

Solid Earth Physics Seminar, Harvard University

Thursday 2 Nov 2017, 1:30 pm, 4th Floor Faculty
Lounge, Hoffman Lab, Oxford Street

Bayesian Moment Tensor Inversion for Repeating Earthquakes – From Induced Seismicity to Pico-seismicity (Acoustic Emission)

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Abstract: We studied the source mechanisms of repeating earthquakes in multi-scales: from induced seismicity in oil/gas fields to pico-seismicity in the laboratory. A Bayesian source mechanism inversion method was used for the analysis of field and laboratory data. The seismicity that occurred in the oil/gas fields is probably induced by fluid injection and/or extraction, reactivating of the pre-existing faults. Double-couple dominant source mechanisms were obtained for the field data and the importance of the regional stress field and local fault networks in generating that micro-seismicity was observed.

Laboratory generated acoustic emissions (AEs) can be used to study different rupture processes (e.g., hydraulic fracturing, stick-slip) in a controllable way. We studied the rupture processes in a saw-cut Lucite and an intact Berea sandstone samples. Both samples were subjected to conventional triaxial loading. Ultrasonic acoustic emissions (AEs) were monitored with eight PZT sensors. For the saw-cut Lucite sample, two cycles of AEs were detected with the occurrence rate that decreased from the beginning to the end of each cycle, while the relative magnitudes increased. Correlation analysis indicated that these AEs were clustered into two groups – those with frequency content between 200-300kHz and a second group with frequency content between 10-50kHz. The high-frequency events, with almost identical waveforms, are from the sharp local asperities on the saw-cut plane. The locations of the low-frequency events show a slow slip process leading to the high-frequency events for each cycle. In this single experiment, there was a correlation of the proximity of the low-frequency events with the subsequent triggering of large high-frequency repeating events. For the failure experiment of the intact Berea sandstone sample, after the eventual fracture plane was formed in the sample, the location of the pico-events delineated the topography of the irregular fracture plane. The double-couple dominant source mechanism of these events indicated a slip fracture with the maximum differential stress in the vertical direction. In our laboratory experiments for saw-cut Lucite and intact Berea sandstone samples, we found that the locations of the pico-seismicity delineate fault planes and the moment tensor results reveal the detailed rupture processes and stress conditions.