"Is it pyrite, or a shed?": intricacies of Induced Polarisation surveying near grounded metallic infrastructure

Regis Neroni*
Fortescue Metals Group
PO Box 6915, East Perth, WA 6892
rneroni@fmgl.com.au

Sam Corbett
Fortescue Metals Group
PO Box 6915, East Perth, WA 6892
scorbett@fmgl.com.au

SUMMARY

Metallic grounded infrastructure commonly found in built-up areas such as fences, sheds and various dwellings, can produce induced polarisation anomalies often indistinguishable from bedrock responses typically targeted by base and precious metals explorers. Unintended presence of measurements that have been affected by such cultural causative sources in input datasets for inverse modelling can lead to misleading resulting models and compromised exploration performance. Circumvention of anticipated cultural interference during data acquisition cannot always be guaranteed in built-up areas due to the often-inevitable density of grounded infrastructure and limited land access. Instead, survey design should be optimised to deliberately collect data affected by cultural contribution in order to facilitate accurate interpretation of anthropogenic responses in resulting inverted models.

After demonstrating the threat of unmindful induced polarisation surveying near grounded metallic infrastructure, we present the results from an unprecedented optimised time-domain 3DIP dataset using trilinear multi-dipole arrays, which is trusted to enable the confident discrimination of undesirable surficial anomalies from features deemed worthy of follow-up investigations despite patchy land access.

Key words: Induced Polarisation, trilinear array, multi-dipoles.

INTRODUCTION

The studied project is located in a regional area of Australia which contains basement geology prospective for copper mineralisation associated with disseminated sulphides and overlaid by variable overburden tens to hundreds of meters thick. As a result, common exploration techniques relying on surface expression are restricted to small and sporadic basement windows. The heterogeneous magnetic and mass properties of the cover also hinder basement potential field mapping. The Induced Polarisation (IP) technique is therefore a preferred local project-scale exploration tool.

IP surveying in built-up areas is challenging for three main reasons. Restricted land access can result in a patchwork of discontinuous survey areas, and the failed detection of a potential orebody located under an inaccessible property. Metallic grounded infrastructure commonly found in built-up areas such as fences, sheds and various dwellings, can produce IP anomalies often indistinguishable from bedrock responses typically targeted by mineral explorers. Finally, the use of high voltage electrical equipment in populated areas must be accompanied by additional safety considerations (but this will not be the focus of the discussion herein).

CHARACTERISING IP RESPONSES FROM GROUNDED METALLIC INFRASTRUCTURE

The IP response of cultural objects has been acknowledged and studied in the past, but mostly as a theoretical forward modelling exercise (e.g. Nelson, 1977, Holladay and West, 1984), and lacking actual field examples. Here, a full-scale orientation survey was conducted in order to determine whether grounded metallic infrastructure could have a significant contribution in typical measured apparent chargeabilities. The survey layout emulated a standard dipole-dipole time-domain (0.125Hz) survey using 50m transmitter (Tx) and two colinear receiver (Rx) dipoles. Dipoles were orientated parallel to a fence erected with metallic star pickets which featured additional buried metallic meshing to block smaller fauna crossings. Rx dipoles were gradually moved away from the fence whilst the Tx dipole remained static, approximately 150m away from the fence, to minimise Electro-Magnetic (EM) coupling interference (Figure 1). The test site was specially selected for its known 100m+ of homogenous and weakly chargeable (~5mV/V) cover (i.e. assumed deeper than the test survey layout's overall depth of investigation) confirmed by nearby water bore drilling, laboratory petrophysical testing and subsequent 3DIP surveying. Figure 1 presents measured apparent chargeability (Newmont standard) as a function of distance from the fence (measured between the middle of the Rx dipole and the nearest part of the fence). Data collected was of very good quality and free of EM coupling interference. Although the anticipated lower apparent chargeability values were recovered approximately 25m away from the fence, soundings in the vicinity of the fence returned apparent chargeabilities up to 25mV/V, i.e. up to five times higher than what would be expected from the laterally consistent surficial geology. It is worth noting that measured apparent chargeability seems to increase exponentially with proximity to the grounded metallic infrastructure and that the distance beyond which the response approaches what would normally be attributed to surficial geology is approximately half the Rx dipole spacing (although no further study has been undertaken to date to confirm whether this observation is scalable to larger Rx dipoles). It was nevertheless subsequently assumed that 3DIP surveying with Rx electrodes in the vicinity of grounded metal infrastructure was likely to result in non-negligible apparent chargeability anomalies produced by surficial cultural causative sources.

SURVEY DESIGN AND RESULTS

Four key considerations have been taken into account to design the customised survey layout.

Firstly, apparent chargeabilities and resistivities were simultaneously measured across interleaved multi-dipoles using 32 channels receivers (a dataset is termed 'multi-dipoles' when data is collected across Rx dipoles of varying sizes, being multiples of the nominal Rx dipole size). The benefit of such optimised arrays has been demonstrated by theoretical 2D and 3D arrays resolution assessments and with small-scale high-density field and experimental datasets (Wilkinson *et al*, 2012, Loke *et al*, 2014, Loke *et al*, 2015). Acquiring multi-dipole datasets increases vertical resolution and can assist the interpreter with the discrimination of surficial causative sources from anomalies worthy of follow-up whilst ensuring acceptable primary voltage levels would likely be recorded by the larger dipoles at least. Figure 2 illustrates the interpreter dilemma working with electrical datasets acquired in built-up areas, and the gain in confidence from additional multi-dipoles data recorded simultaneously (i.e. at no extra cost). Both datasets have been inverted using the same mesh, inversion parameters and achieving similar RMS. Figure 2a (inversion of 100m Rx dipole data only) shows three areas of shallow chargeability anomalism with spurious depth extent which coincide with known cultural features at surface. Figure 2b (inversion of all interleaved Rx multi-dipoles data) discriminates shallower sources (e.g. stations 14350 and 15750) from deeper features deemed of exploration interest (e.g. stations 14750 and 15650).

Three receivers were required to simultaneously record up to 96 data points per current injection in a trilinear layout. Two receivers were setup in an offset configuration to allow for a deeper 3DIP study even underneath areas where access could not be negotiated at the time of the survey, whereas the third receiver was setup in a standard colinear configuration to retain shallow resolution in the centre of each trilinear array.

Nominal Rx dipole size was 150m for the initial acquisition program, and 100m or 50m for identified infill areas where further discrimination of suspected surficial anomalism was required. A transmitter dipole twice or three times larger than the nominal Rx dipole size was preferred to a pole-dipole configuration given the safety consideration of using a remote Tx electrode in the proximity of inhabited dwellings.

Lastly, arrays were comprised of non-rectilinear spreads to enable circumvention of obstacles and exclusion areas. An additional benefit from this is that no data acquired on offset arrays had to be rejected for being in a non-coupling configuration. The resulting customised non-uniform trilinear multi-dipole IP array is depicted in Figure 3.

The large and irregular dataset was inverted in 3D using a non-uniform mesh with Res3DInv software without *a priori* information. And despite the unconventional survey layout, inversion results were deemed satisfactory down to a depth of 500m whilst retaining very good shallow resolution. This was confirmed by subsequent drilling and geochemical assays (Figure 4).

CONCLUSIONS

Built-up areas are a challenging environment for Induced Polarisation surveying given the abundance of grounded metallic infrastructure and patchy land access. The inclusion of apparent chargeability data measured near surficial cultural features can introduce anomalies in inversion models often indistinguishable from those typically targeted by mineral explorers.

A customised irregular trilinear multi-dipole Induced Polarisation array in a built-up area prospective for copper mineralisation associated with disseminated sulphides has been effective in circumventing obstacles and land access restriction issues to provide a high quality and continuous three-dimensional map of chargeability and resistivity distribution. It furthermore provided the interpreter with enough confidence to discriminate blind chargeability anomalies caused by bedrock geology down to a depth of approximately 500m from anomalies likely caused by surficial metallic infrastructure. Such satisfactory characterisation of cultural anomalies nevertheless requires accurate knowledge of all electrodes and nearby infrastructure location, and ideally high-resolution aerial photography of the survey area.

ACKNOWLEDGMENTS

The authors would like to thank Fortescue Metals Group Ltd for the permission to publish this study and ExploreGeo for their expert assistance with the 3D modelling.

REFERENCES

Holladay, S.J. and West G.F., 1984, Effect of well casings on surface electrical surveys: Geophysics, 49, 177 – 188.

Loke, M.H., Wilkinson, P.B., Uhlemann, S.S., Chambers, J.E., Oxby, L.S., 2014, Computation of optimized arrays for 3-D electrical imaging surveys: Geophysical Journal International, 199, 1751–1764.

Loke, M.H., Wilkinson, P.B., Chambers, J.E., Uhlemann, S.S., Sorensen, J.P.R., 2015, Optimized arrays for 2-D resistivity survey lines with a large number of electrodes: Journal of Applied Geophysics, 112, 136–146.

Nelson, P.H., 1977, Induced-Polarization effects from grounded structures: Geophysics, 42, 1241 - 1253.

Wilkinson, P.B., Loke, M.H., Meldrum, P.I., Chambers, J.E., Kuras, O., Gunn, D.A., Ogilvy, R.D., 2012, Practical aspects of applied optimised survey design for Electrical Resistivity Tomography: Geophysical Journal International, 189, 428–440.

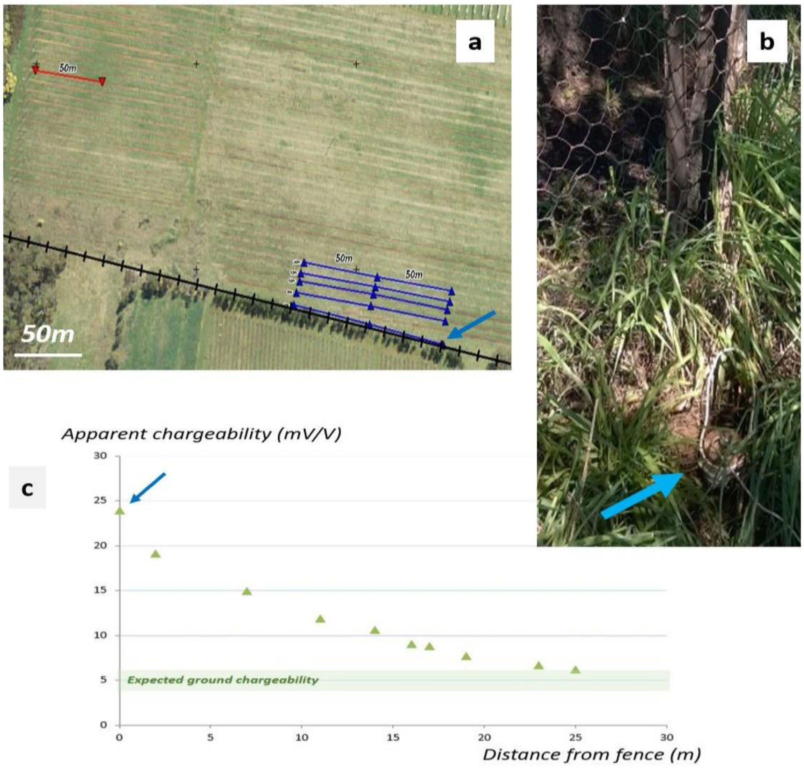

Figure 1. IP surveying results near a grounded metallic fence. (a) Location of survey electrodes (blue = Rx, red = Tx) and fence (in black) over aerial photography. (b) Photography of Rx electrode next to the fence. (c) Measured apparent chargeability values plotted against orthogonal distance from the fence. The blue arrow identifies the closest reading from the fence.

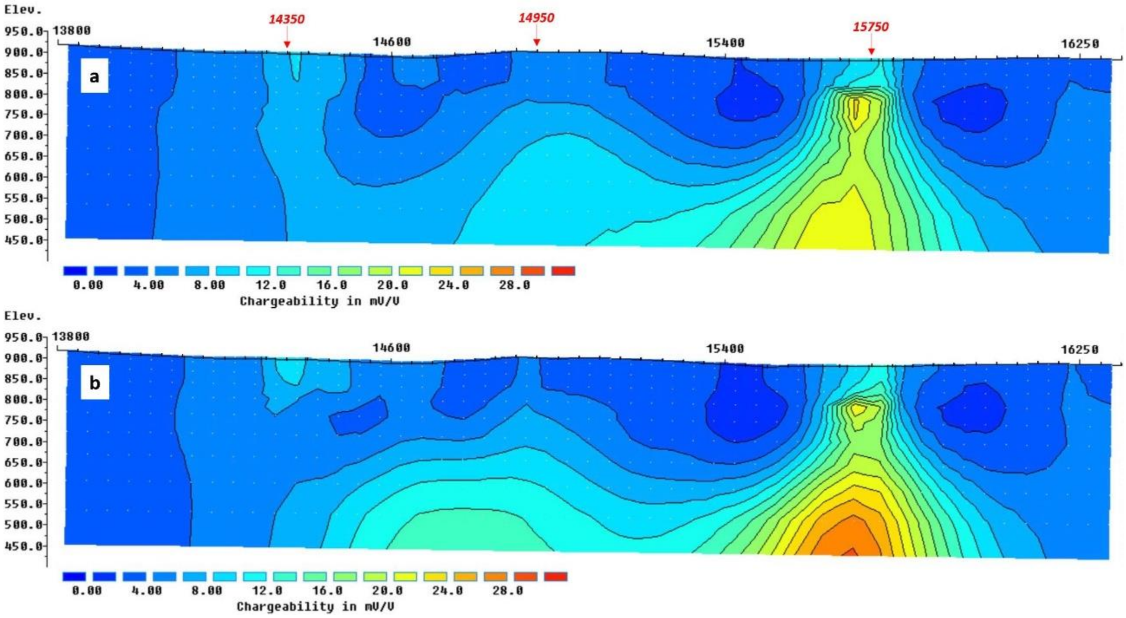

Figure 2. Example of modelled chargeability 2D inversion sections using, (a) 198 valid datapoints from receiver dipoles with 100m spacing only, and (b) 321 valid datapoints from interleaved receiver dipoles with spacing from 100m to 1,200m. In both cases, measured apparent chargeability calculated between 250ms and 850ms has been inverted using the same set of inversion parameters and 10-layer mesh down to 508m with Res2DInv software, and converged after iteration 4 (displayed here) achieving similar absolute RMS errors of 1.19mV/V and 1.13mV/V respectively.

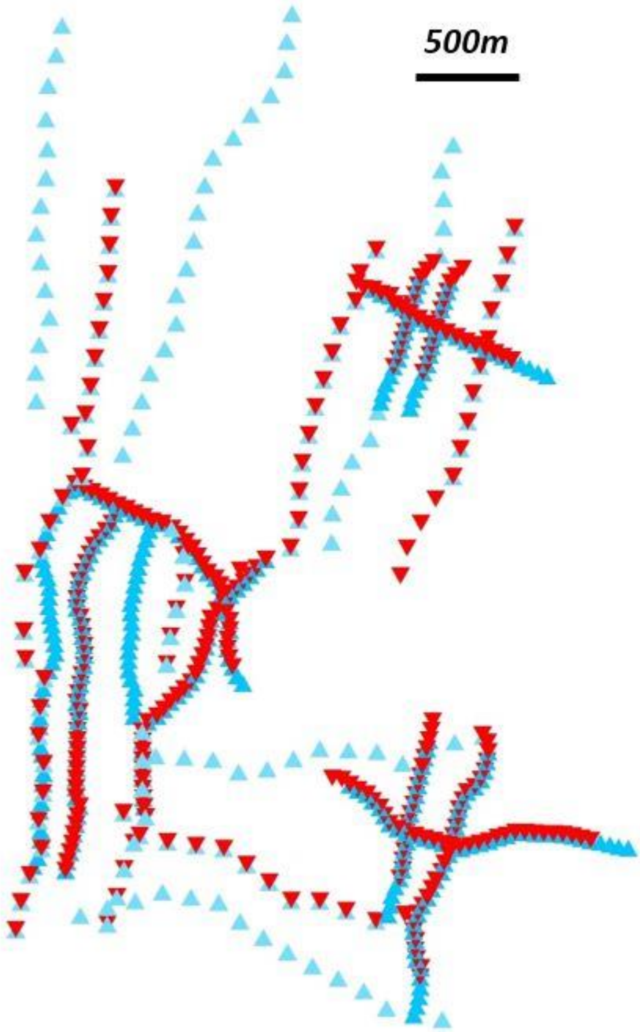

Figure 3. Plan view of customised irregular trilinear 3DIP array layout with electrode locations (blue = Rx, red = Tx).

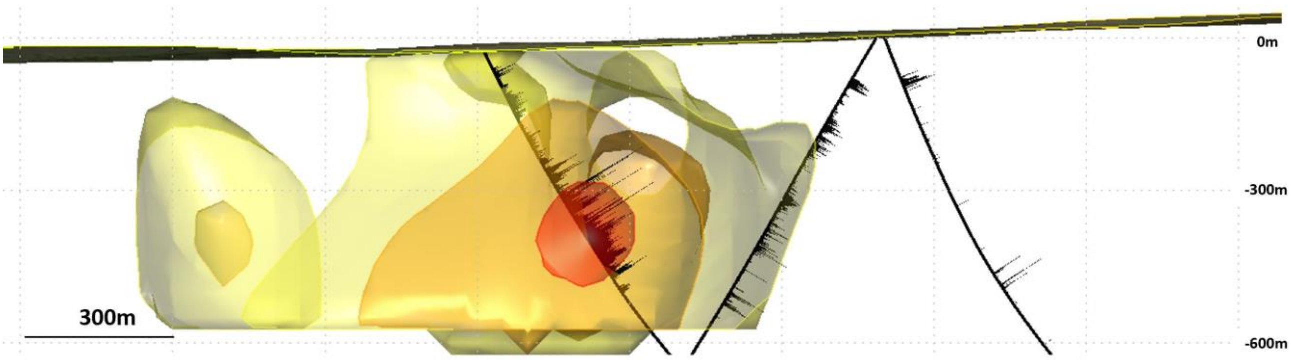

Figure 4. Cross-section of higher modelled 3D chargeability shells (yellow = weak, orange = moderate, red = high) with sulphur content in drilling (black traces).