Natashquan Ni-Cu-PGE prospect, Labrador, Canada

Andrea Viezzoli[1], Antonio Menghini[1] Vlad Kaminski[1],
1. Aarhus Geophysics Aps, Denmark, info@aarhusgeo.com

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. In this case study a HeliTEM survey flown in Labrador, Canada over a Ni-Cu-PGE prospect showed very strong aerial IP effects with multiple negative transients, which were not suitable for conventional interpretation (inversion) methods. In order to invert the data, multiparametric inversion with Cole-Cole modelling was used, successfully recovering the electrical properties of the subsurface, including a chargeable target situated at significant (>100 m) depth, which was later confirmed by drilling and downhole measurements.

Introduction

The airborne TDEM survey was flown using the HeliTEM system in 2013 over Altius Resources Inc.'s Natashquan Ni-Cu-PGE project in Labrador, Canada (Figure 1). The data contains some extreme, localized IP effects (Kaminski et al., 2015). In some parts, the survey showed entirely negative transients (Figure 2). These data were therefore unsuited to conventional TDEM resistivity inversions approach, unless the Cole-Cole modelling was implemented. In 2014 the data were transferred to Aarhus Geophysics for reinterpretation.

__Figure 1.__ Location of Natashquan Ni-Cu-PGE prospect in Labrador, Canada.

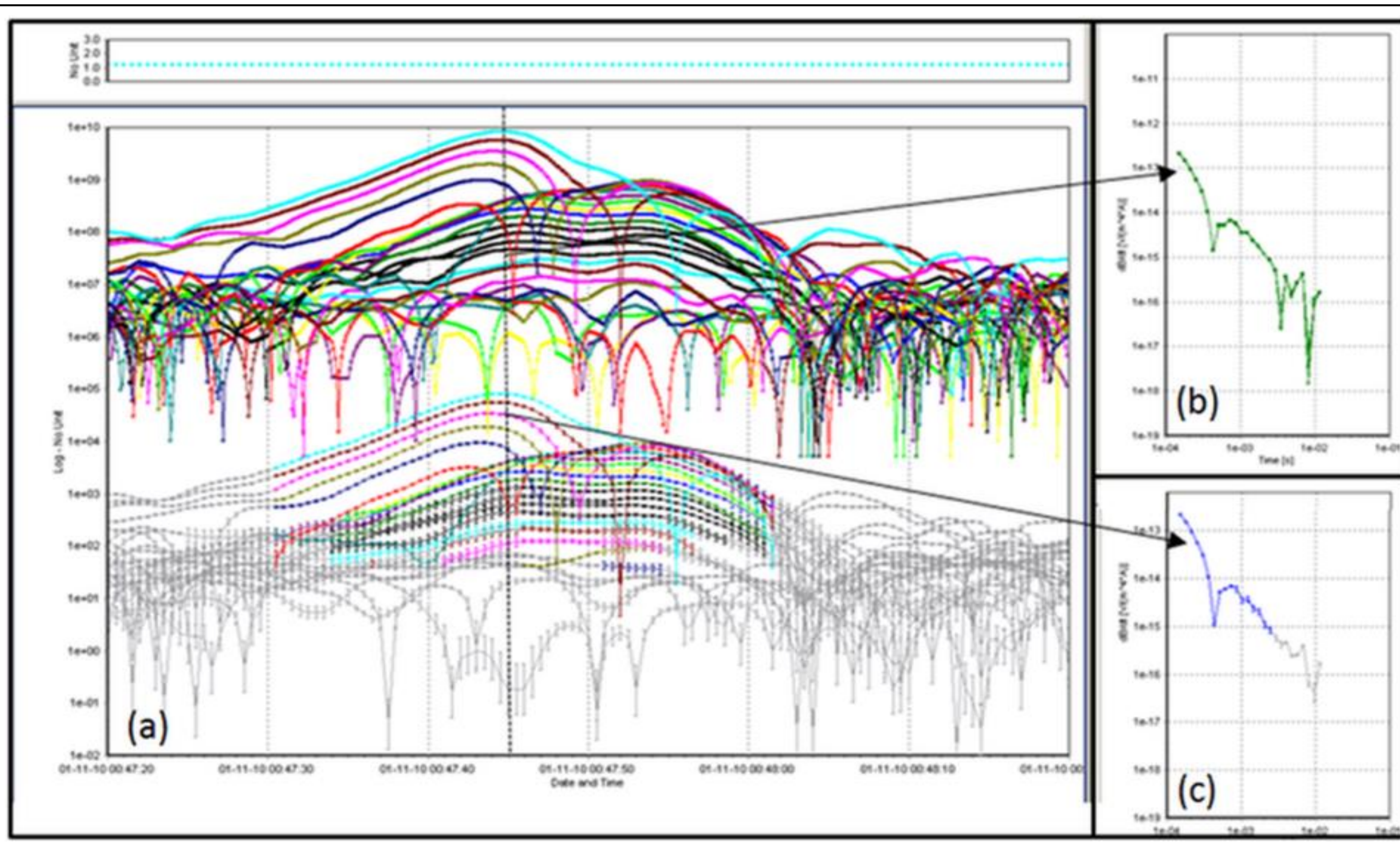

__Figure 2.__ Example of manual data processing of HeliTEM data in presence of IP effects. (a) Profile data: raw - at the top, processed - at the bottom). (b) Raw transient. (c) Processed transient.

Cole-Cole inversion

The data were inverted by Aarhus Geophysics using Spatially Constrained Inversion algorithm (SCI, Viezzoli et al., 2008), modified as per Fiandaca et al. (2012) to accommodate Cole-Cole modelling (Cole and Cole, 1942). The details with regards to inversion details can be found in Kaminski and Viezzoli, 2017.

Figures 3 and 4 show the results of SCI inversion as 2D slices and in profile. The data misfits were very low, showing good convergence to target misfit, measured as difference between observed and predicted data, normalized by standard deviation (Figure 4).

A conductive and chargeable body was predicted to a depth of 100 m under the shallow lake. The isovolumes of conductivity and chargeability were used by the interpreter to design an oblique drill hole to intercept the predicted target. The presence of the target was confirmed by drilling and then the recovered drill core was subject for direct measurements of conductivity and chargeability using the TDIP portable system (GDD instrumentation).

Discussion

The direct core measurements (Figure 4 and table 1) show general correlation with the values predicted by the multiparametric inversions of HeliTEM data, notwithstanding the fact, that the ranges of resistivities and chargeabilities need to be scaled for better agreement, subject to instrumentation considerations.

Table 2. *Results of electrical measurements over core from drill aimed at conductive and chargeable anomaly as recovered from AEM data.*

Position (m) along drilling path (45° dip angle)	Resistivity (Ωm)	Chargeability (mV/V)
24	4024.4	5.100
60	5314.4	1.600
83	7369.9	10.6
93	781.5	1.4
109	3187.5	4.0
141	3673.9	4.4
155	19.0	116.1
167	9.2	241.5
181	7.6	231.6
201	173.0	3.5

Laboratory tests fully confirm the presence of the deep chargeable and conductive target at the predicted depth, overlain by locally resistive and less chargeable strata. Given the different methodologies of chargeability measures obtained from AEM and from direct sampling of the core, one should not expect identical absolute values. The TDIP core measurements were carried out at 0.5 Hz base frequency, while the operating base frequency of the HeliTEM system is 30 Hz. Nonetheless, in this case, both the AEM data inversion and the direct core measurements recovered values in the order of hundreds of mV/V for the chargeability maximum. The conductor imaged through inversion and intercepted by the drilling did not display the anticipated increased voltage response in the data space, before accounting for the IP effect.

Conclusions

This case study shows an example of Cole-Cole modelling not only being responsible for extracting the valuable electrical parameters from the TDEM data, severely affected by IP, but being the only approach, which allowed interpretation of the data, recovering accurate physical properties at significant depth and giving a correctly positioned drill target for the exploration program.

Furthermore, this case study shows recovery of chargeable material straight from airborne data to significant depth, which exceeds our previous estimates of the depth of investigation (DOI) for the multiparametric Cole-Cole inversion models, however supports our theoretical predictions provided in Viezzoli et al., 2017.

Acknowledgements

We would like to thank Anglo American Exploration, Canada Ltd and Altius Resources Inc for allowing publication of this case study .

References

Cole, K. S., and R.H. Cole, 1942, Dispersion and absorption in dielectrics: Journal of Chemical Physics, **9,** (4), 341–351.

Fiandaca, G., E., Auken, A. V., Christiansen, and A. Gazoty, 2012, Time-domain-induced polarization: Full-decay forward modelling and 1D laterally constrained inversion of Cole-Cole parameters: Geophysics, **77**, E213-E225.

Kaminski, V., A., Viezzoli, A., Menghini, and G. Fiandaca, 2015, Case studies of modelling IP effect in AEM data: 21st European Meeting of Environmental and Engineering Geophysics, EAGE, Expanded Abstracts.

Kaminski, V. and A. Viezzoli, 2017, Modelling IP effects in helicopter TEM data: synthetic case studies: Geophysics 82 (2) 1-13.

Viezzoli, A., A. V. Christiansen, E. Auken, and K. Sørensen (2008), Quasi-3D modeling of airborne TEM data by spatially constrained inversion, Geophysics, **73**, F105-F113.

Viezzoli, A., V.Kaminski and G. Fiandaca, 2017, Modelling IP effects in helicopter TEM data: field case studies: Geophysics **82** (2) 23 p.

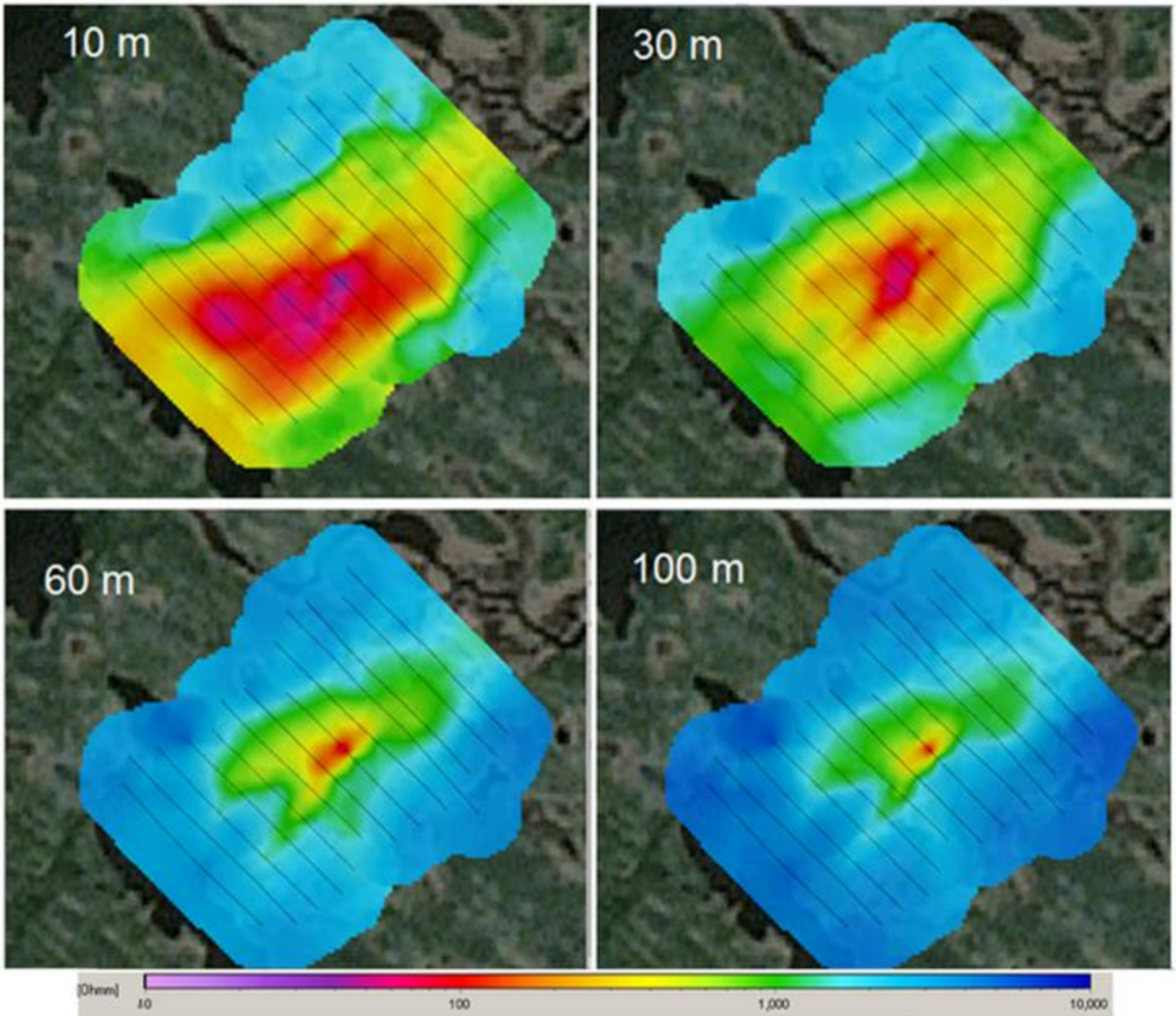

Figure 3.

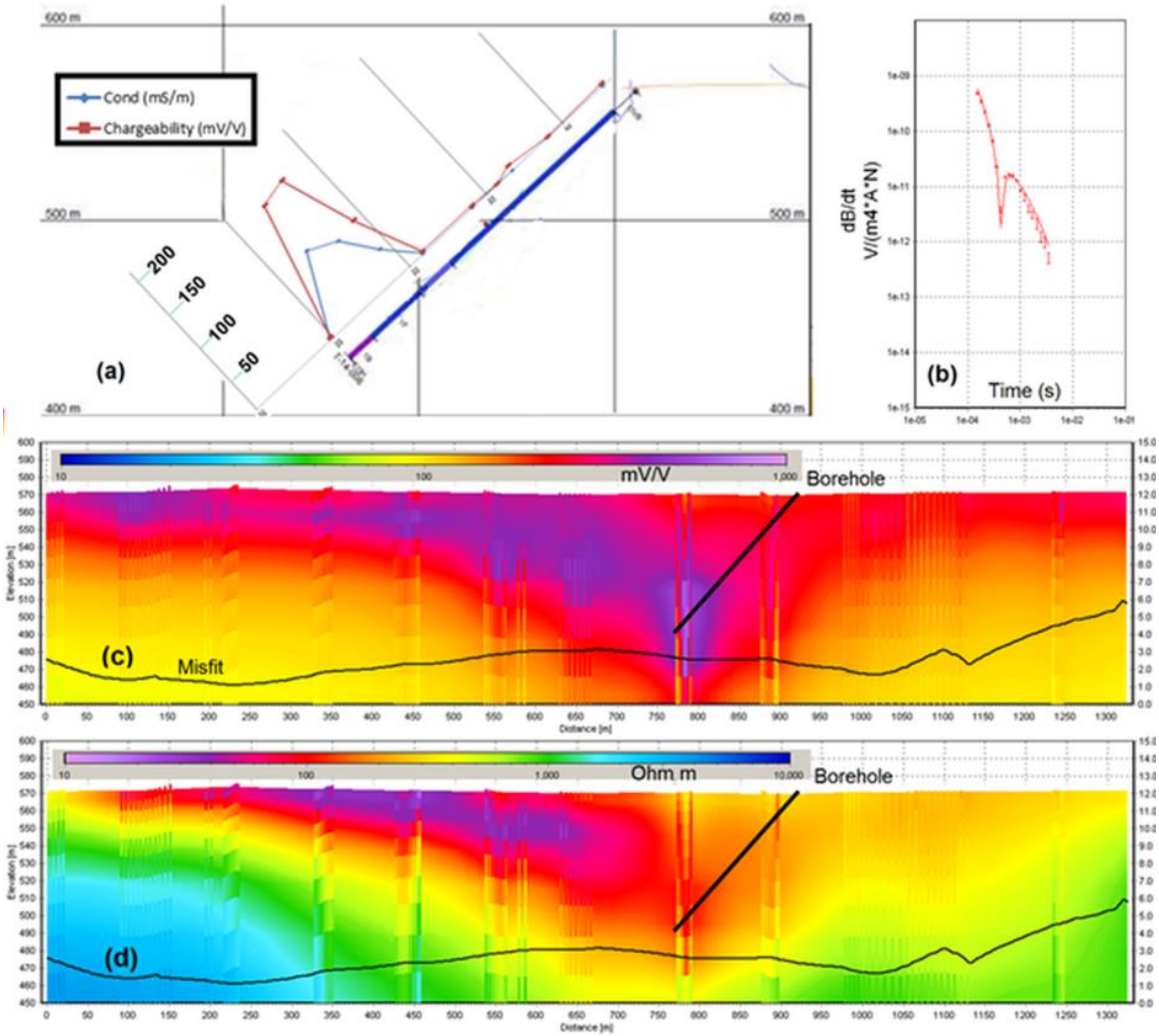

Figure 4. *Results of SCI inversion shown as a cross-section, interpolated across the flight lines and over the target, showing location of drill hole and physical property measurements (see Table 1 for details). (a) TDIP core physical property measurements. (b) Observed data vs predicted data in a single transient (data fit). (c) Interpolated chargeability section. (d) Interpolated electrical resistivity section.*