Geophysical Research Abstracts,
Vol. 11, EGU2009-3466, 2009
EGU General Assembly 2009

Healing of Experimentally Simulated Fractures: Contact Neck Growth, and Strength Evolution of the Interface

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We have designed a laboratory experiment of a simulated rough fracture that undergoes successive cycles of slip and healing under dry condition or in the presence of a reactive fluid. This set-up is a surrogate for the healing/sealing of fractures and faults during the seismic cycle in carbonate rocks, where fluid-rock interactions are operative at the millennium time scale and modify the frictional properties of the interface. A rough slider of sodium chloride is left in contact with a flat glass plate under a constant normal load. The whole set-up is mounted on a microscope and left in a temperature-controlled box. The closure of the interface through several days is measured using high resolution displacement sensors and the contact surface is continuously imaged with a CCD camera. Under dry conditions, a small transient creep displacement perpendicularly to the fracture plane is measured. This deformation lasts for several minutes and finally stops. Under fluid saturated conditions, a slow closure of the rough interface is measured over several days. This closure is concomitant with the growth of contact points, driven by surface tension forces. After 50 hours, up to 10% of the fracture surface is healed by this process. The force necessary to break the adhesion forces, allowing the sample to slide, is also measured after several periods of increasing holding times and shows a power law dependence with time. Conversely, the same experiment under dry condition shows a logarithmic dependence of the static coefficient of friction with time. After each experiment, the fracture interface roughness is measured to nanometer resolution using white light interferometry. The morphology of the contacts is characterized by scaling relationships. Finally, we propose a macroscopic constitutive model of fracture closure and strength recovery, related to the dynamics of the contact asperities, which are seen to flatten and expand through time.