Harvard University -- Solid Earth Physics Seminar

Controls on the Earthquake Source and the Ongoing Controversy of Earthquake Self-Similarity

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4th Floor Faculty Lounge, Hoffman Laboratory, 20 Oxford St.

To investigate earthquake rupture dynamics, and which factors (e.g. normal stress, strain rate, fluids, rheology) govern the earthquake source and consequent ground motions, we need to study earthquakes over a wide range of magnitudes, from a diverse range of tectonic environments. The uncertainties and discrepancies between studies of smaller earthquakes are a frustration to all those who are interested in earthquake source and fault dynamics. There is controversy over whether the earthquake rupture process is self-similar and whether it varies with tectonic setting; different studies give different results. It is unclear whether this is due to differences between the earthquakes, or the analysis methods.

I use a range of empirical Green's function analyses using both direct and coda waves, to determine source parameters of earthquakes (M1-5) from California, NE USA, and also reservoir induced events from NE Brazil. There are differences between the results from the different methods, resulting from the different assumptions, and the limited frequency bandwidth of the available data. Both the low strain rate, intraplate sequences (NE USA and Brazil) have high stress drops, consistent with the hypothesis that fault healing leads to higher energy release earthquakes on slow moving faults.

To investigate the role of fluids in triggering earthquake swarms, I also compare reservoir-induced seismicity to swarms in southern California. High precision relocation of the reservoir-induced seismicity in Brazil reveals clear patterns of seismicity migration following annual changes in reservoir water level. These are used to calculate pore pressure diffusion rates averaging ~15 m/day, increasing to ~50 m/day during the peak seismicity. I compare these seismicity migration patterns and rates with well-located swarms of earthquakes in southern California and show that fluids are the likely cause of about half the migrating swarms.