MobileMT: Next Generation of Passive Airborne AFMAG EM Technology

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ABSTRACT

Expert Geophysics Limited has introduced a new innovation in passive airborne electromagnetics: **Mobile MagneTotellurics** (**MMT**). Designed by Dr. Petr Kuzmin, the patent-pending MMT technology is the most advanced generation of airborne AFMAG technologies. MMT is the product of extensive experience in developing equipment and signal/data processing algorithms for natural electromagnetic fields measurement. This article presents the evolution of AFMAG technology that led to the revolutionary MMT.

INTRODUCTION

The mineral and hydrocarbon exploration industry constantly extends demands for discovering and defining deposits. The MMT technology pushes the limits of existing airborne EM geophysics in sensitivity, resolution, and investigation depth range. Existing electromagnetic "active" systems, such as time-domain, have known limits in sensitivity and resolution, particularly in ranges of high resistivity and high ("super") conductivity. Furthermore, depth of investigation of the "active" systems very often fails to satisfy exploration requirements. Existed airborne "passive" audio-frequency EM field systems have limitations related to high signal noise, limited frequency range and only one component measurements by moving sensor. The new development in the airborne electromagnetic "passive", natural field domain overcomes these limitations.

The source fields for natural electromagnetic (EM) in the audio frequency band are associated with lightning discharges. At some distance from the source, these fields propagate as plane waves with a vertical electric field E, and a horizontal transverse magnetic field H that is perpendicular to the direction of propagation. The presence of lateral conductivity variations create additional secondary magnetic fields related to distortion in the subsurface current pattern. Passive EM technology measures the resulting EM fields, which accurately reflect subsurface conductivity variations.

AFMAG TECHNOLOGY DEVELOPMENT

After the first introduction of AFMAG technology (Ward, 1959), Geotech Ltd. (Aurora, Canada) began developing the new generation of airborne AFMAG system in 2000: a lightweight towed-bird digital receiver (Figure 1). Test results using the system were promising, but showed that the receiver coils were not sufficiently sensitive as they were too small (Lo and Kuzmin, 2008)

Figure 1: Towed-bird AFMAG prototype, 2001, (Kuzmin et al., 2005)

The next step was the design of an egg-shaped receiver with larger, more sensitive coils (Figure 2).

Figure 2: Geotech's airborne AFMAG system in field trials in Sudbury, Ontario with the principal designer, Dr. Petr Kuzmin. (after Lo and Kuzmin, 2004).

The development of AFMAG was partially funded by the Ontario Minerals Exploration Technologies (OMET) program and two mining companies. New coils, suspension system, base stations, orientation sensors, numerical simulation, field trials, data processing techniques, and reporting were accomplished. Geotech also patented the system (Morrison, Kuzmin, 2005, U.S. Pat. No. 6,876,202). The developed system was functional, but it required a number of improvements (Lo and Kuzmin, 2008)

In 2006, Geotech Ltd. field-tested the newly-developed ZTEM system. In the ZTEM system, only the vertical (Hz) component data are acquired at the airborne receiver, while the horizontal fields (Hx, Hy) measured at a ground base-station (Figure 3).

Figure 3: ZTEM z-axis receiver and ground-based prototype reference coils from field tests in northern Ontario, Canada in 2006 (after Lo and Kuzmin, 2008).

In 2007, Geotech modernized the ground based station receivers making them smaller (Figure 4). The successful ZTEM concept became commercially viable in 2007. Subsequent development of the ZTEM system resulted in the fixed-fing (FW) ZTEM system (Legault and Fisk, 2012) and the portable ferrite-cored base-station reference coils (Figure 5) (after Legault, 2012).

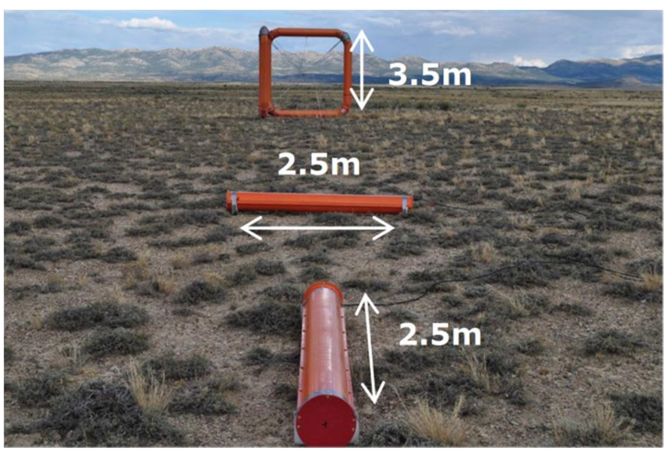

Figure 4: ZTEM base-station receiver in 2007 field surveys in Arizona USA (after Lo and Kuzmin, 2008).

Figure 5: New (foreground) and old (background) ZTEM base station sensors, during field trials in Nevada USA in 2011(after Legault, 2012)

ZTEM systems are based on the simplification that in the absence of local conductors, naturally occurring AFMAG magnetic fields lie in a horizontal plane. However, the presence of a local conductor will modify the magnetic field so that it is not horizontal. If there are changes in subsurface conductance, the ionosphere conductors are neither homogeneous nor stable in time leading to changes of the audio-magnetic field vertical component and thus error in measurement by ZTEM systems. Since error can also be caused by instability of the coil during a survey, ZTEM must uses attitude sensors to correct this error (Morrison, Kuzmin, 2005, U.S. Pat. No. 6,876,202). The quality of error correction is affected by unknown differences between the audio-magnetic field magnitudes in the base and flight points (after Kuzmin et al., 2010, U.S. Pat. No. 6,876,202)

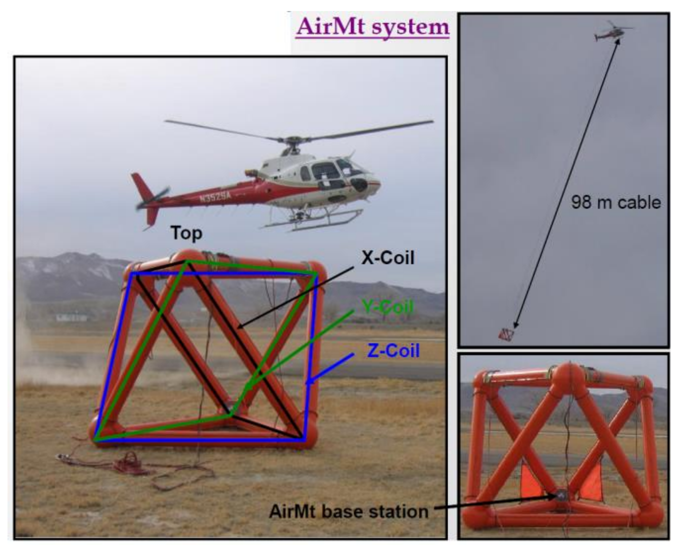

Figure 6: Helicopter AirMt system in Arizona field trials in 2009 (after Kaminski, Kuzmin, Legault, 2010)

In 2009, the AirMt (Figure 6), was introduced (Kaminski, Kuzmin, Legault, 2010). In AirMt, all three orthogonal components of primary and secondary magnetic field (Hx, Hy and Hz) are measured at the receiver, as opposed to a single vertical component measurement in ZTEM. The three measured components are converted into an attitude-invariant tensor amplitude parameter "AP" that effectively eliminates the need for tilt-compensation and therby significantly increases the signal to noise ratio over a ZTEM tipper measurement. AirMt was designed to be the next step in Geotech's AFMAG technology for higher resolution mapping of even deeper geological formations, as well as shallower structures. (after Legault, 2012).

At the beginning 2018, Expert Geophysics Limited introduced the latest and most advanced generation of passive airborne AFMAG EM technology: MMT (Mobile MagnetoTellurics). Designed by Dr. Petr Kuzmin, MMT combines the latest advances in electronics, airborne system design, and sophisticated signal processing techniques. MMT is patent-pending technology utilizing naturally occurring electromagnetic fields in the frequency range 25 Hz – 20,000 Hz.

Figure 7: Helicopter MMT system in Cochrane, Ontario.

An airborne bird, towed by a helicopter, measures variations of the magnetic field with three orthogonal induction coils, while a ground station measures variations of the electric field in two directions. The ratio of magnetic to electric field magnitudes in both in-phase and out-of-phase components provides analytic parameters in selected bands of frequencies. Advanced noise processing of both electronic and signal processing levels ensures high data quality even for low natural EM fields. A cesium-vapor magnetometer facilitates total magnetic field recording. The lightweight, aerodynamic bird is ideal for surveys with small helicopters in rough terrain.

Figure 8: The MMT system with the principal designer, Dr. Petr Kuzmin

CONCLUSION

Mobile MagneTotellurics (MMT) is the latest stage in the evolution of passive airborne electromagnetics. Any exploration program, from regional to prospect scale, will benefit from MMT's broad frequence range, low system noise, and combined electric/magnetic field measurement.

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