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Analysis of flow pathway in a potential granitic host rock using Taiwan's K-area reference case data

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For low-permeability potential host rocks such as granite, the interconnected discrete fracture network (DFN) forms the fast preferential pathways for groundwater. Finding such pathways in fractured rocks thus becomes a vital technique for the final disposal of spent nuclear fuel. A series of techniques were developed in this study, including fracture data analysis, numerical simulation of DFN, upscaling of DFN into equivalent continuous porous medium (ECPM) and finally numerical simulation of brine in the upscaled ECPM.

Investigation data were taken from Taiwan's K-area reference case Table II. Research activities implemented in K-area were for technology development purposes only. In other words, K-area has not been considered as a potential disposal site. Table II summaries the field data from preliminary investigations for the fundamental properties of the potential host rock. Data in Table II include fracture traces from outcrop mapping, borehole image fracture data and large-scale lineament. These data allowed us to analyze fracture intensity, fracture orientation and fracture size. At this preliminary investigation stage, it was decided to use empirical relationships between fracture size to fracture transmissivity as well as to fracture aperture. The deterministic major water-conducting fractures (MWCFs) in K-area have confirmed to be correlated to the Taiwushan fault and its branch fault. Besides the deterministic MWCFs, stochastic fractures were simulated by a DFN recipe that was modified from the original one in Table II. Numerical simulation of DFN and the calculation of its connected DFN were implemented by the commercial software FracMan V7.5. We have developed an upscaling code based on a volume-averaging method for converting a connected DFN into an ECPM. This upscaling code was successfully verified by benchmark examples. The upscaled ECPM is represented by a second-order, heterogeneous and anisotropic permeability tensor field. We also modified the EOS7 module from TOUGH2 such that it is able to make use of the upscaled permeability field for the simulation of brine distribution in K-area. For all boundary conditions, the MWCFs form the preferential pathway for pressure diffusion and brine migration. Furthermore, the brine mass flux from MWCFs to nearby dyke and rock matrix is order of magnitude smaller than that across MWCFs. In other words, the hydrogeologic significance of MWCFs can be easily identified in the upscaled ECPM. In conclusion, combining upscaling and a continuum type flow simulator is a powerful tool for analyzing flow pathways in a potential host rock.