Development of A High-Precision Versatile Automated Laboratory System for Testing Low-Permeability Rocks

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The hydraulic properties of low-permeability geologic media are relevant to numerous geologic processes, such as over-thrusting, earth-quake occurrence, and the generation of abnormal subsurface fluid pressures. The transport properties of such materials are also of fundamental importance for the successful design and/or assessment of facilities associated with many kinds of underground exploitation, such as natural gas production in tight gas sands, underground disposal of radioactive nuclear wastes, and storage of oil, liquefied petroleum gas, natural gas and compressed air.

The rock in deep earth is subjected to both high confining and pore pressures due to the gravitational and structural forces and ground water pressure. In natural groundwater systems, especially in deep ground, the water flow is laminar and the hydraulic gradients are generally less than unity and may be as small as 10E-4 in flat-lying areas. In constructed hydraulic barriers, hydraulic gradients are unlikely to exceed 10 to 20 in most cases. To accurately determine the hydraulic properties of rock specimens in the laboratory, it is necessary to simulate such in situ conditions, specifically, the high confining and pore pressures and low hydraulic gradients.

In this study, we have developed a new and versatile laboratory system that can implement the constant-head, constant flow-rate and transient-pulse tests while simultaneously subjecting a specimen to high confining and pore pressures, thereby simulating in situ conditions at great depths. The effectiveness of this system is demonstrated using experimental data derived from Shirahama sandstone and Inada granite, two rock types widely known in Japan. To put this new laboratory system to practical use, further improvements including the automation of controlling test condition, recording test results and analyzing test results have also been performed. In this presentation, we introduce this newly improved high-precision, versatile and automated laboratory system for testing low-permeability geologic materials.