3-D resistivity modeling of Kusatsu-Shirane volcano, with revisited magnetotelluric data

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Kusatsu-Shirane Volcano is an active andesitic volcano which situated north of the Kanto Plain. Three pyroclastic cones, Motoshirane, Shirane and Ainomine, were formed in Late Pleistocene. The Shirane pyroclastic cone has three major craters at the summit: Yugama, Mizugama and Karegama. The previous studies in geochemistry and seismology fields provided a basic comprehension of the hydrothermal system beneath these craters. Moreover, the 2-D resistivity modeling with magnetotelluric data in the past study demonstrated the resistors and conductors beneath Kusatsu-Shirane Volcano which supplied the understanding of subsurface structures in hydrothermal system of Shirane. Considering the Shirane may have 3-D structures which could prone to error in the 2-D modeling interpretation due to the galvanic effect, a 3-D modeling is necessary to further comprehend the hydrothermal system beneath Shirane pyroclastic cone.

For monitoring the effect of the hydrothermal system changes due to an activity in 2013, we did a magnetotelluric survey in 2017 for obtaining the present data, and combined them with past magnetotelluric and audio-frequency magnetotelluric data, which was permitted in the previous study for 2-D modeling, in the model inversion. The resistivity model was generated with tetrahedral elements and considering the topographic effect. Another model only permitted the past data for comparison.

The final model demonstrated two major conductors. One conductor has 1000 to 500 meters thickness located at 300 meters depth beneath Yugama crater, and extends to the east slope of Shirane pyroclastic cone until Sesshougawara fumarole zone. Another deep conductor on the west of Yugama crater has 600-1000 meters thickness and connects with Manza geothermal field. The model also demonstrated a bell-shape resistor beneath Yugama crater.

The conductor beneath Yugama crater is corresponding to the assumption of hydrothermal system in the previous geochemistry studies. The bell-shape resistor denotes the cap structure of hydrothermal system. With referring to the borehole data, this cap structure represents a clay cap that block the path of heated water. Combining the microseismic monitoring data and inflation data, the fracture in the cap rock is inferred to be the path of upward fluid flow. The newest model demonstrates an obvious difference in the connection between major conductors, which was denoted separately in the previous 2-D model. This result indicates that the system of Manza geothermal field may have stronger relationship with Yugama system then we assumed before. We additionally found a large downward extension of conductor at the southeastern slope of Kusatsu-Shirane Volcano, where is close to Sesshougawara fumarole zone, by comparing the same modeling section with past 2-D model.

The newest 3-D resistivity model provides additional information of the subsurface structures beneath Kusatsu-Shirane Volcano. The comprehension of hydrothermal system beneath Yugama crater is promoted due to the new interpretation.