An Experiment to Trigger a Moderate Earthquake on a Mid Ocean Transform Fault

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Increasing fluid pressure in the vicinity of faults has often be observed to induce small earthquakes. Recently, there have been many examples in the US and Europe of earthquakes associated with underground fluid pumping. Also, filling of water reservoirs often produces small earthquakes, and was apparently responsible for causing the larger 1967 Koyna, India (M6.5) and 1975 Oroville, California (M5.7) earthquakes. Induced seismicity is becoming an important science topic with broad societal impacts.
We are proposing an experiment to understand the initiation of earthquakes by inducing seismic events on a shallow fault with water injection. Increasing the fluid pressure near an active fault will reduce normal pressure on a fault and bring it closer to failure, according to the classic Coulomb failure criterion. A study to monitor the water pressure and subsequent triggered earthquakes can help answer some fundamental questions in seismology about the stress levels that cause earthquakes and the physical conditions that are necessary for a large earthquake to occur. By triggering a moderate earthquake we hope to investigate questions related to earthquake initiation and scaling.
1) What is the strength of faults during earthquakes?
2) Is there an observable earthquake precursory signal? Does it scale with the size of the earthquake?
3) What is the size of the stress perturbation needed to trigger seismicity relative to the strength of the fault?
4) Does the size of the pore pressure or fluid volume perturbation correlate with the size of the triggered earthquake?
Appropriate sites for such an experiment would be transform faults near mid-ocean ridges, such as Blanco on the Juan de Fuca Ridge and Quebrada, Gofar, or Discovery on the East Pacific Rise. In such settings, shallow moderate (M5 to M6) earthquakes occur at repeating intervals of 5 to 15 years. The hypocenters of strike-slip earthquakes on these faults are shallower than for onshore faults because of the high thermal gradient, and thus are more easily accessible by drilling to depths of a few kilometers. We would like to conduct a water injection experiment at one of these sites a few years before the expected earthquakes recurrence, to try to trigger an early occurrence of a moderate-sized event. In addition, earthquakes in this region are often preceded by foreshock sequences.
A 2 to 3 km deep borehole could be drilled into the hypocentral region of a moderate earthquake. Earthquakes along the transforms occur at shallow depth above the 600 ^{o}C isotherm at depths of about 2 to 5 km. Using riser drilling capabilities, water pressurized at various pressures from about 0.001 MPa (about 0.1 psi) to higher values, (possibly 1 MPa, 140 psi) would be pumped into the borehole in order to raise pore pressure in the region of the hypocenter. The upper value for the pumping pressure approaches the values of the static stress drops of the earthquakes.

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