Geophysical Research Abstracts
Vol. 12, EGU2010-5112, 2010
EGU General Assembly 2010

Fault architecture, fault rocks and fault rock properties in carbonate rocks

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The current study addresses a comparative analysis of fault zones in limestone and dolomite rocks comparing the architecture of fault core and damage zones, fault rocks, and the hydrodynamic properties of faults exposed in the Upper Triassic Wetterstein Fm. of the Hochschwab Massif (Austria). All analysed faults are sinistral strike-slip faults, which formed at shallow crustal depth during the process of eastward lateral extrusion of the Eastern Alps in the Oligocene and Lower Miocene

Fault zones in limestone tend to be relatively narrow zones with distinct fault core and damage zones. Fault cores, which include the principle slip surface of the fault, are characterized by cataclastic fault rock associated with slickensides separating strands of catalasite from surrounding host rock or occurring between different types of cataclasite. Cataclasites differ in terms of fragment size, matrix content and the angularity of fragments,. Cataclasite fabrics indicate progressive cataclasis and substantial displacement across the fault rock. Fault core heterogeneity tends to decrease within more evolved (higher displacement) faults. In all fault cores cataclasites are localized within strands, which connect to geometrically complex anastomosing volumes of fault rock. The 3D geometry of such fault cores is difficult to resolve on the outcrop scale. Beside cataclastic flow pressure solution, overprinting cataclastic fabrics, could be documented within fault zones.

Damage zones in limestone fault zones are characterized by intensively fractured (jointed) host rock and dilatation breccias, indicating dilatation processes and peripheral wall rock weakening accompanying the growth of the fault zone. Dilatation breccias with high volumes of carbonate cement indicate these processes are related to high fluid pressure and the percolation of large volumes of fluid. Different parts of the damage zones were differentiated on the base of variable fracture densities. Fracture densities (P32 in m^2 joint surfaces per m^3 rock) generally vary along all investigated faults. They are especially high in more evolved (higher displacement) fault zones where they are associated with large-scale Riedel sehars and in parts of the damage zones, that are next to the fault cores. The assessment of the abundance of small-scale fractures uses fracture facies as an empirical classification providing semi-quantitative estimates of fracture density and abundance. Different units were assigned to fracture facies 1 to 4, with fracture facies 4 indicating highest fracture density.

Fault zones in dolomite tend to have several fault cores localized within wider zones of fractured wall rock (damage zones), even at low strain. Compared to fault zones with similar displacement in limestone, damage zones in dolomite tend to be wider and have higher fracture densities. Dilatation breccias are more abundant. A clear separation of fault core and damage zone is more difficult. Damage zones observed at the lateral (mode III) tips of the analysed strike-slip faults show that hydraulic fracturing and fluid flow through the propagating fault are of major importance for its evolution. A typical transition from the wall rock ahead of the propagating fault to the core of the slipped fault includes: densely jointed wall rock, wall rock with abundant cement-filled tension gashes, dilatation breccia and cataclasite reworking both dilatation breccia and wall rock.

The detailed documentation of different fault zone units is supplemented by porosity measurements in or-

der to assess the hydrogeological properties of the fault zones. High permeability units are first of all located in the damage zones, characterized by high fracture densities. Porosity measurements on fault rocks showed highest porosity (up to 6%) for fractured wall rocks (fracture facies 4) and dilatation breccias (porosity of undeformed wall rock: 1,5 % average, 2 % maximum). Thin sections prove that most of the porosity is carried by uncemented fractures. Fracture porosity therefore is the controlling factor of fault zone permeability. The different types of cataclasite in fault cores show low intra-granular porosities (average 2,5 %) and very low fracture density. They therefore are classified as low-permeability units.