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PANGEO AUSTRIA 2018

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ABSTRACTS

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PANGEO AUSTRIA 2018 – ABSTRACTS

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PANGEO AUSTRIA 2018

UNIVERSITÄT WIEN

Die PANGEO AUSTRIA findet alle zwei Jahre als österreichische Leistungsschau der geowissenschaftlichen Forschung und ihrer Anwendung statt. Das Leitthema der PANGEO AUSTRIA 2018 in Wien ist „Geo-Netz: Vernetzung der Erdwissenschaftler/innen in Österreich“. Damit soll vor allem den Studierenden und den jungen Erdwissenschaftlern/innen die Möglichkeit geboten werden, sich mit potentiellen Arbeitgebern in Österreich zu vernetzen.

Ein breites Spektrum von hochrangiger Forschung, regional und angewandten Themen sollen den Rahmen bieten, in dem ein enger Austausch zwischen Studierenden, Praktiker/innen und Forschern/innen an Universitäten, Museen, Forschungs- und Kompetenzzentren, staatlichen Institutionen, Ingenieurbüros und Industrie stattfinden kann.

Die Bedeutung von regionalen Österreich-relevanten Aspekten soll neben dem Vortrags- und Posterprogramm durch multidisziplinäre Exkursionen unterstrichen werden. Um die Vermittlung geowissenschaftlicher Inhalte an Schulen zu fördern, wollen wir auch spezielle Angebote für Lehrer/innen anbieten.

PANGEO AUSTRIA takes place every two years, showcasing Austrian geoscientific research and practices. The central theme of PANGEO AUSTRIA 2018 in Vienna is “Geo-Net; networking Earth scientists in Austria”. Through this, students and young Earth scientists in particular will be offered the chance to interact with potential employers in Austria.

A wide spectrum of high-quality research, with, theoretical, regional and applied themes, will provide the framework for a close exchange between students, professionals and researchers at universities, centres of excellence, museums, research institutes, government bodies, engineering companies, and other industries.

In addition to the lectures and poster presentations, the significance of regional Austria-relevant topics will be emphasised through multidisciplinary excursions. To support the communication of geoscientific material at schools, we will also provide special offers for school-teachers.

Bernhard Grasemann, Michael Wagreich, Hans-Georg Krenmayr, Mathias Harzhauser, Christian Zangerl

Wien, im August 2018

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Improved inversion of Induced Polarization and Transient Electromagnetic methods to characterize fractured media

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The characterization of aquifers located in fractured rocks requires the development of investigation techniques that permit to gain information with high spatial resolution and across broad spatial scales, considering the large subsurface heterogeneity imposed by fractures, their connectivity and extension. Hence, hydrogeological investigations have exploited the ability of geophysical methods to provide quasi-continuous information about subsurface properties. In particular, the Electrical Resistivity Tomography (ERT) and seismic methods are well-established methods used for the site characterization. Moreover, recent studies have also demonstrated an improved hydrogeological characterization by means of the Induced Polarization (IP) method, an extension of the ERT technique that provides information about the electrical conductivity and capacitive properties of the subsurface. Nevertheless, the uncertainty of the electrical methods increases with increasing the depth of investigation. To overcome this limitation and gain further information about changes in the electrical properties at depth, we here propose the application of Transient Electromagnetic (TEM) soundings, a technique well suited for deep investigations. Hence, variations in subsurface electrical properties can be solved in the shallow to intermediate depths through IP imaging, with deeper information resolved through TEM data. To evaluate our approach, we conducted combined geophysical investigations at three different study areas in Austria. The study areas represent different geometries, namely: (1) near Melk, representing a deep contact (> 50 m depth) between the Molasse formation and the Bohemian massif along the Diendorfer fault system (2) near Untersiebenbrunn, for an intermediate contact (> 20m depth) between flysch and the crystalline basement; and (3) the Rosalia study area, representing a shallow (<10 m depth) contact between soil and fractured gneiss. Our results show the possibility to gain detailed information about lithological changes in the different study areas, with an improved lithological interpretation of the electrical units following a cross-validation of the IP and TEM imaging results. Moreover, inversion of the IP data after inclusion of the TEM information permitted to improve the electrical images. Seismic measurements were also used to validate the contacts observed in the electrical images. Nevertheless, our results clearly demonstrated an improved hydrogeological characterization through the combined application of IP and TEM measurements.

Bringing light into the underworld - optically stimulated luminescence dating of the loess section and wine-cellars of the Loisium wine-world, Lower Austria

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Meyer, Michael (Universität Innsbruck, Innsbruck, AUT)

The study presents investigations of a 12 meters thick sedimentary sequence, newly exposed during construction work at the wine-world Loisium in Langenlois, Lower Austria. Additionally, loess from the wine-cellars of Loisium, situated ~20 meters south and stratigraphically below the main sequence (i.e. 12-14 m depth), was analysed too. The main section is composed of two fluvial gravel and two loess layers containing several horizons of pedogenesis. Numerous normal faults indicate neotectonic activity. To provide a chronostratigraphy, 9 samples for optically stimulated luminescence (OSL) dating were taken. The Single-Aliquot Regenerative-Dose (SAR) protocol was applied for measuring the coarse grain quartz fraction. A temperature of 180°C for both, preheat and cutheat, was chosen for all samples, following the result of dose recovery tests during which preheats were systematically varied. An early-background subtraction approach was used to maximise the proportion of the fast component in the dating signal and to prevent the malign effects of unstable medium and slow components. The resulting equivalent dose (De) distributions show acceptable over-dispersion (< 35 %) and were used for age calculation. The optical ages from the 12 m long main section are in correct stratigraphic order and are not older than marine isotope stage (MIS) 5. The uppermost loess layer from the main section suggests intensive aeolian deposition during the last glacial maximum (LGM) ~21 ka ago. The base of the main section appears to be > 100 ka and further methodological tests to constrain the basal age of this sediment sequence are currently underway. OSL ages of ~34-29 ka were obtained for the loess samples from the wine-cellars (i.e. > 12 m depth). Despite their deeper position, these loess samples are substantially younger than the base of the adjacent main section. This is presumed to be the result of the tectonic displacement along normal faults observed in this area, which in turn suggests substantial neotectonic activity for this part of Lower Austria.

Internationale Schulkooperationen im Rahmen von Erasmus+ – Best practice Beispiele

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Das internationale Erasmus+ Projekt „Living in a smart environment 2030 – Chances and challenges“ mit teilnehmenden Schulen in Belgien, Bulgarien, Deutschland (Projektleitung), Finnland und Portugal Projekt beschäftigt sich auf Basis von drei starken Säulen mit der städtischen Erlebens-Welt der Schülerinnen und Schüler im Jahre 2030. Das ist in etwa der Zeitraum, in dem sie selbst als Erwachsene ihre Umwelt gestalten und eventuell auch eigene Kinder bekommen. Im Rahmen des Projekts möchten wir unser Augenmerk auf drei Hauptaspekte richten:

1) Nachhaltige Stadtentwicklung in einer smart city: Die Schülerinnen und Schüler sollen sich anhand bereits existierender Möglichkeiten und Herausforderungen im Bereich „Nachhaltigkeit“ mit Verkehr, Energie, Wohnen etc. beschäftigen und angesichts ihrer Bedürfnisse und Wünsche für 2030 eigene Zielvorgaben erstellen sowie mögliche Wege dorthin aufzeigen. Dabei ist das Ziel, nicht nur Realitäten und Visionen zu beschreiben, sondern aktiv in die Gestaltung der Umwelt einzugreifen und Schülerinnen und Schüler zu aktiven Teilnehmern zu machen.

2) Migration/Flüchtlinge: Die Lebensrealitäten in Städten Europas im Jahr 2030 werden wesentlich mehr Migranten und Flüchtlinge berücksichtigen müssen als heute. Bedarfe werden eruiert und mögliche Ansatzpunkte herausgearbeitet.

3) Schule der Zukunft: Rasch wandelnde Herausforderungen in den Bereichen Technologien, europäische Gesellschaft und didaktische Erkenntnisse fordern neue Wege in der Schuldidaktik. Wie sollen Schulen im Jahr 2030 aussehen? Was muss eine Schule für Spezifikationen haben, auf die heutige Jugendliche ihre Kinder gerne schicken würden?

Die Arbeit an den Projektsäulen ist gerade und vor allem im Gebiet der Geowissenschaften sehr erfolgversprechend. So werden unter anderem nach Geländeaufnahmen Kartierungen vorgenommen, die digital erstellt werden und somit auch leicht zu teilen sind. Im Sinne Geographischer Informationssysteme (GIS) können unterschiedliche layer erstellt werden (Grünanlagen, historische Informationen, Kunst am Bau etc.), die Betätigung der Schülerinnen und Schüler im Spannungsfeld Umwelt/Raum erfolgt hierbei nicht nur deskriptiv sondern auch gestalterisch.

Das Erasmus+ Programm der Europäischen Union bietet den Schulen, da finanziell gut ausgestattet, herausragende Gelegenheiten internationaler Kooperation. Den Geowissenschaften ermöglichen sich in diesem Kontext großartige Betätigungsfelder. Aus zwei internationalen Kooperationen der vergangenen Jahre werden best practice Beispiele im Bereich des geowissenschaftlichen Arbeitens vorgestellt, um Kolleginnen und Kollegen zur künftigen Teilnahme an Erasmus+ zu motivieren.

Unterrichtseinheiten in den Geowissenschaften von Lehrkräften für Lehrkräfte

Barnikel, Friedrich (Landeshauptstadt München, Städt. Adolf-Weber-Gymnasium, München, GER)

Lehrkräfte der Geowissenschaften an Sekundarschulen fühlen sich oftmals von der universitären Didaktik allein gelassen. Während an den Hochschulen nur in Ausnahmefällen neue Grundlagen für handhabbare unterrichtliche Leitlinien geschaffen werden und die dort tätigen Wissenschaftlerinnen und Wissenschaftler kaum echte Impulse für den Alltag im Klassenzimmer bieten können, da sie zu sehr auf der Meta-Ebene ihrer Fächer Beschäftigung suchen, sehen sich Lehrkräfte zusehends wachsenden Anforderungen auf vielerlei Gebieten gegenüber. Ein probates und vielfach getestetes Mittel in diesem Kontext ist eine persönliche Zusammenarbeit mit Wissenschaftlern benachbarter Hochschulen. Die direkte und unmittelbare Kooperation zwischen Schule und Hochschule kann zum einen aufgrund der Authentizität des Materials, zum anderen durch die credibility der Lehrpersonen bei den Schülerinnen und Schülern punkten.

Als Beispiel kann die Reihe der „Methodenbände“ beim Westermann-Verlag dienen. Die drei Bände sind jeweils das Ergebnis einer beispielhaften Kooperation (meist) europäischer Wissenschaftlerinnen und Wissenschaftler und deutschsprachiger Lehrkräfte unterschiedlicher Schultypen. Dabei stammt jeweils das Material für die Unterrichtseinheiten von der universitären Seite, die didaktische Umsetzung oblag den Fachleuten an den Schulen. In Einzelfällen wurden auch Materialien der Lehrkräfte selber verwendet, die diese beispielsweise auf Urlaubsreisen gesammelt hatten. Viele Lehrkräfte der Geowissenschaften verfügen über nicht nur fundierte Kenntnisse zu einzelnen Spezialthemen, ihre Archive (Photographien, Datensammlungen etc.) sind ebenfalls durchaus für die Erstellung von Unterrichtseinheiten von großem Nutzen. So sind zu den drei vielfältigen Themenkomplexen „Wasser“, „Natürliche Ressourcen“ und „Naturgefahren“ spannende und aktuelle Fragestellungen (und Antworten!) erarbeitet worden.

Die drei benannten Themen und Kooperationstandems zwischen Universität und Schule gehen weitestgehend auf drei Geosciences Information for Teachers (GIFT) Workshops in Wien zurück. Seit dem Jahr 2003 organisiert das Committee on Education der European Geosciences Union (EGU), der größten geowissenschaftlichen Vereinigung Europas, Lehrerworkshops im Rahmen des alljährlich stattfindenden Kongresses der EGU-Wissenschaftler (www.egu.eu/education/gift). Diese Workshops versammeln für drei Tage etwa 80 Lehrerinnen und Lehrer aus rund 20 Ländern im Austria Center Vienna und stehen jeweils unter einem bestimmten Thema, im Jahre 2012 war das „Water“, 2013 „Natural Hazards“ und 2015 „Mineral Resources“. Vor Ort erhalten die Kolleginnen und Kollegen dann nicht nur frischen Input von Wissenschaftlerinnen und Wissenschaftlern, sie engagieren sich auch selbst in Hands-On-Aktivitäten und fördern kollegialen Austausch.

Im Anschluss an den Workshop wurden für die Erstellung der Methodenbände gezielt Wissenschaftlerinnen und Wissenschaftler angesprochen, ob sie nicht ihr Material den Lehrkräften zur Verfügung stellen würden, auf dass diese interessante und etwas über den üblichen Tellerrand des Alltagsgeschäfts hinaus gehende Unterrichtseinheiten erstellen mögen. Die Ergebnisse können gewissermaßen als Selbstschutz gesehen werden, beim Ausbleiben dringend benötigter Impulse für einen modernen Unterricht in Geowissenschaften von Seiten der Hochschulen müssen halt die Lehrkräfte selbst Hand anlegen, Nachmachen erwünscht!

Geological evidences of active tectonics in the Eastern Alps revealed in caves

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Grasemann, Bernhard (Universität Wien, Wien, AUT);
Mitrovic, Ivanka (Universität Wien, Wien, AUT)

So far, field studies, seismic data, and GPS observations have suggested ongoing activity along major tectonic fault systems in the Eastern Alps. According to previous observations, geological and morphological position of potential caves, and hints from cavers some 70 caves have been inspected for traces of active tectonics in the Eastern Alps.

At 25 caves good indicators for tectonic movements post-dating the speleogenesis were found, excluding gravitational mass movements, Pleistocene ice filling, sediment compaction, or vandalism. According to morphological correlations, most of these caves are of Quaternary age meaning that the faults are active ones. At nine locations, dislocated cave passages, which have been coated by flowstone that grew before and after the tectonic event, were dated by the Th/U disequilibrium method. A total of 60 speleothem sub-samples were dated. Outstanding results were obtained from the Obir Caves that developed close to the Periadriatic line (PAL). There, a strike slip fault sets off the dissolutional cave morphology and flowstone layers by 38 cm. 18 U/Th ages reveal that the major offset occurred between 19 and 42 ka. Due to its orientation, the observed fault is interpreted to be associated to the PAL and fault mirrors suggest a seismic behaviour of the fault. Beside some sites where the flowstone was too old (>0.6 Ma) or interpretation was ambiguous at two other sites (Hochschwab/Speikbodenhöhle and Fischauer Vorberge/Emmerberghöhle) the age of the tectonic events could be obtained.

Despite the difficulties attributed to distinguishing a co-seismic and aseismic fault slip, we tried to estimate possible palaeoseismological aspects of the documented recent activity of the Salzachtal-Ennstal-, Periadriatic-, Mur-Mürz-, and Pöls-Lavantal Faults. By comparing the young offsets of the faults with published data (Wells and Coppersmith, 1994; Michetti et al., 2007) we estimated the magnitudes of possible earthquakes. Our data revealed minimum epicentral magnitudes of 5 to 6.5 and intensities ranging from VII to X in paleoseismologically yet unidentified regions.

The SPELEOTECT Project was funded by the FWF (P25884-N29).

Scleractinian corals from the Lower Oligocene of the Eastern Alps, Austria: taxonomic composition, palaeoecology and palaeobiogeography---preliminary results

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Sanders, Diethard (Universität Innsbruck, Innsbruck, AUT)

In the Werlberg Member (Rupelian pro parte) of the Häring Formation (Eastern Alps), an assemblage of colonial corals of 12 species pertaining to 12 genera and 11 families was identified: *Stylocoenia carryensis* (Oligocene–Lower Miocene; Astrocoeniidae), *Acropora lavandulina* (Middle Eocene–Lower Miocene; Acroporidae), *Astreopora* sp. (Acroporidae), *Colpophyllia* sp. (Faviidae), *Dendropgyra intermedia* (Oligocene; Meandrinidae), *Caulastraea pseudoflabellum* (Middle Eocene–Oligocene; Merulinidae), *Symphyllia pseudomeandrites* (Lower Oligocene; Symphylliidae), *Pindosmilia* ? *brunni* (Oligocene; Stylophylliidae), *Actinacis rollei* (Upper Eocene–Oligocene; Actinacididae), *Pavona profunda* (Oligocene; Agariciidae), *Agathiphyllia gregaria* (Upper Eocene–Oligocene; Agathiphylliidae) and *Faksephyllia faxoensis* (Paleocene–Oligocene; Caryophylliidae). This is the first Oligocene coral assemblage reported from the Eastern Alps. The Werlberg Member accumulated during marine transgression onto a truncated succession of older carbonate rocks. The corals grew as isolated specimens and in open carpets mainly in protected shoreface settings punctuated by high-energy events. Coral growth forms comprise massive to sublamellar forms, and branched (dendroid, ramose) forms. Eleven taxa pertain to corals found elsewhere in (sub)tropical reefal and peri-reefal settings, but the caryophylliine 'shallow- to deep-water' coral Faksephyllia also is present. The presence of coral fragments that differ with respect to corallite integration and other skeletal features from the identified species suggests that the diversity of the original biocoenosis was higher.

The assemblage consists of stress-resistant coral genera widespread in the Eocene to Miocene of central and southern Europe, Central America, and Caribbean islands. On the species level, closest correspondence is with faunas of southern Europe, especially with the ones of northern Italy (Lessini shelf) and southern France. With respect to phylogenetic ancestry, the fauna consists of a mix of Mesozoic hold-over taxa with genera that appeared during the Paleogene. Comparison with Oligocene coral assemblages outside of the Alps suggests that, in the west-central Tethys, the northern limit of hermatypical coral growth became constricted from roughly 38°N palaeolatitude during the Rupelian to about 30°N latitude in the Chattian. Only during the Middle Miocene (Badenian stage) climatic optimum, oligotypic assemblages of stress-resistant corals grew again, and for the last time, in the area of the present Eastern Alps.

Equilibrium line altitude (ELA)-reconstructions of a Younger Dryas system in the Eastern Alps

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Bichler, Mathias (Geological Survey of Austria, Wien, AUT)

The key to understand paleoclimate variations in the Alps is the reconstruction of paleoglacial systems in combination with ELA calculations. The principles of ELA's are simple; it marks the line on a glacier's surface, where the ablation area and the accumulation area are in balance (Gross et al., 1976; Sugden and John, 1976). Therefore, it is possible to reconstruct paleoclimate with knowledge of the ELA. During colder and wetter climate periods the conditions favour glacier growth thus the accumulation area grows with the glacier flowing downward. Consequently, the ELA will sink to lower altitudes. The same principle can be applied in the other direction.

To estimate the former ELA's of glaciers many different methods, such as the Toe-to-Headwall Altitude Ratio, Area x Altitude, Accumulation Area Ratio or Area x Altitude Balance Ratio exist (see Benn and Lehmkuhl, 2000 for a summary), have been developed. All of them need at least a rough knowledge of the former glacier surface, which can be reconstructed with geomorphological and geological mapping of the required area (till, lateral and terminal moraines) and/or with the study of airborne laser scans.

The main problem with these methods is time, as it is a lengthy process to calculate the ELA values. Pellitero et al. (2015) built an ArcGIS toolbox, which is meant to highly reduce the time needed for the calculations of ELA's, using the Accumulation Area Ratio, Area x Altitude Balance Ratio, Area-Altitude and Kurowski method. The aim of this work is to determine the efficiency of the ArcGIS toolbox in the day-to-day workflow of ELA-calculations of Austrian alpine glaciers.

We applied and estimated the accuracy of these methods using two recent glaciers, Goldbergkees and the Pilatuskees in Salzburg, Austria. The selected areas offer a robust allostratigraphy with absolute dates of the glacial dimensions since the Younger Dryas = Egesen (Bichler et al., 2016).

Additionally, the ELA's for the Egesen as well as for the Little Ice Age (1850) have been already calculated (Bichler and Reindl, 2013) using the MELM (Maximum Elevation of Lateral Moraine) method and thus provide a good and reliable comparison.

This work shows that the accuracy of the toolbox lies within a discrepancy of 6 meters compared to the mapped values (MELM-method) (Bicher and Reindl, 2013) of the ELA of the Little Ice Age Goldbergkees and between 9 and 31 meters for the Egesen Kolm-Saigurn expansion. We conclude that the toolbox offers an efficient method to improve the ELA calculations in the Austrian Alps.

Geomorphological map and event stratigraphy of Lake Hallstatt

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Lauterbach, Stefan (Christian-Albrechts-Universität zu Kiel, Kiel, GER);
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Lake-floor morphology can reveal detailed information about mass movement activity and sedimentary processes in a lake as reported from recent studies in alpine lakes. For Austrian lakes however, state-of-the-art high-resolution multibeam bathymetry data for Earth Science applications is sparse. Here, we present results of a recent bathymetric survey with the Kongsberg EM2040 multibeam system in Lake Hallstatt, providing a high-resolution digital terrain model of the lake floor (1m raster resolution, dm-scale vertical resolution). Data aquisition and analysis were carried out as part of the Facealps project, which is funded by the Austrian Academy of Sciences.

Several geomorphological features were characterised and distinguished to create a geomorphological map of the lake floor. Deposits of numerous mass movements can be observed in the lake-floor morphology and have been mapped to gain a better understanding of the spatial distribution of mass-movements in the lake. Headwalls on steep, sediment-covered subaquatic slopes show source areas of mass movement deposits on the lake floor, while other deposits can be linked to terrestrial mass-movement activity on the steep slopes above the lake.

The event chronology of Lake Hallstatt was established by combining the bathymetry with information from sediment cores, reflection seismic profiles and historic reports. Some deposits of mass movements in the southern lake basin correlate well with historic reports of earthquakes in 1895, 1892 and 1890 and can be interpreted as earthquake-triggered mass movements.

Tourmaline as a petrogenetic recorder for the polymetamorphic evolution of the Matsch Nappe (Vinschgau/South Tyrol)

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Tropper, Peter (Universität Innsbruck, Innsbruck, AUT)

The Austroalpine nappe stack in the investigated area, located in the Vinschgau area (Southern Tyrol), comprises from bottom to top the Campo-Ortler (COC), the Texel (TC), the Ötztal (ÖC) complexes and the Matsch (MN) nappe. These Austroalpine basement units in the Vinschgau valley (e.g. Matsch Nappe, Ötztal Complex) show a clear polymetamorphic evolution history which can be well reconstructed using the observation of chemical zoning patterns in different minerals such as garnet and tourmaline. Especially in the Matsch Unit, a clear spatial distribution of garnet zoning can be observed: in the west, the garnets show only a Variscan composition (Grt I) with a very small Ca-rich eo-Alpine growth rim (Grt II). Further to the east, into the Ötztal Complex, the proportion of this Grt II rim increases until only a residue of the older core Grt I remains. Special attention must be paid to the eastern part of the Matsch Unit where the garnets surprisingly show a third very low calcium generation (Grt Ib), which occurs between the Variscan core Grt I and the eo-Alpine rim Grt II. Geothermobarometry of the Matsch Unit yielded an increase in eo-Alpine temperature conditions of 500°C to 550°C at pressures of 0.80-1.2 GPa. Similar to garnet a clear spatial distribution of tourmaline zoning can be observed. In the east tourmalines show in BSE images only two visible growth zones (brighter core, darker rim) of growth but only a continuous chemical zonation with Ca-poor cores and Ca-enriched inner rims (correlates with the brighter growth zone in BSE image) and a decrease in Ca and Ti in the outermost rims (correlates with the darker growth zone in BSE image). The zoning patterns of Mg/Fe and Al indicate only prograde growth with increasing T. All tourmalines of this area belong to the alkali group and classify as dravites. This simple chemical zoning in conjunction with the increasing metamorphic grade to the east indicates that only the prograde eo-Alpine metamorphic history is preserved in both growth zones but a decrease in Ca and Ti in the outer growth zone most likely correlates with contemporaneous prograde titanite growth. In the western part of the Matsch nappe this tourmaline zoning type still occurs but in addition visibly more complex zoned tourmalines also occur. Latter complexly zoned tourmalines display at least three or more growth zones. Chemically complex patterns with spikes in Ca, Al, Mn and Ti occur. Although Ca increases towards the rims the extent of this increase is lower in the west than in the east, indicating lower eo-Alpine P-T conditions. Some grains exhibit Fe-rich cores which can be classified as schorl while the remaining tourmalines classify as dravites. The visual and chemical zoning patterns indicate a polymetamorphic evolution of these tourmalines with possible Permian- or Variscan relicts in the cores and increasing eo-Alpine recrystallization towards the east.

Eastern Alpine Seismic Investigation (EASI): aims, deployment and results

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EASI-Alparray Working group

During the first implemented Complementary experiment within the AlpArray (http://www.alparray.ethz.ch) framework, namely EASI (Eastern Alpine Seismic Investigation), 55 three component broadband seismic stations have been deployed along a 540 km profile crossing the Eastern Alps, from the Czech-German border to the Adriatic Sea.

The seismic array has continuously recorded over one year of time from summer 2014 till summer 2015; the stations deployed with an alternate geometry are spaced of about 15 km, in order to maximize the deep coverage along line considering that the majority of the seismic events are coming from North and East (e.g. Japan, and Pacific Ocean) and few are arriving from South and West (Africa and Atlantic Ocean). In this work we show the results obtained employing the teleseismic traces recorded at the stations, and the images of the Earth's outermost layers below the Eastern Alps.

Seismic events occurring far away from the recording stations are hitting the subsurface at an almost vertical angle; this characteristic is the ground for the construction of the receiver functions (RF) time series; the vertical record is indeed the expression of the source and instrument contribution, and can be deconvolved from the horizonthal components, resulting in the near-receiver structure response. Thus the RFs are made of positive and negative phases generated at impedance contrasts (and their multiples), rendering the occurrence of structural discontinuities at depth.

Here we present the results concerning the depth of the Moho and other interfaces, velocity structure and Vp/Vs, imaged with the use of different approaches – depth migrated receiver functions along with manual time picks converted into interface depths, H-k method (Zhu & Kanamori, 2000), harmonic analysis – together with an estimate of their reliability.

Results are showing a sharp Moho beneath the Bohemian Massif until the Bavarian Shear Zone, deepening towards south. On the other hand, the Adriatic Moho deepens from south to north towards the Tauern Window. At the boundary between the two plates, the whole crustal structure looks complex, holding several Ps converted phases, and we observe a 20 km thick velocity-gradient zone between crust and mantle. Moreover we isolate the signal generated by inclined interfaces and anisotropy through the application of the harmonics decomposition of the RFs. At finer crustal scale, the presence of anisotropy is related to the underthrusting of the crystalline basement and syn-orogenic sediments.

Interpretation der Trockenwetterfalllinien von Quellen: Quantitative Methode oder Spekulation?

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Die Erstellung von Trockenwetterfalllinien (TWL) aus den fallenden Abschnitten von Quellschüttungsganglinien gehört zu den Standardmethoden der Hydrogeologie. Insbesondere in der Karsthydrogeologie wird neben einer qualitativen Interpretation der TWL oftmals versucht, quantitative Rückschlüsse auf die Eigenschaften des Grundwasserleiters zu ziehen, etwa auf die Gebirgsdurchlässigkeit oder das abflussfähige Grundwasservolumen. Viele Quellschüttungskurven zeigen jedoch ein zeitlich variables Auslaufverhalten und damit auch eine Streuung der abfallenden Kurvenabschnitte bei der Konstruktion der TWL. Anhand von modellbasierten Betrachtungen und Feldbeispielen wird gezeigt, dass dieser Variabilität unterschiedliche Ursachen zugrunde liegen können, die von Unterschieden der Neubildungsereignisse bis zu Veränderungen im Grundwasserleiter selbst reichen. Eine quantitative Interpretation von Trockenwetterfalllinien ist daher nur als Teil einer umfassenden hydrogeologischen Charakterisierung möglich, die sowohl die geologischen als auch die hydrologischen Gegebenheiten des Quelleinzugsgebiets umfasst. Die Anwendbarkeit der in der Fachliteratur vorgeschlagenen, mannigfaltigen Interpretationsansätze sollte deshalb für jeden Einzelfall kritisch hinterfragt und überprüft werden.

Calcium & iron carbonates from Erzberg - New insights from stable, radiogenic & clumped isotope data

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The iron ore deposit Erzberg represents one of Austria's most prominent geo-sites due to its historic and economic value. It is mainly composed of various carbonates including the dominant minerals siderite, ankerite, (Fe-)dolomite and calcite, as well as scarce and often laminated aragonite-calcite veins ("erzbergite") which precipitated in major vertical fractures. During several sampling campaigns, typical Fe- and Ca-(Mg-)carbonate host rocks and erzbergite veins, as well as modern waters distributed on-site were recovered. Stable, radiogenic and multiply-substituted (clumped) isotope measurements were conducted in order to better understand distinct aspects of genetic, diagenetic and metamorphic origin, and the hydrochemical evolution of modern and past water flowing through the fissured carbonate aquifer at Erzberg.

Radiometric 234U-230Th age determination based on the constant decay of 238U incorporated into $CaCO_3$ yielded absolute ages from 285.1 ±3.9 to 1.03 ±0.04 kyr BP for different erzbergite samples (n=20). The vast majority of samples were dated with high precision, i.e. typical age uncertainties (2σ) from 0.5 to 1 % (decades to few hundred years). Unexpectedly, all vein samples collected from fractures on-site are younger than the last glacial maximum (<~20 kyr BP). Thus, considering the erzbergite formation mechanisms (Boch et al., 2018), the fractures themselves seem of young age too. Clumped isotope measurements of erzbergite aragonite (n=7) revealed cool to near-freezing (water) temperatures of ~0 to 10 (±5) °C, i.e. a rare case of aragonite crystallization at low temperature. This temperature range is i) in line with a higher elevation alpine meteoric setting restricted by recurrent freezing (and dryness) during cool climate intervals and ii) corroborated by meteoric paleo-fluid $\delta^{18}O$ isotope compositions (-11.8 to -8.7 ‰ VSMOW) inferred from the aragonite Δ_{47} and $\delta^{18}O$ analyses, as well as by similar $\delta^{18}O$ and $\delta^{2}H$ isotope signatures of small water flows encountered in fractures today. The stable H and O isotopes of modern waters further support distinct local differences regarding the water infiltration areas and hydrochemical evolution at Erzberg. The latter includes processes such as sulfide oxidation and prior $CaCO_3$ precipitation in the aquifer. A broad range of stable C versus O isotopic compositions of siderite, ankerite, calcite and aragonite supports lime-/dolostones as the principal source rock for erzbergite formation. First clumped isotope data of the iron ore host rocks siderite and ankerite will be presented.

Unwanted mineral deposits in geotechnical settings – Scaling forensic investigation of formation conditions and related material characteristics

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Unwanted mineral deposits (scaling) including various carbonates, sulfates, sulfides and (hydro)oxides constitute a common obstacle impairing water and energy transfers in diverse geotechnical settings, such as geothermal power plants, motor- and railway tunnels, potable water infrastructure or artificial channels. The clogging of wells, pipelines, drainages, filters, valves or heat exchangers mostly depends on natural and man-made (operational) environmental conditions (e.g. physicochemical gradients, flow rate, materials used, geometries, mixing). Based on their installation-specific spatiotemporal evolution, the mineral deposits represent a chemical-sedimentary archive which can be “read” in a scaling forensic approach, i.e. a reconstruction and process understanding of variable environmental conditions determining the scaling progress and scale material characteristics is targeted. We therefore apply high-resolution geochemical and imaging techniques, such as stable isotope and minor/trace element profiles, distribution mapping and fractionation relationships (EPMA, LA-ICP-MS), (electron)microscopic and fluorescence staining techniques in combination with on-site and on-line environmental monitoring of the aqueous solutions, solid phases and the surrounding atmosphere using established and newly developed (e.g. “sinter guard”) data loggers. Hydrochemical modeling and laboratory experiments on fluid-solid interaction complete our approach.

Focusing on the carbonate system, the variable scaling progress and scale material consistency exert a major influence on the frequency of maintenance intervals and cleaning procedures (mechanical, chemical) becoming necessary. Our investigations reveal different depositional mechanisms resulting in hard/soft, compact/porous and rhythmic growth successions (layering) in scales. More specifically, inorganic crystallization mechanisms, such as heterogeneous wall crystallization, homogeneous suspended particulate nucleation or carbonate precipitation from either CO_2 degassing or absorption from the atmosphere are important. Microbially mediated deposition comprises of active (changing chemical gradients, catalytic promotion) and passive (substrate for nucleation and particle entrapment) mechanisms. Further, distinct interfaces exert major effects on crystal nucleation and the overall scaling progress, e.g. carbonate scale vs. substrate (steel, plastics) interface, intercalated mineral layers and the scale growth surface vs. streaming fluid.

Umweltverhalten von Gadoliniumkomplexen

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Abwasserbeeinflusste Oberflächenwässer enthalten durch den Eintrag von anthropogenen Gadoliniumkomplexen aus der MRT-Diagnostik seit über zwanzig Jahren erhöhte Gadoliniumkonzentrationen[1]. Trotz der relativ geringen und spezifischen Konsumationsmengen, ist anthropogenes Gadolinium zu einem nahezu idealen Abwassertracer avanciert und wurde bereits in einer Reihe von hydrogeologischen Studien zur Untersuchung von Oberflächen-Grundwasser Interaktionen verwendet[2,3].

Inertes Verhalten ist die Voraussetzung für die Nutzung jedes Tracers. Bei anthropogenem Gadolinium gehen die Studien durch die hohe Stabilität der Gadoliniumkomplexe davon aus, dass diese nicht transformiert werden. Einige Untersuchungen und Studien zeigen, dass diese Annahme nicht ausnahmslos gültig ist. Zum Beispiel zeigten Birka et al.[4], dass die Komplexe unterschiedliche Stabilitäten gegenüber UV-Strahlung haben. Diese Tendenz deckt sich mit Untersuchungen zur Stabilität von verschiedenen Gadoliumkomplexen im menschlichen Organismus[5].

Der Transport und Verbleib von anthropogenem Gadolinium in der Umwelt ist neben der Stabiltät der anthropogenen Komplexe von weiteren hydrogeochemischen Faktoren abhängig, die auch andere Seltene Erden Elemente (SEE) kontrollieren[6]. Der fluviale Transport von SEE wird vorallem mit natürliche gelösten organischen Komponenten (DOC) assoziiert[7]. Die Unterscheidung zwischen natürlichen und anthropogenen Gadoliniumkomplexen ist bei der Bewertung des Umweltverhaltens folglich von zentraler Bedeutung.

Aus diesem Anlass wurden neben der Stabilität der Gadoliniumkomplexe gegenüber verschiedener Umwelteinflüsse auch anthropogene Einflussfaktoren aus der Abwasserreinigung bzw. Trinkwasseraufbereitung betrachtet. Daraus soll ein differenzierteres Bild vom Verhalten und Verbleib von anthropogenen eingetragenen Gadoliniumkomplexen in der Umwelt gezeichnet werden.

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Cadomian protolith ages of ‘exotic’ mega blocks from Bugaj and Andrychów and their significance for the reconstruction of the palaeogeography of the Western Outer Carpathians (Poland): evidence from zircon U-Pb LA-MC-ICP-MS dating

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Despite the long period of research conducted in the Western Outer Carpathians (WOC) the genesis and tectonic evolution of their crystalline basement is still poorly recognized. At present the crystalline basement is hidden below thick Upper Jurassic-Neogene flysch deposits of the WOC proper. Fragments of crystalline rocks, so-called exotics, interpreted to be derived from uplifted ridges and transported by turbidity currents and debris flows into the adjoining flysch basins, offer the opportunity to investigate the geotectonic history of these no longer existing alimentary areas of the Carpathian flysch.

A number of studies concerning the palaeogeography of the WOC have used a range of geochronological methods to constrain the timing of magmatic and metamorphic processes recorded in the exotics. The general outcome of these investigations is that numerous exclusively pre-Alpine, in parts pre-Variscan ages were determined, but no obvious correlation of stratigraphic and tectonic position and/or geography emerged. From a methodological point of view this is due to the fact that especially K-Ar mica ages are sensitive to thermal and metasomatic overprint thus obscuring any primary geochronological signal directly dating igneous or metamorphic events. This published radiometric age data set is therefore not conclusive for the unambiguous identification of protolith and metamorphic ages, respectively.

The main purpose of this study is to present and discuss zircon U-Pb ages from two exotic mega blocks (a granite from Bugaj and an orthogneiss from Andrychów), representing the alimentary crystalline basement area of hthe WOC flysch. Due to the size of these two exotics (> 100 m) it can safely be assumed that their loci of deposition is far more proximal to their respective shedding ridge(s) than the probably more distally derived pebbles dated in previous studies. Additionally, the latter might easily be re-sedimented making any palaeogeographic implications drawn from ages derived from such rocks severely ambiguous.

The CL images of zircons from both samples reveal typical magmatic textures characterized by a well-defined concentric and oscillatory zoning. A concordia age of 580.1±6.0 Ma of the zircons from the Bugaj granite is considered to represent its uppermost Proterozoic crystallization age. The zircon crystals from the Andrychów orthogneiss yield an age of 542±21 Ma, interpreted as the also uppermost Proterozoic magmatic crystallization age of the granitoid protholith.

The U-Pb zircon ages, derived from the exotic mega blocks thus:

a) directly reflect the presence of substantial amounts of a proximal ‘Cadomian’ aged crust proper in the vicinity of the WOC basement. This is a marked difference to earlier published data, which were gained from cm-dm sized pebbles only. As these can easily be derived from re-sedimented sources the ages do not necessarily reflect direct derivation from a ‘Cadomian’ basement, in as much as transport distances are not known.

b) exotic mega blocks deposited to the WOC basins were related to the Brunovistulicum Terrain. They belong to the group of Vendian/Early Cambrian granitoids, representing the latest, post-tectonic expression of the Cadomian cycle.

These results provide new information to the ongoing discussion of the late Neoproterozoic paleogeography of tectonic units which intervene between the East European Craton (Baltica) and the lithotectonic units of the Variscan orogeny.

Hydraulische Charakterisierung des Hochstegenmarmors am Westrand des Tauernfesters – Brenner Region

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Beim Brenner Basistunnel bildet die Hochstegenzone mit der Hauptlithologie Hochstegenmarmor den aus hydrogeologischer Sicht sensibelsten Abschnitt des aufzufahrenden Tunnelsystems. Als Grundlage für Umwelt- und technische Planung ist eine hydraulische Charakterisierung des Hochstegenmarmos notwendig. Die Fragestellungen erfordern diesbezüglich Angaben über die hydraulischen Durchlässigkeiten, die im regionalen Maßstab wirksam sind, als auch jene, die im Ortsbrustbereich, also lokalen Maßstab zu erwarten sind. Während erstere insbesondere für die Ermittlung der stationären Wasserzutritte in das Tunnelsystem und der Definition des hydraulischen Einflussbereiches desselben Tunnelsystems wichtig sind, sind Kenntnisse über kleinräumige hydraulische Durchlässigkeiten für die Berechnung der instationären und damit der baurelevanten Wasserzutritte von Bedeutung.

Diesbezüglich sind bereits schon die in situ Versuche diesen Erfordernissen anzupassen und unterschiedlich große Gebirgsvolumen zu betesten.

Es werden zusammenfassend die aus hydrogeologischer Sicht relevanten Ergebnisse der Untersuchungen aufgezeigt, welche von herkömmlichen Kartierungs- und Monitoringleistungen bis hin zur Ausführung von komplexen Bohrlochversuchen (Drill Stem Tests) und Langzeitpumpversuchen in Tiefbrunnen in Tiefen bis 800 m reichen.

Zusammenfassend kann festgehalten werden, dass es sich beim Hochstegenmarmor am Westrand des Tauernfensters um eine aus hydrogeologischer Sicht sehr komplexe Einheit handelt, welche sich aus gering durchlässigen Festgestein ($K<1*10^{-8}$ m/s) bis hin zu hoch durchlässigen Karbonatgestein mit lösungersweiterten Hohlräumen bzw. Hinweisen auf Karstphänomene zusammensetzt. Letzters wird durch Auswertungen der Schüttungsganglinien von verschiedenen Quellen bestätigt, welche auf hydraulische Durchlässigkeiten vom seicht anstehenden Hochstegenmarmor in der Größenordnung von 2 bis $6*10^{-3}$ m/s schließen lassen. Aus In situ Versuchen in Bohrlöchern und Tiefbrunnen lassen sich hingegen maximale hydraulische Durchlässigkeiten bis in Tiefen von ca. 600 m unter Geländeoberkante in der Größenordnung von 10^{-6} m/s berechnen. Versuche, welche ein großes tiefgelegenes Gebirgsvolumen betesten, lassen hingegen auf regionale hydraulische Durchlässigkeiten in der Größenordnung von 10^{-7} m/s schließen.

Auswirkungen dieser heterogenen hydraulischen Eigenschaften des Hochstegenmarmors auf das hydrogeologische System in der Brenner Region werden präsentiert.

Influence of Humic Acid and Ionic Strength on the Sorption of Pyrene to Carbonaceous Materials

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Combustion-derived carbonaceous materials (CMs) are highly abundant in natural freshwater systems. Here, the strong sorption potential of CMs can influence the transport and fate of organic pollutants such as polycyclic aromatic hydrocarbons (PAHs) that are released by a variety of sources into surface waters. The nature and extent of their interactions may depend on water chemistry parameters such as ionic strength (IS) and the concentration of natural organic matter (NOM) as well as on the properties of the sorbents. As previously reported, NOM sorbed to CMs can inhibit or slow down the sorption of contaminants to these surfaces. This may either be due to a direct competition for sorption sites or the blocking of micropores by NOM, limiting the access for other sorbates such as organic contaminants. Therefore, the aim of this study was to systematically investigate the influence of water chemical parameters and sorbent properties on sorption of CMs.

Biochar (BC) was selected as sorbent representing a pool of naturally occurring CMs and Graphite (Gr) was selected as model sorbent to investigate the effects of surface properties on sorption. The comprehensive characterization of the sorbents included elemental analysis, specific surface area and pore size distribution derived from N_2 and CO_2 physisorption isotherms of the materials. Sorption experiments were performed with pyrene as model sorbate and polyoxymethylene sheets were used as passive sampler. The influence of i) IS, including the comparison of mono-and divalent salts, and ii) sorbent loading with NOM on pyrene sorption behavior to CMs was tested in background solutions with either deionized water (Milli-Q), 0.01 M NaCl or 0.01 M $CaCl_2$, with and without addition of humic acid (HA, Sigma Aldrich) at environmentally representative concentrations (1 mg C L-1). Sorption isotherms were fitted with the Polanyi-Manes model (PMM). Furthermore, the adsorption of HA to the CMs in the different background solutions was quantified by UV-vis absorption at 254 nm. Additionally, particle size and aggregation of the sorbents as well as of the HA in the different solutions were measured.

The preloading of BC with HA in Milli-Q resulted in a reduction of pyrene sorption to the porous BC surface, whereas no difference in sorption was observed for the flat Gr surface. This indicates that the reduction in pyrene sorption to BC is mainly due to pore blockage by HA rather than direct sorption site competition. Physisorption experiments confirmed that HA loading of BC reduced specific surface area and total pore volume of BC, especially in the lower mesopore range (1.5 - 2 nm). Interestingly, the observed effect of sorption reduction only occurred in MQ and NaCl but not in $CaCl_2$. Preliminary results suggest that the aggregation of HA in $CaCl_2$ leads to size exclusion of HA from micropores and thereby does not hinder pyrene to diffuse into the pores. Further experiments are currently conducted to investigate this hypothesis by quantifying the amount of HA sorbed on CMs. Furthermore, also BC was shown to aggregate in $CaCl_2$, which did not have implications on pyrene sorption, but does affect dispersion stability of BC particles.

Lacustrine Paleoseismology in Tyrol and Carinthia: Establishing the first continuous postglacial earthquake records in Austria

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In formerly glaciated intraplate regions with low deformation rates and moderate seismicity, long-term paleoseismic records are essential to determine the probability of strong earthquakes and assess the seismic hazard. Lake sediments provide a continuous and high-resolution paleoseismic archive, which can record seismic shaking as mass transport deposits (MTDs), turbidites and soft sediment deformation structures. Lacustrine paleoseismological studies have been performed on many small and large alpine and piedmont lakes in the French, Italian and Swiss parts of the Alps, leading to some significant improvements in methodological approaches, detecting of periods of enhanced seismicity and discussion of possible paleo-earthquake scenarios. Remarkably, lakes within the Austrian Alps have not been explored yet for sedimentary evidence of past earthquakes, despite being a country with several areas of moderate seismicity and damaging historical earthquakes with epicentral seismic intensity up to IX-X. Here, we present the research strategies and preliminary results of three new projects on Austrian lake paleoseismology:

Tyrol on Shaky Slopes: Former research has shown that large rockslides in the Fernpass and Tschirgant region cluster around 3-4.2 kyrs BP. The triggering factors of these events, however, are still debated. We investigate the sedimentary infill of Piburgersee, Plansee and Heiterwangersee by reflection seismics and sediment cores, in order to assess the probability that these large rockslides were triggered by earthquakes. Together with seismic surveys and coring on Achensee and Hechtsee, these investigations will help to extend the paleoseismological record of Tyrol into the Late Glacial and reveal the recurrence of local and far-field earthquakes.

QUAKE-LAKE Carinthia: Carinthia and the adjacent Friuli region have experienced several well-documented historical earthquakes in a wide intensity range (V-IX; EMS-98) in 1201, 1348, 1690, 1857 and 1976, with the 1348 event considered to be the strongest historical earthquake (moment magnitude of ~7) in the Alps. Understanding the relationships between seismic intensity and the sedimentary fingerprint associated with these earthquakes enables us to use lake sediments as calibrated paleoseismographs. Finely laminated sediments reveal the potential of dating flood- and earthquake-related turbidites on a very high resolution. The 1348 and 1690 events led to ubiquitous landsliding in the large lakes, whereas in the shallow organic-rich lakes, seiche deposits serve as proxies for seismic activity. Extensive slope failures at the Late Glacial/Holocene transition hint at enhanced seismic activity during postglacial-rebound.

ARMONIA: The Interreg V – Italia-Österreich project ARMONIA will implement the results of both QUAKE-LAKE Carinthia and Tyrol on Shaky Slopes in a database of the region’s strong earthquakes. This will help to improve the Environmental Seismic Intensity Scale and lead to a management model to mitigate the seismic hazard in Austria and Italy.

The Late Glacial and Holocene Sedimentary Infill of Lake Mondsee (Eastern Alps, Austria) and Historical Rockfall Activity revealed by Reflection Seismics and Sediment-Core Analysis

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Glacigenic perialpine lakes can constitute continuous geological archives allowing for reconstruction of lake-internal sedimentological processes and of paleoenvironments since the last glacial maximum (LGM). Lake Mondsee is one of many perialpine lakes in the Salzkammergut, Upper Austria and has previously been studied based on sediment cores for paleoclimate, paleolimnology and (paleo-) ecology. However, the full extent and environment of Late-Glacial to Holocene sediment deposition remained unknown due to the lack of reflection seismic data imaging the 3D sediment accumulation patterns.

In this study, the sedimentary infill of Lake Mondsee was examined by 57 km of high-resolution seismic reflection data (3.5 kHz pinger source) correlated to a new 13.76 m long sediment core. In the northern basin, seismic penetration is strongly limited in most areas because of abundant shallow gas (acoustic blanking). In the deeper areas, the acoustic signal reaches depths of up to 80 ms TWT (two-way travel time), representing a postglacial sedimentary sequence of at least 60 m thickness. The Holocene deposits constitute only the uppermost 11.5 m of the sedimentary succession. Postglacial seismic stratigraphy of Lake Mondsee closely resembles those of well-studied French and Swiss perialpine lakes. Our data show that most of Lake Mondsee's sedimentary basin infill was deposited within a short time period (between 19,000 and 14,500 years ago) after the Traun Glacier retreat from the Mondsee area, revealing an average sedimentation rate of about 1.4 cm/yr.

Compared to other perialpine lakes, the seismic data of Lake Mondsee revealed little indications of mass movement activities during the Holocene. An exception, however, are rockfalls originating from a steep cliff situated on the southern shore of Lake Mondsee, the Kienbergwand. Here, the seismic profiles show mass transport deposits (MTDs), which extend approximately 450 m into the lake and are mappable in an area of about 45300 m2. Sediment cores targeting the MTDs show two separate rockfall events. The older event consists of clast-supported angular dolomitic gravels and sands, showing high amounts of fine fraction. The younger event exhibits dolomitic clasts of up to 1.5 cm in diameter, mixed within a lacustrine muddy matrix. Radiocarbon dating and correlations to varve-dated sediment cores hint at ages of AD 1484 ± 7 for Event 1 and AD 1639 ± 5 for Event 2. Our data show no evidence of a large-scale mass movement affecting Lake Mondsee and its surroundings, but we infer that the present-day morphology of the Kienbergwand is the result of infrequent medium-scale rockfalls.

Recent thrust tectonics in the frontal part of the Eastern Alps: an approach based on integrated subsurface data

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Although the convergence between Adria and Europe is still active, only little evidence for active thrusting was detected in the frontal part of the Eastern Alps. Information on active faulting and focal mechanisms is limited due to low seismicity. The present study is focused on the easternmost sector of the Molasse Basin and the Flysch Unit in Upper Austria, where numerous hydrocarbon exploration wells were drilled by RAG (Rohöl-Aufsuchungs Aktiengesellschaft) during the last decades.

Orientations of the maximum horizontal stress were obtained from borehole image logs (BHI), showing a consistent N-S trend in the study area. These results comply with trends detected in the German part of the Molasse Basin (Reinecker et. al., 2010); however, the active tectonic regime is uncertain. The studied wells were drilled in the in the Flysch and Helvetic Units in the frontal part of the Alps or in the Imbricated Molasse, and in many cases reach the underlying basement of the Bohemian Massif. The detailed analysis of image logs, in particular of drilling induced features and natural brittle structures, identified several perturbations of the stress field along the depth profiles of individual wells, that can be associated to major thrust faults.

At the eastern edge of the study area, abundant stress perturbations are detected near the base thrust of the Flysch Unit and at the main detachment of the Imbricated Molasse, suggesting that these thrust faults are at least locally active. Integration of the BHI results with 3D seismic data confirms that most of the deformation in the Molasse was accommodated before the Burdigalian, but subordinate deformation is recorded in younger sediments (Hall and Innviertel Fm.). In the same area, terraced sediments of middle Pleistocene age are reported to be offset by the frontal thrusts of the Northern Calcareous Alps and the Flysch Nappes (van Husen, 1999), which would confirm recent thrust faulting.

The reactivation of thrusts in the eastern part of the Molasse could be triggered by a structural high of the underlying crystalline basement that is progressively rising towards the NE, and is outcropping just 18 km NE of the study area. Several out-of-sequence thrusts are observed in the frontal part of the Eastern Alps, involving mostly the Helvetic and Flysch Nappes, but also the Northern Calcareous Alps and the Molasse. These structures are particularly abundant east of the study area, where the Bohemian Massif is exposed just 6 km away from the front of the Alps.

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Geology, geoarchaeology or ethnogeoarchaeology? Landscape reconstruction at the Chehrabad salt mine (Zanjan, Iran) since the Achaemenid Period

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The application of natural sciences in archaeological research has been becoming more and more important in the last decades. Methodological issues as well as their relationship and boundaries of different research fields are still in movement. This study uses the landscape reconstruction around the salt mine at Chehrabad (Province Zanjan, Iran) as an example.

Since 1994 the remains of more than five men have been discovered in the Chehrabad salt mine that was active during Achaemenid (6th-4th cent. BCE), Sasanian (4th-6th cent. CE) and up to 2008 CE. Some of these salt mummies are extremely well preserved and together with abundant other organic remains enable exceptional insights into various aspects of past mining activity (http://www.saltmen-iran.com).

Chehrabad is located in the Mahneshan Range in the northwestern Iranian Plateau at an altitude of ca. 1450 m. Geologically the area belongs to the Central Iran tectonic unit and is characterized by folded and thrusted colorful Miocene marl and sandstone, with occurrences of gypsum and salt. These deformed sediments are discordantly overlain by a thin layer of terrestrial Quaternary, up to boulder sized sediments forming a prominent regional flat surface. The present landscape is mainly the result of late Pleistocene to Holocene dissection of above mentioned successions and modern valley fill. During a trenching campaign in 2011, alluvial sediments were exposed up to 5 m depth with preliminary calibrated radiocarbon ages of organic matter indicating sedimentation rates of c. 2-7 mm/a.

In 2016, during a geoarchaeological investigation five < 10 m deep cores have been taken by geotechnical rotary drilling and the sediments documented and sampled in detail. Preliminary results show that the core sediments are dominated by fine to very fine grained sediments, with only marginal gravel layers, which is surprising considering the generally coarse grain-sizes of the present rivers. Additionally, the considerable sedimentation rates from the 2011 investigations are at odd with the observation that virtually all of the rivers in the study area obviously show erosive behavior at present, with their channels being located more than 2 m below the level of the valley fill in some places.

Both observations are difficult to explain by purely fluvial processes and/or base level changes, e.g. by tectonic movements. Therefore it was decided to use an ethnogeoarchaeological approach, including interviews of local residents, for additional aspects. Field surveys and high-resolution digital terrain (DTM) data, calculated by structure-from-motion (SFM) from drone aerial photography showed that virtually the whole valley floor is shaped by inconspicuous field terraces. Additionally, all terraced fields show numerous irrigation channels whose upstream parts are connected with river beds, where the irrigation channels have a considerable lower gradient than the rivers. In this way, water can be transported up to the field levels without any additional support, partly > 2 m above the river, just defined by the length and gradient of the irrigation channel. As the drainage channels only transport fine-grained sediments, only those are deposited on the fields. Fluvial erosion of fields is prevented by stone walls; thus river channels are fixed to their location and hardly are able flooding fields. Both mechanisms contribute to the dominance of fine grain-sizes and scarcity of gravel documented in the cores.

Mg-Isotopie in Magnesiten: Weiterführende Charakterisierung und Implikationen für die Magnesitgenese

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Als Pilotstudie für den Isotopenkatalog österreichischer Lagerstätten wurde im Rahmen eines GBA Forschungsprojektes die Verteilung der Mg-Isotope (24Mg, 25Mg, 26Mg) in Magnesiten einiger prominenter ostalpiner Magnesit-Vorkommen/ Lagerstätten (Breitenau, Hohentauern, Hochfilzen, Radenthein, Kaswassergraben, Kraubath) untersucht. Zur Absteckung der generellen Bandbreite der Mg-Isotopie in Magnesiten sind zusätzlich auch Magnesite einiger ausländischer Loklitäten (Bela Stena/Serbien, Bushveld/Südafrika und Poldasht/NW Iran) analysiert worden, die aus einem zu den österreichischen Lagerstätten konträren geologischen Umfeld stammen. Die Mg-Isotopie gemeinsam mit „traditionellen" Datensätzen (Mineralogie, Haupt-, Spuren-, SEE, C/O-Isotope) und einer anzustrebenden „Clump-Isotopie" ermöglichen neue Erkenntnisse über die physiochemischen Parameter und Prozessabläufe während der Magnesitbildung als auch innovative Modellansätze zur Klärung der Magnesitgenese.

Bei signifikanter Clusterbildung der einzelnen Lagerstättentypen liegt die Streuung der d26Mg-Werte der Magnesite in einem Gesamtbereich von etwa 4 ‰ (-2,88 bis +1,01 ‰; DSM-3). Aus den bisherigen Untersuchungen zeichnen sich folgende Highlights ab: (i) Bei den an Karbonatgesteine gebundenen Spatmagnesiten (Veitsch-Typ) können metasomatische Prozesse u.a. zur hydrothermalen Bildung/Beeinflussung von Dolomiten in den Lagerstätten führen, deren d26Mg-Werte zumeist außerhalb der bekannten Werte für diagenetisch gebildeten Dolomit und Spatmagnesit liegen. (ii) Die Bildung kryptokristalliner Magnesite in ultrabasischen Wirtsgesteinen (Kraubath-Typ) und in kontinentalen aquatischen Sedimentbecken im Umfeld von Serpentiniten (Bela-Stena-Typ) und Basalten (Poldasht-Typ) wird durch Lösungs- und Abscheidungsprozesse mit extremen Fraktionierungsvorgängen gesteuert. Die Streuung der d26Mg-Werte kryptokristalliner Magnesite liegt in dem Gesamtausmaß von 4 ‰. Trotz eines räumlichen Nahbezugs lassen die Mg-Isotopensignaturen kryptokristalliner Magnesite keinen Bezug zu den „Source Rocks" der für die Mineralbildung erforderlichen Mg-haltigen Fluide erkennen. (iii) Der Poldasht Magnesit (W Azerbaijan, NW Iran) und sein hydrologisches Umfeld eröffnen mit der weiten Streuung ihrer d26Mg-Werte (-1,04 bis +2,59 ‰; DSM-3) modellhaft Einblick in die saisonal/klimatisch gesteuerten Wechselbeziehungen und Prozessabläufe einer rezenten Magnesitbildung in Playabecken, die über quartären Basalten situiert sind. Die Untersuchung des Poldasht Magnesits erfolgte im Rahmen eines ÖAW-Projektes.

Origin of arsenic contamination of springs in an alpine environment, examples of the Seckau Tauern Range (Austria)

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For humans arsenic is one of the most toxicologically dangerous elements on the planet. In most cases it occurs geogenically dissolved in drinking water resources. The influencing factors for a contamination of water are widespread and for most locations individual. Four dominant mechanisms are known, two are associated with adsorption processes on metal oxides or clay under an alkaline or a reductive environment. The others are sulfate oxidation and evaporation of geothermal waters. High level contaminations like in Bangladesh are intensively discussed in literature, however low level contaminations are less investigated. This work aims to understand the processes of arsenic mobilization in low contaminated settings bound to crystalline periglacial landforms such as rock glaciers in alpine regions. The investigation area in the Seckau Tauern Range led to new questions related to arsenic contamination of spring water bound to these landforms, since that none of the four dominant dissolution and mobilization processes does fit to the behavior of the investigated springs. Water temperatures between 2-4 °C, short retention times (hours – several months) and neutral pH values are not favorable conditions for dissolution and mobilization. Furthermore, the overall total cation concentration is less than 22.58 mg/l, where Ca^{2+}, Si^{4+}, Mg^{2+}, Na^{+} and K^{+} dominate. Anions, such as HCO_3^-, SO_4^{2-}, NO_3^-, NO_2^-, Cl^- and PO_4^{3-}, are also extremely low concentrated ($\sum$ <27.42 mg/l). Nevertheless, the arsenic concentrations in some spring waters exceed 10 µg/l, which is the recommended threshold (parameter value) for drinking water according to the WHO. The important questions related to this context are: (i) What is the source of the contamination? (ii) What are the dissolution and the transport mechanisms? (iii) Why do they not fit to the dominant processes? (iv) Is an influence discernible due to the hydrogeological behavior of rock glaciers or other landforms like debris talus, etc.? Therefore, water sampling for hydrogeochemical analysis as well as rock and sediment sampling was done to investigate the distribution and the source of the contamination. Additionally, stable isotopic data of the water samples (H, O and S) were taken for a better understanding of the dissolution and mobilization processes. Finally, PHREEQC will be applied for inverse modelling by using the hydrogeochemical data in combination with geochemical and mineralogical data from exposed lithologies of the catchment areas. Thus, this work contributes to a better understanding of the origin and fundamental process of low arsenic pollution in crystalline basement areas.

A study of Rockfall processes at different geomorpholocigal settings through numerical simulations in 3D

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Rockfall behaviour, at different geomorphological settings (i.e. quarry slopes, forest covered natural slopes, natural slopes including a well-established talus cone, gorge-forming slopes), have been analysed by means of real-size field experiments and numerical simulations in 3D.The numerical method used for this study, follows a process-based, hybrid-lumped mass approach, which introduces stochastic ground roughness and hyperbolic restitution factors to rockfall impacts.(Bourrier and Hungr, 2011). Rebound rotational and translational components of a projectile's velocity, are being calculated through Goldsmith's impact model (Gischig et al., 2015). The technique is scripted in Python programming language and the resulting numerical code consists Wurf, which main technical features have been first presented in GeoTirol-PANGEO (Fleris and Preh, 2016).

Different geomorphological environments involve different slope geometries, different key features of structural geology and different lithological-engineering properties. The combination of all field parameters affects rockfall behaviour from initial slope failure, to transitional motion along the slope and finally the runout.

A certain challenge during any numerical rockfall simulation, would be the correct selection of input parameters. Therefore, the purpose of this work is to document a methodology for deriving reliable parameters for Wurf on the basis of back-analyzed field experiments and well documented rockfall events, as well as to investigate parameter space and its relation to distinct geomorphological environments.

Detrital U/Pb zircon age distribution in Alpine metasedimentary rocks of the Koralpe-Wölz nappe system (Eastern Alps)

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The Koralpe-Wölz nappe system as part of the Upper Austroalpine nappes is generally characterized by high grade (amphibolite and eclogite facies) Eo-Alpine metamorphism contemporaneous or subsequent to Alpine nappe stacking. In addition, the units related to the Koralpe-Wölz nappe system were affected by Permian high-temperature – low-pressure metamorphism, basically related to lithospheric thinning subsequent to the Variscan orogeny. While the metamorphic conditions for several metamorphic events are very well constrained, very little is known about the protoliths, in particular the widely distributed metasediments, of the the Koralpe-Wölz nappe system.

In this study we present first data from U/Pb dating of detrital zircons derived from the Plattengneis of the Koralpe and from metapelites of the Rappold Complex in order to constrain potential provenance areas and maximum ages of sediment deposition.

Zircon minerals were analyzed by an Agilent 7500 LA-ICPMS system at the Northwest University (China) and with a Nu Plasma II MC-ICPMS system at the NAWI Graz Geocenter. Zircon ages (206Pb/238U) of the Koralpe show a main peak of Ordovician ages (434 Ma – 472 Ma). The youngest zircons show ages of 309 Ma. Additional age accumulations show ages of 343 Ma, 536 Ma and 604 Ma. Also represented are some ages of 946 Ma and some Paleoproterozoic zircons (1916 Ma). The age distribution within the Rappold metasediments is dominated by zircons with Cardomian ages (585 Ma – 663 Ma). Youngest ages are 333 Ma. Also some Odrovician ages (477 Ma) and some Neoproterozoic (726 Ma – 937 Ma) exist. In addition some zircons with Paleoproterozoic and Archean ages were observed (1653 Ma – 2540 Ma).

The zircon ages of these two units indicate maximum deposition ages of 309 Ma (Koralpe) and 333 Ma (Rappold). Different provenance areas for the Koralpe and Rappold metasediments could be assumed by distinctions in the zircon age distribution.

Thermometrie an Erzen und Nebengesteinen der Sideritlagerstätte Steirischer Erzberg

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Die Temperaturüberprägung der Sideritlagerstätte Steirischer Erzberg und ihrer Nebengesteine wurde durch die Ramanspektroskopie und Elektronenmikroskopie untersucht. Aus der Raman Spektroskopie organisch reicher Gesteine ergeben sich Metamorphosetemperaturen in einem Profil durch die Norische Decke der östlichen Grauwackenzone. In diesem Profil nehmen die Temperaturen von 240°C bis 350°C nach SE zu. Karbonatproben des Erzberges zeigen im Mikrometerbereich mehrere Generationen. Die Bildungstemperaturen der Vererzungen wurden mit dem Siderit-Ankerit-Geothermometer mit 290°C bis 535°C abgeschätzt. Es handelt sich dabei um Temperaturen der Äquilibrierung der Karbonate mit hydrothermalen Lösungen unter Bildung von Eisenkarbonaten. Das Chlorit-Geothermometer ergibt ähnliche Temperaturwerte. Wegen der Temperaturunterschiede zwischen den Proben der Nebengesteine und der Vererzungen muss es sich um zeitlich verschiedene Ereignisse handeln. Die Siderit-Ankerit-Mineralisation ist in der Trias durch hydrothermale Prozesse entstanden und die metamorphe Überprägung ist eoalpidischen Alters.

Searching fore- and afterslides of gravitational mass movements

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Environmental seismology is an emerging field with strong implications for better understanding and mitigating natural hazards. Continuous real-time records of seismic stations allow the precise detection of rapid gravitational mass movements such as rockfalls and landslides on various scales – from local slope monitoring to regional or global detection of large-scale events. Especially when compared with classical detection methods for wide-area coverage, such as remote sensing, seismology has the advantage of providing continuous records with precise time stamps. The seismic waves generated by rapid mass movements enable us to study e.g. repeated failures of a slope with a temporal resolution opens up new possibilities: E.g. we can discriminate subsequent events from the same source region, such as potential foreslides and afterslides, which might otherwise be registered as just a single failure, or with insufficient timing precision. In this study we analyze seismic records obtained from permanent and temporary seismic networks in the Alps and search for fore- and afterslides around the catastrophic 2017 Piz Cengalo, Switzerland rockslide and a series of rockfalls in the Glockner Group, Austria that have occurred in October 2017.

Cold case: in search of the provenience of an exceptionally preserved Cretaceous shark

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The preservation potential of shark skeletons is generally poor. Therefore, complete fossils are rather rare. Due to the rarity of articulated specimens, each exceptionally preserved specimen has a fundamental significance for palaeontology in general.

Herein, we present an about 38-cm-long fossil shark preserved as mould on a sandstone slab. The specimen is stored in the collection of the Kammerhof Museum Gmunden, Upper Austria, but lacks any labels. Therefore, the provenience of the fossil is still unknown.

The aim of the study is to identify the taxon on genus level and to speculate about the presumed geological context of the specimen. A nannoplankton sample of the surrounding sediment revealed a Late Cretaceous age. This information was the basis for further taxonomic classification. Despite the rather poor state of preservation of the teeth a distinct affiliation to Lamniformes, the mackerel sharks, can be proven using a cast of the dissolved teeth. After a detailed anatomical description of the complete skeleton, the search for the origin of the fossil had started. First of all, comprehensive literature research had to be conducted, which revealed evidence of other shark bearing horizons of Late Cretaceous age with rather similar sediment characteristics from the Münsterland Basin in Germany. In a next step a heavy mineral analysis and a thin section of the matrix will be analyzed to compare the sandstone of the German location and to determine the provenance of the sediment, aiming at a sedimentological fingerprinting study.

This case study should demonstrate possibilities, which can be used to determine fossils of historical collections with insufficient or lost labeling, which has otherwise limited significance for research.

Identifying hidden secrets of shark teeth (Chondrichthyes, Elasmobranchii) using sophisticated approaches

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The taxonomy of sharks (Chondrichthyes, Elasmobranchii) remains difficult since this group has a cartilaginous skeleton instead of ossified bones, which makes complete body fossils rather rare. Contrary to the sporadic preservation of skeletons, cartilaginous fishes developed species specific teeth and a permanent tooth replacement pattern, which provides abundant material for classification on all taxonomic levels.

The most important character for classification is the superficial tooth morphology including ornamentation patterns. The crown morphology is an easily accessible character, which allows mostly a prompt although not always distinct identification. On the other hand, the crown morphology is quite plastic and changes easily in relation to feeding adaptations and hunting behaviours. Conversely, the root morphology is more conservative because its only function is to fix the tooth to the jaws. Consequently the root represents a more stable character for supra-species level taxonomy. The nutrient supply of the teeth is provided by nerves and blood vessels that enter through the root and form distinct vascularisations within the root and crown independent of superficial morphological changes. Four distinct, major types (anaulacorhize, hemiaulacorhize, holaulacorhize, polyaulacorhize) and various modifications of these types generally are recognized, which also reveal information about evolutionary traits.

Generally, thin sections of teeth are prepared to investigate their internal structures. The consequence is the loss of most of the tooth. An innovative solution is provided by computer tomography scanning with subsequent visualization using various software packages (e.g., Amira, VG Studio Max, 4d data visualization). Such software solutions are costly. Open-source scientific visualisation software packages, conversely, might represent cost-efficient solutions. Here, we demonstrate the benefit of the free available Drishti software solution, which is user-friendly to generate three-dimensional reconstructions of the internal tooth vascularization pattern including foraminal openings and occurrences and directions of canals. The possibility of non-invasive CT scans and 3D reconstructions of the external tooth morphology in combination with visualization of internal structures is important to provide a better understanding of the evolutionary development of tooth characters in cartilaginous fishes.

Geophysical detection of caves to prevent natural hazards – Two case studies from Lower Austria

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The study area is located near Lunz in the Northern Calcareous pre-Alps at the contact of well bedded limestone (Opponitz Formation) and massive dolomite (Hauptdolomit), both from the Upper Triassic. At the study area electrical resistivity tomography (ERT) and ground penetrating radar (GPR) have been performed to gain information about changes in the electrical properties of the subsurface that could help in the delineation of the cave system. Two case studies are presented: (1) the Forststraßeneinbruch and the (2) Stiegengraben Wasserhöhle. The Forststraßeneinbruch (length 147 m, depth 24 m) was first reported due to a hole opened in a forest road in December 2016. From the survey, it was clear that also other parts of the cave are close to the surface (adjacent to infrastructure) as well. The aim of the geophysical investigation was to delineate the location of further surface near caves that potentially collapse. As there is access to Forststraßeneinbruch and thus a precise cave survey exists, it was possible to compare the results of the geophysical measurements with the real cave extent and thus to check the achievable accuracy.

The Stiegengraben Wasserhöhle is a 1 km-long cave buried by coarse gravel during the construction of a forest road in the 1970's and by a lot of fine grained material recently. The cave acts as a spring during flood conditions but the water could escape through the coarse gravel. Now it is feared that due to the recently plugging of the spring with fine grained material the water pressure could rise inside the cave and mobilize the unconsolidated material, which could result in a debris flow, endangering the houses in the valley below. Ground penetrating radar (GPR) and electrical resistivity tomography (ERT) were used to detect the exact position of the former entrance in order to allow the planned reopening. Here the geophysical investigation aims at identifying the geometry of the cave, as well as the accumulation of fine materials, or water saturated voids.

For the ERT measurements a system with 72 electrodes with 1 m spacing was used, which yielded a penetration depth of 15-20 m. Above Forststraßeneinbruch seven partly intersecting profiles were measured. Due to the dense forest, only five GPR measurements were possible along the same profiles. Therefore, both a 200 MHz and an 80 MHz antenna were used. With the 200 MHz antenna a penetration depth of about 10 m and with the 80 MHz antenna of about 30 m could be reached. Above Stiegengraben Wasserhöhle two profiles were measured along the forest road. Both with ERT and a 400 MHz GPR antenna.

Our results show that ERT is a well suited method which permits to gain detailed information on the geometry and interconnection of the cave system. GPR permits a faster data collection, yet the interpretation of such data is highly improved using the ERT results. Also the comparison of both geophysical methods with the cave survey showed a good agreement.

High-frequency cycles of brachiopod shell beds on subaqueous delta-scale clinoforms (early Pliocene, SE Spain)

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During the early Pliocene, subaqueous delta-scale clinoforms developed in the Águilas Basin, in a mixed temperate carbonate-siliciclastic system. Facies distribution is consistent with the infralittoral prograding wedge model. Stacking patterns and bounding surfaces indicate that the clinoforms formed during the highstand and falling sea-level stages of a high rank cycle. Twenty-two prograding clinothems were recognized over a distance of ≥ 1 km. Biostratigraphic data indicates a time span shorter than 700 ky for the whole unit (MPl3 biozone of the Mediterranean Pliocene). Cyclic skeletal concentrations and occasional biostromes of suspension feeders (terebratulid brachiopods, modiolid bivalves and adeoniform bryozoan colonies), slightly evolved glauconite and occasional Glossifungites ichnofacies formed on the clinoforms during high-frequency pulses of relative sea-level rise. During such stages, increased accomodation space in the topsets of the clinoforms caused a strong reduction of terrigenous input into the foresets and bottomsets, which provided favorable conditions for the development of these suspension feeder paleocommunities. During stillstand stages, however, reduced accomodation space in the topsets eventually resumed progradation in the foresets. In this facies, the abundance of Ditrupa tubes indicates frequent siltation events that drove the demise of terebratulid populations and other epifaunal suspension feeders in the bottomset subenvironments. The occurrence of shell beds on the clinoforms suggests that this case study represents lower progradation rates than standard examples where shellbeds bound the clinobedded units at their base and top only. Most importantly, the distribution of biofacies and ichnoassemblage associations contribute significantly to the understanding of the effects of relative sea level fluctuations on the evolution of subaqueous delta-scale clinoform systems.

Campanian to Maastrichtian planktic foraminifera of the Pálava Formation may point to southward flow of boreal waters into the Penninic Ocean

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In the Austrian part of the Waschberg-Ždánice-Unit, the Pálava Formation consists of glauconite sands/sandstones and grey marls. In order to reveal the areal distribution of Meso- and Cenozoic sediments, several hundred of near-surface samples were taken by hand-drilling (50 to 200 cm depth), with 29 samples from the Pálava Formation. Both facies of the Pálava Formation contain basically the same original foraminiferal composition but those from the glauconite sands are much more corroded, resulting in biased assemblages with predominantly thick-shelled resistant taxa. The state of preservation of the near surface samples varies from nearly pristine (glassy tests) to highly corroded. A general trend of better preserved assemblages towards the northern areas and poor state in the south can be observed. The found foraminiferal assemblages yielded at least 53 planktic species. The ages of the found assemblages range from (middle) Campanian to latest Maastrichtian (*Abathomphalus mayaroensis*-Zone). It is remarkable that Gansserina gansseri has not been found in any of the investigated samples and A. mayaroensis is the most frequent keeled species in the youngest samples. These "cool water"-assemblages may be attributed to the relatively northern position of the sites or a possible southward flow of boreal waters into the Penninic Ocean.

Cyclic paleo-salinity changes inferred from benthic foraminiferal assemblages in the Upper Burdigalian (Lower Miocene) Korneuburg Basin, Austria

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The late Burdigalian (Karpatian) Korneuburg Basin gives an excellent insight into the continuous modification of its paleo-environments and paleo-ecology and therefore into its dynamics over geological time scales. The investigated outcrops provided a unique opportunity to study the change of foraminiferal assemblages in an Early Miocene estuarinemarine system as a response to climate (precipitation) oscillations. To this end, we studied foraminiferal assemblages. Ostracods provided additional information. Paleo-salinities were estimated by applying a transfer equation using modern frequency distributions of indicative foraminiferal taxa. This technique is used here for the first time to reconstruct salinity in the past, and may facilitate further studies in shallow water paleo-environments elsewhere. On the basis of the recorded benthic foraminiferal assemblages, their modern distribution, and several diversity indices (Fisher α, Shannon, Dominance, Evenness), we were able to discriminate between five paleo-environments. Paleo-salinity was the most important environmental factor that governed the distribution of taxa in the Korneuburg Basin. Low diverse brackish environments yielded *Ammonia* and *Aubignyna*. Slightly reduced salinity conditions are dominated by Ammonia with additional taxa and are more diverse. Normal marine salinities are indicated by the dominance of *Heterolepa*, *Gyroidinoides*, or *Bulimina* and go along with a more balanced assemblage composition. Hypersaline conditions are characterized by *Cycloforina* and *Ammonia* and an intermediate diversity distribution. Freshwater samples are free of benthic foraminifera. Environmental changes and consequent ecological stress resulted in an overall low-diverse paleo-ecosystem. Salinity variations are interpreted as being caused by freshwater influx into the system. Seventeen combined increases and decreases of paleo-salinity indicate a coupling with obliquity cycles and a linkage to regional climate changes. The estuarine system of the Korneuburg Basin, that lasted over 700,000 years shows distinct effects of the regional climate regimes on the local micro-fauna.

Delineation of soil structure and the plough horizon through electrical imaging: laboratory investigations

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Tillage has major influence on the soils structure in the top layer of a field and therefore on the surface-groundwater interactions. The resulting soil structure, thus, depends on the method and depth used for tillage. Moreover, repeated tillage results in the creation of a plough pan, a dense layer characterized by low hydraulic permittivity, with the structure of the uppermost layer changing after every field treatment. Adequate field management, for instance to design of artificial irrigation systems require detailed information about the geometry of the plough pan (i.e., depth and micro-topography), as well as the structure of the top soil layer. Some studies have proposed the application of geophysical electrical methods to gain information of the soil electrical properties in an imaging framework and use this information to delineate the plough pan and soil structures. To achieve this, this study investigates the feasibility of electrical resistivity tomography (ERT) to map water paths and the plough pan. To reduce the uncertainties associated to field acquisition, measurements were conducted in the laboratory using an undisturbed soil core with dimensions of 100.1 x 49.5 x 28.8 cm. Different electrode configurations were tested deploying electrodes placed on top and the bottom of the soil core, and with various separations between the electrodes. Data analysis was carefully performed for each dataset to identify and remove outliers (systematic error) and quantify random error and improve the reliability of the resulting inversion results. Imaging results show structures near the surface which could be related to water flow paths. Moreover, a clear contact in the electrical properties may be interpreted as the plough pan. Results presented here demonstrate the potential of the ERT method to assess soil structures with high resolution as required for an improved field management.

The ‘Cretan Detachment’ (Greece): a Miocene thrust or low-angle normal fault?

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The tectonic units of Crete are generally considered to consist of a Lower- and an Upper Nappe System, that are separated by a major tectonic contact. Based on the suggestion that the Upper Nappe System was not affected by Alpine metamorphism it has been proposed that the tectonic contact represents a low-angle extensional shear zone referred to as the ‘Cretan Detachment.’ However, the paucity of consistent and convincing kinematic indicators has been attributed to either bivergent extension or a strong component of coaxial deformation. Moreover, recent data on calcite twinning, Raman spectroscopy of carbonaceous material and illite crystallinity from rocks above and below the tectonic contact of the Upper and Lower Nappe System indicates that the fault was active in the Miocene as thrust at upper crustal conditions.

In this work, we investigate fault rocks of the ‘Cretan Detachment’ exposed in Eastern Crete, where the Tripolitza Unit is juxtaposed against the Tyros Unit. The Tripolitza Unit in the hanging wall consists of Upper Triassic platform carbonates and the Tyros Unit in the footwall is composed of Norian/Rhaetian violet slates, which are part of the Toplou Beds. Major displacement is localized in an almost horizontal detachment with up to 1 m thick (foliated) ultracataclasites and fault gouges, which record a pervasive SCC’ fabrics indicating top-to-N displacement. The material is mainly derived from the violet slates in the footwall that are strongly folded with subvertical limbs overprinted by a subhorizontal axial plane slaty cleavage, which is parallel to the main detachment plane. The low-grade marbles of the overlying Tripolitza Unit are cut by parallel steeply S-dipping antithetic normal faults with cohesive and non-cohesive cataclasites forming bookshelves, which are tilted towards the north. Numerous injection dykes filled with cemented cataclasites suggest overpressured fluids during slip along the detachment. New (U-Th)/He zircon ages are dispersed and as old as 130 Ma, but a significant population of the dates are ca. 17 Ma. These dates are much younger than the published zircon fission track dates for eastern Crete, and help constrain the temperature of deformation to 200 ± 20°C. Although we do not question the occurrence of an earlier thrusting component along this tectonic contact, our data from mainly cataclastic rocks clearly indicate Miocene top-to-N normal slip along this part of the ‘Cretan Detachment.

The Trans Cycladic Thrust: a new major tectonic structure in the Eocene syn-orogenic Hellenic subduction channel (Cyclades, Greece)

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New structural, petrological and geochronological data from the basement rocks on Milos (Kiriaki Complex), together with published data from other Cycladic islands, suggest that the Cycladic Blueschist Unit can be subdivided in two different nappes that are separated by the newly defined Trans Cycladic Thrust (TCT). Both nappes consists of greenschists, marbles, metapelites and metabasic rocks that experienced Eocene peak metamorphic conditions during subduction in the Hellenic subduction channel. (i) The Lower Cycladic Blueschist Nappe, which comprises the islands between Makronisos and Serifos and Milos, Folegandros and Ghiaros, as well as Lavrion and Evia, reached temperatures of c. 400°C and 10 kbar. Decompression related shear deformation reflects top-to-the-W to -S thrusting. (ii) The Upper Cycladic Blueschist Nappe reached temperatures of c. 550°C and 20 kbar. Exhumation-related deformation indicates top-to-the-W to -S kinematics only at lower structural levels; most rocks preserve a top-to-the E to NE shear-sense, indicating apparent normal faulting. Andros, Tinos, Syros, Sifnos, Sikinos and Ios, which all preserve remnants of eclogites, lie within the Upper Cycladic Blueschist Nappe.

Because the exhumed Eocene syn-orogenic Hellenic subduction channel has been strongly overprinted by the Miocene post-orogenic extension, including differential rotation between the Western- and Central Cyclades, the TCT is bent by almost 90° and offset by major low-angle normal faults like the West Cycladic Detachment System. This observation suggests that the Miocene extensional low angle faults did not or only partly reactivated the Eocene crustal-scale faults associated with the extrusion of the Cycladic Blueschist Unit. The lateral continuation of the TCT is still under discussion but of crucial interest for linking the Hellenides with the Taurides.

Progress in investigation of vulnerable stalagmites vibration, numerical and analogue modeling

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Recently, it has been argued that natural intact stalagmites in caves give important constraints on seismic hazard since they have survived all earthquakes over their (rather long) life span. This suggests that the pattern of oscillation should be fully understood, including the splitting of eigenfrequencies that has occurred in recent cave observations. In the present study, we simulate the oscillation of a given stalagmite by setting up four simplified models of the stalagmite. The dimensions of the intact stalagmite were measured in-situ, and the geo-mechanical and elastic parameters of broken stalagmite samples, determined in geo-mechanical laboratory, have been taken into account. The eigenfrequencies of the stalagmite are then calculated numerically, by the finite element method, and compared with the measured in-situ values. The latter have shown splitting of eigenfrequencies, which we were able to reproduce by the numerical model calculations taking into account the asymmetric shape of the stalagmite.

In order to determine the critical value of horizontal ground acceleration, that would have made them failed at different stages of their growth, we need to understand the failure process of these intact and vulnerable stalagmites. More detail information of the vulnerable stalagmites' rupture is required, and we have to know how much it depends on the shape and substance of the investigated stalagmite. Predicting stalagmite failure limits using numerical modeling is faced with a number of approximations, e.g. from generating a manageable digital model. Thus it seems reasonable to investigate the problem by analogue modeling as well. The advantage of analogue modeling among other things is that nearly real circumstances can be produced by simple and quick laboratory methods. The stalagmite model sample bodies were made from gypsum. These bodies were reduced-scale with similar shape as the original, investigated stalagmite. During the measurements, we could change both the shape and the material and the time series of acting horizontal acceleration. Comparing the results from analogue to numerical modeling could improve the accuracy of long-term seismic hazard assessment.

P-T-t constraints for the Variscan history of the Gaugen Complex (Kreuzeck Mountains, Austria, Eastern Alps)

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In the Eastern Alps pre-Alpine metamorphic and plutonic Austroalpine and Subpenninic basement units cover a wide area. Large portions of these units were penetratively overprinted by Cretaceous to Cenozoic deformation and metamorphism, which tended to erase the pre-Alpine features. Consequently, there are only a few areas where the pre-Alpine history of basement units can be studied in detail.

The Gaugen Complex is part of the Drauzug-Gurktal Nappe System (Austroalpine) and covers large parts of the SE Kreuzeck Mountains, south of the Tauern Window. In the Gaugen Complex the Variscan amphibolite-facies metamorphic assemblages are well preserved due to the limited Eoalpine overprint in lower greenschist-facies conditions. The most common lithology is paragneiss with transitions to mica schist. In these lithologies garnet is microscopically abundant and can reach sizes of 1 cm in particular layers. Locally, staurolite and rarely kyanite occur in equilibrium with garnet, indicating amphibolite-facies conditions. A three point Sm-Nd isochron age yielded a late Variscan age of 306 ± 5 Ma (2 garnet fractions, one whole rock fraction). This relatively young age is interpreted as a garnet growth age.

The Gaugen Complex is divided by a large E-W striking Eoalpine shear zone with a north side up sense of shear. One representative sample from each side of the shear zone was chosen for bulk rock and mineral chemical analyses as well as equilibrium phase diagram calculations with the Theriak-Domino software package (NCKMnFMASHT system with excess SiO_2 and H_2O). In the sample of the southern block, the observed equilibrium assemblage Grt-Bt-Ms-Pl-Ilm corresponds to a relatively wide pentavariant field located in the range 570-670°C and 5.5-8.5 kbar. The measured composition of garnet, biotite, plagioclase and muscovite indicates that the observed recorded conditions are at approximately 570°C - 6.5 kbar, which are situated at the low temperature boundary of the Grt-Bt-Ms-Pl-Ilm field. In the sample of the northern block, the observed equilibrium assemblage Grt-Ky-St-Bt-Ms-Pl-Ilm corresponds to a narrow trivariant field located around 640°C - 6.5 kbar. The chemical compositions of garnet, biotite, plagioclase and muscovite calculated at 640°C - 6.5 kbar are in good agreement with their measured counterparts.

Microstructural arguments and equilibrium phase diagrams indicate that the studied parageneses correspond to the metamorphic peak conditions. The blocks to both sides of the shear zone record different peak temperatures (~570°C in the southern block, ~640°C in the northern block) but similar peak pressure (~6.5 kbar). We suggest that these peak conditions were reached in the late Carboniferous according to the garnet age.

Abundance of acidic compounds in Upper Visean black shales from the Dniepr-Donets Basin (Ukraine): advances in facies and maturity assessment

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Upper Visean Rudov Beds are considered the main source rock for conventional oil deposits in the Ukrainian Dniepr-Donets Basin (DDB) and a prospect for unconventionals recently. Understanding maturity and facies variations is key to the economic success of an unconventional target, apart from other commonly accepted quality parameters (e.g. TOC content, thickness and mineralogy). Recent developments of new organic geochemical techniques such as Fourier Transform ion cyclotron resonance mass spectrometry (FT-ICR MS) with Electrospray Ionisation (ESI) in the negative ion mode (–) helped to refine maturity and facies evaluation, enhancing the predictability of source rock quality.

Maturity- and facies variations are commonly investigated by combining organic petrography and organic geochemical techniques including pyrolysis gas chromatography (Py-GC). However, the analytical window of conventional biomarker analyses and Py-GC are limited to a mass range of m/z 50-300, hence covering mainly low-polarity compounds. ESI-(–) FT-ICR MS provides a considerably larger analytical window (up to m/z 2000), allowing detection of high polar compounds (e.g. acidic NSOs). Mahlstedt et al. (2016) and others applied ESI-(–) FT-ICR MS to crude oils, bitumen and source rock extracts and obtained valuable insights regarding maturity-related changes in the abundance of acidic compounds and the influence of biodegradation. We use a combination of ESI-(–) FT-ICR MS and advanced biomarker analyses to characterize acidic NSO compounds of 10 extracts of Upper Visean shales from the so-called Srebnen Bay, located in the NW DDB.

Besides an obvious maturity trend from shallower marginal to deeper basinal positions, marginal samples are predominantly gas-prone, whereas basinal samples hold a potential to yield low-wax P-N-A oils (Misch et al., 2015). Based on these results, a sample set covering different facies zones and a maturity range from 0.6 to 1.2 %Rr was selected for ESI-(–) FT-ICR MS measurements and the further characterization of NSOs.

A maturity trend is visible in the methylcarbazole group of NSOs. The benzocarbazole distributions indicate a slight facies influence besides a maturity related overprint. Ny an Ox class compounds analysed with ESI-(–) FT-ICR MS dominate over Sz class compounds. A decrease of Ox and an increase of Ny class compounds can be referred to ongoing maturation. Samples from a position outside of the Srebnen Bay show slightly increased amounts of Ox class compounds in comparison to samples within the Srebnen Bay at comparable maturity. In general, N1O1 compounds decrease with increasing maturity except two samples located outside the Srebnen Bay which exhibit low amounts of N1O1, likely due to a facies-related overprint. The applied combination of biomarker analyses and ESI-(–) FT-ICR MS helps to verify and refine maturity assessment and to reveal changes in the molecular composition of polar high mass-compounds, either caused by facies changes or other processes (e.g. biodegradation).

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Styles of fault-related folding at the front of the Northern Calcareous Alps

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The Bajuvaric Nappe Complex represents the lowermost tectonic unit at the leading edge of the Northern Calcareous Alps (NCA), which is overthrusted by the Tyrolic and Juvavic Nappe Complexes. Notable differences in the deformational style were observed in these units: Narrow synclines and anticlines are described from the Bajuvaric, whereas faulting and thrusting rather than folding is reported from the Tyrolic (Mandl, 2000).

A structural field study was conducted in the Ternberg- and Reichraming Nappes, which form part of the Bajuvaric Nappe complex in the southeast of Upper Austria. Published structural interpretations and cross-sections from this area present tight to isoclinal buckle folds with thickened hinge zones that are cut by relatively few thrust faults (Tollmann, 1976; Hamilton, 1989; Egger & van Husen, 2011).

Field work has identified fault-related folding rather than buckle folds, thus revealing a different structural style than suggested by previous interpretations. Isoclinal folding does not exist, instead a high number of thrust faults was mapped that control the geometry of the nappe stack. Thrust faulting appears on all scales, causing upright repetitions of strata.

A change of the structural style is evident within the mapped Bajuvaric Nappes: contraction is accommodated by fault-bend folding in the southern zones of the Reichraminger Nappe, whereas fault-propagation folds with typically steep front limbs and blind thrusts are detected in the northern Ternberger Nappe. Commonly the fault-related folds are stacked as duplexes or imbricate thrust systems as a consequence of the low thrust spacing. In particular the frontal area near the base thrust on the Flysch Zone shows a marked decrease of the thrust spacing.

Consistent top NNW shortening along the thrust faults is derived from fault slip data, analysis of SCC'-fabrics and fold geometries. Fold axis trend horizontally in ENE-WSW direction in the entire study area. An exception to this trend is found in the area of Trattenbach, where folds plunge at considerably higher angles up to 40°. Analytical solutions have shown that steep fold plunges up to 50° can be caused at lateral terminations of folds that are either the consequence of oblique/lateral ramps or of lateral displacement gradients (Wilkerson et al., 2001). Simple 3D kinematic forward modeling was used to generate structures with steep fold terminations and to approximate the geological map expression of such structures. The best match with the map was obtained by introducing a lateral ramp that causes displacement of Mid-Triassic marker lithologies as well as steeply plunging folds at the edge of the thrust folds.

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The research of the western Tauern window between 1894 and 1898 in the documents of the mineralogist and petrographer Friedrich Becke. A project of the „Österreichische Akademie der Wissenschaften“

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Friedrich Becke’s notebooks are witnesses of his remarkable and multifaceted scientific oeuvre. Geoscience owes the following discoveries to Friedrich Becke: the theoretical knowledge about crystal classes, the further development of the research regarding feldspars, the technical development of microscopes, and the geological investigation of the Waldviertel, the Sudeten and the Alps. His most significant discovery was the “Becke Line”. The notebooks provide evidence for the mineralogical, petrological and geological techniques used during the late 19th century.

Becke’s notices about his fieldtrips in the Alps are generated in between twenty years, between 1892 and 1912 and are documented in different styles as notebooks, field books and laboratory books. Between 1893 and 1903 he filled 18 field books and three notebooks containing his research in the Eastern Alps. Together with the geographer Ferdinand Loewl (1856-1908) he examines the rocks and geological formations of the Southern Alps of Predazzo and the geological structure of the Zillertal Alps.

Between 1894 and 1898 the Commission of the Academy of Sciences approved a petrographic study of the Zentralkette of the Eastern Alps. Three regions were explored by three scientists - Friedrich Martin Berwerth (1850-1918), Johann Ulrich Grubenmann (1850-1924) and Friedrich Becke. Friedrich Becke conducted research in the eastern and western Tauern Window. The documentation describes his visits in the area of the Zillertal and the Tux Hauptkamm with further studies in the Brenner area extending over 10 years between 1893 and 1903. His active participation in the 9th Geological Congress in Vienna can be seen as a research highlight and also as completing the work in the Zillertal and the Tux Alps. The petrographic laboratory studies of the rocks of the Zillertal Alps lead Becke to fundamental discoveries in the field of crystalline schists and metamorphic rocks.

These two areas of research – Zillertal and Tuxer Alpen respectively Hochalm Massiv – have established the Tauern Window in the Alps and given it a firm place in Alpine geology. With his petrographic research and the resulting findings, Becke sets the basis for future discussions of this interesting area.

The karst bauxite of the Unterlaussa mining area (Upper Austria)

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Four of the six once existing mining fields close to the abandoned miners´ village Weißwasser northwest of Unterlaussa (Upper Austria) are still accessible by underground openings. They operated on boehmitic karst bauxite lenses at the base of the Gosau succession of the basin "Weyerer Bögen".

Twenty-three samples of bauxites and bauxite-related sediments were analysed by means of ICP-MS and XRF. The geochemical samples also include those of four bauxite profiles. In addition SEM, electron microprobe and XRD were used to define the mineralogy and to map element distributions. The XRD analyses revealed that the bauxite-related sediments are not repositioned bauxites but rather immature (not bauxitisized) sediments of which some are probably mineralogically similar to the parent material of the karst bauxite.

In the longest and best-preserved bauxite profile (Almstollen) the REEs (except for Sc and Ce) distinctively accumulated in the lowermost two meters of this six-meter-long profile. Rare earth elements are generally highly enriched compared to average crustal values. However, also other trace elements could be detected in high concentrations. Chondrite-normalized REE patterns of the Almstollen profile indicate reducing conditions in the lowermost two meters of the bauxite body due to negative Ce anomalies. The upward following samples show clear positive anomalies pointing to oxidising conditions.

The karst bauxite of the Unterlaussa mining area can be regarded as an Upper Cretaceous (Turonian) paleosol which was formed in-situ by tropical to subtropical weathering of a precursor sediment on karstified dolostone. This precursor sediment was presumably illite-rich and likely already contained kaolinite. Lateritic material as well as volcanogenic sediments were probable contributors to the parent sediment. Additionally ultrabasic rocks must be assumed in the catchment area of this sediment as chromite and chromium accumulations prove. Conclusively the precursor material can be described as a mixed, fine-grained, polygenetic sediment.

Changing conditions of water saturation are responsible for the layered in-situ concretions (spheroids) which give the bauxite its characteristic pisolitic texture.

The karst bauxite of Unterlaussa was partly resilificated, deferrificated (bleached) and pyritized. Both of the latter processes are attributed to microbial activity. Moreover a presumably microbially mediated uranium mineralisation and a massive aluminium-hydroxide bound chromium mineralisation have been identified.

An enigmatic spring in a hydrothermal cave at the western margin of the Vienna Basin

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The cave Eisensteinhöhle is a 2-km long crevice cave that is significantly overprinted by hydrothermal karst processes. It was opened during quarrying in the Fischauer Vorberge, on the western margin of the Vienna Basin. This pull-apart basin cuts the eastern foothills of the Alps and is formed by a major NE-SW striking sinistral transform fault. The western margin consists of NNE-SSW striking normal faults that create paths for thermal water to rise from the central basin.

In the deepest part of the cave, 87 m below the entrance, is a small pond that sometimes acts as a spring. The cave and in particular the spring have attracted attention since their discovery around 1900. The water level and temperature fluctuate and at a certain level, water visibly discharges into a nearby narrow fissure. A more or less continuous record of sporadically taken data on water level and discharge exists from late 1980s on. As there was no obvious connection to precipitation events or periods, until now, it was impossible to determine how the spring is connected to an aquifer and where the water comes from.

To investigate the tectonic activity of the main fault of the cave an opto-mechanical 3D crack gauge TM-71 was installed. Water level and temperature of the pond are observed hourly by a data logger (SEBA Dipper PT). Furthermore, a simple pumping test was conducted.

The pumping test showed the geometry and the volume of the pond and that it is fed by a very small inlet out of the sandy bottom. At that time, the discharge was only 4.5 l/h but at previous overflow events, discharges of up to 4.8 l/min were recorded.

Water temperature and hydrochemistry hint towards a mixture of an old thermal component and a young meteoric component. The high-resolution data on water level and temperature fluctuations show a relation to certain rainfall events and the sporadically taken long time records show a correlation with annual rainfalls and with groundwater levels in the Vienna Basin.

Within the first two years of the continuous monitoring, the water level was almost stable with few periods of high level (almost at overflow) that lasted for about 3 to 4 weeks each. At the beginning of the first event in October 2015, a minor fault activity was measured in the nearby Emmerberghöhle and a local earthquake (M 2.5) occurred one week later about 10 km from the caves. In July 2017, the water level dropped suddenly and then recovered simultaneously to several weak earthquakes in the vicinity. The water temperature increased during most water high stands and is positively correlated with the water level.

The collected data suggests, that the spring in Eisensteinhöhle is influenced by both, precipitation and tectonics, but a lack of tectonic events leaves this relation unconfirmed.

Hydrochemical Signatures of Groundwaters in Upper Austria – Contributions to a revision of the existing thermal aquifer model

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The North Alpine Foreland Basin (NAFB) forms an intensively used area for hydrocarbon production and for gas storage. Deep groundwaters in the Upper Jurassic (Malm) aquifer and in deeper sections of the Oligocene Linz-Melk Formation are utilized for energetic and balneological use. Furthermore, deep groundwaters tapped by wells with a depth of up to 500 m are used for drinking water purposes in municipal and private supplies. Hydrocarbons have been recovered (partly from the same formations) in the NAFB for decades. In order to allow a juxtaposition of the individual interests and to secure a sustainable usage of the basin´s resources, detailed knowledge of the basin structure, its hydrogeological units and the interactions of the different systems within, is essential.

In a joint effort of Upper Austrian and Bavarian experts and authorities, a hydrodynamic model of the Malm has been established. According to this model, thermal waters migrate from the main recharge area in the Bavarian Forest eastwards to Upper Austria and drain into the Linz-Melk Formation before they reach the discharge in Eferding Basin. However, recent projects have shown that the hydrodynamic model needs a general adaption.

In order to broaden the data base, water samples from private and municipal water suppliers, as well as deep (1521-2060 m) geothermal wells, all producing groundwater from the Malmian aquifer were sampled and analysed regarding their chemical and isotopic composition. Moreover, gases associated with the water were investigated. The objective of this study is to distinguish hydrostratigraphic units based on hydrochemistry and the composition of dissolved and free gases and to identify mixing processes.

Waters of the Malmian aquifer are of the Na-HCO_3-Cl-type with total mineralization ranging between 961 mg/l and 1409 mg/l, whereas groundwaters from younger aquifers are mainly Ca-HCO_3-type waters with average total mineralization of 385 mg/l and 134 mg/l for Innviertel Group and Bohemian Massif, respectively. However, preliminary results indicate mixing of different water types in shallower formations in the Innviertel and Hausruck area. For instance, water samples taken from wells located north and north-west from the city of Wels and south from Sauwald show a chemical composition which is a result of mixing deep Malmian groundwater with younger groundwater. Interestingly, one water sample taken in Andorf shows a composition similar to that of the Malmian aquifer – a Na-HCO_3-Cl-type water with increased mineralisation.

The isotopic signature of the gas taken together with the water samples suggests a microbial origin of the methane in samples from shallower ground water horizons (e.g. Linz-Melk Formation, Innviertel Group), whereas gas from geothermal wells (Malm) shows a mixture of thermogenic and microbial methane. Higher hydrocarbons within these samples support the mixing. It is assumed, that the hydrocarbons partly originate from thermogenic hydrocarbon deposits, either located in Bavaria or Upper Austria.

Dissolved and free methane in these wells support the ascension of deep groundwater. Adjacent faults could serve as possible migration paths for thermal waters. These new findings propose that the existing groundwater model in this region has to be refined due to the observed discharge of Malmian waters.

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Mind the gap! The Sarmatian/Pannonian boundary at the western margin of the Vienna Basin (Austria)

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Sarmatian and Pannonian cores, drilled at the western margin of the Vienna Basin in the City of Vienna, reveal a complex succession of marine and lacustrine depositional environments during the middle-late Miocene transition. Two Sarmatian and two Pannonian Transgressive-Regressive sequences were studied in detail. Identical successions of benthic faunal assemblages and similar patterns in magnetic susceptibility logs allows a correlation of the boreholes over about 3.5 km distance across one of the major marginal faults of the Vienna Basin. For the first time, a distinct and widespread horizon of tubular pyrite aggregates is documented from Lake Pannon deposits. These are explained by sulfate-driven anaerobic oxidation of methane by archaea and sulfate-reducing bacteria during the maximum flooding. Biostratigraphic data combined with rough estimates of sedimentation rates reveal large gaps between the sequences, suggesting that only major transgressions reached this marginal area. In particular, during the Sarmatian-Pannonian transition the basin margin completely emerged and turned into a terrestrial setting for at least 600 ka.

Another hiatus of at least 200 ka separates the two Pannonian sequences. Consequently, the seemingly continuous cores captured relatively short glimpses of geological time. Only careful biostratigraphic and paleoecological analyses of the cores are able to detect these hidden gaps, which may turn into pitfalls for paleomagnetics.

This contribution is part of the project “The Sarmatian/Pannonian Extinction Event within the City of Vienna”, which was supported by the Cultural Department of the City of Vienna and the Commission for Geosciences of the Austrian Academy of Sciences.

Earthquake Location in Austria: Accuracy, Reliability and Improvements for hypocenters after 2000

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Earthquake location at the Seismological Service of Austria (ZAMG) routinely includes a 1D-velocity model (IASP91) and waveform data from the national seismic network (OE). Data from permanent networks of the neighboring countries as well as temporary networks deployed in Austria are also available for analysis. The national seismic network of Austria consists of 19 broad-band stations (isolated places) and 20 strong-motion stations (populated areas). The actual network geometry is unevenly distributed and therefore the accuracy of earthquake locations (especially the focal depth) can vary considerably along Austria. High-precision epicenter locations can be obtained for certain areas in Austria from seismic data of temporary networks such as AlpArray, TU-SeisNet or SwathD. However, for seismic hazard assessment the use of long-term earthquake records with precise hypocenter locations is essential to resolve active tectonic processes and to parametrize active faults.

Reliability network locations are found and are accurate to within 5 km with a 95% confidence level when the GT5 criterion is met. We relocated more than 1200 GT5 events using the probabilistic earthquake location method NonLinLoc combined with a 3D-velocity model to account for the complex structure of the Eastern Alps (MOHO, sedimentary basins). To document our relocations we investigated the differences in depth, latitude and longitude between routine ZAMG locations and the probabilistic earthquake location combined with the 3D-model. Focal depths were also compared to depths derived from macroseismic evaluations.

Absolute location uncertainty was assessed by locating single events from several quarries in Tyrol, South Tyrol, Lower Austria, and Burgenland. For relative location uncertainty events from two recent earthquake series near Fulpmes (Tyrol) and Alland (Lower Austria) were evaluated. We investigated the routine ZAMG location procedure and that of the probabilistic earthquake location combined with either the 3D-model and or the 1D-model.

The new 3D-locations fulfilling the GT5 criteria will be used to delimitate the trend of active faults, to delimitate areas of similar focal depths and to assign representative depths to active faults.

Preliminary data show that for poorly constrained locations (not fulfilling GT5 criteria) the performance of the probabilistic earthquake location with the 3D-model is comparable and sometimes slightly worse than the routine ZAMG location. For well constrained locations (fulfilling GT5 criteria) the probabilistic earthquake location with the 3D-model yields more precise and reliable hypocenter locations. The 3D-locations are slightly shallower as before and are better in agreement with depths derived from macroseismic evaluations.

Übersicht zu wichtigen und aktuell genutzten Naturwerkstein-Vorkommen in Österreich

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Anlässlich eines Vortrages für Bildhauer und Steinmetze im Kärntner Krastal im Oktober 2017 und der damit einhergehenden Publikation (Verein [kunstwerk]krastal (Hrsg.): 50. Steinbildhauer Symposion Krastal - die ersten fünfzig jahre, Wien 2018 in Vorbereitung) wurde eine Karte mit tabellarischer Aufstellung wichtiger Naturwerkstein-Vorkommen in Österreich zusammengestellt, die nun auch im Geologen-Kreis präsentiert wird.

In Österreich werden Gesteine aller drei großen Gesteinsgruppen a) Sediment- oder Ablagerungsgesteine, b) magmatische oder Erstarrungsgesteine und c) metamorphe bzw. Umwandlungsgesteine als Werksteine genutzt. Die Vielfalt der nutzbaren und genutzten Vorkommen hat sich in den letzten 70 Jahren stark eingeschränkt.

Vorkommen von Sedimentgesteinen, die als Werksteine genutzt werden, finden sich sowohl im Bereich der Böhmischen Masse als postvariszische Bedeckung, als auch im Bereich der Alpen, insbesondere der Kalkalpen und der Flyschzone, aber auch im Bereich der von Lockergesteinen dominierten jungen inneralpinen Becken, wie dem Wiener und dem Steirischen Becken. Wichtige Sedimentgesteins-Vorkommen, die als Werksteine genutzt wurden bzw. werden, sind in der landläufigen Steinmetz- und Bildhauer Nomenklatur: Torrener Nagelfluh, Weiße Kremsmünsterer Nagelfluh, Ternitzer und Lindabrunner Konglomerat, Schwarzachtobler Sandstein, Flysch-Sandsteine, Kalktuffe,
St. Margarethener Kalksandstein, Mannersdorfer und Aflenzer Stein sowie Leithakalk diverser weiterer Varietäten, Zogelsdorfer Stein, Untersberger Marmor, Kramsacher bzw. Hagauer Marmor, Schwarzensee-Marmor und die vielfältigen Adneter Marmore.

Unter den in Österreich als Werkstein genutzten magmatischen Gesteinen dominieren die Granite, daneben kommen im Hauptverbreitungsgebiet der Böhmischen Masse (Ober- und Niederösterreich) aber auch Granodiorite und Diorite vor. Weitere, kleinere Vorkommen magmatischer Tiefengesteine liegen in Osttirol und Kärnten, wo im Zuge der alpinen Gebirgsbildung vor etwa 30–40 Millionen Jahren entlang der Periadriatischen Störungszone Tonalite und Granodiorite entstanden. Unter den Vulkaniten Österreichs sind die bekanntesten die Basalte vom Pauliberg und von Klöch.

Die wichtigsten metamorphen Gesteine, die in Österreich als Werksteine genutzt werden, sind: Marmore, Gneise, Serpentinite, Grünschiefer sowie Quarzite. Hervorzuheben sind Wachauer bzw. Waldviertler Marmor, St. Leonharder Granulit und Bittesch-Gneis im Bereich der Böhmischen Masse, Pinolit-Magnesit, Sölker-, Salla- und Krastaler Marmor, Grün- und Chloritschiefer (‚Diabas'), verschiedene Granitgneise und der Plattengneis im Ostalpin sowie Quarzite, Serpentinite, Prasinite, Marmore und Granitgneise im Penninikum und Subpenninikum.

Zur Geologie der Weingärten in den Weinbaugebieten Wachau und Kremstal

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Korrespondierend zur Exkursion werden anhand von Ergebnissen geologisch-lithologischer Detailuntersuchungen, von Analysenergebnissen sowie von Boden- und Gesteinsprofilen die Charakteristika, die geologischen Gemeinsamkeiten und Eigenheiten, sowie die naturräumlichen Unterschiede der beiden Weinbaugebiete dargestellt. Nach Literaturangaben werden klimatische Parameter und regionale Sortenverteilungen ergänzt. Beide sind ausgesprochene Weißwein-Gebiete mit einer starken Dominanz der Sorte Grüner Veltliner vor Riesling.

Während das Weinbaugebiet Wachau fast zur Gänze im engen Durchbruchstal der Donau mit den terrassierten Steilhängen liegt und nur im östlichsten Teil, südlich der Donau bei Mautern, das Alpenvorland berührt, öffnet sich das Weinbaugebiet Kremstal von Krems gegen Osten aus den kristallinen Bereichen des Donau- und Kremstales in die Weite des Alpenvorlandes mit Lockergesteinsdominanz.

In beiden Weinbaugebieten dominiert der Löss als Ausgansmaterial für die Weingartenböden: Im Kremstal mit ca. 58 % der Fläche, in der Wachau aber nur mit knapp 42 %. In beiden Gebieten ist Paragneis als zweithäufigste Weingartenuntergrund, hier ist das Verhältnis aber umgekehrt, in der Wachau sind es etwas über 15 %, im Kremstal etwas über 10 % der Weingarten-Fläche. Weingärten auf holozänen Terrassen bzw. der Flussebene liegen mit knapp 12 % in der Wachau bzw. knapp 9 % im Kremstal an dritter Stelle. Erst ab der vierten Stelle ergibt sich eine qualitative Differenzierung. In der Wachau folgt Orthogneis mit etwas über 8 % der Weingartenfläche und dann Lagen auf Deckenschottern mit Lehmauflage (etwas über 4 %). Im Kremstal nehmenLagen auf alten Terrassen mit Lehmauflage (etwas über 7 %) den vierten Platz und Weingärten auf Konglomerat der Hollenburg-Karlstetten-Formation den fünften Platz ein.

Thermo-dynamic forward modelling of the monazite and xenotime evolution during prograde metamorphism in the Ivrea-Verbano-Zone (N Italy)

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The proper quantification of rates and timescales is critical for our understanding of processes working on Earth. For example, time scales and rates of heating, cooling and exhumation of metamorphic and igneous rocks remain a key problem in tectonics.

Absolute ages and rates of processes are preferentially derived from dating accessory minerals such as zircon, monazite, xenotime, allanite, rutile and titanite. The emerging field of petrochronology relates absolute ages with the petrological information derived from the same minerals. For this approach a comprehensive understanding of accessory mineral petrology is crucial.

The Kinzigite-Formation in the Ivrea-Verbano-Zone offers intensively interlayered lithologies with identical P-T(-d) evolution but strongly varying rock geochemistries, ranging from meta-pelitic, -psammite/-greywacke to -basic rocks with minor calcsilicate and marble. The Val Strona di Omegna transect represents an almost complete section through the mid to lower continental crust with mid-amphibolite facies conditions in the SE and granulite facies conditions in the NW. Previous investigations have shown, that all lithologies comprise the accessory minerals of interest.

P-T phase diagram calculations, e.g. pseudosections, allow to extract P-T information from bulk rock chemistries and mineral paragenesis. Hence it can be a powerful technique to link ages derived from accessory minerals to P-T conditions .

Monazite and xenotime growth and composition will be modelled in the KNCMnFMASH-Y-Ce-P system using the GIBBS program (Spear et al., 1982; Spear, 1988) with the same methodology and thermodynamic data as used in Spear and Pyle 2010. Bulk rock chemistries derived from ICP-MS analysis are available from mid- to upper-amphibolite facies rocks of the Kinzigite Formation from Val Strona di Omegna. Pseudosections in addition to petrographic findings will be presented for a better comprehension of the evolution of xenotime and monazite during prograde metamorphism in the Ivrea-Verbano-Zone.

Hunting for the trap: Applied Structural Geology in OMV Exploration

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In OMV Upstream Exploration we use a variety of structural geological methods for the evaluation of on-shore to offshore exploration prospects. The main techniques applied are 1) kinematic modelling and restoration for validation of seismic interpretation and maps, 2) generation or use of static 3D structural models for fault seal analysis 3) analogue modelling to increase the understanding of processes and structures. This presentation will focus on the workflow for integrated structural geological interpretation. The main purpose of this is to understand the structural architecture of potential hydrocarbon traps and to de-risk the interpretation. Finding a trap in the exploration workflow usually relies on the interpretation of reflection seismic data. Especially in complex deformed areas seismic imaging often is very poor and allows more than one interpretation. In addition in the absence of 3D seismic the available 2D grid of seismic lines might be spatially too sparse for defining reliable closures. As a consequence, the amount of possible interpretations of a potential trap and thus the associated risks are high. A way of reducing the number of possible solutions is the construction of balanced cross sections. However, there might still be several geometrical solution. Thus, it is required to take as many constraints as possible into this workflow in order to find a geometrical correct solution (i.e. balanced) that also reflects process understanding (i.e. when and how rocks and regions deform). Valid solutions should honour the regional evolution, the tectonostratigraphy with a focus on the mechanical stratigraphy and the likelihood for pre-existing structures. Doing kinematical forward modelling helps to understand the geometry and temporal evolution of a structure or an area. Such models should be aligned with knowledge gained from physical and numerical models to make them more consistent. A careful consideration of all constraints yields most plausible solutions for the structural architecture and often yields new insights into the structural geological evolution of the considered region. The workflow will be applied to a case example from the Kirthar Fold belt of Pakistan. By considering all constraints from regional to local, it can be demonstrated that the most likely scenario for the deformation of the central Kirthar fold belt is thick-skinned inversion linked to trailing thin-skinned deformation.

Structural Geological and Salt Tectonic processes in the south-eastern Zagros, Iran

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OMV Upstream and the National Iranian Oil Company are currently working on a joint study focussed on the prospectivity of the South Fars region of Iran. The study area encompasses the offshore Persian Gulf foreland basin along with the simply folded belt of the Zagros, famous for its whaleback folds and salt glaciers. The Zagros formed as a consequence of the collision between the Arabian shield, Eurasia and associated microcontinents. In this presentation we will show key results from two field work campaigns in this region and aim to give some insight into the formation of this spectacular landscape.

Based on field observations, a complex history of halokinetic movements associated with salt diapirism can be inferred and elaborated upon. Salt diapirs, likely present near the surface since the early Palaeozoic, were repeatedly reactivated, generating islands which dispersed any exposed salt derived material into the surrounding sediments. In addition, buried salt diapirs lifted up their sedimentary overburden, generating mass wasting events along the uplifted flanks. The halokinetic movements can be partially linked to the main regional tectonic events such as the Upper Cretaceous ophiolite obduction and Arabian shield–Eurasia continent to continent collision, which has been continual since the Miocene.

In this major Cenozoic event, faults beneath the salt are interpreted as having undergone inversion/reactivation and play a primary role in localizing the thin-skinned deformation above the salt. The Palaeozoic to Cenozoic sediments are detached on the Eocambrian aged Hormuz salt and folded into large scale detachment folds. Folding is controlled by the mechanical stratigraphy, the detachment properties and the basment geometries (faults, paleo-highs) as well as the results of the earlier halokinetic evolution (i.e. heterogeneous sediment thicknesses and presence of salt diapirs). All these factors combined are responsible for the complex present day pattern of folds with its apparently erratic distributed salt diapirs and glaciers in-between. This pattern of diapir distribution is suggested to be inherited from the extensional phase that initiated diapirism and modified by the young contractional deformation.

Differentiation between Miocene and Quaternary displacement at the southern Diendorf Fault

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The Diendorf-Boskovice Fault System is a ca. 200 km long, approximately NE-SW trending fault system that forms the eastern margin of the Bohemian Massif in Austria. It extends towards Brno, where it is supposed to be kinematically linked to the Boskovice furrow. Showing a long-lasting and multiphase history, proofs of NE-SW-trending left-lateral strike-slip partly ductile, mylonitic shear zones during Carboniferous and Permian times are observed. In addition, insights show continuous transtensional left-lateral strike-slip faulting during Miocene.

A closer inspection along the length of the fault system shows segments of different geomorphic characteristics due to the long-lasting tectonic history of the Diendorf Fault System. In addition, earthquakes are observed mainly at the southern part of the Diendorf Fault System (DFS) close to and south of the River Danube, suggesting recent tectonic activity there. Here, we present a multi-parameter study based on geomorphological parameters, geophysical electrical imaging results and structural geological analysis, to investigate the structure and the activity level of the southern segment in greater detail. A clearly visible linear lineament influencing the course of the river running parallel to it and triangular facets on both sides of the valley indicate vertical movement. In addition, detailed electrical resistivity profiles across the fault reveal at least two fault strands displacing the valley-filling sediments. Moreover, the electrical resistivity images display clearly the contact between the shallow sedimentary materials and the deeper metamorphic rocks of the Bohemian Massif. These are clearly offset across the fault zone and can be used to quantify the vertical displacement. Therefore, by using the combined information from geophysical, geomorphic and earthquake data, we can indeed identify the segment of the DFS south of the Danube as recently active. The data allows in addition to distinguish between Miocene and Quaternary offset.

Tektonische Grenzflächen in Niederösterreich – Auf dem Weg zu einer Störungsdatenbank im Maßstab 1:200.000

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Die Komplexität geologischen Wissens hat in den letzten Jahrzehnten stark zugenommen. Vor allem zu Störungen, Scherzonen und Deckengrenzen existieren oft mehr Informationen als in einer Karte sinnvoll und flächendeckend darstellbar sind. Um dieses Wissen adäquat abzuspeichern und später strukturiert abrufbar zu machen, entstand ein Projekt zwischen der GBA und dem Land Niederösterreich zum Aufbau einer Datenbank für Tektonische Grenzflächen für Niederösterreich im Maßstab 1:200.000. Basierend auf der gedruckten geologischen Karte (Schnabel et al., 2002) bzw. deren digitaler Form, wird im Laufe des Projektes der vorhandene Datensatz überarbeitet, mit störungsrelevanten Attributen ergänzt und an den aktuellen Wissensstand angepasst.

Die neu erstellte Datenbank enthält neben Informationen zur geometrischen Orientierung und Kinematik der Störungen auch Details zur zeitliche Eingrenzung der Aktivität. Neben Störungen und Scherzonen im klassischen Sinn sind auch Deckengrenzen zwischen tektonischen Einheiten unterschiedlichen Rangs (Tektonische Groß- oder Untereinheit, Deckensystem, Decke) in die Datenbank integriert. Hierbei wurden neben der zeitlichen Einordnung der Bewegung an Deckengrenzen auch der jeweils maximal erreichte Metamorphosegrad erfasst. Insbesondere im Bereich des Moldanubikums kann somit der komplexe Aufbau des variszischen Gebirges, die Lage und zeitliche Aktivität von Scherzonen und Störungen wie deren partielle spätere Reaktivierung eindrucksvoll dargestellt werden.

Final soll eine Datenbank für Niederösterreich entstehen, welche alle verfügbaren Information zu tektonischen Grenzflächen digital abrufbar und damit schnell und einfach ersichtlich macht. Somit steht dann zum ersten Mal ein geschlossenes, tektonisches und geodynamisches Bild für ein Landesgebiet in Österreich im Maßstab 1:200.000 zur Verfügung. Dieses ist für die Landesgeologie bei Bauwerksplanungen und Aspekten der Raumordnung im Rahmen von Großbauprojekten von praktischer Bedeutung. Dieses Projekt könnte als Pilotprojekt für weiterführende Kooperationen zwischen Bund und Bundesländern dienen, mit dem Ziel, eine nationale Plattform für aktive Störungen zu schaffen.

Investigating stream-aquifer exchange using waterborne spectral induced polarization imaging

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Analyzing stream-aquifer exchange for the management of bank filtration sites requires detailed information on the geometrical and hydraulic streambed properties. Inverse methods in numerical groundwater modeling tend to bear high spatial uncertainty. To reduce these uncertainties fiber-optic distributed temperature sensing (FO-DTS) can be applied but is limited by its unidirectional sensitivity towards groundwater discharge. To gain information with high spatial information, we investigate here the applicability of spectral induced polarization (SIP) imaging, a geophysical method, that provides information about the distribution of the low frequency electrical properties of subsurface materials. In particular, the objective of the study was to evaluate the capability of SIP imaging results to provide spatial estimates of parameters of a Cauchy-type boundary condition, namely hydraulic conductivity and thickness of potentially colmated substream sediment as well as stream stage, as required to improve numerical groundwater models. Hence, SIP measurements were collected with high spatial density using an array of 32 electrodes (at 0.5 m spacing) along a selected reach of a losing-disconnected subalpine stream in a broad frequency bandwidth (0.5-225 Hz). The array was fully submerged at the stream bottom, while the equipment was mounted on a stationary-positioned inflatable rubber boat. The electrical measurements were complemented with hydraulic tests. A total of over 300 depth-discrete transient infiltration tests, using temporarily installed steel piezometers with 10 cm screen length, were performed and analyzed to determine horizontal hydraulic conductivity (k) of the streambed at various depths and positions along the electrical arrays. SIP imaging results expressed in terms of the frequency dependence of the complex conductivity (σ*) have provided two main observations: i) the real component (σ') shows only consistency to the main lithological units, permitting to delineate stream stage and the general substream architecture; whereas the imaginary component (σ'') has revealed a large spatial variability, which in turn is consistent with the variability observed in hydraulic conductivity measurements. Moreover, the correlation between σ'' and hydraulic conductivity values increases with increasing the acquisition frequency, suggesting that fine grains, as the dominating length scale, are enhancing the polarization response. Patterns of the first derivatives of σ'' as a function of depth suggest variable geometry of an immediate sub-stream layer, associated to the strongest polarization effect, as expected of a streambed colmation layer, commonly related to lower hydraulic conductivity compared to the surrounding armor layer and aquifer material. Our results demonstrate the potential of SIP images to assist groundwater flow modeling by providing necessary estimates for Cauchy-type boundary conditions at longer stream-aquifer interfaces. Particularly, the potential improvement of groundwater model predictive accuracy when embedding these estimates into a parameter estimation framework is still open to investigation.

Palaeo-geographical and -historical implications of pollen taxa (e.g., *Sarcandra*, *Phyllanthus*, *Fagus*, *Juglans*, *Lagerstroemia*, *Mortoniodendron*, *Cornus*, *Nyssa*, *Symplocus*; *Iodes*) from the lower Bartonian Chanchang Formation (Hainan, South China) investigated by LM and SEM

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Lower Bartonian samples of the Changchang Basin were palynologically analysed with LM and SEM. The samples are characterized by up to 80% of Quercoideae and other angiosperms that occur in low numbers. Gymnosperms and ferns are rare. The botanical affiliations of the pollen taxa reveal new implications for their palaeo-geographical distribution during the Paleogene: We present the first occurrence of *Sarcandra* (Chloranthaceae), and show that *Laurelia* pollen on Hainan give further evidence for the wide geographical range of this family. *Flueggea* (Phyllanthaceae), that was present in Europe (Lower Eocene) also occurs on Hainan, pointing towards a Eurasian origin of this genus. In contrast, *Phyllanthus* subgen. *Eriococcus* is here described for the first time and, so far, seem to be only Asian in occurrence. The *Fagus*-type from Hainan resembles the extant *F.* "subgen. *Engeriana*" and the Lower Eocene *Fagus* pollen described from NW Canada. This, together with other *Fagus* fossils suggest an amphipacific distribution of an ancient *F.* "subgen. *Engleriana*" lineage during the Eocene. The *Juglans*-type resembles *Juglans* taxa from section *Cardiocaryon* (Asian butternuts), and was contemporaneous with diaspores of *J.* section *Rhysocaryon* from the United States, therefore pushing the divergence-time within this genus further back in time. The *Lagerstroemia*-type is currently the oldest occurrence and closely resembles the Miocene *L. cathayensis* from China and the extant deciduous *Lagerstroemia* taxa from China/Korea. Of the Malvaceae pollen found, the two *Mortoniodendron*-types *shed* light on an unknown palaeo-geographical history: Today, *Mortoniodendron* is restricted to Central America and Miocene pollen have also been encountered in Central America. However, Lower and mid-Eocene pollen from Europe and now from Hainan, indicate a far wider distribution of this genus prior to the early Oligocene global cooling event. Two dipterocarp pollen types (*Dipterocarpus* and *Dryobalanops*) are here described for the first time and corroborate the findings of dipterocarp biomarkers in nearby oil source rocks. The Cornus-type belongs to the "blue-or-white-fruited clade" and, together with fossil data from Europe, suggests a Eurasian origin of this clade, that was contemporaneous with the "cornelian cherry clade" in the U.S.A.. Thus the divergence time within *Cornus* must have been earlier than previously estimated. The *Nyssa*-type closely resembles the extant *N. sinensis* and Eocene *Nyssa* pollen from Europe, but not the ones from the Americas, implying that there was an ancient Eurasian *Nyssa sinensis* lineage stretching from Europe to eastern Asia. The three *Symplocos* type pollen are all related to the deciduous *Symplocos* subgenus *Palura*, an early diverging clade within the Symplocaceae. Upper Eocene *Symplocos* pollen from Germany also belong to this clade and suggests a Eurasian origin for this subgenus. Three Icacinaceae of the *Icacina*-group have been distinguished; two *Iodes* types, one resembling African/Madagascar taxa and one resembling a Melanesian taxon and suggest that the Old World disjunction of *Iodes* in Africa/Madagascar and SE Asia is a Paleogene relict, with the members of this genus previously much more widely distributed. The third Icacinaceae taxon resembles two genera: *Mappia* (today Central America) and *Nothapodytes* (today SE Asia), both members of the *Mappia/Nothapodytes* clade that also must have been widespread in the boreotropical realm during the Eocene.

Die Bibliothek der Geologischen Bundesanstalt (GBA) als zentraler Knotenpunkt in der Vernetzung heimischer Geowissenschaften

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Die Bibliothek und das Archiv der GBA stellt die größte Sammlung geowissenschaftlicher Literatur des Landes dar. Historisch betrachtet verfügt sie dank der Gründung der GBA im Jahre 1849 über umfangreiche Bestände, die vor allem die Länder der einstigen Monarchie betreffen.

Die Schwerpunkte liegen neben der systematischen Sammlung von Publikationen, vor allem auf der Erschließung und der Zurverfügungstellung im Sinne des OPEN ACCESS-Gedankens. Die Bibliothek der GBA agiert als eigenständige Institution in Ergänzung zu den Bibliotheken des Österreichischen Bibliothekenverbundes (https://www.obvsg.at).

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Beschlagwortung: Umfangreiche Beschlagwortung vor allem in Bereich der Geographika. Neben dem UTM-Kartensystem wird auch das BMN- Kartensystem weitergeführt.

Systematische Aufnahme der „Österreichliteratur“: Kontinuierlicher Check der (inter-)nationalen Journale und Medien in Hinblick auf Artikel etc. mit Österreichbezug, die aufgenommen und beschlagwortet werden.

Fokus im Bereich „grauer Literatur“: In Kooperation mit der Österreichischen Geologischen Gesellschaft (ÖGG) werden auch Bakkalaureatsarbeiten erworben, aufgenommen, beschlagwortet und online zur Verfügung gestellt. Darüberhinaus werden Berichte, Gutachten, Studien etc. im Archiv der GBA erfasst. Bei Bedarf können diese GESPERRT werden und stehen dann nur nach Rücksprache mit dem Autor / Auftraggeber zur Verfügung.

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http://www.geologie.ac.at/services/web-services/

http://www.geologie.ac.at/services/webapplikationen/

Korrespondenz der GBA: Die Indices der Protokollbücher (1849 bis 1944) sind digital verfügbar:

http://www.geologie.ac.at/ueber-uns/organisation/abteilung/bibliothek-verlag-archiv/protokollbuecher-1850-1918/

http://www.geologie.ac.at/ueber-uns/organisation/abteilung/bibliothek-verlag-archiv/protokollbuecher-1919-1944/

Das umfangreiche Serviceangebot erfolgt durch das engagierte Team der Fachabteilung Bibliothek, Verlag, Archiv, das verstärkt wird durch wechselnde PraktikanntInnen und Zivildiener, sowie in enger Kooperation mit den MitarbeiterInnen der Fachabteilungen IT & GIS sowie Geoinformation an der GBA.

Rocky Austria online – Lessons learned

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Das 1999 von der Geologischen Bundesanstalt erstmals herausgegebene Buch „Rocky Austria“ wurde in den mittlerweile fast 20 Jahren zu einem Fixpunkt im Bereich der populären Darstellung der Geologie von Österreich. „Rocky Austria“ war Vorlage ähnlicher Publikationen im deutschsprachigen Raum und wird auch bei der universitären Lehre eingesetzt.

Neben einer englischen Version gab es auch schon früh eine erste Webversion, die auf die Eigeninitiative von Gerhard Bryda (GBA) zurückging. Nach dem Relaunch der Website der GBA im Jahr 2013 tauchte rasch der Ruf nach einer neuen Onlineversion von „Rocky Austria“ auf.

Grundlage der nun vorliegenden Onlineversion ist die gedruckte Ausgabe von „Rocky Austria“ in 4. Auflage (2015) des GBA-Autorenteams Ralf Schuster, Albert Daurer, Hans Georg Krenmayr, Manfred Linner, Gerhard W. Mandl, Gerhard Pestal und Jürgen M. Reitner. Das Lay-Out Konzept für die Online-Version stammt von Herbert Hirner (h2p_Büro für Kommunikation; http://h2p.at), die technischen Agenden lagen bei der Firma Körbler, https://koerbler.com); beide waren auch in den Relaunch der GBA-Website involviert.

Für die Gestaltung der Onlineversion galt als einschränkende Rahmenbedingung, dass keine Textadaptierungen, insbesondere Kürzungen, vorgenommen werden sollten, da die Formulierungen in der Druckversion fein aufeinander abgestimmt sind. Vereinzelt, z.B. im Kapitel „Entwicklungsgeschichte/Quartär“, hat das zur Folge, dass die Texte für ein Onlineformat ungewöhnlich lang wirken. Hingegen eröffnet das klare grafische Konzept für die Detailseiten der Onlineversion die Möglichkeit, manche Inhalte durch aussagekräftiges Bildmaterial noch fokussierter darzustellen.

Als innovativ und nachhaltig, im Sinne der gewünschten Verbreitung der Inhalte, ist der Menüpunkt „Service“ anzusehen. Hier stehen die seit Jahren stark nachgefragten, hochauflösenden Grafiken von „Rocky Austria“ im pdf-Format für Unterricht und Lehre kostenlos zum Download zur Verfügung.

Resümierend ist festzuhalten, dass Druck- und Onlineversion nicht 1:1 austauschbar sind; jedes Format hat seine Stärken und Schwächen. Idealerwiese ist die Onlineversion als Ergänzung und nicht als Ersatz der gedruckten Ausgabe zu sehen.

Tectono-metamorphic evolution of the Eo-Alpine extrusion wedge in the Eastern Alps (Oberhof window, Carinthia, Austria)

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During the Eo-Alpine collisional event, eclogite-bearing nappes were exhumed in an extrusion wedge that corresponds to the core of the Upper Austroalpine Unit of the Eastern Alps. Towards the foot- and hanging wall of the wedge, the metamorphic field gradient decreases. As there is little modern P-T-t-D data for low and medium-grade metamorphic units available, their geodynamic significance during burial and exhumation is not well constrained. A suitable area for targeting this open question is the tectonic window of Oberhof (Carinthia, Austria), since the transition between medium-grade and low-grade units is exposed.

A revised map and profile including a consistent stratigraphic and tectonic nomenclature of units in the Oberhof window are presented. Late Ordovician orthogneiss overlain by conspicuous garnet-chloritoid bearing graphite schist, quartzite and dolomite marble corresponding to the Bundschuh Nappe (BN, Ötztal-Bundschuh Nappe System) are exposed in the core of the window. Garnet- and hornblende-bearing schist corresponding to the Gstoder Nappe (GN, Koralpe-Wölz NS) are found structurally above, unlike elsewhere in the Upper-Austroalpine unit east of the Tauern Window. 4 zones with upward increasing phyllonitization are identified within this unit. The window boundary on top is defined by a top-to-the-E shear zone. The hanging wall is comprised by chloritic phyllites and quartzites of the basal parts of the Drauzug-Gurktal NS.

Based on field- and microstructural observations, several deformation events result in the following (micro)structures: (D1) tight folds with strong scattering axes roughly trending E-W to SE-NW, (D2) ductile top-E shearing in the upper part of the section and (D3) shallow-dipping, top-E/ESE normal faults at brittle-ductile conditions. Folding (D1) results in the most pervasive imprint and occurred closely after metamorphic peak conditions. Since it overprints older boundaries related to nappe-stacking (D0) no kinematic indicators of nappe-stacking are preserved and transitions between units are ambiguous. Cross-cutting relationships show that D1 and D2 occurred at least partly contemporaneously. Pseudosection modeling for two garnet-(chloritoid) bearing samples with neglectable retrograde overprint yield ~550°C and ~9kbar for both BN and GN. Simple zoned garnets exhibiting slight decrease of Mn indicates single-phase metamorphism. Raman spectroscopy of carbonaceous material infer metamorphic peak temperatures around 520°C throughout the whole succession.

We suggest that fluid-driven retrogression related to the D2 and D3 top-E shearing events is responsible for the retrogression gradient of peak assemblages as reflected by progressive disappearance of garnet. Rb-Sr cooling ages of biotite around 75 Ma imply a minimum age for this event. Due to the common post-peak history observed in the structurally deeper units, we interpret large scale folding around peak temperature conditions to account for the reversed position of the GN and BN. A conceptual geodynamic model that addresses the geodynamic significance of the transition to the Drauzug-Gurktal NS is presented.

High finite strain flow pattern in marbles around boudinaged dykes

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Analog and numerical models of the progressive evolution of boudinage have shown that the main factors controlling the development and final shape of boudins are the orientation and spacing of the inter-boudin surface, viscosity contrast and the layer thickness. Variation of these parameters can cause complex behavior of boudin separation and rotation of the boudin segments inducing complex perturbation strain in the host rocks.

The former quarry Fehringer nearby Spitz an der Donau (Austria) represents an excellent natural laboratory to study the influence of the geometry of interboudin surfaces, viscosity contrast and layer thickness on boudin evolution at high finite strain. Geologically the exposed rocks belong to the Drosendorfer Nappe system, which is part of the central European Variscan orogeny. The Drosendorfer Nappe comprises a variety of rocks including amphibolites, quartzites, paragneiss, schists and marbles of which the latter represent the main unit within the quarry. The highly deformed rocks have experienced metamorphic conditions of around 700-800 °C at 8 kbar and have been syntectonically intruded by pegmatitic and aplitic dykes. During continuous top-to-the SE shearing, dykes have been rotated into the shear direction resulting in stretching, boudinage and rotation of boudin segments. Interestingly, the observed boudins preserve various shapes including pinch and swell, fish mouth but also blocky geometries suggesting a progressively changing viscosity contrast possibly resulting from local metamorphic or chemical induced rheological weakening or cooling.

The aim of this study is to analyze the deformation mechanisms within boudin segments and their surrounding matrix. Using space for time, the changing deformation mechanisms and flow patterns are characterized for the host rock marbles and the aplitic dykes. First results show that a metasomatic halo, which consists of a thin dark biotite rim and a few millimetres thick, lighter zone, borders the aplitic dykes and the interboudin surfaces and influences the progressive evolution of the boudins. Additionally reprecipitation of quartz can be observed in high strain zones like boudin necks likely resulting in decoupling of single segments. Metasomatism at the dyke rims but also along the interboudin surfaces suggests a feedback of chemical and mechanical processes.

A detailed characterization of the microfabrics by optical and secondary electron microscopy including electron backscatter diffraction mapping help to gain a better understanding of the mechanical and chemical feedback processes at lower crustal conditions.

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Structuring of Geological Datasets in the Scale of 1: 50.000 in Austria – Advantages and Lessons Learned

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The importance of the possibility to process geological data increases permanently and the amount of data is growing enormously. Uniform data structures, based on elaborated data models or given data standards (e.g. INSPIRE, GeoSciML) help to manage and use the data in a structured and sustainable way. A cross-border usability and interoperability of public sector data is also the aim of the European Union directive INSPIRE (2007). The INSPIRE directive (implemented in Austria by BGBl – GeodatenInfrastrukturgesetz, 2010) obliges the Geological Survey to provide its public data information on geology in a semantically and technically standardized form. That means it has to be possible to search, visualize and download spatial data information in a uniform structure and description. Until then, the focus of the Geological Survey has always been on printed map sheets as a work of authorship. Therefore, prior to INSPIRE no overall data model on Geology has been established. The main geologic information linked to the geometry (geological legend) was just stored as plain text information without the possibility for satisfying queries. Hence, it was inevitable to structure geological data information on basis to a well-defined and sophisticated data model in order to publish datasets according to given standards. After being aware of the main geological object classes and attributes to cover, a first approach of data model to structure the map information implied in the legend text and legend structure has been started – the data harmonization process. Eighty-nine geological datasets in the scale of 1:50.000 have been harmonized through that first data structuring process. Now it is possible to run queries, achieving results in the topic of formation age, lithology, tectonic units, etc., over all harmonized geological datasets in Austria. However, the data harmonization points out how important it is to establish and define a common vocabulary for geologic data information (GBA-Thesaurus). A common “language” avoids misleading information and ambiguous interpretation regarding terminology such as homonyms, synonyms, errata, obsolete labels and concept definition. Beside the visualization of geologic feature details, another advantage of the query results is the display of inconsistent data information between the different map sheets. Thus, the data harmonization may be useful for further scientific investigation, compilation, homogenization or adjustment of interpretation of geological data.

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Surface Deformation Rates of a Deep-Seated Toppling Slope Failure in Lienz (Tyrol, Austria)

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Slow slope deformations often emerge as large-scale slope instabilities affecting entire valley flanks and may move only few millimetres per year. Studying these slope instabilities is critical because their activity status is often unknown and long-term processes switch between periods of activity and inactivity, with the reactivations potentially causing localized catastrophic failures.

In Eastern Tyrol, northwest of Lienz, two examples of deep-seated gravitational slope deformations (DSGSDs) within mica schists and gneiss of the Schober Gruppe ranging between 700 and 2900 m a.s.l. were chosen as study sites for combining differential Interferometric synthetic aperture radar (DInSAR) methods for assessment of movement rates.

The slope between Törl (2507 m a.s.l.) the village of Oberalkus (1284 m a.s.l.) is characterised by a saw-tooth slope profile due to a series of counterscarps as a result of deep-seated toppling. This was enabled by joints and faults steeply dipping into the slope (Reitner & Linner, 2009). The uppermost part reveals a 300 m wide graben structure where now fossil rock glaciers have their root zone.

For the long-term detection of deformation rates and defining the historic baseline to tie reactiviation periods to conditioning factors, we sampled the counterscarps and head scarps for cosmogenic nuclide dating with in total 14 samples. Several samples in stratigraphic order allow for the calculation of slip rates throughout the Holocene.

The last decades and present movement rates are processed with satellite InSAR (Interferometric synthetic aperture radar) acquired from ERS, ENVISAT and Sentinel-1. The combination of movement rates derived from these two methods should enable a better assessment of the current status of slope deformation since their onset as well as its potential future development.

The results are presented as part of the VIGILANS project.

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Albite-spodumene pegmatites without large granite intrusions? Exploring the feasibility of the alternative anatectic model

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Albite-spodumene ($LiAlSi_2O_6$) pegmatites are generally considered to be the product of extreme fractionation of melts or fluids deriving from large alkaline granite intrusions. Anatectic melts deriving from partially molten metasediments are in contrast not believed to be a possible source for such pegmatites. In the Austroalpine Unit of the Eastern Alps, albite-spodumene pegmatites are associated with simple pegmatites and relatively small inhomogeneous leucogranite bodies, all Permian in age. Large parent granites were however never observed. Instead, field relations, petrography, geochronology as well as phase and whole rock major- and trace-elements geochemistry suggests that these pegmatites and leucogranites derived from anatexis in upper amphibolite facies of Al-rich metapelite. Bulk rock and LA ICPS-MS mineral geochemistry indicate that before melting, metapelites could have contained significant Li (in average 120 ppm) and that the main Li-carrier in the protholith was staurolite (with up to 800 ppm Li). The aim of this study is to test with geochemical modelling if melting of such metapelites could be the origin of the albite-spodumene pegmatites.

The modelling approach consists in three steps. (1) Thermodynamic modelling is carried out in the NaCaKFMASH system with the Theriak-Domino software package, the tc6 thermodynamic database and the most recent set of activity models for sub- and suprasolidus metapelite. It is used for calculating the proportion of solid phases and melt for two types of scenario inspired from field observations: prograde melting of metapelite and metasomatism of metapelite by migrating melt. (2) Phase proportions and Li-partitioning coefficient are used for calculating the Li-distribution. Different melting models are considered: batch melting, fractionated melting and melting with overstepping. (3) Fractionation of Li in simple pegmatite and leucogranite of known Li-concentration is modelled with mass-balance.

Using conservative parameters and realistic hypotheses, these models show that 15 to 25 vol% melt containing more than 200 ppm Li can escape the migmatite, in case melting is associated with destabilization of staurolite. Following fractionation of the melt with 99% in mass within simple pegmatite and leucogranite containing 100 ppm Li yields high-evolved melts with 10,000 ppm Li. This value corresponds to the Li saturation in felsic melts necessary for crystallizing spodumene. Our geochemical model shows that partitioning of Li between restite and anatectic melt coeval with breakdown of staurolite, followed by fractionation is a realistic genetic process for the formation of the albite-spodumene pegmatites of the Austroalpine Unit.

Pressure, temperature and time constraints for the Wildkogel Nappe (Steinkogelschiefer, Oberpinzgau, Salzburg, Austria)

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The Wildkogel Nappe (Oberpinzgau, Salzburg, Austria) is a tectonic unit of the Upper Austroalpine Unit in the Eastern Alps. It corresponds to the previously defined “Steinkogelschiefer“ lithological unit and is considered as part of the vaguely defined “Innsbruck Quartzphyllite Zone.” However, the Wildkogel Nappe can be differentiated from the “Innsbruck Quartzphyllite Zone” by its lithological assemblage (micaschist, para- and orthogneiss, dolomitic- and calcitic-marble, amphibolite) and upper greenschist facies metamorphic grade (parageneses with garnet and/or biotite in micaschist, paragneiss and orthogneiss). Historically the metamorphism is attributed to the Variscan orogeny, whereas the Alpine signature is thought to be restricted to limited overprinting in the lower greenschist facies. We present new pressure, temperature and time data in order to precisely constrain the Pre-variscan, Variscan, Eo-alpine and Neo-Alpine story of the rocks belonging to the Wildkogel Nappe.

Two representative samples of garnet-micaschists were selected for petrographic characterization, mineral analyses, garnet elemental mapping and calculation of pseudosections. One sample is characterized by two-phased garnet with healed cracks. The Ca-poor garnet core is part of a primary assemblage with An-rich plagioclase, biotite, muscovite and ilmenite. The Ca-rich rim and the healed cracks are part of a secondary assemblage with An-poor plagioclase, biotite, muscovite, epidote and titanite. The second sample possesses fine-grained chloritoid aggregates and one-phased garnet. The chloritoid aggregates are prismatic and interpreted as pseudomorphs after staurolite, belonging to an undetermined primary assemblage without garnet. The garnet is in equilibrium with chloritoid, paragonite, muscovite, chlorite and ilmenite. Pseudosections indicate that the primary assemblages of both samples were stable at ~530°C and 5 kbar whereas the secondary assemblages were stable at ~530°C and 10 kbar. These conditions are consistent with maximum temperatures determined with Raman microspectroscopy on carbonaceous material on separate rocks from the Wildkogel Nappe.

Zircon U-Pb ages in orthogneiss pin the intrusion age of the protolith to the Lower-Middle Ordovician. In addition initial Sr isotopic ratio of a marble sample and an apatite U-Pb age on grains interpreted as detrital and not reset in a chlorite-carbonate schist are consistent with sedimentation in the Silurian to Devonian. An apatite U-Pb age at 309 ± 28 Ma of a garnet micaschist indicates Variscan metamorphism, in marked contrast to Cretaceous Eo-Alpine metamorphism documented by a garnet Sm-Nd age in a garnet micaschist, an apatite U-Pb age in an orthogneiss and a muscovite Rb-Sr age in a marble ranging between 135 Ma and 100 Ma. Multiple single-grain fusion 40Ar/39Ar dating indicates that the nappe boundaries were active between 120 and 90 Ma. Biotite Rb-Sr ages at c. 80 Ma, zircon (U-Th)/He ages from 80-35 Ma and apatite (U-Th)/He ages from 55-2 Ma indicate protracted cooling through the middle and shallow crust during Eo-Alpine exhumation and, likely, thermal resetting during exhumation in the Tauern Window.

This dataset documents the complex history of the rocks belonging to the Eo-Alpine Wildkogel Nappe. It indicates that the Alpine imprint was much more significant than previously recognized.

Towards a new lithostratigraphic and tectonic model for the 'Innsbruck Quartzphyllite Zone' within the Upper Austroalpine nappes (Oberpinzgau, Salzburg, Austria)

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The "Innsbruck Quartzphyllite Zone" (IQZ) extends over 80 km in Austria from Innsbruck (Tirol) in the west to Mittersill (Salzburg) in the east. The IQZ is tectonically bound (1) to the north by Eoalpine (Cretaceous) thrusts, in footwall position below the Staufen-Höllengebirge (Tirolic-Noric Nappe System, including the "Western Greywacke Zone"), (2) to the west by Eoalpine shear zones and faults, in a footwall position below the Ötztal-Bundschuh Nappe System and (3) to the south by a series of Neoalpine thrusts, in a hangingwall position above Penninic, Subpenninic and Lower Austroalpine nappes. These contacts have been partly overprinted or crosscut by Cenozoic faults related to the opening of the Tauern Window and the eastward extrusion of the Eastern Alps (Brenner-Silltal, Engadin-Inntal and Salzach-Ennstal-Mariazell-Puchberg Fault Systems).

Lithologically, the IQZ is dominated by Paleozoic low-grade metamorphic siliciclastic sedimentary rocks intercalated with marble and mafic schist marker horizons as well as Ordovician orthogneisses and Permian metarhyolites. The peak mineral assemblages indicate greenschist facies metamorphic conditions. Additionally, garnet-bearing micaschist, paragneiss and orthogneiss are found as consistent rock units structurally above or within the low-grade units. This includes the hangingwall of the "Patscherkofel Crystalline Complex" (western IQZ, interpreted as an element of the Ötztal-Bundschuh Nappe System), localities of the Tux Alps (central IQZ) and in the vicinity of Mount Steinkogel (eastern IQZ). The internal lithologic and tectonic outline of the IQZ, as well as the correlation of its lower- and higher-grade parts to orogen-scale nappe systems, are still a matter of debate. Furthermore, the limited amount of mapping, structural, petrological and geochronological studies make any attempt for correlating and defining lithostratigraphic and/or tectonic units as well as understanding their deformation and metamorphism uncertain.

In this contribution, we present a new lithological map as well as new structural, petrological and geochronological data for the easternmost part of the IQZ (BMN-map sheet 121 Neukirchen am Großvenediger, Operpinzgau, Salzburg). This data allows us to propose a new lithostratigraphic and tectonic model. We distinguish the lower-grade Kreuzjoch Nappe consisting of rocks of the Gamsbeil Complex and the higher-grade Wildkogel Nappe consisting of the rocks of the Steinkogel Complex. The latter corresponds to the previously defined "Steinkogelschiefer-Komplex", with a wider extent revealed by new mapping. These two nappes are separated by a steep, sinistral, greenschist facies shear zone, which is associated with phyllonitization and retrogression of the Wildkogel Nappe. The contact between the Kreuzjoch Nappe and the Höllengebirge-Staufen Nappe is an Eoalpine top-to-the-WNW thrust. Evidence for both Variscan and relatively early Eoalpine metamorphism in the Wildkogel nappe suggests that this nappe is part of the Ötztal-Bundschuh or Drauzug-Gurktal Nappe System. In absence of significant deformation between the "Western Greywacke Zone" and Kreuzjoch Nappe in the Windau valley, we infer that the Kreuzjoch Nappe is part of the Tirolic-Noric Nappe System, together with the Höllengebirge-Staufen Nappe. This new lithostratigraphic and tectonic model will be tested with field, geochronological, petrological and structural studies, further to the West in the IQZ.

Textband "Isotopenzusammensetzung in natürlichen Wässern in Österreich – Grundlagen und Anwendungsbeispiele zur Wasser-Isotopenkarte Österreichs 1:500.000"

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Isotopendaten des Wassers (Wasserstoff und Sauerstoff) werden in der Hydro(geo)logie insbesondere für die wasserwirtschaftliche Planung, Bestimmung der mittleren Verweilzeit von Grundwässern („Grundwasseralter"), Klimaforschung, Umweltüberwachung und -forensik oder die Bestimmung von Lebensmittelauthentizität verwendet.

In Österreich werden bereits seit Beginn der 1960er Jahre Isotopenmessungen im Niederschlag vorgenommen. Ein weiterer Entwicklungsschritt des bundesweiten Messnetzes war die Erweiterung der Untersuchungen auf die Oberflächengewässer, wie Flüsse und Seen, da Isotopendaten von Oberflächengewässern sowohl Hinweise auf die Isotopenverhältnisse im Niederschlag als auch über die Wasseralter im Einzugsgebiet geben können. So wurde mit Tritium-Untersuchungen an der Donau bereits Mitte der 1960er Jahre begonnen und man kann damit weltweit auf eine der längsten Zeitreihen für Isotope an sehr großen Flüssen zurückgreifen. Mitte der 1970er Jahre wurde z. B. auch der Bodensee und Neusiedler See sowie zusätzliche Fluss- und Seenmessstellen in das Programm aufgenommen.

Das Isotopen-Messnetz wird unter der Bezeichnung „Österreichisches Messnetz für Isotope im Niederschlag und in Oberflächengewässern (Austrian Network of Isotopes in Precipitation and Surface Water = ANIP)" geführt. Die im Rahmen von ANIP erhobenen Daten sowie eine Fülle von Projektdaten verschiedener Institutionen aus einem rund 45 Jahre fassenden Zeitraum für die Wasserstoffisotope Deuterium und Tritium sowie das Sauerstoffisotop Sauerstoff-18 wurden im Jahr 2015 in der „Wasser-Isotopenkarte Österreichs 1:500.000" zusammengefasst, strukturiert aufbereitet und öffentlich zugänglich gemacht.

Ergänzt wird diese Karte nunmehr durch den umfangreichen Textband „**Isotopenzusammensetzung in natürlichen Wässern in Österreich: Grundlagen und Anwendungsbeispiele zur Wasser-Isotopenkarte Österreichs 1:500.000**", der die vorliegenden Ergebnisse auch weit über den Fachkreis hinaus verständlich präsentieren möchte. Dazu werden in den ersten Kapiteln die Isotopenverhältnisse in natürlichen Wässern in ihren Grundzügen dargestellt, um zu erläutern, an welcher Stelle isotopenhydrologische Methoden ansetzen. Für die einzelnen Abschnitte des Wasserkreislaufes – Niederschlag, Oberflächenwässer und Grundwasser – werden generelle Interpretationsmöglichkeiten der Isotopendaten hinsichtlich hydro(geo)logischer Fragestellungen vorgestellt. Konkrete Anwendungsbeispiele ergänzen die vorliegenden Ausführungen. Darüber hinaus wird auf Wechselwirkungen – beispielsweise zwischen Seen und Grundwasser – sowie auf den Nachweis anthropogener Einflüsse im Grundwasser eingegangen.

Mit dem Wissen rund um die Isotopenzusammensetzung der bundesweiten Gewässer in den unterschiedlichen Gesteinsformationen und Klimaregionen, von den Alpen bis in die Tiefebenen, sind letztlich auch wichtige Schlussfolgerungen für eine nachhaltige, dem Klimawandel angepasste Bewirtschaftung von Wasserressourcen möglich.

Die Arbeiten wurden vom Umweltbundesamt im Auftrag des BMNT in Zusammenarbeit mit namhaften österreichischen Expertinnen und Experten – sowohl aus dem angewandten als auch wissenschaftlichen Bereich der Isotopenhydrologie – durchgeführt.

Die Karte (mit elektronisch abrufbaren Daten) mit einer kurzen Erläuterung sowie der Textband sind über die Homepages des BMNT und des Umweltbundesamtes verfügbar.

Tectonometamorphic evolution of the uppermost Upper Austroalpine: Insights from a section across the Gstoder, Bundschuh, Königstuhl, and Stolzalpe Nappes (Gurktal Alps, Austria)

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The Upper Austroalpine (UAA) Unit in the Eastern Alps is a stack of nappes formed during the Cretaceous ("Eoalpine" event), subdivided into nappe systems (NS). While rocks in the central, higher-grade nappes of the Koralpe-Wölz NS are well studied, large parts of the overlying, lower-grade NSs are poorly characterized. We present the results of a mapping project of the Austrian Geological Survey located in the Gurktal Alps. It is a key area for understanding the evolution of the UAA, exposing a continuous section through the upper part of the nappe stack. We here present results and interpretations of Raman spectroscopy on carbonaceous material (RSCM) and zircon (Zrn) U-Pb, garnet (Grt) Sm-Nd, muscovite (Ms) Ar-Ar, biotite (Bt) Rb-Sr, Zrn (U-Th)/-He geochronology as well observations and crosscutting relationships of structures, mineral assemblages, and metamorphic reactions.

From footwall to hangingwall, metasediments in the Gstoder nappe (GN; Koralpe-Wölz NS) are followed by metasediments, M-Ordovician orthogneisses, overlain by Permo-Mesozoic metasedimentary rocks in the Bundschuh nappe (BN; Ötztal-Bundschuh NS). Separated by a jump in metamorphic grade the section continues with metavolcanic rocks and U-Pennsylvanian metasediments in the Königstuhl nappe (KN). This unit is tectonically overlain by metasediments with L-M-Ordovician metaignimbrites, metapyroclastics and U-Ordovician metavolcanics, also covered by U-Pennsylvanian sediments in the Stolzalpe nappe (STN). The latter two nappes belong to the Drauzug-Gurktal NS.

(pre-)Variscan structures are overprinted by a large-scale, isoclinal fold pattern (D1) with NW/SW-SE/NE trending fold axes, superimposed by ENE-verging asymmetric open folds (D2), discordantly covered by post-Variscan sediments in the STN and BN. While garnets-staurolite assemblages in the BN point to amphibolite-facies conditions, the STN reached greenschist-facies conditions, as shown by RSCM. Ar-Ar geochronology demonstrates late Variscan cooling at ~314 Ma in the STN and 156 to 140 Ma mixed ages for the BN, interpreted as incomplete resetting of Variscan ages in the Cretaceous.

Eoalpine tectonics is responsible for the dominant imprint. Isoclinal folds formed coevally with top-to-W/NW thrusts in the BN, KN, and STN and are interpreted as the record of early Eoalpine nappe stacking (D3a). Amphibolite-facies peak conditions in the GN are dated at ~100 Ma by Grt Sm-Nd ages and gives an upper age limit for this event. Open folds in the deepest nappe (GN), isoclinal folds and ductile to brittle normal faults within the overlying nappes (BN, KN, STN) represent late Eoalpine structures during exhumation (D3b). The formation of a large detachment with top-to-E/SE kinematics between the BN and KN is linked to this event. Ms Ar-Ar deformation ages in the BN cover are at ~ 90 Ma and post-dated by Bt Rb-Sr ages at ~85 Ma, indicating rapid cooling through ~300°C. These give a lower limit for the onset of Eoalpine exhumation and normal faulting. Bt Rb-Sr cooling ages in the GN at ~75 Ma are coeval with Zrn (U-Th)/-He ages in rocks of the KN and STN. This indicates that they had already an upper crustal position, while the GN was still exhuming and sets an upper limit for the termination of the Eoalpine exhumation.

Waldmodul für THROW – Berücksichtigung des Einflusses von Vegetation bei 2D-Steinschlagmodellen

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Bisherige Erfahrungen haben gezeigt, dass das Vorhandensein von Vegetation eine signifikante Barrierewirkung auf den Prozess Steinschlag darstellt. Ein Baumanprall reduziert im Allgemeinen die Energie eines herabfallenden Blocks und kann sogar zum kompletten Stillstand eines Blocks führen.

2D-Modelle zur Simulation von Steinschlag sind noch immer von Bedeutung, da die Koordinaten eines 2D-Bemessungsschnitts rel. einfach von Hand vermessen oder aus grob-auflösenden Geländedaten bezogen werden können, wodurch flächige Rasterdaten eines Digitalen Höhenmodells in hoher Auflösung nicht zwingend erforderlich sind. Darüber hinaus werden 2D-Modelle aufgrund ihrer Einfachheit und Zuverlässigkeit bei der Dimensionierung von sekundären Schutzmaßnahmen (Netze und Dämme) eingesetzt.

Bisherige Ansätze bei 2D-Modellen bilden den Effekt von Vegetation stark vereinfacht mit Hilfe von linearen Bremskoeffizienten („drag coefficient“) oder unter Annahme von teilplastischen Stößen ab. Einige Modelle geben der Blockgeometrie große Bedeutung.

Ziel der Entwicklung des Waldmoduls für THROW (Preh, 2015) war und ist es, jene signifikanten Effekte, die bisher nur in 3D abgebildet werden können, auch in 2D möglichst realitätsnah abbilden zu können. Mit Hilfe der Stochastik können die vielen Möglichkeiten der unterschiedlichen Pfade, die ein Block auf seinem Weg hinab nehmen bzw. die Hindernisse, auf die er treffen kann, entlang eines 2D-Schnittes abgebildet werden. Kein Block nimmt in der Natur zwei Mal den gleichen Pfad. So werden die Vorteile von 2D- und 3D-Modellen im THROW-Programm kombiniert.

Die Entwicklung und Implementierung eines stochastischen „Waldmoduls“ in das Steinschlag-Simulations-Modell THROW ermöglicht es, den Effekt von Wald möglichst naturgetreu zu berücksichtigen. Mit Hilfe der stochastischen Variation von Baumpositionen und Baumanprallstellen am Stamm werden für jeden einzelnen Block unterschiedliche Pfade und Hindernisse entlang des 2D-Bemessungsschnittes abgebildet. Als Eingabeparameter sind die Baumdichte, der mittlere Brusthöhendurchmesser (BHD) der Bäume, die Baumarten sowie Anfang und Ende des Waldes erforderlich. Die Berechnung der Baumtreffer ist eine Funktion der Baumdichte, des mittleren BHD, des jeweiligen Blockdurchmessers und der Länge der bewaldeten Böschung.

Je nach Anprallstelle am Stamm wird die translatorische Energie durch einen zufällig ermittelten Energie-Reduktionsfaktor, abhängig von empirischen Daten aus Feldversuchen nach Dorren et al. (2005), abgemindert. Auch die Baumart, die Anprallhöhe sowie der Anprallwinkel beeinflussen die Energiedissipation und werden im THROW-Waldmodul implementiert.

Literatur:

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Provenance of Nankai Trough sediments: investigation via OH defect content of detrital quartz

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In this study, OH defect content of quartz is under investigation for its potential as a provenance tool. Defect formation in quartz is a function of temperature, pressure, and chemical environment under which the mineral is formed. OH defects can be quickly and easily quantified using IR spectroscopy, enabling us to trace this petrological signal through the sediment record, thereby inferring provenance. As quartz is very abundant in most clastic sediments and not subject to hydraulic sorting and alteration processes, our technique is a valuable addition to well established provenance methods.

The Nankai Trough subduction margin off the coast of southwestern Japan provides an ideal testing ground for our approach: The area shows a quite variable history of sedimentation from multiple source areas that have been thoroughly characterized by other techniques (e.g. Underwood & Pickering, 2018). This allows us to cross-reference our results with previous findings, generating a better understanding of the capabilities of our novel method.

Quartz grains from recent river sands show a general trend along Honshu and Shikoku, from very low, monotonous OH defect values (< 4 wt. ppm water) in the east to moderately high and very diverse values towards the west (up to 200 wt. ppm water). Most distinctively, samples from the Izu-Honshu collision zone are virtually OH defect-free. We suggest that this reflects exhumation and consequent erosion of rocks from relatively low crustal levels following collision of the Izu- and Honshu arcs. This hypothesis is supported by data on regional exhumation rates (Clift et al., 2013).

In trench sediments offshore Honshu, we observe a shift from relatively variable OH defect contents, resembling recent central Honshu river sands, to distributions dominated by low values, similar to sediment from the Izu-Honshu collision zone. This is in accordance with a shift from margin perpendicular to trench-axis parallel sediment transport in the Pleistocene: uplift and increased erosion of the Izu-Honshu collision zone increase sediment transport parallel to the trench axis, while activity of the megasplay fault system traps sediment transported across the accretionary prism in the forearc basins. Previous studies on sand petrography also show this distinct shift in sediment routing (e.g. Fergusson, 2005). We take this as a confirmation that OH defect content is indeed a legitimate tool for provenance analysis in tectonically active settings.

Landesgeologie Wien: Beispiele aus Modellierung, Datierung, Archivierung

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Die Landesgeologie Wien ist, anders als die universitäre Forschung, auf geologische Beratung innerhalb städtischer Bauvorhaben fokussiert. Auch in diesem angewandten Schwerpunkt liegen jedoch Möglichkeiten für Auswertung und Interpretation zur Schaffung von Grundlagenwissen. Die Landesgeologie Wien bewegt sich zum größten Teil in verbautem Gebiet (blickt durch Asphalt und Beton), sie berät für städtische Bauvorhaben (Kindergarten bis U-Bahn), ihre Aufschlüsse sind Bohrungen, Baugruben und Tunnel (1 bis 100 Meter tief, lang und breit), sie beprobt für Bodenmechanik und Geotechnik und archiviert für die Ewigkeit.

Drei Schwerpunkte werden vorgestellt:

Geologische 3D-Modellierung wurde in verschiedenen geologischen Environments eingesetzt: in Favoriten in einer Schichtabfolge von den ältesten pleistozänen Donauterrassen bis ins Pannon, zwischen Hernals und Wienerberg in allen Terrassen bis ins Sarmat, sowie in der Innenstadt quer über den Donaukanal zur Donau durch die jüngeren Terrassen bis in die rezenten Ablagerungen. Dabei wurden ca. 3.500 Bohrungen aus dem Baugrundkataster ausgewertet, die darin einzeln ausgewiesenen Gesteinsschichten der Profile zu lithostratigrafischen Einheiten zusammengefasst und so die Schichtkontakte definiert. Diese wurden mit geologischen Karten, dem Geländemodell und vorhandenen stratigrafischen Daten in Zusammenhang gebracht und unter Einsatz des Programms „Leapfrog“ (Firma Seequent) als 3D-Volumenkörpern modelliert. Die Resultate und deren Einsatzmöglichkeiten für die Landesgeologie Wien werden vorgestellt.

IRSL-Datierungen aus der pleistozänen Bedeckung und den Terrassenschottern wurden erstmalig an Proben aus der Wiener Innenstadt ausgeführt. Es wurden Feldspat-Alter sowie einzelne zum Vergleich gemessene Quarz-Alter zwischen 64 und 233 ka ermittelt (pIR-OSL, OSL und pIRIR-290 Alter). Eine erste Diskussion dieser Ergebnisse erfolgt im Zusammenhang mit den bekannten Einstufungen der Wiener Terrassen aus der älteren Literatur sowie aus publizierten aktuellen Daten aus dem nördlichen Wiener Becken.

Der Baugrundkataster Wien ist das größte Archiv von Bohrprofilen Österreichs. Derzeit beherbergt er ca. 62.000 Profile zwischen 0,2 und 650 Metern Tiefe. Er wurde 1946 gegründet und wächst jährlich um ca. 800 Aufschlüsse (Bohrungen, Schächte, Schürfe, Fundamentaufnahmen, Rammsondierungen, ...) an. Die ältesten Profile gehen weit ins 19. Jhdt. zurück, die jüngsten stammen aus den aktuellen Bohrkampagnen. Die Profile sind eine wesentliche Grundlage für die Beratungstätigkeit der Landesgeologie und der Geotechnik für die Bauvorhaben der Stadt Wien. Der Baugrundkataster ist online zugänglich und wird auch von Privatunternehmen intensiv genützt.

"GeoTief Wien" Seismische Exploration für tiefe Geothermie – Ergebnisse einer neuen 2D-Seismik

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Im Rahmen des von der FFG geförderten Projekts GeoTief BASE wurden, mit dem Ziel der Nutzbarmachung der Tiefen Geothermie im Wiener Becken, zusätzlich zu bestehenden Geodaten neue seismische 2D-Daten mittels innovativer geophysikalischer Verfahren im Wiener Becken akquiriert. Neue Erkenntnisse über die komplexe Geometrie der potentiellen Geothermie Reservoire im Großraum Wien sollen gewonnen und ein etwaiges Risiko induzierter Seismizität bei der Nutzbarmachung dieser Energieform abgeschätzt werden.

Die neogenen Sedimente der Beckenfüllung des Wiener Beckens erreichen in diesem Gebiet eine Mächtigkeit von bis zu 4000 m. Direkt unter den neogenen Sedimenten liegen Gesteinseinheiten der Ostalpen (Flyschzone, Kalkalpin, Grauwackenzone und Zentralalpin) von komplexer Struktur und Tektonik. Die hydrothermalen Reservoire liegen dabei in Tiefenbereichen zwischen 3500 m und 6000 m im Kalkalpin, das aufgrund seiner petrophysikalischen Eigenschaften (primäre Porosität und sprödes Verhalten bei tektonischer Beanspruchung) gute Durchlässigkeiten ausbilden kann.

Im Zeitraum Februar-März 2017 wurden reflexionsseismische Daten von zwei sich rechtwinklig kreuzenden und jeweils ca. 12 km langen Linien mit Vibratoren als Energiequelle akquiriert. Anstatt Geophonbündeln in gewöhnlich großen Abständen wurden digitale Akzelerometer (MEMS) in dichten Abständen (10 m) als Einzelsensoren eingesetzt. Mit ebenfalls dichten Vibratorpunktabständen (10m/20m) ergibt sich eine deutlich erhöhte vertikale und horizontale Strukturauflösung. Die Sensoren wurden als 3-Komponenten-Empfänger ausgeführt, so dass es die zusätzliche Auswertung der Scherwellen ermöglicht. Wir berichten über die Ergebnisse des reflexionsseismischen Processings der
P- und S-Wellen. Diese Messungen stellen einen ersten Schritt zu einer umfangreicheren Exploration mittels 3D-Seismik dar, die für das 4. Quartal 2018 geplant ist.

Sieve curve analysis to estimate K in fine grained mass movement and moraine material – a critical review

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Grain size analysis is commonly used to estimate hydraulic conductivity of unconsolidated debris or sediments when hydraulic tests are not available. However, this approach is bound on some crucial assumptions and is representative for a very limited scale. Properties of rock mass deposits precluding most grain size approaches comprise (1) wide range of grain sizes, especially high fines content (2) irregular grain shapes promoting large grain contact areas (3) strong scale dependency of grain properties (4) considerable volume of voids non-participating in the flow process (5) significant scale dependency of rock mass deposit properties beyond the sample scale. These properties violate the underlying assumptions of purely empirical formulae such as Hazen, Beyer, Seelheim, USBR, Kaubisch and Fischer, Alyamani and Şen, Krumbein and Monk, Boadu. Hydraulic characterization of mass movement debris and moraine material with high fines content is challenging as their properties are inappropriate for most of the empirical and semi-empirical formulae. As such the applicability of estimating K of existing common formulae was tested on mass movement debris and moraine material with high fines content taken from drillings near Freibach, Carinthia. The empirical methods and the below mentioned semi-empirical approaches were applied within this study to quantify and demonstrate the error by the application of a wrong method. Investigation of the theoretical background of widely used semi-empirical formulae (Slichter-Terzaghi, Kozeny-Carman) reveals that assumptions accepted to derive these formulae are violated by the same class of deposits. The greatest impact on the resulting uncertainty stems from the difficulty to assess geometrical properties of the rock mass deposit, as porosity and specific surface, in a reasonable way. As a result, obtained values of hydraulic conductivity scatter over several orders of magnitude depending on the chosen method. Besides the difficulty to derive appropriate formulae for these conditions, their calibration and verification are especially difficult in these cases. These difficulties arise from the susceptibility of respective samples to internal erosion, thereby complicating the evaluation of permeameter tests. The study results illustrate the strong dependency of computed values on the choice of method and estimation of parameters, rather than on properties of the aquifer.

Leakage detection in an industrial water pipe network using induced polarization imaging

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The integrity of water pipe networks in large industrial sites is critical to sustain an efficient mode of operation. Common approaches used to detect leakage are based on direct analysis, which are commonly time consuming and may require excavations, i.e. are largely invasive. In this context, non-invasive geophysical methods appear as suitable and cost-effective tools to evaluate the integrity of water pipes and detect leakages. In particular, here we propose the application of the time-domain induced polarization (TDIP) imaging method, a technique highly sensitive to the presence of metallic materials, as well as to changes in the subsurface water content. To evaluate the applicability of the method, we present here imaging results for data collected along thirteen transects collected within an industrial site in Austria, targeting at the detection of possible leakages in a water pipe network. Such pipe is coated by a plastic-based insulator to prevent corrosion of the metal. Hence, the failure of the insulator leads to corrosion and damage to the pipe and the leakage. Moreover, the lack of an insulator coating the pipe causes an increase in the IP effect due to the contact of the metal and soil. Measurements were performed using 1 m electrode spacing and a dipole-dipole electrode configuration to image the near subsurface with high resolution. The measurement conditions were particularly challenging as, considering the industrial context, most investigated areas were covered by a concrete overlay. Hence, installation of the electrodes was done within holes drilled into the concrete to properly put in contact the electrodes with soil materials, and to ensure acceptable contact resistances, as required to deliver high current injections and enhance the signal-to-noise ratio. Nevertheless, data quality was affected by major differences in the contact resistances and thus, the currents injected, as well as by the presence of anthropogenic structures associated to cultural noise. Therefore, we performed an extensive analysis of the data prior to inversion, aiming at obtaining imaging results not affected by systematic errors. Imaging results presented here indicate a close correlation of the electrical properties with the location of confirmed leakages and the Ground Penetrating Radar measurements, thus demonstrating the potential of the method.

Shallow-water Cretaceous-Paleocene transition associated with a rocky low-energy shore: The Kambühel section (Northern Calcareous Alps)

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In shallow-water limestones, stratigraphically fairly complete K-Pg boundaries are rare. At Kambühel, Northern Calcareous Alps (NCA) of Austria, a K-Pg boundary (KPB) is exposed that comprises a hiatus from the upper part of planktonic foraminiferal zone CF3 (*P. hariaensis*) zone of the uppermost Maastrichtian to within planktonic foraminiferal zone P1a (P1a(1) pro parte) of the lower Danian. Age-dating of the section rests on planktic foraminiferal assemblages.

The Maastrichtian limestones are bio-lithoclastic packstones rich in larger benthic foraminifera (e.g., Orbitoides, Lepidorbitoides, Siderolites); these limestones accumulated in a neritic environment. Near their top, the limestones are rich in microkarstic cavities and patches and dykes of diagenetic grainstone.

The KPB is a hardground of complicated relief with anamplitude up to a few decimeters. The hardground is riddled by marine borings and potential root casts. Along the hardground, delicate projecting 'ridges' and 'blades' of limestone between deeper erosional pits were preserved. The top surface is encrusted by benthic foraminifera and serpulids. The hardground started as a subaerial exposure surface that probably was covered by vegetated soil. Upon earliest Danian transgression, the soil was stripped, and the hardground was further shaped by boring and encrustation. The preservation of the complicated hardground relief records a low-energy rocky shore. The hiatus across the K-Pg hardground is bracketed to ~700 ka, similar to hiatuses in many deep-water successions.

The lower Danian limestones, in turn, are poorly-sorted litho-bioclastic grainstones to rudstones with shelter and keystone pores, respectively. Many bioclasts are rounded and strongly abraded, microbored and/or encrusted by red algae and sessile foraminifera. Similar features are displayed by lithoclasts derived from the underlying Maastrichtian limestones and from older rocks. The grainstones–rudstones record early vadose diagenesis (meniscus and pendant cements, interstitial micro-hardgrounds, interstitial geopetals of micropeloids) or, more commonly, of cementation in form of fringes of fibrous cements. Limestones of these characteristics comprise a package ~ 8 m in thickness that hosts abundant shells of rhynchonellid brachiopods. The Danian limestones above the KPB represent beachrocks and, less commonly, cayrocks. A hard-substrate shore zone with shady overhangs is underscored by the abundant rhynchonellids. Within the Danian succession, another hardground has been identified approximately 6.5 m above the K-P boundary. Based on planktic foraminiferal assemblages, the hiatus across the intra-Danian hardground is estimated at 1.5 Ma. The upper part of the Kambühel succession consists of ?Selandian-Thanetian grain- and packstones and, at the top, of an upper Thanetian interval a few meters thick of float- to rudstones rich in colonial corals, red algae (corallines, Parachaetetes), dasycladaleans, and milioline foraminifera.

Geochronological pitfalls in petrochronologal research – the case of instrumental elemental fractionation effects

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Petrochronological investigations have developed into a back-bone of hard-rock geology by routinely combining geochronology (mostly age data from in-situ U-Th-Pb dating) and petrology thus allowing to gain deeper insights into the P-T-t evolution of metamorphic and magmatic rocks.

An underlying assumption is that both the geochronological and the petrological data used to establish the P-T-t models are both accurate and precise. But the in-situ dating community has for a long time known that instrumental elemental fractionation effects (IEF), often called „matrix effects“, can be detrimental to the achievable overall accuracy, and to some extent also the precision of in-situ ages. Uncorrected IEF can cause age shifts of several %, as has been shown for zircon, monazite, xenotime, rutile.

IEF have three different sources: a) variable crystal chemical composition; b) crystallographic orientation of the analysed mineral; c) experimental setup.

Ad a) Corrections schemes have been proposed which claim that the procedures successfully correct for IEF. Corrections schemes are mostly one-dimensional. For example are Th or U concentrations of monazite used to correct the IEF of SIMS dating; Y and REEs concentrations can be used to correct the IEF of xenotime SIMS and LA analyses. But it has been demonstrated that these one-dimensional corrections are not sufficient to effectively correct IEF. Multi-dimensional corrections schemes are recommended to allow for properly correcting the IEF for any given mineral composition. Such multi-dimensional IEF effects are widespread. This means, that age data gained on minerals showing a large variability in composition are prone to exhibit IEF and thus are not properly corrector for by using published one-dimensional IEF correction schemes. But it is exactly the correlation of changing mineral composition with changes in P-T conditions which is used for petrochronological investigations. This means that the observed correlation of mineral ages and P-T conditions can be spurious and so geologically misleading. Observed age differences can at last in parts be analytical (from IEF) and do not necessarily reflect i.e. protracted mineral growth on a certain part of a P-T evolution. It is thus proposed that petrochronological age data be thoroughly tested for IEF and that multi-dimensional corrections scheme are i) established and ii) routinely used.

Ad b) Crystallographic orientation has shown to be of importance for SIMS analysis of baddeleyite and cassiterite leading to age deviations of several percent. Published data seems to indicate that no analytically resolvable orientation effects are present for zircon and monazite. For LA analysis no orientation effects have been reported yet. For petrochronological data to become geologically more significant orientation effects have to be investigated systematically. This is especially true for in-situ analyses in thin sections or polished rock slabs. Mineral grains embedded in epoxy resin disks show a non random crystallographic orientation (i.e. zircons are embedded parallel the c-axis) thus minimizing orientation effects of IEF. In contrast to this minerals in situ show a ± random orientation thus making orientation effects on IEF more critical.

Ad c) The influence of different instrumental setups on IEF can nowadays be properly corrected for. It is thus proposed that these IEF are of minor importance when compared to the other two sources of IEF.

Pb nano-spheres in seismically deformed zircon from the Ivrea-Verbano Zone

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Zircon, the most common U-Pb geochronometer, may exhibit a great complexity of it internal structures, including growth zoning, lattice distortion and inhomogeneous distribution of trace elements and radiogenic isotopes on micro- and nano-scales. Zircon grains from the granulitic metapelites of the Ivrea-Verbano Zone in the Southern Alps are hosted by (ultra)mylonites and are associated with seismically-produced pseudotachylitic veins. In these tectonic settings, zircon grains were subject to crystal-plastic and brittle deformation regimes. The goal of our study was to investigate possible inhomogeneities of trace elements distribution at different scales, and, if present, to evaluate their effects on measured isotopic ages.

To reveal the zircon U-Pb age, zircon was studied by sensitive high-resolution ion microprobe (SHRIMP). To characterize deformation patterns in zircon we employed electron backscatter diffraction (EBSD) mapping. To study the effect on trace elements distribution in the selected deformed grains we used secondary ion mass spectroscopy (NanoSIMS), and to decipher nano-textural features – transmitted electron microscopy (TEM).

The U-Pb age of analysed zircon is 280 Ma with inherited cores yielding 574 Ma. The age of 280 Ma indicates the time of peak granulite metamorphic conditions in the unit.

EBSD mapping indicated planar deformation bands (PDBs) and other crystal-plastic deformation patterns, such as chess-board patterns, bending of the lattice, marginal grain size reduction; as well as planar, curviplanar and non-planar fractures. NanoSIMS mapping documented clusters of radiogenic Pb associated with the PDBs with higher degree of misorientation. PDBs also facilitate diffusion of Y, Yb, Ce and P in the affected grains.

The TEM study revealed arrays of straight dislocations in glide configuration, indicating crystal-plastic deformation without annealing. Crystalline Pb nanospheres of 5-7 nanometer diameter, not associated with the dislocations, were also documented with TEM. Nanospheres usually contain other elements such as Si, Al, Na and Ca. In contrast to Pb spheres documented in UHT Enderby Land (Antarctica) and Kerala Khondolite Belt (India), which are built of metallic Pb, the spheres in Ivrea-Verbano Zone are composed of Pb oxide. Oxidation might be caused by the presence of fluid, as the nanospheres are frequently associated with porosity, which, in turn, could be a product of fluid-induced dissolution-reprecipitation.

This is the youngest documented population of zircon with Pb spheres in deformed crystal lattice. Our observations shed a new light on the Pb behaviour in zircon, and, following this discovery, the existing model of nanosphere formation mechanism should be revised. We did not find any noticeable effect of Pb nanospheres on measured U-Pb ages.

Petrogenesis of Triassic and Cretaceous metamorphic rocks from Khanom (Peninsular Thailand); monazite CHIME dating and thermo-barometry

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Thailand is built-up by two major terranes which both have their origins in Gondwana; Sibumasu in the west and Indochina in the east. In between the so called Inthanon Zone and the Sukhothai arc belt are situated. Whereas such a terrane model was established in the northern part of the country and is widely accepted, the terrane arrangement and derivation in the south is still a matter of debate. Thus further petrochronological work is currently conducted in Peninsular Thailand.

One candidate for further work is the Khanom complex, a polymetamorphic crustal unit located in Peninsular Thailand SE of Surat Thani. It was first described by Kosuwan (1996) and consists of high-grade gneisses, schists, calcsilicates, marbles and is crosscut by post-orogenic granites. The complex is examined to bring more clearness whether these rocks have a similar evolutionary history to the high-grade metamorphic rocks in the north of the country or not.

Petrological investigations combined with geochronological studies were carried out on two gneisses (Haad Nai Phlao Gneiss and Laem Thong Yang Gneiss), to further understand the metamorphic and the timing and tectonic evolution of Peninsular Thailand.

These gneisses are typically granitic in composition and thus mainly consist out of feldspar, quartz and two micas. Whereas the Laem Thong Yang Gneiss is coarse-grained and has big feldspar augen, the Haad Nai Phlao gneiss is fine to coarse-grained with interlayers of calcsilicate and fine-grained amphibole bearing gneiss. Garnet and aluminosilicates which were formerly described could not be found.

Al-in-hornblende barometry (Schmidt, 1992; Anderson, 1996) coupled with monazite-xenotime thermometer yield peak pressure estimates around 0.61 ± 0.03 GP) and a wide temperature range of 624 ± 91 °C.

Furthermore, in-situ chemical Th–U–total Pb isochron method (CHIME) monazite dating was applied: two different events could be determined one at 216 ± 19 Ma and the other at 87 ± 7 Ma).

The relationship between spodumene pegmatites, pegmatites and leucogranites from the Austroalpine Unit (Eastern Alps)

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Thousands of Permian pegmatites are distributed over more than 400 km in the Austroalpine Unit (Eastern Alps). They formed during the Permian event characterized by lithospheric extension, causing crustal basaltic underplating, high temperature-low pressure metamorphism (HT-LP) and intense magmatic activity within the crust. Highly fractionated spodumene ($LiAlSi_2O_6$) pegmatites occur in spatial association with less fractionated leucogranites and simple pegmatites. Based on a combination of mapping, analysis of field relationships, major and trace element analysis of whole rock and single phases as well as geochronology, we suggest that the pegmatites formed by anatexis of their metapelitic country rocks. This is consistent with the virtual absence of huge co-genetic fertile granites.

Mapping indicates that units of migmatitic mica schists with densely interlayered simple pegmatites represent areas with aborted melt generation, whereas relatively small, inhomogeneous leucogranitic bodies with aplitic to pegmatitic textures represent zones of melt accumulation. Areas with spodumene-bearing pegmatites and other highly fractionated pegmatites represent structurally higher levels. The magmatic assemblage of simple pegmatites and leucogranites consists of Kfs+Qz+Pl+Ms+Grt+Trm. Accessory minerals such as beryl or Nb-Ta phases are very rare. Sm/Nd garnet ages on simple pegmatites, leucogranites and spodumene pegmatites yield ranges 247-288 Ma, 263-268 Ma and 259-287 Ma, respectively.

Magmatic muscovites from more than 500 samples of simple pegmatites, leucogranites and spodumene pegmatites as well as cm-sized single muscovite crystals from migmatic mica schist were measured with LA ICP-MS and plotted in classical classification diagrams. Muscovites from simple pegmatites and migmatitic mica schists mostly plot in fields of muscovite bearing and muscovite barren pegmatite classes. Muscovite from leucogranites plot together with those of highly evolved simple pegmatites in field of moderately evolved classes. Muscovite from spodumene pegmatites reach the fields of moderately to highly evolved pegmatites but never the one of the spodumene pegmatite class. All muscovite analyses plotted together indicate a common linear trend that is interpreted in terms of magmatic fractionation. Whole rock major element analyses indicate a peraluminous felsic composition for all three rock types. Whole rock trace element analyses are consistent with magmatic fractionation.

All in all migmatites, simple pegmatites, leucogranites and spodumene pegmatites are contemporaneous and cogenetic. Pegmatitic melts formed by anatexis during regional metamorphism in the Permian. Melt accumulation and fractionation via crystallization of simple pegmatites and leucogranites lead to the formation of spodumene pegmatites.

Geoarchaeological studies of a Middle-Neolithic circular enclosure near Velm, eastern Austria

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A geophysical survey done by ground penetrating radar (GPR) of a middle-Neolithic triple ditch circular enclosure (German: “Kreisgrabenanlage”) and its environs showed high reflections at 1.3 to 1.7-meter depth, which could not be explained by geophysical methods alone. These reflections especially occur at the locations of the posts belonging to the palisades of the enclosure as well as the adjacent buildings dating to the same period. Vibration core samples of post holes of the enclosure and of one building where retrieved to investigate the cause of the reflection. Additionally, three cores were taken from the ditches of the enclosure to evaluate the potential of further geoarchaeological work on such structure. The core samples from the post hole bottom show more cementation of the sediment at this depth, which can be attributed to the stronger reflection seen by GPR. The core samples from the ditches show typical ditch infillings at the lower 2 meters expected from a site situated in an alluvial environment, with slope wash in the form of gravelly sand or silt. At the third meter the substrate changes to layers of clayey, low-energy water-lain sediments with signs of lamination and organic inclusions. Samples for radiocarbon dating show an age for the organic inclusions around the 11th and 10th century BC, making those sediments about 6000 years older and thus highlighting that the ditches are not deeper than 2 m and also relatively shallow comapred to other circular enclosures. The occurence of water-lain sediments that date to the uppermost Pleistocene hints at a buried wetland under Holocene gravel sediments which will be the focus of further investigations.

Paleogene deep-water facies of the Upper Gosau Subgroup at Gams (Styria, Austria)

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The Gosau Group of Gams comprises deposits of Late Turonian to Ypresian age which rest unconformably upon Permian – Jurassic strata of Tirolian nappes (Northern Calcareous Alps, NCA). Outcrops of the Nierental Formation (Upper Campanian – Selandian) and the Zwieselalm Formation (Maastrichtian – Ypresian) were investigated along Gamsbach creek and some tributary creeks between Krautgraben and Gamsforst in the eastern Gams basin.

Detailed sedimentological studies within the Upper Gosau Subgroup above the K/Pg were made, including bed-by bed measurements of sections, heavy mineral-, microprobe- and thin section analysis. Biostratigraphic correlation of sections is based on calcareous nannoplankton and led to a composite section with four facies assemblages for the investigated area.

The Danian section of the Nierental Formation (NP1 – NP4) consists of hemipelagic to pelagic red and gray marls and marly limestones, intercalated with minor thin, normally graded, sandy and silty turbidite beds as well as slump beds and submarine debris flow deposits. Turbiditic sandstones are rich in carbonate and include redeposited material from NCA, bioclasts (foraminifera, corallinacea) are common. Debris flow deposits include also Paleocene limestones. Variable geometries (channel-fill, lenses) and textures (matrix- to clast-supported) of these mass transport complexes are present.

The basal part of the Zwieselalm Formation (NP5 – NP12) is indicated by the first thick (> 1 m) turbiditic sandstone bed. An interval (NP5 – NP9) of gray carbonate-rich sandy and silty turbidites (i. e. “classical turbidites”), gray marls and marly claystones changes into a carbonate-poor succession (NP9 – NP10) of sandy and silty turbidites and claystones. Turbiditic shales are dark gray, only a few centimeters thick and mostly devoid of carbonate. The Paleocene/Eocene-boundary interval is characterized by thin-bedded turbidites with russet to brown claystones, deposited below the calcite compensation depth (CCD). An interval (NP10 – NP11) of turbiditic sandstones with higher carbonate contents follows, intercalated with gray, reddish and greenish marls. Towards the top of the Zwieselalm Formation (NP12), the thickness of fine-grained sandstone beds decreases. Breccia layers at the base of turbidites and several slump beds are characteristics of the Zwieselalm Formation. Thicker sandstones show Bouma Ta-e sequences, more frequent thinner beds often only show Tcd sequences. Water escape structures, bioturbation and amalgamation of turbiditic sandstones are visible in all sections. Thinning- and fining-up cycles indicate small turbidite fan(s) prograding into a confined slope basin.

Heavy mineral- and thin section analysis suggest a mixed siliciclastic-carbonate source from the rising metamorphic hinterland, the NCA and small contemporaneous carbonate platform areas. Material derived from the south filled up a (partly) confined slope basin along the active margin of the Austroalpine microplate.

Multi-Isotopenmessungen ($^{18}O/^{2}H,^{3}H/^{3}He,^{13}C/^{14}C$) bestätigen aufsteigende Karstwässer an den Windener Quellen (Leithagebirge)

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Die Windener Quelle, der nahegelegene Heidebrunnen und der kürzlich neu errichtete Brunnen 2 samt begleitender Erkundungsbohrungen liegen am Nordosthang des Leithagebirges im Gemeindegebiet von Weiden am Neusiedlersee. Diese wurden vom Wasserleitungsverband Nördliches Burgenland gefasst, errichtet und für die Trinkwasserversorgung fortlaufend genutzt. Die Schüttung der Windener Quelle beträgt durchschnittlich etwa 13 L/S. Dem Heidebrunnen werden bei Bedarf etwa 10 L/s entnommen und Wässer des neuen Brunnen 2 sollen mit durchschnittlich ca. 10 L/s. Die Wässer sind im Chemismus alle sehr ähnlich, vom Typus erdalkalisch-sulfatisch, mit einer Leitfähigkeit von 700–1000 µS/cm und einer relativ hohen Temperatur von ca. 13° C. Tektonisch gesehen liegen diese im Bereich der Randbrüche des Leithagebirges. Während die Quelle und der Heidebrunnen im badenischen Leithakalk austreten, befindet sich der neu errichtete Brunnen 2 in einem tektonisch stark zerlegten triadischen Dolomit. Klüftiger Dolomit wurde bis zur Endteufe von 150 Meter erbohrt. Den Kern des Leithagebirges bilden variszische Glimmerschiefer und Paragneise. Die hier angewendeten Isotopenuntersuchungen ($\delta^{18}O$,^{2}H, $^{3}H/^{3}He$, ^{13}C und ^{14}C) an den drei Entnahmepunkten im Mai-Juni 2017 haben in Kombination mit den von der Geologischen Bundesanstalt an der EKB01 Winden erhobenen Isotopen- und Chemiedaten zu folgenden Schlussfolgerungen geführt:

Die frei ausfließenden und gepumpten Wassermengen sind eine Mischung von im Einzugsgebiet neugebildeten Grundwasser und an Störungen aufsteigenden sehr alten Tiefenwässern. Das ist zweifelsfrei durch hohe Helium-4 Edelgaskonzentrationen, den Radiokarbon (^{14}C)-Messungen und den bereits früher bekannten erhöhten Wassertemperaturen von 13-14°C belegt.

Je nach Abschätzung der Endgliederkonzentrationen wird von Mischungen zwischen 10 bis 50 % sehr alter aufsteigender Wässer ausgegangen.

Je nach dem Anteil der aus dem Niederschlag „neugebildeten“ Komponente ist die alte Komponente ungefähr 10.000-15.000 Jahre alt und durch seine langen Verweilzeiten in den unterlagernden Karbonatgesteinen durch einen erhöhten Sulfatgehalt charakterisiert. Das steht auch im Einklang mit niedrigen $\delta^{18}O$-Werten von -12 bis -11,5 ‰, was auf eine Infiltration während eines kühleren Klimas schließen lässt.

Die Abschätzung der Verweilzeit der „jüngeren tritiumhältigen“ Komponente ist ungemein schwieriger, da aus den Heliummessungen wegen der hohen ^{4}He-gehalte (Mantelhelium?) kein eindeutiges Alter berechnet werden kann, sodass die beste Schätzung im Bereich von 10–40 Jahren liegt. Diese könnte im Heidebrunnen noch jünger sein.

Die „junge“, neugebildete Komponente ist leider auch durch einen erhöhten Nitratgehalt charakterisiert, der entsprechend dem abgeschätzten Alter durch geringe Grundwasserneubildung wenig verdünnt wird und neben aktuellen Einträgen auch aus Düngung zurückliegender Jahrzehnte stammen kann.

Im Bereich Winden wird die Neubildung von Grundwässern aus Niederschlägen durch an Störungen aufsteigende Tiefenwässer gesteigert. Dies weist den Vorteil auf, dass einerseits durch menschliche Aktivitäten erhöhte Nitratgehalte und aus den Tiefenwässern angereicherte Sulfatgehalte gegenseitig abgemischt werden. Speziell durch die in Form von Mittel- bis Feinkies neogen umgelagerten Triasdolomite liegt bis in eine Tiefe von 24 Meter ein ausgezeichneter, durch aufsteigende Tiefengrundwässer angereicherter, Lockersediment-aquifer für eine Wassererschließung vor.

Nitrogen-isotopes and multi-para-meter sewage water test for identification of nitrate sources: Groundwater body Marchfeld E of Vienna

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The application of nitrogen and oxygen isotopes in nitrate allows, under favourable circumstances, to identify potential sources such as precipitation, chemical fertilisers and manure or sewage water. Without any additional tracers the source distinction of nitrate from manure or sewage water is still difficult (Kralik et al., 2008). Even the application of boron isotopes can in some cases not avoid ambiguous interpretation.

Therefore, the Environment Agency Austria developed a new multi parametrical indicator test to allow the identification and quantification of pollution by domestic sewage water. The test analyses 8 substances well known to occur in sewage water: Acesulfame and sucralose (two artificial, calorie-free sweeteners), benzotriazole and tolyltriazole (two industrial chemicals/corrosion inhibitors), metoprolol, sotalol, carbamazepine and the metabolite 10,11-Dihydro-10,11-dihydroxycarbamazepine (pharmaceuticals) (Humer et al., 2013). These substances are polar and degradation in the aquatic system by microbiological processes is not documented. These 8 Substances do not occur naturally which make them ideal tracers. The test can unveil 0.1 % of wastewater in the analysed water sample.

This ideal coupling of these analytic tests helps to identify the nitrogen sources in the groundwater body Marchfeld East of Vienna to a high confidence level. In addition, the results allow a reasonable quantification of nitrogen sources from different types of fertilizers as well as sewage water contributions close to villages and in wells recharged by bank filtration. Combined data indicate that the nitrogen input from mineral fertilizers increased from 2006 to 2013, but the contribution of sewage water to the Marchfeld groundwater is still present (Humer et al., 2015).

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Foraminifera as tool for biostratigraphic cross-correlation of major oilfields in the Vienna Basin

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The Miocene Vienna Basin is among Europe's largest onshore oil and gas fields. Due to the complex tectonic setting, however, an intra basin correlation of Miocene drillings within the Vienna Basin remained difficult.

This project aims at an updated biostratigraphic correlation of cores from four major oilfields (Rabensburg, Bad Pirawarth, Matzen and Aderklaa), which will be backed by north-south seismic cross-sections throughout the Vienna Basin

One of the main objectives is to obtain information about thickness and position of the supposed lower Miocene deposits and the stratigraphic content of middle Miocene deposits,that are varying considerably in thickness from well to well. The tectonic setting impedes with a straightforward correlation of single 3D seismic reflectors. To obtain a reliable correlation, biostratigraphic data have to be acquired.

Especially the interpretation and correlation of thickness and distribution of the various Miocene formations is challenging due to major canyon structures and other erosive features. These have been unknown from surface outcrops and, therefore, the existing lithostratigraphic schemes need a re-evaluation.

The main analyses are based on benthic and planktonic foraminifera to assign the deposits to regional biostratigraphic zones and to allow a correlation with international stages. In addition, palaeoecological data will be used to describe the palaeoenvironmental conditions and their changes through time.

Combined with core-log data, such as spontaneous potential, resistivity as well as modern 3D seismic data, information about palaeotopography and palaeogeography during deposition will be acquired. Furthermore, misinterpretations concerning the local stratigraphic setting should be resolved and a correct intra-basin correlation in respect to Ottnangian, Karpatian and Badenian units will be accomplished.

Therefore, the new biostratigraphic data and derived integrated stratigraphy will allow establishing of a modern lithostratigraphic scheme for all seismic units. As such, this integrated approach will provide a framework for a modern sequence stratigraphy of the Vienna Basin.

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The effect of the volume fraction of garnet on the deformation behaviour of eclogite

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Owing to the formation and presence of potentially large amounts of eclogite this metamorphic rock's deformation behaviour is of great importance for the rheology of the lithosphere in continental collision and subduction zones. The rheological behaviour of poly-mineralic rocks depends on the relative amount, the distribution and the strength of their components. We constrained the rheological behaviour and microstructural evolution of synthetic eclogite aggregates, composed of garnet and omphacite in varying fractions, by deformation experiments. Aggregates, synthesized in a piston cylinder apparatus to control the relative proportions of garnet and omphacite, were deformed in a modified Griggs apparatus at temperatures and pressures characteristic for in-situ conditions at plate boundaries. A series of aggregates containing volume fractions of 0, 25, 50, 75 and 100 % garnet were deformed at 1000 °C, 2.5 GPa and a strain rate of 3*10-6 s-1. The deformed two-phase aggregates are characterized by a distinct foliation defined by a strong shape preferred orientation of garnet and omphacite. In aggregates containing a volume fraction of 75 % garnet, strain is accommodated by a combination of crystal plastic deformation of garnet and omphacite as well as conjugate sets of cracks with respect to the maximum compressive stress direction. Misorientation deviation angle maps reveal intracrystalline misorientations up to 5° and 10° for garnet and omphacite respectively. Aggregates containing equal volume fractions of garnet and omphacite show similar intracrystalline misorientation of both phases but less cracking. Elongate omphacite crystals are aligned perpendicular to the shortening direction. In aggregates containing a volume fraction of 25 % garnet, omphacite forms interconnected weak layers presumably accommodating most of the strain. Low angle grain boundaries and recrystallized grains are common indicating the onset of dislocation climb and associated recovery mechanisms. Some large (40-70 µm) garnet crystals embedded in the omphacite matrix exhibit fine-grained tails perpendicular to the shortening direction. The tails are formed by small (<10 µm) neocrystallized grains nucleated from fragments of the initial garnet as indicated by chemical zoning observed in back scattered electron images. In contrast to two-phase aggregates mono-mineralic aggregates, do not show a distinct foliation, but large (40-70 µm) omphacite crystals are embedded in a fine-grained (<20 µm) matrix of equally-sized, polygonal omphacite grains indicating recrystallization. Garnetite exhibits mostly brittle deformation in the form of conjugate stets of microcracks with respect to the maximum compressive stress. The microstructures resulting from the deformation experiments show a switch from a load bearing framework (≥75 % volume fraction garnet) towards the development of interconnected weak omphacite layers (≤50 % volume fraction garnet) accompanied by a switch from overall brittle to crystal plastic dominated deformation behaviour.

Diskussionsvorschlag für ein differenziertes Begriffssystem lithotektonischer Einheiten

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Zur Beschreibung und Gliederung der Erdkruste und des lithosphärischen Mantels stehen eine Reihe von Klassifikationsschemata zur Verfügung. Dabei handelt es meist um monohierarchische Begriffssysteme (z.B. im Falle lithostragraphischer Einheiten) die vielfach bewährt und z.T. auch offiziell kodifiziert sind, beispielsweise seitens der IUGS (International Union of Geological Sciences).

Ein Defizit in dieser Hinsicht besteht in Bezug auf die Nomenklatur von Einheiten, die auf tektonischen Kriterien beruhen. An der Geologischen Bundesanstalt wurde auch für dieses Thema ein erster Ansatz für ein „kontrolliertes Vokabular“ entwickelt und im GBA-Online-Thesaurus zugänglich gemacht. Der gegenständliche Vorschlag soll dazu dienen, dieses Konzept weiter zu entwickeln und in Beziehung zu anderen Klassifikationsschemata zu setzten, die für die Beschreibung der Lithosphäre benötigt werden.

Die bereits von Neuendorf et al. (2005) definierte „Lithotektonische Einheit“ wird als ein gemeinsames Vorkommen von Gesteinen, basierend auf Struktur- oder Deformations-Charakteristika, wechselseitigen Relationen, Ursprung oder historischer Entwicklung beschrieben. Diese Einheiten können laut Definition magmatisch, sedimentär oder metamorph sein.

Es handelt sich dabei also um einen sehr weitläufig interpretierbaren Begriff. Zur Vermeidung von begrifflichen Widersprüchen erscheint es sinnvoll, unterhalb der Lithotektonischen Einheit folgende Differenzierung vorzunehmen: Für jene Typen von Einheiten, die primär anhand der Ausbildung ihrer Begrenzungsflächen (tektonisch, sedimentär, magmatisch-intrusiv und ggf. weitere Arten von Grenzflächen) beschrieben werden, wird der zusammenfassende Begriff „Tektogenetische Einheit“ eingeführt. Dies scheint berechtigt, weil beispielsweise auch die Genese einer Diskordanz an der Basis eines Sedimentbeckens oder der Intrusionskontakt eines Intrusivkörpers mit tektonischen Prozessen in Verbindung gebracht werden kann. Bei den „Tektogenetischen Einheiten“ wird daher, neben „Tektonischen Einheiten“ auch die Einführung von „Tectono-sedimentären“ und „Tectono-magmatsichen Einheiten“ vorgeschlagen.

Für den anderen Typus von Lithotektonischen Einheiten, nämlich jenen, deren Beschreibung sich auf die geotektonische Position (im Sinne des plattentektonischen Settings oder Environments) dieser Einheiten bezieht, wird die Bezeichnung „Plattentektonische Einheit“ vorgeschlagen.

Durch die Auftrennung des Konzepts „Lithotektonische Einheit“ in diese beiden unabhängigen Klassifikationsschemata wird es möglich, dass „Tektogenetische Einheiten“ (z.B. Decken) als Bestandteile von ganz unterschiedlichen „Plattentektonischen Einheiten“ (z.B. von Aktiven oder Passiven Orogenen, von Akkretionskeilen, etc.) betrachtet und für deren Beschreibung verwendet werden können.

Insbesondere auf gedruckten Geologischen Karten werden häufig unterschiedliche Typen von Einheiten miteinander kombiniert, was für die konzentrierte Darstellung der geologischen Verhältnisse in einer einzigen Informationsebene auch sinnvoll ist. Für die Verwaltung von geologischer Information in GIS-Datenbanken, ist es jedoch vorteilhaft, wenn die diversen Begriffssysteme und Informationsebenen strikt getrennt sind. Der gegenständliche Vorschlag soll daher insbesondere der Verwaltung geologischer Information in GIS-Datenbanken dienen.

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Hydrogen bonding in natrochalcite $NaCu_2(SO_4)_2(OH)\ 2H_2O$ under high pressure

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Natrochalcite and its isotypic compounds have hydrogen bond lengths, which are among the shortest for known inorganic crystals structures (Krickl & Wildner, 2007). Especially for natrochalcite at ambient pressure neutron diffraction experiments have shown a very short "double-well low-barrier" hydrogen bond between O_4 and O_4', connected by a symmetry element, as well as a short asymmetric hydrogen bond between O_4 and O_2 (Chevrier et al., 1993). Low-temperature or high-pressure behaviour of these extremely strong hydrogen bridges are not yet known. The change in pressure or temperature can lead to the formation of an even shorter "single-well no-barrier" hydrogen bond, which is known e.g. for $K_3H(SO_4)_2$ below 100 K (Perrin & Nielson, 1997). Furthermore, such a single-well no-barrier hydrogen bond was not characterized with Raman spectroscopy so far.

With the help of a diamond anvil cell and several crystals (around 40x40x60 μm^3 in size), natrochalcite was investigated by in-situ pressure increase using a Horiba Jobin Yvon LabRAM-HR 800 Raman spectrometer, a Bruker Tensor 27 FTIR spectrometer as well as a Stoe StadiVari single-crystal X-ray diffractometer with micro source and PILATUS detector. The investigated pressure range is within 0.0001-10 GPa and the spectral region is between 40 cm-1 (400 cm-1 for FTIR) and 4000 cm-1.

In contrast to first X-ray diffraction results, which suggest continuously shrinking O_4-O_4 and O_4-O_2 distances, two discontinuities possibly due to phase transitions can be seen around 2 and 6 GPa. This is visible in the lattice vibrations, the vibrational bands of Na-O/Cu-O polyhedra, in the sulfate stretching and bending vibrations, as well as in the hydrogen stretching vibrations, producing shorter and longer hydrogen bonds.

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Geologische Umweltbildung im Naturpark Zillertal

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Der Naturpark Zillertal bietet allen interessierten Schulen ein Programm an, das beim Schlegeisspeicher stattfindet. Die Schulklassen werden in einem Gasthof untergebracht und werden von ausgebildeten Naturparkführern betreut. Am ersten Tag stehen die archäologischen Funde am Pfitscher Joch, am zweiten Tag die Geologie des Tauernfensters im Vordergrund. Dafür habe ich in Absprache mit dem Naturpark ein interaktives Programm zusammengestellt, das die Entstehung des Tauernfensters und die Gesteine der Greiner Serie auf Volksschulniveau thematisiert. Ich berichte über das Programm an sich und die ersten Erfahrungen.

A bird's eye view of a 443 million year old ice sheet: using aerial imagery to characterise deep time glacial landscapes

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A series of spectacular soft-sediment grooved pavements are exposed at Pakhuis Pass in the Western Cape Province, South Africa. These features record the processes of soft-bed deformation beneath a Late Ordovician (ca. 443 Ma) ice sheet. Until now, detailed understanding of these features has progressed little since their original documentation by Rust (1967), other than being used as prima facie evidence for the passage of past ice masses over Gondwana. Using aerial imagery acquired using a DJI Mavic Pro Unmanned Aerial Vehicle (UAV), we document the heterogeneity of three selected pavements in the Northern and Western Cape Provinces. Developing digital elevation models from the data allows the recognition of glacial lineations in otherwise comparatively flat and featureless bedrock surfaces, and allows flow pathways to be mapped. At Pakhuis Pass (Late Ordovician). We map ridges and grooves of up to 50 cm amplitude, and demonstrate bifurcation of these at the decametre scale. Unusual transverse structures with a sinuous to curvilinear geometry are ubiquitous, and testify to processes of deformation orthogonal to the main ice flow direction. It is tentatively suggested that the assemblage of structures record the partial coupling of an ice sheet to its bed, and speculated that collectively the soft-sediment grooved pavements may record the passage of an ice stream over the Pakhuis Pass area.

What was the original paleogeographic position of the Rhenodanubian Flysch (Eastern Alps, Austria)?

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The Rhenodanubian Flysch is a complex of tectonic units continuously outcropping along the frontal part of the Eastern Alps. These units lay on the European Helvetic units, and are overthrusted by the Northern Calcareous Alps (Adria plate margin). The Rhenodanubian Flysch consists of a Cretaceous shaly “basal complex”, followed by Coniacian-Campanian and Maastrichtian-Ypresian formations, indicating that the basin was undeformed till lower Eocene time.

Even if the Rhenodanubian Flysch represents one of the most striking features of the Eastern Alps, due to intense deformation and poor outcrops, its original paleogeographic position is poorly constrained. As these units are closely associated to both ophiolite and Helvetic units, they are traditionally interpreted as originally located at the edge of the European basement.

If we zoom out from the Eastern Alps, Helminthoid Flysch with similar age and comparable facies assemblages are observed in the both Western Alps and Northern Apennines. In the Western Alps, the Parpaillon and San Remo units consist of shaly “basal complex” (upper Cretaceous) and by a Campanian-Maastrichtian Helminthoid Flysch, locally with the intercalation of sandstones. No tertiary sediments are observed. These units are completely detached from the substrate, and lay on the Brianconnais and Delphinois Units of the European margin.

In the Northern Apennines the Helminthoid Flysch Units are widely exposed, and are grouped into the External Ligurian Units. With the only exception of the Antola Unit, the External Ligurian Units are thrusted to NNE directly over the Adria Margin and are in turn overthrusted by the Internal Ligurian Units, consisting of ophiolites and sediments of the Ligurian Ocean.

Two kinds of “basal complexes” are observed in the External Ligurian Units. Some have blocks of various origin (ophiolites, granitoids, granulites, sedimentary rocks), indicative for a source area with a thinned continental crust. Other units display a basal complex with upper Cretaceous shales and thin turbidites. The Flysch is usually referred to the upper Campanian-Maastrichtian, with Tertiary siliciclastic turbidites (Paleocene or Lower Eocene).

Due to the characteristics of the “Basal Complex” and the tectonic position, the External Ligurian Units are located at the transition zone between Adriatic and Ligurian crust.

The similarities between the Helminthoid Flysch of the Alpine-Apennine System suggest to locate these units in the same paleogeographic region, that based on the presented data was located at the edge of the Ligurian Ocean, close to a thinned continental crust (either Adria or Europe, based on the interpretation).

The tectonic position of the units in both Eastern and Western Alps is compatible with both paleogeographic interpretations. More complex to explain is the position of the External Ligurian Units in the Northern Apennines, as they are squeezed between the remains of the Ligurian ocean and the Adria margin, suggesting that the original position of these units was close to Adria. With this interpretation, we can speculate that in the Eocene part of the Flysch Units experienced an Alpine deformation with thrusting towards Europe, whereas the rest of these units remained close to the original position and were subsequently included in the Apennine structures.

Erste systematische Fossilgrabung nach permischen Tetrapodenfährten in den Gailtaler Alpen (Kärnten, Österreich)

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Im Sommer 2017 wurde von Gerlinde Krawanja-Ortner, Leiterin des Geoparks Karnische Alpen, ein Ausgrabungsteam zusammengestellt, um in Rotsedimenten der permischen Laas-Formation im Gailtal bei Kötschach-Mauthen systematisch nach Fährten von frühen Wirbeltieren (Tetrapoden) zu suchen. Die Grabungsaktivitäten zielten auf einen natürlichen Aufschluss am Kötschacher Berg im mittleren Lammer Graben, in dem der wissenschaftliche Leiter der geologisch-paläontologischen Grabung, Dr. Sebastian Voigt (Urweltmuseum GEOSKOP, Deutschland), bereits im August 2013 fossile Saurierspuren gefunden hatte (Voigt & Marchetti, 2014).

Die erste und lange Zeit einzige Platte mit fossilen Saurierspuren aus der Laas-Formation wurde Ende der 1970er Jahre in der Nähe des Lammer Grabens nordwestlich von Dobra entdeckt. Der Wirbeltierpaläoichnologe Hartmut Haubold (Universität Halle/Saale, Deutschland) hatte die Spuren auf der Dobraer Platte als cf. Ichniotherium cottae bestimmt, kurz danach publiziert von Niedermayr und Scheriau-Niedermayr (1980).

Bei der Grabung von 2017 konnten neben paläökologisch wertvollen Marken und Spuren wie Trockenrissen, Wellenrippeln, Regentropfen, mikrobiell induzierten sedimentären Spuren, Wurzeln und diversen Invertebratenichnia insgesamt sechs verschiedene Arten an Saurierspuren identifiziert werden. Dabei handelt es sich nach vorläufiger Bestimmung um *Amphisauropus* Haubold, 1970, *Batrachichnus* Woodworth, 1900, *Dromopus* Marsh, 1894, *Ichniotherium* Pohlig, 1892, *Varanopus* Moodie, 1929 und *Tambachichnium* Müller, 1954. Besonders häufig traten Spuren der Gattung Amphisauropus in unterschiedlicher Qualität auf. Herausragendes Objekt ist eine Schrittsequenz von *Amphisauropus* auf einer ca. einen Quadratmeter großen Platte.

Die Spurenfauna vom Kötschacher Berg repräsentiert nicht nur den bislang ältesten Nachweis vierfüßiger Landlebewesen in Österreich, sondern auch mehrere Erstnachweise für den gesamten Alpenraum. Die qualitätsvollsten Gesteinsplatten werden im Besucherzentrum des Geoparks Karnische Alpen in Dellach im Gailtal in einer Sonderausstellung, die das gesamte Ökosystem des lokalen Unterperm veranschaulichen soll, in erweiterten Ausstellungsräumen gezeigt. Die geologischen und paläontologischen Grabungsergebnisse deuten daraufhin, dass das Grabungsgebiet im frühen Perm Teil einer stark belebten Flusslandschaft mit regelmäßigen Überflutungen war.

Als Erzeuger der weit verbreiteten Spurengattung Ichniotherium, Belege kennt man aus dem späten Karbon und frühen Perm von Afrika, Europa und Nordamerika, gelten reptilähnliche Amphibien aus der Gruppe der Diadectomorpha (Voigt et al., 2007). Die Diadectomorpha bilden stammesgeschichtlich die Schwestergruppe aller höheren Landwirbeltiere, sie sind quasi der letzte gemeinsame Ahne von Säugetieren, heutigen Reptilien, Dinosauriern und Vögeln. Darüber hinaus nehmen die Diadectomorpha eine besondere evolutionsökologische Stellung ein, insofern sich darunter wohl die ältesten bekannten pflanzenfressenden Landwirbeltiere befinden.

Amphispauropus ist eine Ursaurier-Spurengattung, die nach neuesten Erkenntnissen nur aus dem frühen Perm (Cisuralium) bekannt ist. Insgesamt deutet die fossile Wirbeltierspurenfauna aus dem Lammer Graben auf ein Alter der Laas-Formation hin, das im Bereich des mittleren Cisuraliums vor ca. 285-290 Millionen Jahren anzusiedeln ist (Voigt & Lucas, 2018).

The Weinsberg granite – connecting the prime example of late-Variscan crustal recycling from source to emplacement

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The Weinsberg granite, a very coarse-grained K-feldspar phyric biotite granite, dominates the South Bohemian Batholith. Whereas the granite intruded the Moldanubian nappes in the Waldviertel area clearly discordant, in the southwestern part of the batholith the granite occurs within the Bavarian Unit, where intense crustal anatexis characterizes the country rocks. Moreover, rare Opx-bearing variants are embedded in the Weinsberg granite within the Bavarian Unit (Frasl & Finger, 1988). These differences may be attributed to key processes of granite evolution: magma formation by partial melting of continental crust and melt transport in the Bavarian Unit as well as the final stage of discordant emplacement at the eastern margin of the batholith. Comparing these different parts of the batholith two interesting questions arise:

1) Is it possible to relate the huge eastern part of Weinsberg granite to a source area like the Bavarian unit? Especially the Opx-bearing granites give evidence to magma formation by large-scale fluid absent melting of biotite, plagioclase and quartz in the lower crust at 850°C and maximal 0.7 GPa (Finger & Clemens, 1995). Orthopyroxene-rich cumulates in the Bavarian Unit possibly indicate areas close to magma formation. A systematic evaluation of enclaves in the eastern emplacement area proved the known occurrence of xenoliths from country rocks and absence of basic enclaves. In addition, enigmatic quartz-rich enclaves in cm-scale and pseudomorphous intergrowth of biotite and quartz within aggregates of biotite were repeatedly identified. These findings may be remnants from Opx-bearing cumulates respectively single crystals from the source region, which ascended with the magma. The geochemical and isotopic characteristics of the Weinsberg granite (c.f. Gerdes et al., 1998) indicates that a crustal segment like the Bavarian unit could be a reliable crustal source.

2) Which kind of impacts to the country rocks occur along the eastern contact due to the emplacement of the large Weinsberg granite pluton? In tribute to historical concepts (c.f. Suess, 1926) the frequent cordierite-paragneisses of the Monotonous Group were for long times regarded as possible contact metamorphic aureole from the granite emplacement. However, in the region of the Ysper valleys, garnet-sillimanite-paragneisses of the Gföhl Nappe System crop out near the granite contact. Nevertheless, the granite contact of this Nappe System gives a well record of the extent of contact metamorphism. Very close to the granite contact, kyanite was decomposed to corundum and up to 1 km distance from the contact andalusite formed in two-mica orthogneisses. Furthermore, alteration by induced fluid circulations reaches 2 km distance. Rb-Sr ages of biotite confirm the reheating in the aureole and batholith cooling below 300°C about 15 Ma after the emplacement around 328 Ma.

These observations suggest that the potassium-rich magma of the Weinsberg granite was generated basically by dehydration melting of biotite-bearing ortho- and paragneisses in the lower crust. Possible remnants of orthopyroxene indicate this lower crustal source for the whole pluton. The emplacement, as final stage of the granite forming process, took place in a depth lower than 16 km, proved by contact metamorphism with andalusite.

Lower Cretaceous ammonites from the Northern Calcareous Alps (Hauterivian – Barremian, Upper Austria)

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A new ammonite fauna is presented for a Lower Cretaceous pelagic to hemipelagic succession of the Bajuvaric Langbath Zone (Northern Calcareous Alps, Upper Austria). The studied sites are outcrops of the High Bajuvaric Unit west of the Lake Traunsee, in the northernmost part of the Northern Calcareous Alps. The ammonites and accompanying fauna (nautiloids, belemnoids, aptachi, bivalves, gastropods, sponges, echinoids) from the Klausbachgraben area originates from the upper Hauterivian to lower Barremian deposits of the Schrambach Formation. The Schrambach Formation consists mainly of light and dark grey marly limestones and marls from the Lower Cretaceous. Ammonite material is known from private collections but nothing was published until today. The sites can only be accessed with permission from the forest agency, over a steep forest road which has its initial point on the main road from Altmünster at Lake Traunsee to Steinbach at Lake Attersee. Abundant ammonites enable recognising the standard Mediterranean ammonite zones, from the Upper Hauterivian *Balearites balearis* Zone (*Balearites balearis* Subzone) up to the Lower Barremian *Kotetishvilia nicklesi* Zone. Numerous ammonite species are documented for the first time from the Northern Calcareous Alps. Ammonite abundances are clearly linked to sea-level changes from Late Hauterivian to Early Barremian times. The accumulations in distinct layers (horizons, mass occurrences) are triggered by redeposition of ammonite shells. The ammonite composition of the Schrambach Formation sheds light on the Lower Cretaceous palaeobiogeography of the northernmost parts of the Northern Calcareous Alps, the Bajuvaric Units. The new ammonite fauna also provides insights into the faunal composition and distribution within the investigated interval, linked to other Mediterranean areas and assemblages.

The ammonite assemblage consists of 13 families including 28 different upper Hauterivian to lower Barremian genera: Phylloceratidae (4%) with *Phylloceras*, *Phyllopachyceras*; Lytoceratidae (5%) with *Lytoceras*; Desmoceratidae (51%) with *Plesiospitidiscus* (dominant element with 85%), *Barremites*, *Abrytusites*, ?*Melchiorites*; Pulchelliidae (1%) with *Buergliceras*, *Discoidellia*, *Kotetishvilia*; Haploceratidae (1%) with *Neolissoceras*; Crioceratidae (27%) with *Crioceratites*, *Pseudothurmannia* (dominant element with 72%), *Paracostidiscus*, *Sornayites*; Emericiceratidae (1%) with *Honnoratia*, *Paraspiticeras*; Acrioceratidae (1%) with *Acrioceras*; Ancyloceratidae (0.25%) with *Toxancyloceras*, *Ancyloceras*; Leptoceratoididae (2%) with *Hamulinites*, *Sabaudiella*; Hamulinidae (4%) with *Anahamulina*, *Amorina*, *Hamulina*; Megacrioceratidae (2%) with *Liautaudia*, *Megacrioceras*; Macroscaphitidae (0.1%) with *Macroscaphites*. The nautiloid genus *Eucymatoceras* (1%) accompanies the ammonite fauna.

Sinemurian biostratigraphy of the Tannscharten section near Reichraming (Lower Jurassic, Schneeberg Syncline, Northern Calcareous Alps)

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Lower Jurassic pelagic to hemipelagic sediments are known to form a significant element of the northernmost tectonic units of the Northern Calcareous Alps (e.g. Ternberg-, Reichraming-, Frankenfels-, and Lunz-nappes). In the Reichraming Nappe comprising the Lower Jurassic Tannscharten locality, Liassic cephalopod-bearing deposits are recorded in a deep water limestone facies, the Allgäu Formation (= “Lias Fleckenmergel”).

Lower Jurassic ammonites were collected from deep water limestone of the Tannscharten section southwest of Reichraming (Upper Austria, Northern Calcareous Alps). The outcrop provides a rich Upper Sinemurian (Lower Jurassic) ammonite fauna of the Allgäu Formation. The area is situated in the westernmost part of the Schneeberg Syncline in the north of the Reichraming Nappe (High-Bajuvaric Unit). The ammonite fauna consists of seven different genera, each apparently represented by 1-2 species. Echioceratids are the most frequent components (*Echioceras*, *Leptechioceras*, *Paltechioceras*), followed by the phylloceratids (*Juraphyllites*, *Partschiceras*), and oxynoticeratids (*Gleviceras*, *Paroxynoticeras*). *Juraphyllites libertus*, *Partschiceras striatocostatum*, *Gleviceras paniceum*, *Echioceras quenstedti*, *Echioceras raricostatoides*, *Paltechioceras boehmi*, *Leptechioceras meigeni*, *Leptechioceras macdonnelli* and *Paltechioceras oosteri* are new for the Schneeberg Syncline and allow for the first time a detailed biostratigraphy of the *Echioceras raricostatum* Zone. The assemblage is correlated with other faunae from Austria, Germany, United Kingdom, France, Switzerland and Romania. The cephalopod fauna consists of a mixing of the Northwest European Province and the Mediterranean Province. The detailed biostratigraphy based on ammonites is presented.

The ammonite data are the first step in a detailed biostratigraphic scheme for the westernmost part of the Schneeberg Syncline, a tectonic key-area in the Reichraming Nappe (Northern Calcareous Alps). More investigations on this important occurrence of the Allgäu Formation will take place within a planned project on the Jurassic and Lower Cretaceous climate. The project comprises the present work as part of the basic framework. Additional ammonite collections (bed-by-bed) will be carried out in the next decade to precise the exact position of zone-, subzone- and biohorizon-boundaries. Analyses will include palaeomagnetics, isotopic composition and geochemical analyses along with a detailed biostratigraphy based on micro- and nannofossils.

Electrical modelling for an improved understanding of GPR signatures in alpine permafrost using results obtained from different geophysical surveys

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As a consequence of climate change, current environmental research focuses on understanding the effect of extreme atmospheric events, for instances, in the degradation of alpine permafrost. To this end, here we present the modelling of Ground Penetrating Radar (GPR) monitoring signatures collected at the summit of Hoher Sonnblick in frame of the ATMOperm project. The Hoher Sonnblick is located in the Austrian Central Alps, 3106 m above sea level, where a permanently installed monitoring array permits the collection of Electrical Resistivity Tomography (ERT), which provides information about changes in the electrical resistivity in an imaging framework. To improve the interpretation of the observed changes in the electrical properties, and to extend the investigation to areas away of the ERT monitoring, we performed GPR monitoring measurements in a series of profiles spread across the entire summit area. GPR is a well-stablished method in permafrost investigations used to gain structural information about lithological changes and to evaluate variations in the active layer, taking into account the contrasting electrical properties of frozen and unfrozen materials. Nevertheless, in comparison with previous studies at the Hoher Sonnblick, GPR investigations in our study aimed not only at the identification of possible interfaces, but to develop a methodology for the modelling of subsurface electrical properties for an improved understanding and interpretation of GPR and ERT imaging results. To achieve this, we investigated the synthetic response for subsurface models taking into account the resistivity distribution in the subsurface as derived from ERT monitoring data and literature. Further analyses were performed on several synthetic and field data sets, varying the properties of the electrical structures, for instance, geometry and electrical contrasts. Comparison of synthetic and measured radargrams permitted us to evaluate the proposed model. This interactive process was repeated for each profile and for data collected along the monitoring dataset. Finally, we quantified the temporal variations in the electrical properties to assess seasonal changes in the active layer. Modelling results demonstrate the applicability of the proposed methodology considering signal reflection and attenuation to validate the interpreted lithologic and thermal units within permafrost environments.

Regional archaeological visibility and preservation in arid environments: incidence of geo-environmental processes (Yocavil Valley, Northwest Argentina)

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The Yocavil Valley is a north-south oriented tectonic valley measuring ca. 120 x 30 km, limited by the Cumbres Calchaquíes and the Sierra del Aconquija to the east and the Sierra de Quilmes to the west, and is discharged by the Santa María river. It is characterized by an arid climate and scarcely developed soils.

Our study area corresponds approximately to the central third of the Sierra de Quilmes. We have studied the use of space at a regional scale and its changes during the pre-Hispanic agrarian stage (ca. 100-1535 AD). We can show the impact of geo-environmental processes on the archaeological visibility, preservation and consequently the resulting spatial patterns.

We integrated topographic, geological, soil and hydrological data into a geomorphological map of the study area. Surface surveys were carried out by transects that repeatedly linked the hillside with the valley floor, registering archaeological sites and collecting surface archaeological finds. In three areas, we excavated pits along the line of greatest slope. In the pits, stratigraphic profiles were documented and samples analyzed for grain-size, morphology, composition, phytolith content. Taphonomic traces were registered for the ceramic assemblages, including size, shape and rounding.

As a result, areas were differentiated by their archaeological contexts. In the highest part of the piedmont, sedimentation dominates over erosion, architectural structures are visible on the surface and archaeological materials are found up to 50 cm depth. In the middle part of the piedmont, deposits with archaeological evidence are scarce although architectural structures are perceived. Finally, in the distal part sedimentation was dominant, with presence of pre-Hispanic materials up to 6 m depth. These differences determine that the archaeological visibility is greater in the upper and middle part of the piedmont than in the distal end. Subsurface preservation is greater in the lower part and the highest parts of the piedmont, compared to the middle part, where it is scarce.

The distribution of surface and excavated pottery sherds reflects these differences of formation processes, controlled by topography and thus the recorded archaeological spatial structure. The high frequency of archaeological remains in the proximal part of the piedmont matches with the location of persistently occupied residential and productive areas. The low number of sherds in the mid-piedmont sector match with the location of productive areas, with farming terraces and scattered closed structures, where occupation was less recurrent and smaller frequencies of pottery sherds are expected. Finally, the higher number of sherds in the distal sector and/or valley floor also corresponds to persistent pre-Hispanic occupations. The pottery sherds assemblages exhibit traces of horizontal displacement and mixing processes but with only minor effect at a regional scale. In addition, there is relationship between the relative chronology of the surface sherds and those from excavations. We conclude that the spatial patterns established by the pottery sherds are reliable, although with a greater impact of erosion on the frequency of the sherds in the middle part of the piedmont.

Current status of the Central Paratethys Neogene stratigraphy

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The Central Paratethys (CP) was an Oligocene to Middle Miocene European epicontinental sea settled north of the Eastern Alps, Dinarides and Carpathians and south of the European platform. It was a highly dynamic area due to the ongoing Alpine orogeny, resulting in a quickly changing paleogeography. Its westernmost parts between Munich and Linz became terrestrial already during the Early Miocene, its southern domain was not part of it before the Middle Miocene. Major control on the Neogene paleoenvironmental development in the CP were tectonics driving the evolution of the Pannonian Basin System (PBS), including initiation of the pull-apart type Vienna Basin and the sag type Transylvanian Basin. The PBS synrift phase was generally constrained to the Early and Middle Miocene, its postrift phase occurred during the Late Miocene and Pliocene, initiating the disintegration of the CP. Thereby, its western domain (Pannonian Basin System) turned into a fully isolated long-lived lake, whereas its eastern domain (Carpathian Foredeep - Dacian Basin) became integrated into the Eastern Paratethys (EP), extending eastwards via Black Sea to the Central Asia. During open marine phases, the CP was an embayment of the proto-Mediterranean Sea, connected via the Slovenian and Rhône basin gateways. Consequently, its stratigraphy correlates in the first line with the Mediterranean one. During endemic events the stratigraphic correlation with the EP, increases.

A regional chronostratigraphic system was developed gradually since the 1950-ties to fix the correlation of the various Paratethyan basins. The Early to Middle Miocene interval include five CP stages - Egerian, Eggenburgian, Karpatian, Badenian, and Sarmatian. The Late Miocene to Pliocene interval also include several formalized "CP stages". Currently, these are the Pannonian and Cernikian for the PBS lacustrine successions including the Transdanubian as substage of the Pannonian. The Pontian, Dacian and Romanian stages are confined to eastern Paratethyan basins and therefore, its use in the CP is abandoned.

This regional chronostratigraphic system is deeply rooted in the distribution and occurrence of shallow benthic taxa, such as mollusks and benthic foraminifera. These are especially useful during endemic intervals, but do not allow reliable correlations of basinal settings. Therefore, planktic organisms, such as planktic foraminifera and calcareous nannoplankton in marine settings and dinoflagellates in lacustrine deposits, are increasingly used for intra- and interregional correlations. In addition, geochronological methods including Ar/Ar dating of volcanic ash layers, Sr concentration in fully marine shell material, and beryllium-10 cosmogenic dating for Upper Miocene to Quaternary continental deposits, gained increasing interest. Correlation methods depending on calibration by former constrains include magnetostratigraphy and astronomical tuning, yet they both need long continuous successions being very rare. Finally, sequence stratigraphy proved useful for correlation of eustatic sea-level change with the open ocean, but is potentially overprinted by geodynamics.

This is a contribution to the Scientific Project "Stratigraphy, geodynamic development and paleogeography of the Vienna Basin: a cross-border correlation of data between Austria and Slovakia" (Scientific & Technological Cooperation with Slovakia 2018-19, No. SK 09/2018).

Geochemical characterization of granitoids of the Seckau Complex (Eastern Alps)

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Recent studies revealed that the granitoids of the Seckau Complex are part of both a late Cambrian to Early Ordovician, and Late Devonian to early Carboniferous (early Variscan) intrusive complex (Mandl et al., 2018). While the older intrusives comprise primarily S-type granitoids, the early Variscan granitoids evolved from I-type to S-type. This study provides new geochemical data on main-, trace and RE elements in order to reveal the evolution of Variscan magmatism, magmatic differentiation, and the influence of pre-Variscan continental crust on Variscan magmatism within the Seckau Complex.

Recent studies revealed a more distinct subdivision of the Seckau Complex based on petrological, geochemical and geochronological criteria (Mandl et. al., 2018). The Glaneck Metamorphic Suite comprises predominantly paragneisses with U-Pb zircon ages in the range between 572 ± 7 Ma and 559 ± 11 Ma and represents the oldest dated rocks within the Seckau Complex. Highly fractionated S-type granites of the Hochreichart Suite indicate a magmatic event between 572 ± 7 Ma and 559 ± 11 that may also have caused migmatisation of distinct domains of the paragneisses. The Hintertal Plutonic Suite displays a second intrusion event ranging from 365 ± 11 Ma to 343 ± 7 Ma and comprises I-type granitoids (Pletzen Pluton) as well as S-type granitoids (Griessstein Pluton). Granitoids of the Pletzen Pluton are characterized by variable SiO_2 contents and a magmatic fractionation trend seen in variable Rb/Sr ratios. Granitoids of the Griessstein Pluton indicate high SiO_2 values and are defined by the dominance of muscovite in contrast to biotite (Mandl et al., 2018).

On the (Y + Nb) vs. Rb tectonic discrimination diagram for granites the metagranitoids of the Hochreichart Plutonic Suite and the Hintertal Plutonic Suite plot both predominantly in the volcanic-arc granites field (VAG), reflecting geochemical signatures of an active continental margin (subduction-related setting). Only few samples are marginally located in the syn-collisional granites field (syn-COLG) and into the within-plate granite field (WPG), respectively. Most likely, these samples also reflect a VAG setting as the same tectonic setting can be assumed for all metagranitoids of the Seckau Complex.

Based on field evidence where the Griessstein Plutone is found between the Late Cambrian/ Early Ordovician Hochreichart Suite and the Late Devonian/ early Carboniferous Pletzen Pluton, a possible assimilation of Hochreichart granitic rocks into the marginal portions of the Pletzen intrusives was tested. By using average major and trace element compositions of Hochreichart and Pletzen plutonic rocks it was not possible to obtain the measured composition of the Griessstein Pluton. The same result was obtained when considering the hosting paragneisses as contaminant for the Pletzen intrusives. Therefore, we conclude that the Griessstein Pluton is considered to be the result of a fractionation process from the Pletzen Pluton where small amounts of wall rock were assimilated or a small portion of a SiO_2-rich melt was incorporated.

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Mandl, M., Kurz, W., Hauzenberger, C., Fritz, H., Klötzli, U., Schuster, R.: Pre-Alpine evolution of the Seckau Complex (Austroalpine basement/Eastern Alps): Constraints from in-situ LA-ICP-MS U-Pb single bond zircon geochronology, Lithos 296-299, 412-430. DOI: https://doi.org/10.1016/j.lithos.2017.11.022, 2018.

The Rannach Formation – A Permian Trough within the Austroalpine Seckau Nappe

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Permian to early Mesozoic sedimentary units, known as Central Austroalpine Mesozoic (CAM), are widely dispersed within the Austroalpine basement nappes due to Eo-Alpine stacking and subsequent extension. Prominent examples for CAM are the Brenner Mesozoic west and the Stangalm, Thörl and Rannach Permo-Mesozoics to the east of the Tauern Window, respectively. Along the eastern margin of the Eastern Alps those units have been summarized to as “Semmering Quartzite” or “Alpine Verrucano”.

Most of the clastic Permian sequences have minor thicknesses between few meters (Brenner, Stangalm units) to at maximum 100 meters (Thörl unit). An exception is the Rannach Formation within the Seckau nappe with up to 1000 meters of clastic meta-sediments. Hence we consider this unit as possible Permian trough that developed within a Permian rift setting.

Several profiles across the Rannach Formation show a single general fining upwards sequence with 120-150 meters basal conglomerates followed by 600-700 meters sandstone and up to 300 meters of fine-grained clastics (phyllites) on top. Carbonate beds as developed elsewhere (e.g., Stangalm unit) are nearly absent. Provenience studies and relictic sedimentary structures suggest deposition of mature sediments eroded from an intra-continental source related to the basement underneath, possibly starting with alluvial fan deposits grading upwards into lower energy fluvial systems. Comparable Permian sedimentary troughs are absent in the Eastern Alps but are known from Southalpine domains (Orobic Basin, Collio Trough, Bolzano Basin).

The basement within the Seckau Nappe (SeckauComplex) was recently sub-divided into the following units (Mandl et al., 2018):

The Glaneck Metamorphic Suite comprises predominantly paragneisses with U-Pb zircon ages in the range between 572 ± 7 Ma and 559 ± 11 Ma and represents the oldest dated rocks within the Seckau Complex. Highly fractionated S-type granites of the Hochreichart Suite indicate a magmatic event between 572 ± 7 Ma and 559 ± 11 that may also have caused migmatisation of distinct domains of the paragneisses. The Hintertal Plutonic Suite displays a second intrusion event ranging from 365 ± 11 Ma to 343 ± 7 Ma and comprises I-type granitoids (Pletzen Pluton) as well as S-type granitoids (Griessstein Pluton).

The detrital zircon age spectrum from the Rannach Formation reflects the geochronological ages from the suites described above, indicating a rather local provenance of the clastic sediments, in addition to zircons in age range of ca. 290 Ma. These latter ages are not documented in the aforementioned suites of the Seckau Complex, but might be derived either from late diabase dikes crosscutting several lithological units that were covered by the Rannach Formation, or from more regional sources of widely distributed Permian magmatic rocks being part of the Austroalpine basement nappe system. Anyhow, these 290 Ma detrital zircons provide a maximum age for onset of sedimentation within the Rannach Formation.

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Das westliche sinistrale Saalachzonen-Störungssystem – Neue Daten zur Abgrenzung der Tauglboden von der Hallstatt Mélange (Unken / Salzburg)

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Die Geologie der Unkener Mulde und ihre östliche Begrenzung wird aufgrund der polyphasen tektonischen Geschichte der Nördlichen Kalkalpen seit über 100 Jahren bearbeitet und unterschiedliche Modelle versuchen die Lagerungsverhältnisse zu erklären. Auf Basis der Neudefinition der Saalachzone (Missoni & Gawlick, 2010) als Hallstatt Mélange (Strubberg Formation überschoben von Sandlingalm-Formation; Hoch-Tirolikum) und deren Matrixdatierung (Quast et al., 2010) folgert sich eine Abtrennung der Saalachzone von der Unkener Mulde (Tauglboden-Formation; Tief-Tirolikum) an einer sinistralen Seitenbewegung (früher „Saalach-Westbruch“). In jüngster Zeit hat sich herausgestellt, dass der Grenzbereich Tief-Tirolikum zu Hoch-Tirolikum im Detail wesentlich komplexer ist. Eine neue geologische Kartierung im Raum südwestlich von Unken mit begleitenden biostratigraphischen und mikrofaziellen Untersuchungen inkl. Komponentenbestandsanalysen der verschiedensten Massenumlagerungen in radiolaritischer Matrix zeigt deutlich komplexere Verhältnisse im Kontaktbereich Unkener Mulde/Saalachzone.

Das Liegende der Saalachzone bildet rhätischer Dachsteinkalk, dem Rotkalke der Adnet-Gruppe und die Strubberg-Formation inkl. der basalen Klauskogelbach-Subformation (Dachsteinkalkmegabrezie mit Vilser und Klauskalk als Matrix) auflagern. Auf diese überschoben liegt die Sandlingalm-Formation mit evaporitischer Haselgebirgs-Mélange an der Basis. Die Lärchberg-Formation stellt die höchste tektonische Einheit dar. Die Saalachzone wird im Westen durch sinistrale Seitenbewegungen von einer tektonischen Schuppe abgetrennt, die weder der Saalachzone noch der Tauglboden Mélange zugehört. Die erhaltene Schichtfolge entspricht jener der Trattberg-Schwelle sowie den auflagernden Ober-Jura- bis Unter-Kreide-Sedimenten (Oberalm- bis Roßfeld-Formation). Aufgrund des Fehlens des Oberalmer-Basiskonglomerates kann ein Ablagerungsraum nördlich der im Tithonium kollabierenden Trattberg-Schwelle rekonstruiert werden.

Im Zuge der Lateralen Tektonischen Extrusion werden die unterschiedlichen tektonischen Einheiten an sinistralen Seitenbewegungen (u.a. Saalach-Westbruch) in ihre heutige Position bewegt: dabei entspricht die heute westlichste Einheit (Unkener Mulde = Tauglboden Becken) der im Ober-Jura paläogeographisch am nördlichsten positionierten Einheit. Die Einheit der südlichen Trattberg-Schwelle nimmt die zentrale Position ein und die Saalachzone repräsentiert die im Ober-Jura paläogeographisch am südlichsten gelegene Einheit.

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Incomplete Ostwald ripening in Triassic primary dolomites

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The primary formation of dolomite in ancient evaporative environments is difficult to trace, as often dolomitization is a result of later diagenetic overprint. Recently Preto et al. (2015) found evidence of primary dolomite in the Carnian Travenanzes Fm. in the Venetian Alps. This geological unit experienced very little tectonic overprint, which increases the chance to preserve pristine sedimentary structures, petrographic textures, crystallographic microstructures as well as mineralogy. The studied section contains homogeneous, nodular and laminated dolomite beds, intercalated in a 100-m-thick sequence of alluvial clay. A “primary” origin of these dolomites is suggested by the presence of nano-crystalline structure of some crystal aggregates, identified by transmission electron microscopy (TEM). Hence, primary dolomites of the Travenanzes Fm. provide a unique window to interrogate past processes and environmental conditions conducive to dolomite formation.

Our new studies by electron microscopy showed a fine-grained dolomicrite matrix consisting of micrometre sized subhedral to euhedral crystals, which are commonly surrounded by an outer rim entirely filling the interstices. Further analysis by electron backscatter diffraction (EBSD) mapping on polished thin sections revealed that the outer rims represent syntaxial cement that formed during dolomite mud lithification. EBSD mapping revealed a bimodal size distribution of dolomite grains. Larger grains commonly have a round or irregular shape. To further examine the crystallographic features by high-resolution TEM, a 50 nm thick foil was extracted from one of the larger grains using focused ion beam milling (FIB). Based on the EBSD data the FIB section was oriented so that the c-axis of the dolomite crystal is perpendicular to the foil plane. TEM analysis revealed structures of nanoparticles, which are however embedded in larger domains with more or less unique crystallographic orientation.

Based on our observations, we suggest that nanocrystal aggregation is one of the nucleation and growth pathways for dolomite formation, and that this mechanism operated in the Travenanzes depositional environment. Primary porosity was then filled by syntaxial dolomite. The Travenanzes dolomite has not been pervasively affected by Ostwald ripening, which supports the notion that they are truly primary precipitates preserved within a Triassic clay-rich sequence.

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Das Potential von kritischen Hochtechnologiemetallen in Buntmetallsulfidvorkommen der Ostalpen

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Die Konzentrationen von Hochtechnologiemetallen werden in Buntmetallerzen der Ost- und Südalpen erstmals mittels der Laser Ablation-ICP-MS Methode untersucht. Sphalerit ist der wichtigste Träger der kritischen Hochtechnologiemetalle Germanium (Ge) und Indium (In), sowie eine potentielle Quelle für Kobalt (Co), Gallium (Ga) und andere Spurenelemente. Die wirtschaftliche Bedeutung dieses Minerals wird durch die jahrhundertlange Bergbau- und Verhüttungstätigkeit in den Ostalpen unterstrichen. Insgesamt wurden mehr als 6000 Punktanalysen auf 311 polierten Dünnschliffen durchgeführt, die 28 individuelle Erzvorkommen repräsentieren. Diese Vorkommen stammen aus karbonatgebundenen Pb-Zn-Erzen vom Bleiberg-Typ in triassischen Nebengesteinen, aus stratiformen sedimentgebundenen Buntmetallerzen in paläozoischen Sediment- und Vulkanitabfolgen, sowie aus diskordanten Gangvererzungen in paläozoischen Gesteinen. Die Analysenergebnisse belegen zwei klar abzugrenzende Sphalerittypen: (1) in nicht metamorphen Karbonatsedimenten sind die Sphalerite typischerweise arm an Fe (<1%), Mn, Co, Ga, In, Sn und Sb; sie können jedoch erhebliche Konzentrationen der Elemente Ge (bis >500 ppm), As, Tl und Pb aufweisen. (2) Sphalerite in stratiformen und Ganglagerstätten in niedrig- bis mittelgradig metamorphen Gesteinen sind an Fe, Co, Cu, Ag, In und Sn angereichert. Es gibt jedoch große Variationen in beiden Gruppen, sowie auch ungewöhnliche Elementassoziationen, wie z.B. Ge-Sb-Co in der Ganglagerstätte Metnitz in der Gurktaldecke.

Regional betrachtet sind die Sphalerite in der ladinischen und karnischen Stufe des Drauzug-Gurktal-Deckensystems und des Südalpins ähnlich und unterscheiden sich lediglich in der Magnitude ihrer Elementanreicherungen. Vorkommen in den Nördlichen Kalkalpen sind demgegenüber an Ag angereichert. Sphalerite in höher metamorphen anisischen Gesteinen des Brennermesozoikums sind auffallend arm an Spurenelementen. Die stratiformen Erzlager des Grazer Paläozoikums und der Gurktaldecke führen generell Fe-reichere Sphalerite, die meist nur gering an Co, Ag, Ga, Sb und In angereichert, sowie sehr arm an Ge sind. In der Kieslagerstätte Walchen (Ennstaler Quarzphyllitdecke) und in der karbonatgebundenen Lagerstätte Leogang treten Fe-In-Co-Cu reiche Sphalerite neben In-reichem Chalkopyrit auf. Die stratiforme, hochmetamorphe Lagerstätte Schneeberg ist ebenfalls durch die Assoziation Fe-Co-Cu-In charakterisiert.

Die Verteilung der Spurenelemente innerhalb eines Vorkommens sowie eines Lagerstättentyps ist generell heterogen. Der große Datensatz ist jedoch für viele Vorkommen statistisch relevant und spiegelt die Spurenelementverteilung in den Erzen wider. Wenn verlässliche Daten zu Erzreserven oder Ressourcen zur Verfügung stehen, lassen sich daraus Ressourcenwerte für die kritischen und seltenen Elemente errechnen. Im Hinblick auf die zukünftige Versorgung mit kritischen Metallen liegt die Bedeutung von Zn-reichen Erzen in den Ost- und Südalpen somit vor allem auf Ge. Die laufenden Untersuchungen der Begleitminerale Chalkopyrit, Pyrit und Pyrrhotin vergrößern das vorhandene Potential deutlich, da diese ebenfalls charakteristische Spuren- und Nebenelementverteilungen aufweisen. Entsprechend aufbereitete Sulfiderzkonzentrate könnten dann durch Anwendung moderner metallurgischer Verfahren für die Extraktion von Nebenmetallen in Frage kommen.

Anthropogenic deposits – Vienna's Anthropocene

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The term Anthropocene stands for the time of the rising anthropogenic influence on the Earth System and especially on geological processes. Potential Anthropocene geological units are thin but distinct and globally widespread, changes are long-lived or irreversible. Anthropogenic deposits under cities such as Vienna stretch from pre-historic and historic to recent times and are caused by a combination of human and geological forces. A new project, financed by the WWTF (Vienna Science and Technology Fund), investigates the growth of the Anthropocene signal in the urban environments of Vienna. “The Anthropocene Surge” (ESR17-040) is a unique interdisciplinary project, combining natural sciences, humanities and art, which is regarded as a chance for a holistic view on the Anthropocene, its stratigraphy and perception.

The key hypothesis of the project is the Anthropocene surge, the accelerating and propagating wave of human influence on the environments and urban geology. The main research question is how the Anthropocene evolved in the urban environments of Vienna and what anthropogenic markers can be identified.

Firstly, the project aims at a genetic classification of anthropogenic sediments to develop the stratigraphy of Vienna's Anthropocene growth. The record of the Anthropocene surge in the sedimentary archive will be investigated with geochemical methods to detect trace metal contamination.

Secondly, the geometry and topography of anthropogenic units and horizons will be incorporated into a GIS and build the basis for a 3D model of the anthropogenic units, showing not only their present form but also their evolution in time. Historical maps, as e.g. by the famous Austrian geologist Eduard Suess, will be added to the model to implement and review the mid-19th century growth of Vienna.

Thirdly, an essay film will be created accompanying the research and reflecting on the trajectories of the Anthropocene within different fields and methods. By recording the flow of scientific samples from humanly modified ground to a 3D modeled landscape, the points of contact between analog and digital stratifications and their potential interactions will be traced.

Clay mineralogy of Miocene mudstones of the Lower Austrian Molasse Basin

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The stratigraphy of the Lower Austrian Molasse Basin (LAMB) was investigated in a joint project of OMV and the University of Vienna which aimed at a revision of the local lithostratigraphy. Herein, we analysed the clay mineralogy of 7 wells across the LAMB.

In the LAMB Karpatian sediments overlying a carbonate minimum interval are attributed to the Laa Formation. Beneath the Laa Formation the Traisen Formation, formerly Oncophora/Rzehakia Beds, comprises the uppermost Ottnangian sand-dominated and calcite poor sediments south of the Danube river. In the north the newly defined late Ottnangian Wildendürnbach Formation represents central basinal turbiditic and pelitic deposits and is also poor in calcite. The fine grained and carbonate bearing sediments below the Traisen and Wildendürnbach Formations are named Robulus Schlier s.l. The lower boundary of the pelitic Schlier-succession is marked by bioturbated sandstones. The also informal term Basal Sands shall be used here for the basal quartz, K-feldspar and kaolinite-rich, but mica-poor sands, covering the basement. These sands are partly attributed to the Linz-Melk-Formation.

The results of the qualitative and quantitative evaluation of clay minerals in the seven wells allow some correlation with recently proposed formation boundaries. In wells Schaubing and Streithofen 1 the sediments of the Traisen Formation exhibit distinctly higher kaolinite contents and smectite/illite(mica) ratios than the underlying Robulus Schlier s.l. Very reduced smectite and increased kaolinite content distinguish the Basal Sands from Robulus Schlier s.l. in well Streithofen 1. High smectite peaks in well Wildendürnbach K4 occuring in parts of the Wildendürnbach Formation can be explained by volcanic ash input.

High-pressure behaviour of the LiInGe2O6 (LIG) – LiScGe2O6 (LSG) solid solution

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Pyroxenes are among the most abundant minerals in the upper mantle of the Earth. Knowledge about their high-pressure behaviour is of particular interest because phase transitions of pyroxenes are discussed as being responsible for discontinuities in seismic wave propagation (Woodland, 1998). The compression behaviour of pyroxenes does not follow the bulk modulus – unit cell volume relationship for isostructural compounds as proposed by Anderson and Anderson (1970), but strongly depends on their chemical composition (Hofer et al., 2015; Nestola et al., 2012), therefore systematic investigations seem to be inevitable in order to be able to predict their high-pressure behaviour.

In this context bulk moduli of both end members LiInGe2O6 (LIG) and LiScGe2O6 (LSG) and one intermediate LiIn0.1Sc0.9Ge2O6 (LISG) composition have been determined in a high-precise lattice parameter experiment using an Stoe AED II single crystal X-ray diffractometer. For each pressure point about 15 unique diffraction peaks were used for the sample crystal and quartz (pressure standard [Scheidl et al., 2016]) in order to refine lattice parameters. In the case of LSG and LISG a first order orthorhombic to monoclinic phase transition was identified, whereas for LIG no evidence for a structural phase transition could be found up to at least 9.6 GPa.

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Optical dating of geological and archaeological rock surfaces potential and limitations of a new dating tool for the earth and archaeological sciences

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Luminescence dating is a well-established chronological technique normally applied to fine-grained (< 300 µm) sediments of clastic origin to estimate the time since sediment burial. Further development of this technique suggests that it can also be used to determine the exposure history of solid rock surfaces (e.g. Sohbati et al., 2012), which is based on the following principle: below a certain ambient temperature (i.e. closure temperature) latent luminescence begins to accumulate within the crystal lattice as a function of time due to the naturally occurring ionizing radiation inside rocks. Once the rock is exposed to daylight, e.g. due to erosion or transportation, this latent luminescence begins to gradually reset. The resetting (or bleaching) will eventually leave the topmost millimetres (typically < 30 mm) of a rock surface completely bleached. The rate of bleaching reduces systematically with depth (due to lower daylight intensity) to negligible values at depths where the luminescence signal is effectively unbleached and in field saturation. Given sufficient time, the profile reaches a secular equilibrium, where the rate of trapping due to ionising radiation becomes equal to the rate of detrapping due to daylight exposure at all depths. For a rock which is not in secular equilibrium, measuring and calibrating the depth-dependent luminescence signal below the exposed surface (via generating luminescence-depth profiles) allows – in principle – the exposure age of a geological or archaeological rock surface to be constrained (i.e. rock surface exposure dating; Sohbati et al., 2012, Sohbati et al., 2015; Meyer et al., 2018; Gliganic et al., 2018). As such rock surface exposure dating provides similar but complimentary information to surface exposure dating using cosmogenic radionuclides.

In this presentation the application potential of rock surface exposure dating will be discussed and methodological limitations evaluated. Dating studies applying rock surface exposure dating to archaeological sites, including a lithic quarry site from the Tibetan Plateau, and to crystalline head scarps in order to constrain the timing of alpine mass wasting processes will be presented.

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Isotopes and microstructures from calcite veins of the Izu-Bonin fore arc and the Amami-Sankaku basin: vein formation conditions, ages and deformation

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Five drill cores, drilled by International Ocean Discovery Program (IODP) expeditions (351 and 352) in 2014 from the outer Izu-Bonin (IB) fore arc and the Amami-Sankaku basin (ASB) near the Kyushu-Palau ridge, were selected to improve the understanding of supra-subduction zones (SSZ) as a birthplace of ophiolites.

On the basis of vein samples, hosted in boninites, fore arc basalts (FAB) and FAB-like rocks, vein precipitation and deformation conditions were investigated. In this contribution we present stable (δ18O and δ13C), clumped (Δ47) and Sr isotopes (87Sr/86Sr), rare earth elements (REE) and microstructures of vein precipitates.

Veins formed predominantly as a consequence of hydrofracturing resulting in the occurrence of complex vein systems and breccias. Extensional veins occur only subordinately. The most abundant vein mineral is (low Mg-) calcite determined by Raman spectra and electron microprobe analyses. Minor amounts of zeolite observed in vacant places and selvages result from alteration of volcanic glass during interaction with a fluid.

Morphology and growth patterns of the vein precipitates define four major types: type I veins reflect neptunian dykes indicated by micritic infill. Type II veins are characterized by blocky carbonates that locally exhibit growth zonation and deformation microstructures. Type III veins display syntaxial growth and elongated blocky carbonates. They occur predominantly as asymmetric syntaxial veins, locally showing more than one crack and seal event. Type IV veins are defined as antitaxial fibrous carbonates.

Stable isotopes and first clumped isotope data of all vein types hosted in IB fore arc and ASB rocks point to marine carbonates that precipitated at temperatures around 20°C and up to 70°C, respectively. Additionally, REE patterns indicate a seawater fluid that was locally modified by fluid-rock interaction. 87Sr/86Sr isotope data give maximum ages of vein formation between 52 and 49 Ma for IB and ASB, respectively. Furthermore, isotopes indicate ongoing vein formation and precipitation for at least 25 Ma.

Blocky carbonates from type II veins display microstructures like deformation twins, undulatory extinction and subgrain boundaries. Twin densities indicate differential stresses around 110 ± 20 MPa. Based on high differential stresses, deformation temperature is considered to be lower than 100°C, probably due to high strain rates. EBSD analyses indicate a maximum rotation of subgrain boundaries around 15°.

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Microporosity in solid bitumen: The key to unconventional reservoir potential in the Ukrainian Dniepr-Donets Basin

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The evaluation of an unconventional reservoir requires knowledge of commonly accepted parameters like TOC, thickness, thermal maturity, etc., but microstructural features such as organic matter (OM)-hosted porosity are of equal importance for a successful unconventional target. Broad ion beam – scanning electron microscopy (BIB-SEM) offers a great opportunity to investigate relatively large (1-2 mm^2), damage-free specimen surfaces at high resolution. We use this technique on areas large enough to be representative for the quantification of OM- and mineral-hosted porosity and the analysis of pore geometries, resulting in a better understanding of shale diagenesis, primary oil migration and evolution of microporosity. BIB-SEM maps at 312x, 1250x, 10kx and 20kx magnifications were acquired for 17 Upper Visean shale samples from the Ukrainian Dniepr-Donets Basin, covering a broad maturity interval of 0.65 – 2.7 %Rr (vitrinite reflectance) and different mixtures of type II (marine) and III (terrestrial) kerogen.

Results show that SEM-visible (~30 nm of equivalent diameter at 20kx magnification) porosity is less than 2 % in most samples. OM-hosted porosity, restricted to secondary solid bitumen, makes up a significant proportion (10-60 %) of total visible porosity. A good correlation was found between total porosity and OM-hosted porosity (R2 >0.9), and the amount of OM pores furthermore shows a weak correlation with the bulk quartz content (R2 ~0.65). The type of OM pores (pendular/interface vs. spongy) is reflected by the individual size distributions, as spongy pores usually feature smaller sizes (<50 nm), compared to pendular or OM/mineral-interface pores.

We interpret our results so that most porous solid bitumen in oil-prone rocks at peak oil maturity formed after primary oil migration, which accumulated an earlier oil phase in quartz-rich layers, that became nanoporous during secondary cracking. The amount of OM-hosted porosity therefore depends on the availability of intergranular pore space in which the early oil phase is accumulated. The process of progressive transformation into a porous solid bitumen residue is also indicated by elevated saturated/aromatic compound ratios and a high total yield of extractable hydrocarbons, suggesting that OM pores are actually filled with a lighter oil phase. In the terrestrially dominated organofacies, pore generation in pyrobitumen due to gas generation occurs significantly later and less intense. These results are in contrast to conventional models of the evolution of pore space in organic matter of marine shales, which were the starting point of the analysis of our samples. Hence, it is important to combine organic petrography and high-resolution imaging to clearly discriminate different OM types and their individual microstructural properties.

In-situ formation of authigenic clay and carbonate minerals within solid bitumen is likely related to organic acids formed during bitumen decomposition, implying the presence of an aqueous phase even in pores that are apparently filled exclusively with solid bitumen. OM decomposition might furthermore trigger mineral authigenesis (e.g. albite, Fe/Mg carbonates), which we found to have a great influence on porosity characteristics and mechanical properties of a shale.

Carnian outer shelf succession in the Budva Zone (Montenegro)

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Along the coastal site of the Budva Zone in Montenegro, the deposition of open-marine sediments started in the Middle Anisian (Late Pelsonian), time equivalent with the oceanic break-up of the Neo-Tethys. Shallow-water carbonates, open-marine limestones, radiolarites, bentonite horizons, volcanic resediments, and silicified mudstones to hemipelagic carbonate sequences in upsection positon characterize in general the Middle Triassic sedimentation on the outer continental shelf. The paleoenvironmental evolution in the depositional setting was controlled by stratified volcanic activities and a related ocean-acidification. Shallow-water carbonate production on the mid continental shelf lasted from the latest Ladinian onwards. Hinterland influence and thickness of sediment deposition varies with the palaeogeographic position on the shelf.

In the Cordevolian the studied open-marine succession in Canj consists of grey-reddish hemipelagic carbonates with stratified accumulations of halobiids. In this temporary very low-energetic environment shed mass transport deposits, whose clasts derived from the former horst complexes. A long lasting sub-marine gap of the entire Julian to Tuvalian 1 is related to a very long lasting emergence of the Wetterstein Carbonate Platform. From the Tuvalian 2 onwards the continuing hemipelagic carbonatic sequence is characterized by an increasing energy level in the depositional environment that is reflected in unsorted accumulations of echinoids and halobiids, but also in a gradual oxygenating sediment colour. The shedding of the mass transport deposits lasted in repeating successions until the earliest Tuvalian 3, which corresponds with the time contemporaneous volcanic activity known in the eastern Mediterranean orogen. The clast spectra consist predominately of recycled Carnian sequences. An order of dissolution and recrystallization reactions in the lithifying breccia caused to a fermentative decomposition of the organic matter, metal sorption onto suspended particles, and to the formation of authigenic minerals. The latest Tuvalian 3 to earliest Lacian 1 is nicely documented by conodonts and associated macrofossils as *Halobia* sp., *H. beyrichi* (Mojsisovics) and *H. styriaca* (Mojsisovics) (Cafiero and De Capoa Bonardi, 1980). From the Late Carnian onwards lasted on the shelf a normal-marine depositional environment with high sedimentation rates of grey hemipelagic carbonates.

This Carnian trend in the open-marine Hallstatt limestone succession can be directly correlated with other high resolution Hallstatt limestone successions, dated by means of conodonts in the e.g. Eastern Alps, Western Carpathians, Dinarides and Turkey. A deposition in an independent deep-water basin (Mirdita-Pindos) is not mirrored in the depositional characteristics nor tectonostratigraphic events.

Acknowledgement

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Contractional tectonics in the Murán Nappe of Callovian age, Western Carpathians (Slovakia)

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Numerous models try to explain the tectonic and paleogeographic controversies of the Silicicum in the Inner Western Carpathians, but none of them accounts the structural and facies relationships with satisfaction. The composition of the tectonic outliers, their diagenetic/thermal overprint, and their emplacement structures belong to the open questions in the geodynamic evolution of the Western Carpathians. On the official geological map the Silicicum of the Muráň plateau mirrors a continuous shallow-marine carbonate platform evolution from the Anisian to the Rhaetian. Locally, open-marine carbonates of the Early Jurassic occur. Our new data from the western Muráň plateau contrasts clearly the actual concept to interpret the Silicicum as a unified superunit: the Silicicum on Mt. Červená exist in two depositional settings with differences in the facies zones and stratigraphic ranges. Older sediments from the detached middle continental shelf rest on younger ones that formed the proximal shelf, separated by a Callovian thrust fault.

The (overlying) thrust nappe consists of a latest Ladinian - Early Carnian sedimentary sequence: Forereef limestones from the Wetterstein carbonate platform margin characterize the lowermost depositional sequence of this nappe outlier. Increased slope highs reduced the rate in the platform progradation and led to a retrogradation in reddish siliciclastic to silicified mud lenses and collapse breccia deposits. Sponges, microbes and other reef-builders of the reef core are only poorly preserved. Beyond the end-Wetterstein platform sea-level drop a new platform established on the continental slope and shed shallow-water debris in the open-marine setting (= Leckkogel Formation).

The (parautochthonous) carbonate basement consists of a ?latest Norian - Callovian sedimentary sequence: Open lagoonal to backreef sediments from the Dachstein carbonate platform characterize the lowermost depositional sequence of the Late Triassic proximal shelf. After the emergence of the Dachstein platform and a sea-level rise in the late Hettangian deepened the paleoenvironment (= Hierlatz Limestones), and a pelagic carbonate platform formed upsection (= Adnet Formation). Exposures of Middle Jurassic sediments are so far not well studied. The parautochthonous sequence on Mt. Červená ends with Callovian radiolarites deposited in a restricted paleoenvironment. Previous publications on Silicicum outliers confirm the Callovian age, but the interpretation is modified now (Dumitrică and Mello, 1982; Sýkora and Ožvoldová, 1996).

Our results show that the Middle-Late Jurassic contractional tectonics affected also the Muráň unit of the Silicicum, and substantiate the interpretation of the Silicicum as single nappe (Gawlick et al., 2002). Early and Middle Triassic series of the Muráň nappe remain enigmatic in their paleogeographic position. Albian-Aptian tectonics caused the emplacement of the Silicicum on the underlying Veporicum.

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Exploring the Nanogeochemical Environment Using single particle ICP-TOF-MS

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With the increasing need to better assess the potential risks that nanomaterials pose to human health and the environment, new techniques and methods capable of detecting and characterizing nanomaterials in complex matrices were needed. Subsequently, single particle ICP-MS was developed and proved capable of assessing nanomaterial behavior at environmentally relevant concentrations (ng L -1) and in complex matrices such as biological fluids, wastewater treatment sludge, and colloidal systems in peat bigs, rivers, oceans and many other geochemical systems. However, the conventional quadrupole instruments had been limited to only one element per particle detection events, removing any possibility of distingushing nanoparticles of similar elemental compositions. With the introduction of ICP-time-of-flight-MS (ICP-TOF-MS), nearly the entire mass range (7-250 m/z+) can be detected and quantified on a single particle basis. With this powerful capability, there are now several potential opportunities to rediscover the natural nanogeochemical environment at a scale not previously possible. By examining natural colloids and mineral nanoparticles on a single particle basis, processes such as aggregation, dissolution, sulfidation, and complexation can all be examined in their native media, limiting the possibilty for measurement artifacts. Insight into these processes may help us better understand urgent environmental concerns such as acid mine drainage and colloid-facilitated transport of toxic metals. Moreover, this method could potential be used to characterize natural environments based of the number and size distrubtion of nano-sized particles, thereby providing an avenue to better assess the sensitivty of specific environments to global change impacts.

Pliocene and Pleistocene fluvial deposits in the Vienna Basin – Status of numerical age dating using the cosmogenic nuclide pair ^{26}Al and ^{10}Be

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Quaternary sediment transport via the Danube River into the Vienna Basin (VB) resulting in fluvial sediment deposition was largely influenced by glacial-interglacial variations in a generally uplifting area. Today, these sediments form the upper part of the sediment sequence of the VB and also form terraces in the more uplifted blocks of the VB. In addition, the VB is shaped by the tectonic regime of a large subsiding pull-apart structure related to the Vienna Basin Transform Fault System (VBTFS; Decker, et al. 2005, Salcher et al., 2012) between the Eastern Alps and the Western Carpathians. Thus, fault activity dissects the terrace staircases after primary fluvial deposition. Age determination of terrace sediments may enable (1) to find a possible link between terrace formation and climate change, and (2) constraining the vertical displacement of different tectonic units during the timespan of terrace formation.

The VB terrace record north of the Danube is considerably different from the south. In the north one large terrace, the Gänserndorf Terrace was abandoned between 190 000 and 220 000 years ago (Weissl et al, 2017; Braumann et al, in press). This terrace is bordered by two smaller terrace bodies to the east and west where the eastern terrace was dated to 340 +/- 170 kyr (Braumann et al, in press). In contrast, south of the Danube different fault blocks with up to six terrace levels are present in isolated blocks where they form staircases with terrace base elevations ranging between 25 and 130 m above today's base of the Danube. These terraces have been strongly dissected by faults related to the sinistral movement of the VBTFS and have been the focus of this study.

The cosmogenic nuclide pair of 26Al and 10Be was used for isochron burial dating of terrace sediments to the south of the Danube River. This method uses the differential decay of both in-situ produced isotopes to calculate the time of terrace abandonment. The Danube derived sediments in the VB are quartz-dominated coarse, uncemented fluvial deposits that are well-suited for burial age dating due to the presence of large individual cobbles that share the same post-depositional history, but have different pre-exposure and transport histories (Balco and Rovey, 2008).

Numerical age dates of selected terraces south of the Danube (city of Vienna, Rauchenwarth/Fischamend area, Arbesthal Hills, and Hainburg Hills) will be presented and the relative incision rate of the Danube (i.e. uplift rate of selected blocks) for this time interval will be calculated.

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Statistical methods – An important tool for understanding cave genesis?

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A preliminary cave classification scheme based on the main genetic processes and applied on 6205 caves in Lower Austria and adjacent areas brought surprising results (Oberender & Plan, 2018). So was the number of caves that had developed due to weathering and erosional processes almost as big as the number of caves, which had developed due to solution of carbonate rocks (i.e. karstic caves). In addition, regional differences in the dominant cave types of close-by mountains could not be easily explained by a single parameter as e.g. lithology. Therefore, the input data were extended to:

Basic cave data: length, vertical extent, maximum horizontal extent.

Location data: elevation, inclination and slope exposure (cardinal direction).

Lithology and tectonics: the cave's host rock lithology and its distance to the closest tectonic feature (cave entrance coordinates – nearest fault).

Hydrology: distance to the discharge system.

Applying a multiple target analysis on the data categories mentioned above shall help to identify the parameters that have a higher influence on cave genesis then others.

The Basal Amphibolite in the central Tauern Window: new chemical data and implications for Early Palaeozoic paleogeography

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The Basal Amphibolite is an Early Palaeozoic sequence of metabasites and meta-ultramafic rocks in the central Tauern Window; it is mainly exposed around the Granatspitz dome underlying the magmatic series of the Habach Complex. The palaeo-tectonic setting, its pre-Alpine palaeogeographic position and the emplacement age of the Basal Amphibolite are strongly debated. This study presents new high-quality bulk rock chemical data of several lithologies within the Basal Amphibolite in order to constrain its geotectonic setting. Additionally, a palaeogeographic model is presented.

Three types of metabasites can be distinguished: amphibolites, hornblende-biotite schists and hornblende-biotite gneiss. The amphibolites are coarse-grained, massive to banded with the assemblage hornblende + plagioclase with minor biotite, epidote, chlorite and rutile. It shows slight enrichment of LILE and LREE compared to MORB. Especially Th is elevated and scatters strongly indicating varying degrees of crustal contamination. More massive types may represent metagabbros.

Hornblende-biotite schist is fine to medium-grained and well foliated. It consists of hornblende, biotite, plagioclase, quartz, with varying amounts of garnet and titanite. Formerly this schistose rock was interpreted as a stronger deformed variety of amphibolite (Frisch and Raab, 1987). However, the new geochemical data indicate that there are significant chemical differences; i.e. it is higher in LILE and HFSE and has about 10 times higher (La/Yb)cn values. The hornblende-biotite schist is interpreted as a higher fractionated melt from the same parental magma.

Hornblende-biotite gneiss forms so far unrecognised m-wide, discordant, late-magmatic intrusive stocks and dykes. It is mesocratic due to higher modal contents of quartz + feldspar and absence of garnet. It has a dioritic composition and represents the highest fractionated rock in the Basal Amphibolite. The very similar trace element composition indicates a common magma source of all metabasites, which was enriched relative to N-MORB. An origin in a back-arc setting is envisaged possibly influenced by continental (?) arc magmatism.

An updated palaeogeographic model includes: 1.) Subduction and formation of an Andean-type continental arc at the northern Gondwana margin in the Late Neoproterozoic/Early Cambrian. 2.) Formation of a back-arc basin behind the active continental margin. This might represent an unsuccessful and aborted attempt to open the “Proto Rheic Ocean” in the Cambrian. 3.) As part of the Avalonia Terrane, the Rheic Ocean finally opened in the Ordovician. Subsequent spreading of the Rheic ocean moved Avalonia to the north where it finally collided with Laurentia in the Silurian (Caledonian orogeny). The Habach Complex might represent the corresponding arc to the Proto Rheic Ocean back arc basin where the Basal Amphibolite unit formed. The following Variscan and Alpine orogenies obscured most of the primary features making interpretation of Early Paleozoic features difficult.

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Interacting folds, faults and thrusts – the conundrum of the Karwendel zone of slices ("Karwendelschuppenzone")

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The Karwendel mountains of the Tyrol have been considered a key area for the nappe tectonics within the Northern Calcareous Alps (NCA). On one hand, km scale outcrops expose one a major thrust, but on the other hand, minor thrusts and faults offset the major thrust. We have studied this zone in some detail, and present an attempt to unweave the kinematic evolution.

The oldest structure in the area is the (1) thrust, that superimposes Upper Permian to Lower Triassic evaporites of an upper thrust sheet with approximately 3 km of competent carbonates onto Lower Cretaceous marls of a lower thrust sheet. The geometry is that of the upper flat in a ramp-flat structure, and thus the hanging wall was not folded during Early Cretaceous emplacement. However, the thrust is folded in a NNE-verging km-scale Gamsjoch anticline. This fold, and the thrust, are offset by (2) WNW-striking sinistral transtensive strike-slip faults, and (3) low-angle long-limb thrusts that repeat the main thrust.

Sinistral strike-slip faulting (2) reactivated a preexisting, deep-reaching shear zone, which enabled the ascent of basanitic melts (Ehrwaldite dykes and sills), that occur in a 50 km long, roughly E-W-striking zone in the northern Karwendel and southern Wetterstein mountains. The shear zone has been related to Jurassic-Cretaceous intercontinental transform faulting. Beside the sinistral offset, the reactivation caused oblique normal offset of the southern block.

The long-limb thrust (3) truncates the strike-slip faults (2) and the main thrust (1). Locally, the incompetent Jurassic-Cretaceous succession is buttressed against the strike-slip fault in the footwall of a long-limb thrust. Orientation analysis of outcrop-scale structures in the Jurassic-Cretaceous sedimentary succession documents NW- to NE-verging folds, the first only preserved in more competent Upper Jurassic marly limestones, while structures in Cretaceous marls directly below the main thrust, and below the long-limb thrust are exclusively NE-verging. Folds in the hanging wall of the main thrust are N- to NNE-verging. Obviously, older structures could only be preserved in more competent rocks.

The following evolution of the Karwendel zone of slices is proposed:

• Intrusion of Ehrwaldite dykes and sills in the Lower Cretaceous along an E-W intercontinental transform

• Stacking of thrust sheets at the end of the Lower Cretaceous (1)

• Paleogene reactivation of the transported transform in the allochthon causing S-block down oblique sinistral normal faulting (2)

• Late Paleogene to Neogene reactivation of the main thrust (3) causing the long-limb thrust to climb the step created by preceding oblique normal faulting (2)

The observations and interpretations presented show how the localization of deformation is controlled by pre-existing structures. Folding is localized by the pre-existing transform, oblique slip normal faulting by the pre-existing fold, and long-limb thrusting is localized by pre-existing normal faults. As a consequence of the superposition of deformations and associated complexity, the Karwendel zone of slices has not been interpreted properly, and the boundary between thrust sheets has been placed at the long-limb thrust.

Deep-Seated Gravitational Slope Deformations in the Austrian and Italian Alps: Characteristics and Dating

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Deep-seated gravitational slope deformations (DSGSDs) are large to extremely large, slow moving mass movements generally affecting the entire length of high-relief valley flanks, extending up to several hundred meters in depth, which can frequently spread beyond the slope ridge and they have been recognized to affect different lithologies at many sites worldwide. Large parts of a DSGSD can accelerate and result in catastrophic rock-slope failures and secondary landslides are common in the lower part of these slopes.

One of the most pending questions concerning DSGSDs are their long-term evolution as their dynamics on centennial to millennial time scales is difficult to capture. Because DSGSDs last for ≥102 to 105 years and are characterized by complex and temporally variable displacement behaviour (two basic long-term movement patterns, i.e. slow continuous creep and discrete episodic movements), constraining the timing of such movements is of paramount importance. Although there are several geochronological and stratigraphical methods, which have been used to constrain the chronology of DSGSDs, dating of DSGSDs is still in its infancy.

We present some examples from the Austrian and Italian Alps, where the (joint) application of different dating methods (cosmogenic nuclide exposure dating, U-series disequilibrium dating, radiocarbon dating) achieved reliable results on the long-term evolution of DSGSDs. This data is fundamental in the view of engineering geological modelling and extents the time-frame of DSGSD displacement measurements (D-GPS, DInSAR, precise levelling …) from a few decades to several thousand years.

The upper Ottnangian Calcite Minimum Interval: A solution to many problems?

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The lower Miocene stratigraphy constitutes a major challenge for Paratethys research. Old geographic borders (such as the Iron Curtain) and insufficient biostratigraphic resolution resulted in different, contradictory concepts. Further on, regional Paratethys stages such as the Eggenburgian, Ottnangian and Karpatian pose a high geochronological resolution. If concepts such as lower/middle/upper Ottnangian/Karpatian are taken into account, the resolution lies in the order of 0.1 Ma.

Recent work demonstrated, that much of these concepts and models for the Molasse and Vienna Basin and therefore the age of these strata must be revised. But important fossils needed for an explicit allocation to certain regional stages are often absent. Therefore, additional tools for a detailed stratigraphic correlation are needed.

We recently demonstrated the existence of an interval of sediments with reduced calcite and pyrite contents. These sediments are barren in micro- and nannofossils and correspond to the Traisen Formation and its deep distal continuation, the newly defined Wildendürnbach Formation. According to the calcareous nannofossil-content of over- and underlying strata, these deposits fall into the calcareous nannofossil zone NN4.

It is known, that the Traisen Formation was deposited in brackish waters which are attributed to the upper Ottnangian Rzehakia Lake System. It can be assumed, that the CMI is the biostratigraphical, mineralogical and chemical expression of the Rzehakia Lake System. The upper Ottnangian is usually assigned as the time of brackish lakes in the Paratethys realm. Therefore, the CMI as expression of this environmental conditions constitutes a valuable tool for an exact localization of the very short (ca. 0.2 Ma) time span of the upper Ottnangian with its mostly fossil-free deposits in Lower Austria. This allows the detailed definition and correlation of lithostratigraphic units throughout the lower Austrian Molasse Basin, to the Vienna Basin and to the continuation of the Molasse Basin in the Czech Republic.

The improved border-crossing correlation of lithostratigraphic units solves additional problems. Since years, a discussion is going on whether the “Oncophora Sands” (defined as Traisen Formation south of the Danube) were deposited under marine or brackish conditions. It can be shown, that the CMI clearly underlies the “marine Oncophora Sands” around Wildendürnbach. These sands are of Karpatian age and belong to the Laa Formation.

Intensity Prediction Equations as an intensity proxy for historical earthquakes

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Equations that predict ground-shaking distribution (Ground Motion Prediction Equations -GMPs) expressed in terms of PGA, PGV or intensity and as a function of magnitude and distance, are a key for hazard and risk assessment providing information beyond focal parameter. Real-time ShakeMaps provide a prompt assessment of the scope and impact of an event, estimation of losses by calculating the extent of the affected area, which is likely to meet the highest intensities when an earthquake occurs and therefore, decision making. GMPEs also play an important role for the development of seismic hazard maps, public information and education.

Intensity Prediction Equations (IPEs) can also be used to study historical earthquakes, where some difficulties to gather information, find testimonies or identifying marks of the event might be found.

The purpose of this work is to test the IPE for Austria with historical earthquakes and compare the results with recent earthquakes with similar epicenters to the historical ones. Therefore, three strong historical earthquakes were selected from the Austrian database, Hall in Tirol (1670 – with an epicentral intensity (I_0) of $VIII$); Wiener Neustadt (1768 – with $I_0 = VII$); and the Schwadorf earthquake (1927 – with $I_0 = VIII$). In agreement with this selection, three earthquakes with similar locations were selected in the period from January 1992 to February 2018: Schwadorf (21.11.2001 with $I_0 = V$ and local magnitude (m_l) of 3.5); Wiener Neustadt (25.07.2005 with $I_0 = V - VI$ and $m_l = 3.5$); and an earthquake in Hall in Tirol (09.08.2013 with $I_0 = V - VI$ and $m_l = 3.7$).

Intensity prediction equation – ShakeMap – for Austria

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Improvements to the intensity prediction equation (IPE) for Austria are undertaken continuously.

Austria is characterized by a moderate seismicity and rather low hazard areas. However, earthquakes can still cause great damage and losses, especially in densely populated and industrialized areas. The aim of this study is to obtain an intensity prediction equation for risk and hazard assessment with the final goal of updating the Austrian seismic hazard map from the macroseismic data base.

So far, the IPE model has been obtained using an ordinary Least Square Adjustment. The inclusion of topographic information was taken into account before the model computation. Once the data was modelled, a geology correction, based on a classification of eleven geological units, was obtained and applied to the data set.

As a further step, a relationship between Vs30 measurements and intensity data is presented. A side from this, our ground-shaking model was also verified.

The data set includes more than 250 earthquakes between the years 1000 and 2014. The selected earthquakes had to meet the following criteria: the moment magnitude was constrained to be greater than or equal to 3; only IDP's with local intensities equal to or greater than III were kept; and exclusively events with at least 10 IDP's were used.

As verification of the IPE, the events, which met the same requirements as the ones to compute the model, from the period 2015-2017 were evaluated. The data set comprises a total of 19 earthquakes and almost 17.000 IDP's. The results will be presented in the meeting.

The use of amplitude measurements for detecting and locating local earthquakes in the Austrian seismic network

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This study focuses on testing the robust method to detect and locate earthquakes by means of amplitude measurements with data from the Austrian seismic network (ZAMG – Zentralanstalt für Meteorologie und Geodynamik).

The proposed localization method is based on the minimization of maximum resultant ground velocities in sliding time windows covering the whole registered event. The basic idea is that any small seismic source can produce large amplitudes, as long as it is located close enough to the seismic station sensor. The developed method is based on an empirical model of the ground shaking obtained from amplitude data of earthquakes in the area of interest, which were located using traditional methods. Using the Back-Projection approach, we can rapidly determine an event location and its magnitude without picking phases.

The maximum resultant ground velocities are back-projected to every grid point of the study area applying the empirical amplitude – distance relation. We refer to these back-projection values as Back-Projected Ground Velocities (BPGV) or pseudoMagnitudes. The number of operating seismic stations in the network equals the number of pseudoMagnitudes at each grid-point. The method introduces the new idea of selecting the minimum BPGV at each grid-point for further analysis. If no detectable earthquake (earthquake strong enough to exceed the detection threshold) occurred, the spatial distribution of the minimum pseudoMagnitudes constrains the magnitude of weakest earthquakes hidden in the ambient noise. In case of a strong enough earthquake, the spatial distribution of the minimum pseudoMagnitudes shows a significant maximum at the grid-point nearest to the actual epicentre. The application of this method is restricted to the area confined by the convex hull defined by the seismic station network. Additionally, one must ensure that there are no dead traces involved in the processing.

This approach is almost insensitive to outliers (data from locally disturbed seismic stations). The idea of obtaining and storing a Back-Projected Matrix (BPM), independent of the registered amplitude, for each seismic station has the advantage of saving computational time for the calculation of the final maximum pseudoMagnitude, at every grid-point.

The improved method is applied to a new data set obtained from the national Austrian seismic network (ZAMG). The method has been tested for a larger data set and for an extensive seismic network.

Allochthonous salt and the formation of overturned to recumbent thrust sheets in the Northern Calcareous Alps

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The Northern Calcareous Alps (NCA) formed as a salt-detached fold-and-thrust belt during two main stages of shortening: in a foreland position on the lower plate during the Middle Jurassic to Early Cretaceous closure of the Meliata ocean and as part of the upper plate during continent-continent collision between Adria and Europe from Eocene times. The Permo-Mesozoic sedimentary succession involved in the fold-and-thrust belt is dominated by thick non-metamorphic Triassic to Jurassic platform carbonates, underlain by a Permian-Triassic layered evaporitic sequence (i.e., Haselgebirge and Reichenall Fms.) and covered by mid Cretaceous to Miocene synorogenic deposits.

A prominent feature of the NCA is the existence of large panels of inverted stratigraphy. These structurally overturned panels extend up to 10 km across strike and have been traditionally regarded as inverted thrust sheets. Their kinematics, however, are poorly constrained. From temperature data, there is no evidence for syn-folding metamorphic conditions and the overturned sections do not show intense strain as in well documented examples of recumbent forelimbs, e.g. in the Helvetic nappes of the Western Alps. Published cross sections from the NCA either show isoclinal folds with long overturned limbs, or fault related folds involving a layer-cake stratigraphy but avoiding those areas with overturned panels.

The extent and geometry of these overturned panels and their contacts have been critically examined for the Sulzbach "nappe" in the area between Göstling and Annaberg. Coherent panels with an inverted stratigraphy have a typical to maximum extent of 2 to 3 km. More extensive inverted panels are actually separated by steeply dipping faults, which have been previously interpreted as strike-slip faults that dissect formerly coherent overturned panels. Instead, panels with a normal sedimentary polarity are more extensive and made up by a thicker Triassic to Lower Cretaceous stratigraphic succession. We found that: a) remnants of Permian salt (Haselgebirge Fm.) mark the trace of the contacts between these units; b) the Triassic stratigraphic thickness of overturned panels is reduced compared to neighboring non-inverted panels; and c) significant variations in thickness and facies do occur across salt-bearing contacts.

According to these observations, these contacts are interpreted as secondary welds between salt-controlled mini-basins, where the thick non-inverted panels correspond to the subsiding mini-basins and the thinner stratigraphic units to the roof top of salt inflated areas. The lateral extent of both panels is controlled by the original amount of Permian salt, the dimensions and aspect ratio of the inflated salt areas, and the ratio between salt rise and sedimentation rates. An initial rotation of the thin roof cover is related to salt evacuation triggered by downbuilding and extensional deformation of the continental margin, and later during early shortening, and was controlled by the thickness of both the inflated salt and the overburden. Orogenic shortening leads to squeezing of inflated salt walls and diapirs, and to further rotation of the thinned stratigraphy to produce the overturned panels or megaflaps.

Geologisches 3D-Modell von Österreich – 3D AUSTRIA

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Im Rahmen der Kompetenzinitiative „Geologische 3D-Modellierung“ wird erstmals ein generalisiertes geologisches 3D Modell von Österreich erstellt, welches die europäische und die adriatische Platte, die alpinen Deckenstapel und deren synorogene Ablagerungen räumlich darstellt. Die Datenerhebung, Modellierung und Qualitätskontrolle erfolgen in enger Zusammenarbeit zwischen kartierenden und modellierenden GeologInnen der Geologischen Bundesanstalt.

Als Kartengrundlage für die Modellierung dient die Multithematische Karte von Österreich 1:1.000.000 (http://geolba.maps.arcgis.com/apps/webappviewer/index.html?id=0e19d373a13d4eb19da3544ce15f35ec). Die zu modellierenden geologischen und tektonischen Einheiten richten sich nach Schuster et al. (2015). Aufbauend auf diesen und weiteren publizierten Karten (z.B. Froitzheim et al., 2008), sowie auf Profilschnitten und regionalen 3D-Modellen („Molassebecken“ – Pfleiderer et al., 2016; Tauernfenster – Götzl et al., 2015; Steirisches und Wiener Becken – Götzl et al., 2012) werden sieben Einheiten modelliert:

Neogene Sedimentbecken (autochthone Molasse, Steirisches und Pannonisches Becken, inneralpine Becken)

Decken (Untergrund mit permo-mesozoischer Bedeckung) des ostalpinen Deckenstapels

Decken (Untergrund mit permo-mesozoischer Bedeckung) des südalpinen Deckenstapels

Decken im alpinen Deckenstapel, entstanden aus dem penninischen Ozean (Penninikum, Flyschzone)

Decken im alpinen Deckenstapel, entstanden aus dem europäischen Kontinent (Subpenninikum, Helvetikum, allochthone Molasse)

Europäische Platte inklusive Prä-Neogener, autochthoner Sedimentbecken

Adriatische Platte inklusive Prä-Neogener, autochthoner Sedimentbecken

Jede dieser Einheiten ist durch ihren paläogeographischen Ursprung bzw. ihre tektono-metamorphe Entwicklungsgeschichte charakterisiert. Die Grenzen zwischen den Einheiten werden durch bedeutende sedimentäre und tektonische Grenzflächen definiert, wie z.B. die Diskordanz an der Basis der Neogenen Sedimentbecken, die „Alpenfrontüberschiebung“, die Überschiebung von Penninikum auf Subpenninikum oder die Überschiebung an der Basis der ost- und südalpinen Deckenstapel. Als Unterkante des Modells dient die Strukturkarte der Mohorovičić-Diskontinuität (Ziegler & Dèzes, 2006), welche die Grenzfläche zwischen Erdkruste und -mantel sowohl der europäischen als auch der adriatischen Platte darstellt.

Nach Fertigstellung wird das Modell über den Darstellungsdienst für geologische 3D-Modelle auf der Homepage der Geologischen Bundesanstalt öffentlich sichtbar gemacht werden.

Spectroscopy and machine vision – a replacement for manual gravel analysis?

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Petrographic gravel analysis is usually carried our manually, making it time-consuming, subjective and not perfectly reproducible. For automated gravel analysis, the Geological Survey of Austria operates a petroscope which uses spectrometric (Hofer, 2011) and laser triangulation (Lee et al., 2005) techniques to determine rock type and geometric properties of each individual grain within a sediment sample.

A feeder system separates the sample and forwards the particles onto a conveyor belt where they are scanned individually by a spectrometer and by two laser cameras. Due to the resolution of the cameras, the minimum detectable particle size is 2 mm. Geometric properties include the length of the three main axes and derived parameters such as elongation, flatness, angularity and sphericity as well as the shape and flakiness index of each particle. For the entire sample, the grain size distribution is also calculated. Reflectance spectra are interpreted in terms of rock type using multivariate functional regression analysis which allows to estimate the percentages of rock types present in the lithological spectrum.

While the determination of particle geometry is well tested and provides reliable results (Hofer & Bach, 2015), the determination of rock type is currently limited by the spectrometer which only measures in the visible and near-infrared light spectrum (380 – 930 nm). Algorithms are trained so far on crushed rock samples of andesite, basalt, chert, dacite, dolomite, gabbro, gneiss, granite, greywacke, limestone, rhyolite and serpentinite. Rock types in these samples are classified with an accuracy of 96 %.

To improve rock type identification, ongoing work focuses on collecting more samples including all major rock types occurring in Austria and on using an additional spectrometer measuring at wavelengths of 1300 – 2500 nm. Furthermore, adaptive techniques such as novelty detection are being developed for automatic extension of the classification model. The aim is to increase the number of recognizable rock types and to quantify statistically the heterogeneity within rock types.

Results will be used to forecast technical material properties of sediment samples (attrition, resistance to fragmentation, friction angle), to derive their aggregates resource potential (e.g. suitability for concrete, railway ballast) but also to study their sedimentary context (provenance, transport mode and distance, depositional environment). With its improved functionality, the petroscope can be used in quality control systems for aggregates by producers (gravel pit operators) and customers (construction sites, concrete plants).

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Reconstruction of sedimentary basin properties using Bayesian fusion: theoretical framework and applications

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Defining a “complete, multi-physics model” of a sedimentary basin, i.e. its structure and its physical properties, is fundamental for the exploration of its geo-resources. Single models of complementary physical properties (e.g. elasticity and resistivity) have often been integrated to obtain a multi-physics model of basins. However, integrating single models that (a) exploit observables displaying different depth- resolutions, (b) are based on data recorded during different surveys, i.e. observables collected with different field geometry, and (c) are obtained using different geophysical tools, i.e. different methodologies for solving different geophysical inverse problems, is not a trivial problem. One of the key-issues that needs to be faced is the correct estimation of the uncertainties on the final “complete model” parameters, which requires the coherent “weighting” of the different single models with the final solution.

We present a new “Bayesian fusion” algorithm, where results obtained during previous investigations of a rock volume are re-appraised within the same volume. The new technique exploits previous information on each physical property in form of known Posterior Probability Distribution (PPD) of the parameter over the study volume. Such PPDs are integrated in a single 3D structure (i.e. all the physical parameters display the same geometrical distribution within the volume), where value of the physical properties are fully consistent with the assumed PPDs. The theoretical framework of the new algorithm is presented in details, for simple (e.g. integration of single 1D models in a 2D profile or 3D model) and complex cases (e.g. integration of models derived from both “derivative” and “integral” observables). Both synthetic and field measurements are used to illustrate the potential of the new algorithm.

Rare karren features indicate a previously unknown Pleistocene landslide-dammed lake (Lower Austria)

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Numerous enigmatic tube-shaped holes in the limestone ceilings of overhangs and small caves in a restricted area north of the village St. Aegyd am Neuwalde (Lower Austria) have been known at least since 1933 when they have been declared Natural Monument. So far, no detailed study concerning their origin has been conducted. The vertical holes occur in Middle Triassic limestone and they are almost perfect cylinders tapering gently to a rounded apex. Their diameters are up to 5.5 cm and their depths reach 45 cm. They occur on both sides of the Unrechttraisen valley located in the north-eastern part of the Northern Calcareous Alps. Almost identical features were described from the shores of lakes in western Ireland and termed röhrenkarren or tube karren (Simms, 2002). According to Simms's model, they have formed by condensation corrosion within air pockets trapped in limestone overhangs by rising water levels during floods. The occurrence of these features is surprising, because presently, there is no lake and so far, no palaeolake has been known from this area. Based on high-resolution airborne laser scanning data and detailed field observations, a landslide deposit was identified in a narrow section of the valley, downstream of the röhrenkarren sites. Additionally, fine-grained, partly laminated sediments with abundant dragonfly (Anisoptera) or flatworm (Turbellaria) eggs, indicative of lacustrine sediments, were documented up to ca. 100 m above present riverbed. These data indicate that a previously unknown landslide had dammed the Unrechttraisen River resulting in a ca. 100 m deep lake. The röhrenkarren have formed due to fluctuations of the lake level, resulting from differences in river run-off and seepage through the landslide dam. Since 230Th/U-dating of calcite crusts covering some röhrenkarren was not successful, the age is not well constrained.

Gipsvorkommen im Untergrund Niederösterreichs: Abgrenzung, Risiken, Datierung

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Leicht wasserlösliche Gesteine wie Gips oder Salz im Untergrund können durch Auslaugung Hohlräume im Untergrund verursachen. Im Bereich von Siedlungen stellen neben Regenwasser auch anthropogen eingebrachte Wässer wie versickertes Regen-, Dachwasser oder Wasser aus Swimmingpools ein zusätzliches Gefahrenpotential dar. Die dadurch entstehenden unterirdischen Hohlräume führen in Folge zu Senkungen, Verbrüchen und Erdfällen, die gerade in Siedlungsgebieten eine besondere Gefährdung darstellen.

Das Untersuchungsgebiet liegt in der Gemeinde Hinterbrühl innerhalb der Nördlichen Kalkalpen am Alpenostrand im Bereich der Überschiebung der Göller- auf die Frankenfels- und Lunz-Decke. An der Basis der Göller-Decke befindet sich eine tektonisch deformierte Schuppenzone („Basalteppich“) aus permischen bis untertriassischen Sedimenten, „Permoskyth“, sowie Schollen von Mitteltrias, Jura und kalkalpenfremden Schürflingen. Im Bereich des „Basalteppichs“, der sich über einen großen Teil des Gemeindegebietes inklusive der Ortschaften Weissenbach und Hinterbrühl erstreckt, ist mit Gipsführung zu rechnen.

Im Auftrag der Marktgemeinde Hinterbrühl wurden 2015 die Grundlagen zur Gipsführung im Gemeindegebiet erhoben, um eine Basis für die Bewertung der geogenen Gefährdung durch gipsführende Gesteine im Untergrund durch Auslaugung zu schaffen. Neben einem umfangreichen Literaturstudium inklusive der Durchforstung moderner Datenbanken und historischer Karten, dem Sammeln von Hinweisen aus der Bevölkerung, der geologischen Aufnahme von Baustellen, der Analyse des hochauflösenden Laserscans sowie dessen Verifizierung im Gelände wurden entlang von Bächen und an Wasseraustritten Messungen der elektrischen Leitfähigkeit durchgeführt. Da die elektrische Leitfähigkeit des Wassers ein Maß für seine Mineralisierung darstellt, kann so auf hohe Sulfatgehalte rückgeschlossen werden. Um diese richtig interpretieren zu können, wurden an ausgewählten Messstellen Wasserproben entnommen und hydrochemisch analysiert. Mittels einer Abflussmodellierung konnten Bereiche abgegrenzt werden, die als morphologische Einzugsgebiete für Gipslösung in Frage kommen.

Die Untersuchungsergebnisse bildeten die Grundlage für ein Gutachten des Geologischen Dienstes der NÖ Landesregierung und führten 2017 zu einer Bausperre in Teilen der Gemeinde und damit zur Notwendigkeit der Vorlage eines geologischen Gutachtens zur Sicherstellung der Tragfähigkeit des Untergrundes im Vorfeld jeglicher Bautätigkeit in den betroffenen Bereichen.

Durch die detaillierte Aufnahme von 15 Kern- und 2 Erdwärmesondenbohrungen sowie mineralogischer, geochemischer und mikrostratigraphischer Analysen ist die Verbreitung der gipshaltigen Gesteine des permoskythischen Haselgebirges und der kalkalpenfremden Schürflinge nun besser bekannt, zudem konnte auch eine Tiefenreichweite gipshaltiger Gesteine bis 80 m nachgewiesen werden.

Schwefelisotopenuntersuchungen an Proben aus Weissenbach stellten den Gips in das oberste Perm bzw. die unterste Trias (Haselgebirge), eine ähnliche Einstufung wurde auch für Proben aus Kernbohrungen in Alland ermittelt. Diese Werte sind vergleichbar mit publizierten Werten aus der näheren Umgebung.

3-D shear velocity model of the Eastern and Southern Alps from ambient noise tomography

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While the upper crustal velocity structure of the Eastern and Southern Alps is not well-studied by earthquake data and active seismology, we present in this study high-resolution 3-D shear velocity models from ambient noise tomography. We have used two years of continuous data recorded at 71 permanent stations and 19 stations of the AlpArray-EASI profile during 2014 and 2015. Cross correlations of ambient noise are computed to estimate the Green's functions of surface waves propagating between the station pairs. Dispersion curves of Rayleigh and Love waves are constructed between 1 and 50 seconds, and are then inverted to obtain group velocity maps as a function of frequency. We first show 2-D maps of both Rayleigh and Love-wave group velocity. These group velocity measurements are then inverted to obtain shear-wave velocity models. These models show that velocity variations at short periods correlate very well with surface geology and tectonic units. The results clearly show low-velocity zones associated with the sedimentary basins, the Po-Plain and the Molasse Basin. We find large high-velocity zones associated with the crystalline core zone of the Alps. Small-scale velocity anomalies also position a number of geological units such as the Ötztal metamorphic block, the Koralpe crystalline basement, and the Gurktal block. We observe a clear velocity contrast in the Tauern Window. Vertical cross-sections derived from the velocity model show the depth extent of the geological units and faults, as well as a pronounced mid-crust seismic discontinuity mainly under the Southern Alps.

Timing and geochemistry of calcite veins in pillow lavas of the Troodos ophiolite: implications for fluid composition and vein mineral growth in a supra-subduction zone

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The Late Cretaceous Troodos supra-subduction zone ophiolite exposes well-preserved and heavily veined pillow lavas that lack an emplacement-related metamorphic overprint and thus represent an outstanding example of fossil fluid circulation through oceanic crust. Minerals precipitated from these paleo-fluids in fractures (veins) and may have inherited geochemical signatures of their source and the prevailing environment.

Based on cathodoluminescence petrography, fluid inclusion microthermometry, rare earth element (REE) and isotope geochemistry ($^{87}Sr/^{86}Sr$, $\delta^{13}C$, $\delta^{18}O$, and Δ_{47}), we discuss the potential fluid sources, determine the time and temperature of vein mineral precipitates, and further provide insights into vein mineral growth dynamics using the example of zoned calcites.

Veins were subdivided into (1) syntaxial calcite, zeolite, or quartz veins related to extensional fracturing and being either accompanied by a median line (crack and sealing) or late-stage calcite crystals (incomplete sealing), (2) blocky calcite veins associated with hydrofracturing and host rock brecciation, and (3) antitaxial fibrous calcite veins that formed by diffusion-crystallization processes. Most veins show seawater-dominated REE distribution patterns (e.g., negative Ce and positive Y anomalies) and their $^{87}Sr/^{86}Sr$, $\delta^{13}C$, $\delta^{18}O$, and Δ_{47} isotopic compositions are in agreement with precipitation from seawater at low temperatures (≤40 °C). A few veins, however, reveal very low $^{87}Sr/^{86}Sr$ (~0.7061) and negative $\delta^{13}C$ (-5.4 to -10.2 ‰ VPDB) suggesting some contribution of mantle CO_2 from degassing magmas and/or leaching of the host rock. These samples correspond to higher formation temperatures (≥140 °C) that are inferred from fluid inclusion and clumped isotope measurements.

Calcite formation and fracturing of syntaxial crack and sealing veins are dated by matching their $^{87}Sr/^{86}Sr$ ratios with the well-established seawater Sr isotope curve. Low temperature vein mineralization was predominantly driven by hydrofracturing and host rock brecciation and took place between 91.5 and 82.5 Ma. The succeeding phase of low temperature antitaxial fibrous calcite vein growth from 75.0 to at least 64.9 Ma temporally overlaps with the rotation of the Troodos microplate which might be reflected by prominently curved calcite fibers. The young age (22.7 Ma) of a late-stage calcite sample coinciding with initial uplift is as unique as its flat REE distribution pattern without any Ce anomaly. High temperature calcites are assumed to have been precipitated shortly after host rock solidification in order to provide sufficient heat to increase the temperature of circulating fluids up to 210 °C. They are characterized by Mn-controlled oscillatory growth zonation that is partly interpreted as closed-system geochemical self-organization. Mn-rich growth zones correlate with higher $\delta^{18}O$ (-4.1 to -9.9 ‰ VPDB) and accumulations of decrepitated fluid inclusions due to isobaric cooling, while significantly lower $\delta^{18}O$ (-17.3 to -22.3 ‰ VPDB) is restricted to Mn-poor zones with well-preserved fluid inclusions. This elemental and stable isotopic zonation including variations within individual growth zones may be related to disequilibrium precipitation.

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Organic metamorphism during thrusting within the Eoalpine upper plate (NW margin of the Gurktal nappes, Eastern Alps)

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Burial heating and Eoalpine (Cretaceous) thrusting of the very low- to low-grade metamorphic Königstuhl and Stolzalpe nappes above higher-grade metamorphic basement nappes (e.g. Gstoder and Bundschuh nappe; Iglseder, this volume) transformed carbonaceous material into anthracite, metaanthracite and semigraphite.

In a kinematically well-constrained section at the northwestern frontal margin of the upper Austroalpine nappe stack, this transformation has been investigated by vitrinite reflectance measurements and Raman spectroscopy of carbonaceous materials (RSCM). A continuous RSCM trend indicates an equilibrated temperature profile of ca. 200-600°C along an almost complete section through the Eoalpine upper plate. By the use of an automated peak fitting software and a thermometrically well-calibrated reference series, the IFORS approach of Lünsdorf et al. (2017) estimates continuously the metamorphic peak temperatures in a deep crustal section. The certainty of ca. ±25°C at a confidence level of 0.9 resembles the data variability within a sample location. Due to the large calibration range, the method is able to reconstruct a thermal crustal profile in three dimensions, showing geodynamic processes in the area of the Gurktal Alps.

Reference:

Lünsdorf, N. K., Dunkl, I., Schmidt, B. C., Rantitsch, G., Eynatten, H. von (2017): Towards a higher comparability of geothermometric data obtained by Raman spectroscopy of carbonaceous material. Part 2: A revised geothermometer. Geostandards and Geoanalytical Research. 41, 593–612.

Characterization of a deep-seated rock slide in a glacier-retreat environment (Ötztal Valley, Austria)

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Deep-seated rock slides are widespread processes in Alpine valleys, particularly on slopes affected by glacier-retreat. The spatio-temporal evolution of these rock slides is influenced by various predisposition factors, such as topography, lithology, geological structures, in-situ-stresses, groundwater flow, glacier and permafrost degradation, and temperature fluctuations.

In this study failure and formation processes, and the deformation behaviour of a highly active deep-seated rock compound slide in a glacier-retreat environment, in the upper Ötztal valley (Tyrol, Austria) is investigated. The rock slide is located at the SE-facing slope above the Marzellferner valley glacier and measures about 400 m in width and 600 m in height (main scarp at 2850 m a.s.l.). Based on historic and remote sensing data from 1893 onwards, the toe of the valley glacier has retreated approx. 2 km and has lost of more than 150 m of its thickness. GPS and tachymetric survey campaigns initiating in 2012 show a high actual activity of the slide i.e. reaching annual rates of several decimetres per year and indicate a temporal relationship between the glacier retreat and the rock slide activity.

Geologically, the rock slide is situated in the metamorphic units of the Ötztal Crystalline of the Upper Austroalpine Nappe System and is composed of paragneisses, mica-schists and banded amphibolites. Geological structures (e.g. foliation planes, joints, brittle fault zones) influence the failure geometry and the kinematics of the rock slide. Distinctive geomorphological features, i.e. primary and secondary scarps, uphill and downhill facing scarps, horst and graben and structures, as well as trenches and tension fractures indicate a complex failure and deformation process of the rock slide, characterised by zones of internal extension and compression. Based on an extensive field survey campaign, geomorphological and geological structures were mapped in order to develop a geometrical, kinematical and geomechanical model of the rock slide. In addition, deformation monitoring data were analysed to distinguish between individual rock slide slabs of variable activity and to study the influence of the Marzellferner glacier retreat on the rock slide velocity.

Thermochronological constraints on the tectonometamorphic evolution of the Meran-Mauls nappe stack (South Tyrol, Italy)

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Between Meran and Mauls in South Tyrol (Italy) the hanging wall of the Periadriatic fault system is built up by a stack of basement nappes with nearly no Alpine metamorphic overprint. Only in one location a small remnant of Mesozoic cover rocks is preserved on top of the basement. Since this nappe stack is bordered by important fault zones on all sides, its lateral continuation remains unclear. New Rb/Sr bt measurements along a ~ N-S transect across all four units of the MMB yield predominantly, pre-Alpine ages (140 to 346 Ma), while Zircon and Apatite fission track analyses show a narrow range of agesbetween 14 and 20 Ma (zircon) and 6 to 17.5 Ma (Apatite). Altogether, this results in a narrow window for thermal conditions during the Alpine evolution. Together with thermobaric constraints and petrographic observations, a comparison with other tectonic units of the Austroalpine domain is aspired to put the Meran-Mauls nappe stack in a wider tectonic context.

Kythnos, Western Cyclades, Greece; a field guide

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This poster illustrates a new field-guide to the island of Kythnos, within the Western Cyclades: this can be downloaded from the QR-code on the poster. Kythnos comprises schists and marbles of Cycladic Blueschist Unit in the Lower Cycladic Blueschist Nappe, in the footwall of both the Eocene Trans Cycladic Thrust and the Miocene West Cycladic Detachment System (WCDS), with a small outcrop of the WCDS hanging wall (Pelagonian Zone) in the southwest of the island. Stretching lineations change from ENE-WSW directed in the north and east to NNE-SSW in the south, reflecting a reorientation of the strain due to Eocene exhumation from HP metamorphic conditions towards the WCDS extension direction; overall, finite strains increase towards the south and west.

The guide documents six day-long excursions, with a total of 63 stops; for several excursions more outcrops than can be reasonably visited in one day are given, allowing some choice in the outcrops seen. However, the island is so small (20 x 11 km) that almost any selection of outcrops can be included in a day, since most lie beside or close to a road and require little walking. Descriptions of several outcrops as seen from the local ferries are also given.

The guide documents both the dominant and unusual lithologies on the island as well as the major structural features of the island. In particular; deformation associated with the emplacement of the Pelagonian Zone hanging wall along the West Cycladic Detachment System; the development of an intermediate-scale low-angled detachment linking higher-angled Riedel fractures (Ag. Ioannis Detachment); the pervasive thinning and down-faulting of the rocks to the west, with contemporary ductile deformation in blue-grey marble and brittle deformation in quartz-rich layers within the blue-grey marble.

The hanging wall to the West Cycladic Detachment System; new data from Aghios Georgios, Western Aegean, Greece

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The central Aegean formed by extension due to Oligo-Miocene-aged rollback of the Hellenic subduction zone superposed on an exhumed Eocene HP-terrane, the Cycladic Blueschist Unit (CBU). Imbrication during exhumation formed two major nappes in the CBU; the Lower and the Upper Cycladic Blueschist Nappes. Subsequent extension was accommodated on several low-angled normal detachments, with a regional bimodal extensional shear-sense; detachments in the Northern Cyclades had top-N/NE displacements, cutting the Upper Cycladic Blueschist Nappe, whilst the West Cycladic Detachment System (WCDS), in the Western Cyclades, had a top-SSW shear-sense, cutting the Lower Cycladic Blueschist Nappe.

Above the Upper Cycladic Blueschist Nappe, well preserved outcrops of the overlying Pelagonian Zone are exposed on Syros (Vari Unit) and on Andros (Makrotantalon Unit). In contrast, the Pelagonian Zone is only sporadically exposed directly above the Lower Cycladic Blueschist Nappe, as hanging wall ultracataclasitic and cataclasitic dolostones of the WCDS.

However, Aghios Georgios, a very small island to the SSW of the Western Cyclades, must also lie in the hanging wall of the WCDS, which is preserved as footwall ultramylonites in the CBU exposed to the NNE on Makronisos. Recent work on Aghios Georgios revealed that the island comprises essentially two lithologies. The eastern part consists of granitoid gneisses that gave a U-Pb zircon age of 249 ± 3 Ma; these rocks are lithologically very similar to quartzofeldspathic orthogneisses in the Vari Unit in SE Syros, intruded at 240-244 Ma (early Triassic). The eastern part of Aghios Georgios comprises schists, including relict blueschist facies assemblages, that gave three white-mica Ar/Ar ages between 52-48 Ma, with a further sample giving dispersed dates between 57-77 Ma, all significantly older than the 15-23 Ma white-mica Ar/Ar ages from the CBU on Makronisos. These schists might be comparable to the Makrotantalon Unit on Andros, which includes an early Cretaceous high-P assemblage correlated with a high-P metamorphic event seen elsewhere in the Pelagonian Zone.

The Marinoan 17O depletion (MOSD) event in northern Baltica

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The formation of sedimentary barite crystal fans directly after the Marinoan glaciation at ~635 Ma was a global phenomenon, with documented occurrences in South China, West Africa, Laurentia, and Central Australia. Their uniqueness lies in both their morphology, which likely occurred only once in the Earth's history, and their non-mass-dependent ^{17}O-depleted oxygen isotope compositions. This indicates an ultra-high pCO_2 post-Marinoan atmosphere, consistent with a hard Snowball Earth. The extant model for barite fan growth is that they formed in shallow water on or inside cavities in horizontally deposited cap dolostones, where an influx of sulfate from oxidative surface weathering combined with Ba^{2+} from upwelling of deeper waters. Here we present an example from northern Baltica (in today's East Finnmark, N. Norway) that essentially supports this model, but with a set of distinctive palaeogeographic, sedimentary, geochemical, and stable isotope features.

In East Finnmark, barite occurs only in the Ruossoaivi-Lappaluokoaivi area, west of Varangerfjord. Barite fans grew either directly on a smoothed but very uneven end-Cryogenian, post-Marinoan glaciated Archean crystalline basement surface or on/within the basal few centimeters of the immediately post-glacial carbonate/clastic sediments (Nyborg Formation), although no direct relationships between the barite fans and the cap dolostone have been found.

Barite also occurs as random blades within the sediments, cutting coarse dolomite, and as euhedral prismatic crystals within calcite veins. Fans are generally less than 2 cm thick and are sometimes overlain by sandstones; evidence for multiple growth phases, not all fanned, and breakage/redeposition of barite has been found. One sample shows macroscopic features suggestive of a short phase of sinter deposition during or before barite growth. SEM investigations show that the original matrix has been completely or nearly completely replaced by calcite and quartz in all samples; barite blades have also been partially replaced by calcite and quartz.

REY analysis of calcite from 10 fractions from four samples indicates non- or only very slightly saline fluid conditions; as REY are typically stable during diagenesis/alteration, these analyses most likely reflect the initial depositional conditions. Sedimentation occurred in a flooded glacial palaeo-valley that formed a restricted tidal or very shallow-marine environment with a high input of fresh water.

Analysis of 10 samples gave $\Delta^{17}O$ values ranging from -0.36‰ to -1.08‰. The northern Baltica barite fans probably grew the closest to a palaeo-continent amongst all the known occurrences, which is consistent with their ^{17}O anomalies being the largest (down to -1.08‰) recorded. The variable $\Delta^{17}O$, $\delta^{18}O$, and $\delta^{34}S$ values of these newly discovered barite fans fit the global distribution and represents the first Marinoan ^{17}O depletion (MOSD) record from Baltica.

Direct observation of dislocations nucleation in pyrite using combination of electron channeling contrast imaging and electron backscatter diffraction

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Crystal-plastic deformation is one of the main mechanisms to accommodate large amounts of strain within the lithosphere. Despite the importance of understanding dislocation nucleation and arrangement, the only widely accepted method for direct observation of dislocations in geological materials so far is transmission electron microscopy. Herein we present a first study using a combination of electron channeling contrast imaging (ECCI) and electron backscatter diffraction (EBSD) to visualize and analyze dislocations nucleating along micro-cracks and at their tips in a geo-material. The study focuses on a pyrite sample from the Detour Lake mine, a Neoarchean orogenic gold deposit located in the northwestern Abitibi district within the Superior Province, Canada. Maximum peak metamorphic conditions of 550°C, close to the brittle-ductile transition and pyrite being a semi-conductor, makes this the perfect study to test this new approach. The investigated sample shows a pyrite layer located at the margin of a sulphidized quartz vein within a mafic-volcanic host rock. The host rock is composed of quartz, albite, actinolite, chlorite, biotite and sulphide phases including pyrite. Additional quartz and calcite occurs in veins and sealed cracks. The matrix consists of fine grained quartz and albite often polygonal in shape, together with finely dispersed biotite defining the foliation fabric. The pyrite layer is strongly fragmented resulting in a jigsaw-puzzle like structure, which is built up of fragments ranging in size between 50 and 3000 µm. Brittle fractures are sealed by carbonates, quartz and chlorite. Different to the matrix, vein quartz reaches grain sizes up to a few millimetre in size and shows sutured grain boundaries together with small bulges. Undulatory extinction, deformation lamellae and subgrains are common. A variety of brittle to brittle-plastic deformation structures has been observed including: (A) intracrystalline-micro cracks, which are aligned en-echelon linking up in a relay style; (B) reactivated intracrystalline-micro cracks; (C) non-reactivated intracrystalline-micro cracks accompanied by a minor crystal-lattice rotation and a crystal-plastic zone; and (D) late brittle fractures cross cutting brittle-crystal plastic structures. Herein we focus on structures (B) and (C) which show a clear dependence of brittle and crystal-plastic deformation behavior on a micrometer scale. Stress concentration at the micro-crack tip appears to result in the emission of dislocations in the immediate vicinity of the tip. Furthermore, the reactivation of micro cracks is accompanied by the nucleation of dislocations and crystal-plastic behavior resulting in the development of complex dislocation structures and low-angle grain boundaries. EBSD maps reveal an increase in misorientation towards micro-cracks consistent with a greater dislocation density along cracks observed by ECCI.

Electrical Properties in Vineyard Soils

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Geophysical imaging provides valuable information on the spatial variability of soil properties by resolving for the quasi-continuous variations in subsurface properties. In particular, changes in the electrical properties can be used to delineate lithological changes and preferential groundwater flow paths. Hence, within this study, we investigate the applicability of electrical and electromagnetic methods to obtain information on the subsurface electrical resistivity distribution in vineyards aiming at a better understanding of the link between textural and electrical properties of the subsurface and their connection with grapevine quality. In particular, we applied the low-induction number electromagnetic (EMI) and Induced Polarization (IP) techniques in two different wine-growing regions in Austria (Burgenland and Lower Austria). The first measurements were conducted in Apetlon (in March, 2017), along six profiles; whereas during the second campaign, measurements were performed in Höflein (in April, 2017), along fourteen profiles. Soil information, provided by the Geological Survey of Austria (GBA), was incorporated for an improved interpretation of the electrical signatures in terms of the textural properties of the soil. Our results permitted a comparison of both the EMI and IP methods regarding the depth of investigation and resolution in the imaging results. Moreover, the combination of both techniques, as well as the geological data, lead to an improved delineation of lithological structures and the characterization of preferential groundwater flow patterns.

The dynamic history of Mars – adding another puzzle piece from the analysis of Ca-phosphates in martian meteorites

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The existing meteorite record encompasses 208 martian among the ~67,400 classified meteorites in our collections only – some of which may be even paired. In the absence of martian sample return missions so far and in addition to data from martian landers, probes and remote sensing, these rocks, however provide fundamental insights on the formation and evolution of Mars. Martian meteorites are subdivided into (i) nakhlites - olivine-bearing clinopyroxenites, (ii) chassignites - dunites and olivine-chromite cumulates, (iii) Allan Hills (ALH) 84001 - ultramafic orthopyroxenite, (iv) Northwest Africa (NWA) 7034 and paired samples - polymict, regolith breccias, and (v) shergottites - the largest suite of martian rocks. The latter are of magmatic origin and divided into: (a) basaltic, (b) lherzolitic, and (c) olivine-phyric rocks. According to their degree of bulk rock LREE depletion, generated by different degrees of partial melting of the martian mantle, shergottites are subdivided into enriched, intermediate, and depleted rocks. Among the present accessory phases in martian meteorites, apatite group minerals ($Ca_5(PO_4)_3(Cl,F,OH)$) and merrillite ($Ca_{18}Na_2Mg_2(PO_4)_{14}$) are of particular interest, as they occur as abundant, late-stage phases, and, thus are major sinks for incompatible trace elements, such as REEs, U, and Th, making them well-suited for combined chemical- chronological investigations. Martian apatites are prime carrier phases for the halogens F, Cl, Br, I and OH. They are mostly considered to be of magmatic origin, and thus act as a probe for the volatile element and water contents of the mantle sources. Some Ca-phosphates, however, may be affected by assimilation of crustal component(s) on Mars during the latest stages of basaltic crystallization, or interaction with Cl-rich crustal fluids. In this study, a member of the basaltic, enriched suite of shergottites has been selected – the Ksar Ghilane (KG) 002 meteorite, discovered 2010 in Tunisia, hosting an unusually high modal abundance of 3.4 vol.% and up to mm-sized merrillite and apatite grains, exceeding those of other martian meteorites. In a multidisciplinary, high-spatial resolution analytical approach, analysis of Ca-phosphates permits insights into the formation environment and alteration processes of the host rock. The petrological record, together with chronological constraints using the 238U-206Pb systematics reveal that igneous Ca-phosphate in KG 002 formed 80 ± 59 Ma (2σ) ago, the youngest martian phosphate date obtained so far. The REE concentrations, halogen zoning in both phosphate species and variability in x-site occupancy of apatite, together with the chemical record of merrillite indicate crystallization from a highly fractionated, volatile-rich (halogens, OH, and Na), and ferrous source melt and a phosphate crystallization sequence. Microstructural investigation revealed only weak alteration of the grains caused by metamictization and shock metamorphism after crystallization. The halogen (F, Cl, Br, I) and stable chlorine isotope signature, expressed in standard $\delta^{37}Cl$-notation with a positive signature of +0.67 ± 0.14 ‰ (1σ), are different to that of other enriched basaltic shergottites. These findings may be explained by interaction/assimilation of Cl-enriched martian crust to a slightly higher degree when compared to other enriched basaltic shergottites. Hydroxyl-poor merrillite is identified as additional carrier phase for volatiles in martian magmas.

Field- and microscopic investigation of iron oxide and calcite coated fractures in glauconitic sandstones, quarry Strombauamt, Greifenstein, Lower Austria

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In the quarry “Strombauamt” at Greifenstein, Lower Austria, iron oxide coatings occur on structural discontinuities in massive sandstones. Since these sandstones are outcrop analogues of hydrocarbon reservoir rocks in the subcrop of the Vienna Basin, their capability to reduce permeability was investigated. The mineralogy, chemical composition and (micro-)structures were analysed to assess the origin of these crusts. The sandstone belongs to the Greifenstein Formation of the Rhenodanubic Flysch Unit and was deposited during the Upper Paleocene to Lower Eocene. The iron crust bearing beds are up to 10 m thick massive sandstones of a channel fill in a classical turbidite succession.

A 250 m E-W section at the southern wall of the quarry shows the deposits which are partly dissected by faults encrusted with iron oxides. The red to orange crusts are prominent features within the thick-bedded sandstones at the base of the quarry, but do not continue into the overlying thin-bedded sandstones. Occasionally, the crust is covered by synkinematic calcite fibres that formed on the fault planes, and/or idiomorphic calcite and quartz. Structural evidence indicates that at least some of the iron encrusts deformation bands, which formed early after the deposition of the sandstone in yet unlithified sediment. Iron-encrusted fractures are mostly dipping steeply to the west or the east.

The sandstones are glauconite-rich quartz arenites cemented by calcite. X-ray diffraction used to determine the mineralogical composition of the crust identifies mainly quartz, K-feldspar, calcite, mica (glauconite) and traces of goethite as evidence of an iron mineral. The iron coating following some joints affects the outermost 0.5 mm up to 5 mm of the sandstone forming a macroscopically distinct red zone. SEM microscopy combined with EDAX shows that the iron mineral is an iron oxide that either forms thin coatings around most of the grains or crosscuts through minerals in the form of veins. Broken grains that are later cemented by the iron oxide also show evidence of tectonic influence.

In further investigations, sandstone plugs with and without iron crusts will be analysed with a gas permeameter. The iron content of the different calcite cements as well as the exact composition of the iron oxides will be determined with an electron microprobe, which will tell us more about the history of fluid flow and cementation. Furthermore, stable oxygen and carbon isotope of the calcite could be used to determine the origin of the fluids.

With the present results, we propose that iron rich fluids that filled the fractures in the compacted sediment induced the precipitation of iron oxide on grain boundaries, possibly twice. Some of these fractures were later filled with secondary calcite indicating shear along the fractures.

The source of iron can either be external or from within the sandstone itself. The sandstone contains abundant glauconite, a mineral that forms in shelf areas with reduced oxygen availability and thus contains divalent (mobile) and trivalent (immobile) iron. Therefore, glauconite can be a source of divalent iron that oxidizes rapidly to form iron oxides. An internal source of iron has the following implications: (1) sediment deformation when the sediment was only partly consolidated to allow diffusion from within the sand(stone) and (2) presence of an electron source giving electrons to the pore water to allow oxidation.

The Central Tunisian Atlas as potential key area for late Mesozoic non-marine research and supra-regional biostratigraphy: A micropalaeontological perspective

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Non-marine (here used for 'continental' aquatic or limnic/lacustrine, and terrestrial palaeoenvironments and deposits) calcareous microfossils such as ostracods and charophytes are among – if not the – most useful groups for biostratigraphical and palaeoenvironmental application in late Mesozoic successions. While regional biostratigraphy based on Mid–Late Jurassic–Early Cretaceous non-marine ostracods and charophytes has a long tradition, the practical implementation to supra-regional biostratigraphy is still strongly hampered. During the last few decades, however, modern insights into non-marine ostracod and charophyte palaeobiology and palaeobiogeography and new data have expedited the process of taxonomic revision and facilitated new approaches and tests for prior hypotheses of supra-regional to global distribution. In particular, the dispersal strategies and mechanisms of certain non-marine ostracod groups and of charophytes are the same, i.e., they are passively transported by larger animals over short and long distances, crossing migration barriers.

Mesozoic non-marine to marine transitions and respective successions are known from the Central Tunisian Atlas (CTA) and the Tunisian Saharan Platform (TSP) (north Gondwana, southern Tethys margin). Transgressions and regressions onto the essentially stable Saharan Platform and coeval tectonics produced a complex pattern of basins and islands, and the non-marine successions of both the CTA and TSP well document deposits of contemporaneous Peri-Tethyan islands (PTIs) offshore northern Gondwana. Ongoing research in Tunisian Mid-Jurassic to mid-Cretaceous non-marine (lacustrine) sedimentary archives reveals partially new, rich ostracod faunas and charophyte floras, many elements of which can be linked to Gondwana, i.e., West Africa and South America on the one hand, and Eurasia (partially North America) on the other hand. Considering varying dispersal vectors coming into question at different time intervals (e.g., evolution of birds) in the context of plate tectonics, palaeoclimate and sea-level changes, the late Mesozoic PTIs are coming into the centre of attention for non-marine supra-regional correlation as based on ostracods and charophytes. Our new discoveries do not only improve the regional biostratigraphy but also facilitate (improved) supra-regional correlations in this time interval and support concrete considerations of faunal and floral exchanges between South America and Asia via North Africa and the PTIs, for example. New joint research projects involving Tunisian and Austrian scientists are dealing with the documentation, characterisation, refined stratigraphy, and evolution of late Mesozoic lake-systems and their deposits in the Central Tunisian Atlas. This includes the regional to supra-regional context with respect to non-marine to marine correlations and the relation of these ancient lake ecosystems to, and their control by, (plate-)tectonics, palaeoclimate and sea-level changes.

Neotectonic deformation and modified sediment fabrics of a late Pleistocene talus succession, Central Apennines

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Active normal faulting controls surface topography of the Central Apennines. Normal faulting post-dates Late Miocene foreland-directed stacking of the Apennines fold-and-thrust belt, and partly overlaps with Plio-Pleistocene exhumation and surface uplift. Studies on neotectonic deformation in the Apennines in many cases use talus deposits as deformation markers, but the deformed talus itself is rarely subject to investigation. We investigated an excellently exposed talus succession that underwent the hitherto last increments of activity of a normal fault.

Whereas the footwall of the studied fault consists of Meso-Cainozoic deep-water limestones, deformed talus deposits are confined to the fault hangingwall. The footwall displays a fault core of ultracataclasite that was subject to meteoric-diagenetic overprint (e.g., dissolution pores lined by cement, intrabrecciation); ripped-up calcite cements floating in ultracataclasite record fault reactivation during diagenetic overprint. The considered talus of pebbly scree-slope deposits accumulated mainly from grain flows and cohesive debris flows, and is intercalated with soil levels. Whereas the packages of scree represent relatively dry conditions, the soils record more humid interludes characterized by climb/densening of vegetation. Deformed strata and intercalated, radiocarbon-dated soils allowed to define three talus packages: (1) package A, ~30–25 ka in age, is paraconformably overlain by (2) package B younger than ~25 ka and that, in turn, is truncated along the base of the present topsoil. Along strike, the topsoil is locally underlain by (3) the youngest package C that perhaps accumulated during the Holocene. Together, package A and B are deformed into heteroaxial folds, (a) a syncline-anticline couple with axes at high angle to the normal fault plane, and (b) a recumbent fold with an axis roughly parallel to talus depositional strike. Field evidence indicates that faulting had ceased for a longer interval of time, but the time of cessation is difficult to constrain.

The talus is rich in clasts that were fractured while embedded in the sediment, giving rise to a specific, secondary sediment fabric. In addition, many clasts show planar contacts and are arranged into subvertical stacks (‚clast pillars'). Diagenesis records distinct phases of cementation, separated by fracture and/or intense dissolution of, each, matrix, cement and smaller lithoclasts. A speleothem flowstone along a fracture in talus package A shows successive precipitation, dissolution, and fracturation. The contrast between the ultracataclastic fault core, formed probably at 1-2 km in depth, and the overlying deformed talus indicates that the present fault/talus-ensemble records only the last increments of downfaulting. The complexity of the studied talus succession, including its deformation, stratigraphic architecture, sediment fabrics and diagenetic successions, provides an example for similar, less well-exposed talus subject to faulting.

Strain distribution in refold structures

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Superposition of folding can lead to very complex 3D layer geometries (i.e. refold structures), which when observed in 2D (e.g. outcrop) are called interference patterns. Commonly used names for the different patterns are 'crescent', 'mushroom', 'hook', 'bird's head', 'dog's tooth' and 'S-Z-W-M' shapes. Refold structures are typically divided, based on their 2D interference pattern, into four types (Type 0-3; Ramsay 1962). Based on the 3D refold structure, this nomenclature, which is widely used by structural geologists, has been extended to six types (Grasemann et al. 2004). In the extended classification Type 03 is identical to Type 0; Type 01 and Type 02 do not generate an interference pattern (hence they were excluded in the original classification), but do fold a lineation contained within the first fold. Perhaps most importantly various transitional forms can be better classified using the extended scheme and, although the end members Type 01 and 02 do not generate interference patterns, transitional forms (Type 01 ↔ 02) do. The purpose of this study is to analyse strain distributions of computer generated refold structures, assuming that the XY-plane and the long axis of the finite strain ellipsoid are parallel to the foliation and lineation, respectively. These synthetically generated strain distributions, plotted on a stereonet, can serve as an aid for structural geologists in deciphering the type of refold structure in situations where either passive markers are absent or the refold structure does not exhibit an interference pattern (as in Type 01 and Type 02).

IRIS Online (Interaktives Rohstoff Informations System), ein Beispiel für ein weltweit einzigartiges digitales Rohstoff-Informationssytsem

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Eine moderne Rohstoffpolitik baut auf einer maßgeschneiderten Rechtsbasis und einer Informationsbasis auf. Die Bereitstellung rohstoffrelevanter Basisinformationen ist eine wichtige Aufgabe der öffentlichen Verwaltung. Bergbauunternehmen sollen ihre Explorationsstrategien auf verlässliche und ausreichende Basisinformationen aufbauen können. Die gedruckte und im Jahr 1997 veröffentlichte „Metallogenetische Karte“ war ein erster Markstein. Im Jahr 2002 wurde erstmals ein digitales Rohstoff-Informationssystem IRIS entwickelt, welches auch detaillierte Abfragen nach Rohstoffvorkommen erlaubte. Im Gegensatz zur „statischen“ gedruckten Karte erlaubte dieses CD-ROM System erstmals die gleichzeitige Darstellung von Geologie, Geochemie, Aerogeophysik und Rohstoffvorkommen. Im Jahre 2009 wurde schließlich das System als Internet Version freigeschalten. Grundlegende neue Erkenntnisse über den tektonischen Aufbau der Ostalpen mit bemerkenswerten Auswirkungen auf die Rohstoffführung insbesondere des präalpinen Basements waren Grund genug, die gesamte tektonische Datenbasis und auch die gesamte Rohstoffdatenbank gründlich zu überarbeiten. Darstellbar sind:

verschiedene frei wählbare geologische und tektonische Basiskarten (Neue tektonische Karte 1:1 Mio, Geologische Übersichtskarte 1:500.000, Geologische Bundesländerkarten 1:200.000, Geologische Karte 1:50.000 -gedruckt und GEOFAST)

frei wählbare Karten der Metamorphose-Ereignisse (variszische, permische, kretazische, känozoische Metamorphose)

frei wählbare Geochemische Karte (Ergebnisse der geochemischen Bachsediment Untersuchungen mit über 34.500 Probenpunkten und 35 Elementen; Darstellung geostatistischer Analysen (Anomalien m+2s, Hauptkomponentendarstellung)

frei wählbare Ergebnisse der aeromagnetischen Vermessung des Bundesgebietes

frei wählbare topographische Karten (topographische Karten, Satellitenkarten)

Detaillierte Informationen von fast 5700 Rohstoffvorkommen (Lage, Form, Rohstoffinhalt, Rohstoffgruppen (Eisen und Stahlveredler, Nichteisenmetalle, Edelmetalle, Energierohstoffe, Industrieminerale) Profildarstellungen, fast 17.000 Literaturzitate, z.T. adlib-verlinkt).

Ergebnisse von Isotopenanalysen

Abfragemöglichkeit über die historischen Bergbauaktivitäten nach Jahrhunderten bzw. über den prähistorischen Bergbau

A new 3D shear velocity model of the wider Vienna Basin region from ambient noise tomography

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Accurate velocity models of the Earth are a prime result of seismological study, which are useful on one hand for understanding the tectonic evolution of an area, and on the other hand for improving the evaluation of natural resources, and for better locating seismic events. The Vienna Basin (VB) is generally thought to be an area of low seismicity and low to moderate seismic hazard, but some authors argue that the seismic hazard in the region is underestimated.

In this study, we retrieve a shear velocity model of the crust in and around the VB. We use continuous seismic records of 63 broadband stations (47 temporary stations of the temporary AlpArray network (http://www.alparray.ethz.ch) and 16 permanent stations, operated by national services) to retrieve inter-station Green's Functions from ambient noise cross correlations in the period range of 5s - 25s. From these Green's Functions we measure Rayleigh wave group travel times and invert them to retrieve a 3D shear velocity model of the study area in the top 30km. The resulting model provides previously unachieved resolution in this area, and matches well with the few known crystalline basement depths from boreholes. For depths, larger than those reached by boreholes, the new model allows new insight into the complex structure of the VB and surrounding areas, including deep low velocity zones. The new model will also open new possibilities for improving earthquake locations, and for better predicting ground motions associated with potential earthquakes in the area.

The Alland earthquake series: Location, source mechanism and implications for the regional stress regime

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The Vienna Basin is one of the seismically most active regions in Austria. Because of population density and sensitive infrastructure, seismic hazard assessment in the area is of critical importance. In probabilistic seismic hazard assessments, the region is classified with low to moderate seismic hazard and the maximum credible magnitude was estimated to be around 6. Paleoseismological studies suggest that the region may have suffered earthquakes of magnitude ~7 in pre-historical times.

In 2015, an earthquake occurred ~20km west of Vienna (ML 4.2), near the town of Alland, in an area that has been relatively quiet seismically throughout the last centuries. According to the Austrian Earthquake Catalogue, there have only been 14 earthquakes within a radius of 15 km around the epicentre since 1200 before this event. Of the 11 instrumentally-recorded events, none have exceeded magnitude 2.5. While the economic impact of the Alland earthquake was small, it is a notable event in the regional context, due to its larger magnitude, and to its probable thrust-faulting type. It may thus shed light on the tectonic regime in the area, e.g. on the question which faults are active at present. Thrust faulting has been a prime feature throughout the Alpine orogeny, but so far it has seemed to not leave a strong mark in instrumental seismicity and ongoing deformation in the Alps.

In this study, we present main- and aftershock locations, the source mechanism of the main-shock from moment-tensor inversion, and to which degree it aligns with known geological features in the area. We will also discuss the implications for stress field and regional tectonics, and briefly touch the assessment of the regional seismic hazard.

Hiding beneath a volcano: the Santorini Detachment System (Cyclades, Greece)

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The cores of most Cycladic Islands are formed as consequences of early Paleogene high-pressure subduction processes of the African plate beneath Europe, and Miocene extensional exhumation of the subduction channel. The island of Thera (Santorini) resides in the Hellenic Volcanic Arc, and is dominated by Quaternary eruptive volcanic material atop pre-volcanic basement. Composed primarily of crenulated pelitic schists, meta-conglomerates, and calcitic marbles, the basement is present at two main localities. Within the caldera walls, the area near the port of Athiniós exposes Ms(Phg)-Chl-Ab-Bt schists and metabasites with marble interlayers, which possess relict glaucophane and crossite indicating blueschist facies metamorphism. Detrital zircon U-Pb geochronology from this package of rocks yields a dominant ca. 650 Ma Pan-African signature, and very few zircon dates <500 Ma. Foliation-defining white mica bundles give 40Ar/39Ar dates of 25-19 Ma and zircon (U-Th)/He (ZHe) dates are 11-8 Ma. A cross-cutting dacitic dike is 8.5 ± 0.2 Ma based on zircon U-Pb dating. The petrologic and geochronologic characteristics of the metamorphic rocks of Athiniós are traits of the Cycladic Blueschist Unit (CBU) found as footwall rocks on other Cycladic islands. Another outcrop of the CBU below the volcanic rocks is located north of Emporió that contains pelitic schists and conglomerates with an interbedded meta-rhyolite that displays clear eutaxitic microstructures and porphyritic quartz and feldspar phenocrysts with zircon dated at 235.0 ± 1.4 Ma. White mica ages give 40Ar/39Ar dates of 26-23 Ma, and ZHe dates are ca. 12 Ma. Separated by a major detachment system, the newly discovered Santorini Detachment with top-to-SE shear sense, the highest mountains of the island (Profítis Ilías and Mésa Vounó) are composed of metamorphosed "Pantokrator" facies carbonates containing large, well-preserved Upper Triassic Megalodon fossils. Between these two mountains, low-grade meta-conglomerates occur in a complex refolded syncline, which has been also reworked by SE-directed shear. White mica from this package of rocks occurs as thin ribbons aligned with the dominant foliation and as isolated, slightly corroded grains, apparently detrital that yield Jurassic to early Paleogene single grain 40Ar/39Ar dates, with a dominant Paleocene signature. Zircon He-dating similarly reveals dispersed ages between 36-15 Ma suggesting Miocene temperatures were not high enough (<200°C) to completely reset all of zircon cooling ages. The rocks of the hanging wall above the newly discovered detachment most likely belong to the Pelagonian zone with a Triassic carbonate platform discordantly transgressed by an Eocene flysch deposit. These new results require re-evaluation of the southern limit of Miocene extensional systems in the Cyclades realm.

Seismo-acoustic signals of the Baumgarten (Austria) gas explosion detected by the AlpArray seismic network

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On December 12, 2017 a devastating release and combustion of gas occurred at the Baumgarten gas hub in Eastern Austria, which is a major European distribution node for natural gas. We have detected the resulting seismo-acoustic signal on permanent and temporary broadband seismic stations at distances between 30 and 175 km from the gas hub, most prominently in the 2-4 Hz range. Two distinct phase arrivals correspond to acoustic waves traveling through the troposphere and stratosphere. The passing of a cold front shortly before the explosion led to several temperature inversions at low altitude, and acoustic waveguides within the troposphere that facilitated our infrasound detections at distances as close as 50 km from the source, in addition to the commonly observed stratospheric reflections. 3D acoustic raytracing using temperature and wind velocities from the from the HRES (high-resolution) forecast model of the European Center for Medium Range Weather Forecast (ECMWF) has allowed to precisely relate the spatial distribution of our detections with calculated surface bounce points of infrasound rays. This has provided a precise and independent estimate of the time of the accident, to be used in forensic investigations. In addition to the acoustic signal we find evidence for weak seismic phases on the stations closest to the gas hub, yet the sudden release of gas above the surface generated acoustic waves more effectively than seismic waves. After the first explosion signal, we also detect a prolonged coda of elevated noise, which is probably due to ongoing gas release and/or the fire from the escaping gas.

Spacing of bending-induced fractures at saturation: Numerical models and approximate analytical solution

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Although the origin of outer-arc extension fractures is well-understood and documented in many natural examples, geomechanical factors controlling their (finite or saturation) spacing are hitherto unexplored. This study investigates the formation of bending-induced fractures during constant-curvature forced folding using Distinct Element Method (DEM) numerical modelling. The DEM model comprises a central brittle layer embedded within weaker (low modulus) elastic layers; the layer interfaces are frictionless (free slip). Folding of this three-layer system is enforced by a velocity boundary condition at the model base, while a constant overburden pressure is maintained at the model top.

The models illustrate several key stages of fracture array development: (i) Prior to the onset of fracture, the neutral surface is located midway between the layer boundaries; (ii) A first set of regularly spaced fractures develops once the tensile stress in the outer-arc equals the tensile strength of the layer. Since the layer boundaries are frictionless, these bending-induced fractures propagate through the entire layer; (iii) After the appearance of the first fracture set, the rate of fracture formation decreases rapidly and so-called infill fractures develop approximately midway between two existing fractures (sequential infilling); (iv) Eventually no new fractures form, irrespective of any further increase in fold curvature (fracture saturation).

Analysis of the interfacial normal stress distributions suggests that at saturation the fracture-bound blocks are subjected to a loading condition similar to three-point bending. Using classical beam theory an analytical solution is derived for the critical fracture spacing, i.e. the spacing below which the maximum tensile stress cannot reach the layer strength. The model results are consistent with an approximate analytical solution, and illustrate that the spacing of bending-induced fractures is proportional to layer thickness and a square root function of the ratio of layer tensile strength to confining pressure. Although highly idealised, models and analysis presented in this study offer an explanation for fracture saturation during folding and point towards certain key factors that may control fracture spacing in natural systems.

Evolution of thalattosuchian crocodylomorphs – the role of the neurosensory system in adaptations to a secondarily aquatic lifestyle

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During the Mesozoic Era, numerous reptile groups secondarily adapted to an aquatic lifestyle. One prime example are crocodylomorphs (crocodylians and their extinct relatives). During the Mesozoic not only did they occupy semi-aquatic environments, but even terrestrial and pelagic-marine ones. This diversity demonstrates that they have been remarkably successful during the last 200 Million years of their evolutionary history. The best adapted to a life in the open ocean were Thalattosuchia. These ancient crocodylomorphs evolved from terrestrial ancestors into semi-aquatic forms and then adapted to a pelagic marine lifestyle. From the Early Jurassic to the Early Cretaceous these globally distributed crocodylomorphs include two families: the Teleosauridae and the Metriorhynchidae. The former are characterised by gharial-like body plan, with an elongated, slender snout, osteoderms covering their dorsal surface and unspecialised limbs. They occupied shallow marine environments with a semi-aquatic lifestyle similar to extant gharials. Metriorhynchids, adapted to open marine environments with paddle shaped limbs, lack of bony osteoderms and a vertically oriented tail fluke. While these osteological changes are well known, their sensory evolution remains poorly understood. Functional aspects of their neuroanatomy are essential to get an insight into paleobiology, behaviour and how ancient animals interacted with their environment.

Based on digitally segmented endocranial structures (such as the brain cavity, bony labyrinth and sinuses) derived from CT datasets, we can draw inferences about thalattosuchian sensory capability and evolution. Thalattosuchians, like cetaceans underwent a similar land-to-sea transition with reduction of air sinuses and semicircular canal size. In the most basal thalattosuchians (e.g. Pelagosaurus typus, Steneosaurus cf. gracilirostris), the pharyngotympanic sinus system is reduced and does not enclose the bony labyrinth and brain cavity dorsally, compared to most other crocodylomorphs (including extant crocodylians). Further reductions in the pharyngotympanic sinus system are present in the pelagic metriorhynchids. The overall bony labyrinth shape and especially the three semicircular canals show a reduction convergent to other secondary aquatic vertebrates such as cetaceans and various marine reptiles.

Secondary adaptation to a life in the open ocean represents a prime example of a major evolutionary transition. Our findings show that thalattosuchian neuroanatomy adapted to a marine lifestyle before large-scale osteological shifts (i.e. evolving flippers and a tail fin) and these could have underpinned the success of this remarkable group of animals.

Assimilation of Electrical Resistivity Tomography (ERT) and Ground-Penetrating Radar (GPR) data in the inversion of Refraction Seismic Tomography (RST) data for an improved spatial characterization of alpine permafrost

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In frame of the ATMOperm project funded by the Austrian Academy of Sciences, several geophysical methods were applied at the summit of Hoher Sonnblick (3106 m.a.s.l.) with the objective to determine the distribution of frozen and unfrozen materials in the subsurface. The geophysical survey included Refraction Seismic Tomography (RST), Electrical Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR). RST permits to solve for variations in the velocity of seismic waves, with several studies exploiting the increase in P-wave velocities (Vp) with increasing ice content, and thus, permitting to map frozen rocks. However, at the Hoher Sonnblick, changes in the seismic velocity with depth have been reported to be associated with the presence of frozen fractured rocks in the near surface and the bedrock. Hence, further information is required to improve the interpretation of the seismic results for an improved delineation of the active layer. Therefore, we conducted ERT and GPR surveys, which represent well-established methods for the characterization of permafrost rocks, exploiting the significant contrast in the electrical properties from ice and water. Moreover, GPR permits to solve for structural variations in fractured rocks with high spatial resolution. Hence, we present here the first results regarding the assimilation of ERT and GPR data to improve the inversion of RST surveys conducted at Hoher Sonnblick. In this study, we investigate the incorporation of structural information obtained from the processed GPR data to define the geometry of the initial model whereas ERT imaging results are used to refine its elastic parameters. Statistical analysis of the inversion results obtained using an ensemble of different initial models allowed the quantification of the impact of the complementary information as well as an investigation of the limitations of this joint processing approach.

Near-surface investigation of a slow moving landslide by means of broad-band ambient seismic noise monitoring

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Landslides situated in inhabited areas are geohazards posing a serious threat to those human settlements and the associated infrastructure. Commonly, the investigation and monitoring of landslides follow a multidisciplinary approach integrating geotechnical, hydrological and geophysical methods, amongst others. Such a multidisciplinary monitoring network has been deployed at the Salcher landslide located in the municipality of Gresten (Lower Austria) since 2014, aiming at the collection of long-term observational data sets. Since March 2018, a broad-band seismic monitoring network has been installed at the Salcher landslide to complement the existing geotechnical and geoelectrical monitoring systems. The seismic network consists of three stations within the landslide and one reference station installed in the vicinity, at the stable counter slope. Each station is equipped with a Geospace 4.5 Hz 3C geophone, with one of the stations also including three additional Geospace 4.5 Hz vertical geophones. Furthermore, to investigate events over a broad frequency bandwidth extending two orders of magnitude below the natural frequency of the geophones (periods ~ 100 s), we deployed two Nanometrics Trillium 240 broad-band seismometers, one installed within the landslide, and the second one at the reference station. All sensors are connected to Trimble REF TEK 130 broad-band seismic recorders. We analyzed the seismic monitoring data to discriminate events associated with the landslide activity and hydrological processes, such as precipitation and groundwater flow. Events of teleseismic origin were excluded based on earthquake catalogues, whereas local anthropogenic events were identified by a novel event detection algorithm relying on microphone recordings. Information regarding the spectral content and the incidence of landslide-related seismic events were the base for a better understanding of the landslide dynamics whereas the correlation with complementary data sets might help to define precursors for an imminent acceleration phase. Furthermore, we plan on the analysis of ambient seismic noise interferometry by means of computing cross-correlations of the seismic records at different frequency ranges to reveal changes of the seismic velocity within the landslide.

On the applicability of microphone readings for robust event detection in broad-band ambient seismic noise

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Recent studies in landslide investigations have revealed promising results in the application of seismic noise analysis to delineate hydrogeological processes such as surface water infiltration and groundwater flow. However, the need for flexible monitoring geometries in landslides, where deformation rates could significantly change in space and time, demands the deployment of mobile stations with near-surface sensors which are easier to install and retrieve on a short notice. However, the deployment of mobile stations leads to the contamination of the seismic data due to airborne noise. Thus, the analysis of ambient noise, commonly associated to low signal amplitudes, demands the development of algorithms that permit to differentiate between airborne and seismic events. A commonly used technique for seismic detection is the STA/LTA principle suitable for the detection of local, micro and distant seismic events controlled by adequate parameter settings. However, in case of shallow sensor installations (depth ~ 1 m) its performance is limited, due to irregular manmade seismic signals. Thus, a proper discrimination of subsurface sources and the removal of airborne events are mandatory for an adequate processing of seismic noise. Hence, we present here the application of microphone readings for event detection in broad-band seismic data. Our detection strategy assumes that for shallow installation depths similar waveform behavior and patterns in seismic and microphone data. Seismic events of subsurface origin are detected by means of robust outlier detection in the amplitude ratio computed from those complementary data sets. We evaluate this alternative detection approach using data recorded with Nanometrics Trillium 240 broad-band seismometers and a GRAS 46AE free-field microphone. Both sensor types are connected to Trimble REF TEK 130 broad-band seismic recorders. The detection results are compared to the earthquake catalogue published by the Seismological Service of the Central Institute of Meteorology and Geodynamics (Zentralanstalt für Meteorologie und Geodynamik, ZAMG). With this robust technique, we reliably detect seismic events of varying amplitude which permits a pre-filtering of seismic data to enhance the analysis of ambient seismic noise in landslide studies. We believe that our method is a step forward in the development of automatable algorithms that permit a quasi-real time processing of large seismic datasets.

The new Austrian Core Facility for Scientific Core Analyses: Introduction and first scientific achievements

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Since 2017, the new Austrian Core Facility at the University of Innsbruck operates the first research facility in Austria that provides state-of-the-art laboratory infrastructure for logging and scanning of cores obtained by drilling and coring. The lab is equipped with three scanners that all make use of non-destructive analysis techniques to provide high-resolution data for scientific core analyses: 1) a *Geotek* Multi-Sensor Core Logger measuring physical property such as P-wave velocity, gamma density, and magnetic susceptibility (downcore resolution 1 mm). 2) a *Smartcube* Camera Image Scanner for 1000 dpi photo-imaging split sediment cores and whole-round rock cores (360° scan). 3) a *COX Analytics* ITRAX XRF core scanner that collects radiographic images and element profiles of the core surface by X-ray Fluorescence in the range Si to U in downcore resolution of 50 and 200 micrometer, respectively.

This presentation aims at introducing the ACF to the Austrian Earth Science community and will present first results from a wide range of scientific applications that already used the new infrastructure to analyze:

whole rock drill cores from the Brenner Basis Tunnel to study how the metamorphic fabric of the Zentralgneiss links to anisotropy of p-wave velocity and deduce mechanical stratigraphy of the Zentralgneiss to Hochstegenmarmor transition for core-to-core correlation and paleogeography interpretations

plug-samples from drill cores for petrophysical characterization to deduce the depositional vs. diagentic properties of the Leitha limestones

peat bog cores from the Alps and the alpine foreland to link element profiles with data from pollen analyses for advanced palynological reconstructions and studies of past human-environment interactions

shallow-water lake cores from archeological lake-dwelling sites in the Mondsee-Attersee region, to use element data as chemical proxy for characterizing and analyzing cultural layers

sediment cores from the high-alpine Saldur Lakes to use element chemical data as proxy for lake – (glaciated vs non-glaciated) catchment interaction to decipher past climate change in high Alpine regions

sediment cores from several Alpine-valleys and perialpine lakes to physically and chemically characterize turbidite deposits as proxy for processed-based interpretation and distinction of past meteorological and/or geological extreme events such as floods, mass movements and earthquakes

Speleothem cores from the Conturines Cave for testing new applications of high-resolution chemo-stratigraphy for paleoclimate research applications.

Relevance of salt on sedimentation and later deformation of the Northern Calcareous Alps fold-belt (NCA), Austria

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The NCA are a E-W striking 700km long salt-detached fold and thrust belt constituted by thick Neo-Tethyan Triassic platforms and mid to Upper Cretaceous syn-orogenic deposits.

Thick Triassic carbonate platforms constitute the structural framework of the NCA. The major formations are the Wetterstein Formation and the Hauptdolomit Formation which were originally deposited onto a widespread layered evaporitic sequence of uppermost Permian to lowermost Triassic age (Haselgebirge and Reichenhall Formation). Remnants of those evaporites (i.e. clay, Rauhwacke, Anhydrite, Gypsum, sandstones, etc.) are found today associated to major tectonic contacts along the complete length of the NCA. More complete sections of the Haselgebirge, sometimes carrying Halite, are found in the southernmost tectonic units (Juvavic nappe stack).

Structural and stratigraphic data collected in recent field campaigns in the NCA revealed the existence of salt withdrawal mini-basins bound by deformed salt welds which are remnants of former salt walls and diapirs that became squeezed upon shortening. Inflated salt bodies between those mini-basins have been the controlling factor during sedimentation causing rapid thickness changes due to salt migration and also for the deformation of the NCA during later shortening phases. The structures documented by our fieldwork are comparable in terms of geometry, dimensions and aspect ratios to published structures from the offshore South Atlantic margin and the Pyrenean rift.

Stratigraphic work from the past as well as from recent mapping campaigns and the construction of cross sections have demonstrated the strong heterogeneity of the Neo-Tethys passive margin architecture, in terms of sedimentary facies and thickness distribution. These extensive differences are a result of the highly dynamic sedimentary evolution due to the presence and the mobility of salt.

Permian to Lower Triassic evaporites are present over a large part of the NCA. We therefore propose that salt tectonics has been a primary architectural element in the NCA, from its beginning as a continental rifted margin until the subsequent deformation phases on the alpine fold-and-thrust belt.

The concept of salt tectonics will give a new perspective to the NCA which will produce models to explain many long-debated questions like rapid facies changes or massive differences in sedimentary thickness.

Coniacian ammonites from the Gosau Group of the Salzkammergut (Austria)

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Long neglected Coniacian ammonites in the Gosau Group are now under study as one of us (W.-P. Maherndl) collected a representative sample in the road tunnel N of Bad Ischl. We compare dominating Forresteria alluaudi (Boule, Lemoine & Thévenin, 1907) from the road tunnel with South African material (Kennedy, Wright & Klinger; 1983). It turned out that variability is the most distinctive characteristic of the group.

Neither in the road tunnel during construction work nor at one of the other collecting sites of Strobl/Weißenbach are measurable sections for bed by bed collecting. The chronostratigraphic sequence is therefore based upon comparison of local finds with well documented areas (France, South Africa, Madagascar). As we have finished the work on the Santonian and Turonian ammonites of the Gosau the study of the Coniacian ammonites will be the temporary end of studies on Cretaceous ammonites of the Salzkammergut. In the foreseen paper on the Coniacian ammonites we include improved geological documents of the area.

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Structural and molecular spectroscopic behaviour of the Mg-Mn kieserite solid solution, (Mg,Mn) $SO_4 \cdot H_2O$, with relevance to icy satellites of Jupiter and Saturn

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The investigation of the presence of sulfates in our solar system receives growing attention, as these compounds significantly influence melting equilibria on the icy moons of Saturn and Jupiter, leading to the existence of subsurface oceans and even cryovolcanism (Kargel, 1991, McCord et al., 2001). Although higher-hydrated sulfates such as epsomite and mirabilite dominate on their surfaces, it is not excluded that low-hydrated Mg-sulfates, such as kieserite ($MgSO_4 \cdot H_2O$), are also present, as indicated by the results of high-pressure experiments (Kargel, 1991, Nakamura and Ohtani, 2011). Given the significant content of Mn-sulfate in the soluble fraction seen in some carbonaceous chondrites (Frederiksson and Kerridge, 1988), an intermediate composition of kieserite and other Mg-sulfates on the icy moons along the Mg/Mn solid solution series may be expected. The relationship of structural and spectroscopic properties along the entire Mg-Mn kieserite solid solution range is of particular interest, in view of the known differences between both endmembers.

We hereby present first results on structural and lattice parameter changes from single crystal X-ray diffraction data of hydrothermally synthesized material with variable Mg/Mn ratio. Respective FTIR and Raman spectra reveal a slight decrease in the wavenumber positions of the vibrational modes of the SO_4 tetrahedra, as the Mn/Mg ratio progresses towards Mn-dominant compositions. A well-resolved IR absorption band at around 840 cm-1 shows a significant decrease in wavenumber position with increasing Mn-content. The entire Mg-Mn kieserite solid solution shows Vegard-type behaviour, i.e. lattice parameters as well as spectral band positions change along linear trends with increasing Mn content. While the changes in wavenumber position observed for the SO_4 absorption features in the IR spectra are too subtle, the changes in the wavenumber position of the ~840 cm-1 band enable to roughly estimate the Mn/Mg ratio in extraterrestric kieserite from present and future IR remote sensing data as well as in-situ measurements. The narrow bands in Raman spectra with few overlaps make it possible to infer on the Mn/Mg ratio even using the changes in wavenumber position of the sulfate vibrational modes.

As a complication, noticeable changes in the wavenumber position of the ‘diagnostic’ bands are observed with decreasing temperature. Despite these deviations (which can in addition be compensated by the knowledge of the measurement temperature), one can roughly determine the chemistry of extraterrestric kieserite along the Mg/Mn binary join from vibrational spectra acquired by orbital reconnaissance missions and future lander missions to the icy moons of Jupiter and Saturn.

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The Jurassic Gresten facies of the European margin in Austria, Hungary and Romania: a regional overview

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The *locus typicus* of the Gresten facies has been described from the Lower Jurassic strata of the Gresten Klippen Zone in Upper and Lower Austria. This particular lithofacies development, i.e. fluvial, limnic to coastal coal deposits overlain by open marine marls spans the Hettangian to Sinemurian stages of the Lias and was deposited on the south-facing passive margin of the European plate. A very similar Jurassic lithofacies succession, also traditionally designated as having a Gresten-facies, is known from the autochthonous cover of the Molasse Basin and the Vienna Basin in Austria. However, these “Gresten beds” are Aalenian to Bajocian (Dogger) in age and therefore they span a significantly younger (by about 20-25 million years) time-interval than their Liassic counterparts.

Similarly, Dogger fluvial to neritic sandstones (Bals Formation) are also known from the conjugate margin of the Bohemian segment of the European margin, on the northern part of the Moesian Platform of Romania. The occurrence of distinct Gresten facies siliclastic units with coals in various parts of the broader Alpine, Carpathian and Pannonian realm is interpreted as the result of progressive syn-rift extension and subsidence. At least in the Mecsek unit in the SW Pannonian Basin and the Mesozoic substratum of the Vienna Basin, the formation of coal can be directly tied to subsidence in extensional half-grabens. Whereas there are significant age differences between the various Gresten facies successions described here, they were all deposited in an isopic facies on the northern, European margin of the opening Neo-Tethys.

Significant age differences (i.e. Lias versus Dogger) between the various locations of the Gresten facies occurrences are attributed to different onsets of syn-rift extension along the peri-Tethyan margins. The importance of the Gresten lithofacies is that its neritic sandstone units are producing reservoirs in the Vienna Basin, Austria, and in the Moesian Platform, Romania/Bulgaria. However, the Gresten-facies Lias sandstones in Hungary did not provide reservoirs to date, although this fact is probably due to differences in the petroleum system elements other than reservoir quality.

To address the differences in reservoir quality of the various Gresten sandstone units, their provenance was addressed using detrital zircon age dating. A very large-scale sampling campaign, ranging from Austria to Romania, provided interesting differences highlighting along-strike variations in the pre-rift basement of the Jurassic European margin.

Calcification of the eucaryotic microalga Oocardium stratum NAEGELI 1849 (Zygnematophyceae): Exploring the niche of a highly effective biocalcifyer

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Aside of physical processes (e.g., CO_2 degassing due to turbulence) the formation of spring-associated limestones (SAL) is generally ascribed to the biological activity of cyanobacteria, mosses and diatoms. The eucaryotic micro-alga Oocardium stratum is a highly effective biocalcifyer that is increasingly identified in limestone-precipitating springs (LPS) worldwide. Inspection of numerous LPS of the Eastern Alps, however, shows that this micro-alga is not found at every spring; if present, it typically dominates the benthic calcifying assemblage. This calls to better understand the ecological requirements of O. stratum.

Based on observation of a selected spring over more than a year, and integrating results of previous works, we indicate that O. stratum is adapted to: (Ultra-)Oligotrophic, shallow, highly turbulent, ambient-temperature (4.7-20°C) spring streams with Ca-(Mg)-HCO_3-(SO_4) waters that achieve significant oversaturation for low-magnesian calcite. Oocardium persists over a wide range of concentrations – over two or three orders of magnitude – of CO_2 (uptaken for photosynthesis) as well as of Ca^{2+}, sulfate and nitrate. To date, no uncalcified sheet-like biofilm of O. stratum cells has been observed by us or is described in literature. O. stratum can calcify so rapidly as to outpace potential competitors (mosses, cyanobacteria). Only diatoms gain from being associated with O. stratum in finding highly differentiated microhabitats on Oocardium calcite. Whether O. stratum, in turn, profits from diatoms via community metabolism is not clarified. For O. stratum, calcification is not facultative (as for cyanobacteria) but essential to its life strategy. In lack of specialized tissues or symbionts that would support the branching mucus stalks in upward growth, precipitation of a calcite tube can be seen as a solution to the problem of being held against gravity, to stay competitive in keeping substrate occupied. Zygnematalean algae date back at least to Cambro-Ordovician times, and photosynthetic eucaryotes and spring habitats exist since the Proterozoic. Fossil spring limestones previously thought to be of cyanobacterial origin only thus may comprise a hitherto unidentified "eucaryotic component", or may even have been largely produced by calcifyers similar to O. stratum.

Mineralogical-petrological and experimental investigations of pyrometamorphic rocks from the Hatrurim Formation (Israel)

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The aim of the investigation was the mineralogical and petrological description of pyrometamorphic rocks from the Hatrurim Formation combined with experimental investigations and pseudosection modelling. The rocks from the Hatrurim were formed by combustion pyrometamorphism of limestones and marls. They contain several unusual minerals, like nagelschmidtite and brownmillerite, kalsilite-O1 (monoclinic polymorph) which are to date only known from synthetic cement clinkers. The analyzed rocks from the Hatrurim contain a complex mineral assemblage of gehlenite, kalsilite-O1, pseudowollastonite, Ti-garnet, apatite, rankinite und hematite and the thermodynamic calculations indicate extremely high temperatures >1200°C. Five experiments using natural dolomites and quartzphyllite starting materials were carried out at temperatures of 1200°C and 1300°C. The mineralogical comparison between the natural samples and the experiments showed only agreement concerning a few minerals, such as gehlenite and garnet.

Characterization of Ti-bearing garnets from the Hatrurim Formation (Israel) was realized through the utilization of optical microscopy, µ-XRF (micro-X-ray fluorescence) spectroscopy, EMPA (electron microprobe analysis), Raman spectroscopy and SCXRD (Single Crystal X-Ray Diffraction) on the sample Apo4. The main paragenesis was identified as Ti-garnet, kalsilite-O1, apatite, rankinite, wollastonite and gehlenite. Further identified minerals are flamite, barioferrite, magnetite and a mix of (Ni,Cu)-spinels. Distinctive color zoning, observed in Ti-garnets, was analyzed with all methods, mentioned above. The measured TiO_2 concentration (from 2 to 13 w%) and SiO_2 (from 25 to 34 w%) in Ti-garnets are highly correlated. Mineral formula calculations of garnet yielded the garnet endmembers andradite, schorlomite-Al, schorlomite and grossular in accordance with the observed Ti-zoning. These results helped to derive the possible cation exchange mechanisms $Ti^{4+} \rightarrow Si^{4+}$ trough displacement of Al^{3+} or Fe^{3+} from the octahedral position to the tetrahedral position, or the direct exchange of [r + OH_4] 4- → Si^{4+}. Raman spectroscopy supports these estimations through displacement of the tetrahedral vibration bands to lower wavenumbers. Raman measurements also provide evidence of an OH component on the tetrahedral position, which is obviously independent of the Ti-concentration. The unit cell parameters of garnet crystals with different Ti content (TiO_2≈ 2-13 wt%), and other minerals were determined using single-crystal X-Ray diffraction method. The crystal structure characterization of Ti-bearing garnets was done applying site population refinements. Results of refinement have confirmed that these Ti-garnets are characterized by the schorlomite substitution $Ti^{4+} \rightarrow Si^{4+}$, where Ti^{4+} preferentially occupies the octahedral (Y) site and mainly Fe^{3+} occupies the tetrahedral (Z) vacancies. Furthermore, unit cell parameters and refined chemical compositions of garnets with different Ti content can be directly compared with crystal-chemical analysis of Ti-bearing andradites from different localities in the world (Armbruster et al. 1998).

Thermodynamic calculations using the software THERMOCALC only yielded limiting T-estimates between 1136°C and 1500°C. Pseudosection calculations using the software DOMINO yielded a narrow range of temperatures between 1120° and 1250°C.

Pseudosection modelling of eclogite-facies microdomains in metapelites and metagabbros using calculated 'micro' bulk compositions

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Pseudosection modelling is a powerful tool for monitoring the metamorphic evolution of rocks as a function of *P-T-X-n*H_2O. Usually these calculations are done using the bulk rock composition of a sample but this approach is then meaningless when it comes to partially equilibrated samples where metamorphic reactions take place only on a very local scale. One way to circumvent this problem is to calculate „synthetic" bulk compositions by considering only the minerals where reactions take place. This can easily be achieved by using the software Rock Maker (Büttner, 2012) where one can calculate any bulk composition based on the stoichiometry of the minerals involved. In this study this approach was used in 1.) partially equilibrated metapelites and 2.) experimental investigations of the gabbro-eclogite transformation at 700°C and 2 GPa.

In the metapelites at Val Savenca in the Sesia-Lanzo Zone, Italy Alpine eclogite-facies metamorphism and restricted fluid flow led to partial transformation of Variscan amphibolite-eclogite facies metapelites (garnet + biotite + sillimanite + K-feldspar + plagioclase + quartz) to zoisite ± jadeite + kyanite + phengite + quartz. This transformation took place under *P-T* conditions of 1.7 – 2.1 GPa at 600°C and low *a*(H_2O) of 0.3-0.6. The textures in the Val Savenca metapelites show relict igneous biotite which is replaced by the assemblage phengite + omphacite ± kyanite ± garnet if it is adjacent to former plagioclase. These omphacitic areas contain no zoisite. Thermodynamic modelling of biotite-plagioclase microdomains was done by calculating pseudosections of stoichiometric mixtures of biotite and plagioclase using the ratios 1:1, 1:2, 1:3, 1:5 and 1:10 using the program THERIAK-DOMINO (DeCapitani & Petrakakis, 2010). Calculations using a biotite-plagioclase ratio of 1:1 yielded biotite still to be stable. The ratio 1:2 yielded the mineral assemblage garnet + omphacite + phengite + zoisite + rutile but no kyanite. The ratio of 1:3 yielded the same assemblage but with kyanite stable only at low H_2O contents. Higher ratios yielded only more complex assemblages also involving two micas. The calculations reveal that 1.) plagioclase reacts to a higher extent than biotite which is obvious since no relict plagioclas is left anymore and 2.) the amount of coexisting H_2O was very low since kyanite occurs in the microdomains.

The experimental investigations of the gabbro-eclogite transformation using drilled cores of a fine-grained gabbro from the Odenwald at 700°C and 2 GPa yielded the mineral assemblage omphacite/jadeite + zoisite + paragonite ± garnet ± hornblende. Thermodynamic modelling was only successful when orthopyroxen-plagioclase micro-domains were considered. Calculations always yielded the assemblage omphacite/jadeite + zoisite + + garnet + kyanite but the jadeite contents of the newly grown omphacites could only be sufficiently reproduced when the plagioclase : orthopyroxen ratio was higher than 3 :1. This study shows that reproduction of the observed mineral assemblage in the plagioclase-biotite microdomains is quite successful and provides estimates on the amount of fluid present during eclogitization.

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The persistence of memory: experimental simulation of geodynamic processes using natural starting materials

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The metamorphic evolution of a rock can be deciphered using three approaches: 1.) the practical geothermobarometric approach (inverse modelling), 2.) the theoretical pseudosection approach (forward modelling) and 3.) the experimental approach. Whereas with the first two approaches it is possible to constrain several stages of the *P-T-X* evolution but how do we know what assemblage is actually present at desired *P-T* conditions and what is the mineralogical „memory" of a rock? Hence the experimental approach allows the detailed investigation of a distinct *P-T* condition of a rock. Therefore, experimental investigations should be viewed as a forward modelling technique and allow to put additional constraints on the evolution of a rock under defined *P* and *T* conditions and hence represents a snap-shot of a *P-T* point of the evolution of a given rock! For this purpose, simple experiments using natural rocks as starting materials can easily be conducted. The disadvantage of this method lies in the complex chemical compositions of natural rocks and the deviation from chemical end-member systems. Therefore these experiments need to be evaluated not only 1.) in terms of their ability to reproduce the natural observations but also 2.) in their ability to reproduce theoretical calculations. In this study experimental investigations of 1.) collision-related metamorphism of a muscovite-rich quartzphyllite sample (Grt_1 + Ms_1 + Ch1 + Bt_1 + Rt) and 2.) subduction-related metamorphism of a plagioclase-rich quartzphyllite sample (Grt_1 + Ab + Ms_1 + Chl + Ilm) were investigated. 10% of water was added to the experiments to facilitate sufficient reaction progress.

In the first set of experiments four different P-T conditions were chosen to represent a clockwise *P-T* loop: 400°C, 0.8 GPa, 600°C, 1.2 GPa and 500°C, 0.4 GPa. Each P-T condition lastet 8 days. In addition to the 32 days experiment, an additional experiment with a duration of 16 days was conducted, where all four *P-T* conditions were run subsequently. Both experiments yielded the mineral assemblage: $Grt_{2,3}$ + Sta + Ms_2 + Bt_2 + Chl_2 + Ilm. In addition four separate experiments were conducted to identify the characteristic mineral assemblages at each of these *P-T* conditions. Pseudosection modelling using DOMINO-THERIAK yields very good agreement between calculated and observed assemblages except for calculated chloritoid and observed staurolite.

In the second set of experiments a hypothetical P-T path with three different P-T conditions (8 days each) of 500°C 1 GPa, 600°C 1.8 GPa and 500°C 0.5 GPa was simulated experimentally for 24 days. The experiment yielded the complex newly-grown mineral assemblage: $Amp_{1,2,3}$ + Ms_2 + Rt. Ms_2 shows an increase in Si, amp_1 is a Ca-rich glaucophane, amp_2 is glaucophane and amp_3 is cummingtonite. Due to the low temperature, too little time and small amounts of fluid, only incomplete mineral reformations were observed. The comparison with the theoretically calculated paragenes using DOMINO-THERIAK is due to the lack of newly-grwon omphacite and garnet only moderate.

This study shows that forward modelling using whole-rock experiments does indeed yield a mineralogical memory that can be attributed to different P-T stages and thus allows the comprehensive characterization of metamorphic mineral assemblages in a given sample. Thermodynamic testing is still hampered by the complex nature of the bulk compositions of the starting materials.

Geologie-Ausbildung für Schüler und Lehrer in der Tschechischen Republik – ein Bericht über das Geodidaktische Zentrum in Rícany

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Die Qualität des geowissenschaftlichen Unterrichts hängt von der Ausbildung der Lehrer und von den Unterrichtsmaterialien ab. An manchen tschechischen Gymnasien beherrscht noch der Geist der verstaubten Museen aus der habsburgischen Ära den Geologie-Unterricht: Kristallgeometrie und chemische Zusammensetzung der Minerale zu pauken, ohne „normale“ Gesteine je in die Hand genommen zu haben. Noch vor 20 Jahren hat die Theorie der Geosynklinale die Begriffe der Geodynamik an den tschechischen pädagogischen Hochschulen gefüllt. Deshalb besteht bei der heutigen Lehrergeneration teilweise noch eine Unsicherheit oder Unwissenheit. Über endogene Prozesse wird nicht gerne unterrichtet. Eine grundlegende moderne geowissenschaftliche Ausbildung ist hier notwendig. Das Geodidaktische Zentrum in Říčany wurde unter Mitwirkung von der tschechischen Akademie der Wissenschaften errichtet. Es bietet die Möglichkeit, aus der artifiziellen schulischen Lernumgebung heraus zu kommen. Angestellt sind hier u.a. promovierte Geowissenschaftler, die den Schülern sowie den Lehrern die Zusammenhänge der Plattentektonik verständlich erläutern können. Viele Erkenntnisse gewinnt man hier selber durch Experimente und Analogmodellierungen. Lernen durch Erleben ist äußerst effektiv. Ein sinnstiftendes Lernen weckt die Leidenschaft für Geowissenschaften bei allen Altersgruppen.

The reconstruction of microbial habitats during Mesoproterozoic stromatolite formation

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Ancient stromatolites mainly consist of authigenic carbonate which may have formed within living microbial mats and, hence, provide unique archives of local physico-biogeochemical conditions within the mats and of the prevailing water chemistry of the paleo-depositional environment. In this study we report trace element and Cd isotope data of individual mesobands of Late Mesoproterozoic domal stromatolites and conophyta from the Paranoá Group (Brazil).

Carbonate leachates of domal stromatolites show rather flat shale-normalized REY patterns (subscript SN) with slightly positive Y_{SN} anomalies indicating that the carbonate was formed in a very restricted environment dominated by terrigenous REY from the continental hinterland. In contrast, conical *conophyta* with typical seawater-like REY_{SN} patterns formed in a milieu dominated by open ocean seawater. The lack of positive Eu_{SN} anomalies suggests that the (sea)water present at both locations was not significantly influenced by high-temperature, hydrothermal fluids, while negative Ce_{SN} anomalies indicate slightly oxidizing conditions in the atmosphere-hydrosphere system during the Late Mesoproterozoic.

In combination with redox-sensitive trace elements such as Ce, Mn and U, the additional analysed $\varepsilon^{112/110}Cd$ values can be used to clearly distinguish between two carbonate endmembers that formed at the seawater-microbial mat interface and the interior of the ancient microbial mat, respectively. Hence, the geochemical reconstruction of stromatolite environment suggests that REY geochemistry in stromatolite-associated carbonate is a reliable proxy to reconstruct the physico-chemical conditions in Precambrian microbial habitats and further highlights Cd isotopes as novel geochemical proxy to gather unique insights into microbial habitats and element cycling on Early Earth.

Mechanical properties of coal macerals: A nanoindentation study

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The mechanical properties of kerogen macerals are considered an important influencing factor for the fracture behavior of organic matter-rich shales and coals, and hence fracture permeability that directly controls the producibility of unconventional resources such as shale gas or coal bed methane. We investigated the mechanical properties of macerals (liptinite, vitrinite, inertinite) in 12 Carboniferous coals from the Ukrainian Donets Basin, covering a maturity range from 0.62 to 1.47 %Rr (vitrinite reflectance). Nanoindentation tests were conducted as the inherent inhomogeneity of coals with differing maceral and mineral proportions requires characterization at the micro-/nanoscale. Maceral-specific material parameters such as hardness (H) and reduced elastic modulus (E_r), as well as the dominating deformation type (plastic vs. elastic) estimated from the shape of the individual load-deformation curves, were correlated with coal rank and parameters related to the depositional setting (e.g. ash yield).

The results indicate that apart from maturity, multiple factors control the mechanical properties of macerals in coals. H and E_r of vitrinites do not follow a clear maturity trend, as a result of multiple influencing factors like mineral matter inclusions, depositional conditions, complex changes in the organic matter structure with increasing rank, and possibly the generation of nanoporosity at advanced maturity levels. A good correlation was found between the bulk ash yield and the mechanical strength of vitrinites at comparable rank (~ 0.7 %Rr).

The mechanical properties of inertinites do not correlate with coal rank; instead, they are mainly controlled by the prevailing conditions (temperature, exposure) during paleo-wildfires, indicated by a correlation of the measured inertinite reflectance with both H and E_r. Liptinites are strongly influenced by transformational processes related to devolatilization at low to medium rank, as well as later hydrocarbon generation, resulting in a peak of H and E_r at medium rank (~0.7 %Rr). Variations in the depositional environment (e.g. increased organic S content due to marine influence) might play an additional role.

In order to achieve a better understanding of the interdependency between mechanical properties and microstructural features (e.g. nanoporosity, mineral inclusions), advanced characterization techniques such as transmission electron microscopy (TEM) are required.

Rust never sleeps: Mineralogisch-chemische Untersuchung von Korrosionsprodukten an archäologischen Eisenobjekten

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Schon seit langer Zeit stellt die Restaurierung von Eisenobjekten ein großes Problem in den archäologischen Wissenschaften dar. Die Probleme treten dabei ab dem Zeitpunkt der Freilegung des Artefakts auf, da hierbei die Umweltbedingungen der Eisenobjekte drastisch verändert werden. Dadurch entstehen mehrere unterschiedliche Korrosionsprodukte, wie zum Beispiel Magnetit, Hämatit und Lepidokrokit oder Akaganeit. Akaganeit, mit der Formel β-FeOOH, ist dabei die problematischste Phase, weil die Bildung mit einer Volumenzunahme verbunden ist, was wiederum in einer Abplatzung von Schollen resultiert und in der sukzessiven Zerstörung des Objekts endet. Um die Ausbildung dieser Phase zu unterbinden und somit dieses Problem lösen zu können, wurde eine Versuchsreihe an archäologischen Eisenobjekten gestartet, in der man verschiedene Lagerungs- und Verpackungsmethoden an Eisenobjekten mehrere Monate testen konnte. Um die einzelnen Korrosionsphasen zu bestimmen, wurden die Proben anschließend mittels mineralogischer Analysemethoden auf deren Zusammensetzung untersucht. Zum Einsatz kamen dabei die Elektronenstrahlmikrosonde, die Mikro-Röntgenfluoreszenzanalyse, die Raman-Spektroskopie und die Pulverdiffraktometrie.

Die Untersuchungen haben gezeigt, dass bei der Bildung der unterschiedlichen Phasen auch der pH-Wert eine große Rolle spielt und aufgrund der beobachteten Mineralparagenesen (Akaganeit vs. β-$Fe_2(OH)_3Cl$) im gesamten Bereich des Eisenobjekts kein konstanter pH- und Eh-Wert herrscht. Deshalb lässt sich von lokalen Schwankungen im 10er µm-Bereich dieser beiden Werte an den Bildungsorten der unterschiedlichen Korrosionsphasen ausgehen. Auch die Verfügbarkeit von anderen ionischen Spezies wie SO_4^{2-}, Cl^- und CO_3^{2-} divergiert in der Probe, so dass sich die Minerale Schwertmannit ($Fe_8O_8(OH)_6SO_4$*nH_2O), Siderit ($FeCO_3$) und sogar Chukanovit ($Fe_2(OH)_2CO_3$) bilden. Besonders das Vorkommen der Karbonatphasen zeigt, dass es neben oxidischen auch anoxische Milieus gibt. Die große Inhomogenität der einzelnen Lagen innerhalb der Korrosionsschicht lässt auf lokalen Änderungen von Parametern wie pH, fS_2, fO_2 und Cl-Gehalten im 10er µm-Bereich schließen. Dies führt zu einer sehr komplexen Struktur der Korrosionsschicht für deren detailliertes Verständnis zahlreiche weiterführende Untersuchungen notwendig sind.

Zusammenfassend lässt sich jedoch sagen, dass die Bildung der Chloridphasen bereits im Boden stattfindet und sich dadurch nicht verhindern lässt. Es ist nur möglich das Fortschreiten der Oxidation von β-$Fe_2(OH)_3Cl$ zu β-FeOOH entweder mit Verpackungsmethoden, die eine möglichst geringe Sauerstoffzufuhr gewährleisten, zu verlangsamen oder durch sofortiges Einlegen in eine Natriumsulfitlösung die Chloridphasen nahezu gänzlich zu entfernen. Bei der letzten Methode gilt jedoch zu beachten, dass diese nur an Eisenobjekten ohne Tauschierungen, also ohne Verzierungen mit anderen Metallen, durchgeführt werden darf.

Spring water temperatures affected by cooling effects of relict rock glaciers – preliminary results of the Niedere Tauern Range, Austrian Alps

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Coarse blocky material is known to have a ground cooling effect in contrast to other types of surface material. The thermal regimes of blocky surface layers of two relict rock glaciers with opposing aspects are investigated and related to water temperature fluctuations at springs draining these relict rock glaciers. Air, ground surface and ground temperature in 1 m depth at several locations at both rock glaciers and water temperatures of the emerging springs are analyzed. The blocky surface layer of the SW-exposed rock glacier generally exhibits lower temperatures than the one oriented to the NE despite the aspect-related higher potential solar radiation. Variations in the seasonal snow cover seem to play a major role herein as the blocky surface of a rock glacier might be better coupled to the atmosphere, resulting in enhanced cooling. Water temperature fluctuations – e.g. short cold temperature pulses ahead of water temperature increase related to “warm” recharge events during summer – indicate a cold water source (piston flow effect) and / or a rapid cooling of event water in the vicinity of the spring during infiltration. Current data analysis points towards potential sporadic permafrost lenses, but verification thereof is not trivial based on the preliminary results. However, this knowledge is essential for the understanding of the groundwater storage of (relict) rock glaciers and is required in the light of climate change and human needs related to runoff in alpine catchments.

Riding down the river sitting on natural suspended matter? Assessing the fate of nanoparticles

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The increasing use of engineered nanoparticles (ENPs) inevitably entails emissions to surface waters, which raises concerns about their fate. The water column is an inherently heterogeneous system: a range of components from truely dissolved, via macromolecular to particulate matter, the separation of which is only operationally defined. Within this continuum of matter particulate contaminants like engineered nanoparticles (ENPs) can undergo various processes such as stabilisation by natural organic matter (NOM), attachment to each other, or to natural suspended particulate matter (SPM), termed homo- and heteroaggregation respectively. These processes are decisive for advective transport or sedimentation of ENPs and likely impact on their bioavailability.

In natural waters interaction between SPM and ENPs (heteroaggregation) is much more likely than homoaggregation. Still, we are lacking simple experimental protocols capturing the complexity of the aqueous system, when assessing the fate of contaminants in the water column. Designing an experimental protocol that adresses heteroaggregation requires an informed selection of system components reflecting relevant characteristics of natural water systems, such as encountered pH ranges, electrolyte composition & concentrations, and composition and concentration of both NOM and SPM. With regards to the hydrochemistry, this has been effected in course of the development of the recently adopted OECD test guideline No. 318 on ENP dispersion stability, which covers homoaggregation and NOM stabilisation.

In order to also tackle heteroaggregation as the most environmentally relevant process, the challenge of selecting adequate SPM analogues has to be faced. Therefore, we did a thourough literature review on riverine SPM composition. Typically we find complex flock-like structures consisting of mineral and organic fractions colonised by microbes. The dominant minerals were found to be phyllosilicates (clays, chlorite and micas), but also feldspars, quartz, carbonates and oxides (mainly iron); with Illite, kaolinite and smectite being the most abundant clays. The organic carbon fraction in SPM is typically <10 %wt and includes a range of substances from refractory (humic/fulvic-like) to rather labile organic polymers, associated with microbial exopolymeric substances (EPS).

Aiming at covering a diverse spectrum of surface chemistries, we selected illite, quartz and hematite as model mineral SPM components and conducted screening tests to optimise their mixing ratios. Furthermore, screening tests involved various “labile” EPS-like molecules (carbohydrates and protein-like substances) up to 6 %wt organic carbon. Selected mixtures were then investigated regarding their flock formation behaviour in different hydrochemistries, as well as their heteroaggregation behaviour and removal of ENPs from the water column after gravity separation.

Flock formation as well as heteroaggregation behaviour involvinng ENPs differed depending on the level of complexity of the SPM mix. Positive surface charges introduced by iron oxides, as well as bridging-flocculation effects by EPS-like molecules seem to be crucial for SPM flock formation. Furthermore, complex SPM flocks deviated from simple SPM analogues with regards to their heteroaggregation behaviour and ENP removal, indicating that complexity of SPM cannot be ignored when studying the fate of ENPs in surface water systems.

Mineralogical properties of continental related pelites in the Eastern Alps

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Mineralogical properties of continental sediments and sedimentary intercalations in Alpine units from Austroalpine zones and Klippen belts were investigated to figure out depositional characteristics and lithofacial variations. Beside the occurrence of continental deposits as whole formations, intercalations of continental origin appear in Calcalpine carbonate complexes and coarser grained layers of the Klippen belts and in Lower Austroalpine sequences.

For the analyses a desert related example of the Lower Triassic Werfen-Formation and the Upper Triassic continental Keuper development of the Lower Austro Alpine Semmering complex and intercalations within the Calcareous Alps and the Keuper of various Klippen belts were taken into account. For the detail analysis the sampling was focused on following locations: Lower Triassic sediments of the frontal zone of the Goeller Nappe, in the area of Hinterbrühl/Weissenbach, Upper Triassic Keuper sediments of the St. Veit Klippenbelt near Vienna, the shear slice within the base of the Goeller Nappe in the area of Hinterbruehl, an intercalation (“green layer”) in the Hauptdolomit of the Lunz Nappe in the quarry Kritsch near Vienna, and a red intercalation in the Hauptdolomit of the Reisalpen Nappe near Altenmarkt/Triesting.

Qualitative and quantitative mineralogical analyses were carried out by X-ray diffraction analysis with a specific focus on clay mineralogical characteristics. On the base of preliminary investigations the mineralogical differentiation of the investigated locations took place by the following mineral groups, representing main components of the analysed pelitic sediments: amount of quartz, the content of dolomite and/or calcite, the occurrence of feldspars, the composition of clay minerals represented by the mica group minerals, mixed layer clays (especially illite- and smectite), the presence of kaolinite and chlorite, and in red layers the occurrence of hematite. As a main result of the comparison between the analysed continental related objects, the source of the red intercalation within the Hauptdolomit of the Reisalpen Nappe near Altenmarkt/Triesting differs significantly concerning the lithofacial characteristics. For comparison reasons samples of limnic/lacustric sediments of the Lower Gosau group are analysed. The investigations turn out, that the mineralogical characteristics of the pelitic sediments allow to distinguish variations of the different locations concerning sedimentation areas and depositional conditions.

ARMONIA - Homogenization of cross-border accelerometric networks between Northeastern Italy and Austria: Selection of new sites and instruments for Earthquake Monitoring in Austria

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The seismically active Southeastern Alps region has a moderate seismic hazard with an expected maximum acceleration for an exceedance probability of 10% in 50 years of 0.250 g. In the border region between Austria and Italy several seismological networks are operated. The main ones are the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) seismological network, the Friuli Venezia Giulia Accelerometric network (University of Trieste), which is integrated to the National Accelerometric Network (Dipartimento della Protezione Civile Nazionale) and the Austrian seismological Network (ZAMG, Vienna). These three networks are all part of the Central Eastern European Earthquake and Research Network (CE3RN). The interregional ARMONIA project between Austria and Italy aims to an improved cooperation between the civil protection institutions for disaster reduction in case of strong earthquakes in the cross border region. In such a case sharing of real-time seismic data is essential for determining areas with the highest intensities and the probable impacts.

The national seismic network of Austria consists of 19 broad-band stations (isolated places) and 20 strong-motion stations (populated areas). The actual network geometry is unevenly distributed and therefore the accuracy of earthquake locations (especially the focal depth) can vary considerably along Austria. The densest network distribution is found in the central part of Tyrol. The estimated network threshold for automatic identification of local earthquakes varies between magnitude 0.8 < Ml < 1.8. For the site selection of new stations we generated and combined maps for the location accuracy (GT5-criteria), population data, maximum documented intensity of settlements, epicenter location of documented earthquakes that have caused damage, the network magnitude threshold and the national seismic hazard map.

Guidelines for instrument selection are part of the technical criteria and include – in no particular order – resolution, bandwidth, integration into the data acquisition system, station maintenance and last but not least the price. A selection of instruments will be installed for duration of several weeks in the seismically very active region Umbria in Italy. This should allow recording at least a few earthquakes under natural conditions. The test will be continued under laboratory conditions on the Conrad-Observatory, a high-quality research facility near Vienna. In the second phase of the test and based also on the experiences of the initial installation, a manual for instrument installation will be compiled.

Towards a new seismic hazard map of Austria

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For hazard assessments, ground motion measurements from felt earthquakes in Austria were collected and various statistical parameters were derived. The local earthquake catalogue has been verified for the completeness and was compared with those of neighbouring countries. Source mechanisms were determined and collected and local site effects were investigated. GMPEs for intensity and ground motion were developed and selected. The results lead to a new ShakeMap algorithm which is implemented into the real-time system of the local Seismological Service of Austria.

Now we are looking for the next steps towards a new seismic hazard map of Austria. We show first results derived from our input data with the OpenQuake-engine from GEM (Global Earthquake Model). We are discussing the challenges we are facing during the development of a hazard map in a mountainous region and the definition of local fault and area sources.

The tectonic contact between the Bundschuh and Murau Nappes (Upper Austroalpine Unit, Stadl an der Mur, Austria)

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The exact position and kinematics of tectonic contacts between different nappe systems within the Upper Austroalpine Unit are still poorly explored. In this work, we investigate the contact between the Bundschuh Nappe (BN, Ötztal-Bundschuh Nappe System) and the Murau Nappe (MN, Drauzug-Gurktal Nappe System) south of Stadl a.d Mur. We documented the lithologies and structures across the contact and investigated the garnet-bearing micaschist and paragneiss from both nappes in order to characterize the exhumation history. The BN is exposed in footwall position and consists of a crystalline basement (paragneiss, micaschist) with transgressive overlying Permo-Mesozoic metasediments (metaconglomerate, quartzite). The MN, in hanging wall position, is comprised of metasediments (micaschist, marble, greenschist) of Palaeozoic age and overlain by Permo-Mesozoic cover rocks (quartzite, marble). The top of the deformed Permo-Mesozoic metasediments of the BN defines the nappe boundary.

In both nappes, four main deformation phases have been identified at outcrop scale and in thin sections. The main layering dips shallowly to N and E in the BN and to NE in the MN (D1). It is deformed by isoclinal folds with NE- to E-dipping fold axes, cleavage domains and microlithons structures (D2). Ductile to brittle-ductile top-to-the-E shearing, indicated by quartz CPO and SPO as well as C'-fabric is interpreted as the expression of an early phase of Eoalpine exhumation (D3). Brittle top-to-the E and NNE shearing with kinking of the earlier fabric corresponds to the late Eoalpine exhumation (D4).

In both nappes, the investigated thin sections have similar characteristics, with a lepidoblastic microstructure and nearly almost similar index minerals (garnet, muscovite, paragonite, chlorite, biotite, ilmenite) and mineral proportions. The only significant difference is the occurrence of chloritoid porphyroblasts in the samples of the BN and the slightly higher biotite content in the MN. In both nappes, orientation of inclusions in garnet indicates garnet growth during phases D1, D2, SEM imaging, and chemical profiles in garnet show a systematic continuous core to rim chemical zoning.

Raman microspectroscopy on carbonaceous material yielded temperatures of 520°C in the BN and slightly below 500°C in the MN. Thermodynamic modelling was carried out for a sample from the BN, showing a garnet-chloritoid-chlorite-muscovite-paragonite-ilmenite equilibrium assemblage interpreted as a peak assemblage. For the analysed bulk rock chemistry, this assemblage correspond to a narrow field located at 510-540°C and 9-11 kbar. The compositions of garnet, chloritoid, chlorite and white mica calculated for this P-T range are in good agreement with the measured ones. These peak conditions are consistent with the results of Raman microspectroscopy. The fact that both units show one phased garnets is a new finding, especially in the BN.

A gigantic marine ostracod trapped in mid-Cretaceous amber of Myanmar (Burmite)

Xing, Lida (China University of Geosciences, Beijing, CHN);
Sames, Benjamin (Department für Geodynamik und Sedimentologie, Wien, AUT);
McKellar, Ryan C. (Royal Saskatchewan Museum, Regina, Saskatchewan, CAN);
Xi, Dangpeng (China University of Geosciences, Beijing, CHN);
Bai, Ming (Chinese Academy of Sciences, Beijing, CHN);
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The Burmese amber (or 'Burmite', ~99 Ma, Myanmar), widely known for exquisite preservation of a mid-Cretaceous terrestrial faunas including dinosaur remains and birds, also yields marine macro- and microfossils which can provide important contextual information on paleoenvironment and amber formation.

Our first finding of a valve of a 'gigantic' (12.9 mm) marine ostracod in a specimen of Burmese amber effectively doubles the age of the ostracod amber record, but also offers the first representative of the Subclass Myodocopa (Ordovician to recent) in amber, an exclusively marine and weakly calcified group with a poor fossil record (Xing et al., 2018). However, lacking soft parts and the complementary right carapace valve combined with a broader range of carapace features and examples of morphological stasis, restrict our inferences at lower taxonomic level.

The amber that constitutes our specimen was produced under two distinct sets of conditions. Subsequent resin flows in the amber specimen contain terrestrial arthropods (spider fragments) and insect frass. The 'marine' resin flow that contains the ostracod is relatively clear and is separated by a prominent drying line from a secondary 'terrestrial' resin flow that contains multiple, dark, organic particles of insect frass, as well as the fragmentary remains of spiders. These features resolve an enigmatic taphonomic pathway which seems to be much less elaborate than scenarios for inclusion of aquatic (freshwater mostly) organisms in amber proposed before and support a marginal marine setting for resin production. The resin was probably released underwater or at the water's edge, encapsulating the ostracod, then the resin mass dried subaerially for a significant length of time before a subsequent resin flow captured a range of terrestrial inclusions. This combination of marine and terrestrial resin flows may have been brought about by variation in water levels. While many sites of the mid-Cretaceous Burmese amber exhibit marine influences (marine fossil content), full paleoenvironmental and geological details for the numerous amber-producing sites in the Kachin state of Myanmar have yet to be reported.

In addition to its significance of the Burmese amber deposits as important archive for mid-Cretaceous terrestrial life and biodiversity, our find emphasizes the significance and further potential of these deposits as archive for contemporaneous marginal marine life and biodiversity.

Reference:

Xing, L., Sames, B., McKellar, R., Xi, D., Bai, M., Wan, X. (2018): A gigantic marine ostracod (Crustacea: Myodocopa) trapped in mid-Cretaceous Burmese amber. Scientific Reports 8: 1365. https://www.nature.com/articles/s41598-018-19877-y (Open Access)

Holocene benthic baseline communities in the northern Adriatic Sea and their collapse due to anthropogenic impact

Zuschin, Martin (Institut für Paläontologie, Wien, AUT);
Gallmetzer, Ivo (Universität Wien, Wien, AUT);
Haselmair, Alexandra (Universität Wien, Wien, AUT);
Tomašových, Adam (Earth Science Institute, Bratislava, SVK)

The shallow northern Adriatic Sea has a long history of anthropogenic impact that reaches back many centuries. While the effects of human impact over the past decades were extensively studied, the major ecological turnovers during the entire Holocene remain poorly explored. In this study, we reconstruct ecological baselines defining benthic ecosystem composition prior to major anthropogenic changes. For this purpose we study benthic communities from four 1.5 m long sediment cores, which cover the whole Holocene succession of the northern Adriatic Sea. We discriminate between natural and anthropogenic drivers based on 1) temporal changes in the composition of molluscan communities observed in sediment cores; and 2) changes in concentrations of heavy metals, pollutants, and organic enrichment. The sediment cores cover a broad range of low-sedimentation settings and reach back to the Pleistocene-Holocene boundary allowing for a stratigraphic distinction of the major phases of the Holocene. During the transgressive phase and the maximum flooding zone, sea-level rise, the establishment of the modern circulation pattern, and climatic fluctuations determined the development of benthic communities in shallow-water, vegetated habitats. After sea-level stabilisation, the communities remained relatively unchanged and can be considered as baseline communities that started to change markedly only with the intensification of human impacts in the late high-stand leading to a dominance of infauna and a decline of epifauna at all sites. The trend is paralleled by an increase of suspension-feeding species at the expense of grazers and deposit-feeders. This profound ecological change affects species diversity, life habits and habitat conditions and shows that modern soft-bottom benthic communities, in the northern Adriatic Sea, hardly reflect the high geographic heterogeneity of the pre-anthropogenic benthos.

Underlined numbers (e. g. 123 or **123**) – presenting author
Bold numbers (e. g. **123**) – first author

TAGUNGSPROGRAMM PANGEO 2018, Wien (Sessionprogramm)

23.9.2018

08:30 Exkursion I: Semmering-Basistunnel (L. Weber). Treffpunkt UZAII, Althanstrasse 14

08:30 Exkursion II: Vom Grundgebirge bis zum Löss: Geologische Highlights der Wachau (B. Grasemann,T. Sprafke & M. Heinrich). Treffpunkt UZAII, Althanstrasse 14

17:00-19:00 Registrierung am Tagungsort UZAII, Althanstrasse 14

19:30 Icebreaker Party im Naturhistorischen Museum Wien (Burgring 7, 1010 Wien)

24.9.2018

08:00-16:00 Registrierung am Tagungsort UZAII, Althanstrasse 14

HS3

08:30 **Eröffnung: Wagreich (Moderator)**

Grußworte:
Petra Heinz (Dekanin der Fakultät für Geowissenschaften, Geographie und Astrophysik)
Bernhard Grasemann (Präsidenten der Österreichischen Geologischen Gesellschaft)
Mathias Harzhauser (Abteilungsdirektor Geologie des Naturhistorischen Museums Wien)
Peter Seifert (Direktor der Geologischen Bundesanstalt)

		HS3	HS2	Clar Saal
	09:00-10:00	**Quartärgeologie: Spötl (Moderator)**	**Umwelt: Micic (Moderatorin)**	
	10:00	Kaffeepause	Kaffeepause	Kaffeepause
	10:30-12:00	**Sedimentologie/Stratigraphie: Piller (Moderator)**	**Lagerstätten: Weber/Melcher (Moderatoren)**	
	12:00	Mittagspause	Mittagspause	Mittagspause
	13:30-15:00	**Petrologie/Geochronologie: Huet/Klötzli (Moderatoren)**	**Ingenieurgeologie: Preh (Moderator)**	**Lehrer Session: Summesberger (Moderator)**
	15:00	Kaffeepause	Kaffeepause	Kaffeepause
	15:30-17:00	**Petrologie/Geochronologie: Huet/Klötzli (Moderatoren)**		
	17:00-18:00	Poster Session		
	18:00	Ehrungen ÖGG: Grasemann		
		Otto Ampferer Preis: A. Rogowitz; Hans Höfer von Heimhalt Preis: D. Misch		
		Ehrenmitgliedschaft bei der Österreichischen Geologischen Gesellschaft: Konrad Hösch, Georg Friebe		
		Preis "Vorwissenschaftliche Arbeit im Bereich Erdwissenschaften":		
	18:30	Plenarvortrag L. Weber: “Energiewende = Rohstoffwende?”		

		HS3	HS2	Clar Saal
25.9.2018	08:30-10:00	**Angewandte Geophysik: Adrian Flores-Orozco (Moderator)**	**Paläontologie: Zuschin (Moderator)**	
	10:00	Kaffeepause	Kaffeepause	Kaffeepause
	10:30-12:00	**Geophysik: Lenhardt (Moderator)**	**Paläontologie/Stratigraphie: Zuschin (Moderator)**	
	12:00	Mittagspause	Mittagspause	Mittagspause
	13:30-15:00	**Strukturgeologie: Schöpfer/Hinsch (Moderatoren)**		
	15:00	Kaffeepause	Kaffeepause	Kaffeepause
	15:30-17:00	**Tectonik und Hydrogeologie in Fold-and-Thrust Belts: Plan/Ortner (Moderatoren)**		
	17:00-19:00	Poster Session		
	19:30	Konferenz-Dinner (Melker Stiftskeller, Schottengasse 3/3, 1010 Wien)		

		HS3	HS2	Clar Saal
26.9.2018	08:30-10:00	**Hydrogeologie: Birk (Moderator)**		
	10:00	Kaffeepause	Kaffeepause	Kaffeepause
	10:30-12:00	**Regionale Geologie: Iglseder (Moderator)**		
	12:00	**Abschlussveranstaltung: Wagreich (Moderator)**		

27.9.2018

08:30 Exkursion III: Geologie und Geomorphologie des Neusiedlersees (E. Draganits). Treffpunkt UZAII, Althanstrasse 14

TAGUNGSPROGRAMM PANGEO 2018, Wien (Vortragsprogramm)

23.9.2018

08:30 Exkursion I: Semmering-Basistunnel (L. Weber). Treffpunkt UZAII, Althanstrasse 14

08:30 Exkursion II: Vom Grundgebirge bis zum Löss: Geologische Highlights der Wachau (B. Grasemann,T. Sprafke & M. Heinrich). Treffpunkt UZAII, Althanstrasse 14

17:00-19:00 Registrierung am Tagungsort UZAII, Althanstrasse 14

19:30 Icebreaker Party im Naturhistorischen Museum Wien (Burgring 7, 1010 Wien)

24.9.2018

08:00-16:00 Registrierung am Tagungsort UZAII, Althanstrasse 14

	HS3				
08:30	**Eröffnung: Wagreich (Moderator)**				
	Grußworte:	Petra Heinz (Dekanin der Fakultät für Geowissenschaften, Geographie und Astrophysik) Bernhard Grasemann (Präsidenten der Österreichischen Geologischen Gesellschaft) Mathias Harzhauser (Abteilungsdirektor Geologie des Naturhistorischen Museums Wien) Peter Seifert (Direktor der Geologischen Bundesanstalt)			
	HS3		HS2		Clar Saal
09:00-10:00	**Quartärgeologie: Spötl (Moderator)**		**Umwelt: Micic (Moderatorin)**		
	Neuhuber, Stephanie; Ruszkiczay-Rüdiger, Zsòfia; Braumann, Sandra; Hintersberger, Esther; Plan, Lukas; Fiebig, Markus; Grupe, Sabine; Payer, Thomas; Lüthgens, Christopher; Braucher, Règis	Pliocene and Pleistocene fluvial deposits in the Vienna Basin - Status of numerical age dating using the cosmogenic nuclide pair 26Al and 10Be	Montano, Manuel; Tepe, Nathalie; von der Kammer, Frank; Hofmann, Thilo	Exploring the Nanogeochemical Environment Using single particle ICP-TOF-MS	
	Plan, Lukas; Stöger, Tobias; Draganits, Erich; Gier, Susanne	Rare karren features indicate a previously unknown Pleistocene landslide-dammed lake (Lower Austria)	Walch, Helene; Praetorius, Antonia; von der Kammer, Frank; Hofmann, Thilo	Riding down the river sitting on natural suspended matter? – Assessing the fate of nanoparticles.	
	Daxer, Christoph; Moernaut, Jasper; Taylor, Timothy; Haas, Jean Nicolas; Strasser, Michael	The Late Glacial and Holocene Sedimentary Infill of Lake Mondsee (Eastern Alps, Austria) and Historical Rockfall Activity revealed by Reflection Seismics and Sediment-Core Analysis	Kralik, Martin	Nitrogen-isotopes and multi-parameter sewage water test for identification of nitrate sources: Groundwater body Marchfeld E of Vienna	
	Draganits, Erich; Khoshraftar, Reza; Saeedi, Sahand; Schimerl, Nicolas; Aali, Abolfazl; Bagherpour-Kashani, Natascha; Boenke, Nicole; Stöllner, Thomas	Geology, geoarchaeology or ethnogeoarchaeology? Landscape reconstruction at the Chehrabad salt mine (Zanjan, Iran) since the Achaemenid Period	Hoehn, Philipp; Flores Orozco, Adrián	Investigating stream-aquifer exchange using waterborne spectral induced polarization imaging	
10:00	Kaffeepause		Kaffeepause		Kaffeepause
10:30-12:00	**Sedimentologie/Stratigraphie: Piller (Moderator)**		**Lagerstätten: Weber/Melcher (Moderatoren)**		

	Strasser, Michael; Huang, Jyh-Jaan; Moernaut, Jasper; Ali, Ahmed; Burger, Ulrich; Christoph, Daxer; Geitner, Clemens; Haas, Jean Nicolas; Koinig, Karin; Kowarik, Kerstin; Molenaar, Arianna; Oeggl, Klaus; Spötl, Christoph; Stückler, Georg; Wagreich, Michael	The new Austrian Core Facility for Scientific Core Analyses: Introduction and first scientific achievements	Ebner, Fritz; Hippler, Dorothee; Dietzel, Martin ; Mali, Heinrich; Ovissi, Masoud; Ghorbani, Masoud	Mg-Isotopie in Magnesiten: Weiterführende Charakterisierung und Implikationen für die Magnesitgenese		
	Meister, Patrick; Habler, Gerlinde; Frisia, Silvia; Zhang, Huiming	Incomplete Ostwald ripening in Triassic primary dolomites	Melcher, Frank; Onuk, Peter	Das Potential von kritischen Hochtechnologiemetallen in Buntmetallsulfidvorkommen der Ostalpen		
	Koukal, Veronika; Wagreich, Michael	Paleogene deep-water facies of the Upper Gosau Subgroup at Gams (Styria, Austria)	Posch-Trözmüller, Gerlinde; Peresson, Mandana; Hobiger, Gerhard; Atzenhofer, Bernhard; Wessely, Godfrid	Gipsvorkommen im Untergrund Niederösterreichs: Abgrenzung, Risiken, Datierung		
	Mandic, Oleg; Harzhauser, Mathias	Current status of the Central Paratethys Neogene stratigraphy	Hampl, Ferdinand Jakob	The karst bauxite of the Unterlaussa mining area (Upper Austria)		
	Harzhauser, Mathias; Mandic, Oleg; Kranner, Matthias; Lukeneder, Petra; Kern, Andrea K.; Gross, Martin; Carnevale, Giorgio; Jawecki, Christine	Mind the gap! The Sarmatian/Pannonian boundary at the western margin of the Vienna Basin (Austria)	Weber, Leopold	IRIS Online (Interaktives Rohstoff Informations System), ein Beispiel für ein weltweit einzigartiges digitales Rohstoff-Informationssytsem		
	Pfleiderer, Sebastian	Spectroscopy and machine vision – a replacement for manual gravel analysis?	Heinrich, Maria	Das Projekt IRIS-Baurohstoffe in Österreich im Rahmen der Initiative GBA-Forschungspartnerschaften Mineralrohstoffe		
12:00	Mittagspause		Mittagspause		Mittagspause	
13:30-15:00	**Petrologie/Geochronologie: Huet/Klötzli (Moderatoren)**		**Ingenieurgeologie: Preh (Moderator)**		**Lehrer Session: Summesberger (Moderator)**	
	Tropper, Peter; Mair, Philipp; Schantl, Philip; Jestl, Stefan; Niederstrasser, Stefan	The persistence of memory: experimental simulation of geodynamic processes using natural starting materials	Illeditsch, Mariella; Preh, Alexander	Waldmodul für THROW – Berücksichtigung des Einflusses von Vegetation bei 2D-Steinschlagmodellen	Barnikel, Friedrich; Seifert-Lorenz, Ulrike; Brütting, Tobias; Plötz, Robert	Internationale Schulkooperationen im Rahmen von Erasmus+ - Best practice Beispiele
	Rantitsch, Gerd; Iglseder, Christoph; Huet, Benjamin; Hollinetz, Marianne Sophie; Werdenich, Manuel	Organic metamorphism during thrusting within the Eoalpine upper plate (NW margin of the Gurktal nappes, Eastern Alps)	Fleris, Emmanouil; Preh, Alexander	A study of Rockfall processes at different geomorpholocigal settings through numerical simulations in 3D.	Barnikel, Friedrich	Unterrichtseinheiten in den Geowissenschaften von Lehrkräften für Lehrkräfte
	Griesmeier, Gerit; Huet, Benjamin; Schuster, Ralf; Grasemann, Bernhard	P-T-t constraints for the Variscan history of the Gaugen Complex (Kreuzeck Mountains, Austria, Eastern Alps)	Fuchs, Florian; Hibert, Clément; Lenhardt, Wolfgang; Bokelmann, Götz; the AlpArray Working Group	Searching fore- and afterslides of gravitational mass movements	Hamilton, Margret	The research of the western Tauern window between 1894 and 1898 in the documents of the mineralogist and petrographer Friedrich Becke. A project of the "Österreichische Akademie der Wissenschaften".
	Neugschwentner, Bernhard; Kloetzli, Urs; Kanjanapayont, Pitsanupong; Konecný, Patrik; Broska, Igor	Petrogenesis of Triassic and Cretaceous metamorphic rocks from Khanom (Peninsular Thailand); monazite CHIME dating and thermo-barometry	Hormes, Anna; Reitner, Jürgen; Vecchiotti, Filippo	Surface Deformation Rates of a Deep-Seated Toppling Slope Failure in Lienz (Tyrol, Austria)	Hofmann, Thomas; Dörflinger, Elfriede	Rocky Austria online – Lessons learned

		Klötzli, Urs	Geochronological pitfalls in petrochronologal reserach - the case of instrumental elemental fractionation effects	Ostermann, Marc; Zangerl, Christian; Ivy-Ochs, Susan	Deep-Seated Gravitational Slope Deformations in the Austrian and Italian Alps: Characteristics and Dating	Lantschner, Magnus	Geologische Umweltbildung im Naturpark Zillertal
		Quandt, Dennis; Micheuz, Peter; Kurz, Walter; Krenn, Kurt; Hippler, Dorothee; Kluge, Tobias; Boch, Ronny; Hauzenberger, Christoph	Timing and geochemistry of calcite veins in pillow lavas of the Troodos ophiolite: implications for fluid composition and vein mineral growth in a supra-subduction zone	Burger, Ulrich; Perello, Paolo; Lorenzi, Stefano	Hydraulische Charakterisierung des Hochstegenmarmors am Westrand des Tauernfesters - Brenner Region	Vesela, Petra; Jana Švandová; Kateřina Čiháková; Jakub Halaš	Geologie-Ausbildung für Schüler und Lehrer in der Tschechischen Republik – ein Bericht über das Geodidaktische Zentrum in Říčany
	15:00	Kaffeepause		Kaffeepause		Kaffeepause	
	15:30-17:00	**Petrologie/Geochronologie: Huet/Klötzli (Moderatoren)**					
		Tropper, Peter; Krüger, Biljana; Stiller, Veronika; Rauch, Leo; Joachim, Bastian; Angerer, Thomas	Mineralogical-petrological and experimental investigations of pyrometamorphic rocks from the Hatrurim Formation (Israel)				
		Meyer, Michael	Optical dating of geological and archaeological rock surfaces – potential and limitations of a new dating tool for the earth and archaeological sciences				
		Rice, A Hugh N.; Bao, Huiming; Viehmann, Sebastian; Peng, Yongbo	The Marinoan 17O depletion (MOSD) event in northern Baltica				
		Talla, Dominik; Wildner, Manfred	Structural and molecular spectroscopic behaviour of the Mg-Mn kieserite solid solution, (Mg,Mn)SO4·H2O, with relevance to icy satellites of Jupiter and Saturn				
		Huet, Benjamin; Knoll, Tanja; Schuster, Ralf; Paulick, Holger	Albite-spodumene pegmatites without large granite intrusions? Exploring the feasibility of the alternative anatectic model				
		Roszjar, Julia; Whitehouse, Martin J.; Terada, Kentaro; Fukuda, Kohei; John, Timm; Bischoff, Addi; Morishita, Yuichi; Hiyagon, Hajime	The dynamic history of Mars – adding another puzzle piece from the analysis of Ca-phosphates in martian meteorites				
	17:00-18:00	Poster Session					
	18:00	**Ehrungen ÖGG: Grasemann**					
		Otto Ampferer Preis: A. Rogowitz					
		Hans Höfer von Heimhalt Preis: D. Misch					
		Ehrenmitgliedschaft bei der Österreichischen Geologischen Gesellschaft: Konrad Hösch, Georg Friebe					
		Preis "Vorwissenschaftliche Arbeit im Bereich Erdwissenschaften":					
	18:30	**Plenarvortrag L. Weber: "Energiewende = Rohstoffwende?"**					
		HS3		HS2		Clar Saal	
25.9.2018	08:30-10:00	**Angewandte Geophysik: Adrian Flores-Orozco (Moderator)**		**Paläontologie: Zuschin (Moderator)**			

	Steiner, Mathias; Gallistl, Jakob; Maierhofer, Theresa; Flores-Orozco, Adrian	Assimilation of Electrical Resistivity Tomography (ERT) and Ground-Penetrating Radar (GPR) data in the inversion of Refraction Seismic Tomography (RST) data for an improved spatial characterization of alpine permafrost	Gebhardt, Holger; Bettina, Schenk; Wolfgring, Eric; Irene, Zorn	Cyclic paleo-salinity changes inferred from benthic foraminiferal assemblages in the Upper Burdigalian (Lower Miocene) Korneuburg Basin, Austria	
	Roser, Nathalie; Flores-Orozco, Adrian; Steiner, Matthias; Denk, Astrid	Electrical Properties in Vineyard Soils	Kranner, Matthias; Harzhauser, Mathias, Mandic, Oleg; Piller, Werner E.; Strauss, Philipp; Siedl, Wolfgang	Foraminifera as tool for biostratigraphic cross-correlation of major oilfields in the Vienna Basin	
	Aigner, Lukas; Bücker, Matthias; Steiner, Matthias; Gallistl, Jakob; Flores-Orozco, Adrian	Improved inversion of Induced Polarization and Transient Electromagnetic methods to characterize fractured media	Lindenbauer, Julius; Voigt, Sebastian; Herret, Marie Theres; Kain, Pia; Wohlschlägl, Ricarda; Krawanja-Ortner, Gerlinde	Erste systematische Fossilgrabung nach permischen Tetrapodenfährten in den Gailtaler Alpen (Kärnten, Österreich)	
	Katona, Timea; Gallistl, Jakob; Schlögel, Ingrid; Flores-Orozco, Adrian	Leakage detection in an industrial water pipe network using induced polarization imaging	Thi Hoang Tran, Ha; Rott, Eugen; Sanders, Diethard	Calcification of the eucaryotic microalga Oocardium stratum NAEGELI 1849 (Zygnematophyceae): Exploring the niche of an highly effective biocalcifyer.	
	Maierhofer, Theresa; Aigner, Lukas; Steiner, Matthias	Electrical modelling for an improved understanding of GPR signatures in alpine permafrost using results obtained from different geophysical surveys	Schwab, Julia; Young, Mark; Walsh, Stig; Witmer, Lawrence; Herrera, Yanina; Brusatte, Stephen	Evolution of thalattosuchian crocodylomorphs - the role of the neurosensory system in adaptations to a secondarily aquatic lifestyle	
	Golab, Antonia; Gallistl, Jakob	Delineation of soil structure and the plough horizon through electrical imaging: laboratory investigations	Summesberger, Herbert; Kennedy, William J.; Wagreich, Michael	Coniacian ammonites from the Gosau Group of the Salzkammergut (Austria)	
10:00	Kaffeepause		Kaffeepause		Kaffeepause
10:30-12:00	**Geophysik: Lenhardt (Moderator)**		**Paläontologie/Stratigraphie: Zuschin (Moderator)**		
	Schneider, Felix Michael; Fuchs, Florian; Kolinsky, Petr; Caffagni, Enrico; Serafin, Stefano; Dorninger, Manfred; Bokelmann, Götz; the AlpArray Working Group	Seismo-acoustic signals of the Baumgarten (Austria) gas explosion detected by the AlpArray seismic network	Zuschin, Martin; Gallmetzer, Ivo; Haselmair, Alexandra; Tomašových, Adam	Holocene benthic baseline communities in the northern Adriatic Sea and their collapse due to anthropogenic impact	
	Jud, Markus	GeoTief Wien Seismische Exploration für tiefe Geothermie - Ergebnisse einer neuen 2D-Seismik	Sames, Benjamin; Trabelsi, Khaled	The Central Tunisian Atlas as potential key area for late Mesozoic non-marine research and supra-regional biostratigraphy: A micropalaeontological perspective	
	Papí Isaba, María del Puy; Jia, Yan; Weginger, Stefan	Intensity prediction equation – ShakeMap - for Austria	Baron-Szabo, Rosemarie C.; Sanders, Diethard	Scleractinian corals from the Lower Oligocene of the Eastern Alps, Austria: taxonomic composition, palaeoecology and palaeobiogeography---preliminary results	

	Qorbani, Ehsan; Zigone, Dimitri; Bokelmann, Goetz	3-D shear velocity model of the Eastern and Southern Alps from ambient noise tomography	Garcia Ramos, Diego Antonio; Zuschin, Martin	High-frequency cycles of brachiopod shell beds on subaqueous delta-scale clinoforms (early Pliocene, SE Spain)	
	Schippkus, Sven; Zigone, Dimitri; Bokelmann, Götz	A new 3D shear velocity model of the wider Vienna Basin region from ambient noise tomography	Palzer-Khomenko, Markus; Wagreich, Michael; Knierzinger, Wolfgang; Meszar, Maria E.; Gier, Susanne; Soliman, Ali; Kallanxhi, Madalina -Elena	The upper Ottnangian Calcite Minimum Interval: A solution to many problems?	
	Steiner, Matthias; Straka, Wolfgang; Flores-Orozco, Adrian	On the applicability of microphone readings for robust event detection in broad-band ambient seismic noise	Tari, Gabor; Strauss, Philipp	The Jurassic Gresten facies of the European margin in Austria, Hungary and Romania: a regional overview	
12:00	Mittagspause		Mittagspause		Mittagspause
13:30-15:00	**Strukturgeologie: Schöpfer/Hinsch (Moderatoren)**				
	Hinsch, Ralph; Pelz, Klaus; Schuller, Volker; Thöny, Wolfgang	Hunting for the trap: Applied Structural Geology in OMV Exploration			
	Misch, David; Klaver, Johannes; Gross, Doris; Sachsenhofer, Reinhard F; Schmatz, Joyce; Urai, Janos L.	Microporosity in solid bitumen: The key to unconventional reservoir potential in the Ukrainian Dniepr-Donets Basin			
	Hinsch, Ralph; Sellar, Christopher; Bretis, Bernhard; Gharabeigli, Gholamreza; Morsalnezhad, Davoud; Lovett, Tam; Gruber, Karin; Julapour, Ali Asghar; Tari, Gabor; Kosi, Walter	Structural Geological and Salt Tectonic processes in the south-eastern Zagros, Iran			
	Schneider, David; Grasemann, Bernhard; Lion, Allan; Soukis, Kostis; Draganits, Erich	Hiding beneath a volcano: the Santorini Detachment System (Cyclades, Greece)			
	Schöpfer, Martin; Lehner, Florian; Grasemann, Bernhard; Kaserer, Klemens	Spacing of bending-induced fractures at saturation: Numerical models and approximate analytical solution			
	Kraus, Katrin; Renner, Jörg; Grasemann, Bernhard; Rogowitz, Anna	The effect of the volume fraction of garnet on the deformation behaviour of eclogite			
15:00	Kaffeepause		Kaffeepause		Kaffeepause
15:30-17:00	**Tectonik und Hydrogeologie in Fold-and-Thrust Belts: Plan/Ortner (Moderatoren)**				
	Strauss, Philipp; Granado, Pablo; Pelz, Klaus; Roca, Eduard; Thöny, Wolfgang; König, Michael; Peresson, Herwig	Relevance of salt on sedimentation and later deformation of the Northern Calcareous Alps fold-belt (NCA), Austria.			
	Pelz, Klaus; Granado, Pablo; Strauss, Philipp; Roca, Eduard; König, Michael; Peresson, Herwig; Muñoz, Josep Anton	Allochthonous salt and the formation of overturned to recumbent thrust sheets in the Northern Calcareous Alps			
	Habermüller, Mario; Grasemann, Bernhard; Exner, Ulrike	Styles of fault-related folding at the front of the Northern Calcareous Alps			

		Baron, Ivo; Plan, Lukas; Grasemann, Bernhard; Mitrovic, Ivanka	Geological evidences of active tectonics in the Eastern Alps revealed in caves		
		Gribovszki, Katalin; Kovács, Károly; Esterhazy, Sofi; Mónus, Péter; Kiszely, Márta; Bokelmann, Götz	Progress in investigation of vulnerable stalagmites' vibration, numerical and analogue modeling		
		Hardege, Jonas; Plan, Lukas; Winkler, Gerhard; Baron, Ivo; Grasemann, Bernhard	An enigmatic spring in a hydrothermal cave at the western margin of the Vienna Basin		
	17:00-19:00	Poster Session		Diskussion Junior Section ÖGG: Markus Palzer-Khomenko (Moderator)	
	19:30	Konferenz-Dinner (Melker Stiftskeller, Schottengasse 3/3, 1010 Wien)			
		HS3		HS2	Clar Saal
26.9.2018	08:30-10:00	**Hydrogeologie: Birk (Moderator)**			
		Kralik, Martin; Bieber, Gerhard; Papp, Erika	Multi-Isotopenmessungen (18O/2H,3H/3He,13C/14C) bestätigen aufsteigende Karstwässer an den Windener Quellen (Leithagebirge).		
		Birk, Steffen	Interpretation der Trockenwetterfalllinien von Quellen: Quantitative Methode oder Spekulation?		
		Boch, Ronny; Leis, Albrecht; Mittermayr, Florian; Simic, Sanja; Eichinger, Stefanie; Grengg, Cyrill; Hippler, Dorothee; Almer, Martin; Dietzel, Martin	Unwanted mineral deposits in geotechnical settings – Scaling forensic investigation of formation conditions and related material characteristics		
		Hartl, Irene; Benold, Christian; Eichinger, Florian; Elster, Daniel; Goldbrunner, Johann E.; Götzl, Gregor; Gross, Doris; Hobiger, Gerhard; Kralik, Martin; Kriegl, Christian; Pytlak, Lukasz; Sachsenhofer, Reinhard F.; Schubert, Gerhard	Hydrochemical Signatures of Groundwaters in Upper Austria - Contributions to a revision of the existing thermal aquifer model		
		Philippitsch, Rudolf; Humer, Franko	Textband "Isotopenzusammensetzung in natürlichen Wässern in Österreich - Grundlagen und Anwendungsbeispiele zur Wasser-Isotopenkarte Österreichs 1:500.000"		
		Wagner, Thomas; Pauritsch, Marcus; Hergarten, Stefan; Winkler, Gerfried	Spring water temperatures affected by cooling effects of relict rock glaciers – preliminary results of the Niedere Tauern Range, Austrian Alps		
	10:00	Kaffeepause		Kaffeepause	Kaffeepause
	10:30-12:00	**Regionale Geologie: Iglseder (Moderator)**			

		Jawecki, Christine; Weil, Jonas; Decker, Kurt; Hintersberger, Esther; Novothny, Agnes	Landesgeologie Wien: Beispiele aus Modellierung, Datierung, Archivierung		
		Krenmayr, Hans Georg;	Diskussionsvorschlag für ein differenziertes Begriffssystem lithotektonischer Einheiten		
		Huet, Benjamin; Iglseder, Christoph; Schuster, Ralf; Schneider, David; Rogowitz, Anna; Linner, Manfred; Grasemann, Bernhard	Towards a new lithostratigraphic and tectonic model for the “Innsbruck Quartzphyllite Zone” within the Upper Austroalpine nappes (Oberpinzgau, Salzburg, Austria)		
		Iglseder, Christoph; Huet, Benjamin; Schuster, Ralf; Rantitsch, Gerd; Dunkl, Istvan; Ratschbacher, Lothar	Tectonometamorphic evolution of the uppermost Upper Austroalpine: Insights from a section across the Gstoder, Bundschuh, Königstuhl, and Stolzalpe Nappes (Gurktal Alps, Austria)		
		Ortner, Hugo; Kilian, Sinah	Interacting folds, faults and thrusts - the conundrum of the Karwendel zone of slices ("Karwendelschuppenzone")		
		Hintersberger, Esther; Griesmeier, Gerit; Iglseder, Christoph	Tektonische Grenzflächen in Niederösterreich - Auf dem Weg zu einer Störungsdatenbank im Maßstab 1:200.000		
	12:00	**Abschlussveranstaltung: Wagreich (Moderator)**			
27.9.2018	08:30	Exkursion III: Geologie und Geomorphologie des Neusiedlersees (E. Draganits). Treffpunkt UZAII, Althanstrasse 14			

PANGEO 2018, Wien (Poster)

Poster werden an allen drei Tagen ausgestellt (Postersessions jeweils 24. und 25. 9. 2018, 17:00-19:00) Posterformat A0 Portrait)

		Thema	Autor		Titel
POSTER					
		Regionale + Petrologie		26	
P001		Regional Geologie	Christine	Hörfarter	Structuring of Geological Datasets in the Scale of 1: 50.000 in Austria – Advantages and Lessons Learned
P002	1	Regional Geologie	Andrea	Schober	Geologisches 3D-Modell von Österreich – 3D AUSTRIA
P003	2	Petrologie, Regionale Geologie	Magdalena	Mandl	Geochemical characterization of granitoids of the Seckau Complex (Eastern Alps)
P004	3	Regional Geologie	Nils	Frank	Detrital U/Pb zircon age distribution in Alpine metasedimentary rocks of the Koralpe-Wölz nappe system (Eastern Alps)
P005	4	Regional Geologie	Mandl	Magdalena	The Rannach Formation – A Permian Trough within the Austroalpine Seckau Nappe
P006	5	Regional Geologie	Marianne Sophie	Hollinetz	Tectono-metamorphic evolution of the Eo-Alpine extrusion wedge in the Eastern Alps (Oberhof window, Carinthia, Austria)
P007	6	Regional Geologie	Manfred	Linner	The Weinsberg granite – connecting the prime example of late-Variscan crustal recycling from source to emplacement
P008	7	Regional Geologie	Alexander	Ordosch	The Basal Amphibolite in the central Tauern Window: new chemical data and implications for Early Palaeozoic paleogeography
P009	8	Regional Geologie	Martin	Reiser	Thermochronological constraints on the tectonometamorphic evolution of the "Meran-Mauls nappe stack (South Tyrol, Italy)
P010	9	Regional Geologie	Peter	Tropper	Tourmaline as a petrogenetic recorder for the polymetamorphic evolution of the Matsch Nappe (Vinschgau/South Tyrol)
P011	10	Regional Geologie	Manuel	Werdenich	The tectonic contact between the Bundschuh and Murau Nappes (Upper Austroalpine Unit, Stadl an der Mur, Austria)
P012	11	Regional Geologie	Nicola	Levi	What was the original paleogeographic position of the Rhenodanubian Flysch (Eastern Alps, Austria)?
P013	12	Regional Geologie	Manfred	Maxl	Das westliche sinistrale Saalachzonen-Störungssystem - Neue Daten zur Abgrenzung der Tauglboden von der Hallstatt Mélange (Unken / Salzburg)
P014	13	Regionale Geologie	Jolanta	Burda	Cadomian protolith ages of 'exotic' mega blocks from Bugaj and Andrychów and their significance for the reconstruction of the palaeogeography of the Western Outer Carpathians (Poland): evidence from zircon U-Pb LA-MC-ICP-MS dating
P015	14	Regional Geologie	A. Hugh N.	Rice	Kythnos, Western Cyclades, Greece; a field guide
P016	15	Regional Geologie	A. Hugh N.	Rice	The hanging wall to the West Cycladic Detachment System; new data from Aghios Georgios, Western Aegean, Greece
P017	16	Regional Geologie	Bernhard	Grasemann	The Trans Cycladic Thrust: a new major tectonic structure in the Eocene syn-orogenic Hellenic subduction channel (Cyclades, Greece)
P018	17	Petrologie	Heuser	David	Thermo-dynamic forward modelling of the monazite and xenotime evolution during prograde metamorphism in the Ivrea-Verbano-Zone (N Italy)
P019	18	Petrologie	Benjamin	Huet	Pressure, temperature and time constraints for the Wildkogel Nappe ("Steinkogelschiefer," Oberpinzgau, Salzburg, Austria)
P020	19	Petrologie	Urs	Kloetzli	Pb nano-spheres in seismically deformed zircon from the Ivrea-Verbano Zone
P021	20	Petrologie	Tanja	Knoll	The relationship between spodumene pegmatites, pegmatites and leucogranites from the Austroalpine Unit (Eastern Alps)
P022	21	Petrologie	Anna	Rogowitz	Direct observation of dislocations nucleation in pyrite using combination of electron channeling contrast imaging and electron backscatter diffraction.
P023	22	Petrologie	Maditha	Kurz	Hydrogen bonding in natrochalcite NaCu2(SO4)2(OH)·2H2O under high pressure
P024	23	Petrologie	Johannes Michael	Meusburger	High-pressure behaviour of the LiInGe2O6 (LIG) - LiScGe2O6 (LSG) solid solution
P025	24	Petrologie	Julia	Roszjar	The dynamic history of Mars – adding another puzzle piece from the analysis of Ca-phosphates in martian meteorites
P026	25	Petrologie	Peter	Tropper	Pseudosection modelling of eclogite-facies microdomains in metapelites and metagabbros using calculated "micro" bulk compositions
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		Ingenieugeologie Strukturgeologie		10	
P027		Ingenieurgeologie	Christina	Rechberger	Characterization of a deep-seated rock slide in a glacier-retreat environment (Ötztal Valley, Austria)
P028	1	Strukturgeologie	Christoph	Daxer	Lacustrine Paleoseismology in Tyrol and Carinthia: Establishing the first continuous postglacial earthquake records in Austria
P029	2	Strukturgeologie	Bernhard	Grasemann	The 'Cretan Detachment' (Greece): a Miocene thrust or low-angle normal fault?
P030	3	Strukturgeologie	Esther	Hintersberger	Differentiation between Miocene and Quaternary displacement at the southern Diendorf Fault
P031	4	Strukturgeologie	Stephan	Höpfl	High finite strain flow pattern in marbles around boudinaged dykes
P032	5	Strukturgeologie	Peter	Micheuz	Isotopes and microstructures from calcite veins of the Izu-Bonin fore arc and the Amami-Sankaku basin: vein formation conditions, ages and deformation
P033	6	Strukturgeologie	Diethard	Sanders	Neotectonic deformation and modified sediment fabrics of a late Pleistocene talus succession, Central Apennines.
P034	7	Strukturgeologie	Alexandra	Schagerl	Strain distribution in refold structures
P035	8	Strukturgeologie	Sven	Schippkus	The Alland earthquake series: Location, source mechanism and implications for the regional stress regime
P036	9	Strukturgeologie	Kurt	Decker	Recent thrust tectonics in the frontal part of the Eastern Alps: an approach based on integrated subsurface data
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		Mineralogie Lagerstätten		6	
P037		Lagerstätten	Ronny	Boch	Calcium & iron carbonates from Erzberg – New insights from stable, radiogenic & clumped isotope data
P038		Lagerstätten	Sabrina	Frühauf	Thermometrie an Erzen und Nebengesteinen der Sideritlagerstätte Steirischer Erzberg
P039		Lagerstätten	Ferdinand Jakob	Hampl	The karst bauxite of the Unterlaussa mining area (Upper Austria)
P040		Lagerstätten	Maria	Heinrich	Übersicht zu wichtigen und aktuell genutzten Naturwerkstein-Vorkommen in Österreich
P041		Lagerstätten, Kohlenwasserstoffe	Doris	Groß	Abundance of acidic compounds in Upper Visean black shales from the Dniepr-Donets Basin (Ukraine): advances in facies and maturity assessment
P042		Mineralogie	Sanja	Vranjes	Mechanical properties of coal macerals: A nanoindentation study
		Geophysik		9	Poster
P043		Geophysik	???	???	???
P044	1	Geophysik	Irene	Bianchi	Eastern Alpine Seismic Investigation (EASI): aims, deployment and results.
P045	2	Geophysik	María	del Puy	The use of amplitude measurements for detecting and locating local earthquakes in the Austrian seismic network
P046	3	Geophysik	Helmut	Hausmann	ARMONIA – Homogenization of cross-border accelerometric networks between Northeastern Italy and Austria: Selection of new sites and instruments for Earthquake Monitoring in Austria
P047	4	Geophysik	Stefan	Weginger	Earthquake Location in Austria: Accuracy, Reliability and Improvements for hypocenters after 2000
P048	5	Geophysik	Nicola	Piana Agostinetti	Reconstruction of sedimentary basin properties using Bayesian fusion: theoretical framework and applications
P049	6	Geophysik	Matthias	Steiner	Near-surface investigation of a slow moving landslide by means of broad-band ambient seismic noise monitoring
P050	7	Geophysik	Stefan	Weginger	Towards a new seismic hazard map of Austria
P051	8	Geophysik, Speläologie	Barbara	Funk	Geophysical detection of caves to prevent natural hazards – Two case studies from Lower Austria

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		Hydro+Umwelt				
P052		Umwelt	Robert Martin	Brünjes		Umweltverhalten von Gadoliniumkomplexen
P053		Umwelt	Stephanie	Castan		Influence of Humic Acid and Ionic Strength on the Sorption of Pyrene to Carbonaceous Materials
P054		Umwelt	Markus	Eder		Origin of arsenic contamination of springs in an alpine environment, examples of the Seckau Tauern Range (Austria)
P055		Hydro	Ulrich	Burger		Hydraulische Charakterisierung des Hochstegenmarmors am Westrand des Tauernfesters - Brenner Region
P056		Paläontologie		7		
P057		Paläontologie	Iris	Fuchs		Cold case: in search of the provenience of an exceptionally preserved Cretaceous shark
P058	1	Paläontologie	Iris	Fuchs		Identifying hidden secrets of shark teeth (Chondrichthyes, Elasmobranchii) using sophisticated approaches
P059	2	Paläontologie	Holger	Gebhardt		Campanian to Maastrichtian planktic foraminifera of the Pálava Formation may point to southward flow of boreal waters into the Penninic Ocean
P060	3	Paläontologie	Alexander	Lukeneder		Lower Cretaceous ammonites from the Northern Calcareous Alps (Hauterivian – Barremian, Upper Austria)
P061	4	Paläontologie	Petra	Lukeneder		Sinemurian biostratigraphy of the Tannscharten section near Reichraming (Lower Jurassic, Schneeberg Syncline, Northern Calcareous Alps)
P062	5	Paläontologie	Benjamin	Sames		A gigantic marine ostracod trapped in mid-Cretaceous amber of Myanmar (Burmite)
P063	6	Paläontologie	Benjamin	Huet		Palaeo-geographical and -historical implications of pollen taxa (e.g., Sarcandra, Phyllanthus, Fagus, Juglans, Lagerstroemia, Mortoniodendron, Cornus, Nyssa, Symplocus; lodes) from the lower Bartonian Chanchang Formation (Hainan, South China) investigated by LM and SEM
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		Stratigraphie, sedimentologie, Erdölgeologie		11		
P064		Sedimentologie	Sebastian	Viehmann		The reconstruction of microbial habitats during Mesoproterozoic stromatolite formation
P065	1		Daniel	Le Heron		A bird's eye view of a 443 million year old ice sheet: using aerial imagery to characterise deep time glacial landscapes
P066	2	Sedimentologie	Eva	Wegerer		Mineralogical properties of continental related pelites in the Eastern Alps
P067	3	Sedimentologie	Lisa	Rücklinger		Field- and microscopic investigation of iron oxide and calcite coated fractures in glauconitic sandstones, quarry Strombauamt, Greifenstein, Lower Austria
P068	4	Sedimentologie	Diethard	Sanders		Shallow-water Cretaceous-Paleocene transition associated with a rocky low-energy shore: The Kambühel section (Northern Calcareous Alps).
P069	5	Sedimentologie	Sigrid	Missoni		Carnian outer shelf succession in the Budva Zone (Montenegro)
P070	6	Sedimentologie, regionale Geologie	Sigrid	Missoni		Contractional tectonics in the Muráň Nappe of Callovian age, Western Carpathians (Slovakia)
P071	7	Sedimentologie	Maria	Meszar		Anthropogenic deposits - Vienna's Anthropocene
P072	8	Sedimentologie	Maria	Meszar		Clay mineralogy of Miocene mudstones of the Lower Austrian Molasse Basin
P073	9	Sedimentologie	Dominik	Jaeger		Provenance of Nankai Trough sediments: investigation via OH defect content of detrital quartz
P074	10	Sedimentologie, Quartärgeologie	Simon	Kainz		Sieve curve analysis to estimate K in fine grained mass movement and moraine material – a critical review
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		Quartärgeologie, Geoarchäologie, Speläologie		9		
P075		Geoarchäologie	Felix	Köstelbauer		Geoarchaeological studies of a Middle-Neolithic circular enclosure near Velm, eastern Austria
P076		Geoarchäologie	Mario Gabriel	Maldonado		Regional archaeological visibility and preservation in arid environments: incidence of geo-environmental processes (Yocavil Valley, Northwest Argentina)
P077		Geoarchäologie	Peter	Tropper		Rust never sleeps: Mineralogisch-chemische Untersuchung von Korrosionsprodukten an archäologischen Eisenobjekten
P078		Quartärgeologie	Fabian	Auer		Bringing light into the underworld – optically stimulated luminescence dating of the loess section and wine-cellars of the Loisium wine-world, Lower Austria.
P079		Quartärgeologie	Moritz	Bauer		Equilibrium line altitude (ELA)-reconstructions of a Younger Dryas system in the Eastern Alps
P080		Quartärgeologie	Thomas	Berberich		Geomorphological map and event stratigraphy of Lake Hallstatt
P081		Quartärgeologie	Christoph	Daxer		The Late Glacial and Holocene Sedimentary Infill of Lake Mondsee (Eastern Alps, Austria) and Historical Rockfall Activity revealed by Reflection Seismics and Sediment-Core Analysis
P082		Quartärgeologie	Maria	Heinrich		Zur Geologie der Weingärten in den Weinbaugebieten Wachau und Kremstal
P083		Speläologie	Pauline	Oberender		Statistical methodes - An important tool for understanding cave genesis?