Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

STT03-P01 Room:Convention Hall Time:May 23 17:15-18:30

Magnetic Constraints on the Basement Structure of the Northern Kyushu, Southwestern Japan

OKUMA, Shigeo[1*], NAKATSUKA, Tadashi[1]

[1]Geological Survey of Japan, AIST

Aeromagnetic anomalies in the northern part of the Kyushu Island, southwestern Japan were reduced onto a smoothed surface of 1,500 m above terrain to compile a new aeromagnetic anomaly map (total magnetic intensity) on a scale of 1:200,000 (Okuma et al., in press). The reduction to the pole anomalies were calculated from total magnetic intensity anomalies as well and compared to the geology (Ozaki et al., in press) and rock magnetic properties (Petrophysical Database of Basement rocks in Japan for the 21st Century (PB-Rock 21), http://riodb02.ibase.aist.go.jp/pb-rock21/index.html) of the area.

In general, the aeromagnetic anomalies seem to be associated with the outcrops of basement rocks such as late Cretaceous granitic rocks and Paleozoic ultramafic rocks. As for magnetic susceptibilities of the late Cretaceous granitic rocks, there are obvious differences among them: older and younger members of late Cretaceous granitic rocks show magnetic susceptibilities equal and higher than 10^{-3} (SI) and lower than 10^{-3} (SI), respectively. Exceptions are older late Cretaceous granitic rocks east of the Tagawa-Kokura fault, which show magnetic susceptibilities lower than 10^{-3} (SI). Magnetic highs lie mainly over the older late Cretaceous granitic rocks and reflect their high magnetic susceptibilities.

The most obvious magnetic anomaly of 400 nT is distributed with a wavelength of about 50km in the E-W direction over the Seburi Mountains southwest of Fukuoka. To better understand the subsurface structure of the area, 3D imaging with source volume minimization (Nakatsuka and Okuma, 2009) was applied to the aeromagnetic anomalies. An E-W cross-section of the 3D magnetic model shows the magnetization high area of 1.0 A/m occupies the Seburi Mountains with a thickness of 20km. According to the seismic activity of the area from 1923 to 2008, major earthquakes with magnitudes larger than 3.0 seem to have occurred only at the boundary of the magnetization high area but not inside. This suggests the magnetization high area indicates the distribution of the granitic body of the Seburi Mountains.

Keywords: magnetic anomalies, aeromagnetic anomaly map, rock magnetic property, 3D imaging, Kyushu

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Aeromagnetic 3D subsurface imaging and its application to the data of Otoge Cauldron, Shitara area, Central Japan

NAKATSUKA, Tadashi[1*], OKUMA, Shigeo[1]

[1]Geological Survey Japan, AIST

In survey methods using potential field such as in aeromagnetics, there is a theoretical difficulty of non-unique source solution for the observation, whereas data includes structural information of wide depth range. In order to overcome this difficulty, the analysis methods with any structural regularization have been developed, and the validity of the strategic regularization would be a primary concern in practice.

We have developed a software of aeromagnetic 3D subsurface imaging, which is applicable to helicopter-borne magnetic (total force) surveys in mountainous regions, and based on the compact regularization to constrain source magnetization succeeding the idea developed by Last and Kubik (1983), Portniaguine and Zhdanov (2002). Our method accepts the surface undulation and variable thickness slicing of model layers, and the regularization criterion of minimum effective source volume is adopted.

The software was first applied to synthetic and geologic models to evaluate its characteristic ability of recovering source structure and to examine the efficiency of the method. In spite of the intrinsic difficulty of the non-unique problem, the results revealed that good recovery of subsurface image can be achieved by a proper choice of trade-off parameter to assure the compactness, and it was proven that the compact regularization is useful to interpret magnetic anomaly data in terms of 3D source configuration.

The helicopter-borne magnetic survey data in the Shitara area was put into analysis by this 3D imaging software. The geology of Shitara area is characterized by middle Miocene Otoge and Shitara igneous complexes, the Otoge Cauldron structure with stock, and post-cauldron intrusions of dike swarms (Otoge cone sheets and Shitara central dike swarm). The 3D imaging analysis of magnetic anomalies revealed the magnetization structure (to the depth of 3000m) of the magma reservoir of Otoge Cauldron, the Otoge cone sheets, and Otoge stock, to be consistent with existing studies from surface geology.

Keywords: aeromagnetic, 3D imaging, compact inversion, source volume minimization, helicopter survey, Otoge Cauldron

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Performance of digital servo sensor for gravity survey using a carrier

OGURA, Yumiko[1*], Yokoi Isamu[2], Suda Haruo[2], TOKUE, Satoshi[1], MORIKAWA, Hitoshi[1], KUSUMOTO, Shigekazu[3]

[1]Tokyo Institute of Technology, [2]Tokyo Sokushin CO., LTD, [3]Graduate School of Science and Engineering for Research, University of Toyama

Modeling ground structure is one of the most important topics for the estimation of seismic hazard these days. Gravity survey is one of exploration methods. We can estimate ground structure by using information of gravity anomaly which comes from heterogeneous density structure of the ground. Generally speaking, there are high correlation between density and velocity structure of the ground. Thus, the gravity survey is comparatively easier than other exploration method to estimate the ground structure, so that it is very suitable for the aspect of the seismic hazard projection.

For the gravity survey, spring-type relative gravimeter is usually used. This type of gravimeter can provide accurate data. However, it is very expensive and difficult to handle. Furthermore, it takes much time to obtain adequate data. From these reasons, data which is required to model ground structure is not so enough in the present time.

Under such background, we began to develop a simple and inexpensive sensor which can measure anomaly on a mobile carrier, such as vehicle, ship, aircraft, and so on. In a case where a gravimeter is used with a mobile carrier, we may survey the gravity over larger area in shorter time than using conventional survey techniques. Generally speaking, for the gravity survey, the gravity should be measured with resolution of 10 micro Gal at least. However, the signal obtained from gravimeter is contaminated by various noises: vibration of a carrier, circuit noise of a system, fluctuation of temperature, and so on.

Thus, we have to develop a sensor, and a method to analyze observed data, which can provide accurate data of gravity under very noisy environment.

We have developed a new sensor with digital feedback system, which has high resolution and large dynamic range. The performance of the sensor is examined in this study. For this purpose, two different types of observations were carried out.

From the static observation in a tunnel, it is found that the sensor can respond to gravity caused by the earth tide. Furthermore, we can say that the algorithm of digital feedback system has room for improvement.

From the observation on a ship, high frequency vibration which has big amplitude makes the gravity blind. If the carrier's vibration is so strong, it is impossible to estimate gravity using simple filtering. However, we can obtain the signal correspond to the gravity from Hilbert Huang Transform (HHT).

Keywords: gravity survey, digital feedback system, Hilbert-Huang transform

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THREE-DIMENSIONAL MODELING STUDY OF SEA EFFECTS ON EM FIELD INDUCTION USING GREATEM SYSTEM

ABD ALLAH, Sabry[1*], MOGI, Toru[1]

[1]ISV Hokkaido University

To understand the sea effects on electromagnetic field (EM) induction at sea-land boundary using GRounded Electrical source Airborne Transient ElectroMgnetics (GREATEM) system, we computed time-domain EM responses for 3D structures applying a 3D EM modeling scheme based on finite difference (FD) staggered rectangular non-uniform grid formulation for the secondary electric field with continuous components of tangential electric and normal magnetic fields (Fomenko and Mogi, 2002).

The 3-D response were calculated by computing secondary EM field originating by 3D anomalies which induce the primary EM field on a horizontal multi-layer structure by a grounded electrical dipole source. Time-domain responses were computed by the sine or cosine transformation from the frequency-domain data. The range of computing in frequency-domain is 10000 to 0.01 Hz and transient time responses were obtained at 0.0001 to 1 sec. The models consisted of two adjacent layers of different conductivity, where the sea is very thin sheet of a perfect conductor placed on top of a uniform half space earth medium. The EM responses are calculated for different models when the grounded electrical source is located at (10, 20 and 300m) of coastline in landward and the uniform half space earth medium resistivities vary from high resistive host rock (100 ohm m) to high conductive host rock 1 ohm m.

The 3D modeling results have shown that, the sea effect on EM field induction at sea-land boundaries using GREATEM system is function in the distance between the ground electrical source and coastline, for example the sea effect EM field induction in case the source is located at 10m or 20m of coastline in landward is higher than the case when the source is located at 300m of coastline in landward. Also the sea effect on EM field induction at sea-land boundary is function in the host rock resistivity, for example in case the host rock resistivity is 100 ohm m the effect of sea on EM field is higher than the case when the host rock resistivity is 10 ohm m.

Keywords: AEM, GREATEM, 3D EM modeling

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Applicability of grounded-source airborne electromagnetics to coastal areas: Northwestern Awaji Island case

TSUKUDA, Kazuhiro[1*], ITO, Hisatoshi[1], KIHO, Kenzo[1], Hideshi Kaieda[1], Koichi Suzuki[1], MOGI, Toru[2], Akira Jomori[3], YUUKI, Youichi[4], ABD ALLAH, Sabry[2]

[1]CRIEPI, [2]Hokkaido Univ., [3]NeoScience Co., [4]Oyo Co.

Understanding geological and hydrogeological characteristics in coastal areas is important in many ways and especially for siting of geological disposal of nuclear wastes. We have developed a type of airborne electromagnetics (AEM), called grounded electrical source airborne transient electromagnetics, or GREATEM, in which we have succeeded to increase the depth of investigation from conventional 200 m to 300-350 m in an alluvial coastal plain, Kujukuri, Japan. Here, we present another application of GREATEM to northwestern Awaji Island. Compared to Kujukuri, the northwestern Awaji Island is a rugged mountainous area, and hence much difficult to apply AEM. It is also characterized in that granitic rocks are widely distributed and a distinct fault, the Nojima fault, which was activated in the 1995 Kobe earthquake, lies parallel to the coastal line. Our temporary conclusions are as follows: Although it is difficult to obtain the exact electric resistivity value for granitic basements, remarkable differences exist between onshore and offshore underground resistivities. By applying a slow flight speed of ˜40 km/h, we could obtain offshore underground resistivities to a depth of ˜500 m, which should be the world's deepest investigation depth by AEM.

Keywords: Airborne electromagnetics, Geological disposal, Coastal area, Awaji Island

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Remote radiation monitoring of radioactive cesium by unmanned helicopters at the soil contaminated area in Fukushima

SANADA, Yukihisa[1*], KONDO, Atsuya[1], Takeshi Sugita[1], YUUKI, Youichi[2], TORII, Tatsuo[1]

[1]Japan Atomic Energy Agency, [2]OYO CORPORATION

By the nuclear disaster of Fukushima Daiichi Nuclear Power Plant (NPP), Tokyo Electric Power Company (TEPCO), caused by the East Japan earthquake and the following tsunami occurred on March 11, 2011, a large amount of radioactive materials was released from the NPP. An emergency radiation monitoring, in order to evaluate the effects of such radiation on the surrounding environment, as well as ground measurements were conducted from the sea and air. As a means of radiation monitoring from the air, aerial monitoring using manned helicopters was conducted in the whole area of East Japan. Although manned helicopters can monitor a large area in a short time, flight at an altitude of 150 m or lower is prohibited by the Aviation Law in Japan. Therefore, it is difficult for a manned helicopter to measure the radiation profile near the ground and to measure the radiation level in a complicated terrain. In recent years, technologies for autonomous unmanned helicopters (AUHs) have been developed and applied to natural disasters. In expectation of the application of the AUHs to aerial radiation monitoring, we had developed a remote radiation monitoring system. Then, we measured the radiation level by using unmanned helicopter in soil contaminated areas by radioactive cesium emitted from the NPP to evaluate ambient dose-rate distribution around the areas and to investigate the decontamination effect by the measurements before and after decontamination treatment. Here, we reports on the measurement technique and the result.

This system we used is mounted a plastic scintillation detector (size: 270 x 300 x 20 mm) on the AUH (RMAX G-1, Yamaha Motor Co., Ltd.), and can fly for the destinations and return by the automatic operation, and the radiation data can be measure during the flight. Radiation data are transmitted immediately with image and position data to the monitoring station on the ground. It is possible to monitor these data on the map of the computer display in the real time. At this time, we have fled the AUH at 30 - 50 m high above the ground in the contaminated areas around the NPP. Furthermore, this system was also installed two GPS sensors on the AUH, and measured the latitude, longitude, and the flying altitude at the same time. The flying altitude from the ground was obtained by subtracting the altitude obtained by the DEM (digital elevation model) data from that of the helicopter. The attenuation coefficient of air was obtained by flying at some altitudes (5 - 50 m) in above the test-line selected for the comparison with the ground data. Moreover, the conversion coefficient of the ambient dose-rate was calculated by the comparison of the ambient dose-rate measured by an NaI survey-meter with the counting rate at 1m height evaluated by using the attenuation coefficient. Finally, we made maps of ambient dose-rare distribution from the analyzed results of radiation by using a GIS software.

In addition, we developed a system using a manual operated unmanned helicopter to fly complex terrain and measure the radiation in narrow areas. In this system, both a CCD camera and a GPS sensor are installed besides a radiation detector using a plastic scintillator, we can measure the radiation, the monitoring position and image in real time.

We present the outline of these systems and the measured results obtained in Fukushima Prefecture.

Keywords: unmanned helicopters, airborne survey, radioactive cesium, the nuclear disaster of Fukushima Daiichi NPP