Emplacement mechanisms of evaporite mélanges: conceptual models and application to Northern Calcareous Alps

Neubauer, F., Schorn, A. & Leitner, C.

Dept. Geography and Geology, University of Salzburg, Hellbrunnerstr. 34, A-5020 Salzburg, Austria (Franz.Neubauer@sbg.ac.at)

Because of the very low shear resistance, evaporite mélanges often form decollément surfaces of extensional and contractional allochthons. Evaporites are commonly deposited in an early stage of passive continental margin formation and are overlain by thick successions deposited during the subsequent thermal subsidence stage. These latter rocks are resistant against penetrative internal deformation. Evaporite mélanges are common (1) at passive continental margins, where they are deformed during gravity-driven raft tectonics in an extensional geodynamic setting, and (2) in external foreland fold-thrust belts within a convergent geodynamic setting. In the following, we first review the most important features of both settings and then we apply these to the Northern Calcareous Alps (NCA). In gravity-driven raft tectonics at passive continental margins, an upper extensional domain is separated from a lower compressional domain at its toe. Ocean-directed rafting at low temperatures is mainly driven by thickness variations of the overburden, occurs during intermediate stages of the depositional history of the passive margin succession and may last as long as a topographic gradient is in existence. The resulting structure of the extensional domain is characterized by pronounced thickness variations of the syn-tectonic overburden within halfgrabens. In contrast, external foreland fold-thrust belts are generally transported continent-wards during episodic stages of shortening after the termination of the sediment deposition, and no pronounced thickness variations occur in the overburden except in wedge-top basins. In nature, earlier extensional deformation may have been overprinted by subsequent contraction causing complications in the structure of the thin-skinned fold-thrust belt. The central and eastern NCA are called to have formed by gravity-driven sliding of thick masses of mainly Middle-Upper Triassic carbonate platform and basin sediments on the uppermost Permian-Lower Triassic evaporite mélange (Haselgebirge Fm.) during Mid–Late Jurassic times. Main arguments for this interpretation are the presence of major Haselgebirge bodies within mainly Upper Jurassic formations and the presence of up to hill-sized blocks (mainly limestones of the Hallstatt facies realm) in a Haselgebirge matrix. This interpretation also assumes a continent-ward motion, considered as sliding into local basins, e.g. the Lammer basin. We challenge the interpretation of gravity-driven emplacement of the present structural edifice and present the following arguments for an essentially Early–early Late Cretaceous age of emplacement of cover nappes with evaporitic mélange at the base. Based on cross-sections between Hall/Tyrol and the eastern margin of NCA distributed over ca. 450 km, we distinguish three architectural modes of Haselgebirge occurrences: (1) sulphate-dominated N-vergent thrust sheets; (2) double-vergent halite-rich diapiric bodies soling in N-vergent thrust faults; these bodies are sometimes overprinted virtually by mixed thrust-strike-slip faults; and (3) sulphate-dominated post-metamorphic normal faults (e.g., Rettenstein). Type (1) N-vergent nappes were transported continent-wards against gravity on ductile evaporite mylonite zones partly over the Lower Cretaceous siliciclastic Rossfeld Fm. Ductile mylonite zones are well preserved mainly in sulphates (anhydrite, polyhalite) and partly dated at ca. 110 Ma. Such mylonitic ductile shear zones were mapped in several areas from the southern margin (Werfen Imbricate zone) to close to the northern margin of the NCA (Berchtesgaden – Dürrnberg). Except differences between Hallstatt and Dachstein facies realms, no significant local thickness variations and wedge-shaped strata are known in neither Middle–Upper Triassic nor Jurassic stratigraphic units. Exclusive Jurassic raft tectonics as mechanism for evaporitic mélange emplacement seems therefore unlikely. Of course, the new interpretation does not exclude earlier stages of local gravity sliding, e.g. during Jurassic/Cretaceous, likely in front of convergent allochthons. However, the main body (Juvavic tectonic units) emplaced along a “high”-temperature sulphatic ductile shear zone (Haselgebirge evaporite mélange) in a Cretaceous fold-thrust belt.

Acknowledgements: Work is supported by FWF grant no. P22,728 Polyhalite.

Source rock investigations and organic geochemistry of a Cretaceous succession of the Outer Dinarides (Mokra Gora, Tara Mountain, SW Serbia)

Neumeister, S.[1], Banjac, N.[2], Bechtel, A.[1] & Gawlick, H.-J.[1]

[1] University of Leoben, Department for Applied Geological Sciences and Geophysics, Chair of Petroleum Geology, Peter-Tunner-Straße 5, 8700 Leoben, Austria (stefan.neumeister@unileoben.ac.at);
[2] University of Belgrade, Faculty for Mining and Geology, Department for Geology, Kamenicka 6, 11000 Belgrade, Serbia

A Cretaceous (Albian to Turonian) succession containing organic-rich sediments is exposed in the area of Mokra Gora and Tara Mountain (SW Serbia). Four sections representing different positions of the basin were investigated regarding source rock potential and organic geochemical characteristics. The Cretaceous geodynamic history and the depositional settings of organic-rich sediments in the Alpine-Dinaric realm is still not completely understood and controversially discussed. After an orogenetic process with decreasing tectonic activity during the Late Jurassic to Early Cretaceous a new depositional cycle started around the Early/Late Cretaceous boundary. In the Outer Dinarides of SW Serbia a Cretaceous sedimentary succession on top of the former nappe stack is preserved. The investigated succession is characterized by a basal transgressive part (Albian) followed by a series of alternating layers of siliceous to marly limestones and thin bedded black marls rich in organics (Cenomanian). This series represents a deepening upward. The black marls contain pithonellas, rarely heterohelicides, hedbergellas, ammonites, echinoderms and molluscs. On top of the investigated succession light limestones with rudists, shell fragments and gastropods represent a shallow water development of Upper Cenomanian to Turonian age.

The stratigraphic age of the organic-rich interval is proven as Cenomanian by means of *Aeolisacus inconstans, Ovalveolina maccagnae, Rhapidionina laurinensis* and *Cisalveolina fraasi.*

All samples were investigated by means of Leco- and Rock Eval analyses regarding their source rock characteristics. For selected samples organic-geochemical analyses were performed to determine the origin and composition of the organic matter.

The black marl development in the investigated area can be divided into two parts due to the gained results. The samples of the stratigraphic lower part reach peak values of more than 18 % total organic carbon (TOC) and hydrogen indices (HI) of greater than 700 mg HC/g TOC. Based on a modified van-Krevelen-diagram the kerogen of the samples can be classified as type I and II. Lamalginite is by far the most abundant maceral in these samples and indicates algae to be the primary source of the organic matter. In the stratigraphic higher part values for TOC and HI are below 2.5 % and 400 mg HC/g TOC, respectively. The samples plot in the field of type II and III kerogen. The frequent abundance of vitrinite also indicates a stronger terrestrial influx for these samples. Tmax-values between 400 and 426 °C indicate low maturity of 0.3 to 0.5 % Ro for all investigated samples of the succession. This is confirmed by organic geochemical results (sterane-ratio, MPI). Results of organic geochemistry analyses further argue for open marine to transitional depositional environments with anoxic to partly euxinic conditions poor in oxygen. The organic matter is mainly of marine origin, terrestrial input is more important for the upper units of the succession. This argues for differing water depths. The presence of arylisoprenoids is an indicator for photic zone anoxia. Cadalene, which is typical for terrestrial input, could be detected in the higher parts of the succession displaying the transition to more shallow water environments.