Mt. Milligan

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Summary

There have been multiple manifestations of IP effect in Time Domain Airborne EM data (TDEM). This phenomenon is known to be responsible for incorrect inversion modelling of electrical resistivity, lower interpreted depth of investigation and lost information about chargeability of the subsurface, as well as about other valuable parameters. Historically there have been many suggestions to account for the IP effect using the Cole-Cole model. In the current paper we show the possibility of extracting IP information from airborne TDEM data using this same concept, including inverse modelling of chargeability from TDEM data collected by VTEM, over Mt. Milligan Cu-porphyry deposit, BC, Canada.

Introduction

Mt. Milligan is a large Cu-Au porphyry deposit situated in central British Columbia (Figure 1). Geologically, the Mt. Milligan deposit is a mineralized zone within a porphyrite-monzanite stock (MBX), hosted within andesites and volcanites of the Takla group (DeLong et al., 1991). There are two types of alteration present in the Mt. Milligan deposit: potassic and propylitic. These alterations are responsible for different physical properties. Chargeability is a crucial property for the Mt. Milligan deposit, as it may be indicative of the gold-bearing mineralization, which is undetectable otherwise due to poor electrical conductivity of the mineralization (Oldenburg et al., 1997).

Figure 1. Location of Mt. Milligan depost, BC, Canada.

In 2008 the deposit was surveyed by the VTEM system at the request of Geosceince BC and showed significant IP effect in the data (Figure 2). Previous attempts to invert these data include Schwatzbach et al. (2013), which was done without consideration of the IP effect. Kwan et al. (2015b) have recently contributed to analysis of the IP effect in these VTEM data.

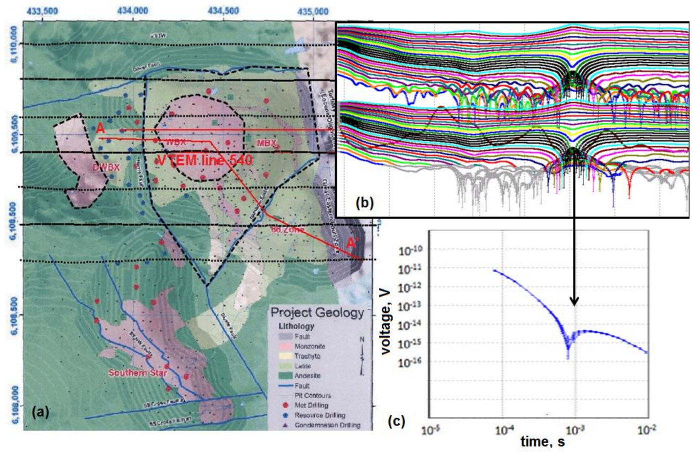

Figure 2. (a): Bedrock geology of Mt. Milligan deposit. (b): visible IP effect in VTEM data (flight line 540). (c): IP effect in individual transients.

SCI inversion

For the purpose of current study, the VTEM data were inverted using SCI approach (Viezzoli et al, 2008. A first attempt was made without the consideration of the IP effect, and then the data were inverted in IP mode, incorporating the Cole-Cole model (Cole and Cole, 1942, Fiandaca et al., 2012). Figure 3 shows the comparison of resistivity depth sections with and without modelling of the IP effect, both clipped to interpreted depth of investigation. As it can be seen in Figure 3, the "MBX" marks the extent of the monzonite stock, which, along with Rainbow dike are showing the highest grades of Au concentration in the deposit (DeLong et al, 1991). In this figure there is significant improvement in depth of investigation (DOI), due to modelling of the IP effect. Furthermore, the improved resistivity section (b) shows good correlation with the geology (e.g. the resistive response of DWBX and MBX zones, the conductive signature of overburden, WBX, and "66" zones).

Results

The results of the SCI inversion in IP mode were interpolated to populate a 3D volume. The 3D volume was then sliced in XY direction, generating resistivity and chargeability depth slices, plotted over the bedrock geology (Figures 4 and 5). The recovered chargeability was further investigated and compared to the chargeability section recovered from ground IP survey (Oldenburg et al., 1997). This comparison is shown in Figure 6. The profile adapted from Oldenburg et al. (1997) is nearly coincident with VTEM flight line 540, however the actual ground IP data was unavailable to us and therefore the comparison is based on visual inspection of the results.

Conclusions

Applying the Cole-Cole model in the inversions of TDEM data we show the ability to map the 3D distribution of physical parameters in the subsurface, which brings new value to mineral exploration. In our first example, we show improved resistivity imaging by virtue of accounting for the IP effect in the TDEM data, as well as capability to map chargeability, which is to an extent in agreement with ground IP survey

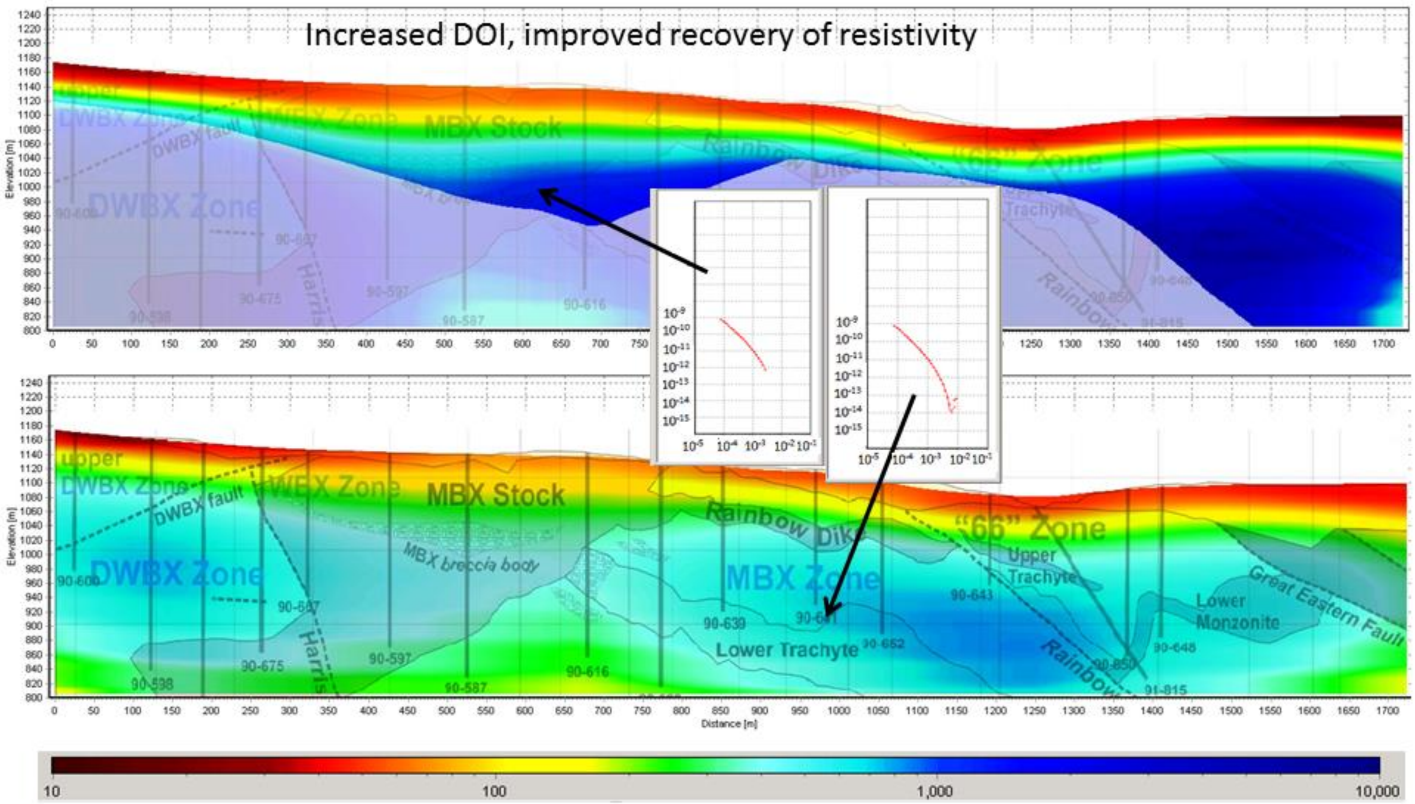

Figure 3. Top: non-IP inversion of VTEM data over Mt. Milligan deposit; bottom: IP inversion (Cole-Cole model) over Mt. Milligan deposit (interpolated to populate the AA' cross-section).

results. Not only the IP inversion brings greater depth of investigation and improved recovery of electrical resistivity, but in the case of the Mt. Milligan deposit, the ability to extract chargeability plays a crucial role, since the deposit is electrically resistive and chargeability becomes a primary quality in overall detectability of the deposit (Oldenburg et al., 1997).

Acknowledgements

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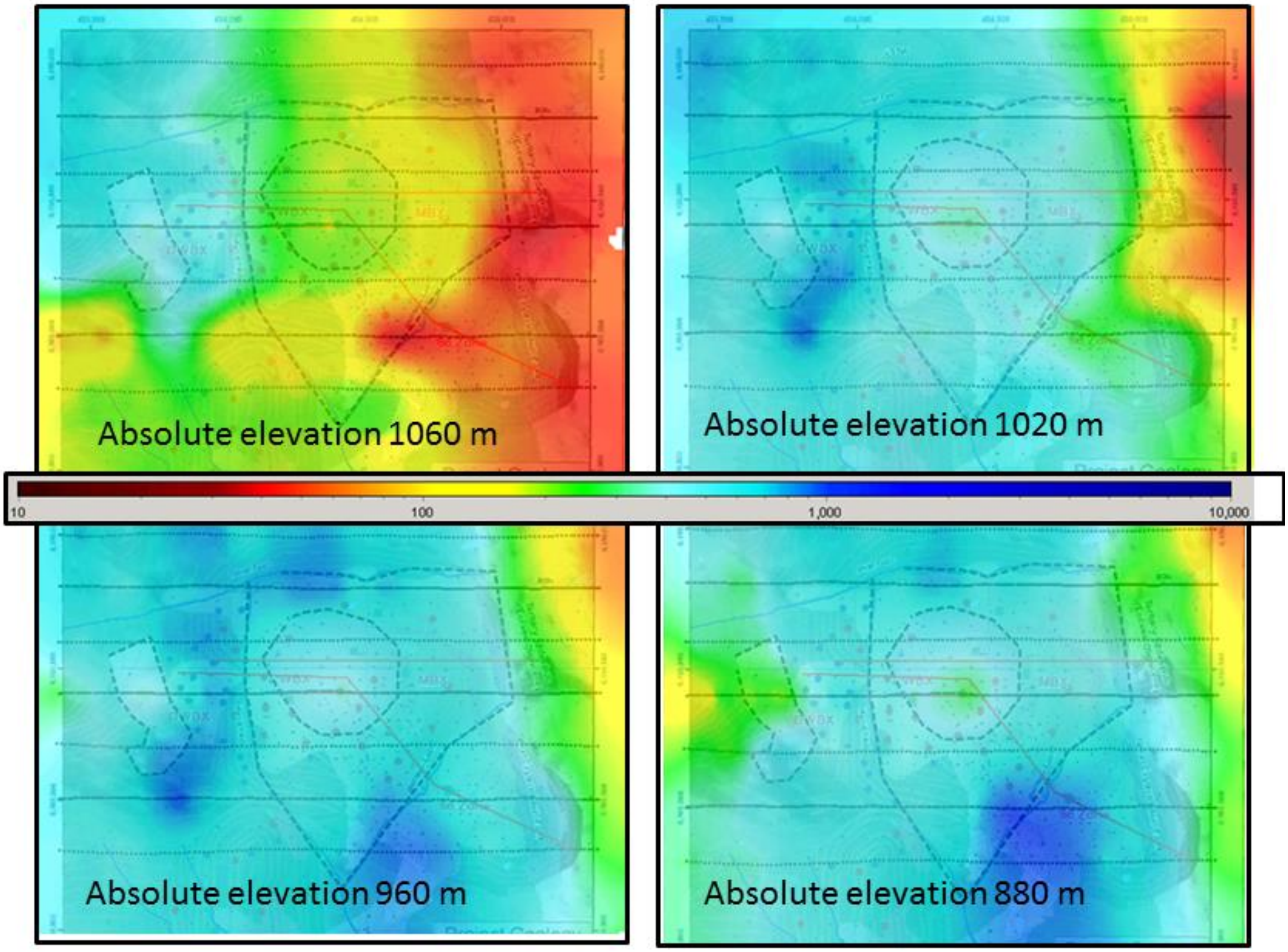

Figure 4. *Series of resistivity depth slices (Ohm m), generated from an SCI quasi-3D inversion 3D volume interpolation.*

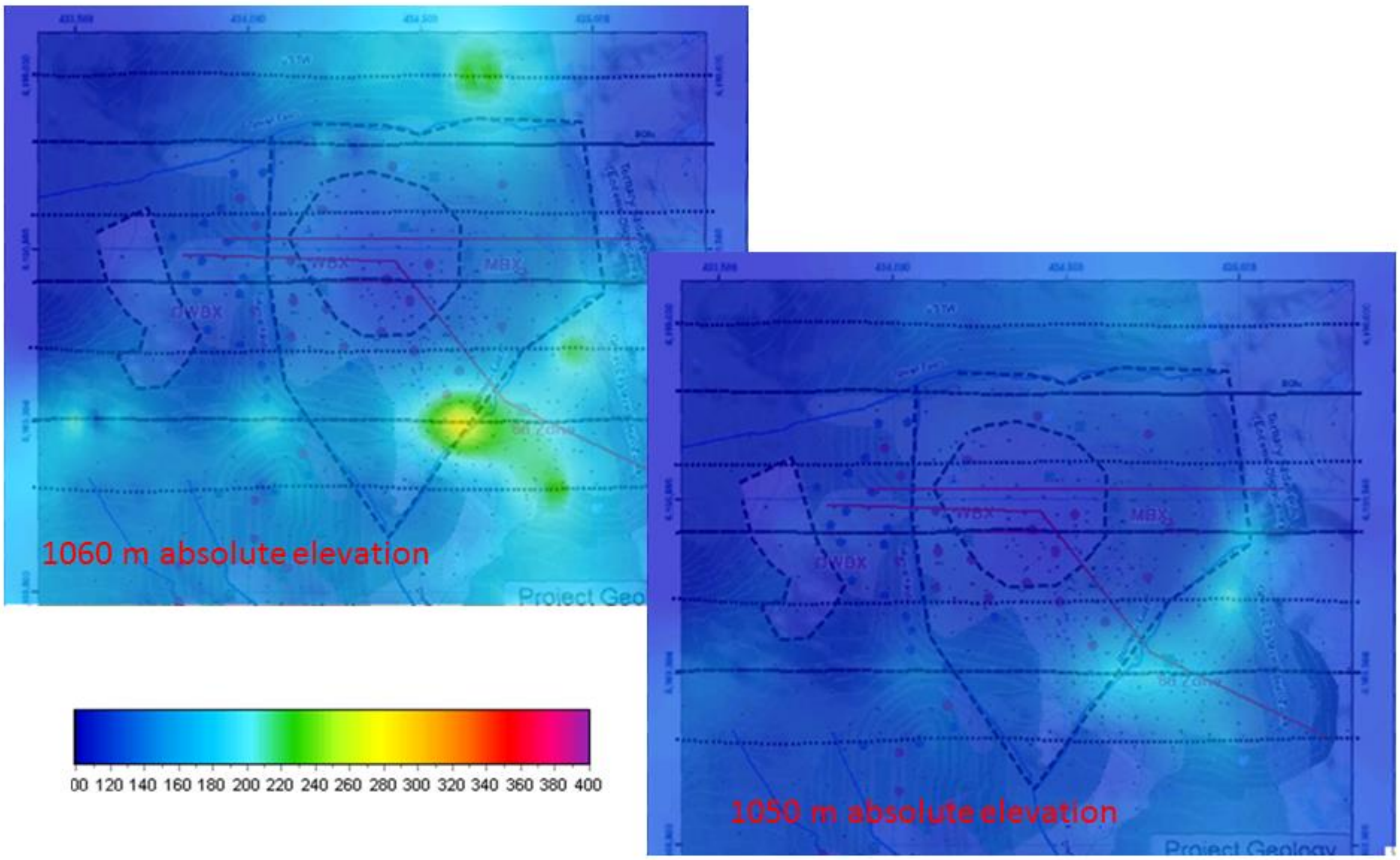

Figure 5. *Chargeability (mV/V) depth slices produced from interpolated results of Cole-Cole SCI inversion 3D volume interpolation.*

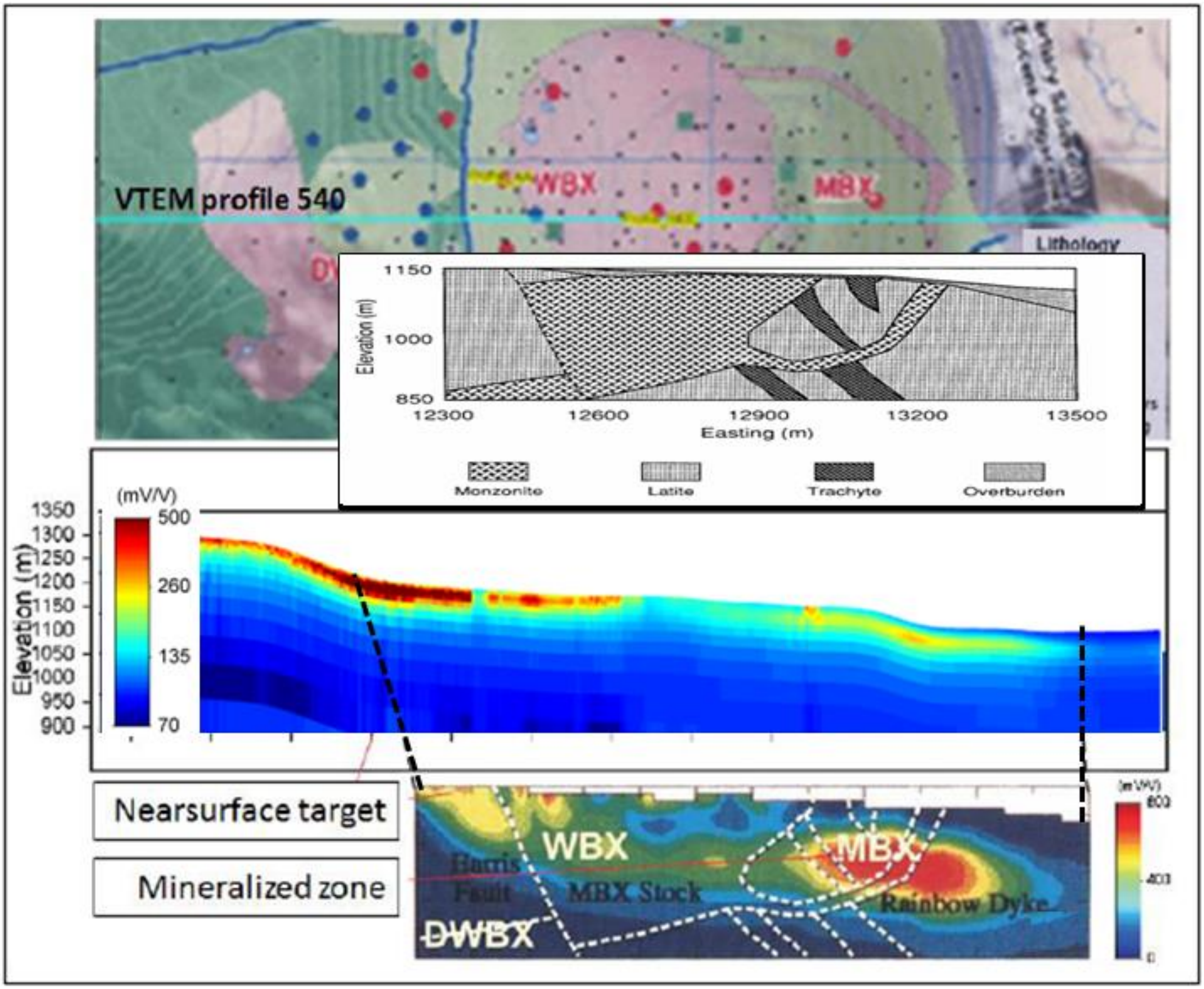

Figure 6. Comparison between ground IP chargeability and chargeability recovered from TDEM data (individual columns).