Estimation of Temperature and Permeability Distribution in Kakkonda Geothemal Field, Iwate Prefecture, Japan, Using Neural Network

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Estimation of temperature distribution around a geothermal field is important to understand a geothermal system. A major method for understanding the temperarure structure of the subsurface is to dig a well, but it costs a lot to dig just one well. Previously, temperature distributions were successfully estimated by a neural network based on temperature logs and magnetotelluric (MT) data (Spichak V.V. (2006), Ishitsuka et al., 2018). This method firstly trains the relationship between three-dimensional locations, resistivities and temperatures by a neural network. Then, the optimized neural network is used to estimate temperature distribution based on a resistivity structure obtained by the MT method. But, not only temperature but also permeability are important physical parameters to evaluate a geothermal system. In this study, we developed a method to estimate permeability distribution as well as temperature distribution by a neural network. The methodology was applied to the Kakkonda geothermal field, Japan. We used the temperature and the resistivity logs data provided by Tohoku Sustainable & Renewable Energy Co. Inc.

Since permeability along a well is not generally measured, we created a training data of permeability from existing resistivity data, we first estimated permeability along a well based on porosity deduced from resistivity log using the Archie’ s law. The temperature dependence of the resistivity of water was corrected at the processing. In addition, we assumed that the salt concentration at each depth was equal to the salt concentration of the collected fluid inclusion. Subsequently, the porosity was converted into the permeability by the Kozeny-Carman equation. Data about D 95 and mineral isograds were also added to the training data to further improve the estimation.

We then estimated temperature and permeability distribution around the target area. For training data, we used temperature logs and the estimated permeability logs using resistivity profiles at the 20 wells. To estimate temperature distribution, we used the 3D resistivity structure made by the MT survey (Yamaya et al., 2017).

The result exhibited that both temperature and permeability show a distribution according to the physical law. As for the temperature, the high temperature part assumed to be a heat source was estimated in the deep part, and the permeability showed high values in the low specific resistance part. With the increase in the types of input data, our method enables to estimate more accurate distribution.