MobileMT - direct field comparisons with other methods. Strengths and weaknesses.

The most effective way to assess geophysical methods and technologies is by directly comparing field data and results.

This paper compares the Mobile Magnetotelluric (MobileMT) system with ground MT, airborne TDEM, ZTEM, drawing from presented and published case studies.

MobileMT, a passive source system that utilizes natural electromagnetic fields, offers unique advantages such as deep penetration, high spatial and in-depth resolution, sensitivity to any direction of geoelectrical boundaries, and the ability to detect differentiations in a very wide resistivity range, including highly resistive geological features.

By analyzing real-world survey data, this study aims to highlight the strengths of the MobileMT system while identifying the limitations of alternative airborne EM technologies. These insights will help to select the most suitable method for geological settings and mineral exploration objectives.

Many other direct comparisons of actual field data will be presented and published soon.

Example 1 – South Australia. Comparison with ground MT

a. ***4th AEGC: Geoscience – Breaking New Ground – 13-18 March 2023, Brisbane, Australia;***

b. ***MDPI "Minerals"*** Natural Field Airborne Electromagnetics—History of Development and Current Exploration Capabilities;

c. ***PDAC-2022 Geophysical Session***

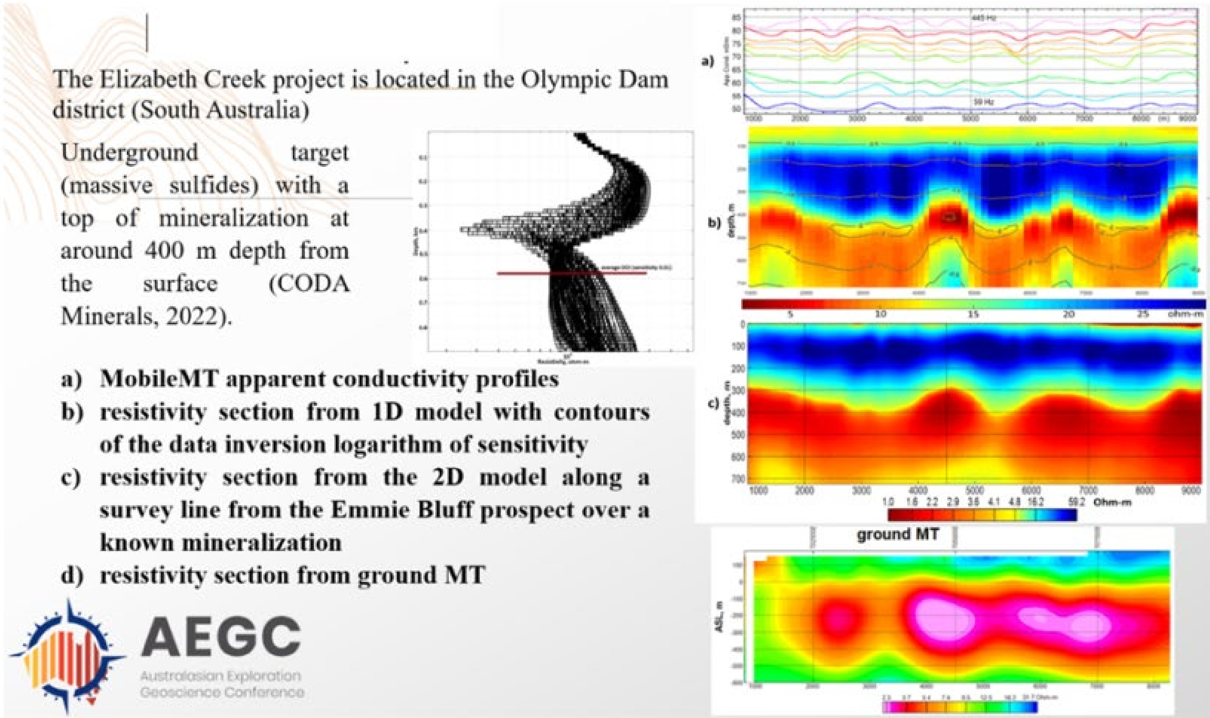
The Elizabeth Creek project is located in the Olympic Dam district, which is a belt of Cu-enriched basement of the Gawler Craton, South Australia. The district's Mesoproterozoic and older crystalline basement is overlain by a thick succession of Neoproterozoic, Cambrian, and younger sedimentary basin rocks known as the Stuart Shelf. The copper-cobalt deposits (fine-grained sulphides) are hosted by flat-lying undeformed Late Proterozoic sedimentary rocks deposited on the Stuart Shelf. These platform sediments are known as the 'Cover Sequence,' and they unconformably overlie the complexly deformed and metamorphosed igneous rocks of the Archaean basement.

The Emmie Bluff prospect in the North of the Elizabeth Creek project is an underground target with a top of mineralization at around 400 m depth from the surface.

Historically, several active source airborne EM surveys have been flown in South Australia, including VLF (very low frequency), frequency-domain and time-domain surveys. Due to the presence of highly conductive cover, the success of these methods to aid in the location of ore deposits has been very limited.

Despite the conductive cover/regolith, which limited the success of other airborne EM technologies, the MobileMT data were successful in the mapping of the stratabound zones with related mineralization at depth.

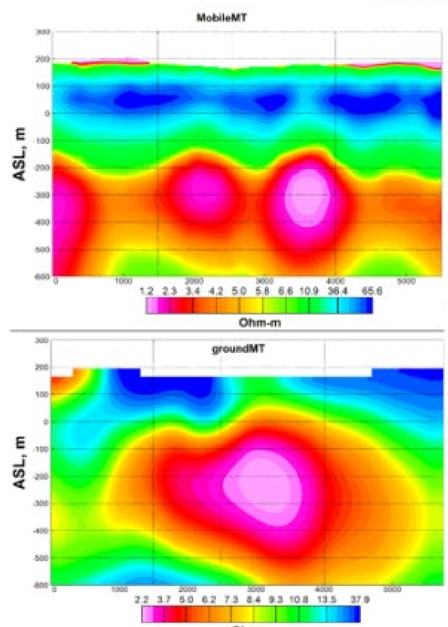
Line 1



Ground magnetotelluric data were acquired between 0.001 and 250 Hz with a site spacing of approximately 500 m. Twelve frequencies were involved in the MobileMT data inversion between 27 and 445 Hz. The depth range of the sections is limited by the MobileMT depth of investigation estimated for the survey area. Higher in-depth resolution of MobileMT inverted data in the first 300 m depth is explained by the MobileMT expanded frequency range between 250 and 445 Hz, in comparison with ground MT.

This field example demonstrates the exploration capabilities of the airborne MobileMT technology in a highly conductive environment with a decent depth of investigation. Direct comparison of the airborne EM with ground MT resistivity shows a good match between the two resistivity-depth images.

Line 2

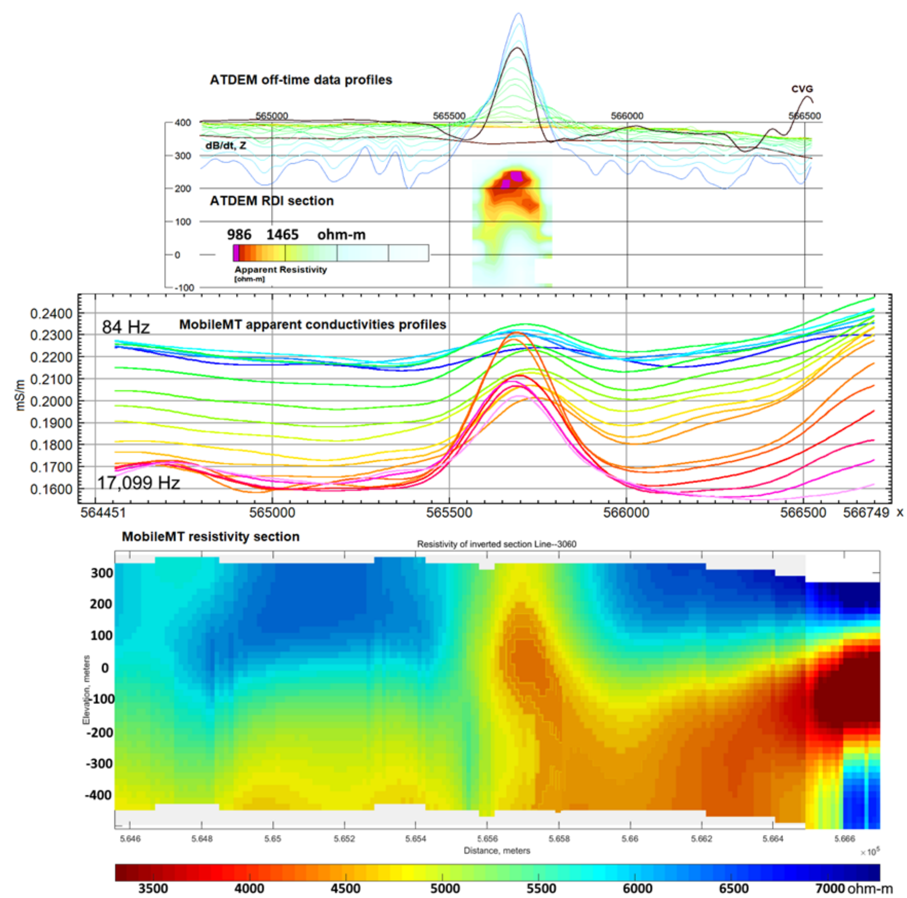


Example 2. Northern Ontario. Comparison with airborne time-domain (ATDEM)

(8th International Airborne Electromagnetics Workshop, 3-7th September 2023, Fitzroy Island and in MDPI "Minerals" Natural Field Airborne Electromagnetics—History of Development and Current Exploration Capabilities)

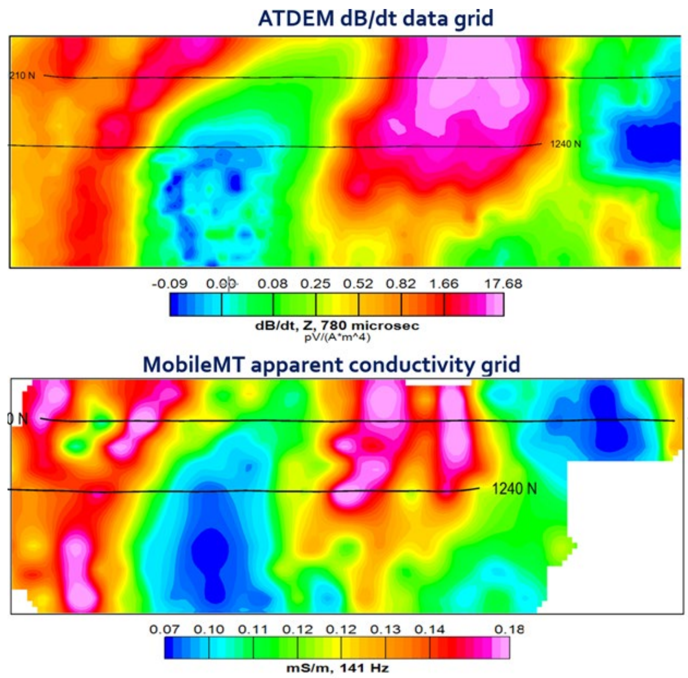
This example presents ATDEM and MobileMT data along a survey line crossing the known KL-22 kimberlite pipe in northeastern Ontario. The off-time dB/dt Z ATDEM data is significantly affected by the IP effect induced by the documented surficial till layer. In contrast, MobileMT provides a complete resistivity model, as it remains unaffected by the IP effect and offers sensitivity to a broader range of resistivity variations at significantly greater depths.

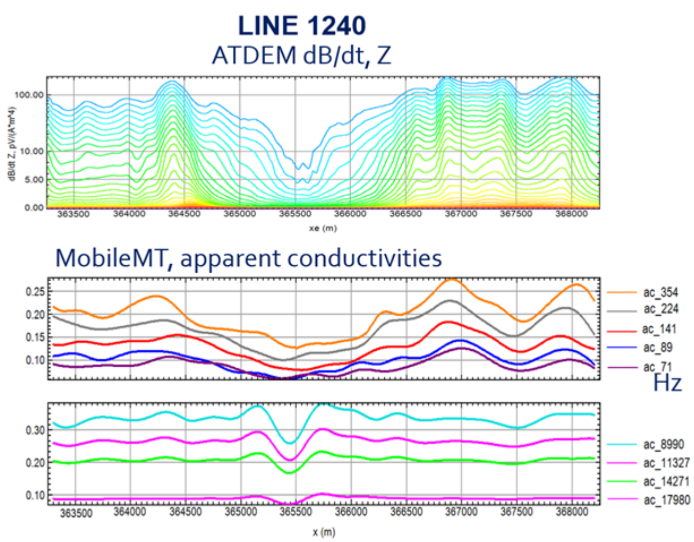
The location of the kimberlite is delineated through an increase in the apparent conductivity data for all frequencies, but particularly at higher frequencies, demonstrating the ability of the MobileMT technology to resolve near surface conductive features along with deep structures.



Example 3. Western Australia. Comparison with airborne time-domain (ATDEM)

(*8th International Airborne Electromagnetics Workshop, 3-7th September 2023, Fitzroy Island*)

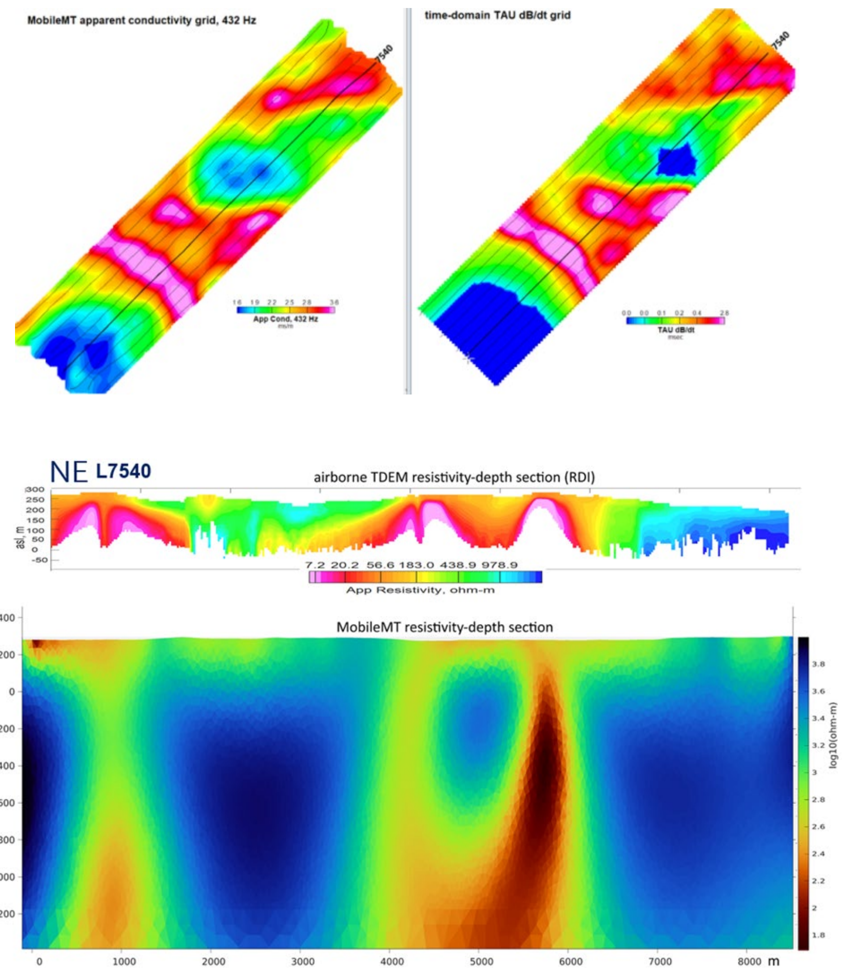




Example 4. Northern Ontario. Comparison with airborne time-domain (ATDEM)

(***8th International Airborne Electromagnetics Workshop, 3-7th September 2023, Fitzroy Island***)

The field example demonstrates a strong correlation between MobileMT data and airborne TDEM in plan view for mapping the relatively shallow tops of conductors (MobileMT apparent conductivity vs. time-domain TAU grids in the top images). However, unlike ATDEM, MobileMT captures the deeper continuation of the conductors, providing a more complete and geologically meaningful subsurface image.



Example 5. Athabasca Basin. Shea Creek uranium deposit. Comparison with ZTEM and ground TAMT

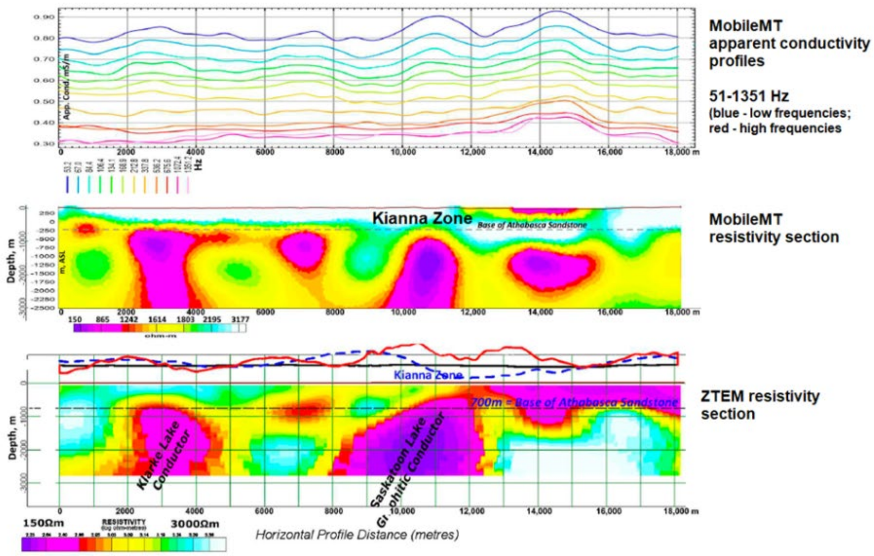
(***In Special MDPI Minerals Issue, 2024 "Advances in Magnetic and Electromagnetic Techniques for Mineral Exploration: Enhancing Resource Discovery"*** Airborne Natural Total Field Broadband Electromagnetics - Configurations, Capabilities, and Advantages)

The figure below compares resistivity sections derived from MobileMT and ZTEM data along the same survey line crossing the SLC with the Kianna deposit and the Klarke Lake structural conductor. Apparent conductivities across twelve frequency windows used in MobileMT data inversions are displayed over the resistivity section. While both systems detect major conductive structures, they differ in performance in several aspects.

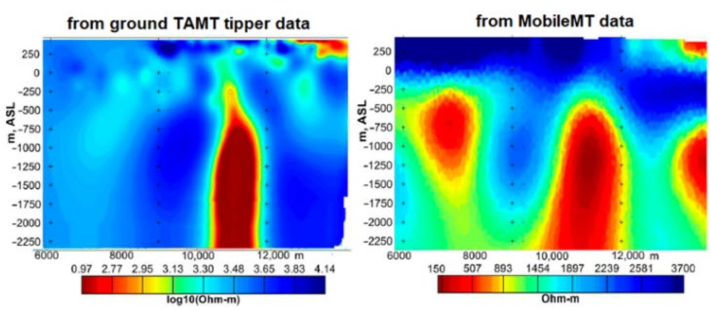
- Unlike ZTEM, the MobileMT system clearly identifies the unconformity contact between the more resistive Athabasca sandstones and basement rocks at a depth of 700–750 m below the surface.

- On the right side of the survey line, ZTEM depicts a continuous conductive layer at the top, ranging from 700 to over 1000 m thick, interpreted as Douglas Formation mudstones. According to the descriptions of stratigraphy and sedimentology of the western Athabasca Basin, the thickness of Douglas Formation mudstones typically does not exceed 200 m. MobileMT provides a more detailed depiction in this segment, revealing a near-surface conductive layer with a thickness of approximately 200 m (likely corresponding to the Douglas Formation mudstones) and a distinct conductor in the basement.

Data from the ground transient audio magnetotellurics (TAMT) method exploiting linearly polarized signal of sferics were collected in the summer of 2005 over the Shea Creek deposit. The TAMT resistivity section extracted from a 3D model of the tipper data is shown in the figure below, along with MobileMT resistivity distribution in the same line range. The shape of the Saskatoon Lake conductor, as recovered from MobileMT data, is well aligned with the results of the ground TAMT survey. The tipper component of the TAMT data (Zxy/Zyx/Tx/Ty), like ZTEM tipper data, doesn't reflect the sub-horizontal unconformity contact. In contrast, MobileMT's total field data clearly recovers the contact.



Resistivity sections over Kianna Zone

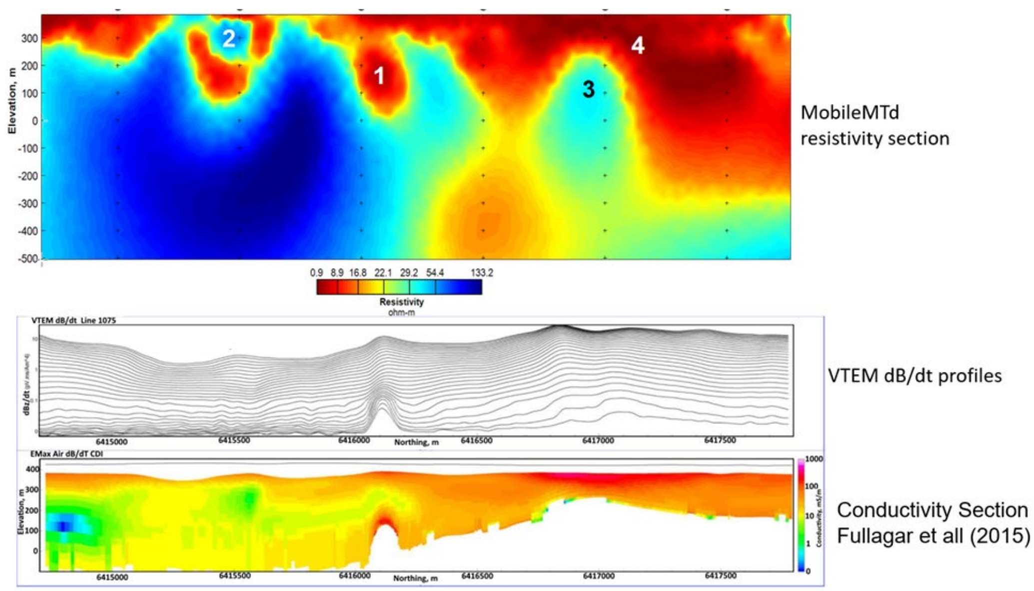


Example 6. Western Australia – Forrestania Greenstone belt. Comparison MobileMTd with ATDEM.

(***SEG Summit on Drone Geophysics 2024 "Drone-borne natural electromagnetic field measurements for subsurface exploration")***

The nickel-bearing IR2 conductor is a small 75x75 m target. Top of the target is around 100 m depth from the surface and it dips 30-40 degrees.

MobileMT recovers the conductor (1) in its full extension, when the airborne time-domain can see only top of the conductor. The northern part of the line (right side) is absolutely non-visible from time-domain data under the conductive overburden. In this part of the section, MobileMT recovered the comparatively resistive dome similar unit (3) surrounded by highly conductive zones (4). The small near-surface resistor (2) on the southern part of the line (left side) is visible in both time-domain and MobileMT data.

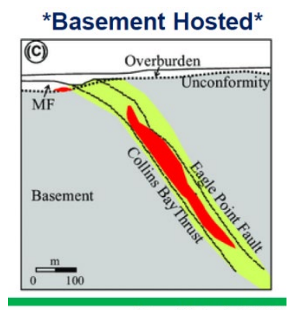


Example 7. Athabasca Basin. An edge of the basin - Comparison with ATDEM

(*8th International Airborne Electromagnetics Workshop, 3-7th September 2023, Fitzroy Island*)

In the Athabasca Basin, "unconformity-related" is often assumed to mean mineralization occurring strictly at the unconformity. However, this is not the case. Deposits can form at the unconformity, as well as above and below it. Additionally, the same mineralization processes that occur within the sedimentary basin also extend to the surrounding areas. As a result, rather than relying solely on deep underground mines to access mineralization beneath the sandstone, open-pit mining can be used in peripheral areas where the sandstone cover is thin.

The geological model of the "basement hosted" uranium deposits is below.



From Li et al. (2016)

The comparison below highlights the depth of investigation limitations of airborne TDEM (ATDEM). The ATDEM resistivity depth image, overlapped with the MobileMT resistivity section, demonstrates this limitation even in a resistive environment. ATDEM detected only the upper portion of the "thin" conductor closer to the surface, whereas MobileMT reveals two adjacent subvertical conductors extending to greater depths.