Estimation of subserface temperature by geophysical data using Artificial Neural Network

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Accurate estimation of the underground temperature is essential for the resource evaluation of a geothermal reservoir. However, the quantity of temperature data measured in boreholes is usually limited and therefore the estimation of temperature distribution at depth is often difficult. General relationship between resistivity and temperature has been studied in laboratory experiment by using drilling samples, but it is not always applicable because there are many factors that affect the resistivity value.

We have tried to indirectly estimate the underground temperature by geological and geophysical data. By using Artificial Neural Network (ANN) trained by geological and geophysical data, this study aims to estimate underground temperature by resistivity data obtained from magnetotelluric (MT) sounding. MT investigation can estimate resistivity of deep underground easily and reasonably. If we can estimate temperature of deep underground from MT data, for example, we can find a promising geothermal reservoir and decide the location for development of a geothermal power plant.

We chose the Kakkonda geothermal area, Iwate Prefecture, Japan, as a test site of this study. It is because the area is underlain by a high-enthalpy geothermal system, reaching 500℃ at 3700m depth. In addition, many drillings and geological surveys were carried out before so we can get many data to educate the ANN.

We educated the ANN by each borehole position, depth and temperature data from well logs, resistivity data from MT sounding, and micro-earthquake hypocenter distribution that disappeared below the brittle-ductile boundary. After that, we tested various ANN structures to verify output temperature with observed temperature in the well-WD-1 up to 2.5 km depth. Then we estimated temperature up to 3.7 km depth of WD-1 to use the constructed ANN showed good result at testing.

As a result, we obtained good agreement up to about 3.1 km depth by several constructed ANNs. However, fitness was not good at blow the sealing layer (appeared at around 3.1 km depth), because resolution of resistivity structure of deeper part is too coarse to emerge changing temperature.

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