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Programme and Abstracts

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PROGRAMME

09.00 - 09.30 Morning coffee and croissant

09:30 - 09:40 Opening

09:40 - 10:00 **Beccari, V.**, Adams, A., Angeloz, A., Basso, D., Caragnano, A., Del Piero, N., Dietsche, P., ymard, I., Farley, N., Fau, M., Foubert, A., Hallock, P., Lauper, B., Lehmann, A., Maillet, M., Negga, H., Ordonez, L., Peyrotty, G., Rime, V., Rüggeberg, A., Schoellhorn, I., Spezzaferri, S., Stainbank, S., Vimpere, L.: CUSO ESPP tropical marine ecology and sedimentology course, Maldives 2018: Preliminary results

10:00 - 10:20 **Douillet, G.A.**, Dietrich, P., Schlunegger, F.: Hummocky-cross-stratification formed by supercritical flows? Insights from tidal to fluviodeltaic successions (Nama and Karoo-Kalahari basins, Namibia)

10:20 - 10:40 **Lazarev, S.**, de Leeuw, A., Stoica, M., Mandic, O., Krijgsman, W.: Integrating fauna and sedimentary facies for better paleogeographic reconstruction: A case study from the semi-isolated Dacian Basin, Eastern Paratethys (Late Tortonian – Messinian)

10:40 - 11:40 Coffee/Tea and posters

11:40 - 12:00 **Wohlwend, S.**, Bernasconi, S.M., Deplazes, G.: A high-resolution C-isotope chemostratigraphy through the latest Toarcian to Early Aalenian units in northern Switzerland

12:00 - 12:20 **Bilobé, J.A.**, Feist-Burkhardt, S., Adatte, T., Eyong, J., Samankassou, E.: Tectono-stratigraphic evolution of the Mamfe Sedimentary Basin, southwestern Cameroon

12:20 - 14:00 Lunch and group picture

14:00 - 14:50 **KEYNOTE: Dubois, N.**, Ladd, N., Haas, M., Camperio, G., Lloren, R., Röthlin, R., Krentscher, C.: Tracking our ancestors legacy in lake sediments

14:50 - 15:10 **Makhloufi, Y.**, Châtelin, F., Davaud, E., Grosjean, P., Le Cotonnec, A., Moscariello, A., Samankassou, E.: Using UAV photogrammetry for high-resolution 3D digital outcrop and reservoir models: A case study in the Jura Mountains, France.

15:10 - 15:30 **Nigg, V.**, Wohlwend, S., Anselmetti, F.S.: Nearshore sediment stratigraphy from Lake Sils, Engadin: insights to lake-level fluctuations and tsunamogenic sublacustrine mass-movement processes

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

16:30 - 16:50 **Gegg, L.**, Buechi, M.W., Mueller, D., Preusser, F., Deplazes, G., Madritsch, H., Anselmetti, F.S.: The history of the overdeepened Lower Aare Valley: insights from scientific drilling and outcrop data

16:50 - 17:10 **Courtney-Mustaphi, C.J.**: Are colluvial soils on kopjes a potential geoarchive of palaeoenvironemtal change in semi-arid regions?

17:10 – 17:30 **Vasilyan, D.**, Lazarev, S., Sahakyan, L., Hovakimyan, H., Maul, L., Rugenstein, J.K.C.: Late Miocene – Pleistocene continental record of Armenia (Lesser Caucasus) and its paleogeographic implication.

17:30 - … ***Closure and apéro***

POSTERS

Angéloz, A., Weger, R.J., Eberli, G.P., Meyer, M., Samankassou, E.: Electrical resistivity and petrophysical parameters of Upper Jurassic carbonate platform deposits (Jura Mountains, France)

Areias de Oliveira, C., Valle, L.G.R., Barbosa, C.F., Vaconcelos, C., Ariztegui, D.: Sedimentological variability and carbonate precipitation on two hypersaline lagoons of the Brazilian coast - Preliminary results

Bruni, E.T., Ott, R., Picotti, V., Gallen, S., Haghipour, N., Wegmann, K.: Origin and late Quaternary emplacement of the unique fans in the Klados River catchment, Crete, Greece

Buechi, M.W., Deplazes, G., Anselmetti, F.S.: Sedimentology of the glacial facies within the Deckenschotter of Northern Switzerland

Capelli, I., Adatte, T., Föllmi, K., Scasso, R., Kietzmann, D., Reubi, O., Cravero, F., Catalano, J.P.: Mineralogical and geochemical analyses of the Vaca Muerta-Quintuco system (Tithonian-Valanginian) in the Chacay Melehue area, Neuquén Basin, Argentina.

Carraro, D., Moscariello A., Ventra, D.: Comparative architectural analysis of large fluvial-fan successions: styles of aggradation, channel-belt avulsion and overbank organization

Courgeon, S., Samankassou, E., Meyer, M. : Basin-scale chemostratigraphy of Mesozoic carbonate series in the Great Geneva Basin (Switzerland, France) – *Preliminary Results*

Dieleman, C., Christl, M., Vockenhuber, C., Akçar, N.: Dating Swiss Deckenschotter with isochron-burial dating

Eymard, I., Bilmes, A., del Pilar Alvarez, M., Feo, R., Vasconcelos, C. Arizteguí, D.: Growth morphologies and plausible stressors ruling the formation of Late Pleistocene lacustrine carbonate buildups in the Maquinchao Basin (Argentina)

Feenstra, E.J., Birgel, D., Heindel, K., Wehrmann, L.M., Jaramillo-Vogel, D., Grobety, B., Frank, N., Hancock, L.G., Van Rooij, D., Peckmann, J., Foubert, A.: Constraining the formation of authigenic carbonates in a recent seepage-affected cold-water coral mound by lipid biomarkers

Fentimen, R., Lim, A., Foubert, A., Rüggeberg, A., Wheeler, A., Spezzaferri, S.: Comparison between living and dead benthic foraminiferal assemblages in a cold-water coral environment: the Moira Mounds (North-east Atlantic)

Fleischmann, S., Picotti, V., Rugenstein, J.K.C., Bernasconi, S.: Isotope stratigraphy of a Tethyan platform and slope across the Pliensbachian-Toarcian. The impact of the precursor of the Toarcian-OAE and effects on carbonate productivity

Garefalakis, P., Schlunegger, F.: Controls of surface and deep crustal processes on the 20 Ma-old Burdigalian transgression in the Molasse basin

Huber, M.L.: Boulders for paleohydrology - using allochthonous boulders in fluvial channels for peak discharge and maximum flood height estimations

Maillet, M., Huang, W.T, Li, X., Yang, Z.Y., Guan, C.Q., Zhang, Y.L., Ueno, K., Samankassou, E.: Growth dynamics of a Pennsylvanian carbonate platform and coral reef development: Record from Ziyun, Guizhou (Southern China)

Morlock, M.A., Vogel, H., Hadi, J., Foubert, A., Ariztegui D., Melles, M., Russell, J.M., Bijaksana, S., and the TDP science team: A novel 4D-view on sediments: insights to sedimentation processes and post-sedimentary mineral formation

Negga, H., Jaramillo.Vogel, D., Rime, V., Schaegis, J.-C., Perrochet, L., Filfilu, E., Hailu, A., Braga, J.C., Atnafu, B., Kidane, T., Foubert, A.: Pleistocene paleo-environmental changes in the Danakil Depression (Northern Afar, Ethiopia)

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Adatte, Thierry	Lausanne
Akçar, Naki	Bern
Amschwand, Dominik	Bern
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Angéloz, Aurelie	Geneva
Anselmetti Flavio	Bern
Areias de Oliveira, Camila	Geneva
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Beccari, Valentina	Fribourg
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Zimmerli, Geraldine	Fribourg

Electrical resistivity and petrophysical parameters of Upper Jurassic carbonate platform deposits (Jura Mountains, France)

Aurélie Angéloz*[(1)], Ralf J. Weger[(2)], Gregor P. Eberli[(2)], Michel Meyer[(3)], and Elias Samankassou[(1)]

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The Canton of Geneva is exploring the potential for exploitation of geothermal energy in the Great Geneva Basin. The project, GEothermie2020, aims to target several reservoirs in shallow to deep settings. The Upper Jurassic deposits in subsurface, especially in the *Complexe récifal* and *Calcaire de Tabalcon* (Meyer, 2000), appear to exhibit promising reservoir qualities. The site studied in Prapont (Jura Mountains, France) is a potential outcrop analog for the targeted reservoirs. The outcrop displays the uppermost part of *Calcaire de Tabalcon* and two subunits of the *Complexe récifal*, namely the *Calcaires récifaux* overlain by the *Calcaire de Landaize*. The present study aims to characterize electrical resistivity parameters along with porosity and density measurements of these deposits and to evaluate the link between these parameters and lithology.

Resistivity measurements were performed with NER Autolab 1000 system over a range of efficient pressure from 2MPa to 60 MPa following the method described in Verwer et al. (2011). Porosity was measured using helium pycnometry. Dolomite content was determined semi-quantitatively with X-ray diffraction (XRD) measurements. The cementation factor is determined through Archie's law (Archie, 1947).

Data analyses highlight clear trends. Overall, electrical resistivity (i.e. formation factor) is correlated to porosity, in line with Archie's law prediction. The *Calcaire de Tabalcon*, exhibiting subtidal facies, is less porous in areas containing a higher amount of dolomite. The cementation factor varies insignificantly and is loosely correlated with the dolomite content. In the reefal zone from the *Calcaires récifaux*, a higher percentage of matrix, i.e. fewer corals, accounts for more porosity and the electrical resistivity is low. This effect is smoothed by a positive correlation between the cementation factor and porosity. The *Calcaire de Landaize* contains some dolomitized layers. The variation of the cementation factor is low and shows weak correlation with the percentage of dolomite.

Overall, the cementation factor decreases with increasing dolomite content and increases with matrix percentage. This result contrasts to previous findings which tend to show that the mineralogy (limestone vs dolomite) does not affect the resistivity (see discussion in Verwer et al., 2011). Furthermore, porosity appears to play a major control on the cementation factor, a link that was rather assumed for mudrocks due to high conductivity minerals (Norbisrath et al., 2017). This link between porosity and cementation factor

observed in the present study differs from that of Verwer et al (2011) who showed that carbonate samples originating from different locations do not show a correlation between the two factors.

The effect of diagenesis including dissolution and dedolomitization, reported in Makhloufi et al. (2018), on the cementation factor has not been evaluated yet.

This study demonstrates that the impact of the cementation factor on the range of the resistivity is significant and needs to be taken into account for interpretation of resistivity logs and for the analysis of resistivity tomography acquired in the field.

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Sedimentological variability and carbonate precipitation on two hypersaline lagoons of the Brazilian coast - Preliminary results

Areias de Oliveira, Camila *[1,2], Valle, Luis Gustavo R. [2], Barbosa, Cátia F. [2], Vaconcelos, Crisógono [3], Ariztegui, Daniel [1]

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Brejo do Espinho and Lagoa Vermelha are part of a larger complex of lagoons bordering the Rio de Janeiro State coast (TURCQ et al., 1999). These two neighbouring shallow hypersaline lagoons are situated between two parallel barrier dunes and located along the coast between Saquarema and Arraial do Cabo, 100 km east of Rio de Janeiro (Brazil). They have been formed as a result of Holocene sea-level oscillations between 5100 and 3900 yrs. B.P. (MARTIN et al., 1986). Their geomorphological position allows water seepage from the Lagoa de Araruama on the continental side and seawater from the Atlantic Ocean influencing its hydrology (VASCONCELOS; MCKENZIE, 1997). The occurrence of an oceanographic upwelling zone promotes a semi-arid microclimate in the region (BARBIÉRE, 1984) generating hypersaline conditions. Brejo do Espinho and Lagoa Vermelha are among the few sites in the world where it has been discovered modern primary dolomite precipitation and microbial mat/stromatolite formation (BAHNIUK, 2013). For this reason they have attracted the attention of many researchers that have used them as analogues to develop geological models to understand dolomite formation in the rock record (VASCONCELOS & McKENZIE, 1997, VASCONCELOS et al,. 2006).

We are investigating sedimentary cores in both lagoons - Brejo do Espinho and Lagoa Vermelha - using an integrated approach that includes petrophysical properties along with grain size, organic matter and carbonate content to better understand the sedimentary variability throughout time. Identifying modifications in the chemical conditions of the water column such as alkalinity, oxidation state and associated changes in sedimentation within a robust chronological framework will contribute to understand the impact of sea level oscillations on the sediments of these lagoons (ARIZTEGUI et al., 2015). Two sedimentary cores LBE 18-1 and LV 18-2, 100 and 154 cm long, respectively, were obtained in June 2018 using PVC tubes. Once in the laboratory, the cores were first logged using a multi-sensor core logger (MSCL) every 0.5 cm with 250kHz in order to obtain the p-wave velocity, gamma-density and porosity. The cores were further split into two halves, described and sampled at 2 cm resolution. The samples were stored at +4°C and divided into subsamples for additional analysis.

Both core sediments are basically composed of sand and silt with some clay content, varying from grey to dark grey sandy mud, with some white intervals of carbonate mud. Core LV 18-2 has a strong carbonate concretion in the middle, and the carbonate content varied

between 8 to 96 % (average 49% and std 25%) whereas LBE varied between 51 to 96 % (average 76% and std of 12%). The P-Wave values for the Brejo do Espinho core ranged between 1376 to 1673 m/s (average 1605 m/s and std 33 m/s), gamma-density showed a specular image of the porosity ranging from 0.93 to 1.65 g/cm^3 (average 1.45 g/cm3 and std 0.09 g/cm3), with higher values related to lower water and TOC content. To Lagoa Vermelha P-Wave values ranged between 107 to 1822 m/s (average 1497 m/s and std of 263.65 m/s), gamma-density showed values ranging from 2 to 1 g/cm3 (average values of 1.3 g/cm3 and std of 0.17 g/mc3), porosity exhibited mirror image with values varying from 1 to 0.4 (average 0.85 and std 0.09) with higher values related to carbonate content.

These preliminary data have revealed distinct inputs of siliciclastic material most probably associated with both wind stress and sea level oscillations that have influenced carbonate deposition on both lagoons.

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CUSO ESPP tropical marine ecology and sedimentology course, Maldives 2018: Preliminary results

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The Conférence Universitaire de Suisse Occidentale (CUSO) has 33 doctoral programs, one of which is in Earth Surface Processes and Paleobiosphere (ESPP). Overall, CUSO aims to promote creativity, scientific quality and students' general ability to deal with challenges in contemporary academic, administrative and business environments. In this regard, the ESPP doctoral program conducted a field course in the Maldives from the 1–8 September 2018. The key focus was to provide students with in-situ experience in tropical marine ecology and sedimentology. Overall, 17 students, from the University of Fribourg, Lausanne, Geneva and Bern, together with eight Experts and Assistants participated.

In 2015, the International Union for Conservation of Nature (IUCN), REGENERATE Project conducted research in the Maldives to assess coral-reef resilience within this region. Thus, the main aim of the ESPP fieldtrip was to conduct a similar expedition to assess the current conditions and to document any changes in the tropical ecosystems since 2015. In total, three islands were visited representing examples of three different management plans, i.e., a community managed island: Rasdhoo; an uninhabitated island: Vihamaafaru; and a resort island: Maayafushi.

Throughout the fieldtrip, experts gave daily practical and theoretical lessons to the students, providing a comprehensive overview of tropical marine environments. Both coral-reef and lagoonal habitats were sampled, with students actively participating in all aspects of the fieldwork. The former involved multiple point-intercept transects at 10 m depth, sampling of foraminifera and echinoderm surveys. The latter incorporated multibeam surveys, discreet sampling and documentation of facies changes across the lagoons. In addition, water sampling for geochemical analyses and photosynthetic active radiation (PAR) light readings were carried out across both habitats. Preliminary data were analysed by the students during the cruise that already provides insight into the current state of the three island communities. Additional data processing is ongoing (e.g. Foram Index, *Amphistegina*

Bleaching Index, SEDCON Index, a more detailed investigation of the coral ecosystem at 10 m and analysis of sediments at the lagoonal transects) and will provide further insight into the changes experienced in these ecosystems over a three-year period from 2015–2018.

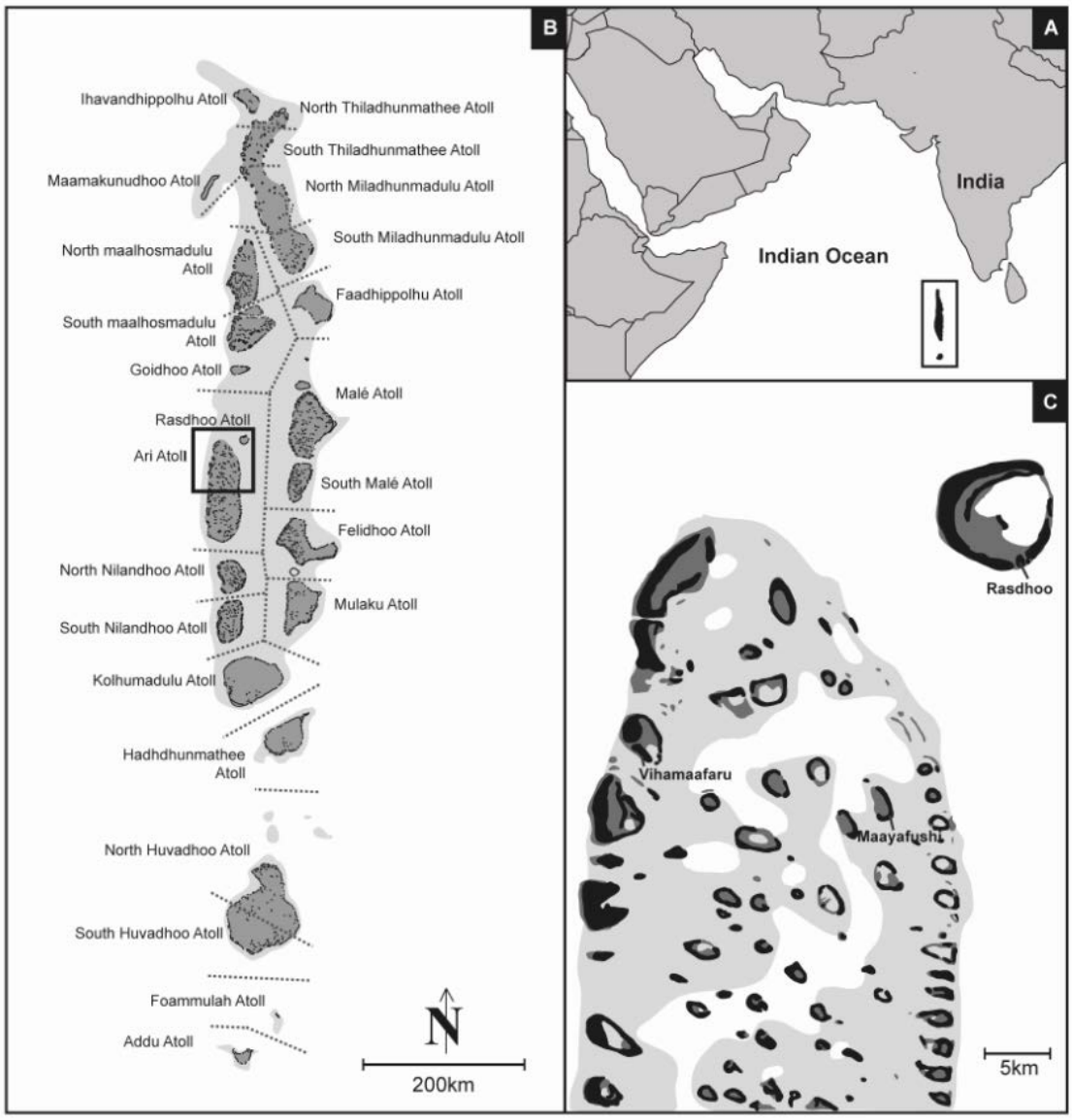

Figure 1. Location map showing the three investigated islands in the North Ari Atoll (Modified from Pisapia et al., 2017).

Tectono-stratigraphic evolution of the Mamfe sedimentary basin, southwestern Cameroon

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The Mamfe sedimentary basin, located in the southwestern region of Cameroon, is one of various extensions of the Benue Trough that covers regions in Nigeria and Cameroon. It is a rifting basin formed in response to the Gondwana break-up and subsequent separation of the later South American and African plate during early Cretaceous (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).

The age of deposits as published in the literature ranges from early to late Cretaceous, mostly because current dating does not cover the whole basin due to lack of paleontological data and scarcity of good outcrop exposures in this rainy region. The provenance of Mamfe sedimentary basin infill, in particular if deposits were exclusively continental, remains also poorly explored, as does the timing and spatial distribution of depositional history.

The present study addresses some of these issues, in particular the understanding of depositional environment using sedimentology along with XRF and LA-ICP-MS geochemical analyses. The study further intends to evaluate the hydrocarbon potential based on organic geochemistry including Rock-Eval and to date the sediments trough palynological analysis.

Preliminary results based on fields observation and petrography reveal distribution of massive and stratified sandstone, laminated carbonaceous clay shale, laminated siltstone, and limestone. The main constituents include quartz, feldspars, mica flakes, carbonates, sulfur-bearing minerals (barite, authigenic pyrite) and phosphate-bearing minerals (fluorite, apatite). Most of detrital minerals are subangular to subrounded indicative of close proximity of source area. The matrix includes carbonaceous clay, ferroan clay as well as carbonaceous and siliceous cement. Palynological data point to Cretaceous to Cenozoic ages, a novelty for the basin infill. XRF analyses indicate a mixed source of provenance dominated by igneous felsic rock and, to lesser extent, mafic source. The geochemical index of alteration suggests that sediments underwent low to moderate alteration in arid conditions. The ratios of rare-earth and trace elements such as U/Th, Ni/Co, V/Cr and V/Sc indicates that sediments were deposited predominantly under oxic conditions with the influence of intermittent anoxic phases. Rock Eval method reveals organic matter maturity and excellent source rock potential in the basin.

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Origin and late Quaternary emplacement of the unique fans in the Klados River catchment, Crete, Greece

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This study presents new data on the formation of large Holocene fans and terraces. The focus lies on the ~11.5 km^2 Klados River basin located on the southwestern coastline of Crete, Greece. This catchment is notable for the preservation of remnants of a large, triangular telescopic fan at the sea-shore, and a flight of terraces upstream indicating previous large-scale episodic sedimentation events. The seaward facing cliffs of the fan are unique among other alluvial fans on Crete in terms of their large size and step-wise stratigraphy (
Figure *1*).
A study performed on the fan sequence placed fan formation into the Pleistocene based on IRSL dating and explained its development with tectonic activity and resulting sea-level changes (Mouslopoulou et al. 2017). This interpretation is not satisfying because of absent dating, missing explanation for the disproportionate amount of sediment compared to the catchment size, and missing discussion about differences between this fan and others more proportionate in Crete. Moreover, the spatial confinement of the terraces to this one valley is at odds with tectonic forcing and gradual deposition by the river.
We provide an alternative explanation for the provenance and formation mechanisms of this unique fan sequence based on radiocarbon dating, mapping, sedimentology, stratigraphy, and a landslide runout model. The fans and terraces in the valley are substantially younger than previously suggested and originate from the fluvial reworking of a landslide triggered by one of the rare earthquakes that are known to have affected the island in the Holocene (Ambraseys 2009). This is substantiated by a landslide deposit in the lower reaches of the gorge and a probable source area in the headwaters of the river. We tested the feasibility of the event in the catchment using DAN3D-Flex, a dynamic runout model. The best-fit result reproduces the landslide deposition parameters as reconstructed from field evidence. Thus, we conclude that the valley was filled with a fractured, partly liquified landslide body that subsequently provided the sediment for the fans and terraces. Support for a Holocene formation history of the deposits in the valley comes from 6 radiocarbon bulk sediment samples and a terrestrial snail shell from the telescopic fan units which date consistently within the late to mid Holocene, and two Vermetid shells that were collected from a tidal notch that corresponds to the paleo-shoreline uplifted by the 365 AD earthquake (
Figure *1*). The tidal notch provides an invaluable age reference since a buttress unconformity exists between the lower fan and the notch. Based on these field observations and geochronology, we conclude that the fans and terraces in the valley were formed in the Holocene.

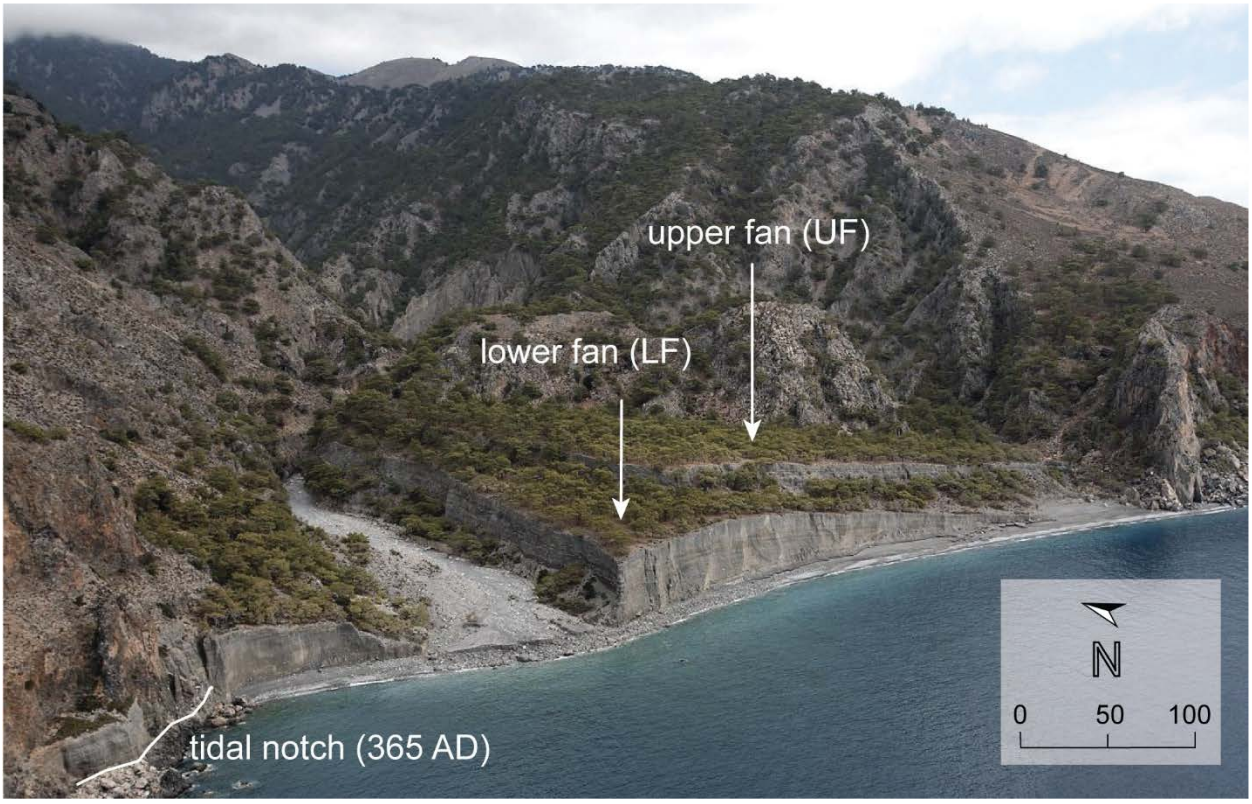

Figure 1. The river mouth at Domata beach is dominated by the escarpments of the telescopic fans termed upper fan (UF) and lower fan (LF). Neighbouring river systems do not show any similar deposits, which suggests catchment-intrinsic factors forced the Klados River into building the fans. A first assessment of relative stratigraphy of fan formation is derived from the unconformity between the LF and an uplifted tidal notch related to the earthquake of 365 AD (tripinview 2017).

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Sedimentology of the glacial facies within the Deckenschotter of Northern Switzerland

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The Höhere and Tiefere Deckenschotter Groups of Northern Switzerland are dominated by fluvial to fluvio-glacial sediments. In some outcrops, the gravelly facies is associated with diamictons interpreted as glacial tills (e.g. Heim 1891, Frei 1912, Graf 1993). Despite the importance of these presumed glacial deposits as markers of ice-contact during the Early Pleistocene, they remain relatively poorly studied. We present results from an ongoing project to better constrain the depositional environment of these diamicts at selected key sites using detailed macro- to microscale sedimentology, fabric and geotechnical analyses. Our analyses will help to better constrain the extent and characteristics of glacier advances related to the first extensive glaciations of the Alps.

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Mineralogical and geochemical analyses of the Vaca Muerta-Quintuco system (Tithonian-Valanginian) in the Chacay Melehue area, Neuquén Basin, Argentina.

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The Vaca Muerta-Quintuco system is an organic-rich, marine, shale succession deposited during the Tithonian-Valanginian in the Neuquén Basin, western Argentina. During that time, the basin was a semi-restricted back-arc basin, located to the east of a volcanic-arc and periodically flooded by the Paleopacific Ocean (e.g., Legarreta and Uliana 1996).

The Vaca Muerta Formation constitutes an outstanding unconventional oil and gas reservoir, and has received worldwide attention during the last decade, because of its high organic matter content (up to 12 %, average 4 %) and its exceptional petrophysics properties.

The Vaca Muerta-Quintuco system is 884 m thick in the well-exposed surface section of Chacay Melehue, located in the northern part of the basin. The basal deposits are characterized by basinal facies of the Vaca Muerta Formation (carbonate ramp), progressively covered by pro-deltaic/offshore deposits of the Quintuco Formation (see Kietzmann *et al*. 2016, Capelli *et al*. 2018).

50 samples of the Chacay Melehue section were analysed to determine major and trace elements, bulk and clay mineralogy, as well as organic matter content (TOC) and maturity. This mineralogical and geochemical study, with special focus on organic matter accumulation and detrital input shows how the sedimentary environment changed, allowing us to infer major paleoclimatic changes through the Tithonian-Valanginian.

The basal 300 m of the section (early Tithonian-Berriasian of the Vaca Muerta Formation) are characterized by well-laminated marls and mudstones with common calcite concretions. Bulk mineralogy is constituted by quartz (13-75 %), calcite (0-74 %), feldspar (2-40 %) and clay minerals (4-14 %), which are dominated by illite-smectite mixed-layers (I/S), with a progressive increment of Fe-chlorite towards the top of the interval. TOC values vary between 0.3 and 3.9 %, with two specific stratigraphic intervals of TOC > 2%. Biostratigraphy of ammonites allowed the correlation of those organic-rich intervals with the two major marine transgressions observed in the basin: T1-T2: lower to middle Tithonian and B4-V1: upper Berriasian to lower Valanginian (see Desjardins *et al*. 2016). The first 300 m are also characterized by a noticeable enrichment of redox-sensitive trace-elements (e.g.,: Mo, U, Ni, V), when compared to average shale (Wedepohl 1971).

The 584 m of the upper part of the section (upper Vaca Muerta and Quintuco Formations) are characterized by well-laminated marls and mudstones, lacking calcite concretions, with

fine sandstones progressively appearing in the succession. The clay mineralogy in this interval is characterized by variable contribution of I/S and Fe-chlorite. TOC values are relatively lower, and a major decrease in the redox-sensitive trace-elements is recorded.
Chemical Index alteration (CIA) and the Al_2O_3/TiO_2 ratio increase towards the top of the system. This trend suggests an increase in the weathering conditions on the continent, starting in the Berriasian and continuing towards the Valanginian, leading to an increment of detrital input and the consequent development of the mixed siliciclastic-carbonate deposits of the Quintuco Formation.
Rock-eval pyrolysis for the whole column revealed an overmatured stage of the organic matter, probably linked to an important burial in a high thermal gradient basin, which can be explained by the proximity of the volcanic-arc. The high-diagenetic grade reached by the unit in this area has triggered transformations of the initial mineralogy of the system. Mixed-layers I/S are a consequence of the progressive illitization of smectitic layers, which may have constituted the original clay mineral fraction. This hypothesis is supported by studies done in less diagenetized regions of the basin, where smectite and I/S characterize the clay mineralogy (Scasso *et al*. 2005). On the other hand, Fe-chlorite may be a diagenetic product, probably developed from kaolinite or berthierine precursors. A kaolinitic precursor would represent another proxy supporting a change to more humid conditions, in agreement with CIA trends.
In conclusion, preliminary geochemical and mineralogical analyses point out to a significant paleoclimatic change, initiated during the lower Berriasian and developed towards the Valanginian. This paleoclimatic change resulted in the progressive increment of detrital input from the continent in the upper part of the column, precluding the accumulation of organic-rich mudstones that characterizes the Vaca Muerta Formation in the lower part of the column.

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Comparative architectural analysis of large fluvial-fan successions: styles of aggradation, channel-belt avulsion and overbank organization

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Recent developments in fluvial geomorphology and sedimentology suggest that fluvial fans might be responsible for accumulation of great volumes of clastic successions in continental basins. The possibility of identifying a "typical" stratigraphic signature for aggrading fluvial fans (Figure 1) opens a new perspective to interpret continental records, where distinguishing the effects of autogenic dynamics from those of allogenic forcing remains a major challenge. Fundamental questions remain on the origin of these systems and on mechanisms governing the evolution of their drainage networks. Avulsion, frequently observed on active fans, is the fundamental process driving the areal distribution of runoff and sediment transport on fan surfaces over long timespans. This study is an outcrop-based analysis of architectural patterns and of spatio-temporal trends in avulsion mechanisms through Palaeocene-Eocene Colton-Wasatch fluvial-fan system of the Uinta Basin (central Utah). Main objectives are: 1) to characterize stratigraphic patterns from mesoscale to system scale; 2) to interpret their origin in order to unravel mechanisms of system-scale aggradation/progradation, which ultimately led to the distributive organization of drainage and sediment diffusion through the system; 3) to carry out compositional and provenance analysis to identify geochemical signatures of allogenic controls.

As a side project, we would like to test the response of a generic fluvial fan to allocyclic and autocyclic controlling factors through a 3D stratigraphic model. Our goal is to simulate different controls on the development of a distributive fluvial fan system or megafan (Fontana, Mozzi and Bondesan, 2008; Weissmann et al., 2013) in an endorheic basin setting, therefore isolated from a marine coastline and from direct base-level interference. By means of a stratigraphic forward model called DionisosFlow (Granjeon and Joseph, 1999), we aim to examine the consequences auto- versus allocyclic sequences in fluvial fan. Various scenarios of variable discharges and sediment loads will verify what thresholds in such parameters (and under what basic physiographic settings) may lead the system to build up an aggradational distributive landform (Figure 2).

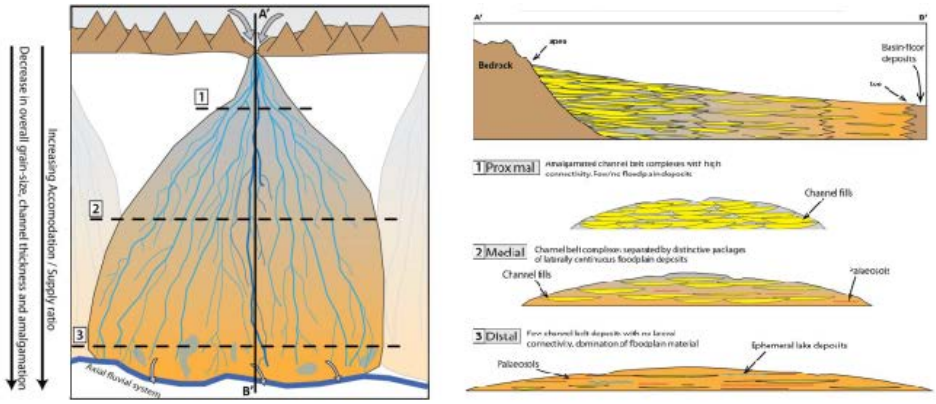

Figure 2. Generalized sedimentological and architectural trends, from proximal to distal, for deposits of an idealized fluvial fan. The distance from apex to toe vary from a few tens to hundreds of km (after Owen et al., 2015 and Moscariello, 2017).

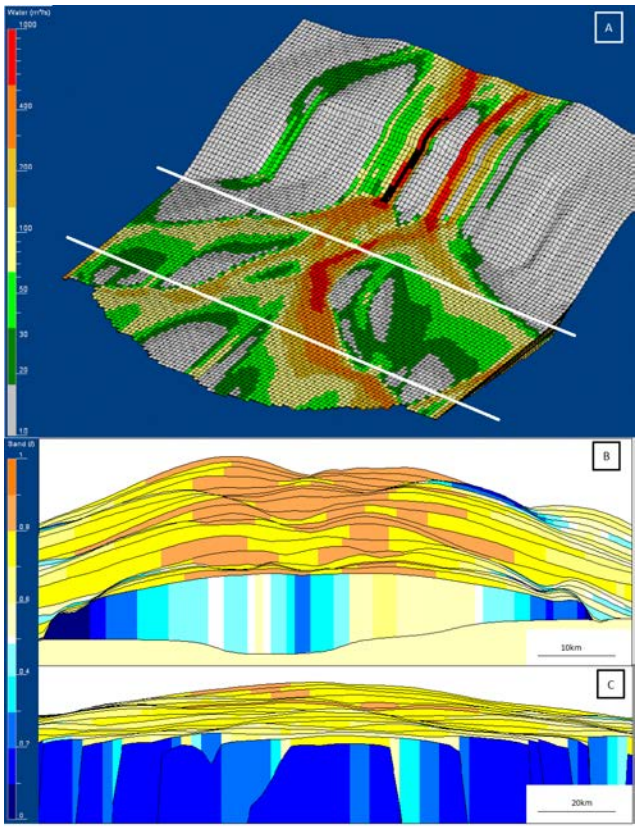

Figure 3. From early DionisosFlow models. A) View of a general fluvial fan. Color palette displays water flow (log scale, m3/s). This crude fluvial network already displays a distributive sediment pattern with lobe switching through nodal avulsion and lateral aggradation. B, C) Cross section extracted from the same model. Proximal (B) and distal (C) transect. Color palette indicates the sand content (%). Having selected only two sediment classes (sand and silt), values close to 1 mean high sand content whereas the lower the values, the more the silt percentage.

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Basin-scale chemostratigraphy of Mesozoic carbonate series in the Great Geneva Basin (Switzerland, France) – *Preliminary Results*

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The fluctuations of stable isotope ratios, especially those of Strontium (Sr) and Carbon (C), represent well-established stratigraphic proxies for Phanerozoic marine carbonate series. Global $^{87}Sr/^{86}Sr$ (McArthur et al., 2012) and $\partial^{13}C$ (Saltzman and Thomas, 2012) reference curves are commonly used as chronostratigraphic markers for regional-scale studies. From the Middle Jurassic to the Early Cretaceous, various marine carbonate deposits including reefal formations and coarse bioclastic limestones, micritic limestones and marls accumulated in the Great Geneva Basin (Switzerland and France).

This project, which focuses on the chemostratigraphy of this complex Mesozoic carbonate succession aims at: (1) refining the regional chronostratigraphic framework, (2) developing new correlation tools at the local and basin scales and (3) better assessing the various diagenetic processes and their potential impact on isotope ratios. This preliminary work focuses on the chemostratigraphy of the Kimmeridgian (Upper Jurassic) reefal complex and investigates the fluctuations of associated $\partial^{13}C$, $\partial^{18}O$ and $^{87}Sr/^{86}Sr$ ratios on bulk carbonates at two sites: first on exposed outcrops along the basin edge (Jura Mountains, Echallon and Prapont sections) and second, on rock cores of the Humilly-2 well located in the Geneva Basin center.

The first results show that the C, O and Sr isotopic fluctuations recorded in the reefal carbonate units differ significantly from global Kimmeridgian trends. The combined analysis of these fluctuations evidences various diagenetic overprints and might provide new insights to refine biostratigraphic boundaries. Our findings also highlight different diagenetic histories between the reefal carbonates of Prapont/Echallon outcrops and those of Humilly-2 well. These variations might reflect, at the basin scale, distinct burial histories or fluids circulations that could be related to basin structuration and evolution and/or local environmental parameters. At local scale (Echallon and Prapont outcrops), multi-element isotope signal represents an overall interesting and reliable correlation tool.

This work is being conducted in the frame of the GEOTHERMIE 2020 project that aims at evaluating the geothermal potential in the Geneva Canton.

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Are colluvial soils on kopjes a potential geoarchive of palaeoenvironemtal change in semi-arid regions?

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Sources of recent (Holocene) palaeoenvironemntal change are infrequent across semi-arid regions. Yet, arid and semi-arid areas cover over 40% of the terrestrial Earth and are important environmental and cultural landscapes that are a major source of natural capital and ecosystem services (Grove, 1977, Thomas, 2011). In arid regions, minor hydroclimatic variability and disturbances have profound effects on the abiotic charactersitcs and the supported biota, which can rapidly and often irreversibly be modified by anthropogenic pressures (Sinclair and Fryxell, 1985; Miles et al., 2006). Kopjes are subaerially exposed portions of weathered and eroded inselbergs that intermittently punctuate the savannahs and woodland ecosystems of Serengeti National Park, northern Tanzania, a UNESCO World Heritage Site (Fig. 1). The protrusion of these landforms above the grass-dominated savannahs and their ruiniform geomorphology (Migoń et al., 2017) make them key components to the soil, vegetation, and wildlife, of savannahs. Kopjes and rocky hill habitats represent <1% of the total area of Serengeti National Park yet contribute greatly to biodiversity (Timbuka and Kabigumila, 2006; Byrom et al., 2015a and b). Historically, people have made use of kopjes for rock shelters (Bower and Gogan-Porter, 1981; Bower and Chadderdon, 1986), specialised foraging locations and viewpoints for hunting, communications, and cultural use (Mabulla, 2005).

Because there are so few palaeoenvironmental geoarchives in semi-arid lands and because of the importance of kopjes to biodiversity and people, we wanted to investigate the natural history and potential resilience of these ecosystems. We collected the soil profile from a small crack, dammed behind woody shrubs, on the surface of a granitic inselberg in the Moru Kopjes, Serengeti National Park, Tanzania (Fig. 1 foreground). The soils within the crack supported grasses, *Aloe* sp., and two shrub species. Preliminary soil descriptions show poorly sorted regolithic soils derived from the parent granite, which are rich in rootlets and contained minor abundances of charcoal. Soil characterisation and microfossil analyses (pollen, charcoal, grass cuticle, phytoliths) continue and radiocarbon dating of the stratigraphy is pending. We expect to develop a dataset useful for first asking whether these types of deposits can be useful for developing Holocene-aged palaeoenvironmental records that will be interpreted alongside other forms of retrospective data, such as historical photography, maps, and ethnographic data.

Figure 1. A east-facing view from atop Ngong Rock, Moru Kopjes, showing the colluvial soil site (foreground) and the flat savannah landscape surrounding the kopjes (background). Photograph taken 20 November 2018.

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Dating Swiss Deckenschotter with isochron-burial dating

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Deckenschotter (*Cover Gravels*) deposits are characterised by a succession of glacio-fluvial sediments intercalated with glacial and/or overbank deposits and occur within and beyond the extent of the Last Glacial Maximum (H. R. Graf 1993). They represent the oldest Quaternary deposits in the Northern Alpine Foreland and document the landscape changes during the Early and Middle Pleistocene (H. R. Graf 1993). During the past 2.6 Ma, at least 13 glacier advances overrode the Northern Alpine Foreland (Schlüchter 1988). The imprints of these advances can be tracked in four distinct units, which are divided by their morphostratigraphy and their topography. They are attributed to have a reversed stratigraphy, which means that older deposits are located at a higher elevation than younger ones. The units are from old to young: Höhere Deckenschotter (HDS; Higher Cover Gravels), Tiefere Deckenschotter (TDS; Lower Cover Gravels), Hochterrasse (HT; High Terrace) and Niederterrasse (NT; Lower Terrace) (H. R. Graf 1993, 2009). A significant phase of incision separated the HDS from the TDS (H. Graf and Bitterli 1999). For a long time these units were correlated with the stratigraphy of Southern Germany after Penck and Brückner (1909). The HDS was therefore correlated with Günz, TDS with Mindel, HT with Riss and NT with Würm (Ellwanger et al. 2011; Preusser et al. 2011). The timing of the Deckenschotter deposits is still poorly understood and absolute are scarce. A new chronology has been established recently in several HDS and TDS outcrops by isochron-burial as well as depth-profile dating. This new chronology suggests an age of 2 Ma for HDS and 1 Ma for TDS, respectively (Akçar et al. 2014, 2017; Claude et al. 2017). However, mammal fossils found at Irchel are challenging the existing chronology, since 2 Ma old deposits are situated at the same morphostratigraphical position as 1 Ma old ones (Bolliger et al. 1996; Claude 2016). Therefore, how far does the chronology explain the approach *"same elevation means same age"*?

In this study, we investigate Swiss Deckenschotter outcrops at Irchel, the area around Mandach and Lake Constance in detail to establish a new chronology for Early to Middle Pleistocene glaciations in the Northern Alpine Foreland with isochron-burial dating. Furthermore, we will implement these results into a more complex landscape evolution model than thought so far. To achieve these goals, we sampled eleven new Deckenschotter sites: three HDS sites at Irchel, three HDS and three TDS sites around Mandach as well as one HDS and one TDS site in the area around Lake Constance. At least nine clasts of various lithologies, shapes and sizes as well as one sediment sample consisting of quartz pebbles were sampled per site. After the physical quartz separation, ^{10}Be and ^{26}Al are extracted from five clast samples and the sediment sample for the accelerator mass spectrometry (AMS) measurements at ETH Zurich. In addition to this, sediments will be analysed to identify the sediment source, the paleoflow regime, the transport mechanisms and the depositional environment.

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Hummocky-cross-stratification formed by supercritical flows? Insights from tidal to fluviodeltaic successions (Nama and Karoo-Kalahari basins, Namibia)

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Hummocky-Cross-Stratifications (HCS) are meter-scale, low-angle dune-forms with a 3D extent seemingly unrelated to a growth direction. Typical are concordant and discordant (erosive) laminasets forming bundles and swales. HCS generally consist of silt to fine sand and occur within dm to m thick bedsets. In this contribution, structures that resemble HCS are investigated from outcrops in Namibia from the Haribes Member (Nama group) and Mukorob Formation (Karoo Supergroup).

Since their early recognition, HCS are taken as typical for lower-shoreface/upper-offshore environments. They are traditionally interpreted as formed by the oscillation of large waves triggered during storm events. However, several studies have addressed the possibility that some HCS-like structures could instead represent deposits from Froude-supercritical flows such as antidunes (Prave & Duke 1990, Yagishita 1994, Myrow et al. 2008, Mulder et al. 2011). In addition, HCS-like features have been reported in a variety of settings where the influence of storm waves cannot have played a role. The recent advances on supercritical bedforms enables to refine the understanding of these structures with a similar shape but different origin, for a reconciliation of contrasting conclusions. Here, we report observations from two distinct settings where such HCS-like features could represent antidunes and cyclic steps from Froude-supercritical currents.

The Haribes Member (Nama Group, Fish-River Subgroup, Narabis Formation) consists of an alternation of dm- to m-thick sandstones and silt-to-mud beds. The sandstones contain oscillation and current ripple horizons, desiccation cracks, rip-up clasts and cross-strata, these sometimes stacked in an apparent herringbone configuration. Altogether they are organized in shallow (<10 m) channels 100's of m wide. The Haribes Member has been interpreted to record shallow to subaerial processes in tidal flat to fluvio-delta plain environments (see Miller 2008), an interpretation in agreement with the observed facies association. Within these sandstone beds, low-angle structures are present that share all characteristics of HCS. The bedforms are organized in periodic patterns with a wavelength between 3 and 12 m. In a nearshore environment, storm-reworked deposits such as generally interpreted for HCS have a very low preservation potential. Rather, these HCS-like features could represent antidunes formed in shallow streams in a Froude-supercritical regime. Such features have a sedimentary signature similar to storm-related HCS and could be mistaken in the field. If interpreted as antidunes, the periodicity of structures would

correspond to a stream depth from 0.5 to 1.9 m for velocities between 2.16 and 4.3 m/s (using equations in Prave 1990).

The second examples appear in the postglacial Mukorob Formation (Lower Ecca Group, Karoo Supergroup) forming here a > 50 m-thick coarsening-upward succession. The base of the succession is dominated by shales with intense bioturbation reworking any sedimentary structures and grades into medium sand beds with low-angle laminations and sporadic HCS. They are overlain by coarse sandstone channels containing silicified wood fragments from the Auob Formation (Miller, 2008). Of interest here is the sand-dominated, upper part of the Mukorob Formation. It mainly comprises trough and tabular cross-beds. However, some exposures exhibit thick (5 m) units of well-sorted sandstone beds organized as a stack of swales and HCS-like features. This facies association is laterally confined and seems to belong to a channel fill. Whereas the general Mukorob-Auob sequence fits with the scenario of a prograding delta, the origin of the channelized swales and HCS remains unclear. In particular, the inferred stratigraphic position (extremely shallow to subaerial) and lateral confinement are not compatible with a storm wave reworking of the upper offshore. Rather, this HCS-like facies fits better with a scenario where the mouths of distributary channels are regularly flooded by shallow currents in Froude-supercritical regime. These currents would repetitively fill and flush sediment in a dynamic setting, leading to the stack of swales and HCS, which likely represents a type of cyclic steps. These field structures are furthermore similar to cyclic steps from analogue experiments (e.g. Vellinga et al 2018). Here again, the interpretation in terms of Froude-supercritical bedforms (cyclic steps) seems the best viable interpretation.

In summary, while HCS have generally been interpreted as upper offshore recorders of storm events, there is evidence, both from the field and analogue experiments, that similar structures can also represent antidunes and cyclic steps formed in Froude-supercritical regime. Such an interpretation has implications for the reconstruction of ancient bathymetry and depositional environments.

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Tracking our ancestors legacy in lake sediments – *Keynote*

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Lake sediments form unique archives of early human activities, especially following the transition from hunter-gatherers to agricultural societies. In particular, the emergence and ensuing evolution of land-use is clearly recorded in the organic fraction of lake sediments from around the globe. As a result of the erosion of "old" soil the total organic carbon content in sediment increases increases, as does the age of the deposited organic material. Furthermore, this organic material contains fossil molecules (biomarkers) that can be useful to reconstruct past human activities: (1) Plant waxes, which, like pollen, reflect the vegetation changes caused by deforestation and the start of cultivation, (2) in rare cases, specific biomarkers can be attributed to a particular crop and allow the history of its cultivation to be reconstructed, and (3) biomarkers such as stanols and bile acids can be used to trace the presence of humans and their livestock.

Disentangling early anthropogenic signals from climatic variations is challenging, but well worth the effort as it provides clues to the timing of human migrations, the impacts of settlement on the landscape and the aquatic systems, and the vulnerability of early civilization to climate change. The hydrogen isotopic composition of certain biomarkers, such as the plant waxes, is a useful tool to trace hydroclimatic changes and thus to differentiate anthropogenic from climate-driven soil erosion. Ultimately, a multi-proxy approach that includes the distributions of lipid biomarkers and their stable isotope composition can inform us on past interactions in the human-climate-environment nexus.

Growth morphologies and plausible stressors ruling the formation of Late Pleistocene lacustrine carbonate buildups in the Maquinchao Basin (Argentina)

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The Maquinchao basin is a continental lacustrine system in southern Argentina. It provides an ideal site to study carbonate buildups, the role of microbes in their development and their implications in paleoenvironmental reconstructions. Presently the basin encompasses two lakes (Carri Laufquen Grande and Carri Laufquen Chica) joined by the ephemeral Maquinchao River. Fossil microbialites are found south and southwest of the largest lake. Preferential areas of development for fossil microbialites have been mapped using a high-resolution differential GPS. Outcrops are located between 820 m and 830 m, higher than actual lake levels and the Maquinchao River where living microbialites have been observed. Field data along with microscopical observations and XRD analyses have revealed a heterogeneity in both distribution and macro- morphotypes since carbonate buildups display different morphologies such as crust, columns, open flower-like, rounded and ellipsoids. Conversely, on the meso- and micro-scale they show more homogenous morphologies including laminations and shrubs. These microbial buildups are associated with basaltic substrates of variable size from pebbles to boulder. The homogeneity in meso- and micro- structures argue in favor of stable intrinsic parameters (i.e. microbial communities) whereas the variable macromorphotypes indicate changing extrinsic constraints such as steepness, energy and turbidity. The occurrence of distinctive buildups morphotypes separated in different outcrops and topographies suggest that Maquinchao microbialites are indicative of former Maquinchao big lake water levels. Thus, Maquinchao microbial buildups are a very valuable proxy for water level evolution and therefore paleoenvironmental reconstructions. They can be further used to seek the causes behind the apparently random distribution of morphological types and extension of microbialites in the geological past.

Constraining the formation of authigenic carbonates in a recent seepage-affected cold-water coral mound by lipid biomarkers

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During the MD194 EUROFLEETS Gateway Marion Dufresne expedition, a 30-meter high recent cold-water coral (CWC) mound (Alpha Mound) on Pen Duick Escarpement in the Gulf of Cadiz was revisited. Alpha Mound is subjected to hydrocarbon seepage and offers a unique opportunity to study methane-derived authigenic carbonates in modern CWC mounds. Through combining organic and inorganic geochemistry with mineralogical and petrographic analyses, the anaerobic oxidation of methane (AOM) and its effects on the sedimentary fabric were investigated. The occurrence of AOM was identified by characteristic lipids coinciding with the presence of a semi-lithified zone consisting of authigenic aragonite, high-magnesium calcite and dolomite. Authigenic high-Mg calcite is unequivocally attributed to AOM, acting as a lithifying agent, but authigenic aragonite and dolomite are tentatively interpreted to be derived from other diagenetic processes, such as abiotic mineral formation and bacterial organoclastic sulphate reduction. Among the lipid biomarkers in the semi-lithified zone are isoprenoid-based archaeal membrane lipids and glycerol dialkyl glycerol tetraethers (GDGTs), with abundant GDGT-2, representing a pattern typical of anaerobic methane oxidizing archaea (ANME). The $\delta^{13}C$ values of the ether-cleaved monocyclic biphytanes are as low as –100‰. Archaeal biomarkers are accompanied by bacterial dialkyl glycerol diethers (DAGE) with two anteiso-C_{15}/anteiso-C_{15}-alkyl chains with $\delta^{13}C$ values of –81‰, interpreted to be derived from sulphate-reducing bacteria. These low values confirm the presence of AOM, a relationship that was suspected but could not be proven based on only moderately ^{13}C depleted bulk sediments of Alpha Mound. Our new approach confirms that lipid biomarkers are an effective tool for distinguishing different early diagenetic processes in CWC mounds. The lipid signature and mineralogical patterns suggest that ANME-1 thrived in the (deeper) subsurface sediment at times of slow and diffusive seepage. Because only diagenetically stable AOM biomarkers are preserved in the layers where authigenic carbonates are abundant, the semi-lithified zone most likely represents a palaeo-SMTZ. Although no relationship between seepage and growth of corals is apparent in Alpha Mound, methane-induced lithification apparently protects the mound against erosion and acts as a hard substrate for CWC larval settlement.

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Comparison between living and dead benthic foraminiferal assemblages in a cold-water coral environment: the Moira Mounds (North-east Atlantic)

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Cold-water coral mounds are common structures along the North-east Atlantic continental margin. They develop at a variety of depths, from 600 to 1200 metres, and vary significantly in size and shape, reaching up to 200 metres high. The Moira Mounds form small (maximum of 10 metres high), numerous cold-water build-ups in the Porcupine Seabight off southwest Ireland. Currents play a key role in the development of cold-water coral environments, bringing nutrients and preventing smothering of the living corals by excessive sediment input. The high current speeds, reaching up to 40 $cm.s^{-1}$ in the Moira Mounds, may mobilise benthic foraminifera after their death. Thus, quantifying the impact of post-mortem processes in such dynamic environments is key to the use of fossil benthic foraminiferal assemblages as a paleoenvironmental proxy.

The study of stained (living) and unstained (dead) benthic foraminiferal assemblages from three different size fractions, 63-125μm, 125-250μm and >250μm, allowed to highlight important differences between living and dead assemblages from the sediment surface. The impact of the late North-East Atlantic bloom at our study site in early June may explain the high abundance of living phytodetritus feeding foraminifera, such as *Alabaminella weddellensis* and *Trifarina angulosa*. On the contrary, species such as *Cassidulina teretis* and *Sigmoilopsis schlumbergeri* are exclusively present in the dead assemblage. We suggest that these species are part of a reworked glacial assemblage. Destruction of small agglutinated tests may also be responsible for differences between living and dead assemblages. Grain size analysis (laser diffraction) of surface sediments (bulk and siliciclastic fraction) provided a better constraint on particle size variation and allowed to compare off and on-reef sites. The lower mean grain size in the presence of cold-water coral framework implies that small mounds such as the Moira Mounds play an active role in sediment baffling. Hence, the cold-water coral framework may have an impact on the taphonomy of foraminiferal communities through accumulation of eroded sediments.

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Isotope stratigraphy of a Tethyan platform and slope across the Pliensbachian-Toarcian. The impact of the precursor of the Toarcian-OAE and effects on carbonate productivity.

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The Toarcian Oceanic Anoxic Event (T-OAE) (at ca. 183 Ma) of the Early Jurassic is a major perturbation of the global carbon cycle, documented by a 5-8‰ shift in negative carbon isotopes followed by a positive carbon isotope excursion (CIE) (Jenkyns, 2010). Some hundreds of thousands of years earlier, at the Pliensbachian-Toarcian (P-To) boundary, a similar pattern of a minor (~1-2‰) negative CIE, followed by a positive shift can be observed in carbonates, organic matter and fossil wood (e.g. Hesselbo et al., 2007; Littler et al., 2010). This event, like the T-OAE, is associated with rapid and pronounced global warming, increased hydrological cycling, a mass extinction and a carbonate crisis, and has been referred to as the Pliensbachian-Toarcian (P-To) boundary event in literature (Bodin et al., 2016). This precursor of the T-OAE and its possible connection to the T-OAE has not been well understood so far, possibly due to the wide occurrence of gaps and condensed sections across the P-To boundary (e.g. Pittet et al., 2014).

Chemostratigraphic and biostratigraphic correlations ($\delta^{13}C_{carb}$) of a well-dated and complete slope-succession with the adjacent carbonate platform sediments, spanning the uppermost Pliensbachian to the lower T-OAE in Northern Italy, allowed us to reconstruct a detailed stratigraphy to test the response of the carbonate factory to the P-To event and the T-OAE.

Starting at the latest Pliensbachian (*hawskerense* subZone), a negative C_{carb}IE of around -1.5‰ was observed in the slope and platform margin successions, and assigned to the P-To event. The grainstones preserving the P-To CIE at the platform margin document the recovery of platform productivity following its emersion in the latest Pliensbachian. However, soon after the P-To event, carbonate productivity at the platform margin was not able to keep up with the ongoing transgression, allowing the partial drowning of open-sea thin-bedded micritic limestones. This platform drowning can most likely be attributed to oceanographic changes induced by the carbon cycle perturbation of the P-To event. At the end of this perturbation (top *tenuicostatum*), a skeletal grainstone interval at the platform margin documents a depositional regression, which has not been described in literature so far.

The negative CIE of the subsequent T-OAE is recorded in well-bedded, micritic limestones of the platform margin and inner platform, documenting a renewed transgression and drowning of the platform at the onset of the *serpentinus.* The first transgression pulse created the accommodation space for the *hawskerense* and *tenuicostatum* sediments at the platform margin. After the top *tenuicostatum* stop or even decrease of the sea-level, the second transgressive pulse reached the inner platform only at the onset of the *serpentinus*, therefore explaining the missing uppermost Pliensbachian (including the P-To event) and the *tenuicostatum* succession in the inner platform section. Figure 1 shows a summary of plot of

the main stages of platform and slope evolution from the Late Pliensbachian to the Early Toarcian, obtained by combining isotopes measurements with stratigraphic observations.

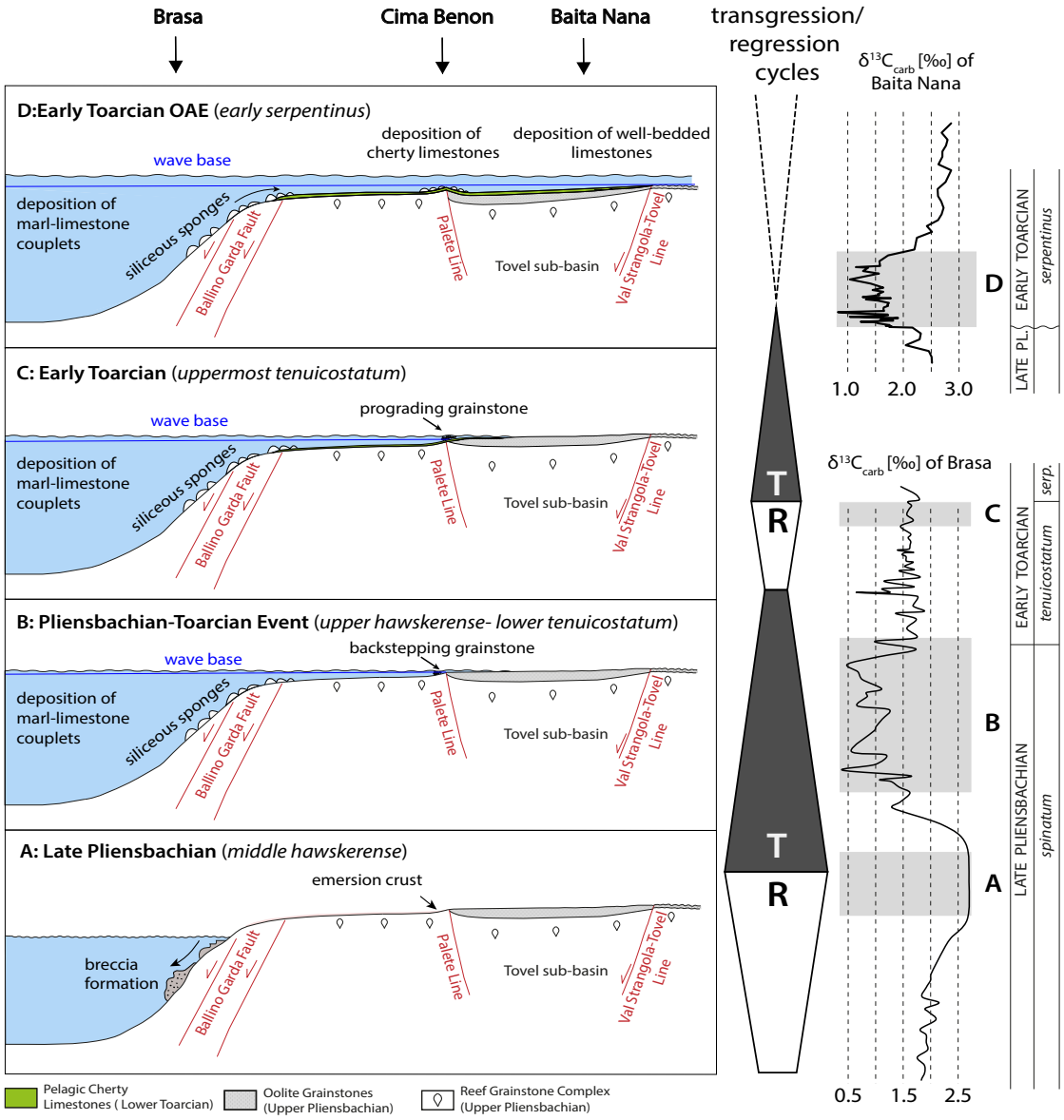

Figure 1. Time evolution of platform and slope over the Pliensbachian- Toarcian transition and the Early Toarcian. Transgression and regression cycles as well as the measured isotope curves, which were adapted to the pictures, can be seen on the right.

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Controls of surface and deep crustal processes on the 20 Ma-old Burdigalian transgression in the Molasse basin

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The evolution of the Swiss Molasse basin has been well explored, but the processes leading to the 20 Ma-old Burdigalian transgression are not fully understood yet. In this case, deposition of the Upper Marine Molasse (OMM) has been related to a combination of reduced sediment fluxes, a rise in global sea level and changes in surface loads (Sinclair et al., 1991). While the sedimentary responses to these effects have been well explored in the past years (e.g. Allen et al., 1985; Sinclair et al., 1991), the relative contribution of deep crustal delamination processes has not been considered in detail yet. Here, we focus on the 20 Ma-old delamination of the Aar-massif (Herwegh et al., 2017) and the related slab roll-back tectonics (Kissling and Schlunegger, 2018) and its possible contribution to the Burdigalian transgression. We proceeded with detailed field examinations and analysed several outcrops across the Swiss Molasse basin according to their sedimentologic records including palaeo-bathymetrical conditions, sediment discharge directions (from ripple marks, parting-lineations, imbricated clasts and solmarks) and inferred depositional settings. We compiled additional data from literature to reconstruct the evolution of the Burdigalian seaway and contributions of surface controls and deep crustal processes.

Field work showed that at the proximal eastern basin border, deposition of the OMM started at c. 20 Ma within a wave-dominated environment. Discharge directions reveal a radial pattern with a NE-directed tendency. At c. 19 Ma m-thick sandwaves, possibly deposited in an offshore environment, record a distinct change to deeper bathymetrical conditions. We interpret this time as the onset of the maximum flooding-stage (MFS) which is also accompanied by a change in the depositional environment towards a tidal-dominated setting. Measurements of palaeofow directions show a W – E-directed transport, which eventually changed to a radial N-oriented pattern. The investigated sequence ends with c. 17.9 Ma-old palaeo-soils. At the proximal western basin border, the sedimentary architecture records the onset of the OMM around c. 19.7 Ma where sediments were deposited within an estuarine-environment. Palaeoflow directions imply a NE-directed transport. Similar to the east, at c. 19 Ma, m-thick sandwaves, formed within an offshore environment, mark the onset of the MFS. Also similar to the east, sediment transport at that time was W – E oriented, however with a NE-directed tendency. The sequence in the east terminates with c. 17.6 Ma-old deltaic to fluvial sediments where discharge directions show a N – NW-oriented transport. Sites at the distal basin margin in the east and the west have been correlated by using seismic lines (Schlunegger et al., 1997) and through a sequence stratigraphic approach. Sedimentation at distal sites started at c. 19 Ma, contemporaneous with the onset of the MFS recorded at proximal sites. The sedimentary architecture in distal positions is characterized by the occurrence of several m-high fossiliferous sand-waves ("Muschelsandstein"), possibly deposited within an offshore environment. Sediment transport in the distal eastern part is SW-oriented, while discharge directions in the distal

west show a NE-oriented flow, both pointing towards a possible depocenter situated in front of the Aar-massif.
In summary, sedimentological investigations revealed changes in palaeo-depositional settings, changes to deeper bathymetrical conditions and shifts in discharge directions. Moreover, deepest bathymetrical conditions are recorded during the MFS at c. 19 Ma together which was associated with a widening of the Swiss Molasse basin.

We suggest, that both surface and deep crustal processes contributed to the marine ingression leading to the Burdigalian seaway. In the case of deep crustal processes operating at the slab-scale, the deepening and widening of the basin is related to the delamination and northward thrusting of the Aar-massif at c. 20 Ma (Herwegh et al., 2017). The associated fast period of roll-back subduction of the European slab (Kissling & Schlunegger, 2018) resulted in the formation of accommodation space and thus in the deposition of the offshore "Muschelsandstein"-sand-waves at distal positions in the basin. At a smaller scale, the exhumation of the Aar-massif was dynamically coupled to the underlying foreland plate, where the flexural response to surface loading (uplift of Aar massif) primarily depends on the mechanical strength of the foreland plate. In this case, depocenters are expected to experience a backstepping while distal and lateral positions reacted with upward-directed bulging of a few tens of meters (Sinclair et al., 1991. In this context, the inferred subtidal shoals near Fribourg are interpreted as a western lateral forebulge, which might have established in response to shifts in surface loads caused by the rising topography above the Aar massif. The contribution of surface controls on the marine ingression is manifested by a combination of reduced sediment fluxes and a global sea level rise. Indeed, estimates of sediment volumes show a reduction of c. 30% for the Central Alps (Kuhlemann et al., 2002) during the time of the Burdigalian transgression, and times of global sea level drops and rises can be correlated with phases of erosion and deposition in the Molasse. While these mechanisms may be capable of controlling the marine ingression, they cannot explain shifts in the basin's geometry. In this case, the delamination of the Aar-massif and related rollback subduction resulted in the deepening and widening of the basin and thus formation of accommodation space, and in subtle flexural adjustments recorded by subtidal shoals.
We conclude, that both, surface and deep crustal processes contributed to the establishment of the Burdigalian seaway. These signals related to the above mentioned processes can be extracted from sedimentary archives of the OMM by using detailed sedimentological and chronological datasets.

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The history of the overdeepened Lower Aare Valley: insights from scientific drilling and outcrop data

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During the Pleistocene, extensive and repeated glaciations have carved the foreland of the European Alps and left deeply incised trough structures, overdeepened valleys, behind. Subsequently, these sediment traps were infilled with sub-, pro-, or non-glacial deposits, sometimes related to multiple glaciations. Therefore, overdeepened valleys can serve as excellent archives of pre-LGM glaciations, whose relics were otherwise largely overprinted by the following ice advances. However, the timing and processes of formation of overdeepenings in the Alpine foreland are discussed controversially.

To gain insights into the pre-LGM glacial and fluvial history of northern Switzerland and to constrain the process of subglacial erosion, we currently investigate the Lower Aare Valley with four scientific drillings (Quartärbohrungen, QBO; *Fig. 1*). These are targeted at the overdeepened Gebenstorf-Stilli trough and the Rinikerfeld paleochannel, and are complemented by field work. Our study area is situated just beyond the local LGM, at the confluence of the Aare with Reuss and Limmat, where the valley is deeply incised (>100 m below surface) into limestones of the Lägern Anticline (the southeastern margin of the Swiss Jura).

In 2018, we recovered more than 350 m of drill cores. Here, we present first results of our sedimentological, geotechnical, and geochronological analyses.

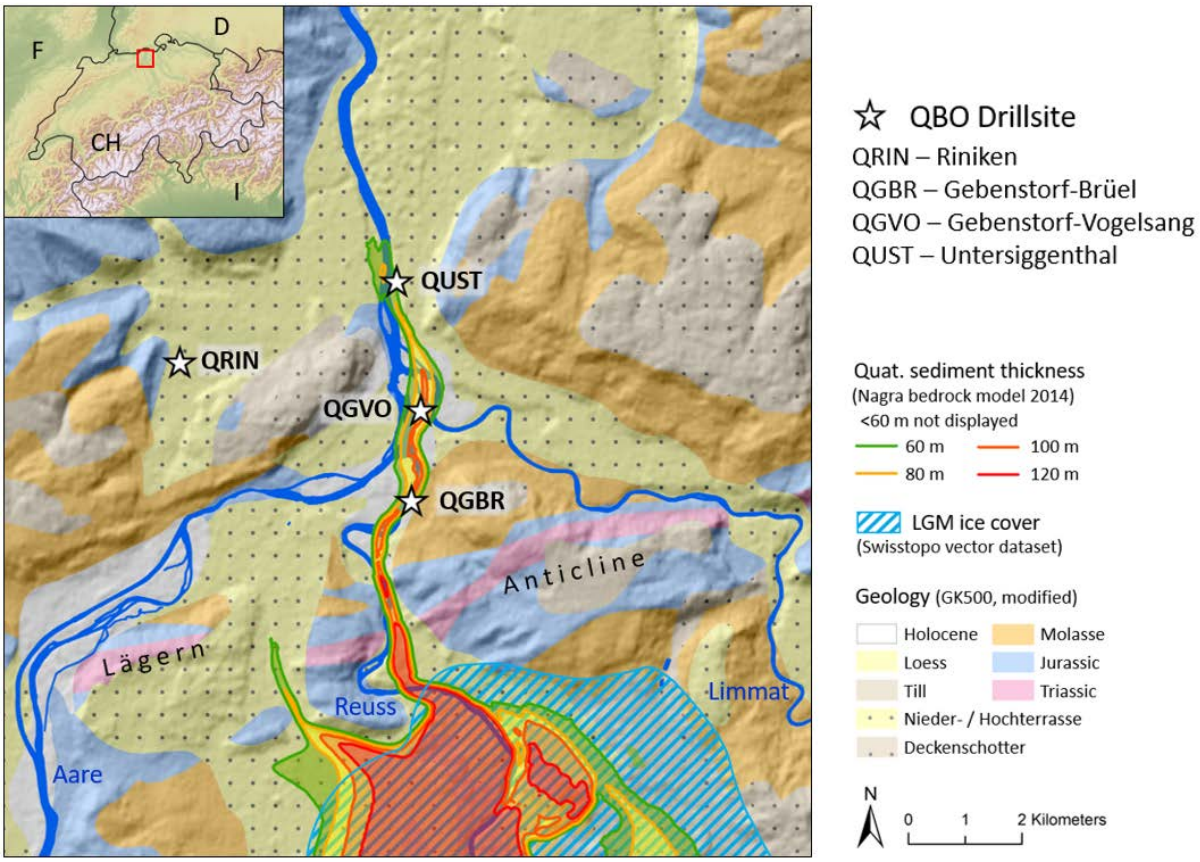

Figure 1. Geological map of our study area in the Lower Aare Valley.

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Boulders for paleohydrology - using allochthonous boulders in fluvial channels for peak discharge and maximum flood height estimations

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The Matlab® code package presented here allows fast and simple application and comparison of three different approaches for paleo-hydrological peak discharge and maximum flood height estimations from fluvially transported boulder clasts in a delimited channel reach (allochthonous: originating elsewhere). All approaches are drawn from existing literature which proofed most reliable and appropriate for implementation in this field of research.

Costa's (1983) empirical approach is based on a total of 17 measurements gathered from the literature in order to perform a power-law regression on diameter values bigger than 500 mm and average velocity of water flow under flash flood conditions. Clarke (1996) and Alexander & Cooker (2016) approaches are theoretical force balance derivations. All approaches are following the incipient motion principle (Costa, 1983; Clarke, 1996): They compute flow velocities for turbulent, Newtonian fluid flow when a boulder of given diameter (D) initiates motion on the stream's bed. Threshold conditions required for movement of large grain-sizes do only appear during high-magnitude flood events and maximum transported grain sizes can represent maximum flow conditions in a fluvial channel. Boulder diameter and density of surveyed boulders is tied directly to maximum cross-sectional average flow velocity during a flood event.

The Gauckler-Manning formula was used to convert cross-sectional average flow velocity from the three approaches outlined above to peak discharge estimates and maximum flood heights in a fluvial channel (Gauckler, 1867; Manning, 1891). A Matlab® code of Rosenwinkel et al. (2017, Supplementary Materials) was adopted which allows to solve Gauckler-Manning formula for the input of an arbitrary and irregular shaped channel cross-section by utilizing a numerical optimization scheme.

All the paleo-hydrological calculations performed in this code package are based on the assumption of turbulent, Newtonian fluid flow without shear strength. This includes also the empirical coefficients adopted from literature. The approaches used by Costa (1983), Clarke (1996) and Alexander & Cooker (2016) give values in the same order of magnitude for average flow velocities, peak discharges, and maximum flood heights, but these values deviate still to some extent from each other. Due to the consistency of the results using these approaches, they can be considered reliable. The most recently published study by Alexander & Cooker (2016) produces the lowest values by including the more advanced impulsive force consideration into their formulation. Therefore their values could potentially be more representative than values from the other two approaches.

The Matlab® code package is accessible via following URL:
https://gitlab.com/mlh300/bouldersforpaleohydrology

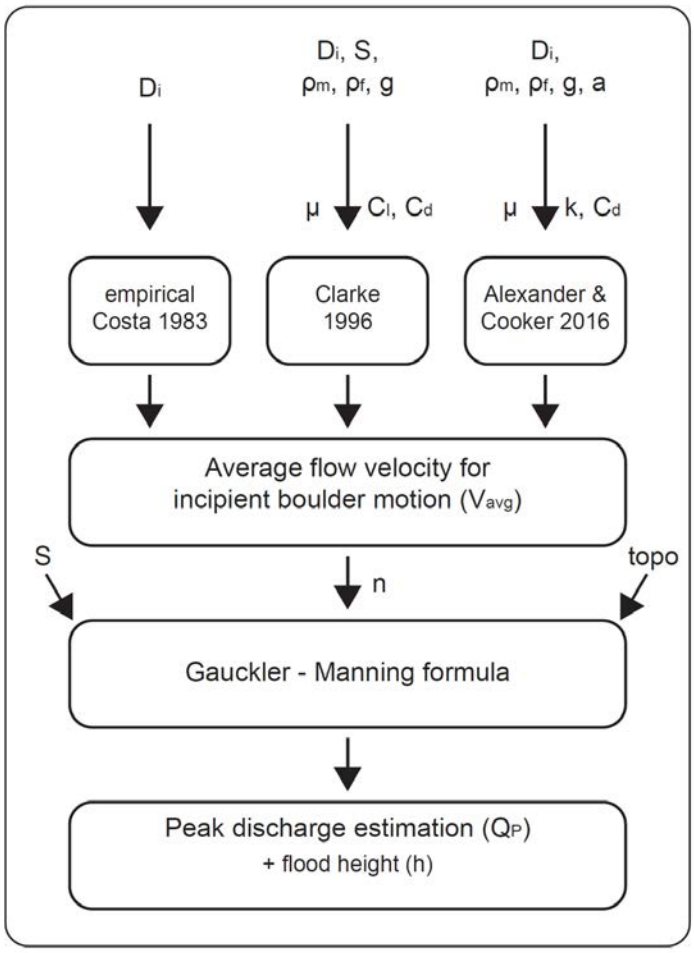

Figure 1. Flow-chart showing steps of computation for Matlab® codesof the boulders-for-paleohydrology code package. General input parameters on very top together with input coefficients below next to arrows. Topographic input (topo, S) is not added until Gauckler-Manning formula is applied.
D_i is intermediate grain diameter; S is bed-slope, ρ_m is boulder density; ρ_f is fluid density; g is gravitational acceleration; a is the rate of change in time of the fluid velocity relative to the boulder; μ, C_l, C_d and k are coefficients.

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Integrating fauna and sedimentary facies for better paleogeographic reconstruction: A case study from the semi-isolated Dacian Basin, Eastern Paratethys (Late Tortonian – Messinian)

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Accurate paleogeographic reconstructions are sometimes hampered by contradicting proxies. These contradictions may arise from intrinsic complexity, which might not be reliably captured and represented using separate proxies. This is for example the case for semi-isolated basins. Over time, these basins typically alternate between being fully marine basins and isolated lakes, undergoing spectacular water level fluctuations and bearing different types of fauna. They are widely distributed nowadays and have been common in the past. Among them are the recent Black Sea, Azov Sea, Mediterranean and the past Paratethys. For understanding their past, an integrated multi-faceted approach is highly needed.

In semi-isolated systems, the water level of marginal basins is determined by water exchange with a central basin and/or by local fresh water input. Connection with a central, more saline basin creates density-driven water exchange that brings denser (saline) water into the (fresher) marginal basin. However, a lowstand in the central basin may lead to a situation where one-way flow occurs from the marginal to the central basin. In this case the only water source in the marginal basin is the local fresh water input. Consequently, reconstruction of salinity trends can allow us to identify the main driver of observed lake level changes (i.e. whether driven by river input or interbasinal connection). The most common proxy used for salinity reconstruction is fauna, mainly molluscs and microfauna (ostracods and foraminifera). However, since these groups represent different ecological settings, they might show contradictory salinity trends. Such conflicting data trends can lead to errors in paleogeographic reconstructions.

Here we present our integrated biostratigraphic and sedimentary facies analysis data on the Khersonian – Maeotian section from the semi-isolated Dacian Basin. The 1300 m section represents a high range of littoral, deltaic and coastal environments. Our integrated data revealed intervals with contradicting salinity estimations suggested by molluscs and microfauna. Here we show how these discrepancies can be explained from a sedimentological point of view and how an integrated approach is important for paleogeographic reconstruction.

Growth dynamics of a Pennsylvanian carbonate platform and coral reef development: Record from Ziyun, Guizhou (Southern China)

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Currently, the Carboniferous is considered as a period of global recession in metazoan reef building subsequent to the Late Devonian extinction events. Although small and scarce examples of Carboniferous shallow-water coral-bearing bioconstructions were reported, corals played a minor role in their construction (Fagerstrom, 1987; Enpu *et al.*, 2012). However, in Southern China, a large Pennsylvanian coral reef was recently reported in Bianping (Ziyun County, Guizhou), considered as the largest Pennsylvanian metazoan frameworks in the world (Zhang *et al.*, 2010). To understand the overall context of this reef growth, two sections have been investigated, located in Zhongxinzhai and Brickyard villages respectively (Houchang, Ziyun). Both sections are dated as Late Pennsylvanian, contemporaneous with the Bianping coral reef.

The studied material consists of 125 samples which were analyzed for petrography following Dunham (1962). Facies are grouped in seven Microfacies Types (MFT) including green algal packstone-grainstone, coated grain grainstone, phylloid algal boundstone, microbial boundstone, bioclastic packstone-grainstone-rudstone, burrowed wackestone-mudstone and pelagic mudstone.

The first section (Zhongxinzhai) is composed of an alternation of green algal packstone-grainstone, coated grain grainstone, phylloid algal boundstone, microbial boundstone, bioclastic packstone-grainstone-rudstone and burrowed wackestone-mudstone, deposited at the shelf margin. Nearby and contemporaneously to this section, several bioconstructions have been reported including the large Bianping coral reef (Zhang *et al.,* 2010), phylloid algal bioherm (Enpu et al., 2007) and microbial mounds. Conversely, the second section (Brickyard) is dominated by pelagic mudstone alternating with episodic calciturbidites and thin marl intervals, attesting of a deep depositional environment (slope/toe-of-slope).

The petrographic analyses coupled with the large diversity of reported reefs allow to propose a new carbonate platform geometry for the Late Carboniferous. This model differs from that widely reported from Pennsylvanian platforms, known to exhibit high-relief steep slopes and predominantly constructed by microbial boundstone (Bahamonde *et al.*, 1997, 2004, 2008; Della Porta *et al.*, 2003, 2004; Della Porta, 2003; Chesnel *et al.*, 2015). Therefore, the example reported here, characterized by the exceptional occurrence of coral reef, deviates from, and adds to, models currently well established for this time window.

Ongoing investigations including dating (Sr isotopes and biostratigraphy) as well as geochemical analyses (C and O isotopes) targeting seawater composition, will provide additional information to improve the understanding of the occurrence of metazoan reefs at odd with current models for the Pennsylvanian.

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Using UAV photogrammetry for high-resolution 3D digital outcrop and reservoir models: A case study in the Jura Mountains, France.

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To better characterize the geometry, architecture, distribution and lateral variations of the different sedimentary units present in the Great Geneva Basin sub-surface, high-fidelity 3D depositional models are required. Photogrammetry using Unmanned Aerial Vehicles (UAV) has become an efficient, low-cost method capable of producing high-resolution, photo-realistic 3D models of rock outcrops. These models, once interpreted and imported into a 3D geologic modelling software (e.g. Petrel©), can help understanding spatial relationships between geological objects and identifying geological structures as well as sedimentary bodies (Blistan et al., 2016). The aim of this study is to produce a high-resolution 3D digital model of the Upper Jurassic Reef Complex cropping out in the Saint-Germain-de-Joux area in the Jura Mountains, Eastern France. This outcrop has proven to be a good analog to the Upper Jurassic limestones present in the Great Geneva Basin sub-surface (Fookes, 1995). Furthermore, these limestones are considered as a potential target for geothermal energy production.

The outcrop model was obtained using Agisoft Photoscan©. The acquired model was then interpreted in terms of depositional environments using Virtual Reality Geological Studio©. This interpreted model is further used to constrain dimensions and orientations of the different sedimentary bodies with great accuracy. Once imported in Petrel©, these data are used to produce a high-fidelity depositional model which can be propagated into the whole basin.

The study presented here will help to improve the current 3D model of the Geneva Basin. Moreover, this project is of added value for the Electrical Resistivity Tomography study of this outcrop currently being developed at the University of Geneva. Additionally, the data produced in this study will provide key inputs for reservoir modeling which is crucial for further potential exploitation of geothermal energy in the Canton of Geneva.

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A novel 4D-view on sediments: insights to sedimentation processes and post-sedimentary mineral formation

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Until recently, analyses of lake sediments were either limited to a 2D study of the sediment core surface, or volumetric analysis, for which the sedimentological structure needed to be destroyed. To overcome these limitations, we combined high-resolution 3D-microCT-scanning (µm-scale) of fresh lake sediment with XRF-scanning, micro-XRF mapping, and traditional thin section analysis. MicroCT-scanning facilitates the observation of sedimentary structures at the mm-scale in 3D prior to analysis, while high-resolution mapping in 2D aids characterisation of the observed structures once the fragile sample is conserved in resin.

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. In the cores, high density contrasts between the clay-rich sediment matrix and postdepositional alteration products such as siderite ($FeCO_3$) and Millerite (NiS) provide an ideal setting for microCT analysis on characteristic sediment core sections. Geochemical information from the embedded sections is provided by high-resolution XRF-scanning and micro-XRF mapping of the samples.

MicroCT scans reveal µm-thick vertical voids filled with high density mineral precipitates related to post-depositional fluid circulation, as well as coatings of high-density material (mainly siderite), around low-density centres. We observe beds of siderite, which appear continuous in 2D, but prove to be separated structures in 3D space. A crack showing vertical displacement in the sediment is, in 3D space, visualised as a plane, which points towards a rupture, perhaps seismically induced, that promoted precipitation of siderite on the newly-formed surface. The combination of high-resolution imaging with XRF element scans allows a novel, very detailed 4D-view of sedimentary structures that identifies processes involved in authigenic mineral formation and their relation to palaeoenvironmental changes in the lake and its catchment.

Pleistocene paleo-environmental changes in the Danakil Depression (Northern Afar, Ethiopia)

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The Danakil Depression, located in the northern apex of the Afar triangle, Ethiopia, is part of an active rifting zone due to the break-up of the Afro-Arabian plateau since Oligocene times. The Danakil Depression is nowadays a dry desert with elevations of 120m below sea level in the central part of the basin. According to seismic data and new core analyses, a 2km thick evaporite sequence alternating with marine marls evidence several episodes of Red Sea incursions followed by desiccation.

The presence of at least two fringing coralgal reef terraces outcropping at the the western margin of the basin, confirms that open marine Red Sea conditions were established during interglacial Marine Isotope Stages (MIS) 5e and 7 (Jaramillo-Vogel et al. 2018). Monospecific bivalves, associated microbialites, aragonitic crusts and coeval spherules, present on top of the coralgal reef units and pre-dating massive gypsum deposits, indicate the intermediate step-wise closure of the connection with the Red Sea and the systematic shift towards more hypersaline environments.

Interestingly, in several outcrops along the margin it is possible to observe lacustrine sediments that are intercalated between the two marine terraces. The occurrence of these unconsolidated sediments, rich in gastropods and charophytes, can be followed along several kilometers. They follow an erosive surface caused by the desiccation of the basin after MIS7. But, the transition to the marine deposits of MIS5e could be localy gradual or could be marked by a transgressive surface.

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Nearshore sediment stratigraphy from Lake Sils, Engadin: insights to lake-level fluctuations and tsunamogenic sublacustrine mass-movement processes

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Lake Sils (4.1 km^2, 1797 m.a.s.l, depth 71 m) is an Alpine lake connected downstream to a chain of four lakes located in the Upper Engadine in the southeastern Swiss Alps. The NE-striking valley located along the Engadine Line is a moderately active fault-system with low-magnitude historical earthquakes.

Our study focuses on the lake-level reconstruction of Lake Sils based on nearshore and onshore sediment cores and a literature review. The observed nearshore sedimentary sequence consists of four lithological units with a peat horizon sandwiched by lacustrine sediments below and an erosive contact to an overlying fining upwards sandy sequence. The organic-rich horizon in 50 cm depth below the lake-floor has an age of 1745±35 cal BP and reflects lake-level low stand around the Roman era. In-situ grown, standing trees found in Lake Sils dated to 1888 ±18 cal BP (Vattioni, 2018) and 1313±22 cal BP (Schlüchter et al., 2018) support the hypothesis of a lake-level low stand of at least 4 m, respectively 20 m, below today's level during this time. The overlying sandy unit is interpreted to be related to a large mass-movement identified in the deep lake basin by Blass et al. (2003) deposited around cal AD 700 in Lake Sils with a thickness of up to more than 6 meters and a total estimated volume of $6.5 \cdot 10^6$ m^3. The mass-movement originated from the Isola Delta, the major riverine input, and likely caused a large water displacement resulting in a tsunami wave inundating the shore of Lake Sils. This wave is interpreted to cause the deposition of the fining upward sandy sequence that, moreover, could have buried four Roman altars at Sils Baselgia found during constructional excavations in 1964 (Rageth, 2002). The impact of the mass movement and its related tsunami wave rearranged substantially the shoreline geomorphology and might be one of the causes for the abrupt lake-level rise thereafter. Future studies will provide new insights into timing of the lake-level rise, neotectonic activities of the Engadine Line and instabilities of the Isola delta.

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Late Miocene – Pleistocene continental record of Armenia (Lesser Caucasus) and its paleogeographic implication.

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The late Miocene – Pleistocene is time of a comprehensive environmental transformation in Eurasia. Tectonic activation along Arabian – Eurasian collision zone together with global climatic cooling caused restructuring of Caucasian landscapes and rise of modern ecosystems. The basin record of Paratethys of that time displays several strong faunal turnover events. Nevertheless, the question on the terrestrial ecosystem response to such great changes is still open due to lack of representative terrestrial record. Moreover, the specific contribution of climatic and tectonic drivers in paleoenvironmental change is poorly studied.

Here we present our preliminary results of the interdisciplinary study on the late Miocene – Pleistocene succession from Armenia (Lesser Caucasus). The studied section Jradzor is located in Central Armenia on the Eranos Mountainous Chain (1940 m a.s.l.) and represents a wide range of continental depositional environments with 15 horizons of vertebrate fossil fauna.

Six sedimentological units can be identified in the section. Unit 1 is represented by white thinly laminated diatomite characterizing distal lacustrine deposits. Unit 2 overlies the previous unit with a highly erosive contact and consists of volcanic ashes and sands. Units 3-6 are represented by alternation of deluvial (slope erosion), fluvial (ephemeral river channels), aeolian (loess) and pedogenic type of sediments characterizing deposition in continental setting.

The faunal record of the lacustrine unit 1 provides aquatic forms (fishes and frogs). The fossiliferous horizons of the units 3, 4, 6 contain vertebrate groups including amphibian, reptilian, avian and mammalian remains. All vertebrate groups suggest warm, rather dry and open habitats. Based on a complex dating approach (mamma fauna, paleomagnetic dating) the age of the units is estimated as: late Miocene (unit 1-3), early Pliocene (unit 4), Pliocene-Pleistocene (unit 5) and Late Pleistocene (Unit 6). The further age model will be clarified by K/Ar dating of 6 six volcanic ashes present throughout the section.

With a purpose of paleoclimatic and paleotopographic reconstruction the isotopic analysis have been applied. The $\delta^{18}O$ analysis on the palaeosol carbonates (as a tracer of precipitation moisture sources and palaeotopography) did not show any substantial changes of the meteoric $\delta^{18}O$ since the late Miocene. The $\delta^{13}C$ data do show substantial changes, including a decrease from high, but variable values in the late Miocene to a low value in the Pleistocene.

A high-resolution C-isotope chemostratigraphy through the latest Toarcian to Early Aalenian units in northern Switzerland

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The upper Staffelegg Formation (Rietheim & Gross Wolf Members) and the overlying Opalinus Clay were deposited during the Late Toarcian to Aalenian in the Early to Middle Jurassic. The Liassic sediments consist of dark black bituminous to silty marls and the Opalinus Clay of dark grey to black calcareous and silty claystone. Based on the mineralogy and grain-size, the Opalinus Clay, however can be further divided into sub-units. The extent of these decametre scale sub-units can be investigated by comparing the records of different outcrops and drill cores from northern Switzerland. To predict potential lateral facies changes within the Opalinus Clay, the depositional environment must be investigated applying a compositional but also a chronological differentiation.

Biostratigraphy based on ammonites and palynomorphs is a frequently applied method to establish a chronology in these clay rich Jurassic sediments. Previous studies indicate that the top of the Staffelegg Fm and thus the onset of the Opalinus Clay is diachronous (e.g. Feist-Burkhardt & Pross, 2010; Hostettler et al., 2017). However, the resolution of these biostratigraphic tools is mostly not high enough to differentiate the sub-units of different drill cores within the Opalinus Clay. Therefore, in this study the potential of high-resolution carbon isotope stratigraphy measured on carbonates and on organic matter will be presented. The established C-isotope chemostratigraphy shows several distinct negative and positive excursions which can be mostly followed throughout the drill cores from Lausen, Schafisheim, Riniken, Weiach, Benken to Schlattingen over about 75 km. A negative excursion is present in all cores in the lowermost Opalinus Clay in the Opalinum Subzone of the Opalinum Zone. A second excursion with an increase of values can be seen in the uppermost part of the Opalinus Clay succession in the Comptum Subzone of the Opalinum Zone. These two excursions may reflect the global variation in the C-isotope record in the earliest Aalenian. Together with the under- and overlying formations a temporal period from the Toarcian oceanic anoxic event to earliest Bajocian can be covered.

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