Harvard University -- Solid Earth Physics Seminar

Thermal pressurization of pore fluid - mechanism for seismic and aseismic self-healing fault slip

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Thursday 1 March, 2:30 pm
4th Floor Faculty Lounge, Hoffman Laboratory, 20 Oxford St.

Abstract
There are several lines of evidence that suggest that thermal pressurization (TP) of pore fluid within a low-permeability fault core may play the key role in the development of earthquake slip. To elucidate effects of TP on spontaneous fault slip, I consider solutions for a steadily propagating slip pulse on a fault with a constant sliding friction, the level of which may reflect other thermally-activated processes at the rupture front (e.g., flash heating). These pulses are characterized by initial stage of intense undrained weakening of the fault (when fluid/heat can not yet escape the frictionally heated shear zone), which gives way to partial restrengthening due to increasing hydrothermal diffusion under conditions of diminished rate of heating, leading to eventual locking of the slip. The rupture speed of these pulses is decreasing function of the thickness of the principal shear zone. For lab-constrained values of fault-gouge parameters, the solution scaling predicts earthquake slip on a millimeter-to-cm, thin principal shear zone; and aseismic slip propagating at 10 km/day with slip rates 1-2 orders above the plate rate on a relatively thick (~1 m) shear zone. These and other predictions are consistent with the independent sets of observational constraints for large crustal and subduction interplate earthquakes, and slow slip transients (North Cascadia), respectively. The predicted maximum co-seismic temperature rise is low, precluding the onset of macroscopic melting and some of thermal decomposition reactions, recently suggested to explain strong co-seismic fault weakening, over much of the seismogenic zone.