Geophysical Research Abstracts
Vol. 13, EGU2011-12070-1, 2011
EGU General Assembly 2011

Experimental Measurements of Fault Wear and Permeability Evolution along Faults during Progressive Slip

Marc Andre Strutz, Tom Mitchell, and Jörg Renner
Institute of Geology, Mineralogy & Geophysics, Ruhr-University Bochum, Bochum, Germany (marc.strutz@rub.de)

Little is currently known about the dynamic changes in fault-parallel permeability along rough faults during progressive slip. With increasing slip, asperities are worn to produce gouge which can dramatically reduce along fault permeability within the slip zone. However, faults can have a range of roughness which can affect both the porosity and both the amount and distribution of fault wear material produced in the slipping zone during the early stages of fault evolution.

In this novel study we investigate experimentally the evolution of permeability along a fault plane in granite sawcut sliding blocks with a variety of intial roughnesses in a triaxial apparatus. Drillholes in the samples allow the permeability to be measured along the fault plane during loading and subsequent fault displacement. Use of the pore pressure oscillation technique (PPO) allows the continuous measurement of permeability without having to stop loading. To achieve a range of intial starting roughnesses, sawcut surfaces were prepared using a variety of corundum powders ranging from 10 μm to 220 μm, and for coarser roughness were air-blasted with glass beads up to 800 μm in size. Fault roughness has been quantified with a laser profileometer. During sliding, we measure the acoustic emissions in order to detect grain cracking and asperity shearing which may relate to both the mechanical and permeability data.

Permeability shows relative reductions of up to over 4 orders of magnitude (from 10^{-14} m^2 down to as low as 10^{-18} m^2) during stable sliding as asperities are sheared to produce a fine fault gouge over displacements of up to 6 mm. This variation in permeability is greatest for the roughest faults, reducing as fault roughness decreases. The onset of permeability reduction is contemporaneous with a dramatic reduction in the amount of detected acoustic emissions, where a continuous layer of fault gouge has developed and asperities of the host rock are no longer in contact. Following large stress drops and stick slip events, permeability can both increase and decrease due to dynamic changes in pore pressure during fast sliding events. The amount of fault gouge produced is related to the initial roughness, with the roughest faults showing thicker fault gouge layers at the end of slip. We quantify the roughness both before and after experiments in addition to measuring the amount of wear material produced. We also explore the effect of strain rate on wear material produced. Our results have significant implications for permeability evolution of natural fault zones in which many existing studies have been shown to have a wide range of roughnesses.