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Sedimentary environment of a halite-mudrock mélange (Haselgebirge Formation, Eastern Alps)

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During Variscan orogeny in Carboniferous times, Gondwana and Europe collided to form Pangea (Stampfli et al., 2013). The succeeding Permian was a time of continental consolidation and erosion of the uplifted Vaiscan mountain belt but also its destruction by rifting processes forming the Tethys Sea (in its initial definition). During late Permian (c. 255–250 Ma), when the later Eastern Alps were located around north of the equator, evaporites of the Haselgebirge Formation (now exposed in Northern Calcareous Alps) were deposited. The location of the deposits was at around 10° north of the equator, which would be at the transition from a tropical climate to a moderate to semi-aride climate nowadays (Blakey, 2008), but on the other side the average temperature can be assumed higher than today (Berner, 1998). In salt mines, the Haselgebirge Fm. consists of a two-component tectonite of c. 50 % halite and 50 % sedimentary clastic and other evaporite rocks (Schauberger, 1986; Spötl 1998). Most of the clastic rocks are mud- to siltstones (“mudrock”). Its present appearance as a tectonic mélange is a result of the superimposed stages of Alpine orogenic events during Jurassic, Cretaceous and Cenocoic times. During the present study, we investigated the sedimentary/ diagenetic development of the evaporite rocks by field work in underground salt mines (Hallstatt, Berchtesgaden, Bad Dürrnberg, Altaussee), thin section analysis, SEM, RDX and EMPA. Mudrock needs a quiet or non-turbulent environment to settle down. Higher water energy leads to non-horizontal structures like ripples, re-sedimentation of clasts and a larger grain size. Therefore, water depth was in general deeper than 5 m, but the question remains unanswered how deep the basin could become in its deepest parts. Massive anhydrite rock precipitated from sea water (layered, black), while nodular/mosaic anhydrite (red) crystallized within the sediment (earlier or coevally). The transition gypsum [U+F0AE] anhydrite comprises a volume loss of c. 40 %. However, no compaction structures or pseudomorphs after gypsum were observable. Different from recent Quaternary deposits (Warren, 2006), anhydrite must have precipitated from seawater or substituted gypsum in an early stage, probably in highly saturated halite brines. The grain size of anhydrite (0.2–0.4 mm) is supposed to be mainly from these times of early diagenesis, although it may have increased slightly during later Alpine orogeny. The chronological succession of diagenetic structures revealed as follows: (1) deposition of mudrock and layered anhydrite (and nodular anhydrite in the sediment), (2) water escape structures in mudrock, (3) halite hopper crystals in mudrock, (4) transformation from grey to red mudstone, (5) authigenic quartz and authigenic feldspar in mudrock and (6) growth of authigenic anhydrite (called “Muriazite”, often 0.5–2 cm) and authigenic polyhalite in mudrock/ anhydrite. The age of polyhalite [K2Ca2Mg(SO4)4•2H_2O] was dated at the University of Salzburg at c. 235–220 Ma (Leitner et al, 2013). In fact, all preserved diagenetic structures of the Alpine Haselgebirge Fm. in salt mines developed within the first 15–30 Ma after deposition.