Geophysical Characteristics of the Carrapateena Iron-Oxide Copper-Gold Deposit

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SUMMARY

The Carrapateena iron-oxide copper-gold deposit is located 160km north of Port Augusta, within the eastern margin of the Gawler Craton, South Australia. The deposit was discovered, in 2005, by RMG Services Pty. Ltd. Subsequent exploration by joint venture partner, Teck Australia Pty. Ltd., demonstrated strong similarities with Olympic Dam, albeit at a much smaller scale. In April 2011, Oz Minerals purchased Carrapateena and soon afterwards released an inferred resource for the southern portion of the deposit of 203Mt @ 1.31% Cu, 0.56g/t Au, 270ppm U_3O_8 and 6g/t Ag.

Carrapateena lies beneath approximately 470m of moderately conductive Stuart Shelf sediments, presenting significant technical challenges to exploration. Therefore, geophysical surveys played an important role in both discovery of the deposit and subsequent delineation. Work undertaken by Teck comprised laboratory petrophysical measurements and gravity, aeromagnetic, IP/resistivity/MT, EM and down hole surveys.

Results show that Carrapateena lies on the south-western margin of a broad magnetic anomaly of moderate amplitude, being associated with a weak, discrete, ellipsoidal magnetic response, and near-coincident, weak, bullseye gravity high. The mineralised system is also associated with a distinct conductivity anomaly. However, chargeability data are less convincing, being strongly impacted by the thick and conductive nature of the cover sequences. EM surveys did not provide any responses attributable to bedrock conductors and are not recommended for this style of deposit. The observed geophysical responses at Carrapateena are dominated by the presence of Fe-oxides, particularly hematite, with sulphide mineralisation playing a lesser role.

Key words: Carrapateena, gravity, IP/resistivity, iron-oxide copper-gold deposit, magnetic.

INTRODUCTION

The Carrapateena iron-oxide copper-gold deposit is located approximately 160km north of Port Augusta and 100km south-east of Olympic Dam, within the eastern margin of the Gawler Craton, South Australia. Following its discovery, in 2005, by RMG Services Pty. Ltd., the deposit was extensively explored by joint venture partner, Teck Australia Pty. Ltd., (Teck) prior to being sold to Oz Minerals Ltd., in April 2011. Teck's work demonstrated Carrapateena has strong similarities with Olympic Dam, albeit at a much smaller scale.

Limited information has been published about the Carrapateena deposit. Fairclough (2005) discussed the regional geological setting and discovery history. Vella and Cawood (2006) provided a preliminary description of the local geological and geophysical setting. And, Vella and Emerson (2009) comprehensively reviewed the physical properties of Carrapateena.

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The results of this work, described in detail below, show that the observed geophysical responses at Carrapateena are dominated by the presence of Fe-oxides, particularly hematite, with sulphide mineralisation playing a lesser role.

GEOLOGICAL SETTING

The following description of the Carrapateena geological setting is taken from Vella and Cawood (2006). Carrapateena lies at the intersection of an interpreted major NNE – trending structure and the NW – trending fault corridor, thought to have played a role in focussing Olympic Dam mineralisation. The cover sequence comprises outcropping Arcoona Quartzite, overlying Corraberra Sandstone, Woomera Shale and variably gritty siltstones to sandstones, with minor interbeds of dolomite. A basal conglomerate marks the unconformity between these sediments and the older crystalline basement.

Cu-Au-REE mineralisation at Carrapateena is hosted within the Carrapateena Breccia Complex (CBC), occurring in a hematite – quartz – sericite – mineralised sequence, of partly conglomeratic sediments, with clasts and fragments of granite, gneiss and vein – quartz (Figure 1). The host rock is a variably foliated and/or sheared gneissic quartz granite and quartz diorite, which has been age dated at 1857+/- 6 Ma, assigning it to the Donington Suite. The basement rocks are locally intruded by felsic and mafic dykes.

Alteration minerals are mainly hematite, chlorite and sericite, with locally abundant quartz and carbonate (siderite and/or ankerite). Secondary minerals include barite, monazite, anatase, magnetite, apatite, fluorite and zircon. Copper sulphide mineralisation comprises chalcopyrite, bornite, and rare chalcocite, mainly as disseminations, blebs and veinlets. Pyrite is locally abundant.

Drilling has returned some spectacular intercepts. For example, CAR050 intersected 905m @ 2.1% Cu and 1g/t Au. Oz Minerals Ltd. have recently released an inferred resource for the southern portion of the deposit of 203Mt @ 1.31% Cu, 0.56g/t Au, 270ppm U_3O_8 and 6g/t Ag (Masters, 2011).

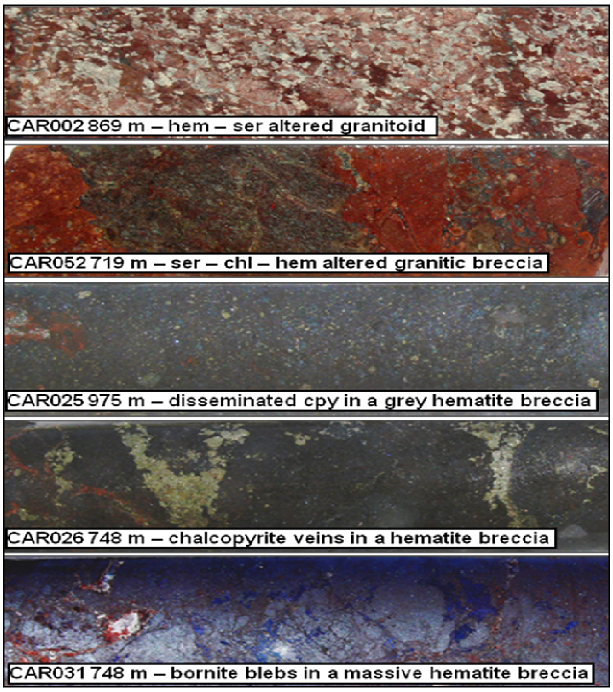

Figure 1. Selected drill core samples from Carrapateena showing the host rock, breccia textures, alteration and mineralisation (Note: hem = hematite, ser = sericite, chl = chlorite and cpy = chalcopyrite).

PHYSICAL PROPERTIES

Laboratory physical property measurements were undertaken by Don Emerson (Systems Exploration (NSW) Pty. Ltd.) on 72 drill core samples from Carrapateena. The cover sequences generally exhibit low densities, magnetic susceptibilities, chargeabilities and EM conductivities. Apparent porosities are quite high and P-wave velocities are variable. With the exception of the Arcoona Quartzite, which is highly resistive, the cover sequence rocks are weakly to moderately conductive and exhibit significant electrical anisotropy.

Basement rock densities increase with increasing hematite and/or magnetite and/or sulphide content. As expected, magnetic susceptibilities correlate with magnetite content. EM conductivities are generally low, with rare exceptions. The sulphide mineralisation at Carrapateena occurs predominantly as disseminations and blebs, with less common veins, suggesting that EM would not be an effective exploration tool here.

Lower resistivities and higher chargeabilities among the basement rocks correspond to increasing sulphide mineralisation, associated with increasing iron (hematite +/- magnetite) content. Separation of the contribution of sulphides from that of iron oxides is difficult. There are clear examples of barren (specular) hematite breccias exhibiting an IP effect comparable to their sulphide mineralised counterparts. For further information on Carrapateena's physical properties, the reader is referred to Vella and Emerson (2009).

GEOPHYSICAL SURVEYS

Aeromagnetic Survey

In December 2005, Fugro Airborne Surveys flew an airborne magnetic and radiometric survey over Carrapateena. Data were acquired on 200 m - spaced east-west lines, with a mean terrain clearance of 50m. Carrapateena lies on the south-western margin of a broad magnetic anomaly of moderate amplitude and is associated with a weak, discrete, ellipsoidal magnetic response, being elongated in a north-south direction and having an amplitude of around 200nT (Figure 2).

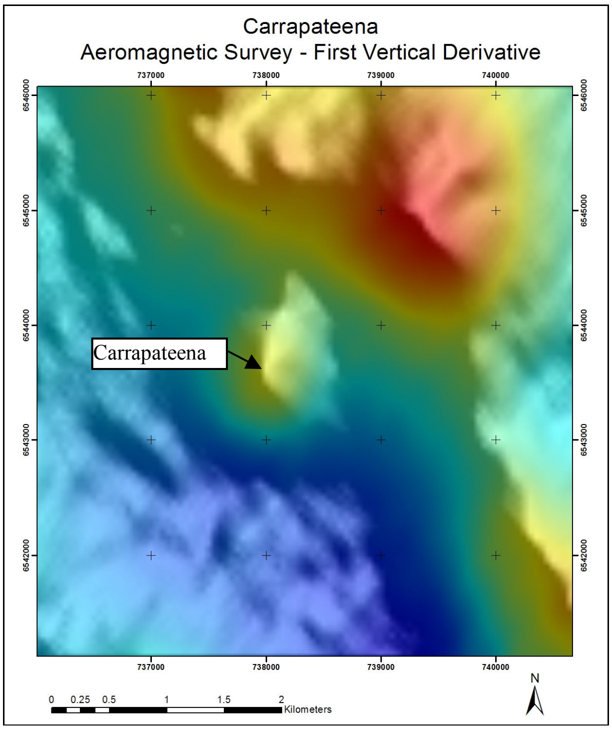

Figure 2. First vertical derivative image of Carrapateena.

Gravity Surveys

Three separate gravity surveys were conducted over the Carrapateena deposit. In 1996, Dynamic Satellite Surveys collected 204 gravity stations, on a 500m x 500m grid. Then in 2003, MIM collected 207 gravity stations on a 400m x 400m grid. And in 2006, Haines Surveys collected data for Teck on a 200m x 200m grid. The deposit is characterised by a weak (2.5mGal) bullseye gravity high (Figure 3), near-coincident with the observed magnetic response.

Jim Hanneson (Adelaide Mining Geophysics), during the early stages of exploration, undertook detailed forward modelling that suggests the gravity and magnetic responses could be explained by a non-magnetic, vertical cylindrical body, with a diameter of 1km and average density of 3.27g/cm^3, overlying a less dense and weakly magnetic body, having an average magnetite content of no more than a few percent. Similar results were obtained from 3D inversion modelling (Figure 4). Drill holes, to depths in excess of 1500m, confirm that hematite dominates in the shallower part of the deposit, with increasing magnetite being observed at depth.

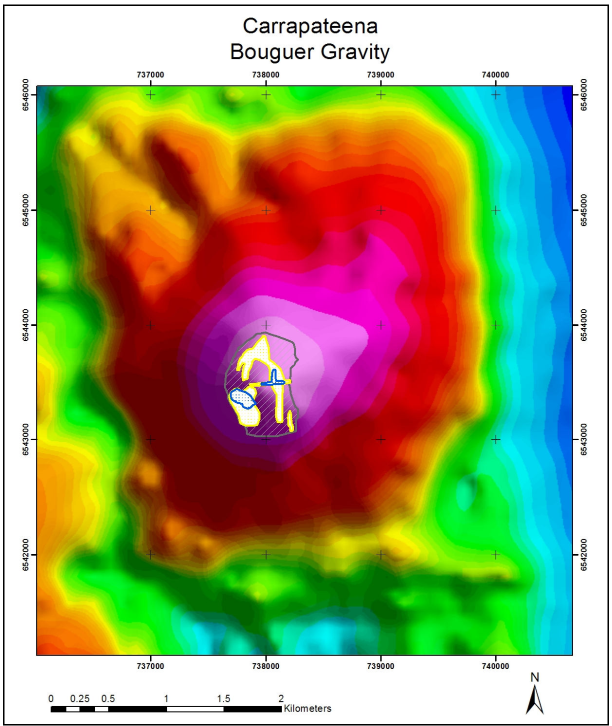

Figure 3. Approximate surface projection of the hematite breccia body (grey), chalcopyrite mineralisation (yellow) and bornite mineralisation (blue), superimposed on an image of Bouguer gravity.

IP/Resistivity/MT Surveys

In 2003, using its then proprietary MIMDAS system, MIM Exploration Pty. Ltd. undertook six lines of IP and MT surveying over the Carrapateena Prospect. The 5km long lines were spaced 400m apart and data were acquired in a standard 2D array, using a pole – dipole configuration, with a 200m dipole spacing.

While the IP data were ambiguous, modelling of resistivity data over the peak of the gravity anomaly indicated the existence of at least 150m of conductive (0.05 – 0.1S/m) overburden, overlying a several hundred metre thick layer of relatively resistive (>150ohm.m) material, with the underlying basement exhibiting variable, but significantly lower, resistivities. In particular, a deep conductive zone was interpreted to be coincident with or slightly north of the gravity response. The Carrapateena discovery hole (CAR002) was targeted on these anomalies. For further information about this survey, the reader is referred to Vella and Cawood (2006).

In 2006, Search Exploration carried out a 2D high-powered IP/resistivity survey, using proprietary technology. The data were collected using a 50kVA transmitter and full time series Induced Polarisation Acquisition Unit (SSIP16). Data were collected on seven east-west lines, 300m to 400m apart, with

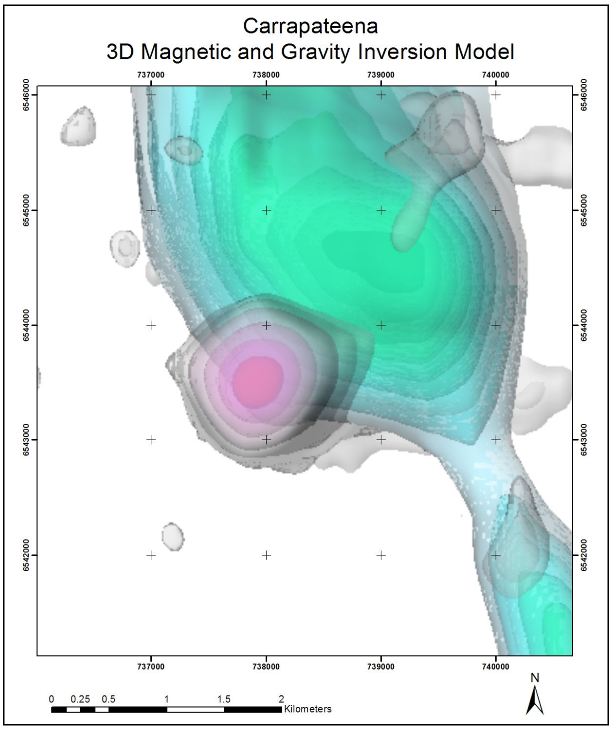

Figure 4. 3D gravity and magnetic inversion model (by Craig Beasley, Wave Geophysics), using high-pass filtered (10km) data. Iso-surfaces of density contrast are pink-grey and iso-surfaces of percent magnetite are green-blue. The gravity model was constrained by incorporating a reference model comprising an overburden layer (450m thick, with a density contrast of -0.1 g/cm^3), overlying a half space.

readings being taken at 100m intervals. Line length varied from 3.9 to 5.1km, with a total of 40.7 line km of data collected. Maximum transmit current was 68A.

Data quality was very good overall, however, some data were negatively impacted by EM coupling and tellurics. These were minimised through sophisticated processing, shared collaboratively between John Paine (Scientific Computing and Applications) and David McInnes (Montana Geophysics).

Subsequent inversion modelling (using 2D Zonge and UBC codes) demonstrated a good correlation between the observed conductivity and gravity anomalies and hematite +/- sulphide mineralisation intersected by drilling. The chargeability data, however, were less certain. On some sections there was good correspondence between chargeability and drill results. While on others, chargeability anomalies appeared to be shallower than expected. Interpretation of the results was complicated by the presence of specular hematite, which can exhibit an appreciable chargeability, but was often not logged in detail.

In 2006, Carrapateena was also surveyed using GRS's MIMDAS system. Data were collected using a "ghost-line" 3D setup, comprising three overlapping three-line girds, thereby also providing seven co-linear 2D lines of pole – dipole IP/Resistivity/MT data. Each line was 4km long, being spaced 400m apart, with a receiver dipole length of 200m. Transmitter locations extended east and west of the array by 500m. A Zonge GGT10 10kVa transmitter was used and the nominal transmit current was 3 to 8.5A.

The MT data for all lines were characterised by clean impedance estimates for frequencies to below 0.1 Hz. The resistivity and IP data acquired were generally of good quality, although this was limited by the magnitude of IP signals, relative to the magnitude of residual EM coupling, at a location with significant low-frequency tellurics. Pole – dipole data contained less EM coupling than dipole – pole data, therefore, the latter was excluded from input into the inversion models.

Like the 2D high-powered IP/resistivity survey and the 2003 MIMDAS survey, a good correlation was observed between the conductive and gravity responses at Carrapateena (Figure 5). However, subtle chargeability anomalies have been negatively impacted by substantial EM coupling, particularly on the eastern side of the survey in the proximity of Lake Torrens and associated creeks, and significant low-frequency tellurics. Therefore, it was concluded that the resistivity and MT results would be a more reliable guide for targeting than the chargeability.

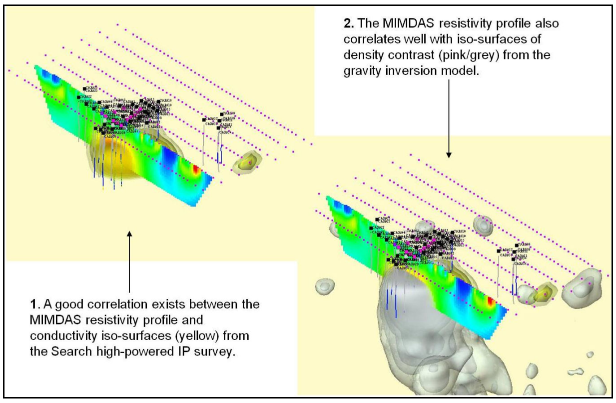

Figure 5. Line 6543400N. A comparison between 2D Search resistivity data and 3D MIMDAS resistivity data.

Down Hole IP/Resistivity Surveys

Between 2006 and 2008, a variety of down hole IP/resistivity surveys were carried out over Carrapateena. The data were collected using Search Exploration's full time series Induced Polarisation Acquisition Unit (SSIP16) and a 50kVA transmitter.

In-situ measurements of IP/resistivity were made in 21 Carrapateena drill holes, using a collinear Wenner array, in which the electrode spacing was 3m. Readings were taken at 10m intervals. Radial IP/resistivity measurements were also made in six drill holes in which a single transmitter electrode was placed near the bottom the hole and two other transmitting electrodes were placed about 1.5km from the drill hole and at the drill hole collar. This provided three separate transmitting arrays. Potential electrodes were then set up on eight radial lines around the transmitting drill hole. For each line there were five potential electrodes, 100m apart. Cross-hole dipole – dipole IP surveys, using a 100m transmitter dipole in one hole and a 50m receiver dipole in the other hole, were also attempted.

The in-situ IP/resistivity measurements were extremely useful in furthering the understanding of the electrical properties of the Carrapateena rocks. However, the radial DHRESIP does not appear to have worked in the way it was intended, presumably being a victim of 470m of moderately conductive cover and significant electrical anisotropy. Results from the cross-hole surveys were inconclusive and it may be worthwhile re-processing and re-modelling these data.

EM Surveys

In 2007, Outer Rim Exploration Services conducted 3-component down hole EM surveys in four drill holes, and read one surface moving loop profile. The data were collected using a 42 channel Crone Pulse EM system, and receiver coil. A 600m x 600m transmitter loop, with a transmit current of 27A, was used for the down hole surveys, while the surface profile was read using a 200m x 200m in-loop configuration, with a transmit current of 30A.

Given the disseminated nature of the sulphide mineralisation observed to date, it was not surprising that there were no convincing responses that could be attributed to bedrock conductors away from the drill holes. Similarly, the surface profile did not yield a credible anomaly over the Carrapateena deposit.

CONCLUSIONS

Results show Carrapateena is associated with a weak, discrete, ellipsoidal magnetic response, and near-coincident, weak, bullseye gravity high. The mineralised system is also characterised by a distinct conductivity anomaly. However, the chargeability data are less convincing, being strongly impacted by the thick and conductive nature of the cover sequences. EM surveys did not provide any responses attributable to bedrock conductors and are not recommended for this style of deposit. The observed geophysical responses at Carrapateena are dominated by the presence of Fe-oxides, particularly hematite, with sulphide mineralisation playing a lesser role

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