



# HOKKAIDO UNIVERSITY

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## 学 位 論 文 審 査 の 要 旨

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## 学 位 論 文 題 名

A three-dimensional Resistivity Structure Study Using Airborne Electromagnetics: Application to GREATEM Field Survey Data

(空中電磁法による 3 次元比抵抗構造の研究 : GREATEM 探査データへの応用)

Recently, applications of airborne electromagnetic (AEM) survey techniques have been introduced for environmental protection and natural disaster prevention in various fields. However, challenges for using AEM surveys in exploration areas include such issues as the high cost of conducting the survey, and safety, as using the AEM survey at low altitude. Another issue is the need to increase the depth of penetration to detect deeper structures. The grounded electrical-source airborne transient electromagnetic (GREATEM) system was introduced by Mogi *et al.* (1998, 2009) to overcome the issues. The system uses a grounded electrical dipole source as a transmitter and a three-component magnetometer in the towed bird as a detector. With a grounded source, a large-moment source can be applied and a long transmitter-receiver distance can be used to yield a greater depth of investigation. Other advantages include a smaller effect of flight altitude and the possibility of higher-altitude measurements. Data are recorded in the time domain, providing a raw time series of the magnetic fields, with the result that a noise filter can be easily introduced.

Although one-dimensional (1-D) inversion methods, assumed plane layered subsurface structure, were widespread in the interpretation of AEM surveys, they often fail to recover even simple three-dimensional (3-D) targets. The 1-D inversion results were feasible in that the horizontal resistivity contrast was not much higher, but they were not reasonable in that the horizontal resistivity values were greatly changed.

The objective of the study of this dissertation was to establish a method of constructing a 3-D subsurface electrical resistivity model for a complicated structure using GREATEM data. Numerical forward modeling was performed using the 3-D electromagnetic modeling computing scheme, which is based on the modified staggered-grid finite-difference method (Fomenko and Mogi, 2002) and adding a finite-length electrical-dipole source routine, to generate 3-D resistivity structure models of GREATEM field survey data. The author has verified the 3-D electromagnetic modeling computing scheme by comparing the results of a quarter-space and trapezoidal hill models with the results of the 2.5-D finite-element method by Mitsuhata (2000), and the 3-D finite-difference program with the spectral Lanczos decomposition method developed by Druskin and Knizhnerman (1994). This method was then used to study the possibility of detecting a conductor under shallower sea, the effects of sea and topographic features.

A GREATEM survey was performed at Kujukuri beach in central Japan, where an alluvial plain is dominated by sedimentary rocks and shallow water. A reliable resistivity structure was obtained at a depth range of 300 to 350 m both on land and offshore, in areas where low-resistivity structures are dominant. Another GREATEM survey was performed at a location in northwestern Awaji Island, where granitic rocks and Paleogene sedimentary rocks crop out onshore. Resistivity structures at depths of 1 km onshore and 500 m offshore were revealed by this survey. The author participated in these field surveys and also experienced a part of data processing. And the author performed numerical forward modeling using the 3-D electromagnetic modeling computing scheme to generate a 3-D

resistivity structure model from GRETEM field survey data at both Kujukuri beach and the Nojima fault.

In conclusion, the author confirmed the accuracy of our 3-D forward modeling computing scheme and evaluated the effects of complicated structures, such as sea or topography, on GRETEM data. The author has used this method to generate a 3-D resistivity model from GRETEM field survey data acquired at the Kujukuri beach and the Nojima fault. As for results, the author obtained information regarding seawater invasion area in sedimentary rocks and a resistivity structure along an active fault and indicated that the GRETEM system can be used for the assessment of natural disaster areas. Therefore, we acknowledge that the author is qualified to be granted a Doctorate of Science from Hokkaido University.