3D imaging clay-cap and underlying gas reservoir by magnetotelluric modeling and micro-earthquake monitoring at Kusatsu-Shirane volcano, Japan

Yasuo Ogawa[1], Nurhasan .[2], Sabri B. Tank[3], Naoto Ujihara[1], Yoshimori Honkura[1], Teruo Yamawaki[1]

[1]Tokyo Institute of Technology, Japan, [2]Bandung Institute of Technology, Indonesia, [3]Bogazici University, Turkey

E-mail: oga@ksvo.titech.ac.jp

Kusatsu-Shirane volcano, Japan, is historically known for active phreactic eruptions. The geothermal system underneath the volcano has been investigated by geochemistry and qualitative models have been proposed (ohba, 1994). During the active period in 1990s, the peculiar volcanic tremors (tornillo) were observed, which were explained by vapor-fluid resonance in a horizontal crack system under the crater lakes (Nakano et al., 2003). During the same period, temporal magnetic field showed the patter of demagnetization implying the increased temperature beneath the peak (Yamazaki et al., 1992). However, the underlying structure of the volcano remained unknown.

We have done magnetotelluric measurements at 85 sites covering the whole summit area (2kmx2km) of Kusatsu-Shirane volcano, with average site spacing of 200m. We used full impedance tensor in the frequency ranges between 100Hz to 1Hz for three-dimensional inversion (Siripunvaraorn and Egbert, 2009). We found a bell-shaped conductive layer at the peak area, which are interpreted as a layer containing clay by referencing to the borehole core samples. The top of the clay cap thins corresponding to the recent (2006-present) new active geothermal manifestations at the Yugama-Mizugama cater pits.

The bottom of the clay cap has a southward gentle slope and it coincides with upper bound of the micro-earthquake distribution. This coincidence confirms that the clay cap and gas supply from the south are causing increased pore pressure leading to active microseismic activity with magnitude between -1 to 1.

On the other hand, the bottom of the clay cap has a northward vertical slope and the northern rim has a shape of a thick vertical wall. Correspondingly, this wall shuts the seismicity completely.

The most active fumaroles distribute in the northern slope of the volcano, which is further north beyond the clay cap. This means that the most active fumaroles are located at the rim of the clay cap. The gas passage seems to be completely open as there is almost no microseismic activity under the fumaroles.

Clay cap distribution is also supported by the CO2 discharge mapping (Saito et al., 2004). The seismic resonator and source of the demagnetization during the 1990s activity are located beneath the clay cap at the peak. Thus the magnetotelluric 3d imaging of clay cap and underlying microearthquakes give important information on the phreatic eruption environment.