THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF ECONOMIC GEOLOGY

THE GEOLOGY OF THE CALLINGTON AREA

R. Grasso and J.B. McManus,
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SUMMARY

This report is submitted as part of the Honours Economic Geology course during the year 1954.

Particular attention was paid to the structure and structurel environment of the mineralisation during mapping in the Callington area.

From observed facts, interpretations have been made relating to the geological history, type of mineralisation and the structural control. Each mine has been discussed in some detail and suggestions have been put forward to consider some of the workings as economic prospects when market conditions are favourable.

The history of the mines, the mining methods and detailed production figures have not been discussed.

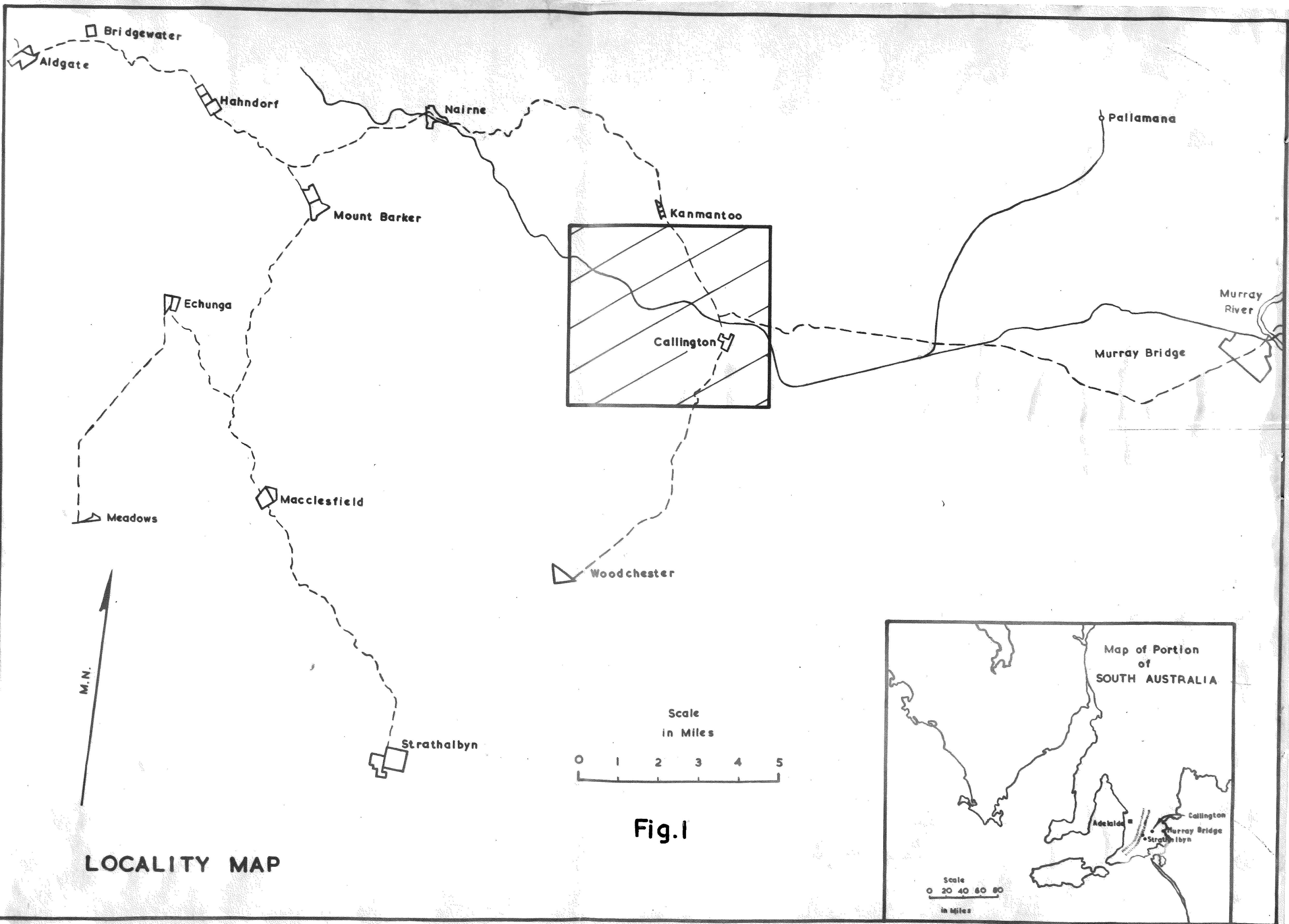


Fig.1

LOCALITY MAP

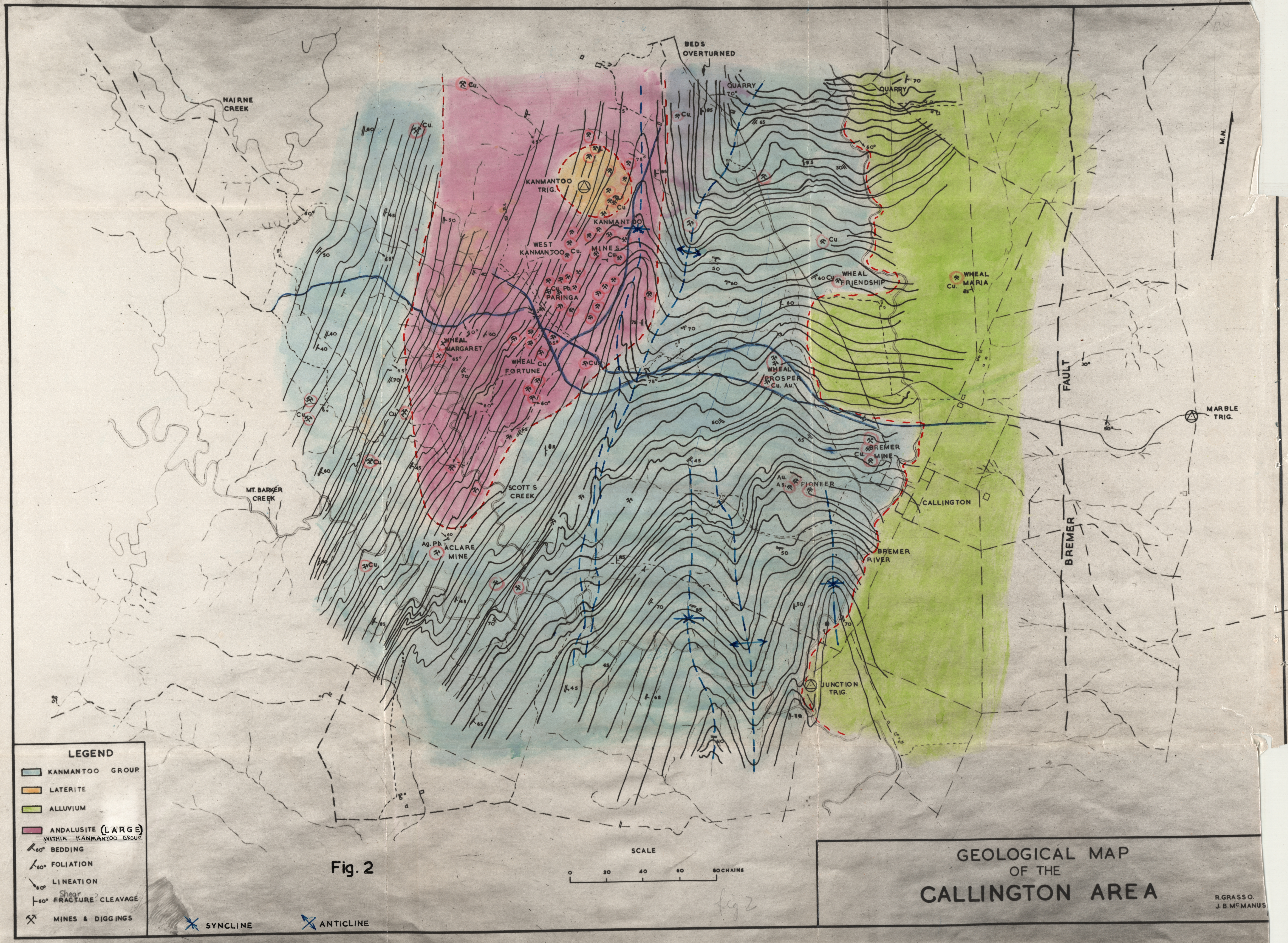

NAIRNE CREEK
BEDS OVERTURNED
QUARRY
KANMANTOO TRIG.
KANMANTOO MINES
WEST KANMANTOO
PARINGA
WHEAL MARGARET
WHEAL FORTUNE
WHEAL FRIENDSHIP
WHEAL MARIA
WHEAL PROSPER
BREMER MINE
PIONEER
CALLINGTON
BREMER RIVER
JUNCTION TRIG.
MARBLE TRIG.
BREMER FAULT
SCOTT'S CREEK
MT. BARKER CREEK
ACLARE MINE
M.N.
LEGEND
KANMANTOO GROUP
LATERITE
ALLUVIUM
ANDALUSITE (LARGE) WITHIN KANMANTOO GROUP
BEDDING
FOLIATION
LINEATION
FRACTURE Shear? CLEAVAGE
MINES & DIGGINGS
SYNCLINE
ANTICLINE
SCALE
0 20 40 60 80 CHAINS
GEOLOGICAL MAP OF THE CALLINGTON AREA
R. GRASSO.
J. B. McMANUS

Fig. 2

INTRODUCTION

(a) Aim of work

Geological mapping was carried out in the Callington area as part of the Economic Geology course. The Honours Petrology students paid special attention to the petrology and metamorphism while the Economic Geology students mapped the structure and noted the mineralisation in relation to the structure.

Mapping was done on a scale of 1 inch represents 20 chains, this being the scale of the aerial photographs.

A base map was prepared from aerial photographs by using a slotted template. The coordinates of the following second class triangulation points which were obtained from the Department of the Army:

1.	Kanmantoo	E 201008	N665972
2.	Marble	E 208252	N663111
3.	Junction	E 203639	N659925

were used to control the area. An area of 22 square miles was mapped. (See Fig. 1.)

(b) A fact map, an aerial photograph plot, field notes and aerial photographs will accompany this report.

PREVIOUS INVESTIGATIONS

Apart from early mining workers, Dr. W.G. Woolnough (1908) was the first to publish any geological data relating to the area. He traversed the area, described some rock types and assigned a tentative pre-Cambrian age to the basement rocks.

Other workers have assigned a pre-Cambrian age to the Kanmantoo group in general, while Sprigg and Campana in 1953 considered the Kanmantoo Group to be of Cambro-Ordovician age.

S.B. Dickinson in 1942 was the first to publish work on the structure of the area. A.A. Gibson, Mines Department of South Australia has written a [illegible] report on the Wheal Friendship mine; [illegible] this report is not published. A. Whittle, Mines Department of South Australia intends to publish some work on the petrology of the rocks surrounding Callington and Kanmantoo. (personal communication)

GEOGRAPHY

Topography and Drainage.

Size of the area is 22 square miles approximately. Callington, which is on the Adelaide- Melbourne railway line is near the centre of the area.

In the western half of the area there is relatively high ground, (highest point is the Kanmantoo triangulation station - 763 feet) while on the east the ground flattens out towards the Bremer fault scarp. The fault scarp runs north-south.

Three factors may account for the low lying area in the east:

1. The area is on the down-throw side of the Bremer Fault.
2. Underlying rocks are mainly shales and sandy beds, therefore eroded easily
3. The E-W striking beds are broken by the N-S striking shear cleavage

The Bremer River flows from north to south parallel to the Bremer Fault, while the western side of the area is drained by the Scott's and Barker Creek. Barker's Creek joins the Bremer River to the South of Callington. Streams arising on the slopes of the Bremer Fault Scarp, quite often, do not reach the Bremer River, but fan out and are absorbed in the alluvium. The topography is semi-mature.

Rainfall and Vegetation

Callington receives an average annual rainfall of 15 inches. It has been noted that the average rainfall declines at the rate of one inch per mile as one travels eastward from Mount Barker, so the western portion of the area receives more rain than the eastern portion.

Eucalypt and wild tobacco trees (Nicatiana glauca) occur in the watered parts, while tea-trees (Casuarina) occur throughout the area. Mine timber would have to be obtained elsewhere.

The rivers flow intermittently, but salt free water is obtainable at a shallow depth.

Cultivation

Wheat and sheep farming is carried out in the area; wheat is grown on the alluvium in the east while the sheep are raised on the relatively high ground in the west.

Accessibility.

All parts are accessible and a main road and railway run through the area.

GEOLOGY

STRATIGRAPHY

Rocks of the Kanmantoo Group are the basement rocks in the area. The age of these rocks is not known with certainty; they may be pre-Cambrian or Cambro-Ordivician.

Beds in this group were deposited as interbedded argillaceous and arenaceous sediments and have undergone regional, dynamic and contact metamorphism to give schistose rocks. Some of the metamorphosed beds are now:

Andalusite schists
Knotted andalusite schists
Andalusite - Staurolite schists
Andalusite- garnet-biotite schists
Sericite schists
Quartz-biotite-feldspar schists
Bi-mica achists
Quartzites (not true quartzites) from siliceous sediments.
Actinolite - Muscovite-Epidote- Quartz - albite rock (very minor occurrence near the Aclare Mine)

Sandy schist (quartz-biotite-feldspar) is the major rock type.

In the southern portion of the area there are more shales white sandy beds and quartzitic beds than there are in the northern portion. The beds in the southern portion are stratigraphically above the beds in the north (See Fig. 2 The structure).

Localised high zones of metamorphism have been shown on Fig. 2 . In the zones there are rocks which contain large porphyroblastic andalusite crystals,(up to 1 inch in length) staurolite and garnet. (Staurolite is generally associated with stress, while andalusite is an anti-stress mineral. This mineral assemblage is very uncommon, but it does occur in Banffshire, Scotland). Quartz blows, veins, stringers and pipe-like structures have*intruded the sediments.

It is considered that there are two or more periods in which the quartz entered the sediments of the Kanmantoo Group.

Unconformably overlying the beds of the Kanmantoo group are remnants of a superficial iron laterite which is best seen on the ridge west of the Kanmantoo mines. This laterite could have been formed during Mesozoic or early Tertiary time when pene-planation was taking place.

Thin depositions of Kunkar are found in the eastern portion of the area. In places the Kunkar has been deposited directly on top of the beds of the Kanmantoo Group, while in other places the Kunkar can be seen on top of a coarse gravelly material. The age of the Kunkar on top of the gravels would be post movement on the Bremer Fault. If Kunkar is found on top of the Bremer Fault scarp, then the Kunkar on top of the Kanmantoo beds could be pre movement on the fault. It is more likely that the Kunkar on top of the beds and on the gravel have the same age, that is post fault movement (Pliocene-Pleistocene).

The gravel-like material either derived from a river or material deposited along the fault is only seen in small creeks that have cut through the alluvium. This gravel-like material would be post-faulting.

Recent alluvium occurs mainly in the east, but there are small patches of alluvium throughout the area. Where the thickness of alluvium could be determined it did not exceed 30 feet.

* the term "intruded" is not used in the sense to indicate that the quartz entered as a magma, but in the sense that the quartz was in solution or in a gaseous phase and crystallisation occurred later)

History and Metamorphism

1. Sprigg and Campana (1953) have considered that the rocks of the Kanmantoo group may have been deposited during Cambro-Ordovician time under unfossiliferous marine conditions and that the rocks are a major element of the Adelaide Geosyncline. The thickness of the beds is probably greater than 30,000 feet and its dominant facies are comparable with the Alpine Flysch.

2. Under conditions of such a thickness of sediments a low grade of metamorphism may have occurred.

3. Igneous activity gave rise to localised highs of metamorphism during the early stages of folding. Almandine garnets and staurolite were formed under conditions of stress and temperature in favourable beds. Quartz intrusions would probably be associated with this period. The quartz would be high temperature quartz.

4. Jointing, foliation of rocks and fracturing of rocks.

5. Stress conditions released, but temperature remained with the formation of small regional (A70-76) andalusites along the bedding in favourable beds. (One would have to assume that there is an igneous body near the area - either connected with the granite body at Murray Bridge which lies about 10 miles to the east or the solutions that granitised sediments at Monarto - 7 miles to the north east).

6. Mineralising quartz has brought about recrystallisation in the area producing large andalusites (A70-49) that have pushed aside the foliation. In places the quartz has forced the foliation aside.

7. Period of Erosion, resulting in peneplanation and secondary enrichment of the ore deposits.

Formation of superficial laterite during this period.

8. Pliocene - Pleistocene Faulting (Bremer Fault)

9. Deposition of gravel-like material and Kunkar.

10. Erosion continuing to enrich the ores and alluvium being deposited.

Outside the area of high grade metamorphism (garnet-staurolite-andalusite) a variation in metamorphism is noted. The variation in sediments could accoubt for this feature.

Two periods of quartz have been mentioned in the history of the area. It is possible that more than two periods of quartz intrusions occurred.

Quartz outcrops occur as shown on the "Fact" map accompanying the report. The quartz can be divided into 5 types.

1. Milky white quartz that outcrops along the bedding in bodies up to 2 feet in width and as much as 50 yards in length. This quartz is fractured. During the early part of mapping the fracture directions were noted, but the strikes and dips of the fractures gave no particular pattern, although there is a fracture striking E - W that could be connected with the E-W joint in the area.
The early miners have not worked this quartz.

2. Quartz "blows" up to 15 feet in diameter and are milky white in colour similar to the quartz described above. This quartz is highly fractured and has not been worked for minerals.

3. Quartz showing parallel and intersecting planes. The planes vary in colour. The quartz is more translucent than the milky quartz and is best seen near the Paringa & West Kanmantoo mines.

4. Mineralised quartz is more quartzitic and crystalline in appearance. Fracturing is not as prominent as in the other quartz. Very little mineralising quartz is to be found but it was observed in the Aclare adit in places between 800 feet and nearly to a 1,000 feet. Fallen material prevented inspection further along the adit.

5. In the southern portion of the area quartz was observed to occur in small lenticular joints up to 1 inch in width and 8 feet in length. This quartz could be segregation quartz.

The reasons for considering some of the quartz to be high temperature will be listed when describing the mineralisation.

Although 5 types of quartz occur, the milky quartz and lineated quartz are given a pre-fracturing age while the mineralising quartz is post-jointing and post foliation. Large andalusite crystals are associated with the mineralising quartz. These large crystals occur along bedding planes and across the bedding and in all instances force the foliation aside.

Structure

(a) Folding

Under conditions of deep burial the beds became plastic and were folded into a south pitching syncline with drag folding and crenulations on the limbs. Minor anticlines and synclines have been mapped within the syncline (See Fig. 2) Micro folding is noted and is associated with the S-E plunging lineation (see hand specimen A70-122W).

The plunge of the beds varies between 20° to the south to near vertical to the south. The axial plane strikes N-S approximately and is near the vertical.

In the west the beds dip at 40° to 85° to the east with some overturning, while the beds in the east strike E-W approximately and are covered with alluvium. To the east of the mapped area the Bremer Fault strikes N-S approximately.

Beds on the eastern limb of a tightly folded syncline just to the south and to the east of Kanmantoo township are overturned. Bedding-cleavage relationship could not be observed, but the structure is such that the beds on the limb must be overturned for a short distance. Near the Roper and Boundary shafts at the Kanmantoo mine the beds are dragged under where they turn in strike and now dip to the north giving the impression of a pitch reversal.

Drag folding has occurred in both the incompetent argillaceous sediments and in the relatively competent siliceous schists.

The oldest beds outcrop in the west and north. There is no marked horizon or definite division of sediments, excepting that more shales and highly siliceous sediments outcrop in the south.

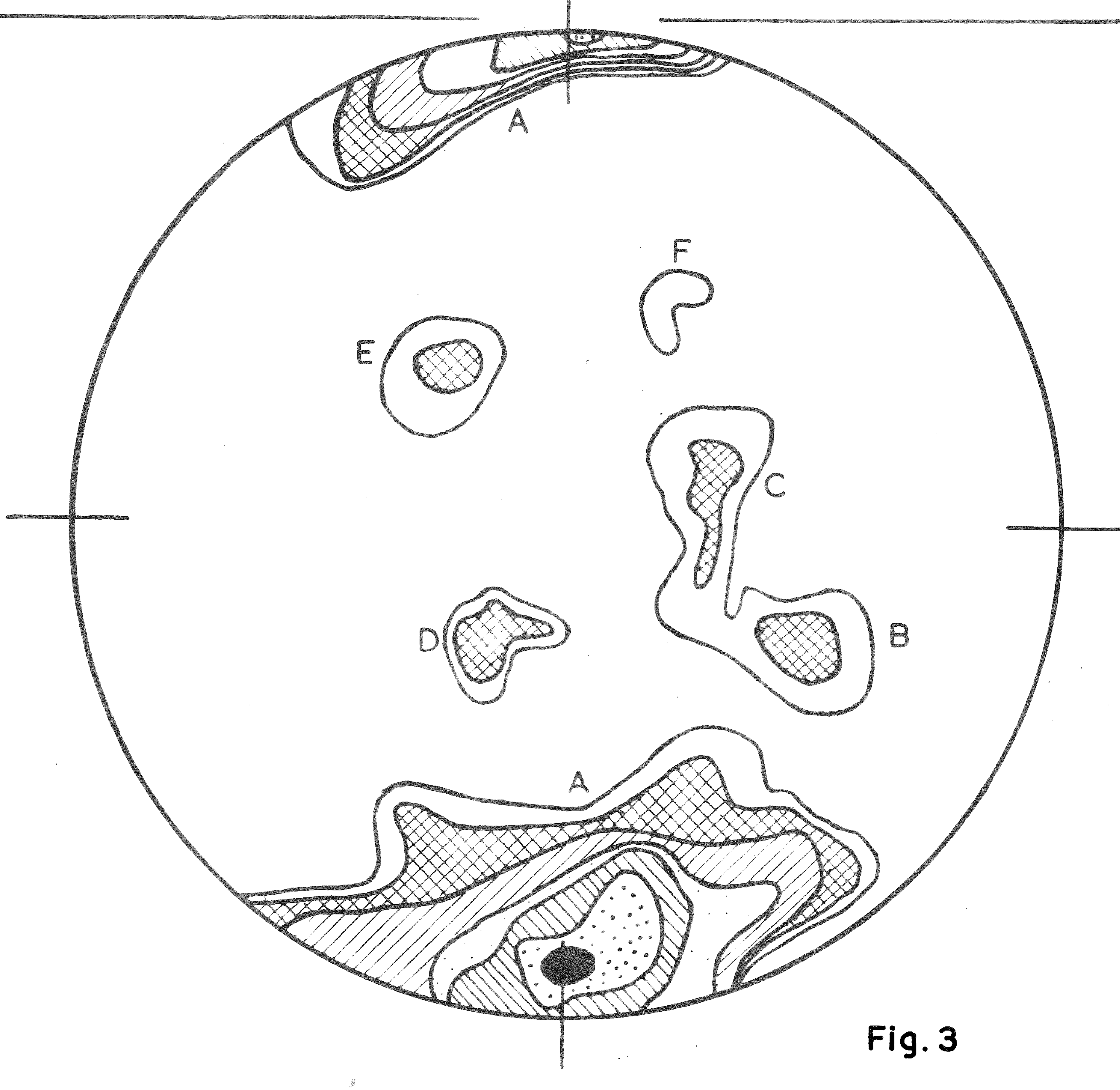


Fig. 3

243 POLES OF JOINTS. PLOTTED ON EQUAL-AREA NET
[LOWER HEMISPHERE PROJ.]

CONTOURS 1%, 1½%, 2%, 4%, 8%, 12%, 16%.

A. MAIN JOINT SYSTEM STRIKE APPROX. 90° DIP APPROX. 80°N.
B. STRIKE 205° DIP 40°W
C. STRIKE 175° DIP 25°W.
D. STRIKE 125° DIP 20°N.
E. STRIKE 55° DIP 35°E.
F. STRIKE 110° DIP 40°S.

Occasionally the white (slightly iron stained) sericite schists can be followed for a few hundred yards. Whether the beds lens out or whether the incompetent sericite schists continue along the strike cannot be determined with certainty. However in a railway cutting to the S-E of the Kanmantoo mines three sericite beds are disclosed, whereas these beds are not seen on the surface, therefore indicating that the beds need not lens out along the strike. Lensing out of siliceous schists in sandy schists can be observed in the Aclare adit from 480 feet to 580 feet from the entrance.

No large faults were mapped, but small movements down the bedding planes have been noted. A small iron stain fault (6 feet) striking E-W was observed on the roadway near the Kanmantoo workings.

(b) Jointing.

The poles of the joints mapped have been plotted on an equal area map using the lower hemisphere. Six joints systems occur in the area (See Fig. 3). Although the E-W striking joint system dipping 80°N is the most prominent on the plot, it is necessary to point out that this joint is very prominent in the field and one has a tendency to map it in preference to other not so well defined joints.

As the fold axis strikes N-S, the E-W joint dipping steeply north could be the A-C joint of the strain ellipsoid. Only in one place was movement observed on a joint, (377 feet in the Aclare adit). The movement was a few inches and the joint almost horizontal.

With the six joint systems,

1	A	strike	90°	Dip	80°N
2.	B	"	205°	"	40°W
3	C	"	175°	"	25°W
4	D	"	125°	"	20°N
5	E	"	55°	"	35°E
6	F	"	110°	"	40°S

and no movement on the joints it is difficult to tie the joints in with the directions of a strain ellipsoid.

Quartz often fills the E-W joint, but nowhere in the area could quartz be observed filling the other joints.

Mineralisation has been noted to be present in the E-W joint. (This will be discussed under mineralisation).

There is a very prominent S-E lineation in the area which is not parallel to the fold axis; probably the joint striking 205°, dip 40°W being at right angles (approx.) to this lineation may be indicative of a later slight movements.

Creeks often follow joint direction.

(c) Foliation

Foliation is generally parallel to the bedding which strikes between north and020°, but where there is a turn in bedding the foliation cuts the bedding. The strike of the foliation in the west lies between north and 020°, but in the east the strike is near north. Undoubtedly the attitude of the beds in the west has influenced the strike of the foliation. Foliation is best seen in the sandy schists and micaceous rocks but not well shown in the harder siliceous rocks. The foliation dips from 45° to 85° to the east. Even where the east limb of the tightly folded syncline near the Kanmantoo mine dips west steeply, the foliation still dips east steeply.

(d) Lineation

Lineations measured in the foliation plane plunge to the south east and to the south (See Fig. 4)

The plunge of the S-E (120) lineation is variable, but in general it is 65°. This lineation is associated with micro-folding in places, (see hand specimens A70-122W and A70-C4) in other instances the lineation appears to be the result of slippage or the intersection of cleavage and bedding or foliation planes. As mentioned under jointing; the joint striking 205° and dipping 40°W may be associated with this lineation. As some of the S-E lineations are associated with micro-folding it is possible that a movement may have occurred while the rocks were still in a plastic condition. (If the Bremer Fault existed in Palaeozoic time a slight movement could have taken place to produce the micro-folding which produced the lineation).

The south (175°) lineation corresponds with the direction of the fold axis. This lineation appears to be due to intersecting planes rather than mineral elongations. Folding of the beds would produce this lineation. At no place could the plunge of the bedding and the plunge of the lineation be observed together to determine if the plunge of the lineation may be slightly steeper than the plunge of bedding as noted in other parts of the Kanmantoo Group.

(e) <u>Shear Cleavage</u>

Shear Cleavage is used in the sense as described in the Journal of Geology (1940). "This type of cleavage consists of roughly parallel, closely spaced surfaces of shear displacement on which platy minerals may have developed and into which they may have been dragged.

When spacing is unusually close, shear cleavage may simulate and be easily confused with flow cleavage.

Shear cleavage may be developed in rocks having earlier flow cleavage or bedding foliation. Shear can be either parallel to the flow cleavage or it can cut the flow cleavage at a large angle."

The [illegible] cleavage dips steeply to the east, but occasionally it dips steeply to the west. In general the strike of the shear cleavage is the same as the strike of the foliation.

Particular attention was paid to shear cleavage and foliation, as most ore bodies strike in a N-S (approx.) direction, [illegible]

Shear cleavage is not well shown in the hard siliceous beds but is well defined in the incompetent beds.

Small movements down the foliation planes were noted; these movements would produce the shear cleavage throughout the area. As most mine workings are inaccessible one cannot say that the shear cleavage cuts the foliation. In the underground workings the foliation is well defined, but the shear cleavage was not pronounced or not showing at all. The shear cleavage and foliation cause the

THE PLOT OF 18 LINEATIONS

PLOTTED ON EQUAL AREA NET

CONTOURS 5%. 11%. 22%. 33%. 44%.

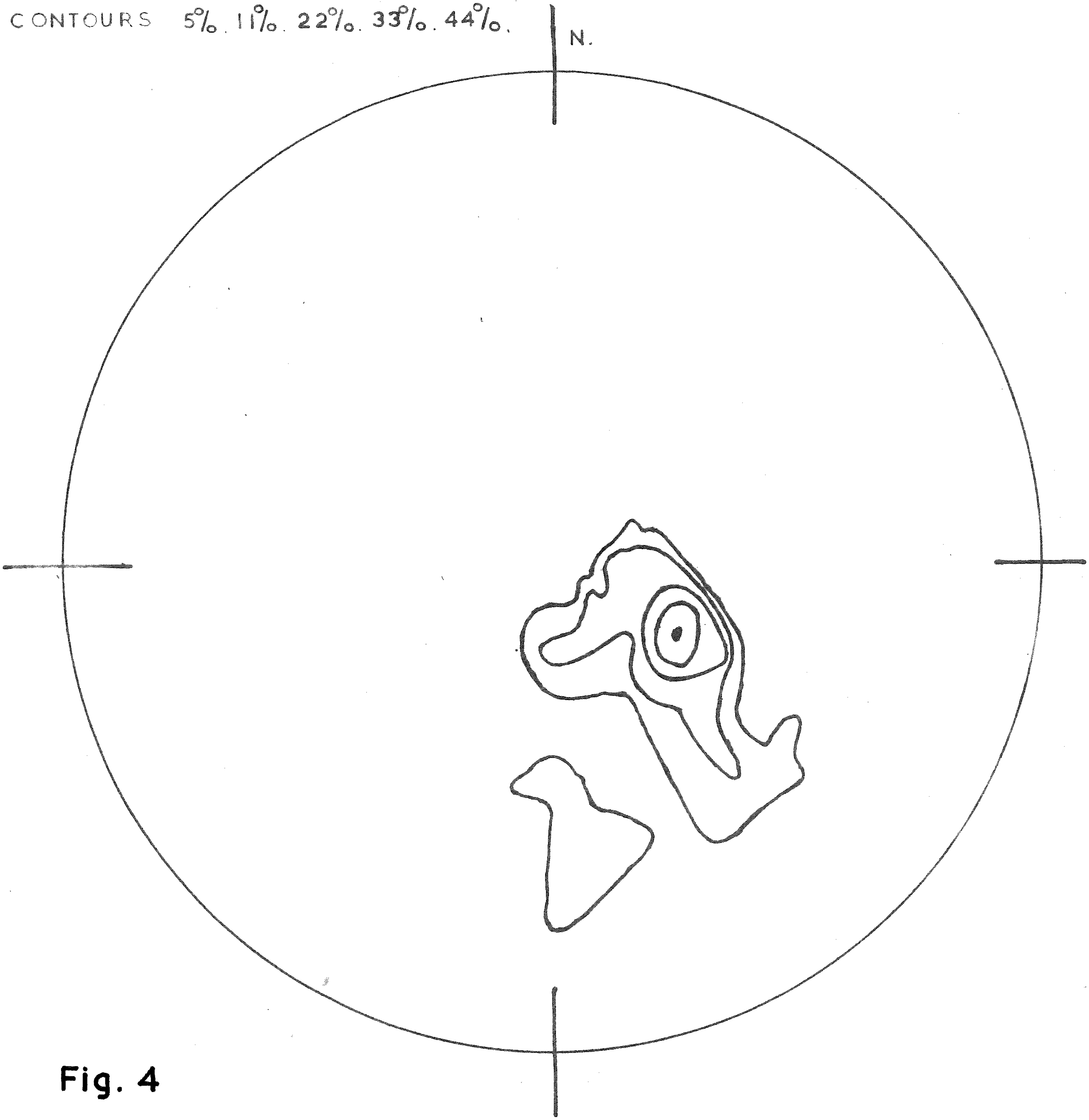


Fig. 4

A. MAIN LINEATION. STRIKE 120° PLUNGE 65° S.E.

B. SUBSIDIARY LINEATION. STRIKE 175° PLUNGE 40° S.

beds to be broken badly where the beds turn in strike towards the east or west.

For some time it was thought that the foliation and shear cleavage were the same structures, however in some shaly beds the closely spaced parallel shears were observed, but the foliation was hardly developed. When surface mapping an occasional steep west dip was mapped, but in no place in the area could foliation be found to be dipping to the west.

Probably the foliation controlled the shear cleavage.

Origin of the ore deposits.

Copper, lead, zinc, silver, arsenic and gold are the economic minerals that were mined in the area. Siliceous sediments have been quarried near Kanmantoo for road metal. Copper was the chief economic mineral. The type of minerals mined will be discussed when describing the separate mines.

Data obtained from literature and from observations in the field revealed that the ore minerals are associated with small hypogene quartz veins and stringers.

In most cases the veins follow the bedding or foliation, but some veins are near the vertical. Small irregular veins have been mined out as a whole.

It is considered that the mineral bearing quartz is a later phase of igneous activity to the NE and E of the area. (The Monarto and Murray Bridge granites). By association of minerals and the type of structure shown, a hypothermal to mesothermal origin of the ores is given according to Lindgren's Classification. Quartz is the gangue mineral.

It is necessary to point out that the arsenopyrite, gold and copper minerals would be nearer to the igneous bodies than the lead, zinc ore bodies of Wheal Margaret and Aclare. This would be in keeping with the zones as listed by Emmons (Gold Deposits of the World)

The reasons for considering the mineralising quartz and the lineated quartz to be high temperature are:

1. The production of large andalusites near the mineralising quartz in favourable beds. Even small quartz stringers often show andalusite crystals forming on the edges.

2. Magnetite and specularite were found in a piece of quartz on the surface at the Kanmantoo mines.

3. ex-solution bodies of chalcopyrite in sphalerite have been described by Mr. Whittle (personal communication). This is not a definite criteria for high temperature, but it must be listed as a possibility.

4. Some quartz exhibited pseudo-cleavage planes, parallel and intersecting. Elsewhere in Australia these pseudo-cleavage planes are observed in quartz of magmatic origin, that is the end products of acid igneous intrusion. (In this case it would be a magmatic quartz) (A.A. Gibson, personal communication)

5. In many cases where the mineralised quartz contacts sediments a layer of biotite is formed. This could be an indication of high temperature (Lindgren 1933)

6. Tourmaline was noticed in pieces of quartz lying on the surface to the east of the Wheal Friendship mine and at the Kanmantoo mine.

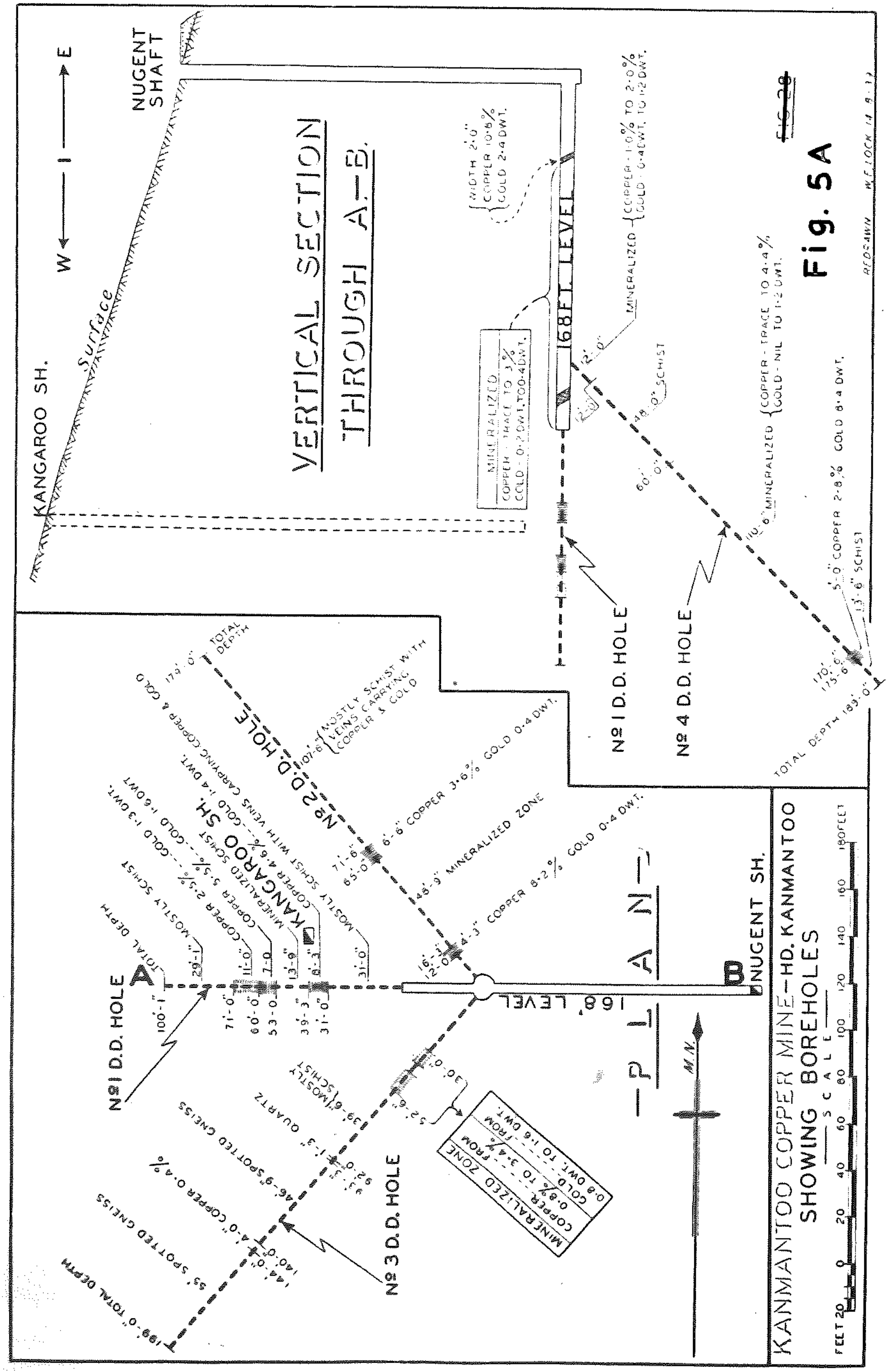
No pegmatites were mapped. Mica is not associated with the quartz and only one specimen revealed feldspar (Oligoclase).

7. Association of economic minerals in quartz could be indicative of high temperature.

The ore deposits occur with the quartz, also in the country rock along foliation planes, while some chalcopyrite occurs as a replacement mineral in the sediments and in many places the copper solutions derived by oxidation have impregnated the schists.

Relationship of Ore bodies to Structure:

It can be seen from Fig:- 2 that there is the possibility that the Aclare, Wheal Fortune, Paringa, Kanmantoo, Wheal Friendship and Wheal Maria mineralisation may be associated with a series of beds passing through these mines. On the other hand there is no particular series of beds through the Bremer-Wheal Prosper and Pioneer mines. The mineralisation in each mine area will be



above, was published in *Mining Review*, No. 70, p. 65. It shows the assay results of lodes intersected by the diamond drilling carried out by the Austral Development Company, and the relative positions of the lodes. It will be noted in this figure that, besides copper, the gold contents of the lodes are given. In the old reports on the Kanmantoo Mine the presence of

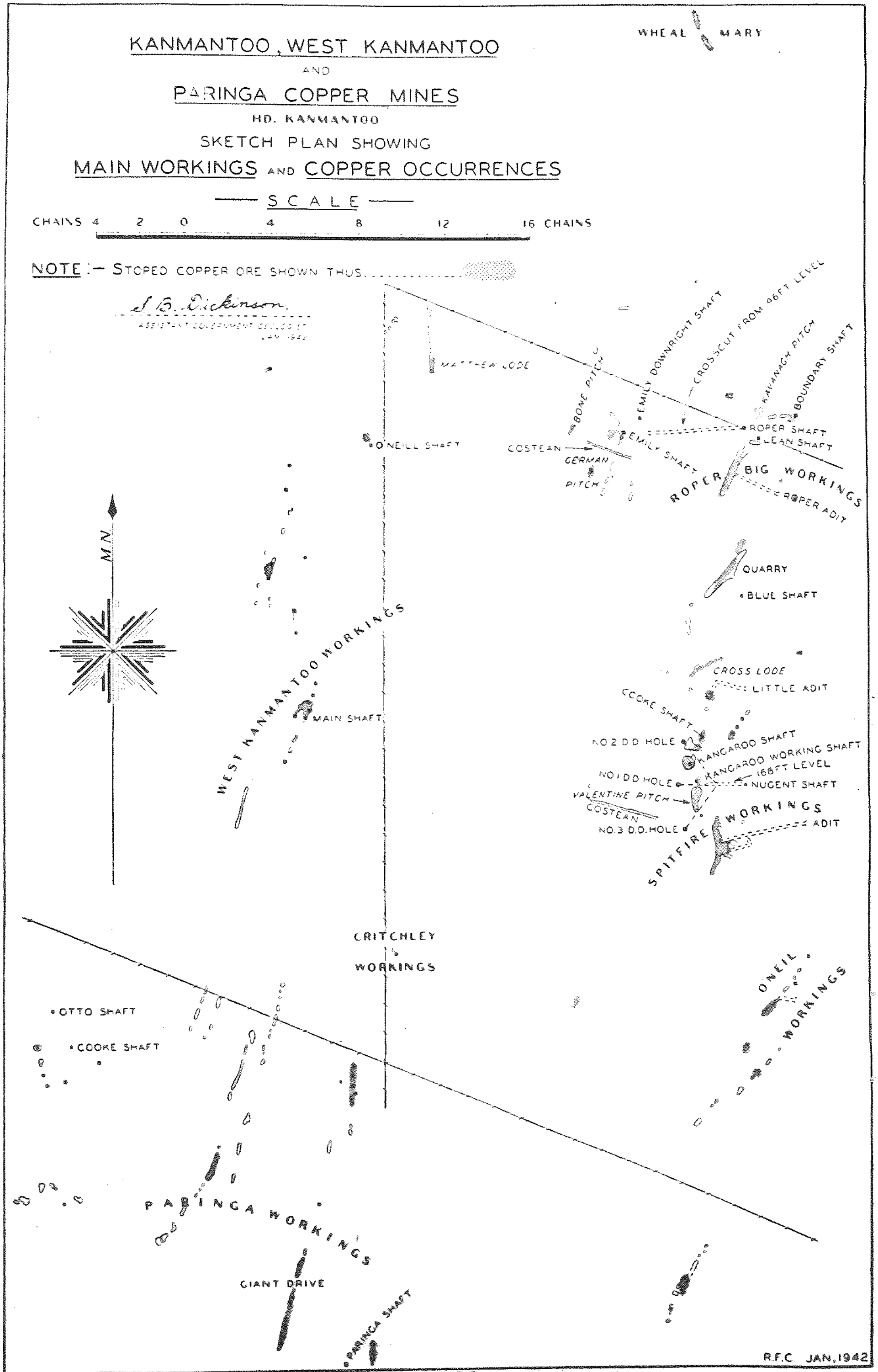

KANMANTOO, WEST KANMANTOO
AND
PARINGA COPPER MINES
HD. KANMANTOO
SKETCH PLAN SHOWING
MAIN WORKINGS AND COPPER OCCURRENCES
SCALE
CHAINS 4 2 0 4 8 12 16 CHAINS
NOTE :— STOPED COPPER ORE SHOWN THUS
S. B. Dickinson
ASSISTANT GOVERNMENT GEOLOGIST
WHEAL MARY
MATTHEW LODE
O'NEILL SHAFT
M.N.
BONE PITCH
EMILY DOWNRIGHT SHAFT
CROSSCUT FROM 96FT LEVEL
KAVANAGH PITCH
BOUNDARY SHAFT
ROPER SHAFT
LEAN SHAFT
COSTEAN
EMILY SHAFT
GERMAN PITCH
ROPER BIG WORKINGS
ROPER ADIT
QUARRY
BLUE SHAFT
CROSS LODE
LITTLE ADIT
COOKE SHAFT
NO 2 D.D. HOLE
KANGAROO SHAFT
KANGAROO WORKING SHAFT
168FT LEVEL
NO 1 D.D. HOLE
NUGENT SHAFT
VALENTINE PITCH
COSTEAN
NO.3 D.D. HOLE
SPITFIRE WORKINGS
ADIT
WEST KANMANTOO WORKINGS
MAIN SHAFT
CRITCHLEY WORKINGS
O'NEIL WORKINGS
OTTO SHAFT
COOKE SHAFT
PARINGA WORKINGS
GIANT DRIVE
PARINGA SHAFT
R.F.C. JAN, 1942

FIG 25

Fig. 5 B


NAIRNE CREEK
138
KANMANTOO TRIG.
124W
110
111
C8
KANMANTOO MINES
112
113
C9
C5
C4
C7
117
116
115
123W
122W
WEST KANMANTOO
120W
A70-K.M.
122
123
125
126
124
127
128
C11
WHEAL FRIENDSHIP
WHEAL MARIA
134
135
M.N.
119W
121W
PARINGA
139
129
130
131
128W
A70-P.M.
25
21
9
8
7
23
3
93
92
WHEAL MARGARET
127W
SCOTT'S CREEK
125
31
38
48
49
16
17
WHEAL FORTUNE
65
67
46
63
69
76
80
WHEAL PROSPER
C10
102
103
137
136
MARBLE TRIG.
142
126W
125
R4
BREMER MINE
104
MT. BARKER CREEK
R2
140
145
107
143
PIONEER
114
CALLINGTON
101
147
99
100
C3
ACLARE MINE
144
BREMER RIVER
C36
C28
109
C37
C33
C29
C30
120
119
JUNCTION TRIG.
121B
C27
118
C25
C19
C26
121A
121
Fig.6
SPECIMEN LOCALITY MAP
PETROLOGY STUDENTS HAVE CUT SLIDES OF THE SPECIMENS UNDERLINED.
R.GRASSO.
J.B.McMANUS.
1954.
fig 6

described separately.

a. Kanmantoo mine

Most of the lodes strike N-S approx. and dip east although the Boundary lode strikes E-W. One vein striking N-E was encountered. This vein was located 90 feet in the cross cut striking west from the bottom of the Nugent Shaft (See Fig. 5A)

The ore bodies are generally pipe-like, with the largest ore-shoot being 12 feet wide and 14 feet long at 78 feet in the Kangaroo lode. There are nine main lodes in the Kanmantoo mine, namely the Kangaroo, Emily, Boundary, Spitfire, Giles, Emu, Rundle, Rodda lode, Roper, Quarry and cross lodes. The three first mentioned produced the most ore. (19,000 tons of ore were produced at the Kanmantoo mine)

No workings are below 170 feet, although diamond drilling had been carried out in 1938 by Austral Development Limited (See Fig. 5a 5b). The drilling assay values are marked on the figure. Number 4 drill hole was stopped on account of an inflow of water.

Several areas in the mine contain quartz stringers. These areas have been worked out as a whole.

Most of the ore recovered was in the oxidised zone. The ore values declined as the primary chalcopyrite was reached.

Copper carbonates and oxides, grey ore and chalcopyrite, plus a little gold and silver were mined. A chemical test revealed that the black oxide is tenorite, while the carbonates are malachite and azurite. The grey ore would probably be tetrahedrite. Black material that is often found on joint planes near the mines was tested and found to be manganese dioxide.

Assay values taken from dumps and old faces in the Kanmantoo mines are found in Mining Review 17, 1912, page 49. Assay values as high as 32.3 per cent copper were determined. Silver and gold were present.

During the mapping of the area the following grab samples were taken at the Kanmantoo mines (The specimen numbers can be found on Fig.6)

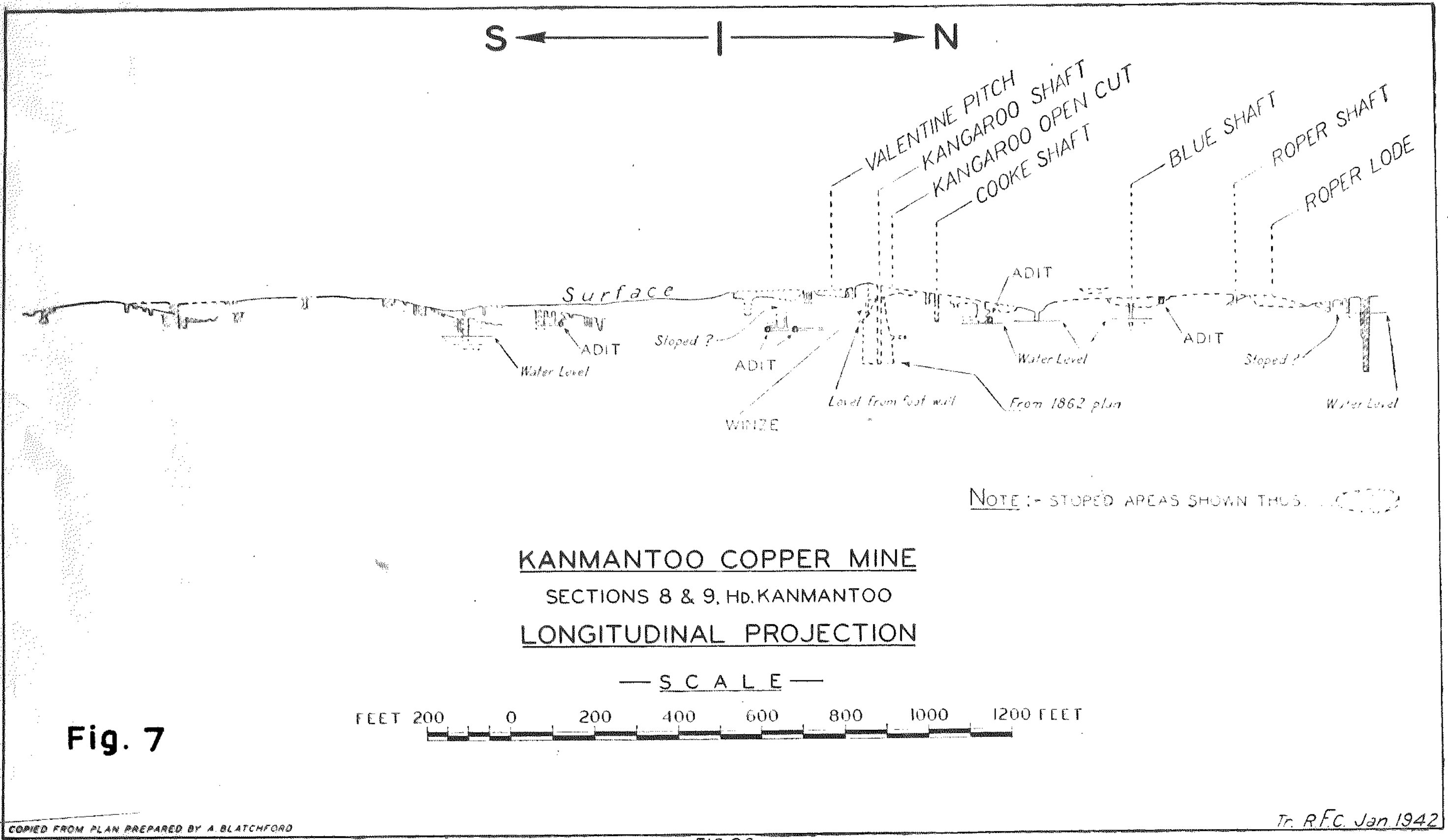

S
N
VALENTINE PITCH
KANGAROO SHAFT
KANGAROO OPEN CUT
COOKE SHAFT
BLUE SHAFT
ROPER SHAFT
ROPER LODE
Surface
ADIT
Water Level
Stoped ?
ADIT
WINZE
Level from foot wall
From 1862 plan
ADIT
Water Level
ADIT
Stoped ?
Water Level
NOTE :- STOPED AREAS SHOWN THUS
KANMANTOO COPPER MINE
SECTIONS 8 & 9, HD. KANMANTOO
LONGITUDINAL PROJECTION
— SCALE —
FEET 200 0 200 400 600 800 1000 1200 FEET
Fig. 7
COPIED FROM PLAN PREPARED BY A. BLATCHFORD
Tr. R.F.C. Jan 1942

FIG 26

A 70-111	Assay done on Pyrite crystal in quartz	0.3%	Copper
A 70-112	Schist	0.3%	Copper
A 70-112	Chalcopyrite in siliceous rock	2.5%	"
A 70-115	Oxide in schist	5.5%	"
A 70-121W	Carbonates in schist	32.5%	"
A 70-128	Oxide in schist	6.0%	"
A 70-128	(Another Specimen) Oxide in schist	15.0%	"
A 70-131	Quartz with black oxide	0.2%	"

Silver and gold was not tested for in these samples.

In the most productive areas and deepest workings of the Kanmantoo mine (See Fig. 7), that is near the Kangaroo shaft and Roper Shaft, there is a turn in strike of the beds in each case. Near the Boundary Roper and Boundary shafts the beds are folded tightly and dragged under to the north. The ore body appears to be pitching north. As the Boundary lode strikes E-W it is possible that the bedding direction and E-W joint may coincide in places.

Near the Kangaroo lode a drag fold has been mapped. This drag fold pitches south, and the ore bodies appear to have pitched south.

Wherever a little mineralising quartz remained in the workings at Kanmantoo it was observed to favour a sandy bed between the more micaceous andalusite bearing beds.

Mining reports of the mine do not reveal whether there are small sandy beds between the micaceous beds. When the diamond drill hole and cross-cut information was published it only disclosed that the hole passed through country rock or garnet schists or mineralised schist.

Intersecting fractures could have localised the ore. (S.B. Dickinson 1942) Undoubtedly the pipe-like nature of the ore-bodies in places would suggest that intersecting fractures localised the ore.

As small stringers of quartz occur in the sandy schists between the andalusite bearing micaceous beds it is thought that more detailed mapping in the early mining days may have proved whether this was so at depth.

In both the highest mineralised areas of the Kanmantoo mine small tight folds have been mapped.

A combination of these 3 factors may have localised mineralisation.

1. Intersecting fractures
   (shear cleavage with a joint)
2. a favourable bed.
3. Small tight folds or drag folds.

(b) West Kanmantoo.

Copper was the mineral mined at West Kanmantoo. Like the Kanmantoo mine, copper carbonates, oxides and sulphides, were extracted.

Cooke shaft reached a depth of 168 feet. The shaft follows the lode and dips to the east at 80°. The lode strike N-S (approx.). No information can be obtained to determine the dimensions of the ore bodies, but the lode was 3 feet wide with 1 foot on the hanging wall mineralised and only 3 inches to 4 inches on the foot wall contained ore. Very high grade carbonate ore was located on the 132 ft. level.

Small stringers of quartz were observed to favour a garnet bearing Sandy bed between the andalusite bearing beds. Here again, similar to Kanmantoo, these sandy beds may asssist in localising the ore. No minor folding could be detected at this mine.

(c) Paringa.

Paringa and West Kanmantoo mines are situated on the western side of the ridge dividing these mines from the Kanmantoo mine.

Copper was the main mineral mined, but some black lead carbonate was located.

Most of the vein and pipe-like lodes strike N-S (approx.) but in the S-W portion of the Paringa mine area the workings follow an E-W direction. No minor folding could be mapped to coincide with the E-W joint direction.

The Paringa shaft reached a depth of 255 feet. At the 240 ft. level cross-cutting east (200 feet) and west (180 feet) has been carried out.

Assays values obtained in the Giant grave lode indicated that the hanging was well mineralised and the footwall poorly mineralised.

Copper carbonate tetrahedrite, and some cuprite were the main copper minerals found.

Information obtained from (Record of Mines, 1908) indicates "high grade ore occurs where quartz veins cross the metal-bearing strata". Close inspection of the small quartz mineralised stringers in the eastern portion remaining at Paringa revealed that they favoured a sandy schist. In general the quartz veins did not cross the strata but run parallel to it. In places the lode was 5 ft to 6 ft wide.

As the lode strike directions in the S-W portion coincide with the prominent joint direction it may be assumed that mineralising quartz could favour a joint.

Assay values as high as 29% copper, 24% lead and 24.5 ozs. of silver per ton were obtained. Up to 1908 only 900 tons of ore were raised.

(d) <u>Wheal Fortune</u>

These small workings strike parallel to the bedding and dip steeply to the east. The mine is a few hundred yards south of the Kanmantoo mine. "Gophering" would be the term to use when describing the mining method.

No published information could be located. Copper stains and oxides were noticed on the surface and in the dumps.

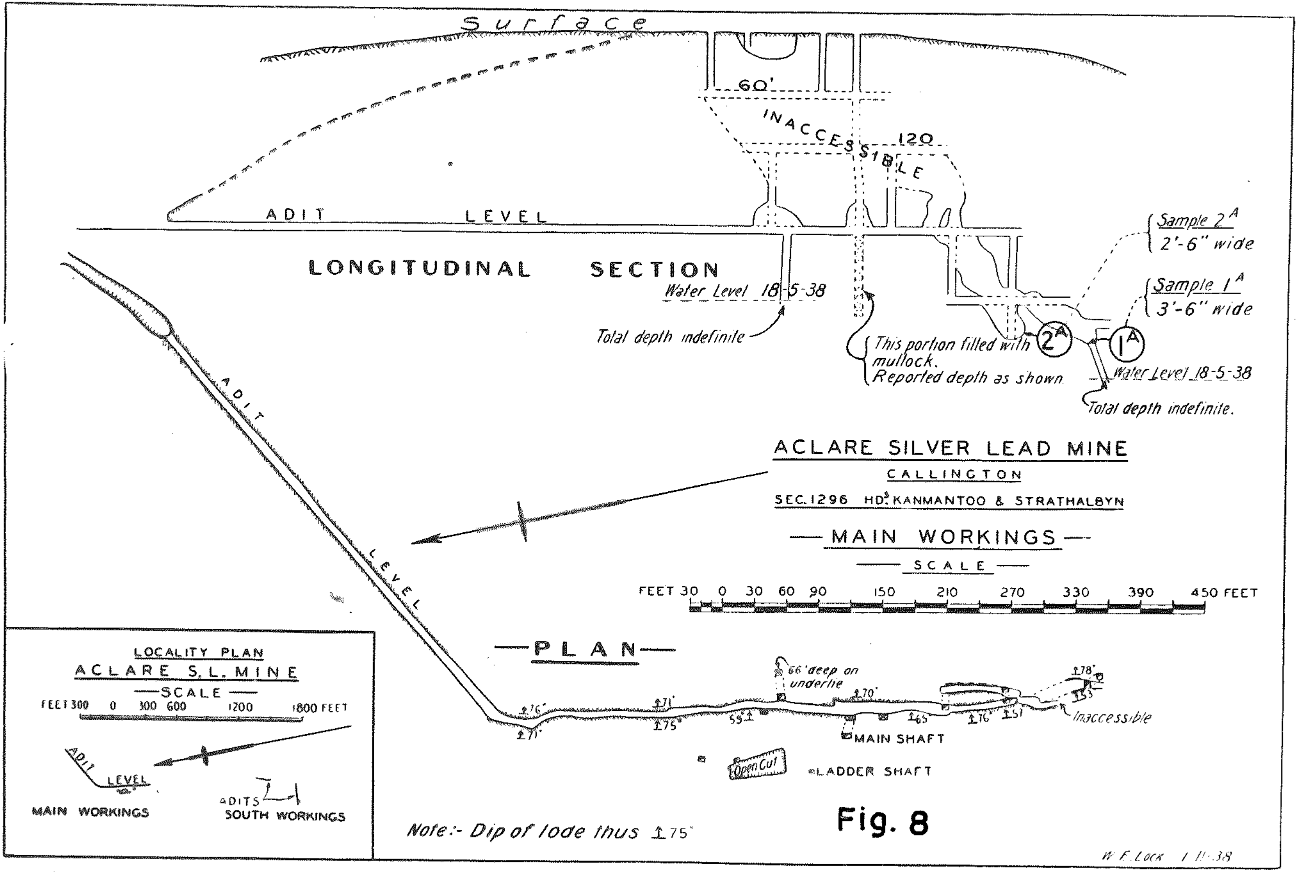
In this area the biotite layers along the quartz contacts can be observed. Manganese dioxide stained joint planes.

(e) <u>Wheal Margaret.</u>

Small shafts dip to the east in this area. Lead, zinc and copper minerals were found on the surface. In the hand specimens primary lead and zinc sulphides can be seen, but the copper is oxidised. The ore can be seen to favour the schist beds as well as being associated with the quartz. As no data is available relating to this mine, it can be assumed that the ore bodies dip east and strike parallel to the bedding (010^{o}).

(f) <u>Aclare Mine</u>

Aclare is one of the 3 large mines in the area (Kanmantoo, Bremer and Aclare). There were 9 lodes in this mine, striking 010^{o} and dipping 70^{o}E east, being the same strike and dip as the


Surface
60'
INACCESSIBLE
120
ADIT LEVEL
LONGITUDINAL SECTION
Water Level 18-5-38
Total depth indefinite
This portion filled with mullock. Reported depth as shown
Sample 2A 2'-6" wide
Sample 1A 3'-6" wide
Water Level 18-5-38
Total depth indefinite.
ACLARE SILVER LEAD MINE
CALLINGTON
SEC.1296 HDS. KANMANTOO & STRATHALBYN
MAIN WORKINGS
SCALE
FEET 30 0 30 60 90 150 210 270 330 390 450 FEET
ADIT LEVEL
PLAN
66' deep on underlie
Inaccessible
MAIN SHAFT
LADDER SHAFT
Open Cut
LOCALITY PLAN
ACLARE S.L. MINE
SCALE
FEET 300 0 300 600 1200 1800 FEET
ADIT LEVEL
MAIN WORKINGS
ADITS
SOUTH WORKINGS
Note:- Dip of lode thus 75°
Fig. 8
W. F. Lock 1-11-38

Aclare Mine.

sediments. The minerals occur associated with quartz in siliceous schists and in white quartzite beds. A gossan material is associated with the white quartzitic bed.

Lead, zinc, silver, arsenic and a little copper has been mined. The minerals were present as sphalerite, galena, a little antimony, gold, silver and nickel were found at depth (1937).

F.L. Stillwell (1937) did a mineragraphic study of the ore in a siliceous schist.

It was noted that the sphalerite contained some tetrahedrite; this is common in mineralisation.

Very rich ore was removed from this mine; down to 30 feet 50% lead and 90 ozs silver per ton were recovered from the ore bodies. From 30 feet to 114 feet very little lead was found, but 40% zinc and 60 ozs to 302 ozs silver per ton were removed.

As can be seen from figure (8) the ore bodies in general pitch south.

The workings are down to 300 feet (approx.) in the southern portion of the lode.

Literature relating to the mine indicates that there is ore remaining at depth to the south of the main shaft. Stoping of the ore bodies ceased as it was difficult to raise the ore to a level where it could be transported to the shaft. The intention was to sink a new shaft to the south of the present main shaft. This shaft was not sunk and as far as can be ascertained no further work has been done in the stopes.

(The owner of Alambie Homestead in the West of the area thought that work had been carried out underground in the Aclare mine since 1945. He thought that Zinc Corporation Ltd. did the work. If this is so then there is the possibility that further drilling had been done in the southern portion of the mine.)

In the Mining Review Number 68 it is stated that samples taken from a stope 100 feet below the tunnel (that is 280 feet) and 200 feet south of the shaft assayed 2.9% lead, 10.9% zinc and 12 ozd 6 cwt of silver per ton. Another taken 90' below the tunnel (that is 270 feet) and 150 feet south assayed 2.3% lead, 16.2% zinc and 14 ozs 1 cwt of silver per ton. A trace of gold was in both samples. It was also stated that this ore could be concentrated by flotation methods.

In places the ore bodies reach 7 feet in width with weaker mineralisation on the foot and hang walls up to 36 feet.

It is possible to travel along the adit (See Fig. 8) for over 900 feet; at 800 ft. approx. to over 900 feet (where filling blocks the adit) small amounts of lead, zinc and copper (chalcopyrite were observed. The specimens taken were not assayed, although specimens A70-C3 taken from the surface earlier gave 3.9% lead 0.3% copper and no silver.

Mineralisation in the adit favoured sandy and siliceous schists There is some confusion in the literature relating to the mine. In the Record of Mines, 1908, it is stated in that the lodes have an underlie of 2½ in the fatham. This underlie would be near 70°E. Further down page 162 it is mentioned that the ore shoots dip at 30°E and also on the same page it mentioned that the lode has an underlie of 1 in 3; this would give a dip of near 70°E. It is almost certain that term dip as used in the Record of Mines should be pitch.

(g) Bremer Mine

Unlike the six mines mentioned above the Bremer Mine is not associated with the western limb of the regional syncline. Large andalusites are not associated with the mine.

The mine occurs in the trough of the regional syncline, with sandy schists and many shales in the area. The beds vary in strike and outcrops are not numerous.

There were two lodes at the Bremer mine both striking NW with a west underlie of 2 in 6 (70°W approx.). Boundy's lode is 350 feet to the east of the Bremer lode.

S.B. Dickinson (1942) stated that the lodes occupy fault fissure This information must have been obtained from old company reports or newspapers as itis not available in the Record of Mines or Mining Reviews.

Workings in the mine reached a depth of 618 feet where ore values become much less (2% - 3% copper) approximately 20,000 tons of ore were raised and values as high as 25% to 30% copper were obtained. Chalcocite and azurite were the main minerals, also chalcopyrite, tenorite, bornite arsenopyrite and bismuth.

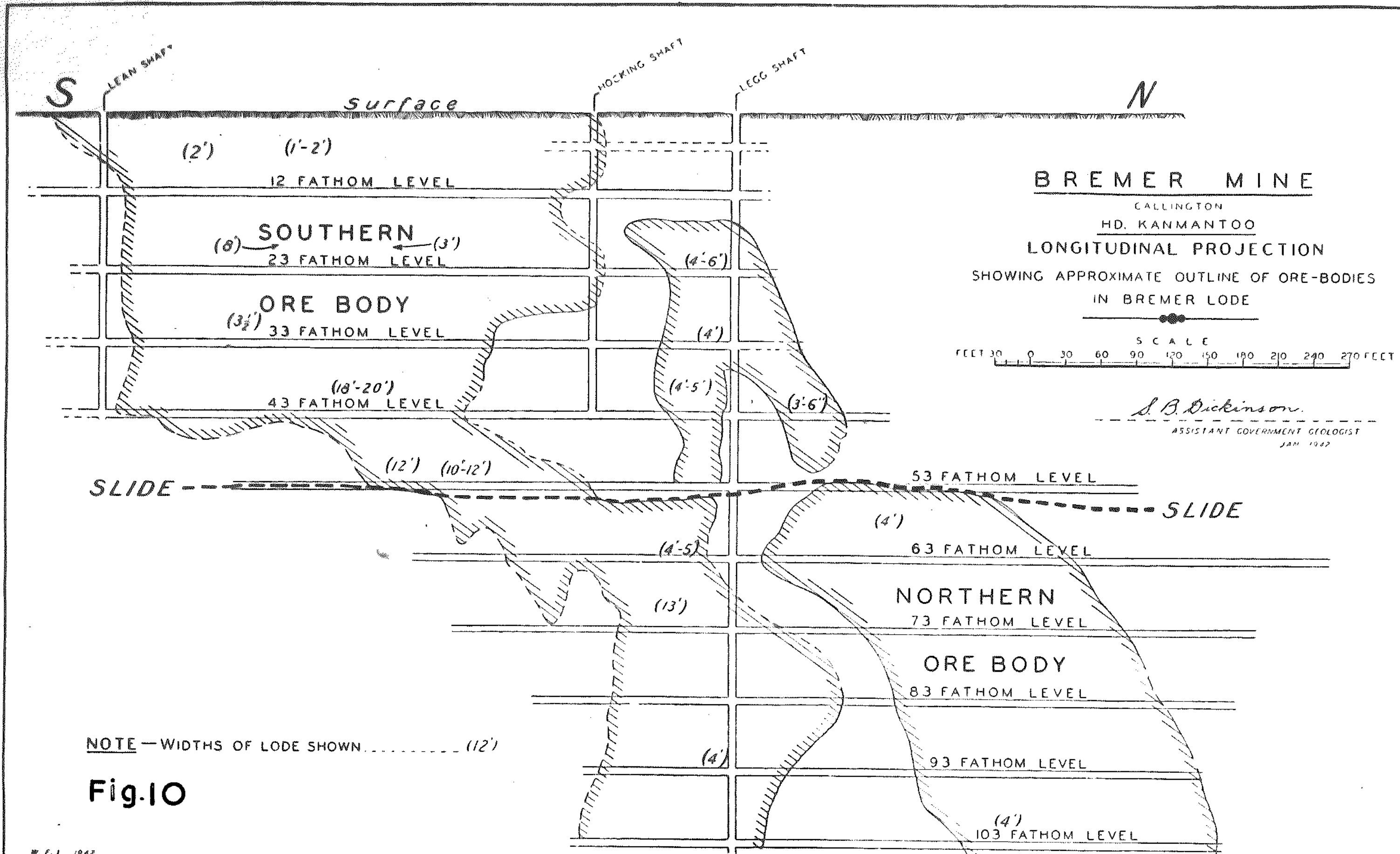

BREMER MINE
CALLINGTON
HD. KANMANTOO
LONGITUDINAL PROJECTION
SHOWING APPROXIMATE OUTLINE OF ORE-BODIES
IN BREMER LODE
SCALE
FEET 30 0 30 60 90 120 150 180 210 240 270 FEET
S. B. Dickinson.
ASSISTANT GOVERNMENT GEOLOGIST
JAN 1942
S
N
Surface
LEAN SHAFT
HOCKING SHAFT
LEGG SHAFT
12 FATHOM LEVEL
23 FATHOM LEVEL
33 FATHOM LEVEL
43 FATHOM LEVEL
53 FATHOM LEVEL
63 FATHOM LEVEL
73 FATHOM LEVEL
83 FATHOM LEVEL
93 FATHOM LEVEL
103 FATHOM LEVEL
SOUTHERN
ORE BODY
NORTHERN
ORE BODY
SLIDE
SLIDE
(2')
(1'-2')
(8)
(3')
(3½')
(18'-20')
(12')
(10'-12')
(4'-6')
(4')
(4'-5')
(3'-6")
(4')
(4'-5)
(13')
(4')
(4')
NOTE — WIDTHS OF LODE SHOWN .... (12')
Fig.10
W.E.L. 1942

FIG 27

Workings extending over 1200 feet in length. In the Bremer lode the ore persisted down to 618 feet. Two shoots were worked, one of these had a vertical extent of 300 feet and was 364 feet in length with a width of 1 foot to 2.5 feet.

The second shoot commenced at the 318 feet level and persisted to 618 feet where the grade diminished.

Boundy's lode to the east and extended over a distance of 350 feet. The grade was lower than in the Bremer lode.

No lodes were intersected when a cross-cut 200-300 feet was driven westward.

In general the whole ore body appears to pitch to the north (See Fig. 10)

If the ore did occur in fault fissures, there is a possibility that the shear cleavage may have produced these movements. When mapping in the field it was noted that the workings were along a line of bearing 330°. If this is an indication of the direction of the lode then the possibility of shear localising the ore is greater. In figure a slide is shown. If the word slide is used in the Cornish sense then movement on the slide would be near the horizontal and post vein material.

The ore in this mine is associated with quartz.

As large andalusites are not seen near this mine, it can be explained by the fact that small regional andalusites are not in the mine area, (but do occur to the north of the mine), therefore recrystallisation in favourable beds did not take place.

No surface data could be obtained for the localisation of minerals in the mine although from the structure it is unlikely that the lodes could line up with the bedding in places.

(h) <u>Pioneer.</u>

Gold and copper were mined in these small workings. The ore bodies strike NE with a slight dip NW and the lode is 3 feet to 5 feet wide. It is associated with ferruginous quartz, slates and Kaolin.

In the centre of the ferruginous shale the gold values is 1 dwt per ton. On the footwall side of lode in the Kaolin the gold value is 2 ozs 15 dwts, while the hanging wall ferruginous schist assay value is 3 dwts per ton. The gold has favoured the Kaolin rock

One shaft has a depth of 95 feet while the other has a depth of 100 feet vertical and 25 feet on the underlie.

In this mine the strike of the lodes does not coincide with the bedding. One of the joint systems in the area strike NNE and dips 40°N. No reason for mineralising can be given from observed facts.

An average value of 8 dwts of gold per ton was obtained, but the percentages of copper obtained could not be located.

Arsenic has also been mined in the Pioneer area. It occurs in a decomposed iron stained schist associated with an iron bearing rock and quartz enclosed in the country mica schist rock.

The workings are shallow (about 15 feet to 20 feet) and the assays show 29.9% arsenic with a trace of gold.

About 10 chains south and 3 chains north of the workings the presence of arsenic ore has been shown by trenching.

This mine may become important if for some reason the importing of arsenic into Australia is restricted or stopped completely.

(i) Wheal Prosper

Copper and gold were mined at Wheal Prosper. There is little or no mined material lying on the surface. The lodes cannot be related to the structure as no report or surface detail is available. Two shafts were sunk, one being 100 feet (approx.) and vertical, the other is 20 feet deep at the present time.

(j) Wheal Friendship

Quartz stringers in this area cannot be related with any certainty to the structure. The workings are small and copper was mined.

Two miners removed a few tons of ore during April, May and June of this year. A quartz stringer containing oxidised ore was followed for a few feet.

As mentioned previously it is possible that favourable beds pass through Wheal Maria, Wheal Friendship and along the western limb of the regional syncline. (See Fig. 2)

(k) Wheal Maria

Some copper was removed from this working. The working is now only a small depression with a slight copper stain. There are siliceous beds in the area, but outcrops are scarce. The Workhing Mining Company intended to test the Wheal Maria property, but sufficient funds were not available.

(l) Other Mine Workings.

Many shafts sunk in the area did not appear to have yielded any minerals. In the southern portion of the area it can be seen from the figure that there are unproductive workings. Miners have sunk shafts in iron stained beds probably hoping to find a repetition of gold deposits as found at the Pioneer mines.

Mining methods, detailed production figures and the history of the mines will not be discussed. The data can be obtained from Mining Reviews, Record of Mines, Geological Survey Bulletin and from the Mines Department of South Australia. The various Mining Reviews and Bulletin will be listed in the bibliography.

All mines in the area are in a state of disrepair and often filled with water.

Economic considerations.

If any economic ore-bodies are located in the area and mining commences then water, electricity, transport and second class timber are available.

Good water can be obtained at a shallow depth when the various creeks and the Bremer River are not flowing.

Electricity, if needed, could be connected to the workings at considerable expense; it would be cheaper to use some type of engine to produce electricity.

The main Melbourne-Adelaide railway line traverses the area. Ore could be removed more cheaply by rail than road, however supplies could be supplied by road.

No suitable timber is available at Callington, but second class mine timber would be available a few miles to the west.

CONCLUSION

Mineralisation in the Callington area is associated with high temperature hypogene quartz veins (mesothermal to hypothermal according to Lindgren's Classification). It is assumed that the mineralising solutions are derived from the igenous body (Murray Bridge granite) or granitising solutions (Monarto) which are found in the east and north east of the area. There is no definite proof to say that the mineralisation is connected with the igneous activity outside the area.

Mineralisation favours the west limb of the regional syncline and could be localised by the following factors:

1. Intersecting fractures (shear cleavage and a joint)
2. a favourable bed
3. localised by small tight folds or drag folds.

The structure indicates that the same beds pass through many workings although the beds could lens out along the strike.

Large andalusite cyrstals are found associated with most of the workings on the west limb of the syncline and are attributed to recrystallisation following the entry of mineralising quartz.

(In the geological history of the area it is considered that the small regional andalusites were formed after folding and the release of stress, although it is possible for the small andalusites to be formed before stress conditions, these could withstand disruption. The production of small regional andalusites after folding is thought to be more likely.)

As development in the Kanmantoo and Paringa mines has shown that the area between these mines is only mineralised to a small extent it would be unwise to consider an open cut mining method. Most of the high grade oxidised ore has been removed and drilling has explored the possibility of ore to the west of Kanmantoo, while cross-cutting has been done to the west and east of Paringa mine.

If work has been carried out since 1945 at the Aclare mine then the working information may prove helpful. According to reports, ore exists at depth (about 300 feet) to the south of the main shaft at Aclare.

Some arsenic is available near the Pioneer mine. As Australia is short of arsenic this prospect should be noted. Other ore remaining in old workings shows low assay values and many of the mines are filled with water.

If lead and zinc market prices rise abruptly then the Aclare mine could be considered to be a good prospect.

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LIST OF ROCK MINERALS AND ROCK SLIDES

A 70 - 3
" - 7 *
" - 8 *
" - 9
" - 16
" - 17
" - 21
" -23
" - 25
" - 31 *
" - 38
" - 46
" - 48
" - 49 *
" - 63
" - 65 *
" - 67 *
" - 69 *
" - 76 *
" - 80 *
" - 92
" - 93 *
" - 99
" -100 *
" -101 *
" -102
" -103 *
" -104 *

A 70 - 107
" - 109 *
" - 110
" - 111
" - 112 *
" - 113 *
" - 114
" - 115
" -, 116
" - 117
" - 118
" - 119 *
" - 120
" - 121
" - 121 B
" - 122
" - 122A
" - 123
" - 124 *
" - 125
" - 126
" - 127 *
" - 128
" - 129
" - 130
" - 131
" - 134
" - 135 *
" - 136 *
" - 137 *
" - 138
" - 139
" - 140
" - 142
" - 143
" - 144 *

A70 - 145 *
" - 147
" - R 2
" - R4
" - R5
" - C3 *
" - C4 *
" - C5
" - C7
" - C8 *
" - C9 *
" - C10 *
" - C11
" - C19 *
" - C19A *
" - C19B
" - C25
" - C26
" - C27
" - C28
" - C29
" - C30
" - C33
" - C36
" - C37
A 70- 119 W
" - 120 W
" - 121 W
" - 122 W
" - 123 W
" - 124 W
" - 125 W
" - 126 W
" - 127 W
" - 128 W
A70 - K.M.

* slides have been cut for these specimens.


NAIRNE CREEK
KANMANTOO TRIG. 765
SCOTT'S CREEK
MT. BARKER CREEK
BREMER FAULT
MARBLE TRIG.
CALLINGTON
BREMER RIVER
JUNCTION TRIG.
M.N.
LEGEND
QUARTZ
ALLUVIUM
60° BEDDING
60° FOLIATION
60° LINEATION
60° JOINT
60° FRACTURE CLEAVAGE
PITCHING SYNCLINE
PITCHING ANTICLINE
CALLINGTON AREA
FACT MAP
SCALE 4" Rep. 1 Mile
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