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Characterization of mass transport based on in-situ crosshole tracer tests in a sedimentary rock

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For performance assessing the geological disposal of high-level radioactive waste, it is important to appropriately understand characteristics of mass transport into the hostrock as natural barrier. Therefore, it is need to obtain various parameters contributing for advection, dispersion, and diffusion into the hostrock by carrying out in-situ tracer tests.

On the Horonobe Underground Research Laboratory Project by Japan Atomic Energy Agency in the Horonobe area, northern Hokkaido, underground facilities have been constructed. As of Jan. 2012, the Ventilation Shaft, the East Access Shaft and the West Access Shaft have been drilled up to the depth of about 345 m, 310 m and 47 m respectively. And the drifts, connecting the shafts, at 140 m and 250 m in the depth have been excavated. In this study, in-situ crosshole tracer tests were carried out at the 250 m drift to confirm applicability of the in-situ crosshole tracer test equipment and establish methodologies of the in-situ tracer test at the sedimentary hostrock such as the Horonobe area.

The test location is in 250 m Niche off the Ventilation Shaft No.1. From the bottom of this niche, 3 boreholes were drilled (direction: N45 degrees E, dip: 60 degrees downward, diameter: 106 mm, length: about 30 m, arrangement of boreholes: regular triangular prism shape, distance between boreholes: 1m). And then, core observation, physical and fluid loggings and in-situ hydraulic tests were carried out. The in-situ tracer test is implemented by using fractures (T: 10^{-8} to 10^{-6} m^2/sec) extracted based on results of these tests and geological judgments.

Tracers used in this study are Uranine, Deuterium, Anion (Iodine, Bromine and etc.), Cation (Cesium, Strontium and etc.), and rare-earth elements (Europium and etc.) which are stable isotopes. The equipment is composed of rods and packers, and has a test interval of 15 cm length. In addition, for in-situ on-line fluorometric analysis by optical fiber system, flow cells are installed into injection and withdrawal lines in test intervals respectively. Dipole tracer test was implemented, and withdrawal water samples were taken by a fraction collector. Without the on-line analysis, a spectrofluoro-photometer for Uranine, an absorption spectrophotometer for Deuterium, and an ICP-MS or Ion chromatographer for other tracers have used to analyze concentration of tracers.

Results of dipole tracer tests (injection flow rate: 60mL/min., extraction flow rate: 60mL/min.) repeatedly executed showed that the recovered tracer is 20 to 25% (max. 52%), peak arrival time by the on-line analysis is 800 to 900 sec., one by the water sampling analysis is 1400 to 1500 sec., and the first detection time by the on-line analysis is about 550 sec., one by the water sampling analysis is about 1000 sec. after tracer injection beginning. Execution of tests by various dipole ratios had not influenced values of the recovered tracer. Accordingly, it is guessed that the direction from injection interval to extraction one crosses the background flow direction at right or high angles. Because peak arrival times of runs by using Uranine and Deuterium are almost corresponding, it has been clear that Uranine functions as non-sorbing tracer on these conditions at the Horonobe URL.

On the in-situ crosshole tracer tests in this study, from results of Uranine and Deuterium measurement, the applicability of the in-situ crosshole tracer test equipment and the approvability of the tests had been confirmed. Also, it had been confirmed that the test methods including countermeasures against degas from groundwater is effective. The analyses of sorbing tracers have been executed, and then, it is planed that characteristics of mass transport are evaluated based on that analytical result. Achievement of this study will be reflected in the next in-situ tracer experiment which will be carried out at drifts of the Horonobe URL at 350 m in the depth.