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The internal structure of faults and brittle shear zones: what happened prior to brecciation and cataclastic flow?

F.J. Brosch, W. Kurz

Institute of Applied Geosciences, Graz University of Technology, Rechbauerstr. 12, A- 8010 Graz, Austria (brosch@egam.tugraz.at; kurz@egam.tugraz.at)

Upper crustal fault zones are structurally complex zones of brittle deformation. In the past decades, a better understanding of the internal structure of brittle fault zones as well as dicrete fractures has been achieved from both field work (e.g., Sibson, 1986; Chester et al., 1993; Caine et al., 1996), laboratory fracture experiments, and numerical models. Generally, three structural elements may be discriminated for brittle fault zones (following Caine et al., 1996): (1) the protolith or host/country rock consisting of unfaulted rock mass bounding the fault-related structures; (2) the damage zone, characterised by minor faults, fractures, veins, and fracture networks; these structures are generally related to the processes of fault zone formation and fault growth. Generally, the transition from the host rock to the damage zone is gradual. (3) the fault core, where shear is localised. In this study, we focus on the transition from the host rock to the damage zone in order to document the structures forming during the initial phases of fracturing and subsequent fault zone evolution, i.e., the fractures that formed prior to the formation of fault breccias and cataclasites. These features are to be studied along several major strike-slip faults in the Eastern Alps, e.g., the E-W trending Thalhof fault being a segment of the Salzach-Ennstal fault system, the NW-SE trending Palten-Liesing fault, and the NW-SE trending Mölltal fault in the southern part of the Eastern Alps as well. The Thalhof fault shows predominant left-lateral displacement, the Palten-Liesing and Mölltal faults show right-lateral displacement. The transitional segments from the host rock to the damage zone are characterised by the formation of closely, millimeter- to centimeter- spaced fractures, 5-20 cm in length, at high angles (70-90°) to the fault zone boundaries. In Mohr-Coulomb terms these may be described as R'-fractures bounding slender slab-like or columnar rock lamellae. As-

suming that the fault zone is constant in thickness, the consequent synthetic rotation of these slabs results at first in the formation of kink bands parallel to the intersection of the fault zone boundary with the rock lamellae (i.e., subperpendicular to the displacement vector). Subsequently, fracturing along these kink bands and breaking-up to smaller fragments with independent rotational and translational movements may display the transition to the formation of breccias and cataclastic fault rocks. Subsequent shear is assumed to be localised along these fracture zones. This suggests that double-slide conjugate shearing and synthetic rotation of slabs in terms of a bookshelf mechanism play a major role during the initial phases of the evolution of a brittle fault zone.

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