Geophysical Research Abstracts
Vol. 12, EGU2010-14088, 2010
EGU General Assembly 2010

Semi-brittle flow in granitoid fault rocks

Matěj Peč (1), Holger Stünitz (2), and Renée Heilbronner (1)

(1) University of Basel, Department of Geosciences, Switzerland (matej.pec@unibas.ch), (2) Universitetet i Tromsø, Institutt for geologi, Norway

Strength of the upper crust is at its peak around the frictional–viscous transition. The behavior of crustal scale faults is strongly influenced by the processes taking place under these conditions. Our aim is to investigate the influence of grain size reduction by fracturing on the dominant deformation mechanism in fine-grained fault rocks.

We performed a series of simple shear experiments on granitoid fault gouge in a Griggs solid medium deformation rig. Crushed Verzasca gneiss powder ($\leq$ 200 μm) with 0.2 wt% water added was placed between alumina or Verzasca gneiss forcing blocks pre-cut at 45° and weld-sealed in gold or platinum jackets. All experiments were run at 300°C or 500°C and 500 MPa confining pressure.
In order to be able to analyze the starting material, two experiments have been pressurized to the run conditions but were not deformed. All major phases (Qtz, Kfs and Plg) deform by fracturing at the grain-to-grain contacts. The average aspect ratio (L/S) is 2.13, the average values for paris and deltaA (Heilbronner & Keulen 2006) are 7.6 % and 6.5 %, respectively, and are similar for all phases. Grains are slightly aligned perpendicular to the shortening direction. The porosity estimate by image analysis is $\sim$28%.
This material is deformed under conditions favoring frictional deformation (shear strain rates of 10ˆ-4 secˆ-1 and 10ˆ-3 secˆ-1) to a gamma-value of up to 2.7. Typically, the peak shear stress is $\sim$900 MPa. We observe neither temperature nor strain rate dependence in these experiments so we infer that the deformation is purely frictional. Microstructural observations reveal shear localization through the development of S-C-C´ fabrics and an overall grain size reduction that reaches its maximum in the C´ shear bands (grain size < 10 nm) that form at an angle of 18° to sigma 1. Most of the deformation is accommodated by Kfs and Plg. Qtz has a slightly higher average aspect ration (2.3) than the feldspars (2.0) and seems to be the strongest phase. Average paris and deltaA values for qtz grains are higher (12.29% and 7.33%) than for feldspar grains (10.64% and 5.19%) due to cleavage effects on fracturing. The grain aggregates have a monoclinic symmetry and often form “core-and-mantle” structures where the core is formed by a less fractured porphyroclast and the mantle is formed by finely fractured material. These aggregates show a strong SPO synthetic with the induced sense of shear. The porosity estimate by image analysis is < 3%.

The transition from frictional to viscous deformation in the fine-grained gouge is induced after reaching a given gamma-value (2.5) by stopping of the displacement motor. The samples are then left to relax the peak differential stress over one week. We observe slow shear strain rates (up to 10ˆ-8 secˆ-1) and pronounced temperature dependence (500°C experiments relax on average 100 MPa more shear stress and achieve 0.03 mm more vertical displacement than 300°C experiments). The estimated stress exponents are in the order of 13 – 30 suggesting that the gouge deforms by a combination of frictional and viscous deformation mechanisms. However these numbers have to be regarded with caution given the poor stress resolution of the Griggs rig. Microstructural observations show cementation of small grains into bigger ones with lobate grain boundaries indicating that solution-precipitation creep takes place in the fine-grained shear bands. Further, we observe the re-orientation of the C´ shear bands to an angle of 30° to sigma 1. The temperature dependence of deformation in conjunction with solution-precipitation microstructures indicate that the slow deformation is partly accommodated by diffusion creep.

References: Heilbronner, R. and Keulen N. (2006) Grain size and grain shape analysis of fault rocks. Tectonophysics 427:199-216