Geomagnetic evidence for the episodic fluid intrusion associated with the 2014 unrest of Kusatsu-Shirane volcano

*Wataru Kanda[1], Yasuo Matsunaga[1], Takao Koyama[2]

1. School of Science, Tokyo Institute of Technology, 2. Earthquake Research Institute, University of Tokyo

In Kusatsu-Shirane volcano, the elevated seismic activity, which accompanied a remarkable deformation and a change in the chemical compositions of volcanic gas, was observed from March 2014. In May 2014, a rapid change in the total geomagnetic intensity was observed, which was thought to be caused by demagnetization of the subsurface rocks around the Yugama crater. The amount of change was about one nano Tesla at the maximum, but the rate of change was rapid: the total intensity decreased only for about three weeks and did not show a significant change in the following two years. In this study, we attempted to infer temperature change accounting for this rapid geomagnetic variation within the volcanic edifice by a numerical simulation of hydrothermal fluid.

We used HYDROTHERM3.1.1 developed by the USGS for the simulation. The calculation was made within a cylindrical domain of 5km in height and 5km in radius. A high-temperature fluid was emplaced along the center axis as a source of temperature and flow fluctuations. A uniform permeability structure was assumed except for the low-permeable clay layer proposed by resistivity structure at the depth of 100 to 400m. Parameters such as permeability were adjusted so as to explain the average heat discharge at the surface, and the magnitude and time-scale of geomagnetic variation. We assumed that the hydrothermal fluid and the surrounding rocks were in an equilibrium state. The temperature dependence curve of the magnetization of rocks, which was used to transform temperature distribution into the magnetization distribution, was made from the experimental data for the volcanic rocks sampled in the summit area presented by Yamazaki et al. (1992).

Changes in the geomagnetic total intensity were calculated by the input of the high-temperature fluids at the depths. The geomagnetic variation occurred from the onset of fluid input and terminated when the fluid input was interrupted. Then, little change was calculated also after 100 days. The temperature distribution showed almost no change after 100 days, and the high temperature state was maintained beneath the clay layer. After numerous simulations were performed with changing several parameters, we found that the geomagnetic variation observed in May 2014 and the subsequent stagnant state of the total intensity could be explained by the temporary input of high-temperature fluid of higher than 400 degrees with a flux of 20 ton/sec for about three weeks. This possibly detected the discharge process of magmatic fluids caused by a breach of the sealing zone proposed by Ohba et al. (2008).

Keywords: hydrothermal system, Kusatsu-Shirane volcano, hydrothermal simulation, geomagnetic field variation

