Advances in Helicopter Airborne Electromagnetics

Shane Mulè
Fugro Airborne Surveys, Australia
3/435 Scarborough Beach Road, WA
smule@fugroairborne.com.au

Stephen Carter
Fugro Airborne Surveys, Australia
3/435 Scarborough Beach Road, WA
scarter@fugroairborne.com.au

Peter Wolfgram
Fugro Airborne Surveys, Australia
3/435 Scarborough Beach Road, WA
pwolfgram@fugroairborne.com.au

SUMMARY

Launched onto the Australian market in early 2011, HELITEM is a powerful helicopter time domain electromagnetic system. It was developed by Fugro Airborne Surveys for exploration applications with an emphasis on the detection of deep conductors. Recent innovations have seen an increase in the peak dipole moment and a new receiver platform that have further improved the signal to noise ratio of HELITEM data.

To test the performance of the HELITEM system in the Australian environment, a survey was completed over the Forrestania EM test range. A range of modelling techniques were applied to the survey data to extract features in the ground response. Correlations between the modelled results and known target parameters confirmed the ability of the HELITEM system to detect targets in typical Australian conductive overburden conditions.

Key words: airborne electromagnetics (AEM), time domain electromagnetics (TDEM), HELITEM, Layered Earth Inversion (LEI)

INTRODUCTION

Airborne electromagnetic surveys have been around since the late 1940s. First developed for fixed wing systems it was later applied to helicopter configurations to improve spatial resolution and increase the amplitude of the ground response through a reduction in flying height and aircraft speed. Helicopter systems were primarily used for frequency domain EM, however in recent years improvements in system design have allowed helicopter time domain EM to evolve. The applications of airborne electromagnetic surveys are broad and continually expanding. Examples include detection of massive sulphides, regolith mapping, palaeochannel definition and groundwater studies.

HELITEM SYSTEM

HELITEM is a helicopter time domain electromagnetic system that has been developed by Fugro Airborne Surveys since 2005. It was developed for exploration applications with an emphasis on detection of deep conductors. It operates with a towed transmitter/receiver geometry. The standard system configuration of the HELITEM system is presented in Figure 1. The transmitter waveform is bipolar, represented by a half sine wave with an on-time pulse width of approximately 4 milliseconds and off-time recording interval of approximately 16 milliseconds. In its current configuration the peak dipole moment is $2x10^6$ Am^2. The received waveform is recorded by 3 identical receiver coils aligned in three orthogonal directions each recording the dB/dt EM response.

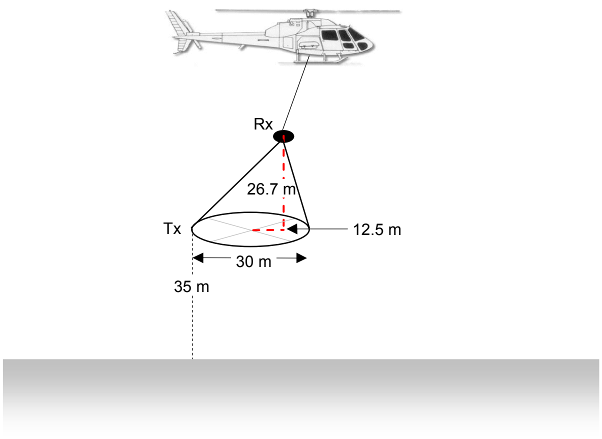

Figure 1. System configuration of HELITEM

Recent development of the HELITEM system has resulted in an improvement in the systems' signal to noise ratio. This improvement is predominantly the result of a large increase in the transmitter moment to $2x10^6$ Am^2 and the development of an innovative suspension cone receiver platform. The new platform is designed to maintain a more stable geometrical relationship with the transmitter and to reduce receiver coil motion during flight.

EM TEST RANGE

The Forrestania EM Test Range is situated approximately 350 km east of Perth and west of the Beautiful Sunday nickel mine site (Figure 2). Two conductive targets exist in the test block, of which the shallow thin conductor, IR2, is of specific interest. This conductor is believed to be an extension of the Flying Fox ultramafic sequence (Image Resources NL, 2005). Ground and airborne EM surveys have been completed over this target. Historical ground survey modelling results of IR2 have concluded that it is less than 100 m below the surface, has a spatial size of approximately 75 m strike by 75 m depth extent, has a conductance of over 7000 S and dips to the north by 30 – 40 degrees (Southern Geoscience Consultants, 2011). It has also been concluded that the conductor is hosted in a highly resistive basement beneath a conductive overburden of between 10 and 20 S.

Fugro Airborne Surveys has recently flown its HELITEM system over the IR2 bedrock conductor. We compare and analyse the EM data along with synthetic modelling results to reveal the systems strengths and recent advancements.

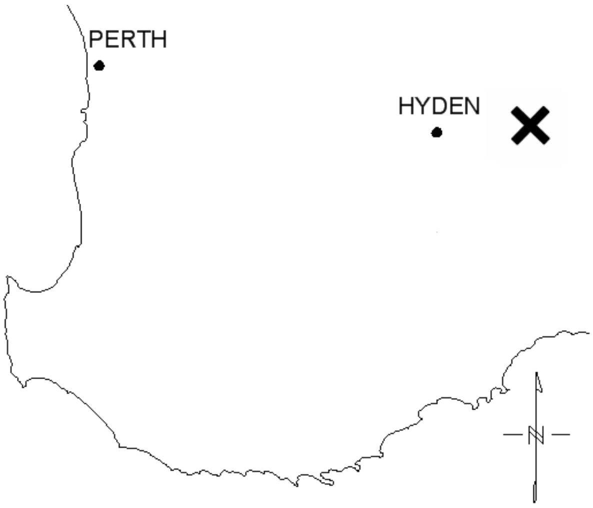

Figure 2. Location of Forrestania EM Test Range

DATA

The EM component X, Y and Z dB/dt and B-field data are presented in Figure 3. The line presented was flown directly over the IR2 bedrock conductor perpendicular to the strike direction. The depth and dip of the IR2 conductor can be approximated by qualitative analysis of the collected profile data. The horizontal separation between the X component peak and X component trough is used to estimate the depth of the conductor. Using this method we estimate the depth of the IR2 conductor to be 65 – 70 m.

The Z component peak appears to the north of the known conductor position, as would be expected for a conductor dipping moderately to the north. The position of this peak along with the lack of a strong second peak are compared with forward modelling results to reveal an approximate dip angle of 50 ± 15 degrees. To improve this estimate we can examine the X component peak to trough amplitude ratio. This method reveals a ratio of 3 which when compared to theoretical modelling results reveals an approximate conductor plate dip angle of 35 degrees. The conclusions from qualitative analysis are in good agreement with previous studies over the target. Quantitative analysis must then be done to improve conclusions made at this initial stage.

MODELLING

An initial estimate of the layered earth environment is determined by creating a Conductivity Depth Image (CDI) from the collected data (Macnae et al., 1998). EMFLOW was used for this task. Due to the approximate nature of CDIs, Layered Earth Inversions (LEIs) were created to improve the layered earth model. To reduce the number of iterations required during the LEI processing, the CDI was used as a starting model. Conclusions from the LEI model were used to define the conductance and thickness of the overburden and resistive host for the bedrock conductor IR2. Results from these initial models show good agreement with the layered environment concluded by previous studies.

Once the layered environment has been well described, the task of defining the conductor plate itself was undertaken. Due to the thin plate nature of the target and the presence of a conductive overburden LeroiAir (Raiche et al., 2006) was chosen for plate modelling. EMIT Maxwell (ElectroMagnetic Imaging Technology (EMIT), 2011) was used to run, analyse and present the modelling results. Initially synthetic profile data was created using forward modelling to better define the plate size and dip. Results from forward modelling show good agreement with plate specifications concluded by previous studies. Using these results as a starting model we then ran inverse plate modelling to determine a final plate model from the collected profile data.

CONCLUSIONS

Recent developments in the HELITEM system including the increase in the peak dipole moment and innovative receiver platform have resulted in an improvement in the systems' signal to noise ratio. Three component data collected with this system enabled quantitative modelling of the IR2 conductor geometry at the Forrestania EM Test Range.

ACKNOWLEDGMENTS

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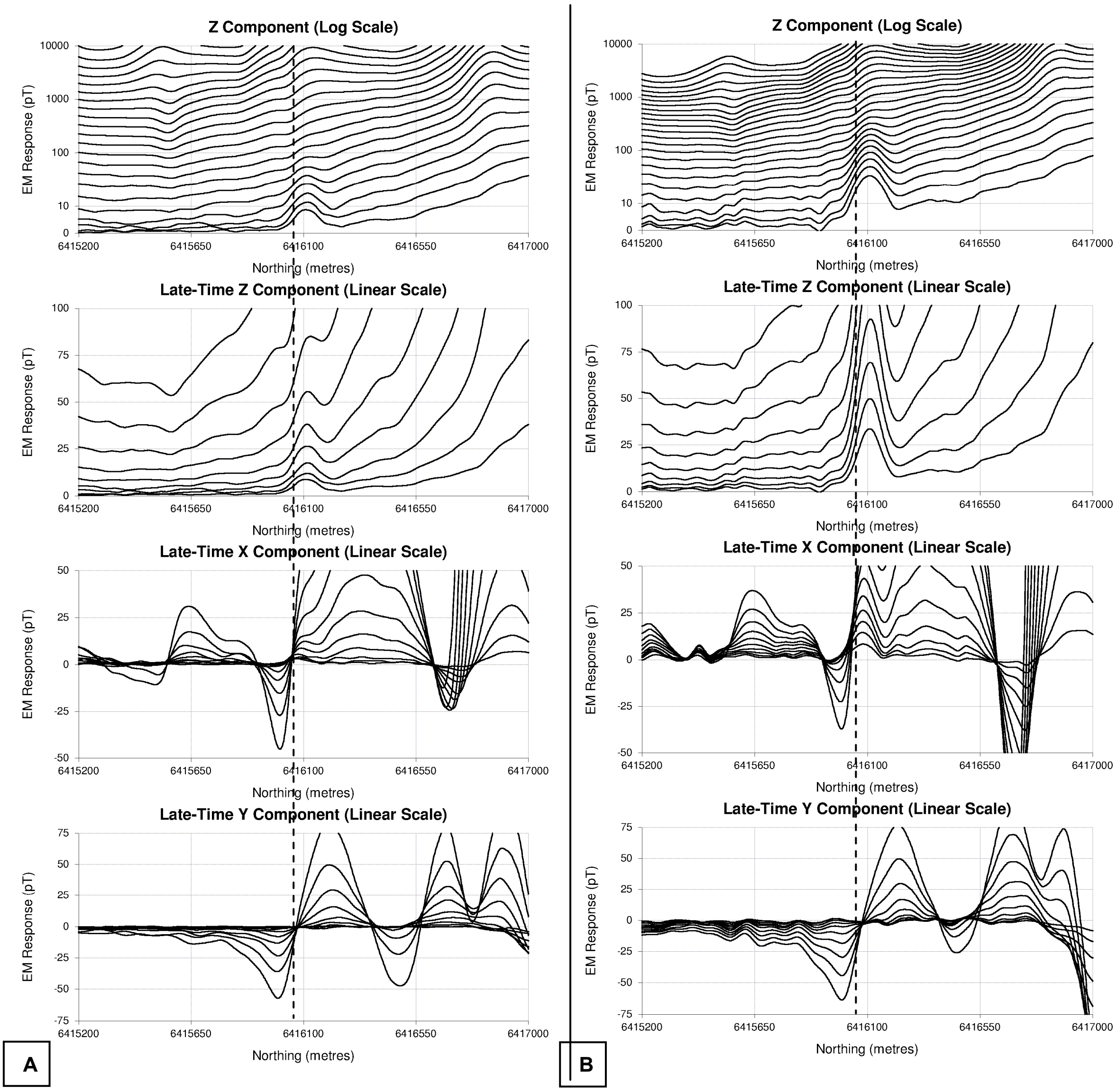

Figure 3. Z, X and Y component profile data A) dB/dt, B) B-field. Note: the dotted line represents the position of the conductor IR2