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THE CARRAPATEENA IRON OXIDE COPPER GOLD DEPOSIT, GAWLER CRATON, SOUTH AUSTRALIA: A REVIEW

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Abstract - The Carrapateena iron oxide copper-gold deposit (203 Mt @ 1.31% Cu, 0.56 g/t Au, 0.27 kg/t U) is located within the Olympic IOCG Province on the eastern rim of the preserved Gawler craton in northern South Australia, approximately 100 km southsoutheast of Olympic Dam. The deposit is hosted by strongly brecciated granitoids which have been dated at 1857±6 Ma and are assigned to the Palaeoproterozoic Donington Suite. It occurs within the core of a north-south oriented, 30 × 100 km mass of that suite, that is overlain 10 to 15 km to the west by ~1590 Ma mafic and felsic volcanic rocks of the Gawler Range Volcanics, which are comagmatic with the Hiltaba Suite granitoids that host the Olympic Dam deposit.

The ore deposit lies beneath a ~470 m thickness of flat lying Neoproterozoic sedimentary rocks, and occupies a north-south elongated area of approximately 800 × 600 m at the unconformity surface with the underlying Palaeoproterozoic host rocks. It is reflected by a broad, weak and diffuse 200 nT magnetic peak and a slightly offset, ellipsoidal, 3.5 km diameter, 2 mGal gravity anomaly.

Mineralisation is confined to a steeply plunging, pipe-like body of hematite and hematite-granite breccia, the Carrapateena Breccia Complex (CBC), which is interpreted to be cut at its centre by an east-west- to eastnortheast-trending complex zone of faulting. To the north of this inferred zone of faulting, the mineralised mass is wedge-shaped, tapering rapidly downward into the fault zone and may conceivably follow that structure to depth. To the south, the CBC comprises an irregular, ~300 to 400 m diameter, ellipsoidal-cylindrical mineralised body that has been traced by drilling from the unconformity to a depth in excess of 1 km below that surface, from where it continues unclosed.

Mineralisation is zoned laterally outward, and to the north, vertically downward, from bornite to chalcopyrite-bornite to chalcopyrite to chalcopyrite-pyrite. Three kernels of bornite-rich mineralisation have been delineated, one wedge-shaped zone to the northeast that tapers southward into the inferred central zone of faulting, and two steeply plunging elongate zones, one above the other, in the upper and lower parts of the core to the main mineralised pipe-like mass of the CBC in the south.

The principal alteration minerals are hematite, chlorite and sericite, with locally abundant quartz and carbonate (siderite and/or ankerite), and secondary barite, monazite, anatase, magnetite, apatite, fluorite and zircon. The host CBC varies from heterolithic clast- to matrix-supported hematite-rich breccias. Many of the clasts are milled and rounded, and are predominantly of gneissic diorite, with granite gneiss and vein quartz. Higher grade copper intersections are typically associated with a grey hematite matrix within strongly brecciated granite.

Introduction

The Carrapateena iron oxide copper-gold (IOCG) deposit is located approximately 100 km southsoutheast of Olympic Dam and 160 km north of Port Augusta in South Australia, immediately to the southwest of the Carrapateena embayment on the central-western shore of Lake Torrens (Fig. 1). The discovery diamond drill hole, CAR002, intersected significant IOCG mineralisation in June 2005, comprising 178.2 m @ 1.83% Cu, 0.64 g/t Au, 0.21% Ce, 0.13% La and 59 ppm U, from 476 m, ending in mineralised hematite breccia at a depth of 654 m. This hole was drilled by RMG Services Pty Ltd (RMGS), an unlisted company incorporated in South Australia, and was 50% funded by the South Australian Government's Plan for Accelerated Exploration (PACE). It was targeted on a coincident gravity and weak magnetic anomaly (Vella and Cawood, 2006, Fairclough, 2005). RMGS subsequently entered into a joint venture with Teck Cominco Australia Pty Ltd (now Teck Australia Ltd), a division of Teck Resources Limited of Canada, who assumed the role of manager. A drilling program and preliminary scoping study were carried out to assess the extent of the mineralisation and the potential development of an underground copper-gold mine on the deposit, the shallowest point of which is approximately 470 m below the surface. Drilling on the project was completed in February 2008 (Teck Annual Report, 2009), although no resource figures were released. Following the Global Financial Crisis, Teck and RMGS sought a third party to develop the deposit.

On the 9th March, 2011, OZ Minerals Limited signed an agreement to purchase the Carrapateena copper-gold project from RMGS (58%), Teck Australia Pty Ltd (34%) and various minorities (8%). Following the announcement, OZ Minerals released an audited inferred resource for the main deposit, at a cut-off of 0.7% Cu, totalling 203 Mt @ 1.31% Cu, 0.56 g/t Au, 0.27 kg/t U, 6 g/t Ag in the southern half of the deposit area. The northern half, with a potential to contain a further 25 to 45 Mt @ 1.0 to 1.1% Cu, 0.4 g/t Au, 0.14 kg U_30_8 requires additional drilling to advance to resource status. The inferred resource in the southern half of the deposit area (south of 6 543 450 mN; Fig 6) is based on 45 504 m of drilling in 33 diamond drill holes (OZ Minerals Explanatory Notes, April, 2011).

Carrapateena is one of a number of significant IOCG-style deposits and mineralised systems distributed along the eastern margin of the preserved Gawler craton (Fig. 1). These include the Olympic Dam (Reeve *et al.*, 1990, Reynolds, 2000), Prominent Hill (Belperio *et al.*, 2007; Freeman and Tomkinson, 2010) and Hillside (Conor *et al.*, 2010) deposits, and the historic Wallaroo-Moonta mining

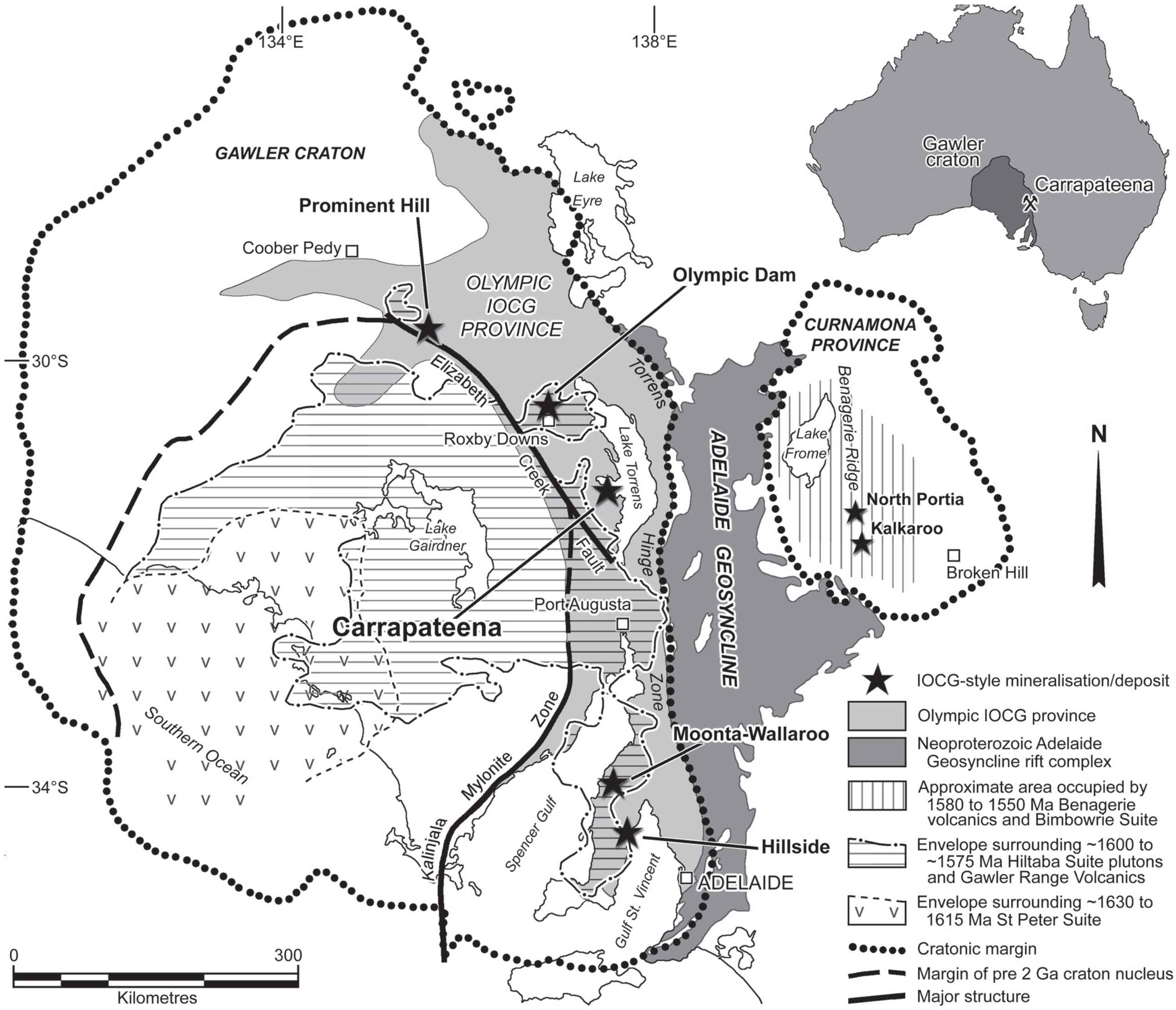

Figure 1: Location and setting of the Carrapateena copper-gold deposit in the Olympic IOCG Province (after Skirrow, 2007) on the eastern margin the Gawler craton in northern South Australia.

field (Conor *et al.*, 2010). In the Olympic Dam-Carrapateena district there are a number of other IOCG-style mineralised systems, including Acropolis and Wirrda Well (Patterson, 1986; Cross, 1993), Oak Dam (Davidson and Patterson, 1993; Davidson *et al.*, 2007) and Emmie Bluff (Gow, 1996) See figs. 2 and 3 for locations of these occurrences, and Hayward and Skirrow (2010) for geological summaries.

This brief paper is intended to compile the available public domain information on Carrapateena so that this important IOCG system can be compared with the other major deposits of this type from around the world that are described within this volume.

Regional Setting

Carrapateena, Olympic Dam, Prominent Hill, Moonta-Wallaroo and Hillside and all of the other significant known IOCG mineralised systems of the Gawler craton are hosted within Palaeo- to Mesoproterozoic rocks and are distributed along the eastern edge of the currently preserved craton to define the Olympic IOCG Province (Fig. 1), as proposed by Skirrow *et al.* (2002). This province is now known to have formed broadly coevally along the length of the province at ~1600 to 1570 Ma (Skirrow *et al.*, 2007). The framework and tectonic history of the Gawler craton and the Olympic IOCG Province are described in detail in Hayward and Skirrow (2010) and will only be summarised herein.

The oldest rocks of the Gawler craton comprise Mesoarchaean to early Palaeoproterozoic metamorphics and igneous suites that form a core to the craton, immediately to the west of the Olympic IOCG Province. On its eastern margin, and within the Olympic IOCG Province, this older nucleus was overlain after ~2000 Ma by the Hutchison Group, a sequence of subaerial to shallow marine clastic and chemical metasedimentary rocks, with minor felsic and mafic volcanic rocks, that were deposited on a continental passive margin (Parker, 1993; Daly *et al.*, 1998). Within the Carrapateena-Olympic Dam region, this succession, which is not obvious, is inferred from seismic data. Along the eastern margin of the craton, including the Carrapateena district, the cratonic core and the Hutchison Group were both intruded by ~1850 Ma granitoids of the Donington Suite during the Cornian orogeny (Hand *et al.*, 2007; Reid *et al.*, 2008). This suite is dominated by granodiorite gneiss, with subordinate metamorphosed alkali-feldspar granite, gabbronorite, tonalite and quartz monzonite intrusions with mafic dykes (Ferris *et al.*, 2002).

Between ~1770 and 1740 Ma, subsequent to the emplacement of the Donington Suite, extension along the eastern, northern and western margins of the craton, resulted in the development of a series of extensive basins, some of which contain bimodal volcanic rocks. These include the Wallaroo Group, which is extensively developed within the Olympic IOCG Province and is an important host to IOCG alteration and mineralisation in the Moonta-Wallaroo and Olympic Dam-Carapateena districts. Evidence from seismic, magnetotelluric and Sm-Nd isotopic data suggest that Archaean rocks may extend eastwards beneath these younger sequences to at least the Elizabeth Creek Fault, just west of Carrapateena in the north, and the Kalinjala Mylonite Zone to the south (Fig. 1). During the Palaeoproterozoic, the Curnamona Province is believed to have collided with and been accreted to the Gawler craton in the east. A major linear discontinuity in magnetic and gravity data beneath the Neoproterozoic cover of the Adelaide Geosyncline intracratonic rift complex is interpreted to mark the suture zone (Hayward and Skirrow, 2010, and sources quoted therein).

The interval between ~1730 and ~1630 Ma encompasses the Kimban orogeny (1730 to 1690 Ma), Ooldean Event (1660 to 1630 Ma), and the widespread emplacement of various felsic igneous rocks, and formation of several small intracontinental sedimentary basins (Hand *et al.*, 2007). Towards the close of the Palaeoproterozoic, from ~1630 to 1615 Ma, the Nuyts Volcanics and St Peter Suite bimodal magmas were emplaced in the southwestern part of the Gawler craton, which although poorly exposed, cover an extensive area (Fanning *et al.*, 2007; Fig. 1).

Between ~1600 and ~1575 Ma the centre of magmatism shifted eastward with the development of the high-volume intrusive Hiltaba Suite and extensive co-magmatic bimodal Gawler Range Volcanics (GRV) to form a large felsic igneous province (covering a preserved area of >25 000 km^2) over the central and eastern parts of the Gawler craton, including the Olympic IOCG Province. Hiltaba Suite plutons are relatively oxidised, silicic (mostly >70 wt.% SiO_2) I- and A-type, generally metaluminous granitoids, which range in composition from granite to quartz monzodiorite, with strong enrichment in uranium, fluorine and other HFSE (Creaser and White. 1991; Johnson and Cross, 1995; Jagodzinski, 2005; Budd, 2006; Zang *et al.*, 2007). While Hiltaba Suite plutonism is estimated to have persisted over ~25 m.y., the few high precision geochronological constraints on the GRV suggest volcanism was temporally relatively restricted to a few million years around ~1592±3 Ma (Fanning *et al.*, 1988; Johnson and Cross, 1995). The lower GRV are predominantly moderately dipping dacite and rhyolite, with locally thick developments of basalt and andesite, while the upper part of the overall succession is dominated by flat lying dacite and rhyolite flows and ignimbrites. Between 1580 to 1550 Ma, magmatism progressed eastward to form the Benagerie volcanics and Bimbowrie Suite I- and S-types in the Curnamona Province, the easternmost development of the diachronous eastnortheast-trending corridor of continental I- and A-type magmatism that extends across the Gawler and Curnamona cratons from the St Peter Suite in the southwestern part of the craton (Hayward and Skirrow, 2010; Fig. 1).

Known significant IOCG districts/deposits within the Olympic IOCG Province, including Carrapateena, are found where oxidised (magnetite-series), A-type granitoid plutons of the 1595 to 1575 Ma Hiltaba Suite were emplaced into an accreted Palaeoproterozoic terrane, and where mafic volcanic rocks of the lower GRV are most abundant. IOCG mineralisation mostly formed during a short lived episode of northnorthwest-southsoutheast extension that approximately coincided with eruption of the GRV (ca. 1595 to 1590 Ma), but was preceded and followed by more protracted northwest-southeast to northnorthwest-southsoutheast contraction (Hayward and Skirrow, 2010).

After Hiltaba Suite magmatism, tectonism appears to have migrated northwards and westward, with the ~1570 to 1540 Ma Kararan and 1470 to 1440 Ma Coorabie orogenies respectively. The Archaean to Mesoproterozoic crystalline basement rocks of the Gawler craton were not subjected to any substantial deformation after ~1450 Ma until the early Palaeozoic Delamerian orogeny (Parker, 1993).

Much of the Olympic IOCG Province is overlain by flat lying Neoproterozoic to Lower Palaeozoic sedimentary rocks of the Stuart Shelf, equivalents of the sedimentary succession of the Adelaide Geosyncline intracratonic rift complex which separates the Gawler craton and Curnamona Province and was the result of extension preceding and during to the rifting and breakup of the Rodinia supercontinent from immediately to the east of the Curnamona Province. The margin of the current Gawler craton is taken to be the Torrens Hinge Zone (Fig. 1), a major structure which also marks the transition from the Stuart Shelf to the thick sequence of the Adelaide Geosyncline 30 to 40 km to the east of Carrapateena and Olympic Dam.

Geological Setting

The Carrapateena IOCG deposit is hosted within the vertical, pipe-like Carrapateena Breccia Complex (CBC) which is developed within variably foliated and/or sheared gneissic quartz-granite and quartz-diorite, that has been dated at 1857±6 Ma and assigned to the Donington Suite. These Mesoproterozoic rocks are unconformably overlain by a Neoproterozoic sedimentary cover sequence of the Stuart Shelf (Vella and Cawood, 2006). In plan, the downward tapering CBC covers an area of approximately 600 × 800 m at the unconformity and persists over a vertical interval in excess of 1000 m below that surface (Brodovcky, 2010; Figs. 6 and 7).

Within the Carrapateena-Olympic Dam district, below the Neoproterozoic unconformity surface, the metagranitoids of the Palaeoproterozoic Donington Suite occur as a series of extensive batholithic bodies, with Carrapateena occurring within the core of a mass of this suite interpreted to cover a north-south elongated area of approximately 100 × 30 km. This mass is surrounded on all sides by unconformably overlying metasediments of the ~1760 to 1740 Ma Wallaroo Group and to the west by mainly mafic volcanics of the Lower GRV (Fig. 3). Although the Olympic Dam deposit lies within a large mass of Hiltaba Suite granitoid that immediately underlies the Neoproterozoic unconformity, no significant Hiltaba Suite intrusives have been interpreted below that surface in the vicinity of Carrapateena (Skirrow, *et al.*, 2007).

The Carrapateena Breccia Complex (CBC) varies from heterolithic clast- to matrix-supported hematite-rich breccias. Many of the clasts are milled and rounded such that the 'breccia' may have the appearance of a 'conglomerate' when samples are viewed in isolation. The clasts are predominantly of medium grained, gneissic diorite, with granite gneiss and vein quartz, variably altered to chlorite, sericite and hematite, as well as hematite-dominated clasts of earlier breccia phases within a matrix with a variety of textures that has also been altered to an assemblage of hematite, quartz and sericite (Fig. 5a).

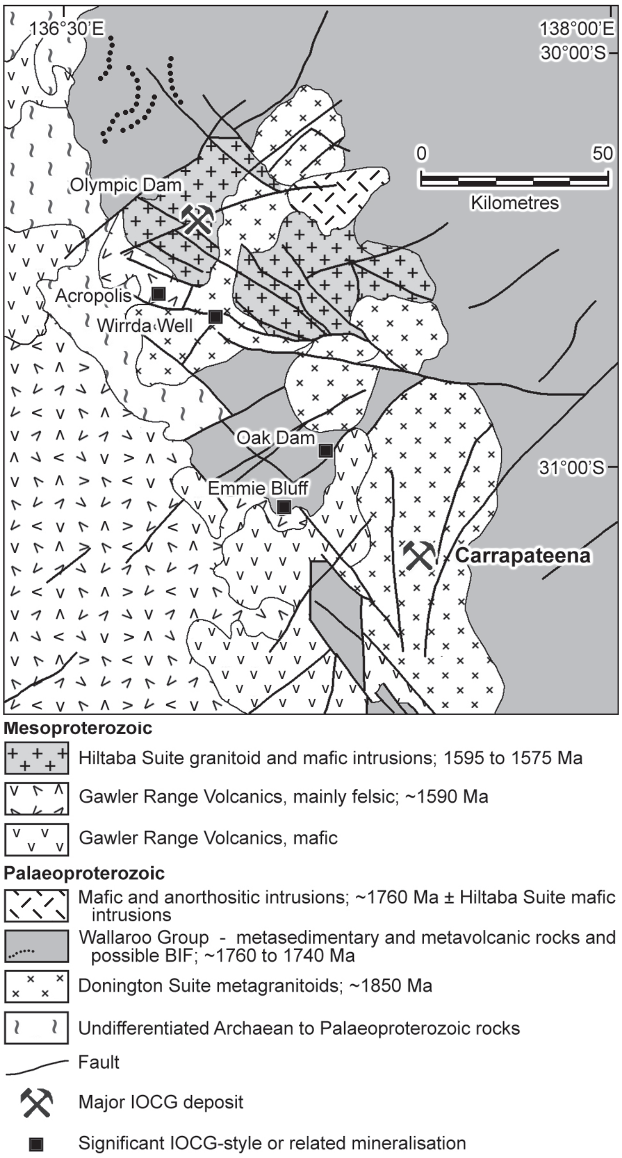

Figure 2: Interpreted pre-Neoproterozoic basement geology of the Olympic Dam-Carrapateena district showing locations of major IOCG deposits and significant IOCG-style or related mineralisation (after Bastrakov *et al.*, 2007)

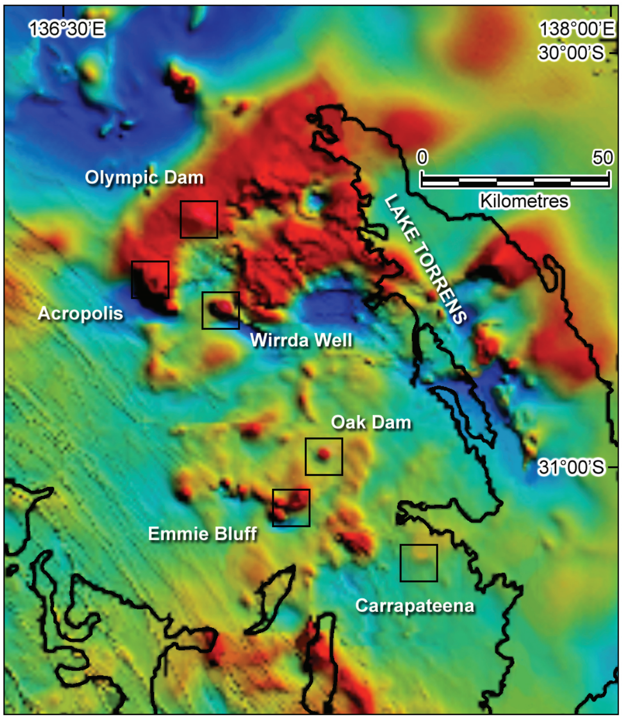

Figure 3: Total magnetic intensity image of the Olympic Dam-Carrapateena area showing locations and the reflection in magnetic data of major IOCG deposits, significant IOCG-style or related mineralisation and iron-alteration systems. This figure covers the same area as Fig. 2. TMI data provided by Primary Industries and Resources, South Australia (PIRSA).

The unconformity between the host Donington Suite and the cover sequence at Carrapateena is marked by a thin basal conglomerate up to 10 m thick composed of well rounded clasts of granite, volcanic rocks, quartz and hematite, some of which are mineralised, within a fine-grained matrix. This variably developed unit is overlain by the Whyalla Sandstone of the Umberatana Group, which is approximately 65 m thick and comprises variably gritty siltstones to sandstones, with minor dolostone, locally stromatolitic, interbeds (Vella and Cawood, 2006). Vella and Emerson (2009) have instead reported the Umberatana Group at Carrapateena as comprising from the base, the Angepena Formation composed of 40 m of shales

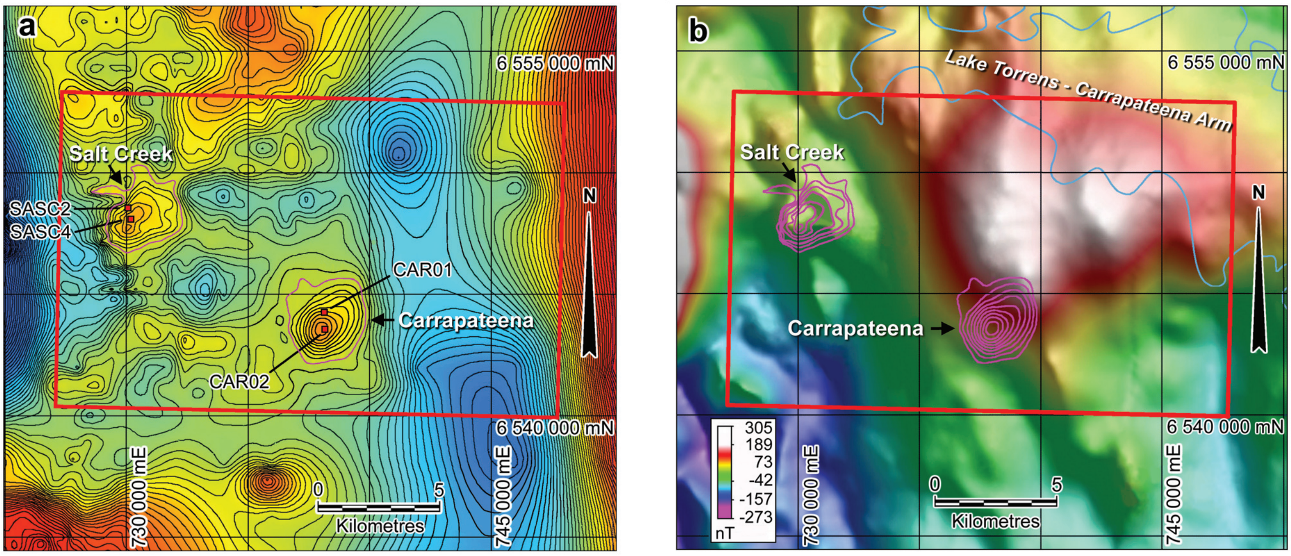

Figure 4: **a** Residual Bouger gravity data image of the Carrapateena project area (MIM Exploration Pty Ltd, 2003; 400 x 400 m station spacing) showing selected drill hole locations and the anomalies associated with the Salt Creek prospect and Carrapateena deposits. Contour interval = 2 gravity units. Red line is the outline of the Carrapateena project area, EL 2879. **b** Detailed total magnetic intensity image of the Carrapateena project area with superimposed gravity anomalies (from Fig. 3a) of the Carrapateena deposit and the Salt Creek prospect. Images modified and reproduced with the consent of Teck Australia Pty Ltd and RMG Services Pty Ltd.

and siltstones, the 30 m thick Reynella siltstone and the overlying 10 m of dolostones that constitute the Nuccaleena Formation. The succeeding Wilpena Group commences with the 270 to 300 m thick dark red-brown shale with blue-grey silty beds that constitutes the Woomera Shale. The overlying Corraberra Sandstone comprises 25 to 40 m of purple-brown, medium- to fine-grained arenite, overlain in turn by a 90 m thickness of the outcropping Arcoona Quartzite, composed of white, silicified, coarse-grained quartzite (Vella and Cawood, 2006).

The geometry of the gravity anomaly reflecting the CBC (Figs. 4a and 4b) is controlled by northeast-striking faults, superimposed upon a broader northwest-trending structural grain evident in the aeromagnetic data (Fig. 3; Vella and Cawood, 2006; Fairclough, 2005). A structural analysis shown in Hayward and Skirrow (2010) suggests Carrapateena is developed close to the intersection of faults of these two trends, although the same analysis indicates the interval between and beyond Carrapateena and Olympic Dam is dominated by a grid pattern of northwest- and northeast to northnortheast structures. The Carrapateena gravity target is associated with a strong northwest to northnorthwest trending structure evident in detailed aeromagnetic data. This structure appears to bound the southwestern margin of the main magnetic anomalous zone below Carapateena (Fig. 3). On more detailed regional imagery than that shown on Fig. 3, this same structure can be seen to be also be associated with the Oak Dam and Wirrda Well IOCG-style mineralised systems (Figs. 2 and 3).

Discovery

Following the discovery of the Olympic Dam IOCG deposit in 1975, the Gawler craton was subjected to increased exploration activity. In the immediate Carrapateena area, this resulted in a number of holes being drilled at the Salt Creek prospect in the late 1970s and early 1980s by a joint venture partnership of Carpentaria Exploration and Seltrust, targeting gravity and/or aeromagnetic highs. Salt Creek is approximately 10 km northwest of where Carrapateena was later to be discovered. One of these holes, SASC04, was completed at 1250 m and intersected hematite-sericite altered granitoids of the Mesoproterozoic Donington Suite from a depth of 540 m to the bottom of the hole, but without significant associated copper mineralisation. The titles held were subsequently relinquished, although preservation of the core at the Primary Industries and Resources SA (PIRSA) core library provided important encouragement and information for later explorers (Fairclough, 2005; Vella and Cawood, 2006).

In the mid-1990s, RMGS applied for Exploration Licenses to the south of Carrapateena, in the southern part of Lake Torrens, with the aim of providing salt for a proposed petrochemical plant at Port Bonython. During subsequent research in the PIRSA library, the principal of RMGS, Rodolfo Gomez, was attracted to the potential for IOCG mineralisation in the Gawler craton. As a consequence, the company applied for EL2170 (subsequently EL 2879) in 1996, based on the premise that the presence of the Torrens Hinge Zone through the area made it prospective for this style of mineralisation (Vella and Cawood, 2006). The Torrens hinge zone (Fig. 1) marks the transition from the thick Neoproterozoic succession of the Adelaide Geosyncline intracratonic rift complex to the east, and the flat lying equivalent sediments of the Stuart Shelf that overlie the Meso- and Palaeoproterozoic, and Archaean rocks of the eastern Gawler craton which host the major IOCG deposits.

Interpretation of regional aeromagnetic and gravity data, acquired by PIRSA, indicated an Olympic Dam-style potential field anomaly at Carrapateena. Additional gravity data was collected by a joint venture of RMGS and General Gold Resources Ltd., confirming the presence of a discrete gravity response. In 2003-04, a joint venture was formed between MIM Exploration Pty. Ltd. (formerly Carpentaria Exploration), Terramin Australia Ltd. and RMGS, and further gravity data collected (Fig. 4a). MIM also completed six 5 km long, 200 m spaced (north-south) lines of induced polarisation (IP) and magnetotelluric (MT) surveying, using its then proprietary MIMDAS system (Fairclough, 2005). Although interesting anomalies were detected on the northern end of two of the MIMDAS lines, MIM withdrew from the JV due to corporate issues related to their takeover by Xstrata. Terramin also withdrew soon after to concentrate their attention on other projects (Vella and Cawood, 2006, Fairclough, 2005).

Many geophysical similarities to the Olympic Dam deposit were recognised by Chris Anderson and Associates, consultants to RMGS. These included broadly coincident gravity and aeromagnetic anomalies, although of a much lower magnitude with gravity peaks of ~2 mGal, compared to 17 mGal at Olympic Dam, 22 mGal at Acropolis and 6 mGal at Wirrda Well, and magnetic highs of ~200 nT, compared to the ~1600 nT at Olympic Dam, ~5500 nT at Acropolis and ~1800 nT at Wirrda Well (Fig. 3; Vella and Cawood, 2006). It should be noted however, that the northern part of the Olympic Dam-Carrapateena district is dominated by strong, areally extensive magnetic responses, due largely to broad magnetite alteration, encompassing the Olympic Dam, Acropolis and Wirrda Well mineralised systems which are all characterised by strong, discrete magnetic anomalies. In contrast, to the southeast, Carrapateena is situated on the edge of a weak magnetic anomaly, within a more subdued magnetic regime (Fig. 3).

A 3D geological inversion of geophysical data also proved encouraging, as was the recognition of a slight offset between the gravity and magnetic peaks (Fairclough, 2005) as illustrated on Fig. 4b. The Carrapateena deposit is situated on the southwestern margin of a broad, weak to moderate amplitude magnetic anomaly (Fig. 4b), and is associated with an ellipsoidal, weak, discrete, north-south elongated magnetic anomaly evident from more recent detailed data (Vella and Cawood, 2006). The ellipsoidal gravity anomaly at Carrapateena, has an amplitude of ~2 mGal and a diameter of approximately 3.5 km (Figs. 4a and 4b). The geometry of the gravity anomaly is influenced by northeast striking faults superimposed upon the overall northwest oriented structural grain of the surrounding area as evidenced in the aeromagnetic data.

Interpretation of the MIMDAS data suggested a deep conductive zone coincident with, or slightly north of the coincident gravity and magnetic response. Modelling of chargeability data produced more ambiguous results, with anomalous responses interpreted to be at shallower depths within the Neoproterozoic cover rocks (Vella and Cawood, 2006, Fairclough, 2005).

In 2005, RMGS applied for PACE funding of four drill holes to test the anomalies, later to be reduced to two, the first targeting the MIMDAS and the second, the discovery hole, to test the coincident gravity and magnetic anomalies. The first of these holes, CAR001 commenced with a 240 m reverse circulation (RC) pre-collar that was terminated in cover sequence Woomera Shales. The

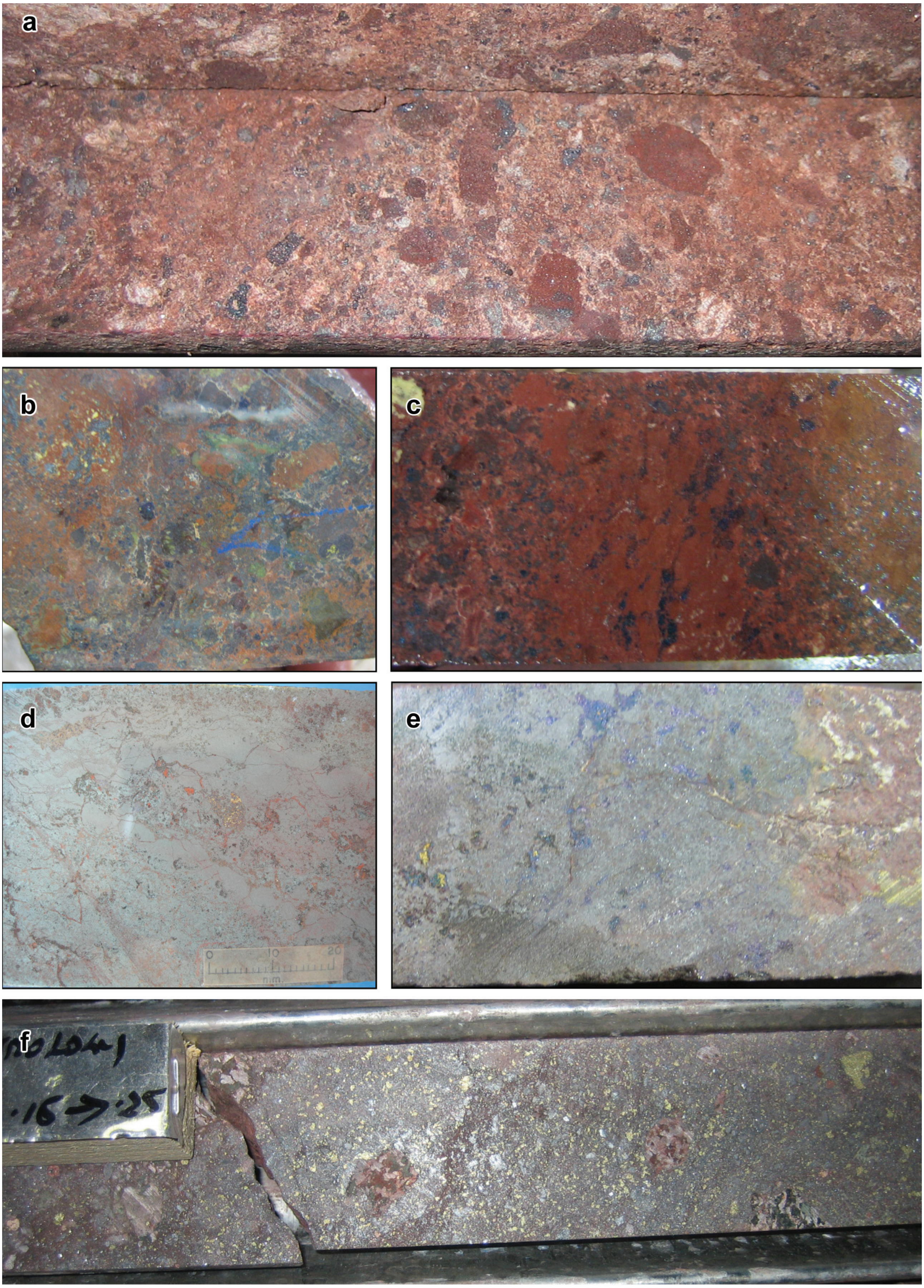

Figure 5: **a** - Heterolithic hematite breccia from the upper bornite zone of drill hole CAR002; **b, c, d** and **e** are all from the upper bornite zone of CAR002 (between 476 and 531 m) with predominantly bornite and lesser chalcopyrite - each sample is approximately 5 cm high; **b** - Hematite altered granite breccia with bornite matrix; **c** - Chlorite altered granite breccia with a grey hematite matrix (from 476 m); **d** and **e** - Higher grade ore which is typically associated with dense grey hematite breccia matrix (**d** from 490.4 m); **f** - Mineralised hematite breccia with chalcopyrite from the lower chalcopyrite zone from below 599 m. Images provided and reproduced with the consent of Teck Australia Pty Ltd and RMG Services Pty Ltd.

Table 1: Selected drill intersection intervals and assays from the Carrapateena project scoping program (Brodovcky, 2010).

HOLE No.	From (m)	To (m)	Interval (m)	Cu (%)	Au (g/t)	U (ppm)	Ag (g/t)
CAR002	**474**	**696**	**222**	**1.56**	**0.56**	**61**	**5.8**
including	*476*	*531*	*55*	*3.25*	*0.43*	*60*	*16.3*
CAR031W1	**582**	**992**	**410**	**1.88**	**1.20**	**343**	**18.7**
including	*858*	*992*	*134*	*2.85*	*1.48*	*477*	*28.9*
CAR050	**487**	**1392**	**905**	**2.08**	**0.98**	**278**	**8.5**
including	*1203*	*1278*	*75*	*4.63*	*1.10*	*429*	*25.9*
CAR051W1	**608**	**1511**	**903**	**2.15**	**0.66**	**316**	**9.0**
including	*1174*	*1343*	*169*	*4.30*	*0.74*	*317*	*23.0*
CAR053W1	**1005**	**1402**	**397**	**2.45**	**0.77**	**301**	**11.9**
including	*1191*	*1402*	*211*	*3.51*	*0.96*	*360*	*18.5*
CAR073	**506**	**1411**	**905**	**2.17**	**0.89**	**255**	**11.5**
including	*518*	*600*	*82*	*4.78*	*1.13*	*179*	*26.0*
CAR073W1	**555**	**859**	**304**	**2.83**	**0.99**	**308**	**19.2**
including	*555*	*699*	*144*	*3.56*	*1.04*	*246*	*25.0*

diamond core tail continued on through the cover sequence and then intersected a broad zone of basaltic rocks to a total depth of 571 m, with reported steely hematite and crackle breccia, but no significant mineralisation. It is now apparent that CAR001 was sited within 100 m outside of the Carrapateena Breccia Complex (CBC), and less than 200 m from the main copper-sulphide zone of the Carrapateena ore deposit (Fig. 6). The second hole CAR002, which was vertical and collared 500 m due south of CAR001, had a 299 m RC pre-collar,

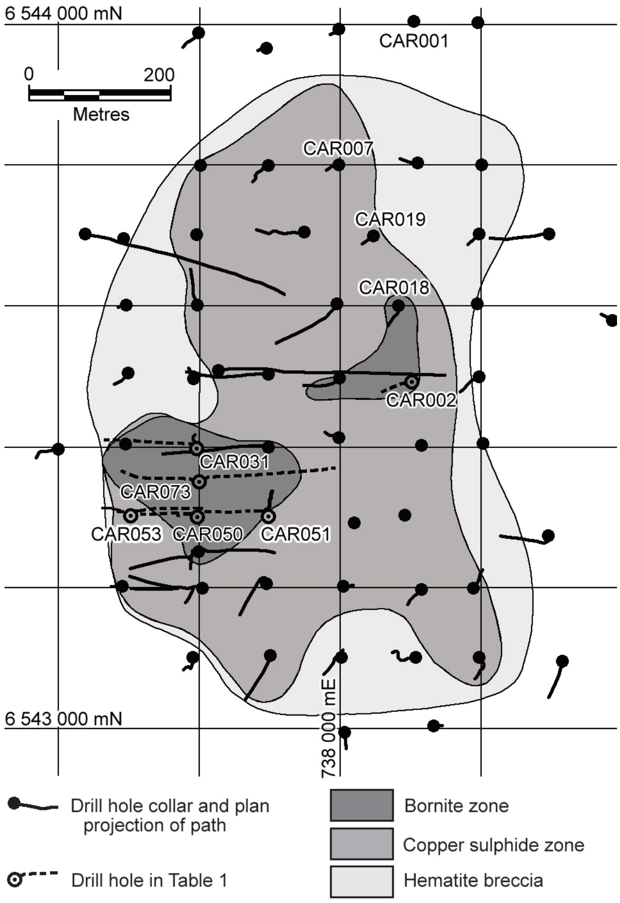

Figure 6: Location and plan projection paths of Carrapateena project scoping study drill holes overlain on the generalised mineralogy/alteration zoning. The drill holes reported and ore intersections recorded in Table 1 are differentiated and numbered (after Brodovcky, 2010).

again ending in cover shales, before the diamond core tail which was completed at a total depth of 654.2 m in June 2005. The hole passed into basement at 476 m, from where it intersected 178.2 m of variable intensity hematite alteration, sulphide development and brecciation of the CBC to the end of the hole. This mineralised interval averaged 1.83% Cu, 0.64 g/t Au, 0.21% Ce, 0.13% La and 59 ppm U (Vella and Cawood, 2006, Fairclough, 2005).

Mineralisation

The bulk of the current public domain information relating to the mineralisation at Carrapateena is from drill hole CAR002 (Fig. 6). This hole passed into basement close to the margin of a steep shoot of bornite rich mineralisation, intersecting: (1) a 73 m interval, from ~476 to 549 m, of bornite-rich breccias and bornite stringers (Figs. 5a and 5c), averaging 2.89% Cu, 0.4 g/t Au (0.7% Cu cut-off), with some chalcocite near the top; (2) a 58 m thick zone, from 549 to 607 m, of hematite altered and brecciated, more gneissic and granitic material, averaging 0.94% Cu, 0.9 g/t Au; (3) a 33 m thick zone, dominated by hematite alteration and chalcopyrite (Fig. 5f) from 607 to 641 m which averaged 1.53% Cu, 0.7 g/t Au (0.5% Cu cut-off); and (4) a 13.2 m thick interval of more pyritic and hematite altered mineralisation from 641 m to the end of hole at 654.2 m which assayed 0.65% Cu (Fairclough, 2005). The overall average of the 178.2 m interval from 476 to 654.2 m was 1.83% Cu, 0.64 g/t Au, 0.21% Ce, 0.13% La and 59 ppm U (Vella and Cawood, 2006). The top 55 m of the bornite zone from 476 to 531 m averaged 3.25% Cu, 0.43 g/t Au, 16.3 g/t Ag and 60 ppm U (Brodovcky, 2010).

Vella and Cawood (2006) have alternatively divided the overall intersection into three mineral zones of (1) an upper interval in which bornite dominates from 476 to 531 m within a hematite breccia; (2) a middle bornite-chalcopyrite interval from 531 to 599 m, hosted by alternating granite- and hematite-breccias; and (3) a chalcopyrite zone within dominantly polymictic hematite/granite breccia from 599 to 654.2 m.

The same authors also note that the higher grade copper intersections are typically within a grey hematite matrix to a strongly brecciated granite (Figs. 5b, 5c, 5d and 5e - all from the bornite zone). Fig. 5b shows an 'earthy' dark red to brown hematite altered granite breccia with a blue/purple bornite matrix, while Fig. 5c is a chlorite altered granite breccia with a grey hematite matrix containing blue/purple blebs of bornite and yellow/gold blebs of chalcopyrite from close to the unconformity with the overlying Neoproterozoic cover. In places chlorite alteration within the granite breccia is intense, giving the appearance of a metasediment. Fig. 5d is a fine-grained crackle-breccia of hematite altered rock containing yellow/gold chalcopyrite within the breccia matrix, while Fig. 5e is an image of a medium-grained grey, intensely hematite altered rock with blue/purple bornite and yellow/gold chalcopyrite within fractures and as disseminated blebs (Vella and Cawood, 2006).

Within the chalopyrite zone, that sulphide occurs as blebs and disseminations within the hematite breccia matrix (Fig. 5f) and as veins (Vella and Cawood, 2006).

The principal alteration minerals are hematite, chlorite and sericite, with locally abundant quartz and carbonate (siderite and/or ankerite), and secondary barite, monazite, anatase, magnetite, apatite, fluorite and zircon. Hematite is present in three forms, (1) a fine-grained earthy-red (Fig. 5b), (2) massive steely-grey (Fig. 5d), and (3) coarse, platy, grey specular varieties (Vella and Emerson 2009).

The deposit exhibits a lateral and vertical zonation of sulphide minerals, taking the form of three, separate, near vertical kernels of high-grade bornite rich ore which

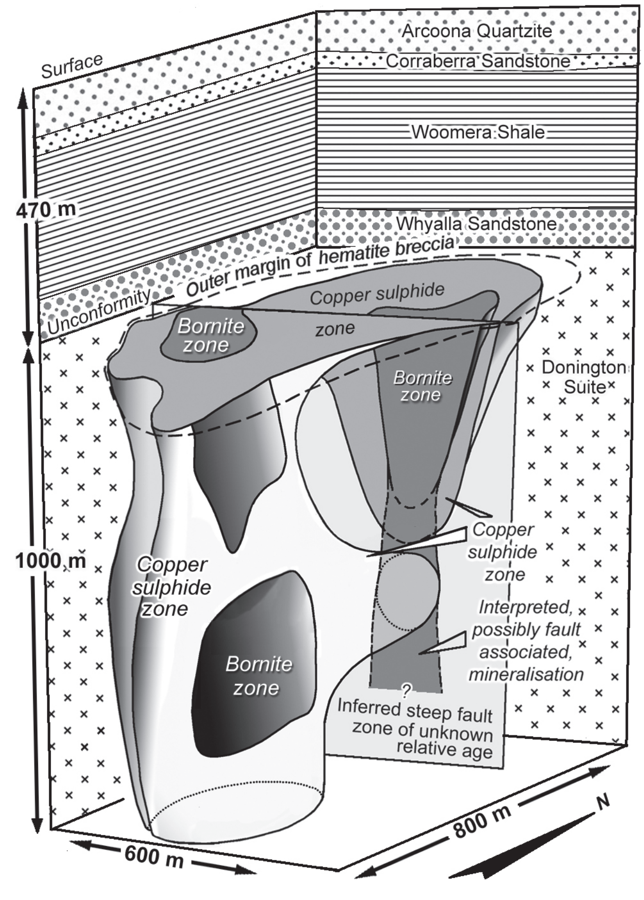

Figure 7: Simplified schematic sketch block-model of the Carrapateena copper-gold deposit (based on a 'wire-frame' model in Brodovcky, 2010) showing the stratigraphic setting, extent of the bornite, copper-sulphide and hematite breccia zones at the unconformity between the Mesoproterozoic host Donington Suite granitoids and the Neoproterozoic cover rocks (based on Fig. 6), and the generalised shape, dimensions and distribution of the copper-gold ore zones below this surface. There is insufficient information to interpret the inferred central steep fault as either a late offset feature, or an early structure influencing the distribution of mineralisation, or both.

pass out through a mixed bornite-chalcopyrite zone to a peripheral pyrite-chalcopyrite assemblage. Overall, the main mineralised zone is a "pipe-like", downward tapering mass, with a north-south elongated oval shape at the Neo- to Palaeoproterozoic unconformity surface where it has plan dimensions of approximately 800 × 600 m. This mass of sulphide mineralisation apparently lies within a marginally broader cylindrical zone of hematitic breccia (the CBC). The main sulphide zone has been drilled to a depth of more than 1000 m below the unconformity and continues to greater, untested depths (Fig. 7; Brodovcky, 2010).

In the core of the southern section of the main sulphide-rich "breccia pipe", there are two bornite zones, one above the other (Fig. 7). Each is of the order of 150 to 300 m in diameter, with vertical extents of 300 to 500 m. The northern limit of the upper of these zones abuts an inferred complex zone of faulting, which may also truncate the southern margin of a third, elongate bornite zone to the northeast (Brodovcky, 2010). The broadly spaced, 200 m centres drill pattern (locally infilled to 100 × 100 and 50 × 100 m; Fig. 6) of mostly vertical holes straddles, but has not intersected this interpreted structure. The timing of this inferred fault zone is not known. It may either predate and influence the distribution of mineralisation, or post-date and displace the ore zones, or both.

The three bornite zones are surrounded by a 'copper sulphide zone' which is presumed to include a mixed bornite-chalcopyrite, chalcopyrite and chalcopyrite-pyrite transition outward from the bornite zones, as reported in CAR002. The wire-frame block-model of Brodovcky (2010) suggests the margins of the enveloping 'copper sulphide zone' taper rapidly with depth to the north and south-east of the inferred central fault zone, but remain steep to the south and southwest (see Fig. 7).

The northeastern bornite zone, through which the discovery drill hole CAR002 passed, has an 'L' shape at or just below the unconformity surface, and appears to represent a downward tapering wedge (Fig. 6). On its southern margin, this wedge may either pinch-out into the inferred fault zone, or follow it to depth; both options are illustrated on Fig. 7 (after Brodovcky, 2010).

A north-south fence of 100 m spaced drill holes reported in McGeough and Tyne (2007) reflect the geometry of the northern part of the complex, including the northeastern bornite zone. The thickest section of this bornite wedge is represented by drill hole CAR002 which intersected 123 m of bornite and bornite-chalcopyrite mineralisation before terminating in a thick zone characterised by chalcopyrite. Approximately 100 m to the north, CAR018 encountered only ~50 m of bornite zone mineralisation, followed by 100 m of mineralised granite breccia before again ending in a thick chalcopyrite dominant section. A further 100 m to the northnorthwest, CAR019 passed through a thin interval of granite breccia below the unconformity, and then into around 350 m of chalcopyrite rich mineralisation, with minor bornite at the top of the section, before ending in hematitic granite breccia. CAR007, another 100 m to the northnorthwest, and <100 m from the copper-sulphide zone margin, only intersected around 100 m of the chalcopyrite zone before being completed in a thick interval of hematitic granite breccia.

Drill holes for which assays have been released (Table 1; Fig. 6) have all intersected the bornite zones. The high grade intervals of these holes, generally comprising 55 to 210 m of 2.8 to 4.8% Cu, 0.5 to 1.15 g/t Au, appear to represent intersections through these bornite zones.

Only one of the holes that passed through the northeastern of these zones, CAR002, is listed. The high grade intervals of CAR073, CAR073W1, CAR031 (averaging 3.6% Cu, 1.2 g/t Au) represent the upper bornite zone to the southwest, while CAR050, CAR051W1, CAR053W1 (averaging 4.0% Cu, 0.9 g/t Au) passed through the underlying block. Above and/or below the bornite zones, within the core of the main sulphide-rich "breccia pipe", these same steep drill holes intersected intervals of 700 to 830 m averaging 1.25 to 1.9 % Cu, 0.65 to 0.95 g/t Au, believed to predominantly comprise a chalcopyrite(-bornite) assemblage.

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