Geophysical Research Abstracts
Vol. 18, EGU2016-5511-1, 2016
EGU General Assembly 2016

A Potential of Borehole Strainmeters for Continuous Monitoring of Stress Change Associated with Earthquakes

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The borehole strainmeter data, which often detect the crustal deformation signals associated with earthquake occurrence, were utilized to investigate earthquake-induced stress changes. Eight strainmeters installed in Anza, southern California, USA recorded sudden deformation signals caused by two earthquakes that occurred in 2010: M7.2 Baja California (BC) earthquake and M5.4 Southern California (SC) earthquake. The strainmeter data we compiled are noise-filtered, from which effects of earth tide, grout curing, and barometric pressure change have been eliminated and are thus deemed to represent tectonic deformation. In an attempt to calculate stress changes from what we observed from the strainmeter data, we derive a simple equation that relates the deformation to the stress change by assuming that the rock around the strainmeters is homogeneous, isotropic, and linear-elastic. The application of the equation to the strainmeter data enable us to observe the variations in the axes and the magnitudes of stress change with time during several hours before and after the earthquakes. Before the earthquakes, the axes of the maximum stress change in compression are predominantly N-S direction, which is subparallel to the compression axes of the two earthquakes' focal mechanism solutions. This may suggest that the strainmeter data captured pre-earthquake stress buildups that triggered the earthquakes. Upon the onset of earthquakes, the stress magnitudes in N-S direction tend to decrease, which may represent earthquake induced stress relief. The stress drops at the strainmeter site are evaluated at an order of 10^{-2} MPa for the BC earthquake and 10^{-3} MPa for the SC earthquake. These values of stress drops are two and three order of magnitude lower than those at the respective focal points. We interpret that the difference between the stress drops at the strainmeter site and the focal points may be due to stress dissipation. In order to verify this interpretation, we conduct Coulomb stress transfer models to estimate the stress drops using various earthquake parameters (earthquake magnitudes, fault length, and slip displacement), and the modelled transferred stress drops at the strainmeter site are estimated to be similar to (or an order of magnitude lower than) those determined from the strainmeter data. Our study demonstrates that there is a strong applicability of the strainmeter data for continuous stress monitoring with a special emphasis on earthquakes.