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53

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

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1959, NO.8

PRELIMINARY REPORT ON A RECONNAISSANCE GRAVITY SURVEY IN THE GEORGINA BASIN AREA, QUEENSLAND.

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ABSTRACT

A reconnaissance gravity survey was carried out during 1957 in Northwest Queensland between Urandangie, Mount Isa, Cloncurry, Boulia, Glenormiston and Tobermory to determine gravity Bouguer anomalies and investigate their relation to the geology of the south-eastern part of the Georgina Basin and adjoining areas of the Cloncurry-Mount Isa Fold Belt.

The results of the investigation show a predominating south-southeast trend of high Bouguer anomalies - accompanied to the east and west by gravity "Lows" - associated with Pre-Cambrian formations of the Cloncurry-Mt. Isa area.

The axis of the main gravity "High" appears to continue to the southeast into the Great Artesian Basin.

In the western part of the surveyed area the main trend of the gravity contours is northwest and follows in a general way the known geological boundaries particularly in the area between the Toko Range and the Georgina River.

A gravity "High" west of Boulia indicates a north-west trend in the older formation perpendicular to the known trends of the outcropping Cretaceous beds.

1. INTRODUCTION

Following geological surveys carried out by the Bureau of Mineral Resources, Geology and Geophysics in the Georgina Basin, Northwestern Queensland since 1956, a reconnaissance gravity survey was carried out during the 1957 field season in the region south of a line from Urandangie to Mount Isa and Cloncurry and north of a line through Boulia, Glenormiston and Linda Downs.

The area is in an important one in the search for oil. Some of the older formations, which crop out in the southeastern portion of the Georgina Basin can be considered as potential source beds and might extend under a cover of Mesozoic beds further south and southeast into the deeper regions of the Great Artesian Basin. It was the purpose of this survey to map gravity Bouguer anomalies, to relate them to known major structures, to use them to help recognise and follow, if possible, the more important tectonical features, and to assess the likely relation between such features and gravity anomalies which are known to occur over much of the Great Artesian Basin.

2. CONDUCT OF FIELD WORK.

The gravity party of two geophysicists J.R.H. van Son (Party Leader) and R. Underwood and two field-hands spent from the end of May 1957 to the beginning of October on the field work.

The Georgina Basin Survey covers the area of roughly 22,500 square miles between latitudes 21° and 23° and longitudes 138° and 140° 15'.

Survey traverses were selected along existing roads and station tracks. Two hundred and nine gravity stations were read at an average interval of five miles over a total length of 1,000 miles of survey lines.

A large part of the topographic work required for the identification of station sites on airphotos, semi-permanent marking of stations, and the establishment of altitudes by barometer readings on some of the traverses was also carried out by the gravity party in addition to gravity readings.

Five hundred and eighty miles of base traverses were conventionally levelled by a topographic survey party supplied by the Department of the Interior, which also established astro-fixes at roughly 40 mile intervals to provide control points for the topographic base plan.

Railway levels supplied by the Queensland Govemn-ment Railways were used with gravity stations observed at mile posts along the Cloncurry-Dajarra and Duchess-Mount Isa railway tracks.

On the remainder of the traverses altitudes were obtained by using two Askania Micro-Barometers (Nos. 531, 316 and 5112 305). In an attempt to eliminate the effect of atmospheric pressure fluctuations from the barometric altitude determinations, two observers used two instruments following a field procedure, briefly described as follows:

On each interval between any two adjacent stations, barometer readings were taken simultaneously by both observers (A and B) at the first station. Then B moved on to the second station while A remained at the first station and at a predetermined time readings were taken simultaneously at both stations. Finally observer A also moved on to the second station, where the instruments were again read simultaneously. The process was repeated from station to station.

Check levelling carried out during the 1958 season with level and staff has shown that errors of only 3 to 5 feet occur with barometric altitudes, established in this manner.

Gravity-meter Worden No. 61 was used throughout the survey for gravity observations. The time drift of the instrument was closely controlled by re-occupying stations within one hour. The instrument drift appeared at times to be somewhat irregular: mean loop errors, however, remained within reasonable limits not exceeding a maximum of 0.4 milligals.

Gravity ties were made to the B.M.R. Pendulum Stations at Cloncurry and Boulia. The gravity meter interval did not agree with the difference between the pendulum values. When this is considered along with ties made during the 1958 season to Longreach and Birdsville pendulum stations it is believed that the accepted gravity value at Boulia is too low. The revised observed gravity value at Boulia may now be

978, 793.20 milligals as compared

with 978, 791,90 milligals, established by earlier pendulum work. However these figures will still need further adjustment.

Because of the absence of station descriptions it was impossible to make accurate gravity ties to the gravity stations established along the Cloncurry-Duchess-Mt. Isa Road by the University of Sydney during the 1954 survey. As relatively strong Bouguer anomaly gradients occur over the Pre-Cambrian rocks in this area, the B.M.R. findings agree only in a general manner with the earlier anomaly values with unexplained local discrepancies exceeding five milligals.

The gravity-meter used inthe field was calibrated against the observed gravity values of base stations near Melbourne, as a result of which a scale factor of 0.08895 milligals per division was determined for the reduction of field observations.

3. DISCUSSIONS OF RESULTS

The preliminary results of the Georgina Basin gravity survey of 1957 shown as Bouguer anomaly contours on plates No. 1 and No. 2, using as a topographic base the F 54 SW and F 54 NW sheets of the eight miles series map of Queensland.

Beds of Cretaceous age occupy a large portion of Queensland and compose the uppermost layers of sediments in the Great Artesian Basin. These beds, including sandstones, shales, conglomerates and concretionary limestone, are relatively low in density and high in porosity.

A uniform rock density (=1.9) between station sites and sea level was assumed for calculation of Bouguer anomalies. This was chosen as being representative of near surface Mesozoic and Tertiary rocks in the Artesian Basin. Variations in elevation of Pre-Cambrian and Palaeozoic rocks, both exposed and covered, are expected to exert a strong influence on the Bouguer anomaly contour pattern.

A higher density (between 2.2 and 2.5 or even higher) would be more applicable to eliminate the topographic effect for Palaeozoic formations, which crop out over wide areas of the northern and western portion of the surveyed area. However 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 affect the general pattern of the anomalies. Cretaceous and Tertiary beds crop out in the southeast of the area and Recent alluvial deposits containing loose sand and gravel beds of a very low density is found in the wider creek and river beds of the present drainage system.

Density data obtained from laboratory determinations of rocks collected from outcrops are tabulated in Table No. 1: this list includes - for comparison - the densities of Cretaceous rocks encountered in bores drilled at Haddon Downs in the north-eastern corner of South Australia and Wyaaba Creek near the Gulf of Carpentaria; both bores being within the Great Artesian Basin.

Bouguer anomaly contours shown on Plates 1 and 2 are of a preliminary nature and may be subject to small corrections for the following reasons:

(a) The observed gravity value at Boulia Pendulum Station is not yet finalised.

(b) There is no control of the contours between traverses, mainly in the area between Roxborough Downs and Buckingham Downs on Plate 2. Additional gravity station are required to determine the contours and the magnitude of the anomaly more precisely.

The main pattern of Bouguer anomalies, as shown on the accompanying plates indicates the following significant features:

(a) A zone of high Bouguer anomaly occurs in the eastern part of the investigated area with a maximum of +45.9 milligals on Station 4-6 near Duchess.

The general trend of this anomaly is south with a slight east tendency. Strong gravity gradients occur along its flanks and maximum gravity gradients observed are immediately east and west of Duchess. The axis of the highest Bouguer anomaly values runs

through Duchess south into the Burke River Valley where immediately south of Noranside Bouguer anomaly values exceed +30 milligals. The Duchess-Noranside gravity "High" appears to continue in a more south-eastern direction into the Great Artesian Basin. In the area between Noranside and Chatsworth the spreading of the 20 milligal contour indicates a broader anomaly pattern.

(b) A distinct gravity "Low" occurs in the area between Malbon, Devoncourt and Agate Downs approximately 25 miles east of the Duchess gravity "High". The trend is south-southeast.

(c) A narrow zone of low Bouguer values accompanies the Duchess-Noranside "high" along the western side. This "Low" is noticeable at Station No. 4-2 northeast of Dajarra and also at Station No. 7-4 southeast of Buckinham Downs and again at Station No. 6-1 northeast of Boulia. The anomaly is lowest near Buckinham Downs with -12.0 milligals Bouguer value at Station No. 7-4. Additional gravity stations would be required to delineate this "Low" more precisely.

(d) Predominating northwest trends are typical of the Bouguer anomaly contours over the southwestern and western portion of the surveyed area, mainly along the course of the Georgina River and between Smoky Creek and Moonah Creek.

(e) These northwest trends terminate in an extensive gravity "Low" which occurs north of Linda Downs homestead and more or less along the course Pituri Creek. The northwest trends are shown by a series of alternate "Lows" and "Highs".

(f) The area between Cottonbush Creek and Smoky Creek may be expected to have generally high Bouguer anomaly values. +15 milligal is indicated around the margins of the area. Additional gravity stations are required to determine the true Bouguer anomaly. Additional gravity stations are also required over the area east of Roxborough Downs to determine if the "Low" to the north of Linda Downs continues towards the southeast.

4. INTERPRETATION OF RESULTS.

In the following a preliminary interpretation is given with reference to the anomaly pattern as a whole rather than detailed features. Additional gravity field work of a semi- detailed nature has been completed during the 1958 field season mainly in the area of the Toko Range northwest of Glenormiston and east of the Burke River between Boulia, Marenda and Fort William homestead. At the time of this report results of the more recent work were not available for plotting.

The following principle applies in the assessment of Bouguer anomalies:

Relatively high Bouguer anomaly values indicate the presence of high density rocks

in outcrop or at shallow depth. Relatively low Bouguer anomaly values indicate a thickening of rocks of comparatively low density. Strong gravity gradients are typical for either faulted or highly folded beds with the gravity "High" being indicative of the crest of a fold or the upthrown side of a fault.

Table No. 2 shows greenstone, a Pre-Cambrian basic lava, is highest in density (=2.92), and sandstone of Ordovician age is lowest in density (=2.12) among the Palaeozoic and Pre-Cambrian specimens collected in the outcrop area.

Highest Bouguer anomaly values were established in the field near Duchess where highly metamorphosed rocks, including gneiss, gneissic granite porphyries and amphibolites of Pre-Cambrian (Lower Archaeozoic?) age occur together with greenstone.

From the gravity anomaly pattern it appears that the core of folded rocks, which form a major tectonic feature of the Pre-Cambrian area between Cloncurry and Mount Isa, extends most likely south-southeast under Cambrian, Ordovician, Cretaceous and Tertiary cover beds towards Fort William homestead and further southeast into The Black Mountain and Mount Datson structure.

A fault, which is known to exist east of Duchess with Lower Archaeozoic rocks outcropping on the upthrown (western side) and Proterozoic (Upper Archaeozoic?) rocks together with Cambrian beds on the eastern, downthrown side is associated with extremely strong gravity gradients between Stations 4-6 (+45.9 milligals) and Stations 4-7 (+27.00 milligals).

Pre-Cambrian rocks west of Duchess near Bushy Park appear to be bounded also by a fault as indicated by the strong gradient established between Stations 8-1 (+35.15 milligals) and Station 8-2 (+18.28 milligals).

The gravity "Low" between Malbon, Devoncourt and Agate Downs, where Cambrian sediments occur in outcrop, might be explained by a thickening at depth of the relatively unaltered and less folded sediments of Proterozoic age, which underlie the Cambrian beds. A gravity "High" of limited extent north of Malbon might be associated with the occurrence of greenstone.

In conclusion it can be stated, that gravity anomalies with extremely strong gradients which occur over the eastern portion of the Cloncurry-Mt. Isa Fold Belt are in agreement with the existence of highly folded and faulted formations.

Strong gradients are absent - in the pattern of anomalies west of the line from Mount Isa to Boulia, where Cambrian and Ordovician rocks of sub-horizontal bedding crop out over a wide area. From the more gentle features of the gravity anomalies, it can be concluded that the formations at depth are more horizontal in the western portion.

However, directly west of Boulia a gravity "High" of limited extent and northwest trend has been established

in an area where sub-horizontal Cretaceous and Tertiary sediments crop out. This suggests the existence of a horst-like feature within the Pre-Cambrian basement and, probably, in any overlying Palaeozoic formations.

The extensive "Low" north of Linda Downs homestead indicates a probable thickening of the Cambrian sediments in a northwestern direction.

Two low anomalies of limited extent southwest of Carandotta and south and west of Ardmore suggest the possibility of shallow basin areas bounded by tongue-like "Highs" in the basement topography. This interpretation is supported by the occurrence of Proterozoic beds between Urandangie and Warwick Downs as shown on the Urandangi sheet (1951) of the 4 mile geological map series

TABLE NO. 1

ROCK DENSITIES

SOUTHEAST GEORGINA BASIN AND GREAT ARTESIAN BASIN.

Type	Age/Locality.	Density grammes/ccm.
Greenstone	Pre-Cambrian, Dajarra	2.92
Limestone	Ordovician, Linda Downs	2.82
Limestone	Cambrian Urandangie	2.80
Shale	Pre-Cambrian, Dajarra	2.73
Limestone	Ordovician Linda Downs	2.72
Calcite, Crystalline	Duchess	2.64
Limestone	Cambrian, Dajarra	2.63
Ribbon Stone	Pre-Cambrian Cloncurry	2.62
Phyllite	Pre-Cambrian, Cloncurry	2.55
Sandstone	Ordovician Toko Range	2.12

Type	Age/Locality	Density grammes/ccm.
Weathered Sandstone	Ordovician Toko Range	1.6
Sandstone, Shale and Clayish Beds	Winton Formation, Haddon Down Bore Santos No.1.	1.82 (mean value of several specimens).
Shale	Tambo Formation, Frome-Broken Hill Wyaaba Bore No.1	1.9

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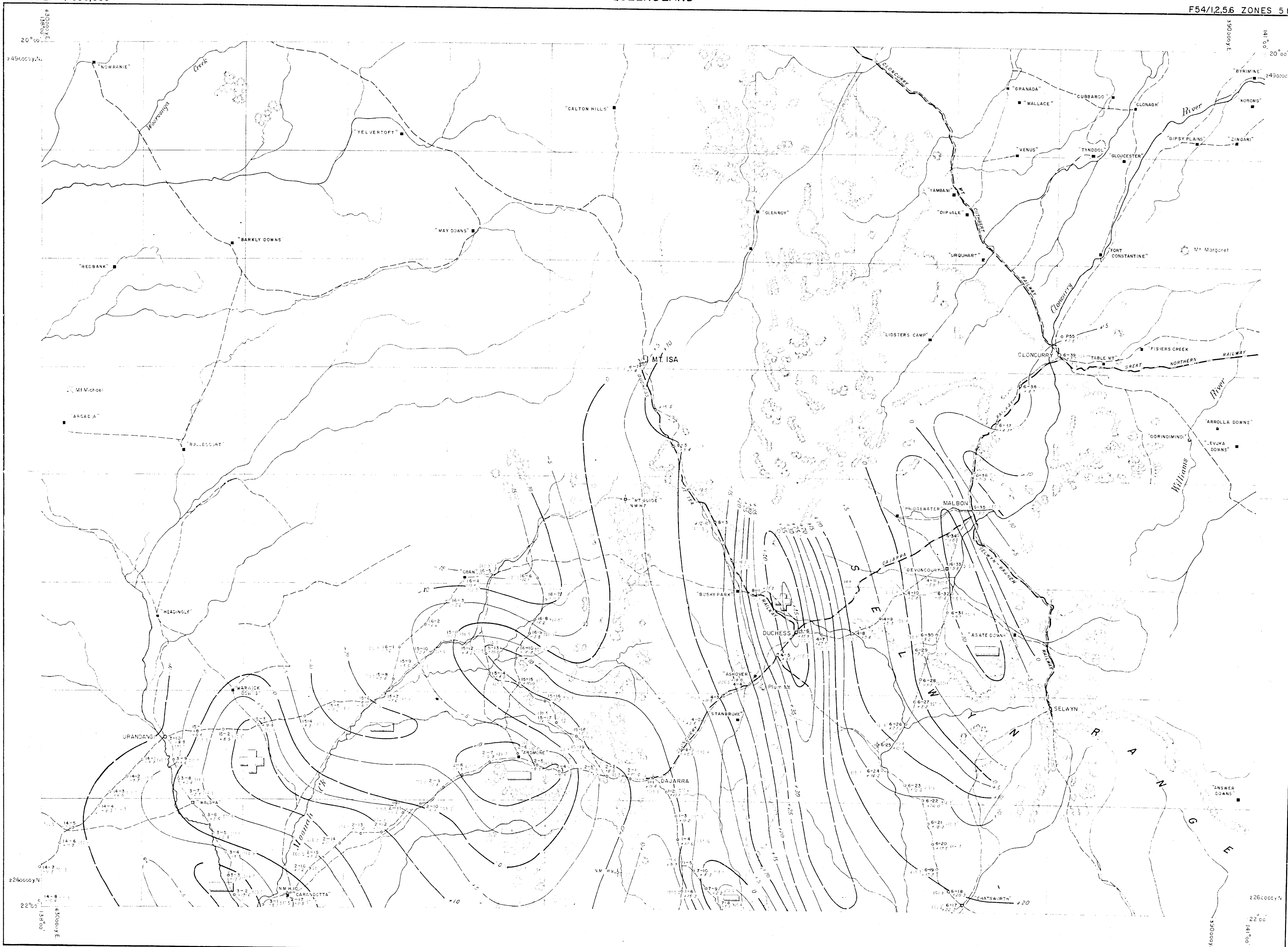
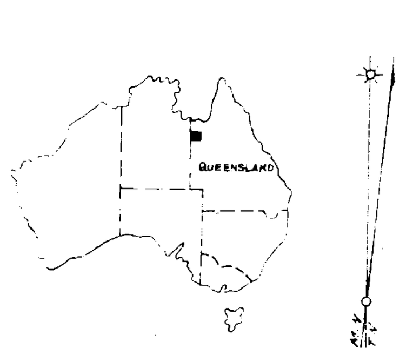
AUSTRALIA 1:506,880

F54/NW
QUEENSLAND

PLATE 1
F54/1,2,5,6 ZONES 5 & 6



LOCATION



E53/SE	E54/SW	E54/SE
AVON DOWNS	F54/NW	F54/NE
HUCKITTA	F54/SW	F54/SE

REFERENCE TO AUSTRALIAN NATIONAL 8 MILE MAP SERIES

MAP DATA

PROJECTION: *TRANSVERSE MERCATOR, AUSTRALIAN SERIES.*

CONTROL: *NATIONAL MAPPING DIVISION 4 MILE MAPS, PHOTO MOSAICS AND ASTRONOMICAL FIXATIONS.*

DETAIL: *GRID AND GRATICULE COMPUTED AND COMPILED BY THE GEOPHYSICAL DRAWING OFFICE.*

PLANIMETRIC DETAIL PLOTTED FROM NATIONAL MAPPING DIVISION 4 MILE MAPS AND PHOTO MOSAICS AND 4 MILE MILITARY SHEETS.

GEOPHYSICAL DATA FROM R.A.A.F. 1:50,000 AIR PHOTOGRAPHS, TRANSFERRED TO 4 MILE PHOTO MOSAICS, THEN REDUCED TO MAP CONTROL SCALE.

RELIABILITY: *(A) PLANIMETRIC — RELIABLE*
(B) GEOPHYSICAL — GRAVITY RECONNAISSANCE

RECONNAISSANCE GRAVITY SURVEY (1957)
GEORGINA BASIN
BOUGUER ANOMALY MAP

SCALE IN MILES
8 4 0 8 16 24 32

LEGEND

TOPOGRAPHY

ROAD	WATERCOURSE
TRACK	HOMESTEAD

GRAVITY

o	GRAVITY STATION	0, 5, 3	GRAVITY CONTOURS IN MILLIGALS
35-18	STATION NUMBER		
+12.2	RELATIVE BOUGUER ANOMALY		GRAVITY HIGH ANOMALY
420.3'	ALTITUDE IN FEET		GRAVITY LOW ANOMALY

EXPLANATION

RELATIVE BOUGUER ANOMALIES ARE BASED ON THE VALUES OF FOLLOWING B.M.R. PENDULUM STATIONS:

No 55 - CLONCURRY, QLD. - 978,650.7 MILLIGALS
No 56 - BOULIA, QLD. - 978,791.9 "

AN AVERAGE DENSITY 1.9 HAS BEEN ASSUMED FOR ROCKS BETWEEN STATION SITE AND SEA LEVEL IN REDUCTION OF GRAVITY VALUES

ELEVATION DATUM - M.S.L. (QUEENSLAND STATE DATUM).

GEOPHYSICAL SECTION, BUREAU OF MINERAL ...

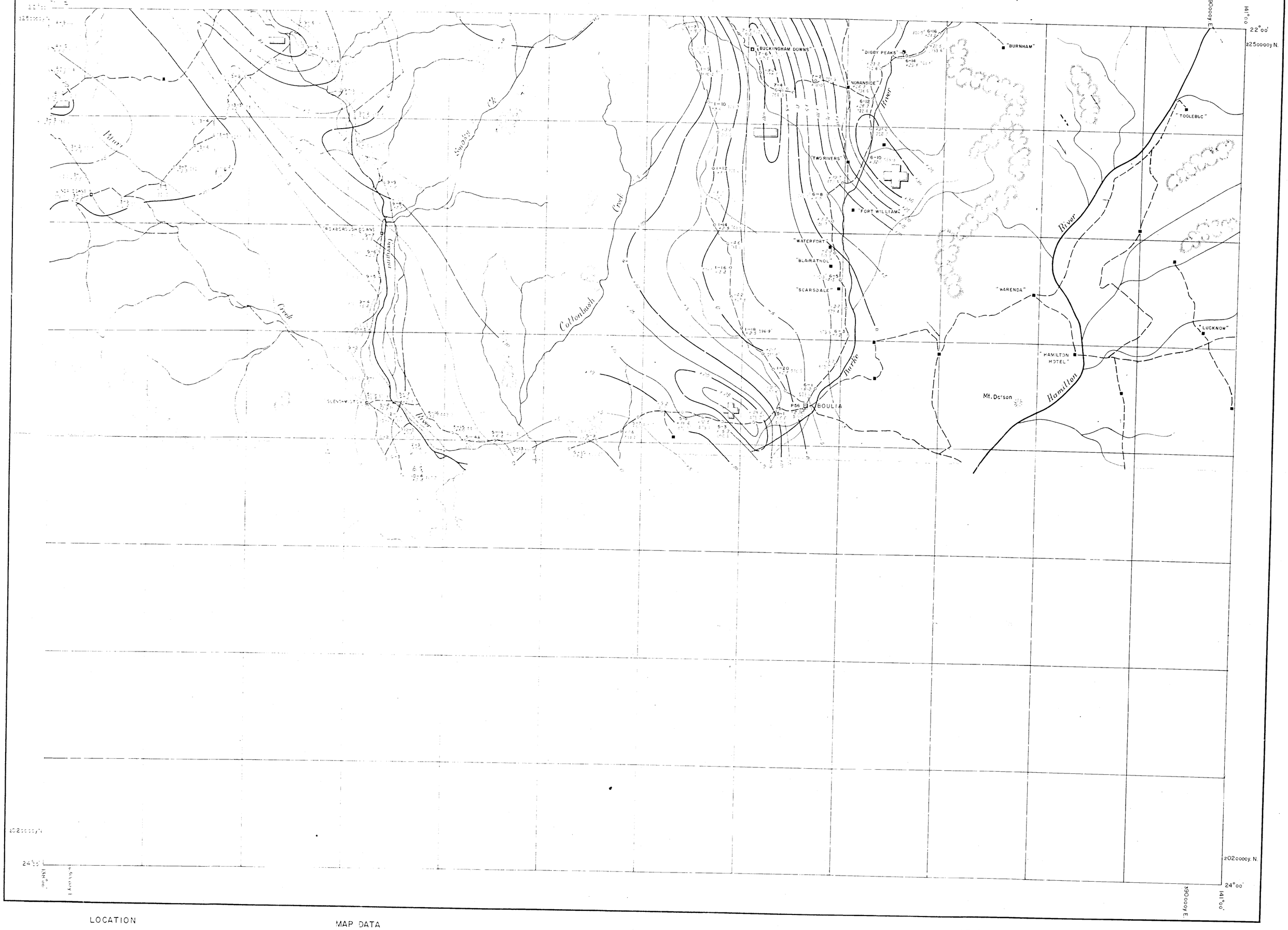
G276-3

AUSTRALIA 1:506,880

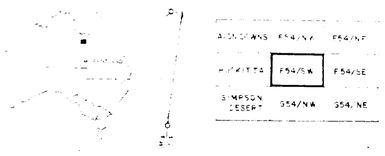
F54/SW
QUEENSLAND

PLATE 2

54/9,10,13,14 ZONES 5 & 6



LOCATION



REFERENCE TO AUSTRALIAN NATIONAL 8 MILE MAP SERIES

MAP DATA

PROJECTION: TRANSVERSE MERCATOR, AUSTRALIAN SERIES

CONTROL: NATIONAL MAPPING DIVISION PHOTO MOSAICS AND ASTRONOMICAL FIXATIONS

DETAIL: SHIP AND TRAVERSE SURVEYED AND SURVEYED BY THE GEOPHYSICAL DRAWING OFFICE

PLANIMETRIC DETAIL PLOTTED FROM NATIONAL MAPPING DIVISION PHOTO MOSAICS

GEOPHYSICAL DATA FROM RAAF VERTICAL AIR PHOTOGRAPHS, TRANSFERRED TO 4 MILE PHOTO MOSAICS, THEN REDUCED TO MAP CONTROL SCALE

RELIABILITY: (a) PLANIMETRIC DETAIL RELIABLE WITHIN
(b) GEOPHYSICAL — DEGREE RECONNAISSANCE

RECONNAISSANCE GRAVITY SURVEY (1957)
GEORGINA BASIN
BOUGUER ANOMALY MAP

SCALE IN MILES

8 4 0 8 16 24 32

LEGEND

TOPOGRAPHY

ROAD
TRACK
WATERCOURSE
HOMESTEAD

GRAVITY

0 GRAVITY STATION
35-18 STATION NUMBER
+12.2 RELATIVE BOUGUER ANOMALY
420 S ALTITUDE IN FEET
0 5 3 GRAVITY CONTOURS IN MILLIGALS
GRAVITY HIGH ANOMALY
GRAVITY LOW ANOMALY

EXPLANATION

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No. 55 - CLONCURRY, QLD. - 978,650·7 MILLIGALS
No. 56 - BOULIA, QLD - 978,791·9 " .

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ELEVATION DATUM - M.S.L. (QUEENSLAND STATE DATUM)

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

G276-3