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Aeromagnetic survey of Nishinoshima volcano by using drone: the current situation and future outlook

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Nishinoshima volcano in the Ogasawara (Bonin) island arc erupted in 1973-1974 for the first time since its discovery in 1702, and has intermittently erupted since November 2013. According to Iizuka et al. (1975), Nishinoshima volcano was formed after the last geomagnetic reversal event (˜0.77 Ma) because all rocks obtained from Nishinoshima showed normal remnant magnetization. Eruption style changed from Strombolian activity to a violent Strombolian eruption in June 2020 (Yanagisawa et al., 2020). Unfortunately, there is no permanent observation network on or around the island, only satellites can periodically observe volcanic activities such as thermal anomalies of the island (Kaneko et al., 2019). The volcanic island offers an opportunity to study island-forming eruption processes (Maeno et al., 2016) and formations of continental crust (Tamura et al., 2019). Thus, we have approached these issues through magnetic anomalies of the island. The magnetic anomaly images obtained by satellites are very coarse, and we decided to measure total magnetic anomalies above the island by using the drone with the potassium magnetic sensor developed by Tierra Tecnica Ltd. (Tokyo, Japan).

The aeromagnetic surveys were conducted during the cruise of the Japan Meteorological Agency weather ship Keifu-Maru in June 2019, and covered an area of about 3 km x 3 km including the emergent part of Nishinoshima volcano. We extracted the magnetic anomaly induced by the magnetization structure from the observation data and estimated the magnetization structure from the anomaly by applying the 3D inversion (Utsugi, 2019), which combines L1 and L2 norm regularizations. We conducted a cross-validation procedure (e.g., Bishop, 2006) to simultaneously determine optimum values of a regularization parameter and a hyperparameter. We found that Nishinoshima volcano had an average magnetization of about 3.0 A/m and that two more strongly magnetized bodies existed as of 2019 beneath the volcanic vent at about 300 m below sea level and the northeast slope of the volcano at depths between 300 and 800 m below sea level. These features may represent large bodies of solidified magma of the previous eruptions in 1973-1974. This study demonstrated the utility of this relatively safe and inexpensive observation method and this data analysis method for investigating the magnetic structure of remote volcanic islands. Repeated future surveys of this type may enable us to monitor volcanic activities that affect the magnetization structure of volcanoes. Therefore, we will conduct aeromagnetic surveys using the same drone system during the cruise of Shinsei-Maru in January 2022 in order to compare magnetic anomalies and magnetization structures before and after the eruption style change.