Configurations of Airborne Total-Field Passive Electromagnetic Systems and Their Applications

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SUMMARY

This paper outlines the principal configurations of the airborne total-field passive electromagnetic system MobileMT and demonstrates how each configuration is matched to specific exploration objectives, terrain conditions, and geoelectrical environments. The main objective is to show that airborne passive EM has developed beyond a single platform into a practical family of systems, including the original heliborne MobileMT, the lightweight MobileMTm, the UAV-based MobileMTd, and the hybrid MobileMT–TargetEM configuration. Field examples from the El Teniente porphyry system in Chile, the Chrome Mountain target in the Stillwater Complex, recent MobileMTd applications, and a hybrid case study from Western Australia demonstrate the practical outcomes of these developments. Together, they show that the different MobileMT configurations are purpose-built tools that extend airborne passive EM into structurally complex porphyry systems, rugged magmatic sulphide environments, conductive-cover settings, and areas where IP effects or other limitations reduce the effectiveness of time-domain EM data alone.

Keywords: airborne electromagnetics; passive EM

INTRODUCTION

Airborne electromagnetic methods are commonly grouped into active systems, which use a controlled primary field, and passive systems, which rely on naturally varying electromagnetic fields. Active time-domain airborne EM systems remain important in mineral exploration because of their focused source field and well-established interpretation workflows. However, their effectiveness may be reduced in highly resistive environments, in settings with conductive overburden that limits the depth of investigation, in rugged topography where terrain clearance becomes critical, and in situations where parasitic IP or SPM effects complicate the EM response. These limitations have encouraged the development of broadband passive systems capable of recovering subsurface resistivity across a wider range of geological conditions.

MobileMT is a broadband natural-source total-field airborne EM method that records natural electromagnetic field variations with three orthogonal airborne dB/dt components and orthogonal grounded electric lines at a stationary base station (Prikhodko et al. 2024). The synchronized data are processed to derive admittance responses and apparent-conductivity estimates in multiple narrow frequency windows across a broad frequency band. In the heliborne configuration, the usable frequency range typically extends from about 26 Hz to 21 kHz, whereas the UAV configuration extends the lower end of the spectrum to roughly 14–20 Hz. As a result, the system is sensitive to both conductive and resistive geological structures, as well as to geoelectrical boundaries in any direction, while reducing dependence on precise sensor attitude.

This total-field passive concept has been adapted into several configurations to address different exploration objectives and operating conditions. The original heliborne MobileMT is the standard broadband configuration for regional-to-detailed resistivity imaging. MobileMTm is a lighter and more precisely positioned version suited to high altitudes, rugged terrain, and tighter survey geometry. MobileMTd extends the method into a UAV format and offers denser spatial sampling, reduced motion-related noise, flexible survey timing, and greater depth potential in conductive settings because of its lower usable frequencies. The hybrid MobileMT–TargetEM configuration combines passive AFMAG/VLF and active time-domain responses within the same streamed dataset, providing a broader geoelectrical response than time-domain data alone.

Configurations and Field Applications

Heliborne MobileMT over a structurally complex porphyry system: El Teniente, Chile

The El Teniente porphyry system provides a strong example of the application of broadband total-field passive EM in a geologically complex mineral environment. The district is characterized by rugged Andean topography, intrusive centers, hydrothermal alteration, and strong structural control, all of which place high demands on airborne geophysical methods. MobileMT data acquired over the area produced coherent apparent-conductivity patterns and resistivity-depth sections that resolved features consistent with porphyry architecture, including a central resistive zone interpreted as the potassic core, surrounding conductive alteration zones, and subvertical conductive structures interpreted as feeder pathways (Figure 1). In this setting, the value of the method lies not simply in anomaly detection, but in imaging the broader resistivity framework of the mineral system while preserving geological coherence in structurally complicated terrain. This makes heliborne MobileMT particularly suitable for porphyry exploration where both resistive and conductive elements are important and where structural imaging at depth is required.

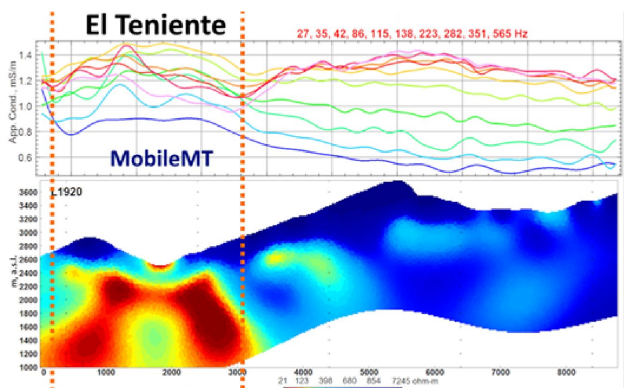

Figure 1. MobileMT apparent conductivity profiles (top) and inverted resistivity section (bottom) over El Teniente porphyry deposit (Chile).

MobileMTm in rugged magmatic sulphide exploration: Chrome Mountain, Stillwater Complex, Montana

A different application is represented by the Chrome Mountain target within the Stillwater Complex, Montana, where a helicopter-borne MobileMTm survey was conducted to support 3D geological modelling and identify conductive structures associated with Ni-PGE-Cu-Co-Au mineralization. Chrome Mountain is a rugged, high-relief target where several EM methods have been applied, including historical helicopter frequency-domain EM, a recent helicopter-borne time-domain survey using TargetEM. In this context, the MobileMTm configuration is particularly relevant because its smaller and lighter receiver allows safer low-level operation, improved positioning, and better suitability for detailed surveying in difficult terrain. The MobileMTm results (an example in Figure 2) were integrated with geological, geochemical, and drill-hole information to assess their correlation with known mineralization and to support interpretation of the lower Stillwater Complex. This example shows how the lightweight heliborne configuration extends total-field passive EM into detailed surveys over rugged magmatic systems where depth of investigation, precise positioning and operational flexibility are critical.

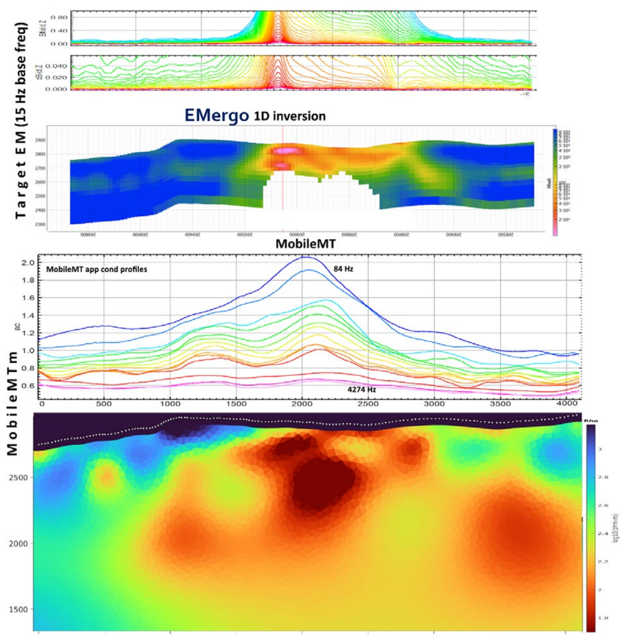

Figure 2. TargetEM data profiles and inverted resistivity section (top); MobileMTm data profiles and resistivity section (bottom) over Chrome Mountain Ni-Cu deposit (Montana).

UAV MobileMTd for dense sampling and enhanced low-frequency performance

The drone-borne MobileMTd system extends the same total-field passive measurement principle into a UAV format. It uses a drone-towed three-component magnetic receiver and a remote electric-field base station, with joint processing that yields rotationally invariant admittance data without requiring strict attitude control of the airborne sensor. Compared with helicopter acquisition, the UAV system offers several important operational and technical advantages, including lower flight speed, denser along-line sampling, reduced motion-related noise, and the ability to operate after sunset during periods of stronger natural EM activity. Its lower-frequency extension is especially important for improving depth of investigation in conductive environments and for imaging beneath conductive overburden. These characteristics make MobileMTd more than a smaller airborne platform; it is a distinct configuration that extends passive EM to high-resolution surveys over difficult-access terrain and geoelectrically challenging environments (an example in Figure 3). The system is therefore particularly attractive where lower frequencies are required and where flexible, lower-cost deployment can materially improve survey design.

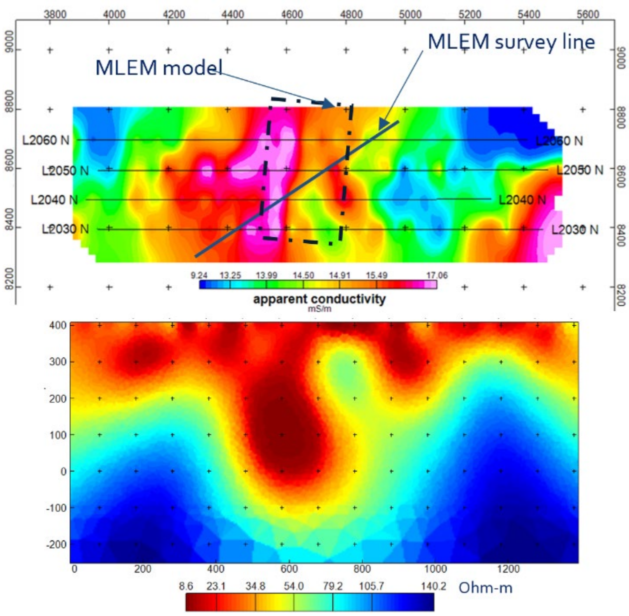

Figure 3. Ground MLEM survey line and projected model over MobileMTd apparent conductivity grid, 71 Hz (top); MobileMTd resistivity section over the conductive target (Western Australia).

Hybrid MobileMT–TargetEM for combined passive and active responses

The hybrid MobileMT–TargetEM configuration is designed for situations in which passive and active EM strengths are most effective when used together. TargetEM records full streamed data from three orthogonal magnetic components, horizontal electric-field channels at the base station, and transmitter current, allowing simultaneous extraction of time-domain, AFMAG, and VLF responses from the same airborne dataset. In this hybrid mode, passive data are particularly valuable where time-domain EM alone is less informative, including highly resistive terrains, superconductive targets, rugged relief, and conditions affected by IP or SPM effects. By extending resistivity sensitivity beyond the range emphasized by the time-domain response alone, the passive AFMAG component improves geological interpretation and reduces ambiguity.

A case study from Western Australia further illustrates this advantage. In that example, the time-domain response was strongly affected by IP, whereas the AFMAG data preserved a more coherent resistivity picture of the subsurface (Figure 4). The comparison demonstrates the practical value of the hybrid configuration: when the inductive time-domain response is distorted or obscured by IP effects, the passive AFMAG component can provide a more stable basis for geological interpretation and help recover features that are not reliably resolved in the time-domain data alone. This makes the combined system especially attractive, where a single airborne survey must address multiple geoelectrical conditions or target styles.

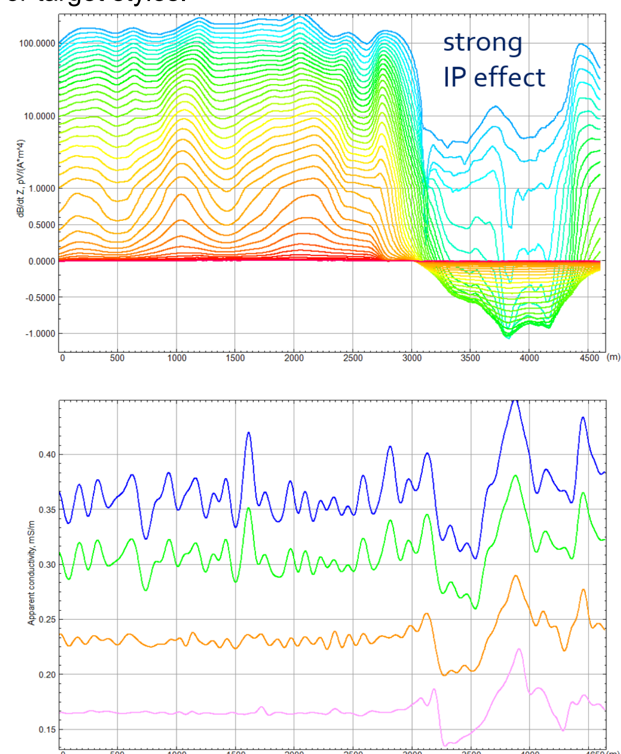

Figure 4. Time-domain (TargetEM) dB/t Z data profiles (top), AFMAG high-frequencies (12-18 kHz) apparent conductivity profiles (bottom). Western Australia.

Conclusions

Airborne total-field passive EM has developed from a single airborne concept into a practical family of system configurations matched to different exploration requirements. The original heliborne MobileMT remains the standard broadband platform for regional-to-detailed resistivity imaging. MobileMTm provides a lighter and more precisely positioned solution for rugged terrain, high-altitude operation, and tighter survey geometry. MobileMTd extends the method into a UAV platform and offers lower frequencies, denser spatial sampling, and greater depth potential in conductive settings and beneath conductive overburden. The hybrid MobileMT–TargetEM system combines passive and active responses in a single dataset and is particularly valuable where time-domain EM alone is limited by resistive terrain, high conductance, rugged relief, or parasitic IP/SPM effects.

The field examples considered here demonstrate that these configurations are not merely platform variants, but purpose-built tools that extend airborne passive EM into structurally complex porphyry systems, rugged magmatic sulphide environments, conductive-cover settings, and areas where passive and active methods are most effective when used together. Collectively, they show that airborne total-field passive EM has matured into a scalable multi-platform exploration technology with broad applicability across a wide range of targets, terrains, and operational conditions.

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