Frédéric Cappa, – TO seminar Nov. 12th 2013

Slow slip and seismicity induced by hydraulic stimulation of a fault zone at meter-scale

The role of fluids in faulting is a central question in geophysics because fluid pressures are suspected to influence the initiation of slow slip and dynamic rupture. Yet to date few data are available to constrain the fluid-mechanical coupled effects on faulting, at appropriate scales. Here we present unique measurements of induced slip on a natural fault under monitored mechanical and hydraulic conditions. We report continuous measurements of strain, seismicity and fluid pressure (few MPa) during slow slip (mm- scale) activation on a 10-m long segment of a normal fault. The episodicity of fault slip is related to dilatancy-strengthening revealed by transient pore-pressure drops. We calculate that the slip is initiated by the fault material frictional weakening, the pore pressure increase just being the trigger. Then, there is a competition between high-pressure fluid diffusion in the fault zone and multiple slow ruptures that generate 80% of the seismic energy until the permeability/porosity increase progressively become the predominant control on slip of large fault segments. Detection of variations in these pressure transients and their correlation to seismicity allow capturing irreversible evolutions of fault friction that lead to the nucleation process. Such results are crucial in defining mechanisms of natural and induced earthquakes, their precursors and risk assessment.