**Linking flume and field: Bedform in cohesive Sand-Mud in the Dee Estuary, UK**

Baas, J.H.[1], Baker, M.[1], Hope, J.[2], Malarkey, J.[1], Rocha, R.[1], and COHBED Project Team[3]

[1] School of Ocean Sciences, Bangor University, Menai Bridge, Isle of Anglesey, United Kingdom – j.baas@bangor.ac.uk
[2] Scottish Oceans Institute, East Sands, University of St Andrews, St Andrews, United Kingdom
[3] Alan Davies (Bangor University); Daniel Parsons, Leiping Ye (University of Hull); Jeffrey Peakall (University of Leeds); Dougal Lichtman, Peter Thorne (NOC Liverpool); Sarah Bass, Andrew Manning, Robert Schindler (University of Plymouth); Rebecca Aspden, Emma Defew, Julie Hope, David Paterson (University of St Andrews)

Recent laboratory experiments and field measurements have shown that small quantities of cohesive clay, and in particular 'sticky' biological polymers, within a sandy substrate dramatically reduce the development rate of sedimentary bedforms, with major implications for sediment transport rate calculations and process interpretations from the sedimentary record.

Flow and sediment transport predictions from sedimentary structures found in modern estuaries and within estuarine geological systems are impeded by an almost complete lack of process-based knowledge of the behaviour of natural sediments that consist of mixtures of cohesionless sand and biologically-active cohesive mud. Indeed, existing predictive models are largely based on non-organic cohesionless sands, despite the fact that mud, in pure form or mixed with sand, is the most common sediment on Earth and also the most biologically active interface across a range of Earth-surface environments, including rivers and shallow seas.

The multidisciplinary COHBED project uses state-of-the-art laboratory and field technologies to measure the erosional properties of mixed cohesive sediment beds and the formation and stability of sedimentary bedforms on these beds, integrating the key physical and biological processes that govern bed evolution.

The development of current ripples on cohesive mixed sediment beds was investigated as a function of physical control on bed cohesion versus biological control on bed cohesion. These investigations included laboratory flume experiments in the Hydrodynamics Laboratory (Bangor University, Wales) and field experiments in the Dee estuary (at West Kirby near Liverpool, UK). The flume experiments showed that winnowing of fine-grained cohesive sediment, including biological stabilisers, is an important process affecting the development rate, size and shape of the cohesive bedforms. The ripples developed progressively slower as the kaolin clay fraction in the sandy substrate bed was increased. The same result was obtained for xanthan gum, which is a proxy for biological polymers produced by microphytobenthos. Yet, the xanthan gum was several orders more effective in slowing down ripple development than kaolin clay, suggesting that the cohesive forces for biological polymers are much higher than for clay minerals, and that sedimentological process models should refocus on biostabilisation processes.

The first results of the field experiments show that the winnowing of fines from developing ripples and the slowing down of current ripple development in mixed cohesive sediment is mimicked on intertidal flats in the Dee estuary. In particular, these field data reveal that current ripples in cohesive sediment are smaller with more two-dimensional, straight crestlines than in non-cohesive sand. The wider implications of these findings will be discussed.

**Swelling caves from the weathering zone of anhydrite rocks in western Ukraine**

Bąbel, M.[1], Yatsyshyn, A.[2], Ługowski, D.[1], Nejbert, K.[1], Olszewska-Nejbert, D.[1], Bogucki, A.[2], Kremer, B.[3]

[1] Faculty of Geology, University of Warsaw, PL-02-089 Warszawa, Poland - m.babel@uw.edu.pl
[2] Faculty of Geography, National University of Lviv, 79000 Lviv, Ukraine
[3] Polish Academy of Sciences, Institute of Paleobiology, PL-00-818 Warszawa, Poland

Weathering of the anhydrite rocks, exposed during the exploitation of the Badenian (Middle Miocene) gypsum deposits in the Pisky quarry, near Schyrets', 25 km south of Lviv in west Ukraine, has led to development of the unique deformational structures at the bottom of the quarry. The formation of these structures is in progress since 90's of the XX century, when they were recorded in the initial form for the first time by the authors. The structures originate due to volume expansion during hydration of anhydrite ($CaSO_4$) and its transformation into secondary gypsum ($CaSO_4 \cdot 2H_2O$). The deformation includes the formation of bulges, domes, pressure ridges and tepee structures, as well as associated network of fractures, joints, as well as thrust and strike-slip faults. The deformation structures appear at the bottom of the quarry, within the area ca. 150x100 m, in the marginal zone of a small pond with the seasonally fluctuating water level. The presence of this pond apparently accelerates the hydration processes of the anhydrite rocks. Within the periodically flooded and emerged area, some tepee and dome structures grow rapidly attaining relatively large sizes – commonly over one meter in height. Because the open empty interiors of some domes and tepees are large enough to shelter a man these interiors can be considered as caves, and represent thus a specific kind of caves related to volume increase during hydration of anhydrite called the swelling caves (Germ. *Quellungshöhlen*). Swelling caves are rare and so far known only from several places in the world including Germany, USA, and Canada. More than ten of such swelling caves have now been discovered in the Pisky quarry. The most spectacular cave occurs within the anhydrite-gypsum dome, which is over 2 m high, 18.1 m long and 15.5 m wide. The cave within this dome is 9.5 m in length, 7.8 m in width, and 1.2 m in height, and is the largest in volume. The highest cave occurs inside the giant tepee structure having the shape of a inverted letter "V" and attains 2.4 m in height. The sizes of the caves grow because the process of anhydrite hydration continues. The monitoring of the rate of the deformation in the period 2009-2014 based on the system of benchmarks fixed in the rocks revealed a differentiated rate of fracture opening and overthrusting of gypsum-anhydrite slabs. Commonly this rate is in order 1-3 mm per year, however in some places, where the pressure associated with hydration of anhydrite is rapidly released, this rate attains a few tens of centimeters per year and is associated with the formation of the new swelling caves in these places. One of such caves suddenly appeared in 2012-2013, and in May 2014 it attained over 1 m in height. The Pisky quarry offers thus a unique possibility to study the swelling caves in time of their creation and to monitor their evolution. It is expected that karst dissolution will lead to destruction of these rare forms in future.

Acknowledgements: Research sponsored by National Science Centre, Poland, grant no. DEC-2012/05/B/ST10/00918.

**Holocene paleo-earthquake successions, established by turbidite paleosismology along the Algerian margin, reveal bimodal seismic sequences**

Babonneau, N.[1], Ratzov, G.[1], Cattaneo, A.[2], Lateb, T.[1, 3], Déverchère, J.[1], Yellès, K.[3]

[1] IUEM, Laboratoire CNRS UMR6538 « Domaines Océaniques », Université de Brest (UBO), Place N. Copernic, 29280 Plouzané, France – nathalie.babonneau@univ-brest.fr
[2] IFREMER, Géosciences Marines, Laboratoire « Environnements Sédimentaires », BP 70, 29280 Plouzané, France
[3] CRAAG, BP63, Bouzareah, Alger, Algeria

Northern Algeria is affected by seismic activity resulting from the slow convergence between the African and European plates (~3mm/yr). It occurs through moderate to large earthquakes, activating fault segments partly located offshore along the Algiers segment, as shown by the 2003 M 6.9 Boumerdès earthquake. This earthquake triggered numerous and widespread turbidity currents responsible for 29 submarine cable breaks in the Algerian basin, over ~150 km along the margin. This event demonstrates the multi-source and multi-path character, and the distal extension of turbidity flows triggered by earthquakes along this margin segment.
While the signature of turbidity currents is mostly erosional on the continental slope, these submarine gravity events are preserved as fine-grained turbidite deposits in the distal basin alternating with hemipelagic sedimentation.
A large dataset of piston cores was collected along the Algerian margin during four oceanographic cruises between 2003 and 2007 (Maradja 2003, Prisma, Maradja 2, and Prisme Cruises). Along the Algiers segment, the cores located in the distal part of the margin (close to 2003 cable break sites) were firstly studied in order to identify the turbidite deposits correlable at regional scale, as the possible signature of turbidity currents generated by earthquakes.
Radiocarbon datings provide age models for hemipelagic sediments and allow establishing chronology of turbidite deposits. Results on sediment core PSM-KS23, the most distal core collected along the Algiers segment, show 12 turbidites during the last 9 ka with irregular recurrence intervals ranging from ~200 to ~1700 years. Two historical events are potentially recorded in the last 2000 years. A bimodal time distribution of events is distinguished with clusters of 3 to 4 events with mean recurrence intervals of ~200-900 years, separated by periods of quiescence of ~1.2-1.7 ka.
Turbidite correlation between distal and proximal cores is complex along the Algiers segment. The number and frequency of turbidites increase toward the base of the slope and the age uncertainties increases with the reduction of hemipelagic intervals.
Along the El-Asnam margin segment, located to the west of the Algiers segment, deformation is mainly accommodated onland along thrusts and strike-slip faults, as attested by the Orleansville M 6.7 event in 1954 and the El Asnam M 7.3 earthquake in 1980 located ~20km southwards. In 1954, the earthquake also generated turbidity currents on the submarine slope, documented by the break of submarine communication cables. Sedimentological and chronostratigraphic analysis of piston cores collected at the base of the submarine slope of the El-Asnam margin segment show that thirteen coastal paleo-earhquakes underpin clusters of 3 to 6 events with mean recurrence intervals of ~300-600 years, separated by two periods of quiescence of ~1.7 ka without major events.
The Holocene turbidite record in two adjacent tectonic segments of the Algerian margin provides a new paleoseismic catalog. It outlines a similar pattern consisting of periods of low reccurence intervals (few hundreds years) alternating with periods of quiescence without any major earthquake over a thousand of years. Such sequences support earthquake supercycling, and show that it should be a major strain release process along the Africa-Eurasia plate boundary.

**Study on the Cretaceous tight oil reservoir quality in JiuQuan Basin,Western China**

Bai, B.[1], Zhu, R.[1], Li, T.[1], Luo, Z.[1], Su, L.[1]

[1] State Key Laboratory of Enhanced Oil Recovery (Research Institute of Petroleum Exploration & Development), Beijing 100083, China - baibin81@petrochina.com.cn

The tight oil reservoir in the Cretaceous Xiagou formation of JiuQuan basin located in the western part of China includes many rock types,such as terrigenous sedimentary rock, carbonate rock,mixed sedimentary rock and exhalative rock.The main lithology contains dolomitic mudrock,argillaceous mudstone,dolomite-bearing mudrock,mud-bearing dolomite, and mudstone.The main composition consists of dolostone, calcite, plagioclase, k-feldspar, clay minerals,quartz and organic matter.The reservoir exhibits poor physical property,with porosity of 0.6%-8% ,the average of which is 2.33%,and its air permeability is only 1.1md.To the reservoir,its microscopic structure is complex,which is one of the key factors influencing reservoir quality.

1).Seasonable terrigenous materials flowed into the center of lake,forming alternative laminations of organic and non-organic minerals.The lamination associations are summarized as:A.organic matter+dolomite、calcite ; B.organic matter+dolomite、albite and quartz ; C. illite+quartz+albite+ chlorite. The organic matter,with laminated and scattered microscopic distribution feature, cooperates with non-organic minerals,forming symbiosis of tight oil source and reservoir rock.

2).The reservoir pore-throat type、size and distribution closely relate to mineralogical composition.In the laminations of high-content carbonate or felsic minerals, intragranular corroded micropores in dolomite and intergranular micropores in feldspar develop,with the pore diameter ranging from 500nm to 2300nm,seen as large micro-scale pores ; In the laminations of high-content organic or clay minerals,nano-scale organic micropores dominate,the size of which is from 50 to 800nm. Micro-fractures develop between laminations of organic matter and non-organic minerals,with an extension of 1 to 10um,acting as the important determinant of highly permeable reservoir and also the main pathways of occurrence and movement for tight oil.

3).The source-reservoir rock microstructure and fracture systems predominantly control tight-oil accumulations.Laminated organic matters expel hydrocarbon more easily and they are the preferable collection area for tight oil at low-maturity evolution stage of organic matters.Scattered organic matters have trouble in hydrocarbon expulsion,and they are advantageous collection area for tight oil at high-maturity evolution stage of organic matters.

Therefore,the microscopic distribution feature of reservoir minerals, mineralogical composition and micro-fractures altogether mainly control the reservoir quality,besides,they are also the basis of realizing symbiosis of tight oil source and reservoir rock, determinating the storage, flow, and accumulation of tight oil.

**Quantitative Analysis on the Formation Mechanism of Chang 8 Tight Sandstone Reservoir in Southwest of Ordos Basin**

Bai, Q.[1], Yang, S.[1]

[1] College of Geosciences in China University of Petroleum, Qingdao 266580, China - baiqinglin123@126.com

Chang 8 member of Trassic deposited in braided stream delta front in the southwest of Ordos Basin. The tight reservoir with average porosity of 7.34% and average permeability of $0.46\times10^{-3}um^2$ are in a current depth of 2000-2500m. The diagenesis and porosity evolution was analyzed by means of casting thin sections, cathodoluminescence, scanning electron microscope and so on. Sandstone reservoirs are currently in the stage A of middle diagenesis phase. The main causes of low porosity and permeability include 5 aspects. (1) The fine grained sediments make the original porosity and permeabillity of reservoir be poor. (2) The easily deformed components of Rock debris and micas hold a high proportion in rocks, which results in large loss to the reservoir space. (3) The strong calcareous cementation due to sufficent carbonate supplies in source region, accompanying the cementation of clay minerals block most of pore and throat. (4) Tectonic study results indicate that no significant structural activities developed after Triassic Yanchang Formation deposited. The pore fluid saturated with carbonate can't exchange actively with outside so that there are few acid water effectively dissolve the reservoir. As a result, limited amount of secondary pores generated. (5) The asphaltenes produced in the process of oil migrating in the skeletal sand bodies filled part of pore and throat, which decreases the reservoir properties. Taking different factors into consideration, calculated the evolution parameters of reservoir physical properties and quantitaive analyzed the evolution characteristic of porosity. The result shows that the porosity of primary sediment particles is about 31.6%. Compaction and cementation make the largest contribution to the destruction of reservoir physical properties, which makes the porosity reduce 15.9% and 8.4%. In addition, porosity reduces 3.76% in the process of asphaltenes filling and porosity increases only 3.8% in the process of dissolution.

**Sedimentation Microfacies Identification Based on Wavelet Transformation Fine Depicting Shape of Well Logging Curves**

Bai, Q.[1], Yang S.[1]

[1] College of Geosciences in China University of Petroleum, Qingdao 266580, China - baiqinglin123@126.com

Wavelet transform technology can fine depict shape characteristic of well logging curves, which is able to rapidly and accurately identify sedimentation microfacies by using well logging information. This method can reduce the uncertainty of using traditional log facies analysis to identify sedimentation microfacies. The representative sedimentation microfacies with obvious facies marker was selected from small layers of Chang 8 member in the southwest of Ordos Basin. The variation in direction of the well logging curves was presented by calculating the first order of center distance. Then wavelet transform technology was used to reconstruct high-frequence information and low-frequence information of these logging curves. The first 10 low-frequence wavelet coefficients can perform well in reconstructing varation trend of logging curves. There are significant differences in the wavelet coefficients and reconstructed low-frequence curves and high-frequence curves among different sedimentation microfacies. The variation law of low-frequence wavelet coefficients in every microfacies was analyzed from the hydrodynamic force and other sedimentology aspects. By doing these, the abstract information of sedmentation microfacies belonging to geological space was converted into specific low dimensional feature vector of digital space. Based on this point and combing the characteristic of low-frequence curves and high-frequence curves, a set of sedmentation microfacies identification templates were established. Sedimentation microfacies was identified by calculating the minimum Euclidean distance of logging curves between small layer and identification templates, with combination of comparing the characteristic of low-frequence curves and high-frequence curves between them. The results show that the coincidence rate can reach up to 95% after contrasting identification results with the sedimentation microfacies of core wells, which is better than the results of using traditional log facies analysis to identify sedimentation microfacies. The method not only transfer the complicated issue of sedimentation microfacies identification into a simple process of calculating several low-frequence wavelet coefficients, but also enlarge the discrepancy of different sedimentation microfacies to promote the accuracy of identification.

**Presence of ankerite in the Timber Bay Formation (Pliocene, Mayaguana, Bahamas): a testimony of specific conditions during dolomitization?**

Baldessin, E.[1], Kindler, P.[1], Machel, H.G.[2], Adatte, T.[2]

[1] Section of Earth and Environmental Sciences, University of Geneva, 13 rue des Maraîchers, CH-1205 Geneva, Switzerland - Erika.Baldessin@unige.ch
[2] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada, T6G 2E3
[3] Institute of Earth and Environmental Sciences, University of Lausanne, Geopolis, CH-1015 Lausanne, Switzerland

The discovery of non-stoichiometric, Fe-rich dolomite in the Timber Bay Formation (Pliocene) on Mayaguana Island, SE Bahamas, is of major importance because this type of dolomite has not yet been found on other Caribbean islands, and further provides constraints on the characteristics of the precursor limestone and the environmental conditions during dolomitization.

The Pliocene Timber Bay Formation (TBF) is unique in the Bahamas. While it crops out at the surface of Mayaguana, a small carbonate island nestled in the southeastern part of the archipelago, equivalents of this unit are found only at considerable depth on other Bahamian banks. The TBF forms low-elevation reefal terraces made of partially to completely dolomitized coral-algal boundstone with a bioclastic grainstone matrix. Petrographically, these dolostones consist of two types of dolomite: (a) a fine-crystalline, polymodal, planar-s dolomite that mimecally replaces micrite and allochems (mainly red algae, echinoderms and foraminifera), and (b) limpid dolomite cements that form either isopachous rims or blocky fillings in both inter- and intragranular pores. A late phase of sparry low-Mg calcite cement occludes some pores.

X-ray diffraction analyses were performed on fourteen dolostone samples collected from three localities (Little Bay, Curtis Creek, and Timber Bay) along the north coast of Mayaguana. Although the X-ray patterns of the dolomite show some traces of the precursor calcite, the TBF dolostones mainly consist of heterogeneous, Ca- and Fe-rich dolomite showing a sharp diffraction peak between 30.65° and 30.85° 2Θ.

The texture of the TBF dolomite could be due to the high permeability of the precursor limestone and/or its mineralogy. In a highly permeable carbonate precursor, the flow of diagenetic fluids is rapid, leading to the development of numerous nucleii and thus many small crystals that preserve the original fabric of the precursor limestone. As for the mineralogy, the dolomitization of metastable carbonates (aragonite or HMC) occurs at a faster rate than that of low-Mg calcite, thus resulting in non-stoichiometric dolomite. Influence of both factors could explain the texture and stoichiometry of the TBF dolomite. The presence of iron in the composition of most of the TBF dolomite could indicate: reducing conditions during dolomitization, influence of continental groundwaters, or an eolian contamination. Since Mayaguana is an isolated carbonate platform away from any continental influence, the role of continental groundwater can be ruled out.

This research is supported by the Swiss National Science Foundation (grant n° 200020-140420/1).

**Diverse provenance of Pannonian Basin loess indicated by quartz grain SEM images**

Banak, A.[1], Pavelić, D.[2], Kovačić, M.[3], Mandic, O.[4]

[1] Croatian Geological Survey, Department of Geology, Sachsova 2, HR-10000 Zagreb, Croatia – abanak@hgi-cgs.hr
[2] Faculty of Mining and Petroleum Engineering, University of Zagreb, Pierottijeva 6, HR-10000 Zagreb, Croatia
[3] Faculty of Science, Department of Mineralogy and Petrology, University of Zagreb, Horvatovac 95, HR-10000 Zagreb, Croatia
[4] Geological-paleontological Department, Natural History Museum Vienna, Burgring 7, A-1010 Wien, Austria

Loess is terrestrial clastic sediment, composed dominantly of silt-sized particles formed by the accumulation of wind-blown dust. It is usually inter-bedded with soil horizons forming loess-paleosol successions (LPS). Two loess profiles were chosen for the purpose of this investigation. First one is Zmajevac Pleistocene loess-paleosol sequence (LPS) in the easternmost Croatian region of Baranja. It is exposed along the southern slope of Bansko hill on the western bank of the Danube River. The investigated 17.5m thick section displays 4 paleosols embedded in loess. Second one is located in Daranovci, on the northern slopes of Požeška Mt., in Western Slavonia region and it is 150km westward from Zmajevac LPS. It is 25.5m thick section comprised of loose silt and thin conglomerate lenses within. The complex process of producing and transporting silt/sand particles can be best explained with SEM images, which display shape of quartz grains and their surface microtextures. The study of surfaces under high magnification provides insight into the mechanical fractures of quartz grains and explaines different types of origin and transportation processes.

On most grains from Zmajevac LPS conchoidal fractures and V-shaped percussion marks are visible. Conchoidal fractures were detected in over 40% of the grains in the samples. A small number of grains have conchoidal fractures that are nearly the size of the length of the longer axis of the grain, while the majority of grains have conchoidal fractures with 1/3 or 1/4 of axis length. V-shaped percussion marks are visible in 15% of the grains. They are usually clustered on smooth, flat surfaces of grains, although in a small number of grains single V-shaped percussion marks are present. SEM images of quartz grains confirmed complex multi-phase transport mechanisms preceding final deposition. The proposal for division into five phases for Zmajevac profile has been made as follows: (1) Grinding, abrasion, thaw-freezing process, (2) fluvial transport, (3) sedimentation in plains, (4) dried sediment deflation (5) aeolian silt sedimentation.

The second loess profile in Daranovci dispalys different provenance of quartz grains. Conchoidal fractures that are visible in 40% of grains are one of the most distinct features observed on quartz grains from loess deposits. They can be an effect of glacial and aeolian transport of silt and sand. Another process which can produce these kind of features on quartz grains is salt weathering. Salt weathering can produce up to 12% of silt and sand quartz relative to the whole rock mass from which they originated. Conchoidal fractures observed in samples from Daranovci are not so deep and distinct as in samples from Zmajevac LPS, which leads us to conclusion that salt weathering, and not glacial grinding is dominant process which induced their formation. A majority of grains on their surface also have fracture faces. These features can be formed in almost any kind of geological processes. Feauters observed on SEM images from Daranovci samples imply that quartz grains originated by salt weathering during arid period of early Miocene.

Acknowledgements: This paper was supported by Projects no. 181-181-1096-1093, 195-1951293-2703 and 195-1951293-0237 of the Ministry of Science, Education and Sports of the Republic of Croatia.

**Microbial mat-related structures in siliciclastics as palaeo-environmental proxies: examples from Precambrian Vindhyan basin and modern Gulf of Cambay, India**

Banerjee, S.[1]

[1] Department of Earth Sciences, Indian Institute of Technology Bombay, Powai, Mumbai-400076, India – santanu@iitb.ac.in

Although Precambrian siliciclastics remained overlooked many years for microbial mat record, the last decade witnessed considerable focuss on this topic. This study presents microbial mat-related structures (MRS) in siliciclastic rocks of the ca. 1.7 to 0.6 Ga Vindhyan Supergroup in central India for their palaeo-environmental implications. Study of modern MRS, carried out in hypersaline tidal estuaries in the Gulf of Cambay is presented to provide high-resolution environmental interpretations of shallow marine-originated Precambrian mat features. Inferred palaeo-environments of deposition of the ~4.5 km thick Vindhyan sedimentary succession range from marine outer shelf to subaerial, through inner shelf, shoreface and coastal. Repeated swings through this depositional settings caused alternations between transgressive systems tracts (TSTs) and highstand systems tracts (HSTs). The inner to outer shelf-originated shale members develop deepening- and fining upward TSTs till the maximum flooding zone is reached, and the sandstone members, mostly of shallow marine origin largely constitute the HSTs. The microbial mat features reported from the shales of the TSTs include wavy and crinkly carbonaceous laminae, rolled-up and folded carbonaceous laminae and pyritic laminae. Although predominantly low energy depositional setting in subtidal conditions favoured uninterrupted microbial mat growth, occasional high energy events related to storms, however, caused tearing, transportation and deformation of mat fragments. The soles of storm-laid sandstone beds in TSTs contain various features related to impressions of torn mat fragments, while the bed-tops commonly exhibit varieties of wrinkle structures. Interbedded sandstone at the bases of the HSTs exhibits broadly similar characteristics as those of TSTs, the MRS comprise wrinkle structures, kinneyia, elephant-skin features and occasional disc-shaped microbial colonies. The maximum diversification of MRS on sandstone bed surfaces has been observed in shallow marine segment of the HSTs, environmental implications of which is better constrained on the basis of study of modern MRS. Petee ridges, sand-cracks, gas domes, multi-directed ripples, reticulate surfaces, sieve-like surfaces, disc-shaped microbial colonies and setulfs are mostly found in upper intertidal to lower supratidal conditions in modern envrionment. Formation of roll–up structures, rafted-mat fragments, sand chips and multidirectional ripple marks in these zones requires action of currents strong enough to cause deformation of microbial mat-covered sandy surfaces. Beyond this zone, the wave/current actions may be too weak in the upper supratidal condition to form these MRS, while too strong energy conditions in the lower intertidal condition discourages mat growth. Drying and desiccating mat in these zones produce petee ridges, sand-cracks and gas domes. Formation of setulf is related to eolian actions against minute obstacles such as torn mat fragments and the feature is commonly found in microbial mat covered sands in upper intertidal to lower supratidal zones. Wrinkle structures and patchy ripples reflect broader range of palaeogeographic settings from the supratidal to shallow subtidal conditions and are not suitable as palaeo-environmental proxies. Vindhyan case study suggests a range of settings for the MRS, which is considerably broader than intertidal–supratidal niches of the modern setting. As such, the MRS greatly enhances the resolution of palaeo-environmental interpretations of Precambrian sedimentary succession, and extends the proxies available to sedimentologists for such studies.

**Mineralogy and Diagenesis of the Paleoproterozoic FA and lower FB Formation, Franceville Basin, Gabon**

Bankole, O.[1], El Albani, A.[1], Gauthier-Lafaye, F.[2]

[1] Laboratoire Hydrasa, IC2MP, UMR 7285, Universite de Poitiers, 5 rue Albert Turpin, 86073, France – olabode.bankole@univ-poitiers.fr
[2] Centre de Sedimentologie et Geochimie de la Surface, CNRS Universite Louis Pasteur, 1 rue Blessig, 67084 Strasbourg

The Paleoproterozoic (2.1Ga) Franceville series represents one of the oldest world petroleum systems and ranked as one of the major Precambrian accumulations of organic matter. The series has been divided into five lithostratigraphic units, namely: FA, FB, FC, FD and FE Formations. The FA Formation consists of unmetamorphosed uranium and bitumen mineralized sandstone and conglomerate that was deposited during the early evolution of the Franceville basin, a continental basin in south eastern Gabon. This study involves sedimentological and petrographical analysis of the oldest FA Formation and basal part of the overlying FB (FB1) Formation from the proximal to distal part of the basin.

Three lithofacies assemblages can be recognized in the FA Formation consisting of conglomerate, sandstone, and minor mudstone. The facies associations indicate deposition in fluvial and fluvio-marine transitional environments. Three principal colour variations are identified from the base to the top: red/pink-green-black/grey which are independent on lithofacies assemblage. The colour contacts between these sediments are irregular which suggests diagenetic control to changes in oxidation-reduction condition during fluid flow. Three lithofacies consisting of sandstone, black shales, mudstone characterizes the lower sediments of the overlying marine FB1 Formation.

The rocks of the FA Formation present a succession of upward-finning to coarsening successions consisting of poorly sorted, coarse grained arkosic arenite fluvial facies in the lower unit and moderate to well sorted medium grained quartz arenite tidal-deltaic facies at the uppert part of FA Formation with interlayer mudstones. The quartz arenites undergo early secondary silica cementation and serves as diagenetic aquicludes for fluid flow and subsequent diagentic changes. The arkosic arenites have undergone significant diagenetic alteration processes such as compaction, grain dissolution, and cementation. Clay minerals, carbonates, anhydrite and barite are the main authigenic cement minerals. XRD and SEM/EDX data reveal that illite and Fe-chlorite are the only authigenic clay minerals present in the FA Formation while FB1 Formation consists an assemblage of illite, chlorite, and mixed-layer illite/smectite. Illite and chlorite form as pore filling, grain linings, and replacement minerals in feldspar and mica. The clay mineral diagenesis at lower FB1 consists of transformation of I/S mixed layer from R0 to R1. Illite is the most abundant clay minerals and present in all the samples from the top to bottom while Fe-chlorite is limited to samples above an approximate depth of 500m within the FA Formation. The mineralogical assemblages and textural occurrence of the mineralogy suggest that the main diagenetic process is circulation of fluid which is controlled by the hydraulic properties of the lithofacies.

**Shoreline prediction under conditions of global climate change using a semi-empirical model**

Banno, M.[1], Kuriyama, Y.[2], Hashimoto, N.[3]

[1] Port and Airport Research Institute, 239-0826 Yokosuka, Japan - banno-m@pari.go.jp
[2] Port and Airport Research Institute, 239-0826 Yokosuka, Japan
[3] Kyushu University, 819-0395 Fukuoka, Japan

Future sea-level rise and change of wave climate due to the global climate change will cause severe beach erosion. Although many studies focus on future shoreline change, models considering the influence of changes in sea level and wave conditions simultaneously have been little used to predict future shoreline positions.

We developed a shoreline change model in which the effects of changes of wave regime and sea level are incorporated, in order to predict future shoreline positions along the Hasaki Coast of Japan, facing the Pacific Ocean. The high-water shoreline positions used for the model calibration cover all workdays during period 1986 to 2007 along the Hasaki Coast.

The future shoreline positions from 2008 to 2095 were predicted with the scenarios of sea-level rise of IPCC AR4 (59 cm / 100 year). The future trends of wave climate change follow the high-resolution atmospheric general circulation model and the global wave model, which predict that the future mean wave heights will decrease near Japan, whereas extreme wave heights would increase. The calculations were repeated 10,000 times using normal random number generation by Monte-Carlo simulation.

The predicted shoreline position at the present high-water level shows a shoreline-retreated of approximately 20 m in 2095 owing to the sea-level rise. Given the rise in the reference sea level, the future shoreline position at high water would be approximately 40 m landinward of the present one.

On the other hand, the future wave climate change tends to increase the variation of the future shoreline positions, especially at the seaward side of the distribution. This is because the seaward shoreline change will be enhanced by a decrease in the averaged wave height, but the backward one due to an increase in the extreme wave heights will be suppressed by non-linearity of the shoreline response to the wave energy.

**Geochemical characteristics of glauconite within transgressive deposits of Early to Late Cretaceous Karai Shale, Cauvery Basin, India**

Bansal, U.[1], Banerjee, S.[1], Pande, K.[1]

[1] Department of Earth Sciences, Indian Institute of Technology Bombay, Powai, Mumbai–400076, India – uditabansal.geo@iitb.ac.in

This study presents geochemical characterization of glauconites within transgressive systems tract deposits of onshore Karai Shale in Cauvery basin and constrains its age by Ar–Ar method. Detailed petrography and XRD study was performed before mineral chemical analysis of 125 sample points of glauconite by EPMA and Ar–Ar geochronology. The roughly 450m thick Early to Late Cretaceous Karai Shale gradationally overlies Dalmiapuram Formation, exhibits deepening upward trend at the lower part, shallowing upward trend at the upper part and unconformable contact with the overlying Garudamangalam Sandstone. The lower part of the Karai Shale is highly fossiliferous, containing belemnites, bivalves, foraminifera, ostracoda, bryozoa and algae, whereas the upper part is poorly fossiliferous. The glauconitic interval (~50.8m thick) of the Karai Shale occurs near the top part of the deepening upward transgressive segment, close to the maximum flooding zone. Green shales of glauconitic interval (1.5m to 9m thickness) are intervened by occasional 15cm to 80cm thick, sharp–based, storm-originated calc–arenite beds and moderately dispersed phosphorite (fluorapatite) nodules. Dark green to moderately green glauconite grains comprise about 40 to 50% of the constituents in shales and calc–arenite beds. The typical foraminiferal assemblage of *Rotalipora reicheli, Praeglobotruncana stephani, P. delrioensis, Gavelinella plummerae, Gyroidinoides globosa* indicate outer shelf depositional setting. Petrographic studies reveal three modes of occurrence of glauconite, as (i) pellets mostly of fecal origin (ii) infillings in bioclasts and (iii) replacement along detrital mica grains which is referred to as vermicular glauconite. XRD studies reflect characteristic peak of 10Å from basal (001) reflection of glauconite. The average $K_2O$ content of glauconites decreases from 6.34% in pellets to 5.36% in vermicular variety through 6.16% in infillings. Average total $Fe_2O_3$ is higher in pellets (27.17%) compared to infillings (25.76%) and vermicular variety (25.81%). The $K_2O$ content of the glauconites suggests 'evolved' to 'slightly evolved' stage of maturation. All varieties of glauconites (except bryozoan pore infillings) exhibit variation in composition from core ($K_2O$ ~6.50% and $Fe_2O_3$ ~27.48%) to the rim ($K_2O$ ~4.92% and $Fe_2O_3$ ~22.59%). Rims are, therefore, indicative of possible later alteration in presence of K–poor water. CaO content of the glauconite infillings is considerably less (average 0.37%) notwithstanding bioclast substrate. Average $K_2O$ of the infillings varies depending on the type of bioclasts, viz. 6.81% in foraminifera, 6.73% in ostracoda and 5.60% in bryozoan pore. The variation in $K_2O$ content may be related to preferred circulation of K-rich fluid through large pore system in bioclasts, causing greater degree of maturation. The cross plot of $K_2O$–$Fe_2O_3$ (total) and $K_2O$–$Al_2O_3$ displays good correlation which suggests simultaneous fixation of total Fe in octahedral sites and K in interlayer sites. $Al_2O_3$–total $Fe_2O_3$ plot exhibits negative correlation indicating substitution of the former by the latter during the course of glauconitization. The results of cross plots contradicts established 'Verdissement theory' of glauconitization and suggest that initial authigenic precipitates of K–poor glauconite was matured by simultaneous addition of K and total Fe. Ar–Ar dating of two glauconite samples from 17.25 m segment of the glauconitic interval provides 121.80±6.8 Ma and 98.02±0.59 Ma which indicate a sedimentation rate approximately 0.75m/Ma.

## $^{14}$C mapping of organic carbon in continental margin surface sediments

Bao, R.[1], McIntyre, C.[1, 2], Zhao, M.[3, 4], Eglinton, T.I.[1]

[1] Biogeoscience group, Geological Institute, ETH Zürich, 8092 Zürich, Switzerland - rui.bao@erdw.ethz.ch
[2] Laboratory for Ion Beam Physics, ETH Zürich, 8092 Zürich, Switzerland
[3] Key Laboratory of Marine Chemistry Theory and Technology (Ocean University of China), Qingdao 266100, China
[4] Ministry of Education / Qingdao Collaborative Innovation Center of Marine Science and Technology, Qingdao 266100, China

Continental shelves form a crucial interface between the land and the ocean, receiving organic carbon inputs from both reservoirs. These systems account for ~90% of global organic carbon burial in the modern oceans, however considerable uncertainty remains concerning the source and fate of organic carbon delivered to, and produced over continental shelves. In particular, controls on spatial variability in the content and composition of sedimentary organic matter on continental shelves remain uncertain. In addition to the magnitude and nature of organic matter supply from terrestrial sources and from surface ocean productivity, there is evidence that hydrodynamic processes and physical protection mechanisms play a critical role in influencing the dispersal and eventual burial of organic matter on the continental shelf.

Through combined organic geochemical and sediment fabric analysis of bulk surface sediment samples and corresponding grain size fractions, we show that sedimentological processes in the Chinese marginal seas (CMS) exert important control on composition and age of organic carbon. Variations in hydrodynamic sorting and physical protection of organic matter are observed in relation to grain size and related sedimentary properties. An extensive survey of CMS surface sediments reveals that pre-aged organic carbon is associated with distinct grain sizes. Organic carbon contents and isotopic compositions coupled with grain size distributions suggest that pre-aged organic matter with relatively high organic carbon content and $^{13}$C-depleted signatures, accumulates on the inner shelf and in high energy regions. As a consequence of protracted entrainment in deposition-resuspension loops, the organic matter becomes more refractory during aging, and subject to widespread dispersal via benthic nepheloid layer transport. These results shed new light on the sources and fate of organic matter on continental shelf seas, and on controls on organic carbon preservation in underlying sediments. Pre-aged organic carbon may be an important consideration in developing budgets of global terrestrial organic carbon burial on the continental shelves.

**Upper Cretaceous of Albas syncline (Northern Pyrenees, France) - A highly pedogenized Distributive Fan System**

Barnier, M.[1], Rubino, J.-L.[2], Malartre, F.[3], Delgorgue, V.[2], Arnaud, B.[3]

[1] Total Norge, Stavanger, Norway - manine.barnier@external.total.com
[2] Total SA, CSTJF Avenue Larribau, Pau 64018 cedex, France
[3] ENSG Rue du Doyen Marcel Roubault, BP40 54500 Vandoeuvre, France

In the E-W trending Albas syncline belonging to Northern Pyrenees folded belt, (SE France), a well dated Campanian-Maastrichtian continental series, 200m thick, is continuously exposed over more than 6km at right angle from the sediment supply. The series is deposited during a quiescence phase of foreland basin flexure as shown by regional isopacity. A detailed stratigraphical and sedimentological analysis allows to evidence three depositional sequences with depositional environments ranging from fluvial channels, palustrine and lacustrine carbonates. The first Campanian-Maastrichtian sequence is laterally onlapping against a palaeohigh and starts with transgressive lacustrine limestones, then the overlying prograding part of the sequence consists of anastomosed isolated sandy channels showing a gradual channels width increases from base to top. Channels are isolated within reddish pedogenised flood plain silts and shales. At the base of the Upper Maastrichtian, a sharp contact occurs. It corresponds to a continental sequence boundary with minor erosion. It is sealed by a network of amalgamated conglomeratic channels forming an almost continuous belt, most likely deposited during an aggradational phase; with a slight base level rise. The average channels width within the belt upward increases. Then a new flooding occurs with palustrine to lacustrine limestones interbedded with extensive red soils. A new phase of continental progradation occurs including by place meandering channels grading again into isolated sandy to conglomeratic channels. Like in the underlying sequence, meanwhile the upward coarsenning character of the fluvial series, the channels width also increases. Finally near the top of the section an incision occurs (IVF type), it is filled with stacked narrow (10 to 50m in width) sandy or conglomeratic channels and then a major lacustrine carbonates bar defined the latest Maastrichtian lacustrine flooding prior to the K/T boundary. The overlying prograding part of the sequence is very thin and includes a single channel belt prior to a new lacutrine flooding within the Danian.

The vertical evolution of the regressive fluvial series of the two Cretaceous superimposed sequences shows a channels pattern which do not corresponds to this classically encountered in conventional alluvial sequence where channel width decreases upstream in the prograding profile. Here, their width increases, is more in agreement with this found in Distributive Fan Systems which are also prograding, In such systems which could be deposited all along the drainage basin, the channels width trend is clearly increases upstream as well as the grain size.

In addition because of the low sedimentation rate and a permanent water table in a poorly drained flood plain, most of the series including the sandy channels are entirely pedogenised making sometime difficult the sedimentary features identification with the pervasive development of tubular roots network.

Preliminary regional correlations tends to suggests even if the slope gradient of the fluvial system are high according to the above described facies association that we are not far away from the marine base level (less than 50Km northwestward), however any tidal evidence being observed, we are confident that we are significantly upstream of both tidal limit and bayline.

**Process-Based Modelling of Sediment Deposition and Compaction: Stratigraphy in the Peïra Cava sub basin at reservoir scale**

Basani, R.[1], Aas, T.E.[2], Hansen, E.[1], Howell, J.[3]

[1] Complex Flow Design AS, Trondheim, Sør Trondelag, Norway – riccardo@cfd.no
[2] Statoil ASA, Stavanger, Rogaland, Norway
[3] University of Aberdeen, Aberdeen, United Kingdom

Turbidity currents are the most important mechanism for the dispersal and deposition of sand in deep-sea settings and thus of major importance for the formation of oil and gas reservoirs in deep water deposits. Turbidity currents are difficult to study in modern environments, while their laboratory representations are typically hampered by scaling issues, unrealistic geometries, and short durations. Computational fluid dynamics (CFD) is being developed to fill the gap between the small and large scale, integrating data from nature, theory, and experiments.
The deterministic process software MassFLOW-3D™ has been developed and successfully used to construct a 3D model for the simulation of turbidity currents. All principal hydraulic properties of the flow and its response to topography can be monitored in 3D over the full duration of the turbidity current.
The aim of the current study is to confirm the applicability of process-based modeling to predicting bed geometry and grain size distribution in a single bed (Marker Unit 5) in the deep-marine Peïra Cava Basin (Eocene-Oligocene Annot Sandstone, SE France), extensively studied by Amy et al. (2007).
The modelling required a seafloor surface to represent the base of this particular bed at the time of deposition. The first stage of the modelling was to create the pre-MU5 stratigraphy to capture the bathymetry onto which the MU5 bed was deposited. This was done with four composite flow events starting from the base Annot Sandstone surface (reconstructed from outcrop observations) with subsequent modelling of compaction and isostatic bending after each flow simulation. The cumulative deposited thickness of the four flows matched the observed thickness at the control points.
In a second phase the process-based flow simulation of the MU 5 bed, starting from the thus created surface, was performed. MU5 stratigraphy is present in 6 of the 7 available logs which were used to constrain the input parameters for the simulation. The thickness values available were used to estimate the total sediment volumes in the system, and therefore the boundary conditions for the numerical simulations.
Four grain sizes were used for the MU5 flow simulation: 80 µm,200 µm, 400 µm and 1 mm, based on the available data-points. Available data suggested the initial volumetric concentration of each grain size: 35% very fine sand, 35% fine sand, 20% medium sand, and 10% coarse sand.
The total flow volumetric concentration was 10%, based on the literature. With regards to thickness and distribution of grain-sizes at the available data points, the results for the MU5 sand bed were encouraging, in particular for the coarse- and medium-sized particles. Detailed modelling of the key bed resulted in a good match between the calculated de-compacted thicknesses of the bed at the know data-points and the sediment deposited during the flow simulation. There is a reasonable match between the observed and modelled grain size distributions although with some deviation. Overall the study has confirmed the capability of the MassFLOW-3D™ software to deal with multiple grain-sized turbidity currents and that process-based modelling is a useful tool for predicting the distribution of sand thickness and grain size, which in turn is a proxy of modelling stratigraphy for reservoir quality. We suggest that such an approach can be part of a probabilistic workflow and be used to capture likely ranges of parameters for improved exploration and reservoir management.

**Influence of subaqueous processes on the construction and accumulation of an aeolian sand sheet**

Basilici, G.[1], Führ Dal' Bó, P.F.[2]

[1] Department of Geology and Natural Resources, Institute of Geosciences, State University of Campinas, 13083-870, Campinas (SP), Brazil, Tel. 55.19.35214577. Fax: 55.19.32891562 - basilici@ige.unicamp.br
[2] Universidade Federal do Rio de Janeiro;

In aeolian sand sheets the interaction between aeolian and subaqueous processes is considered one of the principal factors that controls this depositional environment. To examine the role played by the subaqueous processes on the construction and accumulation of sand sheets, surface deposits and subsurface sedimentary sections of a currently active aeolian sand sheet, located in the Upper Tulum Valley (Argentina), have been examined. On the sand sheet surface, airflows enable the construction of nabkhas, wind-rippled mantles (flattened accumulations of sand forming wind ripples), megaripples, and small transverse dunes. Subaqueous deposits consist of sandy current ripples covered by muddy laminae. The latter are generated by annual widespread but low-energy floods, that emanate from the nearby mountains in the aftermath of episodes of heavy precipitations. Deposits of subaqueous origin constitute 5% of the accumulated sand sheet thickness.

The construction of the sand sheet is controlled by meteorological seasonal changes: the source area, the San Juan river alluvial fan, receives sediment by thaw-waters in spring-summer; in fall-winter, when the water table lowers in the alluvial fan, the sediment is available for aeolian transport and construction of the sand sheet area. The flood events play an important role in enabling sand sheet accumulation: the muddy laminae serve to protect the underlying deposits from aeolian winnowing. Incipient cement of gypsum on the sand and vegetation cover acts as an additional stabilising agent that promotes accumulation. Episodic and alternating events of erosion and sedimentation are considered the main reason for the absence of soils and palaeosols. Results from this study have enabled the development of a generic model with which to account for (i) the influence of contemporaneous subaqueous processes on the construction and accumulation in recent and ancient sand sheets and (ii) the absence of developed soils in this instable topographic surface. FAPESP, process n. 2012/232090, is thanked for financial support.

**Palaeosol as stratigraphic and palaeoenvironmental proxies in aeolian succession**

Basilici, G.[1], Führ Dal' Bó, P.F.[2], Marinho, T.S.[3]

[1] Instituto de Geociências, UNICAMP, Brazil - basilici@ige.unicamp.br
[2] Universidade Federal do Rio de Janeiro
[3] Universidade Federal do Triângulo Mineiro

Although the palaeosols are an useful tool for palaeoenvironmental and stratigraphic studies of the continental sedimentary successions, they are yet few known amongst the sedimentologists. This work used the palaeosols and deposits to genetically discriminate the stratigraphy and the palaeoenvironmental evolution of the Bauru Group (Upper Cretaceous, SE Brazil). This unit is a sandstone succession, in which the palaeosols constitutes on average 65% of the thickness. The deposits were formed on an aeolian sand sheet by wind ripples activity on dry or damp surfaces and by subaqueous flows on local and temporary flooded surfaces (playa-lake). In order of abundance, the palaeosols are: Aridisols, Vertisols, Alfisols, Inceptisols, and Entisols. Aridisols testify an arid or semiarid environment, characterised by thick calcrete horizon (Bk), clay illuviation horizon (Bt), and well-developed structures. Alfisols have thick Bt horizon and absent or reduced Bk horizon, molar relationship basis/alumina greater than 1, and well-developed structures; they suggest more humid climate with forested surface. Vertisols have high content of expansive clays and they are characteristic of environments with well defined dry and humid seasons. Inceptisols and Entisols are few developed palaeosols; Entisols are not more than 0.3 m thick, and they show only A and C horizons. The distribution of palaeosols and deposits allows to distinguish three genetic-stratigraphic units. The lower unit is 36 m thick and is constituted of Alfisols, Entisols, climbing translatent strata, adhesion laminations, and subaqueous flow deposits. The deposits suggest a groundwater level near or temporarily above the topographic surface in a palaeoenvironment where clastic transport was dominated by wind. The palaeosols indicate interruptions of the depositional processes and the establishment of a forested environment. The intermediate unit, 46 m thick, shows and interbedding of climbing translatent strata and Entisols. This second unit suggests a general aridification of the environment due to the abundance of wind ripples and the presence of Entisols, that indicate only short interruptions of the sedimentary aeolian processes. The upper unit, 85 m thick, show 92% of the thickness constituted of palaeosols, organised in pedocomplexes. The palaeosols are mostly formed of Aridisols, and secondarily of Vertisols, Entisols Inceptisols, and Alfisols. The deposits are constituted of climbing current ripple sandstone, which constitute the parent material of the palaeosols. In general, this interval records arid or semiarid climate and long interruptions of the sedimentary processes which caused well-developed palaeosols profiles.

In conclusion, the Bauru Group formed in an arid and/or semiarid aeolian sand sheet where the sedimentary and pedogenic processes were controlled by the climate. The drier phases are represented by period dominated by wind deposition and the more humid phase are represent by an interruption of the sedimentation and pedogenesis. In this general context, the lower unit testifies a period of lesser aridity with forested surfaces, characterised by local and temporary groundwater level at or close the topographic surface. The climate became drier during the deposition of the intermediate and upper unit. However, the periods of pedogenesis were shorter in the intermediate unit, and longer in the upper unit. FAPESP, process n. 2012/232090, is thanked for financial support.

**Cumulative palaeosols: a particular geological conditions for "accumulation" of sauropods eggs (Upper Cretaceous, Tama, La Rioja)**

Basilici, G.[1], Fiorelli, L. E.[2], Hechenleitner, E. M.[2], Grellet-Tinner, G.[2]

[1] Instituto de Geociências, UNICAMP, Cidade Universitária, Campinas, 13083-870, Brazil – basilici@ige.unicamp.br
[2] Centro Regional de Investigaciones Científicas y Transferencia Tecnológica (CRILAR-CONICET), Entre Ríos y Mendoza s/n., 5301, Anillaco, La Rioja, Argentina.

The Los Llanos Formation is a stratigraphic unit that crops out in La Rioja Province. Whilst the age of this formation is still debated, fossil remains of sauropods (bones and eggs) and ostracods indicate a Cretaceous age. In this communication, the palaeoenvironmental aspects that allowed the "accumulation" of sauropod eggs will be discussed. We will consider the aspects of construction, accumulation, and preservation of the eggs, considering them as part of the geological record. At the discovery site of the eggs (Tama, La Rioja), the Los Llanos Formation is 160 m thick. It consists of poorly sorted, on average fine- to coarse-grained sandstone, and few beds of sandy conglomerate. The sandstone beds represent a succession of palaeosol profiles, whereas the sandy conglomerate beds appear to have been yielded by no-channelized subaquatic flows. The lack of clastic fraction less than coarse-grained silt coupled with abundant rounded and frosted grains of medium-grained sand and rare ventifact pebbles suggest that the parent material was transported and deposited by wind. The palaeosols succession is characterised by a prevalent pale reddish orange colour, infrequent Bk horizons (calcrete), and rare silica pseudomorphs after gypsum that suggest oxidising and arid palaeoenvironmental conditions. However, light gray horizons, ubiquitous root traces, and platy structures, separated by thin sparitic laminae, indicate localised stagnant-water in the ancient soil profile and root activity. Thus, the palaeosols suggest semi-arid conditions, with sufficient precipitation to sustain an adequate vegetation cover. The palaeosol profiles are immature because pedogenic features, which form in a time interval greater than 1 ka, are uncommon, and the Bk horizons are limited to isolated nodules. Moreover, the horizons show an exaggerated thickness, on average more than 1 m. Immaturity and highly thick horizons suggest that the palaeosols were formed in environments subjected to high sedimentation rate by wind action. The pedogenesis kept pace with the sedimentation, and the deposits were pedogenised shortly after their formation. However, the soils did not acquire well-developed structures because the continuous input of sediments increased the topographic surfaces and continuously rejuvenated the soils. The palaeosol profiles formed under such conditions are called cumulative.

In conclusion, (1) the "construction" (ovideposition) of the sauropod eggs was promoted by a vegetated palaeoenvironment with shallow groundwater level, which was adequate for sauropods nesting; (2) the "accumulation" (burial) of the eggs was facilitated by the high rate of sedimentation; (3) the "preservation" is due to the creation of accommodation space, which origin is debated.

Acknowledgments: FAPESP, process n. 2012/232090, is thanked for financial support.

**Carbonate Deposition in the Great Salt Lake, Utah**

Baskin, R.L.[1], Wright, V.P.[2]

[1] University of Utah, Salt Lake City, Utah 84112 - rlbaskin@usgs.gov
[2] Natural Sciences, National Museum of Wales, Cardiff, UK

Great Salt Lake, Utah is the largest known extant carbonate lacustrine deposystem, providing an analogue for terminal lake carbonates in rift systems. Limited siliciclastic input has created a carbonate province currently covering over 4,000 square kilometres, with a carbonate factory dominated by aragonite ooids and microbialites.

The hydrologically closed lake has limited groundwater recharge and no significant hydrothermal input. Spring mounds occur locally along the lake margins but larger sub-lacustrine mounds are still poorly understood. Waters of Great Salt Lake are supersaturated with calcium carbonate throughout the year and become significantly more saturated during the summer months. The lake is subdivided by a causeway that limits the supply of fresh water and sediment available to the north part of the lake. Halite currently precipitates in the area north of the causeway and microbialite development has ceased in salinities of ~26%.

Developing a stratigraphic facies model presents problems as the current deposystem is likely less than 10, 000 years old, although the rift system has over 4kms of post-Oligocene sediment fill. The lake is shallow, with an average depth of 4.45 meters, with a maximum depth of 10 m. The prevailing wind is from the NW and the long axes of the lake sub-basins are north-south, and with wave base around 4m most of the lake is wave-influenced. Ooid shoals dominate many shorelines and the supra-littoral zones are commonly veneered by oolitic intraclast breccias.

Microbial bioherms cover more than 1,000 square kilometres and occur as dispersed to laterally-connected forms, ranging from centimetres to over 2m in diameter, with relief up to 1.5m. They are prone to burial by sediment and are extensively developed on topographic highs formed on the footwalls of small faults, being onlapped by sediments on the footwalls. Thus the microbialites are highly sensitive to salinity, and water depth in terms of wave energy, light availability, and sedimentation.

Great Salt Lake is an example of a high energy, ramp-margin lake and predicting what might enter the stratigraphic record is highly speculative. Preservation potential of microbial deposits in the lake depends, in large part, on the hydrologic balance. The present ooid-microbialite sediment veneer might be preserved under salt, deeper-water sediments, or eroded during an extended lowstand. Examination of sub-bottom lithology and the hypersaline north part of the lake provides clues as to possible methods of preservation for such fragile and unique deposystems.

**Shelf Morphology as an Indicator of Sedimentary Regimes: The Case Study of the Eastern Brazilian Shelf**

Bastos, A.C.[1], Marangoni, M.B.[2], Quaresma, V.S.[1], D'Agostini, D.P.[1], Bourguignon, S.N.[1], Cetto, P.H.[3], Silva, A.E.[1]

[1] Departamento de Oceanografia, Programa de Pós Graduação em Oceanografia Ambiental, Universidade Federal do Espírito Santo, Brazil - Alex.bastos@ufes.br
[2] Laboratório de Geologia Marinha, Programa de Pós-Graduação Geologia e Geofísica Marinha, Universidade Federal Fluminense, Niterói, RJ, Brazil.
[3] GeoRadar Serviços Offshore, Rio de Janeiro, RJ, Brazil.

Modern shelf morphology is the result of the interplay between short and long term sedimentary processes. The relation between rates of sediment supply/carbonate growth and the creation of accommodation space not only control coastal transgression and regression, but also define the shelf sedimentary regimes acting to shape the seabed. Therefore, shelf morphology and sedimentology are investigated in order to discuss how these characteristics can be representative of distinct sedimentary regimes. The study area is located in the eastern Brazilian shelf where coastal retrogradation and progradation coexist with the most important coral reef system of the South Atlantic. A compilation of existing published and unpublished data was carried out in order to produce morphological and faciological maps and to compare the mapped features with high-resolution seismic and sonographic data. The results show three major regions or morphological compartments: Abrolhos Shelf, Doce River Shelf and the Paleovalley Shelf. Rhodolith beds predominate over the outer shelf along the entire area, coralline reefs are present along the northern Abrolhos inner shelf, and a significant terrigenous mud deposit is observed associated to the Doce River adjacent to the inner shelf beds. The rest of the shelf is composed of bioclastic or terrigenous mud sand and gravel. Terrigenous sedimentation is always restricted to the shoreface or inner shelf shallower areas and carbonate sands and gravels are predominant elsewhere. The Abrolhos shelf shows two distinct sectors; the northern area characterized by mixed terrigenous sedimentation supplied by a longshore current mainly from coast to shore, and a carbonate sedimentation characterizing the inner and outer shelf. The southern shelf morphology and sedimentation are controlled by a preexisting topography and is typically a depositional shelf with associated rhodolith beds. The Doce river shelf is a supplying area where 5 to 8m thick regressive deposits with downlapping clinoforms occur. Southward from the Doce river shelf, a significant shift in sedimentary regime is observed as the morphology becomes very irregular with associated hardbottoms and unfilled paleovalleys. This is the Paleovalley shelf deposition sector. The interpretation shows that the entire study area can be defined as a mixed sedimentation shelf, showing supply and deposition regimes. Shelf morphology is responsible of these changes. Carbonate/terrigenous deposition occur during a highstand/regressive phase coeval along the eastern Brazilian shelf, either laterally and across shelf. This lateral/along coast variation in sediment supply and carbonate growth lead to distinct lateral facies and geometry, so these spatial changes in morphology and facies is very important for the correlation or interpretation of the geological record, especially stratigraphic surfaces and sequence units.

**Oman oases: contrasting carbonate sediments on the Gondwana margin in the immediate aftermath of the Permian-Triassic boundary mass extinction**

Baud, A.[1], Goudemand, N.[2], Brosse, M.[3], Frisk, Å.[3], Bucher, H.[3], Richoz, S.[4]

[1] Parc de la Rouvraie 28,CH-1018 Lausanne, Switzerland - aymon.baud@unil.ch
[2] Paleobiology Group, Stanford, Palo Alto, CA, USA
[3] Paleontological Institute and Museum, CH-8006 Zurich, Switzerland
[4] Institute of Earth Sciences, University of Graz, Heinrichstrasse 26, Graz, A-8010, Austria

Basal Triassic carbonate sediments are cropping out on the Gondwana margin in Oman, which are well dated (*Hindeodus parvus* to *Isarcicella isarcica* zones). These sediments reveal the contrasted oceanic conditions that prevailed in the immediate aftermath of the end-Permian "great dying".

The Griesbachian shallow water carbonate platform consists of a 20 m. thick stack of light grey lime mud beds (5-20 cm thick), and is lacking skeletal material and trace fossils. This shallow water platform exported non-skeletal lime mud on the slope. Extended slope deposits are exposed in the Wadi Maqam of the Sumeini area in northwestern Oman. The Permian-Triassic Boundary shales are overlain by laminated limestone, which are 10m thick, and consist of lime mud, which is locally thinly contorted, without any skeletal elements. Some trace fossils appears only in the upper part of the *Isarcicella isarcica* conodont zone.

Coeval, Griesbachian shallow oceanic plateau carbonates were recently discovered in the Batain area (southeastern Oman). These are reworked as boulders in mid-Jurassic conglomerates. In marked contrast with the shallow water platform sediments, these boulders consist of highly diversified skeletal accumulations. A one-meter thick boulder contains a varied and abundant benthic and nektonic fauna of crinoids, echinoids, ammonoids, bivalves, gastropods, microconchids, ostracods, conodonts and foraminifers.

Echinoderms are the main component of the calcarenite (lime packstone with lime mud matrix). The disarticulated crinoid columnals are mixed with mostly unbroken molluscan shells showing no signs of abrasion or bioerosion. This preservation suggests either absence of or minimal lateral transport.
This crinoidal limestone, deposited within the early to mid Griesbachian *Hindeodus parvus* to *Isarcicella isarcica* conodont zones, differs from the coeval part of the less diversified Wasit block, recording a coquina build-up floating in calcite cement (lime floatstone).

There is no evidence of anoxia on this well oxygenated shallow neritic plateau, nor any sign of "intense post-extinction acidification". This may explain why the Oman neritic oceanic plateau records a very early (i.e. Griesbachian) episode of marine ecosystem recovery.
The oceanic mounds or plateaus apparently escaped the environmental deterioration that prevailed on the continental platform and slope and may have functioned as oases.

**Paleoweathering profile developed on homogenous sedimentary basement: an integrated approach from the CDB1 deep borehole (Rennes Basin, France)**

Bauer, H.[1], Wyns, R.[1]

[1] BRGM, ISTO, UMR 7327, BP 36009, 45060 Orléans, France - h.bauer@brgm.fr

Weathering profiles are mostly studied on their upper part (crust, saprolite) where leaching and concentration/precipitation of valuable element occur. For water resource and hydrocarbon purpose, the transition between saprolite and fresh basement is of utmost importance. Here is found the fissured layer, a highly fissured bedrock that it favorable for aquifer/reservoir properties. Such a weathering profile model is well known on igneous and metamorphic rocks, but curiously very poorly documented on sedimentary, non-metamorphic, basement.
On behalf the CINERGY project, a 675m-long borehole (CDB1) was cored through the sedimentary infill (405 m), then the weathered basement (110 m) and finally the fresh bedrock (160 m). The basement is made of the "brioverian schists", which actually are epimetamorphic shales and fine grained sandstones, highly folded and cleaved.
Here is presented an integrated (well-logging, mineralogy, petrography) study of the weathering profile that has been preserved under the sedimentary infill of the Rennes Basin.
The well logging tools include Gamma-Ray, long and short resistivity, neutron porosity, gamma-gamma density, Pef, Full wave Sonic, BHTV and caliper. The cores were regularly sampled for total rock and clay mineralogy and some petrographic control were realized on specific facies and fracture fillings.
The core description gives a first visual sequence of the weathering profile. From up to bottom, we observe a 1 m-thick interval of massive ochrish clays, followed by 0.7 m-thick of structured ochrish clays, becoming greyish downward. The clays tend to become harder downward, and from around 422 m to ~470 m, the shales look highly fractured. From 470 m to the bottom of the core, the rocks look very hard.
When looking at the physical parameters from the well logging, the interval boundaries do not look the same, and especially the saprolite/fissured layer boundary is very hard to point out, as the parameters show a gradual change all along the weathered profile. It is only towards 520 m that parameters (GR, sonic, resistivity) seem to reach a steady state, highlighted by the very monotonous lithology of the basement.
The clay mineralogy is made of kaolinite, illite and chlorite. Chlorite is dominant below 510 m whereas kaolinite becomes more abundant from this depth upward; illite looks quite constant throughout the core.
Petrographic control on the fracture fillings shows a polyphased precipitation of chloritic quartz, followed by carbonated (calcitic and dolomitic) and pyritized fillings. Oxidization of pyrite into goethite is observed even deep into the weathering profile (480 m).
These first results show that the classic model of weathering profile is not suitable for sedimentary basement, which is in this case made of argillaceous sediments which did not develop a real fissured layer and so did not allow the aquifer/reservoir layer to take place.

Acknowledgements: The CDB1 borehole was funded by Région Bretagne, CG35, Chartres-de-Bretagne, Rennes Métropole, IAV, SMG35, SMPBR and Préfecture de Bretagne. The BRGM, AELB and ADEME agencies funded the scientific survey and geological studies.

**Palaeoenvironments and palaeoclimate records in lacustrine deposits at the Eocene-Oligocene Transition. New insight from de CDB1 borehole (Rennes Basin, France)**

Bauer, H.[1], Châteauneuf, J.J.C.[2], Bourdillon, C.[3], Saint-Marc, P.[4], Guillocheau, F.[5]

[1] BRGM, ISTO, UMR 7327, BP 36009, 45060 Orléans, France - h.bauer@brgm.fr
[2] BRGM (retired) 8 quai du Châtelet, 45000 Orléans, France
[3] ERADATA, 170 avenue Félix Geneslay 72100 Le Mans, France
[4] SEMM LOGGING, Les Maufras - 18360 Vesdun, France
[5] Université de Rennes 1, UMR 6118 Géosciences Rennes, Campus de Beaulieu, 35042 Rennes Cedex, France

On behalf the CINERGY project, a 675m-long borehole was cored through the sedimentary column (405 m) and the basement (270 m).
The studied interval encompasses 3 lithostratigraphic units, from 66m to 405m depth. The chronostratigraphic framework of the sedimentary series relies on benthic foraminifera and palynology. Palaeoenvironmental reconstruction is based on sedimentology, pollen analysis and clay mineralogy.
The *Natica* Marls Fm (66-85m) is a lagoon-marine unit exhibiting metric sequences from restricted bay to salt marsh (schorre). Pollen grains, Mollusks and Dinocysts assemblages give a Rupelian age.
The Lower Sapropels Fm (85-375m) is the thickest unit and exclusively made of lacustrine and palustrine clay deposits. Clays are either thinly laminated (varve-like) or massive, blocky with pedoturbation and/or brecciated fabric, alternating in thick (20-40m) sedimentary sequences. Both facies show varying organic content, up to 40% TOC. Pollen assemblages show a bimodal repartition between the laminated and massive facies. The former are interpreted as an open lacustrine system and the latter, as a closed lacustrine system whose floating mats vegetation, characterized by papyrus and lotus is typical of permanent flooded areas.
The first occurrence of the Early Rupelian marker *B. hohli* is observed at 195.13m. First results from magnetostratigraphy and cyclostratigraphy argue for an E/O boundary at ~202 m depth. The Eocene-Oligocene Transition is thus recorded in a detailed, continuous depositional environment.
The Chartres-de-Bretagne Fm (375-405m) corresponds to alternating sandy and clayey deposits. Depositional environments range from fluvio-lacustrine to fluvio-marine settings with occasional mangal development as attested by *Avicennia*. The formation is assigned to the Bartonian by benthic foraminifera and palynology. The lowermost samples yielded a 'Biarritzian' age, which is equivalent to the Early-Middle Bartonian.
The palynological record shows a gradual palaeoclimate change. The Bartonian is quite similar to the Lutetian of the Paris Basin, with a warm and humid "tropical" climate. The Early Priabonian, up to 278m, is still under humid and warm conditions, but development of herbaceous vegetation attests for a slight seasonality. During the Late Priabonian, a large development of Pinaceae coeval with a decrease in megathermic flora points to the EOT major climatic change. Indeed, Early Rupelian assemblages show even greater percentages in Pinaceae (above 50%) despite a steady lacustrine environment. The very last megathermic elements disappear at the base of the *Natica* Marls Fm.
The clay mineralogy evolution looks more abrupt. The clay assemblage from the Bartonian to the Late Priabonian is fully kaolinitic. The Early Rupelian assemblage is still dominated by the kaolinite but smectite appears in a significant amount (up to 60%). Whether the sudden mineralogical change across de E/O boundary is related to a change in source material or to a change in the hydrolysis in soil clay production, a climatic origin is very likely.

Acknowledgements: This work was funded by Région Bretagne, CG35, Chartres-de-Bretagne, Rennes Métropole, IAV, SMG35, SMPBR, Préfecture de Bretagne, the BRGM, AELB and ADEME agencies.

**Tectonic controls for location of swamp to continental lacustrine–flood plain deposition in tropical settings (Andes of Colombia)**

Bayona, G.[1], Jaramillo, C.[2], Montes, C.[3]

[1] Corporación Geológica ARES, Colombia - gbayona@cgares.org
[2] STRI, Panamá
[3] Universidad de los Andes, Colombia

Cenozoic deformation in the northern Andes controlled tectonic subsidence in continental basins, whereas humid conditions in tropical settings favored development of water columns. We review how the changes in tectonic setting controlled the areal distribution of swamp to lacustrine – flood plain continental deposition.

1. CRUSTAL TILTING, CARIBBEAN SUBDUCTION

Crustal tilting framed the one km-thick coal-bearing strata accumulation in swamps (Guaduas Fm.) during Maastrichtian time in the south and then in the north during the Paleocene (Umir, Cerrejon fms). Maastrichtian swamps document marine influence, whereas Paleocene swamps are continental. Internal crustal-tilting blocks favored the accumulation of thick flood plain deposits with paleosol development (Bogota Fm.).

The crustal tilting model explains a large separation of source-sink areas, with high subsidence in one border and low topography in the opposite border. The large distance between exposed source areas and the basin favored accumulation of fine-grained strata in 100´s km width and several 100´s km long swamps and flood plain conditions. Fine-grained sandstone interbeds have dominantly sheet-like geometries, documenting dominance of unconfined fluvial processed bordering the swamps or cutting the floodplains.

2. STRIKE-SLIP SETTING

Eocene oblique subduction of the Caribbean plate conditioned deformation in basins adjacent to the collisional margin allowing the record of one-km-thick units within isolated basins bounded by internal uplifts. The record consists of fine to medium grained channel-fill sandstones interbedded with floodplain mudstones with strong paleosol development in the south (Fusagasuga Fm.), whereas basins in the north are more humid favoring localized development of swamps and paleosol profiles (Esmeraldas Fm.). In the northern area, a marine incursion favored the thin record of ephemeral lake system.

Internal uplifts and basin geometries are more related to strike-slip tectonics, with localized depocenters for deposition of swamps and flood plains, and only one marine ingression is recorded at the top of the northern unit.

3. FORELAND SETTING, PACIFIC SUBDUCTION

Pacific plate subduction favored the development of mountain belts bounded by continental foreland systems. In the western Magdalena foreland basin, the only record of fresh-water conditions is during the Early Miocene (Santa Teresa Fm) within a wedge-top depozone. In the central axial cordillera foreland basin, uppermost Eocene to lower Oligocene strata (Usme –Concentration fms) record swamp deposition with brackish-water influence. Elongated swamp-lacustrine systems are bounded by the geometry of thrust belts.

Basal sandstones of the eastern Llanos foreland basin (Carbonera Fm.) are overlying by mudstones that accumulated in ephemeral lakes that separates orogen- from forebulge-derived fluvial systems. Dynamic topography and flexural subsidence and global rise of sea level favored a regional marine transgression that covered rapidly the Llanos basin (ca 400 km width by 600 km long) in ca 20 Ma. Deltaic-fluvial sandstones (upper Carbonera Fm.) rapidly filled the large-scale brackish to lacustrine system. However, an increase of tectonic subsidence and climate in the Middle Miocene favored the record of large-scale fresh water lakes with temporal connection with brackish to marine waters (Leon Fm). The onset of late Miocene Andean deformation caused the basin-wide filling of the lake system.

**Documenting the timing of change of regional drainages during the Paleogene in the northern Andes**

Bayona, G.[1], Lamus, F.[1], Cardona, A.[2],

[1] Corporación Geológica ARES, Colombia - gbayona@cgares.org
[2] Universidad Nacional de Colombia

Uplift of ranges in the northern Andes began since latest Cretaceous time, creating northeast to east-flowing drainages that change to the present northward direction of the Magdalena and Cauca rivers in Colombia. When was formed this northward-directed river system? Integration of stratigraphic, provenance and thermochronological analyses in the 2.2 km thick Paleogene succession of the axial zone of the Eastern Cordillera (Usme Syncline, US) and 2-km thick section in the western thrust belt (Fusagasuga Syncline, FS), allow proposing a evolution model of the paleo-Magdalena drainage. The location of these two sections is fundamental to understand when the Central Cordillera stopped supplying sediments to sections located in the axial zone of the Eastern Cordillera.

Sedimentological and palynological analyses in both sections indicate the dominance of continental environments for Paleogene strata. Palynology and detrital volcanic zircons indicate different age for thick paleosols record. The 1.4-km-thick paleosol and fluvial record in the US indicate a late Paleocene-early Eocene, whereas coeval strata in the FS are 100 m. In contrast, the 1.7-km-thick paleosol and fluvial succession in the FS is Middle Eocene-Oligocene, whereas coeval deposition in the US decreased abruptly with dominance of fluvial quartzose strata.

Provenance analysis integrates sandstone petrography, heavy mineral association, and detrital zircon geochronology. In the US, sandstone compositional maturity decreases upsection from quartzarenites and sublitharenites in lower Paleocene strata to litharenites and feldspathic litharenites in upper Paleocene – lower Eocene strata, with a volcaniclastic interval. In contrast, compositional maturity increases abruptly to sublitharenites and quartzarenites in middle Eocene-early Oligocene strata. Heavy mineral association changes similarly to the sandstone composition, being the volcaniclastic interval upper Paleocene strata with the highest concentration of unstable minerals. In the FS, sandstone compositional maturity decreases upsection in Middle Eocene-Oligocene strata with a higher content of feldspar grains than in the Usme section. Heavy mineral association is dominated by apatite and garnet, with no major changes in the stratigraphic column. Detrital zircon ages in the Paleocene-lower Eocene strata of the US, and for all the units in the FS, show dominance of 70-90 Ma and 220-290 Ma populations indicating supply from the Central Cordillera. In contrast, detrital zircon ages older than 500 Ma increased in samples of middle Eocene-Oligocene strata of the US are interpreted as reworking of the Cretaceous sedimentary cover.

The change in sandstone composition, heavy mineral association and detrital zircon ages in the US is coincident with a change from high subsidence rates in late Paleocene – early Eocene time to an interval of low subsidence rates in middle to late Eocene time. Detrital zircon population, reworked Cretaceous pollen and glauconite, and the change in sandstone composition indicate provenance from westerly uplifts during the Paleocene-early Eocene (Central Cordillera + nearby uplifts with Cretaceous cover). Source areas for middle Eocene-lower Oligocene strata in the US were composed of quartzose Cretaceous rocks located eastward; at this interval tectonic subsidence rates decreased in comparison with coeval strata in the FS, where the provenance analysis indicate supply from the Central Cordillera. The change of source area in middle Eocene time and onset of exhumation in early Oligocene time coincides with culmination of deposition along the axial zone of the Eastern Cordillera and generation of northward-directed paleodrainage systems.

**The influence of climate on an evolving fluvial system: an example from the Cretaceous Ghaggar-Hakra Formation, Barmer Basin, Rajasthan, India**

Beaumont, H.[1], Clarke, S.[1], Taylor, A.[2], Whiteley, N.[3], Mohapatra, P.[3]

[1] Basin Dynamics Research Group, School of Physical and Geographical Sciences, Keele University, Keele, Staffordshire, UK - h.beaumont@keele.ac.uk
[2] Ichron – part of the RPS Group, Century House, Gadbrook Business Centre, Northwich, Cheshire, U.K
[3] Carin India, 3rd and 4th Floor, Vipul Plaza, Sun City, Sector 54, Gurgaon, India

Fluvial systems are often strongly influenced by the prevailing climatic conditions under which they evolve. An example of this is the Cretaceous-aged Ghaggar-Hakra Formation, exposed at outcrop in Barmer Basin, Rajasthan, India. It is a poorly-documented fluvial sedimentary succession that comprises three distinct fluvial channel-dominated sandstone units that interbeds with significant thicknesses of mudrocks that are devoid of channel elements. This work presents the first detailed account of this succession from outcrop studies, which in time, will be compared to a subsurface dataset where the same sandstones are part of a producing reservoir. We attribute to evolution of the formation to a single fluvial system in response to variations in climate and sediment supply.

Starting at the base, the Darjaniyon-ki Dhani Sandstone, comprises debris- and fluid-flow successions, distinctive of an immature fluvial system with a high sediment load. The second sandstone, the Sarnoo Sandstone, constitutes point bars, chute channels and amalgamated channel-fills which we attribute to a low-sinuosity meandering fluvial system. The upper-most sandstone succession is the Nosar Member which constitutes amalgamated channel-fill succession of braid bars with little floodplain deposition typical of a braided fluvial system.

The intervening mudrocks of the Ghaggar-Hakra Formation are attributed to floodplain deposition. In general the floodplain lacks fluvial channels (such as chutes and rills) and locally develops palaeosols, which suggests a high rate of sediment supply to the floodplain. There is a marker vertisol horizon below the Sarnoo Sandstone which suggests a significant drying out period which is key point in the evolution of the fluvial system.

We interpret the evolution of the fluvial succession from high sediment bed-load more chaotic short-lived braid plain into extensive floodplains with sinuous river channels. The Nosar Member marks the change back to a long-lived regionally mapped braided system. The palaeodrainage direction remains constant during this time; however, the fluvial style changes reflect variations in river gradient, runoff and bedload linked to climate cyclicity and active tectonics. The outcrops are located in uplifted and rotated footwalls to a set of Mesozoic-aged faults. It follows that climatic / tectonic influence on fluvial development has significant implications for reservoir quality of the Ghaggar-Hakra Formation.

Acknowledgements: Cairn India for funding and administrating all field work and providing working materials, gratitude goes to Ichron (part of the RPS) for the latter.

**Deciphering creep *versus* co-seismic offset increments on submerged sections of active faults through associated sedimentation. Tentative paleo-magnitude estimations**

Beck, C.[1], Campos, C.[1]

[1] ISTerre, UMR CNRS 5275, University of Grenoble-Alps-Savoy, 73 376 Le Bourget du Lac, France – beck@univ-savoie.fr

Beside trenching across outcropping active faults, the analysis of lacustrine or marine sediments deposited above such faults, along submerged segments, may represent a useful complement of the onshore data for earthquake hazards estimation. As faults behavior may consist, either in a continuous slow displacement (creep), or in spaced co-seismic offset increments (or both in some cases), this discrimination is a key datum. For the later ones, assessment and quantification of seismic hazards is based on seismotectonic parameter (rupture length, offsets, etc.) and chronology.

We present several case studies where we could characterized specific sedimentary events and their particular geometrical relationship with active faults, in marine basins. Based on high resolution seismic imaging and core analyses, recent sedimentary archives permit: 1) to assess co-seismic offsets through coeval sedimentary events (homogenites resulting from reflected tsunamis), 2) to estimate recurrence time intervals of major events for the last 20 000 yrs. Furthermore, in one favorable case (Lesser Antilles, Sea of Marmara central basin), co-seismic offsets could be precisely measured. Taking into account the precision of high resolution seismic profiles and a possible sediment compaction, the vertical component of the total displacements appears - for the observed period - as resulting of the sum of co-seismic offsets (little or no creep). Thus, paleo-magnitudes could be proposed, adding geometrical and mechanical data.

**Earthquake imprints on 400 years of marine sedimentation in the western Gulf of Corinth, Greece**

Beckers, A.[1, 2, 3], Hubert-Ferrari, A.[1], Beck, C.[2], Tripsanas, E.[8], Reyss, J.-L.[4], Albini, P.[5], Rovida, A.[5], Scotti, O.[6], De Batist, M.[7], Sakellariou, D.[8], Bernard, P.[9]

[1] University of Liège, Institut de Géographie (B11), Dept of Physical Geography and Quaternary, Liège, Belgium - abeckers@doct.ulg.ac.be
[2] ISTerre, CNRS UMR 5275, University of Savoie, F-73376 Le Bourget du Lac, France
[3] FRIA, Brussels, Belgium
[4] LSCE, CNRS UMR 8212, avenue de la Terrasse, 91198, F-91191 Gif-sur-Yvette, France
[5] Istituto Nazionale di Geofisica e Vulcanologia Via E. Bassini, 15, 20133 Milano, Italy
[6] Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Fontenay-aux-Roses, France
[7] Renard Centre of Marine Geology, University of Gent, B-9000, Gent, Belgium
[8] Institute of Oceanography, Hellenic Center of Marine Research, GR-19013 Anavyssos, Greece
[9] IPGP, CNRS UMR7154, PRES Sorbonne Paris Cité, France

The Corinth rift is one of the fastest spreading rifts on Earth. In the western tip of the Rift, no major historical earthquake ($M_w \geq 6$) is known for the last 300 yrs, while the geodetic extension rate is the highest of the whole Corinth Rift. The question of seismic hazard is consequently particularly relevant. In this framework, we investigated the offshore sediments in order to look for sedimentary signature of past earthquakes. 12 short gravity cores have been retrieved in different environments: two shelves (40 and 100 m deep), one sub-basin (180 m deep) and the deep Gulf axis (330 m deep). The cores are 0.5 to 0.85 m long, permitting to analyze up to 400 yrs of sedimentation. Several sedimentological analyses have been performed: magnetic susceptibility, grain-size, XRF, ASM. Chronology is based on $^{137}Cs$ and $^{210}Pb$ decay. In parallel, an in-depth analysis of existing and newly found documents has been done to re-interpret macroseismic intensity fields of historical earthquakes and to build an updated earthquake catalogue for the area. These new data allowed us to estimate a macroseismic intensity threshold for submarine slope failures in the area, based on 16 reported events. Sedimentary events have been identified in all cores. On the first shelf, despite a visually homogenous, silty, sedimentation, 3 events have been highlighted by high resolution grain-size analysis and $^{210}Pb$ decay profile's disturbances. The upper one could be a back-wash flow tsunami deposit. On the second shelf, 4 high-concentration density flow deposits occurred with a recurrence time of ~58 yrs. In the canyon and in the sub-basin, sandy turbidites occurred with recurrence times of ~26 and ~56 years respectively. The possible seismic origin of these deposits is discussed based on their sedimentary characteristics and the macroseismic intensities assessed for the sediments source areas for each core location.

**Dolomitizing fluid flow along fractures – Case study on textures in dolomitized Permian host rock in the Central Oman Mountains**

Beckert, J.[1], Vandeginste, V.[1], John, C.M.[1]

[1] Qatar Carbonates and Carbon Storage Research Centre, Department of Earth Science and Engineering, Imperial College London, SW7 2BP London, U.K. - j.beckert12@imperial.ac.uk

Dolomitization occurring at intermediate or deep burial conditions is commonly linked to preferential fluid flow along fractures. Fracture-related breccia structures associated with these dolomite bodies represent a frequently observed phenomenon, e.g., linked to burial leaching by mixing or cooling of formation fluids, or to fault activity. However, the presence of breccia structures could arguably also refer to eodiagenetic karst processes predating the migration of dolomitizing fluids.

In order to establish a breccia formation model we investigated a tens of meter wide breccia structure hosted in dolomitized Permian platform carbonates (Lower Khuff equivalent) in the Central Oman Mountains. This research is especially of importance with respect to petrophysics as large scale dolomitized breccia structures form potential heterogeneities and can yield high porosities relevant to the Lower Khuff reservoir rocks.
Field observations, thin section analyses and stable carbon and oxygen isotope measurements from samples taken across the breccia, allowed us to distinguish an early diagenetic dolomite phase generated during Triassic times (ED) and a late diagenetic dolomite phase (DT2). The latter is related to the migration of warm fluids during mesodiagenesis (End Triassic to Mid Cretaceous).

The investigated large-scale breccia structure within a DT2 dolomite body reveals angular limestone and ED clasts floating in a medium- to coarse-grained dark red DT2 dolomite matrix. In addition, DT2 clasts were observed at the periphery of the breccia structure. The clast arrangement is very poorly sorted and lacks gravity grading, compositional sorting or coarse-grained cement phases covering clasts. Primary meteoric cement phases are absent. As a rarely observed phenomenon horizontal to subhorizontal pipes at the edge of the breccia show angular clasts penetrating the pipe walls.

The lack of clast sorting and the lack of indications in favour of the involvement of meteoric fluids suggest breccia formation is not related to the formation of collapse structures and karstification during early diagenesis. This assumption is supported by horizontal pipes filled with unsorted clast material. Furthermore, the presence of stylolite strike - dip directions in breccia clasts deviating erratically from orientations measured in the surrounding host rock, implies that the brecciation postdates burial pressure solution.
From a tectonic point of view, none of the regional tectonic lineaments reveal gouges that are tens of meters wide and, hence, the observed large breccia features are unlikely to represent a single major fault gouge. V-shape fractures within clasts as well as clasts penetrating pipe walls point to the involvement of hydraulic fluid flow along feeder faults and fractures at the base of the breccia.

In summary, the framework of abrasion processes along fractures, hydraulic fluid flow and partial dissolution potentially initialized the formation of the large scale breccia fabric. Furthermore, different clast compositions with respect to dolomite phases point to at least two pulses of fluid migration, potentially linked to differences in the hydraulic fluid pressure regime.

This study is funded jointly by Qatar Petroleum, Shell and the Qatar Science & Technology Park.

**Fluvial silicoclastic and tufa facies from upper Pleistocene deposits: the Quequén Salado Valley (Argentina)**

Beilinson, E.[1], Tomassini, R.[2], Rabassa. J.[3], Zárate, M.A.[4], Gasparini, G.M.[5], Deschamps, C.[6]

[1] Centro de Investigaciones Geológicas (UNLP-CONICET) - beilinson@cig.museo.unlp.edu.ar
[2] UNS – CONICET
[3] CADIC-CONICET y UNTDF
[4] INCITAP – UNLPam – CONICET
[5] Museo de La Plata (UNLP) - CONICET
[6] Museo de La Plata (UNLP) - CIC

In the Quequén Salado River (SE Buenos Aires province, Argentina) several upper Pleistocene tufa successions were identified, interbedded with silicoclastic deposits. The main objective of this contribution is to elaborate a facies model for the tufa successions and to propose a palaeoenvironmental framework for both, tufa and silicoclastic deposits.

The succession studied can be divided into three different stratigraphic intervals according to their vertical facies arrangement. The lower interval has a tabular geometry and a thickness of 1.7 m. Deposition began with massive sandy siltstones with abundant root casts (Fm facies) followed by laminated pale olive (colour code: 10Y 6/2) mudstones (Fl facies) with root casts and gastropods. These deposits are followed by coarse siltstones with a variable content of bioclasts (Sb facies) that show a vertical arrangement from very fragmented to well preserved gastropod shells. This gradation is accompanied by a change towards finer deposits. Finally, this lower interval ends with a framestone of macrophytes (Lst 1 facies) and rudstones and floatstones of phytoclasts with a micritc matrix and malacofauna (Lph facies).

The base of the middle stratigraphic interval is an erosive surface followed by a tabular to lenticular phytoclastic limestone (Lph facies). These deposits are 30 cm thick and do not show internal organization. The identifiable biologic content are fragments of stems. On top of the Lph facies, a tabular boundstone with horizontal and undulating lamination can be recognized (Ls facies) which top is characterized by an erosive surface followed by lenticular conglomerates (G facies). Lenses are 15 to 20 cm thick and 4 m wide. Finally, lenses and patches (30 to 40 cm thick) of a boundstone of charophytes characterize the top of the middle interval. Charophytes display several morphologies from calcified bushes, vertical or inclined, alternated with laminar forms (Lch facies).

The upper stratigraphic interval is the thickest of the studied succession with almost 2.5 m thick and tens of meters of lateral extent and a general lenticular geometry. It starts with a phytoclastic limestone (Lph facies). Phytoclasts are large (around 10 cm) and surrounded by a micritic matrix. Planar and undulatory layers of a microbial boundstone (Ls facies) follow Lph facies deposits. The top of this interval is characterized by alternating deposits of a boundstone of vertical stems with calcitic coating, mm to cm in diameter and up to 1 m long (Lst 2 facies); botryoidal laminar crusts, 5 – 10 cm in diameter and mm thick laminae of micirte and sparite (Lsp facies) and 20 cm of bioclastic sandstones and marls with fragmented malacofauna and macrophytes.

The vertical arrangement of the identified facies allowed to propose different facies models to account for the palaeoenvironmental evolution of the analyzed succession. Deposition started with fluvio-palustrine and palustrine deposits (Fm, Fl, Sb, Lst 1 and Lph facies). Deposition of Ls, Lch and G facies points to the development of fluvio-lacustrine tufas, with Ls facies interpreted as calm areas. Finally, Ls, Lst 2 and Lsp facies indicate increased energy and the development of tufa facies in a fluvial environment, characterized by barrages. Here, Ls facies were interpreted as accumulated in fast-flowing areas of the river bed such as cascades.

**Mass wasting processes and their triggering mechanisms in Hardangerfjorden, Western Norway**

Bellwald, B.[1], Hjelstuen, B.O.[1], Sejrup, H.P.[1], Haflidason, H.[1]

[1] Department of Earth Science, University of Bergen, Allégaten 41, N-5007 Bergen – Benjamin.Bellwald@geo.uib.no

Submarine failures are a common sedimentary process within fjord systems and may represent a severe geohazard to infrastructures and populations along fjord coastlines. The triggering mechanisms of these failures are, however, still not well constrained. This study aims to better understand the processes involved in mass wasting in fjords, to determine triggering mechanisms and to reveal new knowledge about mass wasting frequencies for the time period since the Last Glacial Maximum. In order to resolve these questions we combine TOPAS high resolution seismic profiles, bathymetric data and up to 16 m long sediment cores from the inner part of the Hardangerfjorden system, which has a distance of 70 km from the coast. The Hardangerfjorden system is the third longest fjord in the world and has a width of 1-10 km, a maximum water depth of 860 m and fjord flanks that are up to 80° steep. The fjord bottom, on the other hand, has a gradient of around 1°. The fjord system was last deglaciated shortly after the Younger Dryas time period and geomorphologic thresholds are separating it into several basins.

Our results show that the fjord basins are filled by up to 150 m of sediments (estimated volume of 3 $km^3$), of which the lower part is characterized by glacimarine deposits and the upper part by stacked slide debrites intercalated by turbidite layers. All in all, seven slide debrites are identified and can be followed for about 40 km in the different fjord basins. The slide debrites have a maximum thickness of 14 m and their transport seems to have occurred along significant glide planes, which can be traced into slide wedges deposited along the fjord flanks. At a depth around 55 m below seafloor of the deepest basin, the deposits change abruptly into a continuous laminated character. We assume that these glacimarine sediments, which may partly be intercalated by turbidite layers, were deposited during the last deglaciation/deglaciations of the fjord system. The identified slide debrites are assumed to have mainly been initiated during the rapid uplift of Fennoscandia immediately following the melt-down of the ice sheet.

Ten prominent slide scars, having heights of up to 15 m, are crossing the fjord bottom in the study area. We note that the observed seabed slide escarpments are often associated with up to 0.6 $km^2$ cone-shaped depocenters of higher sediment flux from the fjord flanks. Processes involved in the build-up of these rapidly deposited depocenters may thereby have acted as potential triggering mechanisms for slides and turbidity currents moving towards the deepest part of the fjord. Subaerial datasets suggests river floods, glacier outbursts, landslides and snow avalanches as the significant processes building up these cones. Younger Holocene submarine mass movements in Western Norwegian fjords have previously been attributed to the Storegga Slide tsunami (8200 cal. BP), variations in climate (around 3000 cal. BP) and earthquakes (around 2000 cal. BP).

Acknowledgements: We thank Captain John Hugo Johansen and the crew onboard R/V G.O. Sars for their help collecting data during the research cruise in February 2014. Special thanks goes to DOF Subsea Norway AS and Statnett for the use of their bathymetric dataset.

**The difficulty of understanding Tunnel Valleys and their infill dominated by northward dipping clinoforms in the Southern North Sea – a 3D seismic and borehole data study**

Benvenuti, A.[1], Moscariello, A.[1]

[1] Department of Earth Sciences, Section of Earth and Environmental Sciences, University of Geneva, Rue des Maraîchers, 13, CH-1205 Geneva, Switzerland - antonio.benvenuti@unige.ch

Tunnel Valleys (TVs) are the most typical landforms created by conspicuous erosion of the substrata by glacial-related processes. Their genesis is still debated and generally associated with 1) catastrophic jökulhlaup-like outbursts, 2) a steady state overpressured condition or 3) a time transgressive formation following the retreating ice margin. TVs can be left completely unfilled or partly/ totally filled with sediments. Sediments could be laid down by glacial-related processes during or shortly after the ice-retreat (e.g. subglacial to proglacial range of processes…) or/and by different post-glacial processes in several depositional environments.
The main aim of this study is to clarify the genesis of the incision, the sediment provenance (i.e. syn-glacially reworked bedrock vs. postglacial sourced fluvial deposits), the chronostratigraphy of the sediment succession and, subsequently, the process which driven the sediment deposition.
Here, we present the results of an architectural and compositional study of a buried TV in the Dutch sector of the Southern North Sea (SNS) focusing on the terminal sector (last 40 km) of the largest TV of the SNS (width: 5 km, thickness: 400 m, length: 100 km ca.). For this study a high resolution 3D seismic database is used to map the TV and its infill geometries in detail. The seismic interpretation is constrained by compositional data from cutting samples and a gamma ray log from a gas exploration well (K14-12) entering the TV in the study area.
The TV has a strikingly straight north-south orientation with the exception of its southernmost part in which it exhibits a more sinuous geometry. The valley base is flat in its southernmost sector while it is incised by a narrow channel (686m wide and 65m deep in average) to the North. Tributary valleys are present on both sides of the TV; their depth is considerably lower than the TV floor. The overall infill geometry is dominated by northward-dipping seismic stratigraphic units that diverge in shape and seismic facies, varying from transparent to high-amplitude reflectors in parallel to more complex to chaotic reflector geometries.
Such dominant infill architecture is partly consistent with other TVs described in the SNS area (e.g. the backstepping clinoforms of Praeg 1996; 2003; Moreau et al., 2012); however, it is clearly more complex than simple prograding clinoforms: 1) the size of seismic bodies changes considerably along and perpendicular to the valley axis, 2) very differently and shaped seismic bodies constitute the TV infill, 3) channel-like geometries are present towards the top of seismic bodies and 4) the infill of tributary valleys consistently shows specific shapes where they connect with the TV.
Results from seismic stratigraphy and geomorphological analysis provide insights on TV formation which we interpret as dominated by meltwater erosion in subglacial environment during an ice-retreat phase. The presence of a narrow incision at the bottom of the valley highlights the importance of the erosive action of confined subglacial meltwater. This localized erosion probably occurred at the same time as the erosion occurring at the base of the ice, which was mainly able to enlarge and deepen progressively the valley bed. These observations point towards a steady state formation of the tunnel valley rather than a catastrophic one.
The results from stratigraphy, grain-size distribution, biostratigraphy, palynology and clay mineralogy on cutting samples from the TV's infill sediments do not univocally indicate whether the infill depositional process was linked to glacial processes or to fluvial/deltaic deposition from South in a post-glacial time. However, the TV infill is dominated by a fining-up sequence which, together with the clinoform architecture, suggests that sediments were provided from the North. Therefore, a glaciogenic infill is more plausible than a post-glacial deltaic filling process from South. On the other hand, the presence of lacustrine proxies (gastropods and pollens) of non-glacial origin within the deposits makes the interpretation difficult and requires further analysis.

**Unravelling the glacial imprint on a thick sandstone dominated deposit using provenance data – Tazekka (Morocco)**

Benvenuti, A.[1], Moscariello, A.[1], Ghienne J.-F.[2]

[1] Department of Earth Sciences, Section of Earth and Environmental Sciences, University of Geneva, Rue des Maraîchers, 13, CH-1205 Geneva, Switzerland - antonio.benvenuti@unige.ch
[2] Institut de Physique du Globe de Strasbourg, UMR7516, CNRS/Université de Strasbourg, France

Glaciogenic sediments of the Hirnantian glaciation have been deposited in several areas of North Africa and Middle East during Late Ordovician times. These may form important hydrocarbon and groundwater reservoirs however their highly heterogeneous nature makes the prediction of their lateral extension difficult. Detailed outcrop studies therefore can help to understand better these sedimentary systems. In Morocco, subglacial incisions and related infill can be detected in the Anti-Atlas region (Central Morocco) while sandy units in the Tazekka National Park (NE Morocco) are thought to be distal glaciomarine in origin. The latter sector of Morocco is thought to be located beyond the maximum extension reached by the Ordovician ice-sheet front where only glaciomarine conditions were recorded, as shown by the presence of fine-grained strata with dropstones. Here, the sand-dominated syn-glacial succession (Tifarouine Fm.) can be divided into 4 stratigraphical units which alternate similar characteristics: Units 1 and 3 would refer to distal turbidite deposits while Units 2 and 4 are likely to be originated by proximal high energy flows. The facies variability is likely to reflect the two glacial advances registered in Anti-Atlas through subglacial incisions, namely Units 2 and 4 reflecting more proximal conditions than Units 1 and 3. However, the different aspect of these units may also be related to different transport/depositional processes related to different sources of material which may be involved in the glacial related deposits (e.g. glacially eroded basement vs Cambro-Ordovician sediment). Possible source rocks for glacial related sediments could in fact be units which are now cropping out or are in direct contact with glacial related sediments: (1) The Western African Craton (from SE), which crops out in the Reguibat shield (Mauritanie) and to the South in the Leo-Man ridge (Mali); (2) The Touareg Shield (Hoggar area; from SW), which crops out in Algeria; (3) Reworked mature Cambro-Ordovician sediments (both from SW and from SE).

The aim of this study is to unravel which causes mainly contributed to the creation of the Tazekka succession and determined its variability (provenance vs hydraulic sorting based). A better understanding of the provenance and depositional processes leading to the formation of sand dominated glaciogenic units will improve the understanding of the regional distribution of these deposits and help developing a conceptual model for proglacial deposition at the margin of the Late Ordovician ice-sheet. Preliminary results of a high-resolution set of major and trace element geochemical analysis, together with analysis of heavy minerals spectra and automated petrography modal mineralogy, performed on 170 rock samples collected from a pre-, syn- and post-glacial sedimentary sequence in the Tazekka National Park (NE Morocco) are here shown.

Acknowledgments: The authors would like to thank Jean-Francois Ghienne, leader of the project involving many universities on the Moroccan “glacial” Ordovician, and all people involved in it for the great opportunity to work on this subject and their sedimentological interpretation of the Tazekka succession where our study is based on.

**Sedimentation on the Eocene Arabian Carbonate Platform: Outcrop studies from Central Oman**

Bernecker, M.[1], Mattern, F.[2]

[1] Department of Applied Geosciences, AGEO, German University of Technology in Oman, GUtech Halban Campus, Barka, Sultanate of Oman - michaela.bernecker@gutech.edu.om
[2] Earth Science Department, Sultan Qaboos University, 123 Al Khoud, Sultanate of Oman

The Eocene is an epoch characterized by a warm climate and widespread shallow marine seas. The biogenic carbonate production was very high in this warm and tropical, life-supporting environment. The SE Arabian shelf was a tropical carbonate factory at that time, located in middle to low latitudes producing thick successions of biogenic limestone, deposited around the Hajar Mountains in Central Oman.

We study Eocene outcrops in Central Oman focussing on carbonate sedimentology and stratigraphy. Sections were measured and samples taken for thin-section analysis to investigate the depositional patterns from West to East to compare the facies variations from more landward and more seaward parts of the platform. The following limestone formations of Central Oman were selected for this study: the Jafnayn and Seeb formations in the Capital area in the East and the Dammam Formation in the West, close to the Emirati border.

The studied limestone succession covers a time span from the Early to Middle Eocene. Biostratigraphic attribution could be confirmed by larger benthic foraminifera (LBF).

The Jafnayn Fm contains thick bedded to massive bioclastic wackestone to packstone partly with quartz grain layers and can be divided into several main lithofacies types: wackestone to packstone with a varying percentage of alveolinid foraminifera, rhodolithic bindstone with encrusting corallinacean red algae, boundstone to floatstone with corals forming isolated dendroid or globular colonies and coral banks, gastropod floatstone, -yster rudstone and mudstone to wackestone with burrows and bioturbation.

The Seeb/Dammam FMs occur as a thick succession of nodular, poorly bedded bioclastic packstone to wackestone or grainstone containing larger benthic foraminifera (LBF) dominated by *Nummulites/Assilina* and *Discocyclina*. Minor components include smaller benthic foraminifera, bivalves, gastropods and echinoid fragments.

These two predominantly carbonate formations (Jafnayn and Seeb/Dammam) are locally divided by intercalations of evaporites and siliciclastics of varying thickness (Rusayl FM). The lithofacies of this formation includes dolomitic sandstone and claystone, bioclastic and microbialitic limestone. This facies could be interpreted as a restricted marginal marine shelf environment.
During the Eocene the Arabian platform was subjected to widespread subsidence followed by extensive transgression and aggradation of thick bedded, tropical marine limestone. The onset of the carbonate platform development correlates with the Early Eocene climate optimum (EECO).

The investigated limestone formations represent the two main phases of the Early Paleogene carbonate platform development on the SE Arabian shelf: 1) Late Paleocene/Early Eocene (Jafnayn FM) and 2) Middle Eocene (Seeb & Dammam FMs in Central Oman outcrops).
Facies variations along the W-E transect show an inner shelf to an outer shelf setting. Local morphologies are formed by patchy colonial coral and incrusting coralline red algae bio-constructions in the Early Eocene and by accumulation of larger benthic foraminifera (LBF) as shoals in the Middle Eocene.

**Turbidite paleoseismology along the Chile continental margin – feasible or not?**

Bernhardt, A.[1], Strecker, M.R.[1]

[1] Department of Earth and Environmental Sciences, Universität Potsdam, Karl-Liebknecht-Strasse 24-25, 14476 Potsdam, Germany - anne.bernhardt@geo.uni-potsdam.de

Although much progress has been made in the assessment of seismic recurrence intervals of great subduction-zone earthquakes using terrestrial paleoseismological records and geomorphic analysis, the finer details of the formation of these extreme events and their significance for an unambiguous evaluation of seismic hazards are the subject of ongoing controversy. Paleoseismological records often provide excellent information on multiple seismogenic ruptures of areally extensive seismotectonic segments on centennial to millennial timescales, but terrestrial archives can be incomplete and sometimes even selective in their rendition of past extreme events. Turbidite paleoseismology, the analysis of the frequency of turbidity current deposition and its use to decipher the recurrence of large earthquakes, may bridge the gap between different and disparate paleoseismological data sets to provide a potential means to guide infrastructural planning, development, and seismic hazard mitigation along convergent margins. To establish recurring seismicity as a trigger mechanism for turbidity currents, however, synchronous deposition of turbidites in widely spaced, isolated depocenters has to be demonstrated.

Here, we present two marine sites along the Chile active margin that were tested for the feasibility of compiling paleoseismic records based on turbidite deposits. Our results suggest that the deposition of widespread, synchronous turbidity currents triggered by seismicity is largely controlled by sediment supply and, hence, the climatic and geomorphic conditions on the adjacent continent; as sediment supply is mainly driven by the strong onshore rainfall and surface-process gradients and the related geomorphic processes in the drainage basins. We find that the feasibility of compiling a turbidite paleoseismic record depends on the delicate balance between sufficient sediment supply providing material to fail frequently during seismic shaking, and sufficiently low sedimentation rates to allow for the accumulation of planktonic foraminifera for high-resolution radiocarbon dating.

We conclude that between 29 and 32.5 °S lat, Holocene turbidite paleoseismology is not feasible, because sediment supply from the semi-arid mainland is too low and almost no Holocene turbidites are recorded in cores. In contrast, frequent Holocene turbidite deposition may generally correspond to seismic and paleoseismic events in the region between 36 and 38°S lat. However, high sedimentation rates on the order of 1-6 m/ kyr prevent high-resolution radiocarbon dating. The region between 32.5 and 36°S lat is best suited for turbidite paleoseismology and corresponds to the northern part of the rupture zone of the Maule earthquake (2010, Mw = 8.8) and the rupture zone of the 1985 earthquake offshore Valparaíso (Mw = 7.8). Here, sediment input may be high enough to grant failure during major seismic events, but sedimentation rates are neither as high nor as low as in the northern sectors to prevent establishing a chronology of individual events.

Acknowledgements: We thank the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) Hannover and the MARUM Center for Marine Environmental Sciences Bremen for granting access to their sediment cores. M. Wiedicke-Hombach and A. Lückge from the BGR and D. Hebbeln, M. Mohtadi, U. Röhl, and V. Lukies from the MARUM Research Center provided invaluable help during core analysis and sampling.

**Record of major climate changes documented by rapid transition between climate sensitive facies: hints from sedimentological observations**

Berra, F.[1]

[1] Università degli Studi di Milano, Dipartimento di Scienze della Terra "A. Desio", Via Mangiagalli 23, 20133-Milano, Italy - fabrizio.berra@unimi.it

Juxtaposition of climate sensitive facies represents the best evidence of changes in the past climate, that can be gradual or rapid. Nevertheless, the reliability of different types of facies as proof of past climate is extremely different, so that detailed sedimentological observations are required to correctly interpret climate constraints from sedimentary rocks: some sediments can be considered important and indisputable witness of specific climate conditions (i.e. sabkha facies), whereas other are more ambiguous. The strengthen of climate interpretation from ancient successions thus requires a detailed sedimentological database which is improved by the integration of observations on the same time interval at a regional scale, as local observations often are not able to consider all the different types of data that can be obtained by a wider-scale investigation.

The Mesozoic sedimentary record of Western Tethys is characterized by facies changes that can be gradual or, frequently, rapid. In some cases, these changes record also changes in the climate conditions by the geologically rapid and synchronous changes of climate-sensitive facies. Whereas gradual changes are of difficult interpretation and requires the integration of different analytical methods for a correct, high-resolution reconstructions, the study of sedimentary succession highlight the presence of major, abrupt facies changes between units that clearly record the juxtaposition of rocks that were deposited in markedly different climate conditions. Clearly, these major changes are better expressed when different depositional system are directly superimposed, without a significant gap in sedimentation.

In the Triassic succession of the Western Tethys different examples of rapid changes of climate-sensitive facies are recorded, favoured by deposition in a tropical belt where dominantly carbonate platform systems are episodically affected by input of siliciclastics. The rapid shift between these two systems represents a favourable situation for the study of the registration of major rapid climate changes in the deep past. The shift from pure carbonate environments to siliciclastic-dominated facies can be followed from shallow water (carbonate platform top) to deeper water settings. Whereas on platform top the transition between carbonate and siliciclastic sedimentation is frequently associated with a gap in sedimentation (recorded generally by subaerial exposures of the platform top), the corresponding basinal change is instead characterized by continuous sedimentation, thus permitting to identify the nature of this transition, that is invariably sharp in the considered successions. The observations from the Triassic succession of the Western Tethys indicate that major climate changes are well-documented in the lithological record, when climate sensitive facies are identified at a regional scale by detailed sedimentological analyses. Furthermore, it is possible to demonstrate in the studied succession that climate changes are frequently associated with sea-level fall, suggesting that also in the greenhouse Mesozoic successions it is possible, in favourable conditions, to associate major climate changes with sea-level fall, as typically observed in the Quaternary ice-house conditions. The observed evolution represents a possible model for other major rapid changes between different types of climate sensitive facies (also with different frequencies), that are described in different basins and in different time intervals.

**Resedimented carbonates in a fault-controlled intraplatform basin: a depositional model from field data (Zorzino Limestone; Southern Alps, Norian, Lombardy, Italy)**

Berra, F.[1], Bonamini, E.[2]

[1] Università degli Studi di Milano, Dipartimento Scienze della Terra, Via Mangiagalli 34, 20133-MI, Italy – fabrizio.berra@unimi.it
[2] ENI SpA, Via Emilia 1, 20097-San Donato Milanese, MI, Italy

Resedimented carbonates present a wide range of sediment textures, mostly controlled by various gravity-driven processes, such as slides, slumps, debris flows, turbidity flows. Resedimented carbonates in intra-platform basins may reach considerable thickness and, where basin circulation is restricted, frequently contain a significant amount of organic matter, thus becoming potential source rocks.

This study defines the processes governing the deposition of resedimented carbonates close to high-relief carbonate platforms. The study focuses on the definition of the source area by employing a integrating paleogeography and microfacies of selected stratigraphic sections from the basinal carbonates.

The studied basinal successions (Upper Triassic, Southern Alps of Italy) were deposited during the Norian syndepositional extensional-transtensional tectonic event that dissected the large flat-topped inner platform system of the Dolomia Principale. This event created numerous intraplatform troughs, where up to 1000 m of dark, bedded limestones and dolostones, bordered by talus breccias, were deposited.

Seven stratigraphic sections, from proximal to depocentral basinal areas, have been studied and sampled. Sediment composition and sedimentary structures were utilised to identify facies associations, to define their occurrence in the different parts of the basin and to reconstruct the source area of the carbonate material (platform top vs. slope). For each facies type, a dominant depositional process has been proposed.

The distribution of sediment was strongly controlled by the steepness of the slope which, in turn, was often fault-controlled. Sediments bypassed the slope to be deposited at the toe of slope and in the basinal area, with rapidly changing sedimentological features from proximal to distal settings. Slope failures are highlighted as the source of a significant proportion of fine-grained slope facies to the intraplatform basin. The contribution of the carbonate high is volumetrically small and is limited to the proximal area of the basin. In the studied setting, most of the basinal sediments are thus provided by the slope, a fact that strongly differentiates between the depositional processes in carbonate basins with respect to siliciclastic basins, where the input point of sediments is geographically relatively fixed.

An abundance of pelagic carbonate mud and early marine cementation also played a major role in the studied carbonate depositional system, affecting sediment stability on the slope. Syndepositional tectonics were also important in controlling the depositional processes in the studied basins, probably triggering major collapses along the slope.

The facies associations along a proximal to distal depositional profile of the studied Late Triassic intraplatform basins reflect the contribution of the different depositional processes. Sedimentary characteristics are controlled by cementation, source area, depositional profile and slope topography, showing a facies pattern significantly different from that observed in resedimented siliciclastic basinal successions.

**Late Paleozoic glaciation and post-glacial transgressions in eastern peninsular India: extent and implications**

Bhattacharya, B.[1], Bhattacharya, H.N.[2]

[1] Department of Earth Sciences, Indian Institute of Technology, Roorkee, Uttarakhand, India– 247667 – bb.geol.dgc@gmail.com, bbgeofes@iitr.ac.in
[2] Department of Geology, Presidency University, 86/1, College Street, Kolkata, India– 700073

Sedimentary rocks of the Gondwana Supergroup (Late Carboniferous to Early Cretaceous) occur in multiple half-graben type basins, distributed along major palaeorift valleys in peninsular India. The basal most unit of this Supergroup, the Talchir Formation (Late Carboniferous to Early Permian), distinctly differs from the overlying lithounits in terms of its sedimentological and ichnological attributes, manifesting evidences of continental glaciations and marine interactions. This glaciation event corresponds to the Late Paleozoic icehouse condition that affected widespread areas in most of the Gondwanaland continents. Talchir Formation represents the sole paradigm of this event in peninsular India.

Facies attributes of the Talchir sedimentary successions (average thickness varying from ~100m to >400m) from ten adjacent Gondwana Basins in eastern peninsular India reveal altogether sixteen facies types, with full or truncated preservation in individual basins. Correlation of vertical sedimentary logs prepared from each of the basins show the nature of facies transitions within three broad co-genetic facies associations, viz., (i) the proglacial conglomerate-sandstone facies association (TCS), (ii) the foreshore-shoreface conglomerate-sandstone-mudstone facies association (TCSM) and (iii) the prodelta-shelf sandstone-mudstone facies association (TSM). Overall facies architecture reflect initial ice-covered terrestrial subglacial sedimentation, subsequent reworking and emplacement of glacigenic sediments by subaqueous mass-flows and shallow marine processes in front of the ice-grounding line, and finally covered by post-glacial storm-laid prodelta-shelf to slope sediments.

The facies succession manifest repeated phases of glacial retreat-advancements accompanied by shifts in the position of the ice-grounding line during phases of climatic amelioration, leading to development of alternate HST and FSST separated by major sequence boundaries. Decoupled ice sheet and floating icebergs contributed ice-rafted debris (IRD) to these sediments. Gradual retreat of the ice sheet with climatic amelioration restricted the supply of IRD towards top of the succession. Crustal downsagging due to glacier loading forced a sustained onlap of shoreface-shelf sediments (a LST, followed by a TST) on the glacigenic sediments. Reworking of these sediments by open marine tide and wave/storm and intense bioturbation by marine invertebrates (mostly crustaceans, soft-bodied annelids and worms, gastropods, bivalves, etc.) help to interpret the extent of marine incursion. The marine flooding event with climatic amelioration related to glacial retreat led to favourable ecological condition for abundant sediment-organism interactions. This transgressive sequence (TST) ends up with a thick, basinal mudstone at the top, which represents the MFS, marking the end of the Talchir depositional system. Subsequently, complete disappearance of the ice sheet caused basinal exhumation along with crustal upliftment due to isostatic rebounce, leading to a major regressive pahse with development of multiple horst-graben bounded basinal systems, which received post-Talchir coal-bearing Gondwana sediments.

**Sedimentology and ichnology of Permian fluvio-marine Barakar Formation, Raniganj Basin, India**

Bhattacharya, B.[1], Banerjee, S.[2], Bhattacharjee, J.[1], Bandyopadhyay, S.[2]

[1] Department of Earth Sciences, Indian Institute of Technology, Roorkee-247667, India – bb.geol.dgc@gmail.com; bbgeofes@iitr.ac.in
[2] Department of Geology, Hooghly Mohsin College, Chinsurah, Hooghly, West Bengal-712101

Integrated sedimentologic and ichnologic analysis of the Permian Barakar Formation allows recognition of a sedimentary succession resulting from tide-wave influenced fluvio-marine interactive depositional system, as exposed along different streams and mine-cut sections in the Raniganj Basin, peninsular India. Based on detailed facies analysis and delineation of the facies associations, two main sub-environments were identified, viz., (i) a fluvio-deltaic sequence with meandering distributary channels prograding over delta front depositional system, characterizing the lower part of the succession, and (ii) a marine tide-wave influenced transgressive fluvio-estuarine system, constituting the upper part of the succession. Both the lower and the upper part of the succession contain abundant coal seams. Thickness of the coal seams decreases upsection. The transgressive upper part of the succession is characterized by vertical increase in ichnodiversity and bioturbation intensity with gradual changeover from brackish-water to fully marine ichnofaunal assemblages.

Fluvio-deltaic sediments in the lower part of the succession are mostly unbioturbated, and dominantly formed as a falling stage system tract (FSST) with marked erosional surfaces, caused by a major regressive phase related to climatic amelioration and post-glacial (post-Talchir) crustal rebound. The estuarine deposits in the upper part of the succession, on the other hand, represents phases of sustained sea level rise at a later phase and its intercalation with the fluvial system producing lowstand system tract (LST) followed by transgressive systems tract (TST). This sequence comprises tidal channels, tidal point bars, coal-bearing marshes, and estuary mouth deposits.

Infaunal distributions vary as a function of sediment grain size and subaerial exposure condition. Muddier substrates that experience less subaerial exposure display a higher degree of bioturbation (bioturbation index [BI] 2–5). Sand beds are generally bioturbated to a lesser degree (BI 0–1) except in the lower distributary plain with higher degrees of bioturbation (BI 3–5). Estuarine ichnofabric is characterized by simple tiering structures, low degrees of bioturbation, low ichnodiversity, and dominance of simple burrows produced by inferred trophic generalists of mixed *Skolithos-Glossifungites* ichnofacies. The wave- and tide-modified marine transgressive sequences dominantly bear deposit-feeding burrows with low bioturbation intensity, belonging to an impoverished *Cruziana* ichnofacies. Burrow density, trace fossil size, and homogeneity in the vertical distribution of the trace fossils increase in the seaward direction. Overall shallow-tiered ichno-communities, impoverished trace-fossil assemblages, dominance of deposit-feeding structures over minor suspension-feeding elements suggest that different paleoenvironmental stresses, such as changes in salinity, water turbidity, and fluctuations in energy with sedimentation rates, affected the sediment-organism interaction pattern in the tide-wave influenced fluvio-marine setting during the Permian time.

Acknowledgements: B. Bhattacharya is grateful to Department of Science and Technology (DST), Government of India, for financial support in the form of 'Fast Track Research Project for Young Scientists' (No. SR/FTP/ES-170/2010).

**Outer marginal post-rift collapse along the north-western fringe of Indian shield - evolution of a Paleoproterozoic continental passive margin**

Bhattacharya, H.N.[1]

[1] Department of Geology, Presidency University, Kolkata, India, 700073 - hbaruamu@gmail.com

The Aravalli Supergroup exposed around Udaipur, Rajasthan, India records an uniterrupted history of Paleoproterozoic rift-related sedimentation along the north-western flank of the Indian shield. Due to inversion during Paleo/Mesoproterozoic and deep erosion, the Aravalli basin provides an opportunity to evaluate paleogeographic and tectonic evolution of the basin through analysis of outcrop scale data. Sedimentary successions that are exposed between a number of linear basement highs (rift shoulders) represent unconformity bounded half-graben fill mega-sequences that preserve records of sedimentation under active tectonic control. Detailed analysis of such successions reveals how the process of gradual or rapid foundering of the basin floor coupled with phases of intermittent exhumation took place during movements along basin marginal or intra-basinal master faults that controlled the sedimentation pattern. Each half-graben shows asymmetric sediment-filling with coarser basin margin clastics in the east and deep-water and finer basinal clastic sediments in the west. Initial riftogenic carbonate dominated shallow margin carbonate-siliciclastic facies association was capped by a top rift unconformity which represents an appreciable time period for basinal reorganization. Some of the half-grabens experienced repeated syn-rift fault controlled foundering before exhumation and development of top rift unconformity. A 3.5 km thick fining upward flysch-turbidite succession was floored by short-lived storm induced platformal sediments and overlapped the top rift unconformity. These overlapping deep basinal sediments signify an appreciably faster rate of basinal subsidence to accommodate deep basinal sediments. The total thickness of the deep-water facies assemblages is higher in those half-grabens, which occur towards west, away from the main continental block, indicating development of larger and deeper basins towards west. Such westerly deepening advocates in favour of formation of a larger half-graben encompassing earlier half-grabens and basin wide tilt of the crustal segment. The tilting may be explained as result of shearing along the crust mantle boundary and exhumation of upper mantle serpentinised ultramafics towards the continent-ocean transition zone. Rapid subsidence or 'sag' attests to pre-drift collapse phase of the passive continental margin evolution and is strictly tectonic in nature. Such a tectonic model for the evolution of Aravalli sequences finds strong support from a modern analogue along the southeastern cratonic margin of Brazil, where riftogenic sediments are buried under deep basinal sediments under the influence of rapid tectonic collapse.

This rift-collapse succession was accreted on the Indian shield margin at c. 1650 Ma following a terminal orogeny. A crustal level regional fault, related to this movement marks the outer boundary of this accreted succession. Serpentinised ultramafic bodies were tectonically emplaced along the boundary fault.

Acknowledgements: The author thanks the authority, Presidency University, Kolata for financial support and students who have accompanied him in the field.

**Authigenic carbonates from Gulf of Mexico Gas Hydrate Seafloor Observatory archive sources and dynamics of fluid seepage**

Birgel, D.[1], Feng, D.[2], Peckmann, J.[1], Roberts, H.H.[3], Joye, S.B.[4], Sassen, R.[5], Liu, X.-L.[6], Hinrichs, K.-U.[6], Chen, D.[2]

[1] Department of Geodynamics and Sedimentology, Center for Earth Sciences, University of Vienna, 1090 Vienna, Austria - daniel.birgel@univie.ac.at

[2] Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China
[3] Coastal Studies Institute, Department of Oceanography and Coastal Sciences, School of the Coast and Environment, Louisiana State University, Baton Rouge, LA 70803, USA
[4] Department of Marine Sciences, University of Georgia, Athens, GA 30602, USA
[5] Environmental Research Group, Texas A&M University, College Station, TX 77845, USA
[6] Organic Geochemistry Group, MARUM Center for Marine Environmental Sciences & Department of Geosciences, University of Bremen, 28359 Bremen, Germany

Authigenic carbonate rocks were recovered from the Gulf of Mexico gas hydrate seafloor observatory Mississippi Canyon (MC) 118 at approximately 900 m water depth. The rocks were studied for mineralogy, bulk geochemical composition, and lipid biomarkers. They occurred as fractured blocks and nodular masses incorporated in carbonate breccias. The major composition of carbonates comprises high-Mg-calcite and aragonite. The stable carbon isotope composition ($\delta^{13}C$) of authigenic carbonate ranged from –29.8‰ to –18.1‰ vs. V-PDB, suggesting mixture of various carbon sources. Oxygen isotopes ($\delta^{18}O$) ranged from +3.4‰ to +5.8‰. Most likely, the observed $^{18}O$-enrichment in relation to the calculated equilibrium values reflects decomposition of gas hydrates. The most abundant lipid biomarkers preserved in the carbonates were isoprenoidal glycerol dibiphytanyl glycerol tetraethers (GDGTs), predominated by GDGTs containing either 2 or 3 cyclopentane rings. GDGT-2 and GDGT-3 are typically indicators of anaerobic methane oxidizing Archaea (ANMEs). This assumption is further confirmed by the extreme negative $\delta^{13}C$ values of the GDGTs, measured as mono- and bicyclic biphytanes (derived after ether cleavage of GDGT-2 and -3), which is characteristic for ANMEs. Interestingly, large differences between the $\delta^{13}C$ values of the archaeal diether archaeol and acyclic biphytane (derived from cleavage of GDGT-0) on the one hand, and monocyclic biphytane (GDGT-1/GDGT-2 derived) on the other hand, suggest the presence of Archaea other than ANMEs. Archaeol and GDGT-0 (containing two acyclic biphytane moieties) are commonly assigned to various methanogenic Archaea. At the MC118 seep and gas hydrate site, microbial communities must cope with rapidly changing conditions, as well as longer-term fluctuations in oil and gas seepage or the temporary cessation of hydrocarbon flux. The change from methane seepage to oil seepage and vice versa in addition to flux variability apparently favors the establishment of complex prokaryotic communities dominated by Archaea. In addition to anaerobic oxidation of methane, local production of methane is apparently significant at the study site based on the prominent occurrence of biomarkers of methanogens in the authigenic seep carbonate. This finding adds to the ongoing multidisciplinary effort to better constrain the environment at the MC118 hydrate observatory site and to determine the locally dominant biogeochemical processes.

**Sedimentation Modelling as a proxy tool for reconstruction of a Falling Stage System Tract on a Proterozoic Carbonate Ramp: Evidence from Simla Group, Western Lesser Himalaya, India**

Biswas, A.[1], Mukhopadhyay, B.P.[1], Banerjee, T.[1], Mazumdar, P.[1], Thorie, A.[1]

[1] Dept. of Earth Sciences, Indian Institute of Engineering Science & Technology, Shibpur, India – ananyageol@gmail.com

Rifted continental margins are often characterised by accumulation of thick sedimentary sequence that is attributed to a prolonged phase of subsidence due to gravity loading. The Proterozoic Simla Group of the western Lesser Himalaya, India is an example of a rifted basin comprising 1500m thick coarsening-upward clastic succession characterised by the development of a mixed siliciclastic-carbonate ramp sequence topped by a regressive succession of a fan-delta deposit ultimately incised by a veneer of thin fluvial deposit. The Simla sequence is divisible into the lower Basantpur, middle Chaaosa and upper Sanjauli Formations. Outcrop based facies analysis of the Basantpur Formation allows reconstruction of a distally steepened carbonate ramp influenced by sea level fluctuations, where outer, mid and inner ramp sub-environments were identified. Spatial arrangements of seventeen lithofacies illustrates that the ramp is distally steepened with an interval of deep-water carbonates. The outer ramp is characterized by oolitic grainstones, calcareous black shale, calcarenite, silty shale, black shale and calcareous debrites. The mid ramp is characterised by low-energy facies affected by storms with abundance of molar tooth carbonates. The inner ramp is predominant and characterized by tidal flat facies (wackestones, packstones, grainstones, cross-bedded quartz-arenites, quartzose dolosiltite, dolomudstone, wavy–lenticular bedding and symmetrical ripples) dissected by tidal channels and abundance of algal mounds. This transition from inner-mid to outer ramp is marked by a distinct slope break that has been cited as an example of a distally steepened ramp.

The mid-Simla fan-delta siliciclastics cap the Basantpur limestones due to forced regression and develop a Falling stage system tract (FSST). Sea level history of the Simla Group is represented by two types of stacking pattern: a normal progradational shoreline pattern with well developed transgressive Basantpur sequence sets (TST) and an abrupt-regressive Chhaosa fan-deltaic succession capping the TST. Base of the FSST sandstones marks the sequence boundary between the regressive Chhaosa succession and the transgressive Basantpur limestones. Sedimentological study suggests the middle to upper part of the Simla Group reveals preservation of fan-delta environments. Three facies associations have been delineated (i) Fan-delta front deposit (channelised conglomerate, cross-stratified pebbly to conglomeratic sandstones, wave-rippled sandstone) (ii) Delta-slope deposit (sandstone with cross-stratifications, slump beds, chaotic pebbly mudstone) and (iii) Prodelta deposit (couplets of fine sandstone and siltstone and turbidites with $T_a$, $T_b$, and $T_c$ units). The upper part of the fan-delta recorded a major marine regression leading to the shifting of the shoreline basinward thereby resulting in fluvial incision on its top. Development of a braided ephemeral fluvial system with prominent fluvial incision is marked by presence of conglomerate-sandstone facies associations, sandstones with couplet beds, channels, laminations, pebbly sandstones, clast-supported conglomerates. Prominent fluvial incision on top of the fan-delta deposits marks the presence of sub-aerial TYPE 1 unconformity. The fluvial deposits on the fan-delta mark the closure of sedimentation in the basin which ultimately got terminated by a major marine transgression leading to deposition of the overlying Neoproterozoic Infrakrol-Krol carbonates in the south western part of the basin.

Acknowledgement: We are thankful to ONGC,Ltd.,India for providing fund to undertake the research.

**Reevaluation of the Pennsylvanian subtropical successions of Wyoming and surroundings (United States): implications for the low-latitude response to dynamic glacial regimes**

Blanchard, S.[1], Fielding, C.R.[1], Frank, T.D.[1]

[1] Department of Earth and Atmospheric Sciences, University of Nebraska-Lincoln, Bessey Hall, Lincoln, NE 68583 - sebastien.blanchard@huskers.unl.edu

The dynamic character of the Late Palaeozoic Ice Age is evident from near-field, glacial deposits, but its impact on climate and sea-level variations in low-latitudes is not well constrained. Some recent studies have attempted to resolve paleotropical climate evolution and to provide interpretations of relative sea-level fluctuations, but they have focused mainly on the records present in carbonate platform and cyclothemic successions (humid to seasonally-dry environments). Alternations between aeolian sandstones, sabkha deposits and calcic paleosols are known from the Pennsylvanian of the western United States, and thus provide a potential record of the arid subtropical response to these dynamic changes. In this study, we provide a new interpretation for the stratigraphic architecture of the Amsden and Tensleep Formations (early to middle Pennsylvanian / Northern Wyoming, USA) using both surface exposures and available subsurface data. The Amsden Formation is characterized by a basal sandstone member overlain by red siltstones containing occasional evaporites and pisolitic layers. The upper member consists of dolomite beds containing marine fossils and evidence for pedogenic modifications. The Tensleep Formation contains a wider range of facies that abruptly varies, both vertically and horizontally. Our preliminary results indicate that the Amsden and Tensleep Formations record a change from low to high-amplitude relative sea-level variations that could be related to changing glacial conditions in southern Gondwana. We then compare this new understanding with the available descriptions for equivalent formations in surrounding states. Units composed of alternations between aeolian sandstones and shallow marine dolomites are widespread and found in time-equivalent intervals in Montana, Dakota, Utah, and Colorado. These units are found interbedded with thick intervals dominated by marine limestones, which may represent periods of prolonged relative sea-level highstand. Intervals dominated by high-frequency and high-amplitude sea-level fluctuations seem to correspond to periods where widespread glacial deposits have been documented around southern Gondwana. Reevaluation of these formations, when compared to our new understanding of the dynamic late Palaeozoic climate, can provide new constraints for the timing and magnitude of climate and sea-level changes.

**Organic-sedimentary processes of the Salgada lagoon (Rio de Janeiro, Brazil) during the past 7000 years ap: paleoenvironmental implications**

Blanco, A.M.[1], Fernandes, C.[1], Silva, C.[2]

[1] Universidade Federal Fluminense, Departamento de Geoquímica Ambiental – angelicablanc@mail.com
[2] Universidade Federal Fluminense, Departamento de Geología

The northern sector of Rio de Janeiro State coast preserves coastal plains that were formed under the influence of sea level oscillations, generating lagoonal systems influenced by terrestrial and oceanic sediment sources and usually of high salinity. This study aimed to characterize the paleoenvironment of the Salgada lagoon, which is part of the Paraíba do Sul river delta complex. This was revealed through the use of lithology, C:N ratio, $\delta^{13}C$ and $\delta^{15}N$ isotopes of the organic matter (OM) and a chronological model using $^{14}C$ of the OM on core S-15. The chronological model was constructed by linear regression with ages calibrated using the CALIB 7.0 software and 2σ confidence intervals for the selection of the most probable ages. It recovered sediment representing an interval of approximately 7.0 kyrs. The S-15 core results showed three units (I , II, and III) and nine lithological subunits (A, B, C , D, E , F, G , H and I) correlated to sediment and OM variations. The siliciclastic sediment records intercalated phases of mud-sandy and silt-clay mud suggesting energy variations in the system. The isotopic geochemistry of S-15 core showed little variation throughout the sedimentary succession. The variability of $\delta^{13}C$ and $\delta^{15}N$ suggested three phases of organic sedimentation (fluvial, estuarine and lagoonal) due to the transition from the marine environment to the lagoonal, influenced by river delta evolution and sea level variations. The values of C:N ratio suggests mixture sources of allochthonous and autochthonous OM (C3 terrestrial plants, bacteria, and phytoplankton). The regional semiarid conditions imposed by the coastal upwelling favored the precipitation of salts and carbonates, since the isolation of the lagoon in the coastal plain. The geochemistry and sedimentation processes changed through time creating specific conditions for the development of microbial mats. The high $\delta^{15}N$, the increase in the total organic carbon percentages, and low C:N indicated a primary production of OM determined by cyanobacteria to the top of the sedimentary succession since 3.0 kyrs when the conditions to the carbonate precipitation started to be created in the system with the precipitation of stromatolites from 2.8 kyrs to the present.

**Organic Matter Source Assessment from Lake Constant Sediments: Does Mineralogy Exercise Control over Organic Matter Preservation?**

Blattmann, T.[1], Wessels, M.[2], Plotze, M.[1], McIntyre, C.[1], Eglinton, T.[1]

[1] ETH Zürich - thomas.blattmann@erdw.ethz.ch
[2] ISF Langenargen.

Knowing the provenance of organic carbon (OC) preserved in sedimentary archives is one of the most fundamental prerequisites to interpreting Earth history archives. OC sourced from terrestrial versus aquatic, and pedogenic versus petrogenic sources exhibit different molecular and isotopic characteristics. Traditionally, stable carbon isotopic compositions often measured in conjunction with OC to nitrogen ratios have been utilized for assessing organic matter provenance. This study investigated source-to-sink processes influencing OC in the Lake Constance drainage basin with particular emphasis on the role of mineralogical overlays on OC transfer and preservation. In addition to information derived from stable carbon isotopic and elemental composition, this study exploited the augmented resolution provided radiocarbon isotopic composition for enhanced interpretation and quantification of OC type.

This study employed isotope mass spectrometry for assessing stable carbon isotopic compositions and accelerator mass spectrometry for determining radiocarbon content of OC from bulk samples. Prior to isotopic analysis of OC, inorganic carbon was removed by vapor acidification. For identifying and quantifying mineralogical compositions, quantitative x-ray diffraction with Rietveld refinement was employed. Specific mineral surface areas were assessed with adsorption of nitrogen and water. Density fractionation using sodium polytungstate heavy liquid separation was employed to isolate OC-rich mesodensity fractions from environmental matrices. Oxidation treatments using buffered sodium persulfate were performed to assess resistance of OC to wet chemical assault, used here as a crude assessment of refractory components.

Pedogenic, petrogenic, and lacustrine OC from the Lake Constance catchment and basin yielded pools of distinct stable carbon and radiocarbon isotope ratios. This allowed the quantitative assignment of OC type contributing to the bulk OC composition using a ternary mixing model. The soil end member is characterized by an elevated bomb carbon signature with a $C_3$-plant character. The lacustrine end reflects a light phytoplankton signature with lower radiocarbon values, presumably reflecting a hard water effect. The influx of rock-derived, radiocarbon-dead OC is exposed by $^{14}C$ depleted inputs especially from Rhine sediments. Strong trends between mineral surface area and OC contents found for soils and sediments suggest associations between organic matter and mineral surfaces. Large amounts of oxidation-resistant OC fractions were found in phyllosilicate-rich (smectite and illite), high-surface-area soil and sediment mesodensity fractions, supporting the notion that phyllosilicates participate strongly in the stabilization of organic matter. There is evidence for associations between petrogenic OC and quartz in modern soils and sediments inherited from eroding parent sedimentary rocks. Environmental matrices with phyllosilicate fractions high in smectite content exhibit rapid OC turnover.

Coupled stable and radiocarbon measurements provided constraints on contributions of pedogenic, petrogenic, and lacustrine OC to Lake Constance. Petrogenic OC, which represents a significant but previously unrecognized component of Lake Constance sedimentary OC, must be sourced mainly from the Bundnerschiefer formations. Trends between OC amount, isotopic composition, mineralogy, and mineral surface area hint at associations between organic matter and mineral surfaces.

**Mutual alteration of sediments and hydrothermal solution in the Guaymas Basin, Gulf of California**

Blinova, E.V.[1], Kurnosov, V.B.[1]

[1] Geological Institute, Russian Academy of Sciences, 119017-Moscow, Russia – blinova.helen@gmailcom

The Guaymas Basin represents a modern example of tectonics, sedimentation, and high hydrothermal activity during the early stage of oceanic crust formation by rifting of the continental crust. Up to 440 m thick Upper Pleistocene hemipelagic diatom ooze and turbidites overlay here the newly formed basaltic basement. Guaymas Basin includes two segments – southern and northern troughs. During 64 cruise of DSDP there were situated three drilling sites: 477 in southern trough, 481 in northern trough and 478 between them. There was measured a heat flow on each site and the highest level was registered in the southern trough (up to 20 HFU).

The most important difference of Guaymas Basin from other rift zones in the ocean is thick sedimentary cover, because of extremely high rates of sedimentation. Sediments are hydrothermally altered under the influence of fluids ascending through the sediment strata. Sediments from the hole 477A are mostly altered up to greenschist facies of metamorphism with chlorite-epidote-sphene-pyrite-pyrrhotite mineral assemblage, which reflects the temperature of a mineral formation near 300°C. In addition the sediments are intruded by a doleritic sill in the interval 58–105 m.

The study of sediments from DSDP Holes 477 & 477A (the southern rift of the Guaymas Basin) in thin sections as well as by XRD, ICP-MS, XRF showed their mineralogical and chemical transformation under a strong influence of hydrothermal solutions strengthened by thermal impact of the sill. The comparison of altered sediments from holes 477/477A with unaltered sediments from holes 478, 481 shows that the process of water-rock interaction has varying degrees of influence on the transformation of hydrothermal solution for different groups of chemical elements. The contents of Zn, Cu, Cd and Fe++ are several times higher in altered sediments while on the contrary the contents of Rb, As, K, Br and Cl are several times lower. These two groups of elements have the most important value to the transformation of hydrothermal solution composition. For other elements, such as Pb, Be, Co, Si, Ca this influence is not so obvious and can be characterized as insignificant. In addition these results were compared with known data of chemical composition of hydrothermal solutions in Guaymas Basin and on the 21°N on the East Pacific Rise where is no sedimentary cover. As a result there is an assumption that solution in Guaymas Basin, which goes directly to the sedimentary cover differs from solutions on 21° N EPR. The main reason of this difference is the fact that seawater in Guaymas Basin is probably partly altered during its downward path through the sedimentary cover in a circulating cell. This research used samples and data provided by the Ocean Drilling Program and was funded by the Russian Foundation for Basic Research (grant №11-05-00347).

**Evolution of hydrocarbon seepage mechanisms and flux through time deduced from the vertical succession of methane-derived authigenic carbonates: A case study from Gigors, SE France**

Blouet, J.P.[1], Imbert, P.[2], Foubert, A.[1], Pierre, C.[3], Ho, S.[4]

[1] University of Fribourg, Department of Geosciences, 1700 Fribourg, Switzerland – JeanPhillipe.blouet@gmail.com
[2] Total S.A., 64018 Pau, France
[3] Université Pierre et Marie Curie ; LOCEAN, Institut Pierre Simon Laplace, place Jussieu 75252 Paris, France
[4] 3D Lab, Cardiff University, School of Earth and Ocean Sciences, Main Building, Park Place, CF10 3YE Cardiff, UK, Wales

Fluid seepage is an important phenomenon occurring in different marine settings and can include leakage of hydrocarbons from marine sediments. The precipitation of authigenic carbonates associated with seepage of methane-rich fluids is the result of the anaerobic oxidation of methane coupled with sulfate reduction. The morphology and geometry of methane-derived authigenic carbonates (MDAC) is strongly influenced by the processes and style of methane seepage.

In order to establish a potential link between the mechanisms and fluxes of seepage and the geometric character of MDAC, the Aptian/Albian Marnes Bleues Formation, well-exposed in Gigors (Vocontian Basin, SE France), has been investigated in detail. The Marnes Bleues Formation in Gigors is characterized by several types of carbonate concretions, which have been classified based on their morphology and mapped over an area that is 150 m in vertical and 200 m in lateral extent. A detailed petrographic study of the sampled carbonate concretions has been performed using classic microscopy, SEM, fluorescence and cathodoluminescence microscopy. Stable isotope analyses have been measured to trace the diagenetic pathways and the fluids involved in carbonate precipitation.

Mapping and sampling of the carbonate concretions distinguished two main morphologies: 1) sub-spherical nodules and 2) complex ramified carbonate tubes characterized by a central conduit. The carbonate concretions are either aligned along beds, gently crossing stratigraphic layers or clustered in vertically stacked groups.

Stable isotope analysis provides evidence that concretions are depleted in δ13C (with lowest values of -41‰PDB), and slightly enriched in δ18O (as high as 1‰PDB) in comparison to normal marine carbonates. These values imply that anaerobic oxidation of methane is most likely responsible for the precipitation of the carbonate concretions that can thus be interpreted as MDAC.

Based on the amount of MDAC quantified through mapping, it is possible to calculate the hydrocarbon flow necessary to precipitate the observed quantity of carbonate concretions. Preliminary calculations indicate an estimated flux of approximately $10^{-2}$mol/m²/year. This value is far below the quantity of methane measured in modern seep environments, suggesting that only a certain quantity of methane has been involved in the formation of MDAC. However, we are aware that mapping is only based on the exposed sections and that 3D analysis of the whole outcrop may reveal a larger quantity of MDAC.

The carbonate concretions aligned along specific beds may indicate a widespread and relatively short methane venting event, while the vertically stacked succession of MDAC clusters could be the result of a multi-phase but focused seepage mechanism.

**Timing and causes of multiple carbon isotope excursions during the Early Jurassic (late Pliensbachian – Toarcian)**

Bodin, S.[1], Krencker, F.-N.[1], Kothe, T.[1], Heimhofer, U.[2], Kabiri, L.[3], Immenhauser, A.[1]

[1] Ruhr-Universität Bochum, Institut für Geologie, Mineralogie und Geophysik, D-44870 Bochum, Germany – Stephane.Bodin@rub.de
[2] Leibniz Universität Hannover, Institut für Geologie, Callinstraße 30, D-30167 Hannover, Germany
[3] Faculty of Science and Techniques Errachidia, University of Moulay Ismaïl, BP 509, 52000 Boutalamine-Errachidia, Morocco

Across the Pliensbachian-Toarcian boundary (P-To, Early Jurassic), ca. 1 Myr before the Toarcian Oceanic Anoxic Event (T-OAE), an initial negative carbon isotope excursion has been documented in western Tethys sedimentary rocks. In carbonate, its amplitude (2–3‰) is similar to the subsequent excursion recorded at the onset of the T-OAE. The significance of this first carbon isotope shift, in terms of paleoenvironmental interpretation and triggering mechanism, remains however elusive.

Taking advantage of expanded and rather continuous sections in the High Atlas of Morocco, several high-resolution, paired organic-inorganic carbon isotope records have been obtained across the Upper Pliensbachian - Lower Toarcian interval. At the onset of the T-OAE, an abrupt 1–2‰ negative shift is recorded in both organic and inorganic phases, succeeded by a relatively longer term 1–2‰ negative trend and a final slow return to pre-excursion conditions. In accordance with previous interpretations, this pattern indicates a perturbation of the entire exogenic carbon isotope reservoir at the onset of the T-OAE associated with the sudden release of isotopically light carbon into the atmosphere. By contrast, there is no negative shift in carbon isotopes for the P-To event recorded in bulk organic matter of Morocco. Given the strong dominance of terrestrial particles in the bulk organic matter fraction, this absence indicates that massive input of $^{13}$C-depleted carbon into the atmosphere is not likely to have happened during the P-To event. A pronounced (2‰) and abrupt negative shift in carbon isotope is however recorded in the bulk carbonate phase. We suggest that this decoupling between organic and inorganic phase is due to changes in the nature of the bulk carbonate phase due to the neritic carbonate factory collapse occurring during the P-To event.

Even though no massive injection of light carbon isotope into the ocean/atmosphere is observed at the onset of the P-To event, the latter is nonetheless associated with numerous features common to the T-OAE event. These include a pronounced warming (ca. 4°C), marine transgression, a significant extinction among different faunal and floral groups, a drastic reduction of neritic carbonate production and enhanced hydrological cycling. This raises the question on the exact causes and consequence of the release of $^{13}$C-depleted carbon into the exogenic reservoir during the T-OAE, which will be discussed in the light of recurrent perturbations of the carbon cycle during the Early Jurassic.

Acknowledgments: This research was financed by the Deutsche Forschungsgemeinschaft (DFG, project n° BO 3655/1-1 and BO 3655/1-2).

**Early Bajocian hydrocarbon-seep carbonates (High Atlas, Morocco): witness of environmental change and the collapse of a neritic carbonate factory**

Bodin, S.[1], Rose, J.[1], Hönig, M.[1, 2], Krencker, F.-N.[1], Niedermayr, A.[1], Kabiri, L.[3]

[1] Ruhr-Universität Bochum, Institut für Geologie, Mineralogie und Geophysik, D-44801 Bochum, Germany – Stephane.Bodin@rub.de
[2] Royal School of Mines, Department of Earth Science and Engineering, Imperial College London, SW7 2BP, London, UK
[3] Faculty of Science and Techniques Errachidia, University of Moulay Ismaïl, BP 509, 52000 Boutalamine-Errachidia, Morocco

Numerous episodes of neritic carbonate factory change or demise are observed during the Middle Jurassic. Their exact timing, spatial extension, cause(s) and consequence(s) remain however poorly understood. In Morocco, outstanding exposures reveal a complex history of neritic carbonate factory development during the Aalenian-Bajocian, intersected by several drowning episodes or drastic reduction in carbonate production.

The most prominent carbonate platform demise event occurred during the earliest Bajocian (Discites ammonite zone). It was followed by a relatively long period of non-deposition or marl-dominated sedimentation before the reinstallation of vigorous neritic carbonate production during the late early Bajocian (*Humphresianum* ammonite zone). Within middle lower Bajocian deposits, several seep carbonates and carbonate concretions are observed in deep-water settings. Seep deposits are made of decimetric beds, showing numerous chimney and pipe structures, characterized by several phases of $^{13}$C-depleted authigenic carbonates. Bioclasts (mostly small fragments of bivalves and serpulids) are numerous in some phases.

The development of hydrocarbon seeps during the middle early Bajocian, as well as their relationship with the collapse of neritic carbonate productivity, can be explained by a common array of causes. Indeed, the middle early Bajocian of Morocco was a period of high primary productivity (as highlighted by enhanced phosphorus content and relative enrichment of organic matter in deep-water marls). Therefore, seawater eutrophication might explain the demise of the shallow-water carbonate factory, whereas the subsequent deposition of organic matter-rich sediments may have provided the background for hydrocarbon generation and seepage.

Acknowledgments: This research was financed by the Deutsche Forschungsgemeinschaft (DFG, project n° BO 3655/1-1 and BO 3655/1-2).

**Ultrasound video interpretation of transport and deposition of sediment gravity flows**

Boffo, H.C.[1], Buffon, P.[1], Manica, R.[1], Borges, A.L.O.[1], Moraes, M.A.S.[1]

[1] NECOD – Núcleo de Estudos em Correntes de Densidade - Instituto de Pesquisas Hidráulicas da Universidade Federal do Rio Grande do Sul – Brazil - carolina.boffo@ufrgs.br

Physical simulations of sediment gravity flows were performed aiming to visualize mechanisms of transport and sediment deposition: a regular side view with a camcorder; a very detailed side view (high-speed camera) and a non-intrusive inside view with two medical ultrasound recorders at the centre of the flume. Two series of experiments were performed in a 2D glass flume, 4.5 m long x 0.4 m wide x 0.13 m high. Gravity flows consisted of different ratios of non-cohesive (mineral coal $d_{50}$ = 42 µm) and cohesive sediment (kaolin $d_{50}$ = 7 µm) ranging from 25% to 85% clay and from 5% to 35% by volume. The mixtures were injected into a continuous flow with flow rates between 0.06 and 0.2 l/s, and flow advance velocities varied between 8 and 12 cm/s. Ultrasound recorders were at 1.2 and 2.7 m from the injection point and the 700 fps high-speed camera at 1.95 m. Videos from both camcorders and ultrasound records were transformed into image sequences for analysis and interpretation. A carefully analysis in terms of geometric current parameters, such as head height, thickness of the current, upper and inner mixed layer and near-bed concentration shows two distinct mechanisms of transport and deposition: (1) classical low-density turbidity current [cv = 5 %] characterized by turbulence-dominated flows and deposition of individual particles (aggradation beds) and (2) high-density turbidity currents with massive deposition by frictional (low amount of clay) or cohesive freezing (high amount of clay) after the passage of the very turbulent head of the current. Moreover, a bipartite flow with significant velocity differences was observed in the near-bed high-concentration layer, caused by the presence of singular lower density stratification layers. The mechanism of generation of these layers is still unclear; however observations suggest that the formation of bands of different densities may be linked to early hydrodynamic processes nearby the injection point. The initial turbulence is damped by the high amount and/or cohesiveness of particles, and as a consequence a massive layer close to the bottom slips downwards along the channel with shear on the top of this layer. After the injection finished, the density current settled immediately and water escape was observed within the high-density deposits.

The use only video analysis (particularly ultrasound video) proved to be a complementary tool leading to a better detailed understanding of the mechanisms of transport and deposition of density currents formed by a wide spectre of the sediment gravity flows (flow turbidity currents to closely debris flows). The mechanism of transport and deposition will be discussed and compared to current models.

**Methanogenesis-driven formation of siderite concretions and a fresh-water limestone induced by swamp development in the Neogene Orava-Nowy Targ basin**

Bojanowski, M.J.[1], Wysocka, A.[2], Łoziński, M.[2]

[1] Institute of Geological Sciences, Polish Academy of Sciences, Twarda 51/55, 00-818 Warsaw, Poland – mbojan@twarda.pan.pl
[2] Faculty of Geology, University of Warsaw, Żwirki i Wigury 93, 02-089 Warsaw, Poland

The Orava-Nowy Targ basin is an intramontane basin situated on the Slovakian-Polish cross-border area north-west of the Tatra Mountains. It is filled with more than 1.3 km terrigenous series of mainly clastic deposits with frequent intercalations of lignites and pyroclastic layers. The sedimentation has taken place in rivers, lakes or swamps since Miocene. Siderite concretions occur in grey silts representing overbank deposits that are covered by clays intercalated with lignites deposited in swamps. One of the lignite layer is directly overlain by up to 20-cm thick fresh-water, organic carbon-rich limestone containing gastropod and ostracod shells which are very well preserved and apparently in life positions. Petrography and stable C and O isotopic composition of the concretions and the limestone was examined in order to recognize their genesis and sources of substrates.

Rhizoliths occur in the concretions, but not in the surrounding sediments, suggesting that the concretions formed very early and close to the sediment surface where roots could reach. The concretions acted as shelters preserving the structure of roots which were otherwise lost in the surrounding sediments. Rhodochrosite filling these structures is the first generation of carbonate cements. It is depleted in $^{13}C$ by 13 to 22‰ relative to the PDB standard. The main concretionary cement is siderite which postdates rhodochrosite and is significantly enriched in $^{13}C$ by 3 to 8‰. $\delta^{18}O$ values do not differ between those cements and range from -6.1 to -3.5‰ which is typical for meteoric water. This sequence of cements and their C isotopic compositions indicate that concretionary growth commenced with rhodochrosite precipitation around roots as a result of the oxidation of isotopically light organic matter coupled to Fe and Mn reduction in suboxic conditions. However, the main stage of siderite concretion formation took place in anoxic conditions at a shallow burial depth when methanogenesis operated. The concretions are found in silts only in sections where they are capped by lignites representing swamp deposits. Therefore, particularly favorable conditions for carbonate cementation occurred where the host sediments were covered by peat. Transition from flood plain to swamp resulted in decelerated sedimentation rate which hindered compaction and in increased organic deposition which enhanced preservation of organic matter from oxidation. This allowed for the development of anoxic conditions at a shallow subsurface and the production of isotopically heavy inorganic carbon by methanogenesis. Such prolonged steady-state diagenetic conditions permitted this extensive siderite precipitation.

The limestone bed exhibits very high $\delta^{13}C$ values that range from 4 to 13‰ and very low and invariant $\delta^{18}O$ values that range from -7.9 to -7.2‰. This isotopic composition is similar to that of the concretions and indicates methanogenesis as the main source of inorganic carbon. However, petrography and preservation of fossils indicate that the limestone formed in subaquaeous conditions over peat. This shows that methanogenesis operated not only in subsurface, but methane was also liberated to the water column inducing carbonate sedimentation. The limestone occurs in different parts of the basin, but does not form a continuous layer. Thus, there were rather small and isolated water bodies in the basin where biogenic methane was produced from organic carbon-rich substrate during Miocene.

Acknowledgements: This study was financed by the National Science Centre (grant no. 2011/01/B/ST10/07591).

**Millennial-scale response of a western Mediterranean river to climate changes : A view from the deep sea**

Bonneau, L.[1, 2], Jorry, S.[2], Toucanne, S.[2], Silva Jacinto, R.[2], Emmanuel, L.[1]

[1] Laboratoire Biominéralisations et Environnements Sédimentaires, ISTeP-UMR 7193, Université Pierre et Marie Curie, 75252 Paris, France
[2] Laboratoire Environnements Sédimentaires, IFREMER, 29280 Plouzané, France – lucile.bonneau@upmc.fr

During Late Quaternary, Southern Europe has repeatedly undergone rapid climatic changes including Dangaard-Oeschger cycles and Glacial termination that affected erosion of land surfaces (Hinderer 2001; Macklin et al. 2012) and may have resulted in changes in the sediment budget delivered to the ocean (Kettner and Syvitsky 2008; 2009). These changes remain difficult to detect from the marine sedimentary archive because of the strong overprint exerted by the associated high-frequency high-amplitude sea level changes. Uncertainties remain about the ability of fluvial systems to transmit the signal of those perturbations into the ocean (Castelltort and Driessche 2003; Allen 2008; Simpson and Castelltort 2012; Armitage et al. 2013). This study is focused on the sediment deposition pattern of the Var sedimentary system (VSR), located in the NW Mediterranean Sea, where the absence of a continental shelf results in direct connection between the Var river mouth and the deep basin during both high and low stands of the relative sea level (Savoye et al. 1993).

Based on high-resolution stratigraphic of four cores collected on deep-sea turbiditic levee (Var Sedimentary Ridge) we reconstructed Late-Pleistocene-to-Holocene temporal changes of unconfined turbidity current activities. Fluctuating turbidite frequency of the VSR indicates highest frequencies during maximum glacial conditions (16-30 ka). The turbidite frequency rapidly decreases thereafter, i.e. during the last glacial-interglacial transition (Termination 1), and reaches minimum values during the Holocene. During MIS3 and MIS4 (30-75 ka), peaks in the turbidite frequency occurred synchronously with Dangaard-Oeschger stadials, while interstadial conditions correspond to low to very low turbidite frequencies. As a result, the turbidite activity seems to be directly connected to Dangaard-Oeschger climate perturbations according to a cold/high turbidite activity - warm/low turbidite activity pattern.

We conclude that turbidite activity on the VSR mainly reflects changes in magnitude of hypepycnal currents spilling over the ridge in relation with variations in the sediment concentration of the Var River floods. We show that this signal is sensitive to changes in sediment flux induced by climatic perturbations occurring inland: (1) the decrease in glacier-derived sediment input after glacier retreat (2) changes in erosion induced by Dangaard-Oeschger shifts in the vegetation. Our findings show that rivers can transmit climate-driven high-frequency changes in pure sediment flux to deep-basin.

**Authigenic clays of microbial origin: How to identify them in ancient sedimentary rocks?**

Bontognali, T.R.R.[1], Ruiz, F.M.[2], Nascimento, G.S.[1], McKenzie, J.A.[1], Vasconcelos, C.[1], Anjos, S.[3]

[1] ETH-Zurich, Geological Institute, Sonneggstrasse 5, 8092 Zurich, Switzerland – tomaso.bontognali@erdw.ethz.ch
[2] Instituto Andaluz de Ciencias de la Tierra, Av. de las Palmeras 4, 1810 Granada, Spain
[3] Petrobras E&P, Av Republica Chile 330, Rio de Janeiro, Brazil

Research conducted in natural environments, as well as the results of laboratory experiments, have shown that microbes can mediate the formation of clay minerals in various geological settings, at low temperatures and neutral pH. The results of these studies challenge the commonly held view that authigenic clays precipitate from solution exclusively in restricted lakes characterized by unusual water chemistry, or in proximity of deep-sea hydrothermal sources. Indeed, in the presence of microbes or within biofilms, authigenic clays have been observed to precipitate from normal sweater.

A series of laboratory experiments designed to understand the mechanism through which microorganisms mediate the formation of clay minerals has been carried out at the Geomicrobiology Laboratory of ETH Zürich, using both cultures of living microbes and artificial organic compounds that simulate functional groups present in natural biofilms.

The results of these experiments suggest that extracellular polymeric substances (EPS) that are released by microbes in their surrounding environments play a key role for the mineralization process, by binding and concentrating silica, and by stabilizing cations in specific coordinations, which is crucial for the initial nucleation step of the clay mineral.

Organic molecules that have chelating properties resulted to be particularly efficient in promoting this microbially influenced mineralization process, mediating the formation of various type of smectites at 25°C and pH7.

Experiments are currently in progress to find geochemical signatures that allow for differentiating, within ancient rocks, clay minerals that formed abiotically through metamorphic, high-temperature reactions from those that formed through the microbially influenced process described above. Specifically, we are testing the hypothesis that Si absorption on EPS may be accompanied by a kinetic isotopic fractionation, causing a distinctive geochemical signature that is eventually preserved into the clay mineral.

An unambiguous identification of microbial clays in ancient rocks would allow for more accurate paleoenvironmental reconstructions, which, in some cases, may fundamentally differ from that based on a "classical interpretation" of these silicates minerals.

**Characterization of the pre-OAE1a Event (early Aptian): reconciliation of sedimentology and carbon isotope records along the NW Tethyan Margin (Switzerland and SE France)**

Bonvallet, L.[1], Godet, A.[2], Adatte, T.[1], Spangenberg, J.E.[3], Arnaud Vanneau, A.[4], Stein, M.[5], Föllmi, K.B.[1]

[1] Institut des Science de la Terre, Université de Lausanne, CH-1015 Lausanne, Switzerland – lucie.bonvallet@unil.ch
[2] Department of Geological Sciences, The University of Texas at San Antonio, TX 78249, San Antonio, USA
[3] Institut des dynamiques de la surface terrestre, Université de Lausanne, CH-1015 Lausanne, Switzerland
[4] Association Dolomieu, 38700 Grenoble, France
[5] Institut de Physique du Globe de Strasbourg, University of Strasbourg – EOST, 67084 Strasbourg, France

The early Aptian Oceanic Anoxic Event 1a (OAE1a, approximately 120 My ago) is the best studied palaeocenographic event of the Early Cretaceous. It has been triggered by important climate change linked to the Ontong Java Large Igneous Province activity. The OAE1a is associated to the presence of black shale deposits in basins and to a negative spike followed by a positive excursion in the carbon-isotope record. Several evidences suggest that climatic perturbations started well before this event. On the northwestern Tethyan margin, the type of carbonate production changed twice from photozoan (Urgonian Limestone) to predominantly heterozoan, as a response to increased detrital and nutrient input, and led to the subsequent deposition of the Rawil and Grünten Members ("Lower and Upper Orbitolina Beds") in the early Aptian before the unfolding of the OAE1a.

Our research aims at illustrating the palaeoclimatic impact on the sequence stratigraphic organisation of the lower Aptian Rawil and Upper Schrattenkalk Members. Sediments of the Rawil Member and equivalents are widespread around the Tethys, and are characterized by important Orbitolinids contents. Studies dealing with this member suggest synchronous deposition. We studied the stratigraphy and sedimentology of the two aforementioned members based on the observation of thin sections and carbon-isotope records of outcrops from the Helvetic nappes in Switzerland (L'Ecuelle section in the Morcles nappes, Tierwis and Valsloch sections in the Säntis nappe), which are representative of the northwestern Tethyan margin. Based on facies and microfacies evolution, these sections were correlated with sections from the Vercors, Chartreuse and Bornes Massifs in southeastern France. With regards to the carbon-isotope records, the trends are less well correlated with the basinal records, because of diagenetic effects and the incomplete sedimentary record on the platform. However, $\delta^{13}C$ records are useful to identify and confirm emersion phases, and - combined with biostratigraphy and trends in both facies and microfacies as well as in sequence stratigraphy, they may be used for short distance correlation in both members studied here. Furthermore, this study highlights a similarity in the succession of the microfacies types in the parasequences on a large scale through the northwestern Tethyan margin (Vercors, Chartreuse, Bornes, Helvetic nappes). The microfacies and sequence-stratigraphic correlation scheme allows us to quantify the hiatus linked to the emersive sequence boundary of this first sequence of the Aptian.

**Possible connection between large volcanic eruptions and level rise episodes in the Dead Sea Basin**

Bookman, R.[1], Filin, S.[2], Avni, Y.[3], Rosenfeld, D.[4], Marco, S.[5]

[1] Department of Marine Geosciences, Charney School of Marine Sciences, University of Haifa, Mt. Carmel, Haifa 31905, Israel - rbookman@univ.haifa.ac.il
[2] Department of Transportation and Geo-Information Engineering, Technion – Israel Institute of Technology, Haifa 32000, Israel
[3] Geological Survey of Israel, 30 Malchei Yisrael St., Jerusalem 95501, Israel
[4] Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
[5] Department of Geophysics and Planetary Sciences, Tel Aviv University, Tel Aviv 69978, Israel

The June 1991 Pinatubo volcanic eruption perturbed the atmosphere, triggering short-term worldwide changes in surface and lower troposphere temperatures, precipitation, and runoff. The following winter was anomalously wet in the Levant, with a ~2-meter increase in the Dead Sea level that created a distinct morphological terrace along the lake's shore. Given the global radiative and chemical effects of volcanogenic aerosols on climatic systems, we tested the hypothesis that the 1991-92 winter shore terrace is a modern analogue to the linkage between past volcanic eruptions and a sequence of shore terraces on the cliffs around the Dead Sea Basin.

Analysis of historical annual precipitation series from Jerusalem showed a significant positive correlation between the Dust Veil Index (DVI) of the modern largest eruptions and corresponding annual rainfall. The DVI was found to explain nearly 50% of the variability in the annual rainfall, such that greater DVI means more rainfall. Other factors that may affect the annual rainfall in the region as the Southern Oscillation Index (SOI) and the North Atlantic oscillations (NAO) were incorporated along with the DVI in a linear multiple regression model. It was found that the NAO did not contribute anything except for increased noise, but the added SOI increased the explained variability of rainfall to more than 60%. The atmospheric effect of the volcanic aerosol cloud produced after the Mt. Pinatubo eruption shows responses in the climate system on a hemispherical to global scale.

Volcanic eruptions with a VEI of 6, as in the Pinatubo, occurred about once a century during the Holocene period at a rate that persisted throughout the last glacial-interglacial cycle, though with large variations in the mean. This occurrence is similar to the frequency of shore terrace build-up during the Lake Lisan desiccation. Sixteen shore terraces, detected using airborne laser scanning data, were interpreted as indicating short-term level rises due to episodes of enhanced precipitation and runoff during the dramatic drop in Lake Lisan's (palaeo-Dead Sea) level at the end of the Last Glacial Maximum. The terraces were compared with a dated time series of volcanogenic sulfate from the GISP2 ice core, and similar numbers of sulfate concentration peaks and shore terraces were found. Furthermore, a significant correlation was found between $SO_4$ concentration peaks and the heights of the terraces. This correlation may indicate a link between the explosivity of past eruptions, the magnitude of stratospheric injection, and their impact on the northern hemisphere water balance. The record of such short-term climato-hydrological effects is made possible by the dramatic desiccation of Lake Lisan. Detailed records of such events, albeit rare because of their vulnerability and short longevity, provide an important demonstration of global climatic teleconnections.

**Evaluation of sedimentological changes in the Brazilian equatorial margin under drilling activity**

Borges, M.[1], Vital, H.[1]

[1] Programa de Pós-Graduação em Geodinâmica e Geofísica, Universidade Federal do Rio Grande do Norte, Campus Universitário, C. P. 1596; 59072-970, Natal – RN, Brasil – miguelborges@hotmail.com

Petroleum exploration activity occurs on the offshore Potiguar Basin (NE Brazil), from very shallow (2-3 m) until about 50 m water depth, extending from Alto de Touros (RN) to Alto de Fortaleza (CE). Take in account the biological importance and the heterogeneity of sediments on this area, it is necessary the understanding of the sedimentological dynamics, and mainly the changes generated by petroleum exploration to prevent possible damages to environment. Despite the intense activity of oil exploration in this area, and the environmental monitoring reports carried by oil industry, research papers are still rare. In order to fill this gap, this study was developed to evaluate sedimentological, mineralogical and geochemical changes in the vicinity of a exploration well, here designated as well A, located on the Middle continental shelf, near the transition to Outer shelf from NE Brazil. The well selected for this study was the first one drilled with Riserless Mud Recovery technology (RMR) in Brazil. The main difference from this to the conventional method is the possibility of drilling phase I of the well with return of drilling material to the rig tank, minimizing fluid and gravel discharging around the well, during this phase. Monitoring consisted of three surveys, first of them done before start drilling, the second one done 19 days after the end of drilling and the third one done one year after then. Comparison of the studied variables (calcium carbonate and organic matter content, sediment size, mineralogy and geochemistry) was done with their average, median and coefficient of variation values to understand the changes after drilling activity. The results indicated a predominantly sandy environment along the three surveys. Calcium carbonate and organic matter content showed a good correlation, increasing in deeper areas (near Outer shelf). Siliciclastic sand facies sediments are prevalent at all surveys, and quartz is the main component (more than 80%). Silica, aluminium, potassium, calcium and bromine are the mean elements for this siliciclastic sand facies. Iron, titanium and manganese were most described in heavy minerals (garnet, turmaline, zircon and ilmenite). Granitic rock fragments and mud aggregates also were observed. Bioclastic facies sediments are dominated by coralline algae (more than 45%) and mollusks (more than 30%), followed by benthic foraminifera, bryozoans and worm tubes. More rarely was observed ostracoda and spike of calcareous sponge. For this facies the predominant elements are calcium and magnesium, from bioclastic organisms and calcite cement generated at higher depths. Take in account the low changes of the sediments from one cruise to the other, and the using of RMR method in the drilling, it was possible to conclude that drilling activity did not promote significant alteration on the local sediment cover.

Acknowledgments: Thanks are due to PETROBRAS, PRH22-ANP/MCTI (CTPETRO) and CNPq for funding support.

Keywords: Continental Shelf, oil exploration, Potiguar Basin.

**Late Bronze Age Lacustrine Deposits Trapped within the Losentse Alluvial Fan in the Central Swiss Rhône Valley**

Boulicault, L.[1], Sartori, M.[1], Moreau, J.[2], Moscariello, A.[1]

[1] Earth Sciences Department, Geneva University, Switzerland - lise.boulicault@etu.unige.ch
[2] IGN Department, Copenhagen University, Denmark

The glacial Swiss Rhône Valley (Valais) is filled up with c. 900 m of Quaternary sediments deposited by glaciers, alluvial fans, temporary lakes and the Rhône River.
In this study, we focus on the Losentse alluvial fan, one of the largest active fan of the central Swiss Rhône Valley. This work aims at understanding the evolution of the fan through time and space and in particular with respect to the larger trunk of the valley.
The Losentse fan extends over c. 8 $km^2$, with a radius of 3 km and a slope of ~4° to the south. The Losentse channel incises the fan and shows natural cross-sections up to 10 m high and 500-m long, allowing the description of 5 detailed stratigraphic logs. The fan mostly consists of a vertical stack of amalgamated conglomeratic debris-flow deposits forming gently dipping tabular beds. The beds are occasionally interrupted by graded lenticular gravels and coarse-grained sand plugs within channels (bed load deposits).
The detailed sedimentary analysis revealed, intercalated within the conglomeratic debris flow succession, the presence of c. 2 m-thick clayey and silty deposits containing several wood fragments and well preserved fresh-water gastropod shells. The deposits are draping the distal and mid parts of the fan up to the altitude of 520 m. To explore the fine-grained lacustrine deposits continuity, two Ground Penetrating Radars (GPR) antennae (250 and 50 MHz) have been used to produce radar reflection profiles at different resolutions and penetrations. Seven kilometres of profiles oriented slope-parallel and along the contour lines have been acquired in total. The GPR data show the wide 3D spatial extension of a sharp reflector visible on all the GPR profiles. The correlation of those profiles with the sedimentary logs allows us to interpret this sharp reflector as being the fine-grained lacustrine layer within the fan. The AMS Carbon-14 dating of the fresh-water gastropods contained within the fine-grained deposit indicates a 2810 BP (+/- 30 yrs) age. Therefore, we interpret those deposits as the record of a major lacustrine event during the Late Bronze Age.
The lacustrine deposits found in the Losentse fan are 45 m above the current altitude of the Swiss Rhône Valley. If this lake is a local feature it implies the presence of an approximative 50-m high dam in the distal part of the fan during the Late Bronze Age. There are no geomorphological evidences for such a dam however other lacustrine deposits have been discovered below 520 m in two other places in the Swiss Rhône Valley. Those deposits also contain wood fragments and fresh-water gastropods and their Carbon-14 age determinations are under progress.
We expect the new datings to help the correlation with the other lacustrine deposits strengthening a wide Central Swiss Rhône Valley lake hypothesis. It is suggested that landslides have locally concealed the valley section during a short period of time. The narrowest and nearest potential damming site is the Saint Maurice glacial sill.
This hypothesis could also provide an explanation to the lack of human settlements below the altitude of 520 m in the Swiss Rhône Valley during the Late Bronze Age.

We acknowledge the Augustin Lombard and the Murithienne Fundations, The Institute of Geophysics of the University of Lausanne and the IGN Department of the University of Copenhagen for their financial and technical supports.

**How catchment geologies can influence alluvial fans? Comparative study of three alluvial fans and their respective catchments in the Swiss Rhône Valley**

Boulicault, L.[1], Moscariello, A.[1], Sartori, M.[1], Ventra, D.[1], Moreau, J.[2]

[1] Departement of Earth Sciences, Section of Earth and Environmental Sciences, University of Geneva, 13, Rue des Maraîchers, 1205 Genève, Switzerland – lise.boulicault@etu.unige.ch
[2] IGN Department, Copenhagen University, Denmark

The Swiss Rhône Valley is filled with ~900 m of Quaternary deposits. This study focuses on the comparison of three fan-catchment systems in the valley, the Illgraben, the Losentse and the Abboyeu alluvial fans by integrating different methods. We aim at understanding how catchment attributes (shape, relief, geology, etc.) can influence alluvial-fan morphologies and their internal stratigraphic architecture.

The Illgraben and the Losentse fans have similar areal extent with 9 km² and 8 km², although the Losentse catchment is 3 times larger (30 km²) than the Illgraben catchment. The Abboyeu system is smaller: 2 km² for the fan and 6 km² for the catchment. Longitudinal exposures along incised fan channels offer stratigraphic sections up to 15 m high and 500 m long. The fans mostly consist of vertically stacked and amalgamated debris-flow deposits with intercalated channel-fills and graded lenticular gravels from runoff processes. The Losentse fan also contains a laterally continuous, 2m-thick unit of massive, silty-clayey and weakly laminated lacustrine deposits intercalated within the debris-flow units constitutive of the fan.

Systematic textural analyses were carried out for the main depositional units within each fan. As a result, it appears that the Illgraben debris-flow deposits feature a larger volume of clayey-silty matrix than the Losentse or Abboyeu fans, implying dominantly cohesive flow rheology. Gravel clasts were sampled within each fan for petrographic analysis. Topographic and geological maps for the catchments were integrated into a GIS model with maps of vegetation type and cover, in order to provide 'erodibility maps'. As expected, debris flows comprise clasts provenance mainly from denudated and fractured zones in the catchments. Finally, we noticed that the Losentse fan surface morphology presents a knickpoint at ~520 m asl, possibly related to the occurrence of lacustrine deposits. We used Ground Penetrating Radar (GPR) for imaging the spatial extension of the lacustrine deposits as well as the internal architecture of the fan. GPR profiles show that the fine-grained lacustrine deposits are continuously traceable within the fan up to its medial section (~520 m asl), suggesting that the lacustrine deposits draped the distal and medial fan segments during temporary impoundment of a lake body. Profiles also highlight the complex 3D architecture of debris-flow deposits within the fan.

This study illustrates the importance of both catchments attributes (shape, relief, geology, etc.) and valley attributes (available space, base level, etc) on fan morphology. A systematic analysis of additional fan-catchment systems along the Swiss Rhône Valley will enable us to better understand the Quaternary morphological evolution of the valley.

**Sedimentary evolution of a chalk contourite system (Stevns-2 core, Upper Cretaceous, Denmark)**

Boussaha, M.[1], Stemmerik, L.[2], Thibault, N.[1], Moreau, J.[1]

[1] University of Copenhagen, Department of Geosciences and Natural Resource Management, Øster Voldgade 10, Copenhagen 1350 Denmark - myriam.boussaha@ign.ku.dk
[2] Natural History Museum of Denmark, Øster Voldgade 5-7, Copenhagen 1350 Denmark

Chalk is a marine fine-grained sediment formed by the accumulation of coccoliths, calcitic remains of microscopic phytoplanktonic algae. The Upper Cretaceous chalk of the Danish Basin constitutes an excellent hydrocarbons and groundwater reservoir, which has fostered research in this area. However, sedimentary processes involved in chalk deposition are still poorly understood. Many studies on chalk from the Danish Basin are in progress in order to understand and explain the different mechanisms leading to chalk deposition, remobilization and later, diagenesis.
We present results from an integrated study of the Stevns-2 core (eastern Denmark), resolving the main processes and settings leading to the deposition of Chalk. The core penetrated 350 m of upper Campanian–Maastrichtian sediments (upper Chalk Group), and was studied in great details. Numerous methodological analyses have been used, including facies descriptions, calcareous nannofossil biostratigraphy, ichnology, wireline log analysis and bulk oxygen and carbon stable isotope geochemistry.
The calcareous nannofossil biozonation spans the time interval from the UC16a$^{BP}$ (upper Campanian) to NNT1 (lowermost Danian) and is tied to carbon-isotope stratigraphy. Oxygen isotopes trends record successive climatic events occurring in the Late Cretaceous: (1) the late Campanian warm climatic optimum, (2) the early Maastrichtian cooling event, (3) the mid-Maastrichtian warming event, (4) the late Maastrichtian cooling event and (5) the end-Maastrichtian greenhouse warming. The sedimentological data display a the distribution of facies through time evolving from: (1) alternating marl and mudstone-wackestone chalk with conglomerates, to (2) bioturbated white mudstone and wackestone chalk alternating with grey chalk and laminated chalk, then to (3) flint alternating with laminated chalk, mudstone and wackestone chalk, and finally to (4) bryozoan wackestone and packstone.
Our study shows how the chalk deposits are influenced by global and regional mechanisms. The facies evolution displays short-term cyclic patterns evolving from wackestone-dominated facies to mudstone-dominated facies. The short-term cyclic trends from coarse- to fine-grained are interpreted as finning-upward depositional sequences, and may be related to 4$^{th}$ and 5$^{th}$ order sea-level changes. Long-term cyclic patterns evolve from mudstone-dominated facies to conglomerate-dominated facies and then to wackestone-dominated facies. The long-term sequences can be correlated with palaeotemperatures (bulk oxygen isotopes). Therefore we suggest that chalk deposition in the Late Cretaceous Danish Basin resulted from the interplay between palaeoclimatic (palaeotemperature) and sea-level variations.
In addition, some particular wackestone facies can be defined by their high content in coarse clasts and bioclastic laminae. The laminae are interpreted as the result of winnowing/erosion from high velocity bottom currents. The sedimentary signal is superimposed onto the global climatic and eustatic record. The occurrence and frequency of the wackestone compared with the mudstone facies can thus reflect changes in the intensity of bottom currents throughout the late Campanian–Maastrichtian. The intensity of contour currents is probably driven by climate. This sedimentary record may constitute a new proxy for palaeoenvironmental reconstruction of the Chalk Sea.

Acknowledgments: Funding for this study was provided by Maersk Oil, the Danish Natural Science Research Foundation and the University of Copenhagen.

**Factors controlling development of modern hypersaline microbialites, Cayo Coco lagoon, Cuba**

Bouton, A.[1], Pace, A.[2], Vennin, E.[1], Bourillot, R.[2], Thomazo, C.[1], Visscher, P.[3], Dupraz, C.[3], Désaubliaux, G.[4], Portier, E.[4], Rojas, R.[5]

[1] Laboratoire Biogéosciences UMR uB/CNRS 6282 Université de Bourgogne, 6 boulevard Gabriel, 21000 Dijon, France - anthony.bouton@u-bourgogne.fr
[2] ENSEGID, EA 4592, – Institut Polytechnique de Bordeaux, 1 allée Daguin, 33607 Pessac, France
[3] Department of Marine Sciences, Center for Integrative Geosciences, University of Connecticut, 1080 Shennecossett Road, Groton, CT 06340, USA
[4] GDF-Suez, Direction E&P, 1 place Samuel de Champlain, 92930 Paris la Défense Cedex, France
[5] Museo Nacional de Historia Natural, Obispo 61, Plaza de Armas, 10100 Ciudad Habana, Cuba

The study of modern microbial-dominated carbonate sedimentary systems contributes to our knowledge of environmental conditions required for (i) microbial mats to establish and (ii) their particular morphologies. Furthermore, specific morphologies of extant microbialites may facilitate interpretation of ancient microbial-dominated systems

Extant microbialites are found in Cayo Coco, located at the Atlantic side of Cuba. These systems developed in a complex lagoonal network, the Cayo Coco Lagoonal System (CCLS), located on southern side of Cayo Coco and in connection with the Bahía de Perros, a hypersaline (30 to 80 ‰, obtained from the conductivity) coastal lagoon measuring 40 km by 20 km with a depth of less than 3 m. The study site is situated in a lagoon to the far east of the CCLS, where the system terminates, extending over 1000 m with a width of 600 m and a maximum water depth of 80 cm. Due to its furthest position from the intake of surface oceanic water, the lagoon appears to be predominantly fed by subsurface recharges. Therefore, it presents the most confining conditions of the CCLS. This lagoon, at the time of the campaign (January 2013), is a slightly alkaline (pH ranged between 8.19 and 8.77) and hypersaline (67 and 75‰) water body surrounded by tropical mangrove in its western and southern border. We discuss the origin of the morphological characteristics of this lagoonal system, and propose a heritage from a Pleistocene aeolian dune field. The development of microbial systems probably results from induced prevailing physico-chemical conditions. Four main depositional environments can be distinguished (from the edge to the center of the lagoon): (i) Hinterland mangroves; (ii) Supratidal bedrock; (iii) Intertidal mudflats and (iv) Subtidal lagoon. Most of the mineralizing mats are present in the intertidal mudflat zone, while the center of lake is covered with soft mats. Nine macrofabrics can be distinguished among mineralizing mats. Microbialites show different morphologies at windward and leeward margins. The leeward area is covered with flat to low-relief hemispheroid mats, while the windward-margin is covered with laminated microbialites, including parallel ridges, forming cm to dm reliefs above the surrounding sediment. Ridge crests are perpendicular to the dominant winds, indicating a strong control of wind waves and associated erosion on microbialite morphology.

We identify several external controlling factors (confinement of the lagoon, bathymetry, wind…) which could influence the distribution of the different microbial structures and allows us to propose a comprehensive conceptual model of controls in microbialites formation which might help us in the future to better understand Phanerozoic to Precambrian microbialites deposits.

**Facies analysis of the Holocene wildfire related megaflood sediments of the Huis River, Western Cape, South Africa**

Bowen, D.A.[1], Bordy, E.M.[1], Moore, J.[2]

[1] Department of Geological Sciences, University of Cape Town, 7701, Cape Town, South Africa – devonb@live.co.za
[2] Department of Geology, Rhodes University, 6400, Grahamstown, South Africa

Wildfire and subsequent flash-flooding are common in semi-arid environments and are key driving forces in the evolution of the biodiversity and geomorphology of these regions. As modern processes, these phenomena are relatively well-understood, but their role in the shaping of the geological record of semi-arid environments has been poorly studied. The Holocene sediments of the bedrock-confined upper Huis River of the Western Cape, South Africa, have provided an opportunity to study the unique erosional-depositional dynamics created by the interaction between these processes.

This study examined a number of semi-consolidated, charcoal-bearing Holocene sediment outcrops, preserved *in situ* in the Palaeozoic bedrock-confined valley of the upper Huis River. The sediments are vertically extensive, preserved up to 11 m above the present-day riverbed. There is a strong textural contrast between the massive, vertically-extensive proximal deposits, constrained by the canyon walls, and the distal, layered deposits at the down-slope positioned mouth of the canyon. With the aid of field-based facies analysis techniques, five distinct, yet genetically related sedimentary facies associations can be identified. Radiocarbon analysis of selected charcoal specimens revealed that the major depositional events occurred from 2165 ±37 to 653 ±35 year ago.

Evidence for peak flood conditions are preserved in a compacted massive orthobreccia layer, grading into a parabreccia, at the base of the succession. Their sedimentary features suggest that these layers are products of a non-cohesive pseudoplastic debris flow. The overlying, semi-stratified to massive parabreccia represents a transitional, high matrix strength debris flow deposit, with evidence of heterogeneous fluid content and flow behaviour. Graded gravelly-sand deposits overlying the parabreccia represent the overriding of the low-cohesion debris flow tail. Charcoal-rich, massive to horizontally laminated sands with openwork quartz sand to grit lenses, preserved in a small cave, are evidence for scouring by eddy currents, followed by eddy abandonment and deposition from standing water in a hollow. A series of massive sand layers and sandy-gravel lenses, with basal units of clast-supported gravel, indicate intermittent periods of channel flow, reworking of older debris flow sediments and immature pseudoplastic debris flows. A series of massive sands, with imbricated gravel lenses conclude the succession forming a gravel armour over the older sediments.

These facies associations are interpreted as the evolutionary record of sediment gravity flow events associated with a series of floods. The initial debris flow deposits, give way to cyclic deposits over time. The spatial proximity of the debris flow-filled canyon to the redeposited, layered sediments at the canyon mouth, with a steep change in outcrop height and without evidence of a transitional zone, suggests that the debris flow was retarded behind a blockage in the mid-canyon, and redeposited sediments accumulated down-current from this mid-canyon obstruction. These charcoal-bearing sediments preserve evidence for several palaeofloods, at least one of which was a high magnitude flood event (i.e., a megaflood), which was potentially preceded by a major wildfire that likely maximized the erosional and sediment carrying capacity of the flood. This association highlights the importance of wildfire in regulating flash-flood cyclicity and the possible role of wildfires as triggers of megafloods.

Acknowledgements: The authors would like to acknowledge the financial contributions of the African Origins Platform and the National Research Foundation of South Africa to the completion of this project.

**Quantifying the contribution of seagrass carbonate factories from the Paleocene to the Present**

Brandano, M.[1, 2], Cuffaro, M.[2], Gaglianone, G.[1], Mateu-Vicens, G.[3], Petricca, P.[1]

[1] Dipartimento Scienze della Terra, Università Roma La Sapienza, P.Aldo Moro 5, I-00185, Roma, Italy – marco.brandano@uniroma1.it
[2] Istituto di Geologia Ambientale e Geoingegneria (IGAG) CNR, Sez. Sapienza, c/o Dipartimento Scienze della Terra, Università Roma La Sapienza, P.Aldo Moro 5, I-00185, Roma, Italy
[3] Càtedra Guillem Colom Casasnovas, Universitat de les Illes Balears, Cra. de Valldemossa Km 7,5, 07122 Palma de Mallorca, Spain

Seagrass produce extensive submarine meadows in the euphotic zone along temperate to tropical coastlines worldwide. Seagrass meadows host a diverse array of organisms, dwelling either as epiphytic or infaunal forms. Many of these organisms possess a calcareous skeleton (i.e., echinoids, molluscs, bryozoans, foraminifers, red algae), which contributes to the role of the seagrasses as carbonate-sediment factories. Since the impact of carbonate production and accumulation in the global carbon cycle is of fundamental importance to Earth's climate, this work aims to assess the efficiency of this factory by quantifying the epiphytic carbonate production of a *Posidonia oceanica* seagrass from the southern Tyrrhenian Shelf (Maratea, Southern Italy). Thirty six shoots of *Posidonia oceanica* were sampled, dried, weighed and combusted to calculate the amount of epiphytic calcareous portion (ashes calcimetry). The shoot density range was also measured in order to obtain a range of the epiphytic carbonate production for the Tyrrhenian shelf and make a comparison with other Mediterranean localities. The average carbonate production of *Posidonia oceanica* meadows of the Tyrrhenian Shelf is 400 gr $m^2$ $year^{-1}$.

As seagrass appeared during Late Cretaceous times, and were widespread throughout the Paleogene and Neogene, we aim to investigate the contribute of the seagrass carbonate factory between the Paleocene to the Present, quantifying the rations of cost development during this time. For this purpose, we propose to test global plate tectonic reconstructions, obtained with recent rotation vectors relative to the mantle, over several time intervals, selected to correspond with key lithospheric plate reorganizations.

**Role of lateral tributaries in the morphodynamic evolution of tidal meander bends: inferences from the Venice Lagoon (Italy)**

Brivio, L.[1], Ghinassi, M.[1], D'Alpaos, A.[1], Finotello, A.[1], Carniello, L.[2], Marani, M.[2, 3]

[1] Dept. of Geoscience, University of Padova, Via Gradenigo 6, 35131 Padova, Italy – lara.brivio@studenti.unipd.it
[2] Dept. Civil, Environmental and Architectural Engineering, University of Padova, Via Loredan 20, 35131 Padova, Italy
[3] Division of Earth and Ocean Sciences, Nicholas School of the Environment and Department of Civil and Environmental Engineering, Pratt School of Engineering, Duke University, Durham, NC 27708

Despite meanders being ubiquitous features of the tidal landscape, very few papers have analyzed their morphodynamic evolution or internal architecture, particularly compared with their fluvial counterparts. We contribute to filling this gap in understanding by analyzing echo-sounder data from a tidal point bar located in the northern part of the Venice Lagoon (Italy), the largest Mediterranean brackish water body. A sub-bottom sonic profiler was used to obtain a high-resolution characterization of sediment velocity and stratal architecture of deposits along a bend of the Gaggian channel. Sub-bottom profiles were collected along transects oriented both parallel and transverse to the main channel axis. At the study site the channel is 100 m wide and 3 – 5 m deep, it defines a bend with a curvature radius of about 200 m, and receives numerous tributaries both along the inner and outer bank zone. The two main tributaries entering the outer bank have also been analyzed, to obtain information on the interaction between water and sediment fluxes at confluences. The point bar occupying the meander bend consists of silty sand deposits. The deepest part of the main channel hosts medium to medium-coarse sand. Fine sand and silt occur along the thalweg and at the outlet of the two tributaries. Geophysical data highlight the presence of two main laterally extensive key surfaces, which separate the in-channel deposits into three sedimentary units (up to 6.0, 4.0 and 3.5 m thick, respectively), associated with three main depositional stages of meander bend evolution, which emphasize ebb-dominated transport. The first stage is associated with the formation of laterally-accreting, point-bar beds dipping at about 10-20°. The second stage is associated with aggradation and lateral accretion in the landward side of the meander bend. The third stage is characterized by accumulation of deposits at the outlet of the two tributaries entering along the outer bank of the channel. A numerical model for sediment entrainment, transport and deposition promoted by the combined action of tidal currents and wind waves in shallow micro-tidal systems has been used to analyze the morphodynamic evolution of the bend. Model results suggest that important changes in flow and solid discharges have occurred in the main channel and within the tributaries in the last seventy years. Model results also emphasize the progressive increase in the flow and solid discharges within the tributaries, which likely affected sediment dynamics and deposition patterns within the main channel, where sedimentation occurs unexpectedly along the outer bank.

**Fault creep revealed by the mismatch between trench-documented fault displacements and a nearby record of lacustrine seismites**

Brocard, G.[1], Anselmetti, F.[2], Adatte, T.[3]

[1] Department of Earth and Environmental Sciences, University of Pennsylvania, USA – gbrocard@sas.upenn.edu
[2] Institute of Geological Sciences, University of Bern, Switzerland
[3] Institute of Earth Sciences, ISTE, University of Lausanne, Switzerland

The Polochic and Motagua strike-slip faults accommodate the 2 cm/y displacement between the Caribbean and North American plates in Guatemala. Both faults have the potential of producing major destructive earthquakes, as demonstrated by the Mw 7.5 earthquake of 1976 on the Motagua fault that claimed more than 25,000 lives. Other major earthquakes have been attributed to these faults based on the areal extent of destructions to Precolombian Mayan cities and churches. The available record, however, remains surprisingly poor in major earthquakes, suggesting that the historical record is either incomplete or that major earthquakes are effectively infrequent. To understand the behavior of the plate boundary we have started opening trenches across the Polochic fault in Late Pleistocene, Holocene and recent fluvial sediments at several locations along more than 50 km of the fault trace. We have combined the trenching with the study of seismites in a lake Chichój, located only three kilometers from the Polochic fault, to analyze the corresponding seismicity.

Trenching in Uspantán and Agua Blanca reveals distinct slip event along the Polochic fault than were $^{14}$C-dated and span the Late Pleistocene to late Columbian period. In Agua Blanca, 7 km from the lake, the fault displaces soils less than 350 years old.

The lake itself is ideally suited for a high resolution paleoseismic studies: mapping shows that it is comprised of three separate basins and up to 3.3m-long gravity cores show that each of them contains a distinctive record of slumps and turbidites. Turbidites produced by floods and subaqueous mass wasting have completely distinct geochemical, mineralogical and magnetic signatures, allowing for an easy identification of turbidites produced by lacustrine slope failure. Using $^{210}$Pb and $^{136}$Cs we dated and correlated turbidites and slumps produced coevally in adjacent basins in the 20$^{th}$ Century. By comparing the 20$^{th}$ Century earthquakes record to the lake record, we found that MMI of VI and higher are necessary to trigger turbidites and slumps in the lake.

Using this calibration we analyzed our longer $^{14}$C-dated earthquake record spanning the past 12 centuries, and identified a cluster of earthquakes with MMIs > VI between 830 and 1450 AD. The oldest seismite matches widespread destructions in Mayan cities around 830 AD. Surprisingly however, no significant earthquakes are recorded between 1450 and 1976 AD. Yet, trenches opened only 7 km from the lake demonstrate that substantial slip occurred over this specific time period on the Polochic fault. We propose therefore that fault slip was not accompanied by any substantial earthquake production, and must have been achieved either by creeping on the fault, or less likely by a swarm of earthquakes with magnitudes smaller than $M_w$ 5.

**Methodologies for estimating sediment output from soft rock cliffs under rising sea level**

Brooks, S.M.[1]

[1] Department of Geography, Environment and Development Studies, Birkbeck, University of London, Malet Street, London WC1E 7HX, UK - s.brooks@bbk.ac.uk

Soft rock cliffs around the world retreat rapidly (typically 3-5 $ma^{-1}$). Elevation and alongshore extent combine with rapid retreat to deliver large volumes of sediment to the nearshore zone. These sediments contribute to natural shoreline protection (salt marshes and nearshore sand bars). However, decadal scale variations in sediment release rates, reflecting alternating phases of transport-limited and supply-limited sediment delivery, drive similar variations in protective capacity. In this paper a new methodology is developed to enable the rapid and accurate quantification of sediment release from rapidly-retreating soft rock cliffs at decadal, annual and event-based timescales. The methodology is applied for the recent past (last 20 years), in the present-day and for the near future (next 50 years), to quantify sediment release as shorelines respond to rising sea levels and changing storminess. Knowledge of future sediment inputs to the nearshore zone is especially important for sediment transport modelling and for medium-term (50-year timescale) shoreline management.

For the recent past, georeferenced aerial imagery provides an accurate (± 50cm horizontally) record of shoreline position, defined using the digitised clifftop. For retreating cliffs in East Anglia imagery is available annually since 1992. For the present, Real Time Kinematic (RTK) / Global Navigation Satellite Systems (GNSS) field surveys (accurate to ±50 mm) provided changing cliffline positions for individual events. Under different sea level rise scenarios, future cliffline positions were modelled using a shoreline response model, calibrated against past sea level rise and cliffline retreat rates. Topographic imagery enables heights and alongshore extent of past, present and future clifflines to be determined. Digitised clifftop polyline shapefiles created within the GIS software package ArcMap 10, were superimposed on topographic images obtained using Light Detection And Ranging (LiDAR) and the minimum, maximum and mean cliff elevations were extracted for each cliffline. The combination of cliff extent, cliff elevation (adjusted for sea level rise) and retreat rate was then used to find decadal, annual and event-based sediment release rates.

Inter-annual variation in sediment release since 1992 was found to range between ca.20 000 $m^3$ $a^{-1}$ (low retreat) and 300 000 $m^3$ $a^{-1}$ (high retreat). Importantly, quantification of sediment release under individual storm events was also assessed. The storm that occurred on 5-6$^{th}$ December, 2013 brought considerably elevated (>2m above predicted) water levels to the southern North Sea and was the greatest storm surge on the UK east coast for 60 years. RTK GNSS field surveys before and after this event, along with the utilisation of the ArcMap methodology, showed that the volume of sediment released in this one event was ca. 150 000 $m^3$, well in excess of annual sediment volumes delivered in many individual years. Future sediment release volumes also showed considerable decadal variation, dependent upon the topographic elevations encountered as the cliffs retreat.

Sediment transport modelling has traditionally relied upon past estimates of sediment inputs which are lumped over time. The methodology developed here will enable future sediment volumes and their associated annual, decadal and event-based variability to provide improved input data to such models. This is particularly important for shallow basins such as the southern North Sea, where modelling the evolution of naturally protective sedimentary structures is important for near-future coastal management planning.

Acknowledgements: The author acknowledges aerial imagery (Shoreline Management Group (Anglian Region) of the UK Environment Agency), Environment Agency LiDAR imagery and NextMap data (UK NERC Earth Observation Data Centre).

**Late Quaternary aggradation rates and stratigraphic architecture of the southern Po Plain, Italy**

Bruno, L.[1], Amorosi, A.[1], Severi, P.[2], Costagli, B.[1]

[1] Department of Biology, Earth and Environmental Sciences, University of Bologna, Via Zamboni 67, 40126- Bologna, Italy - luigi.bruno4@unibo.it
[2] Geological, Seismic and Soil Survey, Regione Emilia-Romagna, Italy. Viale della Fiera 8, 40127- Bologna, Italy

Enhanced accumulation and preservation of huge sedimentary packages in the Po River Basin has taken place since the Pliocene, because of continuing tectonic subsidence. The Po Plain, thus, represents an ideal site to assess changing aggradation rates and their influence on stratigraphic architecture. Based on a subsurface stratigraphic database of thousands of boreholes, a markedly contrasting stratigraphy of Late Pleistocene and Holocene deposits is reconstructed across the southern Po Plain. Laterally extensive fluvial-channel bodies and pedogenized floodplain muds, dating back to 40-18 cal ky BP, are unconformably overlain by Holocene (< 12 ky BP) overbank fines, with lateral transition to ribbon-shaped fluvial-channel bodies. Holocene alluvial deposits grade seaward into predominantly palustrine, lagoonal and nearshore facies associations. The Pleistocene-Holocene boundary is marked, in general, by a stiff paleosol dating back to about 13.5-10 ky BP. Lateglacial sediments (18-12 cal ky BP) are patchily distributed in the subsurface of the Po Plain.

Sediment accumulation curves from 37 radiocarbon dated cores reveal a sharp increase in aggradation rates (AR) at the transition between Late Pleistocene deposits (0.2-0.9 mm/y) and Holocene sediments (0.9-2.95 mm/y). No specific trends were found within the Holocene succession, where AR may vary locally between 0.5 and 75 mm/y. Where present, Lateglacial deposits display AR similar to the Holocene values. The mean AR calculated for both Late Pleistocene and Holocene show progressively increasing values from the Apenninic margin to the coastal plain, as an effect of large-scale basin configuration. Holocene AR, however, exhibit systematically higher values than Pleistocene AR irrespective of location in the basin.

We infer that low AR between 30 and 18 ky BP reflect fluvial activity under low accommodation (lowstand) conditions, with lateral migration through contemporaneous bank erosion and sediment deposition. Extensive pedogenesis occurred in the interfluves, interrupted by short periods of aggradation. During the Lateglacial, early transgressive alluvial sedimentation was restricted mostly to narrow valley systems. During the Holocene, under higher accommodation conditions, rivers aggraded, locally reaching values higher than 20 mm/y. Late transgressive sedimentation took place almost continuously in the interfluves, where only short periods of pedogenesis are recorded. In more distal positions, estuaries, bays and lagoons formed with rising sea level, whereas progradation of deltas and strandplains occurred during the subsequent sea-level highstand. In these areas, an extremely variable spatial distribution of AR was primarily controlled by autogenic processes, such as channel avulsion, delta lobe switching and local subsidence.

Our results are in line with data from coeval alluvial-coastal plain systems in and outside the Mediterranean area, which show the same contrasting AR distribution of uppermost Pleistocene and Holocene deposits. Stratigraphic analysis of four pollen profiles spanning Marine Isotope Stages (MIS) 1 to 5e (last 130 ky BP) are consistent with data from the last 30 ky BP, showing high AR (0.27-2.54 mm/y) during the interglacials/interstadials (MIS 5e, 5c, 5a and 3) i.e., periods of increasing accommodation. In contrast, periods of sea-level fall/lowstand (= glacials/stadials – MIS 5d, 5b, 4 and 2) are characterized by significantly lower AR values (0.1-1.25 mm/y).

**Ichnodiversity as a proxy for environmental stress and stability in facies analysis: Potential and limitations**

Buatois, L.A.[1], Mángano, M.G.[1]

[1] Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, Saskatchewan, Canada - luis.buatois@usask.ca

Ichnology has experienced an explosive development during the last forty years and its application in facies analysis has been at the front of this field. Ichnodiversity is commonly used as a proxy for environmental stress and stability in facies analysis. Within this conceptual framework, low ichnodiversity is therefore thought to indicate stress factors, such as salinity dilution by freshwater discharge (e.g. estuaries, deltas), hypersalinity (e.g. underfilled lakes), oxygen depletion (e.g. restricted basins), and high energy (e.g. foreshore, upper shoreface, strongly storm-affected lower to middle shoreface). On the contrary, high ichnodiversity is thought to reflect stable and predictable environmental conditions, namely normal-marine salinity, well-oxygenated bottom and interstitial waters and low energy, as typically illustrated by offshore and weakly storm-affected lower shoreface complexes.

Although ichnodiversity is a valuable tool in facies analysis, its uncritical use may be misleading. Potential pitfalls result from the fact that ichnodiversity is strongly influenced by taphonomy, macroevolution, and complex feedback loops between environmental conditions and the role of animal activity. The importance of taphonomic factors on ichnodiversity cannot be overemphasized. For example, if monospecific ichnofaunas occur in intensely bioturbated ichnofabrics produced by deep bioturbators, the low ichnodiversity may have a taphonomic origin rather than an ecologic one, because deeply emplaced structures tend to destroy shallow-tier ones, thereby dramatically reducing ichnodiversity. The counterpart to this situation is that high diversity of superficial to shallow-tier trace fossils may result from enhanced preservation in cohesive substrates due a poorly developed mixed layer, rather than a true reflection of ecosystem performance. The macroevolutionary dimension of ichnodiversity should be taken into account as well. Ichnodiversity has experienced different trajectories in various depositional environments through the Phanerozoic and is, therefore, the result of the interplay between evolutionary radiations and mass extinctions. Trace-fossil facies models need to be calibrated according to geologic time. Finally, the complexity of the interactions between animals and substrate are illustrated by coral reef ecosystems, where the relationship between diversity of bioerosion structures and environmental stability is far from simple. It has been shown that moderate levels of bioerosion may promote diversity and stability of coral reefs in many ways. However, if environmental conditions decline for a long time, then the reef ecosystem collapses. Under these conditions, diversity and intensity of bioerosion are inversely related to environmental stability, with bioerosion becoming a major agent of biological destruction.

In short, robust trace-fossil models need to be constructed by finding innovative ways of integrating all available lines of evidence and applying conceptual tools. Ichnodiversity cannot be assessed without analyzing their building blocks, the trace fossils themselves, as well as the associated sedimentary fabric, the role of the fossilization barrier as a taphonomic filter, the macroevolutionary dimension of biogenic structures, and the complexities of animal-substrate interactions.

**Micropaleontological assemblages from the Lowermost Cretaceous of the eastern part of the Getic Carbonate Platform (Romania)**

Bucur, I.I.[1], Lazar, I.[2], Săsăran, E.[1], Grădinaru, M.[2], Grădinaru, E.[2]

[1] Babeş-Bolyai University, Department of Geology 400084 Cluj-Napoca, Romania – ioan.bucur@ubbcluj.ro
[2] University of Bucharest, Department of Geology, 010041, Bucharest, Romania

The studied arrea is located in the eastern part of the Southern Carpathians, and represents the easternmost part of the Getic Carbonate Platform. We investigated several sections from two regions: Dâmbovicioara and Codlea-Braşov. Both are characterized by a stratigraphic succession in which Upper Jurassic-Lowermost Cretaceous Štramberk-like, white massive limestones are covered by uppermost Valanginian-Hauterivian, up to Aptian, marly-limestones, limestones and marls. In both regions, a hardground-type unconformity was identified. The aim of the present contribution is to investigate the micropaleontological assemblages from the carbonates below and above the unconformity, and to check the possibility of dating the two rock sequences, and thus to identify the gape corresponding to this unconformity.

The Štramberk-like limestones from Dâmbovicioara region delivered a quite rich micropaleontological assemblage consisting of foraminifers and calcareous algae . Among foraminifers the most important are: *C. campanellus, C. cherchiae, C. delphinensis, Conicopfenderina*? *jourdanensis, Haplophragmoides joukowskyi, Meandrospira favrei, Montsalevia salevensis, Pfenderina neocomiensis, Protopeneroplis banatica, P. ultragranulata, Pseudotextulariella courtionensis*, ?*Valdanchella* and other unidentified orbitolinids. Calcareous algae are represented by *Clypeina parasolkani, Pseudocymopolia jurassica, Salpingoporella pygmaea, S. praturloni, Selliporella neocomiensis*. Microfossils are less frequent in the marly-limestones and limestones above the unconformity. The hemipelagic deposits just above the unconformity contain calcareous dinoflagellate cysts among which we identified *Crustocadosina semiradiata olzae*. The stratigraphic range of the foraminifera and algae cover, as a whole, the late Berriasian-Valanginian time interval. Because *Meandrospira favrei* a foraminifer found only in Valanginian-Lower Hauterivian deposits was detected both below and above the unconformity, and *Crustocadosina semiradiata olzae* having a range from Valanginian to Aptian occurs above the unconformity, we consider that the unconformity, correspond most probably to a time gape between Early and Late Valanginian.

In the Codlea area, the uppermost part of the Štramberk-like limestones contain a quite similar foraminiferal assemblage. that indicate a Berriasian-?Early Valanginian age interval. The basal bed of the deposits situated just over the uncomformity in the Codlea section contains, together with rare foraminifera, few calpionellid and calcareous dinocyst assemblage: *Calpionella alpina*, *C.elliptica*, *Tintinopsella carpathica*, , *Calpionellopsis oblonga*, *Cadosina fusca fusca*, *Colomisphaera conferta*, *C. vogleri*, *Crustocadosina semiradiata olzae*, and *Stomiosphaera echinata*. This assemblage indicate a Middle Berriasian-Valanginian-?Hauterivian age. Considering that from this bed was previously described an upper Valanginian ammonites fauna, we consider that this bed represents a condensed level. Comparying this situation with Dâmbovicioara region, we assume that the unconformity from Codlea is also intra-Valanginian, most probably located within the lower Valanginian. The micropaleontological data suggest that the unconformity is most probably diachronic in the two investigated regions.

Acknowledgement : The research was financed by the grant PN-II-ID-PCE-2011-3-0025.

**Sediments from glacially overdeepened valleys as archives of past glaciations**

Buechi, M.W.[1], Lowick, S.E.[2], Graf, H.-R.[3], Menzies, J.[4], Anselmetti, F.A.[5]

[1] Institute of Geological Sciences and Oeschger Centre of Climate Change Research, University of Bern, Bern, Switzerland - marius.buechi@geo.unibe.ch
[2] Institute of Geological Sciences and Oeschger Centre of Climate Change Research, University of Bern, Bern, Switzerland
[3] Dr. von Moos AG, Geotechnisches Büro, Gächlingen, Switzerland
[4] Department of Earth Sciences, Brock University, St. Catharines, Canada
[5] Institute of Geological Sciences and Oeschger Centre of Climate Change Research, University of Bern, Bern, Switzerland

The sedimentary infill of overdeepened glacial troughs in the Alps and their foreland provides an important archive reflecting environmental processes during the Middle and Late Pleistocene. Such records are crucial to complement the fragmentary character of the terrestrial Quaternary stratigraphy in repeatedly glaciated areas, and to reconstruct the timing and extent of past glaciations. While the formation of overdeepened valleys, or 'tunnel valleys', by subglacial processes of warm-based glaciations is undisputed, the timing of erosion and the nature of subsequent infilling are largely unknown.

We are currently investigating the geometry and infill of a major overdeepened valley system in Northern Switzerland (~5 km N of the airport of Zurich). Five drill cores, of up to 190 m long, that recovered the complete valley fill down to bedrock have allowed a detailed stratigraphic and macroscopic description of the sediment. Further analysis has also been conducted following sampling for bulk geochemistry, quantitative clast lithological analysis, micromorphology and for optically stimulated luminescence (OSL) dating.

The sediments comprising the valley fill consist of laminated fines and sands as well as intercalations of coarse diamictons. The lithofacies associations are interpreted as reflecting transitions from subglacial or ice-proximal basin-floor sedimentation, to ice-distal glaciolacustrine sedimentation. Micromorphological analysis of diamictons shows evidence of different degrees and styles of deformation, which potentially allows the distinction of subglacial tills from diamictons formed by other processes, e.g. subaqueous debris flows. Direct dating of glaciolacustrine fines using OSL indicates high sedimentation rates and distinct hiatuses.

Overall it appears that that the changing focus and magnitude of subglacial erosion allows sediments of older glaciations to be preserved in overdeepened valleys. The associated nested depositional geometries are therefore the expression of several erosional and depositional phases.

This project is a pilot-study in the context of the international drilling initiative “Drilling overdeepened Alpine valleys” (DOVE) that aims to drill overdeepened valleys all around the Alps and involves all Alpine countries (ICDP proposal status). More information available here:
http://www.icdp-online.org/projects/world/europe/alpine/details/

**Chemical composition of Lake Bafa Sediments: Implications for the Holocene environment of Western Anatolia**

Bulkan, Ö.[1], Toksoy, B.[1]

[1] Istanbul University, Geological Engineering Department, 34320 Avcılar, Turkey - bulkan@istanbul.edu.tr

Lake Bafa is characterised as a significant inland lake area (water surface:315 $km^2$, volume: 692 $hm^3$, maximum depth: 20 m) around the Aegean coast of Western Turkey. Lake was formed as a brackish residual lake in the southern part of the former Latmian Gulf and lost its connection to the Aegean Sea during the Late Holocene. In this study, lithological, sedimentological and chemical characteristics of Lake Bafa sediments are investigated along an east-west directed profile. Within the aim of the study, two cores were taken from the lake (Baf36:1.3 m; Baf37:4.2 m) and additional one location drilled (BS: 12m) in the swamp area. These sections contain sediments, accumulated during the last 5000 years and indicate marine, lagoon and lake transitional phases.

A systematic study was performed by using digital X-RAY Radiography, TOC analyzer, ICP-Ms method and AMS radiocarbon dating applications. These methods were applied to define the chemical conditions of the Lake Bafa, in terms of salinity, redox, organic matter productivity and initial enrichment processes of inorganic carbonate, within the water column.

Sediments retrieved from the western swamp area contain sand layers in the uppermost 3 m. Through the lower parts of the section, layers enriched in *Cardium* shells and sands (3-4.2 m depth interval), homogenous and varved clays (4.2-9 m depth interval) and coarse sand bands (9-12 m depth interval) were observed. TOC values are in the range of 1 to 0.3% within an average value of 0.6%. Average Ca (10%), Sr (268 ppm) and Ba (372 ppm) concentrations indicate time-dependent enrichments.

Sediments collected from the recent lake area indicates homogenous massive mud layers in the uppermost 1 m of the core, deposited in the lake environment. A characteristic layer, enriched in *Cardium* shells, is recorded between 2.1 and 2.2 m depth. Furthermore, laminated silt-clay intercalations and sand layers are observed in the lower parts of the core (3.2-4 m). Primary enrichment of Ca, Sr and Ba elements are relatively higher than the sediments investigated in the BS section, with the average values of 12%, 428 ppm, 310 ppm, respectively. Primary enrichment of Ca, Ba and Sr increases through the western parts of the lake. On the contrary, lower contributions of detrital elements are observed (K:1.7%, Ti:0.3%, Al:7%) in western parts. Higher TOC values are determined, in the range of 5.2 to 1.7%, within the average value of 4.4%.

Consequently, chemical characteristics of the sediments, collected from Lake Bafa and surrounding swamp area were investigated along an east-west profile. Lake record indicates a time-dependent change, beginning with a marine phase to high productive brackish lake environment. Recent conditions led to enhanced organic matter deposition, especially in the western parts of the lake.

Acknowledgements: This study is supported by the TUBITAK with the project number 113Y070 and Istanbul University research fund with project numbers 28942 and 17828.

**The effect of surrounding physical processes on depositional environment of the Lake Bafa (Western Anatolia), during the last 2500 years**

Bulkan, Ö.[1], Yalamaz, B.[2], Çağatay, N.[2]

[1] Istanbul University, Geological Engineering Department, 34320, Turkey - bulkan@istanbul.edu.tr
[2] İstanbul Technical University, Geological Engineering Department, 34469, Turkey

Lake Bafa is a brackish residual lake located in the southern part of the former Latmian Gulf, with a water surface of 315km$^2$, volume of 692hm$^3$ and a maximum depth of 20m. The aim of the study is to define the main external effects which control the depositional environment of Lake Bafa, in terms of energy level variations, changes of the main transport mechanisms and their sources. A systematic multi-parameter study was performed on dated lake sediments (Core: Baf37), which covers the uppermost 4.50m section of sedimentary record. Within the aim of the study, Geotek multi sensor core logger (MSCL), X-RAY radiography and laser particle size analyser were used to determine the physical properties of the sediments. Furthermore, TOC Analyser was applied for the determination of Total Organic Content (TOC) and Total Inorganic Carbon (TIC) contents.
Sedimentary record indicates marine, transitional lagoon and lake phases. Homogenous thick mud layers of the uppermost 1m of the core, consists higher TOC values within the range of 4 to 2.5%, has probably been deposited in a permanent lake phase. Lowest TOC values are measured for the 1m to 3.2m interval, with a minimum value of 1.3%. A contribution of *Cardium* shells are observed below the 2.1m depth. Additionally, a characteristic layer, enriched in *Cardium* shells is recorded in between 2.1 to 2.2m depths. The deeper parts of the core (2.2 to 4.2m depths) consists higher organic matter contribution with a maximum value of 5.3%. Furthermore, the most obvious variations of the TOC contributions are also observed in lower parts of the core (especially in the 3.2-4m interval). The main sedimentary characteristic of the lowest parts of the core is laminated silt and clay intercalations, cutted by the sand layers. Coarse sand layers were probably deposited in a high energy environment producing the mass flow events. Furthermore, simultaneous variations of the grain size distributions, densities, TIC and TOC contributions are also observed.
Consequently, a marine-lake transition is recorded in the 2.1m depth of the core, indicated by a layer, enriched in *Cardium* shells. After the deposition of this characteristic layer, a permanent lake sedimentation phase is proposed. During the last 100 years, a tendency through the higher energy environment and shallow water conditions are also suggested.

Acknowledgements: This study is supported by the TUBITAK whit the project number of 113Y070 and Istanbul University research fund with the project number of 28942 and 17828.

**What do we know about the deposition of calcareous nannofossil ooze of the Late Cretaceous, NW Europe?**

Buls, T.[1], Anderskouv, K.[1], Thompson, C.E.L.[2], Stemmerik, L.[3], Fabricius, I.L.[4], Friend, P.L.[5], Bjerrum, C.J.[1]

[1] Department of Geosciences and Natural resource Management, University of Copenhagen, Oester Voldgade 10, DK-1350, Copenhagen K, Denmark - toms.buls@ign.ku.dk
[2] School of Ocean and Earth Science, University of Southampton, National Oceanography Centre, Southampton, Hampshire SO14 3ZH, United Kingdom
[3] Natural History Museum of Denmark, Oester Voldgade 5–7, DK-1350, Copenhagen K, Denmark
[4] Department of Civil Engineering, Technical University of Denmark, Brovej, Building 118, 2800 Lyngby, Denmark
[5] Pacific Rubiales USA Inc., 5555 San Felipe St, Suite 1250, Houston, Texas 77056, USA

The notion of chalk deposits as uniform, monotonous sequences of pelagic sediments settled in a quiescent environment have been shown incorrect. An abundance of sedimentary structures, e.g. drifts, sediment waves and moats, visible in the chalk of NW Europe provides evidence for a dynamic depositional environment. Speculation on the strength of the currents that shaped the seafloor of the Cretaceous Chalk Sea on the European shelf has been based on only a few studies of modern deep sea calcareous sediments that hardly can be used as an analogue for European Cretaceous chalk ooze. Our work presented here focuses on experimental studies of the physical behaviour of calcareous nannofossil ooze from the Late Cretaceous European shelf in an attempt to improve the understanding and reconstruction of the depositional environment of this time. Experimental ooze was produced by gently disaggregating very fine-grained, non-cemented, highly porous Maastrichtian chalk with < 2 % non-carbonate content. Image analysis of backscatter scanning electron micrographs and laser-based grain-size analyses confirms that the experimental ooze is texturally comparable to the chalk. A series of experiments were conducted using annular flumes to study the influence of bed density (varying for different pre-experiment consolidation times), smectite clay content and organic matter on the mobility of the ooze. Results show a positive correlation between bed density and erosional threshold and a negative correlation with rate of erosion. Increasing clay mineral and marine organic matter concentration also results in increasing bed stability. Significantly, low amounts of organic matter (< 1 wt. %) have a similar effect on the mobility of the ooze as much higher smectite clay content (30 wt. %). Future experiments will quantify the impact of bioturbation on bed stability.

**Evolution of a glacially-sourced subaqueous fan complex: proglacial to ice contact facies in the Kingston Peak Formation, Sperry Wash, California**

Busfield, M.E.[1], Le Heron, D.P.[1]

[1] Department of Earth Sciences, Royal Holloway, University of London, Egham, Surrey, TW20 0EX – Marie.Busfield.2011@live.rhul.ac.uk

The early Cryogenian (Sturtian) Kingston Peak Formation is a glacially-influenced siliciclastic succession which outcrops in the Death Valley region, California. The formation is subdivided into four units (KP1-4, in ascending stratigraphic order), comprising a pre-glacial unit succeeded by three glacially-influenced sequences. KP3 represents the thickest and most extensive unit, forming the entire exposed section at Sperry Wash, and correlated to a major re-advance in the Kingston Range type section[†]. At Sperry Wash, ice-distal proglacial turbidites initially lack a clear glacial influence, although this becomes increasingly prevalent up-section with the introduction of ice-rafted debris (IRD) and interbedded glaciogenic debris flow deposits. These deposits are succeeded by ice-marginal and in turn ice-proximal facies comprising a spectrum of thick-bedded IRD-bearing turbidites, hyperconcentrated and cohesive debris flow deposits, lonestone-bearing shales and rain-out diamictites. These strata are interpreted to record deposition on the fringe of a grounding-line fan. The succession is capped by a thick accumulation of subglacial diamictites, interbedded with glaciotectonically deformed finely laminated sediments, representing the ice-contact fan apex, deposited during peak glacial conditions. The recognition of subglacial diamictites stands in contrast to interpretations of earlier authors who preferred an entirely proglacial origin for these strata. Multiple onlap surfaces above the subglacial diamictites likely reflect episodes of minor transgression following initial ice retreat; however the top of the succession is truncated by an angular unconformity with the Cambrian Noonday Dolomite Formation. Overall the Sperry Wash section demonstrates a clear progradational signature driven by advance of the ice front, as evidenced in the increasing glacial influence up-section and evolution from proglacial to ice-contact depositional environments.

[†]See Le Heron & Busfield: New insights into the processes of glacial re-advance in a Sturtian snowball Earth event.

Acknowledgements: This work was partially funded by the Geological Society of London Fermor Fund. The authors are extremely grateful to Tony Prave for general guidance and field assistance.