Rept. Bk. No. 53/96
G.S. No. 2137

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

GEOCHEMISTRY SECTION

Report on

RE-APPRAISAL OF BURRA MINES AND DISTRICT

by

B. P. Thomson, M.Sc.
Senior Geologist

17th October, 1961

D.M. 1794/61

RB 53/93

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SUMMARY

The recognition of the role of slumping of sedimentary breccias and stratiform mineralisation in the localisation and origin of the Burra Main Orebody is discussed and recommendations for further work are made.

LIST OF FIGURES

		Plan No.
Fig. 1	Burra Mine. Main Open Cut, detail of sedimentary breccias, mineralisation.	S 2900
Fig. 2	Burra Mine. Main Open Cut, detail of flowage of mineralised shale in dolomite.	S 2901
Fig. 3	Burra Mine. Main Open Cut. Detail on east wall of ore zone showing deformation of ore "shale".	S 2899
Fig. 4	Burra Mine. Schematic diagram of slump breccia and Burra ore bodies.	S 2902
Fig. 5	Geological Map (after S.B. Dickinson 1942) of Burra Burra Mine area and Structural Features. Scale 1 inch = 500 feet approx.	61-729
Fig. 6.	Regional Geological map (after S.B. Dickinson 1942) of Burra District Scale 1" = 60 chains (approx.)	61-730
Fig. 7	Plan of portion of Hundred of Kooringa, Co. Burra, showing proposed prospecting area. Scale 1" = 80 chains.	61-722

INTRODUCTION AND HISTORY OF MINING AND EXPLORATION.

Discovery of copper ore at Burra, 100 miles north of Adelaide marked the beginning of mining as an important element in the economy of the young colony of South Australia. During the period from 1843 to 1877 when active mining of the rich carbonate ore ceased, the Burra Mines produced 235,000 tons of ore, approximating a grade of 22% copper. This production represents 51,600 tons of metallic copper, valued at current prices at £A15,740,000. A total of some 700,000 tons of ore and country rock were removed during underground and open cut mining.

According to Dickinson (G.S.S.A. Bulletin 20), the closure of the mine resulted from the low grade of the primary sulphide ore, heavy pumping and transport costs and the prevailing low price of copper (about £60 sterling per ton). The deepest level (510 feet) was reported at the northern end to have been in sulphide ore, probably of 3% Cu grade (p. 75 Bulletin 20). A diamond drill hole put down in 1898 intersected 191 feet of sulphide mineralisation of unknown but probably low grade below the southern end of the open cut between 813 feet and the bottom of the hole at 1004 feet. A second drill hole in the same vicinity intersected low grade sulphide mineralisation from 706' to the bottom of the hole at 787 feet.

Subsequent interest in the mine has been sporadic. R.W. Segnit (1939) briefly described the geology of the mine and the adjacent area in Survey Bulletin 18. S.B. Dickinson (1942) in Bulletin 20, summarized all available data as well as providing very useful surface geological maps of the region. Dickinson concluded that exploratory efforts should be best expended in locating a new secondarily enriched body. He recommended that a geophysical survey should be made of the concealed area north of the ore body. Although admitting that the data was lacking to enable an estimate of tonnage and grade of the primary ore, Dickinson believed that the primary mineralisation below the main ore body was low grade and confined to limited channels.

In 1951, Dr. M.D. Garretty, consultant geologist, approached the Mines Department on behalf of a major Australian and a major American mining company, regarding further investigation of the Burra area. As a result of these enquiries and consultations C. Wegener (D.M. 1154/51) mapped a further area north of Burra several miles beyond the limits of Dickinson's mapping.

A geophysical survey (gravity, magnetic and self potential) was carried out over part of the concealed area north of the ore body, as originally recommended by Dickinson.

The results of the Geophysical Survey (Geophysical Report 5/52, Kerr Grant) gave no encouragement for drilling in the northern area. Dr. K.R. Miles, then a Departmental Senior Geologist, recommended in 1952 (D.M. 1154/51) that two exploratory holes be drilled, one 1000 feet deep to test the anticlinal fold east of the Burra mine and one 800 feet deep below the ore body - to give "authoritative information regarding the primary (sulphide) zone below the known ore body." The drilling was not done because the overseas mining company concerned in the original arrangements apparently did not consider the drilling venture worthwhile.

In 1953, M.L. Reyner and R.K. Pitman of the U.S.A.E.C. made an appraisal of the other copper mines of the Burra District (D.M. 1863/53). Their report contains useful data on Karkulto, Princess Royal, Utica Mines etc. They did not consider that any of the mines represented interesting copper prospects, and did not recommend diamond drilling.

In 1956, A. A. Gibson made a brief geochemical reconnaissance in the vicinity of the Burra. Two interesting facts were established by Mr. Gibson (personal communication).

(i) The concealed area north of the Burra Mines is underlain by transported gravels at a depth of at least 5 to 6 feet. Therefore any future geochemical sampling will have to be done by deep sampling of buried residual soil or rock using a power auger or drill.

(ii) Rock sampling in a traverse along the main road S.W. of Burra and along the strike extension of the ore body showed a marked stratigraphic distribution of copper in the Torrensian sediments.

L.G. Nixon (D.M. 1210/57; G.S. 964) reported on diamond drilling of Torrensian dolomitic limestones west of the Burra Mine. Mr. Nixon noted the occurrence of "porphyry" float west of the area mapped by Dickinson.

On November 30th and December 1st, 1960, the writer and Mr. R.P. Coats inspected the Burra main open cut and the Utica and Princess Royal Mines with Mr. W.N. Thomas of the Zinc Corporation. The interest was largely in possible lead zinc mineralisation. Samples of manganese and

ochre from the Burra Open Cut and the Princess Royal mines were collected by the writer. Assays showed several percent of copper but only traces of lead and zinc.

During this visit slump structures were noted in one place in the main open cut, but the main mass of breccia there was thought to be possibly diapiric in character. Similar breccia was noted in a narrow zone at the Princess Royal. A specimen of black chert was also collected by writer and showed typical small scale sedimentary breccia structures identical with the cherts in the Torrensian near Adelaide on the Echunga 1 mile sheet. This was thought to be of stratigraphic significance at the time but its value as a clue to the character of the large scale breccias was not fully appreciated. The writer was unable to locate the porphyry dyke shown on Dickinson's map. Pink quartzose rock in the open cut superficially resembling porphyry was believed to be silicified dolomite.

On 25th September 1961 the writer spent one day at Burra with a visiting Geologist. Most of the time was occupied in examining in detail the clear rock exposures in the main open cut.

Figures 1, 2 and 3 record some of the many observations made that clearly showed to the satisfaction of the writer that the sedimentary breccias and slumps could be observed on all scales from zones a fraction of an inch thick to zones 10 feet or possibly hundreds of feet thick and that the copper mineralization was emplaced before or during consolidation of the sediments. This new data requires a complete change in our mode of appraisal of the Burra ore body and its environment which to date have been considered in previous investigations solely from the point of view of hydrothermal emplacement, structural control and secondary enrichment.

A first requirement is a discussion of the geological succession.

STRATIGRAPHY

The Burra Mine is located in a dolomitic sequence of the Adelaide System underlying the Sturtian Tillite, and approximating to the lower dolomites and magnesite beds in the Torrensian of the type section near Adelaide. No magnesite has yet been found at Burra, although it may well be present.

The following table of the stratigraphic succession is adopted from Dickinson (G.S.S.A. Bulletin 20).

	Thickness in feet	Unit Name	Unit No.	Lithology etc.
↑				
Upper Glacial Sequence	500	Upper Tillite	7	Well bedded tillite with erratics
	10000	Slate Group (Tapley)	6	Varve-like
Interglacial Sequence	400	Quartzitic sandstone	5	Auriferous at Mongolata (may correlate with Kapunda "arkose").
↓	5700	Shale sandstone group	4	Variegated soft and friable merges into unit 3.
↑	5000	Lower Tillite (Sturt)	3	Massive tillite interbedded with coarse grained sandstone, crossbedded (fluvioglacial). Sequence may merge into unit 2.
Lower Glacial Sequence	7500	Calcareous shale Group	2	Grade downward into lenticular dolomitic facies containing massive dolomite, sandstone and carbonaceous mudstone. From north to south lower part of sequence appears to change from dolomitic to argillaceous facies. Sandstone member towards top of sequence may equate with Stonyfell quartzite.
	2300	"Upper limestone Group"	1D	Laminated dolomites and limestones grading upward into shales. Incompetent character noted by Dickinson may represent tendency to slump in pre-consolidation stage.
	250 or less	Banded dolomite "No. 1 marker bed"	1C	Dense finely banded dark dolomite. In part cherty. Numerous small scale slump structures and thin sedimentary breccias. Rare thin mineralised shaley partings and lenses.
	0 to + 100	Calcareous shale Group	1B	Dark finely laminated chert, dolomite carbonaceous and calcareous shale with disseminated fine grained sulphide mineralisation in bedding. Dark ovoid nodules in places, after phosphate or scapolite. 1B may be incorporated in part in 1C by slumping.

+ 1500	"lower limestone group"	1A	Recrystallised dolomites and limestones in places relationship obscured by large scale breccia structures, which may include parts of 1A, 1B, 1C and 1D.

REGIONAL DISTRIBUTION OF MINERALISATION

Dickinson (Bulletin 20) (see fig. 5 & 6 attached) shows the Burra ore body to occur largely within unit 1A and 1B. Some additional mineralisation also occurs with breccia in unit 1A to the S.W. and N. of the Burra Mine. Workings also occur half a mile south of the main road. The Utica and Princess Royal - with breccia - 8 mile southsoutheast of Burra are slightly higher in the sequence in unit 1D.

The following table has been compiled from reports by Reyner and Pitman in D.M. 1863/53; they show that in the region copper mineralisation within a radius of 14 miles of Burra occurs in the sequence up to the Sturt Tillite stratigraphic level.

Mine	Locality	Stratigraphic Unit	Host Rock	Depth of mining, mineralisation	Production
Burra	Burra Township	1A, 1B, 1C	dolomite breccia	Shaft to 600ft. Drilled to 100.4 ft. Cu carbonates, chalcocite, chalcopyrite, pyrite.	235,000 tons 25% Cu
Bon Accord	Burra Township	1C (?)	dolomite	Shaft to 300 ft. Cu Carbonates and oxide	No production
Princess Royal	8 mi. S.S.E. Burra	1D	dolomite in places breccia	Shaft to 180 feet Cu carbonates with Mn oxides	+ 600 tons 18% to 27% Cu

Mine	Locality	Stratigraphic Unit	Host Rock	Depth of mining, mineralisation	Production
Utica	8 mi. S.S.E. Burra	1D	dolomite and chert	Shaft to 103 feet. Quartz calcite veins with Cu carbonates, chalcopyrite, bornite, barytes reported.	+ 50 tons
St. Elmo	South of Burra	1D or 2	dolomite	Shaft to 105 feet. Irregular quartz stringers with Cu carbonates	+ 20 tons
Karkulto (Royal Mining Co.)	1½ mi. N.E. of Black Springs	2	slate	Shaft to 120 feet. Siderític lode.	850 tons mainly Fe oxide for smelter flux.
Karkulto (S.A. Mining Assoc.)	2½ mi. N.E. Black Springs	2	slate	Shaft to 240', siliceous lode with Fe and Cu sulphides	7500 tons Fe ore for smelter flux. 70 tons Cu ore.
Edelweiss	14 mi. S. of Burra	2	Thin bedded dolomite, some interbedded slate.	Shaft to 170 feet.	No recorded production.
Apoinga	9 mi. S.W. of Burra	2	Slate near base of Sturt tillite.	h to 80 feet cross-cutting veins quartz calcite, siderite with traces Cu carbonates	No recorded production
West Burra	4½ mi. S.W. of Burra	3	Sturt Tillite	Shaft to 157 feet. Calcite siderite quartz veins with chalcopyrite and pyrite.	27 tons 29% Cu.

THE 'BRECCIA PROBLEM"

Segnit (G.S.S.A. Bull. 18) considered the breccia clearly exposed on the western side of the Burra open cut near Groves shaft to represent a tillite. Close examination of the exposure shows the rock to be composed of rounded masses and angular fragments and blocks of dolomitic rocks with rare fragments of shale and sandy sediments and rounded pebble like bodies of quartz or chalcedony. The matrix is fine grained and dolomitic.

Dickinson (G.S.S.A. Bull. 20) discounted the tillitic origin and is uncertain although he favoured a tectonic origin he also considered they may have a "talus" origin at an unrecognised unconformity. A possible diapiric origin was entertained last year by the writer and R.P. Coats. The writer now advocates a preconsolidation origin for the breccias.

ORE CONTROLS

The ore body is localised in one or more slump breccia rolls. Sedimentary breccias are a feature of this part of the Torrensian succession and the process appears to have been repeated many times in the vicinity of the ore body. In fig. 1 for example "boulders" of breccia occur within a slumped and brecciated zone. This fact also indicates a syngenetic origin for the copper as it is difficult to imagine hydrothermal solutions collectively replacing the boulders without leaving traces of mineralisation in the matrix.

Mineralised shale lenticles have been plastically deformed in the unconsolidated state during slumping and consolidation movements. The shale with copper mineralisation has been squeezed and "squirted" into fractures and boudinage structures in the associated dolomite (see fig. 2 & 3).

Fig. 4 represents the simplest possible interpretation of rotation of the beds into their original attitude of deposition. The interpretation owes much to the excellent work of Snyder and Odell (Geol. Soc. Am., V. 69, No. 7, 1958) on similar structures in South East Missouri lead deposits in palaeozoic limestones of the Mississippi Valley type. Mr. L.G. Nixon was first to suggest that such ore controls may exist at Ediacara. In North America some exploration companies are employing similar concepts. In Australia slump rolls, breccias and folds have been suggested as ore

controls in Mt. Isa, Tennant Creek and Broken Hill. I doubt whether at any of these localities the evidence is so striking and convincing as at Burra.

In the north face of the open cut the many slump folds indicate a constant direction of slumping from the east in Torrensian time. The "pile up" of the top of the breccia mass in fig. 4 is deduced from observations in the north end of the open cut and Dickinson's outline of breccia areas. It can be observed from slump direction exposed that the beds have been rotated some 230 degrees from an original horizontal position; about 180 degrees of this rotation is tectonic.

FURTHER WORK

It is apparent the first step in an exploratory investigation of the Burra deposit is to elucidate the shape and orientation of the breccia slump roll or combination of such structures. Such structures need not coincide precisely with later tectonic structures; indeed it would be a miracle if they did. The recent observations show the slump folds plunge gently in a southerly direction at the north end of the open cut, roughly in harmony with the regional change of pitch from north to south in the complex synclinal area east of the ore body.

The longitudinal section (see fig. 5) indicates a continuous plunge of the breccia zone in a southerly direction in depth.

The second step in the investigation is to determine the relationship of mineralisation to the breccia zone. In a sense this will mean study of the ore occurrence from the point of view of the "source area" of the mineralised material and its incorporation and distribution in the breccia mass. The first two steps will entail detailed mapping and recording of many observations and will be a challenge to the skill of the geologists who do this work.

The second step will lead to a drilling campaign to determine grade and tonnage of mineralisation in the concealed breccia mass in the primary sulphide zone. In the course of this work other targets for secondarily enriched ore may be found.

The third and final step is to seek information on the character of the mineralisation in the shaley source beds (probably unit 1B) down dip and to the east. These could conceivably be the host for a stratiform deposit of sufficient grade and tonnage as to warrant mining. Information on this problem will be obtained if drilling is carried out at the second step.

Detailed mapping of the IB beds to the south of the mine should be done, followed by geochemical sampling of this unit and a geophysical survey (magnetic, gravity and electro-magnetic) of cross traverses along its extension to the south to the limit of map (fig. 6). Aeromagnetic contour maps will shortly be available for study on a scale of 1 inch to 1 mile.

RECOMMENDATIONS

1. The Mines Department should take steps to secure land, which in this case is largely freehold. The area recommended is shown on Fig. 7.

2. Detailed mapping of the Burra open cut should be made on a scale of 1" = 40 feet, showing complete structural detail of sedimentary and tectonic structures and mineralisation.

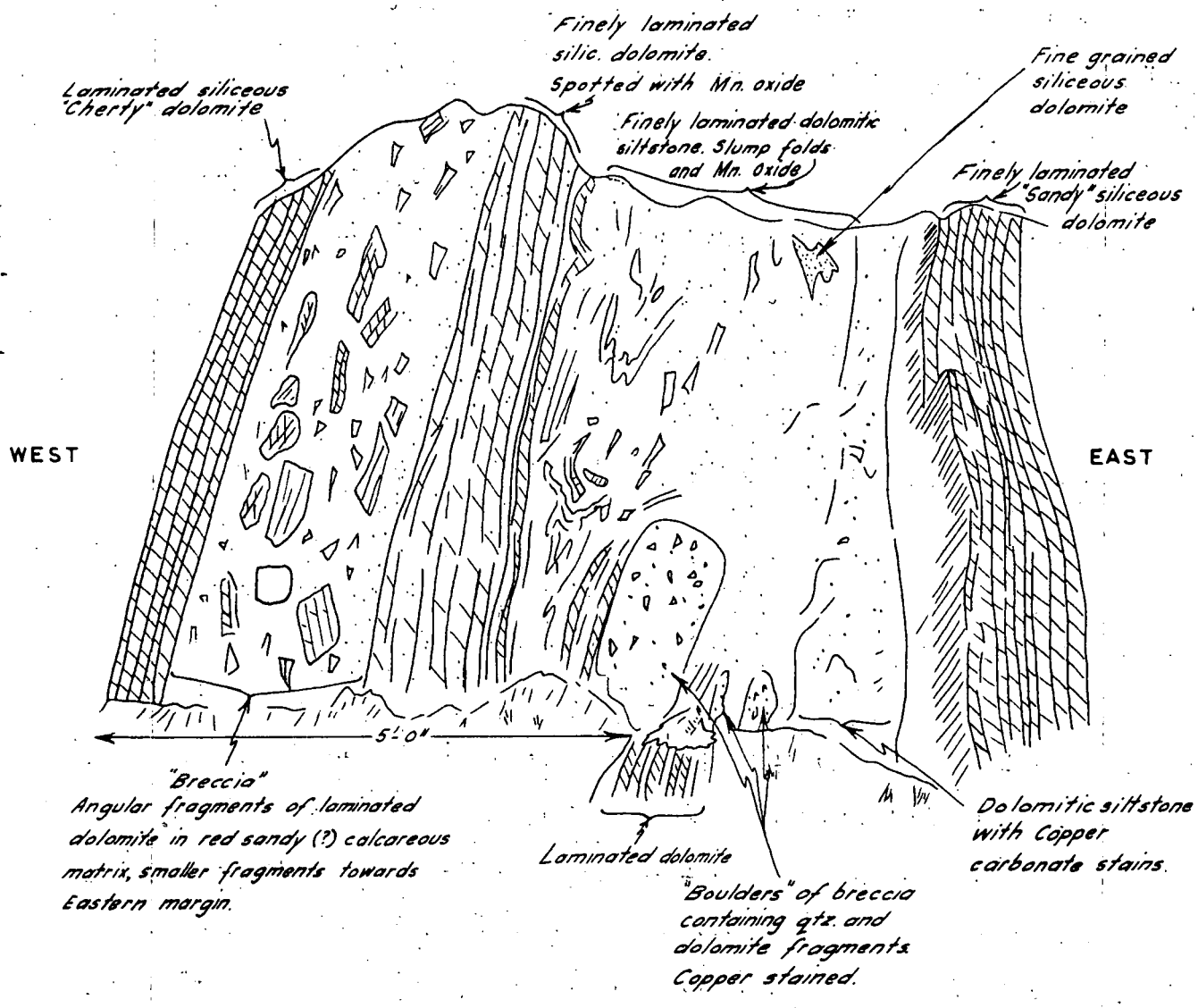
3. Mapping of Bed 1B and area : to east should be made on a scale of 400 feet to the inch, with further detail in areas of interest.

4. Geochemical and geophysical surveys should be made of the area covered by item (3).

B P Thomson

B. Thomson
Senior Geologist
GEOCHEMISTRY SECTION

BPT:AGK
17/10/61



Detail of portion of Northern end of open cut on Eastern margin of ore zone showing. Sedimentary breccias, slump structures, copper mineralization in breccia boulders. Beds are overturned. Sedimentary facing to East.

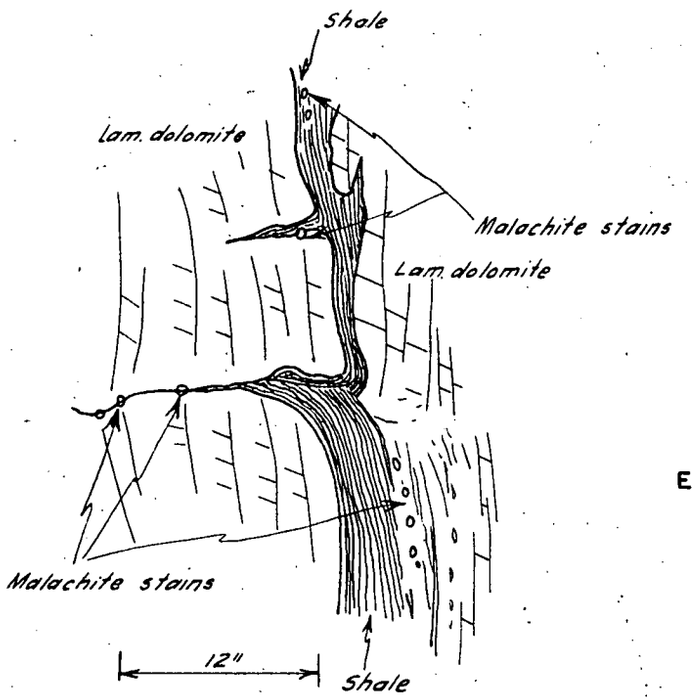
FIG. 1

To accompany report by B.P. Thomson

S.A. DEPARTMENT OF MINES

Approved	Passed	Drn. B.P.T.	BURRA MINE MAIN OPEN CUT	D.M.	Scale
		Tcd. A.W.		Req.	S 2900
		Ckd.			G e G
Director		Exd.			Date 11-10-61

200—7·61 3805



Detail on North face, illustrating flowage of shale, with malachite, into fractures in laminated dolomite.

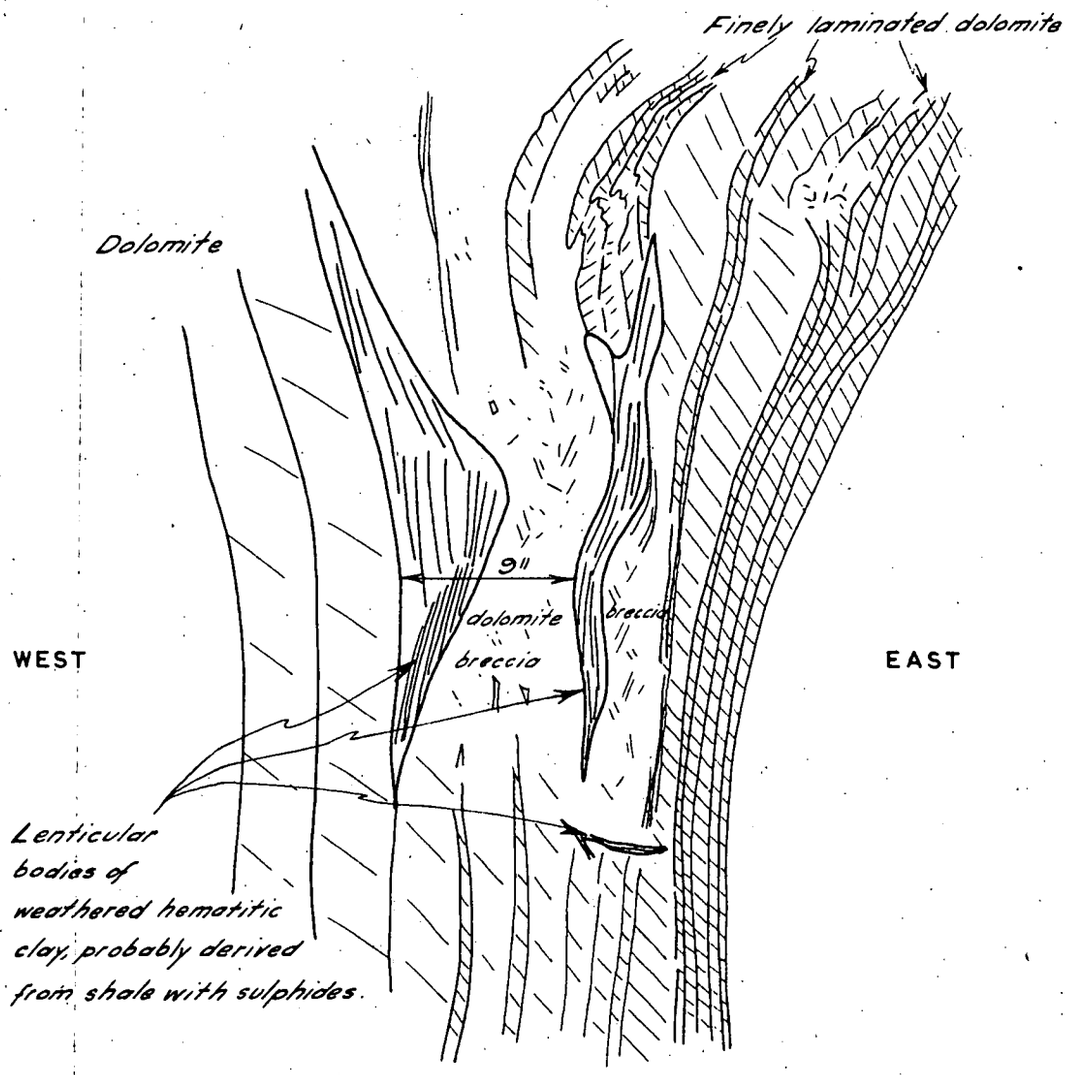
FIG.2

To accompany report by B.P. Thomson

S.A. DEPARTMENT OF MINES

Approved	Passed	Drn. B.P.T.	BURRA MINE MAIN OPEN CUT	D.M.	Scale
		Tcd. A.W.		Req.	S2901 Ge G
Director		Exd.			Date 12-10-61

200—2·61 3805



Detail on East Wall of Ore Zone showing deformation of "Ore Shale" probably contemporary with slumping brecciation and compaction of dolomite.

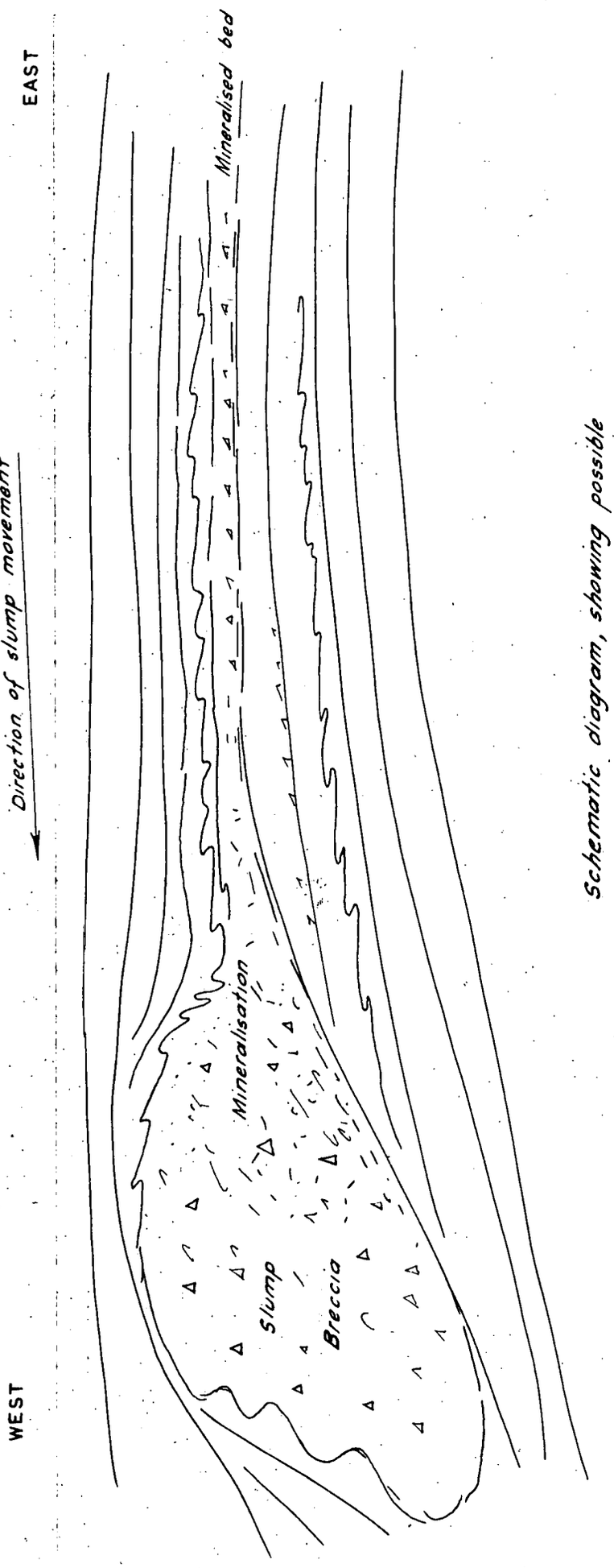
FIG. 3

To accompany report by B.P. Thomson.

S.A. DEPARTMENT OF MINES

Approved	Passed	Drn. B.P.T.	BURRA MINE MAIN OPEN CUT	D.M.	Scale
		Tcd. A.W.		Req.	S2899 Ge6
		Ckd.			
Director		Exd.			Date 11 - 10 - 61

200—9·61 3805



Schematic diagram, showing possible slump breccia localising Burra Ore bodies.

FIG. 4

To accompany report by B.P. Thomson.

S.A. DEPARTMENT OF MINES

Approved	Passed	Drn. B.P.T.	BURRA MINE MAIN OPEN CUT	D.M.	Scale
		Tcd. A.W.		Req.	S2902
		Ckd.			G e G
Director		Exd.			Date 12-10-61

200—2·61 3805

N

See Enlargement

BURRA NORTH

RS

Cu

BURRA MINES

Railway

Cu

BURRA

A

A

B

B

KOORINGA FAULT

PRINCESS ROYAL MINE

Cu

C

C

UTICA MINE

Cu

A

A

CROSS SECTION A-A

B

B

Kooringa Fault

CROSS SECTION B-B

C

C

Kooringa Fault

PRINCESS ROYAL MINE

CROSS SECTION C-C

COLUMNAR SECTION

THICKNESS IN FEET

5200 SHALE-SANDSTONE GROUP

5000 LOWER TILLITE

Sandstone

7500 CALCAREOUS SHALE GROUP

Interbedded shale and dolomite

Carbonaceous shale

2300 UPPER LIMESTONE GROUP

250 Banded dolomite

1500+ Calcareous shale

LOWER LIMESTONE GROUP

LEGEND

Fault

Anticlinal Axis

Synclinal Axis

Copper Occurrences Cu

After S.B. Dickinson, 1942 — (Geological Survey of S.A., Bulletin No. 20) & C. Wegener, 1951.

SCALE

MILES 1 0 1 2 3 4 5 MILES

61-730

B.P.Thomson, Senior Geologist.

S.A.Dept.of Mines.

SCALE

FEET 500 0 500 1000 1500 2000 2500 3000 FEET

N

LEGEND

- Slate — 4
- Lower tillite — 3
- Mainly shale, sandstone and dolomite — 2
- Upper limestone group — 1D
- Banded dolomite, No.1 Marker bed — 1C
- Calcareous shale – with chert, dolomite, Fe Sulphide — 1B
- Lower limestone group – calcareous dolomites — 1A
- Reconstructed Ore outline
- Mineralisation
- Slump breccia (observed)
- Slump breccia (inferred outline)
- Open cut mine or quarry
- Anticlinal axis
- Synclinal axis
- Strike and dip of bedding — 15
- Pitch — 5

To Terowie

Main Road

Railway from Adelaide

BURRA R.S.

BON ACCORD SHAFT

ALLEN SHAFT

GRAVES SHAFT

MAIN OPEN CUT

WATERHOUSE SHAFT

MORPHETT SHAFT

HECTOR SHAFT

TINLINE SHAFT

TINLINE FAULT

SHAFTS

KINGSTON FAULT

BURRA NORTH

BURRA

TOWNSHIP

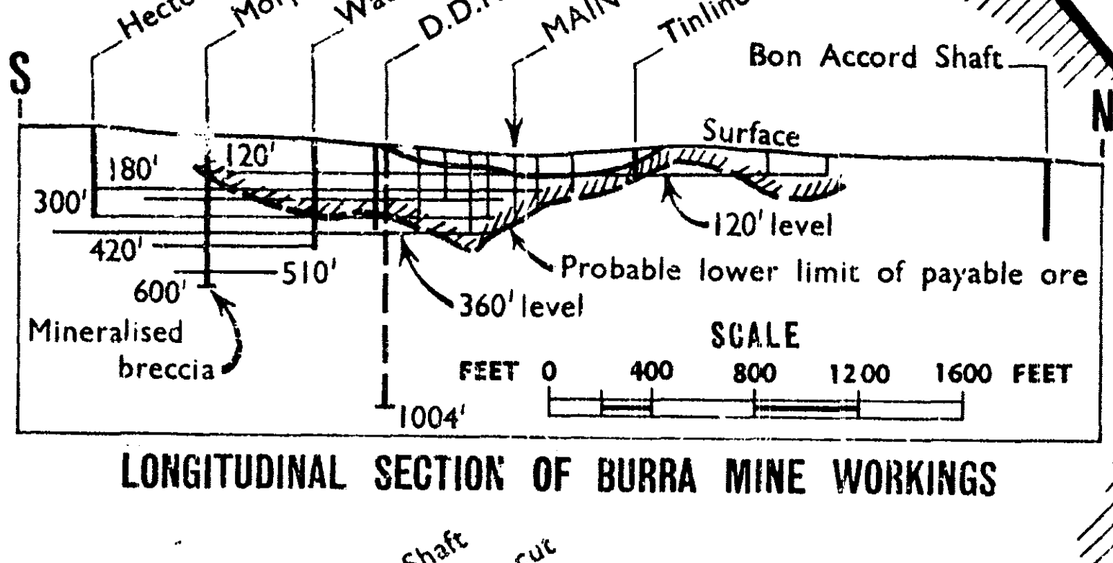
BURRA CREEK

Road from Adelaide

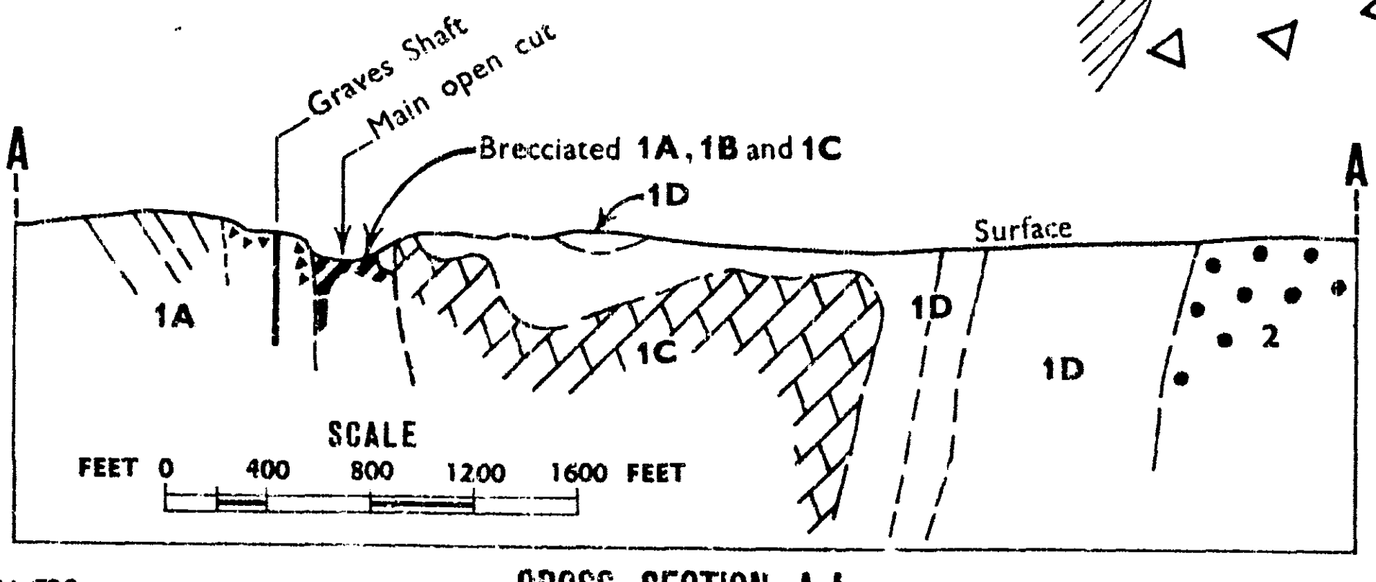
KOORINGA FAULT

SHAFTS

A — A



LONGITUDINAL SECTION OF BURRA MINE WORKINGS



CROSS SECTION A-A

After S.B. Dickinson 1942
(S.A. Geol. Survey Bulletin 20)

61-729

B.P. Thomson, Senior Geologist

S.A. Dept. of Mines

138°55′

139°00′

33°40′

33 40′

33°45′

33 45′

123
117
57
3034
130
3035
42
41
3033
3037
3039
3038
9
Railway
8
3040
2071
2070
143
142
131
132
65
68
Main
2069
2067
2068
4
7
71
BURRA
NORTH
2278
2277
191
Road.
2276
192
BURRA
2267
2264
193
2263
176
194
2266
2265
2259
C
2258
246
2257
247
2256
249
2198
251
2197
253
2199
2
2056
254
E
256
260
257
28
186
40
93
97
5
3
99
29

PROPOSED PROSPECTING AREA

SCALE IN CHAINS

40 20 0 40 80 120 160 200

61-722

B.P. Thomson, Senior Geologist.

S.A. Dept. of Mines