

Determining the transport properties of geological materials in the laboratory: Theories and practices

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Safety assessment of facilities associated with geological disposal of different 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 mainly controlled by advection, dispersion, sorption, and chain decay. Determination of both hydraulic and diffusive transport properties of geologic media is, therefore, of fundamental importance for safety assessment.

Although geological media can be fractured and heterogeneous, and tests can also be performed in situ, laboratory testing of representative specimens has been a very useful and widely adopted approach for characterizing the necessary properties of geological materials, i.e., the necessary input parameters for mass transport simulations. Compared to the in situ tests, laboratory experiments are relatively cost-effective, and test conditions can be well controlled. This feature of laboratory experiments facilitates investigating the effects of some important factors on a specific property, such as the effects of stress condition on hydraulic and/or diffusive properties, of a geological material.

In this study, we present a systematic consideration for determining both the hydraulic and diffusive transport properties of low-permeability geological materials in the laboratory. Rigorous theoretical solutions to major laboratory permeability and diffusion tests are introduced. Typical concepts for designing a versatile laboratory permeability test system and a small-sized through-diffusion test apparatus are illustrated. The effectiveness of the theories and system design concepts for both permeability and diffusion tests are demonstrated with representative experimental results.