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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/164

ADAVALE BASIN SEMI - DETAILED GRAVITY SURVEY,

SOUTH QUEENSLAND 1964

by

F. DARBY

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1966/164

SUMMARY

Between August and December 1964, a semi-detailed gravity survey was conducted for the Bureau of Mineral Resources by Compagnie Generale de Geophysique along seismic traverses of Phillips Petroleum Company in the Adavale Basin, south-west Queensland. There is excellent qualitative correlation between the gravity pattern and the sub-surface geology, gravity 'lows' corresponding to areas of pre-Permian sedimentation of the Adavale Basin, Cooladdi Trough, and Westgate Trough. Steep gravity gradients correspond to the faulted and steeply truncated margins of these depositional areas. However, no large gravity expression is found of some structures within the Adavale Basin, such as the Gilmore Trend and the Etonvale Dome. This is probably due to the density changes within the basin sediments and within the basement. The gravity anomaly over the north-easterly extension of the Cocladdi Trough is not consistent with the thickness of sediments indicated by seismic work. A more detailed interpretation of the results is recommended when more density information becomes available.

1. INTRODUCTION

This Record presents the preliminary results and interpretation of the 1964 contract gravity survey conducted by Compagnie Generale de Geophysique for the Bureau of Mineral Resources, Geology and Geophysics (BMR), along seismic traverses of Phillips Petroleum Company in south-west Queensland. Approximately 10,000 square miles were surveyed (Plate 1) covering parts of BLACKALL, ADAVALE, AUGATHELLA, QUILPIE, and CHARLEVILLE. The survey commenced on 17th August and was completed on 15th December 1964. It was conducted from 14 base camps.

The initial part of the survey was the establishment of a network of primary bases, each base being read three times for the purpose of drift control. This network of bases (Plate 3) was adjusted between the Isogal values (B.C. Barlow, pers.comm.) at Quilpie Airport (979,007.97 mgal) and Charleville station No. BM-35 (978,967.36 mgal). The remainder of the stations (Appendix A), approximately 2700 of them, were established and adjusted within this basic network. The survey was also tied to a number of gravity control stations of the 1964 BMR helicopter gravity survey (see Appendix A.).

Elevation data for the survey were based on the levelled network of seismic traverses of Phillips Petroleum Company. Three different datum levels were used for these elevations, namely benchmarks at Quilpie, Yaraka, and Charleville. To establish the elevations on to a common datum the elevations tied to Yaraka were reduced by 18 ft and these tied to Charleville by 28 ft.

The survey was planned as a semi-detailed gravity survey along seismic traverses to determine the correlation between the geological structure of the Adavale Basin and the gravity anomalies. The majority of the stations were planned to be read at one-mile intervals but over important structures the separation was decreased to one-third of a mile, in an attempt to delineate these structures more precisely. The survey was located within the area of the 1964 BMR helicopter gravity survey, which will provide the regional gravity setting of the area. The survey was planned over a known pre-Mesozoic basin to determine the nature of the gravity anomalies associated with such basins and so provide criteria to aid the interpretation of gravity anomalies in other parts of the Great Artesian Basin.

2. GEOLOGY

The survey area is situated within the Eromanga Basin. The surface geology within this part of the Eromanga Basin is poorly exposed, the outcrops consisting almost entirely of a superficial lateritic zone developed on Cretaceous sediments. The geology presented in this report is based on seismic surveys and drilling operations conducted for Phillips Petroleum Company and Sunray Mid-Continent Oil Company (Phillips-Sunray).

Beneath a cover of Mesozoic sediments there are thick deposits of Palaeozoic sediments forming the Adavale Basin, which is a structural remnant of a basin of deposition of Carboniferous-Silurian age, deformed and largely removed by erosion prior to Permian times. The Mesozoic sediments range from 4000 to 9000 ft in thickness and are regionally tilted to the south-west. Local structure in the Mesozoic formations is believed to be predominantly the result of draping, due to the compaction of the Palaeozoic sediments (Phillips-Sunray, 1961-1964). The NE-trending Adavale Basin is about 60 to 70 miles wide and contains a maximum thickness of about 18,000 ft of sediments.

The stratigraphic succession in this area has been obtained from the Buckabie No. 1, Cothalow No. 1, Etonvale No. 1, Gumbardo No. 1, and Gilmore No. 1 wells drilled by Phillips-Sunray. The general succession found in these wells and in the Boree No. 1, Westbourne No. 1, and Canaway No. 1 wells drilled by American Overseas Petroleum Ltd (Amoseas) is shown in Table 1. Details of the succession in each well are given in Appendix B.

The basement rocks of the Adavale Basin are variable, e.g. granite, phyllite, and basalt were encountered in Buckabie No. 1, Etonvale No. 1, and Gumbardo No. 1, respectively. Sediments within the Adavale Basin also have greatly varying lithologies. The Gumbardo Formation consists predominantly of acid volcanic flows, altered lithic tuffs, and re-crystallised, silicified crystal tuffs. The overlying Etonvale Formation consists mainly of shallow marine and contintental sandstones and shale with some calcareous sediments. There are rapid facies changes in this formation as shown by the 1500 ft of rock salt and dolomite found in Boree No. 1 (Amoseas, 1964). The overlying Buckabie Formation is a sand-shale sequence. It is therefore apparent that rapid changes in lithology occur both within the 'basement' and within the sediments of the Adavale Basin.

Structure

The Adavale Basin is bounded on the east, south, and south-west by major faults (Plate 2) and sharply truncated monoclines, with structural relief on 'basement' frequently exceeding 15,000 ft across a relatively narrow belt. In the north-west the Adavale Basin sediments thin by overlap on to the Yaraka Shelf. Many structures have been defined within the Adavale Basin, the major one being a structural 'high' that may extend over the length of the basin, a distance of nearly 120 miles from the Cothalow Arch in the south-west to the anticlinal structures near Carlow in the north-east (Plate 2). Palaeozoic sediments are also found to the south-east of the Adavale Basin in the Cooladdi and Westgate Troughs.

Structures have also been mapped where Mesozoic sediments rest directly on Lower Palaeozoic basement, e.g. the Pleasant Creek Anticline to the east of the Adavale Basin and the Quilberry Creek Anticline to the north-east of the Cooladdi Trough.

3. GRAVITY FEATURES

The area is situated close to the south-eastern margin of the Thomson Regional Gravity Low (Gibb, in prep.). In the northern portion of the Thomson Regional Gravity Low the broad regional 'low' has been partly related to the thickness of Mesozoic sediments and partly related to the Lower Palaeozoic metamorphic basement (Gibb, in prep.). The residual 'lows' are related to intra-basement density variations and to pre-Mesozoic sediments overlying a lower Palaeozoic 'basement'. The present survey was conducted over one of these residual 'lows' (The Adavale Gravity Low) which has been proven, by seismic and drilling exploration, to correlate with a pre-Mesozoic basin. The gravity pattern delineated by the survey described in this Record is illustrated in Plate 4 and the gravity anomaly features of this pattern are described and named in Table 2.

TABLE 1

Stratigraphic succession, Adavale Basin

Age	Formation	Maximum Thickness (ft)	Lithology
Cretaceous Upper	Winton Formation	1350	Sandstone, shale, thinly bedded coal.
	Tambo Formation	1250	Alternating shale and sandstone.
Lower	Roma Formation	920	Fossiliferous shale and minor siltstone; some limestone.
Cretaceous-Jurassic	Blythesdale Formation	1612	Sandstone and shale. Transition Beds - Mooga Sandstone - Fossilwood Beds - Gubbaramunda Sandstone.
Jurassic	Walloon Coal Measures	330	Lignitic shale, thin coal seams, sandstone.
	Hutton Sandstone	880	Sandstone.
Permian		730	Sandstone, shale.
Carboniferous to Upper Devonian	Buckabie Formation	10,000	Reddish-brown argillaceous sandstone, varicoloured shales, conglomerate, some anhydrite.
Middle to Lower Devonian	Etonvale Formation	5,000	Sandstone, shale and carbonate, marine dolomite.
Middle to Lower Devonian Silurian	Gumbardo Formation	2,400	Acid volcanics and tuffs
Ordovician and older	Basement rocks		Granite, phyllite, basalt.

TABLE 2

Gravity anomaly features (Plate 4)

Feature	Name	Description
1	Yaraka Gravity High	Zone of relatively high gravity values in the north-west of the area of the survey.
2	Adavale Gravity Low	Semi-regional gravity 'low' in centre of the Adavale 1:250,000 map area.
3	Thistle Creek Gravity Gradient	South and south-westerly trending gravity gradient to the east of feature 2.
4	Augathella Gravity High	Zone of relatively high gravity values to the east of feature 3. Comprises the Pleasant Creek Gravity High (4a), the Highfields Gravity Low (4b), and the Westbourne Gravity High (4c).
5	Pingene Gravity High	Zone of relatively high gravity values in the south of the area.
6	Cooladdi Gravity Trough	South-easterly trending gravity 'low' to the south-east of feature 2.
7	Quilberry Gravity High	Small gravity 'high' to the north-east of feature 6.
8	Auburn Gravity Low	Gravity 'low' to the north-east of feature 6.
9	Westgate Gravity Low	Gravity 'low' to the east of feature 6.

4. INTERPRETATION

As stated previously the rock types present in the area show great lateral and vertical changes in lithology and therefore probably in density. Density information in the area is limited to samples taken from cores in some of the wells in the area. These cores are not a sufficiently representative sample of the stratigraphy for an accurate evaluation of the density contrasts present in the basin. This is a very serious hindrance in any attempt at quantitative interpretation.

In this area the gravity interpretation is aided by the fact that excellent subsurface control exists over much of the area. Many of the gravity features can be directly correlated to structural elements within the Adavale Basin. Cross-sections AB, CD, and EF (Plates 5, 6, and 7 respectively) show many of these structural elements together with the Bouguer anomaly profile.

Throughout the area there is excellent broad qualitative correlation between the gravity features and the geological structure. The relative gravity 'highs' (features 1, 4, 5, and 7) are associated with areas where pre-Permian sediments are absent or very thin, and the gravity 'lows' (features 2, 6, 8, and 9) are correlated with areas of pre-Permian sedimentation, namely the Adavale Basin (feature 2), the Cooladdi Trough (feature 6), and the Westgate Trough (feature 9). Steep gravity gradients are associated with the major faults and steeply upturned Palaeozoic beds which bound the Cooladdi Trough and the eastern and southern margins of the Adavale Basin. The component features of the Augathella Gravity High (feature 4) can also be correlated with basement topography on this high-standing block (Plate 5).

Each profile shows the structural geology as indicated by seismic work together with three gravity curves. These three gravity curves are:

a) Observed Bouguer anomaly.

b) Computed gravity effect of the Permian-Mesozoic sediments.

c) The residual anomaly when (b) is subtracted from (a).

The gravity effect of the Permian-Mesozoic sequence was computed using the plate formula:

$$g = 12.77 \, dh \text{ mgal},$$

where g is the gravity effect in milligals,
d is the assumed density contrast between the Permian-Mesozoic rocks and basement, and
h is the thickness of the Permian-Mesozoic sequence in kilo-feet.

A density contrast of 0.5 g/cm^3 was used between the Permian-Mesozoic rocks and Lower Palaeozoic basement. Although this may not be the true density contrast it is suitable for demonstration purposes.

The 'residual' anomaly is correlated with density contrasts below the base of the Permian (if the assumption of a uniform density contrast of 0.5 g/cm^3 between the Permian-Mesozoic sequence and the Lower Palaeozoic basement is correct). If no broad regional anomalies are present, the magnitude of the 'residual' anomaly should be the same in all areas where Mesozoic sediments lie directly on basement. However, on the three profiles drawn there is a definite rise in the 'residual' anomaly towards the west. This rise is considered to be substantially greater than any effect due to erroneous density assumptions for the Permian-Mesozoic and could be due to an increase in basement density or a regional rise in a Lower Palaeozoic or Precambrian unconformity towards the west.

Small residual gravity 'lows' (Plates 5 and 6) are associated with the Etonvale Dome and the Cothalow Arch respectively, but these are minor compared to the size and relief of the structures. As Etonvale No. 1 bottomed in granite it is possible that a granite ridge extends along the length of the Adavale Basin. There is no gravity expression of the large fault and trough to the west of the Etonvale Dome (Plate 5) and this is probably due to the effect of varying densities within the 'basement' offsetting the gravity effects of the fault. In fact the presence of granite on the upthrown side may, if absent on the downthrown side, well account for the effect.

There is excellent correlation between the gravity results and the eastern geological margin of the Adavale Basin. The Thistle Creek Gravity Gradient is about 18 mgal in amplitude on the residual anomaly curve (Plate 5), which would indicate a fault with a 6000-ft throw for a density contrast of approximately 0.2 g/cm^3 between the middle Palaeozoic rocks and basement. Such a density contrast is plausible. The gravity gradient indicates that the trace of the fault is about two miles further to the east than indicated by the seismic results.

The Cooladdi Gravity Trough has Bouguer anomaly values similar to those of the Adavale Gravity Low, which suggests that there is a similar thickness of sediments in the Cooladdi Trough as in the Adavale Basin, i.e. about 20,000 ft. This is consistent with the seismic results. However, the north-easterly extension (feature 8) of feature 6 indicates that there is a similar thickness in this area as well, but the seismic results only indicate 5000 ft. This could mean that there is a rapid facies change in this trough or that there is present a yet undetected sequence of sediments. The Westgate Gravity Low (feature 9) is correlated with the north-trending Westgate Trough, which was detected by seismic means.

5. CONCLUSIONS

The semi-detailed gravity survey was successful in that gravity 'lows' are found to correlate with areas of pre-Permian sedimentation and relative gravity 'highs' are related to areas where the Mesozoic-Permian sequence rests directly on basement. Thus there is good qualitative correlation between the gravity pattern and the major structural elements.

However, certain of the large structures within the basin do not have related gravity anomalies. The Etonvale Dome and bordering faults do not appear to have a clearly defined associated gravity feature and the gravity 'high' associated with the Cothalow Anticline appears to be wholly related to the configuration of the pre-Permian unconformity. It is thought that density contrasts within the basement and within the Palaeozoic sediments are common, but without a detailed knowledge of the densities the prediction of intra-basin structures from the gravity pattern must be treated with caution;

even so, the predictions may well be worth checking by further exploration.

However, it has been shown that there is good qualitative correlation between the Bouguer anomaly and/or residual features and many important structural features. It may be inferred that in some cases other gravity 'lows' within the Thomson Regional Gravity Low will correlate with pre-Permian sedimentation.

6. REFERENCES

GIBB, R.A. — Reconnaissance gravity survey, north Eromanga and Drummond Basins, central Queensland (1959-1963). *Bur.Min.Resour. Aust.Rec.* (in preparation).

PHILLIPS-SUNRAY 1961 a — Jundah-Yaraka-Blackwater-Langlo area seismic survey, Qld 1961.*

1961 b — Adavale seismic survey, Qld 1961.*

1961 c — Cothalow No. 1 well completion report.*

1962a — Gumbardo seismic survey, Qld 1961-1962.*

1962b — Etonvale No. 1 well completion report.*

1962c — Buckabie No. 1 well completion report. *Bur.Min.Resour.Aust. P.S.S.A. Rep.* 41.

1963a — Quilberry Creek seismic survey, Qld 1962.*

1963b — Gowan Range seismic survey, Qld 1963.*

1963c — Pleasant Creek seismic survey, Qld 1962-1963.*

1963d — Gumbardo No. 1 well completion report.*

1963e — Highfields seismic survey, Qld 1963.*

1964 — Gilmore seismic survey, Qld 1963.*

AMOSEAS 1964 — Boree No. 1 well completion report.*

* Unpublished reports on Commonwealth-subsidised operations.

APPENDIX A

Survey statistics

Survey commenced	:	17th August 1964
Survey completed	:	15th December 1964
1-mile stations	:	2017
1/3-mile stations	:	600
Tie stations	:	57
Base stations	:	31
Miles of traverse	:	2217
Number of working days	:	111
Miles per day	:	20.0
Gravity meter	:	Worden 709
Calibrations	:	(12.8.64) 1.016(4) mgal per scale division.
	:	(21.12.64) 1.017(6) mgal per scale division.

APPENDIX B

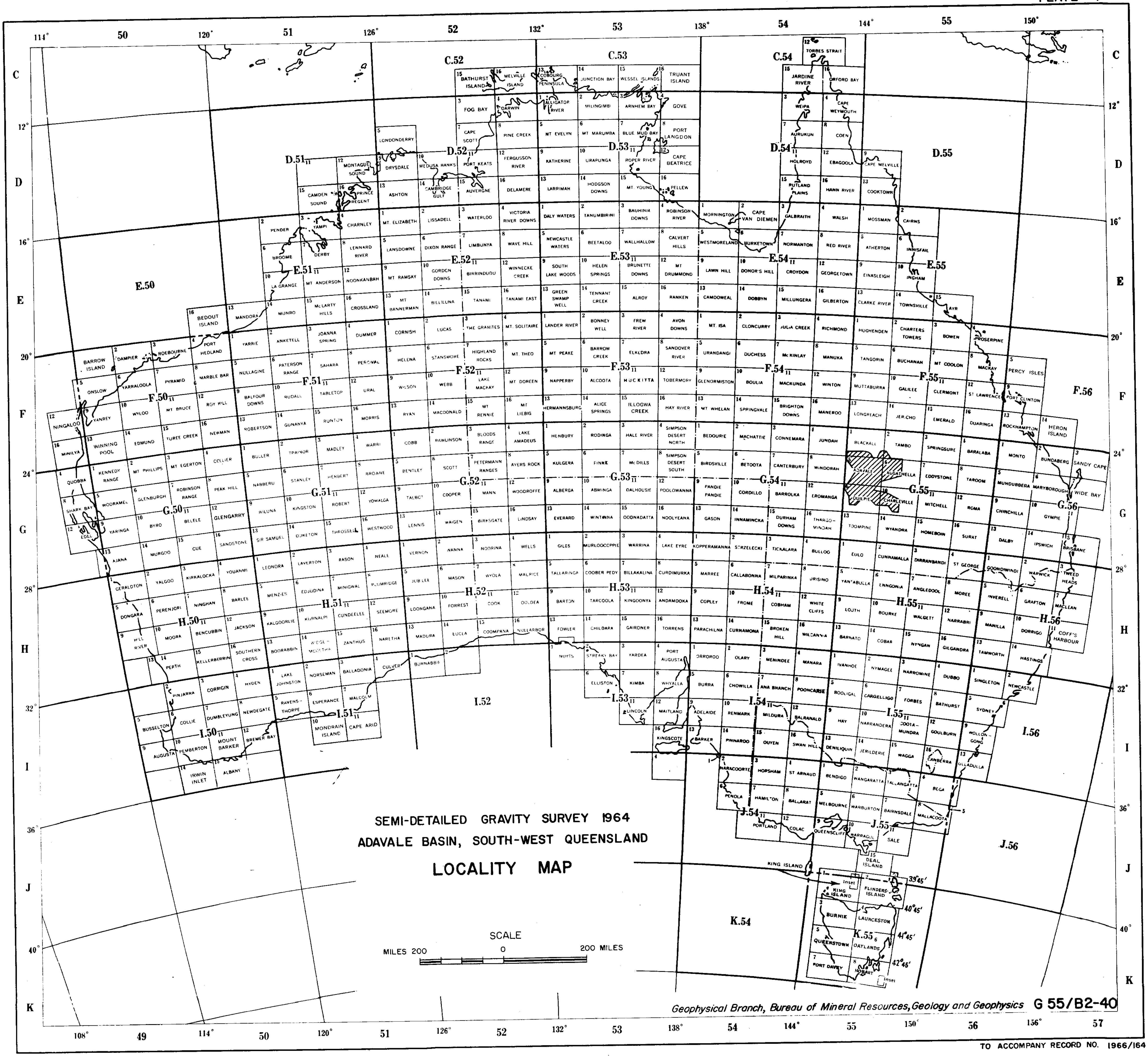
Formation thicknesses intersected in wells

Well Name Latitude Longitude Elevation Bouguer Anomaly		Buckabie No. 1 26°11'40"S 144°16'05"E 724 ft - 33.0	Cothalow No.1 25°43'47"S 144°23'41"E 791 ft - 31.5	Etonvale No. 1 25°09'[illegible]"S 144°59'40"E 1083 ft - 31.9	Gumbardo No.1 25°58'52"S 144°41'41"E 916 ft - 41.0	Gilmore No. 1 25°21'52"S 144°48'54"E 1058 ft	Boree No. 1 24°45'32"S 145°34'36"E 1094 ft	Westbourne No. 1 25°11'27"S 146°08'02"E 1231 ft	Canaway No.1 25°56'06"S 143°57'47"E 770 ft
Upper Cretaceous	Winton Formation	1126	1121	1353	790	1654	-	-	982
Lower Cretaceous	Upper Tambo Formation	621	610	473	518	430	624	886	468
Lower Cretaceous	Lower Tambo Formation	607	653	646	567	718			700
Lower Cretaceous	Roma Formation	810	827	914	917	860	808		717
Upper Jurassic	Blythesdale Formation	1043	1612	944	1094	1018	701	978	1063
Middle Jurassic	Walloon Coal Measures	163	287	325	238	277	305	364	220
Lower Jurassic	Hutton Sandstone	435	-	879	604	829	1332*	2240x	624
Upper Permian		-	-	112	-	-	223	118	-
Lower Permian		102	-	621	-	645	448		-
Upper Devonian - Carboniferous	Buckabie Formation	3900	775 +	-	3356	4101	-	-	-
Middle Devonian	Etonvale Formation	-	-	1395	-	2566	1841	-	-
Lower Devonian		-	-	1878	2309	1148+	2247	-	-
Silurian		-	-	1620	-		234	-	-
Middle Devonian	Gumbardo Formation	-	-	-	2442		-	-	-
	Basement rocks	Phyllite	-	Granite	Olivine Basalt		Silicified Arkose	Indurated Shale	Phyllite
	TOTAL DEPTH	9070	6025	11,368	12,940	14,246	8731	4867	4930

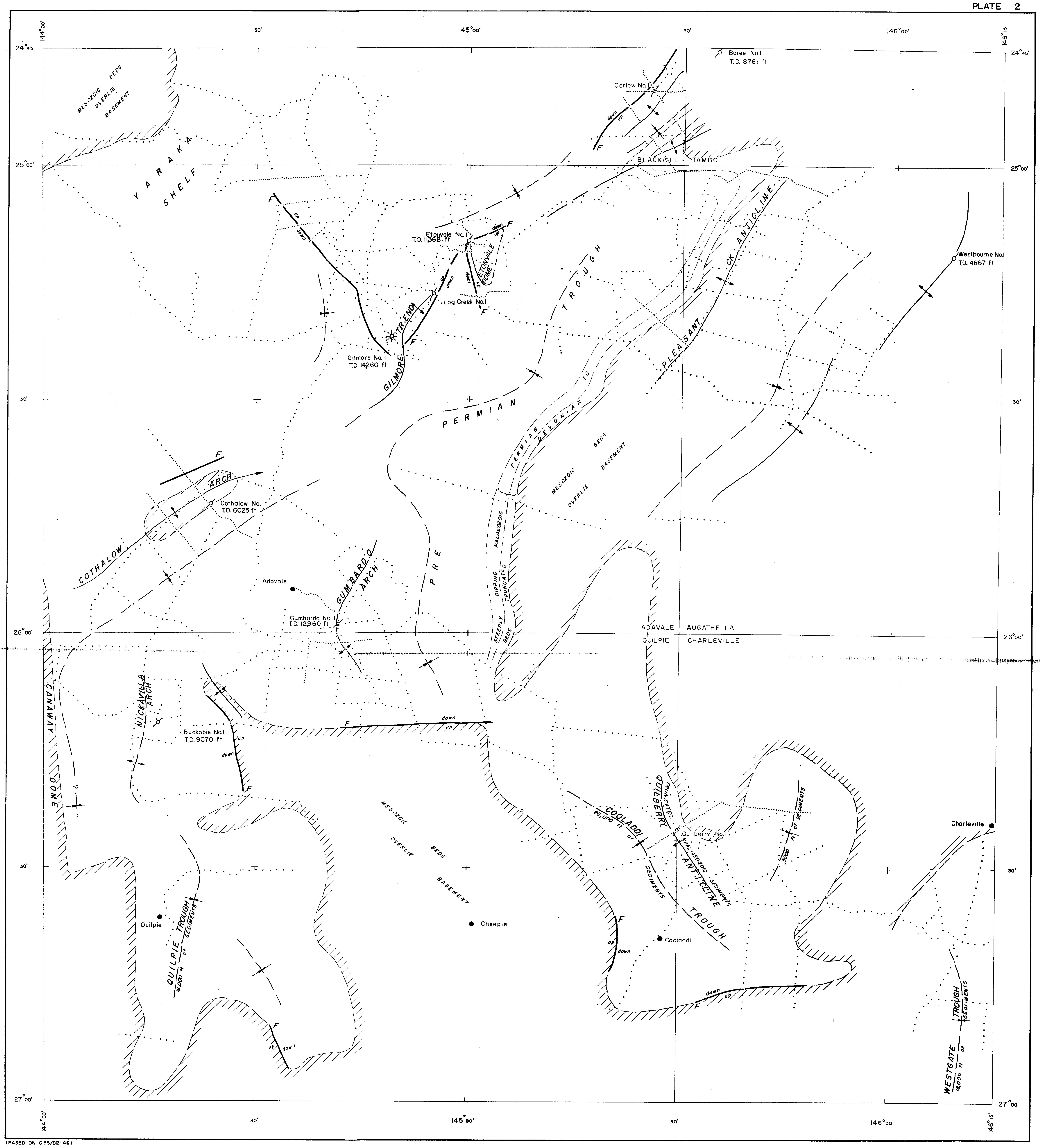
* 43[illegible] ft of Clematis Sandstone

x includes 582 ft of Moolayember Formation and 600 ft of Clematis Sandstone

PLATE 1



TO ACCOMPANY RECORD NO. 1966/164



(BASED ON G55/B2-46)

REFERENCE TO AUSTRALIA 1:250,000 STANDARD MAP SERIES

142°30' 147°00' 24°00' 28°00'

JUNDAH	BLACKALL	TAMBO
WINDORAH	ADAVALE	AUGATHELLA
EROMANGA	QUILPIE	CHARLEVILLE
THARGOMINDAH	TOOMPINE	WYANDRA

LEGEND

- down F up — Fault
- Synclinal axis
- Anticlinal axis
- Edge of high standing basement
- Gravity station
- Well (dry)
- Gas well

SEMI-DETAILED GRAVITY SURVEY 1964
ADAVALE BASIN, SOUTH-WEST QUEENSLAND

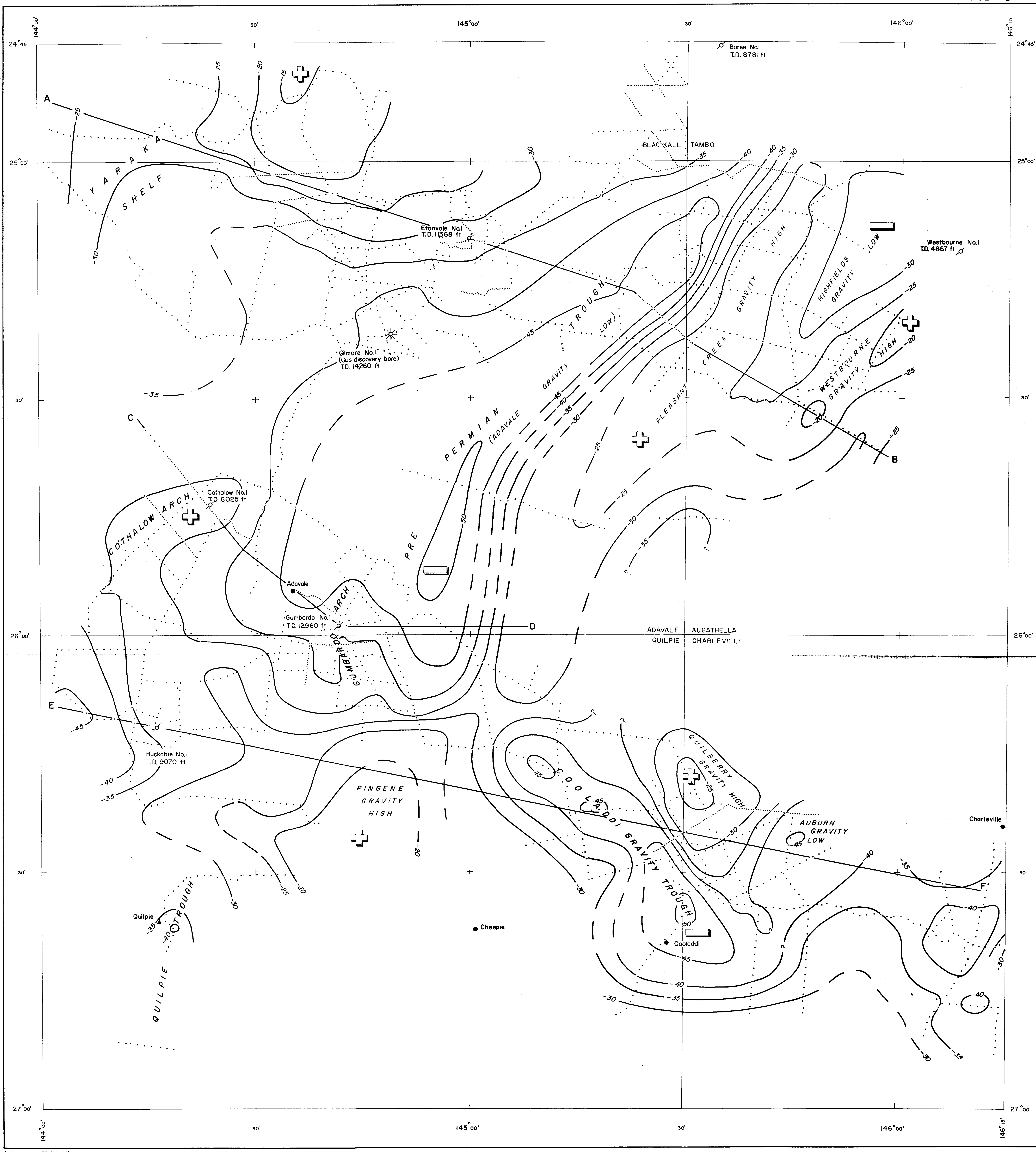
STRUCTURAL PLAN

MILES 8 0 8 16 24 MILES

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

TO ACCOMPANY RECORD NO 1966/164

G55/B2-39



(BASED ON G55/B2-46)

REFERENCE TO AUSTRALIA
1:250,000 STANDARD MAP SERIES

JUNDAH	BLACKALL	TAMBO
WINDORAH	ADAVALE	AUGATHELLA
EROMANGA	QUILPIE	CHARLEVILLE
THARGOMINDAH	TOOMPINE	WYANDRA

24°00' 28°00' 142°30' 147°00'

LEGEND

- Isogals
- Gravity station
- BMR Pendulum station
- BMR Isogal secondary station
- Well (dry)
- Gas well
- A——B Cross-section line

SEMI-DETAILED GRAVITY SURVEY 1964
ADAVALE BASIN, SOUTH-WEST QUEENSLAND

BOUGUER ANOMALIES AND TRAVERSE PLAN

8 0 8 16 24 MILES

Contour interval 5 milligals

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

G55/B2-26

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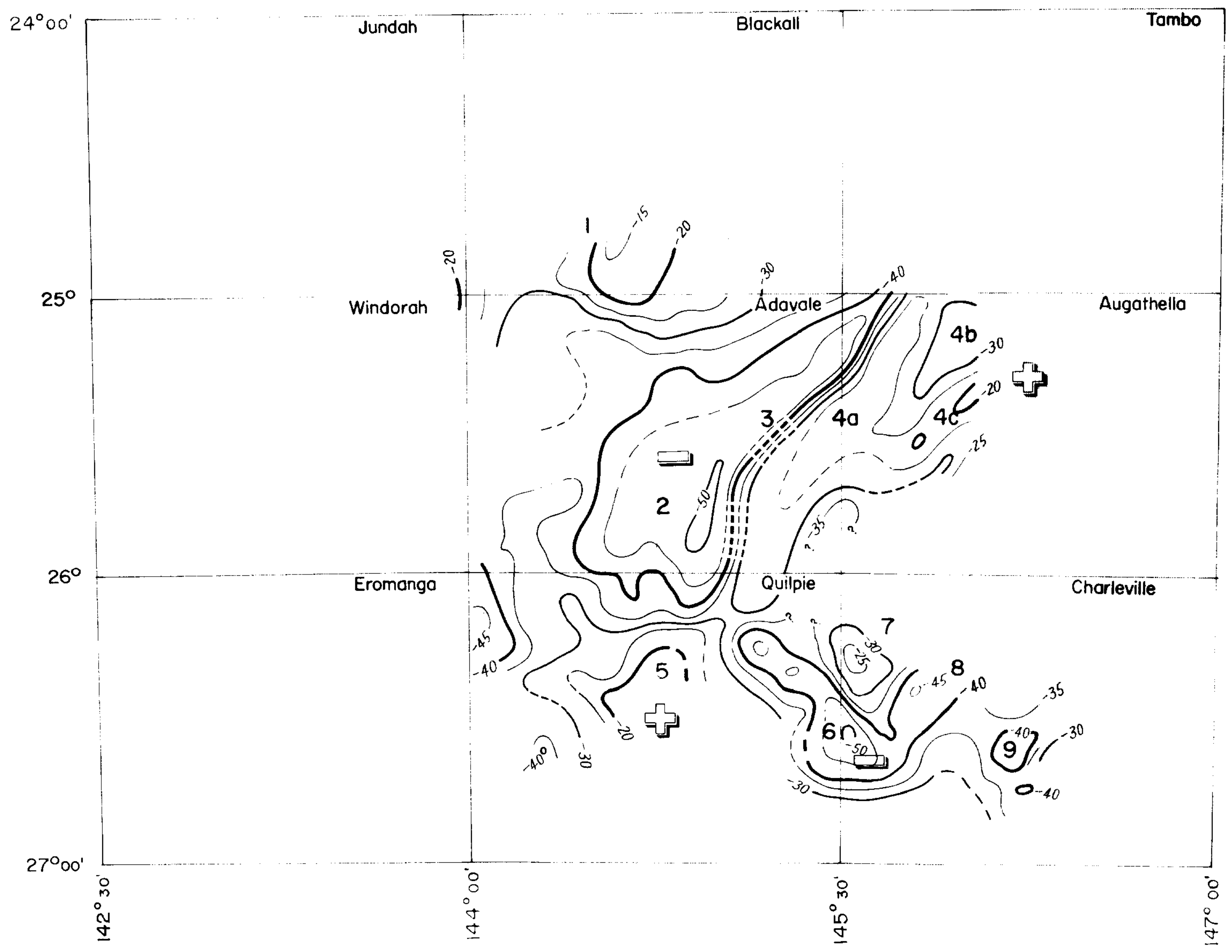
G 55/B2-38



1 ..... Reference Table 2

SEMI-DETAILED GRAVITY SURVEY 1964
ADAVALE BASIN, SOUTH-WEST QUEENSLAND

MAJOR BOUGUER ANOMALY FEATURES

MILES

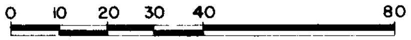
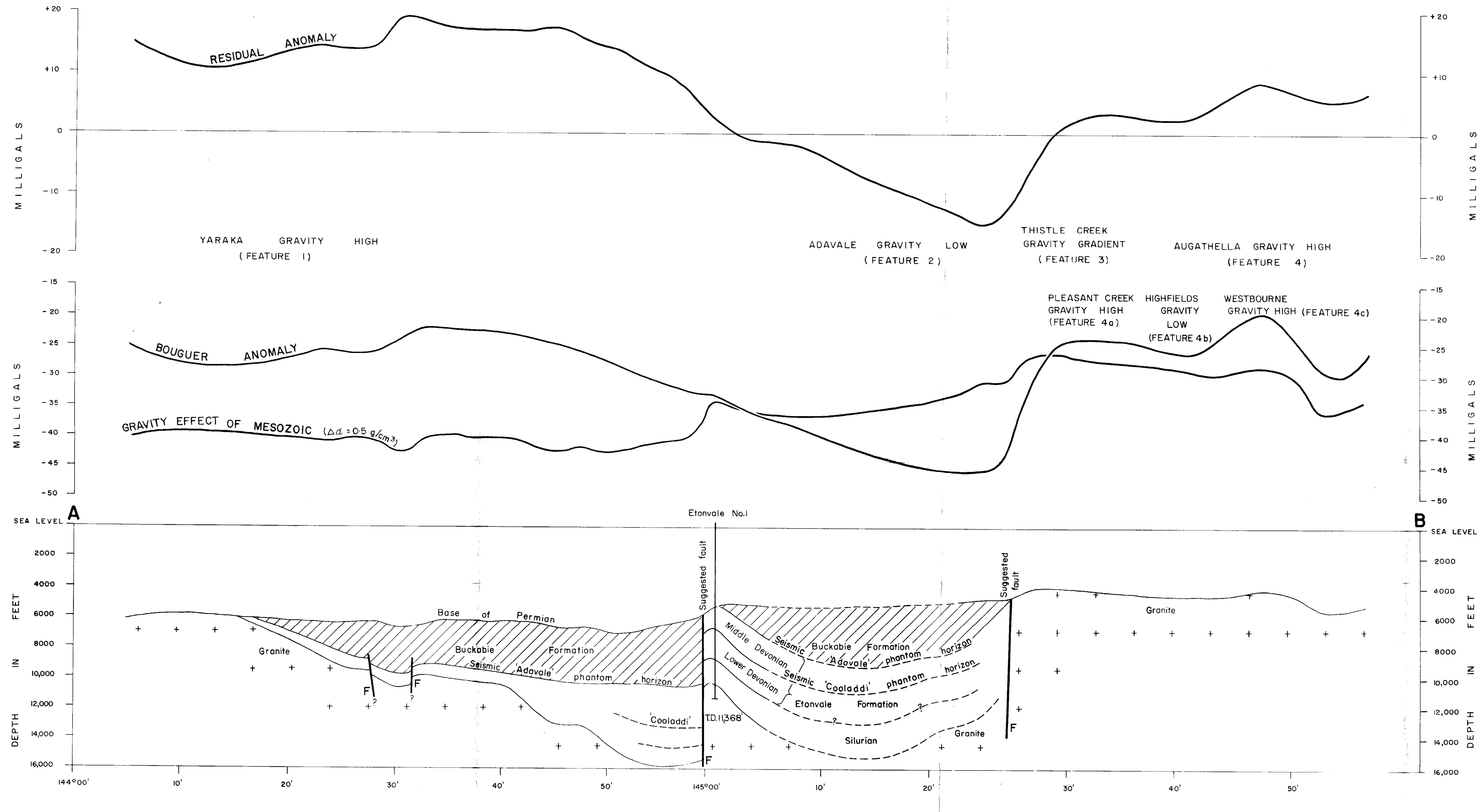


PLATE 4



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SEMI-DETAILED GRAVITY SURVEY 1964

ADAVALE BASIN, SOUTH-WEST QUEENSLAND

CROSS-SECTION A B
GEOLOGY - GRAVITY CORRELATION

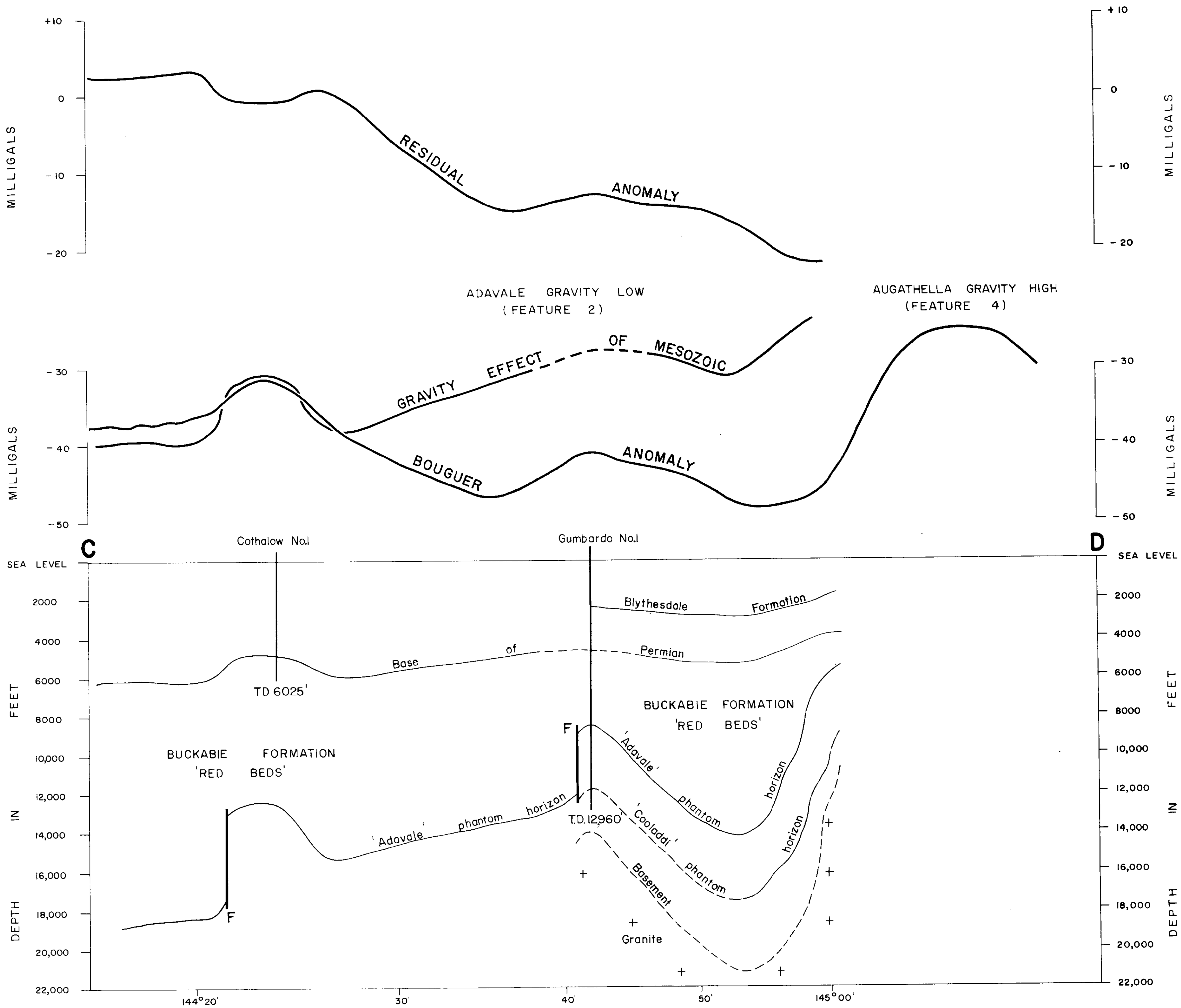
VERTICAL SCALE AS SHOWN

HORIZONTAL SCALE

MILES 8 0 8 16 MILES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G 55/B2-41

TO ACCOMPANY RECORD NO 1966/164



SEMI-DETAILED GRAVITY SURVEY 1964

ADAVALE BASIN, SOUTH-WEST QUEENSLAND

CROSS-SECTION CD
GEOLOGY - GRAVITY CORRELATION

VERTICAL SCALE AS SHOWN

HORIZONTAL SCALE

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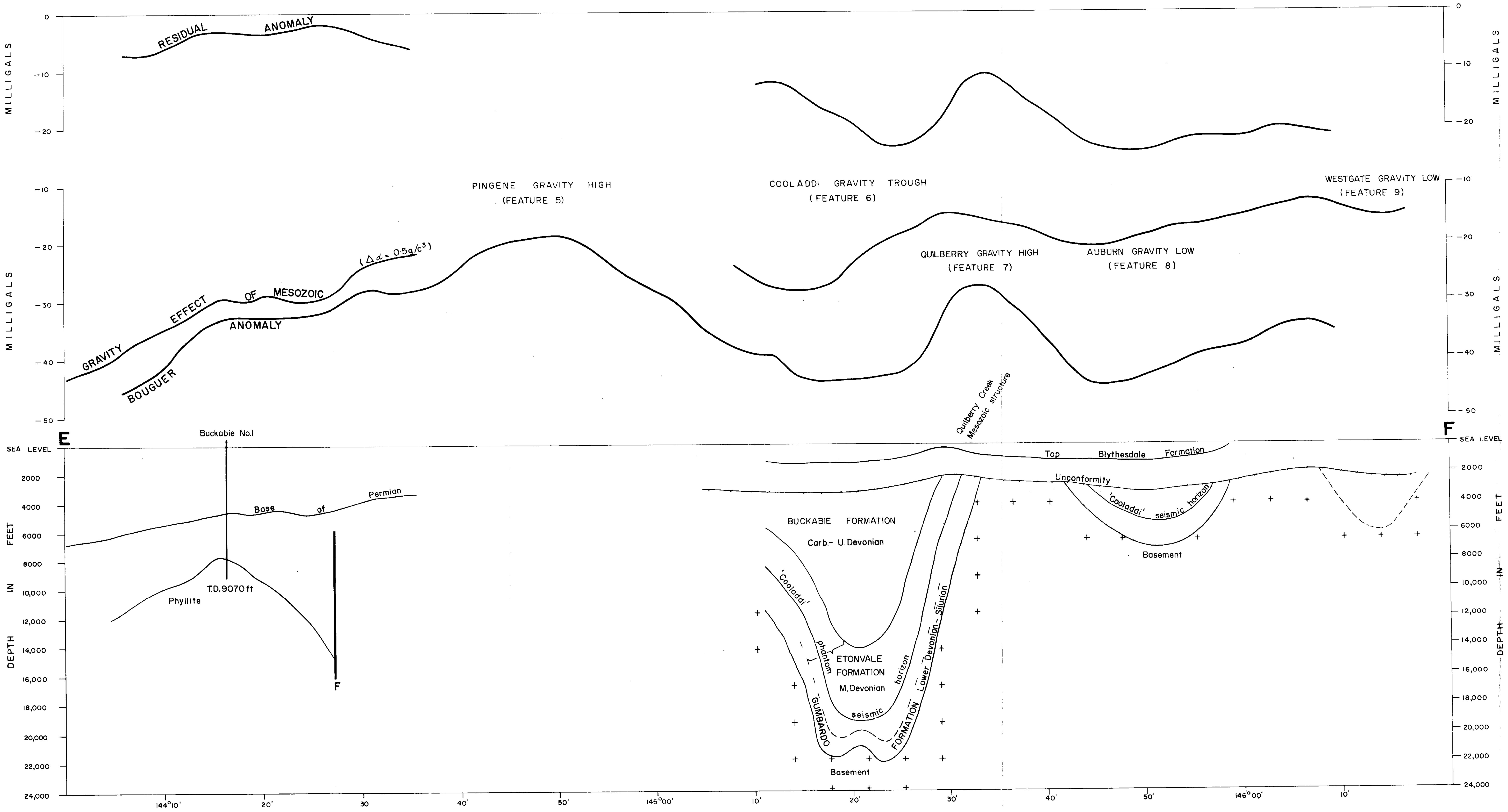
Reference: Phillips-Sunray, 1962a (BMR Subsidy Section reference 62/1587)



SEMI-DETAILED GRAVITY SURVEY 1964

ADAVALE BASIN, SOUTH-WEST QUEENSLAND

CROSS-SECTION EF
GEOLOGY - GRAVITY CORRELATION

VERTICAL SCALE AS SHOWN

HORIZONTAL SCALE

MILES 8 0 8 16 MILES

Reference : Phillips - Sunray, 1963a (BMR Subsidy Section reference 62/1612)

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G55/B2-43

TO ACCOMPANY RECORD NO 1966/164