DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

# BASE METAL MINERALISATION IN THE PERNATTY LAGOON REGION, SOUTH AUSTRALIA

by

R.K. JOHNS
CHIEF GEOLOGIST

Rept.Bk.No.72/189
G.S. No. 4955
DM. No. 1004/72

4th October, 1972

CONTENTS

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rept.Bk.No.72/189
G.S. No. 4955
DM. No. 1004/72

# BASE METAL MINERALISATION IN THE PERNATTY LAGOON REGION, SOUTH AUSTRALIA

## ABSTRACT

Concentrations of copper occur in sandstone (Whyalla Sandstone Member) and dolomite (Woocalla Dolomite) which rest disconformably on an undulating surface of quartzite (Pandurra Formation) in the Mount Gunson area. Several attempts have been made to mine chalcocite and oxidised copper ores on the floor of Pernatty Lagoon and on the marginal tablelands.

Exploration which has been recently undertaken by Noranda Australia Ltd. in the same environment south of Pernatty Lagoon has discovered previously unsuspected, widespread, but low grade zinc, lead and copper sulphide mineralisation in dolomitic black shales (Woocalla Dolomite) which underlie the Whyalla Sandstone Member, generally under cover of Quaternary sand.

Copper mineralisation appears to be concentrated in sandstone and dolomite adjacent to and within a stromatolite reef complex about a basement high (the Pernatty culmination) whereas zinc and lead, in subeconomic concentrations, occur in laterally equivalent dolomitic black shales which accumulated in a restricted lagoonal environment, in depressions within the Pandurra Formation.

## INTRODUCTION

Copper deposits were discovered adjacent to the western shores of Pernatty Lagoon in 1875. Desultory mining operations resulted in the production of 3 250 tons of hand dressed ore, generally containing 8 to 16% Cu, during the period 1898 to 1937. During World War II (in the period 1941 to 1943) 32 380 tons of ore were recovered for treatment at the Broken Hill Associated Smelters at Port Pirie to yield 1 084 tons of copper metal and 14 523 ozs. of silver. Work was discontinued when the

minimum grade of 2.5% Cu could not be maintained by open cast mining.

The known copper deposits comprise discrete, shallow, gently undulating more or less tabular bodies of generally low grade that range up to 15ft. in thickness and are concentrated along disconformities which separate sandstones (Whyalla Sandstone Member) and dolomites with shales (Woocalla Dolomite) from the underlying Pandurra Formation. Ore minerals which include chalcocite, bornite, covellite, malachite, atacamite and chrysocolla occur as a cement to rounded quartz grains in the friable sandstone and as infillings of irregular fractures in dense quartzite on the surface of disconformity. Sulphides (principally chalcocite) are restricted to the floor of Pernatty Lagoon and as unoxidised cores of copper carbonate and silicate veinlets in the deeper levels of the tableland workings above the water table. Elsewhere, oxidised ores including malachite, atacamite and chrysocolla have been exposed in the Mount Gunson workings which range to 60ft. in depth. Copper also occurs immediately above, within and immediately below the dolomite, occasionally with barytes, fluorite and manganese in the "dolomite" workings at Mount Gunson, at Sweet Nell and Fair Nell on the southwestern shores of Pernatty Lagoon.

Geological features of the copper deposits of the Pernatty Lagoon - Mount Gunson area have been previously reported by Wainwright (1914), Dickinson (1942, 1953) and Johns (1965, 1968).

Renewal of exploration activity in 1965 led to reopening of the mine by Mount Gunson Mines Pty. Ltd. in May 1970 when open-cut reserves were put at 3.2 million tons of +1% copper ore. Mining was initiated on the floor of Pernatty Lagoon (Gunyah deposits) and chalcocite was recovered by flotation in a mill constructed on the adjacent tableland (Plate 1). Fall in price of copper and difficulty experienced in treatment of partially oxidised ores forced closure of operations in

December, 1971 and the plant was put on a care and maintenance basis. Details of that company's exploration are still held as confidential.

Manganese and barytes in workable concentrations and fluorite, of academic interest, occur on the floor and adjacent western shores of Pernatty Lagoon within the Woocalla Dolomite immediately above the disconformity (Johns, 1968).

Following an appraisal of the Mount Gunson - Pernatty Lagoon copper deposits a search in the surrounding area for repetition of this type of mineralisation adjacent to the disconformity above the Pandurra Formation was initiated by Noranda Australia Pty. Ltd. in 1967. Exploration undertaken under aegis of Special Mining Lease (SML) No. 152 of 2 700 square miles, during the period 1st July, 1967 to 1st January,1968 led to the selection of several parametres which suggested areas for further investigation. An area of 88 square miles was subsequently granted to Noranda Australia Ltd. as S.M.L. 247 on 1st October, 1968 but this was surrendered on variation of the application to be replaced by S.M.L. 256 over a much larger area of 900 square miles for a two year term (1st October, 1968 to 1st October, 1970). On 5th November, 1970 a reduced area of 519 square miles was granted as S.M.L. 499 and, at expiry on 5th November, 1971 was replaced by S.M.L. 647 of 244 square miles on 25th November, 1971; this was surrendered on 4th July, 1972. The boundaries of these S.M.L. are depicted on the locality plan (Fig. 1).

This report has been prepared to document the results of work undertaken by Noranda Australia Ltd. in the Pernatty Lagoon area and is largely based on company reports of Tonkin (1968), Thomas (1969 a & b), Dunlop (1970) Appleyard (1970) and Thomas and Douch (1971).

## REGIONAL GEOLOGY

The Upper Proterozoic Adelaidean sedimentary sequence exposed in the Pernatty Lagoon area constituted an undeformed shelf facies (Stuart Shelf), extending along the western margin of the Adelaide Geosyncline and forming a cratonic cover of shallow-water marine sediments on the Gawler Platform. This platform is underlain by dominantly metamorphic and igneous rocks.

In the area under review the topography is subdued and is characterised by dissected tablelands and low rounded hills rising 250ft. to 300ft. above sea level and separated by extensive sand plain. The area is bordered along its northern and northeastern perimeters by the dissected Arcoona Plateau, elevated 800ft. with isolated residuals e.g. Mount Gunson, Bonney Bluff and Oakden Hills within it. Rock outcrop and sub-outcrop possibly total 15% of the area; a similar area is occupied by normally dry lakes or lagoons which receive local internal drainage; the balance is obscured by sand plains and dunes.

The stratigraphy and disposition of outcrops depicted in Figure 2 are based on published maps, Torrens 1:250 000 (Johns et. al. 1964), Port Augusta 1:250 000 (Dalgarno et al. 1968) with further refinements by Tonkin (1968).

1. Gawler Range Volcanics

The oldest rocks, which are exposed in the southwestern extremity of the area, comprise felspar porphyry of Carpentarian age; these outcrops mark the northern limits of crystalline basement which underlie the Gawler Ranges.

2. Roopena Volcanics

Lavas penetrated in Beda Bore, drilled in 1912, from 439ft. to 1 099ft. 6 ins. (total depth) were considered by Johns (1968) to be of Willouran age, equivalent to those exposed at Depot Creek and Roopena.

Pyroxene basalt has since been identified from cuttings collected at the bore site (Tonkin, 1968). The lavas are succeeded by what was described as "dark slaty rock", 158ft. in thickness.

3. Pandurra Formation

The oldest clastic rocks in the sequence belong to a formation of arenites known as the Pandurra Formation (Crawford, 1964) and comprise horizontally disposed pebbly quartzite, grits and sandstones. The formation outcrops on the floor of Pernatty Lagoon and in a prominent tableland marginal to its western shore where it forms the lower part of an undifferentiated series named the Pernatty Grit by Johns et. al. (1964). Mapping by Tonkin has delineated the formation near Trevenna Outstation and it extends in a range of low hills from Yudnapinna H.S. southerly to beyond Pandurra H.S. and along the west side of Lake MacFarlane.

Pebbles of the characteristically red coloured grit have been found as erratics in Sturtian glacigenes in the Flinders Ranges and a late Willouran age is assigned, accordingly. At Roopena the Pandurra Formation rests unconformably on Roopena Volcanics (Thomson, 1966).

The formation was penetrated in Beda Bore between 237ft. and 281ft. and in Woomera No. 1 bore from 1 490ft. to 2 005ft. (total depth) without disclosing its base.

4. Woocalla Dolomite

Dolomitic shales, dolomite and finely laminated black shales which comprise the Woocalla Dolomite rest disconformably on the Pandurra Formation and fill depressions on the undulating surface of that formation immediately to the west and south of Pernatty Lagoon. The dolomite beds lens out in the Mount Gunson H.S. locality so that the succeeding Whyalla Sandstone Member lies directly on the Pandurra Formation as it does in the Roopena area and, generally, elsewhere marginal to the

"Pernatty Culmination".

Dolomitic black shales have been intersected in drilling for water supplies over a wide area. Woomera No. 1 bore passed through 372ft. of dark grey finely laminated shale and dolomitic shale between 1 118ft. and 1 490ft. In Beda bore 14ft. of this formation were intersected in the interval 223ft. to 237ft. while a bore located four miles north of Maslin H.S. intersected over 100ft. Gibson's Camp bore drilled in 1891 penetrated "hard blue rock" from 75ft. to 253ft. below white sandstone. Ram Swamp bore, drilled in 1925, two and one half miles north-west of Magnacowie Well, intersected 82ft. of "blue clay" without disclosing its base. Black shales have been observed in the dump of an abandoned well one mile west of McLeay R.S. and in drill cuttings of several water bores sunk in the Trevenna locality. However, the formation appears to be absent in the Yudnapinna H.S. area and at Lake MacFarlane. The shales exposed at Magazine Hill near Woocalla comprise equivalents of the Woocalla Dolomite and are not now correlated with Woomera Shale. Black shales exposed at the copper prospect, 2 miles south-east of Pandurra H.S. are lateral equivalents.

The dolomite which outcrops along the western shore of Pernatty Lagoon and southwards to Lake Dutton is yellow, buff or grey, dense, massive and laminated and exhibits features of shallow water deposition including cross bedding, ripple marks and oolites. Intraformational breccia and crenulated bedding with abrupt terminations are suggestive of a stromatolite reef. Drilling undertaken by Noranda in the Oakden Hills - Lake Dutton - Trevenna area indicated irregularities on the upper surface of the Pandurra Formation in which finely laminated dolomites, shales and muds have been deposited. This suggests black shale deposition in a restricted lagoonal environment on the Pandurra surface with marginal reef complexes about basement highs which correspond to the Pernatty Culmination.

5. Tent Hill Formation

Throughout the extent of the Stuart Shelf this Marinoan formation is typically exposed in tableland margins and in descending order comprise Arcoona (Simmens) Quartzite Member and Corraberra Sandstone Member which passes down into Woomera (Tregolana) Shale Member that occupies the lowermost slopes and underlies the surrounding plains. The basal unit, the Whyalla Sandstone Member, in the type area rests disconformably on the Pandurra Formation. In the Pernatty Lagoon region it is underlain, locally, by the Woocalla Dolomite. The contact between the Whyalla Sandstone and the dolomite is disconformable and local channelling of the dolomite surface can be inferred e.g. at the Gun copper prospect near Mt. Gunson H.S. and elsewhere.

(1) Whyalla Sandstone Member. This unit is characterised by its white colour and by markedly spherical constituent quartz grains within a clayey matrix. Cobbles of purple-red Pandurra Formation are common in the basal beds close to the disconformity. Cross-bedding is common. The unit is often quite shaley towards the base but conglomerates are developed at the base of some sections.

In Woomera No. 1 bore white rounded quartz grit and sandstone, 334ft. in thickness was intersected between 784ft. 6 ins. and 1 118ft. In Beda bore the topmost 223ft. comprised Whyalla Sandstone.

This member thus thickens away from the Pernatty Culmination and represents a return to clastic sedimentation in a shallow water, high energy environment.

(2) Woomera Shale Member. (Tregolana Shale Member equivalent). These shales weather readily to white clay and are seldom seen in outcrop. In Woomera No. 1 bore a sequence of finely laminated purple, brown and green shales, 548ft. in thickness, were disclosed between 236ft. and 784ft. 6 ins. The member thins markedly towards the Pernatty Culmination

and is 30ft. thick where exposed in excavations on the floor of an arm of Pernatty Lagoon, overlying the Gunyah copper deposits (Plate 1).

(3) Corraberra Sandstone Member. Red-brown micaceous, flaggy, fine grained sandstones form the lower slopes of escarpments marginal to the Arcoona Plateau and in outliers in the northern part of the area. Woomera No. 1 bore was collared in this member and the uppermost 236ft. comprise laminated sandstones and siltstones with intercalated shales; slump structures are common.

(4) Arcoona Quartzite Member. (Simmens Quartzite Member equivalent). This is the topmost member of the Tent Hill Formation and is generally 200ft. to 300ft. in thickness. It is a dense white quartzite, containing abundant shale casts, that caps the Arcoona Plateau.

6. Tertiary Deposits

Fluviatile conglomerate of probable Tertiary age are restricted in occurrence in the Pernatty Lagoon locality.

Silicification of older units, particularly of the Arcoona Quartzite Member, Whyalla Sandstone Member and Pandurra Formation is widespread and relates to a period of extended weathering of peneplained surfaces.

7. Quaternary Deposits

Extensive sand plains isolate exposures of ancient rocks throughout the area. The sand is locally derived from erosion of the older sediments and includes a high content of gypsum along the eastern shores of the numerous lakes throughout the area of the Bookaloo Lowlands.

## STRUCTURE

The dominating structure in the region is a culmination expressed by the pre-Marinoan disconformity which outlines inliers of Pandurra Formation protruding through the younger Whyalla Sandstone Member (Fig. 2). It extends from south of Yudnapinna H,S., through

Trevenna O.S., along the western side of Pernatty Lagoon to the northern end of Lake Windabout.

The Pernatty Culmination is a basement high. Erosional irregularities of the surface controlled the sedimentation of the Woocalla Dolomite. Webb and Woyzbun (1967) after study and interpretation of available aeromagnetic data suggested that the configuration of the 'high' was controlled by block faulting.

The platform cover is draped over the irregular gently undulating older surface but it is, essentially, horizontally disposed throughout.

Structural information derived from mapping and interpretation of aeromagnetic data outlined areas which were considered to hold potential for economic copper mineralisation of the Mount Gunson type.

## EXPLORATION, NORANDA AUSTRALIA LTD.

### 1. Regional Surveys

Geological mapping of the 2 700 square miles area of S.M.L. 152 surrounding the Mount Gunson copper deposits was undertaken by Noranda in late 1967 to trace the disconformity which is the locus of copper mineralisation at Mount Gunson (Tonkin, op. cit.).

Geochemical analysis of samples taken from the core of Woomera No. 1 bore disclosed that zinc (in particular) with lead, copper and manganese are concentrated in the Woocalla Dolomite with a peak in metal values occurring at the disconformable contact between the dolomite and the overlying sandstone (Fig. 3). Samples of rock were taken from outcrops adjacent to the disconformity throughout the area and of spoil from wells and boreholes. Terrain difficulties, including extensive wind blown sand cover, incidence of lakes, paucity of outcrop and attitude of the flat lying host to potential targets precluded geochemical soil sampling as a prospecting technique.

2. Geophysical Interpretation

Interpretation of available airborne magnetometer survey results was undertaken by Webb and Woyzbun (1967) to provide information on basement structure and thickness of sedimentary cover. Three zones were distinguished, quite different in character although each display pronounced northwest trends with perpendicular cross trends (Fig. 4):

- the eastern zone, where the trends are masked by sedimentary cover is characterised by broad, deep-seated anomalies, at a depth in excess of 20 000ft. It underlies Lake Torrens with the western boundary being more or less coincident with the limit of the Arcoona Plateau in this region.
- the central zone, disturbed by strong magnetic anomalies considered to be related to basement uplifts and estimated to lie at depths of 4 000ft. to 6 000ft., correlates with the Pernatty Culmination. The Mount Gunson copper deposit coincides with a magnetic anomaly and it was suggested that the major cross feature might represent faults which were instrumental in transport of mineralising fluids. The most favourable areas for search for possible repetitions of this type of mineralisation would thus be located adjacent to local basement uplift where intersected by cross faults.
- the western zone, defined by a series of extensive narrow parallel shallow low-order magnetic anomalies whose sources lie at an estimated depth of between 500ft. and 1 200ft. These are traceable to the south-southeast to the Iron Knob - Roopena area where diamond drilling undertaken by the Broken Hill Pty. Co. Ltd., has now demonstrated that they are related to a doleritic dyke swarm (Jones, 1970). The anomalies, trending NW-SE are interrupted by perpendicular lineaments which represent fractures and faults that now

define the shores of a number of lakes in the region and may have exerted a profound control on sedimentation and mineralisation of the Woocalla Dolomite and basal member of the Tent Hill Formation.

3. Geochemical Surveys

Rock chip samples taken from exposures of Woocalla Dolomite, Whyalla Sandstone Member and Pandurra Formation throughout the area disclosed several areas wherein there are anomalous concentrations of lead and copper. In the Birthday R.S. - Oakden Hills H.S. locality lead contents ranged up to 1850 ppm with copper to 200 ppm adjacent to the disconformity. Similar results were achieved along the disconformity where the Pandurra Formation protrudes through Whyalla Sandstone in the Trevenna Hut - Winnie Pinnie Dam locality. Elsewhere, lead contents of 15 to 20 ppm were determined for clastic rocks with a mean background of 135 ppm in dolomite while associated copper contents were 5 to 10 ppm and 65 ppm respectively.

Black shales penetrated in boring for pastoral water supplies at Greenfields Dam (1 mile west of Birthday R.S.) and in the Trevenna - Winnie Pinnie area showed anomalous lead values which were virgin prospects considered to be worthy of further investigation by drilling (Thomas, 1969a). The lead anomalies were discovered because of the availability of outcrop and of spoil from bores for rock geochemistry. The extensive cover of sand marginal to the axis of the Pernatty Culmination from the Winnie Pinnie area to the northern end of Lake Windabout obscure potential targets over a wide area.

4. Drilling Programme, October to December, 1968

The area chosen for test drilling included a concentration of geochemically anomalous lead and copper values, also sulphides that had been identified in existing borehole samples.

During the period October 4th to December 14th, 1968 thirty holes, aggregating 3 187ft. were drilled in the Winnie Pinnie - Trevenna locality by truck-mounted air drill utilizing a combination of percussion and auger techniques (Thomas, 1969a). The area tested consists of low bare stony hills separated by flat sand plain which supports myall and mulga scrub. Drill holes were spaced at intervals of about one half mile on an irregular grid.

Drilling conditions proved difficult and core recoveries were extremely variable since saline water was generally cut at about 70ft. and resulted in return of sludge from the shallow weathered shale zones, and thus contaminated samples. The results are summarised in Appendix I and depicted in Fig. 5.

Wind blown sand, gravel and clay, with gypsum and kunkar commonly in the upper parts, ranges up to almost 50ft. in thickness and averages about 15ft. The Whyalla Sandstone attains 200ft. in thickness and averages about 50ft. The underlying Woocalla Dolomite proved to be more or less mineralised throughout, containing galena, sphalerite and pyrite. In the upper oxidised zone the formation comprises white, yellow, buff or brown clays and these pass down into unweathered grey shales with dolomite. The formation fills depressions in the undulating Pandurra surface and is variable in thickness, ranging up to 130ft. in WP10.

Base metal contents proved to be highest in two concealed sub-parallel shallow troughs in the Winnie Pinnie Dam locality and these trend more or less northerly. Drilling indicated that the westernmost zone is almost one mile long and one half mile wide where shales, 20ft. to 30ft. in thickness and averaging 0.2% Pb and 0.3% Zn, extend from 40ft. to 135ft. from the surface. In WP17, 38ft. of shale averaging 0.25% Zn and 0.1% Pb, including two 5ft. wide sections containing more than 0.5% Pb and 0.5% Zn. Similar results were disclosed in WP16 and WP15. In the

centre of the area drilled another zone almost two miles long and one half mile wide contains an average of 20ft. to 30ft. of grey clay averaging 0.1% Pb, 0.1% Zn at a depth variable from 30ft. to 100ft. from the surface.

South of Trevenna O.S. at the eastern end of the area drilled, the grey shales are deeper but base metal contents are much lower and both lead and zinc contents rarely exceed 1 000 ppm in the samples recovered.

Lead and zinc contents are more or less sympathetic. A fall-off of base metal values is evident in some holes from the central part of the formation towards both roof and floor (e.g. WP20) while, elsewhere, the highest Pb, Zn contents are highest at the extremities of the formation and decrease towards the centre (e.g. WP10).

Study of the form of the undulatory Pandurra surface, as revealed by drilling, indicates that the zones of black clay with high lead-zinc content are aligned with depressions in this surface. By contrast, the shales over the more elevated portions of this surface were more dolomitic and relatively deficient in base metals (Thomas, 1969a).

Copper contents of samples ranged up to 0.3% but there appears to be no direct relation between higher concentrations of copper with those of lead and zinc. Silver contents proved to be generally in the range 5 to 10 ppm. The general level of manganese in the sections high in lead and zinc is of the order of the combined lead and zinc.

Petrographic examination was made of samples taken from drill-holes showing high concentrations of lead and zinc as under:

| Hole No. | Depth (Ft.) | Pb (ppm) | Zn (ppm) | Cu (ppm) |
|---|---|---|---|---|
| WP15 | 65-68 | 3 400 | 2 800 | 45 |
| WP16 | 40-45 | 6 400 | 3 600 | 100 |
| WP17 | 105½-108½ | 1 500 | 4 800 | 60 |
| WP20 | 95-100 | 4 000 | 960 | 300 |

Sphalerite, galena, chalcopyrite and pyrite were identified as free grains of average 0.3 mm diameter; however some measure up to 1 mm across. Pyrite is common in relatively coarse grains and as extremely fine, disseminated grains some of which are spherical and framboidal. Chalcopyrite is in places altered to chalcocite and minor covellite.

Sphalerite crystals generally enclose dolomite inclusions and thus accounts for lower analyses than might be anticipated in sections that appear to be relatively strongly mineralised with sphalerite.

The presence of sparse primary lead and zinc with minor copper sulphides in a stratiform setting within a black shale phase of the Woocalla Dolomite was thus established but the concentrations are too low to be of economic value.

5. Drilling Programme, March to June, 1971

Seven widely spaced holes were subsequently drilled in a region of sparse outcrop extending from Oakden Hills H.S. to beyond Lake Dutton. It was considered valuable to simultaneously test the hypothesis that the base metals may have originated from hydrothermal intrusion in the region of fault planes. To this end several drill holes were sited close to presumed fault lineations (Thomas and Douch, 1971).

Drilling commenced on 17th March, 1971 and was completed on 13th June, 1971. In all, seven holes were drilled, totalling 2 737ft. of which 1 561ft. were drilled using a Failing WW1 combination rotary and percussion, truck mounted, rig operated by the Department of Mines (Plate 2)

The remaining 1 176ft. were cored by a Department of Mines E1 000 diamond drill rig using 2½ inch BQ diamond bit and core barrel wireline equipment (Plate 3). Core recovery of the shale target sone approached 100%. The results are summarised in Fig. 6, tabulated in Appendix II and detailed below.

LD1 - 308ft. vertical; near Oakden Hills H.S. to probe an area in which surface samples returned anomalous lead and copper values.

Percussion techniques were used to 87ft. rotary with mud fluids from 87ft. to 264ft.; the remainder was cored. Below 7ft. of Quaternary sand cover, Whyalla Sandstone was penetrated to a depth of 260ft. Black dolomitic shale was intersected from 260ft. to 298ft. 6 ins. and this rests on red quartzite of the Pandurra Formation.

The mineralised zone comprises black shales with intercalated light coloured dolomitic shale and dolomite. The beds may be massive or finely laminated with regularly ribboned diffuse or sharply defined alternating black and ligher coloured bands ranging from 1/16 inch to 2 inches in thickness (Plate 4). The beds are generally horizontally disposed but are often delicately waved and slump structures are evident throughout. Similar wavy bedding, truncated by numerous minor faults, is observable at the Woocalla clay quarry [Johns (1968)]. Intensively dislocated dolomitic shale, obviously resulting from slumping of the sediments before compaction, feature intricate pile-up cascade structures, zig-zag folding, disrupted bedding, faulting, boudinage and pull-apart structures, all on small scale.

Finely divided pyrite, sphalerite and galena were recognised by Douch more or less throughout, as disseminated crystals or as concentrations along cross fractures and steeply dipping joints. Analysis of the core over short intervals revealed that lead and zinc are more or less sympathetic and range up to 2 000 ppm with zinc contents being higher

than lead. The uppermost 4ft. 6 ins. of the formation contained 2 000 ppm zinc, 700 ppm lead and 4 600 ppm copper. In the topmost 15ft. of the formation the copper content exceeds 500 ppm but below this it is generally less than 40 ppm. Chalcopyrite was not observed and the traces of copper present were therefore considered by Thomas and Douch (1971) to occur as microscopic chalcopyrite or as chalcocite.

LD2 - 608ft.; north of Lake Dutton

This hole was commenced with the Failing rig which drilled through 40ft. of sand to a depth of 150ft. in the Whyalla Sandstone by percussion technique. Here, shale was intersected and cored using the same rig to 365ft. 9 ins. The hole was cased and completed using the diamond drill.

Woocalla Dolomite, penetrated from 179ft. 6 ins. to 601ft. 10 ins. thus proved to be much thicker than anticipated. Lithology and internal structures were similar to those of LD1; slumping was evident to 450ft. Zinc content ranges to 1 400 ppm over intervals of several feet but over about 200ft. of section it is less than 200 ppm. Lead is concentrated in the upper 50ft. and the lowermost 50ft. of the formation and, throughout the remainder, it is generally less than 100 ppm. As before, the content of copper is uniformly low (seldom exceeding 50 ppm) except in the topmost 10ft. where it attains 1 000 ppm in one sample and averages somewhat less than 500 ppm.

LD3 - 631ft. 11 ins. east of Lake Blyth

The hole was drilled by percussion methods to 273ft. for completion by diamond drilling.

The mineralised dolomitic shale, intersected from 324ft. 1 in. to 629ft. is similar to that recovered from the other holes. As before, the greatest metal concentrations proved to be more or less sympathetic, with zinc contents being higher than those of lead, decreasing from the

extremities of the formation towards the central sector and with minor concentrations of copper in an 8ft. thick section immediately below the contact with the Whyalla Sandstone and over a width of 6ft. at the Pandurra disconformity.

Several samples, representing less than 1ft. of section in each case, contain in excess of 1% zinc and a zone from 604ft. to 628ft. averaging 0.16% zinc. Sphalerite occurs throughout in narrow dolomite bands that are separated by weakly mineralised bands of black shale.

LD4 - 447ft. 4 in.; west of Windy Valley Well

Penetration of the Whyalla Sandstone was achieved with the Failing WW1 to 200ft. and of the underlying Woocalla Shale from200ft. to 443ft. 9 ins. by diamond drilling.

Mineralisation showed a reversal of the trend disclosed by the previous holes in that lead and zinc values are lowest at the contacts and reach a peak in the upper central part of the dolomitic shale. Lead content of samples proved to be less than 800 ppm while zinc contents ranged up to 4 600 ppm over a narrow interval. Minor copper concentration was evident immediately above the Pandurra disconformity.

LD5 - 274ft. 3 in.; South of Lake Dutton; drilled by Failing WW1 to 204ft. 6 ins. through the Whyalla Sandstone and cored by diamond drill through the Woocalla Dolomite, the base of which was at 271ft.

The mineralised formation was less shaley than in previous holes and dolomitic shale was predominant. Massive dolomite, about 5ft. in thickness, comprises the basal bed.

Lead and zinc sulphides are more evenly distributed throughout the section with lead, in association with dolomite sequences, being more abundant and ranging up to 1 250 ppm while zinc ranges to 435 ppm. Minor concentrations (to 400 ppm) of copper are again evident at the upper and lower contacts. Both zones are characterised by slump structures and

minor faulting of dolomitic beds.

LD6 - 222ft. 4 in.; east of Lake Dutton, was drilled to 177ft. with the rotary-percussion plant and thence to completion by diamond drilling.

This site was designed to test a "basement uplift magnetic anomaly" lying at the intersection of two major basement fractures in an area of no outcrop and where no geochemical information was available.

The Woocalla Dolomite, penetrated from 150ft. to 215ft. 8 ins., is weakly mineralised throughout with samples showing generally less than 200 ppm lead and 200 ppm zinc. Copper contents however, are higher; one section from 160ft. to 177ft. contained 800 ppm copper while the core from 210ft. to 216ft. averaged 1 224 ppm. The zones of anomalous copper are associated with more massive dolomites.

LD7 - 247ft.;south east of Trevenna Well was drilled to completion without encountering shale. The Whyalla Sandstone 120ft. in thickness, rests directly on the Pandurra Formation. Interestingly, the lead and copper contents for at least 20ft. above the disconformity approach 2 000 ppm, while zinc content is less than 150 ppm over the same interval.

Drill holes LD2, 3 and 4 were sited adjacent to a zone which was considered by Thomas and Douch (1971) to comprise a graben structure occupied by Lakes Dutton, Finnis and Blyth. Several NE-SW trending faults were detected on air photos and traced on the ground in this locality by minor scarps, sandstone, breccias and vertical foliation in the Whyalla Sandstone. The recognition of a possible structural control in the deposition of base metal sulphides would have assisted in outlining areas of potential economic importance.

"Drill holes LD2, 3 and 4 were drilled close to a photo-lineament, where topographic differences suggest minor recurrent fault movements since Proterozoic times. No evidence was found of any increase in geochemical levels of lead and zinc, attributable to hydrothermal or other effects.

"Depths of basement Pandurra (Formation) suggest that the most interesting results in LD3 may coincide with a shale-filled depression in the basement, and this is the same effect as observed originally in the Winnie Pinnie locality.....this interpretation narrows down the general area of interest to a corridor some six miles in width trending slightly east of north, from south of the Winnie Pinnie Dam area to Birthday siding.

"Anywhere in this zone, except for the Pandurra inlier north of Trevenna O.S. there is a reasonable expectation of geochemically anomalous amounts of lead and zinc within the shale equivalent of the Woocalla Dolomite.

"Two factors appear to have some bearing on mineralisation; proximity to the keel of the basement depression, and the presence of interfingering dolomite and shale facies of sediments. Graben-like movements on lineaments north and south of the lakes may have led to the deposition of great thicknesses of shale and dolomite in the trough occupied at surface by the present lake system".

Mineralisation consists of disseminated aggregates of pyrite, sphalerite, galena and chalcopyrite. The primary host rock appears to be dolomitic shale rather than black shale. The proportion of dolomitic shale was observed to be greater adjacent to the Pernatty Culmination

(LD1, 2, 5 and 6) and to be appreciably diminished in holes removed from it (e.g. LD4). In all holes the proportion of dolomitic shale was greatest in the lowermost 50ft. of the formation. In LD5 and 6 massive dolomite 5ft. to 10ft. in thickness occurs at the base while the remainder of the section comprises more than 50% dolomitic shale.

Galena often occurs as coarse crystals occupying vughy calcite veins within dolomitic shale bands or as "smears" on joint surfaces in shale. Sphalerite generally occurs as disseminated crystals ranging from 0.05 mm to 1 mm diameter with grains of 0.3 mm being common throughout the dolomitic shales and only rarely as coarse crystals in calcite veins. Pyrite is common throughout the black shale.

Though no economic concentrations of lead, zinc or copper were disclosed by drilling, the existence of geochemically anomalous levels of base metal mineralisation were established in a stratiform setting within shaley equivalents of the Woocalla Dolomite over a wide area. The association of galena and sphalerite with thin dolomitic bands within black shale in a basement trough extending over a distance of 20 miles between Winnie Pinnie and Greenfields Dam, are suggestive of a very early if not syngentic origin.

## CONTROLS FOR BASE METAL MINERALISATION

The localisation of the copper deposits at the Pernatty Lagoon - Mount Gunson - Sweet Nell localities and the widespread copper-lead-zinc sulphide mineralisation now disclosed over a wide area to the south are considered to have been governed by several possible controls:

- Pernatty Culmination

This represents a positive pre-Marinoan structural feature with a flanking algal reef in a passive structural environment, situated marginal to small partially enclosed basins on the Stuart Stable Shelf. Crystalline basement rocks outcropped to the west and south

while more or less continuous sedimentation proceeded in the Adelaide Geosyncline to the east.

- the disconformable Pandurra/Woocalla/Whyalla contacts

The disconformities provide favourable loci for introduced mineralisation and potential aquifers for ore fluids. Alternatively they represent a depositional hiatus during which time syngenetic base metal sulphides could have been concentrated on these surfaces.

- Woocalla Dolomite

The dolomite may have produced a sufficient increase in pH to cause the precipitation of sulphides from fluids, bearing base metals and travelling along the disconformities. Such mineralisation could have been syngenetic with the disconformities in which case the dolomite, especially in reef form, would have been an influence in control. If base metals had been introduced to the disconformity, the dolomite would have acted merely as a precipitating agent.

- Basement fractures and basement uplift

The Pernatty Culmination, underlain by basement rocks which are intruded by a swarm of basic dykes and dislocated by a system of major fractures, comprise a potential zone of weakness through which mineralising solutions could have migrated. If basement fracturing followed the deposition of the Pandurra Formation it would have created zones of increased permeability and conduits for passage of fluids in that formation; circulation of meteoric solutions might concentrate dispersed syngenetic sulphides at favourable loci on the disconformities within troughs in the Pandurra surface.

Drilling of a north-west trending magnetic anomaly four miles south of the Katinga Hills by the Broken Hill Pty. Co. Ltd. (Jones, 1970) disclosed dolerite containing 6% to 10% magnetite with traces of bornite and chalcopyrite as grains 0.01 mm to 0.16 mm diameter. Three holes, each 125ft. in depth, intersected dolerite averaging almost 500 ppm copper; lead content is generally less than 50 ppm but attains 200 ppm while zinc approaches 200 ppm. Base metal sulphides have also been disclosed in shales and basaltic lavas at Roopena (Thomson, 1966). Thus, primary base metal sulphide bearing source rocks have been identified in outcrop south of this region and it is almost certain that similar rocks underlie, at shallow depth, the area under review.

The above controls would be effective whether the base metals were originally syngenetic or epigenetic and thus, if these are the major controls for mineralisation, the genesis of the Pernatty type deposits becomes unimportant in the search for further deposits in the area. Favourable conditions exist over a wide area but the search for buried zones of enriched sulphides where economically significant grades may occur will be inhibited by presence of relatively shallow cover provided by the Whyalla Sandstone Member and by Recent sand.

Analogies may be drawn between the mineralised black shales (Woocalla Dolomite) and the Kupferschiefer of northern Europe while the association of copper, lead and zinc sulphides, barytes and fluorite# with black shales and dolomites flanking collenia reefs on basement highes invites comparison with deposits of the Rhodesian copper belt, Pine Point in Canada and with the Mississippi Valley (United States) ore deposits, the origins of which have been variously ascribed to the influence of metal bearing saline solutions or, coversely, to accumulation contemporaneous with sedimentation.

RKJ:FdeA
4.10.72

R.K. JOHNS
CHIEF GEOLOGIST

## REFERENCES

Appleyard, G.R., 1970. S.M.L. 256, Lake Dutton area, South Australia, Report for 6 months ended September 30th 1970.

Crawford, A.R., 1964. Noranda Australia Ltd. Report No. 147 (Unpub.) Dept. of Mines Env. 1043/II. Geol. Surv. S.Aust., 1:63 360 Cultana.

Dalgarno, R., Johnson, J.E., Forbes, B.G. and Thomson, B.P., 1968. Geol. Surv. S.Aust., 1:250 000 PORT AUGUSTA.

Dunlop, A.C. & Dunlop C.P., 1970. Research report, S.M.L. No. 256, Lake Dutton, South Australia. Noranda Australia Ltd. Report No. 137 (unpublished) Dept. of Mines Env. 1043/I.

Dickinson, S.B., 1942. "The Structural control of ore deposition in some South Australian copper fields". Geol. Surv. S. Aust. Bull. 20, pp. 50-65.

_____, 1953. In Geology of Australian Ore Deposits - Symp. 5th Emp. Min. Met. Cong. pp. 517-523.

Johns, R.K., 1965. In Geology of Australian Ore Deposits - 2nd Ed. Eighth Comm. Min. Met. Cong. pp. 297-300.

_____, _____, 1968. Geology and Mineral Resources of the Andamooka - Torrens area. Geol. Surv. S.Aust., Bull. 41.

_____, Hiern, M.N., Nixon, L.G., Forbes, B.G. and Olliver, J.G., 1964. Geol. Surv. S.Aust. 1:250 000 TORRENS.

Jones, M.T., 1970. Results of the drilling of a magnetic anomaly 4 miles southeast of the Katunga Hills, S.A. The Broken Hill Pty. Co. Ltd. report (unpub.) Dept. of Mines Env. 1175.

Thomas, A., 1969a. March progress report S.M.L. No. 256, Lake Dutton, South Australia. Noranda Australia Ltd. Report No. 110 (unpub.). Dept. of Mines Env. 1043/I.

_____ , 1969b. September progress report, S.M.L. No. 256, Lake Dutton, South Australia. Noranda Australia Ltd. Report No. 131 (unpub.) Dept. of Mines Env. 1043/I.

_____ , 1970. S.M.L. No. 256 Lake Dutton, South Australia, Report for 6 months ended April, 1970. Noranda Australia Ltd. Report No. 137 (unpub.) Dept. of Mines Env. 1043/I.

Thomas, A., and Douch, C., 1971. Annual report on S.M.L. 499, Lake Dutton, South Australia. Noranda Australia Ltd. Report No. 163 (unpub.) Dept. of Mines Env. 1541.

Thomson, B.P., 1966. The lower boundary of the Adelaide System and older basement relationships in South Australia. Jour. Geol. Soc. Aust. V13 pt. 1. pp. 203-228.

_____ and Johnson, J.E., 1968. Marinoan stratigraphy Port Augusta region. Geol. Surv. S.Aust. Quart. Geol. Notes No. 25. pp. 4-7.

Tonkin, D., 1968. "Report on Lake MacFarlane region, South Australia". Noranda Australia Ltd. Report No. 103 (unpub.). Dept. of Mines Env. 835.

Wainwright, W.E., 1914. "Report on copper deposits of Pernatty Copper Syndicate". S.A. Rev. of Min. Op. 20 pp. 41-52.

Webb, J.E. and Woyzbun, P., 1967. Interpretation of the results of airborne magnetometer sruvey covering S.M.L. 139, 152 (Stages 1 and 2 (unpub.)). Dept. of Mines Env. 886.

Anon., 1971 S.M.L. No. 499 Lake Dutton, South Australia. Report for the three months ended February 5th 1971

Report for the three months ended May, 5th 1971

Report for the three months ended August, 5th 1971

Noranda Australia Ltd. Reports (unpub.). Dept. of Mines Env. 1541.

# APPENDIX I

## 1968 Drilling results Summary

| Hole No. | Feet From | Feet To | ppm Cu | ppm Pb | ppm Zn | ppm Mu | ppm Ag | Log |
|---|---|---|---|---|---|---|---|---|
| WP1 | 0 | 50 | | | | | | White pink sandstone (Whyalla) |
| | 50 | 80 | | | | | | Grey black clay (Woocalla) |
| WP2 | 0 | 10 | | | | | | Gravels |
| | 10 | 30 | | | | | | Argillaceous sandstone (Whyalla) |
| WP3 | 0 | 50 | | | | | | clays with gravel |
| WP4 | 0 | 20 | | | | | | " |
| | 20 | 84 | | | | | | fine grained light sandstone (Whyalla) |
| WP5 | 0 | 10 | | | | | | Sand |
| | 10 | 60 | | | | | | White, pink sandstone (Whyalla) |
| | 60 | 69 | 130 | 170 | 40 | 25 | | White sandstone " |
| | 69 | 72 | 180 | 140 | 150 | 40 | | Brown-grey clay (Woocalla) |
| | 72 | 78 | 120 | 180 | 150 | 30 | | Black clay " |
| | 78 | 150 | | | | | | Red, pink, white sandstone (Pandurra) |
| WP6 | 0 | 48 | | | | | | Gravel with clay |
| | 48 | 49 | 30 | 70 | 95 | 25 | | Buff clay (Woocalla) |
| | 49 | 53 | 45 | 590 | 50 | 30 | | " " |
| | 53 | 58 | 55 | 1200 | 65 | 20 | | " " |
| | 58 | 63 | 45 | 800 | 55 | 30 | | " " |
| | 63 | 68 | 240 | 1300 | 180 | 30 | | Black clay (Woocalla) |
| | 68 | 73 | 370 | 1400 | 160 | 95 | 10 | " " |
| | 73 | 76 | 1200 | 1800 | 980 | 120 | 30 | " " |
| | 76 | 78 | 3400 | 1900 | 2200 | 90 | 300 | " " |
| | 78 | 79 | 1000 | 1900 | 840 | 100 | 40 | " " |
| | 79 | 88 | 440 | 590 | 600 | 40 | | " pyrite (Woolcalla) |
| | 88 | 90 | 260 | 510 | 200 | 50 | 10 | " " " |
| | 90 | 96 | | | | | | Quartzite (Pandurra) |
| WP7 | 0 | 10 | | | | | | Sand |
| | 10 | 63 | | | | | | White, pink sandstone (Whyalla) |
| | 63 | 68 | 25 | 20 | 20 | 170 | 2 | Khaki clay (Woocalla) |
| | 68 | 73 | 2000 | 290 | 900 | 320 | 10 | Black clay, pyrite (Woocalla) |
| | 73 | 74 | 950 | 400 | 720 | 300 | | " " " |
| | 74 | 90 | | | | | | Red, pink, white quartzite (Pandurra) |

| Hole No. | Feet From | Feet To | ppm Cu | ppm Pb | ppm Zn | ppm Mu | ppm Ag | Log |
|---|---|---|---|---|---|---|---|---|
| WP8 | 0 | 6 | | | | | | Sand |
| | 6 | 35 | | | | | | White sandstone (Whyalla) |
| | 35 | 38 | 120 | 190 | 560 | 90 | | Grey, brown clay (Woocalla) |
| | 38 | 40 | 1300 | 120 | 250 | 200 | | Black clay " |
| | 40 | 44 | 950 | 210 | 300 | 240 | | " " |
| | 44 | 48 | 700 | 880 | 400 | 180 | | " " |
| | 48 | 51 | 200 | 6300 | 7000 | 180 | | " " |
| | 51 | 54 | 340 | 3300 | 1000 | 250 | | " " |
| | 54 | 56 | 200 | 3400 | | 270 | | " " |
| | 56 | 57 | 140 | 3100 | | 270 | | " " |
| | 57 | 60 | 90 | 2900 | | 360 | | " " |
| | 60 | 62 | 140 | 3200 | | 720 | | " " |
| | 62 | 64 | 80 | 1600 | | 8500 | | Grey shale |
| | 64 | 66 | 60 | 2700 | | 4500 | | " " |
| | 66 | 68 | 90 | 5300 | | 9600 | | " galena " |
| | 68 | 70 | 280 | 1600 | 1100 | 9600 | | " pyrite " |
| | 70 | 72 | 800 | 1000 | | 4800 | | Grey shale, pyrite, (Woocalla) |
| | 72 | 74 | 430 | 1100 | | 4000 | | " " " |
| | 74 | 76 | 280 | 880 | 1760 | 4400 | 5 | " " |
| | 76 | 77 | 460 | 1100 | | 6400 | | " " |
| | 77 | 80 | 260 | 680 | 760 | 8800 | | " dolomite " |
| | 80 | 120 | | | | | | Red quartzite (Pandurra) |
| WP9 | 0 | 10 | | | | | | Sandy clay |
| | 10 | 25 | | | | | | White, buff clay (Woocalla) |
| | 25 | 50 | | | | | | Red quartzite (Pandurra) |
| WP10 | 0 | 15 | | | | | | Sandy clay |
| | 15 | 30 | | | | | | White, buff, red clay (Woocalla) |
| | 30 | 35 | 90 | 1500 | 50 | 20 | | Purple Clay " |
| | 35 | 40 | 140 | 2800 | 100 | 60 | | " " |
| | 40 | 45 | 210 | 2400 | 230 | 75 | | Brown Clay (Woocalla) |
| | 45 | 48 | 950 | 1500 | 1300 | 100 | 20 | Black clay, galena, pyrite (Woocalla) |
| | 48 | 50 | 380 | 1300 | 1800 | 430 | 15 | " " " |
| | 50 | 55 | 40 | 1100 | 2400 | 2000 | 5 | " " " |
| | 55 | 60 | 40 | 1100 | 2600 | 1500 | 5 | " " " |
| | 60 | 65 | 50 | 940 | 1200 | 1800 | 5 | " " " |
| | 65 | 70 | 45 | 640 | 1200 | 950 | 2 | " " " |

| Hole No. | Feet From | Feet To | Cu | Pb | Zn | Mu | Ag | Log |
|---|---|---|---|---|---|---|---|---|
| WP10 (con) | 70 | 73 | 140 | 810 | 2200 | 1500 | 5 | Black clay galena, pyrite (Woocalla) |
| | 73 | 74 | 220 | 1000 | 2200 | 1200 | 2 | " " " |
| | 74 | 85 | 55 | 450 | 880 | 2000 | 2 | " " " |
| | 85 | 90 | 35 | 320 | 840 | 3300 | 5 | " " " |
| | 90 | 93 | 45 | 280 | 330 | 2400 | 2 | " " " |
| | 93 | 98 | 55 | 480 | 320 | 2200 | 2 | Black shale galena, pyrite (Woocalla) |
| | 98 | 104 | 50 | 510 | 1000 | 2600 | 2 | " " " |
| | 104 | 110 | 50 | 490 | 900 | 2400 | 2 | " " " |
| | 110 | 115 | 40 | 440 | 400 | 1800 | 5 | " " " |
| | 115 | 120 | 60 | 450 | 1200 | 3400 | 5 | " " " |
| | 120 | 125 | 50 | 710 | 1800 | 2600 | 2 | " " " |
| | 125 | 130 | 55 | 720 | 2000 | 2800 | 5 | " " " |
| | 130 | 135 | 250 | 2600 | 1400 | 3400 | 30 | " dolomite " |
| | 135 | 140 | 600 | 1200 | 1300 | 4500 | 5 | " galena " |
| | 140 | 145 | 380 | 1000 | 1400 | 5000 | 2 | " " " |
| | 145 | 150 | | | | | | Red quartzite (Pandurra) |
| WP11 | 0 | 10 | | | | | | Sand |
| | 10 | 20 | | | | | | White sandstone (Whyalla) |
| | 20 | 52 | | | | | | White, grey brown clay (Woocalla) |
| | 52 | 56 | | | | | | Black clay, galena, pyrite " |
| | 56 | 60 | 20 | 1000 | 2400 | 510 | 10 | Black shale, " " |
| | 60 | 65 | 45 | 1100 | 3000 | 1400 | 10 | " " " |
| | 65 | 66 | 200 | 1100 | 2200 | 2600 | | " " " |
| | 66 | 68 | 120 | 1100 | 2000 | 9600 | | " " " |
| | 68 | 71 | 120 | 1300 | 5200 | 6000 | | " " " |
| | 71 | 76 | 120 | 2900 | 3000 | 3600 | | " " " |
| | 76 | 78 | 230 | 2800 | 2600 | 2800 | | " " " |
| | 78 | 84 | 320 | 1100 | 1400 | 3600 | | " " " |
| | 84 | 89 | 270 | 600 | 1400 | 3800 | | " dolomite " |
| | 89 | 95 | 120 | 440 | 480 | 7200 | | Dolomite, galena, pyrite (Woocalla) |
| | 95 | 120 | | | | | | Red quartzite (Pandurra) |
| WP12 | 0 | 10 | | | | | | Sand |
| | 10 | 30 | | | | | | White sandstone (Whyalla) |
| | 30 | 63 | | | | | | White orange, black clay (Whyalla) |
| | 63 | 65 | 430 | 75 | 150 | 140 | | Black clay, galena, pyrite " |
| | 65 | 68 | 480 | 170 | 290 | 150 | | " " " |
| | 68 | 70 | 290 | 700 | 300 | 160 | | " " " |

| Hole No | Feet From | Feet To | Cu | Pb | Zn | Mu | Ag | Log |
|---|---|---|---|---|---|---|---|---|
| WP12 (con) | 70 | 72 | 160 | 1800 | 560 | 220 | | Black clay, galena, pyrite (Whyalla) |
| | 72 | 76½ | | | | | | ?Quartzite, ?(Pandurra) |
| WP13 | 0 | 10 | | | | | | Sand |
| | 10 | 43 | | | | | | White sandstone (Whyalla) |
| | 43 | 45 | 400 | 40 | 35 | 50 | | Grey clay (Woocalla) |
| | 45 | 50 | 110 | 20 | 20 | 30 | | Grey clay, galena (Woocalla) |
| | 50 | 55 | 35 | 20 | 85 | 20 | | " " |
| | 55 | 56 | 50 | 20 | 190 | 30 | | " " |
| | 56 | 59 | 110 | 50 | 280 | 60 | | Black clay, galena (Woocalla) |
| | 59 | 62 | 600 | 150 | 600 | 160 | | " " |
| | 62 | 70 | 290 | 900 | 450 | 380 | | " " |
| | 70 | 75 | 190 | 1400 | 640 | 1200 | | Black shale, dolomite galena (Woocalla) |
| | 75 | 78 | 450 | 1400 | 3200 | 1500 | | " " |
| | 75 | 85 | 170 | 1500 | 1000 | 1100 | | " " |
| | 85 | 90 | 130 | 1600 | 840 | 2200 | | " " |
| | 90 | 95 | 160 | 720 | 510 | 3200 | | " " |
| | 95 | 100 | 220 | 790 | 490 | 3600 | | " " |
| | 100 | 115 | | | | | | Red quartzite (Pandurra) |
| WP14 | 0 | 5 | | | | | | Sandy clay |
| | 5 | 60 | | | | | | White sandstone, clayey (Whyalla) |
| | 60 | 70 | 110 | 2 | 70 | 130 | | Black shale (Woocalla) |
| | 70 | 75 | 85 | 40 | 90 | 55 | | Black shale sulphides (Woocalla) |
| | 75 | 80 | 170 | 20 | 35 | 30 | | " " |
| | 80 | 85 | 50 | 30 | 70 | 35 | | " " |
| | 85 | 88 | 100 | 550 | 1000 | 1400 | | " " |
| WP15 | 0 | 20 | | | | | | Sand, clay, gravel |
| | 20 | 35 | | | | | | White, buff clay (Woocalla) |
| | 35 | 40 | 130 | 900 | 150 | 40 | 2 | Buff brown clay " |
| | 40 | 45 | 160 | 1500 | 200 | 65 | 2 | Brown clay " |
| | 45 | 50 | 150 | 1600 | 500 | 970 | 2 | Grey clay " |
| | 50 | 55 | 230 | 760 | 3000 | 820 | 2 | Dark grey clay " |
| | 55 | 60 | 110 | 1100 | 4000 | 700 | 16 | Black clay " |
| | 60 | 65 | 40 | 870 | 3100 | 7100 | 6 | Black clay " |
| | 65 | 68 | 45 | 3400 | 2800 | 3100 | 6 | Black clay " |
| | 68 | 75 | 600 | 570 | 380 | 2600 | 5 | Black clay, galena " |
| | 75 | 80 | 340 | 400 | 260 | 3300 | 5 | Black clay, galena " |
| | 80 | 100 | | | | | | Red quartzite (Pandurra) |

| Hole No | Feet From | Feet To | Cu | Pb | Zn | Mn | Ag | Log |
|---|---|---|---|---|---|---|---|---|
| WP16 | 0 | 16 | | | | | | Sand |
| | 16 | 29 | | | | | | White sandstone (Whyalla) |
| | 29 | 40 | 300 | 240 | 340 | 110 | 5 | Black clay, galena (Woocalla) |
| | 40 | 45 | 100 | 6400 | 3600 | 110 | 6 | " " |
| | 45 | 50 | 130 | 4000 | 2400 | 125 | 7 | " " |
| | 50 | 55 | 95 | 3200 | 2800 | 125 | 6 | " " |
| | 55 | 60 | 140 | 4600 | 2800 | 120 | 6 | " " |
| | 60 | 63 | 200 | 2800 | 1900 | 560 | 6 | Black clay, galena, pyrite (Woocall |
| | 63 | 66 | 340 | 170 | 1000 | 3500 | 2 | " dolomite " |
| | 66 | 70 | 160 | 160 | 640 | 4150 | 5 | " " " |
| | 70 | 75 | 220 | 440 | 820 | 2000 | 2 | " " " |
| | 75 | 100 | | | | | | Red quartzite, (Pandurra) |
| WP17 | 0 | 10 | | | | | | Sandy clay |
| | 10 | 80 | | | | | | white sandstone (Whyalla) |
| | 80 | 90 | 75 | 60 | 150 | 120 | 2 | Black clay (Woocalla) |
| | 90 | 95 | 55 | 80 | 160 | 360 | 2 | " " |
| | 95 | 98 | 340 | 300 | 420 | 740 | 6 | " " |
| | 98 | 100 | 300 | 650 | 410 | 940 | 5 | Dark grey clay (Woocalla) |
| | 100 | 105 | 120 | 6200 | 4000 | 1400 | 8 | Dark grey clay dolomite, galena, pyrite, sphalerite (Woocalla) |
| | 100 | 108 | 60 | 1500 | 4800 | 2100 | 6 | Dark grey shale, dolomite, galena (Woocalla) |
| | 108 | 115 | 120 | 1000 | 2600 | 1100 | 2 | " " " |
| | 115 | 120 | 60 | 1200 | 5400 | 1900 | 5 | " galena " |
| | 120 | 130 | 80 | 950 | 2200 | 16000 | 6 | " dolomite " |
| | 130 | 138 | 60 | 800 | 1500 | 1350 | 5 | " " " |
| | 138 | 150 | | | | | | Red quartzite (Pandurra) |
| WP18 | 0 | 5 | | | | | | Sand |
| | 5 | 63 | 20 | 35 | 45 | 45 | 2 | White sandstone (Whyalla) |
| | 63 | 70 | | | | | | Red quartzite (Pandurra) |
| WP19 | 0 | 5 | | | | | | Sand |
| | 5 | 100 | | | | | | White sandstone (Whyalla) |
| | 100 | 110 | 260 | 180 | 300 | 50 | 2 | Blackshale, pyrite (Woocalla) |
| | 110 | 117 | 460 | 1000 | 420 | 2000 | 6 | " " " |
| WP20 | 0 | 20 | | | | | | Sand, clay, gravel |
| | 20 | 87 | | | | | | White sandstone (Whyalla) |
| | 87 | 95 | 560 | 280 | 420 | 2000 | 6 | Dark grey shale (Woocalla) |

| Hole No | Feet From | Feet To | Cu | Pb | Zn | Mn | Ag | Log |
|---|---|---|---|---|---|---|---|---|
| WP20 (con) | 95 | 100 | 300 | 4000 | 960 | 2250 | 7 | Black shale, galena (Woocalla) |
| | 100 | 105 | 90 | 4400 | 4800 | 2450 | | " " |
| | 105 | 110 | 70 | 3900 | 3200 | 2300 | 6 | " " |
| | 110 | 115 | 70 | 3800 | 2400 | 3150 | 6 | " " |
| | 115 | 120 | 240 | 1100 | 640 | 3150 | 6 | " pyrite (Woocalla) |
| | 120 | 125 | 280 | 450 | 400 | 5200 | 2 | " " |
| | 125 | 130 | 190 | 400 | 370 | 1250 | 2 | Black shale, galena, dolomite (Woocalla) |
| | 130 | 150 | | | | | | Red quartzite (Pandurra) |
| WP21 | 0 | 5 | | | | | | Sand |
| | 5 | 60 | | | | | | White sandstone (Whyalla) |
| | 60 | 69 | 15 | 25 | 50 | 830 | 2 | Grey shale (Woocalla) |
| | 69 | 75 | 30 | 90 | 80 | 3700 | 2 | " " |
| | 75 | 100 | | | | | | Red quartzite (Pandurra) |
| WP22 | 0 | 57 | | | | | | White sandstone (Whyalla) |
| | 57 | 62 | 140 | 220 | 130 | 50 | 2 | Black clay (Woocalla) |
| | 62 | 69 | 380 | 140 | 300 | 130 | 10 | Black shale, pyrite (Woocalla) |
| | 69 | 73 | 400 | 250 | 640 | 500 | 5 | " " " |
| | 73 | 80 | 90 | 110 | 270 | 6300 | 2 | Black shale, dolomite (Woocalla) |
| | 80 | 100 | | | | | | Red quartzite, (Pandurra) |
| WP23 | 0 | 5 | | | | | | Sand |
| | 5 | 40 | | | | | | White sandstone (Whyalla) |
| | 40 | 52 | | | | | | White, grey-brown clay (Woocalla) |
| | 52 | 57 | 180 | 360 | 70 | 60 | 5 | Dark grey clay (Woocalla) |
| | 57 | 62 | 1200 | 6000 | 160 | 120 | 10 | Dark grey clay, galena (Woocalla) |
| | 62 | 65 | 140 | 2000 | 900 | 70 | 5 | Dark grey shale, (Woocalla) |
| | 65 | 70 | 40 | 940 | 1100 | 1100 | 5 | " " " |
| | 70 | 75 | 30 | 800 | 1000 | 1400 | 5 | " " " |
| | 75 | 80 | 30 | 1000 | 1000 | 1300 | 5 | " " " |
| | 80 | 85 | 35 | 900 | 3000 | 1200 | 2 | " " " |
| | 85 | 90 | 35 | 700 | 700 | 1200 | 2 | " " " |
| | 90 | 95 | 30 | 250 | 350 | 1700 | 2 | " " " |
| | 95 | 100 | 30 | 280 | 230 | 1600 | 2 | " " " |
| | 100 | 105 | 30 | 190 | 200 | 1800 | 2 | " " " |
| | 105 | 110 | 30 | 220 | 650 | 1700 | 2 | " " " |
| | 110 | 115 | 30 | 260 | 650 | 2000 | 2 | " " " |
| | 115 | 120 | 35 | 260 | 430 | 1800 | 2 | " " " |
| | 120 | 122 | 30 | 420 | 470 | 1600 | 2 | " " " |

| Hole No | Feet From | Feet To | Cu | Pb | Zn | Mn | Ag | Log |
|---|---|---|---|---|---|---|---|---|
| WP24 | 0 | 18 | | | | | | Sand, clay, gravel |
| | 18 | 26 | | | | | | White sandstone (Whyalla) |
| | 26 | 48 | | | | | | White, yellow grey clay (Woocalla) |
| | 48 | 55 | 850 | 2200 | 1100 | 150 | 20 | Grey clay, galena " |
| | 55 | 65 | 45 | 750 | 2400 | 1800 | 5 | Grey shale (Woocalla) |
| | 65 | 70 | 30 | 930 | 3400 | 2800 | 5 | " " |
| | 70 | 75 | 50 | 3500 | 1200 | 2400 | 5 | " " |
| | 75 | 80 | 260 | 2700 | 400 | 3600 | 5 | " " |
| | 80 | 85 | 340 | 140 | 150 | 3600 | 2 | " " |
| | 85 | 90 | 220 | 390 | 300 | 10000 | 5 | Grey shale, dolomite, pyrite (Woocalla) |
| | 90 | 100 | | | | | | Red quartzite (Pandurra) |
| WP25 | 0 | 5 | | | | | | Sand, gravel |
| | 5 | 87 | | | | | | White sandstone (Whyalla) |
| | 87 | 107 | | | | | | Dark grey shale (Woocalla) |
| | 107 | 108½ | 460 | 160 | 440 | 1300 | 5 | " " |
| | 108½ | 117 | 220 | 1400 | 700 | 1500 | 5 | " " |
| | 117 | 125 | 90 | 430 | 420 | 820 | 2 | " " |
| | 125 | 130 | 60 | 930 | 1500 | 1600 | 5 | Dark grey dolomite, galena, pyrite (Woocalla) |
| | 130 | 135 | 70 | 1600 | 2000 | 2000 | 5 | Black shale (Woocalla) |
| | 135 | 140 | 60 | 730 | 1000 | 1200 | 2 | Black shale (Woocalla) |
| | 140 | 150 | 45 | 480 | 1350 | 1800 | 2 | " dolomite (Woocalla) |
| | 150 | 160 | 40 | 380 | 1200 | 1600 | 2 | " " " |
| | 160 | 170 | 45 | 420 | 900 | 1700 | 2 | " " " |
| | 170 | 180 | 40 | 360 | 680 | 1600 | 2 | " " " |
| | 180 | 194 | 90 | 820 | 900 | 2500 | 2 | " " " |
| | 194 | 200 | | | | | | Red quartzite (Pandurra) |
| WP26 | 0 | 9 | | | | | | Sand, clay, gravel |
| | 9 | 119 | | | | | | White sandstone (Whyalla) |
| | 119 | 125 | 200 | 170 | 200 | 130 | 5 | Grey shale (Woocalla) |
| | 125 | 130 | 200 | 780 | 480 | 370 | 5 | " " |
| | 130 | 135 | 140 | 1300 | 470 | 510 | 5 | " " |
| | 135 | 140 | 140 | 830 | 450 | 530 | 2 | " " |
| | 140 | 142 | 240 | 1700 | 2500 | 1700 | 5 | Black shale " |
| | 142 | 150 | 90 | 720 | 450 | 760 | 5 | " " |
| | 150 | 155 | 55 | 600 | 800 | 1000 | 5 | " " |
| | 155 | 160 | 40 | 430 | 200 | 920 | 2 | " " |

| Hole No | Feet From | Feet To | Cu | Pb | Zn | Mn | Ag | Log |
|---|---|---|---|---|---|---|---|---|
| WP26 (con) | 160 | 165 | 60 | 460 | 660 | 1200 | 5 | Black shale, pyrite (Woocalla) |
| | 165 | 170 | 50 | 420 | 650 | 1300 | 2 | Black shale, galena (Woocalla) |
| | 170 | 175 | 60 | 1000 | 700 | 1500 | 5 | Black shale, (Woocalla) |
| | 175 | 180 | 70 | 1000 | 500 | 1900 | 5 | " " |
| | 180 | 185 | 75 | 680 | 300 | 2500 | 2 | " " |
| | 185 | 193 | | | | | | Red quartzite (Pandurra) |
| WP27 | 0 | 35 | | | | | | Red sand, clay gravel |
| | 35 | 62½ | | | | | | White yellow, pink clay (Woocalla) |
| | 62½ | 70 | 40 | 220 | 45 | 30 | 2 | Black clay " |
| | 70 | 74 | 2900 | 300 | 90 | 30 | 5 | Black clay, galena " |
| | 74 | 80 | 1800 | 360 | 1000 | 140 | 5 | " " " |
| | 80 | 83 | 600 | 240 | 900 | 560 | 5 | " " " |
| | 83 | 90 | 90 | 430 | 800 | 1700 | 2 | Black shale, galena pyrite " |
| | 90 | 93 | 170 | 550 | 850 | 1600 | 5 | Black shale |
| WP28 | 0 | 25 | | | | | | Sandy clay, gravel |
| | 25 | 50 | | | | | | White sandstone (Whyalla) |
| | 50 | | | | | | | Red quartzite (Pandurra) |
| WP29 | 0 | 33 | | | | | | Sandy clay |
| | 33 | 114 | | | | | | White sandstone (Whyalla) |
| WP30 | 0 | 9 | | | | | | Sandy clay, gravel |
| | 9 | 62 | | | | | | White sandstone (Whyalla) |
| | 62 | 68 | 350 | 20 | 65 | 40 | 2 | Grey clay (Woocalla) |
| | 68 | 85 | 40 | 20 | 60 | 30 | 2 | Dark grey clay (Woocalla) |
| | 85 | 110 | 20 | 40 | 60 | 40 | 2 | " " |
| | 110 | 120 | 220 | 140 | 440 | 180 | 5 | Black shale " |
| | 120 | 127 | 160 | 1400 | 680 | 420 | 5 | " " |
| | 127 | 129 | 90 | 4000 | 2300 | 1500 | 5 | " " |

# APPENDIX II

## 1971 Drilling Results Summary

| Hole No. | Feet From | Feet To | Cu (ppm) | Pb (ppm) | Zn (ppm) | Ag (ppm) | Log |
|---|---|---|---|---|---|---|---|
| LD1 | 0 | 7 | | | | | Sand |
| | 7 | 160 | | | | | White sandstone (Whyalla) |
| | 160 | 210 | 7 | 20 | 34 | 0.3 | " " |
| | 210 | 260 | 21 | 20 | 20 | 0.2 | White, grey, dark grey-black sandy shale |
| | 260 | 264'6" | 4600 | 700 | 2000 | 4.8 | Black shale, dolomite (Woocalla) |
| | 264'6" | 264'11" | 800 | 380 | 800 | 3 | Shale, dense, brecciated, pyrite |
| | 264'11" | 267'5" | 480 | 100 | 650 | 4 | Laminated black shale, slumps, galena, pyrite |
| | 267'5" | 268'3" | 500 | 150 | 750 | 4 | Black shale, dolomite (4 beds ¼"-1") slumped, galena |
| | 268'3" | 268'8" | 700 | 230 | 1000 | 2 | Fine laminated black shale, slump structures, pyrite |
| | 268'8" | 270 | 600 | 50 | 70 | 2 | Laminated black shale, dolomitic bands, slumped |
| | 270 | 270'11" | 1800 | 75 | 150 | 2 | Black shale, pyrite |
| | 270'11" | 271'3" | 700 | 100 | 110 | 2 | Laminated black shale, dolomitic, slumps, galena |
| | 271'3" | 273 | 500 | 100 | 250 | 2 | " black shale, and dolomite (to 2" bands) pyrite |
| | 273 | 274'6" | 600 | 120 | 320 | 2 | " black shale, slumped pyrite |
| | 274'6" | 276'2" | 600 | 200 | 600 | 2 | " black shale, sphalerite |
| | 276'2" | 276'8" | 380 | 90 | 100 | 2 | " " dolomite |
| | 276'8" | 277'11" | 110 | 120 | 70 | 2 | " " slumped, pyrite galena |
| | 277'11" | 279'9" | 60 | 940 | 650 | 2 | Black shale, dolomite, slumped pyrite |
| | 279'9" | 281'4" | 30 | 1500 | 500 | 2 | " " " galena, sphalerite |
| | 281'4" | 281'7" | 30 | 1600 | 400 | 2 | " " " |
| | 281'7" | 283'3" | 20 | 780 | 750 | 2 | " " " " |
| | 283'3" | 284'2" | 30 | 700 | 1200 | 2 | " " " pyrite |
| | 284'2" | 284'9" | 65 | 1600 | 800 | 2 | Laminated black shale " " |
| | 284'9" | 285'7" | 40 | 700 | 650 | 2 | Black shale, dolomite " " |
| | 285'7" | 286'4" | 35 | 660 | 1000 | 2 | " " " |
| | 286'7" | 286'11" | 30 | 640 | 800 | 2 | " " " galena, pyrite |

| Hole No. | Feet From | Feet To | Cu | Pb (ppm) | Zn (ppm) | Ag | Log |
|---|---|---|---|---|---|---|---|
| LD1 | 286'11" | 287'7" | 40 | 880 | 1000 | 2 | Laminated black shale,dolomite |
| | 287'7" | 292'3" | 28 | 400 | 900 | 2 | " " " slumped galena,sphalerite, pyrite |
| | 292'3" | 293'2" | 25 | 280 | 1400 | 2 | " black shale,dolomite, slumped galena,pyrite |
| | 293'2" | 293'11" | 30 | 390 | 1750 | 2 | " " " |
| | 293'11" | 296' | 35 | 750 | 400 | 2 | " black shale,slumped pyrite |
| | 296 | 296'4" | 38 | 320 | 2200 | 2.9 | Black shale,slumped,sphalerite |
| | 296'4" | 296'9" | 34 | 220 | 680 | 2.7 | Laminated shale,dolomite,slumped |
| | 296'9" | 297'8" | 62 | 250 | 1100 | 2.7 | " " " pyrite |
| | 297'8" | 298'3" | 38 | 190 | 900 | 2.6 | " " " sphal-erite |
| | 298'3" | 298'6" | 36 | 200 | 920 | 2.5 | Black shale,breccia |
| | 296'8" | 304 | | | | | Red quartzite (Pandurra) |

| Hole No. | Feet From | Feet To | Cu | Pb | Zn | Ag | Log |
|---|---|---|---|---|---|---|---|
| | | | | (ppm) | | | |
| LD2 | 0 | 40 | | | | | Sand |
| | 40 | 140 | | | | | White sandstone (Whyalla) |
| | 140 | 176'9" | | | | | White, grey, sandy shale |
| | 176'9" | 180 | 16 | 30 | 210 | 1.4 | Grey shale (Woocalla) |
| | 180 | 182'2" | 113 | 105 | 260 | 6 | Black shale, dolomite, slumped, pyrite galena |
| | 182'2" | 188'3" | 500 | 140 | 385 | 4 | " " " " |
| | 188'3" | 194'8" | 90 | 175 | 495 | 3 | Laminated black shale, dolomite, slumped pyrite, galena, sphalerite |
| | 194'8" | 201'8" | 40 | 965 | 795 | 3.4 | " " " " |
| | 201'8" | 221'10" | 30 | 265 | 360 | 2.2 | " " minor " |
| | 221'10" | 227'6" | 27 | 365 | 745 | 2.3 | " " slumped " |
| | 227'6" | 257'6" | 50 | 235 | 385 | 2 | " " " " |
| | 257'6" | 310'2" | 37 | 75 | 280 | 1.3 | " " occasional sphalerite, pyrite |
| | 310'2" | 318'11" | 48 | 57 | 347 | 0.8 | " " " " |
| | 318'11" | 410'8" | 35 | 60 | 160 | 1 | " " slumped, trace sulphide |
| | 410'8" | 423 | 42 | 80 | 555 | 1.2 | Black shale, dolomitic bands, pyrite sphalerite |
| | 443'8" | 449'11" | 38 | 96 | 672 | 1.4 | " slumped " |
| | 449'11" | 557'5" | 38 | 82 | 210 | 1.5 | Laminated shale, dolomite " " |
| | 557'5" | 567'8" | 34 | 200 | 463 | 2.9 | Dolomite and black shale, pyrite" |
| | 567'8" | 572'10" | 32 | 190 | 825 | 2.9 | Black shale, dolomitic shale" " |
| | 572'10" | 574'10" | 37 | 3133 | 1390 | 2.9 | " " " |
| | 574'10" | 584 | 30 | 300 | 60 | 2.8 | Dolomitic shale, black shale, galena |
| | 584 | 592 | 56 | 880 | 130 | 3.2 | " " pyrite |
| | 592 | 598'3" | 79 | 192 | 212 | 3.7 | " " |
| | 598'3" | 600'2" | 163 | 400 | 538 | 10.1 | " " " |
| | 600'2" | 601'10" | 37 | 86 | 167 | 11.9 | Black shale " |
| | 601'10" | 608'5" | 31 | 75 | 150 | 1.7 | Red quartzite (Pandurra) |

| Hole No. | Feet From | Feet To | Cu | Pb | Zn | Ag | Log |
|---|---|---|---|---|---|---|---|
| | | | | (ppm) | | | |
| LD3 | 0 | 40 | | | | | Sand |
| | 40 | 278'5" | | | | | White sandstone (Whyalla) |
| | 278'5" | 324'1" | | | | | Shaley sandstone |
| | 324'1" | 324'8" | 24 | 60 | 160 | 2.6 | Dolomitic shale,pyrite (Woocalla) |
| | 324'8" | 332'7" | 277 | 154 | 255 | 5.2 | Black shale,minor dolomite,pyrite, galena |
| | 332'7" | 337'2" | 74 | 1272 | 873 | 4.6 | " " " " |
| | 337'2" | 343'6" | 37 | 595 | 766 | 2.9 | " " " |
| | 343'6" | 353'4" | 40 | 444 | 417 | 2.5 | " " " |
| | 353'4" | 384'9" | 47 | 268 | 740 | 2.1 | " " " |
| | 384'9" | 388'1" | 163 | 501 | 1365 | 2 | " " " " sphalerite |
| | 388'1" | 394'10" | 43 | 251 | 618 | 1.7 | " " " " |
| | 394'10" | 398'5" | 31 | 202 | 1219 | 1.8 | " " slumped " |
| | 398'5" | 406'9" | 41 | 171 | 590 | 2 | " " " " |
| | 406'9" | 412'4" | 37 | 141 | 1092 | 1.6 | " " " " |
| | 412'4" | 414'2" | 32 | 120 | 435 | 1.2 | " " " " |
| | 414'2" | 414'9" | 93 | 113 | 3640 | 1.4 | " " " " |
| | 414'9" | 419'5" | 45 | 140 | 897 | 1.4 | " " " " |
| | 419'5" | 456'7" | 45 | 81 | 230 | 1 | Laminated black shale,dolomite, slumped pyrite,sphalerite |
| | 467'7" | 457'4" | 60 | 230 | 4000 | 1 | Black shale,dolomitic;slumped " " |
| | 457'4" | 544'6" | 35 | 72 | 130 | 0.8 | " "minor" trace sulphide |
| | 544'6" | 545'10" | 39 | 70 | 790 | 0.7 | " " " sphalerite |
| | 545'10" | 567'10" | 39 | 84 | 190 | 0.9 | " " in part slumped pyrite,trace |
| | 567'10" | 569'6" | 37 | 90 | 1428 | 1 | " " " |
| | 569'6" | 587'10" | 45 | 108 | 245 | 1.1 | " "minor " |
| | 587'10" | 588'4" | 40 | 110 | 1900 | 1.1 | " " " " |
| | 588'4" | 590'3" | 41 | 117 | 267 | 1.5 | " " " " |
| | 590'3" | 591'10" | 53 | 150 | 1436 | 1.1 | " " " " |
| | 591'10" | 593'4" | 35 | 110 | 470 | 1.4 | " " " " |
| | 593'4" | 593'10" | 32 | 100 | 9200 | 1.4 | " " " " |
| | 593'10" | 594'7" | 46 | 172 | 145 | 1 | " " " " |
| | 594'7" | 597'10" | 36 | 121 | 1171 | 1.5 | " " " " |
| | 597'10" | 600'3" | 48 | 198 | 555 | 1.8 | " " " " |

| Hole No. | Feet From | Feet To | Cu | Pb | Zn | Ag | Log |
|---|---|---|---|---|---|---|---|
| | | | | (ppm) | | | |
| LD3 | 600'3" | 600'9" | 34 | 180 | 1300 | 1.9 | " " " " |
| | 600'9" | 601'10" | 43 | 160 | 360 | 2 | " " " " |
| | 601'10" | 603'2" | 40 | 206 | 1525 | 2.5 | " " " " |
| | 603'2" | 611'11" | 41 | 513 | 1111 | 3.8 | " " " " |
| | 611'11" | 625'7" | 49 | 2164 | 4079 | 5.8 | " " " " |
| | 625'7" | 627'10" | 492 | 2269 | 3380 | 8.8 | " " " " |
| | 627'10" | 629 | 160 | 59 | 47 | 4.3 | Dolomitic shale, pale grey, pyrite |
| | 629 | 631'11" | 135 | 22 | 10 | 0.6 | Red brown quartzite (Pandurra) |

| Hole No. | Feet From | Feet To | Cu | Pb | Zn | Log |
|---|---|---|---|---|---|---|
| | | | | (ppm) | | |
| LD4 | 0 | 30 | | | | Sand |
| | 30 | 100 | | | | White sandstone (Whyalla) |
| | 100 | 171'6" | | | | Grey clayey sandstone |
| | 171'6" | 200'6" | | | | Black shale (Woocalla) |
| | 200'6" | 204'6" | 90 | 270 | 260 | Black shale |
| | 204'6" | 210'11" | 41 | 341 | 629 | " slumped pyrite, galena sphalerite |
| | 210'11" | 217 | 46 | 380 | 480 | " " " |
| | 217 | 224'5" | 39 | 550 | 550 | " dolomite " |
| | 224'5" | 232 | 40 | 441 | 413 | " " |
| | 232 | 246'8" | 36 | 331 | 1323 | " slumped, in part pyrite |
| | 246'8" | 252'10" | 34 | 378 | 633 | " " " |
| | 252'10" | 259'9" | 31 | 227 | 1264 | " " |
| | 259'9" | 264'6" | 36 | 295 | 500 | " |
| | 264'6" | 277'5" | 53 | 276 | 1114 | " " " |
| | 277'5" | 281'6" | 33 | 432 | 510 | " laminated " |
| | 281'6" | 290'6" | 37 | 308 | 1271 | " dolomite, " |
| | 290'6" | 298'6" | 28 | 102 | 490 | " " " |
| | 298'7" | 342'6" | 35 | 74 | 180 | " " minor " |
| | 342'6" | 348'2" | 30 | 71 | 58 | " " |
| | 348'2" | 372'10" | 42 | 78 | 220 | " " crenulated Tr " |
| | 372'10" | 373'9" | 38 | 72 | 1300 | " " " |
| | 373'9" | 385'6" | 51 | 84 | 74 | " " " |
| | 385'6" | 392'1" | 80 | 95 | 315 | " " |
| | 392'1" | 403'8" | 44 | 82 | 44 | " " slumped |
| | 403'8" | 414'10" | 62 | 97 | 270 | " " " Tr. " |
| | 414'10" | 441'4" | 46 | 92 | 65 | " " " in part" |
| | 441'4" | 443'9" | 200 | 102 | 105 | " " " pyrite |
| | 443'9" | 447'4" | 6 | 14 | 8 | Red quartzite (Pandurra) |

| Hole No. | Feet From | Feet To | Cu | Pb | Zn | Log |
|---|---|---|---|---|---|---|
| | | | | (ppm) | | |
| LD5 | 0 | 20 | | | | Sand |
| | 20 | 130 | | | | White sandstone (Whyalla) |
| | 130 | 200 | | | | Shaley sandstone |
| | 200 | 217'6" | 403 | 148 | 346 | Black shale,dolomite,slumped pyrite (Woocalla) |
| | 217'6" | 221'2" | 54 | 470 | 352 | " " "sphalerite, galena |
| | 221'2" | 230 | 36 | 735 | 435 | " " " " " |
| | 230 | 238'5" | 38 | 415 | 315 | " " " " " |
| | 238'5" | 242'1" | 32 | 797 | 227 | " " " " " |
| | 242'1" | 244'4" | 17 | 232 | 290 | " " " " " |
| | 244'4" | 248'8" | 43 | 608 | 147 | " " " " " |
| | 248'8" | 250'4" | 42 | 1250 | 205 | " " " " " |
| | 250'4" | 254 | 38 | 377 | 62 | " " "galena,pyrite |
| | 254 | 263 | 347 | 98 | 209 | Dolomitic shale ½" black shale bands" |
| | 263 | 266'10" | 338 | 134 | 370 | " pyrite |
| | 266'10" | 271 | 218 | 53 | 100 | Dolomite (massive),pyrite |
| | 271 | 272'9" | 15 | 23 | 20 | Red quartzite (Pandurra) |
| LD6 | 0 | 20 | | | | Sand |
| | 20 | 90 | | | | White sandstone (Whyalla) |
| | 90 | 150 | | | | Shaley sandstone |
| | 150 | 160 | 28 | 28 | 46 | Black shale (Woocalla) |
| | 160 | 177 | 800 | 82 | 250 | " |
| | 177 | 181 | 501 | 70 | 155 | Massive dolomitic shale,black shale partings pyrite |
| | 181 | 196'2" | 88 | 54 | 115 | " " " " |
| | 196'2" | 210'4" | 432 | 42 | 118 | " " " " |
| | 210'4" | 215'11" | 1224 | 92 | 135 | Dolomite, black shale,pyrite |
| | 215'11" | 216'8" | 260 | 200 | 170 | " |
| | 216'8" | 222'4" | 23 | 13 | 6 | Red quartzite (Pandurra) |

| Hole No. | Feet From | Feet To | Cu | Pb | Zn | Log |
|---|---|---|---|---|---|---|
| | | | (ppm) | | | |
| LD7 | 0 | 20 | | | | Sand |
| | 20 | 120 | | | | White sandstone (Whyalla) |
| | 120 | 130 | 1400 | 1900 | 150 | " |
| | 130 | 140 | 1800 | 1600 | 140 | " pyrite, galena |
| | 140 | 150 | 240 | 410 | 50 | Red quartzite, pyrite, manganese (Pandurra) |
| | 150 | 247 | | | | " |

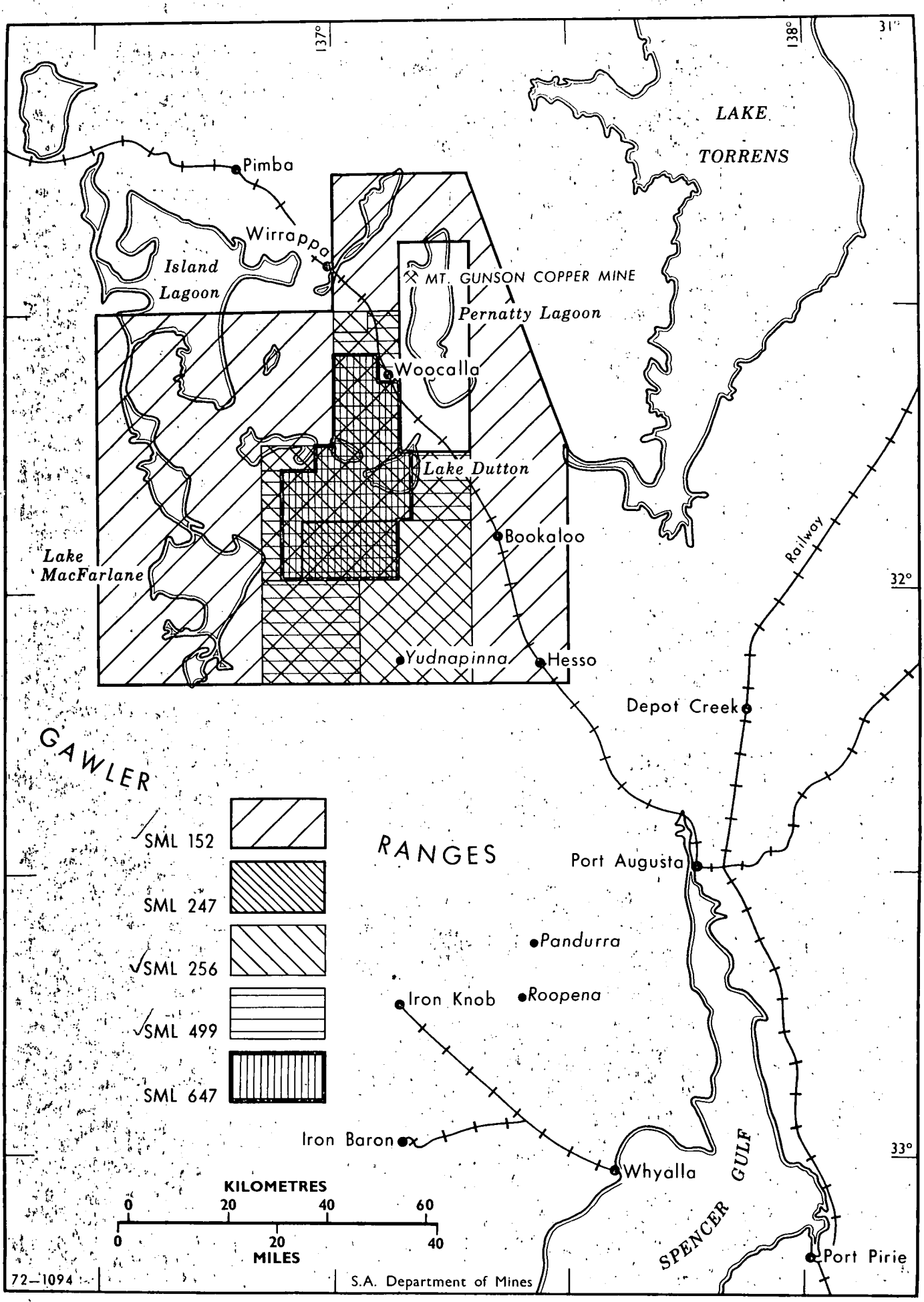
137°
138°
31°
LAKE
TORRENS
Pimba
Wirrappa
Island
Lagoon
MT. GUNSON COPPER MINE
Pernatty Lagoon
Woocalla
Lake Dutton
Bookaloo
Lake
MacFarlane
Railway
32°
Yudnapinna
Hesso
Depot Creek
GAWLER
RANGES
SML 152
SML 247
SML 256
SML 499
SML 647
Port Augusta
Pandurra
Iron Knob
Roopena
Iron Baron
Whyalla
33°
SPENCER GULF
KILOMETRES
0 20 40 60
0 20 40
MILES
Port Pirie
72—1094
S.A. Department of Mines

FIG. 1

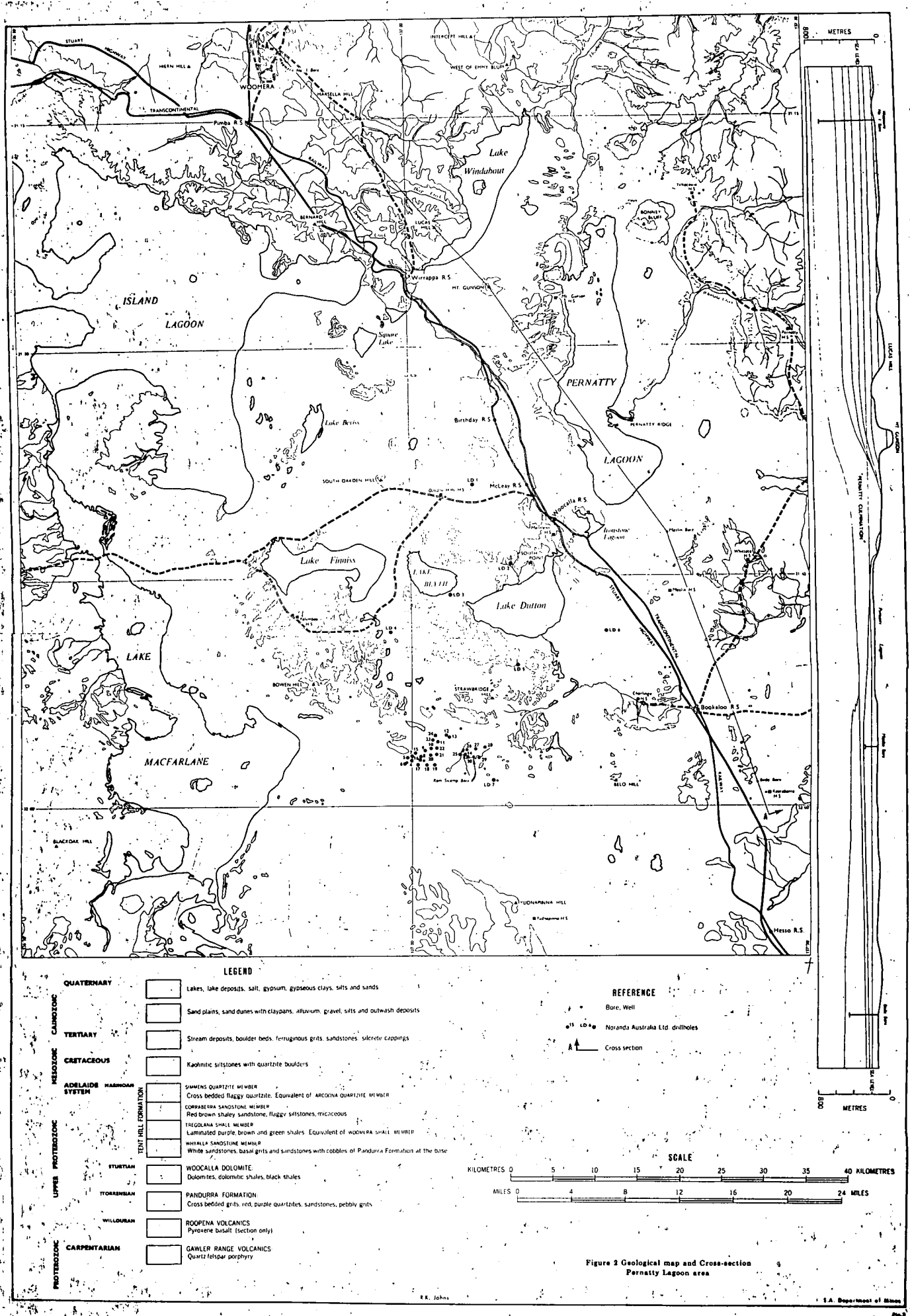


**Figure 2 Geological map and Cross-section Pernatty Lagoon area**

FIG. 2

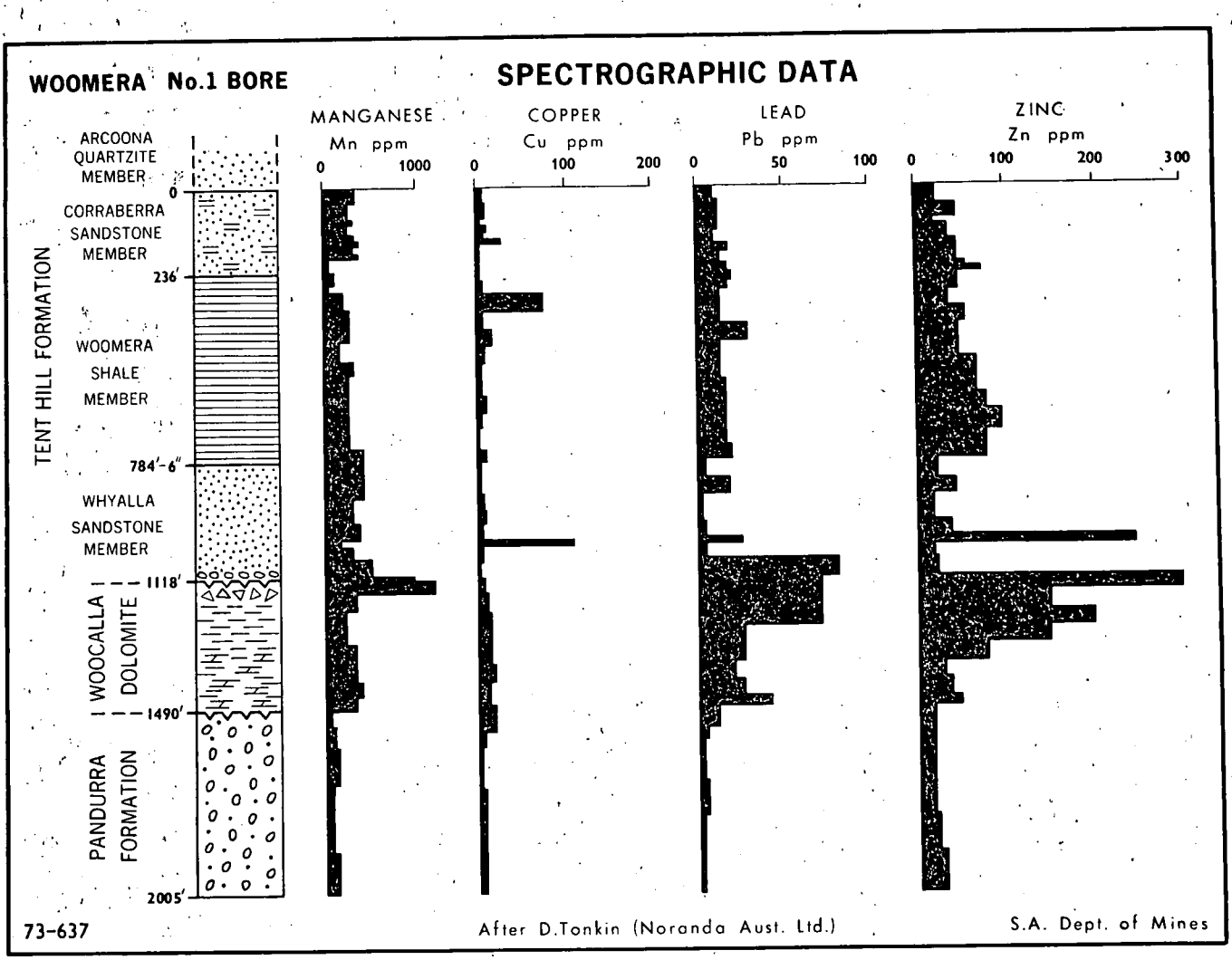
WOOMERA No.1 BORE
SPECTROGRAPHIC DATA
MANGANESE
Mn ppm
0
1000
COPPER
Cu ppm
0
100
200
LEAD
Pb ppm
0
50
100
ZINC
Zn ppm
0
100
200
300
TENT HILL FORMATION
ARCOONA QUARTZITE MEMBER
0
CORRABERRA SANDSTONE MEMBER
236'
WOOMERA SHALE MEMBER
784'-6"
WHYALLA SANDSTONE MEMBER
1118'
WOOCALLA DOLOMITE
1490'
PANDURRA FORMATION
2005'
73-637
After D.Tonkin (Noranda Aust. Ltd.)
S.A. Dept. of Mines

FIG. 3

MISSING FIGURE 4.

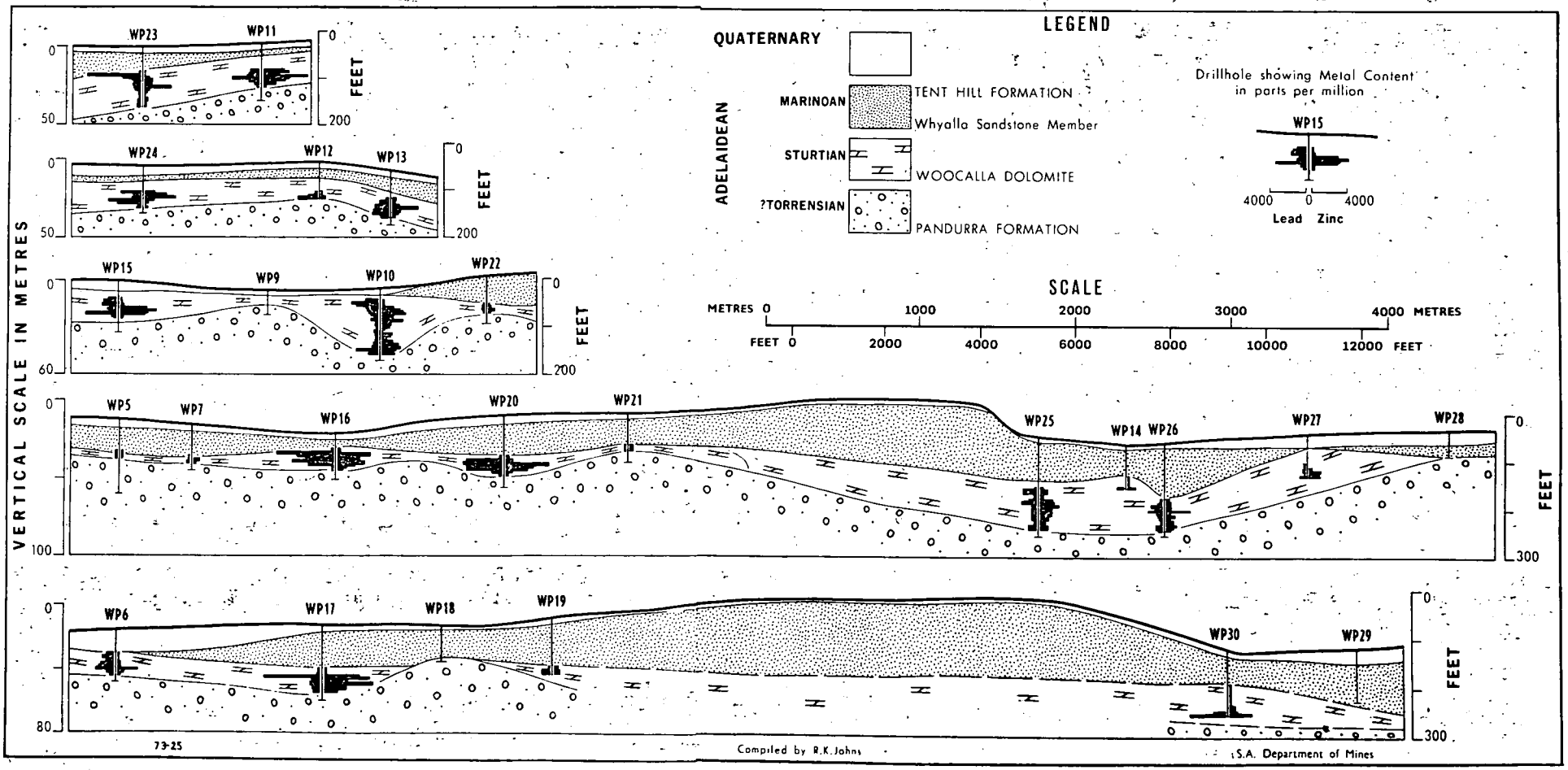
WP23
WP11
WP24
WP12
WP13
WP15
WP9
WP10
WP22
WP5
WP7
WP16
WP20
WP21
WP25
WP14
WP26
WP27
WP28
WP6
WP17
WP18
WP19
WP30
WP29
VERTICAL SCALE IN METRES
FEET
LEGEND
QUATERNARY
ADELAIDEAN
MARINOAN
TENT HILL FORMATION
Whyalla Sandstone Member
STURTIAN
WOOCALLA DOLOMITE
?TORRENSIAN
PANDURRA FORMATION
Drillhole showing Metal Content in parts per million
4000 0 4000
Lead Zinc
SCALE
METRES 0 1000 2000 3000 4000 METRES
FEET 0 2000 4000 6000 8000 10000 12000 FEET
73-25
Compiled by R.K. Johns
S.A. Department of Mines

FIG. 5

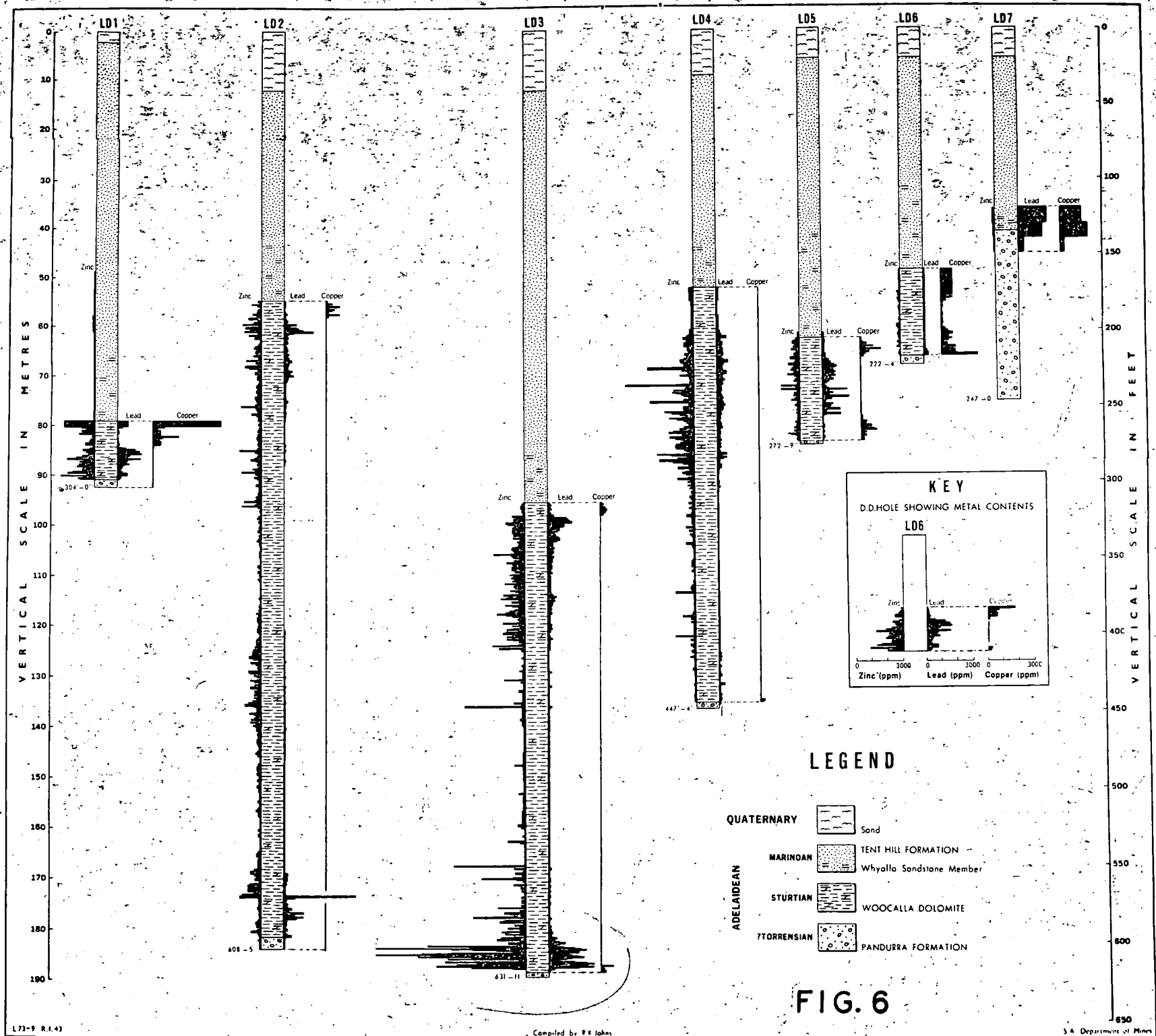


FIG. 6

L73-9 R.I.43

Compiled by R.K.Johns

S.A. Department of Mines

**Plate I**

Gunyah copper deposits, Pernatty Lagoon. Woomera shale exposed in top bench overlies Whyalla Sandstone. Pandurra Formation exposed in face of bottom bench and overlain disconformably by Whyalla Sandstone.

Neg.21573.

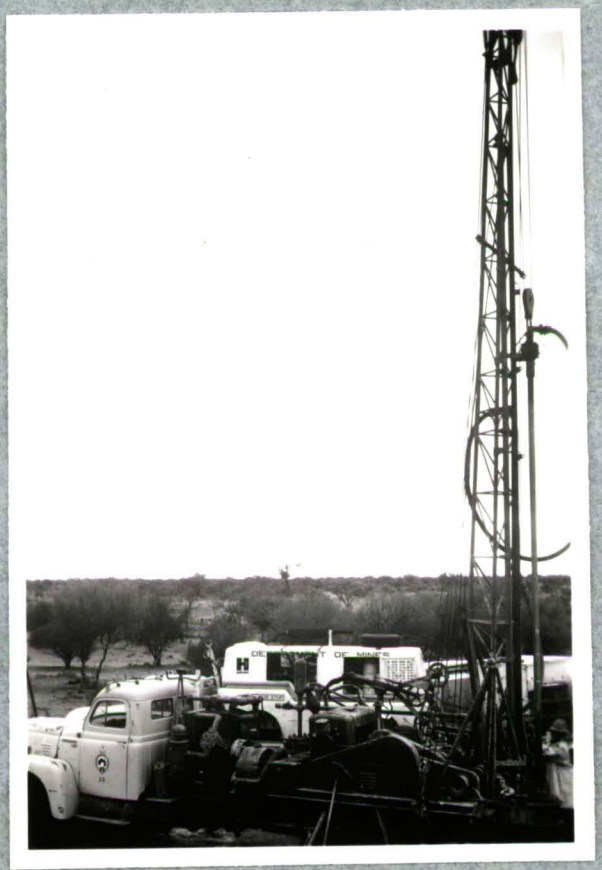

**Plate II**

Failing WW1 drilling rig, Trevenna area.

Neg.22843.

**Plate III**

E1000 diamond drilling rig, Lake Dutton area, bore LD4.
Neg. 22844.

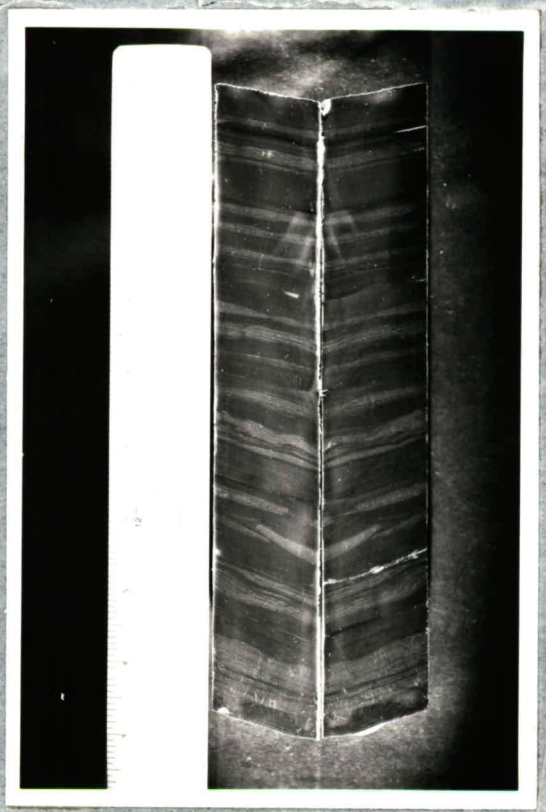

**Plate IV**

Split diamond drill core, Woocalla Dolomite from bore LD4. Light coloured finely laminated dolomite intercalated with black shale.
Neg. 22842.