Priority Subjects — **Establishment of Optimal Risk Management**

Development and Systematization of Long-term Safety Assessment Technologies for Radioactive Waste Disposal

Background and Objective

As storage capacity of the low-level radioactive waste (LLW) in nuclear plants is growing tight, the licensing safety of pit and sub-surface disposal requires review based on a planned schedule. Moreover, in regards to high-level radioactive waste (HLW), the Japanese government is engaged in various efforts such as investigating direct disposal, securing safety in the future and the systemization of site selection.

In this project, R&D of LLW disposal aims to develop methods of gas migration through engineered barriers and to estimate alteration of bedrock by concrete covering in order to build a reliable technology. R&D of HLW disposal aims to confirm the applicability of the methodology for the investigation and assessment of properties of geological environment utilized in site investigation for geological disposal.

Main results

1 Establishment of an evaluation method of gas migration through compacted bentonite

Compacted bentonite and Ca-bentonite mixture, which will be used as engineered barriers for inhibiting migration of radioactive nuclides, are so fine that the hydrogen gas, which is generated mainly by the chemical interaction between aluminum and the alkaline component of cement, cannot penetrate the barriers easily. Thus gas migration tests together with their numerical simulation were conducted using CRIEPI's original code 'GasDeform2D' based on the model of two phase flow through deformable porous media. As a result, it was revealed that the test results, such as stress change and volume of discharged gas, can be reproduced with precision by the numerical simulation (Fig. 1) (N23).

2 Analytical estimation on weathering and alkaline alteration of bedrock wall

Block shape samples of neogene period rock with and without concrete covering were collected from the wall of gallery five years from excavation, then the states of weathering and alkaline alteration were analyzed. Rock without concrete covering showed an oxidization effect with browning to a depth of as much as 1.5 to 3 cm at the surface area. Rock sprayed with concrete showed a rise in Ca concentration and pH, to approximately pH10, up to 20 cm depth beneath the concrete. The amorphous component of rock has reacted with alkaline leachate from concrete to form calcium silicate phase as secondary product, then the pore of rock was filled with the product (Fig. 2).

3 Survey methods considering the reduction of uncertainty in obtaining properties of the deep geological environment to conduct site investigation for geological disposal*1

The Yokosuka Demonstration and Validation project using the Yokosuka CRIEPI test site was conducted to confirm the applicability of the basic methodology of the investigation and assessment regarding properties of geological environment to conduct site investigation for geological disposal. The applicability of important elemental technologies such as a borehole survey and a geophysical prospecting for obtaining information concerning the deep geological environment from the surface has been confirmed through this project [1]. For the purpose of reducing the uncertainty in obtaining the properties of the geological environment, a series of additional surveys (a new borehole survey and crosshole tests between the new and the existing boreholes) was conducted. The contribution and applicability of these additional surveys to improving the degree of understanding of the geological environment was confirmed based on the results of these surveys (Fig. 3).

*1 This research was conducted as a cooperative research project with the Nuclear Waste Management Organization of Japan (NUMO).

[1] H. Kondo et al., J. Geol, Soc, Japan, Vol. 120, No. 12, 447-471, 2014.

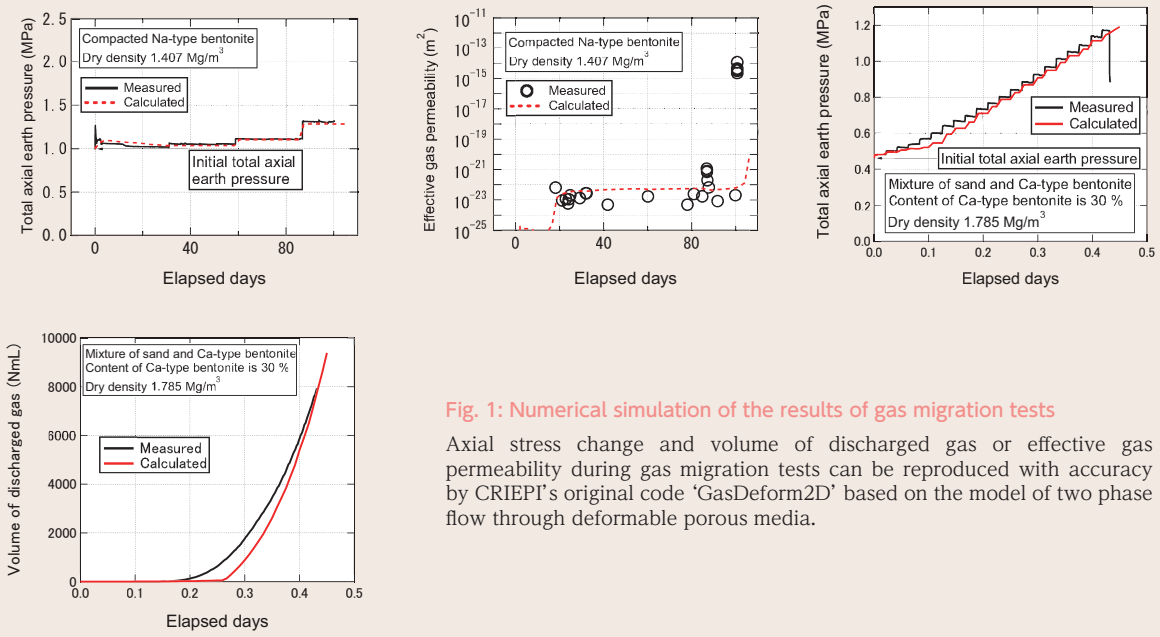

Fig. 1: Numerical simulation of the results of gas migration tests

Axial stress change and volume of discharged gas or effective gas permeability during gas migration tests can be reproduced with accuracy by CRIEPI's original code 'GasDeform2D' based on the model of two phase flow through deformable porous media.

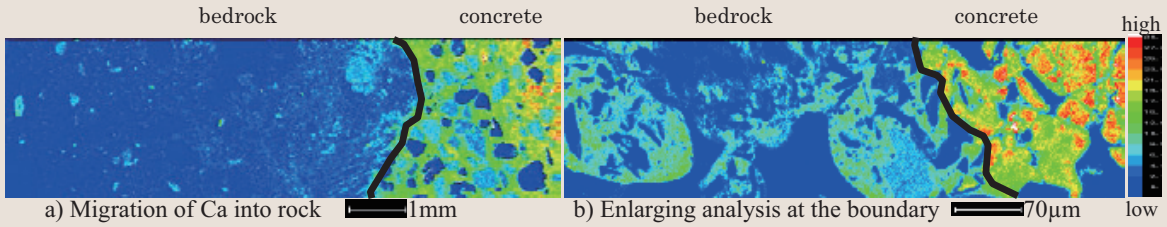

Fig. 2: Ca distribution in bedrock beneath concrete

Ca and OH ion leached from concrete have migrated into the pore of rock, then reacted to form calcium silicate phase at the surface of volcanic glass and clay grain with obtaining a compaction effect in the rock (yellow to green colored contour area in the figures). The compaction effect with dilution effect from ground water derives a depressing effect on the migration of alkali ions.

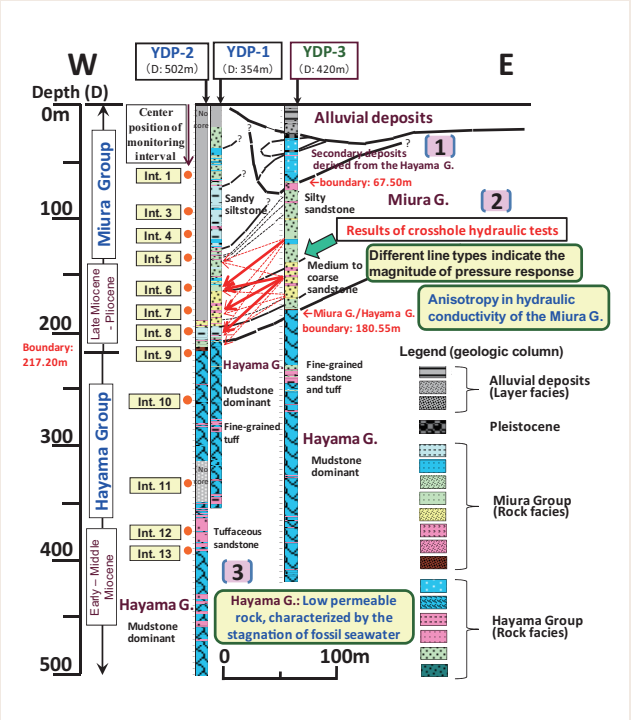

Fig. 3: Outline of the results of borehole surveys and crosshole tests along the cross-section passing through the boreholes of YDP-3 and YDP-2 in the Yokosuka CRIEPI area

A series of additional surveys (a new borehole survey at YDP-3 and crosshole tests between boreholes of YDP-3 and YDP-2) was conducted in the Yokosuka Demonstration and Validation project using the Yokosuka CRIEPI test site. Through these surveys, 1) the distribution and characteristics of the base rock geology under the alluvial deposits, 2) the lateral continuity in geology and the anisotropy in hydraulic conductivity of the Miura Group, 3) the low permeable rock properties of the Hayama Group having stagnant fossil seawater, were revealed with higher reliability than the previous stage surveys (the borehole surveys of YDP-1 and 2). The contribution and applicability of these additional surveys to improving the degree of understanding of the geological environment was confirmed based on the results of these surveys.