Validation flights of the Airborne Radiative Transfer spectral Scanner for a Single-Engine aircraft (ARTS-SE)

*Tetsuya Jitsufuchi[1]

1.National Research Institute for Earth Science and Disaster Prevention

We developed an airborne imaging system, the Airborne Radiative Transfer Spectral Scanner for a single-engine aircraft (ARTS-SE) for volcano observations in June of 2015. The platform for ARTS-SE is a single-engine Cessna 208 aircraft.
ARTS-SE consists of two imaging units. These imaging units are a push-broom imaging spectrometer and a camera system. The ARTS-SE push-broom imaging spectrometer unit covers the wavelengths from 380 to 1,100nm and 8,000 to 11,500nm with 320 bands. This unit consists of two sensor head units (SHUs). These SHUs are the visible-near infrared (VNIR) SHU and the long-wave infrared (LWIR) SHU. These sensor head units are the modified system of our conventional airborne hyperspectral scanner (ARTS). The ARTS-SE camera system unit consists of four cameras. These cameras are the two visible cameras and the two thermal infrared cameras.
Before beginning the operational use of ARTS-SE, it is important to validate its in-flight performance. Therefore, we conducted ARTS-SE instrument validation overflight of the bundle test site (Aichi prefecture), and the volcano observation test flight over an active volcano (Asamayama volcano and Hakoneyama (Owakudani)) in the late autumn of 2015. At the Asamayama volcano and Owakudani district, we could detect the geothermal activities. We are conducting validation for the rectification accuracy using the image data from bundle test site.

Keywords: airborne hyperspectral imager, volcano observations, infrared remote sensing

Characteristics of magnetic anomalies on a high-resolution aeromagnetic anomaly map of Fuji Volcano

*Shigeo Okuma[1], Tadashi Nakatsuka[1], Shun Nakano[1], Hideyuki Satoh[2], Ayako Okubo[3]

1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 2.The Secretariat of the Nuclear Regulation Authority, 3.Hydro-soft Technology Institute Co., Ltd.

Geological Survey of Japan, AIST has complied a high-resolution aeromagnetic anomaly map of Fuji Volcano (in press), based on the data by two aeromagnetic surveys in 2003 and 2007 through latest data processing. The magnetic anomalies of the volcano are affected by terrain magnetized strongly in the present Earth’s magnetic field as expressed on previous regional maps but more detailed information can be seen. For instance, apparent magnetic anomalies are dominant on the northwest and southeast slopes of the volcano, corresponding to chains of lateral craters and some lava flows. Some magnetic high chains are also apparent over the northeastern middle slope, corresponding to the Takamarubi lava flow but long-wavelength ones close to Lake Yamanaka can be treated as an extension of regional magnetic highs from the Tanzawa Mountains. The most significant characteristic is conspicuous magnetic anomalies with a pair of highs and lows elongated in an east-west direction resides over the eastern flank of the volcano as far as the altitude approximately 1,300 m above sea level, suggesting a buried volcanic structure exists there.

Keywords: Fuji Volcano, aeromagnetic anomaly map, magnetic anomaly

High resolution three-dimensional magnetization mapping in Tokachidake Volcano using low altitude airborne magnetic survey data

*mitsuyoshi iwata[1], Toru Mogi[1], Shigeo Okuma[2], Tadashi Nakatsuka[2]

1.Institue of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2.Gological Survey of Japan, AIST

Tokachidake Volcano, central Hokkaido erupted in 1926, 1962 and 1988-1989 from the central part, in the 20th century. In recent years, the volcano is getting active at the 62-2 crater and the Taisho crater. A low altitude airborne magnetic survey was conducted in 2014 mainly over the active area of the volcano by the Ministry of Land, Infrastructure, Transport and Tourism to manage land slide risk in the volcano. We have re-analyzed the aeromagnetic data to delineate three-dimensional magnetic structure of the volcano.

The survey was flown at an altitude of 60 m above ground by a helicopter with a Cesium magnetometer in the towed-bird 30m below the helicopter. The low altitude survey enables us to delineate the detailed magnetic structure. We calculated magnetic anomaly distribution on a smooth surface assuming equivalent anomalies below the observation surface. Then the 3D magnetic imaging method (Nakatsuka and Okuma, 2014) was applied to the magnetic anomalies to reveal the three-dimensional magnetic structure. In this analysis, the magnetic structure with a thickness of 3,000 m was assumed as the initial model. As a result, magnetization highs were seen beneath the Ground crater and other craters around the summit of Tokachidake (62-2 crater, Ground crater, Nokogiridake crater, Suribachi crater and Kitamuki crater). This implies that magmatic activity occurred in the past at these craters. These magma should have already solidified and acquired strong magnetization. Relative magnetization lows were seen directly under the 62-2 crater and beneath the Ansei crater. This implies that these areas are still hot since the magma activity continues.

As described above, the distribution of magnetization can help us to better understand the subsurface structure of Tokachidake Volcano. However, its intensity seems to be more or less low overall compared to previous rock magnetic studies (i.e. Uesawa, 2008). This disagreement might be improved by more appropriate assumptions especially about the thickness of the magnetic model. This point should be further studied in detail.

Acknowledgement

We would like to thank the Asahikawa Development and Construction Department, Ministry of Land, Infrastructure, Transport and Tourism for providing the airborne magnetic survey data of Tokachidake Volcano.

Keywords: Tokachidake, magnetic anomaly, aeromagnetic survey

Three-dimensional Inversion of Grounded Electrical-source Airborne Transient Electromagnetic (GREATEM) Survey Data

*Sabry Abd Allah[1], Toru Mogi[1], Kim Hee[3], Elena Fomenko[2]

1.Institute of siesmology and volcanology-faculty of science, HOKKAIDO UNIVERSITY, 2.Formerly, Moscow State University, Russia , 3.Department of Energy Resources Engineering, Pukyong National University, Korea

Studies have shown that Grounded Electrical-Source Airborne Transient ElectroMagnetics (GREATEM) is a promising method for resistivity structures investigating in coastal areas, in addition to inaccessible areas such as volcanoes, mountains and deep forest cover. To expand the application of the GREATEM system, a three-dimensional (3-D) resistivity model that considers large lateral resistivity variations is required. In this paper, we present a frequency- domain 3-D electromagnetic (EM) inversion approach that can be applied to time domain data from GREATEM. In the frequency-domain approach, TEM data were Fourier-transformed using a smooth-spectrum inversion method, and the recovered frequency response was then inverted. To deal with a huge number of grids and a wide range of frequencies in airborne datasets, a method for approximating sensitivities is introduced for efficient 3-D inversion. Approximate sensitivities are derived by replacing adjoint secondary electric fields with those computed in the previous iteration. These sensitivities can reduce the computation time without significant loss of accuracy. Firstly, we verified both of our forwarding and inversion solutions. We then applied this approach to the GREATEM survey data from Kujukuri beach, central Japan. The inverted results of the field data are well fit with the previous study results at Kujukuri area, suggesting the applicability of this inversion approach for constructing 3D resistivity models from the GREATEM field survey data in the future.

Keywords: Airborne EM, , GREATEM, 3-D inversion, Frequency-domain inversion., 3-D forward modeling

Relationship between Resistivity Distributions by Airborne Electromagnetic Method and Underground Structure

*Teruyoshi Takahara[1], Shuji SETO[1], Kohei NOIKE[1], Kayoko MORI[1], Atsuhiko KINOSHITA[1], Hideaki MIZUNO[1], Katsushi KAWATO[2], Minoru OKUMURA[2], Ryota KAGEURA[2]

1.Public Works Reserch Institute, 2.Nippon Engineering Consultants Co.,LTD.

Frequency of Deep-seated catastrophic landslide is less. However, this phenomena have potential to add serious damage by a lot of sediment. Therefore, it is important to develop extraction method of scale and areas tending to cause deep-seated catastrophic landslide. In previous studies, they studied about how to estimate depth of collapse in the areas tending of cause deep-seated catastrophic landslide using airborne electromagnetic method. As these results, in the areas of past deep-seated catastrophic landslide, it confirmed that there were values of high resistivity at shallow layer. However, there are lack of further studies that how resistivity is affected by geology and groundwater. Therefore, purpose of this study is to understand relationship between resistivity distributions and underground structure.First, we created figures of resistivity distributions of airborne electromagnetic method in pluvial period and not pluvial period. Then, we compared these figures. Next, we estimated groundwater level in studies areas using results of borehole surveys. Last, we compared figures of resistivity distributions and estimated water level. Then, we considered about relationship resistivity distributions and groundwater level.In this study, it was found that the following. In pluvial period, ground plan of resistivity distributions have many low resistivity than not pluvial period. Then, in pluvial period, it confirmed that changes zone of resistivity were unclear. Therefore, it confirmed that there was difference in distribution of resistivity between pluvial period and not pluvial period. It is assumed that groundwater distribution are affected. Then, it confirmed that changes zone of resistivity were generally consistent with ground water level by results of compared with cross section of resistivity and borehole.

Keywords: Deep-seated Catastrophic Landslide, Airborne Electromagnetic Method, Resistivity

Relationship between the average depth of a causative layer and the power spectrum of the vertical gradient component of a gravity gradient tensor

*Shigekazu Kusumoto[1], Motonori Higashinaka[2]

1.Graduate School of Science and Engineering for Research, University of Toyama, 2.JGI, Inc.

In recent decades, six components of the gravity gradient tensor have been observed by gravity gradient exploration, and techniques for estimating the subsurface structure using these data have been studied and developed (e.g., Zhang et al., 2000; Beiki and Pedersen, 2010; Barnes and Barraud, 2012; Martinetz et al., 2013). In such research, filtering to extract the specified wavelength from the total gravity gradient tensors is not conducted frequently for subsurface estimations. One reason for this omission is that the wavelength characteristics differ among the components of the gravity gradient tensor. Filtering is an important data processing method for estimating subsurface structures. When this technique is applied, it is necessary to determine the relationships among the components of the gravity gradient tensor and subsurface structures. In the case of a gravity anomaly, the well-known relationship between the power spectrum and the average depth of the subsurface layer plays an important role in the filtering. Such relationships for the gravity gradient tensor have not been shown thus far. Therefore, we attempted to derive the relationship between the average depth of the causative subsurface layer and the power spectrum of the vertical gradient component of the gravity gradient tensor. Although the gravity gradient tensor has six components, we employed only the vertical gradient component because it has often been used for interpreting data and for estimating subsurface structures. We derived an equation for this relationship, which is shown to be nonlinear in the semi-logarithmic scale. We applied the equation obtained in this study to the vertical gradient component of the gravity gradient tensor observed in the Kuju geothermal area of central Kyushu, Japan, and we obtained results that are consistent with the average depth estimated by spectrum analysis of the gravity anomaly. However, we determined that the equation cannot estimate the average depth of the subsurface layer at the longest wavelength range. In addition, the wavenumber range giving the same average depth as that given by spectrum analysis of the gravity anomaly shifts to a higher and wider wavenumber range.
[Acknowledgment] We are grateful to JOGMEC which permits us to use gravity gradient tensor data obtained in Kuju geothermal area, Kyushu, Japan. A part of this study is supported partially by JSPS Kakenhi 15K14274.
[References] Barnes and Barraud, 2012, Geophysics, 77, G1-G11.; Beiki and Pedersen, 2010, Geophysics, 75, I37–I49.; Martinetz et al., 2013, Geophysics, 78, B1-B11.; Zhang et al., 2000, Geophysics, 65, 512-520.

Keywords: Gravity gradient tensor, Spectrum analysis, Average depth of causative layer

Gravitation exploration as an estimation procedure of a causative potision

*Shigekazu Kusumoto[1], Hitoshi Morikawa[2]

1.Graduate School of Science and Engineering for Research, University of Toyama, 2.Department of Built Environment, Interdisciplinary Graduate School of Science and Technology, Tokyo Institute of Technology

In this study, we propose a new method for estimating the location of a causative body based on the relationship between the body and its three gravitational vector components. The relationship was derived based on the fact that the angle between the observation points of gravitation and the causative body is equal to the angle between the horizontal and vertical vectors of gravitation, and a non-linear equation was obtained. Accordingly, the location of a causative body can be estimated by using a non-linear least square method such as the Gauss-Newton method. Our proposed method is not an inversion method but belongs to the category of semi-automatic interpretation methods such as Euler deconvolution. However, additional information such as the structural index in Euler deconvolution is not required for the calculations in this method, and the location of the causative body can be estimated by providing only the window size for the analysis. In order to confirm the efficacy of this method, we conducted numerical tests using a simple sphere model and a rectangular model. While according to the tests in the sphere model, the 3-D location of the body was estimated correctly, the rectangular model showed the shape to have been estimated correctly. A comparison of the results by this method with those by Euler deconvolution showed the depth estimated by the former to be higher than that obtained by the latter.
[Acknowledgment] This study was supported by JSPS KAKENHI Grant NUmber 15K14274.

Keywords: Gravitation exploration, Euler deconvolution

