Electrical resistivity structure of Kuchi-erabu-jima volcano

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Kuchi-erabu-jima is a volcanic island located about 15 km west of Yakushima Island, about 100 km south of Kyushu, Japan. Phreatic eruptions had been repeatedly occurred at intervals of several to a few tens years around Shindake crater of the volcano since the oldest historic eruption in 1841. Although eruptive activity ceased after the latest fissure eruption in 1980, swarms were observed in 1996, 1999, and 2003-2004 just beneath the crater. In February 2003, fresh fumaroles were recognized at the crater bottom. Those events imply that volcanic activity is the highest since the last eruption.

Hypocenters of volcanic earthquakes were determined with the continuous and the temporal seismic observation network of Kyoto University. Earthquakes were located just beneath Shindake crater at depths of 500-600 m in 1996 and shallower hypocenters were inferred in 2001. Ground water that is expected to widely exist at the shallow edifice may be a cause of those earthquakes, since phreatic explosion was repeatedly occurred in recent activities. Geomagnetic total intensities have been recorded by Kyoto University at the summit area since 2000. The change in total intensities has been observed since 2001, which suggests that thermal energy storage is in progress at the shallow part beneath Shindake crater or around of it. The demagnetized area was inferred at depths of 700-800m beneath the crater, which suggests that heat of the intruded magma was supplied to the shallow part through hydrothermal system.

In this study, we carried out an audio-frequency magneto-telluric (AMT) survey on Kuchi-erabu-jima in order to estimate the detailed electric structure down to 1 km or so. The zone of thermal energy storage inferred from geomagnetic field variations is considered to be a preparation area of the next phreatic explosion. The main objective is to find a relation between the area and the electrical structure.

The AMT survey was conducted during a period of Nov.20-29 in 2004. AMT data were collected at 24 locations at intervals of about 500m. Electromagnetic fields data over the frequency range of 1-10000 Hz were recorded for 11 hours during nighttime at 20 sites and for 3 hours during daytime at 4 sites using three Phoenix Geophysics MTU-5A systems. A remote-reference site was not installed, so that the impedance responses were estimated by a local-site reference.

Since impedance skews at all the sites showed below 0.2, we assumed that a rough structure around this region is two-dimensional and applied a tensor decomposition technique (Groom and Bailey, 1989). The distribution of GB-strike estimates mostly fell between N10E and N15E. As a preliminary modeling, N12.5E was assumed as a strike direction of this region. After the impedance tensor at each site was rotated to the strike direction, it was decomposed to TM- and TE-mode components. A 2D inversion (Ogawa and Uchida, 1996) was applied to each data set along 2 lines across the summit area including Shindake crater.

As results of inversions, resistivity sections showed following features. The surface layers of flank areas showed high resistivity of more than a thousands ohm-m. Especially at the western and southwestern flanks, thickness of the layer was large. This high resistive layer is likely to correspond to the Shindake lava ejected about 1000 years ago. A low resistive layer of 1 ohm-m or so was widely seen over the edifice at depths of 200 to 1000m, which would reflect the water-rich layer. This conductive layer showed local variations: in the northeastern part from No-ike, a resistive gap might exist and conductive layer was shallower around Furudake. In the western side of Shindake crater, this conductor also existed at shallow part, which may correspond to the zone of thermal energy storage inferred from geomagnetic field variations. In the presentation, we will discuss about significance of those conductors by sensitivity analysis.