Harvard University, Solid Earth Physics Seminar
Tuesday, 22 October 2013, 1:15 pm
Faculty Lounge, 4th Floor, Hoffman Lab, 20 Oxford Street

Variations in off-fault damage and hydraulic properties induced by earthquake rupture

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In recent years several studies have identified so-called ‘pulverized rocks’ on various crustal-scale faults, a type of intensely damaged fault rock which has undergone minimal shear strain, and the occurrence of which has been linked to damage induced by transient stress perturbations during earthquake rupture. Damage induced by such transient stresses, whether compressional or tensional, likely constitute heterogeneous modulations of the remote stresses that will impart significant changes on the strength, elastic and fluid flow properties of a fault zone immediately after rupture propagation, at the early stage of fault slip. Here we show that permeability of the damage zone of the San Jacinto fault increases by up to 5-7 orders of magnitude compared to the wallrock, which we attribute to pervasive high-strain-rate coseismic microfracturing. Permeability measured on granitic samples deformed experimentally at high strain rates compare well with permeability measured for natural samples. Analytical solutions of dynamic rupture suggest such strain rates are compatible to natural fault rupture processes. We conclude that the passage of a rupture can lead to significant permanent variations in off-fault permeability which could exert both positive and negative feedbacks on processes controlling fault slip (e.g. thermal pressurization) depending on the type of high-strain rate damage imparted at the rupture tip, potentially act as a toggle switch to either promote or arrest fault slip.