Repeated Drone Magnetic Survey over Usu Volcano, Hokkaido Japan

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We have been developing a drone magnetic survey system using a portable magnetometer with a differential GNSS system (Okuma et al., 2018a). This time we employed a hexacopter with a diagonal axis distance of 995 mm and with a maximum payload of 5.7 kg (Okuma et al., 2018b). A main console of Geometrics G-858 Cs magnetometer, a NovAtel OEM615 GNSS receiver with its antenna and the GNSS data logger were attached to the drone. A Cs sensor was suspended from the drone by a string. We have tested flying attitudes and magnetic noise of the drone by changing a suspending length of the sensor cable. We concluded that an optimum cable length of our system was 0.85 m for surveys over rugged terrains because of the power of our drone. In this case, magnetic noise caused by the drone was estimated to be around 15 nT at the maximum by our experiments (Okuma et al., 2018b).

Using this drone magnetic survey system, we have conducted magnetic surveys over the Usu 2000 eruption area (Nishiyama craters area, Area A) and the southwestern flank of the main edifice of Usu volcano (Area B), Hokkaido Japan (Okuma et al., 2018b). In Area B, a curious magnetic anomaly had been observed by a previous helicopter-borne EM and magnetic survey in late 2000, which was flown at an altitude of 70–100 m above terrain along north–south survey lines and east–west tie lines, spaced 100 m and 1,000 m apart.

In May 2018, the drone surveys were flown at an altitude of 30 m above terrain along east–west survey lines (Area A) and north–south survey lines (area B), spaced 25 m apart. Total magnetic intensities were observed in every 0.1 seconds by the Cs magnetometer with GNSS positioning. According to data processing, the surveys were successful for mapping magnetic anomalies whose general pattern were well retrieved in the both areas, compared to known magnetic anomalies compiled from the 2000 survey.

Then, we applied the generalized mis-tie control method (Nakatsuka et al., 2009) to the magnetic anomalies of both 2000 and 2018 surveys in Area A and calculated temporal magnetic variations at crossover points. Although the survey specification of each survey was different, the result was successful to derive positive magnetic changes larger than 100 nT in and around intensive fumarolic areas of the 2000 eruption. The areas were characterized as apparent negative magnetic anomalies by the 2000 survey and are estimated to be underlain by Pleistocene volcanic rocks with reverse magnetization. Since the beginning of the eruption, the fumarolic activity gradually extended from the eruption center to the NNW along a ridge and lasted for several years. This implies that Pleistocene volcanic rocks constituting the area have been demagnetized by the strong fumarolic activity related to dyke intrusions at the 2000 eruption.

Based on the results above, it is concluded that drone magnetic survey is a promising method to derive long-term temporal magnetic changes and can play an important role to monitor volcanic activity.

[References]

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