Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

STT03-01 Room:102A Time:May 23 09:20-09:35

Aeromagnetic survey using an unmanned autonomous helicopter over Tarumae volcano

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1. Introduction

Recently, a remote measurement technique using an unmanned autonomous helicopter is being developed (e.g. Kaneko et al., 2010). Further improvement of suitable instrumentation and operation techniques are, however, necessary for the application to volcanic fields. Hokkaido Regional Development Bureau (HRDB) has similar type of helicopters for the purpose of disaster survey in hazardous zones at an emergency. The authors and HRDB performed a field experiment by using the helicopter over the summit atrio of Tarumae volcano in 2011. Aerial imaging, experimental installation and collection of a seismometer unit, and an aeromagnetic survey were conducted in the fieldwork. We report the results of the aeromagnetic survey, which was the first low-altitude, dense magnetic survey for Tarumae.

2. Measurements results and data processing

The aeromagnetic survey was performed on September 27, 2011 over the summit atrio. The unmanned helicopter (YAMAHA RMAX-G1) was used as a platform with the aid of real-time differential GPS navigation. Magnetic field was recorded in the Geometrics G858 optical-pumping magnetometer at 10 Hz sampling. Differential magnetic field was obtained taking the simple subtraction of the field at the grounded reference station to reduce the magnetic variations of upper-atmospheric origins. In this study, we inverted the magnetic anomaly map into a non-uniform magnetization model using the code of Kaneko et al. (2010) with a small modification. We modeled the topography-related anomalies by using the 10m-mesh DEM which was provided Geospatial Information Authority of Japan (GSI). Non-uniform distribution of magnetization was modeled as an ensemble of vertical prisms of 100 x 100 m size. In the inversion, we evaluated the objective function as the sum of the L2 norm of the difference between modeled and measured fields, and the norm of the deviation magnetization. We here did not fix a priori the DC component of the magnetic anomaly. We performed the inversion for several values of the DC offset to obtain the optimized se t of model parameters which minimizes the ABIC.

3. Modeling result and discussion

We obtained an averaged magnetization as 5.3 A/m. The summit lava dome showed the magnetization of 3-6 A/m. Meanwhile, relatively small magnetization of 2-4 A/m was estimated at the southeastern part of the dome (which is called 'crater A') and the areas around Nishiyama and Higashiyama mounds at the crater rim. In contrast, northwestern part of the atrio showed relatively strong magnetization (5-8 A/m) compared to the dome itself. These results are consistent with the rough estimation by Sakuma and Murase (1956) based on the magnetic inclination anomaly by using a uniformly magnetized ellipsoid, in which magnetization of the dome and the edifice is estimated as 6-8 A/m and 2-3 A/m, respectively. Such variability may be attributed to the difference in magnetization between blocky lava and pyroclastic deposits, as well as to chemical demagnetization due to persistent fumarolic activity at several vents.

From the viewpoint of an aeromagnetic survey, high positioning repeatability is one of the most advantageous features of such an unmanned autonomous helicopter. Optimized operation of the system would enable us to detect temporal changes associated with volcanic activity in the future.

Acknowledgments: The authors express sincere thanks to Muroran Development and Construction Department, and Sapporo Development and Construction Department of HRDB for the cooperation in the field experiment using their unmanned helicopter. Yamaha Motor Co. Ltd. is deeply acknowledged for their technical support in the field operation. We thank S. Okuyama for the preconditioning of the DEM used in the modeling. This study was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Observation and Research Program for Prediction of Earthquakes and Volcanic Eruptions.

Keywords: geomagnetic field, Tarumae Volcano, unmanned helicopter, magnetic total force