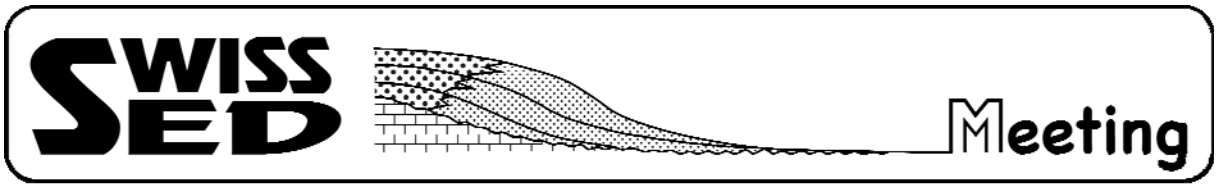

26th SwissSed Meeting

Saturday, 24 February 2018

Fribourg

Abstracts

PROGRAMME

09.30 - 09.55 Morning coffee and croissant

09:55 - 10:00 Opening

10:00 - 10:20 **Schaegis, J.-C.**, Jaramillo-Vogel, D., Negga, H., Wyler, P., Filfilu, E., Atnafu, B., Kidane, T. and Foubert, A.: Carbonate precipitation during the Holocene in hot springs of the lake Afdera (Northern Afar, Ethiopia)

10:20 - 10:40 **Rime, V.**, Mosar, J., Schori, M. and Sommaruga, A.: New possible age constrain on the deformation of the Swiss Neuchâtel Jura Mountains: linking kinematic modelling and Tertiary sedimentology

10:40 - 11:40 Coffee and posters

11:40 - 12:00 **Morlock, M.A.**, Vogel, H., Melles, M., Russell, J.M., Bijaksana, S. and the TDP Science Team: High-resolution geochemical datasets from XRF core scanning enable detailed lithologic descriptions of long sediment sequences

12:00 - 12:20 **Douillet, G.A.**, Yu, N.T., Lin, A.T.S., Giletycz, S.J., Castellort, S. and Schlunegger, F.: Storm deposits in Taiwan

12:20 - 14:00 Lunch and group picture

14:00 - 14:50 **KEYNOTE: Immenhauser, A.**, Pederson, C., Müller, M., Reichelmann, S., Onyedikachi, A.I., Ge, Y., Lokier, S., Dietzel, M., Mavromatis, V., Buhl, D., Jöns, N., Breitenbach, S., Hoffmann, R., Nehrke, G. and Kluge, T.*: Snapshots of Carbonate Diagenesis*

14:50 - 15:10 **Blattmann, F.R.,** Eglinton, T.I., Haghipour, N., Bernasconi, S.M., Dittrich, M., Al-Kuwari, H.A. and Bontognali, T.R.R.: Biogenicity and Fossilization Potential of Polygonal Sedimentary Structures in Evaporitic Environments

15:10 - 15:30 **Maillet, M.,** Wentao, H., Zhuowei, M., Enpu, G., Changqing, G., Yongli, Z., Xiaohong, C. and Samankassou, E.: Growth dynamics of a Carboniferous carbonate platform: Record from Tianlin County, Guangxi Region (Southern China)

15:30 - 16:30 ***Tea and posters***

16:30 - 16:50 **Farley, N.,** Antonioli, G., and Samankassou, E.: Paleoclimate reconstructions in the Tropical South Pacific using *Porites* microatolls from French Polynesia

16:50 - 17:10 **Blattman, T.**, Zhang, Y., Zhao, Y., Wen, K., Lin, S., Li, J., Haghipour, N., Wacker, L., Plötze, M., Liu, Z. and Eglinton, T.: Sedimentary organic matter and its clay mineral associations in the South China Sea: A sediment trap study

17:10 – 17:30 **Angéloz, A.**, Linde, N., Baron, L., Chatelain, F., Grosjean, P., Davaud, E. and Samankassou, E. : Evaluation of carbonate reservoirs in Upper Jurassic deposits (Jura Mountains, France) using electrical resistivity tomography

17:30 - … Closure and apéro

POSTERS

Bilobé, J., Ngos III, S., Ondoa, J.M., Adatte, T. and Samankassou, E.: Structure and tectono-stratigraphic evolution of the Mamfe sedimentary basin, SW Cameroon

Camperio, G., Lloren, R., Ladd, N.S., Prebble, M. and Dubois, N.: Tracing Past Ecosystem Modification in the Pacific Islands of Vanuatu

El Kateb, A., Stalder, C., Neururer, C., Fentimen, R., Spangenberg, J.E. and Spezzaferri, S.: Distribution of benthic foraminifera in the transitional environment of the Djerba lagoon (Tunisia): An ecological overview

Feenstra, E., Fentimen, R., Hall, E., Rüggeberg, A., Van Rooij, D., Bertrand, S., Frank, N., Grobéty, B., Spezzaferri, S. and Foubert, A.: Paleoenvironmental reconstruction of cold-water coral Melilla Mounds (Eastern Alboran Sea)

Fleischmann, S., Picotti, V., Bernasconi, S. and Caves, J.: Isotope stratigraphy and organic geochemistry of platform margin and slope across the Pliensbachian-Toarcian boundary and their relationships with platform drowning and oceanic anoxia

Garefalakis, P. and Schlunegger, F.: Controls of the Burdigalian transgression recorded in the Molasse basin

Guerra, L., Martini, M.A., Piovano, E.L. and Ariztegui, D.: Lacustrine sedimentology and Late Quaternary paleoclimate in the Argentinean Central Andes

Lauper, B., Jaeggi, D., Deplazes, G., Becker, J., Vogel, H. and Foubert, A.: Lithological diversity within the Opalinus Clay of northern Switzerland: towards a subfacies classification scheme

Lloren, R.B., Augustinus, P. and Dubois, N.: Tracking the Maoris: fecal sterols as tracers of changes in paleo-agropastoral activities around Lake Pupuke, North Island, New Zealand

Makhloufi, Y. and Samankassou, E.: Early dolomitization and dedolomitization of the Upper Jurassic limestones of the Geneva Basin (Switzerland and France)

Negga, H., Jaramillo-Vogel, D., Schaegis, J-C., Rime, V., Perrochet, L., Wyler, P., Filfilu, E., Hailu, A., Braga, J.C., Atnafu, B., Kidane, T. and Foubert, A.: Coralgal reefs in the Danakil depression (Northern Afar, Ethiopia)

Nigg, V., Girardclos, S., Kremer, K. and Anselmetti, F.S.: Tsunami deposits surrounding perialpine lakes in Switzerland

Normand, R., Simpson, G., Biswas, R.H., Herman, F. and Bahroudi, A.: Optically stimulated luminescence dating of the Western Makran marine terraces (Iran)

Peyrotty, G. and Martini, R.: Triassic limestones from the Panthalassa Ocean: new insights on Hokkaido Island and Far East Russia

Rime, V., Foubert, A., Negga, H., Schaegis, J.-C., Atnafu, B., Kidane, T. and Wilkinson, J.: Dynamics of the Danakil basin (northern Afar, Ethiopia): new insights in the development of the continent-ocean transition through field, well and seismic data analysis

Stainbank, S., Spezzaferri, S., Rüggeberg, A., Kroon, D., de Leau, E.S., Kunkelová, T., Raddatz, J. and Betzler, C.: The South Asian Monsoon and its concurrent oceanographic influences

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Angéloz, Aurelie	Geneva	Homewood, Peter	Gan
Ariztegui, Daniel	Geneva	Immenhauser, Adrian	Bochum
Bilobe, Jeanne Armelle	Geneva	Lauper, Bruno	Fribourg
Bläsi, Hansruedi	Bern	Lloren, Ronald	Zurich
Blattmann, Franziska	Zurich	Maillet, Marine	Geneva
Blattmann, Thomas	Zurich	Makhloufi, Yasin	Geneva
Blouet,Jean-Philippe	Fribourg	Martini, Rossana	Geneva
Boivin, Simon	Geneva	Mettraux, Monique	Gan
Camperio, Giorgia	Zurich	Morlock, Marina	Bern
Carmalt, Samuel	Geneva	Negga, Haileyesus	Fribourg
Deplazes, Gaudenz	Wettingen	Nigg, Valentin	Bern
Dubois, Nathalie	Zurich	Normand, Raphäel	Geneva
Douillet, Guilhem Amin	Bern	Peyrotty, Giovan	Geneva
De Kaenel, Eric	Mont-sur- Rolle	Picotti, Vincenzo	Zurich
El Kateb, Akram	Fribourg	Remsayer, Karl	Bern
Fabbri, Stefano	Bern	Rime, Valentin	Fribourg
Farley, Nicholas	Geneva	Samankassou, Elias	Geneva
Feenstra, Eline	Fribourg	Schaegis, Jean-Charles	Fribourg
Fentimen, Robin	Fribourg	Schlunegger, Fritz	Bern
Föllmi, Karl	Lausanne	Sharma, Nikhil	Lausanne
Foubert, Anneleen	Fribourg	Spezzaferri, Silvia	Fribourg
Gardien, Véronique	Lyon	Stainbank, Stephanie	Fribourg
Garefalaki, Philippos	Bern	Strasser, André	Fribourg
Geister, Jörn	Bern	Wetzel, Andreas	Basel
Gegg, Lucas	Bern	Winkler, Wilfried	Zurich
Guerra, Lucia	Geneva	Wirth, Stefanie	Neuchâtel

Evaluation of carbonate reservoirs in Upper Jurassic deposits (Jura Mountains, France) using electrical resistivity tomography

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The Canton of Geneva (Switzerland) is exploring potential reservoirs for geothermal energy in the Great Geneva Basin. Based on current first results, the Upper Jurassic deposits appear to exhibit promising reservoir qualities, specifically the *Complexe récifal* and *Calcaire de Tabalcon* (Meyer, 2000). The outcrop studied in Prapont (Jura Mountains, France) includes the uppermost part of *Calcaire de Tabalcon* and two subunits of the *Complexe récifal*, the *Calcaires récifaux* topped with *Calcaire de Landaize*. The study aims to characterize lateral variations of the reservoir properties and to highlight reservoir size using 2D electrical resistivity tomography (ERT).

An empiric law known as Archie's law is used to correlate the properties of the rock (porosity (P), cementation factor (m)) and the resistivity measurement (resistivity of the formation (Rrock), resistivity of the pore water (Rwater)), ordered in the so-called Formation factor F : $F = Rrock / Rwater = P^{-m}$.

The Prapont outcrop is on the side of a hill and the top is flat and covered by vegetation. Fieldwork was carried out to assess lateral variations and for sampling. Petrography and image analysis were performed on thin sections for determination of facies, macroporosity and pore size. Permeability was measured on plugs with a compressed air permeameter and porosity was measured using acetone and mercury to determine the volume of the matrix and the total volume of the plug, respectively. We used these data to predict the resistivity of the samples based on the formation factor equation (resistivity prediction calculation).
2D ERT was acquired on a line of 48 electrodes with an interspace of 8 m (total 376 m) with Syscal Instrument. It begins northwest of the hill, starts down the hill next to a river, goes up through the outcrop for 80 m and continues in the vegetated top. After filtering the data, Res2Dinv (Geotomo software) were used for inversion. Forward modeling was carried out with DC2DInvRes software (Günther, 2004).

Ten facies types were recognized in the field and in thin sections. Accordingly to Fookes (1995), the base of section consists of a subtidal facies, followed by a first reef interval (20 m), overlaid by an interreef interval including sand shoals, a hardground and then a second reef stage exhibiting a wavy upper boundary. The top of the sequence consists of lagoonal facies, beach deposits and supratidal deposits. The two reef intervals are divided into three subfacies types: coral boundstones (in median, 1.2% of porosity and 0.12 mD), reef facies (non boundstone; 13.3% and 3.6 mD) and reef flank facies (17.2% and 3.8 mD).

Based on the resistivity prediction calculation, two facies stand out: coral boundstones and beach deposit grainstones were more resistive than the other facies. The median is higher by two orders of magnitude. The median for each other facies falls within less than one order of magnitude.

ERT was coupled with forward modeling to derive a resistivity model of the subsurface. The inversion of the data shows (1) several resistive rounded patches on the northwest side of the line model and (2) a horizontal resistive anomaly with internal resistive variations in the subsurface of southeastern side. This horizontal anomaly can be divided in one resistive bar and, underneath, some small resistive anomalies. Forward modeling shows that this combination fits the pattern recorded in the ERT. Below the horizontal anomaly, the model becomes uncertain. Several configurations tested for the inversion lead to different models. According to forward modeling, no high resistive and large patch should be expected in the first reefal interval. However, the low resolution calls for caution in interpreting this area.

The model of resistivity is interpreted via resistivity prediction calculation. The subtidal facies was not clearly identified in the ERT results, likely because of the position at the end of the measured line. The first reefal interval is detected with the first anomaly type (1) related to coral boundstones found in the two reef intervals. This interval is not pronounced for the whole profile, the resolution is too low on the southeastern side of the profile. The intereef interval is not expressed and the two reefal intervals merged at the northwest side with ERT. However, related to anomaly (2) some coral boundstones are found southeast around 10 m below the surface. The lagoonal facies is fairly homogenous northwest but disappears in the anomaly at southeast. The horizontal resistive layer from anomaly (2) is related to the continuous layer of beach deposit grainstone topping the series.

From a reservoir perspective, the coral boundstones itself is not considered as reservoir but it is wrapped by reef facies and reef flank facies which exhibit good reservoir properties. Coral boundstones are good indicators in ERT of the presence of reservoirs. The second anomaly type expresses a continuous barrier within in the rock and highlights an upper aquiclude of the reservoir.

The next step is to apply the same methodology in other areas (e.g., in southeastern Germany) where similar deposits occur and geothermal energy is currently exploited to test the reliability of the methods for prospection at a wider scale.

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Structure and tectono-stratigraphic evolution of the Mamfe sedimentary basin, SW Cameroon

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The Mamfe sedimentary basin, located in the southwest region of Cameroon, is a rifting basin formed in response to the Gondwana break-up and subsequent separation of the later South American and African continents (Olade, 1975). It covers an area as large as 2400 km², extending in an NW-SE trending trough with a length of 130 km and width of 60 km. The basin constitutes a narrow extension of the lower part of Benue trough where important oil fields have been discovered (Adebayo et al., 2016).

Numerous geological studies have been carried out on various aspects including geological mapping of the basin, audiomagnetotellurics, aeromagnetic survey, lithostratigraphy, biostratigraphy, geochemistry and general geology (Eseme et al., 2002; Eyong, 2003; Ajonina, 2016). The sedimentary sequence is generally interpreted to be exclusively of continental origin and the lateral equivalent of the fluvio-lacustrine sediments known as Asu River Group of neighbouring south-eastern Nigerian sedimentary basins. However, the extended distribution of salt springs and carbonates in this basin suggests that these deposits were not exclusively continental (Njoh et al., 2015). Further, there is no agreement on the nomenclature used and on the overall tectono-stratigraphy of the basin. The age of deposits published in the literature ranges from early to late Cretaceous, mostly because current dating does not cover the whole basin. The nature of rocks of Mamfe sedimentary basin, in particular if deposits were exclusively continental, remains unexplored, as does the depositional and tectonic history. A better knowledge of the basin is also a key for better evaluation of the source rocks and reservoir potential.

The present study addresses some of these issues, in particular, the reconstruction of the depositional environment using sedimentology along with geochemical analyses of major, trace and rare earth elements. The study further intends to evaluate the hydrocarbon potential based on organic geochemistry including Rock-Eval. Preliminary results show that the Mamfe sedimentary rocks consist of wacke, arkose, subarkose and litharenite. The geochemical data and, specifically a negative anomaly of europium suggest that sediments derived mainly from igneous felsic rocks followed by an intermediate source with a small amount of quartzose sediment of continent provenance according to the scheme of Roser and Korsch (1988). Furthermore, sediments are interpreted to derive mainly from an active and passive margin and less from continental arc island based on Roser and Korsch (1986) and Bhatia and Crook (1986). The values of the weathering parameters CIA (Chemical Index of Alteration) and PIA (Plagioclase Index of Alteration) suggest low to moderate weathering,

which reflect arid condition in the source area. The arid conditions are confirmed by bivariate paleoclimatic plots using the scheme of Sutter and Dutta (1986). The ratios of rare earth and trace elements such as U/Th, Ni/Co, V/Cr and V/Sc indicate that sediment were deposited predominantly under oxic conditions with the influence of intermittent anoxic events. The Rock-Eval data reveal that the Mamfe sedimentary basin exhibits excellent hydrocarbon source rocks, namely oil prone type I, oil prone type II and gas prone type III. The occurrence of sulfur-bearing minerals (barite, authigenic pyrite), phosphate-bearing minerals (fluorite, apatite) and oncolite suggest a mixed source originating from both lacustrine and marine depositional settings.

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Biogenicity and Fossilization Potential of Polygonal Sedimentary Structures in Evaporitic Environments

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Microbially influenced sedimentary structures (MISS) emerge from the interaction between extracellular polymeric substance (EPS) and the sedimentary dynamics of the overlying water body. MISS is essential to the search for the earliest signs of life, on Earth and on Mars. Exploration on Mars is being done by cameras equipped rovers that do not have the resolution for identifying single microfossils. They could though easily spot a cm-size morphological biosignature.

Here, we define a new type of MISS named microbial polygon. It is described as a polygonal structure with a domed rim and commonly occurs in evaporitic environments. Their biogenicity can easily be overseen due to their similarity to abiotic shrinkage cracks, which form as a result of desiccation. Their morphology and mechanism of formation have been studied in two modern Qatari sabkhas (i.e., the Dohat Faishakh and the Khor al Adaid) in order to determine key features of microbial polygons. We have also evaluated the lithified polygonal structures found in Al-Ruwais, Qatar.

Our sedimentological, mineralogical, radiocarbon and geochemical analysis allows one to conclude that these polygonal structures result from microbe-mineral interactions causing stabilization of detrital minerals and precipitation of a micrite. The overall geometry of the structure is determined by the presence of EPS. The key features not found in regular desiccation cracks are rounded and doming rims along the outside, folded laminae as well as the presence of microscale baselaps within the rim area of the mat. Finally, through the study of an approximately 2800 yBP old outcrop in Al-Ruwais, we can show that some key features of the microbial polygons are present and preserved. In other words the microbial mats can survive diagenesis and produce a mineral fossil structure that can potentially be preserved for billions of years.

Sedimentary organic matter and its clay mineral associations in the South China Sea: A sediment trap study

Blattmann, T.*[(1)], Zhang, Y.[(2)], Zhao, Y.[(2)], Wen, K.[(2)], Lin, S.[(2)], Li, J.[(2)], Haghipour, N.[(1)], Wacker, L.[(1)], Plötze, M.[(1)], Liu, Z.[(2)] and Eglinton, T.[(1)]

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Sediment traps deployed in the South China Sea (SCS) collected a one-year time series of sinking particles used to study sediment provenance and organic matter (OM)-mineral interactions. The traps were deployed at 500-4000 meters water depth across three mooring sites. The SCS, one of the largest marginal seas bordering the Pacific Ocean, is influenced by pronounced lateral advection and sediment dispersal into the deep ocean (Zhang et al., 2014). It is also characterized by strong spatial gradients in phyllosilicate mineralogy that lends itself well to constraining sediment provenance based on relative abundances of smectite, kaolinite, chlorite, and illite (Liu et al., 2010).

The stable and radiocarbon isotopic composition of bulk OM from the time series samples provides insight into the provenance and type of OM discharged from land and carried into the deep ocean. Measurements of mineral-specific surface area, cation exchange capacity, and quantitative mineralogical composition provide new evidence into the stabilization effect of different phyllsilicates on OM in the ocean. The radiocarbon isotopic composition exhibits significant variability over the time series, reflecting changes in the source material. During time windows with elevated sediment flux, radiocarbon concentrations of bulk OM are lower, indicating the export of aged terrestrial OM, which reflects contributions of bedrock-derived OM emanating from Taiwan (Hilton et al., 2011). The SCS sediments reveal trends in OM-mineral associations as a function of phyllosilicate mineralogy with smectite and illite/chlorite end members showing strongly contrasting behavior.

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Tracing Past Ecosystem Modification in the Pacific Islands of Vanuatu

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It is widely recognized that our species is causing irreversible ecological impacts through intensive land use and primary resources exploitation. Although these activities are deemed necessary to feed the increasing human population, major attention is drawn to the consequences of such activities in terms of climate change and biodiversity loss. Reconstructing past human activities can help retrieving information on the environmental responses to different rates and degrees of change. These responses are likely to be reflected in the present and in future scenarios.

Small islands, where resources are scarce and space is by definition limited, are paradigmatic cases of anthropogenic impact on ecosystems. First successful settlements in Remote Oceanic Islands came along with major landscape modifications (e.g. land clearance, introduction of allochthonous species) which allowed long-term demographic success by the establishment of extensive agriculture. However, not all the pacific islands testified a successful human establishment. Which factors led to the failure or the establishment of a sustainable human-ecosystems interaction remains an open question. Through the multi-proxy analysis of lakes and swamps sediment cores, we can trace past human arrival and identify consequent landscape modifications in the Pacific archipelago of Vanuatu. We use an integrated approach, combining geochemical tools based on biomarkers (fossil molecules of known origin) with traditional sedimentological, archaeological, and paleoecological methods.

Here we present the preliminary results from the data collected during the last field campaign in the archipelago of Vanuatu (June-August 2017).

Tracing past anthropogenic impacts on these islands not only can provide information on the environmental changes that occurred with human arrival, but can also contribute to identify key factors related to the ecological resilience and the adaptive capacity of socio-ecological systems in changing environments.

Storm deposits in Taiwan

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Many documented offshore sedimentary successions contain anecdotic layers interpreted as storm deposits (tempestites). Such storm signatures generally consist of incidental sandy beds in otherwise muddy, fine-grained planar beds. They are structured as low angle lamination forming meter-scale bulges with variable aggradation direction, the so-called "hummocky-cross-stratifications" (HCS), underlain by low angle erosional swales.

The general interpretation is that episodic, large storm-waves would rework the shelf, whereby sediment from the shore zone is transported to and deposited at deeper offshore areas.
Here, we document a variety of possible candidates for tempestite beds from the Tertiary successions of Taiwan. These examples are used for a discussion on the shore to offshore signature of such events and the influence of basin geometry on tides vs. wave amplitudes.

Taiwan is located on the tropical typhoon path and yearly subjected to such events. Whereas the eastern shore is open to the deep ocean, the western coast looks out onto the "Taiwan strait", a narrow channel (<200 km width, <100 m depth) on the Chinese continental shelf (Figure 2). This configuration provides two end members in terms of hydrodynamic sedimentation processes:
-On the West, the narrow strait is dominated by strong tidal currents, whereas the amplitude of storm-waves is limited by the size of the channel.
-On the East, storm-waves acquire much greater dimensions, but tides are limited in intensity.

Thus, tempestite beds may be better developed and preserved on the eastern coast, whereas the western strait would be dominated by tidal currents with intercalated small storm beds with low preservation potential.

The Tertiary sedimentary outcrops in Taiwan seem to reflect the influence of basin shape. On the Western side, the Mio-Pliocene succession has signature of storm-waves seems less developed. Anecdotic sandy beds are common, but HCS structures are only scarce. Instead, horizons containing wood and terrestrial fragments are common, possibly reflecting flood outbursts rather than storm-waves. The transition to tide-dominated formations occurs without clear evidences of large storm-waves.
On the Eastern part however, the succession (Eocene to Early-Miocene) contains well-developed HCS structures in offshore conditions (Figure 1). The transition into tidal beds

further exhibits layers made up of coarse, gravelly beds, and large HCS structures, suggesting a stronger storm-wave influence, with little reworking from tides (Figure 3).

The Taiwan example records the transition from an open shelf to a strait, and suggests that the geometry of a basin has a strong influence on the depth at which tidal and storm deposits will occur, both boundaries crossing each other's in some cases. Such interplay between the evolution of an orogen and the sedimentary record in its foreland basin can also have been in play in the Swiss molasse basin.

Figure 1. Typical deposits interpreted as tempestites including hummocky cross-stratification in Eocene beds from the NE coast. A) General view of two hummocks, B) zoom in lamination patterns. Pen for scale in both images.

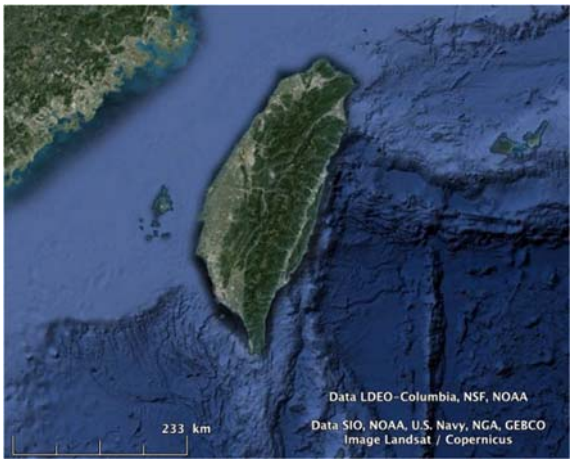

Figure 2. Taiwan Island, with bathymetry showing the shelf, strait on the West side, and Deep Ocean to the East.

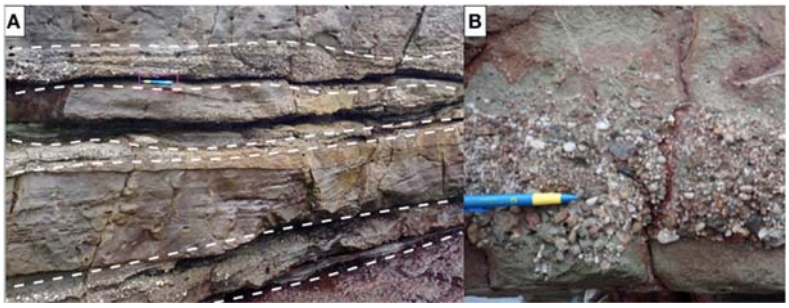

Figure 3. Gravel beds in tidal sediments may be the shoreface record of large storms. A) Stratified gravel beds B) zoom showing transition from gravel-supported to sand-supported and fining up sequence.

Distribution of benthic foraminifera in the transitional environment of the Djerba lagoon (Tunisia): An ecological overview

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The eastern edge of the Djerba Island represents an important tourist pole. The Djerba lagoon is well known by the local population and by tourists but has never been investigated before. In July 2014, surface sediment and seawater samples were collected in this lagoon to measure grain size, organic matter content and living foraminiferal assemblages to describe its environmental conditions. Seawater samples were collected to measure the concentration of 17 chemical elements by ICP-OES. Based on the concentration of major chemical elements, it is observed that the salinity gradient along the studied transect is well pronounced. In addition, salinity clearly affects seagrass distribution and creates different environmental conditions inside the Djerba lagoon. Biotic and abiotic parameters reflect a transitional environment from hypersaline to normal marine conditions. Living benthic foraminifera show an adaptation to changing conditions within the different parts of the lagoon. Species richness and specimen density of foraminifera increase significantly from the inner to the outer parts of the Djerba lagoon. Abundances of *Ammonia parkinsonian* clearly indicate a transitional environment influenced by seawater. Some genera/species correlate with hypersaline waters such as *Ammonia* spp. and *Haynesina depressula*, whilst *Brizalina striatula* characterizes the parts of the lagoon colonized by seagrass. Epifaunal species, such as *Rosalina vilardeboana* and *Amphistegina* spp. colonize hard substrata present at the transition between the lagoon and the open sea.

Paleoclimate reconstructions in the Tropical South Pacific using *Porites* microatolls from French Polynesia

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Porites microatolls are massive corals restricted in their vertical growth by the mean spring low tide water level allowing them to be used as records of sea surface height through time (e.g. Woodroffe et al., 2012). This project comes out of the recently published collaborative study of Hallman et al. (2018) that used a compilation of microatolls from around the French Polynesian Islands to produce a cm-scale sea level curve for the Mid to Late Holocene. For the present study, a few of the largest microatolls (combined with other site specific considerations) used by Hallman *et al.* (2018) were selected to reconstruct the paleotemperatures for key periods in this time span. The approach of combining simultaneous cm-scale sea level record and corresponding climate will be a first.

Firstly we are refining the methodology for reconstructing sea-surface temperatures using the modern (growing) outer rim of *Porites* microatolls and comparing the geochemical tracers within the skeleton with local instrumental data and regional satellite SST data. For context, in coral paleoclimatology the focus has almost entirely been on the vertical growth of massive dome shaped *Porites*. Concerns over the use of microatolls for paleoclimatology come from the fact they may grow in harsher and more variable environments and could therefore presumed to be less reliable. McGregor et al. (2011) demonstrated that with careful choice of well-flushed sites, microatolls show potential for reliable and reproducible paleoclimate reconstructions. Growth rates and $\delta^{18}O$ to temperature relationships have been shown to be similar to those found in massive dome *Porites*.

Using the modern microatoll samples we tested Sr/Ca and $\delta^{18}O$ which produces a good fit between the proxy and instrumental temperature records (MétéoFrance instrumental and AVHRR OISST satellite data). This has calibrated the site specific proxy to temperature relationship and confirmed that the method is suitable to apply to the fossil record.
Details in the Mg/Ca and Ba/Ca ratios show interesting insights into coral growth however do not appear to affect the temperature reconstructions.

With the knowledge learnt and the site/region specific modern calibration assessment of the different paleothermometers, the second and parallel part of the project is to reconstruct the paleotemperatures using the fossil microatolls. The objective is currently set on a well preserved (99.7% aragonite) roughly century and a half long slab from a microatoll that is U/Th dated to 5.594 ±0.047 kyr BP from the island of Tikehau. This period is of importance as it contains limited datasets for the Central Pacific region. The goal is to produce a monthly resolution climate reconstruction with current focus on detailed sampling tracks (considering primary growth axes and skeleton preservation) and producing the Sr/Ca, Mg/Ca and the $\delta^{18}O$ records. Following this the other period of interest is centred around 3 kyr BP as a pre-

industrial record of paleoenvironmental conditions found in Tropical South Pacific which combines with the period of higher than present sea-level from French Polynesia (see Hallmann et al., 2018).

The study presented here shows the potential of obtaining reliable paleoenvironmental reconstructions from *Porites* microatolls and is currently taking that one step further by assessing the most recently proposed methods proposed by the community. With the knowledge carried forward we are reconstructing Tropical South Pacific paleoclimate during key periods at monthly resolution.

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Paleoenvironmental reconstruction of the cold-water coral Melilla Mounds (Eastern Alboran Sea)

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This study presents the results of the multi-proxy characterization of the 5 m long cold-water coral bearing core MD13-3455 retrieved at 319 m water depth from Brittlestar Ridge I during the MD194 EuroFLEETS Gateway Expedition in 2013. The Brittlestar Ridge I is part of the larger Melilla Mound Field, a cold-water coral (CWC) carbonate mound province extending for over 500 km^2 in the Eastern Alboran Sea (Western Mediterranean Sea). Situated near the summit of the ridge, core MD13-3455 is well-located to provide additional information about the paleoenvironmental setting in which the CWC ecosystem developed. So far, CWC bearing sediments from Brittlestar Ridge I have proven to be valuable records for paleo-environmental changes since the onset of the last deglaciation (Fink et al. 2013, Stalder et al., 2015).

The combination of U/Th dating on corals, particle size analysis, Total Organic Carbon (TOC) analysis, Computed Tomography (CT) imaging, XRD/XRF data and the determination of benthic foraminiferal assemblages provides a solid base to decipher major and minor environmental changes in the region. The core presents a succession of units rich in CWC fragments (mainly *Lophelia pertusa*) embedded in a siliciclastic matrix. An extended unit characterized by the dominance of bryozoans is found at the base of the core, whilst the top 20 cm are marked by a change in CWC species, from *Lophelia pertusa* to *Madrepora oculata*. The XRD investigations show that the CWCs and bryozoans are embedded in a matrix consisting of approximately 60 wt.% carbonate phases (i.e. aragonite, LMC, HMC and dolomite) and 40 wt.% siliciclastic minerals (i.e. quartz, feldspars and clay minerals). The U/Th dating on the coral skeletons suggest an age of approximately 2.4 ka for the top of the core and 14.8 ka at its base. In line with other findings of CWC ages in the Alboran Sea, CWCs observed in core MD13-3455 flourished during the Bølling-Allerød warm period.

Benthic foraminiferal assemblages in the bryozoan-dominated part are different from those observed in the coral-dominated sediment above. *Discanomalina coronata*, a benthic foraminiferal species, is more abundant in the bryozoan build-up compared to the coral-dominated sediments. In the coral-rich framework, high abundances of buliminids may represent periods of higher nutrient supply. Overall, infaunal species are more abundant in the coral-supported sediments than in the bryozoan-supported sediments where the abundance of epifaunal foraminifera is noticeably high. The siliciclastic components in the bryozoan-dominated sediments are finer than in the coral-dominated sediments. Similarly, the matrix of the *Madrepora oculata*-dominated sediments in the top 20 cm of the core seems to be finer than the *Lophelia pertusa*-dominated sediments that make up most of the core.

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Isotope stratigraphy and organic geochemistry of platform margin and slope across the Pliensbachian-Toarcian boundary and their relationships with platform drowning and oceanic anoxia

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The Toarcian Oceanic Anoxic Event (at ca. 183 Ma) of the Early Jurassic is one of 4 major global oceanic anoxic events of the Mesozoic and has been extensively studied since its definition by Jenkyns (1988). Similar to other oceanic anoxic events that have been reported from the Cretaceous, it is characterized by a global, typical pattern of carbon isotope excursions reported from carbonates, organic matter and biomarkers: A 5-8 ‰ shift in negative carbon isotopes followed by a positive isotope excursion (Jenkyns, 2010). Some hundreds of thousands of years earlier, at the Pliensbachian-Toarcian stage boundary, a similar pattern of a minor (~1-2 ‰) negative isotope excursion, followed by a positive shift can be observed in carbonates, organic matter and fossil wood (e.g. Hesselbo et al., 2007; Jenkyns et al., 2002). This “minor” perturbation of the carbon cycle has however not been well researched so far (Hesselbo et al., 2007). One potential explanation is the wide occurrence of gaps and condensations across the Pliensbachian-Toarcian boundary, preventing a detailed analysis. In the course of this Master project, a Jurassic carbonate platform and its well- dated, continuous slope succession, both located in the Southern Alps of Northern Italy, will be investigated so as to shed light on the causes of this “small” perturbation and its relation to the subsequent Toarcian Oceanic Anoxic Event. The main method will be the establishment of a high-resolution $\delta^{13}C_{carb}$ and $\delta^{18}O$ isotopic curve, which enables the correlation of three selected platform successions with a slope succession, whose chronostratigraphy is well known. This will be supported by further analysis including the measurement of organic carbon isotopes ($\delta^{13}C_{org}$), redox sensitive trace elements, biomarker analysis, vitrinite reflectance, microfacies analysis and numerical modelling approaches. First results of vitrinite reflectance analyses revealed that the samples of the slope succession are thermally immature, which means that biomarkers should still be preserved and can be analysed. Furthermore, the occurrence of *Carinolithus cantaluppii* in one of the platform sections could be approximately assigned to the very early Toarcian, corresponding to the maximum flooding, where the minor negative shift of carbon isotopes is expected. Based on the stratigraphic description, this maximum transgression could already be correlated over the different sampled platform successions.

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Controls of the Burdigalian transgression recorded in the Molasse basin

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The North Alpine foreland basin deposits reveal crucial information about basin-underfilled and -overfilled conditions and the controls on the basin's geometry through time. Here, we focus on the early Burdigalian, c. 300 m-thick shallow marine sequence of the Upper Marine Molasse group (OMM) exposed in the Sense section, Western Switzerland (Figure 1). These sediments were deposited between c. 20 and 19 Ma (Strunck, 2001) when the Aar Massif in the adjacent Alps started to rise (Herwegh et al., 2017). We aim at unravelling links between tectonics and sedimentation, for which we use the sedimentary fabric exposed in this section as basis.

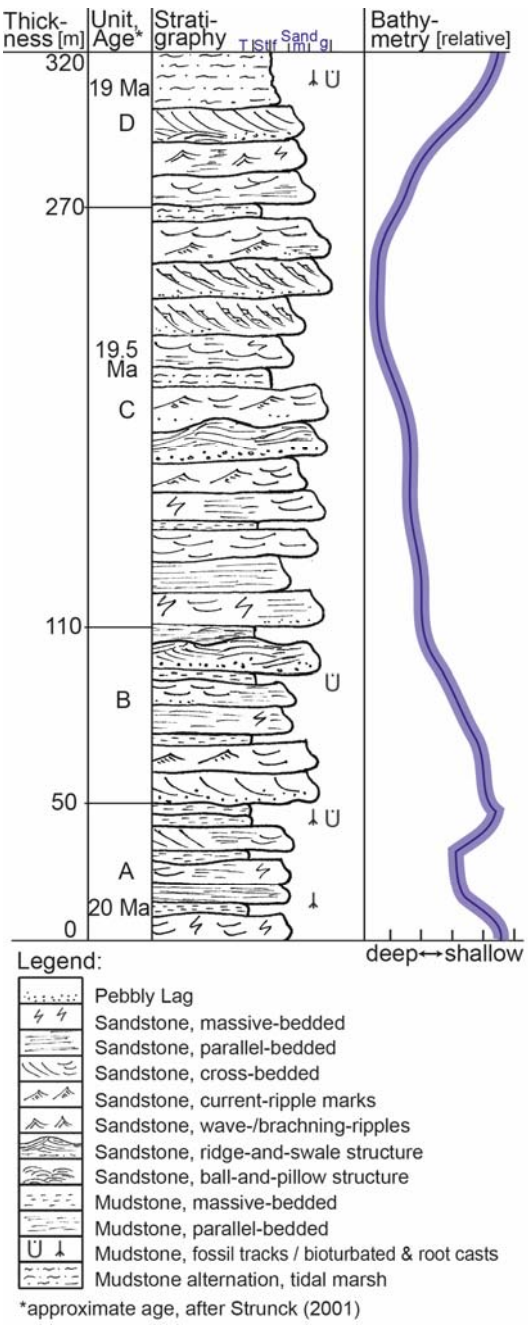

Figure 1. Sketch of the Sense

We group the Sense deposits into four stratigraphic packages (units A to D). The sandstone beds of unit A, which is 50 m thick, have both planar and erosive basal contacts. They are up to 4 m thick and display either a massive fabric or low-angle, m-thick angular cross-beds. Ripple marks and pebbly-lags are visible in places. Individual dm-thick sandstone beds with parallel laminations also occur. The interbedded mudstones are massive-bedded or parallel-laminated. They contain dm-long root-casts and display a yellow-mottled colour. We interpret the unit A deposits to record a terrestrial-, or near-coastal environment, where small rivers or estuaries in a swampy area resulted in the deposition of cross-bedded sandstone beds. Here, the presence of a coast is inferred from sandstone beds with parallel laminations. Massive-bedded sandstones could then represent washover-fans, and the mudstones were most likely deposited either on a fluvial floodplain or a coastal mudflat.

Unit B is 60 m thick. Embedded sandstones are 2-3 m thick and have both planar and erosive bases. They display m-scale cross-beds and fore-sets with well visible top- and bottom-sets. Embedded current-ripple marks, situated at the base of the cross-beds, are draped with a muddy layer. In places, the sandstones display dm-thick suites of

parallel laminations, which include lenses of <1 cm-thick ripple cross-beds. We also observe ridge-and-swale structures. The mudstone interbeds occur as tabular beds, display flaser-beddings and contain exichnias. We interpret unit B deposits as sediments of a coastal marine environment recording tidal- and wave-processes. Here, cross-beds and fore-sets together with top- and bottom-sets are assigned to a Gilbert delta environment. Wave activities in the upper- and lower-shoreface are inferred from the occurrence of parallel laminated sandstones and ridge-and-swale fabrics, respectively. In contrast, mud-drapes on top of cross-bedded sandstones and ripple marks, and flaser-beddings together with bioturbation suggest deposition in a tidal environment with channels and mudflats.

Unit C is 160 m thick and comprises sandstones, which are 5 to 10 m thick and occur as five lithotypes. Meter-thick massive- and cross-bedded sandstones with embedded mudstone drapes are associated with parallel laminated sandstones and ridge-and-swale structures in places. Towards the top of unit C, up to 5 m-thick sandstone beds are normally graded, follow upon an erosive base and display epsilon cross-beds. Interbedded mudstone beds occur as flaser- or lens-beddings. At the top of unit C, sandstone beds are up to 10 m thick and occur as planar- and cross-bedded units where fore-sets host mud-drapes. The deposits of unit C are considered to chronicle a shift from a tidal flat to a subtidal environment and thus record the deepest palaeobathymetric conditions within the Sense section. Here, coastal conditions are interpreted based on the ensemble of parallel laminated sandstone beds and ridge-and-swale structures. In contrast, a tidal flat environment is inferred from the occurrence of lens- and flaser-beddings together with cross-bedded sandstones with mudstone drapings. In this context, fining-upward sandstone beds with erosive bases and epsilon cross-beds possibly mark the deposits of meandering tidal channels. The sandstone beds at the top of unit C are allocated to a subtidal environment, where the construction of up to 10 m-thick cross-bedded sandstones with embedded mud-drapes require strong tidal currents in water depths of several tens of meters.

The uppermost unit D of the Sense section, which is 50 m thick, consists of an ensemble of m-thick cross-bedded, parallel laminated and massive-bedded sandstone beds at the base. Symmetrical branching-ripples, indicative of wave activities, and sigmoidal sandstone beds with fore- and bottom-sets, are also encountered. The overlying c. 20 m-thick mudstones, arranged as individual dm-thick packages, have a massive fabric, contain exichnias and display yellow-mottled colours in places. It thus appears that a regressive phase was initiated with the construction of unit D, where the related deposits are best placed in a wave-dominated environment; however, some shallow intertidal influence is still recorded. Towards the end of the sandstone suite, fore- and bottom-sets of a Gilbert-Delta type delta mark a change towards coastal conditions. The mudstones at the end of the sequence are then interpreted to represent deposits of a tidal flat, where marshy conditions prevailed.

The Burdigalian seaway thus points to a very dynamic basin where underfilled conditions prevailed. Such a situation can result from a rise in the eustatic sea level, a decrease in the sediment supply and an augmentation of subsidence rates. We propose that our reconstruction of relative sea level changes will constrain the temporal correlation with other OMM sections across the basin, and will allow us to extract the tectonic signal from the other possible driving forces.

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Lacustrine sedimentology and Late Quaternary paleoclimate in the Argentinean Central Andes

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We have initiated a multiproxy analysis of sedimentary cores retrieved in high altitude (> 4000 m a.s.l.) shallow lakes (< 2 m water depth) located in different environments from the Eastern Cordillera in order to identify major sedimentological changes and to define their relationship to regional climate. The Laguna Salada Grande (23°S/65°W) is a shallow and endorheic lake located at 4102 m a.s.l. at the Sierra de Aparzo, at the Argentinean Eastern Cordillera. In this region, precipitation is scarce (below 400 mm/year), mainly concentrated during the austral summer (December-March) and supplied by easterly winds of the South American Monsoon circulation system (Zhou and Lau, 1998). Paleoshorelines situated several meters above the present lake level indicate the occurrence of deeper paleolake conditions. Analyses (ongoing) of sedimentary cores and outcrops include: petrophysical properties (magnetic susceptibility and grain size analyses), carbon and nitrogen contents, XRF geochemistry along with a radiocarbon chronology. Preliminary results revealed the deposition of different facies: a) banded and laminated organic dark sediments, with carbonates; b) finely laminated white, light grey and ochre sediments; d) massive inorganic green muds; and d) massive consolidated green muds. These facies indicate significant hydrological shifts in the lake system, with fluctuations between deep-lake conditions and the current playa-lake environment. The examination of laminated sections of the cores is as well analyzed to better understand the sedimentary and geochemical processes occurring within the lake with high resolution. Sedimentary features, such as the presence of organic rich sediments and tuff deposits, can be traced into exposed outcrops in erosion gullies and trenches around the lake, allowing the correlation between sedimentary sequences and the reconstruction of the past paleolake configuration. Despite its altitude, Laguna Salada Grande has not been glaciated during the Late Pleistocene permitting the comparison of its paleolimnological record with reconstructions of the cooling events obtained from glacial fluctuations at the Eastern Cordillera (e.g. Martini et al., 2017). Results from this research will also be compared with previous studies of high-altitude limnogeological records in Santa Victoria range (to the north of the study site) and Altiplano-Puna region (west and north of the study site, e.g. Plackzek et al., 2006), as well as the records from the Pampean Plain lowlands (towards the east of the study site; e.g. Piovano et al., 2009). The regional and large-scale analyses will supply significant information to better understand the past patterns of atmospheric circulation at middle latitudes of South America.

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Snapshots of Carbonate Diagenesis

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We present three case studies including fieldwork and experimental approaches, suggesting that many of the well-trodden paths in carbonate diagenesis research may in fact represent oversimplifications. The scale of our work ranges from the sub-millimetre (thin-section), outcrop (meters to hundreds of meters), to transform fault dimensions (many kilometres). The combination of detailed field studies with state-of-the art analytical work in the laboratory provides insight into fluid-mineral interaction and even evidence for anthropogenic influence on the morphology of recent carbonate cements in marine settings. We discuss how lag and lead patterns in aragonite diagenesis can be revealed by experimental work with petrographic change occurring prior to geochemical resetting during aragonite-to-calcite neomorphism. Finally, we explore an extreme case of carbonate diagenesis, commencing with Triassic early diagenetic dolomitization of a host rock, and ending with severe alteration in the context of a Neogene transform fault.

Lithological diversity within the Opalinus Clay of northern Switzerland: towards a subfacies classification scheme

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The Opalinus Clay, a mudstone formation, is particularly known in Switzerland as being the selected host rock for deep geological disposal of radioactive waste. In this context, small-scale facies variations and heterogeneity in rock properties are investigated. This late Toarcian to early Aalenian age sedimentary succession has been deposited in a storm-dominated, epicontinental sea characterized by relative shallow water depths. The formation has a thickness varying between 80 and 130 m and presents important lateral variations in the facies assemblages. This facies diversity is primary attributed to regional differences in depositional, paleo-environmental and diagenetic conditions.

Recently, the multi-proxy study (petrographic, petrophysical and geochemical analyses) of Opalinus Clay core sections demonstrated that high, intra-facies heterogeneity occurs at dm- to cm-scale. Hence, distinctive subfacies could be distinguished by parameters such as texture (grain size, bedding, fabric and colour), level of bioturbation, dominant mineralogy and occurrence of additional diagenetic features. Being developed on core material from the Mont Terri rock laboratory (Canton of Jura), this preliminary revised subfacies classification is currently tested on cores and outcrops from other locations.

Potential applications for such a subfacies classification scheme may include the prediction of various rock mechanical and petrophysical parameters that are strongly influenced by lithological and (micro)fabric variations, such as failure strength, micro-porosity or anisotropic diffusion. Within the present project, a special emphasis will be devoted to the development of an automatic pattern recognition tool based on the subfacies as smallest unit.

Tracking the Maoris: fecal sterols as tracers of changes in paleo-agropastoral activities around Lake Pupuke, North Island, New Zealand

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In New Zealand, the arrival of Polynesians around 800 years ago brought tremendous alterations in the landscape, including clearing of forests by burning and cultivations. These environmental changes have been well documented in the Southern Island, whereas only few studies exist for the Nothern Island. A key remaining question is, in which islands did the Polynesians first setlle?

Here we present initial results of the downcore fecal biomarker, coprostanol, in Lake Pupuke in the North Island of New Zealand. Tracking these biomarkers in the sediment record will help us unravel when Maoris started agropastoral activities in the area. These biomarker footprints will therefore also help us to further define the timing of the arrival of Polynesians in the North Island of New Zealand.

Growth dynamics of a Carboniferous carbonate platform: Record from Tianlin County, Guangxi Region (Southern China)

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The Carboniferous was a critical period in Earth's history with the Gondwana superglaciation and significant continental collisions linked to the assembly of Pangaea. These changes induced drastic climatic changes, high-frequency and high-amplitude sea-level fluctuations and influenced the evolution of biological communities (Wang et al. 2013). Currently, the Carboniferous is considered as a period of global recession in reef building subsequent to the Late Devonian extinction events (Webb 2002). Shallow-water coralliferous bioconstructions were overall small and scarce and corals played a minor role in their construction (Fagerstrom 1987; Enpu et al. 2012). However, in Southern China, a large Pennsylvanian coral reef was reported in Ziyun County, Guizhou (Zhang et al. 2010). In addition to this exceptional discovery, Carboniferous coral reefs have recently been discovered in two localities in Guangxi, Southern China, yet not studied in detail. To understand the occurrence of these coral reefs and constrain the factors controlling their growth, three sections located around Langping (Tianlin County, Guangxi, Southern China) have been measured and the selected samples analyzed using petrography and geochemistry (carbon and oxygen isotopes). Dating was based on strontium isotopes, in addition to fusulinid-based biostratigraphy indicating a Visean age.

The first section includes three small reefs (6 to 16 m high) built by branching colonial corals along with other benthic organisms. In this section, five Microfacies Types (MFT) were distinguished. The reef substrates and covers are composed of grainstone to rudstone and mudstone to wackestone layers, respectively, exhibiting high-diversity benthic organisms. This scheme is repeated for each small reef. The section measured in the second locality includes a large reef (50 m high) built by branching corals associated to other benthic organisms. The substrate consists of wackestone to grainstone layers rich in coated bioclasts. The reef core is dominated by framestone, alternating locally with thin mudstone, wackestone and packstone to grainstone levels, lacking corals. The cover is composed of coated bioclast grainstone layers. The third section ranges from Late Devonian to Early Permian in age. Facies are grouped in seven MFT, including oncoid grainstone, lithoclastic breccia, coated bioclast packstone to grainstone, skeletal grain packstone to wackestone, crinoid packstone to grainstone, mudstone and coral boundstone.

Based on petrographic analysis, the three sections allowed to reconstruct the paleoenvironments and constrain variations of the environmental conditions during the Carboniferous. In the first section, the vertical distribution of MFT highlights three main repeated cycles. Coral reefs were initiated upon hard substrates, in shallow-water environments. Then, sea level increases, allowing the growth of delicate branching colonial corals, in a moderate energy environment. And, finally, as shown by the composition of the

reef cover lithologies, the limiting factors of the reef growth were variations in water depth. Along the large coral reef section, the paleobathymetry is constrained using the distribution of red and green algae. First, the composition of the reef substrate indicates an initiation in a relatively shallow-water environment. Then, the absence of green algae in the lower part of the core reef is interpreted as indicative of a low- to moderate-energy environment, in the dysphotic zone, below the fair-weather wave base. However, the increase in green algal occurrence from the base to the top indicates a general decreasing trend in water depth. This global decrease is a limiting factor in reef growth. The thin intervals without corals indicate variations of environmental conditions during reef growth. The last section consists of redeposited sediments including large fragment of coral boundstones occurring in the lower part of the section (dated from the Mississippian) exhibiting corals upside down. The rate of autochthonous sediments was obviously low as indicated by sparse matrix. The well-preserved fossils (e.g., long crinoid stems) indicate a short transport from shallow-water to upper slope environments.

Because the study area is located within a stable passive margin, MFT variations are conceived as a response to sea-level fluctuations which ultimately drove the growth and the evolution of coral reefs. Thus, patch-reefs in the first section are limited in size by the shallow-water environment (limited accommodation space), making them sensitive to the small-scale sea-level fluctuations. The large coral reef in the second section is less affected by these fluctuations, but the general decreasing trend of sea level led ultimately to the demise of the reef growth. The large size of the reef and the limited influence of small-scale sea-level fluctuations confirm the environment interpreted as deeper than that of patch-reefs. Calciturbidites, interpreted as deposited in an upper slope environment, represent the deepest setting among those of the three sections.

Although the exposure do not allow for tracing the sedimentary bodies in the field, the spatial distribution of the three sections led to interpret the depositional setting as a low angle platform margin. Currently, the most common platform model for Carboniferous is that exhibiting high relief, steep slope margins (e.g., Cuera and Valdorria Platforms, Spain) where only small and scarce coral-bearing bioconstructions were reported. Thus, the low-angle platform margin recognized in Tianlin provides a novel type in current knowledge. The sedimentary record along the reconstructed platform, in particular the cyclic patterns and the size of coral reefs depending on the position on the platform, mirrors the glacio-eustatic sea-level fluctuations characteristic to the Carboniferous. Ongoing investigations including the study of other settings in Southern China and carbon and oxygen stable isotope geochemistry will provide additional data allowing to constrain further controlling factors such as the role of nutrients and oceanic circulation.

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Early dolomitization and dedolomitization of the Upper Jurassic limestones of the Geneva Basin (Switzerland and France)

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The Canton of Geneva (Switzerland) is currently exploring the opportunities for geothermal energy exploitation in the Geneva Basin (GB) sub-surface. In this context, a structural analysis of the basin associated with reservoir appraisal and rock-typing of reservoir bodies of potential interest were conducted. Diagenesis of carbonate rocks is known to affect the petrophysical properties of the host rock. Assessing the diagenetic history is thus essential when evaluating any reservoir exploitation project.

Horizons affected by dolomitization, the focus of the present study, are of particular interest because they proved to be productive in time-equivalent deposits currently exploited in Southern Germany and are suitable for geothermal energy production. The Upper Jurassic carbonate rocks of the GB (the *Calcaires Récifaux, Calcaires de Tabalcon* and *Calcaires de Landaize* Units) represent the best potential reservoirs. However, these units exhibit strong heterogeneities in terms of reservoir quality with the occurrence of highly porous sucrosic dolomitie intervals in the western part of the basin, becoming tighter to the south-east. Two study sites where the Upper Jurassic carbonates outcrop were selected at the surroundings of the GB: the Jura Mountains (north-western) and Salève Mountains (south-eastern). In addition, one core close to the prospected area was studied (Humilly-2 borehole).
The detailed study in each site focused on (1) assessing texture, fabrics, types and distribution of porosity using petrographical analyses and (2) constraining the paragenesis for each stratigraphic unit using geochemical analyses (O, C, Sr) prior to discussing the cause and effects of dolomitization.

Most of the initial porosity in the different units studied was filled through several stages of blocky calcite cementation during early burial diagenesis. Almost all units exhibit two stages of blocky cementation while the *Calcaires Récifaux* showed a third, incomplete, stage of blocky cementation with preservation of some intracrystalline macroporosity. Two types of dolomite were characterized: (1) fine to medium, euhedral to subhedral, replacive rhombs (D1) and (2) medium to coarse, planar-euhedral, mostly fabric-destructive “sucrosic” dolomite rhombs (D2). The detailed petrographic study showed that the D1 dolomite rhombs are characterized by cloudy cores followed by limpid rims indicating that the cores developed in precursors originally consisting of low-Mg calcite while the rims precipitated from solutions under-saturated in regards to low-Mg calcite. The carbon isotopic signatures are close to the isotopic composition of well-preserved Late Jurassic marine cements suggesting abiotic precipitation excluding the influence of organic matter, meteoric or mixed meteoric/marine water. The oxygen isotopic signatures of D1 dolomite exhibits a slight shift from Late Jurassic marine cements which are interpreted as a sign of precipitation from oxygen enriched fluid, likely evaporitic. This is consistent with previously published reflux type model of

dolomitization induced by high-frequency sea-level changes producing pulses of dolomitizing brines. The D2 sucrosic dolomite represents an advanced level of replacement that obliterated the original fabric leading to high intercrystalline porosity. This dolomitization is the results of shallow burial over-dolomitization after the depletion of sediment-sourced Mg and/or complete dissolution of remaining $CaCO_3$. Radiogenic strontium isotopes data are consistent with an early first stage of dolomitization followed by potential sucrosic dolomite development during burial.

Dedolomitization is observed at different order of magnitude by either: (1) an almost complete dissolution leading to the creation of secondary pore space or (2) a two-step calcitization driven by the infiltration of Ca-rich water leading to dissolution, formation of microvugs and then precipitation of calcite. Isotopic data showing depleted oxygen composition points toward the interaction with meteoric water initiating the dissolution of both early and sucrosic dolomites. This dedolomitization would have taken place during long-term emersion events or after the exhumation of the Upper Jurassic limestones.

The study presented here will help to understand the possible models of dolomitization that occurred in the GB and to provide insights into porosity and permeability distribution that will ultimately help in reservoir modeling, a crucial step for further potential exploitation.

High-resolution geochemical datasets from XRF core scanning enable detailed lithologic descriptions of long sediment sequences

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X-ray fluorescence (XRF) core scanning is a fast and non-destructive method to determine the geochemical composition of sediments. These advantages have facilitated the generation of high-resolution (sub-cm) geochemistry records of long sediment sequences (>100 m). Such long sequences entail new challenges such as detector drift, changing lithologies (and hence different matrix effects), and varying water content with sediment depth. If these are corrected for, XRF core scanning can provide a reliable and consistent record of high-resolution quantitative geochemical information, which can, for example, be used for palaeoenvironmental reconstructions.

We present a study of sediments from Lake Towuti (2.75°S, 121.5°E), one of the oldest and deepest lakes in Indonesia. Cores of the entire sediment infill have been recovered in the ICDP Towuti Drilling Project in 2015, including lacustrine sediments covering several glacial-interglacial cycles. We obtained XRF core scans of the Lake Towuti lacustrine sediments (~100 m) at 0.5 cm resolution. The measurements were corrected for systematic biases in the record (e.g. above-mentioned factors). We find high correlations between corrected XRF measurements of the wet core surface and discrete volumetric ICP-MS measurements for Mg, K, Ti, Cr, Fe (adj. $R^2 > 0.8$), Ca, Mn (adj. $R^2 > 0.75$), Al (adj. $R^2 > 0.5$), and significant correlations for Si, P, and Ni. Given that this compares homogenised volumetric samples with measurements performed on the wet core surface, deviations from an R^2 of 1 are not only related to measurement errors but can also be attributed to spatial inhomogeneities such as those originating from diagenetic mineral concretions. Based on these correlations, we converted XRF counts to quantitative element abundances (wt-%).

We used this quantitative XRF-generated dataset to give a detailed and objective description of the sediment sequence and its respective sedimentological units. To achieve this, we performed an end-member analysis, a method aimed at unmixing a data set into characteristic clusters of -in this case- elemental compositions. For each XRF measurement point, the calculated end-members provide information about the relative importance of different processes for the formation of the respective sediment. The analysis reveals seven distinct end-members, which are interpreted to represent climatic, diagenetic, and tectonic influences on the record. Amongst others, this enables to generate a high-resolution stratigraphic column of the sediment sequence based on the end-member scores. The combination of high-

resolution XRF core scanning, a thorough correction and calibration of the XRF measurements, and statistical tools such as end-member analysis thus allows to give an objective and quantitative description of lithologies in long sediment sequences beyond visual accounts.

Coralgal reefs in the Danakil depression (Northern Afar, Ethiopia)

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The Danakil Depression, located in the Northeastern part of Ethiopia, known as the Afar triangle, is a tectonic depression created by the rifting of the African, Somalian and Arabian plates. The Main Ethiopian rift (MER), the Red Sea rift and the Gulf of Aden rift propagate and converge to the center of the Afar triangle and create a tectonic triple junction. The Danakil depression is thought to be the subaerial continuation of the Red Sea rift. This is supported by the presence of extensional faults having the same direction (NE-SW) as the Red Sea rift axis. In the center of the basin, seismic data witness the presence of evaporitic sequences estimated to be more than 1000m thick, interlaid with marine marls. This, together with the presence of fringing coralgal reefs at the Western and Eastern margins of the basin, indicate several episodes of marine incursion and desiccation in the Danakil depression. The coralgal reefs are composed of at least two terraces dated at ~ 121ka-122ka for the youngest terrace and ~ 210ka-231ka for the oldest terrace. This suggests that the last two marine flooding episodes occurred during Marine Isotope Stages MIS5e and MIS7, respectively. After each of these marine incursions, the basin became hypersaline resulting in the deposition of salina evaporites. Microbialites and aragonite crusts are deposited between the coralgal reef units and the salina evaporites, witnessing their transitional nature. Locally, between MIS7 and MIS5 sediments, lacustrine sediments rich in crab fragments, gastropods shells and charophytes could witness the installment of temporary continental freshwater conditions.
The MIS5e coralgal reefs are patchy and present lower coral diversity compared to the MIS7 coral-algal reef, which is dominated by red algae and branching *Porites*. The development of a coralline algal terrace at MIS7 reef top indicates that the reef reached sea level. The aim of this PhD is to study in detail the two coralgal reef deposits and associated facies patterns to understand the environmental factors influencing their distinct development. This will help to reveal the detailed flooding history of the Danakil Depression.

Tsunami deposits surrounding perialpine lakes in Switzerland

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Tsunamis are not restricted to the marine realm: historical reports, multibeam bathymetric datasets, seismic-reflection surveys and numerical wave modelling reveal that devastating tsunamis occur also in lakes, for instance the perialpine lakes in Switzerland. These events have diverse trigger mechanisms such as earthquakes, rockfalls or spontaneous subaquatic mass movements displacing large amounts of water. For example, a tsunami with run-up heights exceeding 4 m is reported after an earthquake (Mw 5.9) in Lake Lucerne in 1601 AD. The earthquake triggered basin-wide sublacustrine mass-movements with a total volume of hundreds of million m^3 of downgoing sediments. This event resulted in local inundation over a distance of several 100 meters inland and caused even a few causalities. At Lake Geneva, a major rockfall led to the collapse of the Rhone delta in 536 AD causing a tsunami with a height of several meters.

This study focuses on the identification of onshore and near-shore tsunami deposits around major Swiss lakes based on sediment cores drilled along transects in coastal marshes. We investigate in which way lacustrine tsunami deposits differ from their marine counterparts and how terrestrial flood deposits can be differentiated from tsunami deposits. Thus, this study provides the foundation to confirm historic tsunami events and to extend the event catalogue to the prehistoric time period. The established tsunami chronology will be correlated with major mass-transport deposits observed in various lake basins. Moreover, we try to infer run-up height, inundation distance and flow regime based on event deposits. Last but not least, the information gained from tsunami deposits will serve to ground truth results yielded by numerical modelling.

The study presented here is part of an interdisciplinary project addressing the causes, controls, frequency of this to date underrated lacustrine tsunami hazard. The SNF Sinergia projects includes numerical modelling of tsunami propagation and inundation, quantifies the stability and threshold conditions on lateral lake-slopes and develops a holistic framework for probabilistic tsunami hazard assessment.

Optically stimulated luminescence dating of the Western Makran marine terraces (Iran)

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The western part of the Makran subduction zone (Iran) has not experienced a great megathrust earthquake in recent human history. Yet, the presence of uplifted marine terraces along the coast indicates that the margin is still tectonically active during at least the Quaternary.
To better assess the seismic hazard of the region, we have studied, mapped and dated the marine terraces along the Iranian coast in order to understand lateral uplift variations. Systematic stratigraphic logging of the terrace deposits revealed that the sequence is characteristic of a prograding beach overlying an erosive wave-ravinement surface.
The paleobeach deposits, which are good analogues of paleo zero altitude, were dated using optically stimulated luminescence dating (OSL). It was then possible to correlate the different terrace levels of the Makran to the latest sea-level highstands of the Quaternary. Our results exhibit east-west variations in surface uplift rates, also illustrated by lateral tilting of the terraces. Moreover, we detected a region of anomalously high uplift rate, where two MIS 3 terraces are emerged. In other subduction zones, high long-term uplift regions have been noted to coincide with boundaries of historic earthquake ruptures. This could bring some insight on the segmentation of the poorly known Makran subduction interface.

Triassic limestones from the Panthalassa Ocean: new insights on Hokkaido Island and Far East Russia

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In comparison with the well-known Tethyan domain, and despite of the amount of research already carried out, Upper Triassic limestones from the Panthalassa Ocean remain poorly known. However, these carbonates represent a unique opportunity to have a more accurate view of the Panthalassa Ocean during the Triassic. Two of the best areas tu study these carbonates are Hokkaido Island (north end of Japan) and Sikhote-Alin mountain range (Primorsky and Khabarovsk Kraïs, Far East Russia) where many different Triassic limestones outcrops are exposed. These two areas are part of the South—North continuity of Jurassic to Paleogene accretionary complexes, going from the Philippines to Sakhalin Island (Far East Russia). In Southern Japan and Philippines, the Jurassic and Cretaceous portions of these complexes are known to contain tropical Triassic mid-oceanic seamount carbonates of western Panthalassa affinity (Kiessling and Flügel, 2000; Chablais *et al*., 2010; Peybernes *et al*., 2016). For this reason, the aim of our research is to study in detail the Triassic limestones of Hokkaido and Sikhote-Alin mountain range, and to compare them with Triassic carbonates from other Asians accretionary complexes.

In Hokkaido Island, two major tectonic units have been accurately explored and extensively sampled: the Jurassic Oshima Belt (west Hokkaido), and the Cretaceous Sorachi-Yezo Belt (central Hokkaido). The same fieldwork approach has been applied to the Cretaceous Taukha Terrane (Sikhote-Alin, Far East Russia). Through a complete sedimentological, diagenetic and biostratigraphic study, these limestones allow us (1) to compare the depostional settings and biotic assemblages from Tethyan and Panthalassic domains, (2) to better understand the geodynamic evolution of central part of Hokkaido Island and (3) to propose a model of evolution of these carbonates from their deposit to their accretion.

The preliminary microfacies analysis indicates that very similar facies characterise all the sampled blocks occuring on different tectonic units either in Hokkaido or in Sikhote-Alin. Furthermore, the lithology and the aspect of these limestones, as well as their biological composition, are closely related to the Triassic limestones observed in the southern part of Japan (i.e., Sambosan Accretionary Complex; Chablais *et al*., 2010; Peybernes *et al*., 2016). The microfacies are dominated by peloidal packstones-grainstones with many microbial clasts and microproblematica. Oolitic grainstones and Megalodont patches are also very common. A few reef builders such as sponges or coral have also been observed, indicating that the carbonate system where not controled by a reef-barrier morphology.

Two new microfacies, never observed before in the Triassic limestones of Japan, have been found in Sorachi-Yezo Belt (central Hokkaido): (1) Stromatolitic/thrombolitic bindstone with fenestral fabric and (2) Bryozoans-Peloids-Echinoderms rudstone characterised by the lack of reef builders organisms. Thanks to the observation of Foraminifera from these facies, it

appears that some limestones blocks in Sorachi-Yezo Belt are of Permian and Jurassic ages. These blocks, defined previously as Triassic limestones (Sakagami and Sakai, 1979) are extremely important to highlight the mixing of different mid-oceanic carbonates in a unique accretionary complex (Sorachi-Yezo Belt) and then better understand their origin and the process linked to their setting up.

The diagenetic analysis, made on the best preserved limestone blocks, shows ten major events, from early marine diagenesis to accretion-related changes. These limestones underwent a continuous evolution, with no emersion, from an early cementation to a very low compaction imprint which is consistent for mid-oceanic limestones. Indeed, these limestones formed on a topographic high in the middle of ocean which is highly favorable to an early cementation, before burial. The low compaction imprint is linked to this particularity but also to the low sedimentation rate in the middle of ocean which leads to a relatively thin thickness of sediments above these limestones. The carbonates also record an event related to a partial dismantling of the system, marked by the presence of early breccias after shallow burial diagenesis. This episode is probably linked to the collapse of the system after drowning, due to the steep morphology of the substrate. Otherwise, as this event is not widespread, it could indicate a partial dismantling of the depositional system before the burial. This hypotesis could partly explain the specific mode of occurrence of these limestones with outcrops of very variable size and isolated from each other.

The Sorachi-Yezo Belt (central Hokkaido) is composed of Cretaceous accretionary complexes in the East, and of Cretaceous clastic basin sediments deposited on a Jurassic basement in the West. This last part is also marked by a metamorphic zone containing Triassic limestones: the Kamuikotan Zone. The origin of Kamuikotan is still a matter of debate especially because it is not in continuity with any other complex known in the southern part of Japan and also due to the lack of data from this region. This metamorphic area is today considered as identical to the eastern part of Sorachi-Yezo Belt, a Cretaceous accretionary complex, but subducted and then exhumed during the Neogene (Ueda, 2016). In-depht diagenetic and geochemical analyses of Triassic limestones from both the Kamuikotan Zone and the other accretionary complexes in Hokkaido, will allow us to get new data to better comprehend the origin of Kamuikotan Zone.

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Dynamics of the Danakil basin (northern Afar, Ethiopia): new insights in the development of the continent-ocean transition through field, well and seismic data analysis

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The Danakil basin is located in the northern apex of the Afar triangle, which is formed by the convergence of three rift systems: the Red Sea Rift, the Gulf of Aden Rift and the Main Ethiopian Rift, forming a triple junction. While the southern and central part of the Afar represent earlier phases of continental breakup, the Danakil depression constitute one of the few places on earth where incipient oceanic spreading is occurring on land. The Danakil basin is characterized by a topography below sea level, a thinning of the crust, voluminous quaternary effusive volcanism and thick (>1 km) sediment infill, constituted of clastic sediments, large amount of evaporites and reef carbonates deposited during several marine incursions in the depression during the Pleistocene. This setting is thought to represent the continent-ocean transition observed in ancient rift systems.

In order to investigate the rifting processes and the hypothesis of Bastow & Keir (2011) of a recent and rapid stretching of the plate, the understanding of the dynamics of the Danakil basin is crucial. Several mining companies drilled boreholes and conducted geophysical investigation surveys, including reflection seismic in the western part of the basin. Access to these data along with recent (Atnafu et al., 2015) and future field data offers new opportunities for academic research. The combination of field observation, well logging, core and seismic data analysis will allow to better constrain the stratigraphy and the structure of the basin. Based on these data, a new basin model will be produced, which will lead to a better understanding of its history and give insights into the marine flooding events, the tectonic movements and the kinematics of the lithospheric stretching.

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New possible age constrain on the deformation of the Swiss Neuchâtel Jura Mountains: linking kinematic modelling and Tertiary sedimentology

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The Jura is probably one of the most studied fold-and-thrust belts worldwide. Nevertheless, several interesting scientific questions remain unanswered, particularly about the timing of deformation. This study focuses on the Swiss Neuchâtel Jura Mountains and its neighboring French part on a section across Travers - Brévine - Morteau, where the Mesozoic cover is structurally uplifted. Detailed field mapping was conducted in order to constrain a near surface cross-section. Forward modelling was subsequently done in the software Move™ by Midland Valley. The goal of this modelling was to understand the observed surface structure in a kinematically and geometrically consistent forward model.

The proposed solution features a large-scale low-angle thrust fault, the Morteau thrust, which forms the first anticline in the north of the study area. Interestingly, this anticline also marks the northernmost limit of Tertiary marine sediments (Piquerez et al, 2011). It is therefore tempting to suggest that this nucleating anticline formed a physical barrier, which marked the northern coast of the sea associated with the Molasse Basin. North of this limit, terrestrial sediments, including coarse breccia, have been dated at 17 Ma (base of MN5), while marine conditions were still prevailing south of it at the same time (Kälin et al, 2001; Becker, 2003; Havran, 2011). Supported by our kinematic modelling and the sedimentary record, the question therefore arises whether this setting can be used to constrain the first deformation of the Jura Mountains around 17 Ma, which would be older than previously accepted. However, this is not in contradiction with younger ages based on sedimentological evidences in more external parts of the Jura as the deformation is a protracted development involving different parts of the belt at different times. The new possible age would challenge the view that the Jura Molasse is only a pre-deformational deposit.

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Carbonate precipitation during the Holocene in hot springs of the lake Afdera (Northern Afar, Ethiopia)

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During the African humid period (*ca.* 15 ka - 5ka BP), northern Africa was covered with vegetation and large freshwater lakes. Since then, a dry period has turned this green landscape into deserts, salt pans and hypersaline brines. With a salinity of 160g/L, the lake Afdera remains flooded with the help of scarce hot springs still active in one of the hottest and driest place on Earth: the Danakil depression. Structurally, the Danakil depression is a rift valley constituting the northern part of the Afar triangle where three rift systems - the Red Sea, the Gulf of Aden and the main Ethiopian rift - interact. The lake is caught between bifurcating NNW-SSE oriented segments of the Red Sea rift (Erta'ale, Tatali, and Alayta). These active rift segments led to the development of volcanic complexes associated with hot spring systems. Carbonate buildups found around lake Afdera are the result this hot spring activity during the Holocene.

According to a study on diatom communities on ancient lake Afdera terraces (Gasse et al., 1974, 1978), the lacustrine paleoshores were very alkaline during the period from 9.8ka to 7.8ka BP, most likely due to ion discharge through the hot springs. Today, the hot springs have a low HCO_3- concentration and monitoring reveals that the precipitation of calcite is currently inhibited. The present study questions the environmental conditions and controlling parameters of carbonate precipitation in this hot spring system following a 'source to rock' approach. The sedimentological characteristics of the precipitates (mapping and spatial distribution, sedimentary petrography, mineralogy, SEM) and the spring water chemistry (stable isotopes and elemental analyses) are presented here.

The hot springs are distributed along lacustrine paleoshorelines, and can be linked to paleo-lake level fluctuations. The porous and permeable spring deposits are exclusively composed of low-magnesium to pure calcite, along with manganese-rich crusts. The hot spring facies are characterized by laminated crusts, small to large shrubs, sparitic, micritic, peloidal and clotted microfabrics, with encrusted plant remains, gastropods, ostracods and diatoms. The wide variety of facies associated with different cement generations and calcite replacement reflects the dynamics of the spring system and early diagenetic alteration of the spring deposits.

Stable isotope analyses show a direct connection between the springs of the lake Afdera and the meteoric input from the highly elevated Ethiopian plateau on the western ridge of the depression. However, ICP-OES analyses reveal a higher concentration of major elements such

as Na, Cl, Ca, Mg and Si in the spring waters from Afdera in comparison with the springs measured on the Ethiopian plateau. This ion enrichment is associated to the subsurface pathway of the water through the sediment units filling the Danakil depression since the Miocene: a thick evaporitic sequence with halite, lacustrine carbonate and siliciclastic units interbedded with basalt flows.

Through the Holocene, the climate has changed in the Danakil depression. Consequently, the spring activity has evolved and occasionally led to the precipitation of a large panel of morphological fabrics. These results together with ongoing radiocarbon datings will provide a better understanding of climate control on carbonate precipitation.

The South Asian Monsoon and its concurrent oceanographic influences

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The South Asian Monsoon (SAM) constitutes one of the most dynamic climatic systems on earth and its initiation and development is still not resolved. The wind driven deposits, from International Ocean Discovery Program (IODP) Expedition 359, paleoceanographic site U1467; subsequently enable the dynamics of the SAM, starting from its initiation, to be constrained (Betzler et al. 2016A,B). This continuous 12.9 Ma record was retrieved from the Inner Sea of the Maldives and in conjunction with the other EXP 359 sites allows the development of the Maldives regional oceanographic setting and its influences on carbonate platform development to be assessed. Oceanographic properties can be reconstructed including changes in thermocline stratification and the establishment of the Oxygen Minimum Zone (OMZ). We have focused on the last 2 my and coupled planktonic foraminifera assemblage data, quantitative and qualitative, with multi-species geochemical plots ($\delta^{18}O$ and $\delta^{13}C$ stable isotopes and Mg/Ca) to determine changes in water mass properties and thermocline dynamics. Currently, our research focusses on Marine Isotope Stages (MIS) 11 – 12, sampled at a sub-millennial temporal scale from site U1467. There are multiple recognised analogues for our present interglacial; however, each is limited in its application. Thus, the future inclusion of MIS 1 and 5e high-resolution sample sets, in our analysis, will allow us to make the respective comparisons. Additionally, we have compiled an independently astronomically tuned, oxygen isotope stratigraphic record, from site U1467, of a single planktonic foraminifera species *Globigerinoides ruber* (white) s.s. Through this combination of foraminifera assemblage data and geochemical analyses, we hope to better understand how the SAM and its associated ocean currents have changed over the last 2 my.

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