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NORMAL VERSUS STRIKE-SLIP FAULTING—DEFORMATION MECHANISMS DURING EXHUMATION IN THE FOOTWALL OF THE BRENNER NORMAL FAULT (TYROL, AUSTRIA)

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It is a widely accepted and well constrained idea that the Brenner normal fault is a roughly N-S striking major extensional fault zone, which is considered to be responsible for the Miocene denudation of the western parts of the Penninic Tauern Window in the Eastern Alps. The Brenner normal fault is described in literature as a planar, gently west dipping normal fault that divides the rocks of the Austroalpine Ötztal-complex in the hanging wall from the Penninic series of the Tauern Window in the footwall along a broad mylonitic shear zone, which is progressively overprinted by a narrowing brittle fault zone (e.g. Behrmann, 1988, Selverstone, 1988, Fügenschuh et al., 1997).

The purpose of this study is to evaluate the kinematics and relative chronology of deformation in the western Tauern Window. With the presented results the knowledge of the rather "simple" exhumation mechanisms postulated can be extended or improved.

In order to constrain the complex kinematics of the footwall during exhumation, ductile to brittle deformation was studied in detail in the region East of the Brenner Pass (i.e. the Sill valley, Venn valley, Zeischalm and Vals valley). In this area, the Alpine metamorphic Penninic lithologies comprise the Tuxer-Zentralgneis and its metasedimentary cover rocks, namely the Jurassic Hochstegen marble and the Cretaceous Kaserer Series (e. g. Frisch 1974), both belonging to the paraautochthonous (lower) Schieferhülle.

The first prominent deformation phase (D_2) forms an up to 300 m broad mylonitic zone within the Zentalgneis, the Olperer shear zone, which has been formed under amphibolithe facies condition (Lammerer & Weger 1998). This shear zone appears to be NE-SW striking on map view and shows a stretching lineation dipping moderately to the SW. The apparent NE-SW strike is due to subsequent folding and refolding (D_3) of the shear zone by south verging folds with fold axes parallel to the mylonitic stretching lineation. Geometric reconstruction of the original orientation suggests a planar shear zone, which dips shallowly to the WSW (258/19). This orientation closely resembles the geometry of the Brenner normal fault. In a late stage, this refolded mylonitic shear zone is crosscut by vertical, greenschist facies, NE-SW trending sinistral strike-slip zones (D_4). These faults can be traced over a 10 km distance (from the Olperer to the Sill vally). Microstructural analysis of these strike-slip faults reveals a temperature gradient with decreasing temperatures toward the West. Towards the lithologic contact between the Zentralgneis and its overlying cover rocks an increasing strain gradient was observed. Within this area, the SW-dipping stretching lineation (D_2) is progressively overprinted by a younger lineation, which is dipping to the W. Shear sense indicators display a West-directed detachment of the hanging wall block (i.e. Hochstegen marble) along the northern limb of the Tux-antiform (D_4). This movement is similar to the kinematics of the Brenner normal fault (e. g. Behrmann 1988; Selverstone 1988) and is therefore interpreted to be induced by the same mechanisms (i.e. E-W extension). As both strike-slip and normal faults expose the same microstructural features and acted under the same metamorphic conditions, we suggest that both mechanisms acted at the same time during exhumation. The major post-mylonitic deformation is characterised by a conjugate set of East- and West dipping N-S striking normal faults (D_5), which gradually develop out of sinistral strike-slip faults. Fault slip analysis shows that the initially horizontal N-S compression direction rotates into a vertical position becoming an E-W extensional system, which is well in line with the eastward extrusion model of the Eastern Alps (e.g. Ratschbacher

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et al. 1991). After the final movement along these brittle faults they were passively (10-15° clockwise) rotated around an E-W axis. These observations cannot be explained by the "rolling hinge"-model proposed by Axen et al. (1995), but favour a model that includes pre-folding fractures similar to the "fold-fracture" model by Bergbauer & Pollard (2004).
The deformational features presented in this study show the complex kinematics in the western Tauern Window, which were active during exhumation. The interpretation of these data suggests considerable detachments in the footwall of the Brenner normal fault. For this reason the window was not only exhumed by one narrow major extensional fault, but reveals extensive deformation in the footwall within a board area east of the Brenner-Pass. Furthermore, this investigation shows that the recent view of exhumation processes, especially the deformation mechanisms underneath Brenner detachment "sensu stricto", have to be improved.

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