POONA AND WHEAL HUGHES Cu DEPOSITS, MOONTA, SOUTH AUSTRALIA

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LOCATION

The Poona and Wheal Hughes deposits are approximately 3 km NE of Moonta township at 34°02’24”S, 137°36’59”E (Poona) and 34°03’21”S, 137°36’51”E (Wheal Hughes); Maitland 1:250 000 map sheet (S153-12).

DISCOVERY HISTORY

The Moonta-Wallaroo district of northern Yorke Peninsula was an important source of Cu between 1860 and 1923 producing over 350000 t Cu and 2 t Au. The narrow, shear-hosted Cu sulphide lodes are covered by 5-15 m of sedimentary overburden and initial discovery came from recognition of secondary Cu carbonate or chloride in the spoil of wombat burrows. Recent mining operations at Poona and Wheal Hughes (1988-1992) followed a 30-year exploration history in the district by Western Mining Ltd, North Broken Hill Ltd and Broken Hill South Ltd. The lodes were located in 1985 using large-loop (1 km) ground TEM survey with follow up 100 m coincident-loop SIROTEM surveys, and close-spaced drilling of conduction anomalies (Williams and Fraser, 1992; Dentith and Cowan, 2003).

PHYSICAL FEATURES AND ENVIRONMENT

The climate in the Moonta area is semi-arid with rainfall of <400 mm per year. Mean minimum and maximum temperatures range from 6-15ºC (July) to 16-30ºC (January). The landscape is a gently undulating depositional plain with relict seif dunes and loamy calcareous soil that blankets NW-SE trending calcareous dunes and a variable thickness of Pleistocene clay (Hartley, 2000).

The Moonta mines, including Poona and Wheal Hughes, are all within Moonta Porphyry, a Palaeoproterozoic, foliated rhyolite to rhyodacite complex. Relict primary textures in the porphyry indicate a sequence of comagmatic ash-flow tuff and tuff breccia with intrusive microgranite (Lemar, 1975). The volcanics intercalate with Wallaroo Group metasediments, including Doora Member schist and calcilcite which host the Wallaroo Cu deposits, 15 km NE of Moonta. The Palaeoproterozoic rocks were intruded at 1580 Ma by Mesoproterozoic Hillaba Suite granite, now regarded as the source of heat and fluid that mobilized metal ions to sites of deposition in fractures in Moonta Porphyry to form the Moonta Cu lodes (Conor, 2002).

REGOLITH

Basement outcrop near Moonta is restricted to the coast at Moonta Bay, where weathered and mottled Hillaba Suite granite is exposed on the beach platform in unconformable contact with silicified Cambrian sandstone. Here, sections through Pleistocene clay and younger carbonate dunes are also visible in coastal cliffs. The coastal zone north of Moonta Bay includes modern beach and associated dune deposits with saline swamps and clayey alluvium in low-lying areas adjacent to the coast (Figure 1). Inland, the undulating landscape of swale and plateau is covered by loamy calcareous soil that blankets NW-SE trending calcareous dunes and a variable thickness of Pleistocene clay (Hartley, 2000).

In the Poona pit, 0.6 m of calcareous clay loam is developed on 1-2 m thick, calcareous, aeolian sand and silt with platy, nodular and pebbly calcrite. The calcrite overlies 2-4 m of terrestrial red-brown clay showing blocky ped structures and weak mottling. The clay is dominantly mixed illite, smectite and kaolinite, with a variable silt and fine sand content, and is equated with terrestrial lacustrine and overbank deposits of Early Pleistocene Hindmarsh Clay (Zang, 2003). Thin, 20-30 mm wide, alunite seams occur in the clay, some 0.4 m below the contact with overlying carbonates. The clay unconformably overlies Moonta Porphyry that is variably weathered to 15 m, with 4-6 m highly weathered mottled zone (dominantly kaolinite, quartz and Fe oxide-oxhydroxide megamottles) over variably weathered saprolite and saprock. Palaeomagnetic dating of Fe-rich mottles gives an age of crystallization of the magnetic Fe phase as 8±4 Ma in Late Miocene to Early Pliocene times (Pullans, pers. comm., 2004). The weathering front is at approximately the same depth (20 m) as the present water-table (groundwater salinity ~ 42 000 mg/L), but deepens in the ore zone footwall. Here, kaolinitic alteration of the porphyry extends for a further 20 m due to highly acidic conditions from pyrite oxidation (Keeling et al., 2003). In fresh porphyry, the joint and fracture surfaces are commonly coated with halloysite to form an envelope around the ore zone extending to 80 m depth (Figure 2) (Mauger et al., 1997). The halloysite has precipitated from acidic waters migrating down the shear during periodic lowering of the water-table in response to sea level fluctuations over the past 1 Ma (Keeling et al., 2003).

In the Wheal Hughes pit, 1.7 km S of Poona (Figure 1), weathered porphyry is overlain by 1 to 4 m of coarse-grained, arcosic sandstone of the Cambrian Wilmuta Formation; this, in turn, is overlain by 2-4 m of Hindmarsh Clay and calcrite-cemented aeolian deposits.

MINERALIZATION

At Moonta, mineralized veins and lodes, up to 12 m wide and several

Figure 1. Regolith map of the Moonta district showing principal depositional units and location of the Poona and Wheal Hughes mines (after Hartley, 2000).

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hundred metres long, were mined to 650 m depth in Moonta Porphyry. The lodes are mainly tabular veins within fractures and shears that make a series of concentric arcs trending from NNE to ENE. Mineralization includes chalcopyrite, bornite, chalcocite, pyrite, molybdenite, hematite and magnetite, with traces of Au, Ag, Bi, fluorite, fluorapatite and uraninite. The veins have sharply defined contacts with the porphyry wall rock and are pegmatitic with coarse sulphide masses and patches of tourmaline.

The Poona orebody is a thin fissure vein, striking 070°, dipping 50° NW and plunging 22° W. The vein incorporates brecciated and replaced host porphyry and has a strike of some 160 m, terminated by steeply dipping faults. The lode is up to 6 m wide, but averages 3-4 m (Janz, 1990). Primary ore is chalcopyrite and pyrite, with minor bornite and gold. The saprolite is mostly leached of sulphides to 15 m depth, where a 4-5 m thick zone of supergene chalcocite and covellite, with minor digenite, djurleite and native Cu was encountered. The Wheal Hughes orebody includes several ore lenses hosted by a 25 m wide NE-trending shear. The NE part of the deposit, known as Leighton’s lode, consists of a single vein separated from the main lode by a cross-cutting fault. Main mineralization is in two parallel veins, 2–5 m wide, trending 045° and 25 m apart, called the ‘hanging wall’ and ‘footwall’ lodes. A ‘Middle lode’ trending at 030° joins the two parallel lodes. Ore was enhanced at the intersection of the ‘Middle lode’ with the 045° trending lodes. Primary ore is the same as at Poona. Combined production was 18 000 t Cu from 450 000 tonnes of ore grading between 4.6-5.3% Cu and 0.7-1.5 g/t Au (Conor 2002; Both et al., 1993).

REGOLITH EXPRESSION

Atacamite (Cu$_2$Cl(OH)$_3$) in transported clay directly above weathered sulphide ore was recognized in the late 1800s to early 1900s and used to prospect for lodes in the Moonta-Wallaroo district (Jack, 1917). Atacamite was sufficiently concentrated at some sites to warrant treating the clay to extract Cu. Subsequently, Sokoloff (1948) and Mazzucchelli et al. (1980) confirmed that Cu in cover sediments is an effective geochemical tool for locating mineralization in the district. The preferred sampling medium is transported clay directly beneath the

Figure 2. Section through the Poona mine with regolith cover and extent of weathering reconstructed from pre-mining drillhole data and current pit profiles.

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calcrete. Adelaide Resources Ltd (Fairclough and Schwarz, 2003) show good areal correlation of calcrete geochemistry with known historic copper lodes. Thresholds in calcrete were determined as Cu =30 ppm and/or Au =3 ppb. Lateral dispersion of Cu and Au in transported cover is of the order of 100 m and makes a useful exploration target for buried copper lodes, provided dispersion has not been impeded.

Detailed (0.2 m) sampling of transported overburden down pit face profiles at Poona and Wheal Hughes (Hartley, 2000, Lintern, 2004) showed, at Poona, elevated Au in calcrete (5-12 ppb). This commonly is at a maximum in the upper platy and nodular carbonate at about 0.5 m, with some decrease in the underlying pebbly to loose pisolithic carbonate. Gold is also anomalous in the upper 0.5–2 m of Hindmarsh Clay directly beneath the calcrete, but decreases to around 1 ppb or less, in the lower clay (Figure 3). Gold increases again at the contact with weathered porphyry. In accord with earlier studies, Cu is greatest at Poona (>80 ppm) in transported clay directly below or within 1 m of the base of the calcrete zone. This section of clay also includes thin alunite layers that are Cu rich. Uranium (to 36 ppm) and rare earth elements (Ce, La, Sm, Nd) are also enriched in this level of the clay (Hartley, 2000). Throughout the carbonate zone and transported clay layers that are Cu rich. Uranium (to 36 ppm) and rare earth elements (Ce, La, Sm, Nd) are also enriched in this level of the clay (Hartley, 2000).

In areas of thin transported cover at Moonta, pedogenic carbonate or clay, directly beneath the calcrete, but decreases to around 1 ppb or less, in the lower clay (Figure 3). Gold increases again at the contact with weathered porphyry. In accord with earlier studies, Cu is greatest at Poona (>80 ppm) in transported clay directly below or within 1 m of the base of the calcrete zone. This section of clay also includes thin alunite layers that are Cu rich. Uranium (to 36 ppm) and rare earth elements (Ce, La, Sm, Nd) are also enriched in this level of the clay (Hartley, 2000). Throughout the carbonate zone and transported clay layers that are Cu rich. Uranium (to 36 ppm) and rare earth elements (Ce, La, Sm, Nd) are also enriched in this level of the clay (Hartley, 2000).

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In areas of thin transported cover at Moonta, pedogenic carbonate or clay, directly beneath the calcrete zone, provide useful geochemical sample media for locating Cu sulphide mineralization at depth, provided the orebody extends into the zone of weathering and there are no barriers to dispersion.

**DISPERSION MODEL**

\[ B^+\text{Ca} [3] \]

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M.J. Lintern (CSIRO) and M.J. Sheard, (PIRSA) have provided advice and helpful discussion on interpretation of the data.

**REFERENCES**


**SAMPLE MEDIA SUMMARY TABLE**

<table>
<thead>
<tr>
<th>Sample medium</th>
<th>Indicator Elements</th>
<th>Analytical methods</th>
<th>Detection limit (ppm)</th>
<th>Background (ppm)</th>
<th>Maximum anomaly (ppm)</th>
<th>Dispersion distance (m)</th>
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<td>50-100</td>
</tr>
</tbody>
</table>

1. ICP-MS analysis of 0.25g samples after 24 h cyanide digest
2. ICP-MS analysis of 25g samples after 24 h hydroxide digest

Note: Data adapted from Hartley (2000) with background and dispersion estimates taking into account data in Mazzucchelli et al., (1980) and unpublished calcrete data by Adelaide Resources Ltd.