

Seismic Observations in the Repeated Water Injection Experiments at the Nojima fault

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We carried out repeated water-injection experiments in 1997 and 2000 at the Nojima Fault ruptured by the 1995 Mw6.9 Kobe earthquake [Nishigami et al., 2003, in this meeting]. In the experiments, we deployed temporary seismic networks during the experiments repeatedly. The main objects of the seismic observations are to detect changes of seismicity, that is whether induced seismicity occurred or not, and to clarify the mechanism of induced seismicity. The final object of the experiments is to understand a healing process of the Nojima fault with a temporal change of fault-zone permeability. In each experiment, we observed the increase of ultra-microseismicity ($M < -1.2$ to 1.0) at 2.5 - 4.5 km distances from the injection point and 4 - 7 days after the beginning of some water injections [e.g. Tadokoro et al., 2000 (for experiment in 1997); Nagai et al., 2001 (for experiment in 2000)]. Each increased seismicity in the experiments might be induced due to the water injections over thresholds for triggering earthquakes. In the southwest part of injection site, the hypocenters of induced earthquakes were located 1-km shallower than those of background earthquakes. We found that the b-values of induced seismicity were smaller than those of background seismicity. We computed coherencies of waveforms, observed by borehole seismometers in the DPRI 800-m-deep borehole and 1800-m-deep borehole, in each subset of earthquakes and estimated S-P time differences by the cross-spectrum analysis method. The results showed that there were large differences of observed waveforms between before and after the water injections. The earthquakes after the water injections had high coherencies and similar waveforms. From the S-P time differences, these earthquakes migrated away from the injection point. The migration suggested that the induced earthquakes were caused by the water migration. We observed ACROSS signal by borehole seismometers simultaneously [Ikuta et al., 2002], so we separated the observed waveform records into those of natural earthquakes and ACROSS signal components. We analyzed the earthquakes component by the cross-spectrum method again. The third water-injection experiment, including a temporary seismic observation, is going on in 2003 to confirm the differences between induced and background seismicity in these analysis. We will discuss the differences between induced and background seismicity and the mechanism of induced seismicity in repeated experiments.