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From subduction to exhumation: interpretation of fold interference in the NW Tauern Window

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The Tauern Window (Pennine, Central Alps, Austria) is well-known for its subduction- and exhumation history. Our geological mapping in the NW Tauern Window revealed a complex fold interference pattern not identified at this scale before.

These overprint relationships result from a sequence of folding phases in a setting that changed from subduction and nappe stacking to lateral extrusion and exhumation of the Tauern Window. The area of interest is situated at the NW edge of the Tuxer Zentralgneiskern (Subpenninic). Structures in the subpenninic Venediger-, Wolfendorn- and Moderecknappes (Rockenschaub et al., 2007) were investigated in the Schmirn-, Kaserer-, Wildlahner- and Vals valleys.

Folds of the first folding phase (D_1) are high amplitude highly similar isoclinal intrafolial folds from microfold ($<$ 1 mm) to nappe fold ($>$ 1 km) scale. Microfabric relationships indicate that the thermal peak, the Tauern crystallisation at ca. 30 Ma (Fügenschuh, 1997), followed F_1-folding. Microfabrics and mineralogy indicate a temperature jump across the Modereck nappe thrust, so after F_1 at least some movement occurred at the nappe thrusts. We estimate $>$ 450 ˚C (Grt-in) in the Wolfendorn- and $<$ 450˚C (Bt-in, no Grt) in the Modereck nappe. The generally E-W striking configuration of the Tauern Window and the N-vergent nappe structures, including F_1 folds, are consistent with the orientation of smaller scale isoclinal fold structures.

Folds of the second folding phase (D_2) generally have tight NW-plunging fold axes and have only been observed close to the Tuxer Zentralgneiskern, particularly in the Wolfendorn nappe and at the base of the Modereck nappe. The Modereck nappe thrust is also F_2-folded. F_2 fold structures have been mapped up to km scale, particularly around and below the Modereck nappe thrust. We identified such folds at the Tuxer Joch, like Rosenberg (2006), and further SW on a larger scale. These folds have developed after peak temperature was reached.

D_3 is characterised by S-vergent similar folds with steeply dipping axial planes and parallel stretching lineations. Top-W extensional shearbands related to the Brenner extensional fault interfered with these concurrently developed F_3-folds. The Brenner extensional fault system was active from the Eocene-Oligocene boundary to late Miocene (Fügenschuh et al., 1997 and references therein). Pressure solution, involving calcite, white mica, chlorite and quartz was dominant during D_3. This is best observable in the calcphyllites of the 'Bündnerschiefer' in the Modereck nappe and indicates that the main deformation occurred at $\sim$ 300-200 ˚C.

Due to F_3- and F_2 overprinting relationships at the western extension of the Tauern Window the F_1-fold axes do not simply plunge westward, as previously thought. It has been observed on up to km-scale that the F_1-structure continues in SW- direction and downwards in a stepwise manner. These steps follow E-W striking segments along F_3 fold axes and shorter NW-plunging segments along F_2fold axes. At the NW extension of the Tuxer Zentralgneiskern the Permotriassic at the base of the Modereck nappe is clearly affected by these overprint relationships. This results in very much thickened masses where fold hinges of large scale (F_1-,) F_2- and F_3-folds interfere, like the Permotriassic of the Schöbernspitzen, whereas in the fold limbs the Permotriassic is very much reduced in thickness.

We relate these folding phases to a sequence of events that starts with subduction of the narrow Penninic oceanic basin, in which the 'Bündnerschiefer' of the Modereck nappe and of the Nordrahmenzone (Penninic, accretionary wedge) was being deposited. Overprint- and microstructural relationships, the attained P-T conditions as well as the tectonic configuration suggest that the isoclinal F_1-folds are related to subduction and nappe stacking.

The oblique NW-dipping orientation of F_2-fold axes relates to transpression with a sinistral component. So, D_2 occurred during initial lateral extrusion of the Tauern window whilst shorting was still going on. The estimated D_2 P-T conditions at the presently exposed structural level are lower than during D_1, indicating that extension was already going on in the presently eroded roof of the Tauern Window. During the subsequent D_3-phase deformation became more brittle and strain partitioning increased, leading to E-W striking strike-slip zones preferentially developing along F_3-fold limbs that separate E-W-trending large-scale F_3-antiforms. During the relative uplift of the Tauern Window the Brenner fault system increasingly interfered with the other D_3-structures. This can be seen in the area described here, but closer to the Wipptal this evidence is greater, as is the importance of the Brenner fault system.

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