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Auslösung von Bergstürzen durch Erdbeben: Anwendung der Skala für makroseismische Umwelt- und Landschaftsauswirkungen (EEE der INQUA)

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Zur Bestimmung der makroseismischen Intensität verwenden moderne Skalen die Fühlbarkeit der Erschütterung (für niedere Intensitätsgrade), Schäden an Gebäuden (für mittlere und hohe Intensität ab Grad 5) und Auswirkungen auf Landschaft und Umwelt (für höhere Intensität). Das Poster weist auf die jüngsten Fortschritte bei der makroseismischen Beurteilung von Felsstürzen, die im Gebirge in der Nähe des Epizentrums eines Starkbebens aufzutreten. Für Gebirgsareale mit geringer Bevölkerungsdichte stellt die Berücksichtigung von Massenbewegungen einen beachtenswerten Versuch der Intensitätsbestimmung dar, die jecoch in der EMS98 nur sehr kursorisch beschrieben sind. Die Phänomene werden in der Skala für makroseismische Umwelt- und Landschaftsauswirkungen, deren Endfassung 2007 von INQUA publiziert wurde, berücksichtigt. Als Beispiele ihrer Anwendung werden mehrere alpine Beben des letzten Jahrhunderts sowie die historischer Beben von Villach mit dem Bergsturz der Dobratsch-Südflanke (Villacher Alpe) besprochen.
Um Felsstürze für die Intensitätsbestimmung heranzuziehen hat VIDRIH et al. (2001) das Erdbeben im Oberen Isonzotal (Soèa 1998) "als einen Versuch für eine statistisch sinnvolle Beurteilung der makroseismischen Intensität zur Bewertung der seismogeologischen Auswirkungen" ausgewertet. In einer Tabelle werden Volumen und Art des Felsausbruches mit der makroseismischen Intensität des Bebens korreliert. Zuvor wurde bereits für das Friaul-Beben 1976 von GOVI (1977) die Häufigkeit von Steinschlägen bzw. Felsstürzen im Epizentralgebiet aufgrund von Luftaufnahmen ausgewertet. Die makroseismische Intensität des Friaulbebens in Österreich lag im Gailtal bei I = 7. Für das Beben konnten die Orginaldaten der ZAMG eingesehen und in Hinblick auf die Felsstürze bearbeitet werden.
Das „Villacher Beben“ von 1348 führte zu zahlreichen Felsstürze, zum Stau des Gail-Flusses durch einen Bergsturz und zur Bildung eines Sees im Gailtal, der mehrere Jahrhunderte bestand. Über das zweite Villacher Erdbeben im Jahre 1690 sind keine Berichte über größere Felsstürze bekannt, obwohl die makroseismische Intensität beinahe so hoch war, wie die des Bebens von 1348 (GANGL & EGGER 2006). Wahrscheinlich lag das von Felsstürzen betroffene Gebiet nahe des Epizentrums nördlich der Stadt Villach. Die Südflanke des Dobratsch in Kärnten kann als eine Art Testgebiet für Felsstürze betrachtet werden, die durch historische Erdbeben ausgelöst wurden und die Bewertungen der lokalen makroseismischen Intensität erlauben. Die Bewertung von historischen Ereignissen kann im Gebirge durch die Berücksichtigung von Felsstürzen auf eine breitere Datenbasis gestellt werden.

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Geological profiles through the poly-phase deformed Paleozoic of Graz

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The Upper Austroalpine / Upper Central Austroalpine Paleozoic of Graz consists of a 30 x 50 km sized nappe complex built up mainly of low-grade carbonates and schist of Silurian to Carboniferous age. It lies on top of high-grade Middle Austroalpine / Lower Central Austroalpine crystalline basement, and it is discordantly overlain by a small Cretaceous Gosau Basin and by the Neogene Styrian Basin. As such, the Paleozoic of Graz records many of the sedimentological, tectonic and metamorphic events that formed the present Eastern Alps since the early Paleozoic.
Stratigraphy, palaeontology, internal structure and metamorphism of the Paleozoic of Graz were extensively studied over the past 180 years, and resulted in over 500 publications (e.g. FLÜGEL & HUBMANN 2000 and references therein). However, remarkably no geological profiles through the *entire* Paleozoic of Graz are published and the complex, poly-phase tectonic history is still not fully understood.
We present geological profiles through the entire Paleozoic of Graz in order to understand the actual 3D geometry of this complex. As a base, we use 1:50 000 geological maps, a 10 m digital elevation model, local detailed maps and profiles, drillhole data and descriptions of structure and stratigraphy from various publications listed in FLÜGEL & HUBMANN (2000).
The structure of the Paleozoic of Graz, as revealed by the profiles, is dominated by the following elements: (i) a probably Variscian (?) large-scale isoclinal fold with an ~E-W trending axis in the lower nappe complex bringing Silurian schist on top of Devonian limestone, (ii) early Cretaceous W to NW directed thrusts and open to tight folds separating the Paleozoic of Graz into an upper and a lower nappe system, and (iii) late Cretaceous to Tertiary ductile to brittle normal and strike-slip faults defining the borders against the surrounding crystalline basement. Which of these events could have led to the emplacement of the Paleozoic of Graz on top of the crystalline basement is discussed.

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Reconstruction of a lost Triassic-Jurassic ocean as evidenced by mélange analysis in the Mirdita ophiolite zone (Albania)

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The Albanian ophiolites of the Mirdita Zone represent remnants of Mesozoic oceanic lithosphere within the Dinaride-Hellenide segment of the Alpine orogenic system. They form a coherent, north-south trending belt and consist of a large variety of rocks attributed to originally complete ophiolitic sequences thought to derive from a narrow Jurassic ocean between Apulia in the west (= Ionian zone and equivalents with Late Triassic Hauptdolomite equivalent restricted lagoonal sediments) and the Korabi-Pelagonian microcontinent to the east (= Korabi zone with Late Triassic lagoonal Dachstein limestone facies), called Pindos Ocean (or Mirdita Ocean according to several authors).

Creation of oceanic crust in the „Mirdita-Pindos Ocean" is inferred by the most authors to have started around the Early/Middle Jurassic-boundary followed by intra-oceanic subduction in Late Jurassic times. The age of the ocean seemed to be proven by radiolarians from sediments associated with basaltic and dacitic lavas which gave Late Bajocian to Early Callovian and Middle Callovian to Late Oxfordian ages, respectively. The ophiolite suite is closely associated with radiolarites and ophiolitic mélanges containing blocks of up to kilometer-size.

Mélange formation is generally considered to have taken place during post-sedimentary thrusting in Tithonian time. We dated matrix and components of the mélange by radiolarians, conodonts, and other taxa. The components consist of radiolarites (equivalent to the Meliata facies in the Alpine-Carpathian realm as well as radiolarites from the original ocean floor), pelagic limestones (different Hallstatt facies block – grey and red Hallstatt facies as known from the Hallstatt Mélange in the Northern Calcareous Alps) and shallow-water limestones (Dachstein limestone facies), all of Triassic age, as well as ophiolites. Triassic radiolarite as a primary cover of ophiolite material proves Middle Triassic onset of ocean-floor formation. The mélange contains a turbiditic radiolarite-rich matrix, dated as Late Bajocian to Early/Late Oxfordian. It formed originally as a primary synorogenic sediment (radiolaritic wildflysch sequence) formed simultaneously during west-directed thrusting of ophiolite and sediment-cover nappes representing ocean floor and underplated fragments of the western continental margin (Korabi-Pelagonia units), later overprinted by contemporaneous and younger tectonics forming a typical mélange. The tectonic structures formed during these orogenic events are sealed by Late Jurassic platform carbonates (Kurbnesh carbonate platform equivalent to the Plassen Carbonate Platform in the Northern Calcareous Alps).

From the scenario we see no evidence for an independent Mirdita-Pindos Ocean. An in-situ position of the Mirdita ophiolites would mean that the Triassic passive continental margin with its typical facies arrangement from the pelagic outer shelf (Hallstatt limestone facies) towards the inner shelf with its reefal and lagoonal carbonates (Dachstein limestone facies, Hauptdolomite facies) would have been disrupted by a Triassic-Jurassic ocean. Remnants of the passive-margin sequences are found both to the west and the east of the present Mirdita Zone.

Therefore we conclude that the Mirdita Ophiolite Zone is no more in its original position relative to the geologic units to its east and west but must be a far-traveled part of the Neotethys Ocean (Vardar segment), brought into its present position by west-directed far-distance thrusting from the Vardar Zone.

Tressenstein limestone revisited (Austria, Northern Calcareous Alps)

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The knowledge of the evolution of the slope facies („Tressenstein Limestone") and the interaction with the basinal facies is one key for the reconstruction of the sedimentary dynamics of the Alpine Late Jurassic to Early Cretaceous (Late Oxfordian to early Late Berriasian) Plassen Carbonate Platform. For this reason, the type-locality of the Tressenstein Limestone (Tressenstein Formation), Mount Tressenstein near Bad Aussee in the Austrian Salzkammergut, and the equivalent section Hornkogel near Bad Goisern were re-investigated.

The sedimentary succession at Mount Tressenstein represents a series of mass-flow breccias, calciturbidites and slide blocks consist of shallow-water material derived from the Plassen Carbonate Platform s. str. to the south (with e.g., *Protopeneroplis ultragranulata, Coscinophragma* aff. *cribrosum*, „*Tubiphytes*" *morronensis, Trocholina* cf. *involuta, Andersenolina* cf. *elongata, Pseudocyclammina lituus, Mohlerina basiliensis, Radiomura cautica, Lithocodium aggregatum, Troglotella incrustans, Calcistella* cf. *jachenhausenensis, Mercierella*? *dacica, Carpathocancer triangulatus, Terebella lapilloides,* and *Clypeina sulcata)* alternating with basinal wackestones of the Oberalm Formation with radiolarians, spicula and calpionellids (e.g., *Crassicollaria intermedia* and *Crassicollaria intermedia)*.

The „Tressenstein Limestone" at the type-locality overlies variably-coloured condensed cephalopod limestones, erroneously equated with the *Acanthicus* Limestone (= Agatha Formation = Kimmeridgian age). The latter is assigned to the Early Tithonian, a time of low sea-level and emersion of parts of the Plassen Carbonate Platform.

Previous assumptions of the Tressenstein Limestone to represent the slope deposits of the Late Oxfordian to early Late Berriasian Plassen Carbonate Platform are incorrect approaches. In fact, the coarse-grained resediments of Mount Tressenstein were deposited in a basin and are of Late Tithonian to ?Early Berriasian age and therefore time- and facies-equivalent to the Barmstein Limestone.

The onset of deposition of the Mount Tressenstein resediments seems to be conform with the first deepening event in the lagoonal areas of the Plassen Carbonate Platform. Their subsidence was counterbalanced by enhanced carbonate production during the Late Tithonian, contemporaneously with the break-down of the Trattberg Rise and equivalents (e.g., Brunnwinkl Rise/Wolfgangsee area). The massive export of carbonate mud and detritus into the adjacent basins resulted in the lithologic change from radiolarites to carbonates with intercalated mass-flow deposits consist of shallow-water carbonates in a typical fining-upward succession. During the latest Tithonian to Early Berriasian the deepening of the Plassen Carbonate Platform was accompanied with increased mass mobilizations (Barmstein Limestone megabreccias) before its final drowning. The successions of the type-localities of the „Tressenstein Limestone" and the Barmstein Limestone as well as the similar section Hornkogel show little differences in their lithologic evolution, but all comprise mass-flow breccias and calciturbidites of the same age intercalated in hemipelagic *Calpionella*-bearing biomicrites of the Oberalm Formation.

An unambiguous and applicable criterion for distinction of Tressenstein and Barmstein Limestone on a smaller scale can not be defined. Both terms were established in the 19th and early 20th century in no accordance with formal lithostratigraphic framework. However, since the term Barmstein Limestone was introduced about 50 years earlier it clearly must have priority. „Tressenstein Limestone" as the classical term for the slope and reef near sediments of the Plassen Carbonate Platform cannot be used any longer.

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