DEPARTMENT OF MINES
SOUTH AUSTRALIA

MAGNETIC AND GRAVITY INTERPRETATION
ON NULLARBOR-FOWLER 1:250 000 SHEET AREAS

by

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D.M. No. 646/75

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DEPARTMENT OF MINES
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ABSTRACT

In an area of limited outcrop on the western margin of the Gawler Craton, gravity and aeromagnetic interpretation is used to delineate basement units. Fault structures divide the NULLARBOR and FOWLER 1:250 000 sheet areas into five zones.

The western zone is an area of deep basement (2 000 m). Prominent in this zone is a large circular, intrusive body 5 000 m deep and 10 000 m radius at the intersection of two major faults. Three central zones constitute the margin of the Gawler Craton. They contain linear magnetic anomalies and the interpreted rock types are basic with some banded iron formations. These zones are indicative of high grade metamorphic rocks and interpreted depths range from 1 000 m to less than 500 m. The eastern zone (on FOWLER) is within the central area of the Gawler Craton and contains acid rock types. Several large granitic bodies are outlined and depths in this zone are shallow with occasional basement outcrops.

I. INTRODUCTION

The area of this study is on the western side of Eyre Peninsula at the head of the Great Australian Bight (Fig. 1). Remarks on physiography, climate and economic importance of the eastern Eucla Basin margin may be found in reports by Firman (1973, 1975). Economically the area has attracted interest in exploration for oil uranium, lignite, alunite and even gold and copper. Gypsum and common salt have been mined at Lake MacDonnell.

This investigation was undertaken to coincide with and complement explanatory geological notes on FOWLER by the Regional Mapping Section of the Geological Survey (Firman, 1975). In this report "NULLARBOR" and "FOWLER" in block type refer to the 1:250 000 map sheet areas.

In general the geological configuration of basement can only be established by geophysical methods. Scarcity of basement intersections and outcrop severely limits the amount of geological control available on which to base geophysical interpretation. Several old water bores intersecting basement were logged by drillers and bottom rock types may be wrongly classified.

The area covered by the report is on the western rim zone of the Gawler Craton (Thomson, 1974) and the tectonic features revealed by detailed and regional geophysics will be discussed in the section on regional interpretation. (III part 4). Treating NULLARBOR and FOWLER together gives a profile of events right across the western margin of the Gawler Craton.

II PREVIOUS GEOPHYSICAL EXPLORATION

Geophysical Surveys in the NULLARBOR-FOWLER Region
(ref. Atlas of Technical Data S.A. Dept. Mines)

	YEAR	AREA	DETAILS	REFERENCE
1) Aeromagnetic				
	1965	Eucla Basin	Reconnaissance Lines	Quilty and Goodeve BMR Record 1958/87
	1966	Offshore	12.8 km spacing N-S lines 450 m height	Outback Oil Co. N.L. Shell Development Pty. Ltd. Env. 648, 223.
	1970	COOK, OOLDEA, BARTON	1.6 km spacing E-W 150 m height	Waller et al. (1972) BMR rec.1972/60
	1972	FOWLER, NULLARBOR, COOMPANA	1.6 km spacing E-W lines 150 m height	BMR

2) BMR Marine Survey

1974	Great Australian Bight	Shipboard gravity magnetic and seismic profiles N-S traverses 40 km spacing	J. Willcox BMR record 1974/47

3) Gravity

1966	Eucla Basin	4.8 km x 4.8 km grid	Outback Oil Co. Env. 537, 549
1969	Eucla Basin	7.2 km x 7.2 km grid	BMR and S.A. Dept. Mines

4) Seismic

1967	Eucla Basin	Reconnaissance Seismic Refraction	S.A. Dept. Mines RB.60/30

5) Airborne Radiometric

1969	SML.316 FOWLER	3 km spacing N-S 46 m height	Australasian Mining Corp. Env. 1200

6) Ground Radiometric

1970	SML.365,367 FOWLER	Various locations	Australasian Mining Corp. Env. 1316,1317
1968	SML.149 FOWLER	Various locations	Mines Administration Pty. Ltd. Env. 869

III INTERPRETATION

1. Procedure

The procedure used in interpreting the aeromagnetic data was firstly to produce a trend map to overlay the aeromagnetic map (Fig. 2) and to divide the area into discrete zones (Fig. 3). The flight chart records were then used for quantitative estimates (dip, depth, width) on individual anomalies. These data were used to produce an overlay incorporating all geophysical and geological observations (Fig. 4).

Overlays were also used to compare regional gravity maps with aeromagnetic maps on the 1:1 000 000 scale and to put individual features into a regional context. Other data used were lineaments interpreted from E.R.T.S. images and aerial photography, which were related where possible to gravity and magnetic features. This information was supplied by the Regional Geology Division.

2. Detail on NULLARBOR and FOWLER

Detailed interpretation of geophysical patterns on FOWLER and NULLARBOR is discussed in terms of discrete zones. Figures 1, 2, 3 are referred to by coded references to anomalies and areas.

Zone A is the western section of NULLARBOR and coincides with a depression within the Eucla Basin, in which depths to magnetic basement are of the order of 2 km. There are indications of major lineaments in this portion but these are better viewed in the context of the surrounding 1:1 000 000 scale contour map (see Regional Interpretation Section).

A prominent feature in this zone is the large circular negative anomaly (A1). Calculations based on a vertical cylinder show this source to be 5 km deep and of 10 km radius. The significance of the negative amplitude indicates the body is remanently magnetised in a direction opposed to the current earth's field. It has a susceptibility of .004 c.g.s. units which puts it in the range of a basic intrusive and it is below the magnetic basement. On a wider scale this body is seen to occur at the intersection of two major faults (Encl. 3).

Mallabie 1 is an oil exploration well in the far west of NULLARBOR, and the sequence intersected by it is shown in Table 1. Granite gneiss basement was reached at 1 341 m and has a measured susceptibility of .005 c.g.s. units. The volcanic section is of interest as it is a possible equivalent of the Roopeena Volcanics on the east of the Gawler Craton. These volcanics

TABLE 1

STRATIGRAPHIC SECTION IN MALLABIE NO. 1 OIL EXPLORATION WELL

Drilled by Outback-Pickrel August 1969

Total Depth 1 495 metres

DEPTH (m)	AGE	ROCK TYPES	CORE SAMPLES (depth m)	SG (gm/cm^3)	SUS (Cgs units)
0-33	Lower Miocene	Nullarbor Limestone	-	-	-
33-188	Upper Eocene	Wilson Bluff Limestone	-	-	-
188-347	Lower Cretaceous	Sst, mst, conglomerate	195	1.95	.0003
347-436	Lower Permian	Sst, silt clay	426	2.28	-
436-916	Cambrian	Sst, silt	657	2.34	-
916-1205	Proterozoic (Adelaidean)	Volcanics (Roopeena?)	923	2.63	.00005
1205-1341	Proterozoic (Adelaidean)	Reddish sandstone	1226	2.46	-
1341-1495	Lower Proterozoic (Carpentarian)	granite gneiss	1406 1495	2.64 2.73	.0019 .005

were tested and found to have very low susceptibility and thus are not a source of magnetic anomalies in this region.

Very little other information is available on crystalline basement in this zone. Apart from the granite gneiss little is known about the geological province of this basement. The eastern boundary for Zone A corresponds approximately to the 1 000 m magnetic depth contour, east of which, wave lengths of the magnetic anomalies become progressively shorter over a 20 km range, indicating shallowing of basement (Fig. 2). The edge of this zone is not sharply defined but seems to be due to a gentle down-warping of the basement over a distance of 30-40 km under the Eucla Basin. This downwarp corresponds to a gravity low of -50 m gals (Enc.1).

Zone B as outlined coincides with a discrete gravity high of 30 mgals (Encl.1). The characteristic magnetic patterns show linear features trending north-easterly in the northeast, turning to westerly in the central area of the zone. The general trend of dips in this zone is to the southeast. A profile of the gravity anomaly along line C-D across the gravity high is shown in figure 2. This profile shows series of step faulted contacts of Zone B with Zone A and also the more subtle contact with Zone C. Magnetic horizon depths in this zone range from 500 to 1 000 m and susceptibilities indicate basic rock compositions, being in the range .001-.005 c.g.s. units.

Zone C is on the eastern edge of the gravity high (Zone B) and contains more continuous magnetic anomalies than Zone B. The trend is north-easterly and the general dip direction is southeast. A prominent band passes through this zone with a high susceptibility (.02 c.g.s. units) and is possibly a banded iron formation. Other features may be due to basic intrusives or high grade metamorphics (granulites).

Zone D is bounded on both sides by extensive faults. On the eastern side the Pintumba Fault, a major fault, is clearly indicated both on magnetic and gravity anomaly maps. Figure 5 shows the gravity anomaly over this fault and a step model fitted to it. Assuming a density contrast of about .2 gm/cm^3 the depth of block D would extend to more than 10 km. The second derivative of gravity calculated for profile C-D also pinpoints the fault position.

The magnetic anomalies in Zone D trend northeast and susceptibilities range from .005-.02 c.g.s. units. There are continuous basic bands and some banded iron formation beds dipping steeply southeast. A notable feature in this zone is the cross cutting faults which displace the beds.

These western zones (B, C & D) are characteristic of high grade metamorphic zones such as occur at Broken Hill.

Anomaly Z (Figure 6) illustrates the difficulty in interpreting the compound anomalies in these zones. This anomaly may be due to several closely spaced sheet-like bodies, and interference between anomalies prohibits individual calculation of dips, widths and depths. Taking a smoothed version may give a general idea of the band width, but, an inaccurate assessment of depth and an incorrect dip value. Two alternative interpretations are shown but it is considered likely the source of the anomalies is a series of iron formation bands.

Eastern Zone

To the east of the Pintumba Fault is the core area of the Gawler Craton, which is very different geologically to the rim zone to the west. To the west of this fault rock types are more basic and hence of higher susceptibilities and densities, while to the east acidic rock types with lower susceptibilities and densities predominate.

The main magnetic features in this eastern zone are large circular areas (G) which have relatively few magnetic anomalies and which coincide with gravity lows of up to -60 mgals. These represent areas of granitic batholiths and there are some outcrops in these areas. The depth to magnetic basement contour map (Fig. 7) shows cover in these areas to be relatively thin. The lower density and uniform magnetic properties are characteristic of granite bodies. A similar as yet unexplained feature occurs in the north-eastern region of NULLARBOR (G5).

Less distinct features of this zone are the more strongly magnetic circular areas (GA, GB). These could be a more magnetic type of granite corresponding to a different phase of tectonism or alternatively a phase of remobilised gneisses (adamellites).

Between the granite bodies in the eastern zone there is evidence of folded sedimentary (or layered) horizons. Some dip estimates indicate a sequence of folds as shown in Fig. 4. The large anticlinal feature X has limbs which dip at 62° and consists of several beds. There is a suggestion that the nose of this fold continues down to the southwest of FOWLER but due to the strike direction only irregularly spaced flight lines cross it. Along the southern limb of fold X is a circular plug feature (D) 700 m deep and 1.5 km in diameter with a susceptibility of .03 c.g.s. units. This indicates an intrusion with at least 10% magnetite content.

In the northeast of FOWLER there are suggestions of some east-west dyke-like bodies, but due to the east-west flight line direction these are difficult to follow. The outcrops in this area are adamellites which are likely to contain magnetic horizons.

3. Depth Estimates

Depth estimates using a half slope method were carried out on alternate flight lines on FOWLER. From flight records it is evident that there are at least two levels of source rocks and this gives erratic depth values. Spectral analysis of wavelength filtering could help resolve the sources but these techniques were not used due to the regional nature of this study. To try to improve the depth values the interpreted depth data were digitised and then processed by computer onto a regular 5 km and 10 km grid. These were then filtered and contoured (Fig. 7). The resultant map is a trend map only and the depths are not accurate. Several features shown in this map are:

(1) the Pintumba Fault which shows up along a 150 m contour,

(2) granite bodies which are coincident with the highs,

(3) a general deepening to the west and

(4) a large central high which coincides with the eastern margin of the Chundie Embayment (Firman, 1975).

4. Regional Interpretation

The 1:1 000 000 scale gravity and magnetic maps are valuable in giving a regional aspe[illegible]al features observed on NULLARBOR and FOWLER. These m[illegible]ented as Enclosures 1 and 2 and an overlay of dominant features [illegible]closure 3.

The circular negative an[illegible]y on NULLARBOR is seen at this scale to be at the intersection of two ma[illegible] faults. The northeast trending one can be traced up to the Coober Pedy sheet. It is associated with highly magnetic dykes and is known as the Karar[illegible]ault. It appears that the basic material in anomaly A1 has intruded an em[illegible]asised crustal weakness at the join of two faults. Some E.R.T.S. lineaments have also been found to coincide with these faults.

To the west of the Denman Trough (Wopfner, 1969) the basement again becomes relatively shallow with depths up to 1 000 m in the COOMPANA area. However, a large negative feature B1 is superimposed at an estimated depth of up to 15 km.

Zone B is truncated at both ends but Zone D is seen to extend to the northeast, up to TARCOOLA (Gerdes, 1975). The magnetic contours over the Great Australian Bight are based on widely spaced data and it is difficult to extend trends in that direction. However, zone D appears to turn southward and forms a rim zone to the Gawler Craton. Based on the gravity data the Pintumba Fault extends 100 km to the south of the coast.

A generalized cross section (Fig. 8) across the eastern Eucla Basin shows the change in magnetic and gravity fields across the depression. The section is diagrammatic as several sources of information are projected and the magnetic data change scale in the east. The magnetic profile shows, from the west, short wavelength anomalies and depths of up to 1 000 m. The longer wavelength occur in the depression and shallower sources less than 500 m are shown over FOWLER. The low intensities over the granite zone are typical of shallow weakly magnetic granites.

IV. CONCLUSIONS

The Gawler Craton consists of a central region of Cleve Metamorphics intruded by several phases of plutonism with overlying, extensive areas of volcanics. The limit and character of the western margin is uncertain (Thomson, 1974). The boundaries on this margin defined geophysically are shown in Figure 9.

The depression under the eastern Eucla Basin is defined by magnetic and gravity patterns and, in general, trends to the northwest. The central feature in this depression is a very large basic body which occurs at the intersection of two major faults. The northeast and south-east extensions of these faults define the western flank of the polygonally bounded Gawler Craton. There is a suggestion of a north-south boundary with evidence from E.R.T.S. lineaments and from magnetic data.

To the east, Zones B, C and D constitute a rim zone to the central craton. These zones are dissected by several faults generally parallel to the rim and dominated by the Pintumba Fault. This fault represents the boundary between the central area and the rim. The rock types in the rim zone are in general more basic and hence higher in susceptibility and density than the central area. Magnetic interpretation shows them to be likely banded iron formations and basic igneous bands. Two large areas of gravity highs seem to be separate high density blocks within this rim.

The rim zone provides the most speculation on the tectonics of the area. The general magnetic dips are towards the central areas which is not compatible with onlapping magnetic sediments. A possibility is that a former basinal area with banded iron formations and basic volcanics has been squeezed into isoclinally folded layers and overturned. This may be the case if the area is between two stable crustal areas which were thrust towards each other. Alternatively the rim may be a zone of extensive basic intrusions by dyke swarms. A third possibility is that it is a zone of high grade metamorphics.

The central areas to the east of the Pintumba Fault is a more acidic province. It is dominated by granitic bodies and Cleve Metamorphics which are generally acid gneisses. The granite bodies are clearly outlined by magnetic and gravity methods and an indication of composition obtained.

The analysis of gravity and magnetic data provides a subsurface interpretation of geology (Fig. 4) in NULLARBOR-FOWLER. This investigation shows that detailed interpretation of regional geophysical surveys is a necessary adjunct to the surface geological study of areas of limited basement exposure.

V. ACKNOWLEDGEMENTS

I would like to acknowledge discussion and information from B.P. Thomson and J.B. Firman of the Regional Geology Division, S. Aust. Geological Survey.

24th November, 1975
DR:IA

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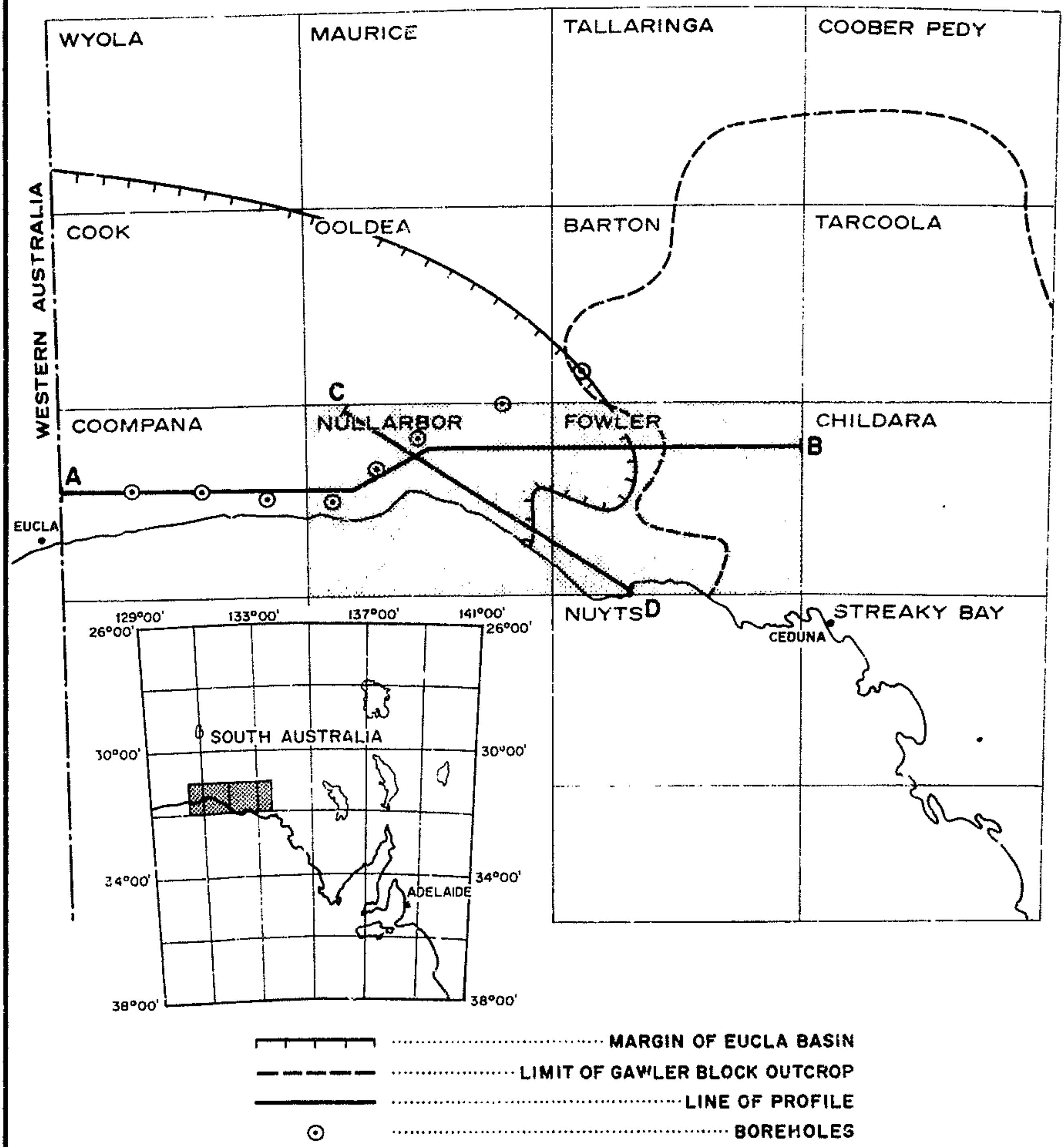


FIG. 1

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE:
COMPILED: D.ROBERTS	NULLARBOR-FOWLER AREA GEOPHYSICAL INVESTIGATION **LOCATION MAP**	DATE: NOV. '75
DRN: R.G. CKD.		DRG. Nº S-12013

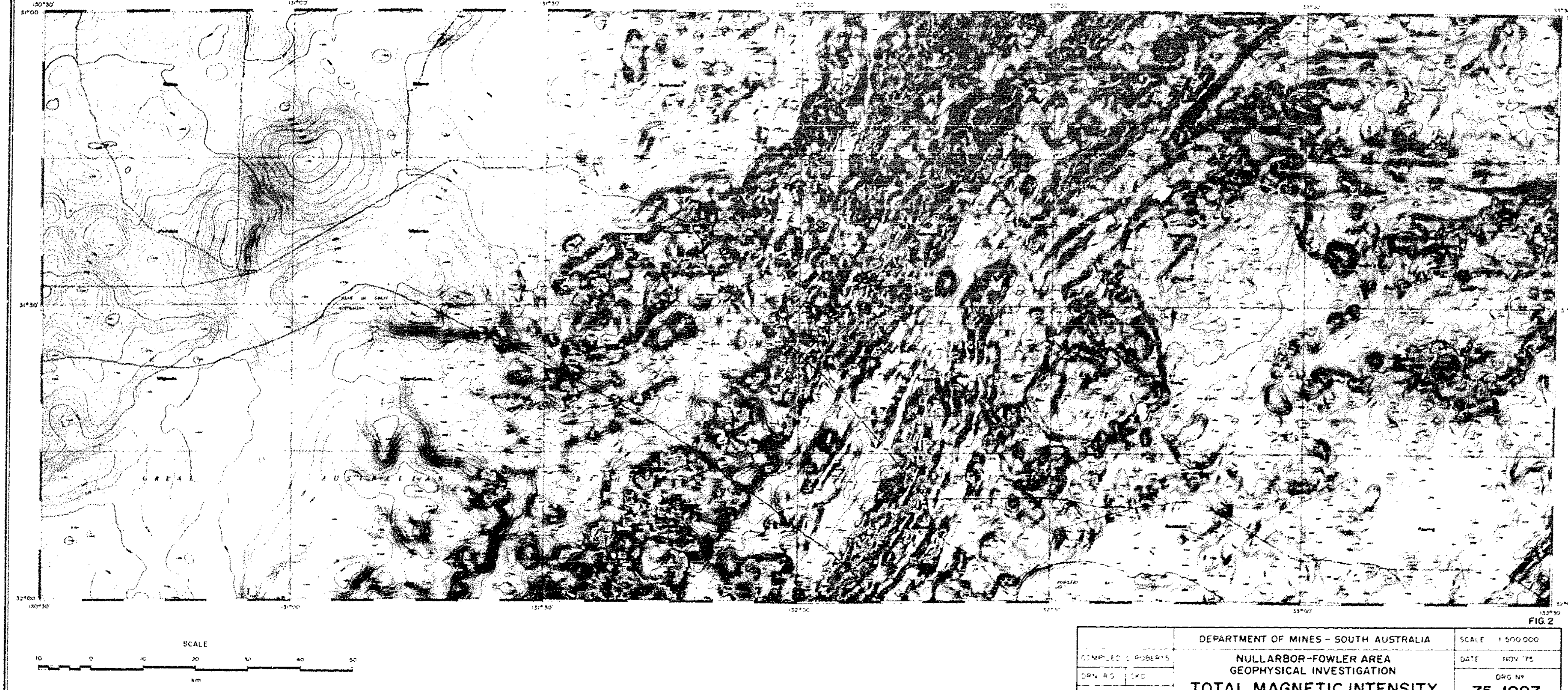


FIG. 2

	DEPARTMENT OF MINES - SOUTH AUSTRALIA	SCALE 1:500 000
COMPILED C. ROBERTS	NULLARBOR-FOWLER AREA GEOPHYSICAL INVESTIGATION	DATE NOV '75
DRN. R.G. | CKD.	TOTAL MAGNETIC INTENSITY	DRG Nº 75-1097

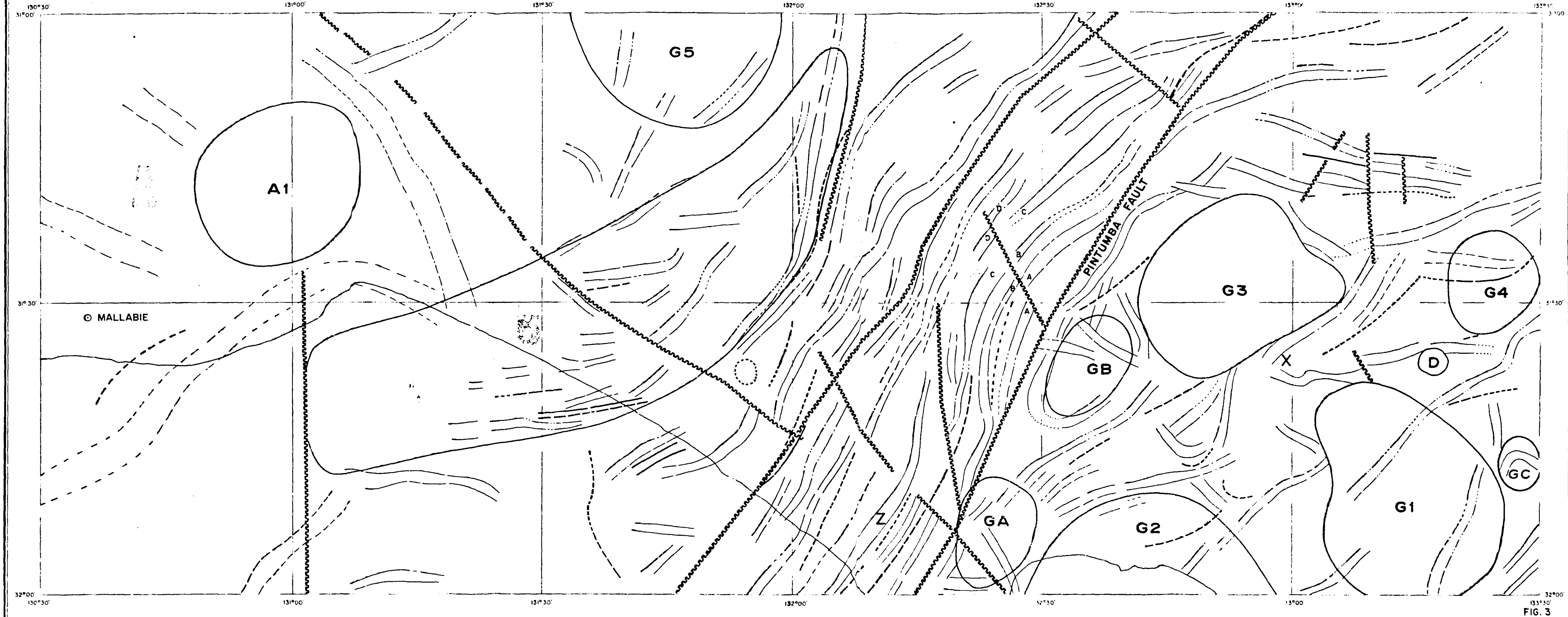


FIG. 3

SCALE

10 0 10 20 30 40 50

km

REFERENCE

FAULT

HIGH / LOW — MAGNETIC TRENDS

ZONES

	DEPARTMENT OF MINES - SOUTH AUSTRALIA	SCALE 1:500 000
COMPILED D. ROBERTS	NULLARBOR-FOWLER AREA GEOPHYSICAL INVESTIGATION	DATE NOV '75
DRN RG / CKD	MAGNETIC TREND MAP	DRG Nº 75-1098

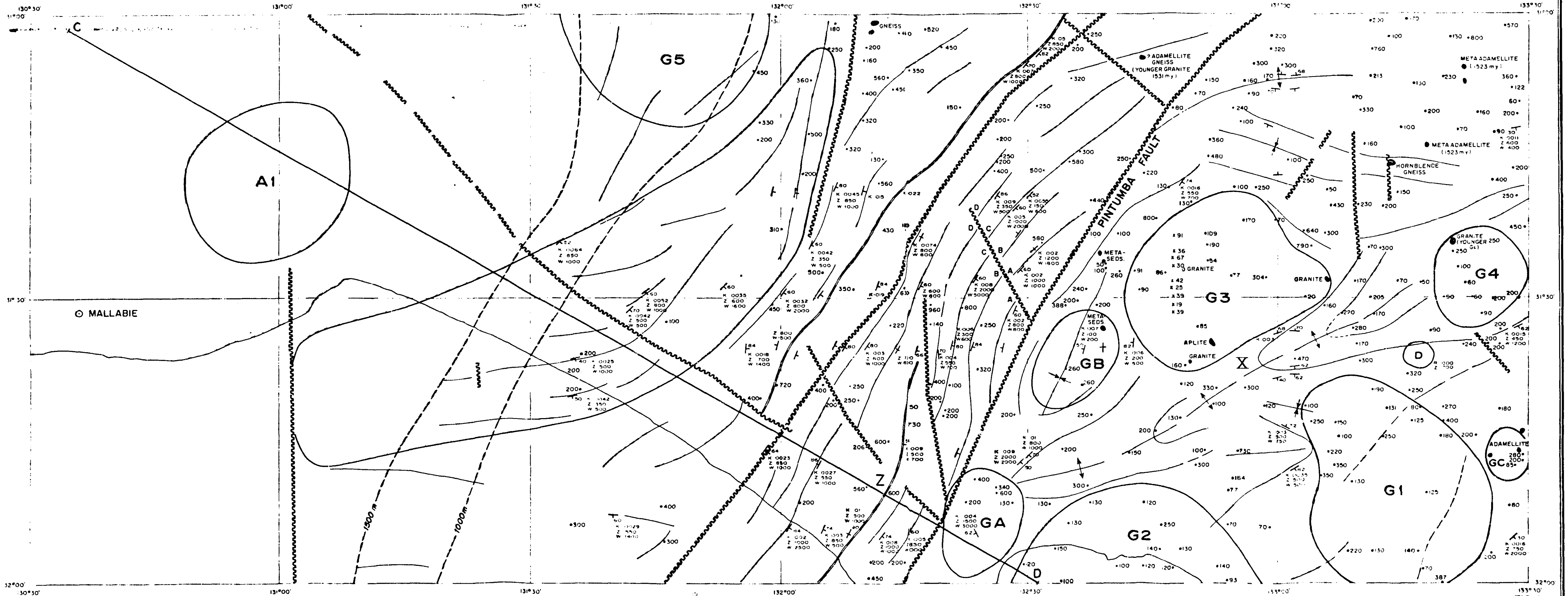


FIG. 4

REFERENCE

MAGNETIC DEPTH CONTOURS	
LAYERING	
FAULTS	
SYNCLINE	
ANTICLINE	
BANDED IRON FORMATION	
T 60	DIP, DEGREES
K	SUSCEPTIBILITY - C.G.S. UNITS
Z	DEPTH
W	WIDTH — METRES
R	RADIUS
×25	BOREDEPTHS TO BASEMENT
•130	DEPTH POINTS (metres)
	BASEMENT OUTCROP
G1 ETC	GRANITE
GA ETC	ADAMELLITE
	ZONES

SCALE

10 0 10 20 30 40 50

km

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE 1:500 000
COMPILED D. ROBERTS	NULLARBOR-FOWLER AREA GEOPHYSICAL INVESTIGATION	DATE NOV '75
DRN RG / CKD	GEOLOGICAL INTERPRETATION	DRG Nº 75-1099

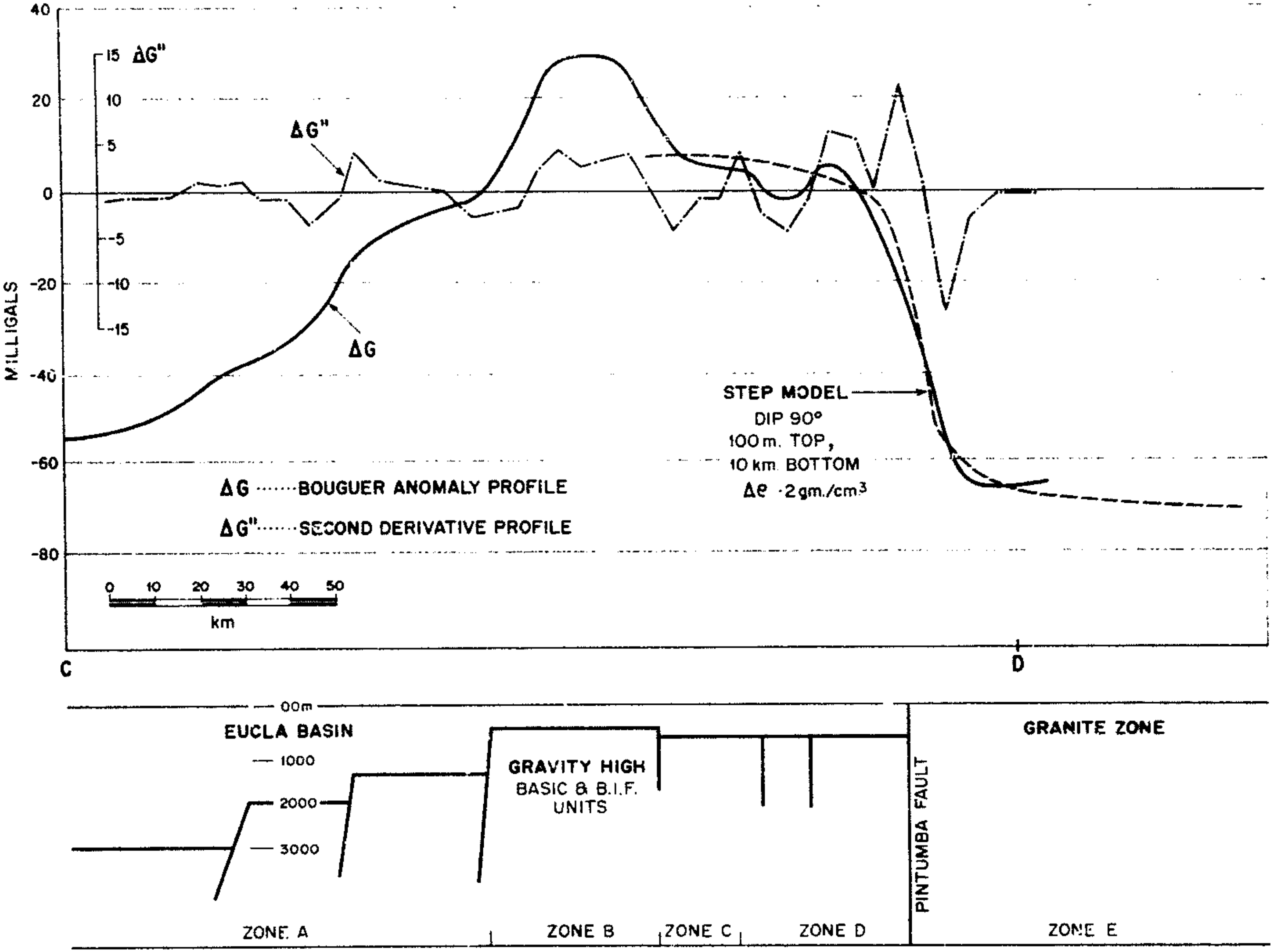


FIG. 5

DEPARTMENT OF MINES – SOUTH AUSTRALIA

NULLARBOR-FOWLER AREA
GEOPHYSICAL INVESTIGATION

GRAVITY PROFILE C-D

COMPILED: D ROBERTS

DRN. R.G. CKD:

DATE: OCT. '75

DRG. Nº S-12014

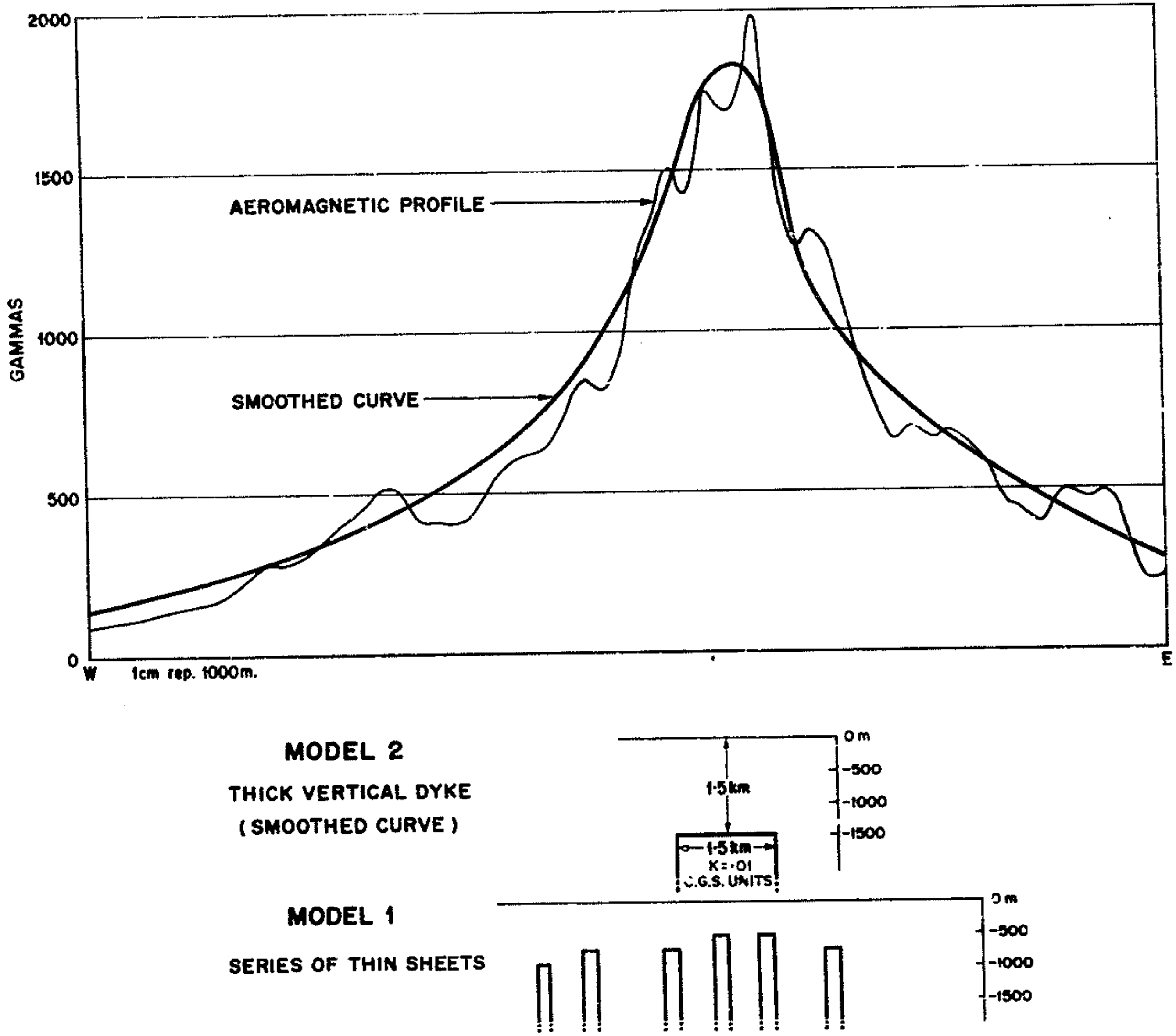


FIG. 6

DEPARTMENT OF MINES – SOUTH AUSTRALIA

NULLARBOR-FOWLER AREA
GEOPHYSICAL INVESTIGATION

MAGNETIC PROFILE OVER ANOMALY 'Z'

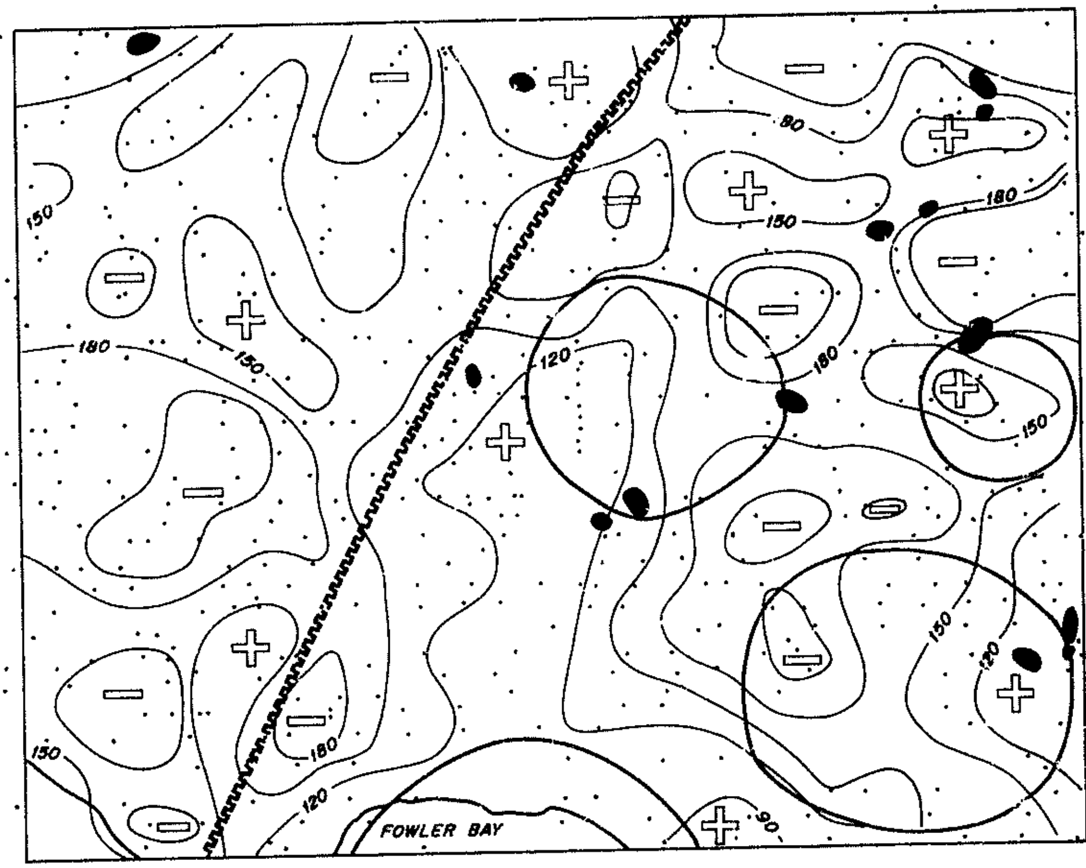
COMPILED: D.ROBERTS

DRN: R.G. CKD:

DATE: OCT. '75

DRG. Nº S-12015

FOWLER 1:250 000 SHEET AREA



GRIDDED .... 5 km. GRID

SMOOTHED .... CENTREPOINT 1/8 WEIGHT

CONTOUR INTERVAL ... 30m. BELOW GROUND LEVEL

DATA POINT .... •

BASEMENT OUTCROP .... ⬬

FAULT .... ʌʌʌʌʌʌʌʌ

GRANITE BODIES .... ⬭

FIG. 7

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE:
COMPILED: D.ROBERTS	NULLARBOR-FOWLER AREA GEOPHYSICAL INVESTIGATION	DATE: NOV. '75
DRN: R.G. CKD:	**DEPTH TO MAGNETIC BASEMENT**	DRG. Nº S-12016

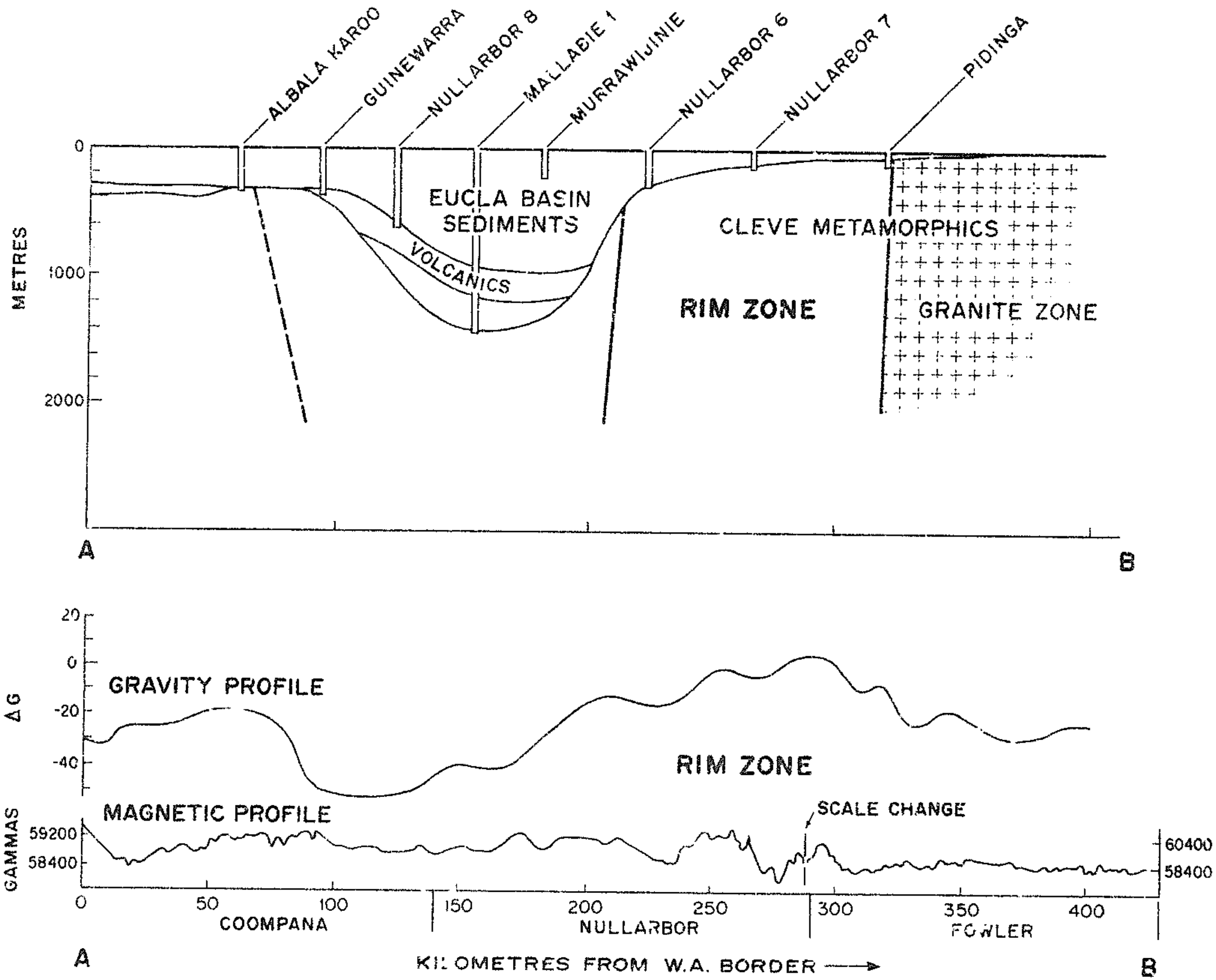


FIG. 8

DEPARTMENT OF MINES – SOUTH AUSTRALIA

NULLARBOR-FOWLER AREA
GEOPHYSICAL INVESTIGATION

REGIONAL PROFILE A-B

COMPILED: D.ROBERTS

DRN: R.G. | CKD:

SCALE:

DATE: NOV. '75

DRG. No S-12017

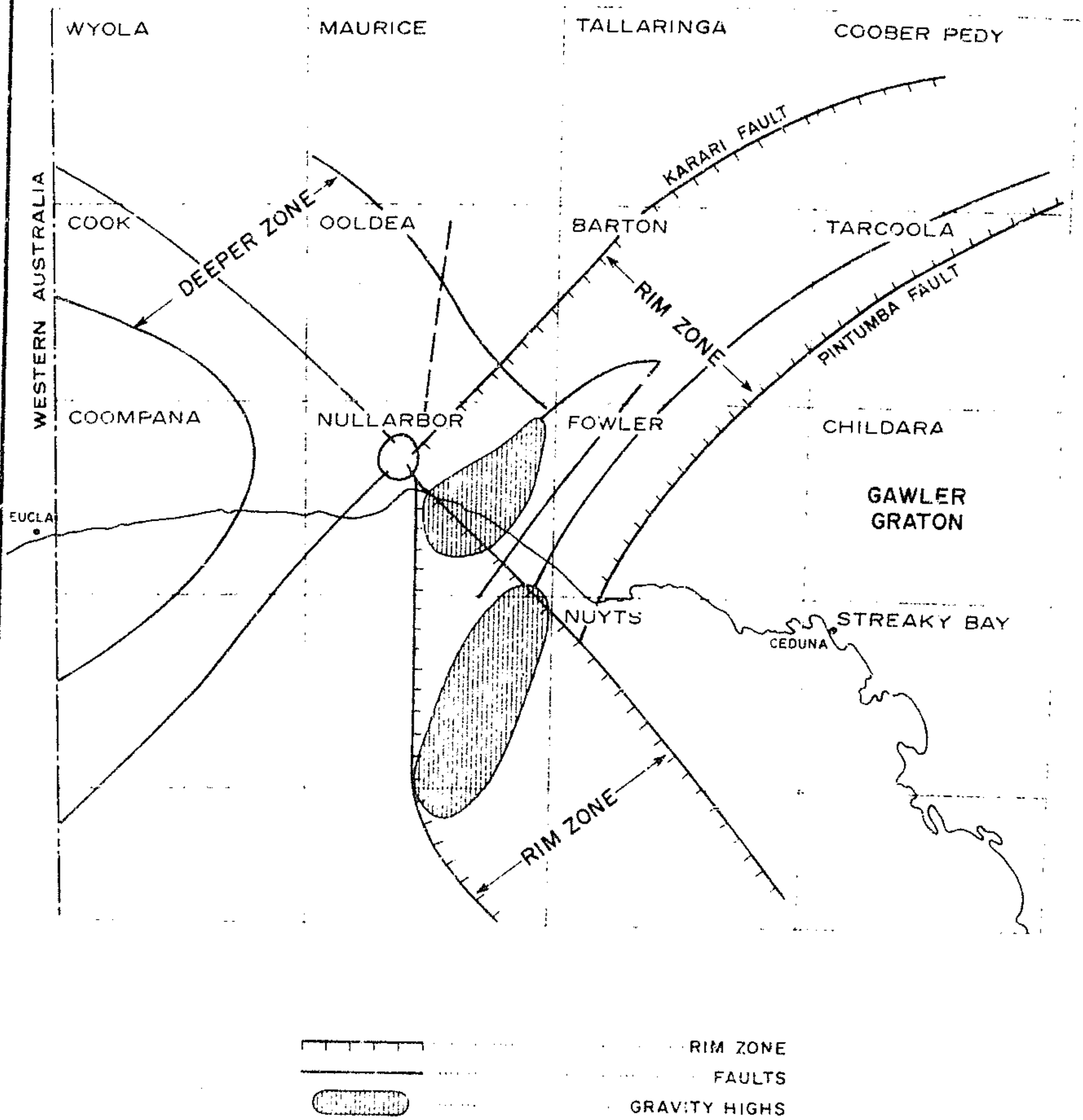


FIG. 9

DEPARTMENT OF MINES – SOUTH AUSTRALIA

COMPILED D ROBERTS

DRN: R G | CKD

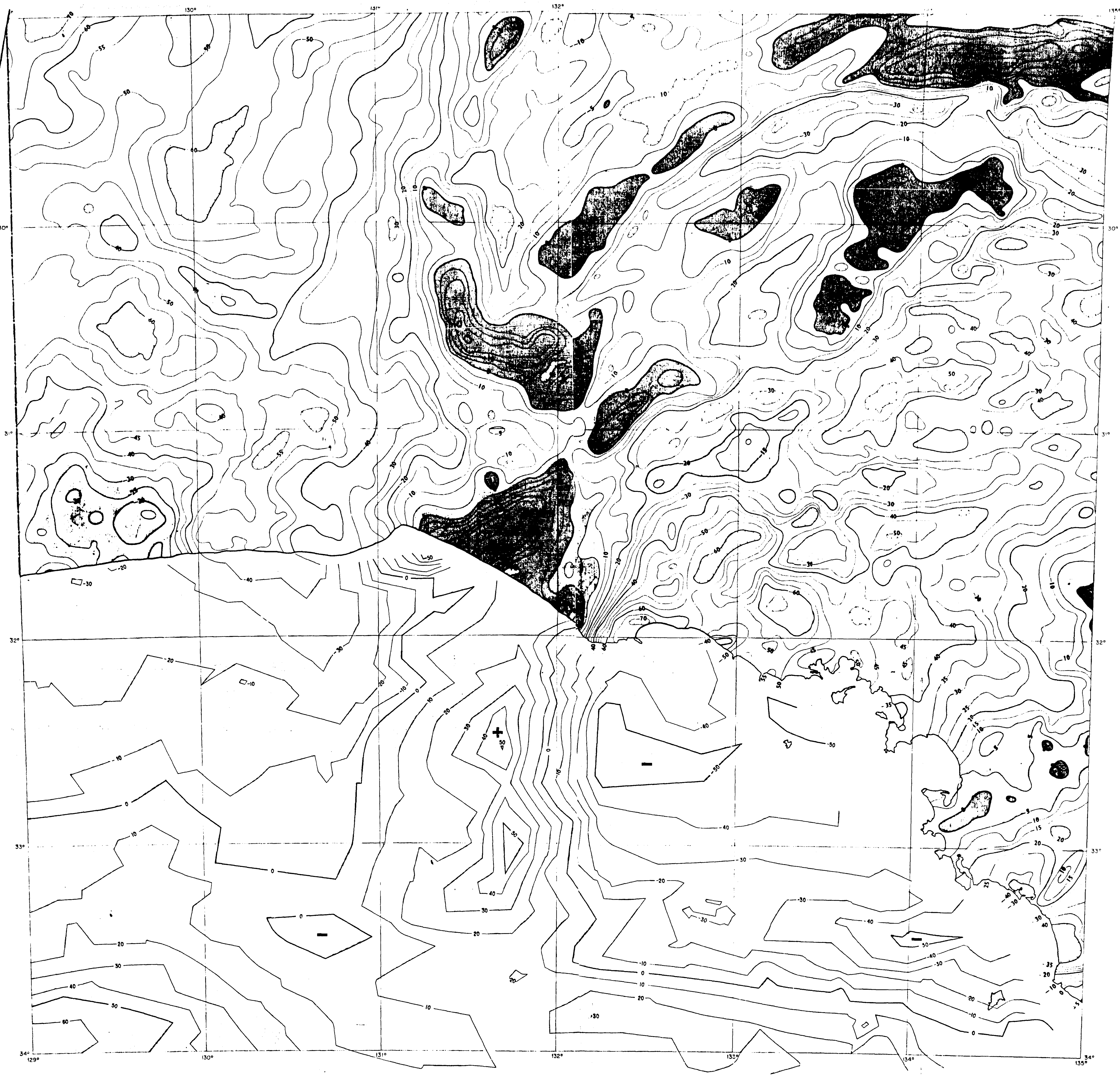
NULLARBOR-FOWLER AREA
GEOPHYSICAL INVESTIGATION

REGIONAL BASEMENT GEOLOGY

SCALE

DATE NOV '75

DRG No S-12018



SCALE

20 0 20 40 60 80 100

km

ONSHORE DATA FROM STATE 1:1000000 MAP
CONTOUR INTERVAL: 5 milligals

OFFSHORE DATA FROM B.M.R. CONTINENTAL SHELF SURVEY
CONTOUR INTERVAL: 10 milligals.

ENC.1

DEPARTMENT OF MINES-SOUTH AUSTRALIA				
NULLARBOR-FOWLER AREA GEOPHYSICAL INVESTIGATION				
BOUGUER GRAVITY CONTOURS				
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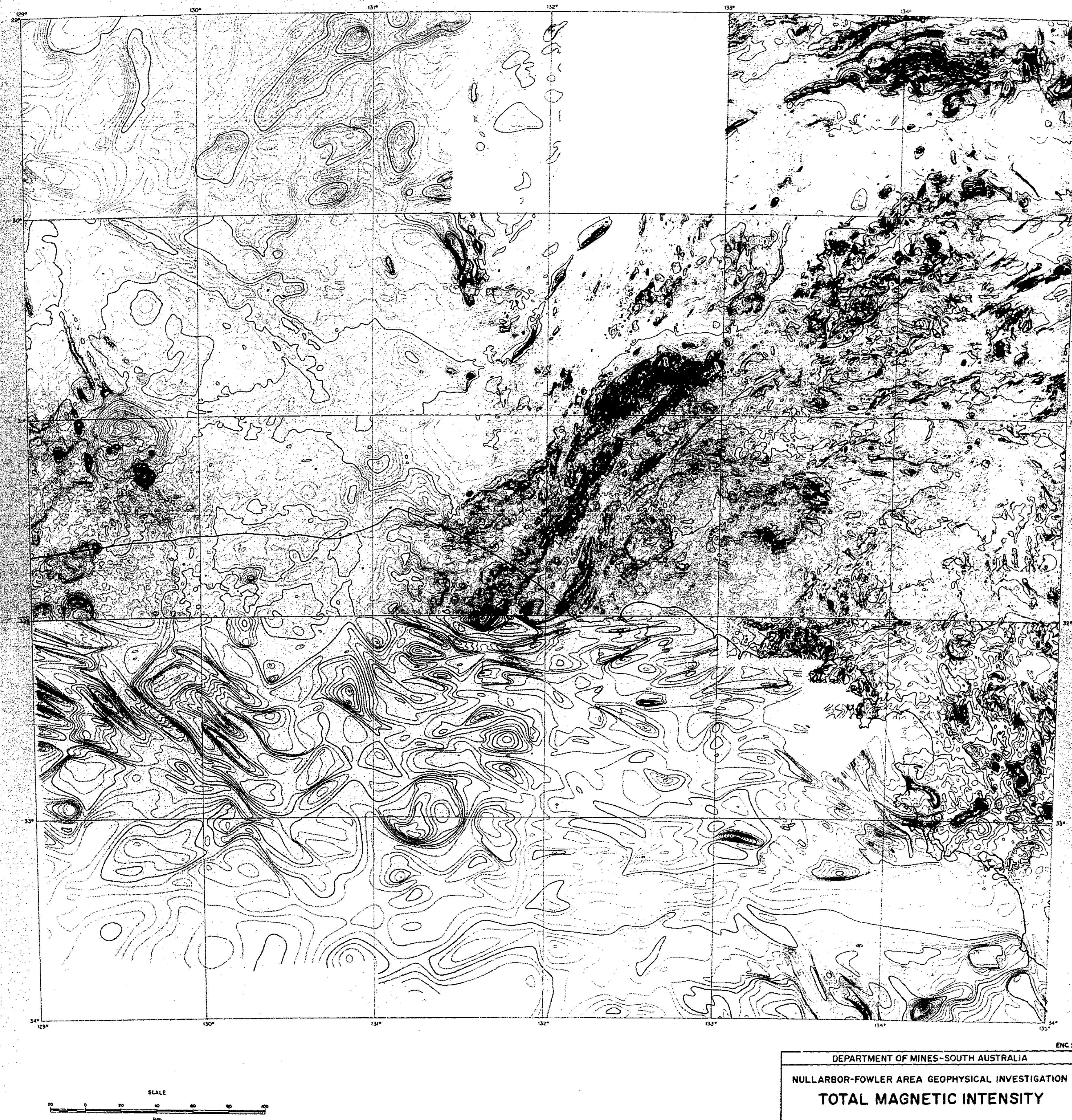
DIRECTOR OF MINES		CKD:	DATE: OCT '75	75-1100



ENC. 2

DEPARTMENT OF MINES–SOUTH AUSTRALIA				
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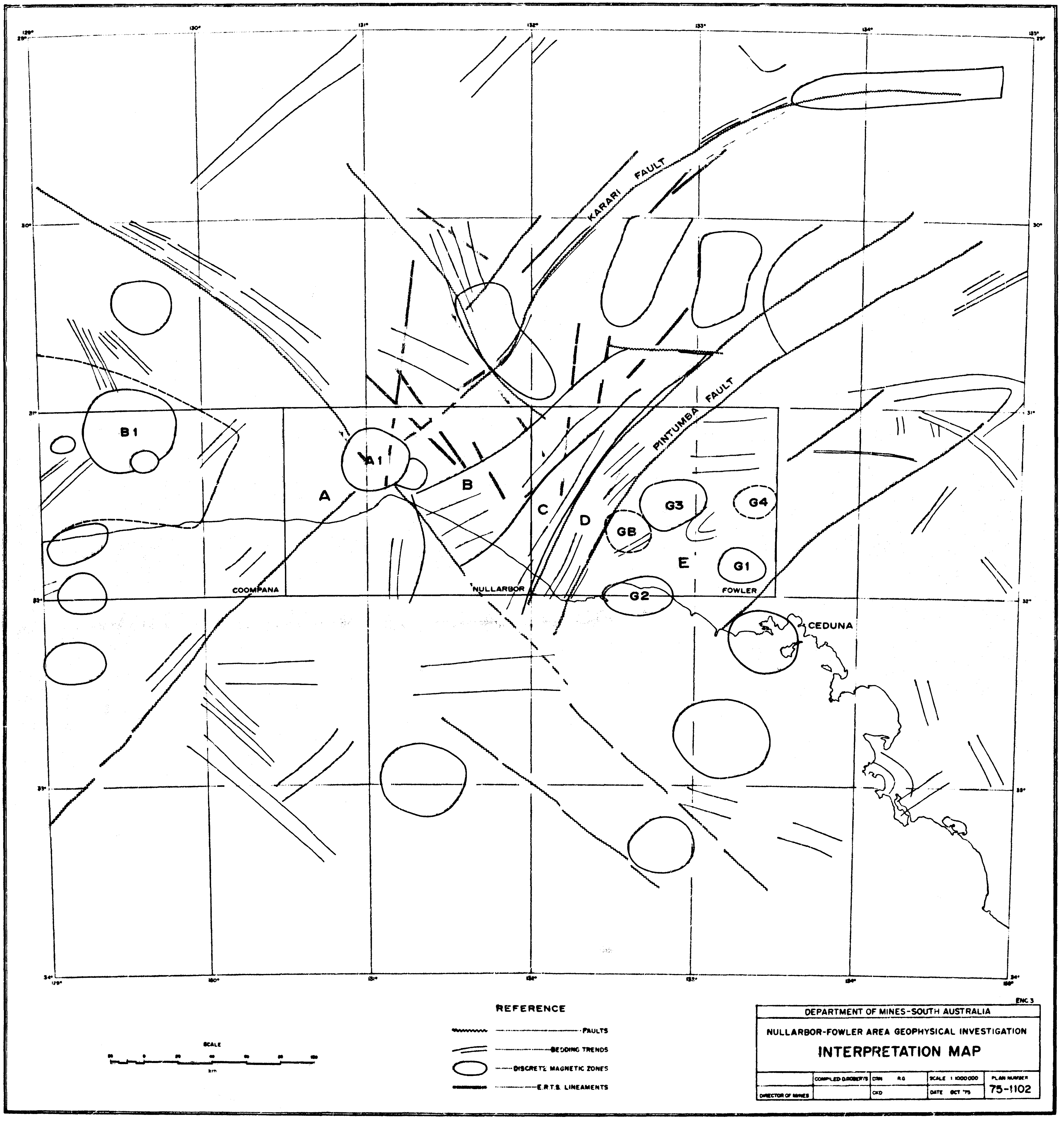
KARARI FAULT
PINTUMBA FAULT
B1
A1
A
B
C
D
E
GB
G1
G2
G3
G4
COOMPANA
NULLARBOR
FOWLER
CEDUNA
REFERENCE
FAULTS
BEDDING TRENDS
DISCRETE MAGNETIC ZONES
E.R.T.S. LINEAMENTS
SCALE
km
ENC 3
DEPARTMENT OF MINES-SOUTH AUSTRALIA
NULLARBOR-FOWLER AREA GEOPHYSICAL INVESTIGATION
INTERPRETATION MAP
COMPILED D.ROBERTS
SCALE 1:1000000
DATE OCT '75
PLAN NUMBER
75-1102
DIRECTOR OF MINES