

An assessment of Geotem, Falcon® and ZTEM surveys over the Nebo Babel deposit, Western Australia

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SUMMARY

The Nebo Babel Ni-Cu deposit was discovered in 2000 by Western Mining Corporation (WMC). BHP acquired WMC in 2005 and advanced the project. In 2014, BHP optioned the property to Cassini Resources and in 2016 Cassini partnered with Oz Minerals to further advance the project. During the period when WMC and BHP held the project, extensive airborne geophysical investigations were conducted including Geotem, Falcon®, ZTEM, AirMt and Spectrem. Parts of the mineralized system respond well to the various airborne EM techniques but the response overall is complicated by the presence of extensive paleochannel development. A combination of 1D, 2D and 3D processing techniques have been applied to the EM data so as to better understand the overall system responses and where possible, see if it were possible to separate the basement conductive response from that of the overlying Tertiary channels.

Key words: Nickel-copper, chonolith, airborne geophysics, geophysical inversion.

INTRODUCTION

The Nebo Babel deposit is hosted within a concentrically zoned, olivine-free, tube-like (chonolithic), gabbro-norite intrusion associated with the 1,078-Ma Giles complex layered intrusions in the Warakurna igneous province, eastern Western Australia (Seat et al., 2007). The fault-offset Nebo Babel chonolith extends for 5 km and has a cross-section of 1×0.5 km. The basic shape of the system is shown in Figure 1.

In 2001, WMC had a Geotem 25 Hz survey carried out over the then recently discovered Nebo Babel deposit. This survey showed there were a number of discrete conductive features associated with Nebo and Babel, as well as extensive conductive responses attributed to the development of paleochannels in the area (Magee 2009). In 2006, a Falcon survey was carried out over the deposit area (Dyke 2007). This survey showed there were discrete density responses associated with the Nebo Babel mineralized system. In 2010, ZTEM and AirMt surveys were carried out on a limited basis over the primary deposit area and were assessed by Legault et al., 2012. The results presented here are from that assessment and only the ZTEM outcomes are examined as the ZTEM and AirMt outcomes are quite similar. These surveys showed both responses that could be attributed to the sulfide mineralization as well as the extensive Tertiary channels known in the area. In 2012, Spectrem was conducted over the area (G. Walker, per. commun., 2012). In this present assessment, the Geotem, Falcon, ZTEM data will be examined.

GEOLOGY

A plan through the deposit is shown in Figure 2. The main mineralized zones are indicated, as are the EM picks from the Geotem survey.

A long section through the deposits is shown in Figure 3. The original shape of the chonolith is apparent, with the two pieces gently dipping to the west and off-set laterally and vertically along the Jamieson fault.

As they have a strong influence on the geophysical response in the study area, a section through a paleochannel is shown in Figure 4 (Magee 2009). Such features are typically filled with lower density sediments and are channel ways for high salinity fluids, hence producing strong gravity and EM responses.

AIRBORNE SURVEYS

Geotem-Flown in 2001, this survey covered an extensive area around the Nebo Babel deposit. A time constant image is shown in Figure 5, with the area of the deposit circled. The numerous meandering dendritic conductive features are believed to be the expressions of paleochannels. One such feature is apparent in the vicinity of Nebo Babel.

Layered earth inversions (1D) and picking of the discrete EM responses in the vicinity of the deposit were carried out. Figure 6 shows the Geotem time constant and TMI-RTP responses around the deposit area; also shown are the EM picks and the outlines of the chonolith zones.

The EM responses are quite localized near the two zones. While these responses are deemed to be reasonably conductive, the time constant response does not highlight the area of discrete picks as such but rather shows a series of broadish responses that appear to be a blurred reflection of the combination of paleochannel responses and the higher conductance discrete sulfide zones. The TMI-RTP shows that there is a direct magnetic high associated with Nebo but that Babel appears to be associated with a relative magnetic low. Overall the magnetic response around the deposit is complex. The importance of this as it relates to the economic geology is unclear

Falcon-BHP carried out Falcon AGG and magnetic surveys over the Nebo Babel area in 2006. This was first reported on by Dyke (2007) and formally published by Oldenburg and Pratt (2007). The AGG results for the entire survey are shown in Figure 7 and the detailed response over the Nebo Babel area is shown in Figure 8. The AGG survey shows there are two discrete density highs associated with the two parts of the mineral system. A major density low also defines the location of the Jameson fault which is believed to be a paleochannel. The Falcon results are not believed to be detecting the massive sulfide zones mapped by the Geotem survey but rather correlate with the high density gabbro intrusives.

ZTEM-An orthogonal survey path was employed as shown in Figure 9 (all the ZTEM images presented here are from Legault et al., (2012)). The image is a sum of the horizontal derivatives of the tipper components at 75 Hz (termed the 75 Hz IP DT). These results show responses in the vicinity of the known intrusives and mineralization but these are not unique and there appears to be a strong overprint in conductivity responses due to the paleochannels in the area. The 75 Hz IP TPR outcome in Figure 10 shows a very similar outcome to the DT result but is overall a smoother outcome.

Figure 11 shows the Geotem Bfield Z Ch 5 result and the ZTEM 75 Hz DT (as Figure 9) over the deposit area. On both results there appears to be a NE-trending conductive limb that correlates with the location of the majority of the Geotem picks. Note that this trend is displaced to the north of the mapped outline of the gabbro intrusives. The gabbro intrusives apparently contains more disseminated mineralization but this is deemed an IP target and not likely responsive to EM (G. Walker, per. commun., 2012).

The ZTEM results show an ellipsoidal feature just south of the outline of Babel that has a shape and orientation very similar to the intrusive outline but displaced 1 km to the SW. This type of pattern is what a resistive intrusive body would be expected to produce (Witherly and Sattel 2012) but the off-set is unexplained based on current geological knowledge. Modeling of the Falcon results suggests the Babel intrusive plunges to the west (G. Walker, per. commun., 2012) and possibly the ZTEM resistive response is a reflection of this as well.

1D, 2D and 3D modeling of the Geotem and ZTEM was carried out using a variety of inversion programs so as to try and better understand the geometric nature of the conductivity responses in the vicinity of the Nebo Babel deposit. The Geotem data were processed with a 1D layered earth algorithm and modeled with the Maxwell parametric code to produce 3D plate models. The ZTEM results were processed using 2D and 3D codes (Legault et al 2012).

The results obtained for ZTEM L1430 over Babel (see Figure 10) are shown in Figure 12. Displayed are the ZTEM 2D and 3D inversions and the Geotem 1D inversion along with the Maxwell plate models for that location (Geotem L22021). Note that the vertical scales are optimized for the outcomes and so the ZTEM has a 1.6 km vertical scale and the Geotem 600 m. The major differences are that the ZTEM seems to image the conductors deeper than the Geotem; also, between the 2D and 3D ZTEM, the 3D outcomes appear deeper and more diffuse.

CONCLUSIONS

The results of a variety of airborne results over the Nebo Babel Ni-Cu deposit have been examined. The two EM surveys have been processed and compared. Paleochannel responses prevalent in the area produced significant responses in the EM. With the EM techniques, it is difficult to define with certainty whether the EM responses were bedrock or surficial in nature. However, the active source EM system, Geotem, provided sharper responses to the presumed bedrock sources and hence provided better discrimination compared with the AFMAG technique. A Falcon survey over the deposit showed strong positive density responses over the two ultrabasic zones and a pronounced low density linear corresponding to a known paleochannel.

ACKNOWLEDGMENTS

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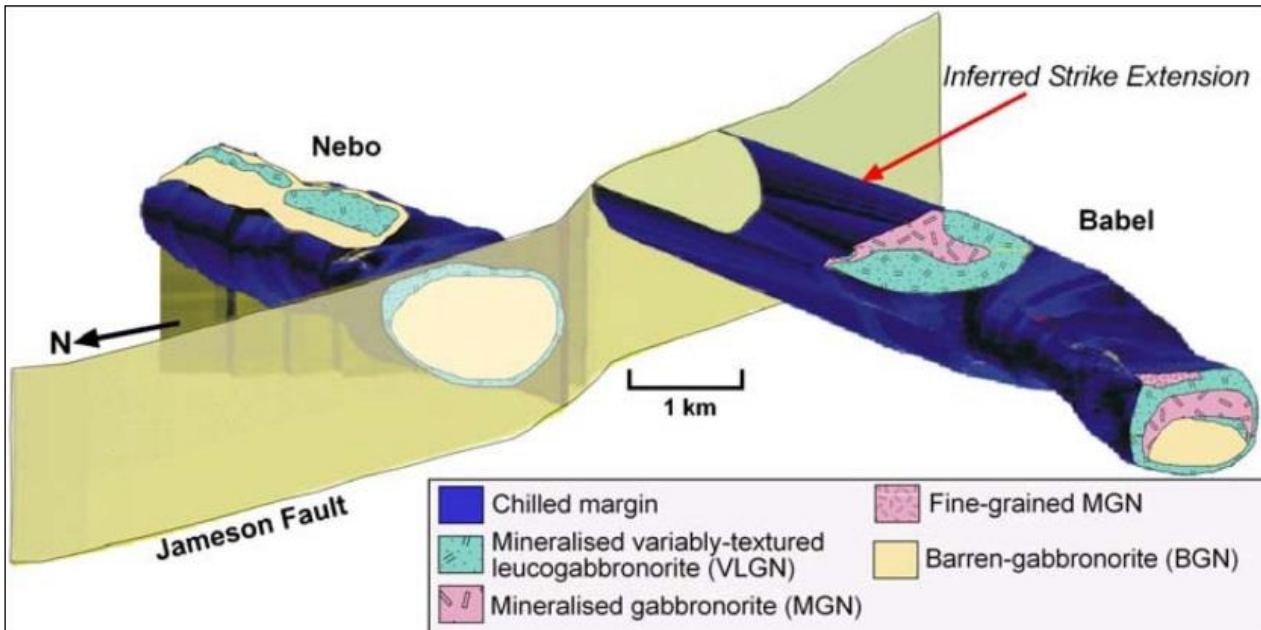


Figure 1: Schematic of the Nebo Babel deposit; it formed as a single entity but is now split along the Jameson fault (from Seat et. al., 2007).

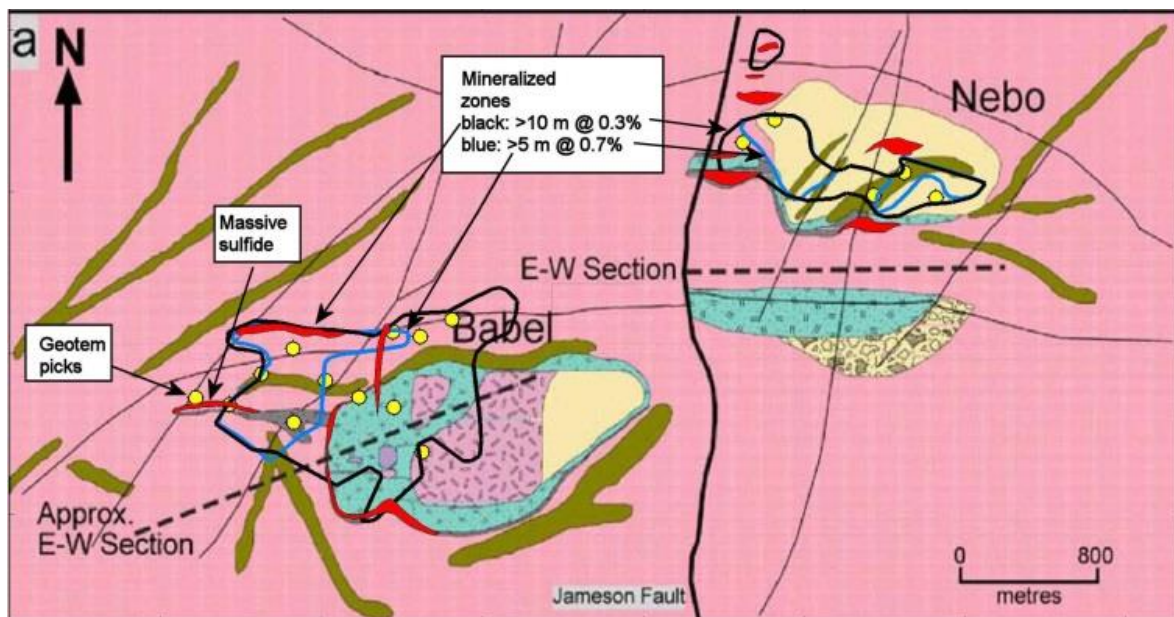


Figure 2: Geology plan with mineralized zones and EM picks (Seat et. al., 2007).

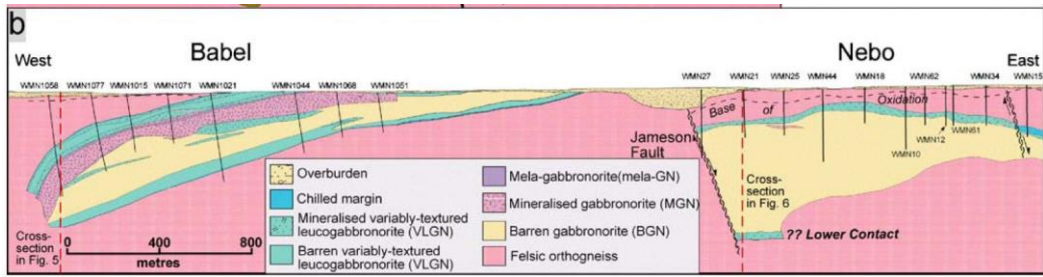


Figure 3: Cross-section looking to north through the Nebo Babel deposit (Seat et. al., 2007). The geological legend applies to Figures 2 and 3.

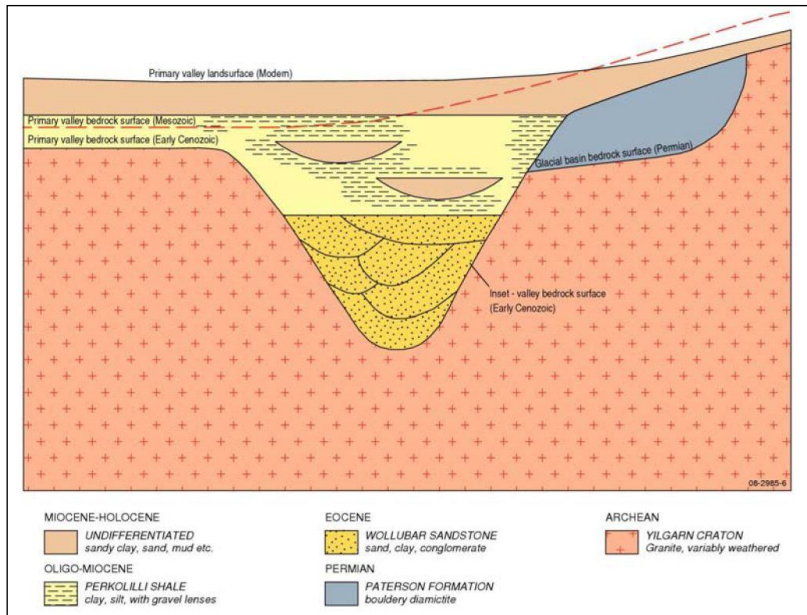


Figure 4: Cross-section through paleochannel found in Yilgarn (after Magee (2009)).

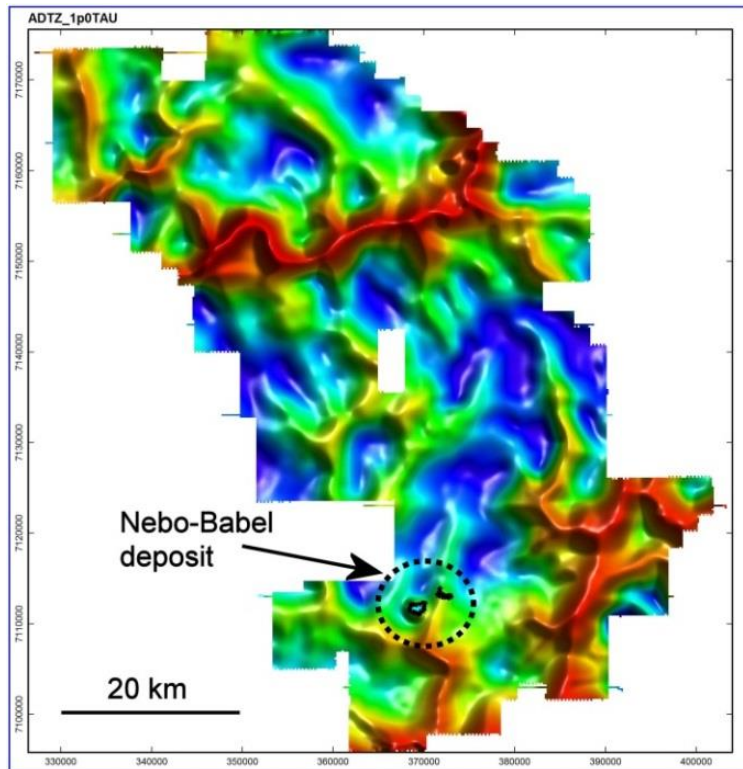


Figure 5: Geotem survey showing time constant and location of Nebo Babel deposit.

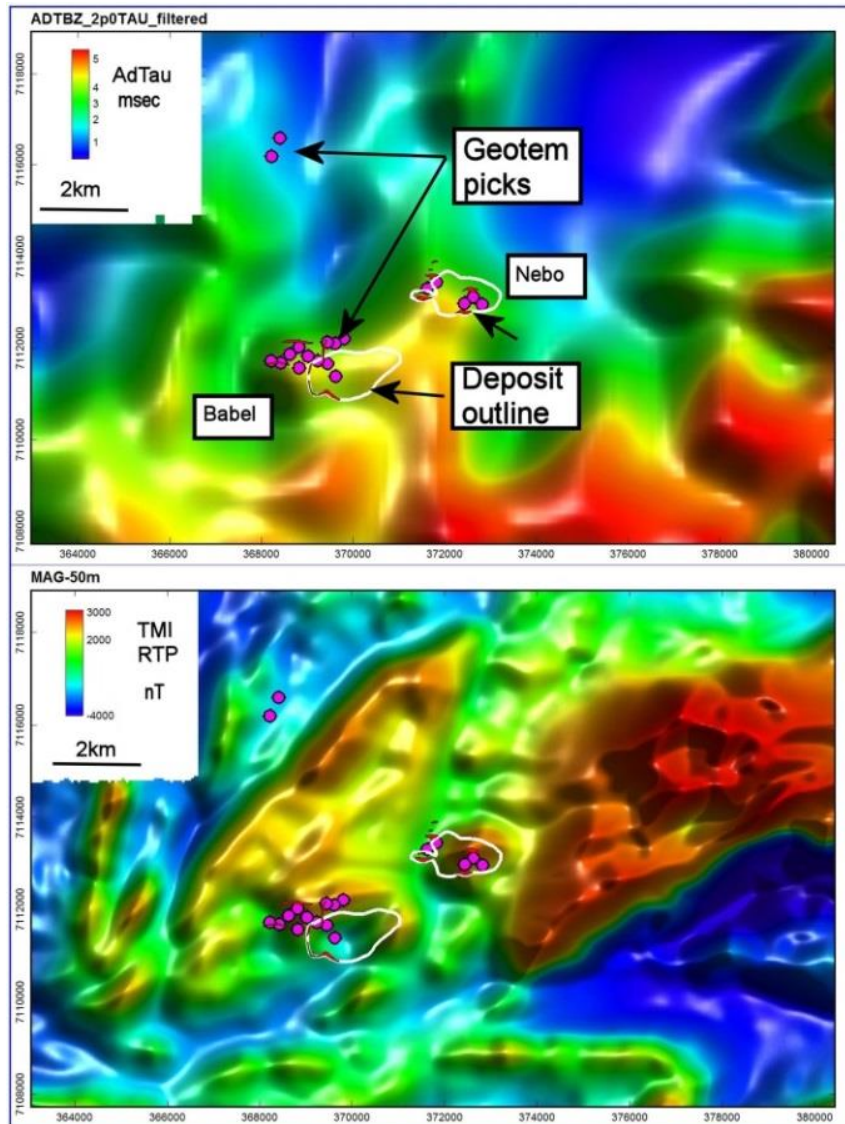


Figure 6: Geotem time constant (top) and TMI-RTP responses in the vicinity of Nebo Babel deposit; EM picks and chonolith zones also shown.

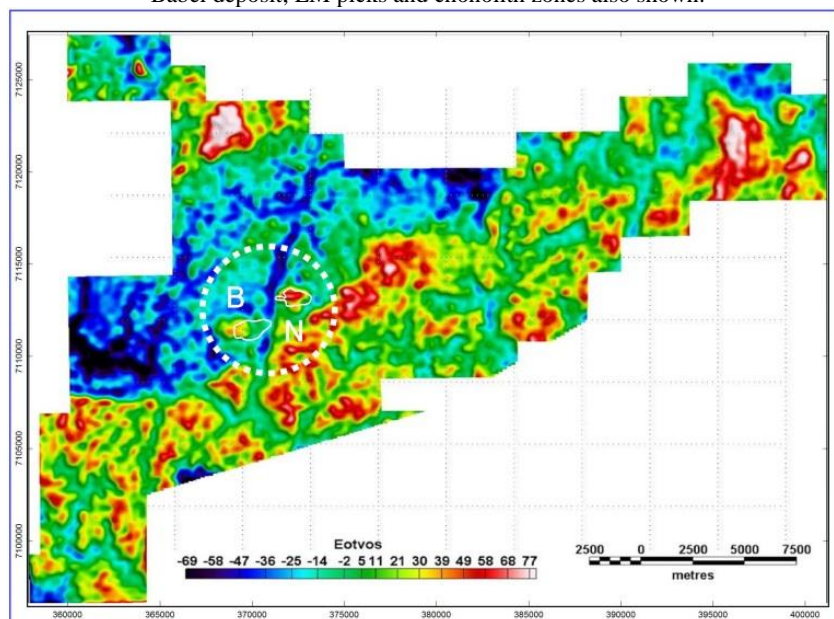


Figure 7: Falcon AGG regional coverage; deposit area highlighted (Dyke 2007).

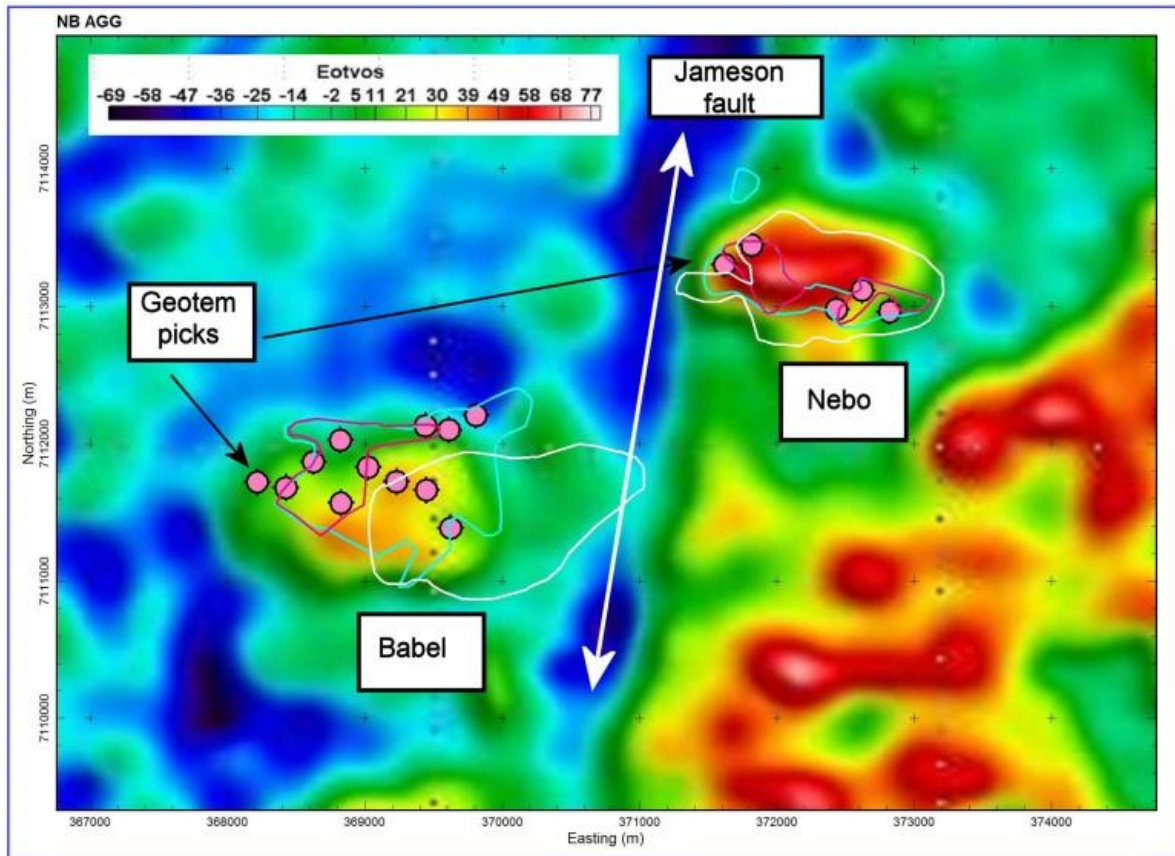


Figure 8: Falcon coverage over Nebo Babel area (Dyke 2007).

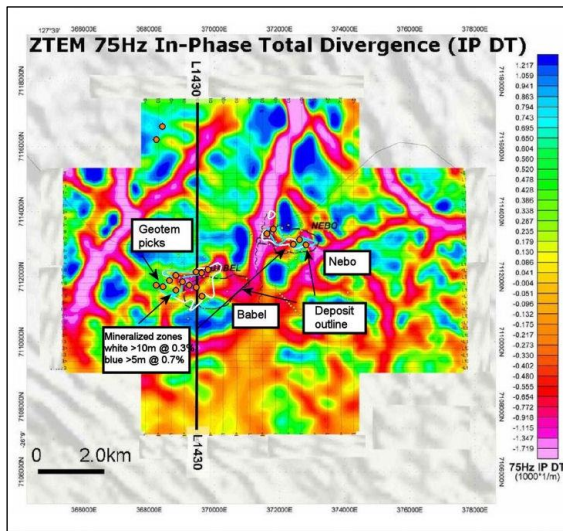


Figure 9: ZTEM merged grid of 75 Hz IP DT-
Legault et al., 2012

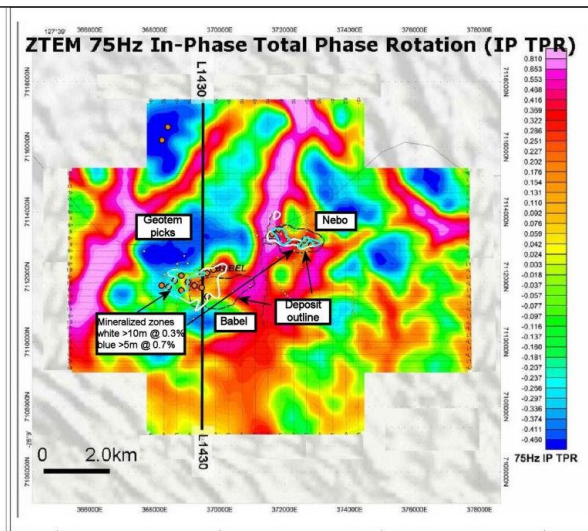


Figure 10: ZTEM merged grid of 75 Hz IP TPR-
Legault et al., 2012.

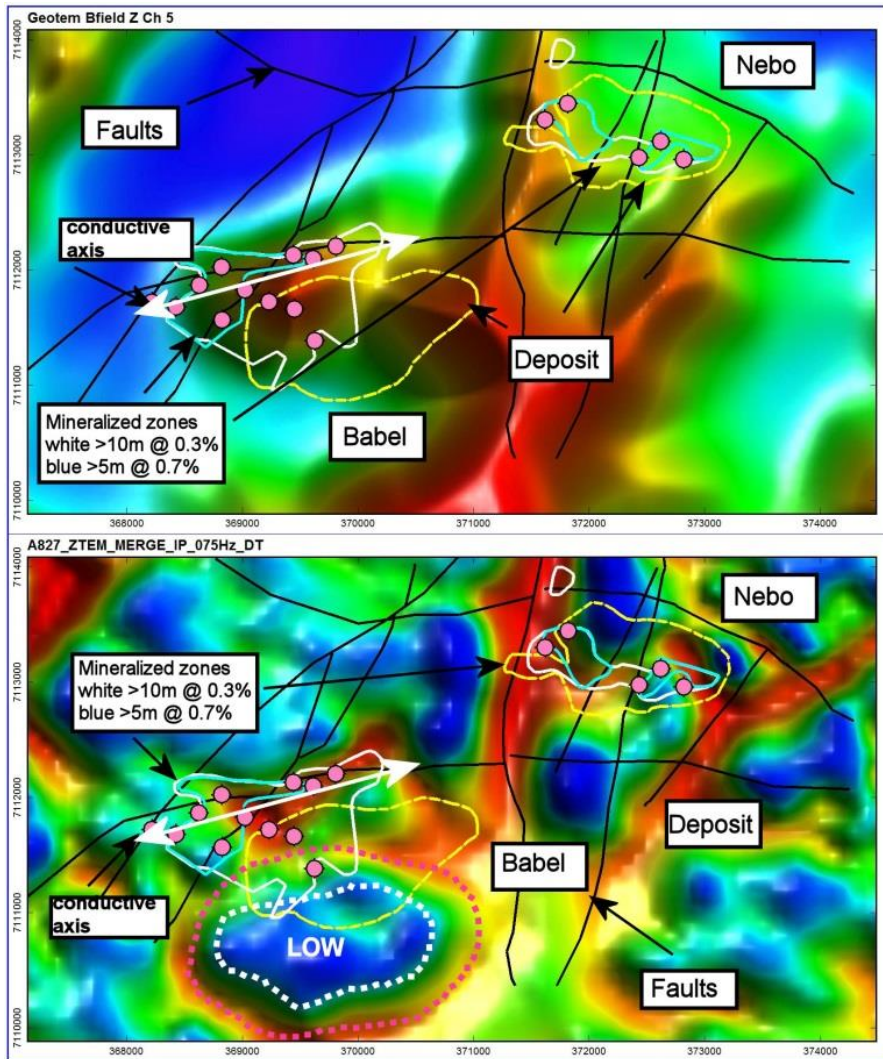


Figure 11: Geotem Bfield Ch 5 (top) and ZTEM 75 Hz IP DT with interpretive notes.

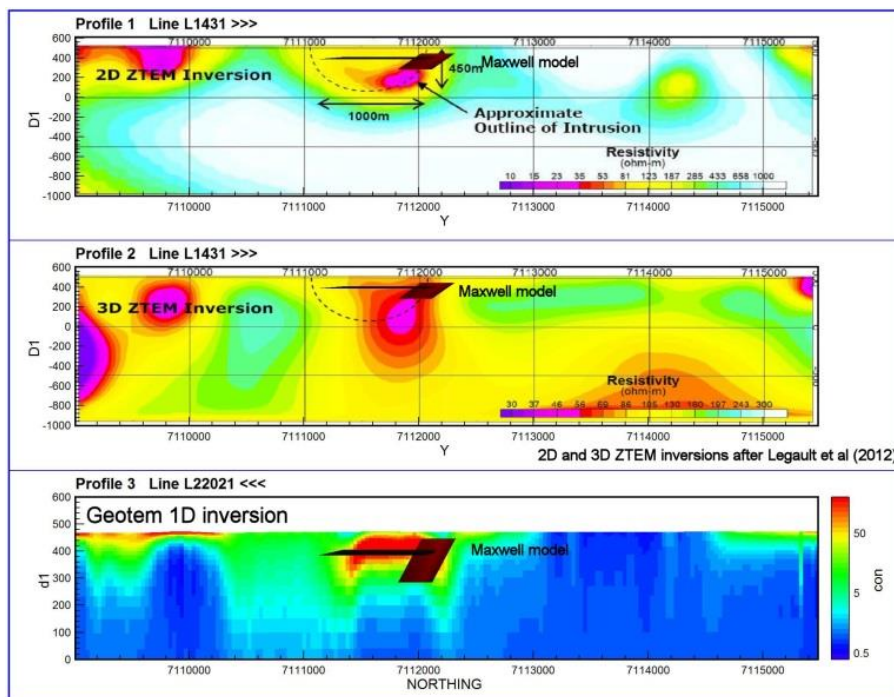


Figure 12: 2D and 3D ZTEM inversions for L1430 and 1D inversion of Geotem Z dB/dt.