide scale. Determining the origin of the thenardite deposits as related to the diagenetic alteration of a pre-existing mirabilite permits the establishment and characterization of a time period where temperature was subject to a significant decrease and aridity and a sedimentary environment where the brines were concentrated by a cooling–freezing mechanism that led to the formation of thick well-differentiated mirabilite layers. The former were later diagenetically transformed to thenardite. Therefore, the correlation of terrestrial and marine records contributes to a more precise knowledge of environmental and climatic changes on a global scale. The formation of these salts also suggests use as a possible analogue with comparable deposits from extreme conditions such as Antarctica or Mars.

A Miocene delta body developed in a shallow saline lake: The control of the tectonic activity on the stratigraphic architecture (Teruel Basin, Spain)

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The northern sector of the Teruel Basin (NE Spain) is a N-S trending (15 km wide, 40 km long) half-graben structure. During the Neogene, fault activity in the eastern, active margin generated an endorheic trough. The syntectonic fill corresponds to the development of alluvial fans fed in the margins that spread towards a wide, though shallow, central lacustrine area.
In the central zone of the basin, the movement of the eastern boundary faults generated a large accommodation space, while the passive margin acted as a gentle ramp with dip increasing towards the active margin. The passive margin ramp geometry was only broken by a steeply-dipping fault system concentrated in a narrow fringe. During the Late Miocene, the distal part of west-sourced long alluvial fans that graded eastwards into a saline lake dominated this area. Within this picture, a coeval carbonate delta grown in the western lake coastline has been recently discovered.
The delta body, covering an area of ca. 5 km^2, is integrated by an up 70-m thick series made on sand, silt and interbedded tufa levels. They are organized in three coarsening-upward sequences interpreted as related with three progradation pulses. Concave and convex sedimentary bodies with thickness of several metres to tens of metres corresponding to mouth bars and terminal distributary channels represent the delta front. Individual terrigenous strata show a wide variety of sedimentary structures as horizontal- and cross-lamination, and trough, planar and hummocky cross-stratification. Soft-sediment deformation structures as dikes and slumps are also present. Tufa levels are scarce and represent marshes crossed by distributary channels. DRX analyses and optical microscope observations reveal a carbonate-dominated composition, including the most terrigenous sediments, which are mainly integrated by tufa remains and small gastropods.
Our investigations allow us to propose that the steeply-dipping fault system situated upstream the delta cut the regional aquifer made on permeable Jurassic rocks and permitted groundwater ascent, possibly as thermal springs. This scenario, together with warm climate conditions prevailing during delta construction, enabled tufa generation. A high topographic gradient related to faulting would favoured erosion of these delicate deposits by channels reaching the tufa-dominated areas, tufa remains being transported downstream as suspension load and deposited in the lake body. The described features suggest a delta controlled by buoyancy (hypopycnal flow) due to the strongly contrast between the freshwater supplies and the saline lake water. In any case, friction processes due to the shallowness of the lake area would be also important.
Deltas constructed in shallow lakes are scarce, particularly due to the non-availability of the required accommodation space. The particular geological framework of the studied area (increase of accommodation space due to tectonic activity, freshwater supplies enhanced by groundwater flow, erodible carbonate deposits upstream, saline lake) favoured the construction of a thick delta body that in a stable tectonic setting would have not been generated.

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Clastic episodes within pelagic deposits of the Umbria-Marche Basin (Northern Apennines, Italy): Evidence for Early Cretaceous tectonics?

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Resedimented intervals characterize different stratigraphical levels in the pelagic succession of the Umbria-Marche-Sabina Domain (Central and Northern Apennines, Italy). While gravity deposits related to the Early Jurassic Tethyan rifting are well known in the literature, the occurrence of calcirudites and calcarenites interbedded with the Middle-Upper Jurassic and the Lower Cretaceous pelagites is underinvestigated. Barremian-Aptian clastic levels, bearing coeval shallow-water material, punctuate locally the pelagic successions of Central and Northern Apennines. While the existence of a wide productive carbonate platform in Central Italy (Latium-Abruzzi Platform) can easily explain the presence of such material in the neighboring basins, the provenance of detrital bodies in areas lying paleogeographically at greater distances from this platform is less obvious, as those areas were separated from the Latium-Abruzzi Platform by a belt of resediment-free pelagites. Three stratigraphic sections of the Maiolica and Marne a Fucoidi Formations, sampled across the Mt. Primo area (Umbria-Marche Ridge, Northern Apennines), are characterized by spectacular breccia and calcarenite intervals. Facies analysis indicates a gravity-driven origin for the clastic levels, interpreted as debris-flows, or turbidity flows where graded/laminated calcarenites are observed. The massive lensoid-to-tabular levels are interbedded with the typical pelagic mudstones of the Maiolica Fm. and with the marly lower portion of the Marne a Fucoidi Fm., forming collectively a >60 m-thick interval. In thin-section, rudstone-to-floatstone microfacies are dominated by loose benthic foraminifers, dasycladal algae, microbial crusts, *microproblematica* and bivalves, indicating a productive photozoan-type carbonate platform(s) as the source area(s). Associated millimeter- to centimeter- size lithoclasts are made of: i) Lower Jurassic and Lower Cretaceous shallow-water carbonates; ii) Jurassic mudstones and wackestones referable to the pelagic Umbria-Marche succession; iii) calpionellid-rich soft pebbles (lower part of the Maiolica Fm.).
The occurrence of *Hedbergella similis* in the lowermost sampled pelagic levels, coupled with the occurrence of *Montseciella arabica* and *Suppiluliumaella polyreme* in the calcarenites, suggest a Barremian-early Aptian age for the clastic interval.
The punctuated occurrence of great volumes of resedimented material in pelagic basins is generally related to tectonic perturbations of the depositional setting or to sea-level oscillations, or both.
We interpret our clastic deposits as related to synsedimentary extensional tectonics for several reasons: i) the sudden switch from typical pelagic to coarse sedimentation, with abundant benthic material sourced from an unknown carbonate platform (unexposed at present, and most likely located several tens of kms away from the study area), suggests tectonic activity affecting the source area and triggering submarine slides; ii) the occurrence of Cretaceous lithoclasts of shallow-water carbonates suggests tectonic backstepping and dismantling of the carbonate platform margins; iii) the occurrence of lower Jurassic carbonate platform lithoclasts, along with calpionellid-rich pebbles and lithoclasts of Jurassic pelagites, is a clue for tectonic exhumation and erosion of the Jurassic pelagic carbonate platforms located nearby the study area, which were buried by earliest Cretaceous times.
Our preliminary interpretation is consistent with growing evidence from other geological regions across Italy, including the Adriatic subsurface, strongly suggesting the occurrence of a widespread extensional phase in the late Early Cretaceous.

Lower Devonian pelagic red beds from the Barrandian area, Czech Republic

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Red coloured deep-marine sediments are known from several stratigraphic levels of the Phanerozoic including the Lower and Upper Devonian, Carboniferous and Cretaceous. The origin of the red pigment is usually explained by i) post-sedimentary limestone alteration, (ii) detrital input from continent and/or (iii) activity of iron-oxidizing bacterial communities. The carriers of the pigmentation are goethite and hematite.
We studied a carbonate succession of the Lochkov, Praha and Zlíchov Formations, in a 120 m thick section of the Branžovy quarry, Barrandian area, Bohemian Massif. Bound to the underlying Lochkov Formation by a basal unconformity, the basal layers of the Praha Formation are composed of coarse-grained crinoidal limestone that pass upward into dark nodular calcisiltite and calcilutite with dacryoconarid tentaculites and abundant stromatactis structures (sheet cracks) forming an upward fining (transgressive) sequence. The upper parts of the Praha Fm. contain a marked 15 m thick layer of red limestone horizon, which can be correlated over distances of several tens of kilometers in the whole Barrandian area. The red pigment is dispersed in the micrite, at stylolites and inside the dacryoconarid shells. The section was logged for facies and field gamma-ray spectrometry with 0.25 to 0.5 m interval and sampled (477 samples) for magnetic susceptibility (MS), reflectance spectroscopy (DRS) and elemental geochemistry (EDXRF).
Relatively high U concentrations and U/Th ratios are typical for the Lochkov Formation while both parameters rapidly decrease in the Praha Formation. The gamma-ray values are low at the base of the Praha Formation, but they markedly increase upwards consistently with the facies/microfacies trends and the fining-upward trend. Red limestones fall within the peak transgressive strata (as documented by CGR, XRF and microfacies). The first derivative of the reflectance curve identifies hematite as the main carrier of red colour in the red limestone samples. Their mass-specific MS values do not significantly differ from the remaining parts of the profile and they are correlated with iron concentrations. However, the red limestone colour is not a function of the Fe concentration.
From the presence of Fe oxy-hydroxides inside dacryoconarid shells and no correlation between Fe and red colour, it can be inferred that the red colour carrier is not directly related to siliciclastic input from the continent and hence it is of diagenetic origin. Being associated with early diagenetic hematite, the red carbonates represent well-oxygenated sea-floor sediments (ocean red beds), which are similar in origin to the Cretaceous ocean red beds (CORBs), a significant feature of peak greenhouse climatic conditions.

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Terrestrial biological turnovers and atmospheric carbon-isotope stratigraphy across the Triassic-Jurassic boundary, Tarim Basin, NW China

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The latest Triassic to Early Jurassic is a key moment in Earth history with global carbon-cycle perturbations. Terrestrial carbon-isotope stratigraphy has proven a powerful approach to stratigraphic correlations, evolution of $\delta^{13}C$ of atmospheric CO_2 and palaeoenvironmental reconstruction for that episode. However, long-term continuous carbon-isotope records have been few reported from entirely terrestrial successions. Macrofossil wood samples were largely collected from alluvial conglomerate, associated braided-fluvial sandstone and siltstone, and bulk organic matter were collected from coal seams, organic-rich mudstone and the laminated shales as supplements. On the basis of the biostratigraphy and boundaries implied by biological turnovers, the terrestrial carbon-isotope stratigraphy in the Kuqa section is well correlated with both terrestrial and marine carbon-isotope stratigraphic records from UK through the Early Jurassic.

The Tarim Basin is situated along the south of Tian Shan. The Tian Shan definitely stood as a positive physiographic feature throughout Mesozoic and Cenozoic time, and supplied sedimentary sources.

The study area, the Kuqa section is located in the north of the Tarim Basin, which is known as a foreland basin. In the Mesozoic, the entirely terrestrial deposition occurs reaching a thickness of 6000–8000 m in the Kuqa depression. The whole Tarim Basin is interpreted to have subsided at a quite steady rate during the Jurassic and thus the lacustrine and associated alluvial deposits are likewise thought to record relatively continuous deposition. The oldest definite terrestrial deposits date back to the Late Permian.

Preliminary Conclusions

1) The carbon-isotope stratigraphy from the Kuqa section can be well correlated with both terrestrial and marine records globally, on the basis of biostratigraphy.
2) The success of stratigraphic correlation further verifies that carbon-isotope stratigraphy is a powerful tool for stratigraphic correlation over long distances, and as a bridge between the marine and terrestrial strata.
3) The carbon-cycle perturbations on a global scale occurred across the Triassic–Jurassic boundary on the short term and through the Early Jurassic on the long term.
4) Palynological overturns recorded in the Kuqa section across the Triassic–Jurassic boundary can be correlated with the terrestrial ecological system in the Newark basin, USA and Eiberg basin, Austria through the same time interval.

A sedimentological and geochemical analysis of Lower Toarcian sediments across a Swiss transect: Evaluating the impact of the Toarcian Anoxic Event

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The Early Toarcian was marked by an oceanic anoxic event (OAE; ~183 Ma, Early Jurassic), which was a global perturbation of paleoclimatic and paleoenvironmental conditions. Indeed, this episode records global warming, enhanced continental weathering, severe biotic crises, whereas extensive organic-rich sediments are noticeable for example in the Atlantic and in the Tethys. The T-OAE is associated with a negative carbon isotope excursion (CIE), recorded both in marine and terrestrial environments, which is commonly interpreted as due to the injection to the superficial reservoirs of isotopically-light carbon derived from the destabilization of methane hydrate in marine sediments and the thermal metamorphism of carbon-rich sediments. These perturbations were commonly related to a phase of intense volcanic activity due to the formation of the Karoo-Ferrar large igneous province in southern Gondwana.
Several studies of the T-OAE have been conducted on sediments in central and northwest Europe, but only few data are available concerning the Swiss sedimentary records. In the Early Jurassic, the northwestern Tethys Ocean predominantly consisted of shallow epicontinental sea with semi-restricted basins. In this ongoing project, we focus on sections corresponding to different paleogeographic domains. Three sites were examined so far on the Jura Plateau (Rietheim, Gipf, Riniken NAGRA Borehole; canton Aargau). The H. exaratum Subzone of the Rietheim and Gipf sections record black shales with high (up to 10 wt.%) total organic carbon (TOC) content consisting mainly of marine phytoplankton and algal material. Redox-sensitive elements such as uranium and vanadium show high ratios with respect to aluminium confirming that bottom waters were oxygen deficient. Interestingly, total phosphorus (Ptot) enrichments during the T-OAE suggest that a part of the remobilized P was trapped within the sediments, likely in the form of an authigenic phase. High chemical weathering indexes (Ln(Al_2O_3/Na_2O) and CIA-K) during the T-OAE suggest an increase in continental weathering rates which is concomitant with kaolinite enrichments in these intervals. The sections in the Jura Plateau record comparable $\delta^{13}C_{org}$ and $\delta^{13}C_{carb}$ profiles in the black shale intervals and highlight the condensation and/or erosion of sediments dated as near the Plienbachian-Toarcian boundary and from the Harpoceras falciferum Zone. The analysis of Swiss sections will assist us in the identification of the mechanisms implied in the condensation and/or erosion of parts of the Lower Toarcian Posidonia Shale. Therefore, it will improve our understanding of the general paleoceanographic conditions leading to the development of widespread oceanic anoxia during the early Toarcian.

Assessing long-term macrobioerosion in the Eastern Mediterranean Sea via micro-computed tomography

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Biological erosion of carbonate substrate is a key process during the (re)cycling of calcium carbonate and the formation of calcareous sediments in the ocean. Wherever fresh substrate becomes exposed it is rapidly colonised by pioneer microbial euendoliths. Mature microboring communities usually develop during the first 6 months of exposure, while macroborers are considered to take more than 2-3 years to establish. In order to monitor the speed at which macrobioerosion affects carbonate substrate, and to provide data on the succession of macrobioeroding communities, a long-term settlement experiment was carried out off the rocky shores of Rhodes, Greece. Marble blocks were deployed at 3-17 m water depth in 1982 and retrieved annually until 1996. The visualisation and quantification of macrobioerosion rates and patterns was based on non-destructive micro-computed tomographic analysis. Our results show that the largest proportion of macrobioerosion in the marble blocks can be attributed to the activity of boring sponges leaving characteristic *Entobia* cavity networks. During the first years the borings are mostly superficial, whereas deeper penetration depths were first observed after 7 years. After 14 years about 30 percentage of the marble block was removed resulting in a bioerosion rate of about 1200 g m^2/yr. These results emphasise the need for long-term studies in order to assess the impact of macrobioerosion on marine carbonate environments.

Exotic Cu-ore deposits related to continental carbonates in arid environments: An example from El Tesoro Basin, Atacama Desert, northern Chile

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The genesis of exotic copper deposits relates to the leaching of hypogene copper sulfide ores hosted on porphyry copper deposits, producing copper-bearing aqueous solutions that will laterally remobilize the metal within the weathering profile. In the Atacama Desert, these solutions percolate Cenozoic gravels and eventually copper precipitates as oxides minerals in surficial sediments and soil profiles, forming the Cu-exotic deposits. Traditionally, the study of these deposits focus on the processes that leads to remobilization and concentration of copper ore, however, little attention is paid to related facies association and the interpretation of sedimentary environments.
Our case of study is placed in the Tesoro open pit mine from Minera Centinela (owned by Antofagasta Minerals S.A.). It is located within the El Tesoro Basin, an intramontaunous forearc basin placed on the western boundary of the Precordillera. The basin is infilled with up to 800 m continental Cenozoic deposits, mainly alluvial and fluvio-alluvial gravels (known as the "Atacama Gravels") with interbedded levels of paleosols and lacustrine sediments. The used methodologies were stratigraphic logging, study of hand samples and thin sections, SEM observations and XRD analysis.
The studied vertical succession is ~100 m thick and contains the two Cu-exotic ore bodies mined in the pit. One of the ore bodies is placed within the lower section of the succession consisting of ~70 m thick horizontally and trough cross-bedded, clast-supported gravels with intercalations of coarse-grained sandstones, mudstones and tabular beds of sandy micrite carbonates. The ore body is 8-10 m thick and shows a remarkable banded texture composed mainly of chrysocolla and ramsdellite (copper-wad), with minor atacamite, paratacamite and opal.
The second ore body is contained in the upper part of the succession. This section is ~30 m thick and consists of horizontally bedded, clast-supported gravels with intercalations of non-stratified, matrix-supported gravels. The 8 to 10 m thick ore body corresponds to gravel deposits in which copper is mainly present as angular to subangular clasts of chrysocolla, whose abundance in the sediments vary from 70% to less than 10%. Chrysocolla may also occurs as coatings on clasts, infilling fractures or as cements. The matrix of the gravels is mostly micrite with some calcite spar.
Both exotic Cu-ore bodies formed under same arid and alkaline conditions, but with remarkable differences in textures and mineralogy. The lower ore body was deposited in surface or subsurface areas as low temperatures gels on the distal part of a fluvio-alluvial system with ponds. In contrast, the upper ore body was formed in an alluvial environment where chrysocolla clasts were sourced from previous exotic deposits and/or supergene enrichment zones. In this case, the copper forming clasts coatings and cements can be the result of copper-bearing solutions that impregnate the gravels and, even, because of copper redistribution due to water table fluctuations during early diagenesis.

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Mechanisms of transport and deposition of high-concentrated density currents: A detailed approach to hydrodynamic and depositional features

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Highly equipped experiments of high-concentrated density currents have been performed in order to identify the transport and deposition mechanisms that occur during the development of different flows and also to compare the depositional structures and upward grain-size profiles with hydrodynamic processes. With the aim of do that, two density currents with volumetric concentrations of 11% (E1) and 30% (E2) and with different ratios of cohesive (kaolin: d = 2,6 and D50 = 6 µm) and non-cohesive (mineral coal: d =1,19 and D50 = 95 µm) sediments have been produced in a long flume (15 m long, 0.4 m wide and 0.6 m deep). 200 liters of mixture were injected into the flume at a constant flow rate of 50 l/min. During the experiments, the flows were image-recorded (high-speed camera, video cameras and medical ultrasound). In addition, two sets of equipments (12 UVP sensors and 3 UHCM sensors) for determining velocity and concentration profiles were positioned at upstream and downstream locations. At the end of each experiment, the deposit was carefully drained to obtain images (strike sections) and also sediment samples at every 50 cm. The analysis of video images, velocity and concentration data showed that the current E1 developed a strong turbulent mixing layer over a slightly more concentrated basal layer. From the ultrasound images, it was observed in the experiment a fall-out settling, as the thickness of deposit increased gradually during the running time. On the other hand, the E2 experiment produced a high concentrated basal layer and a weak turbulent and concentrated layer above. The deposition was en masse with rapid deposition of a thick layer near to the bottom. Regarding the deposits, both strike sections and grain-size analysis of both E1 and E2 showed two distinct stages of deposition, with different textures (grain-size break) were formed: (I) a massive basal bed, with coarser grain size, ungraded or inverse graded in the proximal region, changing to normal graded in the distal region; (II) a thin sheet of fine sediment, whose particle sizes do not vary much over the entire length of the flume. Regarding morphology, the E1 deposit was shorter than the E2. However, on its top, the layer of fine sediments was thicker due to the high turbulence and remobilization of sediments at the mixture layer. Based on the results, it is concluded that the E1 experiment has similar behavior to an inertial high-density turbidity current, presenting a turbulent suspension process with rapid sediment fall-out. Notwithstanding, the inverse-graded or ungraded layer in the proximal region suggests that high pore-pressure hindered the coarser grains settling. The E2 experiment showed different behavior, presenting an en masse settling (massive sand), and inverse graded or ungraded deposits in the proximal and middle sections. At the distal part, the deposit was normally graded. The correlation with natural deposits is not straightforward, but will also be discussed.

Ichnological characterization of the initial stages of the basin-wide transgression of the Pisco Formation (middle Miocene-lower Pliocene), Peru

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The Pisco Formation consists of a succession of sandstone, siltstone and diatomaceous and tuffaceous mudstone with some interspersed layers of phosphate nodules, biogenic conglomerate, calcareous sandstone and mudstone, gypsum, and volcanic ash. The succession corresponds to the last basin-wide marine transgression that extended over the Pisco basin during the Middle Miocene to lower Pliocene.

The base of the formation is an erosional unconformity directly overlain by a layer of phosphate pebble-size nodules within and matrix of fine sandstone. Igneous cobbles and boulders are locally abundant within this layer. In some areas the basal layer consists of fine sandstone characterized by *Glossifungites* ichnofacies (firmground), which locally grades into a *Trypanites* ichnofacies in hardground surfaces and calcareous lithoclasts (rockground). The *Glossifungites* ichnofacies is dominated by *Thalassinoides* and *Gyrolithes* burrows with sharp, unlined walls that penetrate a few tens of centimeters into the fine sandstone of the underlying Chilcatay Formation. Unlined, sub-vertical to vertical *Gastrochaenolites* and *Trypanites* borings characterize the hardground and rockground surfaces. These borings are approximately 18 mm long, lack ornamentation, and their openings are not truncated by erosion. Abundance of burrows and borings varies laterally and between the lower and upper surfaces of lithoclasts. Borings do not intersect but may be in contact with one another. Both burrows and borings are filled with fine- to medium-grained sandstone, though locally they are filled with matrix-supported phosphate pebbles. Commonly this horizon lacks invertebrate fauna, except for some articulated bivalves and oysters, and clusters of cirripeds preserved against some boulders. Marine mammals fossils, both articulated and disarticulated, and tree logs and fragments of wood are locally abundant. This hardground represents an omission surface in an upper foreshore, coastal environment that was cemented and perforated before the onset of the marine flooding of the last Pisco basin-wide transgression in which siliciclastic sediments were deposited.

Moderately bioturbated fine-grained sandstones and siltstones overlie the basal transgressive surface. Burrows are relatively abundant in the lower sandstone layers with sub-vertical to vertical *Skolithos*, *Ophiomorpha* and *Gyrolithes*, and thick horizontal *Thalassinoides*. Burrow filling is similar to the embedded sediment. These burrows lack ornamentation and lining, except for *Ophiomorpha*, which shows walls clad in millimeter-size pellets. Scattered articulated bivalves, clusters of cirripeds, and claws of decapod crustaceans are locally abundant. The lower layers within this succession contain abundant marine vertebrates in some areas. This set of burrows corresponds to a *Skolithos* ichnofacies formed in the foreshore to upper shoreface, sublittoral, moderate-to-high energy environment.

Overlying these lower fine sandstones are layers of siltstones with abundant hummocky cross-stratification and water current structures. These layers are mostly barren of burrows, with some levels showing a low to moderate degree of bioturbation, mostly *Thalasssinoides*, and *Skolithos*, representing the lower shoreface to inner shelf environment.

Overall the degree of bioturbation decreases with the fining-upward succession, although there are several moderately bioturbated levels, some of them underlying fossil-rich, thin phosphate beds.

Foraminifera from nearshore to offshore middle Miocene mudstones from Bęczyn (Carpathian Foredeep, Poland)

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The Carpathian Foredeep is a youngest tectonic unit of Poland occupies the area between the Outer Carpathians and the Mid-Polish Uplands. Origin of the Carpathian Foredeep is directly connected with the Outer Carpathians evolution (details in: Oszczypko, 2006). The Carpathian Foredeep basin was a part of the Central Paratethys which was the northern part of the disappearing Tethys Ocean. Central part of The Carpathian Foredeep is filled with Miocene siliciclastic molasse with evaporites.
Mudstones of the Skawina Formation cropping out in a ravine of Sosnówka stream near Bęczyn (GPS coordinates: N 49, 937384; E 19, 671493) have been studied with special regard to foraminifera. The Miocene deposits lie above the Upper Jurassic rocks (Krach & Książkiewicz, 1948). The analysed Miocene deposits consist of grey, calcareous, soft and plastic mudstones with crumbled bivalves and contain diverse microfossils. Micropalaeontological analysis has revealed that deposits contain numerous benthic and planktonic foraminifera. Insignificantly more common are benthic foraminifera, mainly *Bulimina* sp. and *Uvigerina* sp. *Globigerina* sp. and *Globigerinella* sp. are dominant among the planktonic forms. Agglutinated species are very rare. Following foraminiferal taxa are recognised: *Bulimina elongata*, *Bulimina gibba*, *Chilostomella* sp., *Cibicides aknerianus*, *Dentalina pauperata*, *Elphidium fichtelianum*, *Furkensoina schreibersiana*, *Globigerina bulloides*, *Globigerina concinna*, *Globigerina diplostoma*, *Globigerinella regularis*, *Globigerinoides* sp., *Globulina gibba*, *Guttulina communis*, *Heterolepa dutemplei*, *Lenticulina* sp., *Lobatula lobatula*, *Marginulina* cf. *costata*, *Nodosaria* sp., *Nonion commune*, *Orbulina suturalis*, *Orbulina universa*, *Stilostomella adolphina*, *Subbotina saginata*, *Uvigerina grilli*, *Uvigerina pygmoides, Uvigerina semiornata*. Moreover, the mudstones contain bryozoans, ostracodes, fragments of corals and numerous quartz grains.
Results of foraminiferal analysis point to normal marine conditions from nearshore to offshore environment (Szczechura, 1982; Peryt & Gedl, 2010). Stratigraphically significant are: *Uvigerina pygmoides*, *Bulimina elongata*, *Orbulina suturalis*, *Globigerinella regularis* (Olszewska, 1999) which points to early Badenian (Moravian=Early Langhian). Those palaeontological analysis results are accordant to previous studies of the Skawina Formation in Bęczyn area (e.g., molluscs: Krach & Książkiewicz, 1948; microfauna (stratigraphy): Łuczkowska, 1957; dinoflagellate cysts: Gedl, 2005).

Litho- and palynofacies in the Keuper deposits from Upper Silesia and their environmental implications

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A wide spectrum of lithofacies was recognized in the Upper Silesian Keuper continental succession from mudstone-evaporite in the Chrzanów Formation and Ozimek Member of the Grabowa Formation, through sandstone in the Stuttgart Formation and Patoka Member of the Grabowa Formation and marly mudstone in the Patoka Mbr to limestone in the Woźniki Member of the Grabowa Formation.
For palynofacies the definition of Powell et al. (1990) was applied. Organic matter was classified after APOMC ’93 (Amsterdam Palynological Organic Matter Classification) into the following groups: palynomorphs: spores, pollen, freshwater algae, fungal spores, structural organic matter (SOM): wood fragments, cuticles, degraded structural matter (DOM) and amorphous organic matter (AOM).
Based on percent ratio of the particular kerogen groups four types of palynofacies have been distinguished: the fluvial type in the Stuttgart Formation, Patoka Member of the Grabowa Formation and “Połomia Formation”, the floodplain type in the Patoka Mbr and “Połomia Fm”, the lacustrine type – in the Stuttgart Fm and Patoka Mbr and the playa type – in the Chrzanów Formation and Ozimek Member of the Grabowa Formation
Results of litho- and palynofacies analysis confirm the earlier suggestions that the Chrzanów Fm represents the playa basin and dry, arid climate. Sediments of the Stuttgart Fm originated in fluvial and lacustrine milieu as a result of increase of humidity connected with the Carnian Pluvial Event. The Ozimek Mbr represents playa environments whereas the Patoka Mbr variable fluvial and lacustrine milieu. An increase of humidity in the middle-late Norian corresponds to the Mid-Norian Pluvial Event. The “Połomia Fm” originated in fluvial milieu and reflects wet climate conditions in Rhaetian.

Sedimentology of two new dinosaur sites from the Maastrichtian Tremp Fm (South Pyrenean area, Eastern Iberia)

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The transitional marine-to-continental sedimentary succession of the Maastrichtian South Pyrenean basin yields one of the most important European fossil records (dinosaurs and other terrestrial vertebrates). The different paleoenvironments recorded in the Tremp Fm during this period, from lagoonal to lacustrine and coastal plains (with meandering and braided rivers) have reported a great variety of fossil sites with different sedimentary environments and taphonomic modes. To illustrate it, we describe two new fossil sites from the Tremp Fm: L'Espinau and Molí del Baró-1.
L'Espinau bonebed (Southernmost Ager basin) is a relatively condensed Maastrichtian section of 50m. From base to top, a transition from a coastal environment to fluvial-braided streams is recorded. In the mid-portion of the section there is succession of coastal plain mudstones linked to laterally limited lacustrine limestones. It yields hadrosauroid bones and microvertebrate remains such as bony fishes and rays, amphibians, two different squamates, and four morphotypes of crocodilomorphs teeth. The bone layer consists on a 40 cm-thick grey marly level (45% of $CaCO_3$ with a significant 5% of quartz grains) with high amounts of plant remains and no sedimentary structures. The top of this bed exhibits plant bioturbation in form of ochre mottling. Dinosaur (hadrosauroids) bones and centimetric carbonate intraclasts represent the coarser components of the bed. These bones appear floating in the marly matrix with dips of up to 40º. Most of them, specially the larger ones, are concentred at the base of the layer, then showing a decreasing in size towards the top. Also, the long bone orientation follows a bidirectional arrangement. Finally, the fact that both bones and carbonate clasts show rounded edges and signs of abrasion implies transport for those components. This configuration is compatible with a cohesive mass flow (probably a mudflow) that eroded and transported previous carbonate sediments. Most of the bones are covered by milimetric to centimetric carbonate crusts of micrite, including ostracods, bivalves and planktonic foraminifera. Clasts with the same feautres are also found. These faunal content suggests a lagoonal setting (common in the underlying sediments of the section) for the preexistent environment, in which hadrosauroids bones where buried.
Molí del Baró-1 site (easternmost Tremp basin) is located in a succession of sandstone bodies interbedded within thick mudstone deposits (floodplains) of the Tremp Fm. Particularly, the site occurs in the top of a 10 m-thick, fine grained sandstone unit that displays lateral accretion surfaces arranged in inclined heterolithic stratification (IHS). Plant remains, macrovertebrates (hadrosauroid dinosaurs and crocodyles), microvertebrates (theropod dinosaurs, amphibians and fish remains), gastropods, arthropods and planktonic foraminifera have been recovered from the finest marly sediments (45-50% of $CaCO_3$) of the IHS. This meandering configuration is common in the Tremp Fm and has been regarded as fluvial deposits of a coastal plain environment close connected with the marine influence. The occurrence of non-reworked planktonic foraminifera within the marly sediments of those channels reinforces this interpretation. They represent low energy conditions that allowed the decantation of fine sediments in the inner, non-erosive meander margins.

Shelf-margin clinoforms and fluvial to deepwater depositional linkage in the lacustrine Dacian Basin, Romania

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Depositional environments in the lake Dacian basin of Romania have been reported as predominantly fluvio-deltaic and shallow marine systems. This study is the first to systematically document and interpret the deepwater deposits. Along the northern margin, the entire basin fill is exposed by the late Pliocene uplift events. Sedimentologic data are recorded in five, 500-1000 m thick, stratigraphic sections. The sections include Meotian, Pontian and Dacian time intervals and comprise basin-floor, slope, shoreline, and fluvial deposits. The ca. 300 m thick basin-floor deposits dominated by thinly bedded mudstone and tabular sandstone beds contain also 50-70 m thick succession of 3-5 m thick pebble to cobble tabular conglomerate beds with rare shallow-water fossils. The 400-500 m thick slope stratigraphy is largely represented by fine sediments, 15-50 cm thick 'Bouma beds', which constitute ten of m thick levee and overbank deposits. A 15-20 m thick channel form overlying and onlapping onto an erosional surface comprises 20-30 cm thick normally graded beds that are structureless or planar laminated often with mud clasts. Fossil leaves, tree trunks and small coalified organic fragments are abundant in the deepwater deposits. Cross-bedded pebbly sandstones with shell fragments and heavily bioturbated silty mudstone characterize deltaic deposits on the shelf.
Mio-Pliocene shelf-margin scale clinoforms are imaged in an onshore 3D seismic dataset in the western Dacian Basin. The 400 m high clinoforms with thin topsets, undulated foresets and highly aggradational bottomsets prograded NE-SW for 25 km. The clinoform foresets are dominated by sub-lacustrine canyons and channels which consistently indent the clinoform rollovers. Amplitude maps extracted on the clinoform surfaces and from the clinothem intervals (TVT) suggest coarse sediment lags in the slope canyon and channels thalwegs and sandy basin-floor fans. At multiple locations along the indented rollovers, slope channels are observed to have connection with fluvial channels.
The outcrop observations, the sedimentary structures and abundance of organic detritus, and basin's reduced-salinity condition imply that the turbidite system could be hyperpycnal dominated and that lead to thick sediment accumulation on the basin floor. This is also supported by the fluvial-turbidite channel connection observed right below the shelf edges in the seismic data. In addition, the presence of clinoforms or sigmoidal timelines suggests that the basin conventional lithostratigraphy should be adjusted to achieve better understanding of the basin infill evolution and petroleum reservoir types and distribution in the western Dacian Basin.

Past environmental changes in Spitsbergen fjords inferred from acoustic and lithological data

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The seafloors and sub-seafloors in Spitsbergen fjords provide unique archives to study environmental changes from the last glacial until the present. Acoustic data, including swath bathymetry and high-resolution seismic data reveal information about the dynamics of ice streams draining the northwestern part of the Svalbard-Barents-Sea-Ice-Sheet during the last glacial. Whereas glacial linear features provide evidence of fast ice flow through the fjords, channels and eskers provide information about the hydrological conditions beneath the ice after the termination of fast ice flow. Iceberg ploughmarks suggest that the decay of the ice sheet occurred partly by iceberg calving. Grounding-zone wedges and moraine ridges indicate that multiple halts and/or re-advances interrupted the last deglaciation. Lithological analyses suggest that the last deglaciation terminated around 11,200 cal. years BP in most fjords on Spitsbergen. Most glaciers on Spitsbergen reached their maximum post-glacial extents due to climatic cooling during the Little Ice Age (LIA) or related to surges. In consequence, morphological imprints of glacial activity during most of post-glacial times are absent and environmental reconstructions need to rely on the analyses of sediment cores. The most frequently used proxies are foraminifera, as well as analyses of ice-rafted debris, mass wasting, sediment colour and bulk mineral assemblages. These proxies indicate relatively warm environmental conditions on Spitsbergen between c. 11,200 and 9000 cal. years BP. Glaciers started to grow from c. 9000 cal. years BP and the coldest conditions prevailed between c. 4000 and 2000 cal. years BP.
Glacier fluctuations during the late Holocene led to the formation of characteristic landform assemblages at the heads of most Spitsbergen fjords. These assemblages reflect e.g. rapid glacier advance and termination, as well as a stepwise retreat.
This presentation includes examples of studies using acoustic data and analyses of sediment cores to reconstruct environmental changes on Spitsbergen from the last glacial until the present. It discusses strengths and weaknesses of various proxies and highlights the necessity of multi-proxy analyses to obtain the most reliable reconstructions of past environmental change on Spitsbergen.

Early Mesozoic siliciclastic deposits of the Kalahari Karoo Basin (Botswana): A new perspective

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The Kalahari Karoo Basin (Botswana) is referred to be a part of an intracratonic basins system, developed between the Late Palaeozoic and the Early Mesozoic along the palaeo-Pacific margin of south-western Gondwana. During the early Mesozoic, in particular, it has been supplied by siliciclastic continental sedimentation, characterizing the Lebung Group. This Group overlays the coal-bearing carbonaceous deposits of the Ecca Group, deeply studied for economic purposes. The Lebung Group is subdivided into Mosolotsane Formation and Ntane Sandstone Formation. Sedimentological characteristics and distribution of these continental formations are still far from being understood.

The Mosolotsane Fm consists of 10 to 120 m of fluvial sandstones and conglomerates with cross-bedded stratifications and continental fossils, probably deposed into an arid environment; it is commonly correlated with the Late Triassic-Early Jurassic Molteno and Elliot Fms in South Africa. The overlying Ntane Fm is a thick succession dominated by massive to cross-bedded aeolian sandstones and/or fluvial pebbly conglomerates.

Although recent studies reported the overall characteristic of the Ntane and Mosolotsane Fms these are mainly based on unevenly distributed borehole data and discontinuous outcrop occurrences. These data do not support unambiguously the facies distribution and total thickness of the siliciclastic deposits. Moreover the lack of outcrops in the southern and western regions of the Kalahari Karoo Basin substantially limited the 3D facies analyses of the continental deposits.

Here we use a holistic approach concerning field and petrographic analyses of the Ntane and Mosolotsane Fms coupled with 2D post-stack migrated seismic reflection data of the central Kalahari Karoo Basin. Petrographic analyses will be integrated with the clasts count data collected in order to trace trends in the detritus compositions. Fluvial and aeolian units are classified following their seismic response and then correlated with borehole cores and field survey data. This approach will improve our knowledge of the distribution in the sub-surface of the Ntane and Mosolotsane Fms sediments, avoiding the intensive adoption of time- and money-consuming borehole cores.

The study of the post-stack migrated 2D seismic reflection profiles of the central Kalahari Karoo Basin gives strong constrains for the thickness of the continental deposits and highlights the occurrences of major unconformities and eventually the presence of ore deposits. Elsewhere in southern Africa it has been proved that sedimentological and petrographic studies of fluvial sediments led indirectly to important economic discoveries.

Early diagenetic modification of the trace and rare earth elements record of Devonian carbonates: Maïder Basin conical mounds (Eastern Anti-Atlas, Morocco)

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Carbonate mounds are "mud-dominated deposits with topographic relief and few or no stromatolites, thrombolites or in place skeletons" (Riding, 2002). Despite their fine-grained texture and the absence of a rigid framework of invertebrate skeletons, mounds can develop into large structures with a high angle of accumulation. The diagenetic effects that trigger the early lithification of the steep sides of the conical mounds are still far from understood.
Here we present new data set concerning major and trace element (including rare earth element, REE) analyses of the Middle Devonian carbonates from the Maïder Basin (eastern Anti-Atlas, Morocco). Aim of this work is to use the REE and trace elements chemistry as a tool for assessing the early diagenesis processes that involved widespread geological bodies such as the carbonate mounds.
A variety of different limestone facies, including wackestone, vein filling and cement phases display a coherent normal marine REE pattern characterized by fractioned LREE content (Pr/Yb < 1), slightly negative Ce anomaly, and positive Gd anomaly. Nevertheless anomalous pattern with positive Ce anomaly (up to 2.23) or lack of any Ce anomaly have been found, suggesting variable palaeoredox conditions during the formation of these mounds. The co-variation of trace elements, such as Mo and U, reinforces the chemical constrains given by the REE patterns. Few samples show high positive Ce anomaly coupled with high MoEF/UEF ratio revealing a clear, and probable intermittent, reducing condition. This scenario may be complicated by the dissolution of organic matter during the early diagenetic phases. Consumption of organic matter might indeed result in a "false" positive Ce-anomaly within the pore water precipitates and the contextual consumption of Mo and U.
We found a good correlation between Fe contents and ΣREE in the studied carbonates. Furthermore, the average [ΣREE/Fe] ratio around 0.015 (±3) is consistent in all the samples except for those from vein filling which shift from this average. Fe contents and LREE/HREE ratios correlation and homogeneous [ΣREE/Fe] ratios may suggest a major effect of early diagenesis on the overall carbonates chemistry.
Our results suggest that the precipitation of carbonates within the vein system has been probably triggered by activity of microbial consortium. Evidences of the microbial activity are the peloidal and clotted fabrics preserved within the fracture filling carbonates. Whereas, the bulks of the mound carbonates have probably undergone a different diagenesis, which strongly affected the distribution of redox sensitive elements and partially overprinted the original geochemical signature of these carbonates. We should therefore consider that the assumption that REE pattern is stable within carbonatic lattice is probably imprecise and that Fe-bearing burial carbonatic phases could have influenced consistently the overall carbonate REE pattern.

Assessing the genesis and evolution of biodetrital methane-imprinted carbonates on the Adriatic continental shelf

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The central Adriatic Sea is a well-known region of natural gas production. Presence, migration and occasional escape of gas onto the sea bottom and into the water column is documented by a number of features such as pockmarks and gas bubbling. The central Adriatic is also a site of formation of hydrocarbon-derived carbonate. These carbonates include meter- to decimeter-sized buildups, smaller concretionary aggregates in the studied Bonaccia area.
The carbonate buildups are cemented by micrite and locally acicular aragonite strongly depleted in ^{13}C, showing ^{13}C values as low as about -48‰ VPDB. These values are consistent with the precipitation of carbonates via the anaerobic oxidation of methane performed by microbial consortia. Seeping fluids impregnated post-glacial transgressive coarse bioclastic-rich units. The authigenic carbonates therefore incorporate abundant shell remains including chemosymbiotic lucinid bivalves and burrowing callianassid shrimps. The main products of these processes at the Bonaccia study site are composite bryozoan-dominated buildups, engulfing mud concretions and decapod burrows. The presence of fibrous aragonite cement on the internal walls of these burrows indicates that they acted as preferred expulsion pathways before the formation of the bryozoan buildups. During the Holocene these buildups have been exhumed by erosion and served as hard substrate for fouling benthos (i.e., bryozoans, oysters and red algae).
Here, we contribute to the description and interpretation of the composite Bonaccia carbonates by focusing on the main aspects of their genesis and evolution. Our analysis of the Bonaccia carbonates reveals a complex history, reflecting the interplay of sedimentation in the course of transgression, hydrocarbon seepage and erosion, as well as later, successive colonization by benthos. The Bonaccia case-study can serve as a model for the interpretation of other methane-imprinted carbonatic crusts, which are common in the Mediterranean Sea.

Provenance of the Karpatian (Lower Miocene) deposits in the Central part of the Carpathian Foredeep in Moravia

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Karpatian deposits (Lower Miocene) in the Central part of the Carpathian Foredeep in Moravia are characterized by the dominance of garnets from heavy mineral assemblages. Garnet occurrence ranges between 27.1% and 95.4% (average /AVG 70.4%). Further commonly identified heavy minerals were apatite (0.9-40.3%, AVG 10.0%), zircon (1.2-24.8%, AVG 4.5%), tourmaline (5.1-22.1%, AVG 4.5%) and rutile (0.7-41.3%, AVG 6.2%). The occurrence of kyanite, sillimanite, staurolite, monazite, anatase, titanite, epidote, amphibole and pyroxene highly varies and reaches max. 1%.
Garnet as the most common heavy mineral was further evaluated by analyses of its chemistry, which is widely used for the determination of provenance. The hierarchical cluster analysis was used to distinguish by the detrital garnets of Karpatian deposits. Based on the different chemistry of detrital garnets 10 types (T1-T10) were determined.
Based on lithological description and logging of the boreholes the Karpatian deposits were divided into three depositional units (lagoon - estuary and barrier coastline, foreshore - lower shoreface and offshore). Different source areas for depositional units were proved. The material of basal depositional unit I (lagoon - estuary and barrier coastline) was derived from the local source. The source rocks are supposed to be originated from crystalline basement (Brunovistulicum). The deposits of the depositional unit II (foreshore - lower shoreface) were derived from Moravian-Silesian Paleozoic deposits, primarily from the younger part of Myslejovice Formation. The garnets of similar chemical composition have been described into Luleč conglomerates. The depositional unit III (offshore) sediments indicate a change of the provenance. The rocks of Silesian Unit are main source of the deposits of depositional unit III. The change of provenance is associated with the thrusting of nappes. The continued thrusting led to reconstruction of the foredeep. The cratonward shift of the foreland basin depozones (more than 50 km north-west) is proposed.

Carbonate grain taphonomy and diagenesis on a polar shelf

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Although relatively rare in space and time, carbonates deposited in glacially influenced settings hold great potential for improving understanding of the climate and oceanography of the high latitudes. Perhaps the best-known examples of such limestones formed during the major ice ages of the Neoproterozoic and Late Palaeozoic. Although such deposits give us a valuable view into the past, it must be remembered that they represent the cumulative effects of biological, chemical, and physical processes in a setting that is not conducive to carbonate deposition or preservation. Here, we consider the taphonomic and early diagenetic processes affecting carbonate deposits recovered in piston cores from the Ross Sea of Antarctica, with the aim of developing a conceptual bridge between the modern and ancient for these unique cold-water carbonate systems. Carbonate-rich deposits are preserved on the northwestern part of the Ross Sea shelf, where they mantle areas of the upper slope, shelf edge, and elongate banks that are situated seaward of the grounding line of the Last Glacial Maximum ice sheet. This part of the shelf is swept almost continuously by strong bottom currents and lies beneath an area of very high primary productivity. The carbonate deposits, comprising poorly sorted skeletal sand and gravel, are dominated locally by either stylasterine hydrocorals, barnacles, or bryozoans. There is a disconnect between observations of extant calcareous seafloor communities and the assemblages preserved in the cores examined in this study. The most important and abundant living organisms capable of producing carbonate sediment in marine Antarctic environments today are bivalves, echinoderms, and, to a lesser degree, bryozoans. Two possible explanations for this disconnect are (1) strong bottom currents, which may have limited the biota to those that could colonize rocky substrates, and (2) corrosive bottom waters. Skeletal material is conspicuously bored at the macro- and micro-scales, with overlapping generations of borings recording repeated episodes of grain infestation. A general relationship of increased abundance and diversity of endolithic traces with decreasing grain size suggests that bioerosion is continuous. The effectiveness of bioerosion in grain disintegration in this setting is enhanced by the lack of excavation infill either by sediment or synsedimentary cement. Bores remain empty, physically weakening grains as well as effectively increasing the surface area in contact with corrosive bottom waters. Carbonate accumulation in this high-energy environment where ocean water is close to carbonate undersaturation has major implications for component preservation and thus potential translation into the geological record. Deposits represent the cumulative effects of biological and physical processes that operate in a reciprocal manner. When conditions are favorable, carbonate factories operate to produce carbonate sediment. When favorable conditions deteriorate and factories go dormant, skeletal debris is remobilized by bottom currents and grains are infested by endolithic borers, making them susceptible to fragmentation and dissolution. These carbonates therefore enter the geologic record as unconsolidated deposits with textures that only partially reflect conditions under which they originally formed.

Evolution of the modern sediments of the Amazon River System (Amazonia, Brazil)

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This paper aims to study the evolution of the sediments transported in suspension in the Amazon from the source to the mouth. The sediments transported by the rivers of the Amazon System are sands, siltes and clays. Some large fragments, like pebbles of pumice, float from the Andes in the Amazon down steam as far as Manaus, are also present. Climate and relief of the headwaters, besides the mother rocks, are the factors that influence the first composition of these sediments. The sand composition of the sediments of the Solimões-Amazon and major tributaries are studied to identify and to verify the changes of their composition during the transport. The sand is more easily analyzed than the other components. For this purpose one hundred sandy samples were collected on transversal and longitudinal bars of the rivers during the dry seasons. The identification of the sands was carried out in thin sections with a petrographic microscope. The composition of sands of the Andean tributaries contains a large amount of rock fragments: some fluvial sands in the foothills have more than 50 percent volcanic fragments and on the border of Peru-Brazil-Colombia about 20 percent volcanic rocks fragments are present. On the contrary sands derived from Precambrian terrains are much richer in quartz, as are sands in rivers draining Tertiary molasse. Sand becomes more mature down steam along the main channel of the Amazon: at the mouth the composition shows a content of 98 percent quartz. So a sample analyzed at the mouth of the river does not reflect headwater composition. Abrasion of rock fragments, weathering “in transit “and the contribution by quartz rich tributaries result in an enhanced maturity down steam. The clay composition: kaolinite-illite-montmorillonite is almost uniform along the course of the Amazon.

Response of Tethyan carbonate platforms to the environmental changes associated with Oceanic Anoxic Event 2 (OAE-2)

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Oceanic Anoxic Event 2 (OAE-2), spanning the Cenomanian–Turonian boundary, represents a major perturbation of the global carbon cycle with an extensive deposition of organic-carbon rich deposits (black shales) in ocean basins worldwide. A number of studies have suggested, as potential trigger mechanism of the OAE2, enhanced volcanic activity at mid oceanic ridges and large igneous province (LIP) eruptions. These phenomena would have led to CO_2 degassing, an increase in temperature, and acceleration of the hydrological cycle with enhanced terrestrial weathering and run-off. The excess of nutrients delivered to the oceans would have fuelled primary productivity and the increased flux of organic matter to the seafloor could have created oxygen-poor (sub-oxic to anoxic) deep waters favoring the preservation of organic matter (OM). The sedimentological, geochemical and paleontological aspects of deep water expressions of OAE-2 have been intensively studied in the last few decades, whereas much less attention has been put on the coeval shallow water deposits. The Southern Apenninic Platform (Italy) preserves a record of shallow-water carbonates through the OAE-2, offering the unique opportunity of looking at a continuous archive of paleoenvironmental changes at a tropical latitude far from the influence of a large continental block. Here we present the results of a detailed facies, petrographic (optical microscope and SEM) and geochemical study on two key shallow marine sections, using biostratigraphy and carbon-isotope stratigraphy to establish the time-framework corresponding to OAE-2.
The most characteristic sedimentological features found in the studied sections are laminated, dark-brown, cm-thick beds interbedded with muddy lagoonal carbonates. These laminated deposits are fine grained and relatively enriched in organic carbon compared to the background lagoonal deposits. They cluster together in two distinct stratigraphic positions with respect to OAE-2. The first cluster slightly predates/straggles the onset of OAE-2, whereas the second one occurs at the beginning of the plateau phase of the event. Petrographic and geochemical analyses indicate that the laminite beds are fossil microbial mats dominated by cyanobacteria. The consistent occurrence of these distinctive facies in two specific stratigraphic intervals at different locations across the Apenninic Platform suggests a common causal mechanism that might be related to the global environmental perturbations during OAE-2. In this work we will speculate about the significance of the laminated levels in a global perspective suggesting that they are the immediate response of carbonate platforms to the chemical-physical changes induced by the OAE2.

Barrier system response to a changing sea-level

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Barrier systems form and develop in response to changes in sea-level, sediment supply, wave climate, tidal dynamics, and storminess. It is expected that future changes in these parameters will substantially impact barrier system stability. A more comprehensive understanding of the centennial to millennial evolution of barrier systems is therefore paramount to address and estimate the future development of barrier systems.
In this study, we investigate the Holocene evolution of the Fanø barrier island located in the Danish Wadden Sea. We assess the sedimentary response of the barrier island to different rates of Holocene sea-level rise and indirectly sediment supply, as manifested in the internal architecture of the system. For this purpose, a combination of core well transects and ground penetrating radar (GPR) data was used to resolve the sedimentological and stratigraphic characteristics of the field site. Optically stimulated luminescence (OSL) dating was applied to construct a high-resolution chronology of dynamic changes based on samples from the cored sediments. All data were synthesized to reconstruct the internal architecture of the barrier system complex and its changes throughout the Holocene. The observations were evaluated against a well constrained local Holocene sea-level curve to assess sedimentary responses to changes in the rates of sea-level rise.
We show that Fanø experienced several phases of transgression and regression during the mid- and late-Holocene. These changes were driven primarily by changes in the rates of sea-level rise, sediment supply and by the impact of storms. Our data suggest that comparable rates of sea-level rise can result in very different morphological responses for a single barrier system, due to substantial changes in sediment supply over time. It further appears that a transgressive situation is reached for the studied barrier system for rates of sea-level rise higher than c. 2 mm yr^{-1}. This gives reason for concern, as a number of future sea-level projections indicate that such rates will likely be reached within a few decades from now.

Distribution and main control factors of fine sedimentary rocks in Chang 7 Oil Group of Ordos Basin

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Ordos Basin is located at the connection between the East China stable zone and the West China active zone. The Yanchang period (Chang 10 - Chang 1) is a large-scale depression basin with overall uplifting and stable rise/fall. The deposition of lake basin flourished at the Chang 7 oil layer group. On this basis, we hold that 6 types of fine sedimentary rocks were mainly developed, including fine sandstone, siltstone, dark mudstone, black shale, tuff and carbonate rocks. The space distribution of fine sedimentary rocks is divided obviously into several zones and is mainly affected and controlled by lake basin bed form, depositional system, and water depth.
The lake basin bed form controls the distribution of fine sedimentary rocks. The northeast part of Basin is characterized by slopes of 2-2.5°, development of a meandering river delta depositional system, mainly sandy deposition, distant spread of sand strips, and slow grain-size variation. The southwest part is characterized by slopes of 3.5-5.5°, development of a braided fluvial delta depositional system, mainly sandy deposition, short spread of sand strips, and rapid grain-size variation. Meanwhile, under the regulation of synchronous structural events, the deposits at delta front margins underwent slide and slump along the slopes as well as large-scale gravity flow deposition. Fine sandstone with thick sandbody deposition and low horizontal connectivity is distributed in the proximal slopes, while siltstone with relatively thin sandbody deposition and horizontal continuity is mainly distributed at the foot of distal smooth slopes. Semi-deep lake/deep-lake deposition and muddy deposition mainly developed at the center of the quiet and smooth lake basin.
The depositional system controls the genetic types of fine sedimentary rocks. The fine sandstones in the study area are mainly distributed in the delta front-margin underwater by-channels and the sandy clastic flow depositional environment. The siltstone is mainly distributed in the delta front-margin mouth sandbars, distal sandbars, sheet-like sands, and the turbidity flow depositional environment. The dark mudstone is mainly distributed in the delta front-margin branches and semi-deep lake depositional environment, while the black shale, tuff and carbonate rocks are mainly distributed in the semi-deep lake/deep-lake depositional environment.
The water depth controls the distribution and formation of the dark mudstone and black shale. The dark mudstone and black shale were both formed in the relatively quiet and closed depositional environment, and the differences of their distributions were controlled by the water depth. In the weak reducing/oxygen-deficient environment below the lake level and above the storm wave base, the dark mudstone was mainly developed there because of the relatively sufficient supply of terrigenous detrital materials, rapid deposition, low development of page-shaped beddings, and high content of deposit organic matter. In the anaerobic environment below the storm wave base, the black shale was mainly developed there because of the relatively insufficient supply of terrigenous detrital materials, slow deposition, development of page-shaped beddings, and high content of deposit organic matter.

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Building blocks of the modern Golo submarine fan: Insights from high-resolution seismic data

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Tank experiments suggest that sandy submarine fans in the Froude supercritical regime (i.e., with slopes greater than 0.5 degrees) have unique patterns of channel extension, lobe stacking and channel backfill strongly influenced by the character of supercritical flow (e.g., hydraulic jumps), which differ from those in subcritical experiments (e.g., Hoyal and Sheets, 2009; Hamilton et al., 2015; Cantelli et al., 2004). Definitive testing of such hypotheses can only be carried out in high-resolution seismic data (e.g. close to bed scale resolution).
While sufficiently detailed high-resolution seismic data has been available for some time (e.g., Gervais, 2006), the painstaking interpretation required to decompose the stratigraphy into its fundamental building blocks and reassemble them according to a rigorous temporal framework has not been carried out. A prime opportunity for such a study is the youngest late Pleistocene lobe in the Golo submarine fan system, East Corsica. This 'distributary channel-lobe complex' was traversed by a closely spaced grid of multi-channel sparker 2-D lines with a vertical resolution of two to three meters.
A range of lobe geometries was documented in the Golo fan by Deptuck et al. (2008) depending on the feeder type (gully or long-lived canyon) and the slope. Unlike the Proximal Isolated Lobes (PILS's) on very steep slopes, Complex Mid Fan Lobes (CML's) are located outboard of mid fan valleys. The late Pleistocene lobe studied here is the youngest of these CML's fed by the South Golo Canyon. Previous studies have recognized at least three hierarchical levels of compensation stacking within this lobe: lobe elements, lobes and lobe complex (Gervais et al., 2006; Deptuck et al., 2008; Prelat et al., 2010).
This study focuses on lobe elements that are nested bodies consisting of stacked beds or bed-sets. They appear to be formed of stacked sandy-leveed channels that are very erosive at the classic channel-lobe transition (at the complex scale) and remain erosive until the distal part of the fan when they transition rapidly to subtle aggrading channel geometries to relatively short size unconfined terminal lobe deposits. The lobe elements stack in a generally retreating pattern recognized in isopach maps and the aggrading/retrograding filling of the incised channels.
These observations suggest that real sandy supercritical fans like Golo prograde through cycles of channel extension and backfilling. As in the experiments, the greatest erosion is in the channel upstream of the channel-lobe transition and backfilled by upstream dipping strata (backsets) in a complex fashion. Channel-lobe backsets are the longest and subtlest, while steeper small-scale backsets are associated with bedforms (e.g., Deptuck, 2008). This particular retrograding pattern is in agreement with the interpretation of the Golo fan being fed by turbidity flows in a supercritical regime.
Piston cores enable us to recognize the successions of bedforms that are the basic building blocks of supercritical fans (morphodynamic successions). Linking these successions with surfaces interpreted from the high resolution seismic data enables us to infer architecture from 1-D data like a core or image logs to develop techniques that can be applied to industry quality data.

Modern submarine canyon feeder-system and deep-sea fan facies in a tectonically active margin (northern Sicilian margin)

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Widely used sequence stratigraphic models predict that specific facies assemblages alternate in the stratigraphy of deep-sea fans, depending on the cyclic nature of sea-level variations. Our work tests this assumption through facies reconstruction of submarine fans that are growing in a small basin along the tectonically active Sicilian margin. Multibeam bathymetry, sidescan sonar images, subbottom profiles and core samples are used to reconstruct the processes of sediment feeding to canyon heads, downslope transport through canyon and leveed-channels and final deposition in various lobes. Connected canyons have heads close to the coastline; they can be river connected or littoral cell–connected, the first receiving sediment from hyperpycnal flows, the latter intercepting shelf sediment dispersal pathways. Hyperpycnal flows directly discharge river-born sediment into the head of the river-connected canyon and originate a large turbidite fan. A drift formed by the longshore redistribution of sediment of a nearby delta introduces sediment to the head of the littoral cell–connected canyon, forming turbidity currents that flow within the canyon to reach the basin plain. However, since sediment failure and landslide processes are common in the slope part of the system, a mixed fan, consisting of both turbidites and mass-transport deposits, is formed. Disconnected canyons, with heads at the shelf edge far from the coastline, are fed by canyon head and levee-wedge failures, resulting in mass-transport or mixed fan deposition, the latter developing when the seafloor gradient or the lithology of the failed sediment allows turbidity current formation. Connected canyons form in areas with high uplift rates, where the shelf is narrow and steep and the shelf edge is at a relatively shallow depth. Disconnected canyons develop where there are lower uplift rates or subsidence, where the shelf is large and relatively gentle with a deeper shelf edge. It is deduced that the relative vertical movements of fault-bound blocks control whether canyons are connected to the coast at the present day. The role of tectonics in controlling the canyon feeding processes and the facies of submarine fan growth during highstand periods is therefore highlighted. A further view that arises from our paper is that in active margins, the slope portion of fan systems, through seafloor instability and variations in channel gradient, is a key factor in determining the final deep-sea fan facies, regardless of the distance between the coast and the canyon. The concomitant growth of turbidites, mass-transport deposits, and mixed fans demonstrates that models that predict changes in submarine fan facies on the basis of sea-level cycles do not necessarily apply to systems developed along tectonically active margins.

Onyx-like carbonate veins: A challenging banded deposit for tracing the underground circulation of hydrothermal fluids

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Circulation and upwelling of hydrothermal fluids (gas and/or water), the most distinctive process related to a geothermal system, is always driven by extensional faulting resulting in a network of interconnected fractures which promote permeability in the rock mass and circulation of hot waters. The circulating fluids if characterized by the appropriate chemistry (i.e. supersaturated – bicarbonate waters), can be able to encrust progressively and eventually seal the underground conduits with calcium carbonate crusts made of laminar, onyx-like crystalline calcite and/or aragonite (Onyx-like banded carbonate; Banded travertine Auct.; injection and sill-like veins). Their occurrence within the bedrock and sometimes in the epigean travertine body, marks the pathways and records the dynamic and geochemical behaviour of the circulating fluids.
In this context, if the travertine body represents the epigean/subaerial and distal end of a geothermal circuit, the hypogean network/mesh of onyx-like, banded carbonate veins developed in conduits/fractures of the bedrock, corresponds to the deep “roots” of the overlying epigean system. Useful information about the geometry, kinematics and original fluid geochemistry and petrogenesis can be provided by the multidisciplinary analysis (petrologic; geochemical/isotopic; structural) of the epigean and hypogean deposits of thermal systems exposed in abandoned quarries.
Onyx-like carbonate veins, ranging from some millimetres to a few metres in width, are infilled with juxtaposed, wall-parallel sheets of closely packed crystals in radial acicular bundles or columnar palisade arrays. The crystals are arranged perpendicular to the vein-walls and oriented towards the centre of the vein where the crystal terminations of the two opposed crystalline bands tend to meet and to seal the conduit. Discontinuities in the fluid flux and consequently in the growth of the crystals are marked by the occurrence of more or less developed veneers of microbial, microcrystalline/micritic calcite commonly associated with dissolution/fracturation/boring of the crystal termination faces and by the irregularly alternating sets of limpid and rusty-red stained sheets of crystals.
The petrologic and geochemical features of the crystalline fabrics and the structural characteristics of the veins/fractures suggest a combined action of different leading processes (dilatational fracturing, subsidence and gravitational collapse, gas discharge variations; palaeoclimate oscillations) that can be related to fossil-to-active tectonics in the geothermal system area; palaeoseismological history over restricted time spans and physical-chemical characteristics of the upwelling thermal waters.

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Multi-factor analysis in physical property preservation mechanism of Early Jurassic SanGonghe Formation deep buried clastic reservoir, central of Junggar Basin, China

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Buried in depth of 3300-5000 m, mostly between 3800-4600 m, Early Jurassic SanGonghe Formation in central of Junggar Basin shows a high quality physical property and becomes the most favorable oil producing layer. Despite deep burial depth, the highest porosity of SangGonghe Formation can reach 21% in 4236 m and has an average porosity of 13.28%, for permeability, it can reach 1060 md in 4651 m, and average 26.09 md. Previous researches suggest that this phenomenon is due to secondary dissolution. However, based on microscopic-analysis and other analysis assay data, together with well data, it is discovered that secondary dissolution is only one aspect, property changes of diagenesis fluid, history of strata overpressure, certain burial history and low geothermal gradient are the other four critical factors in reservoir property preservation.
For delta-lake depositional environments and feldspthic lithic sandstone rock type, SanGonghe Formation had an original porosity of 41.8% in average. During the later diagenesis, it shows following typical characteristics: 1) Lots of primary and secondary quartz dissolution, together with considerable amounts of chlorite and its metasomatism on quartz; 2) Overgrowth of feldspar is common; 3) Between detrital grains with chlorite coatings, there exists a certain amount of authigenic kaolinite; 4) Both authigenic chlorite and kaolinite show a positive correlation with porosity and permeability; 5) Dissolution mainly occurs in feldspar, not cement; 6) The grains are mostly in point-line contact which shows medium compaction.
According to these phenomena, diagenesis fluid changes from alkaline to acid can be figured out. Due to alkaline diagenesis fluid has an inhibitory effect on quartz cementation, this change firstly made primary porosity preserved, besides the carbonate and feldspar cementation which occurred in alkaline diagenesis fluid not only can enhance the compressive strength of the reservoir, but also provide dissolved matter in the latter acid diagenesis fluid. So the diagenesis fluid changes then promoted porosity reformulation. Moreover, it is found that authigenic chlorite not only suppress compaction but also accelerate quartz dissolution, thus authigenic chlorite has two ways in preserving physical property of reservoir. Meanwhile, cooperative relation of strata pressure simulation and burial history shows overpressure happened during the early dianenesis, which balanced out porosity loss of compaction. But due to later petroleum maturity, second overpressure began and led to carbonate cementation zone mainly at top surface of overpressure, which has been verified by carbon-oxygen isotope analysis. Furthermore, low geothermal gradient by 2.2 °C/100 m in average retarded the processes of diagenesis.

Consequently, all these favorable factors led to nowadays favorable deep buried reservoir. So a new reservoir evolutionary pattern is proposed to explain the mechanism of deep buried clastic reservoir porosity preservation.

The distributary channel and lake play a role in the growth process of shallow water delta – to Poyang river delta as an example

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The shallow water delta is one of the important causes large area of sand body distribution in basin. Through to the modern Gan river delta sedimentary pit mining multiple parts, and carried out on the delta plain - estuary sandbar, bank, land after sediment lithology, sedimentary facies sequence and sedimentary characteristics of contrast. And on the gan river delta straight river sediments in the center of the sample analysis. Gan river delta plain type straight distributary channel has three kinds of mechanisms for the formation of shallow water delta. Poyang lake, the river type exposure lake basin has four kinds of mechanisms for the formation of shallow water delta. Shallow water delta estuary bank, the bank sediment accumulation and distributary channel to the lake after growth, related to the growth of the river mouth dam, merge, and analyzes its formation process.
On this basis, the combination of Poyang lake water is high, the hydrological characteristics of low water like a river, set up the Gan dynamic growth model of shallow water delta. The Gan shallow water delta and the cause of the Poyang lake area sand distribution evolution process has three stages. The first phase for the early lake sedimentary stage. The water level of lake is low, in the lake development stable dark gray, gray, khaki argillaceous sediments, straight to carry large amounts of sediment into the lake, river estuary in form, transverse longitudinal dam and underwater distributary channel sand deposits. The second phase of water level up to maximum flood period. The water lavei of lake rise early, due to the coming of the flood period, Poyang lake water level fluctuate frequently, lake current, wave and flow scour off the coast of early deposition of delta plain, delta front mouth bar, underwater distributary channel sand body occurs in sheet reformation, sandy areas. Maximum flood period, rivers carry large amounts of sediment into the lake, the lake throughput type flow, flow effect, jacking lake flow velocity is low, sand and mud accumulation in previous large area river channel, embankment and estuary. The third stage of Gan river delta prograde stage. With the coming of the mutagenicity, water lavel of lake drops, the delta plain region, the retreat of the lake, distributary channel of the river deposition of sediment scouring low-lying place, and carried into the lake, and on both sides of the river bank high parts deposition of sediment accumulation is superimposed preserved, which is under the Gan river delta plain development suitable straight, meander sideproduct development, and the reason of the bank deposit has increased every year.

Facies and depositional processes of braided river in lowstand valley: Early Cretaceous Qingshuihe Formation in Shinan Oilfield, hinterland of Junggar Basin, China

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Shinan oilfield, located in hinterland of Junggar Basin, is one of the most studied areas in China due to incredible quantity of hydrocarbons in early Cretaceous strata. From late Jurassic to early Cretaceous, tectonic setting of the basin changed enormously: Jurassic Che-Mo paleo-uplifts which distributed from SW-NE across the whole basin began to be buried and river valleys among uplifts began to be filled instead of incising. Thus, a basin scale unconformity between Jurassic and Cretaceous was formed and early Cretaceous Qingshuihe Formation became a sequence under the background of river valleys geomorphology.
For the lithofacies of Qingshuihe Formation, bottom sandy conglomerate represent LST deposition. Above these coarse grain sediments, 20-150 m thick TST shale which is widely distributed within the basin can be figured out as marker bed. While, sedimentary facies and deposition pattern of the LST sandy conglomerate are still in dispute, most researches are preferred to explain as braided river delta. But this time, based on field outcrop, rock core, well logging, heavy mineral composition, together with 3-D seismic attribute and seismic facies analysis, we found the sandy conglomerate should be braided river sediments of a lowstand river valley.
To recover the original geographic and geomorphic conditions, sequence boundary and maximum flooding surface of Qingshuihe Formation are newly identified. Through 3-D seismic layer flattening interpretation of reference layer and correction of well data, ancient landform before the deposition of Qingshuihe Formation is reconstructed. The figure shows one large and five small scale erosion monadnocks together with valleys among them. According to geomorphology and strata distribution characteristics, 4 basic units are divided to describe sedimentary environment, i.e. erosion highland, river valley, erosion slope and erosion monadnock. Seismic facies which show strata onlap reflections in 10-25 km wide valley reveal the processes of filling, not suitable for delta deposition.
Sedimentary micro-facies of this braided river deposition in valleys can be divided into 6 types. 1) main braided channel: the most coarse-grained, conglomerate, directional alignment of gravels, two-three sections of grain size probility curve, scour surface, intense carbonate cementation; 2) river island: less coarse-grained, sandy conglomerate, many sections of grain size probility curve 3) gulley: fine grained sandstone, scour surface, while this sediments only occur when hydrodynamic weakened; 4) flood plain: due to frequent migration of braided river, the sediments can be rarely preserved, mainly grey green mudstone; 5) river margin: a special type of gravity flow sediments, only found around erosion monadnocks, mixture of sand-gravel and mud, line or arch shape grain size probility curve, angular gravel of underlying strata; 6) erosion gully on monadnock: seismic attributions extraction along strata slicing identify this type of sediments, on rock core scale, coarse sand can be seen injected into weathering variegated mudstone.
Due to frequent migration of main channel, sandbody shows continuous distribution, but can be recognized cutting with each other by seismic facies. When the valleys had been filled-up, braided river turned into delta with lacustrine transgression. Ultimately, a deposition pattern of LST braided river valley is proposed.

Qualitative and quantitative method in recovery of Jurassic prototype basin's original sedimentary system and basin boundary in southern piedmont thrust belt of Junggar Basin

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Located in northwestern China, Junggar Basin is a typical multi-cycle superposed basin. During the Mesozoic era, it was a unified intracontinental depression basin with a further south boundary. From Tertiary, the intensive uplift of southern Tianshan Mountains has changed it into a characteristic rejuvenated foreland basin. Nowadays, the basin shows favorable petroleum prospect in Jurassic reservoirs. But due to later tectonic reconstruction, Jurassic prototype basin topography has changed a lot, especially in southern piedmont thrust belt where there exists strata denudation and deformation. To make Jurassic prototype basin’s sedimentary system and basin range clear in south margin area, qualitative and quantitative methods are used in this paper.
For qualitative methods, firstly, based on apatite fission track ages, conglomerate’s gravel composition, paleocurrent and sandstone composition maturity, uplift orders of different parts in southern Tianshan Mountains and changing trend of basin boundary during Jurassic are recovered. Secondly, sequence stratigraphy and sedimentary facies sequence are comparatively analyzed between critical outcrop sections which are located in thrust belt and present basin boundary, this study reveals how far the prototype basin’s boundary in Jurassic has once reached. Thirdly, by drilling wells’ data and analysis assay data, paleoclimate, stratigraphic distribution and depositional facies are rebuilded.
In quantitative study part, firstly, 4 quantitative relationships are builded by 9 outcrop sections and 21 wells to recover the distance from each point to original basin boundary: ① transport distance and gravel diameter ② transport distance and stable coefficient of heavy minerals ③ transport distance and Q/F+R index ④ transport distance and ratio of sandstone/strata. Secondly, balanced section of stricture are used to calculate the thrust distance of whole strata.
In the last part of study, qualitative achievements and quantitative data are comprehensively analyzed to map the original basin boundary and sedimentary system in Jurassic.
Based on the results of research above, Jurassic prototype basin’s boundaries in different parts are recovered 24.6-102.4 km southward from today’s, besides, a more accurate paleogeographic framework is shown to guide Jurassic petroleum exploration.
Consequently, a new method in prototype basin recovery and sedimentary system analysis is proposed for multi-cycle superposed basin study.

New seismic sequence stratigraphy in the Ría de Vigo (NW Spain)

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In 1970, Pannekoek suggested that the rias were formed during the Miocene, Pliocene and Pleistocene by erosion along a pre-existing fault zone weakened by deep weathering and the marine occupation would be consequence of the eustatic oscillations during the Quaternary. Posterior authors proposed that the rias are the product of tectonic activity associated with the Betic (Alpine) Orogeny along the southern side of the Iberian Peninsula. This activity which propagated along the western Iberian margin reactivated Paleozoic faults and deformed the Mesozoic-Cenozoic sediment cover in Portugal and the Portuguese margin, and is responsible for the faulting, uplift and the erosion of several hiatuses on the Galicia margin.
In the absence of stratigraphic control the possibility that the older sedimentary unit in Ría de Vigo was pre-Wúrm merited serious consideration and most of authors also inferred that the unconformity separating the oldest and youngest sequences was eroded during the glacially induced (Würm) regression.
Recent investigations, including new high resolution seismic data, gravity and vibro-cores, as well as radiocarbon dating have allowed a new interpretation of the stratigraphic record of Ría de Vigo. The presence of Late Pleistocene sediment (pre-Würm) in the ria has been proven for a fist time by radiocarbon. The new sequence stratigraphy analysis permits us to identify the stratigraphic record, its component units and their bounding hiatuses, as corresponding to the changes of relative sea level during at least the last 130 kyr. During the drop of sea-level, after the last interglacial period, a transition from marine to coastal environments took place in the surroundings of the ria. The lowest sea level was reached during the Würm glaciation (20 kyr BP) when the sea level was 120 m b.p.s.l., and the ria was completely exposed to aerial erosive processes. It is not until after the end of the Younger Dryas cold event when the sea level reached the internal area of the ria.

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Shallow gas characterization in the context of high resolution seismic stratigraphy of the Ría de Ferrol (Rías Altas) and its comparison with the Rías Baixas (NW of Spain)

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The Ría de Ferrol, located in the Artabro Gulf (NW of Spain), represents a very especial estuary compared to the well-studied “Rías Baixas”. It is characterized by the scarce influence of upwelling events and its bathymetry presents a very narrow channel that strongly influences water circulation and connects the outher and inner parts. Most of the estuary water comes from the ocean due to the small fresh water input (mainly represented by Xubia river). The tidal prism in the ria represents about 33% of the water content, while it is only 12% in the “Rías Baixas”. The strait reinforces the tidally induced vertical mixing in the channel area, which becomes well mixed, while in the mouth and in the inner part it remains slightly stratified. The Ría de Ferrol covers an area of 21 km^2 and a length of 15 km, with dephts no greater than 33m. It is NE-SW oriented and can be divided into three main geographic areas: the outer part that corresponds to the estuary mouth, the middle strait of Ferrol and the inner part which represents the main surface and is where the harbour and the city of Ferrol are located.
There are scarce scientific studies in the submerged part of the Artabro Gulf (that comprises the rias of A Coruña, Ares, Betanzos and Ferrol), and none of them deal with the stratigraphic record. We present a detailed study of the sedimentary infill using a multidisciplinary approach combining geophysical, geochemical and sedimentological data.
Two seismic surveys were carried out in the area recording 90 km of seismic profiles. Four gravity cores were also recovered in the inner part and sampled to analyse methane, sulphate, TOC, etc. Cores were also analysed by ITRAX core scanner.
Three main seismic units where identified in the inner part of the ria. The youngest unit is delimited at its base by a horizontal erosive surface, showing an aggrading pattern configuration of continuous reflectors, and is correlated to the Holocene sedimentation. The presence of shallow gas in this unit is denoted by the acoustic blanking found in seismic records. The gas was identified as methane by concentration measurements performed in the sampled cores. The first systematic gas mapping and its stratigraphic contextualization has been performed showing the biggest gas field in the inner part of the ria, and smaller gas fields towards the strait of Ferrol. These results are compared with shallow gas occurrences in the Rías Baixas.

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Ophiolitic detritus in Kimmeridgian calcareous basin sediments: Ophiolite obduction as cause for the Middle to Late Jurassic tectonic processes in the Northern Calcareous Alps (Austria)

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The causes for the Middle to Late Jurassic tectonic processes in the Northern Calcareous Alps are still controversially discussed. There are several contrasting models for these processes, formerly invented as "Jurassic gravitational tectonics".

Whereas in the Dinarides or the Western Carpathians Jurassic ophiolite obduction and a Jurassic mountain building process with nappe thrusting is widely accepted equivalent processes are still questioned for the Eastern Alps. For the Northern Calcareous Alps an Early Cretaceous nappe thrusting process is widely favoured instead of a Jurassic one, obviously all other Jurassic features are nearly identical in the Northern Calcareous Alps, the Western Carpathians or the Dinarides. In contrast, the Jurassic basin evolution processes as best documented in the Northern Calcareous Alps were in recent times adopted to explain the Jurassic tectonic processes in the Carpathians and Dinarides. Whereas in the Western Carpathians Neotethys oceanic material is incorporated in the mélanges and in the Dinarides huge ophiolite nappes are preserved above the Jurassic basin fills and mélanges, Jurassic ophiolites or ophiolitic remains are not clearly documented in the Northern Calcareous Alps.

Here we present chromium spinel analyses of ophiolitic detritic material from Kimmeridgian allodapic limestones in the central Northern Calcareous Alps which clearly evidence Late Jurassic erosion of obducted ophiolites before their final sealing by the Late Jurassic–earliest Cretaceous carbonate platform pattern. The new data of detrital chromium spinel grains in the western central Northern Calcareous Alps result in the following conclusions:

1. Erosion of the obducted ophiolite stack started in the Kimmeridgian and not in the Early Cretaceous as previously assumed. This clearly indicates that the first thrusting event related to ophiolite obduction (upper plate) in the Northern Calcareous Alps is of Jurassic age. In a Jurassic strike-slip tectonic environment redeposition of eroded oceanic crust cannot be expected.
2. Geochemical composition of the detrital chromium spinells points to a harzburgite provenance. The (Jurassic SSZ) ophiolites occur in a higher nappe position as the (mainly) lherzolithic (Triassic) ophiolites, as proven in the ophiolite nappe stack e.g. in Albania (Mirdita ophiolites).
3. The southern Northern Calcareous Alps underwent the same Jurassic to Early Cretaceous geodynamic history as the Western Carpathians, the Dinarides, and the Albanides/Hellenides with Middle to early Late Jurassic ophiolite obduction and the onset of erosion of the ophiolitic nappe pile in the Kimmeridgian. A Kimmeridgian to earliest Cretaceous carbonate platform evolved on top of the nappe stack including the obducted ophiolites. Erosion of the obducted ophiolite nappe stack started in the Kimmeridgian and lasted until the late Early Cretaceous (Aptian), but interrupted by the (Late) Kimmeridgian to earliest Cretaceous platform evolution, which protected the ophiolite nappe stack against erosion during that time span. In the Early Cretaceous also this platform was widespread eroded and can only be reconstructed by pebble analysis from mass flows in the Lower–Upper Cretaceous sedimentary successions.

Braided river delta sand-body distribution and reservoir predication in a transfer zone: Example from the Paleogene Wenchang Formation, HZ-A block, Huizhou sag, Pearl River Mouth Basin, China

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The Pearl River Mouth Basin, is one of the most important petroliferous basins in China. The Paleogene Wenchang is an important hydrocarbon-bearing stratigraphic unit (buried depth > 3500 m). HZ-A block, located in the south of Huizhou Sag, covered with 3-D seismic data and only four drilling wells. However, the seismic data is characterized by narrow effective-frequency band and low resolution. Therefore, sedimentary body features including thickness and physical property, which cannot be described precisely and quantitatively by techniques of sequence stratigraphy or seismic sedimentology technology alone.
A high resolution inversion technique named seismic phase-controlled nonlinear random invertion has the advantage of seismic prediction for thin sandstone. It is not limited to the constraint of an initial model and provides inversion results with clear geologic meaning. By using 3-D seismic data and well data, taking techniques of seismic phase-controlled nonlinear random invertion, combined with sequence stratigraphy and seismic sedimentology, sedimentary facies and sand body distribution of the SQ2 of Wenchang formation has been analyzed in detail.
The results are as follows: (1) Lacustrine braided river delta of three periods are identified in the transfer zone (from base to top: namely D-1, D-2 and D-3), the delta was deposited jointly by the provenances, which controlled different periods of delta. The major oil reservoir is located in the D-2, and the thin sandstone layer of 8~15m can be distinguished in inversion profile. (2) The underwater distributary channel and mouth bar are the favorable reservoirs. We also depicted the thickness map of sand-body (porosity >8%) distribution of D-2. (3) Finally the stratigraphic-lithologic trap under the complex geological conditions is identified.
In continental basins, the sedimentary facies change quickly, the thickness of sand body is usually thin and the seismic quality of deep-baried formation is often not good, which bring great difficulties to the predication of sand-reservoir. This study demonstrates that facies architecture and sand-body distribution analysis using sequence stratigraphy, seismic sedimentology and high resolution inversion may serve as an effective approach for petroleum exploration in areas lacking of wells or outcrop data.

An analysis of sedimentary environment of Wufeng Formation of Upper Ordovician in southeastern Chongqing

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There are always two tremendous arguments about the sedimentary environment of Wufeng Formation of Upper Ordovician in South China, which are"deep-sea" and "shallow sea"views. To find out what sedimentary environment it may be, we selected Southeastern Chongqing area as the study area and tried to analyse the nature of the basin, the palaeoecological features of radiolarian and lithogeochemical data of Wufeng Formation.
Firstly, the Middle-Upper Yangtze Area formed the stable crystalline and folded basements in Grenville Orogeny. It experienced two evolutionary phases that changed from extension to compression mechanism in Sinian–Silurian period. In the Sinian-Middle Ordovician, this area evolved from the initial pull-apart basin to the rift basin in an extensional environment. In Cambrian the study area deposited lots of carbonates and formed the carbonate ramp above on the clastic base plate of Nanhua period, and then evolved into a rimmed carbonate platform. In the Middle-Late Ordovician, as the compression and collision intensified, the Central Sichuan, Central Guizhou, and Xuefeng uplifts constantly expanded, and the sea level rose relatively. The rimmed carbonate platform developed in Middle-Upper Yangtze Area was submerged and transformed into carbonate ramp, and finally developed into the"back-bulge"basin confined by the marginal uplifts. The black shales of Wufeng Formation deposited in the "back-bulge"basin.
Secondly, different ecological information of radiolarian represents different depths, we has found out radiolarian in Wufeng Formation in some sections of southeastern Chongqing, which is characterised by sphaerical forms without any spines, monotonous species and low diversity. The faunal characteristics of the radiolarian are similar to those recorded from the Paleozoic epicontinental sea of Atalantic, showing that the Wufeng Formation was formed in a shallow sea environment.
Thirdly, redox conditions in marine settings controlled the concentrations of elements in sediments and sedimentary rocks. Thus, the concentrations of them could be used to reconstruct the paleoredox environment. We have measured the major, rare-earth and trace elements contents in the siliceous rocks samples from Wufeng Formation.MnO/TiO_2 ratios range from 0.004 to 0.25,Sr/Ba from 0.01 to 0.23. U/Th from 0.15-2.20. The ∑REE values vary from 82.7×10-6 to 317.06×10-6,the Ce/Ce* from 0.46 to 0.87 and the average values of Lan/Ybn ratios equal to 7.08. These results show that siliceous rocks with low ∑REE contents and relative LREE enrichment were formed in the continetal –margin environment.
From all the evidence of paleotectonics, palaeoecology and geochemistry, we conclude that the black siliceous rocks in the Wufeng Formation may deposited in a shallow sea environment.

Paleokarst system based on FMI facies analysis: A case study in the Yingshan Formation at the Tazhong uplift in the Tarim Basin, Northwest China

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The northwest-to-southeast-striking Tazhong Uplift is located in the middle of the central uplift belt of the Tarim Basin. The closure of the North Kunlun Ocean during the Middle Ordovician caused the rise, denudation of the Tazhong Uplift. A complicated paleokarst belt formed on the unconformity at the top of the Yingshan formation. Current petroleum exploration in the basin indicates that this horizon contains important karst hydrocarbon reservoirs, so it is necessary to study the paleokarst system by using high-resolution data.
In this study, over 5000 meters FMI images from 20 wells in the Tazhong Uplift were described for paleokarst system in the Yingshan Formation. Static images were used to differentiate lithology while dynamic is used to recognize sedimentary structures and cave fillings. 11 FMI Facies were defined based on the visual appearance of the image. Limited fullbore cores and thin sections were also available to calibrate the lithology for FMI facies and gamma ray curves were required for calibrating cave fillings for its indication to mudstone content.
F1 Caves facies: Bright-dark vertical stripes as collapsed cavers and dark sections different from host rocks as cave fillings of mud could be distinguished in dynamic images. F2 Dissolution breccia facies: Breccias are bright spots in the FMI image has nearly no displacement. Lower conductive material filled the fracture between resistive breccias. F3 Small caves filled with mud facies: Obvious small irregular holes can be seen in the images as black spots, but they are less dissolved than F1. F4 Layered dissolved pores facies: Acicular dissolved holes are like honeycomb bedding distributed. F5 Massive limestone with conductive fractures facies: Fractures are like black sinusoids on resistive background. F6 Paleosol facies: 20~50 cm thick black stripes under the unconformity at the top of the Yingshan Formaiton, the distinguishing feature is the small peak in GR curves. F7 Thin interbedded conductive facies: This facies is often located in the upper section of cave facies in the Yingshan Formation with lower resistivity and higher GR value. F8 Homogeneous formation with high resistivity: It's bright yellow image without bedding structure even in the dynamic image, which represents homogeneous lithology. F9 Inhomogeneous formation with high resistivity: The differences of resistivity in the FMI images reflect the change of sedimentary water energy. F10 Composite facies of conductive fractures and dissolved pores：High angle fractures displayed on the imaging loggings and there are many dissolution pores scattered near the fracture. F11 Composite facies of vertical fractures and stratified dissolved pores: Vertical or near vertical fractures without dissolution on fracture planes but present with stratified pores.
After the analysis of FMI facies compositions in wells vertically and on profiles horizontally, we found two sets of paleokarst systems were formed in the Yingshan formation. F1, F4, F10, and F11 are low in resistivity and high in porosity and permeability, therefore, they can form good quality reservoir. F7, F8, and F9 are form interlayers between reservoirs of the paleokarst system. In these facies, fractures are the prominent passages for fluid flows.

Downstream-migrating fluvial point bars: Architeture and morphodynamics from the Jurassic Scalby Formation of Yorkshire (UK)

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Modern river meanders with down-valley migrating bends (e.g. Beaver River, Canada) demonstrate that the classic textbook model of simple expanding-meander bends cannot be used as a universal guide to interpret the depositional architecture of ancient point bars. We present key aspects of ancient, downstream-migrating fluvial point bars contained the exhumed meander plain of the Jurassic Scalby Formation (Yorkshire, UK). The Scalby Formation is contained in the extensional Cleveland Basin, which was filled with shallow marine and fluvial-deltaic deposits. Within Cleveland basin, minor depocentres such as the N-S trending Peak Through host fluvial deposits resting unconformably atop shallow marine clastics.
Meandering-fluvial deposits at the base of the Scalby Formation are sandstone-dominated and organised in distinct bodies that represent nested, incised-valley fills 4 to 12 m thick. These fluvial deposits are untilted, and currently exposed on a 3.5 x 0.5 km-wide tidal wave-cut platform, a circumstance that makes their analysis in planform particularly favorable. Here we specifically focus on the planform evolution and stratal architecture of downstream-migrating point bars, providing parallels with modern meandering rivers of similar scale. Five well-preserved point bars are analysed through 1:2000-scale facies mapping integrated with stratal architecture, palaeoflow analysis, and nature of adjacent deposits.
The main results stemming from this study are, as follows:
1) Development of downstream-migrating point bars was facilitated by - but not strictly related to - the presence of erosion-resistant outer banks.
2) Downstream migration promoted erosion of upstream-bar portions, subordinate preservation of central-bar sectors, and widespread development of downstream-bar scrolls.
3) The most reliable indicators of regional transport are: i) palaeoflow indicators preserved in upstream-bar deposits; and ii) dip-direction of downstream-bar inclined beds.
4) The sectional architecture of downstream-migrating point bars partially overlaps with that of other fluvial models, indicating that lack of planform exposures may introduce bias when reconstructing fluvial morphodynamics.

Holocene paleo-hydrographic and landscape evolution of the Pisa coastal plain (Tuscany, Italy) integrating remote sensing and high-resolution stratigraphic data

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High-resolution reconstructions of the Holocene fluvio-deltaic depositional architecture and paleo-hydrographic evolution of modern coastal plains are relatively rare, as both require large and dense subsurface datasets. In this regard, an integrated remote sensing-stratigraphic approach can be helpful, since satellite and/or aerial image analyses may identify buried landforms, which could represent significant stratigraphic targets.
We present a high-resolution, cross-disciplinary reconstruction of the mid-late Holocene (last 6000-5000 yrs) stratigraphic architecture from the Pisa coastal plain (Tuscany, Italy), with the specific aim to furnish new insights into the mechanisms of Mediterranean delta plain establishment and development.
On the basis of multispectral and multitemporal satellite images, new drillings were carried out by a portable vibracorer down to 10 m depth.
Specific attention was paid to inferred fluvial traces reconstructed from satellite imagery, which were calibrated to depositional facies (channel sands and levee sandy complex) and stratigraphic depth. This validation process allowed a better delineation of the buried paleochannels, extending stratigraphic correlations between punctual subsurface data.
Several sinuous paleo-traces attributable to the two main river systems feeding the area (Arno and Serchio rivers) were identified at different stratigraphic levels. The evolving paleo-hydrographic network and its related paleo-environments document a two-fold sedimentary evolution during the last 5000 yrs BP.
The first phase, characterized by the development of wide deltaic marshlands crossed by shallow channels and filling the antecedent lagoon, occurred at the beginning of the Eneolithic age (ca. 5000 cal yr BP) and lasted up to the Bronze age (ca. 3800 yr cal BP). Then, an alluvial plain was established in the Pisa city area, passing seawards to a sandy strandplain. The present delta plain began to develop under the influence of a fluvial network whose branches were mainly oriented E-W (Arno River) and N-S (Serchio River). Specifically, two sub-stages can be distinguished: i) a phase of intense fluvial activity with deeply-incised channels and poorly drained floodplain conditions, lasting up to the Etruscan period (2500-2200 cal yr BP), and ii) the onset of a well-drained alluvial plain, at the transition with the Roman age (ca. 2000 yr cal BP) and still in evolution, characterized by more stable and less numerous fluvial channels.

Late Quaternary development of barrier and fringing reefs of Bora Bora, Society Islands, South Pacific: The influence of subsidence, sea level, and antecedent topography

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Bora Bora is a prominent oceanic barrier reef system as it was used by Charles Darwin to illustrate his widely known subsidence theory of reef development. Because no subsurface data existed for this type barrier reef, a drilling project was developed in order to reconstruct late Quaternary reef growth and accretion, and to constrain the influence of controlling environmental factors such as subsidence, sea level, and antecedent topography.
Coring the barrier reef has revealed >30 m thick coralgal and microbial successions of the Holocene, characterized by an upcore transition from an agaricid-rich to a robust-branching *Acropora* assemblage. Coral-rich deposits of an underlying Pleistocene reef contain laminar *Montipora* and agaricids. Holocene reef growth began 10.03±0.05 kyrs BP and modern sea level was reached by the investigated reef during 4.96±0.02 and 2.62±0.02 kyrs BP before present. Barrier reef accretion rates range from 4.81-6.48 m/kyr. Holocene reef terraces up to 1 m above present level are witnesses of a late Holocene higher-than-present sea level. The underlying Pleistocene reef formed 116.93±1.1 kyrs BP, i.e., at the end of marine isotope stage (MIS) 5e, based on a strictly reliable U/Th-date obtained from a pocilloporid coral. Assuming deposition at or close to sea level and a 6 m higher-than-present sea level for MIS 5e, the maximum subsidence rate of Bora Bora may be calculated to ca. 0.31 m/kyr (mm/yr). This value falls into the 0.25-0.4 m/kyr range of the late Quaternary subsidence rate estimated for Tahiti, the postglacial reefs of which were recently drilled during IODP leg 310, but is significantly higher than the subsidence rates estimated earlier for nearby islands that are further away from Tahiti and the archipelago's hotspot.
Fringing reef drilling recovered coralgal and microbial reef sections, as well as abundant sand-rich, unconsolidated sections on top of Pleistocene basalt and soil. A *Montipora–Porites* assemblage transitions upcore to a *Pocillopora* assemblage. No Pleistocene fringing reef was recovered. Fringing reef growth started 8.78±0.05 kyrs BP; Holocene accretion rates range from 3.66-5.20 m/kyr, i.e., lower as compared to those of the barrier reef. Modern sea level was reached by the investigated reef during 5.13±0.02 and 1.96±0.02 kyrs BP.
Collectively, the occurrence of coral assemblages suggests an upcore increase in wave energy. Age-depth plots suggest that both barrier and fringing reefs have accreted in catch-up and keep-up modes, however, more age U/Th age data are being produced to detail and draw final conclusions regarding sea-level control on reef growth. Both subsidence and sea-level rise were certainly crucial for the creation of accomodation space and for late Quaternary fringing and barrier reef development in Bora Bora. Antecedent topography also played a role in that the Holocene barrier reef is located on top of a Pleistocene reef. It is not entirely clear whether the Pleistocene reef was a fringing or barrier reef and whether or not there is a Darwinian fringing-to-barrier-reef transition. However, during the Holocene, both systems apparently developed more or less contemporaneously in Bora Bora.

A new model of transgressive sequence of glacimarginal fan documented in the Middle Pleistocene seasonal push moraine in eastern Poland: Sedimentary and structural record

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In the research of push moraines, most attention has been paid to the explanation of: 1) deformation processes resulting in the formation of glacitectonic structures, 2) morphological and geological conditions of substratum, which has an influence on push moraine formation, and 3) ice-front movement rate and the development of landform systems of glaciers/ice sheets. There has been less focus on mutual features linking sedimentary and structural evolution. Sedimentary features of numerous push moraines indicate that their deposits represent the sequences of glacimarginal fans. However, commonly documented glacimarginal fans show regressive sedimentary sequences.

We propose a new model of transgressive sequence of glacimarginal fan based on detailed sedimentological and structural data obtained from push moraine deposits. The transgressive sequence is evidenced by vertical changes of horizontally stratified deposits (fine-grained sands intercalated with silty sands → medium-grained sands → gravelly sands and sandy gravels → massive and sandy diamictite). In addition, in the proximal and middle parts of the fan, the sequence of detachment folds at various stages of development appears. The geometry of folds varies from tight overturned through open strong asymmetric to open slight asymmetric fold. According to the kinematic model for detachment folding, which recently assumes both limb rotation and hinge migration, the opening of folds in the distal direction may indicate a gradual decrease of horizontal shortening across the folded strata. This tendency is consistent with the results of the line-length and excess-area balancing. The fan formation started from sheet-flood deposition under stagnant ice conditions, and then detachment folding involved the previously deposited fan sediments in response to the horizontal compression induced by the ice front activation. Contemporaneous fan deposition was responsible for the formation of synfolding growth strata observed in synclines. There is evidence of the progressive decrease in dip up-section of these strata. Aside from erosional and clear angular unconformities between growth strata, few examples of the onlapping relationships were analyzed in the backlimbs of folds. Assuming the flexural slip and flexural flow as predominant deformation mechanisms during folding of the growth strata, the rate of synfolding sedimentation might be somewhat lower than the uplift rate of folds.

Sedimentological features of the documented sequences of fan deposits (sand – gravel – diamictite) are commonly regarded as formed by increasing ice melting during the stage of retreat and/or decreasing dynamics of stationary ice margin. In this study, exactly the same sedimentary sequence is interpreted as an example of transgressive sequence, developed under conditions of increasing dynamics of ice margin. A proposed model is based on the assumption that the fan growth and vertical/lateral distribution of sheet-flood deposits was conditioned by the ice thickening and/or steepening of ice-front surface at local scale (ice lobe). Beyond some critical thickness of ice, the ice-front advance can be expected according to the folded strata of the fan. The ice-front activation could be also triggered by seasonal winter accretion of the ice that pushed the fan deposits without overriding them. This conclusion entitles us to interpret this form as seasonal push moraine.

Correlation and depositional features of the Lower Silurian successions in the Zonguldak and Eastern Tauride terranes, Turkey

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Recent work in the less-known Silurian successions in the western Zonguldak Terrane, NW Anatolia, has revealed the presence of Llandovery units. The “black shale member” at the bottom of the succession yielded graptolites of the spiralis–lower lapworthi zones. Further east, the black shales intercalated with yellow shales yielded O. spiralis and R. geinitzianus. The deposition of black shales is related to the time of maximum Silurian sea level that are time-equivalents of the (late Llandovery) violet shales with green layers from a less deep basin in E of the Istanbul Terrane. In the W of the same, reddish sandstones with Fe-oolitic minerals and brachiopod-bearing carbonates were deposited during the late Llandovery maximum transgression. The early Silurian deposits in the Zonguldak Terrane are more akin to those of E Avalonian successions, whereas those of the Istanbul terrane resemble those of the Gondwanan periphery.
The Lower Silurian succession, in the Değirmentaş-Halevikdere section, E Taurides, the Llandoverian part is dominated by black, graptolitic shales with radiolarian ribbon cherts (ca 20 m). The Rhuddanian Akidograptus ascensus, Parakidograptus acuminatus and Cystograptus vesiculosus biozones have been recognized in its lower part, while in the upper part of the succession, the lowermost Telychian Rastrites linnaei Biozone has been documented. The Telychian Spirograptus turriculatus and Streptograptus crispus biozones, as well as the Sheinwoodian Cyrt. rigidus/Monograptus belophorus Biozone have been identified within this succession. Graptolites of Homerian are only found in another section, in the black shales, immediately before the first ocher-colored limestone, which is characteristic for the Ockerkalk Formation in the Thuringian facies. The Tauride successions show considerable lithostratigraphic similarities described initially in Saxo-Thuringia and later in other peri-Gondwanan terrains.
The depositional model in the Taurides accounts the migration of the considered peri-Gondwana terrains from high to low paleogeographic latitudes that has triggered changes not only in the ocean water thermohaline circulation, but also in the wind-driven downwelling or upwelling systems. These changes are responsible for the progressive transition from an oxic regime to an anoxic one in the deep oceanic depositional environments (outer continental shelf, slope, and ocean basin settings) and the deposition of light and dark sediments there.

Analysis of sporopollen assemblages and palaeoclimate studies in early Early Cretaceous, Western Liaoning, China

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1 Regional geological background.
The study area is located in the northeast of the North China platform. It is a part of Mesozoic circumpacific continental margin mobile belt. In the Mesozoic, the area of the platform become to "activation", with forming a series of volcano sedimentary basin. There are NE trending Middle Proterozoic uplift between the basins for the interval. Lower Cretaceous in Yixian formation mainly outcrops in Jinlingsi-Yangshan basin and Yixian basin.
2 Palynomorph assemblage *Cicatricosisporites-Protoconiferus.*
The overall of palynomorph assemblage characteristics in the Zhuanchengzi bed of Yixian formation are dominant by gymnosperm pollen, especially bisaccate conifers pollen (88%-94%), pteridophyte spores are less (2%–12%) , and angiosperm pollen are few (?) (0–1%).
Specific assemblage characteristics are as follows:
(1) Pteridophyte spores are 18 genera and 24 species , more monotonous species and low proportion, the content of no more than 1%, but is of great significance. There are early Cretaceous typical molecular, just as *Cicatricosisporites*, *Lygodiumsporite*, *Aequitriradites* and so on.
(2) The total gymnosperms is 28 genera and 37 spices, among which the bisaccate conifers pollen with the largest number , takes up 77%–90 %. It is dominant by ancient type pollen with imperfect differentiation of the bodies and their airbags, as *Protoconiferus, Protopinus , Protopicea, Protopinus, Pseudopicea, Piceites* and so on. And there are also some pollen with perfect differentiation of the bodies and their airbags, such as *Picepaepollenites*, *Pinuspollenites*, *Abietineaepollenites*, *Cedripites*, *Podocarpidites* etc. In addition, single ditch pollen just as ginkgo and cycads have some content, such as *Cycadopites*, *Ginkgoites*, *Monosulciles*. Classopollis pollen reacting arid environment appears only sporadically in individual samples, and Psophosphaera pollen also reacting arid environment have some content.
3 Palaeoclimate and palaeoenvironment indicated by the spores and pollen fossils.
According to the ecological characteristics of sporopollen spectrum and palynological parent plants, vegetation type, climatic zone type and humidity type are clalssified quantitively in the Zhuanchengzi bed of Yixian Formation in Western Liaoning. The results indicate that the palaeoclimate is overall warm and humid, and various palynological vegetation types, such as coniferous forest, deciduous forest, evergreen broadleaf forest, herbs, shrubs, and etc. during the period of the Zhuanchengzi bed in Yixian formation. Local palaeoclimatic evolution is from warm to much warmer, simi-humidity to humidity. Palytological vegetation type is always coniferous forest. The coexistence of deciduous forest, evergreen broad-leaf forest, herbs, shrubs and some arid plants indicate vertical zonation of vegetation and climate change seasonally.

Microborings in the tests of micro and macrofossils from Turkey

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Bioerosion is a common process in hard substrates. This study introduces examples of microborings in calcareous tests of micro and macrofossils from various localities of Turkey, formed in shallow-water palaeoenvironments. Most of the larger benthic foraminifera and molluscs are perforated by microborings. Comparison of microborings in microscopic and macroscopic fossils, their palaeoecology and taphonomy are revised herein based on previous and new materials.
Microborings in the tests of the late Cretaceous to Palaeogene larger benthic foraminifera occur as meandering tunnels and grooves and are visible on the surface. Most are 50-100 microns (*Maeandropolydora osmaneliensis*, *Curvichnus semorbis* and *Trypanites helicus*) wide and circular in cross-section. These reflect bioerosional activities such as parasite and hermit life modes, and can be assigned to the ethological category dominichnia.
Another example is from a rocky palaeoshore exposed at a sea cliff. Bioerosion trace fossils are present in limestone boulders of shallow-marine and lacustrine settings, as well as bivalves and gastropods of late Miocene age. The ichnotaxa include macroborings produced by duraphagous drillers (*Oichnus* isp.), phonorids (cf. *Conchotrema* isp.), clionid sponges (*Entobia* cf. *goniodes*, *E. geometrica*, *E. laquea*, *E. ovula*, *E.* cf. *solaris*, *Entobia* isp.), endolithic bivalves (*Gastrochaenolites torpedo*, *Gastrochaenolites lapidicus*, *Gastrochaenolites* isp., *Phrixichnus* isp.), polychaete annelids (*Maeandropolydora* isp., *Maeandropolydora sulcans*, *M. decipiens*, *Caulostrepsis taeniola*, *Caulostrepsis* isp.), echinoids (cf. *Circolites* isp.) and spinculid worms (cf. *Trypanites* isp.). They are interpreted as dominichnia. Barnacles are also common as encrusters. The obtained data from microscopic bioerosion structures show that various borings in both micro and macro fossils are related to different types of tracemakers.

Primary dolomite sedimentation and new undiscovered Upper Jurassic lithological units in the Rachów Anticline, central Poland and their paleogeographic significance

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The Rachów Anticline discovered by Samsonowicz in 1925 constitutes the most south-western corner of the Lublin Trough and from the South border with the Carpathian Foredeep. The outcrops along the Vistula River gave an access to the Upper Jurassic (Kimmeridgian and ? Tithonian) deposits. They are unconformably overlain by the Lower Cretaceous (Albian) and Upper Cretaceous (Cenomanian and Turonian) deposits. The area of Rachów and Annopol has been studied mostly for economic purpose, particularly for the Albian and Cenomanian phosphorites.
As in case of the Upper Jurassic deposits the so far studies are extremely rare and are limited to only few publications, where Jurassic deposits of Rachów area were only mentioned for comparison purpose. In general, the Kimmeridgian and possibly ?Tithonian deposits were considered to be represented by light-grey and yellowish limestones, marly limestone, calys and marls and organogenic limestone with admixture of quartz sand.
This, however, general lithologic subdivision does not play with our new studies. The section exposed at Jakubowice consists of organogenic limestone and dolomites with up to 2–3 cm extraclasts of quartz, lydite and older Jurassic limestone. The succeeding beds are composed either of limestone or dolomite what rather exclude their post depositional dolomitisation. Moreover, in both lithologies there are prominent shell-beds consisting almost exclusively of internal and external moulds of the representatives of *Exogyra*, *Trigonia* and *Terebratula*. Usually one of the species is in dominance, forming rather monospecific assemblages suggesting on rather restricted environmental condition during deposition of those rocks and confirm the primary dolomitisation processes.
Within the dolomite-limestone succession there occur beds of pure, white dolomites and calcareous quartz sandstone with spiculite, limestone and dolomite extraclasts. Amongst, the so far undiscovered lithologies, most prominent are black sandstones with dolomite cements. They are composed of angular quartz, with metamorphic extraclasts, coal and kaolinite. The bedding plans are full of nicely preserved flora remains.
Such a characteristic of the studied succession indicate on consecutive restricted marine or evaporate lagoon extremely shallow (tidal flat?/protected lagoon?/beach) sedimentary environment resulted in deposition of limestone and dolomite respectively, in addition to emerged events proved by black sandstone with flora.
For the time being the biostratigraphic data do not allow for a precise age determination, although more or less it can be attributed to the Upper Kimmeridgian. However, the presence of lower Tithonian deposits in the Rachów Anticline cannot be rejected. The studied succession falls exactly to characteristic of Ruda Lubycka and Rawa Ruska Formations, expanding their spatial distribution from Wołyń, Lublin Trough, up to the northern peripheries of the Holy Cross Mountains.

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Lithogenic input and redox variations in the Upper Berriasian of the Western Balkan (Barlya section): constraints from magnetic stratigraphy and geochemistry

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Upper Berriasian to basal Valanginian part of the Barlya section (West Balkan Mts, Bulgaria), of ca. 38 m thickness, is represented by a transition between the pure micritic calpionellid limestones of the Glozhene Formation towards the clayey limestone–marl alternation of Salash Formation. The section is adequately dated by calpionellids, calcareous dinocysts and magnetostratigraphy. It covers the stratigraphical interval from the upper part of Calpionella elliptica Subzone and Stomiosphaerina proxima Zone (upper part of magnetozone M17r) up to the Berriasian/Valanginian boundary (Praecalpionellites murgeanui/Calpionellites darderi subzonal boundary, Colomisphaera conferta Zone, magnetozone M14r). Stepwise increase of fine grained lithogenic input is manifested by increasing magnetic susceptibility (MS). MS correlates very well with Al content as well as with other lithogenic elements (e.g. Ti, Zr, Th, Rb). The most important sedimentary change took place in the lower part of the Upper Berriasian (between Simplex and Oblonga Subzones, lower part of M16n) where marly sedimentation started to increase and to replace the carbonate. The Th/K, Zr/Al and Ti/Al ratios increase up the section which might account for increasing contribution of heavy minerals towards the Berriasian/Valanginian boundary. It might also be interpreted as a result of weathering intensification and climate humidity increase throughout the Upper Berriasian. The sediments are generally well oxidized as indicated by the low U/Th (between 0.21 and 0.83) and Ni/Co (between 0.84 and 6.11) ratios. A clear decreasing trend of the U/Th and Ni/Co ratios is observed which evidences a general correlation between oxygen availability and clastic input. However, in the topmost part of the section an inverse correlation is observed and oxygen deficiency apparently accompanies the increasing terrigenous influx. The phosphorus enrichment factor (EF P) correlates positively with the carbonate content. Correlations of the EF P with $\delta^{13}C$ and redox proxies are complex. It seems that different forcing mechanisms operated in the lower and upper parts of the Upper Berriasian, i.e. in the intervals below and above the top of M16n magnetozone. The onset of marly and terrigenous sedimentation in the Upper Berriasian can be followed in many sections of the Western Tethys: e.g. in the Central Western Carpathians, Eastern Alps and Western Cuba. Its explanation is not well understood as it correlates in time with both the sea-level regression and humidity increase as well as with some regional tectonic phenomena in the Carpathians and Alps.

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Borings and etchings in the Upper Bathonian-Lower Callovian oolite of the Paris Basin (France)

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The oolite of the "Dalle Nacrée" Formation in the Paris Basin is made of marine calcareous ooids with, from base to top, radial (and therefore likely to have been calcite), concentric and micritic fabrics, each corresponding to a discrete stratigraphic unit. Several hardgrounds and oolitic pebble-cobble layers in the succession are encrusted and bored. Three main types of boring have been identified ranging in sizes from some tens of µm (sponge borings) to centimeters (bivalve borings), with an intermediate category (worm borings). Some worm borings have rough walls, where early marine fibrous cement is less corroded than the cortices of cemented ooids. The key to understanding this differential dissolution could be related to organic matter, present within the ooid cortices but lacking in the fibrous cement. Polychaete worms that use chemical means (enzymes or acids) to bore are probably responsible for these peculiar borings. A secondary conclusion is that partly or fully leached ooid cortices do not necessarily indicate an original aragonitic mineralogy of the dissolved parts.

Significance of partial leaching in calcareous ooids: The case study of Hauterivian oolites in Switzerland

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In the Canton of Vaud (Switzerland), two Hauterivian oolitic units were penetrated by a borehole. In both units, the ooids are partly leached. More specifically, the ooid cortices were partly leached and some ooid nuclei appear suspended in the middle of cortical moldic cavities created by leaching, rather than having fallen to the bottom of these cavities before the final cementation take place. We demonstrate that these ooids were originally calcitic, not aragonitic, not "two-phase" nor "bimineral". This leaching is not an early diagenetic feature related to subaerial exposure, but a late diagenetic feature, possibly related to the migration of acidic pore waters, brought about by Alpine tectonics and/or karstification.

The contribution of some Bryopsidales to the production of limestones

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Calcareous green algae (CGA) are an artificially united but highly heterogeneous group of large unicellular benthic algae with one character in common: all have the capability of secreting a calcareous coating on the outer side of the cytoplasmic envelope. Today, we shall consider the Bryopsidales, the $CaCO_3$ of which is precipitated to form their external (extra- and inter- cellular) coating is aragonite. They are a major contributor to carbonate sedimentation at all scales from clay-sized particles (aragonitic needles) to coarser grains (sand and gravel) and even to plurimetric sedimentary structures. Recent studies on living *Halimeda* have shown that some of the Bryopsidales have the capability to calcify strongly in the lower portion of the euphotic zone (where respiration becomes more important than photosynthesis in the process of mineralization) and to produce positive sedimentary reliefs (bioherms) in situ below the fair-weather wave base. Previous models of paleoenvironments considered their presence to indicate shallow-water, that is the upper euphotic zone (from the sea surface down to -25 m), and predominantly low-energy, protected, lagoonal environments. When the algal remains were found in grain-supported facies, they were taken to have been subjected to dynamic transport and therefore indicative of high-energy environments of deposition. The new deeper-water finds have changed interpretations of the environments ascribed fossil algae. A current conception is that ancestral inarticulated Bryopsidales could have grown at depths as great as -120 m (near the base of the lower euphotic zone).

Predicting clay mineralogy distribution in deeply buried sandstone reservoirs using a modern estuarine analogue approach

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One of the major causes for porosity- and permeability-loss is the growth of authigenic quartz cements at depths exceeding 2.5 km (>80 °C) in the subsurface. However, grain-coating Fe-rich chlorite preserves porosity by inhibiting quartz cement in some deeply buried sandstone reservoirs. The dominant control on the type and occurrence of chlorite is the initial (i.e. depositional) mineralogy, because chlorite cement is considered to be largely isochemical during burial diagenesis. Diagenetic illite and kaolinite are considered to be poor for reservoir quality because they typically block pore throats, and so reduce porosity and permeability. As spatial coverage of core is limited within tidally-influenced hydrocarbon bearing sandstones, a high resolution analogue study of clay mineralogy in sand-dominated modern estuarine sediments has here been adopted.
This research focuses on the origin, abundance and distribution of clay minerals (specifically chlorite) within the Ravenglass estuary, UK. X-ray diffraction was performed on both fine clay fraction (<2 µm) and coarse-grained fraction (>2 µm) of surface samples, to reveal the mineralogy and mineral proportions of the framework grains, bioclasts proportions and fine clay fraction. Distribution maps of clay minerals show clear relationships between chlorite, illite and kaolinite abundance throughout multiple estuarine sub-environments. High resolution clay mineral index maps (<2 µm) reveal that: 1) chlorite preferentially accumulates toward the upper portion of the estuary, within tidally-dominated facies; 2) illite is the most abundant clay mineral displaying a ubiquitous distribution independent of depositional environment, and; 3) kaolinite is more prevalent in the lower portion of the estuary, within higher energy depositional environments. Preliminary results suggest that clay mineral distribution is controlled by the hinterland geology and estuarine circulation.
In order to better understand early clay mineral diagenesis, one metre cores have been collected from the relatively chlorite-enriched portions of the estuary. By integrating surface and shallow core (<1 m) datasets, it is evident that the distribution of detrital clay mineralogy can be predicted as a function of depositional environment and grain size. By including such datasets within models of oil and gas fields, areas of enhanced and degraded reservoir quality can be predicted on a stratigraphic reservoir-scale basis.

Paeleoecological and sedimentological characteristics of Sarmatian sediments from the Hrvatsko Zagorje Basin (Croatia)

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Miocene deposits of the Hrvatsko zagorje Basin belong to the south-western marginal belt of the Pannonian Basin System. Sedimentological, paleontological and mineralogical investigations were performed on three outcrops of Sarmatian deposits located on the North-western part of Hrvatsko zagorje. Sarmatian sediments of this area were deposited in two depositional environments of reduced salinity: near shore deposits composed of conglomerates, sandstones, biocalcirudites, biocalcarenites and marls, and offshore deposits with local input of clastic material represented with marls and silts with sand intercalations. The mineral association of the sands and silts which consists of garnet, dolomite, glauconite, tourmaline, zircon and rutile indicate a local origin of the material. Marls predominantly consist of calcite and clay minerals, while quartz and feldspars are less abundant. The calcite content varies from 20 to 80%. Among clay minerals, in the less than 2 µm insoluble residue fraction, smectite, illite, chlorite and kaolinite were determined.
Furthermore, the deposits of these facies associations contain numerous fossil species. The deposits determined as near shore are rich with typical Sarmatian macrofossils: *Ervilia dissita dissita, Ervilia dissita podolica, Irus (Paphirus) gregarius dissitu*s and *Mactra vitaliana eichwaldi*. The association of foraminifera which consists of *Anomalinoides dividens* and *Elphidium reginum* indicates a Lower Sarmatian age. Besides typical Sarmatian fossils, in these deposits numerous microfossils redeposited from Badenian, Lower Miocene and Eocene sediments are present as well. Offshore deposition characterised by *Elphidium hauerinum* and *Porosononion granosum* association of foraminifera indicates the Upper Sarmatian age. Dinoflagellate cysts *Polysphaeridium zoharyi, Lingulodinium machaerophorum* and *Spiniferites* spp. of the open marine environment and prasinophytes phycomas *Tytthodiscus mecsekensis* and *Hidasia racemosa*, from restricted environments indicate Polysphaeridium zoharyi – Lingulodinium machaerophorum Zone (Pzo-Lma) of Sarmatian age. The development of the Sarmatian from the North-western part of the Hrvatsko zagorje Basin is in accordance with the developments in other parts of the Central Paratethys.

The architecture of Lower Cretaceous clastic wedges in Svalbard and the northern Barents Sea: The influence of sea-level change in a low-angle ramp setting

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The Lower Cretaceous strata in Svalbard are divided into the Rurikfjellet, Helvetiafjellet and Carolinefjellet formations. Together, they form a >1000 m thick sequence that records long-term shoreline progradation and back-stepping in response to a full cycle of relative fall and rise in sea-level.
The Rurikfjellet Formation (Berriasian–Hauterivian) consists of outer shelf deposits in its lower part and inner shelf to delta front deposits in its upper part, recording an overall upwards shoaling. The formation was deposited during southward shoreline migration in response to uplift of the northern Barents Shelf margin during the initial opening of the Canada Basin. The overlying Helvetiafjellet Formation (Barremian–early Aptian), which shows an overall transgressive development, consists of a fluvial sandstone sheet overlain by aggrading to back-stepping paralic deposits. The succession is bounded below by a regionally extensive unconformity that formed during the uplift climax in the Barremian. This caused significant erosion across large parts of Svalbard and created incised valleys on the shelf. The valleys acted as by-pass zones during relative sea-level fall, but were backfilled by braided stream deposits or by tidally-influenced bay-head delta deposits during earliest rise in relative sea-level. The forced regression has previously been classified as non-accretionary. However, in order to achieve shelf equilibrium, the eroded sediments must have accumulated in depocentres south of Svalbard. This study documents forced regressive deposits below the Barremian unconformity at several locations in the southern and eastern Spitsbergen. These deposits occur as thin (<5 m) packages of shallow marine origin, commonly with sharp bases, and indicates that the forced regression was in part accretionary, especially in the distal areas that were less influenced by uplift. A similar-aged clinoform succession (Barremian–Aptian) that occurs in the offshore areas south of Svalbard is therefore suggested to be the distal segment of the onshore forced regressive system. The low-angle ramp and shallow water setting, coupled with high sedimentation rates promoted rapid progradation over long distances. This resulted in spatially extensive, low-angle facies lines in the depositional dip direction and with the long-term regressive-transgressive turn-around point far out onto the shelf. A similar setting is also envisaged for the lower part of the Carolinefjellet Formation (Aptian), which is interpreted to represent the distal equivalent of the Helvetiafjellet Formation deltaic system. It consists of extensive sandstone sheets that internally are characterized by wave and storm -wave generated structures and shoaling-upward trends. The sandstone sheets were deposited within an offshore transition to lower shoreface setting on a storm-dominated and shallow but distally-deepening shelf. The sheet-like nature of these deposits also reflects the low-angle of the shelf as well as the shallow waters which enabled basinal processes (mainly storm waves) to rework delta lobes into amalgamated sheets and transport sand far out onto the shelf. Within the Carolinefjellet Formation, no upper shoreface, backshore or paralic deposits have been recorded at any locality in Svalbard, indicating very low-angle facies lines, and that the inferred deltaic shoreline must have been located somewhere northwest of the present day outcrop belt.

Glauconite genesis from Corumbataí Formation (Goiás State, Brazil)

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The deposition of Corumbataí Formation, Permian age has been attributed to marine environment, coastal, continental, depending on its location in the Paraná Basin, being generally associated with the process of continentalização toward the top. Underling this unit, the Irati Formation is constituted by intercalations of carbonate rocks and black shales, typical of restrict depositional conditions. In the studied area (Northern portion of the basin), the contact of the Corumbataí Formation on the Irati is a calcitic layer pseudomorph over evaporite, showing structures "desert-rose". This layer is overly by fine-grained sandstones and siltstones levels, which are succeeded by greenish ones. Green angular grains of glaucontic minerals are dispersed among clastic sediments, indicative of allochthonous or parautochthonous origin. However, in siltite levels, thin green fibers cover quartz core and replace phyllosilicates, them they look like autochthonous minerals. In contrast of the southern portion of the basin, where shallowing facies are evident, the northern portion has the evaporite layer covered by glauconitc facies and cross stratifications sandstones, characteristic of sub-aqueous deposition. The characterization of glauconitic minerals in an attempt to know their genesis contributes to the definition of the nature of this body water. This is fundamental for the understanding of the paleogreography of the basin.
For this study, samples were collected from the Cuiabano Stream (Goiás State) and prepared for petrographic, X-Ray Diffraction and microprobe analyses.
XRD diffractograms were obtained from randomly powder and oriented preparations of <2 fraction, separated by centrifugation. Analyses were performed using a Rigaku Ultima IV diffractometer (Ni-filtered Cu-Ka radiation), and 2 a 80 2 teta, step 0.025. The diffractograms were interpreted with the software JADE 9.0 (MDI). XRD patterns of samples show the presence of peaks at 14 and 10A.The first one shifts to 17 A after glycol saturation and its high saddle/peak ratio is typical of a random glauconite/smectite, while the10A peak correspond to illite/glauconite.
Chemical composition from green grains was determined by microanalyses on thin sections, using a JEOL, JXA-8230, under 15 kV and 1,5 mA; count time of 10 a 20 seg., and a spot size of 01 µm. The structural formula for glauconite was calculated on the basis of 44 negative charges and assuming all iron to be ferric. Glauconitic minerals are siliceous species, K content from 1.3 to 1.5, and an octaedral composition of similar amounts of Al (1– 1.5), Fe (1–1.3) and Mg (1.1–1.5).
Most glauconitic minerals from geological record originate on the continental shelf. However, some studies have shown the formation of glauconitic minerals in environment lacustre, being its chemical composition and mineral associations, conditioned by the local context. Decomposition of diffractometric peaks, new preparation for XRD and microanalyses are being done for better understand the genesis of glauconitic minerals from Carumbataí Formation.

Application of seismic sedimentology on the architecture analysis of meandering river reservoirs: A case study of N38 fault block of Jidong Oilfield in China

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Although the high lateral resolution of seismic data makes up the shortcomings of the low lateral resolution of logging, the vertical resolution of seismic data is insufficient to meet the needs of reservoir architecture research. Therefore, it is a great challenge to use seismic data to characterize reservoir architecture in detail. This paper, taking N38 fault block of Jidong Oilfield in China as an example, studies the architectural dissection of meandering river reservoirs from different hierarchies using seismic sedimentology, which have significant meanings for improving the accuracy of reservoir architecture characterization.
The study area has 43 wells altogether with well spacing about 50-150 m. There abundant core and well-logging data. The 3D seismic data covers an area of about 3 km^2 with initial dominant frequency being about 37Hz. Using methods such as 90° phase shift, seismic inversion and attribute analysis, the boundary of composite channel belt is first determined by interaction of plane and profile view. Secondly, the seismic data is processed to improve the vertical resolution by frequency spectrum imaging and forward modeling technology. On this basis, using core, well-logging and dynamic data comprehensively, and under the guidance of architectural mode of meandering river, the boundary of single channel belt is characterized, and the distribution of sandbodies within point bar is finally established. Followings are the main conclusions.
(1) Forward modeling analysis shows that the seismic profile by 90° phase shift can identify the relatively thick sandbodies (10-20 m) directly. Additionally, the relatively thin sandbodies (less than 10m) within a single layer have a general good positive relationship with seismic attributes.
(2) Based on well-logging facies analysis, empirical formula and the contact relationships of single rivers, it has been concluded that the average thickness of single channel sandbodies is about 13m with maximum thickness reaching 15 m, and the average width of single channel sandbodies is about 240 m with maximum width reaching 460 m. (3) By validation of multiple methods, the width of point bar is about 300-400 m; the inclination of lateral accretion bedding is about 3.1°; the horizontal spacing is about 40 m. (4) Combined with dynamic data and strata slice, the distribution of single sandbodies of different episodes is characterized precisely, and the spatial evolution mode of meandering river is finally established.

Peculiar fabric of a Jurassic resedimented carbonate: A result of silica diagenesis? (Gerecse Mts., Hungary)

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Basinal and slope carbonates characterize the Upper Jurassic succession of the Gerecse Mts. that was part of the southern shelf of the western Neo-Tethys Ocean during the Triassic–Jurassic period. A 50-cm-thick chert bed marks the deepest depositional environment. This layer is overlain by a limestone breccia, deposited in slope environment. The aim of this work is to reveal the diagenetic history of this enigmatic formation.
The breccia was assigned to the Oxfordian stage based on ammonites. The thickness of the rock unit changes between 30 and 50 cm, its lower and upper boundaries are uneven. The 0.2 to 15-cm-sized, red to white breccia clasts are rounded. Two types of clasts were identified; i) limestone of wackestone fabric, most probably derived from the underlying basinal carbonates, and ii) "composite" clasts, made up by micritic to microsparitic zones of various thickness. White to orange, finely crystalline to micritic, calcite coatings cover the clasts. The matrix is finely crystalline calcite. The micritic part of the "composite" clasts and the coatings, as well as the rhombohedral core of the microspar crystals, is non-luminescent, whereas the rim of the microspars exhibits bright orange CL. Some composite clasts are silicified in patches. Silica is present along calcite crystal boundaries. Silicification was also observed along fractures in the overlying limestone beds. The micritic-microsparitic fabric surrounding the silicified zone is very similar to that of the breccia. Furthermore, the chert hosts 1 to 10-µm-sized calcite inclusions. The micritic-microsparitic coatings of variable thickness might be remnants of mineralized microbial films. However, no sign of microbial microfabric, such as clotted micrite, or micropeloids, was observed. Microspar is known to occur in meteoric and marine-burial environments either as cement or as a result of recrystallization or replacement. The micritic-microsparitic fabric of the coatings and the "matrix" of the breccia is most likely the result of a neomorphic process. The precursor mineral may have been either aragonite or opaline silica. Spatial relationship to the silicification may suggest that silica diagenesis played a role in the formation of the peculiar texture of the breccia.

Genesis of Late Triassic peritidal dolomites in the Transdanubian Range, Hungary

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In the Late Triassic 2–3 km thick platform carbonate succession was formed along the passive margin of the Tethys Ocean. Certain parts of the platform carbonates were affected by pervasive dolomitization while other parts are only partially dolomitized or non-dolomitized. In the Transdanubian Range, Hungary the Late Triassic platform carbonates are widely extended and numerous data are available for the space and time relations of the dolomitized and non-dolomitized units. This geological setting provides a unique opportunity for the study of paleogeographical and diagenetic controls of dolomitization of the whole platform complex. Petrographic features and stable isotope characteristics of the studied successions suggest the predominance of penecontemporaneous and early diagenetic dolomite genesis. Study of the transitional interval between the pervasively dolomitized and the non-dolomitized sequences revealed the general presence of microcrystalline dolomite in the micritic elements of the partially, selectively dolomitized supratidal/intertidal microbial deposits; thus, an early stage of microbially-mediated dolomite precipitation is inferred which was probably complemented by penecontemporaneous mimetic replacement of precursor carbonates due to evaporative pumping or a seepage influx. Dolomitization of the subtidal facies took place via reflux of slightly evaporated sea-water. Dolomitization of the previously deposited carbonate mud commenced during the next subaerial episode but the process of early diagenetic dolomitization might have continued during the later exposure events. Recurring subaerial exposure is one of the controlling factors of the early dolomite formation that is of critical importance. This is the main controlling factor of the areal extension of the early dolomitization of the studied platform carbonates. However, the climatic conditions are also crucial. Although the sea-level controlled unconformity-bounded cyclic facies pattern did not change significantly in the internal platform belt during the studied nearly 20 My long time-range, dryer climate during the Late Carnian to Late Norian favoured dolomite formation while increasing humidity led to gradually decreasing intensity and termination of early dolomitization processes by the latest Triassic (latest Norian–Rhaetian).

Geochemical provenance study on detrital zircon – An attempt to decipher the paleoposition of Mexican terranes

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Like the margins of other continents around the Pacific Ocean, western North America consists from Alaska to Mexico of terranes. Several decades of extensive research on Upper Triassic sediments, mainly focused on the Tethyan provinces in the Alps, have been conducted. For this reason the paleogeographic, as well as the paleoenvironmental reconstructions for the Panthalassa Ocean remain undetailed. For many of these terranes the origin and their paths through Panthalassa persist mysterious.
The REEFCADE-project addresses these issues, by investigating individual terranes, reconstructing their respective geologic history in a multi-disciplinary approach, and in a final comparison to unravel the respective paleotectonic evolution.
For this study two potential terranes in Mexico, with Upper Triassic carbonate occurrences have been chosen: the Antimonio Terrane (Sonora), and the Vizcaíno 'composite' Terrane (Baja California Sur). Due to the scarcity, and discontinuity of the outcrops, a simple paleoenvironmental reconstruction is impossible.
The sedimentary successions of the investigated localities are of very different nature. On the one hand those found in Sonora show shallow marine deposits, comprising carbonates with variable amounts of siliciclastics, and calcareous-bound, commonly fossiliferous silt- to fine sandstones. On the other hand, the series found in Baja California Sur are interpreted as deeper marine, and slope derived. Inside the limestone clasts of the Breccia member of the San Hipólito Formation, shallow water faunal assemblages have been identified.
Through comparison of the two areas, we want to proof/disproof a proximal relationship between the investigated terranes. During two field campaigns, samples for thin section preparation, palynological analysis, and zircon separation were taken. Due to the advanced recrystallization levels, fossil-derived information is limited. On the contrary, petrographic data can provide useful data supporting paleoenvironmental, as well as paleogeographic reconstructions.
The siliciclastic components represent remains of an arkosic arenite. Potential protoliths are plutonic intrusions inside the North American craton. We separated, and dated zircons from Sonora by LA-ICP-MS. By comparison with known ages from intrusions, we expect to grab new insights into the paleolatitude, and ultimately also the sense of movement of the investigated terranes.

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Diagenetically-induced heterogeneity in meandering fluvial reservoirs. A Triassic example

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Diagenetically-induced heterogeneity has a major impact on reservoir properties. Near-surface and shallow-burial diagenetic processes have a substantial control on further deep-burial diagenesis, constrained by remaining porosity, and consequently on reservoir quality evolution. The present study is conducted on a Triassic outcrop analogue of heterogeneous meandering reservoirs. In a well-constrained sedimentological framework (Viseras et al., 31st IAS Meeting of Sedimentology), a high resolution petrographic analysis is performed on 23 fine to very fine-grained samples by: (i) Gazzi-Dickinson point count to characterise the type and distribution of depositional texture, framework composition and cements precipitation chronology, and (ii) a custom diagenetic point-count for a semi-quantitative description (100 points/thin section) of the primary and secondary pore spaces in the same area of the Gazzi-Dickinson point-count. Collective effect of depositional and diagenetic fabrics on petrophysical properties is evaluated by mercury injection-capillary pressure analysis. Intergranular volume as well as compaction and cementation indexes for porosity loss are also calculated. Results are validated by chemical analysis of sandstone composition via inductively coupled plasma optical emission (ICP-OES) and mass spectrometry (MS) to obtain data for 49 elements (ten majors, twenty-five trace and fourteen rare earth elements) (Caracciolo et al., 31st IAS Meeting of Sedimentology). Depositional texture consists of very fine to fine-sized, well sorted grains. It displays sedimentary structures such as cross and parallel lamination highlighted by laminae with higher mica and matrix content composed of silty quartz and feldspar grains sometimes embedded in a clay groundmass. Results reveal that small-scale internal heterogeneities associated to the abundance of detrital matrix affect, in large extent, spatial distribution and intensity of the main early diagenetic processes. Furthermore, matrix distribution is strongly facies-related as a result of the hydraulic sorting effect. Differences in diagenetic evolution among depositional facies exert a primary control on the resulting porosity (type and abundance) and permeability. By linking depositional and diagenetic features, accurate predictions and assessments of reservoir quality trends are possible.

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Sedimentation styles in an intracratonic rift system; an example from southeast Australia

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The Otway and Gippsland basins are two of a series of Late Jurassic–Cretaceous rift basins that formed along the southern margin of Australia as it separated from Antarctica during the breakup of Gondwana. Both basins have been successfully drilled for hydrocarbons, and understanding the sediments and their characteristics is vital to further exploration. In order to advance the understanding of sediment deposition, external controls, such as basin structures and climate, must also be understood. This research is focussed on the Barremian–Albian Upper Strzelecki Group of the Gippsland Basin and the Aptian–Albian Eumeralla Formation of the Otway Basin, both of which were likely sourced from a volcanic complex to the east of the Gippsland Basin and represent a dramatic change from the slightly older (Tithonian–Barremian) Crayfish Group sediments that were derived Palaeozoic basement rocks exposed along the rift margins. The systems present across this region include channel sandstone, crevasse-splay sandstone, floodplain siltstones and mudstones, palaeosoil, coal seams and lacustrine shales. Particular attention is being paid to the volume of sediment within this fluvial system, with the hopes of understanding in detail, some of the physical aspects of this system: width, depth, sediment load and sinuosity and how each of these may be affected by regional tectonic activity. Overall, the aim of this research is to define the relationship between sedimentation and basin structures within the Otway and Gippsland basins and ultimately produce a regional model that explains the co-existence of trunk river deposits and extensive coal measures in a cold climate deposition system fed by a massive influx of volcaniclastic debris.

Genesis and preservation of environmental signals in a tufa analogue: Insights of carbonate precipitation rates and factors quantification

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We have analyzed and studied a carbonate crust that has been formed in the interior of a water drainpipe from a building in San Sebastian, Spain. During 13 years (from the moment of the building construction till the moment of sampling) the carbonate crust has been precipitating forming a body that, at some places of the tube, gets to almost plug the tube diameter.
The petrographic, geochemical and mineralogical characterization of the carbonate crust permit to characterize it as an alternation of laminae composed of sparite crystals that grow towards the center of the tube. These laminae appear forming condensed horizons that normally amalgamate vertically, whereas they appear separated by longitudinal pore spaces. It is mainly composed of calcite (91 %), with minor amounts of quartz (3 %) and phyllosilicates (6 %). The $\delta^{18}O$ isotopic values of the carbonate crust appear in a range between 11.67 to 12 ‰ SMOW, whereas the $\delta^{13}C$ isotopic values around -28 ‰ PDB. The carbonate crust is formed at clear positions within the tubes, either at the upper part of the tube, where the tube surface is radiated by solar light; parts where the tube has an inflexion due to its accommodation to the building structure and where water accumulates for a certain period of time. In both cases it has been observed the existence of plant material and organic matter coating the tube surface.
This tube appears as an analogue environment to those where natural tufas form: streams with water circulation but with places where water is stagnant for certain periods of time (points where the tube get to be horizontal and water ponds are created) and with abundant plant and organic material contents. Tufas in the geological record constitute rich archives of palaeoenvironmental information. In natural environments, they commonly form under temperate conditions, in spring or swamp deposits, associated to vegetation commonly colonized by cyanobacteria and diatoms. Within the tube, the water ponding and the accumulation of plants and bacteria in the walls have generated a microbial mat environment that has provided a substrate for mineralization forming a tufa.
Knowing the timespan of the tufa formation permits to establish a direct relationship between the climatic conditions where the tufa has formed and the geochemistry of the water from which it was precipitated. Comparing these parameters it is possible to calculate the precipitation rate of the carbonate tufa as well as determine which are the main factors controlling its formation as well as quantify these factors. This quantification will permit to directly evaluate climatic changes from similar deposits in other parts of the world, as well as infer paleoenvironmental conditions from tufa deposits of the geological record.

Drowned reefs as agents of climate change: New constraints from the shelf-edge of the Great Barrier Reef, Australia

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Coral reefs constitute one of the most extensive carbonate factories and, over geological timescales, can be a significant oceanic and atmospheric CO_2 source. Yet their role in postglacial climate change remains elusive. This understanding is hindered by the difficult access to the Pleistocene coral reefs drowned during the last transgression. Using a unique dataset of two shelf-edge sites of the central Great Barrier Reef (GBR), Australia, we provide new constraints on local- and shelf-scale shallow-water carbonate budgets and also extend these estimations globally. Pre-Holocene, shallow-water carbonate accumulation has been previously unaccounted for in global models, and our first-order estimates provide important new constraints on postglacial atmospheric and climate change.
The datasets were composed of a dense array of 2D seismic lines, high-resolution (5 x 5 m) multibeam bathymetry, seafloor samples, and data from 34 boreholes in 17 drilling locations (IODP Expedition 325) with downhole logs and cores, radiometric ages and lithological interpretations. A digital elevation model (DEM) of the entire GBR (100 x 100 m) and a recently available GIS dataset of the Holocene reef features were used for regional estimations of carbonate accumulation.
Locally, we reconstructed the 3D sub-surface architecture of the two study sites (Hydrographers and Noggin Passages) using the seismic profiles, which, together with the bathymetry data, permitted the calculation of bulk volumetrics of the postglacial reef. Core interpretations confirmed the shallow (0-30 m), reefal nature of the shelf-edge formations, and radiometric ages confirmed their pre-Holocene, postglacial ages (11 to >20 ka BP). The cores provided the petrophysical parameters (density, porosity) needed to assess the $CaCO_3$ accumulations at these two sites.
Regionally, the DEM of the GBR was used to reconstruct the postglacial transgression, and to quantify the marine-flooded area through time. Applying geomorphic and volumetric parameters calculated at the study sites, it was possible to obtain a reasonable estimate of carbonate accumulation in the GBR from the Last Glacial Maximum through to ca. 10 ka BP. The GIS dataset and published GBR data were used to estimate the Holocene reefal accumulation.
We found that, despite occupying only between 1.2 to 2.4% of the total GBR shelf, the shelf-edge reefs constitute an important portion (10 to 20%, 135 Gt) of the total postglacial shallow-reef $CaCO_3$ accumulation in the GBR. The majority (ca. 750 Gt) is attributed to the Holocene reefs. Applying the GBR parameters to published estimates of global Holocene reef areas and assuming similar Holocene-to-Pleistocene accumulation ratio to the GBR, we estimate that some 1500 Gt of $CaCO_3$ may have accumulated globally in shallow waters during pre-Holocene, postglacial times. These results suggest a stronger influence of coral reefs in postglacial climate change than previously acknowledged. Interestingly, the timing of the drowned reefs accumulation in the GBR matches episodes of postglacial sharp increase in atmospheric CO_2 and a period of decrease in atmospheric $\delta^{13}C$.

Synsedimentary-fault-controlled hydrothermal dolomitization of Triassic slope and basinal deposits, Hungary

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Dolomitization of tens to hundred-metre-thick carbonate slope and basinal succession occurs via an effective fluid circulation mechanism since the replacement process requires large amount of Mg-rich fluid interacting with the $CaCO_3$ precursor. In the western-end of the Neotethys, fault-controlled extensional basins developed during the Late Triassic spreading stage. In the Buda Hills and Danube-East blocks (Transdanubian Range), distinct parts of silica and organic matter-rich slope and basinal deposits are dolomitized. Petrographic, geochemical and fluid inclusion data delineate two dolomite types: (1) finely to medium crystalline and (2) medium to coarsely crystalline. They commonly co-occur and show a gradual transition. Both exhibit breccia fabric under microscope. Texture of the dolomite crystals reveals that the breccia fabric is not inherited from the precursor carbonates but it was formed during the dolomitization process and under the influence of repeating seismic shocks. Dolomitization within the slope and basinal succession as well as within the thin breccia zones of the underlying basement block is interpreted as being related to fluid originated from the detachment zone and channelled along synsedimentary normal faults. Conceptual model of dolomitization suggests that pervasive dolomitization occurred within and near the fault zones. Permeable beds have channelled the fluid from the vicinity of faults upward and toward the basin margin where the fluid was capable of partial dolomitization. The fluid inclusion data compared to vitrinite reflectance and maturation data of organic matter suggest that the dolomitizing fluid was likely hydrothermal which cooled down via mixing with marine-derived pore fluid. Thermal gradient is considered as a potential driving force for fluid flow.

Pulsing turbidity currents

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Many of the key processes controlling geo-physically important density driven flows are enigmatic, with current research focused on the behaviour of both compositionally-driven and particle-laden density currents as well as the characteristics of their deposits. It has been reported that pulsing within turbidity currents can arise during flow generation or during interaction between flows at confluences. Thus, 1) successive sea floor slope failure events occurring at canyon heads may produce pulsing turbidity currents; 2) where faults lie across a series of interconnected submarine channels, they can synchronously trigger separate turbidity currents within each channel that combine to produce pulsing flows downstream of confluences. 3) It has been further proposed that pulsing character within seismically-triggered turbidity currents may relate directly to the sequence of ground accelerations that initiated the flow. In each case, the grading characteristics of turbidites may serve as a proxy for flow pulsing. Analyses of flow pulsing and initiation linked to deposit analysis critically depend on whether velocity surges are preserved or dissipated within gravity currents.
Experiments were conducted to investigate the dynamics of pulsing turbidity currents. A simple lock exchange gravity underflow generation methodology was employed, with two locks set up in series, enabling the generation of pulsing flows. Denser-than-ambient fluids in each lock box were dyed with different colours prior to release, enabling the time and space evolution of pulsed flows to be captured by an array of five interlinked HD cameras. Control parameters in all experiments included the initial volumes, densities and viscosities of the fluids making up the flows, and the density of ambient fluid. It was observed that the interaction between two surges varies was dependent on the viscosity of the body fluids of the flows. In experiments with low density and low viscosity fluids, the second pulse intruded into and swiftly overtook (i.e. merged into) the first current which had become stratified due to turbulent mixing between the flow surface and its overlying ambient. These results suggest that multi-pulsed turbidity currents rapidly merge and that deposits with complex grading patterns likely reflect local scale processes; this result provides a constraint on the interpretation of turbidite grading profiles. For experiments in which the body fluid was very viscous (but with the density excess kept the same as the other set of experiments) stratification was suppressed, and the second pulse supplied energy to the first in the form of a bore, which accelerated the first current. When the bore reached the front of the first pulse, the viscous flow transitioned into a dilute (comparatively inviscid) turbulent flow. The effects of pulse interaction within relatively viscous gravity currents appear complicated and difficult to predict; this is an area requiring further work.

Determining depositional age of an Early Jurassic reef in the El Antimonio Group of Sonora, Mexico, and the implications for coral recovery after the end-Triassic mass extinction

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Within the Santa Rosa Formation of the El Antimonio Terrane in Sonora, Mexico, are two previously unstudied reef-like carbonate buildups containing rare Early Jurassic corals. A global mass extinction occurred at the Triassic-Jurassic boundary and coral reefs experienced considerable stress near the end-Triassic. During this period of global climate change approximately 200 million years ago, sea level was dropping and the Central Atlantic Magmatic Province was releasing prodigious amounts of greenhouse gases and volatiles with increasing ocean acidity. Corals reefs collapsed abruptly during the end of the Triassic. While the Jurassic recovery was underway during the first few million years following the extinction event, reefs were exceedingly rare and coral diversity did not fully recover until 25 million years later. The dynamics of coral reef collapse and recovery are relevant to understanding marine deposition and the nature of ecological stresses following the mass extinction. Compared to the Tethys, precious little is known about the recovery in western North America where reefs and diverse corals of the Late Triassic inhabited volcanic settings of eastern Panthalassa. The Sierra de Santa Rosa Formation is divided into lower, middle, and upper members encompassing approximately 1500 meters in thickness and includes fossiliferous, shallow to deeper water marine sequences in strata tectonically overlying Precambrian metamorphic basement rock. The shallow-water, reef-like limestone patches described here are located in the middle member of the Sierra de Santa Rosa Formation and consist of two separate but related carbonate rock buildups with steep dips and many reef-like characteristics. The lowermost reef patch Unit A, is composed of a 30-meter thick massive limestone buildup, and the uppermost reef patch Unit B, a 25-meter thick massive limestone body. Abundant colonial corals, branching corals and subordinate bivalves are found in both reef patches. Unit B displays 2-meter high branching and platy coral colonies in 4-meter thick boundstone. Most coral fauna consists of colonial scleractinian corals but are highly recrystallized and partly silicified, revealing only macroscopic details. Ammonites collected near the succession locality in the Sierra de Santa Rosa indicate ranges in age from the uppermost Sinemurian to the lower Pliensbachian. The carbonate buildups are separated by a 15-meter-thick interval of medium- to-coarse grained sandstone and mudstone. The interbedded sandstones contain detrital zircons. U-Pb zircon dating is underway to determine the maximum depositional age. Data is used to test paleogeographic and tectonic models for northwestern Sonora and adjacent USA. The Sonoran reef-like buildups are perhaps the only Early Jurassic examples in the USA and Mexico. The coral faunas and other marine fossils of these Sonora reefs provide relevant data with which to assess paleoecology, paleobiogeography and biotic recovery during the critical interval following the end-Triassic mass extinction.

The response of mid-Cretaceous shallow water carbonate factories to the climatic/oceanographic events: Case study from central-southern Apennines (Italy)

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The mid-Cretaceous represents one of the classical "Greenhouse" period in the history of planet Earth. Intensive volcanic activities, major sea level rise, high CO_2 partial pressure, carbon cycle perturbations, marine organisms turnover and possibly different oceanic current systems and no major ice caps in north and south poles are characterized this time slice of geological time scale. Since carbonate rocks are product of oceanic/climate systems therefore carbonate platforms represent one of the most important archive in the Cretaceous period and could be invoked to understand more about climate and oceanic/atmospheric systems in the past times.
Extensive studies have been focused on (hemi)pelagic and outermost shelf environments to decipher causes, effects and consequences of OAEs. By contrast, the shallow water environments have received less attention regarding to the overall response to environmental changes linked to oceanic anoxia and consequent paleoecological conditions
In order to document and decipher more about the mid Cretaceous, we have selected central-southern Apennines (Italy) carbonate sequences ranging from the Latest Barremian to the Early Albian, analyzed by means of a multidisciplinary approach including detailed biostratigraphy, sedimentology and litho-bio facies analysis, and stable carbon and oxygen isotopes. This allowed identifying six intervals characterized by specific trends. The detailed bed-by-bed analysis enabled us to trace lateral and vertical sedimentation patterns inside the above intervals.
The studied limestones were deposited in shallow water systems lacking clear drowning events or biological crises leading to severe carbonate factory extinctions. Nevertheless, remarkable and synchronous drops in the biotic component characterize the recognized units. The shift in the biotic assemblages and the outbreak of particular organisms indicate the recurrence of significant conditions of stress in the water mass resulting in repeated carbonate factory decline episodes. The recovering of the carbonate factory occurred by means of benthonic communities showing characteristic trends and resulted in new sedimentary carbonate systems whose biotic assemblages markedly diverged from the former ones.
Two mains gaps characterise the analysed successions. The first gap is witnessed by an erosive surface; the second one is marked by a sharp variation on the stratal pattern characterizes the related boundary, marked in the field either by a well developed erosion surface or by repeated exposure surfaces marked by microkarst and incipient pedogenesis.
The analyzed successions document the coupling of significant tectonic and general climate control on the sedimentary patterns. The facies analysis, compared with the geochemical data and the biostratigraphic constrain, well supports the climatic interpretation deriving from the paleoecological meaning of the recognized biotic and facies assemblages.

Linking climate change and hominin evolution: New palaeoclimate evidence and the limitations of the hominin fossil record

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A number of recent studies have compared the Plio-Pleistocene palaeoclimate record with various aspects of the hominin fossil record, including speciation, extinction and species diversity. When events within both domains are temporally coincident, a causal relationship is often assumed, and hypotheses are put forward to explain the possible mechanisms for these relationships. However, the hominin fossil record is notoriously incomplete, and this may limit the degree to which events within hominin evolution can be meaningfully compared with palaeoclimate proxies. In this presentation I will explore the environmental and stratigraphic biases that impact our interpretation of the environmental hypotheses of hominin evolution. I will also present a new high-resolution palaeoclimate record from a South African speleothem and discuss Plio-Pleistocene inter-annual rainfall variability and its possible influence on early hominin evolution.

Triassic slope and basinal carbonates at the western end of the Tethys (NE Hungary) – microbial boundstone and the associated deposits

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Specific microfacies, such as boundstone dominated by clotted micrite, occur in the Middle and Upper Triassic slope carbonates in the Aggtelek–Rudabánya Hills, NE Hungary. Their examination may contribute to the understanding of the Reifling-type slopes of the NW Tethys and possibly shed new light on the Triassic palaeogeographical picture. Based on thin section analysis of more than 1800 samples six microfacies associations (MA) including 15 microfacies types were distinguished. MA–A comprises five different types of clotted micrite boundstone that are characterised by in situ precipitated calcite as a result of degradation of organic compounds. Other common features are the elongated, occluded pores called stromatactis structures. Microfacies types A1, A2, A3 and A4 are interpreted as being formed on a carbonate slope occupied by a microbial mat while A5 is related to a platform/margin environment that marks the upper limit of the slope. MA–B contains bioclastic packstones and grainstones with different skeletal grain compositions. Types B1, B2 and B3 were likely deposited via short-term depositional events; B4 can be interpreted as a forereef slope facies. The four types of wackestone containing pelagic fossils in MA–C represent open marine deposits. MA–D is peloid packstone–grainstone consisting of encrusted reef detritus that was reworked onto the upper slope. The mudstone of MA–E occurs exclusively overlying platform carbonates, which implies rapid facies change as a consequence of drowning event.
The palaeoenvironmental reconstruction revealed that the slope was controlled by microbially mediated carbonate production which was occasionally intercepted by detrital grains reworked from platform area and downslope redepositional processes. Distal slope area and the basin were devoid of microbial activity; instead they were characterised by pelagic sedimentation. These formations are already well known from the Triassic sequences of the Southern Alps but they were hitherto unknown from the Northern Calcareous Alps and the related shelf zones.

Developing a regime diagram for mesoscale morphodynamic structure on submarine fans

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A regime diagram for the autogenic architecture of submarine fans, analogous to that for bedforms, could be a powerful tool for prediction in deep water systems. The question is: can modes of channel-lobe organization (mesoscale structure) be represented on a multidimensional ('regime') diagram based on fluid dynamic and sediment transport variables, like Froude number, Rouse number and Reynolds number, linked to slope? While shallow marine systems are typically controlled by allogenic baselevel and accommodation, autogenic processes tied to slope evolution may dominate in submarine fans. Equilibrium concepts like grade (sediment transport equilibrium) and normal flow (fluid equilibrium) may be too coarse, applying to latter stages of fan growth and describing only a small proportion of fan strata.
Flume (2-D) experiments of bedforms indicate that microscale structure responds primarily to the vertical structure of the flow (boundary layer structure). In contrast (3-D) tank experiments that develop channels indicate that mesoscale structure, like channel-lobe organization (stacking and architecture), responds to along-channel changes in flow thickness (flow surface profiles). The simplest approach to approximating flow profiles along channels are analytic solutions to the steady depth averaged flow equations for dilute flow which predict the basic interactions between flows and slope changes/bumps. In turbidity currents these may be analogous to the rapidly and gradually varied solutions for open channel flows (e.g., Chow, 1959) but tend to deviate under supercritical conditions due to flow entrainment (Long, 1962). The new model captures the relevant dynamics of time-averaged morphodynamic interactions between channelized flow and lobes for strata thicker than a channel depth, for example, where a mouth bar chokes the flow (supercritical or subcritical choke). The longest instantaneous length scale predicted by the model is the characteristic length of the M1 backwater related to Froude subcritical avulsion, describing a hierarchy of lobes up to the fan scale (largest lobe). Flow scale strata (e.g., Bouma sequences) and bedform strata develop at hierarchical levels below this channel-lobe scale, while large-scale allogenic strata bound it from above. The question remains, can we develop a mesoscale regime diagram based on these equations? Is it possible to represent morphodynamic feedback mechanisms, avulsion cycles, stratal patterns and submarine fan-lobe hierarchy on such a regime diagram?
Applying the Chezy equation to submarine fan slopes suggests that small coarser grained fans in active tectonic settings tend to be supercritical. Larger fans on passive margins are more complex and tend to oscillate around Froude critical flow. For example the Congo/Zaire fan is likely to be subcritical in the deep leveed channels, supercritical in the canyon and down the levees following an avulsion and critical to subcritical on the most distal lobes. Successions of strata indicate a hierarchy of Froude number cyclicity as the slope oscillates at different scales. While the ultimate scientific objective is to link a range of scales of autogenic sedimentary structures through the fluid and sediment transport processes these concepts might also be applied by industry to better integrate data, for example well data (core and logs) and seismic data.

Two scales methods of seismic sedimentology for delta deposition research

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The resolution of Seismic data is restrictions to carry on sedimentary research of thin sand with seismic data. However, Seismic Sedimentology broadens seismic data applications for thin sand with stratigraphic slices. This paper respectively proposes two slice methods to analysis regional deposition distribution and area sand distribution respectively.

The Key is Seismic Sedimentology emphasizes the vertical and horizontal resolution of seismic data be same. Because the actual size of sedimentary bodies are generally much larger than the horizontal resolution of seismic data, using stratigraphic seismic slices which representative the horizontal seismic response of a certain deposition period to study delta deposition is reasonable. Studies suggest that stratigraphic slices represents simultaneous deposition feature and truly reflect the horizontal characteristics of delta sedimentary body only in sequence stratigraphic frame control.

When the aim is to study the regional distribution of sedimentary for a set of fourth-order sequence stratigraphic, this paper presents large-scale stratigraphic slicing method. The maximum number of slices extracted from a sequence stratigraphy is only 2-3. These slices can reflect the sedimentary characteristics of the beginning, change and end of the fourth-order sequence. This method is suitable for large area regions.

When the aim is to study the feature of Sandstone distribution in a set of fourth-order sequence stratigraphic, this paper presents small-scale stratigraphic slicing method. The number of slices extracted from a sequence stratigraphy is 6-12. These slices can reflect the feature of Sandstone distribution. This method is suitable for a small area of the region.

With the above two methods, this paper has studied the SQ7 of Wen Jisang area in the Turpan-Hami basin. Using large-scale slice method, the direction of material source and the sedimentary characteristics of controlled by faults was determined. With small-scale slice method, the feature of Sandstone distribution was accurately predicted. The research results indicated the direction of lithologic reservoir exploration and predicted sandstone reservoir for oil and gas exploration.

Research on the flow units of braided river reservoirs: A case study of Bentiu1 Sand Group in Fula North Oilfield of Sudan

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Braided river reservoir is an important type of the terrestrial reservoirs. Nowadays, extensive studies have been carried out on the heterogeneity of thick braided river reservoirs, but understandings of the differential distribution law in thick braided river reservoirs are not deep enough. Therefore, this paper, taking the thick oil reservoirs of Bentiu1 Sand Group in Fula North Oilfield of Sudan as an example, aims at studying the flow units of braided river reservoirs using hierarchy analysis method, which is constrained by the reservoir architecture. The characterization of flow units in braided river reservoirs is necessary for the development of remaining oil. Followings are the main results and conclusions.
(1) Results show that the reservoir quality of the study area is mainly controlled by sedimentation because the diagenesis is generally weak and the normal faults of the research area are opening. The flow barriers in the study area are therefore mainly mudstone barriers, including flood plain mudstone, semi filling mudstone and filling mudstone of braided-channel, and interbar mudstone. (2) By correlation analysis between various flow parameters and productivity index per meter, permeability was finally optimized as the classification parameter of flow units. Three types of reservoir flow units (I, II and III) were classified using truncated Gaussian method. Flow units I have the best reservoir quality with permeability of more than 350mD, and productivity index per meter of 0.20~0.32t/ (MPa·d·m). The thickness is generally greater than 4m. Flow units II have relatively good reservoir quality with permeability of 25~350mD, and productivity index per meter of 0.04~0.20t/ (MPa·d·m). The thickness is about 2~4m. Flow units III have poor reservoir quality with permeability of less than 25mD, and productivity index per meter of 0.02 ~0.04t/ (MPa·d·m). The thickness is thin, generally less than 2m. (3) The combination model of flow units in single sand body includes four types: homogeneous cycle type, positive cycle type, composite cycle type and reverse cycle type, respectively. Among them, the most common type is the composite cycle type. In plane view, flow units I are mainly distributed in channel bars (especially the downstream end of channel bars); flow units II are mainly distributed in braided channels and at the margin of channel bars; flow units III are less distributed overall, and most of them are distributed in the area near mudstone barriers.

Rudist bivalves as chemostratigraphic archive: Towards an improved chronostratigraphy of Urgonian carbonate platform evolution in the subtropical Tethyan realm

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The aim of the current project is to improve the chronostratigraphy of subtropical Urgonian carbonate platform ecosystems facing the Vocontian Basin in the Northern Tethyan realm. Therefore, two shallow water limestone successions (Sausset-les-Pins and Martigues sections), both representing the proximal part of the Provence platform (Marseille area, SE France), have been investigated applying high-resolution chemostratigraphy and detailed sedimentological analysis. Sections are composed of peloidal to bioclastic packstones and grainstones rich in rudist bivalves (Urgonian limestones sensu stricto) and subordinate mudstones and wackestones. In contrast to bulk carbonate material, the outer (fibrous prismatic) low-Mg calcite shell layer of rudists (here: *Toucasia*, *Monopleura* and *Requienia*) is relatively resistant against diagenetic alteration and therefore serves as substrate for isotope analyses. The obtained characteristic carbon- and strontium-isotope pattern allows for a precise correlation with stratigraphically well-constrained Tethyan shallow-water and hemipelagic reference sections (Cluses, Angles). Based on this correlation, the Sausset and Martigues section in southern Provence contain a stratigraphic gap of at least 1.2 Myr, spanning large parts of the Upper Barremian. Moreover, the revised bio-chemostratigraphy of this part of the Provence platform provides first evidence for a synchronous demise and break-down of Northern Tethyan carbonate platform production in the run-up to the Oceanic Anoxic Event (OAE) 1a.

Shallow-water sea-surface temperatures and seasonalities from the subtropical Tethyan realm: Evidence for Mid-Cretaceous greenhouse climate variability

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The dramatic and stepwise emplacement of large igneous provinces is generally accepted as primary driver of Cretaceous Oceanic Anoxic Events (OAEs). Although excess output of volcanically induced greenhouse gases should have promoted “super greenhouse phases”, several studies provide evidence for transient Cretaceous “cold snaps”, particularly during the Barremian-Aptian stage. To date, reconstructions of Cretaceous sea surface temperatures (SSTs) are predominantly based either on $\delta^{18}O$ analyses of pristine foraminiferal calcite or on crenarchaeotal membrane lipid distributions (TEX_{86}) in pelagic deposits. Both types of proxies provide at best estimates of mean annual SSTs of open ocean settings.
In order to better understand the dynamics of Cretaceous global warmth and the impact of fluctuating SSTs on carbonate platform ecosystems, the current project aims at reconstructing the stratigraphic and spatial evolution of subtropical shallow-marine sea-surface temperatures. Well-preserved low-Mg calcite rudist shells hold a strong potential to act as archives for the reconstruction of Cretaceous palaeoclimatic and palaeoenvironmental conditions, as ontogenetic isotopic and trace element variability of these shells also resolve sub-annual (seasonal) temperature fluctuations. In the context of the current project, high-resolution sclerochemistry ($\delta^{18}O$, Mg contents) has been performed on rudists derived from chemostratigraphically ($^{87}Sr/^{86}Sr$, $\delta^{13}C$) well-constrained Barremian–Aptian carbonate platform settings in the subtropical Tethyan realm (France, Croatia, Spain, Portugal). The outcome of this work will be of significance both for those studying the triggering factors of oceanic anoxic events and the palaeoecology of rudist bivalves.

Gypsum speleothems in lava tubes from Lanzarote, Canary Islands. Did you say gypsum?

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Lanzarote is the easternmost island of the volcanic Canary archipielago considered together with Fuerteventura the low relief islands of the archipielago. These island receive less rain than 300 mm/year. Basaltic lava flows preserves lava tubes formed during cooling and solidification of external parts of lava, while internal parts were still hot and flowing. When lava flow stopped the lava abandoned the tubes, and the tubes preserved empty. These tubes actuate as caves and some of them develop speleothems. Pardelas/El Covón, and Chifletera lava tubes occur within Middle Pleistocene lava flows which are surrounded by Holocene lavas from the 1730-1736 eruption. Pardelas/El Covón main entrance is located very close the western coast sea cliffs while Chifletera is 400 m inland.

Although carbonate is abundant in calcretes and in the aeolian sand deposits of the island, the speleothems observed in Pardelas/El Covón, and Chifletera lava tubes are constituted mainly by gypsum and minor halite. The speleothems observed are 1) sugar-like powder accumulation on the walls and floors; 2) claw-like stalactites; 3) desert rose formations on the walls; 4) fracture filling speleothems; 5) cotton-like crystal aggregates and 6) micrometric whisker crystals. The mineralogy of these speleothems varies from 100% gypsum in the case of stalactites and desert roses, to a mixture of gypsum and halite in small concentrations in the aggregates and powder. The microtexture of these speleothems is varied, being the most common the lenticular formed by packed small (≈ 150 µm) crystals arranged heterogeneously. In other cases lenticles are organised in a feather-like arrangement. Microcrystalline gypsum, with no preferred orientation and disperse halite crystals is found in the cotton-like and powder speleothems. In the case of the desert roses, stalactites and fracture fillings, the speleothems are composed of gypsum macro crystals reaching 5 cm long.

The $\delta^{34}S_{CDT}$ values of the gypsum speleothems ranges from 18.2‰ to 19.2‰, being the present day sea water values of 20.9‰. The $^{87}Sr/^{86}Sr$ ratio for Pardelas/El Covón (0.708930-0.708976) is slightly lower than sea water values (0.70916) while for Chifletera (0.708618-0.708671) the values are closer to those described as the aeolian dust input ratios.

Sulphur isotopes and cave setting suggest that the sea spray could be the main source of sulphur for the sulphate speleothems although a slight contribution of volcanic SO_2, could have decreased the $\delta^{34}S_{CDT}$ signal. The $^{87}Sr/^{86}Sr$ ratio also supports the sea spray contribution although 400 m inland, in Chifletera the contribution of aeolian dust input could be more important.

Sedimentation rates and large-scale fluvial architecture. Deciphering the basin external controls

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The LAB (Leeder, Allen, Bridge) models on large-scale fluvial architecture consider that a decrease in accommodation space favours the development of high interconnected channel belt architecture, but experimental basin (Paola´s Group) models consider that a decrease in accommodation space does not creates the mentioned architectural pattern. The outstanding outcrops (a succession thicker than 2600 m) of the Gómara fluvial system in the Paleogene of the Almazán basin (Spain), are an excellent example of the changes in the large-scale architecture of a fluvial system and evidences how this changes are related to the tectonic evolution of the basin.
The magnetostratigraphy of the Gómara fluvial system has allowed to create a map of the Paleogene magnetic reversals and to cross it with a channel belt map which shows the large-scale architecture of the basin. The analysis of the data consists of calculating the sedimentation rates (SR) for the whole succession and to compare these data with the different large-scale architectural pattern. The areas dominated by vertical-stacked calcretes record SR of 3 cm/kyr and the areas dominated by lacustrine/palustrine facies record 9 cm/kyr. The low interconnected ribbon-shaped channel fills occur in areas with sedimentation rates between 30 and 40 cm/kyr. The high interconnected sheet-like channels develops in areas with 10 cm/kyr. Assuming that sedimentation rates reflect the accommodation space, this study supports the idea proposed by the LAB models which says that a reduction in accommodation space favours the development of highly interconnected channel belts (for constant avulsion rates). It is important to remark that a change in accommodation space (i.e. tectonically driven) produce a change in the sedimentary mass balance what approaches the LAB ideas with the latter conclusions of the experimental models.
This work provides age constrain for a thick fluvial succession in the Almazán basin and calculates the sedimentation rates for the large-scale architecture of a fluvial system revealing that highly interconnected sheet-like channels occur at lower SR than the low interconnected ribbon-shaped channels. Previous work indicates that also high sedimentary supply is needed to form the high interconnected sheet-like channels, which could be very interesting to the industry because are considered excellent reservoirs.

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Palaeoproductivity proxies in the Middle–Upper Jurassic radiolarian-bearing deposits of the Western Tethys Fatricum Domain (Poland and Slovakia)

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Middle–Upper Jurassic radiolarian-bearing limestones and radiolarites were studied in the Krížna Nappe of the Tatra Mountains (Central Western Carpathians, southern Poland and northern Slovakia). This nappe belongs to the Fatricum Domain, which during most of Jurassic time, was one of the domains lying between the Alpine Tethys to the north and the Meliata Ocean to the south. The succession studied shows a strong similarity to Jurassic successions of other Tethyan basins.
The upper Bathonian–upper Kimmeridgian radiolarian-bearing deposits are 30 m thick. Microfacies, magnetic susceptibility (MS), carbon isotope, geochemistry, carbonate content and diversity of radiolarian assemblages were studied in six sections.
The middle Callovian–lower Oxfordian interval is characterised by drastically reduced carbonate content in all the studied sections, whereas increase of carbonate content occurs in the middle Oxfordian–upperKimmeridgian. This phenomenon recorded in the Western Tethys is interpreted as a result of climate warming and aridization which was favourable for carbonate producers.
The older (upper Bathonian–lower Oxfordian) part of the sequence is characterised by grey and green radiolarian-bearing deposits, whereas the younger more calcareous are firstly variegated and then red. This color change reflects redox conditions in the depositional and early diagenetic environment from oxygen depleted to oxic.
MS positively correlates with lithogenic elements (Al; Al-normalized Ti, K and Zr) as well as with Ba which is a productivity indicator (Al-normalized Ba). Such coincidence may indicate a relationship between detrital input and high productivity. The values are low in the late Bathonian, then high in the latest Bathonian–early Oxfordian interval (UAZ 7–8) with a prominent maximum in the middle/late Callovian, low again in the middle Oxfordian, then high in the latest Oxfordian and low in the early Kimmeridgian.
Nassellaria/Spumellaria (N/S) ratio fluctuates in accordance with MS and the above listed elements. The observed pattern results from ecological requirements of these two groups of radiolarians. Spumellaria, which tend to be predominantly symbiont bearing, develop in lower productivity and live in near surface waters, whereas Nassellaria, which are deeper dwelling, non-symbiotic forms, inhabit higher productivity environments.
Such a coincidence may be explained by fluctuating input of nutrients from neighboring lands caused most probably by climate changes, for instance enhanced continental weathering and runoff (cf. Baumgartner, 2013). Increased input of nutrients during humid climate leads to sea-water eutrophication, whereas decreased input leads to oligotrophication.

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Detachments and mass transports along low-angle slopes: The onset of the Tithonian carbonate ramp progradation along the Eastern Sardinia Jurassic passive margin (Italy)

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Carbonate megabreccias associated with submarine unconformities are documented on several passive margin slopes and, recently, they have been recognized on carbonate platform marginal slopes. Their depositional architecture and regional correlation are poorly described in the geological record, due to the lack of well-exposed outcrops. The geodynamic and stratigraphic evolution of the Tithonian (Late Jurassic) Southern European passive margin was characterized by frequent mass transport events with the deposition of carbonate megabreccias and the development of large-scale submarine unconformities with different genetic interpretations.
This study investigates the depositional facies and stratigraphic architecture of upper Tithonian carbonate megabreccias, which were deposited on top of a laterally continuous, submarine erosional unconformity. This unconformity overlies outer ramp calci-mudstones (Pedra Longa Fm., up to 30 m thick), accumulated in a protected intraplatform basin (Baunei Basin) following an early Tithonian transgression. These calci-mudstones are partly coeval and separate two progradational eastward gently dipping carbonate ramp systems (Mt. Tului and Mt. Bardia Fms). The studied megabreccias are likely associated with a regressive trend marked by the sharp contact between the thin-bedded Pedra Longa strata and massive shallow-water coarse-grained Mt. Bardia Fm. carbonates.
The erosional unconformity is documented over an area exceeding 6.5 x 2.5 km and it is characterized by a gentle incision in the most proximal part of the basin, while basinward (eastward) it comprises narrow (3-6 m wide) and 2-4 m deep, erosional incisions filled by thick chaotic megabreccia lenses (up to 20 m thick). The macro and microfacies of these breccias include both clasts and matrix deriving from prevalent shallow-water inner ramp, lagoonal oo-bioclastic grainstones/packstones and Pedra Longa Fm. intraformational calci-mudstones. Minor erosional events, with prevalent intraformational coarse to fine grained breccia lenses and slumping, are locally present in the lower Pedra Longa Fm. Locally, the amalgamation of the upper unconformity (main stratigraphic event) with the underlying local erosional surfaces can remove almost all the Pedra Longa succession (thickness reduced to a few metres). In these locations, the submarine erosions and the top unconformity present more differentiated features: strata-bound erosional surfaces, soft sediment deformations, intra-formational breccia pockets or a sharp boundary without mass transport events.
The possible mechanisms for the megabreccia emplacement include: 1) catastrophic mass transport due to liquefaction processes, failures of shallow-water carbonate sands, along an intraplatform gentle slope, during fast carbonate progradation (sea level lowering associated to tsunami events, and/or tectonic block tilting along the Baunei Basin); 2) polyphasic amalgamated mass transport events related to the fast basinward progradation of proximal ramp carbonates with frequent gravitational failures of marginal oo-bioclastic shoals, and lithified patch reef boulders above still poorly consolidated marly calci-mudstones. Regardless the dominant processes, the lateral continuity of the unconformity, the deposition of megabreccias and their landward correlation with sedimentary dikes and polygenic carbonate megabreccias lenses, cropping outside the Baunei Basin, might be consistent with a syn-sedimentary tectonic control. The megabreccia events of Eastern Sardinia could be correlated to the Tithonian carbonate breccias to megabreccias deposited in different basins of the Southern European passive margin.

Source rock development in front of active continental margins – the Lower Carboniferous of the southern North German Basin, Germany

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The North German Basin (NGB) is part of the European Southern Permian Basin, covering northern Germany to the North Sea. It shows a complex polyphase basin development, including huge Mesozoic and Upper Palaeozoic sediment infill. In the Carboniferous three different facies realms are developed from north to south: carbonate shelf (passive continental margin), starved basin shales and clastic flysch basin (infront of the active continental margin). Three major phases of 'black shale' deposition are developed even within the flysch facies, linked to major transgressive intervals: Lower Alum Shales (middle Tournaisian), Cherty Transitional Beds (upper Visean) and Upper Alum Shales (lower Namurian). While the first two shale formations are restricted to the NGB only, the lower Namurian Upper Alum Shales have equivalents in Belgium, Netherlands and the UK, indicating basin wide deposition of organic rich dark shales.
The lower Namurian Bowland shale of central to northern England is well known as a basinal shale sequence, deposited in an anoxic basin conditions. They show high TOC and mostly mixed kerogen of types II and III in relatively low maturation, indicating very good hydrocarbon potential for conventional and unconventional mixed oil and gas generation. Also in the NGB the lower Namurian Upper Alum Shales seem to be the most prospective shale interval, regarding thickness and TOC. But the few available source rock data show a different scenario. The TOC is mostly poor (to moderate) and rarely moderate to good. Geochemical analysis shows extremely hydrogen depleted kerogens, indicating a very poor hydrocarbon potential. But the maturation is very high, ranging from upper gas window to overmature, raising the question, if the very poor hydrocarbon potential of the lower Namurian shales in northern Germany indicates the primary potential or the residual source rock potential after intense hydrocarbon generation from primary highly productive shales, like the Bowland shale in England.
The current study is focused on the southwestern NGB, which is part of the flysch facies, dominated by clastic sediments shed from the prograding Variscan orogen, but including all three 'black shale' intervals too. Optical kerogen analysis clearly proves, that low TOC levels are primary TOC levels, mostly influenced by sediment dilution within the flysh facies. Also most of the kerogen is made of highly coalified inertinite, recycled kerogen redeposited with the flysh sediments into the basin, unproductive for hydrocarbon production. Organic maturation analysis revealed, that real basin maturation in this part of the NGB is not in the upper gas window to overmature, which was based on recycled highly coalified inertinite, but within the upper oil window only. The position of the southern NGB infront of the prograding Variscan orogen with the high input of recycled sediments into the basin, leads to a very poor hydrocarbon potential, compared to the highly productive shale plays infront of the passive continental margin of central to northern England. This shows the importance of the detailed analysis of the depositional systems of different basin parts for understanding effective source rock development.

Applicability of Nd isotopes and rare earth elements in studies of fossil seep carbonates: An example of the Hollard Mound (Middle Devonian, Morocco)

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Peculiar palaeontological, petrological and geochemical characteristics of seep and vent deposits make their identification relatively straightforward. Nevertheless, predominantly subseafloor mode of seep carbonate precipitation renders our understanding of complex processes controlling this process fragmentary. This encourages seeking additional investigative techniques that may enable insights into subseafloor fate of fluids at seeps and vents. Neodymium isotopes and rare earth elements (REE) are known to constitute particularly sensitive tracers of the origin and composition of fluids. To date, however, REE concentrations and Nd isotope measurements have been scarcely used in investigations of fossil seeps and vents.
In the present approach we measured Nd isotopes, REE concentrations, and stable isotope ratios at a Middle Devonian methane seep of the Hollard Mound (southern Morocco). Relatively radiogenic εNd values as compared to local Eifelian seawater, as well as the presence of consistently appearing positive Eu anomalies in PAAS-normalized REE patterns of the seep limestones reflect former interactions between the seeping fluids and Lower Devonian basaltic volcaniclastics found in the basement of the studied seep. Strongly reducing conditions and increased temperature of methane formation could have played additional role in the development of Eu anomalies. Since all the studied carbonate phases display negative Ce anomalies, the results concur with other studies indicating that seep limestones do not need to show strong Ce-enrichment indicative of anaerobic environments. The methane-charged solutions originated most likely from below the volcaniclastic deposit, and acquired the 143Nd- and Eu-enriched signals due to fluid-rock interactions on their way the seafloor.
The results of the present study show that a combination of Nd, REE and stable isotope analyses can enable unique insights into former migration pathways, origin and composition of fluids, providing clues that could not be gained using other methods, or any of these techniques alone. A distinct contrast between the isotopic and elemental compositions of basement rocks and local seawater is, however, a prerequisite for such information to be detectable in Nd isotope and REE signatures of seep and vent carbonates.

Base-level changes as a major control on sedimentation of the Neogene molasse deposits of the Zagros basin, SW Iran

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The upper part of the Neogene sequence of the Zagros basin consists of a clastic succession which is an excellent example of synorogenic sedimentation as molasse deposited in northern portion of the Persian Gulf foreland basin. This sequence generally consists of three different lithostratigraphic units named as Aghajari and Bakhtyari formations and Lahbari Member. Sedimentological analysis of 3 outcrop sections representing Miocene-Pliocene sediments in the central Zagros resulted in recognizing 9 lithofacies and 4 architectural elements. These lithofacies include conglometate (Gt, Gh, Gmm), sandstone (Sp, Sh, Sr, St) and mudstone (Fm, Fl) that were deposited in meandering stream, braided river and alluvial fan environments. Paleocurrent analysis indicates that these Neogene clastics were mainly drived from Cretaceous to Paleogene highlands in the north of the Zagros Mountains. This stratigraphic record is coarsening-upward and formed by a regressive depositional megacycle under arid climate. Facies and depositional history analysis show that sedimentation of the Zagros molasse was primarily controlled by base-level changes rather than catchment lithology or climate. The sedimentary record of this regressive megacycle reveales the base-level was constantly falling down on one hand and the provenance was uplifting on the other hand. Tectonic activities and Zagros Mountains rising in the Late Miocene resulted in deposition of fining-upward point-bar and floodplain sequences of the Aghajari Formation in low-gradient meandering streams. The Lahbari Member of the Aghajari Formation represents deposition in braided rivers that composed predominantly of flood-plain deposits in the Early Pliocene. Finally, the sedimentary cycle of the Zagros molasse deposits terminated with massive conglomerates of the Bakhtyari Formation deposited in large alluvial fans near the source area.

Carbonate high-energy deposits of potential tsunami origin from the Silurian of Ukraine: Distinguishing lateral redeposition and time averaging using carbon isotope chemostratigraphy

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Stable carbon isotope curves are used as a precise stratigraphic tool in the Paleozoic, even though they are commonly based on shallow-water carbonate record, characterized by low stratigraphic completeness. Identification of episodes of large-scale redeposition and erosion may improve $\delta^{13}C_{carb}$-based correlations. We present a series of at least three episodes of high-energy onshore redeposition in the Makarivka Member of the Ustya Formation from the Homerian (middle Silurian) of Podolia, Ukraine.
The Makarivka Member is emplaced within a tidal flat succession. Its most prominent part is divided into a lower polymictic conglomerate of sand- to boulder-sized clasts representing a range of subtidal facies, and an upper heterolithic unit composed of grainstone and mudstone laminae. Based on analogies with recent tsunami deposits, we propose that this succession represents a tsunami deposit, in which the conglomerate is interpreted to reflect the strongest landward-directed current in the tsunami run-up phase, and the heterolith—alternating high-density landward currents, stagnant intervals allowing mud and land-derived debris to settle, and backwash flows.
The proposed tsunamite was deposited during an interval of decreasing isotopic values of the Mulde excursion, a global $\delta^{13}C$ excursion reaching +5.2‰ (all values VPDB) in the studied sections. Clast redeposition in an interval characterized by rapidly changing δ^{13}Ccarb offers the opportunity to evaluate the degree of temporal and spatial averaging caused by the tsunami. The clasts in the polymictic conglomerate show scattered $\delta^{13}C_{carb}$ values (-0.3‰ to +2.1‰) compared to homogenous (1.3‰ to 1.6‰) values in the matrix. The presence of clasts characterized by low $\delta^{13}C_{carb}$ values is explained by their decrease with bathymetry rather than erosion of preexcursion strata, whereas high values characterize material entrained from the sea-floor and strata directly underlying the tsunamite. Close (1.3‰ and 1.5‰) average δ^{13}Ccarb values suggest that the matrix of the conglomerate is potentially a product of clast grinding.
The position of the Makarivka Mb. places it within a transgressive systems tract, suggesting the possibility conglomerate clasts characterized by a broad range of $\delta^{13}C_{carb}$ values may be a product of erosion and reworking of an interval directly underlying the Ustya Formation. The emplacement of the Makarivka Member postdates, however, the onset of the peritidal sedimentation, indicating that the conglomerate could not be formed as a transgressive lag; instead, it may result from the appearance of tsunami waves during the transition of the continental margin of Baltica to a foreland basin and the development of subduction zone in the southern parts of the Tornquist Ocean.

Stable-isotope chemostratigraphy: Intercontinental correlation of organic carbon and carbonate records, and evidence of climate and sea-level change during the Turonian (Cretaceous)

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Carbon ($\delta^{13}C_{org}$, $\delta^{13}C_{carb}$) and oxygen ($\delta^{13}C_{carb}$) isotope records are presented for an expanded Late Cretaceous (Turonian–Coniacian) hemipelagic succession cored in the central Bohemian Cretaceous Basin. Geophysical logs, biostratigraphy, and carbon stable-isotope chemostratigraphy provide a stratigraphic framework. Similarities and differences between the $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$ profiles are examined, and the time series compared to published coeval marine and non-marine isotope records from Europe, North America and Japan. All previously named Turonian carbon isotope events (CIEs) are identified and correlated at high-resolution between multiple sections, in different facies, in different basins and on different continents. The viability of using both carbonate and organic matter carbon-isotope chemostratigraphy for improved stratigraphic resolution, for placing stage boundaries, and for intercontinental correlation is demonstrated, although anchoring of the time series using biostratigraphic data is essential. An Early to Middle Turonian thermal maximum followed by a synchronous stepped cooling episode throughout Europe within the mid- to Late Turonian is evidenced by bulk carbonate and brachiopod shell $\delta^{18}O_{carb}$ data, and regional changes in the distribution and composition of macrofaunal assemblages. The Late Turonian Cool Event was coincident with a period of long-term sea-level fall, with significant water-mass reorganisation occurring during the mid-Late Turonian maximum lowstand. Falling $\Delta^{13}C$ ($\delta^{13}C_{carb}$ - $\delta^{13}C_{org}$) trends coincident with two major cooling pulses, point to pCO_2 drawdown accompanying cooling, but the use of paired carbon isotopes as a high-resolution pCO_2 proxy is compromised in the low-carbonate sediments of our Bohemian Basin study section by diagenetic overprinting of the $\delta^{13}C_{carb}$ record. Carbon isotope chemostratigraphy is confirmed as a powerful tool for testing and refining intercontinental and marine to terrestrial correlations.

Seasonal record of the stable oxygen and carbon isotopes in the LateBadenian mollusks from the Paratethys (western Ukraine)

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Stable oxygen and carbon isotopes have been analyzed along the growth transect on shells of the gastropod genus *Turritella* and bivalve scallop species *Flabellipecten besseri* collected from the shallow marine Upper Badanian deposits of the Paratethys in the western Ukraine. The *Turitella* sp. comes from calcareous sands in the Zhabiak section which is located in the Medobory backreef setting whereas the scallop comes from quartz sands in the Varovtsi section in more nearshore position. Deposits containing analyzed shells formed in normal marine water as is indicated by the presence of rich marine biotic assemblages with stenohaline fauna (eg. echinoderms).
Measured isotopic profiles both in the case of *Turritella* sp. and *Flabellipecten besseri* cover ca two years of shell growth. Both shells show distinct seasonal variations in oxygen isotopic values that mirror annual temperature oscillation. The *Turritella* $\delta^{18}O$ variations are as large as 1.7‰ (from ca –0.5 to +1.3‰ PDB) what corresponds to ca 8 °C temperature range (from ca +15 °C to 23 °C assuming $\delta^{18}O$ of the Badenian water equal to 0‰ SMOW). Measured $\delta^{18}O$ variations in the scallop shell reach almost 3.5 ‰ (from ca –2.6 to +0.85‰ PDB) which corresponds roughly to 12 °C (from ca +12 °C to 27.5 °C if assume $\delta^{18}O$ of water 0‰ SMOW). $\delta^{13}C$ profiles generally do not show any seasonal variability both in the analyzed gastropod and in the scallop shells. The *Turritella* $\delta^{13}C$ values range generally between +3 and +3.5‰ PDB increasing slightly in the course of the snail ontogenetic growth. The scallop shell, in contrary, shows distinct decrease in $\delta^{13}C$ with age from ca +1.6 to around 0‰ PDB in the analyzed shell segment.

Paleoecological analysis of regressive, detrital Sarmatian deposits between Busko-Zdrój and Chmielnik (Northern part of the Carpathian Foredeep, central Poland)

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Middle Miocene deposits ("detrital Sarmatian", Chmielnik Fm) which cropping out between the Busko-Zdrój and Chmielnik, were deposited during the Badenian/Sarmatian regression on various older rocks (Rutkowski, 1976). Large scale cross bedded quartz sands (clinoforms) in Borzykowa, Suskrajowice and Zwierzyniec were analyzed. The angle of cross bedding measures up to 15°. In outcrops very fine- and fine-grained sands with swaley and hummocky stratification (Leszczyński & Nemec, 2014) are dominated, but in some isolated horizons, medium- and coarse-grained sands, gravel or silt occur. These deposits contain mostly redeposited, Badenian fauna, which does not permit to closer determination of the age. Exposures yield fossils typical of varies marine habitats, also terrestrial forms occur. Presence of both, euhaline organisms and organisms characteristics for mesohaline waters, suggests, that part of these fossils are redeposited. Occurrence of numerous opportunistic bivalves *Mactra* (*Sarmatimactra*) *eichwaldi* with articulated shells in the life position within the clinoforms suggests that they are in situ. Besides, well preserved, small gastropods, mainly *Granulolabium bicinctum* are abundant. Deposition structures in Borzykowa remind sand bars of Gilbert type delta. Such delta could be evidence for the closeness of land and river mouth, what suggest also numerous terrestial gastropods and wood fragments near Zwierzyniec. The small size of bivalves evidences that organisms lived in unfavorable conditions. Mass occurrence of such opportunistic forms in Miocene deposits of Carpathian Foredeep, without other organisms is traditionally considered as an evidence of lower salinity of the Central Parathetys in the Sarmatian (e.g. Czapowski and Studencka, 1990). However in some outcrops of detrital Sarmatian (Zwierzyniec, Suskrajowice, Śladków), molluscs are much more diverse and larger which confirmed by measures of at least 100 specimens from each of the outcrops. Significant lower angle of cross-bedding in Zwierzyniec, suggest lower rate of sediment accumulation than in Borzykowa, furthermore, the same bivalves has bigger sizes. These observations indicate, that the important factor which limit the growth and diversity of organisms from clinoforms (Borzykowa), was high rate of sediment accumulation, not only the lower salinity as previously thought. The lower salinity during the Sarmatian is not questioned here, however, Piller and Harzhausser (2005) suggest otherwise possibility. Thus, it is necessary to continue further sedimentological and paleoecological studies together with statistic analysis of size of moluscs in different facies.

Conjunctive use of spectral gamma ray, magnetic susceptibility, calcium carbonate content and clay mineralogy for cyclostratigraphic analyses of the Serre-Chaitieu section (Aptian, Vocontian basin, South-East France)

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In the early Aptian, the Oceanic Anoxic Event (OAE) 1a is well defined by a negative $\delta^{13}C$ excursion followed by a positive $\delta^{13}C$ excursion, spanning the Deshayesites deshayesi and Dufrenoya furcata ammonite biozones. A cyclostratigraphic approach is performed in the Vocontian Basin, France, to estimate the time required for the carbon cycle recovery following the major disturbance associated to OAE1a and to provide durations of ammonite and foraminifer biozones. The Serre-Chaitieu section, which consists of hemipelagic blue-grey marls with occasional marker limestone horizons and encompassing the Deshayesites deshayesi Zone to the end of the Epicheloniceras martini Zone, was used as a reference section in the Vocontian Basin.
Using field Spectral Gamma Ray (SGR), 450 measurements were performed throughout the section, and a sample of each measured sediment was collected to further perform calcimetry, clay mineralogy, and magnetic susceptibility (MS) measurements. Detrital clay mineral assemblages consist of illite, illite/smectite mixed-layers (I/S), kaolinite and chlorite. Fluctuations of clay minerals are mainly driven by climate change, progradation/drowning of peri-vocontian platforms and sea-level changes. The proportions of illite and kaolinite covary and fluctuate in opposition with I/S. Cyclic fluctuations of relative proportions of clay minerals are particularly well recorded by the kaolinite/chlorite ratio (K/C). Carbonate content and magnetic susceptibility values of the sediment show an inverse correlation which confirms that the magnetic susceptibility primarily reflects the clay content of most sediments. However, magnetic susceptibility is probably also influenced by the presence of pyrite in the analysed samples. SGR and MS show a significant correlation, K and Th being carried mainly by clay minerals.
Spectral analyses, using the multi-taper and the amplitude spectrogram methods, were performed on SGR, MS, $CaCO_3$ and K/C signals to detect sedimentary cycles related to an orbital forcing throughout the series. The stable geochronometer 405-kyr eccentricity cycle well expressed and significant (up to 99% confidence level) is used to provide a robust temporal framework. More than five 405-kyr eccentricity cycles are recognized, providing a total duration of at least 2.49 myr for the whole sedimentary succession. The minimum duration of the D. furcata Zone is assessed at 0.42 myr, and the duration of the E. martini Zone at 1.52 myr. Amplitude spectrograms show a strengthened signal of obliquity during the D. furcata Zone, concomittent with a global cooling and a drop in the atmospheric pCO_2 values and in the sea level, what is consistent with the development of low-extension polar ice. Durations of C-isotope zones, worldwide correlated, are also calculated. From these results, the duration of the return to equilibrium in the carbon cycle in the aftermath of OAE1a could be calculated at 1.35 myr, that should correspond to the sequestration of 28 T_{mol}/yr of carbon.

New conceptions and framework system of base level cycle and its preliminary application

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However, this scheme is simply a concession on different schools of sequence stratigraphy. It hasn't reached the target of multi-theory amalgamation theoretically. After deeply studied, the idea is proposed that base level cycle theory can be altered to get access to sequence stratigraphy standardization. The traditional base level and corresponding base level cycle theory has such defects as uncertainty of sequence order, base level cycle definition and poor operability et al. The new theory system on basic framework of base level cycle considers that base level has 3 movement status including ascending period of base level, descending period of base level and stable period of base level. The four kinds of dynamic process are put forward, which includes base level descending, base level tending to ascend, base level ascending and base level tending to descend. And the definition of base level oscillation sub-cycle is firstly put forward. The new suggestion is made that a base level cycle be a set of formation deposited from the descending to ascending stage of the base level, instead of from its ascending to descending stage. A new base level cycle includes the half cycle from falling base level to rising base level. This cycle is made up of four sub cycles, which are descending sub base level cycle, tending to ascending sub cycle, ascending sub cycle and tending to descend sub cycle. Two neighbored base level cycles vertically are divided by the transition section of base level cycle. When the thickness of the transition section equals to 0, it becomes base level transition surface. The above concept and method system helps to resolve the contradiction between sequence division and partition of development layer series. It provides a new train of thought to establish isochronous stratigraphic framework. The construction of the new framework system makes high resolution sequence stratigraphy more easily to amalgamate with classic sequence stratigraphy. The new theory has been used in planning overall development programs of onshore Qin oil field and ofshore Peng oil field in eastern China (Qin is characterized of Paleogene fan delta, the other is Neogene fluvial facies) and obtained good effectiveness in practical application.

Tectonics-palaeogeomorphology in rift basins: controlling effect on the sequence architecture

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The relationship between deposition and tectonics of sedimentary basins has been a significant subject in recent years. Using typical rift basins such as the Nanpu Sag as an example, combined with the analysis of the tectonics-palaeogeomorphology of basins, we undertook a detailed study of the differences of the third-order sequences in different basins, the combination of depositional systems within the sequence framework and the distribution of depocenters and subsidence centers. Our results revealed a significant relationship between the tectonics-palaeogeomorphology of rift basins and the filling styles of sedimentary sequences. The basin structure plays a primary role in controlling the development of the third-order sequences and the boundary of these sequences is easily formed in basins with gentle slopes, shallow water and a small area. The characteristics of the tectonics-palaeogeomorphology of rift basins are dominated by half-grabens of extensional faults, which affect the temporal and spatial combination of sedimentary systems within the sequences as well as the distribution of depocenters and subsidence centers. Based on the development rules of the faults dominating the half-grabens of extensional faults, rift basins are classified into two types: the single fault segmented-linkage type and the multi-fault combination type. The main controlling factors of the temporal and spatial combination of sedimentary systems and the distribution of depocenters and subsidence centers in different basins are different. The characteristics of early segmentation and later linkage of the faults play a critical role in controlling the sedimentary system combination within the sequence framework and the temporal and spatial differences of depocenters and subsidence centers of the single fault segmented-linkage rift basins, while the differences in fault activities are the dominating factors of the multi-fault combination rift basins.

Provenance and depositional system analysis of sediment routing system in Nanpu Sag, Bohai Bay Basin

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In this study, we use seismic reflection, well and core data to investigate the role that fault system played on the sediment dispersal of Paleogene in Nanpu Sag. Provenance analysis shows the development of two source areas, which are Yanshan organic belt and Shaleitian salient. Mapping of depositional system and sandstone thickness indicates that an upward increase of sand-rich fan type and volume, especially during the deposition of SQ12 (Ed1), the volume of sand-rich fans feed by Shaleitian salient exceeded those feed by Yanshan organic belt.
The differences in sediment dispersal are interpreted to reflect variable sedimentary responses to the morphological modification, which is principally related to the segment and linkage of boundary fault and subsidence history, as evidenced by the catchment expansion of different source areas. We conclude that increased sediment supply to Nanpu sag reflects the control of tectonic played on basin physiography, rather than climate fluctuations. Multi-directional and differential evolution of source area is universal in intra-continental rift basins which highlight the adjustment of sediment routing system generated by this characteristic of rift basin and demonstrates the importance of controls in understanding differential sediment dispersal that present in lacustrine successions.

The morphology and evolution of turbidity channel system and seabed pockmarks: Case study from the X oilfield in Niger Delta Basin, West Africa

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Turbidity channel systems are a common type of sandstone deposit on the continental slope and have proven to be one of the most common types of reservoirs found in deep ocean settings. Channel-levee systems form coarse-grained sediment deposited along channel-axes and fine-grained sands deposited on levees, the morphology and evolution of channel-levee systems are of interest to the petroleum industry. This study focuses on two channel-levee system examples in the Niger Delta basin, West African. An example of deep-buried channel-levee system, and another example of pockmark and shallow-buried channel system in submarine were illustrated. The study area is located on the western Niger Delta slope between water depths of 1200 and 1500 m. It covers an area of about 1250 km^2 and supplied by the Niger River. The high-quality 3D seismic volume used in this study is with 12.5 m bin spacing, and dominant frequency is near 70 Hz (approximately a 7 m vertical resolution).
Several conclusions are obtained from this research: (1) The turbidity channel system is characterized by both meander loop expansion (swing) and meander loop down-system migration (sweep) as it evolved through time. Single channels of different periods inner channel complex show the feature of lateral and down-system migration, which has some succession. The later channel are influenced by earlier channel in morphology, curvature and width. The morphology of two adjacent channels are similar in channels' vertical evolution. (2) There is a consistent increase in sinuosity through time. Based on the similar morphology, the curvature of the later channel system increased and even cut-off in the high curvature site. In the curved segments, the later channel developed relatively a large axis migration and the curvature increased, and it is contrary in straight segments. (3) Seabed pockmarks are a widespread feature of the study area. Pockmarks and the shallow-buried channels were recognized in study area. The pockmarks are circular or elliptical in plan view. The distribution pattern of the pockmarks has a high consistency with the deposition form of the shallow-buried channel system. These depositional boundary-related pockmarks are formed by the fluids migrating along the channel boundary. Obviously, the formation and distribution of the pockmarks controlled by the shallow-buried channel system, we hypothesize that pockmark is a pre-requisite for creation of initial channels in deep-sea environments.

Seafloor pockmarks and linear pockmark trains linked to buried turbiditic palaeo-channel in the Niger Delta Basin, West Africa

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Pockmarks are normally regarded to be manifestations of fluids escape through the seabed. Using high quality 3D seismic data within the Niger Delta Basin, we have identified pockmarks and two sinuous linear pockmark trains that are aligned above the sinuous belt of a buried turbiditic palaeo-channel. Seismic profiles show that these pockmarks developed above buried channels and their underlying chimneys seem to be rooted at the channel–levee interface. Linear pockmark arrays have been observed above the length of buried channels, indicating the escape of fluid from the channel sediment, vertically upward to the seabed. The seafloor pockmarks have two characteristics 1) Within each pockmark train, the pockmarks are fairly uniform in size and spacing, 2) Non-random pockmarks show one type of organized spatial arrangement. Linear pockmark arrays have been observed above the length of buried channels, the main channel is oriented NNE to SSW, the pockmarks to be very well organized and closely follow the path of the sinuous channel.
Pockmarks well develop in the northern, central-eastern and southeastern parts of the study area. They are circular, elliptical and crescentic in plan view. The cross-section of all types of pockmarks are U-shaped. Most of the single circular pockmarks are located in the northern part of the study area, pockmarks occur singly and in organized arrays or ‘pockmark trains’. Most of the elliptical pockmarks occur in the southeastern part of the study area, and the elongated orientation is to the NE and nearly parallel with the buried turbiditic channel. In the southeastern parts of the study area, pockmark trains evolve though time to form deep gullies. The immature gullies seem to be composed of several amalgamated pockmarks which are nearly all ellipse in shape and the long axis is similar with the orientation of the channel. Pockmark gullies may exceed 1 km in width and extend for 5–7 km.
The distribute of pockmarks clearly indicates that fluid seeps are not randomly distributed, but their seabed organization reflects 1) the geometry and morphology of the reservoir, 2) the location of the underlying reservoir where the fluids are coming from. We hypothesize that pockmark is a pre-requisite for creation of initial channels in deep-sea environments. Linear pockmark trains and pockmark gullies may provide preferential sediment transport routes into the deep water.

Sequence architecture and depositional models of Eocene lacustrine basin fills in the Dongying Depression, Bohai Bay Basin, eastern China

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Sequence architecture and depositional models of Eocene lacustrine basin fills in the Dongying Depression, eastern China, were investigated using seismic profiles, complemented by well logging and core analysis data. The middle submember of the 3rd member, Shahejie formation in the Dongying Depression (Es3z) can be divided into one third-order sequence or ten para-sequence sets, based on the characteristics of sequence stratigraphic boundaries and sedimentary successions. Lowstand-transgressive and highstand systems tracts are separated by initial and maximum lake flooding surfaces. During the depositional process of Es3z sequence, a series of syngenetic faults in nearly NE direction formed in Dongying lacustrine basin by regional extention. These normal faults make up the fault slope break zone as their ladder-like distribution in study area. The architecture of Es3z third-order sequence is controlled by the development of fault slope break zone and variation of A/S in the sufficient provenance supply condition. Activities of syngenetic faults lead to characteristics of trichotomy in systems tracts and control the development scope and thickness of lowstand systems tract (LST). LST includes three para-sequence sets and its distribution is limited to the downdropped block of syngenetic faults. The thickness of transgressive systems tract (TST) is small, only one para-sequence set can be identified which corresponds to widely distributed shale in this area. Highstand systems tract (HST) developed anomaly as a result of adequate sediments supply. HST consists of six para-sequence sets and shows progressive progradation of Dongying delta. As a result, Dongying delta front, or shoreline position advanced more than 20 km to the NWW direction. HST is characterized by three different types of progradation in terms of seismic reflection configurations. Early sigmoidal progradation (relative rise of lake-level), followed by oblique progradation (relative stillstand of lake-level), which is then followed by oblique progradation associated with offlap (relative fall of lake-level). These different progradation geometries indicate the succession developed from early ascending to nearly horizontal normal regression, followed by late lacustrine forced regression.

The shell's got rhythm: Deciphering cyclicity in the growth of a Pleistocene shell of the 'Giant Clam' *Tridacna* from Abu Dhabi, UAE

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Over the past few years, shells of *Tridacna costata* have been excavated during dredging of the shallow sub-tidal zone offshore of the island of Abu Dhabi, on the southern shore of the Arabian Gulf. These shells all exhibit an excellent state of preservation with little evidence of post-mortem degradation or diagenesis. Initial radiocarbon dating of four separate shells gave an age of >50,000 years. Consequently, these molluscs predate the last glacial maximum and date from a previous flooding episode in the Arabian Gulf, possibly the last interglacial eustatic sea level high at 120 ka.
Sections of these shells reveal clearly-defined growth bands at three levels of cyclicity. An analysis of oxygen and carbon isotopic composition in sclerochronological transects of two shells (a juvenile with 3, and an adult with 14 annual growth increments) produced calculated seasonal palaeotemperatures ranging between 18-28 °C. These temperatures are lower than Recent shallow marine temperatures offshore of Abu Dhabi (21-34 °C).
In order to clarify our understanding of the relationship between palaeotemperature and shell growth we performed an analysis of growth band thickness for all three observable scales of banding. Oversized thin sections were prepared from a cross section of the larger shell. These were then photographed at high resolution and the images were digitally enhanced in order to better visualise growth layers within the shell structure. In total, the thicknesses of over 3,000 bands were precisely measured along the shell transect.
Our results reveal that the large-scale bands have a clear relationship to palaeotemperature, thus revealing clear seasonal demarcation at this scale. The next order of growth bands appears to be related to lunar cyclicity whilst the highest order of banding, typically in the range of 5-15 µm, is inferred to record either diurnal or tidal cyclicity. These results provide the first documentation of such highly constrained cyclicity from the southern shore of the Arabian Gulf.

Astronomical forcing of sedimentary cycles of the Late Eocene Liushagang Formation in the Bailian Sag, Fushan Depression, Beibuwan Basin (South China Sea)

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Sediments in the Liushagang Formation of Late Eocene form a group of key hydrocarbon play fairways in the Beibuwan Basin, South China Sea. As an important reservoir- forming combination, the first member of Liushagang Formation consist of deltaic siliciclastic and show clear sedimentary cyclicity. According to paleontology research and stratigraphic correlation, the boundary between Liushagang Formation (Els) and Weizhou Formation (Ewz) is regarded as the Eocene-Oligocene boundary. The oxygen isotope dating for well cores from the top of the first Member of Liushagang Formation (Els1) and the bottom of the third Member of Weizhou Formation (Ewz3) give an isochron age of 35.2 Ma. Here we use GR logging data as a paleoenvironmental proxy to conduct a detailed cyclostratigraphic study of the Els1 in the Bailian Sag, Fushan Depression. Power spectra, evolutionary fast Fourier transformation and wavelet analysis all reveal significant sedimentary cycles in Els1. The ratios of cycle wavelengths in these stratigraphic units are 21: 5: 2.8: 1.2: 1, and are interpreted as Milankovitch cycles of 400 ka and 96 ka eccentricity, 52 ka obliquity, 22 ka and 19 ka precession cycles, respectively. An astronomical time scale is established by tuning filtered 96 ka eccentricity cycles to a target curve of Well L2 in the Bailian Sag.
Based on regional stratigraphic framework, combined with seismic, cores and logging data, the HST of the first member of the Liushagang Formation (Els1) delta in Well L2 was divided into six parasequence sets named Ps1- Ps6. According to the spectrum analysis by Simple Lomb periodogram from PAST program packages, the sediment accumulation rate of each parasequence sets first increased and then decreased as time went by. The sediment accumulation rate of Ps4 reached the maximum (0.127 m/ka) during the most prosperous period of delta prograding. Finally, the duration of each period of parasequence sets and more accurate geological age were calculated on the basis of sediment accumulation rate. The ages of each depth are precisely estimated and provide new constraints on the Late Eocene.

Refined architectural analysis on subsurface reservoirs of delta front: A case study on Lower Cretaceous reservoir in North Buzachi Oilfield

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Delta front deposition is a kind of important reservoirs. Current studies on the architecture of delta front reservoirs mainly focus on the modern sedimentation and outcrops. But architecture of ancient delta, especially delta front, is seldom studied, which is difficult to meet the need of predicting the remaining oil distribution. Therefore, taking Lower Cretaceous Reservoir in North Buzachi Oilfield as an example, we analyzed the characteristics of different architectural elements of delta front, determined the hierarchical system of architecture and summarized sedimental model of delta front using various data including cores, well-logging, seismic and production data. Followings are the main results.
(1) Three architectural elements are distinguished as distributary channels, mouth bars and beach sands in study area. Based on the degree of under-cutting, the distributary channels can be divided into two types: the trunk distributary channels which totally undercut the mouth bars and are formed by avulsion, and terminal distributary channels which partly undercut the mouth bars and are formed by bifurcation around a mouth bar. (2) By anatomizing the compound sandbodies, we summarized four kinds of distributional patterns between architectural elements: continuous distribution of mouth bars, partly continuous distribution of mouth bars, isolated distribution of mouth bars and isolated distribution of beach sands. (3) On the basis of the sedimentary characteristics and forming process of mouth bars, we summarized four identification marks of dividing the single mouth bars: the emergence of mudstone between mouth bars, the difference of elevation between different single sandbodies, the decrease of the sandstone's thickness towards the margin of the mouth bars and lateral superimposition between different single sandbodies. According to these identification marks, we anatomized single mouth bars of different single layers and analyzed quantitative scale of single mouth bars. The scale of mouth bars varies in different single layers due to the sea level fluctuation, the variation of source supply, and the modification of wave and tide on the delta. (4) According to the qualitative and quantitative anatomizing results of reservoir architecture, three-dimensional reservoir architecture model is established precisely in order to study the distribution of remaining oil afterwards.

Diagenetic physical modelling on organic-rich shale porosity evolution

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The study on porosity evolution of shales can help to improve the accuracy of reservoir evaluation and prediction, which is important to sweet-spotting. In this study, we use self-designed reservoir diagenetic modeling system to characterize shale porosity changes with increasing temperature (T) and pressure (P). T_{max}=550 ℃ and P_{max}=275 MPa. There are six sample reactors which can be set different T and P. We can add different fluids and collect the products during the experiment.The samples are modern lacustrine ooze obtained from Fuhai Lake of the Winter Palace in Beijing. TOC is 4.76 wt%. Six experiments have been conducted, and three experiments are at the same T&P to test system stabality. The heating rate is 10 ℃ per hours and the pressure rise step is 10 MPa per time. In this study, constant pressure (40 MPa) is used. Total experiment time is 7 days. Typical diagenetic indicators, i.e., R_o, T_{max}, Illite/smectite ratio are analyzed. SEM is used to obtain high resolution micro-structure images. Our prelimanary results include the following aspects:
(1) Three comparasive groups with 18 samples shows that the difference of Ro is less than 0.2%, indicating good stability of the system.
(2) Relationship between experiment T and geological maturity is established. 250 ℃ correspond to immature stage when R_o=0.5% and T_{max}=435 ℃. 250~370 ℃ correspond to oil window when R_o=0.5%~1.2% and T_{max}=435℃~460 ℃. 370 ℃ corresponds to gas window when R_o=1.3%, T_{max}=460 ℃. 550 ℃ corresponds to late gas window when R o=2.5%.
(3) At early stage (R_o=0.5%), primary intergranule micro-pores dominate storage space. As temperature and pressure increase, the shale enter oil window (R_o=0.5%~1.2%) and the pore space is dominated by nano-scaled pores, usually accompanied with micro-fractures, which could form favorable nano-porosity system with better connectivity. During the gas window stage (R_o>1.3%), because of big surface area, the adsorption of nano-scaled grains is great, which accelerate the process of OM pyrolysis. OM coagulation is observed around nano-scaled grains in mudstone/shale.
Although there are lots of differences between physical modelling and actural geological evolution, multi-parameter diagenesis modeling could help to understand the whole porosity and mineral evolution process in shale, which can provide reference for favorable reservoirs evaluation and prediction.

Microfaunal and microfloral changes during Late Valanginian–Hauterivian in deep-water maiolica type Pieniny Limestone Formation (Orava sector of Pieniny Klippen Belt, Western Carpathians)

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Micropaleontological analysis of Lower Cretaceous maiolica type Pieniny Limestone Formation in the Western Carpathian Pieniny Klippen Belt Unit, located in a active quarry near Podbiel village in the Orava area is presented in this study (GPS: 49°18.257'N 19° 28.041'E). The qarry revealed a suitable outcrop especially in the upper member of this formation, which is characteristic by its frequent bioturbations and black shale intercalations. Black shales in the lower parts of this member are rich on deep water agglutinated foraminifera. Black shales in the upper part of this succession are unusually rich on calcareous walled dinoflagellate cysts. According to the calcareous walled cyst biostratigraphy, the upper member of the formation is dated as Late Valanginian–Hauterivian (Colomisphaera vogleri Zone). Other common microfossils are calcareous benthic foraminifera and radiolaria. Comparison of microfacies and data based on foraminiferal morphogroups, revealed changes of the microfossil record in this monotonous sequence. Paleoenviromental settings are reflected by composition of benthic foraminiferal assemblage. This composition is influenced generally by nutrient availibility and oxygen content. Different benthic foraminiferal assemblages are occurring along radiolarian and dinocyst microfacies turnover. Cysts of calcareous dinoflagellates were observed in thin sections and correlated with their free equivalents obtained from washes samples with respect to their wall structure and texture.

Microbial-formed Fe-Mn oncoids from condensed Lower Jurassic deposits: a case study from Eastern Pontides, Turkey

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Microbial-formed Fe-Mn oncoids occur in red nodular- marly Ammonico Rosso type sediments of the early Jurassic age, which represent the intervals of condensed sedimentation. The Investigated oncoids were collected from Gümüşhane region in the Northeastern Turkey. They are mostly discoidal, and subordinately spherical in shape. The mineralized macro oncoids (35 mm mean size) cosist of microbial laminas which reveals a rhythmic growth in the mineralized macro oncoids. In general, they are characterized by brown, reddish and metallic colours. The oncoids are made up of a nuclei coated by concentric laminas. Besides, ammonoid shells and moulds are cores of the oncoids. The nuclei of the oncoids are made up of bioclastic wackestones. The wackestones are rich in thin shelled ostracods, radiolarians and sponge spicules. The wackestones also include fragments of mollusc shells and benthic foraminifers, among which *Involutina* sp., *Lenticulina* sp., *Frondicularia* sp., and *Nodosari*a sp. In addition, Fe-Mn coated echinoid plates and spines and microborings filled with Fe-Mn oxides on different biogenic components are also found. The cortices of the oncoids consist mostly of wrinkled laminated bands. The bands, however, comprise of partially overlapping laminas, usually alternating between light and dark laminas, little encrusting foraminiferas. The thickness of the coatings is less than 2 mm and the shapes are an arborescent to dendrolitic microstructure. The oncoids are predominantly built of hematite and manganite as revealed by XRD analysis. The chemical composition of oncoidal cortices has shown that iron definitely outranked manganese which confirmed by EDS. The Fe_2O_3 concentration in oncoids is between 3,57 and 4,66 wt.%. The MnO content is always less than 0,5 wt.%. Segmented filaments are observed on the cortices of the oncoids by SEM, which allowed us to identify webs of filaments with a cylindrical shape. These are mostly like fungal hyphae. Morphology and dimensions of the mineralized structures in the oncoids show that they are microbial origin. However, the precise identification of microbe types are seems to be impossible. But the filamentous bodies most probably represent mineralized bacterial cells. Precipitation of the mineralization is related to the benthic microbial communities, probably corresponding to the fungal mats and other microbes. The mineralized oncoids are widely known throughout the Mesozoic of the Tethyan region in condensed pelagic sediments. The mineralized oncoids could be connected either with the local conditions or with the eustatic movements. Mineralized oncoids and condensed sedimentation should be typical for the eustatic high stands. The mineralized oncoids record condensation processes related to the deepening of the passive Tethyan margin.

Geomicrobiological processes in daily laminated travertines

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Travertines, carbonate precipitates from highly saturated hot spring water, is one of the modern analogs for some ancient stromatolites (e.g. mini-stromatolites) because their fabrics resemble to the ancient stromatolites in terms of sub-mm order lamination and scarcity of detrital particles and calcified microbes. We have studied sedimentology, geochemistry, and microbiology of travertines in several localities in Japan and Indonesia, and found that the sub-mm order laminations are basically daily. Here we demonstrate some of key features in the daily laminated travertine.
First, textures of the daily laminated travertines are controlled by mineralogy; calcite travertines generally show porous textures consist of tree-like aggregation of rhombic crystals (dendrite), while aragonite travertines are densely packed by radially expanded needle crystals. Regardless of the mineralogy, a series of samples through day and night showed that cyanobacteria and their metabolism directly or indirectly contribute the development in daily lamination. For calcite travertines, phototaxis movement of filamentous cyanobacteria generates a regular daily rhythm consisting of the daytime development of biofilm and the nighttime calcification on the travertine surface. This type of the daily lamination can be developed at low-flow sites of the aragonite travertines. While at high-flow sites of the aragonite travertines, heterotrophic bacteria play a main role. A thin biofilm is developed during daytime by the heterotrophs that fuel on organic matter supplying by filamentous cyanobacteria. Heterotrophs disturb the crystal growth of aragonite and leave fine-grained texture of the daytime layers.
Our microbiological analyses found that the microbial taxonomic composition of the biofilm is sensitive to water temperature. Below 40 degree, filamentous cyanobacteria (and a peculiar heterotrophs) are abundant, while coccoid cyanobacteria replace the community around 50 degree. When the temperature is above ~55 degree, purple sulfur bacteria form a thin biofilm on the travertine surface and develop less clear lamination with daily rhythm. Daily rhythm of photosynthesis is robust, and its metabolic effects marked the daily change in travertine textures.
Despite of 100-yr-long study history of taxonomy, paleontology, and sedimentology of stromatolites, the periodicity of the stromatolite lamination has not been understood well. Because of the robust nature of photosynthesis, some laminations in stromatolites (such ones in mini-stromatolites) were likely daily. Such assumption can specify the growth rate of the ancient stromatolites and provide insight into understanding conditions of the ancient ocean.

High-frequency, small-scale paleosol horizons in the Lower Jurassic formations of the Tripolis unit (central western Crete)

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An Early Jurassic (Late Lias) cyclic lagoonal-peritidal stratigraphic unit from the central western Crete (Tripolis unit) has been sedimentologically studied. The Tripolis carbonate unit corresponds to the eastern (internal) part of the mainland Gavrovo-Tripolis platform that represents the most important external platform of the Hellenides. The Gavrovo-Tripolis platform was separated from the Apulian platform, one of the so-called Periadriatic carbonate platforms of the Tethyan realm, during the Pliensbachian, when the Ionian epicontinental basin was differentiated. The studied Tripolis carbonate sequence consists of meter-scale, upward-shallowing successions of restricted inner-carbonate platform facies, including cyclically repeated subtidal, intertidal, and supratidal facies. Lithofacies associations include dolomitic intra-peloidal-shelly packstones to grainstones/rudstones dominated by fossils characteristic of restricted shallow marine biota (bivalves, gastropods, benthic foraminifers, and ostracods); they represent shallow subtidal to intertidal, moderately high-energy sediments deposited in an inner platform setting. This lithofacies association has been intermittently, subaerially exposed and has undergone diagenetic processes in an inter- or supratidal environment. Cyclothems are bounded by dolocretes (laminar dolocretes, peloidal-pisoid dolocretes, and massive dolocretes), recording successive episodes of prolonged subaerial exposure at the end of each depositional cycle. Laminar dolocretes are characterized by several calcrete and vadose fabrics; including fenestral cavities with geopetal structures and micritic coatings, crudely-pelleted walls, infill of rootlet moulds (alveolar texture), intergranular micritic bridges, meniscus cement, in-situ brecciation, and circumgranular cracking. The cyclothems are stratigraphically located within the studied Lower Jurassic sequence, suggestive of relative sea-level control on the peritidal cyclicity observed. This reflects the combination of uniform tectonic subsidence and eustasy, which results in the formation of a ramp-to-shelf carbonate system with lagoon and tidal flat lithofacies. Sea-level changes are probably caused by climatic, oceanographic, and/or tectonic changes (allocyclic processes). Due to its tectonic evolution, the platform has been repeatedly, subaerially exposed and has undergone diagenetic processes in an inter- or supratidal environment, frequently resulting in dolocretes formation. The extensional tectonic regime, in the Tethys, and the occurrence of two major, globally-recognized, biotic crises in Early to Middle Jurassic times should be taken under consideration.

Growth mechanism of stalagmites, cave environment and water chemistry of the drip waters in limestone caves beneath different vegetation

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Speleothems formation depends on geological, hydrological, water chemistry, climatic factors and so on. Therefore, the isotopic compositions in speleothems are known as a good indicator of paleoenvironment. Especially, the carbon isotopic ratio ($\delta^{13}C_{PDB}$) and growth rate of stalagmites are influenced by climate and vegetation around the limestone cave, and oxygen isotopic ratio ($\delta^{18}O_{PDB}$) is affected by oxygen isotopic ratio ($\delta^{18}O_{SMOW}$) of drip water, water temperature etc. Minami-Daito Island had been an uninhabited island until 1900 A.D. By the cultivation of pioneers after 1900 A.D., the vegetation had changed from sub-tropical forests (C3 plant) to sugarcane field (C4 plant) in the whole island. Our previous study examined the average growth rate, $\delta^{13}C_{PDB}$ and $\delta^{18}O_{PDB}$ of two stalagmites beneath different vegetation. One stalagmite is IM-2 collected from Imamura Cave under sugarcane field and another stalagmite is YS-4 from Yamashita Cave under sub-tropical forests. As a result, the whole average growth rate of the YS-4 stalagmite has not significantly changed before and after 1900 A.D. By contrast, the average growth rate of the IM-2 stalagmite has been changed and a drastically rapid change occurred around 1900 A.D. Furthermore, the $\delta^{13}C_{PDB}$ values of IM-2 before 1900 A.D. showed relatively lower, whereas the values after 1900 A.D. showed relatively higher. So, to clarify the differences in the growth mechanism of stalagmites beneath the different vegetation, we tried to measure cave environment (air temperatures and CO_2 concentrations in both caves and the soils), δDS_{MOW} and $\delta^{18}O_{SMOW}$ of the drip waters of each season from August 2013. In this presentation, we will report the results.
The air temperatures in Yamashita Cave (beneath sub-tropical forests) became high in summer with an increase of air temperature outside, whereas the air temperatures in Imamura Cave (beneath sugarcane field) became high in autumn. About CO_2 concentrations in the caves, there were no large changes in CO_2-cave concentrations with relatively high values (9,710〜11,500 ppm) in Yamashita Cave. By contrast, CO_2-cave concentrations of Imamura Cave showed relatively low values (2,587〜3,685 ppm), and increased significantly in summer. On the other hand, CO_2-soil concentrations within the soil above Yamashita Cave were lower than those above Imamura Cave. The δD_{SMOW} and $\delta^{18}O_{SMOW}$ values of the drip water in Yamashita Cave showed the highest in summer and the lower in autumn (δD_{SMOW} = -35.1〜-27.4‰ , $\delta^{18}O_{SMOW}$ = -5.83〜-4.93‰), while the values of Imamura Cave had the highest in spring (δD_{SMOW} = -35.3〜-19.6‰, $\delta^{18}O_{SMOW}$ = -5.88〜-3.74‰).
The cave environment and water chemistry of the drip waters in both caves showed some differences, and showed seasonal variation in each cave. These differences were considered to be attributed to the difference in evapotranspiration system, infiltration mechanism of surface water, amounts and decomposition rate of organic matter within soil etc. based on the different vegetation.

The effects of flood-ebb flows on a large tidal bar within the tidal-fluvial transition zone

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The transition between fully fluvial and fully tidal environments in river-estuary systems is highly complex. Fluvial and tidal currents interact on daily, seasonal and annual timescales resulting in a moving boundary between ebb and flood flow extents within a transitional zone. As a consequence, the controls on flow and sediment routing and ultimately the sedimentary deposits within the tidal-fluvial transition zone are poorly understood, notably in terms of the relationships between flow structure evolution through the tidal cycle and the bed-sediment-suspension response. This is important as these processes are key controls on bar characteristics and an advance in our understanding of these processes will enable significant insight into the sedimentary record to be progressed via construction of detailed process-product relations within and across the transition zone.
This paper presents results from fieldwork conducted on a large bar within the tidally-influenced region of the River Severn, UK. The Severn Estuary has the second highest tidal range in the world and contains an elongated tidal-fluvial transition zone. Measurements of flow were made around the tidal bar, during a spring tidal cycle, using an acoustic Doppler current profiler (ADCP) on a small research vessel and at a fixed point at the seaward end of the bar using an electromagnetic current meter, with concurrent conductivity, temperature and depth measurements (ECM+CTD). Four sedimentary cores obtained using a bespoke vibrocore rig were also recovered: at the landward and seaward ends of the bar and along a central ADCP transect. The results shows the variation of flow on the flood and ebb tides around a region of complex bed morphology, allowing the influence of flow and the tidal bore on sediment movement and deposition to be quantified. Sediment transport in the channels both around the bar and across the bar top can be compared to the flow patterns identified and the resultant deposits. These results, including the sedimentary sequences identified in core, can be compared to measurements made in other tidal-fluvial transition zones. The implications of the results for interpreting the ancient will be detailed and discussed.

Samuel's paleo-jacuzzi: Dating and clumped isotope-based temperature of the Vértesszőlős Early Man site (Hungary)

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One of the most important Early Man site of Europe is located at Vértesszőlős (Hungary). Here, settlements of Paleolithic people and remains of *Homo heidelbergensis* (named Samuel) were preserved in loose sediments and travertine pools. During the past decades the site has been investigated from many aspects, but still there are open questions regarding its age and the paleoclimatic conditions during the travertine deposition.
In this study U-Th dating and stable- and clumped isotope analyses on 7 travertine samples were performed representing different travertine- and culture layers of the Early Man site, including the footprint layer and the travertine block containing the occipital bone of *Homo heidelbergensis.* Stable isotope and D47 data were measured with a Thermo Fisher Scientific Kiel IV device connected to a Thermo Fisher Scientific MAT 253 mass spectrometer at ETH Zürich. The U-Th dates were determined at the High-Precision Mass Spectrometry and Environment Change Laboratory (HISPEC), Department of Geosciences, National Taiwan University.
The formation temperature of carbonates can be estimated using the clumped isotope method, which requires no assumptions about the oxygen isotope composition of water from which the carbonate precipitated. The clumped isotope thermometer was calibrated recently using recent travertine and tufa deposits and here we apply this calibration for first time on ancient travertines to calculate the temperature of precipitation and to get information about climatic conditions during the presence of Heidelberg-type human at Vértesszőlős. Our D47 data indicate that the temperature of the precipitating water has varied between 13 and 21 °C and it was 17 °C during the precipitation of the travertine containing the occipital bone of *Homo heidelbergensis*. The earlier indirect estimations based on the composition of the malaco faunas suggested for a temperature similar to the present conditions, however, the malaco-thermometer indicates only the conditions of the vegetation period (mid-tempereature of July). Based on earlier studies the age of the site was placed to the „Inter-Mindel" period or to the Upper Biharian stage after the biostratigraphy; recent studies, however, questioned the validity of these identifications. The U-Th dating in 1965, 1973, 1980 and 1983 yielded various ages ranging from 202 kys to >350 kys. According to our U-Th analyses the age of the Vértesszőlős travertine at the occipital bone is about 315±72 kys, which is very close to the data (333±17 kys) measured by Hennig et al. (1983). The age of the eastern continuation of the foot-mark surface is 310±30 kys and the age of the lower part of the lowermost culture layer is 328±28 kys. These results shed new light to the absolute chronology of the travertine complex and the Lower Palaeolithic site, which was known from samples collected from not controlled stratigraphic position and measured more than 30 years ago.

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Low verses high oxygenation of the seawater in which Permian-Triassic microbialites formed: Has the problem been solved?

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Post-extinction microbialites are widespread in Tethys Ocean shallow marine carbonate sequences after the end-Permian extinction event. Controversy has continued in recent years about whether the microbialites grew in oxygenated water or water low in oxygen. Physical evidence is conflicting: pyrite framboids (generally considered to form in anoxic conditions) are found in the microbialites along with ostracods and small gastropods (which need oxygen to live). Potential solutions include: A) the ostracods and gastropods lived in microenvironments of oxygen-rich waters in an otherwise low oxygen setting; B) the redox boundary was very shallow in the sediments so that pyrite framboids formed diagenetically just below oxygenated sediments that supported shelly animals; C) pyrite framboids that formed in the water column below the redox boundary were upwelled and advected into shallow oxygenated waters.
Recent attempts to resolve the issue using redox-sensitive elements suggest that the water was oxygenated. Such evidence is supported by the likelihood that these shallow marine carbonates were formed in water that was mixed and therefore in contact with the atmosphere to allow the water to be oxygenated. These studies are powerful indicators that the microbialites grew in oxygenated water. However, geochemical studies have not so far distinguished between the microbial fabric and the adjacent sediments containing shelly fossils. Although it is likely that the two materials were formed in the same environment, the absolute proof that they were both formed in oxygenated conditions is not yet obtained.
Therefore, although it is now very likely that the end-Permian microbialites formed in oxygenated conditions, we are still awaiting final confirmation. However, whether this is confirmed or not, the problem of what processes caused the microbialites to form, and why they are such thin deposits (maximum 15 m thickness) remains unresolved.

Siderite is an optimal precursor for microbially-mediated iron oxide cementation in sandstones

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Iron oxide mineralization is widespread in sandstones. Locally (e.g., Navajo Sandstone, Chinle Formation, and Umm Ishrin Sandstone) this mineralization can result in rocks that are spectacular visually. Some of these accumulations are characterized by pervasive cementation adjacent to fractures or in centimeter-thick concentric or sub-parallel to parallel bands. We have concluded that these accumulations are the products of evolving fluid-rock-microbe systems. The geometry of the accumulations require that the iron was transported in aqueous solution, but the size of boxwork concretions and the distance between bands of iron oxide cement, require that iron transport was limited to centimeter to decimeter-scales (during production of the iron oxide mineralization). These accumulations require that precipitation of iron oxides occurred in a geochemical trap as the solubility of ferric oxides is sufficiently low that multiple pore volumes of solution were required to transport sufficient iron to fill the pore space. The presence of iron oxide mineralization adjacent to open fractures and the occurrence of cement that encloses friable rock indicates that the rock was cemented with a ferrous iron precursor prior to uplift. Oxygen, not iron was introduced to the formation.
We have concluded that dissolution of siderite and subsequent microbial oxidation of the aqueous ferrous iron is responsible for much of this spectacular iron oxide cementation. Siderite has been unstable at the Earth's surface ever since the Great Oxidation Event. Although siderite can form readily in the subsurface where significant partial pressures of CO_2 or H_2 may be present, upon exposure to the modern atmosphere ferrous iron must be oxidized to ferric oxide. Both siderite solubility and rates of siderite dissolution increase with decreasing pH. At near-neutral pH, rates of siderite dissolution are maximized under anoxic conditions (Duckworth and Martin, 2004). Microaerophilic iron-oxidizing bacteria can utilize the ferrous iron as an electron donor at a redox interface located millimeters to centimeters from the siderite-solution interface. The subsequent precipitation of iron oxide during hydrolysis generates acid that can promote further siderite dissolution. The gradual invasion of siderite-cemented aquifers by oxidizing waters comprises the optimal conditions for the generation of thick bands of iron oxide cement. Carbonates that contain less iron than ankerite will oxidize abiotically upon exposure to the atmosphere but are apparently not suitable substrates for iron oxidizing microbes. Oxidation of pyrite, on the other hand requires sequential electron transfers from adsorbed species to sulfur before ferrous iron can be liberated (Rimstidt and Vaughan, 2003). This process generates sufficient unbuffered acid that the liberated iron tends to be dispersed. Although pyrite mineralization is capable of generating thin, diffuse sets of Liesegang, it apparently does not generate thick concentric or sub-parallel bands of cement.

Strategic use of landscape by hominins in the southern Kenya Rift constrained topographic reconstruction, soil nutrients and animal distributions

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We present a landscape reconstruction for a key site in the Kenya Rift, Olorgesailie, used by hominins between ~1.2 to <0.5 Ma. It contains hominin artefacts, fossil mammals, and evidence of large-mammal butchery. It was used by Palaeolithic hominins for ambush hunting of large prey animals. We introduce new methods in support of this landuse hypothesis using tools developed to study faults, and soil edaphics by mapping of nutrients critical to the health of herbivores. This allows us to identify the limited routes of movement and grazing areas available to large mammals in the region and show the strategic location of Olorgesailie as a base for their exploitation by hominins. We carried out field analysis to characterize aspects of the geology, soil quality (edaphics) and tectonics in order to identify 'good' and 'bad' regions for grazing animals. First results indicate that the flood trachytes at the valley floor produce poor soils lacking important nutrients, whereas the soils on sediments close to the hominin site are much more attractive grazing sites. As the rift floor today is different from when the site was occupied we created a palaeoDEM using techniques developed to model tectonic faults. This way it is possible to identify how fault motion has changed the landscape and allows us to consider how *Homo* used the site region to exploit prey species and avoid predators. The faunal community of Olorgesailie is dominated by and large-bodied grazing species such as white rhinoceros and wildebeest. These animals would have been restricted to flatter areas for their routes through the region. Our mapping shows that such routes are limited, and this means that *Homo* could predict the routes that prey animals would take en route to the sources of drinking water (palaeolake Olorgesailie). The location of the site in relation to the wider landscape shows that the hominins placed themselves in the best position to conduct ambush hunting. Also, few carnivores where present, so the region was much safer for hominins to use for hunting. Our analysis indicates the unique features of the Olorgesailie site and why it repeatedly attracted human activity over a long period of time. It also provides the earliest evidence of strategic landscape use for ambush hunting ever documented.

Paleoenvironmental reconstruction based on sediment sections of Béke Cave, Hungary

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The aim of this study is to present the results of the stratigraphical, sedimentological and geochemical analyses (XRD, XRF, total carbon content, diffuse reflectance and differential thermal analysis) of some sediment sections of Béke Cave (Aggtelek Karst, Hungary).
The cave was formed within Triassic limestone that is covered by Miocene, Pliocene and Pleistocene sediments (e.g. sandy gravel, silt and red clay) in its catchment area. The studied sediment sections were preserved in safe geomorphological position among others in the middle part of the main passage of the cave and in the estaurine part of the longest branch.
According to the geochemical analyses, in silt the dominant mineral is quartz. Besides this, illite, illite/smectite, kaolinite and goethite are represented in the layers. In clayey laminas the higher than 3.0 SiO_2/Al_2O_3 ratios (3.29-3.85) refer to Pleistocene siallitic weathering proceeded in terra rossa before them infiltration to the cave. The mineral components indicates the formation of poor weathering complex in an acidic, leaching environment.
The mineral composition of the clay fraction, the presence of iron minerals and the absence of calcite suggests the short transport pathway of the fluvial sediments. The poorly-moderately sorted layers with subangular gravels also confirm this presumption: the nearby sediments of the surface originated from various geological age, were redeposited following a short transport in the cave.
The variable sediment stratas of cave sections were classified into groups by cluster and discriminant analysis. The Wilk's lambda values shows that the most important properties in the classification were (in order) the inorganic and organic carbon content, subsequently (mostly the clay and iron) mineral composition and at last the gravel content.
Based on detailed analysis of cave sediment sequences various surface processes and sedimentation phases were identified.
Different kind of sand and clay layers, cave terraces, as well as cascading channels were identified at the main passage. These channels are probably seems to be a cross section of a filled branch or were the meanders of the main cave stream. The variable and polimodial grain size distribution reflect fluctuation in transport energy which refer to the changing in paleoenvironmental conditions. As a result of stratigraphical investigations 6 main sedimentation periods and sub-periods were identified: cave terrace formation and graded sand accumulation, still sedimentation period under reductive conditions, long term change of a gravel into sandy clay stream bed sequence, development of a meandering and then a braided channeled cave stream, cave terrace forming.
More than 1 meter thick, various grain sized section was identified in the lower branch. The development started with a strong corrosional and erosional phase characterized by paleogeomorphological phenomenom (cave terrace) and coarse grained gravel, which were overlaid by a 40 cm thick clayey strata. 0.5 cm thick calcite crust was intercalated in the clayey sediment during the period when the fluvial activity stop. After that varve like sediments deposited which possibly indicated rythmical, annual changing period. The final event of the sedimentation was the accumulation period of the overlying red clay and calcite crust.

Investigation on geomorphological and morphostratigraphical levels according to joint of sediment mapping and 3D laser scanning methods on the example of Béke Cave, Hungary

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Various geomorphological levels can be found along cave passages which have been formed by dominantly erosion-accumulation processes caused by cave streams. Two main type of terraces could be differentiated by their origin in Béke Cave (Aggtelek Karst, NE Hungary):
(1) Cave erosional terraces developed by the effects of climatic changes during the humid interglacial periods of Pleistocene or indirectly by the change of the erosion base level due to tectonic activity. Erosional terraces could be identified by geomorphological analysis of cave platforms –almost horizontal steps appeared on wall.
(2) The material of accumulation terraces could be deposited from cave streams during the humid periods of Pleistocene. The matrix of the terrace conglomerate was cemented and preserved by carbonate or limonite intercalations.
This phenomenon could be identified in different heights on the wall of cave passages and/or in sediment sequences.
Joint sediment mapping and 3D laser scanning methods were applied to determine the different morphostratigraphical levels in Béke Cave:
The relative distance of sediment sequences from each other and from the recent stream bed was measured by a Leica Disto laser distance meter along 300 m length in the main passage.
3D model of the same cave section was built to identify cave erosion terraces based on laser scanning surveys using Leica ScanStation C10.
Based on the results of the joint method analysis, complex geomorphological-geological long section model of the passage was created.
The identification of the different morphostratigraphical levels helps (1) to correlate the various cave sediment sequences, overlaid (or deposited on) the cave platforms, (2) to specify the chronostratigraphical position of the key sections of the cave, and (3) to connect the various terrace levels to the Pleistocene climate cycles.

Soft sediment deformation structures induced by seismo-tectonic activity in Bigadiç (Balikesir) Neogene lacustrine deposits, western Turkey

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This study aims to investigate the characteristics and formation mechanism of soft sediment deformation structures in Neogene sediments cropping out near Bigadiç in the west of Elazığ. In the region, on the Paleozoic and Mesozoic-aged basement rocks, the growth faults and dislocations caused significant topography and subsidence in pre-Miocene times. As a result, lacustrine depositional environments were formed and the Neogene sediments were deposited here. Original sequence observed in the study area comprises bedrock unit, basal volcanic unit, bedded limestone unit, lower tuff unit, lower borate unit, upper tuff unit, upper borate unit and the Quaternary formations. Sedimentological examination of the study area enabled the description of the following facies: massive conglomerate, massive sandstone, siltstone, organic-rich claystone, massive limestone, stratified limestone, organic rich limestone, the intercalated limestone-organic rich claystone, marl and borates (laminated, bedded, nodular, massive). These facies, in association with agglomerate, lapilli stone and tuffs, were deposited in a deep lake setting. Soft sediment deformation structures observed commonly in Bigadiç and close by regions are examined under seven groups. These are: slump, convolute lamination, load cast, flame structure, clastic dikes, broken-mixed layers and syn-sedimentary faults. Deformation mechanism of these structures is related to liquefaction, fluidization, shear stress, density difference and brittle behavior. The trigger mechanism for the action of the deformation mechanisms is the seismo-tectonic movements.

Characteristics and formation mechanism of soft sediment deformation structure observed in alluvial fan deposits, Kuşcular Formation (Lower Paleocene), western Elaziğ, eastern Turkey

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This study aim to investigate the properties ve formation mechanism of soft sediment deformation structures in the alluvial fan deposits of Kuşçular Formation outcropping in the west of Elazığ.
Kuşcular Formation is composed of conglomerate, pebbly sandstone, sandstone, red and green mudstone, gypsum-bearing mudstone and secondary gypsum. Unit is built of alluvial fan facies association (inner range, mid-range and outside range), and dry mud flat-playa facies association. North of the study area, it is known Keban metamorphite rocks (Permo-Triassic) overthrust on Elazığ Magmatits (Senonian) from north to south in Lower Paleocene. This is known as Pertek thrust fault. Pertek thrust fault of the Late Cretaceous tectonics since proven with other events that occurred about becoming effective, depending on the north-south direction, considering the direction of compression stress. Soft sediment deformation structures developed at different levels of the outer fan deposits of Kuşçular Formation. They are; small-scale slumps, large-scale slumps, load cast, flame structures, sand dikes, interpenetrative cusps, mixed beds, and syn-sedimentary faults. Deformation mechanism is associated with liquefaction, fluidization, shear stress and brittle behavior. Seismic shock can result liquefaction and fluidization in sediments. The presence of intraformational unconformity in the distal facies in the unit indicates that tectonic activity was effective during Lower Paleocene in the region. Criteria such as regional tectonic active (Pertek thrust fault), be limited to the undeformed layer of soft sediment deformation structures, showing tens and show hundreds of meters continuity, to repeat at different levels, showing similarity to the seismic induced deformation structures and deformation structures created experimentally in laboratory conditions indicate that the soft sediment deformation structures described in Kuşçular Formation formed seismic and seismo-tectonic activities.

From deposits to rock in the laboratory. Is it possible? Microfacial analysis.

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The southern part of the Kraków-Częstochowa Upland comprises numerous outcrops of Upper Jurassic carbonates showing variable facial development. Three lithologically highly diversified facies were identified: bedded, massive and gravity-flow.
The laboratory studies focused on the bedded facies and aimed to estimate the amount of their compaction. A series of oedometric experiments were undertaken on samples specially prepared from grinded carbonate rocks. Both the grains size and the perecentages of fractions in a mixture were determined by microscopic examination of thin sections. Microfacial development was described in accordance with Dunham classification system. The AnalySIS FIVE DOCU image analysis software was used for measurements of grain diameters. The results allowed for selection of the following grain-size subsets: 0.063–0.125; 0.125–0.25; 0.25–0.5; 0.5–1 and >1 mm, in accordance with the Wentworth-Udden particle scale. Fraction <0.063 mm was regarded as the matrix. Fraction <0.063 mm constituted 80% of total volume of the grains, the percentages of the remaining subsets were as follows: 0.063-0.125 mm – 4%, 0.125-0.25 mm – 8%; 0.25–0.5 mm – 5%; 0.5–1 mm – 2 % and > 1 mm – 1%. Hence, the samples for oedometer consolidation experiments were prepared by mixing the relevant proportions of the fractions and then mixing the samples with water 1:1.
After the experiments, oriented thin sections were cut from the compacted samples and studied under the microscope. It was found that images of compacted samples do not differ significantly from those of raw samples collected from the outcrops of bedded limestone facies. The grading was poorly visible and, locally, even absent, which maked the microscopic images of prepared samples very similar to microfacial features of the raw samples. However, some larger grains revealed rusty rims of thickness <0.02 mm. The origin of this effect is a matter of discussion. One possible interpreation is that the rims represent the initial stage of pressure solution. This process usually appears in sediment under the overburden load corresponding to 200-300 m of burial depth. Alternative, although less probable explanation is the effect of initial cementation. Finally, the rims might have originated from sample preparation failures, as e.g. contamination of material during the grinding of rock samples or dissolution of some components by water.

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Stratigraphic architecture of aeolian dune interactions

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The stratigraphic record created by fields of migrating sand dunes consists of sets of cross-strata and bounding surfaces. This stratigraphic architecture is typically interpreted as created by an orderly migration of dunes as depicted in deterministic models. This traditional depiction of migrating dunes as trains of isolated, unchanging forms, however, is now known to be unrealistic, as shown by a large body of static and time-series remote images of dune fields, experiments, and numerical models. Rather, dunes change shape (deform) as they migrate, and interact through a series of collisions in which dunes merge, laterally link, and break apart and recombine over a time scale of years to decades. Indeed, dune interactions are thought to be inherent to dune fields and to be the dynamics through which dune-field patterns emerge (i.e., self-organize) and evolve within a set of boundary conditions. The recognition of dune interactions as inherent to aeolian dune systems raises the possibility that an entire class of signature architectures of bounding surfaces and cross-strata resulting from dune interactions has gone misidentified or unrecognized. A unique data set for the crescentic dunes at White Sands Dune Field in New Mexico allows for the coupling of documented dune interactions with their resultant stratigraphic architecture. Dune interactions are documented by a decadal time-series of aerial photos and lidar-derived digital elevation models (DEM). Stratigraphic architecture is revealed in plan-view cross-strata and imaging of dune interiors with ground-penetrating radar (GPR). The focus here is upon a common type of interaction, defect repulsion, in which a faster-migrating dune termination or defect migrates up the stoss slope of a target dune and merges with a segment of the target while the adjacent target segment is ejected. The interaction architecture consists of lateral truncation of the target-dune set by a bounding surface. Cross-strata of the defect tangentially approach and downlap onto the surface, with an angular relationship between the cross-strata and the surface dip directions. The surface turns laterally to be congruent with cross-strata of the annealed lee face of the defect and target segment. The geometry of the interaction surface and the cross-strata has attributes of both superposition (second-order) and reactivation (third-order) bounding surfaces, but is distinguished by its irregular occurrence.

Experimental bedforms created under gravity flows

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Bedforms are sedimentary features that develop at the interface between a fluid flow and a sediment bed. Because different types of bedforms form under particular combinations of flow and sediment characteristics, their properties have being commonly used to aid interpretations and inferences on the nature of depositional environments. While subaerial bedforms are relatively well understood, their counterparts in deep-water remain elusive largely due to the difficulty of direct observation in their natural settings, the limited number of experimental studies, and in general due to increased flow complexities that remained to be explained. Available experimental data indicate that the basic modes of bed instability are similar, however regimes of deep-water equilibrium bedforms may be richer and scaling relationships may vary due to differences in flow structure.
Extrapolation of equilibrium regime diagrams developed for subaerial bedforms to the deep-water realm has been widely practiced without much testing. As part of a larger program on systematic experimental testing of bedforms created by dilute gravity flows (density and turbidity currents), we have used conservative saline density currents as a useful approach that lies in between the simpler and well understood shallow water flows, and the highly complex turbidity currents. We report here experimental results on subcritical to critical saline density currents running over beds of low-density plastic (D50~300 microns; SG~1.5) or sand (D50~200 microns; SG~2.65), in a 12-m long, 0.20 m-wide acrylic flume submerged in a large fresh water tank. Results we present here support preliminary investigation on subcritical bedforms and include equilibrium bed configurations and detailed flow measurements (velocity and density profiles) from ten experiments with densimetric Froude numbers ranging from 0.5 to 0.98, under bypass conditions. Currents were 20-40 cm thick and run for a max of about 7.5 min with incoming constant water discharge and density, water discharges ranging 370-514 liters/min, initial bed slopes of 1.5 to 2.5º, and depth-averaged fractional density excess ranging from 0.008 to 0.028. Detailed velocity profiles were measured with an ultrasonic velocity profiler (UVP), and point-sampling was used to extract density distributions through the vertical.
Ripples were the pervasive bedform type observed for all the runs reported here, including flows at or around critical conditions (i.e. densimetric Froude around unity), for both sediments used (plastic or sand). The ripple interpretation is supported by the values of bed dimensionless shear stresses calculated (derived from velocity profile analyses), when contrasted using classical dimensionless diagrams common for subaerial bedforms and flows, along with observations of bed evolution well documented with cameras. Our results are in agreement with other reported experimental evidence that suggests that, at the laboratory scale, upper-regime plane beds are not the common bed configuration around critical flow conditions for gravity currents. We speculate this might be a consequence of the lower flow velocities (and thus sediment transport) required in gravity underflows to attain the critical condition, as gravitational forces are reduced. Thus, inversion of gravity flow bed features based on known subaerial bedform regimes based solely on Froude considerations might be potentially misleading.

Braided river reservoir architecture research progress

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Fluvial facies reservoir is the significant object of hydrocarbon reservoir geology research in the mid-late period of Chinese eastern oilfield development. Reservoir architecture refers to the different classes of reservoir blocks morphology, size, direction and its superimposed relationship, and its core is hierarchy and structuredness. Ancient outcrop and modern deposition are the first choice data to build architecture pattern. The underground reservoir architecture research is mainly used in oil exploitation geology field. According to different data types, which divided into ancient outcrop, modern deposition and underground reservoir, the article reviewed the research progress of braided river reservoir architecture research and summarized research results at home and abroad in three aspects. The paper expounds the reservoir architecture theory origin, basic principle and classification system, and compared the reservoir architecture theory and traditional theory of sedimentary microfacies. Furthermore, in order to combined with oil field production requirements better, the paper states the current problems and developing trend in the study of reservoir architecture theory, provides a reference to braided river reservoir architecture mode for the future research.

Seismic stratigraphy and sedimentary evolution of the SW Cyclades plateau

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The Cyclades Plateau, in the Central Aegean Sea, in between the dozens of islands hosts several marginal basins that formed in different periods: from the Upper Miocene to the Upper Quaternary. Present day water depths of these basins range from 100 m to over 700 m, they are connected to the surrounding deeper basins via shallow channels or down to 600 m deep straits and their geological and paleogeographic evolution can only be deduced by elucidating the marine sedimentary sequences and their bounding unconformities. Here we concentrate on the SW part of the Cyclades Plateau that in its outer periphery also hosts two major volcanic centers of the South Aegean Volcanic Arc: Milos and Santorini. Here we present post 2012 collected high resolution sparker data, collected by Athens University, that together with older air-gun and multichannel seismic reflection data are interpreted in order to synthesize the sedimentary evolution of the region.
The outer periphery of the SW Cyclades Plateau south of Kithnos to Milos- Folegandros and Santorini is surrounded by deeper basins that as revealed on multichannel records contain marine Post Messinian sediments up to 1500 m thick and locally thin evaporites. Pliocene and Quaternary volcanic and volcaniclastic products from Milos did not advance much further north onto the Cyclades Plateau. On the contrary Quaternary volcanic products from Santorini advanced mainly to the west and south and are found interlayered within the sediments of the Christiana-Milos basins. The Folegandros Basin forming in between Milos-Folegandros-Paros-Sifnos islands contains up to 1500 m thick marine post-Messinian sediments. In the Lower Quaternary vertical aggradation of sediments was dominant around the encircling peripheral island margins while in the Upper Quaternary clinoform progradation and outbuilding especially from the NE (Paros Island) is exemplary portrayed on high resolution profiles. The recognition of the sequence stratigraphy of the prograding coastal clinoform wedges formed during low post MIS 20 sea levels and their submergence state suggests that the rate of basin subsidence was outspaced by sediment supply.
Further northeast of Sifnos a drastic subsidence occurred in the Middle Quaternary opening the marine connection to Folegandros basin to the south. The basins to the east south of Kithnos-Serifos-Kithnos are floored by terrestrial to coastal Upper Miocene and Pliocene sediments that are unconformably covered by uppermost Pliocene-Low Quaternary marine sediments. Perhaps the most significant paleogeographic change in the Cyclades was the active subsidence in the uppermost Quaternary of the Kithnos-Serifos strait. Early Pliocene to low Quaternary Submarine fans and fan deltas formed at the westward exits to the Myrtoon basin of the SW Cyclades plateau straits.

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Ancient *Microcodium* and modern calcified roots: Spot the differences!

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Microcodium is a problematic biogenic carbonate feature with a very distinctive cellular aggregate structure, composed of individual polyhedral, elongate crystalline elements of calcite, arranged in a radial pattern. It has a discontinuous stratigraphic distribution spanning from the late Palaeozoic to Quaternary, with a peak occurrence during the late Cretaceous and the early Palaeogene. Massive accumulations of *Microcodium* mostly occur in continental deposits but also within shallow marine successions, especially in the peri-Mediterranean area, where they can form stratigraphic levels, several metres thick, composed almost entirely of in situ aggregates. Even in the marine successions, *Microcodium* appears to be exclusively related to subaerial exposure and soil formation, typically on carbonate-rich substrates. It can be one of the dominant components in palaeosols (calcretes) and palaeokarstic sediments, as well as within floodplain and palustrine deposits.
Intracellularly calcified fine roots of higher plants display a distinctive aggregate structure, composed of individual calcite-filled cells of the root cortex. They are widespread and abundant in the Mediterranean calcareous soils where they can locally represent more than a half of the soil mass.
The fundamental structural similarity has led some of the early researchers to interpret *Microcodium* as a product of root calcification. Morphological similarity has been supported by the apparent ability of both features to dissolve and intensely corrode carbonate substrates, furthermore, carbon and oxygen stable isotope signatures of *Microcodium* and modern calcified roots do not exhibit significant difference. Yet some recent papers have argued against the root origin of *Microcodium* and suggested to search for its relationship with soil saprotrophic fungi or actinobacteria, referring to morphological and geochemical evidence, supposedly incompatible with calcium carbonate biomineralization in plant roots.
The aim of this contribution is to show pros and cons of the opposing hypotheses using comparative analysis of the architecture of *Microcodium* aggregates and calcified roots. Morphology and crystal ultrastructure of *Microcodium* elements, variability of modern calcified roots and their stable isotope signatures will be discussed in the context of calcium carbonate pathways in soils and the physiology of biomineralisation in plant roots, fungi and actinobacteria, based on fossil and recent material from Slovenia, Croatia, France, Spain and the Bahamas.

Lamination of in situ calcified cyanobacterial mats: Lesson from cultured multilayered marine microbial communities

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Many ancient marine carbonate stromatolites exhibit characteristic lamination comprised of alternation of distinct micritic and sparitic laminae. Such lamination is usually interpreted as the result of seasonal climatic fluctuations causing periodic environmental changes in the ambience of the growing microbial mat. Our knowledge on the origin of such lamination is, however, restricted to analyses of fossil material, because modern stromatolites with similar lamination are not known from today's open marine environments. Our study on marine cyanobacterial mats from coastal sediments of Inner Danish Water (Nivå Bay, Øresund, Denmark) cultured in a closed system for over three years showed that a multilayered microbial system generated mineral laminae composed of two types of calcium carbonate precipitates: (i) micrite type mineralization by <1 µm-sized globular nanograins of Mg calcite (occasionally with an admixture of nanograins of magnesium silicate) occurring in the mucilage of the living cyanobacterial layers, particularly dense at their basal part, interlayered with (ii) sparite type of mineralization by a variety of >1 µm-sized Mg calcite/aragonite particles. The latter, which are represented by a great variety of morphs (anhedral and subhedral grains, hemispheres, dumbbell- and peanut-like bodies, and subglobular aggregates of dagger-like and rhombic, platy crystals) occurred in microbial zones built of phototrophic purple bacteria where dead cyanobacteria were degraded by heterotrophic bacteria. We found that precipitation of $CaCO_3$ morphs in cyanobacterial mats could have occurred simultaneously in metabolically active cyanobacterial layers and in the biomass of degrading cyanobacterial layers. The formation of such a variety of carbonate precipitates in the studied mats would probably required involvement of different processes. In the case of living cyanobacterial layer a spontaneous mineralization occurred, resulting from the high pH induced by photo assimilatory uptake of CO_2 and/or HCO_3^- by cyanobacteria, causing an increase in carbonate ion concentration and high $CaCO_3$ supersaturation level, whereas in the case of purple bacteria layers the ultimate cause for precipitation of the calcium carbonate grains was a high $CaCO_3$ supersaturation caused by influx to the precipitation medium of excessive calcium from the degrading cyanobacterial biomass which stored (complexed) Ca^{2+} during life time. Such bimodal microbially induced calcification can, in our opinion, be regarded as precursor for alternating micrite and sparite layers characterizing many fossil stromatolites. The pronounced alternation of in vivo and post-mortem generated calcareous layers in the cultivated cyanobacterial mats may also suggest the existence of similar multilayered microbial systems generating the huge masses of in situ calcified ancient marine microbialites characterizing particularly the Precambrian sedimentary record.

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Heavy mineral analysis and garnet geochemistry of hardrocks and modern stream sediments from the Western Gneiss Region, SW Norway: Implications for provenance analysis

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Heavy minerals are valuable indicators about the geological framework in the source area, hence they are widely used in sedimentary provenance analysis. The heavy mineral garnet has important provenance applications, because it exists in a wide range of rocks and its chemical composition depends on the composition of the source rock and on pressure and temperature conditions during garnet formation (e.g., Morton, 1985; Krippner et al., 2014). Because mantle-derived garnets can be related to diamond-bearing intrusives, they are important indicator minerals in diamond exploration (Grütter et al., 2004).
Heavy mineral data and garnet geochemistry of stream sediments and adjacent hardrocks from the catchment area draining the Almklovdalen peridotite massif in SW Norway were collected to study to what extend the heavy mineral suites and garnet composition of the stream sediments reflect the mineralogy of the source rocks. Commonly, in heavy mineral studies, the 63−125 µm grain-size fraction is used. In our study, we analysed several grain-size fractions (63−125 µm, 125−250 µm, and 250−500 µm) in order to test if there is a grain-size dependence of heavy mineral composition and garnet geochemistry.
The Almklovdalen area is located in the Western Gneiss Region (WGR). The WGR comprises Precambrian basement and allochthonous cover units, metamorphosed and deformed during Caledonian orogeny induced trough collision between Baltica, Laurentia and Avalonia under closure of Iapetus Ocean (Robert and Gee, 1985; Cuthbert et al., 2000; Beyer et al., 2012). The Almklovdalen peridotite massif consists mainly of dunite and harzburgite, which is evident in the heavy mineral spectra. However, pyrope-rich garnets in river samples are more frequent in the coarser grain-size fraction. This demonstrates grain-size inheritance from source to sediment. This has to be considered when analysing modern sediments for provenance analysis using heavy minerals, because necessary information may not be recorded and data are likely being misinterpreted.

Stratigraphic architecture of Devonian lacustrine basins of northern Scotland

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In Northeastern Scotland, the Orcadian Basin hosted large lacustrine systems which developed during Devonian times (c. 400 Ma). The pre-Devonian metamorphic basement unconformity is only exposed in a small number of places around the basin margin and therefore the characterization of the nature of this important surface has received relatively little attention. We have utilized vintage onshore seismic to gain a better understanding of the pre-Devonian basement physiography. Onshore exposures of the top Moine, base Devonian unconformity surface is exposed have been visited to ground truth our subsurface interpretations.
The studied deposits have been deeply buried then exhumed so that they are exposed widely onshore. Post Caledonian tectonism has faulted and folded the Devonian succession making it challenging to reconstruct the stratigraphy and the basin architecture from geological data only. The Devonian sediments were deposited in a continental environment and fluvial and alluvial deposits are interbedded with lacustrine units. These lacustrine facies contain fishbeds which are organic rich mudstones with moderate source potential. Variations in burial history have resulted in variations in the source rock maturity of the fishbeds.
A large dataset of 2D seismic reflection profiles are available from across the study area. The dataset is of mid 80's vintage and covers the Caithness and the Ross and Cromarty areas (NE Scotland). The survey consists of 33 profiles making up 416,92 km of data on an area of 140 X 40 km. The vintage data have limited horizontal and vertical resolutions. To enhance the images, we have used a dip-steering median filter. To depth convert the horizons, stacking velocity analysis has been performed. In parallel, newly acquired field data are used to correlate with the seismic profiles. Correlations made to deep borehole data (Tain-1 well) have allowed marker beds to be attributed to specific seismic reflections. Finally, gravimetric data are used to calculate the depth to basement.
The main focus of this work is to fully interpret the seismic architecture of the Devonian basins by integrating seismic and potential fields based depth to basement mapping techniques. Within the basin fill specific stratigraphic horizons and structural domains have been mapped. Seismic velocity analysis has contributed to the production of the basin maps. Understanding the stratigraphic architecture of the basin will bridge the gap between onshore field data and offshore North Sea wells and seismic. We expect to provide new insights into the North Sea's geological history, as well as a better understanding of the offshore Devonian hydrocarbon play.

The Early Jurassic *Lithiotis*-type bivalves-bearing peritidal carbonates (Gavrovo-Tripolitza Unit, Peloponnesus, Greece)

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The analyzed carbonate rocks occur in the southeastern Peloponnesus in Greece and belong to the Gavrovo-Tripolitza tectonic unit, which is the most internal (eastern) part of the External Carbonate Platform of the Hellenides. The Late Triassic carbonates are mostly represented by dolomites and constitute the base of the Upper Triassic to Upper Eocene neritic succession of the Tripolitza subunit. They underlie the Early Jurassic (Sinemurian–Pliensbachian) carbonate sequence characterized by diverse facies types representing shallow-marine and/or restricted-marine facies of a peritidal platform. Specifically, the lower part of this sequence comprises dolomites, dolomitic limestones and limestones representing subtidal and/or intertidal-supratidal facies in a shallowing-upward cyclic development. Some pedogenic-type intercalations occur in the middle part of the sequence, indicating paleosol levels. At a higher position there are exclusively open-marine subtidal limestones sometimes full of shells, mainly represented by megalodontids and *Lithiotis*-type bivalves.
The best outcrop of this part of the Early Jurassic sequence occurs in the Reichea section (near Molai town) and near Tsitália town. In the former there is a more continues sequence (over 140 meters in thickness) of medium- and thick-bedded limestones which are bivalve-rich beds in several horizons. The *Lithiotis*-type bivalves are represented by *Lithiotis*, *Cochlearites*, *Litioperna* and *Opisoma* genera, but usually they occur in monospecific associations in separated beds. Taphonomic and paleoecological investigations indicate autochthonous, at most parautochthonous, accumulations of their shells, mainly manifested by lack of disarticulation of both shells, with their occurrence often in vertical, life- position. Unlike the latter examples the beds filled with megalodontid bivalves constructed storm-generated tempestites very often, with typical for such origin beds with sharp soles, gradation of fragmented and crushed shells up to fine-grained bioclastic limestones in higher parts of beds. Such features indicate shallow-marine conditions during their sedimentation, between normal- and storm-wave bases. Contrary to such beds, the *Lithiotis*-type bivalves-rich layers occasionally manifest lens-shape biostromes filled with shells of these bivalves without any evidence of reworking effects, suggested in-situ autochthonous accumulations. But in sporadic cases/beds, many shells are not disarticulated, and almost all are in horizontal position. Such features indicate parautochthonous occurrence originating in shallow-water conditions with weak bottom currents.
From the paleoecological point of view, the bivalves of this group preferred restricted marine environments (numerous examples exist in several countries with these Early Jurassic bivalves: Morocco, Italy, Slovenia, Croatia, Oman etc) mainly connected with lagoon-type regimes, and presumably have been constructed specific barrier between these lagoons and open-marine realms. In the present case, bivalve-rich beds are intercalated with several horizons of ooid/oncoid-rich limestones and/or bioclastic limestones with stenohaline solitary corals. Additionally, some beds have thick horizons of lenticular and/or columnar stromatolites which indicate a shallow-sea photic zone of quiet environments interrupted by higher energy conditions, as mentioned above, and recorded by storm-type deposits.
In conclusion, the Early Jurassic *Lithiotis*-type bivalves-bearing limestones in the Peloponnesus form a very well-documented transitional zone between restricted-marine (lagoon?) and open/full-marine paleoenvironments. Comparison studies of similar occurrences of such type of bivalves-bearing units are necessary for a better understanding of their origin and paleoecological significance.

The 2D-pattern of the Miocene deposits in the marginal part of the Carpathian Foredeep (Miocene, Poland)

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The research was focused on the geometry of the Miocene deposits from the northeastern border part of the Carpathian Foredeep and the Lublin Upland, in the area of the Roztocze Hills, close to the Józefów village. In two quarries, Józefów and Pardysówka, basic lithological and sedimentological observations, supplemented by Electrical Resistivity Tomography (ERT) measurements were done. The aim was to join macroscopic field observation in the quarries with the shallow geophysical prospection. Moreover, unclear relationship between sedimentary pattern in the zone probably affected by synsedimentary tectonics during the final stages of the foreland basin evolution was discussed.
Józefów and Pardysówka quarries are located in the distance of about 950 meters from each other. Both of them are characterized by Miocene (Badenian, Sarmatian) complex, starting with the conglomerate made of quartzitic pebbles, chert and rhodolitie nodules. Higher in the profile, quartz-calcareous light brown sandstones occur. The upper part is built of organodetritic limestones laminated with clays (up to 25 meters). The whole complex is located directly on the Cretaceous basement and is inclined slightly toward the south. The content of quartz grains in the profile is variable. A series of sedimentary structures (eg. trough cross-stratification, erosion channels, ripple cross-lamination) occur in the described rocks. The most typical of these are "scour and fill" structures of a probable syn-tectonic origin. They are elongated N-S, therefore on this basis it can be concluded that the main direction of sediment transport in the area during the sedimentation was from the north to the south, towards the Fore-Carpathian Basin. They occur throughout the highest part of the observed profile. These structures have a height of several tens of centimeters to several meters and a width of up to several tens of meters.
In both quarries many normal and reverse faults were found, associated with post-sedimentary Miocene or younger seismic activity in the area. Their planes are parallel to the Carpathian Foredeep marginal zone. All observed faults are crossing all the layers at a slight angle.
Electrical Resistivity Tomography profiles were done in short distances from the quarries. This method allowed to obtain depth of up to 140 meters. On the longest profile located between quarries (1, 100 meters) the main fault of Carpathian Foredeep marginal zone is noticeable. This reverse fault intersects all visible layers, except Quaternary sediments. To the north - east of it there are many 2nd-ordered faults (normal and reverse).
Additionally, the profile clearly shows the differences in resistivity of rocks (much higher in the case of organodetritic limestones in comparison with the clays occurring below quaternary sediments). Further studies will have to clarify the distribution of different types of rocks and faults in the nearby area.

Salt tectonics versus Mesozoic sedimentation in central Mid-Polish Trough – results of integrated geological-geophysical study

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The Permian to Cretaceous Mid-Polish Trough was filled with several kilometers of Permian and Mesozoic sediments, including thick Zechstein (approx. Upper Permian) salts, and was completely inverted in Late Cretaceous - Paleogene times. The presence of thick salts gave rise to the development of a complex system of salt structures. Salt pillows and reactive diapirs started to form in early Triassic, triggered at least in part by regional basement faulting. In the Late Triassic some of the salt pillows reached diapiric stage. After their further growth in Jurassic to Early Cretaceous times, salt structures were compressionally reactived during regional inversion of the Mid-Polish Trough. Continuous growth of salt structures strongly controlled Mesozoic depositional systems, with thinner sedimentary cover characterized by generally shallower facies developed above salt structures, and larger thickness and deeper facies located within the intervening synclines. The most complex salt structures are known from the central, Kuiavian segment of the Mid-Polish Trough, where the large Klodawa salt diapir is located along with by several salt pillows and other smaller diapirs. In this area, various unconventional exploration targets have been identified. Middle Jurassic Dogger shales are 42 m to 154 m thick, with TOC's in the 1% - 3% range, and the Upper Jurassic Kimmeridgian shale is between 72 m and 123 m thick, with TOC's up to 4.5%.
Reprocessed legacy and newly acquired high-resolution 2D data seismic data, calibrated by deep wells, allows better constraints on the timing of salt-structure growth and, as a consequence, the evolution of the source rock. Cross-section construction and restoration suggest that basement faulting beneath the Klodawa diapir exerted significant control on the evolution of the Mesozoic petroleum system; thin-skinned supra-salt syn- and post-depositional faulting also played important though more local roles. The results of advanced seismic data interpretation such as seismic inversion and seismic attribute analysis provided additional information on lateral facies and thickness variations within the Mesozoic sequence, especially within the synclines located between salt structures that lack any well control. Quantitative lithology prediction was achieved using model-based post-stack seismic inversion algorithms and various seismic attributes calculated and analyzed for selected key 2D seismic profiles. Seismic stratigraphic interpretation proved substantial thickening of deeper facies (e.g. organic-rich Kimmeridgian shales) towards the center of the local sub-basins controlled by active salt structures.

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Importance of carbonate hiatus concretion layers in the middle Eocene depositional sequence of Kachchh, India

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The Paleogene rocks of Kachchh are generally regarded as a condensed sequence. The authors during field work in this region observed several horizons of intense bioturbation and bioerosion throughout the succession. This is suggestive of breaks in deposition, contrary to the prevalent belief. Though, a local diastem during the Middle Eocene times (Harudi Formation) was suggested earlier on the basis of a gap in foraminiferal record, no prominent stratigraphic breaks were recognised. We record, here, intra-formational stratigraphic breaks suggested by the occurrence of two hiatus concretion layers in the Harudi Formation. Carbonate hiatus concretions are known from nearly all ages except the Cainozoic where phosphatic hiatus concretions commonly occur. This report is therefore the first global record of Paleogene carbonate hiatus concretion. The older of the two horizons is associated with mazes of *Thalassinoides* and shell concentrations. Whereas, the younger horizon is closely associated with bioclastic accumulation of the large benthic foraminifera, *Nummulites obtusus*. The concretions consist of yellowish to buff coloured micritic mud. The variably shaped concretions are heavily bored on all sides and strongly abraded indicating moderate hydrodynamic conditions in inner shelf settings. The hardground borings include eight ichnospecies under four ichnogenera *Gastrochaenolites*, *Maeandropolydora*, *Trypanites* and *Entobia*. When compared to the biota of hiatus concretions known from other ages, epilithozoans are poorly represented here. These hiatus concretions evince reduced or no siliciclastic input, carbonate precipitation accompanied by early diagenesis. Further, the concretionary horizons indicate two flooding surfaces. The association of these hiatus concretions with oyster shells in the lower horizon and calcitic tests of *Nummulites* alone in the upper horizon indicate a 'calcite sea' during Lutetian in the Kachchh Basin. It can, therefore, be surmised that these concretions were effected dominantly by sea level change and carbonate precipitation in the ‘calcite sea’ prevailing during Lutetian times in the Kachchh Basin.

Hydrocarbon exploration in volcanic systems: Evaluation of reservoir potential

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Volcanic complexes are generally avoided in petroleum exploration. Nevertheless, while looking at the size of the objects these questions should rise in the explorer's mind: "Can this object be part of a petroleum system? Can it be reservoir? Can we evaluate the potential of this area and how to predict the facies and reservoir properties?"
The inventory of the fields already producing in this kind of reservoir reveals that the interest of this thematic is proved. In Japan since the 60's the Green Tuff formation is producing gas in the Niigata Tertiary basin and in China several fields are already producing in volcanic reservoirs, as the Qingshen gas field in the Songliao Basin. Moreover, volcanic reservoirs are one of the main targets in future exploration in this country. Other examples in the world also exist even if they are less documented.
However, a lot of examples would justify the petroleum major's hesitation to implement a well in a volcano. Dry wells in volcanic tight rocks while the target was a carbonate platform constitute one the main fear of the explorers. So the main challenge is to understand the keys that would help predicting the volcanic reservoir properties. Lithology, depositional facies, diagenesis, fracturing… The same scientific approach than is sedimentary geology might be used. Understanding of the geodynamic context, the magma and tephra type, the fluid circulation and the burial history could lay the foundations to build a depositional model and to predict the facies occurrence and its reservoir properties; or at least give keys to evaluate the risks.
Using modern and fossils analogs can help to predict the geometries and heterogeneities, while field analogs can give keys for reservoir property evaluation and diagenesis history. But how to choose a pertinent analog? In sedimentology the choice of an analog is guided by the similarities with the studied case in terms of depositional environment. In volcanology, what could be the best factor to choose an analog?
With a brief example we will discuss this point and compare some seismic lines with field and outcrop analogs, to finally propose a hypothesis for the evaluation of the petroleum potential in this area.

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The Hominin Sites and Paleolakes Drilling Project: Testing hypotheses of climate-driven human evolution and dispersal

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Numerous hypotheses linking climatic change to human origins, evolution and dispersal have been debated in recent decades. Long palaeoenvironmental records from continental sites that may allow tests of these hypotheses are rare, and are distant from fossil hominin sites. The Hominin Sites and Paleolakes Drilling Project (HSPDP) aims to assemble continuous high-resolution palaeoenvironmental records spanning critical intervals of human evolutionary history from lacustrine sites close to and stratigraphically tied to globally-significant hominin sites in East Africa. Together the five sites (Northern Awash and Chew Bahir, Ethiopia; West Turkana, Baringo Basin, and Lake Magadi, Kenya) will provide continuous, high-resolution, multi-proxy palaeoenvironmental records over significant portions of the last ~3.5 million years, allowing correlation of environmental changes to the more fragmentary record of human and mammalian evolution, dispersal, extinction, and cultural innovation. Following a 17-month campaign, drilling was completed in November 2014, with ~1756 m of core collected from 11 boreholes, and a total drilling length of 1930 m (avg. 91% recovery).
Cores analysed to date incorporate a range of lacustrine deposits, as well as some palaeosol and fluvial intervals. Abundant lacustrine and watershed fossils evident in the cores, coupled with sediments suitable for obtaining continuous organic geochemical, isotope and trace element archives, promise to yield highly resolved records of climate history for the region. Significant climatic changes appear to be recorded through major transgressional/regressional depositional patterns, some of which appear to be cyclic. Ultimately, statistical techniques will be used to define the most significant climate shifts and periods of maximum variability in the records, and then used to model the natural selection and dispersal of human populations, measured from regional densities of archaeological sites.

Climatic context of modern human dispersal from north-east Africa

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Climatic change is widely believed to have played a role in the emergence of anatomically modern humans in eastern Africa about 150,000–200,000 years ago and their subsequent dispersal into Asia. A shift to wetter climate at ~70,000 years ago following severe aridity is often cited in support of a genetically determined date of early modern human expansion within and beyond Africa at ~60,000 years ago. However, some palaeontological and archaeological data indicate earlier dispersal out of Africa at ~125,000 years ago. Here we report a deep seismic and near-continuous lake-sediment record of climatic change for the last 150,000 years from Lake Tana in the Ethiopian highlands, close to the area of human emergence, and to the likely dispersal routes from Africa. The Tana sequence shows strong variation in moisture balance during glacial intervals (Marine Isotope Stages 2-4, 6), but a stable, moist climate during the last interglacial MIS 5, especially MIS 5d (ca 113,000–97,000 years ago). Interglacial stability following environmental variability in MIS 6, would have favoured human population growth and range expansion, supporting the fossil and archaeological evidence for early human dispersal from Africa.

Facies architecture of gravelly and sandy supercritical bedforms in subaqueous ice-contact fans

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Subaqueous ice-contact fans are commonly deposited by high-energy plane-wall jets from subglacial conduits into standing water bodies. Their deposits are characterised by the rapid expansion, dilution and deceleration of the highly concentrated flows. Hydraulic jumps, which occur in the zone of flow transition, have a fundamental impact on the facies architecture of initially supercritical jets. We present field examples from Middle Pleistocene subaqueous fans, which were deposited in deep ice-dammed lakes at the margins of the Middle Pleistocene Scandinavian ice sheets across Northern Germany. The studied gravelly and sandy successions represent deposits of the zone of flow transition of supercritical jets.
The gravel-rich subaqueous fan deposits are characterised by large-scale scour-fills (up to 25 m wide and 3 m deep; Winsemann et al., 2009), displaying both foreset and backset bedding. Scour-fills comprising gravelly backsets are interpreted as deposits of cyclic steps. The scour-fills form the basal part of 2-6 m thick successions, which are bounded by laterally continuous subhorizontal erosional surfaces. Up section, the successions comprise 1-4.5 m thick crudely stratified coarse-tail normally or inversely graded gravel, subhorizontally stratified gravel and trough cross-stratified gravel. These deposits are interpreted as deposits of antidunes and 3D dunes and indicate different stages of flow deceleration and dilution. The gravelly successions may be capped by 0.5-2.5 m thick low-angle cross-stratified pebbly sand, which is interpreted as deposit of stationary antidunes.
Downflow and up-section the gravelly successions pass into sandy successions, which include deposits of chutes-and-pools, breaking antidunes, stationary antidunes and humpback dunes (Lang and Winsemann, 2013). The sandy deposits are dominated by laterally extensive 1-4 m thick thinning upwards packages of sinusoidal stratified sand (wavelength: 1-12 m, amplitude: 0.1-0.5 m) deposited by stationary aggrading antidunes, forming under quasi-steady flows at the lower limit of the supercritical flow stage. The stationary antidune packages are separated by erosionally based deposits of chutes-and-pools, breaking antidunes and humpback dunes. Farther downflow the succession passes into deposits of large 3D dunes and climbing ripples. The large-scale lateral and vertical successions of bedforms are interpreted as representing the temporal and spatial evolution of the highly concentrated supercritical meltwater jets, which were characterised by depletive flows due to expansion, deceleration and hydraulic jumps. Small-scale facies changes and the formation of individual bedforms are controlled by fluctuating discharge, pulsating unstable flows, bed topography and the related hydraulic roughness.

Down-dip termination of the Carboniferous Ross Fan System in the Inner Shannon Area, Western Ireland – new insight from core and outcrop

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The Pennsylvanian Ross Sandstone Formation forms part of a major progradational and shallowing-upward basin-fill succession in western Ireland. It is well-exposed in the sea cliffs in the outer Shannon Estuary (Loop Head peninsula) where a combination of behind-outcrop drilling and biostratigraphy correlation have established a 490 m thick stack of at least nine sandy deep-water fan systems separated by variable condensed sections. Palaeoflow measurements indicate a north-easterly dispersal and it is likely the system was weakly confined by a pre-existing trough (earlier Mississippian-age crustal extension). Previous work has shown that the Ross thins to the east and north, and must shale-out by onlap and/or down-dip pinch-out. The onlap is confirmed by biostratigraphy correlation but details are poorly constrained. The Ross is underlain by mudstone-dominated basin-floor strata (Clare Shale Formation) and is overlain by base-of-slope and slope deposits (Gull Island Formation) recording advance of an unstable slope, although the direction of progradation has been controversial (axially from the SW or transversely from the NW).
Scattered outcrops and limited borehole data in the inner Shannon estuary and mid-Clare are critical to constrain the down-dip extension of the Ross system. Previous outcrop studies have described a much thinner Ross section at Inishcorker and Foynes (over 50km east of the Ross type section on the Loop Head) involving only the youngest Ross cycles in the west. A re-interpretation of the inner Shannon outcrops is now possible given a new GSI 09/04 borehole in the Inishcorker area, a re-analysis of Foynes Island sections and new biostratigraphic data. The biostratigraphy underpins a composite section linking all the key inner Shannon sections and establishes that the Ross-equivalent succession is c. 40 m thick and is wholly in Clare Shale facies (barren and goniatitic mudstones with local nodules). This is sharply overlain by 4m of fine-grained turbidites that thicken northwards and which are covered by an 8-15 m thick mass-transport deposit (MTD) in all sections. The remaining section (c. 120 m) comprises at least eight MTDs (each up to 20 m thick) alternating with turbidite packages (each up to 14m thick) that locally contain megaflute erosion surfaces. The sandstone sedimentary structures suggest transport to either the NE or SSW. Deformation structures (mainly folds) in the MTDs infer southerly transport and they rework deep-water sand and mud. The biostratigraphy indicates the transition from Clare Shale to the MTD-dominated succession in the Foynes and Inishcorker sections are of similar age (R70-R90 zone), coeval with the Ross-Gull Island transition in the west. The Ross system is inferred to shale-out by eastwards and north-eastwards downlap along the trough axis; there is no evidence for a significant southerly confining slope in the inner Shannon outcrops although the Ross-equivalent Clare Shale section thickens north from Foynes to Inishcorker. A coeval age for the arrival of slope facies in the outer and inner Shannon confirms rapid advance of a separate transverse slope system from the NWN that presumably overstepped any extension of the earlier Ross system into east Clare with slumps shed from the slope interacting with residual axially-sourced sands.

Carotenoids in recent sediments of the Gulf of Gdańsk (Baltic Sea)

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Carotenoids are a large group of natural compounds, which are ubiquitous in the environment. The considerable pool of these compounds are contained in freshwater and marine organisms: plants, algae and bacteria. Dead phytoplankton and zooplankton cells, zooplankton fecal pellets and detritus from deteriorating organisms are precipitating from water column and accumulate on seabed. Additionally, the pigment pool in sediments is supplemented/modified by benthos. Because of this carotenoids are used as chemotaxonomic markers of plankton in water column and proxies in sediments. They differ in stability and, due to that, carotenoids in marine sediments are indicators, not only of organic matter sources and different factors characteristic for water, but also of post-depositional conditions. At first, carotenoids and their derivatives were followed qualitatively in deep sediments. As a result of development of various chromatographic techniques in the last thirty years, the quantitative studies of these compounds has been reported mainly for water column as well as for recent sediments. However, papers concerning carotenoids, in recent marine sediments, are still scarce.
This work presents a concentration and distribution of selected carotenoids in recent sediments of the Gulf of Gdańsk. The Gulf collects waters of the Wisła (Vistula), the largest Polish river and the second largest river flowing into the Baltic. It is a highly eutrophic area of high primary production and high sedimentation rate. The Deep of Gdańsk (the deepest part of the Gulf of Gdańsk) collects autochthonic particulates, those introduced by the Wisła waters and those formed as a result of flocculation in the freshwater/seawater mixing zone. All these make the Gulf of Gdańsk an interesting area for studying the processes governing sedimentation in a transitional area where carotenoids are very good proxies.

Sediments were collected during cruises of r.v. 'Oceania' organized for the CLISED project (Climate Change Impact on Ecosystem Health - Marine Sediment Indicators, 2014-2017, Polish-Norwegian Research Programme operated by the National Centre for Research and Development. No Pol-Nor/196128/88/2014), from the surface (0-20 cm) with a core sampler. During collection, the physico-chemical parameters of near bottom waters were measured. Just after collection the sediments were frozen and kept in such a state until analysis in land laboratory. After extraction, carotenoids were analysed using high performance liquid chromatography (HPLC-DAD). The results were discussed in relation to environmental conditions and physico-chemical parameters characterizing sediments, such as organic carbon or granulometry.

Microbialites associated with Middle Jurassic (Bathonian–Callovian) condensed sequences from Southeastern Carpathians, Romania

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The Middle Jurassic sequences from eastern part of the Getic Domain (Median Dacides) are characterized by condensed units with different thickness and stratigraphic extensions, as well as by the presence of neptunian dykes, clastic dykes and by submarine syntectonic sedimentary breccias, generated during the contemporaneous extensional tectonics. The aim of this contribution is to report new data concerning the morphological variability, as well as geochemistry and mineralogy of different types of microbialites associated with these deposits and to assess their possible microbial origin. The studied region is located in the eastern part of Southern Carpathians (Rucăr-Bran zone).
Several types of microbialites were identified in the studied successions. The Bathonian–Early Callovian condensed unit contains the two types of microbialites: (1) ferruginous microstromatolites that cover the hardground surfaces or form the coat of the oncoids and macro-oncoids, associated with agglutinated polychaete tube worms, serpulids, bryozoans and encrusting foraminifera and (2) *Frutexites* endostromatolites and ferruginous crenulated microstromatolites associated with various cavities. The Middle–Early Callovian condensed sequences show higher diversity of microbialites: (3) carbonate microbialites (skeletal stromatolites to thrombolites) filling the fissures and fractures of in situ fracture trough extensional breccias; the angular clasts of breccias are represented exclusively by metamorphic rocks and are coated by few generations of microbialites which predate, are synchronous or postdate the formation of early diagenetic marine cements. The isopachous fibrous-rim cements (IFC) continue to growing as inclusion-rich radiaxial fibrous calcite cements (RFC) and is overlain by scalenohedral cements (SC). The micropeloidal laminae of stromatolites locally contain well preserved calcified bush-like fossil microbial filamentous structures. Successive generations of stromatolites are affected by micro-fractures disrupting the continuity of laminae and are separated by numerous angular clasts of stromatolites and debris of cements, probably as effects of synsedimentary extensional tectonics producing faulting-induced seismic activity that determined stromatolites disruption and resedimentation; (4) iron-rich agglutinated peloidal microbialites intercalated with laminae of *Favreina carpatica* coprolitic grainstone; locally the peloidal agglutinated laminae are associated with ferruginous pendant crenulated microstromatolites and *Frutexites*-like structures; (5) carbonate peloidal agglutinated stromatolites with internal crude wavy laminations associated with ostracod *Pokorniopsis* and rare serpulids trapped within the microbial fabric.
For all the studied microbialites stable isotopic compositions of IFC and RFCs is relatively uniform and normal-marine origin. The carbonate stromatolites from fracture breccias reveal carbon-oxygen isotope ratios obtained from RFC passing to SC, that display negative values commonly assigned to meteoric zone.
Development of different types of microbialites and their association with specific metazoans assemblages are of palaeoecological significance as they represent records of short-term episodes with distinct environmental parameters during prolonged intervals of reduced sedimentation. The ferruginous microbialites were formed in particular microenvironments developed in open marine shelf environments below fair-weather wave base. The carbonate microbialites coating the metamorphic clasts of different types of breccias were formed probably in very shallow-water marine environments affected by fresh-water incursions. Such depositional settings were appropriate for development of cryptic microbial assemblages associated with cavity dwelling metazoan faunas.

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Exceptionally preserved bioerosive structures on an intra-Valanginian phosphatized drowning unconformity from Southern Carpathians (Romania)

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During Late Jurassic–Early Cretaceous interval, a complex carbonate platform system developed along the northern passive margin of the Tethys, throughout the Getic Domain. The studied region is located in the eastern part of Southern Carpathians (Dâmbovicioara area). Carbonates sequences cropping out in this region reflect the evolution of different settings of the platform. They document successive stages in evolution of the Getic platform during Berriaisian–Late Hauterivian time interval: from shallow water carbonate platform to subaerial exposure, then intra-Valanginian development of an inherited rock ground (IRG) discontinuity and flooding of the platform generating a drowning unconformity, followed by gradual drowning during the Hauterivian. The shallow water carbonate platform (Stramberk-type limestones) was affected by intra-Valanginian synsedimentary normal-faults producing low angle tilted blocks with gently deepening toward East and South. The topmost part of the Stramberk-limestones is cut by the IRG discontinuity showing an erosive surface with cavities, neptunian dykes and bioerosive structures filled with two types of sediments: the first one is represented by phosphatized bioclastic packstone and the second one is glauconitic wackestone which belongs to the overlying unit. The irregular surface of the unconformity offered numerous cryptic habitats preferred by the entobians and the associated euendolithic microorganisms. The macro-borings cut cleanly the bioclasts, intraclasts and the fenestral cavities marginally coated with meteoric cements and filled with vadose silts, indicating that the substrate was lithified and the subaerial exposure took place prior to drowning.
The macroborings are represented mainly by the ichnogenera *Entobia*, *Trypanites* and *Gastrochaenolites*. The *Entobia* morphology is highly divers corresponding to Clionaidae and Phloeodictyidae families, but most probably other endolithic sponge families are also represented. The specimens have small single almost spherical to ovoid chambers, or large chambers with irregular morphology, or multiple connected chambers. The exploratory canals are simple, almost straight, with greater length then diameter, only rare branching of the radial canals was observed. The boring surface of most of the chambers and exploratory canals bear a cuspate microsculpture. Detail of scars left by carbonate carving sponge cells are so well preserved as can be observed the concentric surface feature marking the progression of cell margins carving carbonate chips. In the infilling of the majority of the entobinas chambers well preserved spicules occurs, the skeletal opal being replace with sparry calcite.
The micro-bioerosion patterns are in good agreement with the rapid sea-level rise during the incipient drowning when considering the ichnobiocenosis which reflects dysphotic conditions (*Scolecia filosa*/*Eurygonum nodosum*). Numerous others micro-borings (*Saccomorpha clava*/ *Orthogonum lineare*) suggest aphotic ichnocenosis and are associated with entobians chambers. Such assemblages might be also indicative for cryptic habitats very abundant on the irregular surfaces of the drowning unconformity. Less illuminated habitats could be possible generated to a decrease of water transparency due to the upwelling currents which strongly increased the nutrient level.
The studied intra-Valanginian drowning unconformity reveal the diversity of bioerosive structures exceptionally preserved three-dimensionally by phosphatization and emphasize the importance of bioeroders as reliable paleoenvironmental indicators.

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Sedimentological record of the Jurassic–earliest Cretaceous history of the Moesian plate passive margin (Danubian units, Romanian Carpathians)

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The Danubian units are supposed to derive from the East European Plate continental margin, represent the most external Carpathian basement/cover unit (Marginal Dacides) and were originally part of the Moesian foreland. The unique, one of the longest (over 300 meters in thickness) and continuous sequence of the Danubian units is represented by Munteana–Dumbrăviţa section along Romanian side of the Danube River. This deepening-upwards sequence is full record of opening oceanic realm since the earliest Jurassic up to the earliest Cretaceous and generally is represented by the lowermost Jurassic terrestrial siliciclastics, transgressive mixed carbonate-siliciclastic strata (Lower–Middle Jurassic), pelagic carbonates and carbonate-siliceous rocks (Upper Jurassic), red nodular and micritic limestones with cherts (uppermost Jurassic–lowermost Cretaceous).
The main aim of this study is detail, bed-by-bed documentation of change paleoenvironmental regimes using multidisciplinary investigations, where sedimentological analysis are one of the most important. The oldest strata (Hettangian–Early Sinemurian) are represented by terrestrial conglomerates, sandstones with paleosoils, mudstones and coal beds with *Thaumatopteris*-type plants. Still younger (Sinemurian in age) are brownish massive, medium- and thick-bedded calcareous sandstones (with ferruginous ooids) full of shallow-water benthic fauna (bivalves, brachiopods – sometimes as coquinas and gastropods), rare ammonites and rich belemnites, and occasionally with pieces of wood. Cross-bedding structures are popular in this part of sequence and storm-generated shell-beds as well. More carbonate layers are younger (Pliensbachian–Toarcian/?Lower Aalenian) and represented by grey coral-bearing bioclastic limestones with bivalves (i.a., *Lithiotis*-type), brachiopods and gastropods (*Aptixiella*-type). This unit represents short-lived shallow-marine carbonate platform with coral patch-reefs on the margin. Rapid change of sedimentation took place during Middle Jurassic (Bajocian–Bathonian) time when cherry-red crinoidal limestones with last occurrence of small grains of quartz were accumulated. Toward the top of this unit a condensed bed rich in reelaborated ammonites (Bathonian–Lower Callovian) occur. The top of this bed is marked by hardground surface covered by ferruginous microstromatolites. Just above spectacular domical stromatolites are developed, representing the base of the next unit (Lower Callovian). These features recorded drowning effect of older carbonate platform and then deep-marine red marls and/or limestones of nodular character (*Ammonitico Rosso*-type) originated of full pelagic sedimentation. But the deepest character of sedimentation has been manifested by multicoloured siliceous limestones and/or radiolarites of the Middle Callovian age. Younger (Upper Callovian/Oxfordian–Lower Kimmeridgian up to Tithonian) are reddish nodular limestones of the *Ammonitico Rosso* facies again but with numerous intercalations of allodapic limestones, which are full of irregular carbonate clasts even of extremely shallow-water environments. These several inter-bedded intraformational breccias and calciturbidites are characterised by fractionation of grains/clasts and are effects of destruction of shallow-marine carbonate platform which surrounded deep-marine basin floor (result of Neo-Cimmerian movements). The youngest unit is represented by thin- and medium-bedded *Maiolica*-type micritic limestones (uppermost Tithonian–Lower Hauterivian) still a pelagic type of sedimentation in quiet deep-water environments.
The Munteana–Dumbrăviţa section, as one of the best profiles of the Danubian units in Southern Carpathians documents very well the gradual opening of Severin oceanic domain along the passive margin of the Moesian Platform.

Micro Raman spectroscopy as a tool for Cr-spinels analyses: Can it be used for finding Cr-spinels provenance in paleogeographic reconstructions?

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Cr-bearing spinels can be found in different geological environments, usually related to mafic and ultramafic rocks. In nature, several cations can enter into the structure originating a solid solution with a general formula (Mg, Fe^{2+})(Al, $Cr)_2O_4$. As a detrital mineral, the Cr-spinel is widely used because its chemistry is diagnostic of parental melt composition and crystallization conditions, it is resistant to low-grade alteration and mechanical breakdown, it is a widespread accessory mineral in rocks that are potential source of sediments such as ophiolites. Considering that Mg, Fe^{2+}, Al and Cr are the most abundant elements in spinels one of the most used diagram for classifying them is the Cr/(Cr+Al) vs. Mg/(Mg+Fe^{2+}) that allows to discriminate among different tectonic setting and source rocks.
For this study we analysed natural Cr-bearing spinels with $0.03 < Cr < 1.68$ atoms per formula unit coming from mantle xenoliths, alpine peridotites, ophiolites, layered complexes and meteorites in order to better define the behaviour of the Raman modes according to their chemical composition. Preliminary data suggest that the most promising peaks are those at about 650 cm^{-1}, 694 cm^{-1}, 748 cm^{-1}. It looks that the relative intensities and shifts of these peaks can be related to the Cr/(Cr+Al) ratio. It seems possible, but still to be accurately verified, that relative intensities could also be related to the Mg/(Mg+Fe^{2+}) ratio.

Seismic geomorphology characteristics of confined gravity-flow depositional system and principle control factors of its formation in lacustrine basin of non-marine faulted-depression, Eastern China

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Drilling practice shows that the depositional period of Es1z member of Qikou sag of Bohai Bay basin, located in North part of China, experienced the rapidest Subsidence and largest extension of Lacustrine range in paleogene. The main part of depression as a whole primarily deposited deep-lacustrine mudstone, while the sandstone merely developed in Qinan and Qibei area. The sandstone in Qinan is mainly gravity-flow channel micro-facies, while the Qibei area deposited gravity-flow fan.
The high-resolution 3-D seismic data was employed to recover the paleo- geomorphology of Es1z member. Then, constrained by high frequency isochronous stratigraphic framework, the nonlinear stratal slices and RMS amplitude, instantaneous frequency, instantaneous phase as well as coherence attribute are integrated to study this kind of gravity-flow in terms of configuration, distribution and principle control factors of formation. The result shows that the paleo-geomorphology of Es1z member exhibits obvious coexistence of underwater valley and underwater depositional pond. In the east and west part of Qinan area, influenced by the underwater micro-uplift and faulted mountains, the valley heightening from north to south exhibits widely with gentle slope. The valley served as source transportation channel and favorable location for unloading of coarse clastic materials of gravity-flow during this period. Confined by the valley, the gravity-flow channel sandstone body that experienced migration of multiple period, was formed. The stratal slicing and RMS amplitude attribute display crossing and superposed channel presenting snake-bending like with strong amplitude abnormality. The instantaneous frequency attribute shows obvious abnormality of channel-like with low frequency. The contact part between channel and its around mudstone exhibits distinct change in phase. Also, the coherence attribute shows evident low coherence abnormality in channel. When tending northward out of the ending part of channel, the geomorphology gradually turns into pond-like presenting flat shape with gentle slope in the lacustrine basin center. The middle-fine grained deposits disperse in a large scale. Consequently, a plenty of lobe-like fans exhibiting vertically thin-interbed of sandstone and mudstone were developed. Due to the little difference of acoustic impedance, the depositional scale and evolutional law of each fan unit can only be dictated by stratal slicing showing tiny strong amplitude. It is hard to identify each fan by employing RMS amplitude, instantaneous frequency attribute, instantaneous phase attribute and coherence attribute.

Characterization and modeling of paleokarst cave reservoir in different karst zones in Tahe Oilfield, Tarim basin, China

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Tahe oilfield is the typical carbonate fracture-carvity reservoir in the north uplift of Tarim Basin, western of China. The carbonate fracture-cavity reservoir, with various types of reservoir space, has characteristics of very strong heterogeneity, controlled by paleotectonic and paleokarstification. Caves play the leading role in oil and gas storage and more than 70% of oil and gas production come form this. So quantitative characterization of the cave distribution in the three dimensional space is most important for oil exploration and development. In this paper, taking Tahe block 4 as an example, we present a systematic method to characterize and model the palaeokarst caves.
Because of different genetic types of karstification, different Karst Zones developed different types of caves. We divided the caves into underground rives, doline caves and isolated caves. According to outcrops, cores, logging data and seismic data, doline caves, the vertical karst forms with thickness greater than the length and width, mainly develop in the epikarst zone. Isolated caves, oval-shaped irregularly, have poor lateral continuity and mainly develop in the vadose zone. Underground rivers with good continuity horizontally, mainly develop in the runoff zone. Doline caves with complex and various of fillings are almost full filled. Isolated caves are mainly filled with Collapse breccia. Underground rivers are mainly filled with sand and mud fillings and fluvial beddings are visible in cores. Impedance attribute has a good corresponding relation with the cave reservoir. Caves, which are greater than 15 m, can be identified by impedance and we call it the big scale cave. And the cave, smaller than 15 m, cannot be accurately identified by impedance, but has a response with seismic attribute, and we call it the small scale cave. In this paper, we first build a model using seismic attributes truncation and then correct the model according to the prior geological patterns artificially. In the end we get the 3D model of big scale caves. The training images, described as the concept of underground complex heterogeneous body, provide prior information of reservoir architecture for multi-point simulations. Small scale caves have similar genetic type of karstification with big scale caves but different intensity of karstification. Thus, Small scale caves and big scale caves have characteristics of similar architecture and different sizes. Taking big scale cave model in different karst zones as training images relatively, can ensure the stability of training images to a certain extent. According to the sizes of small caves and large caves, we set up the proportion relationship, and established the model of small caves using multiple point geostatistics simulation taking the cave explaination of well logs as the hard data and development probability as the soft data. Finally, we merged the two model together and get the model of palaeokarst cave reservoirs. This model has been well applied to production and development of oilfield for reservoir engineering.

Integrated provenance analysis of fluvial sandstones from the Middle Jurassic Shaximiao Formation in Western Sichuan Depression, China

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Western Sichuan Depression is a hotspot for petroleum exploration in Sichuan analogous foreland basin. Previous researches have agreed that Longmen Mountains which located in the west were the primary siliciclastic sediment suppliers of Western Sichuan Depression in the middle Jurassic Shaximiao period. However, in recent years, studies at more accurate levels showed that an amount of fluvial channels in the depression were parallel to the strike of Longmen Mountains. The confusions of sedimentary source-to-sink directions and fluvial channels' distribution hindered the exploration of oil and gas.

Based on field outcrops observation, heavy mineral analysis, sandstone composition analysis and seismic slices analysis, this study identified two main sedimentary source directions in the middle section of Western Sichuan Depression. Utilizing outcrops observation, cores description and logging data analysis, the study described the fluvial channels' distribution in different times.

At the western margin of the depression, controlled by tectonic movements of the middle section of Longmen Mountains, source-to-sink direction was perpendicular to the strike of the mountains, from northwest to southeast, forming alluvial fans and fluvial deposits. Meanwhile, in the northeast, meandering river channels whose source area located in the northern section of Longmen Mountains, flowed from northeast to southwest, paralleled to the strike of the mountains. These long meandering channels were the result of continual converging of sediments in smaller scales from different directions. After the two trends gathered in the central region of the depression, the fluvial channels turned south to the center of subsidence, forming delta and lake deposits.

Due to the unsynchronized tectonic movements of different sections of Longmen Mountains and the relatively arid climatic environment, the amount and transport distance of sediments on the two main source directions kept changing, which resulted in different features of the fluvial channels' distribution in different times of Shaximiao Period.

Reservoir architecture analysis of fan-delta front in Wangguantun Oilfield

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Fan-delta reservoir is an important reservoir in China. At present, the studies of fan-delta reservoir are mainly focused on the outcrop and the modern deposition , while research on underground reservoir architecture of fan-delta front is few.Analysis of oil reservoir architecture is significant in deepening the research on reservoir geology and remaining oil exploitation.In this paper, taking Formation of Zao-5 member in Wangguantun Oilfield as an example, integrating of outcrops, cores, logging data and dynamic data, we anatomized the single sandbody and internal elements of fan-delta front reservoirs.And then using of new infill well, we analyzed the oil and water movement controlled by reservoir architecture , and summarized the distribution patterns of remaining oil.
The architecture units such as braided channel, mouth bar and sheet sand are identified . There are five types of combination relations in the plane: channel-channel, channel-mouth bar, channel-sheet sand, mouth bar-sheet sand and single channel. Braided channel and mouth bar are mainly shown as progradation superimposed and parallel superposed along the source direction, and a small amount of cross- superimposed. Different types of single sandbody has different scale. The channel is 0.7 to 7.2 meters thick and 80 and 400 meters wide. The mouth bar is 1.5 to 8 meters thick and 150 to 500 meters wide. The architecture elements inside the braided channel includes forsets and forset sand bodies, and due to the changes of lacustrine level, the vertical patterns of the forset sandbodies are divided into progradation type, retrogradation type and aggradation type and mixed superimposed, with progradation angle in 2° to 5°. Distribution patterns and potentials of different sandbodies are different: sheet sand and mouth bar are the further potential, and within the braided channel, foresets controls the vertical distribution of the remaining oil which is enriched in the updip direction of forset sandbodies.

The sedimentation dynamic processes and origin of shelf fine-grained deposits in the Yellow and East China Seas

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The global average sea level was 120 m lower than present during the Last Glacial Maximum (LGM) around 22–20 cal kyr BP (Fairbanks, 1989), and the sea level in the east China Sea (ECS) probably was rather lower at -135 m than today (Wang et al., 1992). Thus, most area of the yellow Sea (YS) and the ECS was exposed to air, and only the Okinawa Trough had been covered by seawater. Consequently, the shelf circulations disappeared during the LGM and began to form as the postglacial sea-level rise, which controls the modern dispersal, transportation and deposit patterns of sediment and their evolution processses. Due to good paleoenvironmental records to be preserved and good study topic on “source to sink” with huge discharges from the neighboring rivers of the Korean Peninsula and Mainland China, the fine-grained deposit bodies in the YS and ECS shelf have attracted many research subjects and common concerns. Although many papers on the mud sedimentary systems have been published, which mainly based on research cooperation between China and Korea, many aspects of sedimentary and dispersal system in the YS and ECS are poorly understood so far, because of lacking comprehensively interdisciplinary study. For example, the oceanic circulation patterns associated with sediment transport and resuspension in the YS and ECS were underestimated and neglected in most of the previous studies (Yang et al., 2003). The central YS mud (CYSM) and the southwestern Cheju Island mud (SWCIM) with good continuity and uneven thickness is a sink of fine sediment and carbon as well as a natural laboratory for studying the modern shelf circulation deposition mechanism. Therefore, for the future international cooperation between China and Korea, we suggest that comprehensively interdisciplinary research researches should be more important than that of the previous studies. We will select the CYSM and the SWCIM as the main research area and employ modern technogical methods, such as sediment trap, submersible buoy, circulation parameter and suspended matter analysis, sub-bottom profile, sediment core drilling, numerical simulation and sedimentary dynamics. Observing modern processes and co-analysis together with history records should be the proper access to the understanding of the origin and dispersal patterns of the YS and ECS sediments, and accordingly to the modern shelf circulation deposition mechanism.

Sequence stratigraphy of the Denglouku Formation in the Changling Depression, Songliang Basin, China

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A sequence stratigraphic framework of the Cretaceous Denglouku Formation in the Changling Depression in the underfilled Songliao Basin has been established based on the analysis seismic 3D/2D data, drilled cores and well log data. The Cretaceous Denglouku Formation can be divided into four third-order sequences. These sequences are, from bottom to top, Sq1, Sq2, Sq3 and Sq4. Sq1 is mainly distributed in the northern sub-depression and consists primarily of a transgressive systems tract (TST) and a normal regressive highstand systems tract (HST). It is bounded by a regional unconformity below and the maximum regressive surface above. Sq2, which is primarily bounded by maximum regressive surfaces both below and above, also consists of a TST and HST and is distributed in the southern and northern sub-depressions. Sq3 is bounded below by a maximum regressive surface in the southern and northern sub-depressions and a regional unconformity in the central uplift. Sq3 also has a TST and HST and is distributed more widely than the underlying sequences, firstly depositing across the entire depression. Sq4 is bounded by a maximum regressive surface below and another regional unconformity above. As the most widely spread depositional sequence, Sq4 could also be divided into a TST and HST. Braided river delta is interpreted as the main sedimentary facies in the study interval. These sequences were deposited in a back-arc rift basin during a transitional period from rift subsidence to down-warp subsidence. A sequence stratigraphic model is discussed based on the above interpretations. Typical unconformities are absent due to the absence of base level fall. Instead, maximum regressive surfaces, which are generally reworked by transgressive ravinement, act as the sequence boundaries. Each sequence bounded by these surfaces can be divided into two systems tracts: a TST and a HST. On land, a TST is characterized by a decreasing channel/floodplain ratio, and an HST is characterized by an increasing channel/floodplain ratio. Lakes are analogues to marine settings in which the shoreline shifts basinwards and landwards, and their strata show alternating transgression and regression patterns. These transgressive and normal regressive systems tracts in the general model are not necessarily symmetrical because the symmetry depends on the specific association and relative frequency of rapid and slow base level rises. The results of this study may encourage the application of similar approaches to the correlation of successions occurred in analogous settings.

Tight oil reservoir quantitative classification study based on gray correlation analysis method

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Based on the definition of tight oil from domestic and overseas scholars and organization, the definition or the contents of tight oil is determined in this study according to relationship of the source rocks and reservoirs and the practice of studying and development. The tight oil not only refer to oil that accumulates in tight sandstones or carbonates, but also includes shale oil that occurs in shale formation self-generated and self-stored and without migration. Based on clarifying tight oil's definition and content, the evaluation index are analyzed combining with the reservoir characteristics, those index should include:Total Organic Content, organic matter maturity, porosity, permeability, formation pressure, reservoir depths, source rocks thickness, reservoirs thickness, crude oil density, Brittleness mineral content and reservoir distribution area. The key indications are selected to evaluate the tight oil based on the determining scope of tight oil. By using Grey Correlative analysis, the tight oil reservoir could be quantitatively evaluated and classified, and the results fall in line with the geological studies, which proves that the Grey Correlative analysis is sturdy in tight oil reservoir evaluation. The classification result indicates that: Chang 6 and Chang 7 reservoirs of Yanchang formation in Ordos Basin are favorable type-Ⅱ reservoirs; The Middle to Lower Jurassic in Sichuan, Shahejie formation of Bohaiwan Basin and Qaidam Basin are ranked as type-Ⅲreservoir, which show great potentials and serve as current exploration targets. The Tiaohu formation of Santanghu basin has lower reservoir quality, categorized into the Ⅳ reservoir with limited potential. Even though the thickness of the source rocks and tight reservoir of Bakken formation of Williston basin are unfavorable, it is still a high quality reservoir, because the excellent source rocks, relatively high formation pressure and widely distributed source and reservoir sedimentary rocks have worked as its advantages and make up for the inadequacy of its thickness.

Characteristics of tight gas reservoir in the Upper Triassic Sichuan Basin, Western China

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The western Sichuan Basin is a foreland basin formed in the Late Triassic at the front of the Longmen Mountain in the western Sichuan Province of China. The Upper Triassic Xujiahe Formation in the basin is an ultralow-permeability and low-porosity tight sandstone and shale gas reservoir.

Tight gas reservoirs are often defined as gas-bearing sandstones or carbonates having in situ permeabilities to gas less than 0.1 mD. This paper offers an integrated approach to describe microstructure characteristics of tight sandstone and shale gas reservoir. In particular, the primary and secondary porosity of a tight gas sandstone are identified and quantified in three dimensions using X-ray Nano-CT imaging and visualization of core material at the pore scale. 3D images allow one to map in detail the pore and grain structure and interconnectivity of primary and secondary porosity. Once the tomographic images are combined with SEM images from a single plane within the cubic data set, the nature of the secondary porosity can be determined and quantified. In-situ mineral maps measured on the same polished plane are used to identify different microporous phases contributing to the secondary porosity. Once these data sets are combined, the contribution of individual clay minerals to the microporosity, pore connectivity, and petrophysical response can be determined. Insight into the producibility may also be gained. This illustrates the role 3D imaging technology can play in a comprehensive reservoir characterization program for tight gas.
Three types of microfractures, intragranular, grainedge, and transgranular microfractures, developed in the tight-gas sandstones of the western Sichuan Basin. Microfracture formation reflects tectonism, overpressuring, and diagenetic processes.
Tensional microfractures related to overpressure formed in the middle–Late Cretaceous. The existence of overpressure reduced effective stress, promoting opening-mode fracture growth. The existence of tension fractures can also be used as an indicator of ancient overpressure in a sedimentary basin. Diagenetic fractures formed from the Late Triassic, when the foreland basin of the western Sichuan Basin formed, to the Early Cretaceous. Under rapid sedimentation and intense compaction, intragranular microfractures formed because of the crushing of quartz grains and cleavage in feldspar. At the same time, under the influence of compaction and pressure solution, diagenetic transgranular microfractures formed along the microbedding planes and are parallel to the directional fabric of platy minerals. The intragranular and grain-boundary fractures are developed discretely at different structures, have small size and permeability, and are a major factor in storage of gas.
Tectonic microfractures controlled by fold thrust and lithology are developed at all of the gas fields and have the largest contribution to gas production. Diagenetic microfractures distributed along the microbedding plane and microfractures related to overpressure have little contribution to gas production.

Sequence architecture and depositional evolution of the northwestern continental margin of the South China Sea

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The sequence architecture and depositional evolution of the Late Oligocene to Qauternary continental margin of the Pear River Basin, the northwestern South China Sea have been documented in the paper based on integral analysis of 2D and 3D seismic data, borehole loggings and cores from oilfields. The section can be divided into four composite sequences (CS1-CS5) defined by regional unconformities related to tectonic uplifts or regional sea level drops and 18 sequences confined by local unconformities or correlative conformities, with their ages constrained by biostratigraphy of foraminifera and calcareous nannofossil. Each of the composite sequences with an average time span around 10 to 12 Ma, comprise a regional depositional cycles from transgression to regression. The unconformity at the base of the lowest CS1 is regarded as a breakup unconformity formed during around 23 Ma, which shows an abrupt change from fluvial-lacustrine to marine deposits in the basin. The base of the CS2 is another important unconformity formed during 21 Ma and suggested as the regional breakup unconformity for the all South China Sea Basin. Following this a rapid regional transgression occurred at the lower part of the composite sequence CS2, which resulted in the transition of shallow marine to slope and deep-water basin setting, and this is mainly attributed to the result of regional thermal subsidence of the South China Sea Basin. The unconformity at the base of the CS5 was formed in coeval with the initial closure of the South China Sea in the northern part of the basin. A number of large scale depositional-geomorphological systems are recognized in the continental slope complexes: (1) fluvial delta and prodelta turbiditie fan (lower parts of the CS1 and CS2); (2) outer shelf-slope unidirectional shift valley systems (lower parts of CS3 and CS4); (3) slope fan systems (lower parts of CS3 and CS4); (4) large scale slope clinoforms (CS5); (5) slump and soft deformed complexes (CS4 and CS5). They are recognized by distinguishing lithofacies associations and seismic geomorphological features. The continental slope underwent a depositional evolution from costal or delta, to outer shelf or slope-edge deltaic and prodelta turbidite, slope and lower slope fan and slump deformed deposits, accomplished with the opening and spreading of the South China Sea Basin. The study shows that the sandy deposits of the slope-edge delta, prodelta turbidite and slope fan formed as the lowstand systems tracts comprise the important reservoirs in the studied area.

Lacustrine fine-grained sedimentary petrology research progress

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At present, the depositional mechanism and genetic model for fine-grained sediments and rocks is intensively studied. There are a variety of environments likely to contain organic-rich shale, which really is a good news for unconventional oil and gas exploration. However, in the process of practice, shale and other fine-grained formation, is complicated than we imagine. Even in marine succession, fine-grained rock properties could quickly change in the longitudinal and transverse, let alone the lacustrine fine-grained deposition. A detailed sedimentological investigation of Permian-aged shale in Northwest China has carried out outcrop, core, mineral elements, isotope, organic petrology, micro structure study, expect to understand the physical, chemical properties and depositional environment of lacustrine fine-grained rocks, to establish the rock physics response, thereby guiding plane prediction.
Based on the experience of shale oil/gas exploration, TOC and hydrocarbon content is significantly positive correlation, especially in the maturity of oil window. Permian in Northwest China is of hot climate, evaporated lakes. However, the drought did not cause the root of the high salinity (2%). Occasional seawater intrusion, periodically increased water salinity, brought a lot of nutrients at the same time, then biological bloom often has a response to high salinity here. After the regression of sea waters, salinity in lake gradually decreased, which may be due to the reduced temperature. From hot to warm climate (C isotope dropped), precipitation increased and lake water became freshening. As the water deepening, the water column stratification again effectively produced an environment lack of oxygen at the bottom of lake, providing favorable conditions for the preservation of organic matter. Meanwhile, due to the expansion of lake basin, the impact of provenance was reduced, organic matter contained more sapropel group, such as water creatures, algae, etc.
Permian lakes in Northwestern China had a lot of carbonate, including calcite and dolomite. The dolomite was confirmed as biogenic primary dolomite by the evidence of isotope and microstructure. The organic matter may contribute to the formation of dolomite, so dolomite was scattered within the interval of rich organic matter only. It is often seen that feldspar, quartz or organic matter was interbedded with micro calcite layer, which was formed by resuspension. Calcite layer was organic-poor. Although the environment of calcite formation may be too clean and of low productivity, but the stability of anoxic condition effectively protected the thin layer of organic matter, even in shallow lakes.
While understanding the formation mechanism of the organic-rich shale, mm level of lithofacies change, is very difficult to be accurately identified on logging curves. The sedimentary environment of rapid change cause no partition in logging response characteristics, which bring very great challenge to prediction. Application of neural network identification, is still impossible to distinguish all the fine-grained sedimentary rocks.
In this study, the experiment process of rapid transitional phase was summarized, one of the most critical procedures is depth shift in the core, because ten centimeters of error can cause rock and logging facies don't match at all.

Sedimentologic features of the *Sabellaria spinulosa* reefs in the Adriatic Sea (Torre Mileto, northern Gargano Promontory, southern Italy)

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Sabellaria spinulosa (Leukhart, 1849) is a tube-building epifaunal polychaete worm found in the subtidal and lower intertidal/sublittoral zone. It is a suspension feeder which builds rigid tubes by cementing together sand and shell fragments. Although the worms of *S. spinulosa* are widespread both along Mediterranean and Atlantic coasts of Europe, they rarely form large reefs and often they only encrust the hard-substrate with isolated tubes. For this reason, the main sedimentologic features associated with *S. spinulosa* reefs are poorly known. Recently, some large *S. spinulosa* reefs have been reported along the Torre Mileto coastal area (northern Gargano, southern Italy, Adriatic sea) for the first time in the Mediterranean sea. In this work, we describe in detail the textural, mineralogical and morphometric features of the sedimentary materials that are trapped in the reefs trying to evaluate the role of *S. spinulosa* in the selection of sandy grains. The sampling operations (involving reefs and adjacent shallow seafloor soft-sediments) were carried out during different seasons of the year and along three transects perpendicular to the coast from the backshore to the offshore transition (the local wave-base is about 5-6 m). Some image analysis procedures (using ImageJ and ArcGis) have been carried out on a large number of photos taken on reef slices (macro-photos) and thin sections (with scanner acquisition and at different microscopy magnification). The reefs of *S. spinulosa* are made up of a 50% of solid volume (sediment trapped directly in the worm tubes and particles occupying the intertubes zones), 30% of intergranular porosity and 20% of worm tubes. Comparing the grain-size and composition of sands of the sorrounding shoreface environments and the sands trapped in the reef by the worms activity, we quantitatively conclude that: 1) *S. spinulosa* worms do not select sandy-grains for their composition being similar in the worm tubes, intertubes areas and in the bottom soft-sediments (quartz, carbonate lithoclasts and bioclasts); 2) these worms select a small range of grain-size particles (with a diameter comprised between 120 µm and 250 µm). There is a clear linear correlation between the tube diameters and the D50 of the trapped sands, showing that *S. spinulosa* worms aggregate larger grains when they grow up. The entire grain-size distribution of tube and intertube parts is quite similar to the bottom soft-sediments; 3) the morphometric analyses (calculation of *Aspect Ratio*, Circularity, Elongation, etc.) carried out on both tube and intertube sands show a preferential use of elongate and ellipsoidal particles in the worm tubes. Finally, we have tried to evaluate the role of *S. spinulosa* reefs in the dynamics of local coastal erosion analysing the evolution of these beaches during time, with a geomorphological and sedimentologic approach.

Base level changes during Paleocene in Lishui Sag, East China Sea Basin Chronology of fluctuating base level during Paleocene in Lishui Sag, East China Sea Basin

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Paleocene series in Lishui Sag is a potential gas-bearing interval which could be divided into three third-order sequences or seven systems tracts according to previous research. In order to interpret the sequence division better and reveal the controlling factors of sea level changes, base-level change research is raised in this paper.
Five specific methods were used in this study to establish a base-level changing curve. These methods include stacking pattern, coast onlap, INPEFA (Integrated Prediction Error Filter Analysis), paleontological analysis and geochemical analysis. The results acquired from these methods were then quantified with particular standards. And since each method has its advantages and disadvantages, their results were synthesized with an empirical formula. Through this process, a comprehensive base-level changing curve was established and it was then compared with the global sea level curve. Meanwhile, a relative water depth changing curve was also established along this process.
This base-level changing curve established in this study perfectly coincides with the sequence division of preceding work. The curve climbed steadily throughout the period of Yueguifeng Formation and lower Lingfeng Formation (about 66.5 Ma to 57 Ma ago), and then it fell sharply at the onset of upper Lingfeng Formation period. After that, the base-level climbed again until 55 Ma ago when Mingyuefeng Formation started to deposit. And then, another steady climbing period commenced until 53Ma ago. By the comparison of the local base-level curve and the global sea level curve, it is considered that the dominate controlling factor of base-level change during late Lingfeng Formation period and early Mingyuefeng Formation period is global eustatic fluctuation while the dominate factor during the rest time of Paleocene could be tectonic movement.

The principle and method to enhance geological constraint by inserting virtual wells in facies controlling stochastic reservoir modeling

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The common practice in reservoir modeling is to infer variables' correlation from well data at first, and then to do spatial interpolation and stochastic simulation based on various Geo-statistical methods, which is the process from mathematical statistics to geological understanding; however; geological conceptions can not be fully exhibited in the final reservoir model by merely using this kind of variable correlation. A new method is proposed in this paper to enhance the geological constraint by inserting virtual wells during stochastic reservoir modeling. Firstly, set the variogram model that can characterize the heterogeneity characteristics of the whole region based on the comprehensive study of geological background. And then, the distributive characteristics of estimation variance by using kriging interpolation algorithm is analyzed. After that, larger value areas are selected to interpolate virtual wells. Meanwhile, the geological information are considered to pick the exact locations of virtual wells. Secondly, the property values (mainly porosity and permeability) of the virtual wells are given based on the seismic property of impedance-porosity. Thirdly, the kriging interpolation is done again using the virtual well as “hard data”, and then select relative larger estimation variance value areas and insert virtual wells again. Repeat the above two steps iteratively until the estimation variance distribution of the whole region is uniformly distributed. Finally, fitting the variogram parameters based on virtual and existed well data together and then proceed property modeling. In this way, the former geological conceptions can be smoothly merged into the process of reservoir modeling. Taking Es34-2 of B oil-field of Bonan basin as an example, stochastic reservoir modeling is proceeded by adopting the method illustrated above. The result shows that this method enhances reservoir model's accuracy effectively, which is more geological reasonable. In the end, the accuracy of the outcome model is discussed, and modeling error's causing reasons and the methods of diminishing error are analyzed.

Controlling factors and reservoir model of contact metamorphic rocks in northern slope of Gaoyou sag in Subei basin, eastern China

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Diabase intrusions are wildly encountered in Paleogene Funing formation in the northern slope of Gaoyou sedimentary sag, Subei basin of eastern China. According to the analysis of detrital mineralogy and fabric, especially authigenic mineral assemblages derived from consecutively sampling, the country rock effected by intrusion can be roughly divided into two belts outward into sedimentary formation: contact metamorphism and contact diagenesis, while intermediate and low-grade metamorphic zones can be recognized within the contact metamorphism belt in responding to grading petrological features. After metamorphic process, mudstones are modified to be slates or hornfels, while sandstones turn into metamorphic sandstones. The reservoir spaces of effected country rock are analyzed, they are mainly composed of intercrystalline micropores, microcracks, dissolved micropores and fractures in metamorphic mudstones, original interparticlepores, intergranular dissolved pores, intragranular dissolved pores, moldic pores and ultra-large pores in metamorphic sandstones. In general, the reservoir properties of metamorphic mudstones (especially hornfels) are enhanced and become favorable reservoir. However, the reservoir properties of metamorphic sandstones are harmed compared to normal sandstones. The reservoir property results are derived from reservoir spaces analyzing and petrophysical data. The causative factors to country rock are discussed in hydrocarbon reservoir perspective. For effected mudstones, hornfel fissures are caused by physical pressing introduced from diabase intruding process; slate microfissures are produced from hydrothermal flows; intercrystalline micropores of slates and hornfels are formed during cooling. For effected sandstones, the emplacement of diabase compacts the country sandstones; hydrothermal dissolution produces secondary pores or fissures; activated cementing reduces former existed pores. Based on the investigation of diabase intrusion characteristics and distribution, petrological and petrophysical characteristics of metamorphic mudstone and sandstone, the effect of diabase intrusion on reservoir properties, the model of reservoir development of contact zones is established finally. The relationship between igneous intrusion and hydrocarbon accumulation is also generally discussed at the end.

Extensive reworking of Pliocene sapropels by low-oxygen adapted benthic meiofauna

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The dynamic interaction between marine sediments and burrowing fauna represents one of the key biogeochemical processes on Earth. Benthic animals facilitate sediment irrigation and oxygen ingress through burrowing and accelerate organic matter (OM) degradation through ingestion, physical comminution and enzymatic breakdown. Since their proliferation in the Cambrian, animal burrowers have left an indelible signature on the sedimentary record in almost all marine environments, with the seeming exception being low oxygen environments. In modern environments, however, sub-mm benthic meiofaunal animals are adapted to low oxygen, even sulfidic conditions. Though less well known than the larger benthic fauna, meiofauna are more abundant in most modern marine sediments, occupy a greater range of environments including oxygen-depleted environments, and have an impact on sediment biogeochemistry similar in magnitude to the macrofauna. However, almost nothing is known about their impact on ancient marine sediments because they leave few recognizable traces. Here we show, in Pliocene-aged sapropels from three sites in the Eastern Mediterranean, the first reported trace fossil evidence of meiofaunal activity and its relation to changing oxygenation.

The Pliocene sapropels are a classic low-oxygen facies commonly used as an analogue system for the widespread, high TOC black shales that characterise economically and oceanographically important intervals in the Palaeozoic and Mesozoic. We apply a novel imaging approach comprising back scatter electron (BSE) microscopy of Ar-ion polished samples to demonstrate that meiofauna comprehensively reworked the uppermost 3-4 cm of the sapropels under oxygen-depleted conditions that excluded macrofauna. The meiofauna fragmented and ingested organic laminae, emplacing 15-70 µm diameter (type A) faecal pellets without visibly influencing the macroscopic sediment fabric. Larger, 60-300 µm (type B) faecal pellets are restricted mainly to the upper cm of the sapropels studied. Chondrites trace fossils post-date meiofaunal activity and, unlike the faecal pellets, are readily identified by visual inspection.

Benthic nematodes are a common, widespread class of meiofauna in modern sediments, and are able to tolerate severely dysoxic and even sulfidic conditions. Nematodes from modern low-oxygen settings have body diameters closely corresponding to the size range of the type A faecal pellets, so that we interpret the concentration of type A pellets to be the product of marine nematodes living in and reworking the sediment during freshening phases of sapropel deposition. The size and ovoid shape of the type B faecal pellets, on the other hand, is more consistent with a small macrofaunal or large meiofaunal polychaete origin.

There are no documented examples of comprehensive meiofaunal reworking of marine sediments in the geologic record yet intervals featuring abundant, in situ benthic meiofaunal faecal pellets and fragmented OM laminae are present in Pliocene sapropels at all three sites studied. This raises the question: how common is meiofaunal reworking of sediments under low oxygen conditions that are prohibitive to macrofauna? While sapropels are commonly used as a model system for anoxic preservation of OM, are they also generally representative of meiofaunal modification that has as yet gone unnoticed in other fine-grained, high TOC sediments from low-oxygen environments?

Deltas sourcing tidal straits: Observations from some field case studies

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Deltas prograding into straits dominated by co-axial tidal currents represent the major sediment source for tectonically-confined seaways. Deltas impinging tidal straits seems to be linked with the configuration of the seaway margins. Tectonically-active steep straits usually lack deltaic deposits, due to the high gradient and the direct transfer of river sediments toward the strait deep center (e.g., the Pleistocene Catanzaro or the modern Messina Straits of Italy). Conversely, deltas develop well across gently-sloping strait margins, as tectonically stable seaways favor clinoform progradation (e.g., the western margin of Cretaceous Western Interior Seaway in USA or the modern Klang Delta in the Malacca Strait).
The results of facies-based studies on the above-quoted delta examples are presented, attempting a first reconstruction of their distinctive stratigraphy.
The Calabrian Arc is a ca. 200-km-long orogen which assumed an archipelago configuration during its Neogene tectonic translation toward the Ionian Basin. This setting produced several seaways crossing perpendicularly the arc and exchanging water masses through the two interlinked basins regulated by powerful tidal currents in phase opposition. Many intervals of these strait-fill successions are today well exposed in Calabria, including transgressive deltaic complexes. These consist of basal breccias, passing upward to normally graded sediment-gravity flow sandstones, interpreted as proximal deltaic lithofacies. These deposits are erosionally overlain by vertically-stacked sets of tidal cross strata, forming 20-30-m-thick tide-dominated delta front complexes. Palaeocurrents measured across the entire section progressively deflect in their average direction, from roughly perpendicular, to parallel to the strait axis.
The Cretaceous Western Interior Seaway formed a ca. 4,500-km-long, N-S marine passageway in a retro-arc foreland basin during the easterly migration of the Sevier orogen toward the Colorado Plateau. Tidal waves entering the seaway from the Gulf of Mexico controlled the distal, subaqueous segments of many regressive deltas prograding into the strait from its western margin. These systems have muddy to rippled prodelta and lower delta-front reaches, and upper delta front tidal sand dunes displaying strong bi-directionality. Also in this field example, deltaic sandbodies were deflected by strong tidal currents running N-S in the seaway, the tidal gyre enhanced at times by poor seaway connection towards Canada.
A common element in deltas sourcing tidal straits seems to be an upward progressive change in the dominant process of sediment dispersion recorded in the vertically stacked delta facies. Early clinoform progradation was dominated by river and wave influenced lithofacies, whereas late deltaic wedges have delta-front deposits re-shaped by the dominant tidal strait circulation. In the WIS the late tidal reworking was enhanced by shallowing during progressive forced regression. The regime change is also recorded in the average progressive variation of the palaeocurrent patterns and consequent deltaic front deflection toward the dominant seaway trend.
These outcrop examples suggest a preliminary hypothesis on the depositional style of deltas prograding into tectonically-confined straits dominated by co-axial tidal flows. The studied deposits also form strong analogies with the spatial distribution of many sand-rich hydrocarbon reservoirs investigated along the margins of confined, narrow-linear basins and whose interpretation is still debated.

Mud ball diagenesis: From sideritic floodplains to iron-oxide-rich channel lags

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Mud balls are commonly preserved as lags in modern fluvial channels, and mm-scale siderite ($FeCO_3$) nodules are widespread in modern floodplain muds. Distinctive concretions composed of heavy rinds of iron oxide that surround iron-poor, mud-rich cores are common along bases of fluvial cross-bed sets of the Cretaceous Dakota Formation, Nebraska, USA. The cores of the concretions contain 46 to 89% void space. Evolution of rinded concretions began when intraformational clasts were eroded from sideritic soils, transported, abraded and deposited in river channels. Iron-rich rinds formed on the mud balls because concretion interiors remained anaerobic, even as oxygen accumulated in the pore waters of their surrounding, permeable matrix. Iron oxide first precipitated at redox boundaries at concretion perimeters and formed an inward-thickening rind. Acid generated by the oxidation reaction drove siderite dissolution to completion, creating the highly porous, iron-poor core. Iron-oxide rinds are indicators of the former presence of siderite, a mineral that forms only under reducing conditions, during either early or late diagenesis. Siderite is vulnerable to complete oxidation upon exposure, so the distinctive rinded mudballs are valuable clues that aid recognition of methanic floodplain palaeoenvironments.
Rhombic iron-oxide pseudomorphs after siderite are abundant, but patchily distributed in outcropping channel sandstones of the Dakota Formation. Coarse, unoxidized siderite is present in subsurface. The iron-oxide/ siderite cement in these sandstones strongly suggest that the ancient watercourses were “gaining” (rather than “losing”) streams. Anaerobic groundwater moved downward through marshy floodplain sediment and discharged into channels. Siderite precipitated there as coarse, early cement. Oxidation of the siderite in the mud balls and in the coarse cement was late diagenetic, likely Quaternary. We are not aware of reports of coarse, early siderite from modern channel sands; such cements, however, would be easy to overlook. Rinded mud balls appear to be quite common in the rock record. We have also found them in the Triassic Shinarump Member of the Chinle Formation (southern Utah), and in the Paleocene Hanna Formation (central Wyoming).

Neogene microbial iron-oxidation in a Jurassic eolian sandstone

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Spheroidal, iron-oxide concretions (“Moki marbles”; 1 mm to 15 cm in diameter) are widespread in the Navajo Sandstone of southern Utah, and have garnered attention due to their similarity to structures on the surface of Mars. Much larger concretions (several meters long and one meter-wide) are abundant in the middle Navajo at several localities between Escalante and Fruita, Utah and along the East Kaibab Monocline. Rind-like, iron-oxide-cemented sandstone defines the perimeters of the spheroids and the large concretions; on the large structures, these can be up to 25 mm thick. Friable sand occupies the interiors of some of the smaller concretions, but in most of the large ones, core stones are present. These cores contain abundant, rhombic, iron-oxide pseudomorphs after siderite. The largest concretions are usually partitioned by multiple, iron-oxide-coated joints and contain multiple core stones.
We interpret the iron-oxide-rich concretions to be the altered remains of siderite concretions of similar size and shape. The oxide-lined joints are unique records of Plateau uplift. Some of the vertical joints that cut the siderite concretions abut (are younger than) horizontal joints that likely formed within 100 m of the land surface. Joints acted as conduits for meteoric water that oxidized the siderite. Iron-oxidizing microbes colonized redox boundaries and precipitated the oxides along the joints and concretion perimeters. Oxidation took place below the water table because ferrous iron from dissolving siderite had to diffuse lateral distances of several decimeters to form the joint linings. Cores, however, probably were oxidized abiotically, above the water table.

Depositional ages of clastic metasediments from Syros and Samos, Greece: Results of a detrital zircon study

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The islands of Syros and Samos are part of the Cycladic archipelago located in the Aegean Sea. The Cyclades are part of the Attic-Cycladic Crystalline Belt, a tectonostratigraphic unit of the Hellenide orogen that covers large parts of the Aegean region. It consists of an upper and a lower (=Cycladic blueschist unit, CBU) tectonic unit, each with different P-T-D-t histories. The general geologic evolution and distinct metamorphic events of the study area are well constrained by previous studies. However, pre-metamorphic history and litho-/tectonostratigraphic correlations remain largely unclear. Available geochronologic data from siliciclastic metasediments of the CBU are restricted and indicate Permian to Late Cretaceous sedimentation. To provide a better understanding of the geodynamic history it is neccessary to identify differences in time of sediment accumulation and provenance within the Aegean region. The main objective of this study was therefore to refine maximum depositional ages of siliciclastic rocks of the CBU by U-Pb geochronology of detrital zircons.

New data of samples from the Ampelos unit on Samos revealed a polymodal age distribution pattern within overall spectra ranging from ~320 Ma to ~3.2 Ga. The population is characterized by a significant amount of Cambrian–Neoproterozoic zircons. Similar age distribution patterns are also known from nearby areas, for instance, the southern Aegean belt, northern Greece or NW Turkey. In contrast to other available data from the Cyclades, the total absence of Mesozoic zircons is a unique feature. Youngest zircons yielded Variscan ages but due to the small number their significance remains unclear. Hence, the maximum depositional age of Samos samples is indicated by a well-constrained age group at 500-550 Ma and highlights the importance of 'Pan–African' source rocks.

Results of four samples from Syros differ significantly and reveal distinct regional differences in time and provenance of sediment deposition. Samples record an enormous input from Permo – Triassic sources, reflecting well-known Triassic magmatic activity in the larger study area. The overall contribution from Variscan and older sources is minor and not even existent in two samples from the southern tip of the island. The maximum age of sedimentation is indicated by a group of Triassic to Cretaceous zircons and is substantially younger compared to Samos. Combination of new and published data even suggests longer lasting sediment accumulation to Late Cretaceous time. Some very young single spot ages turn up at 35 and 45 Ma, respectively, but these can be related to metamorphic processes in the CBU.

Reservoir affected by weathered crust karstification in upper assemblage of Ordovician Majiagou Formation of eastern Ordos Basin, China

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Weathered crust karstification plays an important role in reservoir formation. Reservoirs affected by weathering crust karstification generally possess good physical properties. The Ordos Basin, located on the North China platform, is the second largest inland sedimentary basin in China. Huge gas reserves have been found in the upper assemblage of the Ordovician Majiagou Formation, which shows that these strata are good reservoirs for gas accumulation. Because the specific features and change in physical properties of reservoirs are unclear, this study investigates the characteristics and distribution rules of favorable reservoirs to predict their horizontal distribution in the research area; this can help lay the foundation for further gas exploration.
On the basis of observational data from well core samples and sections and from geochemical analysis such as carbon–oxygen isotope and fluid inclusions in this area, this study examined the petrological characteristics of different types of reservoir spaces. Furthermore, the study examined pore structure and filling characteristics, and finally predicted the distribution of favorable reservoirs.
The study showed that the most significant types of gas reservoirs in this area are micritic dolomite and crystal dolomite with gypsum nodules. The main reservoir spaces of the study area are solution pores, solution fissures, structural fractures, mould pores of gypsum nodules, inter-crystalline pores, inter-crustal breccial pores, and microfractures. Among them, the most important reservoir space is the mould pores of gypsum nodules; the larger and more the reservoir space, the better is the gas reserve. As for the filling characteristics, the mould pores of gypsum nodules in the study area are not completely filled; therefore, the reservoirs are of good quality. The calcite mineral plays a leading role in the filling of the mould pores of gypsum nodules; the more the pore is filled, the worse it is for the reservoir connectivity.
The investigation of reservoir characteristics showed that MW12, MW13, and MW22, which developed mould pores of gypsum nodules, have lower pore filling degree and form better gas reservoir with large spaces. However, the MW41 has a relatively higher pore filling degree and is poor gas reservoir.

Coastal dunes as archive of seasonal wind intensity (Łeba, Poland)

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This study proposes a non-invasive method to reconstruct wind-field variations from coastal dunes with annual resolution. Dunes at the Polish coast near Łeba consist of two genetic units: primary dunes, composed of up to 18 m high eastward-dipping foresets, which are temporarily superimposed by smaller secondary dunes. Ground-penetrating radar (GPR) data reveal that the foresets of the primary dunes are bundled into packages showing a characteristic pattern of alternating low- and high-amplitude reflections. High-amplitude packages are composed of quartz sand with intercalated heavy-mineral layers. Low-amplitude packages, by contrast, lack these heavy-mineral accumulations. Net dune progradation is the result of sediment accumulation at the eastern slope of the dunes and attributed to the prevalence of westerly winds. Reversal winds, i.e. winds from the east, winnow the lee slope, leaving layers enriched in heavy minerals. Sediment transport to the lee slope is enhanced during late summer and autumn whereas easterly winds occur predominantly during winter and spring. As a result of these seasonal wind-field variations, the sedimentary record of each year is imaged in the GPR data with a low- and a high-amplitude interval. This pattern is a persistent feature of the Łeba dunes and regarded as a "sedimentary bar code" with varying thickness of individual packages reflecting annual changes in the wind field. Dendrochronological methods were adopted to overcome hiatuses and dune-to-dune variations in bar code quality. As a result, a composite bar code showing wind-field variations for the time period 1987 to 2012 is presented. Finally, reconstructed data were compared to a meteorological time series.

Stable isotope-based reconstruction of climate and vegetation during Hominin evolution in the Malawi Rift

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The isotope geochemistry of pedogenic carbonate and fossil herbivore enamel is a powerful tool to reconstruct terrestrial paleoenvironments. Here we present the first pedogenic Plio-Pleistocene long-term carbon ($\delta^{13}C$) and clumped isotope ($\Delta 47$) records from the Chiwondo Beds, one of the earliest hominid fossil sites in the East African Rift System (EARS).
The studied 5.0 to 0.6 Ma deposits in the Karonga-Chilumba area (NE shore of Lake Malawi) comprise abundant pedogenic carbonates and fossil remains of a diverse fauna, including two hominid fossil finds: a maxillary fragment of *Paranthropus boisei* and a mandible of *Homo rudolfensis*, both dated around 2.4 Ma.
We contrast $\delta^{13}C$ values from pedogenic carbonate with data from fossil enamel, of different suid, bovid, and equid species. We complement the former by $\Delta 47$ thermometry data as a proxy for soil temperature. Our data represent a southern hemisphere record in the EARS, a region particularly interesting for reconstructing vegetation patterns and correlating these across the ITCZ with data on the evolution and migration of early hominids and the proposed boundary shift between different savanna types. As our study site is situated between the well-known hominid-bearing sites of eastern and southern Africa it fills an important geographical gap for early hominid research.
Results of over 600 pedogenic carbonates from over 25 sections show $\delta^{13}C$ values that consistently average around -8.5 ‰ over the past 5 Ma with no significant short-term excursions or longer-term trends. The data from molar tooth enamel omnivores (suids) compliment these findings with average $\delta^{13}C$ = -10.0 ‰. The absence of long-term trends towards more positive $\delta^{13}C$ values contrasts the increasing role of C4-grasslands in the northern EARS. By analyzing enamel of specialized grazers such as equids and bovids, we show that the environment in the southern part of the rift was not homogeneous with a high woody fraction but the $\delta^{13}C$ values around 0 ‰ indicate instead a presence of open grassland savannas with a large portion of C4 biomass. Our data hence point to regional differences in climate and vegetation dynamics during the Plio-Pleistocene in the EARS. It therefore documents persistence of paleoenvironmental dynamics in the southern branch of the EARS at times of early hominid evolution.

Types and Distribution of Fine Sedimentary Rocks in Chang 7 Oil Group of Ordos Basin

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Ordos Basin, located in the west North China Platform, is a cratonic basin formed through stable deposition and depressive migration, during which the Cenozoic and Mesozoic basins were superimposed onto the Paleozoic basins. It was divided into 10 oil layer groups (Chang 10 to Chang 1) based on lake basin deposition & evolution sequences and longitudinal oil-layer distributive laws. In particular, Chang 7 was the flourishing period during the development of Yanchang Formation lake basin. At this period, a delta-lake-gravity flow depositional system was formed, with widely- developed fine deposition as well as favorable dense oil gas reservoirs and shale oil gas reservoirs.
Through the study of outcrop, core, laboratory analysis and other information, in the study area , according to particle size, fluid properties, deposition mechanism, structure can identify 16 kinds of rocks with: fine sand face with horizontal beddings (Fp), fine sand face with flow water cross beddings (Fc), fine sand face with wave-built cross beddings (Fw), massive mud-clay-containing fine sand face without beddings (Fm), fine sand face with torn mudstone fragments (Ft), and fine sand face with graded beddings and bottom die structure. Siltstone face with wave-built cross beddings (Sc), siltstone face with ripple beddings (Sr), siltstone face with massive deformed beddings (Sm), and siltstone face with Bouma sequence (Sb). Mudstone face with horizontal beddings (Mh) and mudstone face with horizontal veins (Mg). Shale face with laminated horizontal beddings (Sh) was identified in the black shale. Strip-like tuff face (Tb) and thin-massive tuff face (Tl) were found in the tuff. The carbonate rocks were mainly at the lentoid limestone face (Ll).
The facies correspond to different loggings. Then rock-electricity relations were built on basis of the lithology and well logs in the tested rock cores. The data of thickness of small layers in Chang 7 involving 180 test points were summarized. The horizontal distributions of fine sedimentary rocks in the Chang 7 oil layer group were plotted. Clearly, the grain-size of deposits and the amount of sandy deposition gradually decreased, while the amount of muddy deposition was improved from the margins to the center of the lake basin. In particular, Fp was mainly distributed in the underwater by-channels, Fc in underwater by-channels and river-mouth sandbanks; Fw, Sc Sr and Sm mainly in distal bars and sheet-like sand; Mh in the bays between branches; Ft mainly in slump deposits; Fm in sandy clastic flow deposits; Fg and Sb mainly in turbidite deposits; Mg, Sh, Tb, Tl and Ll mainly in semi-deep lakes/deep-lakes.
We study the types and distribution of fine sedimentary rocks in Chang 7 oil layer group, and thereby build a basin fine deposits distribution pattern. This pattern helps to predict the space spread of dense reservoir sandbodies and hydrocarbon source rocks, as well as allocation of resource storage. This study provides some significance for further exploration and development of dense oils (shale oil).

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Tufa fluvial deposits: Beyond the sedimentary model

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A complex sedimentary system developed in the Añavieja–Dévanos Basin (NE Spain) during the Holocene. Alluvial fans spread into a shallow lake that connected downstream with a tufa barrage fluvial system with sparse vegetated areas. Sedimentological model is the most common information extracted from the study of tufa fluvial deposits, but if preservation conditions have been favourable, they can also be studied under the sequence stratigraphy perspective and give us important clues for economic purposes.
Under this perspective, climate changes during the Holocene have been inferred from the sedimentological, mineralogical and palinological study of several cores extracted in the Añavieja system, pointing out their potential in palaeoclimate studies. Our investigations show that dry climate conditions prevailed in the area during the onset of the Holocene changing towards more humid conditions from 8705 yr BP, when Mediterranean vegetation expanded. In any case a drier episode occurred between 8500 and 4000 yr BP, as recognised in other Spanish registers. Human activities started about 1200 yr BP.
The unexpected thickness of the Holocene fluvial series (more than 20 m-thick) recovered by coring, both in tufa barrages and pools, motivated a GPR research to infer the subsurface geometry, connectivity of the porous facies, and the main cause for the high sedimentation rate. From GPR profiles two main radarfacies (RA and RB) were defined. They alternate in the flow direction and were contrasted with cores and outcrops. RA corresponds to inhomogeneous areas with hyperbolic anomalies, low to middle propagation velocity, high penetration depth and reflectors with a changing dip and random pattern. RB shows a more homogeneous behaviour, higher propagation velocity, high attenuation and subhorizontal reflectors. Cores drilled over RA and RB are integrated by tufa levels but in RA, interbedded marls with oncolites and tufa remains are also common, whereas in RB intercalations are sandy and marly. RA corresponds to tufa constructions and RB with pool facies although tufa levels (RA) also developed in the pools either as small bioconstructions or barrage erosion products.
GRP profiles have permitted non-outcropping barrages and pools to be identified. Moreover, they confirm an aggrading system characterized by asymmetric growth if the pools are considered. Pool sediments onlap barrages but contacts are more progressive in the barrage downstream face than in its upstream face, indicating higher connectivity between the more porous barrage facies and tufa levels inside the pools downstream. Aggradation was related with the local base level induced by damming.
Our results show the possibilities that offer combined geophysical and stratigraphic studies in highly erodible tufa deposits, not only for refine sedimentological models but also for knowing the causes of the fluvial dynamics through time. Besides, it points the usefulness of these deposits from sequence stratigraphy studies if they have been highly conserved, and its potentiality as reservoirs proving a higher connectivity than expected.

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A number of several warmer spells noted on eastern Svalbard during Younger Dryas - a bidecadal resolution of paleoceanographic record of Atlantic Water variability

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The Younger Dryas (YD; c. 12,800–11,500 cal yr BP) was a major climatic event during the transition from the last glacial period into the present Holocene interglacial, characterized by a rapid and short-term temperature decrease. YD event was likely driven by the weakened North Atlantic Meridional Overturning Circulation, a result of the Lake Agassiz outburst or the interaction between the sea ice and thermohaline water circulation leading to a reduction of Atlantic Water transport to the north and a dominance of fresher Arctic Water.
The multi-proxy data from a high-resolution marine sediment record retrieved 100 km east of the mouth of Storfjordrenna (southern Svalbard) show that the heavier $\delta^{18}O$ values recorded, e.g., 12,720 cal yr BP and 12,100 cal yr BP, correlate with reduced to absent IRD fluxes, whereas the peaks of lighter $\delta^{18}O$, e.g., 12,450 cal yr BP, 12,150 cal yr BP, and 11,780 cal yr BP, occurred synchronously with significant enhanced IRD fluxes. The lack of IRD, occasionally for several decades, might reflect temporary polar conditions characterised by the formation of perennial pack ice in Storfjorden that locked icebergs proximal to their calving fronts and prevented their movement over the coring site. Contradictory, periods of accelerated AW inflow (e.g. 12,450 cal yr BP, 12,150 cal yr BP, and 11,780 cal yr BP) resulted in massive iceberg rafting and delivery of IRD to Storfjordrenna, thus reflecting more sub-polar conditions. Our records show that Younger Dryas was not uniformly cold and that at least a number of warmer spells occurred on eastern Svalbard.

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Stromatoporoid biostromes in the Upper Silurian of Podolia (Ukraine) as dynamic bioaccumulations

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In the Late Silurian the present-day Podolia region was a part of a vast carbonate shelf with a constant facies pattern that rimmed Baltica from the south (Silurian orientation), stretching from modern western Ukraine, through Belarus and north-eastern Poland to the Baltic States and the island of Gotland. A central position on the shelf was occupied by a zone of stromatoporoid shoals, which separated the inner shelf lagoonal environments from the outer shelf and slope facies that pass into basinal graptolitic shales. During sea-level fluctuations, the position of particular facies belts shifted, but the general pattern remained unchanged. Today the Podolia region offers the best exposures of a wide-spread facies belt. Most of the exposures are located along deeply incised valleys of Dnister river and its northern tributaries and in numerous active quarries. In the Podolia region, the Upper Silurian (Ludlow and Pridoli) shallow water inner shelf facies, represented mainly by fine grained peritidal laminites and dolomicrites with ostracods and eurypterids, are commonly intercalated by variously developed stromatoporoid beds. Traditionally these beds were interpreted as biostromes marking the deepest (or at least the most open-marine) environment in a peritidal cyclic sedimentary pattern. However, recent studies have revealed that most of these beds are in fact developed as horizontal and lenticular parabiostromes with erosional bottom surfaces and are composed of overturned and often fragmented massive stromatoporoid skeletons, which is typical of most Silurian-Devonian stromatoporoid "reef" deposits. Some of the lens-shaped beds represent infillings of sea bottom depressions, such as tidal channels. The biogenic material has been transported landward from their offshore habitats by high-energy sedimentary events punctuating the shallow water shelf and deposited in shallow lagoonal settings on lee sides of stromatoporoid shoals. Several depositional features of the stromatoporoid beds, such as the source of redeposited material including open-marine fauna, depth of erosion, lateral continuation on vast distances and co-occurrence with flat-pebble conglomerates, indicate that the onshore redeposition was caused by factors with energy levels exceeding those of average storms. Detailed studies of morphometrical features of the redeposited stromatoporoids, including the analyses of their shapes, living surface profiles, dimensions, basal surfaces and arrangements of growth bands (latilaminae), performed in a number of localities, point to a calm original growth environment with a low deposition rate, which enabled their undisturbed growth. The stromatoporoid habitats were most probably located well below storm wave base, in which the bottom waters were interrupted only by very high-energy phenomena, such as extreme tropical hurricanes or tsunamis. The vastness of the area covered by the parabiostromal beds and the lack of lateral size segregation of the stromatoporoids in some aspects resembles the distribution of modern tsunami-derived material and differs from the typical distribution of storm-derived deposits. The dynamic nature of the stromatoporoid beds has to be taken into account when constructing the curves illustrating bathymetrical and facies development of the Silurian succession in Podolia.

Geothermal derived carbonate deposition in a volcanic plateau (Viterbo, Italy)

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A large thermal complex comprising numerous high temperature springs (52°C to 65 °C) of sulphate-alkaline-earthy waters and related carbonate deposits forming a large irregular shield-like complex, crops out in the volcanic district west of the town of Viterbo (N of Roma-Italy). The thermal springs (more than 50 small hydrothermal vents most of them now inactive) and numerous deep wells are located west of the Tiber River along a structurally controlled geothermal area coinciding with the uplift of a deep calcareous structure bounded by extensional faults and buried by the pyroclastic deposits of three volcanic districts (Cimino, Vico and Volsini) active between 1,35 Ma e 90 ka. There is a great variability in the lithofacies of the carbonate bodies derived from the thermal system, due to different factors controlling turbulence and velocity of the flows, such as the proximity to the thermal vents, the length of the outflowing water paths and related temperature decrease, and mainly the flat substrate morphology of the volcanic plateau. Consequently several depositional environments can be individuated: i) the carbonate deposits surrounding the main spring areas (Bulicame, Bagnaccio, Fosso delle Farine e Terme del Masso) which can locally precipitate at rates greater than 70 cm/year (e.g. Le Zitelle Spring) are represented by small, generally low relief bodies of typical compact, well-bedded travertine with microbial laminites dominant on crystalline facies. ii) in more distal conditions, due to the general flat/gently undulated morphology and to the cooling of the waters, swamps or shallow lakes can be formed so that the carbonate facies gradually evolve to palustrine or stream tufas and lacustrine lime muds. iii) in the distal end of the thermal-spring system, cooled thermal derived waters are mixed with surface rainwater or fluvial waters, forming irregularly staked lenticular edifices of characteristically porous phytohermal or phytoclastic facies. In larger shallow lakes, sporadic interruptions of lime-mud deposition are marked by discontinuity surfaces represented by reddened horizons and buried palaeo-soils. In the more distal areas, the lateral progradation of the carbonate deposits on the low-relief morphology results in a complex accumulation of carbonate and fluvial/colluvial sediments. The recurrence of periods of calcium carbonate precipitation and intervals of starvation suggests an allocyclic climatic control on the geothermal flow rate even though in a thermal system, autocyclic mechanisms have to be also taken into account.

Palaeoproterozoic sedimentation in the Cuddapah Basin of southern India

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The study focuses on the south-western arcuate margin of the Palaeoproterozic Cuddapah Basin located on the Eastern Dharwar Craton of south India. The basin margin, although modified by episodes of younger faulting, is primary and its surrounding and underlying bedrock comprises granite-gneisses with slivers of Archaean greenstones.The crystalline bedrock along the basin margin is overlain by a Palaeoproterozic sedimentary succession comprising the Papaghni and Chitravati groups, separated by a prominent regional unconformity. The study is limited to the Papaghni Group, which commences with the Gulcheru Formation, a thick (~285 m) highstand regressive wedge of conglomerates and sandstones, passing upwards into sand–mud heterolithic deposits and a transgressive stromatolitic carbonate platform of the overlying Vempalle Formation (~2100 m thick). The sedimentary facies associations of the Gulcheru Formation indicate local alluvial-fan deltas ensuing from sea-drowned bedrock valleys between much longer segments of the basin-margin cliffy coast dominated by wave action and affected by storm events. The alluvial-fan systems prograding into the basin were dominated by debris flows, fluvial sheet floods, hyperconcentrated flows and shallow ephemeral braided streams, and were wave-worked in their seaward frontal part. Wave-dominated was also the basin-margin shoreline between these alluvial entrances, comprising a gravelly to sandy foreshore zone with cliff-derived rock falls and a broad sandy shoreface.
The subsequent offshore development and landward advance of the Vempalle Formation carbonate platform, as a coastal barrier, cut off the direct impact of waves on the coast. The back-barrier zone then became sheltered from wave action as a lagoon dominated by tidal currents and storm washover processes, accumulating heterolithic deposits and being gradually onlapped by the landwards-expanding stromatolitic platform. Instead, the clinoformal seaward front of the carbonate platform became a wave-dominated shoreline. In the environmental context of the basin's initial wave-dominated clastic shoreline, the development of the carbonate platform came somewhat unexpectedly and must have apparently been triggered by favourable offshore conditions. The cause of the marine transgression that expanded the platform landwards and the cause of the subsequent regional regression (major stratigraphic unconformity) remain to be unclear. They could be due to eustatic sea-level changes and/or forced by the basin tectonism.

Depositional environments of the Ordovician Umm Sahm Sandstone Formation in southern Jordan

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The Umm Sahm Sandstone Formation crops out in the southern desert, and is characterized by it's dark brown weathered colour, tabular bedding, extensive jointing, and steep cliffs. The upper boundary of the Umm Sahm Formation is marked by a sharp contact between the soft, varicoloured claystones of Hiswah Formation and the underlying prominent, hard and cliff form topography. The lower boundary is trnsitional with the Disi Sandstone Formation. Lithological trnsition changes from white, friable sandstones to dark hard sandstones. The thickness of Umm Sahm Formation is about 200 m, and is comprised of two facies: fluvial facies and marine facies. The fluvial facies proportion is about 93% of the total thickness. The lower part of the succession passes upward from the Disi Sandstone Formation into similar massive white sandstone facies exhibits similar white colour, fine- to coarse-grained sandstone, pebbly, rounded morphology, trough and planer cross-bedding with graded foresets, and overturned cross-bedding, but is more hard, extensively jointed. Trough and planer cross-bedding are unidirectional and are orientated towards the north and northwest. Some beds contain quartz granules and pebbles (rosy, milky and smoky coloured) up to 2 cm across and flat lying intraclasts up to 3 cm long. Light brown and cream coloured quartzarenite similar to that of Umm Ishrin Sandstone Formation are most common. These are more hard, trough cross-bedded, with overturned cross-bedding, extensive joints and steep cliffs, but the tear-like drop features typical of Umm Ishrin outcrops are absent may be due to the lack of oxidized shales there. Whereas, the marine facies occupies three intervals in the middle part of the succession, and constitutes about 7% of the total thickness. It is composed of laminated and thin bedded fine-grained sandstones, siltstones and mudstones (rhythmites, tidalites). They are varicoloured (white, gray, greenish, maroon) with abundant trace fossils (cruziana, harlania, rozphycus). These are rippled (oscillatory, current, interference), which indicates tidal environment. The presence of hummocky cross stratification indicates the first existed short-lived tempestite conditions during the Paleozoic erathem of Jordan. The vertical arrangement of both fluvial and tidal facies indicates three successive transgressions and regressions. These marine incursions indicate the successive shoreline advance of the Tethys ocean which was located northward to inundate the southern braid plain.

Tivoli travertine deposits: A 3D sedimentological model of a reservoir analogue

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The continental carbonates such as travertine show a complex facies distribution, related to the environment where they are developed. In fact, they are hardly influence by the physical-chemical-biological conditions.
The carbonate rocks of pre-salt, discovered in 2006 (Lula field) offshore Brazil, and then later in Angola have shown similarities with the travertine bodies. So, continental carbonates may possess good characteristics as reservoir rocks.
Unfortunately the knowledge on these reservoir due their complexity properties in general is limited. However, after this discovery, the attention of the scientific community towards continental carbonates has grown, focusing mainly on the study of the facies and the reconstruction of the depositional environments.
The lapis tiburtinus of Tivoli, is probably the best known continental carbonate system, famous to the world as ornamental stone.
These travertine deposits develops in a relatively small sedimentary basin (3x5 km^2) confined on the North by the Cornicolani Mountains, to the East by the Lucretili Mounts. The South part of the basin is limited by the Aniene River and the volcanic Castelli Romani reliefs.
The interaction between the aquifers belonging to the carbonate domains, the deep faults and the magma chambers of the volcano present in the area produces a mix of gas and water and forms a fluid supersaturated in calcium carbonate, which ascends along faults and forms travertine when it reaches the surface.
In Tivoli quarry, it was possible to divide the various sedimentary bodies based on lithofacies and sedimentological characteristics: two classes of environments were defined, one subaqueous, very shallow, characterized by the deposition of facies type Shrubs and one palustrine, characterized by the presence of immature paleo-soils.
Moreover, these lithofacies are separated by erosional surfaces, sometimes covered by immature paleo soils, testifying of changes in sedimentation related to fluctuations of the water table or climate changes.
With the purpose to understand better the sedimentary facies distribution, in time and space, and architecture of the travertine bodies, a 3D model was performed.
This model allowed the correlation of different quarries, emphasizing the organization and lateral facies variation. This model together with a detail lithofacies description will help to improve the paleo-environmental model.
These tool is usefull to understand the complex distribution of travertine systems. And they can be applied as analogues for the pre-salt reservoirs, due their depositional lithofacies similarities and also geobody architecture.

The Sinemurian carbonate buildups of N'zala (Central High Atlas, Morocco): Facies, architecture and geodynamic setting

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Solving the puzzle of the Sinemurian carbonate buildups located in the northern part of the N'Zala Liassic succession (Central High Atlas, Morocco), require a multidisciplinary approach including mapping, stratigraphy, carbonate microfacies analyses and biosedimentology.
New geological and stratigraphic data obtained form fieldwork of the study area, improved the understanding of the upper limit of the build-ups and showed a geometrical irregularity that suggests a diachronic extinction.
The geological timing with a standard section on the left side of Oued N'Zala, allowed the sketching of isochrones, which are continuous and visible within the geographic space. It shows that these mounds are quite evident in the Lower Sinemurian-Upper Sinemurian transition. They locally growth in the Upper Sinemurian, whereas disappear at the bottom of the Lower Carixian.
These carbonate buildups result characterized by Hexactinellids and Lithistidssiliceous sponges, microbialites with thrombolytic and stromatolitic structures, and encrusting organisms such as bryozoans and annelids, with abundant carbonate matrix which consist of organic-rich and compact dark microcrystalline calcite of microbial origin (automicrite), and a grey micrite (allomicrite).
Considering the composition and shape, of the studied units whose thickness is almost (~160 m thick) we have recognized three different sectors:
- A lower part (30 m thick) characterized by small (~0.5 m high) carbonate mounds with a simple lenticular shape and siliceous sponge-rich boundstones;
- A middle part (45 m thick) characterized by large (~2 m high) carbonate mounds with a complex shape, siliceous sponge and thrombolites boundstones;
- An upper part (70 to 100 m thick), Viewed from afar, this unit shows a massive appearance With a less developed dome shape. This portion of the stratigraphic section consists of meter thick lenticular bodies with a decametric extension where the thrombolites and siliceous sponges become very rare and we noticed the appearance of solitary corals. The lenticular bodies in this upper unit are surrounded by some ferruginous spaces with a surface strengthened rich in ammonite of sinemurian-carixian boundary.
The sedimentological and paleontological data-set of the N'Zala carbonate build-ups will be discussed according to a paleoenvironmental reconstruction provided. Our data seem to point to deep and open marine depositional conditions, we also note that this studied buildups could have developed below fair-weather wave base, mostly within reach of the storm wave base, in the lower infratidal to circatidal domain, in the sub-photic zone. The evolution of the described paleoenvironments seem closely related to a change of the sea bottom morphology resulting from a major platform dislocation step within the Lower Sinemurian-Upper Sinemurian transition period. Their localized persistence in the Upper Sinemurian could be related to the irregular distribution of the surrounding sediments or to the development of localized highs in the underlying substratum.

Characteristics and Genetic mechanism of Cretaceous Bashijiqike tight sandstones in the Kuqa foreland thrust belts, Tarim Basin, China

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The Cretaceous Bashijiqike tight sandstones are important gas reservoirs in the Kuqa Foreland thrust belts, Tarim basin. The Bashijiqike reservoir is low porosity and low permeability tight reservoir with average porosity of 4.6% and average permeability of 0.068×10^{-3} μm^2 in a current depth of 6000-7900 m. Integrated study on depositional environment, lithology, diagenesis and tectonism has been conducted to unravel the genetic mechanism of the tight reservoir. The development of deep effective reservoir is comprehensively controlled by the following multiple geological factors.
The distributary channel sand body in the delta front, which superimpose and extend very far towards the central basin, show stronger compaction resistance and more vulnerable dissolution owing to their coarser grain size, well sorting. Early carbonate cementation with about 6-9% components in eodiagenesis，which derived from the original alkaline pore water with saturated calcium carbonate under semiarid climate, and the special burial regime as early long-term slow shallow burial with late short-term rapid deep burial model could effectively retard compaction and help preserve porosity. Low paleogeothermal gradient (2.1 ℃/100 m) and paleogene thick gypsum-salt layers with high thermal conductivity suppressed pressure solution and limited late carbonate precipitation. Observation from thin sections, cathodoluminescence images show that concave-convex grain contacts and stylolite is not developed, late carbonate cement is minor (2-3%), authigenic quartz cement is minor (1-2%). Structural position has important controls on compaction and the distribution of fractures and subsequent dissolution, the structural position exposed to more intense stresses showed that the intergranular volume (IGV) decreased and the tectonic fractures increased, the increased fractures result in stronger dissolution of carbonate cements and feldspar. Deposition, diagenesis, tectonic should all be considered in the favorable reservoir prediction in the study area.

Controls of eustatic movement on the Cambrian Longwangmiao Grain Bank Reservoir in Eastern Sichuan Basin, China

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The Cambrian Longwangmiao carbonate grain bank reservoir is important gas exploration target in eastern Sichuan basin, China. Eustatic movement, deposition facies, diagenesis were determined through petrographic studies from outcrop, core, logging, geochemical analysis. The results show that there is a close relation between the development and evolution of carbonate grain bank facies reservoir with the eustatic movement. 1. Sea level change controls the stages and the plane distribution of the grain bank development. Longwangmiao reservoir mainly consists of a set of platform facies carbonate and evaporate, which are composed of dolostone and limestone with sandstone and mudstone and gypsum salt rock, and reservoir thickness of 60-120 m. It was thought Longwangmiao is a Ⅲ-sequence, and the transgressive system tract is thin, which composed of argillaceous dolomite and argillaceous limestone. The HST is divided the stratigraphic sequence into 3~4 Ⅳ-level sequence of shallowing upward cycles, which composed of grain dolomite, grain limestone and dolomicrite. The grain bank reservoirs form in the HST, and mainly distribute in the upper part of the secondary cycle, which shallowed the longitudinal accretion overall by the multi period to high frequency superimposed cycles, and this develops relatively large formation thickness grain bank and long stretching hundreds of kilometers beach belt. 2. The pore types of the grain bank reservoirs in the Longwangmiao deposited at the early of regression hemicycle are dominated by relic primary intergranular pores and intergranular dissolved pores resulted from burial dissolution, with rare early subaerial dissolved pores. While the pore types of the grain bank reservoirs in the Longwangmiao deposited in the late of transgression hemicycle are dominated by intragranular dissolved pores resulted from the early subaerial dissolution, with the early reservoirs being improved by late burial dissolution. 3. Evaporative pumping dolomitization and seepage reflux dolomitization are interpreted two probable dolomitization in the Longwangmiao reservoir. Dolostones is more developed in the HST than that in the TST. In the transgressive system tract, secondary dolomitization results in average dolomite intergranular porosity of 4-5%, and in the HST, strong dolomitization results in dolomite intergranular porosity of 7-9%. The fact proved that dolomitization and reservoir quality are controlled by eustatic movement.

Sedimentary characteristics and types of reservoir in Kelimoli formation, Tianhuan North, Ordos basin

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The Kelimoli formation within the lower Paleozoic stratum is the key object in Tianhuan North, Ordos basin. The analysis of the lithology in Kelimoli formation, which includes the dominant rock types of argillaceous limestone, dolomitic limestone and limy dolomite stone, shows a difference between the upper Wulalike formation including calcareous clay in the bottom and the lower Zhuozishan formation in which the micrite is dominant in the uppermost, and also shows that the Kelimoli formation developed in restricted platform ,open platform, platform margin reef and platform slope sedimentary environment.
The presence of the mass dark gray conglomerate and the slump structure in the core of Kelimoli formation reveals the presence of gravity flow whih distributes in south-northwarding and east-westwarding thicker in research area. In the aspect of physical property, the general porosity is ca.2%~3%, and the average permeability is about 0.194×10^{-3} μm^2 while up to 15.6×10^{-3} μm^2 locally. The main four types of reservoir are presented as gravity flow sedimentary reservoir, dolomite reservoir, the reef flat reservoir and the paleokarst fracture-cavity reservoir .And the paleokarst fracture-cavity reservoir is the most potential reservoir with excellent physical property, which distributes widely in Kelimoli foramation. Based on the drilling hole, paleokarst fracture and cavity usually develop on the slope of the paleokarst highland on which there is a strong hydrodynamic force. Meanwhile, the surface runoff runs slowly and permeates into the fracture in the limestone stratum much more, which enhance the karstification on the flat slope. And the paleokarst fracture-cavity reservoirs developed under the paleo-weathered crust in 0~150 m range with a normal distribution characteristic, and the karstification ,called bedding karstification ,will probably disappear when the distance is over 150 m. Therefore, it is significant to discover the hydrocarbon potential of Kelimoli formation based on the further analysis of reservoir.

The depositional architecture of Mass Transport Deposits from the Ventimiglia Flysch Fm. (Eocene, NW Italy): Implications for seafloor reshaping and turbidite deposition

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Submarine mass wasting is recognized as one of the main contributors to the reshaping of seafloors. A number of failure and transport mechanisms, including block and debris slides, slump and debris flow or any combination thereof are reported in the literature, reflecting the degree of disaggregation and the rheology of materials involved. Although recent advances in subsurface and seafloor imaging allow a gross characterisation of erosive and depositional features of mass transport deposits (MTDs), their sub-seismic architecture is still relatively understudied, limiting our comprehension of MTDs process sedimentology.
This study investigates an extensive 20-80 m thick MTD deposited as part of the Upper Eocene Ventimiglia Flysch Fm., the predominantly turbiditic infill of the Ventimiglia sub-basin of the Alpine foreland basin, NW Italy. The turbidites were sourced from the south and were deposited on top of the hemipelagic marlstones of the Middle Eocene Marnes Bleue Fm. (MB) within an N-S trending elongate depocentre. The MTD occurs around half way up the 1 km-thick preserved turbidite stratigraphy and crops out intermittently across a 5 by 15 km area. Field evidence of possible failure head scarps within MB (e.g. scalloped top and sections with reduced thickness), coupled with the paleotopography inferred from regional studies, suggest that the MTD resulted from a collapse of the western basinal slope via a mechanism of submarine slide block detachment.
The main features of the MTD include from bottom to top: i) a substrate zone where the underlying turbidites are deformed and locally detached; ii) a basal MTD surface, which locally cuts up to 20m into the substrate; iii) a clast-supported chaotic megabreccia with irregular top, composed of metre to decametre-scale MB blocks with sharp margins and intact internal stratigraphy and rare rafts of turbidite sandstones and iv) a matrix-supported crudely graded monomictic conglomerate of MB, partially filling the top irregularities of the underlying unit and becoming dominant in MTD distal reaches. In addition outsized MB blocks (up to 10s of metres thick, and 100s of metres in length) occur either in the lower unit or at MTD edges as isolated rafts. The lower unit is interpreted as the product of a submarine debris slide involving blocks of semi-lithified MB, whereas the uppermost conglomerate unit is thought to represent a trailing cohesive debris flow which develops by frictional abrasion of MB clasts and can outrun the main MTD deposit. Lastly, isolated rafts of MB are inferred to represent out-runner blocks. Spatial variations in MTD internal character and thickness allow three zones to be distinguished: i) a proximal zone where erosion prevails over deposition; ii) a dominantly depositional medial zone with positive relief and iii) a quickly tapering distal/marginal zone with highly irregular planform. The MTD erosion/deposition budget detailed here adds to understanding where major ponded accommodation space is likely to occur in association with MTDs.

New constraints for the Geological Time Scale for astrochronology of the Valanginian-Hauterivian stages (Early Cretaceous) from gamma-ray spectrometry signals

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Tethyan palaeoenvironments in the Valanginian and the Hauterivian stages are affected by a series of global perturbations in the carbon cycle, coeval with carbonate platform drownings, high levels of primary productivity, ecological turnovers and development of widespread black shale levels. Meanwhile, the volcanic activity of the Parana-Etendeka large igneous province (LIP) occurs between Southern America and Namibia. The linkage of this complex suite of events is not yet resolved, partly because the Early Cretaceous time scale needs to be better constrained. Here, we aim at providing a reference astrochronological framework for the Hauterivian Stage, that could be then anchored on radiometric ages to resolve the chronological relationships between volcanic and palaeoceanographic events.
Two sections are explored: La Charce (Vocontian Basin; SE France) is the GSSP candidate for the Hauterivian Stage and Rio Argos (Subbetic Domain; SE Spain) is the GSSP candidate for the Barremian Stage. Both sections are composed of hemipelagic marl-limestone alternations, in which clay mineral, geochemical and faunal contents reveal a cyclicity related to the lithological alternation. A total of 1,996 measurements of gamma-ray spectrometry (GRS) have been performed in situ, with a reproducibility of 5%.
Spectral analyses, performed to detect sedimentary cycles, allowed the 100-kyr and 405-kyr eccentricity cycles to be detected throughout the studied intervals. The total duration of the Hauterivian Stage is thus assessed at 5.93 ± 0.41 myr, which challenges the duration proposed in the Geological Time Scale 2012, but which is in agreement with most of cyclostratigraphic studies performed in the Tethyan realm. By anchoring this duration to the astrochronology of the Valanginian Stage (Martinez et al., 2013), and to the new radiometric ages extracted from tuff levels in Hauterivian of the Neuquén Basin, new ages are proposed for the base of the Valanginian Stage at -136.79 ± 0.76 Ma, the base of the Hauterivian Stage at 131.69 ± 0.76 Ma, and for the base of the Barremian Stage at -125.75 ± 0.76 Ma. In addition, a new age estimate is proposed for the onset of the Mid-Valanginian "Weissert" Carbon Isotope Excursion (CIE) at -134.96 ± 0.76 Ma. This new Cretaceous time scale is based on robust stratigraphically well-constrained radiometric ages and on a precise astrochonological framework. This study shows that the Parana-Etendeka activity coincides with the start of the Weissert CIE, confirming the relationships between LIPS and dramatic changes in the palaeobiosphere.

First characterization of the Maximum Interglacial (120 kyr BP) in the Ría de Vigo (NW Spain): A reinterpretation of the sedimentary infill

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The Ría de Vigo is the most southerly of the Rías Baixas of Galicia. This ria, with a total area of 176 km^2, has a distinctive funnel shape. The ria has a NE-SW central channel with a maximum depth of 55 m. Towards the inner part, the water depth decreases, with the lowest values in San Simón Bay (average depth = 7 m). The coastal area is characterized by granites and Paleozoic sedimentary rocks, metamorphosed during the Hercynian orogeny, and affected by NE-SW, N-S and NW-SE system faults.
Previous studies carried out in the Ría de Vigo attributed most of the sedimentary infill of the ría imaged in high resolution seismic records to the last 20 kyr. However, new geophysical, sedimentological and radiocarbon data obtained in the study area during seven surveys, lead us to make a new reinterpretation of the sedimentary record of the ría.
A total of seven sequences has been identified in the seismic records, where the oldest one (Sq1) is preserved in troughs between the preexisting faults, in the deepest and outer areas of the ria, and it was deposited during the Miocene-early Pleistocene. Sequences Sq2 to Sq5 were deposited during the Riss-Würm (130 kyr ago) and the Würm (20 kyr) glaciations. The sequence Sq6, also of Pleistocene age, is attributed to the sedimentation occurred in the ria after the Last Glacial Maximum, and is confined to the outer and deeper areas of the ria. The youngest sequence Sq7 corresponds to the Holocene sedimentary infill. The changes in the sedimentary environments of the ria along the last 60 kyr are reflected in the sedimentary facies recovered in the vibrocores and are mainly driven by climatic conditions and relative sea-level variations.
In the light of new results, a new and accurate sea level curve for the last 130kyr can be elaborated for the Atlantic Galician coast.

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Influence of sediment supply on the stratigraphic architecture of a Gilbert-type delta complex (Pliocene Siena Basin, Italy)

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The stratigraphic architecture of Gilbert-type deltas is mainly controlled by three factors: relative sea-level variations, tectonics and the amount of sediments supplied to the river mouth. Variations of sediment supply can be connected to several factors often acting in a not easily predictable way and consequently estimate this value in ancient settings is often impossible.
In this contribution, we present the preliminary results of a study carried out on a Pliocene Gilbert-type delta complex located in the southern Siena Basin (Tuscany, Italy). This complex is composed of two coeval deltaic branches, spaced about 400 m apart. The coevality of the branches ensure that, eventually climate-induced base-level changes would influence the delta complex in the same way. Moreover, some stratigraphic markers at the base and at the top of the successions documented the fact that subsidence acted uniformly in the area during deposition. Concerning the sediment supply, even if absolute estimation is impossible, some stratigraphic data (e.g. distributary channel dimensions and the average grain size of the sediment supplied) allow the relative estimation of the amount of sediment delivered to each delta branch. Consequently, this deltaic complex represents a good natural laboratory for testing the effect of sediment supply variations on the stratigraphic architecture of Gilbert-type deltas.
More specifically, the delta branch characterized by a great sediment supply shows high foresets (of up to 60 m) and a well-expressed progradational and aggradational trend. Conversely, the coeval delta branch which receives a minor amount of sediment is composed of smaller delta foresets (of 5-8 m) vertical stacked up to form an aggradational and retrogradational stacking pattern. This suggests that, in the former case, the amount of sediment supplied to the river mouth is enough to balance and overcome the created accommodation space, causing the contemporaneous aggradation and progradation of the system. In the latter case, the amount of sediment is not enough to balance the created accommodation space. This study suggests that sediment supply can play an important role in the stratigraphic architecture of Gilbert-type deltas, and that the amount of sediment delivered to river mouths can drastically change over short distances (i.e. within the same deltaic complex and/or basin). Consequently, this controlling factor must be taken into account, even for small and confined settings.

The oldest ice crystal casts, in the Neoproterozoic Luapula Beds, NW Zambia: Evidence for freezing temperatures in the aftermath of the Marinoan glaciations

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The Neoproterozoic Katanga Supergroup of Central Africa (Zambia and D.R. Congo) contains two major diamictite units, formed during “Snowball Earth” glaciations: the Grand and Petit Conglomerats, occurring within the Nguba and Kundelungu Groups respectively. The older Grand Conglomerat is correlated with the global 750-710 Ma Sturtian glaciation, while the Petit Conglomerat is correlated with the ca. 635 Ma Marinoan glaciation. The Petit Conglomerat consists mainly of a diamictite varying in thickness from 80 m in the north, to <25 m to the S and W. It is very widespread, covering an area of >65 000 km^2.
On the NE margin of the Katangan basin, equivalent rocks of the Petit Conglomerat in the Luapula Beds (NW Zambia) onlap against the basement rocks of the Bangweulu Block. They are ~100 m thick, and consist of a series of alternating conglomerates and poorly sorted pebbly sandstones with scattered angular to subangular pebbles, many of which exhibit a triangular form and faceted appearance. In places these sandstones grade into pebbly wacke-stones. These facies are interpreted as periglacial outwash gravels. Immature, feldspathic, pebbly sandstones, which are interbedded within the conglomerate complex are trough crossbedded with ripple marks, and have peculiar cracks with polygonal outlines in plan view, resembling patterned ground typical of periglacial regions. These are interpreted to be a relict three-dimensional network of ice veins in a permafrost environment.
Overlying the Petit Conglomerat Formation in the Luapula Beds, there is a thinly laminated pink dolomite, interpreted as a cap-carbonate deposited during post-glacial transgression. This grades upwards into fine-grained red shales (Upper Shale) with well-preserved flat-topped ripple marks, and tool marks, including vortex-related obstacle marks. At one locality (S11°22’50.6”, E28°27’14.7”), the Upper Shale contains bedding-plane markings consisting of linear grooves up to 45 mm long and 2 mm wide, which taper at both ends. Longer, thicker grooves tend to be parallel, while shorter, thinner grooves either intersect these, or branch off from them at angles >60°. The grooved shales have been examined using high-resolution microfocus X-ray tomography. The results show that the grooves were produced by an indentor, which also caused slight compaction of the sediment immediately under some grooves (which shows up as denser material, causing greater attenuation of X-rays). The grooves range in thickness from 4 mm to 0.5 mm, and are 1 to 0.5 mm deep, with equant to dish-shaped cross sectional profiles. They intersect at angles ranging from 35° to 85°. The grooves closely resemble impressions of water ice crystals growing in modern sediments, and are interpreted as having formed by intrasediment ice crystal growth, during which downward crystallization pressure was exerted on the underlying sediment, resulting in greater compaction under some crystals. These impressions are the oldest known fossil imprints of ice crystals (previously known from Eocene, U. Cretaceous and U. Devonian beds), which grew under conditions of sub-freezing temperatures, within the sediments. They indicate that in the Luapula Beds, cold temperatures (possibly diurnal?) still prevailed in postglacial environments in the aftermath of the Marinoan Snowball Earth glaciation.

A large fluvio-deltaic system evidencing the final stages of the Paratethys evolution at the East Carpathian foreland

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The focus of the study is the Balta Formation (BF – hereafter). It is a large accumulative body with unclear boundaries and origin occupying the uppermost parts of the modern uplands of the south-western borderland of the East European Platform and fringing the Carpathian Orogen. Its age is estimated as Middle Sarmatian–Early Pontian (Tortonian in the international timescale). This study presents the first integrated lithofacial analysis brought up to define the genesis of the BF. It is based on more than 100 studied outcrops supported by numerous borehole logs. Additionally, the study involved analysis of data on stratigraphy, paleontology, paleoecology and palaeogeography. We identified seven sandy and two muddy lithofacies, which were further used to describe their frequent stacking patterns – one river and three deltaic successions.
The river succession consists of simple channel and overbank units. Corresponding river could be defined as sandy flat-land meandering, with biphase hydrologic regime and enriched with fine suspended load. The two most widespread deltaic successions evidence unstable channelized flows which are believed to be interdistributary channels; the remaining succession suggests weak currents indicating probable delta front position. Together with rarity of wave induced facies, these facts imply a fluvial-dominated deltaic environment. According to thickness of sandy units, the paleodepth of basin adjoined to delta was less than 10 m. This suggests dominance of friction forces in the river mouth causing limited distribution of sediment towards the basin and significant erosion in delta front zone. Additionally, the faunal data indicate that basin had reduced salinity suggesting the possibility of homopycnal flow. All these conditions could be responsible for inexpressiveness of progradational (coarsening upwards) trend. In fact, most deltaic successions begin with a sharp contact of sandy units with underlying uniform muds. The deltaic interpretation is supported by a wide spectrum of independent conclusions, primarily including paleoecology and paleoclimate.
On a larger scale, the deltaic successions are identified as high-frequency allocycles, determined by relative basin-level oscillations, which were induced by tectonic and (or) climatic factors. The cycle begin with delta progradation associated with stable or falling relative basin-level and end with delta abandonment and advance of basin environments due to relative level rise.
In result of this study, the BF amalgamated many deposits that previously described as separate stratigraphic units but showed great lithofacial unity. In this volume, the BF goes over into other sandy deposits of a coastal environment towards the east and west; in southward direction and downwards it is replaced by thick offshore muds. It represents a gentle monocline dipping in S-SE direction with a thickness reaching 350 m.
The occurrence of successions on different levels and vast area suggest that development of the BF as a depositional system occurred in lateral and vertical directions; first of which was determined by general basin regression and second – by cyclic accumulation. The BF could be concluded to be one of the final stages of the Paratethys basin evolution, evidencing its retreat.

Silica diagenesis in spicule-rich carbonates and siliciclastics: Tempelfjorden Group (Middle-Upper Permian), Loppa High and Svalbard, Norwegian Barents Sea

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The origin and diagenesis of marine cherts is still under investigation after a century of research. It is widely accepted that silicification process begins at an early stage of burial and is controlled by the composition and thermal history of a host biosiliceous sediment. Nevertheless, the role of substrate composition and fabric (e.g., presence and distribution of organic matter, carbonate material, and clay minerals, spatial variations in permeability, or pH of pore waters) in the process dynamics and emplacement of chert is not fully understood yet. This study further explores the issue of substrate control for selective silica replacement, based on the chert-bearing succession of the Middle-Upper Permian Tempelfjorden Group, the Barents Sea. We examined chert and host facies in one core in the Loppa High (an isolated, easterly-dipping paleohigh close to the Norwegian coastline) and in several outcrops in the Svalbard archipelago (a distal segment of the northern Pangean shelf). The two localities differ markedly from each other with respect to depositional facies, diagenesis, burial history, and silicification patterns, but both record all stages in silicification progress, including a final complete replacement. The 200-m-thick Svalbard succession consists largely of black bioturbated, spiculitic, calcareous mudstones-packstones with less contribution of bioclastic tempestites and sandstones. The strata were buried during the Mesozoic to the depth of around 3 km. The chert occurs as: 1) replacement of skeletal grains; 2) mm-thick rings around burrows or replacement of a burrow infill; 3) nodules that mimic a nodular (bioturbated) fabric; 4) irregularly-shaped nodules cross-cutting sedimentary interfaces; 5) laterally extensive beds and lenses; and 6) void- and fracture-filling cements. In contrast, the 50-m-thick Loppa High core comprises, in the lower half, brown bioturbated spicule-rich dolostones and, in the upper half, a poorly-sorted breccia which most likely resulted from the emersion and karstification of the underlying terrain in the uppermost Permian and subsequent cave-system collapse in overburden by the overlying Triassic deposits. The chert replaces: 1) a burrow-infilling sediment; 2) both nodules and matrix within the primary bioturbated dolostones; 3) clasts within the breccia; and 4) the entire fabric of the bioturbated dolostones and breccia. Despite the variety of macroscopic forms, the chert mineralogy is simple in both localities and includes principally microquartz that replaces bulk fine-grained background sediment and some bioclasts, lutecite that partially substitutes shell structure, and chalcedony and megaquartz as a pore-filling cement. Both examples show that silicification took place very early and preceeded compaction, cementation, and brecciation. The main factor controlling selective replacement within a substrate was spatial variations in permeability which were in turn related to bioturbation. The silica was derived from dissolution of sponge spicules and the chert development continued until the local silica source was exhausted.

Epigenetic silicification of Upper Oxfordian limestones in the Sokole Góry (Kraków-Częstochowa Upland)

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An epigenetic mineralization was encountered in the Oxfordian bedded limestones exposed in the Sokole Góry situated in the Kraków-Częstochowa Upland (Southern Poland). Various types of mineralized rocks were observed: porous, silicified limestones accompanying the joint systems and faults, crusts capping the erosional surface of limestone beds and continuous zones of silicified limestone rimming the early-diagenetic cherts. The main epigenetic mineral is cryptocrystalline, granular quartz accompanied by minor goethite, hematite, barite, galena and sfalerite.
The bedded limestones have been subjected to intensive tectonic deformations since the early diagenesis, which facilitated their later, epigenetic silicification. The first dislocations affected partly non-lithified sediment, as documented by deformations of early-diagenetic cherts. In the subsequent, prolonged deformation stages, the already lithified limestones were fractured and faulted resulting in brecciation of a part of early-diagenetic cherts.
The epigenetic mineralization of bedded limestones was at least a two-stage process. During the first, Early Cretaceous (probably Valanginian) stage, under the subtropical climate conditions, the pedogenic silcretes had formed at the erosional surface of denudated Upper Jurassic carbonate complex. Such silcretes highly limited the progress of the first karstification phase of Upper Jurassic carbonates initiated in the Hauterivian. The sources of silica accumulated in pedogenic silcretes were descending solutions enriched in silica derived from the weathering zone. This silicification affected the topmost part of Upper Jurassic carbonate complex and migrated through the vadose zone into the deeper portions of bedded limestones along the joint systems and stylolites. The Early Cretaceous tectonic activity generated new dislocations and re-opened the existing faults, which were subsequently filled with permeable Albian quartz sands. These openings have become the migration pathways for ascending, warm, relic, sulfide-carrying hydrothermal solutions at the second formation stage of epigenetic mineralization. The new solutions partly dissolved the limestones and altered the Lower Cretaceous pedogenic silcretes as well as leached silica from the Albian quartz sands, which filled the fissures and covered the Jurassic limestones. The newly supplied silica precipitated on pedogenic silcretes and, as concentric rims, on brecciated, early-diagenetic cherts. The second-stage mineralization proceeded under phreatic conditions, presumably close to a fluctuating zone of the mixing of ascending, warm hydrothermal solutions and descending groundwaters, which is typical of the formation of groundwater silcretes. The brecciated cherts acting as silica crystallization nuclei indicate that the second mineralization stage followed the final phase of Cenozoic faulting.

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Stratigraphic framework and sedimentation controls on deposition of the Lower Old Red Sandstone of the Midland Valley of Scotland and associated outliers

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The 9 km thick Lower Old Red Sandstone (LORS) succession of the northern part of Midland Valley Basin ranges from Wenlock to Emsian in age and is heavily dominated by conglomerates in the east, passing westwards into sandstones and siltstones. Deposition occurred mainly through fluvial and alluvial systems with facies developing mainly across the Strathmore region, but also with associated deposits occurring northwards across adjacent areas of the Scottish Highlands. Despite advances in provenance studies in recent times the true tectonic setting of the basin and origin of a source terrane is poorly constrained. Palaeocurrent data reveals conflicting evidence for sources to the north, east and south, while grain size distribution suggests a proximal source possibly lying to the east of the basin. In addition, provenance data suggests a northern and unknown easterly source of sediment. Significant uncertainties also exist in the understanding of lateral facies variation across the basin, and subsequent correlation with the LORS outliers. Point counting can give a quantitative analysis of the composition of the sandstones or conglomerate matrices, and when combined with other measures such as clast count data and palaeocurrent indicators can be used to further constrain stratigraphic relationships. The aim of this work is to better establish the stratigraphic framework of the northern Midland Valley Basin and associated LORS outliers and to establish the key controls and source of sedimentation during deposition of the LORS.

The application of automated mineralogy to the heavy mineral provenance of Permo-Triassic red-bed successions in SW England

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Sedimentary rocks from the Permo-Triassic New Red Sandstone (NRS) of SW England were used to test regional heavy mineral provenance correlations. Automated mineralogy was used to analyse and categorise heavy mineral concentrates, by QEMSCAN technology (Quantitative Evaluation of Minerals by SCANning technology); a user defined SIP (Species Identification Protocol) was produced to differentiate heavy mineral groups. The SIP was tested against traditional microscopy techniques and mineral categories were also verified by electron-microprobe analysis.
A robust methodology was developed, involving an aqueous solution of sodium polytungstate (SPT) with a specific gravity of 2.9, to produce heavy mineral assemblages with minimal incorporation of diagenetic iron-oxide grain coatings. The heavy mineral separates predominantly comprised tourmaline, rutile, biotite, zircon, ilmenite and sometimes garnet. QEMSCAN analyses were compared against other techniques to both validate the SIP categories and optimise the SIP for these assemblages. QEMSCAN output included: semi-quantitative statistical data, so-called due to reduced element calibrations in comparison to the electron-microprobe; and false coloured mineral maps, which were used in combination with the prepared heavy mineral separations, for example targeted mineral analysis using the electron-microprobe. Data is typically represented using relative bar and pie charts for selected heavy mineral groups, such as the opaque fraction or 'common' heavy minerals fraction.
The variability of heavy mineral assemblages was tested; laterally along the same beds using two examples, one from the Permian another from the Triassic; vertically across beds of the Permian Newton St. Cyres Breccia Formation; and finally in a regional study of the Triassic Sherwood Sandstone Group. Results indicated that regional correlations between samples could be made with confidence, and localised source inputs could be identified, of which some may represent local reworking of the older parts of the NRS succession while other minerals likely represent direct erosion of igneous sources. Persistent, long term heavy mineral signatures were identified, in part represented by tourmaline from the denudation of the Cornubian Batholith to the west, and also staurolite as an indicator heavy mineral from older metamorphic sources to the south of the area. These long term background signatures were tempered locally by less common heavy mineral representations of garnet (andradite and spessartine) and apatite.
The application of heavy mineral provenance studies to barren red-bed sequences has significant implications for the oil and gas industry. The technique can accurately detect provenance trends in large scale regional studies, and this research has already created interest in applications to North Sea Triassic red-beds, however, it does require sample preparation and careful sample selection for optimal representation of the formations of interest. The application of automated mineralogy using QEMSCAN allowed a large amount of data to be collected in this research compared to traditional methods, and therefore helps to improve the quantity and quality of data and subsequent interpretations.

Sequence stratigraphy and sedimentary architecture of the Palaeozoic intracontinental Parnaíba Basin, NE Brazil

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Intracontinental sedimentary basins are poorly understood, with little agreement on the tectonic processes that lead to their formation and the subsidence mechanism(s) controlling these large basins over time. There are additional uncertainties regarding controls on stratigraphic architecture and the variation in volumes of contained oil and gas reserves. This paper seeks to address some of these areas of conjecture using the example of the Parnaíba Basin, which spans several states in NE Brazil. The Parnaíba Basin is a Palaeozoic intracontinental basin covering an area of 600 000 km^2 and containing a sedimentary fill that spans the Silurian-Cretaceous periods. The sedimentary succession has a maximum thickness of 3.5 km, representing a range of climatic conditions and depositional environments. There is evidence of multiple transgressive-regressive sedimentary cycles. Published chronostratigraphic compilations represent 2D transects; the most recent of these being a stratigraphic chart, published by Petrobras in 2007 which is oriented NW–SE across the basin. This chart emphasises basin-wide unconformities formed in Early Devonian, Early Carboniferous, Late Carboniferous, Late Triassic, Middle Jurassic, and Late Jurassic times. These unconformities separate layer-cake packages of sediment, again of basin-wide extent. Recent publications have built upon this simple 2D framework, providing updated biostratigraphic and paleogeographic interpretations. However, this transect (which may be correct in the NW-SE orientation) does not accurately depict the complex stratigraphic relationships in this large basin. Detailed analysis of the existing geological map using ArcGIS indicates local unconformities in the SW and east of the basin, with complex subcrop patterns rather than the parallel architecture of the current stratigraphic model. These observations are backed up by well and seismic data, petrophysical analysis, and outcrop observations from two field seasons. We will present a novel, detailed wrap-around stratigraphic chart for the Parnaiba Basin. The results are shown both in time and in depth. This work aids a more sophisticated understanding of the basin architecture than existing 2D stratigraphic columns and has allowed us to better interpret local tectonic events in this large basin. This work will improve understanding of the Parnaíba basin in particular and of intracontinental basins in general.

Calcium carbonate spherulites or just botryoidal growth?: Insights from a sublacustrine and alkaline carbonate setting

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Although carbonate spherulites are well known to form in a wide range of carbonate environments, the environmental conditions that underpin their origin are poorly constrained. To understand the sedimentology of spherulitic carbonate deposits, we must disentangle the chemistry and origin of the water involved in the precipitation of these sort of facies.
We have analysed an interesting type of unique fabrics (calcium carbonate spherulites, botryoidal crusts, and spherulitic boundstones) formed in sublacustrine carbonate settings (Carboniferous, East Kirkton Limestone, Scotland). Some of these precipitates grew in close association with organic- to mudstone-rich argillaceous matrices, primary fine-grained chert, and volcaniclastic-igneous tuffs.
Spherulitic 'floatstones' are the most abundant component (spherical to sub-rounded carbonate particles, up to 3 mm in diameter, with sweeping extinction) commonly displaying a nuclei (tiny micritic/ ash intraclasts or woody fragments) upon which fibro-radial calcium carbonate crystals grew normal to the core.
Alternatively, widespread botryoidal crusts (individual and compound fans made of submillimetre-thick calcium carbonate 'spherulitic' fabrics, also with sweeping extinction) were observed partially coating previous carbonate surfaces and grains.
A detailed petrographic analysis of the syndepositional and deformational (burial) microfabrics lend support to the view that both spherules and botryoidal crusts may have an origin as primary coated-grains rather than being formed as secondary burial products. Accordingly, these weird carbonate nucleation patterns do seem to have acted largely in the sediment-water interface rather than beneath the sediment.
We present a hypothesis that hydrolysis of the alkaline igneous basement originated the rare lake water chemistries that permit spherulitic and botryoidal growth to develop. A revealing sedimentological model, which integrate classic approaches and new biogeochemical paradigms, is also presented.

Impact of stevensite minerals in the nucleation of abiotic $CaCO_3$ spherulites: An experimental approach

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The role of extracellular polymeric substances (EPS) and aminoacids in the nucleation of calcium carbonate spherulites and associated carbonate species is well-known, but still poorly constrained. Moreover, alkaline and saline lacustrine carbonate environments are also prone to generate authigenic hydrated magnesium clays (stevensite group). Here we present a novel and tightly-controlled microcosm experimental work which aims to understand the role of hydrated magnesium clays in solution (stevensite) on the type, morphology, and carbonate precipitation rates. Experimental solutions were generated from large batches of a synthetic cell-free solution designed to be similar to waters found in hyperalkaline, saline lakes (using composition drawn from Mono Lake, California). Experiments were performed under complete sterility (powdered chemicals and glasswear were heat-sterilised by autoclave at 160°C for 2 hours). Flasks were sealed and agitated by a flask shaker and maintained for 24 or 45 days at 25°C. Elemental x-ray analyses and SEM observations were carried out on the silicate and carbonate precipitates obtained after experiment termination.
Our results demonstrate that a high alkaline and high saline cell-free synthetic solution enriched in EPS organic molecules influenced the precipitate morphology giving rise to spherular and botryoidal crystal shapes. Furthermore,the same synthetic solution supersaturated in stevensite failed to promote nucleation of abiotic calcium carbonate spherulites and botryoidal crusts. Surprisingly, only patchy prismatic subhedral to euhedral calcium carbonate crystals were formed under these conditions: the presence of dissolved stevensite minerals reduced the precipitation rates of calcite. These findings suggest that the nucleation of spherulitic calcite and botryoidal crusts is more likely to occur under the influence of organic complexation processes than through the catalysis of hydrated magnesium clays.

The response of limnic and swampy ecosystems to the Holocene abrupt climate changes recorded in the sediments from two river valleys in NW Poland, Baltic Sea area

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Climate changes and water level fluctuations associated with them are known to be ones of the major drivers of ecosystems evolution during Holocene. The general trend of early and middle Holocene climate transition from cool to warm and late Holocene deterioration of thermal conditions is punctuated with several short-term climate fluctuations of an abrupt character, such as PBO, 8.2 or 4.2 ka. Water level changes are an element of the environment that strongly responds to changes induced by both global (climatic) and local / regional (e.g. post-glacial rebound) factors and in the same time is quite easily traceable in the fossil record of different groups of organisms.
In this study we uses the results of macrofossil analysis of different taxonomic groups of aquatic and wetland organism, non-pollen palynomorphs analysis and the geochemical analyses of sediments to reconstruct the Holocene changes of the local lacustrine and swampy ecosystems in two river valleys in NW Poland – the Dziwna and the Rega, both discharging into the Baltic Sea – with a special regard to climate changes and palaeohydrological processes.
In the study area we identified a number of palaeohydrological events of various origin. In the early and middle Holocene they were primarily a result of climate change, and some of them are likely to be associated with cool oscillations recorded on a global scale (rapid climate changes RCC or abrupt climate changes ACC); these include 8.2 ka and 4.2 ka events. On the studied sites in the Dziwna and Rega valleys, the 8.2 ka event resulted in water level rise, expressed as the beginning of the biogenic sedimentation after a long term hiatus. The 4.2 ka event had a significant impact on the local ecosystem in the Dziwna valley and contributed to the shift from lacustrine to riverine conditions. Increase in the frequency of extreme weather events was reported for that time in many sites worldwide. Also in the Dziwna valley sediments, a strong palaeobotanical and geochemical signal documents the catastrophic event, probably a storm of significant strength, which resulted in intrusion of the marine waters into a former lake. This substantial event began the fluvial phase of the site development and started the domination of the Baltic Sea impact on the environmental conditions.

Calcareous nannofossil dating and microfacies analysis of Late Cretaceous deposits from Zakynthos Island (Preapulian Zone, Ionian Sea, western Greece)

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The Ionian islands are situated on the west part of the Hellenic Arc, part of the most active plate margins in the Mediterranean.
The westerly-verging Hellenides fold-and-thrust belt in this area comprises the deformed Meso-Cenozoic basinal succession of the Ionian Zone, which thrusts over the time equivalent slope unit of the Preapulian Zone. The basal front of this tectonic contact outcrops along the eastern edges of Kefalonia and Zakynthos islands.
Furthermore, the palaeoenvironmental transition between the Late Cretaceous persistent carbonate platform 'Apulian' facies and the time-equivalent 'Pre-Apulian' facies is exposed on the island of Zakynthos.
Nannoflora analyses is conducted for the first time, providing detail dating of the outcropping Cretaceous strata. Also, microfacies are investigated in order to appreciate the changes of palaeoenvironments during the Late Cretaceous.
Thick-bedded calcareous strata outcrop on the westernmost edges of the island, and contain microfacies and microfossil assemblages characteristic of the edges of Cretaceous carbonate platforms, including rudists in life position. The remainders of the Cretaceous outcrops are composed by slope facies, comprising an intercalation between thin-bedded, fine-grained pelagic calcareous strata and thicker-bedded and coarser-grained depositional events. The latter can be sub-divided into massive megabreccias strata, dominated by near platform microfacies, (wackestone-packestone) and thinner-bedded calciturbidites, which are composed by a mixture of pelagic microfacies and re-transported neritic assemblages.
Most of the samples proved barren of calcareous nannofossils, perhaps due to an intense diagenetic and tectonic history. However, a section to the south of the island (Lithakia-Agalas) was both continuous and relatively prolific. In the investigated section, strata form a north-east-dipping monocline, spanning the transition from the edge of the Apulian platform (to the westernmost edges) and the Pre-Apulian slope facies.
Calcareous nannofossil assemblages are dominated by *Watznaueria barnesae*, *Quadrum garneri* and *Retecapsa crenulata*. Campanian-Maastrichtian markers such as *Reinhardtites levis*, *Quadrum trifidum*, *Broinsonia parca* [range: UC15e (72.05Ma)-UC14 (81.43Ma)] occur in the central and eastern part of the island, indicating a Campanian–Maastrichtian age. Older nannofossil assemblages were logged in the westernmost part of the study section. The sediments are either lower Late Cretaceous strata revealed to the west of the section because of the geometry (consistent with the dip of the strata) and/or represent the contribution of older material eroded from the edge of the platform and re-deposited on a proximal slope area.
The only other sampled sections containing nannofossils are in the northern part of the island, around the village of Orthonies. Here, a typical slope succession (alternations between thinner-bedded more pelagic strata and thicker-bedded re-sedimented deposits) are characterized by poor nannofossil assemblages. This succession is not older than Turonian, as suggested by the occurrence of Micula staurophora, and the oldest part of the section is not younger than Early Campanian, as indicated by the presence of *Lithastrinus grilli* [range: Early Campanian to Late Coniacian; UC15d (75.93Ma)-UC11 (86.50Ma)].

Sediment-fauna interactions in recent fluvial deposits (Dunajec River, SE Poland)

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Riverine system is a particular place for interactions between biosphere and the deposited sediments. It is characterized by large energy gradients in relatively short time, which forces special adaptations of burrowing animals recorded in bioturbational structures (Buatois & Mángano, 2004). Predators produce mainly shelter burrows (interpreted as domichnia), and saprofags, especially earthworms, produce locomotion and feeding structures (pascichnia). Such structures have been studied in non- or poorly vegetated, sandy or muddy Holocene alluvia in the lower reach of the Dunajec River flowing through the Carpathian Foredeep in SE Poland. The observed burrows are mostly produced by a variety of organisms, including the European mole (*Talpa europaea*), common earthworm (*Lumbricus terrestris*), ground beetles (Carabidae), solitary bees (*Ammophila*), red fox (*Vulpes vulpes*), European beaver (*Castor fiber*), shrews (Soricidae), European otter (*Lutra lutra*), several species of mice (Muridae), voles (Myodae, Microtae), and the swallow sand martin (*Riparia riparia*). Burrows of a few species of ground beetles have been subjected to more detailed studies (Mikuś & Uchman, 2013a). Fertile deposits of older (early to middle Holocene) terraces, formed with many long-term interruptions in sedimentation processes, have a well-developed soil levels, more vulnerable to burrowing than recently deposited sediments. The terraces contain layers of sands and muds, which primary sedimentary structures and layer boundaries are completely or partly disturbed by bioturbation. Organic-rich muds have been moved up and down and mixed with sand. Moreover, sediments have been leached into open burrows during floods or rainfalls. In the natural levee sediments, mostly fine to medium sands, are horizontally burrowed, foremost by earthworms (Lumbricidae). Vertical, long (over 2 m deep) burrows of larger earthworms cross cut the natural levee sediments and enter buried soils. They were formed during a long period between flooding events reaching into the soil profile. Not rarely, the vertical burrows follow living or dead roots. As the European mole feed on earthworms, their burrows commonly co-occur. Diversity and abundance of burrowing animals in the riverine environment are mainly controlled by water-level fluctuations, foremost these which cause floods or droughts. According to our preliminary observations, the highest biodiversity of infauna occurs under moderate level of river disturbances. With low level of disturbances, larger, long-living species dominate, whereas with high-level disturbances small, short-living forms prevail (Mikuś & Uchman, 2013b).

Unusual speleothems from a non-spelean environment - Mineral precipitates of the Széchenyi Spa (Buda Thermal Karst, Budapest, Hungary)

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Széchenyi Spa receives its water-supply from the Városliget-II water well tapping the deep karstic reservoir of the Buda Hills. The yield of the well is 379,5 l/min, temperature: 76 °C, TDS: 1774,5 mg/l. Water is conducted from the well-head through 200 mm diameter pipes into cylindric storage tanks from where it is conveyed to the users, according to actual demand. Flow velocity decreases in the tanks and, as a result of the sudden pressure drop, gases (CO_2 and H_2S) escape and dissolved solids precipitate. In 2012 when after ~ 50 years of operation cleaning of the storge tanks became necessary we had the opportunity to descend into one of the empty tanks to investigate the unusually rich, spectacular mineralization on site. Samples were taken and afterwards analysed in the laboratory (optical and CL-microscopy, XRD, SEM, isotope-geochemistry).
The bulk of the precipitate formed under phreatic conditions, at the bottom and along the lower reaches of the walls of the tank. It proved to be low-Mg calcite, forming loose microsparry „aggregates" the upper (outer) surface of which was overgrown by coarse-grained sparry crystals. In the latter, occasionally, small clusters of aragonite-needles could be detected as inclusions. Along the walls of the tank white gypsum crusts were also observed. In the upper part of the tank, where - as a result of daily water-level fluctuations - conditions repeatedly changed from phreatic to vadose, varicoloured Fe-Mn oxide crusts covered the calcareous endrustation of the walls, suggesting that divalent Fe and Mn dissolved in the thermal water became oxidized and precipitated on contact with atmospheric oxygen. Abundant vertical dissolutional grooves cut into the calcareous crust in this redox zone point to probable ferrolysis in action accompanying the hydrolysis of these cations.
Macro- and micromorphology and mineralogy of the precipitates and the chemistry and temperature of the thermal water are displayed and the analogy with speleothems known from Pleistocene to Recent caves of the Buda Thermal Karst is discussed.

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Algae and palaeoenvironment: Case study of upper Jurassic-lower Cretaceous limestones from Piatra Craiului (South Carpathians, Romania)

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Situated in the eastern part of the Southern Carpathians (Romania), the Piatra Craiului massif represents a fragment of the eastern sector of the" Getic Carbonate Platform". This carbonate platform system covered the Southern Carpathians during the late Jurassic-early Cretaceous. The 800 to 1000 m thick carbonate succession of the Piatra Craiului massif represents a huge regressive sequence. It begins with external-platform to slope deposits in the Kimmeridgian, followed by platform margin (reef limestones) in Early-Middle Tithonian, platform interior in the Late Tithonian-Lower Berriasian, and peritidal limestones (mostly intertidal and supratidal) in the Upper Berriasian-Lower Valanginian.
We analysed four main sections measured in the northern part of the Piatra Craiului massif in order to correlate the calcareous algae record with the main facies of the limestone and to establish an algae-environment correlation.
Eight microfacies (MF) types have been separated. The MF1 and MF2 (coarse bioclastic rudstone and coral-microbial boundstone) are the main components of the reef-slope and platform-margin environments. The MF3 and MF4 (bioaclastic-intraclastic grainstone and ooidal-peloidal grainstone) characterise the innner platform environments. The MF5 to MF8 (fenestral wackestone, cyanobacteria-bearing bindstone, fenestral-bioclastic packstone/grainstone and non-fossiliferous mudstone) are characteristic for the peritidal, frequently restrictive, most internal platform environments.
The presence of calcareous algae can be related with two major associations of depositional environments:
1) Reef-slope and platform-margin environment, with *Clypeina sulcata*, *Petrascula bursiformis* and *Salpingoporella pygmaea*, and
2) Internal platform environment with
2a) subtidal domain, containing *Campbelliella striata*, *Clypeina parasolkani*, *Clypeina sulcata*, *Salpingoporella annulata*, *Salpingoporella pygmaea*, *Steinmaniporella kapelensis*, and
2b) intertidal and supratidal domain, with dominant rivulariacean-type cyanobacteria.
The last 300 m of the carbonate succession from Piatra Craiului is dominated by these peritidal limestones mostly with very shallow subtidal, intertidal and supratidal carbonate deposits. Within this succession a recurrence of typical high-energy subtidal platform-interior deposits was recorded at some levels, with large dasycladaleans: *Pseudocymopolia jurassica*, *Salpingoporella praturlonii*, and *Selliporella neocomiensis*.
Concluding: The Kimmeridgian to Lower Valanginian carbonate deposits from Piatra Craiului indicate a general trasition from slope and platform-margin to internal platform environments. Dasycladalean algae have been frequently identified within the carbonate platform margin and subtidal platform interior. In the more internal areas, restrictive, lagoon or intertidal pond-type environments developed in which cyanobacteria flourished.

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Presence of rare earth metals in Late Triassic Hallstatt Limestones, Northern Calcareous Alps (Austria, Germany)

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New biostratigraphic, sedimentological, and geochemical data and a thorough review of existing literature modify existing knowledge on the sedimentology, palaeogeography and ocean acidification of the Late Triassic Hallstatt margin from the Northern Calcareous Alps. Criteria are drawn from examples on the variegated Hallstatt facies of the Kaelberstein quarry, Germany and the Bad Duerrnberg church section, Austria. The siliceous, deep-water limestones of the Poetschenhoehe quarry, Austria represent the oceanward sedimentation on the Triassic passive continental margin.

In Early Norian hemipelagic settings, distant to large carbonate platforms, shedding of carbonate mud during sea-level highstand has still major control on sediment accumulation rates. In the Lacian 2, the Massiger Hellkalk is formed in high sedimentation rates by low energetic, biturbated biomicrites of deep-water biota. Seismic shocks induced by an initial stage of ?strike-slip tectonic or ?an extensional pulse, favour in monomict breccia horizons mixing advection of seawater through the sediment, coupled with a Na-Cl-anomaly and singular negative shifts of O-isotopes. Shallow-burial fluid flow and acidic formation fluids of surface-near temperatures drive rapidly the accumulation in the homogenized sediment and thus favour sulphate reduction and an anaerobic methanotroph archaea, which is suggested by a biodegraded microfabric, altered apatite surface on conodonts, and the SO_4-, F-, and J-ionisation. At the base of the Lacian 3, biogenic hydrate water releases in the hemipelagic sediment are coupled with another Cl-anomaly. At the top of Lacian 3 first hardgrounds were established as a consequence of reduced sedimentation rates.

In the Alaunian 1, strong tectonic pulses triggered by strike-slip motions destabilize the geometry on the Hallstatt margin. Variations in the morphology, climatic cooling, and eustatic pulses are coupled with a change in ocean circulation. In rapidly accumulating hemipelagic biomicrites of the Hangend Rotkalk and the Poetschen Limestones, the organic matter becomes extracted by an anaerobic metanotrophic archaea under the presence of metal chelates. A higher biological availability of REE and some similarities of lanthanides (III) with calcium (II) process these bacteria to replace Ca into Ce in the biomolecules of (some) deeper water biota, suggested by altered apatite crystallinity on conodonts and fluctuations in the Ca-ionisation of the palaeo-seawater. Erosion of an uplifted deeper continental crust-fragment in the hinterland resulted in enriched values of transition metals.

The Alaunian/Sevatian boundary in the Hallstatt margin is characterized by an abrupt change in deposition. Formation of pull-apart basins perpendicular to the margin is evidenced by polymictic breccia formation. An increased availability of metal chelates and REE is catalysed microbial activity in the palaeo-seawater. Any hydrothermal fluid flow can be excluded on the Late Triassic Hallstatt margin.

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A Late Triassic fore reef evolution of the Dachstein platform (Berchtesgaden, Germany) - tectonostratigraphic and geochemical aspects

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The Late Triassic fore reef evolution of Mt. Jenner in the Berchtesgaden Alps, Germany offer a rare geological archive, in which shallow-burial dolomite formation can be studied in context with sequence stratigraphic cycles in the Norian Dachstein carbonate platform growth.
From the uppermost Carnian to Early Norian the internal fore reef architecture is formed by sequences comprised of dissolution breccia at the base, followed in the lower part by pack-/grainstones to float-/rudstones with shallow and hemipelagic bioclasts, and is overlain by higher energy shallow-water resediments. Sequences in Middle Norian change to recurrent alterations of a shallower, higher energy framework and deeper water bioclasts.
In the uppermost Tuvalian 3 to Lacian 2I transgressive/regressive cycles throughout the earliest Dachstein platform progradation require eustatic lowering of the hydrologic baselevel combined with massive shallow-burial dolomite formation in the fore reef. Mixing advection of seawater with meteoric water through the sediment favours low Ca/Mg ratios, salinities with an increasing palaeo-seawater ionisation in Br, Li, Na, Cl per cycle, and surface-near temperatures. The composition of well-oxygenated depositional conditions suggests that aerobic bacteria activity biodegrade directly the organic matter from primary producers, which is consistent with the SO_4, J and F-poor ionisation. The palaeo-seawater ionisation of Ca, which is analysed by the Crush Leach method, is weakly affected by dolomitization in the platform margin, and follows the depositional trend of Ca-rich ionisation by a pelagic- and Ca-poor ionisation by a shallow-water influence. A ?tectonic or strong ?eustatic pulse in the Lacian 2, as known in the hemipelagic Hallstatt zone, is reflected by enriched values in Cr, V and Ti, and display erosional products of a volcanic/?ophiolitic hinterland.
The Lacian 2II until Lacian 3 sedimentation is dominated by several eustatic sea-level changes with exposure and stratabound dolomitization in the shallowing-upward cycles. Sulfate reducing bacteria favour in restricted conditions the formation of a distinctive clotted-peloidal micrite microfabric, which is consistent with a significant deceasing Cl- and increasing SO_4-ionisation. Characteristic Hopanes in this low energetic environment indicate an input of palaeosoil with biodegraded land plants. Only, in the uppermost cycles of Lacian 3 occur Griphoporella and Aciculella dasycladacaen algae.
Ongoing transgression, or increasing subsidence or a biogenic crisis led to aggradation in the Alaunian. Massive dolomite formation ended in the Alaunian 1b with the occurrence of *Epigondolella* n.ssp. B *sensu* Krystyn. Stratabound dolomite horizons top each eustatic sea-level cycle. Whereby, each sequence is characterized by shallowing upward cycles with karst fissures. Corals and dasycladacaen algae recover in the Alaunian 3 and bloom in the Alaunian 3II. The tectonic pulse at the Alaunian/Sevatian boundary terminated the platform margin evolution on Mt. Jenner.
This Late Triassic fore reef architecture can be directly correlated with other high resolution Dachstein platform successions, dated by means of conodonts in the eg., Eastern Alps, Western Carpathians and Julian Alps.

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3D visualisation of a Jurassic oolitic system with GPR data, Isle of Portland (UK)

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The Isle of Portland shows exposure of uppermost Jurassic oolitic carbonate all along its coast and within several inland quarries. The exposure quality is very high with a potential 3D control. The site has a potential to understand the 3D architecture and the sedimentary dynamic of an oolitic system. However, only punctual observations of logs (1D), sometimes correlated have been published. The papers place a shore line between the Isle and the continent striking NEE-SWW and facing towards the Channel. Facies changes are attributed to rapid sea-level variations and Walter's Law.
Following some preliminary field observations, we have decided to shoot an extensive GPR survey of the same stratigraphic interval (The Portland Freestone). With a total of 85 GPR profiles, we have produced grids on top of most of the coastal cliffs and quarry faces. We have encountered 3 main architectures, 2-m-high bars with steep clinoforms, 10s of metres-wide channels plugged with a variety of organism and stacked aggrading bundles of multidirectional dunesets. The whole dataset does not illustrate any major unconformity which could be attributed to a sharp sea-level drop. We have interpreted our sedimentary architecture to be the result of mixed hydrodynamic conditions associated with wave activity and tidal currents. The Isle shows a island barrier complex which migrates basinwards but also expands laterally, filling up the available space and cannibalising itself. More proximal facies are effectively observed in the north of the Isle towards the former continent or lagoon. However, the survey clearly shows that the shore zone progrades broadly towards the SW, partially away from the Channel, with an obtuse angle compared to former reconstructions. This result suggests that the oolitic shore zone system forms a large spit platform, pointing south, illustrating a contorted and complex shoreline/barrier.
The combination of sedimentology and geophysics allowed to reevaluate the depositional system of the Isle of Portland oolitic deposits. It also challenges the sea-level reconstruction of this interval and the palaeogeographic reconstructions in the basin by showing shoreline trajectories. The multidisciplinary approach permitted to view and analyse a Jurassic depositional system almost alike what can be done on active oolitic systems. The approach has a tremendous potential to better understand cliff exposures and in particular to produce reservoir analogues.

Topographic modification by lithospheric flexure during glacial maxima: Tentative reconstructions of southern North Sea landscapes during the Elsterian

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Tunnel valleys have long fascinated the geoscientists by their scale and the intensity of the sedimentary processes necessary to their formation. The filling of tunnel valleys in the southern North Sea is mainly made of clinoforms prograding north. A new sedimentological model has been developed, stating that the incision and the filling of the valleys are separate in times and from distinct processes. The erosion surface and consequently the tunnel valleys' peculiar incision geometry are preserved after ice recession, forming sediment traps. The infill is interpreted as proglacial for the newly observed south-dipping clinoforms and postglacial for the north-dipping clinoforms onlapping the later. The north-dipping clinoforms are interpreted to be formed within a large deltaic system associated with the Rhine-#Meuse #river(s). The delta was probably infilling a lake containing 100's of m overdeepnings (the under-filled tunnel valleys). The presence of clinoforms 50-80 m above the valley shoulders indicates the potential depth of the lake around the overdeepenings. However, remains of the regionally extensive lake are elusive and seldom preserved onshore. We have hypothesised that the depression hosting the lake was controlled by the lithospheric flexure which was present only during the glacial maximum and consequently difficult to pinpoint by only analysing the present topography. In this depositional system, a competition exists between one of the biggest rivers of Europe facing ice sheets and the proglacial supply, generating a very intricate stratigraphy. We intend to solve part of the problem by numerically reconstructing the local landscape with the ice sheet and its isostatic depression. This allows the location of potential depocenters and lake thresholds/spillways to better understand the river migration and the position of the lacustrine systems. The Elsterian reconstructed landscape is unexpected since we show that the orientation of the slopes are locally reversed and the altitudes were drastically different between the glacial maximum and interglacial times.

From ooze to sedimentary rock, the first diagenetic processes affecting the chalk of eastern Denmark

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The Stevns peninsula, situated in the eastern Danish Basin at the fringe of the Baltic Sea, is an ideal target for studying the early stages of diagenesis that affected the Upper Cretaceous chalk during its burial to 500-1400 m depth. For the present study onshore and offshore high-resolution seismic reflection profiles, high-resolution wireline logs and sedimentological data from a fully cored borehole, and field information from quarry and coastal cliff exposures were taken to inform about early diagenetic features. This integrated approach for the first time enabled placing different processes operating in the chalk sediments at widely different scales into a single diagenetic model:
At Stevns the chalk is affected by an extensive polygonal fault system which is expressed in onshore and offshore seismic profiles. Smaller scale contractional features like deformation bands (hairline fractures), stylolites and fluid escape structures can be studied using outcrop and core data. The spatial relationship between stylolites and fractures suggests pressure solution as trigger for shear failure that in turn led to the initiation of the polygonal fault system. Early diagenetic structures strongly affect reservoir properties of the chalk both by establishing compartments and vertical connections. A better understanding of these reservoir modifications will be critical for improving the predictive capability of models describing the behaviour of drinking water and hydrocarbons hosted in chalk sedimentary rocks.

Distribution and environmental controls on contemporary and late-Holocene inshore coral reef growth under conditions of high terrigenous sediment inputs on the central Great Barrier Reef

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Inshore turbid-zone reefs on the central Great Barrier Reef (GBR) experience naturally high sedimentation regimes caused by the wave-driven resuspension of fine terrigenous-dominated sediment deposited on the continental shelf during the Last Glacial Maximum and augmented with modern fluvial inputs. Although high turbidity is often regarded as detrimental to reef "health" by reducing scleractinian coral growth and calcification, abundance and diversity, and increasing incidences of disease, evidence of established coral communities and of reef development throughout the mid- to late-Holocene is documented for several inner-shelf locations. However, logistical difficulties associated with conducting field studies within these turbid environments has led to a poor understanding of the extent, contemporary ecology and past accretionary history of inshore reefs compared to their 'clear water' counterparts from mid- and outer-shelf settings. Here, we present the first large-scale seafloor mapping of the inshore central GBR, in which datasets aim to establish the spatial extent and composition of the benthic communities associated with these turbid-zone reefs, and from which core records to determine reef chrono-stratigraphy have been recovered. Towed benthic video surveys and high-resolution single- and multi-beam bathymetric mapping was conducted across Paluma Shoals, within Halifax Bay, central GBR, to establish key inshore habitat types and construct digital elevations models of the seafloor topography. Results showed that Paluma Shoals encompasses a sequence of previously unknown proximal reefs that occur across a range of evolutionary states, all of which support high live coral cover (21%-70%) and coral diversity (21 genera). Reefs form upon distinct subaqueous linear ridges that are young in age (921-2078 cal y BP) and have accreted relatively rapidly during the late-Holocene (1.8-3.0 mm/y). Reef accretion has been continually associated with the accumulation of large quantities of terrigenous sediment that have been incorporated into the reef matrix. Contemporary coral communities were clearly stratified across a narrow depth range as a consequence of diminishing light conditions caused by high water turbidity. Highest diversity occurred on the reef tops (-0.4 m LAT), whereas extensive monospecific *Turbinaria* sp. "coral carpets" inhabited deeper reef slope and inter-reefal areas (-4 m LAT). Palaeoecological records show the long-term persistence of coral communities since reef initiation and comparable depth-stratification of corals assemblages to contemporary reefs. Findings highlight the importance of inshore shelf environments as a critical habitat for coral reef development and challenge existing preconceptions that high turbidity is inherently unsuitable for coral growth, as inshore coral cover and net reef accretion rates either match or exceed typical values reported for other GBR shelf areas. This study provides a unique insight into the response of coral communities, both past and present, to changes in habitat-related environmental conditions, as reef structures transit through different stages of geomorphic development within inshore turbid-zone environments.

Depositional model for a prograding oolitic grainstone wedge (Lower Kimmeridgian, Iberian basin)

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Facies architecture and bedding patterns of the lower Kimmeridgian Pozuel Formation evidence that this 50–70 m thick oolitic-grainstone unit conforms to the infralittoral prograding wedge (ILPW) model instead of the classic models used for interpreting oolitic grainstones sandbodies on carbonate ramps or platforms (i.e., bank-margin shoal complexes, beaches and beach ridges).
Ten lithofacies have been distinguished in the Pozuel Formation: 5–10° dipping clinobedded oolitic grainstone foresets passing to tabular oolitic packstones-grainstones, which interfinger the muddy basinal bottomsets. Landwards, the clinobeds pass into subhorizontal topsets composed of trough cross-bedded to structureless oolitic grainstones; oolitic-skeletal grainstones with stromatoporoids and coral-stromatoporoid-microbial mounds. Siliciclastic lithofacies and oncolitic/peloidal packstones occur at the innermost position. These lithofacies stack in strike elongated, 5–20 m thick, 0,5–2 km dip-oriented wide, aggradational-progradational packages with complex sigmoid-oblique geometries.
Lithofacies, depositional geometries and stacking pattern permit to summarize the main characteristic of such Upper Jurassic oolitic infralittoral prograding wedge potentially to be applied in other oolitic sandbodies both in outcrops and subsurface: 1) sediment production within the wave action zone, 2) grainstone-dominated textures, 3) prograding basinward onto basinal muds, 4) laterally (strike) extensive, paralleling the shoreline, 5) variable thickness, commonly of few tens of meters, 6) broadly sigmoidal to oblique internal architecture, with topsets, foresets and bottomsets, 7) dip of foresets close to the angle of repose, 8) topsets deposited in shallow-water, extending through the shoreface, from the shoreline down to the wave base, 9) mounds, either microbial or skeletal, may occur in the topsets.
This genetic model can be applied to other grain-dominated lithosomes, some of them forming hydrocarbon reservoirs, e.g., the Jurassic Hanifa Formation and some Arab-D (e.g., Qatif Field) in Arabia, the Smackover Formation in northern Louisiana and south Arkansas, the Aptian Shuaiba Formation (e.g., Bu Hasa Field) and the Cenomanian Mishrif Formation (e.g., Umm Adalkh Field) of the Arabian Gulf.

Influence of storm surges on coastal morphology - an example from western part of Mierzeja Wiślana sandy barrier, Northern Poland

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Coastal morphology of the Southern Baltic is strongly influenced by winter storms. Mierzeja Wiślana barrier was chosen to show an example of local storm surge regime influence on processes of erosion and accumulation within sandy barrier. Recognition of geomorphological features together with preliminary lithological analysis were done in the area of interest. Classification of landforms based on field observations, photographs, satellite images and LiDAR datasets. Point cloud from LiDAR was converted into TIN surface and 3D digital elevation model. Most characteristic features of terrain morphology were recognized and classified with typology proposed by Morton and Sallenger (2003). In chosen locations, sediments were described to depth of 1m and most important lithological features were documented.
Three types of erosional and two types of depositional features related to storm surges were recognized. Erosional forms included dune erosions, channel incisions and washouts. Depositional forms included perched fans and washover terraces. Sheetwash lineations were absent. Washovers created in the west part of Mierzeja Wiślana were built by sandy material from foreshore, beach and aeolian dunes. Medium or coarse sand, generally well sorted, was most common. In central part of active washover terraces horizontal structures were observed in prepared trenches. In upper parts, cross stratification was also observed. Several markers evidencing marine origin of sediments were recognized, including shell fragments and amber. On the top of inactive washover terraces peat was formed with thickness up to 50 cm. Roots and worms slightly deformed older storm sediments.
Preliminary geomorphological recognition and interpretation of study area showed how sediments related to washovers can be preserved under local storm surge regime. Further laboratory studies will allow for better understanding storm surge influence on sediments formation in the coastal areas of Southern Baltic.

Provenance of the Rub'al Khali desert sands, Uunited Arab Emirates; analysis of heavy minerals by ICP-AES

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Correlation and provenance of geological materials can be achieved through several techniques; a common and popular approach is by the analysis of heavy minerals (density > 2.85 g/cm^3). Traditionally this would involve the counting and identification of different mineral species using a petrological microscope. This can be time consuming and costly; geochemical analysis of heavy minerals by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) offers a faster and cheaper alternative. The ICP-AES approach establishes the relative or absolute abundance of key elements linked with specific heavy minerals; apatite, chrome spinel, monazite, titanium oxides (rutile, titanite, anatase etc) and zircon. Inherent difficulties with this method include the dissolution of highly resistant minerals and potential matrix interferences, both physico-chemical and spectral. Whilst this technique lacks the sensitivity of a traditional optical counting using a petrological microscope, it does provide unique mineral-chemical signatures, broad trends in major cation groups and the quantification of rare earth elements.
The method was applied to the provenancing of the modern dune sands which form part of the Rub al' Khali desert, United Arab Emirates (UAE). For this study, 194 samples were collected from modern dune sands, palaeodunes and Miocene sandstones across the UAE. Heavy minerals were concentrated using a typical "sink float" heavy media separation using lithium-heterotungstate.
Classification of sediments and their associated source(s) were constructed through the comparison of the geochemistry associated with ultrastable heavy minerals and unstable heavy minerals. There is generally good source agreement between the ultrastable and unstable heavy minerals. Differences in source between the ultrastable and unstable heavy minerals can reflect potential mixing of source sediment or the preferential dissolution of the more unstable heavy minerals. Interpretation and correlation of the geochemistry associated with these mineral groups has yielded four potential sources for the formation of the Rub al' Khali desert. The three dominant sources include; Miocene sediments which are predominantly derived from the Arabian-Nubian shield, sediment derived from the Hajar Mountains of the Oman and unconsolidated sediment derived from the emergence of the Persian Gulf during the Quaternary. A fourth, albeit minor contribution is sourced from the reworking of the Barzaman Formation.

Controls on the accumulation and preservation of aeolian successions

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The construction of aeolian dune-field systems is commonplace in both modern desert and non-desert settings. For many such systems dune construction has progressed to a state whereby an aeolian accumulation has formed such that the level of the interdune floor between actively mobile dunes has been elevated substantially above the regional base level. However, the long-term preservation potential of many present-day dune-field accumulations is very low, principally because many such systems are currently developed in stable intracratonic settings for which rates of long-term subsidence are very slow. Large bedforms in many present-day tropical aeolian desert dune fields are legacy forms that were constructed and underwent accumulation during the last glacial maximum when the climate was generally colder, drier and windier than today. Several factors have promoted the stabilization of these legacy bedforms: (i) the present-day climate is not sufficiently windy to enable the aeolian transport of large volumes of sediment for further dune-field construction; (ii) the sediment supply that was used to construct many large present-day dune fields has now been exhausted or rendered unavailable for aeolian transport following Holocene transgression; (iii) stabilizing agents on dune surfaces, such as vegetation and precipitate crusts, have become increasingly significant in response to a shift to a more humid climate; (iv) intra-dune-field water tables have risen to a level whereby they now restrict sand transport across damp or wet interdune surfaces.
In the ancient record, many preserved aeolian successions are interpreted to have accumulated via the synchronous migration and climb of bedforms that led to the generation of multi-metre-thick, vertically stacked sets of cross-bedded strata. Indeed, so-called “bedform-climbing” appears to have been a dominant mechanism that controlled the accumulation and preservation of many well-known aeolian successions developed in actively subsiding Permian to Jurassic basins of the Colorado Plateau region. However, several other exceptional preservation mechanisms are also documented from other aeolian dune-field successions, including: (i) flooding by transgression; (ii) inundation by flood basalts; (iii) stabilization of bedforms in response to climate change to preserve relic topography; (iv) migration of bedforms into pre-existing topographic depressions ranging in scale from entire basins to salt-solution pockets; (v) the presence of interdune depressions developed between stabilized bedforms acting as local accommodation centres for younger bedforms. These varied preservation mechanisms mean that the aeolian stratigraphic record is far more complex than previously thought.

Hydro-sedimentary processes in a beach-headland system

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Understanding hydro-sedimentary processes in space-limited environments as embayed beaches is a key question to reconstruct preterit and predict future coastal evolution forced by the mean sea level rise. Moreover, such knowledge is a fundamental management tool in areas where coastal erosion is currently a worrying fact. This work aims thus to assess the sedimentary contribute, provided by the alongshore transport, to feed embayed beaches.
At the southernmost rocky coast of Portugal (Algarve), beaches occurring at the cliffs' foot are separated by headlands connected to shore platforms forming littoral cells as a consequence of the extremely karstified carbonate landscape. The survival of those beaches depends almost exclusively on the alongshore drift.
In order to assess the effectiveness of the sedimentary transport induced by diverse wave climate, we used marked sands and tracked their path during a total of nine tidal cycles (two field campaigns: March and November, 2014). For this, we sampled in each cycle at the nodes of geo referenced net along the coast. Additionally, topographic surveys were done to determine the relationship between the wave heights, the morphodynamic state of the beaches and the grain size distribution. Numerical models were used to simulate the nearshore hydrodynamics to be correlated to the sand transport pathway and velocity.
During the field experiences the waves approached the coast from WSW (243°- 263° March and November respectively) and the mean significant wave height ranged from 1.1 m-1.5 m. The morphodynamic state of the beaches was mainly reflective. The most different morphodynamic aspect between the two field campaigns was the topographic continuity between the shore platform and the beach surface. In opposition to November conditions, during the first campaign in March, the surface of the rocky platform was at least 50 cm higher than the beach surface. The pattern of the grain size distribution was always parallel to the shoreline ranging from coarse sand at the backshore and high tide terrace to medium sand at the beach face with patches of fine sand close to the low water level of spring tide. During the first phases of the rising tide the cellular circulation was more important than the alongshore currents whereas current pattern and therefore sediment transport were determined by the beach morphology and dimensions during the last phase of the high tide.
Our results show that: (i) when waves approach perpendicularly the coast, the shore platforms induce strong variation on the wave shoaling and the resultant rip currents favour the cross-shore transport direct towards sea, (ii) strong morphological control of the hydro-sedimentary processes in the studied beach-headland leads to an inefficient downdrift transport of sand. The, narrowing of the beaches will be a natural consequence of the sea level rise due to the lack of sediment and the limited accommodation space and, once they as they act as buffer dissipating the wave energy, the cliff erosion and retreat is expected to increase.

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Contrasting styles of sedimentation on the opposing limbs of blind-thrust synclinal troughs in an evolving orogenic wedge-top basin (Eocene Dinaric Foreland, Croatia)

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The Eocene–Oligocene Dinaric peripheral foreland basin in the northern Dalmatia developed by a SW-directed orogenic thrusting and comprised two distinct palaeogeographic zones: a shallow-marine proximal foreland where a calciclastic succession of neritic to terrestrial sediments known as the Promina Beds was deposited, and a deep-water distal foreland accumulating turbiditic deposits known as the Dinaric Flysch. The proximal foreland evolved gradually into a thrust wedge-top ('piggy-back') basin, while the tectonically quieter distal foredeep was filled up with the Dinaric Flysch and was eventually onlapped by the Promina Beds. The progressive tectonic shortening of the orogenic thrust wedge caused formation of a series of SW-vergent blind-thrust growth folds within the wedge-top basin, resulting in its compartmentalization into an array of narrow, high-relief marine sub-basins (synclinal troughs), where the main part of the Promina Beds succession was deposited.
An illustrative example of these troughs is the Novigrad sub-basin, a SE-trending synclinal swale formed close to the orogen front and filled with sediments in the middle to late Eocene. The two opposing limbs of the asymmetric synclinal trough show markedly different styles of sedimentation. The steeper NE limb hosted coarse-grained shoal-water to Gilbert-type deltas, whereas the gentler SW limb hosted a wave-dominated gravelly shoreline (foreshore zone) with sandy shoreface, heterolithic sand-mud offshore transition and muddy offshore zone. The offshore-transition and offshore deposits here are commonly intercalated with foreshore-derived, gravelly debris-flow and slump deposits, which represent resedimentation pulses triggered most probably by a normal faulting of the syncline limb growing in its relief.
A similarly contrasting style of sedimentation is recognizable on the opposing limbs of other synclinal troughs in the Dinaric wedge-top basin in northern Dalmatia, with the steeper NE limb shedding sediment gravity flows and the gentler SW limb hosting a littoral system prone to gravitational collapses and resedimentation. This evidence indicates a wedge-top basin turning into a system of blind-thrust growth folds as a result of tectonic contraction. The structural development in such a deformation system is intricate, as it may involve both in-sequence and out-of-sequence thrusts, as well as back-thrusts and related pop-up ridges. In addition, the entire thrust wedge-top basin may be episodically uplifted piggy-back by its soling master thrust and be episodically subsiding due the crustal load of orogen thrust-sheets. The inherent short-term variability in the syndepositional tectonic development of a wedge-top basin bears several important stratigraphic ramifications as to the facies record and relative sea-level changes: (1) drastic facies changes may occur over short distances away from the orogenic front; (2) a forced or normal regression on one limb of a synclinal trough may be coeval with a transgression on the other limb; (3) some of the marine transgressions and regressions may occur synchronously on both limbs of the synclinal trough, irrespective of the difference in local bathymetry and sedimentary environment; and (4) progressive unconformities may be a common feature of the basin-fill succession. This Dinaric case study may be relevant to a palaeogeographic development of the wedge-top parts of the 'inner' Carpathians and other orogenic belts.

Formation conditions of the permian bitumen-containing sediments in the east of the East European platform (Russia)

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Areas of bitumen-containing rocks are mainly located on the territory of the Republic of Tatarstan. Here revealed to 150 deposits of natural bitumen, whose resources according to various estimates range from 1.5 to 10 billion tons. Natural bitumen deposits in Tatarstan confined to Permian sediments and deposited near the surface (to a depth of about 400 m). Bitumen deposits are confined to the sand rocks packs of sheshminskiyu horizon (Ufimian stage), which is divided into two layers: the sand-clay and clayey sands. Bitumen saturated rocks are mainly small-cross-bedded, at least - medium-, polymictic sands and sandstones. Petrographic studies have shown that the mineral composition of all the studied sandstones belongs to greywacke group. The grains of quartz, feldspar, mica, and particles of volcanic rocks are found as part of clastic material of sandstones. Clastic material is bad sorted and not been subjected for long time sloshing of. In the studied sandstones are found fragments of effusive rocks, plagioclase, amphibole, biotite, quartz and others. Source of clastic material were crumbling rock complexes of ancient Ural mountains. Among them are a group of rocks which have ultramafic (ultrabasites), basic (basites) and acidic (granites) composition. According to EPR found that the samples presented by two types of organic matter which have the oil and coal origin. Oil substance has the migration nature and, most likely, due to the influx from the deeper horizons (Carboniferous deposits). Organic matter of coal origin is the remains of plants (algae) and indicates the formation of deposits in an aqueous environment in the coastal marine environment.
Sandstone cement is clay-carbonate, sometimes carbonate, occurs pore, pelitomorphic and basal matrix. Matrix and cement are important parameters characterizing the properties of permeable sedimentary rocks. The presence of carbonate cement which is formed at the stage of diagenesis and fills the pore spaces of rocks has a negative impact on their reservoir and permeable properties. The studied samples are characterized by a high degree of reservoir properties. According to X-ray computed tomography hollow core-pore space of the rocks represented by a system of interconnected pores. Notes clearly expressed pattern of increasing the frequency of occurrence as a function of decreasing pore size. On the tomographic slices are also observed some more dense inclusions of various shapes, consisting of grains of rock-forming minerals, ore minerals (pyrite) and intergranular space. The mutual arrangement of grains of detrital minerals causes mild banding rocks. Intergranular space debris components largely filled with a material of cement. Confining beds of natural bitumen deposits is a pack of gray-colored clay, lying at the base of the Kazan stage. The results indicate a close connection of the bitumen substance deposits with the conditions of their formation and can be used during the exploration and development of these fields.

Microfacies Analysis, Paleontology and Biostratigraphy of Paleocene Lockhart Limestone from Pail Area, Central Salt Rang, Pakistan

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The Salt Range is a feature of particular geological interest for its exposed rocks ranging from Pre Cambrian up to recent. Paleocene and Eocene sedimentation is rich in foraminifera in entire Salt Range of Pakistan. Larger Foraminifera are abundant and contribute a major part of this period. They are regarded as useful tool for biostratigraphic dating of shallow marine sediments. This study is comprised of microfacies analysis paleontology and biostratigraphy of Lockhart Limestone. Thin sections of rock samples collected from measured section were observed under microscope. A number of microfossils from larger foraminifera and smaller foraminifera were clearly identified. Based on Dunham's textural classification and allochem counts three facies were established: Nummulitidae Mudstone, Nummulitidae Wackstone and Nummulitidae Packstone. Abundance of benthic foraminifera and scarcity of planktonic foraminifera in Lockhart Limestone indicates shallow, inner neritic, open-marine environments of deposition. Presence of larger foraminifers species like; *Lockhartia haimei*, *Lockhartia conditi* indicates Upper Paleocene age of Lockhart Limestone.

Depositional and Sequence Stratigraphic Framework of Lacustrine Turbidite System in the Third Member (Es3) of Shahejie Formation, Dongying Sag, China

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Deepwater sandy turbidites are well known as moderate to excellent reservoir for hydrocarbon accumulation. Lacustrine turbidites has gained prime importance after recent discoveries in Dongying sag and other basins. The turbidites of third member (Es3) of the Eocene Shahejie Formation were deposited in rifting Dongying Basin. The target layer of Es3 display full depositional cycle starting from prograding in the bottom, aggrading in the middle and retrograding at the top in the study area. On the third order, Es3 was deposited during lowstand systems tract when the basin was rapidly subsiding due to active rifting. On the fourth order, the target layer is composed of lowstand systems tract (LST) and transgressive systems tract (TST). For the purpose of this paper, we recognized three depositional stages on the bases of facies analysis. Detailed core description helped us to identify significant sedimentary characteristics to define depositional facies. Five facies were defined by integrating data from core description wireline log and petrography; (1) Fan channels (2) Interchannel mud (3) Lobe Sand (4) Sheet sand (5) Outer fan mud. We extended these facies to seventy-one uncored wells based on SP and conductivity log response. The facies distribution was mapped in three different depositional stages i.e progradation, aggradation and retrogradation separately to develop a depositional model. The constructed model revealed the whole depositional episode of turbidites system. Deposition initiated from slumps and debris flow in very initial stage and later turned into sublacustrine fans when sediment supply outpaced the accommodation space rapidly. In second stage, the rate of sediment supply and accommodation space was near to equal that resulted in development of thick fans and turbidites. Third stage marks the rise of lake level that outpaced sediment supply and resulted in landward retreat of fan sediments and thin sheet sand deposited over fan sediments. The rate of accommodation space was mainly influenced by local tectonics as subsidence of basin was controlled by the rifting. Establishing depositional stages and mapping, the distribution of facies will enhance the understanding of reservoir architecture. In general, the definition of depositional facies will lead to comprehensive reservoir characterization in F29 area of Dongying sag.

Solar influence and hydrological variability from a speleothem annual record during the Holocene: A multi-proxy study (Molinos cave, NE Spain)

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We present a multi-proxy approach to reconstruct Middle-Late Holocene climate conditions in NE Spain based on lamina thickness, colour parameters and isotope ($\delta^{18}O$ and $\delta^{13}C$) variations recorded in a stalagmite from the Iberian Range (MO-7, Molinos Cave). The uppermost section of MO-7 stalagmite (14.7 cm) grew between ~7.2 and ~2.5 kyr BP with a hiatus from ~4.9 to ~4.3 kyr according to the age model constructed from 5 U/Th dates and annual lamina counting. The speleothem displays a very well-marked internally banded structure, composed of 4105 doublet lamina interpreted to be of annual origin. Three methodologies of spectral analysis (Lomb periodogram algorithm, REDFIT module and wavelet analysis) were applied to 11 time series of continuous- and discrete-signal records, obtained from proxies of lamina thickness (light, dark and doublet lamina), colour parameters (R, G, B and L*, a*, b*) and isotopic composition ($\delta^{18}O$ and $\delta^{13}C$). Results reveal common solar periodicities of decennial (~83-yr Gleissberg) and centennial scale (mainly ~204-yr De Vries-Suess) during Mid-Late Holocene times that unlikely are artefacts of any single technique.
Considering the whole MO-7 stalagmite an excellent correlation between lamina thickness, colour parameters and stable isotope values is observed. Thicker and darker (reflected light) laminations grew during intervals characterized by more negative $\delta^{13}C$ values, thus interpreted as more intense or longer rainy winter-spring season periods with increased infiltration into the cave as a result of a higher precipitation-evaporation balance in the region. At a longer-term scale, a dry period (thinner and lighter lamination and $\delta^{13}C$ values of -7.47‰ in average) is defined during the lower section of the stalagmite (7.2 to 4.9 kyr) while, on the contrary, the upper part after the hiatus (4.3 to 2.5 kyr) corresponds to a wet period ($\delta^{13}C$ values of -8.56‰ in average). There is no clear correlation with temperature variations since oscillations in $\delta^{18}O$ values are too small and do not show robust evidences of good correlation with global temperature records such as Bond events or sunspots cycles. However, the onset of Holocene precipitation of carbonate in MO-7 stalagmite appears associated to a wet period (cold in Bond curve) whereas the hiatus and the end of growth are related to dry times (warm in Bond curve). An explanation for this association of cold-wet periods throughout the Holocene in a Mediterranean continental climate is related to the expected decrease of evaporation if temperatures are colder and a consequent increase of water availability. This environmental trend fits well with the Holocene climatic regional scenario.

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The modern dynamics of a coastal lagoon reconstructed through multiproxy analyses on nearby shallow marine sediments

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The Cíes Islands archipelago is a coastal insular system situated at the mouth of Ría de Vigo (NW Iberia) and forming part of the 'Atlantic Isles of Galicia National Park'. It consists of three major islands: namely from north to south Monte Agudo, Faro and San Martiño, and a number of islets. The natural values of this insular system have been rewarded with the highest European standards of protection: this is a site of community importance (SCI) and birds special protection zone (BSPZ), recognized by the Convention for the Protection of the marine Environment of the North-East Atlantic (OSPAR Convention). Particularly, the sand-confined coastal lagoon represents the most distinctive icon of the National Park but coastal erosion and the recent construction of sea defences seems to be reducing its natural development as altering the delicate hydrological regime and community structure.
Previous lithostratigraphic and palynological studies developed in the lagoon sedimentary infill concluded that the Holocene sedimentary record commenced ca. 7700 cal yr BP by fresh-water ponding or peat sedimentation, although lagoonal and marine sedimentation only occurred since ca. 3700 cal years BP. Nevertheless, essential details of the more recent environmental history of the lagoon (including the probable occurrence of ephemeral successional stages) remains obscure because of the sediments deposited after ca. 3700 cal years BP are predominantly coarse sand and abraded shell fragments that have been reworked by washover and eventual barrier breaching.
Multiproxy analyses were performed on an infralittoral sedimentary sequence located at the eastern margin of the Cíes Islands, in the mouth of Ría de Vigo (NW Iberia), in order to reconstruct the modern dynamics of the coastal lagoon located between the main two islands. Our approach comprised: 1) a series of early seismic and multibeam surveys set aside to reconstruct the topography of the basin, to deduce the most probable source-areas for the different compounds of the sediment, and to select the optimal point to be cored; 2) lithological, textural, elemental and chronological studies that were carried out on the core; and 3) detailed palynological studies that were performed on one it, including the analyses of the pollen, non-pollen palynomorphs (NPP) and dinocysts content. Our results revealed noticeable environmental alterations affecting the area during the last three millennia, mainly driven by the changing climate and oceanic conditions, but also by the vicissitudes of the historic human occupation of the islands. Several relatively cold stages (the 2.8 ka BP event and the Little Ice Age), which were characterised by more intense upwelling regimes affecting the ria, alternated with other warmer stormy periods when downwelling conditions prevailed. All these circumstances affected the regional relative sea-level, the evolution of the coastal ecosystems (including the equilibrium between the lacustrine, marsh, dune and lagoon systems in the islands) and the trophic stage of the shallow marine waters surrounding the archipelago.

The hidden face of the karst or the hidden karst phase in the Lower Cretaceous of the Serranía de Cuenca basin (east-central Spain)

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The rifting cycle that affected the Mesozoic Iberian Basin (east-central Spain) during the Upper Jurassic-Lower Cretaceous induced a generalized thermal uplift. On the marginal areas of the basin this resulted in the development of a circa 30 M.y. long stratigraphic discontinuity.
The current Serranía de Cuenca (Southwestern Iberian Basin) coincides with part of the area affected by such thermal uplift and did not record sedimentation from the end of the Oxfordian until the Upper Barremian, when stretching finally affected the area. La Huérguina Limestones Fm. corresponds to the Upper Barremian record of syn-rift sedimentation that occurred in small basins of graben and half-graben type, and under seasonal subtropical climatic conditions. Therefore, the deposits of La Huérguina Fm. overlie marine Oxfordian limestones that show overspread pedogenic and karstic features developed on top that confer to the J-K discontinuity its characteristic red color. The chiefly carbonate sediments of La Huérguina Fm. were deposited in distal alluvial, palustrine and lacustrine environments fed by superficial flows and groundwaters that leached the Jurassic carbonate substrate, providing hardwaters to the sedimentary environments. Traditionally, the karstic features associated to the discontinuity (J-K Red Karst) underlying La Huérguina Fm. have been thought to correspond to the karst system that was active and supplied the waters that maintained the depositional system of La Huérguina Fm. However, this hypothesis is not supported by some geochemical and stratigraphic evidence and should be reviewed.
The Jurassic-Cretaceous discontinuity corresponds to a table-like almost horizontal surface with very minor erosion of the Jurassic limestones. It is characterized by a very outstanding red color associated to iron oxides. Most of the exokarstic marks were probably blurred by later pedogenic features. However, some scarce endokarstic features are preserved. Karstic bauxites and bauxitic clays are preserved with in-situ haematite roots inside meter-size dissolution dolines and also associated to decayed speleothems in collapsed caves which are only visible in plan view. No endokarst features are actually observed in cross section. The J-K Red Karst has a special Sr/Sr signal with high values that suggest a Paleozoic source for the isotopes, most likely an influence inherited from the bauxites origin. These karstic bauxites were later incorporated as recycled material in the lowermost part of the La Huérguina Fm. This probably caused the collapse of the emptied caves, the resulting Jurassic blocks being also incorporated into the distal alluvial sediments that characterize the lower half of La Huérguina Fm. succession. The occurrence of bauxitic material in the form of red and orange marls decreases rapidly in the lower meters of the La Huérguina Fm. though the Jurassic blocks and decayed speleothems are incorporated into upper sediments.
By the time the dominantly lacustrine carbonate deposits that characterize the upper half of La Huérguina Fm. succession are deposited, the J-K Red Karst is already buried. Therefore, the karstic waters that feed the upper lacustrine sedimentary system must derive from a different karst system occurring on fresh Jurassic limestones.

Flood-dominated systems: A fundamental type of fluvio-deltaic sedimentation (a lesson learnt from the ancient)

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During the last two decades growing evidence in support of the importance of flood-dominated fluvial and fluvio-deltaic depositional systems in ancient stratigraphic records has challenged classical sedimentological models still essentially based on a uniformitarian approach. Especially in exposed orogenic-belt basin fills, the great majority of ancient depositional systems appear to be dominated by subaerial flood-generated sediment gravity flows and their extension as hyperpycnal flows in adjacent lacustrine and marine basins. Vertically and longitudinally graded flood units are thus the most common type of deposit in such systems.

Paradoxically, most criteria set forth for the description and interpretation of deep-water turbidite sandstone facies seem equally useful in the description and interpretation of both fluvial and fluvio-deltaic deposits. In particular, channels and lobes – the two basic elements comprising most turbidite systems – are also typical of delta-front and delta-slope settings dominated by hyperpycnal flows (or better shallow-water turbidity currents) exiting river mouths as jet flows. Facies types developed during the process show a typical proximal to distal pattern of grain-size variations, with bypassing prevailing in the proximal segment and deposition prevailing in the distal one.

Flood-magnitude – essentially controlled by climate and basin physiography – ranges between small and almost uniformitarian to huge and catastrophic, as in the case of late glacial Lake Missoula events.

In this paper, we present and discuss the results of more than twenty years of field work based on high-resolution physical stratigraphy, which have allowed us to identify the facies tracts that can be considered diagnostic of a series of intergradational ancient flood-dominated fluvio deltaic systems, whose end members are represented by fan delta and river delta systems. In spite of great variability in terms of geometry and facies types, these ancient depositional systems are both characterized by very distinctive delta-front deposits consisting of sharp-based and parallel-sided, graded sandstone beds commonly containing hummocky cross stratifications. These deposits are commonly mistaken for storm-dominated nearshore and shelfal deposits, but, more likely, they represent the most genuine expression of fluvial-dominated delta-front sedimentation, where impressive sediment accumulations are deposited by shallow-water turbidity currents triggered by flood-generated sediment gravity flows exiting river mouths and entering seawater. Needless to say, we do not intend to deny that flood-dominated fluvio deltaic systems can be influenced and modified by waves and/or tides but, unfortunately, for thirty years, the dogmatic assumption that HCS is the criterion to recognize storm-dominated shelves has hampered any attempt to improve our understanding of fluvio-deltaic systems. The study of ancient floods and their deposits opens a new and important field of research of great interest to the society because of its inherent relevance to climate changes.

Genetic stratigraphy of Coniacian deltaic deposits of the northwestern part of the Bohemian Cretaceous Basin

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Based on a combination of outcrop and subsurface data, this paper presents a description and interpretation of principal lithofacies and regional-scale depositional geometries in sandstones of early to middle Coniacian age in the northwestern part of the Bohemian Cretaceous Basin. A depositional model of nearhore deposition presented here interprets the depositional system as dominated by coarse-grained deltas that prograded from the faulted northern basin margin, the present-day Lužice (Lausitz) Fault Zone. The deltaic systems were the primary loci of clastic sediment deposition upon entering the basin, but the deposits of the delta fronts as well as part of the prodeltaic facies were further reworked by vigorous tidal currents, in particular in shallow-water settings. Steep, Gilbert-type foresets formed mainly in delta fronts that prograded into deeper water, reaching up to c. 100 m in some units. This depositional model is largely analogous to that developed in other parts of the basin (e.g. Český ráj or Broumovské stěny Cliffs), with the exception of very large-scale dunes that locally occurred in the present study area.

Regional correlations utilizing well-log and core data made it possible to correlate nearshore sandstone units to their fine-grained time-equivalents in the mud-dominated offshore realm, and subdivide the depositional record into genetic sequences, bounded by surfaces of maximum transgression. The genetic sequence-stratigraphic framework was then applied in construction of a time-slice reconstruction of regional palaeogeography from latest Turonian to middle Coniacian times.

In comparison to the upper Turonian (TUR 7) sequence dominated by vertical stacking of sandstone bodies deposited in shallow water, sequences CON 1 to CON 3 were deposited in a setting of generally increasing depth through time, most probably due to increasing subsidence rate. The transgressive–regressive history of the study area during latest Turonian and Early Coniacian reveals three major transgressions in the study area: 1) approximately at, or immediately prior to, the Turonian/Coniacian boundary, 2) at the base of CON 2 sequence (base of *Cremnoceramus crassus crassus* Zone), and 3) at the base of CON 3 sequence, within the *Volviceramus koeneni* Zone. Of the above mentioned maximum flooding episodes, (1) and (2) have their counterparts in a different depocentre in the same basin, but also in Western Canada, suggesting a significant role of eustasy in their formation. Further conclusions on eustasy require caution, however, because of the clearly significant role of accelerating subsidence as well as supply from an actively uplifted source area during the early and middle Coniacian. Local stacking patterns of deltaic bodies in the study area differ from coeval ones in the separate depocentre of Český Ráj developed further east along the Lužice Fault Zone. It is likely that the increased tectonic activity between the latest Turonian and middle Coniacian was a precursor to the onset of shortening that eventually led to the well-known inversion of basins in the northern Alpine foreland. The exact kinematic role of individual tectonic structures remain to be understood in the near future, using data on evolution of basin-fill geometries through time, such as provided by this study.

Holocene sediments of the Songjiho lagoon on the eastern coast of Korea

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The eighteen major lagoons in the eastern coast of Korea are important requisites of superb natural landscape, and valuable environmental and ecological resources. These lagoons were formed several thousand years ago due to the shoreline changes and the formation of the sand bar across the mouths of estuaries, and have the characteristics of both freshwater and sea water. This kind of coastal environments is under increasing pressure as a result of increasing human populations and the by-products of inland human activities. The impact on these productive and economically important environments has become a major concern. The Songjiho lagoon is quite small, which has an average depth of 2.06 m, a water surface area of 0.56 km^2 within a catchment of 5.40 km^2, and a shoreline length of 5.56 km, but is known to preserve the natural conditions.
Undisturbed sediment core SOJ-2 (length 10.7 m) was retreived from the Songjiho lagoon. Among the about 8000 years sedimenetary record, sub-millimetric laminations (varves) are well developed in the interval from elevation -7.83 to -6.92 m. The finely laminated sediment typically comprises couplets of alternating light- and dark-colored mud. The laminations become progressively less distinct, grading into homogeneous clays deposited after 4260 cal. yrBP. The formations of lamination in sediments are functions of several factors, mainly lake morphometry, watershed topography, the annual influx of mineral grains and organic matter, and so on. The laminated sediments are known as an excellent archive which allows to reconstruct changes of global climate, and meteorological and geological conditions.
The aims of the interdisciplinary research project are to describe the general stratigraphy of the lagoon sediments including their chronology, and to elucidate the relationships among lagoon sedimentation, coastal environmental change, and relative sea-level rise during the last 8000 years. To achieve the aims, we analyzed sediments of the past 8000 years from the Songji lagoon for a suite of geochemical and sedimentological indicators commonly used in paleoclimatic studies, including grain size, magnetic susceptibility, organic carbon and nitrogen, and sediment accumulation rate. Results were compared with the previousely reported paleoenvironmental changes.

Palaeoenvironmental changes at the onset of the Messinian Salinity Crisis (NW Italy): A microbial perspective

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The Phanerozoic giant evaporite basins of the Earth have been formed due to environmental change and were extensively studied by combining sedimentologic and geochemical analyses, however, detailed geomicrobiological studies have not been carried out yet. We present a lipid biomarker study on sediments straddling the onset of the Messinian Salinity Crisis (MSC) in order to evaluate the response of eukaryotes and prokaryotes, but especially Archaea, to the transition from normal marine waters to the peculiar extreme conditions postulated by the traditional model of environmental evolution associated with the salinity crisis. The samples derive from the northernmost fringe of the Mediterranean basin (Pollenzo, NW Italy), where the MSC advent coincides with the deposition of shale and carbonate-rich beds; the latter are considered as deep water counterparts of the shallow water gypsum layers. Both pre-MSC and MSC deposits display similar molecular fossil assemblages, sourced from all three domains of life (Eukarya, Bacteria and Archaea), mainly represented by isoprenoidal alcohols, fatty acids, sterols, long chain *n*-alkanes and *n*-alcohols. After the MSC onset, however, a sharp increase of long chain *n*-alkanes, *n*-alcohols and *n*-fatty acids is observed, indicating a larger input of terrigenous organic matter, most likely sourced by enhanced riverine runoff. Interestingly, this coincides with an increase of sterols (sitosterol and dinosterol) (average ^{13}C –24‰), typically interpreted as markers of algal blooms possibly reflecting eutrophication. In addition, Archaea flourished, mainly reflected in the biomarker patterns by the archaeal membrane lipids including glycerol dibiphytanyl glycerol tetraethers (GDGTs) and diphytanyl glycerol diethers (DGDs). Whereas the occurrence of GDGT-5 (caldarchaeol) is a good indicator of a “normal” marine water column during the early phases of the MSC (planktic *Thaumarchaeota* are the most likely source organisms), a sharp increase of DGDs (especially extended archaeol, which is only sourced by halophilic archaea) indicates a profound change in the archaeal community structure after the advent of the crisis. Most likely this increase reflects a bottom seawater salinity rise. This study highlights that lipid biomarkers are excellent recorders of changing environmental conditions that led to the formation of ancient evaporite giants.

Depositional environment and provenance analyses of the Zöbing Formation (Upper Palaeozoic) in Austria

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The erosional remnants of the continental Permo-Carboniferous deposits of the Zöbing Formation in the Lower Austria were studied by a spectra of sedimentological methods (facies analysis, depositional architecture, sandstone petrography, heavy mineral assemblages, chemistry of garnet, rutile and spinel, zircon study, major and trace elements) in the 23 relative small outcrops. The aim of the study was better determination of the depositional environment and source areas, their possible evolutions and understanding of ruling factors of deposition. Fourteen lithofacies and four facies associations have beed identified i.e. (a) non-channellized fine-grained deposits; (b) channelized sandstones, (c) non-channelized conglomerates, and (d) channelized conglomerates. Occurrences of these facies asscociations vary within individual members of the Zöbing Formation. Non-channellized fine-grained deposits are interpreted as a product of deposition in shallow, semi-permanent pools located on floodplains. Channelized sandstones are connected with fluvial processes and mostly represent crevasse channels cut into the floodplains. Channelized conglomerates originated from coarse-grained confined/channelized flows and are interpreted as hyperconcentrated flows (watery debris-flow surges). Non-channelized conglomerates are interpreted as product of alluvial fan and alluvial plain systems. Close association of non-channelized and channelized conglomerates and floodplain deposits points to coarse-grained fluvial system or fluvial fan accompanied by extended floodplain. Terminal fluvial systems developed under the influence of semi-arid to arid climatic regimes is supposed to be the depositional model for the Zöbing Formation.
Absence of cohesive debris flows, absence of muddy intraclasts in the conglomerates and dominance of deposits of water-flows over deposits of debris flows, all to a small role of chemical weathering in the source area, where dominate acidic magmatic and metamorphic rocks, rapid physical erosion and redeposition. Petrographical and geochemical studies confirm that the detritus of the Upper Palaeozoic deposits was mostly derived from primary sources formed by crystalline rocks. The role of metamorphites (particularly metapelitic rocks - mica schists, paragneisses, felsitic granulites) was predominant along with the importance of the presence of magmatic and volcanic rocks. The source area is predominantly located in the Moldanubian unit. The general provenance evolution over time does not indicate the successive exhumation of a simple structured (lower- to higher grade metamorphic source) orogen but may be interpreted as differences in expansion in the source areas. The basal successions are typified by material from the local/adjacent sources whereas the wider provenance and variations in the role of the primary and recycled detritus are assumed for the further parts of the successions. The source areas seem to be largely stable during the depositional history, reflecting the tectonic history and resulting depositional phases.

"Bottomsets" of the lava-fed delta of James Ross Island Volcanic Group, Ulu Peninsula, James Ross Island, Antarctica

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Lava flows from land into the body of standing water become fragmented and may produce deltaic bodies with external morphology and internal stratigraphy analogous to that of alluvial Gilbert-type deltas. The descriptions of lava-fed (hydroclastic) deltas are much less common in the geological literature than the studies of alluvial deltas. Moreover foresets and topsets of hydroclastic (hyaloclastic) deltas attracted significantly more attention than bottomsets. Results of sedimentological study of the three geographically separated outcrops of bottomsets of a single lava-fed delta (Pliocene) in the area of the Ulu Peninsula, James Ross Island (Antarctica) are presented. Deposits of traction currents, deposits of volcaniclastic debris flows and products of such flows transformations (both low- and high-density turbidity currents) together with glacigenic deposits were all recognised within studied bottomsets. Existence of submarine proglacial environment formed prior to formation of volcaniclastic deposits is supposed. The principal role of mass flow processes was recognised and explained by relative steep slopes of the lava-fed deltas. The distribution of lithofacies significantly differs in the individual outcrops. These variations in sedimentary succession and also in thickness of “bottomsets” of the single lava fed delta suggest principal role of local condition and paleogeography for development and preservation of this part of delta depositional system. Moreover proximal and distal setting can be followed and direct vs. more distant relation to over-riding lava-fed delta supposed. The sedimentary succession terminated by foresets of hyaloclastite breccia.

Comparison of sedimentological processes and stable isotopic composition of a cave hosted travertine deposit (Béke Cave, NE-Hungary)

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Travertine deposits are frequent in the caves of the Aggtelek Karst that hosts the World Heritage Baradla Cave system. The travertines are formed as dams and terraces in underground creeks as well as massive deposits at cave springs.
A white travertine deposit in Béke Cave formed at undergound springs was sampled by taking a 40 cm long drill core for sedimentological and geochemical investigations.
In the upper 30 cm of the core material the dip of the macroscopically visible laminae changes from 30° to 0° several times indicating multiple microterrace progradation. Dense, white calcite with columnar texture alternating with porous, columnar calcite are characteristic in horizontal laminae while branching feather or sparry crystals alternating with dark micrite are more common in laminae with steep dip. The upper 3 cm, and the recent surface of the core consist of sparry crystals and pisolites deposited from the pool. Thin, luminescent detrital layers parallel to the lamination (they often coincide) are common in all types of microfabric. Lamination is not continuous in the lower 10 cm of the core due to its chaotic texture with large branching sparry crystals and intraclasts.
The 40 cm long core was dated by U-Th age dating and lamina counting. Due to detrital Th contamination 4 out of 8 U-Th analyses did not yield any meaningful age data, the other 4 results were used only for the estimation of the age period covered (recent to about 4 ky BP). Lamina counting was possible in the younger ~30 cm, yielding 416 laminae in 281.7 mm. Optical microscopic analyses revealed that these macroscopically well visible laminae are often consisting multiple, rhythmically deposited, detrital layers that – compared with the U-Th age estimation – may be related to the 11 years solar cycling. Lamina counts and U-Th age estimations were used as a base of an age-depth model.
Stable C and O isotope compositions and trace element concentrations were measured along several transects on the surface of the travertine in order to determine weather the carbonate show signs of kinetic fractionation. Changes in microfabric were compared against the C and O isotope composition record of the core. While all microfabric types vary on the same intervals of stable C and O isotope composition, abrupt changes in stable isotopic composition coincide with the changes in microfabric. Variation of microfabric shows a good correspondence with lamina thickness and $\delta^{13}C$ values with more negative $\delta^{13}C$ data in sections with reduced lamina thickness, e.g. 3,5 ky BP.
Comparing the C and O isotope composition records of the core with independent stalagmite records from the region, strikingly good correspondences are revealed, which suggests that the selected travertine drill core data may potentially be useful as a paleoclimate proxy.

Basement tectonic heritage on the development of the Brazilian sedimenatry basins

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In Brazil, the large interior cratonic basins (“syneclises”), as well as the smaller ones (interior rifts, aulacogens), present an important degree of dependence from the nature, structural framework and thermal age of its basement during their different stages of evolution and post–sedimentation preservation. The large cratonic basins were deposited either on the syn-Brasiliano cratonic nucleus of the Amazonian Craton (> 1,0Ga), or over the regions activated tectonically by the Neoproterozic folded belts (~ 0.9 – 0.6 Ga).
Over the Amazonian Craton, a series of basins with Paleozoic and Mesozoic sediments were formed over an area of more than 1,2 million km^2. In the eastern part, the Amazonas Basin was deposited over the oldest rocks of the Amazonian craton (> 1,8 Ga) and a very long and wide E-W Neoproterozoic to Cambrian rift was the precursor site for the Paleozoic stages of sedimentation. The basement of its western part, below the Solimões and Pastaza Basins, is formed by fold belts of Mesoproterozic ages (<1,60 Ga). These were deeply affected by the Andean orogenies, and present a complex scenario of shear zones, structural inversions, block uplifts and folds (+basaltic magmatism) of late Jurassic ages.
The Parnaiba basin at the north-northeastern part of the continent (ca. 600,000 km^2) presents a relatively small triangular shaped cratonic core as basement (>1,0 Ga), surrounded by a branching system of orogens of the Brasiliano tectonic cycle (~ 500-600 Ma). Since the earliest depositional phases, the tectonic development of these fold belts was important, and the two main depocenters of the basin are located along these neoproterozoic shear belts. During the entire Paleozoic history, active tectonics produced different kinds of deformation in the basin, especially along the trace of the Transbrasiliano Lineament, which cuts across the basement of the Parnaiba Basin in its southeastern part. In addition, a Mesozoic tectonic reactivation was the cause of a pervasive basaltic magmatism.
The Paraná basin at the S-SE part of the continent (ca. 1,200,000 km^2) presents, as basement, a cratonic nucleus (“Paranapanema”, > 1,8 Ga) surrounded by a system of Brasiliano orogens. The influence of the basement structural weaknesses is detected over and along the main shear zones of the Brasiliano folded belts. Moreover, all the orogenic phases of the Andean tectonic chain, during the Paleozoic, present some degree of influence to the development of the cratonic sedimentary sequences of the basin. The small interior basins (interior rifts, aulacogens), which are widespread in northeastern Brazil, may be subdivided in two groups: a) a widespread group occurring within the Borborema Province, which took advantage of the weaknesses of the neoproterozoic branching system of orogens, especially the old shear zones. Actually, they are just remnants of the “Slossian” sequences which covered vast portions of the region, trapped by reactivation events along the neoproterozoic faults. b) The Recôncavo-Tucano-Jatobá basin in Pernambuco and Bahia states, which is a Mesozoic aulacogen that firstly followed the structural trends of the São Francisco Craton and later followed the structural trends of the southern part of the Borborema Province.

The interaction of eustasy, climate and tectonics controlling early dolomitisation of shallow marine Cenomanian strata of the Iberian Peninsula

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Dolomitisation of Lower-Middle Cretaceous carbonate platforms is not well documented, perhaps because of high global sea level and humid climatic conditions. Cenomanian strata of the Iberian Basin, deposited in a semi-arid climate belt due to a rain-shadow effect, show differential dolomitisation across a ~100 km long platform. Field and petrographical data reveal a progressive decrease in the amount of dolomitisation towards the south in middle Cenomanian strata, while the reverse is true in upper Cenomanian strata. This suggests that there was also a tectonic control on fluid flux.
During the Cenomanian, the Iberian Peninsula was characterised by a shallow intracontinental platform flooded from the Atlantic to the north and the Tethys Ocean to the south, which were separated throughout much of the Cenomanian by the Seuil topographic high. The platform was flanked by the Hesperian and Ebro massifs which show continental sedimentation.
Initial flooding of the basin occurred in the middle Cenomanian and is characterised by the undolomitised, shallow marine, subtidal Santa Maria de los Hoyas Formation. This formation is sharply overlain by the pervasively dolomitised Villa de Ves Formation which is composed of metre-scale upward shallowing peritidal cycles. Both of these formations clearly show deeper facies to the south. Planar dolomite fabrics, lack of evaporite deposits, $\delta^{18}O$=-1.1 to -4.1‰ PDB, $\delta^{13}C$=-2.0 to 2.0‰ PDB and trace element concentrations indicative of marine fluids all suggest that dolomitisation occurred via mesosaline evaporated seawater, in part mediated by microbial processes. Given the southerly dipping ramp, dolomitising fluids are interpreted to have moved from north to south.
Rapid sea level rise in the upper Cenomanian led to connection of the Atlantic and Tethys Oceans, deposition of mid-ramp facies of the Picofrentes Formation and cessation of dolomitisation. Subsequently, the entire Iberian Peninsula tilted towards the NW resulting in tidal flat development in the south. Reflux of dolomitising brines, leading to dolomitisation, was initiated. Given the planar dolomite fabrics, $\delta^{18}O$=-4.0 to -2.0‰ PDB and $\delta^{13}C$=-2.0 to 2.0‰ PDB dolomitisation is interpreted to have occurred from mesosaline fluids. The total amount of dolomitisation decreases from south to north, a reversal of the trend seen in the middle Cenomanian.
In conclusion dolomitisation in the Iberian Basin during the Cenomanian was principally controlled by interaction of eustatic sea level changes and tectonics. Both of these factors control relative sea level, which given an overall arid climate, caused pulsed migration of mesosaline refluxing brines.

Carbonate petrofacies interpretation of borehole image (FMI) with a comparative petrographic evaluation: A case study from an outcrop well in Bachu uplift, Tarim basin

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It’s difficult to carry out detailed identification and classification on carbonate rocks and petrofacies with conventional logging techniques. Carbonate textures with unique image characteristics allow the correlation between borehole image (FMI, XRMI, EMI, Star-imager and MCI) and depositional rocks. Here, a special well called TK-1 was initially drilled in the Ordovician carbonate outcrop in Buchu uplift, Tarim basin. This well is designed as a standard coring well and logging calibration well which collected continuous cores in the whole depth interval and acquired four series of comprehensive geophysical logging datasets. The petrology analysis with cores and casting thin sections in TK-1 makes it possible to evaluate borehole image (FMI, EMI and MCI) in detail.
“Core-log” calibration, especially for borehole image, is useful for the correction of core pieces to the appropriate in-situ depth position and core reorientation. Here, firstly the cores (up to 100 meters long) were proportionally corrected in depth and orientation with respect to borehole image. A full set of FMI logs (21.5 m-208.5 m), 112.32 meters cores (60 m-186.9 m with 93.6% coring recovery rate) and 100 casting thin sections were evaluated in this study.
Core and casting thin section provide mm/um scale information including lithology, sedimentary structure and rock texture, while FMI image allows sedimentary definition on a mm scale (probably even less for fractures). The integration of core, casting thin section and FMI in TK-1 makes it possible to finely analyze the comparative borehole image in petrographic view and dig every detail in borehole image including one mottled spot, single resistivity or conductive image strip and some other image characteristics, which thus make clear on the micro-mechanism of image feature differences. Each type of carbonate rocks correlates to its unique borehole image features and the same rock type may include at least two image features due to texture types, the ratio of different textural constituents and their internal arrangement. Every mottled spot or single strip in FMI image indicates one special depositional or diagenetic property (drilling-induced image features not included in this well). Borehole image can clearly outline an organic framework whose size is greater than equipment resolution (0.2 in). Although diagenesis like dolomitisation, dissolution, pressure-solution is reflected by their special image features, they don’t impact the lithology identification for borehole image. This study shows the merits of petrofacies interpretation based on borehole image and provides a new method proved critical for fine description of image logging, also provides a standard reference for imaging interpretation in other carbonate formations where have not been cored or core recovery has been incomplete.

Trace fossils from the Upper Cretaceous Elbtal Group (Cenomanian–Lower Coniacian, Saxony, Germany)

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The sedimentary rocks of the Cenomanian–Lower Coniacian Elbtal Group of Saxony are a classic area of geoscientific research since more than two centuries. In the course of a taxonomic revision of the Cretaceous fossils of the unit, the trace fossil inventory has been studied both in the collections of the MMG and in the field, also making use of the new and improved integrated stratigraphy of the Elbtal Group.
The taxonomic revision resulted in the recognition of 1) simple traces: *Lockeia amygdaloides* (Seilacher), *Skolithos linearis* (Haldeman), *Bergaueria* isp., *Planolites* isp., fugichnia; 2) branched traces: *Chondrites targionii* (Brongniart), *Ophiomorpha saxonica* (Geinitz), *Ophiomorpha* isp., *Thalassinoides suevicus* (Rieth), *Keckia annulata* Glocker, *Keckia cylindrica* Otto, *Keckia nodulosa* Otto, *Asterosoma*? *wohlfarthi* (Otto); 3) horizontal concentric traces: *Asterosoma radiciformis* Otto, *Asterosoma* isp., *Dactyloidites ottoi* (Geinitz); 4) three-dimensionally coiled traces: *Gyrolithes saxonicus* (Häntzschel); 5) actively backfilled traces: *Lepidenteron lewesiensis* (Mantell), *Lepidenteron mantelli* (Geinitz); 6) spreiten structures: *Zoophycos* isp., *Teichichnus* isp.; 7) borings: *Entobia cretacea* Portlock, *Gastrochaenolites torpedo* Kelly & Bromley, *Teredolites clavatus* Leymerie, *Teredolites longissimus* Kelly & Bromley; and 8) coprolites: *Koprolithes mantelli* Geinitz.
The depositional system of the Elbtal Group can be approximated with a grain size-graded shelf according to the onshore–offshore-related hydrodynamic and bathymetric gradients. Rocky shorelines of the Saxonian Cretaceous Basin are characterized by *Entobia* and *Gastrochaenolites* (Trypanites ichnofacies). The sandy nearshore zone of high and permanent water energy is dominated by vertical structures such as *Skolithos*, the shafts of *Ophiomorpha*, *Gyrolithes* and *Bergaueria* as well as *Dactyloidites* (Skolithos ichnofacies). The transitional facies of the Elbtal group (offshore transition zone) is characterized by a predominance of horizontal traces and high ichnospecies richness and abundance. Typical elements are networks of *Ophiomorpha*, *Thalassinoides*, *Keckia*, *Lockeia*, *Asterosoma* and *Bergaueria*, displaying the Cruziana ichnofacies. The offshore zone below storm wave base, dominated by muddy sediments (argillaceous marls and silty limestones), is pervasively bioturbated and individual ichnotaxa are difficult to recognize. In some cases, *Thalassinoides*, *Lepidenteron, Planolites, Zoophycos* and *Chondrites* can be identified. Driftwood with *Teredolites* is not rare and occurs across the ichnofacies belts that are characterized by gradual transitions. Tubular tempestites (coarse-grained infills into formerly open burrows) are common throughout the strata of the Skolithos and Cruziana ichnofacies and show the importance of storms for the deposition of the Elbtal Group.

Variability of tsunami deposits associated with coastal environmental settings that change over time

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Recent post-tsunami surveys and paleotsunami investigations revealed typical characteristics and variability of tsunami deposits. The variability of tsunami deposits is caused not only by onshore tsunami behavior but also by coastal environmental settings. The onshore tsunami behavior is controlled mostly by offshore tsunami waveform and coastal topography. The coastal environmental settings include material component and grain size features of the beach sand, and surface vegetation and micro-topography where the tsunami inundated and the deposition occurred. It is noted that these local environmental settings are reflected seasonal changes and secular changes at each site for long years.
A good example of how the features of tsunami deposits are controlled by local environmental settings at the time of the tsunami impact the coastal area is shown in a coastal wetland in Urahoro, Hokkaido, Japan. At the site, large tsunamis caused by earthquakes along the Kuril trench are known to have impacted every 400-500 years for last 3,500-4,000 years. We could observe at most 10 sandy to silty tsunami deposits. The features in thickness and grain size patterns and material components are not same one another. For example, the latest tsunami deposits in the 17th Century is thickest and the thickness varied with a wavelength of 50 cm to 1m. These wavelengths are similar to the vegetation-induced micro-topography (tussocks or Yachibouzu in Japanese) created in the present wetland in cold districts. The similar pattern is *seen for the 12-13th Century tsunami deposits but the older deposits show simple sheet-like distribution inferring that the area was not cold enough to develop tussocks.
The variability of the tsunami deposits is, therefore, useful to correlate sandy layers of the same tsunami origin based on their material components and thickness and grain size patterns. At some sites along the Pacific coast in Hokkaido, we could show the difference of inundation distances among the paleo-tsunami deposits. To understand size variability of the paleo-tsunamis is important for tsunami hazard assessments based on geological investigations.

Construction and destruction of recent rhodoliths – a case study of rhodoliths from Giglio Island, Italy

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Rhodolith beds are one of the main benthic communities dominated by marine macrophytes and are a critical habitat for conservation in coastal areas. In this study, void spaces of rhodoliths have been analyzed in order to understand their growth histories and related environmental conditions. Present-day rhodoliths from the Island of Giglio (Tyrrhenian Sea, Italy) have been investigated with special regard to shape, growth-forms and taxonomy of constructing flora and fauna, porosity and bioerosion. The techniques used include sectioning and micro-computed tomography (micro-CT). Rhodolith shape is determined following a sphericity equation based on the measurement of principle axes. Porosity within the nodules is calculated using image processing software based on slab surfaces and micro-CT enabling the recognition of different void types at different scales as well as their distribution within the rhodoliths.
The studied rhodoliths range in size from 4 to 13 cm and are spheroidal to sub-spheroidal in shape. They are predominately constructed by coralline red algae with minor contributions by bryozoans and serpulid worm tubes. Measured porosity values range from 3 to 41 % in volume, whereby three different types of porosity could be distinguished: primary, constructional and destructional. 1) Primary voids are present within single cells of the coral-line algae. 2) Constructional voids are caused by amalgamated protuberances of coralline algae thalli. 3) Destructional voids are produced by dissolution of nucleus as well as potential soft bodied animals and by bioerosion. Bioerosion is present at different scales including *Trypanites* and *Gastrochaenolites* ichnotaxa, with the degree of bioerosion (bioerosion index, BI) ranging between low (BI= 2) and moderate (BI= 3).

Genetic mechanism of fine sedimentary rocks in Chang 7 Oil Group of Ordos Basin

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Ordos Basin is located at the west North China Platform. Ordos Basin at late Triassic was a large depressed lake basin with continuous deposition. Under the structural pattern of steep southwest part and smooth northeast part, the southwest part of Yanchang Formation was a braided fluvial delta depositional system, the northeast part was a meandering river delta depositional system, and the middle part was a lake-gravity flow depositional system. On basis of lake basin deposition evolution sequence and oil layers longitudinal distributive laws, the Yanchang Formation was previously divided into 10 oil layer groups (Chang 10 - Chang 1). Specifically, Chang 7 group was the flourishing period of lake basin development, when fine deposits were widely developed. The hydrodynamic conditions and transportation/deposition mechanisms both differ among different depositional systems. Thus, the genetic mechanisms of fine deposits in Chang 7 are very complex and diversified.
Through the research of outcrop, core, comprehensive analysis data, we find 4 deposition genetic mechanisms in Chang 7 oil layer group, including traction current transport & deposition, gravity/gravity flow transport & deposition, volcanic debris transport & deposition, and dissolved material transport & deposition.
The traction currents originated from water flows and waves, while the weak or strong hydrodynamic conditions led to the differences in the depositional mechanisms. The low-energy hydrostatic environment is dominated by suspended deposition. The main facies include mudstone face with horizontal beddings, mudstone face with horizontal veins, and shale face with page-shaped horizontal beddings. The high-energy environment is dominated by leaping and rolling deposition. The main facies include fine sand face with horizontal beddings, fine-sand face with water flow cross beddings, fine-sand face with wave-built cross beddings, siltstone face with wave-built cross beddings, and siltstone face with ripple beddings.
The gravity/gravity flow actions are composed of slump, non-viscous clastic flow, and turbidity flow. Under the mechanism of gravity transport & deposition, the deposits under the action of gravity will slump and then transport and deposit as masses, which lead to the development of fine sand facies with torn mudstone fragments. Under the action of non-viscous clastic flow, the deposits will transport and deposit as masses, which leads to the development of massive mud-clay fine sandstone without beddings. Under the action of turbidity flows, the deposits mainly deposit as suspensions, and two facies developed, including fine sandstone face with graded beddings and bottom die structure, and siltstone face with Bouma sequence.
The mechanism of volcanic debris transport & deposition can be divided into the air-carried type and the water-carried type, which both belong to suspended deposition and can be separated by the single layer thickness. The air-carried type is dominated by the strip-shaped tuff facies, while the water-carried type by thin-massive tuff facies.
Under the mechanism of dissolved material transport & deposition, the carbonate deposits in the quiet salty water environment mainly deposit as chemical precipitation, and the main face is lentoid limestone face.

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Late Pleistocene fluvial sedimentation in the Upper Morava pull-apart basin: Stratigraphy, facies analysis and sediment provenance patterns

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Upper Morava Basin (UMB) is a syndepositional pull-apart basin developed at the contact of the Bohemian Massiff with the Outer Western Carpathians and drained by the Morava River and its tributaries. UMB is a 90 km long and 30 km wide graben-like depression controlled by NW - SE striking faults of the Elbe-Odra zone. Tectonic activity of these faults strongly influenced the basin fill stratigraphy and structure, surface morphology and rapid switching between sources areas of its siliciclastic sediments. The basin is filled by Upper Miocene/Lower Pliocene to Pleistocene/Holocene lacustrine and fluvial sediments with maximum thickness locally exceeding 300 m. Differential tectonic uplift and subsidence in the UMB is documented in the variable depths of erosion of the preQuaternary deposits as well as in the relative height of terrace systems, which are preserved on the slopes of adjacent elevations and beneath the active river floodplains. Stratigraphy, depositional environmental and provenance patterns of the UMB were studied from lithofacies analysis, grain-size distribution, petrophysical patterns, clast composition heavy-mineral spectra and bulk-rock and single grain geochemistry. Four wells were drilled and several hundred-m-scale outcrops in sand pits and river banks were studied. The studied fluvial sediments are mostly coarse-grained and poorly sorted facies Gt, Gh, Gmg and Gmm (Miall, 2006) forming sedimentary bodies with thickness up to 10 meters. These sandy gravels alternate with more-fined grained sands of the facies classes Fsn, Fm, Fl and Sh. Petrophysical patterns (mass specific magnetic susceptibility, sediment colour) and element geochemistry in drill cores make it posible to observe three distinct fluvial phases. Heavy mineral data and clast composition indicate that these phases were sourced from different source areas, mostly located in the NE part of the Bohemian Massiff. OSL and 14C dating (ages from Early Saalian to Holocene) suggests that differential subsidence played an importent role in the infill of the basin.

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Gondwana tectonic event roll on the sequence stratigraphy patterns of Silurian deposits of Iran

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The Iranian Plate consists of Central Iran Microcontinent, Alborz and Sanandaj-Sirjan, of probable Gondwanan or peri- Gondwanan affinity, known as a part of the larger Cimmerian continent during evolution of the Paleo-Tethys and Neo-Tethys oceans. Kopet-Dagh area in the North-East of Iran, was part of the Turan Plate and the Hun superterranes, until the Paleo-Tethys started to opening and the Hun superterranes rifted away from the north of Gondwana. Due to a better understanding about sedimentary conditions of Iran and Turan plate (during the evolution of Paleo-Tethys Ocean), two stratigraphic sections (Central Iran Microcontinent and Kopet-Dagh) of Silurian Niur Formation measured and studied. Lithostratigraphy and facies analysis of Silurian Niur Formation at Central Iran Microcontinent and Kopet-Dagh sections proves the existence of submarine volcanic rocks, limestones, shale and sandstones at two sections. The existence of submarine volcanic rocks at the base of both section, probably related to opening of Paleo-Tethys ocean at Late Ordovician-Early Silurian time. Based on lithology, sedimentary structures and texture, twenty four (consist of sixteen carbonate, five silisiclastic, two carbonate-silisiclastic and one volcanic) facies, recognized in two measured sections. These facies deposited in five sedimentary environments such as low to high energy conditions of tidal flat, low energy conditions of lagoon, high energy conditions of bioclastic shoal, high energy conditions of patch reef and also open marine environments. Field observations and facies distributions demonstrated these strata were deposited in a mixed carbonate-silisiclastic homoclinal ramp that preserved two third-order depositional sequences (DS1 and DS2) with non-erosional sequence boundary. In the Central Iran section, Silurian Niur Formation was deposited during Llandovery-Pridoli so that TST and HST of DS1 and also TST and lowermost HST of DS2 were deposited during Llandovery, and rest of HST continuing in the Devonian deposits. Whereas in Kopet-Dagh section, Niur Formation was deposited in Llandovery-Wenlock so that TST and HST of DS1 and TST of DS2 deposited during Llandovery and HST of DS2 deposited in Wenlock. According to this, both sections are started with sub-marin volconic rocks and other open marine facies as TST stage of DS1, similar to other place at the Middle East and global transgressive phase. Although there are evidences of passive rifting activities during the Early Silurian that led to the separation of Turan from Iran Plate, similarities between depositional sequences of Central Iran and Turan Plate demonstrated these plates were not completely detached basins during the Early Llandovery and facies differences in two sections during this time may be related to local tectonic activities. From the Middle Llandovery time with formation of different depositional sequence at both section, the rifting likely led to the separation of Turan from Iran Plate and formation of different depositional sequence in two sections. Similarities of sequence stratigraphy patterns of these sections to other places at the world and Middle East region demonstrated that global eustatic changes were premium stimulus of observed relative sea level changes during the Silurian, although local tectonic events and fault activities could provide complications and differences on these patterns.

Uranium in the coal zones of the Springbok Flats Basin, South Africa

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Uranium is known to occur in coal and carbonaceous shale in the upper part of the Coal Zone and within the sandstones of the Late Permian Ecca Group in the Springbok Flats Basin of South Africa. High concentrations of uranium occur in the vicinity of granitic palaeoridges and beneath coarse-grained, granite-pebble-bearing sandstones of the Late Triassic Molteno Formation, where it unconformably overlies the Coal Zone. Previous studies suggest that the uranium has originated from granites of the Bushveld Complex, which surround and underlie much of the Springbok Flats Basin. The uranium in the Coal Zone is thought to have been epigenetically emplaced from oxidised fluids that migrated from both the granitic palaeoridges and adjacent hinterland, and/or from the overlying Molteno Formation sediments, which contain abundant granitic detritus. For areas where the Coal Zone is not truncated by the Molteno Formation, some authors suggest that the uranium mineralisation could have originated from descending ground waters which dissolved uranium from the overlying Beaufort Group during its diagenesis. Uranium precipitated when it entered the reducing environments associated with carbonaceous sediments.
The origin of uranium mineralisation in the Springbok Flats Basin has not previously been investigated in detail. A new project to study uranium mineralisation and the provenance of sedimentary rocks of the Springbok Flats Basin has been initiated to better understand the distribution, content, form of occurrence, and sources of uranium. Available results show that uranium is indeed concentrated in the upper portion of Coal Zones, supporting the hypothesis of precipitation from descending ground water. While coffinite has been observed, the uranium in coal is in most cases not hosted in a discernible (> 1 µm) mineral phase, and submicroscopic coffinite and/or hosting of uranium in organic molecules is suspected.

The role of high-resolution biostratigraphy in the delineation of reservoir architecture and the potential use of calcareous foraminifera in identifying system tracts

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This work was originally conceived as a research-based BSc (Honours) project in conjunction with RMA Group to characterise reservoir architecture of the West Linapacan oil-field, hosted by Lower-Middle Miocene, fractured, siliciclastic and calciclastic sediments of the Northwest Palawan Basin, Philippines. The main carbonate-turbidite reservoir unit was previously modelled with a "layer-cake" stratigraphy, despite a calciclastic submarine fan depositional model and the internal heterogeneity that is often associated with turbidite deposits in this environment. This study aimed to evaluate this stratigraphic model by assessing the vertical and lateral heterogeneity between four wells across the field, utilising a variety of techniques. Understanding the lateral heterogeneity of the reservoir was essential for the optimisation of development wells.

The stratigraphy was analysed using foraminiferal biozonations, high-resolution biostratigraphy, petrographic analysis of cuttings and well logs. Four distinct stratigraphic packages (Packages A-D) of various thicknesses (30-60 m) were identified within the reservoir unit. Each package varied in carbonate grainsize (calcarenite-calcilutite) and fabric (packstone-mudstone), gamma response and the presence of key bioevents. Three of these packages (A-C) could be correlated to nearby wells. However, minimal penetration of the reservoir unit in some deviated wells prevented the correlation of the deeper stratigraphy around the field. Though this research supports a coarse scale layer-cake stratigraphy on a scale >10 m, lateral variations in carbonate grainsize, fabric and texture, as well as gamma ray response, indicate that there is significant variability on the finer-scale (<10 m). Understanding this variability is an important step towards re-defining the depositional model for the field.

The application of high-resolution biostratigraphy, utilising planktonic foraminifera from cuttings samples, revealed a distinct pattern between the abundance of *Globoquadrina venezuelana* through time and changes in biozone throughout the wells. Large increases in the proportion of *G. venezuelana* (10-30%) in counts ranging from 100-200 specimens occurred just prior (3-10 m) to changes in planktonic foraminiferal biozone. These also coincided with major lithological changes and are indicative of a significant perturbation in palaeoenvironment. Smaller fluctuations (5-10%) in species abundance were also noticed within the upper reservoir and occur in close proximity (3-10 m) to changes in lithology, most notably, prior to increases in coarser-grained facies identified in thin section. Increases in *G. venezuelana* are interpreted to represent parasequence boundaries, suggesting that the shedding and transport of calcareous material via turbidity currents increased during times of reduced sea-level.

This study demonstrates the importance and versatility of high-resolution biostratigraphy in aiding the identification of internal stratigraphic architecture. Additionally, the study of select taxa can be used to understand the controls and influences of carbonate turbidite depositional systems, or, potentially, siliciclastic systems and how these relate to sequence boundaries in deep water sediments with uninterrupted sediment deposition.

Stromatactis-like cavities from the Wielkanoc quarry (Southern Poland) – experimental studies and implications to genesis of stromatactis

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Stromatactis-like cavities in the Wielkanoc quarry occur within the complete sequence of Upper Jurassic massive limestones. The carbonate buildup is composed of overgrowing microbialites, siliceous sponges, and hermatypic cladophyllid corals. These organisms built the reticular framework in which intra-framework spaces are filled with wackestones, packstones, or bioclastic grainstones. Distinctive are elongated and oval pores, up to 2 cm long and about 4 mm across developed in such sediments. In some pores partly dissolved cladophyllid corals are preserved. At the weathered rock surface, stromatactis-like cavities appear as single cavities, up to about 4 cm wide and 2 cm high, but usually are smaller. Under the microscope, the stromatactis-like cavities occur within thrombolite-sponge and *Crescentiella*-peloid wackestones. The roofs of cavities are usually irregular. In some cavities, roofs have smooth, arcuated surfaces. The upper parts of the stromatactis-like cavities are filled with multi generation carbonate cements, whereas their lower parts are occupied by the internal sediments composed of the same constituents as the surrounding rock.
The formation model of stromatactis-like cavities presented here assumes the presence of precursor cavities and dynamic loads within partly lithified sediment. It seems that such cavities were formed by dissolution of corals during early diagenesis when sediment infilling the intra-framework spaces was incompletely lithified. Dissolution of corals disturbed the primary stress field within the carbonate buildup and generated the secondary stress characterized by the appearance of compressional forces in the walls of cavities and tensional forces in their roofs. The lack of support of poorly cemented sediments over roofs of cavities might have caused their instability and collapse. The internal erosion of sediment might have resulted from vibrations generated by periodical rejuvenation of movements along the Kraków-Lubliniec Fault Zone in the Late Jurassic and/or by local collapses of buildup frameworks. The presence of tensional stress in the roofs of cavities combined with the low strength of sediment might have caused separation of single grains or the compact aggregates of grains from the roofs of cavities. The falling material were deposited at the bottoms of cavities producing the internal sediments. Falling down of sediment particles from the roofs caused upward migration of cavities.
Experimental studies were run in a water tank in which two blocks of limestone powder were formed. The cavities of dimensions 36 x 12 mm, oriented horizontally and vertically, respectively, were formed within a blocks of limestone powder. Dynamic loads were generated by hitting the basement of the tank. Generation of dynamic load in limestone powder disturbed stability of material over the roofs of cavities. Material fallen from the roofs and walls was deposited at the bottoms of cavities and, in this experiment, corresponds to the internal sediment filling the natural stromatactis-like cavities. The cavities were not entirely filled with the internal sediment because of this compaction and leveling of cavity floors. Final bottom surfaces of cavities were wavy or flat, whereas their roof surfaces were domed. In both samples, the final cavities were displaced in comparison to their initial position.

The influence of climatic conditions and subsequent diagenesis on heavy minerals in Danish sandstones at depths of 0–5 km

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The basement of the Fennoscandian Shield has through eras supplied material to the Norwegian-Danish Basin. Differences in provenance can therefore be excluded as a cause of the variations in heavy mineral contents in the derived sediments. Heavy mineral assemblages of sands and sandstones from depths of 0–5 km onshore Denmark show trends that are primarily related to climate and diagenesis. The studied Triassic red beds were deposited during hot arid climatic conditions, and the climate had changed to warm humid conditions when Triassic-Jurassic paralic-marine sediments were laid down. Warm temperate humid conditions prevailed during deposition of Miocene fluvio-deltaic sands. Fe-Ti-oxides are dominant in the shallowly buried humid sediments, Ti-oxides dominate in the deeply buried humid sediments and Fe-oxides/hydroxides are more predominant in the arid deposits. Some of the Ti-magnetite and ilmenite in the humid sediments have transformed into leucoxene and rutile by leaching of Fe and this process is strongly promoted by increased burial depth. All garnet grains are dissolved below c. 3 km depth. The preservation of amphibole/pyroxene during burial is promoted by arid depositional conditions. Depth trends are most evident in the heavy mineral assemblages from the warm humid sandstones where the amounts of zircon and rutile are relatively enriched with increasing depth. This is because the contents of garnet, amphibole/pyroxene, ilmenite and Ti-magnetite decrease downwards due to diagenesis. About 100 samples were analyzed with computer-controlled scanning electron microscopy (CCSEM) where the modal abundances of 1200 heavy mineral grains per sample were determined. Energy dispersive X-ray spectrometry was combined with contrasted back-scattered electron micrographs to determine the element composition of each grain.

Diagenesis, provenance and depositional environments of the Bunter Sandstone Formation: Detailed interpretation of reservoir quality using a combined approach

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The Bunter Sandstone Formation in the northern North German Basin has large geothermal potential with high porosity and permeability (generally >15% and >100 mD, respectively) and with pore fluid temperatures that are adequate for geothermal energy production (c. 55–60˚C). A combined investigation of diagenesis, provenance and depositional environments is used to identify the reservoir rocks that possess the best quality. This is accomplished by integrating various methods including: seismic reflection data, sedimentological description of cores, mineral quantification by point counting, measurement of porosity and permeability, heavy mineral analysis and zircon U–Pb geochronometry. An overall correlation exists between porosity and permeability in the sandstone intervals of the Bunter Sandstone Formation and the scatter along the general trendline is related to grain size, detrital composition, clay morphology and type of cementation. The reservoir quality of the Solling Member (upper Bunter sandstone) is good in most of the sandstones, but it is poor where abundant clay or pervasive cementations by anhydrite, carbonate or halite occur. Ephemeral fluvial sandstones are dominant in this member and they have a local sediment source in the Ringkøbing-Fyn High. Thus the architecture and diagenetic alterations of this reservoir are variable and difficult to predict due to the depositional environment. The Volpriehausen Member (lower Bunter sandstone) has excellent reservoir quality because the sandstones are aeolian, weakly cemented and clay-free. Furthermore, they have a wide lateral and fairly constant vertical distribution since large quantities of mature sand were supplied from distant source areas in the Variscan belt.

Sequence stratigraphy architecture and variations of aeolian deposits preservation in a coastal environment (Permian Cutler Group, SE Utah, USA)

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Some architectural models of the sequence stratigraphy integrate aeolian deposits. They discuss their preservation potential according to variations of the climate changes, the accommodation space and sediment supply. However, few of these models consider the preservation of aeolian deposits according to the associated environments.
The aim of this presentation is to constrain the expression of the genetic units, to propose an architectural model and to discuss the variations of preservation of the aeolian deposits. The sedimentological analysis and sequence stratigraphy interpretation lead to discuss about spatial and temporal evolutions of depositional environments.
This study focusses on the Lower Permian series of the Cutler Group (Paradox Basin, SE Utah). These series are characterised by fluvial and coastal aeolian deposits within a semi-arid climate. Their excellent exposition in the canyons in the SE Utah, allowed detailed sedimentological and sequence stratigraphy studies from five sedimentological sections. These sections are located along a profile from a proximal domain dominated by fluvial deposits to a distal domain dominated by aeolian dunes.
A detailed sedimentological analysis allows to distinguish aeolian from subaqueous dunes (often under-estimated) and to characterise the diversity and the evolution of the aeolian facies along the depositional profile. The characterisation of the bioturbations, fauna or flora, specifies the sedimentological model. The integration of the whole information constrains the genetic units and the correlations (from the reservoir scale to the basin scale).
Consequently, high-resolution sequence stratigraphy analysis allows to propose a stratigraphic architecture integrating the variations of preservation between aeolian, fluvial and marine deposits and describing the aeolian associated facies. In a first stage, we define the genetic units of this complex depositional environment within a semi-arid climate. In a second stage, we discuss several architectural models within this coastal marine basin. Thus, the Cutler Group evolve from a coastal marine environment, with low aeolian deposits preservation, toward a more well preserved aeolian dunes domain and finally to a fluvial dominated system with very low preservation of aeolian deposits.

Petrography and geochemistry of organic matter from a paleo-petroleum system (Cameros Basin, Central Spain)

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The Cameros Basin is a paleo-petroleum system formed in the north-eastern Iberian Peninsula. The basin formed during the Mesozoic Iberian Rift and later on it was inverted during the Alpine orogeny. Hydrothermal events took place during the post-extensional and inversion stages, producing important impact in the thermal history of the basin. In order to establish the source rock of the system, the characterization of the organic components, the petroleum-generative potential and the thermal maturity stage of the basin infill are analyzed in detail.
Several organic rich units of the stratigraphic record of the basin appear as potential source rocks for hydrocarbons generation, although their characteristics differ depending on their location. Organic matter content in the northern sector is scarce and limited to vitrinite, inertinite and solid bitumen particles. The TOC (<1%), S2 (<0.3 mg HC/g rock), HI (<50 mg HC/g TOC) values and the mature to overmature thermal stages (%Ro from 1.7 to 4.6 %) measured indicate low hydrocarbon potential. An inversion of the vitrinite reflectance with depth trend is observed close to faults and permeable lithologies. Instead, the southern sector of the basin is characterized by abundant organic matter remains and immature to early oil-window thermal conditions, with TOC (>2%), S2 (from 10.85 to 123 mg HC/g) and HI values (from 23 to 715 mg HC/g TOC) that indicate high hydrocarbons potential.
The different preservation and maturity of the organic matter in the basin are consequences of a differentiated subsidence rate that determines different thermal evolutions. The circulation of hydrothermal metamorphic hot fluids in the northern-central sector during the evolution of the basin stressed these differences and additionally it causes anomalous distribution of the thermal conditions in the stratigraphic record and the formation of alteration textures in the organic matter.
The results of this study demonstrate that combination of petrographic, geochemical and sedimentological data is of great utility when reconstructing paleo-source rocks in basins undergone a complex thermal evolution, consequently characterized by a low organic matter preservation. Our results can have important economic implications to oil exploration through similar basins.

Carbon and oxygen isotope record from the Rhaetian interval at the Kardolína section, Slovakia

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Triassic/Jurassic boundary (TJB) of approximately 201.3 million years ago is known as a stratigraphic boundary recorded one of the big five Phanerozoic mass extinctions. Catastrophic processes such as widespread eruption of the Central Atlantic Magmatic Province (CAMP) flood basalts and the sudden release of methane from gas hydrate have been proposed to account for the TJB mass extinction event. In order to infer the Late Triassic to Early Jurassic environmental changes in the northwestern Tethys Ocean, the stratigraphic variations of δ^{13}Ccarb and δ^{18}O in the TJB limestone succession (~ 100 m in thickness) in Slovakia were examined. The Kardolína section studied here crops out on a western slope of the Mt Pálenica in the Belianske Tatry Mts in Slovakia. This section consists of a shallow marine carbonate sequence of the Rhaetian Fatra Formation and the overlying Hettangian Kopieniec Formation. The Fatra formation represents a ramp facies deposited along the small pull-apart Zliechov Basin in the Western Carpathians. Our microfacies analysis revealed that the depositional environment of the lower part of the Fatra formation is in the slope to basin facies on the carbonate ramp. The Fatra Formation shows cycles with shallowing upwards patterns, as indicated by facies changes from bioclastic wackestone to bioclastic-oolitic packstone-grainstone. The carbon isotopic values are relatively stable in the Fatra Formation. Our analysis showed that the negative carbon isotope excursions (CIE) were found in four stratigraphic levels of the Kardolína section. The lower three CIEs occur during the deposition of non-fossiliferous lime-mudstone, which are formed in a period of subaerial exposure. The largest negative CIE was observed across the Fatra Formation and overlying Kopieniec Formation. This negative CIE must correlate to the initial excursion observed in the TJB sections from other Tethyan localities (e.g., Austria, Italy, and Hungary).

Thermal conductivity of sedimentary rocks as function of Biot's coefficient

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Effective thermal conductivity (ETC) of a sedimentary rock is conventionally modelled as a sum of contributions from solid and a fluid by using porosity to describe the quantity of each phase. But because heat transfer in a sedimentary rocks, with stagnant fluid, is governed by the solid contact path, a porosity based ETC-model must necessarily include quantification of this path. Introducing α as Biot's effective stress coefficient, such quantification is presented as (1-α), which when interpreted as the degree of cementation is equal to the solid contact path. Acknowledging (1-α) as the governing heat path, a series-parallel ETC-model is established for a unit volume with porosity ϕ. The unit volume is composed of two parallel heat paths: solid to solid contacts (1-α) and remaining solids (α – ϕ) in series with the pore fluid ϕ. Porosity and α can both be evaluated from conventional bore hole logs. So by including α in the model, ETC can be directly modelled from logging data provided thermal conductivity of the contributing minerals is known.

Depositional architecture of a travertine dome structure, Ballık area, Denizli, western Turkey

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A travertine dome structure exposed in a quarry at elevations between 650 and 730 m (asl), located in the easternmost part of the Ballık travertine area, Denizli, western Turkey, has been studied. In the quarry, the travertine body displays an asymmetric domal (or mound) structure, which is approximately 750 m long and 200 m wide in N-S and E-W directions, respectively. The quarry is still being excavated. Total thickness of the travertine sequence is at least 50 m. The structure has been surrounded by a siliciclastic cover unit of 45 m in thickness from the west. The siliciclastic cover unit consisted mostly of conglomerate, sandstone and red to green mudstones. Conglomerates, derived from the uplifted bedrocks to the north, include mostly pebbles of Mesozoic limestones and eroded Quaternary travertine. The cover unit has been interpreted as alluvial, ephemeral stream and shallow pool deposits. The domal body was cross-cut by numerous normal faults that are mostly NW-trended.
The travertine sequence of the domal mass starts with low grade slope facies on the south and north flanks, with slope angles up to 25°. The slope facies is dominated mostly by bryophyte travertine and associated layers of crystalline dendrite lithotype. These dominant lithotypes are accompanied by interlayers of monoclastic travertine and erosion surfaces. The slope facies passes gradually upward into waterfall facies, developed on the north and south flanks of the domal structure. Brown-coloured bryophyte travertine of the waterfall facies is associated with vertical to subvertical crystalline dendrite travertine. The latter is white, compact and thin bedded to laminated. In addition, within the waterfall facies, monoclastic travertine lithotype is observed in shapes of lense and pocket.
The $\delta^{13}C$ and $\delta^{18}O$ values of the travertine samples ranged from −3.3 to +0.8‰ (PDB) and from −11.4 to −7.8‰ (PDB), respectively. These negative to less positive $\delta^{13}C$ values possibly relate to mixing between deeply sourced CO_2 and soil-derived CO_2 and are similar to those from the western part of the Ballık area. The Sr content of 184 to796 ppm is low compared to the other travertine localities of the Denizli Basin.
As a whole, travertine deposition of the domal mass evolved gradually from dominantly sub-aqueous environment, represented by the horizontal to sub-horizontal layers, to sub-aerial slope and waterfall environments.
The dome structure studied could be considered as reservoir analogue with respect to the dome-shaped Presalt continental carbonates from the South Atlantic.

Fine-grained and coarse-grained lacustrine turbidite systems in Fushan Depression, Beibuwan Basin, South China Sea: Implications for sedimentation and reservoir potential

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As a hydrocarbon-bearing succession, Paleogene Liushagang Formation in Fushan Depression (Beibuwan Basin) is mainly composed of fan delta and braided river delta sediment, and can be divided into three third-order sequences (SQE*l*s3, SQE*l*s2 and SQE*l*s1), in which two deepwater depositional systems has been deciphered as fine-grained and coarse-grained lacustrine turbidites based on the integration of drilled cores, wire-line logs and 3-D seismic survey. Although these two deepwater sediments are classified into the same facies category, i.e. lacustrine turbidite system, they are distinctive with each other greatly. The fine-grained turbidite, deposited during SQE*l*s1 and located in the western part, is composed of fine- to medium-grained sand being bedded with thin silt-rich shales. The deposits are mainly gray-white fine sandstone, gray pebbly greywacke and muddy intraclasts with typical structures containing climbing ripple, gradational laminations and small cross-laminations. However, the coarse-grained turbidite, formed during SQE*l*s2 in the east, is characterized by medium to coarser sand size, and comprised of greywacke, gray pebbly sandstone and gray to white conglomerate associated with massive bedding, deformed and slump structures.
A comparison between fine-grianed and coarse-grained turbidites reveals their reservoir differences from petrologic composition, porosity and permeability, and pore types by analyzing more than 300 thin sections. More specifically, the sediment in the fine-grained turbidite, composed by 40%~72% quartz, 3%~17% feldspar and 17%~40% lithic fragments, is of poor reservoir quality with a relatively lower porosity ranging from 5%~18%, a low permeability of less than 1 mD, and a relatively low carbonate cement content of 2%. By contrast, the coarse-grained turbidite consists of 50%~62% quartz, 5%~15% feldspar and 23%~40% lithic fragments, and presents a relatively better reservoir properties than that in the fine-grained one characterized by a porosity of 8.1%~22.4%, an average permeability of 116 mD and an extremely low carbonate cement content of 0.5%.
Beyond the comparison of reservoir properties, further contrastive analysis between the fine-grained and coarse-grained turbidites indicates that they belong to two different types of sedimentation. The fine-grained one slides and slumps from the lower fan fringe of braided river delta due to a combinational mechanism: high sediment pore pressures arising from rapidly sediment-accumulating at the slope-edge can cause instability and commonly initiate shelf-edge failure; correspondingly, these sliding and slumping are accompanied by the activity of Meitai Fault in the south. On the other side, once sediments reaches and spillovers the slope-break, a suddenly changed relief from 3°~5° to 7°~9° and an increased accommodation space make coarse-grained sediments discharged on the slope and onto basin floor, and a coarse-grained turbidite formed. These sand-rich sediments show a nonefficient transportation, and are adjacent to source area and controlled by the geomorphology of flexure slope-break belt. Therefore, a comparative study on these two turbidites advances the understanding of sedimentation and regional tectonic influences associated with hydrocarbon-bearing potential and exploration direction, and this endeavor might be of great significance for local oil industry.

Bed thickness distribution in classical deep-marine turbidite systems: Examples from the Marnoso-Arenacea (NE Italy), and Grès d'Annot (SE France) Formations

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The frequency distribution of turbidite bed thicknesses potentially contains information about the flow hydrodynamics, the processes by which flows are initiated and the character of their sources. Three main statistical models have been proposed to describe turbidite bed thickness distributions: a lognormal distribution model, a (segmented) power law model, and an exponential model.
This study aims to evaluate the applicability and limitations of each of these above models in characterizing deep-marine turbidite systems. The purpose is to develop a statistical methodology that may be used to evaluate the depositional sub-environment of turbidite deposits or to point out basin-wide differences between depositional systems (e.g. confined or unconfined deposits).
Field data were collected from classic outcrops of two well-studied deep-marine systems with well-understood stratigraphic architecture: the Marnoso-Arenacea Formation (Miocene), in northeastern Italy, and the Grès d'Annot Formation (Eocene-Oligocene), in southwestern France. Fieldwork involved extensive sedimentological logging of the turbidite successions and gathering of detailed bed thickness data in different environments. Statistical processing of collected datasets focused on fitting the frequency distributions to lognormal, power-law and exponential models.
Results for selected sections in both studied deep-marine systems indicate a prevalence of lognormal distributions, with mixtures of different lognormal thickness populations for each section type (i.e. proximal vs distal). Differences in the number, variance and proportion of lognormal mixture components seem to be related to the presence of different types of beds, probably representing denser versus more dilute flow types. In addition, observed differences in the patterns of lognormal mixture components may be related to the presence of beds deposited by hybrid (turbidite-debrite) flows, particularly in the distal, unconfined lobe/basin plain deposits of the Marnoso-Arenacea Formation. Another issue that may be affecting the individual characteristics (mean, standard deviation, mixture proportion) of the observed lognormal distribution models is the definition of individual measured beds. The presence of well-defined hemipelagic muddy beds in the Marnoso-Arenacea Formation permits the identification of each individual turbidite flow, but this is not possible for the Grès d'Annot system, where the sandy turbidite events are often amalgamated.
On the other hand, bed thickness datasets in both studied deep-marine systems are not well-fitted to power law or exponential thickness distribution models. Some datasets of very thick beds can be defined as having a power law tail. This could be useful from a reservoir characterization perspective, provided that the bed thickness range for which the model holds lies in the sub-seismic scale and the distribution of thick beds is not already recognized from well-log or geophysical analysis.

Basin margin high-density gravity flow deposits from the Late Cretaceous of Cauvery Basin, India

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Gravity flows are unique sedimentary processes which deliver huge volumes of sediments to basins and host a majority of the recently discovered hydrocarbons in deep water reservoirs. They are the main reservoirs in the Cauvery and other basins along the passive Eastern Continental Margin of India. In the basin, gravity flows have been studied only from subsurface cores, well logs and seismic data. However, their record and studies in exposed sequences were not available. The exploration and exploitation of these reservoirs therefore faced set-backs due to absence of detailed understanding of controls on their distribution, internal architecture, flow rheology, diagenesis and depositional mechanisms.

The present work deals with a recently discovered channelized complex of high-density sediment gravity flows, found in outcrops close to the basin margin. The complex is exposed, towards the top of Late Turonian – Coniacian, Trichinopoly Group, 1 km southeast of Alunthalaipur (N11°03'2.29", E78°54'48.61"). It has an average width of ~500 m and is exposed for ~1500 m along its course.

Three types of channelized systems are noticed as we move from the southern to the northern outcrops viz. shoestring channel, channel belt and levee belt.

The shoestring channels show 1-1.5 m incisions into buff gypsiferous sandy clays of the Trichinopoly Group. These channels are sinuous, narrow (average width 3 m) with general flow direction from WSW to ENE. They are filled with very coarse fining-up sandstones with floating outsized pebbles to cobble sized clasts derived from the Precambrian crystalline basement; and are massive hard and compact. The channel fills are bioturbated with *Thalassinoides-Ophiomorpha* burrows.

Northwards, low sinuosity, stacked and multilateral amalgamated, unconfined to partially confined channels and channelized lobes are observed (width to height ratio 1:10 to 1:20). The proximal portion of these channels contain massive sandy to gravelly deposits (average thickness 2 m); while distally the grain size and bed thickness reduces to medium to coarse sand, 0.1 – 0.5 m thick. The fills in the channel belt and lobes are interpreted to be non-Newtonian debris flow sandstones, deposited by frictional freezing of a non-cohesive laminar flow. Distal units show normally graded sandstones with floating clasts and an uppermost finer, parallel laminated or cross-bedded portion; indicating transformations from high to low density turbidity flows. Mottling due to bioturbation, biogenic escape structures, vertical water escape pipes, convolute bedding and clay clasts are common.

The levee complex occurs along the northern margin of the channel complex. The levees, made-up of sands, silts and clays showing normal grading and parallel bedding, are deposited due to suspension sedimentation from low density turbidity currents. The bed thickness and grain size gradually reduces towards the top. Occasionally, ill preserved trace fossils, possibly belonging to *Cruizana* ichnofacies are present.

Analysis of the graded profile in the basin suggests these gravity flows originated from a high relief provenance and were deposited proximally due to loss of gradient on entering the basin. Subsurface data, however indicates that such flows are also deposited tens of kilometres away from the basin margin.

Grain size controls on the morphology and stratigraphy of river-dominated deltas

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The proportions of sand and mud that make up a river-dominated delta strongly determine its topset morphology, which in turn controls its internal facies and clinoform geometry. These relationships allow prediction of the stratigraphy of a delta using the character of its topset and reconstruction of deltaic planform from measures of clinoform geometry. This paper presents results from the Delft3D modeling system which was used to simulate nine self-formed deltas that possess different sediment loads and critical shear stresses that are required for re-entrainment of mud. The simulated deltas were set to prograde into a shallow basin without waves, tides, Coriolis forcing, and buoyancy. Model results indicate that sand-dominated deltas are more fan-shaped whilst mud-dominated deltas are more birdsfoot in planform, because the sand-dominated deltas have more active distributaries, a smaller variance of topset elevations, and thereby experience a more equitable distribution of sediment to their perimeters. This results in a larger proportion of channel facies in sand-dominated deltas, and more uniformly-distributed clinoform dip directions, steeper dips, and greater clinoform concavity. These conclusions are consistent with data collected from the Goose River Delta, a coarse-grained fan delta prograding into Goose Bay, Labrador, Canada and also allow us to undertake a re-interpretation of the Kf-1 parasequence set of the Cretaceous Last Chance Delta, a unit of the Ferron Sandstone near Emery, Utah, USA. We argue that the Last Chance delta likely possessed numerous distributaries with at least five orders of bifurcation.

The use of GPR to investigate the internal structure of travertine strata

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One of the main problem working at relative small scale in travertine outcrops is the definition of their internal structure for both ornamental stones exploitation and pure geological studies. Sedimentological analysis performed on travertine outcrops showed how complex could be their internal facies organization and, consequently, their porosity due to rapid lateral internal variability (cavities, fractures, stratifications, fabrics…).
The possibility to predict travertine internal structure from not quarried bodies may helps in the definition of exploitation strategy or, in a larger context, to their structural/sedimentary asset. Non-destructive Ground Penetrating Radar (GPR) techniques have been applied to the Rapolano travertine systems cropping out about 40 km south of Siena (Tuscany, Central Italy).
The studied travertines consists of Middle-Late Pleistocene and Holocene hot water carbonates, mainly deposited in slope system environment along a normal fault located in the eastern margin of the Neogene-Quaternary Siena Basin. Such deposits are well exposed in several quarries and along a fissure ridge system developed on the trace of a minor fault.
GPR survey has been conducted using 80, 200 and 600 MHz shielded IDS Corporation Radar antennas along the Terme San Giovanni fissure ridge and Querciolaia-Rinascente quarry areas. The first survey was aimed to the definition of the internal structure of travertine forming the ridge, the second to the analysis of the quarried slope system travertine.
The investigated depth is function of the used antenna and on the weave propagation velocity. In particular the survey has investigated depth comprised between 1 and 6 m with a resolution ranges from few (1-2) to 10 centimetres. The investigated depth is comparable with the high of the quarried terraces, never exceeding 10 m, and with the high of the fissure ridge (5-6 m).
All surveys have underlined that radar waves easily propagate inside the travertines. This has allowed a well imaging of their internal structure and acquired data may be discussed in broad and particular view.
- Broad: the radar signal of travertines is very specific. This allows a very accurate definition of local stratification and subsurface sedimentary organization, with consequences for prediction of fracture systems and intercalations with some other non-carbonate material. In the Querciolaia quarry the extent of the potential exploitable travertine and its thickness have been mapped. In the fissure-ridge area the relationship between the travertine and surrounding clay are very clear.
- Particular: GPR survey resolution offers the possibility to investigate the internal structure of travertine layers. In particular the presence of cavities have been enhanced as well as changes in strata dip or geometry. Moreover, the high resolution of the high frequency antennas gave the opportunity to image the micro structures visible at the outcrop scale, such as micro karst systems, and centimetric stratal architecture of the imaged body. A 3D survey conducted on a 10 by 15 m outcrop has imaged the cavities spatial distribution.

Thermal Properties of Gassum Fm and Recovery Efficiency for Thermal energy storage

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Thermal rock properties, such as Thermal Conductivity and Heat Capacity, are of interest for geothermal applications, e.g. heat storage. A heat transfer model of the Gassum Formation (Stenlille-Denmark) was built to calculate the recovery efficiency of the sandstone reservoir following to the injection of hot water. The Gassum Formation is composed of a series of quartzarenite sandstone bodies with heterolithic sand-shale intervals in between.
We estimate two thermal properties (Thermal Conductivity and Heat Capacity) according to:
• A well log based prediction, using GR, Density and Neutron logs.
• Using Common Mixing Models in a monomineralic case. Common Mixing models help us to calculate Thermal Conductivity in wet conditions and are based on different combinations of three parameters: Thermal Conductivity of the solid part of the rock (assuming 100% of Quartz), Thermal Conductivity of water and Effective porosity calculated subtracting the contribution of shale part to the total porosity.
• Using Common Mixing Models considering mineralogical composition. Gassum Formation is basically composed of Quartz (72%) K-Feldspar (7.4%) Albite (2.4%) Kaolin (6.2%) Illite (5.3%) and Mixed Clay minerals (4.5%)
Then the heat storage site in a confined sandstone aquifer was numerically simulated using COMSOL Multiphysiscs based model. The model is based on Finite Elements analysis and attempt to model the heat front propagation and heat storage in the reservoir considering a single injection well. The model is tested increasing the flow rate of the injected hot water (90 °C) and increasing recovery efficiency (from 21% to 77%) and increasing produced water temperature (from 40 °C to 70 °C) were noticed. Based on the results, Thermal Conductivities for sandstones are in the range 2-4 W/m*K and for claystones in the range 2-3 W/m*K. These are theoretical values obtained by the different methodologies that we used. We perform also a statistical error analysis based on experimental data where we find that the error range varies a lot from 6% (Well log based Prediction) up to 30% (Common mixing Models: monomineralic case). Heat Capacity is calculated to be in the range 900-1000 J/kg*K with only 10% of error range.

Recurrence of Hirnantian and Famennian deglaciation facies pattern – the causes and consequences

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During examination of several sections with glaciomarine diamictites both around O/S and D/C boundaries authors noted distinctive similarities between facies pattern successions. These similarities were observed in storm-dominated sequences (tempestites), lying directly on the diamictites and followed by deeper and calm water dark fine-grained siliciclastics.
On the SW Baltica shelf (Polish segment), Hirnantian glaciation (O/S) is manifested by marine, fine-grained, distal diamictites. Three glaciomarine horizons (up to 3 meters in summary thickness), which are interbedded with marly deposits were observed, frequently showing both brittle and plastic deformations, caused by iceberg keel seabed scouring. In the other sections, the bed rich in well sorted, rounded and polished quartz grains (“millet seed”) with grains of glauconite and rectangular limestone clasts and forms a sort of postglacial “cap bed,” playing a similar role like cap-carbonates on Cryogenian diamictites. Occurrence of such extrabasinal, allochtonous, coarse-grained material within a calm, marl-dominated sedimentary system, can be indicative of a widespread, mass wasting, high-energy event (severe storm?). In one Polish section, until now, diamictites pass into Llandovery glauconite and shell hash rich, marly beds, that indicate condensed, transgressive lag deposits. Similar glauconite-rich transgressive sequences are known from Llandovery basinal succession of the Cinncinnati arch (central USA). Where glaciomarine sediments are lacking, bioclastic limestones with *Hirnantia* sp. brachiopod fauna laterally replace this diamictite triplet. All examined sections are overlain by black, laminated Llandovery graptolitic “hot shales,” interpreted as typical transgressive, anoxic and fertile sedimentary realm deposits. A Hangenberg deglaciation succession (D/C) examined in two sections from Madre de Dios Basin (northern Bolivia). There the authors observed Famennian glaciomarine diamictites, several dozen meters in thickness. Similar to the Hirnantian case, Devonian diamictites are followed with probable Tournaisian storm-dominated siliciclastics sequences and finally with prodeltaic deposits, indicative for calm and high bioproductivity environment. In these particular two sections have not been found glauconite grains, however mass occurrence of this mineral was reported from several post-Hangenberg condensed, transgressive sections from Rhenohercynian basin, as well as Illinois basin (central USA). The similarities between Hirnantian and Famennian deglaciation facies patterns, observed by the present authors, and which occur globally, suggest remarkably similar factors (such as climatic, eustatic, hydrodynamic, redox conditions, bioproductivity etc.) controlling sedimentary regimes and their successions on a global scale. Careful analysis of these two particular cases can be a solid base of general deglaciation model construction, applicable also for other glacial events during Earth history.

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Stormy warming-up of Baltica shelf: transition from Hirnantian „iceberg alley" to Llandovery „hot shales”

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Ordovician/Silurian transition has been examined in outcrops and well cores along the southern shelf of Baltica in a 1700 km long transect stretching between the Oslo Graben in the northwest and the Podillia Basin (Ukraine) in the southeast. This boundary interval consists of three facies associations (FA) arranged vertically in a transgressive succession of glaciomarine diamictites (FA1, storm deposits (FA2) and black shales (FA3).
FA1 reveals pods of quartz dominated, very poorly sorted, fine pebble sandy mudstone, up to 6 m thick, showing angular to rounded granule and small pebble clasts that are chaotically set up within a dark grey, silty-clayey matrix, rich in white mica flakes and locally exhibiting laminated portions. This diamictite facies occurs in three beds, which are separated by light gray, bioturbated marls showing signs of both plastic and brittle deformations. Angular or plastically deformed marl clasts, up to 10 cm in size, are embedded locally in the diamictite matrix. In places, FA1 appears as breccia, in which broken blocks of marls are cut by irregular diamictite veins, whereas at other locations it is reduced three, discrete and undeformed layers, up 1.5 cm thick, of fine-grained quartz wackes. FA1 has been recognized from Pomerania through the Lublin Basin and farther to Podillia, and its lateral equivalents comprise carbonate quartz-less marls and limestones, containing *Hirnantia* sp. shell accumulations ascribed to the Late Ashgill (Hirnantian). The diamictites are interpreted as glaciomarine deposits and the associated deformations as caused most likely by iceberg grounding. The abundance of the scouring marks might be related to the periodic activity of an “iceberg alley” (analog of the Pleistocene Heinrich events), which extended northwards to the tropical Baltica shelf and was fed with icebergs calved off from the edge of Gondwana ice sheet.
FA2 comprises coarse-grained siliciclastic-carbonate rocks, built of perfectly rounded quartz grains mixed with glauconite and dispersed limestone clasts. In the Oslo Graben, these deposits form channelized, fining-upward units of limestone block-bearing, matrix-supported conglomerate and breccia, overlain by cross-bedded quartz-oolitic sandbars (“millet seed” sandstones). Farther southwards, FA2 does not exceed 50 cm in thickness and consists of cm-thick, sharp-based beds and lenses of calcareous sandstone with dispersed <1cm carbonate clasts, interbedded with dark, bioturbated mudstones. FA2 is interpreted as tempestites reflecting period of increased storm activity by rapid postglacial warming-up that provoked unstable atmospheric conditions on the global scale. The southward fining of the tempestite beds may reflect distal trends along storm paths. Overlying FA3 comprises Llandovery, black, graptolitic, organic-rich, laminated, argillaceous mudstones interbedded locally with greenish grey, bioturbated mudstones, which both onlap to the E (cratonwards) and SE Upper Ordovician carbonate platform. The mudstones record high bioproductivity and intermittent anoxic/suboxic bottom conditions at water depths located below storm-wave base and dominated by slow-suspension settling.
The described tri-partite (diamictite-tempestite-“hot shale”) succession is correlative with similar O/S transitions around the globe and indicates post-glacial warming up and global transgression.

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The stratigraphic significance of turbidite deposition under partially ponded conditions: Bed statistics and onlap geometries, Castagnola mini-basin (Early Miocene, NW Italy)

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Confined depocentres (such as salt withdrawal minibasin or structurally confined basins in active settings) represent important depositional sinks for deep-water sediments. Most classic models of turbidite bed statistics and onlap geometries are underpinned by the assumption that as a confined basin fills, the transition from a fully ponded to a non-confined condition is represented by only a relatively minor proportion of the basin fill. Although tectonic deformation can provide a mechanism to increase the proportion of the fill that records partially ponded conditions, i.e., when basin subsidence and sedimentation rates are similar, this condition might not be very common. However, even in a structurally quiescent basin, flows of different volumes will have different abilities to escape the confining topography. Hence, the range of the flow volume distribution will define the minimum duration of the situation when at least some flows are partially ponded. Moreover, aggradation on the basin margins/sills can occur while deposition in the depocentre takes place. This probably most commonly occurs under partially ponded conditions (when the lower concentration and less erosive part of the flows are able to escape the confinement and deposit material on the basin sill). This process will increase the thickness of basin fill deposited under partially ponded conditions.
The Castagnola sub-basin (Early Miocene, Tertiary Piedmont Basin, NW Italy) is a small (10-20 km^2) minibasin filled by c. 1 km of southerly-sourced siliciclastic turbidites; there is no evidence of significant tectonic deformation during deposition. The northern and southern basin margins are fully and partially preserved, respectively, allowing different onlap geometries (feathered vs abrupt) to be recognised. The succession is tabular at the km scale, with erosion limited to a small number of thicker beds; net-to-gross evolves from 0.2 at the base to 0.7 toward the top. Thick mud caps in the lower section, along with presence of reflected ripples and overall sheet-like architecture of the turbidite system are suggestive of ponded deposition. While the gross evolution of the basin is that of a transition from dominantly ponded to non-ponded conditions, marked by the disappearance of thick mud caps and sandstone beds with reflected facies, a significant thickness of the stratigraphy (c. 400 m) shows less dramatic but still resolvable trends of net to gross increase and mud cap to sandstone bed thickness decrease, interpreted as a signal of long-lasting partially ponded conditions. The high proportion of the stratigraphy laid down under partially ponded conditions has implication for classic fill-and-spill models, turbidite beds pinch-outs and onalp geometries and for techniques used in the subsurface to infer ponding conditions (such as bed thickness statistics). Understanding the factors controlling the degree of ponding, together with any associated diagnostic signatures in the resulting deposits, represents an advance in establishing predictive models for confined basins.

Carbonates and related facies with vestiges of biomarkers from the Chattisgarh Basin, India: Clues to redox conditions in the Mesoproterozoic ocean

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Two Mesoproterozoic carbonate platforms characterized by distinctive profiles, facies, and evolutionary sequences developed in the Raipur Group of the Chattisgarh Basin, southern India. The Charmuria/Sarangarh Limestone (~490m), the lower platform, is a non-stromatolitic ramp, mostly composed of planar tabular bedded micritic carbonate-shale rhythmite with minor mixed siliciclastic-carbonate components in the lower part, and a black sand-free limestone (Timarlaga Mbr) in the upper part grading, upward into brown shale of the Gunderdehi Formation. The platform developed largely below fair-weather wave base, but experienced frequent storms during early stages of platform development followed by a major transgression, and deposition below storm wave-base. Input of siliciclastic shales are the possible cause of the demise of the lower platform. The upper platform, the Chandi/Saradih Limestone (670m) developed chiefly in the intertidal to shallow subtidal environment with prolific growth of stromatolites. The microbial system evolved from a restricted embayment to open-marine conditions, as evidenced from the change in morphology and shape of the stromatolites. Tectonics and eustatic sea-level change played a major role in controlling the broad facies pattern and platform evolution.
The $\delta^{13}C$ signatures of the Chattisgarh limestones, falling within a relatively narrow range (0 to +4 ‰), are typical for Upper Mesoproterozoic carbonates. $\delta^{18}O$ values however have a greater range (-5.7 to -13.3‰) indicating significant diagenetic alteration of some samples. Low total organic carbon values observed in carbonates and shale possibly result from degradation, high thermal maturity, and poor preservation of organic matter and/or low productivity due to poor nutrient supply. The lack of 17β,21α (moretanes) and high Tmax values suggest mature organic matter in the non-stromatolitic ramp. A paucity of diagnostic eukaryotic steroids indicates that algae were rare in the Chattisgarh Basin. A high content of hopanes supports a generally bacterially-dominated Proterozoic ocean in which the various stromatolites flourished. Anoxia (euxinia) likely existed below storm wave base during the deposition of the Timarlaga Limestone whereas the Gunderdehi shale and Chandi/Saradih stromatolite facies were deposited in more oxic seawaters, all consistent with previously proposed redox heterogeneity in the Proterozoic oceans.

Origin and sequences of sedimentary structures of shelf macrotidal sandstone bars in the Neoproterozoic Kerur Formation of the Badami Group, Kaladgi Basin, India

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The Neoproterozoic Kerur Formation (aka the Cave Temple Arenite; ~285 m), of the Badami Group, unconformably overlies the Kaladgi Group and passes up to the Katageri Limestone with a sharp contact. The Kerur Fm. consists mostly of mineralogically and texturally mature silica-cemented medium-grained sandstone (with subordinate conglomerate), siltstone, and shale. The sandstone outcrops as isolated or stringed hills in a large lowland of mudstone. The studied litho-succession is divided into two major units: (a) a lower unit consisting of furiously cross-stratified coarse- to medium-grained, feldspathic sandstone with a few scattered pebbles and lenticular beds of conglomerate. The deposits occur as shallow, fining upward wide channel fill bodies (1-2 m deep) with a high width/depth ratio (5:1), which are commonly amalgamated into thick sheets. The dominant paleoflow is toward SSW; and, (b) an upper unit constituting the main body of the Kerur Formation and consisting of medium-grained, very well-sorted, quartzarenite (<5% mud) and feldspathic sandstone, locally with coarser pockets and thin beds (10-20 cm) with isolated pebbles. They form positive-relief sandbodies, which are made up of “wavy parallel” or “pinch and swale” beds (thickness varies between 0.5-2 m). Most of the beds pinch out laterally within 5-10 m, but a few thick amalgamated beds could be traced laterally for over 50 m or more along the strike. The upper surfaces of the sandstone bodies are slightly convex upward and slope away in all directions from the crest region forming shoaling up linear bars and ridges, commonly more than a kilometre in length, and separated from each other by muddy to low-energy sandy deposits. Upper surfaces of a majority of thick beds show development of wave ripples and dunes, locally with marked concentrations of very well-sorted and well-rounded coarse sand and granules in the troughs. The dunes are generally symmetrical to slightly asymmetrical, straight to sinuous crested, with low amplitudes and broad wave lengths, and commonly exhibiting tuning fork bifurcations. Dune crests are generally parallel to the trends of the linear bars, with sharp or round crests, and with smaller ripples within the troughs of larger ripples. The dunes show discordant chevrons or vertically upbuilding bundles of strata, off-shooting and mud-draping foresets, or bidirectional foresets. The trough cross-strata (1-2 m wide), occur as cosets (0.5-1.5 m thick) of herringbone cross-stratification, and commonly with reactivation surfaces.
The facies in the lower part of the succession was deposited in braided streams. The upper facies was deposited by large, migrating bedforms in high energy wave-reworked zones. Deposition involved repetitive cycles of tide-dominated to wave-dominated sedimentation, possibly within macrotidal range, stacking tidal dunes into sand ridges. Bipolar, bimodal distribution of foreset azimuths, with the modes between NE and SW indicate that these sandbodies developed as transverse to shore parallel bars and ridges.

Geological and geochemical analysis, basin modeling of the Neogene sediments of a hydrocarbon exploration area, southern part of the Great Hungarian Plain

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For the studied hydrocarbon exploration area in the southern part of the Great Hungarian Plain the last significant basin model was prepared at the end of 80's with the former approach and technology. Ever since significant amount of new information emerged, new seismic, drilling and geochemical results came out. During our work 1D and 2D models of subsidence and maturation history was prepared for the Neogene sedimentary succession of the studied basin based on the available organic geochemical data. The numerical basin modelling means imaging of the geological processes during development of the sedimentary basin. Our purpose with the modelling is to determine the hydrocarbon potential and time of generation, as well as the potential accumulation place and amount of hydrocarbon resources in the area.
The 1D and 2D basin models were prepared with the help of PetroMod software based on seismic interpretation of the sedimentary succession in Kingdom. The data for the modelling were derived from drilling results and literature, based on these it was possible to create the evolutionary and geological model of the area. The studied basin formed during the synrift phase of development of Pannonian basin, so along a strike-slip zone during the Middle Miocene extension. After it the basin filled with deep-marine sediments in the Karpatian stage. It is overlayed by a thick conglomerate succession which is probably related to a Gilbert-type delta system. In the Lower Badenian stage carbonate formations deposited in the basin as the result of transgression. In the deep basin, away from the coast pelitic sediments deposited. In the Upper Badenian and Sarmatian there was no sedimentation or the sediments eroded during the further tectonic events. The environment of Pannonian sedimentation cycle is represented from deep water, prodelta formations, through a delta slope – delta plain formation to alluvial plain formation.
In the studied area source rocks are the organic matter rich parts of the Karpatian and Badenian sediments. During the modelling higher and lower heat flow profiles were used which were received after the calibration to the temperature and vitrinite reflectance values measured in the modelled well; in one case the heat flow was calibrated to the Badenian source rocks, in other case to the Karpatian source rocks.
It was concluded that one part of the basin shows hydrocarbon generating capacity significantly higher structural position compared to the average in Hungary, and the maturity is different in the adjacent basin too, the sediments of the studied basin have higher maturity. Comparing the 1D basin models prepared by us and former experts for the studied basin we can determine that the top of oil window is significantly shallower in the fresh model.
To solve the current geological uncertainties a 2D regional maturation model was developed for the better understanding of the hydrocarbon generation prospective of the exploration license.

How the Coriolis force impacts paleoenvironmental record? A case study of Hornsund fjord (Spitsbergen, Svalbard)

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The aim of the study was to define spatial and temporal changes of benthic foraminifera biodiversity in the context of the 20th century climate warming. The benthic foraminifera abundance and species composition in Spitsbergen fjords are controlled mainly by the glacial meltwater discharge and Atlantic water influence, two factors that are strongly affected by climate warming. Hornsund is one of the most glaciated fjords of Spitsbergen, what makes it a suitable site for studying the climate change phenomena. Moreover, the main glacier fronts in Hornsund are located in the inner bays and along the northern side of the fjord. Due to the Coriolis force, the shelf-originated water is transported mainly along the southern side of Hornsund and glacier-originated water masses are guided along the northern side. Therefore, we have chosen study sites located at the northern and southern side of the fjord and reflecting the influence of glacial outflows and Atlantic water influx, respectively.
The investigation of two sediment cores, spanning approximately 120 years, was completed with the use of classical paleoceanographical proxies: biodiversity of foraminifera, stable isotope ($\delta^{18}O$, $\delta^{13}C$) composition, properties of sediment and the hydrology of studied fjord. The environmental response to the 20th century warming differed in the northern and southern part of Hornsund. Due to the Coriolis effect, the southern core was strongly influenced by shelf water masses and therefore reflected the large – scale shelf processes (i.e. the balance between Arctic and Atlantic water masses). The northern core reflected local conditions and its hydrology was shaped mainly by glacial runoff. The influence of Coriolis force was the most apparent before ~ 1950, when tidewater glaciers fronts were still relatively close to the samplings sites. The glacial impact in the northern core was reflected in relatively higher SAR, elevated and variable IRD flux and $\delta^{18}O$, suggesting intensive calving and freshwater delivery. The paleoenvironmental record of the southern core displayed low and stable SAR and IRD and light $\delta^{18}O$, what reflected inflow of STW and limited glacial impact. After ~ 1950, when glaciers proceed the retreat to the inner bays, sediment and meltwater delivery to the central fjord was limited. At that time the discrepancy between stations was expressed mainly in the foraminiferal abundance and diversity. The southern core was characterized by significantly higher number of species, mainly due to the presence of large number of accessory species, associated with warm and highly productive STW. The foraminiferal fauna of northern core was dominated by small number of opportunistic species, characteristic for glacier-proximal sites.

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The importance of spin: Global submarine channel dynamics

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A marked latitudinal variation has been observed in the sinuosity of submarine channels, with all the most sinuous examples relatively close to the equator, and nearly straight channels towards the poles. However, the underlying mechanics controlling this distribution have been less clear, with the spin of the Earth and its associated Coriolis force, and/or latitudinal climatic controls on sediment and flow type, being suggested. Here we present the first-ever experiments of channelized turbidity currents running over an erodible bed under the influence of rotation. We systematically varied rotation speeds to mimic changes in Coriolis forces with latitude to analyze intra channel-deposition patterns as a function of latitude in sinuous and straight model submarine channels. The experiments revealed a striking systematic change in deposition and erosion between the poles and the equator. At low latitudes erosion and significant point bars formed on alternate sides of meandering channels but decreased with increasing latitude. At high latitudes, deposition (or erosion) occurred along one side of channels. These findings support a conceptual framework that varying depositional patterns arise due to shifts in the force balance of centrifugal and Coriolis forces between different latitudes leading to strongly meandering channel systems near the equator but rather straight channels in high latitudes, at least for the largest channels. In addition, field data from both the modern ocean floor and the ancient rock record show differences in channel geometries supporting this conceptual model. We hypothesize that channel deposits vary on a global scale which offers a new approach to interpret deep-sea architectural features.

Lower Permian cool-water microbial carbonate mud-mounds of the Sverdrup Basin, Arctic Canada: A unique phenomenon driven by oxidation of phosphate

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The Sverdrup Basin (Canadian Arctic) has preserved the record of oceanic change in the Early Permian that saw warm-water photozoan carbonate s in the Asselian shift to cool-water heterozoan carbonates in the Sakmarian. The likely causes for this shift are intensification of upwelling along the western margin of Pangea in response to global warming and the subsequent closure of the Uralian connection with the warm Tethys Ocean. While algal reefs are ubiquitous in Asselian and older strata, reefs of any kinds are absent in the Sakmarian and younger Permian succession, except for two areas on Ellesmere Island where dozens of mud-mounds occur within the Raanes Formation. These mounds grew on a prograding sigmoidal slope in front of a distally-steepened ramp dominated by turbidites and tempestites composed of variably silty heterozoan wackestone and packstone replete with brachiopod, echinoderm, bryozoan and sponge spicule. There is no evidence of early submarine carbonate cementation in these beds, which are commonly over-compacted and littered with micro-stylolites. Phosphate (presumably derived from upwelling) occurs disseminated in the muddy matrix and as early cement in bryozoan zoecia.
Individual mounds are 30–150 m high and 100–1000 m wide multi-layered sigmoidal structures. They comprise a massive lime mud-dominated core passing laterally into well-bedded 20–45o inclined flanking beds. A sharp erosional truncation surface invariably occurs at the base of each mound. The mounds display a gradual contact with surrounding strata both upslope and downslope. Where observed the mound tops are also truncated off by an erosion surface. The non-reefal beds immediately beneath the mounds are typically red-weathering and contrast sharply with the greenish-brown colour of phosphate-containing Raanes sediments. The red colouration comes from iron oxide that replaced the phosphatic material in the host sediments. The mounds are pure carbonates with inter- and intra-particle early marine radiaxial calcite cement. The mounds comprise pelleted microbial micrite and mini-micrite associated with well-preserved bryozoan, echinoderm and sponge. Sponge spicules, *Tubiphytes* and eolasciodiscid, nodosarid and tetrataxid benthic foraminifers complete the biota. Open space stromatactis-like cavities, up to 5 cm in width, are cemented by multi generations of radiaxial isopachous cements. A later burial sparry calcite phase of burial origin occludes the remaining porosity.
A unique circumstantial set of conditions allowed these mounds to grow in spite of cool, relatively deep water conditions along an unstable slope. Diagenetic processes occurring at the oxic-dysoxic interface immediately beneath the Raanes sea beds concentrated iron phosphate minerals. Occasional slope failure exposed the phosphate-rich sediment to the oxic sea floor beneath truncation scar thus triggering extensive, possibly microbial, oxidation of iron phosphate. This resulted in the replacement of phosphate by iron oxide and the liberation of phosphate in the environment thus providing a concentrated source of nutrients for calcium-carbonate fixing mud-mound generating microbes. Once mound growth started, it progressed rapidly adding successive layers of early lithified microbial carbonates upon which a sessile benthic biota thrived. The process stopped as the mounds reached fair-weather wave base and ran out of space to grow.

Sediment transport and depositional style of sediment-laden gravity

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Subaqueous sediment-laden flows are thought to be the main mechanism transporting sediments to the deep sea. Such transport and deposition varies significantly between flows and within individual currents. Understanding the processes governing these flows is crucial to building predictive models of flow behaviour, sediment transport and deposition and is applicable to a wide range of disciplines. Here a holistic framework that bridges our current understanding of how sediment is transported and deposited for a wide range of sediment-laden flows is proposed. This framework encompasses a current velocity - yield strength phase-space that can now be divided into four zones: turbulent support; laminar support; turbulent settling; and laminar settling. Each of these transport and settling zones are described and linked to known processes and depositional styles. Furthermore, the proposed framework allows prediction of the transport and settling behavior of particles of a specific size for a known flow and sediment-water mixture conditions.

Controls on carbonate and evaporite deposition of basal Zechstein (Wuchiapingian) in SW Poland

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The PZ1 evaporite basin in the Wolsztyn High area is a classic example of filling of antecedent topography by halite. The development of basal Zechstein strata indicates the existence of a diversified relief after the flooding of the pre-existing depression by the transgressing Zechstein Sea. The deeper parts of the basin were the place of development of thin basinal Zechstein Limestone showing sedimentary condensation manifested by bored and encrusted grains and thick evaporites (mostly halite). Shallower parts of the basin are related to the tectonic Wolsztyn–Pogorzela palaeo-High (WPH), the south-eastern termination of the Brandenburg–Wolsztyn High (western Poland), which during Late Permian times was an intra-basin ridge surrounded by Upper Rotliegend sedimentary basins within the Southern Permian Basin. The WPH is characterized by common occurrence of isolated reefs in Wuchiapingian times that developed on uplifted tectonic blocks. The lateral persistence of the units distinguished in the Zechstein Limestone profiles suggests that the individual reefs had similar depositional histories. On the other hand, diversified thickness and size of the reef bodies as well as the diversions from a typical profile manifested by a lack of some lithological units of the Zechstein Limestone reflect the size, morphology and different subsidence rate of particular tectonic blocks in their basement.
The analysis of 2D sections extracted from the 3D seismic data showed that instead of three conventionally recognized evaporitic units in the PZ1 cycle, five units occur (from the base to the top: Lower Anhydrite A1d, Lower Oldest Halite Na1d, Middle Anhydrite – A1s, Upper Oldest Halite – Na1g, Upper Anhydrite – A1g). In a particular place their number may vary from two to five. There are two complexes of A1d occurring throughout the platform and basinal zones showing deepening-upward (transgressive) trend. The halite sedimentation in the deepest parts of salt basins began shortly after the deposition of the upper A1d complex while in the sulphate platform areas the sulphate deposition have continued. The Na1d deposits occur in the depressions. Between the halite basins, anhydrite platforms occur, and the thickness of anhydrite platform deposits is smaller than it is observed in salt basins. The Na1g in turn is recorded above the anhydrite platform. The two halite units represent different phases of development of halite basins. Formation of the Na1d basins was related to the pre-Zechstein depressions, although in some cases their syndepositional subsidence was controlled by reactivation of former faults within the sub-Zechstein basement. In turn, the Na1g basins used the accommodation space created due to anhydritization of the A1d deposits composed originally of selenitic gypsum and related volume loss. The prime controls on deposition of the PZ1 evaporites in the area studied were: (1) bathymetrical differentiation of sedimentary basin, both inherited and tectonicly modified during deposition, and (2) dehydration of original gypsum deposits. There is no doubt that also the differential compaction was partly responsible for the origin of anhydrite platforms, and this was closely related to different times of anhydritization in sulphate platforms and adjacent basins.

Pisolite facies in the Wuchiapingian Brońsko and Kościan isolated reefs of western Poland

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The tectonic Wolsztyn–Pogorzela palaeo-High in western Poland during Late Permian times was an intra-basin ridge surrounded by Upper Rotliegend sedimentary basins within the Southern Permian Basin. On uplifted tectonic blocks isolated reefs in Wuchiapingian times developed. They are characterized by lateral persistence of five units distinguished in the Zechstein below the Werra Anhydrite; this suggests that the individual reefs had similar depositional histories. The topmost unit of the Zechstein Limestone (Ca1) is stromatolitic–pisolitic carbonate a few metres thick. The general shallowing-upward nature of Zechstein Limestone deposition resulted in that in the upper part of the Zechstein Limestone bryozoans, the main reef-building organisms, disappear and stromatolites occur, possibly due to a considerable shallowing of the sedimentary environment associated with evaporative drawdown. Further sea-level fall resulted in subaerial exposure of considerable parts of the Zechstein Limestone in the Wolsztyn-Pogorzela High.
The stromatolitic-pisolitic unit is mostly dolomitic and in some cases shows brecciation. It is often composed of stromatolites (both planar and microdomal), fenestral peloidal dolomites, pisoids and calcrete. Occasionally intraformational tepees were recorded. This lithologic association shows remarkable similarities to the back-reef facies of the Capitan Limestone of the Gudalupe Mountains, New Mexico and Texas. In particular, co-occurrence of tepee structures, pisoids and fenestral peloidal dolomite strongly suggests a peritidal environment characterized by intense precipitation from very shallow hypersaline waters at a topographic high both in the Capitan Reef Complex and the Zechstein isolated reefs of western Poland. The palaeogeographical context of both these areas is different. In the Capitan Reef Complex the high separated an evaporitic lagoon from a more open marine area in contrast to the Zechstein where this high was encircled by an evaporitic basin.

Sedimentary history and biota of the Zechstein limestone (Wuchiapingian) Jabłonna Reef in western Poland

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The Jabłonna Reef, one of the reefs formed in Wuchiapingian times in western part of the Wolsztyn Palaeo-High (SW Poland), is characterized by quite irregular outlines and consists of three separate reef bodies (c. 0.5-1.5 km^2 each; the thickness of reef complex is usually >60 m). It is penetrated by four boreholes which show two distinct phases of bryozoan reef development during the Zechstein Limestone deposition. The first one occurred early in the depositional history and botryoidal aragonitic cementation played very important role in the reef formation. This phase of bryozoan reef development terminated suddenly; one possible reason was that the relative change of sea level – first the fall and then the rise, disturbed the upwelling circulation. Consequently, the bioclastic deposition was prevailing for quite a long time until the second phase of bryozoan reef development occurred, but it was not accompanied by dubious early cementation. During this second phase, reticular fenestellids bryozoans were dominating forms. Subsequently, microbial reefs developed which abound in the upper part of the Zechstein Limestone sections. The general shallowing-upward nature of deposition in the Jabłonna Reef area resulted in that the reef-flat conditions characterized by omnipresent microbial deposits, first became characteristic for centre-located boreholes. Then, the reef-flat started to prograde and eventually the entire Jabłonna Reef area became the place where very shallow subaqueous deposition occurred.
Five biofacies are distinguished in the Jabłonna Reef sections: Acanthocladia at the base, then mollusc-crinoid, brachiopod-bryozoan, *Rectifenestella* and, at the top, stromatolite. They represent shallowing-upward cycle, possibly with some important fluctuation recorded by the characteristic lithofacies boundary corresponding to the Acanthocladia/mollusc-crinoid biofacies boundary. The $\delta^{13}C$ curves of the Jabłonna 2 and Jabłonna 4 boreholes enable to correlate the trends in the middle parts of both sections and confirm the strong diachroneity of biofacies boundaries except of the Acanthocladia/mollusc-crinoid biofacies boundary that is roughly isochronous. The presence of echinoderms and strophomenid brachiopods indicates that until the lower part of the Rectifenestella biofacies the conditions were clearly stenohaline. Subsequent elimination of stenohaline organisms and progressively poorer taxonomic differentiation of fauna assemblage is characteristic for slight, gradual rise of salinity. Taxonomic composition of organisms forming the Jabłonna Reef shows similarity to reefs described from Egland, Germany as well as the marginal carbonate platform of SW Poland. Filled fissures were recorded in the lower part of the Jabłonna Reef. Aragonite cementation recorded in some fissure fillings implies that they originated in rocks exposed on the sea floor and are neptunian dykes.

Vegetation and temperature-related degradation of terrestrial organic matter during the Toarcian Oceanic Anoxic Event (Early Jurassic) recorded in marginal-marine shales in Poland

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The formation of black mudstones, rich in total organic carbon (TOC) is associated with anoxic marine bottom waters, most prominently connected with Oceanic Anoxic Events (OAEs). One of the best-documented and most severe of these events is the Early Toarcian OAE (T-OAE, ~183 Ma ago) that lasted for c. 300 – 500 kyr (Boulila et al., 2014). The T-OAE is associated with a high rate of organic burial, coincident with a prominent negative carbon isotope excursion (CIE), expressed in series of stratigraphically abrupt steps reaching magnitudes of ~6 ‰. In the Polish basin, strata coeval to marine black shales of the T-OAE are represented by poorly consolidated green/grey mudstones, claystones and siltstones, with subordinate sandstone intercalations (Ciechocinek Formation), deposited in a large embayment/lagoon (Pieńkowski, 2004). The organic matter studied in 420 samples is strongly dominated by terrestrial type III/IV kerogen of a low thermal maturity. Carbon-isotope data from the separated woody organic matter in Toarcian successions of the Polish Basin (Hesselbo and Pieńkowski, 2011) show negative carbon isotope excursions (CIEs), which occurred in major steps, reproducing observations on CIEs in marine successions and recently correlated to c. 30 - 34 kyr obliquity forcing of climate (Boulila et al., 2014). Contrary to the open marine basins, where negative $\delta^{13}C$ values are associated with high total organic carbon (TOC) content, in the Polish Basin sediments deposited during the negative CIEs show lowest TOC contents. Furthermore, colour and elemental geochemistry contradict anoxic conditions in the whole Lower Toarcian in Poland. This is attributed to the general shallowness of the basin and destruction of the halocline. Palynodiagrams of selected borehole sections reflect the composition of standing vegetation, showing conspicuous plants' response to the climatic perturbations. Changes of palynofacies also reflect climate changes, which are evidenced also by other data. Of particular significance is climatically controlled degradation of terrestrial organic matter. The organic carbon pool in soils and its destruction may have played an important role in the carbon cycle during the T-OAE.

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Interaction of deepwater sandstones with the substrate: Analogues from Numidian turbidites (Miocene) of Sicily

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Deepwater quartz-rich sandstones derived from mature cratons form reservoirs in many hydrocarbon provinces. These include not only rifted margins of the Atlantic but also tectonically active margins where turbidity currents have interacted with deformed substrate. An understanding of the controls on the distribution of sandstone body thickness and architecture will aid exploration and production strategies in these areas. The Numidian “flysch” is an Oligo-Miocene succession of clean, quartz-rich deep marine sandy turbidite deposits sourced from the North African craton and transported northwards across the continental margin into the foredeep system of the Apennine orogen. The regional extent of these sands is well-established; they extend for some 500 km along strike and down dip with outcrops preserved within the Maghrebian-Apennine thrust belt of Sicily and southern Italy. These deposits are commonly regarded to have been deposited on undeformed substrate within ancentral foredeep, however there are evidences that the turbidity flows interact with active basin evidenced by large scale onlap and relationship between basin floor and slope substrata. This work focuses on detailed mapping of the Numidian stratigraphy and establishing the chronostratigraphic and structural relationships to underlying and overlying stratigraphic units in order to constrain local and regional basin architecture. Key stratigraphic sections were logged and palaeocurrent data collected to establish sand fairways across Sicily. Also eleven sandstone samples were analyzed by LA-ICPMS and show detrital zircon ages strongly consistent with African source signature. Biostratigraphic samples (foraminifera) were collected to establish chronostratigraphic context and correlation between the sections. Panoramic views were traced to follow lateral continuity and geometry of the beds. Future work will focus on extending the study across northern and Central Sicily to better constrain the influence of basin tectonics on ponding and deflection of the Numidian gravity flows.

Examples of catastrophic saltwater inundations (storms or tsunamis) on the southern coast of the Baltic Sea during the late Holocene, north Poland

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The Baltic Sea is not considered as an area affected by tsunamis. However, during the Late Pleistocene and Holocene several tsunami events were interpreted from sedimentary record in Sweden and Estonia. On the other hand, on the southern coast of the Baltic Sea are known historical accounts on "der Seebar" (sea bear). Their descriptions reveal many features typical for tsunami, but their genesis is still unknown and the sedimentary effects have not been discovered. Here we present evidence of sandy event layers from several study sites on the Polish coast of the Baltic Sea. The sea-level inundation was accompanied by a meteorological storm (as on the 17th September 1497) or took place without a storm (3rd April 1757 and 1st March 1779). On the study area, three major events were recognized that occurred during the last two thousand years. The greatest event took place in the late 15th century (1497). Sedimentological, micropaleontological and geochemical analyses along with AMS 14C dating were applied for trenches and sediment cores, as well as for a number of reference samples from beach, dune and local soils. Sandy layers were identified in the peat deposits developing during the last ~2000 years. They reveal a number of typical features of tsunami deposits (significant lateral extent, thickness, rip up clasts, chemical and micropaleontological evidence of marine origin). The precise ^{14}C dating along with the historical accounts from one of the study sites revealed that the layer extending at least 1.4 km from the modern coasts was deposited by likely the biggest storm during the last 2000 years, which took place in 1497. These storm deposits were likely formed during inundation of the low lying coastal plain after major breaching of coastal dunes resulting in tsunami - like flow pattern and similar sedimentological effects. Discontinuous sand layer of younger age (18th century) and similar properties to the previous one may be related to described "der Seebar" event. The study revealed that the southern Baltic sea coast may be affected by much larger coastal floodings than know from more recent accounts and observations. These events left also sedimentary deposits, which resemble tsunami deposits. It is likely that in similar settings in case of storm surge causing uni-directional inundation of coastal plain the resulting deposits from storms and tsunamis may not be possible to be recognized.

Marine to fluviatile Cenozoic sediments in the Canton of Jura at the interface between two tectonic and sedimentologic provinces

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During the last two decades the study of the Cenozoic deposits of the so-called "Jura-Molasse" in the area between Porrentruy and Basel re-intensified, stimulating more complex interpretations of the palaeogeographic evolution and lateral facies changes. The timing of the latter in view of the tectonic and sedimentologic development of the Upper Rhine Graben and the Swiss Molasse Basin however still presents a complex puzzle.
The so-called "Cyathula-Bank" (after *Crassostrea cyathula*) from the uppermost part of the several hundred meters thick Late Rupelian marine Froidefontaine Subgroup illustrates exemplarily the complexity of the palaeogeographic situation in the research area during the Oligocene. This historic lithologic unit occurs near the south-eastern margin of the Upper Rhine Graben. In the past it has been interpreted as a marker bed subdividing the marine to fluviatile "Molasse alsacienne" s.l., possibly representing a short-term transgressive event within the final regressive phase of the Froidefontaine Subgroup.
A preliminary analysis of cores drilled in the marginal Delémont (Sub)Basin however indicates the occurrence of a well-defined, densely packed cyathula-bearing (coquina) sandstone bed at the base of a condensed, 5 to 20 m thick marine series equivalent to the much thicker Froidefontaine Subgroup of the Upper Rhine Graben.
This stratigraphic and geographic disparity of occurrences of oyster beds either during the transgressive or regressive phase of the Froidefontaine Subgroup requires a new interpretation of this lithological unit. A plausible solution represents the definition of the "Cyathula-Bank" as an estuarine/deltaic, laterally limited, possibly repetitive regional facies. It is related to quickly changing palaeoenvironments induced by the vast "Molasse alsacienne"-river system, which progrades in the Late Rupelian as an extension of the fluviatile Lower Freshwater Molasse deposits ("USM") from the overfilled Swiss Molasse Basin to the southeast. The northwards-directed development of the delta and the resulting complex regional palaeogeography may explain the scattered regional occurrences of oyster beds through time. The arrival of fluviatile sediments from the Swiss Molasse Basin occurs not isochronously and is clearly evidenced by changes in faunal assemblages (autochthonous vs. allochthonous, marine vs. freshwater), heavy mineral associations (spectrum change) and sedimentological features (disconformity, increase in coarse clastic sediments, point bars).
The occurrence of oyster beds at the base of the marine series in the Delémont basin raises the question about the supposedly uniform timing of the initial transgression (Ru2 transgression) in the different subbasins of a tectonically active Graben. A related question concerns the possible occurrence and reach of a second transgression-regression cycle (Ru-3?) in the marine Froidefontaine Subgroup as hinted by the lithostratigraphic evolution of the area.

The role of the flow regime in the sorting of heavy minerals in Pleistocene glaciofluvial sediments with a high sedimentation rate

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Heavy minerals respond to changes in current conditions particularly in dependence of their density, shape and size. Although sorting depends mainly on shape and size, heavy-mineral sorting also depends on the transport conditions; heavies tend to be transported under low-energy conditions by sliding and rolling, whereas saltation and suspension dominate under high-energy conditions. An important factor controlling the sorting of grains in fluvial environments is the depth/current-velocity ratio; this determines whether an upper or a lower flow regime prevails. The sedimentation rate also affects the heavy-mineral composition of sandur and ice-marginal valley sediments, as they are characterized by rapidly changing meltwater discharges and thus by the flow regime.
The heavy-mineral content of sediments from Weichselian sandurs and a coeval terrace of the Toruń-Eberswalde ice-marginal valley in NW Poland was investigated. It appears that most changes in the proportion of the various heavy-mineral species in gravelly and sandy sediments must be ascribed to changes in the flow regime. In addition, the turbulence of the current and the bedform played a role; during the transitional regime between the upper and the lower flow regime, for instance, when sediments were eroded and reworked repeatedly, the resulting assemblages contain the highest content of garnet. Most of the ultradense minerals were selectively deposited under conditions of the lower flow regime.
The high content of ultradense heavy minerals in sands (almost twice as high as in gravels) can be explained by reworking of the analysed fraction. Sandy sediments were reworked more frequently than gravels, due to the difference in the dominant type of transport. The percentage of platy minerals (e.g. biotite) in the sediments formed under the conditions sketched above increases with increasing current energy toward the upper flow regime, whereas, in contrast, the percentage of the densest heavy minerals decreases when the current energy increases toward the upper flow regime. It is interesting in this context that the average percentage of one mineral (amphibole) is fairly constant in all types of gravelly and sandy sediments for both flow regimes.
Heavy minerals deposited by streams with rapidly changing discharges and a high sedimentation rate (which is common for glaciofluvial streams) can, by combining data about the composition of the assemblages with data about the heavy-mineral characteristics (size, rounding, colour, etc.), help in reconstructing the flow regimes under which glaciofluvial sediments were deposited and in estimating the turbulence and mode of sediment transport in these streams.

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Pleistocene earthquakes induced by glacio-isostatic rebound in Poland and Latvia

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Seismites formed by earthquakes related to glacio-isostatic rebound are known from numerous places, particularly on the northern hemisphere. The north-eastern part of Latvia and the north-western part of Poland were not affected by sufficiently strong endogenic tectonic activity during the Pleistocene and during historical times to form seismites; this implies that the Pleistocene seismites must be attributed to glacio-isostatic rebound. Disturbances of the Earth's crust can be induced by loading/unloading cycles resulting from alternating advances and retreats of an ice sheet. Such isostatic rebound may induce earthquakes that leave traces in the form of layers characterised all over by soft-sediment deformation structures (SSDS).
In two outcrops with rebound-induced seismites, formed after retreat of the ice of the Saalian and Weichselian glaciations, respectively, have been recognised. Two seismites occur at Siekierki (NW Poland), and seven at Valmiera (NE Latvia); both sites contain several seismites. The seismites at Siekierki occur in Weichselian glaciolacustrine sediments, whereas those at Valmiera occur in the distal part of a sandur. The outcrop at Siekierki is 3.5 m high, whereas the section at Valmiera in a cliff along the Gauja river is some 7 m high. All seismites extend laterally over hundreds of meters. Most seismites are sandwiched between undeformed sediments, but occasionally immediately on top of each other. Both the seismites and the undeformed layers consist of fine-grained sand, very fine-grained sand and admixtures of fines; no difference in grain size is found. Most of the SSDS in the deformed levels are loadcasts, pseudonodules, flames, and fluid-escape structures. Moreover, the tendency of some pseudonodules that affect each other in confined layers suggests that these layers underwent loadcasting during several phases.
The Baltic region and adjacent areas are nowadays areas of relatively low seismic activity, but some small and moderate earthquakes occurred in historical times. No earthquakes were, however, documented for north-eastern Latvia and north-western Poland, although both sites under study are located above major faults that seem, however, no longer active. As both areas were covered by ice and must have undergone glacio-isostatic rebound several times during the Pleistocene, it is possible that this was accompanied by re-activation of subsurface faults. Earthquake activity probably triggered by glacial isostatic adjustment has also been noted in NW Germany and in northern Ireland. The spatial extent, the frequency of seismites and the older faults zone in the bedrock (probably re-activated during the Pleistocene) are important for a better insight into how glacio-isostatic rebound took place.

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Similarities and contradictions of depositional conditions in the selected Late Devonian Hangenberg black shale horizons

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The Hangenberg event is recognized by faunal, lithological and geochemical changes at the end of Devonian. These changes are correlates with e.g. glacioeustatic fluctuations, oceanic overturn or global eutrophication marked by deposition of the Hangenberg Black Shale (HBS) and its equivalents in many European and Moroccan sections. Recent studies (Marynowski et al., 2012, Palaeo3 346-347, 66-86) display volcanisms as additional factor that might have played important role in the Hangenberg extinction.
The results of our detailed geochemical investigations carried out around the Devonian/Carboniferous boundary (HBS and its equivalents) from the Polish and German part of the Laurussian Shelf (Holy Cross Mountains and Rhenish Massif), provided details about the environmental conditions during the latest Famennian and the significance of such factors as e.g. anoxia and volcanism in the mass extinction event.
Sulphur isotope values recorded at two sections (Kowala and Drewer) repeat the pattern of inorganic and organic redox indicators suggesting restricted bottom water conditions occurred during deposition of both initial and final stages of the HBS. Similarly, molybdenum isotope data indicates global anoxic conditions during sedimentation of the HBS, interrupted by less restricted redox conditions. A positive organic carbon isotope excursion, in magnitude of ca. 4‰ was noticed in Oese and Riescheid sections. This excursion is associated with the Hangenberg Event (Hangenberg Isotope Excursion) but not with black shale occurrences. The positive organic carbon isotope anomalies were also reported by Kaiser et al. (2006, Palaeo3 240, 146-160) from Carnic Alps and Hasselbachtal section (Rhenish Massif). In contrast to German and Alps sections the $\delta^{13}C$ values of the HBS at Kowala outcrop show a negative excursion following with the $\delta^{13}C_{org}$ increase (ca. 3‰). This isotopic drop is associated with deposition of the twenty centimeter thick layer of tuffites in the middle part of the HBS.

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3D model of a barrage tufa as a potential analogue for carbonate reservoirs (Guadix Basin, S Spain)

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The excellent preservation and diversity of the exposed carbonate and siliciclastic fluvial facies of southern Spain make them ideal candidates for analogue hydrocarbon reservoir studies.
The present study focuses on a Pleistocene tufa outcrop located in the Rambla Becerra area, Guadix Basin (Betic Cordillera, southern Spain). The outcropping forms a dome-shaped tufa build-up, interpreted as a ramp-like buttress of inclined tufa beds downstream of a tufa barrage. This butress connects donwstream with a ponded area, and forms part of much larger stepped fluvial tufa system, showing small cascades, barrages and dammed areas.
The data (sedimentary logs, interpreted photomosaic, lithofacies descriptions and geochemical data) gathered from the outcrop have been used as a base for the present study.
The main surfaces (base, top and boundaries between sedimentary bodies) of the tufa deposits were delimited in the field using differential GPS. The surfaces delimit several sigmoidal bodies formed in the ramp-like buttress as a result of the destruction of a now eroded barrage (macrophytic phytoherm).
Five petrofacies have been identified in the outcrop using a pre-existing, well-defined lithofacies scheme. The petrofacies have been defined using the following criteria: (1) the formation of the sediments (in-situ precipitation of carbonate vs. detrital, reworked sediment); (2) sediment fabric (clast-supported, matrix-supported or massive); (3) clast size; and (4) sorting of the sediments.
The five resulting petrofacies are ordered from the least porous to the most, and they have been assigned different values of porosity.
The integration of the data allows to develop a 3D stochastic facies model of the outcrop, which will enable us to determine how the petrophysical properties vary within the tufa deposit and how that would affect potential reservoir properties.

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Characterising palaeoenvironments of early human settings in the Guadix Basin (Betic Cordillera, S. Spain)

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The Guadix-Baza Depression (Betic Cordillera, Granada Province, Spain) was targeted by the Ancient Human Occupation of Britain Project (AHOB3) as one of the locations to investigate the natural factors controlling human dispersals in Europe. During the Pliocene and the Pleistocene, the Guadix basin and the neighbouring Baza basin constituted an endorheic depression divided in two palaeogeographical sectors, a predominantly fluvial basin (the so-called Guadix Basin) and a lacustrine (sensu stricto) basin (Baza Basin).
The Guadix Basin has proved to be a key area for unravelling the evolution and migration routes of early hominins and associated fauna into Europe from Africa and Asia. Its importance stems from the presence of continuous sedimentation over the last 4 million years and the excellent preservation of a large number of Quaternary archaeological and palaeontological sites.
From the six genetic units in which the basin infill has been divided, the two youngest ones (units V and VI) have yielded the archaeological and palaeontological sites, located mainly in the central sector of the basin.
A number of detailed stratigraphical, sedimentological, petrological and geochemical studies have been carried out in the central sector of the Guadix Basin, in the sediments of unit V and unit VI, with the aim of characterising the palaeoenvironmental evolution of the Guadix Basin over the last 4 Ma.
As a result, we now know that during unit V (until 1.778 Ma ago), the Guadix Basin was dominated by a high sinuosity fluvial system that created wetlands in its floodplain, fed by transverse alluvial fan systems. In more humid periods, the fluvial system would occupy most of the axial valley of the basin. In contrast, during more arid periods, the alluvial fan transverse system would prograde and its facies would occupy a large part of the central valley. By the time of deposition of Unit VI, the basin was almost totally infilled by sediment, leading to flattened topography, the renewed dominance of the fluvial system in the valley and the formation of extensive wetlands.
Here we aim to show how stratigraphy, sedimentology and geochemistry can be combined with palaeontological and palaeoantrological studies to provide a framework for early hominin studies in these changing environments. Our research contributes to understanding of the evolution of palaeoclimate and the palaeolandscape, in particular the identification of perennial freshwater sources that may have influenced the distribution of both early hominins and the contemporary fauna.

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Factors controlling the facies distribution of calcareous tufas and travertines: Examples from southern Spain (Alcalá and Guadix Basins)

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With the exception of a few studies, the abundant tufas and travertines in the Neogene-Quaternary extentional basins of southern Spain have received little attention.
The factors controlling tufa/travertine facies may be both biotic (related to microorganisms precipitating the carbonate) and abiotic (non-related to biomediation of precipitation). Among the ones that have an impact on the microorganisms are the climate (temperature and humidity), the light, the turbidity of water and its temperature. In contrast, the factors that induce carbonate precipitation independently of the presence of the microorganisms are related to physical processes and to the chemistry of the water in which the carbonate precipitates.
In the present work we focus on some of these factors when comparing the facies distribution, the sedimentological features and the geochemical signature of four different Plio-Quaternary carbonate outcrops (three from the Guadix Basin and one from the Alcalá Basin) located in the central Betic Cordillera, southern Spain. Although one of them is considered a travertine (the temperature of the current spring feeding the system is 34.5 ºC), the general layout of the depositional environment is similar in most of them.
Based on their facies model, three of the studied outcrops , including the travertine, fit in the stepped fluvial conditions described in the works by Arenas-Abad and collaborators, with cascades/waterfalls, barrage and dammed zones, while the fourth outcrop corresponds to a palustrine tufa developed under low gradient, non-stepped fluvial conditions. However, the isotopic signature for each of the four outcrops is different.
Apart from the palaeoenvironmental information that it provides, the distribution of facies becomes an important issue when dealing with outcrop analogues. In this case, the travertine outcrop has been studied by other authors as an outcropping analogue for CO_2 storage, while two of the other (both calcareous tufas), are being currently studied as potential analogues for carbonate hydrocarbon reservoirs. The fourth one, a palustrine tufa, does not present the characteristics to be used as an analogue for either.
The overall aim of the present study is to compare the four outcrops to gain a better understanding of the factors controlling the facies distribution between them.

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Calcareous Algae and depositional environment of the Upper Jurassic carbonate deposits from Căprioara-Pojoga Area - Mureş Trough (Romania)

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The studied area represent a individualized ridge between Caprioara and Pojoga villages, located in the left side of Mureş River Valley, approximately 80 km from Deva town (West Romania). The carbonate deposits that form this small massif are represented by Upper Jurassic Stramberk-type limestones which are folded into an NE-SW-oriented syncline. Our study is based on the investigation of samples collected from three diffrent sections: Campul Babei Hill (south of Căprioara village), Căpriorişca Valley (quarry), and Dineş Valley (5 km east of Căprioara village). Detailed investigation was made in order to reveal microfacies characteristics and micropalaeontological associations. The sedimentary succession of Câmpul Babei Hill is composed of levels of coral-stromatoporoid-microencruster bioconstructions associated with back reef carbonates. The internal sediment of the bioconstructions is composed of bioclastic packstone and grainstone with coral fragments, echinoid fragments, bivalves and calcareous green algae such as *Clypeina sulcata*, *Salpingoporella pygmaea*, *Gryphoporella jurassica*, *Nipponophycus ramosus* and rivulariacean-type cyanobacteria. Towards the upper part of the section, it can be noticed a transition to a granular facies, represented mainly by grainstone/packstone with reef fragments and ooids. Besides the taxa mentioned above, the following microfossils were identified in these deposits: *Salpingoporella annulata*, *Campbeliella striata*, *Suppiluliumaella* sp., ?*Cylindroporella* sp., *Pseudoyiclamina lituus*, *Coscinoconus alpinus*, *Mohlerina basiliensis*, *Mercierela dacica*, nerineid gastropods and rivulariacean-type cyanobacteria. On the top of these carbonates, micritic subtidal deposits are starting to develop, represented by bioclastic mudstones and wackestones interlayered with fenestral bioclastic packstones. The second succession is composed mainly of brecciated bioclastic packstones with oncoids in the lower part, followed by fine micritic banks and intertidal fenestral limestones with rare dasyclads in the middle part of the section. The overlaying deposits are represented by limestones with carophytes and ostracods indicating most probably a fresh water supply. The third analysed succession is similar to the first one and it is made of coral-microbial bioconstructions with microbial structures (algal mats, stromatolites, thrombolitic crusts and peloidal micrite) and microencrusters *Crescentiella morronensis*, *Labes atramentosa*, *Lithocodium aggregatum*, *Bacinella*-type structures, *Radiomura cautica*, *Petrurbatacrusta leini*, *Koskinobulina socialis* associated with bioclastic grainstone/packstone with ooids and reef fragments. The micropaleontologic assemblages (dasyclad algae and benthic foraminifera) indicate a Late Jurassic (Kimmeridgian-Tithonian) age for the Căprioara-Pojoga limestone deposits. The microfacies analyses corroborated with the taxonomic associations identified in the Campul Babei Hill, point to reef-crest and probably upper slope depositional environments, gradually passing into back reef facies deposits, towards the upper part of the succession. The second section indicate in general, a gradual tansition from deeper to shallower facies represented by the superposition of intertidal and supratidal facies on the subtidal ones. The succession on the Dineş valley was formed in a subtidal shallow water depositional environment, with algal mats and small biconstructions.

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Stratigraphic architecture and reservoir quality in the Upper Permian sequences of the Johan Sverdrup field, Norway

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The Johan Sverdrup field is a predominantly clastic field that represents one of the largest oil discoveries ever made on the Norwegian shelf. An associated discovery in the carbonates of the Zechstein Group (Upper Permian, carbonates and evaporites, with relatively minor clastics) provides important new data on the northern margin of the northern Permian basin within of Pangea which occupied much of the present-day North Sea.
The depositional setting of the Zechstein reservoir in the Johan Sverdrup field is in a basin margin transition between the anhydrites and mudstones of the basin and the shallow water carbonate ramps and platforms that bordered the basin. Due to limited seismic resolution and lack of fossils for biostratigraphy at least two correlation schemes can be constructed based on log correlations.
In this presentation we discuss the sedimentation/diagenesis model of the carbonate ramp and how the dolomitization and dedolomitization overprinting has significantly affected the reservoir properties of the Zechstein reservoir.
The Zechstein reservoir in the carbonate ramp may be divided into different units purely on lithologic and petrophysical grounds which are from bottom to top:
(1) Lowermost consists of medium- to thick-bedded, bioclastic and bioturbated wackestone and lime mudstone, with local slump and debrite horizons deposited in moderate water depths on a carbonate ramp. This part of the formation is generally dolomitized, although the lowermost part is locally limestone. (2) Rudstone package made up of up to boulder-sized clasts of stromatolitic and thrombolitic boundstone with a wakestone and oolitic grainstone matrix derived from a peritidal/reefal shelf margin. Above this an interval of oolitic grainstone marks a shallowing event which is overlain erosively by coarse sandstone and an evaporite residue depending of the position in the shelf margin. (3) A further episode of deepening with the establishment of a laminated dolo-mudstone unit deposited in a distal slope or basinal setting. (4) Uppermost unit of the reservoir is interpreted as a collapse brecciated calcite microspar with no preservation of original depositional textures.
On the basis of core, detailed logging and sampling and integrating sedimentological work, petrographic interpretations, and geochemical analyses, conceptual models including syndepositional and burial diagenetic processes to understand and delineate reservoir and their relationship to the tectono-stratigraphic events.
Recognition of the facies geometry within a hypersaline carbonate platform indicates that potential carbonate foreshore in the shore-shelf depositional model is the most favorable target, wherein grainstone and dolomitized grainstone are characterized by high reservoir quality of the carbonate ramp model.
The depositional units were overprinted by different diagenetic regimes, syndepositional and burial diagenetic processes (dolomitization, dedolomitization, cementation, micritization, calcitization and anhydritization) which allowed recognition of five carbonate fabric/units, respectively: Tight secondary limestone, leached dolomite, vuggy secondary limestone, vuggy dolomite and tight dolomite.
Based on information from core, logs, formation pressure build up and sampling, the matrix properties of the dolomitic part of the reservoir are of excellent quality with porosities ranging from 12-25%, permeabilities up to 1Darcy. The dedolomitic intervals are represented by poor properties, a mode porosity of 2.5% and permeabilities lower than 1mD.

Internal waves and carbonate systems

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Carbonate platform architecture influence variability in the properties of carbonate reservoirs. Recognition of new or previously enigmatic stratigraphic details can induce a redesign of production strategies by promoting more realistic models of inter-well heterogeneities or can trigger renewed exploration interest. Recognition of the role of internal waves in carbonate systems provides a new dimension in which to interpret carbonate platform architecture.
Internal waves, which propagate along the pycnocline, are ubiquitous in oceans and lakes. In siliciclastic systems, the turbulence induced by breaking internal waves on sloping surfaces induces sediment remobilization on shelves and continental slopes. In carbonate systems, in addition to sediment remobilization at the breaker zone, both the pycnocline and the associated turbulence shape carbonate production by influencing biological systems. Relatively high concentrations of phyto- and zooplankton typically occur at the nutricline, which coincides with the upper part of the pycnocline. The nutricline generally begins in the lower part of the photic zone, where nutrient-rich (deeper) water can mix upward via upwelling or internal waves, and where available light energy, not nutrients, limits primary production.
Strong pycnoclines are beneficial for plankton-feeding sessile organisms, e.g., corals, sponges, stromatoporoids, rudists, etc. This explains why most Phanerozoic metazoan mounds are in mid- or outer ramp settings. Moreover, low-light adapted coralline algae can also thrive and produce a large amount of sediments at the intersection of the pycnocline/nutricline with the seafloor; a common occurrence during the Cenozoic.
A weaker pycnocline, however, should be more beneficial for small and unattached mixotrophs such as the larger benthic foraminifers; the turbulence associated with strong internal waves would produce hydrodynamic instability. This may explain the dominance of LBF on the warm Tethyan shelves during parts of the Paleogene and Miocene.

Building dynamic models for the interpretation of palynological data in turbidite fan deposits

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This research aims to analyse palynofloras in turbidite fan depositional systems, identifying a suite of numerical approaches to constrain palynomorph distribution. Relative stratigraphy in deep water turbidite sequences is a key to understanding reservoir geometry, heterogeneity, connectivity and, consequently, reservoir quality. An accurate modelling of biofacies-lithofacies variation can help to achieve a better comprehension of the system. Constraining palynofloras into depositional facies requires a dynamic approach as the distribution of terrestrially sourced and marine palynomorphs within turbidite sequences is controlled by taphonomy and ecology. Any subsequent model should aim to synthesise biofacies and sedimentary facies from slope to toe within turbidite systems.
Palynoflora from two outcrop examples (Numidian Formation in Sicily and Ainsa complex in Spain) have been studied and are compared with subsurface data from the Wilcox Formation, Gulf of Mexico and Forties Formation, North Sea Basin. Criteria for the selection of field sites included: derivation from a stable cratonic block; good exposure at seismic and sub-seismic scales, from slope to toe; a well studied and comprehensive stratigraphic framework; a late Cretaceous to Cenozoic system; known climatic variability, in order to uncouple climate from tectonic forcing on facies relationships.
Results from the Miocene Numidian turbidite system in central-northern Sicily from a proximal to distal transect can be summarized as follows: palynoflora is abundant and characterized by dinoflagellate cysts, pollen, spores and chlorophycean algae, in varying frequencies; there is an alternation between quite well preserved samples and degraded palynoflora; *Pediastrum* is common, suggesting a freshwater source; bisaccate pollen are consistently recorded throughout the log and, as has been noted by previous studies, they can distinguish between Numidian Formation and pre-Numidian units. Palynofloras behave as silt sized particles in sedimentary systems. The implications are that the Numidian sediments studied were stored in shallow marine, shelfal environment prior to redeposition in deep water. The source area may have fluctuated along the shelf, leading to variation in the dinoflagellate cyst and chlorophycean algae frequencies.

On the use of deep-sea gravity-flow deposits to unravel seismic hazard: Turbidite paleoseismology of the northern Hikurangi subduction margin of New Zealand

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Deep-marine depositional systems are of particular interest for hazard assessment as they provide a well preserved and continuous sedimentary record of past climate, sea level fluctuations, oceanographic conditions and tectonic activity. While climate changes and glacio-eustatic fluctuations are well preserved at 10^4 time-scales, episodic tectonic deformation or rapid and extreme climatic events are a primary driver for turbidite production at 10^2-10^3 time-scales. Specifically we use turbidites to characterize the signature of moderate-to-great earthquakes in the geological record to establish a better understanding of paleoseismic hazard. Quaternary turbidites preserved in deep basins along active plate boundaries have proven to be powerful tools for establishing calendars of paleo-earthquakes. In New Zealand, sediment cores collected in strategic locations along the convergent Hikurangi Margin has preserved a 20+m thick sequence of cm-thick turbidites interbedded with hemipelagite and air-fall tephra beds. Age control is provided by an exceptionally dense set of AMS dates and tephrochronology. The turbidites facies varies from muddy to sandy with evidence of rare hyperpycnites and volcanoclastic turbidites. High-resolution sedimentological, chronostratigraphic, petrophysical, geochemical and micropaleontological analyses of the material indicate that most turbidites are the distal expression of earthquake-triggered submarine landslides that occur on the continental slope at 150 – 1000 m water depths. Inter-core correlations along and across the margin using similarities in sedimentary facies, petrophysical properties and ages indicate the synchronicity of 41 turbidites, the signature of 41 moderate-to-great earthquakes that have occurred along a 200 km-long section of the margin between 390±170 and 16,450±310 yr BP. Well-established empirical relationships classically used to evaluate slope stability were adapted to deduce the magnitude Mw and location of paleo-earthquakes. Here, earthquake-related turbidites are associated with ruptures of two of the largest upper plate faults and the subduction interface, which are all capable of generating Mw ≥7.3. This innovative approach improves the qualitative method for identifying and dating paleo-earthquake evidence by quantifying the magnitude and evaluating the source of prehistoric earthquakes.
Turbidite paleoseismology will help to better constrain and assess seismic hazard of sensitive coastal areas. In New Zealand, the 16,000 year-long paleo-earthquake catalogue extracted from this study of deep-sea turbidite successions outreaches the 200 year-long historical record. Although only 10% of earthquake sources are recognized with this technique (3 out of the 26 known active faults), it provides a precise age estimate of each event and complements the probabilistic model deduced from other seismotectonic studies.

Quantitative compositional analysis of the Lochkovian-Pragian boundary event at "Na Chlumu Quarry" (Prague Synform, Czech Republic)

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The Barrandian area (Prague Synform, Bohemian Massif) is a stratotype area for the Lochkovian-Pragian boundary event, which is connected with faunal and facies overturns associated with a global sea level fall. Carbonate compositional variations were studied on 49 samples from ~100 m thick section “Na Chlumu Quarry” to provide an insight into the nature of this event. Principal component and cluster analysis were applied on grain size and compositional point count data. Biased patterns resulting from covariance structure of closed data were reduced by using the log-ratio methodology. About 25 m thick succession of the Lochkov Formation is composed of fine- to coarse-grained crinoidal calcarenite, slightly nodular in some parts. Thin-bedded limestones with rare shale intercalations and chert nodules grade upwards into massive, light grey, white or rose ones, forming a coarsening-upward succession. Microfacies (type A) correspond to moderately- to moderately well sorted, very fine- to fine-grained calcarenite (packstone) with crinoids (≤53.3%), peloids (≤10.3%) and less abundant trilobites, ostracods, brachiopods and bryozoans (each ≤2.3%). The microfacies B (present only in one sample) corresponds to moderately sorted calcisilitite (wackestone) with abundant sponge spicules (11.7%). Light grey- to rose, medium- to very coarse-grained crinoidal calcarenite of the basal Praha Formation is trough cross-bedded and wavy-laminated. It corresponds to the microfacies C, which is a moderately sorted pack/grainstone with abundant crinoids (≤61.3%) and less abundant bryozoans (≤7%). Trilobites, brachiopods or ostracods do not exceed 3.7%; peloids are rare (≤0.3%). This microfacies grades upwards into fine-grained, moderately sorted calcarenite (wacke/packstone; microfacies D) with crinoids (≤43.3%), pelagic dacryoconarid tentaculites and molluscs (both ≤3.7%). The percentage of trilobites, brachiopods, ostracods or bryozoans does not exceed 5.3%. Higher parts of the Praha Formation comprise grey, slightly nodular calcilutite/calcisiltite with rose patches, red nodular calcilutite/calcisiltite, grey nodular calcilutite/calcisiltite with greenish shale intercalations and “graptolite event” beds composed of calcisiltites with black shale intercalations. Microfacies (type E) correspond to moderately sorted, fine-grained calcisilitite to very fine-grained calcarenite (wackestone) with abundant dacryoconarids (≤10.7%), crinoids (≤10%), and molluscs (≤4%). Trilobites, brachiopods, ostracods or bryozoans do not exceed 4.7%. Bioerosion in trilobites and crinoids was observed.
The sequence of microfacies C to E represents a prominent fining-upward succession, which is associated with deepening-upward trend inferred from the allochem composition.
The allochem composition corresponds to heterotrophic carbonate producer assemblage while the geometry of carbonate bodies suggest a ramp setting for the Lower Devonian carbonates of the Prague Synform. The compositional data analysis indicates that the Praha Formation succession represents a distinct lowstand- to transgressive succession, with a prominent sequence boundary situated close to the Lochkovian/Pragian stage boundary. This is consistent with petrophysical patterns at numerous sections across the Prague Synform as well as with data from elsewhere. The principal component analysis and hierarchical clustering show a clear separation of different microfacies types according to dominance of the corresponding patterns. These effects are highlighted due to relative scale property and scale invariance of the original samples, taken into account by the log-ratio methodology.

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Margin sedimentary record of active deformation due to the subduction of topographic asperities (Carnegie Ridge, Manta-Plata area, Central Ecuador)

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The uplift of the coastal cordillera of central Ecuador is likely a consequence of the subduction of the Carnegie Ridge (400km wide, 2km high), which diverts the sediment routing to the oceanic trench that is now largely starved. However, in active subduction margins, the causes, the timing and the amplitude of uplifts and the lateral distribution of active tectonic deformation, which drives the main sediment paths, are still a matter of debate. Large scale tectonic forcing as well as local subducting plate topography influence the distribution of erosion and deposition areas, the location of creeping and locked interplate zones and hazards such as the occurrence of the deadly known megathrust earthquakes.
The aim of this study is to analyse the sedimentary signature of the subduction of topographic asperities of the Carnegie Ridge during Pleistocene times. We interpret high-resolution (50-450Hz frequency) multi-channel (72 channels) and single channel (Sparker) seismic data, piston cores, sediment profiles (3.5khz) and high-resolution multibeam bathymetry acquired during the ATACAMES cruise of the RV L'Atalante, in 2012.
In the La Plata Island-Manta Peninsula region, the results show a full and detailed record of the last nine, 100kyrs-scale, Pleistocene sedimentary sequences deposited in intra-shelf basins, at and -just seaward of the shelf break. These sequences are tied to piston core data and to well-dated, quaternary onshore exposures and a flight of coastal marine terraces of Canoa and Tablazos formations on the Manta Peninsula and La Plata Island. These sequences correlate very well to the global ice volume and deep marine temperature changes (d^{18}O) curve of Lisiecki and Raymo (2005) for the last 0,7Ma pointing to a strict climatic control on depositional sequence preservation. However, the subsidence of the continental shelf acoustic basement, estimated by the stepwise backstripping of the sedimentary record, exhibits a complex deformation pattern with uplifting and subsiding regions.
Deep marine seismic data, currently under processing, show evidences for a subducted seamount beneath La Plata Island and GPS data indicate an important interplate coupling in the same area with the potential to generate an Mw 7-7.5 earthquake. The pattern of the continental shelf deformation is consistent with the shape of this seamount. We tested the hypothesis of a link between the deformation and the subduction of the seamount, by comparing a stepwise subduction of the seamount to the palinspastic restoration of the deformation of the continental shelf for the last 1Ma. This comparison shows that the collision probably started c.500kyrs ago, together with the syntectonic sedimentation, and drastically slowed down by c.50kyrs, with the sealing of most of the deformation on the shelf.

Carbonate lithoclasts identified by cathodoluminescence as a new provenance indicator of the Cergowa submarine fan sandstones (Lower Oligocene)

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The Oligocene-age Cergowa sandstones from the Outer Carpathians (SE Poland) represent a variety of mass gravity flow sediments deposited on a submarine fan. The Cergowa lithosome is a part of the Menilite Beds–Krosno Beds sequence. The cathodoluminescence images of the sandstone samples enabled the detection of previously unknown types of lithoclasts representing various carbonate rocks exposed to erosion in the source area: (i) microbreccia, (ii) tectonised immature calcarenite/wacke, (iii) microsparite and sparite, (iv) packstone and (v) dolostone.
The microbreccia consists of variably oriented micro-veined fragments of microsparite cemented with sparite that does not extend beyond the microbreccia grains outlines. The shape these grains resulted from transport-related abrasion within the source area. These characteristics imply two stages of fragmentation: the first stage resulted from tectonic fragmentation of microsparite and the second involved erosion and abrasion of the microbrcciated source rock.
Low textural maturity of the calcarenite/wacke grains suggests that their source rock resulted from short distance of transportation and rapid deposition of carbonate detritus. The veinlets continuing through the whole grain are suggested to be the features of a slightly tectonised immature calcarenite exposed to erosion in the source area.
Microsparite and sparite fragments devoid of tectonic microstructures were derived from limestones that did not undergo any significant tectonic deformations.
Shapes of the packstone lithoclasts, deformed and surrounded by quartz sand grains indented into their outlines imply their redeposition as soft intraclasts eroded from the littoral zone surrounding the source area. Their composition is so similar to the carbonate matrix that the latter is here considered as a result of squashing of soft packstone intraclasts.
Subrounded-to-rounded shapes of dolomite grains that display a characteristic zonation observed under cathodoluminescence implies erosion of secondary dolostone that resulted from dolomitisation by pore fluids, the composition of which was controlled by influx of meteoric waters with variations of concentration of Fe ions. It is suggested that the dolomitisation process affected carbonate rocks fringinfg the source area and exposed to erosion due to eustatic sea-level fall during the Oligocene “icehouse” period.
The above carbonate lithoclasts detected by the cathodoluminescence, provide new details on the complex composition of the Silesian Ridge, which acted as the source area located to the NW and S of the Cergowa depository. The distinguished lithoclasts can be divided into two groups. The first group includes grains derived from the fringe of the provenance area (packstone and zoned dolostone). The second group includes lithoclasts resulting from erosion of tectonised parts of the provenance area (microbreccia and tectonised immature calcarenite/wacke) and its tectonically intact segments (microsparite and sparite).

Tempestites? Turbidites? Contourites? The Lower Paleocene *Microcodium*-bearing calcarenites of the Spanish Subbetic Zone revisited

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Microcodium is a calcareous structure originally consisting of aggregates of elongated calcite crystals of (sub)millimetre length, which is generally accepted it is formed in carbonate-rich soils in association with plant roots. Once created *Microcodium* crystals are very resilient and can withstand substantial reworking, having been reported in eolian, fluviatile and marine environments. Calcarenite units containing abundant reworked *Microcodium* remains occur, intercalated within red-bed marine hemipelagic deposits, in widely scattered outcrops across the entire Subbetic Zone (SE Spain). This contribution is focussed on two groups of these outcrops, one situated near the village of Majalcoron and the other along the lower reaches of the Fardes River, about 80 km to the east. Thin-sections reveal that, in both cases, the calcarenites comprise between 40% and 90% of *Microcodium* crystals, usually as individual prisms but also as rosettes, which implied a derivation from nearby emerged source areas. However, thin marly intercalations between the calcarenites contain calcareous nannofossils and a well-preserved assemblage of microfossils, mainly planktonic foraminifera (up to 93%), benthic foraminifera (dominated by calcareous taxa such as *Nuttallides truempyi*), radiolarians and ostracods (*Cytherella*, *Bairdia*, *Krithe*, *Cardobairdia*, *Paracypris*, *Eucytherura* and *Phacorhabdotu*s), all indicative of a deep marine depositional environment. Trace fossils in the calcarenites, mainly *Skolithus*, *Zoophycus*, *Palaeodictyon* and *Taphrhelminthopsis*, support that interpretation.
The Majalcoron calcarenite succession is 56 m thick, with palaeokarstic features at its top. It is formed by laterally continuous beds, some of them up to 1.2 m thick, but generally ranging between 25 and 70 cm. Most beds have sharp or erosional bases and, frequently, rippled tops. Internally they may be either massive or parallel-laminated, occasionally with faintly developed graded bedding. Hummocky cross-stratification also occurs and, mainly based on that, it has been suggested that the Majalcoron calcarenites were resedimented in a shallow marine environment affected by storm waves.
The succession in the Fardes River outcrops is up to 100 m thick, and has two different parts. In its lower 40 m it is mainly formed by thin-bedded calcarenites (1-10 cm), often amalgamated or separated by mm-scale marly intercalations. Most calcarenite beds have rippled tops and internally are either massive (bioturbated?) or exhibit poorly defined cross-laminations. These structures, coupled with the scarcity of marls, are indicative of persistent low-velocity currents, suggestive of contour currents. By contrast, in the upper 60 m of the succession, the calcarenites and marls occur in a similar proportion, with most calcarenite beds having well-developed Bouma sequences. Theses calcarenites range between 15 and 50 cm in thickness, with one bed reaching 180 cm, and can be unambiguously interpreted as turbidites.
In this contribution tentative models for the three different types of *Microcodium*-rich calcarenite accumulations of the Majalcoron and Fardes River outcrops will be discussed.

Silica/carbonate sediments in thermal setting: Deposition and diagenesis of Paleocene travertine sequence in south-east Brazil

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Continental carbonates are formerly known as effective tool for paleoclimatic investigation and for local dating through their preserved biota. Since the discovery of the massive carbonatic South Atlantic hydrocarbon reservoirs (Pre-Salt) the interest in these terrestrial carbonates has increased. In Brazil only few examples of continental carbonates are known, and only the occurrence described in this study could be recognized as thermal continental carbonate or travertine. The occurrence is part of the sedimentary sequence of the Itaboraí Formation, deposited in Itaboraí Basin, located in Rio de Janeiro state, about 60 km from the city of Rio de Janeiro. The basin is dated back to the Paleocene (57 My) due the vertebrate fossil content, which are deposited in a small half graben basin (1,5 km x 0,5 km). Despite the small size of the basin, it represents a huge source of geological information, including a diverse fossil assemblage, occurrence of travertines and exposition of alkaline dyke. Due to these characteristics, the Itaboraí Basin is also used as analog model for some specific Pre-Salt carbonatic reservoirs regions. Most of the studies regarding the basin are related to the extensive fossil community from the lake-fill facies association, which are not directly related to the travertine deposition. The study presented here intend to recognize the structures and textures of the travertines in thin sections, describing the facies and identifying the silica-travertine relationship in order to understand what type of facies association occurred in this sequence. The macro and microscopic features observed indicated major abiotic influence during the process of precipitation, controlled by degasing and cooling of the thermal process. The silica and the carbonates appears in alternated laminations and in dissolution-like facies. The interpretation is that probably occurred two phases of interaction between silica and carbonates, one in a alternated depositional system and other during diagenesis. The origin of the thermal activity is probably the tectonics pulses of the hemi-graben system. Stable isotope ratios provided contrasting results, with values close to those expected for thermal carbonates signature, but not so different from those expected for meteoric carbonates signature, leading to an interpretation that the water recharge and discharge of the water reservoir is very fast and close to the thermal origin of the travertine system.

Bryozoans as the main constructor of the Zechstein reefs

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During the Permian, the main reef forming organisms were calcareous algae, sponges and bryozoans, accompanied by rugose corals, fusulinid foraminifera, brachiopods and nautiloids. In the Late Permian Zechstein basin the fusulinds did not occur, and the role of the sponges, calcareous algae and corals was limited. The shelf margin reefs of this basin created a few thousand kilometres long system, one of the biggest reef systems in the history of the Earth. They were accompanied by reef archipelagos inside the basin. Such an accumulation of isolated reefs also occurs on the north slopes of the Wolsztyn Palaeo-High. These reefs are very interesting objects for the petroleum companies, because they are excellent reservoirs of gas deposits. Despite their small size owing to a high porosity, exceeding 40% in some portions of the deposits, the gas resources have been hitherto documented to reach several dozen billion m^3. Each reef is usually up to a few km^2 in area. The maximum thickness of deposits not exceed 100 m.
A strong connection between the formation and growth of reefs and the relative sea level fluctuations can be demonstrated. Those changes were associated with both global as well as local fluctuations due to a high tectonic activity of the Variscan front. A high variability of the environmental conditions caused frequent changes in the composition of main reef forming organisms. This enabled the separation of a series of biofacies and thus a facilitation of describing each stage of reef growth.
The main reef forming organisms are the bryozoans. They all are stationary epifaunal suspension feeders. Due to their high capability to adapt to changing environmental conditions, the representatives of this group of organisms appear in almost all the varieties of reef deposits. In vertical sections a very clear zonation of occurrence of individual bryozoan groups can be observed. This allowed the isolation of a few morphological and taxonomical groups among them, very helpful in secretion and characteristics of biofacies.
The following morphological groups of the bryozoans have been distinguished:
Reticular – zoaria developed as delicate nets. These include primarily fenestellids (*Rectifenestella*, *Spinofenestella*). Colonies aided stabilization on the bottom with thorns. Characteristic of shallow, calm waters of the back reef. They often occur among stromatolites. In slightly more stormy waters occurred cylindrical zoaria *Kingopora* and *Synocladia* with more massive zoarias clinging to hard fragments of the ground.
Branched – the basic reef forming organisms in the described reefs. Mainly acanthocladid *Acanthocladia* branched fenestellids *Thamniscus*. Zoaria sporadically maintained in the life position, predominantly in the form of heavily crushed detritus.
Columnar - narrow columns resistant to stronger water currents. They occur sparsely (mainly *Dyscritella*, only in some layers they form bigger accumulations. They attached to a hard ground. Their larvae settled on the remains of bivalves or brachiopod shells. They predominantly occur along with the branched zoaria.
Massive - the least frequently occurring group of the bryozoans. Slightly more frequent among them are encrusting forms (on molluscs, brachiopod shells or crinoid plates).

Identification of lithology and lithofacies type and its application in Chang 7 Tight Sandstone Oil in Heshui Area, Ordos Basin

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Heshui area is located in the southwest of Shanbei slope of Ordos Basin in China with gentle structure. Yanchang Formation is terrigenous clastic rock series of fluvial facies and lacustrine facies formed in the process of continuous depression and stable settlement in Ordos Basin, vertically divided into 10 oil layer groups. During the deposition of Chang 7 member, the basin was in the maximum lake flooding period, developed sandy debris flow and turbidite fans in the center and on the slope, and resulted in the complex dense lithology. Large amounts of oil have been produced from the deep water gravity flow (sandy debrite, turbidites) sandstones in Chang 7 oil layers. Lithology and lithofacies play important roles in the formation of effective reservoir in tight sandstone oil reservoir. The characteristics of lithology and lithofacies in Chang 7 tight sandstone oil in Heshui area are studied by using core observation, thin section analysis, conventional logs and image logs processing, scanning electron microscope, as well as general physical analysis. Chang 7 tight oil reservoir is mainly sandstone caused by sandy debris flow, turbidity current and slump, and its source rock is mainly mudstone and oil shale. According to sedimentary environment, lithological association, rock structure and composition, Chang 7 is further divided into six lithology and lithofacies: fine sandstone of sandy debris flow, fine sandstone of turbidity current, siltstone of turbidity current, fluxoturbidite, mudstone of semi-deep water or deep water and oil shale. Based on conventional logs and image logs scaled by core data, this paper establishes the evaluation criterion of logging identification in different lithology and lithofacies, realizes the identification and classification of lithology and lithofacies in single well on the longitude, and further explores its relationship with TOC content, overlap rule of sand body and brittleness index. Finally oil-gas testing data and oil-gas interpretation results are combined to illuminate the quantitative control of lithology and lithofacies on physical property and oil-gas possibility of tight oil reservoir. The identification and classification of lithology and lithofacies in single well on the longitude and the analysis of its relationship with reservoir quality contribute to predicting the distribution of residual oil and establishing accurate logging interpreting models for reservoir parameters. The study of lithology and lithofacies of tight oil can lay foundation for later analysis of diagenesis and pore structure, as well as for the prediction of high quality reservoir; it can also provide theoretical guidance and technical support for comprehensive assessment of tight sandstone oil and for prediction of favorable zones in oil-gas reservoir development.

Quantitative logging characterization method of diagenetic facies for Chang 7 Tight Sandstone Oil Reservoir in Heshui Area, Ordos Basin

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Heshui area is located in the southwest of Shanbei slope of Ordos Basin in China. Yanchang formation of the Upper Triassic is terrigenous clastic rock series of fluvial facies and lacustrine facies formed in the process of continuous depression and stable settlement in Ordos Basin, vertically divided into 10 oil layer groups. During the deposition of Chang 7 member, the basin was in the maximum lake flooding period, and developed sandy debris flow and turbidite fans in the center and on the slope. Experiencing long diagenetic evolution, Chang 7 member formed current reservoir characteristic. Diagenetic facies is the material reflection of diagenetic environment, which is also the production of diagenesis and evolution stages in specific sedimentary, physical and chemical environment. It includes characteristics of rock particles, cement, fabric and cracks-holes. Diagenetic facies plays an important role in the formation of effective reservoir in tight sandstone oil reservoir. In this paper, diagenesis and diagenetic minerals of Chang 7 tight sandstone oil reservoir in Heshui area of Ordos Basin are studied by using core observation, thin section examination, scanning election microscope data, cathode luminescence and physical property analysis. According to the types and intensity of diagenesis and the combination feature of diagenetic minerals, diagenetic facies in research area is qualitatively divided into four types, including instable components dissolution facies, clay minerals filling facies, carbonate cementation facies and tight compaction facies. Then based on the analysis of conventional logging curves, such as gamma log, density log, acoustic transit time log, compensated neutron log and resistivity log, which are sensitive to diagenetic facies, crossplots are made to further quantitatively classify the four diagenetic facies and establish logging cognition model of diagenetic facies. Take Cheng 96 well in Heshui area, for example. The quantitative recognition and classification of diagenetic facies coincide well with thin section of sampling point, formation testing and physical property analysis in single well on the longitude, which verifies the reliability of the model. The study of quantitative logging characterization method of diagenetic facies can provide theoretical guidance and technical support for comprehensive assessment of tight sandstone oil and for prediction of favorable zones in oil-gas reservoir development.

Codification of lithofacies at a transition from marine to fluviatile environments: A simplified approach

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For a precise communication between scientists a common "language" is needed, including lithofacies description. An extensive compilation was effected by Andrew D. Miall and has been widely used since. We adopted the latter as basis for a simplified way to describe sedimentary structures in a deltaic context in Cenozoic sediments in NW-Switzerland. Acronyms consist basically of 3 letters, a fourth may be added to denote special features.
The first letter applies to the sediment type, with "paraconglomerate" (P) and "orthoconglomerate" (O) replacing "gravel" and "matrix/clast-supported" (G and m/c). The second letter denotes the bed geometry (new w = "wedge-bedding", e = "erratic" and ? = "not observable"). The third letter stands for the structures within the bed, e.g. h = "horizontal lamination", u = "upper sigmoidal lamination". If discernible, a fourth letter may be added for post depositional activity (e.g. b = "bioturbation", r = "root tracks", d = "desiccation cracks"). Late Rupelian deltaic sediments in the Delémont Basin may serve as an example: "Sph" stands for "horizontally planar bedded sand", "Stc" equals "trough bedded sand with cross-laminations", "Ppm" represents "planar bedded massive Paraconglomerate" and "F/S?c" means "silt to sand of unknown bed's geometry with cross-laminations".
In this context an extensive dense accumulation of mud pebbles at the base of a river channel needs to be addressed as either a "paraconglomerate" or a "orthoconglomerate", whereas larger, not rounded clay fragments and blocks have not been denoted yet. This represents a curious case in which a fine-grained sediment, which normally acts as matrix, provides the individual clasts that are supported by a matrix of coarser sand. We would invite discussion concerning theses special cases!

Reassessment of the K/T boundary site at Nasiłów, Poland – new sedimentological model in relation to Chicxulub impact

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The so far sedimentologic model at the K/T boundary at Nasiłów, Poland assumed the presence of a hiatus covering the topmost Maastrichtian [Cretaceous] and lower Danian [Paleogene]. Such an assumption led to complex model of sedimentation including multiply erosion, reworking, exhumations and phosphatization events. The study section, in general, is composed of (from bottom to top): 1) Kazimierz opoka unit topped by hardground; 2) chalk-like sediment; 3) glauconite-quartz send; 4) phosphate lag deposit; 5) geize sediment.
The reassessment of the so far model of sedimentation at Nasiłów combined with new multistratigraphic studies and detailed centimeter-scale sedimentological analyses reveals unexpected results, what lead us to propose a new model of sedimentation at this critical boundary.
The presence of large hiatal event has been based on paleomagnetic studies and remagnetisation in the critical interval. Our preliminary results did not confirmed the remagnetisation at the boundary interval what stay in contrary to previous research and are in line with new biostratigraphic data (foraminifera and dinoflagellata cysts). This indirectly show that the whole critical interval could be within the 29 reversed magnetochrone [29R] what would be in line with other well known K/T sections worldwide.
Reassessment of foraminifera succession raveled the presence of P0 and P1 foraminifera zones of earliest Danian age, which were formerly undiscovered. Dinoflagellate cyst succession recognized at Nasiłów, although less clear-cut as foraminifera, also point at uppermost Maastrichtian age of opoka and chalk-like sediment and earliest Danian age of geize part which cover the glauconite-quartz unit. Additionally, preliminary heavy-mineral analyses show that reworked glauconite-quartz sand has an admixture of heavy grains not present below (in the opoka and chalk-like units), thus indicating intensive upload of detrital material and start-up of new, however, still unknown alimentation areas.
The "iridium layer" or "fish clay", currently not present in the study section, were most probably deposited at the top of reworked glauconite-quartz sand and then remobilized downward. This is confirmed by a small enrichment of the glauconite-quartz sand in Ir-Pl rare earth elements. Such a behavior of Ir-Pl REEs was proven in several sections worldwide.
Summarizing, the proposed model of sedimentation, from bottom to top is as follows: 1) deposition of the Upper Maastrichtian [UM] opoka; 2) formation of hardground [UM]; 3) deposition of chalk and marly chalk-like sediments at the top of hardground together with still Cretaceous fossils, especially belemnites of the Belemnella kazimiroviensis group [UM]; 4) removal of chalk-like sediment and upload of sand and glauconite together with redeposited Upper Maastrichtian fossils during e.g. heavy storms or tsunami related to Chicxulub impact; 5) deposition of spongy carcass, ripped from different (shallow and deep) habitats at the top of glauconite-quartz sand; 6) deposition of supposed "iridium layer" and downward remobilization of Ir-Pl REEs together with phosphatization of spongy and other macrofossils; 7) deposition of geize sediment of lowermost Danian age (Paleogene) proven by presence of the P0 and P1 foraminifera zones.

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Deep versus shallow? Deltaically influenced sedimentation and new transport directions – case study from the Upper Campanian of the Roztocze Hills, SE Poland

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The Campanian and Maastrichtian (Upper Cretaceous) deposits of the Roztocze Hills, represented mainly by opokas, sandy opokas, gaize or sandy limestones have been consequently considered to represent relatively deep, shelf type deposits. The so far studies placed the opoka-like facies close or at the axial part of the Danish-Polish Trough, which has usually been equated with its deepest part, with main transport direction along its axis.
The current studies covering the “middle/upper” Campanian deposits showed unexpected sedimentological features, which are in contrast with the supposed deep depositional environment.
Here we present a three-fold lithological cycles which can easily be attributed to deltaic or deltaically influenced deposits. Each of the cycle consists of (from bottom to top): 1) dark, muddy slightly calcareous unit, which contain the finest sandy fraction, a lot of plant debris partly carbonaceous and it is usually 30-40 cm thick; 2) the lower unit pass gradually but fast, within 10cm interval, into second unit, usually 150-250 cm thick. This unit contains more sand, with a little bit larger fraction; 3) the last unit, usually 20-40 cm thick is most distinct and is represented by light grey, very hard sandy limestone with less amount of sandy fraction and highest content of $CaCO_3$ out of those three units. This unit has variable thickness, and sometimes thin out, to appear again in few next meters. It contain largest amount of fully marine fauna including relatively frequent cephalopods (ammonites and nautilioids), inocerams and echinoids. Larger wood fragments, preserved as external mould, are also not uncommon features of this unit.
Additionally, the analysis of anisotropy of remanent magnetization revealed the SW – NE direction of material transport what is in contrast with supposed material transport along the axis of the Danish-Polish Trough.
Such a characteristic is consequently repeated again and again within the c.a. 40 m thick succession of "middle/upper" Campanian available to study. Moreover, some other indicator like bivalve Pinna cretacea and representatives of Neithea known exclusively from shallow or extremely shallow environments prove the deltaic or deltaically influenced origin of above mentioned succession and stay in contrast to so far understanding of depositional environment of the Upper Cretaceous strata in Roztocze Hills in eastern Poland.

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What fossilized hailstone impression reveal about the dynamic of the Precambrian Atmosphere

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Hailstones from some 600 Million years ago, conserved in time as imprints of hailstone, impacted onto sebkha deposits of recent Mauritania [Western Africa], which in this time was not so far from the South Pole. These impressions have revealed an interesting story about the dynamic of ancient atmosphere, paleoclimate and indirectly paleogeographic position of Africa. Studies, encompassing the use of hailstone imprints as a potential indicator of atmosphere's paleodinamics, paleoclimat or paleogeography, have never been undertaken for obvious reasons – the hailstone imprints have never been reported. However, in the Precambrian, the frequency and preservation potential of hailstone imprints are expected to be higher than today. It is because the land was devoid of vegetation and therefore the areas potentially affected by hailstorms are markedly larger.
The hailstone impressions are sedimentary impact structures of fundamental importance and can be involved to solve rudimentary questions concerning different aspects of the ancient atmosphere, especially its dynamic and climate processes. In case of the Precambrian, our knowledge about the atmosphere is based mainly on geochemical data and computer modeling instead of hard proofs preserved in the geological record. So far the hailstone imprints were not investigated as a potential climate indicator. Based on the example from Mauretania the interpreting potential of hailstone impression is demonstrated.
The origin of hailstone requires specific dynamic condition of the atmosphere. They are created only in the Cumulonimbus clouds which formation require a combination of specific atmosphere's properties – temperature, air pressure and troposphere thickness. And this is first information about the conditions in Neoproterozoic atmosphere which, at least in this aspect, seems to be some kind similar to Recent atmosphere.
Additionally, recent hailstorms are generally restricted to mid-latitude setting, being virtually absent from circumpolar and circum-equatorial latitudes. According to the most recent paleogeographic maps, in the Precambrian times, Mauritania was located around 70 degrees south latitude. The presence of sabkha deposits on the one hand and proof of occurrence of hailstorms in high southern latitude, far beyond common present occurrences of hailstorms, on the other, suggests significantly different climate zones distribution and atmospheric circulation in the Neoproterozoic. Alternatively, the paleoposition of Africa is simply wrong…?
Therefore, the hailstone impressions, in the past sediment brings new light on several fundamental questions i.e.: i) the dynamic of the paleoatmosphere in the evolving Precambrian and Early Paleozoic atmosphere; ii) its properties that promote or hinder the formation of hailstone in the past; and iii) could be used as an additional indicator in the interpretation of the paleoclimate zones and paleogeographic architecture of continents.

Calibration of Upper Miocene sea level fluctuations from karst development in reef-slope deposits (SE Spain)

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The sedimentary record provides numerous evidences which allow reconstructing of sea level changes, their rates and amplitudes. These evidences are usually related to vertical shifts of pinning points, which are points of quantitative constraint on the position of past sea level stands relative to a geologically-defined reference elevation. Reconstructions of ancient sea level changes are usually based on the study of such pinning points, especially those related to coral reef positions, and on the analysis of $\delta^{18}O$, an ice-volume proxy, in pelagic sequences. Sea level curves developed according to these indicators, however, differ in the amplitude of the sea level fluctuations. Other attempts to trace sea level changes are based on the analysis of coastal-karst marine sedimentary infilling or cement mineralogy. In order to identify new pinning points, two clinoform bodies and a lowstand inverted wedge from the Upper Miocene carbonate platform of Cariatiz (SE Spain) were selected to analyse diagenetic variations indicative of sea level fluctuations. The lower clinoform body (LCB) presents three diagenetic zones: DZ1 with dissolution of bioclastic components and DZ2 with calcite-cement precipitation in the solution pores. The calcite cements are granular, drusy and radiaxial fibrous, of meteoric origin as deduced from cathodoluminescence, energy-dispersive X-ray spectroscopy as well as $\delta^{13}C$ and $\delta^{18}O$ isotope analyses. DZ3 presents moldic porosity after aragonite bioclasts and rarely granular calcite cements partially infilling solution pores.The upper clinoform body (UCB) and the lowstand wedge (LW) present diagenetic features similar to those in DZ3. The distribution of the diagenetic zones implies karstification during the sea level lowstand recorded by the LW deposition. LCB was exposed due to the sea level fall, triggering the dissolution of aragonitic components in the meteoric-vadose zone and calcite precipitation in solution pores in the meteoric-phreatic zone. DZ1 and DZ2 correspond to the meteoric-vadose and meteoric-phreatic zone, respectively. The diagenetic alteration related to DZ3 and the diagenetic features in the LW and the UCB, are probably related to a major sea level lowstand 5,71 myr ago. DZ1 and DZ2 represent the outcrop record of sea level fluctuation between 5,74 and 5,72 myr ago including a sea level fall of 23,5 m and a sea level rise of 31 m. The observed sea level fluctuations differ from estimated sea level curves as published elsewhere. The position of different diagenetic zones of the karst is proposed as a new type of pinning point, and represents an outcrop calibrator for the different amplitudes of sea level change in literature.

Lithofacies and microfacies of Toarcian Ammonitico Rosso from the Southiberian Palaeomargin (Betic Cordillera, South Spain): Approaching palaeoenvironmental reconstruction

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The Toarcian ammonitico rosso facies were widespread in the Mediterranean Tethys (between 15-30º N latitude) in the North Gondwana Palaeomargin (Apulian promontory and North African Margin) and southern Iberian Palaeomargin (Betic Cordillera). These facies were associated with epioceanic slopes of a sedimentary swell-trough system related to the extensional phase of continental rifting. Studies of these facies are relatively scarce as compared to those of Toarcian black shales. The example studied – in the Median Subbetic (Southiberian Palaeomargin) – shows the progressive installation of ammonitico rosso facies during the Toarcian with an evolution to hemipelagic swells after the fragmentation of carbonate platform.
During the latermost Pliensbachian to Bifrons Zone (Middle Toarcian), sedimentation was dominated by epioceanic limestones and marls with a high influence of neighbouring shallow environments represented by common turbidite-tempestite beds (with shallow water foraminifera and ooids). Microfossils and trace fossils provide no evidence of oxygen restricted conditions. In the Gradata Zone (Middle Toarcian), the ammonitico rosso facies debut (red nodular limestones and marly-limestones rich in trace fossils *Phycodes*, *Planolites*, *Thalassinoides* and *Chondrites*). Progressively more pelagic conditions and a restricted connection with emerged lands and carbonate platforms are reflected by the decrease in sedimentation rate, lesser input of turbidite-tempestite beds and increase of ammonitellas and radiolarids. The sea-level fall in the hemipelagic swell during the Middle-Late Toarcian favoured a low sedimentation rate and sediment-winnowing by currents, with subsequent condensation and nodulation. The combined action of burrowing, compaction and dissolution controlled nodulation, which ranges from diffuse nodules to sharp edge nodules. The sedimentation rate conditioned the time available for nodule growth, the migration of the Ca^{2+} and HCO_3- precipitation horizon, and the nodulation degree (from horizons with diffuse edge nodules or semicontinuous to continuous layers formed by the coalescence of sharp edge nodules).

Iron crusts of the Middle–Upper Jurassic unconformity of the External Prebetic (Betic Cordillera, SE Spain)

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Discontinuous sedimentation is characteristic of epicontinental shelf environments of the South-Iberian Palaeomargin during the Middle–Late Jurassic transition. In the Jurassic palaeogeography of this palaeomargin, the Prebetic represents an epicontinental shelf. Hardgrounds, iron deposits (crusts, ooids, pisoids and oncoids), condensed levels and palaeokarst features are distinctive and recognizable characteristics, marking the unconformity between the shallow facies (Middle Jurassic) and the hemipelagic spongiolithic limestones (Upper Jurassic). This boundary is represented by a first order unconformity, which involves stratigraphical gap ranging between Upper Bathonian–Middle Oxfordian. The irregular surface is, in some places, covered by a thin iron oxides impregnation affected by borings. Locally, a thin iron crust (< 5 cm) with iron ooids and pisoids appears over this unconformity capping the Bathonian oolitic limestones. These ooids and pisoids (type-A of Reolid et al., 2008) are characterised by thin, regular lamination in concentric layers enclosing a nucleus. The chemical composition varies between 80% Fe_2O_3 in the iron crust and 67% in the coated grains. The mineralogical composition of the iron crust and ooids is primarily goethite whereas hematite is exclusive of the iron crust.
Over the unconformity and the iron crust, exist one or two decimetric beds of ferruginous oolitic limestones with iron ooids coming from the iron crust (82%) and new iron ooids with thick, irregular lamination enclosing a variable nucleus including bioclasts and foraminifera (type-B of Reolid et al., 2008). The top of the Bathonian oolitic limestones is locally brecciated in the eastern External Prebetic. Fe-Mn crusts (< 15 cm thick) and macrooncoids (< 5 cm diameter) coating the breccia clasts in the top are common. This crust shows a poorly developed lamination. Under scanning electron microscopy it is composed by prismatic crystals of hematite, microbial filaments and diatoms. The chemical composition of these iron crusts is mainly CaO (49%) and Fe_2O_3 (6%), and the mineral composition is calcite and hematite.
Later, the sedimentation began with spongiolithic limestones rich in ammonoids and planktic foraminifera (*Globuligerina*) of the Middle Oxfordian.
The sequence of processes related to this unconformity includes a relative sea-level fall with erosion resulting in a paleotopography were iron crust was developed. The mineralogical composition of the iron crust and type-A iron coated grains is similar to that of ferruginous pisolitic plinthite (highly-weathered redoximorphic soil). A coastal plain with periodically flooded soils would be the likeliest scenario. The return of the marine conditions is indicated by the presence of hardgrounds characterised by thin ferruginous surfaces with borings and laterally thicker iron crusts and oncoids rich in diatoms and microbial filaments. Subsequently, condensed and hemipelagic, ferruginous oolitic limestones rich in ammonoids (Middle Oxfordian) are deposited associated with major flooding of the Prebetic shelf and the erosion of ferruginous pisolitic plinthite. Finally, sedimentation followed with hemipelagic spongiolithic limestones and marl-limestone rhythmites during the middle and late Oxfordian.

Basins of fate: Tectonics, sediments and human evolution

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Much of human evolution during the last 6 million years unfolded in the eastern African Rift Valley, during a period of profound climate change operating in a complex tectonic landscape. How might we detangle the relative contributions of climate and landscape change on hominin evolution? And what is the most appropriate spatial scale on which to consider palaeoenvironmental reconstructions and the role of climate and landscapes on our evolution? Recent work, for example, has stressed the importance of lakes and their sensitivity to climate change controlled by basin topography. The authors have shown using remote sensing of the Okavango Basin (Botswana) how seasonal and decadal climate variation are buffered by the hydrogeology of this tectonic basin. This contrasts with a tendency for amplification in non-tectonic basins such as Lake Chad (Chad). Similarly, the paleontological record also suggests that some basins may have acted as climate refugia, offering stability to fauna during periods of climate changes. What is emerging from the multi-disciplinary approach is the idea that different sections, or basins, of the rift respond to the same climate forcing in different ways leading to different evolutionary pressures. The basin inhabitants – hominins and as well as other fauna – of each basin may experience different fates in the face of similar climate change. This intriguing idea is explored in this paper, and may help to explain much of the observed complexity in our ancestral fossil record and the associated palaeoenvironments.

Lower Cretaceous depositional systems in the outer part of the Eastern Carpathians

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The outer nappes of the Eastern Carpathians are known as the Moldavides. Their sediments derive from the remnants of the Alpine Tethys.This ocean has been closed starting with the Cretaceous.
The Moldavide oldest sediments are Lower Cretaceous black shales. At the beginning of the Late Cretaceous, the anoxic/dysoxic setting shift to an oxic one, mirrored in the deposition of variegated shales. The Vrancea Nappe, the outermost unit of the Moldavides where Cretaceous deposits crop out, occurs in several half windows. Our investigation focused on the southern Vrancea Halfwindow and on the Bistriţa Halfwindow, placed in North-Eastern Carpathians. In the Bistriţa Halfwindow, the Lower Cretaceous Sărata Formation is divided into three members: (i) The Lower Member, Barremian-Early Aptian in age, composed of black shales, interbedded with thin sandstones and siderites; (ii) The Middle Member, Late Aptian-Early Albian in age, made by siliceous black shales; (iii) The Upper Member, Late Albian in age, characterized by the sedimentation of carbonate sandstones and chert nodules. Within the latest Cenomanian, variegated shales accumulated. In the southern Vrancea Halfwindow occurs the Barremian-Lower Albian Streiu Formation, in the approximately the same depositional interval as shown by the Lower and Middle members of the northern Sărata Formation. The Streiu Formation is mainly made by black and grey shales, alternating with thin sandstones and siderites. The Total Organic Carbon (TOC) content of the black shale is between 0.3 and 1.5 %. The Streiu unit is overlain by the Tisaru Formation, which displays two distinct units: (i) The Lower Member, with Upper Albian to Lower Cenomanian rhythmical alternating grey shales, marls, thin sandstones and rare black shales and may be correlated with the Upper Member of the northern Sărata Formation; (ii) the Upper Member, which the base is placed within the Middle Cenomanian, starts with couplets of radiolarites and grey-green shales, followed by variegated shales and marls, with interbedded sandstones. The upper member of the Tisaru Formation represents a southern equivalent of the variegated shales from the Bistriţa Halfwindow. The units in which black shales prevail, such as the Lower and Middle members of Sărata and Streiu units, were deposited in a slope setting in the eastern part of Moldavide basin. Their features are lobe fringe and interlobe associations having hemipelagites and low-density turbidites along with erosional gully and slump deformational structures. Upper Member of the Sărata Formation shows the characteristics of channel fill or proximal lobes as an effect of bioclastic high-density turbidity currents. In the Late Cretaceous, the depositional features shift in both investigated southern and northern halfwindows, due to the Moldavide basin deepening. This change led to the occurrence of radiolarite/shale couplets and variegated shales. The clast source is an eastern extrabasinal, expressed in green metagraywacke occurrence from the Eastern European Platform, but also an intrabasinal one, mirrored by the presence of carbonate and siliceous bioclasts. Probably, the Albian sedimentological changes were mainly the effect of mid Cretaceous tectonic events, such as the thrusting of western Eastern Carpathian nappes, the Median Dacides, towards East.

Using heavy minerals to discriminate local and distal deposits in a basin sourced by a continental-scale river system

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The Olla Formation (Late Pliocene) is part of a sedimentary sequence of deltaic rocks that are exposed in Fish Creek Wash, Anza-Borrego Desert State Park, southern California. The Formation consists of interbedded sediments from two provenance regions. One sediment type has been classified as L-suite and represents locally sourced sediments from the basin margin. The other sediment type is the C-suite, which consists of delta top deposits sourced from the Colorado River.

This study shows how heavy mineral profiles can identify major changes in sediment input in basin deposits. Heavy mineral characteristics of sediments from the Olla Formation are compared with locally sourced deposits shed directly from the basin margin (Canebrake Conglomerate), which are typical L-suite, and Colorado River derived sediments of the Imperial Group and the Arroyo Diablo Formation, which are typical C-suite. This comparison reveals interbedding of sediments with contrasting provenance. The interbedding can be identified by colour variations seen at outcrop. The L-suite sediment appears green while the C-suite sediment is a buff yellow. Field observations show that where the two sediment types are in contact, sometimes the boundary is sharp and erosive, whilst other times sediments with intermediate characteristics are present. These intermediate beds indicate (on most occurrences) where Colorado River derived channels have eroded down into locally derived deposits and reworked some of this material. The intermediate beds represent a zone where the eroded and reworked local material is redeposited with some of the Colorado River sourced material.

Using a combination of stable mineral ratio cross-plots and varietal heavy mineral analysis (garnet geochemistry), the study shows that the apparent provenance changes that occur on an outcrop scale can also be identified in the heavy mineral portion of the sediment. These methods link the key sediment types in the Olla Formation to their source region and illustrate how sediment mixing occurs on a delta top environment in close proximity to an active basin margin at the time of deposition. The study also illustrates that the reworking and diluted redeposition of a sediment by a differently sourced sediment system can be identified on a mineralogical level. This method could be important for identifying unconformity scale reworking of sediment significant in the petroleum system in the subsurface.

Villalba Baja travertine: An example of Pleistocene spring deposit from Teruel Basin (Spain)

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Teruel Basin is a half-graben developed over a Mesozoic substrate in the East of Iberian Peninsula and filled with continental Miocene to Holocene sedimentation. Clastic alluvial deposits passing to palustrine and lacustrine limestones and gypsum are the typical Cenozoic lithologies, whereas the hinterland is constituted by Mesozoic rocks (mostly carbonates and evaporites). These lithologies are entrenched by Alfambra River which during the Quaternary formed a series of fluvial terraces.
Villalba Baja travertine is placed on a semicircular hill overlying Miocene lacustrine deposits. These travertines are being quarried as building stone. The quarrying activity destroyed the main deposits, but also exposed fractures filled with travertine.
Two main groups of facies have been defined: subaerial travertine facies and internal facies. Subaerial facies include constructive facies (travertine *s.s.*) and surficial incrustations of Miocene limestones. Travertine consists of (i) charophyte mounds encrusted by coarse crystalline calcite, (ii) laminar bodies with wavy morphology adapted to their substrate, and (iii) massive irregular bodies. Subaerial incrustations formed on Miocene limestones exposed along the hill slope (downslope from travertine deposits). Cementation and incrustation produced lobulated bodies in downstream direction with higher topographic expression than unmodified Miocene limestones.
Internal facies modified the original Miocene substrates which are composed of: (i) laminar micrites consisting on banded mudstones, packstones with ostracods and bivalve fragments, and microsparite laminae; (ii) massive micrite with clotted fabric consisting on mudstones with not biological remains and wackstone-packstones with ostracods, charophytes, bivalves, gastropods and peloids. These rocks are fractured and modified (dissolved and then cemented, and even recrystallized) due to water circulation. Fractures are filled by coarse crystalline crusts.
Villalba Baja travertines are related to extensional character of the basin. The formation of these deposits may be related to N-S trending faults that bound the basin, but also to near E-W trending faults intersecting those N-S faults. Deposition could have started on Middle to Upper Pleistocene as is suggested by their relationships with middle and upper terraces of the Alfambra River, in the later stages of fluvial incision. Observed facies formed in low flow energy which precipitated micrite from warm (20 °C to < 40 °C) waters as is suggested by biological content (mainly charophyte mounds). It is remarkable that most of the hard facies of the system are not constructive facies ss, but the modification of previous lithologies due to water circulation. A variety of biogenic and abiogenic processes interacted to form all these facies.

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Changes in coated grain-types from travertine to tufa deposits in Azuaje carbonate building (Canary Islands, Spain)

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Varied types of coated grains have been found in perched and fluviatile travertines and tufas along 3 km of Azuaje Ravine in the volcanic island of Gran Canaria (Canary Islands, Spain). The systems show a clear evolution from travertine to tufas along the Ravine. Coated grains have been grouped into ooids and oncoids based exclusively on their characteristics
Ooids show regular concentric smooth envelopes and 0.1 mm-2 mm in size. Three main types of cortex have been distinguished: (i) radial fibre or acicular crystals comprising the whole cortex diameter and crosscutting the lamination, (ii) banded-radial arrangements with alternating layers of radial fibres and micritic layers, and (iii) micritic. Nuclei are intraclasts, peloids, spherulites, small plant part moulds, or may absent by dissolution, or undistinguishable from the cortex. Ooids are commonly spherical to ellipsoidal. Frequently two or more individual coated grains agglutinate and form compound grains. Mineralogy varies between aragonite and aragonite-calcite.
Oncoids are 0.4 mm to several millimetres and exceptionally tens of centimetres (nuclei of palm tree leaf moulds). They display two main types of coatings: (i) thin, irregular, dense micritic laminae, and (ii) generally thicker porous laminae usually made of dendritic, shrubby, or columnar (branched) crystal aggregates, containing alternating lamination. Lamination is slightly wavy to mammillated. Nuclei are similar to those of the ooids, being intraclasts and plant moulds (leaving moldic porosity) the most common. Shapes are varied and generally irregular depending strongly on the shape of nuclei. Mineralogy varies from aragonite, to aragonite-calcite mixtures, and to exclusively calcite in tufa.
Diagenetic changes are widespread, being apparently more intense in travertine than in tufa facies: aggrading recrystallization, aragonite inversion, dissolution, and cementation are the most common processes.
$\delta^{13}C$-$\delta^{18}O$ plots from each individual deposit show positive covariant trends. Isotope signals of coated grains are indistinguishable from other of the same deposit. $\delta^{13}C$ decreases as the amount of calcite increases which suggest: a) that primary aragonite facies are heavier in carbon than those composed of calcite, and ii) diagenetic transformations deviate the primary signals to heavier ^{13}C values.
Ooids are restricted to travertines. Oncoids are ubiquitous, but changing strongly their features in downstream direction. Tufa deposits placed downstream only content oncoids with intraclasts and large plant moulds as nucleus, as well as thicker and more irregular coatings, than those found in upstream travertines.
Coated grains formed with low to no displacement, as is suggested by their high diversity and the uncommon occurrence of deposits with mixed grains. Scarcity of detrital clasts as nuclei of coated grains suggests low clastic input from upstream but also from ravine walls. These may be related to slope stability, but also with the absence or attenuation of floods.
Restricted distribution of ooids, sharp changes in oncoid type, mineralogy, isotopes and diagenesis suggest an abrupt change downstream in environmental conditions reflected in changes in vegetation and $CaCO_3$ precipitation rates and mineralogy.

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High-resolution ichnological approach of the Cretaceous-Paleogene boundary deposits in the Agost section, Spain

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A detailed ichnological analysis of the Cretaceous–Paleogene (K-Pg) boundary section at Agost (Betic Cordillera, Alicante Province, southeast Spain), one of the best known, expanded, and complete K-Pg boundary sections worldwide, was carried-out in order to better understanding the environmental consequences of the K/Pg event on the macrobenthic tracemaker community. The section analyzed is composed of greenish gray latest Maastrichtian marls intercalated with marly limestones (Raspay Formation), belonging to the Plummerita hantkeninoides Biozone, overlain by lowermost Danian sediments (Agost Formation) of the Guembelitria cretacea Biozone composed of the dark boundary clay, white marls and rose marly limestones; a 2 mm thick rusty layer at the base of the boundary clay marks the K-Pg boundary (Molina et al., 1996; Chacón & Martín-Chivelet, 2005). In the highly bioturbated uppermost Cretaceous sediments, light- and dark-filled trace fossils were recognized (Rodríguez-Tovar and Uchman, 2004), evidencing several phases of colonization; light-filled trace fossils and bioturbational structures are interpreted as Maastrichtian in age, whilst the trace fossils assemblage filled with dark clay was dated as earliest Danian (Rodríguez-Tovar et al., 2004).
A new high-resolution ichnological analysis of the Danian trace fossils observed within the Maastrichtian deposits was made. The trace fossils include *Planolites* isp., *Chondrites targionii*, *Chondrites affinis*, *Chondrites* isp., *Thalassinoides* isp., *Zoophycos* isp., *Trichichnus linearis*, *Trichichnus* isp., cf. *Pilichnus* isp., ?*Teichichnus* isp. The latter three ichnogenera are described in the Agost section for the first time.
The lowermost Danian clay contains *Zoophycos*, ?*Planolites*, and *Chondrites*. *Chondrites* and *Zoophycos* are slightly deformed due to low consistency of the sediment (soupground conditions). *Zoophycos* was recognized for the first time in the dark boundary clay, and in the overlying rose limestones. The trace fossil assemblage is ascribed to the Zoophycos ichnofacies (sensu Seilacher, 1967). The trace fossil assemblages are similar below and above the K-Pg boundary. This supports the idea about minor influence of the K-Pg boundary event on the macrobenthic trace-maker community.

Mg/Ca ratios in freshwater microbial carbonates: Thermodynamic, kinetic and vital effects

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The ratio of magnesium to calcium (Mg/Ca) in carbonate minerals in an abiotic setting is conventionally assumed to be predominantly controlled by (Mg/Ca) solution and a temperature dependant partition coefficient. This temperature dependence suggests that both marine (e.g. foraminiferal calcite and corals) and freshwater (e.g. speleothems and surface freshwater deposits, “tufas”) carbonate deposits may be important archives of palaeotemperature data. However, there is considerable uncertainty in all these settings. In surface freshwater deposits this uncertainty is focussed on the influence of microbial biofilms. Biogenic or “vital” effects may arise from microbial metabolic activity and/or the presence of extracellular polymeric substances (EPS). This study addresses this key question for the first time, via a series of unique through-flow microcosm and agitated flask experiments where freshwater calcite was precipitated under controlled conditions. These experiments reveal there is no strong relationship between (Mg/Ca) calcite and temperature, so the assumption of thermodynamic fractionation is not viable. However, there is a pronounced influence on (Mg/Ca) calcite from precipitation rate, so that rapidly forming precipitates develop with very low magnesium content indicating kinetic control on fractionation. Calcite precipitation rate in these experiments (where the solution is only moderately supersaturated) is controlled by biofilm growth rate, but occurs even when light is excluded indicating that photosynthetic influences are not critical. Our results thus suggest the apparent kinetic fractionation arises from the electrochemical activity of EPS molecules, and are therefore likely to occur wherever these molecules occur, including stromatolites, soil and lake carbonates and (via colloidal EPS) speleothems.

The impact of the Apennine chain on deposits issued by the explosive eruption of Campanian Ignimbrite 39,000 years ago

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Taking into account the effects of an eruption on the environment, is here analyzed the specific case of the impact of the Apennine chain on deposits issued by the explosive ignimbritic eruption.
The eruption is the 39ka Campanian Ignimbrite of 200 km^3, which took place in the Campanian Plain, a wide flat area extended between Naples and Caserta, and delimited by the Apennine foothills toward north, east and south, and by Tyrrenian sea, toward west. For its important volcanic activity the Plain has been identified as “Campanian Volcanic Zone (CVZ). The CVZ, since the time of its formation, had the structure of a “graben”. The tectonic lines, along which the lowering are well recognizable on the edge of the plain, are faults oriented NE-SW and NW-SE. Considering the CVZ as a regional tectonic depression, many authors believe that many voluminous pyroclastic flow eruptions were vented directly from Apennine sedimentary fault graben, the last being the 39 ky Campanian Ignimbrite (CI). The CVZ is then considered as an area in which during the Quaternary there have been major volcanic phenomena that significantly contributed to defining the current morphological aspect of a perfectly flat area. In this morphological context, they then had a fundamental role in the relationship between erosion of rivers flowing across the plain in relation to sea level variation during the Quaternary period. The effects of morphological variations are well evident in the adjacent Apennine areas. Many intra-valleys of the Apennines, in fact, appear completely filled with very thick ignimbrite deposits up to considerable distances from the CVZ source area. It is interesting to note even the relationship between the deposition of ignimbrites and Apennine barrier. At points where the pyroclastic flow is wedged in a transverse valley, the deposit that settles over the barrier is thick ignimbrite. However, where the flow impacts with the relief, even for heights of 800-1000 m, only a small part of the eruptive cloud crosses the summit, depositing tiny thick ignimbrite deposit.
In conclusion, we believe that the CVZ and adjacent areas of the Apennines is a clear example of the relationship between a regional ignimbritic eruption, and the influence exercised by sedimentary structures that form a barrier around the source area.

Signatures of the past in tidal environments: Insights from the Southern Venice Lagoon (Italy)

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The Venice Lagoon represents an outstanding example of man-landscape co-existence. Among its typical features, salt marshes are governed by the interaction between physical and biological processes. Because of their unique position in the tidal frame, salt marshes represent a crucially important ecosystem providing valuable services to the environment. They furnish a shoreline buffer against waves and storms, filter nutrients and pollutants, enhance yield of fisheries and serve as an important carbon sink. Salt marshes in the Venice lagoon are currently exposed to possibly irreversible transformations due to the effects of climate changes and human interferences, as in other cases worldwide. The increasing rate of relative sea level rise and the decreasing sediment supply are the dominant factors controlling the emergence or the drowning of salt marshes, and consequently their disappearance. Analysing signatures of landscape changes in the stratigraphic record is crucial to refine our knowledge of tidal landform dynamics and it is a first step to develop predictive morphodynamic models. The southern Venice lagoon is suited to analyze the response of tidal morphologies to changes in environmental forcing. The upper part of the Holocene succession is suggested to be the result of a human-induced transgression, where salt marshes started to contract since the 16th century. The Brenta River, re-directed twice into the lagoon in the 16th and the 19th century, used to play quite a relevant role in terms of freshwater and sediment input in this area. To analyze the response of the environment to these changes, we collected 25 cores (1.0 to 1.5 m deep) along a NE-SW linear transect about 5.2 km long cutting through salt-marsh, tidal-flat and subtidal-platform deposits. Through sedimentological analyses we defined the spatial arrangement of swamp, salt-marsh, wave-worked, distributary paleo-channel and tidal-flat deposits along the transect. GPS coordinates and surface elevations were measured for each core, while organic and inorganic sediment content, magnetic susceptibility and grain size distribution were investigated along some guide-cores. To determine the amount of the organic matter, Loss On Ignition and a treatment with H_2O_2 were used, and the particle size analysis was carried out with a Mastersizer on the inorganic fraction of the same samples. The study succession was also dated through 14C and 137Cs geochronological analysis. Our results suggest that salt-marsh sedimentation occurred above deltaic peat by gradual transition since the 14th century. Salt-marsh aggradation stemmed out from both mud settling and organic accumulation, although magnetic susceptibility reveals that in some intervals the inorganic deposition dominates over organic accumulation. Salt-marsh aggradation shows different accretion rates during time, and occurred in parallel with the decrease in salt-marsh extent and the tidal-flat expansion. Here the wave worked deposits were originated as a selection pavement due to wave-winnowing erosion triggered by salt marsh drowning, and the organic mud accumulation took place above the shell-rich lag as consequence of the progressive water deepening.

Processes controlling chalk deposition in the Cretaceous North Sea: A numerical modeling study

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The Upper Cretaceous (~100-66 Ma) of Northwest Europe is characterized by thick successions of chalk, a biogenic pelagic sediment consisting of coccolith fragments with no modern analogue. These deposits serve as important reservoirs for hydrocarbons and ground water. In recent decades, it has become clear that these deposits were shaped by depth contour following currents and gravity flows, and not simply a result uniformly vertical settling of coccoliths (Surlyk and Lykke-Andersen, 2006), leading to spatial variability in reservoir properties
It has been conjectured, that the warm Cretaceous Greenhouse climate and high sea level resulted in the breakdown of the oceanographic front at the continental shelf edge, as we know it today in mid-latitude areas (Hay, 2008). Furthermore, the deep shelf conditions and very warm seasons most likely resulted in the continental shelf seas having a stratified structure similar to that of the open oceans, leading to a thining of the surface Ekman layer. With warmer climate, evaporation on stratified continental shelf seas may have resulted in preconditioning of the waters where winter cooling may have caused cascading of dense, higher-salinity coastal waters. Such cascading may have resulted in depth contour following currents in the intermediate waters in and below the pycnocline and significant oxygenation of deeper shelf waters.
Here we explore the quantitative physical basis for the conjectures using the 3D Regional Ocean Modeling System (ROMS) forced by results from ocean-atmosphere global climate models. We couple the model to a sediment transport module permitting assessment of the oceanographic processes influencing the chalk thickness variation as a function of idealized shelf bathymetry configurations. The numerical modeling grid is configured to represent the overall geometry of the paleo-North Sea during the Late Cretaceous. Model forcing for seasonal variations in winds and temperature is informed from the abovementioned global climate models, while the critical shear stress and settling velocity of chalk ooze is derived from experimental values.

Comparison of detrital age distribution using hierarchical clustering methods

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The development of analytical systems such as Laser Ablation – Inductively Coupled Plasma Mass Spectrometry allows to acquire quickly large sets of age data. As a result, detrital zircon U-Pb geochronology is now commonly used as a tool to determine sediment provenances or to correlate sedimentary units (among other applications). Such studies rely on the comparison of age distribution, either with the known ages of the potential sources or with other age distributions, respectively, and an assessment of the similarities between age distributions. While the human eye performs quite well qualitative recognition of similarities, it must be emphasized that detailed interpretation based on a simple visual inspection is always prone to produce potential bias, especially when dealing with large and complex data sets.
Various approaches based on Bayesian mixture modelling, multivariate analysis, kernel functional estimation, multidimensional scaling, “similarity” or “overlap” (introduced by G. E. Gehrels), have been recently proposed in order to resolve quantitatively this issue. Here, we propose and evaluate others methods that rely on hierarchical clustering methods (Unweighted Pair Group Method using arithmetic Average and Neighbor Joining) after quantifying the dissimilarities between age distribution using the “similarity”, the “overlap” or the L2 distance (the Scilab code used to carry out these comparisons, implemented by G. Cousin, is available on request from the authors). We then estimate (i) the efficiency of these methods to retrieve an a priori known stratigraphy using U-Pb/detrital zircon geochronological data sets obtained on samples with a known stratigraphic position, (ii) the effects of the various zircon selection procedures (random or hand picking of zircon grains) prior to their U-Pb analyses and (iii) the influence of the diverse procedures used to filter U-Pb data (concordance or probability of concordance threshold). Finally, we discuss the pros and cons of these hierarchical clustering methods to determine sediment provenances with respect to natural bias such as the differential weathering of source rocks and/or hydraulic sorting.

Late Holocene evolution of sandy beach ridge plains from Danube delta

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Recent studies on the Holocene evolution of Danube Delta focused on establishing a chronological framework for its formation and development but lack morphogenetic interpretations of encompassed complex beach ridge systems.
This study offers an insight into beach ridge plain development through the detailed reconstruction of paleoshorelines. Variations in patterns of progradations and morphological expression of these deltaic deposits record spatial and temporal changes in various environmental parameters such as sediment supply, wave and wind regime. The interaction of these control factors was investigated and a genetic classification of beach ridge plains from Danube Delta is provided.
We use geomorphological, sedimentological methods together with newly obtained Optical stimulated luminescence (OSL) dates and ground-penetrating radar (GPR) scanning for high-resolution paleogeographical reconstruction of beach ridge evolution and for better understanding of such sedimentary systems in terms of internal architecture, depositional processes and driving mechanisms.

Beach-foredune sand budget along the Łeba Barrier, south Baltic coast, Poland – pilot study and implications for coastal erosion assessment

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The Łeba Barrier is part of a well-developed barrier-lagoon coast. The coast is barred and tideless, and the beach is backed by WSW–ENE oriented foredune ridges. The wind regime of the coast is dominated by westerly winds (prevailing directions of 240°-280°). Taking into account the orientation of the coastline, which changes along the barrier from 50°-230° to the west to nearly 90°-270° to the east, these are alongshore and oblique onshore winds. The estimated aeolian sand budget suggests that only some sections of the coast are privileged in terms of foredune formation. However, along sections of the coast predefined as both privileged and unprivileged for foredune development, there are zones marked by nearly continuous growth of foredune ridges, as well as zones where the beach and foredunes suffer intensive destruction. These zones of foredune growth and erosion alternate along the coast. A possible explanations for this alternation includes fluctuations in the littoral sediment budget along the shoreline which, in this region, is controlled by the amount of sand coming from coastal erosion. The present study aims to evaluate short-term changes in sediment budget along a part of the barrier coast and determine the dynamics of erosion-accumulation zones which are probably the most important factor controlling the foredune formation.
The field work was carried out at 10-km-long coast section where three accumulation zones and three erosion zones alternate. The survey included topographic profiling along: 1) shore-normal transects spaced every 100 m (within beach-foredune system) and 2) shore-parallel transects: cliff top line, cliff foot, beach axis and swash zone (within erosion zones). The elevation data were obtained by means of trigonometric leveling using the total station and differential GPS measurements. Data were collected in 2013 and 2014. Additionally, the Digital Elevation Model with a spatial resolution of 1 m derived from airborne LIDAR data acquired in 2011 was used. The detailed shore-normal beach-foredune profiles were made to display changes in topography in two successive periods: 2011-2013 and 2013-2014. Further examination of the data focused on spatio-temporal changes in the position of inflection points marking the borderline between areas of positive and negative sediment balance. The results of sand balance were mapped using the local polinomial trends gridding method. The anisotropy of spatial distribution of positive and negative balance values was modeled to improve the maps.
Zones of foredune growth and decay are spaced regularly, every 1.1-2.4 km. The preliminary results show that western accumulation zone, located at the cost oriented 50-230°, slightly expanded in analyzed period (both towards NE and SW). The cliff separating it from next accumulation zone extends along the coast section which orientation changes from 50°-230° to the west to 70°-250° to the east. Both accumulation zones located to the east of the cliff shifted eastward. These results show that zones of coastal erosion are not stable in time and thus coastal protection actions must take into account changes in interannual sediment budget.

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Vertical distribution of grain size within sandy cloud transported by wind

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It is commonly assumed that the coarsest wind-blown sand grains move on (creep) or close to the bed (reptation) whereas finer grains travel by leaping (saltation) and can reach a height of tens of centimeters. However, some research show that fining of grain size with elevation happens only in the near bed 15-20 cm thick layer and in the higher part of the wind stream the trend is reversed. The purpose of the present study was to study size distributions with heights above the bed.

The field experiments were performed at the top part of a single dome dune at the coast of Sao Bento do Norte (northern coast of Rio Grande do Norte, Brazil). The wind speed and direction were measured by automatic meteorological stations with three-cup anemometers and vanes placed 1 m above the ground. Measurements of the mass flux profile were made using vertical passive sand traps 0.5 m in height. A single trap consists of 28 chambers inclined at 30°. The opening of each chamber is 0.01 m wide, while the height equals 0.0125 m (16 chambers covering a vertical span from the bed to an elevation of 0.2 m) and 0.025 m (12 chambers at elevation of 0.2-0.5 m).

The uppermost sand layer of the dune was composed of moderately sorted medium quartz sand. During measurements the surface was dry and covered with small ripples. The vertical distribution of horizontal mass flux was analysed from the results of measurements made during maximum flux conditions. It was assumed that if the amounts of sand trapped in successive downwind sand traps (arranged along wind parallel transects) were comparable, the stream was saturated. The wind speed ranged between 10.32 m/s and 11.50 m/s, and the sand transport rate was in the range of 0.0177-0.0288 kg/m/s. The measured vertical distributions of mass flux are best described by an exponential-decay function.

A total of twelve usable samples of vertical flux profiles were collected. Sand samples from the trap chambers were weighed and sieved at ¼ phi intervals. The maximum weight of samples from the trap chambers slightly exceeded 30 g and many samples were less than 5 g. Therefore, to make sieve analysis, samples from adjacent chambers were joined.

Mean grain size decreases steeply with elevation in the near-surface layer, reaching a minimum at the height of ca. 0.1 m. Above this height the mean increases and at highest elevation it exceeds the mean size of grains moving close to the bed. There is no obvious relationship between mean grain size of sand transported by wind and dune surface sand. Sorting of sand transported by wind is better than sorting of surface sand and generally increases with elevation. A reverse trends in skewness and kurtosis occurs at an elevation of 0.10-0.15 m above the bed. Their values decrease with elevation below this zone and increase in the upper part of sand cloud.

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Middle Holocene paleotsunami deposits at Rowy, south Baltic Sea coast, Poland

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Tsunami deposits were not known along the south Baltic coast for a long time. However, recently potential tsunami deposits were reported. Results of present research on the Holocene evolution of the South Baltic coast also provided evidences of event layers, probably of tsunami origin.
The investigations were carried out in the Rowy area, Polish middle coast. The study site is located within the western part of the Gardno-Łeba Lowland which is a stretch of well-developed barrier-lagoon coast.
Event layers occur on the bottom of two semi-spherical hollows eroded in glaciolimnic silts (14C date: 14310±150 BP) and glaciofluvial sands and gravels of the Late Weichselian age. In the area under investigation the upper surface of sediments building the Pleistocene plateau is lowered forming 1-km-wide isthmus between present-day sea coastline and Gardno lake. The hollows are 170-230 m in diameter and 12-14 m deep. They were localized by means of electromagnetic inductive conductivity profiling method (horizontal dipole mode) and 57 borings up to the depth of 15-20 m.
The event layers are 0.23-3.03 m (on average 1.09 m) in thickness and constitute the lowermost part of the deposit succession filling up the hollows. The boundary with the underlaying glaciolimnic clays and silts is erosive. The hypothetical tsunamite is represented by poorly sorted marine sands (mean 1.2 phi) with admixture of bioclasts and pebbles (maximum particle size: -2 - -5 phi); in some sedimentary logs, lumps of blue-grey glaciolimnic clays are present in the lowermost part of the layers. No internal stratification was noted within the layers, but locally the upward-fining trend was observed. The most distinctive feature of the deposits is enormous amount of allochthonous detritus of biogenic origin: 1) marine, brackish and occasionally freshwater shells and shell debris of mollusks and snails (mainly *Cerastoderma* sp. and *Macoma balthica*, e.g. in log L500, at the depth of 9.2-9.9 m, 1398 specimens were identified); 2) plant macrofossils from marine nearshore zone (e.g. *Najas flexilis*, *Ruppia maritima*); 3) shreds and lumps of peaty material, gyttia and organogenic silts; 4) numerous lumps of charcoal reaching size of 10-15 cm; 5) numerous accumulation of wood pieces and tree branches; 6) pine trunks. All these features are commonly considered as being indicative of the tsunamite.
The sharp boundary with overlying freshwater lake gyttja (5-7 m in thickness) suggests the abrupt termination of an extreme event. The lake existed ca. 5 100 years and then evolved into a peatbog which existed until the fifteenth century CE. Sea water inundated the area 400-500 years ago and the sand barrier was formed by numerous storm surges. Age of the biogenic detritus found in the tsunami layers ranges between 10 390 do 6670 cal. yr. BP, whereas the oldest gyttja covering the event layers is 6560 cal. yr. BP old. It means that the tsunami occurred between 6670 a 6560 cal. yr. BP.

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Middle Jurassic platform margin collapse recorded in succession of the Slovenian Basin

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The area of study lies at junction of Southern Alps and External Dinarides. In the Mesozoic, the region was divided into south-lying Dinaric Carbonate Platform (DCP), intervening E-W striking Slovenian Basin (SB), and north-lying Julian Carbonate Platform; the later drowned and turned into pelagic plateau in the Middle Jurassic. These paleogeographic units are well-studied in high-relief Alpine areas of western Slovenia, where SB succession is tectonically positioned in lowermost Southalpine nappes. On the other hand, eastward continuation of the SB was so far only poorly investigated. We present first detailed study of its sections in the Škofja Loka area in central Slovenia, where SB succession is highly deformed, thrusted over DCP carbonates, and is uncomformably overlain by undeformed Oligocene conglomerate.
Three sections were logged within the investigated area: southern Dešna section, intermediate Podpurflca section, and northern Trnje section. The base of all sections is Norian-Rhaetian Bača Dolomite, which is bedded dolomite with chert nodules and intercalated dolomite-chert breccia megabeds with evidence of paleofaulting. This formation ends with intensely silicified dolomite. In Podpulfrca and Trnje sections, Bača Dolomite is overlain by 80 m thick Hettangian-Pliensbachian Krikov Formation composed of thin-bedded hemipelagic limestone, which is a facies typical of southernmost parts of the SB that are devoid of otherwise characteristic calciturbidites. Upwards, it is overlain by 10 m thick Toarcian marl of Perbla Formation and then by several-tens-of-meters thick interval of Middle Jurassic limestone resediments. In Podpulfrca section, resediments reach thickness of 30m. They begins with a breccia megabed which deposited as a debris flow and is composed of ooidal/peloidal grainstone matrix with clasts of basin as well as platform origin. Among later, the Late Triassic clasts were proven by foraminifera. Breccia is overlain by similarly composed but finer-grained calciturbidites, which are the youngest Jurassic strata in this section. In Trnje section, resediments are 60 m thick and are represented by two breccia megabeds, separated by 2 m thick radiolarian chert interval. These megabeds have equivalent composition as previously described breccia. They are overlain by 70 m thick succession dominated by radiolarian chert which contains another 20 m thick breccia megabed in the central part of the succession. Jurassic strata end with mid-Tithonian-Berriasian Biancone Limestone. Radiolarian chert, although more marly, and Biancone Limestone are found also in Dešna section, where they overlie with a prominent gap the Bača Dolomite. The Jurassic succession is followed by erosional disconformity covered by mid-Cretaceous Lower Flyschoid Formation.
Large stratigraphic gaps that characterize SB succession in the Škofja Loka area are related to marginal position of studied sections within the basin. Dešna section is the most proximal to DCP and was deposited in area of predominant erosion and/or non-deposition. Podpulfrca section is more distal, and Trnje section that exhibits most complete stratigraphic succession has inner-basin affinity. The investigated SB sections demonstrate relatively quiet pelagic sedimentation in the Jurassic, with short interval of intense resedimentation in the Middle Jurassic. Composition of limestone breccia indicates collapse of the DCP margin, which reached with erosion downwards to Late Triassic carbonates.

Lacustrine/palustrine carbonates and paleosols interfingered with shallow marine platform carbonates. Aptian-Albian transition. Sierra de Bedmar-Jódar, Prebetic, southern Spain

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The Sierra de Bedmar – Jódar is a large outcrop of the so-called "Prebetic of Jaén" which, along with the Golondrina Mountain, constitutes the most oriental outcrops of this part of the Prebetic Zone. Only Cretaceous and Miocene rocks make up the whole outcrops. The Cretaceous is represented by a thick succession of Valanginian–Cenomanian carbonates among which a hiatus embracing the Hauterivian and Barremian, and a thick succession of shallow marine carbonate platform deposits point up. In the northeastern part of the Bedmar- Jódar outcrop the shallow platform carbonates give way laterally and vertically to a succession of continental, fresh water and pedogenic sediments.
The continental succession outcrops capping a set of shallowing upward cycles of Late Aptian age. The top limestone bed of these cycles makes the base of the continental succession. Texturally it is a wackestone – packstone with miliolids and orbitolinids (*Orbitolina* (*Mesorbitolina*) *subconcava*), peloids and medium-fine sand (less than 0.5 mm) quartz grains. Locally an incipient grumelar texture and dessication cracks are present. The top of the bed is a burrowed, FEO stained irregular surface. From this bed upward a 22.5 thick succession of lacustrine/palustrine and pedogenic sediments outcrops. Limestones with charophytes, peloids and other bioclasts, mainly small fragments of thin shelled ostracods and gastropods; beds with a laminated appearance given by the horizontal arrangement of dessication cracks filled with sparite or ferruginous dolomite; nodular and brecciated limestones with round or angular nodules of centimeter size embedded in a softer chalky matrix and limestones with very apparent root moulds which are filled with a micrite lighter colored than that of the host rock, are some of the lithologies and features making up most of the succession. Toward the upper part of the succession some bed of micrite with miliolids is interbedded and about 7 m below the top of the succession a 35 cm thick bed of wackestone with orbitolinids (*Orbitolina* (*Mesorbitolina*) *subconcava*) occurs. Newly brecciated limestones, with abundant root moulds and charophytes and marls with some centimeter scale quartzite clast outcrop. The last 6 metres of the succession are made up by limestones and marly limestones with brecciated appearance and dessication cracks in its lower part, contanining charophyites but also gastropods and rudists.
The presence of *Orbitolina* (*Mesorbitolina*) *subconcava* at the base and upper part of the succession characterize the Late Aptian–Early Albian, according to the calibration between shallow water benthonic and pelagic scales made by the authors and co-workers. The microfacies described were first deposited in lacustrine/palustrine environments adjacent to a shallow carbonate platform. This context was very sensitive to relative sea level fluctuations. The quoted environments would have been developed during sea level lowstands with pedogenic processes affecting the sediments during drying periods.

Genesis of the halite crystal casts and accompanying deformation structures: a case study from the Frasnian Stipinai Fm. (Main Devonian Field, northern Lithuania)

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Calcareous silty arenite from the lower part of the Frasnian Stipinai Formation contain a wide range of deformation (haloturbation) structures, disturbing its primary sedimentary features. Unique quality of preservation of the haloturbation structures allows to reconstruct the mechanism of their formation and determine the sequence of early diagenetic environmental changes. Discussed silty arenite (up to 4 cm thick) is sandwiched between dolomitic marlstones. It is composed of quartz and feldspar grains and mica flakes, cemented by poikilitopic calcite cement. Haloturbation structures include halite crystal casts as well as sink-hole and dewatering structures. Well-preserved casts of halite crystals (with protuberance up to 6 mm) occupy the lower surface of the bed. There are present casts of both: large (> 10 mm wide) single hopper crystals (or their intergrows), or casts of small halite cubes. Individual casts show variable morphology and orientation. There are casts of: three crystal faces; one complete face and incomplete three, two or one another faces; only one face; crystal edge or a corner only; one slightly depressed crystal face with elongated corners (pagoda-like halite skeletal crystals); and intergrowths cubic and/or hopper halite crystals. The casts are filled with structureless silty arenite. Rare, poorly preserved casts are also present on the upper surface of the bed. They are preserved as cubic shallow depressions or low elevations. In cross section perpendicular to bedding occur sink-hole structures, developed as funnel-shaped sediment disturbances. They often compose of two adjacent or partly overlapping funnels. The structures pierce the bed and manifest on the top surface as shallow conical depressions. Halite crystal casts are also related to water-escape structures filled with homogenous arenite, which cause up-wrapping of disrupted lamina sets. In discussed cast-bearing bed halite hoppers precipitated from NaCl-over-saturated pore waters, when the sediment remained in the marine phreatic zone. Formation of skeletal hopper crystals take place when supersaturation reaches a critically high point. It resulted in rapid growth of corners and edges of crystals. Such fast crystals growth within silty arenite did not disturb its primary sedimentary structures. The subsequent dissolution was caused by the influx of marine water, undersaturated with respect to halite, which resulted in formation of unstable caverns in sediment. The processes took place before the sediment cementation. Scale of subsequent deformations depends on the primary size of the halite crystal as well as its location in respect to the lower bed boundary. If the halite hopper grew on the interface of the silty arenite and dolomitic marlstones, more of the overlying sediment was involved in collapsing into space after crystal dissolution. Water-escape structures also originated as a consequence of crystal dissolution which caused a disturbance of state of equilibrium between grain framework and pore waters. Moulds which formed between the top of silty arenite and overlying cohesive mudstones were filled by local quick sand flows. In that way could originated elevated casts on the upper bedding surface. Described haloturbation structures originated as the result of syn- or post-dissolution sediment collapse and fluid escaping that disturb primary sedimentary structures.

Features of syntectonic continental sedimentation along the north-eastern margin of the Oligo-Miocene Sardinian-Rift (back arc) Basin (Italy)

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On the eastern Margin of the so-called Sardinian Rift, Oligocene to Miocene sedimentary successions record syntectonic colluvial/alluvial deposition (Ussana Formation). The geodynamic setting in which the Ussana Fm accumulated was that of the onset of a back-arc basin. Along the faulted eastern margins of this "rift" system, the Ussana Fm exhibits both weathered/fractured basement "passing" to eluvial/colluvial facies and coarse-grained alluvial/fluvial facies. These deposits developed within "rift"-related sub-basins where weathered substrate contributed to product clasts with large cobbles and pebbles and coarse to very coarse sands resulting in heterometric continental breccias, conglomerates and coarse to medium grained sandstones reflecting the basement lithology.
All the observed sections measured in outcrop suggest very different depositional settings, related to the evolution of the Oligo-Miocene Sardinian Rift. The reconstruction of the north-eastern margin of the basin is proposed taking into account: (i) 2D outcrop reconstructions, obtained from lithostratigraphic correlations of the main measured sections across specific transects oriented normally to the extensional-system axis, (ii) the tectonic style of depressions where sediment accumulated during subsequent evolutionary stages, and (iii) the resulting physiographic settings. The proposed reconstruction is in accordance with some models of rift evolution. These models suggest that a progressive faults-linkage process along an evolving normal fault array results in specific rift-basin stratigraphic patterns commonly recorded in extensional systems.

Platy coral assemblages in the oldest Middle Triassic scleractinian reefs from Silesia, Poland

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Scleractinian corals and coral buildups in the Middle Triassic (Anisian; Muschelkalk in the lithostratigraphy of the Germanic realm) of the Upper Silesia (southern Poland) are known since the middle of 19th century. About 20 species of colonial corals were described till now from these oldest (Pelsonian) in situ scleractinan buildups, or reefs in a broad meaning (Morycowa, 1988). They were developed in the Germanic Basin being the part of the Peri-Tethyan domain influenced by early opening of the Tethys Ocean (Szulc, 2000). The sponge- and coral-dominated bioherms in Tarnów Opolski quarry occur as isolated knobs or complex mounds of 2–80 meters across and several meters high. Ecological succession – from sponge to coral buildups – reflects shallowing-upward trend. Coral-dominated buildups consist of branched (phaceloid) corals *Volzeia szulci*, succeeded by platy corals, nearly exclusively *Pamiroseris silesiaca* (Morycowa, 1988; Bodzioch, 1991; Szulc, 2000; Morycowa & Szulc, 2010). Macroorganisms associated with P. silesiaca include mostly crinoids, brachiopods, bivalves and sponges. The presentation is focused on palaeoecological aspects of platy corals grouped in layers 30–50 cm thick. The observable width of corals is maximum 24 cm (in isolated limestone block), mostly 5–12 cm, hight mostly 1–1.5 cm, thus coral assemblages can be classified as platestones, forming bioherms of constratal growth fabric. Sedimentation rate was low, as indicates the presence of microbial crusts on the upper part of the coral skeleton, with episodes of sediment input. Platy corals from the studied buildups were interpreted (without detailed descriptions and discussion) in previous studies as often or locally encrusting. The presence of cryptic epibionts (serpulids, microbialites) on a lower side of coral skeleton indicates on free space between an aboral side of coral and a sediment surface. The absence of microencrusters on a lower and upper surface of coral skeleton in some colonies is due to dissolution, evidenced by stylolites observed along these surfaces. Previous interpretations placed *Pamiroseris silesiaca* in shallow-water, high energy environment. Here, I assume that corals developed in an environment with changing hydrodynamics. Turbidity due to re-suspension of carbonate mud (but not necessary in a high energy regime) certainly caused decreased light intensity. Tiers and growth-interruption surfaces are observed in skeletons of *P. silesiaca*, reflecting episodes of sudden sediment input and higher energy events. Flattening morphology in assemblages dominated by non-encrusting platy corals is widely interpreted as an optimal growth form in low light, deeper environment or in shallow-water, but with more turbid waters. The review of platy coral assemblages included examples since the Upper Triassic (Rosen et al., 2002). Platy coral assemblages from Silesia are the oldest example of that ecological coral community, and rare example of this community developed in a shallow-water environment. If the photoadaptive model, i.e. platy coral morphology as a response to limiting light, is correct, then platy corals from Silesia may support hypothesis that some of the earliest scleractinian corals were zooxanthellate.

External morphology of detrital zircon in sediment provenance studies: An example based on the Ropianka and Menilite formations (Skole Nappe, Polish Flysch Carpathians)

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The zircon populations from the Campanian–Maastrichtian part of the Ropianka (Upper Cretaceous–Palaeocene) and Menilite (Oligocene–lower Miocene) formations in the the Skole Nappe in Poland were examined to evaluate interpretations of the external morphology of detrital zircon in provenance research. The sediments have well defined palaeocurrent directions and described heavy-mineral assemblages, including HRHMA analyses, which help to verify interpretations of zircon morphology in sedimentary provenance research.
The identification of the source rocks supplying depositional basins is a difficult task in the study of monotonous heavy-mineral assemblages, lacking or poor in diagnostic provenance-sensitive minerals. Zircon is regarded as one of the most resistant of the heavy minerals in sedimentary rocks, with regard to weathering and burial diagenesis. It is also sensitive to the host environment, which may control its morphology during petrological processes. Zircon typology, based on the evaluation of external zircon faces, assumes that the growth of zircon pyramids is controlled by the aluminium and alkali content in the parent melt, while the development of prisms depends on the crystallisation temperature. Several investigations proved correlation of zircon types with host-rock geochemistry. The typology method was widely used as a petrogenetic indicator of zircon host environment. It was also successfully applied to protolith evaluation, palaeogeographic and geotectonic reconstructions of source areas, and comparative studies of sediments. To obtain additional data, zircon typology may be supplemented with measurements of crystal elongation, i.e. length:width ratio. However, the external morphology of detrital zircon is nowadays commonly omitted in provenance studies and replaced with detailed single-grain geochemical studies and radiometric dating.
The current study showed that detrital zircon typology, along with elongation measurements, provides general information on source petrography and, under favourable conditions, is a valuable tool for comparison of the zircon populations in sedimentary deposits regarding their provenance. The zircon populations examined from the Ropianka and Menilite formations display large similarities with respect to external crystal morphology, twinning, melting features, etc. which indicate provenance from the same type of protolith. Moreover, the similar contributions of the dominant euhedral zircon subtypes and crystals of definite elongation in older (the Ropianka Formation) and younger (the Menilite Formation) deposits indicate that the lithology of the source rocks for zircons did not change through time. Zircon morphology studies give comparable results for the HRHMA method which shows that the methods may be successfully applied to provenance research of heavy-mineral populations in sedimentary rocks.
Studies of the morphology of detrital zircon yield only basic knowledge, as for geotectonics and igneous source rocks. However, it permits the recognition of potential source areas and rocks that will be the focus of further analytical research. Nevertheless, if none of the crystal types dominate, it is rather impossible to determine clearly the source-rock lithology on the basis of only zircon typology and elongation measurements.

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Inception and crisis of a Miocene temperate-type carbonate shelf in a compressive setting (northern Apennines)

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A detailed study including stratigraphy and composition has been performed on shallow-water carbonates of early middle Miocene age deposited in a wedge-top basin in the northern Apennines. In the representative outcrop of Torriana (Val Marecchia valley, Romagna Apennines) more than 140 samples were collected in order to identify factors controlling the inception and crisis of the shelf.
The succession unconformably rests on the allochthonous Ligurian units and is constituted by up to 100 m thick carbonates and mixed siliciclastic-carbonate rocks. The basal portion consists of rhodalgal rudstones and grainstones dominated by echinoids, bryozoans, coralline algae and benthic foraminifera. It gradually passes into mixed carbonate-siliciclastic shallow water-facies, characterized by an increase in terrigenous components and planktonic and benthic taxa. The occurrence of glaucony-rich packstones with abundant planktonic foraminifera marks the transition to the upper fine-grained sediments.
Results of a detailed compositional study evidence four main phases in the platform evolution, and a progressive decreasing of the carbonate productivity, gradually replaced by detrital sedimentation.
Regional factors linked to the Apenninic tectonics seem to primarily support the eu- to mesotrophic conditions in the examined carbonate shelf. However this time interval (late Burdigalian–Serravallian) is characterized by the global fertility event, the Monterey Event, recorded also in the Mediterranean. The stable isotopes study show that this global event also influenced the carbonate production.
The inception and demise of these temperate rhodalgal-foramol carbonate sediments located in a wedge-top basin is primarily controlled by synsedimentary tectonics related to the thrust migration, through the combined effect of two processes: increasing the subsidence of the basin, and triggering the terrigenous discharge from the erosion of uplifted Apenninic areas.

The production and fate of fish-derived carbonates in shallow warm-water carbonate provinces

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Carbonate muds are volumetrically important sedimentary components in many modern and ancient shallow warm-water carbonate provinces, and understanding their origins can provide key insights to palaeo-environment, palaeo-ecology, and palaeo-climate. However, the origins of fine-grained carbonates in modern systems are much debated, and resolving their provenance in ancient carbonate successions is even more problematic. Marine bony fish are a prolific source of fine-grained calcium carbonate, which precipitates in the piscine intestine as a by-product of normal physiological processes. Modelling estimates indicate these carbonates contribute up to ~1x1011 kg·$CaCO_3$·yr^{-1} to the global marine carbonate production budget and ~6x106 kg·$CaCO_3$·yr^{-1} across the Bahamian platform, and they are now considered a potentially important source of fine-grained carbonate sediment in shallow warm-water carbonate provinces such as the Bahamas. However, their preservation potential and sedimentary fate in such settings remains unclear, largely because the diverse array of carbonate phases produced by fish includes several that are probably among the least stable to occur on these carbonate platforms.
To address this issue, we have evaluated the carbonate phases and their abundances as produced by 22 fish species common in the Bahamas, and combined these data with production rate data and fish census data to model platform-wide and habitat-specific production with particular regard to phase abundances. In addition, we exposed sub-samples of the main carbonate phases produced by fish to sea water and pore water conditions for up to seven months to demonstrate empirically their short-term sedimentary fates. Combining both datasets, we consider the overall short-term sedimentary significance of fish-derived carbonates in shallow warm-water carbonate provinces.
Our findings indicate that fish-derived carbonate phases are highly varied at the point of excretion, with significant contributions to platform-wide production from low Mg-calcite (LMC; ~20 % total production), high-Mg calcite containing 5–25 mol% $MgCO_3$ (HMC; ~25 %), high-Mg calcite containing >25 mol% $MgCO_3$ (VHMC; ~35 %), magnesium-rich amorphous carbonate (ACMC; ~13 %), and aragonite (~6 %). Further analysis of production models indicates considerable variations in phase abundance according to depositional environment, and also suggests historical production rates may have been up to 140 % higher than current rates. Experimental sea water and pore water exposures indicate that these phases have considerably different short-term post-excretion fates: ACMC is highly unstable and undergoes complete dissolution within a few days of excretion, whereas all other phases persist for at least several months, with LMC and aragonite displaying no discernible changes. However, HMC and VHMC exhibit extensive surface etching and significant reductions in $MgCO_3$ content after these short exposures, indicating incongruent dissolution of these phases can proceed rapidly after excretion.
The major implication of these findings is that the sedimentary significance of fish-derived carbonates is varied; some phases accumulating as sediment and others dissolving rapidly. Nevertheless, these unstable phases may exert considerable influence on pore water compositions and syndepostional diagenetic processes since they could represent an important source of magnesium within surface sediments. Of wider significance, these findings have implications for the way in which we understand the marine inorganic carbonate cycle.

Rifted Hercynian basement and mixed carbonate/siliciclastic sedimentation in the Jurassic of the Longobucco Basin (NE Calabria, S Italy)

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The Late Paleozoic-Early Mesozoic Calabria was part of a vast non-subsident high of the Hercynian basement until the latest Triassic (Rhaetian), when thin fluvial deposits document the inception of the “Alpine” sedimentary cycle. This occurred at the periphery of a continental rift, which elsewhere is documented by a few kilometers-thick succession of syntectonic continental to marginal marine deposits. Marine transgression is recorded by mixed carbonate-siliciclastic shelf deposits with common ooid bars and abundant plant material. This wide shelf was tectonically extended around the Sinemurian/Pliensbachian boundary. While hangingwall basins subsided rapidly, hosting a deep shelf to turbidite basin succession up to >1km thick in the Pliensbachian-early Toarcian, the footwall blocks stood proud to constitute an offshore belt of small islands made of Paleozoic rock (Caloveto High, Mt Scarborato-Cicchello High), encircled by ephemeral narrow fringes of dominantly coral-reef carbonates with admixed coarse siliclastic debris. Interestingly, the exhumed phyllite basement along faults was initially colonized by microbial communities, documented by clotted fabrics, *Frutexite*s and bacterially-induced cementation. Erosion of the crystalline basement at basin-margins, linked with ongoing faulting, was accompanied by frequent rockfalls, producing laterally continuous megaclastic belts which were the sites of free-fall, debris flow and rock avalanche processes. The widespread submarine exposure of basement rocks at the footwall of synsedimentary faults resulted in the onlap contacts of basin-fill units, clastic to pelagic (marls, limestones, cherts), with phyllites or granite. A new tectonic phase in the Toarcian resulted in the rejuvenation of Pliensbachian margins, as well as in the fragmentation and foundering of the footwall-block islands. Here, drowning of the carbonate factories is documented by Rosso Ammonitico caps, and by a dense network of spectacular neptunian dykes of red pelagites, affecting the basement as well as the shallow-water limestone. Widespread pelagic conditions in the Middle and Late Jurassic, in a dominantly post-rift regime, are recorded by Posidonia limestone, cherty radiolarites and Aptychus limestone, followed by Maiolica facies in the Early Cretaceous. These pelagic deposits host resedimented levels which bear locally derived basement material, as well as distal turbidites with shallow water material which were sourced by unpreserved carbonate factories in the Longobucco Basin, like those found in Southern Calabria and Sardinia. The onlap unconformities of cherty basinal units with the shallow water limestone substrate at basin-margins are marked by chert crusts and silicification of the latter, in analogy with examples reported from the Umbria-Marche-Sabina Apennines. As a result of involvement of the Longobucco Basin in orogenic processes during the Tertiary, the intrabasinal highs, marginal Early Jurassic fault escarpments, and onlapping basinal deposits are commonly found carried piggyback at the hangingwall of thrusts, with folded basinal deposits at the footwall. Also, the basin fill units display spectacular examples of buttressing against the Jurassic submarine paleoescarpments.

Planktonic foraminifera of the Cretaceous Oceanic Red Beds (CORBs) within the volcano-sedimentary series from the Eastern Pontides (Giresun, NE Turkey)

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The Upper Cretaceous lithologies in the Eastern Pontides, NE Turkey, are mainly represented by thick (up to 2000m) volcano-sedimentary series which include Cretaceous Oceanic Red Beds (CORBs) with abundant planktonic foraminifera. These red beds in this region are important as they are unique paleontological data source to date the volcano-sedimentary series. Planktonic foraminiferal assemblages of the pelagic limestone interlayers were documented in order to date the Upper Cretaceous Giresun volcano-sedimentary series from the central parts of the Eastern Pontides.
The Upper Cretaceous volcano-sedimentary successions in the Giresun area comprise five formations from bottom to top; Çatak, Kızılkaya, Çağlayan, Tirebolu and Tonya formations. The lower three formations include eight different levels of planktonic foraminifera-bearing red limestone interlayers, which are represented by carbonate mudstone and wackestone depositional texture. 0.7-m, 7.71-m and 34.35-m-thick three limestone levels were observed within the Çatak Formation. The Kızılkaya Formation includes 28.75-m and 18,80-m-thick two levels, while the Çağlayan Formation comprises 7.5-m, 5-m and 21.79-m-thick three levels. Planktonic foraminifera were studied from thin sections of 295 limestone samples collected from that eight limestone levels. Planktonic foraminiferal content of these levels varies from quite abundant and diverse assemblages to moderate or poor to rather poor assemblages. The planktonik foraminifera obtained are represented by dominance of double-keeled marginotruncanids, which are associated with dicarinellids. Inoceramid prisms are concentrated in certain beds. The planktonic foraminifera assemblages dominated by *Globotruncana linneiana* (d'Orbigny), *Dicarinella asymetrica* (Sigal), *Dicarinella concavata* (Brotzen), *Marginotruncana coronata* (Bolli), *Marginotruncana marginata* (Reuss), *Marginotruncana paraconcavata* Porthault, *Marginotruncana pseudolinneiana* Pessagno, *Marginotruncana sinuosa* Porthault and *Marginotruncana tarfayaensis* (Lehmann) are observed through almost all levels. Presence of *D. asymetrica* and taxa similar to 'pill-box-like' morphotypes of *G. linneiana* in almost every sample from the lowermost one of the eight levels suggests that the age of the older level is late Coniacian-Santonian or Santonian. Furthermore, presence of marginotruncanids in overlying all seven levels also suggests that the age of these levels should not be older than late Coniacian and should not be younger than Santonian.

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Post-glacial Arno Delta evolution: Depositional processes and controlling factors

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In order to address the key-factors that may drive the establishment and the evolution trends of a genuine deltaic depositional setting, we present the Lateglacial-Holocene depositional history of the paleo-Arno Delta from the subsurface of the Pisa coastal plain (Tuscany, Italy).
Integrated stratigraphic, micropaleontological, palynological, remote sensing and radiocarbon analyses allowed the identification of five major steps in the post-glacial sedimentary-morphological evolution of the study area: 1. Early transgressive phase (ca. 13-8 ka): development of a wave-dominated estuarine depositional setting within the Arno paleovalley, incised during the Last Glacial Maximum (LGM). 2. Late transgressive phase (ca. 8-7 ka): complete valley filling and first establishment of a wide lagoon system. 3. Late transgressive to early highstand phase (ca. 7-4 ka): early phase of paleo-Arno Delta build-up. The lagoon persisted up to about 5 ka, then evolved into a vast marshland crossed by distributary channels. 4. Late highstand phase (ca. 4-2 ka): establishment of the modern wave-dominated Arno Delta, with poorly drained floodplains in distal transition to prograding strandplains. 5. Human-influenced delta evolution (2ka-present day).
During the early and late transgressive phases, which predate the establishment of the deltaic depositional environment, pre-existing valley morphology, high rates of sea-level rise and tectonic subsidence acted as driving factors of sedimentary evolution. Following paleovalley filling, differential compaction between the soft organic-rich valley-fill sediments and the indurated and pedogenized interfluvial deposits influenced the persistence of the lagoon in the ancient paleovalley area. The transition to a prograding delta system was encouraged by the decrement of eustatic rise rate, along with a marked change to less humid climate conditions at the end of the Holocene climatic optimum (ca. 5 ka). The progressive reduction of the forests, in part attributable to an incipient anthropic pressure on the landscape (deforestation), induced an intense fluvial activity and alluvial aggradation during the late highstand phase. The anthropic control became increasingly important during the last 2 ka, especially for the evolutionary trajectory of the Arno Delta through extensive water works, land reclamation and soil use. Moreover, starting from the contemporary-age meander rectifications, dam constructions and sediment extractions from the Arno bed led to a strong sedimentary deficit of the delta system that since 1850 is under strong erosion processes (up to 1.5 km of coast lost).

Distributions of *Plagioptychus* rudist bivalves in the siliciclastic-carbonate Late Cretaceous shallow marine deposits of the Apuseni Mountains

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The Late Cretaceous shallow marine succession of the Apuseni Mountains comprises mixed siliciclastic-carbonate deposits ranging in age from the Late Turonian to the Early Maastrichtian. The resulting deposits consist of alternating conglomerates, bioclastic marls and sandstones, and rudist-bearing limestones. Over one hundred specimens of *Plagioptychus* genus have been investigated from different occurrences of Late Santonian-Early Campanian shallow-marine sequences from Gilău Mountains (Corni Quarry, Creasta Pietricelei Hill, Liteni), Borod (Pietrele de Moară and Gruieţ brooks) and Rosia basins (Misia Hill) in order to understand the correlation between paleoenvironments versus presence/abundance of *Plagioptychus* genus. Species of *Plagioptychus* are elevators to clingers rudist having an inequivalve right valve, smaller than free left valve. The elevator morphotype of *Plagioptychus* is characterized by a strong, curved umbo of the free valve and an elongated or low conical, attached valve. The clinger morphotype is characterized by a globose or grypheate left valve having a strong umbo with asymmetrical curvature towards the anterior face. The attached valve is gyropleuriform with thin to medium outer calcitic shell layer and thin inner layer without pallial canals. Both elevator and clinger morphotypes record great variations in dimensions of valves. The presence and/or abundance of *Plagioptychus* specimens within the shallow marine Late Santonian-Early Campanian sequences of the Apuseni Mountains depends on some parameters such as the substrate, water energy and sediments inputs. Thus, the thick shelled, robust, and commonly larger *Plagioptychus* with commissural diameter of upper valve ranging from 60 to 120 mm occur usually like attached clingers or elevators at the base of the coral-rudists bioconstructions or hippuritid/radiolitid lithosomes in all studied occurrences. The most abundant and best preserved specimens with both valves belong to *Plagioptychus aguilloni* d'ORBIGNY and they acted as "pioneer shells" to colonize the submarine fans delta and provided a substrate for installation of the coral-rudist bioconstructions and/or hippuritid/radiolitid lithosomes. They are found in calcareous marls/sandstones or in thin compact limestone levels deposited in shallow marine environments with reduced siliciclastic input and moderate to high energy.
On the other hand, the smaller, thinner-shelled form of *Plagioptychus* with low elongated-conical right valves in which the commissural diameter does not exceed 50 mm, lived either as isolated individuals in coral-rudist bioconstructions (Gilău occurrences) burrowing through sediment of mudstone to wackestone texture, or in hippuritid/radiolitid lithosomes (Borod and Rosia occurrences) with bioclastic wackestone-packstone internal sediment. Algal encrustations and perforations produced by various organisms are also frequent and suggest that the coral-rudist bioconstructions and hippuritid/radiolitid lithosomes were deposited in shallow marine environments with intermittently reduced siliciclastic input and low energy.

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Late Jurassic calcareous algae reworked in carbonate platform slope environments

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The main purpose of this study comprised a sedimentological and micropaleontological study of the limestones from the Geomal quarry. These limestones are located at the basal part of Măgura Geomalului Hill (Apuseni/Trascau Mountains, Romania) being the constituent part of an olistolite of considerable dimensions. The Geomal limestones belong to the sedimentary cover of the Bedeleu Nape. The basal part of this nape consists of keratofires and calcalcaline ophiolites which are associated with jaspers and Oxfordian-Tithonian carbonate rocks. The Oxfordian-Kimmeridgin succession is overlain by Tithonian-Neocomian Stramberk type massive limestones.
The studied olistolite was detached from the Upper Jurassic-Lower Cretaceous Bedeleu Carbonate Platform and relocated in Upper Cretaceous deposits. Mixed Badenian carbonate-siliciclastic sediments are covering these Upper Cretaceous deposits.
The objectives of this study involved the identification of the main facies, depositional envirnoments, micropaleontological assemblages and age of the studied deposits. Eighty-six limestone samples were processed in order to prepare thin sections which were then used for the description of the most important facies and microfossils.
Based on the sedimentological and micropaeontological features, several associations of facies were recognised. They are characteristic for reef, open carbonate platform and slope environments. The following facies associations were identified: 1) intraclastic extraclastic bioclastic floatstone with sponge spicules; 2) coarse intraclastic bioclastic rudstone/grainstone; 3) coral, sponge and microbial bioconstructions; 4) peloidal bioclastic grainstone/wackestone/packstone
The micropaleontological assemblage consists of dasycladalean algae [*Campbelliella striata* (CAROZZI), *Neoteutloporella socialis* (PRATURLON), *Clypeina sulcata* (ALTH), *Salpingoporella pygmaea* (GUEMBEL), *Terquemella* sp., *Nipponophycus ramosus* YABE & TOYAMA, *Triploporella remesi* STEINMANN, *Griphoporella* sp., *Petrascula* sp.], microbial microproblematic organisms (*Lithocodium aggregatum* ELLIOTT, *Crescentiella morronensis* (CRESCENTI)), foraminifera (*Coscinoconus* sp., *Troglotella incrustans* WERNLI & FOOKES, “*Trocholina*” sp., *Lenticulina* sp.), sclerosponges, (*Cladocoropsis mirabilis* FELIX, *Neuropora lusitanica* TERMIER & TERMIER) and rivularian type cyanobacteria. Based on this assemblage, the age of this olistolite is Kimmeridgian-Upper Tithonian. The quarry limestones are overthrown. As a consequence, older deposits are located in the upper part and younger deposits are present at the base. Calcareous algae are present mainly in the lower part of the quarry, in breccia slope deposits. Large dasycladalean algae are characteristic for high energy environments. They are associated with smaller species which prefer protected, low energy, intrareef or subtidal environments. The existence of several important regressions during the Upper Jurassic is pointed out by the presence of reworked dasycladalean algae in slope breccia type deposits. The slope breccias are rich in magmatic extraclasts. They originate from the island arc located beneath this carbonate platform. All these features indicate a sea level fall at the end of Jurassic.

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Evolution of non-marine Quaternary deposits in the Danakil basin (NE Afar, Ethiopia): Preliminary results

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The Danakil basin is a rift valley constituting the northern part of the Afar triple junction, defined by the intersection of three extensive structural systems: the Red Sea, the Gulf of Aden and the main Ethiopian rift. During fieldwork in January and February 2015, different sedimentary units were described to understand the evolution of the depositional settings in the basin. Since the mid-Pleistocene, the Danakil basin has been connected at least two times to the Red Sea – during MIS 5 and MIS 7. Episodes of opening and successive closure led to the formation of rapid alternating depositional environments, which range from marine to hypersaline, as well as lacustrine and fluviatile. During closure of the Danakil depression, humid periods alternated with extreme dry periods resulting in the temporarily flooding of the basin through seasonally runoff from the Ethiopian Plateau. This study tries to understand the spatial and temporal distribution of continental deposits in the Danakil basin and how they relate to the climatic and tectonic evolution of the basin.

Different core sections have been described in the northern part of the basin. Originally drilled for potash exploration the cores revealed a succession of centimeter-scaled carbonate and siliciclastic layers intercalated with evaporitic units. Several intervals illustrate a series of flood events occurring during humid periods followed by total evaporation.

Ancient quaternary lacustrine outcrops at the western margin of the basin display a succession of fluviatile over lacustrine brackish to hypersaline deposits intercalated with microbialites and calcarenites. The microbial carbonates – characterized by conical buildups associated with rhizoliths – are deposited directly on top of an evaporitic sequence. These deposits are witnessing bigger flooding events with the transition from fresh water lakes towards hypersaline conditions.

Recent hot spring carbonates appear under different forms along the hypersaline lake Afdera in the southern part of the basin. In close interaction with the recent hot springs, oncoid grainstones and boundstones with algal mats are produced on the lake shore. Within the present-day lake, cone-shaped microbialites – encrusting plant roots – have also been found. Comparing recent and ancient lacustrine deposits within the Danakil depression will allow understanding better the relation between the episodes of flooding occurring during the Quaternary and the evolution of the depositional settings in the basin. Moreover, studying the nature of hot spring carbonates and hypersaline microbialites will give more insights in the environmental conditions and controlling biotic/abiotic parameters under which they formed.

Selenite pseudomorphs in Mid-Cretaceous Neotethyan metasediments of Anatolia's HP/LT belts

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So called "Rosetta Marble" was defined in SW Anatolia as 3D-radiating textures of dm-to-m-long calcite rods in the HP/LT metamorphosed Mid-Cretaceous hemi-pelagic carbonate sequence of the Ören Unit. Rosetta Marble of the type locality is interbedded with meta-chert beds. Rare aragonite relicts and Sr-rich, fibrous calcite pseudomorphs after aragonite witness the HP metamorphic imprint of this sequence during the closure of a Neotethyan oceanic domain during latest Cretaceous–Palaeocene times.
We investigated the Rosetta Marble of the Ören Unit, as well as other known and newly found localities in the Tavşanlı and Afyon zones, and the Alanya Massif and Malatya area, to decipher the metamorphic, diagenetic and sedimentological significance of these uncommon textures. Based on field, petrographic and geochemical investigations, we document a wide variety of Rosetta-type textures. A striking resemblance with well-known gypsum morphologies (e.g. shallow-tail, palm-tree textures) suggests that Rosetta Marble was initially composed of selenite. The absence of anhydrite pseudomorphs indicate that gypsum transformed into calcite soon after the deposition by the mean of a sulphate reduction reaction. The gypsum-to-carbonate transformation requires that organic matter intervened as a reactant phase. Since all Rosetta Marble occurrences are related to subduction-metamorphism, a thermochemical reaction might be considered. Relics of radiolarians suggest that the meta-chert layers were deposited in a hemi-pelagic regime.
Rosetta Marble exposures are widely distributed over 600 km along the Neotethyan suture zone. During deepening of the Neotethyan Ocean in Mid Cretaceous times, basin-wide and cyclic sedimentation of gypsum and radiolarite occurred. Cascading brines may serve as ion supplier to deeper parts of the basin. Favourable climatic conditions triggered the formation of massive evaporites: hot temperatures during Aptian times, slow oceanic circulation and a semi-closed character of the basin. The findings of massive selenite pseudomorphs in a hemi-pelagic sequence have major impact on palaeogeographic reconstruction of Neotethyan basins in the Eastern Mediterranean during Cretaceous times.
Besides hemi-pelagic Mid-Cretaceous selenite pseudomorphs, Rosetta Marble originally deposited in Triassic times was found. These marbles are chert-free and represent an opposite environmental setting that is related to rifting processes. Massive meta-evaporite deposits of a Mid-Cretaceous hemi-pelagic environment and a Triassic shallow-marine setting, nowadays located in Anatolia's HP/LT belts need to be considered as possible palaeo-salinity-crises.

Sedimentological, climatic and environmental changes during the early Jurassic (Hettangian- Pliensbachian) on the northern Tethys margin (Switzerland)

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The Early Jurassic period is a time of significant changes in continental configurations, oceanographic patterns and climate conditions, which led to several biotic crises and environmental perturbations. During this period, the Boreal and Tethyan realms were covered by shallow shelf areas including islands of various sizes, swells, submarine sills and deeper sub-basins, which record several anoxic events and carbon-isotope perturbations. However, their geographic extents and their causes are still understudied and controversially debated. In the present project, we propose to study these changes in section and cores located in Switzerland using sedimentology and geochemistry (carbon- and oxygen-isotope, Rock-Eval, phosphorus content, mineralogy, trace and major element content and clay analyses) with the purpose to:

- Create a complete and detailed model of deposition for each section
- Describe the lateral evolution of the registered formations
- Reconstruct the impact of phosphorus on the environment
- Determine associated climatic, environmental and paleogeographic changes
- Link the model of deposition with local and global environmental and climatic change

One outcrop (Frick) and three boreholes (Riniken, Pfaffnau and Kreuzlingen), recording fully marine sections spanning from the Hettangian to the Pliensbachian, are currently studied. These sections show a complex and dynamic depositional history, marked by the presence of hiati, condensed beds, phosphate- and fossil-rich strata, erosional bases, etc. These features reflect the important hydrodynamic changes linked to tectonically induced submarine relief prevailing in this region.
Preliminary results from the Frick section suggest that the carbon cycle was subjected to major changes from the Hettangian to the Pliensbachian on the northern Tethys margin. Three major perturbations in the carbon-isotope records have been recorded. (1) The lower liasicus zone (Early Hettangian) is marked by a negative excursion (CIEorg - 2 ‰) and by low oxygen conditions as shown by uranium and molybdene enrichments and higher organic-carbon and pyrite contents. This CIEorg was likely caused by a variation of the quality of organic matter (marine during the CIEorg and later on, continental) and probably by the release of gas hydrates and/or CO_2 resulting from coeval volcanic activity. (2) The Early-Late Hettangian boundary is characterised by a negative CIEorg of 1 ‰, by the deposition of bioclastic carbonates and the recovery of skeletal carbonate producers marking the stabilization of carbonate production under reduced pCO_2. (3) The Sinemurian-Pliensbachian boundary records a negative CIEorg of 3 ‰ suggesting an injection of isotopic light carbon.
The low organic-carbon and trace-element contents, the continental origin of organic matter, the presence of benthic organisms and sedimentary figures indicate that, with the exception of the Early Hettangian, the sediments have been deposited under rather well oxygenated conditions during the Early Jurassic in this area.

Facies and architectural analysis of sandy, large-scale foresets (Agrio Fm., Argentina): Insights into the middle-term construction of shoreface clinoforms

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Everyday hydrodynamic processes in wave-dominated, sandy beaches (strandplains, barriers) are well understood, but far less known are, however, the processes involved in the accretion of sediments deposited in the surf to shoaling zones to produce the middle-term (102-103) progradation of a shoreline. GPR-based studies in modern systems typically show closely spaced, seaward-dipping reflectors (1-10°), which are attributed to represent the foreshore/upper-shoreface progradation with time (i.e. clinoforms). Erosional surfaces at different scales are also described in these studies. Ancient equivalent of these sandy clinoforms are yet to be widely reported.
This study presents a facies and architectural analysis of large-scale foreset beds occurring at the top of a 12 m-thick parasequence in the Lower Cretaceous Agrio Fm., in the Neuquén Basin (Argentina). Foresets and surroundings sediments are exceptionally exposed along a 1.7 km-long, mostly 2D outcrop. Offshore mudstones and offshore-transition muddy sandstones interbedded with HCS-sandstone beds occur at the base of the sequence. The latter grades vertically into bioturbated sandstones (*Ophiomorpha* burrows) with sporadic cross-lamination and/or amalgamated HCS-beds, interpreted to represent a lower-shoreface setting. This facies pass upwards to interbedded bioclastic and fine-grained sandstones with planar-lamination, small-scale trough cross-stratification and asymmetric ripples that collectively form the foreset beds. Wave-ripple crests in different facies suggests a NE-SW shoreline orientation.
The large-scale foresets (2-3 m thick) mostly comprise tangential (or sigmoidal) beds dipping in an offshore direction (northwest). They are organized in foreset packages bounded by erosional surfaces. Individual foresets are traced down-dip for a few to tens of meters (mean=11 m), and they commonly downlap on, or become parallel to, the bounding surfaces. The average gradient for foresets is close to 1/7 (7.6°). Internally, foreset packages show a lateral change from parallel-laminated facies in the foresets, to cross-stratified and rippled, bioclastic-rich sandstones in the bottomsets. Erosional surfaces bounding foresets packages are marked by amalgamation of carbonate-rich beds, and they have a scarp-like geometry truncating older foresets. The steep segment of each erosional surface pass into a subhorizontal bottomset that can be traced down-dip for up to 120 m (mean=59 m), until it grades laterally into bioturbated sandstones.
The large-scale foresets are interpreted to represent the middle-term offshore accretion of sediments deposited in the surf/breaker zone. Dominant parallel laminations in foresets reflect upper-flow regime plane-bed conditions in the proximal setting. Alternation of bioclastic-poor and bioclastic-rich beds likely suggest fair-weather and storm accumulation, respectively. Asymmetric ripples and small dunes on the bottomsets migrate either onshore or highly oblique with respect to shoreline, suggesting formation on the breaker to build-up zones. Further downdip, wave ripples (fair-weather) and 3D large ripples (storms) formed in the sandy inner shoaling zone (lower shoreface), but were heavily disrupted by infaunal organisms. Major erosional surfaces reflect shoreline retreat that could be linked to changes in wave regime or to a decrease in sediment supply. The high contribution of carbonates associated with these discontinuities point out to strong influence of the latter. The findings of this study provide outcrop-based, ground truth for worldwide, GPR-based research on recent analogue systems.

Sedimentary depositional characteristics of intertidal algae build-up rim and their implication on past sea level reconstruction

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Algal reefs of Mediterranean Sea develop in a wide range from very shallow to deep marine shelf environments. The Intertidal facies is known as "Trottoir" and consists of non-coralline algae built-ups mound or rim like bodies. Its forming process is quite long and requires a near-stable or slowly rising sea-level, therefore intertidal algal rims are widely used as marker for paleo-sea level elevations.
Despite, several studies of micro/macro fauna and flora assemblages and ecological conditions have been performed on modern analogue, rare are sedimentological studies achieved to define the depositional processes that triggered their formation.
Along the western coasts of Sardinia Island (Italy) several well exposed MIS 5e (125 ka) patches of paleo-algal rims occur. These represent an ideal opportunity to acquire and interpret the sedimentary processes responsible for their development in a mixed siliciclastic-carbonate intertidal environments.
Two mainly scenarios were identified: 1) Rocky boulder-strewn shores. Fallen boulders on the shore platform form several wave-sheltered shady rock-pools where incipient algae encrustations start to develop rimming blocks just at the level of the tidal range. This environment also works as trap for long shore carried sediments that commonly alternate with the bio-construction. Under relative stable or slowly sea level rising conditions, the encrusting processes can fill all spaces among blocks. At the maximum expansions, algal mounds may be connected each other and spreadout on the platform.
2) Sub-horizontal high tide shore platform along flat coast. Shore platforms are often exposed to the sub-aerial processes and to the over-washing wave storms, thus the platform surface is largely characterized by shallow or deep pipes and/or pools carved into the easily-erodible bedrock (e.g. poorly lithified sandstone). These holes work as trap for the water and loose sediment that are accumulated and stored at pool bottom. The incipient algal rims takes an advantage of this sheltered humid microenvironment, rimming the edges of the pool and using the loose sediment as "aggregate" to strengthen the overall rim body. The algal rim keep growing into this “nursery” and when the pool is completely filled, the rim spreadout laterally on the substrate. This environment is however also related to clastic sediment supply, which accumulates synchronously with the bio-construction growing. Thus, alternate clastic and bioclastic layers can occur dependently to the algal binding and sedimentation ratio. Under relative slow sea level rising, mounds can growth vertically and laterally following the mean sea level fluctuation up to cover the overall the platforms reaching the Trottoir (pavement) appearance.
The sedimentary feature described in association with the flora and fauna assemblage descriptions allow to distinguish the intertidal algae built-ups from deeper ones, providing an helpful tool for past sea level reconstruction in mixed siliciclastic-carbonate environments.

Morphodynamics and internal structure of talus slopes in the polar environment

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The talus slopes are one of the most common sedimentary environment in the polar regions. As the slopes have developed in the conditions of the periglacial zone in Spitsbergen since deglaciation, they may be the record of events and climate conditions from the beginning of the Holocene age in the area.

The comprehensive studies on the subject of talus slopes developing in the polar environment are presented in this poster. The relation between sediment's maturity and activity of slope processes has been described on the basis of fieldwork and scientific observations. The most significant information about morphodynamics of talus slopes was obtained in the course of granulometric measurements of coarse fraction material from the whole surface of slopes (99 sites) as well as fine fraction material from the distal parts of slopes (17 samples). The internal structure was imaged with the usage of electrical resistivity tomography (ERT). The whole was completed by morphometric and morphogenetic measurements. The matter of chemical weathering (dissolution of rocks) in conditions of the periglacial zone was clarified with hydrogeochemical analysis.

The aim of the studies is to describe the mechanisms of contemporary movements of material on talus slopes in the polar environment. Particularly important information is included in the type of deposition. The sediment maturity and internal structure, which are preserved in the material, are the way of understanding processes and conditions that are crucial for shaping talus slopes. The preliminary model of the evolution of talus slopes in the polar environment was based on these research.

The fieldwork has been carried out in the post-glacial Brattegg Valley during the summer 2012. The study area is located in the Wedel Jarlsberg Land (SW Spitsbergen) on north-western regions of Hornsund Fjord. From the west the valley is limited by the low mountain range composed of Precambrian crystalline rocks (quartzites and amphibolites) which culminate at the top of Gullichsenfjellet (583 m a.s.l.). The talus slopes have been developing on all slopes of the valley. This processes have been apparent on eastern slopes in particular. The group of 8 talus cones was recognized. The proximal slope segment is characterized by a steep cant (40-45˚) and apex at 230 m a.s.l. The material of the distal part is deposited in proglacial Myrkt Lake. Some of the cones, which are distant from the lake's coastline, evolve into alluvial fans (5-10˚).

The main mechanisms of contemporary transport of material on talus slopes in the polar environment are particle fall and rock fall. The debris flow tracks are often observed in proximal slope segment. The distal part is shaped by snow and rock avalanches. The fine fraction sediments are transported by solifluction and suspension transport. The evolutionary model of slopes for polar regions should assume intensity of chemical weathering and dissolution of rocks.

Rock-fluid interaction and related processes due to magmatic intrusions in the Devonian Khyber Limestone (Khyber Agency, NW Pakistan): Implications on dolomite formation and related conceptual model

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Thick carbonate successions of Devonian Khyber limestone affected by magmatic intrusions in the Khyber Agency, NW Pakistan. Field investigations, petrographic studies, geochemical signatures and isotopic analyses were carried out to examine the source of hydrothermal solutions responsible for the diagenetic alteration of the surrounding carbonate rocks. Field observations indicate sharp contact between the host limestone and the dolomite rock, indicating sudden interaction resulted in the alteration of host rock. Progressive change in the mineralogy of the host limestone from the contact of the magmatic intrusion indicates extent of contact metamorphism in the host limestone. Coarse crystalline, nonplanar saddle dolomite showed initial phase of dolomitisation resulted from hydrothermal fluids ejected before the emplacement of magmatic intrusion. Contact metamorphism resulted in the alteration of saddle dolomite into twinned calcite (marble) during magmatic intrusion. Late stage, pore-filling dolomitization resulted from Mg-rich fluid associated with final product of magmatic intrusion. Major and trace-element geochemistry of the intrusive body and host limestone indicate that mafic igneous intrusion resulted in the alteration of host limestone. Besides this, Mg-rich fluids responsible for dolomitization were also associated with magmatic origin. In addition, geochemical studies also helped in establishing paragenetic sequence of the studied rocks. Stable isotope studies indicate depleted $\delta^{13}C$ and $\delta^{18}O$ isotopic values (from -10.08% to -8.468% V-PDB), which showed high temperature fluid (> 80 ºC) resulted in dolomitization.
In conclusion, conceptual model is proposed which indicate that fluid-rock interaction resulted from magmatic intrusions resulted in various diagenetic alterations in the host limestone.

Depositional settings of the stromatolitic unit in Cambrian Muzaffarabad Formation, Muzaffarabad area (Azad Kashmir, Pakistan)

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A thick stromatolitic unit forms upper part of ~900 m thick Muzaffarabad Formation (Cambrian) in the Muzaffarabad area, Azad Jammu & Kashmir. Field observations and petrographic studies in the two studied sections (Yadgar and Khilla) revealed planar to wavy bedding with distinct laminations (crptmicrobial laminites), stromatolites and jelly-roll structures characterized the unit. Most are cryptalgal laminites. In the Yadgar section, stromatolitic structures ranges in length from 9 to 60 cm and height from 7 to 23 cm, whereas size of these stromatolites decrease towards the top of the horizon. Hummocky cross stratification and heterolithic stratification observed in the study area, which indicated storm conditions during the formation of algal flats. In the Khilla section, stromatolites mostly occur in the form of vertically stacked hemispheroids and laterally linked hemispheroids. Besides this, jelly roll structures are also reported, which are diagnostic of microbial activity. Other sedimentary structures include: fenestral fabrics, desiccation cracks as gas bubble trails and imbricated intraclasts.
In conclusion, stromatolitic unit formed in the peritidal environments, comprising supratidal, intertidal and subtidal conditions. It is revealed that two asymmetric cycles representing progradation sequences are recognized in the study area. Besides this, low energy conditions prevailed except periodic storm activity as indicated by the presence of hummocky cross stratification, heterolithic stratification and presence of imbricate clasts.

Seismo-stratigraphy and drowning of the Paleogene carbonate platform, offshore Indus Basin, Pakistan

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The identification of local and regional factors governing the demise of a carbonate platform system can help significantly to the reconstruction of the depositional, tectonic and eustatic history which control the platform architecture. The offshore Indus Basin of Pakistan contains spectacular examples of drowned isolated carbonate platforms developed on paleohigh. This paper addresses the architecture and the drowning history of a few of the isolated carbonate platforms with a focus to the sequence stratigraphy. Six transgressive-regressive units were recognized based on the stratal stacking patterns, logging data and bounding surfaces characterized by high amplitude contrasts. The progradation of the platform margin is minor, and when resolved appears as shingled seismic reflection patterns. During the early platform growth stages, the carbonate factory produced mostly backstepping to aggrading patterns. Localized rapid growth of the carbonate factory produced small mounds during a regional keep up cycle. Backstepping caused the shrinking of these bank top mounds, which finally drowned. The most prominent unconformity of the system is interpreted as the drowning unconformity, marking the end of the Paleogene carbonate growth, and tracing a convex upward mounded shape. In the borehole, the drowning event is marked by a rapid transition from shallow water grainstone and packstone facies to siliciclastic rocks succession of the Indus Delta. Increase in shale content in the drowning sequence and in the overlying sediments is taken as an indication that the siliciclastic influx from the Indus delta was a relevant factor inducing deterioration of the carbonate factory.These are the preliminary results of ongoing work which show the excellent potential of these data sets for a better understanding of the Paleogene evolution of the offshore Indus Basin which also has a high relevance for applied aspects.

The Lower Permian evaporite formation of the Dnipro-Donets Depression (Ukraine): Sedimentary and geochemical peculiarities

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One of the three evaporite formations of the Dnipro-Donets depression – the postrift-platform Lower Permian Formation – occupies the larger part of the depression. The depth of the formation base ranges from 50 to 4060 m and its thickness varies from 40 m in the NW to 1737 m in the SE part of the depression. The formation is underlain by the Kartamysh red-coloured terrigenous formation and is subdivided into two subformations: the rock-salt-bearing Mykytivka–Slovyansk and Kramatorsk K-Mg-salt-bearing ones. The rock-salt subformation, which is up to 1200 m thick, is represented by alternating layers of rock salt (up to 75 m thick), limestones, mudstones, marls, anhydrites and halopelites. The K-Mg-saltsubformation, up to 960 m thick, is composed of rock-salt with anhydrites, salt-siltstones, sandstones and halopelites, as well as K-Mg- and Mg-salt seams. Up to six large-scale cycles are distinguished in this subformation, with halite-siliciclastic rocks and/or anhydrites in the base and with thick rock-salt or salt-siliciclastic bed at the top. The lowest cycles are covered by the aforementioned K-Mg salt and bisschofite seams.
The following depositional settings have been identified: a “deep water” basin with rock-salt accumulation (Sloviansk subformation, bedded rock-salt with small-scale “annual” cycles); carbonates, anhydrites and rock-salt forming large-scale cycles, a “shallow water” basin with laminated anhydrite-carbonate (formed after bacterial gypsum-carbonate transformation), nodular and lenticular anhydrite; saline lagoon and shallow continental basin (playa?) deposits. Depositional lithofacies and fabrics of Permian evaporites (such as anhydrite pseudomorphs after grass-like gypsum, laminated, «chicken wire», «tepee» textures, chevron halite etc.) have been revealed.
The sulphur isotope composition has been determined for the anhydrite of the rock-salt interlayer and rock-salt insoluble residue, kieserite, and pyrite. The $\delta^{34}S$ values of anhydrite sulphur (sulphate lithofacies) from basal beds and layers in rock-salt range from +6.5 to +16.9‰ for the Mykytivka subformation; they range from +7.4 to +13.2‰ for the Slovyansk subformation and are +7.l‰ for the Kramatorsk subformation; the sulphur isotope composition of anhydrite from rock-salt insoluble residue (halite lithofacies) ranges from +8.4 to +15.3‰; the $\delta^{34}S$ values for sulphates of kieserite from carnalite-kieserite rock insoluble residue (bisschofite lithofacies) range from +8.4 to +8.9‰; $\delta^{34}S$ value for pyrite from rock-salt insoluble residue is – 8.3‰. The measured isotope composition ratios ($^{87}Sr/^{86}Sr$) vary from 0.70779 to 0.70810. The figures are consistent with the Lower Permian part of the oceanic Sr-isotope curve in the Phanerozoic.
The radioactive elements distribution across the section of the Formation shows deviations from general U, Ra, Th and K patterns, as does the ratio of Th/U, which indicates postsedimentary transformations.
The main established diagenetic feature of the Lower Permian formations is halocatagenesis, whose indicators are mineral neoformations in terrigenous rocks – dolomite, anhydrite, barite, celestine, halite, sylvite and high-salinity chlorine-calcium brines with a high content of microcomponents.

Architecture of coarse grained (conglomeratic) deep water lobes at the base of a sandstone dominated fan, Jurassic Los Molles Formation, Neuquen Basin, Argentina

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The complex structural and stratigraphic framework of the Neuquén Basin affected by Triassic-Jurassic extensional processes formed a deep basin and accumulated coarse-grained gravity flow deposits on the lower slope and basin floor. Lower Los Molles Formation exposes the succession of turbidites from conglomerates to mudstones over a 9 km outcrop belt. The Los Molles Fm. is over 1000 meters thick and its base is ~100 meters consisting of 3 units capped by 1-3 m thick conglomerates. This initial deep water fan units start with unusual pebble- and cobble-rich conglomerate beds at its base. To characterize the conglomerate lobes and their link with the other basin-floor lobe complexes, satellite images, DEM (Digital Elevation Model), photomosaics (a few km), and 19 measured sections (30-190 m thick) have been collected and interpreted. In all units measured, each lobe contains, from bottom to top, very coarse, poorly sorted, and erosional-based conglomerates (1-3m) overlain by amalgamated, normal graded turbidite sandstones (20-30 m), and silty mudstones (up to 10m). Each of these 3 facies forms a succession (about 30-40 m thick) of lobe complexes with an overall fining upward trend. The conglomerate thickness and lateral extent decreases upwards as the third (uppermost) conglomerate layer demonstrates rather discontinuous, lenticular bodies. In contrast, the sandstone increases upward in thickness and has finer grain size and better sorting. The conglomerates are interpreted as debris flow deposits based on their structureless and poorly sorted texture. However, few conglomerate deposits are at times erosional at the base, poorly sorted throughout, but some capped by normal grading for up to a third of their thickness. Normal grading suggests debris flow transforms into turbidity flow vertically. Flute marks associated with conglomerate beds indicate paleoflow toward the east, in contrast to the younger sandy fans that prograded dominantly north-northeastwards. The Var River system in southern France is a modern analog with pebbles and cobbles transported to deep water via steep gradient slope. Similarly, coarse sediments in the Los Molles Fm. bypass the shelf and steep slope to build the initial conglomerate base of the fan. In summary, the earliest Los Molles conglomeratic fans are linked with high relief of the basin margin that later decreased and formed sandstone dominated fans.

Cyclostratigraphy and environmental magnetism approach on the Lochkovian and Pragian from the Praha region, Czech Republic

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The uncertainties on the Devonian time scale are still in the order of several millions of years (e.g. the error bars on boundary between the Lochkovian-Pragian and Pragian-Emsian being respectively of 2.8 and 2.6 Myr; Becker et al, 2012). These large uncertainties are interfering with a detailed understanding of major environmental and evolutionary changes occurring during the Early Devonian. In order to improve the Geological Time Scale, spectral analysis of paleoclimate proxies has been classically applied to Cenozoic and Mesozoic sections. When shown to reflect a detrital signal, which is influenced by climatic variations, Magnetic Susceptibility (MS) has been proven as a useful tool for identifying climatic cycles. Their steady duration unveiled by spectral analysis can subsequently be used to improve the time scale. However, it is important to assess the influence of diagenesis. In this respect, we provide hysteresis analysis in order to get insight into the nature and the origin of the magnetic minerals that constitute an important driver of the variation in the MS signal.
In this study, we focus on two sections from the Prague Synform (Czech Republic). The first section is the Pozar-3, a relatively condensed section in its upper part, encompassing the Lochkovian, Pragian and part of the Emsian. The second section is the classic Pod Barrandovem section, which includes the Pragian and reaches the mid-Emsian. Sampling interval is 10 cm in the lower part and 5 cm in the upper part of the Pozar-3 section (~1700 samples) and is 10 cm throughout the Pod Barrandovem section (~1600 samples). Sedimentation is rhythmically, dominated by slightly clayey offshore limestones, being mostly calciturbidites and hemipelagites (e.g. Hladil et al., 2010). Typical MS values in the Pozar-3 section are around 0.9x10-8 m^3/kg (0.3 and 1.4 for Lochkov and Praha formations, respectively) and 1.4x10-8 m^3/kg in the Praha Formation, at the Pod Barrandovem section. The MS signal in these rocks is inferred as being controlled by impurities of aeolian origin, as well as pyrrhotite in the Lochkov Fm. and bacterially induced and recrystallized hematites, also iron oxyhydroxides, in the Praha Formation (reviewed by Hladil et al., 2010). We are currently exploring various spectral approaches to identify key periodicity in both sections.

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Preliminary assessment of particulate matter magnitude mobilized by mechanical effects on the Estuary Complex of São Marcos, Maranhão, NE of Brazil

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Located in the northern state of Maranhão, the Estuarine Complex of São Marcos is characterized by the high presence of mangrove forest and presents a mixed type tide, with semi diurnal predominance, which has average amplitude, about 3.3 meters, reaching more than 7 meters during periods of spring. This estuary holds a high concentration of Total Suspended Solids (TSS) due to the contribution of large river discharges, especially the Mearim basin. The proposed problem is preliminarily is to evaluate the magnitude of the contribution of Total Suspended Solids (TSS), mobilized by dredging, in relation to the movement of the background of the Complex, using TSS data, bottom sediment granulometry and current speed. The particle size distribution is based on the bottom sediments of data collected by 3 points (P01, P02 and P03) with the assistance of a "Van Veen" grab. In order to obtain the average speed of the current values and backscattering acoustic signal ADCP was held a section/transect of approximately 21 km inside the estuary, in which water samples were performed with 5L Van Dorn bottle, at different depths for the direct determination of the concentration of TSS. The intensity of the acoustic signal received by the transducers from the sampled layers is related to the density or quantity of TSS. Therefore, the echo intensity data stored by ADCP were correlated from the Sonar Equation, with data collected in situ (water samples). In this profile it was estimated a transport of about 397,000 tons per hour of the total of TSS. If we linearly distribute the transportation, we can divide the profile for 41 sectors of 500 meters each, ie, each section of 500 meters is a transport of 9,450 tons per hour. Given that the average current velocity profile was 0.6 m/s and in order to having erosion and transport velocity, according to the diagram Shields (1936), the grain size should be ≥0, 1 mm, it can be inferred by analyzing the average percentages of the particle size of points P01 (50.3% of fine sand), P02 (67.4% of fine sand) and P03 (85.6% of fine sand), approximately 100% of the dredged material is transported. That is, for speeds above 0.1 m/s all the material will be transported. Based on this, we assume one dredged volume of 900,000m^3, assuming a density about 2000 kg/m^3, we will have approximately 1,800,000 tons of material. If dredging last approximately 40 days we will have 45,000 tons per day or 1.875 tons per hour. Comparing the value of the dredged material with naturally transported value (background), that is, the ratio (1.875/9.450) T/hour, presented a preliminary estimate of the percentage representing the dredged material over ground transport, or is, in a sector of approximately 500 meters (background) the dredged material is about 20% of total suspended solids.

Severe and rapid sea level changes affecting Devonian mud mounds from Belgium

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In this study, we focus on the early and middle Frasnian stratigraphic interval from the Ardennes area in Belgium, with a multidisciplinary and high-resolution study, including detailed sedimentology and magnetic susceptibility measurements, to identify the main paleoenvironmental changes affecting this interval. Three mud mound levels are observed, in stratigraphic order, the Arche, La Boverie and Lion mounds, surrounded and separated by shales. The three mounds are characterized by the same facies and relatively similar facies evolution through time. The base of the mounds shows deep mound facies (mud, stromatactis, crinoids) and the upper part of the mounds shallow mound facies (lagoonal facies, laminites). The mound succession is interpreted as related to the following events: the base corresponds to transgressive and high stand system tracts; overlain by a sharp transition with shallow facies that correspond to a main regression; followed by the next transgressive system tracts, which corresponds to the upper part of this mound and the lower part of the next mound. Then, again a sea-level drop occurs below the top of this lithostratigraphic unit and is followed by the next transgressive stage etc. A similar transgressive-regressive history is interpreted for all three mounds. As the La Boverie mound is only 35 to 45 m-thick, compared to the 100 m-thick Arche and Lion mounds, the two sea-level fluctuations occurring at the base and top of the La Boverie mound are considered as very severe and rapid, occurring within 1 My. An important transgression is interpreted as occurring during the global negative carbon excursion, the punctata Event, recorded worldwide (synthesis in Racki et al., 2008). During this interval, strong and sharp variations are also recorded in the magnetic susceptibility curve.

Evolution of the Silesian ridge in the light of outcrop spectral gamma-ray records obtained from siliciclastic fill of the Silesian basin; the Mazák and Godula Formations, Czech Republic

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In siliciclastic sediments, the concentrations of K, U and Th are driven by mineral and chemical composition, which, in turn, results from combined effects of source-rock composition, climate and topographic gradient in the source area, transporting and depositional mechanisms and post-depositional processes.
This case study is focused on the Upper Cretaceous deep-marine synorogenic siliciclastics of the Mazák and Godula Formations, which build part of superficial thrust sheets of the Silesian Unit of the Outer Western Carpathians. These sediments represent relicts of sedimentary fill of the Silesian basin. Facies stacking patterns, paleocurrent data and presence of “exotic” clasts document that phases of increased filling of the basin correspond with main tectonic phases in the source area (Silesian ridge).
The main aim of this work is investigate the possible connection between major changes in stacking patterns of the siliciclastic facies (based on outcrop facies analysis and outcrop gamma-ray logging) and changes in their source areas (based on modal composition of sandstones; transparent heavy mineral assemblages; WDX SEM analyses; X-ray powder diffraction analyses and the outcrop spectral gamma-ray record).
Concentrations of K, U and Th are partly dependent on grain size, which is suggested by the relatively higher radioactivity of mudstone and fine-grained thin-bedded facies compared to thick-bedded sandstone and conglomerate facies. However, this grain-size dependence of the gamma-ray data is low at specific stratigraphic levels at the base of the Lower Godula Member and near the base of the Upper Godula Member. These levels coincide with a decrease in mineral maturity of sandstones and, hence an increase in their radioactivity. The sedimentary succession of the Mazák and Godula Formations can be subdivided into three stratigraphic segments with their boundaries situated close to Mazák/Godula Formation and within the Middle Godula Member. The lower segment is predominantly supplied from a low-radioactive cratonic source (quartz-rich plutonic rocks, limestone and chert clasts). Sandstones of the Mazák Formation showing very low radioactivity can be easily distinguished from high-radioactivity ones of the Godula Formation. The middle segment is supplied from transitional continental sources (mica schists, gneisses). The provenance change, attributed to the intensive uplift and erosion of the source area correlates with the onset of the Subhercynian orogenic phase in the Carpathian orogen. The upper segment is predominantly supplied from recycled orogenic source. Detritus derived from high-grade metamorphic rocks (gneisses, granulites) predominates over magmatic rocks. The base of the upper segment is associated with a prominent increase of U and Th concentrations and values of SGR. The stratigraphic variation of spectral and standard gamma-ray data corresponds with the changes of sandstone detrital composition. Outcrop gamma-ray spectrometry proves to be a useful indicator of provenance changes in synorogenic sedimentary successions and contributes to the discussion about the Upper Cretaceous tectonic evolution of the Outer Western Carpathians.

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Microfacies and environment of deposition of the Jahrum Formation, Zagros basin, Iran

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The Eocene.Jahrum Formation is a carbonate hydrocarbon bearing reservoir in the Zagros basin. Previous studies introduced two different depositional settings (distally steepened ramp and open shelf) for deposition of the Jahrum Formation in Fars area of the Zagros basin. This study is aimed to define the depositional settings based on analyzing microfacies and environment of deposition of the Jahrum Formation, in one of the oilfield, located in Fars area.
The research is based on 270 thin sections of available 120 m core interval. Thin section analysis are due to depositional texture, skeletal and non-skeletal associations. As a result of this study, 12 facies and 5 related subfacies identified as follows: 1- Bioclast pelagic foraminifera Nummulitidea dolomudstone/wackestone, 2- Bioclast peloidal Nummulitidae dolomudstone/wackestone, 3 Bioclast Discocyclinidea packstone/rudstone, 4- Bioclast Discocyclinidea Nummulitidae wackestone/packstone/rudstone 5- Bioclast Nummulitidea wackestone/packstone/floatstone, 6- Bioclast red algal Nummulitidea packstone/grainstone, 7- Bioclast Rotalia Nummulitidea packstone/grainstone, 8- Bioclast lense-shaped Nummulitidea packstone/grainstone, 9- Bioclast Orbitolites Nummulitidea packstone/grainstone, 10- Bioclast miliolida coral floatstone, 11- Bioclast miliolida dolowackestone/packstone/grainstone and 12- dolostone with evaporates. Along to these facies, some reworked stormed influence sediments characterizing with erosional surface are associated.
These associations next to lack of restricted lagoon facies lead to introduce an open (mid and inner) shelf setting for deposition of the Jahrum Formation in the study area. Middle shelf identified by occurrence of facies 1 to 7. Facies 8, mostly nummulites grainstone formed in a high energy bank environment and facies 9 to 12 reflect deposition in an inner ramp setting.

How natural levees are build-up? – the recent examples

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Levees – natural depositional forms build-up during flood along river channels – are well described in terms of morphology. However, they are poorly described with regard to their sedimentology. Results of previous works on recent flood deposits accumulated in the proximal part of the floodplain have shown that river flood sedimentation is strongly conditioned by local factors and still not well studied and understood. The increase in extreme rainfalls generating larger and more frequent floods – observed in recent times – allows to observe the formation of flood depositional forms and study their deposits.
The particular purpose of the study was to show the variation in grain size parameters within thick flood sands (thickness of 1.0 m) deposited in levees after two large floods which took place within valley of sand-bed meandering river (Warta River, central Poland) in 2010 and 2011.
Vertical successions of levees, sampled every 5 cm, represented pensymmetric and/or coarsening-upward sequences. Such a trend, combined with the phases of rise and fall of water level, was basis to propose the model of sedimentation within levees during the flood. The model includes 4 flood stages:
1) Initial flood rise – fine-grained sand enriched in plant debris coming from the erosion of river banks and floodplains;
2) Fast water rise – period defined by the maximum transport rate and formation of inversely graded sand sequence;
3) Slower rise and stabilisation of water level – deposition of fining-upward sand and plant remnants from the floating load;
4) Falling water level – the flow energy is too low to transport sand; thus the stage is not recorded in deposit succession.
The results of this study showed that the flood deposits represented the stages of water level rise and stabilisation (culmination), while the falling water stage was not recorded. According to the proposed model, maximum grain size corresponds to the maximum increase in the discharge (IP – the inflection point) and thus, it does not coincide with the culmination of the flood.
Grain size analysis of levee sand showed that statistical grain size parameters depicted a marked trend – in scatter plots of mean vs. skewnees and mean vs. kurtosis, the examined deposit exhibit V-shape point arrangement. The trend is interpreted as the result of mixing of grain subpopulation transported in the bed load with sediment transported in graded suspension. Mixing of grain subpopulations in clastic deposits has already been documented in deposits of meandering river bars and tidal environment, but it has not been observed in levee deposits yet.

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Dynamics of cyclic step bedforms generated by carbonate sediment gravity flows – the outcrops of the Favignana Calcarenite (Sicily, Italy)

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Sand and gravel accumulations in deep-water environments result from the activity of sediment gravity flows. Such flows are shown to be frequently supercritical. The understanding of lithofacies distribution and stratigraphic architecture at bed- and lamina-scale in deep-water deposits is thus intimately linked to the understanding of the morphodynamics of supercritical flow bedforms and their resulting sedimentary structures, which advanced greatly over the past few years through physical and numerical modelling. Field observations, however, remain limited.

Here, we present the thick beds of the Pleistocene Favignana Calcarenite, which were formed by supercritical sediment gravity flows travelling down a cool-water carbonate ramp into offshore settings. Backset-dominated sedimentary structures are interpreted as aggrading cyclic steps deposits (wavelength ~20 m, amplitude ~2 m). Cyclic steps are stable bedforms characterised by a train of hydraulic jumps overriding a series of downstream-asymmetric steps. The gentle stoss side of the step is marked by a thick accelerating subcritical flow that reaches the critical Froude number at the crest and transforms into a thin supercritical chute down the lee side. When the chute enters the trough between two steps rapid deceleration switches the flow-regime back to subcritical. The transition of supercritical to subcritical flow is expressed by the formation of a hydraulic jump.

The transition from rapid suspension fallout (hydraulic jump) to traction sedimentation (accelerating subcritical flow) is reflected in a downstream-fining and -thinning of backsets. Individual backsets (~10 cm thick) display inverse grading resulting from traction carpet sedimentation. Continued deposition of backsets forced the hydraulic jump, and thus the erosive supercritical chute, to migrate upstream. Hence, backsets terminate upstream into concave-up scours. Internal flow pulsation resulted in each subsequent backset to truncate the preceding one, generating a composite erosion surface. Upstream migration of the bedform and the downstream-fining of individual backsets resulted in the fining upward of the bed. Aggrading conditions led to limited erosion on bedform lee sides. Hence, backsets deposited into concave-up scours in their upstream portion are shown to become convex-up in downstream direction (preservation of the crest), locally continuing farther downstream into concave-up geometries once more, repeating the sequence.

Time-progressive morphodynamic reconstructions of flow and bed reveal that besides short pulses, resulting in the deposition of individual backsets, also pulses of longer duration were present. These longer pulses are related to a temporarily downstream migration of the hydraulic jump (flushing), probably linked to flow discharge fluctuations. Preliminary results of numerical modelling of the studied structures reveal that short pulses are around 20 second duration and that long pulses occur on the order of several minutes. Locally, backsets show wavy geometries, interpreted as the presence of superimposed antidunes. This allows the estimation of other flow parameters using basic hydraulic equations that link antidune wavelength to thickness and velocity of the sediment gravity flow.

Our outcrop analyses shine new light on sedimentary structures in deep-water sand and gravel accumulations formed by supercritical gravity flows. Flow processes and their fluid mechanics are linked to sedimentary structures and sub-bed-scale lithofacies distribution and stratal architecture.

Tsunamis and major storms on Mediterranean cool-water carbonate ramps – the event beds of Favignana Island (Italy)

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The Neogene of the Mediterranean contains several cool-water carbonate ramp successions with bioturbated tempestite and/or subaqueous dune cross-stratified clinobeds. Anomalously thick, wavy backset beds (resembling but not representing stacks of channel fills) are commonly intercalated. We present a genetic model to interpret such carbonate sand accumulations which may host significant hydrocarbon reservoirs.
We answer the following questions:
(1) Which physical sedimentary processes created wavy backset beds and subaqueous dune deposits?
(2) Which time scales characterize the deposition of both types of facies?
(3) Which types of event produced them?
(4) How does this affect the evolution of Mediterranean cool-water carbonate ramps?
The Pleistocene carbonate ramp deposits of Favignana Island (Italy) comprise a ~50 m thick prograding succession of dm to m-scale bioturbated subaqueous dune cross-stratified clinobeds. The succession is interrupted by 35 wavy backset beds of up to 10 m thick. The two facies occur in equal proportions. Quarries scattered across the island and a large sea cliff (1.2 km by 50 m) offer textbook exposures.
(1) Time-progressive morphodynamic reconstructions of flow and bed reveal that wavy backsets were generated under standing antidune waves in dense supercritical underflows travelling down the ramp slope. The breaking of such waves invoked hydraulic jumps depositing backsets in concave-up scours while they migrated upstream.
(2) Basic hydraulic equations show that dense underflows with velocities around 1-2 m/s were ~1.5 m thick. These flow parameters, together with bed dimensions, allow for the estimation of flow durations. The up to 10 m thick wavy backset beds were deposited in 2-10 hours. Sediment flux calculations for subaqueous dune deposits show cumulative flow durations of 1.25±1 yr.
(3) Strontium isotope stratigraphy reveals that a clinobed couplet, consisting of a package of subaqueous dune deposits and a wavy backset bed, represents ~10 ka. A package of subaqueous dune deposits comprises 50-300 events. Hence, events lasted 1.5-9 days with recurrence periods of 33-200 yr (based on cumulative flow duration). Subaqueous dune deposits are interpreted to represent major storms. In contrast, events related to wavy backset beds deposited an equal amount of sediment within a couple of hours, reflecting sedimentation rates several orders of magnitude greater. Therefore, such events, occurring on average once every 10 ka, are not linked to major storms, but to rare catastrophic events of much greater magnitude which rapidly swept enormous amounts of material off the platform. We suggest the latter to be related to tsunamis.
(4) On an every-day basis, the carbonate ramp was characterised by almost no sediment transport. Half of the sediments were deposited in ~0.02% of the time, when major storms created wind-induced currents resulting in subaqueous dune migration. The other half was delivered in an instant by short-lived tsunami-induced gravity flows. The studied deposits are comparable to several fossil cool-water carbonate ramps in the Mediterranean. We suggest that these deposits, characterised by wavy backset beds, record a very non-linear sedimentation history punctuated by high-energy (storms) and extreme-energy events (tsunamis). Our results provide a new way to interpret fossil cool-water carbonate ramp successions.

Multiscale and multidimensional petrographic, microstructural and sorption capacity characterization of selected Early Palaeozoic shales from the Baltic Basin: Sasin, Pasłęk and Pelplin Formations – preliminary results

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We present the results of petrographic and microstructural study of shale samples. Investigated set of 13 samples was studied using several techniques allowing for characterization of their mineralogy, microstructure as well as CH_4 and CO_2 sorption capacity.
The samples studied represent thin-laminated mudrocks, partly composed of elongated lenses comprising quartz, feldspar and white micas as framework grains. In some samples barite and titanium oxide are present. Opaque minerals are represented mainly by pyrite, occur both, as relatively large, elongated concentrations of crystals aggregates of up to 2.5 mm in length and as framboids of up to 20 microns in diameter. Most of opaques represent presumably early(?) diagenetic phases. The matrix of investigated samples is composed of a mixture of clay minerals, true micas and chlorites. Carbonates, both dolomite and calcite, occur as small crystals from 10–30 microns in diameter, evenly dispersed in the matrix. Bulk chemistry show that in terms of main and trace elements, including REE, investigated samples are similar in composition to North American Shale Composite (NASC) and to other Paleozoic shales like Post Archean Australian Shale (PAAS). Mineral composition observed during petrographic studies was verified quantitatively with bulk rock quantitative phase analysis and the X-ray diffractomery with pattern summation model.
Total Carbon (TC) content as well as Total Organic Carbon (TOC) were measured using LECO analysis. Values of TC fall into range from 2.23% to 7.32%, whereas TOC is in the range between 0.37% and 1.10 %.
Porositymeasured using Water Immersion Porosimetry (WIP) is in the range from 4.6% to 9.1%. The same sample set analyzed using Kerosene Immersion Porosimetry (KIP) gave porosity values from 2.8% to 7.9%. Both porosity analyses represent connected porosity available for water and hydrocarbons, respectively.
High resolution imaging and EDS automated analysis (QEMSCAN) were used to determine the porosity, mineral composition, grain size and pore system characteristics both in 2D and 3D. Pore analysis was based on focus ion beam slicing (FIB-SEM) and image analysis. The results of 2D and 3D studies are compared with results of WIP and KIP.
In order to assess sorption capacity of shales towards CH_4 and CO_2 we have carried out high pressure sorption tests. Sorption tests were conducted at reservoir temperature of 80°C and up to the pressure of 18-20 MPa on the accurate manometric sorption setup. Sorption experiments were conducted on ground and dried samples with high purity gases. Obtained excess sorption isotherms for CH_4 followed typical Langmuir isotherm with slow monotonic increase in sorption capacity above 10 MPa. In case of CO_2 excess sorption a rapid decrease in sorption capacity is observed within supercritical region of CO_2 (i.e.>7 MPa). Results of those experiments are compared with XRD quantitative analysis and TOC, TC results in order to understand the sorption behavior of minerals and organic matter of shales.
Proposed set of methods enable to characterize gas shales in a variety of scales providing basic information in planning CO_2 sequestration in this type of rocks.

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Lateral accretion rate of the tide-dominated freshwater Pitt River, Canada and implications for the rock record

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There is a research bias towards the study and quantification of channel migration in river reaches that are not affected by tides; the evolution of fluvial channels modulated by tides and those that experience tidal reversals have largely been ignored. It is generally assumed that tide-influenced and tide-dominated river channels have negligible accretion rates, and hence, lateral accretion deposits identified in sedimentary strata are interpreted as fluvial or tidal backwater deposits.
Vibracores collected from the tide-dominated, fluvially influenced Pitt River, Canada are used to quantify the lateral accretion rate of the Pitt River and characterize freshwater tidal deposits. Channel deposits exhibit rhythmic alternations of very fine sand and silty-mud that form cm- to dm-scale bedsets dominated by parallel lamination with intermittent current ripple lamination. The rhythmic alternations reflect tidal cyclicity and seasonal changes in fluvial discharge. Throughout the course of preserved point-bar migration, river water was fresh, and this is determined using both palynological and ichnological data. Carbon-14 age dates indicate that the Pitt River was established over 3000 calendar years BP. Based on the maximum distance from the modern channel thalweg to the position of our cores, the calculated maximum mean channel migration is 0.33 m a^{-1}. Compared to bank erosion rates of meandering rivers, the Pitt River has migrated roughly four times slower than expected for a non-tidally influenced river of similar catchment size.
Based on these data, we suggest that lateral accretion deposits in the rock record should not be automatically attributed to wholly fluvial systems – tides may have impacted sedimentation. The integration of ichnological and palynological data with sedimentological and morphological interpretations will lead to improved paleo-depositional interpretations, and enable differentiation of lateral accretion deposits deposited in fluvial systems from those deposited in tide-influenced river reaches.

A giant antacid? Carbonate saturometry in interstitial waters

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One of the consequences of an acidifying ocean is the possibility of increasing dissolution of carbonate sediments, at and below the sea floor. What we don't yet know for many environments is how carbonate dissolution changes with distance below the sea-floor. We emplaced carbonate of different mineralogies at various levels below the sea-floor down to 1m, using a perforated pipe designed for the purpose, in sediments located in Otago Harbour and off Otago Peninsula (South Island, New Zealand) as well as at Port Pegasus (Stewart Island, New Zealand) for periods of 3 months to two years. The specimens included biogenic mollusc aragonite, biogenic mollusc low-Mg calcite, marble, and limestone. Weight loss, and therefore carbonate dissolution, in most samples was minimal. It appears that temperate coastal interstitial waters at depths up to 1 m in sediment are not yet undersaturated with respect to aragonite or calcite. Bottom waters in all three locations have saturation levels of 2.3 to 2.8 wrt aragonite, and 3.6 to 4.3 wrt calcite, so this result is consistent with surface advection into sediments of up to 1 metre. When surface waters become undersaturated wrt calcite and aragonite, however, it could be expected that carbonate dissolution will not just occur at the sea floor but into and even below the so-called 'taphonomically active zone'.

Geochemical evidences of water column euxinia and cyanobacterial blooms during the Ordovician–Silurian mass extincion event

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The end-Ordovician biocrisis is one of the “Big Five” mass extinctions of the Phanerozoic (Sepkoski, 1996). It is the second largest in terms of the percentage of species loss (86%) (Sheehan, 2001). Independent methods like: sedimentological observations, total organic carbon (TOC) and total sulphur content, inorganic proxies, pyrite framboid diameter study as well as organic geochemistry were used to examine the redox conditions during the Ordovician–Silurian (end-Ordovician) mass extinction event. The shale samples from the Zbrza well (Holy Cross Mountains) are characterized by significant variations in TOC, ranging from c.a. 0.2% to the highest value reaching 8.3% at the O/S boundary. TOC content pattern across the section corresponds generally to the inorganic proxies values as well as to total sulphur content, reflecting variable redox conditions. Generally, all of our inorganic redox proxies are in accordance with each other, and indicate a variety of bottom water redox fluctuations. The V/Cr, U/Th, Mo, Uauthig. U/Th are low through almost the entire Katian and Hirnantian. During the end of Hirnantian just before O/S boundary a huge shift was noted when all inorganic proxies showed increasing values connected with more oxygen restricted conditions. The highest peak of anoxic/euxinic conditions was detected during Llandovery, right after the O/S boundary. The youngest part of the Zbrza section characterized by lower values of indicators listed above. The V/(V+Ni) has indicated generally more restricted redox conditions through whole profile. Pyrite framboids are common in almost all the Ordovician and Silurian shales. Older part of Wolka Formation contains large populations of small framboids (mean diameters around 5 µm), with low standard deviations, while the younger part of the formation does not contain framboids at all. The end of Hirnantian is the beginning of change in redox conditions with large population of small framboid pyrites, what continues through the whole Llandovery. The set of organic indicator has been elaborated for Ordovician and Silurian rock samples. The most restricted redox conditions at the O/S boundary indicated by inorganic proxies have been confirmed by concentration of aryl isoprenoids. The ratio of steranes to hopanes is low through the Wolka formation, while increasing during the O/S boundary indicating increase of algal blooms. Values of the 2-MeH index has showed three peaks of cyanobacteria activity after the Hirnantian mass extinction event.

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Depositional systems in the Early Palaeozoic of NE Poland – implications on hydrocarbon source rock development

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The early Palaeozoic shale belt of Poland has become a major target of unconventional shale gas exploration in Europe, leading to intense studies of the shales all along this zone. This very little- to non-deformed 700 km long belt is placed between the Eastern European Platform in the NE and the Paleozoic Platform in the SW, a complex mosaic of terranes including the Caledonian orogen. Deposition took place in the Caledonian foredeep limited to the east by the shelf ramp of the East European craton. The shales are increasingly calcareous towards the passive continental margin of the East European craton in the NE and more silty towards the active continental margin of the Caledonian orogen in the SW. TOC content decreases in both directions.
The current study is focused on microfacies and kerogen analysis of the uppermost Ordovician to lower Silurian sediments in four wells in NE Poland, to provide detailed insight into the depositional environment and its effect on source rock generation. Sedimentological, paleontological and petrographic characteristics of the post-Hirnantian marlstones and claystones indicate their deposition during the post-glacial transgression and following basin deepening, which is consistent with the global environmental changes after the Late Ordovician glaciation. It also shows proceeding hypoxia of the seabed and bottom waters, finally resulting in deposition of bituminous claystones in low-energy, slow-accumulation and oxygen-deficient conditions of an outer shelf setting, favouring preservation of organic matter. Within this the low-energy environment, several tempestites have been identified, indicating episodically storm events. The fine-grained succession also shows features of gravity flows, indicating a certain amount of sediment reworking and redeposition. Both lead to intermittent growths of oxygen levels in the oxygen-deficient bottom-water conditions, affecting significantly the source rock development.
Source rock analysis was focused on Optical Kerogen Analysis, a workflow based on optical analysis of kerogen composition, preservation and maturation. Major target was the detailed analysis of the kerogen mix in the shales, based on the quantification of each kerogen type within each sample. This led to the quantification of the productive kerogen (net TOC) versus the total kerogen (TOC) in each sample and also the ratio of oil-prone versus gas-prone kerogen within the productive kerogen was analysed. Analysis of kerogen preservation provided infprmation on the microporosity of the organic matter in the shales, an essential parameter for the gas storage capacity. Finally organic maturation was analysed by means of palynomorph colour indices and fluorescence colours for detailed maturation analysis of the shales. Optical Kerogen Analysis shows significant amounts of highly oil-prone kerogen type I, which was not recognised in geochemical analyses, in several samples. Detailed kerogen composition is strongly influenced by lithofacies, showing the best potential in marlstones and the poorest potential in redeposited bioclastic limestones. Preservation analysis indicates that often low TOC values represent low primary TOC levels. Optical Kerogen Analysis showed low maturation of basal to lower oil window, indicating the potential for shale oil plays instead of gas shale, which favours a different source rock composition.

Kinematic indicators in gravity-driven mass transport complexes: A case study from San Carlos, Baja California, Mexico

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Mass transport complexes (MTCs) make up a large fraction of sediments deposited on the continental slope, with their initial movement involving slope failure and subsequent downslope motion involving changes in material properties of the sediment induced by compaction, dewatering and enhanced shear strain. The structures and kinematics developed in these deposits have been described from both seismic and outcrop studies. The present study focuses on exposures along sea cliffs at San Carlos, Baja California in Mexico, and is located about 85km SE of El Rosario. The San Carlos area represents a forearc basin filled with sediments of the Upper Cretaceous Rosario Formation, and comprises deposits of shallow to deep-marine, slope and submarine canyon fill.

The MTC exposed at the shoreline of Punta San Carlos is emplaced amidst tilted or potentially folded sections of thin bedded turbidites (TBT's), and is composed of 14 mass transport intervals that were categorized into slumps, blocky slumps and rotated slides according to their internal organization. There are three slump intervals marked by the presence of slump folds including sheath folds in a muddy matrix. Blocky slumps also form three intervals, characterized by the presence of highly bioturbated coherent blocks wrapped in a disaggregated muddy matrix containing small folded coherent fragments of sand, and capped by an overlying shell-rich layer. Finally, rotated slides form 9 intervals that comprise the main part of the MTC; and are made up of concave upwards slides of heavily bioturbated TBT's, displaying an erosive base, or a highly disaggregated layer representing the basal shear surface where the slide translated over it. Each mass transport style has its own sets of kinematic indicators. Within slump intervals, folds appear as recumbent, overturned, rootless and sheath folds with hinge lines aligned along NE-SW trends. Within blocky slump intervals, original bedding and shear fabrics around blocks define two trends of NW-SE and N-S block rotation, with a stronger cluster towards the S and SE. The shear fabric commonly appears as rootless folds around the blocks. Within rotated slides, bedding typically dips towards the S-SE, while thrust faults dip towards the SSE. These kinematic indicators collectively suggest an overall transport direction towards the S-SE, which is perpendicular to the main inferred SW-W paleoslope direction (similar to the present slope direction). These data lead us to suggest that the MTC's at San Carlos may be the result of a steep slope (reflected by thin deposits with a small run-out distance and surrounded by TBT's), together with an embayed section of the slope, thereby resulting in the two main N-S and NW-SE transport directions.

Evolution of reservoir property in different geological conditions – a case study in Dongying depression of China by using physical simulation methods

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Different sedimentary environmental reservoirs developed in different positions of a basin. The lithology, burial history, geothermal conditions and formation fluid are diverse, yielding the evolution characteristics of reservoir property are different. The main goal of this paper is to study the evolution of reservoir property in different conditions by using physical simulation methods, to make up for the blank zone of sedimentary sand bodies vertically and discover the errors of using present porosity and permeability data to inverse the reservoir evolution history. The experiment instrument was designed by ourselves, it simulated the overburden pressure during the diagenetic process by using the pressurization system, and simulated the formation temperature by using the heating system. It can measure the changes of porosity and permeability in different temperature and pressure condition during the diagenetic process at the same time, so that we can simulate the diagenetic process and evolution mechanism of reservoirs. Our experiments took Dongying depression as the study area and selected the sands sample at the beach of Qingdao, which parent rock is in accord with the stratum. We simulated porosity and permeability parameters of reservoirs in four conditions, namely different lithology, formation fluid, burial history and geothermal gradient respectively. Then we obtained the experimental data, formed the corresponding maps and built regression equations.
Analyzed all experimental results, we drew the following conclusions: (1) Porosity presents logarithm relevant and permeability has exponent relation to grain size. If only consider the reservoir lithology, with the same provenance, similar sorting and psephicity, porosity will increase while permeability decrease with an increase on grain size; (2) Actuation duration of pressure is linear with porosity. With acidic formation fluid, the compressive ability of the rock is the worst. But in certain conditions of temperature and pressure, acidic fluid can make the reservoir forming secondary pores; (3) Porosity has exponent relation to temperature. Rapid burial can save considerable porosity. Without considering other diagenesis, the longer the burial time is, the worse the porosity and permeability parameters are; (4) The higher the temperature gradient is, the higher the porosity reduction rate with burial depth is.

Sequence stratigraphy characteristics of Carboniferous-Permian in Beishan and its surrounding areas, across Inner Mongolia Autonomous region, Gansu province and Xinjiang Autonomous region

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Beishan and its surrounding areas are located in tectonic intersectant area of northern China plate, Tarim plate, Kazakhstan plate and Siberia plate, in stratigraphic transition zone of the Carboniferous–Permian of Inner Mongolia and Tianshan, and in paleogeographic intersection area of Paleoasian Ocean and Paleo-Tethys Ocean. The research on Sequence Stratigraphy has important practical significance about the region evolution, the oil and gas geological conditions and its resource potential.
Based on a large number of field geological surveys, it shows that, in this study area, the identification of sequence interfaces of Carboniferous–Permian mainly includes: unconformity surface, ancient weathering surface, lithofacies mutation surface, the transformation surface of parasequence superimposed style and trace element abundance. The Carboniferous–Permian is divided into seven second-order sequences and eighteenth third-order sequences (including eight Type-sequences and ten Type-Ⅱ sequences.
The transgressive system tracts (TST) are the main part of the Carboniferous–Permian sequence. Lowstand system tracts (LST), shelf marginal system tracts (SMST) and highstand system tracts (HST) account for a small proportion. Transgressive system tracts (TST) are mainly composed of shallow sea shelf clastic facies, carbonate platform facies and limited bay facies. Shelf marginal system tracts (SMST) are mainly composed of open coast facies. Lowstand system tracts (LST) are mainly composed of alluvial fan systems, braided delta systems and fan delta systems. Highstand system tracts (HST) are mainly composed of open coast facies, braided delta facies and carbonate platform facies. The parasequence includes four kinds: coarsening-upward parasequences, fining-upward parasequences, interbeds of clastic rocks and carbonate rocks and interbeds of volcanic rocks and carbonate rocks parasequence.

The development of large-scale sand bodies within transfer zones in a deep water basin: A case study of the Changchang-Heshan Depression in South China Sea

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Structural transfer zones are common phenomena in the South China Sea (SCS). Present day oil and gas exploration considers transfer zones usually to be the entrance of provenance and control the distribution of large-scale sand bodies. This paper analyzes the correlation between the structural transfer zone and the presence of sand bodies within Changchang-Heshan depression, which belonged to the deep water basin in SCS, to determine the favorable conditions of formation for large-scale sand bodies.
Within the past decade, the Baiyun and the Liwan depressions, both of which are near the study area, have had favorable oil and gas exploration results. The theory of the “Control action of transfer zone on sand body development” applies well to these areas. The study area has the characteristic of a “self-source rock and self-reservoir” in paleogene Wenchang formation and Enping formation. As the source rocks and reservoirs are always found together, the large-scale sand bodies are easy to be good reservoirs containing oil and gas.
First, based on 2-D seismic data of the study area, two degrees of structural transfer zones were classified into four types, according to scale and focusing on their faults inclinations and terminations: the synthetic approaching, the synthetic overlapping, the antithetic overlapping, and the collateral. Second, under the theory of the “from source to sink”, the sedimentary sequence and the development of the sand bodies were considered to be controlled by the structural transfer zone. Third, the scale and type of the sand bodies were quantified on the basis of seismic data and then source rocks can be confirmed around the sand bodies. The study determined that development of the largest scale of sand body was controlled by the synthetic approaching structural transfer zone. This type of transfer zone formed wide and flat provenance channels which stemmed from river systems of each direction and ultimately formed a braided delta. The delta can be identified for its typical S-type and complex progradational reflection in seismic sections. Each structural transfer zone had specific characteristics, such as the influence of the synthetic overlapping structural transfer zone and the extent of sand body approximately parallel to fault strike. The greater the degree of overlap of the faults, the more parallel the sand bodies ran to the fault strike. In the antithetic overlapping structural transfer zone, the provenance channels were narrow and steep and easily formed a fan delta. In the collateral structural transfer zone, the distribution of sand bodies was confined by two collateral faults, so the development of the sand bodies was determined by the distance between terminal faults.
This paper establishes the relation between the structural transform zone and the genesis of large-scale sand bodies. Studying the style, scale, and combination of structural transfer zones were found to be critical for evaluating large-scale sand bodies when no drilling wells are possible. Overlapping structural transfer zones and their associated sand bodies should be targeted as areas of future oil and gas explorations.

Petrographic, mineralogic and geochemical properties of Yeniceoba-Cihanbeyli Tertiary Basin-fill deposits

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Central Anatolia contains a number of Tertiary basins, that is bounded by large tectonic belts (Taurides to the South, Pontides to the North), and located between the important basins (Tuzgolu and Haymana). The Yeniceoba-Cihanbeyli Tertiary Basin, represented by three formations, Gokdag (Late Oligocene), Cihanbeyli (Kuşca Member - Middle Miocene) and Insuyu (Late Miocene-Early Pliocene) respectively. This study deals with gypsum of Gokdag Formation, alternating dolomitic limestone, tuffite and tuffitic sandstone of Kuşca Member and rhizoliths of Insuyu formation. According to field observations, petrographic and SEM (Scanning Electron Microscopy) studies, three types of gypsum occurences has been defined as alabastrine, porphyroblastic and satin-spar, which also contains some late diagenetic celestite mineralizations. Kusca Member has been divided into three facies. These are tuffite, sandstone and dolomitic limestone. Mineralogical (XRD) and petroghraphical analysis reveal considerable amount of ophiolithic-derived contribution in the tuffite and sandstone facies. The unit is conformably overlained by Insuyu Formation which contains alternating highyl porous rhizoliths, plant-dominated calcrete and red/grey mudstone.
The isotope measurements of the gypsum of Gokdag Formation yield $^{87}/^{86}$Sr:0.707663 to 0.707768, which are compatible with those of Oligocene marine water, it is also supported by palinologic dating. Kuşça Member and Insuyu formation yields negative values of δ^{13}C (-0.4 to -8.0) and δ^{18}O (~-3.8) and δ^{13}C (-2.2 to -7.1) and δ^{18}O (-1.6 to -6.8), indicating low salinity fresh water environment with minimal biogenic activity.

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Aggradational lobe fringes in deepwater turbidite systems: The influence of subtle intrabasinal seabed topography on sediment gravity flow processes and stacking patterns

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The behaviour of sediment gravity flows is strongly influenced by underlying seabed topography over a wide range of scales. The long-term impact of subtle intrabasinal seabed topography on the facies distribution and sediment dispersal patterns in a 100 - 300 m thick succession of basin-floor lobe deposits has been investigated in Unit A, Laingsburg Formation, Karoo Basin, South Africa. Unit A comprises six sand-prone lobe complexes (A.1 – A.6) separated by regional mudstone intervals that record basin-wide shutdowns in sand supply. Logged outcrop sections and core from research boreholes over a 22 km S-N depositional strike transect permit changes in sedimentary facies and thicknesses to be documented within each lobe complex.
Sand-prone deposits are limited to the southern part of the study area. Laterally extensive chaotic silt-prone intervals pinch out to the SE. The most northerly outcrops display silt-prone thin-bedded successions that share close facies affinities with submarine levee deposits identified in other parts of the stratigraphy. Overall, the thickness of Unit A decreases to the NW from 300 m to 100 m as the proportion of deformed strata increases. Northward changes in facies associations and thicknesses are interpreted to have been caused by a low angle (<0.7°) SE-facing intrabasinal slope that created lateral confinement across strike to the NW. Thin-bedded deposits to the north are successively sand depleted because the confining slope induced rapid deposition of dilute parts of sediment gravity flows and aggradational stacking of lobe fringes. Chaotic deposits are interpreted as slides and debrites that were sourced from the NW down the SE-facing intrabasinal slope. Deposition of aggradational lobe fringes occurred higher on the intrabasinal slope than the silt-prone debrites and slides.
This facies association is suggested to be characteristic of the lateral fringes of weakly confined lobes, and inferred to help confine the flows on the basin floor. Observations made in Unit A can be used as analogues for hydrocarbon reservoirs where subtle seabed topography can strongly influence the distribution of sedimentary facies and hence reservoir quality.

Late Cretaceous tectonics vs. sedimentation within the Miechów Trough (SE Poland), or how inversion of the Alpine foreland shaped local depositional systems

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The Miechów Trough forms SE part of the Szczecin-Łódź-Miechów Synclinorium that developed along the SW flank of the Mid-Polish Swell, major Alpine (Late Cretaceous–Paleogene) inversion structure in Poland. This study was focused on the role which local tectonic processes might have played in forming the Upper Cretaceous sedimentary cover of the Miechów Trough. It was based on relatively dense coverage of 2D seismic data, well logging data, gravity data (Bouguer anomaly maps) and on geological information derived from outcrops and other sources. Precise well calibration of seismic data necessary for detailed seismostratigraphic interpretation was achieved using check-shot data and synthetic seismograms, constructed using measured and calculated sonic and density logs. Various well logs were used to precisely delineate thickness and lithological characteristics of the Upper Cretaceous succession.

The Upper ?Albian–Cenomanian succession consists mostly of siliciclastics (conglomerates, sandstones and glauconitic sands) while Turonian–Maastrichtian succession is dominated by carbonates; limestones, marls and opokas. Increased influx of the terrigenous quartz and glauconite is observed in the Santonian. The peak transgression in the Early Turonian and following subsidence acceleration (Middle Turonian) brought overall homogeneity of facies.

The ?Albian–Santonian interval is characterized by numerous stratigraphic gaps and unconformities, which could have been a result of the mid-Late Cretaceous tectonic movements and regional variations in the subsidence rate. In the NE part of the Miechów Trough subsidence was most likely faster than in the SW part. More continuous sedimentation that characterizes the Campanian may be due to the constant rate of subsidence over the entire basin. Increased content of terrigenous quartz in the Lower Maastrichtian carbonates may have been caused by onset of the Alpine inversion.

Interpretation of seismic data and gravity maps allowed to defined major tectonic grain that has partly controlled Late Cretaceous sedimentation within the SE part of the Miechów Trough. It consists of three NW-SE oriented mostly reverse fault zones rooted in the Paleozoic/Precambrian basement (Opatkowice, Zagość and Kostki Małe fault zones). These fault zones are mostly associated with typical inversion anticlines developed within the Mesozoic (Triassic–Upper Cretaceous) cover. Cenomanian formed N-S elongated sub-basin with thickness distribution independent from these three main tectonic fault zones. Ensuing Late Cretaceous sedimentation seems to have been at least partly controlled by local tectonics, as localized thickness changes defining syn-kinematic strata are directly associated with fault zones. Localized thickness increase within the fault-related inversion anticlines could be observed up to the Lower Campanian which testifies extensional character of these faults and associated localized subsidence. Along the Kostki Małe fault zone rapid change of the kinematic characteristic and transition from extension to compression could be observed. This suggests significant role of strike-slip movements along this fault zone. Final pulse of the inversion tectonics must have taken place in the latest Maastrichtian–Paleogene but all the associated syn-kinematic cover has been eroded from the uplifted hinges of the inversion anticlines.

Photosymbiosis and the geologic evolution of reefs and carbonates

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Reef organisms are well known to engage in photosymbiosis. This process provides metabolic advantages and rapid growth to to the host, produce massive calcification for the host and protection for the algal symbionts. Photosymbiosis has stimulated the evolution and extinction of reef systems from the Proterozoic to the Cambrian until the Recent. This process has been most evident in tropical, shallow-water oligotrophic settings. Direct access to the sun's energy created strong selective pressures producing the algal-host symbiosis in polyphyletically distinct algae and host organisms and at multiple times over geological history. Photosymbiosis likely accounts for the remarkable reef growth and carbonate sedimentation in the tropics through time. The algae-host symbiosis is difficult to demonstrate directly in fossils because the symbionts do not fossilize. However, the presence of photosymbiosis in selected fossils and fossil groups is a working hypothesis based on modern photosymbioses and on specific morphologic adaptations, stable isotopes, photosynthesis. Large size, massive skeletons, unusual or complex morphology, and tropical paleobiogeography indicate that photosymbiosis has a long geologic history. Stable isotopic analyses have been used to demonstrate photosynthetically influenced carbonate secretion by the hosts in some well-preserved scleractinian corals and foraminifera. Photosymbiosis can be assessed as a driving force in reef evolution through careful analysis of the characteristics of organisms and reefs. Photosymbiosis is strongly indicated in the Late Ordovician to Devonian reef interval, during the late Paleozoic, early Mesozoic and during the Cenozoic. Early Cambrian reefs indicate photosynthetic primary producers but with somewhat weaker evidence of photosymbiosis. Photosymbiotic reef ecosystems appear to have collapsed during mass extinctions and these failures were driven by the demise of the symbiosis or extinction of the symbionts. In these cases, reef gaps in the geologic record indicate the breakdown of photosymbiosis as a contributing factor in reef extinction. Reef extinctions were closely synchronous with mass extinctions of other marine organisms and terrestrial biotas. This fact suggests that an all-pervasive factor affected all ecosystems. Such a factors as the rising CO_2 in the atmosphere and oceans as a result of the release through volcanism is indicated clearly in the geologic record of reefs and carbonate deposition. Carbon dioxide emissions into the atmosphere cause warming in the oceans as well, and its dissolution into the oceans promotes the lowering of oceanic pH. In modern seas, warming and acidification take tolls on coral reefs through the exclusion of symbionts from the hosts. Of course, such warming in both the atmosphere and oceans would also influence organisms in other ecosystems as well, thus accounting for the widespread, simultaneous extinctions. Photosymbiosis is recognized as a driving force in reefs and carbonate rocks and in the geologic record is providing important connections with the present day.

Sediment bypass in deep-water systems

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Submarine gravity flows are a key process for transporting large volumes of sediment from the continents to the deep sea. The location, volume and character of the sediment bypassed by these flows dictates the aerial extent and thickness of the associated deposits. Despite its importance, sediment bypass is poorly understood in terms of flow processes and the associated stratigraphic expression. We first examine the relationships between the physical parameters that govern bypass in flows, before assessing the variable stratigraphic expression of bypass from modern seafloor, outcrop and subsurface data sets. Theoretical and numerical approaches distinguish grain size, slope, flow size and sediment concentration as parameters that exert major controls on flow bypass. From field data, a suite of criteria are established to recognize bypass in the geological record. We identify four bypass-dominated zones, each of which is associated with a set of diagnostic criteria: Slope-Channel Bypass, Slope-Bypass from Mass Wasting Events, Base-of-Slope Bypass, and Basin-Floor Bypass. As the expression of bypass varies spatially and is dependent on the scale of observation, a range of scale-dependant criteria are required for robust interpretation of these zones in the field or subsurface. This synthesis of deep-water sediment bypass highlights the challenge in quantitatively linking process with product. The establishment of criteria to recognize sediment bypass, qualitatively linked with flow processes, is an important step towards improving our understanding of submarine flow dynamics and resultant stratigraphic architecture.

Contourite sedimentation in the deepwater Gulf of Cadiz: Principal results & new paradigms, IODP Expedition 339

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The South-western Iberian margin holds an unmistakable signal of Mediterranean Outflow Water (MOW) following its exit through the Strait of Gibraltar. It also represents a key area for understanding the effects of tectonic activity both on evolution of the Gibraltar Gateway (GG) and on margin sedimentation having major implications for global climate and oceanography. Following the Integrated Ocean Drilling Program (IODP) Expedition 339 we present important new results on the evolution of the MOW, the timing and effects of tectonic activity, and the nature and architecture of sedimentation along the Cadiz margin.
Following opening of the Strait of Gibraltar (5.33 Ma) a weak MOW started to flow into the Atlantic about 4.5- 4.2 Ma. It was not until the Late Pliocene and early Pleistocene that an enhancement of MOW circulation into the North Atlantic occurred, evidenced by two significant events at 3.2-3 Ma and 2.4-2.1 Ma marked by widespread depositional hiatuses. The Quaternary succession shows a much more pronounced phase of contourite drift development, with two periods of MOW intensification separated by a hiatus at 0.9 Ma. Dominant alongslope processes, coupled with downslope inputs have established the slope architecture we see today. MOW significantly contributed to an enhancement of the Atlantic Meridional Overturning Circulation (AMOC) and, consequently, to global climate.
Tectonic controls on margin development are evidenced by the closure of the Atlantic-Mediterranean gateways in Spain and Morocco just over 6 Ma, the opening of the Gibraltar Gateway at 5.3 Ma, downslope sediment transport and contourite drift evolution. Based on the timing of events recorded in the sedimentary record, we propose a tectonic pulsing in the region at a timescale of approximately 1 My, linked with asthenosphere activity.
The Gulf of Cadiz is the world's premier contourite laboratory and thus presents an ideal testing ground for the contourite paradigm. Following examination of over 4.5 km of contourite cores, the existing models for contourite deposition are found to be in good working order. Their further study has begun to allow us to resolve outstanding issues of depositional processes, drift budgets, and recognition of fossil contourites in the ancient record onshore. The expedition also verified an extensive distribution of clean and well sorted contourite sands, covering >4000 km^2 along the mid-slope terrace and contourite channel network. These represent a completely new and important exploration target for potential oil and gas reservoirs. Preliminary work has shown a remarkable record of orbital-scale variation in bulk sediment properties of contourites at several of the drift sites and a good correlation between all sites. The climate control on contourite sedimentation is clearly significant at this scale; further work will determine the nature of controls at the millennial scale.

Quantitative assessment of reservoir quality in thin-bedded turbidite facies

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Variation in the degree of heterogeneity in hydrocarbon reservoirs has significant impact on fluid flow during production and may lead to bypassed oil being trapped in low-permeability reservoir compartments. This is particularly critical in producing from marginal turbidite fields with significant thin-bedded turbidite (TBT) successions.
Principal geological attributes of TBTs have been extracted from a large number of studies of modern, ancient and subsurface systems. These attributes include: facies and facies associations; sand-shale ratio; sand/shale geometry and dimensions; sand connectivity; sediment texture; small-scale sedimentary structures; and small-scale vertical sequences of bed thickness. Combination of these attributes enables definition of four fundamental attribute indices that influence reservoir quality of TBT successions and consequently impact vertical and horizontal hydrocarbon fluid flow in producing turbidite reservoirs. The attribute indices are: (1) the Sand Connectivity Index (SCI), derived from the nature of bed/lamination cross-cutting relationships, which is useful in the prediction of sand continuity and connectivity; (2) the Sediment Textural Index (STI), derived from the mean grain-size property, which provides insight into sediment maturity, transport and depositional history; (3) the Facies Ratio Index (FRI), derived from Bouma/Stow sequence combination and selected facies ratios, which helps prediction of facies distribution and energy regime of the depositing turbidity current; and (4) the Micro-fracture index (MFI), derived from the micro-fracture density, style and distribution, which is useful as a predictor of fracture-induced porosity capable of affecting fluid flow in hydrocarbon reservoirs.
This approach has been applied to subsurface core data from eight North Brae Field wells to assess reservoir quality of sand/silt parts of the TBT. A combination of results, including analysis of backscattered electron (BSE) images, reveals that facies association 1 (FA1) is characterised by high-to-very high connectivity index and texturally mature, fine to medium-grained, moderately to well-sorted sand. In addition, core-based porosity, horizontal and vertical permeabilities indicate that it has the best characteristics favourable for development in producing turbidite fields. This is followed by FA2, for which vertical connectivity constitutes a major risk in the presence of shale lamination. FA3 is a promising reservoir-quality facies, particularly where sand percentage and SCI are over 60% and 40%, respectively. FA4 comprises texturally mature, fine to medium sand grains that are largely well sorted. However, very low SCI constitutes a big risk to vertical fluid flow. Facies associations 5 and 6 are not considered suitable for conventional reservoir development but may represent favourable candidates for shale gas exploitation.

From turbidites to debrites – the upper Godula Formation vs the lower Istebna Formation (Late Cretaceous, Silesian Succession, Western Flysch Carpathians)

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The Upper Cretaceous (Coniacian–Maastrichtian) deep-marine depositional systems were interpreted from the Upper Godula Beds (upper Godula Formation) and the Lower Istebna Beds (lower Istebna Formation). The sedimentary successions of these formations crop out over large areas of the Silesian Nappe in the Western Flysch Carpathians. Their flysch-type siliciclastic deposits were studied in the Moravian-Silesian Beskids and in the Silesian Beskids (Czech and Polish Outer Carpathians).

The upper Godula Formation is dominated by a sandstone-mudstone facies association (S-M). The S-M sequences consist of relatively laterally continuous sandstone and mudstone couplet interbeds. The S-M deposits are composed of thin-bedded, fine-grained, normally-graded sandstones, typically with flute casts and usually a ripple-laminated top, with mudstone intercalations.

The S-M succession is overlain by the lower Istebna Formation deposits, represented primarily by a sandstone-conglomerate facies association (S-C). The S-C contains sandstones, gravelly sandstones, sandy conglomerates and conglomerates, mainly composed of thick, massive, amalgamated, irregular and discontinuous complex bodies, without clay-silt interbedding. There are also subordinate gravelly mudstones and synsedimentary-deformed deposits.

Depositional conditions likely changed significantly near the Santonian Campanian boundary within the Silesian Basin (one of the outer Carpathian subbasins). Initially, in the southern facial zone, rhythmic sedimentation took place, generated by pulses of fluid-sediment gravity flows. Turbidity current sediments were related to a channelized piedmont ramp. The siliciclastic ramp was formed by overlapping "underfed" fans, consisting of outer lobe- and fan fringe sheet deposits. Hemipelagic sedimentation and tractional bottom-current seabed reworking have also contributed to the development of the lithofacies architecture.

The orderly turbidite system was replaced by a chaotic debrite system. In the new depositional regime, sedimentation was mainly controlled by quasi-laminar and hydroplastic debris flows. Influenced by surface deconcentration and elutriation, such flows could partially transform into turbulent suspensions, resulting in hybrid deposition (debrite-turbidite hybrids). A linearly sourced, essentially non-channelized deep-water slope apron was built by coalesced lithosomes forming high-relief apron slope covers. The apron development resulted from mass redeposition, activated along the overburdened shelf-edge zone and on the proximal slope. The sandstone-to-conglomerate debrites and gravelly mudstone debrites were created via deep-water gravity-driven sedimentary processes, dominated by sandy-gravelly and muddy-sandy-gravelly mass movements, evolving into mass flows. One activated gravity sedimentation process (a single sedimentary event) released local material, which created a "chain reaction" and mass resedimentation in the basin (overlaps of various events and processes ultimately forming composite bodies). Secondary members of the apron architecture were relatively small, unstable cut-and-fill structures (wash-out, chute/channel) intersecting the basin slope covers.

The transition from a turbidite depositional system to a debrite system can be explained by the increase in orogenic activity continuing in the Alpine Tethys, and its repercussions reflected in the Carpathian province. The tectonic reorganization caused intensified diastrophic activity of the source areas (rotational uplift and increased denudation), including the elongated Silesian Ridge blocks (one of the sub-ridges separating Carpathian subbasins) supplying the Silesian Basin half-graben. Tectonically enforced relative regression, contributing to the uncovering of older basin sediments, with a simultaneous slope angle increase, resulted in effective mass redeposition.

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The impact of post-Little Ice Age glacier retreat and paraglacial landscape transformation on coastal evolution in Svalbard

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Understanding the mechanisms that control High Arctic coastal zone evolution is crucial to enable the deciphering of landscape changes and associated shifts in sediment fluxes triggered by climate change.
The gravel-dominated barrier coastlines of the Svalbard archipelago provide an excellent location to examine the processes that control High Arctic coastal change. Of special interest are the mechanisms by which polar coasts respond to enhanced landscape change following deglaciation, including those associated with the abrupt climate warming observed since the end of the Little Ice Age (LIA).
Paraglacial processes operating on Svalbard have already reduced glacial processes to a secondary role in controlling landscape change as a result of post-LIA warming. This change is apparent in slope, valley floor and glacier foreland systems, where glacigenic landforms are being denuded by fluvial, aeolian or mass-wasting processes that are being accelerated by permafrost degradation. However, the impact of these changes on the coastal zone is uncertain because of few studies of pre- and post-LIA coastal change.
Existing sediment budget studies in Svalbard have focused attention on quantifying the volumes of sediment transported by glacial rivers and derived from glacier erosion and reworking of fluvial catchment sediment. Little attention has been paid to the functioning of sediment storage and reworking systems within coastal zone.
Our research aims to address this deficiency by improving our understanding of the mechanisms of recent adjustment of the High Arctic coastal zone to non-glacial conditions. In this paper, we summarize the results of several coastal studies carried out by Polish and international research teams along paraglacial coast of Svalbard during the last 20 years.
We reconstruct the post-Little Ice Age evolution of coasts in western, central and southern Spitsbergen to illustrate the highly variable coastal zone responses to paraglacial landscape transformation associated with recent glacier retreat. Our results document dramatic changes in sediment flux and coastal response under intervals characterized by a warming climate, retreating local ice masses, a shortened winter sea-ice season and melting permafrost. Our research was based on a combination of methods including aerial photogrammetric and GIS analyses, sedimentological tests of coastal deposits and field-based geomorphological mapping in Billefjorden, Tempelfjorden, Bellsund and Hornsund.
The study highlights the need for a greater understanding of the controls on High Arctic coastal sediment budgets, especially given the potential for future accelerated warming and sea-level rise.

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Upper Pleistocene to Holocene sequence stratigraphy of a sea-connected inland collapse basin: The Taipei Basin, Taiwan

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Taipei Basin is a fault-bounded half-graben located in the northern Taiwan orogenic belt and developed since ~400 ka ago due to tectonic collapse after the orogeny. Up to 140 meter-thick sediments have been accumulated for the past 50 ka. This upper Pleistocene to Holocene fluvial to estuarine sediment package reflects the competing effects of fault-controlled tectonic subsidence, variations of eustatic sea levels and sediment supply. We apply facies analysis and radiocarbon dating on cores retrieved from tens of boreholes in the basin. Published data on foraminifera is also used to better characterize paleo-environments. With these data, we are able to establish a robust sequence stratigraphic framework for the studied succession. Our results indicate that thick lowstand systems tract (LST) of mostly fluvial conglomerates, spanning the age of 45-22 ka deposited during lowstand of eustatic sea levels are well preserved. The overlying transgressive systems tract (TST) (around 30-8 ka in age) are of meandering and estuary origins with anomalously thick sediments near the basin-bounding fault, indicating high rates of basin subsidence due to normal faulting. The facies patterns of TST are similar with open-coast estuaries though the Taipei Basin is an inland basin where the estuary, characterized by low tidal and wave activities, was connected with the seawater by a ~10 km long tidal channel, the paleo-Tamsui River. The maximum marine flooding occurred around 8 ka, around 2 ka earlier than the earliest highstand of eustatic sea level, which is of 6 ka. The rate of sediment supply has subsequently outpaced the rate of tectonic subsidence since ~8 ka, resulting in the filling up of the estuarine collapse basin to become fluvial settings with a network of tidal channels to form the highstand systems tract (HST). Local unconformities near the base of HST are found in the areas away from the basin-bounding fault, interpreted to result from tectonic tilting of the downthrown block. This study provides an example for facies and sequence stratigraphic development for a sea-connected and active inland collapse basin, yielding insights on the competing effects on sedimentation between rates of fault-controlled basin subsidence, eustatic sea-level changes and sediment supply.

Euxinic conditions and high sulfur burial in the Alpine Tethys during the Toarcian Oceanic Anoxic Event

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The Toarcian oceanic anoxic event (T-OAE; 183 Ma) was accompanied by severe biotic and geochemical perturbations that are considered as some of the most severe of the Mesozoic era. Nevertheless, paleoceanographic conditions during the T-OAE remain poorly understood owing to the relatively low number of marine successions investigated so far. In this study we report new geochemical data and pyrite framboid size measurements from the marine section of Zázrivá, northwestern Slovakia, which was deposited in the poorly studied Alpine domain of the Tethyan Ocean. The lowermost *serpentinum* ammonite Zone records high total organic carbon (TOC) contents (2 to 5 wt.%) and very low organic carbon isotope values (between –30 to –32‰) characteristic of the T-OAE interval in coeval sites. The size of the pyrite framboids, the high S contents independent of TOC and low sulfur isotope values ($\delta 34S<–15‰$) indicate that the deposition of this interval took place under sulphidic and anoxic conditions (euxinia) interrupted by brief events of improved oxygenation. The total sulfur contents are exceptionally high (4-12 wt. %), a feature that can be explained by the combination of high detrital input and euxinic conditions that supplied elevated amounts of sulfur and reactive iron for enhanced syngenetic pyrite formation. These results suggest that basins of the Alpine Tethys may have accumulated considerable amounts of sulfur and carbon during the T-OAE.

Dinoflagellate cyst stratigraphy of the menilite shale beds from the Skole and Boryslav-Pokuttya Units, Outer Carpathians (Aksmanice outcrop) – a preliminary results

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Transition zone of external parts of the Skole, Boryslav-Pokuttya and Stebnik Unit, Polish Flysh (Outer) Carpathians, contains flysh sequence with frequent interbeddings of menilite beds from the Oligocene and Early Miocene. The area of study is located at Aksmanice, on the south of Przemyśl, in south-eastern Poland, close to the border with Ukraine. Due to common occurrence of well-preserved microfossils (dinoflagellates, silicoflagellates, nannoplankton, foraminiferas), this lithostratigraphic unit has been an object of palaeontological studies for over 100 years. The menilite beds yield high amount of palynological organic matter and are the principal source rocks for hydrocarbons across the Carpathian Belt area. These deposits are mainly represented by various lithology: siliceous black shales, dark-red and grey mudstones, nearly all types of sandstones, cherts, siliceous marls, also some sections are composed largely of thin limestone beds. Layers were strongly disrupted by the tectonic processes caused by folding and overlapping Outer Carpathians Nappes during final stages of alpine orogenesis.
The aim of the study is to carry out biostratigraphy and confirm age of layers of untcertain age from Aksmanice outcrop. 17 samples selected from forty-three recovered from the menilite beds were processed and analyzed for organic walled dinoflagellate cyst (dinocyst).
Dinoflagellates are excellent tool used in biostratigraphic analysis: they are widely spread around the globe and are well preserved in deposits. Palaeoecological analysis of dinocyst assamblages from Aksmanice suggest a middle shelf environment. *Wetzeliella* and *Deflandrea* found in studied samples prefers brackish water, but can also spread in relatively high nutrient ocean environment. The appearance of *Wetzeliella gochtii* in some samples indicate Rupelian (lower Oligocene) is the age of beds from Aksmanice outcrop. In palynological maceration residue also occurred other palynomorphs - algae and sporomorph.

Application of an integrated geophysical approache to analysis the coarse sedimentary sequences based on the well-log, seismic and 3D Magnetotelluric data

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How do you analysis the sedimentary sequences of very coarse sediments, if only some field outcrop, well-log and seismic data in the subsurface. Exactly, I have come crossed such problem. From the filed outcrop, we could confirm that there are all conglomerate deposits in those three strata at the north of Kuqa depression, which is the latest foreland basin in China. But the outcrops were all at the margin of the basin, so how to study the subsurface conglomerate sediments in middle of the basin, with some discrete wells and its borehole log and some seismic data. Finally, we propose an integrated approach by using 3D Magnetotelluric survey, and also well log and seismic data. Because we find out that high resistivity was often corresponding to conglomerate layers and the correlation is very clearly. So, we could use well log to calibrate the resistivity value range of different rocks and sedimentary facies, use the seismic data to build the strata framework, and at last build the lithology framework of conglomerate layers by interpreting the 3D Magnetotelluric profile. After we finished the first trial of that integrated approach in the Cenozoic of Kuqa depression, we could confirm that it is a very effective method to study conglomerate distribution. According to the distribution characteristics, we believe that the formation, distribution and scale of conglomerate were controlled by tectonic, topography and supply of provenance (TTS), which formed three tectonic-sedimentary fan models in Kuqa depression.

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Reservoir architecture analysis of shallow delta plain of the 4th member of Quantou formation in Fuyu oilfield

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The 4th member of Quantou formation is typically deposited in shallow water delta. Take block 19-7 in western area of Fuyu Oilfield for example, make full use of core data, log data, production performance and other information, analyzes and summarizes characteristic of different levels of architecture interface. Shallow delta plain distributary channel stacked vertical, horizontal contiguous. The type of architecture interface is divided into argillaceous, calcareous, boulder clay layer and physical mutation interface. Level 6 architecture is equivalent to the set of complex channel systems or river valley, level 5 architecture is equivalent to micro-facies, level 4 architecture is equivalent to a single channel, level 3 architecture is equivalent to the interlayer in a single channel. The interlayer in a single channel approximate horizontal distribution, the well space the interlayer can be contrasted is about 100 m. Using reservoir architecture analysis methods, analyze the reservoir architecture of shallow delta plain level by level, focus on level 3 and 4, establish a three-dimensional model of reservoir architecture in the end.

Temporal and spatial distribution of radiolarites in the Northern Calcareous Alps

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Radiolarites in the Northern Calcareous Alps are geomorphologically not conspicuous like the Triassic limestones, but they show significant amount among another lithologic bodies, especially in the Jurassic. In the Middle-Late Jurassic the trench-like basin fills (carbonate-clastic radiolaritic flysch) could reach a thickness of about 2000 metres, but radiolarites cover in Callovian-Oxfordian time practically the whole area of the Austroalpine in varying thickness. These radiolarites vary sedimentologically from black, greenish to red ribbon-like radiolarites and greyisch fine-laminated turbiditic variations. They often overly condensed red nodular limestones of the Klaus Formation. Here especially the radiolarite sections with underlying red nodular limestones, dated with ammonoids, play an important role to calibrate the existing radiolarian zonations. We present such key sections in the Northern Calcareous Alps, i.e. the Brielgraben section (middle Callovian), the Klauskogelbach section (lower Callovian) and the Fludergraben section (Oxfordian) of the Salzkammergut area.
By the results of age determination we have clear insight of radiolarites importance for tectonic evolution of the Northern Calcareous Alps resp. the reconstruction of the Middle to Late Jurassic compression. The radiolarite basins in the southern part of the Northern Calcareous Alps were formed in sequence, indicating propagating nappe thrusting. In these basins radiolarites act as matrix for huge bodies of reworked carbonates: some slide complexes can reach km^2 size, olistostromes are a typical feature. Later these basins fills were incorporated in the nappe stack and called the Hallstatt and Tauglboden Mélange.
It is very important to note, that the onset of radiolarite deposition is not contemporaneous. In the southernmost Northern Calcareous Alps, where the first trench-like basins were formed due to the propagating nappe front, radiolarite deposition started in the Bajocian/Bathonian. The next generation of basins was formed in the Callovian and carry the most important part of the Hallstatt Mélange. More to the north the trench-like basins were formed around the Callovian/Oxfordian boundary (Tauglboden Mélange). On top of the nappe stack a Kimmeridgian to Berriasian carbonate platform pattern evolved (Plassen Carbonate Platform). Therefore radiolarite deposition in the remaining trench-like basins changed to calcareous radiolarites or cherty limestones partly rich in *Saccocoma*, especially in the Hallstatt Mélange areas. More to the north, radiolarite deposition prevailed until in earliest Tithonian. In that area of the Tauglboden Mélange the transition from radiolarite to more calcareous deposition is of late Early Tithonian age. North of the Tauglboden Basin again a carbonate platform evolved in the Kimmeridgian and influenced the northernmost Northern Calcareous Alps.

Provenance signals in Early Palaeozoic sandstones in the Lublin Basin (SE Poland): From passive margin to collision suture

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The petrography of 22 samples provided by Orlen Upstream from Early Palaeozoic sandstones in the Lublin Basin has been investigated to determine their provenance and basin tectonic setting. Modal abundances in the sandstones were determined by point counting of 200 to 450 grains per thin-section. To minimize the effect of grain size variations rock fragments were counted using the Gazzi–Dickinson method. Grains < 0.03 mm were assigned to matrix.
Middle Cambrian as well as Early sandstones are well sorted arenites comprising rounded to very well rounded grains. Late Ordovician siliciclastics represent mainly poorly sorted diamictites comprising thin sandy laminae composed of angular to sub-angular framework grains. On the other hand, Late Silurian sandstones are poorly sorted wackes comprising angular to sub-angular grains. In terms of framework grains and textural maturity these rocks define three groups: MC - Middle Cambrian and Early Ordovician, LO – Late Ordovician and LS – Late Silurian. Sandstones of group MC are dominated by monocrystalline (mean ca. 70%) and polycrystalline (mean from 7 to 13%) quartz grains. Micas and feldspars are occasionally present, whereas no rocks fragments are observed. Group LO arenites differs from group MC mainly by slightly lower amount of monocrystalline quartz (mean 65%) as well as somewhat greater amount of feldspars (mean 2.5%) and lithic sedimentary grains (mean 1.0%). It contains similar to group MC amount of polycrystalline quartz (mean 12%). Framework grains of group LO comprise mainly monocrystalline (mean 21%) as well as polycrystalline (mean 12%) quartz grains and feldspars (mean 12%). Mean total value of volcanic, sedimentary and metamorphic grains reach up to 9%. The mineralogical maturity expressed quantitatively by the mineral maturity index (MMI, ratio between silicate grains and the sum of feldspar and lithic fragments) systematically decreases up the stratigraphic profile from 103 - 120 for MC sandstones, through 27.5 for LO group sandstones to 2.1 for LS wackes.
The results of this petrographic study clearly indicate that the analyzed sandstones are compositionally diverse and were probably derived from at least two different sources. Middle Cambrian up to Late Ordovician quartz arenites were derived from the continental block/craton interior. This is in accordance with high MMI of these rocks exceeding 19. On the other hand, petrography of framework grains of Late Silurian wackes suggests collision-suture and fold-and-thrust-belt source. Moreover, these rocks represent immature sediments as shown by their lower than 3 MMI. Therefore, we suggest that sediments deposited during Middle Cambrian to Late Ordovician most probably records transition from deposition on a stable craton to extensional setting related to development of a passive continental margin of Baltica. This is reflected in shifting the maturity index towards lower values up the stratigraphic profile. Contrastingly, Late Silurian wackes were most probably deposited in a compressional context in a foreland basing situated in front of Caledonian orogeny formed in response to collision of Baltica with Avalonia.

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High resolution sedimentary and landform record of glacial post Little Ice Age activity from Hornsund fjord, Svalbard

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The southern Spitsbergen (European Arctic), due to its position next to oceanic polar front, is particularly sensitive to ongoing climate changes. One of their most spectacular effects is the rapid retreat of tidewater glaciers during the post-Little Ice Age period (after ~1900 AD) observed in many subpolar fjords in Svalbard. It has resulted in formation of new bays in the inner parts of the fjords. In the present study we focused on the inner bays of Hornsund fjord, where three major bays, namely Brepolen, Samarinvagen and Burgerbugta were formed due to glacier recession at an average rate of 1.6 km^2a^{-1}. The goal of this study is to link the historical data on glaciers front positions, glacier surges, climate record with the submarine landforms and high resolution sedimentary record in order to apply the latter to decipher pre-historical climate and glacial changes.
The study is based on high-resolution swath bathymetry surveys with multibeam echo sounder, shallow seismic survey and analyses of twenty six up to 3 m long sediment cores collected with gravity corer during R/V Helmer Hanssen cruise in October 2014. The cores were X-rayed, analysed for basic physical properties (e.g. magnetic susceptibility) and geochemistry (with X-ray core scanner). Selected cores were subsampled for further grain size analyses and ^{210}Pb and ^{137}Cs dating.
The seafloor bathymetry data revealed a number of landforms related to glaciers flow (streamlined bedforms), as well as to glacier margins (annual push moraines). The latter allow for approximate correlation of the historical glacier front positions (measured during summer) and submarine annual moraines (formed during winter). In the sediment cores two type of sediments were found: subglacial till and overlying laminated glacimarine mud with abundant ice rafted clasts. The latter point to high sediment accumulation rate, which is estimated to be on average in order of 1 to 5 cm per year. The thickness of lamina depends mainly on distance from the sediment source and thus reflects fluctuating positions of glacier fronts. The periods of increase ice rafting are likely related to surge events. The combination of physical and geochemical sediment properties with high resolution sediment chronology (based on laminations and dating) proves suitable for deciphering sediment provenance and glacier history in the region. The record is partly mixed due to effects of glacier surges, rainfall events, as well as periods with long lasting sea ice cover. However, analyses of historical data enhanced the interpretation of sedimentary record and provide hints to identify the specific processes and events in the sedimentary record.

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New insights in tsunami hazard assessment in polar regions from studies of the 2000 AD tsunami in Vaigat Strait, west Greenland

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To date, the effects of tsunami have been mainly reported from tropical and temperate regions. Tsunami in polar regions have largely been recorded in fjords, which are particularly prone to hazards associated with landslide-generated tsunamis. The rapid climate warming being observed in the high latitudes is leading to an increase in human activities in the coastal zone, leading to an increased need for hazard assessment. Here we report the geological and environmental effects of a landslide-triggered tsunami that occurred on 21st November 2000 in Vaigat Strait, northern Disko Bugt in west Greenland.
We report sedimentary and geomorphological effects of the tsunami along eighteen coast-perpendicular transects in a range of depositional settings: cliff coasts, narrow to moderate width coastal plains and a coastal lake. At each setting we provide a detailed map using a laser scanner and DGPS survey. The tsunami deposits were described from closely spaced trenches and, from the lake, by a series of sediment cores. At each setting we examined the sedimentological properties of the deposits, as well as their bulk geochemistry and diatom content. Selected specimens of living shrub, *Salix glauca* (greyleaf willow) from inundated and non-inundated areas were collected to assess the impact of the event in their growth ring records. Offshore sediment samples, modern beach and soils underlying the AD 2000 tsunami deposits were sampled for reference.
The observed tsunami run-up exceeded 20 m next to the tsunami trigger – a rock avalanche - and up to 10 m on the opposite coast of the fjord. The inland inundation distance ranged from several tens of meters to over 300 m. The tsunami frequently caused erosion of existing beach ridges. The tsunami deposits mainly comprised gravels and very coarse sand. They were over 30 cm thick close to the coast and in front of inland scarps. The grain size and mineralogical analyses revealed that the major sediment source were the adjacent beach and beach ridge deposits. The tsunami deposits fined landward across the wide coastal plain. However, in narrower settings confined by steep slopes, the deposits revealed coarsening landward, although they originated from beach, suggesting that the sediments were deposited during the tsunami backwash. A characteristic feature related to the tsunami deposits were "mud pats" - up to 1 m in diameter and about 20 cm thick silty deposits - which locally occur on top of the tsunami deposit. They are interpreted as the result of the melting of icebergs washed inland by the tsunami. The tsunami deposits were enriched in saltwater indicators, namely sodium and chloride. The tree-ring analyses of *Salix glauca* samples revealed that the tsunami-impacted area was immediately colonized during the following summer. The results of this study will serve as a guide for further studies of palaeotsunami in polar regions.

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Petrographic evaluation of diagenetic components in Lower Miocene sandstone (Kishartyán, northern Hungary)

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The shallow marine sandstone (Pétervására Fm) was deposited via tidal currents during the Eggenburgian in the North Hungarian Bay. In the area of Kishartyán, erosion of the rocks created spectacular forms, such as bed-parallel, longitudinally-arranged, lensoid overhanging blocks. The goal of this study is to investigate the diagenetic history of this formation and if it is possible to find the relationship between sedimentary structures, diagenetic alterations and the present morphology of the sand bodies.
The sandstone is cross-stratified, burrow mottled or structureless due to bioturbation. Composition varies between subarenite and litharenite, grain size varies between very fine and coarse. The most abundant detrital grains are mono- and polycrystalline quartz. Sedimentary rock fragments, such as cherts and dolomites, and metamorphic rock fragments are also common. Ductile grains are represented by micas, altered volcanoclastic rock fragments and glauconites. The distribution of matrix and cement is heterogeneous and their quantity is variable. Matrix-rich sandstone is usually highly compacted, exhibiting long and concavo-convex grain contacts and deformed ductile grains. Matrix-poor sandstone can be well cemented or can have high open porosity, and in both cases the grade of compaction is moderate.
Circumgranular scalenohedral siderite around detrital dolomite clasts is the first eogenetic cement phase and it is abundant in all the investigated samples. Two different types of mesogenetic ferroan calcite cements were distinguished that postdate chemical compaction. 1. Grain-replacive calcite, which displays gradual transition to commonly zoned calcite spar cement. 2. The successive calcite phase fills the remaining pore spaces and it has either equant mosaic or granular morphology. Its Fe content is higher than that of the earlier phase. Other diagenetic components are albite overgrowths cement and replacement in detrital K-feldspars, K-feldspar and quartz overgrowths cements. In the matrix-rich samples, pore-filling kaolinite booklets and pyrite framboids are abundant; additionally mixed-layer illite-smectite structures are also present.

One basin, three different turbidite systems: Late Miocene, Makó Trough, Pannonian Basin, Hungary

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The Neogene Pannonian Basin surrounded by the Carpathians, the Dinarides and the Western Alps is a mosaic of mostly elongated troughs and elevated highs in between. During Early to Middle Miocene rifting continental to marine settings related to the Paratethys developed. It was followed by long-term thermal subsidence, which led to the formation and maintenance of deep basins, some hosting 6000 m thick sediments untill now. The Late Miocene successions accumulated in the large, brackish Lake Pannon, During the 7 million year history of the lake three different type of turbidite systems evolved, demonstrated by the example of the Makó trough, where the lacustrine record exceeds 4200 m. More than 400 m core, well logs and seismic shows their character.
The oldest turbidite systems deposited when enlargement of the lake area and the increase of water depth occurred. Angular, subangular clast of basement origin indicate local sediment sources and short transport distances in the 11,6-7 Ma interval. The lowermost 500 m consists of siltstones, coarse- to fine-grained sandstones with Bouma-sequences and poorly sorted gravelly, silty sandstones with a variety of soft-sediment deformations. In addition to turbidity currents, sandy grain flows might have been dumping clastics in very short time. The next 500 m is actually a calcareous black marl with significant TOC and points to slow accumulation rates. These marls contain coarse conglomerates variably with clast- and matrix-supported fabric and also various sand beds depositing from debris flows and gravelly- to sandy turbidity currents. As the normal regression of the lake shore 3-400 km far to the north began at about 9.5 Ma ago the marls became clayey. This interval is marked by intercalations of conglomerates, coarse sandstones and a very strange lumpy, silty sandy facies. The latter are interpreted as hybrid even beds (HEB). With the overall regression, at about 7 Ma ago the depositional pattern drastically changed. The delta-shelf-slope feeder system bypassed the largest topographic barrier northwest to Makó trough. Turbidity currents, transporting sand from distal Alpine-West Carpathian sources arrived to the ultimate sink without being trapped in upstream depressions. They covered rapidly the floor everywhere, and in the following 1 Ma basin-centered sandy turbidites, in form of small lobes, stacked to build lobe complexes accumulated up to a thickness of 1000 m in the still deep and narrow trough. HEBs and direction of channels reveal that it was a confined setting.
Finally the topographic differences got mostly eliminated by filling up the depression, and the feeding shelf-slope progressed with 400-500 m high clinoforms. Their upper portion is silty-clayey, however the lower consist of sandstone packages of 30-50 m thick only. This third-type of turbidite system was not confined, reduced thickness of lobes indicate fairly free spreading. Shelf-edge trajectory was either rising or flat, reflecting variations in lacustrine base level and sediment supply. During periods of rise turbidite systems consisted of tens of kms long channel-levees and complex lobes, while during stagnant base-level coarse clastics accumulated directly at the slope toe as simple lobes, or slump units.

Deltaic architecture in the Late Miocene Lake Pannon: Integration of outcrop, well log, high resolution seismic datasets

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Lake Pannon was a large brackish water body in the Pannonian Basin during the Late Miocene. It got filled up by sediments shed from the Alps and Carpathians via fluvial to deltaic feeder systems. A wide morphological shelf developed with inner-shelf to shelf-edge deltas, transiting repeatedly due to recurring floodings. Variations in accommodation, an interplay of subsidence and climatically driven lake-level changes, was reflected by deltaic successions. They accumulated up to 1000 m thickness in basin interiors, and only to 200 m above sublacustrine highs, were space was limited. The largest hydrocarbon field in the Pannonian Basin is in the deltaic suit, therefore hundreds of wells and cores were studied. Deltaic deposits also crop out in 40 m high cliffs, where sedimentary facies, fossils, gamma ray and magnetic susceptibility was recorded. The architecture of the deltaic bodies were revealed by high and ultra-high resolution seismic images acquired nearby during the past decades. Local well data integrated with seismics and outcrops resulted in understanding short and long-term evolution of deltas.
Coarsening upwards units of 2-8 m thickness are made up of cyclic repetition of marls, silts, sands, organic-rich clays or thin lignite seams. The marls contain shell-accumulations above the cycle boundaries which are overlain by an increasing number and thickness of cross-laminated, fine-grained sand beds revealing combined effect of currents and waves. Medium to fine-grained cross-stratified sands with erosional base pointing to unidirectional currents also developed. The fauna faithfully reflects the patchy environmental conditions, and encompasses a wide spectrum of ecological groups, from brackish littoral through freshwater and terrestrial molluscs. The successions represent lacustrine parasequences, shallowing up units deposited as interdistributary bay fills, delta-plain marshes and distributary channel fills. Their variation mostly follows autocyclic environmental changes.
Gamma-ray and magnetic susceptibility, reflecting the lithological character was measured in the two largest outcrops. Despite the differences in scale correlation to “traditional” well log data points to the presence of a longer term cyclicity, i.e. 30-50 m coarsening successions, which are interpreted as delta lobes. Their stacking reveal climate-driven variations of base level.
High- and ultra-high resolution seismic data displays architecture of lacustrine deltas on two scales. Small unconformity-bounded progradational units, clinoforms of very low angles with a thickness of few meters were mapped. Boundaries are shown as high amplitude, good continuity reflections with toplaps or erosional truncation below and downlaps above. They also commonly appear above 1-5 m deep, 50-200 m wide channel-forms of low-amplitude, poor seismic facies. Some shows a meandering pattern, others are anastomosing in map view. These units are in good agreement with field observations and reflect the geometry of the small lacustrine parasequences described in outcrops. The high resolution images depicts stratigraphy up to a depth of 150 m. Clinoform packages of 20-50 m thick, their overlaps and stacking pattern were interpreted as delta lobe progradation. Major lobe boundaries do not always mark major flooding events, but may develop between coeval lobes as well. The overall decreasing thickness of lobes indicates long-term normal regression in Lake Pannon.

Response of micro- and nannofossils to facies changes on northern Tethyan shelves during the Cretaceous–Paleogene transition (Silesian–Subsilesian zone, Polish Outer Carpathians)

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Geological and biostratigraphic data based on foraminifera and calcareous nannoplankton and also other microfossils from the Silesian-Subsilesian zone in the Polish Outer Carpathians has been used for reconstruction of depositional conditions during the Cretaceous-Paleogene. In this marginal flysch basin of the Northern Tethys pelagic Frydek-type marls and also sandstone turbidities (Istebna beds) were formed. The marls accumulated on shelves during the Campanian-Maastrichtian formed submarine slumps in final stage. During this process marls were transported by gravity down the slope. Sometimes the part of them more and more was fluxed and finally processed by turbidity currents on slope. In this zone of the basin coarse sandstones have been accumulated in some places. The fall of the sea level resulted in exposing and denudation of shelves and finally its destruction. In the marls assemblages of small foraminifers dominated by planktonic and calcareous benthonic forms coexisted with other microfauna (large foraminifera, ostracodes) and fragments of macrofauna (bivalves, echinoids, crinoids, sponges). Foraminiferal plankton (G. havanensis and A. mayaroensis zones) and calcareous nannoplankton (R. levis and N. frequens zones) indicate the Early and Late Maastrichtian age. The formation of marls at the boundary of the shelf and slope zone was documented by calcareous and agglutinated benthonic foraminifera belonging to deep and mobile infauna, and sometimes semi-infauna or epifauna, which are derived from slope environments. The part of them are known from shales intercalated with sandstones, which were accumulated by turbidite currents on the slope. Clastic material includes carbonized plant debris and also pieces of coal transported from adjacent lands by rivers and then by submarine flows which partly eroded deposits accumulated on shelf or slope. These process have been also documented in marls of the Campanian by local sandstone bodies (Rybie sandstones) which contain fragments of plants (wood, leaves) and coal. Terrestrial organic matter in marly and sandstone series as well as erosive type of the lithological boundary and sedimentary gaps in the deposits confirm sea-level fluctuations and facies changes in the Campanian and the Maastrichtian. In consequence of supply of clastic material micro- and nannofossils changed in variability and preservation and also have been removed and reworked during the Cretaceous-Paleogene transition. At that time calcareous foraminifers were usually replaced by agglutinated taxa, which became the dominant elements of the assemblages (Rz. fissistomata zone) whereas calcareous nannoplankton were eliminated. However in sandstone series calcareous foraminifers known from the marls appeared quite frequently in the Campanian-Maastrichtian and also occasionally in the Late Paleocene. These assemblages originated from shelves were transported on slope by turbidite currents and debris flows. Fossils document changes in sedimentary regime and decrease of the CCD caused by tectonic activity (Laramide orogeny) at the Cretaceous/Paleogene boundary.
Described redeposition by soft-sediment sliding was important as a down slope process, in which deposits such as thick marl bodies slid into upper bathyal depths. This process was often controlled by synsedimentary and later tectonic movements resulting in the disintegration of the mass transport deposits, and their dislocation along the northern border of the Outer Carpathian units.

Remarks on sedimentation and tectonic deformation from Cretaceous to Paleogene in the Polish part of the Pieniny Klippen Belt (Złatne unit): Micropalaeontological and geological data from breccias at Zaskale

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Foraminifera and calcareous nannoplankton with respect to relation to sedimentation and tectonic deformation from Cretaceous to Paleogene in the SW part of the Pieniny Klippen Belt bordering to the south with the Inner (Podhale Basin) Carpathians are discussed. In this region belonging to the Złatne tectonic-facial zone Middle Triassic-Lower Cretaceous (Aptian) limestones and dolomites segmented into blocks and tectonic slides (Haligovice Klippes) are surrounded by the Lower Cretaceous (Albian)-Paleogene (Eocene) deposits of flysch-type. Deposits of flysch-type include shales and marls form individual lithological units or intercalations in conglomerates and olistostromes which are similar to those known from the Outer Carpathians. The latter deposits are recognized as breccias including broken and crushed fragments of rocks cemented together by a fine-grained matrix. The matrix is similar to or different from the composition of the fragments. Studied samples were taken mainly from matrix and sometimes from fragments of rocks in breccias, which outcropping in the vicinity of Zaskale (Mały Rogoźnik stream). Biotic signals from microfauna and calcareous nannoflora in breccias provided the age of this material and also the duration and intensity of processes, which formed these deposits. Foraminifera and calcareous nannoplankton were dated at the Jurassic, Cretaceous (Albian-Cenomanian, Turonian-Santonian, Campanian-Maastrichtian) and also Early Paleogene (Paleocene and Eocene). In the consequence the fossil material may be correlated with described deposits of flysch type in klippen series. In the most cases studied samples include fossil assemblages of the same age. Sometimes mixed forms of various age (i. e. the lower and upper part of the Late Cretaceous) were noted in the same sample. Quite often the massive shells of the Late Cretaceous foraminifers (Globotruncanidae) are deformated to high degree. Moreover some of them show an intensive dissolution. Similar analogies can be observed in the case of the nannofossils. The skeletal elements of calcaeous nannoplankton had been also subjected to mechanical crushing processes and often corrosion, dissolution and also mineralization. The above mentioned micropalaeontological data suggest that processes forming breccias may have already be intensified at the end of the Cretaceous and then continued during the Eocene. In addition the presence of the Eocene forms indicate that formation of the breccias could have been finished probably at the Eocene/Oligocene boundary. In general, lithological and sedimentological features of breccias were reflected in the numbers and diversity of taxa and their state poor preservation. Micropalaeontological data combined with geological observations show that the breccias may be correlated with syn- and post-tectonic sedimentation controlled by local tectonic activity.

Chloropigments in deep marine sediments as proxies of climate change-driven eutrophication

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Eutrophication is a serious problem of many semi-enclosed seas and coastal marine areas. It occurs intensively in basins of restricted water exchange and mixing. In the Baltic Sea this problem concerns many regions, one of them is the Gulf of Gdańsk, collecting waters of Wisła (Vistula), the second largest river discharging to the Baltic. Eutrophication is connected with high primary production, intensive blooms of algae and cyanobacteria, high sedimentation rate and anoxia. One of the useful indicators of primary production and intensive sedimentation at stagnant hydrodynamic conditions are chloropigment proxies. Chlorophylls-a, b and c and their derivatives in sediments provide information of state of the environment. Relation of these pigments to other proxies is useful in elucidation of processes which occurred during formation of sediments and afterwards, like primary production, phytoplankton taxonomy changes, sedimentation, climate change and hydrological dynamics.
Chlorophyll-a derivatives in old (formed in historical times) sediments have been an object of studies in Marine Pollution Laboratory of IO PAN since almost twenty years. Discovery of undecomposed chlorophyll-a in deep Baltic sediments (Bothnian Bay, Gotland Deep and Bornholm Deep), formed up to 8 000 years ago, gave evidence for occurrence in prehistoric time comparable or even greater eutrophication than that observed nowadays. Relations between chl-a, chl-b and chls-c, as well as some carotenoids in deep sediments from the Gotland Basin suggested that the high pigment proxies originated from cyanobacteria. Analysis of chloropigments-a in deep sediments (380 cm long core) from the Gulf of Gdansk (southern Baltic Sea) confirmed previous observations for Eastern Gotland Basin sediment core that there are greater quantities of chloropigments-a in the deeper layers than in more recent sediments taken from the same site. Studies of this core indicated that there were periods of very high primary production and sedimentation, most probably caused by climate changes in the prehistorical and historical times, but the most intensive pigment maximum corresponded to sediments formed about 2000 years ago, during greatest development of ancient Rome. The chloropigment-a maxima in sediments are formed during warm periods and are preserved due to favourable post-depositional conditions, i.e. lack of mixing, anoxia.

The CLISED (Climate Change Impact on Ecosystem Health - Marine Sediment Indicators, 2014-2017, No Pol-Nor/196128/88/2014) is a project of Polish-Norwegian Research Programme operated by the National Centre for Research and Development. One of the Work Package (WP3) focused on assessing of the biogeochemical sedimentary record over the last millennia, in terms of carbon input, primary production, oxygen depletion and eutrophication. Old sediments of coastal locations of different climate and hydrology (Gulf of Gdańsk - southern Baltic and Oslofjord/Drammensfjord as well as in the Norwegian arctic region) will be analysed and compared. Analysis of results will indicate sediment variability connected to different climatic conditions for the studied areas.

Clastic dykes in copper-bearing strata of the Lubin-Głogów Copper Deposit

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A number of morphological types of clastic dykes has been described in copper-bearing strata of the Lubin-Głogów Copper Deposit (L-GCD). Copper mineralization is hosted in the top part of the Rotliegend sandstones (so-called Weissliegendes Sandstone), in copper-bearing shale (Kupferschiefer) and in dolomites (clayey-, streaky-, and calcareous, from bottom to the top). Mineralization zone thickness reaches more then twenty meters, but at the sites of dykes occurrences does not exceed 3 to 4 m. Most of sandy dykes occurr within Kupferschiefer, but some of them penetrate into overlying dolomites.
When Kupferschiefer is absent and sandstones are directly covered by dolomites, dykes are not observed. Dykes are diverse, both in terms of size (from a few centimeters to three meters or more in length) and shape (from the planar to the spherical forms). Diversified shapes of dykes indicate a changing compatibility (water content) of the sediments in which they penetrate. Dykes were deformed statically (compaction) and dynamicaly (strike-slip movements within the Kupferschiefer). As a result of the overburden pressure, they have been folded. Curly dyke shapes are observed only in the Kupferschiefer and in the lowest part of the dolomite (clayey dolomite). Dykes boundaries in early litified dolomites are planar, sometimes fractured, along the vertical axis of the pressure. Dykes in the Kupferschieefer locally exhibit the effects of small scale horizontal strike-slip movements, are broken, crushed, dislocated, and brecciated. It is difficult, in this case, to identify the dyke root zones. For this reason, they have been described by previous authors as 'tectonic enclaves' - whatever that means.
Dykes are strongly mineralized with copper sulfides, making them more rigid than the surrounding sediments. In some cases, it was found that the ore minerals of dykes are fractured as a result of compaction. This may indicate the early formation of the copper mineralization, much earlier than the main phase of compaction. This contradicts the opinion of diagenetic or late diagenetic origin of copper mineralization in the L-GCD.

Anhydrite/kaolinite core coated grains of the Permian Weissliegendes Sandstone - an unusual type of structures

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An unusual type of coated grain has been identified in rock thin sections of samples of the topmost part of Weissliegendes Sandstone in Lubin-Głogów Copper Deposit (Poland).The coated grains consist of a solid sulphate core, mostly of anhydrite (and/or gypsum), sometimes of anhyrite and kaolinite, and occasionally of kaolinite. Almost all sulfate grains are bound by a ring of dolomicrospar and/or dolospar cortex. The coated grains of anhydrite are uncommon, generally comprising < 4% of the sandstone. Because of rare appearances, it is difficult to determine their position in the profile. Although the proximity of so-called anhydrite sandstone is evident. The structures are mostly round (almost circular in thin section) and 200 - 400 mm in diameter. Mostly dolomite 'cortex' consists of two layers separated by a thin dark lamin (ring), and may grow outwards from core. Internal thin dolomitic lamina 'grows' slightly in the anhydrite nucleus, which makes that its surface is frayed, while the outer 'limina' grows freely in to the intragranular space. Inside the coated granis, along the ahydrite cleavage, dolomite microsparite crystals and metal sulfides are frequently observed.
Many of the coated grains show deformations when in close contact with adjacent detrital siliciclastic grains. A the contact point dolomite cortex is either significantly thinner, or there is lack of it. On the other hand, in the vicinity of the contact, increasing the thickness of the cortex. For this reason, it is not clear whether the development of dolomite cortex is earlier, simultaneous or later than the deformation caused by compaction. Occasionally exploded' grains with a thin and fragmented cortex can be seen, perhaps indicateing broken grains, extreme compaction or the (re)hydratation of anhydrite. It is not clear initial nature of sulphate, whether it was a gypsum or anhydrite? It seems, however, that they were originally aeolian grains accumulate as dunes on the top of sand islands protruding above the Zechstein sea. The dolomite rims of are interpreted to be diagenetic, forming as a result of microbial mediation of pore waters by sulphate reducing bacteria (SRB). It is not excluded that hydrogen sulfide formed in this procces was included in the formation of copper sulfides.

Sedimentology of lower Miocene tidal cross-stratified sandbodies in the central Sardinia: An outcrop analogue for the upper Jurassic Rogn Fm in the Norwegian Sea

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This abstract presents the preliminary results of a facies-based field study carried on a series of stratigraphic sections measured on the lower Miocene succession exposed along the eastern margin of the central Sardinian Graben System. The observed sedimentary features are used to constrain the interpretation of the upper Jurassic Rogn Fm in the Norwegian Sea.
The Oligo-Miocene “Sardinian Rift” consists of horst-and-graben structures controlled by N-S-striking major normal faults, tilted blocks and orthogonal transfer structures. It was interpreted as the eastern palaeomargin of a wider, arrested back-arc basin, developed within the more complex West Mediterranean rift system.
The study succession represents a stratigraphic interval belonging to the so-called “Volcanic-Sedimentary Complex”, which unconformably overlies a Paleozoic metamorphic-magmatic basement. The complex accumulated within the half-graben footwall area of a NNW-SSE-oriented normal fault array and consists of subaerial pyroclastic and lava flows alternating coarse- to finer-grained sandstones and subordinate conglomerates for a total thickness of ca. 150-200 m.
The sedimentary succession, very well exposed between the villages of Mogorella and Villaurbana, ca. 35 km East of Oristano, is ascribed to the Aquitanian-Burdigalian, and consists of poorly to moderately sorted coarse sands, alternating with fine sands and mudstones, and associated with volcanic and bioclastic ash. A wide range of cross stratification and cross lamination characterizes the outcrops. Cross strata form a few decimeter- to meter-scale sandbodies with a decametric lateral extension and are locally incised by channel-shaped lithosomes, including tidal cross strata complexes. Close-up views reveal heterolithic flaser, wavy and lenticular bedding, tidal foreset bundles and herringbone cross sets. Laterally, this facies association is adjacent with tabular sandstone layers, 1-2-m-thick and 50-60-m-wide, alternating heterolithic fine sandstone and mudstone laminae, rich in plant rests, and containing tidal cross lamination.
The preliminary interpretation, based on the observed facies and structure associations, suggests the occurrence of tide-influenced coastal environments, which filled a tectonic-confined valley or embayment during a stage of marine transgression. Tidal influence would have been enhanced by resonance or coastal sheltering during the early stage of the relative sea-level rise, producing possible condition for estuarine-type sedimentation in a tectonically-confined marginal area of a wider graben system.
The general sedimentological features, the lateral extension and the sequence-stratigraphic identity of such tide-influenced interval suggest strong similarities with the depositional setting of the upper Jurassic Rogn Fm in the Norwegian Sea, which is presently investigated as possible hydrocarbon reservoir. Seismic images highlight as this formation transgressively lies on block-faulted basement units, forming isolated shallow depocenters or laterally continuous sandsheets, which were possibly accumulated under oceanographic conditions very similar to those reconstructed in our preliminary characterization of the Sardinian outcrop analogue.

Interplay of turbidite and mass transport deposition in a deep-water setting: The Lower Cretaceous Britannia Sandstone Formation, UK North Sea

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Mass-failure events may affect the bathymetry of the sea floor by remobilising or removing large volumes of sediments, whilst their deposits (mass-transport deposits, MTDs) may further change sea-floor bathymetry. Jointly, these effects may influence dispersal patterns and deposit heterogeneity of subsequent sediment gravity flows, deflecting, ponding or changing the flow behaviour over a relatively small area. The extensively drilled and cored Aptian deep-water succession of the North Sea Britannia Field, Outer Witch Ground Graben, UK, provides an opportunity to document the evolution of the interplay of large-scale mass failures and emplacement of associated turbidite sandstones in an active and continuous tilting of the basin. Combining new and existing data from the Britannia Sandstone Fm. this work aims to study the relationship between bathymetry created by different magnitudes of slope failure and the associated character of later sediment gravity flows. The focus is on the 35 km^2 Platform Area of the Britannia Field, where well-data from 47 wells and sedimentary analyses of core from 13 of those wells (this study plus earlier studies) provide a unique opportunity to characterise in detail reservoir architecture variability in relation to different sizes of MTDs.
Four mass-transport events originated from the local northern margin to the basin, likely triggered by tilting and destabilisation of earlier tabular turbidite deposits and slope material, linked to large-scale differential tectonic and compactional subsidence. Reconstructing the evolution of the tilting of the study area, two classes of MTD can be distinguished: 1) In the lower part of the Britannia stratigraphy, MTDs 1 and 2 rest on an irregular topography formed by evacuation and partial infill of a failure surface with between 50 and 150 meters of relief; the resultant bathymetry was characterised by topographic lows of the order of 100 m depth, healed by sharp-based, medium to fine-grained, clean, amalgamated sandstones; 2) within the central part of the stratigraphy, MTDs-3 and 4 represent smaller-scale remobilisation events which left a less pronounced bathymetry, creating local accommodation of between 10 and 50 m depth, and healed by muddier sandstone beds including subsidiary hybrid-event beds (HEBs) that pinch out and lap onto relatively subtle confining slopes. Towards the top of this interval, a relatively smooth sea floor was re-established with a return to simple tabular sandstone architecture.
This study emphasises the impact varying sizes of MTDs may play in creating bathymetry in deep-water systems and consequently the influence various scales of relief may have on subsequent turbidity currents. In this study there is an association between massive amalgamated turbidite sandstone fill of the accommodation created by large scale MTDs and muddier turbidite and beds and HEBs that onlap and pinch out over the subtle topography associated with smaller magnitude MTDs.

The inception stage of high-relief carbonate platforms: Facies, microfacies and depositional architecture of a Middle Triassic case study

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The inception stage of high-relief carbonate platforms is poorly known in outcrop as the core of carbonate platforms is covered by inner platform facies and bordered by prograding slope facies. Only when erosion discloses the deeper parts of a carbonate platform, rocks formed during the inception stage are investigable. Hints on the way platforms evolve by the coalescence of scattered km-scale nuclei to a wide single platform are provided by seismic lines, but outcrop studies are required to characterise type and distribution of facies and microfacies. Favourable outcrop conditions are provided by the middle Triassic carbonate platform of the Esino Limestone (Southern Alps of Italy), whose erosion favoured the partial exposure of the core of the platform. This platform (up to 800m thick, with a platform-to-basin relief reaching 500 m in the latest phase) records the evolution of a carbonate system from its birth to its demise. The core of the platform is covered by inner platform facies (peritidal cycles) bordered by reef (mostly tubiphytes and porostromata boundstones, associated with bioclastic deposits) and rapidly prograding steep slope facies (reef-sourced breccias). The Esino platform rests upon ammonoid-bearing marly limestones, that represent the substrate on which the nucleation of the platform occurred. Above these, the basal part of the platform is characterized by a 50-70 metres-thick succession of amalgamated intra-bioclastic calcarenites that records a shallowing trend from deeper conditions (black marly limestones) to inner platform settings (peritidal limestones with oncoids, green algae, bioclasts). Eleven stratigraphic sections across this interval have been described; samples have been collected and studied in thin section to characterise facies composition and distribution.
The facies recording the inception stage of the platform are burrowed intra-bioclastic packstone, with associated minor grainstone and bafflestone (the latter more abundant in the upper part of the unit). Among bioclasts, crinoid ossicles dominate. Skeletal grains of bivalves, gastropods and brachiopods are also present. Such intra-basinal debris was probably largely produced by sparse algal reefs, consisting of intra-bioclastic sands stabilized by the baffling action of algae. Deposition occurred in normal marine conditions, likely in low-energy settings (as suggested respectively by the abundance of crinoids and the presence of mud in the interparticle space). Clinostratification of the calcarenites is observed, suggesting that this unit derives from the lateral accretion of detrital wedges sourced by highs where skeletal-producing biota thrived. These basal deposits are thus interpreted as the gradual filling of the depressed areas among the scattered highs where the carbonate factory started to grow. The constant average thickness of this unit and the rapid vertical transition toward inner platform facies reflect a sediment production higher that the accommodation space, resulting in the final coalescence of the carbonate nuclei and the onset of a wide carbonate platform with a different facies organization and composition (slope breccias versus intra-bioclastic calcarenites).
The observed evolution accounts for the common occurrence of coarser, bioclastic deposits characterising the initial stage of a carbonate platforms, with important implications on the predictive model of facies distribution in subsurface settings.

Contact metamorphism and diagenesis of Middle Jurassic coarse-grained fluvial sandstones and its impact on reservoir quality, Traill Ø, East Greenland

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The Middle Jurassic Bristol Elv Formation, Traill Ø, East Greenland consists of two coarse-grained fluvial sandstone units intercalated with fine-grained lacustrine and flood plain sediments, with a thickness of approx. 150 m. The formation is intruded by Tertiary doleritic sills and dykes at Svinhufvud Bjerge, southern Traill Ø.
A basal ~25 m thick coarse-grained sandstone unit positioned immediately above a 30-40 m thick doleritic sill, differs significantly in petrography and porosity/permeability from sandstones higher up in the Middle Jurassic succession, with respect to the scarcity in K-feldspars, mica and early kaolinite, and the abundance of unusually coarse crystalline illitic flakes (up to 70 μm) as well as illitic pseudomorphs after authigenic andalusite and cordierite. This petrographic difference is suggested to be a consequence of contact metamorphism and retrograde metamorphism/diagenesis immediately after the intrusion of the sill.
A ~6 m thick fine-grained unit succeeding the basal coarse-grained sandstone unit probably acted as a barrier preventing the upward flow of hot pore fluid immediately after the intrusion event, thereby hindering significant mineral transformations in the sandstones higher in the succession.
Andalusite and cordierite are well-known from areas of contact metamorphism forming at low pressure and high temperature. They are commonly reported from argillaceous metasediments but are very rarely described from contact metamorphic sandstones. In the studied sandstones, the pre-existing occurrence of andalusite and cordierite is indicated only by illitic orthorhombic and hexagonal pseudomorphs formed by retrograde metamorphism during falling temperature. It is believed that andalusite and cordierite, coarse crystalline illite and the illitic pseudomorphs were formed at the expense of feldspar, mica and kaolinite.
Vitrinite reflectance and organic geochemical data indicate that the contact aureole related to the intrusion only affected the lower part of the succession, at a distance of a little less than the thickness of the intruding sill. Temperature calculations from vitrinite reflectance analyses suggest temperatures at around 340 °C within the basal sandstone, which is in accordance with precipitation temperatures for andalusite (200-770 °C at low pressure).
The formation of coarse crystalline illite and pseudomorphs associated with the retrograde metamorphism/diagenesis of andalusite and cordierite had a significant influence on the permeability and porosity of the sandstones, reducing reservoir quality considerably. This study thus has implication for hydrocarbon exploration in sedimentary basins that have experienced periods of intrusive magmatism.

Implications of magmatism on diagenesis and reservoir properties of Middle Jurassic sandstones, Traill Ø, East Greenland

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An up to 500 m thick succession of Middle Jurassic sandstones of the fluvial Bristol Elv Formation and marine Pelion Formation in the East Greenland basin shows a variety of authigenic mineral phases dominated by quartz cement, carbonate cement, illite and iron-oxide.

Two episodes of burial and uplift are recorded in the diagenetic sequence and cathodeluminescence analyses show that widespread grain-crushing was followed by intense quartz cementation displaying several growth zones. Cathodoluminescence images also show that only insignificant pressure dissolution between detrital quartz grains has taken place. Intense quartz cementation occurs primarily in the fluvial sandstones but the marine sandstones are also highly quartz cemented. However, the amount of quartz cement in the fluvial sandstones varies significantly between two separate geographical areas. In the area with the most intense quartz cementation, macro-stylolites are common and it is believed that stylolitization have been a significant source of silica for quartz precipitation. In general, the sandstones experienced a burial depth of between 2000 and 3000 m, which corresponds to a burial temperature of c. 90 ºC, assuming a geothermal gradient of 30 ºC/km. However, high fluid inclusion homogenization temperatures (117 – 158 ºC) from these intensely quartz-cemented sandstones show that the sandstones have been affected by magmatism, which coincided with the time of maximum burial depth.
Thermal convection flow due to magmatism and probably to a lesser extend introduction of hot silica-rich extra-formational fluids, related to flow along reactivated faults and fractures have contributed to the intense quartz cementation. Further has the increased temperature resulted in dissolution of feldspar and precipitation of illite. These processes have resulted in a drastic deterioration in the reservoir quality of the sandstone formations.

Travelling without moving: ever-changing seabed morphology and the influence of contour currents, from Cretaceous to Present-day, within the Pelotas Basin, offshore Uruguay

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The Pelotas Basin offshore Uruguay is superbly imaged within newly acquired 3D seismic data covering over 13000 km^2. The interpretation of these data shows that, in addition to conventional deep marine systems, the deep marine environment has been dominated by depth-variant bottom currents over the past 125my. The result is a spectacular array of sedimentary features including large sediment drifts, mixed channel/ contourite systems and large sedimentary waves. Many of these features, which are only observed due to the size and dense sampling of the seismic dataset, pose questions about our fundamental understanding of margin morphologies and bedform development in the deep marine environment.
During the Cretaceous period the basin was dominated by huge sediment drifts, comprising linear ridges that can reach 900 m in height, with wavelengths up to 30 km that extend for over 100 km perpendicular, and oblique, to the palaeomargin. This entire train of ridges extends for more than 125 km along slope. The location of these drifts is related to the interaction of underlying basement topography with a southwards flowing contour current that resulted in the creation a lee wave able to move and rework sediment into linear ridges. Erosion on the up-current sides of the drifts, suggests that turbulent flow cells, detached from the main current, were also present. The data also show that downslope flows exploited the topographic lows, resulting in the deposition of mixed contourite/channel systems.
During the early Tertiary a period of major contour current activity is manifested as a regional erosion surface running from the upper slope to the basin floor. This surface was fully subaqueous yet does not have any downslope erosional features such as canyons or channels. In the middle slope area this surface is overlain by a series of coalesced, constructional lineations (50 km long; 35 km wide and up to 100 m in thickness), orientated oblique to the palaeomargin and interpreted as sand ridges. Immediately above these lineations is a spectacular set of arcuate barchan-like dunes that are greater than 40 km wide with wavelengths of 10km and extend in a near-perfect linear train for more than 125 km. Geometrically, based on current bedform stability fields, these features should be relatively coarse-grained but the seismic response suggests they are dominantly fine-grained.
The present oceanic circulation offshore Uruguay is highly complex, with a number of water masses active at various depths. This complexity has been long recognised and is becoming better understood with recent geophysical surveying. In the mid-slope region a southwards flowing current has generated a series of horseshoe-shaped dunes (450 m wide, up to 1 km long and 10 m in height) that are intermingled with local scours. At the base of slope (c.3500 m water depth) a coalesced scour field, parallel to the modern margin, extends for approximately 30 km along the basin floor and 400 m up the lower part of the slope. Individual scours (giant flute marks) which can be 400 m long and 250 m wide clearly demonstrate the erosive power of present day contour currents on along the basin floor.

Determination of permeability and porosity from drill cuttings using the rock typing technique – an example from onshore Tunisia

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Reservoir deliverability is determined primarily by permeability and storage primarily by porosity. Ideally these values are obtained from measurements made on conventional core data but core data, particularly in exploration wells, is relatively rare. Drill cuttings however, are ubiquitous and can be used to provide an alternative means of determining permeability and porosity.
Presented here are the permeability and porosity results from Sidi Dhaher-1, an exploration well drilled in 2011, onshore Tunisia. Part of the analysis undertaken at the wellsite was rock typing; a technique that semi-quantitatively describes rock and pore characteristics from drill cuttings such as lithology, grain size, framework components, cement and porosity types using a high-powered, reflected-light microscope and assigns the sample intervals to one of seven permeability classes.
The permeability estimates for both clastic and carbonate sections was done prior to wireline logging and was then subsequently compared to permeability measured by XPT/MDT wireline tools. A good correlation between both methods was observed.
A review of porosity types in a carbonate sequence was undertaken to identify porosity types and to compare with and assist calibrating wireline log data. Despite the cuttings being typically less than 10mm in diameter, porosity types commonly described in conventional core were observed including vugs and inter and intra particle types. Overall a good correlation was observed between rock type and wireline derived porosities.
The results demonstrate that rock typing is an alternative and valid means of estimating permeability and porosity from drilling cuttings in both clastic and carbonate reservoirs.

The tectonically-confined foredeep turbidites of the Cervarola Sandstones Formation (Miocene, northern Apennines, Italy)

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The Cervarola Sandstones Formation (CSF), Aquitanian-Burdigalian in age, was deposited in an elongate, NW-stretched foredeep basin formed in front of the growing Northern Apennines orogenic wedge. As other Apennine foredeep deposits, the stratigraphic succession of the CSF records the progressive closure of the basin due to the propagation of thrust fronts toward north-east, i.e. toward the outer and shallower foreland ramp. This process produces a complex foredeep characterized by synsedimentary structural highs and depocentres that can strongly influence lateral and vertical turbidite facies distribution. Consequently, the main objective of this work is to describe and discuss this influence, on the basis of a new high-resolution stratigraphic framework obtained by measuring six stratigraphic logs, for a total thickness of about 1500m, between the Secchia and Dolo Valleys (20 km apart). In particular, the relationship between the turbidite sedimentation and the ongoing tectonic activity during the foredeep evolution has been described through various stratigraphic cross sections oriented parallel and perpendicular to the main tectonic structures. The latter are NW-SE oriented, i.e. in the same way of the main paleocurrents that are directed toward SE.
On the basis of the facies associations described in the studied succession and on the analogy with other foredeep deposits of the northern Apennines, such as the Marnoso-arenacea Formation, we can argue that, in this area, the Cervarola basin was a highly confined foredeep controlled by intense synsedimentary tectonics. The most important evidence supporting this hypothesis is:
- the upward increase, in the studied stratigraphic succession (about 1000 m thick), in the sandstone/mudstone ratio, grain sizes and shallow water trace fossils (*Ophiomorpha*) testifying the high degree of flow deceleration related to the progressive closure and uplift of the foredeep.
- the occurrence in the upper part of the stratigraphic succession of coarse-grained massive sandstones overlain by tractive structures, such as megaripples and traction carpets passing downcurrent into fine-grained laminated contained-reflected beds. This facies tract is interpreted as related to deceleration and decoupling of bipartite flows with the deposition of the basal dense flow and bypass of the upper turbulent flows that can experience rebound and reflection processes.
- occurrence of intra-formational slumps, consisting of highly deformed portions of a fine-grained succession, indicating syn-sedimentary tectonic activity of the tectonic structures able to destabilize the margins of the basin.
- the impressive lateral facies changes between intrabasinal topographic highs characterized by fine-grained and thin sandstone beds, as well as marlstone and depocentres characterized by thick to very thick coarse-grained massive sandstones.
- The common occurrence of amalgamation surfaces, flow impact structures and mud-draped scours related to sudden deceleration of the turbidite flows induced by structurally-controlled confinement and morphological irregularities.
In conclusion, the CSF has many analogies with the facies associations occurring in other tectonically-controlled foredeeps such as those of Marnoso-arenacea Formation (northern Italy) and Annot Sandstone (south-western France) showing that thrust fronts moving towards the foreland were able to produce a segmented foredeep that strongly influenced the turbidity current deposition.

Cross-currents turbidite facies tract in a structurally-confined asymmetrical mini-basin (Priabonian-Rupelian, Ranzano Sandstone, northern Apennines, Italy)

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The literature on confined-ponded basins in intraslope settings highlights the importance of these types of basins in the entrapment of sand. The tectonically-confined basins in wedge-top and inner foredeep settings such as, for example, the Ainsa System in the south-central Pyrenees, the Annot Sandstone in south-western France and Marnoso-arencea Formation in the northern Italy, offer a great opportunity to study field analogs with facies associations similar to those described in the intraslope setting of divergent margins.
This is also the case of the Ranzano Sandstone in the northern Apennines (Italy), which has been interpreted as a low-efficiency turbidite system deposited in a series of small piggy-back basins. In particular, this work focuses on one of these minibasins (i.e., the Val Pessola basin), where the Ranzano Sandstone is dominated by two facies types: 1) thick to very thick pebbly coarse- to very coarse-grained massive sandstones characterized by amalgamation surfaces, flow impact mudstone breccias and water escapes (F5 in Mutti's scheme), which form stratigraphic successions of poorly sorted deposits with a very high sandstone/mudstone ratio; and 2) thin to medium thick, relatively well-sorted, coarse- to very coarse-grained sandstones characterized by a lower megaripple division overlain by a train of fine-grained ripples, which are sharply capped by a thin mudstone division through a marked break in grain size (F6). The detailed facies analysis carried out in the entire basin, however, highlights substantial lacking of facies F8 (massive medium-grained sandstones) and F9 (fine-grained laminated sandstones and mudstones).
Furthermore, a detailed physical stratigraphic analysis shows that the studied deposits are characterized by cross-current asymmetrical facies distribution. In other words, in a transect oriented E-W (i.e. roughly perpendicular to the general paleocurrents directed toward SSW) the coarse-grained amalgamated massive sandstones (F5) that onlap against the eastern basin margin grade toward the W into a stratigraphic succession dominated by F6 megaripples over very short distances. This westward lateral facies change is also associated to: 1) a progressive deviation of the megaripple paleocurrents towards the W; i.e. moving towards the western sectors of the basin, the megaripple paleocurrents increasingly diverge toward the W;
2) a progressive westward increase in the number of coarse-grained megaripples (F6);
3) a progressive decrease in bed thickness characterizing the F5 massive facies.
This cross-current transition is interpreted as being related to bipartite turbidity currents experiencing decelerations against a relatively steeper eastern margin, producing flow decoupling and consequent bypass of upper turbulent flows that can spread out toward the less steep western bounding slope. The lateral spreading of turbulent flows can rework the coarse-grained massive facies producing the tractive structures (F6) indicating westward flow divergence. The general absence of the medium, fine-grained sands and mud testifies that these grain sizes must have been transported by the bypassing turbulent flow in another adjacent basin. In conclusion, the described deposits can be deemed equivalent to the "fill-and-spill" phase described in the ponded intraslope basins of the Gulf of Mexico and other confined settings.

Ambient occlusion – a powerful algorithm to segment skeletal intrapores and gastral cavities in dendrophyllid cold-water corals

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During the last decades, (micro-)computed tomography (CT) has gained increasing attention for the description and quantification of skeletal structures. Within coral research, CT has been used to determine the surface area of corals, to examine the pore-network and to determine the porosity within coral skeletons. Here, we present the ambient occlusion algorithm as powerful tool for the segmentation of pore-networks, exemplified on a dendrophyllid coral. The concept of ambient occlusion is widely used in computer graphics to enhance the rendering of 3D objects. Its potential for image segmentation, however, has not been considered so far.
Within dendrophyllid corals, the complex pore-network is extensively connected to its exterior surface. The same accounts for the gastral cavity, which exhibits a broad opening. Analysing these structures requires the discrimination of the enclosed space from the sample surrounding space (all normally filled with air). This presents a crucial processing step for the analysis of the pore network, its connection to the gastral cavity and its porosity distribution within the skeleton. We show that the ambient occlusion algorithm enables a fast and representative segmentation of both skeletal features by using different 'ambient' thresholds. Subsequently, volume determinations, porosity determination and pore-network analysis can be easily performed. In addition, it renders cropping of the measured sample volume prior to biomould and pore segmentation in rocks unnecessary, and, thus, allows one to perform analysis on the entire sample volume measured. The segmentation via the ambient occlusion algorithm can be applied to a variety of porous (bio)materials such as bryozoans, echinoderms or bone substitutes.

Multi-scale dissolution events in Western-Tethyan peritidal carbonates close to the Triassic/Jurassic boundary

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The stratigraphical and sedimentological study of uppermost Triassic-lowermost Jurassic sections of peritidal carbonates, in north-western Sicily, allows differentiation of multi-scale dissolution events that affected the carbonate platform interior during the uppermost Rhaetian. The Triassic cycles show extensive phenomena of stratabound dissolution that can be defined as three main types: vug, moldic and "spongy-like". The dissolution horizons are particularly concentrated in the subtidal members of cycles. The creation of different types of porosity seems to be mainly controlled by the textural characters of the host-rock. In particular the cm-scale bioturbation in muddy sediments, was probably formed by crustacean decapods, is the most important factor in determining the spongy-like pattern. The fluids responsible for the stratabound dissolution, the morphological comparison of the spongy-cavities with recent similar examples from modern carbonate platforms, coupled to geochemical data, supports the influence of a mixing water lens. Such a lens could have been established during the periodic exposure of the platform (documented by thick paleosols at the top of each cycles) by freshwater recharge from an adjacent exposed area.
Later dissolution events, at a larger scale, are superimposed on the stratabound dissolution cavities. Giant caves up to 100 m in diameter, filled up by collapsed breccias, scattered over a distance of about 1 km, along a narrow stratigraphic interval. Among the breccia elements, the presence of clasts arising from the spongy-like horizons, suggests that cavern dissolution post-dates the stratabound dissolution. Up-section from the cave alignment, a karstified surface covered by a particularly thick red paleosoil, is laterally correlated with a structure that is interpreted as a paleo-sinkhole, and considered as the subaerial surface connected to the cave system. The biostratigraphic data support a late Rhaetian age for this surface, coincident with the T/J boundary, based on the LO of Trasina hantkeni, which falls about 100 m above the karstified surface. The amount of the exposed stratigraphic thickness during the formation of the cave system is estimated at about 130 m, a value that is difficult to explain simply in terms of eustatic variation. So we consider, a possible influence of a tectonic control induced by the ongoing rifting relating to the opening of the adjacent Alpine Tethys.

Preliminary results of the Quaternary Sarıkavak tufa deposits as palaeoenvironmental and palaeoclimatic indicators (Denizli-SW Turkey)

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Sarıkavak tufa occurrences constitute the 20- to 40- m-thick (~3 km^2) and they located the northeast of Denizli (SW-Turkey). These calcareous tufa deposits disconformably overlie on Tertiary Acıgöl Basin, which contains a thick succession of sandstones, conglomerates, claystones, followed by clayey limestones, marls and mudstones. Sarıkavak tufa deposits are bounded by Acıgöl Graben which occurred during Neotectonic extensional movements in SW-Turkey. In this present study is to reveal palaeoenvironmental and palaeoclimatic implications of tufa deposits according to first preliminary results. For this aim, it has been performed that the field investigations to help infer sedimentary facies models and laboratory analysis to obtain some clues for climatic changes. Sarıkavak tufa outcrops precipitated in fluvial depositional environment which consisted of braided, barrage/waterfall and fluvio-lacustrine systems. In addition to that seven lithofacies have been determined depends on the detail field observations. These are stromatolitic tufa, intraclast, phytoclast, lithoclast, oncoidal tufa, macrophytes and palaeosol layer. Sarıkavak tufa deposits have been dated from 308ka to 80ka using by U/Th method. Taking into account all ages, it seems that the construction of the Sarıkavak tufa deposits occurred between interglacial (MIS 9, 7 and 5) and glacial (MIS 6) period. Moreover, the determination of stable isotopes composition $\delta^{13}C$ and $\delta^{18}O$ were performed on the bulk tufa samples. According to analysis results, $\delta^{13}C$ values have in the range from 1.50‰ to −1.63‰ V-PDB and $\delta^{18}O$ values in the range from −10.83‰ to −9.3‰ V-PDB. $\delta^{13}C$ values of tufa deposits indicate mainly the mineral origin of carbon e.g. limestone dissolution process and these isotopic values are typical for thermal tufa. $\delta^{18}O$ values show significant variations in temperature reflected warm and cold periods among MIS 7 (interglacial), MIS 6 (glacial) and MIS5 (interglacial). Dating results in this present work are in good agreement with $\delta^{18}O$ values and further dating and isotope investigations of more compact form of tufa deposits would give more information about climatic and environmental conditions of tufa formation in Denizli and surrounding areas.

Diversity of channels and lobes in the deep-water Lake Pannon, southern Transylvanian Basin

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Deep-water sedimentation was widespread in Lake Pannon during the Late Miocene, hence thick turbidite sequences developed. These are potential reservoirs for hydrocarbons in most parts of the Pannonian and Transylvanian Basins. They crop out in the Transylvanian Basin, which provides a unique opportunity to understand their depositional setting as most probably good analogues of their subsurface counterparts. Moreover many lacustrine turbidite outcrops from the south-western part of the basin have not yet been studied in great detail. The aim of our work was to set up a detailed palaeoenvironmental reconstruction. In addition, we did gamma-ray logging in the studied outcrops to aid in subsurface gamma-ray log interpretation.
The facies analysis was carried out in high-resolution (cm-scale). Clast-supported conglomerates are lags of high-density gravelly turbidity currents. Pebbly sandstones and clean sandstones with abundant rip-up clay clasts and water-escape features are products of erosive high-density turbidity currents. Cross and parallel laminated intervals were deposited from low-density turbidity currents. Intervening bioturbated mudstones are of suspension fall-out origin. Laminated mudstones and marls with minor bioturbation were found in one locality (Gusterița), representing hemipelagic sedimentation.
The exposures also allow the detailed description of the architectural elements. Two hierarchies of cut-and-fill structures can be identified at Daia. Very thick gravel and sandstone beds pinch out while thin to medium bedded cross and parallel laminated sandstones and mudstones cover the scour surfaces laterally. The scour surfaces and the heterogeneity of their fill points to a complex channel fill which migrated laterally.
A channel of less coarse material is cut into an alternating mudstone-sandstone succession at Tău. Several phases of migration can be interpreted. Smaller outcrops indicate that several channels with levees developed and were probably isolated.
Alternating mudstone and sandstone show an upward coarsening and thickening trend overlain by very thick amalgamated sandstones at Micăsasa. Shallow scour surfaces separate upward thinning, laterally homogenous successions. The outcrop represents an aggrading channel-levee system.
Laterally extensive sheets with an upward thinning trend are found in Ocna Sibiului. The abundance of flame and dewatering structures and clay clasts suggests erosive currents. The succession is interpreted as a lobe element. A similar facies association with irregular scour surfaces might have developed at the top of a lobe with distributary channels.
Diverse mosaics of a deep-water turbidite system within a relatively short time range have been identified. Complex channels, aggradational channel-levee systems, isolated meandering channel-levee systems, lobes with distributary channel and lobes build up the turbidite system of the Transylvanian Basin. The measured gamma-ray logs reflect the thickness trends and heterogeneity of facies associations. These vertical trends were found to be characteristic for the different architectural elements; therefore high-resolution interpretation of subsurface logs can be done with more certainty in the case of Lake Pannon turbidites.

Confined turbidite basins in the Lake Pannon: Examples from southwestern Hungary

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Uneven basin floor topography significantly alters the route of turbidity currents and the depositional architecture of turbidite systems. Confined basins can develop in a wide range of tectonic settings. The basement of the Pannonian Basin was highly irregular due to normal and strike-slip faulting during synrift extension in the Early to Middle Miocene, minor inversion around the turn of Mid/Late Miocene and recurrence of fault activity during the early Late Miocene. Lake Pannon inundated the relief in the Late Miocene, and even 600 to 1000 metres deep depressions were present. Profundal marls covered unevenly the floor of the deep regions as well as that of sublacustrine highs.

Selected 3D seismic datasets were interpreted and the decompacted thickness of the main sedimentary packages was calculated to reveal the syndepositional palaeotopography. Spectral decomposition was used to map geomorphological architectural elements. Well logs and core studies aided in constraining the stratigraphy and the evolution of deep-water architectural elements.

Two scales of confining topography can be identified. The higher irregularities are in the scale of depressions: they are 10s of kilometres in length, several 100s of metres in depth and are mainly related to the overall structural setting. The smaller ones are in the range of several kilometres in length and 100 metres in depth. The latter have different origins: reactivation of Cretaceous nappes (Drava Basin) or Middle Miocene volcanic edifices (Somogy area) played a role in shaping the topography. This smaller scale confinement can be traced well on 3D seismic volumes. The direction of slope progradation is a major factor in the routing of turbidity currents. Where slope-parallel confining ridges exist, sediment spills into the lower subbasin at one spill point. The development of sheets with continuous seismic facies onlapping basement highs suggests that the lower subbasin was confined. Later on, a well-defined lobe with the channel-lobe transition at the spill point developed. Channels cutting through the lobe may be the result of progradation of the system. As the lower subbasin filled and the base level rose, sediment was trapped in the upper basin, with compensationally stacked lobes. In the next phase of development, channels were still diverted from the covered range but found their way to the then levelled out lower basin. The smaller scale of confining topography was greatly reduced by the time the slope progradation reached the area, but the larger scale of topography still affected slope development.

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Evidences of seagrass meadows and paleoenvironmental changes in the early Eocene carbonate platform of N Oman: A sedimentological, paleontological and taphonomic study

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The recognition and understanding of habitats in the fossil record are of crucial importance in order to investigate paleoecological responses and indirectly infer climate and sea-level changes. However, the low preservation potential of vegetated settings hampers a direct identification of these environments in the geological past. A wide range of indirect indicators has been applied to infer vegetated settings in ancient deposits combining sedimentological, paleontological, taphonomic and geochemical approaches. The latter rely upon the assumption that ancient vegetated areas were comparable to modern ones in terms of habitat functions and type of associated organisms.
Here we present a detailed study of an early Eocene carbonate succession, where, using different approaches, we identify the presence of seagrass dominated facies. Our study offers a good opportunity to look at the main features of “old” seagrasses facies as these developed, only, from the Late Cretaceous.
The studied section crops out in the Wadi Bani Khalid (Tiwi Platform, Oman Mountains). The succession is 63 m-thick and belongs to the upper Member of the Jafnayn Formation. The lower part of the section, until 46 m from the base, is Ilerdian in age and is capped by an exposure surface which represents a major sequence boundary. The rest of the section is of Cuisian age and is capped by a second sequence boundary. Based on the sedimentological and paleontological content four main lithofacies have been recognized.
The studied succession consists, in its lower sequence of well bedded, meters- thick packstones, occasionally packstones-grainstones, yielding abundant alveolinid and acervulinid foraminifera. These latter occur mainly as encrusting (tubular and hook) forms. The encrusted material is, often, lacking. Only few specimens are observed encrusting on other foraminifera (i.e. alveolinids). Intraclasts, peloids, echinoids, *Orbitolites* sp., green and red algae, and small benthic foraminifera are subordinate components of this interval. These deposits pass upward into ~ 17 m of well-bedded (locally cross-bedded) packstones and grainstones with interbedded marls. The limestones contain abundant echinoid fragments, *Orbitolites* sp., rotalids, peloids, intraclasts and quartz grains and subordinated *Alveolina* sp., red and green algae, and bivalve fragments. The lower sequence represents a low-energy shallow lagoon passing upward into a more agitated environment, as suggested by the presence of cross-bedded grainstones likely representing bioclastic bars, occurring within the lagoon.
The foraminiferal assemblage found in the lower sequence and their morphologies suggest an epiphytic adaptation, likely related to seagrasses. Acervulinids foraminifera with tubular and hook form, and motile porcelaneous photosymbiotic foraminifera, as it could have been the case for the alveolinids, have been reported from ancient and modern seagrasses. The nearly disappearance of acervulinids and alveolinids, in the upper sequence could indicate a paleoenvironmental change. The clear shift observed in the foraminiferal assemblage, from *Alveolina*-acervulinid- rich sediments to *Orbitolites*-echinoderms-quartz bearing packstone-grainstones, may be related to changes in sediment composition (from pure carbonates to mixed siliciclastic-carbonates) and/or in hydrodynamic conditions. An increase of siliciclatics could have also affected the type of substrate and possibly increased trophic levels thus leading to the disappearance of the seagrasses and its associated fauna.

Decline of trophic resources in a carbonate ramp setting: the case study of *Lithothamnion* Limestone, Majella Mountain (Central Apennines, Italy)

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The *Lithothamnion* Limestone represents the uppermost carbonate unit of the Bolognano Formation outcropping in the Majella structure, constituting the northern extension of the wide Apulia carbonate platform. This unit well records an excellent progressive decay of trophic conditions, due to the forthcoming Apennines foredeep systems characterised by turbiditic siliciclastic sedimentation during the early Messinian. Sedimentological and compositional analyses were used to reconstruct the depositional model and evolution of platform environmental conditions. The depositional model is consistent with a homoclinal carbonate ramp, with a wide middle-ramp environment in which coralline algae, mainly forming the mäerl facies, dominated carbonate production. This facies was associated with seagrass meadows colonising the inner ramp. The outer ramp, settled in the aphotic zone, was characterised by bioturbated hemipelagic marl rich in plankton foraminifers and pectinids. Three main stages of ramp evolution have been identified. During the first stage, the ramp was subjected to high-energy wave-dominated conditions, favouring the development of deep rip channels in which accumulations of marine vertebrate bones have been recognised. The second stage was dominated by the development of mäerl facies and seagrass meadows, initially in an oligotrophic setting, later followed by a slight reduction of light penetration. In the third stage there was a general increase in fine terrigenous sediments, associated with a further light decrease and also with a spread of coralline algal bindstone facies. This elevated terrigenous input was associated with increased trophic conditions, inferred also by the abundance of planktonic and low-oxygenated foraminiferal assemblages.

Sedimentological study and tentative reservoir characterization of the "Gazda" travertine quarry (Süttő, Gerecse Hills, Hungary)

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The aim of the study was to present a field analogue for the depositional and early diagenetic history of predominantly microbial continental carbonate reservoirs.
Gazda quarry is part of the Pleistocene Süttő travertine complex (Hungary) where the travertine body is exposed within active quarries. The geometry of the travertine beds follows the antecedent land-surface, i.e. a NE-SW striking pre-Pleistocene valley. To the north of Gazda quarry at a relatively higher elevation there is another open-cast operation, called Hegyhát quarry of which the travertine was interpreted to have been deposited in a large carbonate pond by Bakacsi et al. (1994). The geometry of the travertine sequences exposed in the two quarries displays obvious continuity suggesting simultaneous formation. Due to lake-level fluctuations, water could overflow from the Hegyhát area thus causing travertine precipitation along the gently sloping terrain. The overflowing water encountering a supposed topographic "obstacle" formed a shallow pond which was colonized by hydrophilic plants (e.g. reeds) stabilizing a gradually evolving mound. Plant growth was apparently able to keep pace with the progradation of the mound evolving into a gradually asymmetric deposit. Field observations suggest that after passing through the mound, the overflowing water encountered another topographic "obstacle" thus reflecting the existence of another pond. Within the lake system shallow pond-, palustrine-, reed mound– and slope depositional environments could be differentiated.
Stable oxygen and carbon isotope analyses show that water temperature was approximately 25°C and the Gazda travertine complex belongs to the group of meteogene travertines (sensu Pentecost, 2005). According to the petrographic studies the depositional environment was characterized by significant microbially influenced carbonate precipitation.
3D reconstruction of the porosity network suggested that the Gazda travertine complex was dominated by phyto-mouldic and framework porosity. SEM investigations indicated that dissolution and microporosity presumably related to the decay of microbes abundantly present. The reed mound facies displays the highest porosity and permeability values (11.7±5%, 1±2.08 mD). The flat laminated facies shows significant anisotropy in terms of permeability (0.07 mD vertically and 1.35 mD horizontally). The petrographic study verified that low porosity and permeability values were the results of late calcite cementation considerably reducing the original (primary) porosity.
Based on the above investigations, the Gazda travertine complex seems to be suitable for small-scale facies characterization and revealed also the effects of microbial activity related to the various environments. However, due to its diagenetic history (early diagenesis without considerable burial) and its relatively small areal extent the use of the Gazda travertine and similar small-scale, near-surface occurrences as possible field analogues of microbial reservoirs on the large scale, needs be done with caution.

Distribution of Sele Formation deep-marine depositional systems of the Central North Sea

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The Paleocene to Eocene Sele Formation is developed in the basinal region of the Central North Sea and consists of four deep-sea fan complexes; the Forties, Bittern, Cromarty, and Gannet fans. The Forties Fan is the most extensive, and is characterized as a mixed mud-sand, ramp-sourced system. The proximal part of the fan comprises channel complexes of low sinuosity, high lateral offset, and low aggradation. The development of this portion of the fan in a narrow northern corridor of the Central Graben (~ 65 km wide), combined with high sediment supply, resulted in the burial of any underlying topography. To the south of the Arbroath Field c. 150 km down palaeoflow, the Forties Fan becomes unconfined, and in this region is dominated by channel-lobe complexes which interacted with an irregular bathymetry. The distribution of the fan in this distal setting was controlled by the mounded topography produced by the underlying Maureen and Lista fans and mass-transport complexes, which induced an eastward offset of the Forties Fan. Halokinesis, in the form of rising salt diapers, also resulted (in some cases) in local-scale topographic irregularities, the impact of which on the fan distribution depended on the time of their formation and magnitude of their relief relative to the impinging gravity flows. The fan evolved through a series of discrete stages characterised by expansion then contraction of the axial system, with variable contribution from lateral input from the west. A high resolution biostratigraphic framework has enabled detailed mapping of the evolution of the fans as they expanded and contracted in response to relative sea level changes and fluctuations in sediment yield off the Scottish landmass.

The Tremiti Salt Structure in the Adriatic Sea (Gargano offshore, Apulia, southern Italy)

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The Adriatic Sea offshore of Italy is an area of renewed geological interest since some features of its stratigraphic and structural background could be compared with ones of the other side of the Adriatic Sea (Croatia and Albania), where preliminary data suggest good perspectives of oil discoveries.
The reinterpretation of public seismic profiles in the Adriatic offshore of Gargano (Apulia, southern Italy) allowed the detection of a kilometre-scale salt-anticline, the Tremiti diapir, within the larger Tremiti Structure (Festa et al. 2014). This anticline was generated by diapirism of Upper Triassic evaporites within a thick Mesozoic to Quaternary sedimentary succession. Both internal stratal patterns and shapes of Plio-Quaternary units, and the occurrence of an angular unconformity between early Tortonian and Pliocene rocks on the Tremiti Islands, suggest that halokinesis began during the late Miocene and is still active today. An ancient extensional SE-dipping fault, cutting an older Mesozoic low-amplitude anhydritic ridge, played an important role during salt mobilization, which was promoted by NW-SE shortening. The diapir grew in the footwall of this fault, causing its upward propagation. In some places, the ancient fault served as a preferential channel for the upward migration of the salt.

Gravity flows of Mesozoic deposits of Chukotka – paleogeographical and geodynamic evidences

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There are five stages of predominance of gravity mass flows packages of the Anyui-Chukotka fold system. Three stages are recorded for Triassic: Olenekian, Upper Carnian and Upper Norian; Oxfordian-Kimmerigian and Upper Berriasian stages – for the Jurassic-Cretaceous.
We examine the part of Chukotka microplate, the key element in the evolution of the Amerasian basin. The study has reconstructed the Mesozoic depositional history of Northeast Russia. The Chukotka orogenic belts resulted from the suturing of Chukotka microcontinent that was collided to Eurasia margin during the Early Cretaceous Time (Sokolov et al., 2001). The orogeny commenced in Early Cretaceous Time and culminated at the Aptian Time, when orogenic collapse finished with forming postcollisional granite.
The Triassic sedimentation, where Chukotka microcontinent was passive margin of Chukotka – Alaska microplate, finished at Upper Norian Time, where exhumation and local uplifts were. The Triassic deposits represent a siliciclastic turbiditic system directed towards the south (SE-SSE), supplied with recycled detritus. The sediment source changed from low metamorphic to high metamorphic rock. The turbiditic succession consists of a wide range of sedimentary facies, they formed in slope, deep-marine and shelf environments. Gravity flows are: classical turbidites, non-classic turbidites, attributed to high-density and low- density currents, mud-rich turbidite. Sandstones are graywackes and lithic arenites, according to Pettijohn classification (1981). Depositional conditions changed after pause of sedimentation: the phase of Lower–Middle Jurassic is characterized by absence of sedimentation. The next stage of sedimentation was Upper Jurassic–Lower Cretaceous Time. Five different syn-orogenic depressions filled by coarse sediment of foreland basin, sedimentary facies include non classic turbidites attributed to high density currents, fluxoturbidites and gravelly debris flow deposits. A deposit of gravity flows consists of the predominantly arcosic and subarcosic sandstones (J3ox-km and K1b) and litharenites–graywackes (J3t). The direction of currents was from North in the Oxfordian-Kimmerigian and Berriasian Time, and from the South in the Tithonian Time.
Local uplifted basin slope and shelf zone at Upper Norian Time signify completion of sedimentation in the passive margin, the siliciclastic supply was terminated and abandoned turbiditic system. The first phase of compression (Oxfordian Time) recorded by arcosic sandstones, they are widely distribute in the western depression. Another phase of compression (Berriasian Time) recorded by arcosic and subarcosic sandstones. Sedimentation between two orogenic time characterized rhythmic thin-bedded turbiditic sandstones of Tithonian Time by predominantly intrabasin source in the south. Later, in Hoterivian-Barremian Time the main phase of collision was.

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High-frequency, shallow marine clastic sequences across the Turonian-Coniacian boundary, correlated between the Bohemian Cretaceous and Western Canada basins

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The Turonian–Coniacian (T–C) boundary is characterized by a well-defined succession of inoceramids and other biostratigraphic markers recognized in a number of key sections in Europe and North America. In carbon-isotope chemostratigraphy the boundary has mostly been associated with the negative trough of the Navigation C-isotope Event. A fall in sea level somewhere in the broader T–C boundary interval has been interpreted by a number of studies. However, problems with stratigraphic resolution and the incompleteness of many records due to hiatuses and unconformities have prevented a reliable, detailed correlation between basins which is necessary to address the potential eustatic history across this boundary.
Our study focuses on a comparison of clastic depositional systems from two basins, in which 3D physical stratigraphic frameworks were complemented by detailed biostratigraphic and chemostratigraphic data. In the Bohemian Cretaceous Basin of Central Europe, rapid tectonic subsidence combined with abundant sediment supply provided a rare opportunity to study an expanded succession across the T–C boundary, recorded both in offshore hemipelagic facies and nearshore coarse-grained deltas. The transgressive-regressive history of the deltaic system was established with resolution better than 100 kyr in some cycles, based on a detailed biostratigraphic framework and carbon-isotope data from several cores. The T-R history of this interval from the Bohemian Basin was compared to a high-resolution regional stratigraphic framework of the Cardium Formation in the Western Canada Foreland Basin, correlated distally to the Niobrara Formation at Pueblo, CO. Despite the compared basins having different tectonic regimes and vastly different dimensions, most of the high-frequency T-R cycles in the study interval can be correlated in surprising detail, particularly in the uppermost Turonian, which strongly suggests high-frequency eustatic fluctuations across the T–C boundary. Our results emphasize the importance of establishing correlation between high-frequency cycles; lower-frequency stacking patterns can not be correlated because they are dominated by the local signatures of subsidence and sediment supply.

From shallow carbonate ramp to coastal terrigenous input: Sedimentary evolution of the Iberian Tithonian platform (NE Spain)

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Upper Jurassic deposits in the Iberian Basin (NE Iberian Plate) record a relative quiescence period and sedimentation in a broad carbonate platform controlled by homogeneous regional subsidence and sea-level variations. However, at the Jurassic–Cretaceous turnover, increasing tectonic activity involved the uplift of the western margin of the Iberian Basin along with differential subsidence across the basin. Coastal regression and emersion and compartmentalization of the platform resulted in the change from extensive shallow carbonate ramp sedimentation to shallow marine to transitional terrigenous and carbonate deposition in individualized subsiding basin areas.
Two sedimentary stages are documented. During lower Tithonian, an extensive carbonate ramp with a great variety of skeletal and non-skeletal grains displays a complex facies mosaic, indicative of different sedimentary domains within the inner platform, from outer shoals to restricted interior lagoons. A second stage (middle Tithonian–lowermost Berriasian) is dominated by transitional environments, from coastal terrigenous clastic sedimentation to episodic sedimentation in carbonate lagoons. The regressive stage from the shallow carbonate ramp to terrigenous clastic sedimentation with increasing continental influence is presented here, by comparing two areas of the basin with different subsidence rates (i.e., Mezalocha-Aguilón and Galve). Despite the basin-scale sharp change form tectonic quiescence to increasing subsidence and uplift, the sedimentological analysis of these successions indicate the record of the regressive trend varies depending on local subsidence. In subsiding areas (Galve), bioclastic and peloidal lagoonal facies with local oolitic internal bars and increasing terrigenous content alternate with coastal mudstones and sandstones, thus recording a more progressive regressive trend. By contrast, in less subsiding areas (Mezalocha-Aguilón) change from carbonate to siliciclastic is sharp and only thin marine carbonate beds are recorded within the coastal terrigenous succession. Subsiding areas were able to record short-term accommodation gain stages (either related to local subsidence or sea-level) that allowed the episodic marine flooding of coastal areas and deposition of pure carbonate lagoon facies. In less subsiding areas, minor long-term accommodation space did not allow recording the marine flooding associated to short-term accommodation gain stages.

The depth of the Late Miocene Mediterranean Sea and other marine-evaporite basins

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Marine evaporites such as the Permian Zechstein and the Miocene Mediterranean evaporite, are characterized by thick successions (~250-2500 m) that consist of stacked sulphate-halite-potash cycles. The number of cycles is small, typically no more than 6-7, and in almost all cases cycle thickness decreases rapidly up the succession.
It has been shown for the Dutch Zechstein that each cycle is approximately half as thick as the underlying cycle, which was attributed to a mechanism of repeated salt loading and isostatic compensation (Van den Belt & de Boer, 2014). When a 500 metres deep basin is filled with halite, and subordinate sulphate, this causes a subsidence correction of ~250 m to regain isostatic equilibrium. This new basin may subsequently be filled with halite and trigger the formation of a 125 m deep basin, and so on. The ultimate succession reaches a thickness of ~1000 m and is capped by a compound top cycle that represents an “infinite” number of thin cycles. The ideal cycle-thickness pattern for a complete succession (100%) can be written as 50%, 25%, 12.5%, 6.25% and 6.25% (compound top cycle).
An inventory shows that the mechanism applies to other marine-evaporite basins also. This includes the Miocene Mediterranean Sea, the depth of which has been debated for decades. With cycle thicknesses of ~395 m (cycle 2), ~ 215 m (cycle 3) and ~ 95 m (cycle 4), and a total thickness of ~1.6 km, the Western Mediterranean seems to have been about 800 m deep. For the Sicilian succession the cycle pattern is very close to predicted: 445 m (54%, initial basin depth), 226 m (25%), 107 m (13%), 56 m (7%) and 28 m (3 %).
Another example is the thin Devonian Muskeg evaporite succession, which consists of four cycles. Its thickness is ~270 m indicating an initial basin depth of 135 m. The first three cycles are well developed anhydrite-halite cycles, but the top cycle is composed of anhydritic red beds. In other succession the top cycle consists of evaporitic claystones as well, e.g. the Upper Claystone member in the Zechstein Basin and the “Lago Mare’ clays in the Mediterranean. This seems to reflect that towards the end of the process the evaporite basin becomes very shallow and is near sea level, and therefore attracts little ocean water. Poor cycle definition within the top cycles seems primarily the result of “scale of observation”.
It is concluded that the initial depth of marine-evaporite basins equalled 50% of the thickness of the succession and decreased to zero in a stepwise fashion during halite infilling.

Dynamic two-dimensional modelling of the formation of classic Pennsylvanian cyclothems: On how sea-level fluctuations are (not) translated to the sedimentary record

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Cyclothem successions from Pennsylvanian coal basins of equatorial Euramerica are the prime example of cyclic deposition driven by glacio-eustatic sea-level fluctuations. Although there is little doubt that these repetitive successions -consisting of well over a hundred cyclothems- are the result of prolonged waxing and waning of Gondwanan ice caps, results of cyclicity analysis are disappointing and solid quantitative support for Milankovitch control is still lacking.
We developed two-dimensional, forward-modelling software to study the translation of cyclic sea-level signals into facies sequences and determine ideal conditions for preservation of the cyclicity (e.g. subsidence rates, location in the basin). The software simulates shallow-marine/deltaic deposition under fluctuating sea-level and sediment supply (in phase or in anti-phase with sea level) in symmetric or asymmetric basins. Example succession can be drawn from the modelled 2D basin transects for analysis of continuity of sequence, hiatuses and cycle duration.
Live model runs will be presented for two classic cyclothem basins (Appalachian Basin, NW European coal basin) under variable conditions, and it will be shown that subsidence in the classic (U.K. and U.S.) study areas was too slow to accurately record the cyclic signal. Only areas where subsidence rates were as high as ~50 cm/ky (post-compaction), such as in the Netherlands/Germany just north of the Variscan thrust front and in the transtensional Cumberland basin of Nova Scotia, are likely to have preserved fairly complete successions. Still, those sequences contain considerable depositional gaps.

The response of depositional patterns in river deltas to the balance between bed load and suspended load sediment transport

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Sedimentation in deltaic depositional environments is characterised by the hydrodynamic properties of the system (fluvial input, tidal conditions, wave action) as well as the physical properties of the sediment supply (cohesivity, grain size distribution). This study investigates the effects of sediment transport, the process linking hydrodynamics and sediment properties, on the resultant depositional patterns.
In river deltas, the majority of sediment is transported as suspended load with a smaller proportion transported as bed load. While suspended load is relatively easy to measure, bed load is more challenging and is therefore typically estimated or calculated based on the suspended load. It has however been reported that bed load can have a significant impact on river morphology. To date, limited data has been presented on the proportion of bed load transported as a function of the measurable suspended load in river systems, while for deltas there has not yet been a detailed review.
To investigate the effect which the balance between bed load and suspended load transport have on patterns of sedimentation in prograding deltas, we created a set of numerical models using process-based modelling software Delft3D. Delft3D has previously been implemented to study the effect of hydrodynamic conditions and sediment properties on river delta morphodynamics. We have built on these experiments and created a set of models with varying sediment supply and sediment transport definitions. Our models have no tidal signals or wave interaction defined and fluvial input is kept constant. Sediment transport is defined through the Engelhund-Hansen transport formula. We have also chosen to keep the concentration of suspended sediment constant across all the models, so as to illustrate the divergent patterns of sedimentation which can evolve from similar suspended load measurements.
We show that similar behaviour can be achieved by varying either of the ratios cohesive:non-cohesive sediment or suspended-:bed load while keeping the other ratio constant. With relatively higher suspended load, as with increased cohesive sediment, the delta contains fewer, larger channels. The network evolves through infrequent avulsion, eventually leading to rugose shorelines. Sediment is deposited further from the delta apex and spread over a larger area. The opposite is true for cases with relatively higher bed load transport, as with increased non-cohesivity, where the deltas contains more, smaller channels. The network evolves through frequent bifurcations which eventually leads to a smoother shoreline.
This points to the importance of better understanding the balance between cohesive and non-cohesive suspended load relative to bed load transport through field studies. This can improve prediction of sedimentation patterns in both modern deltas and also advance our understanding of ancient deposits.

Ikaite pseudomorphs as cool water proxies in the Lower Cretaceous of the South Shetland Islands, Antarctic Peninsula

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Ikaite, and its pseudomorph glendonite, are calcium carbonate minerals ($CaCO_3$ $6H_20$) associated with marine and lacustrine cold-water environments. Ikaite is metastable under limited conditions of temperature below 5 °C, high alkalinity, and dissolved phosphate: factors related to organic-rich sediments. These restricted parameters of stability make ikaite a useful tool for indicating cold-water environments in ancient deposits.
Glendonite was identified in two Lower Cretaceous sequences of the Byers Group in the South Shetland Islands, Antarctic Peninsula. The marine sequence, located in the Byers Peninsula of Livingston Island, is part of the Sealer Hill Member of the Chester Cone Formation (Upper Berriasian- Middle Valanginian). The litho- and palynofacies indicate a platform depositional environment, with high volcaniclastic input, enriched in amorphous organic matter, where turbidity currents play an important role in the transport and deposition of the sediments. One of the 12 samples studied for palynofacies analysis yielded glendonite crystals. The lacustrine sequence, located at President Head, Snow Island, is part of the upper section of the Cerro Negro Formation (Aptian). In this deposit, mudstone is rhythmically intercalated with fine to medium sandstone, and presents abundant and well-preserved macroflora. Two out of 14 samples analyzed for palinofacies bore glendonite. Its presence can be due to a deposition in the hypolimnion zone - under the thermocline - where cold water, in the absence of oxygen, favors the preservation of organic matter.
According to studies constrained to the Middle Jurassic-Lower Cretaceous using other paleoclimatic proxies (Tex_{86}, $\delta^{18}O$), the climate during this period is mainly tropical to subtropical, even in high latitudes (Littler et al., 2011; Jenkins et al., 2012). Therefore, the existence of glendonite crystals in these two sequences can be attributed to seasonal cold snaps, but more evidence is needed to extend these conditions to the rest of the Antarctic Peninsula during the Lower Cretaceous.

Thermal history and hydrocarbon migration modeling in 2D, in an uplifted, compressional area

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Nowadays hydrocarbon exploration has a key role in our world's economy. Because of the decreasing number of the supplies the smaller accumulations have a bigger and bigger importance. The research of these small accumulations requires a greater accuracy. If we know better the history of a sedimentary basin we can delineate more accurately the places of the possible fields, so we can increase the chance for successful exploration.
The burial and maturity history determination of an area contributes to the success of later researches, because with the help of these models we can obtain information about the position and size of the hydrocarbon accumulations. Moreover we can get important information about the maturation of the source rocks, the onset of the petroleum generation or the migration pathways. Within the framework of a bigger project a model like this was made for an active hydrocarbon research area in the Zagros.
The main aim was to make an integrated model about the study area which handle the structural geological and burial and maturity history information at the same time. All in order to get a more detailed picture about the hydrocarbon system, the accumulations and the migration pathways. To achieve this at first we have to reveal the order and age of the structural elements in the study area and their role in the formation of the recent hydrocarbon fields.
Iraq is one of the most hydrocarbon rich regions in the Middle-East. The Kurdistan region of Iraq lies in the Zagros Mountains which has Paleozoic, Mesozoic and Cenozoic hydrocarbon systems. In the region of the study area the Mesozoic and Cenozoic systems are very productive, but exactly in my research field these systems are mostly dry, because strong deformation occurred in the Paleogene and destroyed more of the accumulations. Nevertheless there is still production in the study area, because the Jurassic carbonates are good reservoirs and they could keep some parts of their hydrocarbons.
To get an integrated picture about the working of the hydrocarbon system 2D seismic section balancing and maturity history modeling were done with Move and Petromod softwares. End results show that the hydrocarbon migration along faults is very strong and causes the disappearing of the light fraction from the system. This is the main reason why wells only find heavy oils in these areas.

Cihanbeyli-Yeniceoba Basin, Central Anatolia, Turkey: Its sedimentary environments, basinal architecture, and structural relationship with Tuzgölü and Haymana Basins

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Central Anatolia, Turkey contains many small to large Neogene sedimentary basins. One of these them is the Cihanbeyli-Yeniceoba basin which is located to the southwest of two largest sedimentary basins in Central Anatolia. The two basins are the Haymana and Tuzgölü basins which contain a thick sedimentary-basin fill ranging from Late Cretaceous to Quaternary in age. The basin- fill consists of shallow to deep marine clastics, carbonates, evaporates; and terrestrial fluvial and lacustrine deposits. In the Cihanbeyli-Yeniceoba basin, the red colored terrestrial clastics of the Paleocene Kartal Formation gradually overly platform carbonates of the Çaldağ Formation which is wide-spread in the Tuzgölü and Haymana Basins. The Kartal deposition continued over the Paleocene carbonate platform units as alluvial fan deposits containing contain coarse pebbles to boulder. Ophiolite clasts and gypsum conglomerate up to several tens of meters in thickness. Palinomorph and $^{87}Sr/^{86}Sr$ isotopes age dating suggest that the ophiolite emplacement in Central Anatolia took place in several episodes from Oligocene to Early Miocene. The ophiolite emplacement caused Nummulithic limestone and ophiolite blocks transported into the terrestrial environments in as exotic blocks. Some of these blocks are very large and yield Middle Eocene age. During the time interval of Late Paleocene-Early Oligocene, the neighboring Tuzgölü and Haymana basins received thick marine sedimentary rock accumulations (over 1000 m) composed of Flysch-type siliciclastic, and reefal carbonates.
In Late Miocene, buried Paleocene platform carbonates were exposed to surface due to intrabasinal uplift. The Late Miocene alluvial fans change composition upward and grade into fans which do not have ophiolite-derived and platform carbonates derived gravels. The alluvial fans also contain large fractures (tens of meters in length) that are filled with filled with satin-spar gypsum cement. These observations suggest to us that the Haymana, Tuzgölü and Cihanbeyli-Yeniceoba basins are genetically related and received sediments simultaneously from Paleogene to Late Miocene.

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Gypsum conglomerate and its environmental implication: An example of Cihanbeyli-Yeniceoba Tertiary Basin, Central Anatolian

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Cihanbeyli–Yeniceoba is a small basin located to the southwest of two large intracontinental sedimentary basins (Haymana and Tuzgölü) in Central Anatolia. The small basin studied differs from the neighboring large basins with respect to basinal configuration and basin-fill deposits. The Haymana and Tuzgölü basins have a very thick depositional intervals (over 1000 m thick) is composed of shallow to deep marine clastics (submarine fans), carbonates, evaporites and subsequently fluvio-lacustrine deposits ranging from Late Cretaceous to Quaternary in age. Whereas Cihanbeyli-Yeniceoba basin is lack of the deep marine clastics and it is represented by thick alluvial fan deposits in the range of late Eocene/ Oligocene to late Miocene based on dating of palinomorph and $^{87}Sr/^{86}Sr$ isotope. The gypsum conglomerate was deposited in front of the ophiolite trusts and accumulated in the stacked small alluvial fans with thick of 3-10 m and lateral extent of 50–120 m. The fans are interfingering with fluvial sediments. The conglomerate layers display wedge-shaped or lobe-building character, and they are represented by bedded, crudely bedded or massive layers (30-150 cm thick) contain well rounded but poorly sorted (2 cm–30 cm dimentions), gypsum-derived (85-95 %) or ophiolite and carbonate-derived (5-15 %) pebbles and clasts. Upward-thickening and coarsening cycles, non-erosional boundary or local incises (30 -60 cm deep), clast-and matrix supported fabric, interbeds of gypsum arenite (15-40 cm thick) and red mudstone (20-50 cm) are typical characteristic features for this grain-flow induced gypsum conglomerate deposited along the trust-dominated basin margin. Its clast composition provides a good record unroofing of the trust front and reveals differences in the bedrock provenance.

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Sedimentary facies of a transgressive sequence in the Pisco formation (middle Miocene-lower Pliocene), Peru

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The Pisco formation in southern Peru consists of a thick succession of fine sandstone, siltstone, and diatomaceous and tuffaceous mudstone, with interspersed hardgrounds, very thin layers of phosphate pebbles, very thin to thin layers of volcanic ash, rudstones and calcite- and dolomite-cemented sandstones and siltstones. The succession records an abundant and diverse fauna of marine mammals, fish, pinnipeds, and other vertebrates, as well as bivalves and cirripeds. This sedimentary succession represents the last marine transgression that extended throughout the Pisco basin.

The base of the Pisco formation transgressive sequence commonly consists of a layer of phosphate nodules and igneous boulders. Phosphate clasts are sub-rounded to rounded very coarse sand to small cobbles, but mostly pebble size, occasionally with small pits and borings. Locally, this layer is a fine sandstone with burrows, hardgrounds, and carbonate-cemented intraclasts, characterized by *Glossifungites* ichnofacies. Fossils are abundant and include shark teeth, fish bones, articulated bivalve shells, disarticulated oysters, and articulated and disarticulated marine mammal bones. Especially remarkable in this basal layer is the occurrence of igneous boulders. They are sub-rounded to rounded, sub-spherical to spherical clasts of granite and diorite/andesite, in sizes that vary widely between 25 cm and 2.5 m in diameter, with smooth surface and few borings. These boulders also occur in other horizons higher in the section within layers of phosphate pebbles, shell beds and/or rudstones with a matrix consisting of mono-mineral associations with shell fragments.

Overlying this basal layer there are layers of brown to greenish, massive, well-sorted fine sandstones interspersed with thin layers of fossiliferous fine sandstone concretions (calcareous or dolomitic). These sandstones are locally flaser-bedded and have abundant current structures. The abundant fossil content in the concretions consists of bivalves (*Dosinia, Anadara*), marine mammal bones (baleen whales, seals, dolphins), shark teeth, gastropods and fish scales. Some levels of concretions lack fossils. Shell beds occur repeatedly at regular intervals in some sections, including layers of *Turritella*, *Dosinia*, oysters, and other shells, often containing abundant marine mammal bones.

Overlying the sandstone is a thick succession of siltstone with abundant current, load, and scour-and-fill structures, hummocky cross-stratification, and parallel lamination. In some exposures, these siltstones are massive. Diatomaceous and tuffaceous mudstones, both massive and with rough parallel lamination, occur on top of some sections, interspersed with thin layers of volcanic ash, phosphate or siltstone pebbles. The mudstone layers lack invertebrate fossils but locally have high abundance of vertebrate fossils, especially marine mammals.

The succession of fining-upward sediments of the Pisco formation suggests a marine transgression with deepening of the basin. Bored hardgrounds and intraclasts indicate surfaces of exposure and erosion in the foreshore, intertidal zone, on which shell, barnacles, whale skeletons and igneous boulders accumulated. The overlying fine sandstones suggest deposition in a relatively high-energy environment in the shoreface. Siltstones with cross-bedding and hummocky cross-stratification indicate storm deposition within the lower shoreface to offshore-transitional environment, above storm wave base. The diatomaceous and tuffaceous mudstones are evidence of the deepening of the basin and deposition in the offshore zone.

Provenance of the Upper Pegtymel formation (western Chukotka)

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The Upper Pegtymel depression is one of the syn-orogenic basins along the southwestern edge of the Arctic Alaska - Chukotka microplate, Chukotka terrane. These basins were formed simultaneously with the closing of the South Anyui Ocean. The collision of the Arctic Alaska - Chukotka microplate with the North Asian craton completed in the Early Cretaceous time.
Upper Pegtymel deposits are presented by interbedding sandstones, siltstones, mudstones and conglomerates, inferred to be gravity flow deposits with representative structures like rip-up clasts, load clasts, graded bedding etc. There are different types of conglomerates in Upper Pegtymel formation: conglomerates in the bottom of graded cycle, conglomerate lenses and tilloids (or pebbly mudstones). Pebbly mudstones are massive poor consolidate mud containing scattered pebbles and intrabasinal better consolidated blocks of sandstones. Debris flow origin of pebbly mudstones proposed by Crowell in 1957, but even today this processes are not well understood. For better understanding the process of deposition of these sequences, we carefully examined all structures and pebbles characteristics from conglomerates. Our data suggest that Upper Pegtymel formation is submarine channel deposits.
According petrography analysis Upper Pegtymel greywackes and litharinites are composed by poly-crystalline and volcanic shape quartz, plagioclase and different lithic fragments (clastic, volcanic and quartz-fieldspate aggregates). These data indicate presence of basinal clastic, coarse crystalline and volcanic rocks in source area. The conglomerate pebbles are dominated by mudstones, siltstones and sandstones, are subordinate fragments of quartz veins and volcanic rocks. Increasing amount of clastic fragments proportionally to increasing of the grain size indicate that clastic source is the nearest one to the depositional basin.
To identify the origin of clastic and volcanic pebbles, they were analyzed by ICP-MS. There are two types of clastic pebbles, first one are very similar to Triassic mudstones by geochemical characteristics, second are identic with the host sandstones. Volcanic pebbles are differ from basaltic andesite to dacite. On discriminant diagrams by Wood (1980) and Pearce (1984) they occupy field of volcanic arc varieties. These data suggest presence of the Triassic mudstone and the island arc formations in source area and active hydrodynamics during sedimentation.

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Genesis of sandstone lenses in a wave-dominated, tide-modulated siliciclastic system (Fezouata Fm, Lower Ordovician, Morocco)

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The Lower Ordovician succession (ca 1000 m of thickness) in the central Anti-Atlas of Morocco is represented by the Fezouata and Zini formations. It consists of fossiliferous siltstones exhibiting many layers containing exceptionally preserved soft tissues of animals, thus recording the Great Ordovician Biodiversification Event. In order to constrain the paleoenvironmental context recording these exceptionally preserved fossils, a model of deposition for the Fezouata and the Zini formations was achieved. Both the Fezouata and Zini formations were deposited in a post-rifting context that created a giant shallow epicontinental sea surrounding the Gondwana. During the Early Ordovician, the sedimentation was wave-dominated and tide-modulated. The sedimentary facies described record deposits from proximal offshore to foreshore with numerous evidences for this double influence.
In the lower shoreface environments, atypical sedimentary bodies (sandstone lenses) showing an elliptical shape in section and an elongated shape in surface are very common. Sandstone lenses are yellowish/orange and strongly indurated. Composed by fine sands and locally by coarse bioclastic discontinuous lags, sandstones lenses are in average ca 80 cm high for ca 1–1,5 m in width. The sandstone lenses are formed by repeated changes in size of the hummocky cross-stratification (HCS) wavelength, and one couplet larger to smaller HCS, or bioclastic layers to sandy HCS, is here defined as one unit. Commonly, 2–8 units constituted the sandstone lenses. Three types of sandstone lenses are identified and described according to their bioclastic content: Bioclastic-lenses (BL-type), Mixed-lenses (ML-type) and Sandy-lenses (SL-type). More precisely, BL belong to the proximal, ML to the intermediate, and SL to the distal lower shoreface.
These peculiar sedimentary bodies are interpreted as being formed during storms, and the influence of tides is responsible for the formation of the units that constitute the sandstone lenses. The analysis of these peculiar sedimentary structures permitted to better define the processes ruling the sedimentation of the Lower Ordovician of the Anti-Atlas, as both storm and tide influences are well-expressed when compared to the other encountered facies of the Fezouata and Zini formations.

Facies and stratigraphic record of a Lower Cretaceous, tide-dominated offshore dunefield (Pilmatué Member - Agrio Formation): Sequential and palaeogeographic implications for the southern Neuquén Basin, Argentina

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The Neuquén Basin conformed, during most of the Upper Jurassic and Lower Cretaceous, an epicontinental sea in which shoreface and offshore environments were dominated by wave and storm processes The Valanginian-Hauterivian Pilmatué Member conforms to this generalization with wave/storm-influenced deposits across the basin. In this context, the development of a relatively thick succession of current-dominated deposits intercalated in offshore mudstones is unusual and its study may reveal information regarding punctuated palaeogeographic reconfigurations associated with periods of tectonic activity. It also provides the opportunity to describe the scarcely registered facies and stratigraphic record of tide-dominated offshore systems in the rock record.

In the Cerro Mesa area (central Neuquén province, Argentina), the studied interval comprises a 30 m-thick succession of mixed (siliciclastic-carbonate) relatively coarse-grained deposits. This succession is sharply placed between offshore mudstones and marls. The lower section is dominated by wavy and lenticular heterolithic deposits (with *Gyrochorte*, *Teichichnus* and *Chondrites*) and massive mudstones, in which at least four discrete units of fine-grained bioclastic sands (up to 1.5 m thick) intercalate. The lower boundary of these coarser units is usually associated with passively filled burrows comprising a *Glossifungites* suite. The sandy units are mainly massive, but they may show ripple cross-lamination and locally larger cross beds. Bioturbation is present mainly associated with *Ophiomorpha* and in less proportion *Teichichnus* and *Palaeophycus*.

In contrast, the upper portion of the succession is dominated by coarse-grained bioclastic sandstones showing a profusion of cross-bedded structures that range between mid-scale, trough cross-bedding to large-scale sets with tangential foresets and abundant reactivation surfaces. In some cases, small-scale cross-lamination is superimposed to the large-scale sets, showing an opposite migration direction. Cross-bedded units coarsen and thicken upwards, reaching up to 4 m in the upper portion, and show great continuity (for up to 1 km), although the lower boundaries may show evidence of erosion. Bioturbation is infrequent, though large *Ophiomorpha* has been recorded in every unit of this upper section.

The abundance of deposits associated with strong unidirectional currents, evidence of reversion of these currents and the profusion of reactivation surfaces within the large-scale cross-sets, suggest the development of tidally induced currents that led to the development of subtidal sand dunes in an offshore setting. The proportion of carbonate components (bioclasts and ooids) indicates a relatively close carbonate factory and the lack of dilution of the carbonates due to siliciclastic input. The overall coarsening- and thickening-upward succession may reflect the gradual downcurrent migration of the dunefield until it is abandoned and covered by a thick succession of offshore fines.

The development of strong tidal currents in this offshore setting during the Early Cretaceous suggests unusual conditions for the Neuquén Basin. These deposits were likely accumulated during a low-order transgressive interval developed after a major relative sea-level fall, which has been associated with local tectonic activity and with reactivation and inversion of older structures. This tectonic activity could have modified the palaeogeography, at least locally, to promote the amplification of tidal currents, effect that could have faded away when the transgression progressed.

The oxalate-carbonate pathway (OCP): A way to precipitate calcium carbonate in acidic environments

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Some unexpected calcium carbonate accumulations are found in tropical soils and paleosols, where the general edaphic conditions and geological settings are acidic. These accumulations are not related to the conventional *per descensum* leaching of calcite, as the upper horizons do not include any traces of inherited carbonate. Consequently, another process must be involved to allow favourable conditions for calcite precipitation in such environments. One characteristic of such soils is their association with specific plants. These plants are systematically calcium oxalate producers. Calcium oxalate is an organic salt, mainly found as crystals in their tissues, and released into the soil medium during the decay of organic matter by various biological actors. Oxalotrophic bacteria use these crystals as carbon and electron sources, leading to the production of hydrogeno-carbonate and an increase in pH. Although soils enriched with secondary calcium carbonate accumulations were formerly acidic tropical soils with a pH < 5, their pH can reach values > 9 when OCP is active and efficient, as measured in the field and demonstrated using a simple biogeochemical model. The concomitant presence of carbonate ions, an alkaline pH, and the calcium ion available in the soil solution leads to the precipitation of soil secondary carbonate at various depths, depending on the distribution of microorganisms, the soil texture, and the age and abundance of oxalate producers. A biogeochemical study of the carbon and calcium sources emphasizes a complex series of coupled pathways of C and Ca involving both plants and geological material, demonstrating a strong relationship between life and minerals.
The consequences of such a pathway in the geological record can be significant: i) OCP could explain the presence of secondary calcium carbonate in carbonate-free watersheds; ii) the observed depth of carbonate nodules is not related to leaching processes, questioning some interpretations of nodule depth as a paleo-rainfall proxy; and iii) OCP constitutes a carbon sink, as long as the calcium ion is not originating from former limestone dissolution.

Mediterranean cold-water coral buildups: Important archives of Quaternary oceanographic modifications

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Modern Mediterranean cold-water coral (CWC) buildups form in bathyal environments due to the aggregations of azooxanthellate branching scleractinian colonies (mostly *Madrepora oculata*, secondarily *Lophelia pertusa*) and large solitary species (*Desmophyllum dianthus*). The simultaneous growth of these corals, often fusing their skeletons together, and the accretion of subsequent coral generations create a complex three dimensional carbonate framework that hosts a large variety of microhabitats and enhances the local seafloor diversity. CWC buildups harbor very diverse benthic communities colonizing both hard substrates, mostly provided by tissue-barren scleractinian skeletons, and fine-grained sediments accumulated due to the baffling action of corals and other branching organisms. The presence/absence of CWC buildups and the taxonomic composition of associated benthic communities is influenced by several environmental factors (such as current intensity, food supply, oxygenation, temperature etc.) connected to small- and/or large-scale oceanographic dynamics. Therefore their evolution through time can be used as a valuable tool to interpret paleoceanographic modifications.
This presentation aims at summarising the state-of-the-art in the study of Mediterranean CWC buildups as archives for paleoenvironmental reconstructions through the Quaternary. Special emphasis is given to the biotic proxy, i.e. the diversity of buildup skeletonised organisms and its relationship to paleoenvironmental modifications.
Data collected so far indicate the presence of CWC buildups in the Mediterranean since at least the Early Pleistocene. However, due to the large lack of information from the end of the Calabrian stage till around 50 ka BP, we do not know if these bioconstructions occurred continuously in the Mediterranean or, more likely, experienced several growth stases. What we can certainly state is that the composition of frame-building scleractinians and associated benthic fauna underwent important modifications from the Early Pleistocene up to now. *Lophelia*-dominated buildups, comparable in terms of structure and taxonomic composition to modern NE Atlantic counterparts, were flourishing in the Early Pleistocene bathyal seafloor of the Mediterranean, hinting at Atlantic-like paleoceanographic conditions. Several species of scleractinians, stylasterids, alcyonaceans, molluscs, crinoids, brachiopods, serpulids and other taxa inhabiting Early Pleistocene CWC buildups are absent in the modern Mediterranean and most of them seem to have disappeared before the Late Pleistocene. Moreover, recent studies on gravity cores from Mediterranean CWC mounds show that important modifications in the composition of benthic paleocommunities occurred also at the Pleistocene-Holocene boundary. Large knowledge gaps still need to be filled, nevertheless paleontological data collected so far clearly indicate that modern CWC buildup communities of the Mediterranean result from the complex interplay between large-scale climate changes and environmental modifications at regional scale.

Proximal storm deposits in tidal environments: An example from the Cenomanian successions in Eastern Bulgaria

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The Cenomanian rocks cropping out in the southeastern Moesian Platform and in the Eastern Balkanides have been considered by some authors as deposits of a shallow marine basin, while others have assumed the existence of two individual basins separated by a narrow strip of elevated dry land. The paleogeodynamic setting is also controversial with interpretations varying from stable platform to back-arc and syn-rift basins. Regarding the depositional environments previous studies have claimed shallow marine origin for the Cenomanian carbonate-dominated successions of Madara Formation and two informal “sandstone” units, and turbiditic origin for the mainly siliciclastic strata of the “flysch” formation.
Newly performed field studies revealed the presence of storm-generated and tidal deposits in the Cenomanian successions of Eastern Bulgaria. The tempestites can be subdivided into four types in order of increasing water depth: 1) pot and gutter casts, 2) layers showing the idealized proximal tempestite sequence, 3) amalgamated hummocky cross-stratified (HCS) beds, and 4) skeletal beds. The pot and gutter casts represent flow-induced erosional structures filled with sandy or carbonate skeletal material. They occur within thin-bedded, mud- or sand-dominated background deposits and can be interpreted as the most proximal storm products formed in the foreshore bypass zone. The second tempestite type comprises beds that consist of a shell layer with sharp erosional base, and an overlying sandstone division with wave ripples on top. The amalgamated HCS beds are grainstones/rudstones showing erosionally truncated bedding planes. Their most prominent characteristic is the presence of large-scale HCS with hummocks reaching length up to 10 m and height up to 1 m. These tempestites are considered as deposited in the lower shoreface zone as a result of multiple storm episodes. The skeletal limestone beds display sharp erosional base and contain abundant articulated and/or disarticulated brachiopod shells with convex-up orientation. This tempestite type was probably produced during the peak of storm events in the lower shoreface zone close to the storm wave base.
The described tempestites are interbedded in tidal successions characterized by the presence of lenticular stratification, channels with lateral accretion surfaces, herringbone cross-bedding, flaser structure, coal laminae, and anhydrite cements. Predominantly siliciclastic deposits of the intertidal zone and carbonate-dominated deposits of the subtidal zone are clearly distinguished. The tidal features were obliterated to a various extent by the contemporaneous storm activity. The new interpretation provides good evidence for shallow-marine origin of the strata forming the lower levels of the “flysch” formation. The correlation between tempestites exposed in the SE Moesian Platform and the Eastern Balkanides suggests the existence of one shallow marine basin during the Cenomanian. This conclusion allows further regional correlation with isochronous deposits in Bulgaria (Central and Eastern Srednogorie Zones and Moesian Platform), and possibly in Romania and Turkey. Moreover, the recognized depositional environments for Cenomanian rocks in Eastern Bulgaria are inconsistent with the evolution and nature of the sedimentary fill in syn-rift basins, and thus preclude previously proposed rifting models.

Using heavy mineral analyses to determine the provenance of Cenozoic siliciclastic depositional systems supplying the northern margin of the Eastern Black Sea

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The Eastern Black Sea is one of the few remaining underexplored hydrocarbon basins in Europe. Reservoir quality is a key risk factor in the basin. The analysis of the up-dip portions of Oligocene to Pliocene depositional systems exposed around its northern and eastern margins enable the composition and provenance of sandstones within the basin to be predicted. Quartz-rich sandstones are present, from northwest to southeast, around the Kerch-Taman Strait, along the flanks of the Russian western Greater Caucasus and in western/central Georgia. These are predicted to form better quality reservoirs at shallow and moderate burial depths than their rock fragment-rich counterparts, due to lesser amounts of compactional porosity loss. Heavy mineral analysis has played an important role in determining the provenance of these quartz-rich sandstones. The determination of provenance sensitive heavy mineral ratios, single mineral geochemical analyses and zircon U-Pb SHRIMP ages were particularly informative. Two major sediment source regions for quartz-rich sandstone have been identified: the Russian western Greater Caucasus, which became a subaerial sediment source in the Oligocene, and the East European Craton-Scythian Platform. Oligo-Miocene sandstones from the Russian western Greater Caucasus were deposited as turbidites in the Tuapse Trough. Sandstones from the East European Craton-Scythian Platform were largely trapped within the Indolo-Kuban Basin north of the Greater Caucasus. They only entered the Eastern Black Sea in large volumes from latest Miocene or Pliocene time in the region of the Kerch-Taman shelf at the western tip of the Greater Caucasus. However, it is possible that a precursor to this system supplied the Oligocene to Early Miocene reservoir sandstones within the Subbotina field on the Kerch-Taman shelf. The Dziruli Massif, in western Georgia, also generated quartz-rich sandstones, but these are not thought to have entered the Black Sea.

Late Jurassic earliest Cretaceous reef analogues for the Eastern Black Sea; palaeogeographic setting, facies, strontium isotope stratigraphy and reservoir potential

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Seismic data have revealed the likely occurrence of Late Jurassic–earliest Cretaceous reef complexes up to 1-2 km thick and 10-20 km wide on the northern Shatskiy Ridge in the Eastern Black Sea. Reefs may also be present on the Mid Black Sea High. Widespread onshore exposures of Late Jurassic - earliest Cretaceous reefs in the Pontides, Russian western Caucasus and Crimea are a similar size to those in the subsurface and form excellent analogues to these potential reservoirs.

The study region formed part of the northern margin of Tethys during the Late Jurassic–earliest Cretaceous. In common with much of the north Tethyan margin, reefs in the study region can be grouped into coral-dominated, siliceous sponge-microbial and microbial types. Coral-dominated reefs occur as patchy and massive forms, and can be subdivided into higher-diversity and low-diversity (platy) types. The former developed at shallow-water platform margins and in platform interiors, whilst the latter occurred in deeper-water mid-shelf settings. Siliceous sponge-microbial and microbial reefs occur as lenses and mounds and are restricted to deeper-water mid-outer shelf environments. The development of these reefs was controlled mainly by local variations in water depth, light, the availability of nutrients, and sedimentation rate. Thick reef occurrences are often associated with fault-bounded platform margins.

In many regions, karstic surfaces/unconformities punctuate the Late Jurassic–earliest Cretaceous carbonate stratigraphy. These may be associated with zones of enhanced secondary porosity and form markers on seismic. The resolution of existing biostratigraphic data is insufficient to test if these surfaces are synchronous between regions. A pilot strontium isotope study of a well-exposed section in the eastern Pontides has been carried out as a result. The section contains a major truncation surface with a local relief of at least 45 m. Isotopic values supported by foraminiferal biostratigraphy indicate that it represents an intra-Tithonian to Berriasian hiatus. This technique has the potential to be applied to other outcrops in the region.

The reefs exhibit a complex pattern of porosity development reflecting independent diagenetic histories involving near-surface and deep-burial dissolution, dolomitization and dedolomitization. Porosity is particularly common in coral-dominated reef facies and consists of both primary and secondary types. The amount of visual porosity estimated at outcrop is up to 5%.

Superimposition of hypogenic and epigenic karst processes documented by speleothems of the Szemlő-hegy Cave (Budapest, Hungary)

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Rózsadomb belongs to the Buda Thermal Karst famous for its hypogenic caves hosted mainly by Eocene limestones. They are thought to have developed in Pleistocene times on interaction with CO_2 and H_2S-rich thermal waters rising along Miocene fractures and discharging at the local base level of erosion. Their corrosivity was apparently enhanced by mixing with local meteoric waters in the discharge zone. Due to tectonically controlled uplift, many caves are now dry and far above the actual base-level. Szemlő-hegy Cave and its speleothems reveal the story of the passage from the hypogenic (phreatic) to the epigenic (vadose) zone and the associated porosity evolution.
Detailed mapping, macroscopic and microscopic observations, XRD, SEM, U/Th and stable isotope analyses permitted to distinguish several speleothems and porosity types.
It is suggested that in the deep-phreatic zone, dissolution was the predominant process of cave formation. Later on as the cave moved from the phreatic to the vadose zone, thermal-water lakes established in the bottom of its NE-SW corridors. Because of evaporation and CO_2 degassing from the lukewarm water surface, condensation-corrosion started in the upper parts of the corridors and resulted in the formation of spheroidal niches. At the same time, in the lower reaches of the cave, around and above the phreatic/vadose interface, precipitation of speleothems of variegated morphologies- and porosity-types began. Below the water-table, 3 to 10 cms thick, low-porosity isopachous calcite crusts grew with the crystals oriented perpendicularly to the cave walls. At the same time on the water surface cave rafts precipitated which subsequently sank to the bottom of the lakes. Chaotic piles of such rafts may have had rather high depositional porosity (cm-sized large pores between the rafts). Later on, however, by overgrowth and by cementation on the lake-bottom, this porosity was efficiently reduced. In the uppermost shallower margins of the lakes rafts remained mm thin and uncemented. Above the surface of the thermal water-lakes, evaporation resulted in precipitation of cave coralloids and frostworks of often rather high porosity. These speleothems consist of calcite and aragonite and in their pores small crystals of barite, dolomite and other high-Mg-carbonates occur. Some cm thick gypsum crusts often cover earlier precipitated speleothems on the cave walls. They are supposed to have formed above the water-table on interaction of the wet host rock with sulphuric acids. Along the interface between gypsum crusts and the cave walls minor amounts of celestite, sepiolite and dolomite were detected. There are also typical vadose zone precipitates (dripstones) in the cave. They formed in Pleistocene to Holocene times and belong to the degradational phase of the cave.
At present, along NW-SE fractures, there is still a definite upward flow of CO_2 dissolving the surface of older speleothems and even the carbonate host rock resulting in a secondary increase of the already existing cavernous porosity.
The observed features may serve as analogues to better understand some details of the porosity evolution of thermal karstic petroleum reseorvoirs.

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Towards 3D reservoir modeling of outcrop analogs through integrated outcrop/behind outcrop characterization. A Triassic example

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In this study, we deal with an example of medium-scale sandstone body of the TIBEM Formation (Triassic of the Iberian Meseta, South-Central Spain), which has been tested in previous works as an excellent outcrop analog for TAGI Formation of Algeria, as well as other reservoirs in fluvial sediments.
In the facies and architectural element analysis made on outcrop a fluvial meanderbelt complex has been identified where the channel and point bar sub-environments can be recognized. The channel depicts a fining and thinning upward succession where three parts can be identified corresponding from base to top to: the phase of maximum activity in the channel, the stage of progressive abandonment and the clay plug when the channel has been definitively abandoned by avulsion. The point bar is represented by epsilon cross-bedded fine sandstone showing internal structure of upslope planar cross-bedding due to migration of megarriples under helicoidal flow conditions. The sandstone beds are separated by cm thick layers of laminated claystone representing periods of inactivity in the point bar. In the upper point bar, low relief convex-up scroll bars and erosion based chute channels develop.
The features recognized in outcrop have been compared with the study of cores from four wells drilled behind the outcrop. In these boreholes we also obtained Natural and Spectral Gamma Ray wire logs as well as Optical and Acoustic Televiewer imagery. Finally it has been developed a petrographic and petrophysic analysis on samples obtained in the different sub-environments identified.
By coupling outcrop and subsurface information (outcrop/behind outcrop characterization, O/BO) we obtained a complete set of data that have been used to develop 3D Poroperm, Facies and Reservoir Quality Index (RQI) models. Models show that the petrophysical properties are strongly controlled by the spatial distribution of depositional facies and the sub-environments they are associated with. Furthermore models exhibit the most interesting facies in terms of quality as reservoir rock are located at the lateral parts of the channel infill and in the scroll bar area.
In this example the comparative study of outcrop, core description, petrophysics and electric well logging are revealed as a very thorough workflow protocol for the study of reservoir analogs.

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Sedimentary functioning of the Albemarle-Pamlico Estuarine System, NC, USA

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Estuaries are critical habitat areas as well as places where people live, recreate, and make their livelihood. The Albemarle-Pamlico Estuarine System (APES) is the second largest estuary in the continental United States, consisting of the Albemarle and Pamlico sounds and the Pamlico River and Neuse River sub-estuaries. Although expansive in size, the system is shallow (<10 m depth) with a minimal tidal range (~0.1 cm). Average water inflow is seasonal, with enhanced discharge in winter months, but occasional tropical cyclones can cause significant flooding. Sediment discharge into the APES is modest, and the existence of few inlets along the Outer Banks limits mixing with the Atlantic Ocean. Human impact on the drainage basin and estuarine system is moderate but increasing with time.
Over the last five years, a considerable volume of sedimentary process data has been collected over various timescales and locations in the APES. More specifically, work has included: deployments of instrumented tripods to examine seabed dynamics; collection and analysis of shallow cores and GIS investigation of aerial photographs and other data. This wealth of data highlights several insights: 1) significant storage of sediment in the fluvial floodplain, 2) seabed erosion and deposition is inconsistent, but net accumulation of 2-4 mm/y is widespread; and 3) shoreline change although variable is generally erosional (~0.25 m/y), supplying sediment to the basin; and 4) storm waves and river floods are controls on this large but shallow estuarine system.

The fate of terrestrial substances discharged from Minjiang River

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Based upon investigated data (including suspended matter, surface sediment) and remote sensing data at the Minjiang Estuary and adjacent shelf, the sediment transport processes of terrestrial substances discharged from Minjiang River and their fate are discussed in this paper. When the terrestrial substances enter into the estuary, they are stored during summer and transported offshore during winter. In spring and summer, amount of suspended sediment is blocked into the area near the estuary when it discharges into the sea under the effect of southwest monsoon; during the autumn and winter, the stored sediment is resuspended and transported southward under the effect of strong hydrodynamic process induced by northeast monsoon. Generally, the suspended sediment can be transported southward to the south Pingtan Island area located at the northwest Taiwan Strait during the winter. However, under the effect of continuous strong cold air mass, the suspended sediment discharged from Minjiang River can reach middle area of Taiwan Strait southward. Comprehensive analysis results of surface sediment indicate that when the sediment leave the estuary and enter the inner shelf, it is transported southeastward continuously after mixing the fine sediment transported by Zhejiang-Fujian Coastal Current, and can reach northwest Taiwan Strait.

Comprehensive characterization of fluvial sedimentary features of strong heterogeneous reservoirs: A case study of the Upper Permian Formation in Su36-11 Experimental Area, Ordos Basin, north China

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Su36-11 Experimental Area is the first horizontal well development project of Sulige Natural Gas Field, the most abundant natural gas field in Ordos Basin, North China. There are 20 horizontal wells and over 100 vertical wells that have been drilled targeted the fluvial sandstone-conglomerate bodies of Member 8, Shihezi Formation, Upper Permian. With these well data and a 230 km^2 of high resolution 3D seismic data, the objective of this paper is to characterize the strong heterogeneity of the fluvial sandstone-conglomerate sedimentary features by bringing together sedimentology and geophysics methods and data, including facies architecture and reservoir quality, which not only determines reservoir volume and flow performance of the gas field, but also provides basis to locate infilling wells, especially essential to the direction and length of new horizontal wells.
A set of geological techniques were employed to comprehensively characterize the sandstone-conglomerate bodies qualitatively and quantitatively integrating subsurface and surface data: (1) Core and wire-line log were used to identify the preponderant lithofacies, distinguish single and superimposed channels belts among wells. (2) The scope and size of single channel and superimposed channel belts were also interpreted from amplitude and variance analysis of 3-D seismic time slices. (3) The boundary of channel, that is, the barrier and baffle of the reservoir, was correlated with wire-line log guided by Datong fluvial outcrop analogue located in east Ordos Basin. (4) Flow units of the sandstone-conglomerate reservoir were divided within single fluvial channel according to physical property (porosity, permeability) calibrated with natural gas production data.
By applying these methods above, a series of conclusions were drawn as follows:
Single and superimposed channel bars, point bars, channels, were recognized as the main reservoir architecture elements of the sandstone-conglomerate bodies with vertical and lateral variation of lithofacies, which can form stacked, high net-to-gross channel belts distributed zonally from north to south. Shale drapes, channel-filling shales within channel belts make barriers and baffles of the reservoir, creating reservoir compartmentalization and reducing vertical and lateral connectivity of the sandstone-conglomerate reservoir. According to interpretation of 3D seismic strata slice, single channel extends from north to south with a width of 100-250 meter and a thick of about 3-5 meter, while a unit bar(channel bar and point bar) about 5-10 meters thick and 800-1200 m width, with a NE-SW directional extension, which is similar with that of Datong fluvial outcrop analogue. Three types of flow units was subdivided using physical properties and permeability barriers, among which type Ⅰ flow unit is the best reservoir with high porosity and high permeability, TypeⅡ comes second and Type Ⅲ makes worst. TypeⅡ flow unit, however, was the dominant reservoir of the study area.
Strong Heterogeneity of fluvial sandstone-conglomerate reservoir sedimentary features of Su36-11 Experimental Area is evaluated comprehensively with integrated sedimentological and geophysical techniques. The deep understanding of the deposition patterns, geometry, dimension, compartmentalization of the sandstone-conglomerate reservoir, as well as its barriers and baffles distribution, is crucial to the efficient development of the gas field.

Principle of fluids migration priority in diagenetic evolution process and its control of tight sandstone reservoir quality of E1f1 in Gaoyou Sag, east China

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Diagenesis of sandstones is mostly interaction between formation fluids and components of sandstones by the medium of pores in sandstones. It's a dynamic process that the flow of formation fluids and pore structures are dependent on each other. This paper aims to investigate interaction between pore scale of sandstones and formation fluids in diagenetic evolution process in tight sandstone reservoirs and its application in oil and gas exploration. Data of the first succession of Funing Formation in Palaeogene (E1f1) which is a typical representative of alkaline lacustrine deposition in rift basin in China is utilized in this study.
We use optical microscope and SEM to observe the dissolution and cementation of sandstones within thin sections and casting thin sections. Cores are used to observe the oiliness and cementation degree. When in same conditions (the burial depth, grain size, sorting degree, rock fabric, sedimentary facies, tectonic setting, etc.), we find that in given sin sections or cores 1) finer pores are always cemented or dissolved more intensely than greater ones 2) much more greater pores contain oil than finer ones 3) microcracks are either filled with oil or cemented and dissolved most intensely. Further experiments of pressured-mercury testing and oil migration accumulation in sand reveal that for pores and cracks of sandstones, microcracks are prior access for fluids in dissolution and cementation process and macropores are easier to be injected with oil than fine ones while the fine pores are usually cemented and dissolved in priority.
Considering the wettability, capillary pressure and characteristics of diagenetic stages, principle of fluids migration priority is proposed as follows. Fluids prefer to percolate in capillary which has smaller resistance. Capillary pressure for acidic and alkali fluid is impetus in water wet sandstones, besides, the capillary pressure is higher for pores with little pore throat radius. Thus, fluid will inject into small pores in priority. Alkali fluid will percolate in small pores in precedence and carbonate minerals precipitate in the diagenetic stage of early B and middle B. Formation fluid becomes acidic when middle A1 stage of diagenesis dominates. Meanwhile, acidic fluid injects into small pores and dissolves early carbonate cementation. However, the capillary pressure is resistance for oil, leading to oil accumulates in pores with big pore throat radius in middle A2 diagenetic stage. Capillary pressure does not play leading role in microcracks. Dissolution and cementation always prefer to take place in microcracks in priority. Within this principle, we predict that for tight sandstone reservoirs: 1) the diagenetic stage of early B, areas with initial bigger pores should be the sweetpoint 2) in the diagenetic stage of middle B, areas with initial finer pores are the perspective exploration target.

Multiple-point statistics approach for architecture analysis on hydrocarbon reservoirs: Field case study on Miocene braided-fluvial sandstones from Gudao Oilfield, Shandong, China

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Architecture analysis is one of the powerful tools for reservoir characterization. Shapes, dimensions and internal structures of sand bodies can be well captured by their architecture elements, thus provides foundations for predicting the location and movement of the fluids inside. This paper takes braided-fluvial sandstones of Upper Guantao member, Guantao formation as a field case , which is a Miocene reservoir for hydrocarbon in Gudong Oilfied, Shandong, China. During tens of years of development, those sandstones have been regarded as a whole unity, and no architecture research has been done on them. Most of the wells have high water cut now, yet there are still newly drilling wells with untouched hydrocarbon found. This indicates an incomplete sedimentary knowledge on the reservoir. The workflow consists 3 parts. First, experimental cores data and log data from a dense wellbore net are analyzed, quantified and identified, from which, according to architecture theory and modern analog, the architecture elements in the sandstones are established. Boundaries are allocated by taking account of dynamic data. Second, multiple-point statistical methods are used to build a random geo-cellular model. The results of the model are a set of realizations with same probability, of which the uncertainty can be quantified. At the end, based on the results of architecture analysis, predictions are made on the locations and movements of the fluids within the sandstones. The results show that the first and the second order boundaries perform considerable control on the movements of fluids where they appear. Water and polymer injected can be stopped by those non-permeable boundaries. The four grading layers of the sandstones represent four sedimentary circles, in which, from bottom to top, the dimensions of the architecture become monotonically smaller. Architecture analytic work is conducted on these sandstones for the first time. Internal structures are revealed. The application of multiple-point statistics, controlling the dimensions and shapes of each architecture elements in the model, makes a transform from concept model within the brains and linguistics of geologists to a random realization space, by which productive data can be analyzed and practical problems can be solved.

Sedimentary characteristics of debrite-dominated turbidite system fed by delta front of Shahejie Formation in Dongying Sag, Bohai Bay Basin, east China

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Sandstone reservoirs of gravity flow, generated by flooding or slope slumping, are becoming one of main targets for oil and gas exploration and development. Sedimentary characteristics and controls of the slope-slumping gravity flow fed by delta front in the middle sub-member of 3rd member, Shahejie Formation (Es3m) in Dongxin area, Dongying sag, were analyzed based on a large number of core, particle size and mineral data combined with core-logging calibration and facies sequence. Flow properties in deep-water environment of Es3m are interpreted and four types of gravity flow, i.e. slide, slump, debris flow and turbidity flow are recognized according to the rock color, gravel composition, sands particle size component, sedimentary structure and facies sequence. Furthermore, slump has been subdivided into sandy deformed slump, sandy torn slump, muddy deformed slump and muddy torn slump based on the composition and deformation degree of rock; debris flow can be subdivided into muddy debris flow, sandy debris flow and mud flow in the basis of supporting mechanism and sediment composition.
Statistics of drilled frequency and sedimentary thickness of single deposition (more than 0.1 m) by different gravity flow indicated that (1) sandy debris flow becomes the most important type with a large thickness and high drilled frequency, (2) sandy slump with a large average thickness, drilled frequency and accumulative thickness, listed the second type and (3) muddy debris flow and slide with minimum accumulative thickness and drilled frequency developed poorly listed in the third one. Relatively, turbidity flow is not the significant sand body type because of thin single and accumulative sedimentary thickness although high frequency of drilling.
Synthetically analysis shows that turbidity systems fed by delta front in this study area are dominated debris flow rather than turbidity current mainly because of the overload of delta front with high sediment supply rate. When the angle of slope more than the angle of repose, overload make the delta front sand body not stable. Besides, fluid type and distribution of gravity flow deposits in this area are controlled by lake-level fluctuation, faulty activity. The lake-level fluctuation leads to the change of sedimentary environment which directly affect the delta foreset mode and stability of delta front slope. Growth fault acts in different intensity in different periods, which dominates slide and slump deposits in falling wall and accelerates the formation and distribution of slumping debrite-dominated gravity flow in lacustrine delta front.
This research is helpful to understand deeply sedimentary characteristics of slumping gravity flow in lacustrine delta front, and evaluate deep-water sandstone reservoir quality.

Configuration and it's control factors of sequence in the Lower Cretaceous, North Yellow Sea Basin

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The classic type I sequence was widely mentioned in the marine basin. However, it was hardly reported in the lacustrine basin because the sedimentary accommodation was primarily controlled by the structural activity rather than the lake level fluctuation. The Cretaceous sediments in the North Yellow Sea Basin belong to the lacustrine facies. The sequence characterized by lowstand system tract, transgressive system tract, highstand system tract, transgressive surface and maximum flooding surface can be clearly identified according to 3D seismic data and well data in the lower Cretaceous. The lowstand system tract includes the incised valley, lowstand wedge and fans. The highstand system tract characterized by the progradational parasequence set is confined by the sequence boundaries and downlap surfaces. The transgressive system tract is characterized by retrogradational parasequence set. The control factors can be concluded based on the geological explaination. The tectonic slope break of the lower Cretaceous was generated by much magma activity which indicated by the test ages and seismic data interpretation. The sediments characterized by the thickness conglomerate indicated the much provenance supply in the early Cretaceous. The red sediments gradually changed into the dark sediments along the slope can be showed by 4 wells data, this indicates that lake level dropped and depocenter migrated down to the basin center. Therefore, three control factors for the generation of type I sequence in North Yellow Sea Basin can be summed as the generation of tectonic slope break, lake level drop and much provenance supply.

Paleozoic and Mesozoic super sequences analysis in Lower Yangtze Plate: Implication of amalgamation of Lower Yangtze Plate with Cathaysia Plate

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Sequence stratigraphy is an integrated response to sea-level fluctuation and geotectonic events. The process of the Lower Yangtze Plate amalgamated with Cathaysia Plate is still on debate now. This paper aims to investigate how the super sequences in Lower Yangtze Plate respond to this amalgamation. We analyze characteristics of Paleozoic and Mesozoic super sequences and their correlations with world eustatic variation cycles and crustal deformation of Lower Yangtze Plate. Field survey, cores depiction, seismic sections, seismic attributes images and well logging data are comprehensively utilized to study lithology and sedimentary facies of system tracts, sequence boundaries and relative sea-level variations. As a result, ten super sequences are constructed and the amalgamation time is confined to begin at late Ordovician and lasts till late Silurian.
From late Sinian to middle Ordovician, four marine carbonate super sequences SS3 to SS6 develop in Lower Yangtze Plate. These super sequences all have the following characteristics: (1) most sequence boundaries are type Ⅱ that are mutation surfaces of lithofacies or biocenosis; (2) lowstand system tract mostly can't be distinguished from the transgressive system tract; (3) relative sea-level changes gradually among successive super sequences; (4) these super sequences share similar sedimentary facies. Then abruptly, a clastic typeⅠsuper sequence SS7 develops from late Ordovician to late Silurian. SS7 is an intact sequence with lowstand, transgressive and highstand system tracts. The bottom sequence boundary of SS7 is angular unconformity that covers most of the Lower Yangtze Plate. Sedimentary facies within these three system tracts migrate in a pattern that corresponds closely with that of a foreland basin. From late Devonian to late Triassic, five marine carbonate super sequences SS9 to SS13 develop. These super sequences share similar characteristics with those of the super sequences SS3 to SS6.
Careful examination of available data reveals close correlation of the relative sea-level fluctuation of SS3 to SS6 with the world eustatic cycles, which is also applied to SS9 to SS13. Lithofacies and sedimentary system mutations, poor correlation of sea-level changes and typeⅠsequence boundary make SS7 exceptional important in analyzing the amalgamation process. Comprehensive analysis reveals the following process of the continental amalgamation of Lower Yangtze Plate with Cathaysia Plate: from late Sinian to middle Ordovician, the Yangtze Plate is tectonically stable and the Huanan Ocean between the two plates has not closed. Sea-level variations control the carbonate type Ⅱ super-sequences SS3-SS6. The Yangtze Plate and Cathaysia Plate continental amalgamation begins at late Ordovician and lasts till late Silurian forming the united South China Plate. The Cathaysian Orogen uplifts in the southern margin of the Yangtze Plate and controls the clastic super sequence SS7 during the amalgamation. After this, from the late Devonian to late Triassic, the lower Yangtze plate develops another sequence stratigraphy cycle of carbonate super sequences SS9 to SS13 of which the eustatic cycles take control again.

Sedimentary environments and their hydrodynamic conditions in the subglacial tunnel: A case study

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Our research allowed us to recognise the sedimentation processes in the subglacial tunnel during the Saalian Glaciation. The Rygałówka site is situated two kilometres from the Polish-Belarusian border, on the NW-SE oriented ridge: 550 m long, 100 m wide and 5-15 m high. The main aim of the study was to clarify complexity of a subglacial tunnel sedimentation. Four sedimentary units (U1-U4) were recognised in the Rygałówka site. The lowermost unit U1 was up to 5 m thick and was composed of cross-stratified clasts- and matrix-supported granules, pebbles and boulders. These sediments filled large-scale troughs at two hypsometric levels. The laminae up to 70 cm thick consisted of clasts-supported granules and pebbles with the openwork structure. The basal and upper parts of the troughs contained matrix-supported gravels, pebbles and boulders with a massive or laminated sandy/clayey matrix. Moreover, the bounding surface of troughs were dipping at low angles towards the north (upstream dipping beds). The second unit U2 consisted of sands, gravels and pebbles with planar and trough cross-stratification dipping to the south or south-east (downstream dipping beds). These medium-scaled lithofacies changed laterally into deltaic lithofacies. In the upper part of unit U2, a graben was identified in which the lower part was composed of till. The third unit U3 was up to 2.5 m thick and also consisted of matrix-supported gravels, pebbles and boulders in sandy or silty/sandy massive matrix. Its upper part was deformed by recumbent and sheath folds. The uppermost unit U4 was to 1.5-4 m thick and consisted of massive and sandy-silty diamicton. Sediments of the units U2 and U3 on the western flank of the Rygałówka ridge were folded. The fold amplitude was over 10 m and the limbs were inclined at 70-85 degrees to the west. Concerning results of sedimentological investigations of the Rygałówka site, several phases of deposition and deformation were distinguished. The subglacial tunnel was developed between an active ice that occupied a glacial depression and a passive ice, located in a marginal zone of an ice-lobe. The presence of till cover on the top of glaciofluvial deposits indicated their subglacial sedimentary environment. The first phase of deposition of gravels, pebbles and boulders took place under supercritical and full-pipe flow under high-pressure conditions. These sediments were commonly observed in eskers and could be also interpreted as a result of catastrophic glacial floods. Locally hyper-concentrated flows were responsible for deposition of matrix-supported pebbles and boulders. The second stage reflected frequent changes in hydrodynamic conditions, from upper to the lower flow regime and deltaic sedimentation. The ice-blocks were also transported in a subglacial tunnel. The last phase of glaciofluvial sedimentation was represented by a high-energy sedimentary environment where hyper-concentrated flows frequently occurred. Finally the subglacial tunnel infill was folded by active ice and after the subglacial till deposition subaerial slumps and slides developed.

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The impact of palaeoenvironmental changes on fluvial depositional systems during MIS 3 and 2 in the Torun Sedimentary Basin (Poland)

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The main objective of the present study was the recognition of the fluvial responses to palaeoenvironmental changes during MIS 3 and 2 against the geological structure of the valleys bedrock in Central Poland (the Torun Sedimentary Basin - TSB). The evolution of fluvial depositional systems in the TSB was investigated by sedimentary genetic interpretation, palaeohydraulic analysis and OSL dating. The TSB was deepened by neotectonic subsidence and glacial erosion during the Middle and Late Weichselian. Within the TSB were deposited cyclically fluvial formations in the times between and after the ice-sheet advances which took place at 50 kyr, 28 kyr and 20 kyr ago. Fluvial formations in the TSB include successions of five fluvial lithotypes (M1, B1-B4). The first lithotype (M1) represents a sand-bed and high-energy meandering river of nival regime. It is characterized by deposits of side bars, the deposition of which took place mainly in the transition conditions from the lower to the upper flow regime or during shallow supercritical flow. The second lithotype (B1) is genetically related to the water flow in a high-energetic and shallow sand-bed braided river. The characteristic element of fluvial architecture was the flat river bed covered by sands in conditions of supercritical flow. Locally, ripples and humpback dunes were developed on the river bed. These types of bedforms were formed in the early stages of river pattern transformation. Fluvial lithotypes M1 and B1 correspond to rivers which existed between 50-30 kyr and 28-24 kyr. These rivers were not fed by meltwater. Climate cooling at the beginning of MIS 2 caused the decrease of flow velocity and Froude number and an increase of unit stream power. The lithotype B2 originated as a result of sand deposition in a sand-bed braided river, dominated by unit transverse bars and sandy megaripples. Litothotype B3 were deposited under stable hydraulic conditions by braided rivers with compound bars. These rivers were fed by meltwater. The fifth lithotype (B4) represents the sand-bed braided river with the bed dominated by sandy and gravelly dunes, sheet beds and sandy-gravelly longitudinal bars. Successions of fluvial lithotypes display palaeoenvironmental changes which affected the channel morphology and river pattern. Moreover the climatic changes were reflected in the changeable distance from the ice sheet to the TSB and thus determined the type of river regime in it, the rate of sediment supply and neotectonic movements. The first transformation of braided channel morphology happened about 30 kyr ago, the second about 24 kyr, due to cyclical changes in river regime from nival to proglacial. Thus, ice-marginal valleys were evolved in the TSB repeatedly during MIS 3 and 2. In the youngest ice-marginal valley the water flow was about 10 000 m^3/s at the end of MIS 2 (deposition of lithotype B4).

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Diagenetic effect on permeabilities of geothermal sandstone reservoirs

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The Danish subsurface contains abundant sedimentary deposits, which can be utilized for geothermal heating. The Upper Triassic–Lower Jurassic continental-marine sandstones of the Gassum Formation has been utilised as a geothermal reservoir for the Thisted Geothermal Plant since 1984 extracting approx. 45 °C warm formation water from two production wells at 1240 m depth. Cored intervals of the Gassum Formation from the Thisted-2 well represent shoreface and estuarine-fluvial sandstones with high average porosity and permeability (29% and 3900 mD). Higher formation water temperatures can be achieved in deeper buried sandstones at other locations in the Danish subsurface. The Aars-1 cores penetrates the deepest drilled parts of the Gassum Formation, reaching a temperature of approx. 107°C and having average porosity and permeability of 9% and 11 mD, respectively. The reduction in porosity and permeability is caused by increased diagenetic changes of the sandstones due to increased burial depth and temperatures. Therefore, the highest water temperatures typically correspond with the lowest porosities and permeabilities. Especially the permeability is crucial for the performance of the geothermal reservoirs. With this study we attempt to explain how diagenesis affects the porosity and permeability and to be able to predict areas with the optimal combinations of minimum diagenetic alterations, highest porosity and permeability and highest water temperatures. Quartz overgrowths gradually increase in abundance with burial and together with ankerite form the most abundant porosity- and permeability-reducing authigenic phases in the deepest buried Gassum Formation sandstones (burial depths > 3000 m). Shallowly buried sandstones (< 2500 m) have higher porosities and permeabilities with a range of different porosity-permeability trends depending on grain size (very fine-, fine-, medium- or coarse-grained) , diagenetic alteration and clay content. The presence of illitic clays, siderite and allogenic clays reduce permeability more than porosity and at least one of these phases is typically present in sandstones having permeabilities beneath the general porosity-permeability trend for each specific grain size class. Sandstones with abnormal high permeabilities (i.e. plotting above the general porosity-permeability trend) have irregularly distributed cement or represent erroneous measurements due to hair-line fractures. Continuous thin chlorite coatings results in less porosity- and permeability-reduction with burial than the general reduction with burial, unless carbonate cemented. Therefore, localities of sandstones characterized by these continuous chlorite coatings may represent fine geothermal reservoirs even at maximum burial deeper than 2500 m.

Stratigraphic and sedimentary record of the Annulata events in the southern part of the Moravian Karst (mid-Famennian, Czech Republic)

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The globally distributed Annulata events represent hypoxic to anoxic transgressive pulses in the late middle Famennian (Upper trachytera conodont zone, base of Platyclymenia ammonoid zone). The event beds are characterized by dark grey to black shales or limestones, which are often rich in ammonoids (e.g. *Platyclymenia annulata*), orthocone nautiloids, bivalves and ostracods. In uncondensed sections, the Lower and Upper Annulata events are typically developed as hypoxic to anoxic horizons separated by better oxygenated interval. Only one event horizon might be developed in condensed sections. The event interval is often overlain by regressive richly fossiliferous „Wagnerbank" equivalents. Both the Lower and Upper Annulata events were previously biostratigraphically recognized because of disappearance of several conodont taxa (e.g. *Palmatolepis glabra lepta*) reaching only to the Lower Annulata event in various European or Moroccan sections.
The middle Famennian carbonates of the Líšeň Formation (Moravian Karst) are represented by grey nodular hemipelagic Křtiny Limestone deposited on bypass slope and by dark grey or black calciturbidites of the Hády-Říčka Limestone. The Annulata event beds occur in the sequence of the Křtiny Limestones in the Ochoz, Hostěnice 1&2 and Mokrá western quarry sections which are currently studied.
In the lower part of the Mokrá quarry section (crepida to marginifera zones) prevail nodular encrinitic wackestones to packstones/floatstones to rudstones previously interpreted as storm beds. In the all sections are developed strongly nodular wackstones (marginifera to expansa conodont zones) locally with transitions to mudstones or to packstones. Indeterminable bioclasts, crinoids or other groups (e.g. ostracods, gastropods, trilobites, cephalopods) and peloids (probably mud peloids) are common. Bioturbations were locally observed. This facies is mostly homogenous without obvious hydrodynamic structures.
The facies of the Annulata event beds are commonly lenticular and correspond to wackestones/floatstones to rudstones with abundant cephalopods and other groups. The variable fragmentation of fossils might reflect phases of calm suspension sedimentation with prevalently complete shells and phases with fragmented shells suggesting hydrodynamic transport which might be triggered by currents or storms.
All studied sections show only one Annulata event horizon. The presence of *Palmatolepis glabra lepta*, *Palmatolepis minuta minuta* or *Palmatolepis rugosa trachytera* in the event beds in Ochoz, Mokrá and Hostěnice 2 sections enables the corelation with the Lower Annulata event. The biostratigraphic data in the Hostěnice 1 section are insufficient for the recognition of the Lower or Upper Annulata events. The base of the postera zone was recognized just above the Annulata event. This suggests the absence of trachytera-styriacus interregnum (or very strong condensation). The interregnum was previously recorded from various European sections in the uppermost part of the Upper trachytera zone which include the Upper Annulata event and Wagnerbank equivalents. The presence of only one and often lenticular horizon of the Annulata event in the studied sections is caused by the condensation and/or by erosion on bypass slope (with possible influence of pressure dissolution). The gamma-ray spectrometry provided higher uranium in the event beds, which probably reflect hypoxic or anoxic conditions.

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Organic matter maturity of the Lower Oligocene black shales in the Flysch Eastern Carpathians and the Transylvanian Basin hinterland, Romania

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Throughout the Paratethys the Early Oligocene sedimentation resulted in accumulation of organic matter-rich rocks of which Menilite Shales are important hydrocarbon source. They were widely studied in the Western but significantly less in the Eastern Carpathians. The purpose of this study is to characterise nature and maturity of the organic matter (OM) from different geological settings in the Eastern Carpathians and Transylvanian Basin (TB) basing on the bulk geochemical data, vitrinite reflectance (VRo) and biomarker maturity parameters. The samples representing dark shales, marls and cherts come from selected sites of the E-W transect of the basin (foreland-hinterland direction): the Vrancea Nappe (VN) and the Tarcău Nappe (TN) of the Carpathians and the E margin of the hinterland (TB).
Bulk geochemical data show that the TOC content is in the range of 0.5-7.9% (avg. 3.2%) in VN, 0.7-4.3% (avg. 1.8%) in TN and 1.1-5.7% (avg. 3.2%) in TB. The TOC values vary significantly within each section, which is related to lithology and OM type. The investigated rocks could be considered as hydrocarbon source rocks with good hydrocarbon potential. According to Tmax values, which decrease from ~429°C in TN to ~425°C in VN, and the C31 homohopane (HH) 22S/(22S+22R) ratios oscillating around 0.33-0.54 (avg. 0.5) for both nappes, the rocks approached the onset of oil generation. The TB rocks show lower HH ratio: ~0.3, consistent with low Tmax values: ~422°C, pointing to immature OM. For all the investigated settings the C30 moretane/(hopane+moretane) ratio is in the range of 0.1-0.26 indicating that for some samples (TN) the threshold of hydrocarbon generation (0.15) has been barely reached. In turn, trisnorhopane ratio Ts/(Ts+Tm) values in the range of 0.17-0.33 do not vary systematically with maturity but seems to be influenced by lithology and redox conditions.
The mean VRo values: 0.4% Ro for VN and 0.5% Ro for TN may not reflect well the authentic OM maturity. Such values imply maturity lower than those suggested by the mentioned parameters. The suppression of VRo can possibly result from bitumen impregnation of vitrinite grains, which is consistent with the occurrence of numerous bitumen bands in the microscope images. This observation comes along with high extractable OM (EOM) yields reaching up to 6.8 mg EOM/g rock in TN and up to 3.3 in VN. The mean 0.4% Ro for TB samples is more reliable and agrees with the maturity level indicated by Tmax values and biomarker parameters.
The differences in the discussed parameters reflect distinct evolution of each Carpathian subbasin and hinterland. Within the subbasins maturity oscillates around the onset of hydrocarbon generation and decreases from the internal to external nappe, i.e. toward the foreland, while in the hinterland OM is highly immature. This results from differences in burial/erosion and heat flows. An increased heat flow characterises the internal units of the Carpathian fold-thrust belt in contrary to TB with lower heat flow. The burial/erosion was higher in the Carpathians and didn't differ much between TN and VN, in contrast to not deeply buried sediments of TB.

Sediment gravity flow systems in a confined tectonically partitioned synorogenic deep marine basin – the Cergowa Beds (Oligocene, Outer Carpathians) in the Dukla and Fore-DuklaTectonic Units: Evidence from palaeocurrents and facies relationships

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The Cergowa Beds (Oligocene) in the in the Dukla and Fore-Dukla Tectonic Units in Poland and Slovakia (Outer/Flysch Carpathians) form a lenticular lithosome composed of two main lithofacies. A sandstone complex is confined to the axial part of the lithosome, and sandstones interbedded with shales occur at its margins. The data published in the past suggest that the Cergowa Beds may form a submarine fan deposited by turbidity currents descending towards the SE from the Silesian Ridge elevated to the NW of the depository. However, a recent study of detailed sedimentological sections and palaeotransport indicators, coupled with age determination, shed new light on sediment supply and distribution systems, with implications for evolution of palaeogeography and basin tectonics.

Based upon autochthonous calcareous nannoplankton, the Cergowa Beds succession represents zones NP23 & NP 24. Frequency distributions of the palaeocurrent measurements and their statistics suggest that deposition during NP23 zone was mostly confined to two parallel troughs extending from NW to SE. The palaeotroughs are defined by alignments of sections characterised by very low scatter of readings (standard deviation $\sigma < 250$). Bipolar palaeocurrent distributions indicate that the southern trough was supplied from two source areas: the Silesian Ridge in the NW and the Fore-Magura Ridge in the SE. However, the northern trough was fed from the Silesian Ridge only. It was widening towards the SE to open onto a broad distal expanse of the Cergowa basin floor. This is indicated by unipolar distributions with low scatter in proximal sections in the NW, whereas the equivalent distal sections in the SE display radiating palaeocurrent patterns with high-scatter (up to $\sigma = 670$) characteristic for a submarine fan body deposited in unconfined part of the basin. Longitudinal facies variations show inversion by comparison with the gradient expected between the proximal and distal parts of a lithosome deposited by turbidity currents gradually losing energy. Namely, sections proximal to the NW source (the Silesian Ridge) display sedimentary facies characteristic for relatively distal settings, whereas distally located sections consist of strata with much more "proximal characteristics". It is suggested that undulations of the northern trough axis resulted in partial sediment bypass through the proximal sector and ponding in the distal area.

Transition from NP23 to NP24 records radical changes in sediment provenance, distribution and facies. The SE source became inactive and supply from the SW source was characterised by predominance of low-energy turbidity currents, which deposited two small retrograding submarine fans composed of distal facies - one located in the southern and another in the northern part of the basin.

These features suggest the following endogeneous controls on deposition in this part of the Cergowa basin: (i) thrust propagation partitioned the synorogenic depository longitudinally into two troughs during NP23; (ii) undulations of the trough axis may have been generated by lateral ramps or strike-slip faults; (iii) subsidence of both source areas during NP24 resulted in submergence of the Fore-Magura Ridge to the SE and marine transgression onto the shelf of the Silesian Ridge NW of the depository.

Facies variations and depositional modes in an olistostrome sequence grading to turbidite fan succession within the Menilite Beds (Oligocene) at Skrzydlna, Polish Outer Carpathians

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A heterogeneous succession of the Menilite Beds (Oligocene) at Skrzydlna, near the southern margin of the Silesian Nappe (Polish Outer Carpathians), contains a broad range of deep-marine facies deposited by a variety of sediment gravity flow processes that resulted in a sequence of ca. 160 m. The "background" deposition is typified by carbonaceous shales interbedded with subordinate thin turbidites (Tcde), siliceous shales, cherty layers and an intercalation of marl. Rapid influx of high-energy mass gravity flows oriented towards the SW deposited a complex of coarse-grained debris flow conglomerates containing pebbles and large blocks classified as olistostrome by previous authors. Turbidite sandstones with variable and subordinate proportion of mudstone interbeds overlie the olistostrome. The most recent observations shed new light on deposit types and mechanisms that formed this succession.
The 43 m thick olistostrome sequence consists of amalgamated debris flow beds in which rich sandy/wacke matrix with extrabasinal granules and pebbles supports isolated blocks (olistoliths) exceeding 0.3 metre in length. The olistostrome base is uneven, grooved and erosionally incised into the underlying marl complex. Olistoliths in the lower part include intrabasinal fragments of plastically deformed sandstone beds. Among extrabasinal olistoliths a 10x2.5 metre slide block of Carboniferous (?) limestone is emplaced in the middle of the complex. Two layers of black shale mark breaks in intervals of high-energy sedimentation. Inverse grading of olistoliths is common in the lower part of the succession. Up the olistostrome sequence, the texture of the matrix is irregularly fining and the structure becomes more orderly. This is also emphasised by a sandstone bed with granule-filled flute casts on the sole surface, which was deposited by a high density turbidity current, and occurs among layers of pebbly debris flow conglomerates. Transition from the olistostrome to the overlying turbidite complex is marked by a few hybrid beds, each composed of turbidite sandstone overlain by linked debrite (wacke rich in mud clasts). The succession above, deposited by surge-type turbidity currents, consists of three fining-upwards cycles. Two of these begin with very thick, amalgamated, massive sandstone beds deposited by high-density turbidity currents that fill channels incised by 2.5 metres into the underlying strata. Bouma sequences, representing normal to diluted turbidites, appear above with Ta-e rhythms fining to Tce in the uppermost associations of thin-bedded sandstones and shales. Reconnaissance textural analysis under microscope on samples collected from a thick Ta interval of one of typical for this section, normally-graded turbidite beds provide insights into the deposition mechanisms of this facies. Namely grain orientation and trends of grain-size sorting suggest that at the stage of consolidation and dewatering: (i) shear in the basal part of the bed resulted in grain orientation, and (ii) fluid expelled upwards from the lower part of the consolidating bed resulted in random orientation of grains, and less good sorting, in the upper part.
These features suggest rapid uplift of the source area resulting in sudden onset of the olistostrome deposition that evolved upwards into proximal turbidite-fan sequence, which subsequently retrograded due to decreasing intensity of supply.

Cyclic lacustrine sedimentation in a meteorite impact crater: the Jwaneng South Structure in the Kalahari, Botswana (SW Africa)

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During regional exploration for kimberlites by De Beers in the Kalahari region of south-central Botswana (SW Africa) in 2006, a pronounced circular Bouguer gravity anomaly was discovered at ~24°46'E, 24°42'S using an airship-mounted full tensor gravity gradiometer. Detailed CSAMT surveys and nine vertical diamond drill holes revealed a circular bowl-shaped structure named the Jwaneng South Structure. It measures 1.3 km in diameter, maximum depth reaches 275 m and is filled with 65 metres of breccias followed by a heterogeneous sedimentary succession that attains a maximum thickness of 212 m. The structure infill is underlain by the 2785 Ma old Gaborone Granite Complex, and 180 Ma-old basalts of the Karoo Supergroup. Any surface expression of this feature is lacking due to the cover of the Kalahari Group aeolian sands (Late Cretaceous to Recent).

The following observations indicate that the Jwaneng South Structure is a buried meteorite impact crater. The rocks have suffered intense shock deformation (although impact-diagnostic PDFs have not yet been found). They are completely shattered into angular fragments of the authigenically brecciated basement and the "fall-back" breccia. Individual mineral grains show features found in known impact structures - including mosaicism, deformation bands and lamellae in feldspars, and cleavage in quartz. Macroscopic indicators of shock include "gries"-textured fragments and shatter cones (multiply-striated joint surfaces) formed by intersecting shock waves. Sedge-like plant fossils at the base of the infilling sedimentary succession suggest a Miocene, or younger, age, i.e. <23 Ma.

The sedimentary succession overlying the "fall-back" breccia consists of the following three facies associations:

1. Sandstone and conglomerate (Sd and Cg). Sandstone (Sd) is represented by medium-grained quartz arenite, yellow, orange and pink, composed of well-sorted and well-rounded grains with frosted surfaces suggestive of provenance from a dune field extending beyond the impact crater rim. The beds are usually massive and amalgamated, but locally show medium-scale cross-bedding. Conglomerate (Cg) intervals associated with the sandstone facies reach thickness of 60 cm and consist of angular to subrounded granules, pebbles and cobbles of granite that commonly are inversely graded and scattered within abundant sand matrix (Sd type).
2. Laminite (Lw). Predominant is laminated and thin-bedded white limestone, with some dolomitic limestone and interlayers of sandy limestone and marl that may contain small "swallow-tail" gypsum crystals. Effects of early diagenetic silicification occur in places; occasional are thin interbeds of Sd-type sandstone.
3. Wacke (Sw), red, thoroughly bioturtbated, with abundant root traces and mudstone laminae preserved only locally.

The facies associations 1 and 2 form six sequences fining-upwards from Sd (or Sd+Cg) to Lw, while the association 3 (Sw) terminates the succession. It is suggested that deposition within the Jwaneng South meteorite impact crater took place in a playa lake surrounded by piedmont fans. The depositional cycles were controlled by climatic oscillations, with wet periods of intense supply of coarse detritus from the crater rim (facies Sd; Sd+Cg), and Lw facies reflecting dry intervals. During the youngest wet period the lake filled up with sand interbedded with mud and was covered by abundant vegetation.

Dating of sub-CCD event deposits by carbonate shells in burrows – conditions and constraints illustrated by an example from the modern South China Sea

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Deposition of an event bed of more than several centimeters in thickness has severe consequences for the seafloor habitat. Many benthic organisms are killed while buried by sediment or affected by the rapidly developing oxygen-deficiency within the seafloor; only a few, well-adapted organisms can survive. Furthermore, the previous near-surface mixed layer that is rich in benthic food is no longer available as food resource. The event deposit itself does normally contain no or only little benthic food due to the origin of this material (sediments already affected by early diagenesis, volcanic ash). Nonetheless, event beds become recolonized within short time by larvae carried by currents. These animals can cover their food demands only from the sediment surface (or sources below the event bed). Small pioneering animals mainly collect benthic food on the sediment surface. In areas that are affected by seasonal fluctuations of primary production – that is most of the world's ocean – some of the material collected during bloom times is stored within burrows to be consumed during non-bloom periods. Planktonic foraminifera shells settle together with organic flocks or pellets quite rapidly to the seafloor (>1-2 cm/s). Therefore, this material arrives even in large water depth below CCD on the seafloor prior to the dissolution of carbonates. There, organic-rich particles and co-occurring shells are collected and stored in burrows where the carbonate escapes dissolution. Modern examples show that the colonizing fauna follows a cache behavior only for a short time until a new mixed layer of 1-2 cm thickness has re-established. Consequently, the burrow fill provides datable shells that provide a quite narrow age spectrum. In turn, burrows within the top of a sub-CCD event deposit, which contain carbonate shells, point to a pronounced seasonality of primary production. In the South China Sea a giant mass-flow deposit (> 15-20 km^3 in volume) occurring in 4200 water depth was dated to have been emplaced about 350 years ago.

Baddeleyite in Triassic loessites of the Smith Bank Formation, Central North Sea, UK: Provenance implications for its first occurrence within a sedimentary rock

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This research reports the first occurrence of baddeleyite (ZrO_2) within a sedimentary rock. The detrital baddeleyite grains were discovered within siltstones belonging to the Triassic Smith Bank Formation of the Central North Sea, UK.
Baddeleyite is a rare mineral in nature. Globally there are less than a few hundred terrestrial occurrences of baddeleyite in its primary form as a refractory mineral in silica-poor igneous and metamorphic rocks. Within the UK, the only known occurrences are in a layered mafic-ultramafic complex on Rhum, a Scourian picrite in the northwest Scottish Highlands, and in the contact metamorphic aureole associated with the Ballachulish Igneous Complex.
Typically the early Triassic Smith Bank Formation of the Central North Sea comprises hundreds of metres of monotonous mudstones interpreted as ephemeral lake or distal floodplain deposits and reported to have a predominantly UK-derived provenance within the Central North Sea. Previous research presented at IAS 2013 has also highlighted the importance of accumulations of wind-blown siltstones, i.e. loessites, within the Smith Bank Formation.
Conventional techniques, such as optical petrography following heavy mineral separation methods, were not utilized within this study due to the fine grained nature of the Smith Bank Formation. These clastic sedimentary rocks have a mean grain size of 16 micrometers. The baddeleyite grains, less than 5 micrometers in size, were discovered and detected by their high back scatter electron (BSE) luminosity using a scanning electron microscope (SEM), the predominant quartz and feldspar grains within the loessites being considerably duller. The baddeleyite grains yielded an energy dispersive spectrum consisting solely of a Zr signal, with no accompanying Si peak.
The baddeleyite grains have been found within the loessites and this has important implications for the provenance and sediment transport pathways of these wind-blown dust deposits. The loessites accumulated within depressions created by halokinesis across a gently undulating continental plain. Contemporaneous early Triassic wind-blown sand dune deposits across Europe suggest that the baddeleyite grains are not sourced from occurrences within the UK, but from elsewhere in Europe most likely the Fennoscandian shield.

The Cenomanian–Lower Coniacian section at Klieve, southern Münsterland Cretaceous Basin, Germany: Lithological succession, integrated stratigraphy and inter-basinal correlation

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In the southern Münsterland Cretaceous Basin (northern Germany), a continuous lower Upper Cretaceous section has been established based on the succession exposed in and subsurface of the Rinsche quarry at Klieve near Anröchte (TK 4415: Anröchte). The Lower Cenomanian to mid-Upper Turonian has been cored (cored borehole KB 4415/1002 drilled by the Geological Survey of Nordrhein-Westfalen) while the mid-Upper Turonian to Lower Coniacian has been studied in the quarry. The section has been subject to an integrated approach applying cm-scale bed-by-bed lithofacies logging, microfacies studies, litho-, bio-, chemo-, event and sequence stratigraphic analyses as well as subsurface geophysical surveys.
The Lower Cenomanian Essen Grünsand Formation rests at 123.60 m depth with an angular unconformity and a glauconitic basal conglomerate on grey-green Palaeozoic shales. Up-section, the Baddeckenstedt Formation follows (up to 97m depth) with the Lower Cenomanian Wamel Member (flinty spiculitic marlstones), grading up-section into Middle Cenomanian marl-limestones alternations. The uppermost Middle to mid-Upper Cenomanian pelagic mudstones of the Brochterbeck Formation are capped at 81.80 m depth by the Kalkknollenbank (plenus Bed equivalent). The Cenomanian–Turonian boundary interval is characterized by ca 2 m of dark marls (Hesseltal Formation) and the following grey-green bioclastic marls of the Lower Turonian Büren Formation range up to 64.80 m depth. The Middle to lower Upper Turonian Oerlinghausen Formation comprises the upper part of the core up to the zero-metre-level. A sedimentological peculiarity is the occurrence of laminated black shale and white limestone facies in the lower Middle Turonian part between 60–55 m depth. The marker bed couplet of the Weiße Grenzbank and marl MTeuto (ca. 44–41 m depth) subdivides the calcareous Middle Turonian part of the Oerlinghausen Formation (flaser-bedded pelagic limestones) into two approximately equally thick intervals while the lower Upper Turonian segment (from ca. 20 m depth upwards) upwards gets increasingly marly. The Klieve section continues in the quarry with the 2-m-thick mid-Upper Turonian glauconitites of the Soest Grünsand Member of the Salder Formation which rests with a major unconformity on the Oerlinghausen Formation. Up-section, ca. 20 m of marls and marly limestones of the uppermost Turonian–Lower Coniacian Erwitte Formation are exposed.
Makro- and microfossil evidence from several levels in the core supports the stratigraphic assignments that have firstly been obtained by regional gamma-ray and lithostratigraphic correlations to neighbouring well-dated sections. Carbon stable isotope analyses are underway and preliminary data indicate that the Soest Grünsand Member of the Salder Formation can in fact be assigned to the mid-Upper Turonian. Argillaceous levels at 24.30 m, 12.40 m and 3.40 m of the core are potential bentonites (TC, TD and TE?) and offer the possibility for tephrostratigraphic correlations. Sedimentary unconformities at the 115.80 m, 110.40 m, 102,30 m, 94.70 m and 82.30 m levels in the Cenomanian as well as at the 64.80 m, 41.60 m, 24.30 m and zero-metre levels in the Turonian give evidence for sea-level changes superimposed onto the early Late Cretaceous overall rise. Their precise dating will give clues for inter-basinal sequence stratigraphic correlations and further chronostratigraphic calibration of the Klieve section that provides a high-quality standard section for the lower Upper Cretaceous of the southern Münsterland Cretaceous Basin.

Bedforms deposited from supercritical density flows: Field examples from coarse-grained channel-levee complexes (southern Central America)

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The Middle to Upper Eocene deep-water succession of the Sandino forearc basin (southern Central America) consists of 2500 m thick stacked channel-levee complexes, which have been deposited in a distal upper to proximal mid-fan environment. In general channel and levee deposits display disconformable contacts and levee beds cannot be traced into the adjacent channels. Channel-fills are characterised by sandy and gravelly bedforms deposited by supercritical density flows. Bedforms include deposits of cyclic steps, upstream and downstream migrating antidunes and stationary antidunes.
Regularly spaced (2.5 to 10.5 m), scour-fills (0.5 to 2 m deep and 1 to larger than 25 m wide) are interpreted to represent the hydraulic jump zone of cyclic steps. The basal scours are commonly filled with massive or normally coarse-tail graded conglomerates and/or pebbly sandstones with abundant rip-up clasts. Partly also backsets can be observed within pebbly sandstones. Downstream the scour-fills commonly pass into subhoziontally or sinusoidal stratified pebbly sandstones, indicating the formation of antidunes on the stoss side of cyclic steps. Above the basal scour fill commonly subhorizontally and sinusoidally stratified pebbly sandstones and sandstones occur deposited from antidunes. They may either show gradational or erosive basal contacts above the scour fill. Wavelengths within pebbly sandstone beds range between 5 to 9.5 m, whereas wavelengths within the finer-grained sandstones are shorter and range between 1 and 4 m. The cyclic step and antidune deposits form up to 15 m thick vertically stacked successions, which fine upwards. These successions are interpreted as resulting from upslope migrating cyclic steps under waning flow conditions.
Occasionally trough cross-stratified pebbly sandstones are interbedded with deposits of sandy antidunes. Troughs are up to 0.45 m deep and up to 3.7 m wide and foresets commonly display a sigmoidal geometry. These bedforms may either represent deposits of supercritical dunes or downstream migrating antidunes. Partly downstream transitions into antidune beds could be observed, pointing to a deposition by downflow migrating antidunes as shown in experiments by Fedele et al. (2009).
The levee-deposits that flank the channels consist of sheet-like thin- to medium-bedded fine-grained sandstones and siltstones with minor mudstones. Beds are massive, horizontally or ripple cross-laminated. Deposits of antidunes frequently occur in coarser-grained crevasse-splay and crevasse-channel deposits.

Dynamical modeling of fluvial deposition processes on Earth and beyond

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Processes of fluvial transport are possible on planetary bodies with sufficiently dense atmosphere and volatile cycle operating on the surface and in the atmosphere. Thanks to the observations of automated space probes it is now known that such conditions existed on surface of Mars in the geological past and exist in the present on surface of Titan, the largest moon of Saturn. Ancient Martian volatile cycle was similar to terrestrial, with standing bodies of water and surface runoff. On Titan the volatile cycle is based on methane instead of water. Numerous hydrocarbon lakes and rivers exist in polar regions of this unique moon. We investigate sediment transport and deposition processes in rivers and lakes on Earth, Mars and Titan. We used numerical model based on Navier-Stokes equations for depth-integrated two dimensional turbulent flow complemented with equations for bed-load and suspended-load sediment transport. We compared such processes in conditions corresponding to surfaces of Earth, Mars and Titan. Despite differences in gravity and composition of liquid and sediment in these environments, we found many similarities in evolution of sedimentary landforms on these bodies. This gives us another tool for understanding the evolution of the surfaces of these planetary bodies. We found that transport of icy grains in Titanian rivers is more effective than transport of silica grains in rivers on Earth or basaltic grains on Mars, for the same assumed total discharge.

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Enhanced provenance analysis of the autochthonous Triassic sandstones of southwest Switzerland using zircon U-Pb dating

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The Triassic Vieux Emosson Formation lies unconformably above pre-Meoszoic basement of the Aiguilles Rouges external massif in the western Alps of Switzerland and France. It consists of up to 10 m of basal conglomerate and sandstone, overlain by up to 10 m of interbedded thin sandstone and shale and thin dolomite beds at the top. Results of detailed facies analysis along a 10 km belt of outcrop indicate deposition in shallow braided stream system for the lower unit and in a terminal splay and playa system for the upper unit. Paleocurrent data indicate sediment transport towards the northwest, from the Vindelician High toward the Germanic Basin. The Vieux Emosson Formation overlies highly weathered crystalline basement with more than 0.5 m of local relief. The Aiguilles Rouges massif consists of complex polymetamorphosed Cadomian-type basement with intercalated Variscan intermountain basins containing Late Paleozoic metasediments. Conglomerates in the lowermost units contain mostly angular quartz clasts, but locally there are abundant metamorphic lithic fragments. Sandstones in the basal unit are lithic arentites, but mature compositionally to sublithic arenites towards the top of the unit. Clast texture and compositions suggest short transport and derivation largely from local basement sources.
U-Pb (laser ablation inductively coupled plasma mass spectrometry) dating of detrital zircons was utilized in order to further constrain the source areas. Two samples (one above and one below a prominent erosional surface within the lower unit) were analyzed from the Vieux Emosson Formation and two samples from the (Carboniferous and Permian) metasedimentary units. Both the Paleozoic and Triassic samples yield abundant Paleozoic and Late Neoproterozoic, and minor amounts of earlier Precambrian ages. The Neoproterozoic and early Paleozoic ages match with the Cadomian and Pan African orogenies and reflect the northern Gondwana margin origin of the Alpine basement blocks. Late Paleozoic ages are from Variscan metamorphic, volcanic and intrusive basement. Except for abundant late Variscan ages from the lower Triassic sample, age distributions from it and the Permian samples are very similar, suggesting similar source areas for the two samples and/or significant reworking of the Paleozoic sediments into the Triassic unit. In both the presence of abundant Silurian and Devonian ages is significant; Middle Paleozoic metamorphic or magmatic events are apparently not recognized in Alpine basement. Possible interpretations are that either the source rocks for these zircons are not yet recognized, they were eroded away, or they were hidden by Alpine tectonism. Alternatively, a northern source area of Avalonian (Caledonian orogeny) basement may have supplied the zircons during the Variscan event and were subsequently reworked into the Triassic. The younger Triassic sample differs from the others with no Middle Paleozoic or Early Neoproterozoic zircons, few Variscan zircons, but abundant Ordovician ages. The younger Triassic sample indicates a significant change in the source area in the uppermost sandstone units. Early Precambrian dates are also different for all of the samples indicating overall widespread source areas for the Late Paleozoic and Triassic units.

Sandstone reservoir quality: Understanding the fundamental processes governing the origin and distribution of clay-coated sand grains in petroleum reservoirs through a modern day analogue

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Porosity and permeability generally decrease with increasing depth in sandstones, however a significant number of deep sandstone reservoirs have anomalously high porosity and permeability. The anomalously high porosity and permeability has been most linked to the presence of clay-coated quartz sand grains in some reservoirs with the clay coat inhibiting the growth of porosity-occluding quartz cement. The extent and completeness of the detrital precursor clay coating is the key factor that controls the inhibition of quartz cement.
We have adopted a novel high resolution analogue approach focussing on the Ravenglass estuary, NW England. This provides a modern reservoir-scale analogue, and covers a wide range of depositional environments. The approach removes the often limited spatial distribution and stratigraphic coverage of subsurface core-based studies. The overall aim of the research is to establish a fundamental understanding on the processes governing the origin, mineralogy and distribution of clay-coated sand, thus facilitating prediction in the degradation of reservoir quality in ancient, deeply-buried petroleum reservoirs.
Extensive surface geomorphic mapping has been performed and high resolution (<1 m) cores have been drilled. Grain size has been determined at 3350 sites in the estuary where the degree of bioturbation has also been established. Detailed analysis of clay coat quality and quantity distribution was investigated through a range of SEM techniques. Petrography revealed the degree of clay-coating and fabric of grain coating clays.
These exceptional data sets have permitted the identification of both spatial and stratigraphic variations in clay-coat distribution and mineralogy, and produced a high resolution analogue of an estuarine succession that is a comparable analogue of a clastic reservoir with clay-coated sand grains.
Results from on-going research have identified:
1. Variations in clay- coat quality and quantity distribution related to specific modern depositional environments.
2. Textural and mineralogical characteristics of modern clay-coats.
3. A clay-coat facies distribution pattern consistent with a comparable North Sea reservoir example from estuarine (fluvial-marine interface) environments.
The results of this work have revealed valuable insights into the fundamental processes controlling the formation and distribution of clay-coated sand grains, enabling the production of a high resolution analogue model to aid subsurface Reservoir Quality Prediction.

Does the fluvio-aeolian sedimentary environment exist?

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Among the terrigenous depositional environments, sediments of fluvial and aeolian environments often co-occur, even though different factors determine their functioning. Therefore, in the last decades, descriptions of fluvio-aeolian deposits have been published in the sedimentological literature, initially described as modern sediments on the polar deserts (Good, Bryant, 1985). Later, they were identified in the fluvio-aeolian sedimentary succession, mainly from the periglacial zone of the last glaciation (Kasse, 2002). However, the very concept of fluvio-aeolian sedimentary (depositional) environment has not been used so far.
Fluvio-aeolian sediments have been recorded as interbeddings of small thickness within the series of fluvial sediments in braided rivers. They developed as a result of (1) aeolian accumulation within drained sandbars or floodplains, followed by fluvial redeposition as well as (2) aeolian deposition on a wet surface previously shaped by fluvial processes.
In the course of the research on the fluvio-aeolian succession in Poland and Western Ukraine, a separate unit with different lithological characteristics was identified on the borderline between fluvial and aeolian deposits. The record of lithofacies shows clear structures typical of aeolian deposition and redeposition developed as a result of subcritical or supercritical flows. These sediments are accompanied by a different spectrum of cryogenic structures – mainly small-scale involutions and fissures of thermal contraction. In terms of texture, they are characterized by the smallest variability in the grain-size parameters (compared to the whole succession), i.e. the average grain diameter, sorting, and in particular skewness, which usually takes positive values. Quartz grains in nearly 100% show traces of processing in the aeolian environment. They are also characterized by the highest degree of aeolization throughout the fluvio-aeolian succession profile, which additionally increases towards the top of the unit profile. Furthermore, the content of heavy minerals expressed as a significant increase in the abrasion-resistant minerals, including in particular garnets, clearly distinguishes these deposits from lower strata of fluvial sediments and upper strata of aeolian sediments sensu stricto.
The aforementioned properties reflect significant homogenization of sediments deposited in the process of alternate fluvial and aeolian redeposition. They confirm the validity of the fluvio-aeolian lithofacial unit distinguished in the fluvio-aeolian succession.
Since the lithofacial complex is of the highest rank in the lithofacial analysis and represents the depositional environment, one can assume that the fluvio-aeolian environment does exist.
One can also follow the analogy of fluvio-glacial environment where fluvial deposition of glacial sediments occur. Similarly, in the fluvio-aeolian environment we are dealing with the aeolian sediments deposited in the fluvial way and fluvial sediments redeposited in the aeolian way.

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Magnetic susceptibility as a stratigraphic tool for correlation of a facies diversified successions: An example from the upper Emsian and Eifelian of the Holy Cross Mountains (Poland)

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A first-order transgression-regression cycle began at the turn of the Early and Middle Devonian. The sedimentary processes, controlled by post-Caledonian palaeotopography, regional extension due to Rhenohercynian Ocean spreading, local tectonic activity, and pulsatory sea-level rise, formed a complicated system of shallow-marine clastic-carbonate sedimentary environments. As a result, a great lithological variety occur in the upper Emsian and Eifelian deposits in Europe. While conodont biostratigraphy achieved too less resolution for detailed correlation between investigated sections, the magnetic susceptibility (MS) record is tested as an alternative tool for stratigraphic researches.

The Upper Emsian and Eifelian in the Holy Cross Mountains (HCM) is the subject of intense investigations, including stratigraphic analyses and reconstruction of facies development. In the Kielce Region of the HCM, the upper Emsian and lower Eifelian carbonates are divided into 7 formations: Porzecze pyrite-bearing and sideritic claystone Formation, Dębska Wola coralline dolomite Formation, Dąbrowa limestone Formation, Dyminy bioturbated dolomicrite Formation in the western part of the region, and Janczyce fenestral dolomite Formation, Jurkowice nodular dolomite Formation and Wojciechowice dolomicrite Formation in the eastern part.

High resolution MS measurements were provided in 9 sections in the Kielce Region of the HCM. Each of them represents 25–200 m thick succession of mixed clastic-carbonate deposits. 4 major (A–D) divided into 10 minor MS fluctuations were recognized in the western part of the region, while 5 major (B–F) divided into 7 minor MS fluctuations were distinguished in the eastern one.

The origin of MS fluctuations was recognized in the Zbrza section – one of the most complete and lithologically diversified succession in the Kielce Region, and transferred into the whole area. Geochemical and petromagnetic analyses (major and trace elements, IRM, ARM, S-ratio) of about 100 samples were performed. The MS record correlates well with terrigeneous admixture, and its primary (sedimentary) origin is postulated. The major MS fluctuations are related to global transgression/regression pulses and the minor ones to meter-scale shallowing-upward allocyclicity.

The MS fluctuations recognized in the investigated sections were correlates. The biostratigraphic boundary between two conodont zones: *Polygnathus costatus partitus* and *Polygnathus costatus costatus* was used as an additional biostratigraphic marker. The B fluctuation is principal and the most characteristic for correlation. This one can be traced along the whole area of the HCM, has the same stratigraphic position in all sections (always ends below the *partitus/costatus* boundary), and cuts the sections independent to their lithology. The correlation of the other fluctuations is straightforward in the western part of the Kielce Region. A serious problem is to correlate the eastern sections with the western ones due to about 2 to 3-times higher thickness of carbonate succession there. After a thickness correction, similarities between the eastern and western MS fluctuations become more obvious.

MS record is a useful tool for stratigraphic correlation of lithologically diversified sections. In the Devonian of the HCM, the MS fluctuations are related to the primary processes, are independent to lithological variety, and can be traced as an isochronous horizons along the whole area.

The missing link: utilising a global interpretation methodology for the rapid interpretation of 140 my of stratigraphy within the Pelotas Basin, offshore Uruguay

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Despite the vast increase in technology and computing power over recent years, the basic premise of the seismic interpretation workflow has remained largely unchanged since the days of hand interpretation, coloured pencils, and contouring. The focus remains on digitising single surfaces at a time to delineate the geological features imaged within a seismic volume. Whilst this is excellent for detailed prospect-level work, we are already beginning to face several major challenges in Exploration which are increasingly difficult to tackle using conventional interpretation methods:

• A explosion in data size: as exploration advances into deeper waters high quality 3D seismic surveys covering tens of thousands of square kilometres are becoming the industry norm. Despite this huge expansion in the volume of data to be interpreted, subsurface team sizes and project deadlines have not increased; so how can we ensure that we are still capturing the most pertinent geological information from so much seismic data?

• Frontier exploration is moving into ever more complex terrains and, as existing basins mature, the focus moves from large structural plays to more subtle stratigraphic traps which are much harder to find and define using conventional mapping techniques.

• Frontier exploration in remote areas tends to involve datasets which are often large but isolated (e.g. South Atlantic) making offset data difficult to tie in. There is therefore a much greater reliance on extracting the maximum geological information from the limited available data in order to understand the depositional environment.

In order to meet these challenges and ensure continued exploration success a step change is required in the way we utilise seismic data. Global interpretation methods provide one such solution for mapping seismic data more efficiently and in greater detail.

This case study shows how a manually constrained inversion scheme can be used to track every event within an extremely large 3D seismic volume (13, 000 km^2) from offshore Uruguay. By picking every seismic event in a volume, rather than breaking the data into classic sequence stratigraphic packages (i.e. sequence boundaries and flooding surfaces), features which are extremely subtle in vertical seismic sections, but regionally extensive, can be extracted. This enables critical insights into depositional environments to be made, in a level of detail which is over and above that possible using more conventional interpretation methods. The ability to slice and pan through the dataset in a stratigraphically consistent manner, gives rise to a comprehensive understanding of the Punta del Este and Pelotas Basins, through the extraction of detailed sedimentological information from the data. Key highlights include extensive fluvial channel systems, within the Punta del Este rift basin (imaged even at 9.5 km TVDSS); huge sediment drifts comprising of linear ridges reaching ~900 m in height, with wavelengths up to 30 km and down slope channel systems in-between; and finally, barchan-like dunes that are greater than 40 km wide with wavelengths of 10 km and extending in a near-perfect linear train for more than 125 km.

Recently growing subaqueous flowstones in selected caves in Slovakia: Occurrence, petrography, and growth conditions

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Carbonate speloethems have attracted a growing interest in recent years, particularly as a reliable palaeoclimate proxy. Several speleothem types have been distinguished and described, also in terms of their shape and petrographical characteristics, which as well concerns those which uncommonly occur. Underground flowstones, which contrary to 'normal' flowstone, grow in riverbeds of underground streams seem to be neglected contrary to their ubiquitous formation in many caves. In fact, they appear to be the last commonly described of the most commonly occurring speleothems.
Subaqueous flowstones have been found in two resurgence caves in Slovak Karst (southern Slovakia), namely Krásnohorská and Drienovska Caves. The flowstones litter riverbeds on the distance of several hundred meters upstream from a resurgence. They form laminated non-porous crusts within channels of the underground streams flowing through the caves. Individual laminae reach up to a few hundred micrometres of thickness and are composed of columnar, blocky and multi–stepped rhombohedral sparry calcites. Subordinately, some of the laminae are composed of micrite. The micritic laminae are enriched in fine, detrital non-carbonate components, especially phyllosilicates, which was proved by EDS analyses. The growth rate of the studied flowstones reach 0.3 mm per year, which seems to surpass that of 'normal' flowstone being fed by a film of water seeping down. The values of $\delta^{13}C$ of the analysed subaqueous flowstones are quite uniform and range from -10.94 to -10.10 ‰ V-PDB whereas the values of $\delta^{18}O$ fall within a range between -8.02 and -7.34 ‰ SMOW.
Seasonal observations conducted between August 2010 and September 2013 reveal that deposition of subaqueous flowstones in the studied caves significantly depends on the local hydrological conditions, particularly groundwater level fluctuations. During the periods of low spring discharges (below 25 Ls-1) subaqueous flowstones were deposited in form of sparry calcites, while during the period of high spring discharges (up to 1500 Ls-1) in form of micrite or they completely stop growing and even become subjected to corrosion. It reflects changes in water supersaturation during this periods. During the former periods SI reaches 0.81 whereas during the latter ones it falls to -0.05. The micritic character of laminae seems to result from incorporation of non-carbonate particles, transported and deposited during high water level, which prevents the growth of columnar crystals. The flowstones in question represent a middle link between speleothems, especially 'normal' flowstones and tufas deposited outside the cavern environment.

The petroleum reservoir characteristic of multi-cycle carbonate systems in the non-marine Jurassic Sichuan Basin, China

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The multi-cycle mixed carbonate and clastic systems are developed in the non-marine Jurassic Sichuan Basin, China. The new oil and gas reserves were discovered in these low-porosity and low-permeability reservoirs in recent years. The sedimentary microfacies and diagenetic phase are main factors influencing reservoir quality. A detailed study on systems tract and parasequences, sedimentary model reconstruction of reservoirs and pore community analysis were finished for predicting favorable oil exploration targets.
The outcrops observation of 10 field points and 20-well cores as well as 50 samples of thin sections and SEM analysis were finished. Two cycles of carbonate and clastic systems were determined in Jurassic Sichuan. The first cycle is transgressive carbonate rocks of Dongyuemiao member and regressive clastic rocks of Maanshang member. The second is transgressive carbonate rocks of Daanzhai member and regressive clastic rocks of Liangaoshang-Shayiduan member. Daanzhai member develops carbonates of littoral and shallow lake bars, and Liangaoshang-Shayiduan member is sandstones of fluvial delta and locally low-density turbidites in moderately deep lake.
For example of Tanba outcrops, two cycles of carbonates and their sequence boundaries were easily distinguished. The second cycle of Daanzhai member has lacustrine shell shoals that can be further divided into core shoal and marginal shoal. The lithology of core shoal is characterized by thick-layer sparry shell limestones with better physical property in high-energy sedimentary environment, which can be potential “sweet spot” of petroleum exploration. The lithology of marginal shoal, located at the vicinity of cores, is characterized by thin-layer muddy shell limestone interbedded with mudstone. One side of marginal shoal is adjacent to shore lake, another fingered into claystones of modelately deep lake. Of them, the petroleum reservoir of multi-cycle carbonate systems are contacted with closely source rocks. The reservoirs bodies in microscopic thin sections and SEM show dissolution pores of inter-shell, dissolved sparry calcites and dissolution crevasse of inter-crystal.
In summary, two cycles of transgression and regression formed multiple carbonate systems with good shoal petroleum reservoir bodies, and favorable oil exploration targets in the non-marine Jurassic Sichuan Basin.

Sedimentary facies difference controlled by segmented activity of synsedimentary reverse fault

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Based on the analysis of core, well logging and seismic data, this paper explicates the planar distribution of sedimentary facies in each layer and counts formation thickness of each layer both on the hanging wall and footwall of the synsedimentary reverse fault in different stratigraphic sections. The layers are corresponding to each other. In addition, this paper adopts growth index to reflect activity intensity of synsedimentary reverse fault and draws evolution diagram of activity intensity of the fault in different locations and different periods. On the basis of above, this paper analyzes the piecewise activity characteristics of Karamay fault and its influence on sedimentary facies during Karamay group. Research shows that Karamay fault shows obvious piecewise activity characteristics including SW and NE two segments. The variation in activity of two segments influences flow direction of paleocurrent and then effects distribution of sand bodies and facies. Generally, the growth index of SW segment is larger than NE segment during S7 sand group. The largest growth index of SW segment is about 3 and NE segment is 2.5. The obduction in SW segment is stronger than NE segment, leading to narrow banding braided channel and floodplain and isolated sand bodies in SW segment but interleaving banding braided channel and continuous sand bodies in NE segment. During S6 sand group, growth index along the whole fault is relative small which means that the fault is inactive. The main facies are lacustrine mudstone and beach sand. The activity intensity of the fault during S5 to S3 sand group is in contrast to S7 sand group. That is, NE segment is more active than SW segment which results in interleaving banding braided channel in SW segment but narrow banding braided channel and isolated sand bodies in NE segment.

Influence of environment on rhyolitic volcanic eruption in lacustrine setting: Early Permian Fengcheng Formation in NW Junggar Basin, NW China

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Subaqueous explosive volcanism buried in ancient sedimentary basins was poorly understood so far despite tens of modern or ancient explosive eruptions erupted under water have been studied in past thirty years. Increasing studies from outcrops play a significant role in better understanding subaqueous eruptions. However, most of the studies mainly focus on effects of volcanic eruption on climate, sedimentation or environment. This study investigated early Permian rhyolitic volcanism from different sedimentary settings of Fengcheng formation in NW margin of Junggar basin, NW China using seismic and borehole data to discuss the influence of environments on rhyolitic volcanic eruption.
Contrastive analysis from five independent, synchronous volcanoes in the first member of Fengcheng formation with similar chemical composition showed that volcaniclastic lithofacies and their successions had a close relationship to depth of eruptive environments (DEE) and magma volume or height of volcanic deposits (HVD). At HVD > DEE, usually in coastal or offshore settings, short-time wet phreatomagmatic euption with thin peperite (A2) and poor-welded tuff (A3) successively transformed quickly into later subaerial magmatic euption shown by upper thicker spherical lapilli lava (D3) with vesicles. At HVD = DEE, usually in shallow lake, a great amount of volcaniclastic deposits settled underwater until exposed finally with thick lithofacies A2, A3 with a few accretionary lapilli, coarsing-upward accretionary lapilli-bearing ignimbrite (B2), accretionary lapilli-rich ignimbrite (B3) caused by phreatomagmatic eruption and thinner autobreccia lava (D2) by final subaerial effusive eruption possibly without water intrusion. At HVD < DEE, usually in semi-deep or deep lake, all volcaniclastics deposited underwater in sequence from lithofacies A2, A3, B3 and suspension pumice deposit (C) completely controlled by phreatomagmatic eruption. Pyroclastic flow was the most significant transport and deposition process after the early strongly explosive surge flow for a eruption in subaqueous settings, and foam lava flow, resulted in pearite ((D1) or D2 under dry and poor-volatile gas condition and in D3 under wet condition, became the main one in subaerial settings. This study demonstrate that sedimentary environments determined by water depth is one of the key factors that control lithofacies type, sequence and eruptive style of rhyolitic volcanoes with very similar magma composition and volatile gas when the eruptive volume is relative stable. This result provides possibly a high-resolution calibration for restoration of paleo-water depth and deductive prediction of paleo-shoreline by identification of volcanic lithofacies and their vertical evolution when one or more volcanoes erupted at HVD >= DEE can be found.

Study of Milankovitch cycles of Palaeogene strata in Zhu I Depression, Pearl River Mouth Basin, South China Sea

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Cyclostratigraphy is a subdiscipline of stratigraphy that deals with identification, characterization, correlation, and interpretation of cyclic or quasi-cyclic variations in stratigraphic records, and in particular, their application in geochronology by improving the accuracy and resolution of time-stratigraphic frameworks. The discovery and development of the Milankovitch theory have made the high-precision identification and division of sedimentary strata possible.

Along with detailed dissection and systematical research on the Paleogene strata of Zhu I Depression, Pearl River Mouth Basin, this study attempts to combine cyclostratigraphy and petroleum geology and to introduce the Milankovitch Cycles, with known structure and duration, into oil and gas geological exploration to meet the requirements of increasing research accuracy for oil and gas exploration.

The Wenchang, Enping, and Zhuhai formations were deposited from bottom to top during Paleogene in the Zhu I Depression. From the drilling data, the rhythmic interbedded strata of siliceous clastic rock of delta facies and carbonate rock of neritic facies are seen to be widely developed in the Paleogene strata in Zhu I Depression, and the strata show strong cycles and rhythms in sedimentary record.

This study investigates the astronomical orbital period in the formations based on the Milankovitch theory by spectrum and wavelet analysis techniques. Moreover, the study takes advantage of the individual well model simulation and filtering techniques to recognize the thickness of the cyclic stratum corresponding to eccentricity, obliquity, and precession. The results show that sedimentation processes during Wenchang, Enping, and Zhuhai periods are affected by astronomical orbital cycles. Corresponding to astronomical cycles (eccentricity (100 kyr), obliquity (40 kyr), and precession (20 kyr)), the Milankovitch cycles are 19.0 m, 9.1 m, and 3.8 m; 17.0 m, 6.8 m, and 3.4 m; and 9.2 m, 3.7 m, and 1.8 m in the Wenchang, Enping, and Zhuhai formations, respectively. Among the three astronomical cycles, the eccentricity cycle has the dominant influence.

Effective hydrocarbon reservoir affected by sedimentation and diagensis in Huizhou25 Sag, Zhu I Depression, South China Sea

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Sedimentation and diagenesis both control the quality of reservoir rock, which is critical for the formation of a viable hydrocarbon reservoir. Results from oil and gas exploration show that the distribution of oil and water is complicated in the Huizhou25 sag, Zhu I depression reservoir. Water accumulates in the high porosity, high permeability shallow formations. While in the deeper, low porosity, and low permeability formations, oil and gas reservoirs are formed. This indicates that the successful formation of hydrocarbon reservoirs cannot be determined by the physical properties of the rocks alone. Instead, we need to consider the reservoir formation mechanism to be able to estimate the viability of reservoirs more comprehensively.
In this study, we investigate the effects of sedimentation and diagenesis on hydrocarbon reservoirs on the basis of drilling data, well-logging data, and reservoir-rock thin-sections. We also investigate the mechanism of reservoir formation and the defining criteria for this mechanism on the basis of laboratory physical simulation experiments. Finally, we predict the spatial distribution of a reservoir in the research area and provide an important foundation for further oil and gas exploration.
The study results show that the porosity and permeability of sandstones and mudstones generally decrease with increasing burial depth and that the physical properties of the reservoir also show this tendency. But given equal depth, hydrocarbons will only accumulate where the porosity and permeability are relatively high. In our experiment, sandstones with different particle sizes exhibiting good sorting were used to simulate the migration of oil and gas. The experiment showed that the oil always migrated from reservoirs with poor physical properties to those with better ones and that the critical condition for hydrocarbon accumulation occurred when the interfacial potential energy of the surrounding rocks was two times higher than that of the sandstone reservoirs. This critical condition had no bearing on the absolute physical properties of the reservoir.
The physical property of reservoir is controlled by sedimentation, diagenesis, burial history of strata, and so on. Different sediments have different physical properties, and diagenesis can change the properties of reservoir during the burial history.
In the Paleogene tight sand reservoirs of the Huizhou 25 sag, Zhu I depression, the difference in the interfacial potential energy ratio between the surrounding rocks and the reservoir is greater than two, therefore hydrocarbons enter the sandstone reservoirs easily. Once the hydrocarbons have entered, the surrounding rocks act as a barrier to prevent them from escaping. Reservoirs affected by compaction and cementation have a lower capillary pressure ratio and therefore show less hydrocarbon accumulation, whereas reservoirs affected by dissolution have a higher interfacial potential energy ratio and display a good quality factor conducive for hydrocarbon accumulation.

Oil shale in the southeastern Russian Platform

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Unconventional resource of oil and gas in Volga-Urals basin in southeastern Russian platform belongs to the deposits of Domanik complex, which was developed in undercompensated hollows and depressions from the beginning Semiluksky (Upper Devonian) to early Tournaisian (Lower Carboniferous) formation. It is not only theoretical but also practical in the studying structure of these sediments, their genesis and typing sections because these oil-gas bearing characteristics are not only existed in the sedimentation of Volga-Ural Basin, but also in other oil and gas provinces of the world.

On the basis of geological and geophysical studies, we use primary exploratory and drilling materials, including core analysis (lithological descriptions, definitions of reservoir properties, geological survey wells, etc.), analysis the lithologic-paleogeographic sedimentary environments of Domanik formation, propose one methodology for the study of paleogeographical reconstruction in the southeastern Russian platform, and confirm the boundaries of its offshore shallow water, its recessed areas and deep water.

Domanik formation in eastern Russian platform covers the portion of Frasnian-Tournaisian lithologic-stratigraphic system, which was formed in uncompensated hollows and depressions from the beginning Semiluksky to early Tournaisian time.

In silty basin of Domanik (Semiluksky) formation it is dominated by carbonate sediments of Domanik facies: dark siliceous-clayey-bituminous limestones with typical complex fauna. Higher in the cross section, Domanik facies are reduced as narrowing axial parts of the Kamsko-Kinel deflections, meanwhile it is developed weakly bituminous and unbituminous carbonate rocks closer to the inner sides. However, these deposits lie in a relatively depressional areas with small thickness.

As general strata dip in the southern and southeastern direction the degree of deep-water precipitation was increased in depressional zones and the rock was respectively compacted with deterioration of reservoir properties, therefore in this condition tectonic fracture is the most important factor in the reservoir formation.

There are differentiated paleogeological conditions in undercompensated hollows and depressions, which are also the reason of heterogeneity facies in some areas (for example, atolls, bioherm, shoals, and so on). All this has appeared a significant influence on the Domanik formation of reservoir properties.

Generally, geological structure and history are not advantageous for the development of large oil and gas reservoirs in the researching areas. Favorable zones are mainly determined by the local lithology and tectonic conditions.

Depositional sequence and lithology assemblages of Cambrian evaporite-carbonate paragenesis in Sichuan Basin

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Recently, high commercial gas flow and abundant gas reserves are discovered in Lower Cambrian Longwangmiao Formation in Sichuan Basin, Southwestern China. However, multiple evaporite-carbonate paragenesis developed in the Cambrian, with complex depositional sequences and lithology assemblages, which is the bottleneck problem that has been holding us back from recognizing the reservoir features and distribution patterns.

In this paper, a integrated study method is put forward for the description of depositional sequence and lithology assemblages. Firstly, with the correlation of seismic, log and geological data, the isochronous stratigraphic framework and depositional sequence are established. Secondly, using well-core, geophysical and wire-line logging, and laboratory results, lithofacies palaeogeography and the types of facies are restored. Thirdly, through studying the kinds of information from drilling data and the geological interpreted results of loggings, cores and outcrops, the spatial styles of lithology assemblages and its controlling factors in Cambrian evaporite-carbonate paragenesis are descripted, and high quality reservoirs are predicted.

The results: 1) Thickness of Cambrian becomes thinner from the southeast to northwest. Strata are missing in paleo-uplift areas, forming an “onlapping at the bottom, truncation on the top” filling structure. 2) Depositional sequence changes from mixed deposition of terrigenous clastics and carbonates deposits in the lower part to carbonate platform in the upper part. The sedimentary systems are made of coastal shelf, mixed shelf, ramp or rimmed platform carbonates and so on. The evaporites are found in Lower Cambrian Longwangmiao Formation, Middle Cambrian Gaotaizi Formation and Upper Cambrian Xixiangchi Formation. Scopes and facies of these three evaporates are different, which is affected by the oldland, palaeogeomorphology and paleoclimate. 3) There are four lithology assemblages, including evaporite-dolostone, evaporite-limestone, evaporite-siltstone-mudstone, and evaporite-siltstone-mudstone-dolostone. The spatial combination styles include thin interlayered, medium thickness interlayered, and unequal thickness interlayered. The controlling factors are micro-facies, lagoonal sediments and its depositional sequence, and the scale of evaporitic lakes. 4) Major producing layers are distributed in Longwangmiao and Xixiangchi formations. The rock types of favorable reservoir are mainly grain, crystalline, and micritic dolostone and its distribution are around the sequence boundaries and controlled by the grain beach facies, fractures, dolomitization, and locations of the evaporitic lagoons.

This paper provides guidelines for the prediction of high quality reservoirs in Cambrian evaporite-carbonate paragenesis in Sichuan. And the future profitable exploration targets presented in the paper ,which are located in the paleo-uplifts and faulted areas which are near to or above the source kitchens, are worthy of attention for the next petroleum exploration of Cambrian evaporite-carbonate paragenesis in Sichuan Basin.

Seismic reflection characteristics and geological models of reefal buildups of Upper Permian Changhsingian in the Sichuan Basin, southwest China

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Exploration of oil and gas in reefs of Upper Permian Changhsingian in the Sichuan Basin, Southwest China are mainly focused on both flanks of Kaijiang-Liangping trough located in the East Sichuan. In other areas of the Sichuan Basin, research information including geological, petrographic and paleontologic data is absent inadequate because of low exploration degree. How to prediction the distribution of reefs and shoals in no well blocks using seismic data remains to be an urgent problem to be solved. In this paper, a lot of data and technologies are adopted. The regional tectonic and sedimentation background is investigated to study the depositional pattern of Changhsingian. Seismic reflection characteristics of reefs and shoals proven by wells in Changhsingian are clarified, and the geological models are established, to provide references for identifying and predicting reefs and shoals in areas with no well. Based on regional tectonic and depositional study, combined with 2D seismic profiles and well data, the paleo-geomorphology and lithofacies paleogeography of the Changhsingian are illustrated in maps. Using 2D and 3D seismic detailed interpretation, seismic reflection characteristics of reefs and shoals proven by wells in different sequences and face zones of the Changhsingian are analyzed. According to well-core, geophysical and wire-line logging, and laboratory experimental results, together with integral seismic interpretations, geological models of reef and shoal development are built for different seismic reflection characteristics, and prediction of reservoir distribution are realized.

The results include: (1) Depositional pattern of Changhsingian in the Sichuan Basin is “three uplifts and three troughs”, with carbonate platforms developed. Reefs and shoals of differents sizes are distributed along platform margin and flanks of the troughs, with intense heterogeneity. (2) Five external shapes and five internal reflection structures are summarized in the Changhsingian, including asymmetric ridge, scarp shaped, low angle hills, lenticular and box shaped appearances, and wavy weak reflection, strong clutter reflection, bedding strong or weak reflection, short strong oblique reflection and blank reflection internal structures. Contacts between reefs, shoals and wall rocks include onlapping, coating, and progradation. (3) Influenced by paleo-landform, eustatic fluctuation and depositional zones, both drowned and dried reefs developed in the Changhsingian. Five geological models are presented, including fault-accretion-asymmetric type, fault-accretion-box shaped type, fault-accretion-scarp type, echelon-scarp-migrating low mounds type, and isolated-wide low mounds type. The former three types usually develop along platform margins during HST, forming thick reefs with high quality reservoirs of reefal dolostones, which are the more favorable reservoirs and profitable targets for natural gas exploration; while the latter two types often develop along platform margins during TST or within the platform during HST, forming mainly grain shoals with thinner reefs and mudstone, resulting in making poorer reservoir quality and less profitable exploration. (4) Favorable reservoirs are mainly distributed on the steep side of platform margin, or with basement faults and always develop vertically at the top of each reef-phase. Dolomitization, multi-stage dissolution, and fracturing are key factors for improving reservoir qualities in reef-shoal complexes.

Micropaleontological evidence for a 4600-year-old marine incursion and associated crustal deformation at a coastal lowland in southeastern Kyushu, Japan

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Subduction along the Nankai Trough conveys the Philippine Sea Plate beneath eastern Kyushu at an average rate of 5–7 cm/yr. Over the past 400 years, several historically-documented earthquakes and tsunamis have occurred in the Hyuga-nada segment of the Nankai Trough. However, it is not known whether any large earthquakes and their associated tsunamis have occurred here in prehistory. Paleotsunami deposits can provide evidence for past events extending back over thousands of years and in this case we use predominantly micropaleontological data to show marine incursion and associated crustal deformation in the southeastern Kyushu region.
We conducted hand coring at a total of 19 study points along two shore-perpendicular transects at a coastal lowland in southeastern Kyushu, Japan. Two thin sand layers (A: 358 cm deep; B: 361 cm deep) bounded by sharp upper and lower contacts with the surrounding mud were evident in the 5 m long sediment core obtained in 220 m from the shoreline. Plant material obtained from mud samples immediately beneath sand layer B was dated to approximately 4600 cal. yr BP. There was also an approximately 4500 year-old Kr-M tephra layer at 331–335 cm deep. Below 450 cm, diatom assemblages contained numerous marine species, while brackish and freshwater taxa were common above 450 cm. There were no marine taxa recorded in the organic-rich muds between 369 and 410 cm deep, but a relatively high percentage including Tryblionella granulate, Planothidium delicatulum, and Parlibellus cruciculus was recorded both within and below the sand layer (360–368 cm). The presence of marine diatoms in sand layer B indicates that these were sourced from seafloor and beach environments. The presence of marine species below the sand layer B can potentially be explained by pre-seismic subsidence. The resting spores of the planktonic diatom Cheatoceros were absent immediately above sand layer A, suggesting that the water depth of the study site became shallower soon after deposition, and that co- or post-seismic uplift is the most likely explanation for this marked environmental change. We infer that the sand layers were most likely deposited by tsunami inundation approximately 4600 years ago. Moreover, if the study site was subsided before and uplifted after deposition, the tsunamigenic earthquake source must be immediately offshore from the study site. This is because teleseismic tsunamis, storms and floods are not unaccompanied by such crustal deformation.

Genetic mechanism and evaluation of low permeability reservoir in Liaodong Bay Sag, eastern China

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The reservoir of Paleogene stratum in Liaodong Bay Sag, eastern China has a low permeability. Based on data of core observation and description, scanning electron microscope (SEM) and core analysis in laboratory, the characteristics and genetic mechanism for low permeability reservoirs was analyzed by sedimentary facies, diagenesis, and pore structure types.
The results show that the pore structures were mainly of primary type, with just a little secondary one, whose amount increased with increasing depth. Sedimentation and diagenesis have impaction on the origin of low-permeability. The sedimentation controls the spatial distribution of reservoir framework and the events and intensity of the subsequential diagenesis. Diagenesis affects both the reservoir spaces and porosity structures.
Braid-delta was developed in Liaodong Bay Sag. The reservoir could easily be compacted for its rapid accumulation, sophictication of different grain sizes, and high feldspar content. The cementation of carbonate rocks and clay minerals have resulted in the decreasing of primary pore, which in turn lowered the permeability. What's more, the difficulty for the underground acidic fluids entering the reservoir hindered the dissolution process of the reservoir.
The analysis on rock samples indicated that the Ro was between 0.4-1.0, T_{max} was between 420-440℃, the rate of montmorillonite in illite-montmorillonite mixed layers was 30%-60%, and the thermal alteration index (TAI) was between 2.3-2.7. The contacting relationship among particles was point-point and pine-line, so the diagnesis stage of Liaodong Bay was early B and middle A.
Based on diagnesis types, logging response characteristics, the vertical and horizontal diagnetic facies, a quantitative classification and comprehensive evaluation index system for different types of diagnetic facies were established, including intensive compaction face, carbonate cementation face, medium compaction-intensive dissolution face, as well as medium compaction-medium cementation-medium dissolution face.

Sequence stratigraphy and sedimentary cycle of Miocene carbonate buildups in Zengmu Basin, the southern South China Sea

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In this work, using drilling, seismic and some palaeontologic data, the Miocene carbonate sequence stratigraphy and sedimentary cycle of Nankang Platform and L-structure in Zengmu Basin was analyzed. And then the sequence pattern of Miocene carbonate in the study area was established. The result showed that three large-scale carbonate sedimentary cycles had been accrued during mid to late Miocene (5.3-16 Ma) in Zengmu Basin, thus this strata can be subdivided into three tertiary sequences (SQ1, SQ2 and SQ3 sequences). SQ1 and SQ3 sequences should be defined as the classical type I carbonate sequences, which was composed of dense algal limestone in low-stand system tracts (LST), argillaceous limestone in transgressive system tracts (TST) and coral limestone in high-stand system tracts (HST). And their property indicated that the development of carbonate buildups experienced a process from open marine platform facies to reef flat facies. Being different form SQ1 and SQ3 sequences, SQ2 sequences belonged to the drowned unconformity type of carbonate sequences. This kind of carbonate sequences is marked by the successions consisted of argillaceous limestone of condensed sequence (CS) and coral limestone (or clastic limestone) of HST. And it's development generally occurred during the phase of sea-level decreasing continuously.

Muliti-scaled heterogeneity of tight sandstone reservoirs and their influenceson on tight oil accumulation — in the Chang 6 Formation in the Upper Triassic, southwesten Ordos Basin, China

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Tight oil has been a hot spot of petroleum exploration and development for the past 20 years. However the controlling factors for tight oil accumulation are not fully understood. Chang 6 member of Yanchang Formation in Ordos basin are typical tight sandstone reservoirs, with poor reservoir property, strong anisotropy. Integrated application of the core, Scanning Electron Microscope (SEM, X-photograph and micro-nano CT reconfiguration technique, to analyze tight reservoir heterogeneity and investigate their influences on tight oil accumulation on the millimeter, micron and nanometer scale. Millimeter scale heterogeneity in tight reservoir is visible in drilling core. The results show that bedding structures and bedding fracture are well developed in reservoirs. Chang 6 Formation developed two types of bedding fractures. One type is horizontal bedding fracture, and the other type is low-angle bedding fracture. Multiple-fractures form bedding fracture system. In the micron scale, SEM was used to examine 2D porous morphological characteristic and pore size at high resolution level. The X-ray 3D imaging and visualization technique could comprehensively study the spatial distribution of throat and pore. The reservoir develops three reservoir space types, such as skeleton-pore (2-30 μm), intra-particle pore (50-500 nm) and micro-crack. Inter-granular skeleton pore and micro-crack belongs to micro-scale range, while intra-particle pore belongs to nano-scale. Inter-granular skeleton-pore is mainly distributed in quartz and feldspar as well as illite clay mineral aggregates. In addition, individual particles show regular polygon shapes, besides, some irregular ones. Intra-particle pore is mainly generated by quartz and calcite dissolution, and the shape of dissolution pore is irregular. Micro-crack which commonly have a width of 1-5 μm and length 50-300 μm cut through feldspar and quartz particles. At the same time, some micro-cracks are restrained in mineral particles. The accumulation of tight oil is comprehensive controlled by bedding structures, bedding fracture and micro-pore. In millimeter scale, massive bedding is beneficial to oil accumulation. Local enrichment tight oil is controlled by bedding fracture, and the distribution of banded tight oil is controlled by the sedimentary bedding structures. In micro-nano scale, tight oil is not only distribute in larger pores, but also in isolated pores with the micro-crack development.

Micro-nano pore network system and the characteristic of tight oil accumulation in the YanChang Formation in the Upper Triassic, Ordos Basin, China

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Tight reservoir is an important field in unconventional resources exploration and development. However, beside the fact that micro pore-throat system and the characteristic of tight oil accumulation are not fully understood. Yanchang Formation in the upper Triassic of Ordos basin is a typical tight sandstone reservoir. Integrated application of the core, X-photograph & micro-nano CT reconfiguration and one-dimensional physical simulation technique to investigate micro-nano pore-throat network system, simulate oil charging and migration under the geological conditions and research tight oil accumulation characteristic in micro-meter scale. Micro-nano CT scanning experiment could get information about pore volume, the longest edge, shortest edge, throat radius and the space distribution of residual tight oil. The core diameter of micro-CT scanning is 2 mm and the core diameter of nano-CT scanning is 65 μm. According to length-width ratio of pore, there are three pore types in tight sandstone reservoir, banded shaped pore (l/d>3), tube-shaped pore (1.3<l/d<3) and spherical pore (0.8<l/d<1.3). In micro-meter scale, banded shaped pore and tube-shaped pore is well developed, and spherical pore is undeveloped. Micro-meter pore volume in sandy debris flows core averages between 50-500μm3, micro-meter pore in turbidite sand bodies core averages between 10-500 μm^3. In nano-scale, spherical pore, with small volume, is well developed. Residual tight oil is mainly distribute in connecting banded shaped pore, a little tight oil is distribute in tube-shape and spherical pore with throat connect, micro-crack as channel pathway for tight oil distribution. According to one-dimensional physical simulation result (core diameter is 2.5 cm), there are two types of oil saturation increase modes in tight reservoir .Type 1, in the early stage of test, oil saturation increases rate is fast, at the end of the test increases rate is slow. Type 2, in the early stage of test, oil saturation increases rate is slow, at the end of the test increases rate is fast. Micro-meter volume in both types of core averages between 0-50 μm^3 and 50-100 μm^3, throat radius averages between 0.065 to 12.44 μm. Compared with type2, banded shaped pore account high proportion in type 1, the throat distributes assembly, large throat is well developed. Further research will connect one-dimensional physical simulation and CT scanning equipment, study the mechanism of tight oil migration and accumulation in micro-scale.

Source reservoir assemblage of tight oil and their influences on oil accumulation — case study from the Chang 7 Formation in the Upper Triassic, southwestern Ordos Basin, China

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Tight sandstone oil is one of the most important unconventional hydrocarbon resources. According to the characteristics of source reservoir assemblage, tight sandstone oil could be divided into two types. One type is coexisting source & reservoir, and the other type is halo oil. Presently there are some debates on the model of hydrocarbon expulsion and the controlling factors for oil accumulation. The Chang7 member of Yanchang Formation in Ordos basin is a typical coexisting tight source & reservoir. Based on the studies of core, drilling and oil production test data, the source reservoir assemblage could be divided into three types. Type 1 reservoir rocks enclosed within source rocks, and type 2 alternate beds of source and reservoir rocks and type 3 source rocks enclosed within reservoir rocks. Different kinds of assemblages have distinct methods of hydrocarbon expulsion and accumulation. Type1, account for 35%, is mainly distributed in lake facies. The isolated turbid sand body developed in thick source rocks, and net to gross ratio is between 4 to 30%. Type2, account for 50%,is mainly distributed in area with vertically overlaying several circles of turbid sand body and lacustrine facies mudstone, net to gross ratio is between 31 to 48%. Type3, account for 15%, is mainly distributed in lacustrine basin margin, net to gross ratio is between 51 to 67%. In the previous two types of assemblages, when the single layer thickness of source rocks is over 55 meter, the pressure coefficient is over 1.52, and more efficient hydrocarbon expulsion by micro-fracture. While when the single layer thickness average between 30 to 55 meter, the pressure coefficient average between 1.3 to 1.52, existing abnormal high pressure zones in source rocks, and expulsion with retardation zone. In the type 3, when the single layer thickness of source rock is less than 30 meter, the pressure coefficient less than 1.3, and full expulsion. Oil &gas shows thickness to sandstone thickness ratio to represent oil accumulation degree. Type1 reservoirs have a maximum oil accumulation degree with the average value is 0.78. While type3 possess a minimum value of 0.6, and the average value is 0.71. The average value of oil accumulation degree of type 2 reservoirs is between type1 and type3. It can be concluded that type 1 is the best for tight oil accumulation, and type 2 is the second but type 3 is relatively poor.

Mud volcanoes in the Northern Zhongjiannan Basin, Western South China Sea: A new type of gravity-flow sediments

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Mud volcano (MV) is a geological structure formed as a result of the emission of argillaceous material on the Earth's surface or the sea floor. It's a significant mark in the modern crustal movement and new tectonic activity. Approximately 1800 MVs have been found on the Earth. The formation mechanisms of MVs have puzzled geologists for a long time. Earthquakes, tectonic movements, fault activity and exploratory drilling have all been scrutinised as possible triggers. In this article, we present a description and analysis of a new type of MVs in the Northern Zhongjiannan Basin (ZJNB), Western South China Sea (SCS).
The study area is located to the south of the Zhongjian Island, at the intersection of the extensional zone of the northern SCS and the transform zone of the western SCS. The ZJNB is a typical continental margin basin, which has experienced from terrestrial facies, transitional facies to marine facies. Form Pliocene to Quaternary, the basin was in the regional subsidence stage with high sedimentation rates (up to 1.2 mm yr-1), accepted the sheet drape deposits of neritic facies and bathyal facies. More than 50 MVs have been found in the Northern Depression of ZJNB. The MV development zone covers an area of about 6770 square kilometers, and water depths are 760 ~ 1460 meters. They are circular or elliptical in plan view and their diameters range from hundreds of meters to more than 2.29 kilometers. The heights of the mud volcanoes vary from tens of meters to 214 m.
Generally, abundant sediments, high pore fluid pressure, and certain trigger mechanisms are the conditions necessary for the formation of the MVs. However, the MVs in the ZJNB have different formation mechanism.These MVs are located at the west continental slope of South China Sea, which formed by the gravity-flow sediments. A amounts of Quaternary sediments accumulated on the slope break with high concentration and rapid velocity. Then the fluid compartment formed. And the liquid couldn't be ruled out. As the sediments load increasing, the compartment would be overpressure. When the pressure is big enough, the overpressure fluid may breakthrough the overlying strata, the MVs formed. So the MVs in Zhongjiannan Basin are a new type, which formed by the gravity-flow sediments.

Reconstructing the depositional environment of the late Sinian Dengying Formation in eastern Sichuan basin and its geological significance

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With a perceived scarcity of Dengying Formation in eastern Sichuan basin, the depositional environment was investigated by using geochemical and stratigraphic proxies in order to inverse geological processes.

Sichuan basin was a rifted basin in late Sinian. On the basic of detrital sediments of Doushantuo Formation, Tongwan movement (from 630 Ma. to 543 Ma. ca.) and the fluctuant rise of sea level leaded to Dengying Formation mostly dolostone and further divided into two supersequences with a regional unconformity as boundary: Tongwan movement Iepisode from Deng-1 to Deng-2 member and Tongwan movement IIepisode from Deng-3 to Deng-4 member.
Deng-1 member, 50~150 m, was argillaceous and micritic dolostone. Deng-2 member, 300 ~ 600 m, mainly possessed algal dolostone with botryoidal structure and interbeds of grain or argillaceous dolostone. Deng-3 member, 30~100 m, was dominated by dark shale and a slightly argillaceous dolostone, siltstone and silicalite. Deng-4 member, 200~250 m, entailed muddy and algal dolostone mainly, followed by grain dolostone.
According to previous research results, algal dolostone and muddy to micritic dolostone of Dengying Formation should be syngenetic or para-syngenetic origin and retain substantial information about depositional environment. There for, Deng-1 sampled micritic dolostone and Deng-3 took samples of argillaceous dolostone, while Deng-4 and Deng-2 both sampled muddy and algal dolostone.
Analysis carbon and oxygen isotopic compositions of 25 samples collected from two outcrops and evaluation the effectiveness of the data, we found that the $\delta^{13}C$ values vary from-2.35‰ to 4.96‰ with an average of 1.93‰ and the $\delta^{18}O$ values vary between-8.72‰ and-1.03‰,-4.41‰ on average. Substituting $\delta^{18}O$ values after correction of period effect into the formulae "$t(℃)=15.976-4.2\ \delta^{18}O\ CaCO_3+0.13(\delta^{18}O\ CaCO_3+0.22)2$"(Xiulian Zhang, 1985), we found that the seawater temperatures varied between 15 ℃ and 35 ℃, suggesting a warm or hot subtropical climate, besides Deng-3 (avg. 29.73℃) and Deng-4 (avg. 27.14 ℃) were higher than Deng-2 (avg. 19.34 ℃) and Deng-1 (avg. 22.12 ℃). Substituting $\delta^{18}O$ and $\delta^{13}C$ values into the formulae "$Z=2.048\times(\delta^{13}C+50)+0.498\times(\delta^{18}O+50)$" (Keith and Weber, 1964), we found that the seawater salinity of Deng-2 (avg. 133.12) and Deng-4 (avg. 129.06) were higher than Deng-1 (avg. 125.97) and Deng-3 (avg.126.17). According to the formulae "$\triangle\delta^{18}O=1.1‰/100\ m$" (Jianxing Qian, 1994), we found the sea level slow transgression in Deng-1, oscillatory regression in Deng-2, transient transgression in Deng-3 and sustained regression in Deng-4.
The paleoenvironment suggested by carbon and oxygen isotopic may indicate that the low temperature and lower salinity of seawater, slow transgression of sea level and flat terrain made Deng-1 a muddy dolostone flat; the lower temperature and high salinity of seawater and oscillatory regression of sea level provided adequate nutrients for hydrobios development, leading to the Deng-2 a tidal flat dominated by algal dolostone; the higher temperature and low salinity of seawater and transient transgression of sea level made Deng-3 a clastic neritic shelf; the high temperature and higher salinity of seawater and sustained regression of sea level leaded to the Deng-4 a tidal flat dominated by muddy and algal dolostone.

Sedimentological characterization of the Devonian Horn River Formation in British Columbia, Canada

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The Horn River Basin in the northeastern British Columbia, Canada, is one of the largest unconventional gas accumulations in North America. It consists mainly of Devonian shales (Horn River Formation) and is stratigraphically divided into 3 members, the Muskwa, Otterpark and Evie in descending order. This study presents sedimentological characterization of each members based on sedimentary facies analysis aided by well-log data from a 160 m long core. From the Horn River Formation, 7 sedimentary facies were classified considering sedimentary structures (i.e., homogeneous, very thinly laminated, thinly laminated, and indistinctly laminated) and sediment color (i.e., dark grey and light grey). These sedimentary facies are interpreted to represent quiescent basin plains and base-of-slope off carbonate platform or reef where sediments were mainly deposited by pelagic to hemi-pelagic settling with infrequent effects of low-density gravity flows.

The uppermost member, Muskwa is a dark grey to black, siliceous mudstones with low detrital silt amounts and high radioactivity on gamma ray logs. In the core, it predominantly consists of very thinly laminated dark grey mudstone (LM-1/d) beds with subsidiary intercalating thin beds of homogeneous light grey mudstone (HM2). Facies LM-1/d is characterized by planar and parallel lamination mostly less than 0.5 mm thick, and also by indistinct or gradational boundaries of facies units. Facies HM2 shows no primary structures except occasional intercalation of laminae, layers or lenses and spots of pyritized materials, and its unit boundaries are transitional. This member is interpreted to represent a pelagic environment in a deep to marginal slope setting with occasional sediment input by low-density gravity flows.

The Otterpark Member is characterized by less bituminous, predominantly medium grey calcareous mudstones in the upper part, and by darker and more bituminous mudstones with only local calcareous-rich laminations in the lower part. In the core, the upper part of Otterpark predominantly consists of thinly laminated light grey mudstone (LM-2/l) beds in which laminae are generally 0.5 - a few mm in thickness, but their vertical change of lamina spacing is more or less nonsystematic or irregular. On the other hand, the lower part of the member generally shows sedimentological characteristics similar to that of the Muskwa (dominantly LM-1/d). This member reflects an upward shallowing environmental change from a deep marginal slope to a shallower reefal slope.

The lowermost member, Evie consists of bituminous, siliceous mudstone transitioning to a wackestone and calcareous mudstone at depth. The core interval of this member shows very thinly laminated light grey mudstone (LM-1/l) beds and indistinctly laminated mudstone (LM3) beds in the upper and lower parts, respectively. Facies LM3 is characterized by thinly laminated with discontinuous or indistinct laminae and distinct to transitional unit boundaries. The Evie Member represents a deep marginal slope setting.

Microbially mediated dolomite and significance of fossilized microbes in Cambrian stromatolites from the Tarim basin, northwest China

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Dolomite [$CaMg(CO_3)_2$] is abundant in sedimentary rocks throughout the geological record, but it is rarely found in modern sediments. Its origin remains a long-standing enigma. Samples of the Cambrian microbial dolomites were collected from Penglaiba section, a well-exposed stratigraphic section in
the northwestern area of the Tarim Basin. This study provides an analogue for mediated dolomites that can precipitate in microbial mats and biofilms. The Cambrian stromatolitic dolomites were studied using high-resolution scanning electron microscopy. The results are as follows: (1) dolomites with 50 nm to 100 nm spherical nanostructures are aggregated into minerals of larger sphericities; (2) nanospherical dolomites of 50 nm to 170 nm diameter are densely arranged as dumbbell-shaped or chained aggregates; (3) silicified filaments, as well as dumbbell-shaped and chain arrangements, are preserved as important microstructures. The ambient temperature was estimated from $\delta^{18}O$ values from early diagenetic dolomite and the presence of structure associated with extracellular polymeric substances (EPS), is composed of fibres arranged in a reticular pattern, would favor epitaxial crystallisation of dolomite on an organic substrate. Additionally, poorly crystallised dolomite formed nanocrystal aggregates that strongly resemble the morphology and size distribution observed in microbial culture experiments. On the basis of sedimentological, compositional, geochemical, and petrographic data, the microstructures were interpreted as nanoglobules that function as bacteria in the nucleation and filament mineralization stages. The microstructures function as such because they are wrapped in extracellular polymeric substance (EPS) or mucus and mineralized fossils. Silicification accounts for the exceptional preservation of microbial mat structures, including biofilms, as well as filamentous and coccoid microbes. In addition, EPS process is capable of binding different elements, with preference for Si, Mg, and Ca. Such suitable composition favors microbe mineralization and dolomite nucleation on organic substrates. These microscopic structures suggest bacterial mineralization and provide visual evidence for the origin of microbial dolomites.

Sedimentology of deepwater lacustrine gravity flow channels in a fault controlled reservoir of Paleocene, Bohai Basin, East China

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The Paleocene reservoir of Dagang Oilfield, which is one of the most important and complex fault-controlled lacustrine reservoirs in China, is located in the north depression of Bohai Basin. The deep water lacustrine reservoir in Dagang Oilfield has experienced significant tectonic and diagenesis throughout its long geological history. These processes have greatly complicated the reservoir properties. However, the fault-controlled deep water lacustrine reservoir has become one of the most important hydrocarbon exploration targets in China due to thick layer and relative good porosity in deep water sedimentary sandstone, which is very important in getting a proper knowledge of remaining oil distribution and improving oil recovery rate.
We describe a sedimentation pattern approach integrating core, well log and seismic data, to reveal the complex deep water lacustrine reservoir in Dagang Oilfield. The fault- controlled reservoir was identified on single wells. And the tectonic evolution history was reconstructed, thus the paleogeomorphology was rebuilt. During the Paleogene, tectonic activity on the Changlu fault that rapidly subsided and deep water environments evolved. Then deep water lacustrine gravity flow channel sedimentary system was formed in the study area. The spatial distribution of the gravity flow channels were predicted with seismic attribute analysis and non-orthogonal wavelet transformation, as it showed an obvious correlation with reservoir revealed by well data. Deposits in the deep water lacustrine gravity flow channels were divided into channel center microfacies, intersections of distributary channel, channel margin, channel inter and lake mud microfacies. Finally, the depositional progresses and developing conceptual model of deep water gravity flow channel sandstone was put forward to predict the high quality sandstone reservoir in the hydrocarbon exploration in rift lacustrine basin with a new insight. Our method may be useful in characterizing similar deep water lacustrine reservoirs in other areas.

The discussion on the classification and architecture model of braided river

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Studies on the architecture of braided river have been carried out by many researchers for a long time. However, the depositional styles of different braided rivers are not well understood. The scale and the stacking relationship of architecture elements are not clearly defined either. In this study, braided rivers are divided into anabranched type and wandering type based on their different sedimentology and hydrology characteristics considering on the classification of braided river proposed by many other scholars. According to the data of outcrop of Yungang Formation in Datong Basin, Shanxi, China, satellite photos of modern deposition, and also the high-quality dynamic and static data from one dense well area of Fula North oilfield of Muglad Basin in Sudan, the architecture patterns of anabranched and wandering braided river reservoir are characterized.
Firstly, anabranched braided channels are relatively fixed and are usually superimposed with braided bar laterally, and the 4th architecture bounding surface between them can be clearly identified on the cross-section. Because the channel cut the braided bar to its bottom, the thickness of a braided channel and its coexisting bar is close to each other. A wandering braided river is formed by rambling flow and its braided bar moves frequently and quickly, thus, the channel of a wandering braided river is not fixed, because of the sand body stacking and overlaying, the braided channel and bar are not easily recognized on the cross sections, only some thin, irregular, small-scale cross-bar channels can be found, so it is hard to recognize the 4th bounding surface between the braided channel and bar.
Secondly, for anabranched and wandering braided river, the width of braided river belts and the width of braided bar have a good positive correlation. For anabranched braided river, the ratio is approximately 1.8, but for wandering braided river, the ratio is approximately 3.7. The braided channel filling in these two types of braided river can be divided into sandy filling, semi-muddy filling, muddy filling channel based on internal filling characteristics.
Finally, for a single braided bar in anabranched braided river, cross-bar channel and silting layer are two main types of architecture elements, and the silting layer can be continuously or locally distributed, the cross-bar channel distributed irregularly. For wandering braided river, silting layers are difficult to reserve due to the strong erosion, only the cross-bar channel deposits are kept inside the braided bar.

Sequence stratigraphy, sedimentary facies and reservoir quality of Es4s in Niuzhuang sag, Southern Slope of Dongying Depression, Bohai Bay Basin, East China

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Shore-shallow lacustrine thin-bedded beach-bar sand reservoir is widely deposited in the upper fourth member of Eocene Shahejie Formation (Es4s) of Niuzhuang sag, within the southern gentle slope of Dongying Depression. The objective of this paper is to establish sequence stratigraphy, sedimentary facies and ultimately to discuss the diagenetic effects on reservoir quality.

Seismic, wireline logs, core observations and analyses are used to interpret depositional settings and sequence stratigraphic framework. Important information regarding the sedimentary facies is inferred from core description and wireline log response while their distribution pattern is derived from isopach maps. Petrographic study based on microscopic observation of optical, cathodoluminescence, confocal laser scanning microscope and SEM along with XRD is used to discuss the fabric, texture, allogenic and authigenic mineralogy of high heterogeneity beach-bar sand reservoir.

Es4s is interpreted as third-order sequence, including lowstand systems tract (LST), transgressive systems tract (TST) and highstand systems tract (HST). We identify 29 parasequences and 7 parasequence sets. Sand-bodies of Es4s are mainly deposited in the shore shallow lake beach-bar (clastic beach-bar as Cx sand group), semi-deep lake (carbonate beach-bar as Cs sand group) and the shallow water channel. The clastic beach-bar is considered as the foremost depositional facies and classified into sand-bar and sand-beach subfacies, further subcategorized into main-bar, bar-edge microfacies and beach-mat, beach ridge microfacies respectively. Fine grain size, poor sorting, continuous thin interbedded mud layers with siltstone/fine-sandstone having argillaceous material in regular intervals and low sedimentological maturity are main causes of depositional heterogeneity. In microscopic analysis, despite of the dissolution of grains and matrix, and also having numerous fractures, destruction of porosity by cementation and compaction are main causes of diagenetic heterogeneity. Secondary pores are developed with the increasing effect of diagenesis causing the dissolution of feldspar grains. Authigenic clays around the grains, pore filled with clays and secondary cementation also destruct the overall porosity and permeability. Therefore, it is characterized as low mature compositional and structural, middle to low permeable reservoir. Beach-bar reservoirs have become one of the most important targets, hence it is necessary to enhance the research work on the sand microfacies. The current study reflects significant insight to understand properties of beach-bar sands and can lead for the comprehensive reservoir characterization and overall reservoir bed quality.

Impact of dehydration of the Zechstein gypsum (A1) on deposition of the Older Potash (K2) in Western Poland, implication for hydrocarbon exploration

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The Upper Permian (Zechstein) deposits in Gorzów Wielkopolski region are well documented. More than a hundred wells were drilled in the area due to significant accumulations of oil and gas in the Main Dolomite (Ca2) reservoir. Additionally, the area is covered by good quality 3D seismic surveys. These data enable detailed analysis of the geological framework for the evaporite-carbonate succession. The hydrocarbon accumulations are situated on a top and in a toe-of-slope setting sulphate-carbonate platform. This sulphate-carbonate platform relief had considerable influence for the deposition of the Stassfurt Salt (Na2 and K2).
The Zechstein Werra Anhydrite Member (A1) is a shallow-water, lagoonal deposit originally deposited as bedded selenite gypsum and deep-water dark, finely-laminated deposit. Dehydration of the first cycle (PZ1) gypsum (A1) and to a minor extent the second cycle (PZ2) gypsum (A2) has caused considerable decrease in their thickness. Significant differences of the sulphate thickness related to the facies belt variability (increase thickness on shallow water platform and decrease in deeper basin) are observed. After filling the sedimentary basin by the Older Salt (Na2) all original topography of the PZ2 was removed. Significant increase of subsidence of the sulfate-carbonate platforms, caused by dehydration of gypsum was marked. The increase of accommodation space resulted in deposition of a thicker lithostratigraphic unit of the Potash Salt (K2), which accumulated in highly restricted settings. This unit is characterized by alternating, relatively thin layers of potassium salts, halite, sulphates and clays. The presence of highly soluble potassium and magnesium salts is confirmed by well logs and chemical analyses of drilling mud.
The average seismic impedance of K2 is lower than the underlying Na2. This allows us to interpret the thickness variations of K2 in the seismic record. The correct interpretation of the K2 unit depends on good imaging of the Z3 stringer (carbonate, anhydrite, clay) between the Na2 (below) and the Na3 (above) salts.
In addition the zones of the increased thickness of the K2 unit can have been laterally displaced (intrasalt detachment) relative to their original position above the shallow water sulphate-carbonate platforms.
In previous depth conversions one velocity for the entire PZ2 salt (Na2 + K2 + Na2r) package was used. Not taking account of the variation of the K2 thickness in the T/D conversion can cause distortion in the depth maps of the Basal Anhydrite (A2). This is very important for defining the geometry of the structural traps of the Main Dolomite (Ca2), especially at the toe of slope of the sulphate-carbonate platforms.

Biostratigraphy of Upper Miocene–Lower Pliocene sediments in the Hellenic fold and thrust belt, Zakynthos Island, Ionian Sea, western Greece

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Zakynthos Island is part of the parautochthonus Apulian lithospheric plate of Hellenic mountain belt and contains rocks of two different geotectonic zones, the western Pre-Apulian zone and the eastern Ionian zone. Structure, sedimentary features, and biostratigraphy were taken into account to provide additional knowledge into the depositional conditions that influenced the sedimentary sequence along the southern coast of Zakynthos. This succession is exposed along the coastal area of Laganas Bay, from the Keri gulf as far as Kalamaki village. A suite of fifty samples were selected from five different sections from the whole sequence. The base of the sequence in the southern end of Keri gulf displays at least three coarsening upward cycles. A detailed calcareous nannofossil biostratigraphy showed that the age of these sediments is Tortonian (biozone NN9 based on the contemporaneous presence of *Discoaster hamatus* and *D. calcaris*). In the area between the Keri gulf and Agios Sostis peninsula the sequence appears to have been influenced by intense tectonic activity. It is featured in its upper part by a slump horizon of Totronian age, where there were found many resedimented mostly Eocene to Oligocene sediments. One depositional cycle at Agios Sostis and fourteen cycles in Kalamaki, during Messina time, with Messinian evaporites, display the influence of the weak activity of the Ionian thrust during the depositional evolution. The top of the sequence (Kalamaki section), where eight cycles with resedimented evaporites and the presence of Bouma sequence, is intimately related to the intense activity of the Ionian thrust because of its proximity to the thrust front whereas; the remotely positioned section (Ag.Sostis section) is little influenced by the thrust activity, where we have only one cycle with resedimented evaporites and the presence of Bouma sequence. Just below the Trubi Formation, rare to common well-preserved small *Gephyrocapsa* spp. and the rare presence of *Ceratolithus acutus*, together with specimens of *Reticulofenestra zancleana* implies an age within the base of the NN12 biozone, in the early Zanclean (5.36 Ma).

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An overview of the petroleum systems in the Ionian Zone, onshore Greece

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The Ionian and Gavrovo zones in western Greece represents the southern extension of the prolific Albanian oil and gas province. Two hydrocarbon systems have been identified here: (1) a Mesozoic oil/gas-prone system, and (2) a Cenozoic system with gas potential. Source rocks in the Mesozoic system have very good to excellent hydrocarbon generation potential and contain kerogen Types I, II and III. Tertiary source rocks have fair to excellent potential with kerogen Type III. The two source rock systems have varying degrees of thermal maturity from immature to post-mature. Tertiary source rocks are not sufficiently mature for oil generation, but are sufficient for gas generation. The complex regional deformation history, with periods of both crustal stretching and shortening has resulted in the development of structural traps. Mesozoic extensional structures have been overprinted by thrusting and favourable trap locations can occur along backlimb thrusts and in the crests of anticlines. Thrust faults may have several pools that have developed in crestal culminations along their length. Trapping geometries may also be provided by lateral discontinuities in the basal detachment horizon, or as a result of the presence of strike slip fault zones. Regional seals are provided by Triassic evaporates, thick Eocene-Oligocene deep-sea fans and Neogene deposits. The hydrocarbon migration took place through major faults but the critical modelling of migration/expulsion vs. structural geology is strongly associated to local factors.

Application of magnetic susceptibility and spectral gamma radiation analysis in distinguishing between various types of graptolite mass accumulations in black shales

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Graptolites are very important lower Palaeozoic index fossils and are commonly used in biostratigraphic, palaeoecological and palaeoenvironmental studies of Ordovician and Silurian black shales. They often occur as monospecific mass accumulations on single bedding planes. Although those phenomena has been known and discussed for many years, their origin still remains enigmatic. Three different factors can be considered as a possible cause of the formation of graptolite mass accumulations (GMA). These are: (1) fossils condensation on omission surfaces, (2) rapid accumulation due to plankton blooms and (3) taphonomic effect (accumulation by redeposition). While post-mortem transport is relatively easy do recognize by current orientated and/or broken rhabdosomes, first two are much harder to distinguish. Five-meter thick succession of Rhudanian (Llandovery, Silurian) graptolitic shale at Bardo-Stawy locality (Holy Cross Mountains, central Poland) contains numerous levels of monospecific *Normalograptus normalis* mass accumulation interlaid by intervals impoverished in graptolites. The profile has been studied by means of high resolution quantitative and qualitative graptolite taphonomy and biostratigraphy as well as magnetic susceptibility (MS) and natural Spectral Gamma Radiation (SGR). The twelve recognized GMA levels found in studied succession can be divided into two/three types due to their different taphonomic features corresponding to their different geophysical response. The whole studied succession can be divided into three stratigraphically subsequent complexes, characterized by domination of different GMA formation process. The lowermost part of the succession (complex A, a*cuminatus* biozone) contains two, relatively fragile peaks in *N. normalis* abundance, characterized by very low average length of rhabdosomes, high MS values, variable thorium-potassium ratio (Th/K) and low authigenic uranium (Ubio) content. These GMA are interpreted as negative feedback between graptolite abundance and size during time of limited bioproductivity of the environment and, possibly, coeval with the minor graptolite extinction event. The next interval (complex B, lower *vesiculosus* biozone) contains four GMA characterized by high average length of rhabdosomes of *N. normalis* and high standard deviation of their size, high Ubio content (which may reflect high TOC level due to small rate of deposition and development of anoxic conditions) and low MS and Th/K values (which suggest decrease of the terrigenous influx during the GMA formation). According to these factors, GMA from interval B are interpreted as formed on omission surfaces during the temporary sediment starvation events (?MFS). Uppermost suit of six GMA (complex C, upper *vesiculosus* and lower *cyphus* biozone) reveals low average length of rhabdosomes of *N. normalis*, low standard deviation of their size, low Ubio content and high MS and Th/K values. Geophysical proxies suggest enhanced rate of sedimentation what is in contrast with high abundance of *N. normalis*. On this background, the negative feedback between the rhabdosome size and abundance is considered as formed as a result of plankton blooms. According to this study, the high resolution SGR and MS analysis may be helpful for distinguishing between various scenarios of GMA formation. This in turn can constitute a very important clue to the interpretation of sedimentary environment of graptolitic shales.

Sedimentary characteristics and seismic sedimentologic interpretation of gravity-flow channels in a continental rifted basin: Paleogene Shahejie Formation, Qinan Slope, Huanghua Depression of Bohai Bay Basin, China

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According to theory of seismic sedimentology and practices in continental basins, this paper puts forward a program of seismic sedimentology suitable for China's continental basins with gravity flow depositional systems in the Paleogene Shahejie Formation on the Qinan slope in the Huanghua faulted depression of the Bohai Bay Basin, China. Seismic lithology study and seismic geomorphology study within high-frequency sequence stratigraphic framework are performed through 90-degree phasing convention, frequency division processing, stratal slicing and core calibration: first, the high frequency sequence stratigraphic framework are Performed through time-frequency analysis and frequency decomposing technology; then application of Seismic geomorphology and macroscopic attribute constraint source direction; Combining with core calibration to determine sedimentary facies types; and lastly, stratal slicing, seismic inversion and 3D visualization showing the spatial and temporal distribution of the gravity flow channel, application of this method and techniques in seismic sedimentology study, gravity flow channel sand body is fine characterized. This study suggests that at least three types of gravity flow deposits developed in the Paleogene fault-depressed lacustrine basin, namely sandy debris flows, slumps and turbidites. Among these, the sandy debris flow is the main and most important depositional type. The gravity currents sediments mostly distribute along the half graben like faulted trough. The gravity flow channel facies can be divided into 4 microfacies including main channel, distributary channel, channel flank and over-flow. Visual attribute interpretation and stratal slices provided sequential imagery of depositional systems of Shahejie Formation, investigated the origins of the sedimentary bodies and their seismic geomorphologic patterns, and revealed the spatial distribution of typical sedimentary bodies and the channel changes in the Shahejie Formation. The results indicated that sandbodies occurred primarily in the main channel and distributary channel. Therefore the discovery of this large-scale lacustrine subaqueous channel system will provide a new target for hydrocarbon reservoirs within the lacustrine mudstones in Huanghua depression of Bohai Bay basin.

Evolution of shelf-margin and foreset during the Early Miocene in the north slope of Baiyun Sag, Pearl River Mouth Basin, South China Sea

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Interpretation of seismic data from the Pearl River Mouth Basin, South China Sea, shows the existence of multiple different periods of shelf break belts during the Early Miocene in the north slope of Baiyun sag. Identifying the position and morphologic characteristics of shelf break belts and tracing the trajectory of shelf-margin migration analyzes the influence of sea-level change on basin filling in the process of migration, demonstrates the model of shelf-margin migration and its characterization of geological significance. During the Early Miocene, The Pearl River Mouth Basin shows a slowly rising of relative sea level from the overall, but during the 21Ma and 18.5Ma, the falling relative sea level caused accumulation of thick and areally extensive superimposed foresets under shelf break. The foresets is easily formed up dip pinchout lithologic trap under the background of clinoform. The direction of Shelf slope break migration not only affected by sea-level changes, but also controlled by other factors, such as structure, sediment supply, climate, subsidence and so on, so sea-floor spreading in the South China Sea, faulting, seism, and different tectonic activities. So the direction of shelf-break belts migration in a partly region probably contrary to the influence by sea-level changes, and it caused to a "shelf-break-belt overlapping" and "shelf-break-belt cross" by multiple different periods of shelf-break. In partly region of the overlapping and cross of shelf-break belts, it shows the phenomenon of progradation under the background of rising sea level.

Impact of subsidence process on secondary porosity development: A case study of Nanpu Sag, Bohai Bay Basin

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The secondary porosity zone of Nanpu Sag, Bohai bay basin and its characteristic was investigated through measured porosity data, content of carbonate data and casting thin section observation. In most area of Nanpu Sag except No.3 structural belt which locates in the south of the sag and is adjacent to ShaBei fault, as same as the other basins of eastern China, the secondary porosity zone develops from 2000 m to 3500 m with strong dissolution of feldspar which is characterized by acidic dissolution and generation of kaolinite which can be seen through SEM, and below the depth of 3500 m, the reservoir is cemented by carbonate strongly, and though casting thin section observation, the calcite cement should generate in the early stage of subsidence. In No.3 structural belt, however, the lower limit deepness of secondary porosity dives to about 4200 m at least (for there is no sample taken more deeply). Considering the organic acid released at primary maturation of source rock and decomposed completely when formation temperature reaches to 120℃, vitrinite reflectance date and formation temperature date were used to identified the nowadays existing depth range of organic acid. The result shows that the depth ranges from 2000 m to 3500 m which matches the depth of secondary porosity zone of Nanpu Sag except No.3 structural belt. Subsidence process analysis shows that in the most area of Nanpu Sag, the subsidence rate of early stage is slow then turning faster, and in the late stage slow again, but in No.3 structural belt, resulting from the impact of Shabei fault, the subsidence rate is faster in the early stage of subsidence than any other structural belts in the sag, and then turns slow in the late stage. An integrated analysis suggests that a fast subusidence rate in the early stage of subsidence can shorten the process of maturity of hydrocarbon source rocks, and a slow rate of sedimentation in the late stage keeps the formation temperature lower than 120 ℃. Hence the organic acid can be preserved for a longer period in this process which extends the deepness of the secondary porosity zone and dissolute the grains just like the reservoir of No.3 structural belt. In contrary, a slow rate combining a fast subsidence leads the organic acid of the formation which is under 3500 m in most area of Nanpu Sag to be decomposed while it released, because when the organic acid released,the formation temperature could get to 120 ℃.

Sedimentary evolution of long-term base level cycle in Karamay Formation in Triassic, Huwan District, Junggar Basin, China

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Huwan district, located in Chinese Northwestern Junggar Orogenic Belt. Based on drilling data and seismic calibration results, Karamay formation in Triassic system was divided into a complete long-term base-level cycle bounded by unconformity and sedimentary transform surfaces. To identify the influence of long-term datum plane cycles on sedimentary evolution, using the dynamic principle of the resolution stratigraphic sequence sedimentation is to analyze the sedimentary system features, and this study illustrates the control mechanism of base-level cycle on the sedimentary environment. Besides, this paper concludes the distribution characteristics of the sedimentary facies belts among long-term base level cycles. The results show that the long base-level cycle in the different ranks goes up and down, which results in the change of accommodation and sediment supply condition and leads to appearance of difference in reservoir sedimentary environment in base-level cycle.

In the transgressive background, the long-term base-level rising cycle is mainly developed with alluvial fan, and mainly experienced three stages, early to rise slowly stage, middle to rise slowly and fall slightly stage, end to rise quickly stage. During the three stage, developed successively in root part of alluvial fan with sandy conglomerate bodies, middle and marginal part of alluvial fan with braided channel, shallow lake facies with beach sand. From root to marginal part of alluvial fan, the reservoir heterogeneity change from strong to weak then stronger.

In the regression background, the long-term base-level falling cycle is mainly developed with braided river delta, and mainly experienced three stages, early to fall slowly stage, middle to rise slowly, end to rise quickly stage. During the three stage, developed successively in braid-river delta front with estuary dam, braid-river delta front with braided channel- diara dam complex, low fluvial-dominated braid-river delta plain. From delta front to plain, the reservoir heterogeneity change from strong to weak.

It is revealed that the the bottom of ascension half cycle and the bottom of descending half cycle of long-terms cycle is superior quality reservoir, the channel region of the alluvial fan middle and braided delta frontal is the best reservoir facies.

The study of biostratigraphy in Sudan Redsea Block-15

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Based on 81 cutting samples from six wells, this research analyzed the biostratigraphy of Sudan Redsea Block-15 by using Palynology and Nannofossils analysis. The lithostratigraphy of the six wells in Block 15 were characterized mainly by sandstones, salt, anhydrites, which deposited in evaporite condition and were not suitable for surviving of Foraminiferal, Nannofossils and plants. However, it can be sure that the development period of Zeit group formation on salt is Miocene to the Holocene; the regional caprock Dungnab group formation development period is late Eocene to middle. Due to the appearance of a huge amount of Pteridophyte spores, the sedimentary environment of Zeit formation can be determined is humid. The research then verified the biostratigraphic classification scheme of this region.

Depositional characteristics, original types and models of lacustrine gravity flow deposits-a case from Lianggaoshan Formation, Middle Jurassic, Sichuan Basin, China

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Lianggaoshan Formation in Sichuan Basin, which is one of the important tight oil reservoirs, is characterized by the presence of lacustrine tight clastic rocks. However, the origin of the sands surrounded by dark mudstones in deep water is undefined. The purpose of this study was to reveal the original types and sedimentation mechanism of these sands in deep water. Detailed information had been acquired through analyses of cores, outcrops, well logs, thin sections of rocks, particle size, geochemical data, and paleogeomorphological data. This study identified four types of gravity flows, which were debris flow, hyperconcentrated density flow, concentrated density flow, and turbidity current. These gravity flow deposits formed two depositional models of slump-induced terbidite fan and flood-induced terbidite fan. Furthermore, the study drawed distinctions between slump-induced terbidite fan and flood-induced terbidite fan in litho-facies assemblages, sedimentary structures, changes of size-grading and energy, trigger mechanism, distribution and its controlling factors, and reservoir properties. It was indicated that paleogeomorphology and provenance controlled the distribution of slump-induced terbidite fan. Nevertheless, flood-induced terbidite fan was triggered by base-level changes and seasonal provenance. In addition, according to the paleogeomorphological and paleoclimate data, the flood-induced terbidite fans dominated during that geological period. It is concluded that the sandstones of flood-induced terbidite fans, with dissolution pores, are favorable tight oil reservoirs.

Concept and application of seismogeology isochronous body: Relationship discuss of seismic Reflection isochronous and geological deposition isochronous

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Focus on the debate of seismic reflection isochronous (SRI) and geologic deposition isochronous (GDI), whether the seismic event is isochronous or not, the concept of seismo-geology isochronous body (SGIB) is proposed. The SGIB refers to the integrated seismic reflection within the seismic reflection data of a single type of geological body, which is deposited and diagenetic in a certain geology period. Here, a single type of body refers to an identifiable geological body that is greater than or equal to the minimum recognizable geological body in seismic data in certain exploration phase. With the improvement of exploration degree, the geological bodies can be gradually refined to the smaller level and the division standard is to meet the present demand for deepen exploration. The concept of SGIB overcomes the biases of SRI and GDI to isochronous. With the constraints of geological scale, the study of isochronous is more objective. It provides a scientific concept for the study of different scale geological bodies in spatial with seismic data by the method of horizon slice and stratal slice. With the application of this concept on the basis of sequence stratigraphic framework establishment and sedimentary system study with seismic data, the plane and spatial distribution of different scale geological bodies are revealed reasonably. It also confirmed that the concept of SGIB is scientific and practical.

Key points analysis of using seismic data to study sedimentary system in terrestrial lacustrine rift basins

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With the wide using of 3D seismic in petroleum exploration and quick growth of data processing for lithologic reservoir exploration focus on relative amplitude preserved and pure wave (post wave volume without any post processing), more and more 3D seismic data is used in sedimentary system study in oil-gas bearing basins. This approach is based on the calibration of drilling and logging data on seismic, with the controlling of isochronous sequence framework and mainly using seismic data to study sedimentary system and sand distribution of exploration targets layers. The purpose is to provide decision making for lithologic reservoir exploration. Focus on the facts that the vertical evolution of sedimentary facies is inherited , but sub-facies and microfacies migrated in plane and single lithologic trap is in small area, all local traps are in group and reservoir thickness is thin in terrestrial lacustrine rift basins. Application in Jurassic to Cretaceous, Taibei depression of Turpan-kumul basin, show that seismic data type selecting, data quality evaluation, horizon and reservoir calibration, isochronous analysis of sequence boundary, top and bottom constrain horizons interpretation of targets and size of time window determination are the key points for using seismic data to study sedimentary system effectively. The key points are the basic for analysis of large-scale sedimentary sub-facies, micro-facies and sedimentary system and provide geologic decision for lithologic traps identification, description, selecting and evaluation in terrestrial lacustrine rift basins. Application shows that this method is effective and practical to lithologic reservoir exploration in terrestrial lacustrine rift basin.

Lithofacies and depositional environment of Upper Ordovician-lower Silurian gas shale in the Sichuan Basin, China

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Sichuan Basin as an important oil and gas-rich basins in western China, was proven the largest number of gas field and cumulative production of natural gas basin. Upper Ordovician Wufeng Formation and the Lower Silurian Longmaxi Formation organic-rich shale is an important objective strata of shale gas exploration and has also made substantial breakthroughs.
Wufeng and Longmaxi Formation stratas were deposited in a deeper water intracraton depression basin that had poor circulation with the open ocean. Seven general lithofacies are recognized on the basis of mineralogy,fabric, biota, and texture through core and outcrop analysis, thin sections, X-ray diffraction (XRD), Scanning Electron Microscope (SEM) and Scanning cathodoluminescence (SEM-CL) data: 1) laminated and nonlaminated siliceous mudstone; 2) laminated and nonlaminated argillaceous shale; 3) calcareous Shale; 4) laminated silty shale; 5) cross-bedding siltstone; 6) shell lime shale (marl); 7) bentonite. Each facies contains abundant microframboids of pyrite (mean 3.4 μm; range 0.6~12 μm), which precipitated from this euxinic water column, and anoxic bottom conditions prohibited bioturbation. Shell fragments with mudstone rip and directional arrangement of graptolites on the top surface indicated traction flow action that transported from shallow water by storm current. Laminated silty shale with rythmic and lenticular bedding and cross-bedding siltstone with sharp upper contacts can be interpreted deposits of bottom current. Our results indicate that most of the quartz silt in our samples does not originate from the continental crust. Instead, it appears to have precipitated early in diagenesis in algal cysts and other pore spaces. Radiolarians living in the water column and siliceous sponge spicules were likely the primary source of silica in the shale.
Available evidence shows that Upper Ordovician Wufeng Formation and the Lower Silurian Longmaxi Formation strata in the Sichuan basin were deposited in a deeper water, euxinic, silled basin well below the storm-wave base. All sedimentological features can be attributed to suspension, storm flow, bottom flow and biological processes.

Analysis of alluvial fan reservoir quality difference based on rock facies and sedimentary microfacies: A case study from Baikouquan formation, Bai 21 well area, Karamay oilfield in Junggar basin

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Alluvial fan sedimentary reservoir have various kinds of lithology and the reservoir property changes great, the distribution characteristic of high quality reservoir is remained to be studied. Through the observation of cores and outcrops, taking Bai 21 well area in Karamay oilfield as an example, the main control factors of reservoir quality difference in alluvial fan is deeply studied. Primary porosity is well developed in the reservoir in study area which has experienced weak diagenesis effect, the reservoir property difference is mainly controlled by sedimentary factors, 10 types of rock facies have been divided in Baikouquan alluvial fan: matrix supported disordered coarse gravel facies (C1); matrix-particles supported medium-fine conglomerate facies (C2); grain supported sandy conglomerate facies (C3); massive gravel-bearing coarse-medium sandstone facies (S1); parallel bedding coarse-medium sandstone facies (S2); tabular cross bedding medium sandstone facies (S3); massive bedding fine sandstone facies (S4); wavy bedding silt-fine sandstone facies (S5); horizontal bedding mudstone facies (M1); massive sandy mudstone facies (M2). The study area mainly develop root fan and middle fan subfacies, the microfacies of main channel, sabsascess and sheetflood is developed in root fan, main channel usually develop high density flow sedimentation with C1, C2 rock facies; sabsascess is distributed in the relatively high position between main channel and sheetflood with C2, S1-S3 rock facies; sheetflood is formed in flood period including C1, M2 rock facies. The microfacies of braided stream belt, braided stream beach belt and overflow belt is developed in middle fan, braided stream belt is composed of a plurality of braided flow channel and scouring surface can be found in bottom with rock facies of C3, S1-S4; braided stream beach belt is composed of a plurality of braided stream islands which formed in vertical accretion and lateral accretion, and contains C2, C3 rock facies; overflow belt is composed of fine grained deposition with S5, M1, M2 formed in flooding period. Physical property and oil-bearing property of different lithofacies have been compared, medium-fine conglomerate (C2) has the best physical properties with large pore and throat which can be defined as typeⅠreservoir, coarse-medium sandstone (S1-S3) and sandy conglomerate (C3) has better properties with medium pore and throat which can be defined as typeⅡreservoir, coarse gravel (C1), silty fine sand (S4-S5) is belonged to type Ⅲ reservoir with small pore and throat. Different facies have different reservoir quality, reservoir property is the best in middle fan subfacies, braided stream belt microfacies is the main high reservoir quality developing zone, braided stream beach belt and main channel microfacies is sub-high reservoir quality developing area, sabsascess, sheetflood and overflow belt have poor reservoir quality.

Controls of intrabasinal faults on colluvial depositional system and lithologic reservoirs: A Case from the Wendong Oilfield, Dongpu Subbasin

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Wendong Oilfield is located in the middle of Dongpu Subbasin in east China, with growth and arcuate faults widely developing. Tectonic movements happened frequently during the depositional stage of the Shahejie Formation, Paleogene, and colluvial deposits were well developed, forming the main lithologic traps. A detailed study based on the analysis of outcrops, well cores, well logs, 3-D seismic data and laboratory experiments illuminated that the kinematic and geometric characteristics of the fault systems were closely related to the turbidite deposition and reservoirs of the study area. Understanding the controls of the intrabasinal faults of this area on colluvial depositional system and reservoirs provides a perspective that can improve lithologic reservoirs exploration.

Movements of the northern faults were stronger than those of the southern ones, thus accommodation spaces of the downthrown sides appeared larger and colluvial deposits developed better in the north. The sedimentary facies mutated across growth faults, with sand bodies thickening on the downthrown sides. According to the shapes of the combinations of the dominant and adjusting faults, fault systems can be divided into three patterns: comb-shaped fault system, brush-shaped fault system and fork-shaped fault system. Sediments deposited along the growth faults were commonly unstable and the sand bodies would slump and be aligned into different patterns corresponding to the fault systems. Since the gravity flows commonly crevassed at the crossings of different faults, the adjusting faults had a fundamental control of the stacking patterns of sediments. The geometric characteristics of a single arcuate fault also had obvious effects on the distribution of sediments. The colluvial deposits were mostly developed in the arc center of an arcuate fault, while the arc flank was the boundary of different groups of colluvial deposits. In the cross section, if the fault-ramp was a dip-slip one whose inclination angle was small, the colluvial deposits were commonly distributed to far source areas while sediments on a steep ramp were distributed nearer.

The faults also had controls of lithologic reservoirs. Firstly, faults were principal factors that had influence on the reservoir distribution by controlling colluvial depositional system. Secondly, during the synsedimentary faulting, sand bodies of the colluvial deposits slumped into the deep-semideep lake where lacustrine effective source rocks were enriched along the dip-slip fault-ramps and deposited there. Therefore, the faults established an effective connectivity between the traps and source rocks. Thirdly, associated fractures that extensively developed in the arc center of the faults could improve the reservoir property as well as connect the traps and source rocks.

Hydrothermal dolostones of Lower Cretacious Tengeer Formation in Baiyinchagan Depression, Erlian Basin, China

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In the recent years, a set of zeolitic dolostones and zeolite stones, with single layer thickness of 0.2-1.5 m, has been discovered within the deep lacustrine mudstone of the Lower Cretaceous Tenggeer Formation in the Baiyinchagan Sag. Data from thin sections, electronic probe microscopy, energy spectrum and whole rocks X-ray diffraction show that the mineralogy is composed of ankerite (Fe 0.5%-5%), natrolite, analcite, sjogrenite, barite and pyrite. Ankerite crystals, with gain size vary from 10µm to 200µm, are characterized by abundant crack, wavy extinction and saddle-shaped. Shaly and micrite texture, and intraclastic texture with intraclast composed by dolomite and zeolite are well developed and several typical structures are also identified, including contemporaneous deformation structure, stockwork structure and breccia structure. The dolostone with high content of U (40~60 ppm) and Th (60~100 ppm) shows extreme anomalous response in gamma ray logs (700~1100 API), which is 2~4 time higher than that of normal mudstone. The constituent and content of trace element such as Cu, Ni, Co, Fe, Mn are consistent with that of modern submarine hot water deposition in the Red Sea. Furthermore this set of deposition is mainly distributed along the basement rift. All the above characters provide evidences that these dolostones are deposited in the environment affected by thermal fluid from the mantle through the deep mega fault. A few cases like this hydrothermal deposition have been reported all over the world in the past years. The process and mechanism of hydrothermal sedimentation is not well understood and there is no some mature depositional model so far. Thus the study on the hydrothermal deposition will further enrich the modern sedimentary theory, find out the more hydrothermal ore deposits and provide new oil and gas reservoir targets suggestion for future petroleum exploration.

The effects of diagenetic clay minerals on deeply buried reservoir sandstones using combined petrography and EBSD analysis

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The early Jurassic sequence of the Kuche Sag of Tarim Basins has been examined with respect to mineralogy based on 80 samples from three wells. A clear relationship between clay minerals and reservoir sandstones is demonstrated by electron backscatter diffraction analysis (EBSD) combined with optical and cathodoluminescence petrography study. The Yangxia Formation consists of coarse grained to medium grained lithic arenite with poor porosity. The clay minerals are found to be kaolinite, illite, chlorite and mixed-layer illite-smectite. These clay minerals are present common in dispersed form as grain-coating and clayrocks that range in texture from fine-grained to coarsely conglomeratic. Quartz cement, another important authigenic mineral, is shown to be syntaxial to the nearest host domain, both for monogranular, polygranular, undeformed and deformed quartz. Detailed study on EBSD images shows that the diagenetic sequence of quartz cement and clay minerals is very complicated. Whether clay minerals can moderate the effects of authigenic quartz cement growth on detrital grains depends on the degree of quartz overgrowth. Clay minerals can be partly or totally encapsulated by quartz overgrowth. This study may indicate that grain-coating chlorite can't help to preserve open pore networks, but decrease the permeability and degrade the reservoir character thus affecting their producibility.

Seismic sedimentology of Palaeogene Dainan Formation in Gaoyou sag, eastern China

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Guided by the theories of sequence stratigraphy, quantitative seismic geomorphology and sedimentology, this study focused on the seismic sedimentology of the Palaeogene in Dainan Formation in Gaoyou Sag, eastern China. After Fine sequence stratigraphic framework establishment, the rock-physics relationship of thin sand body and seismic geomorphology were analyzed to establish a seismic sedimentology model of multiple-depositional systems distribution in typical rifted lacustrine basin.
Using technology of fine stratigraphic correlation, the member one of Dainan Formation is divided into three third-order sequence, namely E2d11, E2d12, E2d13 from base to top. And member two of Dainan Formation consists of three third-order sequence and six system tracts, which provided the isochronal stratigraphic framework for seismic sedimentology study. Basin boundary faults and slope break belt are the key factors of controlling the type and distribution of the sequence and systems tract.
Based on key technology of 90°phase conversion, the maximum amplitude of a thin-bed response was adjusted to the center of the bed, making treating seismic events as geologically defined reservoir units. By frequency division interpretation technology by using seismic data of 8~64 Hz frequency for piecewise frequency scan, the best seismic identification of thin sand body thickness is 16~24 Hz frequency, So the average amplitude in 16~24 Hz frequency range was selected for seismic sedimentology study. USA Recon software is employed to extract the amplitude, instantaneous phase, instantaneous frequency, the strength of reflection. Amplitude attribute can accurately predict sand body and depositional systems distribution. Through wells-seismic calibration, sedimentary facies and sand body distribution are depicted after seismic geomorphology and sedimentology study.
The study reveals that various types of sedimentary facies are developed in Gaoyou Sag, including delta, fan delta, nearshore subaqueous fan, lake and slump turbidite fan. Characteristics and spatial distribution of various sedimentary facies are controlled by lacustrine basin texture and tectonic development stage. Nearshore subaqueous fan and fan delta facies were distributed in the south deep slope area, delta was developed in the north gentle slope area, slump turbidite fan and half deep lake - deep lake were found in the deep sag, and shore-shallow lake was mainly developed around the margin of sag.

Magnetic susceptibility studies of lacustrine deposits from the Hoangh Bo Basin - in search of a tool for the reconstruction of climate oscillations (Oligocene-Miocene, NE Vietnam)

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The Hoanh Bo Basin is filled with continental sediments, comprising mainly polymictic conglomerates, sandstones, siltstones and claystones. During intensive field work, a group of Polish-Vietnamese researchers and students conducted a detailed sedimentological analysis in November 2014. Seventeen sedimentary facies were recognized in deposits filling the investigated basin. They were grouped into three facies associations: alluvial, deltaic and lacustrine. Special attention was paid to a 40 metres thick Oligocene-Miocene clayey sequence of lacustrine origin, where basic sedimentological observations were coupled with magnetic susceptibility (MS) record using a portable magnetic susceptibility kappabridge (MS-3 Bartington, UK).

The aim of the MS study was to find the correlation between the MS record and the clay mineral composition which may correspond to climatic changes. Several experiments were conducted to prove the primary origin of the MS signal, i.e. not affected by diagenesis or weathering. Moreover, the XRD results confirm that the MS signal depends on the changing composition of clay minerals (paramagnetics and diamagnetics) rather than the ferromagnetic content. The MS study aimed also at recognizing global climatic changes, postulated in the literature, however, the studied section did not encompass any of these events. Further search for such events would allow to apply MS as a tool for the reconstruction of climate oscillations.

Broad application of the presented methodology in Northern Vietnam in basins whose formation was linked with the Palaeogene-Neogene activity of the Chi Linh - Hon Gai fault zone in relation to the development stages of the Red River Fault Zone would allow recognizing changes of the sedimentation rate and mineral composition. Detailed sedimentological analysis coupled with MS research would enable to create models of sedimentation development, reconstruct the relationship between the changes in the sedimentary sequence, as well as discuss the Oligocene and Miocene climate changes in south-east Asia.

Depositional history of an Upper Cretaceous carbonate ramp in Kefalonia Island (Western Greece)

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Kefalonia lies at the external (foreland) edge of the Hellenides fold-and-thrust system created in response to Cenozoic continental collision that followed the closure of the Tethyan Ocean. During Early Mesozoic times, an extensive rifting had been developed in the western Greek territory, which in Early–Middle Jurassic times, was subdivided into ridges and basins, that corresponded to the Gavrovo and Apulian platforms and the Ionian basin respectively. Paxi zone corresponded to the slope between the Apulian platform and the Ionian basin. Post-rift sedimentation persisted throughout the Cretaceous leading to shallow marine carbonates on the ridges, mixed pelagic/neritic sedimentation on the slope (Paxi zone) and deep-water carbonates in the basin. On the island of Kefalonia appear the Paxi and the Ionian Zones. In this study, an Upper Cretaceous carbonate succession, which is a part of the Paxi Zone, cropping out near the area of Sami (central area of Kefalonia), is discussed in detail with regard to its depositional facies, microfacies, biostratigraphy and palaeoenviroments. The study area averages 400m in thickness and extends along 7 km. 300 samples have been collected for microfacies analysis and the following six microfacies types have been recognized: mudstone/wackestone with pelagic foraminifera (SMF 3), bioclastic floatstone with rudists (SMF 12), packstone/grainstone with benthic foraminifera (SMF 18), floatstone with rudists, gastropods, dasycladacae and benthic foraminifera (SMF 18b), densely laminated bindstone (SMF 19) and fenestral stromatolitic bindstone (SMF 20). Micropalaeontological analysis has revealed the fairly rich content in microfossils such as calcareous algae (*Thaumatoporella* sp.) and benthic foraminifera. The later are mainly represented by *Quinqueloculina* sp., *Dicyclina* sp., *Cuneolina* sp., *Nezzazata* sp., *Nezzazatinella* sp., *Involutina* sp. (or *Spiroculina* sp.), *Scandonea* sp., *Pseudonummoloculina* sp., *Bolivinopsis* sp. and *Textularia* sp. Pelagic foraminifera are very rare and they are represented by *Globotruncana concavata* and *Marginotruncana sigali*. The environment corresponds to a restricted inner platform environment (lagoon-peritidal domain). Detailed lithostratigraphic and micropalaentological analysis revealed clear evidence of periodicity. Cycles consist of alternations of peritidal facies, varying from shallow subtidal to intertidal/supratidal, and follow a shallowing – upwards type of evolution.

Changes in provenance recorded by heavy minerals and luminescence (OSL/TL) sensitivity of quartz: A SE Brazil coastal barrier case

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The São Francisco do Sul (SFS) barrier stands out among the southern Brazilian barriers due to its well preserved geomorphology showing beach ridges (ages older than 2000 years ago) and younger units (ages younger than 2000 years ago) represented by parabolic dunes, blowouts, foredunes and foreshore zones. The progradation of the SFS barrier started at least 4914±475 years ago evidenced by a succession of beach ridges. A pronounced morphodynamic shift occurred around 1891±155 years ago with the development of superimposed parabolic dunes over beach ridges. The onset of this period is marked by a variation in sediment provenance represented by the input of coarser sands and a contrasting heavy minerals suite. Higher concentrations of rutile, kyanite, sillimanite and staurolite point to a metamorphic-dominated provenance of the beach ridge sediments. In turn, the younger units show higher contents of zircon and hornblende, suggesting a greater contribution of sediments derived from igneous rocks A conspicuous association between geomorphological units and the RZi (rutile-zircon index) can be observed. Additionally, sediments from the beach ridges differentiate themselves due to their rounded to sub-rounded zircon grains in contrast to more euhedral to subhedral forms found in other units. This morphodynamic-provenance shift recorded in the heavy minerals data resulted from the strengthening of SSE winds and associated wave systems responsible for the northward alongshore drift. These changes promoted provenance alteration and are linked to a switch from a sea-level progradation forcing to a climate-controlled environment formed by locally sourced sediments. In the past recent years, several studies have examined the role of natural controls in determining the optically stimulated luminescence (OSL) or thermoluminescence (TL) sensitivity signals in quartz grains. These studies evaluate the contribution of source rocks and suggest increases in sensitivity with multiple cycles of sediment reworking in nature that may be reproduced in laboratory conditions with sequences of irradiation, heating and bleaching. In the SFS barrier the OSL and TL sensitivities vary according to geomorphological unit. Sands from the beach ridges show higher OSL and TL sensitivities than younger units. We confront OSL and TL sensitivities to heavy minerals data to better evaluate the significance of the sensitivity signal in appraising the role of sand provenance and reworking. We suggest that heavy mineral analysis may help shed light on the natural controls over the luminescence signals of quartz. Correspondingly, we propose the quartz luminescence sensitivity signal as a proxy for provenance. For these purposes it may complement or replace the time-consuming sedimentological analyses with a fast bulk sample preparation and a simplified luminescence protocol directed to one of the most common minerals in sands. Additionally, the stronger correlation of the 110 °C TL sensitivity signal to heavy mineral data indicates that TL sensitivity may better reproduce provenance and paleoenvironmental changes than OSL sensitivity measurements in our study area and could be used as an alternative method to track source-to-sink systems to monitor past and future environmental change.

Influence of sediment characteristics on geochemical record: Marine sediment study

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Sediment is the medium in which can accumulate larger amounts of toxic substances, as potential toxic elements (PTE), which in turn can cause pollution of the environment. PTE concentration in the sediment is the result of natural (geological background) and anthropogenic (industry, agriculture, transport, cities) sources. Concentration and distribution of PTE in sediment is also dependent on a number of factors, where the characteristics of the sediment are important. Most of the elements that may be toxic to the environment and organisms are attached to fine fraction, and at elevated concentrations in the sediment PTE is also influenced by organic matter. The aim of this study was to identify characteristics of sediment (grain size, mineral composition, amount of organic matter) around mariculture activity and the impact of these parameters on the PTE concentrations.
Sediment was sampled at three locations around sea bass and sea bream fish farms near Vrgada Island (Murter Sea, Central Adriatic) with different degree of input materials for the fish cultivation and at the reference point. Grain size analysis of sediment was carried out using the dry sieving method through eight ASTM standard stainless steel sieves in fractions from > 5 mm to < 0.063 mm. The results were statistically analysed using the program Gradistat. Organic matter (organic carbon) was determined by elemental analyser Carlo Elba EA 1108 with the combustion temperature of 1020 °C. Mineralogical composition was determinate by X-ray powder diffraction (XRD) using a Philips PW 3710 difractometer and CuKα radiation. Multielemental analyses of sediment were performed with X-ray fluorescence (XRF) analyser NITON that gave the analysis accuracy within ± 10%.
The results of grain size analysis showed that in all samples prevail sand fraction (> 80%), while gravel fraction (7.2%) and finer fraction in the size of mud (6.9%) occur in smaller percents. In sediment from all locations dominate carbonates (69 to 98%), in smaller amounts appear quartz (average 10%) and as traces mica (muscovite), feldspars (plagioclase) and clay minerals. The downward trend of C_{org} in sediments with distance of fish cages was observed.
Results of certain PTE concentrations showed an upward trend from coarse to fine grained fraction (As, Cd, Pb, Zn) while for other this trend was more irregular or even reverse (Cu, Ni). Due to very carbonate sediment the latter trends (Cu, Ni) can be blurred. The elements (As, Cd, Pb, Zn) have medium to high correlation with major elements, which reflect the relation to clay fraction more than sand.
Concentration of organic matter (C_{org}) in sediment is medium to high correlated with As, Co, Cr, Cu, Hg, Ni and Pb, and poor correlated with Cd and Zn that show a different influence of Corg on element distribution in the sediment. The enrichment factor with organic matter normalization EFTECorg shows for all elements values <1, which mean that PTE probably bound to Corg.
Described results show that characteristics of investigated sediment in view of protecting the natural environment have a positive effect on the concentration of PTE.

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