A helicopter-borne geomagnetic survey on White Island, New Zealand (FY2004)

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Introduction: In recent years, geomagnetic total field is observed in many active volcanoes aiming for monitoring subsurface temperature or stress field. Ground-based stations or benchmarks have been normally used for this purpose. We, in contrast, aim to detect the volcano-magnetic effect by repeat airborne surveys using a helicopter. White Island, an andesitic volcano isle on the Bay of Plenty, in the northern end of Taupo Volcanic Zone of the North Island, New Zealand, was chosen as the survey target of our three-year project funded by a grant-in-aid for scientific research of JSPS. Flight surveys are planned in the 2nd and 3rd year (FY04 and 05). Basic concepts of the project and the preliminary result of the first magnetic survey are presented below.

(1) Basic ideas: Recent development of positioning technique such as GPS has enabled us to measure an airborne sensor position within accuracy of a few to 10 centimeters. The total positioning accuracy of the whole measuring system including flight speed, sampling timing of the recording devices, and time control is about 20 cm. In contrast, total field gradient at the fight height is typically 1 nT/m or less. Hence, real difficulty to be solved lies in the accuracy and validity of interpolating the magnetic field rather than in positioning itself, because it is practically impossible in an airborne survey to reoccupy exactly the same position as in the previous flight. This sounds a considerable disadvantage for the detection of minute temporal geomagnetic changes from air. In turn, we will be free from very local anomalies due to magnetized materials at shallow ground. In this project, we fly over the area in which a future eruption is expected as dense as possible to prepare a 3D reference magnetic anomaly map. In other words, we overcome the lack of repeatability of positioning by intensive spatial coverage.

(2) Location: For some reasons, White Island is probably one of the best fields in the world for testing and developing a helicopter-borne magnetic survey method aiming for the detection of temporal changes. First of all, this volcano has a long history of geomagnetic monitoring (almost 40 years since 1968). WI sometimes gives a good indication of the volcanic activity (Hurst et al., 2004), having the largest volcano-magnetic change ever recorded on the Earth's surface (~1000 nT). Secondary, it is rather difficult on the island to maintain ground-based instruments or benchmarks in good conditions for a long period, because of the corrosion due to acid gas and frequent explosions. Aeromag surveys can take advantage to the grounded ones here in terms of reducing the regular maintenance. Thirdly, a survey flight in New Zealand reasonably costs less than in Japan.

(3) Tasks: (a) Produce a precise geomagnetic anomaly map as a reference field dataset that enables the detection of a future temporal change due to volcano-magnetic effect. (b) Detect a temporal change between 2004 and 2005, if any. (c) Infer the subsurface magnetization structure of WI.

(4) Preliminary result: Flight surveys were successfully conducted in February of 2005 at two different heights, a 50m-spaced drape flight with a ground clearance of 50m and a 200m-spaced plane flight with an altitude of 350m. A cesium magnetic sensor and a differential GPS are loaded in the bird which is suspended below 40m from the helicopter (a twin squirrel AS355). Sampling was made at every 0.1 sec, corresponding about to every 20 cm along the flying paths. Although topography was partly steep and difficult to follow, data coverage including the crater-lake area was almost satisfactory. The collected magnetic total field ranges within +/- 500 nT, implying that the averaged magnetization of this island is moderate.