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Multiscale Fracture Analysis and Regional Groundwater Flow Estimation of a Granitic Body: a Case Study of Tono Area

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Clarifying the hydraulic properties of geologic media is an important problem that is common to various fields in the geosciences. Especially, in the field of geological disposal of radioactive waste which utilizes the storage characteristics of the geologic structure, the estimation of groundwater flow system of the target area is essential for the safety evaluation. Groundwater flow in the hard rock-mass area is strongly affected by fractures and/or weathering and alternation zone. It is important to estimate the spatial distribution of fractures, weathering and alternation zone in regional scale, after clarifying the relationship between them and permeability of rocks.

Tono area (Gifu prefecture), situated in Central Japan, was selected for a case study of such hydraulic characterization. The study area is overlain the late Cretaceous Toki granite that is the basement rock. We applied GEOFRAC (Koike *et al*., 2012) which is a geostatistical method that simulates regional fracture distribution by incorporating the directions (strikes and dips) of the sampled fracture data. In addition, a permeability test and property analyses of microcracks using rock-core samples were carried out. From these results, the variation of permeability depending on degrees of weathering and alternation of rock-core samples was clarified. The other important feature was that permeability increased toward the fracture plane and along the dominant directions of the cracks. These directions corresponded with the predominant directions obtained using the 3D simulated fractures with GEOFRAC. The existence of the similar trend of fracture directions at different scales; mm to km scale, which is caused by regional stress field, faulting and so on, was also detected.

The permeability dataset obtained from the hydraulic tests of borehole investigation was observed to correlate positively with the size of the simulated fractures. By integrating the hydraulic conductivity calculated based on that positive correlation with the results of GEOFRAC, a 3D permeability model covering the study area of 12 km (E-W) by 8 km (N-S) with a depth range of 1.5 km was constructed using sequential Gaussian simulation. Finally, MODFLOW, one of the computing modular using 3D finite-difference flow model, was applied to this model to estimate the regional groundwater flow system. The result clarified the anisotropic behavior of flows near faults, which was in agreement with the configuration in the continuous simulated fractures.

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References

Koike, K., Liu, C., Sanga, T. (2012): Incorporation of fracture directions into 3D geostatistical methods for a rock fracture system, *Environmental Earth Sciences*, vol. 66, no. 5, pp. 1403-1414.

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