1st Early Career Sedimentologist Meeting (ECSM)

organized by

Fachsektion Sedimentologie / SEPM-CES

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Institut für Geologie, Leibniz Universität Hannover

ABSTRACT BOOK

WELCOME TO THE 1ST EARLY CAREER SEDIMENTOLOGIST MEETING (ECSM)

We would like to welcome you to the 1st Early Career Sedimentologist Meeting (ECSM) organized by the Fachsektion Sedimentologie/SEPM-CES.

The section 'Fachsektion Sedimentologie' is part of the German Geological Society (DGGV) and represents the interests of sedimentologists at German-speaking universities, external research institutions, public authorities and within industry. The section is meant as a platform fostering the exchange and network-building between academia and industry partners and provides a forum for discussion and communication for all aspects within sedimentary geology. A major aim of our section is to support young researchers during the early stages of their scientific career.

The first ECSM is held from 8th to 9th of June 2018 at the Institute for Geology at the Leibniz University Hannover. The ECSM is dedicated to bring together young sedimentologists (PhD and MSc students) and professionals from all around Germany to present and discuss their on-going research in an informal setting. The ECSM will provide an informal platform for young researchers to share research experience, discuss new innovative or controversial topics with established colleagues and initiate future collaborations. Keynote speakers from academia and industry will provide insights in job opportunities for sedimentologists and current research topics.

We hope that you will enjoy the 1st Early Career Sedimentologist Meeting and benefit from presentations, discussions and the get-together with professionals and fellow students.

The organizing team,

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Bryoliths- Enigmatic intergrowth of bryozoans and microbes in the Silurian of Sweden (Gotland)

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Keywords: Bryozoa, Bryolith, Microbial Reef, Positive $\delta^{13}C$ Excursion, Silurian

A rather unique reef type is investigated at the Silurian of Gotland. The reefs are composed of bryozoans, sponges, and microbial crusts, forming complex bryostromatolites, so called bryoliths. Other Palaeozoic reef builders like stromatoporoids, corals and crinoids are present but did not play an important role for the reefs construction. The reefs occur during strong positive $\delta^{13}C$ excursions, and a similar pattern can be observed for comparable Ordovician bryoliths. The main features of the bryolith reefs are growth in various directions (even downward), complex interactions of microbes and other reef forming organisms, strong bioerosion, and enigmatic crystals in fenestral structures. These unusual features indicate very specific environmental conditions, maybe related to climatic conditions during times of carbon isotope excursions.

Holocene mangrove forests in Oman: paleoarchives for climate & sea-level variations

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Keywords: mangroves, paleoenvironment, paleoclimate, sea-level change, Oman

Mangrove forests are sensitive ecosystems that can be found globally between 30° north and south. Several species of plants are adapted to the intertidal zone. This zone marks the transition between the marine and the terrestrial realm. The species association is sensitive to changes in both: climate and sea-level. Therefore, these ecosystems are ideal archives that can be utilised to reconstruct environmental changes. We focus on the coastlines of the Arabian Sea in the northern Indian Ocean, specifically the shores of Oman and western India. Climate variability within our study area is linked to the Indian Monsoon circulation. The recent climate in Oman is arid and there are few mangrove forests. These are made up of only one species, *Avicennia marina*. This species is known to be the most tolerant in terms of environmental conditions. Archaeological and sedimentological evidence suggests that mangroves in Oman were more widespread and also enriched in species at the transition from Early Holocene to Mid Holocene (Berger et al., 2013; Lézine et al., 2002). Hence, either climate conditions were more humid at that time or sea-level was different. First field investigations were carried out along the shoreline of northeastern Oman in February 2018. A mapping of species association in shell middens is indicative for the environment exploited as a food source by early human hunters and gatherers. Occurrence of mangrove-adapted species like the gastropod *Terebralia palustris* verifies the existence of nearby mangrove forests at that time. Based on that we carried out shallow subsurface coring and trenching. Sabkha-environments were the most promising locations for this. Here we identified fine-grained paleolagoon deposits of several metre thickness. First lab-results are promising, we currently carry out grain-size analyses as well as macro- and microfossil content. We concentrate on foraminifera and ostracods as they are known to be sensitive to ecological parameters like salinity, temperature, wave-energy etc. Species association will enable us to characterise marine paleoenvironmental settings. In addition to that we will conduct high-resolution pollen analyses on selected trenches to gain insight into terrestrial paleoenvironment and thereby into climatic conditions and variations. Our dating-approach is based on ^{14}C-dating of molluscs and plant remains.
Next field campaigns will be carried out at the western Indian shoreline. By comparison to the omani sites we expect to be able to reconstruct changes in the Indian Monsoon intensity and extend throughout the later part of the Holocene.

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Hardened faecal pellets as a significant component in deep water, non-tropical marine environments

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Keywords: Carnarvon Ramp, carbonate-microfacies model, aragonite dissolution, calcite cementation, bacterial sulfate reduction

Hardened faecal pellets are classically interpreted to form in shallow, tropical environments. However, faecal pellets deposited in deep, non-tropical marine conditions are poorly studied. IODP Site U1460 on the Carnarvon Ramp (SW Shelf of Australia, 214.4m water depth) recovered a nearly continues Pliocene to Recent record of outer shelf sediments deposited at the transition between cool and warm water environments. Below a depth of ~20 CSF-A (m) the relative abundance of sand-sized faecal pellets varies between 0 and 69 %. The origin and composition of the faecal pellets were investigated using scanning electron microscopy, binocular microscope and X-ray diffraction (XRD). The faecal pellets have a uniform size and shape and tend to occur mainly in relatively deeper water during interglacial times. They are mainly composed of skeletal fragments such as ascidians spicules, planktic foraminifera, sponge spicules and coccolith plates in a mud-sized matrix. The pellets therefore show an identical composition compared to the surrounding matrix, indicating that they have formed in situ. X-ray diffraction shows that the faecal pellets consist of aragonite, low-Mg calcite and dolomite. The aragonite at this study reaches up to 30% of the total bulk sediment and generally decreases with depth due to either dissolution or platform progradation. Aragonite dissolution within the faecal pellets is visible e.g. at the tips of the ascidian spicules. The presence of framboidal pyrite within the pellets indicates bacterial-sulfate reduction (BSR). BSR likely explains the observed aragonite dissolution, which is accompanied by an alkalinity increase and in consequence by the precipitation of calcite and dolomite cements. The occurrence of pyrite in a depth starting at 5 CSF-A (m), indicates that aragonite dissolution and calcite cementation already started in the very shallow burial environment. We suggested that the faecal pellets are hardened due to this early cementation by calcite and therefore can be preserved in the fossil record.

Tracks of a jackal-like predator in association with bird and gazelle tracks in lagoonal sediments of Sorbas Basin, SE Spain

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Keywords: jackal, gazelle, bird tracks, predation, migration

A marine-continental transition from the Tertiary of the Sorbas Member in the Sorbas Basin (SE Spain) is under study. Nearshore shelf/tidal channel sediments are overlain by lagoonal deposits and capped by dunes. In the lagoonal sediments a range of avian and mammalian ichnofossils were found. The bird tracks belong to waders (*Antarctichnus fuenzalidae)*, while the mammalian tracks include gazelle (*Pecoripeda (Gazellipeda) gazelle)* and a jackal-like predator (*Canipeda longigriffa*). Jackals have, so far, not been described in this region. The oldest Canidae remains are from the late Miocene, while the first jackals only occur in the Plio-Pleistocene. This track extends the range of jackal-like predators back to the Messinian and might indicate an expansion to Spain via North Africa.

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Astronomical forcing on the Middle Miocene terrestrial water budget in Central Asia: Evidence for climatic control on Badenian evaporite occurrences

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Keywords: Miocene Climate Transition, Badenian Salinity Crisis, evaporites, astronomical climate forcing

Despite overall desertification in Central Asia during the Cenozoic, a period of elevated moisture transport into Asia's continental interior is evident by widespread occurrences of Miocene lacustrine sediments. This study presents data from the Middle to Late Miocene Aktau succession, Ili Basin, SE Kazakhstan, where cyclical deposition in an endorheic alluvial-lacustrine environment and a low gradient ramp-type basin relief favoured a sensitive record of the basin's water budget. Age constraints are deduced from an integrated approach of magnetostratigraphy, cyclostratigraphy and U-Pb dating of lacustrine carbonates. Consequently, the Aktau succession spans a period from 15.5 Ma to 11.0 Ma, including the Miocene Climate Transition (MCT).
Characterisation of the water budget and the evaporation rate is based on a semi-quantitative, facies derived water level and salinity record, stable isotope ($\delta^{13}C$ and $\delta^{18}O$) and element geochemistry data. Accordingly, a period of extreme aridity with substantial evaporite sedimentation is determined, followed by brine dilution and lake expansion.
Time series analysis of the water level and $\delta^{13}C$ record suggests significant climate forcing dependent on the long (405 ka) and short (~100 ka) eccentricity cycles, with water level lowstands due to high evaporation during eccentricity maxima. The salinity- and $\delta^{18}O$ records, instead, seem to be linked to the 1.2 Ma period in obliquity amplitude modulation. Pulses of evaporitic water concentration are induced by decreased moisture supply to Central Asia at times of low obliquity amplitude (nodes).
The period of evaporite precipitation coincides with (a) the MCT, (b) the Badenian Salinity Crisis (BSC) in the Central Paratethys and (c) the isolation of the Eastern Paratethys. In contrast, the subsequent lake expansion is concomitant with the reconnection of the Eastern Paratethys at the Badenian-Sarmatian boundary. We conclude, that astronomical forcing on global and regional climate exerts a great influence on the water budget of the Ili Basin. Moreover, the Aktau succession provides independent evidence for a common trigger of the Middle Miocene salinity crisis in both, terrestrial and marine settings in addition to the closure and opening of Paratethys gateways. This emphasizes the contribution of atmospheric forcing on the marine BSC at the expense of a solely sea level and tectonics driven control.

Formation of an Pleistocene aragonite lowstand wedge along the North West Shelf of Australia (NWS), insights from Site U1461 of IODP Expedition 356

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Keywords: carbonates, non-skeletal grains, ooids, aragonite mud

The widely used “highstand shedding” concept predicts that carbonate production on flat-topped platforms and distally-steepened ramps peak during sea-level highstand when the inner platform is flooded. In contrast, surface-sediment sampling at the distally steepened ramp of the North West Shelf of Australia (NWS) indicates that very little aragonite mud is produced during modern highstand conditions. Instead it has been proposed that considerable amounts of aragonite have been produced during the last glacial maximum forming a regional aragonite lowstand wedge with a volume which could rival typical highstand systems. To test this hypothesis, we investigated the upper 70 m of Site U1461, which has been cored during IODP Expedition 356, using a combination of geophysical log interpretation, thin-section and SEM petrography, stable oxygen and carbon isotope analysis, and XRD derived mineralogy (n>100). XRD data has been further used to calibrate a nearly continuous XRF-Scan, providing a high-resolution record of mineralogical variation (e.g. aragonite).

The investigated section displays a distinct pattern with alternating changes in core color from dark to light. Dark sections are dominated by calcitic mineralogy and elevated amounts of siliciclastics, while the lighter sections are mainly aragonitic with little to no amounts of siliciclastics. Based on composition the aragonite rich sections are further subdivided into parts which are rich in mud and parts which contain high amounts of non-skeletal grains such as peloids and ooids. Ooids, although not well developed, are a clear indication for a very shallow paleo water depth as well as a high carbonate saturation. They are proposed to have formed during glacials, when elevated aridity and a low sea-level guaranteed favorable conditions for ooid formation along the NWS. The first ooid rich section in particular is thought to have formed during the last glacial maximum (LGM), when a large fall in sea-level (-120 m) brought Site U1461 within very shallow water depths.

Crystal morphology, isotope signatures and mineralogical composition of aragonite micrite indicate formation as a seawater precipitate at times of elevated carbonate saturation. Micrite production and redeposition are therefore proposed to have peaked during sea-level lowstands.

During sea level highstands (i.e. interglacials) a combination of strong riverine input, the unimpeded influence of strong oceanic currents, and a low salinity hindered aragonite production. Instead a calcitic pelagic ooze forms, presently overlying the aragonitic lowstand wedge.

Climate and environmental change in SE Europe over the last 300 years based on the partly varved sediment record of Lake Vouliagmeni (Greece)

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Keywords: Climate variability, Varve microfacies, µ-XRF scanning, Little Ice Age, SE Europe

To gain new insights into past climate and environmental change in SE Europe, a partly laminated sediment record from Lake Vouliagmeni (Eastern Gulf of Corinth, Greece) was investigated, using an integrated sedimentological and geochemical approach. The record spans the last ~300 years (1710-2015 AD), based on an age model established using 210Pb and ^{137}Cs dating as well as varve counting. Microfacies analysis, including standard optical techniques and sub-layer thickness measurement, was carried out. Element geochemical data obtained from high-resolution XRF core scanning were analyzed by applying a principal component analysis. Three major sedimentary units were identified within the record. Based on seasonal depositional models, it could further be shown that the laminated sediments in the record are of annual character, therefore representing true varves. Two major varve types were identified within the laminated sections of the sequence. In addition, depositional processes for the detrital layers observed in the record were discussed.

The proxy data obtained from microfacies analysis, µ-XRF core scanning and principal component analysis were used to reconstruct natural and human-induced ecosystem changes at Lake Vouliagmeni. In addition, the proxy data was interpreted regarding their paleoclimatic and paleoenvironmental implications, indicating changing precipitation patterns in the Eastern Gulf of Corinth during the last ~ca 300 years. Integrating these results with XRF-derived Ti/Ca ratios and K concentrations from other key sites on the Balkan Peninsula (Francke et al., 2013; Morellón et al., 2016; Koutsodendris et al., 2017), the record provides new insights into spatiotemporal precipitation variability in SE Europe, and particularly the Balkan Peninsula, during the end of the Little Ice Age and the onset of modern warming. In conclusion, the sediment record from Lake Vouliagmeni represents a valuable new archive for ecosystem changes in a Mediterranean lacustrine setting and for past climate and environmental variability on the climatically sensitive Balkan Peninsula.

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Anoxic platform top water masses during OAE1a – the carbonate archive

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Keywords: anoxia, Lower Aptian, microencrusters, OAE1a, Tethys

Evidence has been given for a fundamental biotic turnover in the prelude, during, and in the aftermath of the Lower Aptian Oceanic Anoxic Event (OAE) 1a in a series of Tethyan-wide (Oman, Croatia) and proto-Atlantic (Portugal) shallow-water carbonate platforms. The taxonomically problematic microencruster communities referred to as *Bacinella irregularis* and *Lithocodium aggregatum* temporarily replaced coral and rudist-dominated ecosystems. Little is known about the triggering factors that control the temporal dominance of the latter. Our working hypothesis is that in the context of the larger OAE1a, reduced dissolved seawater-oxygen levels of Lower Aptian shallow neritic water masses temporarily impaired oxygen-dependent coral-rudist communities as efficient neritic carbonate producers. Uranium isotope ($^{238}U/^{235}U$) analysis, redox sensitive trace elements as well as Rare Earth Element (REE) patterns, particularly Cerium anomalies, are used in this study as proxies for seawater redox conditions. In combination with detailed fieldwork and thin section analysis, these proxies represent a powerful tool to reconstruct the seawater-oxygen content prior and during the OAE 1a time interval. First $^{238}U/^{235}U$, REE and trace element results from the Kanfanar section in Croatia show a significant decrease in dissolved seawater-oxygen at the beginning of laminar and massive *Bacinella irregularis* and *Lithocodium aggregatum* growth, though to be occurring slightly after the onset of OAE1a. A stratigraphic attribution of the OAE1a time interval in the Kanfanar section was done by Sr-isotope analysis ($^{87}Sr/^{86}Sr$). These data may point towards a dichotomy of oceanic oxygenation levels between the deep and shallow marine area. Given the coeval onset of massive microencruster growth and neritic oxygen level depletion in Kanfanar, the hypothesis of neritic (sub)anoxia as the main controlling factor for the palaeoecological turnover seems plausible. Further work will focus on: (i) the importance of regional factors, here particularly the formation of regionally limited, platform-top anoxic water masses, overprinting a global environmental trend that finally culminated in OAE1a-related basinal black-shale deposits, (ii) the changes in environmental conditions before and after the *Lithocodium aggregatum* and *Bacinella irregularis* interval as well as (iii) the lateral distribution of those microencrusters in Oman, where two *Lithocodium aggregatum* and *Bacinella irregularis* intervals, interrupted by rudist intervals, are present and offering an ideal opportunity for further analysis.

Sedimentological and paleontological investigation of Holocene mangrove swamps in Oman

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Keywords: Oman, mangrove, sea level, granulometry

Mangrove swamps belong to the intertidal zone, which is a highly dynamic environment. Since sea level changes play a major role in growth and decline of mangrove forests, they are often used as a sea level indicator. Furthermore, mangroves are able to minimize coastal erosion by reducing water movement leading to increased sedimentation (cf. Alongi 2008).
The mangrove forest distribution we find today is only a legacy of the forests that occurred during the Holocene (Alongi 2008). This is also the case in the Sultanate of Oman, where there has already been research about Holocene mangrove swamps (cf. Lézine et al. 2002 and Berger et al. 2013). Archaeological evidence indicates a more widespread distribution of mangrove forests in the middle Holocene. Changes in mangrove ecosystems also reflect changes in precipitation and temperature. These climatic factors are related to global monsoonal circulation patterns.
In this study Holocene paleo-mangrove ecosystems are further investigated by sedimentological and paleontological analyses of the soil. A study site south of the city Sur was chosen for field work including 30 drillings and seven trenches. Lab analyses focused on grain-size analysis and geochemical investigations as well as paleontological analysis of molluscs and foraminifera.
We aim to identify the mechanism of environmental changes within mangrove ecosystems. This research will sharpen the picture we have of Holocene mangrove swamps in Oman. Additionally, the analysis of mangroves may reveal further evidence about the environment such as local sea level. As sea level is currently rising due to climate change, this information might lead to predictions of the changes the ecosystem in Oman will experience.

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Pore Type Characterization and Detection of Effective Pore Network with Digital Image Analysis: A case study from Miocene Lacustrine Carbonates (Southern Germany)

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Keywords: Carbonate Pore System, Digital Image Analysis, Lacustrine Carbonates, Nördlinger Ries, Miocene

In addition to routine porosity and permeability measurements, the application of Digital Image Analysis (DIA) results in quantitative data of pore geometry, which is the main factor controlling petrophysical properties in a sedimentary rock. In this study, these DIA-derived data are utilized to characterize each occurring pore type and to detect the most effective pore types which form an interconnected pore network and therefore determine fluid flow and permeability. We provide a step by step workflow of a new approach based on DIA, performed on 76 samples of marginal lacustrine carbonates from the northern lake margin of the Miocene Nördlinger Ries crater lake in Southern Germany. This method comprises four main steps, each providing multi-scale information to characterize each individual pore, each pore type and the entire pore system. Since each pore type is confined by the sedimentary fabric and linked to a distinct genetic process, results can be transferred to recent and ancient analogues settings, and complement to diagenetic studies of the paragenetic history of the pore-hosting sedimentary rock. As a result, the extraction of the interconnected (or effective) pore network leads to an improved correlation between porosity and permeability which eases the often difficult prediction of both petrophysical parameters in carbonates.

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Towards a sediment budget of the Buntsandstein in Europe and its implication for palaeoenvironmental conditions at and shortly after the Permian-Triassic Boundary

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Keywords: Sediment budget, Lower Triassic, Isopach map, Buntsandstein, Depositional area

The palaeoenvironmental turnover at the Permian-Triassic Boundary (PTB) led to a strong increase of clastic sediment fluxes from the continents to the oceans, which is usually interpreted as the response to deterioration of ecosystems, soil stripping and a strong weathering regime. In western and central Europe, this time interval is represented by the lithostratigraphic group of the Buntsandstein. To gain better insight into the dimension of sediment fluxes during Buntsandstein deposition, we calculated the sediment volume of the Lower, Middle and Upper Buntsandstein subgroups based on the compiled Isopach maps of the Southern Permian Basin Atlas (SPBA). In the first step, the sediment distribution area in Lower, Middle and Upper Buntsandstein times was estimated by using the digitized Isopach maps of the SPBA in GIS. Afterwards, the average thickness of each area was calculated from Isopach maps. The volume of sediments contained in an area can be estimated by multiplying the distribution area and the average thickness ($V=A\times T$). Accordingly, the volume of each interpolated sedimentary area was calculated for each time period. The extracted areas and volumes of each period illustrate a steady decrease from Lower, Middle and Upper Buntsandstein by 15 and 21% for the depositional area, and 23 and 45% for the sediment volume. The Lower, Middle and Upper Buntsandstein are estimated to span ~2, ~4.5 and ~1.5 million years, respectively. Using these time estimates the corresponding sediment fluxes are ~10.4, ~3.6 and ~5.9 $\times 10^{13}$ m3/Ma. The strong decrease from the Lower to the Middle Buntsandstein supports the hypothesis of a strong clastic signal close to the PTB (little below or above the lithostratigraphic boundary depending on different authors). This signal decays over ca. 6.5 million years, before a slight increase occurs in the Upper Buntsandstein. This increase may be explained by the wetter climate in the Upper Buntsandstein, higher transport capacities, but still sparse vegetation cover. So far, (bio) chemical sediments are not subtracted from this budget, but are assumed to be small compared to clastic fluxes. Our next steps will involve refining this sediment budget and combining it with provenance data in order to correct for grain size, porosity and sediment recycling.

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Depositional environments and their control on sandstone diagenesis: the example of the mid-Carnian Schilfsandstein (Central European Basin)

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Keywords: Triassic, mid-Carnian episode, Stuttgart Formation, diagenesis, sandstone reservoirs

Previous studies on sandstone diagenesis focussed mainly on general aspects of burial diagenesis, such as compaction, fluid migration phases and related formation of authigenic minerals, and migration of hydrocarbons. In contrast, the control of depositional environments on the formation of eo-diagenetic cements and their implications for burial diagenesis of sandstones has been addressed by only a few studies so far. Ongoing research on Mesozoic sandstone reservoirs of the North German Basin attempts at an exploration strategy contributing to improved predictions of hydrothermal reservoirs, in particular of reservoir qualities. The case study on the mid-Carnian fluvio-deltaic Stuttgart Formation (Schilfsandstein) exemplifies the control of depositional environments on the diagenetic evolution of sandstone reservoirs. Sandy bedforms from brackish-marine delta front and lower delta plain environments, such as distributary channels and crevasse splays, were subject to eo-diagenetic formation of (marine) carbonate cements. During the early diagenesis, this pore-filling cementation supported detrital grains and contributed to low contact strengths. The carbonate cementation was partly replaced by patches of analcime during burial diagenesis and completely replaced during late diagenetic uplift resulting in open pore space. The low contact strengths of deltaic sandstones, loose grains and point contacts predominate, are in contrast to higher contact strengths of fluvial channel and crevasse splay sandstones. These are characterised by convex-concave and sutured contacts, resulting from compaction during early diagenesis. Pedogenic modifications of floodplain sheetsands resulted in lessivation of clay minerals and formation of calcic, gypsic of ferric impregnations, mainly in form of nodules. During early burial diagenesis, the clay translocation resulted in formation of illite/smectite and/or ferruginous coatings around detrital grains. The nodular impregnations partly supported the grain fabric resulting in variable degrees of grain compaction. Both, coatings and impregnations inhibited the growth of authigenic cements on grain surfaces during later diagenetic stages. The late diagenetic replacement of nodular calcic or gypsic impregnations partly contributed to a fabric of floating grains and oversized pores. Suspension load dominated deposits of levees and delta plain wetlands are formed of heterolithes and thin sandy bedforms. These bedforms are characterised by low grain compaction, suggesting eo-diagenetic carbonate cementation, and later formation of pore-filling blocky analcime and mesh-like chlorite contributing to an almost complete cementation of open pore space.

Rift systems in the southwestern margin of Gondwana: provenance and volcano-sedimentary facies reconstruction of the Permotriassic Mitu Group (Central Andes, Peru)

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Keywords: Mitu Group, Permotriassic, provenance, western Gondwana, facies analysis

The transition from the Late Paleozoic magmatic arc regime of southwestern margin of Gondwana to the Andean accretionary orogen initiated in the Early Jurassic. It is marked in Peru and northern Chile by the development of a system of extensional basins developing in the course of the Permian and Triassic. Although important records of both magmatism and sedimentary basins are present along this margin of Gondwana during the Late Paleozoic, it is still controversially discussed whether extensional tectonics occurred in a back-arc or a rift setting. The development of sedimentary models for these extensional basins and its tectonic overprint is complicated by a number of issues. The most important are the lack of a comprehensive analysis of volcanosedimentary facies and depositional environments, the lack of biostratigraphic and chronostratigraphic constraints as well as the scarcity of data on the temporal and geochemical variations reflected by the volcanosedimentary successions. In this study we present first results of our analysis of facies and provenance of Permotriassic basins fills in southern Peru. Our study aims at constraining the sedimentology, chronology, spatial development and tectonic setting of evolving depocenters.

The Permotriassic stratigraphic record in the Peruvian Andes is represented by continental basin fills that consist of stratigraphically poorly controlled volcanosedimentary successions known as the Mitu Group. Fieldwork results in Cusco region indicate that deposition of the Mitu Group and equivalents was initiated by a transition from the carbonates of the upper Permian Copacabana Group via a mixed carbonate-siliciclastic interval of c. 30 m thickness to the siliciclastic and volcanic Mitu Group. The latter is characterized by widespread alkaline and calc-alkaline lavas and ignimbrites interbedded with thick continental successions deposited in fluvial and alluvial environments. The beginning of Mitu sedimentation in the Cusco region is characterized by short-lived intermediate and felsic volcanism interbedded with fluvial deposits, followed by an extended development of floodplain facies and a lack of volcanism. This transits to a coarsening-upward evolution of fluvial facies associated with increasingly voluminous intermediate volcanic rocks. Increased rates of deposition and volcanism took place in semi-grabens accommodating alluvial fans at the top of the Mitu Group.

We constrain provenance and geochronology of the depositional record by single-grain studies of heavy minerals, whole rock and trace element geochemical analysis, U-Pb geochronology of detrital zircon and rutile and Lu-Hf isotope analysis of dated zircons. Here we present first detrital zircon age dates of key strata at the transition to and at the base of the Mitu succession. In previous studies, the upper Permian part of the Mitu Group in the Cusco region has been considered to overlie the limestones and subordinate sandstones of the Lower Permian Copacabana Group above a hiatus. However, our results of both field work and LA-ICP-MS dating of detrital zircons indicate the absence of significant hiatus in a portion of Cusco region, exhibiting an environmental transition from marine to continental conditions during Middle to Upper Permian between the Copacabana and Mitu groups respectively. Two calcareous sandstones from the top of the Copacabana Group gave a maximum depositional age of 262.6 ± 1.5 Ma and 262.5 ± 1.4 Ma respectively. The stratigraphically oldest sample of the Mitu Group yielded a maximum depositional age of 261.4 ± 1.2 Ma. Additionally, four pyroclastic flow deposits ranging from c. 260

Ma to c. 223 Ma indicate that volcanic events in the Mitu basins took place from the upper Permian to the Upper Triassic. A sandstone at the top of the Mitu succession in the Cusco region with a maximum depositional age of 197.5 ± 2.7 Ma indicates that Mitu sedimentation may have persisted in southern Peru until the Early Jurassic.

Calcareous nannofossils from Upper Cretaceous marginal marine deposits and their implications for stratigraphy and paleoecology

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Keywords: micropaleontology, Late Cretaceous, biostratigraphy, chemostratigraphy, Münsterland Basin

The early Late Cretaceous eustatic sea-level rise of about +200 m caused a widespread accumulation of (hemi-)pelagic chalks and marls in former continental areas (Hay 2017, 2008). In these Upper Cretaceous sediments, the highest diversities of calcareous nannofossils in earth history have been documented (Bown et al. 2004). In our study, we investigate the biostratigraphic potential and the paleoecology of calcareous nannoplankton in shallow marine to coastal deposits. Due to post-depositional erosion, these sediments are underrepresented in the geological record. Upper Cretaceous sand- and glauconite-rich marls, deposited about 5-15 km off the paleo-coastline, have recently been cored in 13 boreholes at the southwestern Münsterland Basin. By detailed sampling for calcareous nannofossil analysis and stable isotope measurements ($\delta^{13}C$ bulk carbonate), a stratigraphic framework has been obtained from the successions. All samples are characterized by well-preserved and diverse calcareous nannofossil assemblages of about 50-80 different taxa. The deposits cover an interval of earliest Cenomanian (nannofossil zone UC0-1a) to early Campanian age (nannofossil zone UC14). We identified seven major unconformities at different stratigraphic levels, which allow to reconstruct the development of the paleo-coastline. In addition to the global sea-level rise of the Cenomanian-Turonian interval, independent synsedimentary tectonic movements in the Turonian influenced the regional sedimentation patterns. The diverse nannofossil assemblages in shallow marine deposits further improve the ecological understanding of calcareous phytoplankton through time.

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Carbonates in intra-arc settings: an example from the Tithonian-Hauterivian Toqui Formation in southern Chile.

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Keywords: carbonate, intra-arc, volcanism, shallow-marine, Aysén Basin

The Aysén Basin forms the northern part of the Austral Basin in Patagonia (43°S-50°S). This intra-arc to back-arc basin, developed over volcanic units related to the break-up of Gondwana, was filled by a transgressive-regressive sedimentary succession known as Coyhaique Group (Tithonian-Aptian). Its lower member, the Toqui Formation, comprises a volcanoclastic-epiclastic rock sequence with repeated biostrome-associated limestone intercalations. Microfacies analysis from core-samples and surface outcrops in the type locality (Toqui Mine District) indicate a predominance of ash-tuff and volcaniclastic sandstone, with occasional limestone beds, the latter more common towards the base of the unit. The limestone is here interpreted as a bioclastic (bivalve-bearing) floatstone as well as mud- and fitted packstone. The fossil association is dominated by oysters, trigoniids and other bivalves, but echinoderms, vermetid gastropods and serpulids are also abundant. Volcanic and terrigenous input is also significant but variable, with repeated intervals of lithic tuff intercalation with fiamme-like textures. The Toqui Formation thus represents a shallow marine environment with normal salinity in the back-reef of a rimmed-carbonate shelf. The carbonate shelf was developed in close distance to active volcanic islands in a fault-bounded intra-arc basin. At district scale, rocks were affected by a marked burial diagenesis and skarn-related processes.

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An integrated bio-chemostratigraphic framework for Lower Cretaceous (Barremian-Cenomanian) shallow-water carbonates of the Central Apennines (Italy)

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Keywords: Shallow-water carbonate platform, Lower Cretaceous, Central Apennines, Biostratigraphy, Chemostratigraphy

Shallow-water carbonate platform sections are valuable archives for the reconstruction of deep-time environmental and climatic conditions, but the biostratigraphic resolution is often rather low. Moreover, chemostratigraphic correlation with well-dated pelagic sections by means of bulk carbonate carbon-isotope stratigraphy is notoriously difficult and afflicted with large uncertainties, as shallow-water sections are particularly prone to the impact of diagenesis.
In the current study, an integrated biostratigraphic-chemostratigraphic approach is applied to southern Tethyan Lower Cretaceous carbonate platform deposits (Santa Lucia, Monte La Costa sections) situated in the Central Apennines in Italy. The 600 m thick Santa Lucia section, representing an open lagoonal inner carbonate platform setting, provides a characteristic carbon- and oxygen-isotope pattern that allows for correlation with pelagic composite reference curves (Vocontian and Umbria Marche basins). Calibrated by means of foraminiferal biostratigraphy and rudist bivalve strontium-isotope stratigraphy, the section serves as local chemostratigraphic shallow-water reference for the Barremian to Cenomanian. The 450 m thick Monte La Costa section comprises predominantly coarse grained (biostromal) and often strongly cemented shelf margin deposits. Although benthic foraminifera are scarce and the carbonates evidently suffered strong diagenetic alteration, high-resolution (rudist shell) strontium-isotope stratigraphy in combination with superimposed carbon-isotope trends and biological-lithological changes (e.g., mass occurrences of *Bacinella irregularis* s.l) enables correlation with the Early Albian to Cenomanian portion of the Santa Lucia reference section. At both localities, chemostratigraphy indicates a major gap covering large parts of the Lower and middle Cenomanian.
After having considerably improved the stratigraphic resolution of the studied sections, selected best-preserved rudist shells are going to be used for sclerochronological investigations. This will allow reconstructing the impact of long-term (Myr) and short-term (seasonal) paleoclimatic and paleoenvironmental changes on Cretaceous shallow seas.

Palaeoenvironmental reconstruction of Jurassic–Cretaceous boundary deposits in the Lower Saxony Basin based on micropalaeontology

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Keywords: Jurassic-Cretaceous boundary, palynofacies, palaeoenvironment, ostracods, Wealden

The Jurassic–Cretaceous boundary interval in the palaeogeographically restricted Lower Saxony Basin is characterised by non-marine Purbeck- and Wealden-type sediments. These were deposited under variable saline, freshwater, and brackish–marine conditions (Kemper, 1973; Strauss et al., 1993; Elstner and Mutterlose, 1996). A high-resolution quantitative study of the organic matter content, based on three cores, was performed to characterise the palynofacies and to detect salinity fluctuations. Ostracod based palaeoecological reconstructions in combination with palynofacies data are used for an environmental interpretation.
Palynofacies assemblages are dominated by a complex mixture of granular amorphous organic material (AOM), dinoflagellate cysts, and *Botryococcus* algae. The AOM is interpreted to have originated from phytoplankton or its microbial degradation. Dinoflagellate cysts were assigned to five different morphogroups following Schneider et al. (2017); their distribution is highly sensitive to salinity changes. Prasinophytes, acritarchs, and foraminiferal linings occur only occasionally (<2%). The long-term climatic (Schneider et al., submitted for publication) and hydrological evolution (this study) of the Lower Saxony Basin is interpreted by a stratified water column model. The deposition of organic matter-rich beds (up to 18% of total organic carbon) is explained by the establishment of prolonged anoxic bottom water conditions.

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Provenance information recorded by mineral inclusions in detrital garnet: An example from the HP/UHP Western Gneiss Region in SW Norway

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Keywords: Sediment provenance, Garnet, Mineral inclusions, Raman spectroscopy

In sedimentary provenance analysis, it is of specific interest when high-pressure (HP) and ultrahigh-pressure (UHP) rocks start contributing material to the sedimentary record because this event directly reflects the exposure of deep crustal levels in the source area, which typically has significant geologic and geodynamic implications. Characteristic mineral phases of HP/UHP metamorphism (e.g., glaucophane, lawsonite, omphacite, kyanite, coesite), however, are rarely well-preserved in sediments and sedimentary rocks due to frequent overprinting of the source rocks under lower-pressure metamorphic conditions during exhumation, and the low mechanical and/or chemical stability of these minerals. Here we present the distribution of mineral inclusions in detrital garnets from two proximal modern sand samples taken in the HP/UHP Western Gneiss Region of SW Norway. Overall, all mineral inclusions ≥2 µm were identified by Raman spectroscopy in ~150 fine to medium sand sized garnets of each sample. Besides inclusions of minerals which are abundant in many metamorphic rocks and/or do not point to specific source rocks (e.g., quartz, feldspars, micas), in particular the presence of omphacite, diopside, enstatite, kyanite, rutile, coesite, amphibole-group, and epidote-group inclusions well reflect the geological characteristics of the sampled catchments. The results show that (i) less stable, but for provenance studies important, mineral phases occur as inclusions in detrital garnet, suggesting that these can be preserved in the sedimentary record as long as garnet is stable; and (ii) inclusions in detrital garnet are useful indicators to verify HP/UHP provenance.

Late Holocene sedimentation in coastal areas of the South Shetland Islands (West Antarctic Peninsula, Antarctica)

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Keywords: Climate fluctuation, North Antarctic Peninsula, Holocene, Granulometry, Glaciology

The northern part of the West Antarctic Peninsula reveals a clear response to the modern global warming trend and thus is a key area for the study of global climate change. Earlier studies in Maxwell Bay (between Nelson and King George Island (KGI)) revealed that sediment dynamics can serve as a proxy for the advance and retreat of glaciers, reflecting periods of regional climate variation. This study aims at extending these results to areas further south of KGI. Maxwell Bay is a larger bay with a number of tributary fjords, in which former tidewater glaciers have retreated onto land as a response to the rapid warming trend during the past decade(s). During warmer climate periods, meltwater-transported fine-grained sediment produced clear signals in sediment cores. These are largely absent during colder periods. A sediment core from the coastal South Shetland Islands were taken in March 2016. AMS radiocarbon dates form the basis for a preliminary age model. Multiparameter analyzes including high-resolution granulometry of the core were conducted along with a range of further methods. The core consists primarily of fine-grained silt and show unimodal grain-size frequency distributions throughout. However, there are distinct fluctuations in the mean grain size over longer periods of time. The fluctuations in grain-size parameters resemble those of sediment cores from Maxwell Bay in which they were interpreted to result from climatically-controlled fluctuations in meltwater input. Hence, the fluctuating grain-size data of the core of this study are most likely related to climate variations of the late Holocene. The Medieval Warm Period and Little Ice Age can be distinguished with some certainty. When compared to the results of Maxwell Bay, the signals are much weaker, but still significant.

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From Reefs to Drifts - Miocene/Pliocene Sedimentary Change in the Browse Basin, NW Australia

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Keywords: carbonate reefs, Browse Basin, North West Shelf, drift-deposits, seismic

The upper Miocene to Pliocene interval of the Browse Basin on the Australian North West Shelf (NWS) comprises a significant paleo-environmental change in sedimentary record containing the decay of middle to late Miocene tropical reef build ups buried by drift deposits (Rosleff-Soerensen et al., 2015; Saqab & Bourget, 2015). The triggering factors for this transition (e.g. changes in subsidence, eustasy, current regimes, inversion tectonics) are still discussed and have not been studied in detail. This study focuses on localizing late Miocene to Pliocene reef build ups, analyzing their 3D seismic characteristics and documenting and differentiate the overlaying drift-deposits. The foundation of this project is the investigation of a 2D and 3D seismic-reflection data set covering a study area extending over 130.000 km² supported by industry borehole data (logs, cores, and cuttings). SR-Isotope dating, X-Ray diffractometry and microfacies analysis of upper Miocene to Pliocene sediments were conducted for 19 boreholes around the region and have been integrated into the data set, providing rock evidence on stratigraphic change and biostratigraphy. Wireline logging data of over 40 wells will be compared and integrated to extend the sample data over the entire study area.

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A Quantitative Study on the Wuchiapingian Reef in Laibin, South China

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Keywords: Late Permian, Wuchiapingian, Reef ecology, Microbial carbonates, Recovery

The shallow water ecosystem has been changed significantly after the end-Guadalupian event (Jin et al., 1994; Stanley and Yang, 1994). Although the recent stratigraphic record of losses in groups including foraminifera, brachiopod and others indicate that the range of this crisis started earlier than the Guadalupian/Lopingian boundary, which suggested a mid-Permian (Capitanian) mass extinction (Bond et al., 2010; Wignall et al., 2009), the decreased paleographic distribution and diversity of reefs in Wuchiapingian stage still catches attention (Weidlich, 2002a; 2002b).
To investigate the reef building model and ecology in this post-crisis stage, here we present a quantitative study of Wuchiapingian reef from the Tieqiao Section, which is located at the northen bank of the Hongshui River, Laibin city, South China. It developed at the margin of an isolated platform in the Dian-Qian-Gui Basin, with a thickness of 150 m. According to our results, Tieqiao reef was constructed by calcareous sponges, hydrozoan, *Archaeolithoporella*, *Tubiphytes*, Tabulazoan and microbialites. The calcareous sponges in Tieqiao reef are mainly small broken fragments of Inozoan sponges, which have been encrusted by Archaeolithoporella, Tubiphytes, microbialites and early marine cement in multiple layers. These components were bound together into more solid aggregates, then block sediments, till they became stable enough. Well preserved Sphinctozoan sponges, some of them taller than 30 cm, which are not principal reef builder, has been found in the late stage of reef development, overtaken by Inozoan sponges with encrustation.

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New chronological data of detrital zircons in Ordovician meta-sediments of the Eastern and Southern Alps

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Keywords: U-Pb dating, zircon, Palaeozoic, Meta-Sediments, Eastern and Southern Alps

In Palaeozoic times, the basement of the Alps was located alongside the margin of the supercontinent Gondwana and belonged to the complex association of peri-Gondwana terranes. After the late Neo-Proterozoic Cadomian orogeny, the northern Gondwana shelf platform became mostly a passive continental margin, where thick sequences of clastic sediments were deposited. Stratigraphic gaps in the Cambrian and Ordovician as well as volcanic episodes give evidence for repeated rifting as well as transpressive pulses along the margin in the early Paleozoic. In the Silurian and Devonian clastic sedimentation became more distal and graded into carbonate deposition. The Carboniferous is characterized by flysch deposits and the Variscan orogeny and an unconformity. In the Upper Carboniferous and Permian terrestrial molasse-type deposits are overlain by increasingly marine deposits. In the Cenozoic, the Paleozoic basement and sedimentary successions were incorporated into the Alpine orogen. Where the so called “protoalps” were located at the northern margin of Gondwana is not clarified completely yet and different models exist. With U-Pb dating of detrital zircons a possible source of the sediments can be determined and a potential location of the alpine terranes can be identified. In contrast to the Armorican terranes north of the Alps, detrital zircons of Paleozoic rocks in the Alps have not been studied systematically so far. In order to receive a first insight into detrital zircon age spectra, we analysed three samples from the Austroalpine and three samples from the Southalpine realm (Carnic Alps) by LA-ICPMS. The stratigraphic age are assigned to the Ordovician and Permotriassic. The obtained ages of the detrital zircons show distinct peaks at around 500 Ma – 800 Ma, 900 Ma – 1050 Ma and 2500 Ma – 2800 Ma and indicate a possible provenance of the sediments from eastern Africa. Moreover a magmatic event at around 450 Ma could be determined, which is well known from the Alpine basement (Ceneric Orogeny). Furthermore, the age of some Austroalpine units south of the Tauern Window could be better constrained.

The nature of the mid Barremian event (Early Cretaceous)

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Keywords: micropalaeontology, calcareous nannofossils, mid Barremian event, oceanic anoxic event, stable isotopes

Climatic perturbations during the Cretaceous time interval lead to several so called oceanic anoxic events (OAE's). During these events, ocean bottom waters were depleted in oxygen, causing the distribution of characteristic sediment deposits, namely black shales. OAE's, particularly OAE 1a and OAE 2, have been intensively studied since their first description (Schlanger & Jenkyns, 1976) and their affection on earths' climate, as well as on floral and faunal communities is in large part known.
Apart from these named OAE's, black shales of mid Barremian age are currently being discussed by the scientific community as an indicator for an additional OAE. It is not clear whether this mid Barremian event is either a regional or a global phenomenon and the scientific community is two-minded among this question. Based on studies of mid Barremian black shales from northern Germany it is suggested, that the anoxic bottom water conditions were temperature controlled and clearly reflect a regional signal. On the other hand, mid Barremian black shales have been recognized in the Tethyan realm (Switzerland, Italy, France, Vocontian Basin) indicating a more global distribution of the mid Barremian event. The globally known OAE's, OAE 1a and OAE 2, affected the composition of calcareous nannofossil assemblages and their evolution patterns. This might also be the case for the mid Barremian event and is currently validated by analyses of size variations of calcareous nannofossil assemblages in the Boreal Realm, amongst others in the drill core "Frielingen KB 9". Additionally, stable isotope measurements are currently performed in order to validate, if the shift, which has been recognized for OAE 1a and OAE 2, can also be proved for this event.

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The oldest desert on Earth? A critical review of Archean eolian transport

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Keywords: Eolian, large foresets, facies interpretation, Barberton Greenstone Belt, Moodies Group

The Moodies Group (~3.22 Ga), uppermost unit of the Archean Barberton Greenstone Belt (BGB), South Africa and Swaziland, represents a unique archive of information about the early Earth's surface because of its excellent preservation and mappable facies of sedimentary environments. Widespread braided-river, sandy coastal plains, deltaic, estuarine, tidal, and minor alluvial settings are known. In addition, large foresets in sandstones have been postulated to represent the world's oldest eolianites (Simpson et al., 2012).

It is unknown to what degree the Archean provided the conditions for the formation and preservation of eolian sands. The early emergence of sizeable continents and the increasing availability of plutonic quartz, combined with possibly strong winds and the absence of vegetation, appears to offer plentiful opportunities. It is thus puzzling that very few Archean eolian deposits have been described in the literature; even fewer are confirmed.

Stratigraphy and facies of a large proportion of the Moodies Group outcrop area is not satisfactorily understood. While strata north of the greenstone-belt-axial Inyoka Fault are reasonably well studied, little attention has been paid to Moodies strata south of this fault where Simpson et al. (2012) indicated the presence of eolianites. Cursory mapping of these large-foreset sandstones in 2017 showed that their interpretation is debatable because typical diagnostic features of eolian sandstones, apart from large-scale foresets, are absent from these units. Grain sorting and rounding of grains is mostly poor; most sandstones have a sericite-rich matrix. We could not document characteristic sedimentary structures on outcrop-scale such as inversely graded stratification and pin stripe lamination; map-scale features such as interdune deposits characterized by micro-evaporitic structures, desiccation cracks, and ventifacts could not be identified.

An estuarine or delta-mouth-bar setting appears to be more likely but further field work is necessary to resolve this issue.

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Syndepositional deformation in an Archean sag basin: Powerline Road Syncline, Barberton Greenstone Belt, South Africa

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Keywords: Barberton Greenstone Belt, Moodies Group, sandstone petrology, paleoenvironments, subvertical tectonics.

The Moodies Group (~3.22 Ga), uppermost unit of the Archean Barberton Greenstone Belt (BGB), South Africa and Swaziland, represents a unique archive of information about the early Earth's surface because of its excellent preservation and mappable facies of sedimentary environments. Widespread braided-river, sandy coastal plains, deltaic, estuarine, tidal, and minor alluvial settings are known. However, many areas of the Moodies Group outcrops are not satisfactorily understood in terms of stratigraphy and facies. While Moodies north of the Inyoka Fault is reasonably well studied, little attention has been paid to Moodies strata south of this fault.

Here we present a geological map of Powerline Road Syncline (PRS), a major structure just south of the Inyoka Fault in the central Barberton Mountain Land, showing results of detailed mapping and sampling of Moodies strata during a four-week field campaign in July and August 2017.

PRS is an in map-view ellipsoidal, tightly folded, locally northward overturned doubly plunging syncline, defined by Moodies Group sandstones and conglomerate and framed by older Fig Tree and Onverwacht Groups of the Barberton Greenstone Belt. Sandstones vary widely by sorting, roundness of grains, sedimentary structures, lateral extent and outcrop appearance. Four facies define an overall deepening-upward trend: Sandstones and conglomerate show a transition from braided-stream or distal fan-delta paleoenvironment to subtidal estuarine conditions.

Some units in PRS lack correlatable horizons when traced around the synclinal hinge. Together with significant difference in unit and total thickness on the northern and southern limbs, distinct facies changes in the northwest and southern parts of the PRS, in part across minor faults, indicate syndeformational deposition of Moodies units, likely in a non-actualistic early Archean sag basin dominated by surbvertical tectonics.

Strontium and carbon-isotope chemostratigraphy of Kimmeridgian shallow-water deposits in the Lower Saxony Basin, Northern Germany

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Keywords: Kimmeridgian; Lower Saxony Basin; carbon-isotope stratigraphy, strontium-isotope stratigraphy

The lack of open-marine marker fossils or restriction of local biostratigraphic schemes often hampers the correlation of shallow-marine carbonate deposits with the coeval pelagic counterpart. In such cases, chemostratigraphy appears to be a useful method. However, the shallow-marine bulk records should be treated with caution since they are considered as complex archives which can be influenced by diagenetic alternation and/or local environmental conditions. Here, a new high-resolution chemostratigraphy (carbon and strontium) of the Kimmeridgian has been generated from three shallow-marine sections (Langenberg, Bisperode, Pötzen) in the Lower Saxony Basin (LSB) Northern Germany. Combing with previous high-resolution sedimentological analysis, carbon-isotope data based on bulk materials is strictly evaluated for both diagenetic alternation and local effect. Overall, the carbon-isotope curves are considered to record the global marine signal. Exceptions are characterized by few intervals bearing MA7 (supratidal back ramp) that is interpreted as carrying diagenetic overprint, and by those related to MA6 (intertidal back ramp) which are probably influenced by local environmental signature. Strontium-isotope stratigraphy supports and refines the ostracod biostratigraphic based age of the studied sections. Furthermore, combing with high-resolution carbon isotope data, an integrated bio- and chemostratigraphic age model is established for the Kimmeridgian successions in the LSB, which allows for a precise correlation of the studied sections with Submediterranean-Mediterranean successions. Building onto the present study, shallow-marine carbonate has the potential to act as a qualitative proxy of seawater isotopic composition, and application of carbon- and strontium-isotope stratigraphy to shallow-marine carbonates can be performed when treated with caution.

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