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An approach for predicting the effective diffusion coefficient of rock specimens under high confining pressure conditions

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Safety assessment of facilities associated with geological disposal of various kinds of hazardous wastes, including radioactive nuclear waste, is generally performed by means of mass transport simulations combined with uncertainty and sensitivity analyses. Transport of contaminants, such as radionuclides, through an engineered and natural barrier system is principally controlled by the processes of advection, dispersion, sorption, and chain decay. When groundwater flows are very slow, typically as those in geological formations that are expected to be functioned as the natural barriers for retarding the transport of radionuclides, dispersion may become to be equivalent to diffusion. The determination of both hydraulic and diffusive transport properties of geologic media is, therefore, of fundamental importance for the safety assessment.

Geologic media are known to be heterogeneous and anisotropic, and their hydraulic and diffusive transport properties are sensitive to the stress conditions. Although the effects of stress conditions on hydraulic properties of rock specimens are relatively easier to be determined and/or assessed through laboratory permeability tests, diffusion tests on rock specimens under high confining and pore pressure conditions are technically impractical, and most laboratory diffusion tests have been performed only under atmospheric conditions.

Since the hydraulic and diffusive properties of a rock specimen can be functions of its porosity, a possible way to assess the effective diffusion coefficient of a rock specimen under high confining pressure conditions is to predict indirectly through the results of laboratory permeability tests. In this presentation, a set of results related to the effects of effective confining pressure on permeabilities of Inada granite, Shirahara sandstone and Grimsel granite is presented. The results are then discussed theoretically with respect to the changes in porosities within rock specimens due to the increase of confining pressure. Prediction of changes in effective diffusion coefficient due to the increase of confining pressure is illustrated based on the results of laboratory permeability tests, the relationships between the porosities and permeabilities as well as an empirical equation describing the relationship between the porosity and effective diffusion coefficient.