EAGE

17

Exploration capabilities of airborne broadband natural electromagnetic fields measurements

A. Prikhodko[1], A. Bagrianski[1], P. Kuzmin[2]

[1] Expert Geophysics Limited; [2] Magenta Geophysics Ltd.

Summary

The latest development in the AFMAG family, MobileMT airborne electromagnetic technology based on natural fields, has been used in commercial and test surveys in different geoelectric conditions and for different exploration problems. The presented results are from surveys in a uranium mineralization district, over a gold bearing orogen structure, and in a greenstone belt with the bounded iron formation type of gold mineralization demonstrate wide capabilities of the technique in subsurface exploration which include:

- wide depth range of investigation and deep resistivity imaging even in the presence of conductive overburden;
- mapping geoelectric boundaries from steeply dipping to stratiform horizontal directions;
- targeting discrete resistivity heterogeneity;
- differentiation in high and low resistivity background ranges.

Introduction

Advances in the airborne AFMAG passive electromagnetic fields technology, firstly introduced in 1958, make possible rapid deep exploration of large areas. One of the latest developments in the AFMAG family, called MobileMT, records time-varying magnetic (in the air) and electric (on the ground) fields generated by natural sources in the audio frequency range (Sattel et al., 2019; Bagrianski et al., 2019). The technology is utilizing the natural electromagnetic fields with the frequencies ranging from 26 Hz to 20 kHz (ELF+VLF) what defines its depth range of investigation from near surface up to >1 km depending on geoelectrical conditions. The benefits of the technology in subsurface exploration are demonstrated by practical examples from surveys in different geoelectric conditions for different exploration problems.

Measurements, data processing and inversions

One of possible measuring schemes exploiting natural fields in audio-frequency range using airborne technique is presented in Figure 1. Currents induced by the natural electromagnetic fields in the subsurface are measured on the ground with the grounded electric lines (Figure 1b). This electric component data is synchronized with the measured in the air magnetic components of the natural audio frequency electromagnetic fields (Figure 1a). The tow bird with the sensors measuring the variations of the magnetic field is moving along survey lines, while the electric base station remains in the same place on the ground.

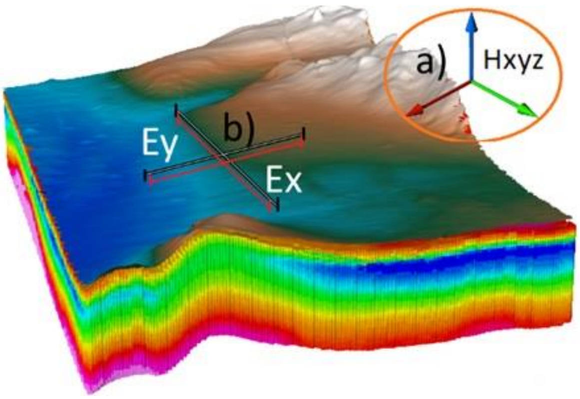

Figure 1 *MobileMT system measurements scheme. a) Towed bird Hxyz receiver b) Stationary ground Exy signal and reference lines base station.*

The ***H*** (magnetic) and ***E*** (electric) components time series data, fully synchronized, digitized, and recorded at 74 kHz frequency, are converted from time to frequency domain using FFT technique. The signals of two horizontal electric components along with three magnetic components are processed with the magnetotellurics response functions based on linear relations between components of the electric and magnetic fields. These relations are expressed by corresponded admittance matrixes. Apparent conductivity, in mS/m, for a series of frequencies, as a parameter of the EM mapping, is the result of modular computation of the matrixes determinants, as rotation invariant parameters (Bagrianski et al., 2019).

Detail and goal-oriented inversions based on adaptive finite elements and regularized non-linear MARE2DEM (Key and Ovall, 2011), is the routine procedure to recover resistivity distribution with depth along a MobileMT survey line. The used by MARE2DEM unstructured adaptively refined finite element grids are very efficient for representing complex structures and discrete targets.

Field examples

The three field examples of MobileMT inverted data in Figure 2 represent different exploration models in highly resistive (a, c) and relatively conductive (b) environments. An example of MobileMT apparent conductivity output data is presented in Figure 2a.

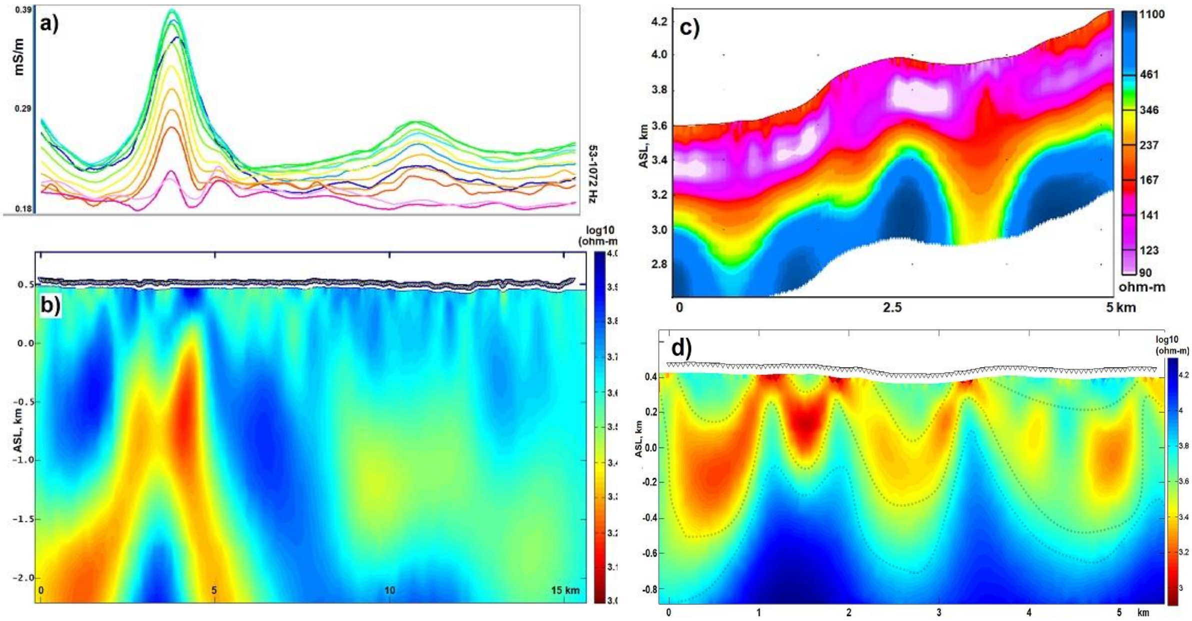

Figure 2 *a) MobileMT apparent conductivity data profiles for different frequencies over a survey line on the edge of the Athabasca Basin (Canada), crossing a conductive corridor controlling uranium mineralization and b) corresponded resistivity section; c) resistivity section over a gold bearing structure in Central Asia, Tien Shan metallogenic belt; d) resistivity section over folded metavolcanics rocks of the Michipicoten Greenstone Belt (northern Ontario) with the potentially gold hosted bounded iron formation layer.*

Conclusions

The field examples from different geoelectrical situations indicate wide capabilities of the airborne electromagnetic technology based on measuring natural electromagnetic fields. The field data are acquired using stationary orthogonal pairs of electrical field sensors (grounded wire dipoles) and towed magnetic field detectors (three orthogonal induction coils). The examples demonstrate resistivity resolution of MobileMT data in both high and low resistivity ranges; great depth of investigation even in conductive environment; sensitivity to any direction of geoelectrical boundaries, from horizontal to vertical.

Acknowledgements

We thank MacDonald Mines Exploration Ltd. and other clients for giving permission to publish surveys results from their respective properties.

References

Bagrianski, A., Kuzmin, P., and Prikhodko, A. [2019] AFMAG evolution – expanding limits. *16th Biennial Conference, SAGA*, Extended Abstracts.

Key, K. and Ovall, J. [2011] A parallel goal-oriented adaptive finite element method for 2.5-D electromagnetic modelling. *Geophysical Journal International*, **186**(1), 137–154.

Sattel, D., Witherly K., and Kaminski, V. [2019] A brief analysis of MobileMT data. *89th Annual Meeting, SEG*, Expanded Abstracts, 2138-2142.