

## 無人ヘリコプターを利用した樽前山の空中磁気測量 Aeromagnetic survey using an unmanned autonomous helicopter over Tarumae volcano

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### 1. Introduction

Recently, a remote measurement technique using an unmanned autonomous helicopter is being developed (e.g. Kaneko et al., 2010). Further improvement of suitable instrumentation and operation techniques are, however, necessary for the application to volcanic fields. Hokkaido Regional Development Bureau (HRDB) has similar type of helicopters for the purpose of disaster survey in hazardous zones at an emergency. The authors and HRDB performed a field experiment by using the helicopter over the summit atrio of Tarumae volcano in 2011. Aerial imaging, experimental installation and collection of a seismometer unit, and an aeromagnetic survey were conducted in the fieldwork. We report the results of the aeromagnetic survey, which was the first low-altitude, dense magnetic survey for Tarumae.

### 2. Measurements results and data processing

The aeromagnetic survey was performed on September 27, 2011 over the summit atrio. The unmanned helicopter (YAMAHA RMAX-G1) was used as a platform with the aid of real-time differential GPS navigation. Magnetic field was recorded in the Geometrics G858 optical-pumping magnetometer at 10 Hz sampling. Differential magnetic field was obtained taking the simple subtraction of the field at the grounded reference station to reduce the magnetic variations of upper-atmospheric origins. In this study, we inverted the magnetic anomaly map into a non-uniform magnetization model using the code of Kaneko et al. (2010) with a small modification. We modeled the topography-related anomalies by using the 10m-mesh DEM which was provided Geospatial Information Authority of Japan (GSI). Non-uniform distribution of magnetization was modeled as an ensemble of vertical prisms of 100 x 100 m size. In the inversion, we evaluated the objective function as the sum of the L2 norm of the difference between modeled and measured fields, and the norm of the deviation magnetization. We here did not fix a priori the DC component of the magnetic anomaly. We performed the inversion for several values of the DC offset to obtain the optimized set of model parameters which minimizes the ABIC.

### 3. Modeling result and discussion

We obtained an averaged magnetization as 5.3 A/m. The summit lava dome showed the magnetization of 3-6 A/m. Meanwhile, relatively small magnetization of 2-4 A/m was estimated at the southeastern part of the dome (which is called 'crater A') and the areas around Nishiyama and Higashiyama mounds at the crater rim. In contrast, northwestern part of the atrio showed relatively strong magnetization (5-8 A/m) compared to the dome itself. These results are consistent with the rough estimation by Sakuma and Murase (1956) based on the magnetic inclination anomaly by using a uniformly magnetized ellipsoid, in which magnetization of the dome and the edifice is estimated as 6-8 A/m and 2-3 A/m, respectively. Such variability may be attributed to the difference in magnetization between blocky lava and pyroclastic deposits, as well as to chemical demagnetization due to persistent fumarolic activity at several vents.

From the viewpoint of an aeromagnetic survey, high positioning repeatability is one of the most advantageous features of such an unmanned autonomous helicopter. Optimized operation of the system would enable us to detect temporal changes associated with volcanic activity in the future.

Acknowledgments: The authors express sincere thanks to Muroran Development and Construction Department, and Sapporo Development and Construction Department of HRDB for the cooperation in the field experiment using their unmanned helicopter. Yamaha Motor Co. Ltd. is deeply acknowledged for their technical support in the field operation. We thank S. Okuyama for the preconditioning of the DEM used in the modeling. This study was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Observation and Research Program for Prediction of Earthquakes and Volcanic Eruptions.

Keywords: geomagnetic field, Tarumae Volcano, unmanned helicopter, magnetic total force

## 航空重力測定における効果的な鉛直加速度補正 Effective vertical acceleration correction in airborne gravity measurements

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日本ではヘリコプターを用いた独自の航空重力測定システムの開発が進められてきた。GPS の利用を除く全システムの国産化が図られ、ヘリコプター搭載型重力計 SEGAWA Model が製作された。SEGAWA Model は、往復残差平均約 1.6mGal という、高水準の再現性をもっている。しかしながら、最も補正量の大きな鉛直加速度補正の最適化、水平加速度補正、フィルタ処理法については、まだ改善の余地が残っている。そこで、これらのデータ処理法について考察を行い、データ品質のさらなる向上を目指していく必要がある。

本研究では、航空重力測定後に行われる補正計算のうち、最も大きな補正量である機体鉛直加速度補正の補正方法について行った考察を報告する。考察した事項は、重力計から出力される 0.1 秒データを 1 秒データに変換する際に、GPS から推定される機体鉛直加速度 (1 秒データ) と最も高い相関をもつように、データ変換開始時刻を変更する。さらに、重力計出力データのシグナルレベルと、GPS から推定される機体鉛直加速度のシグナルレベルを揃えてから種々の補正計算を行う。の考察の結果、2000 年 4 月 27 日のフライトについては、データ変換開始点を -0.8 秒ずらしてやることで、従来の手法によるものと比べて、往復残差平均が 1.2 mGal 改善されることが示された。また、の考察の結果、従来の手法で採用されていたフィルタ幅を、データの品質を著しく落とすことなく、50 秒程度短くできることが示された。

キーワード: 航空重力測定, ヘリコプター航空重力測定, 鉛直加速度補正

Keywords: air-borne gravity measurement, helicopter-borne gravity measurement system, vertical acceleration correction

## Airborne electromagnetic investigation of the freshwater potential in northern Sumatra after the Tsunami of 2004

### Airborne electromagnetic investigation of the freshwater potential in northern Sumatra after the Tsunami of 2004

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The earthquake at the west coast of northern Sumatra, Indonesia, and the tsunami of 2004 caused the loss of life of a huge number of people and the destruction of houses, basic infrastructure and public facilities. With the tsunami large scale saltwater intrusions crept over the coastal regions and destroyed thousands of shallow water wells. The supply of a sufficient amount of potable water in all populated areas was complicated as many water pipes were broken by the earthquake and a huge number of dug wells were unusable. Many new drillings were not successful in finding potable water due to the lack of information about local hydrogeological conditions. Therefore, the Indonesian and German governments set up a project dedicated to re-install the public life of the people living in the coastal regions of northern Sumatra. The focal point of this "HELicopter Project ACEH" (HELP ACEH) was water assessment along the shorelines of Aceh. In order to get a fast overview on the remaining freshwater resources and to assist the Indonesian authorities as well as numerous aid organisations in finding suitable locations for drilling new water wells three helicopter-borne surveys including electromagnetics, magnetics and gamma-ray spectrometry were conducted by the airborne group of the German Federal Institute for Geosciences and Natural Resources (BGR) from August to November 2005 (Siemon and Steuer, 2011).

As the mineralisation of water correlates with its electrical conductivity and therefore freshwater and saltwater can be distinguished in general, it was hoped that electromagnetic data would reveal freshwater resources not destroyed by the tsunami, particularly close to the populated coastal areas. The target areas were the city of Banda Aceh with the district of Aceh Besar on the north coast and the area on the west coast between the towns of Calang and Meulaboh in the district of Aceh Barat (Siemon et al., 2007). In addition to that, Coca-Cola Foundation Indonesia (CCFI) funded a further survey on the north-east coast around the town of Sigli in the district of Aceh Pidie (Steuer et al., 2008).

The electromagnetic surveys revealed several potential freshwater resources and areas of saltwater occurrences were mapped in detail. Many requests by aid organisations for information on the local geological and hydrogeological conditions for planned water wells were evaluated and could be successfully answered in most cases. Close to the coasts, however, the investigation depth of the HEM system was constrained due to highly conductive near-surface saltwater and, thus, ground-based time-domain electromagnetic measurements were necessary to reveal deeper coastal freshwater resources. The combination of airborne and ground-based electromagnetic techniques together with a hydrogeological reconnaissance survey increased the efficiency to estimate the freshwater potential. The airborne geophysical surveys helped to close the gaps between task-force measures and long-term planning as well as between spatial surface mapping and local borehole data. Particularly airborne electromagnetics proved to be a very efficient tool to supply hydrogeological baseline data for rehabilitation programs.

#### References:

Siemon, B. and Steuer, A. (2011): Airborne Geophysical Investigation of Groundwater Resources in Northern Sumatra after the Tsunami of 2004. In: Morner, N.-A. (Ed.), *The Tsunami Threat - Research and Technology*. INTECH, 576-594, [www.intechopen.com/books/show/title/the-tsunami-threat-research-and-technology](http://www.intechopen.com/books/show/title/the-tsunami-threat-research-and-technology).

Siemon, B., Steuer, A., Meyer, U. and Rehli, H.-J. (2007): HELP ACEH - a post-tsunami helicopter-borne groundwater project along the coasts of Aceh, northern Sumatra. *Near Surface Geophysics*, 5: 231-240.

Steuer, A., Siemon, B. and Eberle, D. (2008): Airborne and Ground-based Electromagnetic Investigations of the Freshwater Potential in the Tsunami-hit Area Sigli, Northern Sumatra. *Journal of Environmental and Engineering Geophysics*, 13(1): 39-48.

キーワード: helicopter-borne electromagnetics, electromagnetics, tsunami, groundwater, saltwater intusion

# Japan Geoscience Union Meeting 2012

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

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STT03-03

会場:102A

時間:5月23日 09:50-10:15

Keywords: helicopter-borne electromagnetics, electromagnetics, tsunami, groundwater, saltwater intrusion

## 地表ソース型空中電磁探査法の沿岸域への適用性 - 九十九里と淡路島北西部の比較 - Applicability of grounded-source AEM to coastal areas: Comparison between Kujukuri and Awaji Island cases

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Understanding geological and hydrogeological characteristics in coastal areas is vital because they are the places where most people live and work. Especially, it is important to delineate underground distribution of fresh and saline waters to maintain sustainable development in coastal areas and also for siting of geological disposal of nuclear wastes. As for the latter case, it is desirable to increase the depth of investigation to at least 300 m. To this end, a grounded-source airborne electromagnetics (AEM) is more suitable than conventional AEM. Firstly we applied GREATEM, a type of grounded-source AEM, to an alluvial plain, Kujukuri, where sedimentary rocks and shallow water prevail. The results were remarkable in that a reliable resistivity structure was obtained to a depth of 300-350 m both on land and offshore and low resistivity structures prevail both on land and offshore. We then applied the GREATEM method to northwestern Awaji Island, where granitic rocks crop out onshore. From this survey, we obtained underground resistivity structures to a depth of 1 km onshore and to a depth of 500 m offshore. The results were feasible in that onshore resistivity is much higher than offshore but were not acceptable in that the absolute resistivity value onshore was much lower than the true one. To circumvent this problem, a 3 D inversion technique is currently under development.

キーワード: 空中電磁探査, 沿岸域, 九十九里, 淡路島

Keywords: airborne electromagnetics, coastal area, Kujukuri, Awaji Island

## CONDUCTIVITY RESOLUTION BY VARIOUS HELICOPTER BORNE TEM SYSTEMS CONDUCTIVITY RESOLUTION BY VARIOUS HELICOPTER BORNE TEM SYSTEMS

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The helicopter borne TEM (HTEM) survey technology is fast, effective, and in true sense a technology of the 21st Century as its genre and wide-ranging applications have increased exponentially since the year 2000. Most of the HTEM systems comprise a large transmitter loop source and a small receiver coil located concentrically or at a point above the transmitter loop that is flown below the helicopter. A couple of exceptional systems are GREATEM and FLAIRTEM that respectively employ a grounded cable and a large loop on ground as transmitters. Contemporary HTEM systems employ a wide variety of primary pulse shapes and transmitter moments to stimulate the subsurface in order to elicit response of geological targets. Frequency contents of these pulses determine the nature of decay response of various types of conducting terrains ranging from highly resistive Archaean granitic gneisses to highly conducting coastal regions with saline water. Numerical modeling is carried out to particularly examine and compare the dB/dt response of these terrains as seen and distinguished by various HTEM systems flying airborne transmitting loops (FLTx) and the GREATEM (GRTx) system. For FLTx systems we have also computed the response considering an ideal rectangular pulse for the purpose of comparison. It is found that the HTEM systems employing rectangular pulses yield fastest decaying transient response and provide the best conductivity discrimination among the FLTx systems. The next to follow are the systems that employ trapezoidal pulses. In this case the decay rate is somewhat slower and the conductivity discrimination is reduced slightly. Similar behavior is observed for the HTEM systems employing sinusoidal and triangular pulses with the latter showing the slowest decay rate and the least discrimination capability. It may also be noted here that slower decay rates also imply that as compared to the HTEM systems employing rectangular pulses, those employing trapezoidal, sinusoidal and triangular pulses see the same geological terrain as increasingly more conducting. Computations for the GRTx system reveal that for highly resistive terrains the decay rates for the FLTx and GRTx are found to be comparable. However, for increasing terrain conductivity, the decay rates for the GRTx slow down considerably and are distinctly separate for various conductivities. Thus the GRTx system provides much better conductivity discrimination as compared to various FLTx systems. The results underscore the advantage of GRTx system that uses the galvanic stimulation of the ground at a fixed spatial location in comparison to the FLTx systems that employ a flying transmitter loop in inductive mode with continuously varying location.

キーワード: AEM

Keywords: AEM

## Airborne Gamma-Ray Spectrometry Surveys in Austria - An Overview Airborne Gamma-Ray Spectrometry Surveys in Austria - An Overview

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The Geological Survey of Austria (GBA), Department of Geophysics, has been conducting airborne geophysical surveys since the beginning of the Nineteen-Eighties. The current aerogeophysical system includes an airborne gamma-ray spectrometer (AGRS) used for measuring the natural and anthropogenic radioactivity. The AGRS is equipped with eight downward and one upward looking NaI(Tl)-detectors. The AGRS system of the GBA is designed to cover a broad range of applications like geological mapping, geotechnical applications and radiation protection.

The processing of the AGRS-data mainly follows the IAEA guidelines. The data processing includes aircraft and cosmic background correction; radon background correction; Compton correction using stripping ratios calculated from measurements over four transportable calibration-pads and height correction. The parameters to calculate elemental concentrations are determined from repeated flights at different heights over a calibration profile. In order to consider the topography effect, measured concentrations are calculated in respect to the point on the earth's surface closest to the detector.

Furthermore, we recently developed a vegetation correction for coniferous forests. The vegetation correction uses the first and the last reflection of the laser altimeter to characterize the vegetation. This vegetation correction has been successfully applied to several survey areas since its introduction.

Besides measuring the abundances of potassium (K), uranium (U) and thorium (Th), the AGRS-system is able to detect Caesium-137 (<sup>137</sup>Cs). In contrast to K, U and Th, <sup>137</sup>Cs is entirely of anthropogenic origin. After the Chernobyl atomic accident in April 1986, radioactive elements were transported through the atmosphere for long distances and distributed over vast areas. Depending on rainfall during this period, which caused a washout from the radioactive cloud to the ground, the soil in the affected regions was contaminated by <sup>137</sup>Cs to varying degrees. Although much of the <sup>137</sup>Cs content has already decayed (30.17 years half-life), notable amounts can still be detected in Austria.

In 1990 the GBA conducted an airborne survey in an area called Hausruck, located at the northern edge of the Alps. This survey is not only interesting because it achieved our goals in mapping gravel, but because it is also a good example of the benefit of AGRS over non-energy discriminating instrumentation (like Geiger counters). The northern part of the survey area shows a relatively high level of natural radiation. Due to rainfalls on the northern hillsides of the Alps in the time after the Chernobyl accident, there remains an increased concentration of anthropogenic <sup>137</sup>Cs in the southern part of the survey area. In this situation the total amount of radiation caused by natural and anthropogenic radiogenic elements is nearly the same in the entire area and only energy discriminating instruments like NaI(Tl)- or Ge(Li)-detectors are able to identify and map the distribution of man-made radiogenic contamination.

In 2009 a multi-sensor airborne geophysical campaign was conducted, which consisted of surveys in Austria and Slovenia. These surveys were designed as test studies for the application of airborne geophysics for landslide investigations. In all of the test sites, minima in the concentrations of <sup>137</sup>Cs correlated well with bare surfaces of active landslides, earthflows and zones of higher superficial water flow. One of these survey areas is the test site of Sibratsgfall, a complex of shallow and deep-seated landslides and earthflows. In 2000 the GBA conducted a first survey on this test-site. In 2009 the survey was repeated to monitor changes in geophysical properties of the landslide area. The comparison of the two surveys not only shows minima of <sup>137</sup>Cs over the landslide, but also a faster decrease of the <sup>137</sup>Cs concentration at the landslide than in the surrounding areas.

キーワード: airborne geophysics, gamma-ray spectrometry

Keywords: airborne geophysics, gamma-ray spectrometry

## 航空機モニタリングによる放射性セシウムの沈着量の測定

### Radioactive cesium distribution released from Fukushima Daiichi NPP by aerial radiation monitoring

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We measured the ambient dose-rate and the deposition amount of radioactive cesium by using four helicopters in the whole area of East Japan to investigate the influence of the radioactivity that released in the atmosphere due to the disaster of the Fukushima Daiichi NPP (Nuclear Power Plant), Tokyo Electric Power Company (TEPCO), occurred by the East Japan earthquake and tsunami on March 11, 2011. It reports on the measurement technique and the result.

A massive radioactive materials emitted from the NPP was released in the atmosphere due to the disaster and contaminated soils in the wide area in East Japan. Therefore, we have carried out the airborne radiation monitoring (ARM) in the whole area of East Japan, and investigated the influence of the radioactive cesium of the deposition to the ground level.

The ARM can plainly and promptly understand the distribution of the ambient dose-rate and the deposition of radioactive cesium by measuring gamma rays from the urban area to the forest over the wide range. An aerial radiation monitoring has following advantage. (1) The widespread distribution of radionuclides can be measured with short time by less manpower. (2) Descriptive contour maps of the deposition of the radioactive cesium can be depicted. (3) The radioactivity of the mountains and forests can be measured.

We were each equipped with a different measurement system in four helicopters, and they are large-size NaI scintillation detectors (16 x 4 x 2 inches or 16 x 4 x 4 inches) are being used inside/outside of each helicopter in-flight Both counting rates and the pulse-height distribution data (energy spectrum) were detected at each second. We also installed the GPS sensor in the helicopter, and measured the latitude, the longitude, and the altitude of the helicopter 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 (150 ? 900 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 1 m height evaluated by using the attenuation coefficient.

Furthermore, the deposition amount of radioactive cesium (Cs-134, Cs-137) on the ground was evaluated according to the dose-rate-to-radioactivity conversion coefficient obtained by the result of the in situ Ge measurement on the ground.

We also made maps of the dose-rate and the deposition of radioactive cesium by using the IDW (inverse distance weighted) procedure as an interpolation method of a GIS software.

The map of the ambient dose-rate is shown in Figure 1. It has been understood for the region where the dose-rate is high to extend from the NPP for northwestward, and wide to Gunma Prefecture from the vicinity of Fukushima City in the direction of the southwest. This map is utilized to determine the decontamination area and estimate the variation of contamination areas.

キーワード: 航空機モニタリング, 放射性セシウム, 福島第一原発, 東日本大震災

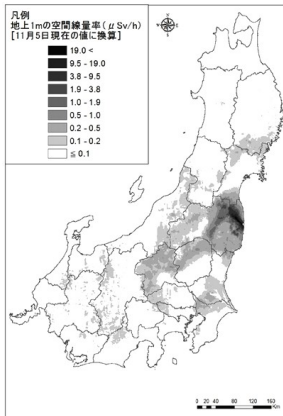
Keywords: Airborne survey, Radioactive cesium, Fukushima Daiichi NPP, East Japan earthquake



STT03-07

会場:102A

時間:5月23日 11:35-11:55



## 除染評価のための気球およびラジコンヘリコプターを用いた空中ガンマ線スペクトロメトリー

### Airborne gamma ray spectrometry using balloon and radio controller helicopter for decontamination evaluation

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Airborne gamma ray spectrometry (AGRS) is the technique used to measure the energy spectrum and intensity of the radiation. AGRS system is newly developed for evaluation of decontamination. Detector packages for airborne spectrometry are made up of 3-inch diameter NaI crystal with a photomultiplier tube. Resolution is about 7%. Peripheral device consist of laser altimeter, GPS, video camera as well as a typical airborne gamma ray device such as pulse height analyzer, etc. 500g KCl reagent bottle is build in near NaI crystal for standard energy of 1,460 keV of K-40. The gamma ray spectrum over the range of 0 to about 2,000 keV is resolved by airborne spectrometers into 1,024 channels. The target nuclides with the emission of gamma rays in range between 0 to about 2,000 keV are natural nuclides (K-40:1460 keV and Bi-214:1765 keV) and man-made nuclides (Cs-137:662 keV), Cs-134:605, 795 keV).

Institute for Rural Engineering has conducted two experimental decontamination of the rice paddy in Iitate Village which has been included in the planned excavation zone with 20-50 mSv/year due to fallout from the Fukushima Dai-ichi Nuclear Power Plant accident; 1) removal of surface soils by fixation agent (RSS-FA) and 2) mixing soils and removal using water (MSRW). Two methods were evaluated by AGRS mounted on balloon and radio controller helicopter (RCH). Area of B site for RSS-FA test is 10,000m<sup>2</sup> within B paddy field (30,000m<sup>2</sup>). Area of C site for MSRW test is 10,000m<sup>2</sup> within C paddy field. Survey area of balloon-AGRS is 225,000m<sup>2</sup> included the test site B and C. Survey spacing is 2.5 m. The spectrometer at height 0.05 m in the air was tows by man-power at speed about 3 km/h (0.83 m/s). Measurements before and after decontamination ware carried out on August 3 and 31, 2011, respectively. Survey area of RCH-AGRS is 600,000m<sup>2</sup> included the test site B and C. Flight height and line spacing was 5 m. Data of both survey is sampled once per 10 second. The balloon AGRS could be used with great success to evaluate RSS-FA and MSRW decontamination of paddy fields (Fig.1). It could exactly identify the places: X, Y, and Z where men trampled on the ground surface. RCH-AGRS could show RSS-FA and MSRW decontamination of paddy and revealed that the low radioactive cesium concentration zone to toward the Niita River, which may be caused by radioactive cesium runoff with rain water. RCH-AGRS is an effective tool for monitoring on secondary rework contamination of fallout as well as decontamination.

Keywords: airborne gamma ray spectrometry, decontamination evaluation, Fukushima Dai-ichi Nuclear Power Plant

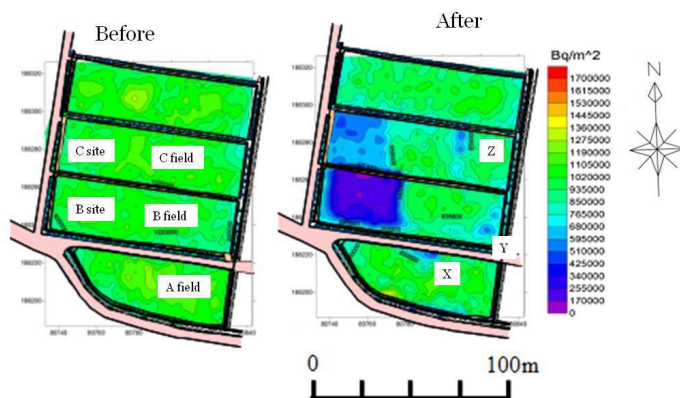


Fig.1 Cs-134 concentration map before and after decontaminations