Estimation of permeability using strain changes due to the water injection experiments

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Three boreholes at 500 m, 800 m and 1800 m depths were drilled at Toshima (34.552N, 134.949E) on the northwestern Awaji Island. The Toshima station is located about 500 meters southeast of the Nojima fault. Water injection experiments based on a scientific drilling program were performed in February - March 1997 and January - March 2000, in order to investigate geophysical characteristics of crustal movements due to water injection into the 1800 m borehole in the fault zone. A multi-component borehole instrument was installed at the bottom of the 800 m borehole located 50 m south-southwest of the 1800 m borehole. The instrument can observe strain changes in the directions of N21W-S21E, N81E-S81W and N39E-S39W. Mukai et al.(2001) calculated strain changes due to water injection using a diffusion equation, although the predicted strain changes did not agree with a part of the observed strain changes. In this study, we revised a boundary condition for a diffusion equation and predicted strain changes due to water injection. The strain changes predicted on a revised boundary condition agreed with the observed strain changes.

Three components of strain showed contractions during the water injection. It is considered that an ascendance of pore pressure due to water injection caused elastic deformation of the crust around the 800 m borehole. We calculated time changes of pore pressure using a diffusion equation and predicted strain changes due to pore pressure at the 800 m borehole. In this calculation, we assumed that pore pressure was 0 Pa on the ground and groundwater could not penetrate through the Nojima fault. Strain changes due to water injection depend on a hydraulic diffusivity and a yield coefficient in the crust.

We determined a hydraulic diffusivity and a yield coefficient in the crust using the strain changes due to one water injection experiment in 1997 and three experiments in 2000. Water was injected for 4 days or more in those experiments. Hydraulic diffusivities were determined to be 0.7 m2/s in 1997 and 0.2 - 0.9 m2/s in 2000. There exists no large discrepancy between the hydraulic diffusivity in 1997 and those in 2000, although it is considered that fractures in the fault zone would be closed by the stress and permeability in the crust would be reduced.

The scientific drilling program is a co-operative program of a university consortium led by the Disaster Prevention Research Institute of Kyoto University. This program is planned and managed through the great efforts of Prof. M.Ando and DPRI stuff. We offer our heartfelt thanks for their work.