Three Dimensional Channeling Flow in a Network of Rock Fractures with Heterogeneous Aperture Distributions

Noriaki Watanabe[1]; Takuya Ishibashi[1]; Nobuo Hirano[1]; Atsushi Okamoto[2]; Noriyoshi Tsuchiya[1]

[1] Environmental Studies, Tohoku Univ.; [2] Tohoku Univ.

Accurate prediction of fluid migration within the Earth's crust is required for various engineering applications such as the geologic disposal of high-level nuclear wastes, and oil/gas exploration. Understanding crustal fluid migration is also essential in the prediction of important natural phenomena including earthquakes and volcanism. Fractures in subsurface rocks behave as major fluid pathways, and identifying fracture flow characteristics is essential to modeling fluid migration pathways. We have been studied fluid flow through various single fractures in granite at a wide range of confining pressures of up to 100 MPa, demonstrating fluid flow along preferential flow paths due to natural heterogeneity of aperture distributions (channeling flow) at every given condition. The fracture plane is consequently divided into three kinds of areas where flowing, stagnant, and no fluid exists. The area with flowing fluid is expected only 5-20% of the fracture plane depending on the aperture distributions. It is therefore necessary to improve the conventional discrete fracture network (DFN) model simulator, in which fractures have been modeled as two parallel smooth plates, by incorporating the heterogeneous aperture distributions. We recently developed a new DFN model simulator, in which natural heterogeneity of the aperture distribution can be taken into account. Preliminary analyses on fluid flow in networks of granite fractures with heterogeneous aperture distributions, which were determined by our previous studies, demonstrated three dimensional channeling flows. We are now proceeding with detailed analyses on the channeling flow and its impact in engineering applications. Additionally, we are proceeding with three dimensional modeling of fluid flow through natural fractures in rock cores by using X-ray CT.