

Shallow thermal demagnetization beneath Tokachidake Volcano revealed by a UAV aeromagnetic survey

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SUMMARY

We estimated the distributions of three-dimensional magnetization intensity beneath the active crater area on Tokachidake Volcano. Our 3D model revealed a low magnetization region corresponding to the crater locations. This distribution was generally consistent with the location of the major fumarolic areas and the low resistivity zone imaged by the 3D inversion of audio-magnetotelluric data (Tanaka et al., 2021). These results suggest that the low magnetization region represents a possible hydrothermal pathway. In addition, another weakly magnetized region was found at an elevation of approximately 1,550 m a.s.l. on the NW side of the 62-II crater (most active crater). This region shows a good correspondence with the surface thermal anomaly on the NW slope. We planned a second observation for this summer, and we would like to discuss the thermal activity in the shallow subsurface of Tokachidake based on the magnetization structure's changes.

Tokachidake is an active volcano located at the center of Hokkaido, Japan. Major historical magmatic eruptions occurred in 1857, 1887, 1926, 1962 and 1988-89. In recent years, phenomena indicating volcanic unrest have been observed. This includes ground deformation and geothermal changes suggestive of shallow pressure build-up and heat accumulation beneath the active crater area.

Prior to this study, ground geomagnetic repeat surveys have been conducted by Hokkaido University and Japan Meteorological Agency since 2008. They revealed continuous demagnetization in the shallow subsurface beneath the 62-II crater associated with the expansion of a high temperature zone at a very shallow depth (Hashimoto et al., 2010). More recently, an ongoing thermal anomaly manifested at the WNW side of the 62-II crater. It suggested lateral migration of hydrothermal water within the stratified edifice. In light of this background, we conducted a drone-borne aeromagnetic survey to detail the subsurface thermal activity beneath the active crater region.

In this study, we collected geomagnetic total intensity data with a GEM GSMP-25U Potassium Magnetometer (rented from Tierra Technica, Ltd.) mounted on a DJI Matrice 300 RTK. The survey area covered a rectangular area of 1.5 km by 1.3 km in the NW-SE and NE-SW directions, including the areas of confirmed thermal activity on the surface around 62-II crater. To account for temporal changes of extra-terrestrial origins, we conducted simultaneous measurements with a GEM GSM-19 Overhauser magnetometer at the reference point located at Shirogane Mohan Farm in Biei, approximately 8 km NNW of the survey area.

Based on the inversion code developed by Koyama et al., (2021), we estimated the 3D magnetization structure from the geomagnetic field data collected by the drone surveys. The horizontal extent of the model space for the 3D inversion was 2 km by 2 km, whereas the vertical extent was 2 km with four layers of 200, 400, 600, and 800 m thick from the surface to the depths. The average magnetization intensity estimated by the least-squares method with the observed data was approximately 2 A/m. The hyperparameter balancing the data misfit term and the model roughness term in the objective function of inversion were determined by the ABIC minimization concept (Akaike, 1980).

This study was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Earthquake and Volcano Hazards Observation and Research Program.

Keywords: Aeromagnetic survey, Drone, Volcano

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