Hydrothermal system of Kuttara Volcanic Group inferred from 3D resistivity modeling (2)

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Estimation of the volcanic hydrothermal system that is composed of an alteration zone, a fluid upflow zone and a heat source, is a key feature in assessing the potential of phreatic eruptions. Magnetotelluric (MT) method is one of the effective ways of estimating such hydrothermal system since it has the sensitivity to hydrothermal fluid and hydrothermal alteration zones. We performed the MT survey at Kuttara Volcano Group, northern Japan, to evaluate imminence of phreatic eruption.

Kuttara Volcanic Group is a basaltic to andesitic volcanic complex in southwestern Hokkaido, northern Japan. Kuttara volcano was formed by several silicic explosive eruptions and construction of an andesitic stratovolcano built up from ca. 80 to 40 ka. Lake Kuttara is a caldera lake formed by a violent explosive eruption at ca. 40 ka (Katsui et al., 1988; Moriizumi,1998). Noboribetsu volcano, post-caldera volcanism on the western foot of the stratovolcano at ca. 15 ka, formed Hiyoriyama cryptodome and Jigokudani geothermal field. We can see weak plumes (110–140 ºC; maximum height of ca. 50 m) near the top of Hiyoriyama cryptdome. We also see hot spring areas around Kuttara volcano at Noboribetsu, Carls, and Kojo-hama.

Although some previous studies (Goto and Johmori, 2011, 2013, 2015) revealed 2-D resistivity cross sections by CSAMT and TDEM methods at Kuttara volcano, they did not image deeper than about 1km. In this study, we carried out a broadband MT survey in 2017 at 49 stations in the area of 20x20 km wide and estimated 3-D resistivity structure of Kuttara Volcanic Group. We used ModEM (Egbert and Kelbert, 2012) as the 3-D inversion code, using a model space containing topography and sea bottom relieves. Responses at twelve periods between 0.00521 and 512 s were selected as the input data of the inversion. Error floors of 5% for the diagonal components of the impedance and 10% for the tippers and non-diagonal components of the impedance were given to avoid too much weighting for these data in the inversion process. Two-step inversion was applied, in which only the tippers were inverted at first, and subsequently, only the impedances were inverted. We already presented preliminary results at JpGU 2018 (Hayakawa et al., 2018). In this presentation, we discuss the results through the sensitivity check. We performed the sensitivity check by measuring the change in RMS due to disturbance of resistivity value in the focusing area.

We summarized the key features of the modeling results as follows. (1) The near-surface resistivity distribution is in good agreement with the surface geology. The resistivity was relatively high (100 to1000 Ωm) on northern and eastern to southern flanks of Kuttara Volcano, where volcanic deposits such as andesite lava flows covered the surface. (2) A low resistivity zone is imaged beneath Noboribetsu hot spring and a columnar low resistivity zone reached to the bottom of Lake Kuttara from the depth. These

low resistivity zones indicate hydrothermal system in the Kuttara-Noboribetsu area. Low resistivity layer is also imaged just below Carls hot spring. However, this low resistivity layer is not sensitive in our inversion since this layer is very thin. (3) Relatively high resistivity zone beneath Lake Kuttara also has insufficient sensitivity. This result indicates we have to perform more dense survey around Lake Kuttara to discuss whether magma or hydrothermal reservoir exist beneath Lake Kuttara or not. Our study is the first 3-D MT modeling for Kuttara Volcanic Group and further detailed comparison to geology, hydrology, drilling data, and hydrothermal simulation is necessary to better understand the current and to assess the potential of phreatic eruptions at Kuttara Volcanic Group.

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