Slow Earthquakes and Weakness of Major Tectonic Faults: Connections Between Fault Strength, Fabric, and the Mode of Frictional

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Abstract: Earthquakes have long been understood as frictional stick-slip instabilities in which stored elastic energy is released suddenly, driving catastrophic failure. In normal earthquakes the rupture zone expands at a rate of a few km/s, as dictated by elastic wave speed, and fault slip rates reach 1-10 m/s. However, tectonic faults also fail in slow earthquakes with rupture durations of months or more and fault slip speeds of ~100 μm/s or less. Slow earthquakes and other forms of transient fault slip can rupture large fault regions, reaching the equivalent of M 8 or larger. They can transfer stress to the seismogenic zone and thereby trigger damaging, normal earthquakes.

In this talk, I discuss slow earthquakes and the spectrum of fault slip behaviors in the context of new results on the role of shear fabric and hydrous clays in determining fault strength and slip behavior. The results on fault strength provide an explanation for the heat flow paradox in central CA and slip on low angle normal faults. Our work shows that fault zone fabric and the presence of clay nanocoatings can cause extreme fault weakness. The extent to which this mechanism operates at greater depths remains an open question. I also summarize recent results showing the first laboratory observations of repetitive, slow stick-slip in fault zone materials, and mechanical evidence for their origin. The experiments were conducted on serpentine fault gouge under stresses appropriate for slow earthquakes in nature. The laboratory slow slip events are accompanied by precursory elastic wave speed reduction that begins up to 60 seconds before failure. We documented a transition from unstable to stable frictional behavior above a threshold velocity of ~10 μm/s. These data provide direct evidence for the hypothesis that slow earthquakes represent prematurely-arrested *normal* earthquakes..