Interpreting airborne electromagnetic data unburdened from induced polarisation effects: an unconventional mineral discovery case study from the eastern Yilgarn region of Western Australia

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SUMMARY

Induced Polarisation (IP) effects commonly distort time-domain Airborne ElectroMagnetic (AEM) data, resulting in atypically fast decaying transients and non-monotonic decay curves. These effects are not always easily recognisable visually, and can subdue, negate, or even overturn the localised expression of potential bedrock conductive sources worthy of exploration focus. The inclusion of such affected data in inversion routines can result in misleading models featuring unusually high resistivity values, erroneously shallower resistive zones, and higher conductivity artefacts near the bottom of the models.

Simultaneously solving for chargeability and resistivity during inverse modelling can drastically improve the resistivity models produced, honouring both the measured AEM data and the geology more closely. These enhanced resistivity models can then be used to simulate what the AEM data would have looked like in absence of IP effects and form the basis for finer interpretation of the profile AEM data. The resulting "IP-free" AEM data can also be used as input dataset for other forward and inverse modelling routines otherwise not yet accounting for the contribution of the IP phenomenon.

This innovative workflow has been successfully applied to a historical heliborne EM dataset acquired in the eastern Yilgarn region of Western Australia. Although significant parts of the survey were initially deemed non-prospective due to the lack of discrete conductors, several distinct weakly conductive features originally masked by IP effects could be recovered and accurately delineated. Drill testing of one of these IP-corrected AEM anomalies intersected disseminated nickel sulphide mineralisation returning 8m @ 0.64% Ni within a broader interval of 17m @ 0.40% Ni from 102m at a depth predicted by traditional thin-plate modelling. The mineralised occurrence has no surface expression or discernible response in the raw AEM data.

Key words: Mineral exploration, airborne electromagnetic, induced polarisation, sulphides, discovery, Western Australia.

INTRODUCTION

Base metal potential at Resources & Energy Group Limited's (ASX: REZ) Springfield prospect was revitalised when trace nickeliferous sulphides were intersected in scout drilling investigations for gold near a gossanous outcrop sampled in 1969 and 1986 by CRA and BHP, respectively. The prospect is part of REZ's larger East Menzies Project located 130km north of Kalgoorlie, in the eastern Yilgarn region of Western Australia (Figure 1). It is underlain by a highly deformed and altered sequence of Archean rocks, which include mafic (high-Mg basalts), sedimentary (pyritic chert, slate, banded amphibolite, fuchsite, tuffaceous metasediments), and ultramafic (meta-komatiites) rocks (REZ, 2021). Petrological investigations on a suite of samples from the scout drilling program confirmed the presence of recrystallised Ni-Fe sulphides (namely pentlandite, violarite, smythite and gersdorffite) of primary magmatic origin hosted within a meta-birbirite, a highly silicified form of komatiite (REZ, 2022).

The identification of these minerals at Springfield signals that the ultramafic rocks within the project area may host larger accumulations of disseminated and massive Ni-Fe sulphides. The view that nickel potential may not have been exhausted by previous exploration triggered the detailed review of existing Airborne ElectroMagnetic (AEM) data over the project. The majority of REZ's tenure, including the Springfield prospect, is covered by a publicly available 150m line spacing helicopter-borne time-domain electromagnetic HELITEM survey flown by Fugro Airborne Surveys in 2013 (MAGIX registration number 70845). The data had already been thoroughly processed and interpreted in 2013 by reputable geophysical consultants who identified and modelled 20 priority areas for follow up amongst over 220 anomaly peaks (Axford, 2014), none of which are located within the interpreted prospective meta-komatiitic unit. A recent review of the dataset highlighted the presence of subtle Induced Polarisation (IP) effects, which are limiting the AEM data's interpretability in the Springfield area (Figure 2).

Replicating the processing and interpretation of the 2013 AEM data was deemed unnecessary given the very high quality of historical work and reporting performed already. Instead, it was decided to implement a modern approach to handling IP effects and assess whether discrete conductive anomalies could have been masked by the unwanted interference.

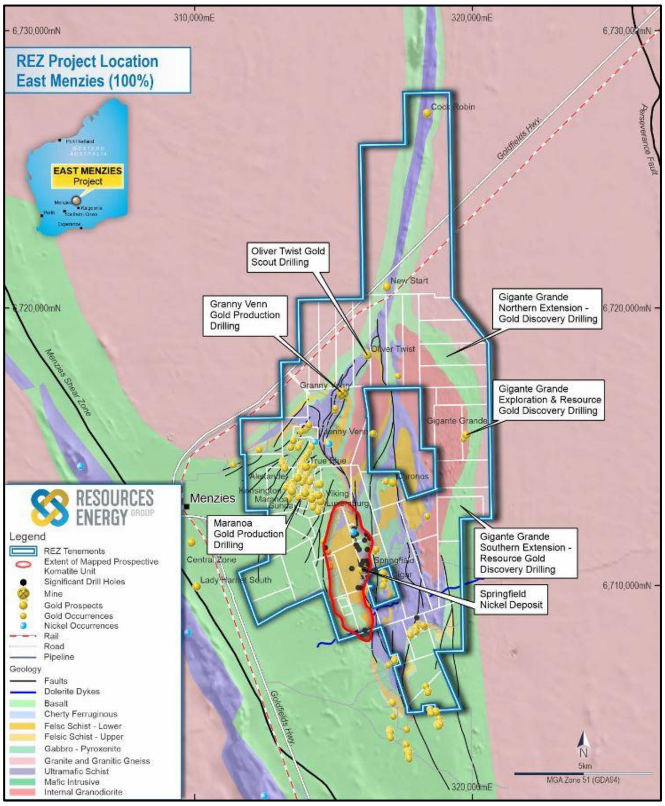

Figure 1. East Menzies Project location and regional geology (from REZ, 2023). The interpreted prospective meta-komatiite unit in the Springfield prospect is delineated in red.

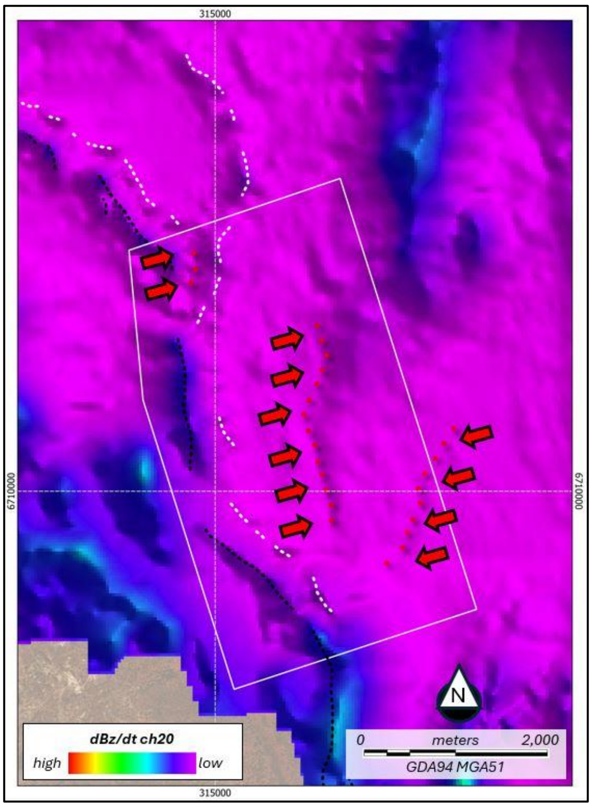

Figure 2. Mid-time AEM data (dBz/dt ch20 – 2.12ms) over the Springfield prospect (white rectangle). Interpreted stratigraphic conductors are depicted with black and white dashed polylines. The red arrows point to semi-linear areas of suspected IP effect expressed as a trough in the mid-time channel AEM data.

METHOD AND RESULTS

IP effects commonly distort time-domain AEM data, resulting in atypically fast decaying transients and non-monotonic decay curves. These effects are not always easily recognisable visually, and can subdue, negate, or even overturn the localised expression of potential bedrock conductive sources worthy of exploration focus. A summary of how IP interference can overcome EM response is presented in Viezzoli et al (2020). The inclusion of such affected data in inversion routines can result in misleading models featuring unusually high resistivity values, erroneously shallower resistive zones, and higher conductivity artefacts near the bottom of the models.

Simultaneously solving for chargeability and resistivity during inverse modelling can drastically improve the resistivity models produced, honouring both the measured AEM data and the geology more closely. The AEM data were inverted using AarhusInv software following a similar methodology than the one described in Kaminsky and Viezzoli (2017) to produce laterally constrained "1.5D" sections of modelled resistivity and chargeability. Forward modelling of the resistivity models alone (i.e. assuming no variation in chargeability and that resistivity is non-dispersive) was subsequently performed to simulate what the AEM data would have looked like in absence of IP effects (vertical component only). The last step was to add sensible noise to the reconstructed AEM data to honour the survey's original detection limits in the local geological environment. The main benefit of this workflow is the ability to apply traditional interpretation techniques, such as EM thin-plate modelling, to AEM data "freed" of IP effects. A potential pitfall of the proposed workflow is that 3D geological effects may not be adequately accounted for during the 1D modelling, which only uses the vertical component.

The processing workflow described above was applied to the Springfield AEM data and resulted in the delineation of several new discrete weakly conductive features. Figure 3 illustrates the uncovering of late-time anomalies visible in the IP-corrected data that were absent in the raw data. The majority of the newly defined late-time anomalies tend to coincide with early-time response typical of regolith origin. This could suggest that the rate of decay of the AEM response from surficial regolith may be exaggeratedly increased by its chargeable characteristics. A small number of higher priority features display isolated late-time signal in the IP-corrected AEM data independently from earlier-time anomalism. Such signature is more typical of discrete bedrock conductors in AEM data.

Detailed quantitative interpretation of anomalies of interest can be achieved by simulating the IP-corrected AEM data with traditional thin-plate modelling (Figure 4). Drillhole SFRC16 was designed to test the IP-corrected anomaly depicted in Figures 3 and 4. It intercepted disseminated nickel sulphide mineralisation returning 8m @ 0.64% Ni within a broader interval of 17m @ 0.40% Ni from 102m at a depth predicted by the thin-plate modelling (REZ, 2023). The mineralised occurrence has no surface expression or discernible response in the raw AEM data.

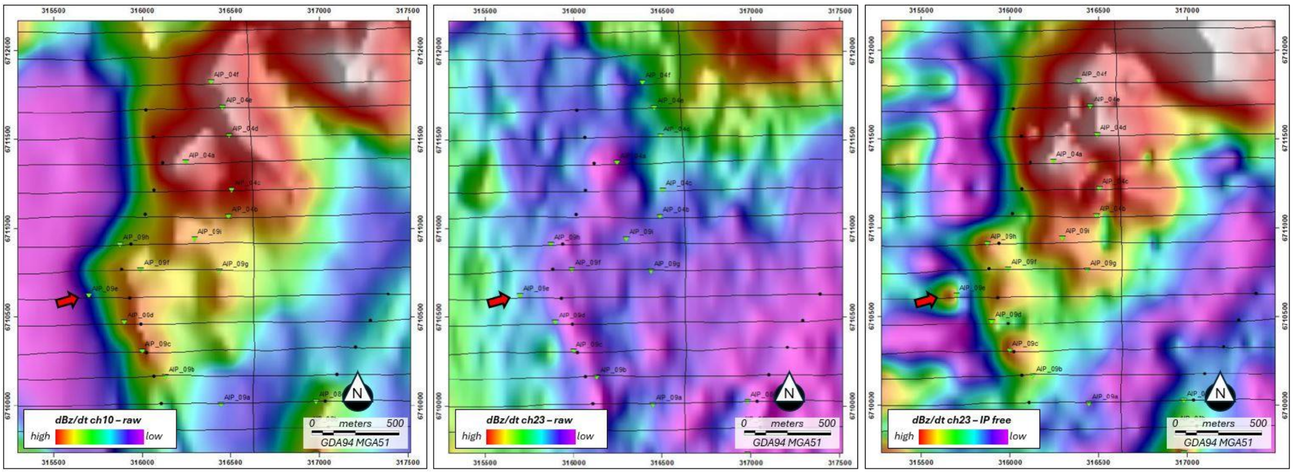

Figure 3. Comparison of AEM data before and after IP correction. Left: Raw dBz/dt ch10 (0.34ms) data. Centre: Raw dBz/dt ch23 (3.72ms) data. Right: IP-corrected dBz/dt ch23 (3.72ms) data. Black dots are the IP-related troughs interpreted from the raw AEM data showed in Figure 2. Green triangles are the newly identified late-time anomalies in the IP-corrected AEM data. The red arrow points to the discrete late time anomaly in the IP-corrected AEM data which was drill tested by drillhole SFRC16.

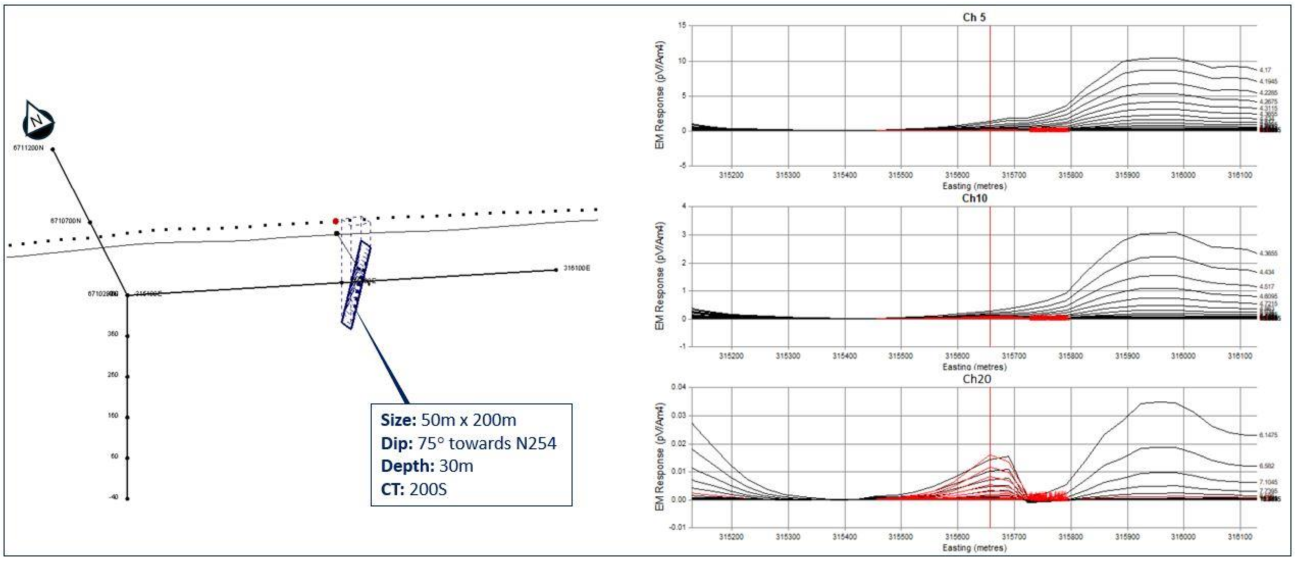

Figure 4. Left: Thin EM plate modelled from IP-corrected AEM dBz/dt data tested by drillhole SFRC16. Right: IP-corrected AEM dBz/dt data profile in black and plate model response in red along line 10470.

CONCLUSIONS

IP effects in AEM data can be subtle and do not always manifest as obvious negative values in the late-time channel data. However, they can still be important enough to mask conductive bedrock anomalies of exploration interest. Drill testing of conductive targets arising from the presented innovative workflow returned significant nickel sulphide mineralisation intercepts at a depth predicted by traditional thin-plate modelling of the IP-corrected AEM data. The mineralised occurrence has no surface expression or discernible response in the raw AEM data. To the knowledge of the authors, this case study is the first documented discovery of potentially economic sulphide accumulation attributed to inverse modelling of the IP contribution out of AEM data.

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REFERENCES

Axford, T., 2014, Stratum Metals annual report East Menzies Goldfield Project – C84-2013 (report A103694).

Kaminsky, V. and Viezzoli, A., 2017, Modelling induced polarization effects in helicopter time-domain electromagentic data: Field case studies: Geophysics, 82(2), 1-13.

REZ, 2021, Resources & Energy Group Limited ASX release dated 13 September 2021: Hints of nickeliferous sulphides at Springfield support historical BHP and CRA findings and potential for further discoveries at East Menzies.

REZ, 2022, Resources & Energy Group Limited ASX release dated 11 January 2022: Magmatic nickel sulphides confirmed at East Menzies Springfield project.

REZ, 2023, Resources & Energy Group Limited ASX release dated 6 June 2023: Step out drilling confirms shallow disseminated nickel sulphides.

Viezzoli, A., Manca, G., and Wijns, C., 2020, Causes and effects of the AIP trap in AEM data: Journal of Applied Geophysics, 175, 103970.