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Characterization of Preferential Flow Path in Fractured Rock Using Heat-pulse Flowmeter

Tsai-Ping Lee (1), Ming-Hsuan Lin (2), Po-Yu Chuang (2), and Yeeping Chia (2)
(1) Institute of Nuclear Energy Research, Taoyuan, Taiwan(f91224208@ntu.edu.tw), (2) Department of Geosciences, National Taiwan University, Taipei, Taiwan

Rigorous thinking on how to dispose radioactive wastes safely is essential to mankind and living environment. The concepts of multiple barriers and deep geologic disposal remain the preferred option to retard the radionuclide migration in most countries. However, the investigation of preferential groundwater flow path in a fractured rock is a challenge to the characterization of potential disposal site. Heat-pulse flowmeter is a developing logging tool for measuring the vertical flow velocity in a borehole under a constant pumping or injection rate and provides a promising direct measurement method for determining the vertical distribution of hydraulic conductivity of formation. As heat-pulse flowmeter is a potential technique to measure low-velocity borehole flow, we adopted it to test the feasibility of detecting permeable fractures. Besides, a new magnetic tracer made by nano-iron particles is developed to identify the possible flow path precisely and to verify the permeable section detected by the heat-pulse flowmeter. The magnetic tracer was received by a magnet array and can also be detected by a sensor of electric conductivity. The test site is located in the Heshe of Taiwan. Eight wells were established in a fractured sandy siltstone for characterizing the fracture network. The test wells are 25 to 45 m depth and opened ranging from 15 to 45 m. Prior to the heat-pulse flowmeter measurement, we also performed surface geological investigation, pumping test, geophysical logging, and salt tracer test. Field measurements using heat-pulse flowmeter were then conducted at a constant pumping rate. The measurement interval is 50 to 100 cm in depth but improved to 25 cm near the relatively permeable zone. Based on the results of heat-pulse flowmeter, several permeable sections were identified. The magnetic tracer tests were then conducted to verify the potential preferential flow pathway between adjacent wells. Test results indicated that water flow in borehole is produced primarily from a few fractures. However, the large aperture and high density of fractures did not certainly correlate well to the permeable section. Integration of heat-pulse flowmeter measurement with other in-situ tests, it is possible to identify the exact location of the highly permeable fractures.