Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

STT58-01 Room:313 Time:April 30 16:15-16:30

Regional Airborne Survey for the Evaluation of Geothermal Potential in Japan

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Japan Oil, Gas and Metals National Corporation (JOGMEC) supports smooth development of geothermal resources in Japan by providing assistance to geological, geophysical, and well-drilling surveys, equity capital or liability guarantees, and information and data on geothermal resources.

As part of them, we planned to conduct evaluation of geothermal potential with airborne technique of gravity gradiometer method and time-domain electromagnetic method.

The gravity gradiometer method measures the differential of gravity, and provides information of much detailed geological structures. The time-domain EM method provides deeper penetration data than the frequency-domain EM method.

Since these methods are state-of-the-art techniques, we demonstrated them first in a couple of area with relatively high geothermal potentials and a lot of surveys conducted.

We carried out airborne survey with the technique of the gravity gradiometer method in the Kuju and the Kirishima areas in 2013. We would like to introduce the result of the airborne survey.

The authors thank local municipalities and related organizations for their understanding and cooperation to conduct the airborne survey.

Keywords: airborne survey, geothermal resources, gravity, gravity survey, electromagnetic survey

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Study on the prediction of the deep catastrophic landslide using the Airborne Electromagnetic Survey

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Recently, the deep catastrophic landslides were occurred frequently including the disaster of the Kii peninsula by typhoon 12 in 2011. The risk evaluation is demanded to be carried out the measures that we can assume at the both sides of the method constructing sabo dams and evacuation method. Recently, the airborne electromagnetic survey is performed a close-up to evaluate the risk of them. Merits of the airborne electromagnetic survey include that a geological feature border in conjunction with the deep catastrophic landslides having possibilities to become clear, hydrological properties may become clear. On the other hand, there is the uncertain element such as the decision method of the ratio resistance level of the geological feature border and the groundwater not being clear. In this study, we have arranged the results such as in the airborne electromagnetic survey, a geological survey, the hydrological investigations for the points where the deep catastrophic landslides were occurred and where airborne electromagnetic survey was carried out so far. The study areas are Byutano river basin (is about 4.4km2), Fujikawa river basin (about 3.7km2), Himekawa basin (about 15.2km2), and Kumano river basin (about 10.1km2). In these areas, in the past, the deep catastrophic landslides were occurred and the airborne electromagnetic surveys were carried out.

First, we have examined ratio resistance properties every area by the airborne electromagnetic survey. The range of the ratio resistance level to appear in the area for showed 1-2400 Ω-m in 1-1200Ω-m, the Kumano river basin in the Himekawa river basin whereas it was 1-400Ω-m in Byutano river basin and the Fujikawa river basin, and the distribution of the ratio resistance level knew that there was a difference by a geological feature and an area. And we have found that there were three patterns of the distributions of the resistance when we have paid our attention to the ratio resistance pattern of the plumb directions from the surface of the slope at the point with the fear of the deep catastrophic landslides to the deep part. From this, the depth that a ratio resistance level changes in the plumb direction may become the fundus of the deep catastrophic landslide. Boring investigations were carried out in Byutano river basin, Fujikawa river basin, Himekawa river basin, and a weathering department and the geological feature border of the virginity part are authorized by the observation of the boring core. The ratio resistance level corresponding to this geological feature border indicates 100Ω-m in Byutano river basin, 70Ω-m in Fujikawa river basin, and in Himekawa river basin indicates 500Ω-m, 680Ω-m, 1000Ω-m.

From these, it was confirmed that the ratio resistance level to correspond to appearance frequency and the geological feature border of the ratio resistance level varied according to an area and a geological feature. Therefore, it is necessary to carry out the risk evaluation of the deep catastrophic landslide after carrying out a boring investigation in addition at a representative point when we carry out the airborne electromagnetic survey, and having arranged a geological feature and the relations of the ratio resistance level.

In addition, at the deep catastrophic landslide point of Kumano river basin, consecutive low ratio resistance zones and the low ratio resistance zone of the plumb direction are common to the valley part from the ridge and are confirmed and agree with the groundwater situation by the hydrological investigation. We need to accumulate data about the ratio resistance structure in conjunction with the deep catastrophic landslide and want to examine the extracting method of the point with the fear of the deep catastrophic landslide, an estimate method of the collapse depth and collapse volume in future.

Keywords: Airborne Electromagnetic Survey, deep catastrophic landslide

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Study on the prediction of the large landslides of the volcanoes using the Airborne Electromagnetic Survey

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In the lower basins of the active volcanoes, there are always the risks that sediment disasters are occurred. Especially, when large landslides are occurred at the time of heavy rains, the landslide sediment become a debris flow and makes a big damage by the sedimentation and the flooding in a lower basin. In late years,the Airborne Electromagnetic Survey is performed a close-up of as means to predict these large-scale landslides. It is necessary to estimate establishing technique to estimate a collapse side, the water sentence process in the slope to predict the slope where there is possibility of the collapse in at the time of heavy rains, but is the situation that is hard to say to be considered about these enough currently.Therefore, in this study, we havetaken Mt. Azuma and Mt. Fuji examples and examined the estimate technique of the collapse side and technique to predict a water sentence process from the result of a geological survey and the quality of the water investigation that we carried out the airborne electromagnetic survey in addition.

First, we performed the documents investigation into the characteristics of the topography, the geological feature, results of the sediment disasters, volcanic activity history there. Next, we performed a field work and confirmed the quality of soil structure in conjunction with the landslides, hydrothermal alteration situation causing the landslides and the hot spring gush situations. We examined areas of the airborne electromagnetic survey in reference to these results.We decided that the top of the mountain body and the representative craters were included and did the investigation object with the area including inclines more than 15 degrees that landslides were possible.The exploration area of Mt. Azuma was about 18km2 and the exploration area of Mt. Fuji was about 120km2.We have arranged themevery depth two-dimensionally so that we could recognizethe result of the helicopter electromagnetic explorationregionally.And, at the area where sediment disasters were easy to be occurred, there were some craters and water level under the ground were high, we have arranged them every depth two-dimensionally so that we grasped ratio resistance levels of the depth direction for running. We have verified the result of the airborne electromagnetic surveyby Comparing with the investigation results of the topographic and geological features.In addition, we investigated hydrology and water quality of the water at 10 neighboring streams in Mt.Azuma for the purpose of confirming the result of the airborne electromagnetic survey in detail.The investigation items werewater discharge, electric conductivity, pH, water temperature and ion silica concentration. In addition, we have carried out the boring investigation for the purpose of checking the ratio resistance levels by the airborne electromagnetic survey and the relations with the geological feature in Mt.Fuji.

We have found that by using the airborne electromagnetic survey in volcano area we could roughly grasp the geological features and underground water levels.From this, wecouldroughly predict the slopes that may collapse at the time of a heavy rain by using the airborne electromagnetic survey. On the other hand, we cannot estimate the collapse depth and the collapse volume in detail when it is only the airborne electromagnetic survey.It is necessary to supplement the results of the in the airborne electromagnetic survey by carrying out other investigations which arethe boring investigations and physics explorations on the ground, the waterquality and hydrological investigation to estimate these.In the near future, we will carry out the investigations including the airborne electromagnetic survey for models in some volcanoes and want to establish the estimate technology of the collapse dangerous points in the volcano areas, estimate technique of the collapse depths and collapse volume by accumulating data.

Keywords: airborne electromagnetic survey, large landslide, volcano

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Verification of the tunnel geological structure based on the helicopter-borne magnetometry data analysis

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1. Introduction

More detailed geological information of tunnel ground is very important for its construction. Especially, geological complicated area, such as accretionary complex, is needed more accurate information for process control and avoidance of risk during construction of tunnels. The authors carried out helicopter-borne magnetic survey to verify its applicability for geotechnical evaluation of a mountainous planned road tunnel in east Hokkaido, Japan. We describe corresponds with the results of the geological profiles estimated from the outcomes of tunnel construction records and its analysis results of magnetic anomalies which was obtained by helicopter-borne magnetometry data.

2. Outline

The geology of the study area is mainly consists of greenstone, pyroclastic sedimentary rock and hyaloclastite, and is mixed with pillow lava, chert and limestone. Many faults are formed in the area around the survey site due to tectonic movements at the time of formation of the accretionary complex and after that. Surveyed tunnel is planed to 910 m long and maximum overburden is 150 m. The magnetic intensity was measured from a helicopter at low altitude using a cesium magnetometer, and a magnetic intensity map was compiled based on the scalar volume of the magnetic force after reduction to pole magnetism. The probable geological model of the tunnel profile was analyzed using the magnetic anomaly pattern. The forward modeling process for the magnetic data was conducted using Mag2dc software (Cooper, 2003) based on the Talwani algorithm for calculation anomalies. The forward modeling was carried out according to the type of magnetic anomaly over blocks/steps, dependence of anomaly on width, depth, susceptibility contrast and dip angle. The tunnel geological models that estimated using the magnetic anomaly pattern were verified by the geological properties from tunnel construction records.

3. Results of survey

Results of this survey, executed in a mountainous area where accretionary complexes are distributed, are summarized as follows:

1) Helicopter-borne magnetic survey was carried out for a tunnel in northeastern Hokkaido and magnetic intensity map was figured. By the correlation to the other results such as the geological survey or the observation of rock type and fracture shear and conditions in advanced core, high magnetic intensity zone corresponded to the sedimentary rock and the fracture and shear zone of hyaloclastite and massive basalt.

2) Two geological models were made by combining helicopter-borne magnetic survey results with geological survey results and magnetic intensity model. The models were correlated to the detailed data obtained by advanced boring core observation, and these distributions are roughly confirmed by advanced boring core observation.

3) In this case study, helicopter-borne magnetic survey provided useful information for effective interpretation. To analyze geological structure by helicopter-borne magnetic survey is very effective to evaluate potential geotechnical issues when excavating a tunnel.

Keywords: helicopter-borne magnetic survey, magnetic anomalies, accretionary complex, road tunnel

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Magnetic structure of the tsunami inundation area of the 2011 off the Pacific coast of Tohoku Earthquake

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In June 2012, the Geological Survey of Japan (GSJ) conducted an airborne EM and magnetic survey over the inundation area by the tsunami of the 2011 off the Pacific coast of Tohoku Earthquake, northeast Japan. The purpose of the survey was mainly to map the resistivity of the subsurface structure associated with sea water invasion by the tsunami. Airborne EM data were successful for revealing the subsurface resistivity distribution as an aid for groundwater assessment of the study area.

Aeromagnetic data were also observed by the survey and processed (Okuma et al., 2013). However, it turned out that the magnetic data seem to be contaminated by artificial noise with amount of ˜20nT probably caused by the survey helicopter. To mitigate directional errors (Herringbone effect), the generalized mis-tie control method (Nakatsuka and Okuma, 2006) was applied to the observed magnetic data and magnetic anomalies were reduced onto a smoothed observation surface. According to the compiled aeromagnetic anomaly map of the Southern Sendai Plain, magnetic highs lie over the Cretaceous granitic rocks with high magnetic susceptibilities (˜10^{-2} SI; PB-Rock 21) outcropping on the north-trending Wariyama Mountains, which may constrain the groundwater flow system. The magnetic highs also extend NE and reach the Pacific coast, implying the existence of Cretaceous granitic rocks. In a map of the Matsukawaura area, an obvious magnetic high lies over the northern edge of the lagoon without any signatures of magnetic sources on surface. To better understand the subsurface structures of the survey areas, we applied 3D imaging (Nakatsuka and Okuma, 2013) to the observed magnetic anomalies. The preliminary results of the imaging indicate magnetization highs lie below the Wariyama Mountains and coastal regions between the Torinoumi Lagoon and Ushibashi river mouth in the Southern Sendai Plain. An obvious magnetization high is present below the northeastern edge of the Matsukawaura Lagoon, corresponding to granitic rocks with high magnetic susceptibilities (˜10^{-2} SI; PB-Rock 21) at a depth of around 300m below the surface in a hot spring exploration well. The details of the 3D imaging will be shown in the presentation.

Keywords: airborne EM survey, tsunami, groundwater environment, aeromagnetic survey, magnetic structure, basement

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Repeated aeromagnetic surveys in Shinmoedake volcano, Japan, by using an unmanned helicopter

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After the 2011 eruptions of Shinmoedake volcano in Japan, we conducted three repeated aeromagnetic surveys around this area, by using an autonomously driven unmanned helicopter. Shinmoedake volcano had sub-Plinian eruptions in the end of January 2011 and its vent was filled by uprising intrusive lavas. After that, some Vulcanian eruptions followed, and then volcanic activities were decreasing gradually up to the beginning of April 2011.

After these events, we conducted aeromagnetic surveys in the end of May 2011, the beginning of November 2011, and the end of October 2013. The Yamaha RMAX-G1 unmanned helicopter was used for our surveys, which was usually used to spray the agricultural chemicals to fields, and can make flights following the programmed tracks within about 1 m precision. Availability of precise flights are a great advantage for repeated surveys in order to detect easily the changes of circumstances, such as, geomagnetic changes due to volcanic activities by measuring at the same positions. Almost 85 km flights in total were made in every survey with a flight speed of about 10 m/s. Flight heights above the ground were almost kept in 100 m.

As the result of some data processing, we clearly detected the change of the magnetic fields around the vent of Shinmoedake, which has a kind of a dipolar pattern with positive changes in South and negative changes in North. This indicates a region around the vent got magnetization due to cooling. The intrusive lava is supposed to be the source of magnetization, and 2.0x10ˆ7 Amˆ2 magnetization of lava is evaluated at the second survey (0.5yr) and 4.8x10ˆ7 Amˆ2 is evaluated at the third survey (2.5yr), compared with the first survey. This means the magnetizing rate is almost related to a square root of the elapsed time and it leads to an implication the lava cooling is dominantly made gradually by thermal diffusion, not by other cooling processes such as thermal convection. The common thermal diffusivity of rocks, however, is too small by one order of magnitude to explain this cooling rate, and intrusion of water in lava, say, rainfall water, may play an important role to raise the effective thermal diffusivity to make the lava cool.