Solid Earth Physics Seminar, Harvard University

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Room 310 Geological Museum

Permeability that Changes over Times

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Abstract:

Earthquakes can increase permeability in fractured rocks. In the farfield, such permeability increases are attributed to seismic waves and can last for months after the initial earthquake. Laboratory studies suggest that unclogging of fractures by the transient flow driven by seismic waves is a viable mechanism. Permeability enhancement by seismic waves could potentially be engineered and the experiments suggest the process will be most effective at a preferred frequency.

We have recently observed similar processes inside active fault zones after major earthquakes. A borehole observatory in the fault that generated the M9.0 2011 Tohoku earthquake revealed a sequence of temperature pulses during the secondary aftershock sequence of an M7.3 aftershock. The pulses are attributed to fluid advection by a flow through a zone of transiently increased permeability. Directly after the M7.3 earthquake, the fault zone was damaged and highly susceptible to further permeability enhancement, but ultimately heals within a month and becomes no longer as sensitive. Longer term healing was seen in the fault zone of the 2008 M7.9 Wenchuan earthquake.

The competition between damage and healing (or clogging and unclogging) results in dynamically controlled permeability, storage and hydraulic diffusivity. Recent measurements of in situ fault zone architecture at the 1-10 meter scale suggest that active fault zones often have hydraulic diffusivities near 10^{-2} m^2/s. This uniformity is true even within the damage zone of the San Andreas fault where permeability and storage increases balance each other to achieve this value of diffusivity over a ~400 m wide region. Fault zones may evolve to a preferred diffusivity in a dynamic equilibrium.