In-situ tracer experiments for granitic rock mass

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For safety assessment for geological disposal of high-level radioactive wastes, it is very important to estimate transport properties of host rock accurately. Therefore the authors have developed an apparatus for in-situ tracer test and the method to evaluate transport properties from the results of tracer tests. Tracer tests were conducted with the testing apparatus at an experimental site in granite area in Japan.

The experimental site was a horizontal gallery at -300 m Stage in the Mizunami Underground Research Laboratory of Japan Atomic Energy Agency (JAEA). Tracer tests were conducted at two boreholes, 12MI31 and 13MI37, excavated from the tunnel wall. From the observation of borehole walls with a borehole TV camera, the response of pore water pressure at 12MI31 during excavation and hydraulic test of 13MI37, the fracture intersecting at 21.90 mabh (meter along the borehole) with 12MI31 is probably identical with the one at 23.14 mabh with 13MI37. The distance between the boreholes was 2.95 metres. According to the prior single-hole hydraulic tests, the transmissivity of the target fracture was 6.9e-8 to 1.1e-6 m^2/sec. Fracture filling materials such as chlorite, clay and pyrite were observed in rock core samples.

Single-hole tracer test is a test where injection and recovery of tracers was conducted at the same section of a single borehole. At first groundwater sampled at the test site was injected into a borehole. After the flow field in the fracture reached a steady state, tracer solution was injected into the borehole. Subsequently groundwater was injected into the borehole as chaser. Finally pumping was conducted at the borehole and tracers were recovered.

Dipole tests were conducted as cross-hole tracer tests. At first sampled groundwater was injected into a borehole and pumping was conducted at another borehole. After the flow field reached a steady state, tracer solution was injected into a borehole and the tracers were recovered at the other borehole. Injection rate was set at one fifth or one tenth of pumping rate to attain high recovery rate.

Fluorescent dyes, Uranine, Amino-G acid, deuterium and iodine as non-sorbing tracers and rubidium and barium as sorbing tracers were used. Water samples were taken from the pumped water with fraction collector and analyzed in a laboratory. Concentration of uranine was measured with online sensors.

During single-hole tracer tests, in the case where pumping was started just after injection of chaser ended, recovery rates of non-sorbing and sorbing tracers were 80 to 90 percent and 70 to 80 percent, respectively. By contrast, in the case where pumping was started some time after injection of chaser ended, recovery rates were decreased from the influence of the background groundwater flow. In both cases, peak concentrations of sorbing tracers were lower than ones of non-sorbing tracers.

During crosshole tracer tests, the recovery rates of non-sorbing tracers were 54 to 63 percent at 10 hours after the tests started in consequence of the background groundwater flow. The recovery rates of adsorptive rubidium were 24 to 25 percent after 30 hours. Compared to the non-sorbing tracers, decay and time lag of peak concentration were observed from the influence of adsorption on rock mass. The recovery rates of more strongly adsorptive barium were only 5 percent after 30 hours. Concentration of barium at the pumping borehole was nearly equal to the background concentration throughout the testing time and no significant breakthrough curves could be obtained. Fracture aperture, dispersion length and distribution coefficients on rock matrix will be evaluated through numerical simulations on the basis of breakthrough curves.

This study was commissioned by the Agency for Natural Resources and Energy in the Ministry of Economy, Trade and Industry. The tracer tests were conducted as a part of a collaborative research with JAEA.

Keywords: tracer test, granite, fracture