(2) The Ferrera phase of the Penninic system of the eastern Swiss Alps equals the Anniviers phase of the Penninic system of the western Swiss Alps. These phases represent the main stage of ductile deformation during nappe formation. Mainly nappe imbrication, associated with isoclinal folding affected the Briançon continental crust. The transport direction is inferred to be NNW and deformation probably took place during the Eocene.
(3) Eocene-Oligocene backfolding and backshearing severely modified the geometry of the Middle Penninic nappes: the Niemet-Beverin phase (in the Grisons) and the Mischabel phase (in the Valais). While thrusting continued at the base of the nappes, large-scale folding affected parts of the nappes. The upper levels of the nappes were strongly affected by top-to-the-S(E) shearing in this process, resulting in the formation of mélange zones. Fold axes associated with this phase constantly trend ENE-WSW in both study areas.

The Tauern Window (Eastern Alps. Austria): a new tectonic map, with cross-sections and a tectonometamorphic synthesis

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We present a tectonic map of the Tauern Window and surrounding units (Eastern Alps, Austria), combined with a series of crustal-scale cross-sections parallel and perpendicular to the Alpine orogen (Swiss Journal of Geosciences in press). This compilation, largely based on literature data and completed by own investigations, reveals that the present-day structure of the Tauern Window is primarily characterized by a crustal-scale duplex, the Venediger Duplex (Venediger Nappe System), formed during the Oligocene, and overprinted by doming and lateral extrusion during the Miocene. This severe Miocene overprint was most probably triggered by the indentation of the Southalpine Units east of the Giudicarie Belt, initiating at around 20 Ma and linked to a lithosphere-scale reorganization of the geometry of mantle slabs. A kinematic reconstruction shows that accretion of European lithosphere and oceanic domains to the Adriatic (Austroalpine) upper plate, accompanied by high-pressure overprint of some of the units of the Tauern Window, has a long history, starting in Turonian time (around 90 Ma) and culminating in Lutetian to Bartonian time (45-37 Ma).

The Tauern Window exposes a Cenozoic nappe pile consisting of crustal slices derived from the distal continental margin of Europe (Subpenninic Units) and the Valais Ocean (Glockner Nappe System). These were accreted to an upper plate already formed during the Cretaceous and consisting of the Austroalpine Nappe pile and previously accreted ophiolites derived from the Piemont-Liguria Ocean. The present-day structure of the Tauern Window is characterized primarily by a crustal scale Late Alpine duplex, the Venediger Duplex, which formed during the Oligocene. This duplex was severely overprinted by doming and lateral extrusion, most probably triggered by the indentation of the Southalpine Units east of the Giudicarie Belt, which offset the Periadriatic Line by some 80 km, beginning at around 20 Ma ago and linked to a lithosphere-scale reorganization of the geometry of the mantle slabs.

While this work hopefully contributes to a better understanding of the three-dimensional structure of the Tauern Window, two important problems remain. Firstly, what was the relative contribution of orogen-parallel extension by normal faulting, escape-type strike-slip faulting and orogen-normal compression, all of which acted contemporaneously during the Miocene? The answer to this question has a strong bearing on the relative importance of tectonic vs. erosional denudation. Secondly, there remains the unsolved problem of the quantification of kinematic and dynamic interactions between crustal (Adria-indentation, Carpathian roll-back and Pannonian extension) and mantle structures (reorganization of the mantle slabs underneath the Eastern Alps) that fundamentally and abruptly changed the lithosphere-scale geometry of the Alps-Carpathians-Dinarides system during a very severe Miocene overprint, initiating at around 20 Ma ago.

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The structure of the Hallstatt evaporite body (Northern Calcareous Alps, Austria): a compressive diapir superposed by strike-slip shear?

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Based on previous detailed mining- and surface geological maps and on own structural observations in the Hallstatt salt mine, we reinterpret the structure of the Hallstatt evaporite body of the uppermost Permian Haselgebirge Fm. within the Northern Calcareous Alps (NCA). The Haselgebirge Fm. is now a rock salt mylonite, which contains, at all scales, abundant lenses of protocataclasite composed of sulphates, mudstones, clay and host limestones. In comparison with results of analogue modeling we interpret the present shape of the Hallstatt body as a WNW-ESE elongated compressive diapir. This diapir is overprinted by N-S shortening and dominantly sinistral shearing along a W-trending shear zone, resulting in elongation and thinning of the evaporite body along the shear zone. The internal structure shows steeply dipping rock units and a steep foliation and the structures are formed by either pure shear flattening or simple shear under mainly subhorizontal maximum principal stresses. Earlier ductile fabrics of likely Early Cretaceous age are preserved in sulphate rocks like anhydrite and polyhalite and are subsequently overprinted by mylonitic fabrics in rock salt and cataclastic fabrics in other rocks. These processes caused cataclastic disintegration of mechanically strong lithologies and the foliation of rock salt wraps around these lenses mainly as a result of shearing.

Because of the low strength of halite, the Hallstatt evaporite body is now subject of recent subvertical shortening and the strain rate of this process could be quantified by deformed subhorizontal boreholes. We quantified the strain rate at 8 x 10-10 [s-1]. This value is similar to such strain rates (10-10 to 10-9 s-1) estimated by the grain size of halite from other salt mines in the NCA (LEITNER et al., 2011). The coincidence of both values argues, therefore, for a sub-recent formation of the halite microfabrics.

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LEITNER, C., NEUBAUER, F., URAI, J.L. & SCHOENHERR, J. (2011): Structure and evolution of a Rocksalt–Mudrock–Tectonite: the Haselgebirge in the Northern Calcareous Alps. - Journal of Structural Geology 33, 970–984.