Rept. Bk. No. 59/121
G.S. No. 3016
D.M. 1231/64

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
METALLIC MINERALS SECTION

ARRDWIE GORGE MANGANESE PROSPECTS: WERTALOONA STATION MINERAL CLAIMS 4597 - 4602 - ADELAIDE CHEMICAL AND FERTILIZER CO. LTD.

by

W.A. Fairburn
Geologist

D.M. 1231/64

18th November, 1964

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ABSTRACT

The manganese ores are associated with, and form part of a secondary, manganiferous, ironstone formation, which caps a mineralized zone in the faulted contact between the Pound Quartzite and the overlying Cambrian limestones, on the eastern limb of a northerly plunging anticline. Tonnage calculations and grade determinations are limited to the secondary gossan type ironstone which was formed under oxidising conditions by secondary concentration. Apart from small replacement pockets in the limestone, the overall grade of mineralization is less than 10% Mn, while reserves probably do not exceed 300,000 tons.

This report includes a description of the mineralogy of the mineralization and a table of assay determinations of samples collected during the investigation.

INTRODUCTION

The Arrowie Gorge manganese prospects, which cover a total area of about 100 acres, was examined on behalf of the Adelaide Chemical & Fertilizer Co. Ltd. between 31st August, 1964, and 4th September, 1964. During the investigation, a topographic survey was carried out by B. Frost surveyors assistant of the Drafting Section of the Department of Mines.

Samples collected during the investigation were submitted for chemical analyses and petrological examination to A.M.D.L.

The writer is indebted to Mr. Walther of the Adelaide Chemical & Fertilizer Co. Ltd. for valuable assistance in locating access roads to the prospect.

Location and Access

The prospect is located in the north-east part of the Flinders Ranges near Mt. Robert about twenty-five miles west of Lake Frome. Blinman is about forty-five miles to the south-west and Wertaloona Station about ten miles to the north-east. (See locality Map Plan No. L64-166). The actual mineral claims lie north and south of a main tributary to Moro Creek which enters Lake Frome. The tributary creek, which so far as is known has no name, is the only creek of importance in the area and will be referred to frequently in the text for descriptive purposes. Arrowie Gorge has been cut by the creek just west of its confluence with Moro Creek.

Access to the prospect is either by way of a track northwards from Wearing Well on the Blinman-Wirrealpa-Wertaloona-Balcanoona road, or southwards from the Wertaloona-Moro Gorge road. This latter track is only suitable for four wheel drive vehicles.

Topography

For the purposes of the topographic survey, an arbitrary datum of 1,000 ft. was taken for station A, and all contouring is based upon this datum. Contours below 920 ft. are drawn at 10ft. vertical intervals, while above 920 ft. at 20 ft. vertical intervals.

The Pound Quartzite gives the maximum relief in the area forming ridges in the north-west which are about 300ft. above the level of the Moro Creek tributary.

Previous Geological Work

There is no known previous geological work from this particular prospect and both the Balcanoona one mile sheet and the Copley four mile sheet in which the area lies have not yet been published.

Guidance to the geology of the area can, however, be obtained from Horwitz (1962) and Dalgarno (1964).

Horwitz in describing the geology of the Arrowie one mile sheet, which lies immediately south of the Balcanoona one mile sheet, refers (P.10) to the Mount John Fault which separates Cambrian rocks to the south and east from the older Adelaide System rocks to the west. The northerly continuation of this fault forms the scarp to the west of the present area (see structural map - Plan No. L64-166) and a north-westerly trending branch from this fault probably occurs along the line of the manganiferous mineralization which again separates Adelaide System rocks from the Cambrian.

Horwitz regarded the Cambrian rocks on the Arrowie sheet as being of Lower Cambrian Age.

Dalgarno in mapping the Lower Cambrian stratigraphy of the Flinders Ranges places the Cambrian rocks south-west of Wertaloona into the Middle Cambrian, and if this is the case, is possibly indicating a faulted contact between the Cambrian limestones and the Adelaide System rocks.

Occurrences of manganese oxides from a similar stratigraphic level to the present prospect have been reported from the Blinman region, at the contact between the Pound Quartzite and the overlying Lower Cambrian limestones. Webb (1961, 1961A and 1961B) has described such occurrences at the Erugunda Manganese Mine, the Bungoola Manganese Mine, and at a third locality fifteen miles east of Blinman. Dickinson (1943 p. 74) described the Erungunda manganese as being psilomelane with some pyrolusite derived from manganese carbonates. At Bungoola the manganese ore was restricted to steeply dipping minor crush zones striking parallel to the bedding of the country rock, while at the third occurrence the manganese mineralization occurred as scattered pods in an area of brecciation marginal to massive Lower Cambrian limestone.

SUMMARY OF GEOLOGY

The rocks occurring in the vicinity of the manganese prospect can be included in the Adelaide and Cambrian Systems with a faulted contact between. Recent deposits are limited to piedmont slopes and alluvial flats. This whole sequence is separated from the Quaternary deposits of the Frome Plains by the continuation of the Mount John Fault (See Structural Map, Plan No. L64-166).

The manganiferous-ironstone material is almost completely confined to the fault zone between the Adelaide and Cambrian Systems although a certain amount of mineralization has migrated outside these limits, particularly into the Cambrian limestones.

Structurally the Adelaide System rocks occur in a northerly plunging anticline with fairly steeply dipping limbs. The Cambrian rocks which are exposed on the eastern flanks of this anticline are more flat lying.

DETAILS OF GEOLOGY

Rock types mapped in the area examined are listed below, with their probable ages and formational names. (See Dalgarno and Johnson 1964A, pp. 12-15).

Recent		(Alluvial Deposits (Gravel Deposits
Cambrian System		(Nodular Limestones (Massive Limestones (Nodular Limestones
Adelaide System Wilpena Group	(Pound Quartzite-Quartzite (Wonaka Formation-Bedded Dolomites (Bunyeroo Formation-Green and (purple shales.	

Recent Deposits

Narrow alluvial flats flanking the main creek grade upwards into gravel or boulder covered slopes fringing most of the hills. The gravel or boulder material is mainly Pound Quartzite or manganiferous ironstone. Frequent small exposures of the manganiferous ironstone can often be seen on these higher slopes particularly north of the creek.

Cambrian System

Nodular Limestones

The upper nodular limestones, which are either near horizontal or are dipping gently eastwards, are exposed in a belt of dissected country cut through by the creek between the eastern edge of the mineral claims and the Mount John Fault. Arrowie Gorge occurs in these limestones. Because of the flat lying nature of the beds the limestone has given rise to flat topped hills and ridges bounded by steep scarps. Like the underlying nodular limestones no fossils were found in these rocks. Generally the limestones display a bedded nature, being composed of rounded or sub-rounded nodules of limestone, one to two inches across, set in a yellow calcareous matrix.

The lower nodular limestones form a series of rounded knolls through the centre of the prospect area, being bounded to the west by the steep dip slope of the Pound Quartzite, and to the east by the scarp of the massive limestones. The largest of the knolls, which is situated in mineral claim areas 4598, 4599, and 4600, (Plan No. 64-166 rises about 150 feet above the creek. It is probable that the lower nodular limestones underly much of the unexposed ground covered by piedmont and alluvial deposits. Where exposed, the lower nodular limestones can be seen dipping eastwards at about 20-30 degrees.

Weathering of the nodular limestones gives rise to a limestone rubble by separation of the nodules from their matrix. This feature is most commonly shown by the lower nodular limestones, which rarely give in situ exposures. The lower nodular limestones have also proved good host rocks for pockets of replacement manganese oxides of enriched grade. Manganese oxides deposited in this way have formed colloform and botryoidal masses. The best examples of the type of replacement deposit occur in the south bank of the creek (specimen No. W.A.F. 70/64) and in pits at the southern end of mineral claim 4602 (specimen No. W.A.F. 52/64 and 53/64). The manganese mineralisation pocket on the south bank of the creek consists of large lumps of manganese oxides in a yellow clay matrix, overlain by a rubble of limestone nodules and manganese oxides. Even where extensive replacement has not taken place, the presence of manganiferous material in the underlying rocks is clearly shown in the surface rubble, where it tends to be concentrated.

<u>Massive Limestones</u>

The massive limestones are best exposed in scarps along the eastern edge of the prospect area both north and south of the creek. At their western edge, these limestones which rarely show bedding surfaces, are dipping eastwards at angles of 20-40 degrees. Eastwards, however, the dips flatten and the limestones become near horizontal. Joints which may be well developed in these limestones are commonly filled with manganese oxides, or manganiferous ironstone.

Weathered surfaces on these limestones north of the creek have yielded small specimens of archyaeocyatha.

An isolated lens of massive limestone is also exposed in M.C. 4599 between the Pound Quartzite and the main mass of the manganiferous ironstone. It is probable that this lens is bounded by faults.

Adelaide System

Pound Quartzite

The Pound Quartzite, which in this area has a maximum thickness of about 1,000 feet, is exposed in a series of fairly rugged scarps along the western edge of the prospect. The quartzite is overlain to the east by the manganiferous ironstone, and underlain to the west by the Wonaka dolomites.

In several localities, the contact between the quartzite and the ironstone, which is believed to be a faulted contact, is formed by a siliceous breccia up to five feet thick. This breccia is best exposed in M.C. 5600, but its presence is also known north of the creek by the occurrence of float.

Generally, the quartzite which strikes in a north-westerly direction dips to the east at angles between 30 and 60 degrees. The angle of dip may, however, steepen near the line of the supposed fault, where the quartzite may have a bleached appearance.

Lenses of ironstone are not uncommon in the quartzite, particularly near the eastern margin, and copper staining can be frequently observed. A conspicuous black band in the quartzite near the crest of the western anticline (see structural Map-Plan No. L64-166) is due to manganese oxide mineralization coating a particular band in the quartzite. This band, which at its widest point may be nearly 50 feet thick, is about 800 feet long and strikes in a north-easterly direction. The oxide coating, which is fairly complete, is about 0.2 cm. thick, and covers fairly normal quartzite which may show fine manganese oxide spotting.

Wonaka Formation

The Wonaka Formation consists of well bedded, cream coloured dolomites, with minor bands of greenish shale. Downwards the formation grades into the Bunyeroo Formation by gradual loss and thinning of the dolomite bands. The main dolomitic bands in the Wonaka are well exposed in secondary scarps under the main Pound scarp, round the flanks of the anticlinal fold west of the prospect area.

Minor faults are fairly common displacing the contact between the Wonaka and the Pound.

Bunyeroo Formation

The Bunyeroo Formation, which consists of purple and green shales with minor thin bands of cream dolomite, forms the core of the anticline west of the prospect.

The Parachilna Formation which normally forms the base of the Cambrian System has not been recognized in the prospect area. Its supposed absence at the top of the Pound Quartzite, could be due to faulting out along the mineralized zone, but as insufficient mapping was carried out in the area this line of evidence to prove faulting cannot be regarded as being reliable.

STRUCTURE

The three most important structural features in the area are:-

(i) The western anticline in the Adelaide System.

(ii) The arcuate mineralized fault line between the Adelaide and Cambrian Systems (which from here on will be referred to as the Teatree Fault).

(iii) The eastern boundary of the Cambrian with the Frome Plain formed by the continuation of the Mount John Fault.

(i) Western Anticline

This northerly plunging anticline, which was mapped by Horwitz on the Arrowie one mile sheet, exposes most of the units of the Wilpena Group (Marinoan) as well as isolated domes of the older Umberatana Group (Sturtian). In the present prospect area (see Structural Map-Plan No. L64-166) only the upper members of the Wilpena Group (as listed on p. 4) were exposed by the anticline.

Although mapping during the examination of the manganese deposit was limited to the eastern limb of the anticline (mainly Pound Quartzite) stereographic plots of dip and strike recordings (II - Diagrams on an equal area net - lower hemisphere) show poor homogeneity with the supposed structure of the anticline (Plan No. 64,844). The orientation of the plots in fact seems to be more closely related to an easterly plunging structure, possibly parallel to the plane of the Teatree Fault.

Strike directions in the Pound Quartzite vary from near westerly to north-westerly, and although they show some parallelism with the line of mineralization they show poor parallelism with strikes in the Cambrian limestones.

(ii) Teatree Fault

This fault is the most significant feature in the area forming the boundary between the Pound Quartzite and the overlying Cambrian limestones. The fault zone which is capped by secondary manganiferous ironstone also has small pockets of copper mineralization. The actual line of the fault is arcuate in shape, varying in direction from west-north-west in the south of the area, to north-west in the north of the area. Overall, it is a normal dip-slip fault with the hade of the fault plane similar or nearly similar to the regional dip in the Pound Quartzite. This latter feature is clearly shown by the parallel relationship of the manganiferous ironstone on the dip slope of the Pound Quartzite, on the eastern side of M.C.4597 and M.C. 4599. The angle of dip of banding in the ironstone also confirms this picture.

Along the western wall of the fault the Pound shows little disturbance, although particularly in the south of the area, there may be local steepenings in the angle of dip. Often the top of the Pound is marked by a siliceous breccia up to five feet thick. As mentioned earlier (p.7) the Parachilna Formation was not found in this area.

On the downthrow (eastern) side of the fault, however, there are more significant features in structural disturbance. Immediately east of the fault, the lower nodular limestones are showing a pronounced easterly dip, and this can also be observed to a lesser extent in the western scarp of the massive limestones (these dips in the limestones are however, much less than dips recorded along the eastern edge of the Pound Quartzite). To the east, the dips flatten, and both the massive limestones and the upper nodular limestones become nearly horizontal. This steepening in dip near the fault could be entirely or partly due to movement on the fault plane, but it is possible that more regional processes may also be involved, to account for the extensive area of horizontal beds. (Dalgarno 1964 p. 3, refers to the basinal structure of the Lower Cambrian).

Perhaps more significant than the change in the angle of dip in the limestones is the marked convergence of the limestone scarp on the eastern side of M.C. 4600, 4601, and 4602 with the strike directions in the Pound. This feature which is most pronounced on the aerial photographs, but is also indicated on the main geological map (Plan No. L64-166) by the strike recordings that are plotted. The convergence could be caused by a thickening of the fault zone, but there also must be some loss in thickness of the lower nodular limestones, which although well exposed in the north of the area, are poorly represented if at all in the south.

The small lens of massive limestone north of the creek with quite steep easterly dips is exposed between the Pound and the manganiferous ironstone. This lens of limestone, which is quite clearly thinning out north and south, is probably bounded by faults in the fault zone, although the faulted contact between it and the Pound was not clearly observed during the survey.

Within the fault zone slickensiding is commonly developed in the manganiferous ironstone.

The northern continuation of the Teatree Fault was not examined, but to the south, the fault appears to join the Mount John Fault near the Ironstone Bore.

(iii) Mount John Fault

The Mount John Fault mapped by Horwitz on the Arrowie sheet continues north-westerly and forms the eastern edge of the present area. It separates the flat lying Cambrian limestones from the Quaternary deposits of the Frome Plains.

MINERALIZATION

Mineralization is of two types: the manganese-iron mineralization in the fault zone (which has given rise to the secondary manganiferous ironstone capping) and the more localised copper mineralization.

Manganese - Iron Mineralization

Examination of the manganiferous-ironstone reveals particularly on the large exposures north of the creek, that the hard, craggy, surface ironstone is resting on a much softer yellow source rock at a depth of about four feet (the thickness of the surface ironstone can vary from a few inches to about eight feet). South of the creek this relationship cannot always be clearly demonstrated. The ironstone may be massive, banded or brecciated, and is commonly slickensided, while manganese rich colloform and botryoidal masses may be found in the replacement limestone deposits.

Petrological descriptions of both the secondary ironstone (WAF 80/64) and the underlying source rock (WAF 81/64) are given in Appendix II, while assay determinations for iron and manganese are listed in Appendix I.

Although there is no doubt that the surface ironstone is derived by weathering processes from the underlying source, the chemical relationship between the two rocks as regards iron and manganese is rather variable. For example the following pairs of samples can be compared:-

Sample No.	Relative Concentration of Fe	Relative Concentration of Mn
(A3972 (surface) (A3973 (subsurface)	1.4	1.7
(A3974 (surface) (A3975 (subsurface)	0.7	9
(A3978 (surface) (A3979 (subsurface)	0.85	36

This shows that although the manganese can be concentrated by as much as 36 times, there could in fact be a relative loss of iron to as low as 0.7, which in part at least must be due to the preferential concentration of manganese.

Most exposures of the manganiferous ironstone show that where appreciable manganese oxide is present it forms an outer skin on the iron oxides, and this feature, particularly with small exposures where good samples cannot be collected, will give manganese values greatly in excess of the true value for the rock in bulk.

An example of this can be illustrated by sample A3964 with 21.3%Mn. (collected from a small exposure) in comparison with samples A3960-62 with 1.54%Mn. (collected from a large exposure) and sample A3970 with 39.5%Mn. (small exposure) in comparison with sample A3969 with 6.87%Mn. (from much larger exposure just to south).

All the samples mentioned above were collected by random chip sampling and would thus tend to concentrate an abnormal quantity of manganese oxide coated material (particularly where the manganese skin is fairly thick). Channel sampling would likewise give the same results. The range of manganese values for the chip sampling is from 0.29% to 39.5%, a ratio of 1:136. In all cases, collection being from exposures which did not show any great apparent variation, apart from differences in the thickness of the manganese oxide coating of the surface material.

North of the creek the sampling method tried was to break up large blocks of rock from an average exposure and take a representative sample. Such sampling will again tend to give rather high manganese values, but will probably give a lower range of values and be more representative of the deposit than the earlier sampling south of the creek. Sampling by this method gave a manganese range of 2.35% to 20.85%, a ratio of 1:8.9

It is suggested that many of the manganese determinations, particularly the higher values, are not typical of the deposit as a whole, and should be ignored.

True sampling of a heterogeneous deposit of this sort is best done by taking large bulk samples or by drilling. Such sampling would be expensive and is not warranted for this deposit.

Although the manganiferous ironstone is mainly confined to the fault zone, lenses and bands of similar material are frequently found in the surrounding sedimentary rocks. The limestones have proved to be the most favourable host rocks, both for cavity and joint filling, and for replacement deposits. Joints filled with manganiferous ironstone can be seen in the massive limestone up to four hundred feet from the fault line. The Pound has not proved to be such a favourable host rock, and bands of ironstone in the quartzite are seldom found over a hundred feet away from the fault.

Migration of manganese and iron into the sedimentary rocks has caused some degree of differentiation depending upon the chemistry of the host rock. In the quartzites the ironstone bands are similar to the main masses, but in the limestones, particularly in the replacement deposits, the greater mobility of manganese in an alkaline environment has caused enrichment of the manganese. The best examples of this are the manganiferous pockets in the lower nodular limestones, a sample from one of which gave a manganese value of 44.4%. Another replacement deposit (sample A3956/64) gave an assay of 19.8% Mn. The manganese oxide coating of a band in the Pound Quartzite (described on p.6) may or may not be related to the main mineralization.

As will be mentioned below, the more localized copper mineralization has only migrated into the Pound Quartzite and is seldom found in the limestone.

This variable migration is a factor depending upon the pH of the environment. Hawkes (1957 p.250) gives the following figures for the pH of hydrolyis of metals from aqueous solutions as hydroxide or basic salt:-

Metal	pH
Manganous	8.5 - 8.8
Ferrous	5.5
Cupric	5.3
Ferric	2.0

Copper Mineralization

Copper mineralization in the fault zone is quite localised and never extensive. Small amounts of malachite have been found at the extreme southern end of the area and an old copper prospect was worked in M.C. 4597. The best illustration of copper mineralization is the frequent green staining in the Pound Quartzite in the first twenty feet west of the Teatree Fault.

Just north of M.C. 4597 near the track to Wertaloona more recent copper diggings include some bulldozer cuts.

RESERVESAND GRADE OF ORE

The assayed grade for manganese in the surface samples has a considerable range, varying from 44.4% Mn. to 0.23% Mn. This range is very largely due to difficulty in obtaining a representative sample. From the information available it would be impracticable to calculate an average grade for the ore deposit, or to calculate tonnages for separate grades. It can however, be fairly safely assumed that the overall grade for the deposit will be less than 10% Mn. Samples giving values higher than 10% are caused by localized areas of slightly higher near surface enrichment, or by preferred enrichment of manganese in replacement deposits and have not been considered in grade and tonnage calculations, as their limited reserves and difficulty of separation would not warrant mining.

The overall grade of iron in the manganiferous ironstones is estimated at 40% Fe.

In determining tonnage of ore it has been accepted that th average thickness of hard ironstone capping containing the concentra ed manganese is four feet, and that mining would be limited to exposures above local base levels. Thus, exposures just showing through surface gravels and alluvium have been excluded. On many of the small ironstone exposures south of the creek the capping is probably more than four feet, but it is also true that over the larger exposures north of the Creek the capping can be less tha four feet. It is not known to what depth or over what area the secondary ironstone occurs below exposure levels i.e. in areas covered by gravels and alluvium.

It is also assumed that recovery of ore from this four feet will be 100% although this is unlikely. True estimates of recovery as with grade could only be obtained by large bulk sampling.

A figure of 10.2 cu. ft. of ore per ton has been used as the conversion factor in the tonnage calculations. This figure is derived from S.G. determinations of collected specimens.

Tonnage Calculations

Locality		Tonnage of Ore
North of the Creek	M.C.4597 and M.C.4599	222,000
	M.C.4598	Nil
	Total -	22,000 Tons
South of the Creek	M.C.4600	68,000
	M.C.4601 and M.C.4602 Less than	2,000
		70,000 Tons
	Grand Total -	292,000 Tons

CONCLUSIONS

It is concluded that the maximum reserves of iron and manganese oxides for the area that are readily mineable with the minimum of development is approximately 292,000 tons. The grade will be less than 10% Mn, and about 40% Fe. Even if the ironstone capping gave 12 ft. of mineable ore the tonnage reserves would stil be under a million tons.

It is extremely unlikely that the deposit has any economi possibilities considering the low tonnages and grade of ore and the remoteness of the area.

No further work on this claim is recommended.

W.A. Fairburn
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WAF:EMD:AWK
18-11-64.

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APPENDIX I

Analyses of Manganese Ore

Report AN/507/65 by Australian Mineral Development Laboratories.

Locality: Balcanoona 1 mile sheet, 6 miles S.W. of Wertaloona, Photograph Flight Run 5, No. 5712.

Identification: WAF 52/64 to WAF 78/64

Sample Nos. A3956/64 to A3979/64

Date Received: 29.5.64

Work Required: Analyses for Mn and Fe

Field No.	Sample No.	Iron (Fe)	Manganese (Mn)
		Analysis per cent	
WAF 52/64	A3956/64	16.1	19.8
WAF 53/64	A3957	13.0	10.4
WAF 54/64	A3958	46.4	2.94
WAF 55/64	A3959	51.5	0.23
WAF 56/64	A3960	28.6	0.29
WAF 57/64	A3961	26.2	3.65
WAF 58/64	A3962	45.1	0.68
WAF 60/64	A3963	31.6	18.15
WAF 61/64	A3964	20.0	21.3
WAF 64/64	A3965	27.0	4.70
WAF 65/64	A3966	4.94	44.4
WAF 66/64	A3967	28.4	12.55
WAF 67/64	A3968	47.2	0.66
WAF 68/64	A3969	46.4	6.87
WAF 69/64	A3970	4.00	39.5
WAF 70/64	A3971	34.1	13.4
WAF 71/64	A3972	41.9	11.2
WAF 72/64	A3973	29.2	6.70
WAF 73/64	A3974	40.3	2.35
WAF 74/64	A3975	57.2	0.27
WAF 75/64	A3976	46.5	0.17
WAF 76/64	A3977	46.3	8.00
WAF 77/64	A3978	31.1	20.85
WAF 78/64	A3979	36.5	0.58

Analysis by: D. McPharlin

Officer-in-Charge, Analytical Section: T.R. FRost

L. Wallace Coffer, Director.

APPENDIX II

Petrological Report

Report MP518-65 by Australian Mineral Development Laboratories.

Locality:	Balcanoona 1-mile sheet, 6 miles S.W. of Wertaloona
	Photograph Flight Run 5, No. 5712.
Identification:	WAF 79/64 to WAF 81/64
	Sample Nos. P1047 - 1049/64
Date Received:	11/9/64
Work Required:	Mineralogical examination.

P1047/64: PS8409: WAF 79/64

This specimen consists of colloform-banded manganese oxides. The minerals are exceedingly fine-grained, making precise identification difficult; however, the minerals are most probably wad and pyrolusite.

P1048/64: PS8409: WAF 80/64 (Surface Ironstone)

The sample consists of brecciated earthy goethite, cemented with fine-grained haematite and siliceous matter.

P1049/64: PS8410: WAF 81/64 (Soft Underlying Ironstone)

The sample is brecciated, earthy, impure goethite, cemented by abundant secondary silica.

Investigation and Report by H.W. Fander.
Officer-in-Charge, Mineralogy Section, H.W. Fander.

L. WALLACE COFFER, DIRECTOR.

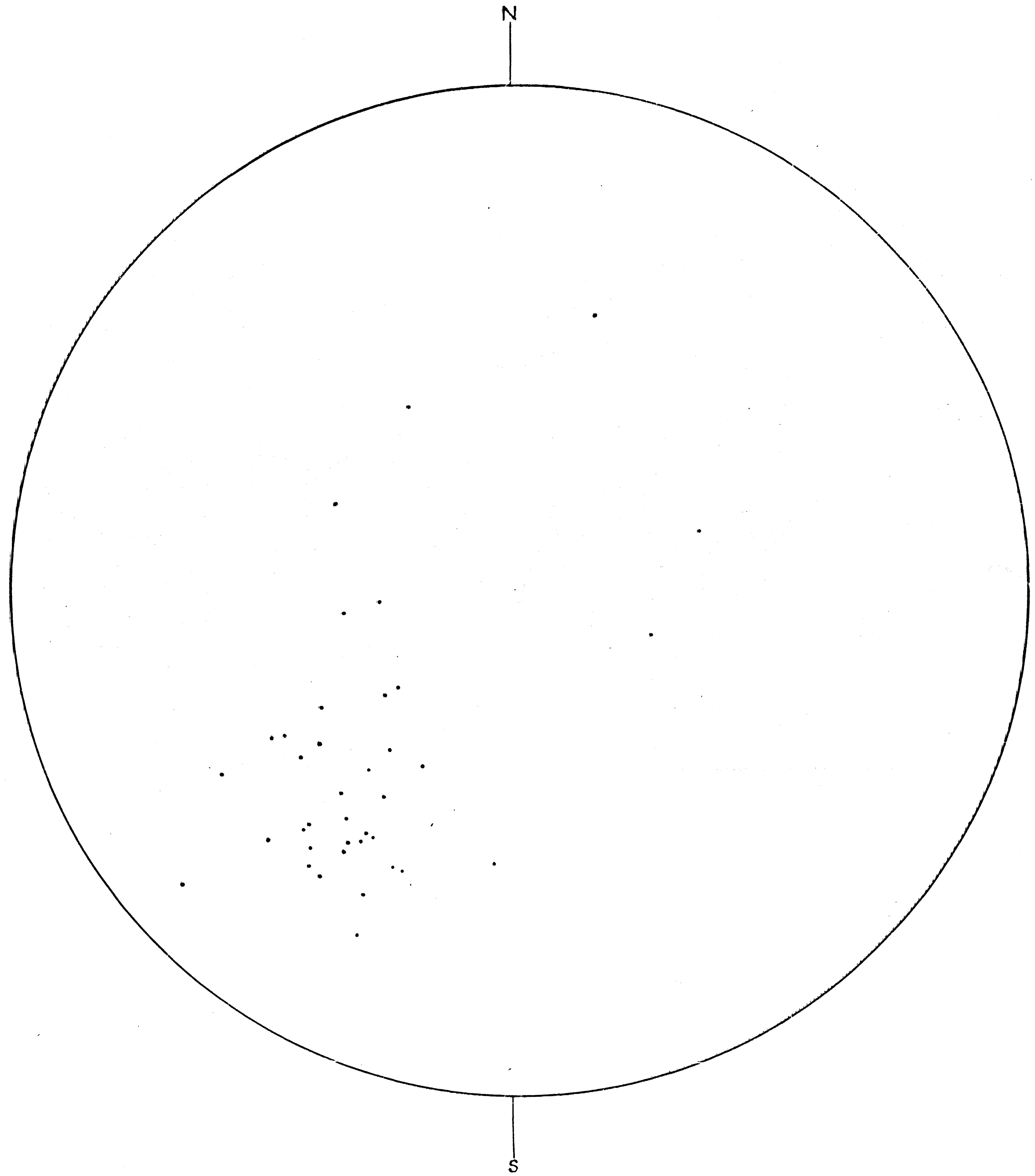
S. A. DEPT. OF MINES

ARROWIE GORGE MANGANESE PROSPECTS
WERTALOONA STATION
GEOLOGICAL PLANS AND SECTION

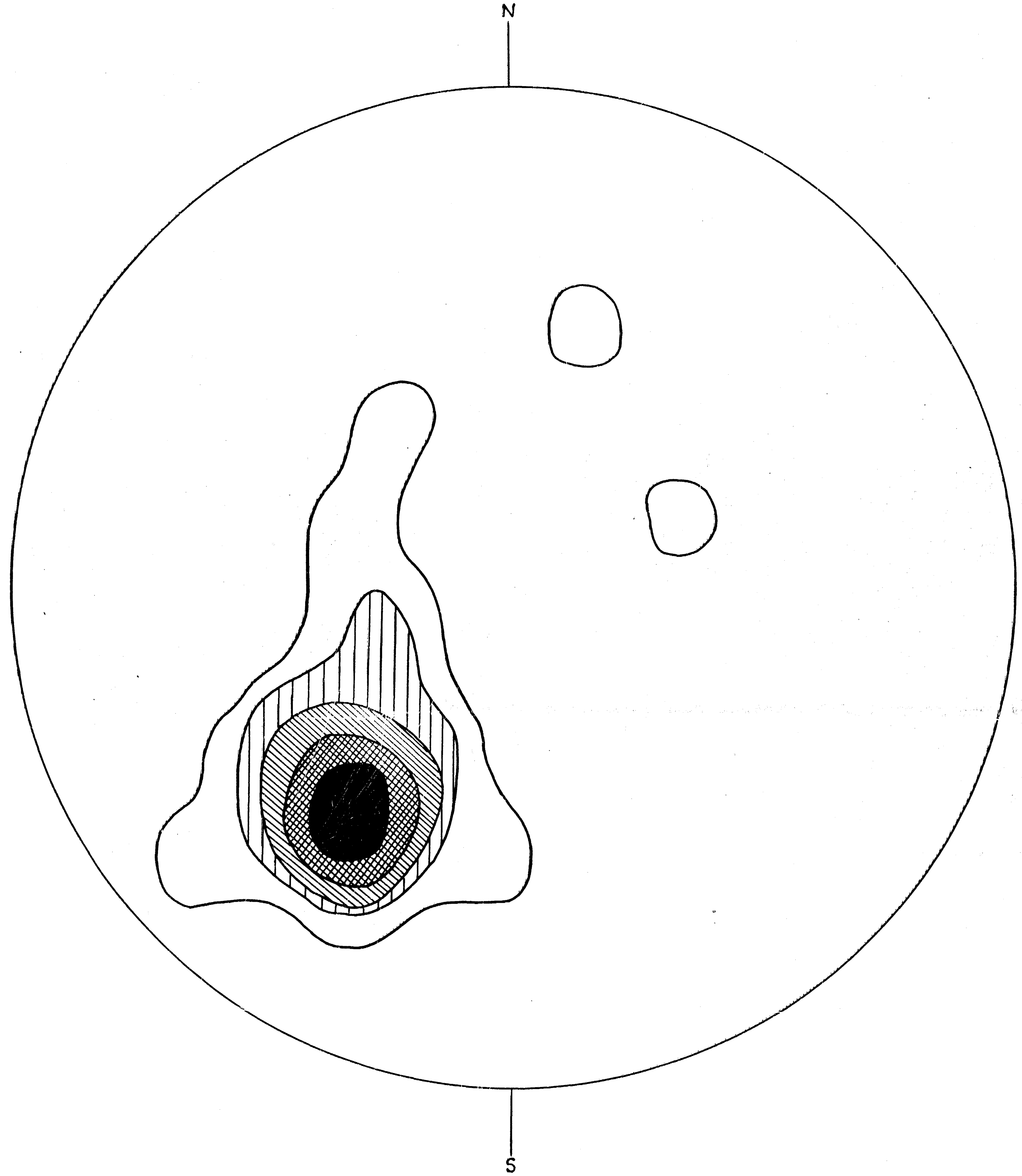
To accompany a report by W. A. Fairburn.

B.L.S. Date: 22-10-64

L64–166



Schmidt net projection poles to bedding (38 readings)



Schmidt net projection poles to bedding (38 readings contoured)
(Contour intervals > 20%, 15%-20%, 10%-15%, 5%-10%, < 5% per 1% unit area)

To accompany a report by W.A. Fairburn.

S.A. DEPARTMENT OF MINES

ARROWIE GORGE MANGANESE PROSPECTS
WERTALOONA STATION
π DIAGRAMS

Approved | Passed | Director
Scale:
Drn.
Tcd. B.L.S.
Ckd.
Exd.
64-844
Cd
Date 22-10-64

No. | Amendment | Exd. | Date