REVIEW OF THE BURRA MINE PROJECT, 1980–2008— A PROGRESS REPORT

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Front cover: Northerly aerial view of the Burra Mine, processing plant and tailings dams in January 1981. (407315)

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Review of the Burra Mine Project, 1980-2008 — a Progress Report

J.F. Drexel

ABSTRACT

The Burra (Burra) Mine, situated 150 km north of Adelaide within the Adelaide Geosyncline, produced 2.7 million tonnes of copper ore in two major mining phases — 1845–1877 and 1970–81. The first phase was initially by underground high-grade tributing, with later open cutting in the 1870s to reduce costs. This realised around 700 000 t averaging 7% Cu. The second phase, carried out by Samin Ltd, was entirely by open cutting a resource estimated at the time as ~3.5 million tonnes grading 1.52% Cu. The final amount of ore mined during 1970–81 was 1.89 million tonnes grading 1.71% Cu. The pre-mining grade was close to 3% Cu.

Field mapping in 1980–81 by Mines and Energy Geologists J.F. Drexel and W.S. McCallum, followed by petrology of approximately 150 rock samples during 1983–84, and reinterpretation of the thin- and polished sections during the current appraisal of the Burra Mine, has concluded that the orebody was developed by secondary remobilisation of presumably primary chalcopyrite mineralisation associated with syn-depositional and post-depositional magmatic and hydrothermal activity during sedimentation of the host Skillogalee Dolomite of Neoproterozoic age. Secondary copper sulphides, mostly chalcocite, developed from the primary sulphides in an epigenetic environment. Primary and secondary sulphides are now scarce in the open cut, but chalcocite, bornite, covellite and chalcopyrite were present at the bottom of the pit. Supergene enrichment developed the main copper minerals that have been mined — malachite, azurite, chrysocolla and cuprite, with lesser native copper and libethenite. These developed as fracture fills and veins in a relatively open-space environment. Gem-quality botryoidal malachite made the mine world renowned during the 1845–77 mining period. Jigsaw and crackle breccias, often copper mineralised, occur in country rock up to 200 m from the magmatic foci, and related mineralisation extends slightly beyond the open cut limits.

The Skillogalee Dolomite in the Burra area consists of a lower portion comprising dominantly pale-coloured dolomite and an upper portion of dark blue-grey dolomite. Within the lower unit, a distinctive assemblage of siltstone, limestone and dolomite that is atypical of the remainder of the Skillogalee Dolomite has been traced southward from Burra towards Robertstown during regional mapping by W.V. Preiss and is labelled 'Nms9' on the Burra 1:50 000 geological map. The name 'Kooringa Member' has been reserved for this unit, and will be formalised in a future publication.

The geology of the Burra open cut is divided in two by the Kingston Shear. On the west side, a diapiric body intruding the Skillogalee Dolomite occupies the entire length of the pit and may extend up to 500 m to the west. On the east side, the greater part of the pit is occupied by an overall east-dipping succession of the Kooringa Member, with pale-coloured dolomites of the Skillogalee Dolomite above and below. Petrographic examination by A. Kemp and M. Farrand indicates that the Kooringa Member contains probable volcaniclastic or air-fall tuff components developed during a period of syn-depositional magmatic activity which culminated in intrusion of a felsic porphyry, which has been dated during this current project at 797±5 Ma by PIRSA Geochronologist A. Reid. This date has led to significant reinterpretation of the timing of primary mineralisation.

Recognition that the porphyry and associated mineralisation are of similar age to the host Skillogalee Dolomite promotes large tracts of the Adelaide Geosyncline as prospective for similar mineralisation. The Burra orebody was previously thought to be much younger than the

dolomite, and probably post-Delamerian, which influenced previous exploration programs. Rather than being confined to a fault-emplacement model for copper mineralisation, the Kooringa Member, which at Burra is ~150 m thick, should now be the focus as it represents a period of possibly widespread volcanism in an otherwise carbonate-dominated sedimentary environment.

Coarsely crystalline dolomitic marble and brecciated dolomitic marble carrying variable amounts of copper sulphides and pyrite were exposed at the very bottom of the open cut and in small pods along Kingston Shear. Of several possible origins considered, recrystallisation and mineralisation by hydrothermal fluids of the lower portion of the Skillogalee Dolomite is considered the most likely.

Diapiric material, which is generally unmineralised, is juxtaposed adjacent to the mineralisation at Burra by the Kingston Shear, and it too may have been tapped from lower in the Adelaidean sequence, using the Kingston Shear as its conduit to higher levels in the sedimentary pile.

RATIONALE FOR THE 1980-81 FIELD MAPPING PROJECT

Adelaide & Wallaroo Fertilizers Ltd, mine operators during the 1970–81 mining phase, made a decision in 1980 to rapidly mine and stockpile ore for processing through the adjacent plant owned by the company. This decision was based on the need to reduce the cost of dewatering the open cut at a rate of approximately 10 ML/d. Twelve dewatering bores were in operation as at December 1979, removing 12 kL/min, which approximated to 27 tonnes of water for each tonne of ore mined (McLean, 1979; pers comm., 2008). Instability of the southeastern pit slope (and its subsequent failure in January 1981) was also taken into account by the company and influenced the decision to rapidly mine the remaining ore over the final six months of operation.

The former Department of Mines and Energy was involved in discussions with the company, particularly on safety issues, and it was at that time that the mapping project was initiated to collect unique geological data before the ore and hosts rocks were either mined out or flooded.

FIELD PROCEDURES

A stadia survey was carried out from late November 1980 until February 1981 by Mines and Energy staff Bob Harris, Mark Flintoft and John Harrison. The author and Wayne McCallum geologically mapped the open cut, commencing early December 1980 and completing the initial work in early February 1981. Field observations were plotted directly onto copies of the surveyed base. A tape measure extended along each mine face was used to determine the location of each sample or annotation site. Each sample location was designated a sequential 'B/80' field number, with the last in-pit sample taken for the mapping project being designated B291/80 (Table 1). All samples were given a weak hydrochloric acid test in the field on both solid surfaces and powdered samples to provide a rudimentary breakdown into limestone, dolomite and non-carbonate materials. A Munsell colour was assigned to all samples, recognising that some units showed a range of colours and that each sample may not be representative of the entire unit.

Detailed mapping was carried out as soon as practical on faces revealed by mining, as subsequent mining was likely to remove the exposure within a day or so. Completed pit faces higher in the open cut that would not be subsequently mined were mapped during periods when it was impractical or unsafe to venture to the lower benches due to mining activity. This method of mapping provided the opportunity to identify rock and ore units in successive vertical 'slices' as mining progressed, although not all parts of the pit could be revisited in this manner due to the rapidity and ever-decreasing radius of operations as the final pit depth was reached.

The worked out faces on the southeastern side of the pit were geologically mapped before the massive slope failure in January 1981. The operating company was well aware of the pit instability through constant monitoring, and modified their mining method to allow as much ore as practical to be recovered without causing further instability or safety concerns prior to the failure. The slope failure, when it happened, effectively sterilized some ore below its toe (reportedly 40–50 000 t, from conversation with mine personnel at the time), and mining proceeded with caution in this area. The numerous shallow benches and faces that pinch out at their southern extremities near the eastern pit base are the result of both pre- and post-slope failure modifications to the mining method.

A short visit was made by Drexel, McCallum and surveying assistant Ashley Smith to the now closed mine on 15/2/84 to survey and sample an aggregate quarry being developed in the eastern pit faces. This has removed most of the former exposures, and scree now blankets lower benches down to the pit pool, which represents the local groundwater level. Samples B292 to B297/80 were taken during this visit.

The only fieldwork undertaken in the Burra area by the Geological Survey since that time has been regional mapping by W.V. Preiss for the second edition of the BURRA 1:250 000 map, and two single-day visits by J.F. Drexel, W.V. Preiss, A. Reid and W.M. Cowley to collect additional samples and information to enable definition of the Kooringa Member (Preiss et al., in prep.).

The accompanying geological map (Fig. 18) represents the mine exposure at its maximum extent on 14 February 1981, the day the mine ceased operating.

LABORATORY PROCEDURES

PETROGRAPHY

A suite of 98 rock samples from the 1980–81 mapping project were submitted to Amdel on 20/7/82, mostly for thin section petrography. Polished section petrography was requested on 12 ore samples, and XRD determination of optically indeterminate phases was requested on a further six. Samples were etched with hydrofluoric acid and stained with sodium cobaltinitrite to help distinguish quartz and felspar. The resulting petrological report (Amdel GS1/1/271 progress report 2; Kemp, 1982) was received on 31 March 1982.

This report highlighted the possibility of a significant number of the samples having a volcanic origin — 37 of the 98 samples were listed as tuffaceous or volcaniclastic. Isolated igneous rocks had been recognised previously in the Burra Mine vicinity by Dickinson (1942 — a feldspar porphyry mapped 600 m southwest of the open cut, but not mentioned subsequently), Nixon et al. (1965 — porphyry within the original open cut), and Scriven (1977 — an interpreted welded tuff). But such a large number of possible new occurrences in what until then had been thought of as a predominantly carbonate sequence had implications for not only the interpretation of the origin of the orebody, but the wider interpretation of the Skillogalee Dolomite.

The thin sections were recovered from Amdel and SA Department of Mines and Energy petrologist Dr M. Farrand was asked to complete his own petrography and comment on the original interpretation by Dr Kemp. His summary was released as Report Book 83/28 (Farrand 1983).

The initial batch of 98 rock samples was predominantly from the ore zone and near environs, and included the feldspar porphyry. To help identify or eliminate this as a possible source of volcanic material in non-ore-bearing units of the Skillogalee Dolomite within the pit, a further 42 samples were forwarded to Amdel on 5/3/84 for thin section preparation, staining with alizarin red, and etching and staining of offcuts with hydrofluoric acid and sodium cobaltinitrite. The sections and offcuts were returned to Dr Farrand for full petrographic analysis within the Department of Mines and Energy. His summary, Report Book 84/62 (Farrand 1984), was completed in July 1984. Specific requirements he reported on included depositional environment, non-carbonate sedimentation, evidence of a pyroclastic contribution within the Skillogalee Dolomite, carbonate sedimentation and diagenesis, and metasomatic changes.

Other samples have been forwarded to Amdel for thin section description or identification of minerals, resulting in the following unpublished laboratory reports:

- Amdel Report GS2099/81 (Dr S. Whitehead) petrographic description of samples 6630RS96 (diapiric float) and 6630RS97 (diapiric breccia) taken two months prior to commencement of the Burra mapping project.
- Amdel Report GS3481/80 (Dr R. Brown) XRD identification of libethenite in a rock sample from an unrecorded location in the ore zone of the Burra open cut.
- Amdel Report GS4433/80 (Dr R. Brown) XRD identification of malachite in a rock sample from an unrecorded location in the ore zone of the Burra open cut.
- Amdel Report GS4536/83 (Dr R. Brown) XRD identification of microcline feldspar in sample B51/80.

GEOCHEMICAL ANALYSIS

A batch of 157 rocks representative of much of the Burra open cut was forwarded to Amdel on 30/11/81 for 'Metalscan' emission spectroscopy analysis. Although less precise than other analytical methods, 'Metalscan' was a cheap, quick and effective way to determine anomalous elemental presence in a large number of samples. The resulting geochemical report (Amdel AC1/1/271) by Dr K. Rowley was received on 2/2/82.

A further batch of 116 rocks comprising most of the remaining Burra project samples was forwarded to Amdel on 8/3/83 for 'Metalscan' analysis. The resulting geochemical report (Amdel AC4694/83) by Dr K. Rowley was received on 28/3/1983.

EARLY REPORTING ON THE BURRA PROJECT

Drexel and McCallum, due to other commitments within the Department of Mines and Energy immediately after the field mapping project, undertook a rapid assessment of all data relevant to the Burra Mine in late 1985. The initial objective was to prepare a comprehensive Report Book on the project. This had to be downsized, and resulted in publication of *Quarterly Geological Note* 98 titled 'Origin and age of the Burra copper orebody' (Drexel and McCallum, 1986), which until now has been the only 'modern' geological summary available. Ancillary unpublished material compiled mostly by W.S. McCallum at that time, including mine survey data, underground levels, drilling summaries and a list of historical maps, are appended to the current report (Appendices A–F).

QGN 98, and its revelation of a much more extensive volcanogenic component in the Burra Mine, caused healthy debate amongst geologists. This resulted in two papers in QGN 126 — Bampton (1993) proposed a diapiric origin for much of the rock mass in the Burra pit, arguing that other diapirs within the Adelaide Geosyncline are known to contain volcanic clasts, and a response by Preiss and Drexel (1993) who provided evidence to the contrary.

Mention of the Burra Mine is made in Preiss (1987, p.105), where evidence for penecontemporaneous volcanism was interpreted cautiously. At that time field evidence still appeared to favour the porphyry as a younger intrusive post-dating the Delamerian Orogeny, and the extent of tuffaceous siltstones within the temporally related Kooringa Member had not been recognised.

MINING AND PROCESSING OPERATIONS

1845-1877

The mineralised outcrop at Burra, discovered in 1845, is described in Auhl (1986) as 'a bubble of copper...cropping through the surface to the extent of from three to six feet above the ground' and 'some fourteen feet in length'. It was unusual in that, rather than being mostly malachite and azurite, typical of other copper deposits in South Australia, it comprised mainly cuprite, the richest of all copper minerals.

Underground mining commenced in September 1845, with ore being sorted on site for transport by bullock wagon to Port Adelaide and shipment to Swansea, Wales, for treatment. Large smelters (The Smelts) built on the opposite side of Burra Creek to the mine were opened in 1849 to save transport

costs. Dewatering the mine was a huge problem, and several Cornish beam engines were employed throughout much of the 1845–77 mining period.

The mine was converted to open cut operations in 1870, and The Smelts were disassembled and shipped to Newcastle. From 1870, most of the Burra concentrates were smelted at Port Adelaide. Open cutting continued till 1875, when the mine operator realised that concurrent underground mining of remaining rich pods was the only way to keep the operation viable. High dewatering costs and depressed copper prices forced the mine to close in 1877.

The 1845–77 period realised around 700 000 t of ore containing ~50 000 t of copper (Drexel, 1982).

1970-1981

The second phase of mining at Burra, carried out by Adelaide & Wallaroo Fertilizers Ltd, was entirely by open cutting a resource estimated at the time as ~3.5 million tonnes grading 1.52% Cu. The company made a decision to rapidly mine and stockpile ore over the final six months of operations for processing through the adjacent plant owned by the company. This decision was based on the need to reduce the cost of dewatering the open cut at the rate of ~10 ML/d. Dewatering commenced in 1975, and 12 dewatering bores were in operation as at December 1979, removing 12 kL/minute, which approximated to 27 tonnes of water for each tonne of ore mined (McLean, 1979; pers comm., 2008). At that time the hydrostatic water level in the pit had been lowered by 69 m, to 3 m below the pit floor. Instability of the southeastern pit slope was also taken into account by the company and influenced the decision to rapidly mine the remaining ore.

Much of the bulk mining, in particular removal of mullock but also mining of friable ore towards the pit bottom, was done by a Marion electric shovel. A Kato excavator was used for selective and below-grade mining. Drilling and blasting were required in the northern part of the pit in the relatively unaltered Skillogalee Dolomite overburden. No blasting was employed during mining of the ore in the southern part of the pit, where it was generally soft, friable and easy to dig.

Two small karst features filled with copper-mineralised clasts were excavated from below the northern haul road for processing, and the karsts backfilled (D. McLean, former Burra Mine Geologist, pers. comm., 2008).

Hard, recrystallised dolomitic ore at the western bottom of the pit adjacent to Kingston Shear, and as a bar across the centre bottom of the pit, was scraped clean of softer ore, and left in place. Much of this was covered with mullock during construction of the haul road to access ore on the eastern side of the pit during the final phase of mining (Fig. 1). This dolomitic ore, although high grade, could not be treated successfully by the ammonia leach process employed at the Burra plant. Similarly, the porphyry, which contained a high percentage of copper sulphide, mostly as chalcocite, was mined and stockpiled to the south of the treatment plant. The stockpile was frequently turned by bulldozer to encourage oxidation, and all porphyry ore was eventually processed through the plant (D. McLean, pers. comm., 2008).

Pods and lenses of high-grade ore were recovered from small areas such as that centred on mine grid 4330mN, 3150mE (AMG 307685mE, 6271645mN) close to the porphyry. This pit, and other similar pits developed during the mining of small ore pods, were subsequently backfilled with mullock to allow construction of the haul road to the bottom of the open cut and mining of the eastern face. It was during this latter stage of operations that the unstable eastern pit wall was induced to fail on 14 January 1981 by the operating company pumping water down the slide surface (Fig. 2). This controlled failure caused ~150 000 t of material to slump to the pit floor, and sterilised some ore (reportedly 40–50 000 t, from conversation with mine personnel at the time).

Operations ceased on 7 February 1981, with a final maximum pit depth of 106 m below surface (Fig. 3). At that time, 4.8 million tonnes of dolomite—siltstone overburden and 1.89 million tonnes of ore grading 1.71% Cu had been mined since 1970 (Armstrong, 2002). The ore stockpile of ~380 000 t continued to be processed by Samin Ltd (which had purchased the mining rights from Adelaide & Wallaroo Fertilizers Ltd) at its adjacent plant for several years, after which various types of copper feed, including copper cement from the Mt Gunson Mine, were used. The product at that time was a range of specialty copper-

based chemicals, including cupric oxide and copper sulphate. An overview of the ammonia process employed is described by Armstrong (2002).

The Burra Copper Sulphate Plant was officially opened by the Hon. R.J. Gregory, SA Minister for Labour, on 13 December 1989. The plant continues operating to the present day, using secondary ores and copper concentrates from other mines around South Australia, including Mountain of Light, Kanmantoo and Mt Gunson, and scrap copper. Its main products are now copper oxide and synthetic malachite. Around 10 000 t of combined products are produced annually.



Figure 1. Preparing the haul road on the western side of the Burra open cut prior to mining the lower southeastern side. Fill is being placed over the worked out area in which mostly recrystallised dolomite marble was exposed. The truck is dumping over the former location of the porphyry shown in Figure 6. Diapir is to the right of view. December 1980. (407316)



Figure 2. Failure of the southeastern pit wall induced on 14 January 1981 by pumping water down the slide at the top of the open cut. (045790)



Figure 3. Burra open cut the day before mining operations ceased on 7 February 1981. The view is northerly along the open cut from the vicinity of Morphett's Engine House. (T026047)

GEOLOGICAL MAPPING AND INTERPRETATION

OVERVIEW

Lithological subdivisions of the Skillogalee Dolomite in the northern two-thirds of the open cut could be traced with confidence during the 1980–81 mapping project, although mullock from active mining operations disguised some benches and faces. The southern third of the open cut contains lithologies that have been altered to varying degrees by a combination of processes including potash metasomatism, silicification, introduction of magmatic phases, brecciation, and acid leaching presumably from the breakdown of metallic sulphides within the original orebody. Partial silicification of predominantly clastic quartz in the siltstone units in the southern third of the open cut has in places increased grain size such that 'sandstone' recorded in this area during mapping does not have a lateral equivalent in the unaltered northern two-thirds of the pit. These factors have made correlation difficult, and that part of the project has yet to be completed — information relevant to any correlation still resides on the original hand-sketched field plans prepared by Drexel and McCallum during 1980–81, and in further examination of the 'B/80 series' of samples taken at that time and stored at the Glenside Core Library.

Acid testing of samples taken during 1980–81 provided a rudimentary breakdown of lithologies into dolomite, limestone and non-carbonate, enabling 14 units to be distinguished within Skillogalee Dolomite exposed in the open cut. Subsequent thin-section petrography identified a 'significant' silt component of quartz and feldspar in samples logged as dolomitic in the field (note that a low threshold of only 15% clastics was sometimes sufficient for the petrologist to denote a rock as 'siltstone'). Dolomite in the field was often identified in thin section as a silty dolomite or dolomitised siltstone. Facies changes, and dolomitisation along bedded units closer to the centre of the open cut, are also present, such that a limestone may, within a few hundred metres, be mapped as a dolomite.

A distinctive package of predominantly siltstone—dolomite—limestone was recognised extending southward from Burra toward Robertstown by W.V. Preiss during regional mapping and labelled 'Nms9' on the Burra 1:50 000 geological map (Preiss, 2002). The term 'Kooringa Member' was reserved with the Stratigraphic Nomenclature Committee for future formal definition (Preiss et al., in prep.). The Kooringa Member is well exposed in the northern haul road of the open cut (Units 2–14 on Fig. 18), which will be used as its type section. It was initially thought that the Kingston Shear may have truncated the lower part of the member, but it is now apparent that the complete unit is preserved and both overlies and underlies pale coloured dolomite of the lower portion of the Skillogalee Dolomite. The dolomitic siltstones identified in thin section sometimes have a K-feldspar component of 50% and more in some laminae and beds. Splintered quartz grains in some add weight to the two petrographers' (Kemp, 1982; Farrand, 1983, 1984) interpretation of a volcaniclastic ash-fall component in several units of the Kooringa Member exposed in the pit. These lithologies provide potential for age dating of any associated zircons.

Stromatolites and cryptalgal laminations are present in some units, particularly in the limestones and pure dolomites. Some limestone beds display extremely regular and rhythmic fine laminations best interpreted as chemical precipitates in a lacustrine environment.

A suite of igneous units identified towards the base and southwestern side of the open cut includes the porphyry and agglomerate. These intrude earlier deposited tuffaceous siltstones and dolomite of the Kooringa Member. Jigsaw brecciation, mostly copper mineralised, occurs within Skillogalee Dolomite units up to 100 m from the northern limit of leaching and alteration. Crackle (granular) breccia within mostly dolomitic units may be related to this — both are presumed to have formed by hydraulic brecciation due to pressurised volcanic fluids, a concept first discussed by Nixon et al. (1965). Near-vertical ferruginous pipes and larger areas of ferruginisation, sometimes with very coarse limonite pseudomorphs after pyrite, occur within and adjacent to the copper mineralisation. These were formerly iron- and perhaps copper-sulphide-rich bodies.

The 'cross-fault' shown by previous authors (e.g. Wright, 1975) and orientated east—west across the centre of the pit was not readily apparent during mapping. The 'fault' was perhaps inferred to account for the rapid change of lithology at the northern edge of the main orebody. It is proposed here that the 'cross-fault' is instead the northerly extent of leaching by acidic waters resulting from oxidation of the primary sulphide orebody to produce the present copper carbonate ore.

The western edge of the open cut is bounded by the Kingston Shear, to the west of which is a small diapiric breccia body exposed over the full length of the pit.

DESCRIPTION OF LITHOLOGIES IN THE OPEN CUT

Bedded Skillogalee Dolomite units

As described in several petrological reports prepared by Amdel and departmental geologists, in particular Kemp (1982) and Farrand (1983, 1984), a large part of the Kooringa Member was deposited in a quiescent, almost stagnant environment that sponsored the deposition of dolomite as a primary chemical precipitate. Minor limestone, sometimes accompanied by algal growth and stromatolites, was also present. The Coorong is a modern analogy.

Into this environment were deposited significant amounts of microcline feldspar and quartz as euhedral to subhedral, sometimes shattered fragments. The freshness of the feldspar, angularity of clasts and high potassium content of the matrix are compatible with, but not definitive of, a volcanic origin, but petrology indicates the most likely genesis as air-fall tuffaceous siltstone horizons. The siltstones, along with interbedded limestones, dololimestones and dolomites, are unusual in a regional context within the dominantly dolomitic Skillogalee Dolomite (W.V. Preiss, PIRSA, pers. comm., 2008). They have been assigned to Units 2–14 described below, and collectively comprise the Kooringa Member to be formally defined by Preiss et al. (in prep.). Unit 1 is a relatively clean dolomite with no indication of silt-sized components, and is assigned to the lower portion of the Skillogalee Dolomite immediately underlying the Kooringa Member. Unit 14, at the extreme eastern edge of the open cut, contains a small amount of limestone, and is therefore also included in the member. To the east of the open cut, the more typical dolomite (with little if any siltstone and limestone) of the Skillogalee Dolomite is exposed.

Unit 1

Dolomite: cream to light grey, massive, extremely fine-grained sedimentary dolomite. Fractured to granular appearance on freshly broken surfaces.

Unit 2

Siltstone, **dolomite**: light to dark grey, banded to laminated ex-pyritic siltstone beds to 100 mm wide interbedded light brown, finely laminated and more massive, light grey-brown dolomite interbeds to 400 mm width. Minor sandy interbeds. More finely bedded in upper 3–4 m.

Unit 3

Dolomite, siltstone: 1.5 m thick medium grey, extremely fine grained, partly cryptalgal-laminated sedimentary dolomite, overlain by a 150 mm thick pale brown laminated siltstone, and an upper 800 mm thick dolomite similar to the lower dolomite.

Unit 4

Siltstone, **dolomite**: fine grained, light orange to buff, finely laminated siltstone interbedded with more weathered and eroded light grey dolomite. Individual interbeds are 50–100 mm wide.

Unit 5

Siltstone, **dolomite**: narrow interbeds of brown, laminated siltstone and medium grey dolomite in lower 3 m; tectonically folded and partly brecciated with minor silicification along northern haul road. Upper 7 m is a soft, altered, copper-mineralised, layered, sandstone-like remnant of the northern orebody; some probable shearing subparallel to bedding.

Unit 6

Dolomite: massive, cream-grey sedimentary dolomite (60–300 mm beds) interbedded with finely laminated (0.5–3 mm) slightly darker grey dolomite and minor siltstone. Stromatolitic in part.

Unit 7

Limestone, dolomite: light grey finely laminated limestone 800 mm thick at base, overlain by ~1 m wide massive medium grey dolomite, then 1 m wide dark grey (almost black), dense, faintly laminated dolomite and tan, very finely laminated dololimestone to limestone. This is overlain by 2–3 m of cryptalgal laminated, stromatolitic and stylolitic limestone. Weathering of the limestone units produces a strong fissile parting.

Unit 8

Limestone, dolomite: white to cream, laminated to massive folded and brecciated limestone-dololimestone lens; trace white mica flakes.

Unit 9

Dolomite, limestone: medium-grey dolomite and limestone interbeds with cream, millimetre-scale laminae. Upper half of the unit is massive grey-buff dolomite with white-cream dolomite interbeds; the top 1 m is laminated grey-buff and white dolomite.

Unit 10

Limestone, dolomite: white to cream laminated limestone with 0.6 m wide grey dolomite band 1 m above base. Overlain by 3 m of white-cream to mid-grey laminated to massive limestone. Upsequence becomes a finely laminated dolomitic limestone, overlain by a very dark grey, black and buff limestone with extremely regular and rhythmic laminations. The top of the unit is buff limestone with fewer and less distinct cryptalgal laminae.

Unit 11

Dolomite, limestone: light grey, hard, dense, massive sedimentary dolomite with minor bedding-confined 'shothole' texture comprising 3–10 mm cavities sometimes filled with red clay. Sandy dolomite and dolomitic limestone in places; minor cryptalgal laminae. Some limestone interbeds to 200 mm.

Unit 12

Dolomite: Massive, light grey dolomite with some thinly laminated beds. Shows strong 'shothole' texture towards base, and cryptalgal laminations towards the top. 'Shothole' cavities of 2–10 mm sometimes filled with a white to yellow powder.

Unit 13

Dolomite: white-grey-cream laminated dolomite with 100–400 mm beds of light grey non-laminated dolomite. Minor limestone interbeds.

Unit 14

Dolomite: 1–5 m wide dark grey dolomite with lighter grey and brown dololimestone or limestone interbeds. Overlain by a fine-grained, grey dolomite with 2–10 mm sandy interbeds outlined by finely crenulated bands of probable stromatolitic origin.

Skillogalee Dolomite units in the southern part of the open cut have been affected by alteration not seen in the northern part of the pit. Silicification, potash metasomatism, hydraulic brecciation, volcanism, and probable leaching and bleaching by acidic fluids released by breakdown of sulphides have transformed the former carbonates and siltstones into clay and sand at the extreme. This made correlation of units difficult along the full length of the open cut, indicated by the undifferentiated southern portion of Figure 1 which, when interpretation is completed, will show mostly Units 1–10 plus the volcaniclastics and ore horizons.

Siltstones of Units 2 and 4 will probably eventually be traced with reasonable certainty as their clastic quartz and feldspar content proved more resistant to alteration. Characteristic millimetre-scale quartz 'discs' containing very small ex-pyrite pseudomorphs just inside their periphery were found in samples B10, B46, B75, B97, B116, B227 and B243; these are thought to belong to Units 2 and 4.

Euhedral white mica books 2–5 mm across were noted in predominantly limestone or dololimestone units during field mapping, and were described in several thin sections (B103, B126, B265 and B266). Petrology initially identified these as muscovite, but in B126/80 Farrand (1984) identified phlogopite, a magnesium-rich mica that usually occurs in crystalline limestones as a result of de-dolomitisation. These mica occurrences are scattered across Units 5, 6, 7 and 10, but may assist in correlation through the southern part of the open cut.

Recrystallised, mineralised dolomitic marble

One of the few indurated lithologies exposed in the bottom of the open cut is a dense, white dolomitic marble with euhedral dolomite rhombs up to 20 mm across. The rock is laced with secondary copper sulphide, oxide and carbonate veining; mineralisation in a polished section of sample B54/80 comprises chalcocite (98%), covellite (1%) and cuprite (1%), with azurite veining and patchy replacement. Despite its copper content, much of the marble was left in place during mining as it was generally too hard to dig by excavator without blasting, and the ammonia process employed at the plant could not effectively recover the high copper content in the sulphide ore (Fig. 4).



Figure 4. Southerly view of selective mining at the very bottom of the Burra open cut on 8/12/80. Less-indurated ore has been mined by excavator, leaving behind the wooden supports and fill from the 1800s underground mining, and hard recrystallised dolomitic marble that could not be free dug. (407317)

All occurrences of the dolomitic marble are in contact or near contact with the Kingston Shear and diapiric breccia. Early reports of copper ore being won from marble breccia are most probably referring to this marble rather than the diapir itself, as no mineralisation of any note was found in the latter during mapping, despite it being in direct contact with high-grade copper ore.

The marble was exposed by mining over a maximum width of approximately 45 m and length of 130 m, with its southernmost limit being at the very southern end of the open cut in the vicinity of Peacock's Shaft. Similar but smaller bodies of the marble up to 30 m in length occur immediately adjacent to the porphyry below Graves Enginehouse, and as 'windows' within faulted Units 1 and 2 further north adjacent to Kingston Shear. The marble in some places has been brecciated (e.g. B282/80).

Three possible scenarios for development of the recrystallised (±copper mineralised) dolomite marble (±brecciation) have been considered:

- The marble may have crystallised from hydrothermal fluids driven from the parent body of the porphyry. The lack of carbonate veining further away from the marble body renders this concept problematical.
- W.V. Preiss (PIRSA, pers. comm., 2008) has suggested that the marble may be a more recrystallised version of the lower Skillogalee Dolomite that occurs immediately below the mine sequence, and also west of the Kingston Shear. It is possible that the folding exhibited in the northern and eastern pit walls is sufficient to allow the lower member to appear in the western and southern part of the open cut. Smaller exposures of marble along Kingston Shear in the northern part of the pit appear to cut across bedding in Unit 1, but the contacts are sheared and the relationships could result from tectonic imbrication in the shear zone.
- The marble may be a carbonatite body, perhaps sourcing material from similar depths to the immediately adjacent diapir. This idea should be tested by geochemistry.

An unusual variant of the marble that can still be accessed in the open cut is at sample site B264/80. The outcrop here is a layered, copper-mineralised recrystallised dolomitic breccia containing clasts and layers of potash feldspar. The feldspar was probably derived from, or associated with, the quartz-feldspar metasomatites common in and around the main orebody. To its immediate east is a dolomite breccia (grey, angular dolomite clasts in a yellow-brown dolomite matrix) containing a possible dolomitic sandstone dyke (sample site B288/80); this breccia is unmineralised, despite being in contact with the heavily copper stained recrystallised dolomitic breccia. A detailed study of this outcrop may provide information relevant to the understanding of potash metasomatism and mineralisation in the Burra orebody.

A small area of the recrystallised, mineralised dolomitic marble at sample site B280/80 differs from the remainder of the marble occurrence in that it shows little recrystallisation by comparison. Instead, the rock appears as a light grey dolomite with extensive malachite—azurite veining, and traces of chalcocite in stringers. A sawn surface of the rock shows numerous arcuate structures that appear to truncate earlier arcuate structures, much like mineralised, interlocking liesegang rings. Petrology by Kemp (1982) indicates that the rock may be dolomitised (a process which would have obliterated former coarsely crystalline components). It could equally be a Unit 1 (or lower) dolomite precursor that escaped the more robust recrystallisation process that may have been associated with the nearby intrusion of porphyry or agglomerate.

Magmatism recorded in the Burra Mine

OVERVIEW

Dickinson (1942) mapped a small body of feldspar porphyry 600 m southwest of the mine but made no further mention of it. Nixon et al. (1965) first identified a feldspar porphyry outcrop in the Burra open cut that had been deliberately avoided by the miners of the 1800s, who were unable to treat the contained copper sulphides (chalcocite, bornite). It was shown on their map (L65-82) as five sub-parallel dyke-like

bodies to the immediate west of the old mine pool (the hydrostatic groundwater level). Nixon and Townend (1966) also reported on the occurrence. The porphyry was completely mined out by the end of the 1970–81 mining phase. Scriven (1977) re-examined the porphyry and interpreted eutaxitic textures characteristic of a welded tuff, and identified it as of rhyolitic composition.

Drexel and McCallum (1986), reporting on outcomes of the 1980–81 mapping program, identified a much larger area of volcanics in the bottom of the open cut, up to 160 by 75 m adjacent to the porphyry. Thin-section evidence cited for recognition of the volcanics included: flow banding, trails of gas bubbles parallel to flow banding, partially digested sedimentary xenoliths, aligned compacted devitrified glass shards, and a very fine matrix of angular quartz and feldspar. It was at this time that an agglomerate was identified (sample B53/80) during routine petrology by Kemp (1982) and Farrand (1983, 1984). Kemp and Farrand also identified numerous samples of Skillogalee Dolomite from the Burra open cut that contain angular subhedral to euhedral feldspar shards and shattered quartz indicating little if any abrasion that would normally be associated with a waterborne origin. Their most probable origin is from volcanic ash clouds.

Several occurrences of probable magmatic rocks within the Kooringa Member have been recorded up to 5 km from the open cut.

TUFFACEOUS SILTSTONES OF THE KOORINGA MEMBER

Within the Burra open cut

Bedded siltstones in Units 2, 4 and 5 along the northern haul road of the open cut contain laminae with a high feldspar content, e.g. B7/80 (50% K-feldspar, 5% plagioclase) and B10/80 (up to 80% feldspar and kaolinite). Towards the centre of the open cut, B274/80 in Unit 4 was identified as containing 40% K-feldspar and 5% plagioclase, with 20% sericitic mica. These locations were re-sampled in December 2008 for geochronology.

Samples B10, 46, 75, 97, 116, 227 and 243, all laminated siltstones, contain millimetre-scale flattened quartz discs with minute ex-pyrite pseudomorphs just inside their periphery. B116 also contains 70% microcline feldspar and 30% quartz. All are probable volcaniclastics from along the length of the open cut; further work is needed before some are assigned to individual Units 2, 4 or 5. The origin of the flattened discs is unknown at present, but may have been derived from a proximal volcanic source.

Sample B122/80, collected during the 1980–81 mapping project from the eastern lip of the open cut, was identified by Farrand (1984) as containing '...the most significant bed of all. This consists of relatively coarse grained, angular fragments of plagioclase in a matrix of coarse and fine grained dolomite...The plagioclase appears to be rather pure albite...It is hard to avoid the implication...that a shower of fragments was contributed to stagnant water by an agency which did not involve increased current action.' This site was also re-sampled in December 2008 for geochronology.

B199/80 is described by Kemp (1982) as a 'very fine-grained, faintly laminated, silicified, dolomitised acid ?volcanic', while Farrand (1983) recognises it as a 'dolomitised shale'. It is much finer grained than other lithologies in the open cut, and differs in that it contains fresh sulphides (~5% total volume) identified in polished section (Kemp, 1982) as pyrite (+99%) and chalcocite (trace).

B101/80, described in field notes as 'highly altered fine-grained siltstone-like rock with contorted dark red-purple and white banding', has not been described in thin section. It is highly reminiscent of a flow banded tuff. B252/80 and B286/80, both from ferruginised pods near the bottom of the open cut, are also potential candidates as volcaniclastics.

B261/80, from very low in the stratigraphic succession on the western side of the open cut, contains 65% feldspar, dominantly microcline, as euhedral laths up to 1.75 mm in thin section. Quartz comprises 20% of the section. Kemp (1982) described the rock as a partially silicified feldspathic tuff. The number and euhedral shape of the laths sets this sample apart from all others at Burra, and its location in the Kooringa Member is still uncertain. It is in an area originally mapped in the field as Unit 1 because of nearby dolomite exposures, but its feldspar–quartz content renders this correlation problematic. It may

be Unit 2, or could be another tuffaceous siltstone below or within Unit 1. The sample is from an area of probable imbrication close to the Kingston Shear, and more detailed mapping is required for a resolution. The tuff should also be sampled for geochronology.

Outside the Burra open cut

Whittle (1966) reported a tuffaceous shale from an old quarry immediately north of the Adelaide–Burra road, approximately 1.5 km south-southeast of the open cut. The important feature in his thin section description is the recognition of a 'smaller proportion of ... zircon...' This shale is within the Kooringa Member as mapped by Preiss (2002), and may prove dateable. Whittle (1973) described a 'fenitised?–carbonatised? chert' from ~200 m south of the open cut (mine grid 3779 N, 3170 E), possibly from a similar horizon.

Redfire Resources (Elliott et al., 2003) reported a possible sheared syenitic rock with residuals of primary quartz—microcline in the small 'Grove quarry' adjacent to the Barrier Highway 5 km north-northwest of Burra. In November 2008, samples were taken for petrography from this quarry by Preiss, Drexel and Cowley who also identified bleached fragmental layers in the nearby exposure as possible volcaniclastics. This occurrence may therefore be a possible northern extension of the Kooringa Member.

Although the Redfire sample may be too altered to provide useful feldspar or zircon, the other samples should be re-examined, or specimens collected from the field or Glenside Core Library, to determine any mineral components, particularly zircon, that may provide an age date for that unit within the Skillogalee Dolomite.

AGGLOMERATE

Sample B53/80, from the bottom of the open cut at least 50 m from the last recorded occurrence of the feldspar porphry, was described by Kemp (1982) as a probable welded tuff, and by Farrand (1983) as an altered ?lava. Both petrographers were quite definite that the rock is of volcanic origin. Farrand stated that '...the flow banding is regular enough to suggest a lava rather than and ash-flow tuff of agglomerate'. He also found xenoliths (undefined lithology) that may have been subject to autobrecciation. The occurrence was noted in the field as an unremarkable 1 m wide pod of dark red ?ferruginised, altered ?feldspathised rock within an altered silicified halo. It is therefore most likely to have formed within a side vent or fissure to a larger volcanic vent from which erupted the ash clouds that contributed feldspar and quartz shards to the siltstones of the Kooringa Member. The agglomerate should therefore be considered within the stratigraphic sequence of the member.

Sample B141/80 was identified in thin section by Farrand (1983) as an agglomerate, and by Kemp (1982) as a breccia composed dominantly of volcanic fragments and fragments of ?siltstone possibly formed by explosive volcanic activity (Fig. 5). This copper-mineralised sample differs from B53/80 in that the clasts are readily visible and clearly are not entirely of local origin. Kemp noted that small, irregular fragments of volcanic glass are common, frequently displaying spherulitic and flame structures. Farrand also noted the jumble of fragments of diverse lithologies, both sedimentary and volcanic, but did not indicate the existence of volcanic glass. The possibility remains that this is an agglomerate, or perhaps an autoclastic volcanic breccia.

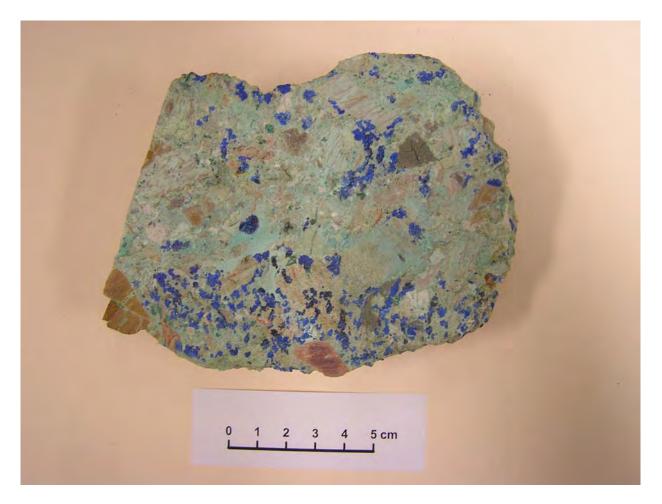


Figure 5. Copper-mineralised agglomerate intruding Unit 5 siltstone, sample site B141/80. (407318)

PORPHYRY

Black and white photographs taken of the mine post-1877 but pre-1970 show the porphyry as a white outcrop perhaps 3 m high at the level of the mine pool. This is one of the five curved but sub-parallel pods that were exposed over a distance of ~30 m (Nixon et al., 1965). Each pod was less than 2 m wide. Only one pod could be accessed during 1980-81 mapping project, and this showed a distinct dyke-like attitude, cutting the near-vertical Skillogalee Dolomite units at a relatively low angle (Fig. 6). Plotting the location of 'porphyry' occurrences at successive levels during mining indicated that the pods plunge ~20° to the southeast at the higher elevations seen by Nixon and Townend (1966), and 50° towards the southeast at the pit bottom.

Sample B285/80 of the porphyry is surprisingly indurated considering the degree of alteration and weathering of immediately adjacent Skillogalee Dolomite country rock. Thin section C35027 indicates a relatively fresh rock with a strong igneous texture of predominantly feldspar and quartz. Coarsely crystalline feldspar patches have been interpreted as phenocrysts of microcline and untwinned K-feldspar in a groundmass of microcrystalline quartz and feldspar, including microcline. Veins and patches of secondary feldspar appear to be mostly albitic. The polished section description (PS30625) identified the sulphide phases as chalcocite (50%) and pyrite (50%), with traces of bornite, chalcopyrite and possibly cubanite.



Figure 6. Porphyry exposed on 7 October 1980 on the western side of the open cut. The porphyry is the narrow ~3 m wide grey zone at extreme right, with wooden supports from previous underground mining operations on either side just below the top of the face. Montmorillonite and kaolin alteration comprises most of the white material to the left of the porphyry. Stope fill and wooden supports are exposed over the remainder of the face. Diapir is in the background. *(407319)*

Age of the porphyry — 797± 5 Ma

Approximately 10 kg of the porphyry (sample B285/80) were collected by Drexel and McCallum in 1981 and stored at the PIRSA Glenside Core Library until commencement of the current project, when the decision was made to age date any zircons recovered from crushing a 1 kg sample. Anthony Reid, PIRSA Geological Survey Branch geochronologist, arranged zircon separation and dated the zircons at Adelaide University using the Laser Ablation – Inductively Coupled Plasma Mass Spectrometry technique (Appendix G).

The age of 797±5 Ma determined from the zircons was most surprising, as field evidence had consistently been interpreted as indicating emplacement of the 'porphyry' and associated mineralisation into a probable post-Delamerian Orogeny near-surface environment. The porphyry was exposed by mining in near-vertical dyke-like bodies cross-cutting at relatively shallow angles steeply easterly dipping Skillogalee Dolomite. It was therefore assumed that the Skillogalee and other Adelaidean units had been folded during the Delamerian into their present attitudes prior to the 'porphyry' and agglomerate bodies being emplaced.

It now appears that the volcanism was penecontemporaneous with Skillogalee-age deposition, and that the porphyry intruded soon after deposition in only slightly discordant sill-like attitudes. It is postulated that the thin bodies of porphyry and agglomerate were likely formed within side vents and sills from a proximal larger parent vent that has not yet been discovered. The porphyry in particular probably intruded late during deposition of the Kooringa Member, as copper-mineralised hydraulic breccias thought to be developed by pressurised magmatic fluids are present throughout the member. The angular clasts derived from the Kooringa Member indicate that induration was well advanced prior to their incorporation into the breccias, presumably aided by rapid carbonate-cementing processes.

Implications for future exploration

It is highly probable that much of the non-carbonate part of the Kooringa Member is of volcaniclastic origin. Only a few representative siltstone samples were taken during the 1980–81 field mapping from its 13 units and these showed no unusual characteristics in hand specimen, but most contained high percentages of feldspar fragments. Geochronology has demonstrated a probable close temporal association between the Kooringa Member and the porphyry, which has great implications for future exploration for similar copper orebodies in the Adelaide Geosyncline. Rather than concentrating on mineralisation related to post-Delamerian igneous intrusion via a pre-existing conduit (the Kingston Shear) as previously thought, the entire outcrop length of the ~150 m thick Kooringa Member holds potential for mineralisation. The prime aim would be to find indications of other volcanic vents throughout this widespread horizon.

POTASH METASOMATISED LITHOLOGIES

Potash metasomatism associated with silicification was recorded in outcrop and in numerous thin sections. First indication of potash feldspar seen during the 1980–01 mapping project was as a widespread pink colouration on many rock surfaces approximately 5–10 m above the final pit bottom. This was not seen at higher levels, perhaps due to weathering effects, or it not having been present at those levels. Sample B191/80, described by Kemp (1982) as containing 77% K-feldspar and 20% quartz, was taken approximately 20 m east of agglomerate sample B53/80 described above. This is a typical sample of a highly feldspathised lithology, identified by Kemp as a ?tuffaceous precursor, and probably belonging to the Kooringa Member.

Numerous other examples of in situ potash and silica metasomatism have been recorded on the accompanying geological map and description of rock samples from the Burra open cut (Fig. 18; Table 1). Many breccia samples also include potash metasomatised lithologies as clasts, indicating that metasomatism occurred early in the mineralising event, possibly around the time of the porphyry intrusion. B198/80 is a spectacular example of potash metasomatised clasts in a 'vein' of malachite at least 70 mm thick (Fig. 7). This sample demonstrates that the ground was thoroughly prepared for copper mineral infusion, probably by hydraulic ramming associated with volcanic fluids. Well-developed botryoidal malachite on the outer edge of the sample demonstrates that the supergene mineralisation was deposited in an open-space environment.

Potash feldspar also occurs in sample B264/80 described above in the section titled 'Recrystallised, mineralised dolomitic marble'. Here, Kemp (1982) records it as occurring as 'replacement of a grey material', as grains of dolomite, quartz and feldspar, and as a part matrix to all the above. Its occurrence at this location is problematic. Figure 8 shows a funnel-shaped mass of potash metasomatised and silicified rock near the southeastern base of the open cut.

TOURMALINISED LITHOLOGIES

Tourmaline was identified by thin-section petrology in several samples, generally from alteration zones around or near the porphyry and volcanic lithologies towards the bottom of the open cut. B212/80 from within 25 m of the agglomerate, described by Kemp (1982) as a 'structureless, friable, dark grey, partially oxidised rock with patches of kaolin', is comprised of 60–70% clay minerals with 15–20% quartz and 10–25% tourmaline. The tourmaline extensively replaces quartz, feldspar and ?kaolinite.

Adjacent sample B201/80, a soft, friable faintly laminated kaolinitic rock is 'dusted' with tourmaline, and has an overall 10% tourmaline content. Sample B250/80 from immediately below the porphyry contains 1% tourmaline, and sample B285/80 of the porphyry itself contains a trace of tourmaline.

No further work has been done on these samples to understand the process of tourmalinisation. From the descriptions above, it probably developed during a metasomatic process after potash metasomatism and silicification, and is probably related to intrusion of the porphyry.



Figure 7. Potash metasomatised clasts in a matrix of malachite in one of the breccia lithologies in the Burra open cut. Sample B198/80. (407320)



Figure 8. Funnel-shaped mass of silicification and potash metasomatism surrounding sample site B195/80 on the southeastern side of the open cut. Kemp (1982) described the lithology as highly altered silicified volcanic rock, probably a tuff. (407321)

Breccia lithologies

Ten types of breccia, some copper mineralised, were mapped in the Burra open cut during 1980–81. Two varieties of agglomerate have already been described above. The recrystallised (± coppermineralised) dolomitic marble is in places also brecciated, either by proximity to the Kingston Shear, or by hydraulic fluids associated with the volcanic processes. The other varieties of breccia are described below.

COPPER-MINERALISED JIGSAW BRECCIA

A breccia comprising light brown non-laminated, ?silicified and ?ferruginised clasts of an unidentified Kooringa Member ?siltstone host was picked up as float from the vicinity of sample site B256/80 during late-1980 mining operations. A sawn surface reveals near in situ clasts enveloped in a matrix of cuprite (+99% identified in a polished section PS30621 of B256/80) and flecks of native copper (Fig. 9). Parts of the cuprite have been pseudomorphed by malachite.



Figure 9. Jigsaw breccia of Kooringa Member siltstone clasts cemented by cuprite and native copper from near sample site B256/80. (407334).

Another jigsaw breccia of faintly laminated Kooringa Member clasts in a matrix of malachite and gemmy azurite crystals was recovered from an approximate mine grid location of 4225mN 3180mE (AMG 307770mN, 6271570mE). This has a most unusual texture in places where clasts have been completely infused with malachite, then the clast rims ?bleached to leave a 'core' of malachite. This alteration has only affected part of the sample, and immediately adjacent clasts appear to be unaffected. (Fig. 10)



Figure 10. Stockwork veins of malachite and chrysocolla in a jigsaw brecciated siltstone host. The parallel banded and botryoidal malachite has precipitated in angular voids, indicating development by hydraulic fracturing rather than dissolution of sedimentary carbonate material. (407323)

COPPER-MINERALISED CROSS-CUTTING FLUIDISED BRECCIA

Several good exposures of layered cross-cutting breccias are still visible in the open cut, the best example being at the base of a mine face at approximate mine grid 4395mN 3240mE (AMG 307720mN, 6271745mE; Fig. 11). Here the breccia is of sand to granule-sized clasts of probable Kooringa Member lithologies and quartz in a finer grained malachite stained matrix. Some larger (~40 mm) angular clasts of pink-coloured ?quartz-?K-spar-altered rock are semi-aligned with the layering, which shows vague signs of grading. Small azurite nodules, probably developed from chalcocite (as discussed under 'Mineralisation'), are arranged in stringers sub-parallel to the boundary of the ~0.7 m wide breccia vein, which extends to the full height of the 5 m bench, although it thins upwards. The vein cuts across the near-vertical bedding in the dolomite host at an angle of ~10°. It is interpreted to have formed as a hydraulically driven fluidised breccia, derived perhaps during emplacement of the porphyry.

COPPER-MINERALISED REBRECCIATED BRECCIA

Sample B37/80 is one of the more important examples of breccia, as it is the only sample recovered during the 1980–81 mapping program that exhibits a re-brecciated breccia texture (Fig. 12). The original breccia of Kooringa Member siltstone clasts was cemented by veins of azurite and chrysocolla, with lesser malachite. This breccia has been clearly disrupted through part of the sample by a secondary brecciation process. The copper-mineralised veins have been truncated, and clasts in the secondary breccia are more finely comminuted. Malachite is the main copper mineral in the matrix of the secondary breccia.



Figure 11. Copper-mineralised, layered, cross-cutting fluidised breccia vein in Unit 10 dolomite ~3 m west of sample site B135/80. Note the stringers of azurite nodules, which are probably pseudomorphs after chalcocite. (407324)

Recognition of a re-brecciated breccia is strong supporting evidence for the presence of hydraulic fluids prior to or during the epigenetic sulphide-mineralising phase associated with intrusion of the porphyry. Subsequent oxidation in a supergene environment altered these sulphides to the present copper carbonates. It is less likely that the hydraulic brecciation occurred during supergene enrichment.

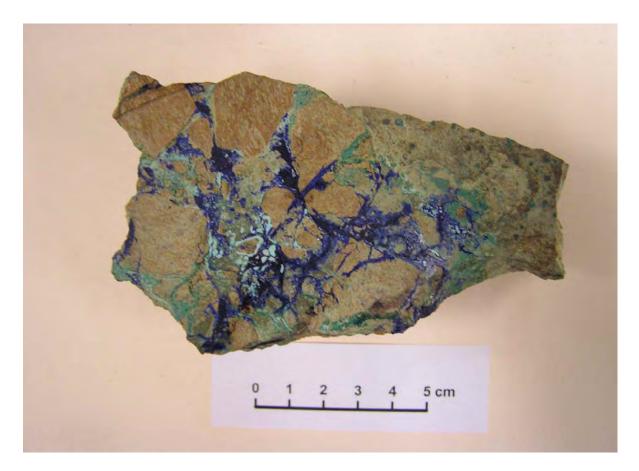


Figure 12. Re-brecciated breccia of altered angular siltstone clasts veined by azurite, malachite and chrysocolla from ~20 m east of the agglomerate near the base of the Burra open cut. The re-brecciated portion is the right quarter of the sample. (sample B37/80) (407325)

KARST BRECCIA

Although not available to inspect at the time of the 1980–81 mapping program, two small karst features filled with copper-mineralised clasts were excavated from below the northern haul road for processing, and the karsts backfilled (D. McLean, former Burra Mine Geologist, pers. comm., 2008). Copper ore in sink hole and solution cavities at Burra had been previously recorded by Johnson (1962) in the general area described by McLean.

COLLAPSE BRECCIA

A breccia mass extending for over 100 m, centred on sample site B30/80, is exposed over two mining bench heights on the central northern lip of the open cut. It is outlined by a ferruginous rim up to 300 mm thick, and capped and underlain by Unit 13 dolomite. Silicified (chert) horizons towards the top of the mass have similar bedding orientations to the immediately adjacent dolomite, but become more disjointed, to the point of appearing brecciated, towards the base of the mass. The breccia was initially thought to be a karst fill, but the description above, in particular its passage upward into undisturbed dolomite, does not support this origin.

The mass was possibly developed by lateral movement of acidic water released by oxidation of the original sulphide orebody when exposed to meteoric water at some stage in the relatively recent past. Leaching and bleaching created space for collapse of the corroded dolomite, with more space being available at the base of the mass where a collapse breccia developed. The siliceous (chert) layers may have formed during the early stages of corrosion, or they may be diagenetic within the dolomite as is common in the Skillogalee Dolomite elswhere. Similar acidic water was probably the agent of leaching of the bulk of the carbonate from the southern part of the open cut.

DOLOMITE BRECCIA AND SANDSTONE DYKES

A dolomite breccia is exposed in several places near the Kingston Shear on the western edge of the open cut, with the best exposure being centred on sample site B288/80 (Fig. 13). Here the breccia comprises angular dolomite clasts up to several tens of centimetres across in a sand-sized dolomite-quartz matrix. Some dolomite clasts are laminated, and may have been locally derived. Despite being in direct contact with a copper-mineralised unit, there has been no remobilisation of copper carbonates into the breccia.

The breccia is unusual in that it contains at least one dolomitic sandstone dyke up to 500 mm wide, with a near-vertical attitude, extending almost the full bench height. The base of the dyke merges into the dolomite breccia described above, but is almost clast free higher up on the mine face. Another similar sandstone unit is centred on B270/80.

Origin of the dolomite breccia is uncertain and several possibilities have been considered:

- being immediately adjacent to the Kingston Shear, it could have formed as a talus deposited against a rising fault block during Skillogalee-age sedimentation, but after earlier deposited carbonates had sufficiently lithified to endure brittle fracturing (cf Napoleon Megabreccia Member; Preiss, 1985).
- it could be a post-depositional tectonic breccia squeezed into its present location by movement along the shear.
- it could be a fluidised breccia injected along the shear by hydrothermal activity.



Figure 13. Sandstone dyke within angular dolomite breccia at sample site B288/80. (407326)

DIAPIRIC BRECCIA

The large body of diapiric breccia on the western side of the open cut, separated from the orebody and Skillogalee Dolomite units by the Kingston Shear, was first recognised as a diapir by Coats (in Thomson, 1963), and supported by Wright (1975). It crops out over the full length of the open cut, but regional mapping by W.V. Preiss (PIRSA, pers. comm., 2008) shows that does not extend more than a few hundred metres north and south beyond the open cut. The adjacent processing plant, stockpiles and tailings dumps have effectively disguised its western limit, but again it is thought to be no more than 500 m wide. Only macro features and structures were mapped in the diapir during 1980–81, as the Skillogalee Dolomite and mineralisation were the main focus of attention before mining removed the evidence.

Matrix to the diapir is dominantly calcite, with subhedral to euhedral dolomite crystals up to several millimetres across. Talc, chlorite and mica are trace to minor constituents. Clasts are mainly angular dolomite and siltstone, with minor biotite schist. These are mostly of granule to pebble size, but several megaclasts are exposed in the open cut. Of note is an overturned heavy mineral laminated sandstone clast almost 50 m across near survey station B10, which was exposed by the former northwestly mine access road. W.V. Preiss (SADME, pers. comm., 1985) identified this as Rhynie Sandstone, which significantly underlies the Skillogalee Dolomite. A 25 m wide crocidolitic siltstone clast, which is now rapidly weathering, is exposed immediately below Graves Engine House. Equally large sandstone and recrystallised dolomite clasts are revealed in the pit faces further south.

Despite its proximal position to high-grade copper mineralisation along most of its length, little evidence was found of mineralisation in the diapir. Minor malachite staining occurs along some shear planes, and a 20 m wide pod of malachite—chrysocolla staining occurs across the diapir, Kingston Shear, Unit 1 and Unit 2 boundaries ~100 m south of the northern haul road. This is reasonable evidence to assume that the diapir was juxtaposed by faulting after the main phase of supergene copper enrichment. The Figure 3 cross-section in Drexel and McCallum (1986), derived mainly from the log of diamond-drillhole BD1B, indicates that the Kingston Shear is listric, and may truncate the orebody and possible volcanic neck at depth. This provides a challenge to find the 'other half' of the Burra orebody, if indeed it exists.

Bampton (1993) believed the diapir to occur on both sides of the Kingston Shear, citing occurrences of volcanic units in other Adelaide Geosyncline diapirs as an explanation for the volcanics present in the Burra open cut. Preiss and Drexel (1993) in their response cited that Skillogalee Dolomite stratigraphy can be traced in places around the agglomerate and porphyry exposures in the pit bottom. There is no evidence of the volcanics occurring as clasts, and alteration haloes including montmorillonite and silicification from around the volcanics extend into the Skillogalee units. Secondly, the Kingston Shear is the regional structure passing through the open cut, not the Tinline Fault as cited by Bampton. His assumption would require two diapirs to be precisely juxtaposed, an unlikely scenario in an already highly fortuitous situation with a diapir being precisely juxtaposed adjacent to a copper orebody. Regionally, the Kingston Shear forms the boundary between highly recrystallised dolomite, locally intruded by diapiric breccia, to the west and fine-grained, well-preserved dolomites to the east. It is one component of a regional series of dislocations extending north-northwesterly for over 200 km from the northern end of the Kanmantoo Trough to Carrieton in the Flinders Ranges. Thirdly, convincing evidence was noted during 1980–81 mapping that the porphyry intrudes in situ Skillogalee Dolomite at a relatively acute angle to bedding, and is definitely not an inclusion within a clast of dolomitic siltstone in a diapir.

MINERALISATION

Burra Mine became world renowned in the mid- to late 1800s because of the large masses of beautifully formed botryoidal malachite and gemmy azurite crystals. The richness of its ore was also well known, with the original surface assay being reported as 70% Cu from cuprite mineralisation (Auhl, 1986). Tributors from that period undoubtedly high-graded their finds of malachite and azurite, with overall recovery estimated at 700 000 t averaging 7% Cu. Ore totalling 1.89 Mt at a grade of 1.71% Cu was recovered during 1970–81. The pre-mining ore grade is estimated at close to 3% Cu.

Burra Mine was also noted for crystalline native copper, flecks up to 10 mm across of which were found during routine diamond sawing of rock samples collected during 1980–81. Libethenite was recorded by Robert Noble (SADME Technical Officer; Noble, 1980) during crystallography and photomicroscopy of mineral samples from across the state when compiling the *Catalogue of South Australian Minerals* — 1983 (Noble et al., 1983). This publication also provides excellent colour images of many of the minerals found at Burra.

Three copper mineralising events have been recognised in the open cut. The first was primary sulphide, presumably mainly chalcopyrite, but only a few remnants of this mineral were recorded during mapping. The porphyry is of such small volume that it is hard to envisage this carrying the volume of copper now extracted from the orebody. Nixon and Townend (1966) noted euhedral chalcopyrite crystals with included bornite blebs that altered to chalcocite on exposure in the porphyry. However, exposures of the porphyry at depth examined during the 1980–81 mapping program revealed mostly pyritohedra up to 50 mm completely pseudomorphed by chalcocite. It is therefore possible that the porphyry was originally pyrite rich but copper poor. It is likely, however, that copper-bearing hydrothermal fluids were derived at depth during the 797 Ma magmatism, and precipitated chalcopyrite in the present location of the Burra orebody (Fig. 14). To infer a younger mineralising event would require too many coincidences to occur in the same location over a long period of time, i.e. magmatism with development of tuffaceous siltstones and intrusion of the porphyry, mineralisation at a later time, then faulting by the Kingston Shear and emplacement of a diapir juxtaposed to the orebody.

Epigenetic alteration and concentration of primary mineralisation resulted in the secondary copper sulphide chalcocite, with some covellite. Later supergene enrichment resulted in formation of the copper carbonates malachite and azurite, and appreciable quantities of chrysocolla (Figs 15–17).



Figure 14. 1.5 m wide ferruginised mass at sample site B286/80 adjacent to a mined out pod of copper mineralisation and ?montmorillonite—?kaolin alteration in the centre of the former haul road on the western side of the open cut. This is possible evidence of former massive sulphide mineralisation at Burra. The photo was taken on 26/5/81, four months after mining ceased, and the natural groundwater table has appeared at lower left. (407327)

Azurite nodules up to 100 mm across were recorded in several locations in the open cut as individuals and as stringers of nodules. Their occurrence was problematic at the time of the mapping project, but subsequent diamond-saw sectioning of several revealed cores of chalcocite. Polished section 30624 of one nodule was described by Kemp (1982) as '...an approximately concentrically zoned specimen of chalcocite, malachite and azurite replacing a coarsely crystalline quartzo-feldspathic rock. Chalcocite occurs as a dense network of fine veins and patches, giving the impression of a breccia.' Azurite (and malachite) in this specimen occurs as an alteration of chalcocite. It is therefore reasonable to assume that the stringers of azurite nodules recorded in the copper-mineralised cross-cutting fluidised breccias described above were originally blebs of sulphide (chalcocite), now pseudomorphed.

Pyrite, generally pseudomorphed by limonite, commonly occurs as very small crystals and blebs disseminated throughout much of the Kooringa Member. Several zones of ferruginisation that are not confined to particular lithologies also contain pyrite pseudomorphs, the largest being on the eastern side of the pit but now removed by recent aggregate quarrying operations. Here, a 40 by 10 m zone of ferruginisation had an outer rim up to 60 mm wide of pyrite pseudomorphs, some nearly as wide as the rim itself.

Of importance in the understanding of mineralisation in the Burra Mine are two samples containing pyrite — B199/80 and B118/80. B199/80, described by Kemp (1982) as a very fine-grained, faintly laminated, silicified, dolomitised acid ?volcanic, and by Farrand (1983) as a dolomitised shale comprised of an ultra-fine-grained mass of clay minerals, contains numerous extremely small sulphide blebs identified in polished section (PS30616) as pyrite (99%) and chalcocite (trace). This sample comes from an area of extreme alteration and weathering near the bottom of the open cut, an environment unlikely to have preserved fresh sulphides. It may, however, be from the very top of an underlying sulphide body.

Sample B118/80, although weathered, contains patches of extremely small fresh sulphide grains, presumably pyrite. It is from much higher in the pit than B199/80, almost at the present watertable. The pyrite appears to be bedded, in continuity with limonite pseudomorphs outside the preserved sulphide patches. The Nairne Pyrite Member within the Kanmantoo Trough may be an analogy. But small cavities within the patches indicate probable dissolution of a soluble mineral. If this is the case, then the sulphide is probably secondary as it would be unlikely to remain unaltered in the presence of a solvent. Silicification may have preserved the sulphide, but thin- and polished section petrology is required to help define an answer.

Listed below are the metallic minerals presently recorded from the Burra Mine, and their abundances based on visual estimates during mapping, and subsequent laboratory analysis. This list is not necessarily comprehensive. Compilation of information contained in the 1980–81 field notes, Kemp (1982), Farrand (1983, 1984), Noble (1983) and other petrological descriptions, should enable a paragenetic sequence, including non-metallic alteration phases, to be constructed.

Name	Composition	Overall relative abundance
Azurite	Cu ₃ (CO ₃) ₂ (OH) ₂	Sub-dominant
Bornite	Cu₅FeS₄	Accessory
Chalcocite	Cu ₂ S	Accessory
Chalcopyrite	CuFeS ₂	Trace
Chrysocolla	CuSiO ₃ .2H ₂ O	Sub-dominant
Covellite	CuS	Trace
Cubanite	CuFe ₂ S ₃	Trace
Cuprite	Cu ₂ O	Accessory
Gold	Au	Trace
Libethenite	Cu ₃ P ₂ O ₈ .Cu(OH) ₂	Accessory
Malachite	Cu ₂ CO ₃ (OH) ₂	Dominant
Native copper	Cu	Trace
Neodigenite	Cu ₉ S ₅	Trace
Pseudomalachite	Cu ₅ (PO ₄) ₂ (OH) ₄ .H ₂ O	Trace
Pyrite	FeS ₂	Accessory
Sphalerite	ZnS	Trace



Figure 15. Mining operations in early 1981 at the southern end of the Burra open cut, just prior to the induced failure of the face at extreme right on 14 January. The worked out area at left has been backfilled to form the haul road to current operations. A very rich zone of predominantly malachite and chrysocolla passes diagonally up the face to the right of the mining equipment. (045361)

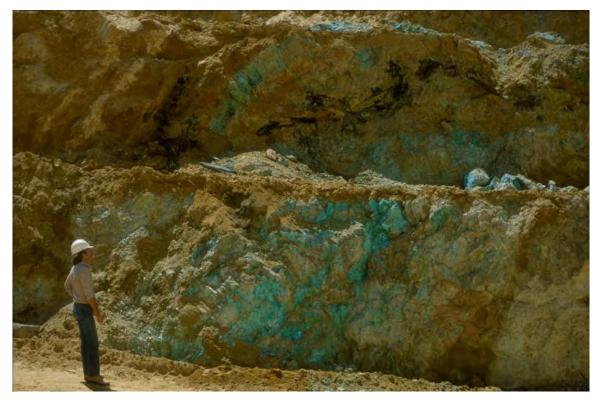


Figure 16. Wayne McCallum examining the malachite-chrysocolla ore zone shown in the image above. (407328)

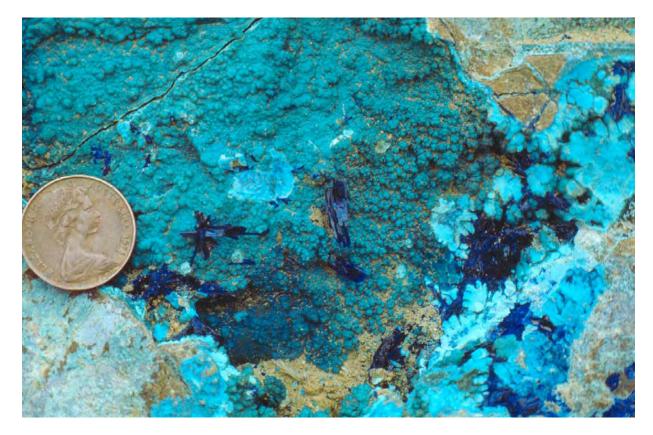


Figure 17. Typical copper ore from near the southeastern base of the Burra open cut. Gemmy azurite crystals rest on malachite and chrysocolla. (048865)

DRILLHOLE INFORMATION

Appendix C summarises SA Department of Mines drilling for the period 1963–64, and Mines Exploration Ltd drilling for 1966–67 is summarised in Appendix D. The latter was mostly for grade control, but eight steeply inclined diamond drillholes (BS1–8) were completed with varying success. Drilling conditions were difficult, particularly through the diapir where talc-enclosed clasts merely rotated on the bit tip, and penetration rates were sometimes extremely slow.

Core for holes BS5–8 is stored in the Glenside Core Library, although some sections are missing. Core for BS1–4 has not been recorded as stored by PIRSA, but there is the possibility of it being in the old 6 foot wooden trays not yet catalogued at the Moonta Core Library. BS4 is of particular importance as it may hold the key to interpreting the orientation of the Kingston Shear at the contact between the diapir and Skillogalee Dolomite.

Drillhole BS1B (Appendix E), drilled from the eastern lip of the pit by Adelaide and Wallaroo Fertilizers in 1981, suggests that the shear is listric, and possibly cuts off the copper mineralisation 200–300 m below the surface.

BS4, spudded in diapir and drilled to the east, was logged in 1966 as passing from marble breccia into the Skillogalee Dolomite. The present author believes there is uncertainty in the drill-log recognition of a distinction between diapir and recrystallised dolomitic marble (which is sometimes brecciated). Much of the hole (including the diapir) was logged as marble breccia. Within the open cut and in nearby outcrops, diapir always occurs on the western side of Kingston Shear. The marble and marble breccia as currently mapped is part of the Skillogalee Dolomite or mineralised sequence, and is always to the east of the shear. Relogging of the core, with the advantage of having had the orebody exposed by mining after BS4 was drilled, may better define the downhole location of Kingston Shear.

The determination of the possibility of the orebody being present at depth below the open cut has great bearing on any future exploration model around Burra. If the orebody is potentially present at depth, then regional exploration could concentrate on similar occurrences along Kingston Shear. If the orebody has been truncated by the shear, then exploration could also be directed towards looking for 'the other half'.

POTENTIAL FURTHER ANALYSIS OF BURRA SAMPLES THIN- AND POLISHED SECTION PETROGRAPHY

A suite of samples collected during 1980–81 field mapping re-examined during the current exercise show probable volcanogenic features, including flow structures, volcaniclastic contribution, and unusual textures not typical of sediments. Specific samples are tabulated in the 'Recommendations' below.

FLUID INCLUSION STUDIES

Quartz sample B204/80 was taken from an area of intense quartz veining adjacent to a large area of potash metasomatism and silicification near the base of the Burra open cut. Quartz sample B281/80 was taken from the porphyry near the central western part of the open cut near the contact with the diapir. Both should be examined for suitability for fluid inclusion studies to help determine the environment under which the guartz formed.

SULPHUR ISOTOPE STUDIES

Numerous samples in the Burra open cut contain pyrite, as both primary and secondary mineralisation. Authigenic disseminated pyrite pseudomorphs ranging from microscopic to millimetre scale are present in siltstone, limestone and dolomite units along the northern pit faces. These areas are still accessible for further sampling if necessary.

Sample B118/80 contains apparently bedded, unaltered pyrite within small patches in an otherwise weathered siltstone. Fresh pyrite also occurs in sample B199/80, described as a dolomitic shale, or a very fine-grained dolomitised acid ?volcanic. Both samples are described above in the section on mineralisation.

Secondary pyrite in vein material, generally quartz, occurs within the main ore zone towards the bottom of the pit. Chalcocite and covellite are common minerals in the porphyry and recrystallised dolomitic marble along the western edge of the orebody.

Sulphur isotope studies may add to the determination of the environment under which the pyrite and other sulphides formed. Sampling of pyrite from the Kooringa Member at a distance from the open cut should provide a benchmark for comparison.

RECOMMENDATIONS

Materials and information gathered during the 1980–81 field mapping program provide a unique record of one of the State's oldest mines. The ore has been all but completely mined out and the open cut flooded. Along with the site now declared as being reserved from the Mining Act, there are only small exposures of remaining mineralisation and limited field evidence to help determine the origin of the orebody. Consolidation of all mapping, rock samples, thin and polished sections, and 35 mm colour transparencies into a linked digital format available on line should be a priority, as this will provide both a scientific and historical database for future work by PIRSA and industry. Listed below are recommendations to consolidate this information:

1. The timeframe for preparation of the current report precluded incorporating all available information from the 1980–81 mapping program and other sources on the accompanying geological map (Fig. 18). In particular, inclusion of additional comments captured on the original hand-sketched field maps should enable a realistic configuration of Units 1–14 to be made along the full length of the open cut. As discussed above, intense leaching and alteration (including silicification, potash metasomatism, probable volcanic effects, brecciation and shearing) in the southern part of the open cut has made correlation of units difficult, but further examination of

- data will almost certainly result in a more complete geological map. **Note:** Not all information collected during the 1980–81 mapping can be represented on the final pit outline, as some observations were taken in areas subsequently mined out.
- 2. All information relating to the ~300 rock samples collected from the Burra Mine should be placed in SA_Geodata. Summary data to each of these currently reside in Table 1 to this report in a format that is readily acceptable into the departmental database. Note: Not all samples collected during the 1980–81 mapping can be represented on the final pit outline, as some were taken from areas subsequently mined out.
- 3. Structural data (predominantly bedding and shear foliation) should be captured from the scanned image and recorded in SA_Geodata.
- 4. Re-examination of the ~300 rock samples has identified a suite of breccias, possible volcanics and potash metasomatised lithologies that should be examined petrologically to help refine the extent of magmatism and metasomatism in the open cut. Of particular importance are:

Field No. (/80)	R No.	Description, and identification required
B101	77488	Highly altered fine-grained siltstone-like rock with contorted dark red-purple and white banding. Is this flow-banded tuff, or an altered, slumped sediment?
B118	77546	Partly weathered pale brown siltstone with fresh pyrite as an apparently bedded constituent of the sediment. Holes within the 'bedded' pyrite layers indicate that a mineral has been leached, yet the pyrite is unaltered. Is the pyrite syngenetic or secondary? A polished section may be required.
B119	77549	Copper mineralised, white-grey weathered ?silty ?ex-dolomite, some laminae; pink and yellow bands may be either laminae or chemical fronts; minor brecciation in places. General description, but with particular reference to alteration.
B135	77611	Pod of copper mineralised breccia which cuts across bedding; angular clasts of pink-coloured ?quartz-?K-spar are semi-aligned; sand-sized quartz in matrix; possible graded layers which in the field show dips of +45°. Is there any evidence of a volcanic contribution in this rock?
B142	77637	Cream, hard, slightly vuggy rock with a mottled, granular appearance; sawn surface shows patchy light pink colouration. Is this a partly silicified and potash metasomatised rock?
B177	77748	Brown, altered breccia; some clasts to 20 mm are laminated ex-dolomite; layering possibly due to 'flow'; slickenslides; copper mineralisation only in matrix. Is there any volcanic contribution that may indicate this rock to be a tuff or agglomerate?
B180	77760	Brown, sandy matrix breccia with angular clasts <5 mm; coarsely layered; possible clasts of malachite-mineralised rock and ?dolomite. Is there any evidence of a volcanic contribution in this rock?
B190	77796	Grey-brown, altered, ?silicified ?siltstone; some beds highly friable (break down into 'silt'); sawn face shows numerous ex-py blebs as stringers that define layering. Is there any evidence of a volcanic contribution in this rock?
B219B	77904	Cream-grey, semi-translucent, ?sericitic,?feldspathised, network-veined rock. Is this a metasomatite?
B227	77932	Brown, laminated, silicified siltstone interbedded with paler yellow-brown ochreous rock; characteristic quartz 'discs' to 1.5 mm. Is there any evidence of a volcanic contribution in this rock?
B248	78002	Two samples: (a) Copper mineralised, cream-grey, partly silicified, bedded but fractured to brecciated dolomitic ore-zone rock with fresh sulphides; (b) well-laminated, altered, dolomitised ?siltstone-?dolomite with dolomite rhombs to 3 mm, dark grey with white laminations. General description of both, but with particular reference to alteration.
B252	78018	Dark red-brown pod of highly altered medium soft rock; light apple-green waxy mineral in places; sawn face shows grey-black, hard ?clasts of unknown com-position in a brick-red matrix; becomes extremely friable when wet. General des-cription , but with particular reference to any volcanic contribution in the rock.
B286	78146	Dark red-brown rock from a ferruginous pipe; breaks down to clay-sized particles when wet; possible rounded quartz-overgrowth grains; may be a highly ferruginised dolomite. Is there any evidence of a volcanic contribution in this rock?

- 5. Three samples of siltstone with probable high feldspar content have been collected from the vicinity of the northern haul road for separation of zircon concentrates. If present, the zircons should provide a direct age of deposition of the Kooringa Member. The age of the porphyry obtained during this study provides a minimum age for the Kooringa Member.
- 6. All volcaniclastic, breccia and metasomatic samples should be categorised, including through whole-rock geochemistry, to help determine or confirm their petrogenesis and relationships. This process can be subdivided into the microcline-rich and albite-rich ?tuffaceous horizons in the Skillogalee Dolomite, and the porphyry, agglomerates and other volcaniclastics associated with the copper mineralisation. Isotopic studies of components of these rocks may assist in distinguishing between magmatic and meteoric water contributions, particularly in relation to copper mineralisation.
- 7. Sample site B122/80 was re-sampled in December 2008 to determine the presence of any zircon crystals that may have accompanied the albite feldspar in an ash cloud as proposed by Farrand (1984) as the most probable source of these clastics in an otherwise quiescent, dolomite-precipitating environment. Likewise, sample sites B7/80 and B10/80, and another site in Unit 2 on the southern side of the haul road just inside the Burra open cut, were re-sampled to determine the zircon content of the K-feldspar-rich laminae which petrology has also indicated developed from probable ash falls. It is recommended that these samples have zircon concentrates prepared and, if suitable, age dated.
- 8. Samples taken by Preiss, Drexel and Cowley in November 2008 from the 'Grove quarry' ~5 km north of Burra require thin section petrography. Lithologies described by Redfire Resources in the quarry include sheared syenite rock and probable potash meta-somatism. This occurrence is a possible northern extension of the Kooringa Member, as mapped on the Burra 1:50 000 geological sheet (Preiss, 2002), and the association with metasomatism provides a possible link to mineralisation in the Burra open cut.
- 9. A dolomite breccia (grey, angular dolomite clasts in a yellow-brown dolomitic sand matrix) at sample site B288/80 includes a possible dolomitic sandstone dyke, and is flanked to the immediate west by a layered, copper-mineralised recrystallised dolomitic breccia containing clasts and layers of potash feldspar (B264/80). This exposure needs detailed examination to determine the origin and sequence of formation, and any data that may shed additional light on metasomatism and development of the main orebody.
- 10. Southeastwards along the same bench described in (6) above, and on the bench below, is a complex area of shearing, alteration, brecciation, and probable imbrication of several rock units. Altered, micaceous siltstone containing 5 mm laminae of almost 100% microcline (B259/80) is one of the lithologies present; this may be Unit 2 or, less likely, another tuffaceous siltstone below Unit 1. A large body of breccia between sample sites B262/80 and B289/80 on this bench was mapped in the field as having bedding of Unit 2 apparently wrapped or draped over the present upper contact. This area needs further detailed mapping before final annotation is made on the geological map.
- 11. A large amount of information is available in the field notes, Table 1, and Kemp (1982) and Farrand (1983, 1984), from which to derive a paragenetic sequence for the Burra Mine copper mineralisation. Some additional thin- or polished section descriptions from the ~300 samples from the project stored at Glenside Core Library may assist.
- 12. Core from diamond drillholes BS5–8 is stored in the Glenside Core Library, but core from several important Burra Mine holes is missing, particularly BS1–4. Phoenix Copper is conducting its own search of the old Broken Hill South coreyard at Broken Hill. Locating the Kingston Shear (if present) in any drillhole should be a priority to assist in determining the orientation of the shear with respect to the possibility of the orebody continuing at depth. Drillhole BD1B indicates that the fault is listric, and may truncate the orebody and possible volcanic feeders at a depth of only a

- few hundred metres. Further evidence to confirm or refute this is required to firm up an exploration model for finding replicates of the Burra orebody, or trying to find 'the other half'.
- 13. All geo-referenced mine plans, including the successive field bench maps produced during 1980–81 and the 1965 surface geology (Nixon et al., 1965), should be 'wire-framed' to produce a pseudo-3D image of the mine geology. To this can be added the 3D orebody outlines prepared by Phoenix Resources from production drilling. As an extension of this, mine-level plans prepared from the late 1800s onwards could be added to indicate the extent of underground mining from 1845 to 1870, after which the mine was operated mostly by open cutting until cessation of the original mining campaign in 1877 (the Nixon et al. (1965) map captures the geology as exposed in 1877). Although the 3D model will have gaps in the data, it should reveal most macro geological features.
- 14. The department has over 400 maps of the Burra area recorded in SARIG (and Appendix F to this report). These should be examined for historically relevant information and added to the 3D image if the data are suitable, and to add to the knowledge base of adjacent areas. As an indication, the SA Department of Mines Annual Report 1961–62 states that 'The old mine area and accessible openings have been mapped in detail at a scale of 1in.=20ft., and a strip of country extending north for several miles and south to the vicinity of the Princess Royal mines has been mapped at a smaller scale'.
- 15. All rock samples collected from the Burra open cut during the 1980–81 mapping project (the 'B/80 series') should be digitally imaged in high resolution using a neutral background (to provide consistent colour tones) to allow on-line perusal of images via SAMREF.
- 16. All thin sections prepared for the Burra Mine Project (~132) should be digitally imaged in plane and polarised light (using identical image areas) to allow on-line perusal via SAMREF. Multiple images may need to be taken of individual thin sections because of the variety of features present, particularly within the breccia and volcanic lithologies.
- 17. Several hundred colour transparencies taken by the author during the 1980–81 field mapping project should be digitally scanned and added to the PIRSA Photo Database. Many of these can be linked to specific locations and subjects in the open cut. Some relate to specific rock samples. Most will require captioning and geo-locating.

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The author is indebted to colleague Wayne McCallum for the meticulous approach he brought to the 1980–81 mapping project. His 'on-the-rocks' discussions were invaluable when recording the field data. Wayne also compiled Appendices A-F in preparation for a draft report circa 1986 on the Burra Mine that did not eventuate due to circumstances beyond both his and the current author's control. Dr Wolfgang Preiss spent countless hours enthusiastically discussing the project in the office and field, allowing the author to firm up interpretations and ideas on the project. His knowledge of the Adelaidean in general. and Skillogalee Dolomite in particular, helped to distil the acceptance of probable ash-fall events recorded in the Burra open cut but not yet recognised elsewhere in that formation. He is also thanked for his meticulous review of the draft to this report. Dr Anthony Reid dated the porphyry and immediately saw the value of attempting to date the ash-fall events recorded in the Kooringa Member. He and Wayne Cowley also assisted Wolfgang Preiss and the author in measuring the type section for the Kooringa Member, and became involved in very useful geological discussions. Ursula Michael and Gareth Davies are thanked for scanning the field maps and associated information, which were then geo-referenced and rectified by Laszlo Katona, George Gouthas and Elaine Appelbee. Wolfgang Preiss used these to prepare a fully symbolised GIS dataset and map representing the present state of knowledge. Glenside Core Library staff Michael Willison, David Groom, Irish Flaherty and Brian Logan are thanked for tracking down Burra rock samples and core collected almost 30 years ago, and making inspection facilities available.

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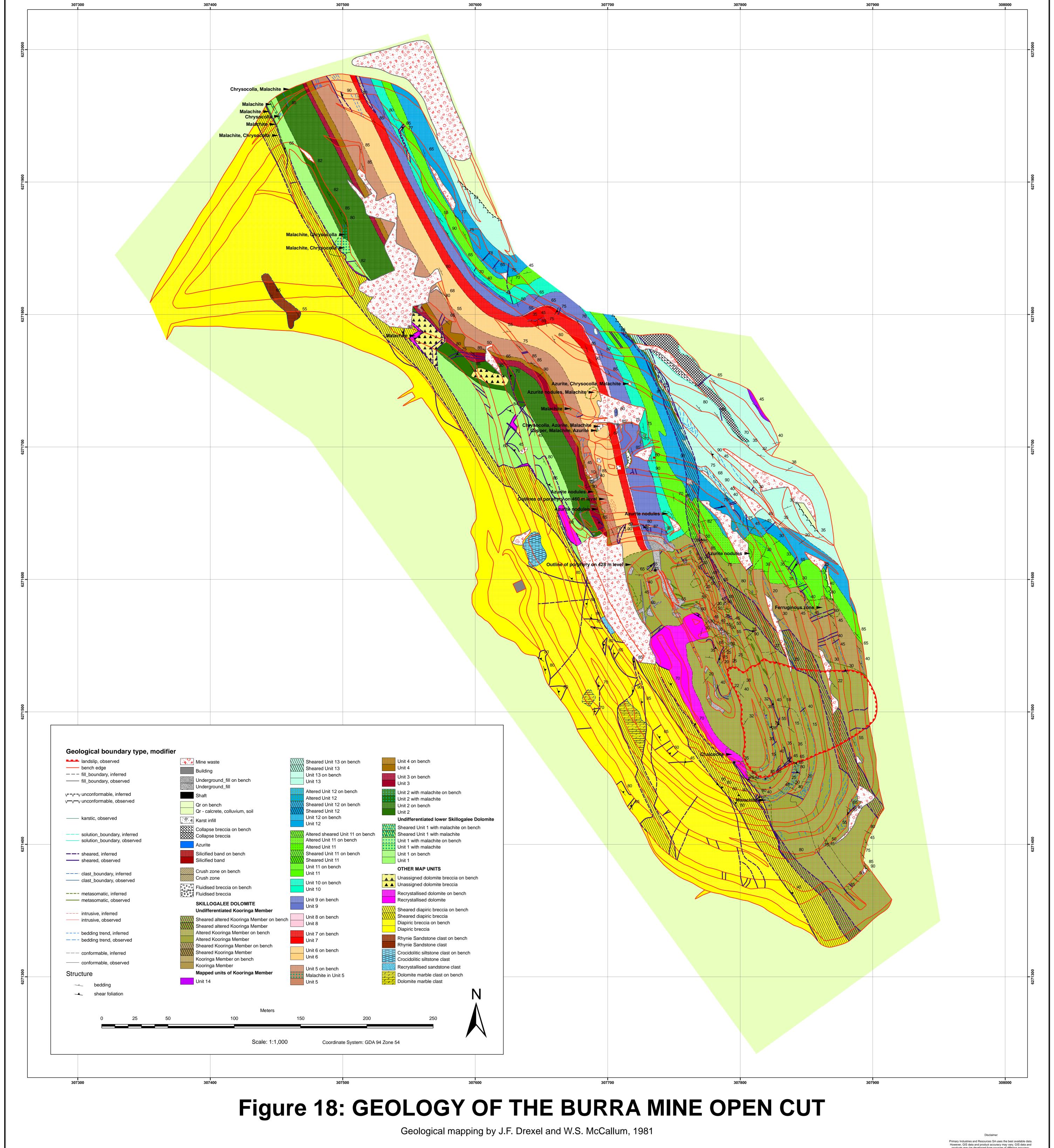
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Tal	ale	1 Summ	arv o	f petrological interpretation	of rock samples fron	n the Burra Mine or	nen cut				
Field No.				i petrological interpretation	or rook samples mon						
(/80) (yellow=check ed at Glenside Core Library; red=checked; sample in office) B1 F3	R No. RS N (663)	No. Thin section No. No. Polished section No. No. Shown otherwise) Geochem analysis No. (Field No unless shown otherwise)	Reaction to 10% HCI (on powdered sample unless shown otherwise)	Field identification by JF Drexel and WS McCallum	Mineralisation (field ID unless shown as TS – thin section) Ma=malachite; Chr=chrysocolla; Az=azurite; At=atacamite; Bo=bornite Li=libethenite; Cu=cuprite; Cpy=chalcopyrite; Cc=chalcocite; Co=covellite; Li=libethenite; Cpy=chalcopyrite; Cc=chalcocite; Co=covellite; Li=libethenite; Cpy=chalcopyrite; Cpy=chalcopyrite; Cc=chalcocite; Co=covellite; Li=libethenite; Cpy=chalcopyrite; Cpy=chalcopyrite; Cc=chalcocite; Co=covellite; Li=libethenite; Cpy=chalcopyrite; Cpy=chalcopyrite; Cp=chalcocite; Co=covellite; Li=libethenite; Cpy=chalcopyrite; Cpy=chalcopyrite; Cpy=chalcopyrite; Cpy=chalcopyrite; Cp=chalcocite; Co=covellite; Li=libethenite; Cpy=chalcopyrite;	Alteration ethenite, (field ID unless shown otherwise)	Petrological identification by Dr A Kemp (Amdel Report 1/1/271)	Petrological identification by Dr M Farrand (RB83/28; *RB84/62)	Most likely rock type and origin (based on field evidence only [thin section modifier in brackets]); pale green=final interpretation; yellow=uncertain or further work before interpretation) (pyritic refers to fresh sulphide in sample; ex-pyritic refers to limonitic pseudomorphs after pyrite) Pink = Kemp and/or Farrand ID; recheck if necessary on thin sections	Most likely unit Key field, thin and polished section features Furthe	er work
B1 F3 B2 F3 B3 F3 B4 F3 B5 F3 B6 A3	77478 101 77829 102 78165 103 78200 104 78240 105 78282 106	11 2.5Y 2.5Y 8/2 2.5Y 8/2 3 10YR 4/6 10YR 4/6 10YR 6/6 6/6 C41983 10YR 6/6	oyR(8/1) Slight V 10YR(8/1) Nil Y 608 Nil B 7/2; SGY7/1 Nil L 7/1) Slight V	rown-yellow, weathered/altered friable fine sand-sized material; sand probably produced by secondary quartz overgrowths prior to weathering; some vague white laminae ight red and pale green, hard, partlysilicified K-metasomatised rock white-cream uniformly coloured, dense, massive to granular dolomite	Many Ma blebs to 0.5 mm Numerous smallex-Py pseudos, radiating Ma xtl aggregates to 2 mm on fractures Sparse Ma blebs and stains Minor very small Ma grains Numerous smallex-Py pseudos, some to 7 mm; Ma blebs and stains to 3 mm	Probable partial quartz overgrowths on clastic grains mm-scale dendritic blebs on some surfaces Some Mn dendrites Partly silicifiedand potash metasomatised qtz veining; some pale green soapy material			Silty dolomite Silty dolomite (sedimentary) Silty dolomite Silty dolomite Silty dolomite Siltid folomite Silicified, potash metasomatised rock Dolomite (partly silicified, sedimentary)	undifferentiated Skillogalee Dolomite metasomatite Possible volcanic; potash metasomatism; similar to B50 and B285 Petrology to re-examine for volcanic contribution 1 Potash metasomatism	
B7 A3 B8 A3 B9 A3 B10 A3 B11 A3 B12 A3 B13 B3	78324 107 78360 108 78397 109 77482 110 77517 111 77552 112 77593 113	17	6/1) Slight M 7/4) Nil P (4/4/4) Nil L (6/6) Nil L 8/1) Slight M	ight brown, laminated siltstone interbedded with more massive grey dolomite; bedded to flaggy; more laminated in upper 3-4 m fledium grey, massive, hard dolomite interbedded with Bg; some probable cryptalgal laminae fale brown, weathered and/or altered, bedded to coarsely laminated non-carbonate rock interbedded with B8; slickenslides on some surfaces ight orange-buff, weathered, laminated, fissile siltstone interbedded with more weathered grey ?ex-dolomite; individual beds 50-100 mm wide; characteristic quartz-ex-pyrite blebs ight red, weathered, laminated, copper-mineralised sandstone-like rock; irregular bedding 5-100 mm thick; distrupted layering; sand-sized quartz shows 'rounding' typical of quartz overgrowths flassive, white, dense, hard dolomite (60-300 mm beds) interbedded with finely laminated (0.5-3 mm) slightly darker dolomite uff-grey, dense, bedded dolomite, laminated towards top; minor 'shotholes' filled with white-yellow sugary material	Numerous very smallex-Py pseudos Some ex-Py holes Larger euhedralex-sulphide pseudosin quartz veins, and much finer grains scattered through thin section (Kemp) Much Chr parallel to laminae; Ma nodules and stains; probableex-Py pseudosin TS (Farrand) Traces of Ma and Chr Minor Ma staining	Trace Mn blebs Minor qtz veining; ferruginisation along numerous fractures White soapy mineral on bedding planes and in fractures; veins of similar material 2-3 mm wide Quartz-ex-pyrite blebs Heavy ferruginisation in places; euhedral qtz in scattered veins; small silicification pods; probable quartz overgrowths Very minor Mn aggregates Trace Mn blebs on some surfaces; some kaolin pods and lenses		*Siltstone or pyroclastic (50% potash feldspar) *Magnesium-rich sedimentary carbonate (95% carbonate)	Sittstone Dolomite (sedimentary) Altered siltstone or dolomitic siltstone Laminated feldspathic siltstone Altered, partly recrystallised siltstone Dolomite (sedimentary) Bedded to laminated dolomite	2 Possible volcanic Petrology to re-examine for volcanic contribution 3 3	on
B14 B2 B35 B2 B16 B2 B37 B2 B18 B2 B19 B2	77627 114 80455 115 77687 116 77722 117 77757 118 77793 119	4 10YR 5 C41988 2.5Y(6 C34942 2.5Y(N3/0) 7 C41989 10YR 8 10YR 9 C41990 10YR	8/1) Slight V 1/70) Slight L 10YR(7/1) Slight to strong D 6/1) Slight N 6/1) Slight N 7/1) Strong on rock V	White-buff, massive to finely laminated, copper mineralised dolomite, similar to B13, but brecciated and contorted jight grey,dense, hard, laminated dolomite with minor cream dolomite interbeds to 100 mm; laminations are evenly spaced at -1 mm lark grey (almost black), dense Jainty laminateddolomiteand tan, finely laminateddolomitewith cream mm-scale laminae; minor warping or rippling of bedding planes; white mm-scale blebs (?precursors to 'shotholes') lassive grey-buff dolomitewith ream min-scale laminae; minor warping or rippling of bedding planes; white mm-scale blebs (?precursors to 'shotholes') lassive grey-buff dolomitewith a much smoother fracture surface white-cream laminated limestone fissile character develops during weathering; 0.6 m grey dolomite interbed 1 m from base; overlain by 3 m of white-cream, laminated to massivenestone (B140)	Ma mineralisation fills voids between breccia fragments Minor Ma-Chr blebs on some surfaces; ex-Py pseudosin outcrop and TS (Farrand) Faint trace of Ma	Much kaolin Many Mn aggregates and dendrites Mn blebbing on fracture surfaces Trace Mn aggregates	— Thinly laminated dolomite (97% dolomite) — — — — — — — — — — — — — — — — — — —	*Silty dolomite; much of the dolomite is secondary and the original rock was probably a quartz siltstone	Partly brecciated, bedded to laminated dolomite Laminated dolomite (sitly) Interbedded dolomite (sedimentary) and limestone Laminated dolomite (sandy dolomite) Massive to laminated dolomite Laminated limestone (dolomite)	6 6 7 Large lath-shaped voids; strong similarity to B103, although the latter has lath-shaped muscovite 9 9 9 10	
B20 B2 B21 B2 B22 C2 B23 C2 B24 C2 B26 D2	77832 120 77870 121 77907 122 77941 123 77972 124 78008 125 78045 126	10 10 10 10 10 10 10 10 10 10 10 10 10 1	7/1) Slight L 3/3) Slight to strong R (6/0) Slight R NY/0) Slight to strong R N4/0) Slight R	inely laminateddolomitic limestone; silty limestone grades upwards toblack-buff laminated limestonethen buff algal-laminated limestone ight grey, massive dolomite showing occasional bedding-confined 3-10 mm 'shotholes'sometimes filled with red or white clay; minor algal structurestimestone interbeds to 200 mm led-weathering, finely laminated (<1 mm) buffolomitic limestonefissile parting and small voids parallel to laminae develop when weathered led-stained, grey massive dolomite, minor laminae, hackly fracture; bedding defined by 'lacy' yellow-brown bands to 4 mm wide led-weathering, light greydolomitewith <0.5 mm brick-red, randomly orientated carbonate rhombs confined to laminaesome white laminations of possible limestone; highly fractured in places led-weathering, dark greydolomite pink ?clay veins to 7mm, hackly fracture, well laminated in places led-weathering, light greydolomite with narrow pinklimestonebands	Minor very small ex-Py pseudos	Mn dendrites and blebs on fracture surfaces Mn blebs on some surfaces Mn blebs on some surfaces	=		Dolomite (sedimentary) with minor limestone interbeds Dolomite limestone Massive dolomite Dolomite with minor limestone Laminated dolomite Laminated dolomite with limestone bands	10 11 11 12 12 11 10 10	
B27 D2 B28 D2 B29 D2 B30 E2 B31 E2 B32 E1	78083 127 78126 128 78151 129 78168 130 78172 131 78175 132	7.5YR 7.5YR 8.8 10YR 9.9 10YR 9.0 10YR 10YR 10YR 10YR 10YR 10YR 10YR 10Y	8/1) Slight on rock C 7/1) Slight M 8/6) Slight N 7/1) Mild to strong on rock L 4/1) Slight D	irey dolomitewith sparsely spaced whitelimestone laminaeto 2 mm ream, calcic dolomitewith irregular 5-30 mm bandsscattered darker laminae to 3 mm; some white mica flakes to 2 mm; some yellow-brown clay-filled vugs ledium grey, massive dolomite; narrow, irregular, cream dolomite veins to 2 mm that do not follow bedding light orange-buff clay to fine angular gravel with 10-40 mm quartz (?chert) or quartzite layers that are disjointed and folded (?slumped), some breccia light tan weathering interbedded light grey massive and light grey bedded (10-50 mm) to laminateblomite some limestone-dololimestone interbeds lark grey dolomite 1-5 m wide with lighter grey-browrlimestone or dololimestone interbedsontaining a few ankerite crystals to 1 mm letter or decided del periodic to 23 the proper fields 2.40 mm delegated, with light brown equipment or proper light to 9.00 mm; and the proper light to 9.00 mm; a few ankerite crystals to 1 mm	Fine euhedralex-Py pseudosin TS (Farrand)	Trace Mn blebs Mn blebs on some surfaces Bands and swirls of ferruginisation generally mimic the qtz layering Limestone shows some ferruginisation			Dolomite with some limestone laminae Calcic dolomite Massive dolomite Undecided; resembles (but is unlikely to be) a karst fill;altered lateral ?volcanic blast material Massive to laminated dolomite with some limestone-dololimestone interbeds Dolomite with some limestone-dololimestone interbeds Pedded to Jernisted delograte (orative temporal) in the programment of the pro	10 10 White mica flakes to 2 mm 12 13 14 14	
B33 E1 B34 F2 B35 G3 B36 F3 B37 F3 B38 F3 B39 F3	78178 133 78181 134 78184 135 78187; 78188 136 78190 137 78193 138 78197 139		8/8) Slight to mild C 2.5YR(8/6) Nil to slight Y 2.5YR(5/6) Nil Y 10YR(5/6) Slight P 7/6) Nil Y	ight grey beddeddolomitesimilar to B31 but more fissile; 2-10 mm dolomite layers interbedded with light brown slightly ferrugino: seram-brown weathering greydolomitewith minor laminae, some beds to 150 mm wide; weathers to a siltstone-like material fellow ochreous, weathered, banded siltstone and harder dark brown ?siltstone fellowish brown, hard, laminatedsiltstone 0.5 mm white-yellow flecks on sawn surface; contains a 0.5-1.0 m copper-mineralised zone sub-parallel to bedding fellow brown, laminatedsiltstone brecciacontaining a large pod of high-grade copper ore similar to B36; sawn face shows aprobable rebrecciated breccia fellow, highly weathered, friable, sometimes laminated, silt@ex-dolomite most of material is fines; some 'rounded' secondary quartz grains fellow, ochreous, faintly layered, weathered ?siltstone with quartz or chert layers parallel to layering; quartz has a granular to massive appearance, almost sandstone-like	Fine eunedraiex-Py pseudosin 15 (Farrand)	Minor ferruginisation of pod-like areas Otz veins to 15 mm, sometimes with copper mineralisation and ex-Py pseudos ?silicified Trace qtz veining Slightly ferruginous; secondary quartz overgrowths Mn staining on some surfaces; qtz pods with granular to massive appearance		Stromatolitic dolomite, 75% dolomite with coarser quartz trapped in aligal mais	Bedded to laminated dolomite (partly stromatolitic sedimentary dolomite with minor sandy interbeds and laminae) Sitly dolomite Altered siltstone Altered siltstone Copper mineralised breccia (feldspathic siltstone clasts) Altered laminated silty ?dolomite Altered siltcified siltstone (silicified ?volcanic rock)	13 undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite mineral breccia Mineralised breccia; sawn face shows aprobable rebrecciated breccia undifferentiated ?Skillogalee Dolomite metasomatite Quartz; possible volcanic; very similar to B41, B57 and B224	
B40 F3 B41 F3 B42 F3 B43 G3 B44 G3 B45 G3	78203 140 78207 141 78212 142 78215 143 78219 144 78222 145	10	Nil V 7/4) Nil Y DYR(7/8) Nil C 8/2) Very slight V	ellow, highly altered, friable ?silty rock; partly brecciated; pale pink ?feldspar patches and quartz pods; some brown, laminated siltstone; minor slickenslides; slump or flow banding highlighted by ?sericite //thite, friable, near-verticalpipe-like body of quartz-feldspar with azurite nodulesmassive quartz in centre of veins ellow ochreous, highly weathered, friable, very fine-grained ?ex-dolomite with mm scale white blebs, and kaolin or alunite veins to 20 mm wide or complete silicification white, saintly layered ?dolomite with some chloritic partings; one orange layer to 5 mm wide of recrystallised, clear dolomite relative to a dolomite clasts in a dolomite matrix; chlorite and talc wrapped around clasts; some possible quartz grains ight brown, soft, earthy laminatedsitstone with harder dark brown silty ?ex-dolomite interbeds; interbedded with B47	Numerous <1 mmex-Py pseudos; Ma blebs to 4 mm are aligned as veins Az nodulesto 20 mm Ma staining Ma stains and blebs on surfaces; numerousex-Py pseudosto 2 mm Ma blebs on fractures; minorex-Py pseudosto 1.5 mm Trace Ma on fractures; smallex-Py pseudosthough rock	Probable potash metasomatismnumerous qtz pods and veins Probable potash metasomatismnumerous qtz veins Kaolin/alunite blebs and veinsXRD of white clay mineral—kaolinite with 10-15% qtz Small qtz blebs (silicification up to 30 mm across) and chloritic shears Some possible talc; chloritic partings to 20 mm long Some probable talc blotches through rock Ferruginous surface coatings	— Quartz 98+% Rock of probable volcanic origin; (70% kaolinite) — Altered and mineralised dolomitic breccia — Possible ?volcaniclastic; high K-spar content	Hydrothermally altered kaolinitic rock, possibly originally a dolomite	Silicified, potash metasomatised rock, possibly siltstone Silicified, potash metasomatised rock in a pipe-like body Dolomite or siltstone that has undergone severe hydrothermal alteration by kaolin-producing solutions ?silicified, highly altered shear rock Altered and mineralised dolomitic breccia; possibly brecciated dolomitic marble Altered silicified ?sheared ?siltstone Feldspathic siltstone, partly kaolinised	metasomatite Potash metasomatism (resembles B5 Quartz; potash metasomatism; very similar to B39, B57 and B224 undifferentiated Skillogalee Dolomite shear rock Chloritic material is similar to B76 mineralised dolo marble shear rock 2 or 4 Interbedded with B47; very similar to B10, B75, B97, B116, B227, B243 which contain quartz 'discs'	
B46 G3 B47 G3 B48 G3 B49 G3 B50 G3 B51 G3 B52 F3	78230 147 78233 148 78236 149 78244 150 78248 151 78253 152		.5YR(6/6) Nil G	copper mineralised dark brown, weathered, layered, hardsity ?ex-dolomiteinterbedded with light brown soft earthy laminatestittstone (B46); granular appearance; rock fabric is mostly secondary silica reliellow weathered friable rock with chloritic partings; silt to fine sand matrix with small flakes of white mica; similar to B43; possibly a highly altered silty dolomite rock, possibly an ex-dolomiticisitstone similar to B48 but no dark green chloritic partings branitic-lookingpink quartz-feldspar rockwith copper mineralisation of B51 ropper mineralisation within B50 quartz-feldspar rock with copper mineralisation of B51 ropper mineralisation of B51 ropper mineralisation of B50 roper mineralisation within B50 quartz-feldspar rock with copper mineralisation of B51 ropper mineralisation within B50 quartz-feldspar rock with copper mineralisation within B50 quartz-feldspar rock within B50 quartz-fe	Ma stains and 20 mm wide vein in the harder rock; trac&hr Many Ma blebs and stains Many Ma blebs sometimes parallel to layering) and stains Much Ma veining (networks to 2 mm wide) and stainingMa-chr traces on fractures; ex-Py pseudossparsely scattered Ma networks to 2 mm wide and staining Ma veins, blebs and fracture coatings throughout; minoAz; minor Cc blebs and veins; Polished section1-2% opaques — Cc 98%, Co 1%, Cu 1%	Chloritic partings on outside of vein; partial silicification Numerous chloritic partings that look like slivers of slate Numerous qtz-Kspar pods and veins;potash metasomatism and silicification Potash metasomatism and silicificationqtz veins to 7 mm wide Partial silicification	Arkosic sandstone; porosity due to selective removal by weathering of kaolinised feldspar — Similar to B5; spherulites indicating devitrified volcanic glass; appears to be a tuff Highly feldspathised tuff; 90% microcline confirmed by XRD (Amdel Rept GS4536/83) Similar to B44; dolomitised breccia		Siltstone altered by hydrothermal fluids (quartz and K-spar), and mineralising with malachite ?silicified, highly altered shear rock Altered silistone Silicified, potash metasomatised rock (possibly an air-fall tuff) Silicified, potash metasomatised rock (possibly an air-fall tuff) Altered dolomite (dolomitised quartz-microcline rock, possibly porphyry, brecciated)	undifferentiated Skillogalee Dolomite Interbedded with B46; chloritic partings may indicate correlation with B43, B76 etc. shear rock Similar to B43 undefined Skillo Similar to B45 mineralised metasomatite Very similar to the porphyry B285; similar to B5; devitrified volcanic glass; potash metasomatism Candidate for age dating of feldspar; petrology mineralised metasomatite Possible dolomitised porphyry; fresh sulphides undifferentiated Skillogalee Dolomite Interbedded with B46; chloritic partings may indicate correlation with B43, B76 etc. Similar to B43 Candidate for age dating of feldspar; petrology dolomitised metasomatite Possible dolomitised porphyry; fresh sulphides	
B53 F3 B54 F3 B55 F3 B56 F3 B57 F3 B58 F3 B59 F3	78257 153 78262 154 78265 155 78269 156 78272 157 78275 158 78279 159	132 C34953 10RI 144 C34954 PS30615 10YR 155 10YR 166 C34955 25Y 17 C34956 7.5YR 10YR 188 10YR		m pod of dark red ?ferruginised altered ?feldspathised rock within the altered silicified halo surrounding recrystallised dolomite of B52 dopper mineralised white, semi-translucent/recrystallised dolomite White vein material probable extreme silicification and ?potash metasomatism of a precursor; saccharoidal quartz on outer edges of sample tark grey laminateddolomite and brown, softer laminatedsiltstone Weathered, sandy, pink quartz-rich rock with pink-orange ?feldspar patches in dark brown silty-sandy material; jigsaw breccia in places wown-white-red, highly weathered/altered, friable, finely laminatedsiltstone Weathered, greenish-stained white-grey rock (?ex-dolomite) with pale green serpentine-like material and malachite as veins and fracture coatings; desiccation cracks indicate high clay content	Az network, some Ma probably pseudomorphingAz, finely dissemintated ?Cc; Polished section1-2% opaques — Cc 98%, Co 1%, Cu 1% Ma as mm-scale blebs, veins and fracture coatings Ma staining parallel to layering and blebs on fractures Ma-quartz veins in dark brown material Minor Ma as blebs to 3 mm Ma in veins and as fracture coatings; possibleAt (Kemp TS)	Mn dendrites and coatings; feldspathised, ferruginised Some dark brown ?ferruginous veins <.2 mm wide Otz vein with a sugary coating Otz veining and silicification Possible serpentine development	Welded tuff (85% feldspar); fine-grained volcanic fragments; altered vesicular glass Dolomitised quartz-feldspar rock — Partly silicified, dolomitised and calcified ?bedded ?tuff Quartz 99+% — Highly altered volcanic glass; structure resembling perlitic texture	Altered lava; xenoliths; strong indications of flow and auto-brecciation Mineralised, dolomitised, quartz-microcline rock — Recrystallised ?chert — Kaolinised rock, possibly originally a normal sediment	Altered, ?feldspathised rock (welded tuff, lava or agglomerate in a volcanic neck) Altered dolomitie (dolomitised silicified and ?potash metasomatised rock) Quartz-?potash feldspar vein material Altered, laminated dolomite-siltstone (dolomitised bedded ?tuff) Hydrothermal quartz vein Highly altered laminated ?siltstone Highly altered 7dolomite (volcanic)	agglomerate dolomitised metasomatite Dolomitisation; probable potash metasomatism; fresh sulphides; similar to B280/80 Photomicrograph of dolomitisation of a metasomatism metasomatite undefined ?Skillo Possible volcanic; euhedral feldspar laths; dolomitisation metasomatite undifferentiated ?Skillogalee Dolomite undifferentiated ?Skillogalee Dolomite Possible volcanic Photomicrograph of laths enveloped by dolomite undifferentiated ?Skillogalee Dolomite Possible volcanic Possible volcanic Possible volcanic	
B60 F3 B61 Not locat B62 F3 B63 F3 B64 E3 B65 E3	78286 160 78289 78290 161 78293 162 78305 163 78309 164	C34958 7.5yr 1 10yr 12 10yr(7/4); 13 7.5yr(6/1) 4 7.5yr(6/1)	(8.2) Slight P	ink-white?metasomatic quartz-feldspar rockimilar to B5; irregular patchy green alteration lark brown breccia with 1-5 mm clasts of ?dolomite and quartz. Numerous black crystal shapes indicate a probable former sulphide pod within the breccia lark brown breccia with 1-5 mm clasts of ?dolomite and quartz. Numerous black crystal shapes indicate a probable former sulphide pod within the breccia lark brown cloomite (1-10 mm nucleii with softer, granular surrounds), with up to 100 mm cream-pink faintly laminated dolomite interbeds arallel-laminated pale brown dolomite interbedded with darker grey laminated but distorted dolomite; some cream-coloured beds up to 500 mm wide link-grey, hard, dolomite; some microfractured texture with white massive bands to 40 mm thick; laminations in places	Ma veining, staining and on fractures; numerousex-Py pseudosto 3 mm Thin Ma veins around quartz fabric in partly silicified part of sampli Some Ma staining; trace Chr	Partly silicified and potash metasomatised to veining Partly silicified Mn blotches on some surfaces Large Mn blebs and dendrites	Microcrystalline feldspathised and silicified ?volcanic rock, probably a ?welded tuff	Possible tuff with quartz and microcline replacement	Silicified and potash metasomatised rock (?tuff) Partly silicified dolomite-quartz breccia Dolomite with laminated dolomite interbeds Laminated dolomite Massive dolomite Dolomite	metasomatite Possible volcanic breccia Not located on map, but probably from western side of open cut east of Kingston Shear 10 9 8 Possibility of white mica in this locality, as seen on 2/12/08 field trip 6	
B66 E3 B67 E3 B68 E3 B69 F3 B70 F3 B71 E3	78312 165 78315 166 78318 167 78321 168 78327 169 78330 170	55 5 5 878 6 1010 6 10 10 10 10 10 10 10 10 10 10 10 10 10	8/2) Nil C 3/6) Mild Y 3/0) Nil V	ink-grey, hard, massive dolomite with some very small voids; partly granular textu late yellow-green coarsely friable serpentine-like rock; sample from Glenside is now white-grey, possibly due to dehydration of clay minerals lopper mineralisedwhite-grey weathered?dolomite porous, partly silicified, with rounded quartz-grain overgrowths ellow, platey, partly silicified sandstone-like rock, ?ex-dolomite, possible bedding; rock is mostly quartz with lesser dolomite white talc-rich rock with minor slickenslides white dolomitic-chloritic shear material; chloritic partings are curved; some large (5 mm) clear dolomite rhombs; large amounts of quartz lopper mineralised white, hard, massivedolomitic ?metasomatite.copper minerals occur as very fine veins and fracture fillings plus surface stains; 2-3 mm wide banding visible in places; dolomite has probably be longer tallicated, problems when the kindlerna.	Minor Ma Minor Ma Ma stains and blebs to 5 mm; lesser amounts of Az; small ex-Py pseudos Very small fresh Py grains Trace to minor Ma; minor ex-Py pseudos to 1.5 mm	Mn dendrities to 5 mm on some surfaces Partly silicified; Mn or ?tourmaline blebs throughout; serpentine Qtz veins to 20 mm wide; partly silicified; faint liesegang rings Talc rich; trace chlorite Mn blebs on some surfaces; chloritic partings			Massive dolomite Altered, serpentine-like rock adjacent to porphyry Altered ?dolomite adjacent to porphyry Recrystallised sandstone clast from within diapir Slickenslided talc-rich rock from diapir within Kingston Shear	porphyry-related alteration altered 2 clast in diapir sheared diapir sheared diapir sheared diapir	
B72 E3 B73 G3 B74 G3 B75 H3 B76 H3 B77 G3	78334 171 78338 172 78342 173 78345 174 78348 175 78351 176	11 C34959 10YR 12 C34960 10YR 14 10YR 15 7.5YF 16 7.5YF	6/8) Nil B (8/6) Nil to very slight P (7/4) Nil P (8/2) Nil P	rownish yellow well-laminated siliceous fabricprobably partly silicified siltstone ne to coarse sand as second component of sample, showing rounded quartz-grain overgrowths rink, highly weathered layered rock; partly sandy without laminations; finer grained laminated material: may be interbedded dolomite-sandstone; rounded quartz-grain overgrowths ale brown, partly weathered, massive to faintly layered, medium-harefiltstone characteristic quartz 'discs' to 1.5 mm rinkish white-green, weathered, partly ferruginised, layered quartale-chlorite' Shear materialsandy in places, with quartz showing rounding due to overgrowths rounding due to overgrowths and the proper mineralised, crudely coarsely layered, partly silicified,dolomitic marble brecci; some angular quartz clasts; euhedral dolomite rhombs to 15 mi	Trace Ma Trace Ma Faint trace Ma Minor Ma, numerousex-Py holes within Qtz Much Az as semi-formed nodules and crystals; minor limonite areas which may bex-Py; no fresh sulphides	Possible minor potash metasomatism Minor Mn blebs Talc-chlorite; partly silicified; partial ferruginisation Partly silicified; trace to minor talc	Dolomitised quartz-feldspar rock Bedded tuff (75% feldspar) Poorly sorted and bedded medium to coarse-grained acid volcaniclastic — — — —	Mineralised, dolomitised, quartz-microcline rock; similar to B54 Siltstone similar to B46 but with strong microcline replacement of the non-mica fractions Siltstone partly kaolinised and with incipient recrystallisation of quartz — — — —————————————————————————————	Silicified, feldspathised, dolomitised and copper mineralised siltstone or dolomite (dolomitised quartz-feldspar rock) Partly silicified siltstone (bedded tuff; potash metasomatism) Altered siltstone (hydrothermally altered by kaolin-bearing solutions and recrystallisation of quartz; acid volcaniclastic) Siltstone Quartz-talc-chlorite shear material Mineralised dolomitic marble breccia	dolomitised metasomatite Fresh sulphides undifferentiated ?Skillogalee Dolomite undifferentiated ?Skillogalee Dolomite 2 or 4 Very similar to B10, B47, B97, B116, B227, B243 which contain quartz 'discs' shear rock mineralised dolo marble breccia	
B78 G3 B80 G3 B81 F2 B82 F3 B83 G3 B84 H3	78354 177 78357 178 78364 179 78367 180 78370 181 78374 182 78378 183	7 2.5Y 18 5YR 19 C34962 10YR 10 5YR(8/4); 11 10YR 12 C34963 10YR 13 C34964 10YR	7/7) Nil Y	copper mineralised, white,recrystallised dolomitic marble/colomite rhombs to 10 mm chopper mineralised pink, crudely layered, coarsely crystallinedolomitic marble dolomite rhombs to 10 mm; crystalline dolomite aggregates to 25 mm; some chloritic partings White, massive dolomitic 'Pbreccia's heared layered dolomitic clasts to pebble size; misshapen rhombs to 15 mm; sandy granular matrix late yellow, highly weathered/altered laminated ex-dolomite; granular (medium-coarse dolomite sand) in places ellow-brown, hackly,?siltstone faint layering on a sawn surface late brown, hard, partly vuggy, disjointed laminated, very fine-grainedx-dolomite vugs may be lined with small calcite crystals lopper mineralised yellow-brown, ochreous, highly weathered copper ore granular (medium sand) texture which may be due to silicification; ??sandstone	Much Ma as fracture coatings Much Ma minor bright blue tarnished sulphide grains2(Cc) sometimes with limonite stains Minor 1-2 mm ex-Py blebs Numerous small euhedraix-?Py pseudosin TS (JFD identification) Much Ma as almost continuous blebs and layers	Minor Mn dendritic aggregates to 3 mm; trace talc Some chloritic partings Pink ferruginisation in places; trace ?kaolin ?Silicified; areas of limonite blebs to 5 mm	— Dolomitic breccia developed by hydraulic fluids — — — Feldspathised, silicified, dolomitised fine-grained volcanic Similar to B202 and 207; kaolinised, silicified rock		Mineralised recrystallised dolomitic marble Mineralised recrystallised dolomitic marble Sheared, brecciated, recrystallised dolomitic marble (dolomitic breccia) Altered, laminated ?dolomite or ?siltstone-?sandstone Altered ?siltstone Altered dolomite (silicified, feldspathised, dolomitised volcanic or siltstone) Altered ?sandstone (kaolinised, silicified rock)	mineralised dolo marble Similar to B77 and B78 dolo marble Similar to B77 and B78 dolo marble Probably related to B77, B78 and B79, but much finer grained and little copper mineralisation undifferentiated ?Skillogalee Dolomite undifferentiated ?Skillogalee Dolomite undifferentiated ?Skillogalee Dolomite Undifferentiat	
B85 H3 B86 G3 B87 G3 B88 G2 B89 G2 B90 G2	78381 184 78385 185 78389 186 78392 187 60830 188 78399 189	14 10VR 15 C34965 10VR 16 C34966 10VR(8/3): 17 18 5YR(7/6):	8/6) Nil Y 10YR(8/6) Nil to slight P	tellow ochreous, highly weathered/silty ?ex-dolomite rock has a fragmental appearance, with small quartz grains in a very fine-grained brown matrix; several 2 mm dark brown dolomite rhombs ellow-brown weathered/siltstonewhich breaks into rhombs; strong but discontinuous laminations in places; some small vugs along bedding; fissile along bedding ale brown weathered, laminated ?ex-dolomiteinterbedded with pale yellow loamy material (mostly fines tovery fine sand erruginised gossan-like layered rock; one part is a weathered granular (partly ?silicifie@x-siltstoneor dolomite elddish yellow weathered partly ferruginised soft siltstone-like rock?ex-dolomite or dolomite siltstone/interbedded with yellow weathered soft ?ex-dolomite with small brown blebs ellow, soft, weathered bedded to laminated partly?kaolinised silty dolomitesome folding or slumping	Trace Ma Faint trace Ma; numerous smallex-Py pseudos in stringers along bedding planes in TS (Farrand) Finely disseminated euhedral grains of ex-Py in TS (Farrand) Trace Ma	Minor to major qtz veining Ferruginised; ?silicified Partial ferruginisation ?Kaolinised, white kaolin to 3 mm on a shear surface	Extremely fine-grained, thinly laminated ?tuff or siltstone Fine-grained altered dolomite	— Kaolinised, silicified, feldspathised pyritic siltstone Dolomitised, silicified ?siltstone; similar to B86 — — — — — — — — — — — — — — — — — — —	Altered ?siltstone or ?dolomitic siltstone Altered, laminated siltstone (very fine-grained kaolinised, silicified, feldspathised ex-pyritic siltstone or tuff) Altered dolomitie (altered dolomitised ex-pyritic siltstone) Pod of ferruginised rock, possibly a siltstone Altered ferruginised bedded ?dolomitic siltstone Altered?silty dolomite	undifferentiated ?Skillogalee Dolomite undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite	
B91 F2 B92 F2 B93 F2 B94 F2 B95 E2 B96 H3 B97 G3	78402 190 78406 191 78409 192 78413 193 78416 194 78419 195 78423 196	10 2.5YF 10R 10R 10R 10R 10R 10R 10R 10YF 1	(8/4)	late yellow, weathered, friable bedded rock with yellow-red laminations and granular sandy beds with kaolin around sand-sized grains; second sample is cream-brown, non-laminality weathered rock late red, weathered, granule-size angulabreccia (60-70% clasts) with a clay-size matrix; white-pink-grey clasts; may be within Tinlines Fauntuff ery pale brown weathered, parallel laminated siltstone kaolinised white-grey highly weathered, friable iron-stained siltstone now mostly fines white, hard, densedolomitewith some laminations; larger massive areas surrounded by granular material typical of dolomites from Burra ted-brown, hard, hackly fracture, massivesittstone (?partly silicified) with some laminations, ?interbedded with lighter coloured completely weathered fines' probably representing a formalomite interbed	Abundantex-Py pseudosin TS (Farrand) Trace Ma Very small ex-Py grains in stringers and disseminated Substantial proportion of ex-Py pseudos (Farrand TS)	Kaolin or alunite on fracture surfaces(Check Amdel Rept AC3421/84, A171/84) Trace Mn blebs Coarse apatite in places (Farrand TS)	Weathered volcaniclastic (85% feldspar) Kaolinised laminated ?tuff or siltstone Partly silicified, fine-grained volcanic-derived rock, possibly a tuff (80% feldspar)		Altered, laminated ?siltstone with granular sandy interbeds ?Volcaniclastic Siltstone (silty shale) Altered ?siltstone (altered kaolinised ?tuff) Massive to laminated dolomite Altered, finely laminated ?silty dolomite or ?siltstone Siltstone interbedded with minor dolomite (possibly a tuff)	undifferentiated Skillogalee Dolomite ?volcaniclastic Possible volcanic (85% feldspar) Petrology to re-examine for volcanic contribution undifferentiated Skillogalee Dolomite ?volcaniclastic 11 undifferentiated Skillogalee Dolomite 2 or 4 80% K-feldspar; apatite in TS; quartz blebs with ex-pyrite inclusions similar to B10, 46, 75, 116, 227 and 243	on, and ?correlation with B101 and B212
B98 G3 B99 G3 B100 G2 B101 G2 B102 F2 B103 F2	78426 197 78429 198 77485 199 77488 200 77491 201 77494 202	1078 1078 188 1078 199 C41994 7.55YF 100 55K 11 1078 12 C34970 1078	R/3 Nil C	copper mineralised very pale brown, partly weathered granular sandstone-like rock with some in situ brecciation; semblance of remnant laminae; possiblyighly altered sediment // white, recrystallised dolomitic copper or, rhombs of dolomite to 10 mm leddish yellow weathered ochreous silistone-like rock; probably ex-silty dolomite; laminations defined by discontinuous white, porous pods several mm wide, possibly a siliceous fabric leark red-purple with alternating white banding; highly weathered/altered fine-grained silistone-like rock; distorted banding may be sedimentary slumping; may be a volcaniclastic rely pale brown partly weathered white-greyolomitewith massive but porous texture; may have some silt component white partly weathered, finely laminated (1-2 mm) platyolomite 2-3 mm euhedral books of randomly orientated white mica	Much veined (to 15 mm wide) botryoidaMa; trace Chr; some ex-Py pseudos Massive (30-40 mm masses), veined and disseminatedCc; much Ma Numerous ex-Py pseudosin TS (Farrand)	Much white kaolin Mn blebs on some surfaces Mn blebbing to 1-2 mm	— — — — — — — — — — — — — — — — — — —	#Fine-grained micaceous siltstone or pyroclastic; coarse rhombic cavities indicate the former presence of ?dolomite	Mineralised, altered, in situ brecciated sandstone-like rock Copper mineralised coarsely crystalline dolomite marbli Fine-grained ex-pyritic siltstone or pyroclastic Possible volcaniclastic Massive dolomite Finely laminated dolomite-limestone	undefined ?Skillo mineralised dolo marble undifferentiated Skillogalee Dolomite ?volcaniclastic undifferentiated Skillogalee Dolomite ?volcaniclastic undifferentiated Skillogalee Dolomite ?volcaniclastic undifferentiated Skillogalee Dolomite 10	
B104 F2 B105 F2 B106 F2 B107 F2 B108 E2 B1109 E2 B110 H3	77497 203 77501 204 77504 205 77508 206 77511 207 77514 208 77520 209	C34971 2_5Y	Nil Y 8/2) Slight V 7/2) Slight P 8/1) Slight V 8/1) Slight V 6/0) Slight D	ink-brown, very soft, friable, faintly laminated?ex-dolomite heavily stained with Mn or Fe; sawn surface is black (almost sooty) with many white mica books 'ellow, highly weathered, finely laminated, fine-grained siltstone which parts along bedding planes; weathers to fines; very small stained vugs after ?pyrite White, massive to occasionally laminated, partly weathered ?silty dolomite inkish grey, weathered, soft massive ?ex-dolomite; now mudstone; dessication cracks; crumbles to fines; slickenslides on some surfaces White-grey, hard, massive, fine-graineddolomitemith semi-shothole' texture; 'shotholes' filled with white ?kaolin stained green-blue with copper lark grey laminateddolomite lighter grey laminations; lacy network texture defined by white material; rare dolomite veins; slumped or folded in places leddish yellow, highly weathered, finely mottled soft rock with sandy patches; breaks down to a yellow silt; sometimes slickenslided	Possible ex-Py vugs Numerous extremely small, black?ex-Py spots Ma traces on surfaces	Jet black ?Mn; ?ferruginised ?Kaolin patches to 0.5 mm Mn dendrites completely cover and penetrate rock, and outline bedding Ferruginised in places; some areas completely altered to very soft, white kaolin Minor Mn aggregates; ?kaolin in 'shotholes' White ?kaolin; some secondary qtz	Finely laminated ?limonitic shale or siltstone	Siltstone with splintered quartz and fresh feldspar, indicating a possible proximal volcanic source Kaolinised, feldspathised, silicified ?siltstone	Altered, laminated 7dolomite or dolomitic siltstone Finely laminated siltstone (possible volcaniclastic) Dolomite ?Dolomite (kaolinised, feldspathised, silicified ?siltstone with a possible volcaniclastic component) Shothole' dolomite Laminated dolomite Altered ?siltstone	7, 8 or 10 Many white mica books; probably highly altered version of B103 ?12 Clots of feldspar with white mica may represent recrystallised fragments of volcanic glass Petrology to re-examine for volcanic contribution 12 Possible volcaniclastic Petrology to re-examine for volcanic contribution 12 undifferentiated Skillogalee Dolomite	
B111 H3 B112 E2 B113 E2 B114 E2 B115 E3 B116 E3	77523 210 77526 211 77529 212 77532 213 77536 214 77540 215	0 C41995 10YR 1 10YR 2 7.5YR(7/0);75Y; 3 7.5YR	8/6) Nil Y 7/1) Strong L ((8/0);10YR(8/2) Slight Ir 8/80) Mild to Strong L 5/5YR(7/4) Slight (/c 7/6) Very slight Y	tellow, soft to medium hard, brown-flecked massive rock; small (<1 mm) semi-rounded multicoloured blebs which may be clasts; white slickenslided ?kaolin material in places; no bedding ight grey, harddolomitewith pink lacy colouration around fractured areas (clasts still in situ) iterbedded, fresh, harddolomite(3 types); (a) laminated darker and lighter grey, (b) massive grey with pink lacy fracture fill, (c) white-cream with faint laminations and hackly fracture ight grey, hard dolomite, faint laminae, some non-laminated interbeds to 30 mm; some small vugs to 10 mm lined with very soft white lining a) Light grey, hard dolomite; possible cryptalgal laminations; minor disrupted layers; some small vugs; partly fractured and discoloured red-brown; (b) dark cream more massive interbeds ellow-weathered, copper mineralised, laminated silty ?ex-dolomite; parts of rock are less laminated; sawn surface shows quartz 'blebs' similar to those at southern end of open cut	Trace ex-Py pseudos Very small ex-Py blebs Faint trace of Ma Faint trace of Ma Minor Ma as blebs and fracture coatings Much Az-Ma; Az blebs to 3 mm cover one surface; Ma blebbing generally parallel to layering; beds cex-Py pseudos	One minor qtz vein Trace Mn blebs Small Mn blebs and dendrites on most surfaces Trace secondary Qtz as blebs parallel to laminae; one qtz vein to 4 mm (curved, lensoidal)		Mudstone; no identifiable carbonate; recrystallisation of silica has increased the grainsize of the extremely fine matrix — — — — — — — Copper mineralised siltstone; pyrite is associated with quartz in early silicification; kaolin is primary (depositional)	Fine-grained siltstone (mudstone with no dolomite component; slight possibility of a volcaniclastic component) Dolomite to dolomitic limestone Interbedded massive and laminated dolomite Dolomite to calcdolomite Dolomite Copper mineralised, silicified siltstone (possible volcaniclastic)	undifferentiated Skillogalee Dolomite 10 9 9 9 7 10 Possible volcaniclastic component 9 7 Petrology to re-examine for volcanic contribution 9 9 7 10 10 10 10 10 10 10 10 10 10 10 10 10	on
B117 E2 B118 E2 B119 D2 B120 D3 B121 D3	77543 216 77546 217 77549 218 77555 219 77559 220 77562 221	6	7/2);7.5YR(5/4) Slight (a 8/1) Slight to mild C 8/2) Mild L 10YR(7/2) Slight to mild (a	White, partly weatheredlimestonewith pervasive grey-brown Mn blebs, veins and dendrites giving the rock a dirry brown appearance a) Grey, hard dolomite with white crackle texture; (b) medium grey recementedolomite breccia(20 mm clasts); (c) weathered yellowpyrite-bearing rock copper mineralised, white-grey weathered ?silty ex-dolomite, some laminae; pink and yellow bands may be either laminae or chemical fronts; minor brecciation in places ight grey-cream, harddolomitewith cream-pink crackle texture comprising sand-sized dolomite granules a) Light grey, harddolomite some crackle texture showing recrystallisation (dolomite rhombs); beds to 100 mm; (b) hard, light gregolomite interbeds with brown stains on laminae; possible ripples or algal growths white-grey-cream laminated to bedded partly weathereddolomitewith slightly sandy interbeds; laminated beds to 100 mm width	Faint traces of Ma Fresh pyrite podsin continuous alignment with ex-Py blebs either side of pods; Py appears to be original rock component perhaps preserved by encapsul Numerous Az nodules to 10 mm; some Ma nodules probably pseudomorphingAz; minor Chr staining Some ex-Py holes<1 mm	ating silica Flakes of muscovite or talc to 1 mm scattered through rock Mn blebs and dendrites; some secondary qtz parallel to bedding	— — — — Dolomitic breccia; also described as a dolomitised quartz/dolomite sandstone —	=	Limestone Pyritic dolomite and dolomite breccia Copper mineralised ?silty dolomite Massive dolomite Dolomite (dolomitic breccia) Sedimentary silty dolomite	12 6 Fresh pyrite pods as remnants within a weathered Skillogalee host Petrology, polished section and sulphur isotope 76 Petrology to determine origin 5 4 13 Possible volcaniclastic albite feldspar contribution Photomicrograph of albite horizon	e analysis to determine provenance
B123 E2 B124 E2 B125 D2 B126 D2 B127 D2 B128 D2	77567 222 77570 223 77573 224 77576; 77577 225 77581 226 77586 227	12 C34975	- N 7/1) Slight L 6/1) Slight N 8/1) Slight V 6/1) Slight V 8/1) Mild to strong on rock V	larrow zone of completely silicified copper mineralisatiorfrom within Tinlines Shear ight grey, hard massive dolomite with narrow laminated beds (more towards the unit top'shothole' dolomitetowards the base, with 'shotholes' containing yellow powder ledium grey, interbedded white laminated and non-laminatedolomite probable sedimentary slumping in places; some beds more vuggy than others, showing occasional 'shotholes' white, massive, dense dolomite with no laminae and little bedding; white mica crystals to 5 mm in places; 1 m of massive medium greplomiteat base tark grey (occasionally almost black)dolomite very well laminated in places; some beds to 1 m of bedded grey dolomite with sparsely spaced white laminae; unit is fissile at base white lical flakes	Much Az-Ma crystallised in cavities in Qtz;Az blebbing to 3 mm; several small blebs ofCu; 5 mm dark masses may besulphide Trace ex-Py blebs<1 mm	Strong silicification (qtz shows feather-like layering) Mn blebs and stains in places Mn blebs Mn blebs; trace muscovite flakes	Irregularly foliated rock composed of fine-grained 'granular' quartz (90%) with minor muscovite (10%) — — — Dolomitised sandstone Thinly laminated dolomite (90% dolomite, 10% quartz)		Highly silicified, layered copper mineralised rock Tinline's Shear Shothole' dolomite; partly stromatolitic dolomite with minor sandy interbeds and laminae Dolomite (cryptalgal-laminated sandy sedimentary dolomite) Dolomite (sedimentary) Dolomite (dolomitised siltstone) Massive to laminated limestone to dololimestone (dolomitised siltstone)	silicified shear Possible fresh sulphides 12 11 11 12 13 14 15 15 16 16 16 16 16 16	d the euhedral 'holes' in B16 lower in the sequen
B129 D2 B130 D2 B131 D2 B132 F2 B133 E2 B134 E2 B135 F2	77590 228 77596 229 77599 230 77602 231 77605 232 233 77611 234	10 10 10 10 10 10 10 10	5YR(7/1) Slight to mild N (5/0) Strong N	White laminateddolomiteat contact with B128 (to east); grades downwards into dark grey laminatedolomitetowards base; both types of dolomite are very hard and dense fedium grey-pink bedded (to 0.8 m)dolomitewith buff-coloured crackle texture and white laminated intebeds; probable cryptalgal laminae showing climbing growth structures; fissile towards base fedium grey, massive dolomitewith buff-coloured crackle texture and a hackly fracture; bedded and laminated in places, particularly towards base white, weathered but generally hard ?dolomite; dendrites penetrate the rock fabric; heavily silicified in places are assivedolomitewith well-defined bedding shown as brown to grey layers white to light grey, hard, slightly weathereddolomite for the process of pink-coloured ?quartz-?K-spar are semi-aligned; sand-sized quartz in matrix; possible graded layers	Probable ex-Py pseudosin TS (Farrand) Extremely small disseminated?ex-Py blebs Trace Ma stains Stringers of Az nodules to 10 mm with 1-2 mmChr halo and lighter green? Ma staining between; small Ma blebs through rock	Much Mn blebs and dendrites; red-brown ironstaining in places; partly silicified Trace Mn blebs 2-3 mm evenly scattered Mn blebs Secondary qtz as ?breccia fragments to 30 mm (laminated breccia frags may be silic. dolo.)		*Dolomite (95% dolomite) with cryptalgal laminae *Sandy dolomite; dolomite replacement of quartz is common; quartz (15%)	Dolomite (sedimentary dolomite with cryptalgal laminae) Dolomite (sandy) Massive to laminated dolomite Dolomite Massive dolomite Dolomite Copper mineralised breccia	7 7 6 6 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	rate: photograph two sawn surfaces
B136 D2 B137 B2 B138 B2 B139 B2 B140 B2 B141 E3	77614 235 77617 236 77621 237 77624 238 77630 239 77633; 77634 240	155 C42002 10YR(6/1); 166 7.5YF 10YR	Strong on rock G	irey massive dolomitewith hackly fracture and minor white crackle texture, interbedded with white laminated gradomitefolded in places; minor vugs interpretated present laminated limestonewith non-laminated cream beds to 50 mm interpretation of the process of a lighter coloured areas to 2 mm across); sharply defined beds with fewer 'shotholes' (powder-lined vugs and lighter coloured areas to 2 mm across); sharply defined beds with fewer 'shotholes' inkish grey, densedolomitewith probable beds of algal structures; calcite veins to 2 mm scattered through rock withite-cream to mid-grey laminated to massivelimestone fine laminae resemble algal structures; overlies B19 interpretation of the process of the short white-cream, angular dolomite and quartz clasts in a fine-grained 'dolomitic matrix; part of matrix is saccharoidal quartz	Ma stains; Az blebs through rock, some as stringers; small scarce blebs oCu to 1 mm	Minor pink ferruginisation of white laminae Recrystallised calcite veins to 3 mm wide; Mn blebs and dendrites to 3 mm on fractures Calcite veins to 2 mm	— Thinly laminated to massive fine-grained dolomitic rock; strong similarities tessed. 54, 121 and 127 No!! — Breccia comprised of volcanic and ?siltstone fragments; irregular fragments of volcanic glass are common	*Dolomite stromatolite (98% dolomite) — Dolomitised siltstone; almost identical to B127 — — — Agglomerate, slightly kaolinised, copper mineralised	Dolomite (sedimentary, with stromatolites) Laminated to bedded limestone Dolomite (dolomitised sittstone) Algal-laminated dolomite Algal-laminated dolomite Algal-laminated limestone Copper mineralised breccia (agglomerate)	6 7 7 9 Similar to B127 in TS 9 Similar to B127 in TS 10 5 Similar to limestone component of B154/80 agglomerate Agglomerate, volcanic glass Photograph sawn surface	
B142 B3 B143 G2 B144 G2 B145 G2 B146 F3 B147 F2 B148 F2	77637 241 77640 242 77643 243 77646 244 77650; 77649 245 77652 246 77655 247	11 10YR 12 C42003 10YR 13 10YR 14 C42004 10YR 15	8/4) Nil Y 8/8) Nil Y 6/6) Slight to mild L - C C	ream, pale brown highly weathered/altered and extremely friable? reproper large are medium hard and more massive; sawn face shows a patchy light prown to solven the reverse of the reproduct of the parts are medium hard and more massive; sawn face shows a broken texture with several large vugs containing remnant white clay	Trace Ma blebs Probable ex-Py pseudos in TS (Farrand) Numerous Mn blebs <1 mm;ex-Py pseudos in TS (Farrand) Chr blebs to 20 mm dispersed through rock; euhedraAz crystals in veins to 5 mm; lesserMa as small acicular blebs; very smallex-sulphide blebs in clasts Trace Ma blebbing	Trace Mn blebs Yellow-brown iron staining along laminae Much white kaolin restricted to bedding and laminae Much Mn blebbing on more solid pieces Smeared Fe-Mn staining on surfaces			Silicified, potash metasomatised rock Siltstone (feldspathic mudstone or ash-fall tuff) Weathered ?siltstone or ?dolomite Dolomite (sedimentary, with stromatolites) Copper mineralised ?dolomite breccia Dolomite (stromatolitic) Altered dolomite	metasomatite undifferentiated Skillogalee Dolomite inneral breccia Strong similarities to B37 Photograph hand specimen 11 Similar appearance to B155	titsm
B149 F2 B150 G2 B151 F2 B152 G2 B153 G2 B154 F2	80454 248 80456 249 77662 250 77664 251 77665 252 77668 253	11 10YF 12 10YF	10YR(6/1) Mild to strong on rock (a	ink-grey, yellow ochreous weathering, medium hard, very faintly laminated 7ex-dolomite; layered but not distinctly laminated of seventh of the property of the	Ma blebs on most surfaces; very smallex-py blebs on sawn surface Very minor, very small scatteredex-py blebs sometimes as stringers	Trace Mn blebbing Mn blebs to 2 mm; white-pale yellow-green talcose material on some surfaces Faint trace of Mn; minor reddish ferruginisation		— Pink dolomite (100% dolomite); possibly stromatolitic — — — — — — — — — — — — — — — — — — —	Altered, faintly layered dolomite Dolomite (sedimentary, with stromatolites) Laminated to bedded dolomite with minor limestone Weathered ?dolomite Dolomite Interbedded limestone and dolomite	12 undifferentiated Skillogalee Dolomite 11 Similar to B155 undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite 10-11 Onable Prince wide each of plantacies in traduction probably butterbarred	
B155 F2 B156 F2 B157 F2 B158 G2 B159 G2 B160 G2 B161 G2	77670 254 77673 255 77677 256 77680 257 77683 258 77690 259 77693 260	14	8/2) Strong V 5/1) Slight to mild G 5/2) Slight to strong (c 5.5/3) Nil D 5/22 Mild G	iream-brown, massive dolomite with numerous small 'ex-pyrite vugs; fractured texture iream-brown, massive dolomite minated dolomite pink colouration and very fine sand along some laminae; minor clay-filled vugs white-cream, hard, dense, bedded (5-20 mm/bloomite resembling reef quartz in places ireay, massive 'shothole' dolomite numerous white-pink clay-filled vugs to 10 mm, sometimes containing grains of blue quartz; no bedding a) Grey dolomite with white ?sandy laminae, interbedded with (b) laminated cream dolomite and (c) massive grey dolomite with 1 mm white ?gypsum laths lark red ochreous ferruginous rock with many haematite pseudomorphs after pyrite; probably ask-pyrite veinat least 60 mm wide ster, massive, hard, fine-graineddolomite tinted light pink by ferruginisation; minor vugs iream-brown, massive dolomite with numerous small 'ex-pyrite vugs; fractured texture	Euhedral cubicex-Py pseudosin TS (Farrand) Pyritohedron pseudosto 8 mm Numerous ex-Py holes<1 mm	Some Mn dendrites Traces of Mn dendrites; may be some silicification Trace Mn dendrites Trace Mn blebs; kaolinisation in TS (Farrand)	— Microcrystalline dolomite;up to 10 mm irregular patches of granular quartz or feldspar; fine-grained volcaniclastic extensively silicified then dolomitised — — — — — — — — — — — — — — — — — — —	Sandy dolomite Dolomitised, silicified sediment; rounded and angular patches of coarse quartz mosaic; similar to B138 (but in a different ur Dolomite (95%); kaolinised; up to 4% feldspar which is probably plagioclase	Laminated dolomite (sandy) Dolomite iliβhothole' dolomite (dolomitised sediment) Dolomite with possible limestone laminae Ex-pyrite vein Massive dolomite Dolomite (sedimentary, with stromatolites)	11 Overwhelming evidence of plagioclase introduction, probably hydrothermal 13 12 11 ex-pyrite vein undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite	
B162 E2 B163 E2 B164 E3 B165 E3 B166 E3 B167 E3	77696 261 77700 262 77703 263 77706 264 77709 265 77712 266 77715 267	11	7.5YR(6/2)	icopper mineralised clast-supported brecciangular cream-buff ?dolomite clasts to 20 mm; some clasts possibly silicified and potash metasomatised; parts of rock are white, sugary elelow-brown-black, friable.ferruginous copper mineralised breccia a) Grey, semi-translucent, laminateddolomite (b) partly weathered pale grey dolomite with minor quartz veins; bedded, with a trace of orange ?feldspar linkish grey, semi-translucent massivedolomitewith minor laminae ery pale brown partly weathered, fine-grained laminated dolomite vicen copper-stained white saccharoidal to powdery silicifiedbreccia; some laminae; nearly in situ breccia clasts to 100 mm ream, faintly bedded fine-graineddolomitewith much sugary breccia	Az nodules and blebs to 8 mm; lesseiMa blebs; trace Chr Much fine-grained crystallineAz veining and Ma blebspseudomorphing Az; velvetyMa crystals on some surfaces; trace to minorCu Trace Chr staining; minor Ma blebs to 10 mm on fractures Faint trace Ma Small velvety Ma crystals on some surfaces; trace Chr	?Partial ?silicification Trace orange ?feldspar; qtz veins; much Mn on some surfaces Much Mn on some surfaces One 15 mm qtz vein diffuses into and replaces host rock; pale green talcose material on surfaces; trace Ma Minor qtz veins to 1 mm Partial silicification; trace ferruginisation	Brecciated siltstone or tuff now partly to completey replaced by azurite		Copper mineralised ?dolomite breccia Copper mineralised breccia Dolomite with possible partial silicification and potash metasomatism Massive dolomite Laminated dolomite Copper mineralised breccia Partly silicifed and brecciated dolomite	mineralised breccia mineralised breccia 6 6 6 6 6 mineralised breccia Indicate breccia on future version of geological in the control of geological in the contr	пар
B169 E3 B170 E2 B171 C3 B172 C3 B173 C3 B174 E3	55958; 77719 268 77725 269 77729 270 77733 271 77736 272 77740 273	10 10 10 10 10 10 10 10	- P 8/2) Strong C 7/1) Strong on rock V 7/16) Mild on rock R 8/2) Mild P	rartly silicified copper-stained breccia some angular clasts (<10 mm) coloured pink-orange; may contain large amounts of quartz in 'rock flour' cream-white laminated dolomite minor pink colouration along some laminae White, hard, dense, partly coarsely crystallindimestone 1 m wide; veins of secondary calcite; of weathered version (B172) teddish yellow, weathered and ferruginised, laminate dimestone 1 m south along strike from B171; slightly folded inkish grey, partly weathered, hard, dense, partly laminatedolomite freen copper-stained dolomitic brecciagranule to pebble dolomite clasts (up to 50 mm) mostly matrix supported, some laminated; some small angular quartz clasts	Minor Ma; Az blebs to 8 mm Trace to minor Ma blebs on surfaces Trace Az patches to 10 mm	Silicification, which encapsulates Ma and Az XRD on vein material identified calcite (dominant), palygorskite, dolomite Mn blebs on surfaces	Breccia comprised of angular, thinly laminated lithic clasts in a poorly sorted quartz-feldspar matrix; similar to B174 — Finely laminated dolomite limestone, extensively recrystallised and veined by dolomite (98+% carbonate) Fine-grained, laminated, iron-rich dolomitic limestone — Breccia of angular fragments of fine-grained tuff or siltstone in a fine-grained ?feldspathic matrix; appears to be a volcanic breccia	- - - - - -	Copper mineralised breccia Laminated dolomite to calcicdolomite Finely laminated limestone Laminated limestone (dolomitic limestone) Partly laminated dolomite Hydraulically formed breccia; volcanic breccia	mineralised breccia 9 10 10 10 10 volcanic breccia Very similar to B238	
B175 No locati B176 F3 B177 E2 B178 E2 B179 E3	77743 — 77745; 77746 274 77748 275 77751 276 77754 277		- C	a) copper-stained granule to pebble, angular, pink-brown dolomite breccia (b) brown ferruginised rock with slickenslides on some surfaces; probably from vicinity of B174 copper mineralised granule to pebble, highly silicified? dolomite breccia frown weathered/altered breccia; some clasts to 20 mm are laminated ex-dolomite; layered in places, possibly due to 'flow'; slickenslides; copper mineralisation only in matrix; resembles agglomerate fream-grey, isoclinally folded laminated dolomite with minor breccia White to pale grey, massive dolomite with a hackly fracture; 1-2 mm vugs; some interbeds <50 mm are laminated; sawn face shows possible hydraulic brecciation	Az nodules with 2-3 mmChr rim Botryoidal Ma and Chr (no Az); narrowChr vein cuts throughMa matrix; XRD identified Chr Trace Ma blebs mainly in ferruginous material Trace of sparsely scattered Az-Ma blebs Faint trace of Ma as <1 mm blebs; some Ma associated with silicification	Mn blebs on some surfaces Olive green serpentine like material in places; ferruginisation along slickenslides; small <1 mm qtz veins Several small muscovite flakes; some silicification (+Ma) parallel to bedding near shear		- - - -	Copper mineralised breccia Sillicified, copper mineralised breccia Sandy breccia Laminated dolomite with minor breccia Partly brecciated dolomite	mineralised breccia mineralised breccia Very similar to B198 ?agglomerate Similar to agglomerate Petrology to confirm ?agglomerate; indicate bre 7 6	eccia on future version of geological map
B180 E3 B181 F2 B182 H3 B183 H3 B184 H3 B185 H3	77760 278 77764 279 77767 280 77770 281 77774 282 77778 283	10YF 12	(6/6) Nil R	a) Brown, sandy matrixsaccharoidal quartz brecci with angular clasts <5 mm; sawn face shows probable K-spar; (b) non-silicified weathered version has yellow-brown clasts with quartz blebs; coarsely layered; pc copper mineralisedwhite-brown, fine to medium-grained partly silicified, porous rock with a completelsilicified and potash metasomatised/pore; quartz veins up to 40 mm wide surrounded by rounded saccharoidal uartz grains that break down to a quartz sand; no indication of lithological precursor rellow-brown, weathered, moderately soft, laminated ?dolomite prown, smooth, clay-rich slickenslided, weathered rock with 10 mm pale green sandy patches ted-brown, altered, friable poorly laminated ?ex-dolomite; white talc flakes; some quartz grains; breaks down to a clay-rich 'silt-sand'; the degree of alteration increases markedly from B182 to B184 related policy, highly weathered/altered, poroussilicified ?ex-siltstone/with slickenslided dark green chlorite plates to 50 mm; breaks down to clay plus rounded quartz grains similar to parts of B181	Ma associated with silicification; scattered Az nodules sometimes follow bedding; some green?Chr staining in 'sand' Ma rich (type not recorded)	Qtz veins to 40 mm surrounded by qtz grains Slickenslides Highly kaolinised in TS (Kemp) Slickenslided dark green chlorite plates	Dominantly quartz 'sand' with most of the matrix (possibly microcrystalline feldspar) missing; may have been an acid tuff		Copper mineralised breccia Copper mineralised, silicified, potash metasomatised breccia Altered, laminated ?siltstone or ?dolomite Altered, sheared ?siltstone or ?dolomite Altered kaolinised ?siltstone Altered, silicified, sericitised, sheared ?siltstone or volcaniclastic	mineralised breccia Similar to B177; possible agglomerate Petrology to determine origin; indicate breccia s mineralised metasomatite undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite possible volcaniclastic	symbol on future version of geology map
B186 H3 B187 H3 B188 G3 B189 G3 B190 G3 B191 G3	77781 284 77784 285 77787 286 77790 287 77796 288 77800 289	5Y(55 5Y(66 2.5Y(67 C34989 5G(68 10YR(6/2) 69 C34990 5YR	Nil P	rale yellow, weathered, chlorite-plated, slickenslided silty rock White, weathered talc-rich? dolomite rock, platy, sheared; mostly quartz with talc coatings Fellow-brown, weathered, bedded (slightly warped), partly recrystallised? sheared? dolomitsheared diapir Ferey-green diapiric breccia hard, dense, massive; 5 mm dolomite rhombs; granule to small pebble clasts; larger 100 mm clasts of translucent grey dolomite, some showing matrix injection veinlets Frey-brown, altered, ?silicified? Silitstone; some beds highly friable (break down into 'silt'); one dolomite vein to 3 mm; sawn face shows numerous ex-py blebs as stringers that define layering fale pink-orange, hard, massive.quartz-feldspar rock	Ma rich; 5 mm ferrug blebs surrounded byMa may indicate former copper sulphides some Ma on fracture surfaces 1 mm ferruginous blebs may beex-Py Numerous 0.5 mm fresh pyritohedrons possible blue Cc blebs Ma blebs and plates; numerous scattered blebs and stringers oex-Py Chr on most surfaces; trace Ma in one qtz vein; numerousex-Py holes and ferruginous cubes	Chlorite plates to 50 mm, slickenslides Talc rich and sheared, platey Sheared Dolomitisation Silicification and potash metasomatism; tracetourmaline apatite and ?rutile in TS (Kemp)			Altered, sheared ?siltstone Sheared talc-rich dolomite or diapiric breccia in Kingston Shear Sheared diapiric breccia Diapiric breccia Diapiric breccia Altered, ?silicified ?siltstone Silicified and potash metasomatised ?tuff	undifferentiated Skillogalee Dolomite Kingston Shear diapiric breccia diapiric breccia Fresh sulphides undifferentiated ?Skillogalee Dolomite metasomatite Tourmaline, apatite and rutile in TS; very similar to B215	
B192 F3 B193 F3 B194 F3 B195 F3 B196 F2 B197 7F2	77804 290 77806 291 77810 292 77813 293 77817 294 77820 —	10 7.5YF 11 10YF 12 C34991 7.5YF 13 C34992 5Y(14 C34993 2.5YF	7/6) Nil Y 7/76) Nil Y 7/76) Nil Y 1/1) — L 7/4) Nil C	igsaw brecciated ?silicified and potash metasomatised rocketwork veinedwith malachite; granule to small pebble size angular clasts containing small ex-py blebs; minor drab green serpentine-like clay 'ellow-brown, highly weathered, friable, laminate@ex-dolomitethat breaks down to a clayey silt; red ferruginised laminae 'ellow-brown, completely weathered clayey silt ight grey saccharoidalquartz rock and sandfrom around a quartz vein; stained green in places by copper iream-yellow, highly weathered rock with distorted (sheared) layering; much white kaolin; sawn face shows numerous tan-coloured non-laminar partings (?sericite) on a mm scale ighly friable, layered quartz (?dolomite) 'sandstone'; not located in the field, but probably from the same bench as B196/80	Chr as 1-3 mm veins and fracture coatings; someAz; Ma as network fracture fillings to 7 mm widepx-Py blebs in clasts Opaque grains of ?Cu in TS (Kemp) 5 mm qtz-Az aggregates; trace Ma Numerous stringers and individual subhedral to euhedral grains @ex-Py < 0.1 mm in TS (Kemp)	Partial ferruginisation TS (Kemp) identified extensively feldspathised clasts; silicification 0.5 mm black ?Mn blebs in sand; TS (Kemp) identified 25% kaolinite grains; probable partial silicification Much white ?kaolin-like material with darker shear layers Probable partial silicification	Highly altered, now dominantly 'sand' with angular fragments of quartz grain mosaics up to 18 mm; fragments of volcanic glass; feldspathised; similar to B54 Structureless friable rock composed of medium to coarse quartz grains (75%) and grains of kaolinite (25%); possibly a highly altered tuff Soft, friable, laminated ?volcanic rock with most of the groundmass altered to kaolinite (75%) —		Copper mineralised metasomatite breccia Altered, laminated ?siltstone Altered, silicified, feldspathised ?siltstone or ?tuff Saccharoidal quartz rock (possibly a highly altered tuff) Highly altered, laminated kaolinitic ?tuff or ?siltstone Saccharoidal quartz rock	metasomatite breccia Clasts are very similar to B215 Photograph hand specimen undifferentiated ?Skillogalee Dolomite ?volcaniclastic ?volcaniclastic Similar oversize quartz grains to those in B181 ?volcaniclastic ?volcaniclastic Similar rounded (overgrowth) quartz grains to B195	
B198 F3 B199 G3 B200 G3 B201 F3 B202 F3	77822; 77824 295 77826 296 77836 297 77840 298 77844 299		Nil to strong	copper mineralised brecciancluding angular potash metasomatised and silicified clasts; botryoidal malachite surfaces in some vugs indicate passive invasion of a pre-existing breccia frey dolomite with cream 0.5 mm blebs; 'waxy' surface; manyresh pyriteblebs through rock; interbedded with light grey massive dolomite ink-brown, partly weathereddolomitecoloured by a pale yellow-green mineral white, beathered clay-rich rock small black and white blebs outline layering; pale yellow-green serpentine-like material on some slickenslides ellow-brown, highly weathered, soft rock which breaks down to a fine sand; remnants of laminae or layering; slightly rounded, small ?secondary quartz grains	Much Ma as vuggy breccia matrix and banded veins to 10 mm coated with several mm of Chr; manex-Py pseudosto 8 mm Ma blebbing within liesegang rings; many <1 mnfiresh Py (possible Cc) blebs through rock;ex-Py with qtz in TS (Farrand); Polished sectior -5% opaques — Py +99%, Cc trace Much Ma as blebs and aggregated blebs on surfaces Some areas of numerous ex-Py blebs to 2 mm; much Chr staining in places	One 2 mm wide qtz vein truncated by the Ma, and several small qtz fragments occur in the Ma Liesegang rings; minor quartz veining to 10 mm Numerous qtz veins to 10 mm;XRD of green mineral identified dolomite, montmorillonite and ?opaline silica Pale yellow-green serpentine-like material on some slickenslided surface stourmaline (10% in Kemp TS); XRD of white blebs – kaolinite	Very fine-grained, faintly laminated, silicified, dolomitised acid ?volcanic Soft, friable, faintly laminated kaolinitic (–90%) rock dusted with fine crystals of tourmaline (10%); possible volcanic origin Soft, friable, weathered rock with kaolinitic laminae; 65% quartz grains in a clay matrix; could be called a 'sandstone', but possibly volcaniclastic	Dolomitised shale, comprising an ultra-fine-grained mass of clay minerals	Copper mineralised, ex-pyritic, angular metasomatite breccia Very fine-grained dolomite (silicified, dolomitised shale or acid ?volcanic) Partly altered, silicified ?dolomite Kaolin rock (kaolinised ?volcanic) Kaolinito ?sandstone	mineralised metasomatite breccia undifferentiated Skillogalee Dolomite or volcaniclastic undifferentiated ?Skillogalee Dolomite Similar to B84 and B207 in TS	
B203 F3 B204 F3 B205 F3 B206 F3 B207 F3 B208 G3	77847 300 77850 301 77853 302 77856 303 77860 304 77864 305	100 10YR 111	Nil C	ellow, highly weathered, very fine-grained (?clayey /ex-dolomite second sample is silicified buartz; minor clay-lined vugs with small crystals of unknown mineral country into a silicitied buartz, remove the country of the country	Ma-Chr veins to 10 mm with ex-sulphide blebs Minor Ma Much Ma as elongate blebs and finely disseminated grains; the largeMa blebs are associated with the qtz veins,Sph grains to ~1.4 mm (Kemp TS) Trace to minor Ma blebs to 5 mm	White 2 mm wide ?kaolin veins, minor ferruginisation; qtz veins or silicification to 40 mm wide, sugary halo Qtz from small vein Potash metasomatism and silicification Yellow-green serpentine-like minera@RD (kemp report) of dark-fined grained rock indicatedourmaline(dominant) Qtz as veins and grains to 10 mm wideyutileneedles in quartz in TS (Kemp)			Altered ?dolomite Quartz from a vein in a area of intense silicification Copper mineralised metasomatite breccia (Tournaline-rich rock) Altered ?sandstone Silicified and potash metasomatised rock (metasomatised ?tuff)	undifferentiated ?Skillogalee Dolomite quartz vein mineralised metasomatite breccia metasomatite tourmaline rock undifferentiated ?Skillogalee Dolomite metasomatite metasomatite possible volcaniclastic Possible fluid inclusion study Possible fluid inclusion study Possible fluid inclusion study Similar to B192 and B198	
B209 G3 B210 F3 B211 F3 B212 F3 B213 F3 B214 F3 B215 F3	77873 307 77876 308 77880 309 77883 310 77886 311 77890 312	16	Nil B Nil B	incount-grey siliceous ?ex-dolomite with minor orange ?feldspar; trace of bedding; much yellow-green alteration as for B200 keddish yellow, highly weathered, soft, friable rock that breaks down to a fine quartz sand; faint layering; rounded quartz-grain overgrowths teddish yellow, highly weathered, soft, friable rock that breaks down to a much finer clayey material than B210; distinct laminae; ?ex-dolomite; minor rounded quartz-grain overgrowths tark grey, highly altered breccia with numerous angular quartz grains; white lathes to 1 mm through rock ellow, laminated, weathered?ex-dolomite(clay, silt); second sample has rounded quartz-grain overgrowths and resembles a friableandstone freem-stained, saccharoidal quartz rockwhich breaks down to a fine quartz sand (probably secondary quartz); some possible 30-40 mm clasts of very fine-grained secondary pink quartz tream-pink, hard, dense,quartz -?feldspar rock of granitic appearance	Numerous ex-sulphide blebsto 4 mm Some ex-Py blebs to 1 mm Blotchy Az associated with 2-3 mm qtz veins; traceMa Ma staining throughout; oneAz-qtz nodule Minor Ma on surfaces; trace ex-sulphide holes rare euhedralPy grains in TS (Kemp)	Much yellow-green alteration; some Mn blebbing Large broken patches of qtz are probably broken up qtz veinstourmaline(10-25%); XRD of clayey rock — 50:50 qtz-montmorillonite Qtz veins; some narrow white ?kaolin veins; pink liesegang rings Minor ferruginous blebs; silicification ?Feldspathised-silicified; later minor qtz veining; frequent apatite crystals (Farrand TS)		Altered ?tuff or ?lava; similar to B52 and 53	Silicified and potash metasomatised ex-pyritic ?dolomite Altered ?sandstone Altered ?solomitic ?siltstone Altered precia (kaolinised, silicified, tourmalinised, fine-grained volcanic) Altered, intercalated dolomite and ?sandstone Saccharoidal quartz rock Silicified and potash metasomatised rock (metasomatised ?tuff)	metasomatite Very similar to B205 and B198, but unmineralised undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite ?volcaniclastic Similar in appearance to B92; ?volcaniclastic Petrology to re-examine for volcanic contribution undifferentiated Skillogalee Dolomite volcaniclastic Petrology to re-examine for volcanic contribution undifferentiated Skillogalee Dolomite ?volcaniclastic Petrology to re-examine for volcanic contribution metasomatite Possible volcaniclastic	on, and ?correlation with B92 and B101
B216 F3 B217 F3 B218 F3 B219 F3 B220 F3 B221 F3	77893 313 77897 314 77900 315 77904 316 77910 317 77913	3 7.5YR(66): 4 C35002 7.5YR(66): 5 C35004, 03		ellow-brown, weathered rock; breaks down to ælayey sandwith probable quartz overgrowths; blocky dark brown harder ?beds; partly brecciated; possiblequartz-feldsparcontent copper mineralised pink feldspathised-silicified rockbrecciated and vuggy	Numerous ex-sulphideblebs in softer rock; muchMa in harder bands 5-15 mm Chr-Az-Maveins; Az or Ma crystals pseudomorphed by Chr, some Az pseudomorphed by Ma; ex-sulphide pseudosto 1 mm Ma, Az, Chr in varying amounts; Ma crystals under drusy qtz in places Chr blebs to 4 mm in places Large number of very smallsulphide blebs; Polished sectior 1-2% opaques — Cc 90%, Py 5%, Cu 5%; Ma in fibrous veins ~0.15 mm thick; possibleLi; Polished Section B219A1-2% opaques — Cc 60%, Py 40%, Cu trace	Narrow qtz veins; apple-green ?montmorillonite alteration Probable potash metasomatism and silicificationnoe qtz vein 20 mm wide Probable potash metasomatism much free qtz (large grains); trace Mn dendrites; ?serpentinisatiorapatite, tourmalinein TS (Kemp)	Hard, microcrystalline quartz-feldspar rock (quartz 70%, feldspar 30%); feldspathised and silicified acid ?tuff (B) Extensively dolomitised (70%), coarsely crystalline quartz-feldspar rock (E) Feldspathised, silicified, partly dolomitised volcaniclastic — —————————————————————————————————	(B) Mineralised, dolomitised quartz-microcline rock (E) Mineralised, kaolinised ?chert	Altered ?siltstone Silicified and potash metasomatised breccia (metasomatised ?tutf) (B) Silicified and potash metasomatised breck (E) Silicified, feldspathised rock, possibly a chert or volcaniclastic Altered, silicified, ?brecciated quartz-feldspar rock Highly altered, partly silicified rock Altered, laminated ?dolomite or dolomitic ?siltstone	undifferentiated ?Skillogalee Dolomite metasomatite Possible volcaniclastic mineralised metasomatite Possible volcaniclastic ?metasomatite & ?dolomite ? resh sulphides ? undifferentiated Skillogalee Dolomite	
B222 F3 B223 F3 B223 F3 B224 F3 B225 F3 B226 G3 B227 G3	77916 319 77919 320 77923 321 77926 322 77929 323 77932 324	9 2.5Y 9 7.5YF 10 7.5YF 11 C35005 — — 12 7.5YF 13 — — 14 5YR(7/2):	P P P P P P P P P P	ink, highly weathered/altered soft, friable probably sedimentary rock with contorted laminae teddish yellow, medium-grained quartz 'sandstone', saccharoidal texture similar to that found around quartz veins teddish yellow, medium-grained quartz 'sandstone', saccharoidal texture similar to that found around quartz veins ted inclusion studiespossible silicification and partial 'Ppotash metasomatismof a 'dolomite ellow-brown, highly weathered/altered, soft, friable rock; now silt to fine sand; quartz grains showing rounded overgrowths restricted to some laminae; clayey in places; some purple laminae copper mineralised brecciquartly in situ); small, angular,laminated cream 'dolomite clasts (5-8 mm but up to 25 mm); clasts completely silicified in places; matrix of copper minerals rown, laminated, blockysilicified silistonenterbedded with paler yellow-brown ochreous rock; from bench above main ore zone; characteristic quartz 'discs' to 1.5 mm	Ma-qtz blebs to 8 mm Trace Ma and ex-sulphidesor Mn blebs Ma patches to 10 mm Ma (lesser Az) as breccia matrix, some probably pseudomorphingAz; coarsely crystallineAz to 8 mm; botryoidal Chr Minor Ma-Chr Minor Ma-bles and veins; employ-By pseudoe	?Kaolin blebs parallel to laminae; secondary saccharoidal qtz; red-brown ferruginisation Possible silicification Silicification; etz veine to 20 mm			Altered, silicified ?sedimentary rock Altered quartz ?sandstone or highly silicified, altered rock Hydrothermal quartz vein (extreme silicification of a fine-grained ?volcanic) Altered, laminated ?silistone to fine ?sandstone Copper mineralised, in situ brecciated, laminated ?dolomite Silicified silistone	undifferentiated ?Skillogalee Dolomite ? quartz vein quartz vein undifferentiated ?Skillogalee Dolomite mineralised breccia 2 or 4 Quartz belbs similar to B39, B41 and B57; possible volcaniclastic Petrology to determine any volcanic contribution Petrology to determine any volcanic contribution	on.
B228 G3 B229 F3 B230 Delete B231 F2 B232 F2 B233 G3 B234 G3	77935 325 77938 326 — Not us 77945 327 77948 328 77951 329 77955 330		77(6) Nil C	sirey, weathered/altered crushed silicified and potash metasomatised rock; some grey shaley waxy ?layers siev-brown, highly weathered, soft, friable poorly to well-laminated rock that breaks down to a fine silty-sand; orange-yellow hackly clay-rich horizointercalated ?ex-dolomite and siltstone lot located and no sample urple-yellow-brown mottled, highly weathered, soft, friable poorly laminated to bedded rock that breaks down to a clayey silt; rounded quartz grain overgrowths; distorted bedding; breccia adjacent to shears ight grey-fawn, weathered claystone; possibly originally allomite faintly bedded; coarser grained more yellowish beds contain a few quartz grains as part of the rock fabric relielow, hard, hackly fracturingsilicified siltstoneunderlain by a yellow ochreous laminated rock; sandy interbeds break down to fine-medium sand opper mineralised, dark brown, highly weathered, soft, friable, laminated medium sandy rock	Minor Ma blebs and veins; smallex-Py pseudos Disseminated, extremely smallex-Py blebs Very minor trace Ma Ma (some Chr) on surfaces and in vugs Much Ma in qtz parallel to bedding and in disjointed veinsMa more abundant in some layers	Silicification; qtz veins to 20 mm Otz grains in stringers that resemble broken up qtz veins Minor 1 mm ?kaolin veins; some qtz veining to 10 mm (qtz now broken up) Otz veins (sometimes broken up) to 10 mm Some chlorite shears			Silicified and potash metasomatised rock Altered, bedded to laminated ?siltstone and ?dolomite — Altered, sheared, laminated to bedded ?siltstone Altered claystone or dolomite Intercalated silicified siltstone and ?dolomite Copper mineralised, silicified ?siltstone (silicified, potash metasomatised ?volcanic rock)	metasomatite undifferentiated Skillogalee Dolomite Skillogalee Dolomite Undifferentiated Skillogalee Solomite	
B235 G3 B236 G3 B237 E3 B238 E3 B239 H3 B240 H3	77958 331 77962 332 77965 333 77967; 77966 334 77969 335 77975 336	SYR	Nil L Nil L Nil L Nil L Nil L Nil L Nil Nil	ight brown, hard, hacklşilicified ?siltstone-?dolomiterith chloritic shear slivers ream-pink-green, partly ?montomorillonite-chlorite ?sandstone showing sand-sized euhedral dolomite grains in a ?montmorillonite matrix; white alteration product; bedded and coarse irregular laminae copper mineralised laminated, fractured andin situ brecciated ?ex-dolomite ellow-brown granule to cobble (50 mm) anguladolomite breccia clasts of laminated to massive dolomite; some silicified rock clasts; one clast may be cryptalgal laminated ?dolomite; pale green waxy clay-sand-rich white, weathered/altered silicified rock, layered with chlorite slivers ellow, highly weathered/altered, layered to laminated rock; brown clay layers define laminae; white-cream talc occurs as distinct horizons	Botryoidal Ma veins <2 mm Ma (some Chr) through rock Az veins to 2 mm showing partial alteration toMa and Chr; Az colouration extends to host rock; fractures and breccia matrix containChr	Chloritic shear slivers ?Montomorillonite and chloritic alteration; white alteration product may be kaolin; dolomitisation Qtz veins, and blebs to 20 mm; chlorite slivers Much qtz that appears to have developed within a porous rock, then the rock being eroded; much talc	— Partly dolomitised, medium-grained quartz(25%)-feldspar(30%) rock; possibly volcanic — — — — — — — — — —		Altered, silicified, sheared, intercalated ?siltstone-?dolomite Partly dolomitised and altered ?sandstone (dolomitised quartz-feldspar rock, possibly ?volcanic) Copper-mineralised, in situ brecciated, laminated ?dolomite Angular breccia of laminated to massive dolomite clasts in a clay-sand matrix Altered, sheared, silicified rock Altered siltstone (altered micaceous sandstone probably sheared by the Kingston Shear)	undifferentiated ?Skillogalee Dolomite undifferentiated ?Skillogalee Dolomite undifferentiated ?Skillogalee Dolomite ### Possible volcaniclastic ### Some jigsaw breccia breccia in 5	
B241 H3 B242 H3 B243 H3 B244 H2 B245 E2 B246 E2 B247 E3	77978 337 77982 338 77986 339 77989 340 77992 341 77996 342 77999 343	C42U10 SYR	8/6) Nil Y 8/6) Mild C 8/4) Very slight P	ink-brown, hard, massive silicified?siltstone interbedded finely laminated, soft cream-yellowclaystone probably anex-dolomite ellow ochreous layered to laminated rock with scattered, rounded (now elongate parallel to layering) quartz grains and veins to 1 mm; apparent gas bubbles in some quartz blebs; probabilitatione between yellow, medium soft, weathered, very fine-grainedolomite ink, soft, weathered/altered, friable, poorly layered/between or sitty dolomite breaks down to a very fine sand; many quartz grains in rock fabric show rounded shapes typical of silicification copper mineralised altered, partly ferruginised, partly layered/ex-dolomitic siltstone topper mineralised completely altered ore-zone rock with much apple-green ?montmorillonite showing desiccation cracks; two sets of slickenslides on one surface intercept at ~60°;	Euhedralex-?Py grains to 0.3 mm partly altered to ?haematite in TS (Kemp); largeex-Py grains are frequently associated with quartz blebs Fine grains of ex-Py pseudosin TS (Farrand) Numerous Ma blebs to 1 mm on one surface Ma blebs along layering; patches ofex-sulphideblebs; some Az nodules; small blebs of Chr in places Scattered Chr blebs to 3 mm and Ma to 2 mm; trace Cu as 1-2 mm blebs; one 15 mmAz nodule	White kaolin veins XRD of hard, microcrystalline ?siltstone indicated qtz 95%, trace feldspar Irregular Mn blebs and well-developed dendrites to 25 mm Some secondary qtz veins Dark Mn staining along some layers;XRD of pale green mineral identified Ma, montmorillonite and minor qtz ?Montmorillonite	Thinly laminated siliceous ?siltstone Finely laminated ?limonitic siltstone or ?tuff (20% feldspar)	*Ferruginous shale — Fine-grained siltstone *Fine-grained dolomite (95%) — — — —	Altered, laminated 'salitstone (shale) Interbedded silitstone and dolomite Altered silitstone (fine-grained silitstone or tuff) Dolomite (sedimentary) Altered, partly silicified sility 'dolomite Copper mineralised dolomitic silitstone Altered copper mineralised day-rich rock	undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite 2 or 4 Possible volcaniclastic; numerous flattened blebs of quartz several mm long similar to B10, 46, 75, 97, 116 & 227 undifferentiated Skillogalee Dolomite 9 10 mineralised rock in 2	
B248 E3 B249 E3 B250 E3 B251 E3	78002 344 78004 345 78011; 78012 346 78015 347	PS30619 — 10YR 166 C35010 — 177 — 179 — 17	- Mild C 2 8/1) Nil C - V - S - Nil A	copper mineralisec, cream-grey, partly silicified, bedded but fractured to brecciatedolomitic ore-zone rock with fresh sulphide; clasts show 'bent' laminations; second sample is well laminated, alteredolomitised silitatione-?dolomitis with dolomite rhombs to 3 mm, dark grey with white lamination luartz showing etched boundary similar to B224; quartz has appearance of having replaced a pre-existing layered rock; minor pink areas are probably K-feldspar, ie the rock may bailiceous metasomatite White-grey highly altered rock; apple-green alteration (has disappeared due to ?dehydration since collection); minor 1-2 mm acicular ?amphibole crystals; waxy khaki-grey ?serpentine coating on some surfaces; lickenslides on one surface, numerous rhombic (not cubic) voids to 1 mm throughout sample; rock breaks down to clay when wet, possibly indicating a former dolor pole-green, highly altered medium hard rock; pink, har@quartz-feldsparpatches in places; ochreous yellow sand to granule breccia on one surface; grey waxy material through rock	Az-Ma veining; Cc-Cu as network veins to 3 mm;Az crystals to 1 mm; second sample hasMa along layers and someCc along layers; Polished section1-2% opaques — Cc 98%, Co 1%, limonite 1%; Ma appears as an alteration product ofCc Trace 0.5 mm ex-sulphide blebs with ferruginous haloes Ma stains; trace 0.5 mm Ma blebs	Otz crystals line some fractures; possible dolomitisation or dolomite recrystallisation in second sample Probable silicification; minor Mn blebs Mn or FeO blebs on most surfaces; ?serpentinisation; minor qtz veining and replacementnagnesioriebeckiteand tourmalinein TS (Kemp) Grey waxy material through rock	K-feldspar(40%)-quartz(40%) rock partly recrystallised to quartz, albite, mica and tourmaline	- - -	Copper-mineralised, in situ brecciated dolomite and dolomitised, altered dolomite-siltstone Siliceous metasomatite or hydrothermal quartz vein Highly altered ?ex-dolomite (quartz-feldspar rock altered to include albite, mica and tourmaline adjacent to the feldspar porphyry Altered quartz-feldspar rock (metasomatite) adjacent to the feldspar porphyry	mineralised breccia at 1-2 contact In situ brecciation; fresh copper sulphides Petrology to determine composition of laminater metasomatite Similar to B224 Albite, magnesioriebeckite and tourmaline in TS altered metasomatite	ed sample
B253 E3 B254 E3 B255 E2 B256 E2	78022 349 78025 350 78028; 78029 351 78031 352	19 C35011 10RI 160	8/2) Slight to mild S	lark red-brown pod of highly altered medium soft rock; light apple-green waxy mineral in places; sawn face shows grey-black, hard ?clasts of unknown composition in a brick-red matrix; becomes extremely friable worpper mineralised, white, very finebreccia; quartz and ?potash feldspar clasts; sandstone-like in places; porous siliceous structure; rounded secondary quartz grains copper mineralised, pink, hard rock completely enveloped and coloured by light apple-green ?montomorillonite; sawn surface shoganulated pink ?feldspar (metasomatite) a soft, apple green ?clay matrix copper mineralised cream-light brown, harddolomite breccia angular clasts to 20 mm, some finely laminated, cemented by cuprite; part of matrix is brown, soft, layered, wrapped around clasts; sawn face of secon ample shows a cuprite nodule with flecks of native copper, extensively replaced by malachite which outlines 'flow' band' copper mineralised brown-dark brown silicified siltstone andtolomite breccia matrix of similar material; clasts to 60 mm sometimes show laminations; sugary and mottled texture in places light grey dense, bard, laminated to heddertholomite approx 1 mm alternating dark and light grey laminate.	Chr stains and veins; Az nodule stringers Ma blebs to 3 mm Ma in networks and matrix; minor to majo:Cu with muchnative copper, Polished sectior >70% opaques — Cu -80%, native copper <1%, Py <1%, Ma 15%, limonite 3%. Abundant Az-Ma pods and stringers; veins to 10 mm and patches or Cu with native copper generally enclosed byMa; Az crystals to 1 mm; Polished sectior 40% opaques — Cu 99+%, native copper <1%	Light apple-green waxy mineral in places; Mn staining Feldspathised, silicified in TS (Kemp) Mn blebs on surfaces, iron oxide on one fracture surface	Highly porous feldspathic (60%) silicified (20%) rock cemented by secondary copper minerals	— Mineralised quartz-microcline rock — — — — — — — — — — — — — — — — — — —	Altered rock adjacent to the feldspar porphyry; "Volcanic Copper mineralised, finely brecciated metasomatised rock Brecciated metasomatised rock Copper mineralised dolomite breccia Copper mineralised siltstone–dolomite breccia	alteration zone in 2 Possible volcaniclastic Petrology to identify rock type mineralised metasomatite breccia in 2 mineralised breccia in 9 Cuprite, native copper and fresh pyrite in PS mineralised breccia in 6 Cuprite and native copper in PS	
B257 B3 B258 B3 B259 D3 B260 D3 B261 D3	78034; 27848 353 78037 354 78041 355 78048 356 78052 357	16 10YF	Mild C C C C C C C C C	ight grey, dense, hard, laminated to bedde dtolomite approx. 1 mm alternating dark and light grey laminae ream-white, harddlapiric breccia partly sheared, angular to subrounded clasts, predominantly of dolomite rhombs to 10 mm; one 40 mm clast; several small quartz clasts fellow, medium soft, highly weathered, friable layered to laminated sheared siltstone or silty ?ex-dolomite; some dolomite rhombs to 5 mm; breaks down to a medium sand; angular quartz clasts to 10 mm in coarser agmental layers; strong slickenslides on many surfaces lightly similar to B259 but with khaki green-grey, sub-parallel but fractured and kinked ?chlorite slivers; rock breaks down to a medium sand; partly corroded pink mineral may be K-spar; white blebs to 15 mm of pos fellow-brown, altered and weathered, friable, layered to laminated siltstone or dolomite; quartz-grain-rich layers vs clay-rich layers plus quartz grains; quartz grains show secondary overgrowth rounding; slickenslide ineral in places; layered rock is in contact with breccia of sand-sized clasts; some semblance of layering in the breccia at a slight angle to the bedding	Trace Ma blebs on surfaces; very fine-grainedex-Py pseudos in darker bands in TS (Farrand) Some Ma staining; abundantex-sulphideblebs sible dolomite	Mn blebs on surfaces, iron oxide on one fracture surface Liesegang rings Fibrous talc in TS (Kemp) Chlorite slivers		*Cryptalgal-laminated grey dolomite (99% dolomite) Micaceous, recrystallised siltstone; similar to B184 and 185; sericitic muscovite Kaolinised quartz-microcline rock; similar to B259	Dolomite (cryptalgal-laminated sedimentary dolomite) Sheared diapric breccia Sheared siltstone (micaceous, recrystallised ?siltstone or ?volcaniclastic) Altered sheared dolomite or siltstone Altered fine sandstone (partly silicified, ?potash metasomatised ?siltstone or feldspathic tuff)	diapiric breccia undifferentiated Skillogalee Dolomite stigntly similar to B259; possible volcaniclastic with 65% K-spar	on
B262 D3 B263 C3 B264 C3 B265 C3 B266 C3 B267 D3	78055 358 78050; 78060 359 78062 360 78065 361 78069 362 78072 363	10 10 10 10 10 10 10 10 10 10 10 10 10 1	77(6) Strong B - Slight C (6/0) Mild L 5*FR(8/3) Strong G 7.5*YR(7/0) Slight G	ight grey, dense, hard, massive, non-laminatedolomite weathers yellow-brown; second rock type is yellow-brown-weatheringitstone with numerous 1-3 mm ill-formed quartz blebs with long axes parallel to bedding received in a grey of an experiment of a grey of	Ex-sulphideblebs in some clasts Ma stains on fracture surfaces and along selected layers; **p-sulphideblebs < 0.5 mm Rare ex-sulphideblebs << 0.5 mm	Otz veins to 1 mm; trace Mn blebs; liesegang rings Mn blebs on some surfaces Secondary pink dolomite veins Mn blebs on some surfaces	— Grains of dolomite, quartz and feldspar set in a matrix of fine-grained feldspar, talc and chlorite Thinly laminated magnesian limestone with rare, thin laminae of non-carbonate material probably of volcanic, air-fall origin Laminated dolomite (95+% dolomite) — Dolomitic breccia comorised of fine-grained, angular dolomite clasts in a crystalline dolomitic matrix		Intercalated siltstone and dolomite Angular dolomite breccia Copper mineralised recrystallised marble breccia Laminated dolomite (laminated dololimestone with a possible volcanic air-fall component) Dolomite (possible air-fall clastic component) Massive to laminated dolomite Angular dolomite breccia	2 unassigned dolomite breccia mineralised dolo marble breccia 6 Similar to B272b; small euhedral muscovite flakes found in TS; possible volcaniclastic 5 Very similar to B273; small slightly rounded muscovite flakes found in TS 5 unassigned dolomite breccia Slightly similar to B271	
B269 D3 B270 D3 B271 E3 B272 D3 B273 D3	78080 365 78087 366 78092 367 78095 368 78098 369	9 5YR(7/1);	77/1) Strong C 88/2) Slight V - V 7//1) Strong L SFYR(7/3) Strong C	White, medium-grained?quartz-dolomite ?sandstone with some clasts to 5 mm of grey ?siltstoneome broken dolomite rhombs, one rhomb to 30 mm; chlorite slivers White, massive ?recrystallised dolomitic rockith translucent grey euhedral dolomite rhombs to 20 mm; granular dolomite-quartz matrix; is a coarser grained version of B268 ight grey, hard, dense, laminateddolomitewith mm-scale light grey-cream laminae and probable cryptalgal laminations; euhedral white mica flakes to several mm scattered through the cream-pink laminae; second ample is cream-pink laminated dolomite with some less laminated beds to 20 mm; minor warping of lamin sery, hard, dense, massivedolomitewith crackle texture and more massive pink dolomite with no discernible bedding	Much Az-Ma as very thin fracture coatings and crystals; minoChr; much Ma occurs as dolomite crystal coatings; trace brown?Cu Minor ex-sulphideblebs	Chlorite slivers; talc fibres in TS (Kemp) Mn blebs on some surfaces Qtz crystals developed in one vug	Dolomitic breccia comprised of fine-grained, angular dolomite clasts in a crystalline dolomitic matrix — Dolomite sandstone (70% dolomite) Coarsely crystalline dolomite with euhedral porphyroblasts of dolomite to 10 mm; partly silicified, ?feldspathised dolomitised ?volcaniclastic — — —	Medium-grained dolomitic sandstone Dolomitised quartz-microcline rock	Angular dolomite breccia Copper mineralised recrystallised dolomite marble Dolomitic sandstone Dolomite marble (dolomitised, silicified, potash-metasomatised rock) Laminated dolomite Massive dolomite	unassigned dolomite breccia mineralised dolo marble unassigned dolomite breccia unassigned dolomite breccia recrystallised dolo marble 6 Euhedral white mica flakes scattered through lighter cream-pink laminae	
B274 D3 B275 D3 B276 D3 B277 I3	78101 370 78104; 27850 371 78109 372 78113 373	70 C42013 7.5YR(8/6) C42014 7.5YR C35020 7.5YR C35021 10YR	10YR(8/1) Nil to strong V 882) Strong P Slight C C 77/6) Nil ir	hithe-grey, hard, faintly laminateddolomite interbedded with platysiltstone inkish white, hard, dense, sometimes layered 'quartz-ricidolomite second rock type is cream-grey dolomite with partial rhomb development and chlorite slivers inkish white, dense, sometimes layered 'quartz-ricidolomite second rock type is cream-grey dolomite with partial rhomb development and chlorite slivers inkish white, dense massive dolomite with possible silicification and potash metasomatism; possibly a more advanced development of '?chlorite slivers and granulation than B275; similar to B271; second sample is ompletely silicified with weathered pink patches that may have been K-spar fellow, weathered, friable, layered sandy rock; in places contains distorted silty laminae; rounded quartz-overgrowth grains in lighter yellow part of rock; second sample shows higher clay and silt content, probably tercalated siltstone-dolomil ellow, granulated or recrystallised, layered dolomite from a '?clast within thdiapir	Numerous very small <0.1 mmsulphide or ex-sulphide:rystals in places Numerous ex-sulphideblebs to 1 mm in both rock types Very small trace of Ma; very small ex-sulphideblebs	Minor qtz veining to 2-3 mm Scattered Mn blebs in places; chlorite slivers ?Chlorite slivers; talc in TS (Kemp) Kaolinite 10% in TS (Kemp) Apatite crystals up to ~0.05 mm are included in dolomite and quartz veins (Kamp TS)	——————————————————————————————————————	Very fine-grained feldspathic siltstone *Dolomite (95% in fine fraction, 70% in coarse)	Altered, intercalated siltstone-dolomite (silicified, fine-grained, feldspathic siltstone or tuff) Dolomitic clast from the diapiric breccia	4 alteration in 2 71 Possible potash metasomatism undifferentiated Skillogalee Dolomite Possible volcaniclastic diapiric breccia Apatite in TS	
	78118 374 78122 375 78130 376 78134 377 78135; 78316 378	75 C35023, 24 — — — — — — — — — — — — — — — — — —	Strong on rock C	opper mineralised, recrystallised dolomite brecctem near Peacock's air shaft; chalcocite matrix to angular coarsely crystalline dolomite clasts to 15 mm	Ma blebbing and veining,Cc veins and blebs;Az veins to 0.3 mm; Polished section10-15% opaques — Cc 99%, Co <1% Many pyritohedrons showing partial to complete replacement by Cc Cc matrix, veins and stringers of disseminated blebs;Az-Ma blebs and crystals in parts of rock containing little sulphides; Polished section70% opaques — Cc 80%, Bo 20%, qoethite <1%	Apatite crystals up to ~0.05 mm are included in dolomite and quartz veins (Kamp TS) Fibrous crystals of talc in the matrix (Kemp TS) Qtz crystals to 5 mm in vugs Some chlorite stringers	Dolomitic quartz sandstone (A) Calcite-dolomite breccia (B) Partly calcified breccia of dominantly dolomitic and volcanic fragments Medium-grained crystalline dolomite; quartz-feldspar-mica now extensively replaced by dolomite; subsequently copper mineralised — —	 - 	Diapiric breccia Copper mineralised dolomite (dolomitised, silicified, potash-metasomatised rock) Quartz vein from the "Burra porphyry" Copper mineralised recrystallised dolomite marble breccia	diapiric breccia mineralised dolomite Fresh sulphides in PS quartz Fresh sulphides in hand specimen mineralised dolo marble breccia Fresh sulphides in PS Fresh sulphides in PS	
B285 F3 B286 E3 B287 I3	d 78140; 78141 380		- H Nil C - E - E - P V	rebably a sample from Kingston Shear incorporating diapiric breccia; much talc leavy azurite nodule110 mm across which, when sawn, shows a 40 mm core of remnant chalcocite with a halo of malachite and outer rim of azurite liveram-grey feldspar porphytyfrom stockpile on bench (near in situ); much grey-blue chalcocite overprint; 'silicified lark red-brown vertical ferruginous pipe in haul road; breaks down to mush when wet; possible rounded quartz-overgrowth grains; may be a highly ferruginised dolomite lale brown, weathered, friable, irregularly layered sandy rock; some elongate pods; probably a highly weathereditstone same as B277; some 2-3 mm elongate blebs that were possibly quartz discs with minute pyrite levely pale brown, fine-medium grained, angular to sub-angular dolomite sandstone from dyke-like bodywithin an unusual dolomite breccia with a predominantly dolomite-quartz sand matrix	Az nodule with aCc core surrounded by Ma; later narrow Ma veins cut all minerals: Polished section 15% opaques — Cc 99%, Co 1% Blebs and semi-connected stringers of Py mostly pseudomorphed by C; Polished section 1-2% opaques — Cc 50%, Py 50%; Bo trace; Cpy trace, possible cubanite Minor Ma stains on fractures	Much talc Bent and contorted talc fibres up to 0.6 mm in TS (Kemp) Trace of tourmalineand rutile in TS (Kemp); apatite (Farrand) Heavy ferruginisation	Coarsely crystalline quartz-feldspar extensively replaced by ?chalcocite, azurite and malachite in a crude zonal arrangement; 30% opaques may have been of Massive, feldspathised, fine-grained volcanic rock, probably a tuff; possible flow structures; up to 30% of the secondary feldspar is relatively fresh albite which may provide suitable material for datir — Fine-grained dolomitic breccia with quartz and dolomite clasts; possibility of volcanic clasts	Cu — Cu — TLava, ?porphyry ?tuff; substantial content of plagioclase (-15%; sodic andesine close to oligoclase) distinguishes this from other 'volcanics' at Burra; one of the xenoliths appears to have an andesitic texture similar to that observed in B — — — — — — —	Sheared diapiric breccia Azurite nodule from ore stockpile withfresh sulphidecore Intrusive feldspar porphyry ("Burra porphyry") Ferruginous pod developed in dolomite Altered siltstone Sandstone from unusual breccia (volcanic clasts)	sheared diapriric breccia azurite nodule float Fresh sulphides in PS Burra porphyry "Burra porphyry" (map symbol Po1); fresh sulphides in hand specimen; tourmaline and rutile in TS Photomicrograph alteration in 2 Probably located close to B250 Petrology to identify rock type undifferentiated Skillogalee Dolomite Similar to B277 unassigned dolomite breccia Similar to B263 and 270, but no large clasts; probable volcanic clasts in TS	
B288 C3 B289 D3 B290 C2 B291 E3 B292 ?G2 B293 ?G2	78158 389	C35320	C L - S - Mild L	If white pod (30-60 mm) material; round, hard white 20 mm centre with softer outer material gipt greyish brown, massive'shothole' dolomite no layering; white, irregular, subangular 2-5 mm pods with gradational boundaries illvery grey-purple mottled crocidolite siltstone clast in diapiery fine to fine sandstone-siltstone gight grey, hard, massivedolomite no bedding; 1-2 mm etched 'calcite rhombs on weathered surfaces gight yellow-grey, slightly irregularly beddedfolomite interbedded with light orange weathered dolomite; rhombs weather out of both; rhombs cross bedding boundaries	Lines of fine grained ex-Py pseudos define bedding in TS (Farrand)Geochem analysis in Amdel Rept AC3421/84 Bands of ex-Py pseudos identified in TS (Farrand)Geochem analysis in Amdel Rept AC3421/84	Partial chloritisation, dolomitisation, calcification Some thin qtz veins; dolomitisation in two stages	Concentrically zoned barite (98%) concretion; determined by XRD Massive, microcrystalline dolomite (90%) with voids up to 7 mm across partly to wholly infilled with soft, white material (possibly kaolinite) Partly dolomitised and calcified volcanic breccia		Barite nodule Shothole' dolomite Crocidolitic siltstone clast from the diapiric breccia (no mention of asbestos in petrographic report) Massive dolomite (sedimentary) Bedded dolomite (feldspathic sedimentary dolomite)	barite nodule in ?1 12 diapiric breccia undifferentiated Skillogalee Dolomite (located on McCallum sketch undifferentiated Skillogalee Dolomite (located on McCallum sketch undifferentiated Skillogalee Dolomite (located on McCallum sketch Similar to B293 and 296 Similar to B293 and 296 Similar to B292 and 296; detrital plagioclase (andesine)	
B294 ?F2 B295 ?F2 B296 ?G2	78159 390 78160 391 78161 392	11 C42018; lost A175/84 — 12 C42019 A176/84 —	Strong on rock P Slight R	ted coloured zone of ?ferruginous staining in slightly altered har dolomite no bedding	Ex-Py pseudos noted in TS (Farrand)Geochem analysis in Amdel Rept AC3421/84 Geochem analysis in Amdel Rept AC3421/84 Geochem analysis in Amdel Rept AC3421/84	May be silicified	- - -	Finely cryptalgal laminated dolomite (95%) Laminated dolomite (75%); calcite (10%), opaques (14%) Fine-grained, massive dolomite (100%)	Dolomite (sedimentary) Dololimestone (finely laminated sedimentary dolomite) Massive dolomite (sedimentary)	undifferentiated Skillogalee Dolomite (located on McCallum sketch undifferentiated Skillogalee Dolomite (located on McCallum sketch undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite (located on McCallum sketch undifferentiated Skillogalee Dolomite undifferentiated Skillogalee Dolomite (located on McCallum sketch undifferentiated Skillogalee Dolomite undifferentiated Skillogal	
B297 ?G2	78162 393	33 C42020 A177/84 —	Very slight P	ink-yellow-cream zone of ?ferruginous, altered dolomite strong yellow surface colour; irregular 1-2 mm laminae with thicker interbeds	Geochem analysis in Amdel Rept AC3421/84	Numerous 1 mm Mn blebs and dendrites	<u></u>	Laminated, partly stromatolitic dolomite (98%)	Laminated dolomite (laminated, partly stromatolitic sedimentary dolomite)	undifferentiated Skillogalee Dolomite (located on McCallum sketch Similar to B33, B124, B136 and possibly B150	



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Government of South Australia

APPENDIX A: BURRA COPPER MINE SURVEYING; MINE GRID AND HEIGHT DATUM

Mine Grid

Local Mine Grid: 1960s (SADM)

The local mine grid was established by the SA Department of Mines during 1962-63.

M. Mason (geologist) and R. Adams (survey assistant) mapped the open cut at 1:240 scale. Surveying, as shown on SADME plan L62-78, included 36 survey stations (i.e. Stations c to g, Station 1, Stations B and B', Stations D to Y, Stations N-2, N-4 and N-5, and Stations C-D and D-A. Survey stations were within, or immediately adjacent to, the 1962 pit limits.

The local mine grid was established with Grid North 43° west of Magnetic North such that Grid North approximated the strike of the orebody. All measurements were imperial. The 10 000 ft E line was arbitrarily positioned adjacent to the west of the pit, and the 15 000 ft N line to the north of the pit, with the 14 500 ft N line through Tinlines Shaft. Height datum was zero at 100 ft below LWOST.

Subsequent SADM geological mapping and drilling (Nixon et al., 1965) was related to this grid.

The grid was extended beyond pit limits in 1964 with pegs at 100 ft coordinate intersections (plan L64-145; M.G. Mason and R. Adams, Stadia Field Books 288, 303 and 304).

Local Mine Grid: 1970–71 (SAMIN)

In 1970–71, SAMIN Ltd established Survey Stations BM01 to BM16 adjacent to the proposed pit limits or within or adjacent to the processing plant and offices (Table A-1).

Stations were plotted on SAMIN Ltd, Burra Project, Mine Layout, plan No. 70-519 at 1:2400 scale, as surveyed by Kinnaird Hill de Rohan and Young, Consulting Engineers. Additional topographic and survey data for the plant and offices were shown on plan 70-520 — Primary Earthworks, Sheet 1; plan 70-572 — Setting Out Details; and plan 70-573 — Setting Out Details.

Coordinates relative to the imperial mine grid were shown for 10 of these stations: BM02, BM03, BM04, BM05, BM07, BM10, BM12, BM13, BM14 and BM15. No elevations were shown for these.

Elevations relative to mine datum (100 ft below LWOST) were quoted for five stations: BM01, BM06, BM08, BM09 and BM16, all of which are along the fence boundary north of the pit and plant. No coordinates were shown for these stations.

Neither coordinates nor elevation were shown for BM11.

Therefore no survey station included both coordinates and elevations.

All subsequent company mapping (i.e. SAMIN Ltd, Adelaide & Wallaroo Fertilizers Ltd) has been based on the local mine grid and local datum, with measurements being metricated in 1973.

SADME Surveying 1980 onwards

1.

As part of the South Australia Department of Mines and Energy (SADME) stadia survey of the Burra open pit during 1980–81 by R.J. Harris (Technical Officer), 12 Survey Stations (B01 to B12) were established (SADME Stadia Field Books 646, 647, 651 and 652). Station B07 was destroyed by subsequent mining, and stations B05, B08, B09 and B12 were destroyed by the 1981 flooding of the pit after the mine dewatering pumps were turned off (Table A-2).

Five stations (NP, NP-A2 and TP 1 to 3) were established by J.D.A. Harrison (Supervising Technical Officer, Surveying). Stations TP1 to 3 were in the District Council rubble pit to the immediate northeast of the Burra Mine (Table A-2).

Nine geographical points near the Burra Mine were surveyed by J.D.A. Harrison, comprising suitable fixed permanent marks for any future survey (Table A-3).

Between 1975 and 1980, Adelaide & Wallaroo Fertilizers completed 16 dewatering boreholes (Boreholes 1–14, PB88 and Bottom Bore). All except Boreholes 1, 9 and 14 were surveyed by J.D.A. Harrison (Table A-4).

Adelaide & Wallaroo Fertilizers established a permanent base station (Station BS, Table A-2) in August 1980 as part of a slope stability control program (Sweetman, 1983, pp.83–85).

Survey station B13 was established in 1984 by A.J. Smith (SADME Field Assistant) in the Roche Bros, road metal pit on the eastern side of the main pit (Table A-2).

2.

Two SA Department of Lands survey stations (6630/1144 and 6630/1157) were located by J.D.A. Harrison in I981, enabling Australian Map Grid (AMG) metric coordinates to be calculated for all post-1980 SADME survey stations, fixed geographic points and boreholes.

Similarly, Department of Lands Bench Mark 6630/4006 was located, enabling Australian Height Datum (AHD) elevations to be calculated for all post-1980 SADME survey stations etc.

3. In order to relate the 1980–81 mapping project by J.F. Drexel and W.S. McCallum to prior work, the original mine grid was re-established by J.D.A. Harrison in 1981.

SAMIN Survey Stations BM02, BM03, BM13 and BM15 were relocated and surveyed, and related to AMG. Their original imperial mine grid coordinates were metricated. From these four points (with coordinates known in both AMG and local mine grid) the local mine grid coordinates for all post-1980 survey stations and fixed points were derived via a Lauf transformation (R.B. Frost, Computer Systems Officer, SADME).

Both Mine Grid and AMG coordinates are shown in accompanying Tables A-I to A-4.

From the relative coordinate systems was derived an accurate measurement of grid north:

Mine Grid North = 323°47'47' True North <u>or</u> Mine Grid North is 36°12[']13' west of True North, equating well to the 43° West of Magnetic North quoted by Mason and Johnson (1962, SADME plan L62-78).

4

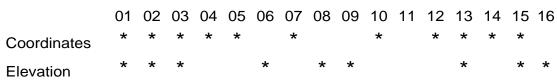
SAMIN Survey stations (1970–71; Table A-I) were updated as follows:

- BM02, 03, 12 and 15 were related to AMG, AHD and Mine Grid (outlined above).
- BM01, which had not been coordinated by SAMIN, was relocated and coordinated.

- Thus BM01, 02, 03, 03, 13 and 15 are the only SAMIN stations for which both elevation and coordinates are available.
- BM06, 08, 09, 11 and 16 were not originally coordinated and could not be relocated, hence their coordinates are unknown.
- Coordinates or elevations for remaining stations were converted numerically from imperial to metric datums.

Data availability is as follows:





where * = data available

Surface Height Datums

Imperial mine height datum for surface data prior to the mid-1970s was zero at 100 ft below Low Water Ordinary Spring Tide (LWOST) at Port Adelaide. The earliest located reference to this datum was Segnit (1939, fig. 45). Prior datums were arbitrary local datums.

LWOST is 1.73 m (5.68 ft) lower than Mean Sea Level (MSL), Port Adelaide. MSL is 0.216 m above Australian Height Datum (AHD) at bench mark 6630/4006 at Burra.

Therefore, 100 ft below LWOST = 100 ft (30.48 m) + 1.73 m - 0.216 m AHD, and 100 ft below LWOST = 31.99 m AHD at Burra.

SAMIN Survey Station BM01 had an elevation of 1712.02 ft, equivalent to 489.83 m AHD using the above conversion, and an elevation of 490.00 m AHD as surveyed from Bench Mark 6630/4006. BM01 was the only levelled imperial survey station to be relocated and re-surveyed in 1981. To correct the slight discrepancy, elevations in feet were converted to AHD by conversion to metres and subtraction of 31.82 m.

Metric elevations used by Adelaide & Wallaroo Fertilizers in the 1970s and 1980s are a direct metrification of the 100 ft below LWOST datum. These elevations have been converted to AHD by subtracting 31.82 m.

Table A-I Survey stations established by SAMIN Ltd, 1970.

_	Mine G	rid	AM	G	ALID
	Easting	Northing	Easting	Northing	AHD
BM01	3200.238	4737.318	307362.186	6271820.013	490.00
BM02	3200.400	3931.920	307837.963	6271170.301	498.84
BM03	2895.600	4267.200	307394.130	6271260.646	518.82
BM04	3322.320	4267.200	307738.233	6271512.668	na
BM05	2895.600	4724.400	307123.758	6271629.434	na
BM06	(3252)	(4724.4)	na	na	(487.76)
BM07	2529.840	4724.400	306828.796	6271412.605	na
BM08	(2895.6)	(4839)	na	na	(482.51)

BM09	(2763)	(4887)	na	na	(475.04)
BM10	2676.530	4843.810	306876.155	6271595.936	na
BM11	(2515)	(4742)	na	na	na
BM12	2750.630	4711.090	307014.653	6271532.820	na
BM13	3017.520	4267.200	307492.430	6271332.670	511.88
BM14	2895.600	4480.560	307268.026	6271432.689	na
BM15	3048.000	4724.400	307246.830	6271719.610	491.8
BM16	(2628)	(4927)	na	na	(471.85)

NB: 1. na = data not available.

^{2.} coordinates in brackets have been scaled from imperial plans.3. relative levels in brackets have been converted from imperial datum, 100 ft below LWOST; other levels have been related to AHD via bench mark 6630/4006.

Table A-2 Survey stations established by SADME, 1980–84.

	Mine	Grid	Α	MG	Elevation	
	Easting	Northing	Easting	Northing	AHD	Comments
B01	2956.442	4265.448	307444.223	6271295.179	520.53	
B02	3187.570	4725.056	307359.194	6271802.626	490.85	
B03	3225.250	4491.335	307527.634	6271636.177	496.15	
B04	3139.936	4446.700	307485.153	6271549.778	486.85	
B05	3198.835	4293.747	307622.998	6271461.178	438.80	Now under water
B06	3071.162	4228.142	307558.775	6271332.861	487.38	
B07	3263.370	4166.760	307750.033	6271396.877	486.52	Destroyed by mining; now under water
B08	3159.981	4165.600	307667.342	6271334.882	420.42	Now under water
B09	3144.510	4170.500	307651.955	6271329.692	418.8	Now under water
B10	3070.467	4618.226	307327.741	6271647.153	502.0	
B11	3053.963	3987.086	307687.259	6271128.288	516.7	
B12	3167.560	4360.740	307558.193	6271496.732	444.6	
B13	3262.342	4145.195	307761.940	6271378.880	486.86	
NP	3189.894	4418.978	307541.832	6271556.917	458.17	
NPAZ	3200.233	4703.475	307382.169	6271792.671	486.50	
TP1	3323.729	4615.461	307533.854	6271794.496	493.43	Council rubble pit
TP2	3343.656	4542.243	307593.142	6271747.151	504.02	Council rubble pit
TP3	3286.776 4487.571		307579.504 6271669.462		502.56	Council rubble pit
BS	Ad		aroo Fertilizers P slope stability co	rty Ltd, base statio	n,	Mounting plate set onsteel post set in
	3458.24	4145.74			487.00	concrete

Table A-3 Survey coordinates, geographic fixed points, SADME, 1981.

.	Mine	e Grid		10	Elevation AHD	
Station	Easting	Northing	AN	iG		
Department of Lands: Co	ordinated point	s (AMG)				
6630/1144	1278.729	5283.261	305491.860	6271112.218	475.90	
6630/1157	-2253.447	-5073.437	307382.859	6260934.604	670.60	
Department of Lands:Ben	ch Mark (AHD)			•	
6630/4006	3440.316	4446.326	307727.718	6271726.784	512.09	
Geographical Points, surv	eyed by J.D.A	. Harrison				
Lookout Hill	3425.687	3745.855	308129.637	6271153.398	532.29	
TV Pole	3421.955	4585.138	307631.034	6271827.959	514.08	
Ladder Pole	2970.803	4334.517	307414.997	6271359.362	524.79	
Johnny Green Chimnev	3655.575	4106.535	308101.710	6271579.928	493.86	
North Chimney	3379.403	3924.344	307986.791	6271269.957	530.84	
South Chimney	3253.521	3843.588	307932.998	6271130.440	531.80	
East Silo Vent	3182.670	5036.963	307170.968	6272051.957	511.29	
West Silo Vent	3155.205	5032.614	307151.303	6272032.204	511.26	
Plant Chimney	2678.396	4720.250	306950.953	6271497.460	505.68	

Table A-4 Adelaide & Wallaroo Fertilizers Ltd dewatering boreholes survey coordinates and underground levels, 1975–80.

Borehole No.		Coordinates mN mE		Collar elevation AHD	Depth (m)	Date	e drilled	Drilled by	Water level	SADME Bore Serial No. 6630-	Old workings encountered (metres depth); from SADME Bore File	Interpreted mine level intersected (fathoms) (from Sweetman, 1983)
1	_		_	-	72.8	drilled	13/06/75	Preiss		1298	72.8	40?
						developed	22/09/75	SADME				
2		3092.037	4315.839	487.57	85.9	completed	03/10/75	Walsh				50?*
	(AMG)	307523.81	6271415.92									
3		3091.704	4313.776	487.73	84.9	completed	28/11/75	Walsh				50?*
	(AMG)	307524.76	6271414.06									
4		3148.000	3912.755	503.20	122.7	completed	15/12/75	Nitschke				50 and 60?*
	(AMG)	307807.02	6271123.89									
5		3146.632	3913.832	503.28	102.5	completed	30/08/76	Walsh	-56.3 m on 27/9/77	1300	43 to 46	20F?
	(AMG)	367805.28	6271123.95		123.0	deepened	July 1979	SADME	i.e. 447 m AHD	1301	74.5 to 78.5	40F?
										1294	100 to 102.5	50F?
											123	60F?
6		3145.305	3914.543	503.12	102.5	completed	15/09/76	Walsh		1299,	43?	20F?
	(AMG)	307803.79	6271123.74		123.0	deepened	July 1979	SADME		1301,	122	60F?
										1348		
7		3143.664	3915.163	502.53	90.0	abandoned	25/08/77;	Sides				
	(AMG)	307802.10	6271123.27)			not deve	eloped					
8		3141.389	3915.447	503.51	141.2	drilled	?	Sides	-76 m on 19/3/78	1295		50F?*
	(AMG	307800.08	6271122.18			developed	14/03/78	SADME	i.e. 437 m AHD	1301	123	60F?
9		Central betw	een boreholes	_	55.5		22/10/78	Walsh	-30 m on 22/10/78	1296	0-13 fill and	
		10, 11,	12, and 13								timbers	
10		3243.841	4344.822	459.3	93.0		27/10/78	Walsh	-18 m on 27/10/78	1292		
									i.e. 441 m AHD			

				1					
11	3172.497	4357.032	445.14	53.0	07/02/79	Walsh			
(AMG)	307564.38	6271496.67							
12	3202.587	4383.809	449.60	62.0	03/02/79	Walsh			
(AMG)	307572.84	6271536.04							
13	3195.539	4301.705	438.77	94.0	02/03/80	Walsh?			
(AMG)	307615.64	6271465.65							
14			?	56.0	26/02/80	SADME	-19 m on 28/02/80 1347	2.5 to 4.5 m	
								8 to 9 m	
								14 to 16.8 m	
								24.5 to 28 m	
								49 to 53 m	
Bottom Bore	3163.062	4166.764	420.57	_	_	_			
(AMG)	307669.14	6271337.64							
PB80	3193.791	4357.993	448.48	-	_	_			
(AMG)	307580.99	6271510.02							

APPENDIX B: UNDERGROUND LEVELS, CONVERSION TO AHD

Underground levels were developed at the following fathom levels:

```
6, 8, 12, 17, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70.
```

The upper four levels to 17 fathoms were not continuous, and no comprehensive maps are available. Below this, the 20, 30, 40, 50 and 60 fathom levels are more extensive than intervening levels. The 70 fathom level is restricted.

Relating the levels to AHD or local mine datum is difficult. Levels were probably measured down from the surface at one of the older shafts, possibly Roach's, Kingston's or Graham's Main Shaft. Surface elevation of these shafts in unknown; no surveyed surface plans are available and the shafts have been destroyed by open cut mining.

Relationship of levels to AHD can only be inferred.

(1) SADME plan 1657

'Traced from very old undated plan loaned by A.F. and P.A. McBride, AMD Buildings, 27/11/40.'

Plans shows main underground levels, and a schematic north–south section, with horizontal and vertical scales 1 inch:40 feet. The following data are derived by scaling from plan 1657.

The difference in elevations between levels, although nominally a multiple of 10 fathoms, is not consistent.

A horizontal, undefined line extends the length of the section, near the top, and may be the datum. This line is above ground through the open cut (pre-1971 extent of open cut) and is below ground in the south of the section, i.e. at Waterhouse, Morphett and Hector Shafts.

Scaled distances between levels are:

• surface to datum? (at Morphett's Engine Shaft

= 9.5 m (5 fathoms)

• datum? to 20 fathoms = 37 m (20 fathoms)

• 20 to 30 fathoms = 20 m (11 fathoms)

• 30 to 40 fathoms = 16.5 m (9 fathoms)

• 40 to 50 fathoms = 23.5 m (13 fathoms)

• 50 to 60 fathoms = 16.5 m (9 fathoms)

• 60 to 70 fathoms = 19.5 m (10.5 fathoms)

Morphett's Engine Shaft: Elevation as surveyed in 1981 is 502 m AHD.

Therefore datum? line on section is 492.5 m AHD

20 fathoms is 455.5 m AHD

30 fathoms is 435.5 m AHD

40 fathoms is 419.0 m AHD

50 fathoms is 395.5 m AHD

60 fathoms is 379.0 m AHD

70 fathoms is 359.5 m AHD

(2) Dickinson, 1942 (page 75)

'At the 30-fathom or 180 ft level, about 40ft, below the present water level, ...'

Static Water Level:

- Mason and Johnson (1962; SADME plan L62-78).
 Water level = 1604.5 ft (mine elevation) in January 1962 = 489.05 m (mine elevation)
 = 457.23 m AHD.
- Nixon, Fairburn and Warne (1965; SADME plan L65-82).

 Water level = 1606.1 ft (mine elevation) on 5 February 1965
 - = 489.54 m (mine elevation)
 - = 457.72 m AHD.
- Sweetman (1983, Fig. 8).

Water level before dewatering:

- = 491 m (mine elevation)
- =459 m AHD
- Static water level in 1984, two years after pumps were switched off = 456 m AHD (approx.).

The mine was not being worked or pumped in 1942. Water level before dewatering is calculated at between 456 and 459 m AHD. Therefore, the 30 fathom level is between 444 and 447 m AHD.

(3) Dewatering boreholes

Dewatering boreholes 1 to 14, as developed for SAMIN or Adelaide & Wallaroo Fertilizers between 13/6/75 and 26/2/80 are detailed in Table A-4 in Appendix A.

Underground workings were intersected in boreholes 5, 6, 8, 9 and 14 as reported in SADME borefiles. Reliable collar elevations and depths of workings are available only for boreholes 5, 6 and 8.

Table B-I shows interpreted mine levels for Borehole 5 (20F, 40F and 50F), Borehole 6 (20F and 60F), and Borehole 7 (60F).

(4) Armstrong (?1981)

Unpublished plan. Section shows open cut, underground levels, shafts and pumps.

```
20 F = 85 m (mine elev.) = 453 m AHD

40 F = 453 m (mine elev.) = 421 m AHD

50 F = 429 m (mine elev.) = 397 m AHD

60 F = 409 m (mine elev.) = 377 m AHD

70 F = 395 m (mine elev.) = 363 m AHD
```

(5) Sweetman (1983; page 33)

- 40 Fathom level is 454 m mine elevation (422 m AHD) and 40 F = 73 m. Therefore zero fathoms is 495 m AHD.
- 60 Fathom level is 413 m mine elevation (381 m AHD) and 60 F = 110 m.
 Therefore zero fathoms is 491 m AHD.

Summary

Results from the above sources are summarised in Table B-1. Results from Dickinson (1942) vary by 10 m from other data, and an average or interpreted best fit of remaining data is presented in Table B-I.

The underground levels were probably not horizontal, varying in elevation by at least several metres across the mine. The levels may have been developed with a slope down to the nearest main shaft to assist ore haulage.

Table B-1 Burra Mine underground levels summary (relative elevations, metres AHD).

	Scaled from SADME Plan 1657	from SADME	Dickinson (1942)	Fertiliz	ide & Wa zers dewa poreholes	atering	Armstrong (1981)	Sweetman (1983)	Interpreted best fit
		(1342)	No.5	No.6	No.8	(1301)	(1303)		
Datum?	492.5							493	
20 fathom	455.5		456 to 459	459		453		455	
30 fathom	435.5	444 to 447						436	
40	419		423 to 427			421	422	419	
50	395.5		399 to 402			397		397	
60	379			380	379	377	381	379	
70	359.5					363		360	

APPENDIX C: SUMMARY OF SADM DRILLING, 1963-64

Data from Nixon et al. (1965) — includes all drill logs and analyses.

- (1) Steep diamond drillholes (Table C-I)
 - DDH 1, to 233.7 m, 17/1/63-2/8/63.
 - DDH 2, to 258.8 m, 9/8/63-6/3/64.
- (2) <u>Sub-horizontal rotary drillholes</u> (Table C-2)
 - RDH 3-12, drilled 29/7/64-6/11/64.
- (3) <u>Vertical percussion holes</u> (Table C-3)
 - PB 1 drilled 2/10/64-23/10/64;

GB 8, 10, 12, drilled 26/10/64-14/11/64;

PB 2-13, drilled 16/11/64-21/4/65.

 Target was 100 ft (30 m) below watertable, BUT GB 8, 10, 12 only to watertable.

PB7 was stopped in unmineralised dolomite at 11.4 m.

PB 12 blocked at 3.8 m, and replaced by PB 13.

Coordinates are from MEPL survey data, as shown on Envelope plan No. 680-16.

Table C-1 Burra copper mine, steeply inclined diamond-drillholes (wet), drilled by SADM 1963–64.

Hole	Depth	Mine cod	ordinates	Collar RL	Azimuth	Inclination
No.	(m)	mE	mN	(m AHD)		
DDH1	233.7	3359.5	4159.6	482.7	270° mag.	0 m – 53°
						30.5 m – 52°
						61 m – 51°
						91.5 m – 50°
						167.6 m – 47°
						198.1 m – 42°
						204.2 m – 42°
						222.5 m – 61°
DDH2	258.8	3316.2	3829.5	524.2	242° mag.	0 m – 65°
						30.5 m – 66°
						59.4 m – 67°
						121.9 m – 70°
						152.4 m – 68°
						201.2 m – 71°
						towards 248° mag.
						231.7 m – 72°
						towards 252° mag.

Table C-2 Burra Copper Mine, sub-horizontal rotary and diamond-drillholes, drilled by SADM 1964.

Hole	Depth	Mine co	ordinates	Collar RL	Azimuth	Inclinatio	Date
No	(m)	mE	mN	(m AHD)	(magnetic)	n	Date
RDH3	25.9	3156.2	4276.0	464.4	249°	-1°	29/7/64-3/8/64
RDH4	36.6	3135.3	4281.8	472.3	241°30′ 0°		4/8/64-8/8/64
RDH5	16.8	3182.1	4325.9	458.3	246°30'	0°	11/8/64–13/8/64
RDH6	36.6	3150.3	4331.1	463.8	247°30'; from 16.8 m 253°	0°	14/8/64
RDH7	85.3	3208.0	4414.1	463.5	225°; from 15.2 m 232°; from 45.8 m	+2°	21/8/64-1/9/64
RDH8	38.1	3208.3	4193.4	471.4	242°30'; from 15.2 m 252°	+2°	4/9/64-8/9/64
RDH9	3.4	3135.8	4197.1	476.9	241°30'	0°	9/9/64-10/9/64
RDH10	36.0	3135.2	4183.8	480.3	235°; from 16.8 m	+2°	11/9/64
DDH11	18.3	3135.2	4272.8	468.1	247°	+2°	16/9/64–18/9/64
DDH12	65.1	3201.00	4552.2	491.9	205°	-28°	6/10/64–6/11/64

Table C-3 Burra copper mine, vertical percussion drillholes, SADM, 1964-65.

Hole	Depth	Mine co	ordinates	Collar RL	Dete
No	(m)	mE	mN	(m AHD)	Date
PB 1	62.5	3159.7	4292.5	460.6	2/10/64-23/10/64
PB 2	54.9	3152.4	4224.4	476.6	16/11/64–23/11/64
PB 3	62.5	3158.2	4143.3	486.8	25/11/64–2/12/64
PB 4	27.4	3174.1	4347.3	459.3	3/12/64-3/2/65
PB 5	29.9	3185.8	4282.0	459.5	4/2/65-10/2/65
PB 6	33.5	3194.5	4260.7	?459.5 (SADM) ?480.6 (MEPL)	12/2/65–22/2/65
PB 7	11.4	3208.0	4323.9	459.2	23/2/65–25/2/65
PB 8	33.5	3211.7	4306.8	458.3	25/2/65-11/3/65
PB 9	64.0	3180.4	80.4 4173.8 4		19/3/65–3/4/65
PB 10	134.1	3169.0	4223.6	480.3	_
PB 11	54.9	3138.3	4223.2	480.9	5/4/65-12/4/65
PB 12	3.8	Loca	tion uncertai	n, replaced by PB	13; no drill log
PB 13	57.9	3144.3	4172.0	483.9	15/4/65–21/4/65
GB 8	25.9	3136.1	4207.4	479.8	9/11/64-12/11/64
GB 10	25.0	3121.5	4221.7	482.4	12/11/64-14/11/64
GB 12	24.4	3167.1	4223.1	479.4	26/10/64–6/11/64

APPENDIX D: SUMMARY OF MEPL DRILLING, 1966-67

(1) Steep diamond drillholes (Table D-1)

- Drillholes BS1 to 5, drilled 3/2/66 to 4/1/67.
- Drillhole BS6 drilled 19/1/67 to 28/2/67, still in progress on 28/2/67 but no later information available.
- Drillholes BS7 and 8, no information available.
- All data adapted from Rogers et al. (1967); includes drill logs for BS 1–5.

(2) Vertical percussion and rotary drillholes (Table D-2)

- Rotary drilling from 14/2/66 to 6/9/66.
- Percussion drilling from 22/2/66 to 28/2/67 (end of report period).
- 57 holes completed, comprising PB 20 to PB 72, and PB 29*, PB 34(2), PB 44(2), PB 56(2) and PB 62(2), but not PB 37.
- Depth and assay data from Rogers et al. (1967).
- Coordinate and elevation data from Envelope plan no 680-16. Elevations of collars were determined barometrically (Keith Rodgers, ex-MEPL staff, pers. comm., c.1985).
- 4. No geological drill logs are available.
- 5. Rogers et al. (1967 (Env. 736)) indicated that drillholes PB 26, 50, 52, 54 and 55 were to be deepened after 28/2/67 but there is no subsequent record.

Table D-1 Burra copper mine, Mines Exploration Pty Ltd, steep diamond-drillholes.

Hole No.	Depth (m)		line dinates mN	Collar RL (m AHD)	Inclin		Date	Reference
BS 1	132.6	3293. 4	3748.7	523.7	226°30'	-55°	3/2/66– 11/5/66	Env. 736, geological log and Cu, Pb, Zn analyses from 91.4 to 132.6 m
BS 2	240.2	3340. 0	4847.5	478.8	226°30'	-65°	3/3/66– 14/6/66	Env. 736, geological log and Cu, Pb, Zn analyses from 140.2 to 167.6 m
BS 3	274.0	3048. 6	3749.0	523.2	046°30'	-55°	25/5/66– 19/7/66	Env. 736, geological log
BS 4	272.2	3048. 0	4114.8	501.6	046°30'	-55°	23/6/66— 9/9/66	Env. 736, geological log, bedding angle log, Cu analyses from 143.2 to 182.9 m
BS 5	148.4	31294 .3	2438.4	_	226°30'	-52°	30/9/66- 4/1/67	Env. 736, geological log and bedding angle log
BS 6	164 m on 28/2/67	2991. 6	4221.5	No data available		19/1/67		
BS 7	?	?	?	No data available		?		
BS 8	?	2991.	4221.5?	No c	No data available			_

Table D-2 Burra copper mine, MEPL vertical percussion and rotary drillholes.

Hole	T	Depth	Mine cod	ordinates	Collar RL	Analy	sis .
No.	Туре	(m)	mE	mN	(m AHD)	Interval (m)	Cu (%)
PB20	С	68.6	3133.3	3992.9	501.7		
PB21	C	68.6	3148.6	3992.9	499.0		
PB22	Ř	27.4	3163.8	3992.9	497.9		
PB23	C	91.4	3134.9	4023.4	501.0	82.3-91.4	0.71
PB24	Č	91.4	3150.1	4023.4	498.1	02.0 01.1	0.7 1
PB25	Č	87.8	3165.4	4023.4	496.9		
PB26	Ř	91.4	3136.1	4053.5	499.7		
PB27	C	70.1	3151.3	4053.5	497.5		
PB28	Č	91.4	3166.6	4053.5	496.2		
PB29	Č	80.8	3181.8	4053.5	494.9		
PB29*	R	13.7	3174.2	4053.5	495.5		
PB30	C	91.4	3141.0	4084.3	497.0	45.7–91.4	2.37
PB31	Č	91.4	3156.2	4084.3	496.0	45.7-31.4	2.01
PB31	R	31.1	3171.4	4084.3	495.4		
PB32	C	80.5	3147.1	4114.8	493.4	39.6–80.5	2.85
PB34	R	24.4	3161.7	4114.8	494.9	3 3.0– 60.3	۷.05
PB34(2)	C	86.9	3163.8	4114.8	494.4	51.8–85.3	1.03
PB34(2)	C	91.4	3177.5	4114.8	494.4	J1.0 - 03.3	1.03
PB36	R	35.1	3192.8	4114.8	492.2		
PB36 PB37	Г		Not drilled	4114.0	432.2		
	Р	85.3		4100 G	471.1		
PB38 PB39	P	86.9	3206.5 3197.4	4198.6 4221.5	469.0	61.0–82.3	1.66
PB40	P ?	86.3 18.3	3212.6	4221.5	469.3 482.4	60.5–85.3	0.96
PB41			3123.0	4252.9		0.70.0	1.00
PB42	Р	79.3	3161.3	4252.2	467.7	0-79.2	1.93
PB43	Р	78.9	3170.2	4252.0	467.5	9.1–77.7	2.49
PB44	Р	35.1	3185.2	4245.7	467.5	9.1–35.1	2.04
PB44(2)	P P	89.3	3182.1	4248.9	467.5	0-89.3	1.71
PB45	Р	91.4	3200.4	4247.4	467.8	12.2–91.4	1.10
PB46	Р	80.8	3215.9	4247.9	468.7	0-9.1	2.02
	_					64.0–73.2	1.56
PB47	Р	54.6	3226.5	4297.7	467.8	0–48.8	1.47
PB48	Р	12.5	3207.0	4325.9	459.4		
PB49	R	36.6	3125.7	4572.0	497.1	0–15.2	1.65
PB50	R	15.2	3134.9	4572.0	496.3		
PB51	R	43.3	3144.0	4572.0	495.3	0-18.3	1.60
PB52	R	39.6	3159.3	4572.0	492.4	18.3–24.4	1.95
PB53	R	39.6	3176.0	4693.9	493.4	0-27.7	1.62
PB54	R	44.8	3185.2	4693.9	492.8	6.1–23.5	2.66
PB55	R	64.6	3194.3	4693.9	492.1		
PB56	R	9.1	3209.5	4693.9	499.0?		
PB56(2)	R	41.5	3210.5	4693.9	490.8?		
PB57	R	49.7	3166.9	4693.9	493.8	00 4 04 4	0.00
PB58	R	97.6	3118.3	3993.1	504.5	88.4–91.4	0.88
PB59	R	80.8	3119.6	4023.4	501.9	0.455	0.0=
PB60	R	97.5	3120.5	4054.1	499.4	0–15.2	2.07
PB61	R	79.3	3122.7	4084.3	497.7	0–6.1	0.90
PB62	R	13.1	3130.6	4114.2	496.3	0-13.1	2.01
PB62(2)	C	88.4	3132.7	4115.4	496.4	0–15.2	1.69
PB63	R	73.2	3191.9	4736.6	490.7	100 100	
PB64	R	91.4	3200.4	4733.5	490.2	12.2–18.3	1.27
PB65	R	36.6	3209.0	4730.0	489.9		
PB66			Not drilled		:		
PB67	R	67.1	3143.0	4623.0	495.4		
PB68	R	42.7	3216.3	4624.0	494.3	6.1–21.3	3.64
PB69	R	79.9	3167.0	4624.7	504.8	12.2–18.0	2.15
PB70	R	37.5	3180.6	4626.9	491.0	6.1–18.3	2.78
PB71	R	38.1	3192.8	4626.9	490.6	2.4–27.4	0.83
PB72	R	44.5	3203.5	4626.9	490.1		

Note: P = Percussion; R = Rotary; C = combination

APPENDIX E: GEOLOGICAL LOG OF ADELAIDE AND WALLAROO FERTILIZERS LTD DIAMOND DRILLHOLE BDIB, AND SUMMARY LOG

Table E-1 Burra copper mine, Adelaide & Wallaroo Fertilizers Ltd, diamond-drillholes 1980-81.

Hole	Mine coo	ordinates	Collar RL	Azimuth	Inclin.	of Deptii Date	Date	Comments
no.	mE	mN	(m AHD)	(mag.)	collar	(m)	drilled	Comments
BD1	3310	4200	483	217°	-50°	54	26/7/80– 29/7/80	Rotary precollar, abandoned
BD1A	3310	4205	483	217°	-60°	135	28/6/81– 26/8/81	Rotary precollar to 101 m, abandoned at 135 m
BD1B	3310	4210	483	217°	-70°	323	1/10/81– 27/10/81	Rotary precollar to 200 m
BD2	3245	4000	498	217°	-75°	288	2/7/81– 28/9/81	Rotary precollar to 101 m
BD3	3300	3800	520	217°	-50°	32	30/7/80– 3/8/80	Rotary precollar, abandoned
BD3A	3250	3800	515	217°	-75°	278.7	31/8/81– 18/9/81	Rotary precollar to 101 m

Table E-2 Geological log of diamond drillhole BD1B drilled by Adelaide & Wallaroo Fertilizers Ltd.

Collar RL 515 m AHD

Coordinates 4210 mN, 2315 mE; inclination 70° towards 217° magnetic at collar Rotary precollar 0–200 m, 17/9/81–30/9/81
Diamond drilling 200–323 m, 1/10/81–27/10/81
Logged by J.F. Drexel and W.S. McCallum, 14–15/6/84

Dep	th (m)		Bedding	
From	То	Lithology	angle to core	Secondary veins and structures
201.1	207.2	Dolomite, light grey; faint to strong white laminae, 1-4 mm. Minor etched out voids concentrated in bedding planes.	90°	201.7 m White dolomite veins, 1-2 mm, perpendicular to bedding.
207.2	208.1	Dolomite, grey, as above.	80-90°	
208.1	212.8	Dolomite, as above, light brownish grey, red iron staining on joints. 211.7-212.0 m Breccia zone; angular (1-15 m) grey dolomite in paler matrix; sharp top and bottom contacts.	90°	 209.5-209.7 m Numerous steep fractures. 212.1 m Dolomite and siderite vein, 5 mm, 10° to bedding. 212.3 m Dolomite and siderite vein, 50 mm. 212.6 m Dolomite and siderite vein, 30 mm, 10° to bedding, including dolomite rhombs.
212.8	216.6	Dolomite, fractured, fawn-brown, few laminae, rare voids, some 10-30 cm thick darker grey dolomite.		 212.8 m Minor fracture zone. 214.6 m Iron-stained fracture zone, 100 mm. 216.24 m White dolomite vein, 30 mm, fractured, with 1 mm pyritohedra.
216.6	229.6	Dolomite, alternating fawn and light grey, 20–60 cm thick; laminae in greyer sections.	70-90°	 216.6m White dolomite vein, 30 mm, with red ferroan dolomite, 45° to bedding. 217.5 and 217.6 m Thin veins, 10-20 mm, white dolomite core rimmed with pyritohedra, up to 20° to bedding. 221.2 m White dolomite vein, 30 mm, 80° to core, pyrite in footwall dolomite for 5 mm and in brecciated hanging wall dolomite for 15 mm. 221.4 m 70 mm breccia, numerous 1-5 mm dolomite veins, vuggy. 223.9-224.2 m Numerous 2-3 mm fractures, infilled with ferroan calcite.
		226.1-226.4 m Pyrite disseminated in dolomite.		
				 226.5 m 70 mm white dolomite vein, 20° to bedding, pyrite in vugs. 227.5-227.7 m White dolomite vein, 0° to bedding, then dolomite vein 90° to bedding; veins include minor pyrite. 229.0 m White dolomite mass, 50 mm, diffuse irregular boundaries, includes pyrite; may replace darker dolomite.
229.6	231.0	Dolomitic siltstone, grey, fine laminae, fissile parting parallel to laminae, lighter below 230.3 m.	70°	230.5 m White dolomite vein, 10 mm, 10° to bedding, pyrite near upper contact.

231.0	235.0	Dolomitic siltstone, light brown, laminated. Light red-purple staining cross-cutting bedding from 231.0 to 232.6 m. Below 231.0 m, hydrothermal alteration(?) has etched selected beds up to 50 mm thick; restricted to light brown dolomite. 231.0-237.9 m Numerous small holes 232.8-233.1 m Extensively etched. 233.9-234.3 m Extensively etched, disintegrated.	75° 45°	
235.0	237.9	Dolomite, laminated, light grey to light orange-brown (hydrothermal?) stained; contorted, soft sediment slumping? Abundant white secondary dolomite.	45°	
237.9	240.0	Dolomite, light grey, few laminae. Abundant fine disseminated sulphide below 237.9 m.	70°	 239.0 m White dolomite vein, 20 mm; dolomite is crystalline in centre, rare pyrite. 239.9 m White dolomite vein, 20 mm, fractured for 50 mm above.
240.0	243.2	Dolomite, grey, laminated.	90°	
243.2	250.1	Dolomite, grey, rare pale laminae; irregular bedding; some parting parallel to laminae. 244-244.4, 245.0-245.1, 245.7-247.0 m Fractured and disintegrated.	50°	Numerous patches and veinlets of secondary white dolomite, crystalline, or vuggy in centre. 247.0 m 120 mm white dolomite mass cross-cutting bedding.
250.1	258.0	Dolomite, grey, poorly defined laminae 1-2 mm; abundant fine (<1 mm) angular etched voids on core surface. 246.4-256.9 m Extensively fractured.	70°	253.0 m 100 mm, fractured and recrystallised irregular grey dolomite with diffuse margins in white dolomite matrix.
258.0	259.4	Dolomite, light brown, fissile discontinuous 1-2 mm laminae, fine pyrite stringers along laminae; plus mid-grey dolomite interbeds. Soft sediment deformation at 259.2		
259.4	267.2	Clay, soft, expansive, off white, friable, montmorillonite? 50-100 mm bands of hard grey dolomite, massive, non-laminated at 259.5, 260.5, 261.0, 261.3, 261.5, 261.7, 263.3, 263.8, 265.3, 265.5, 265.9, 266.6, 266.9 m, i.e. approx. 80% clay, 20% dolomite.		
267.2	270.2	Limestone, pale brown, poorly defined 1-5 mm bedding; with 1 mm by 3 mm banding parallel to bedding. Extensively replaced by grey		267.6 m Calcite vein, 10 mm, 45° to core.
270.2	274.2	Dolomite, fissile, brown, parting 1-3 mm, finely laminated, 100 mm thick beds at 270.2 and 271.8 m, with interbedded grey dolomite. Finely laminated dolomite may be algal. Includes bedded or massive pyrite.	80°	
274.2	295.9	Clay, soft, expansive, friable, comprising 80% of rock, with core as follows:		

277.0		Limestone–dolomite, dark grey, laminated.	277.0 m Pyrite veins parallel and perpendicular to laminae; white dolomite vein with pyrite in centre.
279.6		Dolomite, dark grey, with interbedded brown laminated dolomite.	
280.1		Dolomite, grey. Intrusion of secondary hydrothermal dolomite in 80 mm high domal structure with pyrite stringers. Passive replacement of dolomite in adjacent host.	
283.0		Dolomite, pale brown-pink colour, iron stained or K-feldspar alteration? Pyrite disseminated in dolomite and in thin quartz vein.	
			285.9 m White dolomite and quartz vein 20-30 mm, fractured, rare pyrite in adjacent dolomite.
289.0		Dolomite, dark grey, faint laminae with fine brown laths.	 289.0 m Quartz(?) vein 3 mm, replacing dolomite, subparallel to bedding, plus disseminated cubic pyrite in host. 289.8 m White dolomite, 30 mm, coarsely crystalline cleavage fragments, probably vein.
291.0		Dolomite, dark grey, possible algal laminae, with bedded and disseminated pyrite.	
292.4		Dolomite breccia, angular dark grey laminated dolomite fragments in lighter grey dolomite matrix, all finely recrystallised; bedded pyrite in clasts.	
295.0		Dolomite, grey, with dolomite laths, with etched iron-stained margins.	295.0 m White quartz masses, replacing dolomite, with pyrite on margins.
295.9	298.5	Solid core. Dolomite, finely recrystallised, brecciated?; dark grey clasts and matrix; clasts may be recrystallised dolomite rhombs or rhombs with overgrowths; plus fragments of pink	296.7 m Shear zone, 100 mm, infilled with calcite and fibrous white amphibole. 298.0 m Dolomite vein, 5 mm.
298.5	323.0	Diapiric breccia. Abundant dolomite clasts in dolomite matrix, light brown to grey. Rarer clasts of chloritic siltstone, with bedded pyrite; dolomite rhombs; and pink dolomite with clear dolomite rhombs. Rare pyrite in matrix.	298.5 m Chlorite shear, 100 mm. Fracture or shear zones: 301.1 m 20 mm thick. 302.7 m 200 mm thick. 303.3 m 200 mm thick. 304.5 m 100 mm thick. 315.0 m 100 mm thick. 315.7 m 100 mm thick. 316.4 m 100 mm thick. 316.8 m 200 mm thick. 319.0 m 200 mm thick.
323.0		End of hole	

Table E-3 Summary geological log, drillhole BD1B.

Sedimentary lithology	Alteration	Veining	Sulphide mineralisation in host rock
201.7-229.6 m Laminated very finely recrystallised grey dolomite. Minor etched voids (feldspar?) on weathered surfaces to		201.7-253.0 m Abundant white dolomite veins. Pyrite in veins, near contacts, common from 216.2 to 239.0 m.	201.7-237.94 m Very minor pyrite, less than 1 mm,disseminated in darker dolomite.
229.6-235.0 m Fissile dolomitic siltstone and grey dolomite. 235.0-237.94 m Grey dolomite with soft sediment slumping.	231.0-232.6 m Red iron staining. 231.0-237.9 m Selected dolomite beds are stained light brown, and etched and fretted, resulting in total disintegration in extreme		
237.9-258.0 m Laminated grey dolomite; abundant voids (feldspar?) on weathered surface		253.0-283.0 m Occasional dolomite veins with minor pyrite.	237.9-258.6 m Abundant very fine disseminated pyrite.
258.0-259.4 m Dolomitic siltstone, soft sediment deformation at 259.2 m.			258.6-298.5 m Pyrite increases and is generally bedded, lesser amounts disseminated.
259.4-267.2 m Grey laminated dolomite.	259.4-267.2 m Alteration to friable clay (80% of rock) with remnants of solid core.	267.6 m Calcite vein.	
267.2-270.2 m Pale brown limestone. 270.2-274.2 m Fissile brown dolomite, algal in part? 274.2-278.5 m Grey limestone. 278.5-292.4 m Grey laminated dolomite, possible algal laminae at 291 m.	274.2-295.9 m Alteration to friable clay (80% of rock) with remnants of solid core. 280.1 m Intrusion of hydrothermal dolomite with pyrite stringers in 80 mm dome. Passive replacement, dolomite replacing dolomite, in adjacent host. 283.0-298.5 m Occasional zones of pink K-feldspar(?)	283.0-295.0 m Occasional dolomite and quartz veins.	
292.4-298.5 m Grey dolomite breccia, recrystallised, soft sediment deformation? 298.5-323.0 m Diapiric	295.9 m Solid core.		298.5-323.0 m Trace of pyrite in breccia matrix.
breccia, clasts in dolomite matrix.			
323.0 m	End of hole		

APPENDIX F: INVENTORY OF SADME PLANS

Table F-1 Burra copper mine, plans from underground mining era, 1850-1901, chronological index.

Plan No.	Title	Date	Comments
1988	Surface plan.	1850?	Shows offices, winding houses, etc.
1989	Burra, plan of 30 fathom level.	1850?	Survey of portion from Kingston's No.1 to Ayer's No.1 Shaft.
1981	Traverse of the 30 fathom level.	1850?	Drives and pitches between Kingston's No.1 and Ayer's Shaft.
63-643	Roach's Engine Shaft, Burra Burra Mine.	1850	Timbering and pump mechanism.
1982	Traverse of the 30 fathom level at the Burra Burra Mines.	10/1/1851	Drives between Stock's Shaft and Peacock's Air Shaft.
1985	Traverse of the 40 fathom level at the Burra Burra Mines.	10/1/1851	Drives and pitches on small portion of 40 fathom level.
1987	Traverse of the 50 fathom level.	Aug. 1852	Survey of main drives.
GRG30 series 74	Burra Burra Mines, plan of surface works and underground levels; also cross sections and water lines.	1852- 1853?	Underground levels to 50 fathoms; offices, workshops and shafts on surface; surveyed topographic sections to east of mine. Original coloured plan in State Records.
63-199	Burra Mines. Composite plan showing surface and underground workings.	1852- 1853?	Traced from GRG30, series 74.
1986	Burra, plan of 50 fathom level.	12/7/1855	Sketch of main drives from Peacock's Shaft to Ayer's No.1 Shaft.
1993	Plan of the levels in the Burra Mine.	Late 1850s	Detailed survey of 6, 12, 20, 25, 30, 35, 40, 45, 50 fathom levels.
1994	Composite plan, shows levels to 50 fathoms.		Plan missing; probably similar to 1993.
1984	Burra, plan of 60 fathom level.		Main drives from Roach's Shaft to Morphett's Shaft
1980	Plan of the levels in the Burra copper mines.		Shows 50, 55, 60 fathom levels, main drives from Peacock's Shaft to Morphett's Shaft.
1647	Plan of the levels in the Burra Mine.	Mid-1860s	Detailed survey of 8, 12, 20, 25, 30, 35, 40, 45, 50, 55, 60 fathom levels. Copied from plan lent by A.F. and P.A. McBride in 1940.
1657	Plan and sections of the Burra Mine.	Mid-1860s	Detailed survey of above 12, 17, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70 fathom levels. Copied from plan lent by A.F. and P.A. McBride in 1940.
1983	Burra copper mine. Plan of Allen's and Tinline's Lodes. Also Bon Accord property.	1873	Surface plan showing lode trace.
1990	Burra, bore site.	13/8/1898	
1554	Burra copper mines, longitudinal section.	15/10/1900	Drawn by H.R. Hancock.
1558	Burra copper mines, plan of lodes, open cut and shafts.	15/10/1900	Drawn by H.R. Hancock.
1992	Longitudinal and cross sections, Burra Mine.	10/12/1901	Topographic sections through dumps, ore floors, etc.

Table F-2 Burra copper mine, geological plans prepared in 1941–42 (S.B. Dickinson).

Plan No.	Title	Comments
2144	Burra copper mine, levels and shafts.	Plan missing, probably copied from plan 1657.
2144/a	Burra copper mine, longitudinal projection of workings.	Plan missing, probably copied from plan 1657.
2226	Geological map of Burra Burra Mine area, cross sections, and longitudinal projection of workings.	Reproduced in Bulletin No. 20, Figs 22, 22a.
2230	Burra district, regional geological map and geological sections.	Reproduced in Bulletin No. 20, Figs 21,21a.
4416	Level at 12 fathoms, RL 1660.	Plan missing, probably copied from plan 1657.
4417	Level at 20 fathoms, RL 1660.	Plan missing, probably copied from plan 1657.
4418	Level at 30 fathoms, RL 1535.	Plan missing, probably copied from plan 1657.
4419	Level at 40 fathoms, RL 1490.	Plan missing, probably copied from plan 1657.
4420	Level at 50 fathoms, RL 1415.	Plan missing, probably copied from plan 1657.
4421	Level at 60 fathoms, RL 1365.	Plan missing, probably copied from plan 1657.
4422	Level at 70 fathoms, RL 1300.	Plan missing, probably copied from plan 1657.
4423	Level at 85 fathoms, RL 1210.	Plan missing, probably copied from plan 1657.
4424	Transverse section 0.	Plan missing.
4425	Transverse section 1.	Plan missing.
4426	Transverse section 2.	Plan missing.
4427	Transverse section 3.	Plan missing.
4428	Transverse section 5.	Plan missing.
4429	Transverse section 6.	Plan missing.
4430	Transverse section 7.	Plan missing.
4431	Vicinity of Sheet A-B.	Plan missing.
4432	Vicinity of Sheet C?	Plan missing.
4433	Vicinity of Sheet F.	Plan missing.
4434	Vicinity of Sheet E.	Plan missing.
4435	Vicinity of Sheet D.	Plan missing.
4436	Regional geology, maps and sections, Burra district.	Preliminary version of plan 2230.
4437	Regional geological cross section.	Plan missing, preliminary version of cross sections in plan 2230.
4438	Topographic map.	Plan missing.
4439	Geology of Burra copper mine, first interpretation.	Plan missing, preliminary version of plan 2226.
4440	Portion of plan.	Plan missing.
4441	Portion of plan.	Plan missing.
4442	Northern extension.	Plan missing.
4443	Portion of plan.	Plan missing.
4526	Geophysical layout, Plan No.1.	Plan missing.

Table F-3 Burra copper mine, geological plans, SADM, 1937–65.

Plan No.	Title	Date	Compiler
1004	Geological plan of Burra Mines.	2/3/1937	R.W. Segnit
1562	Diagrammatic section of copper veins showing secondary enrichment.	1940	L.K. Ward, in Bulletin 20, Fig. 24
1531	Geological map of Burra Mines and district.	24/4/1948	R.W. Segnit, plan missing
S560	Burra district factual geological plan.	28/2/1952	C. Wegener
S562	Burra district geological plan.	11/3/1952	C. Wegener
52-125	Geological plan and section of the dolomite quarry, Burra Showgrounds.	28/3/1952	C. Wegener
61-722	Plan of part of Hd. Kooringa Co. Burra, showing proposed prospecting area.	11/10/1961	B.P. Thomson
61-729	Geological map, Burra Burra Mine.	18/10/1961	B.P. Thomson, after S.B. Dickinson
61-730	Regional map of sections of Burra district.	16/10/1961	B.P. Thomson, after S.B. Dickinson
S2899	Burra Mine main open cut, ore zone details of east wall.	11/10/1961	B.P. Thomson
S2900	Burra Mine main open cut, details of portion of ore zone at northern end of open cut.	12/10/1961	B.P. Thomson
S2901	Burra Mine main open cut, shale flowage in north face.	12/10/1961	B.P. Thomson
S2902	Burra Mine main open cut, slump breccia localising Burra ore bodies.	12/10/1961	B.P. Thomson
L72-78	Geological investigation Burra Burra copper mine. Detailed geology of main open cut.	6/6/1962	W. Johnson and M.G. Mason
63-95	Burra Mine traverse section 5.	26/2/1963	W. Johnson, after S.B. Dickinson
L63-169	Burra district regional geological map.	29/5/1963	W. Johnson
63-525A	Burra district regional geological map (legend).	3/6/1963	W. Johnson
63-550	Interpretation of the geology of the Burra Burra Mine.	12/6/1963	W. Johnson
63-552	Geological plan of the Burra Burra Mine.	13/6/1963	W. Johnson and M.G. Mason
63-592	Regional geology, Burra district	1963	Plan missing
L64-65	Geological map of the Burra Mine area.	1964	K.R. Warne
64-59	Geological map of the Burra area.	24/7/1964	K.R. Warne
L64-145	Burra copper mine area. Survey plan.	14/8/1964	M.G. Mason, R. Adams?
L64-164	Burra copper mine area. Geophysical survey location plan.	1964	Nixon et al., 1965 (RB61/47)
64-591	Geological map of the Burra area, showing location of West Burra copper mine.	24/2/1964	K.R. Warne
S3952	West Burra Copper Mine.	18/11/1964	K.R. Warne
65-82	Geological plan, Burra open cut and environs.	1965	Nixon et al., 1965 (RB61/47)
L65-86	Burra open cut and environs, Sample locality plan, showing diamond drill and percussion bore sites.	1965	Nixon et al., 1965 (RB61/47)
65-671	Burra Mine area, cross sections through proposed Diamond Drill Hole No. 13.	18/6/1965	K.R. Warne

Table F-4 Burra copper mine, geophysical plans, 1952–65.

Plan No.	Title	Compiler
52-39	Burra geophysical survey.	McPharlin, D. and Kerr Grant, C., 1952, in Kerr Grant et al., 1952
52-278	Burra North, resistivity plan.	McPharlin, D., 1952, in Kerr Grant et al., 1952
52-279	Burra North, lines of equal vertical magnetic intensity.	McPharlin, D., 1952, in Kerr Grant et al., 1952
52-280	Burra North, Bouguer gravity anomalies.	McPharlin, D., 1952, in Kerr Grant et al., 1952
S672	Burra North, depth resistivity.	McPharlin, D., 1952, in Kerr Grant et al., 1952
S675	Burra North, self potential survey.	McPharlin, D., 1952, in Kerr Grant et al., 1952
S676	Burra North, self potential profiles.	McPharlin, D., 1952, in Kerr Grant et al., 1952
57-221	Burra standard sheet, gravity plan.	Seedsman, K., 1957
61-674	Burra Mine area, potential gradient cross sections of geophysical test traverses.	Bureau of Mineral Resources
62-226	Geophysical survey at Burra SA, Morphett's Shaft and northern layout geophysical profiles.	Bureau of Mineral Resources
62-227	Burra Mine area SA, potential gradient cross sections, geophysical test traverses.	Bureau of Mineral Resources
L62-4	Burra Mine SA, plan and sections of potential gradient contours, northern layout.	Bureau of Mineral Resources
62-532	Burra standard sheet, mosaic of aeromagnetic flight lines.	_
L63-257	Burra area, induced polarization survey, contours of resistivity and induced polarization, Lines 6N, 1N, 6S.	?
63-657	Burra standard sheet, aeromagnetic map of total intensity.	Plan missing
63-678	Burra standard sheet, aeromagnetic map of total intensity.	Plan missing
63-515	Burra Burra Mine area, IP traverses at 200' electrode spread.	Benlow, J.C., 1963, in Report Book 56/136
63-524	Burra area, IP traverse at 400' electrode spread.	Benlow, J.C., 1963, in Report Book 56/136
63-525	Burra area, IP and resistivity sections, 200' electrode spread.	Benlow, J.C., 1963, in Report Book 56/136
63-526	Burra area, IP and resistivity sections, 400' electrode spread.	Benlow, J.C., 1963, in Report Book 56/136
S3406	Burra area, regional sketch map.	Benlow, J.C., 1963, in Report Book 56/136
S3407	Burra area, gravity and magnetic profiles, Line 1N.	Benlow, J.C., 1963, in Report Book 56/136
S3551	Burra area, IP survey. Geological locality plan showing eastern IP anomalies.	Taylor, B.J., 1963
63-997	Burra Burra Mine area, IP traverses at 400' electrode spread showing induced polarization anomalies.	Taylor, B.J., 1963
63-998	Burra area, induced polarization survey, contours of resistivity and induced polarization shot lines.	Taylor, B.J., 1963
L63-257	Burra area, induced polarization survey, contours of resistivity and induced polarization, Lines 6N, 1N, 6S.	Taylor, B.J., 1963
63-999	Burra area, induced polarization survey, metal factor contours showing eastern anomaly.	Taylor, B.J., 1963

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64-249	Burra, resistivity and metal factor contour Lines 6.5N-4N.	Taylor, B.J., 1964
L64-74	Burra Mines, geological regional map. Plan showing induced polarization traverses and anomalous zones.	Taylor, B.J., 1964
L64-75	Burra Mines, induced polarization survey, Zone C, resistivity and metal factors. Plan showing contours.	Taylor, B.J., 1964
L64-80	Burra geological plan showing IP traverses and anomalous zones.	Taylor, B.J., 1964
64-380	Burra area, EM survey northwestern area. Geological plan showing IP and EM grid and associated anomalies.	Taylor, B.J., 1964
64-381	Burra area, EM survey northwestern area. Profiles on Lines 5.5N, 6N and 6.5N.	Taylor, B.J., 1964
64-820	Burra IP survey, first IP report, FE values. Lines 1N, 00, 1S, 2S and 4S.	Fairburn, W.A., 1964
64-821	Burra IP survey, first IP report, contoured FE values. Lines 5N, 2N, 1N and 00.	Fairburn, W.A., 1964
64-822	Burra IP survey, second IP report, contoured FE values. Lines 5N, 4N, 2N, 00, 1S, 2S, 4S and 5S.	Fairburn, W.A., 1964
64-823	Burra IP survey, second IP report, contoured FE values. Lines 6N, 1N and 6S.	Fairburn, W.A., 1964
64-824	Burra IP survey, third IP report, contoured FE values. Lines 4.0, 4.5, 5.0, 5.5, 6.0 and 6.5N.	Fairburn, W.A., 1964
S3887	Burra IP survey, third IP report, FE vectorial analysis. Line 6N.	Fairburn, W.A., 1964
L64-164	Burra copper mine area, geophysical survey location plan.	Fairburn, W.A., 1964
65-209	Burra area, location of traverses, IP and EM anomalies.	Taylor, B.J., 1965
65-210	Burra area, Line 5N. Contours of resistivity and frequency effects with 400' dipole configuration.	Taylor, B.J., 1965
65-211	Burra area, Line C. Contours of resistivity and frequency effects with 200' and 100' dipole-dipole configuration.	Taylor, B.J., 1965
65-212	Burra area, Lines 5.5N and D. Contours of resistivity and frequency effects with 400', 200' and 100' dipole-dipole configuration.	Taylor, B.J., 1965
65-213	Burra area, Line E. Contours of resistivity and frequency effects with 200' and 100' dipole-dipole configuration.	Taylor, B.J., 1965
65-214	Burra area, Lines 6N and F. Contours of resistivity and frequency effects with 400', 200' and 100' dipole-dipole configuration.	Taylor, B.J., 1965
65-215	Burra area, Line G. Contours of resistivity and frequency effects with 200' and 100' dipole-dipole configuration.	Taylor, B.J., 1965
L66-40	Burra area, Line 1N. Contours of resistivity, frequency effect and metal factors; geological cross section.	Taylor, B.J., 1966
L66-41	Burra area, Line 6N. Contours of resistivity, frequency effect and metal factors; geological cross section.	Taylor, B.J., 1966
L66-42	Burra area, Line 6S. Contours of resistivity, frequency effect and metal factors; geological cross sections.	Taylor, B.J., 1966
L66-66	Burra area. Plan showing location of geological boundaries, geophysical traverses, anomalous zones, and power and water facilities.	Taylor, B.J., 1966
66-307	Burra area, Line 6.5N. Contours of resistivity, frequency effect and metal factors.	Taylor, B.J., 1966
S4734	Burra area. Profiles and interpretation of electrical sounding.	Taylor, B.J., 1966
S5375	Burra area. Gravity and elevation profiles of Lines 1N and 6N.	Taylor, B.J., 1966

Table F-5 Burra copper mine, miscellaneous plans, SADM.

Plan No.	Title	Date	Comments
1624	Burra copper dumps.	28/4/1940	Survey of tonnage of copper dumps near Morphett's Shaft, C.E. Gregory
2084	North Works Smelting LLTO.	1941	Title search
2224	Burra copper mines, plan and sheet of calculations.	18/8/1941	Survey of slag dump and tonnage estimate
2258	Burra area.	?	Levelled traverses north and south of mine, prior to geophysics
S744	Burra district copper workings. Locality plan.	17/3/1953	Locations only; R.K. Pitman and M.L. Raynor
54-216	Burra district locality plan.	23/9/1954	Mine locations
L63- 144	Portion of a plan of Burra Corporation.	1963	Cadastral boundaries
63-390	Plan of Burra Corporation.	1963	Plan missing
SK-786	Samin Ltd. Burra operations, dewatering bore at Burra.	18/9/1975	J.H. Perry

APPENDIX G: U-PB ZIRCON DATING OF THE PORPHYRY, BURRA MINE

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Methods

Zircons from two samples of the porphyry, R1662960A and R1662960B (Fig. A), were dated using the laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS) method. Details of the instrumentation and methodologies can be found in Reid et al (2006) and are identical to those followed by Payne et al. (2006) and Wade et al. (2007). Briefly, zircons were separated by standard crushing, magnetic and density processes at a commercial mineral separating laboratory, MinSep Laboratories, Denmark, WA. These zircons were mounted in epoxy resin and polished so as to expose the grains. The zircons were imaged under transmitted light and using cathodoluminescence (CL) function of a Phillips XL-20 scanning electron microscope housed at Adelaide Microscopy, the University of Adelaide. The isotopic analyses were also conducted at Adelaide Microscopy, using a New Wave Research Nd–YAG laser operating at an output wavelength of 213 nm. Ablated material is transported into an Agilent 7500 quadrupole ICPMS within the clear plastic tubing via the action of an Ar–He carrier gas medium. Time-resolved signals of ^{204, 206, 206, 208}Pb, ²³²Th and ²³⁸U acquired with a 30µm spot size and a 5 Hz repetition rate were processed using the GLITTER software of van Achterbergh *et al.* (1999). ²³⁵U was calculated assuming ²³⁵U=²³⁸U/137.88.

The GJ standard zircon of Jackson *et al.* (2004) was used to calibrate Pb/U fractionation, and data quality was monitored by analysing both the 91500 standard zircon and a Sri Lankan gem quality zircon standard, 'BJWP'. Thirteen analyses of 91500 produced a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 1070 ± 41 Ma (MSWD = 0.51) and a $^{206}\text{Pb}/^{238}\text{U}$ age of 1065 ± 10 Ma (MSWD = 0.19), within error of the thermal ionization mass spectrometry (TIMS) age for this zircon ($^{207}\text{Pb}/^{206}\text{Pb}$ age = 1065.4 ± 0.6 ; Wiedenbeck et al., 1995). Likewise, ten analyses of the BJWP standard yielded a $^{206}\text{Pb}/^{238}\text{U}$ age of 729.6 \pm 8.5 Ma (MSWD = 0.61), within error of the c. 727 Ma age quoted for this zircon (Payne et al., 2006; Wade et al., 2007). In general, the low ^{207}Pb signals obtained during the course of the present study mean that the $^{207}\text{Pb}/^{206}\text{Pb}$ and $^{207}\text{Pb}/^{235}\text{U}$ ages are less precise than the corresponding $^{206}\text{Pb}/^{238}\text{U}$ ages, hence the latter ratio is used exclusively in the calculation of weighted mean ages.

Data for ²⁰⁴Pb is compromised by interference from ²⁰⁴Hg, a trace contaminant in the Ar-He carrier gas. Nevertheless, this isotope is monitored for the presence of elevated common Pb. All analyses except one made in the course of this work showed negligible net ²⁰⁴Pb and no common Pb correction has been applied to the data. The analyses with high net ²⁰⁴Pb is flagged in the discussion of the results below and is omitted from the weighted mean age calculations. Weighted mean age calculations and inverse Concordia diagrams have been constructed using Isoplot v3 (Ludwig, 2003), while probability density distributions have been constructed using AgeDisplay (Sircombe, 2004). Inverse Concordia (Tera-Wasserburg) diagrams are very useful since they are able to indicate the presence of common Pb in addition to Pb loss.

Results

Zircon characteristics

Zircon populations from the two samples are exclusively euhedral to sub-euhedral transparent grains (Figs B, C). Grains range in morphology from tabular to needle-shaped, with many grains showing small inclusions of presumably apatite and more rarely, opaque species, possibly sulphide. Under CL the grains show oscillatory zonation typical of igneous zircons, which is consistent with the strongly euhedral, unmodified crystal habit of many of the grains.

Thus the zircons in both samples are interpreted to represent a single population of igneous crystals formed during the crystallisation of the porphyry.

LA-ICPMS results

Forty analyses were made on zircons from sample R1662960A. These analyses range from concordant to strongly discordant, with fourteen analyses being >10% discordant (Table A). Such discordance is not unexpected given the variably altered nature of the porphyry sample. When plotted on an inverse Concordia (Terra Wasserburg) plot, the analyses are seen to cluster around Concordia, with a two analyses lying above Concordia (60A-15, -17), indicating the likely presence of common Pb in these grains. A Concordia age calculated from all the data yields a Model 2 (data points equally weighted, ignoring individual errors) lower intercept age of 787 \pm 8 Ma (MSWD = 2.1; Fig. D). Analysis 60A-32 is 25% discordant and has a comparatively young 206 Pb/ 235 U age of 714 \pm 13 Ma and, since it lies to the right of the Concordia cluster, is likely to have suffered Pb loss. Omitting this data point from the Concordia age calculation yields a more acceptable MSDW of 1.3 for a lower intercept age of 790 \pm 7 Ma. A probability density distribution of the 206 Pb/ 235 U ages reveals a unimodal age population (Fig. D). Omitting the analyses with discordance >10%, a weighted mean 206 Pb/ 238 U age of 795 \pm 5 Ma can be calculated (n = 26; MSWD = 1.09; probability = 0.35). This weighted mean age is inferred to be the best estimate for the timing of magmatic zircon crystallisation in this sample.

Twenty-three analyses were made on zircons from sample R1662960B. Similar to the previous sample the data show a range of discordance with seven analyses being >10% discordant (Table B). The inverse Concordia plot shows a number of analyses lying above Concordia indicating the presence of common Pb (Fig. E). In addition, two analyses, 60B-2 and-21, lie to the right of the main population, indicating they have undergone Pb loss. The probability density distribution for this sample shows the majority of the 206 Pb/ 238 U ages cluster at ~800 Ma, similar to the previous sample (Fig. E). Note that the probability density distribution reveals a slight shoulder to the younger side of the main peak at ~800 Ma. This shoulder appears due to a number of analyses having ages between ~780 and ~760 Ma. It is clear that some of the analyses have undergone Pb loss, and it is possible that a slight lowering of some of the 206 Pb/ 238 U ages has occurred. The suggestion that Pb loss being more prevalent in this sample, R1662960B, compared to the previous sample reflects the more strongly altered nature of this rock. Nevertheless, the data from sample R1662960B remain statistically indistinguishable and a weighted mean 206 Pb/ 238 U age of 800 ± 9 Ma (MSWD = 1.60; probability = 0.05; n = 19) can be calculated from all the data that lies within ±10% discordance.

Since both samples are from the same porphyry intrusion the data may be pooled. A weighted mean 206 Pb/ 238 U age of 797 ± 5 Ma can be calculated from the forty-five analyses that lie within ±10% discordance (MSWD of 1.3; probability = 0.08). This age is considered to be the best estimate from the LA-ICPMS data for the timing of magmatic crystallisation of the porphyry.

References

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Figures





Figure A. Photograph of rock samples from which zircons were extracted. Ten cent coin (22mm diameter) for scale. a. Sample R1662960A. b. Sample R1662960B. Note the presence of sulphides in both samples, an in particular in sample B, where coarse chalcocite and pyrite are observed in the central portion of the sample. *(407329)*

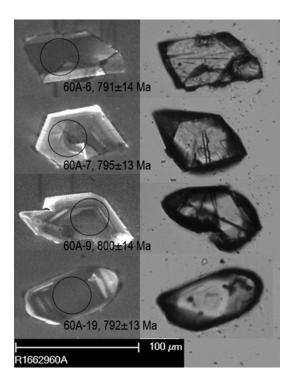


Figure B. Selected zircons from sample R1662960A. Left panel shows CL images and right panel the transmitted light photomicrographs of the corresponding zircons. Also indicated are the site of laser ablations spot analyses with the corresponding ²⁰⁶Pb/²³⁸U age. (407330)

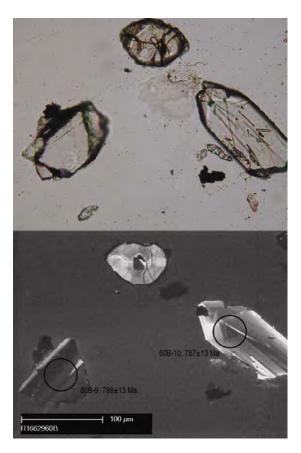


Figure C. Selected zircons from sample R1662960B. Top panel shows transmitted light photomicrographs and the bottom panel the CL images of the corresponding zircons. Also indicated are the site of laser ablations spot analyses with the corresponding ²⁰⁶Pb/²³⁸U age. (407331)

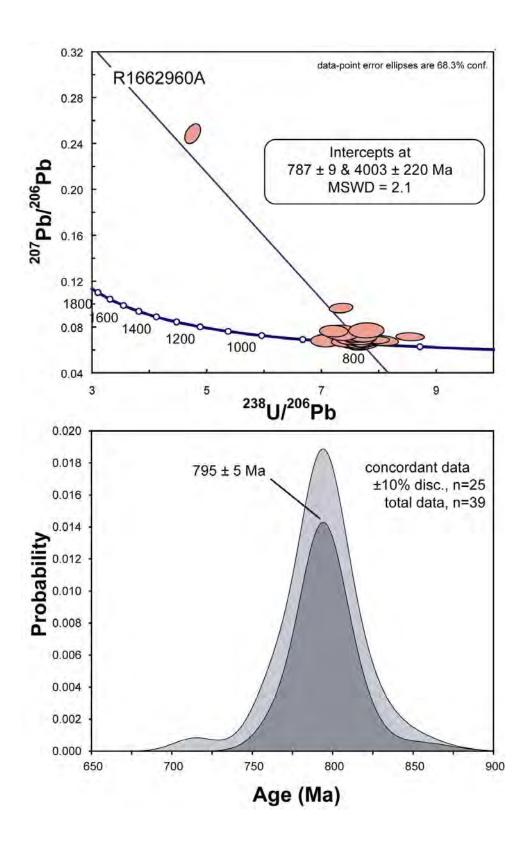


Figure D. Concordia (top) and probability density distribution (bottom) showing concordant (Dark grey) and discordant (light grey) data for sample R1662960A. Age indicated on the probability density distribution is the weighted mean age calculated from the data $\pm 10\%$ discordance.

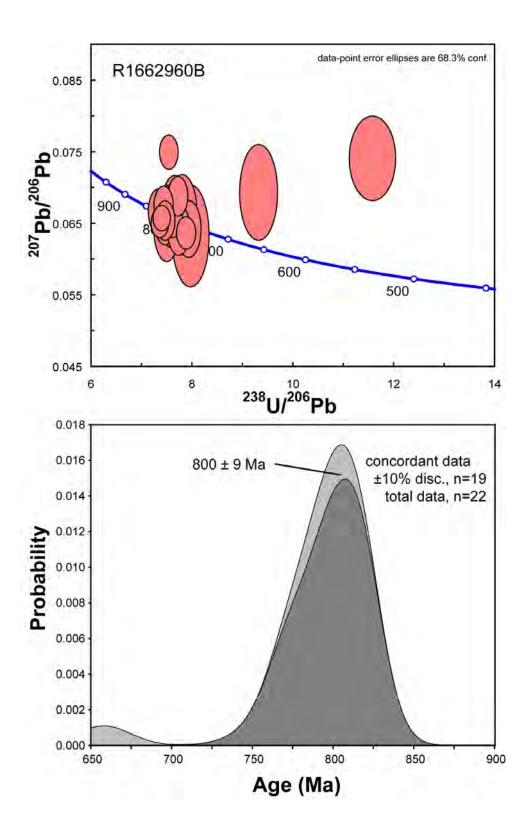


Figure E. Concordia (top) and probability density distribution (bottom) showing concordant (Dark grey) and discordant (light grey) data for sample R1662960B. Age indicated on the probability density distribution is the weighted mean age calculated from the data ±10% discordance.

Table A. Summary of LA-ICPMS analysis of zircons from sample 1662960a.

Analysis	Isotopic ratios							Ages (Ma)							
	Pb207/		Pb206/		Pb207/		Pb207/		Pb206/		Pb207/		disc		
	Pb206	1σ	U238	1σ	U235	1σ	Pb206	1σ	U238	1σ	U235	1σ	%		
60A-1	0.065	0.003	0.1313	0.0027	1.1725	0.0528	769	95	795	15	788	25	-3		
60A-2	0.065	0.002	0.1317	0.0022	1.1751	0.0379	767	68	797	13	789	18	-4		
60A-3	0.064	0.002	0.1303	0.0022	1.1557	0.0384	754	70	790	13	780	18	-5		
60A-4	0.069	0.002	0.1350	0.0022	1.2790	0.0358	891	58	816	12	836	16	8		
60A-5	0.066	0.003	0.1321	0.0025	1.2050	0.0478	812	83	800	14	803	22	2		
60A-6	0.067	0.005	0.1305	0.0025	1.2055	0.0823	838	137	791	14	803	38	6		
60A-7	0.064	0.003	0.1312	0.0022	1.1558	0.0623	739	111	795	13	780	29	-8		
60A-8	0.066	0.004	0.1330	0.0024	1.2042	0.0725	797	122	805	14	803	33	-1		
60A-9	0.064	0.004	0.1321	0.0024	1.1723	0.0723	754	126	800	14	788	34	-6		
60A-10	0.067	0.004	0.1306	0.0024	1.2115	0.0713	847	119	791	13	806	33	7		
60A-11	0.065	0.004	0.1303	0.0033	1.1752	0.0758	789	135	790	19	789	35	0		
60A-12	0.066	0.003	0.1349	0.0029	1.2297	0.0598	811	102	816	17	814	27	-1		
60A-13	0.076	0.004	0.1388	0.0032	1.4459	0.0739	1084	103	838	18	908	31	23		
60A-14	0.067	0.002	0.1309	0.0023	1.2007	0.0420	824	73	793	13	801	19	4		
60A-15	0.096	0.003	0.1365	0.0025	1.8005	0.0582	1542	62	825	14	1046	21	47		
60A-16	0.071	0.003	0.1314	0.0024	1.2796	0.0458	947	74	796	14	837	20	16		
60A-17	0.249	0.006	0.2112	0.0041	7.2385	0.1669	3176	39	1235	22	2141	21	61		
60A-18	0.068	0.002	0.1254	0.0022	1.1703	0.0382	859	68	762	12	787	18	11		
60A-19	0.065	0.002	0.1307	0.0022	1.1758	0.0393	783	70	792	13	789	18	-1		
60A-20	0.063	0.003	0.1308	0.0028	1.1453	0.0595	725	110	793	16	775	28	-9		
60A-21	0.067	0.004	0.1416	0.0035	1.3123	0.0769	844	122	854	19	851	34	-1		
60A-22	0.065	0.002	0.1317	0.0022	1.1828	0.0371	779	66	798	12	793	17	-2		
60A-23	0.067	0.004	0.1244	0.0030	1.1547	0.0652	848	118	756	17	780	31	11		
60A-24	0.063	0.002	0.1294	0.0020	1.1321	0.0298	724	55	784	11	769	14	-8		
60A-25	0.067	0.003	0.1280	0.0026	1.1764	0.0537	828	95	776	15	790	25	6		
60A-26	0.069	0.004	0.1319	0.0030	1.2468	0.0672	887	112	799	17	822	30	10		
60A-27	0.067	0.003	0.1260	0.0025	1.1684	0.0500	847	89	765	14	786	23	10		
60A-28 60A-29	0.067	0.002	0.1308 0.1264	0.0020 0.0025	1.2159 1.1787	0.0286 0.0497	851 859	47 88	793 767	11 14	808 791	13 23	7 11		
60A-29 60A-30	0.068 0.070	0.003		0.0025	1.2564	0.0497	942	94	784	15	826	26	17		
60A-31	0.074	0.005	0.1234	0.0027	1.3915	0.0954	1044	138	824	21	885	41	21		
60A-31	0.074	0.003	0.1303	0.0022	1.1393	0.0457	948	82	714	13	772	22	25		
60A-32	0.069	0.003	0.1308	0.0022	1.2490	0.0428	910	71	793	13	823	19	13		
60A-34	0.069	0.004	0.1306	0.0020	1.2395	0.0692	898	115	791	17	819	31	12		
60A-35	0.070	0.003	0.1324	0.0027	1.2764	0.0553	931	89	801	15	835	25	14		
60A-36	0.066	0.003	0.1265	0.0023	1.1503	0.0434	809	79	768	13	777	20	5		
60A-37	0.066	0.002	0.1312	0.0021	1.1954	0.0356	813	62	795	12	799	16	2		
60A-38	0.064	0.004	0.1329	0.0029	1.1787	0.0621	756	111	805	17	791	29	-6		
60A-39	0.069	0.004	0.1334	0.0030	1.2660	0.0691	899	113	807	17	831	31	10		
60A-40	0.076	0.005	0.1287	0.0034	1.3518	0.0842	1105	125	780	19	868	36	29		
	-														

Note: disc % denotes percentage discordance, where 0 indicates a concordant analysis

Table B. Summary of LA-ICPMS analysis of zircons from sample 1662960b.

Analysis	Isotopic ratios							Ages (Ma)							
	Pb207/		Pb206/		Pb207/		Pb207/		Pb206/		Pb207/		disc		
	Pb206	1σ	U238	1σ	U235	1σ	Pb206	1σ	U238	1σ	U235	1σ	%		
60B-1	0.0667	0.0026	0.1325	0.0025	1.2185	0.0456	830	78	802	14	809	21	3		
60B-2	0.0693	0.0050	0.1075	0.0029	1.0264	0.0709	908	141	658	17	717	36	27		
60B-3	0.0640	0.0027	0.1295	0.0025	1.1424	0.0470	742	87	785	14	774	22	-6		
60B-4	0.0654	0.0038	0.1325	0.0031	1.1944	0.0661	788	116	802	18	798	31	-2		
60B-5	0.0688	0.0022	0.1298	0.0022	1.2299	0.0387	891	64	787	13	814	18	12		
60B-6	0.0658	0.0030	0.1342	0.0027	1.2176	0.0533	799	92	812	16	809	24	-2		
60B-7	0.0662	0.0042	0.1284	0.0032	1.1710	0.0717	811	127	779	18	787	34	4		
60B-8	0.0642	0.0030	0.1263	0.0026	1.1169	0.0511	748	97	767	15	762	25	-2		
60B-9	0.0653	0.0022	0.1343	0.0023	1.2092	0.0394	785	68	812	13	805	18	-4		
60B-10	0.0659	0.0023	0.1317	0.0023	1.1972	0.0418	804	73	798	13	799	19	1		
60B-11	0.0674	0.0022	0.1348	0.0023	1.2524	0.0402	850	66	815	13	825	18	4		
60B-12	0.0645	0.0036	0.1337	0.0030	1.1880	0.0646	757	114	809	17	795	30	-7		
60B-13	0.0650	0.0017	0.1360	0.0021	1.2194	0.0320	775	54	822	12	810	15	-6		
60B-14	0.0666	0.0025	0.1366	0.0025	1.2548	0.0452	826	75	825	14	826	20	0		
60B-15	0.0661	0.0032	0.1329	0.0028	1.2101	0.0573	808	99	804	16	805	26	0		
60B-16	0.0632	0.0053	0.1256	0.0038	1.0943	0.0878	715	169	763	22	751	43	-7		
60B-17	0.0668	0.0037	0.1308	0.0030	1.2056	0.0638	832	110	793	17	803	29	5		
60B-18	0.0749	0.0020	0.1329	0.0021	1.3723	0.0364	1067	52	805	12	877	16	25		
60B-19	0.0665	0.0028	0.1319	0.0026	1.2094	0.0501	823	87	799	15	805	23	3		
60B-20	0.0657	0.0032	0.1317	0.0029	1.1930	0.0557	798	98	798	16	797	26	0		
60B-21	0.0741	0.0046	0.0865	0.0023	0.8822	0.0519	1045	120	535	13	642	28	49		
60B-22	0.0657	0.0015	0.1354	0.0021	1.2261	0.0289	797	48	819	12	813	13	-3		
60B-23	0.0636	0.0018	0.1271	0.0020	1.1145	0.0315	729	59	771	12	760	15	-6		

Note: disc % denotes percentage discordance, where 0 indicates a concordant analysis

APPENDIX H: SUPPORTING GIS DATA FOR REPORT BOOK 2008/16

Compiled by L. Katona, G. Gouthas and E. Appelbee (2008)

GIS methodology for the Burra Mine geology, boundary and 3D datasets.

The sources of the spatial datasets were the 1981 hardcopy base plan map (including the mine grid), mine geology map, base plan elevation map and elevation survey data captured when excavation of the pit was completed.

The 1:500 scale base plan displaying the mine benches was scanned and georeferenced against current ortho-imagery using control points recorded on the mine plans located in and around the mine.

The base plan was vectorised using ArcGIS™ software and edited to remove unwanted lines. The scanned geology map was then georeferenced against the mine grid on the base plan. The geological boundaries were digitised and added to the base plan lines. Conversion of the lines to polygons resulted in boundary (polyline) and geology (polygon) datasets. The geology polygons and boundaries were tagged with their geological attributes and checked for topological correctness.

A version of the base map with elevation survey points was georeferenced to the base plan and the elevation points were digitised from the georeferenced map (into a point dataset). The elevations were then added to the elevation point dataset, referenced from stadia books recorded at the time of the mine survey. In addition to the elevation points, borehole and survey station points were captured and saved in separate point datasets.

The point dataset elevation values were transferred to the base plan lines (where spatially coincident), and these lines were used to generate a 3D triangular irregular network (TIN). Elevation points not spatially coincident with base plan lines were added to the TIN separately. The TIN was resampled to a grid and exported to a variety of GIS and 3D software formats. The Geology dataset was draped over the TIN in a 3D visualisation environment and output to Adobe 3D pdf for display in Acrobat Reader™.

All datasets were converted to MapInfo format and are displayed in layouts supported by Mapinfo and ArcGIS. The file "Directory&File metadata.txt" on the data disk contains a complete explanation of the files contained on the disk.