Rept.Bk.No. 69/73
G.S.No. 4327

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

MINERAL RESOURCES DIVISION

GEOLOGY OF THE BALHANNAH COPPER-GOLD-BISMUTH MINE

Section 4048, Hd. Onkaparinga

- Balhannah Gold Mines N.L. -

by

M.G. MASON
GEOLOGIST
METALLIC MINERALS SECTION

D.M. No. 175/49

18th September, 1969.

Gold Leases Nos 2008 & 2009.

Sect 4048 & 3936

Hund. Onkaparinga.

Mineral Rights alienated from Crown to registered proprietors.

SA & FS. Co[illegible].

"Fern Copper" - Balhannah Mine.

Please identify grey-blackish secondary sulphide mineral(s) coating (approx 1mm thick) quartz vein from Balhannah Mine - Cu, Bi Au (Pb, Zn, Ag accessories)

Known ~~locally~~ as "fern copper" by old miners of Balhannah Mine.

Please also assay for Cu

~~Approx to coating~~

A fine coating of ?pyrite crystals and minor ?calcite gangue mineral occurs on the surface of the ~~new~~ coating which under hand lens ~~appears~~ appear as a v.f.g. blackish amorphous mass of ~~of~~ possibly pyrite and ?chalcocite.

A 1430/73

5

DEPARTMENT OF MINES
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DM.No. 175/49
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5th September, 1969.

DEPARTMENT OF MINES
SOUTH AUSTRALIA

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G.S. No. 4327
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GEOLOGY OF THE BALHANNAH COPPER-GOLD-BISMUTH MINE

Section 4048, Hd. Onkaparinga

- Balhannah Gold Mines N.L. -

ABSTRACT

The Balhannah Mine, situated on Section 4048, Hundred of Onkaparinga, produced 9 tons of bismuth and 170 tons of copper during the period 1869-1875.

Subsequent exploration during 1881, 1889, 1936 and 1949 did not locate additional ore.

The present investigation was undertaken at the request of the operator when driving had disclosed primary bismuth-copper minerals within a series of minor quartz-carbonate veins on the 79 ft. level.

Surface and subsurface geological mapping showed that in the original orebody chalcopyrite, bismuthinite and minor gold occurred within a northwesterly striking, steeply-dipping quartz-carbonate vein up to 10 feet wide and cross-cutting carbonaceous schists, schists and meta-siltstones of the Balhannah Shale Member (Upper Proterozoic). The vein has been segmented by later north striking, east dipping faults.

It is considered unlikely that economic extensions of the original ore shoot are present.

KEYWORDS: Adelaide 1 mile sheet - Copper - Bismuth - Gold - Balhannah Shale Member - Proterozoic Vein Structure - 1969.

INTRODUCTION

The Balhannah Mine is situated in Section 4048, Hundred of Onkaparinga about two miles northwest from Balhannah township (Longitude 138°48'28" East, Latitude 34°58'13" South) within the Adelaide 1 Mile Atlas sheet area.

Mineral Title

The mine is within Gold Leases Nos. 2008 and 2009, being part Sections 4048 and 3936 Hundred of Onkaparinga. The Mineral rights are alienated from the Crown to the registered proprietors of the land, S.A. & F.S. Camac.

Previous Work

Information on the previous history of the mine has been compiled from the published report of an investigation in 1949 by the South Australian Department of Mines (Ridgway 1949) and from information supplied by Mr. H.E.A. McCarthy, who has made an exhaustive search of all literature pertaining to the early operations.

In July 1869, Mr. Ey is reported to have discovered rich bismuth carbonate outcropping on a section belonging to Mr. Camac of Balhannah (Observer, 8th July, 1869) and in the same month an option was taken over the area by the Balhannah Mining Co. Ltd., having a capital of $8,000.

Mining operations commenced in August under Captain O.P. Burt, who managed the mine until March 1870, when H.E. Henkel was appointed manager.

The company exercised its option over the area in December, 1873, and paid the vendor $2,100.

H.E. Henkel originally from the Hartz Mining district in Germany managed the Wheal Gawler Lead mine (Glen Osmond), the Potosi Lead mine near Ambleside and then the Balhannah Mine. He brought out 8 Hartz miners who worked the mine till nearly 1877.

Mining operations ceased in the latter part of 1877, and in January 1878, the company wound up and sold its property to the English, Scottish and Australian Bank Ltd. for $10,000.

In 1881 the mine was purchased by C. Banbury and T.J. Blades, who gave an option to the Balhannah Freehold Gold Mining Co. No Liability with a capital of $60,000.

Under manager F.C. Singleton, the mine was dewatered in 4½ months. The manager reports having sampled the lode in the workings, but the results are unknown. The mine was again abandoned in 1882 without further production.

In October 1883, the Moonta Mines Ltd., purchased the property for $2,000, removed boilers and machinery, and then sold it to Mr. H. Hoyt of Melbourne in October 1886, for $900.

A syndicate purchased the mine in January, 1894 for $1200 and formed the New Balhannah Freehold Gold Mining Co. N.L. in 1889 with a nominal capital of $100,000. There is no record of this company having done any work on the mine.

H.Y.L. Brown investigated the property at this time and reported that all the workings were full of water, but that good samples of ore were obtainable from the dumps and the prospects were good.

In February 1923, the property was sold for $1470 and again in October, 1929, for $2000 when Dr. R. Lockhart Jack inspected and reported on the mine.

In 1932 the Balhannah Gold Development N.L. Company was formed with a nominal capital of $24,000. Pearson in March, 1932, sampled the tailings and slime dumps reported significant silver, copper and bismuth mineral content.

In 1935, Mr. H.E.A. McCarthy secured mining rights over all land surrounding the mine with the exception of an area contained within a radius of 450 feet of the old mine buildings. From 1935 and 1937 diamond drilling was carried out by the Department of Mines on behalf of Mr. McCarthy and

Mr. Kermode. Half the cost of drilling was borne by the Department. In December, 1948, mining rights, over the whole of the mine property were obtained from the estate of the late T. Kermode by Mr. McCarthy, who later formed and transferred all rights to the Balhannah Mines N.L. having a capital of $50,000. This company dewatered the mine and drove on the main lode exposing No. 4 and No. 9 boreholes at No. 4 level.

J.E. Ridgway in 1949 reported on the previous diamond drilling, and mapped and sampled all the accessible workings. He reported that 53 tons of ore from near borehole 4 returned 4 ozs 11 dwt. of gold bullion.

Minor surface shaft sinking at this time revealed little of significance.

Blissett and McPharlin, (December 1966) inspected the mine and recommended geophysical exploration.

An induced polarisation geophysical survey was carried out by McPhar Geophysics Pty. Ltd., in 1967. The anomalies disclosed were drilled using a down-the-hole air hammer drill (Hole numbers 10 to 21). Resulting anomalous copper values intersected in drill holes west of the ore shoot were examined by cleaning and renovating the Old Engine Shaft and driving at the 79 ft. level to intersect holes 17, 19 and 12.

The author visited the mine in December 1968 and at various times thereafter as work progressed. The underground exploration had revealed copper and bismuth minerals within narrow quartz-carbonate veins, and a knowledge of the geology of the area, especially those factors controlling the disposition and grade of these veins was needed to orientate future exploration and development work. Detailed surface and subsurface geological mapping on a scale of 1 inch = 40 feet and 1 inch = 10 feet respectively were carried out. During the survey the shaft was plumbed and underground workings oriented with surface features.

The possibility of the eastern portion of the main lode vein being faulted to an area north of the main shaft was investigated by a geochemical soil sampling survey.

GEOGRAPHY

Balhannah township is located about 20 road miles east of the city of Adelaide in the Mount Lofty Ranges at an elevation of approximately 1,100 feet above sea level. The mine is approached from Balhannah by a bitumen road and is situated on the southern flank of an east-westerly ridge about 100 feet high. Adjacent land is cultivated on the flats and the steeper slopes are used for grazing. Rainfall averages 30 inches per annum.

UNDERGROUND WORKINGS

The 79 feet level via the old Engine Shaft and the Escape Shaft are the only workings now accessible and these were mapped by the author.

The older underground workings consisted of five shafts along the line of lode connecting five main levels. Two shafts, the old Engine Shaft (110 feet deep) and the Main Shaft (257 feet deep) are vertical, the rest underlie within the lode to the south. The workings are at present dewatered by a turbine pump in the Main Shaft, the water being discharged into the adjacent creek.

The No. 1 level (R.L.1010) connects the old Engine Shaft and the Main Shaft while No. 2 level (R.L.970), No. 3 level (R.L.900) and No. 4 level (R.L.850) connect only to the Main Shaft. An intermediate level (R.L.1050) between the two main shafts probably originally connected to the Old Engine Shaft.

The original ore shoot has been stoped from the surface near the old Engine Shaft to No. 3 level 40 feet east of the Main Shaft. The stoped area is in the shape of an inverted delta pitching 45° to the east.

An old adit now used as a magazine is located west of the old Engine Shaft at R.L. 1090 and was driven northerly but failed to intersect a westerly extension of the main lode.

The old workings are accessible from the Main Shaft but the collar would need replacing and the shaft retimbering to a depth of 40 feet if inspection is contemplated

Present underground exploration has been confined to driving from the old Engine Shaft in an overall westerly direction at 79 feet below the collar of the old Engine Shaft. A total of 450 feet has been driven, and stoping along minor veins is in progress about 260 feet west from the old Engine Shaft.

GEOLOGY

The Balhannah Mine is within the Balhannah Shale Member of Proterozoic age. The Member is composed of black carbonaceous schists, grey and green schists and slates, grey to white meta-siltstones and minor dolomite and hematite lenses.

The rocks have been subjected to regional metamorphism to the biotite grade producing schists, phyllites, slates, marbles and gneisses.

The Balhannah Shale Member strikes northerly in the mine area and dips to the east, being part of the western limb of a major anticline whose axis lies two miles east of the mine area (see Fig. 1).

Mechanical deformation has occurred during two or three periods the first being the most intense. This deformation of probable Late Cambrian age was associated with the regional metamorphism and introduction of mineralised fluids. Strain during the main period of deformation was in the form of tight folds, with steeply-dipping, north-striking axial planes. Towards the close of the orogeny, strain changed to steeply-dipping block faulting striking north-northeasterly.

The present geomorphic surface has been produced by two later periods of deformation, strain being confined to movement along old fault planes.

MINE GEOLOGY

Stratigraphy

In the mine area, grey to green schists or slate, black carbonaceous schists or phyllites, white arkosic metasilts and minor dolomites, are the mapped rock types. They may comprise several lenses at different stratigraphic levels rather than be distinct formations. Only the dolomites and iron-rich (weathered from pyrite) slates outcrop.

Dolomite is confined to a small lenticular outcrop just east of the old Engine Shaft and could not be traced underground.

The white arkosic metasilt, which does not outcrop, has been mapped on the 79 ft. level, and reported underground east of the Main Shaft down to the No. 1 level by Ridgway (1949). It weathers readily to a white sandy silt with a fine kaolinitic clay matrix.

Black carbonaceous schist has been mapped on the west side of the white arkosic metasilt on the 79 ft. level, and south of the metasilt occurring near the Main Shaft. It contains up to 15% by volume of iron sulphides as pyrite, much more than the other rock units, and is probably the cause of the induced polarisation anomalies which were recorded in the area.

Bedding in the green schists and slates in the northern and eastern areas of the mine is difficult to discern but it is readily apparent within the white arkosic metasilt and black carbonaceous schist as thin layers of a few mm. width. All the rocks in the mine area have been subject to deformation with development of a crenulation cleavage with planes of maximum movement about half an inch apart. This crenulation cleavage is most pronounced adjacent to fault zones or shears.

Structure

Surface measurements of bedding in the mine area indicate a northerly strike with an easterly dip varying from 30° west of the old Engine Shaft to 60° near the Main Shaft. On the 79 ft. level the bedding strikes northerly and dips 40° east near the old Engine Shaft, changing to a 15° dip 250 feet northwest of the old Engine Shaft.

Deformation of the rocks has been in the form of faulting, crenulation of layering and minor drag folding.

Faults

The can be divided into two types - those which are associated with mineralised veins, and those which post-date mineralisation.

The faults associated with copper-bismuth mineralisation predate the introduction of mineralised fluids but relate to the same orogeny. Direction and amount of movement along these faults is undetermined. The main vein occupies a fault plane which, between the old Engine Shaft and Main Shaft, strikes northwesterly and dips about 70° southwesterly. South of the Main Shaft near the No. 4 level there are a number of small faults arranged en echelon which strike westerly and dip almost vertical. Northwest of the old Engine Shaft on the 79 ft. level the main vein similarly passes into a series of small veins striking more northerly, and dipping near 35° to the west. The spur veins from the main vein may represent small faults but they more likely are infilled open spaces.

Post-ore faults have formed in two major directions, one set striking northerly and dipping 25 to 55° to the east, the other being near horizontal. They are up to a few inches wide, showing slickensiding on their surfaces, and have caused crenulation and folding of the adjacent schists and metasilts.

The northerly striking post-ore faults in the mine area are spaced 10 to 50 feet apart and have segmented the main vein. They show a horizontal component of movement of, west side south, some tens of feet. The vertical component of movement could not be determined and hence the direction and displacement in the fault plane are not known.

Horizontal post-ore faults mapped on the 79 ft. level, show displacement of a few feet, with the top block apparently moving to the northwest. This faulting can only be determined with certainty where vein material is displaced, and there may be other faults of this type which were not detected in the mapping.

Joints

The schists and metasilts in the mine area are cut by one set of joints which strike 208°T and dip 50° westerly. The joint surfaces average one foot apart, are planar, uncoated, and cut the mineralised veins. Rocks in the mine area are classified dynamically as non-brittle and the joints have formed at the same time or later than the post-ore faults under shallow cover.

MINERALISATION

Copper, gold and bismuth minerals are confined to veins crosscutting the country rock within faults or joints. The contacts are sharp but irregular and often have a "herring bone" outline. Only the main vein, emplaced along a fault, has proved of economic significance for the Balhannah Mine, all other veins being narrow with low copper gold and bismuth content.

Within the main vein ore has previously only been extracted from one ore shoot located between the old Engine Shaft and the Main Shaft; 500 feet long, up to 15 feet wide and extending to 400 feet below the surface it pitched 45° southeasterly. Beyond these limits there are only very low copper and bismuth values. Absence of the vein at the surface northwest of the old Engine Shaft and also near the Main Shaft is probably related to faulting. Faults which dip 45° east probably displaced the main vein to the north near the Main Shaft and to the south near the old Engine Shaft; between these shafts faulting has cut the main vein into at least four separate blocks, the southerly block being moved to the east in each case. The group of veins encountered on the 79 ft. level may be the southwesterly extension of the main vein.

Vein Mineralogy

Veins in the primary zone consist of a quartz, calcite, siderite, pistomesite, gangue with pyrite, chalcopyrite, bismuthinite and gold comprising the main primary ore minerals. Talc, sericite, galena, sphalerite, arsenopyrite, marcasite and native bismuth have been reported as accessories.

The following minerals have been reported from the weathered near surface zone - malachite, azurite, chalcocite, covellite, cuprite, native copper, cerussite, hematite, limonite, and bismuth ochre.

Within the main vein, mineral zoning has been determined. Chalcopyrite, bismuthinite and pyrite occur, although not necessarily in association, in the core of the vein; generally at its widest extent. These are generally surrounded by an irregular zone of carbonate gangue minerals, calcite, siderite and pistomesite. Pyrite also tends to occur within the carbonate zone. Quartz occupies the area between the carbonate zone and the vein walls.

Mineral zoning is apparent within veins encountered on the 79 ft. level, and the same pattern is apparent regardless of the size of the veins.

Pyrite occurs not only in veins but also in the host rocks. As Induced Polarisation survey over the mine area by McPhar Geophysics (Bell 1967) indicated an east-west zone of anomalous frequency effects surrounding and paralleling the main vein which later drilling proved to be due to pyrite mineralisation. The pyrite zone is probably not parallel to the rock type, but is more prevalent in the carbonaceous schists adjacent to the main vein, indicating that the pyrite was a part of or related to the introduction of ore minerals.

Weathering of rocks under oxidizing conditions, has generally extended to natural water level which is about 20 feet below the collar of the new Engine Shaft but to somewhat greater depths adjacent to zones of faults, crushed veins and weathered porous rock.

Carbonaceous shales have altered to soft clay with removal of carbonaceous matter and formation of iron oxides from pyrite. Iron oxides have been removed everywhere except at the surface where under high pH control they were precipitated, in a gossan capping.

Carbonate veins have weathered to a ferruginous quartz gossan at the surface passing down to porous quartz below with the removal of sulphide and carbonate minerals. Below the water table some carbonates have been leached, but sulphides are stable, and a porous quartz-sulphide mass containing clay derived from the carbonate minerals results.

Sulphide minerals have been leached to produce a barren surface zone but metals were redeposited in a zone of enrichment within the oxidizing zone or at the top of the reducing zone. Chalcopyrite (a copper-iron, sulphide) weathers to malachite, azurite, cuprite and native copper which were deposited near the base of the oxidizing zone forming a secondarily enriched oxidized zone especially near cross fault zones. Copper which was redeposited in the reducing zone as secondary sulphides (chalcocite and covellite) formed a secondarily enriched sulphide zone. Within the mine primary ore minerals were encountered at, from 30 to 100 feet below the surface.

GEOCHEMISTRY

During the present investigation a geochemical survey was carried out over part of the mine area north of the Main Shaft to locate the extension of the main vein ore

shoot which is believed to be truncated by a fault which strikes northerly and dips 35° to the east. (See Fig. 3). Movement along the fault could have displaced the eastern extension of the ore shoot to the north, and soil samples were taken over its anticipated position but no anomalous copper or bismuth values were recorded. A minor lead anomaly (See Appendix 3) which may be worthy of testing by costeaning was located at 150N 500E.

CONCLUSIONS

The Balhannah mine is situated within carbonaceous schists, slates and metasilts of the Balhannah Shale Member of Proterozoic age, which strike northeasterly and dip about 45° to the southeast.

Epigenetic copper, bismuth and gold mineralisation is associated with quartz and carbonate minerals within a northwest steeply dipping vein up to 10 feet wide. The minerals of economic significance though patchy were high grade and surrounded by a diffuse zone of pyrite concentrated within the grey to black carbonaceous shale. The vein is intersected by a set of later northerly striking faults dipping to the east. Movement along one of these faults in the vicinity of the old Engine Shaft has probably displaced the main lode to the south. This extension is the mineralised set of veins exposed within the present underground workings. The veins are arranged in an en echelon pattern, have similar mineralogy to the main vein, strike northerly and dip at a shallow angle to the west.

The minerals of economic interest were probably introduced during the first main phase of regional tectonism during the Upper Cambrian, after or during folding, and before cross faulting and jointing were developed.

The main vein has been extensively explored by 21 drill holes and it is unlikely that major extensions of the orebody will be found by additional exploration. Minor extensions of the orebody as occurring at the present site of production may be anticipated.

If the main lode and associated minor veins are considered as a unit, further similar units might occur in an en echelon pattern, the axis of which pitches 25° to the southeast. Repetitions would be expected to be of the same size as the main lode of the Balhannah Mine which produced 170 tons of copper and 9 tons of bismuth.

RECOMMENDATIONS

The extraction of ore from the mineralised veins on the 79 ft. level should be continued. It is considered that ore shoots pitching at 30° to the south or southeast are more favourable, and could continue and possibly increase in size with depth.

Regional exploration to locate repetitions of the main lode system to the southeast does not appear to be warranted.

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GEOLOGIST
METALLIC MINERALS SECTION

MGM:NHW:JMM

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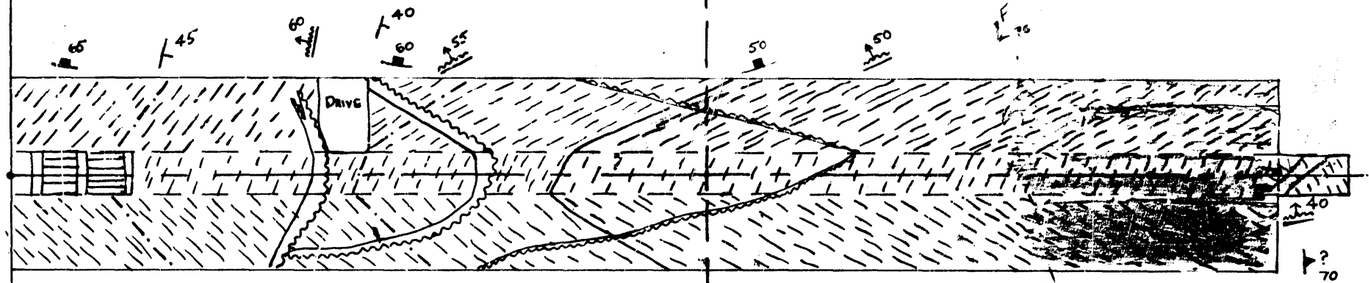
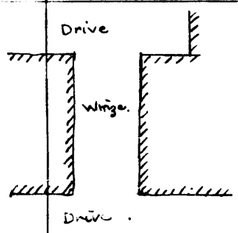
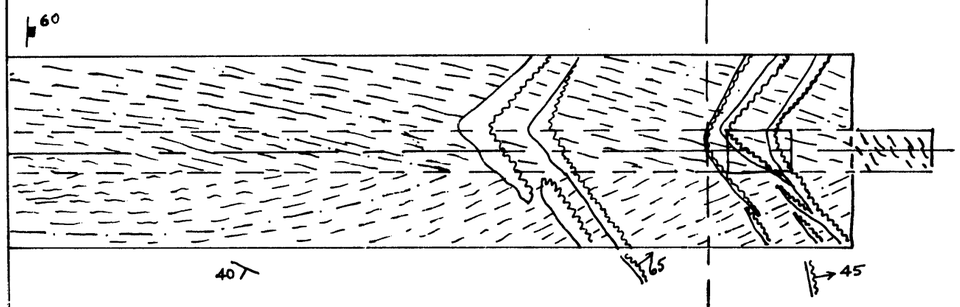
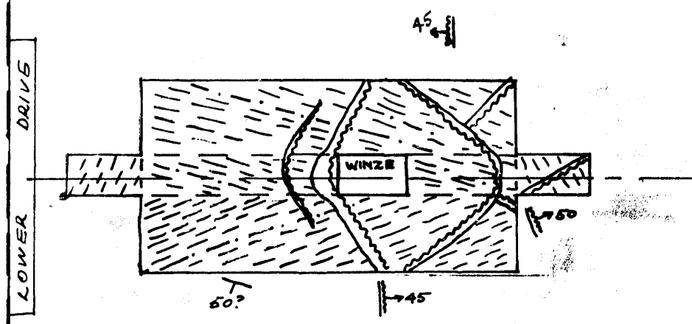
BEARING AND SLOPE	E 45°M 53°T to end of tunnel [Peg 16Ft ← from portal R.L. 1088 Ft] Peg. Near ▲ Nail 45 M Horizontal.	50Ft ▲ Nail 53°T ▲ Nail R.L. Roof 1094 Ft.	100 FG
ROCK TYPE DESCRIPTION	PROTEROZOIC ADELAIDE SYSTEM TORRENSIAN SERIES BALHANNAH SHALE MEMBER. SILTSTONE - Originally grey and white finely laminated Newpale grey green. Fe oxide stained. 70% quartz. 20% feldspar. Rest mica. CARBONACEOUS stained. Finely laminated. Pyrite. Carbonaceous. Limonite carbonaceous Fragments and Fe oxides.	BURRA GROUP SILTSTONE - Originally black now limonite (brown) 10% Fe oxides and voids originally 60% quartz. 20% feldspar. Rest	
WEATHERING	Physical and Chemically rocks are moderately to highly	weathered.	
TUNNEL INTERSECTION PLANS AND CROSS SECTIONS			
ASSAYS (A)			
PETROLOGICAL SAMPLES (P)			
WALL / **TOP** / **ROOF** / **TOP** / **WALL**			
PHOTOGRAPHS			
GROUNDWATER - *quantity & date.*			
STRUCTURES JOINTING *Pattern - attitude, spacing, persistence, character, surface, separation, coating.* FAULTS, SHEARED & CRUSHED ZONES *Attitude, relative displacement, width, character of material.* FOLDS, *Classification, plunge, axial plane, size persistence.*	J_1 60 JOINTS :- Planar, minor Fe oxide coatings 1mm or less width. One major direction. Average. 3Ft apart or more. J_2 060 VEINS :- Near planar up to 1Ft wide. Quartz, siderite, minor pyrite, chalcopyrite and bismuth. Often oxidized to hematite, limonite, malachite. L_2 AXIAL PLANE CLEAVAGE. - well developed - Original direction of bedding often marked. Probably related to mesoscopic fold - axial plane at 75Ft.		
REFERENCES	Plan 49-384		

LEGEND

- Timbering
- 70 Strike & dip of bedding.
- Vertical, X Horizontal
- 20 Strike & dip of cleavage
- 60 " " " jointing
- Vertical jointing
- Horizontal jointing
- Plunge of Lineation
- 60 Crushed zones.
- Shears or faults showing movement
- Channel sample.

PROTEROZOIC BURRA GROUP BALHANNAH MEMBER
- SILTSTONE - Grey and white.
- CARBONACEOUS SILTSTONE

METALLICS SECTION		S.A. DEPARTMENT OF MINES			
LOGGED M.G.M.	Geologist	COPPER - GOLD - BISMUTH - BALHANNAH MINES Sec 4048 HD ONKAPARINGA. GEOLOGICAL TUNNEL LOG - ADIT. A1 (I. McCarthy)			
DRAWN M.G.M.	Senior Geologist	SCALE 1" = 10Ft.	DATE LOGGED 25 Jun 1969	SHEET 1 OF 2	69-91 Hd 7

BEARING AND SLOPE	0 R.L. Roof =1093 Pg Joins drive A1 at 24ft. ▲ Nail. 331°M 339°T Near Horizontal 339°T.	50ft. ▲ Nail. R.L. Top winze 1092	R.L. Roof=1077 Ft. Near horizontal Approx 339°T.
ROCK TYPE DESCRIPTION	PROTEROZOIC ADELAIDE SYSTEM TORRENSIAN SERIES BALHANNAH SHALE MEMBER. SILTSTONE :- Originally grey and white finely laminated, now pale grey green. Fe oxide stained. 70% quartz, 20% Feldspar. Rest mica.	BURRA GROUP	See across
WEATHERING	Physically and Chemically - moderately to highly weathered.		Physically and Chemically - moderately weathered.
TUNNEL INTERSECTION PLANS AND CROSS SECTIONS			
ASSAYS (A)			
PETROLOGICAL SAMPLES (P)			
WALL TOP ROOF TOP WALL			
PHOTOGRAPHS			
GROUNDWATER - quantity & date.			
STRUCTURES JOINTING Pattern - attitude, spacing, persistence, character, surface, separation, coating. FAULTS, SHEARED & CRUSHED ZONES Attitude, relative displacement, width, character of material. FOLDS, Classification, plunge, axial plane, size persistence.	J_1 ∠60 JOINTS :- Planar, minor limonite hematite coatings 1mm or less width. One major direction More than 2.0Ft apart. J_2 ∠60 VEINS :- Near planar up to 1 Ft wide. Quartz, minor siderite, very minor malachite, and fe oxides originally pyrite. L_2 ∠60 AXIAL PLANE CLEAVAGE - noticeable as cumulation of bedding. Average 2inches apart.		J_1 see across J_2 see across L_2 see across.
REFERENCES	Plan 49-384		

LEGEND

Timbering
70 Strike & dip of bedding.
Vertical, X Horizontal.
20 Strike & dip of cleavage
60 " " " " jointing
Vertical jointing.
Horizontal jointing
Plunge of Lineation

60 Crushed zones.
Shears or faults showing movement

PROTEROZOIC BURRA GROUP BALHANNAH SHALE MEMBER.
SILTSTONE - Grey and White.

METALLICS SECTION		S.A. DEPARTMENT OF MINES	
LOGGED M.G.M.	Geologist	COPPER-GOLD-BISMUTH BALHANNAH MINES. Sect 4048 HD ONKAPARINGA. GEOLOGICAL TUNNEL LOG - ADIT A1 (I McCarthy)	
DRAWN M.G.M.	Senior Geologist	SCALE 1"=10ft DATE LOGGED 26 Jan 1969	SHEET 2 OF 2 69-9/9 HG7

BEARING AND SLOPE	Roof R.L. 1024.5Ft — 116·5 M. 124·5T near horizontal — 50Ft	▲ Nail (in roof) — 108 M 116 T — 100Ft ▲ Nail	45·5M 53·5T — ▲ Nail 53·5T — 150Ft Nail. ▲
ROCK TYPE DESCRIPTION	PROTEROZOIC ADELAIDE SYSTEM - TORRENSIAN SERIES - BURRA GROUP. BALHANNAH SHALE MEMBER. SILTSTONE - Grey and white Finely banded. (Av 1mm width)	Grey bands 60% quartz, 20% feldspar, 20 biotite &/or carbonaceous. White bands 60% quartz, 30% feldspar 10% muscovite.	Fragments. minor pyrite.
WEATHERING	Classified on physical character Moderately weathered.	Adjacent to veins minor primary alteration activity - Fe oxides qtz and clay forming at the expense of micas and feldspars.	
TUNNEL INTERSECTION PLANS AND CROSS SECTIONS	OLD ENGINE SHAFT Vertical Timbered. — 79 Ft From collar — PLAT — Drive 1265-3		
ASSAYS (A)	MM3 A17/69 5Ft Vert. Channel. Cu, Au, Ag, Bi, S.	MM4 A18/69 5Ft vert channel Cu. Au. Ag. Bi. S — MM5 A18/69 5Ft vert channel	All samples for Cu Au Ag Bi S — MM1 A15/69 Vein average 2inch wide — MM2 A16/69 Vein — MM6 A20/69 5Ft Vert Chan.
PETROLOGICAL SAMPLES (P)			

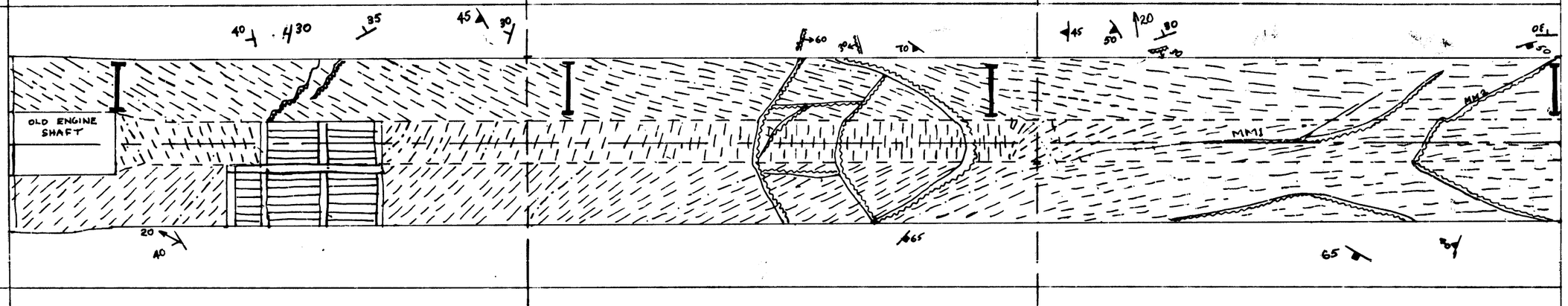
WALL

TOP

ROOF

TOP

WALL



PHOTOGRAPHS	
GROUNDWATER - *quantity & date.*	
STRUCTURES	
JOINTING *Pattern - attitude, spacing, persistence, character, surface, separation, coating.*	J_1 JOINTS :- Planar - minor chlorite coatings 1mm. or less wide Average. 1·5 Ft apart. One direction only.
FAULTS, SHEARED & CRUSHED ZONES *Attitude, relative displacement, width, character of material.*	J_2 VEINS :- Up to several feet wide average 2inches. Quartz, siderite, minor chalcopyrite, pyrite very minor bismuth. Strata on either side often contorted into minor similar folds 2-4inches amplitude. Variable spacing of veins but usually greater than 5Ft.
FOLDS, *Classification, plunge, axial plane, size persistence.*	L_2 AXIAL PLANE CLEAVAGE :- Adjacent to major veins minor similar Folds develop. with axial planes noted as Foliation symbol. Original direction of bedding becomes masked.
REFERENCES	See Plan. 49-384

L_2 developed

1 J_1 developed - Average 0·5 Ft apart.

	MM3	MM4	MM5	MM1	MM2	MM6
S	0·45	0·75	0·6	0·1	0·3	0·7
Cu	–	0·01	–	–	–	0·01
Bi	–	0·015	–	–	–	–
Au	–	–	–	–	–	–
Ag	–	–	–	–	–	–

Timbering
Strike & dip of bedding.
Vertical, Horizontal
Strike & dip of cleavage
" " " jointing
Vertical jointing
Horizontal jointing
Plunge of Lineation

Crushed zones.
Shears or faults showing movement
Sample

LEGEND

Proterozoic — Burra Group — Balhannah Sh. Member: Siltstone - Grey and white alternating finely banded.

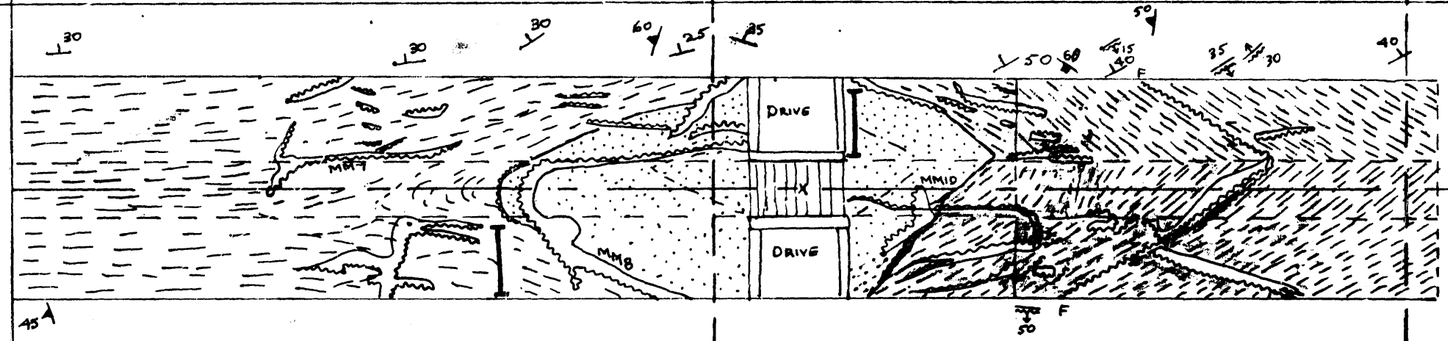
METALLICS SECTION

LOGGED M.G.M. — A.G. Mason Geologist
DRAWN M.G.M. — Senior Geologist

S.A. DEPARTMENT OF MINES

COPPER BALHANNAH MINES
Sect 4048 Hd ONKAPARINGA
GEOLOGICAL TUNNEL LOG - 79Ft Level.
(I. McCARTHY)

SCALE: 1" = 10Ft | DATE LOGGED 21 Jan 69 | SHEET 1 OF 5 | 69-92 Ha7

BEARING AND SLOPE	150ft 45½M 53½T Nail — 45½M 53½T 200ft — R.L. Plat = 1022Ft Nail — Ft 53 ½T
ROCK TYPE DESCRIPTION	PROTERO 201c ADELAIDE SYSTEM TORRENSIAN SERIES BURRA GROUP BALHANNAH SHALE MEMBER SILTSTONE - Grey and white Finely laminated 70% quartz. 20% Feldspar Rest biotite and/or mica. | SILTSTONE WHITE - Finely layered. 70% quartz 20% feldspar rest clay and muscovite. | CARBONACEOUS SILTSTONE - Finely laminated, black. 10% pyrite 20% mica and carbonaceous fragments Rest quartz and Feldspar.
WEATHERING	Physically moderately to highly weathered. Chemically slightly to moderately weathered.
TUNNEL INTERSECTION PLANS AND CROSS SECTIONS	East Plan. MM11 Face As at 12 Jan 69. Plat. West. N.L. — Face 20 Mar 69
ASSAYS (A)	All Assayed for Cu, Au, Ag, Bi, S. MM7 A21/69 Vein | MM8 A22/69 Vein | MM9 A23/69 — 5ft vert channel/ MM12 A26/69 | MM10 A24/69 Vein | MM11 A25/69 Vein | MM2A Veins | MM23 5ft Vert channel.
PETROLOGICAL SAMPLES (P)	
WALL / **TOP** / **ROOF** / **TOP** / **WALL**	
PHOTOGRAPHS	To Face 20 Mar 69
GROUNDWATER - quantity & date.	
STRUCTURES JOINTING Pattern - attitude, spacing, persistence, character, surface, separation, coating. FAULTS, SHEARED & CRUSHED ZONES Attitude, relative displacement, width, character of material. FOLDS, Classification, plunge, axial plane, size persistence.	J_1 ∠60 JOINTS - planar, minor chlorite coatings - 1m.m. or less wide. One major direction. At less 1 ft apart. J_2 ∠60 VEINS - Near planar up to 2ft wide. Quartz siderite minor pyrite chalcopyrite and bismuth. L_2 ∠60 AXIAL PLANE CLEAVAGE - Well developed. Bedding often masked especially adjacent to veins. Determinations from crenulation folds amplitude 1-2 inches.
REFERENCES	

	MM7	MM9	MM8	MM12	MM10	MM11
S	0·2	0·65	0·35	0·2	0·85	3·8
Cu	–	0·01	–	–	0·13	0·05
Bi	–	0·002	–	–	–	
Au	–	–	–	–	–	
Ag	–	–	–	–	–	

LEGEND

Timbering
Strike & dip of bedding. Vertical, × Horizontal.
Strike & dip of cleavage " " " " jointing
Vertical jointing
Horizontal jointing
Plunge of Lineation

∠60 Crushed zones.
Shears or faults showing movement

PROTERO 201C BURRA GROUP BALHANNAH SHALE MEMBER.
SILTSTONE WHITE
CARBONACEOUS SILTSTONE
SILTSTONE

METALLICS SECTION

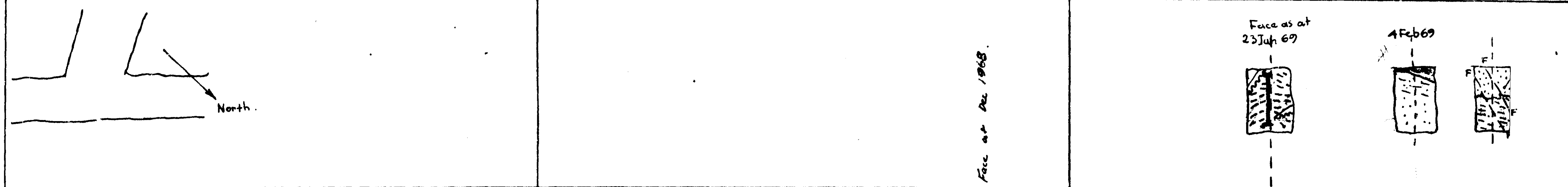
LOGGED M.G.M. — Geologist
DRAWN M.G.M — Senior Geologist

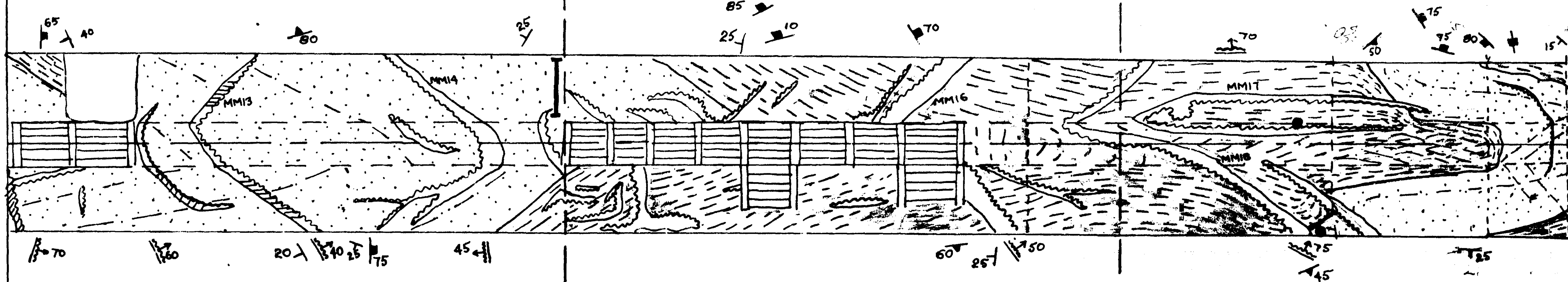
S.A. DEPARTMENT OF MINES

COPPER - BISMUTH - GOLD - BALHANNAH MINES Sect 4048 HD ONTAPARINGA.
GEOLOGICAL TUNNEL LOG
(I.M.°Carthy)

SCALE 1"=10ft | DATE LOGGED 21 Jan 1969 | SHEET 2 OF 5 | 69-929 Hq7

BEARING AND SLOPE	R.L. Roof 1028Ft. 3.5Ft From plat. Near Horizontal 325°M 333°T Nail.	333°T. 333°T. Nail.	R.L. Roof 1031Ft. 001°T.
ROCK TYPE DESCRIPTION	PROTEROZOIC ADELAIDE SYSTEM TORRENSIAN SERIES BURRA BALHANNAH SHALE MEMBER. SILTSTONE WHITE - Finely layered. 70% quartz 20% Feldspar Rest clay and muscovite.	GROUP. CARBONACEOUS SILTSTONE - Black Finely layered 10% pyrite and carbonaceous fragments. Rest quartz and feldspar.	20% mica
WEATHERING	Physically Moderately to highly weathered. Chemically	slightly to moderately weathered.	
TUNNEL INTERSECTION PLANS AND CROSS SECTIONS	North.	Face at Dec 1968	Face as at 23Jan 69. 4Feb69
ASSAYS (A)	All Assayed for Cu Au Ag Bi S. MM13 A27/69 Vein. MM14 A28/69 Vein. MM15 5Ft vert.	A29/69 chan. MM16 A30/69 Vein	MM17 A31/69 Vein. MM18 A32/69 Vein. MM19 A33/69 5Ft vert ch.
PETROLOGICAL SAMPLES (P)			





PHOTOGRAPHS			20Mar69
GROUNDWATER - quantity & date.			
STRUCTURES JOINTING Pattern - attitude, spacing, persistence, character, surface, separation, coating. FAULTS, SHEARED & CRUSHED ZONES Attitude, relative displacement, width, character of material. FOLDS, Classification, plunge, axial plane, size persistence.	J1 60 JOINTS - planar, minor chlorite coatings - 1mm or less wide. One major direction. At about 2Ft apart. J2 60 VEINS - Near planar up to 1.5Ft wide. Quartz, siderite minor pyrite chalcopyrite and bismuth. L2 60 AXIAL PLANE CLEAVAGE - Well developed. Bedding often masked especially adjacent to veins. Determined from crenulation folds amplitude 1-3inches.		Vein average 1Ft thick. Faults, movement along crenulation pronounced adjacent to fault.
REFERENCES	Plan 49-384.		

	MM13	MM14	MM15	MM16	MM17	MM19	MM18
S	6.2%	0.4	0.35	0.1	0.05	0.55	0.2
Cu	2.94%	0.09	0.02	–	–	0.02	0.01
Bi	2.0%	0.004	0.001	0.001	–	–	–
Au	–	–	–		–	–	–
Ag	8.0 ozs/ton	–	–				

Intersection with Drill Hole No 20
Direction 235°M Dip 55° in tunnel
Direction 234.5° Dip 57½° at collar.
R.L. difference collar to midpoint tunnel 62Ft.
Depth hole to midpoint tunnel. 74Ft.

LEGEND

Timbering
70 Strike & dip of bedding.
Vertical, Horizontal.
20 60 Strike & dip of cleavage
" " " jointing
Vertical jointing
Horizontal jointing
Plunge of Lineation
60 Crushed zones.
Shears or faults showing movement
Copper or Bismuth mineralization

PROTEROZOIC BURRA GROUP BALHANNAH SHALE MEMBER
SILTSTONE WHITE
SILTSTONE CARBONACEOUS

METALLICS SECTION		S.A. DEPARTMENT OF MINES		
LOGGED M.G.M.	Geologist	COPPER - GOLD - BISMUTH, BALHANNAH MINES Sect 4048 Hd ONKAPARINGA. GEOLOGICAL TUNNEL LOG - 79Ft Level. (I. McCarthy)		
DRAWN M.G.M.	Senior Geologist	SCALE: 1"=10Ft	DATE LOGGED 22Jan 1969	SHEET 3 of 5	69-926 Hd7

BEARING AND SLOPE

RL Roof 1028 Ft. 111°M. 119°T near horizontal ▲ Nail. 12°T ▲ 163°T 130° raise 200°M. 1 Near Horizontal

ROCK TYPE DESCRIPTION

PROTEROZOIC ADELAIDE SYSTEM TORRENSIAN SERIES BURRA GROUP BALHANNAH SHALE MEMBER.

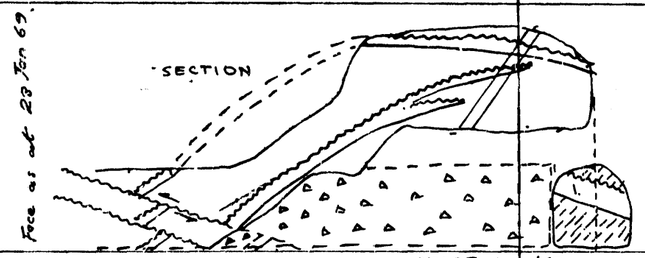
SILTSTONE WHITE:- Finely layered. 70% quartz, 20% Feldspar. Rest clay and muscovite.

CARBONACEOUS SILTSTONE - Black, finely layered. 10% pyrite, 20% mica and carbonaceous fragments. Rest feldspar and quartz.

WEATHERING

Chemically slightly weathered . . Physically highly weathered.

TUNNEL INTERSECTION PLANS AND CROSS SECTIONS

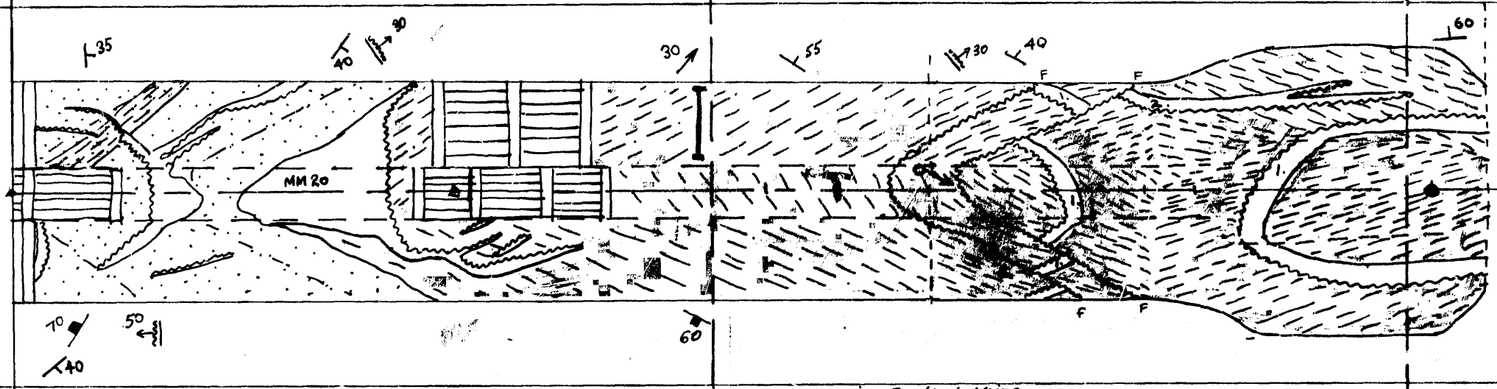


ASSAYS (A)

All assayed for Cu, Au, Ag_2Bi, S.

1 MM20 A34/69 Vein 1 — MMR1 A35/69 5Ft vert chan. — MM 27 A /69 No1 Vein

PETROLOGICAL SAMPLES (P)



PHOTOGRAPHS

Showing Faulted Veins. 20 Mar 69.

GROUNDWATER - quantity & date.

STRUCTURES

JOINTING Pattern - attitude, spacing, persistence, character, surface, separation, coating.

FAULTS, SHEARED & CRUSHED ZONES Attitude, relative displacement, width, character of material.

FOLDS, Classification, plunge, axial plane, size persistence.

J_1 60 JOINTS :- planar chlorite minor coatings 1mm or less width. One major direction. At least 2Ft apart.

J_2 VEINS :- Near planar overall, up to 1.5 Ft wide. Quartz siderite, minor pyrite, chalcopyrite and bismuth

L_2 AXIAL PLANE CLEAVAGE :- Well developed. Direction of bedding often masked. Determined from crenulation Folds amplitude 1-3 inches.

Two parallel Faults 2 inches wide near parallel to building. Post vein in age. Only discernable where veins are cut so probably more common. Average 1Ft wide.

J_2 Only minor

Two subparalled Veins Average 1Ft wide minor chalcopyrite. Flatter dip were a series of veins. An area of overlap with flatter dip and less mineraligation?

REFERENCES

Plan 49-384.

	MM20	MMR1
S	0.6	1.45
Cu	0.10	0.11
Bi	0.05	-
Au	-	-
Ag	-	-

Intersection Bore Hole 12 Dip 58°

LEGEND

Timbering
70/ Strike & dip of bedding.
× Vertical, × Horizontal.
20/60 Strike & dip of cleavage
" " " " jointing
Vertical jointing
Horizontal jointing
Plunge of Lineation

60 Crushed zones.
Shears or faults showing movement

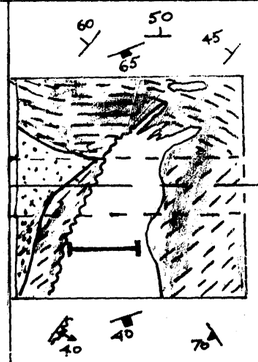
PROTEROZOIC BURRA GROUP BALHANNAH SHALE MEMBER.
SILTSTONE WHITE
CARBONACEOUS SHALE.

METALLICS SECTION

S.A. DEPARTMENT OF MINES

COPPER - GOLD - BISMUTH BALHANNAH MINES
Sect 4048 HUNDRED OF NARIGA
GEOLOGICAL TUNNEL LOG - 79Ft Level
(I. McCarthy.)

LOGGED M.G.M.	Geologist	SCALE: 1"=10Ft	DATE LOGGED 22 Jan 69	SHEET 4 OF 5	69-92c Ha7
DRAWN M.G.M.	Senior Geologist				

BEARING AND SLOPE	R.L. Roof 1028 Ft. 253°M 261°T. near horizontal
ROCK TYPE DESCRIPTION	PROTEROZOIC BURRA GROUP BA-HANNAH SHALE MEMBER. SILTSTONE | CARBONACEOUS SHALE - SILTSTONE. Black, finely layered WHITE. | 10% pyrite 20% mica and carbonaceous fragments. Rest Finely layered 70% quartz. | quartz and feldspar. 20% Feldspar - rest clay and mica
WEATHERING	Physically moderately to highly weathered Chemically moderately weathered.
TUNNEL INTERSECTION PLANS AND CROSS SECTIONS	face at 23/Jan 1969
ASSAYS (A)	MM22 A96/69 Assayed for Cu. Au Ag. Bi S.
PETROLOGICAL SAMPLES (P)	
WALL TOP ROOF TOP WALL	
PHOTOGRAPHS	→ To Face as 20 Mar 69
GROUNDWATER - quantity & date.	
STRUCTURES JOINTING Pattern - attitude, spacing, persistence, character, surface, separation, coating. FAULTS, SHEARED & CRUSHED ZONES Attitude, relative displacement, width, character of material. FOLDS. Classification, plunge, axial plane, size persistence.	J_1 ∠60 JOINTS - planar, minor Fe oxides and chlorite coatings 1mm. or less width. One major direction Less 2.0 Ft apart. J_2 ∠60 VEINS - Lensoid up to 2.5ft wide, Quartz siderite minor pyrite, chalcopyrite L_2 ∠ AXIAL PLANE CLEAVAGE -
REFERENCES	

MM22 Ag = Au = Cu 0.05% Bi 0.025% S 1.35%

Timbering
70/ Strike & dip of bedding.
Vertical, X Horizontal.
20/ Strike & dip of cleavage
∠60 " " " jointing
Vertical jointing.
Horizontal jointing.
→ Plunge of Lineation

∠60 Crushed zones.
Shears or faults showing movement

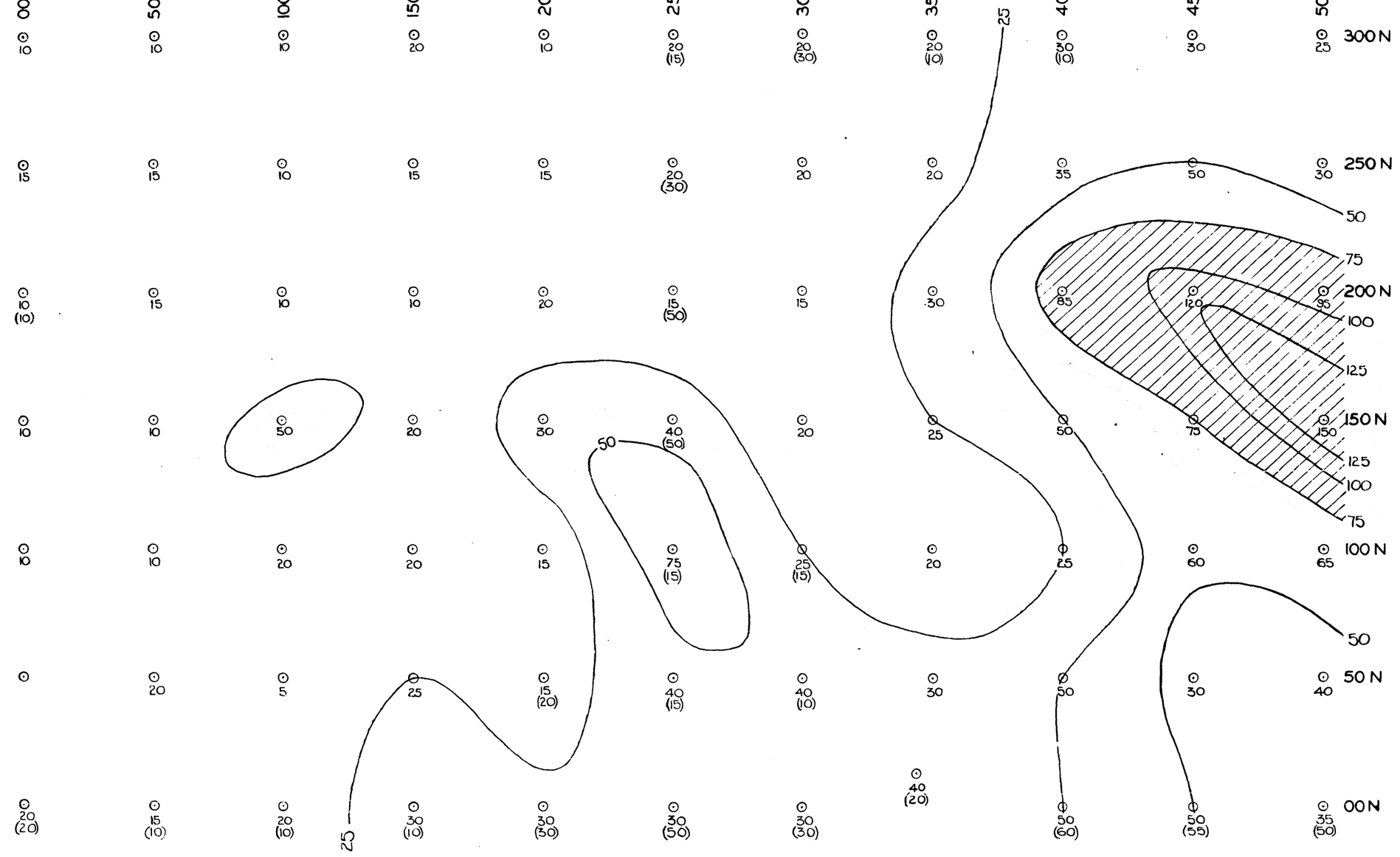
LEGEND

PROTEROZOIC BURRA GROUP BALHANNAH SHALE MEMBER.

SILTSTONE WHITE

CARBONACEOUS SHALE SILTSTONE.

METALLICS SECTION		S.A. DEPARTMENT OF MINES		
LOGGED M.G.M.	Geologist	COPPER - BISMUTH - GOLD BALHANNAH MINES Sect 4048 HD ONKAPARINGA GEOLOGICAL TUNNEL LOG. 70Ft Level. (I. McCarthy).		
DRAWN M.G.M.	Senior Geologist	SCALE: 1"=10ft	DATE LOGGED 20th Jan 1969	SHEET 5 OF 5	69-92d Hg7



SCALE IN FEET

40 0 40 80 120 160 200

10 0 10 20 30 40 50 60

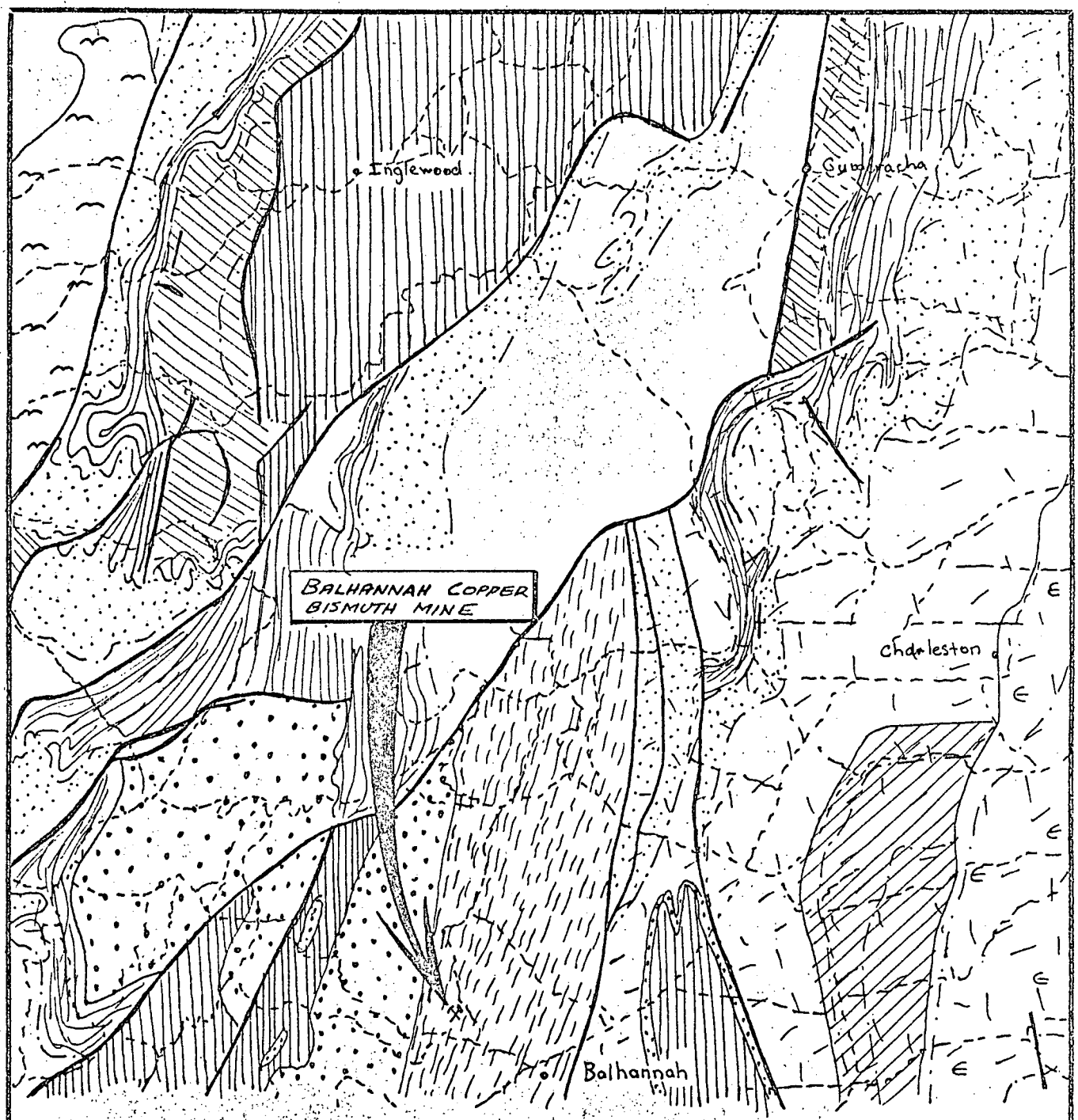
SCALE IN METRES

APPENDIX NO.3.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

COPPER — BISMUTH
BALHANNAH GOLD MINES N.L.
SECTION 4048, HUNDRED ONKAPARINGA
GEOCHEMICAL SURVEY
LEAD RESULTS.

NON - METALLICS SECTION	GEOLOGIST	Drn. M.G.M.	SCALE: 1 INCH — 40 FEET
		Trd. A.G.R.	69-379/6
	P.G. MILLER.	Ckd. L.V.W.	Ha7
Director of Mines	SUP. GEOLOGIST	Exd.	DATE: APRIL 1969



LEGEND.

N

W E

S

Fault

Geological Boundary

Bedding Trends.

Township.

Regional Metamorphism.

PROTEROZOIC

ADELAIDE SYSTEM

TORRENSIAN — BURRA GROUP

STURTIAN — MARINOAN

CAMBRIAN

TERTIARY + RECENT

Slope and alluvial plain deposits.

Metasiltstones and Greywackes.

Siltstones, sandstones, conbonates and tillite sequence.

Saddleworth Formation.

Stoneyfell Quartzite.

Woodsheal Flat shale.

Balhannah shale member.

Skillogalee dolomite.

Aldgate Sandstone.

Mica quartz schists and Granite gneisses.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

M.B. Carson	Drn.	COPPER - BISMUTH - GOLD BALHANNAH MINES. Sect 4048 H° ONKAPARINGA. REGIONAL GEOLOGICAL PLAN. (H. McCarthy).	SCALE: 1 inch = 2 miles.
	Tcd.		S 7153
	Ckd.		Hd 7
	Exd.		DATE: 11 Feb 1969

LEGEND

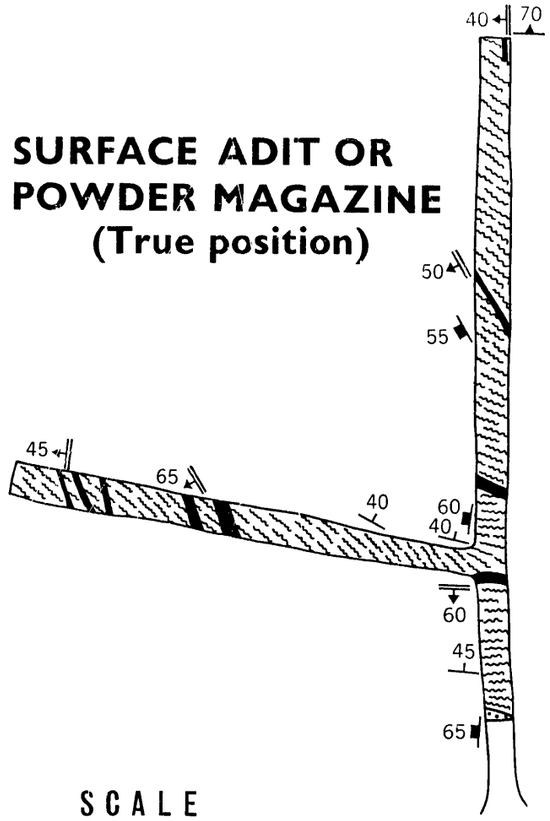
PROTEROZOIC
Torrensian Series

BALHANNAH SHALE MEMBER

- Green brown or grey schist
- Carbonaceous schist or phyllite
- White kaolinitic siltstone
- Quartz-Carbonate Vein (some with Copper and Bismuth)

- 65 — Strike and dip of Quartz-Carbonate Vein
- 70 — Strike and dip of bedding
- 50 — Strike and dip of jointing
- 30 — Lineation
- 80 — Strike and dip of foliation
- **B.H. 19** ● — Borehole
- **D.D.H. 7** ● — Diamond drill hole

SURFACE ADIT OR POWDER MAGAZINE (True position)



SCALE

FEET 10 0 10 20 30 40 50 FEET

METRES 5 0 5 10 15 METRES

N

OLD ENGINE SHAFT

D.D.H. 7
Dip 70°
Depth 220ft.
R.L. collar unknown

D.D.H. 1
Dip 70° Depth 293ft.
R.L. collar 1087ft.

D.D.H. 8
Dip 80°
Depth 100ft.
R.L. collar 1087ft.

B.H. 17
Position approx.
R.L. collar 1092ft.

B.H. 20
Dip 58.5°
Depth 125ft.
R.L. collar 1088ft.

79 FEET LEVEL

B.H. 19
Dip 58°
Depth 150ft.
R.L. collar 1087ft.

B.H. 12
Dip 58°
Depth 300ft.
R.L. collar 1086ft.

Vein 1 Vein 2

69-118

M.G. Mason Geologist

S.A. Dept. of Mines

Geochemical Sampling Grid

Minor Lead Anomaly

00 100E 200E 300E 400E 500E

300N 200N 100N 00

N

B.H. 18 B.H. 17 B.H. 20 B.H. 19 B.H. 12 D.D.H. 3 B.H. 13 B.H. 14 B.H. 16 B.H. 15

D.D.H. 5 D.D.H. 6 D.D.H. 4 D.D.H. 7 D.D.H. 8 D.D.H. 1 D.D.H. 2

Chimney Chimney Old Building Office Shed Store

OLD ENGINE SHAFT ESCAPE SHAFT MAIN SHAFT

Fence Track Creek

REFERENCE

- Borehole — B.H. 19
- Diamond drill hole — D.D.H. 5
- Strike and dip of bedding — 20
- Strike and dip of jointing — 65
- Lineation — 50
- Strike and dip of Quartz Vein — 85
- Quartz Vein
- Fault inferred
- Strike and dip of foliation — 55

LEGEND

PROTEROZOIC Torrensian Series

BALHANNAH SHALE MEMBER

- Schist; Brown iron stained that is originally pyritic perhaps carbonaceous
- Dense, blue-grey dolomite schist —no bedding laminations
- White siltstone and sandstone interbeds carbonaceous shale

SCALE

FEET 40 0 40 80 120 160 200 FEET

METRES 10 0 10 20 30 40 50 60 METRES

69-117

M.G. Mason Geologist

S.A. Dept. of Mines

N

D.D.H. 5
Dip 70° Depth 700ft.

D.D.H. 6
Dip 70°
Depth 271ft.

D.D.H. 4
Dip 70°
Depth 458ft.

B.H. 16
Dip 60°
Depth 230ft.

B.H. 18
Vertical
Depth 200ft.

B.H. 17
Dip 60°
Depth 200ft.

B.H. 20
Dip 58.5°
Depth 125ft.

B.H. 19
Dip 58°
Depth 150ft.

D.D.H. 8
Dip 80°
Depth 100ft.

D.D.H. 7 Dip 70° Depth 220ft.

D.D.H. 1
Dip 70° Depth 293ft.

B.H. 12
Dip 58° Depth 300ft.

D.D.H. 3
Dip 70° Depth 532ft.

B.H. 13
Dip 60° Depth 375ft.

B.H. 14
Dip 60° Depth 220ft.

D.D.H. 2
Dip 70° Depth 700ft.

OLD ENGINE SHAFT

ESCAPE SHAFT

MAIN SHAFT

Chimney

Chimney

Old Building

Office

Shed

Adit level

Wall

Track

Fence

Creek

1190 1185 1180 1175 1170 1165 1160 1155 1150 1145 1140 1135 1130 1125 1120 1115 1110 1105 1100 1095 1090 1085

REFERENCE

Shaft

Diamond drill hole D.D.H. 8

Dump Quarry

Contour (Interval 5ft.) 1180 1175

Costean

Borehole B.H. 17

79ft.level

Adit level

SCALE

FEET 40 0 40 80 120 160 200 FEET

METRES 10 0 10 20 30 40 50 METRES

UNDERGROUND WORKINGS See Fig. 2

69—93

M.G. Mason Geologist.

S.A. Dept. of Mines