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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS.

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PRELIMINARY REPORT OF A GRAVITY SURVEY
IN THE
TOKO RANGE AREA, WESTERN QUEENSLAND

by

F.J.G. NEUMANN

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I L L U S T R A T I O N S.

Plate 1. Gravity Contour Plan, Glenormiston 4-mile Sheet.

ABSTRACT.

A reconnaissance gravity survey was carried out during 1958 near the Queensland - Northern Territory border between the Toko Range and a line from Glenormiston to Linda Downs. It was a south-westerly extension of the 1957 reconnaissance gravity survey of the south-eastern portion of the Georgina Basin.

The combined results of the two surveys are now presented as a four miles to one inch Bouguer anomaly plan, which corresponds to the Glenormiston sheet of the four mile Military Map of Australia.

The main trend of the Gravity Contours is northwest and follows in a general way the known geological boundaries. Near the southern margin of the Glenormiston sheet anomaly trends are more south-southeasterly.

The results of the gravity work reveal significant anomaly features over an area of flatly bedded Older Palaeozoic beds. Gravity anomalies appear to be mainly related to lower basement structures and possibly to Pre-Cambrian faulting.

1. INTRODUCTION

This report describes gravity work which is complementary to the geological and geophysical surveys which were carried out by the Bureau of Mineral Resources, Geology and Geophysics in the Georgina Basin, North-Western Queensland, prior to 1958. This additional gravity reconnaissance work was requested by the Geological Section of the Bureau for the main purpose of investigating the nature of Bouguer anomalies which could be expected in the area of the Toko Range, which is to the southwest of the area previously investigated.

On the surface the northeastern edge of the Toko Range forms an expressive landmark of appreciable steepness with deeply eroded sediments of Ordovician age, including sandstones, limestones and sandy dolomite. These sediments are flatly bedded and most likely overlie a sequence of Upper, Middle and Lower Cambrian rocks, which are known from outcrops further southeast of Glenormiston between Sun Hill and Sylvester Creek on the northeastern portion of the adjoining 4-mile Mount Whelan sheet. Further southwest of the Glenormiston sheet Ordovician beds of the Toko Range area are overlain by sandstones presumably of Mesozoic age (J.N. Casey, 1958).

More specific aims of the 1958 gravity investigation were:

- firstly to shed some light if possible, on the subsurface structure of the Toko Range Syncline, and
- secondly to find some answer regarding the thickness of sediments known from the syncline area as flatly bedded along the eastern limb, in contrast to steep dipping angles in the beds along the western margin of the syncline.

2. FIELD WORK

Topographic surveying of the gravity stations was carried out mainly prior to the commencement of gravity readings by field parties supplied by the Commonwealth Department of the Interior. The survey includes thirty-eight new gravity stations placed at three to five mile intervals approximately between Latitudes 23°00' and 22°30' and Longitudes 138°00' and 139°00' on traverses from Glenormiston to Linda Downs homestead and from Linda Downs back to Glenormiston along the northeastern edge of the Toko Range.

In addition, a traverse fifteen miles long was run south-westerly following the course of the Wheelaman Gorge through the more central part of the Toko Range. This line ends at the Robinson's Dry Bore near the Rabbit-proof Fence.

Where possible, station positions were identified in the field on air photographs and later on, controlled by astrofixes established at Linda Well, Linda Downs homestead, Wheelaman Bore and Robinson's Dry Bore, and using the 4-mile Military sheet for topographic detail. All of the stations occupied along the Glenormiston - Linda Downs track had to be completely surveyed by topographic traversing, as the scarcity of topographic details did not allow the accurate fixation of station positions on air photographs. For the final plotting of the gravity stations, a Glenormiston 4-mile compilation sheet supplied by Royal Australian Survey Corps, 1957, was also used.

Gravity meter Worden No. 140 served during the survey for taking gravity observations. The performance of the instrument was satisfactory, with no irregularities observed in the normal drift curve of the meter. The partial vacuum in the oscillation chamber of the Worden meter was re-established to a pressure less than eight millimetres of mercury before the gravity party left for the field. The scale-value was calibrated against observed gravity values of base station near Melbourne. A scale factor of 0.11114 milligal per division was determined.

Careful handling of the instrument during the period of field use and regular check-readings on previously occupied stations secured a relatively small mean error in loop closures, which was approximately three hundredths of one milligal. A sufficient number of ties were made to the observed gravity values of stations, which were established during the 1957 Georgina Basin Survey. All of the gravity readings in the field were carried out by J.R.H. Van Son, Geophysicist.

3. RESULTS.

In reducing the results of the field readings a uniform density of 1.9 was adopted for rocks between station site and Sea Level. This was chosen as being representative of near surface Mesozoic, Tertiary and Recent beds, while - naturally - a higher density between 2.2 and 2.5 would be more applicable to eliminate the topographic effect of Palaeozoic formation. Variations in elevations of Palaeozoic rocks are moderate in the investigated area and any error, which might occur in the Bouguer anomalies due to an incorrect assumption of near surface density will be relatively small and will not effect the general pattern of the anomalies. As a result of the 1957 Georgina Basin gravity survey, the observed gravity value at the Bureau's Pendulum Station No. 56 at Boulia (Queensland) has been adjusted and a value of

978,793.20 milligals

was used for the Boulia station as more correct for the conduct of gravity ties. For this reason the relative figures of Bouguer anomalies shown on Plate 1 of this report are approximately one milligal higher than those shown on the earlier edition of the Georgina Basin Gravity Contour Plan (Neumann, 1959).

The combined results of the 1957/58 Georgina Basin and Toko Range gravity surveys are shown on Plate 1 as Bouguer Anomaly contours. The contouring on the western portion of the 4-mile Glenormiston sheet is preliminary and might include major errors, as there is no control of the contours between widely dispersed traverses. No gravity data are available as yet on that part of the Glenormiston sheet which is east of the course of the Georgina River. This area appears to have generally high Bouguer anomaly values. Additional gravity work is planned in order to secure in the near future, a more complete and denser gravity coverage over all the area included in the 4 mile Glenormiston map.

The over-all pattern of the gravity contours on Plate 1 reveals major anomalies, which are outlined below:-

- (a) Lowest Bouguer values (Station No. 14 - 12: - 20.5 milligals and No. 14 - 11: -19.8 milligals) were established north of Tobermory near the northwestern edge of the contour map in an extensive gravity "Low", which occurs parallel to and mainly north of Pituri Creek, roughly between Roxburgh Downs and Tobermory homestead. For convenience, this anomaly is referred to as the "Roxburgh Downs - Tobermory Low". This "Low" is terminated by northwesterly and west-northwesterly trends in the contours and appears to widen appreciably west of the Linda Downs - Carandotta gravity traverse.
- (b) Extending south-southeast from the Roxburgh Downs - Tobermory Low are two embayments of comparatively low intensity values: a broader feature of low anomaly between Linda Downs and Wheelaman Creek and a relatively sharp gravity "Low" near Glenormiston between Pituri Creek and the Georgina River.
- (c) A distinctive feature in the anomaly pattern is the northwest running ridge of high gravity intensity, which includes the highest Bouguer anomaly value observed on the 4-mile Glenormiston map, established by gravity stations No. 9 - 11: + 16.3 milligals and No. 9 - 10: +15.5 milligals. This maximum occurs approximately halfway between Roxburgh Downs and the junction of Sandy Creek and Georgina River.
- (d) An expressive gravity "High" also occurs west of Glenormiston, which is terminated to the east by a distinctive and narrow "Low", referred to under (c). The axis of this "High" appears to extend north-northwest from the track which connects Glenormiston and Wheelaman Bore over a distance of approximately twenty miles. An extension to the south of this anomaly into the area covered by the adjoining 4-mile Mount Whelan sheet is likely, though a closed and somewhat isolated maximum of Bouguer anomaly is indicated by gravity stations No. 11 - 3 (+ 9.4 milligals), No. 11 - 2 (+ 10.0 milligals) and No. 42 - 2 (+ 9.8 milligals) at approximately ten miles distance northwest of Glenormiston.
- (e) Two gravity "Highs" of a local type are included in the generally northwest trend of contours, which are approximately parallel to and mainly east of the topographic edge of the Toko Range. These anomalies center immediately west of the Wheelaman Bore and northeast of the Toko Gorge. It is also of interest to note that the gravity gradients, which terminate the eastern margin of the anomaly near Wheelaman Bore are distinctly stronger than those further west on the western section of the traverse through Wheelaman Gorge.

4. INTERPRETATION OF RESULTS.

In the assessment of gravity Bouguer anomalies, the densities of rock formations, which occur in the investigated area, must be considered first, to explain the geological reasons of gravity anomalies. Variations in Bouguer anomalies are in principal produced by the presence of high density rocks at shallow depth below a gravity "High" in contrast to a thickening in rocks of lesser density below areas of gravity deficiency.

Larger anomalies, which might be caused by a deeply subsiding basement under sediments of unusual thickness need not be considered within the limits of this report, as anomalies of extremely large magnitude do not occur in the referred to area.

In highly folded and intensely faulted formations, it is found from experience, that density variations are generally rapid because of the abrupt changes in the nature of the rocks as a result of an increase in tectonic mobility. Relatively strong gravity gradients terminate - as a rule - Bouguer anomalies of both positive and negative signs in areas of tectonic displacement, metamorphism and igneous intrusions.

Density determinations carried out on rock specimens collected from outcrops in the surveyed area show density figures of Cambrian and Ordovician limestones ranging from 2.63 to 2.82 (Neumann, 1959). In contrast, a mean density of 2.1 was found representative for porous Ordovician sandstone, which crops out near the Toko Gorge. As the sequence of Cambrian and Ordovician beds (Ninmaroo Formation, Casey 1958) is flatly bedded over wide areas on the 4-mile Glenormiston map - being mainly undisturbed and unaltered transgressional deposits - no gravity anomalies of appreciable magnitude can be expected from a density contrast between the limestone and sandstone members of these formations. Naturally variations in thickness at depth, either of the limestone or of the sandstone, would give rise to gravity variations.

From the area adjoining the 4-mile Glenormiston map to the east and northeast mainly between Mount Isa and Cloncurry, highly folded and intensely metamorphosed rocks of Pre-Cambrian (Archaozoic) age are known in faulted conjunction with Proterozoic and Cambrian rocks, which, in the area near Duchess, find an expression in relatively distinct gravity anomalies and strong gravity gradients.

If the assumption is substantially correct that similar, though less violent unconformities extend from the east into the Pre-Cambrian basement below the sub-horizontal cover beds of Cambrian and Ordovician age, the gravity anomalies observed in the area of the Glenormiston sheet of the 4-mile map can be most likely considered as expressions of basement faulting, tectonic in origin.

This suggestion is supported by the existence of a ridge of folded and faulted rocks of Lower Cambrian age, followed to the west by Middle and Upper Cambrian beds, which was recently described from the 4-mile Mount Whelan sheet (J.N. Casey, 1958). This ridge of older rocks appears to be related in some way to the strong gravity anomaly and expressive gravity gradients, which were established near Glenormiston and extend over an appreciable distance north-northwest into the valley of Pituri Creek.

The possibility of acid intrusions (granite and porphyries) as a cause of local gravity deficiency in contrast to a rise in the gravity intensity over intrusions of a basic type (greenstone, gabbro) also must be considered in this connection.

Preliminary interpretation of anomalies, which were found as a result of the 1957/58 gravity work on the Glenormiston sheet, is given as follows:-

- (a) In the area defined by the "Roxburgh Downs - Tobermory Low" a thickening in the sediments, including Ordovician and probably Cambrian beds, occurs most likely in a north-western direction, with a widening and relative deepening in the basement structure immediately west of the Linda Downs - Carandotta traverse.
- (b) The south-southeast extension of the "Roxburgh Downs - Tobermory Low" east of the Wheelaman Bore might indicate a sub-basin feature with a thickening of the sediments at depth under the gravity "Low".

The relatively sharp gravity "Low" near Glenormiston in conjunction with the gravity "High" west of it, might be explained by intensive folding and/or faulting in a buried ridge of Lower Cambrian rocks with the possibility of granitic intrusions.

- (c) The northwest running gravity "High" which terminates the northern margin of the "Roxburgh Downs - Tobermory Low" requires a much denser coverage by additional gravity stations for more accurate outlining and interpreting. Tentatively at this stage a horst-like ridge of Older Cambrian and/or Pre Cambrian rocks could be assumed as the nearest explanation. Strong gradients indicate the possibility of northwest faulting, not excluding cross-faults, in conjunction with the buried ridge.
- (d) The gravity "High" centering northwest of Glenormiston is mentioned under (b).

To further investigate the suggested relation of this "High" with Older Palaeozoic formations further south and southeast between Sun Hill and Sylvester Creek, additional gravity data are needed across the known outcrops of these rocks on the Mount Whalan sheet of the 4-mile map.

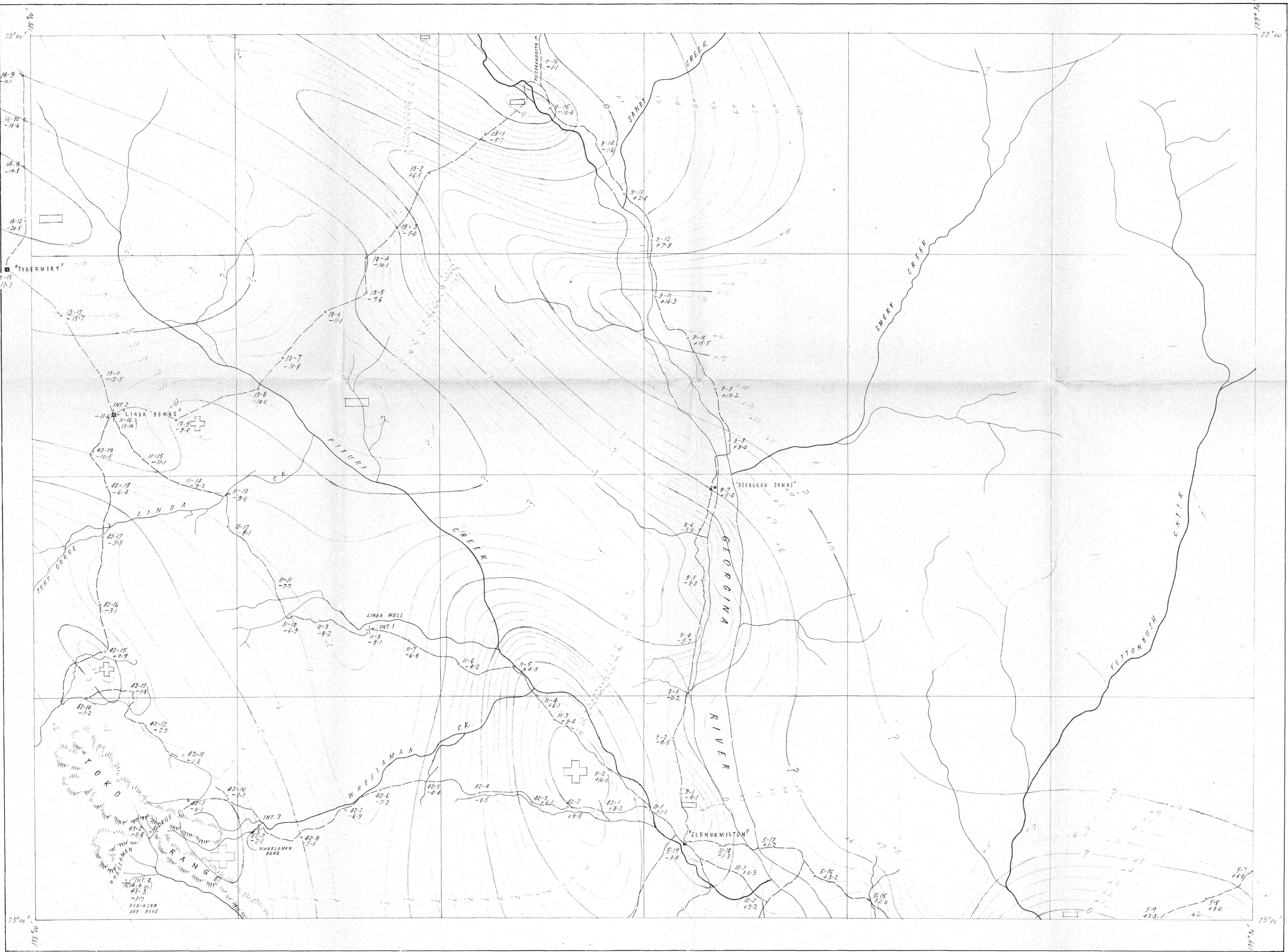
- (e) The eastern margin of the Toko Range Syncline might be terminated by a buried ridge of moderate relief in the basement structure, which finds expression in the higher gravity anomaly of northwest trend between Wheelaman and Linda Creek, which is roughly parallel to the topographic edge of the Toko Range.

Alternatively, these anomaly features could be also explained by accepting basic intrusions of igneous rocks of higher density in the basement without any reflection in the thickness or dipping angles of the cover rocks.

Decreasing Bouguer values near the southwestern end of the Wheelaman Gorge traverse might indicate that sediments are thickening to the southwest. The axis of the Toko Range Syncline, which is further southwest, was not traversed. An extension of the gravity work in the area of the adjoining Tobermory, Lake Caroline and Mount Whalan sheets of the 4-mile map would be required to supplement the gravity coverage of the Toko Range Syncline as a whole.

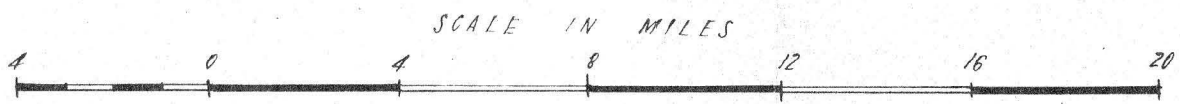
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| LOCATION | | |
|----------------|--------------|------------|
| SANDOVER RIVER | URANDANGI | DUCHES |
| TOBERMORY | GLENORMISTON | BOULIA |
| HAY RIVER | MT WHELAN | SPRINGVALE |

- LEGEND
- 43-2 GRAVITY STATION
 - 0.8 RELATIVE BOUGUER ANOMALY IN MILLIGALS
 - ⊕ GRAVITY HIGH ANOMALY
 - LOW —
 - 2— CONTOUR
 - INT. 2 DEPT. OF THE INTERIOR ASTRONOMICAL FIXATION



BOUGUER ANOMALIES

EXPLANATION

RELATIVE BOUGUER ANOMALIES ARE BASED ON OBSERVED GRAVITY VALUE OF 378,793.2 MILLIGALS AT S.M.R. No. 55 PENDULUM STATION, BOULIA, Q.L.D.

FOR THE CALCULATION OF BOUGUER ANOMALIES 1.9 g/cm³ HAS BEEN TAKEN AS AN AVERAGE ROCK DENSITY.

GRAVITY FIELD SURVEYS BY B.M.R. GEOPHYSICAL SECTION 1957-58

MAP COMPUTED AND COMPILED BY GEOPHYSICAL DRAWING OFFICE FROM DEPT. OF THE INTERIOR GRAVITY SURFACE CONTROL MAP AND R.A.S.V. C.S. PLANIMETRIC MAP AT 4 MILES 1" SCALE.