Geophysical Invesitigation from Taiwan Chelungpu-fault Drilling Project (TCDP): Stress field and Anisotropy

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Abstract

TCDP drilled two boreholes penetrating the Chelungpu fault, where the large displacement was observed during the 1999 Chi-Chi, Taiwan, earthquake. A comprehensive geophysical log had been carried out through the hole to understand the geophysical status of the borehole. In borehole breakouts and drilling induced tensile fractures, the local variations in the direction of maximum horizontal stress (S_{HMax}) were observed at the depth of 1111 m, where the direction of N15°E was observed compared to the tectonic stress direction of N112°E. The simulation of reverse faulting stress regime reproduces the rotation phenomena as breakout directions varied with depth. The hydraulic fracturing experiments and density log help us to constrain the values of stress magnitude. Considering the influence of titling formations, Dipole Sonic Imager (DSI) shows that the fast polarization direction of shear wave is consistent with S_{HMAX} determined from borehole breakouts. Comparison on the seismic velocity anisotropy and borehole breakouts, the anomalies, which might be associated with the existence of slip zones, at the similar depth and stress direction were confirmed.

On the base of the geophysical information, the stress field before the Chi-Chi earthquake was estimated. Our results show that the magnitude of the maximum horizontal stress (S_{HMax}) changed from 45 MPa to 12 MPa, which is smaller than the value of S_{hmin} estimated from the logs near the fault. It suggests the exchanges in the maximum and minimum stress directions after the earthquake. Thus, the reverse regime before the earthquake had been changed to strike-slip regime. This result

agrees with the most of the strike-slip focal mechanisms of the aftershocks in the northern portion of the fault after the earthquake. For the state-of-the-art TCDP borehole seismometers installed in the borehole after drilling, the anisotropy behavior of the micro-earthquakes will be also examined to observe the possible difference in polarization crossing the fault zones to the comparison of the DSI log.