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Numerical simulations of heat transfer through fractured rock for an enhanced geothermal system development in Seokmodo, Korea

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Estimating the expected capacity and efficiency of energy is a crucial issue in the construction of geothermal plant. It is the lasting temperature of extracted geothermal water that determines the effectiveness of enhanced geothermal systems (EGS), so the heat transfer processes in geothermal reservoirs under site-specific geologic conditions should be understood first.
The construction of the first geothermal plant in Korea is under planning in Seokmodo, where a few flowing artesian wells showing relatively high water temperature of around 70°C were discovered lately. The site of interest is a part of the island region, consisting of the reclaimed land surrounded by the sea and small mountains. Geothermal gradient measures approximately 45°C/km and the geothermal water is as saline as seawater. Geologic structure in this region is characterized by the fractured granite. In this study, thermo-hydrological (TH) numerical simulations for the temperature evolution in a fractured geothermal reservoir under the supposed injection-extraction operating conditions were carried out using TOUGH2.
Multiple porosity model which is useful to calculate the transient interporosity flow in TH coupled heat transfer problem was used in simulations. Several fracture planes which had been investigated in the field were assigned to have highly permeable properties in order to avoid the averaging approximation and describe the dominant flow through the fractures. This heterogeneous model showed the rise of relatively hot geothermal water in the densely fractured region. The temperature of the extracted geothermal water also increased slowly for 50 years due to the rising flow through the fractures. The most sensitive factor which affects the underground thermal distribution and temperature of geothermal water was permeability of the medium. Change in permeabilities of rock and fracture within the range of 1 order might cause such an extreme change in the temperature of geothermal water that the measurement of the permeability should be performed through a very careful process in order to guarantee a reliable simulation. As the fracture spacing became narrower, overall thermal distribution appeared to be similar to that from EPM model. This suggests that EPM model, which is easy to design and takes less time, can be replaced for the densely fractured medium. Change in fracture aperture within the range of that of actual rocks did not cause a remarkable difference in temperature distribution, which means that measuring accuracy of the actual aperture value in rocks is relatively less important. This demonstrates that the distribution and the structure of fracture system make a great contribution to the whole simulation for fluid and heat flow mechanisms in geologic medium, and thus require an intensive geologic investigation for the fractures including strike and dip information, permeability and connecting relation. In addition, the simulation results show that the heterogeneous model can include the description for the significant fracture flow and it can be a practical tool for a site-specific simulation for EGS sites. This preliminary simulation was useful to estimate the scale of the geothermal reservoir and the energy potential in Seokmodo and it can be further expanded to a long-term simulation to predict the evolution of the geothermal reservoir under the potential EGS operations.

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