COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1965/58

GRAVITY READINGS ALONG SEISMIC TRAVERSES IN SURAT BASIN, QUEENSLAND AND NEW SOUTH WALES, 1961

by

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ILLUSTRATIONS

SUMMARY

Gravity readings were taken at each shot-point along seismic traverses between St. George and Yelarbon and between Meandarra and Moree, the object of the survey being to correlate gravity data with the results of a seismic survey made previously in the same year by the Bureau of Mineral Resources.

Alternative interpretations of the Bouguer anomaly profiles are possible from the limited gravity data available in the area.

1. INTRODUCTION

In 1961, a seismic survey was made by the Bureau of Mineral Resources in the Surat Basin, in the south-eastern part of the Great Artesian Basin near the New South Wales - Queensland border (Lodwick and Bigg-Wither, 1962). Later in the same year, gravity readings were taken at each shot-point of this seismic survey, i.e. at $\frac{1}{4}$-mile intervals along seismic traverses that extended east-west from St. George to Yelarbon and north-south from Meandarra to Moree. The positions of the seismic traverses are shown in Plate 2.

The object of the gravity survey was to ascertain whether there was any correlation between the gravity results and the seismic results and to establish a link between individual seismic traverses.

2. GEOLOGY

The Surat Basin forms an eastern lobe of the Great Artesian Basin and is separated from the Eromanga Basin in the west by the Nebine Ridge. It is bounded to the east by metamorphic and granitic rocks (Plate 1). The exposed Mesozoic rocks that occupy the upper part of the succession in the Surat Basin are partly fresh water and partly marine deposits.

In the north of the Surat Basin, Permian sediments extending from the Bowen Basin underlie the Mesozoic rocks. Seismic work indicates at least 6000 ft of Permian sediments lying below about 14,000 ft of probable Mesozoic beds at Meandarra (Smith & Lodwick, 1962).

The results of the east-west seismic traverse (Plate 3) indicate the presence of a trough of sediments that reaches a maximum depth of 14,800 ft at Toobeah. This trough is bounded to the east near Goondiwindi by a major system of faults and thrusts that has a downthrow of 7000 ft to the west. To the west of the trough a series of step faults occurs between Bungunya and Talwood. Results of the north-south seismic traverse (Plate 4) show that the Meandarra Syncline, 20,000 ft deep at Meandarra, extends south to Bungunya. This trough is believed to be the southward extension of the Bowen Basin.

3. DISCUSSION OF RESULTS

St. George - Yelarbon traverse

The seismic results (Lodwick and Bigg-Wither, 1962) indicate the geological structure of the section from St. George to Yelarbon (Plate 3). On a western shelf area from St. George to west of Talwood, the seismic results suggest that about 5000 ft of Mesozoic sediments overlie pre-Mesozoic (?Permian) sediments, which thicken from 1000 ft in the west to about 2000 ft in the east of this shelf. The ?Permian beds rest on rock which has a seismic refraction velocity of 19,250 ft/s, and which is probably metamorphic basement of ?Carbo-Devonian age.

Between Talwood and Goondiwindi, the seismic results show a thickening of the Mesozoic sediments to 9800 ft and a thickening of the ?Permian beds to 5000 ft to give a maximum thickness of about 15,000 ft of sediments at Toobeah. This trough, the Toobeah Trough, is bounded to the east by a well-defined zone of faulting, probably reverse faulting, which has a throw of about 7000 ft down to the west. Towards the western boundary of the Toobeah Trough there is a series of step faults successively upthrown to the west.

Twenty miles east of the eastern boundary fault, named the Goondiwindi Fault, seismic refraction work showed that 1900 ft of Mesozoic sediments rest directly on probable metamorphic rocks of the uplifted basement.

An aeromagnetic survey was flown in the Moree - Miles area during 1961 by Adastra Airways Pty Ltd under contract to Union Oil Development Corporation (1961). This survey extends across the seismic and gravity traverse. Depth estimates to magnetic basement have been calculated. As the volcanic rocks of the Kuttung Formation (Carboniferous to early Permian) are the youngest rocks of high magnetic susceptibility (except for the near-surface Tertiary flows), the depth analysis of the anomalies that result from this formation depicts fairly accurately the configuration of the Bowen Basin. The fact that magnetic basement occurs at the base of the Permian sediments of the Bowen Group is of some assistance in correlating the seismic, aeromagnetic, and gravity data along the seismic traverse.

Geologically the cross-section can be divided into three parts (Plate 3):

(a) Toobeah Trough

(b) area east of the Goondiwindi Fault

(c) western shelf area

These will be discussed below.

Toobeah Trough. The Toobeah trough contains about 15,000 ft of Mesozoic-?Permian sediments and is a southerly extension of the Meandarra Syncline (Lodwick and Bigg-Wither, 1962). The aeromagnetic depth estimates also show a sedimentary trough in this region (Union Oil Development Corporation, 1961).

The Bouguer anomaly over this trough is a gravity 'high', which has been mapped to the north and closely follows the synclinal axis of the sedimentary trough (Smith & Lodwick, 1962). In many parts of the Great Artesian Basin, the ?Permian-Mesozoic sediments are less dense than the older Palaeozoic basement rocks; this results in the delineation of sub-basins or local sedimentary troughs as gravity 'lows'. In the area of the Toobeah Trough, however, there is an apparent reverse correlation between the sedimentary structure and the gravity anomaly. This may be explained by a basement that is less dense than the overlying sediments, or alternatively by a basement that is denser than the overlying sediments but including a major density change within the basement at a depth below 15,000 ft, which could overcompensate the negative effect of the overlying sedimentary section of lesser density.

To explain the anomaly having its source in the basement would require the presence of relatively dense basic igneous rocks. Such a body would be expected to cause a magnetic anomaly. However, the aeromagnetic results do not indicate any pronounced anomaly along the axis of the Surat Basin.

A calculation employing the maximum anomaly and maximum gravity gradient indicates that the greatest depth to the top of the body causing the gravity 'high' is approximately 22,000 ft (Bott and Smith, 1958). The top of the body would thus lie between the limits of 15,000 ft and 22,000 ft.

With the gravity data available at this stage it is not possible to choose between the two most-likely interpretations discussed above.

Ten miles west of Goondiwindi (Plate 3), a small anticline, the Callandoon Anticline, is indicated by the seismic results and may be the source of the local gravity 'high' of about 4 milligals centred at Shot-point 72. If this is so, then there is a return to normal seismic-gravity correlation over this anticline.

Area east of the Goondiwindi Fault. The seismic reflection traverse extends only seven miles east of the Goondiwindi Fault. Both reflection and refraction results indicate high-standing basement in this region. Depth to basement immediately east of Fault is 6350 ft (seismic refraction velocity 19,300 ft/s).

A major aeromagnetic feature centred seven miles east of the Goondiwindi Fault has been interpreted as a graben structure with maximum depth to magnetic basement of about 10,000 ft (Union Oil Development Corporation, 1961). It is not possible to confirm the presence of this feature on seismic evidence, as the seismic traverse ends in this region. A major gravity 'high' (F. Darby, pers. comm.) reaches its maximum almost directly over the fault that marks the eastern boundary of the graben.

To investigate this problem further, it would be of value to have:

(a) an extension of the seismic traverse to the east,

(b) a more detailed areal gravity survey.

It is expected that these will be done in due course.

Near the eastern end of the gravity traverse, the gravity anomaly takes the form of a large gravity 'low' named the Yelarbon gravity 'low'. The aeromagnetic results indicate high-standing basement in this area. Consequently, this gravity 'low' may be explained by postulating an extension at depth of the granite which forms the New England Batholith, and which crops out to the south-east. Gravity readings south-east of the traverse (F. Darby, pers. comm.), over outcrops of this granite, gave values as low as -99 milligals compared with a minimum of about -47 milligals in the Yelarbon gravity 'low'. This lends some support for the suggested presence of granite at depth in this area.

An alternative explanation would be that, if correlation is 'normal', Yelarbon gravity 'low' is a southerly extension of the Yarrol Basin. However, this interpretation does not agree with the aeromagnetic data.

Western shelf area. In the area of the western shelf the gravity anomalies cannot be directly correlated with the density discontinuity between the sediments and the basement. Gravity 'lows' and two small gravity 'highs' shown in this part of the traverse are probably expressions of density changes within the basement complex.

Meandarra - Moree traverse

Along this traverse, the seismic results (Plate 4) show a general decrease in the thickness of the Mesozoic sediments from 17,000 ft in the north to about 6000 ft in the south. The depth of Mesozoic sediments in the Meandarra area is given as 14,000 ft by Smith and Lodwick (1962), whereas in this section, which was originally presented by Lodwick and Bigg-Wither (1962), the depth is shown as 17,000 ft. This discrepancy is caused by a difference in velocity data used in the two surveys. The velocity data used by Smith and Lodwick seem more likely to be correct for the Meandarra area, and hence the first figure of 14,000 ft should be accepted. However, the velocity data used by Lodwick and Bigg-Wither are still relevant to the St. George - Goondiwindi - Yelarbon traverse, and depths quoted by Lodwick and Bigg-Wither along this line still stand. Near Meandarra, refraction work suggests that 6000 ft of older sediments may be present below the Mesozoic beds (Smith and Lodwick, 1962). The reverse correlation between gravity and sedimentary structure observed in the Toobeah gravity 'high' on the east-west traverse is repeated, and once again a gravity 'high' is indicated in the deepest part of this syncline.

4. CONCLUSIONS

The main conclusions from this preliminary examination of the gravity results are as follows:

St. George - Yelarbon traverse

Toobeah Trough. The gravity 'high' over this sedimentary trough may be explained in two ways on the basis of present information:

(a) The source of the 'high' is an intra-basement structure, in which case the gravity correlation is 'normal'.

(b) Sediments that are denser than the basement cause the 'high', in which case the correlation is 'reversed'.

Area east of the Goondiwindi Fault. A steep gravity gradient marks the position of the Goondiwindi Fault. Further east, the Yelarbon gravity 'low' may be associated with granitic basement.

Western Shelf area. The gravity anomalies are probably related to density discontinuities within the basement.

Meandarra - Moree traverse

The 'reversed' correlation between sedimentary thickness and gravity 'high' is again observed on this traverse. The explanation of the gravity 'high' may be similar to that given for the gravity 'high' over the Toobeah Trough.

General

When gravity data are limited to single traverses, it is difficult to interpret the anomalies quantitatively because the predominant trends and forms of the anomalies are not fully known. However, in this area the main gravity trends are north-south so that an east-west section will give a good definition of the major anomalies. Obviously the gravity data are still inadequate for a comprehensive interpretation. The area will, however, be systematically surveyed in the future to define the anomalies more completely and the survey will be extended to the east over the outcropping Palaeozoic rocks and New England Granite. Such an extension would show the type of anomalies associated with the probable basement in this part of the Surat Basin.

An extension of the seismic traverse to the east of Yelarbon would help resolve the nature of the geological structure that is causing the Yelarbon gravity 'low'.

5. REFERENCES

BOTT, M.H.P. and SMITH, R.A.	1958	The estimation of the limiting depth of gravitating bodies. Geoph. Prospecting 6 (1), 1-10.
UNION OIL DEVELOPMENT CORPORATION	1961	Preliminary final report on the Moree - Miles aeromagnetic survey. Report on Commonwealth-subsidised operation (unpubl.).
LODWICK, K.B. and BIGG-WITHER, A.L.	1962	Southern Surat Basin seismic survey, 1961. Bur. Min. Resour. Aust. Rec. 1962/183.
SMITH, E.R., and LODWICK, K.B.	1962	Surat Basin seismic reconnaissance survey, Queensland 1960. Bur. Min. Resour. Aust. Rec. 1962/133.

APPENDIX

Organisation of the survey

Logistical organisation

Staff. Geophysicist : M.A. Reid
Field assistant : C. Hin

Vehicles. One International one-ton 4 x 4

Duration of survey. The party commenced operations on 11th October 1961 and returned to Melbourne on 11th November 1961.

Scientific organisation

Instruments. Worden gravity meter, Serial No. 61, with scale factor 0.08994 mgal/scale division, was used throughout the survey. Meter drift was determined by using the looping method, i.e. reading stations in the order 1, 2, 3, 4, 5, 1, 5, 6, 7, etc.

During the survey, the drift rate was often rather high in the morning but it usually levelled of in the afternoons. Evacuation of the meter on returning to Melbourne showed the pressure in the vacuum flask to be several millimeters too high.

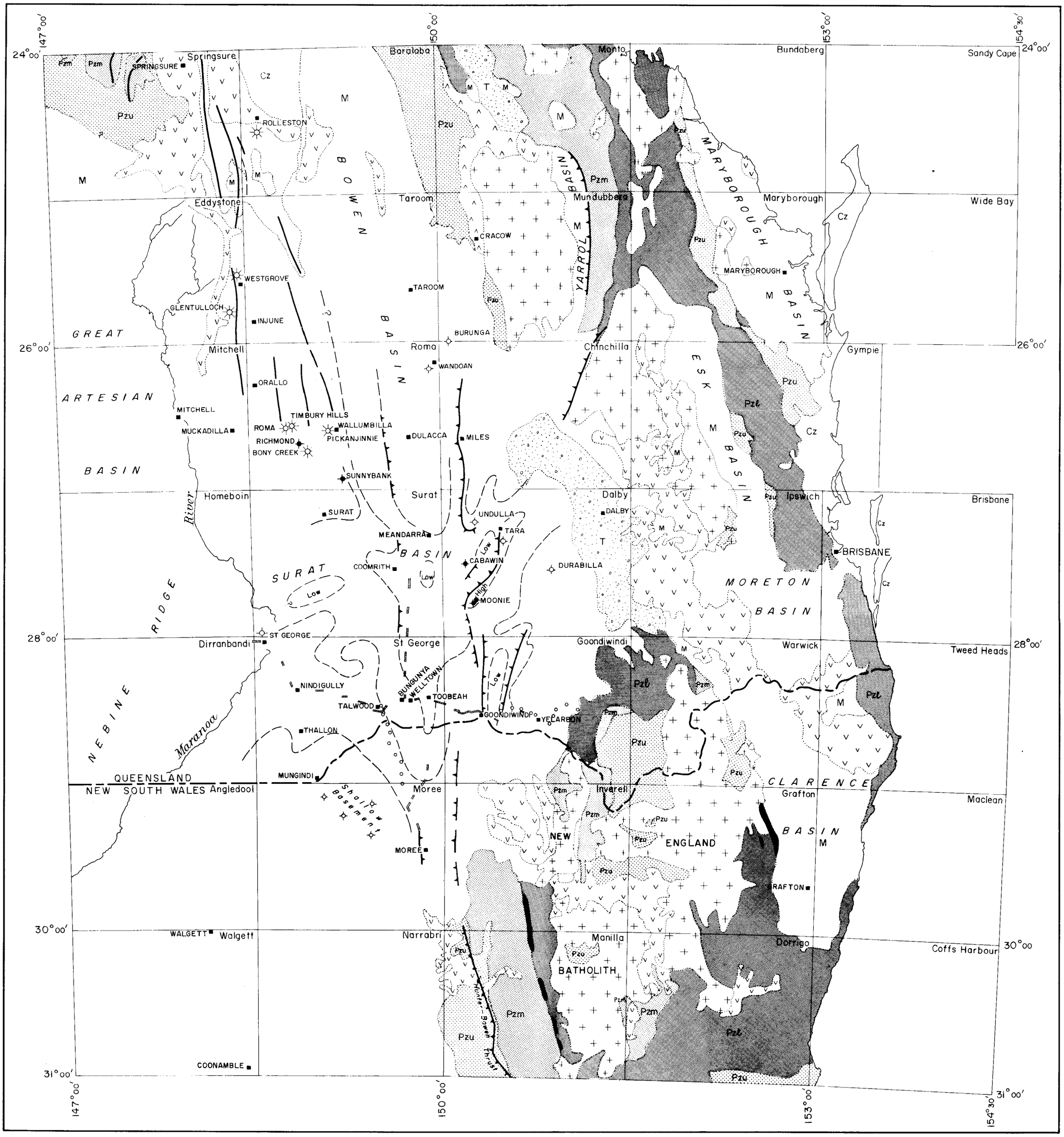
Elevations. Elevations of the shot-points were provided by the Department of the Interior and tied to Queensland State Datum.

Plotting. The co-ordinates of the shot-points were obtained from a map of scale eight miles to one inch. These will be reviewed when more suitable maps are available.

Tie stations. The gravity traverses were tied to other BMR gravity stations at Goondiwindi, St. George, Boggabilla, Bungunya, Toobeah, Talwood, Nindigully, and Moree.

Bouguer anomalies. The Bouguer anomalies were calculated using a density of 1.9 g/cm^3 in the Bouguer correction.

PLATE I



Cz Cainozoic
M Mesozoic
T Tertiary
Pzu Upper Palaeozoic
Pzm Middle Palaeozoic
Pzl Lower Palaeozoic
Granite
Serpentine
Basalt (Tertiary)
Andesite (Pzu)

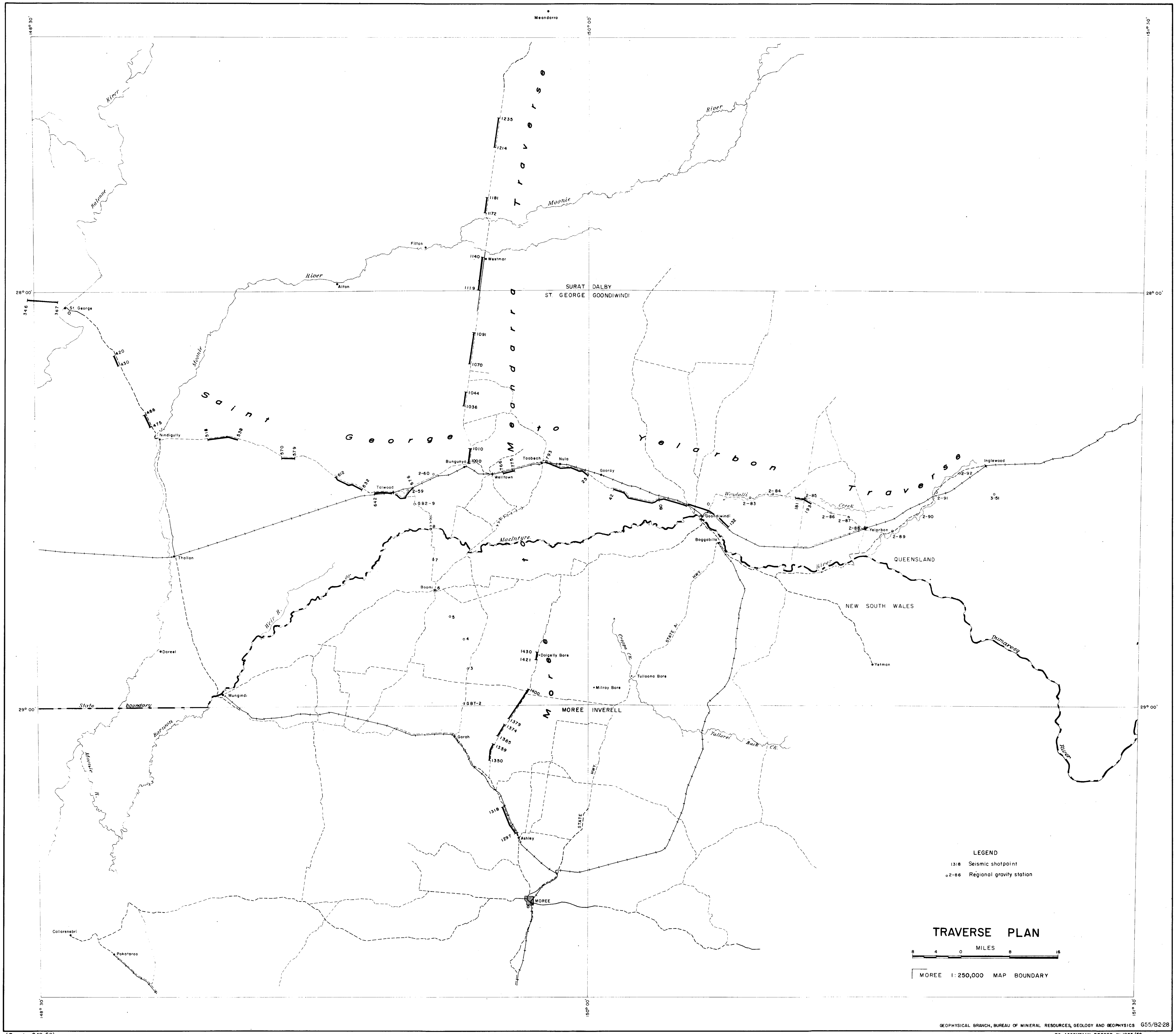
Roma 1:250,000 map area
Named place
Structure formline (from aeromagnetic data)
Geological boundary
Anticlinal axis
Fault or thrustfault
State boundary
Gas bore
Oil bore
Bore with basement intersected, without oil being found
Regional gravity station
Seismic traverse used for gravity readings

Reference: BMR Tectonic map of Australia 1960
Union Oil Development Corporation
Moree–Miles Aeromagnetic Survey 1959/60

SURAT BASIN
GEOLOGY

SCALE
MILES 40 0 40 80 120 MILES

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS G55/B2-27
TO ACCOMPANY RECORD No 1965/58



(Based on G48-50)

WEST

EAST

DATUM 600' ASL.

DEPTH IN FEET

0
5,000
10,000
15,000
20,000
25,000

SEISMIC CROSS-SECTION

'L' Horizon : Probable top of Kianga Formation (Top of Permian)

'G' Horizon : Probable base of Bundamba Group

Zone of 'G' Horizon

Probable 'L' Horizon

'L' Horizon

'L' Horizon probably eroded

'L' Horizon apparently truncated

CALLANDOON ANTICLINE

GOONDIWINDI FAULT

Fault Zone

WESTERN SHELF AREA

TOOBEAH TROUGH

ST. GEORGE

KINGOLLY

BUNDAYA

TILMOOD

TOOBEAH

GOONDIWINDI

YELARBON

MAINTIME RIVER

HOLKWOOD

BOUGUER ANOMALY IN MILLIGALS

0
-10
-20
-30
-40

BOUGUER ANOMALY PROFILE

Regional Gravity Traverse, east of Goondiwindi

YELARBON GRAVITY 'LOW'

LEGEND

- Seismic shotpoint, used as gravity station
- Regional gravity station

ST GEORGE TO YELARBON TRAVERSE

CORRELATION OF SEISMIC AND GRAVITY DATA

Horizontal Scale : 1 Inch = 4 Miles
Vertical Scale : as shown

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

G55/B2-30

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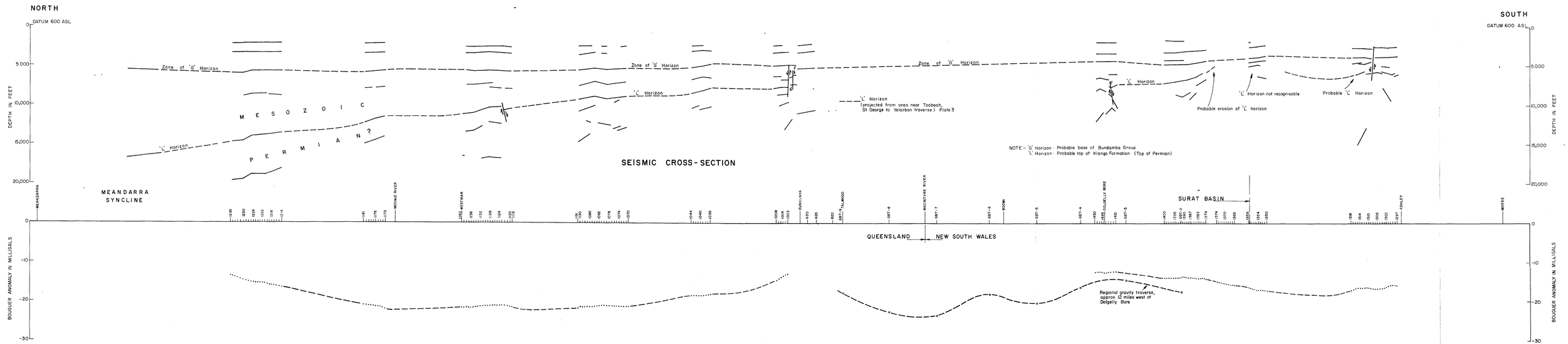
(Based on G55/B3-7)



LEGEND

- Seismic shotpoint used as gravity station
- Regional gravity station

MOREE TO MEANDARRA TRAVERSE

CORRELATION OF SEISMIC AND GRAVITY DATA

Horizontal scale : 1 Inch = 4 miles
Vertical scale : as shown

(Based on G55/B3-11)

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