Audio-frequency magnetotelluric survey on the northern edifice of the Kurikoma volcano, northeast of Japan

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Now we focus the Kurikoma volcano closely at the triple junction of borders of Akita, Iwate and Miyagi prefectures, northeast of Japan. The eruption style of the Kurikoma volcano is magma eruption and phreatic eruption. The Kurikoma volcano is one of important active volcanos and its most recent striking activity was a phreatic eruption in 1944. The site of 1994 eruption is now remained as a crater lake called Lake Showa. Besides the Lake Showa, volcanic gas is even now emitted upstream of a gorge called Jigoku-dani. So far the several researches have reported 2- and 3-dimensional resistivity structures of the crust including the Kurikoma volcano (e.g. Mishina, 2009; Ichihara et al., 2014). Mishina (2009) firstly reported the 2-dimensional resistivity structure targeting the deep volcanic fluid beneath the Kurikoma volcano. The result of Mishina (2009) suggested the existence of volcanic fluid at the depth of several kilometers under the volcanic structure. In this study, we aim to find the structure which becomes the key to the occurrence of the phreatic eruption from the shallow resistivity structure directly under the Kurikoma volcano obtained by AMT survey.

We carried out an AMT survey across a high temperature upstream of a gorge from August to November 2018. This method uses magnetotelluric responses derived from variations in the natural audio-frequency band (approximately 1 to 10^4 Hz) of the electromagnetic field to estimate the resistivity structure in an area down to a depth of a few kilometers. The AMT data were collected at thirteen locations. Two components of the electric field and three components of the magnetic field were recorded for 3 to 24 h overnight using a Phoenix Geophysics MTU-5A system (Phoenix Geophysics Ltd., Toronto, ON, Canada).

In this study, the concept of phase tensor (Caldwell et al., 2004) and induction vector (Parkinson, 1962) was used to evaluate the dimensionality of structure and the characteristic of resistivity distribution. From the results of the phase tensor, the skew angle was less than 5 degree and the ellipticity was less than 0.2 in the range of frequencies higher than 10 Hz. Therefore, it is suggested that the structure around 1 km below the subsurface is a relatively homogeneous structure. Also, in the frequency range lower than 10 Hz, the direction of the induction vectors tends to point towards a lava dome called Tsurugi-dake.

The 2D inversion model with TM-mode data was constructed using the inversion code developed by Ogawa and Uchida (1996). Only the data with small phase-tensor skew angles (< 5 degrees) were used in the 2D inversion in this study, because the data with large skew angles are inconsistent with the 2D structure assumed in the area.

The final model has three characteristic features. The first is that the low resistivity region (C1) beneath the fumarolic area and hot spring zone. The second is that high resistivity zone (R1) is distributed in the lower layer of the low resistivity region (C1) immediately below the high temperature fumarolic area (Jigoku-dani, Iwo-yama and Yuge-yama). It is suggested that the high resistivity zone (R1) is a high temperature body or a steam dominant region because high temperature fumarolic area exposes the surface of the ground. The third is the existence of a relatively high resistivity zone (R2) is located in the lower layer of the eastern part of the low resistivity region (C1). Since the phreatic eruption crater traces are distributed in the eastern part of the east west cross section, it is suggested that R2 is a trace of activities of the phreatic eruption in the past.

Keywords: Resistivity structure, AMT, Kurikoma volcano, Phreatic eruption, Hydrothermal system