Project Subjects

Low level Radio Active Waste Disposal

Background and Objective

A sub-surface disposal site constructed about 50～100 m underground is planned for low-level radioactive waste generated from the driving and decommissioning of a nuclear plant. In the safety evaluation of the sub-surface disposal facilities with the pit disposal facilities, a long-term evaluation is needed on the engineered barrier.

In this project, we studied swelling pressure (which is caused by infiltration of water) and hydraulic conductivity of compacted bentonite. And we studied the method of estimation of residence time of groundwater by using recharge temperature for the natural barrier.

Main results

1. Evaluation of swelling pressure of bentonite as an engineered barrier

Compacted bentonite and mixtures of bentonite/sand will be used as an engineered barrier for facilities of sub-surface disposal. However, results of laboratory tests of swelling pressure often vary considerably even if index parameter, such as effective clay density, is constant. Thus, in this study, effects of test conditions on measured swelling pressure were investigated by numerical simulation using an originally developed swelling model of unsaturated bentonite. Consequently, it was revealed that scattering of measured swelling pressure is mostly attributable to rigidity of swelling pressure test apparatuses and height of specimens (See Fig. 1) [N10015].

2. Evaluation of the low-permeability for the alteration behaviors of bentonite-sand mixture

Bentonite-sand mixture that will be used in an engineered barrier of the radioactive waste disposal facility is required to have low-permeability for the inhibition of migration of radionuclide. The low-permeability of bentonite-sand mixture would be gradually changed due to the interaction with alkaline solution from cementitious materials. Therefore, it is necessary to understand the alteration behaviors of bentonite-sand mixture for assessing the long-term safety of the radioactive waste disposal. In present study, permeability tests were carried out using compacted bentonite-sand mixture with initial dry density of 1.55 Mg/m^3 and alkaline solutions at 50 ℃ for about two years to estimate the alteration behavior and the change in the permeability. As a result, the permeability of bentonite-sand mixture not only increased with alteration but also occasionally decreased due to the precipitation of the secondary mineral (Fig. 2) [N10037].

3. The method of estimation of residence time of groundwater by using recharge temperature

Understanding of flowage of groundwater is required for safety assessment of radioactive waste disposal because radionuclides migrate with flow of groundwater. Residence time of groundwater estimated by using ^{14}C or ^{4}He can provide useful information on it. However, correct estimation of residence time is disturbed by geochemical reactions or ^{4}He flux coming from outside of aquifer. The method to estimate residence time of groundwater by using recharge temperature was proposed, and adequacy of this method was confirmed by using obtained field data (Fig. 3, Fig. 4) [N10036].

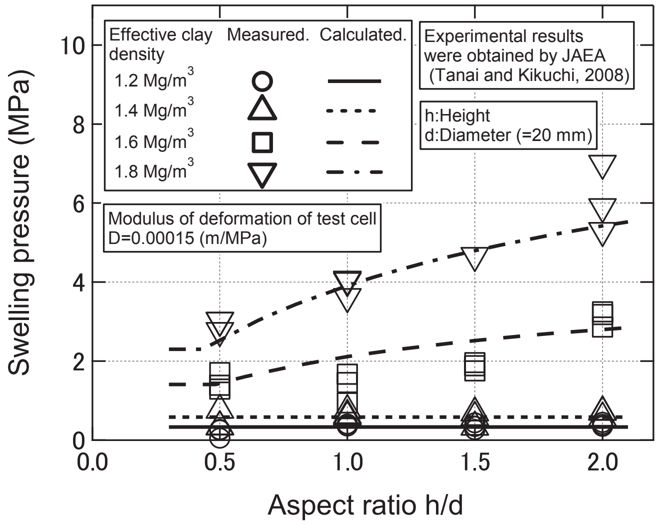

Fig. 1 Effect of aspect ratio of specimens on swelling pressure of compacted bentonite

According to the experimental results, swelling pressure of the specimens of 1.6 or 1.8 Mg/m³ is affected by aspect ratio or height of the specimens. Considering modulus of deformation, the experimental results can be simulated by the proposed method with accuracy.

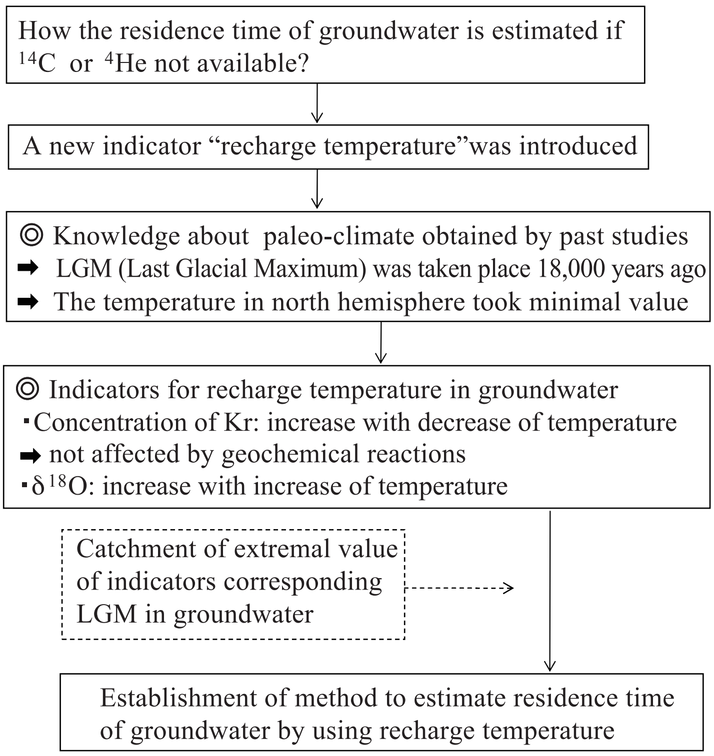

Fig. 3 Estimation of residence time of groundwater by using recharge temperature

The position of groundwater recharged 18,000 ago can be assumed by this method.

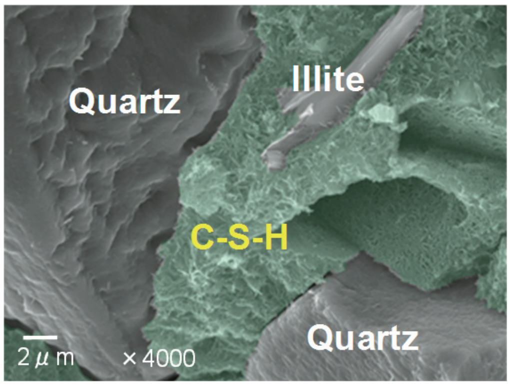

Fig. 2 (a) SEM image of bentonite-sand mixture after the permeability test used $Ca(OH)_2$ solution

Calcium-silicate-hydrate (C-S-H) was precipitated to the pore space of bentonite-sand mixture as a secondary mineral.

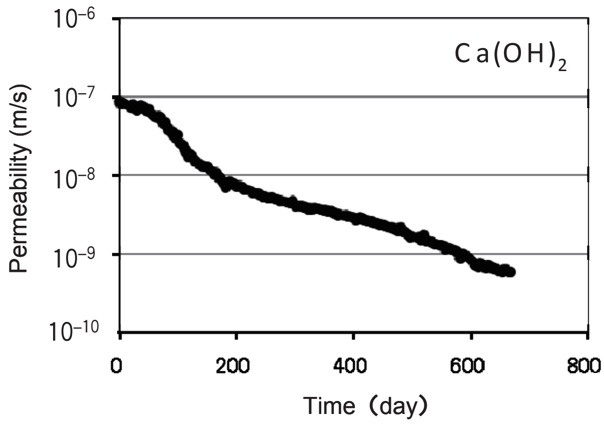

Fig. 2 (b) Change in permeability of bentonite-sand mixture during the permeability test used $Ca(OH)_2$ solution

The permeability of bentonite-sand mixture was continuously decreased by more than two orders of magnitude due to filling of the pore space of bentonite-sand mixture by the precipitation of C-S-H.

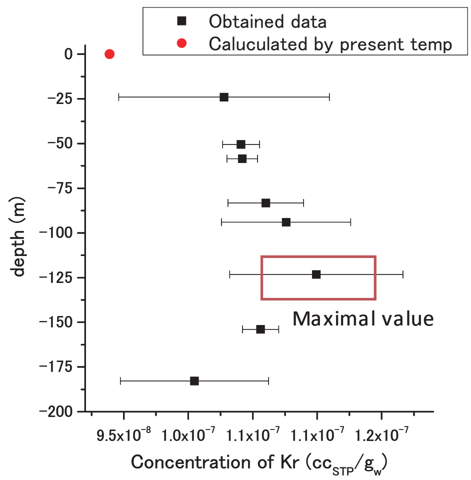

Fig. 4 The relationships between depth versus concentration of Kr

Concentration of Kr showed maximal value at a depth of 120m indicating groundwater at 120m depth recharged at 18,000 years ago.