The influence of a magma chamber on the hydrothermal system in the Kuju volcanic region, central Kyushu, Japan

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Numerical analysis was performed in order to elucidate 3-layered temperature anomalies in the Kuju volcanic region, central Kyushu, Japan. The Kuju volcanic region, in which the Hatchobaru geothermal power plant is located, has been studied by NEDO for the development of geothermal energy since the late 80's. Some numerical models were also constructed on the assumption that geothermal fluids are supplied into a particular underground area like a geothermal reservoir. On the other hand, underground temperature distributions were suggested by NEDO (1987), and existence of 3-layered temperature anomalies was presumed. In addition, an analysis of the three-dimensional seismic velocity structure in the area indicated that a lowVp and lowVs area probably exists beneath Kuju volcano and Otake-Hatchobaru geothermal area (Yoshikawa et al., 2005). We consider the thermal evolution in the area by numerical analysis considering the effect of a magma chamber which must cause phenomena mentioned above.

A 3-D finite difference simulator HYDROTHERM Ver2.2 (Hayba and Ingebritsen, 1994) was applied in this research. The concrete objective region was the area in which temperature anomalies were obtained (NEDO, 1987). We determined physical properties based on NEDO(1984). We didn't take into account of minute difference of physical properties in the area.

First, we constructed a steady state model with no heat source, and calculated up to 150000 years. The thermal evolution induced by the emplacement of magma chamber was simulated by using pressure and temperature distributions from the steady state simulation as its initial conditions. The simulation time was determined as 40000 years after Kamata (1997).

Models of cooling heat source and models assumed heat source keeps its constant temperature were compared. The latter can be interpreted that continuous intrusion of magma occurred. This indicates that the heat source may not be in cooling process. The area in which temperature was from 200 to 300 degree Celsius didn't expand over the basement rock in the model of the cooling heat source.

We also evaluated effects of initial temperature and the scale of the heat source by parameter studies. The calculation implied that the heat source beneath Kuju volcano and Hatchobaru can be dealt as a single one and the period when the temperature of the heat source is constant determines the thermal evolution.

Horizontal temperature distributions of the results were compatible with the actual data at a depth of about 0 to 2000 m bsl. However, temperature distributions at a depth of 80m and the large anomaly of around 200 degree Celsius spreading from the northwestern part to the center of the Kuju volcanic area at a depth between 500 and 2000 m bsl couldn't be reproduced in our models.

In addition, the relationship between heat discharge rate in Kuju-iwoyama, central Kuju and permeability in the conduit was examined. We calculated heat discharge rate in a model without conduit and ones in models with a conduit assigned higher permeability than surrounding area. Heat discharge in the former case was 1.6MW and the latter discharged about 30MW. Ehara(1992) presumed that the heat discharge in Kuju-iwoyama was around 100MW and our results represented about 20 to 30% of the figure.

As the results of this study, activity in magma chamber beneath Mt. Kuju may have been continuing for at least 35000 years. The results also indicate that permeability in the area has obvious influence on heat discharge or evolution of shallow hydrothermal systems.