Simulations of In-situ Tracer Tests at a Single Borehole With a Wall Having Locally Variable Hydraulic Property

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1. Introduction

When disposal tunnels or deposition holes of a deep geological repository for high-level wastes are excavated, it can be happen to damage walls of the tunnels or holes. It degrades resistance of groundwater flow and radionuclide transport at the near-field. In this study, numerical simulations for in-situ tracer tests with a double chamber (dipole) structure in single borehole was conducted in order to identify effects by the damaged structures and design effective field tests.

2. Method

Using field data obtained from boreholes at Research Gallery #6 in KURT, numerical simulations of tracer tests in a single borehole were conducted. A domain for numerical modeling was constructed and hydraulic properties of each layer were assigned according to field tests performed at the boreholes. A local structure with variable hydraulic conductivity, which represents damaged structures by excavation, was assumed to be located between the upper and lower chamber.

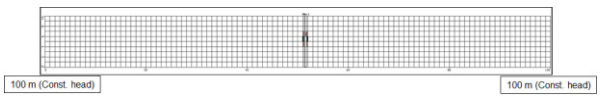

Fig. 1. Discretized modeling domain.

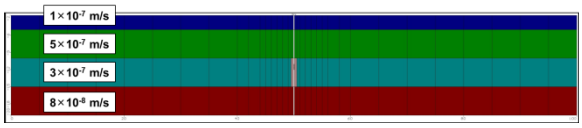

Fig. 2. Distribution of Hydraulic conductivity in the modeling domain.

3. Results

3.1 Transport of Tracer

When a local structure with a variable hydraulic property in a borehole wall was assumed, short-cut flow through the structure occurred during dipole flow tests [1] (Fig. 3). Tracers injected in the lower chamber moved from the lower to the upper chambers, along the groundwater flow field (Fig. 4). Some of tracers transported along the local structures.

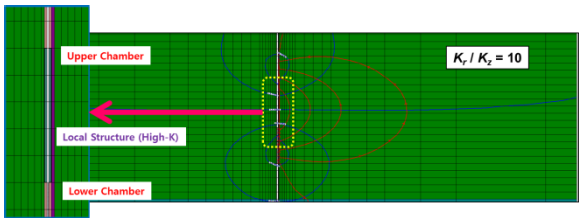

Fig. 3. Groundwater flow path by local structure.

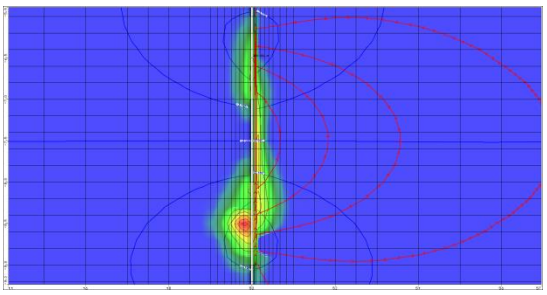

Fig. 4. Tracer transport in a dipole flow test.

3.2 Effect of Local Hydraulic Property

In simulations of tracer tests using dipole flow tests, the local structure behaved as a short-cut of groundwater flow from the lower to the upper chambers when the local structure had more hydraulic conductivity than the surrounding hydrogeological layer. From the simulation results, if the hydraulic conductivity of the local structure was larger than a certain level, 20 times that of the surrounding layer in this study, most of tracers moved through the local structure and the peak time of tracer concentration became shorter (Fig. 5).

4. Conclusions

To investigate an effect of local structure on a borehole wall with variable hydraulic conductivity, numerical simulations of tracer tests using dipole flow tests were conducted. The hydraulic conductivity had influence on a peak time of a tracer breakthrough curve. So, analysis of tracer breakthrough curves may give an implication of local structures caused by excavation. The results of this study can be applied to design effective in-situ test of a dipole flow tracer test.

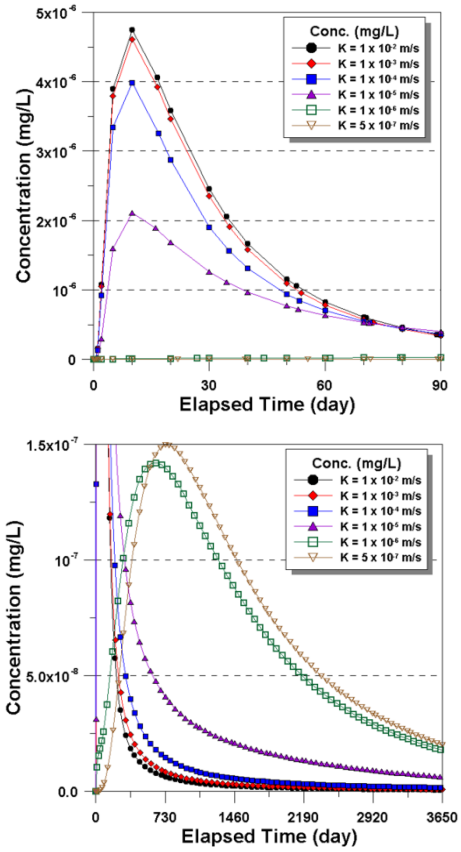

Fig. 5. Breakthrough curves of tracer concentrations for each case of hydraulic conductivities at the local structure.

ACKNOWLEDGEMENT

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REFERENCES

[1] Z.J. Kabala, “The dipole-flow test: a new single-borehole tests for aquifer characterization“, Water Resources Research, 29(1), 99–107 (1993).