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Follow-up drill hole surveying to determine unidentified EM targets

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SUMMARY

In these two case histories, drill hole surveying using down-hole electromagnetic surveys and wireline conductivity probes are used to determine the source of geophysical targets that remained unidentified after initial drill testing.

In the first example, after drilling the identification of the geophysical target remained uncertain, despite surface EM surveys determining it had a high conductance. Subsequent DHEM and conductivity surveys were clearly able to locate and define the targeted conductor.

In the second example, deep AMT targets could not be identified after drill testing. Using data from an AEM survey over the same area, and after subsequent DHEM surveying, it appears that the targets are probably artefacts of complex (frequency dependent) conductivity in the near surface soils and regolith.

Targeting errors are very costly. These examples emphasise how critical follow-up drill hole surveying can be to resolving unidentified geophysical targets and ensuring that exploration practices are sound and efficient.

Key words: AEM, DHEM, complex conductivity, AMT, conductivity logging.

INTRODUCTION

There are many complicating factors that affect EM surveys such as frequency dependent magnetic susceptibility (SPM) frequency dependent conductivity (IP effect) and thick or multiple conductors.

When testing geophysical targets, the source may not be obvious to the eye in the drill core or drill chips. This is particularly the case in reverse-circulation (RC) drilling which is often used to initially test exploration targets. In cases where the target remains unclear after drilling, time must be taken to determine the source of the anomaly. This minimises the risk of unnecessary drill holes in the future. This process usually involves down hole wireline surveying and core testing.

This paper presents two examples where follow-up drill hole surveying was necessary to determine the source of the geophysical target. The first example is of a high conductance airborne/ground EM target that was found to be caused by variations in a thick, weakly conductive shale unit. These variations were not definitely visible in drill core chips but clear in a follow-up drill hole wireline conductivity survey. The conductor can also be observed in a drill hole electromagnetic survey.

The second example is of a drill hole targeting an AMT anomaly. Inversion of the data indicates a deep source; however no deep conductive source was identified in the core or in follow-up DHEM surveys. The DHEM surveys did however show that the surface soils were unusually conductive and a coincident airborne EM survey indicates that the source is likely to be frequency dependent conductivity (polarisation) anomalies in shallow soils.

EXAMPLE 1: HIGH CONDUCTANCE SOURCE

Alchemy Resources Ltd. acquired several airborne EM surveys flown for massive Cu-Zn sulphides at their Bryah Basin project in the Murchison Region of Western Australia. The target was massive Cu-Zn sulphides in the Narracoota Volcanic formation, similar to the nearby DeGrussa deposit. At their Bullgullan Bore prospect, there is no deep drilling and the location of the Narracoota formation was unclear. An airborne EM (VTEM system) survey identified several basement conductors near an area with anomalous Cu concentrations in soil. One conductor (DVT-07) was chosen for possible drill testing. To refine the target model, follow-up ground EM was completed over a single line using 100m x 100m transmitter loops. Readings were made using a coil sensor located in the centre (“inloop” configuration) of the transmitter loop and a fluxgate magnetometer located 150m from the centre (“slingram” configuration) of the transmitter loop. The follow-up ground EM survey confirmed the DVT-07 conductor (80S) but also highlighted a nearby source with higher conductance (1200S) than the DVT-07 target identified in the VTEM survey (Figure 1). The conductors were modelled and the high conductance target was chosen for drill testing with drill hole BLRC001. The depth to target was 170m down hole. After drilling, the geological log from the recovered rock chips contained relatively few units (Figure 2) with disseminated sulphide in siltstone and no clear sign of a conductor. The hole intersected a resistive dolerite sill at the depth of the conductive target.

Drill hole EM surveying had been planned and the results indicated that there was a conductor present at around the target depth (Figure 3). It appeared to be thick and possibly

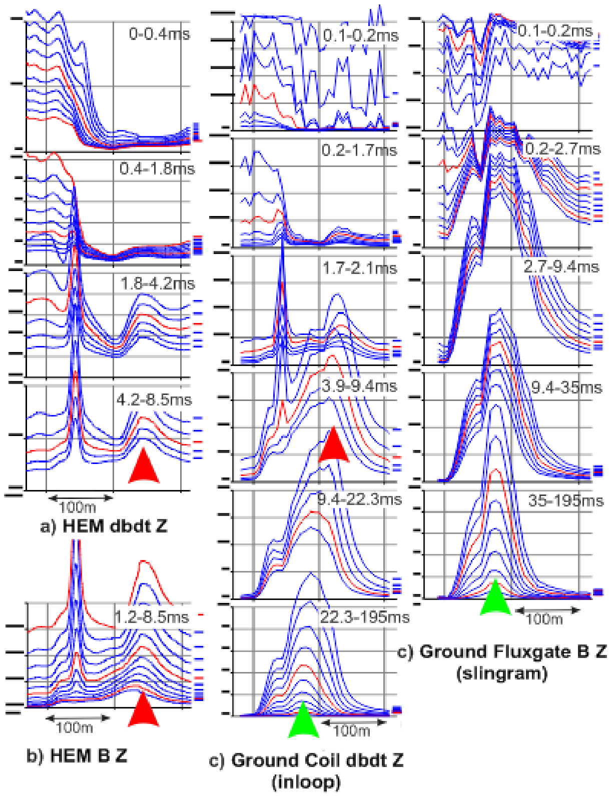

Figure 1. EM profiles for different time delays for a) HEM dB/dt, b) HEM B field, c) Ground Coil and d) Ground Fluxgate datasets. The original DVT-07 anomaly is highlighted with red and the higher conductance source drill tested is shown with green.

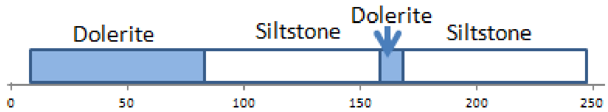

Figure 2. Geological log from test RC drill hole chips showing a resistive dolerite sill in the location of the targeted conductor.

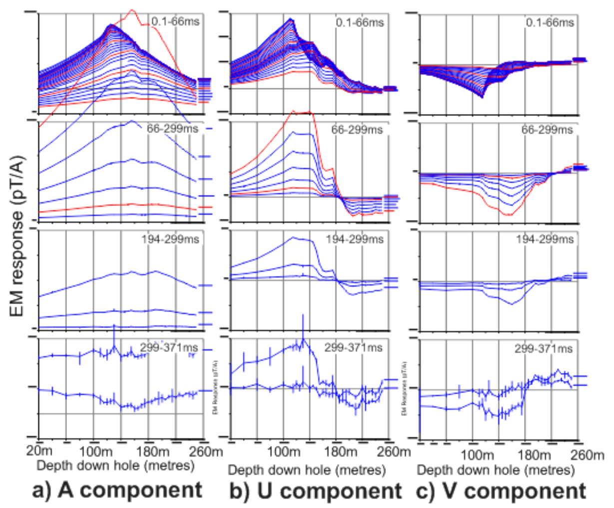

Figure 3. DHEM profiles for BLRC001 showing different time delays for a) A component, b) U component, and c) V component showing that conductor has been intersected.

complex. Because of the apparent absence of an obvious conductor, a relatively inexpensive wireline survey with a conductivity-magnetic susceptibility-natural gamma tool was completed in the hole to assist with understanding of the physical properties of the undifferentiated siltstone.

The magnetic/conductivity results are shown in Figure 4. These clearly show that the siltstone on either side of the dolerite sill is weakly conductive, perhaps as a result of the intrusive sill altering the mineralogy of the siltstone. The high conductance was due to the thickness of the unit which had only modest conductivity. Other internal differences in the conductivity and magnetic signatures are also identified in the siltstone from the wireline survey. Using this data, a relatively simple two conductor model was used to effectively model the DHEM survey data (Figure 5).

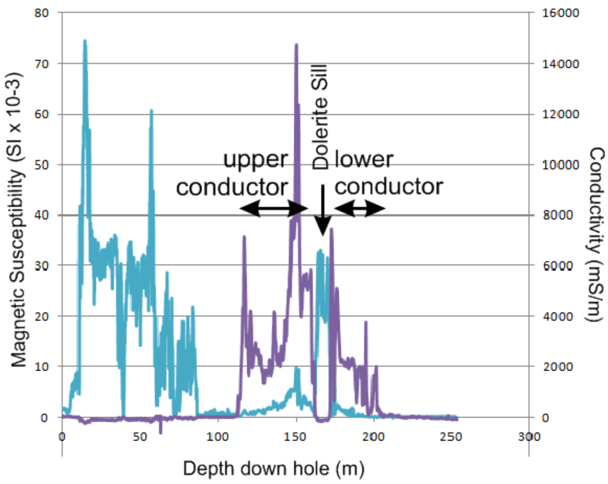

Figure 4. Magnetic susceptibility (blue) and Conductivity (purple) log for BLRC001 clearly showing that a part of the siltstone about the dolerite sill is conductive.

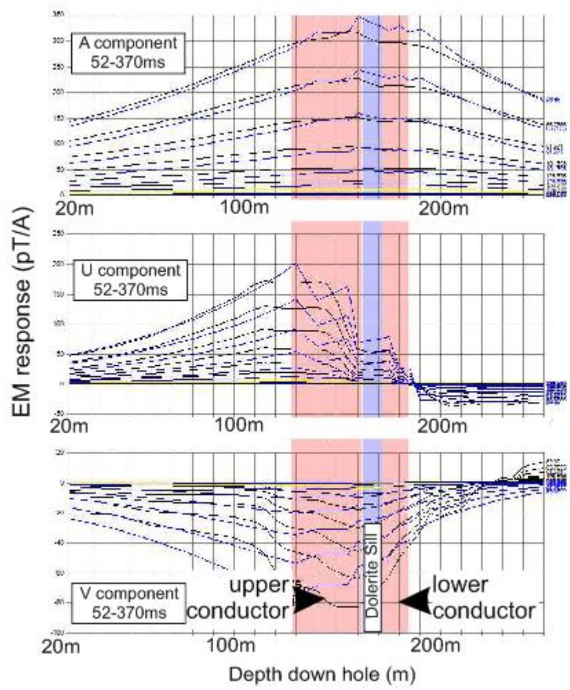

Figure 5. DHEM profiles for BLRC001 the fit of a thick, two conductor model as indicated by the conductivity log

EXAMPLE 2: DEEP AMT TARGET DUE TO COMPLEX SHALLOW SOIL CONDUCTIVITY

In a nearby prospect, an AMT survey was used to explore for deep copper sulphides in a highly prospective position along strike from the DeGrussa copper mine. The data was inverted using both 1D and 2D inversion routines. These showed discrete conductors around 300m deep which can be seen on 20Hz apparent resistivity image (Figure 6). This survey was coincident with an earlier AEM (VTEM) survey and it was noticed that the AMT conductors were coincident with shallow, polarisable, conductive regolith (Figure 7).

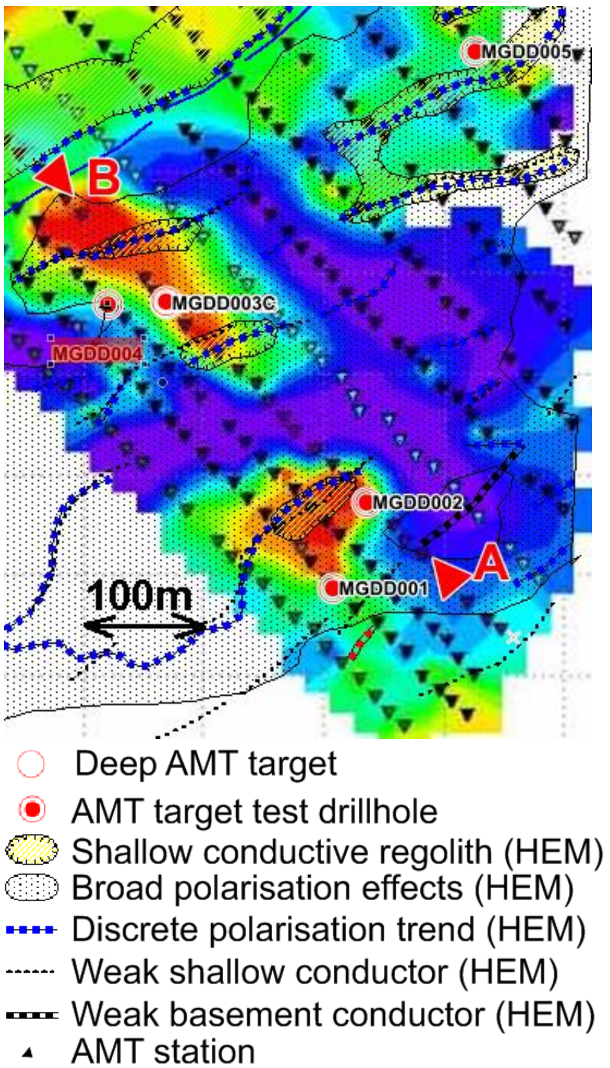

Figure 6 AMT Apparent Resistivity Image (20Hz XY) with superimposed VTEM interpretation showing AMT conductors are coincident with shallow polarisation anomalies

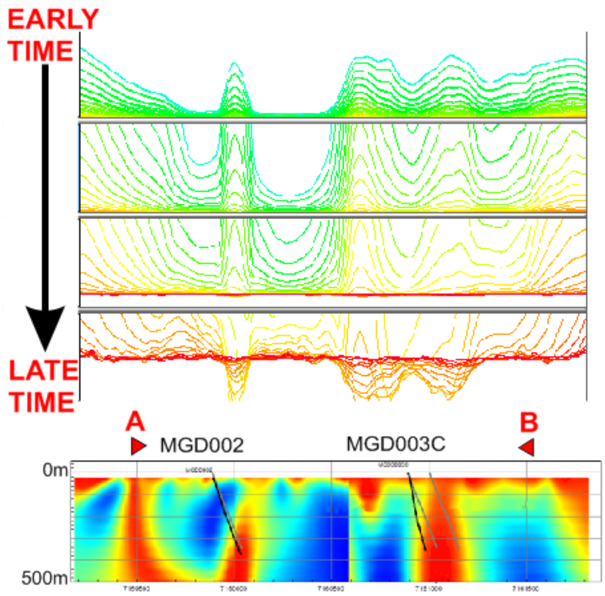

Figure 7 VTEM data profiles and 2D AMT inversion section for section AB in Figure 6. There are coincident deep AMT conductors (red anomaly in the section) and VTEM polarisation anomalies. Polarisation can be clearly identified as negative signal in the late times.

Three of the AMT targets were tested by diamond drill holes MGDD001 to MGDD005 (Figure 6). Two of the holes intersected minor sulphides but nothing was identified as the likely cause of the AMT anomalies.

Magnetic viscosity measurements of the soil were taken for signs of superparamagnetic magnetism (SPM) using a MVM meter and not found to be significant.

DHEM surveys were completed on these holes and the logs for two of them are shown in Figure 8. One of the holes (MGD003) recorded a deep, distant conductor, but otherwise there was no sign of the AMT target. However, it was clear that the regolith was conductive in all of the holes. Ground polarisation can effect AMT data sets (Gasperikova *et al.*, 2007) and it is likely that the AMT anomalies in this case are caused by complex conductivity in the regolith.

CONCLUSIONS

In both examples, follow-up surveying in drill holes was able to identify the likely source of the EM response which would otherwise have remained unresolved. In one case, the targeted conductor was intersected but was not visually distinctive in the drill chips. In the second example, the targeted conductor did not exist and the target is likely to be an artefact of shallow ground polarisation. The issue of frequency dependent soils in AMT surveying may be a much more common problem than is currently recognised.

Drill hole geophysical surveying (e.g. EM, physical properties) is key to identifying the sources of geophysical targets and drill programs should include this critical part of the exploration process.

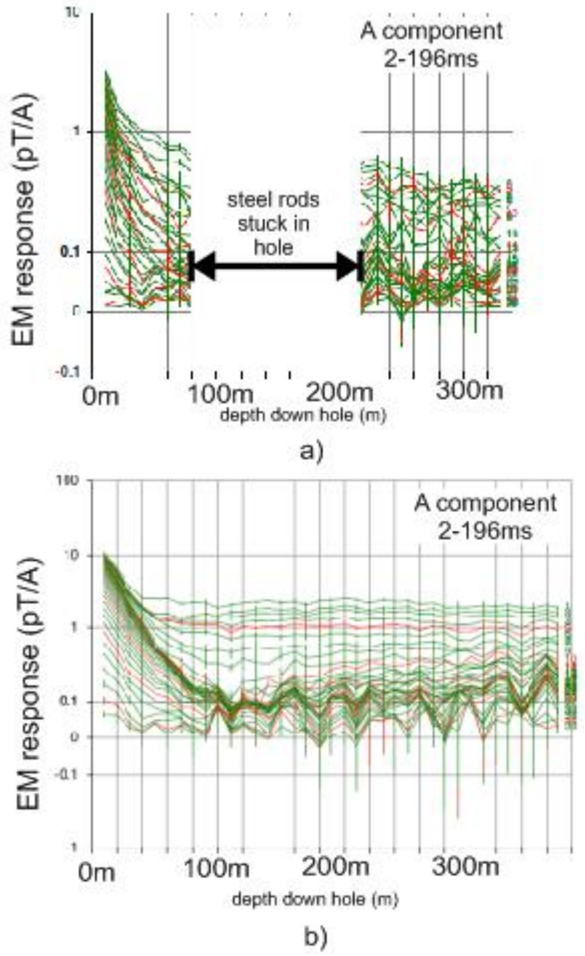

Figure 8 DHEM logs for a) MGDD002 and b) MGDD003 showing highly conductive regolith near surface

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