Switch of kinematics in the Austroalpine basement between the Defereggen-Antholz-Vals (DAV) and the Pustertal-Gailtal fault – Eastern Alps

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Alpine Workshop 2009, Cogne/Italy 16. - 19. September 2009

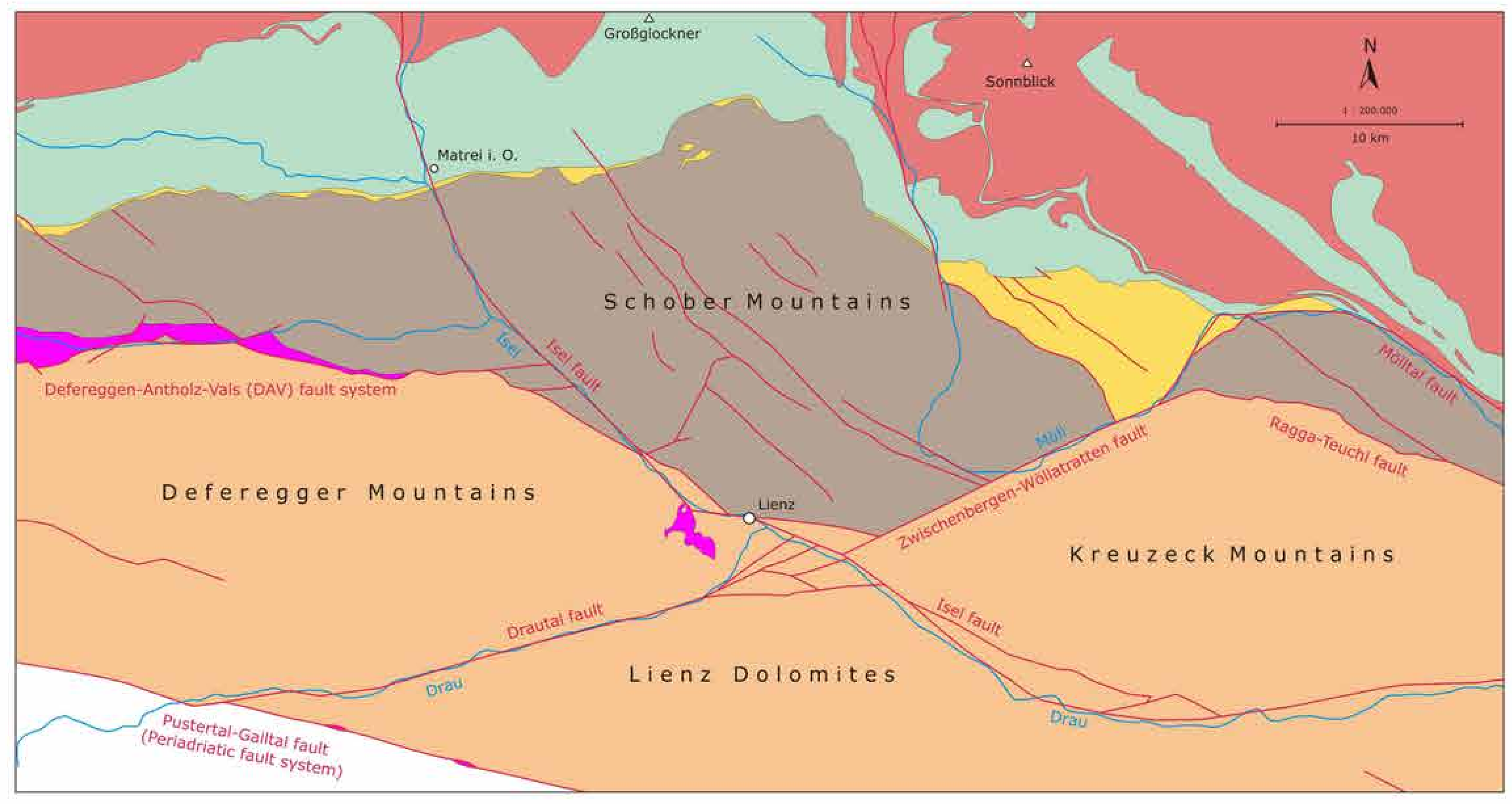
Overview

In the last two decades numerous structural and geochronological investigations of major fault systems have highly improved the knowledge about the Oligocene–Miocene evolution of Austroalpine units in the Eastern Alps (e.g. Ratschbacher et al., 1991, Peresson & Decker, 1997, Mancktelow et al., 2001).

Whereas the tectonic evolution of the Northern Calcareous Alps is well constrained, the dataset from Austroalpine units south of the Tauern Window still remained deficient. Recent investigation of brittle/ductile to brittle structures in the area between the Tauern Window in the north and the Periadriatic fault system in the south provide a new view on the Oligocene to Miocene structural evolution of the Eastern Alps.

In the study areas in East Tyrol and Carinthia the transition from ductile to brittle deformation is controlled by two main fault systems (Fig. 1), the Oligocene sinistral Defereggen-Antholz-Vals (DAV) fault (Borsi et al., 1978) and the dextral Pustertal-Gailtal fault, a segment of the Periadriatic fault system, which mainly accommodated the Miocene lateral extrusion of the Eastern Alps (Ratschbacher et al., 1991, Mancktelow et al., 2001). Furthermore, there are related synthetic faults, as the Drautal and Zwischenbergen-Wöllatratten fault form part of the DAV fault system, whereas the Isel fault correlates with the Pustertal-Gailtal fault.

The new structural data of the current study were collected in the western Kreuzeckgruppe in a position between the major fault zones as well as in the Isel valley northwest of Lienz within the Isel fault (Fig. 5). Thus, the structural data mainly stem from the Drauzug-Gurktal nappe system. In this tectono-metamorphic unit, four pre-Oligocene deformation stages are preserved, which are not discussed here. Therefore, our presentation of the structural evolution starts with stage D5 (ductile/brittle transition).



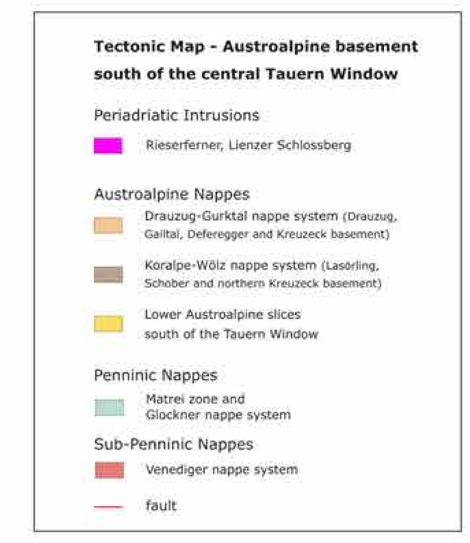


Fig. 1:
Several ductile/brittle to brittle faults dissect the Austroalpine nappe systems south of the Tauern Window. The Oligocene sinistral Defereggen-Antholz-Vals-(DAV) fault system with the synthetic Drautal and Zwischenbergen-Wöllatratten fault is offset by the NW-SE trending Isel fault. The latter may be correlated with the Pustertal-Gailtal fault representing a segment of the Periadriatic fault system.

Sinistral ductile to brittle deformation – *Oligocene*

Kink folds with slightly NW-dipping kink fold axes and moderately NW-dipping axial planes (D5, Fig. 2) represent the initial Oligocene deformation stage, which is accompanied by SW-directed thrusting parallel to D5 axial planes (D6, Fig. 3). The deformation structures reflect shear deformation at the ductile/brittle transition and indicate strong deformation partitioning.

The main shortening direction during D5 and D6 shows NE-SW orientation and marginal counter clockwise rotation during the subsequent deformation stage D7.
The widespread WSW-ENE striking steep D7 faults indicate sinistral displacement and are characterized by their influence on the regional morphology and the related intrusion of periadriatic tonalite dikes (Fig. 4).

This dominant fault system is divided by the younger Isel fault into two segments, the Drautal and the Zwischenbergen-Wöllatratten fault (Fig. 5).
The final stage of Oligocene NE-SW shortening deformation ceased with NW- and SE-directed normal faulting, pointing to NW-SE-directed extension (D8).

Fig. 2:
Thin section photograph of a kink fold hinge of stage D5 (section normal to the kink axis; crossed polarized light below).

Pre-existing grains dominate the quartz microstructure. In some places they exhibit initial bulging. Similarly, white micas are not recrystallised in the kink fold hinge.

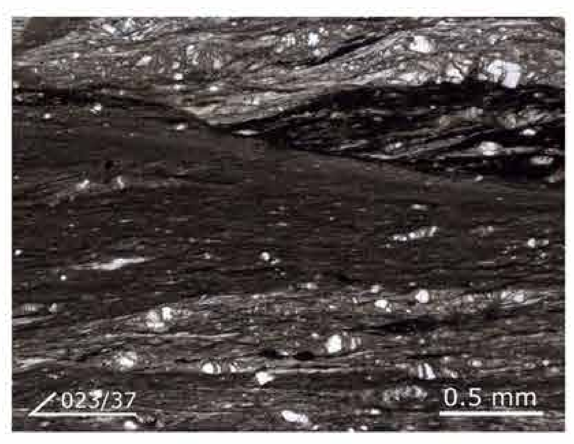
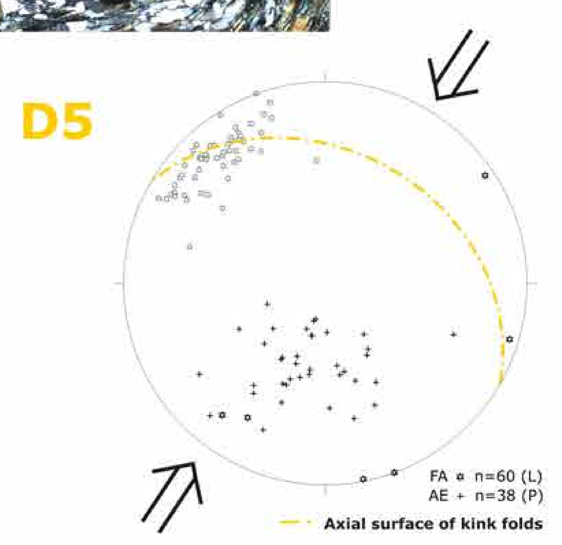
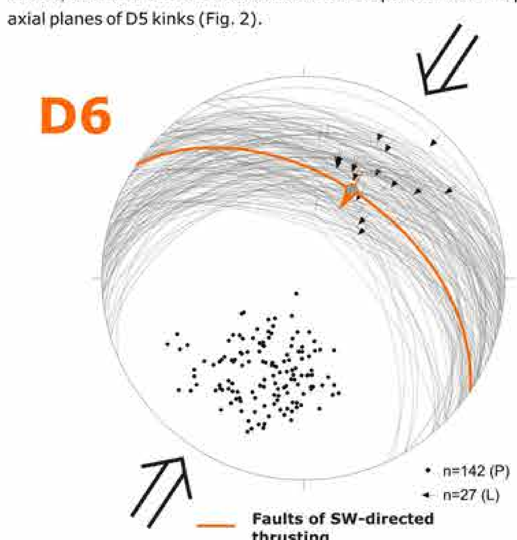


Fig. 3:
Cataclasite with layers of ultracataclasite in a thin section photograph with crossed polarized light (section parallel to the stretching lineation, orthogonal to the foliation). Quartz sigma clasts indicate SW-directed shearing. These cataclasites formed as ductile/brittle to brittle shear zones oriented parallel to NE-dipping axial planes of D5 kinks (Fig. 2).





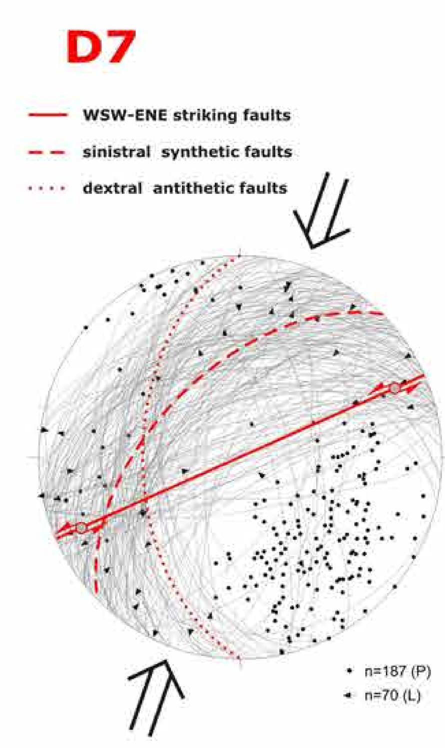
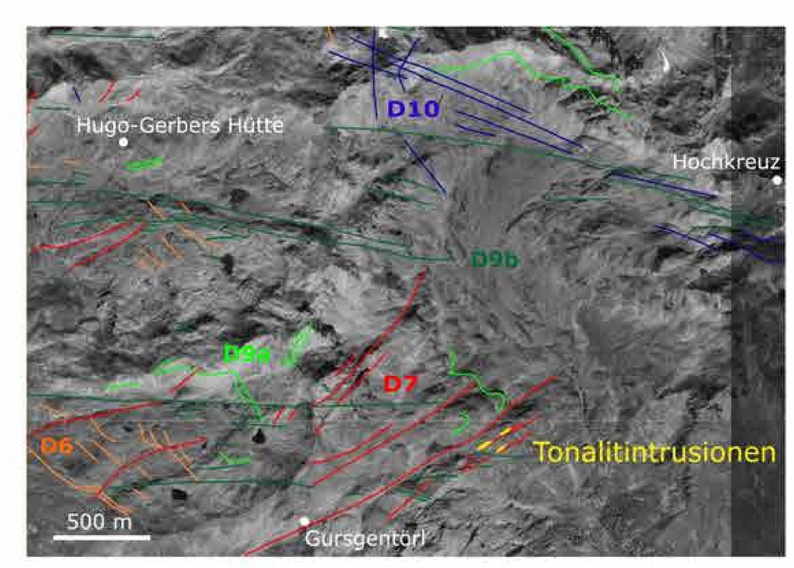
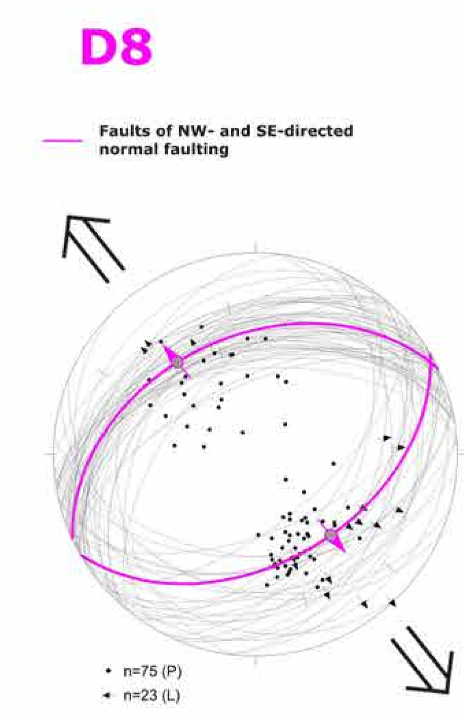


Fig. 4:
A NE-SW striking D7 fault zone appears at the southern border of the study area at Gursgentörl and can be traced towards NE. Several periadriatic tonalite dikes are arranged along these faults and have an elongate shape with the long axis parallel to the strike direction. Nevertheless magnatic contacts with the country rocks are preserved, and the tonalites show no obvious solid state deformation.

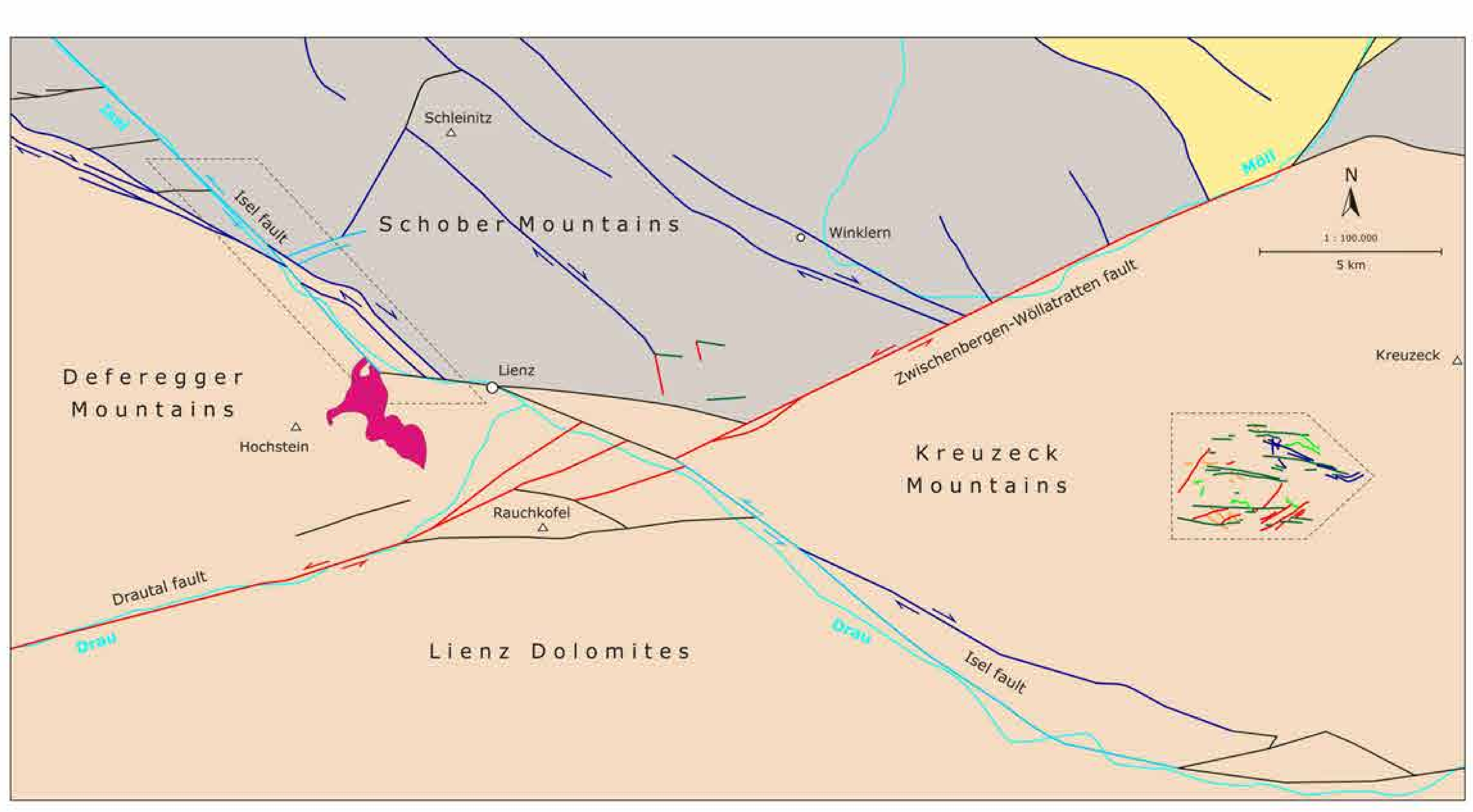




Subvertical W-E striking and low-angle faults

The current study provides the first mention of low-angle faults in the studied area. These are marked by several meters of cohesive cataclastic and ultracataclastic rocks (D9a, Fig. 6). Well developed SCC'-fabrics and slickensides in the ultracataclasites clearly document the S-directed kinematics of this shear deformation.
Furthermore, low-angle faults interact with subvertical E-W striking faults (D9b), which influence the morphology and display cataclastic and ultracataclastic fault rocks (Fig. 7).

Contrasting all other steep faults in the study area their slickenlines indicate a high dip-slip component and display changing displacement directions within individual faults. This may be a consequence of fault rotation with a W-E oriented rotation axis in relation with top to S shearing along the low-angle faults. Therefore, a coherent evolution of D9a and D9b faults is inferred.
Chronologically these faults can be placed between the Oligocene sinistral and Miocene dextral fault systems, because the subvertical W-E faults (D9b) cut D7 structures (WSW-ENE striking) and were partly reactivated by D10, WNW-ESE striking faults (Fig. 4 - Orthophoto, Fig. 7 - Hochkreuz).
The main shortening direction during D9 (N-S) is intermediate between the Oligocene (NE-SW) and Miocene (NNW-SSE) shortening directions.



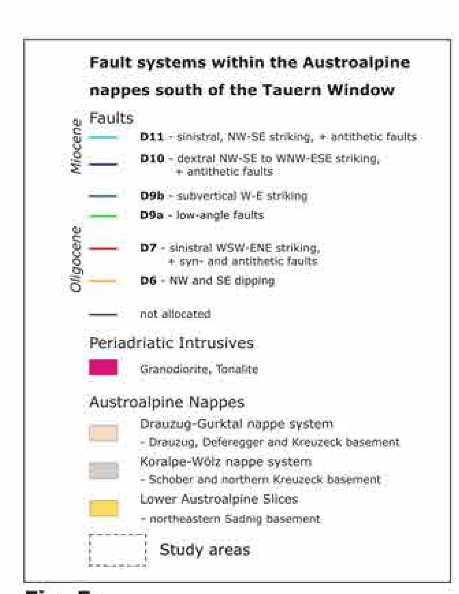


Fig. 5:
Faults are indicated according to the timing of their main activity.

The Oligocene and Miocene strike-slip faults determine the valley trends, but also are widespread and morphologically visible between the main fault zones. In these areas low-angle faults (D9a) and subvertical W-E striking faults (D9b) gain in importance, reflecting a separate brittle tectonic stage.

Fig. 6:
Outcrop photograph of a subhorizontal D9a fault. Cohesive (ultra)-cataclasites with a subhorizontal main foliation show a SCC' fabric that clearly indicates top to S shear kinematics.

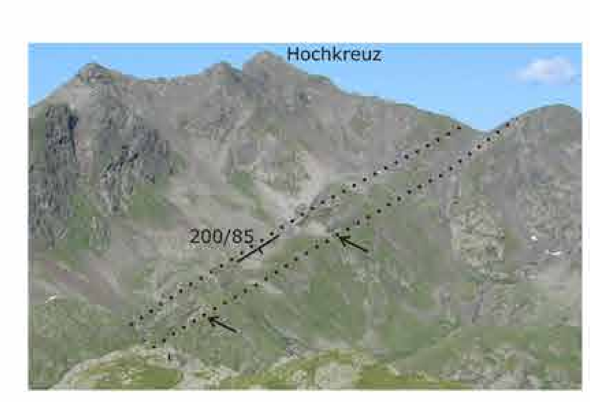
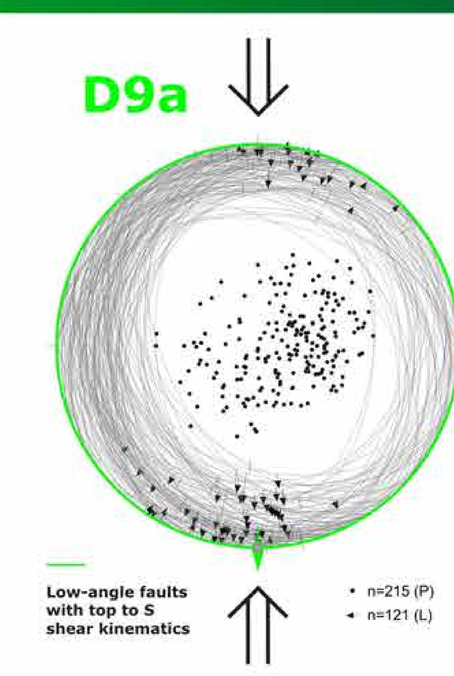
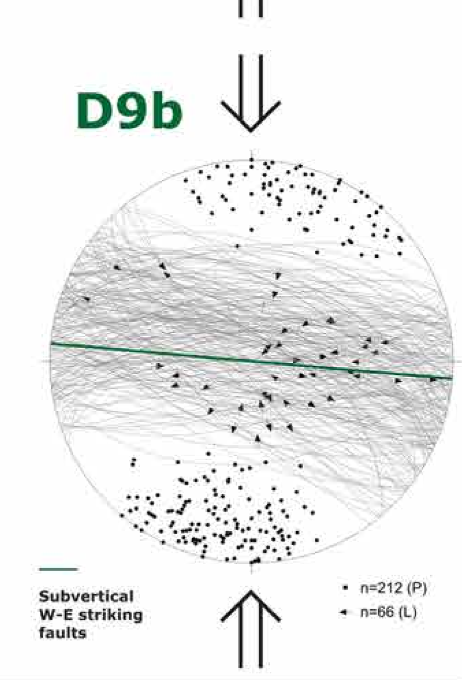


Fig. 7:
A morphologically pronounced D9b fault can be traced in the field photograph. From the saddle south of Hochkreuz two main fault planes trend to the west. View towards east. (compare Fig. 4 - Orthophoto).

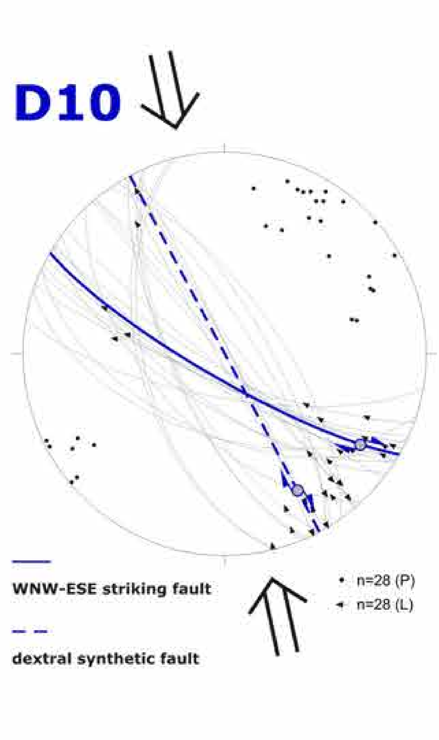




Dextral and sinistral displacing brittle deformation – *Miocene*

The dominating dextral Isel fault has WNW-ESE striking main fault planes and NW-SE oriented synthetic faults, recording the deformation phase D10 (Fig. 5, Fig. 8). The main Isel fault is interpreted as a synthetic fault of the Pustertal-Gailtal fault, which represents a segment of the Periadriatic fault system. The Isel valley between Matrei and Lienz and the Drau valley east of Lienz follow the Isel fault. Also within the basement blocks, for instance in the Schober mountains, morphologically significant faults are frequent. Maximum shortening in NNW-SSE direction is indicated for the deformation stage D10.
Sinistral reactivation of the Isel fault characterizes the last significant phase of brittle deformation (D11), well documented by the displacement of the contact aureole of the Periadriatic granodiorite intrusion west of Lienz (Fig. 9). In this area prevalent NW-SE striking main faults and WSW-ENE striking antithetic faults point to significant W-E shortening.

Fig. 8:
Slickenside with cataclasite on an outcrop picture of the Isel fault, D10 (forest track, Böse Platte, south of St. Johann). Slickenlines dipping towards SE and dextral displacement is indicated by linear steps.



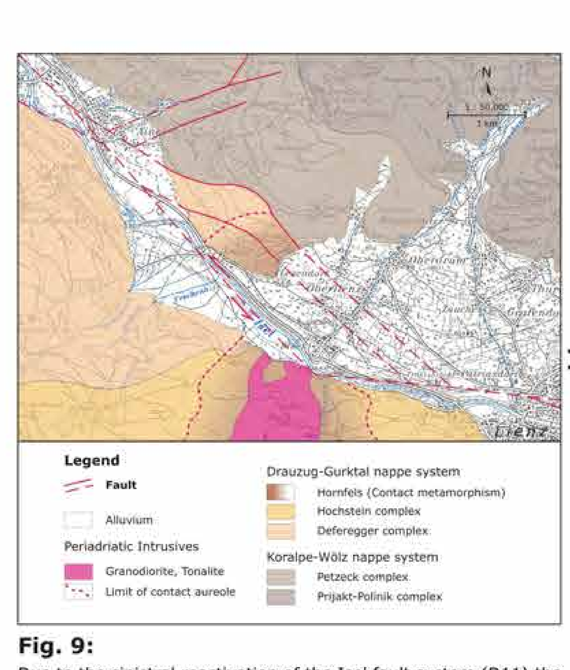
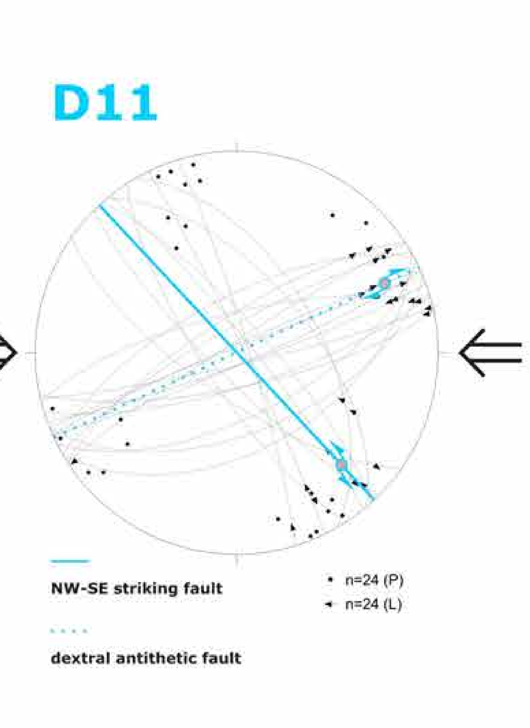


Fig. 9:
Due to the sinistral reactivation of the Isel fault system (D11) the contact aureole of the Periadriatic intrusion west of Lienz is displaced more than one kilometer to northwest.



Summary

Brittle/ductile and brittle structural data of faults in the Austroalpine nappe system between the Tauern window and the Periadriatic fault system record three main stages of fault activity:

1) Sinistral kinematics related with activity of the Defereggen-Antholz-Vals (DAV) fault started with SW-directed thrusting (D6), evolved towards transpressive strike-slip faulting along steep WSW-ENE striking fault planes (D7 - Drautal fault), and ceased with NW- and SE-directed normal faulting (D8). During sinistral transpression Oligocene Periadriatic intrusions were emplaced (Mancktelow et al., 2001; Steenken, 2002).

2) A subsequent change in the stress-field is recorded by subvertical E-W striking faults (D9b) with ultramylonitic and cataclastic rocks and low-angle faults (D9a) with top to S kinematics. These structural features are most prominent in the basement block between the main fault zones of the DAV and the Gailtal-Pustertal fault, and are interpreted to reflect the switch of major deformation from the Oligocene DAV north, to the Miocene Gailtal-Pustertal fault south of the study area.

3) Later, dextral WNW-ESE trending strike-slip faults (D10) formed the remarkable fault systems set up in the Isel, Drau and Möll valleys. These were linked with dextral strike-slip movement along the Pustertal-Gailtal fault as part of Miocene lateral extrusion (Mancktelow et al., 2001). The last stage of significant brittle deformation is characterized by a sinistral reactivation of the Iseltal fault due to E-W compression (D11), which can be correlated with the Late Miocene stress inversion in the Alpine-Carpathian region (Peresson & Decker, 1997).

Literatur

BORSI, S., DEL MORO, A., SASSI, F. P., ZANFERRARI, A. & ZIRPOLI, G. (1978) - Mem. Ist. Geol. Mineral. Univ. Padova, **XXXII**: 17 pp, Padova.
MANCKTELOW, N. S., STÖCKLI, D. F., GROLLIMUND, B., MÜLLER, W., FÜGENSCHUH, B., VIOLA, G., SEWARD, D. & VILLA, I. M., (2001) - Int. J. Earth Sciences, **90**: 593-622, Stuttgart.
PERESSON, H. & DECKER, K. (1997) - Tectonics, **16**: 38-56, Washington.
RATSCHBACHER, L., FRISCH, W., LINZER, H.-G. & MERLE, O. (1991) - Tectonics, **10**: 257-271, Washington.
STEENKEN, A. (2002) - Geotekt. Forsch., **94**, 1-120, Stuttgart.