The sedimentary model and formation mechanism of a sublacustrine fan on the steep slope-offshore and deepwater environment in a faulted basin

Ma, S.[1], Fan, G.[1], Cong, L.[1], Wen, H.[1], Sun, Y.[1], Li, T.[1]

[1] College of Earth-Sciences, Northeast Petroleum University, 163318-Daqing, Heilongjing Province, China – szm6503@sina.com

On the steep slope of a faulted basin, a large set of gravity flow sediments are deposited, and surrounded by deep lacustrine mudstone forming hydrocarbon source rock in the upper and lower, sides and front. The gravity flow deposition system has become an important oil and gas enrichment zone under the conditions of deep water. This paper discusses the sedimentary model and the formation mechanism of a sublacustrine fan on the steep slope-offshore and deepwater environment in faulted a basin, and the effect of a sublacustrine fan on oil and gas reservoirs.

Through comprehensive research to confirm that the facies types of DLH reservoir at Sug oilfield in Bohai Bay Basin, NE China is a sublacustrine fan sedimentary system on the steep slope-offshore and deepwater environment in a faulted basin, the main basis for a matrix-supported, graded bedded, gravel facies (A), parallel bedded coarse- medium-grained sand facies (B), ripple bedded siltstone facies (C), especially the overlapping sequence of AA, ABAB, ABCABC with the typical scour surface at the bottom. The graded bedding, gravel facies (A) are mainly pebbly fine conglomerate, and fine gravel mainly comes from provenance, medium gravel mainly comes from the erosion of the early formation in drainage area, and is of a floating type, multiple composition, poor sorting and grinding, a near source characteristics. Compared with the classic turbidite, a sublacustrine fan has the characteristics of coarse granularity, poor sorting and grinding. A segment thick and development, CDE segment undevelopment, vertical cutting and stacking serious; on the upper part of the steep slope of faulted basin, surrounded by deep lacustrine mudstone at the upper and lower, lateral and front direction.The above features reveal that the type of deposits is different from the typical turbidite, the shallow sublacustrine fan and deep-water distal fine-grained sublacustrine fan.

According to the characteristics of core, logging, facies belt location, the topography of lake bottom, the sublacustrine fan on the steep slope-offshore and deepwater environment is further divided into 4 subfacies and 12 microfacies: inner fan subfacies (main ditch, main ditch levee, interditch, slump microfacies), middle fan subfacies (braided ditch, ditch margin, interditch microfacies), external fan subfacies (terminal seat, interseats microfacies), deep incised fan(incised ditch, ditch margin, terminal seats).

Established a branch ditch sedimentary model about sublacustrine fan on the steep slope-offshore and deepwater environment by fine anatomy of 19 short-term base level cyclic sequences of plane microfacies with 374 development wells.Different from sedimentary model of typical turbidite and traditional sublacustrine fan, this sedimentary model is the dendritic pattern, each branch is a composite shoestring of gravity flow ditch-ditch margin- seats which are controlled by the ditch; each branch is a long and narrow strip; mud or even deep lacustrine mud deposit between branches. The sublacustrine fan is of obvious characteristics controlled by gravity flow ditch.

The formation mechanism of dendritic sublacustrine fan controlled by ditch: during the transgressive and high level system tract of deep subsidence stage, strong flow water system which is near source and clastic supply sufficient flows into the lake and forms a plurality of dendritic debris flow along the main-ditch on the nearshore sublacustrine steep slopes or fault scarp into deep lacustrine, and deposits on the slope and the slope break.

Acknowledgements: This paper was funded by the national science and technology major projects (2011ZX05006-005).

Carbon isotope stratigraphy of the Lower Cretaceous carbonate strata of the Mural Formation, Sonora, Mexico

Madhavaraju, J.[1], Lee, Y.I.[2], Scott, R.W.[3], González-León, R.W.[1], Ramasamy, S.[4]

[1] Estación Regional del Noroeste, Instituto de Geología, Universidad Nacional Autónoma de México, Hermosillo, Sonora 83000, México - mj@geologia.unam.mx
[2] School of Earth and Environmental Sciences, Seoul National University, Seoul 151-747, Korea
[3] Geosciences Department, University of Tulsa and Precision Stratigraphy Associates149 West Ridge Road, Cleveland OK 74020-5037
[4] Department of Geology, University of Madras, Chennai 600 025, India

A thick sequence of clastic and carbonate rocks of the Mural Formation belonging to the Bisbee Group is widely distributed in Sonora, northwestern Mexico. The Mural Formation in north-central Sonora has been divided into six member's viz.: Cerro La Ceja, Tuape Shale, Los Coyotes, Cerro La Puerta, Cerro La Espina and Mesa Quemada members. The purposes of the present study are: a) to provide an isotopic record of the Mural Formation, Sonora, and b) to identify OAE intervals in the Cerro Pimas section.

The petrographic study reveals a range of lithofacies from bioclastic wackestone to boundstones. Prominent age-diagnostic fossils in the limestones of this section are benthic foraminifera. This biota is consistent with the published Upper Aptian to Lower Albian age of strata in this section. The limestones of the Mural Formation show negative to positive $\delta^{13}C$ values (-4.63 to +2.6‰ VPDB) and $\delta^{18}O$ values varying from -12.74 to -8.34‰ VPDB. The absence of correlation between $\delta^{13}C$ and $\delta^{18}O$ values supports a primary marine origin for the $\delta^{13}C$ values of limestones from the Cerro Pimas section.

The carbon isotopic curve of the Cerro Pimas section is compared with published curves of similar age that shows several comparable segments (C9, C10, C11, C12, C13, C14, and C15). In the lower part of the Cerro Pimas section, the Tuape Shale Member shows increased detrital input, followed by decreased detrital contamination in the Los Coyotes Member. Overlying the clastic interval in the Lower Albian Los Coyotes Member (segment C12), the commencement of OAE1b is indicated by an increase in $\delta^{13}C$ value followed by a decrease in $\delta^{13}C$ values. Furthermore, such abrupt changes in carbon isotopic fluctuations indicate the presence of OAE1b in the Mural Formation in northern Mexico and this interval is correlated with the Paquier event. Moreover, another significant negative carbon isotope shift is observed in the upper part of the Los Coyotes Member (segment C13), which also records the oceanic anoxic event that can be correlated to the Leenhardt event. The occurrences of both Paquier and Leenhardt events (OAE 1b sets) in the Cerro Pimas section confirm the global nature of the Early Albian anoxic event.

Geochemistry of beach sands from Gulf of California, Mexico: Implications for paleoweathering and provenance

Madhavaraju, J.[1], Lee, Y.I.[2], Tom, M.[3], Pillai, R.B.[3], Ramasamy, S.[3]

[1] Estación Regional del Noroeste, Instituto de Geología, Universidad Nacional Autónoma de México, Hermosillo, Sonora 83000, México - mj@geologia.unam.mx
[2] School of Earth and Environmental Sciences, Seoul National University Seoul 151-747, Korea
[3] Department of Geology, University of Madras, Chennai 600 025, India

The Gulf of California is an intercontinental NW-SE rift zone with oblique separation of the Baja California peninsula to the west (Pacific plate) and Sonora to the east (North American plate). The structural pattern of the gulf is thus explained by an alternation of short spreading axes and longer dextral transform faults. The continental geologic frameworks adjacent to the coastal regions of Gulf of California, Mexico are dominated by igneous, sedimentary and metamorphic rocks with ages ranging from the Proterozoic to Recent.

Beach sand samples were collected from 3 beaches (Puerto Peñasco, Desemboque and Bahia Kino) located in the northern Gulf of California and 2 beaches (Huatabampo and Altata) located in the southern Gulf of California, Mexico. The textural study reveals that the beach sands from Puerto Peñasco, Desemboque, Huatabampo and Altata are well sorted to moderately well sorted, whereas the Bahia Kino sands are well sorted to poorly sorted. Petrographic studies of beach sand samples show the presence of considerable amount of feldspars.

Most of the sand samples are classified as felsic sands using SiO_2 content. On the SiO_2/Al_2O_3 vs.Fe_2O_3/K_2O diagram, most of the samples from Puerto Peñasco, Desemboque and Bahia Kino plot in the Arkose field whereas Huatabampo and Altata sands fall in the wacke field. Large variation in ΣREE content is observed in Altata sands (109 to 331 ppm) than in Puerto Peñasco (24 to 73 ppm), Desemboque (86 to 102 ppm), Bahia Kino (57 to 89 ppm) and Huatabampo sands (85 to 129 ppm). Such large variation in ΣREE content in Altata sands is likely due to differences in fractionation of minerals. The chemical index of alteration values (CIA: 42 to 52) and A-CN-K (Al_2O_3 – $CaO+Na_2O$ – K_2O) relationships for the five beach areas suggest the prevalence of low weathering conditions in the source areas. In chondrite normalized REE plot, all the sand samples show similar REE patterns with enriched LREE, depleted HREE and negative to positive Eu anomalies. The La/Sc, Th/Sc, Th/Co, Th/Cr, Cr/Th, $(La/Yb)_{cn}$ and Eu/Eu^* ratios suggest that all sand samples were derived from felsic source rocks.

Compare and contrast cuttings and core: characterizing the deep accretionary wedge of the Nankai Trough, Japan

Maia, A.[1], Schleicher, A. M.[2], Fukuchi, R.[3], Song, C.[4], Yang, K.[5], Tobin, H.[6], Hirose, T.[7], Saffer, D.[8], Toczko, S.[9], Maeda, L.[10], and IODP Expedition 348 Scientists

[1] School of Earth and Ocean Sciences, Cardiff University, Cardiff CF10 3YE, UK - maiaar@cardiff.ac.uk
[2] Department of Earth and Environmental Sciences, University of Michigan, USA
[3] Department of Earth and Planetary Science, The University of Tokyo, Japan
[4] Department of Geological Sciences, University of Missouri-Columbia, USA
[5] Department of Earth System Sciences, Yonsei University, Korea
[6] Department of Geophysics, University of Wisconsin-Madison, USA
[7] Kochi Institute for Core Sample Research, JAMSTEC, Japan
[8] Department of Geosciences, The Pennsylvania State University, USA
[9] Centre for Deep Earth Exploration, Japan Agency for Marine-Earth Science and Technology, Japan
[10] Centre for Deep Earth Exploration, Japan Agency for Marine-Earth Science and Technology, Japan

IODP Expedition 348 (part of the Nankai Trough Seismogenic Zone Experiment program – NanTroSEIZE) is the first scientific riser-drilling project to access the deep interior of an active accretionary wedge. One major objective for the primary riser hole at IODP Site C0002 was to understand the tectono-stratigraphic evolution of the wedge beneath the Kumano forearc basin by characterizing lithological and structural variations with depth using cuttings, core, and logging while drilling (LWD) measurements. Cuttings were described at ten-meter intervals from 875 to 3058 mbsf, and cores were recovered from 2163 to 2217 mbsf. As core availability was restricted to a short interval, the study of cuttings was crucial to interpret the lithostratigraphy throughout the drilled interval. The reliability of data acquired from cuttings is often questioned, due to significant artifacts related to the drilling process. The main issues encountered with the use of cuttings are (1) the mechanical deformation of rock chips and disaggregation of less consolidated lithologies caused by the drilling bit, (2) stratigraphic mixing of cuttings within the drilling mud column during their ascent from the bottom of the well to surface or due to collapse/cavings, and (3) contamination and alteration of the natural mineral and chemical signatures by the drilling fluids. The identification of sedimentary and natural deformation structures is limited in cuttings fragments, and features such as grain-size gradation, oriented bedding and faults are only observed in cores. However, cuttings can be used to assess rock textures, mineralogy, geochemistry and fossil content, and to recognize laminations, bioturbation, unoriented micro-fault textures, shear-related striations, small-scale deformation bands and vein mineral precipitation. In Hole C0002NP, the main lithologies observed in both core and cuttings consist of fine-grained turbiditic mudstones with coarser silty and sandy interbeds. The relative proportion of these lithologies in cuttings samples, combined with their mineralogical and geochemical analysis permitted the definition of three lithological units, exhibiting good depth consistency with the unit boundaries determined from the logging data. The difficulties associated with the study of cuttings can be partially overcome by the analysis of different size rock fragments, and integration of logging data and cores of intervals of interest. Despite having some limitations in their use, our results show that drill cuttings are a viable alternative to coring.

Influence of wind-driven bottom currents on the sedimentology of different lake basin types

Mäkinen, J.[1]

[1] Geological Survey of Finland, P.O. Box 1237, FI-70211 Kuopio, FINLAND - jari.makinen@gtk.fi

Lake Oulujärvi in Finland is a large and shallow lake that is comprised three sub-basins: Paltaselkä (area 176 km^2, mean depth 7.4 m), Ärjänselkä (397 km^2, 8.2 m) and Niskanselkä (345 km^2, 7.3 m). Since isolation (9500 years BP), the area of the lake has doubled due to postglacial land uplift/tilting. This, combined with catchment evolution, wave erosion, and wind driven bottom currents has caused a complex sedimentological pattern in different parts of the lake. Because wind-driven wave erosion and bottom currents were expected to increase the complexity of the sedimentary record (SR), the highest SR variation was expected in Niskanselkä and Ärjänselkä, which are wide and open basins. Conversely, SR variation was expected to be lower in Paltaselkä, because the basin morphology is less open, containing many small islands.

The detailed sediment morphology and quality of Lake Oulujärvi was mapped with sub-bottom echo sounding profiles (200 and 24 kHz) at 200-m intervals. The SR was investigated from 157 sediment cores (in average 2 m) using susceptibility measurements, but some cores were analyzed by multielement geochemical determination (EPA 3051). Variation in susceptibility values mainly reflects the ratio of minerogenic/organic material.

The main composition trend, related to the postglacial soil evolution in the catchment, was found to be similar in all sub-basin gyttjas, namely a gradual/stepwise increase in carbon and a decrease in elements bound to fine-grained silicates (Al, Mg, K). However, more detailed SR analysis indicated significant differences between the sub-basins, i.e. each sub-basin has its own SR characteristics.

The SR in Paltaselkä is almost uniform, which indicates constant sedimentological conditions in the whole sub-basin area. Some spatial variation in sediment quality and layer thickness reflects the type of eroded shore soil (sand, till, peat). The greatest variation in the top 30 cm of the SR in Paltaselkä is associated with anthropogenic activity. In Ärjänselkä, roughly half of the accumulation area has the same SR characteristics, but in some high energy/erosion or isolated areas the variability in the SR increases. In some cases, this can be attributed to the horizontal propagation of the accumulation area due to the bottom currents. The mm-scale layering is best developed in a low energy environment. The SR is most variable in Niskanselkä, indicating spatial variability in the basin sedimentology. The abundance of silty/sandy material in some gyttja accumulation areas reflects high-energy bottom currents.

The differences in the sedimentation dynamics were also found to be reflected in the hypsographic data. In Niskanselkä, there are sandy formations with steep ramps, indicated in the hypsographic data as a deflection at the depth of 8 m. In contrast, the hypsographic distribution of Paltaselkä is quite smooth.

Thus, the data indicate that both the size and morphometry of a basin determines the development of the SR. It is suggested that there is a morphometric threshold value, the lake area (km^2)/shoreline (km) ratio, that determines the onset of the wind-driven bottom current dominance of SR development. This threshold value lies somewhere between 0.53 and 0.91 (Paltaselkä – Niskanselkä).

Characterization of syn-diapiric Jurassic sedimentation in the Imilchil Area, Central High-Atlas, Morocco

Malaval, M.[1], Joussiaume, R.[1], Razin, P.[1], Grelaud, C.[1], Messager, G.[2], Martin-Martin, J.D.[3], Saura, E.[3], Moragas, M.[3], Verges, J.[3], Hunt, D.W.[2]

[1] ENSEGID–IPB, 1 allee F. Daguin, 33607 Pessac, France - manon.malaval@ensegid.fr
[2] Statoil, TPD RD, Bergen, Norway
[3] Institute Earth Sciences Jaume Almera, CSIC, Barcelona, Spain

The Jurassic Atlas intracontinental basin in the Central High-Atlas is characterized by a succession of ENE-WSW narrow anticlinal ridges and wide synclines, developed by the diapirism of Triassic sediments and later magmatic intrusion along major synsedimentary faults. The core of the diapiric ridges is made of Triassic red shales, magmatic rocks and some evaporites. These diapiric structures are particularly well preserved in the Imilchil region, an ideal area to study the interaction between sedimentation and diapirism. The objective of this study is to place local diapiric movements and associated deformation and facies changes within the context of regional subsidence and facies patterns. The effects of diapir movements on sedimentation are demonstrated by intra-formational geometries (thickness variations, unconformities), facies variations close to the diapirs (local influence on the depositional profiles), and/or by specific events (erosional surfaces, breccia, condensed levels).

Toarcian to Bathonian halokinetic sequences define two main phases of diapiric activity. The first major phase of diapiric movements occurred during the Toarcian/Aalenian, and is characterized by the presence of progressive unconformities within relatively deep marls and carbonate deposits. In the regional context, this diapiric activity is concurrent with a period of normal faulting. In contrast, reduced diapirism during the Bajocian is recorded by the progradation of oolitic and bio-constructed carbonate platform systems. The second phase of major diapiric activity occurred from the end of the Bajocian to the Bathonian, in relation with a new phase of deformation in the Atlas Basin, associated with magmatic intrusions and tectonic movements. The latter are thought to be responsible for an increase of clastic influx. Carbonate platforms were subsequently replaced by relatively shallow mixed carbonate-siliciclastic and ultimately continental systems, themselves affected by significant synsedimentary diapiric activity and associated deformation. At this stage, the diapirs tended to emerge, and disconnect the mini-basins. The high subsidence rate in these mini-basins allowed the accumulation of 2000 to 3000 meters of sediments during the Bathonian.

Quantitative analysis of Submarine-Flow Deposit Shape in the Marnoso-Arenacea Formation

Malgesini, G.[1, 2, 4], Talling, P.J.[2], Armitage, D.[3], Felletti' F.[4]

[1] National Oceanography Centre, European Way, Southampton, SO14 3ZH, U.K. – giuseppe.malgesini@dappolonia.it
[2] D'Appolonia S.P.A., Via A. Liri, 27 - 16145 Genova - Italy
[3] ConocoPhillips, Sedimentology and Stratigraphy, Houston Texas 770794
[4] Università degli Studi di Milano, Dipartimento di Scienze della Terra, Via Mangiagalli 34, 20133-Milano, Italy

Submarine sediment density flows are one of the volumetrically most important processes for sediment transport across Earth. The sediment concentration of flows that reach the deep ocean has never been measured directly, and understanding these long run-out flows remains a major challenge. The Miocene Marnoso-Arenacea Formation in the Italian Apennines is the only ancient sequence where individual submarine sediment density flow deposits (single beds) have been mapped out for more than 100 km down-flow. Here we document the external shape and internal architecture of thirty-two individual beds that record flow evolution, and which can be compared to deposit shapes in mathematical or experimental models. The large number of beds allows modes of flow behavior to be identified. Larger-volume turbidite are typically dominated by massive or planar-laminated sandstone intervals that have a broad thickness maximum. This shape is important because it suggests that massive and planar laminated sandstones record hindered settling from dense near-bed layers, which have high (> 10 % volume) sediment concentrations. Previously, some authors have inferred that planar-laminated sandstones are mainly deposited by dilute flows. The position of the broad thickness maximum moves basinward as the volume of sand in the flow increases. It is suggested that the position of the thickness maximum depends on flow thickness, flow speed, and sediment settling velocity; as well as sediment concentration, variations in seawater entrainment rate, and local changes in seafloor gradient. Smaller-volume turbidite sandstone intervals are finer grained and dominated by ripple cross-lamination and have a near exponential decay in thickness that is consistent with deposition from a dilute sediment suspension. The rate of near-exponential thinning is controlled by sandstone volume. In contrast, turbidite mudstone intervals show a linear increase in thickness with distance. Flows that entered the basin in opposite directions produced turbidite mudstone intervals that thicken towards the same location, indicating that muddy turbidity currents can drain back over long distances to basinal lows.

Paleoenvironmental analysis of early Priabonian coral buildups, San Martí Xic Formation, Orís (Vic, SE Ebro basin, Spain)

Mancini, A.[1], Ferràndez–Cañadell, C.[1]

[1] Departament d'Estratigrafia, Paleontologia i Geociències Marines; Facultat de Geologia. Universitat de Barcelona, Martí i Franquès s/n 08028, Barcelona - amaninma7@alumnes.ub.edu

The paleoecology of Paleogene hermatypic corals has been traditionally interpreted on actualistic grounds. They have been considered to live, like their recent counterparts, in conditions of clear, shallow, oligotrophic and high energy water, building patch reefs or fringing reefs. Recent studies have shown that most Paleogene coral buildups and some recent counterparts lack a true framework. Instead the are made of colonies surrounded by fine matrix, which correspond to a mixed carbonate-siliciclastic sedimentary environment with turbid and mesotrophic conditions.

We studied the paleoenvironmental conditions of the early Priabonian coral buildups of Sant Martí Xic Fm at Orís (Vic, SE margin of Ebro Basin). The geometry and the internal architecture of the Orís coral buildups were reconstructed from sequenced stratigraphical logs and the analyses of the shape, diversity, and distribution of the coral colonies. The study of litho- bio- and microfacies allowed the paleoecological interpretation and the elaboration of a paleoenvironmental model.

Corals in the Sant Martí Xic Fm developed on low paleohighs at the distal part of the fan delta lobes constituted by sandstones with *Nummulites* and *Discocyclina*, growing discontinuously in width, rather than in height during periods of low sedimentary rate. Laterally, coralline red algae facies were deposited in the low relieves between lobes.

The results are a new contribution to understand Eocene coral buildups developing in mixed carbonate-siliciclastic sedimentation systems, with turbid, mesophotic mesotrophic waters.

Key words: Eocene, cluster reef, corals, mixed sedimentation, paleoecology, larger foraminifera.

The role of paleogeography and tectonic control in the Upper Eocene neritic facies of the NE Ebro basin: the Coll d'Úria Limestones

Mancini, A.[1], Ferrandez-Cañadell, C.[1]

[1] Departament d'Estratigrafia, Paleontologia i Geociències Marines; Facultat de Geologia. Universitat de Barcelona, Martí i Franquès s/n 08028, Barcelona - amaninma7@alumnes.ub.edu

The Bartonian-Priabonian of the NE part of the Ebro basin (Catalonia, Spain), shows different neritic facies developed in a mixed carbonate-siliciclastic platform. These facies, which have been extensively studied in the Igualada and Vic basins, are part of the La Tossa Fm and St. Martí Xic Fm, and represent the last marine event of the basin before its continentalization.

The evolution of these neritic facies are associated to fan delta environments produced by the sediment suplied from the surrounding Pyrenees and Catalan Coastal Ranges. The main biotic components of these neritic facies (corals, larger foraminifera, bryozoa, coralline red algae) are embedded in either carbonate or siliciclastic matrix, directly correlated to the activity of the fan deltas, which also influenced the light penetration and the trophism of the waters.

The Coll d'Úria Limestones, located near Olot (north-estern part of Ebro basin, 54 Km W of Girona 43 Km E of Vic) are the equivalent of the Bartonian-early Priabonian neritic facies of the Vic and Igualada basins. They are an isolated outcrop of hermatypic coral facies between the Vic and Igualada Basins, which can be related to the particular paleogeography of the eastern sector of the Ebro basin, controlled by structural features.

The geometry of the different lithofacies was reconstructed from sequenced stratigraphical logs and the study of bio- and microfacies allowed the paleoenviromental interpretation.

During the Early-Middle Eocene different faults with E-W trends were generated in the eastern part of the Ebro basin. These fault created a horst (Coubet-Olot) and graben (Ripoll-Vallfogona) system, delimitated by the Rocacorba and Amer faults, which configured the paleogeography of this sector. In the Upper Eocene, the tectonic activity stopped and the Horst of Coubet-Olot remained as a paleogeographic high, where an isolated carbonatic sedimentation developed (Coll d'Úria Limestone, equivalent to La Tossa Fm and St. Marti Xic Fm), while siliciclastic sedimentation (sands and marls, equivalent to Igualada Fm) took place in the graben.

After this period of relatively tectonic calm the fault activity restarted, leading to the sedimentation of conglomerates near the Horst paleohigh and fine sands and marls in the graben basin. The horst-graben relieves were smothed and fosilized by the later deposition of the Artés continental formation, when the Ebro basin was closed.

The carbonate platform facies of Coll d'Úria thus date the tectonic activity of the area and define the limits of the Horst of Coubet-Olot, controlled by the activity of the Amer and Rocacorba faults, which acted as a paleogeographic high between the Vic and Girona basins during the Upper Eocene.

Key words: Upper Eocene, neritic facies, mixed sedimentation, hermatypic corals, Ebro Basin, tectonic control.

Reconstructing past sea-level in the Spermonde Archipelago, SW Sulawesi, Indonesia

Mann, T.[1], Schöne, T.[2], Rovere, A.[1, 3], Klicpera, A.[1], Satari, D.Y.[4], Westphal, H.[1, 5]

[1] Leibniz Center for Tropical Marine Ecology (ZMT), 28359 Bremen, Germany – thomas.mann@zmt-bremen.de
[2] Helmholz Centre Potsdam GFZ German Research Center for Geosciences, 14473 Potsdam
[3] MARUM – Center for Marine Environmental Sciences and Faculty of Geosciences, University of Bremen, Germany
[4] Research and Development Center for Marine, Coastal, and Small Islands, Hasanuddin Univeristy, Makassar, Indonesia
[5] University of Bremen, Faculty of Geosciences, Klagenfurter Straße 2, 28359 Bremen, Germany

The reconstruction of relative sea-levels (RSLs) is important for understanding the dynamics and effects of sea-level changes at local scale. Variations in RSL are spatially and temporally not uniform and RSL histories of far-field locations (i.e. far away from former ice sheets) differ from those of higher latitudes due to glacial isostatic adjustment processes. In equatorial regions, leveling and dating fossil microatolls in growth position is a premium tool to assess RSL histories. Microatolls are annular coral colonies with a dead upper surface while polyps grow towards their periphery. In open reef flat positions, they are precise RSL indicators as their upward growth is approximately constrained by mean lower low water (MLLW) levels. Therefore, the relative elevations of the upper surfaces of fossil microatolls provide reliable information about the RSL history in a certain region.

The Spermonde Archipelago in southwest Sulawesi, Indonesia, is formed by about 120 reef islands, some of which are still uninhabited. On the reef flats of Pulau Panambungan, Pulau Samalona and Pulau Barrang Lompo, three islets in the central part of the archipelago, we found several fossil and living microatolls. We surveyed a number of living microatolls using an optical level in order determine their mean thickness and to define the height of living coral (HLC), a datum approximating MLLW. This datum was transferred to the other islands by contemporaneous measurements of the tidal elevation above reference points on the three islands. We furthermore leveled and sampled 14 fossil microatolls located on the reef flat of Pulau Panambungan. The fossil microatolls (probably from the mid- to late-Holocene) range in elevation between +0.01 and +0.25 m relative to present HLC. The highest-elevated fossil microatolls display an eroded surface and have a thickness of 0.15 m. Compared to the mean thickness of living microatolls, it indicates that historical MLLW levels were approximately 0.40 m higher than present-day MLLW.

Variations in the local RSL history largely result from a combination of tectonic, isostatic and gravitational influences on the water level relative to a certain datum. In this presentation we will discuss the impact of different influences on the RSL history in the Spermonde Archipelago and its implications for future sea-level changes in central Indonesia.

Weathering Corrosion Effects on the Porosity of Volcanic-rock Reservoirs

Mao, Z.[1, 2], Zhu, R.[1, 2], Wang, J.[1, 2], Zhang, R.[3], Luo, J.[4], Du, Z.[5]

[1] Research Institute of Petroleum Exploration and Development, Petrochina, Beijing, China – maozhiguo@petrochina.com.cn
[2] State Key Laboratory of Enhanced Oil Recovery, Beijing, China
[3] Chinese Academy of Geological Sciences, Beijing, China
[4] Northwest University/Key National Laboratory for Continental Kinetics, Xi'an, China
[5] Petrochina International Iraq FZE, PetroChina, Beijing, China

Background and methods

The weathering volcanic-rock pools have been found in the Junggar basin in the north-west of China in recent years. The reservoir spaces are mainly the secondary solution pores, dissolved fracture. The reservoir thickness can be up to 400m-450m. Through microscopic observation of weathered cores and physical corrosion simulation test of unweathered volcanic rocks, it is analysized to the weathering corrosion effect on the porosity of volcanic-rock reservoir of pore formation mechanism quantificationally.

The weathered volcanic cores (53 samples from 15 wells of the Carboniferous system in the Junggar basin) were taken to observate pore types, and count content of the different pore under the microscope. The unweathered volcanic rocks basalt rocks (4 samples) and andesite rocks (4 samples) were taken to physical corrosion simulation tests under normal temperature and pressure conditions (25℃, 1atm). The tests were simulated to the geological environments, such as atmospheric water and weathering time, by changing the CO_2 concentration (10^{-6}-10^{-1}mol/L) in solution and solution time (0-4 days).

Results and Conclusion

Weathering corrosion has an important contribution to the porosity of volcanic-rock reservoirs.

1) the feldspar minerals and matrix in volcano rocks is easy to be corroded and formed abundant secondary pores under the weathering conditions.

2) weathering-corrosion pore is the most important reservoir space in this area. Weathering corrosion enhances the quality of volcanic reservoirs significantly. It can be increase porosity of 2.5%, and permeability of 30×10-3μm2.

Acknowledgement: This work was sponsored by National Programs for Fundamental Research and Development of China (973 Program, 2014CB239001), and National Science and Technology Major Project of China (2011ZX05001).

Paleoenvironmental changes in Lake Trasimeno (central Italy) since the middle Pleistocene

Marchegiano, M.[1], Gliozzi, E.[2], Buratti, N.[3], Ariztegui, D.[1], Cirilli S.[3]

[1] Earth & Environmental Sciences, University of Geneva, 13 rue de Maraîchers, 1205 Geneva, Switzerland – marta.marchegiano@unige.ch
[2] Department of Science, University Roma Tre, Largo S. Leonardo Murialdo, 1, 00146 Roma, Italy
[3] Department of Geological Sciences, University of Perugia, Piazza Università 1, 06100 Perugia, Italy

Long terrestrial records such as lacustrine sediments are excellent archives of paleoenvironmental information. While the tectonic evolution of central Italy has been largely studied, there is a clear paucity of paleoenvironmental and paleoclimatic records covering the late Pleistocene. Lake Trasimeno is located in Central Italy (Umbria Region). Previous studies have shown that this presently very shallow (6m maximum water depth) and large lake (surface ~120km^2) was formed at the end of the early Pleistocene during a phase of general uplift in the area. As in most shallow water ecosystems, climate change plays a fundamental role in its evolution. Thus, Lake Trasimeno is an outstanding site to better understand the paleoenvironmental history of this area since the late Pleistocene.

A 175 m long sedimentary core was retrieved by the Geological Survey of the Umbria Region along the present southern shore of the lake (north of the Panicarola town). A multidisciplinary analysis of the lowermost 30 m is now in progress including physical properties, palynology, fossil remains, sedimentological and geochemical analyses. The sediments are relatively uniform comprising mostly green-gray clays with occasional sand intervals and evidence of oxidation layers probably caused by desiccation periods. TOC analyses reveal a low content of organic matter except for one level (from 29m to 29.52m) representing sapropel-like sediments. A preliminary age model based on pollen data suggests that the record may be as old as middle Pleistocene.

Ostracod assemblages in lacustrine sediments provide an excellent tool for paleoenvironmental reconstructions. Despite that the Lake Trasimeno sediments are relatively uniform they contain ostracod remains showing distinctive changes. They are constantly present throughout the core except for the organic-rich level at the bottom and from 13 m to the uppermost part of the core that is sterile. The ostracod-rich interval is generally containing mature communities composed of adults and instars. On the whole, 16 species referable to 12 genera were collected (*Ilyocypris gibba, Candona neglecta, Candona angulata, Cypridopsis vidua, Heterocypris salina*, *Limnocythere* sp.1, *Limnocythere* sp.2, *Limnocythere stationis, Darwinula stevensoni, Cyprideis* sp., *Leptocythere* spp., *Fabaeformiscandona fabaeformis, Cyclocypris ovum, Pseudocandona juv., Paralimnocythere sp.*). Conspicuous changes in the abundance of these assemblages have been identified along the studied core alternating sections with very abundant ostracod remains with others with scant (or even null) individuals. The presence of species exclusives of certain intervals indicates substantial environmental changes. In particular, two intervals are significant for the paleoenvironmental reconstruction of the sedimentary successions: 1) the section from 25.60 m to 23.50 m is characterized by a rich ostracod fauna and presence of halophilic species (*Cyprideis torosa and Leptocythere* spp) that suggests an increasing of TDS concentration; 2) the interval from 21.05 m to 17.60 m contains. *Limnocythere stationis* a central European species, so far signaled for Italy only in the Panicarola core (this study) and in the Holocene of Sicily probably suggesting a period of prevailing cool waters. Starting at 15 m ostracod specimens are badly preserved to finally disappear from 13m upwards.

The medium-low equitability of ostracodes indicates the predominance of one or more species, and thus pointing towards unstable environments. This is also confirmed by the observed medium-low specific diversity. Further ostracod identification as well as their geochemistry (stable isotopes and elemental analyses) will provide a more detailed reconstruction of the timing, tempo and magnitude of paleoclimatic changes in the Lake Trasimeno area.

Integrated stratigraphic-petrographic and biostratigraphic analysis of Modino Unit turbiditic system (Northern Apennines, Italy)

Marchi, A.[1], Pandolfi, L.[1], Catanzariti, R.[2]

[1] Earth Science Department, Pisa University, Via Santa Maria 53-56126 Pisa, Italy – Marchi.alessandra@dst.unipi.it
[2] Centro Nazionale delle Ricerche, Istituto di Geoscienze e Georisorse IGG-CNR Pisa, Italy

The Northern Apennines is a key site for the study of the relationships between tectonic and sedimentation in foreland basins. The Apennine orogenesis started from late Oligocene, trought the formation of a belt verging towards the north-eastern sectors. In conjunction with the movement of overlapping fronts, the foreland basins were originated along the western margin of Adria plate. The migration of the foredeep-belt system is outlined by the infilling sequence age's, getting younger from west to east.
In this geological framework the study of turbiditic deposits internal organization is significant to estabilish which are the sedimentary processes that govern basin fill and their subsequent geodinamic evolution.
In this work we presents the results of integrated stratigraphic-petrographic research on the turbidite system of Modino Unit depositional complex outcropping in the Tuscan-Emilian Apennines.
The Modino Unit turbiditic system provides an excellent opportunity to study the sedimentary and structural variations within the contex of spatial and temoral distribuition of source rocks during the evolution of the Northern Apennines foreland basin.
This study was carried out using a multidisciplinary approach: a stratigraphical study of facies and facies associations, a biostratigraphical study of calcareous nannofossils associations and a provenance study using the modal analysis technique.
The Modino Unit succession shows a thickening and coarsening upward trend, passing from red and green shales with intercalations of turbidite-like-sandstones bed, Fiumalbo Shale Auctt., to a clayey-marly lithofacies, Marmoreo Marl Auctt. The upper part of this Unit is characterized by very poorly sorted corse to medium sandstone, which graded to poorly sorted fine to medium sandstones with horizontal laminae, passing upward to a well sorted medium to corse sandstone characterized by thinning and fining upward horizontal laminae, corresponding to Modino Sandstone Auctt.
The facies analysis on this succession display a clear thinning-upward trend.
Even if local sinsedimentary effects of sin-depositional tectonic activity have also been recorded especially in the lower part of the succession, where we can see associations of proximal and distal facies.
The calcareous nannofossils assemblage assingn the studied sections an age spanning the Lutetian and Chattian, this suggest that this sequence starts its sedimentation in a pre-foredeep stage.
The sandstone petrography makes possibile to place the studied Monte Modino Sandstone in the compositional evolution of the detritus deposited in the Northern Apennines foredeep during Oligocene time, like Macigno Fm. of Tuscan Nappe, but the modal analysis on the turbidite-like-sandstone beds of Fiumalbo Shale we can find a significative presence of non-metamorphic-serpentinite and radiolarite fragments, it's probably suggest a clastic input derived from External Ligurian Units during the middle Eocene.
In conclusion the Lutetian and Rupelian part of Modino Unit succession seems to be supplied by two different source areas, the classic Alpine source area and a more proximal "Liguride derived" source, maybe located in the proto-apenninic wedge. From these data we can assume the Modino Unit depositional system and it's facies association are related to a re-equilibrium along the basin margins during the sedimentation of the turbiditic succession.

Calcareous nannofossils biostratigraphy from Middle Eocene deposits of Jaca Basin (Pyrenees, Spain)

Marchi, A.[1], Remacha, E.[2], Boya Duocastella, S.[2], Roige, M.[2]

[1] Earth Science Department, Pisa University, Via Santa Maria 53-56126 Pisa, Italy – Marchi.alessandra@dst.unipi.it
[2] Departament de Geologia, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain

The Jaca Basin is located in the South of the Pyrenean mountain chain in Spain and was formed by the late Cretaceous and Tertiary convergence between the Iberian and European tectonic plates.

During the Middle Eocene the sediment arising from the uplifting Pyrenees was deposited in the basin, and leading the uplift of Boltaña anticline. For this reason emergent areas were created in the hinterland to the north and northeast of the Jaca Basin (Remacha et at., 1998).

These areas became the source of the first deltaic system infilling Jaca Basin, the Sabiñanigo Sandstones delta of Lutetian age.

A biostratigraphic study based on calcareous nannofossils was carried out on the Middle Eocene deposits of the Jaca Basin.

In this contribution we present the results obtained from the analysis of calcareous nannofossil assemblages from three different sities located in Jaca Basin: Yebra de Basa section, Asieso section and Barós section.
The purpose of this work is to analyze the content of calcareous nannofossils in some sections of Pyrenean areas in order to understand if the associations investigated can be compared and dated with the biozonal schemes used for the Mediterranean area.

Calcareous nannofossils are abundant throughout the studied interval even if they are not well preserved and have low diversity. Most of the important markers used to define the zonations of Fornaciari et al., (2010) are presents but not in all different sections analyzed.

The Barós section shows a relative increase in abundance of small *Reticulofenestra umbilicus* associated with a decrease of *Sphenolithus sp* and *Cribrocentrum reticulatum*, while *Coccolithus pelagicus* and *Ericsonia formosa* not seem to show a remarkable decrease. *Cyclicargolithus floridanus* is one of the dominant placoliths of the assemblage.

From this data the nannofossil assemblages present in Barós section can be dated with the scheme proposed by Fornaciari et al., (2010) and can be compared with the association of Alano section, NE Italy, reported in the work of Toffanin et al., (2011).

Alkaline-earth metal precipitates in meso-oligotrophic Lake Geneva (Switzerland): New clues for understanding the role of microbes in carbonate precipitation

Martignier, A.[1], Jaquet, J.-M.[1], Nirel, P.[2], Ariztegui, D.[1]

[1] Département des Sciences de la Terre, Section des Sciences de la Terre et de l'environnement, Université de Genève, 13 rue des Maraîchers, 1205 Genève, Switzerland – Agathe.Martignier@unige.ch
[2] Service de l'Ecologie de l'Eau, DIME, 23 avenue Ste. Clotilde, 1211 Genève 8, Switzerland

Recent laboratory experiments and field observations imply that cyanobacteria play an important role in carbonate precipitation in both freshwater and marine systems. Several investigations have shown that carbonate precipitation induced by cyanobacteria is not only the result of photosynthesis in carbonate-rich water. But the precise role of these microorganisms in carbonate formation is unresolved and whether they induce mineral precipitation or entrap abiotic mineral precipitates remain open questions. Furthermore, it is not clear yet whether the role of different microorganisms vary from one species to another.

During a water-quality survey in meso-oligotrophic Lake Geneva (Switzerland), suspended matter was collected by filtration on 0.2 micrometer membranes between July 2012 and Spring 2014 at various depths in the water column. In most of the samples, scanning electron microscopy revealed the presence of numerous dark and gelatinous patches occluding the pores of the membranes, containing, in places, clusters of smooth microspheres 0.5-2 micrometers in diameter.

Their chemical composition, determined by semi-quantitative, energy-dispersive X-ray spectroscopy (EDS) shows Mg, Ca, Sr and Ba (alkaline earth metals) to be the dominant cations. Carbon (as carbonate) and phosphorus (presumably as phospho-carbonate) are present as anions. The carbonate microspheres have been subdivided into two types: type I (CaSrBa) occurs as flat, circular clusters, and displays a broad variability in Ba/Ca, even within a given cluster; type II (CaSr) is devoid of Ba, but may incorporate P and S, and occurs as 20 micrometers spherical clusters. In contrast to the former types, phosphorus-rich microspheres are smaller and are found as isolated individuals or loose aggregates. The Type I composition resembles that of benstonite, a Group IIA carbonate that was recently found as intracellular granules in a cyanobacterium from alkaline Lake Alchichica (Mexico).

Lake Geneva microspheres are solid, featureless and amorphous, as shown by TEM in diffraction mode. FIB-made sections through Type II microspheres display a change in composition from the center to the periphery. All types of microspheres are embedded in a mucilage-looking substance (EPS), often in the vicinity of picoplanktonic cells (possibly eukaryotes or cyanobacteria). In summer 2012, the macroscopic physico-chemical conditions in Lake Geneva epilimnion were such as to allow precipitation of calcite, but not strontium and barium carbonates. For these, favorable conditions might have been provided in the micro-environment by the combination of active phytoplankton in an EPS envelope.

An ongoing multidisciplinary research program aims to gain a proper understanding of this intriguing process of alkaline-earth metals sequestration using a combination of methods including SEM/EDX/TEM, epifluorescence microscopy, flow cytometry and genomics. It addresses several questions such as the spatio-temporal distribution of the precipitates, their exact mineralogical composition, and the taxonomy and role of phytoplankton and microbes in the precipitation. Understanding the processes of incorporation of alkaline-earth metal precipitates in lacustrine carbonates and their eventual dependence on the nature of the phylogenetic lineage involved may shed new light on the actual function of microbes in carbonate precipitation.

Formation of kerolite and stevensite associated with Mg-rich carbonates in cave environments

Martín-Pérez, A.[1], La Iglesia, Á.[2], Alonso-Zarza, A.M.[2, 3], Martín-García, R.[3]

[1] Institute of Palaeontology ZRC SAZU, Novi trg 2, SI 1000, Ljubljana, Slovenia - andreamp@zrc-sazu.si
[2] Instituto de Geociencias, IGEO (CSIC, UCM). C/ José Antonio Novais, 2, 28040 Madrid, Spain
[3] Dpto. de Petrología y Geoquímica, UCM, C/ José Antonio Novais, 2, 28040 Madrid, Spain

Mg-clays can be a major component in some alkaline continental deposits, associated with variable amounts of carbonates. The genetic relationship between these clays and the precipitation of carbonates has lately received an increased interest, since a correlation between Mg-Si films/needles/gels and carbonate minerals have been recognised. These Mg-Si phases have been related to the presence of microbial extracellular polymeric substances (EPS) and they are considered to have a role in the precipitation of carbonates, specifically of dolomite.

In Castañar Cave, Spain, Mg carbonates (dolomite, huntite, magnesite and hydromagnesite), together with aragonite, are forming speleothems like crusts, coatings and moonmilk. Interestingly, when observing these minerals under SEM, they are almost always associated with laths and flexible-like mats, which resemble organic biofilms. Detailed observations, however, show that these mats are mineralised, formed by intertwined fibres that exclusively contain Si and Mg, so presumably they are clay minerals.

To characterize these particles, we have performed XRD, SEM, and TEM analysis on two types of samples: unaltered original speleothem samples, and insoluble residue, obtained after dissolution of carbonates by treatment with acetic/Na-acetate solution.

XRD analysis of insoluble residue revealed the presence of kerolite, Mg-smectite (probably stevensite) and minor amounts of sepiolite. The clays display low crystallinity, as evidenced by the lack of sharpness of the peaks in XRD diagrams and diffuse diffraction patterns of single clay particles obtained by TEM. Under SEM the clays show a wide array of textures: individual fibres surrounding dolomite crystal subunits of dolomite spherulites, fibres intergrowing with huntite flakes, and tightly interwoven fibres forming mats. These mats can form flakes, honeycomb structures, wrinkled planar structures, or coatings that tightly cover all carbonate crystals. The attribution of each of these textures to kerolite or stevensite is not always possible, as all of them show almost identical composition, with only minor variations in the amounts of Si and Mg. Composition analysis performed in TEM also show a wide similarity between the samples, and no cations other than Si and Mg have been detected.

The formation of kerolite and stevensite requires high pH, high Mg/Ca ratios, Si availability and, in most cases, evaporative conditions. In Castañar Cave, the dissolution and weathering of the host-rock, composed of magnesite, dolostone, shales and greywackes, provides Si ions and high Mg/Ca ratios to the cave waters. The Mg- mineral assemblages in this cave are formed by increase of Mg/Ca ratios by preferential removal of Ca trough precipitation of aragonite.

Mg-clays can form as alteration products of other clays, as a direct precipitate, or from crystallization of a hydrated Si-Mg gel. Such gels have been often found associated to EPS and related to carbonate precipitation. EPS facilitates the concentration of ions from solution, and the produced Si-Mg phase act as a precursor to dolomite or calcite. In the studied case, no evidence of microbial activity or presence of EPS has been found. The genetic and diagenetic relationships between the Mg-clays and the Mg-carbonates of Castañar Cave need to be better defined, but the formation of colloidal Si-Mg phases itself, biotic or abiotic, may play an important role in the precipitation of dolomite and this possibility will be the aim of future studies.

Evidence of rapid climate change at 10.77 ka coinciding with the Preboreal-Boreal transition in central Europe: a contribution from the varved record of Meerfelder Maar, Germany

Martin-Puertas, C.[1], Tjallingii, R.[1], Deriot, A.[1, 2], Brauer, A[1]

[1] GFZ, German Research Centre for Geosciences. Telegrafenberg D-14473, Potsdam, Germany – celia@gfz-potsdam.de
[2] Université Claude Bernard Lyon 1. 43 boulevard du 11 Novembre 1918, 69622, Villeurbanne Cedex, France

During the early Holocene (11.7-8.2 ka), remnants of the Laurentide ice sheet largely influenced climate in the Northern Hemisphere. In Europe, changes in vegetation define two major climatic stages within this first phase of the present interglacial, the Preboreal (relatively dry) and the Boreal (relatively wet). Environmental changes coinciding with this biostratigraphic transition have been recorded in peat bogs, glaciers and lake sediments, which suggest hemispheric climate change occurring midway through the early Holocene. However, there is still high uncertainty about the timing and abruptness of this climatic change, hence unresolved possible forcing and mechanisms behind. We aim to contribute to the state-of-the-art with a more precise dating and description of the climatic boundaries during the early Holocene in central Europe. For that, we study varve thickness variability and sediment composition obtained by XRF core scanning at sub-annual resolution from the sediment record of lake Meerfelder Maar, in the Eifel Mountains (Germany) during the early Holocene. The Meerfelder Maar varved record is renowned for its high precision chronology and sensitivity to North Atlantic climate variability. Thus, the annual proxy-data, combined with the published decadal to centennial resolved pollen assemblage, allow a better definition of timing and abruptness of the environmental and climatic changes. The Preboreal-Boreal transition is characterized in the Eifel region by a forest succession from *Betula* and *Pinus* species to *Corylus* dominance and abundant *Quercus* and *Ulmus* trees. Our main results show a synchronous change in both the vegetation and the sediments suggesting the climate change occurred at 10,768 varve yr BP, 232 years after the Ulmener volcanic eruption in the Eifel. However, while the vegetation transition lasted for ca. 200 yr, the distinct shift in the composition of the sediments was very rapid, in less than five years. Moreover, composition changes on decadal timescale suggest higher climate instability during the Preboreal interval. Our study supports multiproxy-based paleoenvironmental reconstructions of varved records for a better understanding of the climate variability in the past.

Acknowledgements: We thank the coring team for recovering excellent cores and Dieter Berger and Gabi Arnold for technical support with thin section preparation. This study is a contribution to the climate initiative REKLIM Topic 8 ‘Schnelle Klimaänderungen aus Proxy-Daten’

New annual proxy data from Lago Grande di Monticchio (southern Italy) contributing to chronological constraints and abrupt climate oscillations during the demise of the last interglacial (76-112 ka)

Martin-Puertas, C.[1], Brauer, A.[1], Wulf, S.[1], Ott, F.[1], Lauterbach, S.[1], Dulski, P.[1]

[1] GFZ, German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, Telegrafenberg, 14473 Potsdam, Germany - celia.martin.puertas@gfz-potsdam.de

The varved sediments of Lago Grande di Monticchio (MON) in southern Italy compose the only sedimentary record with an annual resolution and an independent chronology from the present back to the penultimate glacial stage. The chronology is based on varve counting, tephrochronology and $^{40}Ar/^{39}Ar$ dating of tephra layers. The MON pollen assemblage at decadal to centennial resolution has demonstrated that the Mediterranean was sensitive to abrupt millennial-scale climatic fluctuations described in the Greenland ice cores (GS/GI) during the termination of the last interglacial period (70-130 ka). New continuous annual sedimentological proxies and sub-annual element scanner data from the MON sediment record allow a comprehensive reconstruction of abrupt climatic oscillations in the central Mediterranean during this period. Based on a revised MON 2013 varve chronology for the interval 76-112 ka, we present a detailed comparison with the Greenland ice-core record (NGRIP) and northern Alps speleothem data (NALPS). GS 25 to 20 are reflected in the MON sediments as intervals of thicker varves and high Ti intensities, which were interpreted as cooler and wetter episodes and supported by pollen-based palaeoclimate reconstruction. In addition, short-lived oscillations resemble climate changes superimposed to millennial-scale variability, which have been only described in NGRIP and NALPS, so far. Similar to the NALPS timescale, the MON-2013 chronology suggests a longer GS 22 than estimates in both, the GICC05 and AICC2012 ice-core chronologies; however there is still relatively high absolute age uncertainty, especially from GI23 to GI22. The comparison between climatic proxy-records of MON, NGRIP and NALPS suggests changes in temperature were largely consistent along the NW-SE transect between Greenland and the Mediterranean, but latitudinal distribution of atmospheric moisture over western Europe might have been influenced by ice-sheet dynamics.

Diagenetic evolution of continental and marine Cretaceous sandstone reservoirs from the Espírito Santo Basin, eastern Brazil

Martini, M.[1], Zambonato, E.E.[2], Campinho, V.S.[3], De Ros, L.F.[4]

[1] Petrobras, Av. República do Chile, 330, Centro, 13th floor, CEP 20031-170, Rio de Janeiro, RJ, Brazil – matiasmartini@gmail.com
[2] Petrobras, Av. Nossa Senhora da Penha, 1688, Barro Vermelho, Bloco 3 P2-SE, CEP 29057-550, Vitória, ES, Brazil
[3] Petrobras, Av. República do Chile, 330, Centro, 13th floor, CEP 20031-170, Rio de Janeiro, RJ, Brazil
[4] Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, CEP 91501-970, Porto Alegre, RS, Brazil

Cretaceous turbidite sandstones of the Urucutuca Formation and fluvial-deltaic sandstones of the Mucuri Member of the Mariricu Formation are major reservoirs in the Espírito Santo Basin, eastern Brazil. The Mucuri sandstones correspond to marginal facies of the recently discovered "pre-salt" extensive lacustrine carbonate reservoirs. The Aptian fluvial-estuarine Mucuri sandstones are dominantly medium to coarse-grained, poorly sorted, and rich in feldspars, plutonic rock fragments, micas and heavy minerals. Eodiagenetic smectite and K-feldspar authigenesis in these sandstones occurred due to reactions between these unstable grains and alkaline brines from the adjacent lacustrine system. Mesodiagenetic alterations are represented by minor chemical compaction and limited dolomite, quartz, illite and pyrite authigenesis. Heterogeneous, discontinuous dolomite cementation occurred locally. Conversely, pervasive eodiagenetic grain dissolution and kaolinization occurred in the upper Cretaceous Urucutuca turbidite reservoirs, owing to the influx of meteoric waters. Compaction was more important than cementation for porosity reduction, except in the samples with pervasive carbonate cementation. Precipitation of quartz, albite, K-feldspar, pyrite, siderite and TiO_2 had limited effect on porosity. Porosity is mostly secondary from grain dissolution, although primary intergranular porosity is also important. The spatial and temporal characterization of the distribution, types and volumes of the major diagenetic alterations responsible for porosity modification will contribute to reduce the exploration risks and to optimize oil recovery from oilfields producing from Cretaceous sandstones of the Espírito Santo Basin. Furthermore, characterizing the diagenetic alterations of the Aptian sandstones will allow a better understanding of the environmental conditions prevailing along the margins of the lakes where the "pre-salt" carbonate reservoirs were formed.

Retrograding breach flow slides in the Netherlands, observations and numerical modeling

Mastbergen, D.R.[1], Ham, G.A. van den[1], Groot, M.B. de[1], Kaaij, T. van der[1], Peelen, G.P.[1]

[1] Deltares, P.O. Box 177, 2600 MH DELFT, The Netherlands - dick.mastbergen@deltares.nl

Flow slides, defined as retrograding slope and bank failures with successive massive transport of fine sands under water at mild slopes, have been detected frequently in estuaries and rivers in the Netherlands. Similar flow slides with bank failures have been reported in deep sand mining pits during and after dredging.

The nature of flow slides has been investigated since they have accidentally resulted in bank and dike collapse, inundation and environmental damage.
Due to its unpredictable nature, the bank failure itself, let alone the flow of sand under water, was rarely ever observed directly. In general, only the slope profile before and after the event, the damage profile, was measured.

Recently, detailed yearly bathymetry surveys of the Eastern Scheldt estuary near the Storm Surge Barrier have been analyzed. Besides ongoing scour hole development, also a number of large flow slides could be identified, that had occurred in the unprotected estuary banks, under water only. In this paper the properties of one of these large flow slides will be given and the geometry will be used to apply the various numerical models for breach flow slide prediction presented here.

Computations with a simple 1D - 2 layer numerical model (HMBreach) applied to the described flow slide event, prove that under specific conditions a small retrograding breach, that may be caused by local liquefaction or shear failure, can generate a massive supercritical turbidity current, strongly fueled by erosion of the downslope sand surface. Finally, on the mildly sloped toe, the flow decelerates, becomes subcritical and the sand is deposited again.

Similar computations were carried out with the Deltares numerical hydrodynamic model Delft3D-Flow, in which erosion and sedimentation of sand, turbulence generation and density effects are incorporated.
It was investigated if and under which conditions applying a small and slowly upslope moving sand source, the retrograding breach as a moving upper boundary condition, would generate an accelerating, erosive turbidity current. It was found that the sudden triggering mechanism resulting in an avalanche like turbidity current occurred indeed, but for very specific conditions again, depending on breach dimensions, local slope and sand characteristics.
Although the model can compute morpho-dynamic slope development in time, so far it appeared not possible to compute the observed profile after retrogressive breach erosion, probably due to the high flow velocities and erosion rates resulting in large bed deformations and making the flow modeling unstable.

To model the slope development in time and predict the damage profile anyway, a simple 1D parameterized model has been developed (Retrobreach), which is able to describe the retrogression of the breach in time and the flow downslope with erosion and deposition. Although the model is still under construction, it can predict a realistic development of the post-event profile as a result of a breaching flow slide.

Acknowledgements: Rijkswaterstaat is acknowledged for having provided survey data and enabling ongoing research in dike safety assessment.

Impact of pelagic carbonate production (calcareous nannofossils) on CCD fluctuations during the Middle Eocene

Mattioli, E.[1], Salaviale, C.[2], Gollain, B.[1]

[1] Laboratoire de Géologie de Lyon, UMR 5276 CNRS, Université Lyon 1, ENS Lyon, Bâtiment Géode, Campus de la Doua, 69622 Villeurbanne Cedex, France - emanuela.mattioli@univ-lyon1.fr
[2] RPS Goldvale House, 27-41 Church Street West, Woking, Surrey, GU21 6DH, UK

Ocean sediments are mainly formed by pelagic carbonates, constituted since the Jurassic of calcareous nannofossils in great amounts. Cenozoic sediments record glacial and interglacial periods, as well as thermal maximums as the PETM (Paleocene-Eocene Thermal Maximum) and MECO (Middle Eocene Climatic Optimum). The MECO, dated at about 40 Ma, occurred during a period of climate transition, namely the middle Eocene. This geological period shows variations in temperature and atmospheric CO_2, as well as of the carbonate compensation depth (CCD).

This study aims at highlighting the actions and feedbacks between climate (regulated by atmospheric CO_2 concentrations, temperature, etc.), CCD fluctuations and calcareous nannofossils by the study of fluxes, size and assemblages between 48 and 39 Ma. Calcareous nannofossils were studied in ~60 samples taken approximately every 50 cm from the ODP (Ocean Drilling Project) Leg 198 Site 1209A, Shatsky Rise, in the North Pacific. Samples have been prepared with a technique for absolute quantification of nannofossils and studied in optical microscope and SEM for assemblages and biometry.

The age model previously proposed has been slightly modified thanks to new data on nannofossil biostratigraphy and recalibrated according to the GTS 2012. Nannofossil assemblages and size show long-term changes during the Middle Eocene. Namely, *Discoaster* spp. show a decrease in size and relative abundance from 48 to 39 Ma. At 40 Ma, during the MECO, proportions of large coccoliths like *Dictyococcites* spp. and of *Reticulofenestra pseudoumbilicus* (>14 µm) increase.

Nannofossil fluxes show significant increase during the CAEs 1 to 4 (Carbonate Accumulation Event of the authors), but they are low during the MECO. Fluxes seem not to be related to atmospheric CO2 (*p*CO2) changes. Conversely, nannofossil production seems to have importantly impacted the oceanic carbon cycle, by creating a carbonate flux to deep-ocean, in phase with deepening of the CCD.

Differences of the growth mechanism of stalagmites beneath different vegetation in Minami-Daito Island, southwest Japan

Matsuda, H.[1], Kashima, M.[1], Sato, Y.[1], Yoshimura, K.[2], Shimada, J.[1]

[1] Dept. Earth Environ. Sci., Kumamoto University, Kumamoto 860-8555, Japan - hmat@sci.kumamoto-u.ac.jp
[2] Dept. Chem., Kyushu University, Fukuoka 812-8581, Japan

Speleothems are typical terrestrial carbonates and their formation is dependent on a variety of geological, hydrological, chemical and climatic factors. For the reason, isotopic compositions of speleothems are known as a good indicator of paleoclimate and paleoenvironment. Especially, the $\delta^{13}C$ values and the growth rates are considered to be related to vegetation around the limestone cave, and decay of organic matter within the soil zone. Therefore, we attempted to clear the differences of the growth mechanism of stalagmites beneath different vegetation, based on carbon and oxygen isotopic composition and growth rates of stalagmites in Minami-Daito Island, southwest Japan.

To make clear the differences of the growth mechanism of stalagmites, a stalagmite (IM-2) from Imamura Cave beneath sugarcane fields and a stalagmite (YS-4) from Yamashita Cave beneath sub-tropical natural forests were utilized. Dating of the stalagmites was carried out based on annual bands. Samples for the isotopic study were taken along the growth axis from the top 4-cm of the stalagmites at a sampling interval of 0.5 mm. As a result, an average growth rate of the IM-2 stalagmite is 44.9 microns/year before 1900 A.D., while the rate is 226.7 microns/year after 1900 A.D. The $\delta^{13}C$ values before and after 1900 A.D. range from -10.94 to -3.98‰ $\delta^{13}C_{PDB}$ and from -2.52 to -0.86‰ $\delta^{13}C_{PDB}$, respectively. The drastic changes of the growth rate and the $\delta^{13}C$ values at 1900 A.D. are considered due to the change of vegetation from sub-tropical natural forests to sugarcane fields around the cave with cultivation by pioneers since 1900 A.D. On the other hand, the growth rate of the YS-4 stalagmite is about 60 microns/year constantly and the $\delta^{13}C$ values range from -11.85 to -5.00‰ $\delta^{13}C_{PDB}$, and the significant changes of the growth rates and the $\delta^{13}C$ values are not observed around 1900 A.D. This suggests that the growth mechanism of the stalagmite beneath natural forests was not affected by settling of the pioneers. Further, the $\delta^{18}O$ values of both stalagmites range from -8.57 to -6.70$\delta^{18}O_{PDB}$ (IM-2) and from -8.84 to -6.04$\delta^{18}O_{PDB}$ (YS-4), and the values before and after 1900 A.D. are not so different. However, some fluctuations of the $\delta^{18}O$ values are recognized, and this suggests that the $\delta^{18}O$ values of the stalagmites reflect the climatic variation of temperature, $\delta^{18}O$ values of rainfall and so on.

Combining microbial fossil and mineral assemblages to reconstruct paleoenvironmental conditions during formation of Aptian lacustrine carbonate platform, Brazil

Matsuda, N.S.[1], Mutti, M.[2], Campinho, V.S.[1], Dos Anjos, S.M.C.[1], Bontognali, T.[3], McKenzie, J.A.[3], Pacton, M.[4], Vasconcelos, C.[3]

[1] PETROBRAS/EXPLORATION, Brazil - nilomatsuda@hotmail.com
[2] University of Potsdam, Germany
[3] ETH Zurich, Switzerland
[4] University of Lyon, France

The identification of microfossils in ancient sedimentary rocks is a very challenging endeavor, but is justified by the information that such fossil features may provide about the physico-chemical and sedimentological conditions under which the sediment formed. Morphological analysis of putative microfossils represents one of the major criteria for assessing their biogenicity. In some cases, their size, shape, and cell-wall mold allow for a precise taxonomic classification of the fossil structure. Moreover, such microfossils are sometimes found in close spatial association with minerals that are likely to be the result of metabolic activity. Thus, the association of specific microfossil-biomineral assemblages provides additional insight on the physiology of the micro-organisms, allowing for a more accurate reconstruction of the paleoenvironmental conditions.

Here we present the results of a study whose aim was to identify microfossils and other evidence for past microbial activity in rocks constituting an Aptian carbonate platform. This formation extends 800km along the Brazilian eastern coast from Florianopolis High to Abrolhos High and encompasses three basins. These basins were formed during the Neocomian rifting and drifting stages of South American and African continents. Studied samples are from the Santos Basin, where a 5-km-thick sedimentary formation ranging from Neocomian to Tertiary age includes an extensive, ca. 405-m-thick, lacustrine carbonate platform capped by a thick halite deposit.

The different carbonate facies constituting the platform, e.g., laminites, stromatolites, spherulites, and grainy carbonates, suggest that microbes played a crucial role in the formation of the sedimentary sequence. Moreover, such facies often include well-preserved microbial fossils, which we have identified using SEM and spectroscopic (SIMS and NanoSIMS) approaches. Many of the microbial structures are interpreted as fossilized extracellular polymeric substances (EPS), whereas other structures resemble possible Archea cells. Of special interest is the remarkable preservation of twisted microfossil structures that we interpret as microbes belonging to the Spirulina genus. This specific microbial fauna, combined the presence of the dawsonite ($(NaAlCO_3(OH)_2$), is consistent with an alkaline lacustrine paleoenvironment characterized by high salinity and pH above 9. Such conditions, which would also prevent grazing activity, explain the unusually good degree of preservation of the microfossils. Moreover, the presence of calcitic spherulites reinforces the hypothesis that the waters reached the conditions under which microbes ceased their metabolism. Sims and NanoSims measurements of the carbon isotope and C/N ratios reinforce this interpretation.

Depositional Environment and Cyclic Sedimentation in Mixed Siliciclastic, Carbonate and Evaporite in the Permo-carboniferous Sequence of Amazonas Basin, Northern Brazil

Matsuda, N.S.[1], Cacela, A.M.S.[1], Mutti, M.[2], Nazare, C.P.P.[1], Neves, M.P.[1], Melo, E.G.C.P.[1], Cavalcante, L.M.[1], Mendonca, K.R.N.[1], Brazil, F.A. de F.[1], Longhim, M.E.[1], Martins, F.de A.L.[1], Melo, J.H.1, Wanderley Filho, J.R.[1]

[1] PETROBRAS/ Brazil - nilomatsuda@hotmail.com
[2] University of Potsdam/ Germany

The Late Paleozoic was characterized by alternating phases of glaciation and deglaciation, which have produced a widespread cyclothem record on the Pangea super continent as known from the midcontinent of North America, in Europe and in the Arctic. This work presents new data from the intracratonic Amazonas Basin, situated in the Northern Brazil which shows E-W narrow rectangular shape covering an area of about 500,000 km^2 from Para to Amazonas states. Well logging data as well as deep well cores and seismic sections show that the basin is composed of more than 5,500 m thick sedimentary and sub-volcanic rocks ranging from Precambrian to Recent.

The late Carboniferous (Pennsylvanian) to Permian Tapajos Group reaches a thickness of about 1,500 m and is subdivided into four major units: at the base the siliciclastic rich Monte Alegre Formation, overlain by mixed carbonatic-evaporitic and siliciclastic sequences of the Itaituba and Nova Olinda formations and, at the top the red beds of Andira Formation. Nine regional mapeable stratigraphic markers were identified with a core and well log study and have been recognized regional transgressive and regressive events.

The study of outcrop and well core through entire Permo-carboniferous section revealed that the main rocks types are comprised by bioclastics and microbial carbonates, evaporites (halite/ anhydrite) and siliclastics. A total of 25 facies types and six facies associations were recognized and interpreted to reflect three main depositional system: supra-intertidal; subtidal manly composed by proximal carbonatic (lagoon-barrier) and, distal subtidal carbonatic with influence of siliclastics and evaporites. The depositional systems strongly influenced by siliciclastic were most probably deposited during more humid periods, whereas the restricted evaporitic systems were deposited during drier period, suggesting a strong glacial-eustasy climatic control over the sedimentological patterns.

A special attention is given to the about 60 m thick lowermost rich carbonate section named M-65 which can be accessed in the outcrops and well cores. It revealed 22 microfacies mostly carbonates composed of mudstone, wackestone, packstone, grainstone and some siliciclastics. They are enriched in biodebris including brachiopods, echinoderms, foraminiferas, bryozoans, ostracods, gastropods, bivalves and trilobites. Peloids are predominant in some microfacies, mainly in the evaporitic section. Seven environmental domains were identified from microfacies ranging from deep open marine to productive bioclastic bar, protected area as lagoon, restricted flat upper intertidal/ supratidal, and subaerial land area with or without sanddunes. This 60 m section presents a typical sedimentary shallowing upward cycles of about 7,5 m each. Each cycle is identified by the black shale on the bottom and on the top, by evaporites and by a regular occurrence of dolomites with relatively high $\delta^{18}O$ values. Additionally, into the M-65 marker was identified an interesting coal layer measuring about 1,5 m thick full of leaves and trunk fragments considered as the first appearance of coal in the Amazonian Gondwana land.

In summary, the Permo-carboniferous sequence of the Amazonas basin represents a typical intracratonic basin composed of mixed siliciclastics, carbonates and evaporites sedimentary rocks. It shows several shallowing upward cycles pattern considered as controlled by glacio-eustasy climatic control. The tectonic control seems to be minor.

Application of analytical and modeling techniques to burial diagenesis of quartzose sandstones for reducing uncertainty in prediction of hydrocarbon reservoir quality

Matsui, R.[1]

[1] Technical Research Center, INPEX Corporation, 157-0061, Tokyo, Japan - ryoichi.matsui@inpex.co.jp

Diagenetic alteration of hydrocarbon reservoir quality is widely recognized as a major subsurface uncertainty especially for reservoirs under deep burial environments. Since there are a number of potential factors, such as thermal exposure and depositional texture, that can be critical to the burial diagenesis, it is essential to understand the genetic relationship of those factors with porosity preservation and deterioration processes for accurate prediction of reservoir quality, irrespective of field development phases from exploration to exploitation. The example presented here is application to quartzose sandstones of an offshore gas field under appraisal, where a number of wells were drilled to date. However, the reservoir quality remains uncertain for the undrilled area, including peripheral aquifer, which may cause unexpected water production in the earlier stage of production.

The evaluation method is combined use of petrographic analysis and numerical modeling techniques. The analysis utilizes hyperspectral petrographic mapping of sandstone samples including cathodoluminescense and X-ray signals (EDS/WDS) with spatial resolution at a few micrometers and is designed to provide quantitative petrographic measurement, including mineral composition and detrital grain size distribution. Since the reservoir has been subjected to severe thermal exposure, quartz cementation is conspicuous as a major porosity-occluding process. According to the petrographic interpretation, it is concluded that the occurrence of illitic clay seam and the grain size of detrital quartz account for the observed variation in quartz cement volume for a given thermal exposure. The former, which has subsequently evolved into stylolite, effectively promotes quartz dissolution at the contact to supply precipitant to the neighboring detrital quartz grains, and the latter determines total surface area of nuclei for quartz to be precipitated.

A numerical model is then constructed for attempting prediction of reservoir quality at undrilled locations. It comprises forward models where mechanical compaction, quartz surface area, quartz cement volume and preserved porosity are calculated in sequence for each time step. Taking the regional-scale thermo-tectonic history into account, the model allows restoring the diagenetic history of the area by optimizing petrographic parameters with the existing wells used as constraints. In this example, the model suggests impact of the differential thermal exposure caused by the tectonic tilting during the Pliocene and later upon the areal variation of quartz cement volume. As a consequence, the diagenetic alteration of reservoir quality is considered to be primarily constrained by the depositional texture, namely, grain size distribution at the depositional scale, however; the recent tectonic event is interpreted to be of comparable importance and to affect the reservoir quality at the field size scale.

Different kind of Burdigalian coral bioconstructions developed in the Bonifacio Basin

Mazzucchi, A.[1], Bosellini, F.R.[2], Tomassetti, L.[1], Brandano, M.[1]

[1] Dipartimento di Scienze della Terra, La Sapienza Università di Roma, P. Aldo Moro 5, 00185 Rome, Italy – andrea.mazzucchi@uniroma1.it
[2] Dipartimento di Scienze Chimiche e Geologiche, Università degli Studi di Modena e Reggio Emilia, Largo S. Eufemia 19, 41121 Modena, Italy

This study reports facies analysis of coral-rich deposits characterizing the mixed carbonate-siliciclastic systems of the Bonifacio Basin (Cala di Labra Fm). Four localities (Paraguano, Sperone, Ricetti and Rocchi Bianchi) have been investigated, where the exposure along the sea-cliff allowed detailed three-dimensional mapping on photomosaics of coral deposits and lateral and vertical facies distribution. Field observations were complemented with examination of thin sections.
Four coral lithofacies have been distinguished: rigid domestone, loose domestone, loose platestone and coral rudstone to floatstone.
The rigid coral domestone consists of relatively small bioconstructions at Sperone and Paraguano. Massive and domal colonies are closely intergrowth together with rare platy colonies. The inter-coral sediment is a floatstone-packstone dominated by red algae and larger benthic foraminifera (*Miogypsina* and *Amphistegina*) with low siliciclastic fraction. At Sperone is well observable the landward facies transition, from the rigid domestone trough the loose platestone interfingering with hybrid sandstone and finally passing into coarse sandstone with abraded bioclasts. The loose coral platestone facies consists of platy and flattened massive colonies occurring mostly in growth position and frequently dispersed in hybrid sandstone with cross-laminations. The basinward facies transect crops out at Paraguano, where the rigid domestone grades into the loose domestone and finally into the marl facies. The loose coral domestone is represented by sparse massive colonies occurring both in growth position and reworked. Associated sediment consists of floatstone-packstone with abundant red algae branches debris and subordinate bioclastic fragments.
At Ricetti, the Hercynian basement is overlain by conglomerates rapidly colonized by the benthic fauna (oysters and more rare massive coral colonies), which evolve vertically to skeletal fine conglomerates and sandstones. Above these, a small bioconstruction made of the rigid domestone facies occurs, interfingering and laterally passing to *Heterostegina*/*Operculina*-rich skeletal sandstones.
Rocchi Bianchi outcrop records reworked coral deposits. The coral facies is represented by the coral rudstone-floatstone and consists of lenticular bodies with cross-bedding. These are intercalated within nodular- to cross-bedded packstone to floatstone dominated by red algae debris and locally abundant *Heterostegina*/*Operculina* tests. Coral rudstone-floatstone is made up of reworked massive colonies and coral rubble. In addition, oysters and clypeasteroids fragments occur together with common turritellid gastropods and *Heterostegina*/*Operculina* in a hybrid sandstone matrix.
The irregular crystalline basement strongly controlled the depositional systems. Above gently sloping substrate developed a wedge-shaped system. This system was characterized by a nearshore environment under high siliciclastic input and carbonate production in the meso-oligophotic zone, where coral colonies form small patch reefs grading basinward into the marl facies.
Rocky coast may led to the formation of gravelly pocket beaches, where small bioconstruction can be found in the nearshore environment surrounded by skeletal fine conglomerates and sandstones.
Reworked coral deposits intercalated within bioclastic facies represent coral bioconstruction-derived debris resedimented along the slope or at the slope talus of an infralittoral prograding wedge system.

Characterisation of deep-marine depositional system architecture with palynofacies: an outcrop example from the channelized Rosario Fm., Baja California, Mexico

McArthur, A.D.[1], Kneller, B.C.[2], Souza, P.A.[1], Wakefield, M.I.[3]

[1] Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS 91501-970, Brasil – adam.mcarthur@ufrgs.br
[2] Department of Geology & Petroleum Geology, University of Aberdeen, Aberdeen, AB24 3UE, United Kingdom
[3] BG Energy Holdings Limited, Thames Valley Park Drive, Reading, RG6 1PT, UK

Gross scale architectures of deep-marine depositional systems can largely be resolved seismically, but seismic data alone are often insufficient to identify complex stratigraphic architectural elements, e.g. confined levee or terrace deposits. Identification of specific elements of a deep-marine system currently relies on detailed sedimentological studies, which can be problematic in the sub-surface. Here we present the initial findings of an integrated sedimentological and palynological investigation from outcrops of a deep-marine channel complex, which aims to characterize components of the deep-marine system based upon their associated palynofacies.

The Upper Cretaceous – lowermost Palaeocene Rosario Formation, in Baja California, Mexico, comprises the study material. Specifically the canyon confined Arroyo San Fernando channel-levee system, the architecture of which is well constrained by previous work, allowing a high degree of certainty in placement within the channel architecture. Stratigraphic elements reflect a lateral progression from channel axis to distal sub-environments, via overbank-terrace; confined levees internal to the channel belt; the main channel-bounding levee complex, with an inner and outer component, grading into background hemipelagic slope deposits. In conjunction with sedimentological logging of the Arroyo San Fernando, three hundred samples have been collected for palynofacies studies from fine grained lithofacies in the channel axis, channel terrace, confined and external levees, mud rich debris flows and hemipelagic drapes. 10 g from each sample were processed with hydrochloric and hydrofluoric acid and sieved at 10 µm before slide mounting. A count of three hundred pieces of palynodebris per slide was made and the characteristics and size of phytoclasts were recorded.

Samples display a wide range of palynodebris, with a variety of allochthonous terrestrial material and also relatively autochthonous materials inferred to have been produced in the local marine environment. Initial results show a general decrease in sorting of palynodebris away from the channel axis assemblages, which are dominated by dense humic material (e.g. wood particles and resin). Less dense particles (e.g. miospores, phytoplankton and plant cuticle) were retained in suspension at lower energy, to be deposited in greater abundances in channel distal settings. The primary mechanism inferred for causing these changes is hydrodynamic sorting of the palynodebris, with flow strength decreasing at increasing distance from the main sediment conduit, reducing the capacity to transport dense particles. This result demonstrates the role of primary sediment dispersal mechanisms in controlling the distribution of organic matter in channel-levee systems, as well as the internal organization of the sediments.

From the variation in type and abundance of palynodebris observed in the architectural elements, a classification scheme can be developed that enables recognition of the depositional setting within the deep-marine system. The palynofacies are particularly beneficial for discriminating turbidites deposited on confined terraces as opposed to levee sediments. Critically this scheme can be applied to sub-surface samples to assist exploration and characterisation of sub-surface submarine stratigraphic hierarchy, understanding of which is crucial for correct well planning and hydrocarbon field development.

Reconstructing surface residence times from the stratigraphic record using stable cosmogenic nuclides: ^{21}Ne concentrations in the Neogene of the Great Plains, Nebraska

McCann, L.[1], Sinclair, H.[1], Stuart, F.[2]

[1] University of Edinburgh – hugh.sinclair@ed.ac.uk
[2] Scottish Environmental Research Centre, East Kilbride, UK

Cosmogenic nuclides are commonly applied to measuring exposure ages of geomorphic landforms and assessing denudation rates from catchments. These approaches are dominated by the radiogenic nuclides of ^{10}Be and ^{26}Al with half-lives that limit their application to the Quaternary. Here, we investigate a novel application of the stable cosmogenic nuclide ^{21}Ne as a tool for reconstructing the near surface residence time of grains in the stratigraphic record. Our study uses the Neogene succession of the Great Plains in Nebraska where a ~200m thick alluvial succession (Arikaree and Ogallala Groups) records repeated periods of floodplain/channel aggradation and subsequent incision. These changes from accumulation to incision on the Plains have been interpreted in terms of regional tectonic tilting (McMillan et al., 2006; Duller et al., 2012) and climatic change (Wobus et al., 2010). We analyse the ^{21}Ne concentration from quartzite pebbles from Upper Miocene, Pliocene and modern river sediment in order to assess the near surface residence times of the pebbles during these intervals. In order to do this, we also characterised the ^{21}Ne concentrations from shielded samples of the source area (the Medicine Bow Quartzite); this allows us to characterise any non-cosmogenic ^{21}Ne inherited from the source rocks. The results show that the Miocene and Pliocene pebbles contained no more ^{21}Ne than the rocks from which they were sourced, implying exhumation, sediment transfer and burial with no significant residence time in the upper ~2m of the surface. In contrast, pebbles from the modern North Platte River had up to 7 times higher ^{21}Ne concentrations implying sustained near surface residence for these pebbles. This difference between Mio-Pliocene and modern concentrations is interpreted as a record of sustained, slow incision of the Great Plains since ca. 2.5 Ma in response to Pleistocene glaciations.

Submarine paleoseismology along transform boundaries: Enriquillo Plantain Garden Fault, Canal du Sud, Haiti and North Anatolia Fault, Marmara Sea, Turkey

McHugh, C.M.[1, 2], Seeber, L.[2], Cormier, M.-H.[3], Hornbach, M.[4]

[1] Queens College, City University of New York, Flushing, NY 11367, USA - cmchugh@qc.cuny.edu
[2] Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA
[3] Univeristy of Rhode Island, Graduate School of Oceanography, Narragansett, RI 02882, USA
[4] Southern Methodist University, Huffington Department of Earth Sciences, Dallas, TX. USA

Continental transform boundaries cross heavily populated regions and are associated with destructive earthquakes worldwide, such as the devastating 2010 Haiti earthquake along the Enriquillo-Plantain Garden fault zone, and the 1999 Izmit and Duzce earthquakes along the North Anatolia fault, Turkey. The urgent need to improve hazard assessments along these plate boundaries has promoted the rapid emergence of the field of submarine paleoseismology that focuses its analysis on fault segments below or near water bodies. A useful first-order correlation between fault segment ruptures and sedimentation events has been widely established. The current focus is on more nuanced information from the sedimentary signal: How does this signal decay with distance from the rupture? How does the frequency of events affect the strength of the signal?

In Canal du Sud, Haiti, the 2010 earthquake sedimentation event was tracked from the nearshore to the deep basin by measuring the excess ^{234}Th, revealing mass-wasting, turbidites and turbidite-homogenite units. The 2010 turbidite recovered from the deepest part of Canal du Sud (~1700 m water depth) contains a 5 cm thick bed of cross-bedded sand with foraminifers of shallow water affinity and plant material. The transition between the 'carpet' sand and suspended muddy flows of the turbidity current were preserved as folded and contorted deposits in the mud above. This deposit is capped by a 50-cm-thick homogeneous mud, nearly barren of microfossils. The sandy part of the turbidite and muddy homogeneous deposit above share the same geochemical elemental composition and are called a turbidite-homogenite unit (THU). A plume of sediment remained in suspension in the water column for 600 m above the seafloor nearly two months after the earthquake.

The THU in Canal du Sud, however, preserved a selective record of paleo-earthquakes, and may thus provide insights into style of rupture. We document an ~2,000-year gap between THU's in Canal du Sud. This gap correlates with a similar 2,100 yr interval between two uplift events documented for the Tapion Ridge [Taylor et al., 2011]. This compressive structure, located along a bend of the EPG fault, bounds the Canal du Sud basin to the south and was at the center of thrust aftershocks that followed the main 2010 strike slip earthquake. Evidently, many historical earthquakes did not trigger uplift at the Tapion Ridge or turbidites in Canal du Sud. Sedimentation rates in this carbonate setting range from 0.003 to 0.006 cm/year, and we propose that in such low sedimentation rates only earthquakes associated with relative vertical motion under water initiate large-scale sediment transport events such as that generated by the 2010 earthquake.

In contrast, sedimentation rates in the Marmara Sea depocentral basins are much higher (~0.16-0.22 cm/year). THU there constitute ~80% of sediment accumulation (similar for Haiti), and they show a good correlation to all M>=6.5 historic earthquakes that for the North Anatolia Fault extend back for 2000 years BP. Further, there is a robust spatial correlation between THU and the location of historic sea-floor earthquake ruptures inferred from historic data.

We acknowledge the National Science Foundation OCE-0328119 and OCE-1028045 that supported this work

The sedimentation record of the 2011 Tohoku megathrust earthquake along the Japan Trench

McHugh, C.[1, 2, 3], Kanamatsu, T.[3], Cormier, M.-H.[4], Seeber, L.[2], Bopp, R.[5], Ikehara, K.[6], Usami, K.[6]

[1] Queens College, City University of New York, Flushing, NY 11367, USA - cmchugh@qc.cuny.edu
[2] Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA
[3] Japan Agency for Marine-Earth Science and Technology, Yokosuka, Kanagawa, 237-0061, Japan
[4] Univeristy of Rhode Island, Graduate School of Oceanography, Narragansett, RI 02882, USA
[5] Rensselaer Polytechnic Institute, Troy, NY 12180, USA
[6] Geological Survey of Japan, AIST, Tsukuba, Ibaraki 305-8567, Japan

The 2011 Tohoku Mw 9.0 megathrust earthquake and tsunami were devastating for the people of Japan and brought to the world's attention the need for studying the sedimentation record of large subduction earthquakes. In 2013, the Japan Agency for Marine-Earth Science and Technology conducted expeditions NT13-02 and NT13-19 with *R/V Natushima* in 800-5,900 m water depth along the Japan trench slope, above the 2011 megathrust rupture. The goal was identifying earthquake-triggered deposits and mapping their spatial and temporal distribution, as a strategy to measure recurrence intervals of similar ruptures for assessment of seismic hazards.

Twenty-four piston cores, 3 to 6 m long, were recovered during the NT13-19 expedition along a 300 km-long, N-S transect of the mid-slope terrace. This elongated structure is parallel to the strike of the Japan Trench, and located landward of the frontal prism where deformation is most intense. The width of the mid-slope terrace decreases from north to south from ~20-5 km. Thrust and normal faults, sometimes forming steep scarps, define small (5 km long) confined basins targeted for coring.

Short-lived radioisotopes ^{134}Cs, ^{137}Cs and xs^{210}Pb measured in the cores reveal that substantial volumes of sediment were deposited along the mid-slope terrace in water depths of 4,200 m to 5,900 m during and shortly after the 2011 megathrust earthquake and that their spatial distribution reflects differences in the amount of deformation along the 2011 rupture. This earthquake triggered mass-wasting downslope from the 2011 epicentral region, from ~39°N to 38°N. These deposits are 50-100 cm thick and contain, liquefaction and brecciation features, but no evidence of bioturbation. In contrast, the region to the north of the epicentral region, ~40°N to 39°N, was covered by an ~5-15 cm thick drape since the event (<2 years). Detection of ^{134}Cs and enrichment of ^{137}Cs provided a 2011 Fukushima reactor signature, now buried 5-15 cm beneath the seafloor. To maintain the extremely high concentrations in xs^{210}Pb and high sedimentation rates we envision that a fluidized layer of surface sediment was transported downslope, also possibly incorporating ^{137}Cs derived from global fallout over the past half century. Based on these results we propose a three stage depositional model for the mid-slope terrace: coseismic mass-wasting downslope from the region of maximum fault slip, fall out of ^{134}Cs and ^{137}Cs soon after Fukushima, a fluidized layer on top possibly related to sediment failures triggered by aftershocks. These layers of homogeneous sediment can be recognized in the stratigraphic record by their lack of bioturbation and fluidization structures. Their thickness vary according to circumstances on the sea floor, but also depending on the strength of the earthquake source below them. Several older event horizons separated by bioturbated sediments are recognized in the cores. Ongoing studies based on tephra chronology estimated an average recurrence interval of 100-500 years in most cores. But there are cores that display intervals of 1500-2000 years.

We thank the officers and crew of the *R/V Natsushima*; NSF OCE-1139036; JAMSTEC

Non-marine carbonates from the Lower Cretaceous (Valanginian), Maracangalha Formation, Recôncavo Rift System, Northeastern Brazil

Medeiros, E.S[1], Witzke, R.[1], Milhomem, P.S.[1]

[1] Petrobras, Salvador, Brazil – esmedeiros@petrobras.com.br

The Recôncavo Basin, northeastern Brazil, is part of an intracontinental rift system developed during the Early Cretaceous as a response to the extensional processes that resulted in the opening of the Atlantic Ocean. The basin has a complex synrift sedimentary fill. In particular, the early rift lacustrine deposits have been considered a challenge for stratigraphic correlations. Seismic and geological interpretation of the rift section in central Recôncavo Basin has led to the identification of a thick interval of valanginian carbonate rocks. These carbonates are related to the lowermost portion of the Maracangalha Formation, which has been usually referred as a typical record of lacustrine terriginous rocks, comprising shales as well as sandstones related to mass gravity flows and turbidites. Therefore, the carbonates depict a different depositional environment and the lithotypes herein described may define a new lithostratigraphic unit, subdividing the Maracangalha Formation. The aim of this abstract is to characterize the non-marine carbonate rocks and its interpretation within a typical lacustrine terriginous environment in a rift system. Preliminary facies analyses of the carbonate rocks are based on side-wall samples collected from wells drilled close to the flexural border of the Recôncavo basin. Microscopic descriptions, integrated to the well-log curves (gamma ray and resistivity), were carried out to characterize the different lithofacies. The carbonate section includes basal oncoid to intraclastic packstone beds, 10 to 40 meters thick, with a micritic matrix. The oncoid grains have thin irregular coatings with bioclastic nuclei (ostracods) and the intraclastic grains are mainly mudstones. To the top, these lithofacies are followed by oolitic and bioclastic grainstone beds separated by shales. Most of the samples show up to 5% of siliciclastic grains and intense eogenetic calcite cementation is observed throughout the thin sections. The facies associations suggest that deposition would have occurred at the border of a structurally constrained lacustrine carbonate platform, as marginal carbonates. The deposition of different lithofacies would have responded to energy fluctuations in the lake system. The carbonate sequence has a maximum thickness of about 200 meters and extends over an area of approximately 20 km^2. Its occurrence is mainly related to the footwall block of the NW-SE trending Mata-Catu Fault, a relief transversal fault accomodating extension along both the eastern fault system border and the western flexural border. The structural framework led to the development of carbonate deposition by providing a site relatively free of terriginous input. Small occurences of thinner carbonate beds of similar age are found elsewhere, but always related to the flexural margin of the basin.

Porosity and permeability distribution in fluvial deposits affected by extensional tectonics: case study example from the Triassic Sherwood Sandstone Group, UK

Medici, G.[1], Odling, N.[1], West, J.[1], Mountney, N.P.[1]

[1] School of Earth and Environment, University of Leeds, Woodhouse Lane, Leeds, W Yorkshire, LS2 9JT, UK - eegm@leeds.ac.uk

The Sherwood Sandstone Group of the UK is a red-bed succession of continental origin that accumulated in a series of rift basins, the evolution of which preceded the opening of the Atlantic Ocean. In the North Sea and Irish Sea, the Sherwood Sandstone is an important reservoir for hydrocarbons. The principal aim of this study is to identify and quantify the nature of sedimentary and tectonic heterogeneities that influence fluid flow via field- and laboratory-based analysis of samples collected from the East Irish Sea Basin (Cumbria) and the NE England Shelf (Yorkshire). Plug of samples have been tested for porosity and permeability measurements in orientations both parallel and perpendicular to bedding, and sedimentary textures have been investigated at the pore scale using scanning electron microscopy (SEM). The role of lithological heterogeneity associated with the depositional sedimentary architecture of preserved fluvial deposits has been assessed as a control on extensional faulting and fracturing style. A key aim of this work is to unravel the relation between depositional sedimentary architecture and tectonic structures to assess how extensional tectonics can change reservoir permeability properties in the vicinity of faults.

In NE England, the Sherwood Sandstone is generally poorly lithified and comprises mostly fluvial channel deposits. Outcrop analyses demonstrate sedimentary heterogeneities characterized by bed-parallel laminations and low-angle-inclined trough cross-laminations. Porosity ranges from 25% to 35% and extensional tectonic structures (e.g. deformation bands, clay cores) along normal faults are characterized by porosity reduction processes. In NW England, the basal unit of the Sherwood Sandstone Group in the East Irish Sea Basin, the St Bees Sandstone Formation, is dominated by channel deposits. At the type section (St Bees Head), major channel elements comprise fills of alternating bed-parallel and cross-lamination arranged into 2-m-thick units and subordinate fine sandstone and siltstone layers characterized by bed-parallel laminations and desiccation crack structures. Porosity values in channel deposits range from 17% to 22%. The lithology is generally well lithified and extensional open fractures are well developed. Extensional fault zones are characterized by undulating fault planes formed by the coalescence of fracture meshes. Refraction of fractures occurs in response to differences in the lithology of fluvial beds which possess varying mechanical strengths. Thin, fine sandstone and siltstone layers represent the only facies capable of smearing in fault zones, which may locally represent baffles for fluid flow.

Permeability measurements on plugs demonstrate that bed-parallel laminations and cross-laminations act as barriers to fluid flow with flow rates reduced in orientations perpendicular to sedimentary laminations. SEM analyses reveal the presence of platy clay minerals aligned parallel to the laminations in the East Irish Sea Basin as well as in the NE England Shelf region. In NE England, the fluvial deposits are highly porous and permeable, and are dominated by fault clays and deformation bands that act as barriers for fluid flow in hydrocarbon reservoirs. By contrast, in NW England, fluvial deposits are well cemented and organized in lithologically distinct fluvial elements that form separate units. Where affected by extension, such lithological units create fracture meshes of high connectivity that may act as potential flow-paths for fluids.

Acknowledgements: The authors thank Total E&P UK Limited for funding this research.

Upper Pliocene-lower Pleistocene isolated shallow-marine base-of-slope carbonate aprons in inherited indentations of a steep rocky slope (Salento peninsula, Apulia, Southern Italy)

Meloni, D.[1], Moretti, M.[1], Tropeano, M.[1], Gallicchio, S.[1], Sabato, L.[1], Spalluto, L.[1]

[1] Dipartimento di Scienze della Terra e Geoambientali, Università degli Studi di Bari "A. Moro", Italy – demetrio.meloni@uniba.it

In the eastern sector of the Salento peninsula (Southern Italy), a steep rocky slope, where Cretaceous to Pleistocene limestones crop out, connects a wide flat area, about 100 m in elevation, to the coast of the Otranto Strait (Ionian Sea). Along the rocky slope, tectonized pre-Pliocene units played a morphostructural role for the depositional features of younger carbonates.

Stratigraphic and sedimentologic analyses have been carried out on an upper Pliocene-lower Pleistocene carbonate unit (the Calcarenite di Gravina Fm.) cropping out along the coast inside some indentations of the rocky slope. Facies features and stratigraphic geometries of this carbonate unit indicate a deposition along a slope and at its toe. In fact, these deposits form small isolated bodies with a variable thickness (up to several tens of metres), and are composed mainly of floatstones and packstones with coarse-grained bioclasts. The successions are characterized by long basinward-dipping well laminated and stratified clinobeds. These clinobeds are cut by irregular gullies (some meters in width), filled in their lower part by chaotic deposits (debris flow and slide deposits). Locally, tens of meters in length slump scars have been detected. Backsets made up of fine- to medium-grained limestone fill the main slump scars. Basinward, slumped beds occur as isolated thick slide bodies.

Clinobeds developed thanks to grain flows, moving either bioclasts due to a local factory production (red algae, bryozoans, echinoids, brachiopods, planktonic foraminifers) or bioclasts coming from a shallower factory (bentic foraminifers; bivalves). The latter was hosted on the wide flat area today corresponding to the top of the Salento peninsula where upper Pliocene-lower Pleistocene carbonates are attributed to a different unit (the Uggiano la Chiesa Fm.).

The studied carbonates discontinuously crop out at the base of the rocky slope; this discontinuity was an original feature since these deposits mainly developed inside indentations of the rocky slope, inherited by faults, when the region (the whole Salento peninsula and the rocky slope too) was submerged. Inside these indentations and at their base, isolated depositional systems corresponding to small shallow-marine aprons developed; they were both base-of-slope carbonate apron detached from upward-located coeval systems (whose factory could feed the aprons through currents bypassing the upper part of the submerged rocky slope), and, due to their shallow-marine position, also slope aprons fed by a local carbonate factory. These features simulate those ones of a distally steepened ramp, but facies distribution was induced by inherited morphostructural features of the bedrock rather than by the ability of the factories to produce an own depositional profile.

Mixed (bioclastic/lithoclastic) carbonate clinoforms in the Matera area (Plio-Pleistocene, southern Italy): a mathematic approach

Meloni, D.[1], Tropeano, M.[1], Coclite, G.M.[2], Marsico, A.[1], Sabato, L.[1]

[1] Dipartimento di Scienze della Terra e Geoambientali, Università degli Studi "Aldo Moro" di Bari, Via Orabona 4, 70125 Bari, Italy - demetrio.meloni@uniba.it
[2] Dipartimento di Matematica, Università degli Studi "Aldo Moro" di Bari, Via Orabona 4, 70125 Bari, Italy

During the Plio-Pleistocene, the Matera area was part of the foreland ramp of the southern Apennines (southern Italy) (Tropeano et al., 2002). The ramp was characterized by a complex horst and graben structure, that became an archipelago during subsidence (Tropeano and Sabato, 2000; Mateu-Vicens et al., 2008). Around islands, sediment supply was twofold: carbonate lithoclasts derived from exposed highlands and bioclasts produced in the newly flooded areas (Tropeano et al., 2009). Mixing of both types of carbonate particles occurred by deposition in the same environment rather than by mechanical mixing (Tropeano et al., 2010). These sediments form backstepping bodies internally showing a progradation of clinoforms.

After the original definition of clinoform (Rich, 1951), a number of examples from outcrop and subsurface (seismic lines) was described in the literature. Studied cases range from small sedimentary structures (ripples) to basin margins (carbonate-platforms edges). Since the '90s, the interest in the modeling of clinoforms is increasing (e.g. Nittrouer and Kravitz, 1996), and a mathematical approach was proposed to define the observed structures (Schlager and Adams 2001).

In the Mediterranean Sea, well developed, laterally continuous and still actively prograding clinoforms were observed on seismic lines in shallow marine settings (Cattaneo et al., 2004). According to Hernandez-Molina et al. (2000), these clinoforms form sediment bodies below wave base, and develop by avalanche processes induced by waves sweeping the shoreface zone.
The same origin was suggested for the spectacular outcropping clinobeds observed in the Matera area by Pomar and Tropeano (2001).

In order to arrive at a comparative model with clinoforms along present-day Mediterranean margins, a detailed study of the Matera outcrop is in progress. After a field control, the analysis of photomosaics will be used to depict geometries of sigmoidal surfaces. Using dedicated software (Plot Digitizer), these lines will be converted into x-y spatial coordinates. The results will be compared with the equations proposed by Adams and Schlager (2000).

Characteristics and Controlling Factors of Paleogene Shahejie Formation Low Permeability Reservoir of BZ25-1 Oilfield in Bohai Bay Basin, China

Meng, H.[1], Zhong, D.[1]

[1] College of Geosciences, China University of Petroleum, 102249-Beijing, China - pare3000@hotmail.com

Introduction: BZ25-1 Oilfield was located in Bozhong Depression of Bohai Bay Basin in China. The main pay zones were the 2nd Member (called Sha-2) and 3rd Member (called Sha-3) of Paleogene Shahejie Formation. Reservoir of Sha-2 Member, buried in depth of 3200~3400m, had an average porosity of 15.8% and an average permeability of 41.6md; reservoir of Sha-3 Member, buried in depth of 3300~3900m, had an average porosity of 13.9% and an average permeability of 7.7md. Both of two reservoirs showed large contrasts in sandstone compositions, with unexpected low permeability although porosity was moderate-low. So, petrographic analyses were performed to investigate characteristics and genetic mechanism of low permeability reservoirs of the two layers.

Methods: Rock constituents, pore geometry, cement morphology and diagenetic relationships were observed by using polarizing microscope and scanning electron microscope (SEM). Detrital and clay minerals component were analyzed by X-ray diffraction. Porosity and permeability values were examined by core measurements and well logs interpretation.

Results: According to observation of cast thin sections and analysis of SEM, X-ray diffraction and data of well logs, the controlling factors of low permeability of the two hydrocarbon production layers were different.
Reservoir of Sha-3 Member was composed of feldspathic litharenite and lithic arkose which deposited in sublacustrine fan gravity flows. Thus, it was poor sorted with generally coarse grain size (15.4% coarse-sand, 29.0% medium-sand and 27.8% fine-sand in 153 samples), high feldspar (average 36.3%), high lithic (average 17.2%) and also high matrix content (1%~17%) which resulted in lack of primary porosity. The original pore water was alkaline water which formed earlier carbonate cementation and illite cementation within the pores and so that compaction was weak-moderate. Therefore, dissolution pores mainly assembled in some instable minerals such as feldspar and lithic.

Reservoir of Sha-2 Member was dominated by lithic arkose which deposited in braided river delta front and shallow lake beach-bar that belonged to tractive current environments. Thus, it was well sorted with mid-fine grain size (15.2% medium-sand, 41.9% fine-sand and 22.6 very fine-sand in 31 samples), relatively low feldspar (average 33%), low lithic (average 14%) and low matrix content. The shallow water environment and alkaline original pore water with saturated calcium carbonate resulted in earlier strong basal cementation and pore cementation of sparry calcite as well as syngenesis micritic calcite which especially occurred in the northern palaeohigh area. Besides earlier carbonate cementation, shallower burial than Sha-3 also made it had poor compaction. Therefore, dissolution pores mainly assembled in carbonate cement.

Conclusions: The reasons caused low porosity low permeability of Sha-3 were considered as two factors: (1) Large quantities of matrix filled in primary pores that caused earlier poor carbonate cementation; (2) Later poor dissolution owing to lack of carbonate cement. The reasons caused moderate-low porosity low permeability of Sha-2 were also considered as two factors: (1) Earlier strong basal and pore carbonate cementation; (2) Later poor dissolution was connection with fine grain size and mud belt.

Acknowledgements: This study is sponsored by the Tianjin Branch of China National Offshore Oil Corporation Ltd. We thank them for their support and permission to conduct the research.

The palaeoequatorial microbial carbonate province of the Cantabrian Zone (Pennsylvanian, NW Spain)

Merino-Tomé, O.[1], Bahamonde, J.R.[1], Della Porta, G.[2], Chesnel, V.[3], Villa, E.[1], Samankassou, E.[3], Fernández, L.P.[1]

[1] Departamento de Geología, Universidad de Oviedo, 33005, Oviedo, Spain - omerino@geol.uniovi.es
[2] Dipartamento di Scienze Della Terra, Universita´di Milano, Italy
[3] Department of Earth Sciences, Section of Earth and Environmental Sciences, University of Geneva, Geneva, Switzerland

Vast carbonate deposition took place during the Pennsylvanian in the marine foreland basin of the Cantabrian Zone (NW Spain). This basin was located in the eastern embayment of the Palaeotethys Ocean, facing the growing Variscan orogenic chain resulting from the collision between Laurentia and Gondwana. Hot-humid climatic conditions prevailed in this palaeoequatorial area of the E coast of Pangea in a global icehouse context. A wide spectrum of high-relief and steep-fronted microbial-dominated carbonate platforms nucleated nearly synchronously during early Bashkirian times in the distal margin of the foreland basin, over an area as large as 120.000 km^2, according to palinspastic restoration. New geological mapping of the Carboniferous strata of the southern areas of the Cantabrian Zone has allowed to identify and catalogue up to 22 individual carbonate platforms documenting their: 1) areal extent, 2) outcrop dimensions, 3) growth styles and evolution based on stratal patterns, 4) age of drowning and 5) diagenetic overprint by late hydrothermal dolomitization.

Depending on their location in the basin, the rates of accommodation and the terrigenous input, these carbonate systems show different stacking patterns, growth styles and evolution prior to their demise. Close to the orogen, carbonate platforms consisted of isolated bodies of discrete dimensions (from a few km up to a few tens of km in diameter, and 500-1500 m in thickness), which are exceptional outcrop analogues of the subsurface reservoirs of the Pricaspian Basin (e.g., Tengiz, Korolev, Karachaganak). These isolated platforms show limited progradation and their demise is caused by the input of orogen-derived siliciclastic sediments during late Bashkirian to early Moscovian. In contrast, in more distal areas, carbonate platforms grew free of siliciclastic pollution until the late Moscovian-early Kasimovian. This larger timespan allowed for building a giant carbonate platform resulting from the lateral amalgamation of initially isolated buildups. This gigantic carbonate system, the so-called the Sierra del Cuera-Picos de Europa platform, covered an area of 12.000 km^2 and shows remarkably high rates of margin progradation visible in numerous seismic-scale cross sections.

This study permits to constrain the areas of platform nucleation in the basin and proposes a new insight for investigating the geological processes involved in the nucleation of such carbonate systems in marine foreland basins. The data here presented suggest that the spatial distribution of the carbonate build-ups or platforms is random and not controlled by the tectonic regime and configuration, and argue against previous hypotheses suggesting that platform nucleated on paleohighs resulting from tectonically-controlled uplift.

Mid-Carboniferous calci-mudstones, sapropels and gypsum evaporites in northern Spain: analogues for the Mediterranean Sea during the Messinian salinity crisis?

Merino-Tomé, O.[1], Bahamonde, J.R.[1], Fernández, L.P.[1], Della Porta, G.[2], Gómez-Borrego, A.[3], Piñeiro, C.[1], Samankassou, E.[4], Chesnel, V.[4], Martín-Llaneza, J.[1]

[1] Departamento de Geología, Universidad de Oviedo, 33005. Oviedo, Spain - omerino@geol.uniovi.es
[2] Dipartamento di Scienze Della Terra, Universita´di Milano, Italy
[3] Instituto Nacional del Carbón, CSIC
[4] Department of Earth Sciences, Section of Earth and Environmental Sciences, University of Geneva, 1205 Geneva, Switzerland

Dark and finely laminated calci-mudstones and microsparites rich in organic matter accumulated across wide areas of the Variscan marine foreland basin of North Spain (Cantabrian Zone and Pyrenees) during Serpukhovian and early Baskirian times. The San Andres Member of the Alba Formation (Pendelian-early Arnsbergian in age) and the Barcaliente Formation (Late Arnsbergian-Alportian), with a thickness ranging from 70 to 300 m, extend over an area as large as 160000 km^2 in the Cantabrian Zone, according to palinspastic restoration. Both stratigraphic units, consisting of laminated calci-mudstones, are virtually barren of biota (except rare crinoids, calcispheres, ostracods, goniatitids and scarce conodonts), lack sedimentary structures indicative of shallow-water environments and typical subaerial exposure surfaces recording Carboniferous glacioeustacy, and show a decametre-thick cyclic pattern marked by the recurrent occurrence of sapropels with higer TOC values and associated gypsum evaporites.

The marine basin consisted of a subequatorial seaway (remnant of the Rheic Ocean) connecting Panthalassa and Palaeotethys Oceans. The basin closed around the Mississippian-Pennsylvanian boundary, changing fundamentally the global oceanic circulation system, the heat transport and affecting the Carboniferous climate.

The San Andres Member and the Barcaliente Formation are of high scientific interest for several reasons: 1) The decametre-thick cyclic pattern marked by the recurrent occurrence of sapropels with associated evaporites, which might record high-frequency (orbital?) climatic signals in the deep-water setting; 2) The high OM content making these type of laminated calci-mudstones a valuable target for hydrocarbon exploration; 3) The gypsum evaporite levels, recording intermittent hypersaline conditions and providing evidence that the studied basin (a remnant of the Rheic Ocean) could be a good analogue of the Mediterranean Sea (a remnant of the Tethys Ocean) during the Messinian Salinity Crisis. 4) The significant volume of pelagic OM-rich limestones of the Barcaliente Formation (and equivalent units in the Pyrenees) making the basin a giant sink for atmospheric CO_2 coinciding with the worldwide climatic cooling leading to the Late Paleozoic Ice Age.

Carbonate, phyllosilicate and evaporite minerals associated with microbial biofilms, gels and mats in Neoproterozoic tidal flat deposits.

Mettraux, M.[1], Homewood, P.[1], Dos Anjos, C.[2], Lima, R.[2]

[1] GEOSOLUTIONS TRD c/o Petrobras E&P-EXP/GEO, Centro RJ 20031-170, Brazil - moho1959@yahoo.fr
[2] CENPES/PDGEO/IRPS, Petrobras, Ilha do Fundão, RJ 21941-915, Brazil

Microbialites of the Qarn Alam surface piercing salt dome in central Oman contain a Neoproterozoic record of organomineralised carbonates together with minor to trace amounts of environmentally significant minerals including phyllosilicates, phosphate, fluorite, iron oxides and hydroxides as well as halite. Both calcite and dolomite with some accompanying minerals are biologically induced. Several accompanying minerals are significant indicators of chemical conditions during deposition.
The microbialite facies form 10m thick shallowing-up cycles, capped by a caliche crust and a bed of evaporites, indicating emersion and sabkha sedimentation at cycle boundaries. The four main facies show a succession of shallow subtidal to intertidal and finally salina to evaporitic features. From base to top in the cycles these four facies are: planar laminites; crinkly laminites; stromatolitic, layered and massive thrombolites; bushy thrombolites. Sedimentological analyses together with petrographic and geochemical studies suggest that each of the four facies was linked to a somewhat different microbial community: planar laminites with simple pellicular biofilms; crinkly laminites with mats or gels; stromatolitic, layered and massive thrombolites with thicker gels and mats; bushy thrombolites with a more complex community comprising gels and a sponge-like organism. Scattered bacteriomorphs and abundant microbial fossils do not allow identification of any particular microbial group or species.
Although the rocks were buried several kilometres during their 540Ma history, both the organomineralised fabrics of EPS and the earliest cements (laid down during on-going sedimentation) have been extremely well preserved. SEM images of the organomineralised EPS and cathodoluminescence images of the early cements clearly show the primary mineral phases. The values of C and O stable isotopes for the different minerals in microbially induced fabrics (calcite clots, clumps of calcite clots, calcite or dolomite laminae, and matrix dolomicrospar) confirm the lack of resetting of primary chemical composition.
The main products of organomineralisation are calcite and highly magnesian calcite to dolomite (syndepositional biologically induced mineralisation rather than primary biomineralisation or later permineralisation). The minor to trace fractions of glauconite, palygorskite, iron oxides and hydroxides and phosphate are intimately interwoven with the mineralised alveolar EPS structures of calcite or dolomite. These minerals are specifically associated with or limited to one or the other (or several) microbialite facies. They are clearly not a later mineral phase filling pore space or permineralising earlier phases. This suggests that in addition to providing indications of redox conditions, pH and salinity during microbial growth and microbialite sedimentation, the minor components are also a product of organomineralisation. In contrast, the occurrence of fluorite and halite more probably reflect the evaporative conditions toward the cycle tops.
Organomineralised Mg-Ca carbonate in the thrombolites shows values close to dolomite stoichiometry in clotted microspar (EDS spectra of carbonate sediment EPS), and stoichiometric values for some bulk samples (XRD analyses of bulk carbonate sediment) so this organomineralised Ca-Mg carbonate phase may correctly be called dolomite.

Petrobras E&P and Petrobras R&D and Sylvia Couto Anjos are acknowledged for giving support as well as permission to publish these results. Geosolutions TRD and Shuram Oil & Gas kindly provided logistical support for the sampling.

New insight into the origin of porosity in the Aptian Shuaiba Formation, Al Shaheen Field, offshore Qatar

Meyer, A.G.[1], Hollis, C.[1], Marquez, X.[2]

[1] University of Manchester, Manchester, UK - aurelien-meyer@manchester.ac.uk
[2] Maersk Oil Qatar, Doha, Qatar

Lower Cretaceous limestones constitute a prolific interval on the Arabian Plate. Porous sediments commonly reveal complex, multi-modal pore systems, often with average porosities above 20 % and permeabilities of several orders of magnitude. Abundant literature has related this multi-modal porosity to the long-lasting (ca. 5 Ma) subaerial exposure event which resulted from a sea-level drop during the Late Aptian, represented by a plate-wide unconformity and siliciclastic deposits. Abundant mouldic and vuggy porosity, embedded in a microporous matrix, are indeed typical of the upper 10m of the Shuaiba Formation, and sometimes appear associated with infiltrated clastic sediments. However, our preliminary results suggest that meteoric dissolution may have been over-estimated, and that the diagenetic history is more complex and multiphase.

The Aptian Shuaiba in Al Shaheen Field, offshore Qatar, is composed of equatorial, shallow water carbonates deposited on the margin of an intra-platform depression. Well correlations reveal that the main reservoir is organized into a lagoonal platform separated from a muddy basin by extensive rudist deposits. Platform deposits include *Lithocodium*-coral assemblages and deeper-water *Orbitolinid* wackestones. Each depositional environment is characterized by highly variable porosity and permeability. However, although some of that variability can be attributed to primary lithologies, diagenetic processes have strongly overprinted the pore network in the Shuaiba Formation.

Here, we document diagenetic features which weaken the "meteoric model", including: (1) delicate, open macro-moulds that have been preserved from collapse and cementation; (2) porous halos along and adjacent to stylolites and fractures; (3) partial corrosion of mould-filling, burial calcite cements. Intermediate to deep burial conditions are therefore put forward to explain most of the open porosity. Ultimately, the aim of this multi-disciplinary project is to determine clear evidence for the timing of porosity modification, and consider the key processes controlling the distribution of flow-controlling pore types. Ultimately, the project aims to determine the fluid source, mechanism and timing for porosity modification, with relevance to age-equivalent reservoirs across the region.

Acknowledgements: Special thanks to Niels Rameil (Maersk Oil) and Kieron Baggley (Mearsk Oil Qatar) for their collaboration in petrographic descriptions.

Sediment transfer and deposition in the shelf canyon off the Ganges Brahmaputra Delta / Bangladesh

Meyer, I.[1], Palamenghi, L.[2], Kudrass, H.R.[3], Schwenk, T.[2], Spiess, V.[2]

[1] Renard Centre of Marine Geology (RCMG), Department of Geology and Soil Science, Ghent University, Krijgslaan 281/S8, B-9000 Gent, Belgium - Minka@marum.de
[2] Department of Geosciences, University of Bremen, Klagenfurter Straße, 28359 Bremen, Germany
[3] Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Geozentrum Hannover, Stilleweg 2, 30655 Hannover, Germany

In order to better understand the Asian monsoon and climate dynamics at timescales of societal importance, high-resolution sediment archives in the Bay of Bengal were investigated within the BMBF-project "Central Asia Recorded In Marine Archives" (CARIMA). A huge amount of sediment (about one billion tons) is supplied to the northern Bay of Bengal by the Ganges and Brahmaputra river system every year. The sediment is mainly accumulating in the submarine delta offshore Bangladesh and in a deep shelf canyon, called "Swatch of No Ground" (SONG). During the last 50 years the sediment accumulation rate in the prograding submarine delta has considerably changed as only in the central parts the accumulation rate has remained constant with some centimeters per year, whereas the rate has been greatly reduced in the eastern section. In the SONG, which is incised into the Bengal shelf and ends at the submarine delta, the annual accumulation rate decreases with distance from the shore, i.e. from 45 cm to 14 cm. In order to examine the sediment dynamics in the SONG and on the shelf four marine sediment cores with a length of up to 20 m were recovered along the axis of the canyon and analyzed by high-resolution grain-size laser methods, scanned by XRF, and dated by ^{137}Cs isotopes.

Results show that the sediments draping the canyon floor in up to 100 m thick undisturbed packages mainly consist of graded laminated sequences, which are assumed to be produced by tropical cyclones. Each graded sequence begins with a layer of clayey-silty fine sand, grades into mm-thick laminae of clayey silt, and ends with a layer of silty clay. The imperfect grain-size separation within the graded beds is caused by the relatively slow, about one-day long passage of individual cyclones, during which the sediment mobilization increases to a maximum and then decreases again. The storm-induced hyperpycnal suspension descends from the shallow parts of the submarine delta into the canyon as a broad flow and preferentially sand, but also silt and clay will settle from the cloud forming a graded bed. The lamination is suggested to be caused by tidal variations during the supply or by pulsation lobes within in the suspension cloud. Each of the graded layers in the 1994-2006 core sections can be correlated with the record of tropical cyclones of that period. Further detailed dating of other parts of the cores by ^{32}Si will allow a further estimation of the frequency of cyclones affecting the northern Bay of Bengal.

Moreover, the dominance of graded beds in the canyon material clearly demonstrates that the sediment transfer from the inner shelf to the offshore areas is governed by the transport through cyclones. As these frequent high-energy events are regularly affecting many coastlines, cyclones are steering the sediment dispersal in tropical shelves.

The long sediment record of Lake Challa: a unique archive of East Africa's environmental history

Meyer, I.[1], Van Daele, M.[1], De Batist, M.[1], Verschuren, D.[2], and CHALLACEA & DeepChHALLA project partners

[1] Renard Centre of Marine Geology (RCMG), Department of Geology and Soil Science, Ghent University, Krijgslaan 281/S8, B-9000 Gent, Belgium - Minka@marum.de
[2] Limnology unit, Department of Biology, Ghent University, Ledeganckstraat 35, B-9000 Gent, Belgium.

During the "CHALLACEA" project (2005-2008) detailed investigations of Lake Challa revealed that the lake is a key site for reconstructing the climate and environmental history of equatorial East Africa. Lake Challa is a relatively small and deep freshwater lake, located in a volcanic caldera on the eastern slope of Mt. Kilimanjaro and shared by Kenya and Tanzania. Detailed seismic-reflection data show a ~210-m thick sedimentary infill containing distinct seismic-stratigraphic signatures of late-Quaternary lake-level fluctuations representing a detailed record of climatic moisture-balance variations in equatorial East Africa, continuous over at least the last 130 kyr and encompassing in total ~250 kyr. During a field campaign in 2005 a 21.65 m long sediment core was retrieved from the center of the lake, encompassing the last 25,000 years. Various biological and bio-geochemical investigations of this CHALLACEA-core and linked aquatic, soil and surface-sediment samples helped to understand the present-day Lake Challa system as well as to reconstruct environmental changes in the past.

However, the mineral rock sediment matrix of this sediment sequence has not been adequately analyzed and quantified. Hence, a new study will focus on the detailed examination of source areas of the siliciclastic fraction as well as transport pathways and variations in mineral input over time. Outcomes of this work will produce essential information about past environmental variations in East Africa and will allow a reconstruction of changes in various sedimentary processes, like changes in wind speed or direction, hydrological and land-surface conditions in the lake catchment etc. These results will help to strengthen ideas about future climate change in a region which is extremely sensitive to climate-driven changes in water supply, with potentially major impacts on several millions of inhabitants.

Thanks to the high archival quality of the Lake Challa sediment record and its high scientific outcome, ICDP project "DeepCHALLA" was established with the aim to drill a longer sediment record, ideally to the base of the crater infill. The DeepCHALLA project will provide unique information about low-latitude environmental change over a complete glacial - interglacial cycle. It is expected that results of the new study on the available 25,000-year sequence can be applied to the longer DeepCHALLA record and hence open new opportunities to calibrate and quantify East African environmental changes and paleohydrological conditions much further back in time.

Biomarkers of the Fossil-bearing phosphorites from Neoproterozoic Doushantuo Formation at Weng'an, South China

Mi, W.[1]

[1] School of mines, Inner Mongolia University of Technology, Hohhot 100051, China – miwentian1982@163.com

Global phosphogenesis event and biotic evolution events occurred during the late Neoproterozoic-early Cambrian. Economic phosphorite sedimentary body occurs in Neoproterozoic Doushantuo Formation on the Yangtze Platform. The Doushantuo Formation in Weng'an yields the earliest unambiguous fossils, specifically phosphatized animal embryos and cyanobacteria. Here we report the organic geochemistry of the fossil-bearing phosphate strata of the Doushantuo Formation. Then, we discuss the dominant primary producers, the source of organic matter, biomineralization processes and the depositional environment of the fossil-bearing strata.

The extraction process and saturated hydrocarbon were tested in Guangzhou Institute of Geochemistry, Chinese Academy of Sciences. GC-MS analyses of the aliphatic fractions were performed on a Finnigan Voyager analytical system coupled with a DB5-MS fused silica capillary column.

The n-alkanes distribution pattern has a wide range of carbon atom numbers. A series of C_{12}-C_{37} n-alkanes have been detected from the aliphatic fractions in samples analysed. The distribution of n-alkane shows a single-peak type, without any odd to even carbon-number-predominance. nC_{21}^-/nC_{22}^+ is 0.85. $(C_{21}+ C_{22})/(C_{28}+ C_{29})$ has the value of 1.87. The C_{19} shows the main peak, which suggest cyanobacteria as the origin. The feature of n-alkanes indicate that organic source of phosphorite came from early life, such as prokaryotic eubacteria, eukaryotic algae and protozoa, and other microbes, which lived in aquatic environment.

A series of regular isoprenoid hydrocarbons were founded in the aliphatic fractions of sample. The Pr/Ph value is 1.13, which points to oxidation of sedimentary environment, indicative of photosynthesis.

Many steroid hydrocarbons, C_{27}-C_{29} diasteranes, regular steranes and C_{21}-C_{22} pregnanes were detected in phosphorite. The sterane contents of $C_{27}>C_{29}>C_{28}$ in phosphate rock shows asymmetric "V" distribution. C_{28}-steranes in phosphorite suggest that some precursor species of phytoplankton might have existed. C_{27}-steranes predominance in phosphorite reveals that the source of organic matter was imported by cyanobacteria. Cyanobacteria in phosphorus ecological environment should belong to the primary producers, which play an important role on producing organic matter and concentrating phosphorus.

The relative abundance of three pentacyclic terpane was more than tricyclic terpane. C_{19}-C_{29} tricyclic terpanes were founded in the sample. Long chain of tricyclic terpanes may be generated by multicellular algaes of Weng' an Biota. The occurrence of various terpenoids could reveal that the source inputs of sedimentary OM comprise numerous lower organisms contributions, which consistent with the composition of Weng' an Biota. A certain amount of gammacerane was detected, which represented a higher salinity water column. This provides evidence for the biomineralization by numerous organisms in phosphorite.

These biomarkers indicate that organic source inputs of phosphorite come from Weng' an biota. Hence, these biomarkers confirm the biomineralization in phosphorite during the Doushantuo period. Algae, cyanobacteria and eukaryotic phytoplankton were the predominant primary producers during the Doushantuo period in the paleo-ocean.

Acknowledgements: This work is supported by the priority science research Foundation of Inner Mongolia University of Technology, China (Grant no. ZD201322) and scientific study project for institutes of higher learning, ministry of education, Inner Mongolia (Grant no. NJZY14067).

Late Cretaceous paleogeography in West and East Georgia utilising planktonic foraminifera and nannoplankton

Mikadze, K.[1], Gavtadze, T.[2], Manabde, A.[3], Zviadi, C.[2]

[1] Institute of Eartha Sciences, Ilia State University, 3/5 Cholokashvili Ave., 0162, Tbilisi, Georgia – xatmikadze@yahoo.com
[2] LEPL Alexandre Janelidze Institute of Geology, M. Alexidze1/9, Tbilisi 0171, Georgia
[3] Georgian National Museum, Institute of Paleobiology, Niagvris 4, Tbilisi 0108, Georgia

In the Caucasian segment of the Alpine fold belt several geotectonic units are distinguished from each other by structural characters and their history of development. The Cretaceous sediments are mostly developed in the Gagra-Java zone. This zone is part of the Greater Caucasus Fold system (GCFS). The Upper Cretaceous sediments of the Gagra-Java zone are represented mainly by firm carbonate limestones with variegated flints. In the western part of the territory under study, the Upper Cretaceous sediments are mainly represented by carbonaceous rocks: marls, calcareous clays, chalk, calcareous marls. During the field-work 1800 samples were obtained.

At present, there exists a definite methodology for the reconstruction of some parameters of the paleobasin that is based on quantitative interrelations of foraminifer associations. This technique is based on actualistic data from contemporary water areas. The Recent PF (Planktonic Foraminifer) data can be used for the interpretation of the fossil material data applicable in paleogeographic reconstructions specifying paleodepths. According to the percentage of the left- and right-coiling species of *Globotruncanidae* there have been estimated the temperature conditions of the Late Cretaceous basins.

Carbonate Upper Cretaceous strata formed both in epicontinental basins and in comparatively deep, open ocean water areas are planktonogenic by nature. The appropriate quantitative calculations allow to build up the diagrams with curves showing in the section the changes of the Planktonic/Benthic relation, and also ratios "shallow" (down to 50m), "transitive" (50-100m) and “deep-water" (>100m) morphotypes. The course of curves allows approach the problem of reconstruction of transgressive-regressive cycles in the process of paleobasin development. The main factors having influence on foraminifer distributions in water column are depth, temperature and salinity of the marine basin.

Thus on the basis of the detailed analysis of calcareous nannofossils and planktonic foraminifers in the sediments of the Zhinvali-Gombori subzone of the Mestia-Tianeti zone GCFS, all standard zones (CC) of the Late Cretaceous are identified. It has allowed to specify an age range, volume and capacity of lithostratigraphic units, composing the Upper Cretaceous of the Mestia-Tianeti zones.

For this part of GCFS are reconstructed the main paleoclimate and paleogeographic events of the Late Cretaceous. Here has been established the existence of four sedimentary cycles: Cenomanian-Lower Turonian, Middle Turonian-Early Campanian, Late Campanian-Early Maastrichtian and Late Maastrichtian. In the Cenomanian-Early Turonian there was a basin of isolated, regressive sea in the southern part of the moderately cold-water belt. From the Late Turonian the boundary between the warm- and moderately cold-water belts moved to the north. Transgression that started in the Late Turonian lasted till the Early Coniacian. In the middle part of the Early Coniacian is outlined shoaling of the basin. From the Late Coniacian to the end of the Santonian sedimentation took place in the shallow, calm marine basin. The omission of the nannoplankton CC19, CC20, CC21 and CC22a, b zones from the sections of the Zhinvali-Pkhoveli nappe and the analysis of the redeposited forms enables to admit break in sedimentation caused by Early Campanian regression and Late Campanian transgression. At the end of the Middle Maastrichtian took place a short-term regression that was replaced by the Late Maastrichtian transgression.

A simple method to compare length-series to time-series from sections through artificial deltas

Mikeš, D.[1], Berry, R.[1]

[1] Geosciences Department - Nelson Mandela Metropolitan University - PO Box 77000 - 6031 Port Elizabeth, South Africa - dmikes@nmmu.ac

Depo-systems are complex and their behaviour is irregular and unpredictable. A particular consequence of this is that deposition is discontinuous and hiatus occurs, which is pertinent to correlation between locations or with time. Yet to date we ignore the depo-ratio for any depositional system and we therefore ignore the temporal error made in correlations. The objective of the study is to test whether shore line correlates to base level for alluvial shallow deltas. The fundamental question is whether one can infer sea level time-series from sea level length-series.

We create small artificial deltas, which possess sufficient kinetic similarity to justify comparison to large natural deltas. We grow a miniature delta in a flume tank under steady tectonic subsidence, periodic water (sea) level fluctuation and two periodic discharge fluctuation scenarios: in- and out-of-phase with sea level. We take photographs every 10 minutes and digital elevation models every 3.5 hours. At the end we obtain 4 radial cross-sections.

We then convert length-series to time-series by way of a simple yet effective workflow. We measure the shore line in a cross-section for each lamina subsequently, i.e. distance of shore-line to delta apex, lamina for lamina, from oldest to youngest. Thus we obtain a shore line "length-series" of shore line for the cross-section. We then obtain depositional event times from the photographs. Thus we obtain a shore line "time-series" for the same cross-section. We convert the time-series to length-series by omitting hiatus and match the two. We then convert the length-series to time-series and hence obtain shore line time-series. We can now quantify misfit between time-series and length-series.

The results show that deposition events are adequate samples to capture the lower order base level cycles accurately from shore line cycles, but two phenomena create significant misfit between the two: (1) irregular local deposition causes a varying phase shift between sea level and shore line cycles similar to varying sea level cycle period; (2) autogenic phenomena create additional shore line cycles similar to higher order sea level cycles. It is evident that one can not infer sea level time-series from shore line length-series.

Bottom sediments like reflection of sedimentation processes in Klaipeda strait

Mineviciute, I.[1], Gulbinskas, S.[1], Blazauskas, N.[1]

[1] Marine science and technology center, Klaipeda University, H. Manto 84, Klaipeda, Lithuania – ilona@corpi.ku.lt

Klaipeda Strait is characterized as very extensive water and sedimentary matter transit area between the Curonian lagoon and the Baltic Sea. It is not only a geochemical barrier, separating fresh and saline waters, but also a very specific sedimentation zone of high anthropogenic pressure, occupied by Klaipeda port with intensive dredging and shipping activities. Dredging works are carried out in order to maintain the operational depth, also to deepen particular areas. During the last twenty years the depth of the port navigation channel was increased from 8-10 to 12-14, 5 m. These dredging works significantly changed sedimentation conditions, distribution and composition of bottom sediments in the strait area. Previous detailed sediment studies have been done in 1998; after that was concluded that fine sand is prevailing type of bottom sediments in Klaipeda strait.

New full-scale sediment mapping of Klaipeda Strait was completed in Autumn of 2012. The scope of investigations included sediment sampling with Van Veen grab and hydrographical measurements (multi-beam echo sounder GeoSwath combined with side scan sonar). Sediment samples were collected in 197 stations, located in different parts of the strait. In most cases location of stations corresponded to 1998 survey. Grain-size of sediments was analyzed by laser diffraction method (Laser particle analyzer Analysette22 Micro Tec Plus, Fritsch). For sediment classification used a modified Wentworth classification system (adapted for GRADISTAT program) according to Folk classification diagram. For information on sediment grain size evolution and sedimentation conditions were chosen statistical indicators: median (Md), standard deviation (sorting), skewness and kurtosis.

Klaipeda strait according bottom sediments distribution, hydrological conditions and bottom morphology could be divided in three parts: northern, central and southern. In the southern part of strait is very clear differentiation of sediment material displayed by variation of sediment types and quite successive transition from coarse material (in the very intensive transportation zone) to very fine (founded in closed bays of strait or next to berths). Sedimentary material to this zone comes from Curonian lagoon, so this zone could be called like Curonian lagoon accumulation zone. The central part of Klaipeda strait is like transitional zone of sedimentary material. The prevailing type of sediments in this area is sandy silt mostly brought from Curonian lagoon. In the northern part of Klaipeda strait is different situation than in both zones mentioned above primarily because here is sediment transport from the Baltic Sea. Then the main influence for this part bottom sediments composition is accumulation of sea sedimentary material. The prevailing type of sediments in northern part of Klaipeda strait is sand and silty sand.

Deepening of the port have determined accumulation volumes and changed sediment composition. In comparison of studies made in 1998 and now, it is clear, that sediments size is going to fine part. It shows that because the natural and anthropogenic changes in the system Curonian lagoon became more dominating factor for Klaipeda strait bottom sediments composition.

Acknowledgements: This research was made in frame of Interreg BSR program project Sustainable Management of Contaminated Sediments in the Baltic Sea (SMOCS; http://www.smocs.eu/).

Submarine landslide contribution to the Golo Basin filling (Corsica Trough, North Tyrrhenian Sea): influence of tectonics, sea-level variations and contourite drifts

Miramontes, E.[1], Cattaneo, A.[1, 2], Jouet, G.[1], Garziglia, S.[1], Thereau, E.[1], Gaillot, A.[1], Roubi, A.[1], Rovere, M.[1]

[1] IFREMER, Géosciences Marines, Centre de Brest, BP70, 29280 Plouzané, France – elda.miramontes.garcia@ifremer.fr
[2] joint affiliation: CNR-ISMAR, v. Gobetti 101, 40129 Bologna, Italy

The Pianosa Ridge is a tectonic structure in the Northern Tyrrhenian Sea that forms the eastern flank of the Corsica Trough (between Corsica and the Tuscan shelf). The eastern part of the Golo Basin is characterised by submarine landslides and the Pianosa Contourite Depositional System, while the western part is dominated by the Golo turbidite channel-lobe systems. Multibeam bathymetry, High-Resolution-72 traces (50-250 Hz), Sysif deep-towed (220-1050 Hz), Chirp (1800-5300 Hz) seismic reflection profiles and Calypso piston cores were collected during cruises PRISME2 and PRISME3 in 2013. Up to 10 mass transport deposits of different sizes were identified in the study area, showing recurrent mass-wasting processes. Submarine landslides contributed to the basin filling, constrained the turbidite flows from the Golo and confined the distal lobes. The southern part of the Pianosa Ridge hosts the largest submarine landslides: the Pianosa Slump (13.4 km long and 4.8 km wide) and an older landslide (20 km long and 5 km wide). The Pianosa Slump morphology can still be appreciated in the bathymetry despite being covered by a 17-m thick hemipelagic drape. The slump deposit, sampled by a 28-m long Calypso piston core, presents heterogeneous facies derived from different types of flow or an evolving flow. Multiple factors could predispose the recurrent slope instability, such as relatively steep slope gradients (3.5° to 7.5°), the development of contourite drifts that present cyclic changes in lithology and the formation of pockmarks by fluid escapes. The presence of faults near landslide scars suggests that tectonic activity might be the most likely triggering process.

Acknowledgements: We thank the Captain and crew of the PRISME2 and PRISME3 campaigns (2013) onboard R/V Atalante et R/V Pourquoi pas?, respectively. The thesis of Elda Miramontes is co-funded by TOTAL and Ifremer as part of the scientific project TOTAL-Ifremer PAMELA.

Microfacies Analysis and Paleoenvironmental Interpretation of the Eocene Kohat Formation, Gumbat Section, Himalayan Fold and Thrust Belt, Northern Pakistan

Mirza, K.[1]

[1] Institute of Geology, University of the Punjab, Lahore-54590, Pakistan - kamran.geo@pu.edu.pk

A section of the Middle Eocene Kohat Formation has been measured and sampled systematically for the microfacies analysis and paleoenvironmental interpretation in the Gumbat Section, Kohat Basin, Himalayan Fold and Thrust Belt, Northern Pakistan.

The studied section of Kohat Formation is 84 m thick. A total number of 45 samples were collected from bottom to top in such a way that minor lithological variations were noticed and sampled. Out of these samples, 67 thin sections were made that were studied for microfacies analysis and paleoenvironmental interpretation. Four microfacies and eight subfacies have been identified in the section. These microfacies and their subfacies are:

The benthic foraminiferal wackestone faciesis divided into five subfacies: *Nummulites*-milliolid wackestones, *Nummulites-Alveolina*-milliolid wackestones, *Nummulites-Alveolina* wackestones, alveolinid wackestones, *Nummulites-Coskinolina* wackestones.

The benthic foraminiferal packstone facies includes three subfacies: *Nummulites-Alveolina* packstones, milliolid-peloid packstonesand Nummulites-Assilina packstones.
The milliolid–peloid grainstone facies has been also characterized.

These microfacies indicate some interesting results about the paleoenvironments at the time of deposition of the Kohat Formation in this area. The larger benthic foraminifera of different groups have been used for the interpretation of paleoenvironments. These micro organisms show a great susceptibility to the minor changes in climate, depth zone and the nature of substrate. These can safely be used for the paleoenvironmental interpretation of any carbonate system deposited in the marine realm.

On the basis of above mentioned microfacies, it can be concluded that the Kohat Formation in Gumbat area was deposited in low to moderate energy conditions, open marine, shallow shelf environments.

Mineralogical composition of Late Devonian to Carboniferous rocks of the Srebnen Depression (Dniepr Donets Basin, Ukraine)

Misch, D.[1], Wegerer, E.[1], Makogon, V.[2], Prigarina, T.[2], Sachsenhofer, R.F.[1], Scheucher, L.[1]

[1] Chair of Petroleum Geology, University of Leoben, Peter-Tunner-Str. 5, 8700 Leoben, Austria - David.Misch@unileoben.ac.at
[2] Ukrainian State Geological Institute, Chernigiv, Ukraine

The Dniepr-Donets-Basin is a late-Devonian rift-basin, located within the East-European Craton. It contains up to 4 km thick syn-rift sediments, and post-rift successions up to 15 km in thickness. The DDB hosts more than 200 oil and gas fields, mainly in Carboniferous clastic rocks. Oil deposits are found in the shallow NW part, whereas gas deposits prevail in the deeper central and SE parts. Potential source rocks, mostly black shales, occur in various stratigraphic levels. The Upper Visean Rudov Beds, a succession of pelitic rocks up to several tens of meters in thickness overlying a Lower Visean carbonate platform, were deposited in the stage of a post-rift sag. The richest intervals with average TOC contents of 5 % lie within the so-called Srebnen Depression, a vast post-rift syncline surrounded by a reef belt, whereas the marginal areas show less source potential. Within the frame of the present study the mineralogical composition of black shales of Late Devonian to Bashkirian age as well as their stratigraphic and lateral variability were investigated using x-ray diffractometry.

Lower Visean to Serpukhovian black shales in the SE part of the Srebnen Depression are characterized by high quartz and relatively low total clay contents irrespective of the stratigraphic position. In contrast, wells along the eastern and northern margin are characterized by higher clay mineral contents. In these wells kaolinite percentages decrease upwards. The Lower Visean carbonate platform is represented by a carbonate-dominated composition with total carbonate contents above 50% and very high pyrite contents. Increase in siderite coincides with increasing pyrite content, suggesting that S-supply at times did not suffice to bind the iron supply. All profiles show varying amounts of chlorite, illite and illite-smectite-mixed layer minerals with no clear depth relation, as well as varying feldspar contents. Increase in plagioclase indicates changes in origin of the sediment coming from the hinterland. Serpukhovian to Bashkirian rocks are often characterized by relatively high carbonate contents, whereas siderite is typically rare.

The Rudov Beds are often characterized by a mineralogical composition, which is distinctly different to that of over- and underlying stratigraphic units. This is documented i.a. by relatively low kaolinite contents, the presence of apatite, and partly high silica contents. Moreover, significant vertical and lateral compositional variability within the Rudov Beds can be observed.

Whereas clay rich rocks prevail along the northern reef margin as well as in the NW part of the Srebnen Depression, quartz-dominated siliceous facies occur in the SE part. The ratio between brittle and ductile mineral phases has an important effect on the suitability of the source rocks for shale oil and shale gas production. It is worth noting that, as a result of low Mesozoic heat flow, expandable clay minerals are preserved at a depth of more than 5 km. The portion of illite-mica, mixed-layer minerals and kaolinite in the clay mineral fraction is also highly variable. Nevertheless, illite and mixed-layer minerals are typically more abundant than kaolinite within the Rudov Beds, which is in clear contrast to the underlying Lower Visean shales.

Carnian-Norian palaeo-seawater and tectonostratigraphy of an open-marine Hallstatt limestones section in the Budva Zone (Montenegro)

Missoni, S.[1], Gawlick, H.J.[1], Richoz, S.[2], Gorican, S.[3], Prochaska, W.[1], Gratzer, R.[1], Lein, R.[4], Krystyn, L.[4]

[1] Montanuniversitaet Leoben: Department of Applied Geosciences and Geophysics, Leoben, Austria – sigrid.missoni@unileoben.ac.at
[2] University of Graz, Institute of Earth Sciences, Graz, Austria
[3] Ivan Rakovec Institute of Paleontology ZRC SAZU, Ljubljana, Slovenia
[4] University of Vienna, Central of Earth Sciences, Vienna, Austria

In the Budva zone of Montenegro deposition of hemipelagic sediments started in the Late Anisian to ?Early Ladinian with dark grey radiolarian cherts. Ladinian radiolarite deposition gradually passed to open-marine limestone deposition, similar to deep-water Hallstatt limestone successions elsewhere in the Alpine/Carpathian/Dinaride realm. During Carnian to Early Norian a more than 50 metres thick sequence is characterized by (1) a long lasting sub-marine gap (Mid Carnian to early Late Carnian), and (2) a thick middle Late Carnian to Early Norian succession with two intercalated polymictic breccia horizons (one around the Tuvalian 2/3 boundary and another from the Carnian/Norian boundary onwards during the Lacian 1-2).

In the Canj bay (Budva zone), on top of early Carnian reddish-grey nodular limestones, and after a long lasting gap, the reddish to greyish nodular limestones with intercalated *Halobia* beds of the Tuvalian 2 are geochemically characterized by increasing molar ionic-concentrations of Li, Br and Cl. The basal breccia horizon around the Tuvalian 2/3 boundary shows the peak of molar ionic-concentrations in Li, Br, Cl and SO_4. This corresponds exactly to the time equivalent peak measured in the West Carpathians, Eastern Alps, western Julian Alps and may correspond to the contemporaneous volcanic activity as known e.g. in the Buekk Mts. or the Eastern Carpathians. This breccia event is in the Tethyan realm widespread expressed by a rapid deepening, also evidenced in a decrease of the molar ionic-concentrations in Ca, Br, Cl and Li. In contrast to that Tuvalian event the Lacian 1-2 breccia interval shows partially no characteristic excursions in the molar ionic-concentrations. From the Tuvalian 3 onwards a normal open-marine environment is reflected beside the microfacies characteristics also in the molar ionic-concentrations of Br, Cl and Ca.

The trend of the open-marine Hallstatt limestone succession in the Budva zone can be directly correlated with other high resolution Hallstatt limestone successions, dated by means of conodonts in the e.g. Eastern Alps, West Carpathians, Dinarides and Turkey. A deposition in an independent deep-water basin, which should be connected to the Mirdita-Pindos oceanic realm, is not reflected by depositional characteristics, tectonostratigraphic events, isotope excursions or the palaeo-seawater geochemistry.

Acknowledgement: This study is founded by the FWF Hertha-Firnberg project of the Austrian Sciences Foundation T533-N21. Preliminary examinations have been undertaken in the framework of OEAD-WTZ project Sl 05/2007.

Micro-CT: a new, non-invasive approach to characterizing primitive soils

Mitchell, R.L.[1], Kenrick, P.[1]

[1] Department of Earth Sciences, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK – ria.mitchell@nhm.ac.uk

The development of soil ecosystems through geological time has been greatly influenced by the evolution of their plant, animal, fungal and microbial components. We are investigating the properties of modern 'microsoils' colonized and formed in the presence of non-vascular plants to aid the recognition and interpretation of early soil ecosystems in the Lower Palaeozoic (ca. 540 - 400 million years ago).

To visualise the spatial structure of these soils in three dimensions, we employed x-ray micro-computed tomography (Micro CT). We analysed microsoils dominated by bryophytes (i.e., liverworts, mosses) collected from a variety of habitats and substrates from a number of locations within the UK (Brecon Beacons N.P, The Gower Peninsula, and Wimbledon and Thursley Commons). Soils were extracted as small cores (max. 60mm height; 12mm width), air dried and stored in polystyrene vials. Samples were scanned using a Nikon Metrology HMX ST 225 micro-CT Scanner at the Natural History Museum, London. One set of samples were untreated, and a second set were stained with lead nitrate to preferentially highlight the organic plant material from the soil matrix. Using a tungsten reflection target, scans took around 40 minutes. No filter was used on unstained samples (3142 projections; 500ms exposure; 140kV and 140µA; resolution 23µm) and a 0.5mm copper filter was used for stained samples (3142 projections; 708ms exposure; 200kV and 140µA; resolution 23µm). Reconstructions were processed by CT Pro software (Nikon met., Tring). The data was rendered using Drishti v2.4 (Ajay Limaye, Poster presentation, Vis 2006, Baltimore).

We were able to non-destructively reconstruct soil physical structure in particular relating inorganic aspects to the biotic component. Results demonstrate a complex interaction of in-situ organic material (plant rhizoids, micro-organisms (e.g. arthropods)) with inorganic sedimentary components (lithic/mineral grains). Substrate binding of ephemeral dune-slack mosses such as *Ceratodon purpureus* is clearly observed, as well as cushions of the moss *Barbula convoluta* successively growing upon older parts of the plant. Unstained density contrasts between rhizoids of the liverwort *Scapania undulata* (and others) and the surrounding substrate matrix are good enough to give insights into the complex network and organisation of anchoring and water-absorbing tissue below ground. Structures and features of a lower density also prove useful; the networks of air-filled burrows, inter-grain spaces and cracks can provide understandings of how micro-organisms inhabit the soil environment, the porosity of the soils and their desiccation sensitivity, respectively. Our results demonstrate the importance of small bryophyte-scale plants in binding and stabilizing microsoils to a depth of 2cm.

Our Micro CT approach is directly applicable to characterizing palaeosols in the Lower Palaeozoic, opening the way to direct comparisons between early fossil microsoils and their modern analogues. To investigate further the impact of the bryophyte scale plants on microsoil chemistry, we are developing this approach in combination with elemental mapping of the soil profiles and analysis of organically induced microwear on mineral grains. Our overall goal is to investigate the evolution of soils in early terrestrial ecosystems and the nature and impact of weathering in the microsoil environment, and its potential impact on atmosphere and ocean chemistry.

Acknowledgements: Dan Sykes, Rebecca Summerfield, Jeff Duckett, Silvia Pressel, Alex Ball

A lacustrine perspective on turbidite and landslide cycles: implications for subaquatic paleoseismology

Moernaut, J.[1], Van Daele, M.[2], Wiemer, G.[3], Strasser, M.[4], De Batist, M.[2]

[1] Facultad de Ciencias, Universidad Austral de Chile, Chile - Jasper.Moernaut@uach.cl
[2] Renard Centre of Marine Geology, Ghent University, Belgium
[3] MARUM, Bremen University, Germany
[4] Geological Institute, ETH Zürich, Switzerland

Turbidity currents often evolve from earthquake-triggered slope failures (i.e. landslides) via progressive dilution of the sliding mass and flow transformation. Hence, turbidite records are increasingly being utilized to reconstruct the paleoseismic history at oceanic margins. However, multibeam bathymetric mapping revealed that some recent large megathrust earthquakes (e.g. 2010 Chile, 2004 Sumatra) did not provoke any large submarine landslides. This would mean that turbidite records in such regions would provide an underrepresentation of large megathrust earthquake recurrence.

In the present study, we explore the high-resolution lacustrine sedimentary archive and document the repeated deposition of landslides and turbidites in Chilean lake basins. We find striking differences in the recurrence pattern of landslides and turbidity currents, even though we can infer that both types of mass movements are induced by earthquake-triggered failure of hemipelagic sediment slopes. We also performed morphometric analysis, in-situ geotechnical measurements and slope stability modeling to better understand the processes involved in translational failure of subaquatic slopes.

We hypothesize that turbidity currents -and thus turbidite paleoseismic records- can be created by surficial slope failures (< 0.5 m) or sediment resuspension upon seismic shaking. The factors controlling this process are significantly different from the preconditioning and triggering factors of the deep-seated and extensive slope failures typically identified on multibeam bathymetric data and reflection seismic profiles. Hence, the presence/absence of large slope failures on a given ocean margin or lake slope cannot be linked directly to turbidite records and should not be included in feasibility assessments regarding turbidite paleoseismology. Given this hypothesis, we further discuss the need for high-resolution geotechnical characterizations of very shallow soft sediments in the upslope regions to determine in which circumstances turbidity currents can be created independently of large landslides.

Detrital zircon and provenance analysis in Eocene-Oligocene sandstones of the South Sistan Suture Zone, SE Iran: implication on the tectonic setting

Mohammadi, A.[1], Burg, J.-P.[1], Winkler, W.[1], Ruh, J.[1], Von Quadt, A.[2]

[1] Geological Institute, ETH-Zurich, Sonneggstrasse 5, CH- 8092 Zürich, Switzerland – ali.mohammadi@erdw.ethz.ch
[2] Institute of Geochemistry and Petrology, ETH Zurich, Clausiusstrasse 25, 8092, Zürich, Switzerland

The Sistan Suture Zone in eastern Iran is considered to represent a narrow, short-lived strip of oceanic lithosphere. The South Sistan Suture Zone comprises Cretaceous and Early Eocene carbonates followed by turbiditic sediments ranging in age from Early Eocene to Oligocene. We present a provenance analysis on turbiditic sandstones, with the aim at reconstructing the assemblages of source rocks and the tectonic setting from which the clastic material was derived.

Laser ablation ICP-MS resulted in *ca* 2502 new U-Pb ages of individual detrital zircons from 17 Eocene sandstone samples. 1845 detrital zircon ages range from 107 to 40 Ma (late Cretaceous to Eocene, Lutetian). 657 detrital zircon grains from Oligocene sandstones also range from 107 to 43 Ma (late Cretaceous to Eocene, Lutetian).

Hf isotopes analyses were performed on 81 dated zircon grains from 3 Eocene and Oligocene samples. Positive (+2 to +12) value in Late Cretaceous zircons indicate island arc magmatism. Low negative to positive (-3 to +9) values in Paleocene zircons indicate transitional island to continental arc affinity. Negative (-15 to -1) values in Eocene zircons show crustal magma sources, which are common in continental arc environments.

300-400 points were counted in each of 20 sandstone thin sections following the Gazzi-Dikinson method. The sandstones are feldspathic litharenites and lithicarkoses. Feldspar is dominantly plagioclase (> 90%) with minor amounts of K-feldspar. Most of the quartz grains (85%) are mono-crystalline but poly-crystalline grains (≤15%) also occur. Rock fragments are represented by sedimentary, volcanic and metamorphic grains. Volcanic fragments mostly are andesite and volcanic chert. Sedimentary lithic grains comprise mostly sandstone, siltstone, limestone and dolomite. Metamorphic lithic grains generally are low-grade schists and phyllites. In various compositional ternary diagrams, the sources of the sandstones plot in the transitional to dissected arc fields.

200-300 grains were identified and counted in the same 20 samples. Heavy mineral suites show a highly variable composition including (1) a group of ultra-stable minerals (zircon, monazite, tourmaline, rutile, brookite, anatase and sphene) derived from a granitic continental crust, (2) metastable minerals from variable metamorphic-grade source rocks (epidote group, garnet, staurolite, chloritoid, kyanite, andalusite, glaucophane), (3) a group of pyroxene minerals derived from magmatic rocks, (4) Chromian spinel (2-20%) which indicates ultramafic rocks of ophiolitic affinity in the detrital source areas of Eocene and Oligocene sandstones.

These new results, suggest a magmatic arc and synsedimentary magmatic activity from Late Cretaceous to Eocene (107 to 40 Ma). Hf isotope ratios indicate Late Cretaceous-Paleocene island arc system that was changed into a continental arc system in the Eocene. Similar zircon ages and change from island to continental magmatic arc is reported in Pakistan. In addition, the clastic chromian spinel implies that ophiolites were exposed in Late Cretaceous times.

3D and 4D X-ray measurement of migrating sand ripples

Montreuil, S.[1], Long, B.[1]

[1] Institut National de la Recherche Scientifique, 490 rue de la Couronne, Québec (Québec) G1K 9A9 Canada – stephane.montreuil@outlook.com

Sediment transport CT-Scanner-flume experiments provide crucial information about internal bedform structures offering the best setup ever for fundamental and applied research. Passing an acrylic flume inside a mobile CT-Scanner gantry enhances the potential of flume experiments through density profiles. This innovating technique generates a view inside sediment ripples, revealing the dynamic phenomena acting on internal structures. Analysis results have provided a new set of sedimentary parameters defining internal migrating ripple architecture. The aim of this study is focused on the upper bedload transport layer and especially its delimiting point, creating a new definition of datum used as ripple surface, influencing sediment transport estimation.

The 30 x 30 x 700 cm flume used in this research was specially built to fit into a CT-Scanner room and technically designed to avoid X-ray artefacts. The flume is filled with a 5 cm-thick pure silica sand layer and a 20 cm-high water column at 20 °C. The flow (0 – 80 $cm \cdot s^{-1}$) is measured and controlled by an electro-pneumatic valve inside a recirculating circuit.

Two CT-Scanner measurement techniques have been developed: a global measurement technique uses a 3D matrix of 512 x 512 x 1500 voxels of 0.6 x 0.6 x 0.6 mm, resulting in a view at a precise moment in time (Lagrangian); the second (Eulerian) one is the periodic event technique generating a matrix set of 512 x 512 x 30 voxels separated by a Δt from 30 s to hours. From both techniques, matrixes are considered as vertical density profiles imaging the density from the water column to the bottom bed, passing through the boundary suspension-bedload.

Interpretation of raw data images from CT-Scanner-flume experiments necessitate processing through medical reconstruction software. Best results were obtained with the SpineSpi B20s (Siemens) reconstruction filter. Results in HU based on relative density, are converted in SI units of density following a linear equation. Afterward, SI values are calibrated taking into account flume composition, sand properties and fluid density.

Vertical density profiles for a 3D matrix provide values from the suspension-bedload transition towards the sediment bed's interior (d_{50} = 0.470 mm and U = 28 $cm \cdot s^{-1}$). This reveals the impact of water, penetrating up to 10 mm deep into the sediment. This penetrating process is not linear and demonstrates the existence of an unknown internal phenomenon present during sediment transport. The thickness of the upper bedload transport layer varies from 0.6 mm to 10 mm respectively for the ripple summit and trough. Density at the upper suspension-bedload boundary varies, respectively for summit and trough, between 1.026 and 1.318 $g \cdot cm^{-3}$ and at its lower end between 1.645 and 1.903 $g \cdot cm^{-3}$.

When observing density profiles along a migrating sand ripple, it appears that the bed surface used as a datum is located deeper into the sediment. Density values and profiles form at the water column base as a conduct to the definition of a boundary density point (former datum) under an upper bedload transport zone. Underneath this bedload transport zone, the maximum density is reached leading to the definition of a *stricto sensu* ripple surface. This new ripple surface location is 0.6 to 10 mm deeper than the one used in literature and depends on d_{50}, flow current and position along the ripple structure.

Innovative CT-Scanner results have revealed new phenomena that re-open the discussion about suspended and bedload transport during erosion and deposition processes, leading to a new way of looking inside active sediment transport. Protocols and processes developed in this study open new research opportunities in the field of sediment transport.

Evolution of Kumano Forearc Basin from NanTroSEIZE drilling and 3D seismic expeditions

Moore, G.F.[1], Strasser, M.[2], Boston, B.[3], Dugan, B.[4], Kanagawa, K.[5], Underwood, M.[6]

[1] Dept. Geology & Geophysics, Univ. Hawaii, Honolulu, HI 96822 USA - gmoore@hawaii.edu
[2] Geol. Inst., TH, 8092 Zurich Switzerland
[3] Dept. Geology & Geophysics, Univ. Hawaii, Honolulu, HI 96822 USA
[4] Dept. Geol. Sci., Univ. Missouri, Columbia, MO 65211 USA

Sedimentary deposits in the forearc of the Nankai accretionary prism off Kii Peninsula, Japan, record complex interactions between sedimentation and deformation processes. Across the seaward half of the Kumano forearc basin, three-dimensional (3D) seismic data image more than 2 km of sediment in the basin deposited above an upper Miocene-lower Pliocene (5.0-5.9 Ma) accretionary prism. IODP drill cores show that the unconformity between the prism and the overlying basin sediments is time-transgressive. The unconformity separates 5.0 Ma prism rocks from 3.65 Ma basin deposits at drill Site C0002 and 5.6 Ma prism rocks from 3.8 Ma basin sediments at drill Site C0009 (~ 20 km landward of C0002). The basal basin sedimentary sequence is sub-parallel to the underlying accretionary prism and varies in thickness from ~50m in the seaward part of the basin to > 1100m in a basin a few km seaward of Site C0009. The sequence is interpreted as the lowermost forearc basin fill and underlying trench slope basin deposits. The landward thickening of this unit is interpreted to indicate that most of the sediment was derived from the Japanese Islands and was trapped in larger basins higher on the slope.

The acoustic character of most strata filling the Kumano Basin consists of landward-tilted, high-amplitude, laterally-continuous reflections, interpreted as a sequence of turbidites. The turbidites lap onto the older unit. The onset of turbidite deposition in the basin began when accommodation space was created by the uplift of the outer ridge along the splay fault at ~1.65 Ma. The dominant lithology in IODP cores is dark olive-gray silty claystone. Minor lithologies include sandstone, sandy siltstone, silty claystone, calcareous claystone, and fine ash. Most samples are dominated by a siliciclastic grain assemblage of clay, quartz, and feldspar, with variable amounts of pelagic carbonate and a minor but persistent component of volcanic glass. The turbidites are tilted landward, presumably because slip along the megasplay fault promoted uplift at the seaward flank of the basin. Continuation of the uplift also migrated the locus of sedimentation landward. As the basin's depocenter shifted landward, the basin expanded from ~10 km in width to > 30 km.

The basin-fill strata are displaced by very young normal faults, many of which cut and displace the surface sediments. Within the upper km of the basin fill, there is one large-scale (4.5 km x 4.5 km x 135m) Mass Transport Deposit (MTD) as well as several smaller (50-75 m) MTDs. The MTDs seem to be sliding along bedding planes during uplift of the basin sequences.

Proglacial vs postglacial depostional environments, the opposing processes that filled the southern North Sea tunnel valleys

Moreau, J.[1], Huuse, M.[2]

[1] Department of Geosciences and Natural Resource Management, University of Copenhagen, Øster Voldgade 10, Copenhagen DK-1350, Denmark - moreau.juli1@gmail.com
[2] School of Earth, Atmospheric and Environmental Sciences, University of Manchester, Oxford Road, Manchester, M13 9PL Manchester, UK

Tunnel valleys have long fascinated the geoscientists by their scale and the consequent intensity of the sedimentary processes responsible for their formation. Tunnel valleys may be up to 180 km in length, 4 km in width and 450 m in depth. The incisions are formed subglacially by overpressured meltwaters on the outer parts of continental-scale ice sheets. In addition to the peculiar incision process, the filling of tunnel valleys in the southern and eastern North Sea, when imaged by 3D seismic data, show a peculiar infill. In these areas, the infill of the valleys is mainly composed of clinoforms prograding north in opposing direction to the former ice flows whose southward-flowing meltwater excavated the valleys. The first hypothesis, by analogy with some small eskers introduced the concept of backfilling where the eroded sediments upstream is deposited directly below the ice margin, in a conveyor-belt fashion. The formation of the 'backsets' would have been enhanced by supercooling due to the pressure drop during the upward flow of the water from the deepest part of the valleys towards the ice margin, freezing and thus capturing the sediments on the adverse slope. Recently this model has been challenged by new observations on the architecture of the valleys and their infill sediments which appear to show many similarities in common with deltaic clinoforms observed in the pre-glacial succession of the southern North Sea.

The new model states that the incision and the filling of the valleys are separate in times and from distinct sedimentary processes. The valleys are mainly incised by overpressured subglacial meltwater with probably some abrasion as a minor erosive agent including bedrock control on the incision depths and morphologies. The infill is interpreted as proglacial for the newly observed south-dipping clinoforms and postglacial for the north-dipping clinoforms onlapping the latter. The north-dipping clinoforms are interpreted to be formed within a large deltaic system associated with the Rhine-Meuse river(s). The delta was probably infilling a large lake system containing overdeeps (the underfilled tunnel valleys). The presence of clinoforms 50-80 m above the valley shoulders gives a fair idea of what could have been the general depth of the lake. However, the lake was certainly in the isostatic depression after partial or complete ice sheet retreat. The crust and mantle were not in equilibrium during that postglacial time, and the ice might have been occasionally present in the lacustrine basin so that the lake levels may have been very variable and difficult to tie to the present-day topographic configuration. This system of competition between one of the biggest river of Europe facing ice sheets and their proglacial depositional system generates a very intricate stratigraphy with multiple cross-cutting 'basins' in the form of valleys (c. 7 generations) which themselves contain up to 8 complete seismic sequences. Although the task to build up a complete stratigraphic scheme is immense and a long run project, it would be unique for this period in the region. We intend to solve part of the problem by numerically reconstructing the local landscape with the ice sheet and its isostatic depression. This allows to represent a type-sequence helping the understanding of the Rhine-Meuse migration and the position of the lacustrine systems which so far has remained elusive.

Geochemical signature in a tsunami deposit detected in Lagoa dos Salgados (Portugal)

Moreira, S.[1, 2], Costa, P. J. M.[1, 2], Andrade, C.[1, 2], Freitas, M. C.[1, 2], Oliveira, M. A.[1, 2], Silva, T.[3], Lira, C.[1, 2]

[1] Centro de Geologia da Universidade de Lisboa, 1749-016 Lisboa, Portugal - scmoreira@fc.ul.pt
[2] Departamento de Geologia, Faculdade de Ciências da Universidade de Lisboa, 1749-016 Lisboa, Portugal
[3] Institut F.A. Forel, Université de Genève, 10, Route de Suisse, CP 416, 1290 Versoix, Switzerland

Multiproxies are widely used to recognize tsunami deposits in coastal stratigraphy. Among these, the study of source- and environment-sensitive geochemical elements in sediments improve the understanding of these inundation processes. For example, Na, Cl, Br and I have been used as indicators of massive tsunami marine inundation in onshore depositional environments.

In Lagoa dos Salgados (Algarve, south Portugal), a tsunami deposit associated with the AD1755 event has been described in the topmost section of the lagoonal Late Holocene sequence. The tsunamigenic unit is massive and located at 0.40m below surface (*ca.* 1.30m above mean sea level). This bioclastic medium to fine sandy deposit is under and overlaid by organic sandy clayey silt units. Its basal contact is erosive and occasionally presents rip-up clasts from the underlying layers. The tsunami deposit fines and thins inland until disappearance *ca.* 850m from present-day coastline. The lateral change in thickness is accompanied by variation in its sedimentary characteristics. In the seaward section, this sediment is coarser (fraction >63µm averaging 88% and bioclastic $CaCO_3$ 29%); further inland the proportion of mud-sized particles increases with increasing distance from the inlet (fraction >63µm averaging 54%, $CaCO_3$ 23% and organic matter 2%). Both the under and overlying units share strong similarities in texture, and are essentially constituted by brownish silt and clay material (fraction >63µm less than ~30%; $CaCO_3$ averaging 9% and organic matter 4%). Due to their similarities, these units are macroscopically indistinguishable in places where the tsunami deposit is absent.

The objectives of this study are the characterization of the geochemical signature of this event, focusing in: 1) the comparison between the extent of the inundation and that of its lithostratigraphic imprint; and 2) in the detection of the geochemical imprints of the different phases of inundation (run-in and backwash). A number of cores and trench-wall box-cores trending inland from the shoreline were retrieved from the lagoonal space. The coring network allowed sampling the wedging out of the tsunami sedimentary unit and framing sediment up to a distance where its textural imprint could no longer be detected.

Depth variations in elemental contents and ratios (e.g. S, Cl, Ca, Sc, Br, Sr, I, REE, Al/Si, Ti/Ca Fe/Mn, Mn/Ti, Ba/Ti) along the cored sediments provide clues on provenance and help understanding the ability of both tsunamigenic and permanent-regime sediments to preserve a conspicuous imprint of marine inundation. Samples are being analyzed using an ITRAX™ Core Scanner at 4 mm resolution (CACTI, Vigo University). It is expected that the semi-quantitative geochemical results coupled with the sedimentological data will support and improve the preliminary results obtained on this issues at Boca do Rio lowland, a synchronous deposit preserved in similar lithostratigraphic context.

Evidence of great Cascadia earthquakes in small Seattle area lakes

Morey, A.E.[1], Goldfinger, C.[1], Galer, S.[1]

[1] College of Earth, Ocean and Atmospheric Sciences, 104 CEOAS Admin. Bldg., CEOAS/OSU, Oregon State University, Corvallis, OR 97331 - morey@coas.oregonstate.edu

We recently cored several small lakes from the coast to the foothills of the Cascades at the latitude of Seattle, Washington to look for evidence of great earthquakes. High-resolution computed tomography (CT) imagery revealed structure in these sediment cores that appeared otherwise visually homogenous, with only slight changes in color and texture. We compared all down-core physical property (CT and gamma density, RGB imagery, and magnetic susceptibility) data after linking records in time using the occurrence of the Mazama tephra (confirmed by electron microprobe analysis) and AMS radiocarbon ages. Dominant patterns can be traced between lake cores, suggesting the down-core variability represents a regional control driving changes in sediment characteristics. We also find strong correlations between the lake core data and the offshore record of seismoturbidites from Juan de Fuca Channel, suggesting great Cascadia earthquakes control sedimentation in both environments.

Clues to the underlying mechanisms driving down-core variability can be found in sediment composition and setting, which we interpret within the context of the regional glacial history. Leland Lake (0.4 km^2, 6.1 m deep, and 58 m MSL), Tarboo Lake (0.1 km^2, 17.7 m deep, and 195 m MSL), and Lake Sawyer (1.1 km^2, 17.7 m deep, and 156 m MSL) might be considered less than ideal paleoseismic recorders because of basin morphology and minimal overland stream-flow limiting the clastic input available to load lake margins. In contrast, nearby Lake Washington is considered a good paleoseismic recorder because it is a large (88.0 km^2), deep (65 m), and steep-sided lake with numerous subaqueous margin failures. Smear slides show that our cores are composed primarily of diatoms, very fine organic matter, and a much small percentage of fine-grained clastics. We find that variations in both percentage and size of clastic particles drive the down-core variability that links the offshore and lake records. We see an overall increase in the size and percentage of clastics with depth in the cores at Leland Lake (which may reflect the removal of available sediment from a proglacial lake known to have occupied this area as the Puget Lobe retreated), and preliminary observations show that the percentage of vivianite, an authigenic iron phosphate mineral formed in reducing environments, seems to follow clastic variability suggesting a linkage between them. We are exploring the mechanism that strong shaking during an earthquake causes remobilization of margin sediments, and results in redeposition on the lake floor producing an organic-rich environment with the components necessary for the formation of vivianite.

These results show that high-resolution CT density data can be used to identify disturbance deposits in low-sensitivity environments, and that small, flat-bottomed lakes with little clastic input may be good recorders of subduction zone earthquakes. We now have the opportunity to explore the impact of strong shaking from great Cascadia earthquakes using the sedimentary records from the numerous forearc lakes found throughout the Pacific Northwest.

The authors would like to thank the United States Geological Survey for funding this project, and Dr. Brian Sherrod (USGS and University of Washington, Seattle) for providing equipment and expertise invaluable to this project.

Reservoir geology of coal-bearing successions: new insights from outcrop and borehole based study in Eastern Kentucky (US)

Moscariello, A.[1]

[1] Earth and environmental Sciences, University of Geneva, 13, rue des Maraichers, 1205 Geneva, Switzerland – andrea.moscariello@unige.ch

The increased focus on exploration and development of unconventional resources in the last 5-10 years has led to a renewed interest in coal-bearing fluvio-deltaic and coastal plain deposits. The latter holds the majority of coal bed methane resources for which is important to understand the extension and subsurface architecture of coal seams. On the other side, coal-bearing sand rich successions still represent very important conventional reservoirs such as the Coal Measures of Carboniferous in NW Europe, the Jurassic and Cretaceous successions of Eastern Russia and NE China, the Late Cretaceous-Tertiary successions of low latitudes (e.g. Arctic area of Alaska, Canada and Russia) and the Tertiary deposits in the Asia-Pacific region (e.g. Myanmar, Thailand, Indonesia, Australia). In all these cases, predictive model for sand and coal distribution in the subsurface are required to drive an effective and cost efficient hydrocarbon development strategy.

The Eastern Kentucky and West Virginia road network provide world-class exposures of Upper Carboniferous coal bearing successions where the interplay between sand and shale intervals and intervening coals can be studied in detail.

In this paper we present a summary of ongoing research recently carried out on the Pennsylvanian Hyden and Pikeville Formations where architecture and laterial facies variability of clastic deposits and associated coals can be observed and followed for several kilometers thanks to exceptional outcrop quality and dense borehole data from coal mining.

Specifically, this paper focuses on geometry and genetic significance of coal seams and heterolithic clinoforms intervals.

Coals, usually genetically associated with transgressive system tract lies often on top of channel-fill sandstone and under shale dominated intervals the latter recording the transition from a flooded coastal plain to shallow to deep marine environment. However coals are found as well draping irregular topographic surfaces where wide and relatively deep (10-20 m) incisions can be recognised. In this situations coals are typically overlain by channel fill sandstone forming the stratigraphical unit above. Often the sand is not eroding the underlying coal. In this cases, the coals are interpreted as forming during a low stand phase and thus possibly the true indicators of development of incised valleys.

Five to ten meters-high inclined beds made of mixed heterolithic successions of sandstones and shales are associated with both fluvial-dominated mouth bars and point-bars develop in large meandering river systems often developed within estuarine environment. This study highlights the typical 3D features of these deposits allowing the definition of sedimentological and stratigraphical criteria to distinguish these tow systems in the subsurface.

The Carboniferous succession of Eastern Kentucky is then compared with the coeval succession in the North Sea (The Netherlands) to highlight the importance of outcrop based analogues studies to help understanding the overall distribution of subsurface geology by providing practical criteria for a) carrying out a well-to-well correlation and b) reconstruct the overall 3D reservoir architecture.

Preliminary characterization of transgressive deposits in the northern Adriatic Sea (Italy)

Moscon, G.[1], Stefani, C.[1], Correggiari, A.[2], Fontana, A.[1], Remia, A.[2]

[1] Dipartimento di Geoscienze, Università degli Studi di Padova, Via Gradenigo 6, 35131 Padova, Italy – giorgia.moscon@studenti.unipd.it
[2] ISMAR (CNR), Via Gobetti 101, 40129 Bologna, Italy

The Adriatic Sea is an epicontinental semi-enclosed basin characterized by a low axial gradient shelf in the northern and central part and by a steeper gradient in the southern sector. During the Last Glacial Maximum (LGM, 30000 to 18000 year BP) an approximately 300 Km wide stretch of the northern Adriatic shelf was subject to subaerial exposure. The drainage network of this alluvial plain likely comprised a main trunk river, with Alpine and Apenninic tributaries. After 18-Ka the sea-level began to rise from -120 m s.l reached during the LGM and the coastline migrated landwards. Across the low-gradient northern shelf, the stepwise, high-amplitude relative sea-level rise favoured the deposition and in-situ drowning of different generations of transgressive barrier-lagoon-systems. Nowadays from Trieste to Ravenna, these transgressive deposits are located between -10 and -35 m w.d, in restricted areas showing a dominant longshore trend similar to the modern sea-level high-stand deposits. These bodies are wreak of ancient coastal wedges drowned in place and consist of well sorted sands capped by ravinement surface and frequently drapped by a thin veneer of high-stand mud. More transgressive deposits were analysed in order to understand their evolution before and during the last sea-level rise and their sand composition. Deposits located north of the Po delta have been characterized in order to understand their provenance, whereas one deposit situated south of the Po delta has been investigated in order to define the stratigraphic evolution during its formation. For the northern deposits a quantitative compositional point counting of large amount of samples will be carried out according to the standard Gazzi-Dickinson technique. Petrographic results show a compositional variation depending on the areal position of the deposit. The comparison with literature data allow us to distinguish three different petrographic provinces: northern deposits located offshore Lignano show an eastern Alpine signature underlined by the high percentage of terrigenous carbonates; middle deposits situated off-shore of the Venice lagoon show a mixed composition between carbonate Alpine supply and quartzolithic components of the Po drainage basin, while southern deposits located close to the Po mouths are characterized by a quartzolithic signature emphasized also by high amounts of heavy minerals.

Regarding the offshore Ravenna deposit, covered by 765 Km of VHR seismic profiles, the transgressive surface and other three key reflectors have been digitalized and a digital elevation model has been produced for each surface. The surfaces modelling highlights a variation of the fluvial trend from east-northeast before the last-sea level rise and during the deposition of the first three surfaces to east-southeast during the deposition of the more recent key surface.

Petrographic data confirm a different provenance of the deposits according with their position, in addition highlight a potential sediment dispersion linked to opposite marine currents in respect to the present or a northward shifting of the Po River paleo-mouth during the last sea-level rise. Moreover in the southern deposit it was possible highlight the evolution of the coastal plain environment during the last transgressive cycle identifying different fluvial phases between the transgressive and the ravinement surfaces.

X-ray computed tomography analysis of volcanic ash aggregates

Mueller, S.B.[1], Cimarelli, C.[1], Douillet, G.A.[1], Hess, K.-U.[1], Heuss-Aßbichler, S.[1], Kueppers, U.[1], Dingwell, D.B.[1]

[1] Ludwig Maximilians Universität München (LMU Munich) Earth & Environmental Sciences Theresienstrasse 41 80333 Munich Germany – sebastian.mueller@min.uni-muenchen.de

Explosive volcanic eruptions release large amounts of particles into the atmosphere. Volcanic ash, by definition pyroclasts smaller than 2 mm, can be distributed around the globe by prevailing winds. Ash poses hazards to aviation industry by melting in jet turbines, to human health by entering respiration systems and to society by damaging infrastructure. Under certain circumstances, in plumes or pyroclastic density currents, ash particles can cluster together and build ash aggregates. Aggregates range in size from few mm to few cm and may exhibit complex internal stratigraphy. Ash aggregates are heavier and exhibit different aerodynamic properties than the surrounding ash and accordingly fall prematurely than individual ash grains. Ash aggregation is frequently observed in the geologic record and has also been described during eruptions. Still, the physical and/or chemical mechanisms generating the aggregates remain poorly understood. Distinguishing between the three main types of aggregates – ash clusters (massive), cored pellets (containing voids) or accretionary pellets (structures with concentric laminations) – is a first step to approach the understanding of the generation of aggregates. Besides field or thin-section analysis, another powerful tool to describe aggregates is x-ray computed tomography (x-ray CT). X-ray CT has the advantage that it is a non-intrusive method and permits 3D reconstruction of the sample. Further, the high resolution of x-ray CT (up to few µm) allows to image single grains within an aggregate. We use results from x-ray tomography of various ash aggregates (Iran, Italy, New Zealand) together with traditional thin-section analyses in order to describe the different structures and types of aggregates. This is a first step toward conclusions on the genesis of ash aggregation and the ongoing processes in ash plumes and PDCs.

Sedimentary evolution in arid rift basins, El Qaa Fault Block, Suez Rift, Egypt

Muravchik, M.M.[1], Gawthorpe, R.L.[1], Sharp, I.[2]

[1] Department of Earth Science, University of Bergen, Bergen, Norway – martin.muravchik@geo.uib.no
[2] Exploration Research, Statoil ASA, Bergen, Norway

Most of the current sedimentary models for marine rift basins are based on a dominance of relatively humid climatic conditions. As a consequence, they assume the existence of perennial fluvial/alluvial systems constantly providing water and sediments to the marine environment. In arid to semiarid climates ephemeral depositional processes tend to prevail, favoring the development of strongly seasonally controlled sedimentary systems. Their coupling to the growth and evolution of normal fault zones leads to particular patterns in terms of location, geometry and stratal stacking of the sedimentary units. The interrelation between carbonates, evaporites and coarse-grained deltas in arid settings is studied from Miocene exposures of the El Qaa Fault Block, Suez Rift, Sinai Peninsula, Egypt.

Conglomerate- and sand- dominated deltaic lobes up to 120 m thick were deposited at the eastern margin of the El Qaa half graben. They were sourced from the eastern rift shoulder and prograded across the half-graben towards the west. They are characterized by the presence of carbonate at their topsets and evaporite bodies at the bottomsets. The carbonates are of coral and algal origin up to 20-30 m thick that extend laterally for 0.7 to 2 km. The evaporites occur as anhydrite and gypsum forming 5 to 40 m thick tabular massive beds intercalated with mudstones that can extend laterally for several kilometers. The complex stacking pattern defined by the alternation of siliciclastic and carbonate bodies reveals progradational-aggradational cycles within the deltaic system that can be related to the deformation and subsidence of the hangingwall block. The conditions for development of the coral and algal bodies in the topset of the deltas result from a combination of ephemeral alluvial input of sediment and its reworking in the coastal setting. The deposition of the evaporites has a strong regional component defined by the intermittent oceanic connection experienced by the Suez Rift through the Red Sea basin and Mediterranean Sea during the Miocene. The superposition of these together with local effects such as hangingwall block tilting and hangingwall syncline formation proves to be decisive controls on the emplacement of the evaporites.

The results show a complex interaction of arid to semiarid depositional processes controlled by the spatial and temporal evolution of the extensional structures with basin-scale processes such as seawater composition and circulation. The El Qaa half-graben constitutes a perfect analogue for other arid rift basins characterized by hyper-saline and marginal marine successions (e.g. sub-salt hydrocarbon plays in the South Atlantic).

The Clumped Isotopic Signature of Mixed Calcite and Dolomite

Murray, S.[1], Swart, P.K.[1]

[1] Department of Marine Geosciences, RSMAS, University of Miami, 4600 Rickenbacker Causeway, Miami Fl 33149 – smurray@rsmas.miami.edu

The application of the 'clumped' isotopic method (Δ_{47}) to the understanding of diagenesis in carbonates rocks offers the possibility to distinguish the competing roles of temperature and water $\delta^{18}O$ in controlling the $\delta^{18}O$ of the mineral. Although this is true for both calcite and dolomite, the study of dolomite still offers challenges in that there are (i) at least seven equations which link the $\delta^{18}O$ of dolomite to the temperature and the $\delta^{18}O$ of the fluid, and (ii) there is as yet no published empirical calibration between dolomite and Δ_{47}. With regard to the second point is unclear whether the behavior of Δ_{47} with respect to temperature is similar in these two minerals or whether different equations are necessary. In order to better understand these relationships we have examined carbonates which have been partially dolomitized in a core drilled on the margin of Great Bahama Bank (GBB). The majority of the sediments in this core were originally aragonite and formed on the surface of GBB in shallow warm waters (~20-30^{o}C). They were then swept off GBB and deposited along the flank in cool deeper water (~5-10^{o}C). Here they were recrystallized to low-Mg calcite (LMC) and partially dolomitized. It could be argued that if dolomites and LMCs share the same temperature-Δ_{47} relationship, then Δ_{47} should not vary function of % dolomite in the sample. This argument assumes both LMC and dolomite probably formed at the same temperature. The alternative is that if dolomites and LMC have different Δ_{47} -temperature relationships, then the Δ_{47} should change in the samples in which dolomite was higher.

In order to test these ideas, a number of samples, which contained between 5-50% dolomite, were selected from the Clino core. The first step was to measure the bulk stable C & O isotopic and Δ_{47} in the samples. Next the dolomite in each sample was isolated/purified by treating crushed and sieved samples (< 63 μm) with buffered acetic acid. After about two-three hours, the samples were washed and dried and the XRD and isotopic analyses were repeated. If the sample still showed remaining LMC, then the samples were leached for a 2nd or even 3rd time. After each leaching step all isotopic analyses were repeated. In this manner the Δ_{47} could be assessed on the pure dolomite fraction from a specific sample and by interpolation also on the original LMC. Initial interpretation of the data shows that the Δ_{47} does not change as a function percentage dolomite in the sample, implying either a similar temperature- Δ_{47} relationship for dolomite and LMC, or a fortuitous combination of difference in formation temperature between the dolomite and LMC combined with a different temperature- Δ_{47} relationship.