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The influence of trapped high pressure fluids on the earthquake cycle

Stephen Miller (1) and Yuri Podladchikov (2)

(1) Geodynamics, Steinmann Institute, University of Bonn, Germany (miller@geo.uni-bonn.de, +49 228 73 2508), (2) Geophysics Institute, University of Lausanne, Switzerland (Yury.Podladchikov@unil.ch, +41 21 692 44 05)

Recycling of Earth's volatiles provides continuous input to reservoirs trapped at the base of seismogenic zones. The path to that reservoir involves fluid flow through ductile rheology of the deeper crust, and brittle rheology of the upper crust. In the ductie regime, fluids flow by buoyancy/viscous processes, while in the brittle regime, fluid flows is controlled by the hydraulic properties of the crack network. The permeability of the brittle crust prior to an earthquake is low because fractures seal by chemical precipitation, trapping fluids at the base of the seismogenic layer. Large-scale fracture associated with an earthquake can increase the permeability by many orders of magnitude, thus opening up fresh pathways for draining the trapped reservoir. In this view, rich aftershock sequences are the result of the high pressure fluids associated with the draining of the reservior. At deeper levels, non-volcanic tremor and slip has been assoicated with high pressure fluids, but the nature in which fluids play a role is still debated. We show that migrating tremor can be explained by considering the behavior of trapped fluids with a viscous rheology, and show that a large-scale reduction in viscosity at the onset of slip generates and propagates a solitary wave in the form of a porosity wave due to the bouyancy of the fluid. In both cases of brittle and ductile flow, the behavior is controlled by a toggle-switch between little to no permeability toggled to high permeability at slip in the brittle regime; and in the ductile regime, high viscosity is toggled to very low viscosity and transiently allowing bouyancy to dominate. Both of these processes are instrumental in the earthquake cycle because these high pressure fluid reservoirs ultimately assist in the breakdown process at the base of seismogenic zones. These ideas lead naturally to an earthquake cycle that is predominantly fluid-controlled, and in this talk we discuss how fluids, and their transport, affect the earthquake process. We also propose a methodology for monitoring reservoir evolution preceding large earthquakes, and how foreshock processes may indicate a leaking reservoir late in the earthquake cycle.