MURRAY BASIN BASEMENT

DATA PACKAGE

B.J. CLOUGH & L.R. RANKIN

(Compilers)

VOLUME 2 - WELL COMPLETION REPORTS

MURRAY BASIN BASEMENT TRANSECT PROJECT: 1990 WELL COMPLETION REPORTS

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT BK NO. 91/15

MURRAY BASIN BASEMENT TRANSECT PROJECT: 1990 WELL COMPLETION REPORTS

by

L R RANKIN[*], B J CLOUGH[*], M G FARRAND[*], S BARNETT[-], K LABLACK[♦], C G GATEHOUSE[*] AND L P HOUGH[+]

[*] REGIONAL GEOLOGY BRANCH
[-] GROUNDWATER AND ENGINEERING DIVISION
[♦] BIOSTRATIGRAPHY BRANCH
[+] GEOPHYSICS BRANCH

FEBRUARY 1991

DME 281/89

G01755

CONTENTS PAGE NO

CONTENTS (cont.) PAGE

PLATES

Plate No.		Photo No.
1.	Poorly sorted diamictite of the Permian Urana Formation intersected in Peebinga 1. Note conglomeratic clast of quartzite. Interval 538-538.5 m.	39238
2.	Photomicrograph of brecciated basalt, with intersecting calcite & chlorite veins. Fine-grained feldspar laths are visible in the basalt. Peebinga 1, specimen 7028RS32, TSC53475, 610.9 m. Plane polarised light. Field of view approx. 6 mm wide.	39239
3.	Photomicrograph of fine-grained amygdaloidal metabasalt, consisting of relict plagioclase laths within a groundmass of chlorite, calcite and opaques. Amygdales are infilled with cryptocrystalline silica. Peebinga 1, specimen 7028RS31, TSC534744, depth 608.4 m. Crossed nicols. Field of view approx. 6 mm wide.	39240
4.	Irregular, nodular layering within micritic limestone. The layering is weakly brecciated. Peebinga 1, 588 m.	39241
5.	Dark grey to black calcareous shale, brecciated metabasic agglomerate and tuff. Peebinga 1, 620-625 m.	39242
6.	Recrystallised lapilli tuff with abundant pyrite aggregates. Peebinga 1, 605.8 m.	39243
7.	Pyrite aggregates associated with interlayered limestone and black shale. Peebinga 1, 613 m.	39244
8.	?Basalt pillow within tuffaceous volcaniclastics. Peebinga 1, 626 m.	39245
9.	Photomicrograph of well-foliated quartz, feldspar and biotite meta-sandstone. Kringin 1. Specimen 7028RS49, TSC53488, 408.2 m. Crossed nicols. Field of view approx. 4 mm wide.	39246
10.	Medium-grained, grey granite. Wirha South 1, 330.3-330.8 m.	39247
11.	Medium to coarse-grained pink-grey granite to granodiorite, with minor intermediate to mafic xenoliths. Tori Hills 1, 258 m.	39248

Plate No.		Photo No.
12.	Sharp contact between metadolerite and albitite. Peake 1, 183.8 m.	39249
13.	Fine-grained grey albitite with disseminated pyrite. Peake 1, 185.6 m.	39250
14.	Photomicrograph of fine-grained albitite. Note fine to medium-grained quartz and feldspar phenocrysts. Opaque grains are pyrite. Peake 1, 186.5 m. Specimen 6827RS129, TSC53486. Crossed nicols. Field of view approx. 6 mm wide.	39251
15.	Photomicrograph of medium-grained ?metadoleritic amphibolite. Chlorite and hornblende are interstitial to relict interlocking plaigoclase laths. Peake 1, 174.55 m. Specimen 6827RS127, TSC53484. Plane polarised light. Field of view approx. 6 mm wide.	39252
16.	Photomicrograph of ?metadoleritic amphibolite. The specimen consists of medium-grained granoblastic-elongate plagioclase, chlorite and blue-green hornblende. A weak foliation is intersected at a low angle by a narrow vein of pyrite. Caringa 1, 306.8 m. Specimen 6827RS120, TSC52828. Plane polarised light. Field of view approx. 4 mm wide.	39253
17.	Contact between fine-grained chlorite-amphibole schist and granitoid clast. Note pyrite aggregate with boxwork texture within the granitoid. Caringa 1, 296.8 m.	39254
18.	Photomicrograph of sheared contact between amphibole-chlorite schist and structurally-overlying amphibolite. Note development of intense foliation and shear bands within chlorite-actinolite layering. Quartz-rich area on left contains microfolds defined by trails of acicular actinolite. Caringa 1, 287.0 m. Specimen 6827RS130, TSC53504. Plane polarised light. Field of view approx. 6 mm wide.	39255
19.	Granodiorite (LHS) and later metadolerite. Contact between the two units is not shown. Wynarka 1, 173-175 m.	39256

Plate No.		Photo No.
20.	Photomicrograph of metadolerite, consisting of plagioclase laths and interstitial hornblende. Wynarka 1, 174.7 m. Specimen 6827RS151, TSC53525. Crossed nicols. Field of view approx. 6 mm wide.	39257
21.	Photomicrograph of intensely-altered ?metadoleritic amphibolite near contact with granodiorite. Hornblende, chlorite and, to a lesser extent, plagioclase have been replaced by calcite. Wynarka 1, 172.75 m. Specimen 6827RS149, TSC53523. Crossed nicols. Field of view approx. 6 mm wide.	39258
22.	Shear zone within ?metadoleritic amphiboite. Intensely recrystallised chlorite-amphibole layers alternate with calcite layers. Wynarka 2, 173 m.	39259
23.	Photomicrograph of microfolds and disrupted layering within recrystallised ?metadolerite. A weak foliation has developed axial-planar to the microfolds. Wynarka 2, 181.9 m. Specimen 6827RS140, TSC53513. Plane polarised light. Field of view approx. 6 mm wide.	39260
24.	Photomicrograph of calcite and chlorite mylonite. Wynarka 2, 173 m. Specimen 6827RS136, TSC53510. Field of view approx. 6 mm wide.	39261

FIGURES

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT BK NO. 91/15
DME NO. 281/89
DISK NO. G01755

MURRAY BASIN BASEMENT TRANSECT PROJECT: 1990 WELL COMPLETION REPORTS

ABSTRACT

Nine drillholes were drilled to characterise various magnetic domains in the basement to the Murray Basin. Eight of the drillholes intersected Early Palaeozoic basement rocks.

Lithologies intersected were: 1) limestone-shale-basalt (Peebinga 1), which may represent either Normanville Group Truro Volcanics or a correlative of the Mount Stavely Volcanic Complex; 2) ?metadoleritic amphibolite (Wynarka 1 & 2, Caringa 1) and metadolerite intruding rhyolitic albitite (Peake 1) and correlated with amphibolites intruding Kanmantoo Group metasediments in the eastern Mount Lofty Ranges; 3) meta-arkose (Kringin 1) correlated with Kanmantoo Group metasediments and 4) post-Delamerian Orogeny granite to granodiorite (Wirha South 1, Tori Hills 1). Although base and precious metal values were generally low, all of the mafic and associated sedimentary sequences intersected contained abundant sulphide (up to 5%) as pyrite.

In conjunction with previous drilling records and geophysical interpretation, three aerially-extensive provinces of mafic and/or bimodal volcanics and intrusives with considerable potential for stratiform volcanogenic and epithermal feeder-style base metal mineralisation were delineated. Potential for gold and platinum-group-element (PGE) mineralisation in the Early Palaeozoic basement is also considered high.

INTRODUCTION

The Murray Basin, a large intracratonic fluviatile to shallow marine Tertiary sedimentary basin, extends over a large portion of western NSW and Victoria and southeastern South Australia. The basin conceals the pre-Tertiary basement in South Australia between the Late Proterozoic Adelaide Geosyncline and Cambrian Kanmantoo Trough sediments in the west, to the Cambro-Ordovician sediments and volcanics of the Glenelg River and Stavely Complexes to the east in Victoria. Outcrop of basement throughout the Murray Basin is extremely limited, consisting predominantly of isolated granitoid tors near the western margin of the basin and along the Padthaway Ridge.

In 1985, the Bureau of Mineral Resources, Geology and Geophysics (BMR) generated several colour and black and white shaded-relief pixel images of aeromagnetic data over the entire Murray Basin extending from longitude 147° (ca Albury, NSW) to longitude 139° (Mt Lofty Ranges, SA) and between latitudes 32°S and 38°S. These spectacular images proved to be very useful in delineating structural zones and geological subdomains in the concealed basement (D'Addario and Tucker, 1987; Brown *et al.*, 1988; Wellman, 1989). Those zones included a potential extension of the Mount Stavely Volcanic Complex (which contains gold mineralisation near Ararat, Vic.; Buckland, 1986) NNW into South Australia near Peebinga, a long arcuate magnetic zone (containing local mafic and ultramafic (Farrand, in prep.) volcanics near Coomandook) extending from Bordertown through Coonalpyn and Mannum to south of Broken Hill, and several smaller, magnetically anomalous zones of considerable linear extent. A portion of this magnetic pixel image is reproduced in Fig. 1.

Recognition of potentially extensive zones of mafic volcanics in the Yumali-Coonalpyn region of possible Cambrian age and lithologically similar to the economically important Mount Stavely Volcanic Complex near Ararat and the Mount Read Volcanics (which host the Hellyer and Que River Cu-Pb-Zn-Ag-Au deposits) in western Tasmania, has stimulated exploration interest in basement to the SA sector of the Murray Basin.

In late 1988 and early 1989, the Regional Geology Branch acquired a complete set of digital aeromagnetic data of the SA sector. Image processing of the data was conducted by Exploration Computer Services Pty Ltd, with production of a series of 35mm transparency pixel images of the data. Also during the same period, two groundwater observation bores north of Renmark were deepened to pre-Tertiary basement. One of these holes, Nanyah #1, intersected previously unknown (?)Cambrian basalt and dolerite (Preiss and Radke, 1989), further expanding the area of known and potential Cambrian volcanics in SA.

In addition to the (?)Cambrian volcanics, there is also considerable mineral potential in other rock units that may occur beneath the Murray Basin. Cambrian metasediments of the Kanmantoo and Normanville Groups within the Kanmantoo Trough area have been mined periodically for gold and base metals (particularly Cu). Recent reviews of Pb-Zn prospects in SA (Horn and Morris, 1988) and, in particular, of the Kanmantoo Trough (Morris, 1988) identified widespread base metal mineralisation in Cambrian metasediments which have been largely unexplored.

Cambrian metasediments are known from a few drillholes in the Murray Basin region, and have been inferred to extend from the Kanmantoo area across the SA-VIC/NSW border along with local volcanics and granitoid intrusives.

Black Hill, midway between the Mt Lofty Ranges and the River Murray (near Swan Reach), is the site of a (?Cambrian) Ordovician gabbro-norite intrusive complex inferred to have a very deep, mantle-derived source. It has been identified as one of the most prospective platinoid-group mineral (PGM) targets in SA (Farrand *et al.*, 1989) and while several drillholes have been sited around its margins, there have never been any deep drillholes in its central core to test for PGM mineralisation. There are likely to be other gabbronorite intrusives in the western basement to the Murray Basin. Based on this interest in the Proterozoic-Palaeozoic rocks of the southeast of South Australia and on their perceived potential for base metal, gold, silver and PGM mineralisation, proposals were forwarded to the Minister of Mines and Energy in December 1988 to drill a series of rotary drill holes with bottom-hole core along an E-W transect from Black Hill to Peebinga, plus complimentary diamond core drilling of specific targets with potential for mineralisation. Other drilling proposals related to this programme were submitted recommending a 1000 m diamond core drill hole in the centre of the Black Hill gabbronorite complex, a diamond core drilling programme to test for potential base metal-gold-silver mineralisation in the northern Kanmantoo Trough, and a series of rotary drillholes with bottom-hole core in concealed Cambro-Ordovician rocks on Kangaroo Island.

The targets were selected to provide as great a coverage of potential lithological differences in the basement as possible.

Further information on the basement was obtained from drilling records within open file company exploration reports. An initial compilation of this information was produced by B. Clough and L. Rankin, and was comprehensively updated by S. Roberts, a student geologist employed by the Department.

PROJECT AIMS

This programme was specifically designed to aid target delineation of basemetal (plus gold, silver and PGM) mineralisation, and promote further exploration for these resources in areas of perceived potential.

To achieve this it was necessary to compile a series of geological/tectonic maps of basement geology and structure interpreted from a combination of geophysical and drillhole data. This required considerable integration of new (i.e. drillhole) data, detailed geochemical analysis plus detailed analysis and interpretation of image-processed geophysical surveys.

Because of the general N-S elongate to linear nature of subdomains and structural elements identified from the aeromagnetic images, the aim of the drilling project was to identify the basement geology along an E-W transect from Peebinga to Black Hill, and thus characterise the nature and mineral potential of each of the major geophysical subdomains. In doing so, the programme would not only explore specific mineralisation targets, but would aid development of regional models for mineral resource prediction in the concealed basement of southeastern South Australia.

The ultimate aim of this programme has been to produce an atlas of geological and geophysical maps at an appropriate scale (e.g. $1:10^6$) including a brief resumé of geochemical results.

Although not a specific priority, a subsidiary aim of the programme was to compile information on the Cainozoic sediments and aquifers within the Murray Basin, and investigate potential heavy mineral sand mineralisation in the southeast of the state.

DRILLING TARGETS

Initial Appraisal

Prior to selecting drilling targets from the aeromagnetic data, an extensive search was made of all available company and Departmental stratigraphic and hydrological drilling within the western Murray Basin to provide both approximate depth to basement estimates across the proposed Peebinga-Black Hill transect, and to provide (limited) lithological control on several magnetic subdomains. All information was initially compiled on 1:250 000 base plans, and a comprehensive drillhole database was developed for the area by B. Clough and S. Roberts (student geologist).

MBT 1-18 Anomalies

Subsequent to compilation of all previous data, a total of 18 magnetic subdomains were selected as potential drilling targets. The following is a list of these targets and the rationale for selection. Figures 1 and 2 show the locations of drill sites with respect to the magnetic map and topographic maps.

- MBT-1 - An elongate magnetic high, which is aligned with the magnetic domain associated with the mineralised Mount Stavely Volcanic Complex in Victoria. The potential for Au and Pb-Zn mineralisation was considered high.

- MBT-2 - A broad, magnetically quiet zone, initially interpreted as Cambrian sediments.

- MBT-3 - The northeasternmost of three small-scale, discrete circular anomalies aligned along a northeast-trending lineament.

- MBT-4 - An arcuate linear magnetic high of either volcanic, sedimentary or tectonic origin. A possible stratigraphic Pb-Zn target.

- MBT-5 - A broad magnetically quiet subdomain to the west of the MBT-4 linear anomaly. Possibly Cambrian sediments.

- MBT-6 - A broad, elliptical magnetic high anomaly, most likely a Delamerian Orogeny granitoid.

- MBT-7 - The easternmost of two narrow N-S trending linear magnetic high anomalies. Most likely mafic dykes within Palaeozoic sediments. Potential for Pb-Zn and PGM.

- MBT-8 - An isolated magnetic high bracketed by linear anomalies trending N-S and NNW-SSE.

- MBT-9 - A discontinuous linear magnetic high trending NNW-SSE. This anomaly appears to crosscut the general structural grain of the area, and may represent a mafic dyke.

- MBT-10 - A broad, quiet magnetic low subdomain to the north and west of a sequence of magnetic linear highs (MBT 7, 9, 11). This may represent either Palaeozoic sediments or a magnetically quiet granitoid.

- MBT-11 - A broad linear magnetic high trending NNE. Most likely represents a mafic dyke suite.

- MBT-12 - An interpreted synclinal fold hinge defined by curvilinear magnetic high anomalies. This target was considered to have potential for structurally-controlled Pb-Zn mineralisation within folded metasediments/metavolcanics.

- MBT-13 - A small, elongate magnetic high, most likely representing a mafic intrusive. Considered to have potential for base metals and/or PGM.

- MBT-14 - An unusual elliptical subdomain with a mottled magnetic texture. Most likely a Delamerian granitoid.

- MBT-15 - An extensive magnetic gradient lineament trending NE-SW, separating interpreted granitoid and mestasediments. This target was considered to have potential for fault - controlled base metal mineralisation.

- MBT-16 - One of three intense circular magnetic high anomalies, interpreted as possible Black Hill norite-style ultramafic intrusives. This target was considered to have high potential for PGM mineralisation.

- MBT-17 - A large magnetically quiet plateau, south of the major linear anomalies. This may represent an extensive zone of magnetically quiet granitoids.

- MBT-18 - An intense circular magnetic high anomaly, interpreted as a Black Hill norite-style ultramafic intrusive. This target was deleted after a comprehensive check of previous drilling showed the anomaly had been drilled by CRA Exploration Pty Ltd, recovering diorite and gabbro.

Geophysical Modelling

Of the seventeen remaining anomalies, eleven required ground magnetic surveys and computer modelling of the data to accurately position drillsites to intersect magnetically anomalous targets. Subsets of data from the appropriate aeromagnetic flightlines for each of the anomalies were transferred from the original digital data tape to a floppy disk file. The data were then modelled by P. Hough, after assistance from D. Ivic and R. Gerdes, using the TOOLKIT modelling software. The computer models for each of the anomalies are shown in Figs 3a-3l. The original flightline aeromagnetic profiles are shown in Figs 4 and 5. After consultation with D. Tucker (consultant geophysicist), the ideal drillsite for each anomaly with respect to the flightline model was chosen.

P. Hough and L. Rankin conducted ground magnetic traverses over eleven anomalies using a GSM-19 Overhauser Memory Magnetometer, with a station spacing of 25 m and an average line length of 2 km.

The lines were measured by pacing, and pegged at 200 m intervals. With the peak of each anomaly accurately located on the ground, and the ideal drilling positions with respect to the peaks calculated from the flightline models, the final drillsites were easily and accurately located.

As a result of the ground magnetic surveys, it was decided to eliminate MBT-3 and 8 from the programme. MBT-3 was of low amplitude and difficult to pinpoint, and appeared to be centred within an area of high, wooded sand-dunes. MBT-8 proved to be a complex and poorly-defined anomaly, making identification of the target difficult.

1990 Drilling Programme

As a result of the geophysical appraisal of the original 18 targets, plus consideration of the anticipated budget, a final proposal to drill 14 targets was submitted to The Minister of Mines and Energy.

Twelve of the targets were to be rotary drilled by the Department's Drilling Branch to recover 3 to 6 m of bottom-hole core (MBT 2, 4, 5, 6, 7, 10, 11, 13, 14, 15, 16 & 17).

Two other drillholes (MBT 1 and 12) were to be rotary drilled to basement, followed by 140 m of NQ diamond core drilling; they were to be drilled by private contractor. Tenders were called for the project, including a further three 500 m diamond drillholes in the eastern Mt Lofty Ranges (Mount Rufus 1, Frankton 1, Karinya 1), and the tender awarded to Rockdril Contractors Pty Ltd.

DRILLING HISTORY

Drilling Schedule and Conditions

Drilling by Rockdril commenced on 7/3/90 with Caringa 1 (MBT-12). Drilling of the rotary holes by the Drilling and Engineering Services Branch of SADME began with MBT-5 on 29/3/90. Drilling and Engineering Services Branch completed MBT-2, 4 and 5 on 7/6/90, while Rockdril completed MBT-1, MBT-6, MBT-11, MBT-12, MBT-14 and 15, between 7/3/90 and 26/6/90.

The remaining holes (MBT-7, 9, 10, 13, 16, and 17) were not drilled due to insufficient funds.

Prolonged drilling delays, including stuck and broken rods (and drillbits) and lost core barrels plagued the drilling of the first two holes conducted by Rockdril, and caused unforseen expenditure. Upon prolonged discussion between officers of the Regional Geology Branch and representatives of Rockdril, it was agreed that Rockdril's initial insistence on the capability of their rig, a Warman 1000, to drill the proposed holes by air rotary instead of mud rotary, and their refusal to discuss drilling conditions with personnel within the Department was a primary factor in these problems.

Rockdril subsequently converted to rotary mud drilling which resulted in a marked reduction in downhole problems and delays. The holes drilled using this technique (mud rotary) were all completed within budget estimates.

It is strongly recommended after this experience, that companies tendering for Departmental drilling programs should discuss drilling conditions with the Drilling and Engineering Services Branch. It is also recommended that rotary-air techniques should <u>not</u> be used for drilling in cover rocks of the Murray Basin where water-bearing sands, silts and cavernous limestones commonly occur.

Well Completion Details

The following are summaries of the drilling details for each of the 9 holes completed.

Well Name — **Target#**

Peebinga 1 — MBT-1

Unit No.

7028 2SW 484

Location

Latitude	34°58′S
Longitude	140°55′E

~8 km SW of Peebinga

Map References

1:250 000	RENMARK	SI 54-10
1:100 000	PARUNA	7028

Elevation 70 m

Total Depth

636 m

Drilling

Commenced	25/3/90
Abandoned	4/4/90
Recommenced	19/5/90
Completed	3/6/90

Drilling Company

Rockdril Contractors Pty Ltd
PO Box 117
BRISBANE MARKET QLD 4106

Driller

R. Pederson

Drilling Rig

Warman 1000

Construction Details

0 m to 62 m	Drilled with 5½" blade bit.
62 m to 126 m	Drilled with 5½" blade bit.
	Rods bogged - drilled next to rods with NQ roller bit - lost circulation.
0 m to 62 m	Relief hole drilled with 5½" blade bit.
108 m to 114 m	Hooked back to hammer string and ream main hole.
	Rods became bogged, winch cable snapped - rods dropped 18m down hole.
0 m to 90 m	Back reamed hole with no success.
	Lost 2 x (6m x 4 3/4) drillstems
	1 x T35 hammer bit
	1 x 5½" hammer bit
	1 x 3½" IF pin 23 2 3/8 mayhew box
	1 x 2 3/4 IF box to 2 3/8 mayhew box
	1 x 3½ IF box to 3½ AP1 box
	Hole abandoned.
0 m to 89 m	Drilling recommenced using mud.
	Drilled with 7 7/8" blade bit.
89 m to 414 m	Drilled with 5½" blade bit.
	Cased to 414m with steel pipe.
414 m to 636 m	Drilled with NQ diamond core bit.

Aquifers were identified by downhole geophysical logging and isolated by cement plugs.

Well name	Target#
Kringin 1	MBT-2

Unit No.

7028 2SW 483

Location

Latitude	35°00'S
Longitude	140°46'E

50 km NNW of Pinnaroo; 15 km WSW of Peebinga

Map References

1:250 000	RENMARK	SI 54-14
1:100 000	PARUNA	7027

Elevation 72 m

Total Depth

409 m

Drilling

Commenced	21/4/90
Completed	2/5/90

Drilling Company

S.A. Department of Mines and Energy
Drilling and Engineering Services
Dalgleish St
THEBARTON

Driller

L. Moore

Drilling Rig

Portadrill RD2

Construction Details

Hole drilled 90°

0 m to 4.5 m	Drilled with 10" auger, cased with PVC and cemented.
4.5 m to 48 m	Drilled with 7 7/8" stepped blade bit.
48 m to 51 m	Cored with HQ tungsten-tipped core bit; reamed with 7 7/8" stepped blade bit.
51 m to 66 m	Drilled with 7 7/8" stepped blade bit, set 6" steel casing and pressure cemented.
66 m to 196 m	Drilled with 5 3/4" stepped blade bit.
196 m to 199 m	Cored with HQ 4 1/4" tungsten-tipped bit, lost core.
199 m to 200 m	Cored with HQ 4 1/4" tungsten-tipped bit; reamed with 5 3/4" stepped blade bit.
200 m to 298 m	Drilled with 5 3/4" stepped blade bit.
298 m to 407 m	Drilled with 5 1/2" roller bit.
407 m to 409 m	Cored with HQ diamond core bit.

Cemented plugs at 320 m, 210 m and 70 m. All casing removed.

Well Name	Target#
Briaken Park 1	MBT-4

Unit No.

7028 3SW 482

Location

Latitude	34°48′S
Longitude	140°32′E

10 km south of Alawoona

Map References

1:250 000	RENMARK	SI 54-10
1:100 000	PARUNA	7028

Elevation 72 m

Total Depth

539 m

Drilling

Commenced	5/5/90
Completed	7/6/90

Drilling Company

S.A. Department of Mines and Energy
Drilling and Engineering Services

Driller

L. Moore/B. Faulkner

Drilling Rig

Portadrill RD2

Construction Details

Hole drilled 90°

0 m to 5.5 m	Drilled with 10" auger bit, cased with 8" PVC and cemented.
5.5 m to 48 m	Drilled with 7 7/8" roller bit.
48 m to 51 m	Cored with HQ tungsten-tipped bit, reamed with 7 7/8" roller bit.
51 m to 66 m	Drilled with 7 7/8" roller bit, cased with 150mm PVC and cemented.
66 m to 106 m	Drilled with 5 3/4" stepped blade bit.
106 m to 188 m	Drilled with 5 1/2" roller bit.
188 m to 191.15 m	Cored with HG tungsten-tipped bit, reamed with 5 1/2" stepped blade bit.
191.15 m to 326 m	Drilled with 5 1/2" stepped blade bit.
326 m to 402 m	Drilled with 5 1/2" tri-cone roller bit.
402m to 403m	Cored with diamond core bit, lost core, reamed with 5 1/2" stepped blade bit.
402 m to 453 m	Drilled with 5 1/2" stepped blade bit.
453 m to 456 m	Coring with HQ bit.
456 m to 536 m	Drilling.
536 m to 539 m	Coring with HQ bit.

The hole was cased to a depth of 536 m with 80 mm heavy black S+S pipe and pressure cemented. The hole is prepared for possible later deepening to basement by contract diamond driller.

Well Name — **Target#**

Wirha South 1 — MBT-5

Unit No.

7027 4SW 641

Location

Latitude	35°08′S
Longitude	140°31′E

21 km north of Lameroo

Map References

1:250 000	PINNAROO	SI 54-14
1:100 000	PINNAROO	7027

Elevation 90 m

Total Depth

332 m

Drilling

Commenced	29/3/90
Completed	11/4/90

Drilling Company

S.A. Department of Mines and Energy
Drilling and Engineering Services

Driller

L. Moore

Drilling Rig

Portadrill RD2

Construction Details

Hole drilled 90°

0 m to 5 m	Drilled with 10" auger, cased with PVC and cemented.
5 m to 60 m	Drilled with 6" stepped blade bit.
60 m to 63.1 m	Cut core with 4 1/4" HQ3.
70 m to 127 m	Reamed hole and drilled with 7 7/8" stepped blade bit, set 6" steel casing.
127 m to 164 m	Drilled with 6" tri-cone roller bit.
164 m to 200 m	Cored with HQ 4 1/4"; reamed with 6" stepped blade bit.
200 m to 330 m	Drilled with 6" stepped blade bit.
330 m to 332 m	Cored with diamond core bit.

Cement plug set at 188 m to 158 m and 85 m to 65 m. All casing removed.

Well Name — Target#

Tori Hills 1 — MBT-6

Unit No.

6927 4SW 635

Location

Latitude	35°04′S
Longitude	140°14′E

18 km ESE of Borrika

Map References

1:250 000	PINNAROO	SI 54-14
1:000 000	PINNAROO	6927

Elevation 72 m

Total Depth

261 m

Drilling

Commenced	24/6/90
Completed	29/6/90

Drilling Company

Rockdril Contractors Pty Ltd

Driller

R. Pederson

Drilling Rig

Warman 1000

Construction Details

0 m to 19 m	Drilled with 7 7/8" blade bit.
	Cased with PVC.
19 m to 248 m	Drilled with 5 1/2" blade bit.
	Cased to 248m with steel pipe.
248 m to 261 m	Drilled with NQ diamond core bit.

Aquifers were identified by downhole geophysical logging and isolated by cement plugs.

Well Name	Target#
Peake 1	MBT-11

Unit No.

6827 2SW 1634

Location

Latitude	35°21'S
Longitude	139°54'E
4 km NW of Peake	

Map References

1:250 000	PINNAROO	SI 54-14
1:100 000	MOORLANDS	6827

Elevation 8 m

Total Depth

187 m

Drilling

Commenced	4/6/90
Completed	14/6/90

Drilling Company

Rockdril Contractors Pty Ltd

Driller

G. Barlow

Drilling Rig

Warman 1000

Construction Details

0 m to 6 m	Drilled with 10 1/2" blade bit.
6 m to 20 m	Drilled with 7 7/8" blade bit. Cased with PVC.
20 m to 152 m	Drilled with 5 1/2" blade bit. Hole abandoned due to collapsing sand. Hole recommenced.
0 m to 25 m	Redrilled hole with 5 1/2" hammer bit. Reamed with 7 7/8" blade bit. Cased with PVC.
25 m to 175 m	Drilled with 5 1/2" blade bit. Cased with steel casing to 175m.
175 m to 187 m	Drilled with NQ diamond core bit.

Aquifers were identified by downhole geophysical logging and isolated by cement plug.

Well Name		Target#
Caringa 1		MBT-12

Unit No.

6827 4SW 1633

Location

Latitude	35°09'S
Longitude	139°46'E

4 km SE of Wynarka

Map References

1:250 000	PINNAROO	SI 54-14
1:100 000	MOORLANDS	6827

Elevation

71 m

Total Depth

309 m

Drilling

Commenced	7/3/90
Completed	23/3/90

Drilling Company

Rockdril Contractors Pty Ltd

Driller

R. Pederson

Drilling Rig

Warman 1000

<u>Construction Details</u>

Hole drilled 90°

0 m to 134 m	Drilled with 5 1/2" hammer, cased with PVC.
134 m to 182 m	Drilled with NQ diamond core bit. Lost core barrel, NQ rods broken, wireline snapped - hole abandoned.
0 m to 197 m	Redrilled hole 5m to south, using 5 1/2" blade bit.
197 m to 309 m	Drilled with NQ diamond core bit.

Aquifers were identified by downhole geophysical logging and isolated by cement plugs.

Well Name			Target#
Wynarka 1			MBT-14

Unit No.

6827 4SW 1632

Location

Latitude	35°08′S
Longitude	139°43′E

1.5 km W of Wynarka

Map References

1:250 000	PINNAROO	SI 54-14
1:100 000	MOORLANDS	6827

Elevation

72 m

Total Depth

195 m

Drilling

Commenced	16/6/90
Completed	19/6/90

Drilling Company

Rockdril Contractors Pty Ltd

Driller

G. Barlow

Drilling Rig

Warman 1000

Construction Details

0 m to 12 m	Drilled with 5 1/2" hammer bit.
0 m to 12 m	Reamed with 7 7/8" blade bit.
	Cased with PVC.
12 m to 168 m	Drilled with 5 1/2" blade bit.
	Cased with steel casing to 168m.
168 m to 195 m	Drilled with NQ diamond core bit.

Aquifers were identified by downhole geophysical logging and isolated by cement plugs.

Well Name	Target#
Wynarka 2	MBT-15

Unit No.

6827 4SW 1631

Location

Latitude	35°09'S
Longitude	139°38'E

7 km SW of Wynarka

Map References

1:250 000	PINNAROO	SI 54-14
1:100 000	MOORLANDS	6827

Elevation

77 m

Total Depth

188 m

Drilling

Commenced	20/6/90
Completed	23/6/90

Drilling Company

Rockdril Contractors Pty Ltd

Driller

G. Barlow

Drilling Rig

Warman 1000

Construction Details

0 m to 14 m	Drilled with 7 7/8" blade bit.
14 m to 166 m	Drilled with 5 1/2" blade bit.
	Cased with steel casing to 166m.
166 m to 188 m	Drilled with NQ diamond core bit.

Aquifers were identified by downhole geophysical logging and isolated by cement plugs.

Drilling Statistics

A summary of drilling statistics for the contract Rockdril Warman 1000 rig fitted with mud circulation equipment is presented here as a guide for future drilling in the Murray Basin region, and other areas where similar Tertiary/Permian strata conceal basement rocks.

(i) Rotary mud-circulation drilling using 5½ in blade bit.

Average metres/shift	83m
Average non-drilling time/shift	8 hrs
Average number of 4000 litre water loads/shift	7 loads

(ii) NQ diamond coring from basement.

Average metres/shift	23m
Average non-drilling time/shift	4 hrs
Average number of 4000 litre water loads/shift	3 loads

NOTE: Shifts are 12 hrs.

The average time spent surveying and downhole logging was 4 hrs per drillhole. In addition to the above statistics, it was found that approximately one half shift was required for casing down to basement and that one full shift was required for pulling casing and cementing of aquifers for each drillhole.

The rotary mud-circulation drilling penetrated to a maximum of 414m. The NQ diamond coring penetrated to a maximum of 635.7m, including the coarse conglomeratic Permian beds encountered in Peebinga No 1.

Non-drilling time includes all drilling-related tasks except drilling itself, (eg. running rods in or out, reaming, mixing mud, running casing, treating lost circulation etc.) however it does not include time spent surveying which was costed separately.

GEOLOGY

Regional Geology

The area of investigation covers stratigraphic and/or tectonic units of Proterozoic to Early Palaeozoic, Middle Palaeozoic to Mesozoic, and Cainozoic age.

The Proterozoic to Early Palaeozoic rocks include sedimentary rocks, volcanics, metasediments and intrusives of the Adelaide Geosyncline and Stansbury Basin, and interpreted equivalents to the east under the Murray Basin.

The Middle Palaeozoic to Mesozoic is represented by rocks within the Darling Basin, Nadda Basin, Troubridge Basin and the Berri Embayment.

The Cainozoic is represented by Tertiary sedimentary rocks of the Murray Basin. The whole basin is blanketed with a thin cover of Quaternary aeolian sands.

Proterozoic-Early Palaeozoic

Flanking the Murray Basin to the north are deformed Neoproterozoic Adelaidean sediments and volcanics, and Ordovician granitoids. To the east, the basin is also bounded and underlain by sedimentary rocks and metasediments of the Stansbury Basin (Normanville Group) and the deeper marine Kanmantoo Trough (Kanmantoo Group), with Ordovician granitoid rocks and mafic-ultramafic plugs associated with the Delamerian Orogeny. Beneath the Murray Basin, limited drillhole data indicates the presence of sedimentary and meta-sedimentary rocks and volcanics equivalent to those found in the eastern Mount Lofty Ranges, as well as granitoid and mafic-ultramafic intrusives associated with the Delamerian Orogeny.

Middle Palaeozoic-Mesozoic

In the north of the Murray Basin area, the basin is underlain by three major sedimentary successions deposited unconformably on Proterozoic-Early Palaeozoic basement. They include:

(1) Darling Basin:- This is a sequence of clastics of Devonian age (Thornton, 1974; Gravestock and Alley, in prep.) restricted to the narrow Renmark Trough area and considered as an extension of the NSW Darling Basin. The sequence includes fluvial to fluviolacustrine sandstone, siltstone and shale. The greatest thickness intersected is 191 m in Cooltong 1; seismic evidence suggests a possible thickness of over 1500 m in the northern part of the Basin (Thornton, 1974).

(2) Nadda Basin:- This basin, which includes the Renmark Trough, Canegrass Lobe and Paringa Embayment contains a thick Permian succession of shale, siltstone, sandstone, diamictite and conglomerate of the glacigene Urana Formation. The thickest intersection of 395 m occurs in Nadda 1 (Derrington and Anderson, 1970), and seismic evidence suggests a possible maximum thickness of 900 m in the Renmark Trough (Thornton, 1974). Isolated occurrences of Permian rocks occur on the Padthaway Ridge and further south in the Troubridge Basin.

(3) Berri Embayment:- This is a former extension of the Eromanga Basin and contains up to 600 m of Early Cretaceous fluviatile clastics in the Renmark Trough (from seismic evidence; Thornton, 1974). The embayment appears to be controlled by similar tectonic elements to those of the underlying Nadda Basin.

Of the 9 drillholes completed in this programme, none intersected Cretaceous or Devonian rocks, and only Peebinga 1 and Briaken Park 1 intersected the glacigene Permian Urana Formation.

Within Peebinga 1, a total of 178 m (402-580.23 m) of sandy diamictite with coarse polymict conglomeratic horizons and finely laminated siltstone horizons of interpreted Permian age was intersected. The cored interval was from 416.7 to 580.23 m.

The dominant lithology consists of a pale grey to pale green, sandy diamictite. However, this rock type commonly occurs within large graded units (up to 3 m thick) that exhibit coarse polymict matrix-supported conglomerates with well-rounded cobbles up to 250 mm in diameter but averaging 35 mm in diameter, as well as horizons of pale-grey, finely laminated siltstone frequently exhibiting convolute bedding.

Cobbles within the conglomeratic horizons were extremely varied in lithology including granite, diorite, fine-grained (?)volcanics, quartzite and schist (Plate 1).

Fine-grained siltstone within this sequence has been palaeontologically identified as of Permian age (pers. comm. N. Alley) and the whole succession is interpreted as the glacigene Urana Formation.

Within Briaken Park 1 a total of 162 m (377 - 539 m) of sediments interpreted as of Pemian age was intersected. Cored intervals were at 453-456.05 m and 536-539 m. The uppermost cored interval consists of a dark grey relatively massive, laminated shale, identified palaeontologically as of Permian age (pers. comm. N. Alley). The lowermost cored unit consists of a mottled red and greenish-grey polymict, conglomeratic diamictite with sub-rounded and sub-angular cobbles up to 40 mm in diameter.

Both units are interpreted as belonging to the Urana Formation.

Tertiary-Quaternary

The low-lying, saucer shaped Murray Basin extends over 300 000 km^2 of inland southeast Australia, and is flanked by subdued mountain ranges of Proterozoic and Palaeozoic basement. Basement rocks of the Padthaway Ridge form the southwestern margin of the Basin. The Cainozoic sedimentary rocks form an extensive, but relatively thin succession, reaching a maximum thickness of 600 m over the Renmark Trough area.

The Tertiary sediments can be divided into 3 main depositional packages:

(1)	Palaeocene-Eocene:-	Renmark Group:-	fluvial sand overlain by paralic carbonaceous clay and lignite.
(2)	Oligocene-Middle Miocene:-	Ettrick Formation:-	marine glauconitic grey-green marl
		Murray Group limestone	marine bryozoal limestone
(3)	Upper Miocene-Pliocene:-	Bookpurnong Beds:-	marine shelly dark grey clay and silt
		Pliocene Sand:-	fluvial to marginal marine quartz sand

The entire sequence is overlain by Quaternary aeolian sand. The Tertiary sediments intersected by each drillhole are described in the composite logs (Figs 7-15). All of the drillholes except Peake 1 intersected the above Tertiary sequence (with minor variations) above basement. Peake 1 drillhole lies in the Buccleuch Embayment, within which the Pliocene marine sands were removed by an Early Pleistocene marine transgression and a shallow marine limestone was deposited over the Oligo-Miocene limestone. Here also, the marine Buccleuch Group, consisting of carbonaceous clay and bryozoal limestone, overlies and grades laterally into the Renmark Group.

The Murray Group limestone forms an extensive unconfined aquifer containing large quantities of good quality groundwater. It is widely utilised for stock, irrigation and town water supply purposes. The underlying Buccleuch Group and Renmark Group are confined aquifers which are exploited only near the basin margins where they become shallow against basement highs.

Pre-Permian Basement Intersections

The following descriptions for the Early Palaeozoic basement intersected in each of 7 drillholes summarise detailed logging and petrology. The petrology is compiled in Appendix 1, and composite logs for each hole, including descriptions of Tertiary and Permian intersections, are included in Figs 6-14.

Peebinga 1

A total of 55.47 m of approximately equal proportions of metabasic (interpreted as basalt), limestone and black shale (with tuffaceous horizons) were intersected in Peebinga 1.

The metabasics in hand specimen are dark grey with a greenish tinge. Porphyritic minerals and amygdales are often visible as faint outlines, and many thin veinlets of calcite, chlorite and quartz are visible (Plate 2). In thin section the metabasic is usually porphyritic and amygdaloidal and consists of a fine-grained groundmass of interlocking plagioclase laths, opaques, leucoxene, chlorite and carbonate with phenocrysts of plagioclase feldspar from 2 to 5 mm in diameter (often altered to sericite and carbonate) and occasional altered olivine and relict pyroxene phenocrysts. The amygdales are usually infilled with cryptocrystalline silica or chlorite (Plate 3). Shearing and veining commonly disrupt the metabasics, and veins are infilled with carbonate (mostly calcite), chlorite and quartz. Veins up to 10 mm width are common.

The limestone is a grey micrite, exhibiting a distinctive wavy, nodular bedding, at ~40° to the core axis (Plate 4), which is commonly disrupted by fractures infilled by reworked carbonate as well as silica, chlorite, sericite and pyrite.

The black pyritic shale (Plate 5) occurs interbedded with common centimetre-size beds and thicker lenses of grey-green 'tuffaceous' phyllite. Samples of this lithology have been analysed unsuccessfully for palynological dating.

Zones of black, finer grained and more brecciated metabasic 'agglomerate' occur at 592.2 m - 593 m, 600.03 m - 602.6 m and 624.2 m - 627.1 m. These zones commonly occur at the contacts between the metabasic units and either the limestone or black shale. At two of these contacts (602.6 and 624.2), a thin (300 mm thick) bed of tuff containing millimetre-size fragments of the metabasic occurs between the agglomerate and the sediments.

Brecciation of the limestone appears to have occurred in situ since limestone blocks seem to have suffered only minor rotation. The breccia matrix includes reworked carbonate and pyrite. The limestone has been unsuccessfully examined for macrofossils by inspection of slabbed core and acid solution residue.

The grey-green tuffaceous phyllite bands (Plate 6) found within the black shale commonly consist of a mass of fine-grained sericite. However, some more granular horizons (eg. 614.7 - 617.6 m) exhibit fragments of feldspar and aggregates of interlocking plagioclase texture (up to 20 mm diameter) suggesting they are clasts of fragmented metabasics.

Sulphide mineralisation is restricted to the common occurrence of pyrite throughout the section (up to 1% by volume). Pyrite occurs within veinlets and as centimetre-sized aggregates within the black shale (Plate 7), as millimetre-sized euhedral to subhedral grains within the matrix of the limestone breccia, and as veinlets within the metabasics. Pyrite also occurs associated with the rims of clasts within a metabasic tuff at 614.7 - 617.6 m suggesting that pyrite formed during diagenesis. Pyrite is frequently associated with cryptocrystalline silica which forms pressure shadows surrounding the grains, once again suggesting that sulphide mineralisation occurred prior to deformation of the rocks.

Structural deformation within all rock types encountered in the cored interval appears heterogeneous, varying from virtually no preferred grain orientation to development of an intense foliation often associated with shearing (commonly at 40° to the core axis).

Shear zones account for many of the lithological contacts (eg. 589 m, 612.1 m, 614.7 m and 630.7 m). However, sufficient contacts are preserved to demonstrate that the metabasics were introduced coeval with deposition of the limestone and black shale. Evidence for this is suggested by the intimate association of sediments with the metabasics. One example is a metabasic unit (608.3 m - 612.1 m), in contact with overlying limestone, consisting of a vesicular metabasic agglomerate with a micritic and veined carbonate matrix forming 10 - 15% of the total rock. This is interpreted as a lava flow extruded into a carbonate-depositing environment. Further evidence is seen in the interbedding of metabasic lapilli tuffs at the contact with the metabasics and within the black shale units. The metabasics are interpreted as vesicular basalt lavas and associated metabasic fragmental lapilli tuffs. These lavas may have been extruded as pillow lava (Plate 8) as evidenced by the glassy marginal breccias to the metabasic units, suggesting rapid chilling in water. At least two types of lava are recognised; a magnetic lava occurring at the base of the cored interval (630.7 - 635.7 m) and containing phenocrysts of olivine and relict pyroxene, and lavas above this interval which are non-magnetic and do not exhibit either olivine or pyroxene phenocrysts. It should be noted, however, that lavas of this second category are generally more altered which could account for this variation. The magnetic metabasic probably accounts for the local broad magnetic anomaly that was the target for this drillhole. This magnetic high occurs at the northern termination of a broader belt of anomalous magnetic intensity (the Stavely Belt of Brown *et al.*, 1988; also referred to as the Dimboola Gravity-Magnetic Ridge by Vandenberg, 1988) that trends SSE over the Victorian border and includes the Mount Stavely Volcanic Complex.

The dominant lithologies in this drillhole sequence comprise a limestone unit overlying a black shale unit with tuffaceous horions; this sedimentary sequence is interbedded with three vesicular basalt pillow lava flow units, one within the limestone, another at the contact, and the lowermost unit within the black shale. The presence of shearing within the cored interval and the unknown attitude of the sequence precludes direct correlation with other described volcanic sections. However, there may be a link with the Truro Volcanics of the eastern Mount Lofty Ranges where pillow lavas are interbedded with Heatherdale Shale and closely associated with the Fork Tree Limestone.

Kringin 1

The basement intersection (407 m - 408.95 m) consists of medium-grained, slightly porous metasandstone (Plate 9). A foliation of moderate intensity at approximately 20°-30° to the core axis, is defined by the preferred orientation of medium-grained biotite (~25%). A weak quartz grain-shape fabric lies approximately 20°-25° to the biotite foliation. A minor sericitised component (~10%) is probably lithic feldspar.

The grade of metamorphism of the metasediment is moderate, at biotite grade amphibolite facies. The top of the intersection is moderately weathered, and contains minor graphite.

The stratigraphic age of this metasediment is indeterminate, although correlation with Cambrian Kanmantoo Group is most likely. The unit has some lithological similarites to the Tapanappa Formation of the eastern Mount Lofty Ranges area.

Wirha South 1

Two metres (330 m - 332 m) of fine to medium-grained grey granite were intersected at the base of the drillhole (Plate 10). The granite contains fine to medium-grained quartz, plagioclase and orthoclase-microcline with a consertal texture. Minor fine to medium-grained biotite and muscovite also occur.

Chlorite has partially replaced biotite. Plagioclase grains exhibit well-developed concentric zoning.

The granite has undergone minor dynamic recrystallisation during strain, with development of fine-grained recrystallisation rims of quartz and feldspar around original grains. Several medium quartz grains have completely recrystallised to fine-grained polygonal mosaics.

Although the granite has undergone some strain, as indicated by the minor dynamic recrystallisation, there is no planar or linear tectonic fabric evident on either the meso or microscopic scales.

Tori Hills 1

The basement intersection (252-260.6 m) consists of medium to coarse-grained pink-grey granite to granodiorite with several xenoliths of intermediate composition (Plate 11).

The granite contains medium to coarse-grained subhedral to euhedral plagioclase, quartz and K-feldspar. Biotite and hornblende occur as fine to medium-grained aggregates, with partial replacement by chlorite, muscovite and epidote. Plagioclase exhibits well developed concentric zoning. Fine to medium-grained opaques occur as aggregates and disseminated grains within concentrations of biotite and hornblende.

Intermediate to mafic xenoliths up to 6 cm long occur over several intervals. The xenoliths contain fine to medium-grained plagioclase laths, plus medium-grained biotite and hornblende, with minor quartz.

Narrow (<4 mm) veins containing calcite, minor opaques (including ?pyrite) and zeolites, are common. Minor carbonate replacement of feldspar has occurred locally within the granitoid, along with partial sericitisation.

The granitoid has no visible tectonic fabric, and is interpreted as a post-Delamerian Orogeny intrusive, similar to the granitoid intersected in Wirha South 1. A major difference between the two graintoids is their magnetic character; this granitoid appears as a magnetic high anomaly, while the Wirha South 1 granitoid lies within a magnetically quiet zone. This suggests that a major proportion of the opaques occurring in the Tori Hills 1 granitoid consists of magnetite.

Peake 1

A total cored interval of 12.1 m consists of metadolerite (minimum thickness 9.3 m) overlying and intruding an albititic rhyolite (minimum thickness 2.8 m). The contact between the two units is sharp and irregular (Plate 12).

In hand specimen the albitite is a pale grey, fine-grained massive rock with disseminated pyrite mineralisation (Plate 13). In thin section the rock is porphyritic and exhibits a distinctive groundmass of quartz and albite laths up to 0.1 mm in length, with pyrite forming irregular clusters of grains 1.5 mm across. Phenocrysts consist of quartz and plagioclase (Plate 14). Chlorite patches occur throughout the groundmass and suggest alteration of either ferromagnesian minerals or a glassy matrix. Minor epidote occurs as a replacement of ferromagnesian phenocrysts.

The metadolerite in hand specimen is a grey massive rock with a granular texture cross cut by thin carbonate veins (ca. 40° to core axis). In thin section this rock is more coarse-grained, more strongly altered and richer in ferromagnesian minerals than the albitite. The rock consists of an interlocking fabric of plagioclase laths, relict pyroxene, leucoxenised opaque minerals, pyrite and abundant epidote and chlorite replacement, plus minor quartz (Plate 15).

Mineralisation is restricted to pyrite grains (up to 1% by volume) disseminated throughout both rock types.
Both rock types lack an obvious fabric.

The metadolerite and albitite are interpreted as shallow, possibly sub-volcanic intrusives. The metadolerite intrusive unit becomes distinctly finer-grained on approaching the contact with the albitite below. The contact between the two units is sharp and irregular suggesting intrusion of the albitite by the metadolerite.

Caringa 1

A total of 112.2 m of medium to fine-grained amphibolite and amphibole schist, with minor felsic inclusions, were intersected in Caringa 1 (196.3 m - 308.5 m).

The amphibolite contains fine to medium-grained plagioclase laths plus blue-green tabular to acicular hornblende grading to acicular actinolite (Plate 16). Chlorite occurs as a replacement of amphibole, locally grading from partial to complete replacement. A weak foliation (ca. 15°-20° to the core axis) is defined by the preferred grainshape alignment of amphibole and chlorite. Veins up 20 mm wide, containing chlorite + calcite + pyrite (and occasionally ilmenite) are common throughout the core. These are commonly oriented approximately 45° to the core axis. Sphene is a common trace mineral throughout the amphibolite, and epidote commonly occurs as a partial replacement of palgioclase and amphibole. Opaques occur as fine to medium-grained anhedral aggregates associated with amphibole and chlorite.

The lowermost interval of amphibolite (beginning at 308.5 m) gradually grades upwards from medium to fine-grained. From 303 m to 289 m, the amphibolite is fine-grained, grading into an intensely-foliated amphibole-chlorite schist. The schistose phase at several intervals contains clasts of felsic to intermediate granitoids (Plate 17). At approximately 289-300 m, the amphibole-chlorite schist intertongues with an overlying monotonous medium-grained amphibolite. Contacts visible within the core are complex and steep, and appear intrusive, with later localised shearing.

In thin section, as the amphibolite grades into the schistose phase near contacts with the uppermost amphibolite and the granitoid clasts, relict fine to medium-grained subhedral plagioclase laths become overprinted by acicular amphibole + chlorite (Plate 18). Epidote becomes common with the gradation to the schistose phase. The contacts with both the amphibolite and the granitoid clasts are typically sheared, with several episodes of contact-parallel and discordant shearing evident. The amphibole-chlorite schist exhibits excellent development of dynamically-recrystallised mylonitic fabrics, including anastomosing S-C grainshape - shear plane foliations, discontinuous late-stage microscopic kink folds and secondary crenulation cleavages, and the intense recrystallisation of (?introduced) quartz grains to form elongate ribbons of fine polygonal grains.

The granitoid clasts, which vary from syenite and monzodiorite to granite in composition also exhibit evidence of deformation during shearing. Quartz and feldspar within the felsic clasts have undergone dynamic recrystallisation along grain boundaries and within narrow (<1 mm) discordant shears to produce proto-to blastomylonitic textures (terminology of White, 1982).

Contacts between granitoid and amphibole schist are complex, intertonguing and branching. The amphibole schist appears intrusive into the granitoid clasts.

Pyrite is abundant throughout the amphibolite and schist (up to 2% visual estimate), both concentrated in narrow (<2 mm) veins and pods up to 10 mm wide, and disseminated throughout the core. Several pods have a visible boxwork texture. Within the lowermost medium-grained amphibolite interval, discordant narrow pyrite veins are particularly abundant. Some medium-grained euhedral pyrite grains within the sheared schistose phase have well-developed quartz-calcite pressure shadow tails and, less commonly, biotite selveges. This suggests that at least some of the sulphide visible was present prior to deformation.

Graphite occurs locally within the amphibolite along shear planes.

The mafic lithologies are interpreted as uralitised dolerite, emplaced as two intrusions. The uppermost medium-grained metadolerite has been intruded by the lower medium-grained metadolerite, which grades into the fine-grained phase near the contact as a chill margin. The fine-grained phase has subsequently been mylonitised during localised shearing, possibly associated with development of the regional weak foliation in the amphibolite.

The granitoid clasts are interpreted as xenoliths of deeper country rock brought up during emplacement of the second metadolerite. The unique concentration of these clasts within the fine-grained amphibolite phase may be explained by entrainment during viscous flow in the marginal zone of the mafic magma. The proto to blastomylonitic recrystallisation of the granitoid clasts most likely occurred at the same time as shearing along the amphibolite-amphibolite and amphibolite-granitoid contacts.

Wynarka 1

The basement intersection (168.4-191.6 m) is composed of fine to medium-grained amphibolite with varying degrees of alteration and carbonate replacement, plus three intervals of granodiorite (172.8-173.0 m, 1737.7-174.3 m and 175.1-181.4 m) (Plate 19).

The amphibolite typically is composed of medium-grained blue-green tabular to acicular hornblende to actinolite, plagioclase laths, chlorite and fine-grained opaques (Plate 20). Relict pyroxene within hornblende is rare.

Minor quartz occurs throughout the amphibolite. Within the lowermost interval of amphibolite, both quartz and amphibole exhibit dynamic recrystallisation to produce fine-grained mosaic aggregates. Carbonate (calcite) and sericite have replaced the original plagioclase laths to varying degrees throughout the amphibolite. A very weak foliation is locally evident within the amphibolite, and a narrow (2 cm wide) shear zone at 170.7 m, and approximately 60° to the core axis, consists of mylonitic stringers of alternating carbonate and amphibole-chlorite bands, producing a localised intense foliation.

The amphibolite-granodiorite contacts appear moderately irregular and are approximately 30° to the core axis. The contacts are interpreted as intrusive. Approaching the contacts, the amphibolite becomes finer-grained, with almost complete replacement of the amphibolite mineralogy by chlorite and calcite (Plate 21). Within several contact zones, fine-grained secondary epidote is abundant, locally comprising up to

50% of the mineralogy. The gradation of grainsize in the amphibolite towards the contact zones is interpreted as a chill margin, suggesting the amphibolite represents an original dolerite which intruded the granodiorite. Development of mylonitic textures in the chlorite-rich contact zones suggests at least some late stage shearing has occurred.

The granodiorite consists of medium to coarse-grained quartz, plagioclase and orthoclase, with rims of fine, dynamically-recrystallised quartz and feldspar. Narrow (<2 mm) discordant shears contain mosaics of very fine-grained quartz and feldspar. The granodiorite is protomylonitic.

Carbonate replacement within the amphibolite most likely occurred during localised development of shear zones through the intrusive, allowing mobilisation of carbonate-rich fluids. Protomylonitisation of the granodiorite may have occurred at the same time.

Thin (<3 mm) discordant veins of pyrite and ?pyrrhotite occur within the amphibolite and occasionally broaden into patches up to 5 mm wide. Minor disseminated fine-grained pyrite is common. Fine-grained pyrite occurs with calcite in some of the sheared amphibolite-granodiorite contact zones.

Wynarka 2

A total of 21.5 m (166.2 - 187.7 m) of intensely altered and carbonate-replaced metadolerite was recovered. The metadolerite is heavily calcite-veined, and intersected by a shear zone (172.6-174.6) containing abundant sheared and recrystallised calcite plus clasts and bands of metadolerite (Plate 22).

The metadolerite consists of intensely-altered fine to medium-grained plagioclase laths with interstitial chlorite (?after hornblende) and minor quartz. Approaching the fault zone, carbonate replacement of plagioclase and chlorite increases. Associated with the carbonate are minor fine-grained anhedral opaques, including ilmenite and pyrite.
Within the fault zone, breccia clasts of metadolerite lie within a calcite matrix. A solution cleavage is visible in the breccia clasts. The carbonate matrix exhibits a variable-intensity foliation (Plate 23). Where shearing and recrystallisation has been most intense within the zone, alternating bands of recrystallised calcite and intensely altered metadolerite (now calcite + chlorite + opaques) form a streaky mylonite (Plate 24). Two foliations are locally evident in these intervals; an S-plane foliation is defined by elongate calcite and chlorite bands (~20° to core axis) and C-plane shears with fine-grained recrystallised chlorite (~35° to core axis).

A second breccia zone occurs at 181.7-182.4 m. Margins of the fault zones are approximately 30° to the core axis.

Brittle calcite-filled veins from 1 mm to 10 mm throughout the metadolerite are oriented between 10° and 90° to the core axis.

Pyrite occurs throughout the carbonate breccias and metadolerite as fine disseminated grains, commonly associated with carbonate replacement.

The unit is interpreted as part of the metadolerite body intersected in Wynarka 1 to the east, located adjacent to the faulted contact with interpreted metasediment west of Wynarka 2.

GEOCHEMISTRY

Major and Trace Elements

42 samples of drillhole core were geochemically analysed for 11 major elements and 38 trace elements including Rare Earth Elements. A number of analytical methods were used, including:-

ICP (acid digestion) - Major elements
XRF - As, Ba, Bi, Sb, Sn, V, Zr
Atomic Absorbtion Spectrography - Ag, Cr, Cu, Ni, Pb, Zn
Fire Assay - Au, Pt, Pd
ICP - Mass Spectrography - Ce, Dy, Nd, Er, La, Eu, Lu, Yb, Y, Sm, Gd, U, Th, Sr, W, Ta, Mo, Nb, Ga, Co, Cs, Rb.

To reduce variations caused by alteration effects, all analyses were recalculated to 100% volatile free prior to plotting. The geochemical analyses for each drillhole are dealt with in detail.

Peebinga 1

The nine geochemical analyses performed on Peebinga 1 samples reflect the described lithologies. Sample 7028RS24 of the carbonate at 584.13m is high in CaO (47.2%) and contains negligible MgO (0.73%), confirming its lithological description as a limestone. The phyllite (7028RS35) is distinguished by high levels of SiO_2 (66.7%) and Th (22 ppm) but lower Na_2O, TiO_2, Fe_2O_3 relative to the metabasalts in this drillhole. The metabasic tuff (7028RS29) from 605.8m is distinguished from the phyllite (shale) by lower SiO_2 (37%) and when compared to the Peebinga 1 metabasalts is lower in SiO_2, Na_2O, TiO_2, MgO and higher in K_2O, Ba (Fig. 15a).

The metabasic lavas have all undergone greenshist facies metamorphism, and their current altered state is reflected in an average LOI of 6.02%; the least altered metabasic was 7028RS37 with a LOI of 2.54%.

The metabasic lavas plot in the basalt field (close to the alkaline tephrite/basanite field) on the SiO_2 versus Na_2O+K_2O classification of Le Bas *et al.* (1986) (Fig. 16a). In the Zr/TiO_2 versus Nb/Y classification plot (Winchester and Floyd, 1977; Fig. 16b), using elements considered immobile during alteration, the metabasic lavas fall within the field of alkali basalts. This alkaline nature is further emphasised using the total alkalis versus SiO_2 plot, where the Peebinga 1 lavas all fall within the alkaline basalt field of MacDonald (1968) (Fig. 16c).

The alkali metabasalts represent a closely related geochemical series, with similar SiO_2 values (approx. 45%), the exception being 7028RS37 which is petrologically described as a plagiobasalt and has increased SiO_2 (57.3%). The plagiobasalt exhibits a more fractionated character which is reflected in lower levels of MgO, TiO_2, V, Cr, Ba and anomalously high Zr (Fig. 15). The remaining alkali basalts (7028RS38, RS39, RS31, RS25, RS26) represent a series of increasing fractionation (Fig. 15); the more primitive compositions occur in the lower lava flows of the drillhole intersection and are distinguished by presence of olivine phenocrysts and lower concentrations of K_2O, Fe_2O_3, Ba, and As.

Caringa 1

The drilled intersections of Caringa 1 fall into two groups:

(1) metadolerite
(2) granitic xenoliths

Loss on Ignition values for the Caringa 1 rocks are generally low (average 1.04%), suggesting a generally minor degree of alteration, despite undergoing greenshist facies metamorphism.

The metadolerites form a tight cluster on the A-F-M diagram (Fig. 17a) suggesting a closely related group, whereas the granitic xenoliths plot over a larger chemical range.

The metadolerites plot within the sub-alkaline basalt and basaltic-andesite fields of the Nb/Y versus Zr/TiO_2 classification plot of Winchester and Floyd (1977) (Fig. 16b), thus contrasting with the alkaline metabasics of Peebinga 1.

An exception to the closely related metadolerite samples exists in 6827RS120, described petrographically as an albitic metadolerite; this exhibits a more fractionated character with elevated Fe_2O_3, MnO, P_2O_5, Zn, Zr, Th, U, Nb and depressed MgO and Al_2O_3. This more acidic composition is not considered to be caused by either contamination with felsic xenoliths that occur in this drillhole, as SiO_2 values appear unaffected (Figs. 17b and c), or alteration, as LOI values are low (0.63%).

The felsic xenoliths, are petrographically described as monzodiorites and granodiorites as well as more alkaline varieties such as albitites, some of which are porphyritic.

Plotted on the Ba-Rb-Sr classification system of EL Bouseily and EL Sokkaru (1975) (Fig. 18a), the granitic xenoliths plot over a range of rock types from "anomalous" granodiorites through to "normal" diorites. The anomalous characteristic of these xenoliths (high Zr, Sr, Na_2O and low Ba, Rb, K_2O) is also apparent in the Ba-Rb-Zr plot (Fig. 18b), which suggests an alkaline affinity.

Wirha South 1

The granite shows signs of mild alteration with low values of LOI (1.13%). On the Ba-Rb-Sr classification plot (EL Bouseily and EL Sokkary, 1975) this rock falls within the field of normal granites, and has relatively high Ba, Rb and K_2O:Na_2O ratio and low Zr (Fig. 18).

Tori Hills 1

Three samples of granitoid all plot as a tight group within all variation diagrams. This rock plots as a normal granite in the Ba-Rb-Sr classification (Fig. 18a).

Peake 1

The drilled intersection comprises two rock types:

(1) metadolerite
(2) porphyritic albitic rhyolite.

The metadolerites plot on the alkaline/subalkaline boundary of MacDonald (1968) of the total alkalis versus silica plot, indicating that the metadolerites of Peake 1 represent a slightly alkaline variant of those from Caringa 1 (Fig. 16c). These rocks have undergone greenshist facies metamorphism and are mildly altered with LOI values of approx. 2.5%. The albitic rhyolite has a high SiO_2 content (72.8%), and plots in the field of anomalous granites in the Ba-Rb-Sr classification plot (EL Bouseily and EL Sokkary, 1975; Fig. 18a). The albitic rhyolite is enriched in SiO_2, Na_2O, Fe_2O_3, Zr, Y, Ga and Cu but low in K_2O, TiO_2, MgO, Rb and Ba relative to normal granite; this anomalous geochemical character is reflected in the predominance of albite in the phenocrysts and groundmass of this rock. However, on the Zr/TiO_2 versus Nb/Y volcanic classification of Winchester and Floyd (1977) (Fig. 16b) this rock plots as a sub-alkaline rhyolite.

Wynarka 1

The drilled intersection contains two rock types:

(1) metadolerite
(2) granitoid.

Both rock types have been metamorphosed, however, the overall level of alteration is mild with LOI values usually <1%. Two metadolerite compositional groups are apparent from an AFM plot of Wynarka 1 samples (Fig. 19), the least fractionated geochemical type is represented by sample 6827RS151. Both metadolerite types plot in the sub-alkaline field of MacDonald (1968) of the total alkalis versus SiO_2 plot (Fig 16c).

The felsic rocks, described petrographically as protomylonitic granodiorite, plot as a single group of Normal Granites according to the Ba-Rb-Sr classification of El Bouseily and El Sokkary (1975) (Fig. 18b).

Wynarka 2

Intense chlorite + calcite alteration associated with tectonic deformation is the predominant feature of the metadolerites of Wynarka 2, with CaO concentrations up to 28.1% and LOI values up to 24.3% (no doubt much of this being CO_2). All samples with greater than 8% LOI were excluded from geochemical plots, therefore the samples utilised were 6827 RS 139, 142, 149.

In all discrimination and classification plots the metadolerites of Wynarka 2 appear analogous to those of Caringa 1 (Fig. 16).

Geochemical Synthesis

Geochemical analyses of drillcore from the current drilling program exhibit a bimodal SiO_2 distribution between basalts and metadolerites on the one hand and granite/granodiorite and rhyolite on the other.

Furthermore, the mafic rocks fall into two distinct groups:

Group 1 - metabasalts of Peebinga 1
Group 2 - metadolerites of Caringa 1, Wynarka 1 & 2, and Peake 1.

Group 1 metabasalts have the lowest initial SiO_2 level but evolve to the highest SiO_2 mafic rocks. These rocks are alkaline and evolve with rapid enrichment in Fe_2O_3 relative to MgO (Fig. 20a), as well as anomalous enrichment in TiO_2, Ba and As (Fig. 20b).

Group 2 are sub-alkaline (?shallow intrusive) metadolerites exhibiting less marked enrichment in Fe_2O_3 relative to MgO. This group can be further subdivided into:

Sub-Group (a) Caringa 1, Wynarka 1 and 2
Sub-Group (b) Peake 1.

The Peake 1 sub-group represents a more fractionated and alkaline version of the sub-group (a) metadolerites.

Group 1 metabasalts exhibit a wide geochemical range compared to the combined subgroups of the Group 2 metadolerites, suggesting that the Peebinga 1 basalts have undergone a greater degree of fractionation than the metadolerites.

This fundamental division is further emphasised in the Ti/100 versus Zr versus Y*3 discrimination plot (Pearce and Cann, 1973); Fig. 21a) which classifies Group 1 metabasalts as within-plate type, sub-group (a) as mid-ocean ridge type and sub-group (b) as calc-alkali type.

This is further confirmed in the discrimination plot of Meschede (1986) (Fig. 21b), where Peebinga 1 basalts plot as a clear group in the within-plate field and all of the metadolerites plot in the field of normal mid-ocean ridge basalt (N-type MORB).

The majority of granitic rocks classify as I-type granites (classification of Chappell and White, 1974) on the basis of having Mol $Al_2O_3/(Na_2O + K_2O + CaO)$ <1.1; furthermore these rocks are higher in Na_2O for specific values of K_2O than would be expected for S-type granites. The exception is the Wynarka 1 granite. However, this is a borderline case at 1.12 (Mol $Al_2O_3/(Na_2O + K_2O + CaO)$.

The Peake 1 albitic rhyolite, although interpreted as extrusive, represents an anomalous granitic composition and according to the definitions of Whalen *et al.* (1987) would classify as an A-type granite with relative enrichment in Zr, Y and Ga and depletion in CaO and Ba.

<u>Metallic Commodities</u>

Base Metals

Base metal values within the limestone-basalt sequence in Peebinga 1 are generally low. Cu values range from 18 to 64 ppm (maximum within metabasalt), and Pb values range from 15 to 46 ppm (maximum within micritic limestone). Zn values are slightly elevated, ranging from 48 to 190 ppm. A total of 6 samples of amygdaloidal and agglomeratic basalt within the interval 589-636 m yielded values of >100 ppm Zn. The maximum Cu, Pb, Zn values are not coincident in any one sample.

The metabasic suite intersected in Wynarka 1 and 2 and Caringa 1 also has low base metal values. Cu values are generally in the range 4-60 ppm, with an anomalous value of 180 ppm within a zeolite-epidote veined amphibolite in Caringa 1. The zeolite vein contains abundant patches of pyrite up to 10 mm across. Pb ranges from <4 ppm (detection limit) to 66 ppm. The maximum Pb value occurs within a clast of protomylonitic granodiorite contained within metadolerite in Wynarka 1. Zn values range from 15 ppm to 125 ppm, with 6 samples of amphibolite yielding >75 ppm Zn in Caringa 1. These values are scattered throughout the core from 198 to 307 m. Values of >75 ppm Zn are also common throughout the carbonate-replaced metadolerite in both Wynarka 1 and 2.

The Delamerian granitoids intersected in Wirha South 1 and Tori Hills 1 have low base metal values: Cu 6-30 ppm, Pb 34-54 ppm and Zn 58-64 ppm. The ?Cambrian meta-arkose in Kringin 1 also has low base metal values.

The albitite within Peake 1 has an anomalous Cu value of 280 ppm, represented in drillcore by copper staining along fracture planes. Pb and Zn values for the albitite are <50 ppm. One specimen of the metadolerite interpreted to intrude the albitite has an anomalous Zn value of 125 ppm.

Precious Metals

Au values for all of the intersected basement rocks are typically $\leq$ 1 ppb (detection limit). A sample of micritic limestone, and one of phyllite from Peebinga 1 recorded values of 6 ppb Au. One pyrite-rich, carbonate-replaced metadolerite specimen from Wynarka 1 recorded 4 ppb Au. Amphibolite within Caringa 1 contained no Au values above detection limit, but 2 separate felsic to intermediate clasts yielded values of 2 and 4 ppb respectively. The maximum Au value recorded was 8 ppb for granite intersected in Tori Hills 1.

Almost all samples analysed have Ag values $\leq$ 1 ppm (detection limit). Only one specimen of carbonate-replaced metadolerite in Wynarka 2 recorded a higher value of 2 ppm.

Pt and Pd values for all specimens have values at or below detection limits (5 ppb and 1 ppb respectively), with 2 exceptions: 2 ppb Pd were recorded in both a pyrite-rich phyllite in Peebinga 1 and a carbonate-replaced metadolerite in Wynarka 2.

STRATIGRAPHIC AND TECTONIC CORRELATIONS

The weakly metamorphosed basalt-limestone-shale sequence intersected in Peebinga 1 is lithologically similar to the Early Cambrian Truro Volcanics and Fork Tree Limestone association of the Normanville Group in the eastern Mt Lofty Ranges. The basalt also shows geochemical similarities to the Truro Volcanics; both are alkaline and have within-plate characteristics (using the Ti-Zr-Y discrimination fields of Pearce and Cann, 1973; Fig. 22a). However, the basalt in Peebinga 1 occurs at the northwestern termination of the geophysically-defined Stavely Belt.

The Stavely Belt contains calcalkaline volcanics associated with clastic sediments, whereas Heathcote and Mt Wellington greenstone belts further to the east within the Lachlan Foldbelt are dominated by MORB-type tholeiitic basalts, dolerites with occassional boninites and peridotites within the Lachlan

Foldbelt, which are depositionally overlain by Upper Cambrian to Ordovician sediments (Crawford, 1988; Coney *et al.*, 1990). The tectonic setting of the Stavely Belt is ambiguous with some workers (Brown *et al.*, 1968; Crawford, 1988) suggesting the belt is a volcanic arc that formed after Kanmantoo Group sedimentation. However, Cas (1983) and Coney *et al.* (1990) note that no 'trench assemblage' and therefore no facing for an arc have been recognised. A Ti-Zr-Y discrimination plot of all the major volcanic rock types occurring in the Victorian greenstone belts (Fig. 22b; data from Crawford, 1988) shows that tholeiites of the Heathcote and Wellington belts plot in the MORB field, and that andesites of the Mt Wellington belt plot within the calc-alkali basalt field. However, none of the Victorian greenstone belts exhibit the within-plate character of the Peebinga 1 metabasalt (and Truro Volcanics; Fig. 22a). Therefore, several models can be proposed to explain the association of the Peebinga 1 basalt with the Stavely Belt geophysical trend.

The first model accepts that the Stavely Belt represents a volcanic arc formed during reconvergence of a Victorian microcontinental block with the Australian Craton-Kanmantoo Trough during Middle to Late Cambrian (as suggested by Schiebner, 1985 and Brown *et al.*, 1988). However, the volcanics and sediments represented by the Peebinga 1 represent an allochthonous block of Early Cambrian shelf sediments and volcanics of the Stansbury Basin incorporated on the margin of the volcanic arc.

Alternatively, the Mount Stavely Volcanic Complex may be correlatable with the Early Cambrian Normanville Group. The tectonic setting for the volcanics in this instance is problematical, but must account for the calcalkaline nature of the Mount Stavely Volcanic Complex. This may be accommodated by envisaging volcanic arc and back-arc basin development in the southeast along the margin of a continental plate during the Early Cambrian. In this model, both the Stansbury Basin and Stavely Belt are overprinted by major crustal extension and deposition of the Kanmantoo Group.

A third alternative is that the Peebinga 1 basalt is equivalent to a volcanic-arc Mount Stavely Volcanic Complex, and not correlatable with the Truro Volcanics. This correlation would require a change in the geochemical nature and source of the volcanics along the length of the Stavely Belt. At present there is no evidence which favours one model over another.

The meta-sandstone within Kringin 1 is interpreted as equivalent to Kanmantoo Group metasediments. No relationships between these and the weakly-deformed Peebinga 1 sequence can be inferred from geophysical evidence.

The weakly deformed metabasic complex intersected in Wynarka 1 & 2, Caringa 1 and Peake 1 when compared with Victorian volcanics, shows a close analogy to the tholeiites of the Heathcote and Mt Wellington Belts although the andesites and boninites of Victoria are much lower in TiO_2 and higher in SiO_2 than any of the basalts and metadolerites encountered in the South Australian Murray Basin basement (Fig. 23).

The metadolerites intersected in this drilling program mostly have primitive MORB-like characteristics (Fig. 21a), and are geochemically similar to the syn-Kanmantoo Group to syn-Delamerian Orogeny metadolerites and amphibolities reported by Liu and Fleming (1990) (also Liu and Parker, 1990) that intrude the Kanmantoo Group in the eastern Mount Lofty Ranges. These basic intrusives have been interpreted by Liu and Fleming (1990) as intruded within a continental-oceanic marginal crust setting. In the north of the Murray Basin area, a zone of similar magnetic character was found to contain ?Cambrian basic and metabasic dolerite and ?basalt (CRA, 1985; Preiss and Radke, 1988; these rocks are analagous to the metadolerite intersected in Peake 1. This zone, which swings in an arc eastwards into NSW (south of the Broken Hill Block) is interpreted as a volcano-sedimentary belt of late-Kanmantoo Group, early-Delamerian Orogeny affinity. It is probable that the metabasic complex at Wynarka-Caringa-Peake is related to this volcano-sedimentary belt.

The stratigraphic position of the albititic rhyolite intersected in Peake 1 is unknown, although it is possible that it represents a bimodal magmatic component of the pre-to syn-Delamerian Orogeny metabasics. The albititic rhyolite plots within the field of ocean ridge granites in the discrimination plot of Pearce et al. (1984) (Fig. 24) and therefore may represent an acid differentiate of the MORB-like metadolerites. An occurrence of rhyodacite in SADME M129 (Barnett, 1988) which is adjacent to the interpreted extent of the metabasics intersected in Caringa 1, supports this tentative interpretation.

The deformed granitoids intruded by metadolerite in Wynarka 1 and the granitoid xenoliths within Caringa 1 are of unknown age and association. These may represent either felsic differentiates from a parent magma for both the metabasics and granitoids, or represent pre-existing Precambrian or Early Cambrian crust. Similar gneissic and plutonic xenoliths within Middle Palaeozoic mafic dykes in Nova Scotia have been interpreted as fragments of deep crustal basement to the overlying host terrane (Ruffman and Greenough, 1990).

The granitoids intersected in Wirha South 1 and Tori Hills 1 are relatively undeformed, and are tentatively interpreted as late to post-Delamerian Orogeny intrusives, similar to those which are exposed in the Padthaway Ridge area. However, Foden et *al.*

(1990) indicate that the post-Delamerian granites are typically A-type granites whereas the Wirha South 1 and Tori Hills 1 granites represent I-type granites that plot in the "volcanic-arc-granite" field (Fig. 24), and are therefore more chemically analogous to the syn-tectonic granites of the Delamerian orogeny.

The Padthaway Ridge post-Delamerian Orogeny granitoids are associated with porphyritic rhyolite and are geochemically related to amphibolite, intersected in drilling at Meningie, and to the Black Hill gabbro-norite complex (Turner *et al.*, in press). The Black Hill gabbro-norite complex plots in the MORB and calc-alkali basalt fields of Pearce and Cann (1973) (Fig. 25a) and in the MORB and calc-alkali basalt field (Fig. 25b) of Meschede (1986), suggesting a VAB or MORB-type magma parent for this large mafic-ultramafic intrusive.

Weakly-deformed basalt and andesite intersected by CSR (1986) in the Yumali-Coonalpyn region (Farrand, in prep.), although structurally juxtaposed to the post-tectonic granitoids and gabbro intrusives of the Padthaway Ridge area, have within-plate characteristics (Fig. 25c) which, combined with their foliated nature suggest correlation with the Truro Volcanics and possibly the Peebinga 1 volcanics.

An isolated sample from within the Yumali-Coonalpyn area exhibits anomalously high MgO (approx. 15%). The plot of MgO versus TiO_2 (Fig. 25d) shows that this isolated sample correlates with the flat trend of increasing Mgo with constant TiO_2 levels typical of the Black Hill mafic - ultra-mafic suite; whereas boninites with similar MgO levels from Victoria (Fig. 23) are considerably depleted in TiO_2 relative to this sample. It appears therefore, that an equivalent to the Black Hill gabbro-norite magma type exists within the Padthaway Ridge area.

The basalts and andesites of the Yumali-Coonalpyn area show steeply inclined trends of increasing MgO with decreasing TiO_2 (Fig. 25d), analagous to that shown by the Truro Volcanics.

Compilation of geophysical and borehole data has allowed tentative interpretation of the stratotectonic framework of the basement to the Murray Basin (Fig. 26). Based on drillhole intersections of Cambrian mafic volcanics/intrusives and, to a lesser extent, associated sediments, coincident with magnetically anomalous zones, the mafic rocks are interpreted to be areally extensive. Semicircular magnetic zones along the Padthaway Ridge and other magnetically-quiet zones in which granitoids have been intersected by drilling, also suggest that there are large volumes of syn- to post-tectonic granitoids. The paucity of drillhole data and the wide line-spacing of the regional aeromagnetic surveys has limited the identification of granitoids and other domains beneath the deeper eastern section of the Murray Basin.

MINERAL POTENTIAL

Although drilling did not intersect base-metal (or any other) mineralisation, the interpreted stratigraphic and tectonic framework for the region indicates that there are major aerially-extensive areas of basement beneath the Murray Basin with a potential for base metal mineralisation.

Basement intersections from both this program and previous exploration, stratigraphic and groundwater drilling, plus regional geophysical interpretation indicate three major provinces of Early Palaeozoic volcanics and intrusives with potential for mineralisation.

(1) Stavely Belt - basaltic pillow lavas interbedded with pyrite-bearing shelf-facies limestone and black shale intersected in Peebinga are possible correlatives of the Truro Volcanics to the west, or the Mount Stavely Volcanic Complex to the southeast.

(2) A discontinuous arc of bimodal intrusives and extrusives extending from north of the Padthaway Ridge to south of the Broken Hill Block - these are possible correlatives to metadolerite and amphibolite intruded into the Kanmantoo Group both during sedimentation and syn-Delamerian Orogeny, and exposed in the eastern Mount Lofty Ranges.

(3) Padthaway Ridge area - bimodal magmatism, including mafic intrusives and ?extrusives and rhyolitic extrusives associated with post-Delamerian Orogeny granitoids. This province also includes a zone of older, deformed basalt-andesite in the Yumali-Coonalpyn region, possibly related to the Truro Volcanics.

From the limited basement intersections of associations (1) and (2), it is difficult to assess accurately the potential for the existence of extensive ?bimodal volcanism similar to those of the Mount Read Volcanics. However, as noted above, the magnetic domains in which these rocks occur are aerially extensive and offer a large area in which to explore. Furthermore, some of these domains represent relatively shallow basement of the order of 100-200m in depth below ground level in areas where access and availability of facilities are not a problem.

The bimodal volcanism of association (3) suggests similarity with the Mount Read Volcanics, although this association is interpreted to be partly post-Delamerian Orogeny, while the Mount Read Volcanics was deposited prior to the Delamerian Orogeny (Solomon *et al.*, 1988). However, the volcanics in the

Coonalpyn-Yumali area are pre-Delamerian Orogeny, are relatively shallow, and yet have not been fully explored or researched; they may be quite extensive in both area and depth.

Although base metal values within the basement intersections from this programme were low, all of the metabasics and associated sediments contained abundant pyrite as discordant veins, nodules and disseminated mineralisation, with up to 5% visible sulphide. All of the volcanic associations outlined above have potential for stratiform exhalative and/or epithermal feeder zone sulphide mineralisation.

With the presence of possible equivalents to the Mount Stavely Volcanic Complex, plus abundant syn- and post-Delamerian granitoids, there is also a high potential for volcanogenic and/or hydrothermal gold mineralisation.

The potential for PGE mineralisation within mafic-ultramafic plugs of the Black Hill gabbro-norite complex has yet to be tested, but geophysical data plus drilling indicate that there are various intrusives likely to be part of this suite.

REFERENCES

Barnett, S.R., 1989. Murray Basin - hydrogeological investigation. Drilling programme - Mallee region. Progress report no. 8. *South Australia. Department of Mines and Energy. Report* 89/34.

Brown, C.M., Tucker, D.H. and Anfiloff, V., 1988. An interpretation of the tectonostratigraphic framework of the Murray Basin region of southeastern Australia, based on an examination of airborne magnetic patterns. *Tectonophysics,* 154: 309-333.

Buckland, G.L., 1986. Geology and mineral potential of the Mount Stavely Volcanic Complex. Geological Survey of Victoria Report 80. *Department of Industry, Technology and Resources, Victoria, Australia.*

Chappel, B.W. and White, A.J.R., 1974. Two contrasting granite types. *Pacific Geology* 8 ; 173-174.

CRA Exploration Pty Ltd., 1985. Murray Basin, Peake, Redcliffe, Sturtvale, Swan Reach, Waikerie, Narrung, Malinong, Bungunnia, Kakoonie, Karoonda, Mypolonga, Oakbank, Gluepot. Progress and final reports for the period 7.10.80 to 7.3.85. *South Australia. Department of Mines and Energy. Open file Envelope* 3957.

CSR Ltd., 1986. Coonalpyn. Progress and relinquishment reports for the period 28.3.82 to September 1986. *South Australia. Department of Mines and Energy. Open file Envelope* 4719.

D'Addario, G.W. and Tucker, D.H., 1987. Adelaide 1:1 000 000 map sheet Magnetic Domains. Analysis of Aeromagnetic Pixel Map series. *Bureau of Mineral Resources, Australia.*

Derrington, S.S. and Anderson, J.C., 1970. Well completion report Sunset 1, Morakalla 1, Nadda 1 wells. *South Australia. Department of Mines and Energy. Open file Envelope,* 1350.

EL Bouseily, A.M. and EL Sokkary, A.A., 1975. The relation between Rb, Ba and Sr in granitic rocks. *Chemical Geology* 16 ; 207-219.

Farrand, M.G., in prep. Petrology of basement rocks from the southeastern margin of the Murray Basin. South Australia. *Department of Mines and Energy. Report Book.*

Farrand, M.G., McCallum, W.S. and Gerdes, R.A., 1989. The Black Hill norite complex. *South Australia. Department of Mines and Energy. Report Book 89/65.*

Foden, J.D., Turner, S.P. and Morrison, R.S., 1990. The tectonic implications of Delamerian magmatism in South Australia and western Victoria. *In* Jago, J.B. and Moore, P.S. (Editors). The evolution of a late Precambrian - early Palaeozoic rift complex : the Adelaide Geosyncline. *Geological Society of Australia Special Publication* 16 ; 465-481.

Gravestock, D. and Alley, N., in prep. Early to Middle Palaeozoic. *In* Johns, R.K. (editor). *Handbook of South Australian Geology. South Australia. Department of Mines and Energy.*

Horn, C.M. and Morris, B.J., 1988. Summary review of lead-zinc mineralisation in South Australia. *South Australia. Department of Mines and Energy. Report Book 88/76.*

Kuno, H., 1966. Lateral variation of basalt magma type across continental margins and island arcs. *Bulletin of Volcanology,* 29 ; 195-222.

Le Bas, M.J., Le Maitre, R.W., Streckeisen, A. and Zanettin, B., 1986. A chemical classification of volcanic rocks based on the total alkali-silica diagram. *Journal of Petroleoy* 27/3; 745-750.

Liu, S.F. and Fleming, P.D., 1990. Mafic dykes and their tectonic setting in the southern Adelaide Foldbelt, South Australia. *In* Parker, A.J., Rickwood, P.C. and Tucker, D.H. (Editors). *Mafic Dykes and Emplacement Mechanisms. Proceedings of the second International Dyke Conference, Adelaide 12-16 September, 1990.* A.A. Balkema, Rotterdam, pp. 401-413.

Liu, S.F. and Parker, A.J., 1990. Mafic dykes in the eastern Mount Lofty Ranges and Barossa Valley South Australia. *Second International Dyke Conference, Adelaide 1990. Excursion Guide.* Geological Society of Australia.

MacDonald, G.A., 1968. Composition and origin of Hawaiian lavas. *In* Coats, R.R., Hay, R.L. and Anderson, C.A. (editors). Studies in volcanology : a memoir in honour of Howel Williams. *Geological Society of America. Memoir* 116 ; 477-522.

Meschede, M., 1986. A method of discriminating between different types of mid-ocean ridge basalts and continental tholeiites with the Nb-Zr-Y diagram. *Chemical Geology,* 56 ; 207-218.

Morris, B.J., 1988. Review of lead-zinc mineralisation in South Australia - Kanmantoo Trough. *South Australia. Department of Mines and Energy. Report Book 88/22.*

Pearce, J.A. and Cann, J.R., 1973. Tectonic setting of basic volcanic rocks determined using trace element analyses. *Earth and Planetary Science Letters* 19 ; 290-300.

Pearce, J.A., Harris, N.B.W. and Tindale, A.G., 1984. Trace element discrimination diagrams for the tectonic interpretation of granitis rocks. *Journal of Petrology* 25/4 ; 956-983.

Preiss, W.V. and Radke, F., 1989. A new occurrence of mafic igneous rocks beneath the northern Murray Basin. *South Australia. Department of Mines and Energy. Report Book 89/40.*

Ruffman, A. and Greenough, J.D., 1990. The Weekend dykes, a newly recognised mafic dyke swarm on the eastern shore of Nova Scotia, Canada. *Canadian Journal of Earth Sciences,* 27: 644-648.

Thornton, R.C.N., 1974. Hydrocarbon potential of western Murray Basin and infrabasins. *South Australia. Geological Survey. Report of investigations,* 41.

Turner, S.P., Foden, J.D. and Cooper, J., 1989. Post-Delamerian magmatism: tectonic controls on magma chemistry and evidence for post-Delamerian extension. *Geological Society of Australia. Abstracts* 24: 155-156.

Turner, S.P. and Foden, J.D., 1990. The nature of mafic magmatism through the development of the Adelaide Geosyncline and the subsequent Delamerian Orogeny, South Australia. *In* Parker, A.J., Rickwood, P.C. and Tucker, D.H. (Editors). *Mafic Dykes and Emplacement Mechanisms. Proceedings of the second International Dyke Conference, Adelaide 12-16 September, 1990.* A.A. Balkema, Rotterdam, pp 431-434.

Turner, S.P., Morrison, R.S. and Foden, J.D., in press. Source and evolution of the A-type granites and volcanics of the Padthaway Ridge. *Contributions to Mineralogy and Petrology.*

Solomon, M., Eastoe, C.J., Walshe, J.L. and Green, G.R., 1988. Mineral deposits and sulphur isotope abundances in the Mount Read Volcanics between Que River and Mount Darwin, Tasmania. *Economic Geology,* 83/7: 1307-1328.

Vandenberg, A.H.M., 1988. *Palaeozoic stratotectonic and structural map of Victoria. Department of Industry, Technology and Resources, Victoria, Australia.*

Wellman, P., 1989. Structure and subdivision of the Tasman Orogen, on the basis of the gravity and magnetic anomaly pattern. *In*: SGTSG conference: *Australasian Tectonics. Geological Society of Australia. Abstracts,* 24: 165-166.

White, S., 1982. Fault rocks of the Moine Thrust Zone: a guide to their nomenclature. *Textures and Microstructures,* 4: 211-221.

Winchester, J.A. and Floyd, P.A., 1977. Geochemical discrimination of different magma series and their differentiation products using immobile elements. *Chemical Geology,* 20 ; 325-343.

TABLE 1. Summary of Geophysical Modelling of Magnetic Anomalies

ANOMALY #	FLIGHT LINE	FIELD VERIFI-CATION	MODEL FIT	DEPTH BELOW SURFACE	WIDTH	MAGNETIC SUSCEPT-IBILITY	DIP	COMMENTS
MBT 1	1750	YES	Fair-Good	385m	1429m	0.0001	86°E	Modelled as steep, easterly-dipping suite of rocks. Discrete anomaly, no regional gradient involved.
MBT 2	-	NO	-	-	-	-	-	
MBT 3	1850	YES	Fair	318m	714m	0.004	84°W	Modelled as steep westerly-dipping body. Anomaly not located in field - suspected to lie within conservation park.
MBT 4	1650	YES	Poor	250-340m	1500-1650m	0.0006-0.00075	-	Models require more work. Generally a westerly-dipping suite of rocks. Perhaps a regional should be first taken out to assist modelling. Better data subsetting required.
MBT 5	-	NO	-	-	-	-	-	
MBT 6	1810	NO	-	608m	893m	0.00068	76°E	Complex anomaly. Not field verified. Regional gradient involved. Difficult to get a good depth estimate due to complexity.
MBT 7	1770	YES	Fair	251-273m	1017m	0.0005-0.00055	80°E	Modelled as single discrete Degree of fit quite good.
MBT 8	1830	YES	Not Attempted	-	-	-	-	Very small anomaly on the ground. Questionable location of peaks. Ground curves need drift correction.
MBT 9	1890	YES	Not Attempted	-	-	-	-	Needs removal of regional gradient before modelling. Probably needs further fieldwork to extend lines to accurately locate anomaly. Possibly quite deep.
MBT 10	1770	NO	-	-	-	-	-	No flightline anomaly.
MBT 11	2030	YES	Poor	30-162m	1700m	0.006	90°	Complex, degree of fit to model poor. Requires further work.
MBT 12	1890	YES	Fair	84-117m	525m	0.00035	83°E	A good fit obtained using a 5-body anomaly model.

TABLE 1. Summary of Geophysical Modelling of Magnetic Anomalies Continued

ANOMALY #	FLIGHT LINE	FIELD VERIFI-CATION	MODEL FIT	DEPTH BELOW SURFACE	WIDTH	MAGNETIC SUSCEPT-IBILITY	DIP	COMMENTS
MBT 13	1710	YES	Fair	284-318m	950m	0.0005-0.0006	81°W	Requires removal of regional gradient before a good fit can be obtained.
MBT 14	1880	NO	-	-	-	-	-	No flightline anomaly.
MBT 15	1880	YES	Good	50-134m	525m	0.0011-0.000668	83°E	Could have regional gradient removed to make a better model fit.
MBT 16	1700	YES	Fair-Good	117-350m	178-1429m	0.004	83°E	5008 anomaly with suspected shallower bodies. Quite a broad anomaly.
MBT 17	2090	-	-	-	-	-	-	No flightline anomaly.
MBT 18	1040	YES	Good	207-296m	3250m	0.002-0.006	90°	7508 anomaly on flightline data. Approximately 4kms wide with 2 separate peaks. Discrete stand-alone anomaly.

APPENDIX 1

PETROLOGY OF EARLY PALAEOZOIC BASEMENT ROCKS, MURRAY BASIN BASEMENT DRILLING PROJECT

by

M G FARRAND

and

L R RANKIN

G01755

PEEBINGA 1

7028 RS 24 TS C53470

Depth 584.3 m

Rock name Calcite with pyrite mineralisation.

Hand Specimen

Large masses of fine-grained, grey carbonate have been disrupted and intruded by dark, fine-grained material carrying pyrite.

Thin section

The calcite host is micritic and pure except for disseminated pyrite without gangue. Major fractures have been penetrated by solutions carrying pyrite and a gangue of colloidal silica, chlorite and sericite. The mineralisation has also incorporated dolomite from the host rock.

The pyrite consists of euhedral to subhedral grains, irregular patches and what appear to be framboidal forms partly filled in with additional sulphide. Marked pressure shadows infilled with amorphous silica occur associated with the large pyrite grains in the dark matrix suggesting pyrite mineralisation occurred prior to deformation.

PEEBINGA 1

7028 RS 25, TS C53471

Depth 589.5 m

Rock name Amygdaloidal metabasic

Hand specimen

The rock is fine-grained and a relatively uniform pale grey apart from elongated and round patches in the order of 1mm wide of a dark grey colour and branching white veins.

Thin section

Irregular vesicles occur throughout the rock which consists essentially of closely packed plagioclase laths with interstitial opaque minerals. The plagioclase is extensively sericitised and the opaques are strongly leucoxenised. Limonite pseudomorphs may be replacements of ferromagnesian phenocrysts.

The dark patches in hand specimen are probably original vesicles. The walls are often lined with quartz of colloidal origin and filled with fine-grained and fibrous chlorite, often in rosette form. The same chlorite is present in a few veins and in spaces between what appear to be autobrecciated fragments of possibly semi-lithified tuff.

Veins and patches of carbonate are widespread.

PEEBINGA 1

7028 RS 26, TS C53472

Depth 592.4 m

Rock name Fine-grained homogeneous metabasic agglomerate

Hand specimen

Fine-grained, dark grey fragments up to 1.5 cm across are contained in a lighter grey matrix penetrated by a complex network of fine veinlets. Pyrite is abundant in a lenticular patch 2.5 cm long.

The rock is an homogeneous agglomerate consisting of fragments of very fine-grained rock which exhibit an interlocking lath texture presumably after plagioclase but now altered to amorphous silica? and sericite with abundant opaque grains.

Alteration is concentrated along many veinlets and produces various types of lithological changes. A common form of alteration is a conversion to optically amorphous material in which no distinctive optical properties are displayed. This occurs along a few relatively broad bands. Sericitisation takes place throughout the rock on a multiplicity of fine bands in a complex network and often spreads out into surrounding rock. A similar, and partly coincident, network carries a yellow-brown, amorphous material which is probably leucoxene. In a few veinlets the alteration is argillaceous as well as micaceous.

Pyrite grains occur in the matrix without gangue minerals.

PEEBINGA 1

7028 RS 29, TS C53473

Depth 605.8 m

Rock name Partially devitrified ash.

Hand specimen

A pale grey, fine-grained rock contains light coloured veins and light grey patches with pyrite.

Thin section

The matrix of the rock is almost featureless in plane polarised light apart from the same leucoxenised opaques that were seen at 608.4m. With crossed polarisers a very fine-grained, weakly to moderately birefringent mineral displays a strong preferred orientation. This is probably incipient sericitisation of a very fine-grained ash which did not devitrify to produce feldspar laths before developing a micaceous alteration.

Carbonate occurs as small scattered patches throughout the rock, as veinlets with pyrite and as large patches 2.5 cm across. The large patches contain concentrations of euhedral pyrite, often as rims around the margins. They may have originated as nodules at the centres of deposition by diffusion or possibly as lapilli of different rock from the host ash. No features of the original lithology remain.

PEEBINGA 1

7028 RS 31, TS C53474

Depth 608.4 m

Rock name Amygdaloidal metavolcanic rock.

Hand specimen

A light greenish grey, fine-grained rock is homogeneous except for random shaped patches of carbonate and dark greenish grey inclusions with a round to lenticular outline.

Thin section

The main rock represented is fine-grained and strongly altered. It consists of a closely interlocked mesh of plagioclase laths about 0.1mm long and now mainly replaced by carbonate and brown, weakly translucent interstitial grains with a rectangular to irregular outline probably after original opaque oxide minerals.

The intensity of carbonate replacement is patchy and at its most intense consists of total replacement in large patches and irregular veins.

Silica also occurs in irregular veins but more abundantly forms circular, lenticular and irregular patches averaging about 2mm across. These are probably filling vesicles in the original volcanic rock, which was probably a glassy lava.

PEEBINGA 1

7028 RS 32, TS C53475

Depth 610.9 m

Rock name Metabasic agglomerate

Hand specimen

A homogeneous accumulation of massive volcanic fragments up to 2.5 cm across is packed closely together with little or no matrix. If matrix were originally present, it has now been replaced by interstitial carbonate.

Thin section

Fragments in the agglomerate are strongly altered, however lithologies appear to originate from a single metabasic source rock. The metabasic lithology consists of an interlocking texture of plagioclase laths 0.2 to 0.5mm in length with altered phenocrysts, probably feldspar, up to 4mm across.

Dolomitic carbonate is abundant in this specimen and, in addition to the interstitial occurrence noted in hand specimen, forms large patches and veins within the framework fragments. In some fragments sericite is the replacement product.

Some fragments contain opaque grains, now leucoxenised, but pyrite crystals are rare and widely scattered.

PEEBINGA 1

7028 RS 34, TS C53476

Depth 617.6 m

Rock name Lapilli tuff

Hand specimen

Lenticular fragments of metabasic volcanic rocks up to 2cm long are contained in a pale grey matrix probably derived from volcanic ash. Preferred orientation of the long axes of the fragments is at about 30° to the core. Patches and corrugated veins of pyrite possibly formed during diagenesis before the rock was completely lithified.

Thin section

The lapilli are of porphyritic volcanic rocks with an interlocking plagioclase feldspar texture and phenocrysts of altered biotite, zoned feldspar and occasional quartz phenocrysts which may represent replaced feldspar phenocrysts. The magma may have changed towards an intermediate to acid composition which may account for an increase in explosive product.

Sericitisation of the matrix ash is not as pronounced in this specimen as in earlier tuffs but fine-grained sericite is present in material of low birefringence, possibly glass. This may be influenced by factors such as temperature rather than composition of the ash. Much of the sericite is extremely fine-grained and the process of sericitisation may be incipient rather than complete.

Amorphous brown material, probably leucoxene, is abundant.

Pyrite is accompanied by colloidal silica and pale chlorite and veins of the latter minerals are common. Carbonate is extremely rare.

PEEBINGA 1

7028 RS 35, TS C53477

Depth 621.05 m

Rock name Sericitic phyllite with pyrite

Hand specimen

Bands of black and various shades of grey are inclined at a high angle to the short axis of the core sample. The bands are subparallel but branching. The rock is fine-grained. Pyrite is present as several large patches of loosely clustered grains.

Thin section

The colour variations are the product of varied concentration of sericite in a shale. Branching black bands are of organic rich shale. The fabric is probably sedimentary but disturbed. Sericitisation produced a weakly consistent foliation. Pyrite is associated with colloidal silica and carbonate forms veins and patches sometimes associated with quartz. The pyrite occurs as relatively coarse grained euhedral to subhedral crystals.

PEEBINGA 1

7028 RS 36, TS C53478

Depth 621.6 m

Rock name Phyllite and black shale with pyrite.

Hand specimen

A band of fine-grained grey rock occurs with irregular contacts between two bands of black shale. No systematic fabric is apparent in either rock type but fine, irregular veinlets of white mineral and patches of pyrite are randomly distributed in the specimen.

Thin section

The grey rock consists of a mass of fine-grained sericite with a preferred orientation. The black rock is mainly opaque but fine lenses of sericite are sparsely distributed through it. The contact is partly a single irregular plane and partly transitional with lenses of one lithology contained in the other. It is probably a depositional contact between volcanic ash and organic ooze, but was either subject to disturbance during sedimentation and diagenesis and/or affected by later shearing activity.

Random lenses and patches of quartz, carbonate, silica and euhedral pyrite occur together and separately through the rock.

PEEBINGA 1

7028 RS 37, TS C53479

Depth 627.9 m

Rock name Plagiobasalt

Hand specimen

A fine-grained, greenish grey rock exhibits green and white veins but no other textures.

Thin section

The mineralogical composition of this flow is similar to that of the sheared metabasic tuff. The assays differ because the basalt is little altered and contains fewer veins. The basalt is rich in plagioclase with interstitial chlorite and opaque grains. The few veinlets contain chlorite quartz and carbonate.

Plagioclase phenocrysts are prismatic in shape and up to 5mm long. Grain size is strongly bimodal as groundmass plagioclase consists of closely packed laths about 0.5mm long. The laths exhibit a preferred orientation which is strong in places but is not totally consistent. It is typical of magma flow. Multiple twinning is well enough developed in some grains to indicate a composition in the andesine range.

Interstitial spaces are relatively sparse but opaque minerals and chlorite occur between the plagioclase laths.

Chlorite, carbonate and quartz occur individually and together in all combinations in relatively small veinlets.

PEEBINGA 1

7028 RS 38, TS C53480

Depth 630.3 m

Rock name Plagio-metabasic

Hand specimen

The specimen is pale greenish grey with indistinct textures except for several types of discordant veins.

Thin section

The rock consists of fragmented areas of relict interlocking plagioclase, several alteration products and veins containing carbonate, quartz, chlorite and leucoxene.

Plagioclase is fragmented, sericitised, locally replaced and structurally imperfect. Optical properties are too indistinct for compositional identification. Analysis indicates a high calcium content (7.55% CaO) but this is influenced by the dolomite content of the veins. Sodium is more abundant (3.42% Na_2O) than in the specimen from 635.6m but so is the total plagioclase. It is probable that the plagioclase is more sodic than at 635.6m but the data lack precision. Porphyritic plagioclase crystals up to 2mm across and clusters up to 5mm across indicate a source containing phenocrysts but the groundmass feldspar is up to 0.5mm across, indicating residence in a subvolcanic magma chamber before eruption.

Chlorite with weak anomalous birefringence occurs interstitially but is substantially less abundant than plagioclase. Patches of penninitic chlorite may represent altered ferromagnesian phenocrysts but are often linked to thin veinlets of penninite and it is clear that chlorite is also a mobile replacement product.

Opaque grains and small patches of translucent leucoxene are probably original to the magma but leucoxene is also mobile in the system of veinlets and schlieren. The titania content is 2.74% TiO_2.

Lath-shaped and lenticular particles of opaque to translucent material up to 1mm long occur randomly through the rock and are often fractured along and across the length of the particles.

Grains and patches of replacement products occur throughout the rock both interstitially and within the feldspar grains. They include carbonate, chlorite, sericite and leucoxene.

Broad veins are filled with coarse-grained carbonate and quartz both as individual grains and as mosaic patches.

PEEBINGA 1

7028 RS 39, TS C53481

Depth 635.6 m

Rock name Olivine metabasalt

Hand specimen
The rock is fine-grained and dark grey with a greenish tint. Many very fine veinlets of a pale greenish mineral cover the specimen in random to subparallel orientation. Many veinlets are corrugated. Porphyritic minerals are detectable only as faint outlines.

Thin section
Phenocrysts are up to 3mm across. They appear diffuse in hand specimen because they are fragmentary and strongly altered. It is not always clear whether fragmentary crystals are broken fragments of original individual phenocrysts or an open cluster of crystals which were always of finer grain size. The groundmass is mainly composed of plagioclase laths between about 0.1mm and 0.2mm long in a closely interlocked mesh without any apparent preferred orientation. Opaque minerals, amorphous material and fine-grained ferromagnesian minerals are also present. Several types of veinlets may indicate separate episodes of hydrothermal activity.

Many of the phenocrysts are identifiable as olivine, often as fragments surrounded by antigoritic alteration products. Others consist of fine-grained alteration products including platy minerals which are probably talc, antigorite and penninite.

These phenocrysts may originally have been pyroxenes. Some phenocrysts have preserved a prismatic shape but now consist of sericitic mica. There were almost certainly plagioclase.

Groundmass plagioclase is not well enough crystallised to be identified from optical properties but the relative proportions of lime and soda in the assay (9.3% CaO and 2.72% Na_2O) give an approximate indication of the composition of the plagioclase.

Ferromagnesian minerals in the groundmass are interstitial and anhedral. They are probably original pyroxene but cannot be identified optically.

Opaque grains are probably ilmenite and the amorphous material is probably leucoxene derived from the opaques. Titania is assayed as 2.42% TiO_2.

Veinlets contain dolomite and silica, penninite, dolomite and talc, penninite and leucoxene, penninite and dolomite, penninite and siderite and dolomite alone.

PEEBINGA 1

7028 RS 42, TS C53482

Depth 601.1 m

Rock name Metabasic agglomerate

Hand specimen

Several different shades of grey outline round and irregular shapes. A complex system of branching veinlets appears in a greenish grey and a simpler vein system appears in greyish white.

Thin section

Extensive carbonate replacement obscures the exact relationship between several lithologies but their close proximity suggests a collection of heterogeneous volcanic rocks as fragments in a breccia or agglomerate. Glassy, porphyritic and homogeneous meshes of feldspar laths are textures represented. Incipient sericitisation and carbonate replacement on a granular scale emphasise textural differences and add a chaotic character to the rock.

Carbonate also forms thick veins and patches which obscure the boundaries of many fragments.

PEEBINGA 1

7028 RS 43, TS C53483

Depth 629.85 m

Rock name Black shale and green tuff.

Hand specimen

The rock is medium grey with flame-like green textures superimposed on over half the area of the section. A granular texture is visible only in one corner of the specimen.

Thin section

The corner of the section where granularity is apparent bears a similarity to the fragmented metabasic rock sampled 0.5m deeper in the hole. Fragmented feldspar is contained in a matrix of chlorite with carbonate, sericite and leucoxene alteration. The plagioclase is less abundant and the other constituents proportionately more abundant than in the fragmented metabasic sample.

The flame like textures are produced by bands and ribbons of chlorite, carbonate and sericite through a matrix of weakly translucent, amorphous brown material. This is interpreted as the product of shearing of a metabasic volcanic tuff.

KRINGIN 1

7028 RS 49, TS C53488

Depth 408.2 m

Rock Name Meta-sandstone

Hand Specimen

The rock is medium-grained, black and white with a marked foliation. Despite its deep intersection it is friable and presumably weathered.

Thin section

The rock consists almost entirely of oriented quartz and biotite with fine-grained lithic grains and many cavities. Quartz forms separate grains and clusters of a few grains. Many of the single grains and most of the clusters are elongated, usually at an angle of about 25° to the preferred orientation of the biotite.

Biotite (~20%) occurs as well crystallised, subhedral flakes in open bands with a very strong preferred orientation. This produces a foliation but not planes of cleavage. The section is cut perpendicular to the width of the flakes and shows a slight undulation in the foliation.

The lithic component (~10%) is of indeterminate origin. Some grains are sericitised and may be either argillaceous with prograde alteration or feldspathic with retrograde alteration.

WIRHA SOUTH 1

7027 RS 1, TS C53487

Depth 330.8 m

Rock name Granite

Hand specimen

The rock is relatively fine-grained for a granite. Grain boundaries are not sharply delineated and black and white grains appear to be contained in a diffuse grey groundmass.

Thin section

The granite is not porphyritic but a few quartz and potash feldspar grains are appreciably coarser than the average while some patches of quartz and feldspar are finer grained than average. The diffuse grey mass of the hand specimen are probably those seen in thin section as areas of recrystallisation.

Quartz is clearly recrystallised. Much of it consists of partially annealed mosaics in which strain is still apparent. The unusually large grains appear to have grown at the expense of surrounding minerals.

Textures at the margins of large crystals of potash feldspar indicate that the feldspar has grown at the expense of adjacent plagioclase but is in turn replaced by quartz. Some potash feldspar grains are zoned structurally so that centre is orthoclase and the margins are microcline. Microcline is the potash feldspar in the recrystallised part of the rocks. Very little alteration affects the potash feldspar.

Plagioclase grains are often zoned and tend to be more altered than the potash feldspar. Both sericite and coarser grained muscovite are present as alteration products.

Biotite is the original mica but that too has been subject to recrystallisation. Some flakes are partially altered to muscovite while others are replaced by chlorite. Both alteration products are sometimes represented in the same grain.

Apatite and zircon are accessory minerals. Both produce metamict haloes in biotite.

TORI HILLS 1

6927 RS 11, TS C53518

Depth 254.25m

Rock name Xenolith in granite

Hand specimen

No hand specimen.

Thin section

The section consists mainly of the xenolith seen in hand specimen with a fringe of granite at one end. The 3mm brown vein is also represented.

In the granite large crystals of quartz with undulose extinction are similar to those of the other sections. Parts of the crystals are separate from the main body in the plane of section but are optically continuous. In potash feldspar series of weakly oriented quartz inclusions in optical continuity simulate graphic granite.

Potash feldspar is orthoclase with rare patches of microcline and occurs as very irregular, interstitial grains. It is weakly perthitic and unaltered except for the exsolution of fine granules of limonite in a streaky pattern.

Plagioclase occurs as medium grains which are subhedral when isolated and anhedral in clusters. It is often heavily altered to epidote, carbonate, sericite and clay minerals. Traces of zoning are often evident.

Biotite occurs as both euhedral flakes of good crystal structure and as fragmented, ragged, often skeletal flakes of poor crystallinity and strong alteration. Chlorite is the most common alteration product but carbonate, epidote and muscovite also replace biotite.

Opaque minerals occur as irregular inclusions in biotite.

Apatite and zircon are accessories.

The absence of hornblende is noteworthy.

The xenolith consists fundamentally of a closely interlocked mosaic of plagioclase prisms about 0.5mm long. Twinning is poorly preserved but, from the evidence of a few grains, the composition on the basis of extinction angles is oligoclase. Most grains are cloudy with fine grain alteration and do not display sharply defined optical properties, probably because of poor crystal structure. Many crystals are zoned with a highly altered core and margins of clear plagioclase. Irregular fragments of epidote are another common replacement product. Large epidote grains are interstitial.

Biotite is common, largely interstitial and strongly altered to chlorite. A green biotite appears to be an intermediate product in the alteration process. Some flakes are completely replaced by chlorite. Epidote is a minor alteration product of biotite.

Quartz has invaded the xenolith as well as the granite. Interstitial patches of quartz about 0.2mm across extinguish in optical continuity over an area of 3mm in the section. At the edge of xenolith the development of quartz appears to have wedged off fine-grained plagioclase and biotite which are now incorporated in the granite.

The vein is a compound structure. A thin, discontinuous layer of carbonate occurs at each margin but is not quantitatively significant. The margins are also marked in places by thin lines of opaque granules. A more continuous structure is a veinlet about 0.2mm across with opaque margins but consisting of coarse crystals of carbonate as the major filling. The latter veinlet meanders within the main constituent of the vein which is a closely interlocked mosaic of prismatic zeolites. The optical properties of these vary from crystal to crystal within the chabazite-gmelinite series.

TORI HILLS 1

6927 RS 12, TS C53519

Depth 257.5 m

Rock name Granite

Hand specimen

No hand specimen

Thin section

The same minerals as in RS 13 are present in RS 12. The proportion of hornblende is somewhat lower and that of potash feldspar somewhat higher in RS 12.

TORI HILLS 1

6927 RS 10, TS C53517

Depth 254.5 m

Rock name Granite

Hand specimen

No hand specimen

Thin section

The same mineralogy is present in this specimen as in RS 12 and 13. The proportion of quartz is particularly high in RS 10.

TORI HILLS 1

6927 RS 13, TS C53520

Depth 260.5 m

Rock name Xenolithic granodorite.

Hand specimen

White, black and grey crystals are sharply defined. Most grains are about 2 mm across but patches of fine-grained minerals are frequent. A fine-grained, dark grey xenolith occupies 5 cm of the specimen but only part of it is present. A straight brown vein about 3 mm wide cuts the sample.

Thin section

A large xenolith is included in the granite at 254.25m but is not represented in this particular thin section. A considerable quantity of fine-grained material is present, including hornblende. The overall composition of rock in the section is granodiorite with abundant, strongly zoned plagioclase and little potash feldspar.

Quartz occurs as large patches in optical continuity but often discontinuous in the plane of section. The quartz is presumably continuous below or above the plane of section. It exhibits strain polarisation and, from extreme embayment of adjacent minerals, has been emplaced largely by corrosion and replacement after most of the rock had crystallised. Individual grains in the plane of section measure up to 5mm and dispersed grains in optical continuity extend over 1.5cm. Interaction between quartz and potash feldspar has produced an intergrowth of quartz inclusions in feldspar host which resembles graphic granite.

This may be the result of simultaneous crystallisation at the eutectic point but is not completely regular. It appears more likely that a similar intergrowth can be produced by the replacement of feldspar by quartz.

Potash feldspar occurs as small, very irregular, interstitial patches. Both orthoclase and microcline are present.

Plagioclase crystals tend to be euhedral, strongly zoned and partly sericitised. Replacement by quartz diminishes the good shape of crystals. A zone of reaction of the contact with potash feldspar indicates a lack of equilibrium and a minor amount of replacement.

Biotite is the most abundant dark mineral. It consists of subhedral to anhedral flakes, most of which are clustered together with hornblende. Biotite is often altered in part to chlorite and contains large, irregular inclusions of opaque material. Some biotite flakes are poorly crystalline.

Hornblende also occurs as strongly altered grains of poor crystal structure in clusters with biotite. In some grains it appears that biotite is an alteration product of hornblende, suggesting that the hornblende was derived from the xenolith and that biotite was produced by reaction with the granitic magma. This probably does not apply to all biotite, some of which was almost certainly crystallised directly from the granitic magma. Both hornblende and biotite were subsequently altered to chlorite muscovite, epidote and carbonate. A rare mineral in the clusters of dark minerals which is probably an alteration product is aragonite.

Apatite and zircon are accessory minerals occurring mainly in the ferromagnesian clusters.

PEAKE 1

6827 RS 127, TS C53484

Depth 174.55 m

Rock name Metadolerite

Hand specimen

The rock is medium grey, fine-grained with black and white minerals. It is cut by a brown vein and several short white veinlets.

Thin section

The rock is essentially the same as that intersected at 180.75m. Altered and corroded plagioclase prisms and anhedral pyroxene with leucoxenised ilmenite make up the original constituents. Alteration products such as chlorite, epidote and carbonate occur interstitially and as inclusions in earlier minerals. Quartz is common as an interstitial phase and is probably introduced, possibly at the time of alteration.

Meandering carbonate and chlorite veins cut the section.

PEAKE 1

6827 RS 128, TS C53485

Depth 180.75 m

Rock name Metadolerite

Hand specimen

The rock is medium grey and clearly granular in black and white. Pinkish-brown grains are visible in the walls of a small fracture.

Thin section

The rock is coarser grained, more strongly altered and richer in ferromagnesian minerals than the specimen from 186.6m. It consists of plagioclase, relict pyroxene, leucoxenised opaque minerals and abundant epidote and chlorite replacement with quartz as a late stage introduction.

Decussate prisms of plagioclase are too strongly altered and too poorly twinned to determine composition. The abundance of epidote suggests that the present calcium content of the plagioclase may be considerably lower than it was at the time of crystallisation. Many plagioclase exhibit a very irregular extinction which indicates a very imperfect crystal structure.

Very few pyroxene grains show no signs of alteration. Both chlorite and epidote replace large parts of many grains. Enough remains to indicate a brownish monoclinic pyroxene of augite type. Crystal form varies between subhedral prisms to completely anhedral grains.

Brownish, weakly translucent, amorphous grains are probably leucoxenised ilmenite.

Epidote occurs as irregular grains enclosed in both feldspar and pyroxene. It also fills a vein which cuts one corner of the section.

Frequent tufted, fibrous interstitial patches of a penninitic chlorite with anomalous birefringence are either replacing both plagioclase and augite in place or are possibly the results of corrosion and precipitation of all minerals by hydrothermal solution. This type of chlorite is often accompanied by quartz which makes the latter process the more probable. A less optically anomalous chlorite is sometimes a clear alteration product of pyroxene.

A few clusters of pyrite grains are accompanied by a quartz gangue.

Thin brown veins contain very fine grained brown carbonate.

PEAKE 1

6827 RS 129, TS C53486

Depth 186.6 m

Rock name Albitite

Hand specimen

The rock is a uniform light grey colour with yellow reflections from disseminated pyrite grains. Occasional white crystals are distinguishable but without much precision.

Thin section

Plagioclase phenocrysts about 1mm long are sparsely distributed in a groundmass of plagioclase laths about 0.1mm long. Quartz grains are up to 1mm across. Pyrite forms irregular clusters of grains up to 1.5mm across. Epidote and chlorite are alteration products. The assay is distinguished by high soda (6.3% Na_2O) and silica (72.8% SiO_2).

Groundmass plagioclase forms a closely interlocking mosaic and is by far the most abundant mineral present. Few grains are well twinned but from available evidence the composition is in the albite range. Optical sign is positive which confirms identification.

Plagioclase phenocrysts are either untwinned or display only simple Carlsbad twins.

Quartz occurs both as subhedral phenocrysts and as anhedral constituents of the ground mass. Phenocrysts appear to be original since groundmass laths are oriented around them.

Groundmass quartz appears at least in part to be introduced, possibly with the pyrite since it is more abundant in the vicinity of sulphide clusters. Some quartz may have been introduced as colloidal silica.

Pyrite clusters are associated with small, irregular masses of carbonate as well as with quartz grains.

Many small, irregular, ragged interstitial patches of chlorite are disseminated throughout the rock and are probably the only indications of an original minor content of ferromagnesian components, possibly the result of alteration of an interstitial glass between the feldspar laths.

Small, ragged, irregular interstitial grains of epidote may also mark replacement of former dark minerals but may alternatively be evidence of calcium rejection by plagioclase equilibrating at lower temperatures to more sodic species.

CARINGA 1

6827 RS 111, TS C52821

Depth 218.42 m

Rock name Epidotised amphibolite

Hand specimen

The rock is medium grey with a closely interlocked but poorly defined structure. Individual grains are patchy without sharp boundaries.

Thin section

Approximate mode by visual estimation

Epidote	30%	Plagioclase	10%
Amphibole	20%	Opaques	5%
Chlorite	15%	Sphene	5%
Quartz	15%	Limonite	trace
		Leucoxene	trace

Epidote is widespread as formless patches of fragmented grains. From textural evidence epidote has replaced amphibole-chlorite aggregates as much as plagioclase. Epidote is more abundant in this sample than in all others examined.

Amphibole occurs as tabular grains and acicular grains in bundles and individual needles. Chlorite is less abundant than in the other specimens examined. Distribution of amphibole - chlorite clusters in bands and the preferred orientation of many acicular grains impart a directional fabric to the rock.

Quartz occurs as individual grains and mosaic patches in bands parallel to the amphibole-chlorite bands. Much recrystallisation has taken place and it is not certain whether substantial amounts of quartz have been introduced. Frequent zones of recrystallisation may contain quartz.

Plagioclase occurs in the same bands as quartz. It has been extensively recrystallised. Much of the finely recrystallised zones appear to consist of more plagioclase than quartz.

Opaque minerals occur in irregular patches of fine grains. These are surrounded by zones of finely granulated sphene.

Sphene also occurs as coarse grains independent of opaque material.

Some of the opaque grains have been altered to limonite. Some of the sphene has been replaced by leucoxene.

CARINGA 1

6827 RS 112, TS C52822

Depth 242.52 m

Rock name Zeolite vein at contact between medium and fine-grained amphibolite.

Hand specimen

A white vein 2.5cm across cuts the core at 45° to its length. A fine-grained green rock occurs on one side of the vein, a dark grey, medium-grained rock occurs on the other. Patches of pyrite up to 1cm across are present in the vein itself and in both walls.

Thin section

Approximate mode of grey amphibolite by visual inspection

Amphibole	35%	Sphene	trace
Chlorite	25%	Epidote	trace
Plagioclase	20%	Carbonate	trace
Quartz	10%		
Opaques	10%		

Amphibole and chlorite are much more abundant than plagioclase and quartz in the grey, medium-grained amphibolite. The fine-grained amphibolite is not included in the thin section.

Tabular amphibole grains are up to 1.5mm across and make up the major part of the amphibolitic fraction. This is a possible indication of the extent of amphibolitisation since the textural evidence suggests that prismatic amphibole has coalesced to form tabular amphibole rather than that the tabular amphibole has degenerated into prismatic amphibole.

Chlorite often surrounds separate amphibole grains to make a massive patch of ferromagnesian mineral.

Plagioclase and quartz are partly obscured by the growth of acicular amphibole. No multiple twining is evident in the feldspar.

Opaque minerals consist of large, irregular and fragmented patches, probably of pyrite, and of graphite flakes in the zeolite vein.

Zeolites are the most abundant type of mineral in the vein and include several different species based on optical properties. Quartz, plagioclase and possibly alkali feldspar are also present.

Sphene occurs as a few coarse grains in the margin of the vein. Frequently epidote is distributed throughout the amphibolite. A few thin veinlets contain carbonate.

CARINGA 1

6827 RS 113, TS C52823

Depth 250.01 m

Rock name Amphibolite with feldspathic inclusion.

Hand specimen

A dark grey, medium-grained amphibolite is cut by a band of fine-grained, strongly foliated amphibolite (foliation at 60° to the length of the core). One end of the specimen consists of coarse- grained, white crystals with dark, interstitial material and limonite staining.

Thin section

Approximate mode of amphibolite by visual estimation

Amphibole	30%	Opaques	10%
Plagioclase	30%	Quartz	5%
Chlorite	25%	Epidote	trace

Most of the amphibole is anhedral but a few grains are subhedral. Coarse, tabular grains are frequently marked at the margins by clusters of acicular amphibole. Clusters of prismatic to acicular amphibole are random to radiating or form bands, both straight and curved. The inclusion of coarse-grained felsic minerals is invaded at the margins and along grain boundaries by needles of amphibole, many of which are curved.

Plagioclase in the main amphibolite is interstitial but is also invaded by acicular and prismatic amphibole. It is poorly twinned to untwinned and the composition is obscure.

Chlorite forms masses of anhedral grains and patches of alteration surrounding amphibole grains.

Opaque minerals occur as irregular and fragmented patches. One flake of graphite is present.

Quartz is interstitial and forms irregular grains and mosaics.

A few fragmentary patches of epidote are present.

The strongly oriented band which cuts the section consists largely of acicular amphibole with occasional knots of tabular amphibole, quartz and plagioclase. A thin vein of zeolites with low birefringence contains radiating clusters of acicular zeolite. It is subparallel to and at the margin of the oriented band which is probably a shear zone.

The coarse-grained cluster of plagioclase with minor quartz is probably a xenolithic fragment incorporated in the amphibolite. It contains one mass of chloritised and limonitic amphibole which may have been an original mafic mineral. A few grains of limonitic oxide were probably original ilmenite or magnetite but a widespread limonite staining was probably a late stage process, as is fine carbonate veining.

CARINGA 1

6827 RS 114, TS C52824, 278.3m

Depth 278.3 m

Rock name Amphibolite

Hand specimen

The rock is greenish grey, compact and medium to fine-grained with occasional white and green phenocrysts.

Thin section

Approximate mode from visual estimation

Plagioclase	25%	Epidote	5%
Chlorite	25%	Opaques	5%
Amphibole	20%	Sphene	trace
Quartz	20%		

Much of the colourless interstitial material is without twinning but with slight cloudy alteration. Minerals with multiple twins are almost certainly, and cloudy minerals probably, plagioclase but no composition can be determined. Tabular grains are up to 3mm long.

Chlorite is present as partial alteration of amphibole grains but also occurs in separate grains which may be original. Most of the chlorite is a weakly anisotropic type but a few flakes exhibit an anomalous birefringence.

Amphibole is both tabular and acicular. Tabular grains are up to 2mm long with a tendency towards preferred orientation. Clusters of tabular amphibole are up to 6mm across. Most grains are anhedral and strongly to weakly altered. More abundant amphibole is acicular and occurs as fringes to tabular grains and as clusters and bands of grains with a strong preferred orientation. Both types of amphibole are pleochroic from blue green through olive green to pale yellow brown.

Quartz occurs as patches of recrystallised mosaic elongated along the direction of preferred orientation. Bands of recrystallisation are also preferentially oriented. Some of the recrystallised material may be feldspathic.

Epidote occurs as fragmentary patches and clusters of prismatic grains included in, and probably alteration products of, plagioclase.

Opaque grains form irregular patches, probably of ilmenite since they are often surrounded by haloes of sphene.

CARINGA 1

6827 RS 115, TS C52815

Depth 294.05 m

Rock name Contact between amphibolite and granodiorite

Hand specimen

The contact between a dark green, fine-grained amphibolite and a granodiorite is almost parallel to the length of the core.

Thin section

Approximate modes by visual estimation

Amphibolite		Granodiorite	
Amphibole	80%	Plagioclase	75%
Opaques	10%	Quartz	15%
Plagioclase	5%	K-feldspar and granophyre	5%
Quartz	5%	Opaques	2%
Chlorite	trace	Amphibole	1%
Epidote	trace	biotite	1%
Biotite	trace	Chlorite	1%
		Sphene-leucoxene	trace
		Epidote	trace

Only a small sliver of amphibolite is included in the section. Amphibole is by far the dominant mineral and occurs as oriented fine grains. Plagioclase and quartz occur interstitially. Very fine, opaque grains are abundant. Chlorite, biotite and epidote are rare.

The granodiorite consists mainly of albitic plagioclase with grains up to 1mm across in the main part of the section and up to 3mm in the coarse grained inclusion. The margin of the inclusion is marked by a gradational change in grain size.

Some of the quartz may have been introduced since it exhibits a replacement relationship towards the plagioclase. Other quartz is intergrown with alkali feldspar. The latter is a single phase and appears to be anorthoclase rather than microcline.

Disseminated grains and patches of opaque minerals are probably ilmenite. Pyrite occurs in thin veinlets, often with a chlorite gangue.

Clusters of fine prisms of amphibole are more abundant near the amphibolite contact. Biotite and chlorite are more common away from the contact.

Patches of sphene and leucoxene are sparsely distributed. Epidote occurs rarely associated with opaque minerals.

CARINGA 1

6827 RS 116 TS C52825

Depth 295.52 m

Rock name Porphyritic granite

Hand specimen

Pink and white phenocrysts are enclosed in a dark grey matrix or groundmass.

Thin section

Approximate mode by visual estimation

Albite	60%	Leucoxene	2%
Quartz	17%	Amphibole	2%
K-feldspar and granophyre	10%	Chlorite	1%
Biotite	5%	Zircon	trace
Opaques	3%	Epidote	trace

Grainsize distribution of the albite is bimodal. Euhedral to subhedral phenocrysts are up to 8mm long in the thin section while in the matrix or groundmass the average grain size is almost 0.5mm. Some phenocrysts have been fragmented and the fragments are between the two grainsize populations. Recrystallisation is widespread and some has occurred along discordant planes cutting the whole area section.

Quartz forms recrystallised mosaics and also occurs as complex intergrowths with alkali feldspar.

Biotite is widespread but not abundant as clusters of fine flakes. It is mainly interstitial but also occurs in discordant fractures.

Opaque grains and patches are iron oxides rather than sulphides and are often accompanied by leucoxene alteration.

Fine prisms of amphibole are mainly associated with clusters of biotite flakes.

Epidote occurs as inclusions in plagioclase crystals, probably alteration products.

Zircon is extremely rare.

CARINGA 1

6827 RS 117 TS C52826

Depth 295.87 m

Rock name Granodiorite

Hand specimen

Medium-grained, dark grey rock with white crystals about 1mm across. Abundant pyrite.

Thin section

Approximate mode by visual estimation

Plagioclase	65%	Amphibole	3%
K-feldspar	10%	Chlorite	trace
Quartz	10%	Sphene	trace
Biotite	7%	Limonite	trace
Opaques	5%	Epidote	trace

Albitic plagioclase forms a closely interlocked mosaic of anhedral grains up to 2mm across, exhibiting fracture and recrystallisation. A discordant band of recrystallisation suggests that some at least is related to shearing. A slight tendency for elongated plagioclase crystals to form radiating aggregates is possible evidence for a magmatic rather than volcaniclastic origin.

Potash feldspar is mainly anorthoclase.

Quartz consists mainly of scattered patches of recrystallised mosaic.

Interstitial clusters of fine flakes of biotite are widespread. Much of the mica is weakly pleochroic and probably poorly crystalline.

Less abundant clusters of fine-grained acicular amphibole are similarly distributed.

Chlorite is present as an alteration product of biotite and as a primary constituent.

Opaque minerals include fine grains of ilmenite and larger, irregular patches of pyrite. Some iron oxide is limonitic. Clusters of ilmenite grains are sometimes surrounded by structureless leucoxene.

Epidote and sphene are very rare.

CARINGA 1

6827 RS 118 TS C52816

Depth 298.8 m

Rock name Contact between amphibole schist and granite.

Hand specimen

Two lithologies are in contact along a steeply dipping, slightly undulose plane about 30° from the axis of the core.

One lithology is fine-grained, dark green and weakly foliated. On the slabbed surface the fabric is seen as green, brown and grey bands parallel to the contact. Thin, discontinuous bands of sulphide are similarly oriented.

The second lithology consists of white and grey grains about 2mm across in a dark, fine-grained matrix containing abundant sulphide.

Thin section

Approximate modes by visual estimation

Fine-grained schist		Coarse-grained granite	
Amphibole	40%	Quartz	45%
Quartz	30%	Albite	35%
Opaques	15%	Biotite	15%
Chlorite	10%	Opaques	5%
Sphene	5%	Chlorite	trace
Carbonate	trace	Amphibole	trace
Plagioclase	trace	Epidote	trace
Zircon	trace	Zircon	trace

The fine-grained lithology consists largely of flakes of biotite with a strong preferred orientation. Flakes are mainly subhedral with a strong brown to green pleochroism and moderate birefringence. In many flakes the pleochroism and birefringence are weak to absent and the mineral is bright green rather than olive green. This is interpreted as partial to total alteration towards a chlorite of amesite type.

A second type of chlorite with anomalous birefringence is present in trace amounts associated with sulphide bands. This is penninite.

Quartz occurs as fine, anhedral grains throughout the fine-grained lithology. The laminated fabric is the result of variations in the relative proportions of biotite and quartz. Neither mineral occurs entirely without the other.

Two types of opaque minerals are present. Fine grains of a non-magnetic oxide are ubiquitous and are probably ilmenite. Massive lenses of opaque sulphide, probably pyrite, occur in bands parallel to subparallel to the foliation, as can be seen in hand specimen.

Sphene is widely distributed in fine, anhedral grains and tends to be associated with biotite.

Massive carbonate, probably dolomite, is associated with sulphide in bands.

Plagioclase occurs as rare, scattered grains.

Zircon is present but extremely rare.

Within the fine-grained schistose unit, the quartz-rich horizons preserve a foliation oblique to the principal intense foliation within the biotite-rich zones. The general appearance of the schist is of a crenulated schist or mylonite, with an oblique and folded foliation (S-plane) preserved between an intense foliation which may be either a crenulation schistosity or C-plane microshears.

Quartz and plagioclase are the major constituents of the coarse-grained lithology. Both occur as coarse grains but quartz is strongly recrystallised. Patches of fine-grained quartz are the product of several episodes of dynamic recrystallisation.

Plagioclase grains tend to be better shaped than quartz but are also affected by patches of recrystallisation. Symmetrical extinction angles of 17° and a positive optical sign indicate an almost pure albite.

The matrix, interstitial to coarse grains of quartz and plagioclase, consists partly of finely recrystallised mosaics of felsic material but also includes fine flakes of biotite. This biotite is distinct from the green type of mica seen in the fine-grained lithology. It is well crystallised and pleochroic from pale to dark brown.

Two types of opaque material are present. Euhedral grains and irregular patches of pyrite are mainly associated with clusters of biotite flakes in the matrix. The second type consists of large sometimes bent or split, opaque flakes which are almost certainly graphite since this is frequent in the core. The flakes are concentrated at the contact between the two lithologies and are oriented parallel to subparallel to it.

Scattered fine flakes of chlorite and prisms of hornblende appear to be rare alteration products of biotite and tend to be randomly oriented.

Zircon grains are very rare.

Fine grains of epidote are occasional alteration products of plagioclase.

CARINGA 1

6827 RS 119 TS C52827

Depth 297.58 m

Rock name Adamellite

Hand specimen

Clusters and separate grains of pink and white feldspar up to 4mm across and neutral grey quartz up to 2mm across are contained in a fine-grained grey matrix. Many of the feldspars are visibly fractured and fragmented. Pyrite is a minor constituent.

Thin section

Approximate mode by visual estimation

Plagioclase	35%	Sphene-leucoxene	5%
K-feldspar and granophyric intergrowth	25%	Epidote	trace
Quartz	25%	Chlorite	trace
Hornblende	5%	Zircon	trace
Opaques	5%	Zeolites	trace

Plagioclase crystals are large and may initially have been euhedral. Fracturing and recrystallisation is common. From optical properties the plagioclase is oligoclase.

Potash feldspar is present in several forms. Pure microcline is the simplest form and may be the product of recrystallisation. The original form may have been anorthoclase as a single phase. This has unmixed to an antiperthite in frequent instances although in some grains the single phase persists. A late stage in the history of the original magma was possibly the crystallisation of a granophyric intergrowth of potash feldspar and quartz. Many rather irregular examples of such intergrowths are present and may be the product of relatively rapid chilling of the last magmatic fractions. Present textures are somewhat blurred by recrystallisation.

Recrystallisation has involved the mobility of some constituents. Opaque grains of euhedral shaped indicating ilmenite have been concentrated in pods of recrystallised quartz. Other grains are scattered sparsely through the matrix. Sparse sulphide occurs in association with quartz in irregular patches and thin veins.

Patches of sphene and leucoxene are widespread. These are often associated with opaque grains and sometimes with clusters of acicular hornblende. The patches are interstitial to quartz and feldspar but the evidence is not clear as to whether they are part of the original matrix or introduced material.

The third minor component is a pale green, pleochroic hornblende which forms fine, euhedral crystals in radial clusters, random masses and individual grains. It is partly interstitial and often associated with ilmenite, sphene and leucoxene. It is thus possibly part of the original matrix. It is also present in discordant veinlets and as a replacement of plagioclase at grain margins. It is thus also a mobile phase and a known replacement product.

Epidote is present as fine alteration products of plagioclase.

Chlorite occurs as an alteration product of hornblende, as a gangue mineral with pyrite and as a filling of discordant veins.

Zircon is a rare accessory mineral.

A few grains of isotropic to weakly anisotropic minerals are probably zeolites.

The granitoid has undergone minor dynamic recrystallisation during shearing, with the development of both minor rims of new grains around slightly-strained original grains, and narrow discordant shear zones containing fine, dynamically recrystallised quartz, feldspar and biotite.

CARINGA 1

6827 RS 120 TS C52828

Depth 306.8 m

Rock name Albite amphibolite

Hand specimen

The rock is composed essentially of a close intergrowth of green and grey grains about 1mm across. A preferred orientation is detectable and appears to be parallel to the length of the core.

Thin section

Approximate mode by visual estimation

Albite	35%	Chlorite	5%
Tabular amphibole	25%	Epidote	trace
Acicular amphibole	20%	Leucoxene	trace
Opaques	10%	Sphene	trace
Quartz	5%		

Albite is identified by low birefringence and a large positive optic axial angle. The absence of twinning precludes a more precise estimate of composition. The albite is anhedral with a tendency towards elongation parallel to the length of the core. It is interstitial to tabular amphibole and is the host for many radiating and oriented acicular crystals of the second amphibole. Apart from these acicular inclusions the albite contains scattered patches of leucoxene surrounding fine granules of opaque mineral. Fine grains of epidote are occasionally included in albite.

Tabular amphibole consists of hornblende with strong pleochroism from blue green to pale green to pale yellow brown. It is usually anhedral to subhedral but occasionally exhibits euhedral faces. The margins of most grains are ragged and often pass outwards into acicular amphibole. Grains of hornblende usually enclose patches, grains and fine granules of opaque minerals and occasionally inclusions of sphene. Some tabular hornblende is altered in patches to chlorite.

The acicular amphibole is actinolitic but composition is transitional to that of hornblende. Prismatic outgrowths from the tabular hornblende exhibit almost the same pleochroism as the coarser grains but the finely acicular amphibole is pleochroic in pale shades of green. Thinly prismatic amphibole is often oriented in directions close to the axis of the core but the finely acicular crystals are randomly oriented or in radiating aggregates with no apparent relationship to either a directional fabric or to a specific nucleus.

Opaque minerals vary from fine grains to patches with a flaky structure. Granular material is often surrounded by leucoxene and rarely associated with fine grains of sphene. The opaque mineral is probably ilmenite. Flaky material is abundant and often strictly oriented in the same direction as the feldspar and amphibole. It is probably graphite which is frequently visible on shear planes in this part of the core.

Quartz occurs as isolated grains in the feldspathic parts of the rock and as fine-grained mosaics along narrow shears parallel to the fabric outlined by acicular amphibole.

Chlorite is mainly of penninite type and occurs as an alteration product of hornblende.

Epidote is a rare alteration product of plagioclase.

Leucoxene and sphene are associated with ilmenite and amphibole respectively.

CARINGA 1

6827 RS 121, TS C52817

Depth 294.45 m

Rock name Contact between fine-grained amphibolite and granodiorite.

Hand specimen

The contact between a very fine-grained, dark green rock and a coarse to medium-grained light grey rock trends at 30° to the length of the core. Phenocrysts up to 5mm across are localised in a patch 3cm across within the light grey rock. Pyrite is abundant and occurs in a vein 2mm across with quartz, in a series of thin veinlets at and near the contact and disseminated throughout the grey rock with relative concentration in the most coarse-grained patch.

Thin section

Approximate mode by visual estimation

Amphibolite		Granodiorite	
Amphibole	65%	Plagioclase	50%
Plagioclase	25%	Quartz	25%
Opaques	10%	Biotite	10%
Chlorite	trace	K feldspar and granophyric intergrowth	10%
Biotite	trace	Amphibole	2%
		Opaques	1%
		Chlorite	1%
		Sphene	1%

The fine-grained green amphibolite consists dominantly of prismatic amphibole crystals about 0.1mm long and strictly oriented. They are pleochroic from green to pale brown. A few tabular amphibole crystals up to 0.3mm long are randomly oriented.

The rock is finely banded with interstitial plagioclase producing lighter coloured bands. Scattered plagioclase phenocrysts are up to 0.5mm long and are not strictly oriented.

Abundant very fine grains of opaque mineral are probably ilmenite. A few flakes of chlorite and biotite are present.

The amphibolite grades from a fine-grained, weakly-foliated amphibolite with randomly-oriented fine-grained feldspar laths, into an intensely-foliated, sheared amphibole schist at the contact with the granodiorite. The foliation is kinked in several localities, and a weak grain-shape fabric oblique to the contact is visible.

The granodiorite consists of medium to coarse-grained tabular plagioclase intergranular with granophyric quartz-feldspar intergrowths, medium-grained, strained quartz and minor fine-grained biotite and opaques. Small patches of recrystallisation of quartz and feldspar are evident.

Biotite and amphibole with chloritic alteration form interstitial clusters of fine grains which often include sphene. Potash feldspar occurs above or with a granophyric intergrowth of quartz. Opaques consist of fine grains of ilmenite and as large, irregular patches of pyrite with chlorite as a gangue mineral.

CARINGA 1

6827 RS 122 TS C52818

Depth 295.87 m

Rock name Contact between granite and amphibolite

Hand specimen

The specimen contains a contact between a dark green-grey, fine-grained lithology and a medium-grained grey and white lithology. Sheared faces in the core are coated with graphite flakes. The grey lithology contains abundant sulphide.

Thin section

Approximate modes by visual estimation

Amphibolite		Granite	
Amphibole	65%	Plagioclase	50%
Quartz	20%	K-feldspar	20%
Sphene	10%	Amphibole	15%
Chlorite	3%	Quartz	5%
Opaques	2%	Opaques	5%
Epidote	trace	Leucoxene	3%
Plagioclase	trace	Sphene	1%
		Epidote	1%
		Biotite	trace

The fine-grained, dark lithology consists dominantly of fine prisms of amphibole with a very strong preferred orientation. The amphibole is pleochroic from pale brown to green and is probably hornblende.

Quartz occurs interstitially to the hornblende and in sheets parallel to the fabric.

Discontinuous sheets of massive sphene are also aligned with the fabric. The sphene is pale brown with a small, positive 2V of about 30°.

Sheets of chlorite are similar to and associated with those of sphene. The chlorite is a penninite with anomalous birefringence. At and near the contact with the coarse grained lithology amphibole, sphene and penninite are both coarser grained and more abundant, possibly indicating growth through higher temperature.

Opaque material occurs as scattered fine grains through the rock and as masses within quartz sheets. These types are probably ilmenite and pyrite respectively.

The coarse-grained lithology is dominantly feldspathic, with plagioclase more abundant than potash feldspar. The plagioclase is albitic with grains varying from subhedral to anhedral and frequently bent, fractured and fragmented. Recrystallisation along grain margins is common.

Potash feldspar appears to be anorthoclase antiperthite.

At the contact with the fine-grained rock individual grains and large masses of oriented amphibole have been disrupted and incorporated into the coarse-grained lithology.

Quartz tends to be concentrated locally and may also have been introduced in veins and patches late in the history of the granite. It is possible that some quartz is original.

Opaque minerals include fine grains of ilmenite and large, irregular patches of pyrite.

Leucoxene, sphene and epidote occur in patches of cloudy alteration which are widely distributed.

CARINGA 1

6827 RS 123, TS C52819

Depth 286.5 m

Rock name Amphibolite

Hand specimen

A compact, fine-grained grey rock is foliated on a plane about 45° to the length of the core. A thin vein cuts the plane of foliation with an orientation about 20° to the core length. The vein contains pyrite and fine grains of sulphide are disseminated throughout the rock.

Thin section

Approximate mode from visual estimation

Amphibole	40%	Plagioclase	10%
Quartz	25%	Opaques	5%
Chlorite	20%		

Amphibole occurs as fine-grained, preferentially oriented, acicular prisms. Together with parallel chlorite flakes this produces a foliation which anastomoses around knots formed by mosaic quartz to form a knotted schist. Much of the chlorite is penninite.

Fine grained quartz occurs within and between bands of amphibole and chlorite. Coarser grained mosaic patches of quartz form some of the knots in the schist.

Plagioclase also forms bands of elongated grains within and between bands of amphibole and chlorite. Coarse grained plagioclase, sometimes euhedral in shape, forms knots similar to those of mosaic quartz.

Fine grained opaque minerals are widespread but rarely euhedral. Massive pyrite occurs in a thin vein with a gangue of quartz, chlorite and carbonate. A few elongated opaque grains may be graphite.

6827 RS 124, TS C52829,

Depth 286.9m

Rock name Amphibolite

Hand specimen

A dark green, fine grained rock contains relic phenocrysts of white crystals up to 2mm long and darker, rounded inclusions up to 5mm across.

Thin section

Approximate mode by visual estimation

Amphibole	40%	Opaques	10%
Plagioclase	30%	Quartz	trace
Chlorite	20%		

Amphibole crystals include tabular and prismatic forms. Both are pleiochroic from blue green through olive green to pale yellow brown. Tabular crystals are weakly porphyritic, up to 0.5mm across compared with about 0.2mm in the groundmass. Megacrystic amphibole is often corroded and chloritisation of both types is widespread. No systematic compositional difference is evident between groundmass amphibole and megacrysts.

Plagioclase is mainly interstitial but a few crystals are megacrystic and up to 1mm long. In the rounder inclusions individual crystals of feldspar are up to 2mm across. These inclusions are composed of segregations of early minerals and therefore are not amygdales. Most of the plagioclase is untwinned and where twinning is present it is not sharp enough in definition to be used to estimate composition.

Two kinds of chlorite are present. The most common is an alteration product of amphibole and a rarer type appears to be associated with opaque minerals.

Opaque minerals occur as disseminated fine grains and as coarser grained patches. It is not apparent whether more than one composition is involved.

A little quartz is present as a replacement product of corroded amphibole phenocrysts and in association with patches of opaque minerals.

The absence of preferred orientation suggests that the rock may be a post-Delamerian intrusive.

CARINGA 1

6827 RS 125, TS C 52830

Depth 197.9 m

Rock name Amphibolite

Hand specimen

The rock is medium-grained and dark green. Elongated dark green and light grey grains produce a fabric oriented close to the long axis of the core. A thin vein at 45° to the core axis contains yellow minerals.

Thin section

Approximate mode by visual estimation

Plagioclase	25%	Epidote	10%
Amphibole	25%	Opaques	5%
Chlorite	15%	Sphene	5%
Quartz	15%		

Plagioclase forms the major part of the leucocratic fraction. It has been extensively recrystallised. It is interstitial to the green minerals and tends to form discontinuous bands.

Amphibole occurs as tabular and acicular forms and, with chloritic alteration, tends to form discontinuous bands of green minerals which produce the oriented fabric evident in hand specimen.

Quartz occurs as individual grains and patches of recrystallised mosaic in the leucocratic bands. Much of the finely recrystallised material is probably quartz.

Epidote occurs in fragmented patches, mainly in grains of former plagioclase but occasionally as an alteration product of amphibole.

Opaque material forms irregular patches composed of fine grains. It is almost invariably surrounded by sphene, some of which is leucoxenised.

CARINGA 1

6827 RS 126, TS C52820

Depth 285.2 m

Rock name Contact between amphibolite and chlorite schist.

Hand specimen

A contact at 45° to the length of the core divides a fine-grained, dark green rock with a prominent foliation from a pale grey, slightly coarser grained rock without a preferred orientation. A branching fracture system subparallel to the contact carries pyrite.

Thin section

Approximate mode by visual estimation

Amphibolite		Chlorite schist	
Amphibole	30%	Chlorite	50%
Chlorite	30%	Zeolites	30%
Quartz	20%	Plagioclase	5%
Plagioclase	10%	Amphibole	5%
Opaques	10%	Quartz	5%
Epidote	trace	Opaques	5%
Carbonate	trace	Sphene	trace
		Epidote	trace
		Garnet	trace

The amphibolite is the same as that at 286.5m. A directional fabric is constructed by strictly oriented amphibole, chlorite and quartz with minor plagioclase and opaque minerals. Knots are produced by lenses and pods of quartz, chlorite and plagioclase.

The contact is more complex than appears in hand specimen. A straight line is marked in section by a vein containing coarse-grained chlorite and quartz with local plagioclase, epidote and carbonate but this line only separates different lithologies in the centre of the section. The same amphibolite occurs on both sides of the vein for much of its length.

In the centre of the section the amphibolite is disrupted and replaced by contorted veins of coarse-grained penninite and a variety of zeolites. On the basis of optical properties heulandite, thomsonite and chabazite are recognisable species but most properties are transitional rather than sharply distinctive and there is probably a continuous range in chemical composition between sodic and soda-lime zeolites. A contorted carbonate vein is continuous with the carbonate along the contact.

Minor plagioclase, quartz, amphibole and traces of epidote and sphene are present. Sphene often forms a rim around ilmenite grains.

Outlines of cubic minerals now completely replaced by pseudomorphous alteration products were probably calcic garnets.

Large, irregular patches of pyrite are associated with two types of chlorite, one isotopic and the other with anomalous birefringence.

The relative chronology of disruption and metasomatic recrystallisation is not revealed by the petrographic evidence.

CARINGA 1

6827 RS 130, TS C53504

Depth 287.0 m

Rock Name Contact between medium-grained and fine-grained amphibolite.

Hand specimen

The core is split along a plane coated with carbonate and pyrite. These minerals are also apparent within the rock. A similar contact as those examined in RS 131 and 132 is present in this specimen but the fabric is interrupted by pale grey lenses.

Thin section

The contact is between a fine-grained, intensely-foliated amphibole schist, and a medium-grained weakly-foliated amphibolite.

The medium-grained amphibolite consists of anhedral blue-green hornblende and plagioclase with a granoblastic to granoblastic-elongate texture. Common fine-grained opaques are associated with hornblende. Narrow s-c fabric shear zones (<1mm) are defined by finely recrystallised needles of amphibole with fine-grained plagioclase and quartz.

The amphibole schist is formed by mylonitisation of an amphibole + feldspar + quartz amphibolite, producing an intense foliation defined by fine-grained acicular amphibole and elongate recrystallised aggregates of quartz + feldspar plus minor trains of opaques. Narrow calcite and quartz veins are parallel to the contact of the amphibolite and amphibole schist. Several coarse aggregates of quartz and feldspar preserve zones of crenulated foliation within amphibole-rich inclusions.

CARINGA 1

6827 RS 131, TS C53505

Depth 289.8 m

Rock name Contact between banded amphibolite and medium-grained amphibolite.

Hand specimen

A dark green, fine-grained rock shares an irregular contact with a pale, greenish grey granular rock.

Thin section

The fine-grained amphibolite contains a few plagioclase phenocrysts but is very high in prismatic amphibole. The banding is produced by differences in grain size and orientation of amphibole prisms rather than by compositional variation.

The medium-grained amphibolite exhibits a moderately pronounced preferred orientation. It consists primarily of amphibole and plagioclase. It contains abundant quartz but this is probably introduced.

The medium-grained amphibole and, to a lesser extent, the fine-grained amphibolite have been invaded by sulphide, quartz and chlorite, mainly along foliation and discordant veins. The sulphide is probably pyrite. A small amount of carbonate is associated with the mineralisation.

CARINGA 1

6827 RS 132, TS C53506

Depth 292.4 m

Rock name Contact between fine and medium-grained amphibolite.

Hand specimen
A fine-grained, dark green rock has an irregular contact with a pale grey, coarser grained rock. Pyrite is frequent.

Thin section

A fine-grained, well-foliated amphibolite is in irregular contact with a medium-grained amphibolite.

The medium-grained amphibolite consists of a granoblastic to weakly elongate framework of amphibole (?blue-green hornblende) and plagioclase. Opaques occur both as fine anhedral grains, and as minor euhedral grains. Biotite is uncommon, occurring as fine ragged plates. The amphibolite has a weak foliation.

The fine-grained amphibolite consists of fine acicular actinolite, chlorite, minor biotite and very fine-grained disseminated opaques. Minor medium-grained, subhedral plagioclase laths are partially overprinted by amphibole.

The contact between the two amphibolites is highly irregular. Fine euhedral grains of opaques are concentrated in the fine-grained amphibolite near this contact. Medium, euhedral grains of pyrite occur near the contact, and have pressure shadows of biotite and quartz, suggesting the pyrite predates the amphibolite foliation.

Several pyrite grains associated with relic feldspar grains are severely fractured. Pyrite also occurs as discordant veins within the fine-grained amphibolite.

CARINGA 1

6827 RS 133, TS C53507

Depth 296.4 m

Rock name Contact between fine-grained, amphibole-chlorite schist and protomylonitic granite.

Hand specimen

An irregular contact, broadly parallel to the length of the core divides a dark green, fine-grained rock from a grey, coarser grained rock with white crystals and a white selvedge along part of the contact.

Thin section

The specimen contains the contact between a well fine-grained, well foliated amphibole schist and a protomylonitic granite.

The amphibole schist consists of fine acicular ?actinolite-hornblende and minor elongate feldspar grains, plus very fine-grained disseminated opaques. A narrow vein of strained quartz cuts obliquely across the foliation.

The granite consists of medium to coarse plagioclase, orthoclase and quartz grains within a matrix of fine, dynamically recrystallised quartz and feldspar. Fine-grained, ragged amphibole and biotite grains are common. Minor ?magnetite occurs as fine aggregates associated with amphibole grains. Elongate recrystallised ?actinolite occurs associated with narrow shear zones intersecting the granite. The overall texture of the granite is protomylonitic.

Along the contact of the two lithologies, medium-grained biotite, amphibole and stringers of opaques are common. Minor elliptical lenses of quartz exhibit s-c mylonite textures. A step in the contact corresponds to a late stage shear zone which has been subsequently overprinted by further shearing parallel to the general orientation of the contact.

An apparent high-angle discordance between the amphibolite foliation and the granite contact may be due to a small-scale step geometry along the contact, oblique to the plane of the thin section.

?Pyrite veining along the contact extends well into the granite. An elongate, irregular flake of graphite occurs in the granite near the contact.

WYNARKA 1

6827 RS 147, TS C53521

Depth 168.4 m

Rock name Carbonate-replaced metadolerite

Hand specimen

No hand specimen

Thin section

Most of the section consists of fine-grained calcite without any detectable oriented textures. Enough relict plagioclase, hornblende and epidote remains to indicate that the rock was originally a metadolerite.

Zoning is visible in relict plagioclase.

Disseminated fine-grained anhedral opaques are pyrite.

WYNARKA 1

6827 RS 148, TS C53522

Depth 170.7 m

Rock name Metadolerite

Hand specimen

Metadolerite is in contact along an arcuate boundary with a fine-grained rock banded along the same arc with green, light grey and greenish grey colours. The core fractures along the boundary.

Thin section

Under magnification plagioclase is sericitised to the extent that individual grains are not longer distinguishable, particularly close to the contact. Hornblende is distinct but many grains are replaced by chlorite. Quartz and opaque minerals are unaltered.

Occasional interstitial calcite is seen in the metadolerite and the fine-grained white rock at the contact is dominantly, plus opaques and chlorite.

The fine-grained banded lithology appears to be a calcite + chlorite + opaques brecciated shear zone. This may represent a carbonate-rich vein that has been subsequently sheared, or the carbonate may have been introduced during deformation. The mica and opaque-rich bands exhibit S-C mylonite foliations.

Most of the alteration is calcite. Green bands are composed of penninitic chlorite. Pale green bands are carbonate with epidote and chlorite. This is a distinct type of replacement, not encountered deeper in the hole.

WYNARKA 1

6827 RS 149, TS C53523

Depth 172.75 m

Rock name Contact between granodiorite and altered dolerite.

Hand specimen
A tongue of light coloured rock unit with 8mm white crystals is in contact with a brown and grey rock with poorly defined grain structure.

Thin section
The light coloured unit is a feldspathic rock with a high proportion of recrystallised quartz and biotite.

The brown and grey rock is strongly altered dolerite. Traces of dolerite are visible about 15mm from the contact but closer than that the rock is almost completely replaced by a mass of fine biotite flakes and mosaic quartz. Minor epidote and a system of carbonate veins at the contact are also replacement products. Opaque grains, quartz and minor plagioclase and amphibole are occasionally retained from the original rock.

Both the dolerite and granodiorite exhibit protomylonitic recrystallisation, with the contact exhibiting intense recrystallisation and development of a mylonitic foliation. Minor fine-grained opaques, including pyrite, occur with calcite in the contact zone.

WYNARKA 1

6827 RS 150, TS C 53524

Depth 173.25 m

Rock name Dolerite in contact with granodiorite.

Hand specimen

An even-grained dark brown and grey rock with a grain size of about 1mm is cut by a poorly defined band of white minerals.

Thin section

The mafic assemblage of plagioclase, hornblende, quartz, opaques, sphene, biotite, chlorite, epidote, relict pyroxene and apatite is similar to that at 174.7m apart from somewhat finer grain size.

The poorly defined, white minerals are coarse-grained (5mm) plagioclase with minor quartz, biotite and chlorite. These are similar to those in the granodiorite between 175.2m and 182.3m. The crystals exhibit minor recrystallisation along grain boundaries.

Very heavy alteration has affected the dolerite at the contact with the granodiorite replacing the feldspars with a felt of sericite and grains of epidote and the hornblende with penninitic chlorite.

A thin, meandering vein of carbonate cuts both lithologies.

WYNARKA 1

6827 RS 151, TS C53525

Depth 174.7 m

Rock name Metadolerite

Hand specimen No hand specimen

Thin section

The rock is altered but the extent of alteration is substantially less than that affecting metabasic rocks below 182.7m. Plagioclase laths up to 2mm long and hornblende up to 1mm across which is mainly of poor shape and interstitial are the main constituents. Minor constituents are quartz, biotite, opaque minerals, pyroxene, epidote, sphene, chlorite and apatite.

Many plagioclase laths are unaltered. Sharply defined twinning enables a composition on the borderline between andesine and labradorite to be determined from symmetrical extinction angles. The laths are decussate without preferred orientation. Alteration is varied in intensity. Some plagioclase grains, particularly those of tabular rather than prismatic habit, are strongly altered to sericite.

The amphibole is hornblende, pleochroic from pale brown through olive green to blue-green. It is sometimes zoned with brown dominating the pleochroic scheme in the centre and blue-green at the margins. Most grains are interstitial to the plagioclase but some are subhedral and a few euhedral. At least some of the amphibole appears to be original rather than a replacement of pyroxene. Some alteration of amphibolite to chlorite has occurred.

Relict pyroxene is present as inclusions in amphibole. Textural relations suggest that much of the amphibole is an alteration product of pyroxene, the mineral originally crystallised.

Quartz is widespread as an interstitial mineral.

Skeletal opaque minerals are surrounded by a reaction zone of sphene. Biotite flakes often surround such grains and other biotite flakes occur within the vicinity. It appears that titanium from what must originally have been ilmenite has been fixed in sphene while iron released from the same reaction.

Chlorite is a common alteration product of amphibole. The change from blue-green amphibole to blue-green chlorite is a transitional reaction.

Epidote is present as a minor alteration product of plagioclase and, more substantially, in a thin, meandering fracture system.

Apatite prisms are rare.

WYNARKA 1

6827 RS 152, TS C53526

Depth 175.2 m

Rock name Protomylonitic granodiorite.

Hand specimen
No hand specimen.

Thin section

The rock is essentially the same as that from 182m. Minor differences are that more microcline is present, more of the quartz is original and the mica is not as strictly oriented.

Microcline is more abundant as part of a muscovite-microcline association in interstitial bands, not as an original constituent.

Some of the quartz grains have been rounded into shapes with an oval cross section, surrounded by a zone of recrystallisation and sericitisation and embayed by the matrix.

Feldspar grains also exhibit protomylonitic recrystallisation.

Biotite and minor muscovite are somewhat less abundant than in RS 153 and are not quite as consistent in orientation. This may be a result of the orientation of the plane of section.

Differences between RS 153 and 152 are of degree rather than of kind.

WYNARKA 1

6827 RS 153, TS C53527

Depth 182.0 m

Rock name Protomylonitic granodiorite.

Hand specimen No hand specimen

Thin section

Fractured and fragmented feldspars up to 4mm across are contained in a matrix of recrystallised feldspar, biotite, muscovite and quartz. The biotite imparts a weak preferred orientation to the rock. Lenticular areas of sericite replace the rock.

Feldspars occur as individual crystals and clusters. Plagioclase is the main feldspar but occasional crystals of microcline are original constituents. The plagioclase is zoned but appears to be oligoclase for the most part. With 4% Na_2O in the rock, the plagioclase cannot be calcic.

Microcline occurs as both original crystals and slightly distorted grains in bands of biotite and muscovite. In the latter situation the microcline is possibly a product of recrystallisation.

Biotite consists of red brown, strongly pleiochroic flakes both of relatively coarse grain size and as clusters of fine flakes. Both types are aligned with a preferred orientation. The biotite contains inclusions of opaque minerals and abundant zircon.

Muscovite occurs as medium-grained flakes with biotite and microcline. It also occurs as massive sericite which forms lenticular masses replacing many grains of different minerals.

Most quartz occurs as lenticular or irregular masses of highly strained mosaic, as grains up to 3mm across composed of several parts with different optical orientation, as scattered, irregular grains in optical continuity over 8mm and as oriented or irregular fine-grained inclusions in plagioclase.

WYNARKA 1

6827 RS 154, TS C53528

Depth 181.4 m

Rock name Contact of granodiorite and epidote-rich altered metadolerite.

Hand specimen

A grey rock with white crystals up to 5mm across is penetrated by a light green, fine-grained lithology forming two poorly-defined bands.

Thin section

The coarse-grained rock consists of plagioclase, quartz, biotite opaque minerals, microcline and muscovite.

Plagioclase forms zoned, subhedral grains with grain boundaries marked by recrystallisation. Compositions vary between andesine and albite. Not all grains exhibit twinning but zoning is usually evident. Grains are altered to varied extents.

Quartz grains vary between 2mm and a few microns across. Most grains exhibit strain polarisation and the coarse ones are often constructed of partially annealed mosaics of finer grains. Regular to irregular intergrowths of quartz and plagioclase are common. Quartz frequently embays adjacent plagioclase but textural relationships are often concealed by recrystallisation along grain boundaries.

Biotite is interstitial to plagioclase and quartz and consists of clusters of fine flakes of pale, weakly pleochroic mica associated with epidote and opaque minerals with rims of sphene and leucoxene.

Microcline is rare, fine-grained, interstitial and apparently associated with mica. The mica surrounding microcline includes muscovite as well as biotite.

The fine-grained green lithology forms flame-like masses of alteration which extend interstitially into the coarser lithology from the edges of bands of total replacement. The products of this alteration are mainly closely packed, equant, fine grains of epidote. In places interstitial chlorite is present and, where the alteration penetrates the coarse grained rock, biotite accompanies the epidote.

Thin veins of calcite are roughly parallel to the main direction of the body of epidote in the margin and centre of the mass. Pods of mosaic quartz occur along the main axis of the mass.

WYNARKA 1

6827 RS 155, TS C53529

Depth 182.7 m

Rock name Metadolerite with pyrite

Hand specimen No hand specimen

Thin section

The essential mineralogy is the same in this rock as in specimens RS 156 and 157. Grain size is finer, recrystallisation is not as intense and no preferred orientation is apparent. Pyrite occurs in veins about 0.5mm across which broadens into patches up to 5mm across at a few points. A brown carbonate is associated with the pyrite.

Hornblende of the same type as in the coarser grained rocks is more abundant, better shaped and of better crystal structure. Acicular amphibole is present but most grains are subhedral rather than completely anhedral.

Feldspar grains are often recrystallised at the margins but less so in the centres. Extinction tends to be undulose rather than patchy.

Epidote is less abundant but quartz more abundant than in the more recrystallised rocks.

Biotite is common and is little altered to chlorite.

Sphene and apatite are rare accessories.

WYNARKA 1

6827 RS 156, TS C53530

Depth 188.7 m

Rock name Metadolerite.

Hand specimen No hand specimen.

Thin section
Apart from the absence of consistent orientation the rock is almost identical to that at 193.4m. Patches of poorly crystalline hornblende and opaque minerals are surrounded by recrystallised plagioclase and quartz which is more abundant than in RS 157. Epidote is abundant as patches in plagioclase. Biotite is common. Chlorite is rare.

These rocks are identified as metadolerites on the basis of grain size but, since grain size may be a product of recrystallisation, the original rocks may be basalts.

WYNARKA 1

6827 RS 157, TS C53531

Depth 193.4 m

Rock name Metadolerite.

Hand specimen No hand specimen.

Thin section

The rock is strongly recrystallised with one moderate preferred orientation parallel to the length of the section and a second, weak and arcuate, at a high angle to the first. Amphibole, plagioclase and opaque minerals are the main constituents with minor epidote and quartz and very minor biotite and chlorite.

The amphibole is an acicular hornblende with pleochroism from pale green through straw yellow to blue-green. Crystals are often zoned with browner interiors and blue-green margins. Crystal structure is poor and most crystals are acicular or with acicular margins. Little consistent orientation is evident in individual crystals but an imperfect banding is apparent in the overall distribution of amphibole, giving the rock a moderate directional fabric.

Plagioclase is identified from the assay rather than from optical properties. Few grains exhibit measurable and consistent properties and most are clearly partially annealed, strongly recrystallised irregular masses. Recrystallisation is particularly marked at grain boundaries but extends throughout the masses. The weak arcuate fabric appears to be related to regrowth of feldspar rather than orientation of amphibole.

Opaque minerals are irregular as grains and clusters, mainly associated with amphibole.

Quartz is widespread, probably introduced and often a mosaic of partially annealed granules. The history of recrystallisation is complex.

Epidote occurs as irregular patches mainly, but not exclusively, in plagioclase.

Biotite occurs both as an alteration product of amphibole and as independent flakes.

Chlorite is an alteration product of both amphibole and biotite.

WYNARKA 2

6827 RS 134, TS C53508

Depth 167.4 m

Rock name Carbonate-replaced metadolerite.

Hand specimen

The rock is a pale greenish grey with a darker grain structure. Coarse grains of pyrite are visible.

Thin section

Broken plagioclase laths and interstitial penninite are again the main constituents of the host rock, indicating the same metadoleritic composition as has been intersected down to 187.3m.

Carbonate alteration is less intense in this specimen than in others above 185.4m. It affects both plagioclase and penninite. A pale green, isotopic chlorite partly replaces the penninite but does not affect the plagioclase. Quartz is little affected.

The opaque minerals are altered to sphene and leucoxene. A few grains of pyrite are present.

Thin veins of carbonate cut the specimen.

WYNARKA 2

6827 RS 135, TS C53509

Depth 171.3 m

Rock name Strongly altered metadolerite.

Hand specimen

The rock is pale greenish grey with a poorly defined grain structure.

Thin section

The rock is virtually identical to RS 139 from 180.85m. Lath shaped plagioclase identifies the mafic affinity but is strongly replaced by carbonate and a pale green chlorite. Interstitial penninite has also undergone replacement by carbonate and a second chlorite. Interstitial quartz is unaffected. Abundant opaque minerals include altered grains of original ilmenite and a late introduction of pyrite.

Thin carbonate veins cut the section.

WYNARKA 2

6827 RS 136, TS C53510

Depth 173 m

Rock name Calcite-chlorite quartz tectonite.

Hand specimen

Subparallel to undulating white bands, ribbons and streaks cut a grey green rock.

Thin section

White bands consist of coarse-grained calcite. They are subparallel to bands and streaks of penninite with fine-grained calcite which make up the green rock. Some opaque material of indeterminate origin occurs with the chlorite. Quartz occurs as coarse grains with the calcite bands and as lenses of very fine, dynamically recrystallised grains, with the chlorite-calcite bands. A few crystals of pyrite are present. The intense foliation anastomoses around elliptical lenses of calcite.

The nature of the original rock is totally obscured.

WYNARKA 2

6827 RS 137, TS C53511

Depth 173.8 m

Rock name Calcite altered amphibolite + tectonic breccia.

Hand specimen

No hand specimen.

Thin section

The specimen consists of angular clasts up to 1cm wide of well-foliated quartz + calcite + chlorite schist within a matrix of fine- to medium grained carbonate and quartz. The clasts are also cut by narrow calcite and quartz veins, which are commonly offset by solution cleavage and shear-band foliae within the clasts. Minor relic grains of quartz + feldspar occur within the schist.

Both quartz and calcite within the matrix have undergone blastomylonitic dynamic recrystallisation.

The specimen is interpreted as an amphibolite which has undergone mylonitisation and brittle fracturing, with progressive carbonate-chlorite replacement.

WYNARKA 2

6827 RS 139, TS C53512

Depth 180.85 m

Rock name Carbonate-replaced and chloritised ?metabasic rock.

Hand specimen No hand specimen.

Thin section

The rock is a strongly altered plagioclase, penninite and opaque mineral assemblage. Relict plagioclase is lath shaped and penninite is interstitial. Interstitial quartz is present. Opaque minerals are abundant and include late pyrite. The original rock was probably similar to, but more mafic than, the metadolerites intersected deeper in the hole.

Alteration consists mainly of carbonate but includes a second chlorite. Thin veinlets of carbonate and chlorite cut the section.

WYNARKA 2

6827 RS 140, TS C53513

Depth 181.9 m

Rock name Banded calcite-chlorite tectonite.

Hand specimen
Subparallel to undulating ribbons and streaks of carbonate cut greenish grey rock at about 45° to the length of the core.

Thin section
The rock consists of alternating bands and patches of calcite, chlorite, fine grained mosaic quartz and opaque material of indeterminate origin. A few grains of pyrite are present.

The calcite bands exhibit a moderate-intensity S-plane foliation subparallel to trails of medium-grained chlorite. Trails of opaques are both subparallel to the chlorite bands and at a high angle to the foliation. Relic quartz lenses exhibit intense dynamic recrystallisation to produce a very fine-grained mosaic.

The foliation is ~25° to the mesoscopic compositional banding within the specimen.

WYNARKA 2

6827 RS 141, TS C53514

Depth 183.7 m

Rock name Strongly altered ?metadolerite.

Hand specimen

The rock is pale grey green, fine-grained and uniform except for a white band.

Thin section

Alteration is intense in this specimen. Both the feldspars and matrix penninite are replaced to a varied but generally wide extent by carbonate and a second, pale green chlorite.

Quartz is unaffected and opaque minerals are somewhat less altered than in the specimens from 185.4m and 187.3m. Opaque minerals are particularly abundant in this specimen and include both original ilmenite and introduced pyrite.

The white band is a compound, branching vein of calcite and minor quartz.

WYNARKA 2

6827 RS 142, TS C53515

Depth 185.4 m

Rock name Chloritised ?metadolerite.

Hand specimen

The rock is fine-grained, greenish grey and uniform except for a few thin green bands parallel to the length of the section.

Thin section

The same altered mafic as was intersected at 187.3m occurs at 185.4m. Fractured plagioclase crystals are contained in a matrix of penninite. Altered opaque minerals are original, occasional pyrite grains are late introductions. Quartz is interstitial.

Disseminated carbonate is present throughout but no carbonate band occurs in the section. The thin green lines consist of penninite with minor disseminated carbonate.

WYNARKA 2

6827 RS 143 TS C53516

Depth 187.3 m

Rock name Chloritised ?metadolerite

Hand specimen

The rock is medium grey, fine-grained, non-porphyritic and without directional textures except for a crenulated white band.

Thin section

Plagioclase of oligoclase composition is the main constituent and the fresh nature of most of it with well preserved twinning suggests that the original rock was doleritic.

Quartz is interstitial.

The chloritic matrix retains no trace of relic amphibole.

Some of the altered opaque minerals are rimmed with an alteration zone of sphene, suggesting similarity to metadolerites encountered in other holes. A few grains of pyrite are present.

Fine, disseminated grains and patches of carbonate occur throughout the rock, becoming more concentrated towards the white band seen in hand specimen. In thin section this is seen to be a band of carbonate.

APPENDIX 2

ADDITIONAL PETROLOGY

Pontifex & Associates Pty. Ltd.

TEL. (08) 332 6744
A.H. (08) 31 3816
FAX (08) 332 5062

26 KENSINGTON ROAD, ROSE PARK
SOUTH AUSTRALIA

P.O. BOX 91, NORWOOD
SOUTH AUSTRALIA 5067

MINERALOGICAL REPORT NO.5774
by A.C.Purvis PhD.

Date: 30th November 1990

TO:	Mr L. Rankin SADME 191 Greenhill Road Parkside SA 5063
YOUR REFERENCE:	EX 1068 88000/A06/402004
MATERIAL & IDENTIFICATION:	Thin sections provided. 6827, RS113 to 156 (not consective, eight in all)
WORK REQUESTED:	Brief petrographic descriptions
SAMPLES & SECTIONS:	Returned to you with this report.

a.c.Purvis

Ian R. Pontifex
PONTIFEX & ASSOCIATES PTY LTD

SUMMARY COMMENTS

The eight thin sections discussed in this report are of samples from 1:100,000 Map Sheet No. 6827 and include six drill-core samples from Siamon drill holes MBT 12 and MBT 1A. Five separate lithologies are present in various combinations, as:

(1) Generally gneissic tonalite or porphyritic microtonalite, to granodiorite. This lithology is present in 6827 RS116, 121, 133 and 153. It typically has albitised plagioclase ± granophyre and rarely has separate alkali felspar grains (6827 RS153). Biotite and hornblende are present except in 6827 RS153 which has lenses of retrograde muscovite. This was originally a shallow intrusive rock which has been metamorphosed.

(2) Metamorphosed holocrystalline even-grained dolerite, basalt and quartz dolerite. This lithology occurs in 6827 RS113, 130, 132 and 156. It is typified by subequal amounts of hornblende and plagioclase (±granophyre in 6827 RS156), and probably represents relatively small basic dykes which have been metamorphosed but are typically not strongly schistose.

(3) Schistose porphyritic very fine grained basalts occur in 6827 RS121, 132 and 133 intruding tonalite (RS121) or dolerite. These dykes have phenocrysts, microphenocrysts or small laths of plagioclase, which serves to distinguish them from the shear zone (lithology 4). These basalts are very rich in fine grained hornblende and represent very small dykes or the chilled margins of large dykes.

(4) Hornblende rich shear zones Narrow shear zones cut the metadolerites in samples 6827 RS113 and 6827 RS130. These shear zones contain albite as irregularly dispersed grains or in lenses (6827 RS130, where they contain ilmenite), rather than replacing definite phenocrysts or microphenocrysts. The zone in 6827 RS113 is less clearly a shear zone than those in 6827 RS130, where there are three shear zones of different sizes.

(5) Gabbroic anorthosite occurs as a xenolith in sample 6827 RS113. It is coarse grained and is a plagioclase cumulate with postcumulus pyroxene altered to amphibole.

Sulphide, probably pyrite is present in 6827 RS121 and 132. Veins containing albite and ilmenite are present in 6827 RS130 and 132. The vein in 6827 RS130 is in a shear zone that in 6827 RS132 is on the contact between holocrystalline and porphyritic metabasalts.

In summary, these samples represent two suites of igneous rocks, or tonalite-granodiorite suite, and later basaltic to doleritic dykes with a cumulus textured xenolith in one of chilled dykes. The chief difficulty is to resolve the difference between fine grained, sparsely porphyritic to aphyric basalts from hornblende rich shear zones, as both are clearly present. Both can have veins emplaced along their margins and both are strongly schistose.

INDIVIDUAL DESCRIPTIONS

6827 RS113: Metamorphosed dolerite with a probable xenolith of gabbroic anorthosite and a hornblende-rich zone, either a shear zone or a schistose small later dyke. (most probably a shear zone).

The bulk of this section is occupied by a hornblende-rich metadolerite, with zoned pale to deep blue green amphibole apparently replacing clinopyroxene grains to 1mm long. The interstitial material includes clay-clouded plagioclase laths and anhedral grains of clear albite. Opaque grains to 1mm diameter appear to have been recrystallised to fine grained probable ilmenite. Abundant acicular amphibole crystals occur in the recrystallised felspar-rich interstitial areas. A xenolith with a minimum dimension of 20mm consists predominantly of coarse plagioclase grains to 6mm in size, with amphibole replacing post-cumulus oikocrysts, probably of clinopyroxene, and oxidised opaque grains, possibly magnetite or pyrite.

A strongly schistose zone about 5mm wide contains dominant fibrous hornblende and lenses of plagioclase different from those in the host amphibolite, and minor opaque oxides. The schistosity in this zone is crenulate and at a low angle to the margins of the zone, which is consistent with its representing a shear zone.

A vein along one margin of the schistose zone contains felspar, clay and probable stilbite. Other thin veins contain probable adularia.

6827 RS116: Recrystallised albitised probable tonalite porphyry with minor biotite, hornblende, chlorite, magnetite and apatite, trace zircon and pyrite.

Albite	50-55%
Quartz	40%
Hornblende, biotite, chlorite	5%
Magnetite	1-2%
Apatite	<1%
Zircon	tr.
Pyrite	tr.

This is a somewhat heterogeneous rock, most of it is porphyritic with fractured, albitised plagioclase phenocrysts from 1 to 7mm long, clouded by clays. Probable ferromagnesian phenocrysts to 2mm long have been recrystallised to diffuse aggregates of hornblende, biotite and felspar, with inclusions of magnetite, apatite, zircon and rarely, allanite.

The groundmass is predominantly composed of quartz and albitised felspar grains 0.2-0.6mm in size, with minor hornblende, biotite, chlorite, opaque oxides and fine acicular apatite. Relatively even-grained, felspar-rich patches to 6mm in diameter with small recrystallised ferromagnesian grains are possibly xenoliths.

Schistose veins with quartz biotite and chlorite are present. Pyrite is present in thin veins and within some of the recrystallised ferromagnesian grains. There are rare suggestions of recrystallised, silicified granophyre patches in the rock.

6827 RS121:MTB12, 294.45m Contact between, even-grained, albitised, partly granophyric, microtonalite and schistose porphyritic hornblende-rich metabasalt(? dyke) pyrite and clays on and adjacent to the contact.

	Tonalite
Albite	50-55%
Quartz	35-40%
Orthoclase(albitised)	2%
Biotite, chlorite, hornblende	3-5%
Quartz	1.2%
Apatite	<1%
Pyrite	0-5%

The bulk of this section is occupied by a relatively even grained rock, similar to the possible xenoliths in 6827 RS116, but with clouded albitised felspar laths about 1mm long. Phenocrysts to 3mm long are rare, occurring only adjacent to the hornblende-rich schist.

Rare patches of granophyre have been preserved in this rock, with the original alkali felspar altered to albite, locally with a checkerboard texture. Fine ferromagnesian minerals, mostly biotite, with minor hornblende and chlorite, are evenly dispersed but are not strongly schistose. Fine oxides and apatite are also dispersed.

The hornblende schist contains rare scattered plagioclase phenocrysts to 1mm long and moderately abundant (10%) plagioclase microlites set in schistose hornblende. Opaque oxides occur in and adjacent to the phenocrysts and in the schist, particularly along the margin. A vein-like zone, rich in recrystallised albite is present along the contact and contains oxide grains 0.2mm in size.

6827 RS121 : MBT-12, 294.45m continued:

A zone containing abundant pyrite hornblende and clays extends 4mm into the tonalite, and is connected to veins of filamentous pyrite passing into the schist at a low angle (15-20°) to the contact. The schistosity in this area is crenulated but hornblende in the albite-rich contact zone is axial plane to these crenulations. A diffuse vein containing hornblende and biotite carries minor pyrite into the microtonalite.

6827 RS130: MBT12, 287.0m Metadolerite cut by hornblende schist zones with albite and probably ilmenite.

The metadolerite in this sample is less deformed than that in 6827 RS113 with prisms of green hornblende about 1mm long clearly derived from pyroxene crystals, and with recognisably igneous plagioclase laths about 1mm long. Opaque oxides are dispersed as small probably recrystallised grains, and small apatite needles are common. Fine acicular amphibole needles also penetrate into the felspar laths.

Three subparallel zones of hornblende-rich schist, from 0.2mm to over 10mm wide are present within this rock. The narrowest zones are also rich in granular clear albite. One of these is sharply defined but the other has a diffuse contact with the metadolerite, the schistosity developing over a zone up to 3mm wide and swinging from 40° to the shear zone to nearly parallel.

The widest zone is sharply defined with the schistosity parallel to the zone, except in a lens rich in coarse albite, up to 6mm wide, where the schistosity is contorted. Minor albite and oxides are dispersed through this zone, and the albite-rich lens contains coarse probable ilmenite crystals to 2mm long.

6827 RS132 MBT12 292.4m

Contact between metamorphosed holocrystalline basalt and schistose metamorphosed porphyritic fine grained basalt. (both possibly dykes)

	A	B
Hornblende	40%	70-95%
Plagioclase	50%	5-25%
Oxides	7%	5%
Biotite	7%	5%
Pyrite	1-2%	<1%
Apatite	<1%	
Quartz	-	<1%

Part of this thin section is a fine grained metabasalt(A) with amphibole prisms about 0.3mm long and plagioclase laths of similar size. The plagioclase laths are zoned and probably residual igneous grains. Fine oxides and apatite are accessories and there are scattered irregular grains of pyrite.

This rock has been intruded by an even finer grained basalt with scattered phenocrysts and microphenocrysts of plagioclase, typically from 0.5mm to 2mm long in a fine grained, generally hornblende-rich schist. Irregular patches in this schist are richer than the rest of the basalt in felspar and biotite. Small possible vesicles are present containing hornblende, plagioclase, biotite and magnetite.

Fine oxides are concentrated into a zone on, or about 1-3mm from, the irregular contact between the two basalts, within the finer grained rock. This zone also contains fractured porphyroblasts of magnetite set in pressure shadows of quartz, biotite, and chlorite. Pyrite grains occur within this zone and in a fracture parallel to it, but further from the contact.

6827 RS133 MBT12 296.4m

Gneissic albitised microtonalite or microgranodiorite with granophyric patches, c.f. 6827 RS121, and a schistose fine grained basaltic dyke.

Albite	60%%	2-3%
Quartz	30%	<1%
Hornblende	5%	90%
Biotite	3%	-
Oxides	2%	5-7%
Apatite	<1%	<1%?

Part of this rock was a porphyritic microtonalite or microgranodiorite with albitised plagioclase phenocrysts to 4mm long in rare clusters to about 10mm diameter. The groundmass, which is micro gneissic, contains albitised plagioclase laths mostly 0.5-1.5mm in length, recrystallised quartz grains and deformed patches of granophyre with albitised probable alkali felspar. The albite replacing plagioclase is clouded but that in the altered granophyre patches is clear. The biotite and hornblende define a gneissic foliation partly wrapped around the plagioclase crystals, but roughly parallel to the foliation in the adjacent hornblende schist. Opaque oxides and apatite occur in and adjacent to the biotite and hornblende.

The basalt dyke has been altered to a fine grained hornblende schist with fine oxide grains and rare small felspar laths. Minor quartz is possibly present.

The contact is irregular and may have been folded. A lens of quartz and albite occurs on the area of the fold and contains an elongate, bent crystal of probable ilmenite. A thin vein of albite and possible ilmenite has cut the hornblende schist. The albite is altered weakly to clays adjacent to thin clay-filled fractures.

6827 RS153 MBT14, 182.0m Foliated biotite tonalitic to granodioritic gneiss with minor muscovite.

Plagioclase	50-55%
Alkali felspar	5-10%
Quartz	30%
Biotite	7%
Muscovite	5%
Oxides	<1%
Apatite	<1%

Weakly sericitised plagioclase crystals to 3mm long are common in this rock together with deformed quartz grains to 2mm and rare grains of perthitic microcline to 4mm long. The interstitial areas have been recrystallised but appear to have contained some granophyric areas. Some of the finer grained alkali felspar has apparently been altered to albite, so it is difficult to estimate the original alkali felspar content. The original rock could have been a either a tonalite or a granodiorite.

Lenses of schistose biotite are common with lenses of finer grained (retrograde?) schistose muscovite ± quartz occuring with the biotite or separately. Some of the muscovite-rich lenses are up to 8mm long. Accessories include magnetite and apatite.

APPENDIX 3

GEOCHEMICAL ANALYSES

G01755

PEEBINGA 1

MAJOR ELEMENTS IN PERCENT

	7028	7028	7028	7028	7028	7028	7028	7028	7028
	24	25	26	29	31	35	37	38	39
SiO2	9.85	45.60	45.40	37.00	45.90	66.70	57.30	42.80	46.20
TiO2	0.27	3.02	3.98	4.00	2.36	0.75	1.60	2.74	2.42
Al2O3	2.54	16.20	16.60	16.00	15.10	14.10	15.50	14.70	14.20
Fe2O3	4.30	18.10	20.80	14.60	14.80	6.30	12.90	12.80	12.30
FeO	.	.	.	.	.	.	.	.	.
MnO	0.03	0.20	0.28	0.13	0.14	0.06	0.18	0.22	0.15
MgO	0.73	4.86	2.32	2.04	4.44	2.74	1.64	7.40	5.90
CaO	47.20	1.75	1.68	9.35	5.45	1.19	1.87	7.55	9.30
Na2O	0.03	1.05	1.14	0.09	1.47	0.31	6.65	3.42	2.72
K2O	0.53	2.22	3.08	4.02	1.74	3.72	0.17	0.37	0.96
P2O5	0.91	0.46	0.86	0.39	0.38	0.11	0.54	0.34	0.29
H2O+	.	.	.	.	.	.	.	.	.
H2O	.	.	.	.	.	.	.	.	.
CO2	.	.	.	.	.	.	.	.	.
LOI	31.90	6.50	4.82	10.90	8.65	4.90	2.54	8.65	4.98
Total	98.29	99.96	101	98.52	100.9	100.9	100.9	101	99.42

TRACE ELEMENTS IN PPM

	7028 24	7028 25	7028 26	7028 29	7028 31	7028 35	7028 37	7028 38	7028 39
Ag	1.00	-1.00	-1.00	1.00	-1.00	-1.00	-1.00	-1.00	-1.00
As	44.00	82.00	14.00	8.00	42.00	23.00	-2.00	2.00	3.00
Au	6.00 B	2.00 B	1.00 B	2.00 B	2.00 B	6.00 B	1.00 B	1.00 B	1.00 B
Ba	3500	2300	2250	2500	1590	2700	390	320	640
Bi	4.00	-4.00	6.00	8.00	8.00	4.00	-4.00	-4.00	18.00
Ce	34.00	115	110	62.00	58.00	38.00	130	44.00	32.00
Co	6.00	64.00	40.00	42.00	54.00	17.00	12.00	44.00	40.00
Cr	26.00	125	15.00	85.00	105	45.00	12.00	115	105
Cs	0.60	1.20	2.80	2.40	2.20	2.80	-0.20	0.80	0.20
Cu	36.00	35.00	25.00	33.00	32.00	46.00	18.00	62.00	64.00
Dy	5.30	3.00	12.00	7.00	6.00	6.20	15.00	5.80	5.40
Er	3.00	3.30	5.00	3.10	2.50	3.50	7.20	2.70	2.30
Eu	1.60	2.30	3.90	2.30	2.40	1.70	4.00	2.30	2.20
Ga	5.00	28.00	35.00	25.00	24.00	22.00	34.00	24.00	20.00
Gd	7.20	11.00	14.60	3.40	8.00	7.00	16.00	6.60	5.30
La	28.00	54.00	50.00	28.00	26.00	44.00	60.00	20.00	14.60
Lu	0.40	0.60	0.80	0.40	0.40	0.30	1.00	0.40	0.40
Mo	8.00	2.00	4.60	2.60	1.60	2.00	3.60	2.60	2.60
Nb	6.00	34.00	54.00	48.00	32.00	15.60	80.00	20.00	18.00
Nd	32.00	52.00	60.00	34.00	32.00	33.00	66.00	26.00	20.00
Ni	18.00	115	40.00	74.00	82.00	56.00	26.00	90.00	85.00
Pb	46.00	24.00	24.00	15.00	24.00	30.00	20.00	28.00	28.00
Pd	1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	2.00 B	-1.00 B	-1.00 B	-1.00 B
Pt	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B
Rb	15.00	48.00	66.00	72.00	40.00	100	6.00	7.40	17.60
Sb	-4.00	-4.00	5.00	4.00	-4.00	-4.00	-4.00	-4.00	-4.00
Sm	6.80	12.60	15.60	8.00	8.20	9.20	15.60	6.20	6.20
Sn	-4.00	4.00	-4.00	-4.00	-4.00	-4.00	6.00	-4.00	8.00
Sr	300	92.00	100	78.00	155	34.00	310	390	420
Ta	0.40	2.60	4.00	3.20	2.40	1.60	5.40	1.80	1.40
Th	4.90	16.00	6.20	3.60	2.00	22.00	7.40	4.30	1.20
U	3.50	1.50	2.10	1.10	0.60	4.50	2.20	3.10	0.90
V	180	270	230	210	290	110	10.00	310	280
W	1.00	1.00	1.00	1.00	1.00	2.00	2.00	1.00	2.00
Y	38.00	32.00	50.00	28.00	24.00	30.00	64.00	20.00	19.00
Yb	2.30	2.90	4.20	2.40	2.20	4.10	6.00	2.40	2.10
Zn	48.00	190	120	180	130	85.00	155	105	86.00
Zr	-4.00	230	350	280	220	160	640	145	150

(Negative values indicate < ie. less than, . = Not Analysed, B = PPB, % = %)

	KRINGIN 1	WIRHA SOUTH 1	TORI HILLS 1			PEAKE 1		
MAJOR ELEMENTS IN PERCENT								
	7028 49	7027 1	6927 10	6927 12	6927 13	6827 127	6827 128	6827 129
SiO2	72.50	69.20	69.00	68.30	69.50	51.30	53.50	72.30
TiO2	0.66	0.41	0.56	0.56	0.58	1.43	1.33	0.26
Al2O3	11.20	13.50	13.30	13.50	13.50	14.10	14.00	11.40
Fe2O3	4.82	4.72	4.60	4.78	4.90	11.50	10.90	6.40
FeO	.	.	.	.	.	.	.	.
MnO	0.07	0.06	0.07	0.06	0.07	0.19	0.19	0.05
MgO	1.79	1.07	1.17	1.26	1.32	5.45	5.40	0.32
CaO	0.66	1.30	3.03	2.54	2.68	8.15	7.75	0.58
Na2O	11.20	2.48	2.86	2.78	2.92	3.76	3.48	6.30
K2O	4.82	5.25	3.58	3.46	3.50	1.32	1.32	0.06
P2O5	0.07	0.10	0.11	0.11	0.11	0.19	0.18	0.02
H2O+	.	.	.	.	.	.	.	.
H2O	.	.	.	.	.	.	.	.
CO2	.	.	.	.	.	.	.	.
LOI	2.50	0.00	1.22	2.08	0.72	2.78	2.28	2.12
Total	110.3	98.15	99.55	99.43	99.30	100.2	100.3	100.3

TRACE ELEMENTS IN PPM

Ag	-1.00	-1.00	-1.00	-1.00	-1.00	1.00	-1.00	-1.00
As	-2.00	-2.00	-2.00	-2.00	-2.00	2.00	-2.00	7.00
Au	-1.00 B	1.00 B	-1.00 B	-1.00 B	3.00 B	-1.00 B	1.00 B	-1.00 B
Ba	530	520	450	450	490	300	340	15.00
Bi	-4.00	4.00	4.00	10.00	8.00	-4.00	4.00	10.00
Ce	110	110	72.00	68.00	68.00	150	36.00	66.00
Co	12.00	12.00	9.00	10.00	9.00	36.00	34.00	18.00
Cr	46.00	44.00	24.00	28.00	26.00	155	150	6.00
Cs	5.40	12.00	8.40	3.60	9.20	0.40	1.40	0.80
Cu	22.00	6.00	12.00	30.00	11.00	38.00	84.00	280
Dy	4.90	7.20	6.60	5.80	7.60	13.50	11.80	13.50
Er	2.30	3.50	3.70	3.40	4.10	7.40	7.00	11.00
Eu	1.60	1.50	1.40	1.30	1.50	2.30	2.10	2.50
Ga	15.00	17.00	18.00	18.00	20.00	21.00	21.00	20.00
Gd	7.20	8.80	6.30	6.20	7.20	15.00	9.60	14.50
La	56.00	54.00	42.00	39.00	29.00	72.00	14.00	25.50
Lu	0.40	0.60	0.60	0.60	0.70	1.20	1.10	1.60
Mo	1.00	4.00	1.50	2.00	2.00	2.00	2.00	2.50
Nb	12.00	14.00	12.00	12.00	13.00	5.50	5.50	11.50
Nd	44.00	48.00	34.00	31.00	29.50	66.00	23.50	38.00
Ni	40.00	26.00	14.00	14.00	15.00	74.00	65.00	10.00
Pb	32.00	54.00	34.00	52.00	40.00	45.00	32.00	50.00
Pd	-1.00 B	1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B
Pt	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B
Rb	110	220	180	170	175	31.00	36.00	3.80
Sb	-4.00	-4.00	6.00	-4.00	-4.00	-4.00	5.00	-4.00
Sm	8.40	10.00	7.20	6.60	7.20	14.50	7.60	11.00
Sn	4.00	6.00	4.00	6.00	10.00	8.00	4.00	-4.00
Sr	125	135	130	120	130	205	165	38.00
Ta	1.20	2.00	0.80	1.00	1.20	0.40	0.40	1.00
Th	24.00	38.00	18.50	16.50	17.50	37.00	3.70	6.60
U	3.70	3.70	4.20	3.80	2.90	2.30	0.90	1.60
V	70.00	65.00	70.00	85.00	85.00	260	270	-10
W	1.00	2.00	2.00	2.00	2.00	1.00	-1.00	1.00
Y	19.00	30.00	32.00	27.00	36.00	60.00	58.00	94.00
Yb	1.90	3.30	3.60	3.30	4.10	6.80	6.80	10.00
Zn	50.00	64.00	60.00	58.00	58.00	115	125	35.00
Zr	400	140	195	210	185	260	240	350

(Negative values indicate < ie. less than, . = Not Analysed, B = PPB, % = %)

CARINGA 1

MAJOR ELEMENTS IN PERCENT

	6827 111	6827 112	6827 113	6827 114	6827 116	6827 117	6827 119	6827 120	6827 124	6827 125
SiO2	51.30	50.00	49.20	50.80	65.20	67.90	71.20	48.90	52.40	50.20
TiO2	1.47	1.32	1.50	1.51	0.69	0.67	0.68	2.58	1.42	1.51
Al2O3	14.60	15.10	14.70	14.90	14.30	13.80	12.30	13.40	14.50	14.70
Fe2O3	12.10	12.10	13.40	12.60	5.40	4.86	2.76	15.30	12.10	12.00
FeO	.	.	.	.	.	.	.	.	.	.
MnO	0.20	0.18	0.21	0.20	0.06	0.06	0.04	0.25	0.19	0.20
MgO	5.80	5.60	6.60	6.35	1.18	1.69	1.15	5.50	5.85	5.45
CaO	9.75	8.55	8.95	9.05	5.60	2.02	2.36	7.90	6.75	8.85
Na2O	3.06	3.78	3.28	3.34	4.58	5.90	6.45	4.02	4.86	3.02
K2O	0.13	0.20	0.15	0.14	0.40	0.72	0.20	0.16	0.14	0.18
P2O5	0.34	0.33	0.34	0.37	0.37	0.35	0.36	0.48	0.36	0.36
H2O+	.	.	.	.	.	.	.	.	.	.
H2O	.	.	.	.	.	.	.	.	.	.
CO2	.	.	.	.	.	.	.	.	.	.
LOI	0.58	1.90	1.02	0.70	0.97	0.72	0.64	0.63	0.64	2.56
Total	99.33	99.06	99.35	99.96	98.75	98.69	98.64	99.12	99.21	99.03

TRACE ELEMENTS IN PPM

	6827 111	6827 112	6827 113	6827 114	6827 116	6827 117	6827 119	6827 120	6827 124	6827 125
Ag	-1.00	-1.00	-1.00	1.00	-1.00	-1.00	-1.00	1.00	-1.00	-1.00
As	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	2.00	-2.00
Au	1.00 B	1.00 B	1.00 B	1.00 B	2.00 B	4.00 B	-1.00 B	3.00 B	1.00 B	-1.00 B
Ba	20.00	35.00	20.00	33.00	30.00	125	30.00	20.00	25.00	30.00
Bi	5.00	5.00	-4.00	6.00	6.00	8.00	-4.00	4.00	-4.00	-4.00
Ce	14.00	10.60	11.80	12.60	80.00	80.00	80.00	30.00	8.80	13.60
Co	36.00	52.00	33.00	33.00	8.00	9.00	9.00	40.00	35.00	44.00
Cr	24.00	20.00	24.00	34.00	38.00	64.00	32.00	54.00	44.00	38.00
Cs	0.60	0.60	0.80	0.60	0.60	0.60	0.40	0.60	0.60	0.60
Cu	42.00	180	33.00	24.00	60.00	44.00	46.00	30.00	4.00	44.00
Dy	5.40	4.50	5.20	5.20	7.80	10.00	7.80	9.40	5.20	5.80
Er	3.00	2.60	3.10	3.10	4.20	5.60	4.30	5.40	3.10	3.50
Eu	1.30	1.00	1.20	1.20	1.70	1.50	1.50	2.10	1.20	1.30
Ga	19.00	17.00	19.00	13.00	22.00	15.00	10.00	20.00	16.00	19.00
Gd	4.30	3.60	4.20	4.50	7.60	3.60	7.80	8.00	4.20	4.80
La	5.30	4.50	4.70	4.70	40.00	38.00	44.00	11.40	3.20	5.80
Lu	0.50	0.40	0.50	0.50	0.60	0.90	0.60	0.70	0.40	0.50
Mo	0.60	0.60	-0.50	2.60	5.60	6.00	0.60	3.00	1.60	1.60
Nb	2.60	2.00	2.60	2.60	11.60	11.60	11.60	5.00	2.60	2.60
Nd	10.20	8.00	9.20	9.40	36.00	33.00	40.00	20.00	7.60	10.60
Ni	22.00	20.00	15.00	13.00	15.00	6.00	8.00	14.00	18.00	18.00
Pb	20.00	10.00	16.00	16.00	10.00	-4.00	-4.00	22.00	20.00	40.00
Pd	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B
Pt	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B
Rb	10.40	10.80	9.40	10.40	19.00	30.00	8.20	9.00	9.20	11.20
Sb	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00
Sm	3.20	2.60	3.10	3.10	7.60	8.00	7.60	6.20	3.00	3.40
Sn	-4.00	4.00	-4.00	-4.00	4.00	-4.00	8.00	-4.00	-4.00	-4.00
Sr	155	160	140	135	200	86.00	66.00	170	150	145
Ta	0.40	0.20	0.40	0.40	0.30	0.60	1.00	0.40	0.40	0.40
Th	0.60	0.50	0.60	0.90	18.00	19.00	17.60	2.10	0.60	0.80
U	0.40	0.30	0.40	0.40	3.80	4.60	1.30	0.60	0.40	0.40
V	150	140	165	155	55.00	10.00	25.00	135	165	160
W	1.00	1.00	1.00	1.00	1.00	1.00	-1.00	1.00	1.00	1.00
Y	25.00	20.00	25.00	24.00	35.00	46.00	35.00	44.00	24.00	26.00
Yb	2.80	2.50	3.00	2.90	3.30	5.60	3.90	4.90	3.00	3.50
Zn	90.00	63.00	82.00	75.00	18.00	22.00	15.00	96.00	84.00	84.00
Zr	76.00	58.00	70.00	75.00	260	420	280	165	68.00	64.00

(Negative values indicate < ie. less than, . = Not Analysed, B = PPB, % = %)

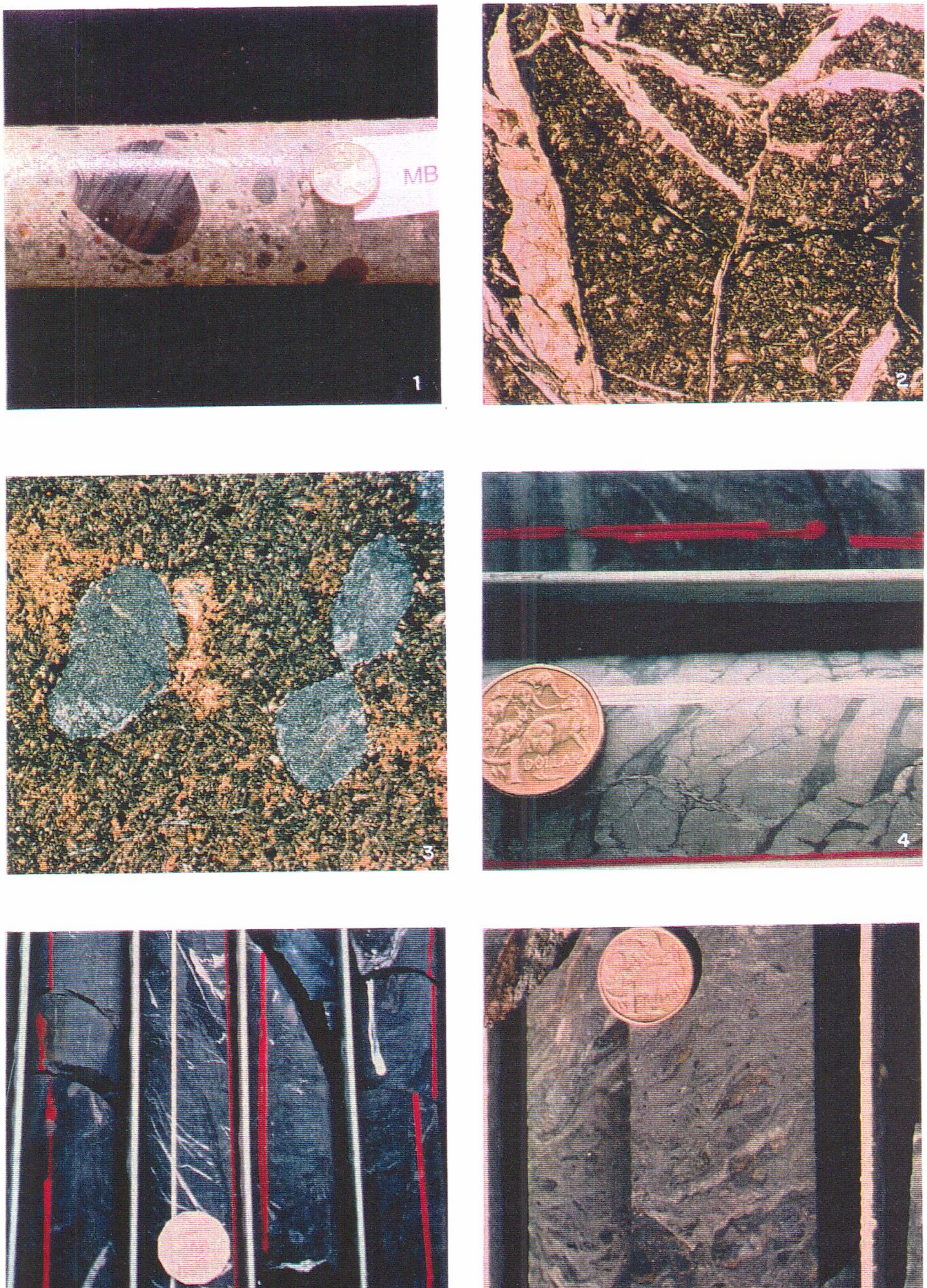
WYNARKA 1 / WYNARKA 2

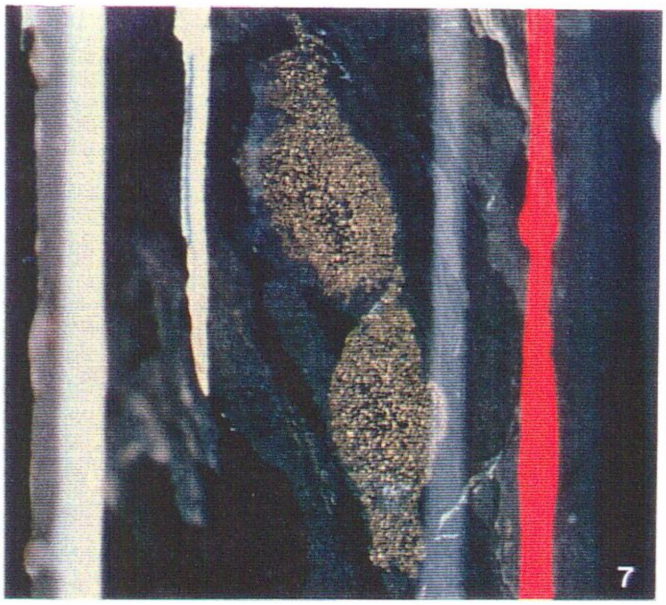
MAJOR ELEMENTS IN PERCENT

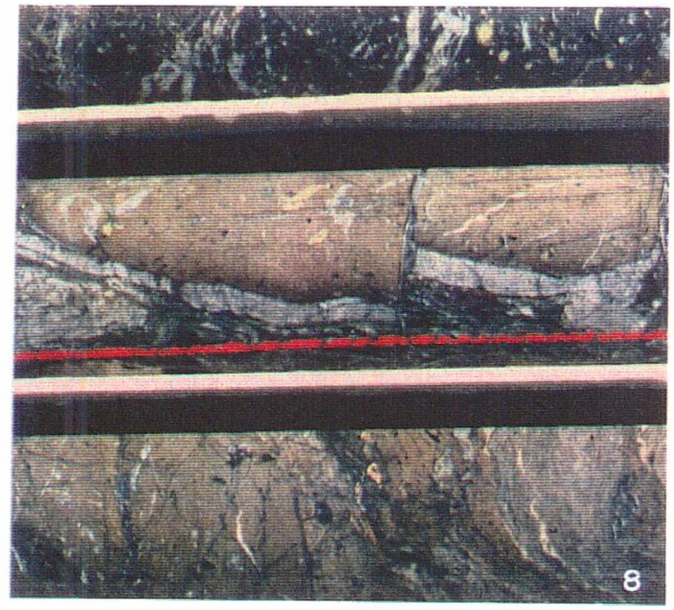
	WYNARKA 1							WYNARKA 2							
	6827 147	6827 151	6827 152	6827 153	6827 155	6827 156	6827 157	6827 134	6827 135	6827 137	6827 138	6827 139	6827 140	6827 141	6827 142
SiO2	34.30	54.60	69.60	70.30	56.40	56.30	55.10	43.90	45.40	45.90	18.80	46.90	29.70	49.20	49.70
TiO2	1.20	1.30	0.60	0.60	1.69	1.65	1.73	1.67	1.71	2.24	0.74	1.88	0.63	1.89	1.95
Al2O3	12.40	14.40	13.70	13.80	13.90	14.00	14.10	12.20	12.40	8.30	4.98	13.50	4.36	13.20	13.80
Fe2O3	4.14	11.60	4.54	4.66	12.70	12.50	13.10	12.90	11.70	8.30	6.30	12.70	6.60	12.30	12.90
FeO	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MnO	0.26	0.18	0.07	0.07	0.18	0.18	0.19	0.18	0.18	0.15	0.37	0.20	0.28	0.17	0.15
MgO	2.26	5.00	1.37	1.39	3.22	3.10	3.48	6.55	5.35	6.85	3.10	5.90	5.40	4.96	5.95
CaO	22.50	8.55	2.04	2.04	6.75	7.90	6.75	8.95	9.20	13.60	35.80	6.70	28.10	7.45	4.98
Na2O	1.87	2.40	2.56	4.00	3.83	3.16	3.54	2.36	3.22	0.31	0.07	3.28	0.05	3.22	3.50
K2O	1.79	1.23	3.90	2.16	0.45	0.50	0.45	0.16	0.21	0.09	0.40	0.22	0.07	0.28	0.19
P2O5	0.15	0.10	0.12	0.14	0.19	0.19	0.20	0.19	0.20	0.14	0.13	0.21	0.09	0.20	0.21
H2O+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H2O	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CO2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
LOI	20.10	1.19	1.10	0.67	0.54	0.45	0.89	11.00	10.30	13.20	29.20	8.00	24.30	7.55	6.90
Total	101	100.6	99.60	99.83	99.90	99.93	99.53	100.1	99.37	100.1	99.89	99.49	99.58	100.4	100.2

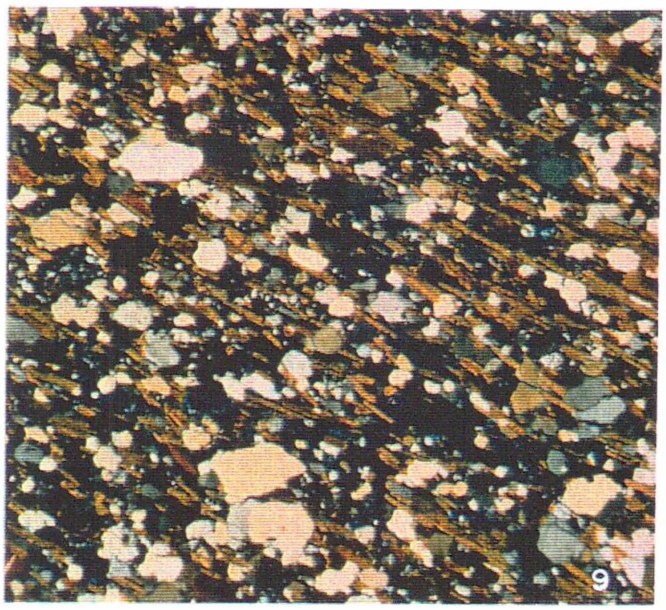
TRACE ELEMENTS IN PPM

	6827 147	6827 151	6827 152	6827 153	6827 155	6827 156	6827 157	6827 134	6827 135	6827 137	6827 138	6827 139	6827 140	6827 141	6827 142
Ag	1.00	1.00	-1.00	-1.00	-1.00	-1.00	1.00	2.00	1.00	1.00	1.00	-1.00	1.00	1.00	1.00
As	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	2.00	3.00	2.00	2.00	-2.00
Au	1.00 B	-1.00 B	-1.00 B	-1.00 B	4.00 B	-1.00 B	-1.00 B	1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	1.00 B
Ba	50.00	120	570	430	60.00	75.00	75.00	50.00	85.00	15.00	15.00	70.00	-10	150	70.00
Bi	4.00	6.00	6.00	12.00	-4.00	4.00	4.00	18.00	6.00	8.00	3.00	5.00	6.00	8.00	5.00
Ce	14.00	26.50	100	96.00	26.50	26.00	52.00	25.00	26.00	49.00	20.50	29.00	16.00	24.00	28.00
Co	40.00	38.00	9.00	10.00	30.00	32.00	37.00	43.00	33.00	24.00	26.00	39.00	43.00	34.00	38.00
Cr	115	30.00	42.00	40.00	10.00	10.00	12.00	38.00	36.00	135	310	50.00	480	46.00	42.00
Cs	1.00	2.40	2.30	2.60	0.60	0.80	0.60	0.40	0.40	0.30	4.40	0.40	0.40	0.60	0.60
Cu	42.00	62.00	15.00	20.00	22.00	23.00	45.00	15.00	30.00	17.00	11.00	18.00	48.00	30.00	20.00
Dy	5.00	6.00	7.60	7.20	7.60	7.80	8.20	7.00	7.20	4.50	3.90	7.60	2.10	7.20	7.80
Er	3.00	3.40	4.10	3.60	4.60	4.50	4.60	3.80	4.20	1.30	2.00	4.40	1.10	4.00	4.60
Eu	1.20	1.10	1.70	1.60	1.70	1.60	1.80	1.80	2.10	1.90	1.40	1.30	0.80	1.80	2.20
Ga	15.00	19.00	19.00	20.00	20.00	21.00	20.00	17.00	18.00	12.00	9.00	19.00	8.00	18.00	19.00
Gd	4.10	5.00	8.40	3.00	6.20	6.40	6.30	6.20	6.40	5.80	4.60	6.60	2.30	6.20	6.80
La	6.20	11.40	47.00	46.00	11.20	10.80	27.50	11.00	11.20	22.00	9.30	15.00	10.40	10.20	11.30
Lu	0.50	0.50	0.60	0.60	0.70	0.70	0.70	0.60	0.60	0.30	0.30	0.70	0.20	0.60	0.70
Mo	2.50	1.00	2.50	2.50	1.00	1.00	2.00	1.00	1.00	0.50	1.50	1.00	0.50	1.00	1.00
Nb	3.00	3.50	14.00	14.50	5.00	5.00	5.00	4.00	5.00	24.50	4.00	5.00	5.00	4.50	5.00
Nd	10.00	13.50	42.00	40.00	16.50	16.00	23.00	17.00	17.00	24.50	13.00	18.00	3.00	16.00	18.00
Ni	63.00	28.00	23.00	25.00	16.00	15.00	22.00	36.00	35.00	93.00	175	44.00	270	38.00	42.00
Pb	52.00	38.00	66.00	42.00	25.00	25.00	36.00	32.00	32.00	32.00	26.00	32.00	24.00	22.00	20.00
Pd	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	2.00 B	1.00 B	1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B	-1.00 B
Pt	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B	-5.00 B
Rb	17.50	54.00	140	110	16.00	21.00	20.00	6.60	10.60	7.00	18.00	3.00	3.40	13.50	7.60
Sb	-4.00	-4.00	-4.00	5.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00
Sm	3.20	4.00	9.00	3.60	4.80	4.90	5.30	4.90	5.00	5.40	3.70	5.20	2.00	5.00	5.20
Sn	4.00	5.00	6.00	10.00	6.00	-4.00	6.00	-4.00	-4.00	-4.00	-4.00	8.00	5.00	-4.00	4.00
Sr	270	140	155	175	170	130	190	170	310	270	250	210	225	310	180
Ta	0.20	0.30	1.20	0.80	0.40	0.40	0.40	0.20	0.40	0.40	0.20	0.40	0.20	0.40	0.40
Th	1.20	3.50	25.50	22.50	3.00	2.90	3.00	1.50	1.80	4.00	0.30	1.90	0.70	1.80	2.10
U	0.40	3.10	4.70	5.80	0.80	0.70	0.80	0.50	0.50	0.50	0.30	0.50	0.30	0.50	0.50
V	320	390	70.00	60.00	370	370	430	410	430	145	160	440	95.00	440	470
W	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Y	24.50	28.00	34.00	29.00	36.00	37.00	38.00	33.00	34.00	16.00	17.50	35.00	9.00	33.00	36.00
Yb	3.00	3.30	3.70	3.10	4.10	4.10	4.40	3.60	3.70	1.60	1.90	4.20	1.10	3.70	4.40
Zn	125	75.00	62.00	66.00	84.00	68.00	110	98.00	98.00	73.00	30.00	120	56.00	120	115
Zr	68.00	30.00	240	230	125	120	120	105	105	210	60.00	120	40.00	115	120


MB
1
2
3
4
5
6

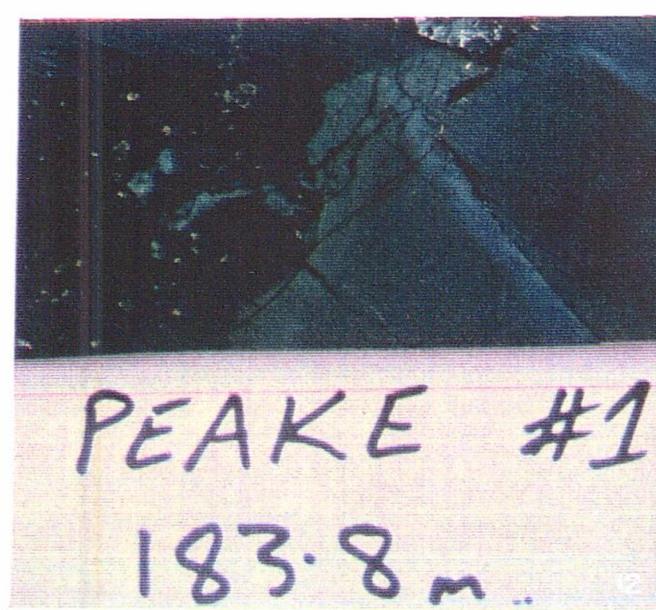

7


8

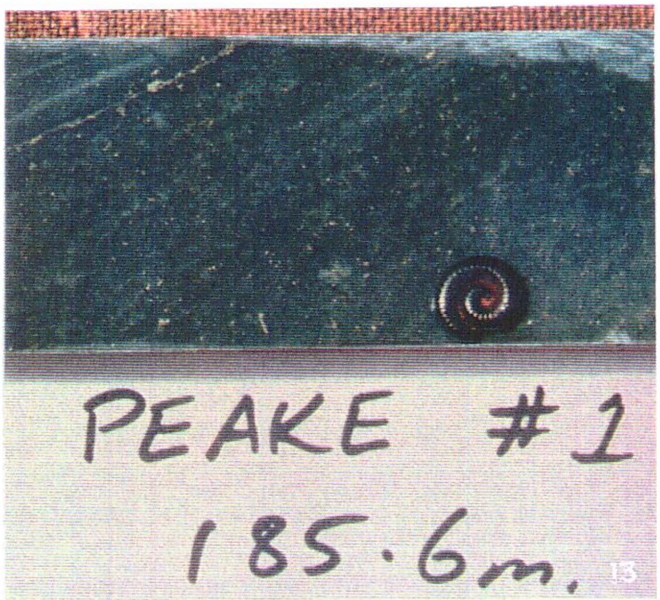

9


10

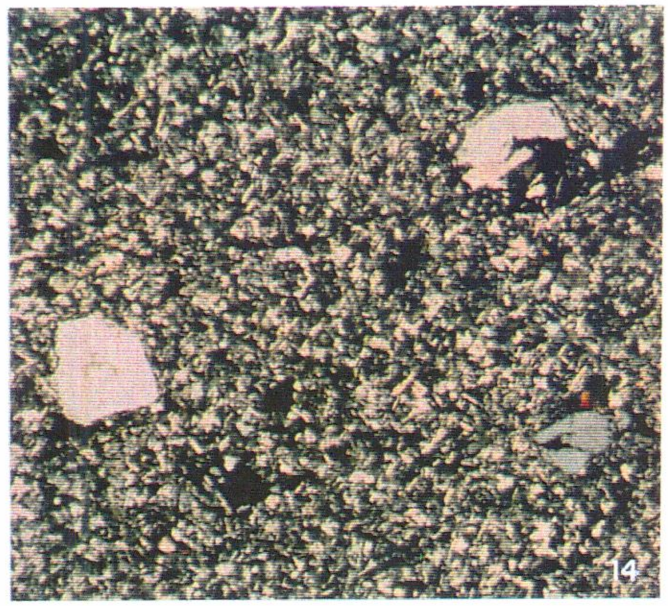
11



12



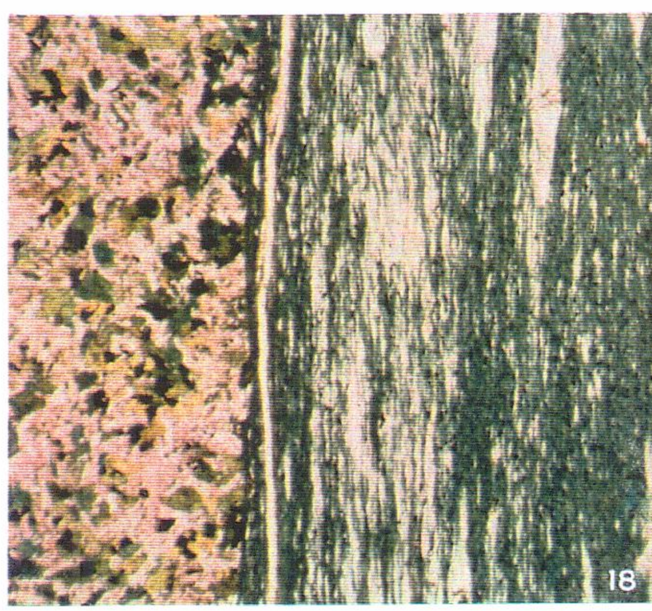
13

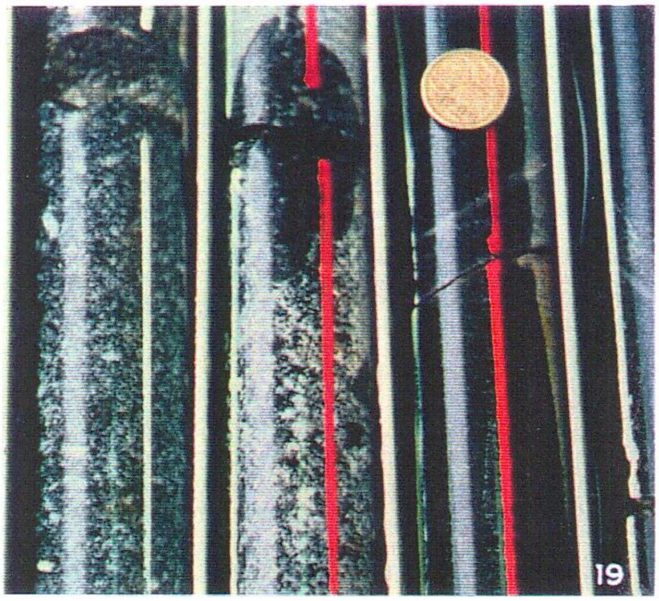

14

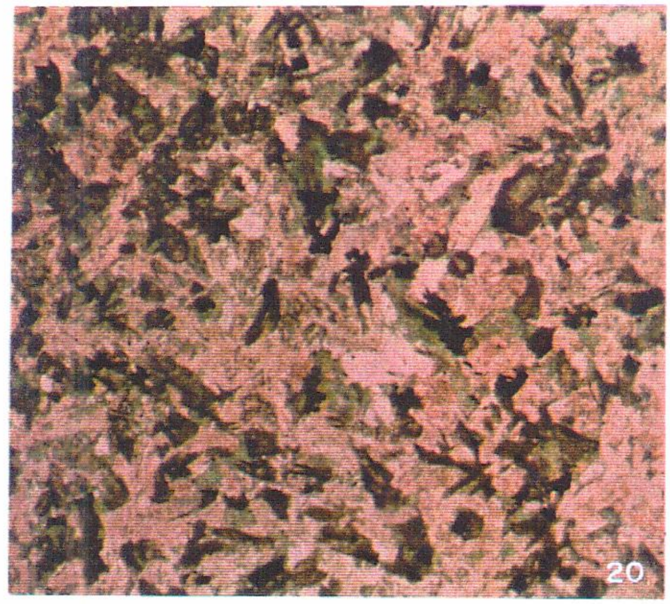

15

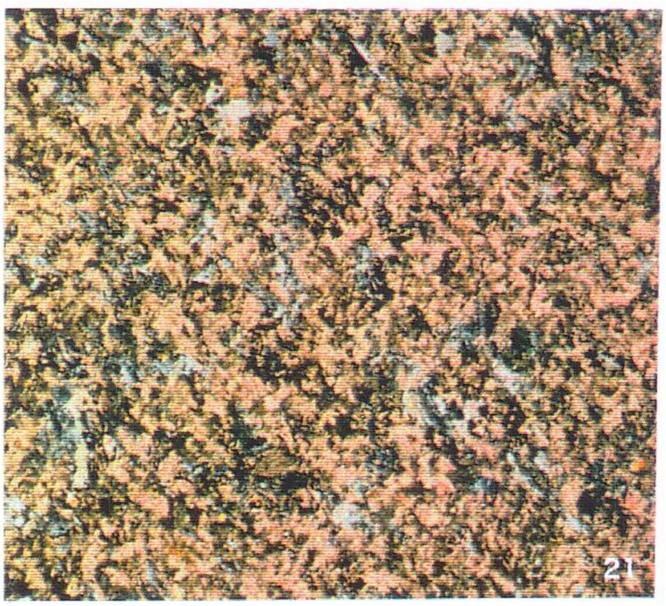

16

17

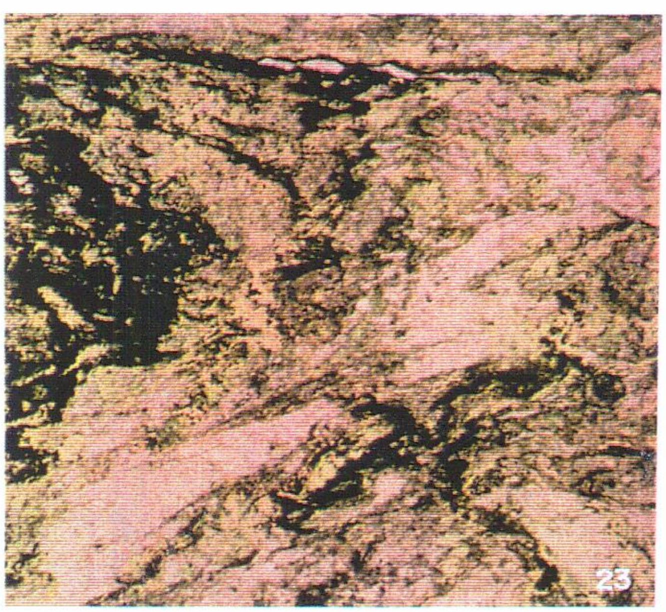

18

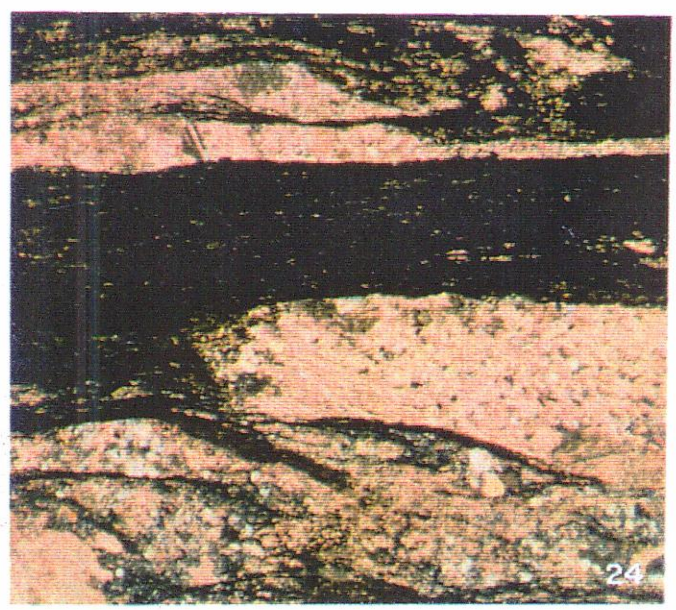

19

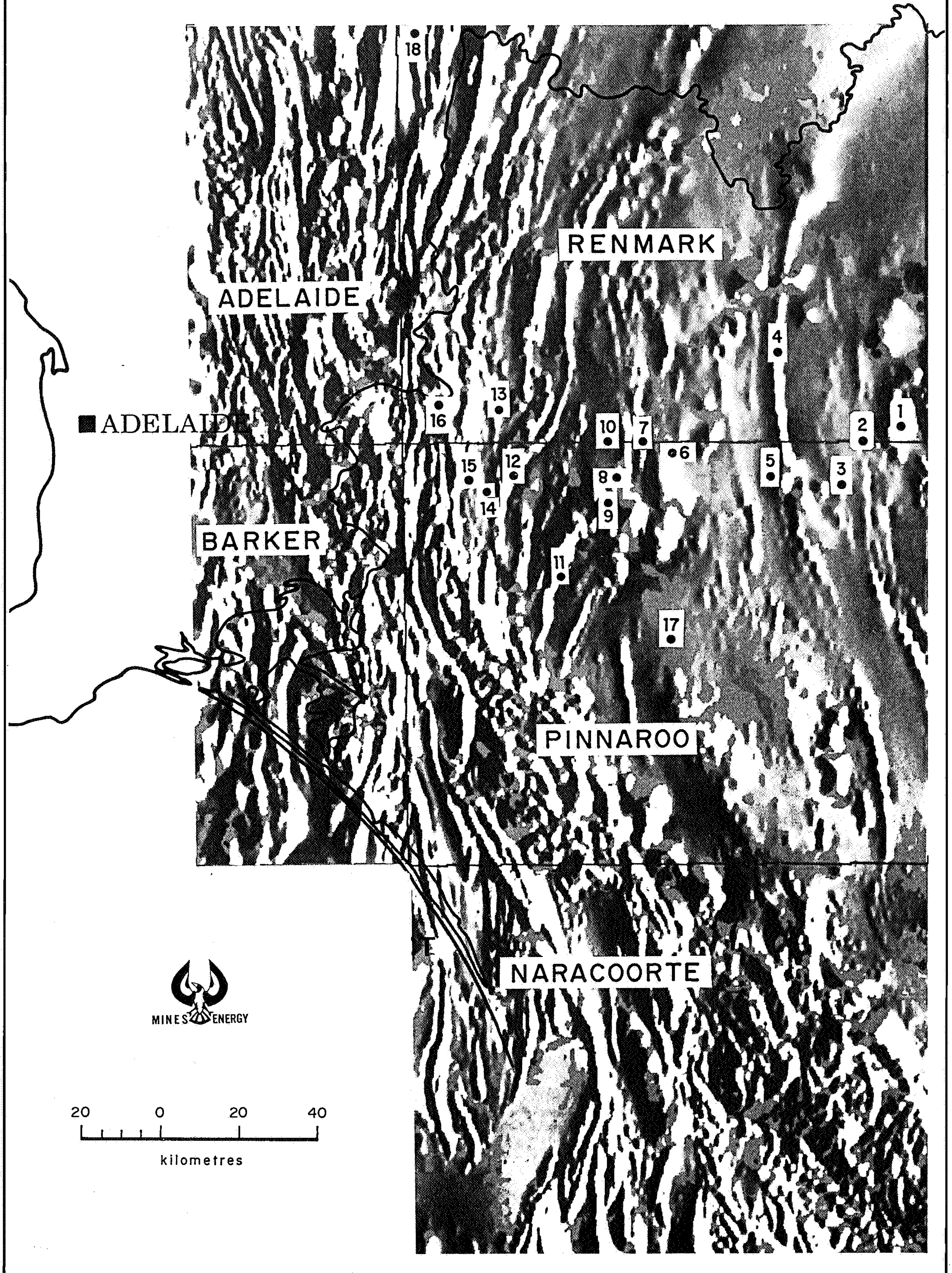

20


21


22


23


24



MURRAY BASIN BASEMENT TRANSECT

GREYSCALE IMAGE OF TOTAL MAGNETIC INTENSITY INCLUDING TARGET MBT ANOMALIES

Figure....1

5154

SADME

S 21913

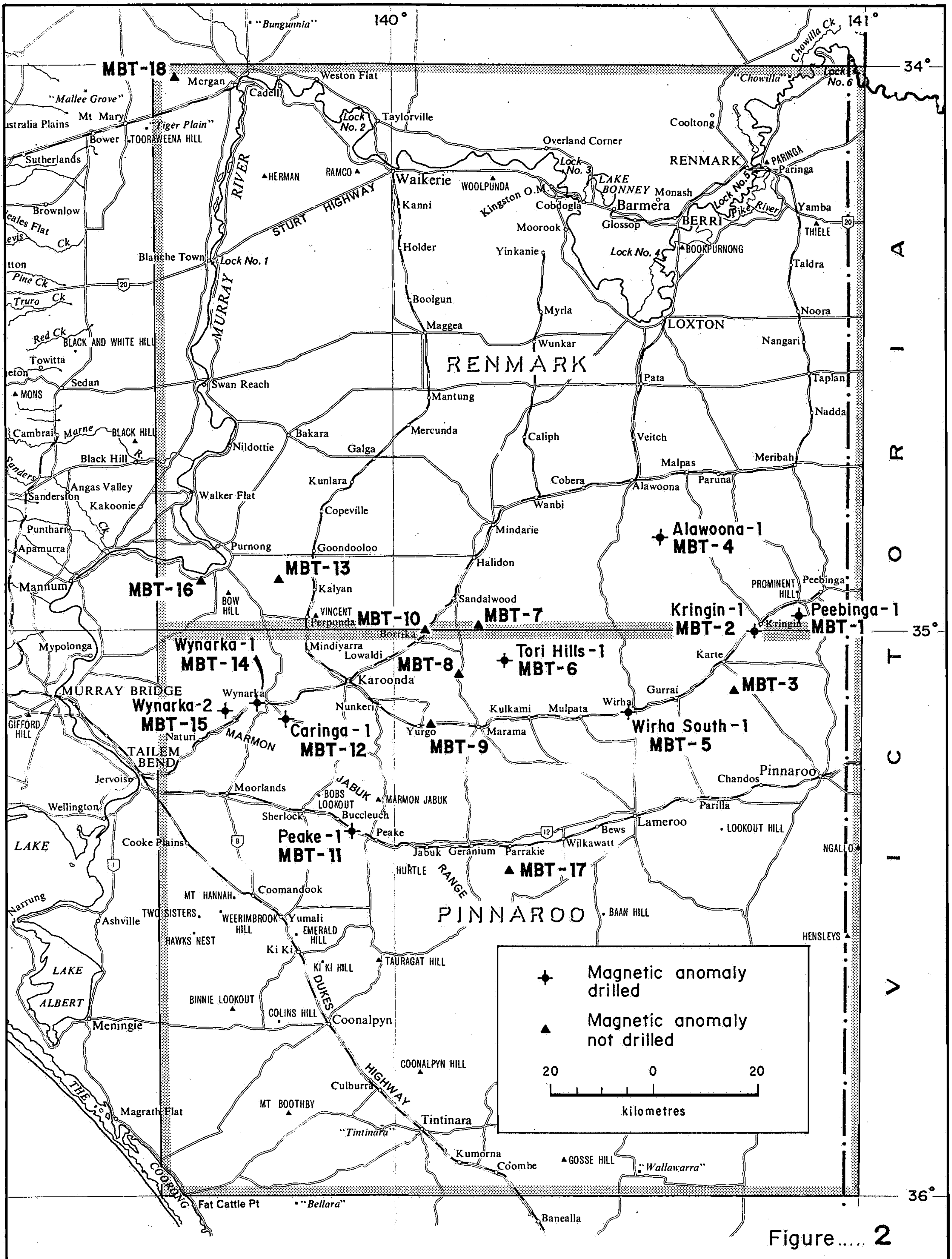


Figure..... 2

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

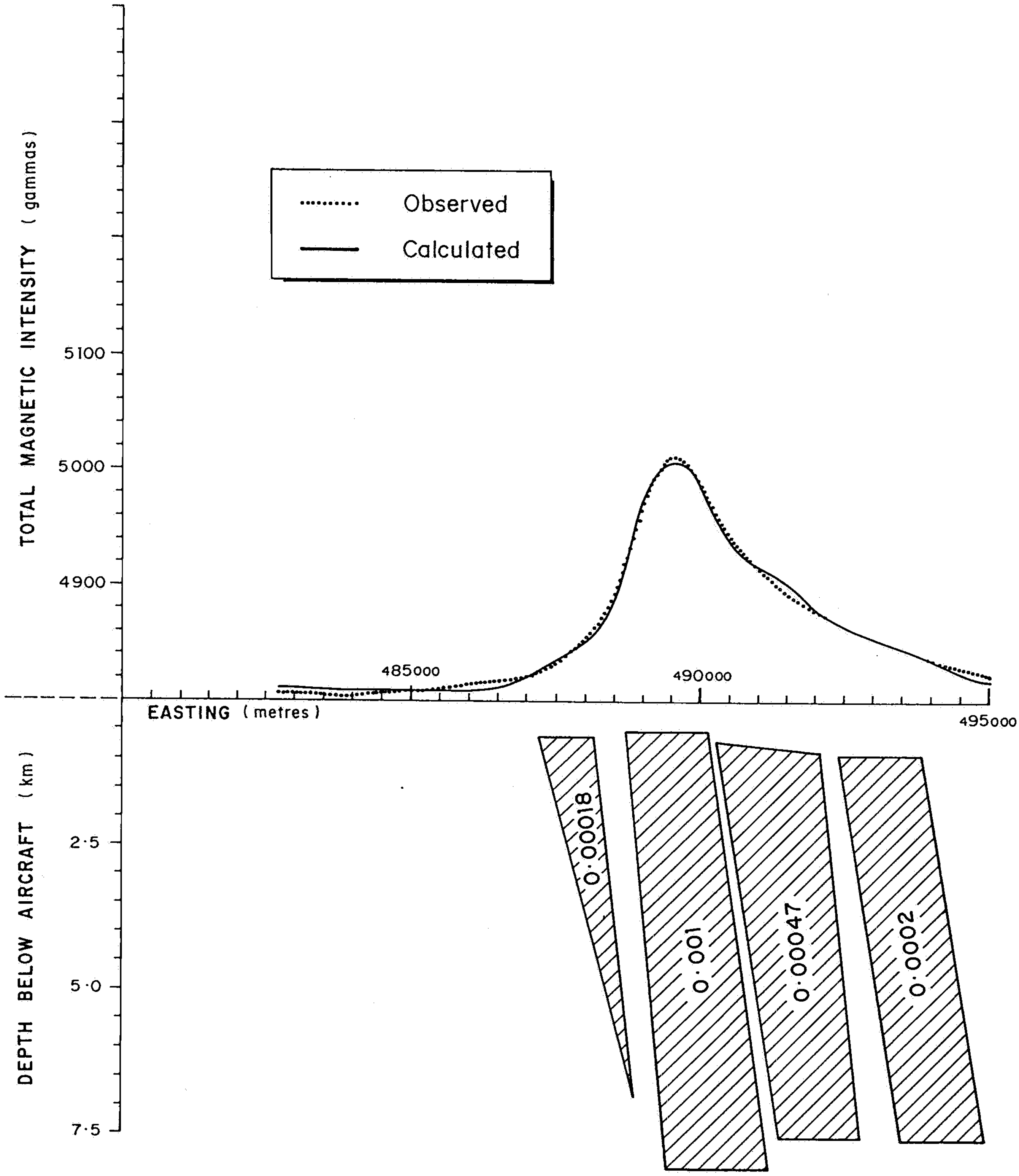
MURRAY BASIN BASEMENT TRANSECT

MAGNETIC ANOMALY AND DRILLHOLE LOCATIONS

COMPILED L. Rankin	C.D.O.	DATE
DRAWN M.R.	SCALE 1: 1,000,000	
DATE Dec '90	PLAN NUMBER	
CHECKED	S 21914	

5154

Flight Line 1750 (Renmark)



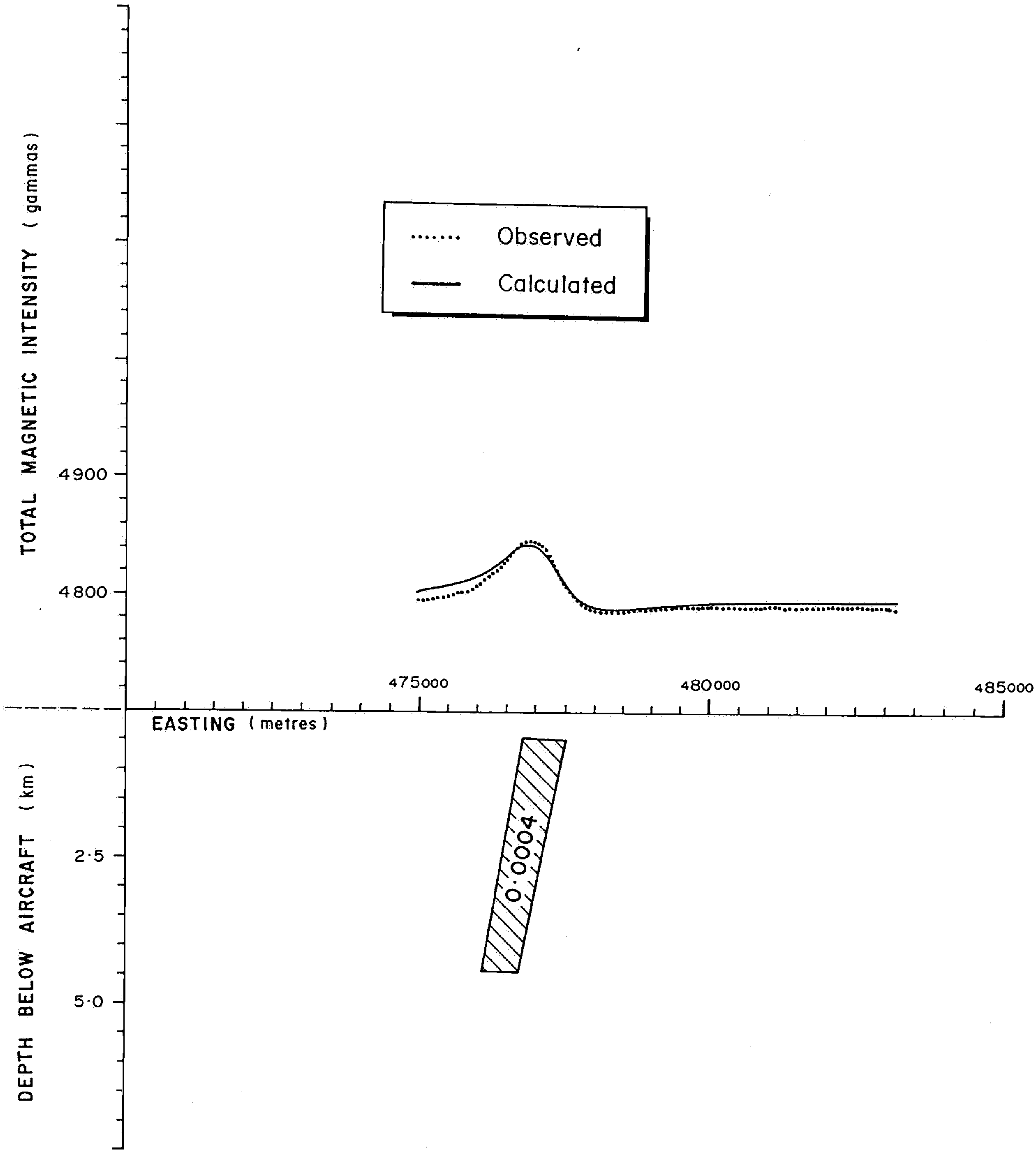
See plan no. 91 - 65 for flight line locations

Figure..... 3A

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED P. Hough	C.D.O. DATE
MURRAY BASIN BASEMENT TRANSECT	DRAWN M.R.	SCALE
MBT - 1 (Line 1750) COMPUTER MODEL OF MAGNETIC ANOMALY	DATE Nov. '90	PLAN NUMBER
	CHECKED	S 21915

5154

Flight Line 1850 (Pinnaroo)



See plan no. 91 – 66 for flight line locations

Figure 3B

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT

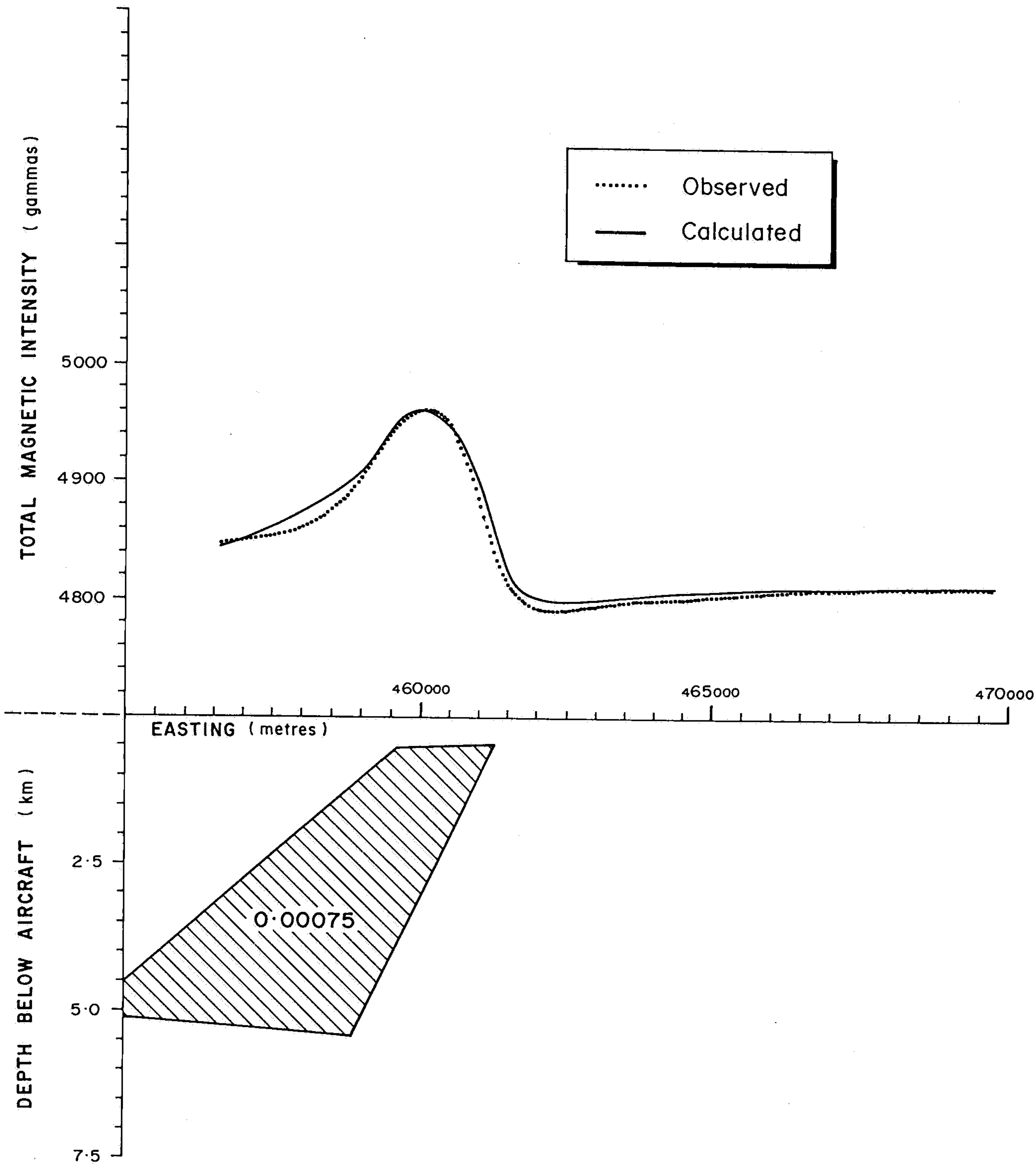
MBT – 3 (Line 1850)

COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	C.D.O.	DATE
DRAWN M.R.	SCALE	
DATE Nov. '90	PLAN NUMBER	
CHECKED	S 21916	

5154

Flight Line 1650 (Renmark)



See plan no. 91 - 65 for flight line locations

Figure 3C

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

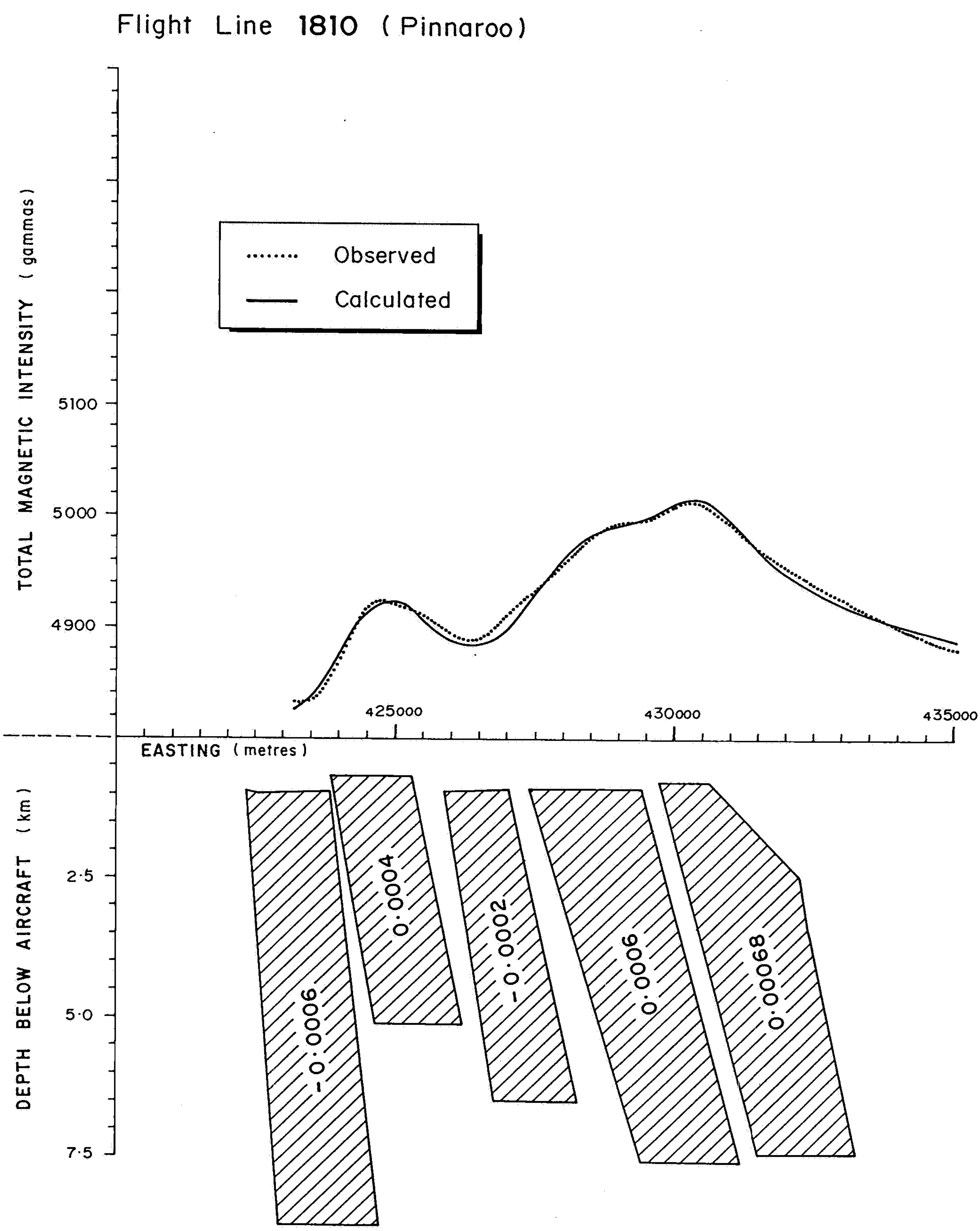
MURRAY BASIN BASEMENT TRANSECT

MBT - 4 (Line 1650)

COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	C.D.O.	DATE
DRAWN M.R.	SCALE	
DATE Nov. '90	PLAN NUMBER S 21917	
CHECKED		

5154



See plan no. 91-66 for flight line locations

Figure..... 3D

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

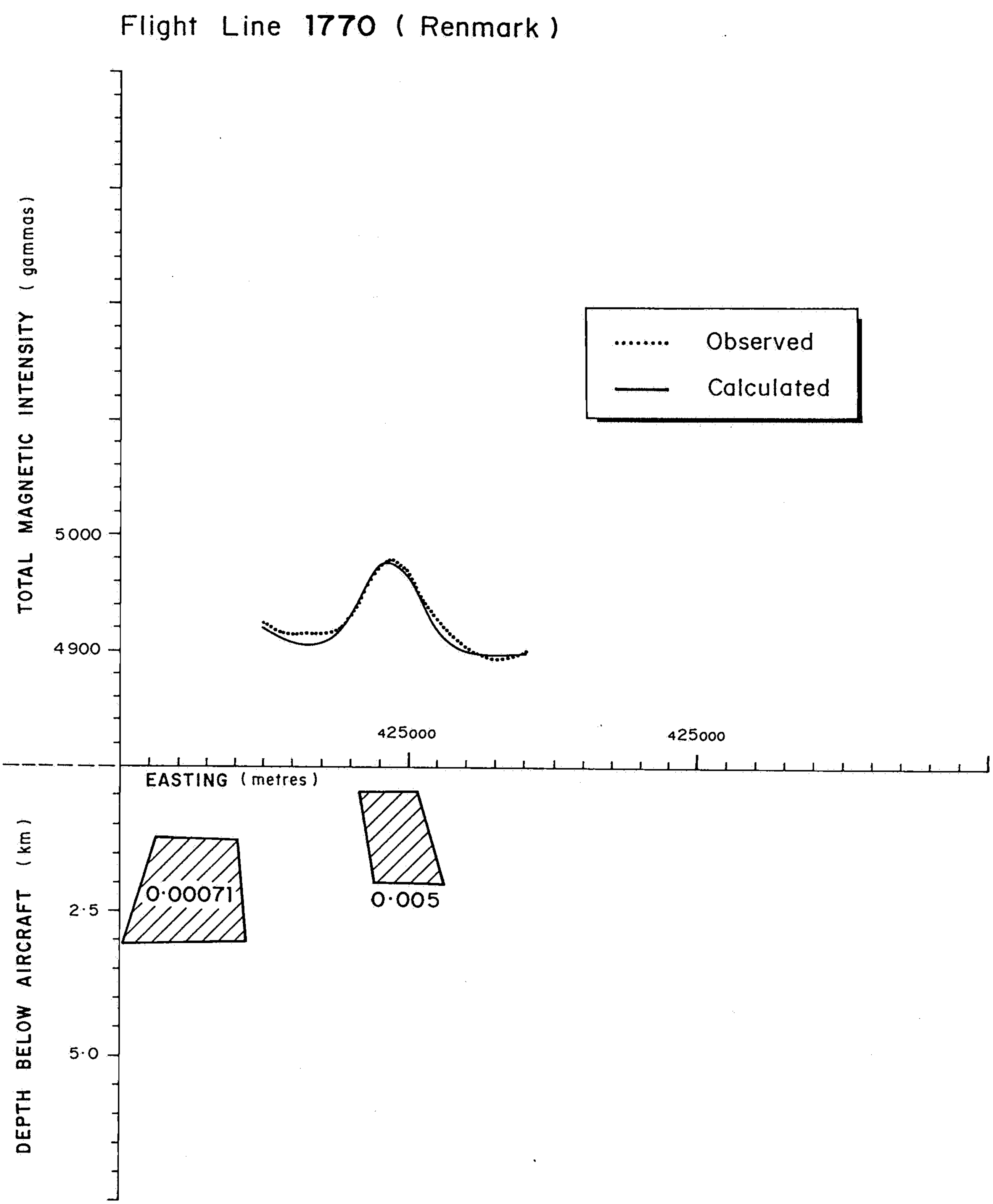
MURRAY BASIN BASEMENT TRANSECT

MBT - 6 (Line 1810)

COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	C.D.O. DATE
DRAWN M.R.	SCALE
DATE Nov. '90	PLAN NUMBER S 21918
CHECKED	

5154



See plan no. 91 – 65 for flight line locations

Figure 3E

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT

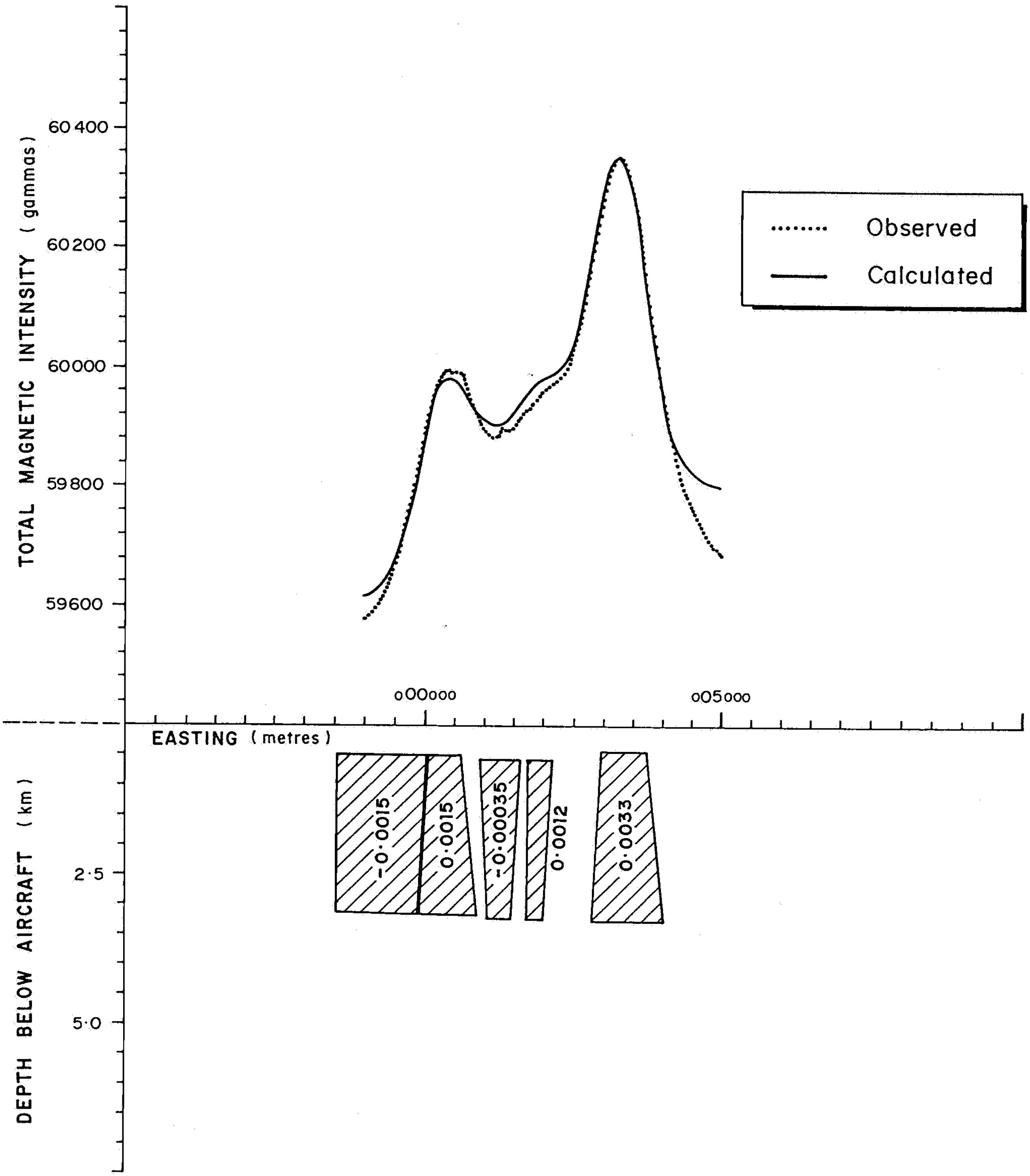
MBT - 7 (Line 1770)

COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	C.D.O.	DATE
DRAWN M.R.	SCALE	
DATE Nov. '90	PLAN NUMBER S 21919	
CHECKED		

5154

Flight Line 1950 (Pinnaroo)



See plan no. 91-66 for flight line locations

Figure 3F

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

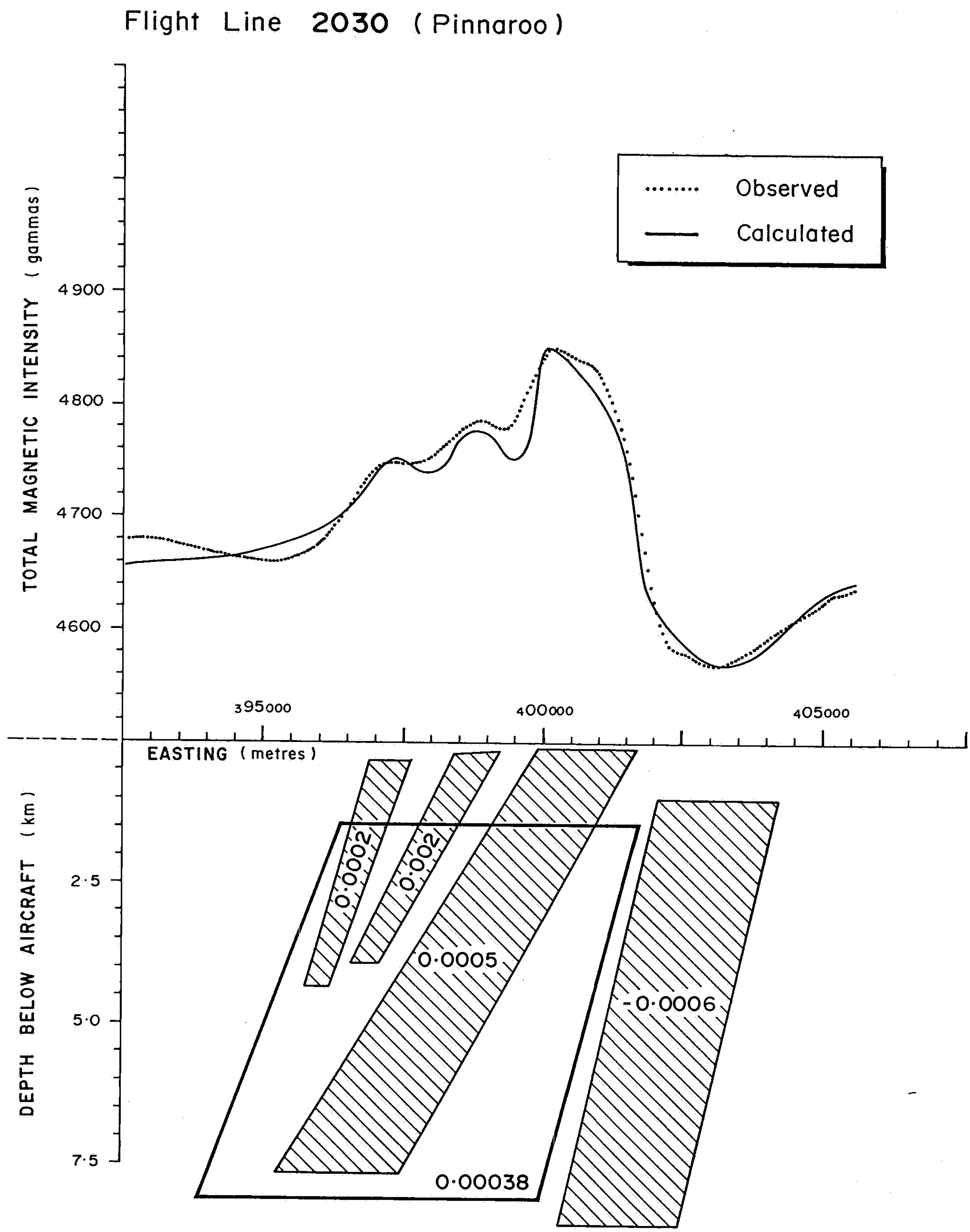
MURRAY BASIN BASEMENT TRANSECT

MBT-9 (Line 1950)

COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	C.D.O.	DATE
DRAWN M.R.	SCALE	
DATE Nov. '90	PLAN NUMBER	
CHECKED	S 21920	

5154



See plan no. 91-66 for flight line locations

Figure 3G

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT

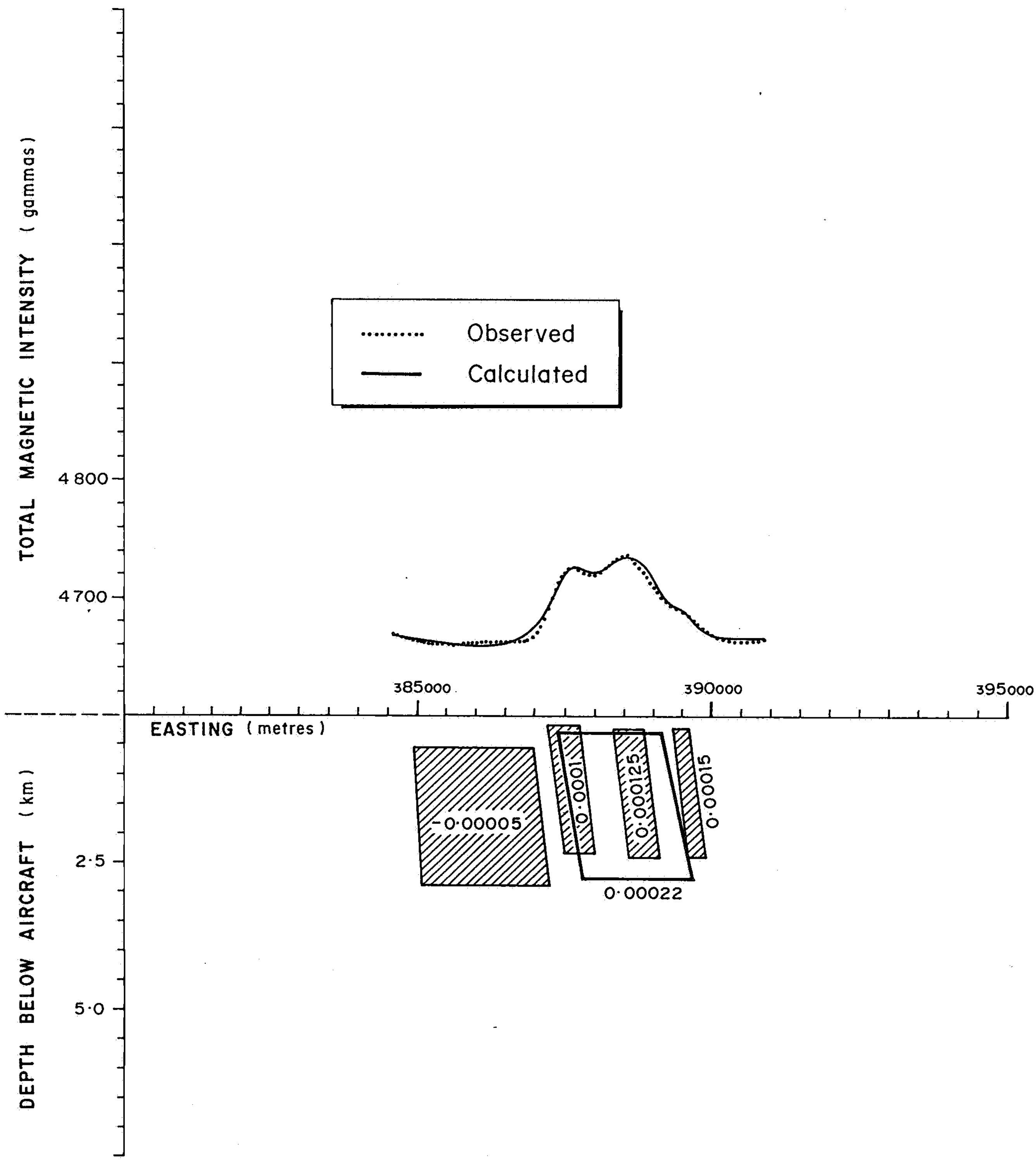
MBT - 11 (Line 2030)

COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED	P. Hough	C.D.O.	DATE
DRAWN	M.R.	SCALE	
DATE	Nov. '90	PLAN NUMBER	
CHECKED		S 21921	

5154

Flight Line 1890_2 (Pinnaroo)



See plan no. 91-66 for flight line locations

Figure..... 3H

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

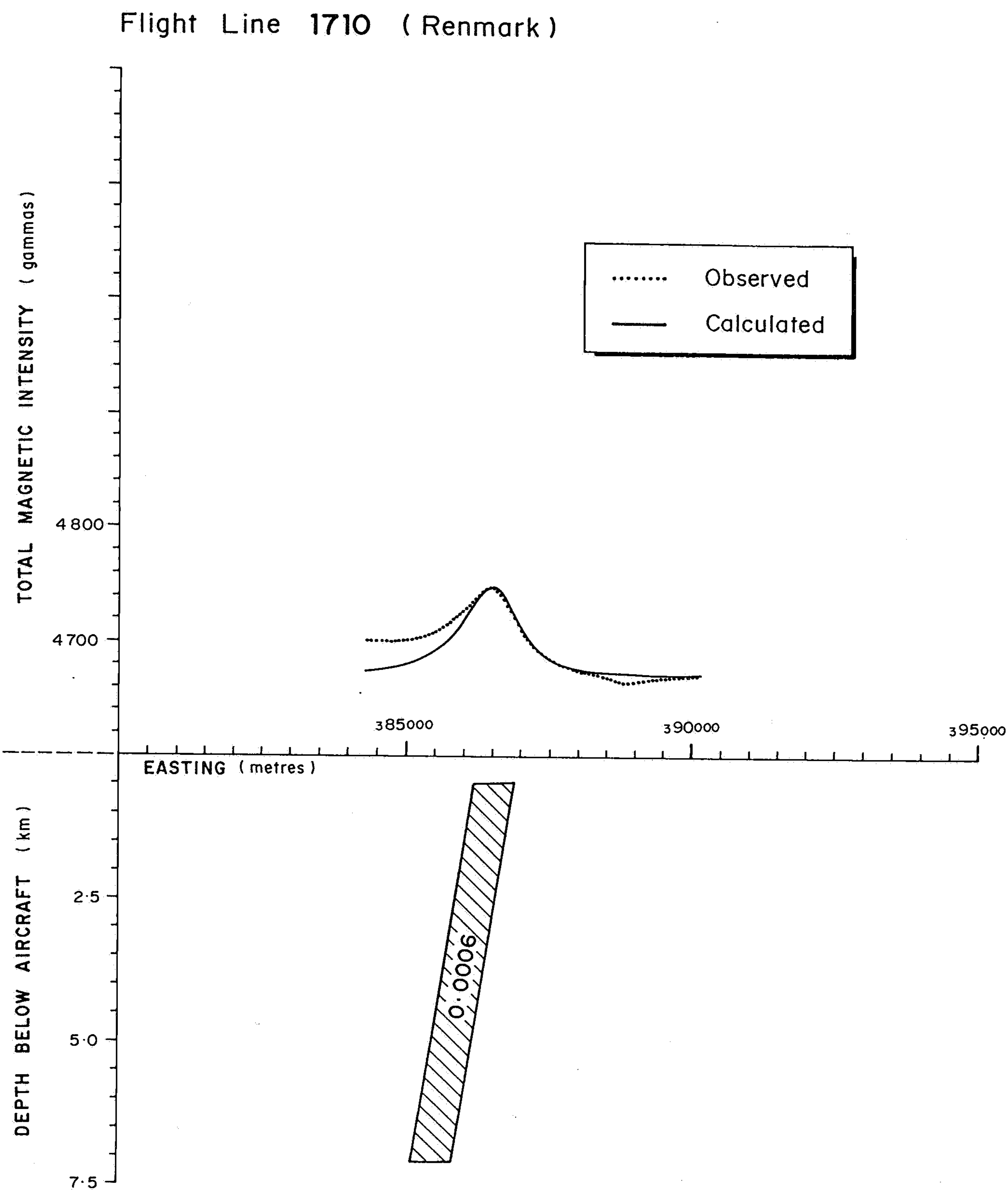
MURRAY BASIN BASEMENT TRANSECT

MBT - 12 (Line 1890_2)

COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	C.D.O. DATE	
DRAWN M.R.	SCALE	
DATE Nov. '90	PLAN NUMBER	
CHECKED	S 21922	

5154



See plan no. 91-65 for flight line locations

Figure 31

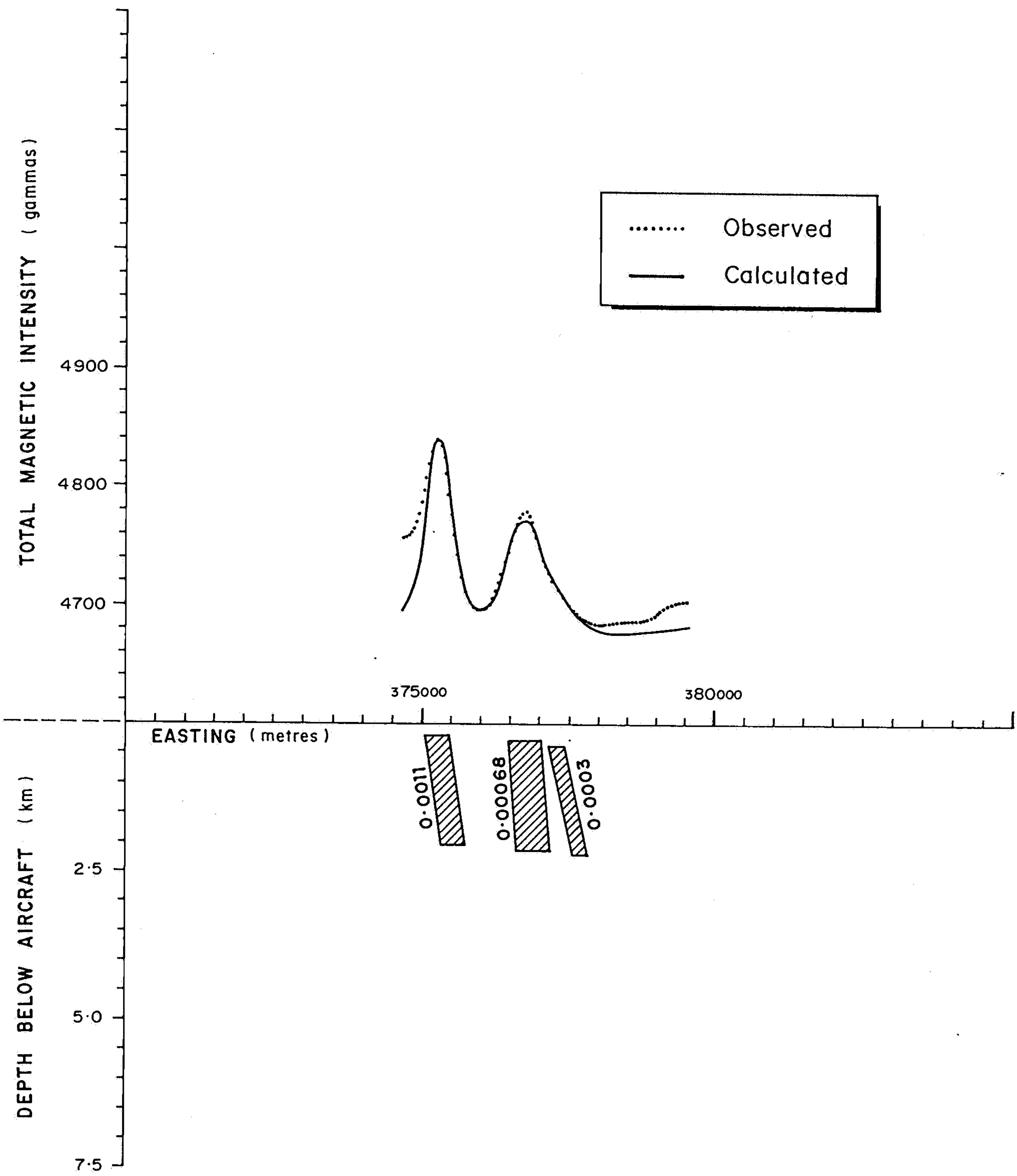
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT
MBT-13 (Line 1710)
COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	C.D.O.	DATE
DRAWN M.R.	SCALE	
DATE Nov. '90	PLAN NUMBER	
CHECKED	S 21923	

5154

Flight Line 1880 (Pinnaroo)



See plan no. 91-66 for flight line locations

Figure 3J

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

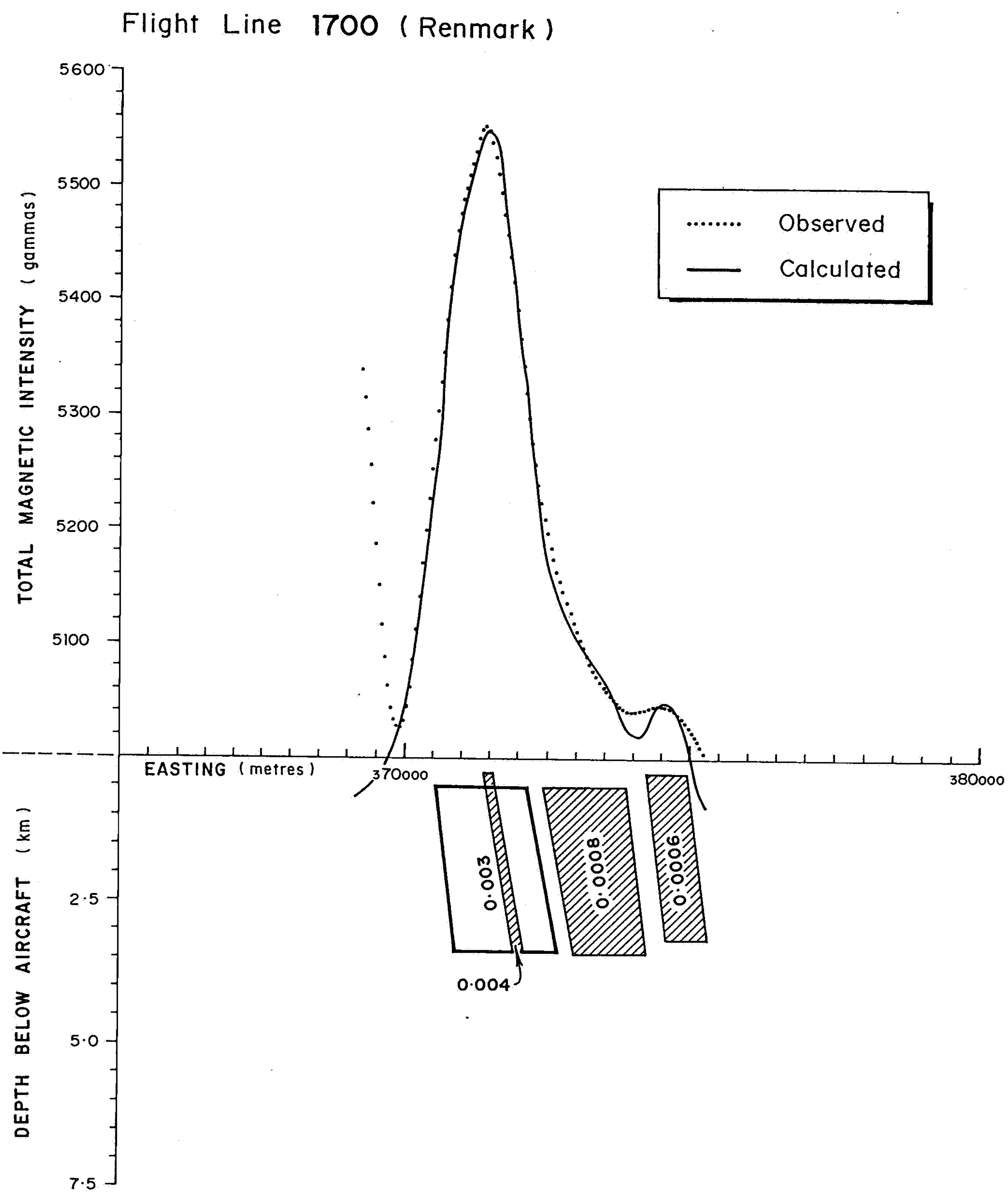
MURRAY BASIN BASEMENT TRANSECT

MBT-15 (Line 1880)

COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	C D O	DATE
DRAWN M.R.	SCALE	
DATE Nov. '90	PLAN NUMBER S 21924	
CHECKED		

5154



See plan no. 91–65 for flight line locations

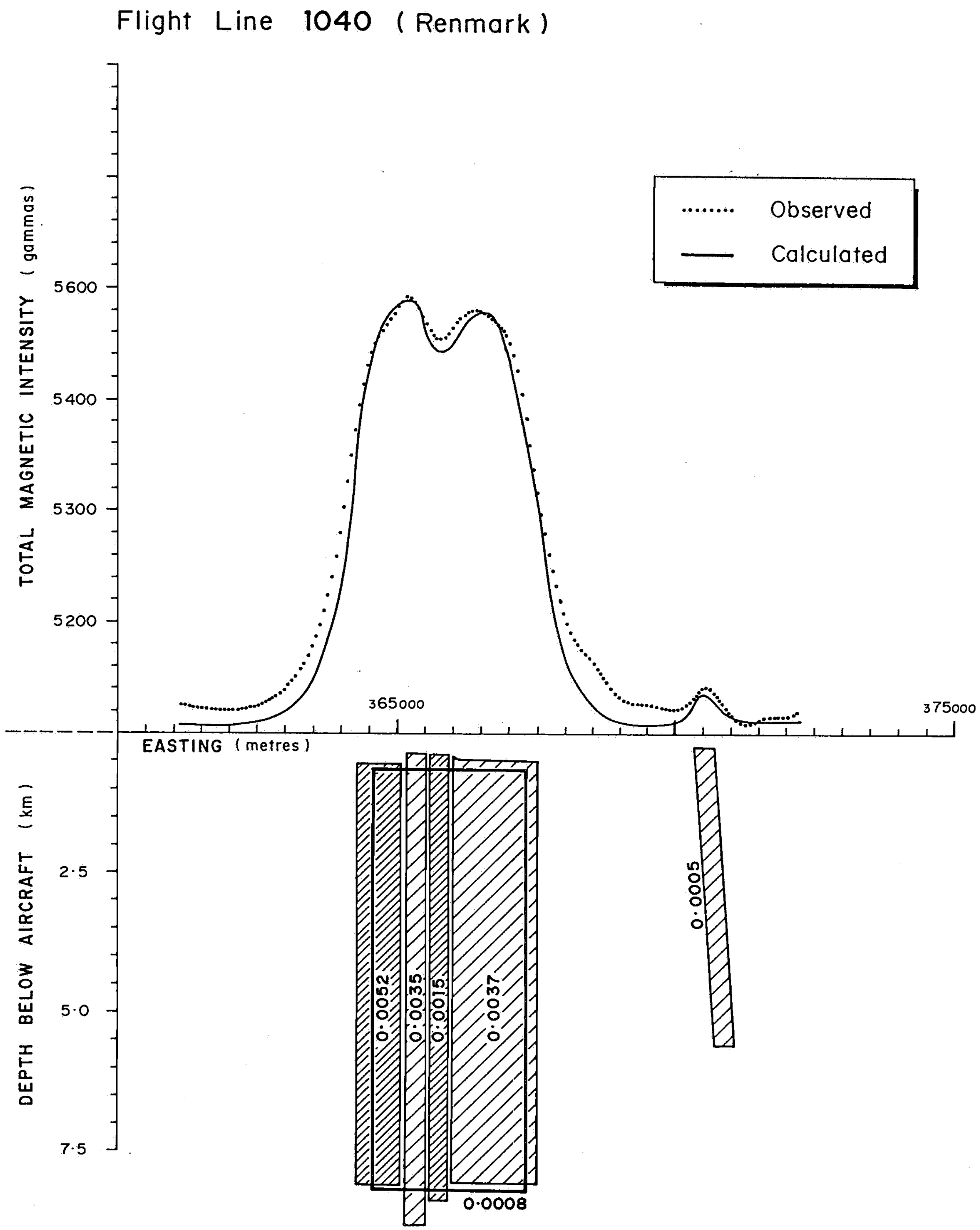
Figure 3K

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT
MBT - 16 (Line 1700)
COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	CDO	DATE
DRAWN M.R.	SCALE	
DATE Nov. '90	PLAN NUMBER S 21925	
CHECKED		

5154



See plan no. 91-65 for flight line locations

Figure 3L

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

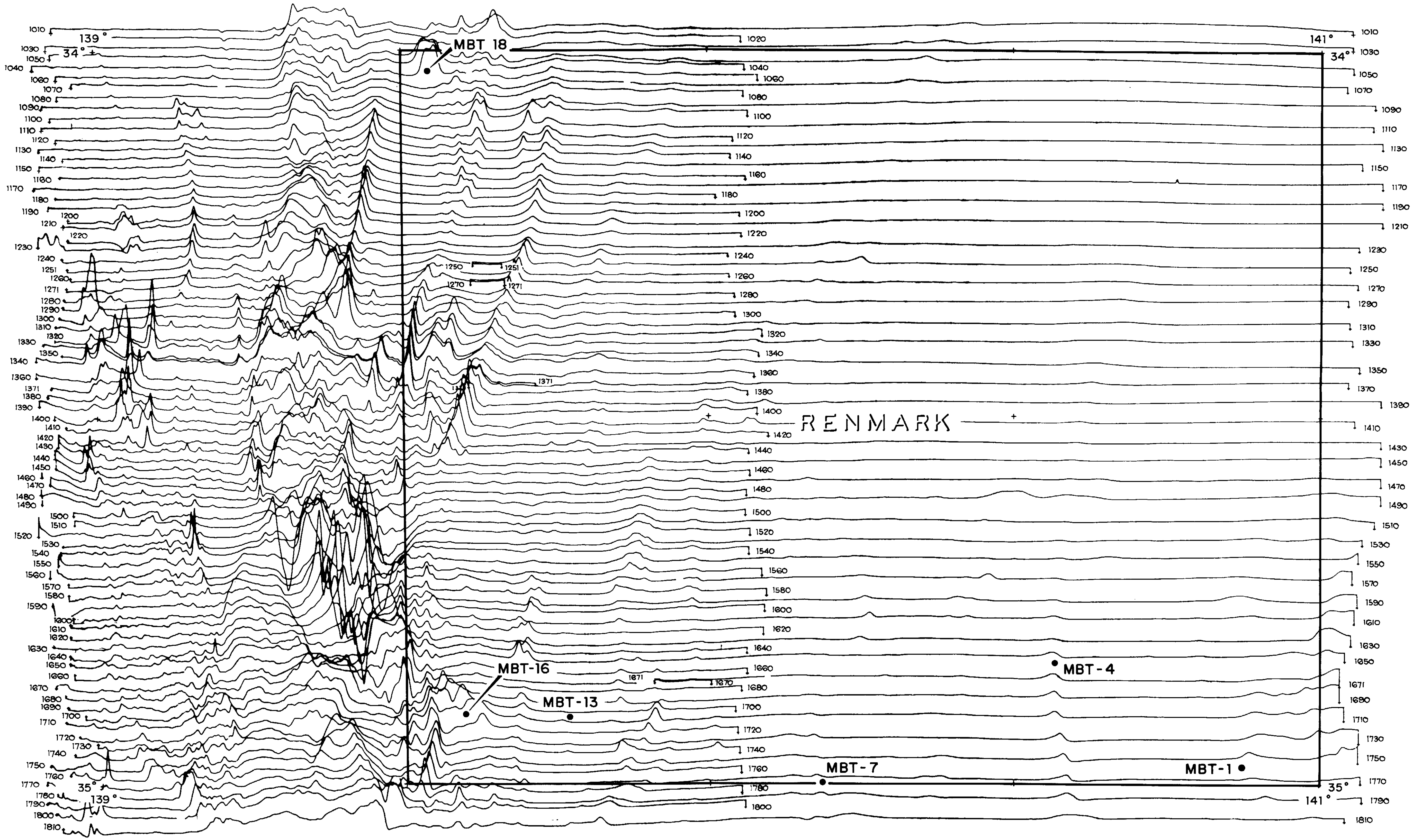
MURRAY BASIN BASEMENT TRANSECT

MBT - 18 (Line 1040)

COMPUTER MODEL OF MAGNETIC ANOMALY

COMPILED P. Hough	C D O DATE
DRAWN M.R.	SCALE
DATE Nov. '90	PLAN NUMBER
CHECKED	S 21926

5154



Total Magnetic Intensity Profiles supplied by BMR (1978)

0 20 40

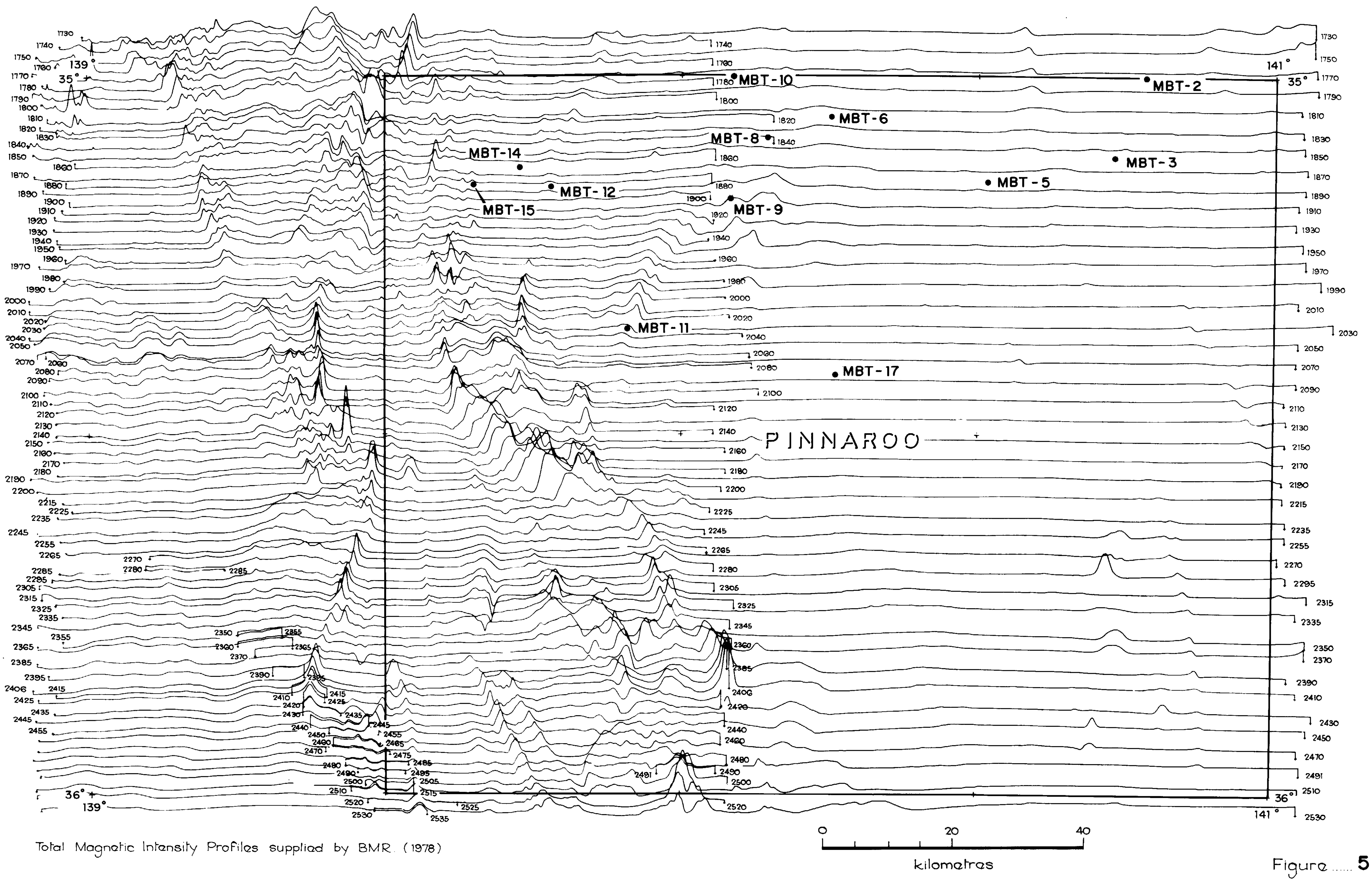
kilometres

Figure 4

• MBT-1 .... Anomaly location

1710 .... Flight line number

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. Rankin	22.2.91 C.D.O. DATE
MURRAY BASIN BASEMENT TRANSECT	DRAWN M.R.	SCALE As shown
RENMARK 1:250000	DATE Nov.'90	PLAN NUMBER
TOTAL MAGNETIC INTENSITY PROFILES AND ANOMALY LOCATIONS	CHECKED	**91-65**



Total Magnetic Intensity Profiles supplied by BMR (1978)

Figure **5**

• MBT-12 ....Anomaly location

2170 ....Flight line number

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. Rankin	LR 22-2-91 C.D.O. DATE	
MURRAY BASIN BASEMENT TRANSECT	DRAWN M.R.	SCALE As shown	
PINNAROO 1:250 000	DATE Nov '90	PLAN NUMBER	
TOTAL MAGNETIC INTENSITY PROFILES AND ANOMALY LOCATIONS	CHECKED	**91-66**	

5154

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
REGIONAL GEOLOGY BRANCH & GROUNDWATER - ENGINEERING DIVISION

PEEBINGA 1

COMPOSITE WELL LOG

DRILLING DETAILS

DRILLING METHOD	Rotary mud and diamond coring
CIRCULATION	
START 19/5/90	FINISH 3/6/90
TOTAL DEPTH	635·7 m

DRILLED BY: Rockdril Contractors

GEOPHYSICAL LOGS

TYPE OF LOG	GAMMA	NEUTRON	SP	CALIPER	DENSITY	PR	
DATE OF RUN	2/6/90						
RECORDED BY	N. Taylor						
FIRST READING (m)	637	637	637	608	608	637	
LAST READING (m)	0	2	410	0	0	410	

PROJECT MURRAY BASIN BASEMENT TRANSECT
FIELD No. MBT-1 UNIT No. 7028002SW00484
LOCATION
ELEVATION 70 m DATUM AHD
LOGGED BY S. Barnett, B. Clough DATE 13/9/90

Figure 6

91-67

5154

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
REGIONAL GEOLOGY BRANCH & GROUNDWATER - ENGINEERING DIVISION

KRINGIN 1

COMPOSITE WELL LOG

DRILLING DETAILS

DRILLING METHOD Rotary mud and bottom hole core.
CIRCULATION
START 21/4/90 FINISH 2/5/90
TOTAL DEPTH 409 m

DRILLED BY : SADME

GEOPHYSICAL LOGS

TYPE OF LOG	GAMMA	NEUTRON	SP	CALIPER	DENSITY	16" NORMAL	64" NORMAL
DATE OF RUN	1/5/90						
RECORDED BY	B. Taylor						
FIRST READING (m)	406	407	405	407	407	407	404
LAST READING (m)	0	33	63	0	0	65	65

POINT RESISTIVITY : 63 - 405 m

PROJECT MURRAY BASIN BASEMENT TRANSECT

FIELD No. MBT-2 UNIT No. 7028002SW00483
LOCATION 35° 00' S 140° 46' E

ELEVATION 87 m DATUM AHD
LOGGED BY S. Barnett, L. Rankin DATE 20/8/90

HYDRO DATA	AGE	UNIT	LITHOLOGY DESCRIPTION
Aquifer	PLIOCENE	PLIOCENE SANDS	0-30 m **SAND**: Fine grained, silty. Pale orange-fawn, subrounded. 30-39 m **GRAVEL**: Moderately well sorted, subrounded to sub-angular. Pale brown. Qtz grains 2-3 mm. 39-46 m **SILT**: Sandy, clayey. Dark fawn, calcareous, micaceous. Shelly 44-46 m.
Con. Layer	L. MIOCENE - PLIOCENE	BOOKPURNONG BEDS	46-57 m **SILT**: Dark grey-green, very shelly, glauconitic, slightly sandy. Occasional carbonaceous fragments. CORE 48-49.9 m.
Semi - confined Aquifer	OLIGO - MIOCENE	MURRAY GROUP LIMESTONE	57-190 m **LIMESTONE**: Silty, pale grey and glauconitic. Fine to medium grained, fossiliferous.
Confining Layer	OLIGO	ETTRICK FM.	190-200 m **MARL**: Silty, glauconitic. Grey-green, darker with depth, fossiliferous. CORE 198-200 m.
Confining Layer	EOCENE	RENMARK GROUP	200-204 m **LIGNITE**: Black-brown, friable. 204-224 m **CLAY**: Dark brown, carbonaceous, slightly sandy, finely micaceous. 215-220 m: Sandy
Aquifer	EOCENE	RENMARK GROUP	224-252 m **SAND**: Medium to coarse grained, moderately well sorted, rounded. Slightly calcareous and fossiliferous.
Confining Layer / Aquifer / Con. Layer / Aqtr.	EOCENE	RENMARK GROUP	252-339 m **INTERBEDDED SAND and CLAY**: Sand and clay as above.
	? CAMBRIAN - ORDOVICIAN	? KANMANTOO GROUP EQUIVALENT	359-407.5 m **CLAY**: Weathered basement. Micaceous, mottled grey and off-white. 407.5-409 m Fine to medium grained quartz-feldspar-biotite metasandstone. Steep foliation ~ 20°-30° to core axis

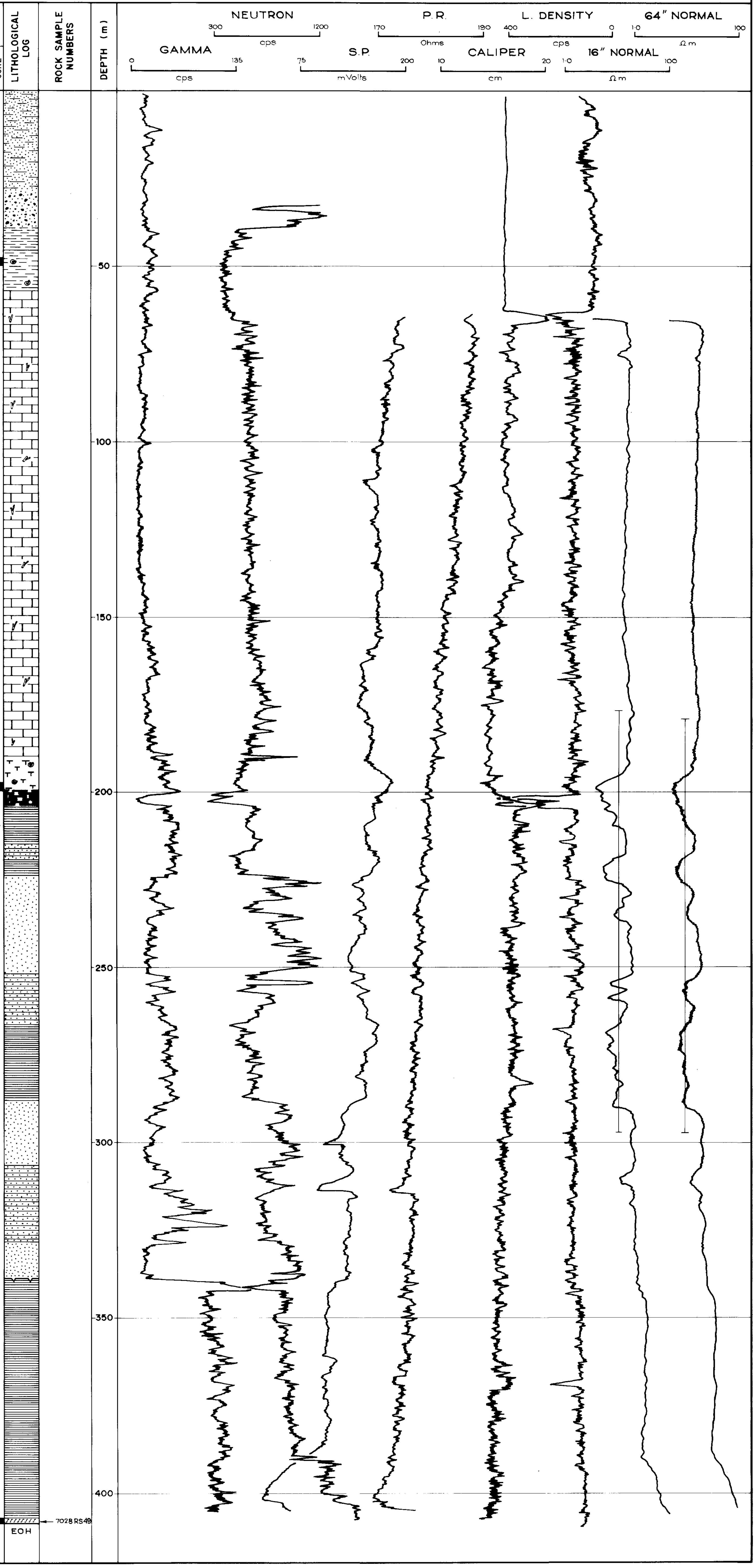


Figure 7

91-68

5154

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
REGIONAL GEOLOGY BRANCH & GROUNDWATER - ENGINEERING DIVISION

BRIAKEN PARK 1

COMPOSITE WELL LOG

DRILLING DETAILS

DRILLING METHOD Rotary mud and bottom hole coring
CIRCULATION
START 5/5/90 FINISH 7/6/90
TOTAL DEPTH 539 m

DRILLED BY: Rockdril Contractors

GEOPHYSICAL LOGS

TYPE OF LOG	GAMMA	NEUTRON	SP	CALIPER	DENSITY	P.R.	
DATE OF RUN	26/5/90						
RECORDED BY	N. Taylor						
FIRST READING (m)	455	457	458	458	458	458	
LAST READING (m)	0	29	60	1	1	66	

PROJECT MURRAY BASIN BASEMENT TRANSECT
FIELD No. MBT-4 **UNIT No.** 7028003SW00482
LOCATION 34° 48' S, 140° 32' E

ELEVATION 70 m **DATUM** AHD
LOGGED BY S. Barnett **DATE** 21/9/90

HYDRO DATA	AGE	UNIT	LITHOLOGY – DESCRIPTION
Aquifer	PLIOCENE	PLIOCENE SANDS	0-43 m **SAND**: Red-orange, fine grained and silty, slightly clayey. 16-40 m: Pale orange, medium to coarse grained, moderately well sorted, subrounded. Becoming coarser with depth. 40-43 m: Silty coarse sand, dark orange with abundant shell frags.
Con.	LATE MIOCENE - PLIOCENE	BOOKPURNONG BEDS	43-51 m **SILT**: Dark grey-green, shelly and glauconitic. Clayey. CORE: 48-51 m.
Aquifer	OLIGO - MIOCENE	MURRAY GROUP LIMESTONE	51-187 m **LIMESTONE**: Off-white - pale grey, 30% shell. Bryozoal fragments. Fine grained. 66-108 m: Predominantly coarse grained, unconsolidated bryozoal fragments. Below 140 m: darker grey and siltier with some well cemented layers. 170-187 m: Less fossiliferous.
Confining Layer	OLIGO	ETTRICK FM.	187-201 m **SILT**: Dark grey-green, shelly and glauconitic. Marly.
Confining Layer	EOCENE	RENMARK GROUP	201-208 m **LIGNITE**: Black - dark brown, friable. 208-241 m **INTERBEDDED CLAYS and SANDY CLAYS**: Dark brown carbonaceous clays with fine to medium grained sandy clays.
Aqu	EOCENE	RENMARK GROUP	241-251 m **SAND**: Dark brown, poorly sorted, medium to coarse grained, subrounded.
Confining Layer	EOCENE	RENMARK GROUP	251-307 m **CLAYEY SAND**: As for 208-241 m.
Aqu	EOCENE	RENMARK GROUP	307-309 m **SAND**: Medium to coarse grained as above.
Confin Layer	EOCENE	RENMARK GROUP	319-335 m **CLAYEY SAND**: As above.
Aquifer	EOCENE	RENMARK GROUP	335-352 m **SAND**: Becoming coarser grained with depth.
Confining Layer	EOCENE	RENMARK GROUP	
	PERMIAN	URANA FORMATION	Dark grey, massive to laminated shale. 536-539 m: Mottled red and green-grey polymict conglomeratic diamictite. Subrounded cobbles up to 40 mm wide. Cobbles include clasts of granite, dolerite & metasediment.

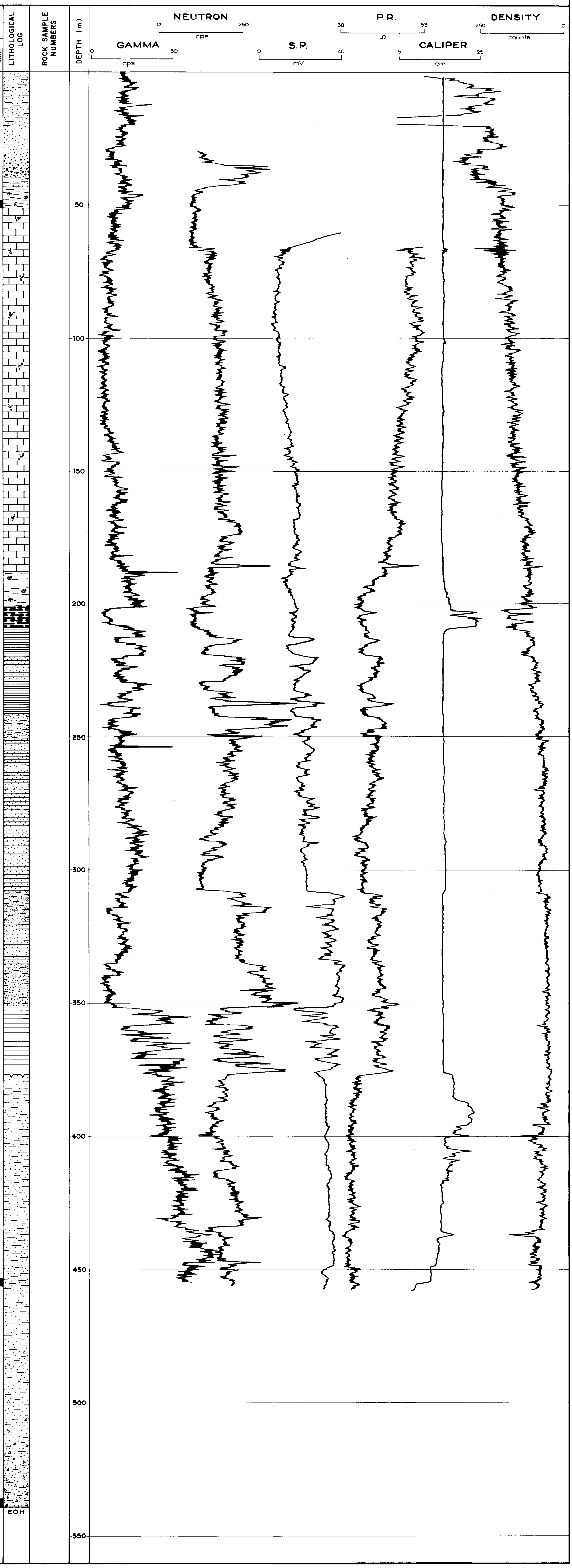


Figure 8
91-69

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
REGIONAL GEOLOGY BRANCH & GROUNDWATER - ENGINEERING DIVISION

WIRHA SOUTH 1

COMPOSITE WELL LOG

DRILLING DETAILS

DRILLING METHOD Rotary mud and bottom hole core
CIRCULATION
START 29/3/90 FINISH 11/4/90
TOTAL DEPTH 332 m

DRILLED BY: SADME

GEOPHYSICAL LOGS

TYPE OF LOG	GAMMA	NEUTRON	SP	CALIPER	DENSITY	P.R.	
DATE OF RUN	10/4/90						
RECORDED BY	B.P. Taylor						
FIRST READING (m)	331	331	333	331	333	326	
LAST READING (m)	0	31	67	1	1	42	

PROJECT MURRAY BASIN BASEMENT TRANSECT
FIELD No. MBT-5 **UNIT No.** 7027004SW00641
LOCATION 35° 08′ S 140° 31′ E
ELEVATION 90 m **DATUM** AHD
LOGGED BY S. Barnett, L. Rankin **DATE** 26/9/90

LITHOLOGY

HYDRO DATA	AGE	UNIT	DESCRIPTION
Aquifer	QUAT.	WOORINEN FM	0-56m **SAND**: Dark red-brown, fine grained, silty.
	PLIOCENE	PLIOCENE SANDS	6-10m: Pale red-brown, fine to medium grained. 10-38m: Pale orange, subrounded, well sorted, coarse grained. 20-23m: Mottled fawn-orange clayey sand. 38-56m: Fine gravel as above
			56-59m **SILT**: Pale orange-brown, shelly, sandy. 59-63m **CLAY**: Dark grey-green, glauconitic, abundant coarse shell fragments and rounded brown limonitic grains. **CORE** 60.1 to 63.1m
	LATE MIO-PLIOCENE	BOOKPURNONG BEDS	63-185m **LIMESTONE**: Off-white, semi-consolidated, fine grained and fossiliferous. 65-100m: Mostly coarse grained unconsolidated bryozoal fragments
	OLIGO-MIOCENE	MURRAY GROUP LIMESTONE	150-164m: Pale grey in colour. 164-177m: Grey, fine grained, slightly glauconitic. Some well cemented layers. Siltier below 171m. **CORE**: 164 to 200m. 177-185m: Grey-green, glauconitic. Darker and siltier with depth. Some shelly layers.
Confining Layer	OLIGOCENE	ETTRICK FM	185-198m **MARL**: Dark grey-green, finely fossiliferous. Fine silt laminations with minor carbonaceous interbeds.
Aqu.		COMPTON CONGL.	198-209m **SAND**: Grey, subrounded and poorly sorted. Fine to coarse grained. Occasional glauconite pyritic nodules and carbonaceous fragments. Slightly fossiliferous.
Con. Layer	EOCENE	RENMARK GROUP	209-219m **CLAY**: Dark brown-black, carbonaceous. 214-216m: Soft white ?limestone.
Aquifer			219-247m **SAND**: Medium to coarse grained, subrounded to rounded, dark brown. Clear quartz grains.
Confining Layer			247-293m **CLAY**: Sandy interbeds as above.
Aquifer			293-306m **SAND**: As above.
		? CAMBRIAN ORDOVICIAN	306-329m **CLAY**: Weathered basement, white clay with angular smoky quartz grains and black biotite flakes. 329-332m **GRANITE**: Grey, fine to medium grained.
			E.O.H. 332m.

CORE | LITHOLOGICAL LOG | ROCK SAMPLE NUMBERS: 7027 RS1

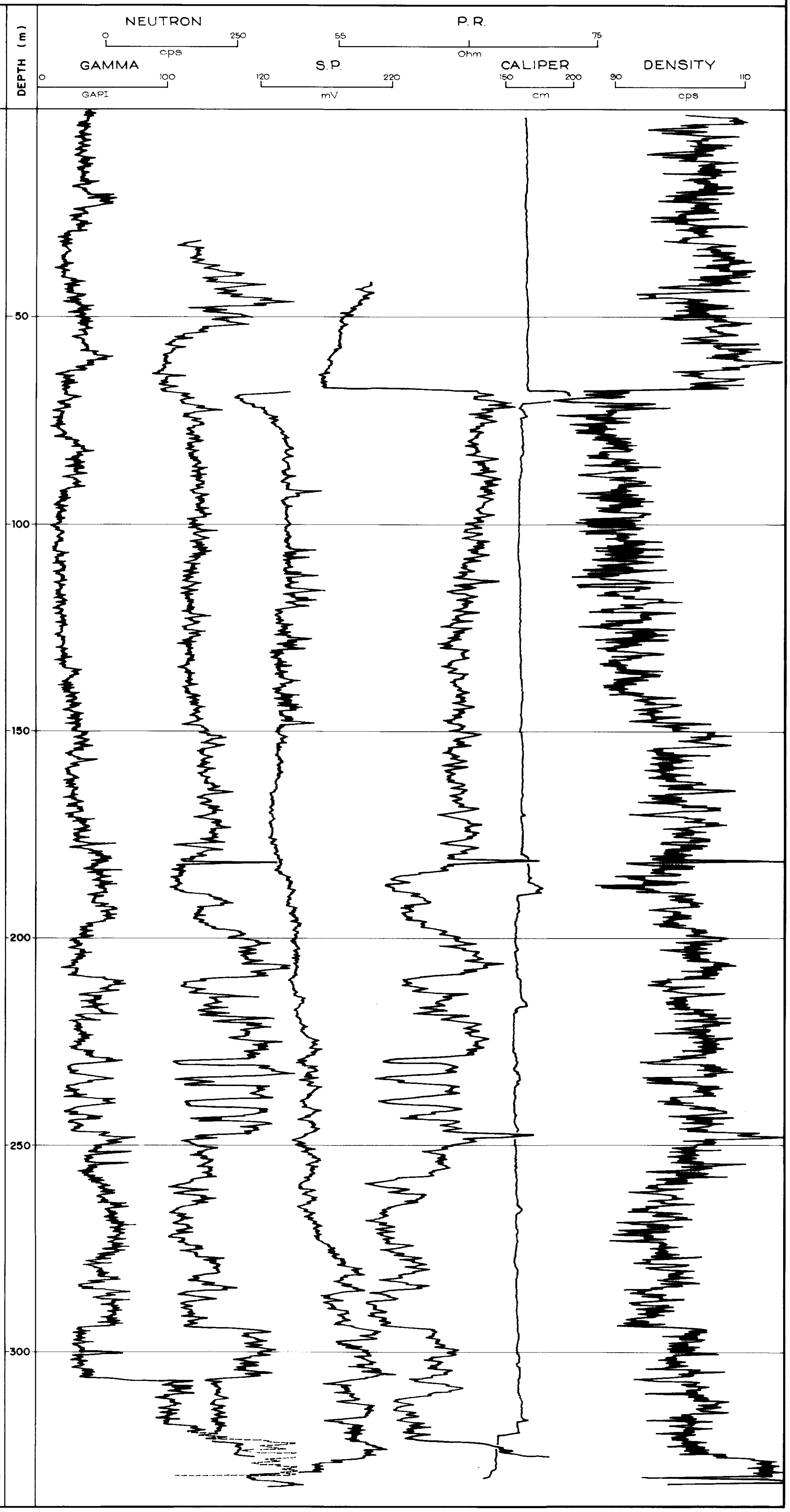


Figure 9
91-70

5154

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
REGIONAL GEOLOGY BRANCH & GROUNDWATER - ENGINEERING DIVISION

TORI HILLS 1

COMPOSITE WELL LOG

DRILLING DETAILS

DRILLING METHOD Rotary mud and bottom hole coring
CIRCULATION
START 24/6/90 FINISH 29/6/90
TOTAL DEPTH 260·6 m

DRILLED BY: Rockdril Contractors

GEOPHYSICAL LOGS

TYPE OF LOG	GAMMA	NEUTRON	SP	CALIPER	DENSITY	
DATE OF RUN	29/6/90					
RECORDED BY	B. Taylor					
FIRST READING (m)	251					
LAST READING (m)	0					

PROJECT MURRAY BASIN BASEMENT TRANSECT
FIELD No. MBT-6 **UNIT No.** 6927004SW00635
LOCATION 35° 04′ S 140° 14′ E
ELEVATION 72 m **DATUM** AHD
LOGGED BY S. Barnett, L. Rankin **DATE** 22/9/90

HYDRO DATA	AGE	UNIT	DESCRIPTION	ROCK SAMPLE NUMBERS
Aquifer	PLIOCENE	PLIOCENE SANDS	0-47 m **SAND**: Pale orange, fine grained and silty to 16 m. 24-33 m: Medium to coarse grained, poorly sorted. Silty with depth. 33-47m: Fine to medium grained sand as above.	
Aquifer	OLIGO-MIOCENE	MURRAY GROUP LIMESTONE	47-165 m **LIMESTONE**: Off-white fossiliferous, very silty. Fine grained and semiconsolidated	
Confining Layer	OLIGOCENE ?	ETTRICK FM.	148-165 m: Grey-green, glauconitic and silty limestone as above.	
Confining Layer	EOCENE	RENMARK GROUP	165-173 m **CLAY**: Dark brown-black, carbonaceous. Slightly calcareous	
Aquifer	EOCENE	RENMARK GROUP	173-210 m **SAND**: Black, poorly sorted, fine to coarse grained. Rounded quartz grains. 185-206 m: Medium grained, clean well sorted sand. 206-210 m: Coarse grained sand as above	
	EOCENE	RENMARK GROUP	210-250 m **CLAY**: Dark brown and sandy (fine grained).	
	?CAMBRIAN-ORDOVICIAN		250-260·6 m: Medium to coarse grained pink grey granite to granodiorite. Occasional intermediate to mafic xenoliths up to 6 cm long	6927 RS 11, 6927 RS 12, 6927 RS 13

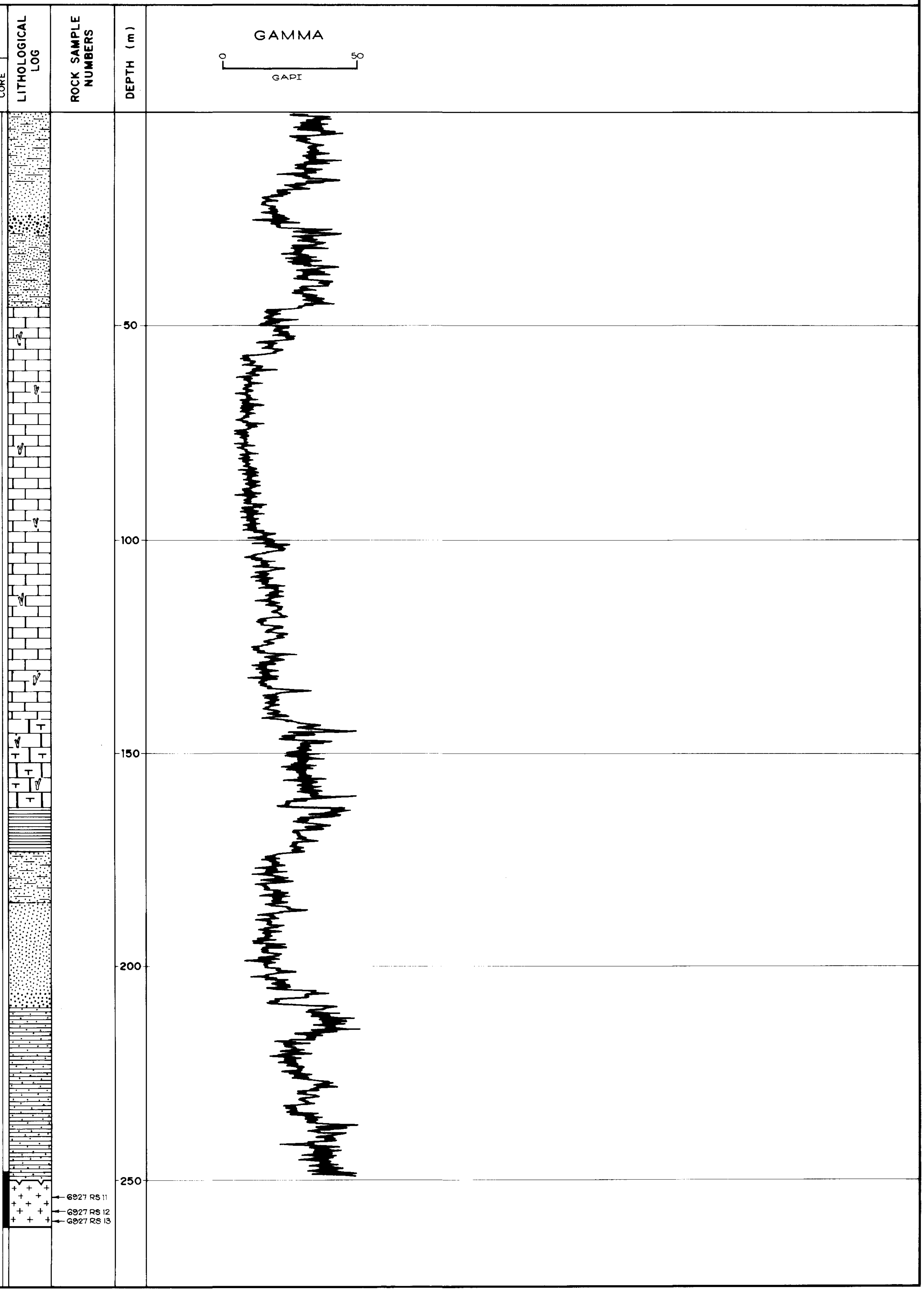


Figure 10
91-71

5154

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
REGIONAL GEOLOGY BRANCH & GROUNDWATER - ENGINEERING DIVISION

PEAKE 1

COMPOSITE WELL LOG

DRILLING DETAILS

DRILLING METHOD Rotary mud and bottom hole coring
CIRCULATION
START 4/6/90 FINISH 14/6/90
TOTAL DEPTH 187 m

DRILLED BY: Rockdril Contractors

GEOPHYSICAL LOGS

TYPE OF LOG	GAMMA	NEUTRON	SP	CALIPER	DENSITY		
DATE OF RUN	6/6/90						
RECORDED BY	N. Taylor						
FIRST READING (m)	186	187					
LAST READING (m)	0	2					

PROJECT MURRAY BASIN BASEMENT TRANSECT
FIELD No. MBT - 11 **UNIT No.** 6827002SW01634
LOCATION 35° 21′ S 139° 54′ E
ELEVATION 15 m **DATUM** AHD
LOGGED BY S. Barnett / B. Clough **DATE** 27/9/90

HYDRO DATA | LITHOLOGY (AGE, UNIT, DESCRIPTION, CORE) | LITHOLOGICAL LOG | ROCK SAMPLE NUMBERS | DEPTH (m) | GAMMA | NEUTRON

HYDRO DATA: Aquifer

AGE / UNIT: PLEISTOCENE – COOMANDOOK FM; ? OLIGO-MIOCENE ? – MURRAY GP LMST ?; EOCENE ? – BUCCLEUCH BEDS; ? CAMBRIAN-ORDOVICIAN

0-4 m CALCRETE: Off-white, nodular, very hard to 4 m.
4-67 m LIMESTONE: Off-white, with dark pink layers. Fine grained

14-35 m: Pale orange, unconsolidated, very fine grained and slightly fossiliferous

35-67 m: Dark fawn, more glauconitic, abundant fine calcite rhombs

67-172 m SAND: Dark brown, very fine grained with occasional glauconitic grains. Slightly fossiliferous. Some black carbonaceous fragments present. Becoming siltier with depth.

95-128 m: Up to 50% shell and bryozoal fragments, medium to coarse grained, off-white

128-162 m: Silty sand as for 67 to 95 m with shelly bed 147 to 153 m.

162-172 m: Dark brown-black lignitic silty sand

172-175 m: Weathered basement
175-185 m: Grey, massive, med-grained plagioclase-pyroxene-chlorite metadolerite. Minor disseminated pyrite mineralisation. Common thin calcite veins ~ 40° to core axis. Becomes finer grained downhole
185-188 m: Fine grained grey albitite. Abundant disseminated pyrite mineralisation. Minor Cu staining on fracture surfaces. Contact with overlying metadolerite is sharp and irregular.

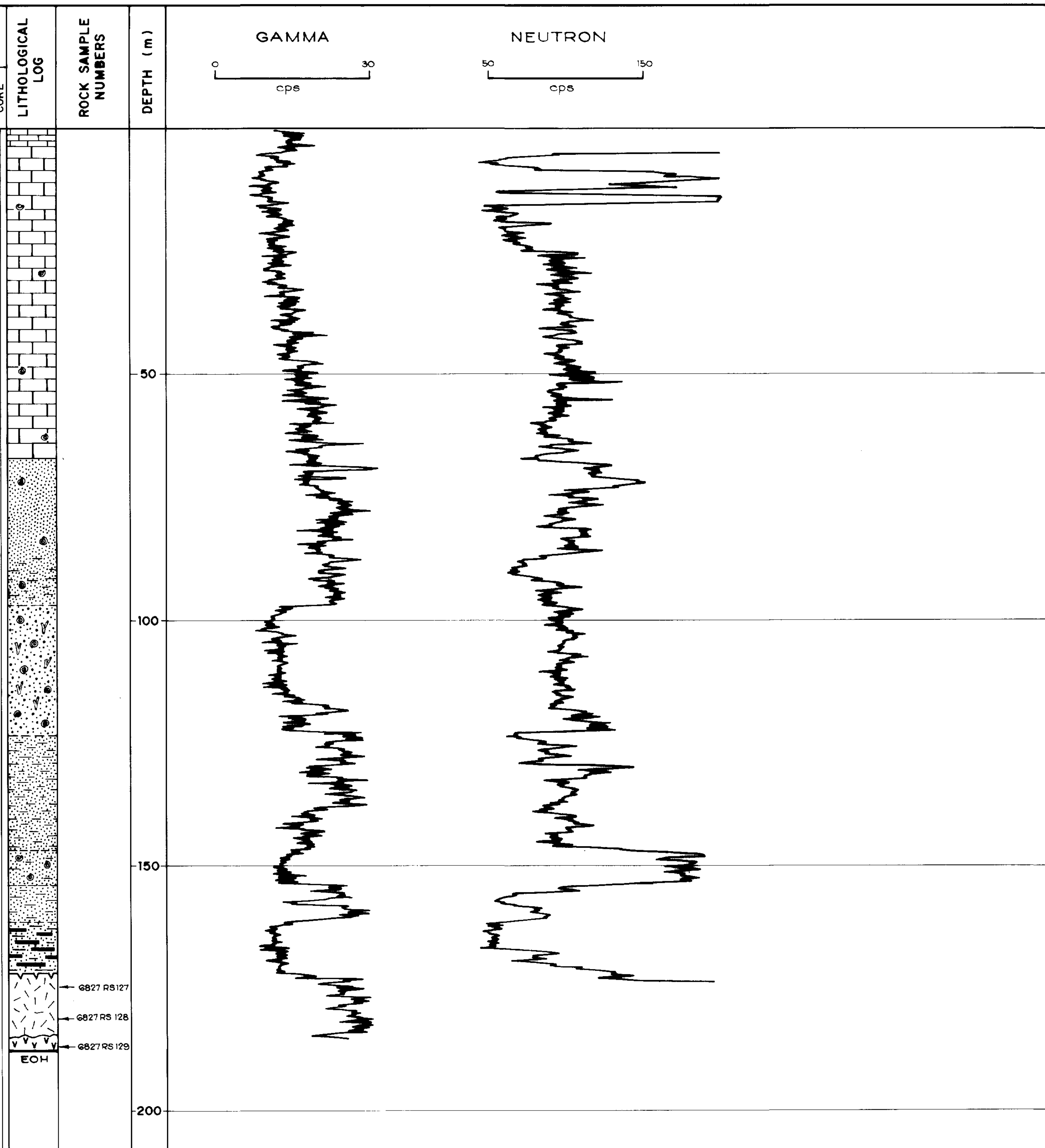


Figure 11 91-72

5154

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
REGIONAL GEOLOGY BRANCH & GROUNDWATER - ENGINEERING DIVISION

CARINGA 1

COMPOSITE WELL LOG

DRILLING DETAILS

DRILLING METHOD Rotary mud + diamond Coring
CIRCULATION
START 7/3/90 FINISH 23/3/90
TOTAL DEPTH 308·5 m

DRILLED BY: Rockdril Contractors

GEOPHYSICAL LOGS

TYPE OF LOG	GAMMA	NEUTRON	SP	CALIPER	DENSITY	SUSC.
DATE OF RUN	N. Taylor					
RECORDED BY	21/3/90					
FIRST READING (m)	304	200		305	306	306
LAST READING (m)	0	58		0	1	196

PROJECT MURRAY BASIN BASEMENT TRANSECT
FIELD No. MBT - 12 **UNIT No.** 6827001SW01633
LOCATION 35° 09' S, 139° 46' E
ELEVATION 71 m **DATUM**
LOGGED BY S. Barnett, L. Rankin **DATE** 13/9/90

HYDRO DATA	AGE	UNIT	LITHOLOGY DESCRIPTION
	PLIOCENE	PLIOCENE SANDS	**0-12 m SAND**: Red-brown and silty. Fine grained. Clayey. **12-40 m SAND**: Yellow-brown, calcareous, fine grained sand. Semi-consolidated.
Aquifer	OLIGO - MIOCENE	MURRAY GROUP LIMESTONE	**40-127 m LIMESTONE**: Pale fawn, fine grained, slightly fossiliferous. Semi-consolidated. **80-90 m**: Light grey, slightly glauconitic. **90-98 m**: More iron-stained fossil fragments, orange in colour. **98-104 m**: Pale olive-green, glauconitic, fine grained. Semi-consolidated. **104-114 m**: Unconsolidated, medium grained, pale green and orange. Fossiliferous. **114-127 m**: Orange, slightly micaceous, fine grained and silty. Sandy toward base.
Confining Layer	EOCENE	BUCCLEUCH BEDS	**127-135 m SILT**: Black, carbonaceous. Lignitic at top, sandy with clay interbeds. Slightly fossiliferous. CORE 137·1 - 181·6 m. **135-154 m CLAY**: Dark chocolate brown and carbonaceous. Finely laminated with silty intercalations. Bioturbation present. Glauconitic shelly and bryozoal layer at base. **154-157 m LIMESTONE**: Strongly cemented pink/grey medium grained for top 30cm, then med./coarse semi-consolidated fawn grey fossiliferous.
Confined Aquifer			**157-181 m SAND**: Dark brown/black, carbonaceous silty sand, non-laminated, very fine grained.
	? CAMBRIAN - ORDOVICIAN		**181-196 m CLAY**: Grey-green, black silt and minor pyrite. Weathered basement. **196·3 - 309 m AMPHIBOLITE**: Medium grained, grey-green, weakly foliated (θ ~ 15°). **196·3 - 198 m**: Weathered amphibolite, abundant green clay, minor carbonate veining. Medium grained hornblende-actinolite + plagioclase + chlorite, minor disseminated opaques, including pyrite. Minor discordant pyrite veins up to 3mm wide. Interpreted as metadolerite. **242·4 m**: 3cm vein of coarse grained calcite + chlorite + 10% pyrite. Vein θ ~ 45° **289 - 300·6 m**: Complex zone of amphibole-chlorite schist grading into fine-grained amphibolite intruding med-grained amphibolite. Contacts typically steep and schist has undergone intense shearing along contacts, producing an intense foliation. Minor xenoliths of protomylonitic granitoid are included in the schistose mafic phase and are intruded by the mafic phase. Minor veins and pods of pyrite. **300·6 m**: Graduation from fine-grained amphibole-chlorite schist into fine to medium-grained amphibolite. E.O.H. 308·5 m

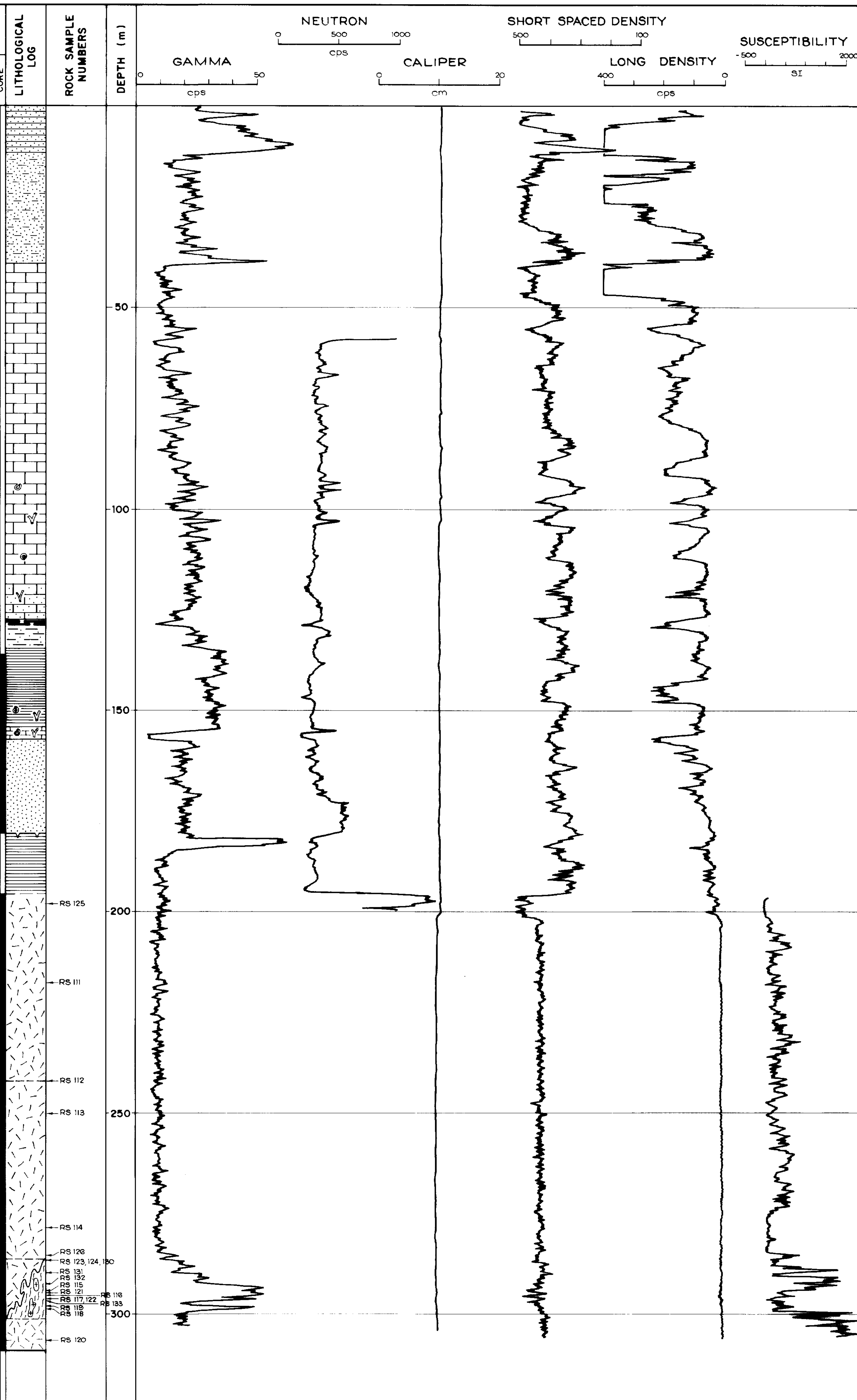


Figure 12

91-73

5154

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
REGIONAL GEOLOGY BRANCH & GROUNDWATER - ENGINEERING DIVISION

WYNARKA 1

COMPOSITE WELL LOG

DRILLING DETAILS

DRILLING METHOD Rotary mud and bottom hole coring
CIRCULATION
START 18/6/90 FINISH 19/6/90
TOTAL DEPTH 195 m

DRILLED BY: Rockdril Contractors

GEOPHYSICAL LOGS

TYPE OF LOG	GAMMA	NEUTRON	SP	CALIPER	DENSITY		
DATE OF RUN	19/6/90						
RECORDED BY	N. Taylor						
FIRST READING (m)	193	168					
LAST READING (m)	0	67					

PROJECT MURRAY BASIN BASEMENT TRANSECT
FIELD No. MBT-14 **UNIT No.** 6827004SW01632
LOCATION 35°08'S 139°43'E

ELEVATION 72 m **DATUM** AHD
LOGGED BY S. Barnett/ L. Rankin **DATE** 30/9/90

HYDRO DATA	AGE	UNIT	LITHOLOGY – DESCRIPTION
Aquifer	PLIOCENE	PLIOCENE SANDS	0-18 m CLAYEY SAND:
			18-42 m SAND:
	OLIGO - MIOCENE	MURRAY GROUP LIMESTONE	42-128·5 m LIMESTONE:
			Becoming more silty and marly toward base
Confining Layer	EOCENE	BUCCLEUCH BEDS	128·5-145 m CLAY: Dark brown, carbonaceous.
Aqu			145-152 m LIMESTONE: Cemented layers, with fossiliferous semi-consolidated layers.
			152-168·4 m CLAY: Weathered basement
			168·4-172·8 m: Medium grained amphibolite. Abundant carbonate replacement. Becomes finer grained downhole. 172·8-173 m: Medium grained granodiorite. Contacts ~30° to core axis. 173-173·7 m: Fine grnd amphibolite. 173·7-174·3 m: Med. grnd granodiorite. 174·3-175·1 m: Med. grnd amphibolite. 175·1-181·4 m: Med. grnd granodiorite. 181·4-195 m: Fine grained amphibolite, grading down-hole into medium to coarse grained amphibolite. Narrow pyrite veins at 182·6 m.

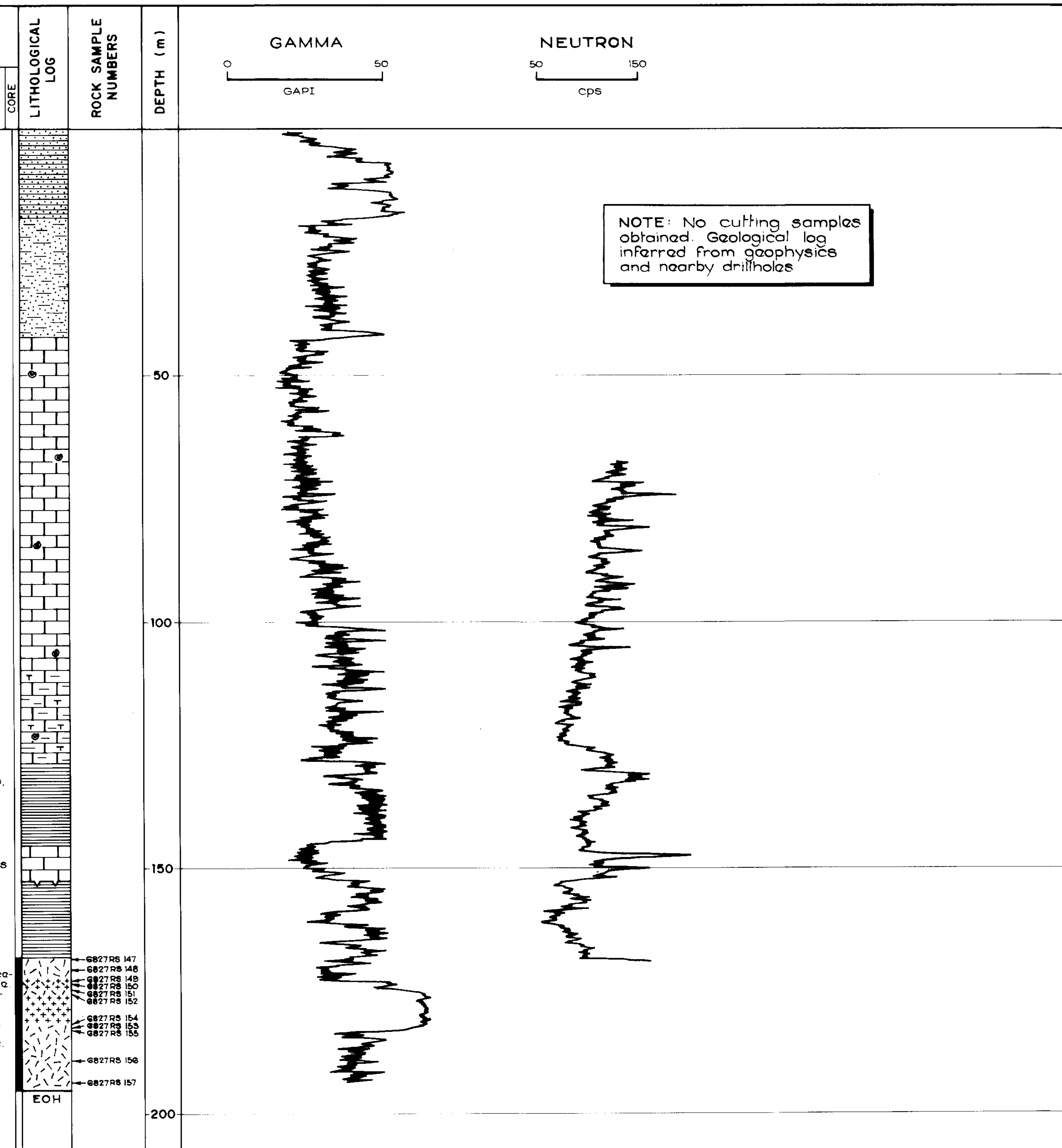


Figure 13

91-74

5154

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
REGIONAL GEOLOGY BRANCH & GROUNDWATER - ENGINEERING DIVISION

WYNARKA 2

COMPOSITE WELL LOG

DRILLING DETAILS

DRILLING METHOD Rotary mud and bottom hole coring
CIRCULATION
START 20/6/90 FINISH 23/6/90
TOTAL DEPTH 188 m

DRILLED BY: Rockdril Contractors

GEOPHYSICAL LOGS

TYPE OF LOG	GAMMA	NEUTRON	SP	CALIPER	DENSITY		
DATE OF RUN	23/6/90						
RECORDED BY	B. Traeger						
FIRST READING (m)	186	187					
LAST READING (m)	0	67					

PROJECT MURRAY BASIN BASEMENT TRANSECT
FIELD No. MBT - 15 **UNIT No.** 6827004SW01631
LOCATION 35° 09' S 139° 38' E
ELEVATION 77 m **DATUM** AHD
LOGGED BY S. Barnett, L. Rankin **DATE** 28/9/90

HYDRO DATA	AGE	UNIT	DESCRIPTION	CORE
Aquifer	PLIOCENE	PLIOCENE SANDS	**0-39m SAND**: Pale orange, silty, fine grained. Slightly micaceous. **16-18m**: Medium-coarse grained.	
Aquifer	OLIGO - MIOCENE	MURRAY GROUP LIMESTONE	**39-94 m LIMESTONE**	
Con. Layer / ? Aquifer	EOCENE	BUCCLEUCH BEDS	**94-122 m CLAY**: Carbonaceous, with interbedded sands and/or cemented limestone.	
	? CAMBRIAN - ORDOVICIAN		**122-166·2 m CLAY**: Weathered basement.	
	? CAMBRIAN - ORDOVICIAN		**166·2 - 187·7 m** Altered and carbonate replaced amphibolite (? metadolerite). Abundant calcite veins and disseminated pyrite. **172·6 - 174·6 m**: Fault zone containing tectonic breccia clasts and sheared bands of amphibolite and chlorite schist within a carbonate matrix. Zone ~ 20-30° to core axis. **181·7 - 182·4 m**: Minor breccia zone with abundant carbonate. Zone ~ 30° to core axis.	core

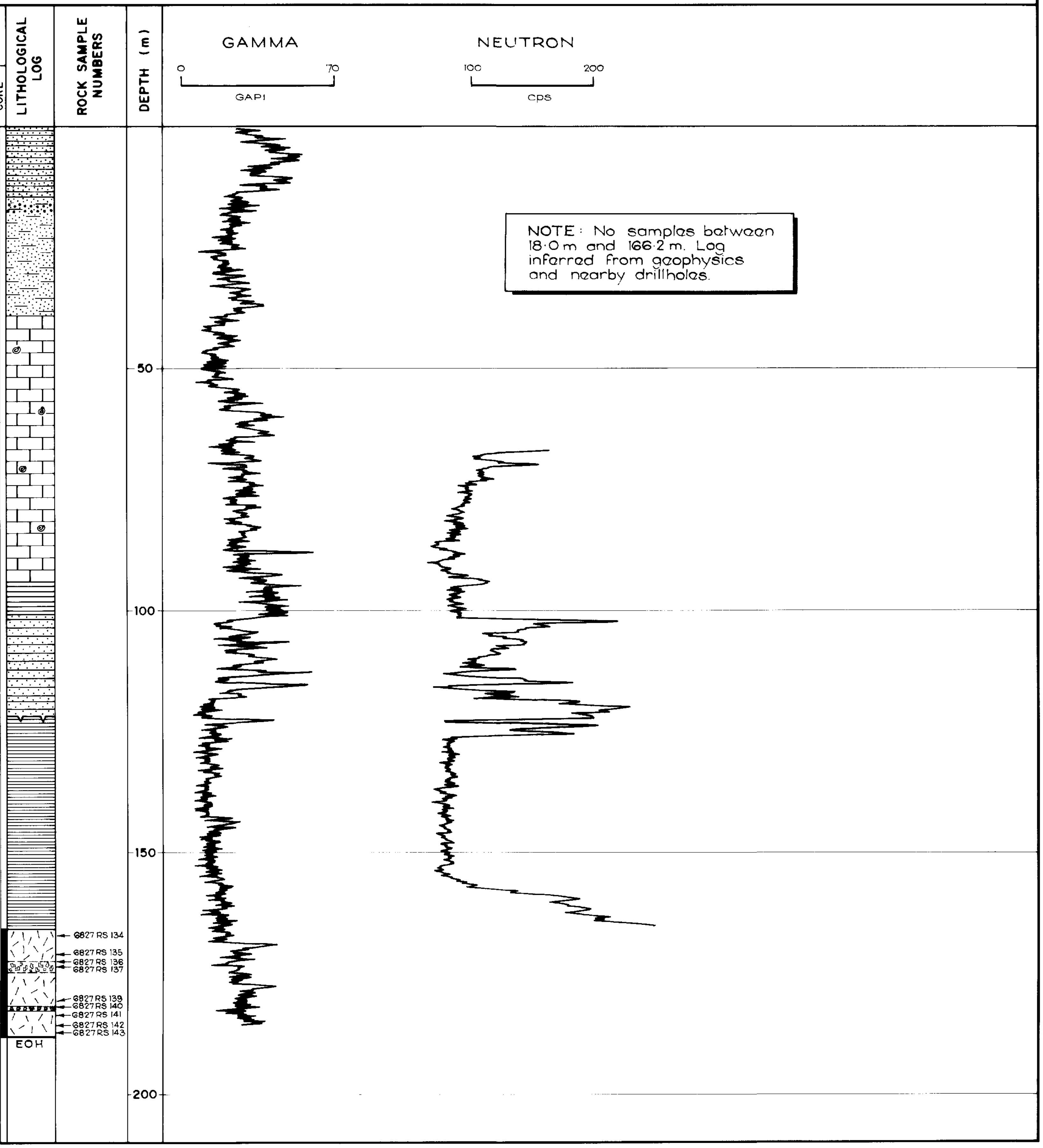


Figure 14
91-75

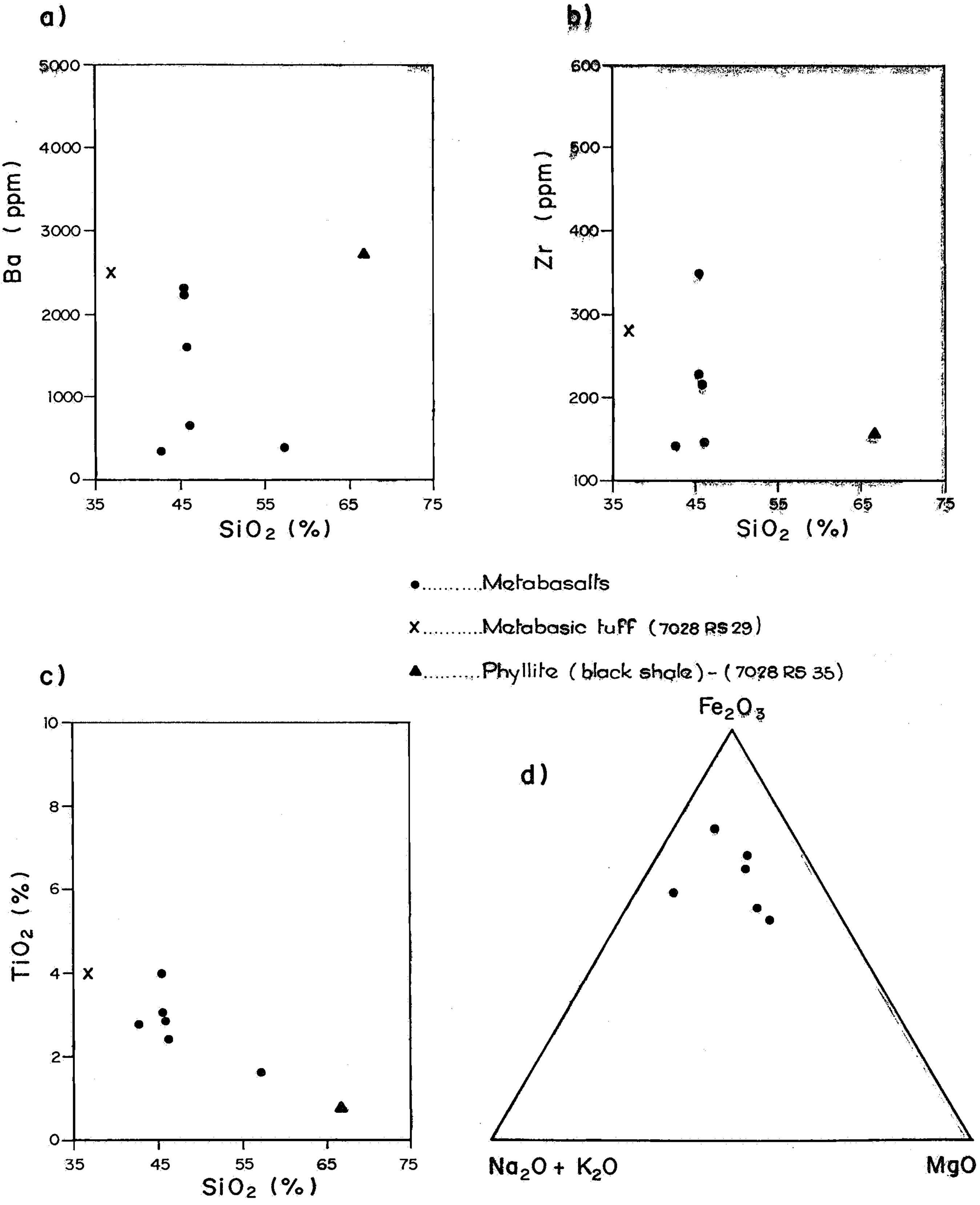


Figure 15

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

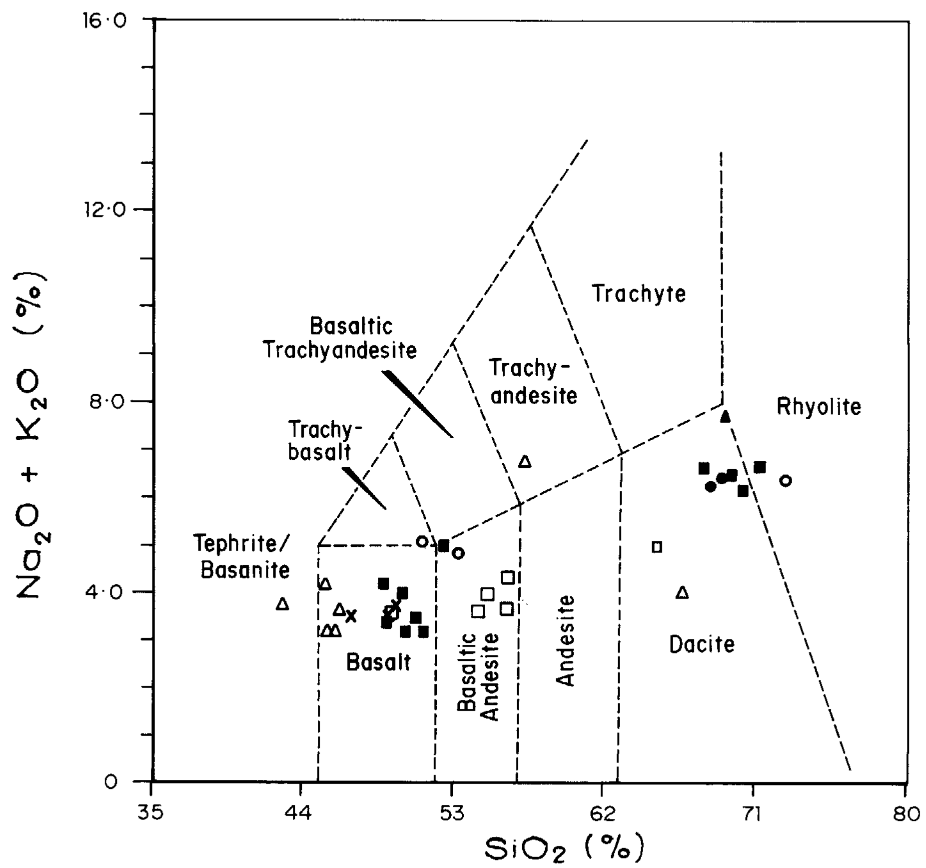
MURRAY BASIN BASEMENT TRANSECT

PEEBINGA 1

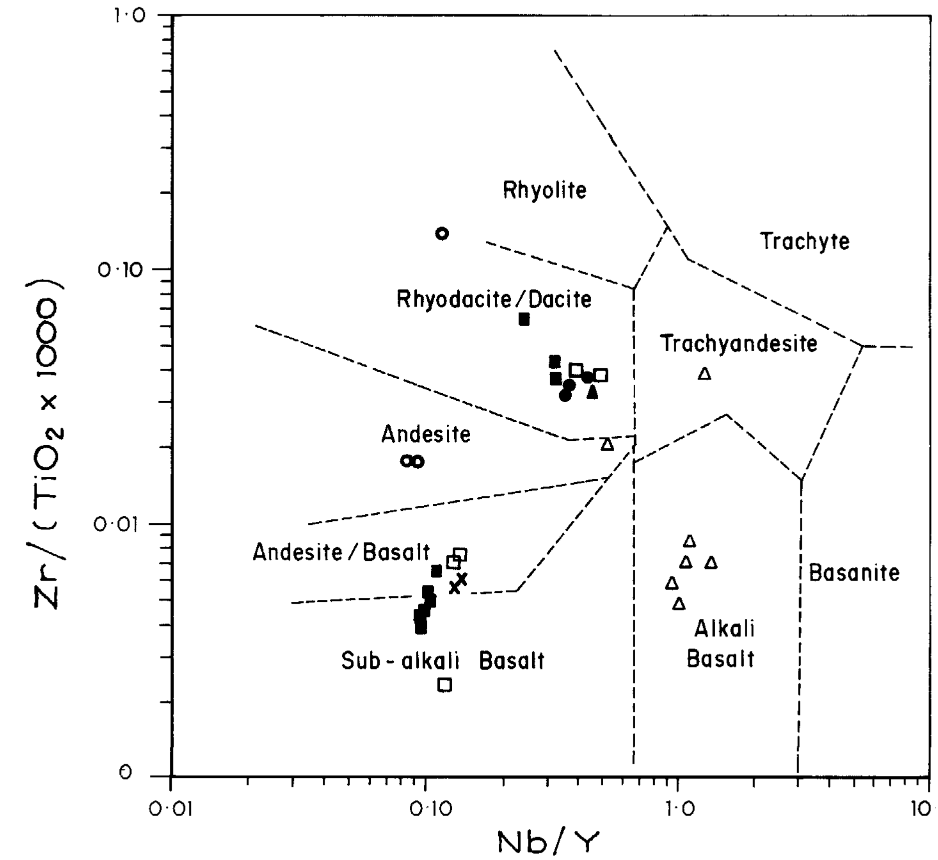
METABASALTS & METASEDIMENTS, MAJOR ELEMENT TRENDS

COMPILED B. Clough	C D O	DATE	
DRAWN M.R.	SCALE —		
DATE Jan. 1991	PLAN NUMBER		
CHECKED	S 21927		

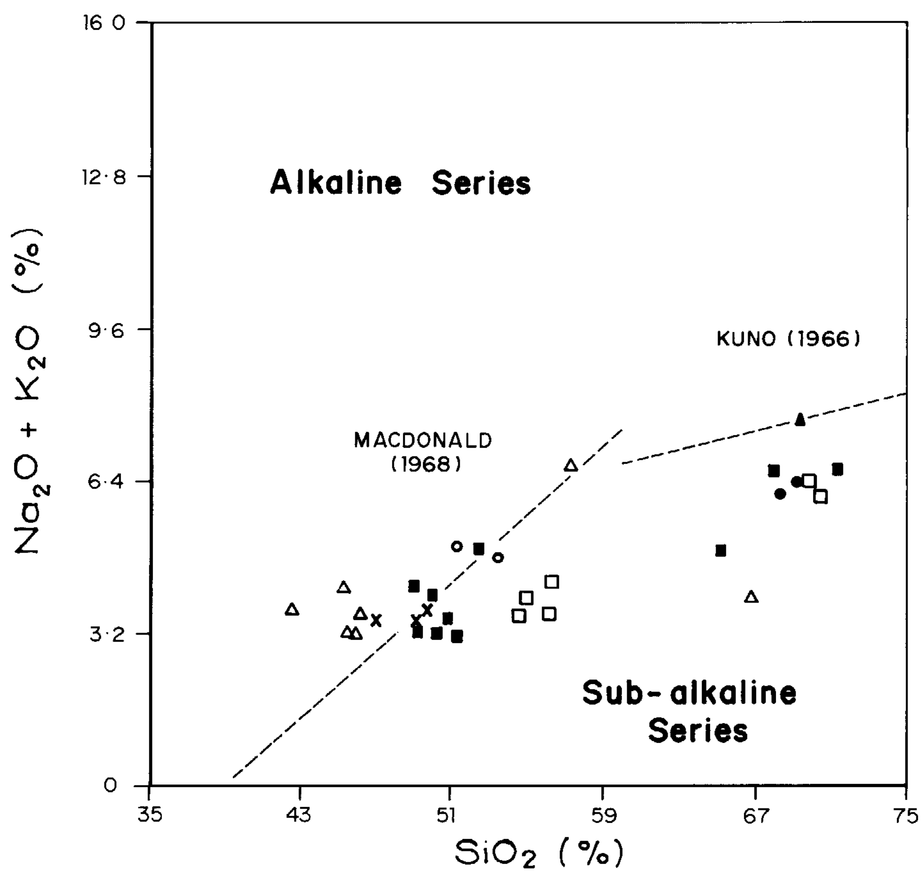
5154



a) Classification of volcanic rocks (Le Bas et. al., 1986)



b) Classification of volcanic rocks (Winchester & Floyd, 1977)



c) Alkali / sub-alkali discrimination boundaries of MacDonald (1968) and Kuno (1966).

LEGEND

- △ .... Peebinga 1
- ○ .... Peake 1
- ■ .... Caringa 1
- □ .... Wynarka 1
- × .... Wynarka 2
- ▲ .... Wirha South 1
- ● .... Tori Hills 1

Figure 16

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED B. Clough	C.D.O.	27·2·91 DATE
MURRAY BASIN BASEMENT TRANSECT	DRAWN M. R.	SCALE —	
CHEMICAL CLASSIFICATION PLOTS FOR ALL SAMPLES	DATE Jan. 1991	PLAN NUMBER 91 - 76	
	CHECKED		

5154

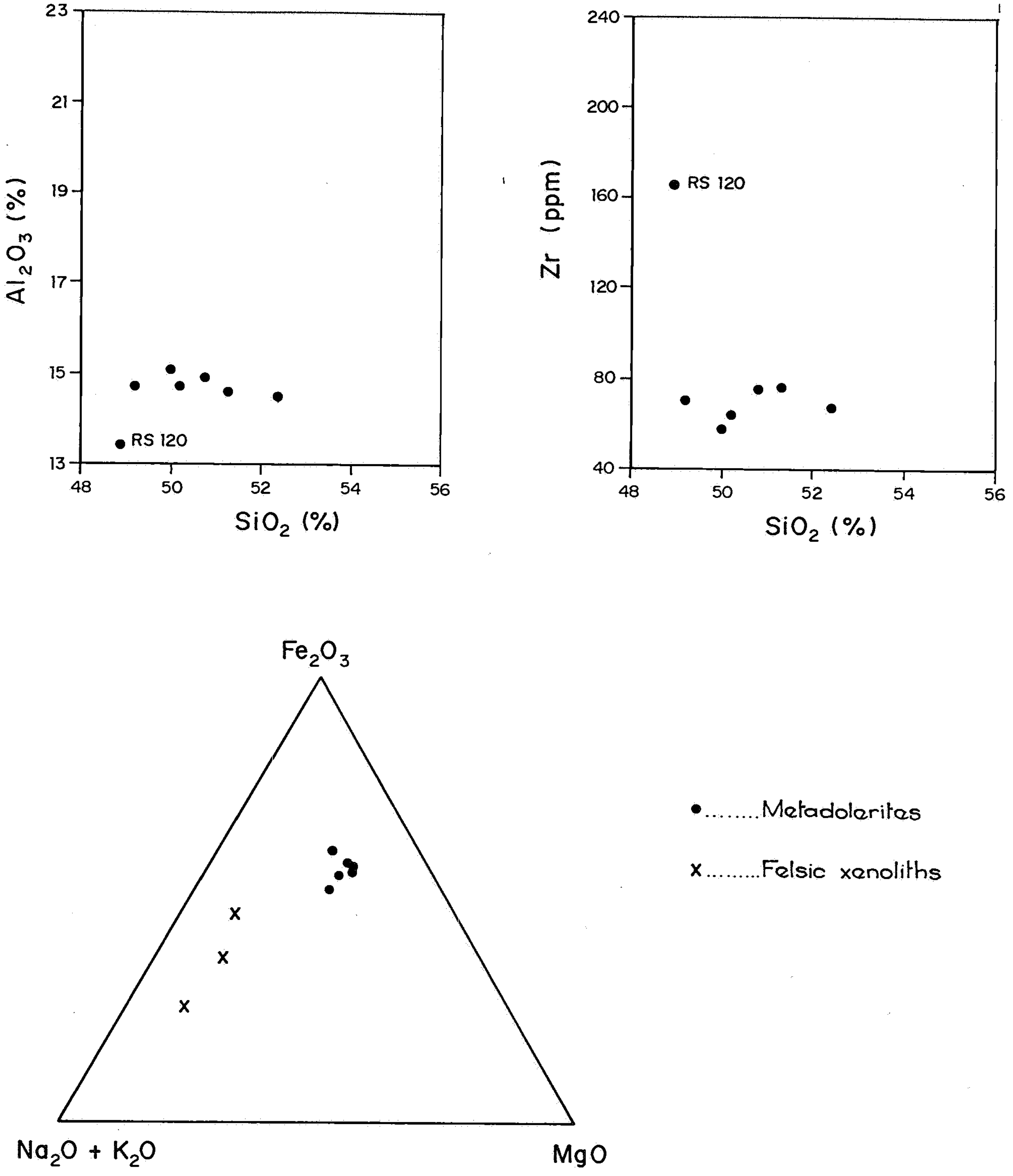


Figure 17

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

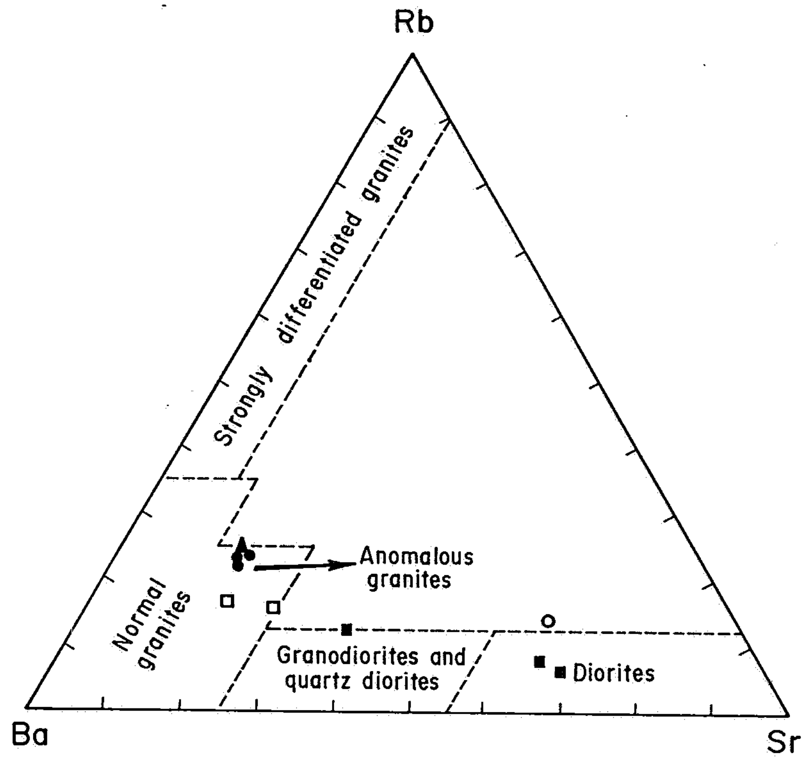
MURRAY BASIN BASEMENT TRANSECT

CARINGA 1

MAJOR AND TRACE ELEMENT TRENDS

COMPILED B. Clough	C D O	DATE
DRAWN M. R.	SCALE —	
DATE Jan. 1991	PLAN NUMBER	
CHECKED	S 21928	

5154



a) Granitic rocks classification (EL Bouseily & EL Sokkary, 1975)

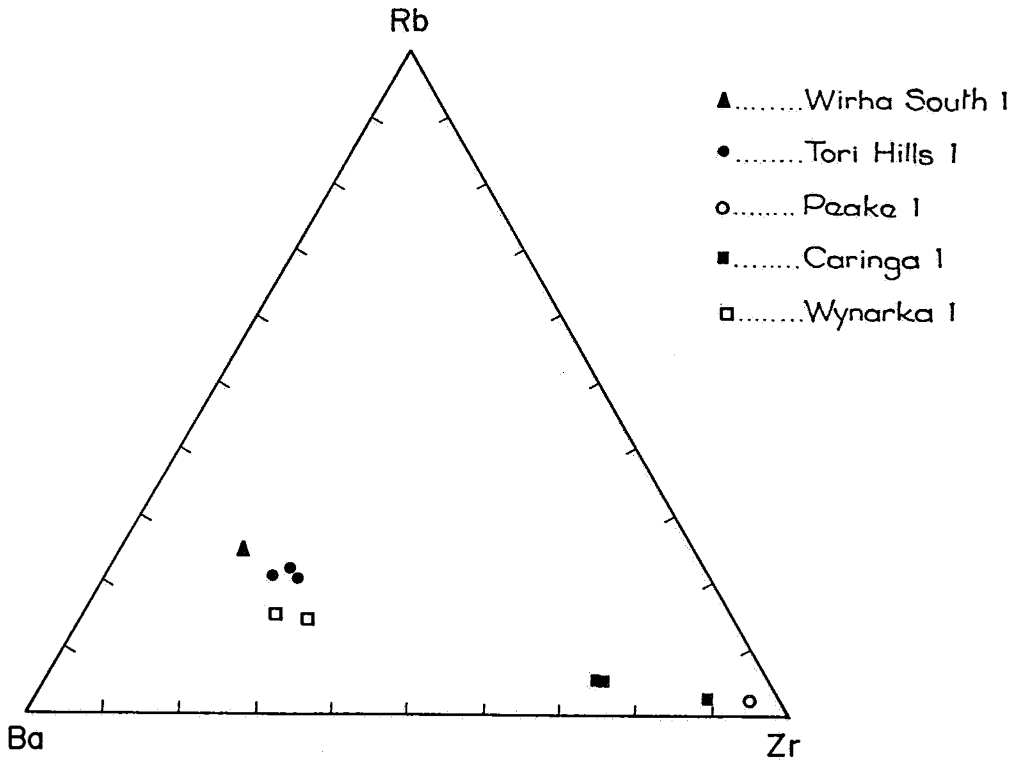


Figure 18

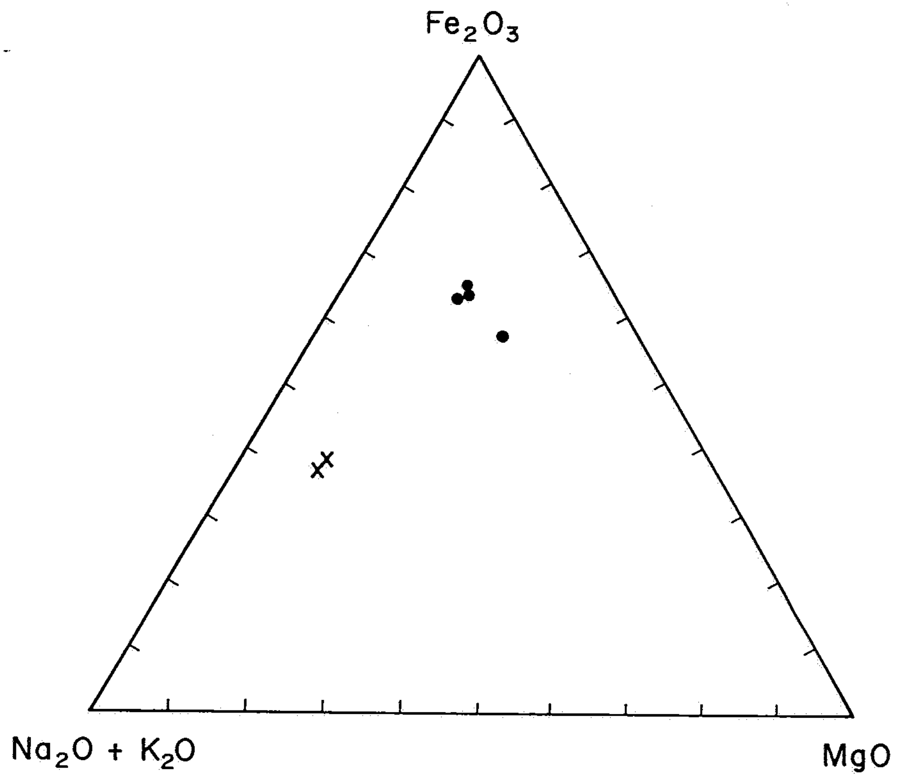
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT

GRANITIC UNITS - TRACE ELEMENT CLASSIFICATION AND TRENDS

COMPILED B. Clough	C D O	DATE
DRAWN M. R.	SCALE —	
DATE Jan. 1991	PLAN NUMBER	S 21929
CHECKED		

5154



●........Metadolerites

x........Felsic intrusive

Figure 19

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

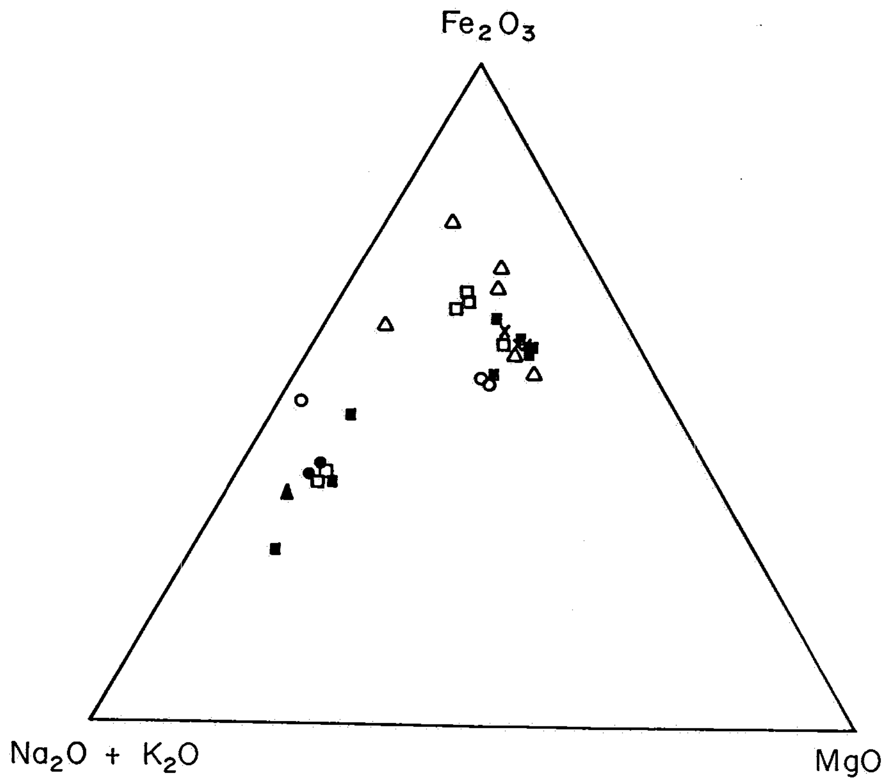
MURRAY BASIN BASEMENT TRANSECT

WYNARKA 1

MAJOR ELEMENT TRENDS - AFM PLOT

COMPILED B. Clough	C D O	DATE
DRAWN M. R.	SCALE —	
DATE Jan. 1991	PLAN NUMBER S 21930	
CHECKED		

5154



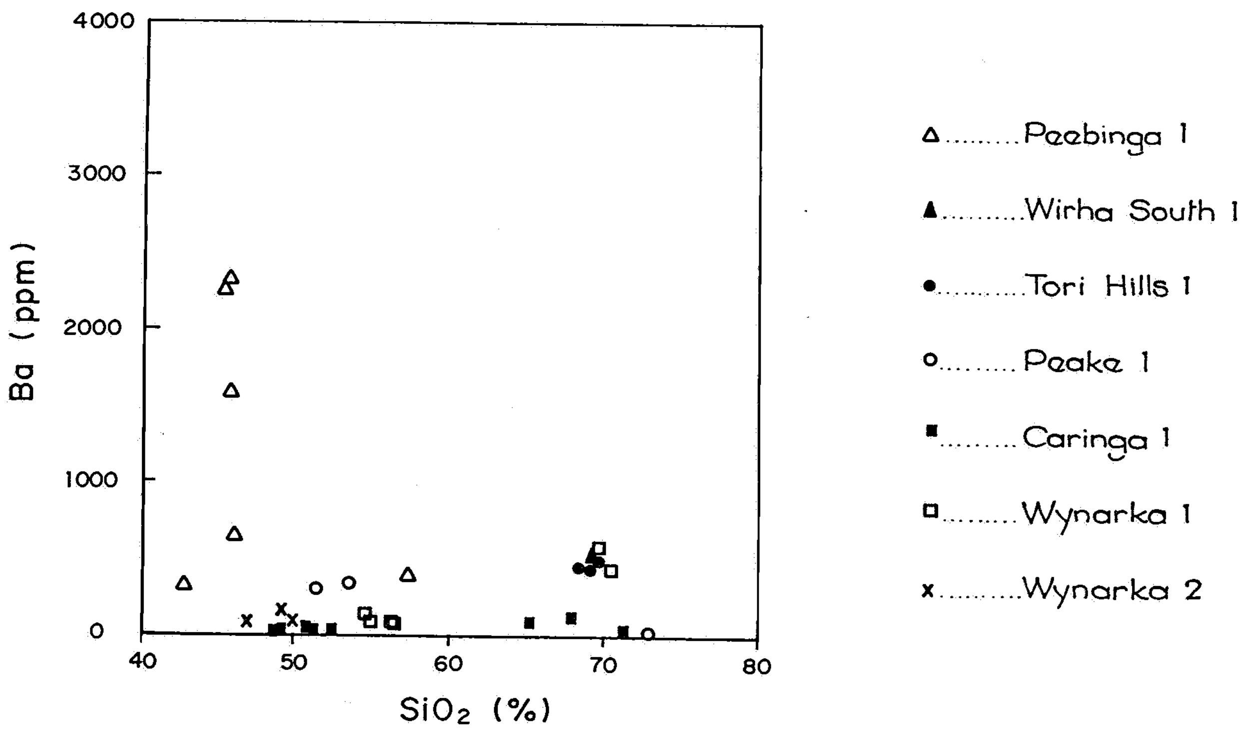


Figure 20

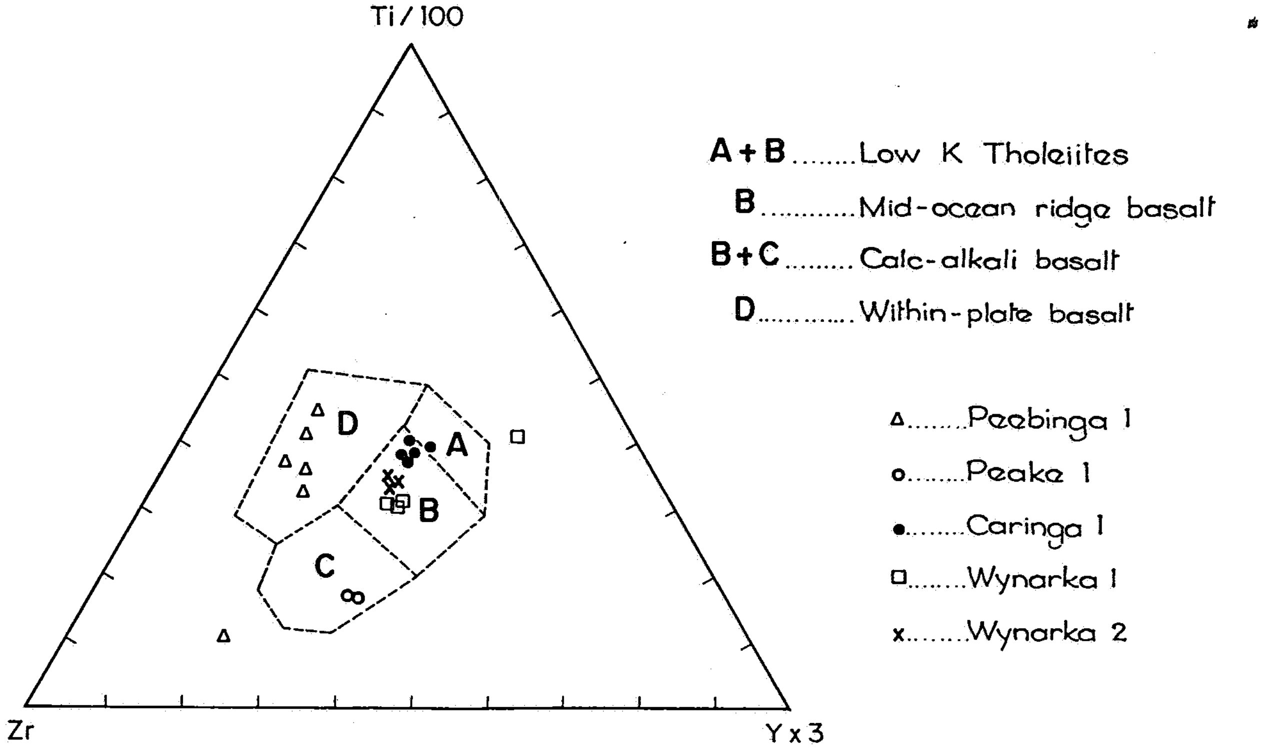
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT

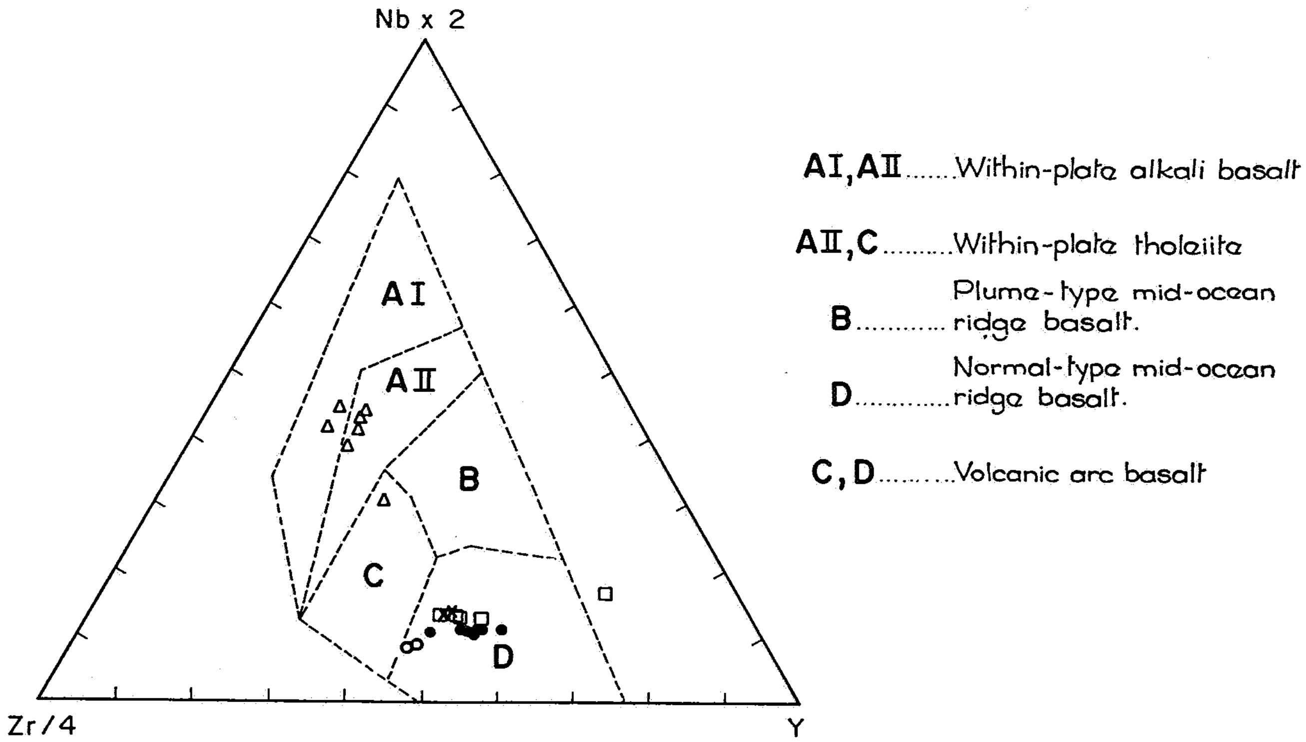
MAJOR AND TRACE ELEMENT TRENDS FOR ALL SAMPLES

COMPILED	C D O	DATE
B. Clough		
DRAWN	SCALE —	
M. R.		
DATE	PLAN NUMBER	
Jan. 1991	S 21931	
CHECKED		

5154



a) Discrimination plot of Pearce and Cann (1973)



b) Discrimination plot of Meschede (1986)

Figure 21

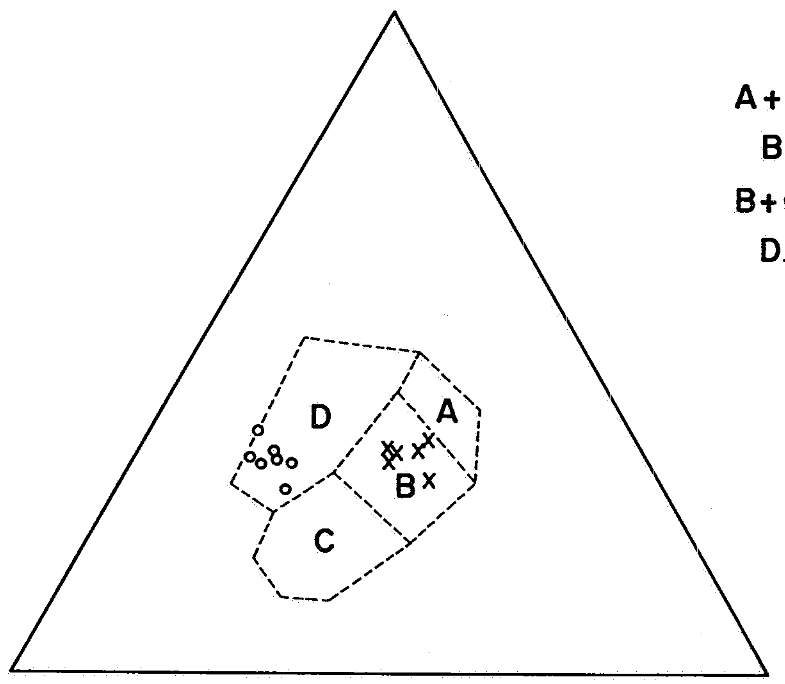
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT

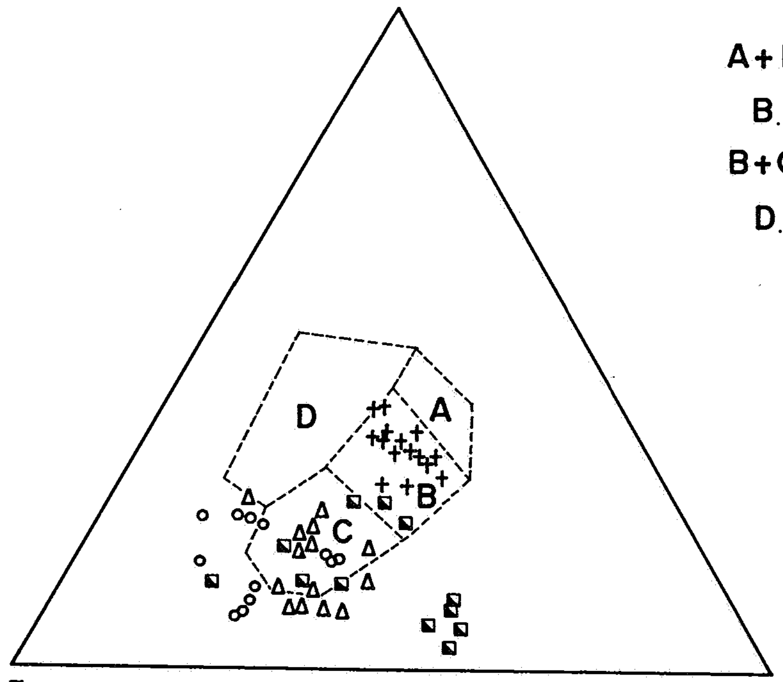
TECTONIC CHEMICAL DISCRIMINATION PLOTS FOR ALL MAFIC SAMPLES

COMPILED B. Clough	C D O	DATE
DRAWN M. R.	SCALE —	
DATE Jan. 1991	PLAN NUMBER S 21932	
CHECKED		

5154



a) Discrimation plot of Pearce and Cann (1973)
Eastern Mt Lofty Ranges data from Liu and Parker (1990)
Mt Rufus 1 data from Gatehouse et. al. (1991)

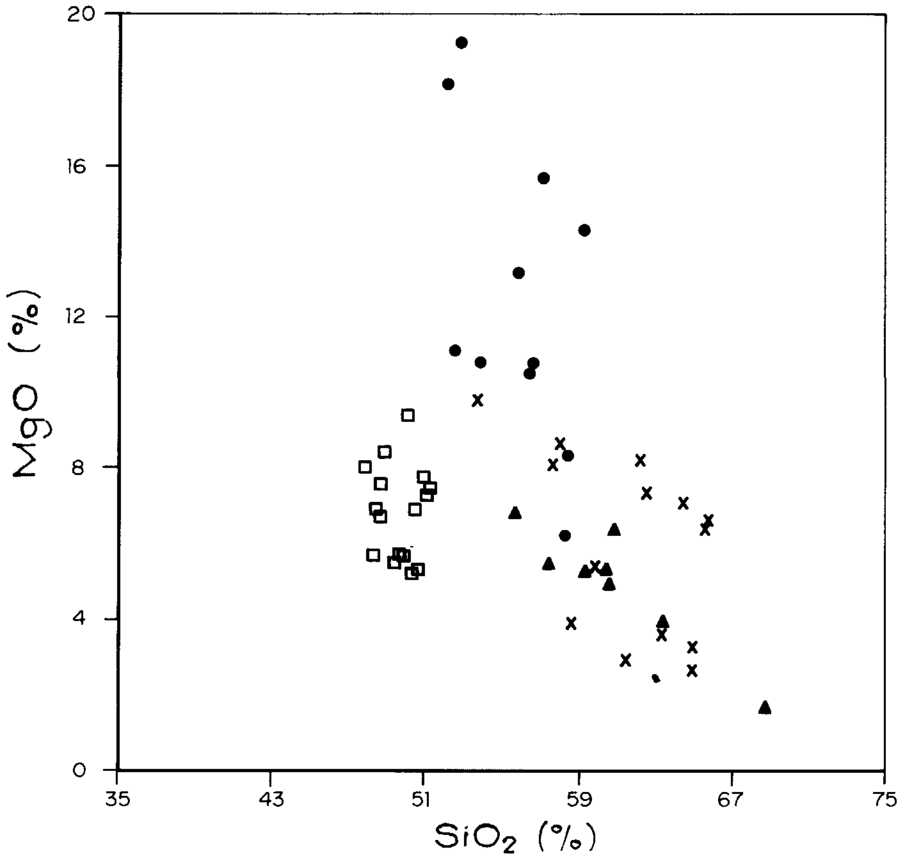


b) Discrimination plot of Pearce and Cann (1973)
Data from Crawford (1988)

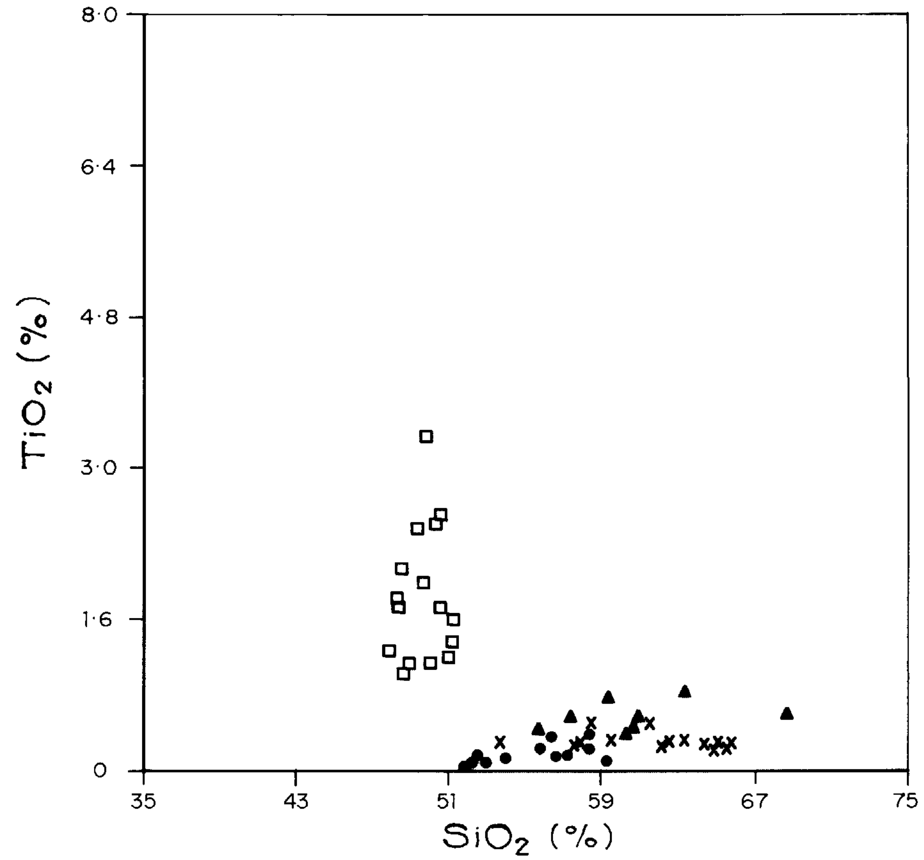
Figure..... 22

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED B.Clough	C D O DATE
MURRAY BASIN BASEMENT TRANSECT	DRAWN M.R.	SCALE —
TECTONIC CHEMICAL DISCRIMINATION PLOTS, SAMPLES FROM ASSOCIATED PROVINCES	DATE Jan. 1991 CHECKED	PLAN NUMBER S 21933

5154



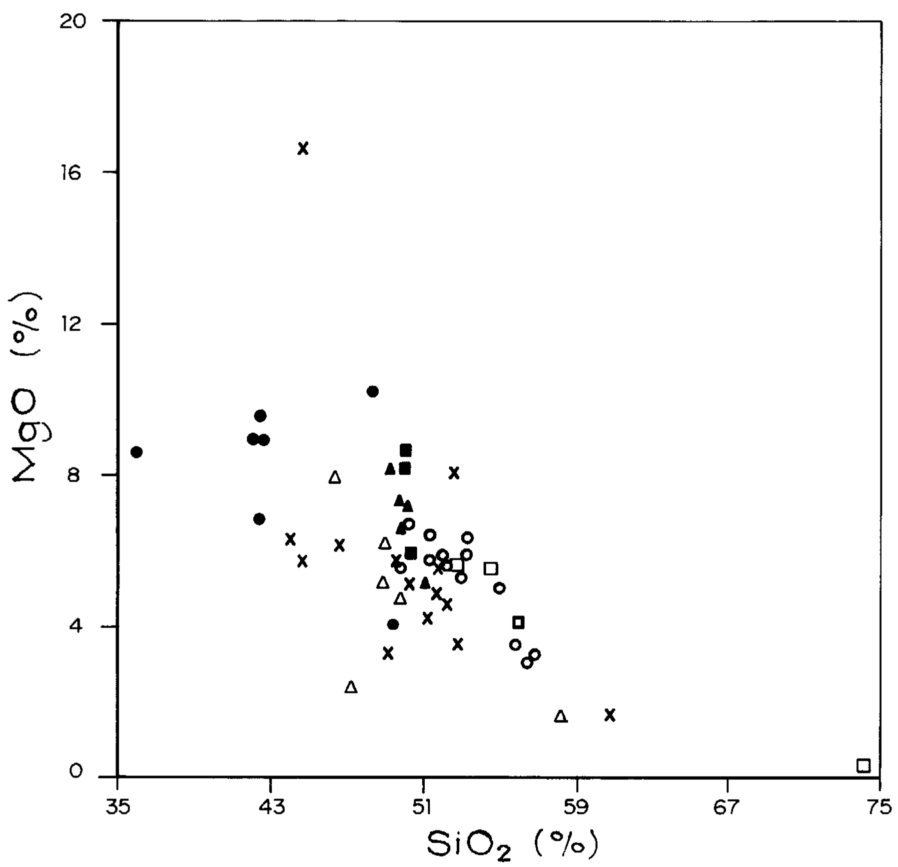
a) Data from Crawford (1988)



c) Data from Crawford (1988)

LEGEND (Figs 23 a,c)

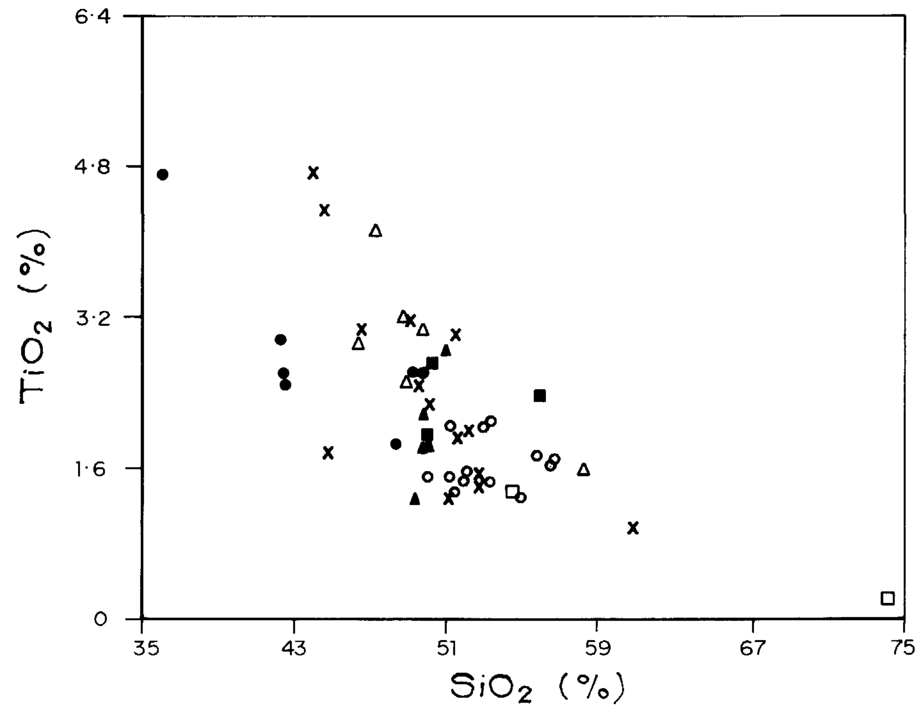
- ▲ Calc-alkali andesites (Mt Stavely Belt)
- ● Boninites (Heathcote and Mt Wellington Belts)
- x Low Ti andesites (Mt Stavely and Heathcote Belts).
- □ Tholeiites (Heathcote and Mt Wellington Belts)



b) Nanyah metabasics data from Preiss and Radke (1989)
Yumali/Coonalpyn metabasics data from CSR (1986)
Eastern Mt Lofty Ranges metabasics data from Lin and Parker (1990)
Mt Rufus 1 data from Gatehouse et. al. (1991)

LEGEND (Figs 23 b,d)

- △ Peebinga 1 metabasalt
- ○ Caringa 1, Wynarka 1 and 2 metadolerites.
- ■ Nanyah 1 metabasics
- □ Peake 1 metadolerite & rhyolite
- x Yumali/Coonalpyn metabasics
- ▲ Eastern Mt Lofty Ranges metabasics
- ● Mt Rufus 1 (Truro Volcanics)



d) As for Fig. 23b

Figure **23**

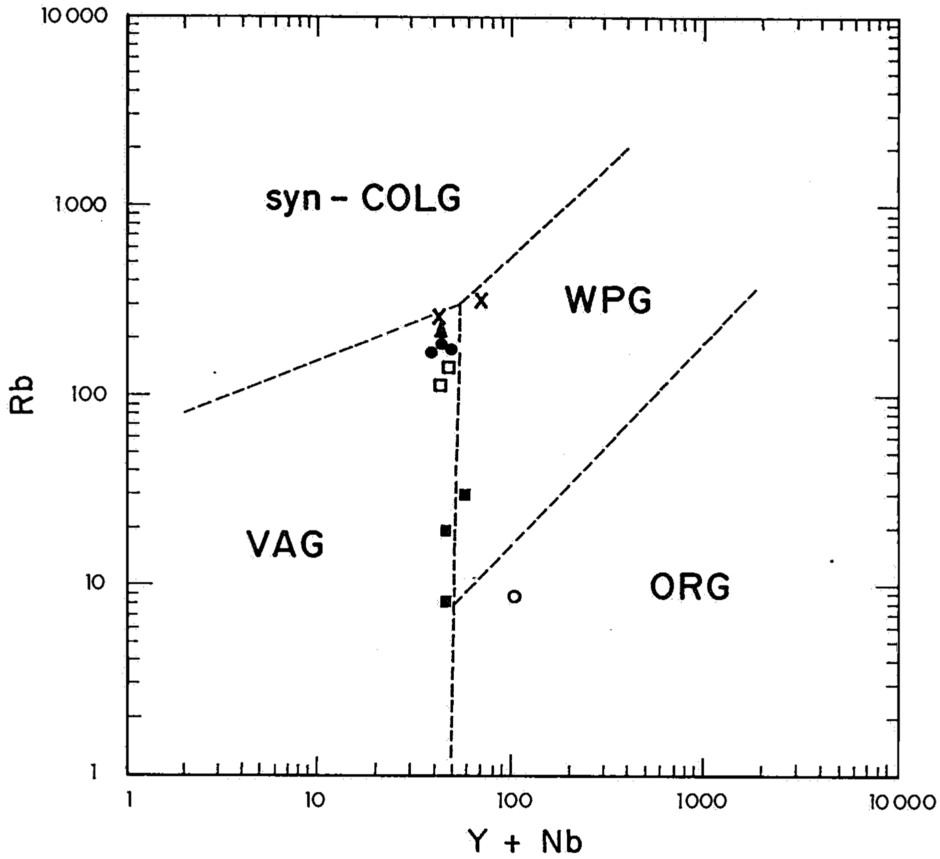
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT

COMPARISON OF MAJOR ELEMENT TRENDS FROM MURRAY BASIN BASEMENT & ASSOCIATED PROVINCES WITH VICTORIAN GREENSTONE BELTS

COMPILED B.Clough	WR 22-2-91 C D O DATE	
DRAWN M. R.	SCALE —	
DATE Jan. 1991	PLAN NUMBER 91-77	
CHECKED		

5154



o......... Peake 1

■.......... Caringa 1

□.......... Wynarka 1

x.......... Wynarka 2

▲.......... Wirha South 1

●.......... Tori Hills 1

VAG .... Volcanic Arc Granites

syn - COLG .... Syn Collision Granites

WPG .... Within Plate Granite

ORG .... Ocean Ridge Granite

Figure **24**

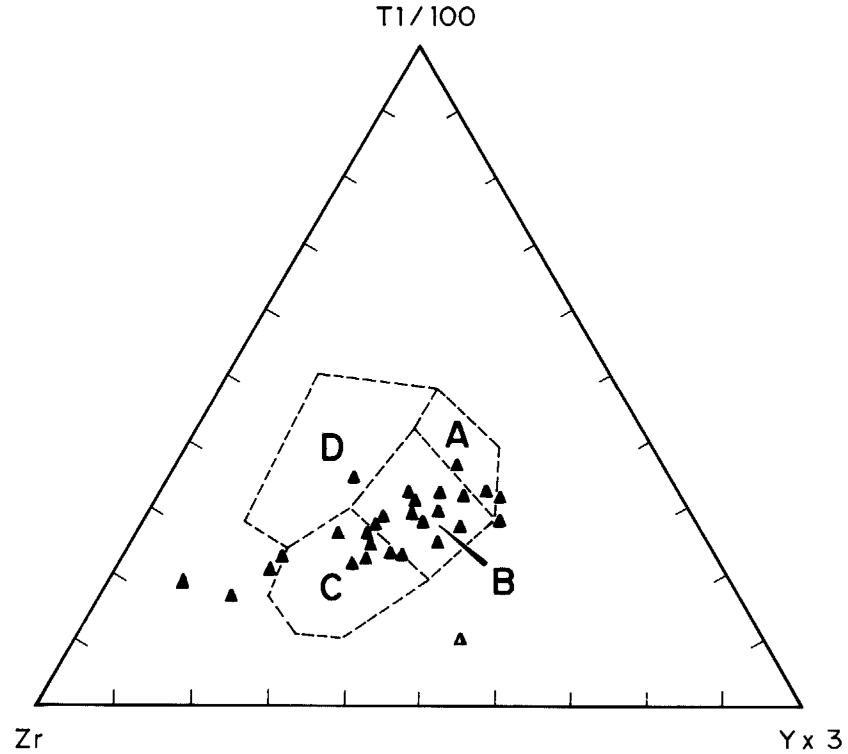
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MURRAY BASIN BASEMENT TRANSECT

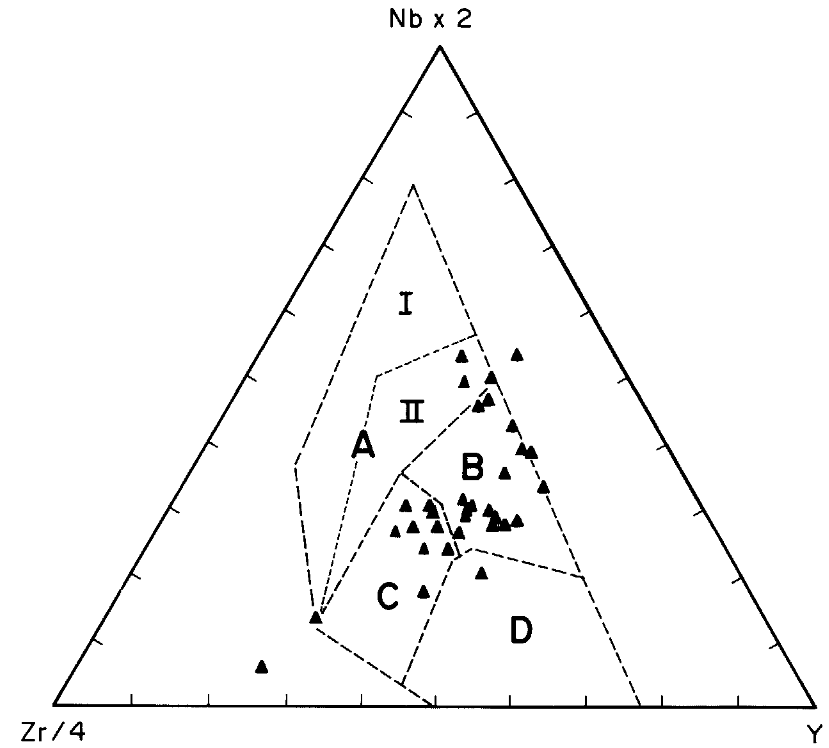
GRANITIC ROCK TECTONIC CHEMICAL DISCRIMINATION PLOT

COMPILED B. Clough	C D O	DATE
DRAWN M. R.	SCALE —	
DATE Jan. 1991	PLAN NUMBER	
CHECKED	S 21934	

5154



a) Discrimation plot of Pearce and Cann (1973)



b) Discrimination plot of Meschede (1986)

AI, AII .... Within-plate alkali basalt.

AII, C .... Within-plate tholeiite.

B .... Plume-type mid-ocean ridge basalt.

D .... Normal-type mid-ocean ridge basalt.

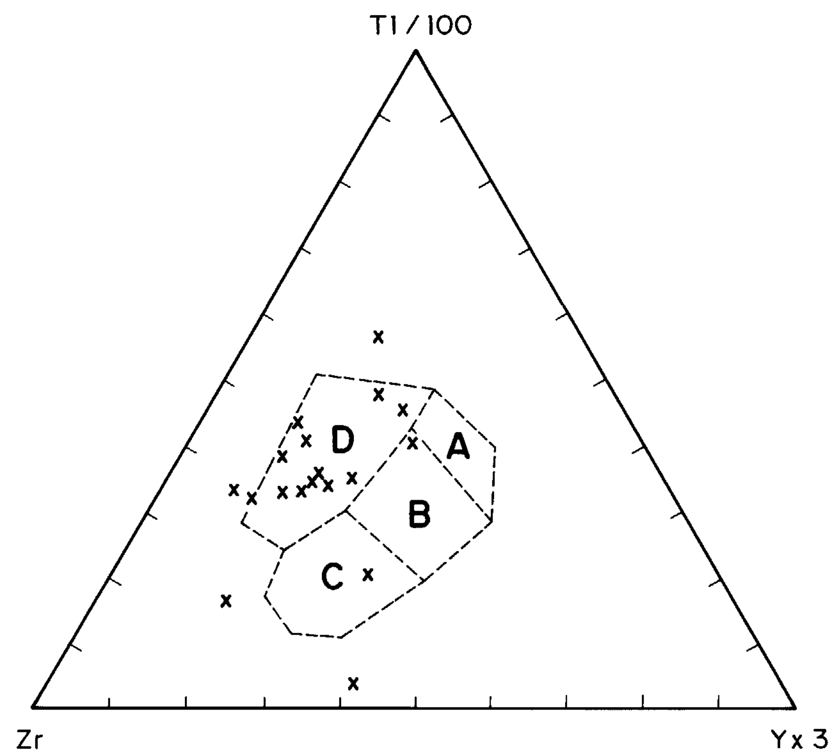
C, D .... Volcanic arc basalt

LEGEND

▲ .... Black Hill Gabbro-Norite Complex.

x .... Yumali / Coonalpyn metabasics.

• .... Mt Rufus 1 (Truro Volcanics)



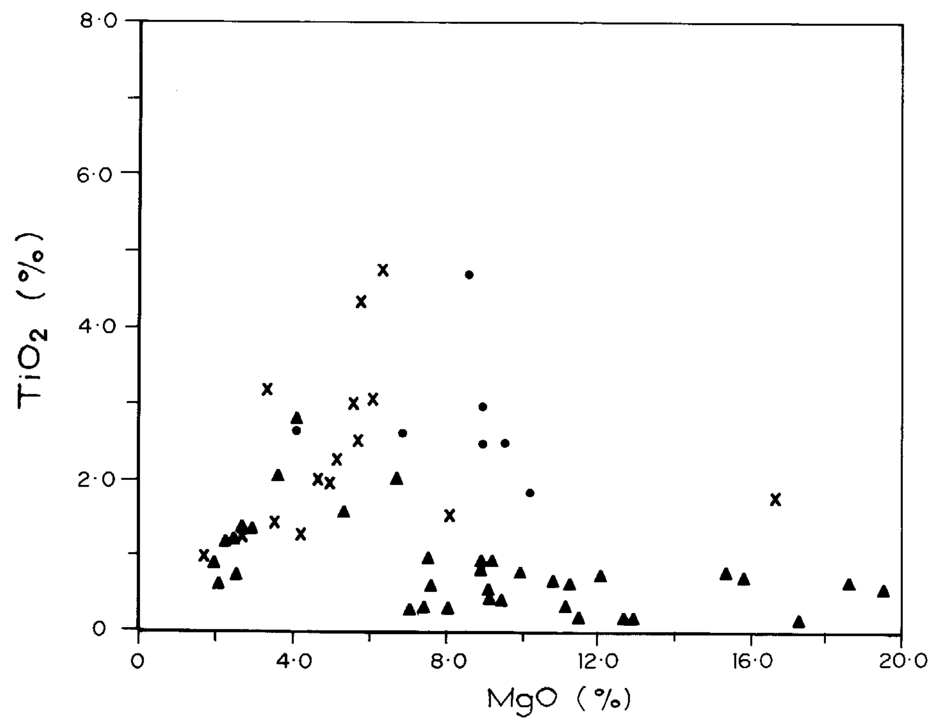
c) Discrimination plot of Pearce and Cann (1973)

A + B .... Low K tholeiites

B .... Mid-ocean ridge basalt

B + C .... Calc-alkali basalt

D .... Within-plate basalt

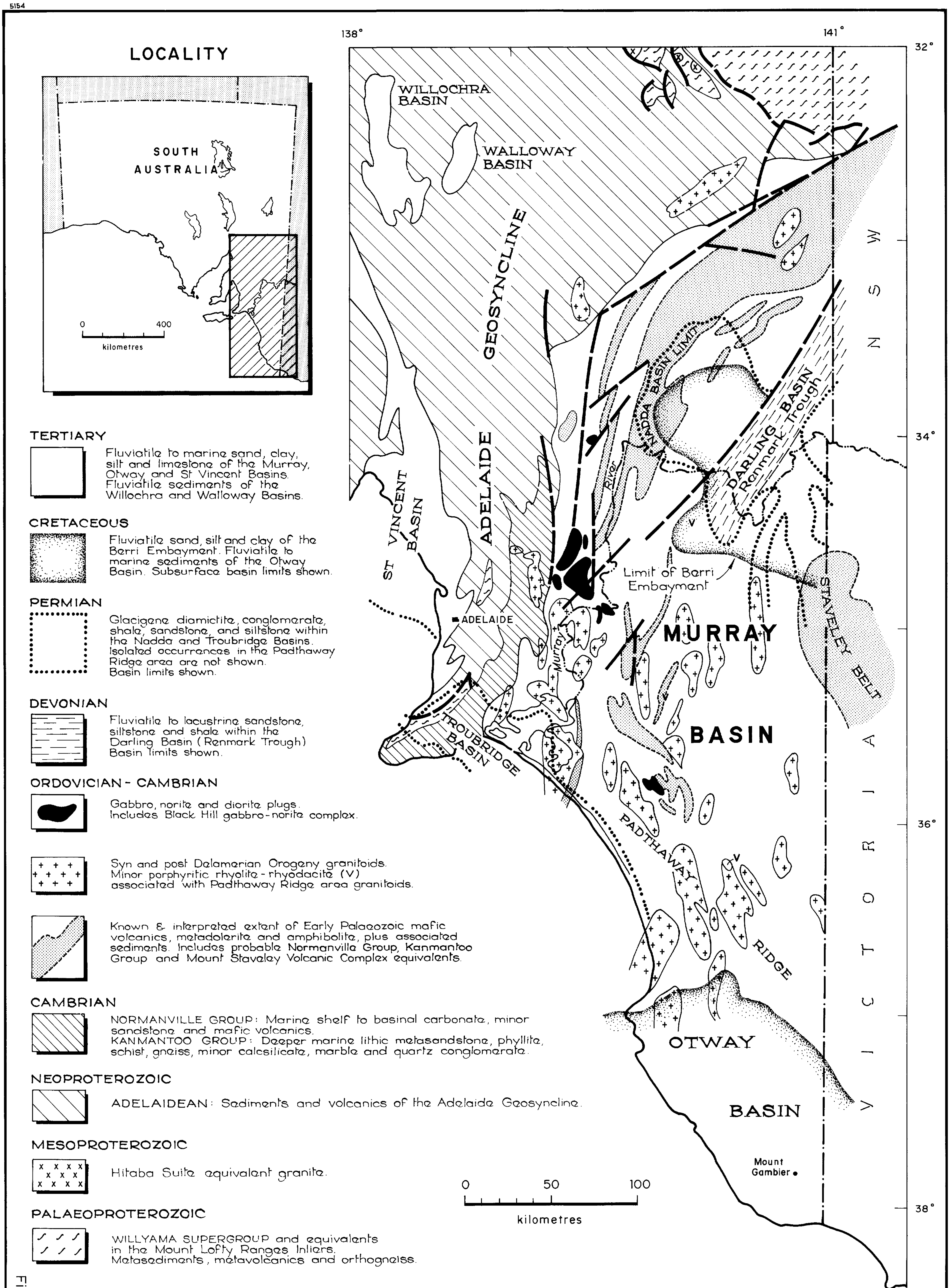


d) Mt Rufus 1 data from Gatehouse et al (1991)
Yumali/Coonalpyn data from CSR (1986)

Figure 25

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED B. Clough	WR 22·2·91 CDO DATE
MURRAY BASIN BASEMENT TRANSECT **COMPARISON OF MAJOR AND TRACE ELEMENT TRENDS FROM THE BLACK HILL COMPLEX & OTHER ASSOCIATED PROVINCES**	DRAWN M. R.	SCALE —
	DATE Jan. 1991	PLAN NUMBER **91-78**
	CHECKED	

5154



REGIONAL STRATO-TECTONIC ELEMENTS OF SOUTHEAST SOUTH AUSTRALIA

91-79
Figure...26