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Posterabstracts

THE LATE TRIASSIC HAUPTDOLOMITE SECTION WIESTALSTAUSEE NEAR HALLEIN (NORTHERN CALCAREOUS ALPS, AUSTRIA): BIOMARKER EVIDENCE FOR THE FORMATION OF ORGANIC-RICH SUCCESSIONS IN SMALL SCALE BASINS WITHIN CARBONATE PLATFORMS

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The origin of organic-bearing reducing sediments within the Late Triassic Hauptdolomite/Dachstein carbonate platform of the Northern Calcareous Alps, a subject of some debate, is clarified by microfacies biomarker analyses that enable the characterization of the depositional environment of the Norian dolomicrites (Hauptdolomite) of the Wiestalstausee section (Lower Tirolic nappe, Salzburg Calcareous Alps). By examining the section using the oxygen-restricted biofacies (ORB) classification, we find ORB 1-4 mostly in the dark grey organic- rich sediments and ORB 6, or normal oxygen conditions for the light grey dolomites. Anaerobic biofacies, characterized by the total absence of benthic organisms and a fissile sediment fabric, predominate for most of the dark grey and micritic parts of the section. The laminated dolomicrites show ORB 3 and ORB 4, containing very few benthic species, which are abundant on some bedding planes in ORB 4. Here, the sediment fabric is planar laminated, but limited bioturbation may occur. This sediment type corresponds to the poikiloaerobic and episodically dysaerobic facies.

The *n*-alkane distribution patterns and relative intensities of steranes are typical for organic matter of predominantly algal and/or microbial origin with minor contributions from land plants. Phytoplankton (including dinoflagellates) and photosynthetic bacteria are considered as the major primary producers of the biomass accumulated within the immature, carbonate-rich rocks. High contents of hopanoid biomarkers and constituents related to the arborane/fernane skeleton are considered to be of bacterial origin and indicate enhanced microbial activity in the sedimentary environment. However, a terrestrial origin (from land plants) of the arborane/fernane-derivatives cannot be excluded. The occurrence of aryl isoprenoids, probably derived from carotenoids of the photosynthetic green sulfur bacteria (*Chlorobiaceae*), indicates the establishment of euxinic conditions in the bottom water.

Comparable diagenetic degradation mechanisms led to the formation of hopanes and hop-17(21)-enes. Methylated chromans occur in low abundance, and the predominant occurrence of trimethylated C_{29} chroman (tri-MTTC) over dimethylated C_{28} chroman (di-MTTC) indicates enhanced salinity in the upper part of the water column. Diagenetic conversion of organic matter under anoxic conditions in a high-sulfur environment due to salinity stratification are further indicated by low Pr/Ph values and high contents of the C_{35} benzohopane compared to the C_{32} to C_{34} homologues. The relative proportions of S/R isomers of the $\alpha\alpha\alpha$ C_{29} steranes and the $\alpha\beta$ C_{31} hopanes are consistent with an organic matter maturity equivalent to vitrinite reflectance values of ~0.5% Rr. This maturity assessment is further confirmed by the predominance of monoaromatic over triaromatic steroids.

In the present study, the interaction of salinity variations, water column stratification, and the establishment of anoxic conditions within a restricted carbonate platform is highlighted using molecular indicators. For the first time, sedimentological and geochemical features provide evidence for the establishment of small-scale anoxic basins through erosion by currents or from the remnants of channels, which were possibly isolated periodically by small scale sea level changes. Changes in carbonate production also may play a role. Beside tectonically induced formation of anoxic basins in the Late Triassic carbonate platform (e.g., Seefeld basins), this mechanism may contribute to the enhancement of the hydrocarbon potential of the Hauptdolomite/Dachstein carbonate platform of the in the whole western Tethyan realm.

THE SEDIMENTOLOGICAL, PALEONTOLOGICAL AND GEOCHEMICAL IMPLICATIONS OF THE BASAL CHOTEČ EVENT (MIDDLE DEVONIAN, EIFELIAN) IN PRAGUE BASIN (CZECH REPUBLIC)

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The Basal Choteč event, first named by House (1985) and typified by sequences in Bohemia (Chlupáč and Kukal, 1986) has been documented in Central and Southern Europe (e.g. Chlupáč et al. 2000), North Africa (e.g. Becker and House 1994), Southern America (Troth 2005), North America (Ver Straeten 2005), Siberian platform (Yolkin et al. 2005) and therefore it is regarded as an important global geo-event. In its type area (Prague Basin) the aforementioned event falls at the boundary between the Třebotov Limestone (Emsian/Eifelian) and the Choteč Limestone (Eifelian) and their equivalents, close above the Lower-Middle Devonian boundary. It is correlated with the base of the *Pinacites jugleri* and *Polygnathus costatus costatus* biozons. The **Třebotov Limestone** is mostly a bioclastic wackestone-packstone with a relatively high biogenic content and intense bioturbation. The presence of micritic matrix, benthic fauna typical for muddy bottom environments and absence of sedimentological features indicating current activity suggest a calm, low-energy, relatively deep sedimentary environment rich in free oxygen (inferred from intense bioturbation and diverse benthic assemblages). The sedimentary environment is interpreted here as proximal offshore, bellow storm wave base. The **Choteč Limestone**, on the other hand, reflects in its development and fossil content perturbation and non steady state conditions. The above mentioned limestone is represented by the alternation of well-sorted peloidal packstone/grainstone and dark lime- mudstone/wackestone and are regarded here as a representatives of tempestites, reflecting in its development eustatic oscillations in sea level.

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PALEOMETEOROLOGY OF DUST EVENTS

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16 long sediment cores from Eifel dry maar lakes have been drilled between 1999 and 2005 by the ELSA project (Eifel Laminated Sediment Archive) and document the last 0 - 140 ka. In this project we will evaluate in detail distinct dust layers, which can be correlated between the cores.

Dust phases (dry and cool winds > 5m/s) over the continent have been related to the cold events in the Greenland ice and North Atlantic sea surface temperature patterns (Seelos & Sirocko, 2006). A continuous dust stack (0-140 ka) for Central Europe is presented by Seelos & Sirocko (2007).

Grain size analysis of individual dust layers is done by the automated method of ultra high-resolution grain size measurements from thin sections, which was developed by Seelos & Sirocko (2005). The grain size composition of individual dust layers between MIS 5e and MIS 1 will be detected in all available cores and will be evaluated for 20 statistical grain size parameters. Gradients in layer thickness, mineralogy, geochemistry (measured by an EAGLE II µXRF) and the grain size composition is used to quantify the principle paleowind direction via the fingerprints of the sediment sources, which is a first indication about the meteorology that lead to the dust transport.

The further objectives of the project are the comparison of observed wind directions with existing model data for atmospheric circulation during MIS 5 to MIS 1. The comparison of the regional dust storms in the Eifel with the large scale patterns of dust transport in the northern hemisphere, as documented in the North GRIP dust particle record (Ruth et al. 2003), should indicate if dust storms in the Eifel are associated with large hemispheric weather extremes (high pressure cells over eastern Europe and Siberia or storms in the west wind drift) and thus with a hemisphere wide forcing process or only local/regional weather anomalies in the Eifel.

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SEDIMENTOLOGICAL, GEOCHEMICAL AND MICROPALEONTOLOGICAL INVESTIGATIONS OF LAKE SEDIMENTS TO RECONSTRUCT LATE GLACIAL/HOLOCENE LANDSCAPE EVOLUTION AT LAGO BUDI (CHILE)

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The coastal lagoon Lago Budi, located in southern Chile (38.9° S) can be characterized through elevated ranges of salinity (7– ~20 ppm), which arise from a spatial connection to the Pacific Ocean. Due to its location, Lago Budi serves as a sediment trap, indicating Holocene landscape evolution.

During a field campaign (German Research Founding Project "Late Glacial/Holocene Landscape Evolution at Lago Budi, Chile (38.9° S) - Paleoseismic Investigations on Lake Sediments") several piston cores were taken to obtain detailed information on intra-lagoon sedimentation processes. Furthermore, the compilation and dating of tsunamigenic sediments should allow a deeper understanding of seismic events and associated tsunami waves on a temporal and regional scale. The influence of such singular events on lake chemistry and the corresponding microfauna also has to be taken into account.

Thus, the aim of the current study was to develop a multi-proxy approch providing the possibility to reconstruct Late Glacial / Holocene landscape evolution with simultaneous consideration of ecosystem modifications mainly caused by the input of allochtonous tsunamigenic sediments.

Based on the analysis of one piston core with a total length of 6 meters a wide range of sedimentological, geochemical and microfaunistical methods was carried out in reconstructing marine, brackish and freshwater conditions, reflecting a weakening respectivly strengthening of the marine impact. To distinguish event-associated disturbances and long-term modifications of the ecosystem grain-size analysis were performed by using laser diffraction technology. In combination with measurements of the magnetic susceptibility several sandy layers could be detected, indicating the existence of tsunamigenic deposits within the lake. In addition, X-ray diffractometry measurements enabled us to determine the origin and structural composition of these layers.

The results of geochemical analysis primarily based on atomic absorption spectrometry and CNS were used to deviate a chronological sequence of different types of paleoenvironments in terms of salinity and nutrient content. Furthermore C_{org}/N-ratios were calculated to identify the influence of terrigenous input.

One of the main focuses of our study was the use of micropaleontological indicators. By applying a paleoecological approach, several taxa of foraminifera, ostracods and molluscs representing brackish respectivly marine environments were identified and analysed quantitatively to reconstruct past habitat characteristics.

COMPOSITION AND ORIGIN OF SANDSTONES AND TUFFACEOUS SANDSTONES OF THE BEACON SUPERGROUP IN NORTHERN VICTORIA LAND, ANTARCTICA

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An up to 300 m thick succession of clastic and volcaniclastic sediments of the Beacon Supergroup overlying a pre-Devonian crystalline basement crops out in northern Victoria Land below the mafic plateau-lavas of the mid-Jurassic Ferrar Large Igneous Province. These Triassic to Early Jurassic sediments document the period directly preceding the Ferrar Magmatism that was associated with the initial break-up of Gondwana. So far neither provenance of the sediments nor the basin evolution have been investigated in detail.

The sediments of fluvial and minor lacustrine origin are divided into the lower Section Peak Formation (SPF) of approximately 200-250 m thickness, which is dominated by quartzose sandstones, and the upper, informally named Shafer Peak Formation (SHF), consisting almost exclusively of reworked rhyolitic fall-out ashes. A Late Triassic to Early Jurassic biostratigraphic age can be deduced from *Dicroidium*-floras in the SPF and floras dominated by cycadophytes and dipterid ferns (lacking *Dicroidium*) in the SHF. The sedimentary succession is intruded by syn- to postsedimentary mafic sills. Associated with the synsedimentary magmatism are local mafic tuff deposits formed by phreato-magmatic eruptions, the so called Exposure Hill Type Events. The crystalline basement in this area is formed by the early Palaeozoic Ross Orogen, which consists mainly of amphibolite to granulite facies metasedimentary rocks (Rennick and Priestley Shists, Wilson Gneiss) and the granodioritic Granite Harbour Intrusives.

The sandstones of the SPF are predominantly sublitharenites and lithic subarkoses. Sorting and roundness of the grains are generally moderate to poor. Apart from the dominant quartz grains they consist mainly of alkali feldspars, plagioclase, metamorphic lithoclasts and volcanic rock fragments of variable chemistry. The most frequent heavy mineral is garnet, only subordinately occur tourmaline, zircon, green hornblende and epidote.

The textural and compositional immaturity of the sandstones indicates a relatively proximal source area. The sandstone compositions plot in the Q_mFL-provenance diagram in the recycled orogen field, which seems to suggest the underlying Ordovician Ross orogen as source of the sediments. The frequent occurrence of volcanic detritus of varying chemical composition has been interpreted in previous models as indication of an active volcanic arc at the Panthalassan (Proto-Pacific) margin. Another, closer source could be the remnant magmatic arc of the Ross orogen. However, mineral chemistry of garnets from the SPF show obvious differences to published garnet analyses of local basement rocks, so that an additional source area is necessary, possibly the East Antarctic Craton. Microprobe data of feldspar show that Ferrar volcanism was not coeval to deposition of sandstones during the SPF as supposed by previous authors.

Still within the upper parts of the SPF greenish-grey to beige tuffaceous sand- to siltstones are intercalated forming a transition to the overlying, 40-50 m thick SHF. Evidence of fluvial reworking is frequent, whereas true air-fall-deposits have not been identified in the SHF so far. The tuffaceous material is very well sorted with fine sand to coarse silt size consisting predominantly of rhyolitic shards, angular quartz, alkali feldspar, and plagioclase. The shards rarely exhibit bubble wall or bubble junction shape, but are in most cases fragmented due to fluvial reworking. Additionally they are secondarily altered to zeolites (clinoptilolite/heulandite) and sometimes to smectites. While most of the analysed samples show varying cathodoluminescence colours for each mineral species, so far one horizon has been found with mineral fragments nearly exclusively of plagioclase (An_{30}) and magmatic quartz. This is interpreted as juvenile material, thus allowing determination of original magma and phenocryst chemistry.

The SHF can be interpreted as a lithological equivalent of the upper part of the Hanson Formation in the Central Transantarctic Mountains, more than 1000 km away. The occurrence of rhyolitic tuffs over such a range along the Transantarctic Mountains requires a distal, ultra-plinian volcanism of yet unknown source. However, a volcanic province of this age and chemistry can be found in the Mount Poster Formation (Ellsworth Volcanic Group) on the Antarctic Peninsula.

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PRELIMINARY NOTE ON THE HELVETIC UNITS AT GEOTOPE LANGER KÖCHEL DISTRICT GARMISCH-PARTENKIRCHEN, SOUTHERN BAVARIA, GERMANY) AND THE FIRST DISCOVERY OF FOSSIL RESIN IN THE FRESCHEN BEDS (LATE APTIAN–ALBIAN)

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Introduction: The Helvetic Units present at Langer Köchel are part of the external zone of the Northern Alpine fold and thrust belt (Schmid et al. 2004: Eclogae geol. Helv., 97, 93–117, Basel) in Southern Bavaria. According to Roeder & Bachmann (Mém. Mus. natn. Hist. nat., 170, 263-284, Paris, 1996), these Helvetic Units form narrow slivers, consisting of steep-flanked, tight and faulted antiformal stacks of thrusted sheets between the detached folded Molasse Units (footwall) to the North and Flysch Units (hanging wall) to the South.

In 1998, for the first time, a cm-sized pebble of fossil resin was found in glauconitic quartzsandstone, exploited at the quarry Hartsteinwerk Werdenfels, which was active from 1927–1999 at the southern flank of the hump Langer Köchel.

Stratigraphy: It starts at the base with monotonous, dark grey and black colored, slightly bituminous, thinly bedded and laminated marlstones attributed to the Drusberg Formation. The presence of *Conorotalites* sp.- probably *Conorotalites bartensteini* intercedens - indicates an early late Barremian age. The stratigraphic passage to lithologies comparable to the Grünten Member - basal part of the Garschella Formation (Linder et al. 2006: Eclogae Geol. Helv., 99/3: 327–341) – is set, where the first intercalation of dark grey colored, dm-thick, marly limestone layers occurs. The sequence is made up of dark grey, laminated marlstone beds up to 1,3 m thick, alternating with grey to dark grey colored, often nodular and in places burrowed, marly limestone strata (max. thickness 70 cm). A late early Aptian age of this unit is supposed. The thickness of this sequence diminishes from ca. 90 m at the western part of Langer Köchel to only a few meters at the eastern side. The stratigraphic contact at the upper boundary of this member signalizes an important and sharp erosional unconformity. The lithologies above - comparable to the Freschen Beds – are made up of medium to coarse grained, dark olive, grey to dark grey colored, medium to very thick bedded, moderately sorted, calcareous and glauconitic quartzsandstone layers (maximum thickness 3,6 m), which are rarely separated by dark grey marlstone layers up to 27 cm thick. The strata, often laminated on mm- and cm-scale, are confined by plane or hummocky super- and subfaces. Close to the base of the upper quarter of this unit, an incompletely graded, 49 cm thick quartzsandstone layer was observed. Above, dm- to m-thick horizons – laterally persistent on 10 m-scale – with significant features of redeposition (cm- to dm-scaled, rounded intraclasts in intensely convoluted quartzarenaceous matrix) are present. The macrofossil content of this unit consists of *Birostrina concentrica* and ammonites, which are still under examination. Ichnolites (*Palaeophycus*, *Thalassinoides*) are common.

The microfauna from the basal layer of the unit yielded *Lenticulina* sp., *Novalesia* sp., *Marsonella* sp. and *Gaudryina* sp. According to correlatives present in the distal Helvetic realm, the age of the Freschen Beds is probably late Aptian to Albian; its thickness is ca. 140 m. It is supposed that its lithologies represent redeposited matter from the Brisi-, Gamser- and Rankweiler depositional areas on the adjacent platform and slope. The passage to the Seewen Formation (Cenomanian - Santonian) is marked by an erosional unconformity. It starts with amalgamated redeposits < 1m (Götzis Beds), which are overlain by pelagites consisting of grey limestone layers, followed by an alternance of brick red and beige colored, marly limestones.

Fossil resin and paleoenvironment: Gas chromatographic and mass-spectroscopic analysis of the fossil resin revealed the total defunctionalization and dealkylation of its constituents. Only traces of a few biomarkers have survived – for instance agathalene –, which indicates its botanic origin from agathic acid: The conifer species *Agathis dammara* and *A. australis* containing this resin at present only occur in the montane subtropical-tropical forests. It is therefore supposed that the paleogeographic provenance of the Werdenfels fossil resin has been a distant mainland positioned further to the east or southeast at low latitude, from where it was transported – attached to driftwood – by surface currents across the late Aptian - Albian Tethys to the Helvetic Realm. It is pointed out that transport and deposition of this fossil resin pebble is linked up with the Cretaceous paleoenvironmental development: The Aptian climate change, which proliferated continental fluvial runoff and the flux of terrigenous matter into westbound longshore currents contouring the Southern European continental margin (Puceat et al. 2005: Earth and Planetary Science Letters, 171/1, 149–156), enhanced the likelihood of dropstone deposition.

THE LOWER MIOCENE PFÄNDER-DELTA ON THE SOUTHERN COAST OF THE MOLASSE BASIN

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The NNE-SSW-oriented Pfänder ridge east of Lake Constance (south-western Germany) marks the foreland dip panel defining the southern margin of the autochthonous Molasse in this area and is composed of a succession of clastic sediments of the Lower Freshwater Molasse, the Upper Marine Molasse and the Upper Freshwater Molasse. This sequence was controlled by the activity of an alluvial fan, the Pfänder Fan, which was situated between the Hörnli Fan to the west at the mouth of the Paleo-Rhine and the Hochgrat Fan to the east at the mouth of the Paleo-Iller. It did not nearly obtain the dimension of these very large fans, but it is detectable as an independent fan since the Lower Miocene [5]. In Lower Miocene times, when the marine Eggenburgian transgression invaded this area, a deltaic complex began to prograde in front of the fan at the coast of the Molasse Sea. Deposits of this deltaic complex within the Upper Marine Molasse are well exposed in deep gorges at the southern and south-eastern slope of the Pfänder ridge between Bregenz (Vorarlberg) and Siebers near Weiler (Allgäu/Germany).

The sharp and erosive base of the Upper Marine Molasse is marked by fluvial conglomerates, which are channel sediments of a proximal facies of a prograding alluvial fan, representing the basal low stand tract of the Upper Marine Molasse. It is overlain by a 50 to 110 m thick monotonous shoreface-succession of glauconitic sandstones on a transgressive surface, representing a transgressive systems tract. This facies type is detectable in all of the studied sections as well as the sections in the vicinity [4]. Above this part of the sequence the increasing activity of the prograding delta complex is detectable by deposits reflecting a higher energetic system with much coarse-grained sediments deposited within channels fed by a fluvial system. This part of the sequence is clearly influenced by tidal activities proven by megaripples and heterolithic facies types. In contrast to the basal third these parts of the sections, which were generated since the delta has been active, are not parallelizable even in closely neighboured sections. This fact was interpreted as the internal structure of the delta divided into different lobes and bays between [4]. The deltaic complex is interpreted as a high stand systems tract which is subdivided into several subordinated small cycles. In the talus centre, in the area around the Wirtatobel gorge, for example two terrestrial horizons are detectable; the second is well known because of its coal mining (vitrain) near Bregenz from 1840 until after World War II [2]. These terrestrial horizons represent a delta plain environment in the centre of the distributary fan, thinning out toward northeast. The heterogenic deposits of the active delta complex are overlain by marls of the transition zone or fine-sands of the lower shoreface in the north-eastern sections, respectively. This upper part of the sequence represents a new transgressive systems tract, may be the high stand systems tract is included, too. It shows the highest sea level of the Upper Marine Molasse Sea, the phase of the maximum transgression [4]. The top of the whole sequence of approximately 400 m thickness is cut by a sharp erosional plane, containing in all probability the regressive systems tract. It is overlain by thick coarse-grained conglomerates of the Upper Freshwater Molasse.

Because of the local character of a fan, controlled by tectonics, climate, compaction and subsidence, the described sequence-stratigraphic interpretation of the Pfänder succession is not clearly parallelizable with the general cyclic structure of the Upper Marine Molasse known from the Swiss [1] and German [3, 6] foreland Molasse.

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APPLICATION OF GROUND-PENETRATING RADAR IN THE DEATH VALLEY FIELD SITE: INFLUENCE OF FERROMAGNETIC MINERALS ON THE PROPAGATION OF ELECTROMAGNETIC WAVES SEND OUT BY GPR

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Originally the study wanted to test the utility of ground-penetrating radar (GPR) in three dimensional imaging alluvial fans in the Death Valley. The test area was chosen due to its prominent alluvial fans flanking the mountain fronts. Lack of vegetation and easy accessibility of fan surfaces combined with coarse-grained sediments and deep groundwater levels seemed to fit perfect for applying the GPR on the sedimentary architecture. Expecting a deep penetration depth of the electromagnetic wave with an excellent signal, we measured shallow penetration depth with a low signal to noise ratio. Moreover we measured high inductivity effects on the cable linking the antennas and the processing unit. Aiming to understand the attenuation and scattering effects of the electromagnetic wave we conducted a GPR "reference" survey using different antennas ranging from 60 to 200 MHZ Although the overall signal to noise ratio was very low with "multiple reflectors", using higher frequencies the quality of the radargrams improved.

To verify the source of attenuation and scattering, sediment susceptibility was measured on different desert pavements, including the measurement of fines and a representative portion of different rock types, trying to consider the different catchments and their underlying lithologies. Measurements were taken on the western and eastern flank of the Death Valley. High susceptibility values of around 0.1 to 43 (normally values are around 0.01) showed in a clear way that there are abundant ferromagnetic minerals in all alluvial fan deposits.

Although it is known that the electromagnetic wave consists of an electric- and magnetic part, oscillating perpendicular towards each other, it is not described in literature that magnetic properties of the underlying sediment can influence the propagation of the electromagnetic wave. Due to high magnetic susceptibility values we propose, that the electromagnetic wave will be reflected and scattered at the surface and gain only shallow penetration depth. The higher the used GPR frequency, the higher was the inertia of the magnetic dipoles in the grains and thus the higher was the penetration depth.

Although the GPR was not able to image the deeper architecture of alluvial fans, it provided some insights into the filling history of the active channels where the transition from the most recent fluvial deposits and alluvial fan bedrock was mapped.

RADIOLARITIC-OPHIOLITIC MELANGE ANALYSIS: NEW POTENTIAL FOR PALAEOGEOGRAPHIC RECONSTRUCTIONS OF LOST OCEANS AS DEMONSTRATED IN THE MIRDITA OPHIOLITE ZONE (ALBANIA)

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The Albanian ophiolites of the Mirdita Zone represent remnants of Mesozoic oceanic lithosphere within the Dinaride-Hellenide segment of the Alpine orogenic system. They form a coherent, north-south trending belt and consist of a large variety of rocks attributed to originally complete ophiolitic sequences through oceanic uppermost mantle and crust. Most recent studies distinguish two different rock associations forming the Western (WOB) and Eastern Ophiolite Belt (EOB). Both are thought to derive from a narrow Jurassic ocean between Apulia in the west and the Korabi-Pelagonian microcontinent to the east called Pindos-Mirdita Ocean.

Creation of oceanic crust in the Pindos-Mirdita Ocean is inferred to have started around the Early/Middle Jurassic boundary followed by intra-oceanic subduction in Late Jurassic times. The age of the ocean seemed to be proven by radiolarians from sediments associated with basaltic and dacitic lavas which gave Late Bajocian to Early Callovian and Middle Callovian to Late Oxfordian ages, respectively. The ophiolite suite is closely associated with radiolarites and ophiolitic mélanges containing blocks of up to kilometer-size. Blocks of Triassic radiolarites in the mélanges were interpreted to have been derived from the continental margins surrounding this short-lived Jurassic ocean. Mélange formation is generally considered to have taken place during post-sedimentary thrusting in Tithonian time.

The Mirdita Ophiolite Zone in Albania is associated with widespread mélanges containing components of up to nappe-size. We dated matrix and components of the mélange by radiolarians, conodonts, and other taxa. The components consist of radiolarites (equivalent to Meliata facies), pelagic limestones (different Hallstatt facies block – grey and red Hallstatt facies) and shallow-water limestones (Dachstein limestone facies), all of Triassic age, as well as ophiolites. Triassic radiolarite as a primary cover of ophiolite material proves Middle Triassic onset of Mirdita ocean-floor formation. The mélange contains a turbiditic radiolarite-rich matrix („radiolaritic flysch"), dated as Late Bajocian to Early Oxfordian. It formed as a synorogenic sediment during west-directed thrusting of ophiolite and sediment-cover nappes representing ocean floor and underplated fragments of the western continental margin. The tectonic structures formed during these orogenic events („Younger Kimmeridgian or Eohellenic Orogeny") are sealed by Late Jurassic platform carbonates (equivalent to the Plassen carbonate platform in the Northern Calcareous Alps).

From the scenario we see no evidence for an independent Pindos-Mirdita Ocean. An in-situ position of the Mirdita ophiolites would mean that the Triassic passive continental margin with its typical facies arrangement from the pelagic outer shelf (Hallstatt limestone facies) towards the inner shelf with its reefal and lagoonal carbonates (Dachstein limestone facies, Hauptdolomite facies) would have been disrupted by an ocean. Remnants of the passive-margin sequences are found both to the west and the east of the present Mirdita Zone. Therefore we conclude that the Mirdita-Pindos Ophiolite Zone is no more in its original position relative to the geologic units to its east and west but must be a far-travelled part of the Neotethys Ocean (Vardar segment), brought into its present position by west-directed far-distance thrusting from the Vardar Zone. In the Northern Calcareous Alps the situation is the same in a number of particulars, although the in Late Jurassic times obducted ophiolite units are not preserved but only indicated in detrital material of the Kimmeridgian to Tithonian radiolaritic wildflysch.

The geological history conforms with that of the Inner Dinarides and adjoining areas; we therefore correlate the Mirdita-Pindos Ophiolite Zone with the Vardar Zone and explain its present position by far-distance west-directed thrusting.

A COMPARISON OF THE LATE TRIASSIC TO EARLIEST CRETACEOUS SEDIMENTARY SUCCESSIONS AND THE TECTONOSTRATIGRAPHIC EVOLUTION OF THE INTERNAL ZONES OF THE BETIC CORDILLERA (SPAIN) AND OF THE NORTHERN CALCAREOUS ALPS (AUSTRIA): PALAEOGEOGRAPHIC IMPLICATIONS

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A comparative study of stratigraphy, facies and paleogeography of the Northern Calcareous Alps (Eastern Alps; Austria, Germany) and of the Internal Zones of the Betic Cordillera (Spain) shows that both regions are very similar in facies development, sedimentary and tectonostratigraphic evolution from the Late Triassic to the earliest Cretaceous. We present some characteristic examples of identical sedimentary successions formed under similar geodynamic conditions.

A widespread Late Triassic shallow water carbonate platform development occurred in the Internal Zones of the Betic Cordillera, producing carbonate sediments with facies similar to those of the well known Hauptdolomit-Dachstein carbonate platform of the Northern Calcareous Alps.

The shallow water carbonate production suddenly ended in both regions around the Triassic/Jurassic boundary, and was associated with the onset of hemipelagic carbonate sedimentation in both areas, except in the Malaguide Domain. This drowning event was additionally marked by fault scarp breccia formation in the Internal Zones of the Betic Cordillera, and block tilting in the Northern Calcareous Alps, due to the starting rifting of the future Penninic-Piedmont Ocean.

The occurrence of the first oceanic crust in the Penninic-Piedmont and Nevadofilabride Realms during Late Pliensbachian-Toarcian times was coeval to the formation of continental margins with a horst and graben topography in their southeastern parts, both in the Eastern Alps and in the Internal Domain of the Betic Cordillera. This was contemporaneous with a deepening event and basin starvation that produced reduced and condensed pelagic successions during the late Early to Midde Jurassic in both regions.

A widespread radiolaritic sedimentation during the Bathonian coincides with the final break-up and spreading of oceanic crust in the Penninic-Piedmont Ocean, and was followed by pelagic carbonate and radiolaritic sedimentation up to the earliest Cretaceous.

To conclude, the Internal Domains of the Betic Cordillera represent, during the Late Triassic to Berriasian, a western prolongation of the Austroalpine Domain. Therefore, the Internal Domains of the Betic Cordillera, as well as their Austroalpine counterparts, form the internal southeastern margin of the Penninic-Piedmont Ocean in contrast to its northwestern margin which was formed by the South Iberian Paleomargin, corresponding to the Prebetic and Subbetic external domains of the Betic Cordillera, and by the South European Paleomargin which corresponds to the Helvetic-Ultrahelvetic domains of the Alps.

Both areas were connected from the Triassic until the earliest Cretaceous and were not separated by an oceanic domain, as partly reconstructed.

A comparative study in the framework: Acciones-Integradas Austria-Spain (ÖAD, Ministerio de Cienca y Tecnologia).

KL-SPEKTROSKOPISCHE UNTERSUCHUNGEN AN KLUFTGEBUNDENEN FLUORITEN VON SABKHADOLOMITEN HYDRAS UND KRISTALLINGESTEINEN DES MITTLEREN SCHARZWALDES

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Fluorite (CaF_2) treten als späte Mineralisationen (50–1500 µm) in Klüften der faziesgebundenen frühdiagenetischen Dolomite Hydras (Oberperm und Obertrias) auf (Gillhaus 2000). Die makroskopisch farblosen Kristalle haben in beiden Formationen eine leuchtend blaue Lumineszenzfarbe ohne Zonarbau und zeichnen sich KL-spektroskopisch durch Eu^{2+}-Dominanz bei untergeordnetem Auftreten von Dy^{3+} aus.

Die hydrothermalen Fluorite aus Gängen in Kristallingesteinen des mittleren Schwarzwaldes sind makroskopisch farblos, grünlich oder blau und nach Werner & Dennert (2004) einer Fluorit-Hauptphase und bis zu drei weiteren Mineralisationsphasen mit Fluorit zuzuordnen. Nach KL-spektroskopischen Untersuchungen sind diese Fluorite reich an Selten Erden Elementen (SEE) und bilden drei Gruppen:

1. Blau lumineszierende Fluorite mit Eu^{2+}-Dominanz und wenig anderen SEE
2. Graugrünlich bis olivfarben lumineszierende Fluorite mit wenig Eu^{2+} und dominanten Peaks von Dy^{3+}, Sm^{3+} und Tb^{3+}.
3. Blaugrün bis blauviolett lumineszierende Fluorite, in deren KL-Spektren intensive Peaks sowohl von Eu^{2+} als auch von den dreiwertigen SEE Dy^{3+}, Sm^{3+} und Tb^{3+} ausgebildet sind.

Die Beschränkung der Fluorite Hydras an Klüfte in frühdiagenetischen Dolomitserien unterstreicht hinsichtlich ihrer Genese eine Laugung aus dem Nebengestein, während die komplexe Abfolge und Zusammensetzung der Fluoritmineralisationen des mittleren Schwarzwaldes durch eine Zufuhr von Lösungen mit variablen Zusammensetzungen aus größeren Tiefen sowie Umkristallisationen jeweils älterer Fluoritphasen zu erklären ist.

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KYANITES FROM MIOCENE (OSM) SANDS OF THE GRAUPENSANDRINNE AND THE ALPINE FORELAND: A VALLEY-FILL STUDY BY MEANS OF CATHODOLUMINESCENCE ANALYTICS

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The Miocene Graupensandrinne is a small, elongated, fluvial sediment structure, which extended along the northern rim of the foreland basin as a palaeo-valley (Buchner, 1996). It consists of poorly sorted sands to fine-gravels. The material is expected to be debris of the basement rocks from the Bavarian-Bohemian-Massive.

Directions of deposition of the Graupensandrinne as well as of the Alpine foreland were compared in a CL-pilot study, illustrated by the mineral kyanite. The mineral luminescense occur in two known colours: red and blue (Marshall, 1988). In the CL-spectra of the examined kyanites intrinsic bands appear at 420 nm and 500 nm. Beside the intrinsic bands, there are two characteristic narrow bands at 688,5 nm and 705,2 nm emerging from a broad band. These are the emission lines of the $3d^3$-transition within a Cr^{3+}-center, which is commonly known from other minerals (e.g. topaz, corundum) (Gaft et al., 2005). Kyanites with a red luminescence exclusively show the two characteristic Cr-bands. Blue luminescent kyanites however show more strongly developed intensities within the range of short-wave radiation, but the appearance of the characteristic Cr-bands is likewise possible. Occurrence and distribution of the red and blue CL-characteristics permit a CL-classification of kyanite in four maintypes as well as in five and two subtypes, respectively (Görgen et al., 2006). For this study the CL-classification was reduced to three maintypes: I – kyanites with a red luminescence, II – kyanites with a blue luminescence, III – kyanites with red and blue luminescence.

This study proves that the kyanites from the Graupensandrinne between its north-eastern end at Kelheim and its south-western end at Riedern am Sand always show the same composition. About 80% are exclusively red luminescent (type I) and about 20% are red and blue luminescent (type III) kyanites, but no blue luminescent (type II) ones occur. The same observation was made at host-rock material from the Bavarian-Bohemian-Massive. In contrast, kyanites from the Alpine foreland south of the Graupensandrinne show all three types of luminescence. With some more than 90% red luminescent kyanites dominate the composition. The remaining percentage of the composition contains nearly equal amounts of blue as well as red and blue luminescent kyanites. Material from the Kaunertal, Ötztal and Pitztal in the Alps show the same composition. Therefore, it is improbable to expect Alpine material being a valley-fill of the Graupensandrinne. In contrast, material from the Bavarian-Bohemian-Massive seems to be responsible for a valley-fill of the Graupensandrinne delivered through the palaeo-river courses of Main and Naab.

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SEDIMENTOLOGIC AND GEOMORPHOLOGIC ANALYSIS OF THE EVOLUTION OF ALLUVIAL FANS IN THE SOUTHERN DEATH VALLEY, CALIFORNIA (SW-USA)

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Alluvial fans are amongst the most complex and less understood continental depositional environments. Little is known about the evolution stages acting through time, undergoing changing external conditions. The aim of this study is to gain new insights into the three-dimensional composition of alluvial fan deposits. Special attention was paid to the depositional processes and the corresponding architectural elements. Changing evolutionary stages (aggradation, pro- or retrogradation) have been interpreted according to the concept of the morphometric base-level.

The study was carried out on four alluvial fans (Anvil Spring Canyon Fan, Warm Spring Canyon Fan, Hanaupah Canyon Fan & Trail Canyon Fan) along the eastside of the Panamint Range in the southern Death Valley National Park. Deeply incised channels made them ideal for sedimentological outcrop studies. The study combines sedimentological work at cut-faces of the incised channels with detailed geomorphologic surface-mapping, supported by remote sensing data. At the cut-faces 1D lithological profiles have been combined with 2D photo mosaics to transfer the lithological information to a quantitative analysis of architectural elements. These elements consist of at least one lithofacies type and are themselves genetically bound to higher-order depositional systems such as braided-fluvial systems or mass flow events. The aim of this analysis was to figure out the change of predominant sedimentary processes. Deciphering the change of sediment supply and accommodation space on alluvial fan deposits we also focused on erosional features (including reworking surfaces and the change of the width/depth distribution of scour pools) and aggradational elements (e.g. longitudinal bars or spill-overs). Comparing the change of base-level between the different alluvial fans allowed us to discern an overall signal of alluvial fan evolution.

Remote sensing data (Landsat 7 ETM+) have been merged with USGS ortho-quadrangle aerial photographs to create high resolution aerial maps. Enhanced by GPS-based geomorphological surface-mapping, it was possible to identify several prominent surfaces as well as neotectonic movements, displayed in normal faults and strike-slip features. These surfaces, differing in relative age, were distinguished by their stage of soil development (Calcretes), development of desert varnish and desert pavement, their preservation potential of former incisions and their neotectonic setting.

These approaches have been summarized to a comprehensive model, identifying the return frequencies and magnitudes of the most important formative processes like debris flows and or braided-fluvial systems.

MICROFACIES, BIOSTRATIGRAPHY, AND GEOCHEMISTRY OF THE HEMIPELAGIC BARREMIAN-APTIAN IN NORTH-CENTRAL TUNISIA: INFLUENCE OF THE OAE 1a ON THE SOUTHERN TETHYS MARGIN

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Marine sediments of the Late Barremian-early Late Aptian interval reflect significant changes of the Mesozoic ocean/climate system, which coincide with several major palaeoceanographic and palaeobiological events. An extraordinary high intraplate volcanism recorded in the Pacific Ocean for the Early Aptian probably led to an intensified greenhouse effect by outgassing high amounts of carbon dioxide into the atmosphere. Especially the late Early Aptian has been focussed by many authors in last and recent years, due to an episode of increased organic carbon burial (Oceanic Anoxic Event 1a). This 50 ka to 1 ma lasting event is commonly expressed by an occurrence of black shales in pelagic successions, associated with significant changes in marine flora and fauna and a global rise in sea-level. In addition, an episode of shallow-water carbonate-platform drowning, which coincides in the initial part with the OAE 1a but lasts up to 4 my is recorded especially from the northern and southwestern Tethyan margin and from circum-Atlantic regions.

In this study, Upper Barremian-lower Upper Aptian hemipelagic deposits of the Hamada Formation in the Djebel Serdj area, north-central Tunisia were investigated in detail on the base of microfacies, biostratigraphy, $\delta^{13}C$ stratigraphy, and geochemistry. Our data provide an insight into the palaeoenvironmental evolution and sea-level fluctuations of the Tunisian shelf. The successions consist of mud-, wacke-, and packstones which reflect mid- and outer-ramp depositional environments. The deposits exhibit an unusually high thickness in the studied area. Within them, the Oceanic Anoxic Event 1a and carbonate-platform-drowning time-equivalent deposits are recognised on the base of planktic foraminifer- and $\delta^{13}C$ stratigraphy. The OAE 1a is characterised by a transgressive facies with high abundances of radiolarians and planktic foraminifers, suggesting meso- to eutrophic nutritive values for the upper water column. Low diversity small benthic foraminifer assemblages suggest dysoxic conditions at the seafloor. Platform-drowning time-equivalent deposits, directly overlying the OAE1a are partly showing a pronounced drop in carbonate content. Based on our microfacies studies, we subdivide the studied sections into four genetic intervals: a pre-OAE 1a interval, an OAE 1a and platform-drowning-equivalent interval, and a post-platform-drowning interval. We present a 3rd order sea-level curve for the Tunisian shelf, derived from the results of our microfacies studies.

FACIES ANALYSIS OF THE LATE PALEOZOIC COARSE-GRAINED CLASTIC DEPOSITS IN THE CENTRAL EUROPEAN BASIN SYSTEM: AN EXAMPLE FROM THE BARNIM BASIN (BRANDENBURG, GERMANY)

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Under the aspect of a lithofacies classification of the Late Paleozoic coarse-clastic deposits (conglomerates and conglomeratic sandstones) of the Barnim Basin in Brandenburg (Germany), five wells with more then 1300 m of core material were studied. The coarse-clastic sequences can be grouped into older deposits which formed during the basin initiation under partial volcano-morphological control, and into younger conglomerates the deposition of which was related to the early Late Rotliegend dynamics of the Southern Permian Basin (see also Gaitzsch 1995).

As a result of the investigation, 16 lithofacies types grouped into six lithofacies associations have been differentiated. With special interest to the spatial and temporal evolution of the coarse clastic deposits, we could distinguish two different types of alluvial fans (stream flow dominated "wet-type fans" and mass flow dominated "dry-type fans"), whose development was climatically as well as tectonically controlled. Similar scenarios have been described for the Rotliegend sediments in the southern North Sea area by George & Berry (1993, 1997) and by Howell and Mountney (1997). Based on the recognition of drying upward cycles, for the Rotliegend evolution of the Barnim Basin, especially for its Grüneberg- and Tuchen Sub Basins, we assume a change from a mainly climatic/volcano-morphologic to a tectonic/climatic control. For most of the cycles, a correlation between the neighbouring sub basins was possible.

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DER STEINPLATTE-KOMPLEX (OBER-TRIAS, NÖRDLICHE KALKALPEN, ÖSTERREICH) – RÄUMLICHE UND ZEITLICHE ENTWICKLUNG EINES KARBONATPLATTFORMRANDES

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Während der späten Trias waren die Nördlichen Kalkalpen Teil eines 500 km langen und 300 km breiten Schelfs am passiven Kontinentalrand der nordwestlichen Tethys. Die paläogeographische Position befand sich ca. 25-30° nördlich des Äquators. Tropische Bedingungen und niedriger Meeresspiegel bedingten das Wachstum gigantischer, bis 2000 m mächtiger Karbonatplattformen, die im Wesentlichen aus dem Hauptdolomit und dem Dachsteinkalk aufgebaut sind. Die südlichen und südwestlichen, ozean-seitigen Ränder dieses Dachstein-Karbonatschelfes wurden von mächtigen Riffkarbonaten gesäumt, die über moderat geneigte Hänge in die pelagische Hallstatt-Fazies übergehen.

In spät-Norischer bis Rhätischer Zeit bedingten verstärkte Subsidenz und terrigener Eintrag vom Keuper-Hinterland die Entwicklung eines Intraschelf-Beckens (Kössener Schichten) im nördlichen Bereich des Karbonatschelfs. Gleichzeitig bewirkte bessere Wasserzirkulation offen-marinere Bedingungen auf der Karbonat-Plattform, wodurch das Wachstum von Korallenkalken begünstigt wurde. Bekannte Beispiele hierfür sind der Steinplatte-Komplex bei Waidring im Grenzgebiet Tirol/Salzburg und die Fleckenriffe von Adnet und der Rötelwand bei Hallein. Diese gehören zu den ersten „modernen" Riffkarbonaten der Erdgeschichte hinsichtlich der Dominanz von Scleractiniern.

Der Steinplatte-Komplex ist ein außerordentlich gut aufgeschlossenes Beispiel eines Karbonatplattformrandes. Tektonisch weitgehend ungestörte Aufschlüsse, Erhaltung der originalen Slope-Topographie und senkrechte Aufschlusswände offenbaren einzigartige Einblicke in die räumliche und zeitliche Entwicklung eines Intraschelfbecken-Karbonatplattform-Übergangs. Vorangehende Studien (Piller 1981, Stanton & Flügel 1989) konzentrierten sich auf die Paläontologie, Mikrofazies und ökologische Zonierung der Rifforganismen. Detaillierte stratigraphische, insbesondere sequenz-stratigraphische Untersuchungen wurden dagegen bisher kaum unternommen.

Neue, hochauflösende und entzerrte Luftbilder (Orthofotos) und ein digitales Geländehöhenmodell erlauben eine präzise Kartierung, geometrische Konstruktionen und genaue Korrelationen, die zusammen die Grundlagen für eine detaillierte sequenz-stratigraphische Analyse bilden. Besonderes Augenmerk liegt hierbei auf dem Einfluß von Meeresspiegelschwankungen auf die Entwicklung des Karbonatplattformrandes des Steinplatte-Komplexes.

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SEDIMENTÄRE GÄNGE DER EISENACH-FORMATION (OBERROTLIEGENDES), WARTBURGSCHLEIFE, THÜRINGER WALD

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Die klassischen Rotsedimentschüttungen der Eisenach-Formation (Oberrotliegendes; ca. 260 Ma) am nordöstlichen Beckenrand des spätvaristischen Werrabeckens im Thüringer Wald bestehen aus verzahnten grobkonglomeratischen „sheet flood"-Ablagerungen alluvialer Fächer und laminierten siltig-tonigen lakustrinen Playa-Ablagerungen. Wir beschreiben hier, nach unserem Wissen erstmalig, zahlreiche sedimentäre Gänge am Geologischen Naturdenkmal der Parkplatzschleife der Wartburg bei Eisenach. Mindestens drei der dort aufgeschlossenen tonigen Siltsteinbänke zwischen den Konglomeraten sind von ca. 20 subvertikalen, bis zu 80 cm langen, in der Regel sich leicht nach oben erweiternden Gängen und Gangnetzen durchzogen. Die dominant mittelkörnige Kiesfüllung in einer tonigen Grobsandmatrix zeigt Merkmale von nach oben gerichteter, intrusiver Sedimentbewegung. Die charakteristische Geometrie von Trockenrissen ist weder in Aufsicht noch in Querschnitt zu erkennen.

Die Gänge entstanden durch abruptes Übersteigen der Zugfestigkeit der Siltsteine senkrecht zu ihrer Schichtung durch Porenüberdruck in der unterliegenden Einheit, unmittelbar gefolgt von schneller, aufwärts gerichteter Sedimentinjektion in die sich nach oben hin öffnenden Spalten. Sediment wurde dabei entlang eines Druckgradienten aus den unverfestigten Geröllbänken injiziert, wobei die ungewöhnlich grobe Korngröße der Gangfüllung auf eine zumindest anfänglich hohe Strömungsgeschwindigkeit der wässrigen Matrix, einen niedrigen Konsolidierungsgrad der einspeisenden Gerölleinheit und damit einen ungewöhnlich hohen Porenüberdruck hinweist. Morphologische Reste der an der Oberfläche entstehenden Sand- und Geröllvulkane („sand boils") wurden von Lützner (1987) im wenige km entfernten Straßenanschnitt Wilhelmsthal dokumentiert; am Wartburg-Parkplatz ist über den Gängen nur selten eine wenige cm hohe, konvex-aufwärts geformte Schichtung erkennbar. Bei Unterschreiten eines kritischen Druckgradienten und damit abnehmender Transportgeschwindigkeit verfüllten zuerst die gröbsten, später immer feinkörnigere Korngrößen die Gänge.

Mechanismen zur Entstehung von Porenwassserüberdruck in den Konglomeratbänken der Eisenach Formation sind vorläufig nur schwer eingrenzbar. Hohe artesische Spannung in den beckenwärts auskeilenden, in ihrem Oberlauf von Regen- und Abflusswasser gespeisten grobklastischen Bänken mag zur periodischen Ruptur impermeabler Abdeckschichten am Fuß der Fächer geführt haben. Dafür spricht das anscheinend weit verbreitete Vorkommen der sedimentären Gänge in zahlreichen Bänken und ihr Auftreten in nichtlinearen „Clustern" vorwiegend am Übergang zwischen grob- und feinklastischer Fazies. Alternativ kann Porenwasserüberdruck auch durch zyklisches „seismisches Pumpen" während Erdbeben in den tektonisch aktiven, von zahlreichen Randstörungen begrenzten Oberrotliegendbecken Mitteldeutschlands entstanden sein. Eine detaillierte Kartierung der stratigraphischen Verbreitung der sedimentären Gänge könnte diese Hypothesen möglicherweise eingrenzen.

CHEMOSTRATIGRAPHY AND PALAEOTEMPERATURE EVOLUTION ACROSS THE TRIASSIC-JURASSIC BOUNDARY

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Carbon-isotope trends are useful tools for stratigraphic correlation, especially during times of major perturbation to the carbon cycle. For the Triassic-Jurassic boundary major perturbations have been documented, but carbon-isotope data only exist for bulk rocks. We have produced carbon and oxygen isotope values from well-preserved oysters with low-magnesium calcite shells that are relatively resistant to diagenetic alterations. These data are generated from Lavernock Point, a section closely adjacent to a candidate stratotype for the base of the Jurassic, at St Audrie's Bay (UK). The carbon isotope signature from St Audrie's Bay, previously defined on the basis of bulk organic matter analysis, is confirmed by our new data. We also have analysed bulk carbonate samples from Cs vár-quarry (Hungary), Kendelbachgraben (Austria), and Lime Regis (UK). These data sets, taken together, illustrate detailed features of the carbon isotope curve including: (1) the initial negative isotope excursion; (2) a pronounced positive excursion, and; (3) an extended main negative isotope excursion. Palaeotemperatures calculated from oxygen-isotope values from Lavernock Point oysters are relatively cool (9 to 15 degrees C) at the beginning of the positive carbon-isotope excursion, and shift to relatively warm values (20 to 27 degrees C) during the main negative carbon-isotope excursion. Our results are compatible with the idea that positive carbon isotope excursions correspond to times of low atmospheric carbon dioxide content, and negative carbon-isotope excursions correspond to times of high atmospheric carbon dioxide content.

A LATE MIOCENE CLIMATE HISTORY – INSIGHTS BASED ON NEW PROXIES

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Major events and trends in Cenozoic climate are well known from deep sea stable isotope records. Knowledge of surface conditions has been continuously increased in the past years but in many cases remains ambiguous due to the susceptibility of planktonic organisms to diagenesis on one hand and limited age resolution in shallow water sediments on the other. The present study introduces an approach which is independent from stable isotope data, integrating a refined chronostratigraphic method using high resolution Sr Isotope stratigraphy and coralline red algae as climate (water depth and temperature) indicators.

A well preserved and for shallow water deposits relatively continuous succession of Tortonian limestones rich in coralline red algae allowed us to apply both methods and to reconstruct a detailed climate history. Up to 100 m thick Tortonian deposits crop out in a 50 km^2 wide area around the city of Matala. The exceptional outcrop condition allowed reconstructing the stratal architecture. Vertical changes in lithology and biotic elements are very similar in the entire area and are interpreted to reflect change in climate and sea level.

The stratigraphy of Tortonian sediments was established using $^{87}Sr/^{86}Sr$ of pectinid shells which were screened carefully for possible diagenetic alteration during analysis. In contrast to the common approach to infer ages by plotting Sr isotope ratios on a smoothed reference curve we employed unsmoothed Sr isotope curves for reference. In contrast to the common method, which due to the short term fluctuation in seawater Sr isotope ratios has a large uncertainty in resulting ages, this approach uses the fluctuation in seawater Sr isotope that are found both in the reference curve and in the measured dataset as an additional information as outlined in Kroeger *et al.* (2007). Sr isotope curves show remarkable similarities to Atlantic $\delta^{18}O$. It thus becomes apparent that fluctuations in Sr isotope ratios also relate to glaciation-deglaciation processes as has been hypothesized by various authors (e.g. Zachos *et al.* 1999) and therefore to eustasy. Such a relationship is supported by the detection of 400 kyr cyclicities in Tortonian $^{87}Sr/^{86}Sr$ records (Sprovieri *et al.*, 2004). Therefore we propose that Sr isotope stratigraphy can also be used as an additional proxy for climate change.

Paleoenvironmental studies on Tortonian limestones were carried out by analyzing coralline red algal assemblages. Coralline red algae are susceptible to both, temperature and light intensity and therefore to water depth. By establishing relative abundances of coralline red algal associations it is possible to define ranges of temperature and water depth. Results for the studied limestone succession on Crete indicate fluctuation between warm temperate and tropical climatic conditions. As indicated by growth band measurements on *Porites* corals, mean winter seawater surface temperatures (MWSSTs) during tropical intervals are between 20 and 21°C. Minimum temperatures inferred from coralline red algae are around 14–16°C. This indicates a temperature variation of 4–7°C during the Tortonian. A conspicuous temperature minimum occurs around 9,4 Ma which coincides with a discontinuity surface with a wide regional extent, interpreted as an eustatic lowstand (Kroeger *et al.* 2007). This interval is also characterized by a minimum in $^{87}Sr/^{86}Sr$ and a maximum in $\delta^{18}O$. Between 8 and 9 Ma, on the other hand the integrated data suggest stable tropical conditions and little northern hemisphere glaciation.

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THE ANISIAN SECTION OF KÜHWIESENKOPF/MONTE PRÀ DELLA VACCA (DOLOMITES, N-ITALY): INTEGRATED BIOSTRATIGRAPHIC, PALEOCLIMATIC AND PALEOENVIRONMENTAL STUDIES

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The discovery of a rich plant deposit at Kühwiesenkopf/ Monte Prà della Vacca (Prags/Braies, N-Italy) gave rise to integrated biostratigrafic, palaeoclimatic and palaeoenvironmental studies of this area, based mainly on stratigraphy, ammonoids and palynomorphs. The 200 m thick stratigraphical sequence belongs to the Dont Formation traditionally considered Pelsonian-Illyrian in age.

Ammonoids collected from the section attribute it to a time interval related at least from the middle Pelsonian (Balatonicus Subzone of Mietto and Manfrin, 1995) to the lower Illyrian. The expanded stratigraphic section permitted also to identify three different palynological assemblages and to calibrate them with ammonoids collected from other important stratigraphic sections (Dont and M. Rite). Comparisons with local biostratigraphical scales, refers the section to the middle-upper Pelsonian following Brugman (1986) or to the middle Pelsonian – lower Illyrian considering Kustatscher & Roghi (2006) and Kustatscher et al (2006).

For quantitative analysis up to 300 palynomorphs have been counted per sample on a total of 84 samples. The results have been applied to several methods known from the literature. Following the procedure outlined by Visscher & Van der Zwan (1981) a general dominance of the hygrophytic taxa becomes evident. This indication suggests a local warm and humid climate confirmed by the dominance of the "wetter" Lowland SEG taxa using Abbink's method (1998). However, throughout the section some oscillations in the palynological composition become visible, also at short time intervals. The cause of these variations could be either due to variations of the climate conditions and/or sea-level fluctuations. Palynofacies analysis indicates a deposition of the organic material in a marginal and shallow environment with short transportation. Since the stratigraphical indications of the formation suggest a basinal depositional environment for the section, the organic material could have been deposited in more basinal conditions.

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UNTERSUCHUNGEN AN BRONZE- UND EISENZEITLICHEN ABLAGERUNGEN VON MASSENBEWEGUNGEN IN EINEM PRÄHISTORISCHEN SALZABBAU IN HALLSTATT (SALZKAMMERGUT, ÖSTERREICH)

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Massenbewegungen (z.B. Felsstürze, Rutschungen, Erd- und Schuttströme) gehören seit jeher zu den gefährlichsten Naturkatastrophen. Heutzutage treten aktive Massenbewegungen besonders in alpinen Gebieten auf und stellen oft eine große Gefahr für Mensch und Umwelt dar. Während es zu aktiven oder rezenten Massenbewegungen zahlreiche Untersuchungen gibt, sind die Ablagerungen reliktischer Massenbewegungen heute aufgrund von Erosion und Verwitterung nicht mehr so leicht zu identifizieren.

Hallstatt (Salkammergut, Österreich) ist für seine Salzlagerstätten bekannt, die schon seit Tausenden von Jahren eine starke Anziehungskraft auf die Menschen dieser Region ausüben. Dank spektakulärer archäologischer Funde kann der untertägige prähistorische Salzbergbau in Hallstatt bis in die Bronzezeit (ca. 1400 v. Chr.) zurückverfolgt werden.

Aufgrund der ungünstigen geologischen und geotechnischen Situation wurde das Hochtal von Hallstatt im Laufe der Jahrtausende immer wieder von Massenbewegungen heimgesucht, die verheerende Auswirkungen für die Menschen hatten. Mächtige mesozoische Karbonatabfolgen liegen hier auf einer duktil-plastischen Unterlage aus permomesozoischen Evaporiten. Dadurch werden große Bereiche dieses Gebietes von tiefgreifenden Massenbewegungen erfasst, die vor allem in Felsstürzen, Rutschungen und Schuttströmen ihren Ausdruck finden.

Bei archäologischen Ausgrabungen wurden bis in eine Tiefe von über 100 m mehrere prähistorische Abbauhallen und Schächte (Bronze- bis Eisenzeit, 1400–300 v. Chr.) entdeckt, die mit meterdicken, teilweise gradierten Ablagerungen solcher Massenbewegungen verfüllt sind. Durch sedimentologische, (mikro-)fazielle und tonmineralogische Analysen dieses Übertagematerials lassen sich erste Erkenntnisse über die Herkunft des Materials und die Art der Massenbewegung gewinnen. Dazu wurden aus dem Bergwerk an verschiedenen Stellen sowohl feinkörnige als auch grobklastische Proben entnommen und getrennt ausgewertet. Das feinkörnige Material wurde einer Korngrößenanalyse und tonmineralogischen Analysen unterzogen. Die grobklastischen Proben wurden nach ihrer Lithologie sortiert; dazu wurde der Rundungsgrad und die Länge der mittleren Achse bestimmt.

Die Ergebnisse zeigen sowohl lithologische, als auch tonmineralogische Unterschiede der Klasten und des Feinmaterials. Daraus lassen sich zwei verschiedene Szenarien zeichnen, die sich zu unterschiedlichen Zeiten im Hochtal abgespielt haben könnten.

ROHSTOFFINTERESSEN UND IHRE GEOLOGISCHEN GRUNDLAGEN IM RHÄTISCHEN DACHSTEINKALK DES STEINBRUCHES STARNKOGEL, BAD ISCHL, OBERÖSTERREICH, ZEITRAUM 2004–2006

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Am Starnkogelsteinbruch und in der näheren Umgebung sind sedimentologisch-mikrofazielle und tektonische Untersuchungen im Gange, von denen wir vorerst folgende interessante, teilweise aber noch weiterer Bearbeitung harrende Details präsentieren.

Der Vorzüge des Materials wegen wurde im Laufe der Jahre der Abbau intensiviert, es kam mit Genehmigung neuer Überscharen zu laufender Steinbrucherweiterung, und dies gewährte, wenngleich aufgrund der komplexen Lagerungsverhältnisse zwar durchaus noch nicht vollständige, so im Laufe der Zeit doch wesentlich bessere Einblicke. Verglichen mit MOSHAMMER (2004), sind nunmehr neue Erkenntnisse speziell bezüglich Faziesverzahnungen zwischen Dachsteinkalk und Kössener Schichten angestrebt worden. Derartige fazielle Zusammenhänge zwischen beiden sind wohl evident, aufgrund allgegenwärtiger massiver tektonischer Einflüsse indes nicht immer leicht mit eindeutigen Belegen zu versehen.

Wir gehen zunächst von einer nach Süden abtauchenden Kössener Abfolge aus, in die aber geringmächtiger Dachsteinkalk eingeschaltet scheint. Ob sedimentär oder aber tektonisch, konnte vorerst noch nicht eindeutig geklärt werden. Diese Kössener Fazies zeigt nach Süden hin eine besonders auffällige schwarz vermergelte Entwicklung und auf den Kalkbänken wellig-dickknollige Oberflächen, alles mit vergleichsweise spärlichem, eingedelltem Bestand an Brachiopoden und Muscheln. In kalkigeren Anteilen konnten wir da und dort lebhafte Bioturbation feststellen.

Bereits tiefer und bis gegen Top der Abfolge treten immer wieder zu großen Stücken zerbrochene Korallenstöcke (ehemals wahrscheinlich kleiner Riffkörper) auf. Sie scheinen von der jeweils nachfolgenden Vermergelung begraben.

Über der geschilderten Kössener Abfolge folgt mächtiger Dachsteinkalk. Durch SE-NW-Einengung kam es zur Ausbildung einer SSW-fallenden Mulden-Sattel-Struktur und nachfolgend zu sinistralen NE-SW gerichteten Zerscherungen, sowohl zwischen Sattel und Mulde als auch des Muldenkerns. Im W-Bereich scheint die Verzahnung DK-KÖSS erhalten, während für den östlichen Muldenflügel der hohe tonige Anteil der KÖSS Gleitbahn und -mittel stellte, weshalb die Kössener Abfolge vollkommen überschoben wurde.

Das Bildungsmilieu des Dachsteinkalkes wird als photisch, flachmarin, subtidal, mit guter Strömung und Zirkulation trübearmen, nährstoffreichen Wassers interpretiert. Durchströmter (riffnaher) Hinterriffbereich einschließlich lagunärer Bildung wird durch verschwemmte Korallen- und große Schwammreste sowie durch reiche Foraminiferen- und Bryozoenfaunen und im lagunären Bereich durch auffallend großwüchsige Megalodonten und Gastropoden, nicht selten sogar eine ganze Muschelbank in Lebensstellung, dokumentiert. Die Dachsteinkalkbänke unterbrechen häufig grüne Tonlagen, 5 bis 10 cm stark, nach tektonischen Gleitvorgängen auch in etwas stärkeren Anschoppungen vorliegend. An den Kontakten zeigen die Kalkbänke oft stylolithisierte Oberflächen, häufig sogar mit cm-tiefen Anlösungen, der Basalanteil der Kalkbank ist oft grünlich ausgeflasert. Unserer Meinung nach sind die meist türkisgrün gefärbten Zwischenlagen Residuate nach wiederholten tektonischen Bewegungen und Drucklösungsvorgängen.

Für den aufgeschlossenen Dachsteinkalk-Kössener-Schichten-Komplex am Starnkogel sind dem Milieu nach **keine Loferzyklen** zu erwarten, und wir haben auch nirgendwo Anzeichen davon bemerkt. Lithologie, Mikrofazies und Wechsellagerung mit den Kössener Schichten bewirkten bei uns immer wieder Diskussionen zu der Frage, ob es sich hier tatsächlich um Dachsteinkalk handle oder aber eher bereits um (zumindest teilweise) dem sogenannten „Rhätolias-Riffkalk"-Komplex zuzuordnende Ablagerungen.

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LOWER CRETACEOUS AMMONOIDS FROM THE DOLOMITES (SOUTHERN ALPS, ITALY)

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Lower Cretaceous ammonoids (n = 424) were collected at the Puez locality in the Dolomites of Southern Tyrol. The cephalopod fauna from the marly limestones to marls here indicates Late Valanginian to Early Aptian age. The underlying Biancone Formation (Maiolica Formation) is Early Valanginian, whereas the lowermost Rosso Ammonitico is of Jurassic to Berriasian age. The deposition of the marly limestones and marls in this interval occurred during unstable conditions.

The ammonoid fauna comprises 27 different genera, each apparently represented by 1-2 species. The complete occurrence at the Puez section is dominated by the Phylloceratina (30%) and the Ammonitina (34%). *Phyllopachyceras* (17%) and *Phylloceras* (13%) from the Phylloceratina are the most frequent components, followed by *Lytoceras* (12%) from the Lytoceratina, and *Barremites* (10%) and *Melchiorites* (8%) from the Ammonitina. Phylloceatidae and Desmoceratidae are dominating the cephalopod-fauna.

Some ammonoid zones defined by Hoedemaeker *et al.* (2003) can be recognized. The following index fossils were examined within the collections of the NHMW (Austria) and the NMB (Italy): for the uppermost Valanginan *Criosarasinella furcillata* (*C. furcillate* Zone and Subzone), for the middle Lower Hauterivian *Olcostephanus (Jeannoticeras) jeannoti* (*O.(J.) jeannoti* Subzone) and for the middle Lower Hauterivian *Olcostephanus (Jeannoticeras) jeannoti* (*O. (J.) jeannoti* Subzone) and *Heinzia sayni* for the lowermost Upper Barremian (*H. sayni* Subzone; Reboulet and Hoedemaeker (reporters) *et al.*, submitted).

The ammonoid fauna contains only descendants of the Mediterranean Province (Tethyan Realm). Most affinities of the cephalopod fauna are observed with faunas from the adjacent areas of Italy (Lessini Mountains, Belluno, southern Trento Plateau), the Northern Calcareous Alps and the Bakony, Geresce and Mecsek Mountains of Hungary. This is explained by the neighbouring position of the latter areas during the Early Cretaceous on the Apulian/Adria block and the Alpine-Carpathian microplate.

The frequency of the ammonoids and the richness of the fauna make this section especially suited to accurately study the vertical ammonite distribution. The main focus in the future will be to investigate in detail the stratigraphic framework of the Puez section. Bed-by-bed collecting is required to obtain crucial data on the ammonoid distribution and occurrence (range). A cooperative project with this aim is planned by the Natural History Museum in Vienna and the Southern Tyrol "Natur Museum" in Bozen.

A further study on the the palaeoecology and synecology of the cephalopod fauna of the Puez section is currently under preparation by Alexander Lukeneder. It focuses on the autecological features exhibited by different fossil groups (annelids, bryozoans, foraminifera, corals) on ammonoid shells, which act as cryptic habitats for different encrusters in the Lower Cretaceous of the Puez locality.

LOWER CRETACEOUS AMMONOIDS AS ISLANDS FOR CORALS (DOLOMITES, SOUTHERN ALPS, ITALY)

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Early Cretaceous ammonoids (424) represent almost the totality of the macrofauna (85 %) at the Puez locality in the Dolomites of Southern Tyrol. The cephalopod fauna from the marly limestones to marls here indicates Late Valanginian to Early Aptian age. The ammonoids are well preserved (mostly in concretions) and appear as steinkerns without shell. The very abundant and generally well-preserved assemblage consists of 27 genera: from phylloceratids *Phylloceras*, *Phyllopachyceras*, from lytoceratids *Lytoceras*, *Eulytoceras*, *Protetragonites*, *Leptotetragonites*; from ammonitids *Neolissoceras*, *Barremites*, *Melchiorites*, *Abrytusites*, *Neocomites*, *Criosarasinella*, *Kilianella*, *Olcostephanus*, *Silesites*, *Jeanthieuloyites*, *Heinzia*, *Discoidellia*, *Acanthodiscus* and from the ancyloceratids *Pseudothurmannia*, *Macroscaphites*, *Dissimilites*, *Acrioceras*, *Crioceratites*, *Anahamulina*, *Hamulina*, *Ancyloceras*. The ammonoid fauna contains only descendants of the Mediterranean Province (Tethyan Realm).

The extraordinarily rich invertebrate fauna consists of ammonoids, ammonoid jaws (aptychi), coleoids, bivalves, brachiopods, serpulids, sea urchins, ophiurids, corals, benthic/planktonic foraminifera and radiolarians. The benthic macrofossils observed in the ammonoid beds comprise bivalves, brachiopods and, surprisingly, corals. Huge number of encrusting species like serpulids and corals were examined.

The most exciting feature of the fauna is the fact that solitary corals of *Cycloseris* sp. lived on ammonoid shells during the Early Cretaceous of the Dolomites. This is not known from other sediments and localities through time and space. The relation between the latter fossil groups is reported for the first time from the Early Cretaceous.

In most cases only the round bottom plate of the corals is visible attached to the steinkerns of the ammonoids. Only rare specimens (2) show three-dimensional preservation of the coral body with its septa. All kinds of ammonoids are attached with relics of solitary corals: lytoceratids, phylloceratids, ammonitids and ancyloceratids, ribbed species as well as smooth species. Therefore a secondary hard ground is needed for settling. The hard substrate must have been available for the epibionts over a quite long time so that they had enough time to settle and grow.

The morphology is similar to that of Upper Cretaceous solitary corals like *Connolites* or *Micrabacia*. Bottom discs are from 2 mm up to 4 cm in diameter. Internal structures, septa and composition, are comparable with the latter species. Despite these similar features it is not known from corals like *Connolites* or *Micrabacia* that they could have lived on ammonoid shells or even 'normal' hardgrounds. Serial thin sections were made and show remarkable differences from other known solitary corals. The described solitary corals needed some time to grow up to a maximal size of 4 cm in diameter. This shows that corals and other encrusters had enough time to overgrow the different shells. The number of about 20 corals attached on ammonoid shells shows that this is common at the Puez locality. A single ammonoid shell could be attached by up to 6 corals on it.

The main focus of future studies of the Puez area will be on the palaeoecology, stratigraphy and synecology of the cephalopod fauna of the Puez section.

A joint integrative high resolution project is planned between the Natural History Museum in Vienna and the "Natur Museum" in Bozen.

The multitasking background contains investigation on fields of macro- and microfossils, isotopes, litho-, cyclo-, magneto-and biostratigraphy as tools for investigating the Lower Cretaceous within the Dolomites. The ambition is to establish the Puez Area as a new key region of the Tethyan Realm.

FLOW-THROUGH EXPERIMENTS OF ORGANIC COMPOUNDS IN CLASTIC RESERVOIR ROCKS

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Within the scope of the DFG-financed project (SPP 1135) we investigate the interaction of petroleum compounds with hematite coatings on mineral surfaces in reservoir rocks and their effects on porosity and permeability. We want to evaluate the hypothesis that liquid hydrocarbons in hematitic reservoirs can generate reactive organic acids and/or carbon dioxide during post-emplacement thermal evolution. The expected outcome could allow a better understanding of mechanisms of reductive bleaching in red sandstones by the presence of liquid hydrocarbons and late stage (syn- and post-oil-charge) porosity enhancement in deep basinal settings with methane source/reservoir potential (tight gas plays).

Flow-through experiments were carried out with red bed sandstones from the Upper Rotliegend and Middle Triassic Bunter under elevated temperature (up to 200°C) and pressure (400 bar) conditions and different reactant fluids. The sandstone samples and the reactant fluids are characterised prior and after experiments. Preliminary short-term experiments started with acidic deionised water (ph 5.7). Mineral reactions are monitored by analysis of the ionic species in the post experimental fluids by Inductively Coupled Plasma-Mass Spectrometry/-Optical Emission Spectrometry (ICP-MS/-OES) and titration methods. They showed a significant concentration of Silica, Calcium, Potassium, Aluminium, and carbonate species. Comparative petrographic-mineralogic investigations of the Rotliegend sandstone samples indicate leaching of carbonate cements and detrial feldspar grains. Pre- and post-experimental permeability measurements showed enhanced permeabilities after the leaching experiment. Further short-term and long-term (10 days) experiments were carried out with organic fluids consisting of a mixture of four n-alkanes (n-Hexane, n-Octane, iso-Octane and n-Decane) in equal volumes. Long-term experiments are planned with carbon dioxide, complex organic fluids or petroleum in interaction with the inorganic framework of water saturated sandstone samples. In the advanced stage of the investigations we will focus on the change of the mineral surfaces caused by reactions with reactants in different scales by Scanning Electron Microscopy (SEM), Vertical Scanning Interferometry (VSI), Atomic Force Microscopy (AFM), and Transmission Electron Microscopy (TEM).

GEOCHEMISTRY OF DETRITAL RUTILE IN LATE PALAEOZOIC SEDIMENTS FROM CHIOS, GREECE

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Knowledge of the provenance of ancient clastic sedimentary rocks is important for exploration of mineral resources, for basin analysis as well as for palaeo-tectonic reconstructions. In addition to whole-rock petrography, geochemistry and heavy-mineral analysis, geochemical discrimination studies of specific detrital minerals are a powerful tool in provenance characterisation. This study focuses on rutile that is one of the most stable heavy minerals during the sedimentation cycle and commonly present as an accessory phase in clastic sedimentary rocks. The Cr and Nb contents of rutile provide information about source rock lithology while its Zr content gives clues about its temperature of formation (Zack et al., 2004a, b; Watson et al., 2006), i.e. magmatic or metamorphic. In a case study, detrital rutile was separated from psammitic samples belonging to three different sedimentary successions (Carboniferous, Permo-Carboniferous, Permo-Triassic) that occur on Chios Island, Greece. The Ti, Cr, Al, Fe, Nb, Zr, Si, and V contents of the rutiles were obtained by electron-microprobe analyses to retrace their provenance.

The Cr and Nb values of the analysed rutile grains show a wide range and indicate that this mineral in the Carboniferous succession is mainly derived from metamafic rocks, whereas in the Permo-Carboniferous and Permo-Triassic successions from a metapelitic source. The calculated formation temperatures using the Zr-in-rutile thermometer are 495–1000°C (according to Zack et al. 2004a) or between 520–850°C (according to Watson et al. 2006) with more rutile of higher formation temperature occurring in the Permo-Carboniferous and Permo-Triassic successions. This feature together with the rutile chemistry indicate a change in source rock lithology through time, which could either reflect an increasing depth of erosion of an exhumed ‘Variscan’ nappe pile of heterogeneous composition in the hinterland or a change in the style of accretion and erosion of different terranes at the southern margin of Laurussia during the subduction of a branch of the Palaeotethys Ocean in the Late Palaeozoic. In general, this study underscores the importance of rutile chemistry and thermometry in quantitative single-mineral provenance analysis and in chemostratigraphic analysis of clastic sedimentary rocks.

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MICROPALAEONTOLOGICAL EVIDENCE OF SALINITY VARIATIONS IN THE LOWER TRIASSIC (GRIESBACHIAN) OF THE DOLOMITES

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The depositional environment of the Werfen Formation has traditionally been interpreted as a protected shallow marine bay. This assumption was based on palaeogeographical reconstructions, as well as sedimentological and palaeontological criteria, particularly on the fact that ammonoids and stenohaline benthic organisms are very rare and do not occur in pre-Spathian strata. The absence of open marine Tethyan faunal elements is most probably due to physical migration barriers and frequent environmental perturbations such as oxygen deficiency and salinity fluctuations. The occurrence of oxygen deficiency in the lower Werfen Formation (Mazzin Member) has been deduced from trace fossil patterns, abundant occurrence of pyrite and gammy ray spectrometry (Wignall & Twitchett 1996). Reduced salinity in the Griesbachian was deduced from the composition of benthic fossil associations, particularly the occurrence of monotypic shelly macrofaunas (*Lingula, Unionites*) in the Mazzin Member.

Micopalaeontological analysis of the Mazzin Member yielded different ostracod assemblages which strongly suggest salinity variations. A marine euryhaline ostracode fauna occurs 3 m above the Tesero Oolite in the Seis section. It consists of large and robust Paraparchitacea without spines representing 90% of the total ostracod fauna. These types of Paraparchitacea were often recorded from various late Palaeozoic littoral environments and are supposed to withstand strong salinity changes (e.g. Bless 1983, Crasquin- Soleau et al. 2005, Tibert & Scott 1999). Due to strong diagenetic carapace alteration and deformation the determination of genera and species is difficult. A preliminary taxonomical analysis suggests, however, that the Paraparchitacea are represented by at least 15 probably endemic species. The marine euryhaline character of this microfauna is additionally supported by the absence of ostracod taxa which are usually abundant in late Palaeozoic-early Mesozoic normal marine shelf environments (e.g. Bairdiacea, Healdiacea). Completely different ostracod assemblages were recorded at 5 m and 6 m above the Tesero Oolite. These assemblages show a higher ecological diversity, although they are strongly dominated by two species of *Cavellina* and *Sargentina*. The occurrence of *Judahella* and *Neoulrichia pulchra* Kozur indicates a normal marine shallow subtidal milieu.

The present data show that ostracods are important palaeoenvironmental indicators in the Werfen Formation particularly with respect to palaeosalinity. The record of salinity fluctuations within the Werfen Formation shows that the faunal recovery pattern in the Lower Triassic of the Dolomites was not only controlled by changes of palaeo-oxygenation levels and is therefore not representative for the global marine recovery pattern as suggested by Twitchett (1999).

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A CASE STUDY OF A POLYPHASE MEGA-IMBRICATE ZONE: THE EASTERN PERIADRIATIC LINEAMENT IN THE KARAVANK MOUNTAINS (AUSTRIA)

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According to the geological maps of the Austrian Geological Survey the east-west trending Periadriatic Lineament (PL) separate the Eastern Alps (Northern Karavank Mountains) and the Southern Alps (Southern Karavank Mountains) in the study area. Former structural investigations showed a laterally far less continuance due to strong segmentation along high-angle faults of limited displacement, numerous of them displacing the lineament also. The geological structures of the Karavanks south of Maria Elend are dominated by E-W- to SE-NW-striking high-angle faults, separating from each other in so far 24 imbricates, crosscuted by faults striking in NW-SE direction. They are of variable size, stratigraphic range, facies, palaeogeographic origin and diagenetic/thermal overprint, which are tested by biostratigraphy, microfacies analysis and measurements of the Conodont Colour Alteration Index (CAI). These individual segments, which derived from different palaeogeographic positions of Triassic-Europe by far tectonic transportation of crustal fragments, can be clearly distinguish by 1) stratigraphic range, facies and palaeogeographic origin, 2) diagenetic/thermal overprint, and 3) a specific structural inventory, which do not strike in the neighbouring segments. These particular sets of structures restricted to individual tectonic entities were created before the amalgamation, and are thus transported structures. Paleozoic and Mesozoic slices are mixed. However, there are successions with affinities to most Triassic(-Jurassic) facies zones of the Northern Calcareous Alps (NCA), the Southern Alps, and the "Slovenian-Bosnian Trough". All these stratigraphic and structural features indicate that enormous amounts of horizontal movements must exist between at least some of these tectonic slices. For example, small-scale segments of Paleozoic sediments, which are located a) west of Mt. Kapellenberg, or b) west of Mt. Großer Muschenig or east of Mt. Kleiner Muschenig, are marked by a complexity in both sedimentary successions and transported tectonic processes, bordered by a complex interplay of boundary conditions. Beside the metamorphic (CAI ~6.0), hemipelagic Devonian limestones of segment I, comprise segment VII Trogkofel limestones with Permian shallow water organisms in partly crinoidal-rich grainstone-oncoids. Another geological complex segment with transported tectonics, located between the Maria-Elend Sattel to the Mt. Kahlkogel is characterized by ?Carnian strongly recrystallized dolomites, overlain by a discontinuity of grey turbiditic to bioturbatic Sevatian radiolarian-rich wackestones and grey Rhaetian to Jurassic argillo-calcareous turbiditic radiolarian-rich wackestones. In these turbiditic, radiolarian-rich wackestones the occurrence of Jurassic radiolarians is reported for the first time in this area. These mostly poor preserved radiolarians indicate a Callovian age. Another interesting fact is the diagenetic/metamorphic overprint of different segments in this area. To the north and northeast Late Carnian reef-near sediments reach CAI 5.5 to 6.0, corresponding to low grade metamorphism. In addition to the stratigraphical and facies constraints also the CAI data prove the mega-imbricate shear zone of the study area. These high values of CAI 5.5 to 6.0 are comparable with the faciesequivalent thermally overprinted rocks of the Ultratirolic unit of the NCA or some individual slide blocks in the Hallstatt Mélange. The thermal overprint of different tectonic slices in this region is therefore transported. Summarising the main structural events of the Karavank Mountains south of Maria Elend, the amalgamation of these imbricates occurred during a long history of deformation in a variety of geodynamic frameworks, significantly changing in place and time. Despite some knowledge about general trends in deformation within the study area, e. g. the fact that the amalgamation of imbricates progressed from south to north and the imbricate zone is often displaced by approximately NE-SW-striking and even younger NW-SE-oriented high-angle faults of limited displacement. The youngest movements are comparable with the lateral tectonic extrusion. This is also kinematically in good correlation with data obtained from outcrops in Slovenia. During the Oligocene extensive magmatism (Periadriatic tonalites) occurred, followed by dextral strike slip movements and major rotations. Lateral motions since the Turonian formed a mega-imbricate zone between the Dinarides and the Eastern Alps contemporaneous with the movement of the Drau Range and the Transdanubian Range towards the east, to their present position.

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MASS-FLOW DEPOSITS IN THE LATE TRIASSIC SEDIMENTARY SEQUENCE OF THE SLOVENIAN TROUGH (SOUTH KARAVANK MOUNTAINS, AUSTRIA)

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The South Karavank Mountains of Austria show a complex geological structure of large-scale mega-imbricate zones to the south of, and parallel to the eastern Periadriatic Lineament. These zones display a suite of individual stratigraphic successions of partly different palaeogeographic origin and can be distinguished in stratigraphic range, facies as well as in late diagenetic/thermal history. Our study area is located between the Maria-Elend Sattel to the east and the Rosenbach Alm to the west where two laterally differing sequences are developed: the eastern sequence, located between the Maria-Elend Sattel to the Kahlkogel peak is characterized by ?Carnian recrystallized dolomites, directly and discontinuously overlain by grey bioturbatic Upper Norian radiolarian-rich wackestones and grey Rhaetian bioturbated limy wackestones followed by Jurassic argillo-calcareous mudstones. The western sequence, located in the area of the Bärengraben to the Rosenbach Alm, is composed of Carnian recrystallized dolomites, followed by ~200 meter thick grey Early to Middle Norian cherty dolomites (= Baca dolomite in the Slovenian Trough), and is overlain by grey thin bedded limestones of late Middle to Late Norian age with interbedded mass-flow deposits in the upper part (Krystyn et al., 1994, Lein et al., 1995). From the two departing successions we assume a primary basin inclination towards the Bärengraben sequence which received from a higher located part components and breccias now missing in the Lower to Middle Norian Maria Elend sequence. The resedimented breccia components are dated by conodonts and radiolarians. The occurrence of Late Triassic radiolarians from the polymict Late Triassic mass-flow deposits of the Bärengraben is reported for the first time in the Karavank Mountains. The mostly poor preserved, pyritized radiolarians again indicate an early to late Norian age. Interestingly, almost all breccia components are limy and not dolomitic, as one would expect from the reworked sedimentary unit (= Baca Dolomite). One may thus assume that the breccia components might have eventually derived from a palaeogeographically different source area no longer exposed in the study area.

The predominantly matrix-supported clast layers are interpreted as debris-flow deposits triggered by local(?) iterative tectonic pulses rather than by sea-level changes because of the several million years (Middle to early Upper Norian) lasting breccia formation. In the late Alaunian to early Sevatian the northwestern Neotethys shelf was affected by transtensional tectonic events forming asymmetric basins in the Hauptdolomite/Dachstein carbonate platforms of the Northern (Seefeld formation, Aflenz basin, Pedata basin – e.g., Gawlick 1998) and Southern Alps. Coeval events have probably similarly affected the Southern Karavanks and may be more widespread developed in the Alpine-Mediterranean domain than previously known.

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PETROGRAPHIC EVIDENCE OF DRAINAGE BASIN CHANGES IN THE SE ALPS FROM THE MESSINIAN TO PLEISTOCENE: THE TAGLIAMENTO PALAEOVALLEY (NE ITALY)

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As most valleys in the Southern Alps, the Tagliamento valley was deeply entrenched as a result of Late Messinian sea level drop.

In the valley-filling deposits six different unconformity-bounded Stratigraphic Units have been distinguished, which can be traced along the valley for several kilometres and allow reconstruction of the palaeodrainage during the considered time span. The sedimentary bodies have been classified as intra-valley coarse-grained fluvial and piedmont alluvial fan related to braided fluvial systems, and Gilbert-type delta conglomerates and sandstones.

Sandstone and pebble petrography supported the stratigraphic subdivision evidencing the evolution of the catchment with time. The older units are characterised by a high carbonate fraction, mostly dolostone and limestone rock fragments, suggesting a drainage basin confined in the Prealps sector where these types of rocks largely crop out. A sharp change in composition occurs between the second and the third unit (Messinian-Pliocene boundary), when the river deposits became more polymict and richer in non carbonate rock fragments, indicating an extension of the catchment towards north, in the Carnian Alps. The fourth unit is characterised by an increase in carbonate elements; this could suggest a new extension of the drainage basin in the Prealps and a likely enhance of sediment supply supported by the Pliocene tectonic activity in the prealpine area. In the younger units of middle Pleistocene age a spread of non-carbonate rock fragments is visible.

To sum up, the trends of the main rock fragment classes show an increase of the limestone fragment ratio and a similar growth of the siliciclastic elements towards the younger units. These types of rock fragments were eroded from the Palaeozoic successions, cropping out in the Carnian Alps, from the early Pliocene and it was probably intensified by the spread of the glaciers from middle Pleistocene onwards.

SILICICLASTIC STRATIGRAPHY IN AN EXPERIMENTAL TANK

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The correct deciphering of (continuous) time in a (discontinuous) stratigraphic reocrd has been one of the fundamental issues of stratigraphy. It is exemplified by the accommodation space equation T + E = S + W, where T is the rate of tectonic subsidence, E is the rate of eustatic sea-level rise, S is the rate of sedimentation, and W is the rate of water depth increase (or deepening). Conveying the complex interplay of these factors as theory to students in the classroom, in particular when loaded with the terminology of sequence-stratigraphic concepts, has traditionally been problematic. The design of appropriate exercises, usually practising the proper reconstruction of past events from industry 2-D seismic reflection lines, has also been challenging.

We constructed a simple portable experimental tank to better communicate concepts and common geometries of lithostratigraphic units at passive continental margins to undergraduate geology students. This tank allows to vary eustatic sea level, sediment supply and tectonic subsidence through base level change in two dimensions. The tank measures 1m (width) x 0,50 m (height) x 0,02 m (thickness) and uses a transparent plexiglas frontboard, adjustable water inflow and outflow taps, a gravity-fed adjustable sediment supply of fine-grained sand, and a number of freely moveable magnets supporting a flexible rubber strip. The latter make adjustments to basement geometry during the experiments possible. Coloured sands, injected at the right time, accentuate the geometry of individual key units (such as incised valley fills, lowstand deltas, lowstand basin floor fans, highstand deepwater condensed sections) and key horizons (such as sequence boundaries, maximum flooding surfaces, and shelf-slope seals).

This experimental setup enables the modelling of the principal stacking pattern geometries along passive margins, consisting of several generations of successive Highstand (HST) and Lowstand System Tracts (LST) while plainly illustrating the dependency of the generated progradational or regressive geometries on the interplay of the above-mentioned variables. As a consequence, students are more likely to recognize unconformities and missing geologic time in seismic sections and correlate correctly the equivalent sedimentary bodies along sequence-stratigraphic surfaces when later exposed to large-scale seismic sections. Digital movies in lecture classes and student-directed experiments in exercise sections using this tank will facilitate the communication of concepts requiring advanced stratigraphic understanding, such as regional stratigraphic syntheses, seismic interpretation, and petroleum geology.

PLEISTOCENE FLUVIAL TERRACES OF THE SVRATKA RIVER – FACIES AND PROVENANCE STUDY

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The middle course of the Svratka river flows through the geologically and geomorphologically complex area around the city of Brno. This area underwent a dynamic development during the Quaternary. Terrace system along the river course developed, witnessing the alternating incision and deposition phases during the last 1 Ma. The Quaternary uplift of the area can be deduced from the incision record of the river system. Sea level changes are assumed to have played negligible role (distance to the coastline, low river gradient).

Three successive river terraces (Pleistocene) were studied within the terrace staircase, the highest of which is about 60 m and the lowest about 15 m above the present river. Preservation of the river deposits is mostly fragmentary. The middle terrace (ca. 40 m above the present river) is the best preserved one (with largest lateral extent and thickness). The terrace sediments are composed of fluvial gravels and sands. Architectural components within the outcrops were defined and include: 1) basal, thalweg-fill deposits, 2) crudely stratified gravely barform deposits, and 3) inclined gravely and sandy barform deposits. Results of facies study reveal deposition in high-energy rivers.

Preserved fluvial deposits provide important sedimentary archive witnessing the condition within both provenance and depositional area during the Pleistocene. Provenance studies are based on the petrography of the pebbles and cobbles, heavy mineral assemblages and results of microprobe analyses of selected minerals (garnet, tourmaline, rutile, spinel). Varying role of distant (crystalline rocks of Moravicum, Svratka and Polička Crystalline Units) and local (Neogene deposits of the Carpathian Foredeep, Permian deposits of the Boskovice Furrow, Devonian conglomerates/"Old Red facies" and magmatic rocks of the Brno Massif) sources can be followed within the terrace system and the possible evolution of the source area interpreted.

CAVE EXCENTRIQUES FROM BREITSCHEID (NW HESSE, GERMANY): UNUSUAL SPELEOTHEMS WITH UNUSUAL CALCITE STRUCTURE AS PROVED BY ELECTRON BACKSCATTER DIFFRACTION (EBSD)

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Excentriques (= helectites) are elongated to vermicular, mostly cm-sized speleothems with a small (Ø < 0.5 mm) central canal growing indepentently from gravity. Their exact genetical conditions are still mostly not understood (Hill & Forti 1997). In most cases calcite excentriques are composed of single crystals (1) (Kempe & Spaeth 1977) or wedge-shaped crystals (2) (Moore 1954).

Our special interest was focused on the polycrystalline structure of the calcites forming the vermicular excentriques from a tributary branch of the Breitscheid-Erdbach cave system which unfortunately is destroyed by now. In thin sections under crossed polarizers the divergent fibrous structure of these speleothems proves to be quite complex. The modern Electron BackScatter Diffraction (EBSD) method reveals the following structure:

Starting from the central part with the canal where the c-axes of the calcite fibres are oriented parallel to the elongation of the excentrique, the cross section reveals three similar sectors with increasing inclination of the c-axes towards the outer rim. This divergence has a maximum in the central outer part of the sectors and decreases to their lateral sides where the orientation is parallel to the elongation of the excentrique again just like in the central part of the section.

This pattern was observed in the thicker adult portions of the samples. As the terminations of the excentriques are shaped nearly pointed most of the calcitic precipitations must have taken place externally. Calcite formation from biofilms seems to be most probable for the excentriques. Here, microbes could profit from the supply with nutrient through the central canal and additionally contribute to calcite precipitation. These considerations may be a potential field of microbiological investigations which repeatedly arose from genetical interpretations of speleothems (Northup et al. 1997). Besides a possible biogenic influence on the formation of excentriques the three sectors seen in the cross section may reflect the trigonality of calcite. But in respect of an exact understanding of the excentriques more investigations are necessary.

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PLIENSBACHIAN RADIOLARIANS IN TELTSCHENGRABEN (NORTHERN CALCAREOUS ALPS, SALZKAMMERGUT AREA, AUSTRIA): A KEYSTONE IN RECONSTRUCTING THE EARLY JURASSIC EVOLUTION OF THE NEOTETHYS

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In the „Hallstatt Mélange" located in the northwest of Bad Mitterndorf, a slide of Pliensbachian marly radiolarites occurs in an upper-Middle to lower-Upper Jurassic succession. The matrix consists of radiolarites, cherty limestones and marls, dated by radiolarians as upper-Middle Jurassic (Callovian). The microfacies and lithology (mainly cherty sediments) of the Pliensbachian slide are nearly identical to those of the matrix, but it belongs to the Lower Jurassic Dürrnberg Formation of the outer-shelf area of the Northern Calcareous Alps (Hallstatt Zone), which was paleogeographically situated in the north-western rim of the Neotethys Ocean. The radiolarian fauna has low diversity but its good preservation allows an accurate age determination. The dating of that cherty slide as Pliensbachian is of high importance because: 1) it notices the first finding of sediments younger than Sinemurian in the Hallstatt Zone of the Northern Calcareous Alps; 2) it represents the first record of Pliensbachian radiolarians in the European Alpine area; 3) it confirms that the north-western passive margin of the Neotethys Ocean persisted in the Alps at least until the Pliensbachian. Our paleontological and stratigraphic data prove that the closure of the Neotethys Ocean in this region is younger than Pliensbachian, but older than Callovian.

We determine following radiolarians: *Foremania sandilandsensis* WHALEN and CARTER, *Canoptum dixoni* PESSAGNO and WHALEN, *Parahsuum longiconicum* SASHIDA, *Laxtorum* sp., *Laxtorum* sp., *Parahsuum mostleri* (YEH), *Praecaneta* ? sp., *Parahsuum edenshawi* (CARTER), *Parahsuum simplum* YAO, *Katroma megasphaera* YEH and CHENG, *Katroma* cf. *bicornus* DE WEVER, *Katroma angusta* YEH, *Bagotum* cf. *modestum* PESSAGNO and WHALEN, *Lantus obesus* (YEH), *Lantus* sp. A, *Gorgansium* sp. 1, *Lantus* sp. A, Nassellaria NA2 sensu YAO, *Orbiculiformella callosa* (YEH), *Spongotropus* sp., *Praeconocaryomma* sp. 2 sensu CARTER in progress, *Spongotripus* sp. B sensu YAO, *Paronaella* sp. 1, *Pantanellium inornatum* PESSAGNO and POISSON, *Paronaella bona* (YEH), *Paronaella tripla* DE WEVER, *Paronaella bona* (YEH), *Homoeparonaella lowryensis* WHALEN and CARTER, *Hagiastrum* sp. 1, *Hagiastrid* g. et sp. indet G sensu YAO (new species) WHALEN and CARTER, *Cyclastrum* sp. A (new species), *Crucella spongase* DE WEVER, *Archaeohagiastrum longipes* BAUMGARTNER.

Middle and Late Jurassic as well as Early Jurassic radiolarian faunas from cherty sediments have been studied in the Northern Calcareous Alps in recent times. The Middle to Late Jurassic radiolarian faunas are well known from a taxonomic and biochronological point of view, whereas some problems remain. By this, in the Northern Calcareous Alps these radiolarian faunas are used for the reconstruction of the basin dynamics and the reconstruction of the destruction of the distal European continental margin in late Middle to Late Jurassic due to the closure of the Tethys Ocean.

Early Jurassic radiolarian assemblages in the Northern Calcareous Alps as well as in the Tethyan realm are rare (Gorican et al. 2003). Hettangian to Sinemurian radiolarian assemblages in the Northern Calcareous Alps are described by Kozur & Mostler (1990) for the continent near part (lower nappe system) of the Northern Calcareous Alps and from Gawlick et al. (2001) for the continent far part (Hallstatt Mélange). The discovery of a well-preserved and diverse radiolarian fauna in Teltschengraben northwest of Bad Mitterndorf represents the first record of Pliensbachian radiolarians in the northwestern Tethys.

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GEOLOGY OF THE BOSNIAN FLYSCH (SARAJEVO – ZENICA AREA, BOSNIA AND HERZEGOVINA) PART 2: DEFORMATION AND BURIAL HISTORY

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The Bosnian Flysch is a Mesozoic tectonostratigraphic unit of the Dinarides stretching from the Southern Alps-Dinarides transition in the NW to the Skadar-Peć fault in the SE. Structurally the Bosnian Flysch is underlain by the Adriatic-Dinaride carbonate platform nappes, the Una-Kuči Nappe, and the Mid-Bosnian Schist Mountains. To the NE, it is bordered by the Pannonian-Golija-Macedonian nappe, the Dinaride Ophiolite Zone and the Durmitor-Gashi Nappe.

The Bosnian Flysch consists of two major units. The lower unit (Vranduk Fm.) is composed mainly of Jurassic to Lower Cretaceous micritic limestones, marls, shales and siliciclastic-dominated sandstones. The upper unit (Ugar Fm.) comprises Upper Cretaceous thin-bedded marly to micritic limestones and marls alternating with carbonate gravity-flow deposits. This unit is characterized by high carbonate content and synsedimentary deformational features (e.g. slumping).

The Vranduk Fm. commonly exhibits outcrop-to-map-scale tight folds (inclined and overturned) and thrust faults. Joints perpendicular to bedding are frequent. The Ugar Fm. is dominated by open to tight folds. Fold vergence and top-to-SW tectonic transport indicators in both units are in agreement with the general Dinaridic strike.

Pelite samples for burial history analysis were taken from the Vranduk Fm., the Ugar Fm. and the black shale matrix of the ophiolite mélange. From each sample, the <2 µm and <0.2 µm grain-size fractions were used to determine K/Ar age, Kübler-Indices (KI), proportions of the illite polytypes, and percent illite in illite/smectite mixed layers. Quantitative clay mineralogy was determined in the <2 µm fraction.

The dominant phase is illite (54–86%) with up to 10% smectite. Chlorite with varying Fe contents amounts up to 46%. Corrensite (<35%) and other chlorite/smectite mixed layers were also found. Kaolinite occurs only in the Ugar Fm., whereas serpentine is restricted to the ophiolite mélange matrix. Corrensite and chlorite/smectite are absent in the Bosna Valley samples. In the <2µm fraction the KI vary between 0.24-0.62°2Θ in the Stavnja Valley and between 0.39-0.45°2Θ in the Bosna Valley. The KI of the <0.2 µm fraction are higher than those of the <2 µm fractions.

Illite polytype quantification of the <2 µm fraction indicates a dominance of $1M_d$ (43–80%) of $2M_1$ (7-53%) illite. There is no regional trend in the illite polytype distribution within the profiles. Illite proportions in illite/EG-smectite exceed 90% in both profiles.

K/Ar ages decrease southwards. Stavnja Valley <2 µm samples range in age, from north to south, from 168.4 +/-3.6 Ma in the ophiolite mélange through 132.6 +/-2.9 Ma in the Vranduk Fm. to 129.7 +/-2.9 Ma in the Ugar Fm. Ages measured on the <0.2 µm fraction range between 149 +/-3.4 Ma and 111.9 +/-2.5 Ma. Bosna Valley samples range between 156.3 +/-3.4 Ma and 138.7 +/-3.3 Ma (<2 µm) as well as 137.8 +/-3.0 Ma and 118.9 +/-2.6 Ma (<0.2 µm). No correlation exists between K/Ar ages and the proportions in 2M1 illite polytypes.

Vitrinite reflectance data from both flysch units and from the ophiolite mélange matrix indicate a maximum overprint temperature of 100–200°C assuming an effective heating time of 10 Ma. Along the Bosna Valley profile, Ro values vary systematically from 1.9% to 0.8% and indicate a southward decrease in thermal overprint. In the Stavnja Valley profile the vitrinite reflectance varies from 1.3 to 2%, with the highest values occurring below the top-to-SW thrust sheets.

K/Ar ages display no correlation with results from the other thermal indicators (KI, Ro%, %I (I/S)) suggesting that the ages result from the coexistence of detrital illite with authigenic illite in the sequence. Therefore, burial depth estimation by means of KI and percent illite in illite/EG-smectite alone is not a reliable tool in the investigated profiles. However, maximum temperatures yielded by vitrinite reflectance measurements suggest a burial depth of 4 to 8 km assuming 25 °C/km geothermal gradient. Due to the presence of some detrital illite and the low thermal overprint, the K/Ar ages are probably slightly older than the main deformation event. Combined with our biostratigraphic data (Christ et al., this volume), deformation of the Vranduk Formation of the Bosnian Flysch took place most likely between 120 and 100 Ma.

DER TSCHIRGANT BERGSTURZ (NÖRDLICHE KALKALPEN, TIROL): PROMINENTES FALLBEISPIEL EINER LITHOLOGISCH UND STRUKTURELL PRÄDISPONIERTEN FELSGLEITUNG

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Mit einem Ablagerungsvolumen von über 200 Mill. m³ (Abele, 1974) zählt der Tschirgant Bergsturz (TBS) in den westlichen Nördlichen Kalkalpen zu den größten Massenbewegungen im Alpenraum. Das weitflächig und tiefgründig aufgelockerte Abbruchgebiet besteht aus mittel- bis obertriadischen Karbonatgesteinen der südlichen Inntal-Decke, die polyphas und heteroaxial gefaltet und zerschert wurden (Eisbacher & Brandner, 1995). Südlich angrenzend folgt die NE-streichende Oberinntal-Störungszone, die aus der Tertiären, NW-gerichteten, durchreißenden Überschiebung des Ötztal-Grundgebirgskomplexes auf den Kalkalpensüdrand hervorgegangen ist. NW-streichende dextrale Blattverschiebungen durchtrennen diese Überschiebungszone und den Deckenstapel der Kalkalpen in der Liegendscholle. Die tief reichende Kataklase ermöglichte eine beträchtliche fluvio-glaziale Eintiefung des Inntals zwischen den Nördlichen Kalkalpen und dem Ötztal-Kristallin.

Das Abbruchsgebiet des TBS, die sog. Weißwand, besteht vorwiegend aus grob gebankten Dolomiten der Wetterstein-Fm und aus engschichtigen Wechselfolgen von Tonschiefern, Dolomiten und Evaporiten (Rauhwacken) der Raibler Schichten. Diese kommen infolge der Deckenstapelung sowohl im Liegenden als auch im Hangenden der Wetterstein-Fm vor, an deren Basis zudem noch geringmächtige Reichenhaller Schichten (am Überschiebungskontakt) und gut geschichtete Kalke und Dolomite der Gruppe des Alpinen Muschelkalks erhalten sind.

Strukturell ist hier ein bemerkenswerter, weil geometrisch äußerst komplex deformierter Großfaltenbau mit z.T. stark überkippten Lagerungsverhältnissen erkennbar. Der Tschirgant ist Teil des Südschenkels der Großstruktur der Tarrenz-Synklinale und wurde im Zuge der Überschiebung des Ötztal-Komplexes steil gestellt und überkippt. Die vorausgegangene, NW-gerichtete Deckenüberschiebung der Inntaldecke äußert sich in der Stapelung mehrerer Teilschollen, wobei die Evaporite der Reichenhaller Schichten und der Raibler Schichten als Abscherungshorizonte dienten. Faziell gesehen erfolgte die Deckenstapelung im Bereich der Faziesverzahnung zwischen der Karbonatplattform der Wetterstein-Fm und Beckensedimenten der Partnach-Fm. Entlang der NE-streichenden schräg sinistralen Tschirgant-Störung wurde der Wetterstein-Riffkalk des Tschirgants nach Süden steil auf stratigraphisch jüngere Dolomite der lagunären Wetterstein-Fm rücküberschoben (Pagliarini, in Vorb.).

Aufgrund der lithofaziellen Ausbildung und komplexen Spröddeformation sind hier sowohl die Anlagen potentieller Gleitflächen als auch die Blockgrößenverteilungen der Sturzmassen deutlich strukturell vorgegeben. Wesentlich ist v.a. die stufenweise Vernetzung von SE-fallenden, i.e. häufig überkippten, Schichtflächen und NE-streichenden sinistralen Bruchzonen mit NW-streichenden dextralen Störungen und Klüften. Im Bereich Weißwand zeigen die kompetenten, tektonisch intensiv überprägten Dolomite der Wetterstein-Fm markante Trennflächensysteme (Schicht- und Störungsflächen, Klüftung), die listrisch aus dem Hang streichen und als pultartige Gleitflächen fungiert haben.

Zudem wurde das Versagen des TBS vermutlich durch Karststrukturen in der Wetterstein-Fm und durch das Auftreten Zehner-Meter mächtiger Rauhwacken der Raibler Schichten am Hangfußbereich gefördert. Mehrere signifikant mineralisierte Quellaustritte weisen auf Lösungsprozesse von Evaporiten hin. Dadurch kann es zur Erhöhung der Gesteinsporosität bzw. zu einer Mächtigkeitsreduktion der Evaporite gekommen sein, was ein gravitatives Nachsacken der hangenden, spröden Dolomite hervorrufen würde. Dieser Vorgang wird als langfristiger, prädisponierender Entfestigungsprozess angesehen. Dem entsprechend gibt es im Abbruchgebiet des TBS und den angrenzenden Gebieten zahlreiche Hinweise für ältere Sackungs- und Kippbewegungen („toppling“) mit Bildung steil stehender, spaltenförmiger Hohlräume die mit bereits verfestigten Breccien verfüllt sind.

Abbruchgeometrien und Ablagerungsgefüge der Sturzmassen belegen, dass sich hier eine initiale Felsgleitung zu einem mobilen Sturzstrom entwickelte, der vor ca. 2900 14C yrs das Inntal verschüttet hat und mindestens 6 km weit in das vordere Ötztal eindringen konnte (Prager et al., dieser Band).

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DYNAMICS OF AN EARLY MIOCENE TURRITELLINE GASTROPOD MASS OCCURRENCE (NORTH ALPINE FORELAND BASIN)

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The mass occurrence of gastropods is a frequently observed, though poorly understood sedimentological and (palaeo)biological phenomenon. One of the fairly well-known groups forming such low-diversity accumulatons are turritelline gastropods, which can occur in high local densities from the Cretaceous until today. Present-day turritelline gastropods are well known and occur worldwide from the shallower to the deeper seas (c. 0-1500 m water-depth, more typically 10-100 m). They are suspension feeders living partly digged into the substrate, +/- parallel to the sea-floor surface. Mass occurrences usually occur in shallow-subtidal, siliclastic environments rich in nutrients due to upwelling

A spectacular example of a fossil turritelline mass occurrence is the so-called 'Erminger Turritellenplatte' west of Ulm. This occurrence is part of the Early Miocene 'Upper Marine Molasse' unit ('Obere Meeresmolasse') in SW Germany, which represents a mainly siliciclastic marine stage of the development of the Alpine Foreland Basin. The 'Erminger Turritellenplatte' was deposited relatively close to the northern shoreline and is supposed to having developed during the maximum flooding of the Molasse Sea.

The 'Erminger Turritellenplatte' is an erosional relic, forming an at least 3.5 m (probably up to 7 m) thick, well-cemented bed with a lateral extension of a few kilometres. The succession is dominated by sandy limestone, sandstone and sand with the gastropod *Turritella turris* occurring in rock-forming quantities, as well as clayey sediments that lack gastropods. Furthermore, the bivalve *Pitar helvetica* as well as oysters and fragments of barnacles occur. Based on detailed sedimentological, palaeontological and taphonomical studies, this paper discusses the sedimentary and biological dynamics behind this unique mass occurrence, the interpretation of which is highly biased by diagenetic and, probably, biostratinomic effects.

PROVENANCE OF ORDOVICIAN AND DEVONIAN SILICICLASTIC SANDSTONES FROM SOUTHERN PERU AND NORTHERN BOLIVIA

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We use provenance analysis as a tool for the paleogeographic reconstruction of the Western Gondwana margin of southern Peru and northern Bolivia during Ordovician and Devonian time. For the study of the siliciclastic sandstones of southern Peru and northern Bolivia different provenance-indicative methods were applied (light mineral, heavy mineral, whole-rock geochemical analysis and geochemistry of tourmalines) in order to get a comprehensive dataset.

The Ordovician sandstones of the Sandia (southern Peru) and equivalent Amutara Formations (northern Bolivia) were deposited in the Peru-Bolivia Through in a back-arc position. The Peru-Bolivia Trough had a NW-SE strike direction and was limited by the Arequipa Massif to the southwest and the Brazilian shield to the northeast. The Ordovician successions have a thickness of up to 7000 m and sediment structures such as current ripples and crossbedding imply a paleocurrent-direction towards the SW. The sandstones of the Sandia and Amutara Formations are mature and relatively quartz-rich but they have a high matrix content of usually well above 20%. To approach the original composition of framework minerals the normative composition was combined with the whole rock geochemistry of the sediments. After recalculation most of the sediments still show a well-recycled nature but indicate a significant larger content of labile components like feldspars and rock fragments. Some of the Sandia Formation sandstones result in having a normative framework composition typical of arc sediments. This arc signature is reinforced by considering the provenance-indicative ratios of immobile incompatible (e.g. La, Th) to compatible (e.g. Co, Sc, Ti) elements, gathered from whole-rock geochemical analysis. Approximately half of the 26 samples from the Sandia and Amutara Formations are felsic, with ratio values typical of sediments of a passive margin setting, whereas the other half is less felsic and preserve characteristics of an active continental margin source. The heavy-mineral spectrum in general and the chemical composition of tourmalines in particular indicate significant reworking of the sediments before deposition. The heavy mineral content is dominated by the stable minerals zircon, tourmaline and rutile (ZTR; mostly more than 90%). Considering the indicative elements Al, Fe, Mg and Ca in the tourmaline chemistry, 85% of the tourmalines from the Sandia and Amutara Formations have a chemical composition typical for metasedimentary protolithes and about 15% for tourmalines grown in granitoids.

The Lower Devonian Cabanillas Group was deposited in a presumably similar plate-tectonic setting to the Ordovician basin. This Group is divided into two sediment successions with different features and location. One succesion (WCo) crops out in the Western Cordillera (near Cabanillas) with a thickness of aproximately 1200m. The other succession (CCo) is preserved on the coastal block, unconformably covering the Arequipa Massif and has only a maximum thickness of 400 m. Paleocurrent direction is towards the East on the WCo site and towards the West on the CCo site. The sediments from the CCo site are significantly less mature than the sediments from the WCo site, as indicated by the normative light mineral content (after recalculation considering the whole rock geochemistry). The CCo sediments contain more rock fragments and feldspar and point to an arc source. This is reinforced by the minor and trace element composition. The average Zr/Sc ratios are 54 and 19 for the WCo and the CCo sites, respectively. This is characteristic for a high degree of recycling at the WCo site and a low degree of recycling at the CCo site, the latter with values close to the upper continental crust composition. From the heavy mineral and the tourmaline chemical analysis both succession show signatures typical for mature sediments. This is demonstrated by the high ZTR content (mostly over 90%) and the high content of tourmalines from metasedimentary sources (WCo: 61,5-67,4% CCo: 100%). The well-recycled nature of the Ordovician and Devonian sediments makes it probable that they originate from a stable inner craton or a reycled older orogen. The additional arc signature from the Sandia Formation could originate from the contemporaneous Ordovician arc or could be an older arc signature. The arc signature of the CCo sediments could be interpreted to support the assumption of a Devonian arc in the region of the Arequipa Massif. Alternatively it could represent an older unidentified arc system. We plan to apply LA-ICP-MS dating of detrital zircons to test the different hypothesis.

INTERANNUAL CLIMATE VARIABILITY RECORDED IN EARLY PLIOCENE MOLLUSC SHELLS FROM COASTAL PERU

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The interaction between the El Niño-Southern Oscillation (ENSO) and long-term future global warming is uncertain. Some models link past and future "hothouse" climates to a shallowing of the east Pacific thermocline and a shift towards a permanent "El Niño-like state" in the east Pacific. This is in contrast to other models indicating little change in the ENSO system under "hothouse" conditions. The early Pliocene, characterized by prolonged global warmth, provides a good testing ground for these conflictive theories. Since ENSO events are tightly coupled to the annual cycle it is essential to use paleoclimate-archives with seasonal resolution to resolve individual ENSO events. The stable oxygen isotopes of mollusc shells could provide the first proxy-record for ENSO events during the early Pliocene. We will evaluate the potential of the mollusc species *Dosinia ponderosa*, from several Pliocene exposures in coastal Peru, as climate archives. A range of analytical methods (scanning electron microscopy, X-ray diffraction, cathodoluminescence) were applied to develop a screening procedure for diagenetic modifications. Replacement of shell calcite by gypsum was identified as the main diagenetic process active in the arid environment of coastal Peru. However, several diagenetically unaltered mollusc shells were identified and selected for stable isotope analysis of seasonal the temperature variability.

STACKED CYCLIC SEDIMENTARY PATTERNS PRIOR TO THE ARABIAN SHELF COLLAPSE (OLIGOCENE/MIOCENE, OMAN)

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The collision of Africa and Eurasia during the Oligo-Miocene and the resultant closure of the marine passage between the eastern and western Tethys (Terminal Tethyan Event) had far-reaching consequences for the distribution of shallow water areas and the course of ocean currents. It was therefore one of the major events for the distribution and evolution of terrestrial, as well as marine faunas during the Cenozoic. The exact timing of the Terminal Tethyan Event is thus crucial for palaeobiogeographic questions. In this context, the emersion of the Arabian Shelf during the Early Miocene was an important step because of a drastic reduction of shallow-water areas. The collapse of the Arabian Shelf was initiated by the opening of the Gulf of Aden during the Oligocene. At this time an extensive carbonate platform existed on the NE rift shoulder in the area of SE Oman. It emerged during the Early Miocene when rifting had ceased and the rift shoulder was uplifted. However, the exact timing of its subaerial exposure is problematic due to the rarity of age-diagnostic fossils in the restricted shallow-marine environment, as well as the so far poor knowledge of the invertebrate faunas. New taxonomic studies of abundant mollusc faunas and some benthic foraminifers from Oligo-/Miocene sections in SE Oman allow a sequence stratigraphic correlation with the Ru4/Ch1-Ch4/Aq1 lowstands of the Hardenbol et al. (1998) sea-level curve. It shows that the termination of rifting in the Gulf of Aden must be back-dated from the middle Burdigalian to the beginning of the early Aquitanian. Therewith, the area of SE Oman was a primary area that became emerged and produced an early permanent restriction of the marine passage between Africa and Eurasia already during the early Aquitanian.

For the uppermost part of the sedimentary succession that developed immediatly before the final emersion of the platform, a cyclic alternation of inter- (B) and subtidal environments (C) documents a fluctuating relative sea-level at different frequences. Single erosive surfaces with palaeokarst cavities and caliche crusts separate larger B-C segments. They display relative long episodes of subaerial exposure and are interpreted to have been formed during lowstands of 3rd order that emerged the platform. Accordingly, they sandwiched a stack of B-C alternations representing a third order sequence. It is composed of short deepening cycles (allocycles). Each cycle starts with a succession of a high frequency fluctuating B-C stack, in which C members are characterised by their low thickness and a shoaling trend. Therefore they are suggested to represent inferior autocycles that formed during the lowstands of the high order sequences. A thick C member that shows an internal deepening follows above. It developed under rising and high standing sea-level of the higher order sequence TST. Our depositional model possibly explains why peritidal cycles did not occur in older tertiary deposits of the Arabian Shelf in Oman although they comprise shallow marine platform carbonates that are equivalent to the C member in facies. It suggests peritidal cycles could have only developed at the end of the synrift stage when the subsidence rate had so far declined that the platform was elevated into the intertidal zone during sea-level lowstands of higher order.

CUPULAS OF THE MALACHITDOM CAVE (SAUERLAND/NRW) – CRYOGENIC SPHEROLITHES WITH UNUSUAL CALCITIC STRUCTURE AND C/O-ISOTOPIC COMPOSITION

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The calcitic cupula-spherolithes, first described from the Malachitdom cave (Schmidt, 1992) show sizes between 1 mm and 11 mm, and a dish-shaped depression on one side. The concave side of the cupulas is quite smooth, whereas the convex side shows subparallel oriented rhomboedral faces at the end of the calcite fibres.

According to Scanning Electron Microscope (SEM) observations these rhomboedral faces are bent-shaped, which coincides with the results of Electron Backscatter Diffraction (EBSD) analyses. These pigmented single fibres are distinguished by a diverging c-axis orientation within the crystals. Beak-shaped spherolithes, which do not have the characteristic indentation but show the same alignment of fibres, are counted to the cupulas in the broader sense as they are found next to the real cupulas.

The results of the C/O-isotope analyses of the cupulas showed $\delta^{13}C$-values ranging from −1 to −5 ‰ VPDB and $\delta^{18}O$-values between −7 and −14 ‰ VPDB. Within the spherolithes a trend becomes apparent for a lighter O-isotopy and a heavier C-isotopy from the inner to the outer parts. According to Žák et al. (2004) those values differing significantly from the composition found in other speleothemes, are explained by the formation of calcites due to slowly freezing water. During this process, the O-isotopy is mainly affected by the formation of ice whereas the C-isotopy is merely influenced by the degassing of CO_2.

The cupula-spherolithes show age ranges from 14.48 ± 0.12 kyr to 15.61 ± 0.20 kyr (U/Th-analyses by Denis Scholz, Heidelberg). This substantiates a genesis during the Weichselian-glacial shortly before the Bölling-interstadial. Probably due to a slow climatic warming lasting for centuries water infiltrated temporary into the cave (lying within the permafrost) and formed an ice-body. On top of the ice liquid water form small pools in which cryogenic calcites formed very slowly (sensu Žák et al., 2004). These were enclosed when the water froze and were later sedimented on the cave floor during the melting of the ice.

Two remain problems:

1. The Weichselian formation of an icebody could not yet be proven for the Malachitdom cave.
2. The dish-shaped depression of the real cupulas needs to be explained.

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'UNDERCLAST PORES' FORMED BY SHALLOWMOST GROUNDWATER FLOW DISTINGUISH TORRENTIAL CHANNEL DEPOSITS FROM DEBRIS FLOWS

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Underclast pores excavated by very shallow groundwater flow focussed underneath coarse gravels to boulders provide a diagnostic criterion to distinguish extremely poorly sorted torrential channel deposits (fluid flow deposits) from similar-appearing deposits of debris flows.

In the Northern Calcareous Alps, except perhaps for major trunk valleys, stream-dominated alluvial fans and talus slopes (many dominated by ephemeral alluvial processes) represent the main sediment storage in valleys and along mountain flanks. On the surface of present-day alluvial fans and talus slopes, the distinction of debris flows from deposits of torrential floods is straightforward. By contrast, in many 'vertical' outcrops of fan and talus successions, extremely poorly sorted debris flows may be difficult to distinguish from similar deposits that accumulated from torrential fluid flows. With respect to bed geometry in outcrop intersection, bed thickness, mean clast size, sorting, and absence of clast size segregation across beds, both types of deposit appear similar. In addition, both deposits may be vertically associated (often in cut-and-fill patterns) with sediments of unequivocal alluvial origin, such as sieve deposits. Debris flows and fluid flows are characterized by different types of downflow imbrication; in two-dimensional outcrops of lithified deposits, however, it is difficult to clearly identify abc-axes of clasts for distinction of imbrications. Furthermore, in both types of deposits, imbrication often is absent in outcrop scale. Whereas a primary matrix of carbonate mud to argillaceous mud is diagnostic of cohesive debris flows, a matrix of winnowed sand is not a good sole criterion for fluid flow/debris flow distinction.

Inspection of numerous fresh exposures in presently-active stream-dominated fans and torrential streams, including the days after floods, indicates that in coarse-grained, extremely poorly sorted fluid flow deposits, larger clasts are underlain by a widespread type of pore here called 'underclast pores'. The pores are present immediately below clasts of coarse gravel to boulder size, are limited in extent to the clast above, are widest near the central part of the clast underside, and taper out towards the clast margins, but also may partly engulf the clast from below. In fresh torrent deposits, closely below the actual sediment surface, many underclast pores are partly or, more rarely, completely filled by an (net) upward-fining layer a few millimeters to a few centimeters thick of carbonate-lithic sand to carbonate mud. Because of later infiltration of carbonate mud into the remnant pore space (a widespread process in talus and fan deposits of the NCA), in lithified deposits, underclast pores commonly are completely clogged by geopetally-laminated sediment. In lithified deposits, because of weathering, the sediment-filled former underclast pores may be overlooked if not specifically searched for. For the interpretation of underclast pores, three observations are significant. (1) In underclast pores, geopetal fillings mainly of silt to mud are widespread below larger clasts where at the surface of the pebbly to bouldery deposit, no sand to mud had accumulated at all or is confined to a few small, thin patches. (2) Underclast pores are limited in presence to (ephemerally active) torrential channels on stream-dominated fans and on talus slopes. (3) In these deposystems, underclast pores are limited to sediments of very poor to extremely poor sorting from mud to cobbles or boulders.

During flood stage, when a larger clast comes to rest on stream bed, formation of underclast pores starts. During peak to waning flood, because the clast focusses subsurface flow within the uppermost centimeters of sediment (hyporheic flow of limnology) into a smaller volume than the flow within the surrounding sediment, according to the Law of Stationary Current Flow, below the larger clasts hyporheic flow is more rapid than in the surrounding sediment, and finer-grained material underneath the clast is swept out. During waning flood, depending on availability of fine-grained sediment, the underclast pore in turn may become partly filled by geopetals of fine sand to carbonate mud. Because of the described conditions of formation, underclast pores can form only in fluid flows, irrespective of whether the extremely poorly sorted clastic material *originally* might have been brought to site by debris flows, and subsequently reworked by torrential floods. In fresh debris flow deposits, no underclast pores were found by the author. In fully lithified successions, underclast pores that commonly are completely or partly filled by geopetally-laminated internal sediments (silt to mud) are an unequivocal criterion to distinguish extremely poorly sorted torrential deposits from genuine debris flow deposits.

FIRST OLIGOCENE CORAL FAUNA FROM THE EASTERN ALPS

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In the Werlberg Member of the Häring Formation (Rupelian, Northern Calcareous Alps, Austria), in carbonate rocks of low-energy rocky to gravelly shores and low-energy lagoonal areas, a coral fauna composed of eleven colonial species has been identified.

During the Rupelian, the area of the future Eastern Alps had largely emerged as an elongate island between the Mediterranean Sea in the south and the Paratethys in the north. The Häring Formation is part of the inner-Alpine Tertiary, and accumulated during Oligocene basin formation along the Inn Valley strike-slip fault (cf. Ortner & Stingl, 2001). Today, in the Eastern Alps, Oligocene shallow neritic rocks are very scarcely preserved.

The Werlberg Member consists mainly of pure shallow-water limestones, and formed during transgression over a truncated substrate of folded and faulted Triassic carbonate rocks. In the basal part of the member, a gradual vertical transition from local rhegolithic breccias into thin intervals of beachface breccias, a persistent matrix of lime mudstone in textures of bio-lithoclastic floatstone and wackestone, abundant carbonate rock gravels to cobbles of extremely angular shape because of densely-spaced macroborings, and *in-situ* preserved thickets of branched coralline algae and/or of branched corals all record low-energy conditions along the marine transgressive fringe. The carbonate lithoclasts are derived from the local rock substrate, and are densely riddled by borings of lithophagids and clionids. The lithoclasts are overgrown by sessile foraminifera, serpulids, vermetids and balanids. In addition, punctate brachiopods are common, and may have thrived attached to hard substrata. Higher up-section, the Werlberg Member may locally contain bioclastic wacke-packstones rich in benthic foraminifera, coralline algae and fragments of branched cyclostomate bryozoans. At a single location, the member includes a package of bioclastic wackestones to floatstones rich in corals; these limestones probably accumulated from a low-energy shallow subtidal lagoon. The Werlberg member is capped by an intra-Oligocene unconformity that formed upon subaerial exposure.

In the intervals that accumulated along the rocky to gravelly carbonate shore, the corals most commonly are coarsely fragmented. In the interval deposited from an overall quiet shallow subtidal setting (lagoon or sheltered innermost shelf), however, integer coral colonies up to a few decimeters in size are common. No reef structure was observed. The corals thrived isolated and in level-bottoms. The coral fauna of the Werlberg Member includes ten genera, and is dominated by genera of large age range (mainly Paleocene to Miocene). The fauna shows highest affinity to both Central European and Caribbean-Central American faunas. On the species level, the Werlberg fauna corresponds best with Oligocene faunas from the circum-Mediterranean domain, in particular with that of the „Lessini shelf" of the Southern Alps. Two species of the fauna (*Syzygophyllia brevis*, *Stylocoenia carryensis*) are identified for the first time in pre-Miocene rocks. The Werlberg fauna consists of, both, branched coral taxa (phaceloid, ramose, ?dendroid) and of massive forms mainly of cerioid, meandroid, and plocoid integration. No solitary corals were found. Compared to recent coral faunas of similar low-energy depositional settings, the Werlberg fauna is of similar to higher diversity. Also, the wide spectrum of coral growth forms, polyp integrations and polypar size underscores that, overall, the Oligocene corals were not subject to elevated ecostress other than potential stress factors that pertain to every shallow subtidal nearshore setting.

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BIO-INDUCED CALCIUM CARBONATE PRECIPITATION IN EASTERN ALPINE SPRING TUFAS

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In Alpine tufa-precipitating springs cyanobacteria, micro- and macroalgae and moss directly induce or indirectly favour the precipitation of a major portion of total calcium carbonate. Other precipitates such as flowstones and pore-filling cements of calcite or aragonite overall are insignificant with respect to volume.

In all investigated tufas, calcium carbonate formed in association with microbes represents a significant to prevalent precipitate that forms first or very early in diagenetic succession. Among the microbes involved in tufa formation, filamentous cyanobacteria, the coccoid desmid *Oocardium*, filamentous chlorophytes and diatoms are important, in variable relative amounts. The filamentous cyanobacterium *Rivularia* shows a wide spectrum of calcification, ranging from scattered isolated crystals to layers of merged crystals, to complete calcification of filament sheaths in large crystals up to about 10 mm in size of calcite. Other filamentous cyanobacteria (e. g. *Scytonema*, *Petalonema*, *Calothrix*, *Phormidium*) were observed to induce precipitation of micro- to orthosparitic crystal aggregates. For these cyanobacteria, the style of calcification seems to depend mainly on the tufa-precipitating potential of the water, such that the resulting microfacies may range from porous aggregates of microsparite to small-crystallite sparite to well-calcified fabrics with the outline of the former cyanobacterial colony well recognizable. A similar style and range of calcification was observed for filamentous zygnemaleans (e.g. *Zygnema*, *Mougeotia*). Overall, however, filamentous zygnemaleans seem to be of minor significance in tufa formation.

The simple coenobia-forming desmid *Oocardium* shows a specific style of calcium carbonate precipitation by forming a calcite ring in the proximity of the immediate cell environment. Concomitant with calcite precipitation, the alga moves up, leaving a tube of mucilage surrounded by calcite behind. Fresh, unaltered calcite tubes show a circular outline, and appear to grow upward on 'step-dislocation like' facets. The precise mode of calcite precipitation immediately adjacent to *Oocardium* cells, however, as yet is poorly documented. By this style of crystallization, laminae of tufa up to nearly 10 mm in thickness per growth season (spring-autumn) can be formed. The initial crystal shape of *Oocardium* tufa, however, is highly unstable; combined recrystallization and further calcite crystallization starts within weeks to months after initial formation. Without knowledge of initial growth form, the resulting microfabric of very large (up to > 10 mm) single crystals of „combispar" calcite (with relicts of *Oocardium* growth tubes) may be difficult to recognize in its origin. In diatom mats, precipitation of densely-spaced but initially isolated calcite micro- to orthospar crystals is induced. The calcite crystals show a set of shapes that perhaps result from different influences (diffusion, fluid transport) during crystallization. Individual diatom frustules may provide a crystallization center to a calcite crystal. Because some diatoms grow in firm mats, the resulting layer of orthosparitic calcite may appear as a cement fringe in field and polished slab, yet owes its first origin to growth of numerous calcite crystals within a densely-populated diatom mat.

Among the macroalgae, the xanthophyte *Vaucheria* gives rise to a specific microfacies. This alga calcifies by progressive nucleation, growth and merging of calcite crystals (mainly well-defined rhombohedra) directly on its surface, until the entire algal filament is encased by micro- to orthospar calcite. *Vaucheria* tufa prevails on a few waterfalls, but typically is present in minor amounts. With respect to their initial calcification, moss plants may show (a) a coating of orthospar calcite, (b) a coating of micrite, (c) a coating of micropeloids, (d) large orthospar crystals on the tips of leaves and/or at the basis of leaves, (e) calcification of cyanoids (e. g. *Rivularia*) or *Oocardium* settled on the moss, and (f) combinations of (a) to (e). We guess that the role of moss primarily is a passive one. By providing a large surface area for water spray and for evaporation, as well as by providing a settlement area to microalgae which, in turn, can induce calcification, moss tufts favour calcium carbonate precipitation. We could not identify a specific type of calcium carbonate crystallisate exclusively tied to moss plants; this underscores that the role of moss rests mainly in its large differentiated surface rather than in physiological traits.

IN VIVO CALCIFICATION OF *VAUCHERIA* (XANTHOPHYCEAE) IN TUFA-PRECIPITATING SPRINGS OF THE EASTERN ALPS

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In Alpine tufa-precipitating creeks, the macroalga *Vaucheria* calcifies *in vivo* by progressive growth of calcite rhombohedra directly on the surface of the alga. Calcification of this alga results in a distinct microfacies observed in both active and fossil Alpine waterfall tufas.

Vaucheria is a xanthophycean macroalga common in springs, streams and rivers of temperate latitudes. Except in waters sufficiently supersaturated for calcium carbonate, this alga does not calcify. The calcification thus pertains to the induced type of biocalcification. In tufa-depositing creeks of the Alps, in low and mid-altitudes, mainly in waterfalls and in cascading reaches *Vaucheria* is fairly common. In these systems, the alga prefers well-lit locations subject to swift and persistent water flow, and forms dense monospecific tufts.

Calcification starts in the proximal (older) parts of algal filaments, by nucleation and growth of calcite rhombohedra directly on the surface of the alga. In most cases, the calcite crystals are of perfect or nearly perfect rhombohedral shape. In early stage of calcification, the calcite rhombohedra are loosely scattered over the surface of the alga. Progressive growth of rhombohedra coupled with continued nucleation of new calcite crystals in between results in a coating of the algal filament by a dense „crystal carpet". In late stage of calcification, the crystals merge with each other along competitive boundaries, resulting in a rigid tube in which the algal filament is completely encased. In standard light microscopy, the calcite crystals begin to be readily recognizable when they had attained microspar size, and they terminate their growth when they had attained a size of about 50-200 microns. We found no evidence for mediation of this style of calcification by other organisms. Although, in some cases, epiphytic diatoms and cyanobacteria were observed on partly calcified filaments of *Vaucheria*, these organisms clearly are not involved in nucleation and growth of the calcite crystals directly on the surface of the filaments. Complete encasement of algal filaments by calcite may impede the metabolic activity of the plant. As a result, the algal filaments die off in their proximal parts while continue to grow in the distal parts, leaving behind the empty crystal tubes of the former algal filament. Because *Vaucheria* grows in dense tufts and meadows, a specific type of cementstone microfacies is produced by the calcification of this alga.

In waterfalls, combined downward growth and contemporaneous calcification of *Vaucheria* may result in bizarrely-shaped, very delicate tufa curtains raging out. In thin section, these tufa curtains consist entirely of *Vaucheria* cementstone. In the shaded understorey of the tufa curtains, other organisms such as moss and/or cyanobacteria may thrive and calcify, giving rise to different microfacies. On the brink of creek cascades and on steep to vertical water-run surfaces, dense stands of this alga may form knobs that, in the resulting tufa, appear as the characteristic cementstone microfacies.

BACINELLA-TYPE FILAMENT STRUCTURES IN UPPER CRETACEOUS SHORE ZONE DEPOSITS (LOWER GOSAU SUBGROUP, AUSTRIA/GERMANY)

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Bacinella irregularis Radoičič is a widespread Middle Triassic to Late Cretaceous micro-encruster of unclear taxonomic affiliation. *B. irregularis* consists of an aggregation of hollow chambers of erratic, irregular shape that are bounded by thin walls of micrite. It is reported mainly from reefal, peri-reefal and lagoonal habitats, where it prevalently encrusts bio- and lithoclasts, or occupies crevices (e. g. crevices on the outer side of shells, skeletons or tests) and cryptic habitats either in interstitial pores or in intraparticle pores (e.g. skeletal pores, borings). *Bacinella*-like „cell aggregates" known as alveolar texture also are present in terrestrial caliche carbonates. Within soils, alveolar texture may result from calcification of fungi in association with microbes, or from microbial aggregates. In the marine environment, most plausible interpretations of *Bacinella*-fabrics refer to microbes (cyanobacteria or micro-algae?), sessile foraminifera, or sponges.

At Mount Untersberg near Salzburg (Austria), a truncated substrate of Upper Jurassic Plassen Limestone is unconformably overlain by shore zone deposits („Untersberger Marmor") that comprise the basal part of an Upper Cretaceous succession (Lower Gosau Subgroup). The Untersberger Marmor is interpreted as a deposit of submarine debris aprons ahead of wave-dominated, transgressive gravelly to rocky carbonate shores. In samples of Untersberger Marmor from quarry Wallinger (Gröding/Salzburg), *Bacinella*-type structures were observed in mixed carbonate-lithic/bioclastic grainstones, as a bridging between individual litho- and bioclasts. Bioclasts include rare small arenaceous and rotaliid foraminifera, debris of coralline algae, serpulids, bryozoans and a large encrusting foraminifer (> 5 mm) with similar appearance of some morphotypes of *Lithocodium aggregatum* Elliott. In thin section, the straight to slightly curved micritic walls (width: ~ 0.02 mm) of the *Bacinella*-type fabrics connect sand grains, resulting in a compartmentalized „pseudo-cell" structure defined both by the grains and the micritic walls between. Some carbonate clasts show irregular surfaces with penetration of *Bacinella*-type structure into the clast, suggesting potential capability of boring. Aside of Mount Untersberg, grain-binding/encrusting *Bacinella*-type structures and cf. *Lithocodium* were found also in other successions of Untersberger Marmor, together with a bioclast spectrum characterized by coralline algae, sessile arenaceous and rotaliine foraminifera, branched bryozoans, serpulids, and (in the basalmost part) brachiopods and echinoid fragments. Conversely, rudist fragments are rare to absent, and colonial corals are extremely rare to most commonly absent. Our observations document the previously unreported presence of binding/encrusting *Bacinella*-type organisms in sandy to gravelly shore zone deposits. In comparison to other palaeoenvironments where *Bacinella*-type fabrics were reported, the overall abrasive shore zone depositional setting of the Untersberger Marmor represents an environment wherein sediment-binding organisms overall are scarce.

KARTE DER TRINKBAREN TIEFENGRUNDWASSER ÖSTERREICHS 1:500.000

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In einigen Gegenden Österreichs ist die Wasserversorgung mangels geeigneter Alternativen auf trinkbares Tiefengrundwasser angewiesen – dies trifft im Besonderen auf Teile des Inn- und Hausruckviertels, die Oststeiermark und das Südburgenland zu. Diese Tiefengrundwässer sind aber auch aufgrund ihrer Verweilzeit und des damit verbundenen Schutzes vor Verunreinigungen von wasserwirtschaftlicher Bedeutung – nämlich in Hinblick auf eine Trinkwassernotversorgung. Sie stellen wegen ihrer langen Verweilzeit eine Grundwasserreserve sowohl für niederschlagsarme Perioden als auch im Falle einer Verunreinigung der oberflächennahen Grundwässer dar.

Da die gegenständlichen Tiefengrundwässer durch Versickerung von Oberflächenwasser und Niederschlag nur langsam erneuert werden, besteht für sie die Gefahr einer Übernutzung – vor allem, weil die Tiefengrundwässer häufig für Einzelwasserversorgungen mit Brunnen erschlossen werden, deren technisch unzureichender Ausbau das ungenützte Auslaufen des unter Druck stehenden Tiefengrundwassers nicht verhindert. Dem wird durch das Errichten von technisch aufwendigen zentralen Wasserversorgungsanlagen entgegengewirkt.

Ende 2005 beauftragte das Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft die Geologische Bundesanstalt mit der Erstellung einer österreichweiten Übersichtsdarstellung der als Trinkwasser nutzbaren Tiefengrundwasservorkommen. Ende 2006 wurde dazu ein Bericht inklusive einem umfangreichen Literaturverzeichnis, Detailkärtchen, Schnitten und einer Übersichtskarte im Maßstab 1:500.000 erstellt (Berka, R. & Schubert, G., 2006: Trinkbare Tiefengrundwässer in Österreich. – Unpublizierter Bericht, Geologische Bundesanstalt, Wien). Im Bericht werden die hydrogeologischen Gegebenheiten der verschiedenen Vorkommen näher erläutert und exemplarisch die chemische und isotopenhydrologische Beschaffenheit dieser Wässer dargestellt.

Die im Rahmen des Projekts erarbeitete Übersichtskarte 1:500.000 wird nun weiter kartographisch bearbeitet und soll gemeinsam mit Erläuterungen publiziert werden. Hauptaugenmerk liegt auf der detaillierten Darstellung der großen tertiären Sedimentbecken, an welche der Großteil der trinkbaren Tiefengrundwässer gebunden ist. Diese Übersichtskarte zeigt als Besonderheit österreichweit die Verbreitung der stratigraphischen Stufen der tertiären Sedimente in abgedeckter Form.

THE IMPACT ON THE LITHO- AND BIOFACIAL DEVELOPMENT OF THE MID DEVONIAN KAČAÁK EVENT IN THE PRAGUE BASIN, THE GRAZ PALAEOZOIC AND THE CARNIC ALPS

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The Kačák Event, named by House (1985), is one of 3 globally documented Mid Devonian events (Choteč, Kačák and *pumilio* Event). It is interpreted as a transgressive event (correlated to the Ie cycle of Johnson *et al*., 1985) and ranges from the upper part of the *kockelianus* to the lower part of the *hemiansatus* conodont Zone. Extensive extinction, substantial reduction in diversity of pelagic and benthic fauna globally, as well as appearance of new faunal elements is characteristic for the Kačák Event. Furthermore, it has played a significant role in evolution of some major fossils groups, such as are: goniatites, trilobites, brachiopods and conodonts (House, 2002; Walliser, 2000). A densely plot of carbon isotope values has recently been given by Buggisch and Joachimski (2006) for the entire Devonian. Their studies reveal a positive carbon excursion from less than 2‰ up to nearly 3.0‰ at the critical time interval.

Prague Basin: Here the Kačák Event shows one of the sharpest stratigraphical and lithological boundaries in the Barrandian area. It is represented by the onset of dark calcareous shale of the Kačák Shale Member (Srbsko Formation) sharply overlying the limestones of the Choteč Formation (Eifelian). In more proximal sequences of the Koněprusy area (Jirásek section), a dark grey bituminous limestone interval of less than 1 m occurs, which is regarded by some authors as an equivalent of the Kačák shales. However it has to be stated that this correlation is not that clear, because *Nowakia otomari* started earlier than the onset of black shales (as well as *Cabrieroceras rouvillei/crispiforme*).

Although the planktonic and nektonic elements were less affected, the decline in their diversity was remarkable. In Prague Basin, about 250 species are described from the Choteč Formation but only about 60 from the Kačák Member (Chlupáč and Kukal, 1986).

Graz Palaeozoic: The pelagic deposits of the Graz Palaeozoic during the middle to upper Eifelian are represented by the St. Jakob Formation (Laufnitzdorf Nappe). The sequence consists of tentaculite bearing limestones and lydites with inter-beds of immature sandstones. The shallow marine equivalent to the pelagic development can be found in the Rannach Nappe (Plabutsch Formation) where a highly diverse carbonate fauna (including stromatoporoids, corals, and brachiopods) developed out of a benthic pioneer community in the course of the transgressive phase.

Carnic Alps: In the Carnic Alps the discussed event is represented by a lithological change from limestones to black shales and lydites within distal slope settings (Oberbuchach II section). In shallow water environments of the Kellerwand Nappe (Spinotti Formation) the mid to late Eifelian transgression results in a change from massive birdseyes limestones (lagoonal to peritidal settings) to thick bedded peloidal limestones (approx. mid to deeper shelf settings). But due to lacking biostratigraphic constraints, it is not clear, whether this change reflects Kačák Event-deposits or not.

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DEPOSITIONAL ENVIRONMENT OF CRETACEOUS SEDIMENTS OF THE CHIKKIM SYNCLINE (SPITI, NORTHERN INDIA)

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The Cretaceous sequence of the Chikkim Syncline (Tethys Himalaya, northern India) is represented by the Giumal and Chikkim formations. The age of the Giumal Formation in Spiti is expected to be Lower Cretaceous in age by a recently discovered ammonoid fauna (Lukeneder *et al.*, in prep.) and by planktonic foraminifera of the Chikkim Formation constraining the latter to range between Late Albian and Campanian (Bertle and Suttner, 2005).

The Giumal Formation measures about 350 m and consists of brown coloured sandstone and dark shale. Five cycles could be distinguished within the succession, of which each starts with a several metres thick interval of black shale intercalated by single beds of fine grained quartz arenites. Along the cycle, sandstone beds become more abundant and increased in thickness (decimetre-bedded), forming 10 to 40 metres thick intervals towards the top. Thickening upward of the beds as well as coarsening upward is observed in each cycle. Usually the uppermost bed of the sandstone-interval is composed of coarse grained matrix with several layers of disarticulated bivalve shells intercalated. While fine grained sandstone beds have a dark, micritic matrix, topmost coarse grained arenites are mature. Sandstone beds contain high amounts of quartz, yield glauconite grains and limonitic clasts. In the lower part of the sandstone-intervals of cycle 2 and 5, ammonoids occur, comprising well preserved planspiral and criocone shell-types.

The Giumal Formation is overlain by the carbonatic sequence of the Chikkim Formation (minimum thickness: 65 m). The base of the Chikkim Formation starts with a relatively sharp contact of well bedded micritic carbonates to a strongly weathered interval of grey calcareous shale of the uppermost part of the Giumal Formation. Within the occurrence of the first limestone beds planktonic foraminifera occur (e.g., *Planomalina buxtorfi* and *Rotalipora appenninica*). Microfacies changes at the boundary of the Lower to the Upper Chikkim Member, where micritic limestone beds (20 cm in thickness) are replaced by thin-bedded carbonaceous marls.

The observed cyclicity of the Giumal Formation most probably represents a siliciclastic slope facies with distal to proximal turbidite fans. Micritic limestones, rich in planktonic foraminifera, hint to pelagic settings, at least for the deposits of the Lower Chikkim Member.

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MICROFACIES OF THE HONGGULELENG FORMATION (LATE DEVONIAN, NW XINJIANG, CHINA)

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The type section of the Hongguleleng Formation, at the Boulongour Reservoir close to the small village of Samontoma, is one of six Late Devonian sections (Boulongour, Genaren, Qiligoa, Emuha, Aoroa and Hebukehe River) in the northernmost Uygur Autonomous Region of Xinjiang, chosen for evaluation of the impact of the Upper Kellwasser Event at the Frasnian-Famennian boundary.

At the Boulongour Reservoir, the uppermost part of the subjacent Zhulumute Formation consists of volcanoclastic sediments with some beds bearing plant remains. The grain size of the tuffaceous beds at the formation boundary decreases from sand/silt to shale with the first bed of the Hongguleleng Formation forming the base of a bioclast-dominated calcareous depositional environment (Xia, 1997).

The formation is divided into two units on the basis of sedimentary characteristics. Unit 1 (approx. 64 m) consists of limestone beds (wacke- to packstone) yielding brachiopod-rich layers with subordinate bryozoans, ostracods and crinoid debris at the base. The fossil diversity increases a few metres above the base of the formation with crinoids and bryozoans becoming the major components; clasts of spiculite occur in some beds. Limestone beds (wacke- to grainstone), generally 1–15 cm thick, alternate with fine grained mudstones from a few cms (middle part of Unit 1) to a maximum of 200 cm (lower and upper third). The upper part of the unit is characterized by layers of carbonate nodules (composed mainly of spiculite mudstones or pelmicritic wackestones) rather that continuity of limestone beds. Cephala of phacopid trilobites are prominent in some limestone nodules.

The first laterally continuous limestone bed above the latter horizon marks the base of Unit 2 (total thickness: 32 m). As in Unit 1, it consists of limestone beds alternating with shale intervals, though with alteration more constant. Beds usually do not reach a thickness greater than 3–5 cm. Inter-bedded mudstone horizons have an average thickness c. 20 cm. The microfacies is dominated by fine-grained peloidal limestones with thin layers of crinoidal debris and sparsely distributed brachiopod and trilobite shells, as well as crinoidal wacke- to packstones (with skeletal grains of non-crinoidal invertebrates subordinate). As the top of the unit is approached, the micritic fraction of the matrix increases.

The sequence is continued above the Hongguleleng Formation by an approximately 100 m sequence of green siliceous and purple silty/sandy mudstones to be discriminated as the Samontoma Formation, named after Samontoma village. This interval has intercalations up to a few metres in thickness of thick-bedded crinoidal grainstones; prominent among these is the low, crinoid- and blastoid-rich ridge referred to as Blastoid Hill by Waters et al. (2003).

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ON THE AGE OF THE SURROUNDING SILICEOUS LIMESTONE OF THE HALLSTÄTTER SALZBERG, NORTHERN CALCAREOUS ALPS (AUSTRIA)

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In the Northern Calcareous Alps, salt deposits of Permo-Triassic age are distributed and excavated. The tectonic position of these salt deposits is discussed very controversially as in situ (v. HAUER 1857, MOJSISCOVICS 1905) or transported (HAHN 1913, GAWLICK et al. 2001) (summarised in TOLLMANN 1985, GAWLICK et al. 2001). One of the key points to solve the question of the emplacement of the Alpine salt deposits is to date the surrounding sedimentary rocks (siliceous limestone to siliceous marls). We examine, therefore, the radiolarian age of one sample (BNU) that derives from the end of the borehole BHTNU 040 bored at the Halstätter Salzberg in the Salzkammergut area. The sample BNU is a dark grey laminated siliceous limestone, in which most radiolarian tests are calcified and few ones are preserved as quartz.

Until now the following radiolarians are identified: *Archaeodictyomitra rigida* PESSAGNO, 1977; *Cinguloturris carpatica* DUMITRICA, 1982; *C.* cf. *cylindra* KEMKIN & RUDENKO, 1993; *Cyrtocapsa mastoidea* YAO, 1979; *Dictyomitrella kamoensis* MIZUTANI & KIDO, 1983; *Eucyrtidiellum circumperforatum* CHIARI et al., 2002; *E. ptyctum* (RIEDEL & SANFILIPPO, 1974); *E. unumaense* (YAO, 1979); *Gongylothorax favosus* DUMITRICA, 1970; *G.* aff. *favosus* DUMITRICA, 1970; *Gongylothorax* sp. C sensu SUZUKI & GAWLICK, 2003; *Hsuum brevicostatum* (OZVOLDOVA, 1975); *H. maxwelli* PESSAGNO, 1977; *Loopus doliolum* DUMITRICA, 1997; *Neorelumbra skenderbegi* (CHIARI et al., 2002); *Parahsuum* sp. S sensu MATSUOKA 1986; *Parvicingula cappa* CORTESE, 1993; *Praewilliriedellum spinosum* KOZUR, 1984; *Praezhamoidellum buekkense* KOZUR, 1984; *Protunuma matsuokai* (SASHIDA, 1999); *Podobursa nodosa* (CHIARI et al., 2002); *Quarticella ovalis* TAKEMURA, 1986; *Saitoum levium* DE WEVER, 1981; *Spongocapsula* sp. A sensu SUZUKI & GAWLICK, 2003; *Stichomitra annibill* KOCHER, 1981; *Stichocapsa convexa* YAO, 1979; *S. himedaruma* AITA, 1987; *S. japonica* YAO, 1979; *S. tegiminis* YAO, 1979; *S. naradaniensis* MATSUOKA, 1984; *Stichocapsa* sp. E sensu BAUMGARTNER et al., 1995; *Theocapsomma cordis* KOCHER, 1981; *Th. medvednicensis* GORICAN, 1999; *Tricolocapsa conexa* MATSUOKA, 1983; *Tr. fusiformis* YAO, 1979; *Tr. plicarum* YAO, 1979; *Tr. tetragona* MATSUOKA, 1983; *Tr. undulata* (HEITZER, 1930); *Tr.* sp. S sensu BAUMGARTNER et al. 1995; *Triversus hexagonatus* (HEITZER, 1930); *Triversus hungaricus* (KOZUR, 1985), *Unuma typicus* ICHIKAWA & YAO, 1976; *Williriedellum crystallinum* DUMITRICA, 1970; *W. dierschei* SUZUKI & GAWLICK, 2004; *Williriedellum* sp. A sensu MATSUOKA, 1983; *Zhamoidellum ovum* DUMITRICA, 1970; *Z. ventricosum* DUMITRICA, 1970.

This fauna resembles that from the Brielgraben which is dated with ammonites as a Middle Callovian (SUZUKI & GAWLICK 2006), and it is included in the *Protunuma lanosus* subzone in the *Zhamoidellum ovum* zone after SUZUKI & GAWLICK (2003). To correlate with the Japanese radiolarian zone, some important species can be mentioned, which indicate a horizon around the boundary between *Tricolocapsa plicarum* and *Tr. conexa* zones: *Cyrtocapsa mastoidea, Tricolocapsa plicarum, Tr. conexa, Tr. fusiformis, Tr. tetragona, E. ptyctum* (MATSUOKA 1983, 1995). Although *Tricolocapsa* aff. *fusiformis* sensu MATSUOKA 1983 that has a smaller basal appendage than typical *T. fusiformis* is commonly included in the samples from Brielgraben of the Middle Callovian, it has not so far been found in BNU of Hallstätter Salzberg. Taking the occurrence of *Z. ovum, S. annibill* and *G. favosus* into consideration, the horizon of the sample BNU is located above the lowermost Callovian (SUZUKI et al. 2001, SUZUKI & GAWLICK 2003). Therefore, the horizon of BNU lies in the Lower or Middle Callovian.

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CALLOVIAN TO OXFORDIAN RADIOLARIANS FROM A "SLOVENIAN/BOSNIAN TROUGH"-TYPE SUCCESSION ALONG THE PERIADRIATIC LINEAMENT (KARAVANK MOUNTAINS, AUSTRIA)

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The Karavank Mountains (Austria) display a suite of individual stratigraphic successions of partly different palaeogeographic derivations, today forming imbricates of variable size. A geological complex segment with a "Slovenian/Bosnian Trough"-type succession is located between the Maria-Elend Sattel and the Schwalbenwand. Above grey thin bedded turbiditic to bioturbatic Sevatian to Rhaetian radiolarian-rich limestones with mass-flow and sliding complex horizons (= Frauenkogel Formation; KRYSTYN et al. 1994) and the Rhaetian to Early Jurassic grey argillo-calcareous bioturbate to turbiditic wackestones (= Hahnkogel Formation; KRYSTYN et al. 1994) follow grey, thin bedded, turbiditic, radiolarian-rich wackestones of Middle/Late Jurassic age (= Kahlkogel Formation, as a part of the Ruhpolding Radiolarite Group).

In these radiolarian-rich wackestones, from the Kahlkogel Formation with mostly poor preserved radiolarians, the occurrence of Middle/Late Jurassic radiolarians is reported for the first time. From these dark radiolarian wackestones, following radiolarians can be identified: *Bernoullius cristatus* BAUMGARTNER 1984, *Archaeodictyomitra* sp., *Hsuum* cf. *brevicostatum* (OZVOLDOVA 1975), *Parvicingula* cf. *dhimenaensis* BAUMGARTNER 1984, *Dictyomitrella* sp., *Triversus* cf. *hungaricus* (KOZUR 1985), *Podobursa* cf. *nodosa* (CHIARI, MARCUCCI & PRELA 2002), *Unuma gorda* HULL 1997 [= *Unuma* sp. A sensu BAUMGARTNER et al. 1995], *Quarticella* cf. *ovalis* TAKEMURA 1986, *Williriedellum dierschei* SUZUKI & GAWLICK in GAWLICK et al. 2004, *Williriedellum glomerulus* (CHIARI, MARCUCCI & PRELA 2002), *Zhamoidellum* cf. *ovum* DUMITRICA 1970, *Stylocapsa oblongula* KOCHER 1981, *Gongylothorax* aff. *favosus* DUMITRICA 1970, *Gongylothorax* sp. C sensu SUZUKI & GAWLICK 2003, *Theocapsomma medvednicensis* GORICAN in HALAMIC et al. 1999, *Tricolocapsa conexa* MATSUOKA 1983, *Tricolocapsa undulata* (HEITZER 1930) [= *Sethocapsa funatoensis* AITA 1987], *Praewilliriedellum* cf. *spinosum* KOZUR 1984, *Stichocapsa convexa* YAO 1979, *Eucyrtidiellum* cf. *unumaense* (YAO 1979), *Eucyrtidiellum unumaense* ssp. (YAO 1979), *Eucyrtidiellum* cf. *ptyctum* (RIEDEL & SANFILIPPO 1974).

BECCARO (2004) reported the occurrence of *Eucyrtidiellum unumaense* from an Ammonitico Rosso section of northwestern Sicily dated by ammonites as Middle Oxfordian to Late Kimmeridgian. The last appearance horizon of *E. unumaense* is revised at least to Middle Oxfordian (upper limit of the *Williriedellum dierschei* subzone of the *Zhamoidellum ovum* zone after SUZUKI & GAWLICK 2003). The radiolaria *Zhamoidellum ovum* (Callovian to Early Tithonian, respectively U.A. Zones 7-11) is the index species for the *Zhamoidellum ovum* zone (Callovian to Oxfordian). *Gongylothorax* aff. *favosus* is defined for the U.A. Zones 7-8 (Late Bathonian to Early Oxfordian - BAUMGARTNER et al. 1995), respectively for the *Protunuma lanosus* subzone (Callovian) to *Williriedellum dierschei* subzone (Early to Middle Oxfordian) of the *Zhamoidellum ovum* zone. Thus, recent systematic studies on *G.* aff. *favosus* obtain in this sample an atypically species, with an inflated, less depressed cephalis in the thoracic cavity. The radiolaria *Podobursa nodosa* indicate only a Middle to early Late Jurassic age, its stratigraphic range should be further studied. *Triversus hungaricus*, originally described in the *Unuma echinatus* zone of southwest Japan and Hungary are determined to be Bajocian in age (YAO & BAUMGARTNER 1995). SUZUKI & GAWLICK (2003) reported this species from the *Zhamoidellum ovum* zone of the Northern Calcareous Alps. *Praewilliriedellum spinosum* was originally also described from the *Unuma echinatus* zone (Bajocian) of the southern Bükk Mountains (KOZUR 1984), and is also reported from the *Williriedellum dierschei* subzone. Consequently, radiolarians from these radiolarian-rich wackestones of this segment south of Maria Elend indicate a Callovian to Early/Middle Oxfordian age.

Hence, the sedimentation until the Middle/Late Jurassic in this belt is in line with the model of out-of-sequence thrusting in the Juvavicum since the Early/Middle Jurassic boundary, and continuous sedimentation on the backlimbs of the nappes. Lateral motions since the Turonian formed a mega-imbricate zone between the Dinarides and the Eastern Alps contemporaneous with the movement of the Drau Range and the Transdanubian Range towards the east, to their present position.

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SEDIMENTOLOGISCHE BELEGE INVERSER LAGERUNG VON GESTEINSEINHEITEN IN DEN NÖRDLICHEN KALKALPEN

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Die Feststellung inverser Lagerung beruht auf der Beachtung des Geopetalgefüges, das sich sowohl aus Karbonaten, als auch siliziklastischen Gesteinen, ablesen lässt. Meist ermöglicht die Gesteinsabfolge zusammen mit ihrem Einfallen eindeutige Aussagen, es gibt jedoch viele Fälle, wo eine Geopetalanalyse notwendig ist. Beispielsweise wenn Internzerschiebung oder andere Störungen den Verband lückenhaft gemacht oder zerrissen haben, wenn sich Fensterinhalte und deren Rahmen in ihren Abgrenzungen nicht klar definieren lassen, wenn Aufschlussarmut vorliegt, wenn, wie etwa bei Bohrungen, Lateralinformation nicht in ausreichendem Maße verfügbar ist.

Bei Karbonaten können sowohl sedimentations- als auch diagenesebedingte Kennzeichen beobachtet werden: Kleinerosionen, wie Kappungen von Lagen, Auskolkungen etc., Einbettungsarten von Fossilien, Füllungsabfolgen in Hohlräumen (Kalzitrasen an den Oberseiten), Entgasungsblasen. In siliziklastischen Gesteinen sind es ebenfalls erosionsbedingte Sedimentmarken, vor allem an Unterkanten von Sandsteinbänken als Ausgüsse von Eintiefungen im unterlagernden Feinsediment, aber auch Internstrukturen von Rippeln. Fehldeutungen können entstehen, wenn beispielsweise Drucksuturen sedimentäre Anlage vortäuschen oder wenn die Unterkante einer Rippelstruktur mit einer Kappung verwechselt wird.

Aus den Nördlichen Kalkalpen werden Beispiele unter anderem aus der „Sattelbachserie" an der Stirne der Göller Decke des Wienerwaldes, aus dem großdimensionalen Inversabschnitt der Sulzbachdecke im Annaberger Fenster und westlich davon, sowie aus einer überschlagenen Flanke der Gosaumulde südlich Hainfeld angeführt. Durch die detaillierte Untersuchung der Gesteine, die bisher als unmittelbarer Rahmen des „Schwechatfensters" galten, nämlich Lunzer Schichten, Reiflinger Kalk und Steinalmkalk, stellte sich heraus, dass diese ebenso invers liegen, wie der bisherige „Fensterinhalt", der aus einer bekannt inversen Schichtfolge aus Jura und Obertriaskarbonaten besteht. Dadurch verbleibt nur ein sehr lückenhafter Rahmen aus einer nächst höheren Schuppe, der Lindkogelschuppe.

Die Untersuchungsergebnisse in der inversen Sulzbachdecke im Annaberger Fenster und im Gebiet der Gfäller Alm sowie das Ergebnis der Bohrung Mitterbach U1, in der ebenfalls die inverse Sulzbachdecke angetroffen wurde, gehen konform mit der Kenntnis um eine 12 km betragende Erstreckung der inversen Serie dieser Deckeneinheit. Dies kann nur durch Abrollbewegung eines liegenden Mulden- Faltensystems erfolgt sein. Inverse Abfolgen sind vor allem in Stirnrollen tektonischer Überschiebungseinheiten sowie bei Einengungen von Muldenzonen, wie Gosaumulden anzutreffen.