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Moving Audio Magnetotelluric (AMT) Test Measurement

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SUMMARY

This study is to test the idea of the developed Audio Magnetotelluric (AMT)method by placing the magnetic sensors in the air instead of burying in the gound. Five channels electric and magnetic fields are measured. The data acquistion time for each station is around 15 minutes and is enough to cover the frequency range from 30 to 300 Hz. Normal MT processing techniques are used for the data collected by the developed method to yield frequency domain transfer functions. The data quality from the test measurement is rather good with smooth apparent resistivity and phase. The developed method is proved to have several supriorites than the normal AMT measurement, and is applicable to shallow depth investigation efficiently in the future.

Introduction

The study in this abstract is sponsored by the Geological Survey of Sweden (SGU) with the project name of Airborne Audio Electromagnetics For Deep Prospecting. The initial idea of the project is to measure the three components magnetic fields on board the aircraft in a frequency band from 30 Hz to 1000 Hz. The measurements of magnetic noise carried out by SGU on board of the airplane showed that the electronic noise generated by the engine of the airplane had a well-defined structure with several harmonics, and the overall background level was increased by ca 20 dB compared with the case when the engine is off. Another experiment was carried out on the road by constructing a rigid frame carrying the magnetic sensors and the frame was installed on a trailer. The generated noise was studied when dragging the trailer behind a car. We found the ignition system in the car generated strong noise in the magnetic fields.

The idea of measuring the magnetic fields on board of the airplane was given up because of the strong generated noise. Another idea came up by replacing the fixed systems with magnetometers buried in the ground in the normal Audio Magnetotelluric (AMT) measurements, the frame with sensors mounted are used instead. Two electric fields are measured at the same time to attain five channels electromagnetic fields. The frame is put on the ground standing still while the data is acquired. We move the frame station by station to cover a complete profile. The new data acquisition technique is named as Moving Magnetotelluric (MMT) and covers a frequency range of 30 - 300 Hz. Normal MT processing techniques are used for the MMT data to yield frequency domain transfer functions.

MMT Field Setup

Same as the traditional AMT measurement, the MMT also measures five channels fields (two electric channels and three magnetic channels). The two electric fields are collected by four electrodes that forming the telluric dipoles. The three channel magnetic fields are measured by three coil-type sensors. Different from burying the coils and electrode in the ground, in the MMT measurement, the lead-lead chloride electrodes are replaced by the steel electrodes which can be easily inserted to the ground. The cable length in each direction is 10 m and dipole length is 20 m for each polarization. The shorter dipole length (100 m for AMT) is later compensated by putting a 10 times gain on the electric fields. The magnetometers were put into three orange cylinders which were firmly fixed onto a wooden frame to allow for the vibrations of the frame to be transferred to the magnetometers (Figure 1). The coils are positioned following the right hand rule system with z positive downwards.
To set up a station, first is choosing a site that is rather flat and putting the wooden frame on the ground, 2 or 3 degrees' tilting of the frame is allowed. A compass is used for direction to the north of the x component coil. All the electrodes should be inserted into the ground at least 5 cm to make sure the steel electrode keep standing. Next step is to connect the sensors to the central unit. Be sure that each sensor is connoted to the correct pigtail of the 3-way cable. It takes 8 to 10 mins to set up a station, then we can start the data logger and wait for 15 mins for data acquisition which is enough to cover the frequency range of 30 to 300 Hz.

Data Quality From A Test Measurement

We chose a test site in Gotland where the earth is layered with a thin limestone on the surface, and conductive mudstone overlying on the crystalline basement (Linde and Pedersen, 2004). The MMT profile is along a small and remote road in the forest. The stationary distance is around 1 km and there are 29 stations in total.
The apparent resistivity and phase of two example stations are shown in Figure 2.They are quite smooth with small error bars, especially for the phase. While the differences on resistivity below 0.007 s (142 Hz) is quite strong as can be seen the YX mode dropping fast from the XY mode. This is caused by the manmade noise in this area, for instance, the power lines. In general, the data quality for the 29 stations is quite high from 10 Hz to 142 Hz.

We inverted the data in 2D. The inverted 2D resistivity model is compared with the previous studies in this area. The model correlates well with the geology and other studies here, showing resistivity variations along the profile and in depth.

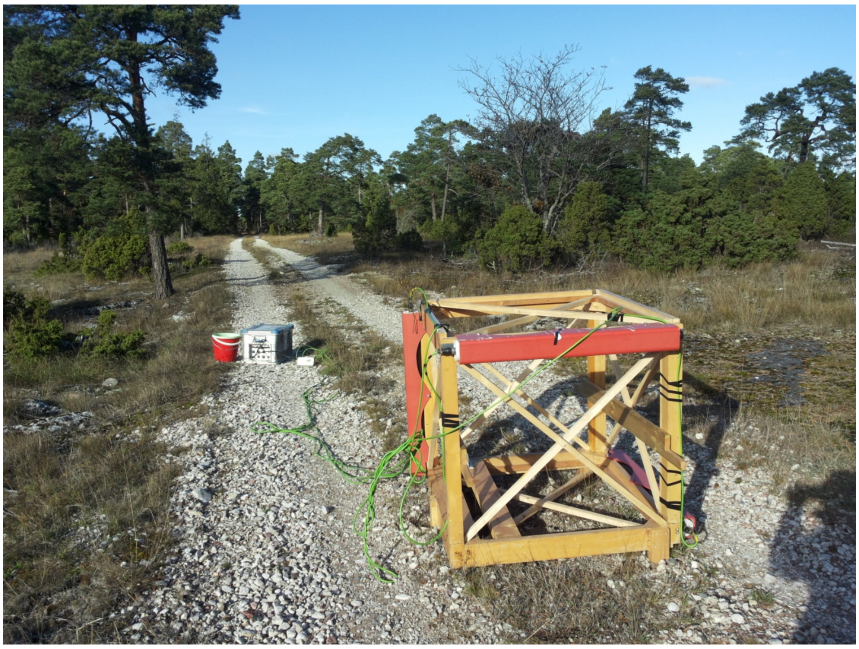

***Figure 1** Moving MT set up in the field.*

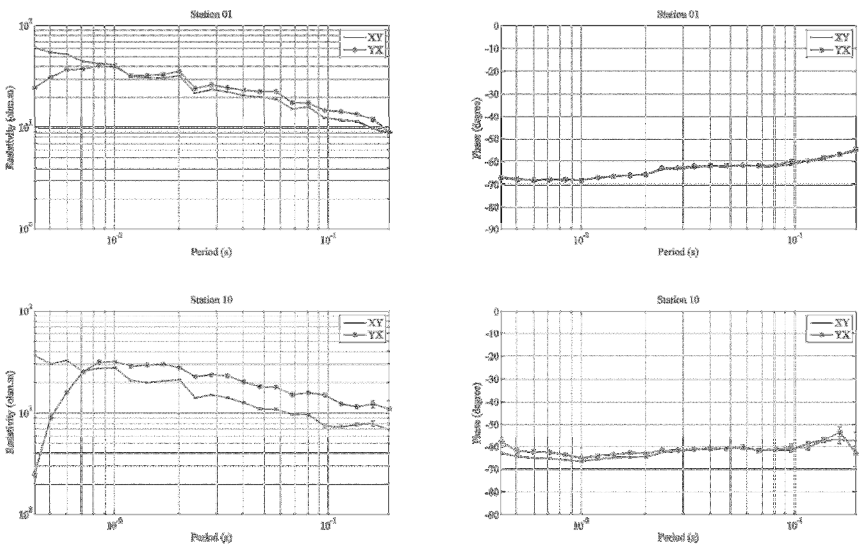

***Figure 2** Apparent resistivity and phase from 2 example stations.*

Conclusions

There are several advantages in the MMT measurement when comparing with the traditional AMT measurement: much time saved by reducing the data acquisition time; more efficient since all the digging work are avoided; less pace needed because of the shorter electrode cables; less carrying work for instance tools for digging; and so on.
The MMT data from the test site show rather good data quality from 10 to 150 Hz. The MMT method can be applied to short period shallow depth investigation efficiently in the future.

References

Linde, N. and Pedersen, L.B. [2004] Evidence of electrical anisotropy in limestone formations using the RMT technique. *Geophysics*, **69**, 909-916.