

Hydrological and chemical cross-hole communication test in Taiwan Chelungpu-fault Drilling Project

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Taiwan Chelungpu-fault Drilling Project drilled two research boreholes (Hole A and B; approximately 40 m of their distance) through the Chelungpu Fault in Da-Keng, which ruptured in the 1999 M_w 7.6 Chi-Chi earthquake, in 2004. A branched borehole was drilled from Hole B in 2005 (Hole C), and then both Hole A and Hole C were perforated at the depth of the fault zone. The depth of perforation is 1111 m in Hole A and 1137 m in Hole C. Between the two boreholes, Fluid Injection Test (FIT) was performed on from November 2006 to March 2007 to estimate permeability and to understand hydrological and chemical properties along Chelungpu fault. Water was injected from Hole C at constant pressure (4 MPa on November 2006 and January 2007, 3 and 5 MPa on March 2007). The arrival of injected water was monitored by seismometers, manometers, a Quadrupole Mass Spectrometry and chemical sensors at Hole A.

Stainless and Tygon^(R) tubes with 6 mm diameter were installed with seismometers in Hole A on June 2006 in order to collect permeated water directly along the fault at 1111 m. The flow rate of water through the stainless tube is 50 - 100 mL/min, which was enough for monitoring the water. Under the flow condition, approximate 3 - 5 hours are taken to come the water up from the fault to the ground surface. Because collected water through the tubes contained gas, the gas was separated from water in a column and then monitored by a Quadrupole Mass Spectrometry. Gas-free water was collected into a cylinder with chemical sensors to monitor pH, conductivity, turbidity, Oxidation Reduction Potential (ORP), Dissolved Oxygen (DO), salinity and temperature.

1st FIT on November 2006, tap water was used for injected water, which was characterized by high ORP (250 mV) and high DO (5.6 mg/L). Because well water at Hole A was characterized by low ORP (-350 - -150) and low DO (0.5 mg/L), the arrival of injected water can be found by rise of these values. In fact, the values of ORP and DO increased to -50 mV of ORP and 2 mg/L of DO 6 days after a one-day slug test. This suggests that the pass at depth communicates with two boreholes. 1st FIT was performed for approximately 100 hours from 22:00 on 7th to 8:30 on 12th November. As a result, the values of ORP and DO increased on 13th November, which is 6 days after starting 1st FIT as well as in the previous slug test. Turbidity increased on 15th November, and then water flooded at Hole A on 17th November. This suggests that the permeability is 10^{-16} m² assuming that the width of a permeable zone is 1 m by the preliminary estimation of the permeability based on the model of Kitagawa et al. (2002).

We present results of gas measurement with chemical monitoring during FIT. In addition, we will report the results of chemical monitoring in 2nd and 3rd FIT on January and March 2007.