An assessment of 3D ZTEM results over three deposits

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SUMMARY

The ZTEM airborne EM system was introduced into commercial service by Geotech Ltd. in 2006. ZTEM is unlike other EM systems in that it relies on the measurement of natural occurring EM fields in the AFMAG frequency range of 25-720 Hz.

As a primary survey outcome, a ZTEM survey produces in-line and cross-line tipper data; Tzx and Tzy, at a series of frequencies. The contractor provides a suite of filtered X and Y spatial grids and 2D conductivity depth inversions have typically been provided using the Tzx component.

More recent, full 3D inversion of data has begun to be applied which provides concurrent information about cross-line (derived from the Tzx) and along line (derived from the Tzy) data.

The exploration value of inversions whether 2D or 3D is not yet well established due to 1) the limited surveys available to date and 2) limited availability of inversion codes and their application. In the present assessment, 2D and 3D inversion results over three deposits will be examined and considered in terms of the geological knowledge available at each site.

Key words: AFMAG, ZTEM, 2D, 3D inversion and minerals exploration

INTRODUCTION

The ZTEM system (built and operated by Geotech Ltd.) measures the AFMAG responses of naturally occurring subsurface currents, induced by distant lightning discharges. The vertical component is measured from a helicopter platform, while the horizontal components are recorded on the ground at a base station; data are typically acquired over a frequency range of 25-720 Hz. Various methods are used for the modeling and interpretation of ZTEM data, including 2D and 3D inversions, Karous-Hjelt filters and the derivation of apparent conductivity; these are discussed in Sattel and Witherly (2012a, 2012b).

In the present study, the results of ZTEM surveys carried out over three mineral deposits are examined in light of 2D and 3D inversions performed on the survey data. The three deposits are the Morrison porphyry copper-gold system in British Colombia, Canada, Nevada the Cinco de Mayo carbonate replacement deposit (CRD) deposit, Chihuahua Mexico and the Cortez Summit Carlin-style deposit, Nevada

PROCESSING

In the present study, 2D and 3D processing has been carried out on the ZTEM results. The 2D algorithm is based on a 2D MT algorithm developed by Constable and Wannamaker (deGroot-Hedlin and Constable, 1990 and deLugao and Wannamaker, 1996). The algorithm derives the in-line (Tzx) tipper profiles from the computed transverse electric (TE) response. The 3D inversion algorithm used on the data was developed by Holtham and Oldenburg (2010), and is based on earlier work by Farquharson et al. (2002). Rather than invert individual Tzx profiles, the 3D inversion simultaneously inverts the in-line Tzx and across-line Tzy data of multiple flight lines using a Gauss-Newton approach.

FIELD RESULTS

Morrison Deposit, British Colombia
The Morrison deposit is porphyry copper-gold system located in central British Colombia. The deposit has a measured and indicated resource of 115.3 Mt @ 0.44 Cu and 0.20 % Au (Pacific Booker Minerals web site). In addition to the Morrison deposit, a second mineralized zone called Hearne Hill is located several kms. to the SE of Morrison. Hearne Hill is described as a breccia style deposit containing mainly copper mineralization. One geological assessment suggests Hearne Hill is the fault off-set lower part of the Morrison intrusive. ZTEM was carried out over the deposit in May 2010 (Legault 2010). An outline of the survey over the deposit area is shown in Figure 1.

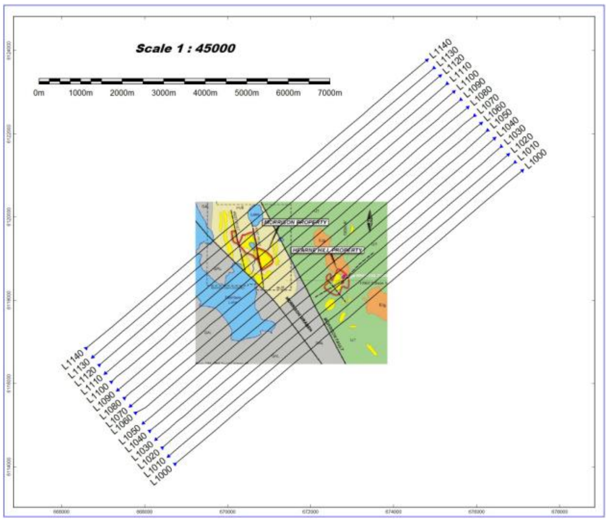

Figure 1: Flight path of ZTEM over Morrison deposit.

The 360 Hz IP DT result is shown in Figure 2. The Morrison deposit site within a wedge shaped grabben over a resistive high (blue). The bounding faults appear as linear highs and show good agreement in at least the western part of the survey area. Hearne Hill lies outside the grabben and is associated with a conductive annulus response very different from Morrison. There is little mapped geology elsewhere to assess the other features in the ZTEM survey but a number of major structures or contacts are apparent to the NE of Hearne Hill. The responses west of Morrison and Hearne Hill appear muted in comparison and may in part be caused by the water (lake) covering part of the area and extensive glacial sediments. There are several 'pot hole' type resistivity highs in this area and a junior explorer has been investigating these features.

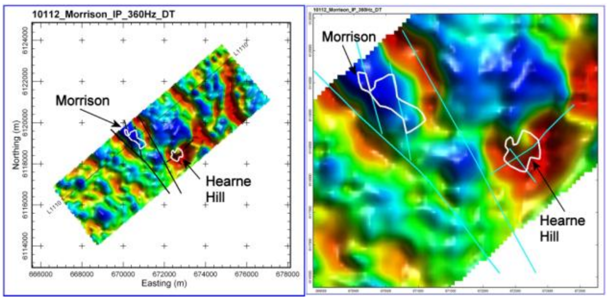

Figure 2: 360 Hz IP DT result.

Figure 3 shows the 2D and 3D inversion results for L1110 through the Morrison deposit (Figure 2). There are some differences

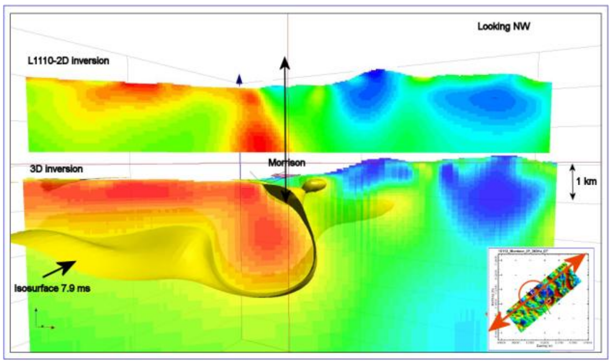

Figure 3: 2D and 3D inversion results for L1110.

Figures 4 & 5 shows depth slices of the 2D and 3D inversion models. At a shallow depth, the two models look quite similar but at a moderate depth (500 m), two along-line conductive features emerge in the 3D result that is not recovered in the 2D result. The strongest feature is associated with Hearne Hill and to date has undergone limited testing.

Cinco de Mayo Property, Mexico

The Cinco de Mayo (CDM) property (Robertson and Megaw 2009) is located in north-central Chihuahua, Mexico. CDM is comprised of several different mineralized systems that are all thought to be part of a CRD style deposit. The focus of the current assessment is the Pozo Seco deposit. Pozo Seco was discovered in 2009 and there is currently a resource of 29 Mt of 0.147% molybdenum and 0.25 g/T gold contained in a shallow elongate deposit as is shown in Figure 6.

ZTEM was flown over the property in 2009. The flight block with respect to the Pozo Seco deposit is shown in Figure 7.

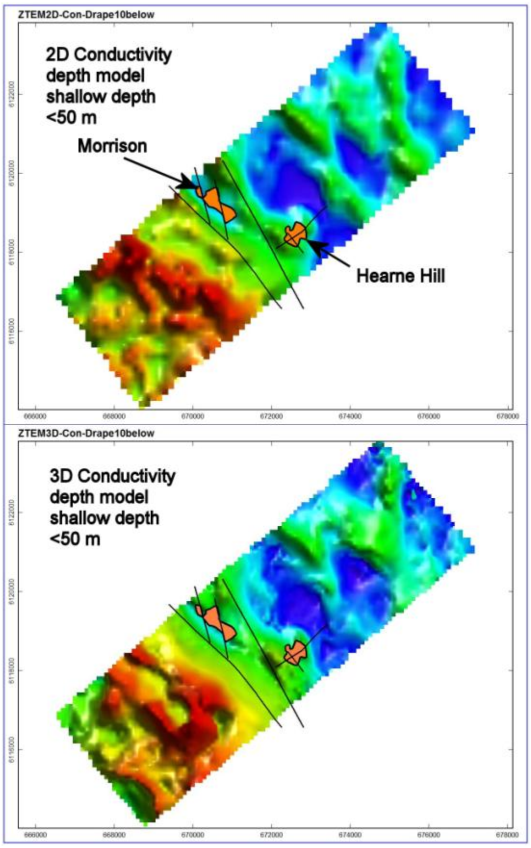

Figure 4: 2D (top) and 3D depths slices; at a shallow depth, results appear quite similar.

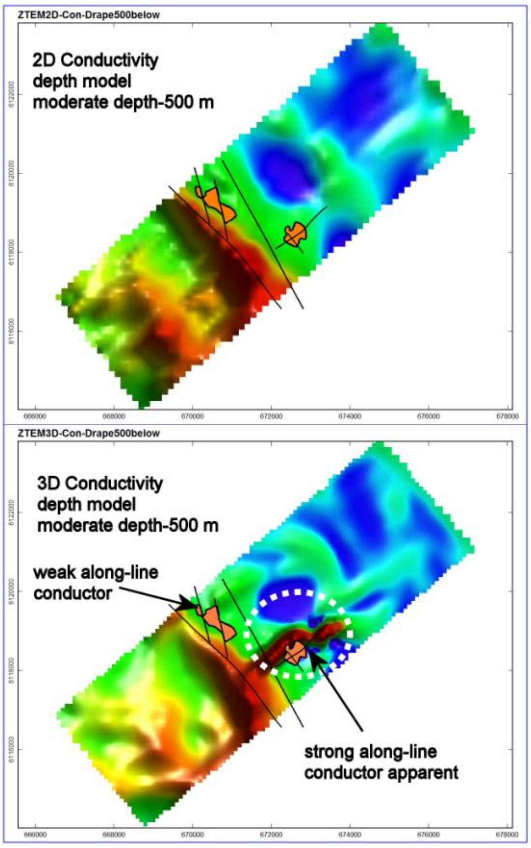

Figure 5: 2D (top) and 3D depths at a moderate depth (500 m), the two along line features emerge in the 3D model.

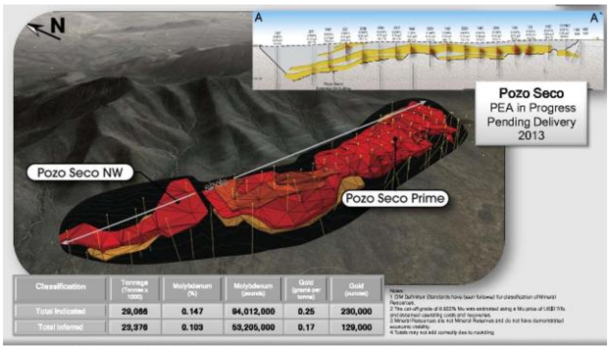

Figure 6: Conceptual 3D representation of Pozo Seco deposit (from MagSilver web site).

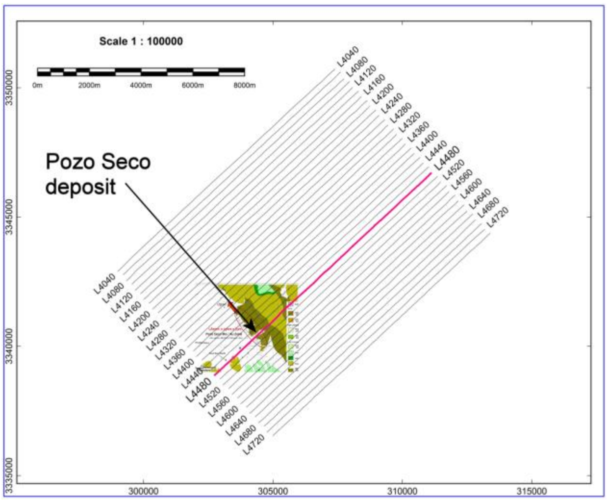

Figure 7: ZTEM flight showing the Pozo Seco deposit.

The 90 Hz Geotech-provided grids IP DT and IP TPR are shown in Figure 8. The Pozo Seco deposit is located along a major linear zone that shows up in both the DT and TPR images. Some cross-structural features are apparent in the ZTEM, particularly the DT image. Such structures are thought likely important in localizing the mineralization.

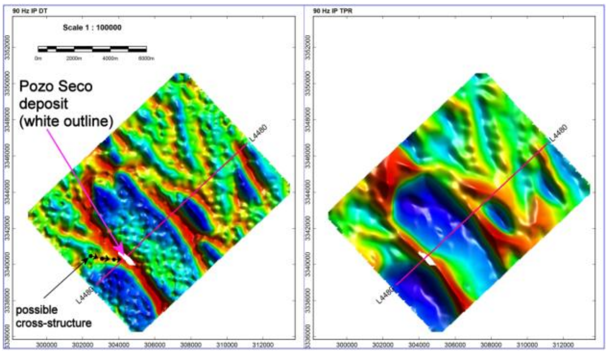

Figure 8: Images of the 90 Hz IP DT and TPR results.

Both 2D and 3D inversions were carried out on the data. Figure 9 shows a sectional display that compares the 2D and 3D results over the Pozo Seco deposit along L4480 (located in Figure 8). The 2D and 3D sections look similar with a gentle dip of a conductive zone to the east. The 3D result looks smoother than the 2D. The deep-seated magnetic high on the bottom panel is thought to be likely the source of the hot fluids and potentially the mineralization located at Pozo Seco.

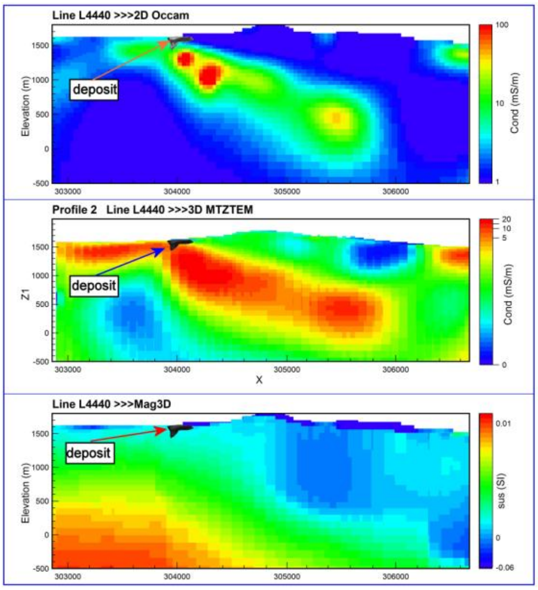

Figure 9: 2D and 3D inversion results for L4480 through the Pozo Seco deposit. Mag3D model at bottom of the plot.

Cortez Summit, Nevada

The Cortez Summit property is situated along the Battle Mountain-Eureka Trend in central Nevada (Figure 11). There are two major resources nearby; the Goldrush resource and the Red Hill resource with over 7 million ozs of contained gold (Barrick 2011). The historic Buckhorn deposit lies just to the NE of the property. ZTEM was carried out over the southern part of the property as part of a larger test of the technology.

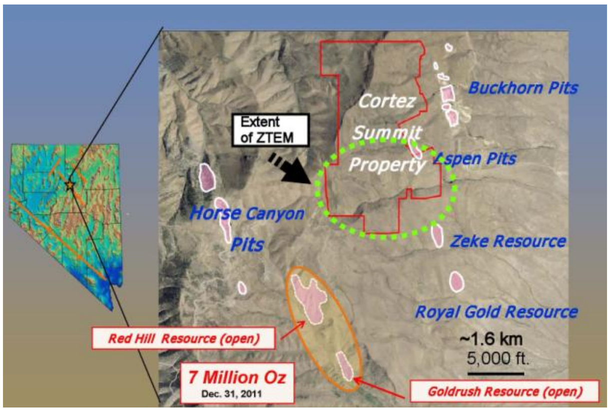

Figure 10: Location map showing the Cortez Summit property and surrounding deposits/resources.

With the Carlin-style deposits, fine grained gold is typically hosted in sedimentary rocks, frequently close to major structures. Figure 12 shows two sections from the Goldrush and Red Hill deposits. The ZTEM coverage over the Cortez Hill deposit is shown in Figure 13; the images shown are the 30 Hz IP DT and 180 Hz IP DT. The 30 Hz response shows some NNW grain but a NE-SW trend is also apparent (highlighted with the double headed white line). With the 180 Hz data however, the grain is strongly NNW. This level of difference is unusual and suggests that there is a change in the underlying rock fabric, with the NNW grain being the shallow component and the NE grain being the deeper response.

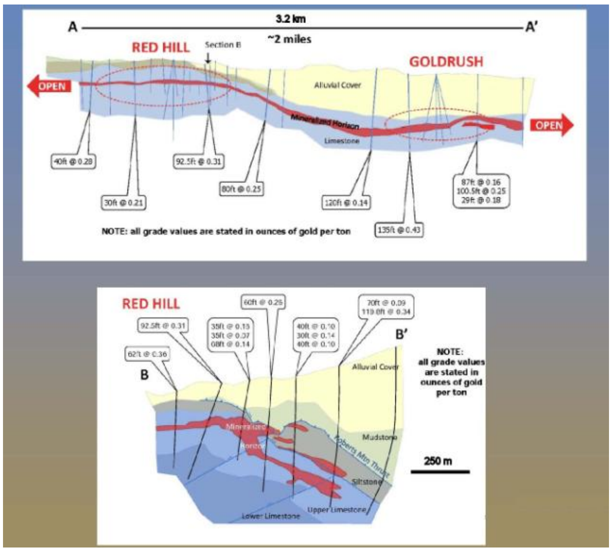

Figure 11: Geological sections through the Goldrush and Redhill deposits (Barrick web site).

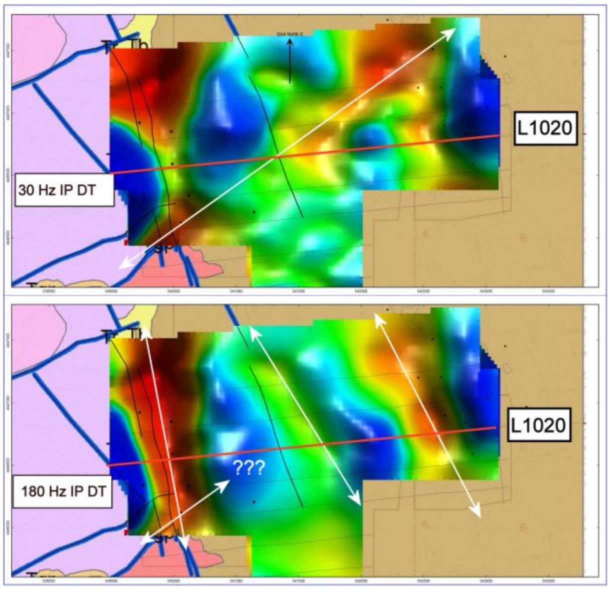

Figure 12: 30 Hz IP DT (top) and 180 Hz IP DT images showing mapped structures (black) and ZTEM indicated structures (white double arrows).

Figure 13 shows the conductivity depth inversions for the 2D and 3D models. The 3D model appears somewhat sharper than the 2D but the major difference is that the model range for the 2D model shows a much broader dynamic range than the 3D model shows. The reasons for this are unclear.

CONCLUSIONS

The value of 3D modelling for ZTEM surveys is still being assessed by the user community. The lack of easily available public domain codes and their complexity in operation means that 3D inversion at this stage is only getting limited use. Acquisition of ZTEM data is as well still relatively new and the authors have seen examples where the Tzy data does not agree with the Tzx data and has to be removed from the inversion.

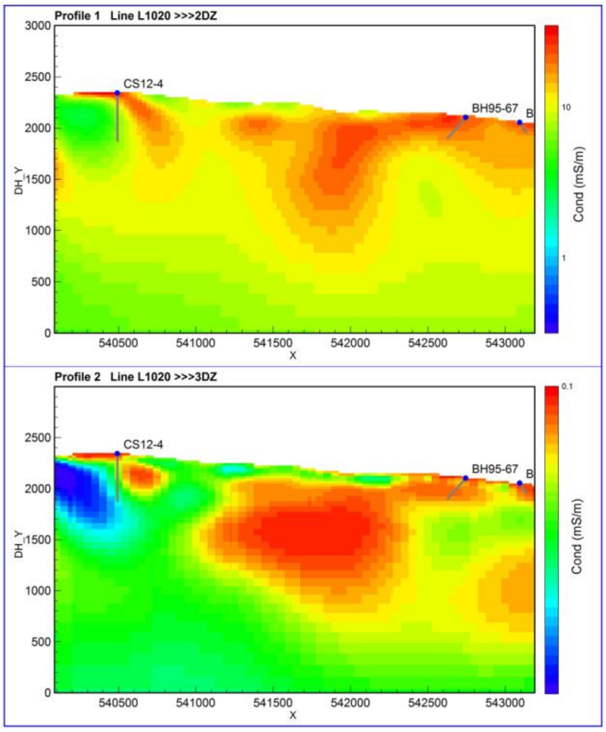

Figure 13: 2D (top) and 3D inversion models for L1020.

The geological assessment of 2D and 3D inversion results is also still in its infancy and more publically vetted cases studies need to be produced in order for the community's knowledge base to be at an effective level.

ACKNOWLEDGMENTS

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