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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1964/131

NORMANTON TO DALY WATERS RECONNAISSANCE GRAVITY SURVEY,

QLD AND NT

1959-60

by

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SUMMARY

A reconnaissance gravity survey was made by the Bureau of Mineral Resources, Geology and Geophysics in the area between Normanton (Queensland) and Daly Waters (Northern Territory) in 1959; a short traverse connecting Daly Waters with the area near Nutwood Downs was added during the 1960 field season.

The objective of the survey was to investigate the relation between major gravity anomaly features and geological structure, in an area which includes three major basins, viz. the Carpentaria, McArthur, and Georgina Basins. The results show a general decrease westwards in the Bouguer anomaly values with distinct gravity variations superimposed. The relation between these gravity anomaly features and geology is shown.

Maximum gravity anomalies which occur in the eastern portion of the area surveyed are probably related to Precambrian basement lithology.

1. INTRODUCTION

From August to November 1959 the Bureau of Mineral Resources, Geology and Geophysics made a reconnaissance gravity traverse from the southern fringes of the Gulf of Carpentaria in Queensland across the Barkly Tableland to Daly Waters in the northern portion of the Northern Territory. The traverse referred to commenced at Normanton and ended at the Bureau's pendulum station No.33 at Daly Waters.

During the initial period of the survey a gravity tie was made in order to connect the Bureau's pendulum station No.55 at Cloncurry with a gravity station occupied during the course of two earlier surveys at Normanton Airport.

A short gravity line was added to the western end of the Normanton-Daly Waters traverse in September 1960. This survey included gravity stations observed along the road from Daly Waters to a point about 20 miles beyond Nutwood Downs Homestead (Lonsdale, 1963).

A total of 224 gravity stations was established on traverses more than 1100 miles long, thus giving an average station separation of about five miles.

All of the topographic surveying and levelling required in the fixation of gravity station locations and in the determination of station altitudes was done by the Department of the Interior, Canberra. This Department also prepared the four-mile surface control maps necessary for the original plotting of the stations.

Originally it was planned to commence the 1959 survey in Burketown (Queensland) and to follow tracks through Doomadgee Mission, Calvert Hills, Borroloola, and O.T. Downs to Newcastle Waters and then proceed to Wyndham after tying to the Daly Waters pendulum station and looping back to O.T. Downs.

The survey was started in Cloncurry in order to establish gravity control between the Cloncurry pendulum station and Normanton Airport. Many readings were repeated because of irregular instrument performance. These factors delayed the 1959 survey, which had to be terminated at Daly Waters owing to rapidly deteriorating weather. Consequently the short traverse mentioned above to run east-north-easterly from Daly Waters was completed during the 1960 season under the supervision of the Bureau's Resident Geologist stationed at Darwin.

Detailed information concerning the staff members participating in the field work, the time-table of the survey, and the equipment used in the field is listed in three appendices at the end of this Record.

During the 1959 survey roads in the area traversed were in fair to good condition, except for a section between Normanton and Burketown, which was found to be very rough in places.

Petrol and emergency supplies could be obtained from Alice Springs, NT by mail planes operated by Connellan Airways Ltd.

Radio contact was maintained throughout the survey with Royal Flying Doctor bases at Cloncurry and Darwin. Darwin was contacted after the survey party moved into the area west of Borroloola.

2. PHYSIOGRAPHY AND DRAINAGE

Physiography

As a result of geomorphological studies conducted in connexion with the Bureau's recent geological investigations in the area traversed, the following main physiographic features have been described:

(a) Coastal plains

These plains occur as a broad fringe along the Gulf of Carpentaria, being formed by low-lying remnants of an early Tertiary land surface. The plains are studded with scattered hills.

(b) Dissected tableland and Gulf fall area

As a physiographic unit the belt of the dissected tableland and Gulf fall extends westerly from the coastal plains referred to above. In this belt the original laterite cover has been widely removed by abrasion and erosion, so that Upper Proterozoic rocks are now exposed over a wide area. Mesas composed of Cretaceous sediments indicate the altitude of the previous land surface.

(c) Barkly Tableland

This plateau-like region of about 800-ft altitude above sea level is essentially composed of Mesozoic (Cretaceous) and Lower Palaeozoic sediments. These sediments are capped with duricrust and laterite which have been formed on the surface during early Tertiary time. The eastern edge of the Barkly Tableland is marked by a distinct scarp about 100 ft high.

(d) Georgina Basin

This region is also referred to in early literature as the 'Barkly Basin'. Physiographically this basin is mainly a broad valley that is drained by the Georgina River and its tributaries. It is mainly limestone country covered with alluvial soil in association with sandy river beds in the lower portions, and with laterite occurring along the margins of the basin area.

Drainage

The watershed dividing the inland from the seaward drainage cuts across the area surveyed from south-east to north-west.

By far the greatest portion of the area is a basin of inland drainage via the Georgina River and its tributaries to Lake Eyre. In the north-west the Daly River drains a portion of the area south-west of Daly Waters into the Timor Sea. Most of the annual rainfall flows into the Gulf of Carpentaria through the McArthur, Robinson, Calvert, Nicholson, Gregory, and Leichhardt Rivers.

As the rainfall is seasonal the problem of water supply in the area as a whole is overabundance of water during a relative short period from November to March and insufficient supply for the remaining months. The average annual rainfall ranges from 39 inches at Normanton to less than 20 inches near Beetaloo. The annual total near Daly Waters ranges from 26 to 27 inches.

3. TOPOGRAPHY AND GEOLOGY

The main geological structure of the region traversed includes three major basins, viz. the Carpentaria, McArthur, and Georgina Basins.

In addition gravity data and geology indicate the existence of several minor basins, two of which have been given names, viz. South Nicholson and Undilla Basins. The approximate location of these Basins is indicated in Plate 1.

The geology of the area west and south-west of the Gulf of Carpentaria has become better known during the past few years because of ground traverses made by the Bureau's geologists as part of the survey of the Carpentaria Gulf and Barkly Tableland region.

The following notes on topography and geology have been prepared essentially by the Geological Branch of the Bureau. Minor alterations have been added in order to allow for recent findings and for the results obtained by drilling a number of stratigraphic bores, mainly in the search for oil.

Topography

Major topographic features are illustrated in the cross-section shown in Plate 6. From Normanton to station No.L31 the survey passes over coastal plains which are at 20 to 300-ft elevation above sea level. Between stations No.L31 and L34 there is an increase in elevation to 700 ft above sea level. The elevation decreases as the coastal plains east of and around Borroloola are approached.

Partly because of the valley of the McArthur River, low country was traversed south of Borroloola as far as station No.L80. West of this the surface gradually rises to station No.L100, on the eastern side of the Barkly Tableland which is 600 to 800 ft above sea level and extends from station No.L100 westwards to Newcastle Waters.

Geology

The regional geology of the area is shown in Plate 1; more-detailed geological boundaries are illustrated in Plate 3. The stratigraphic sequence of geological formations is listed in Table 1.

Explanatory Notes have been issued by the Bureau for the following 1:250,000 map areas.*

WESTMORELAND	(Carter, 1959a)
DOBBYN	(Carter, 1959b)
MOUNT ISA	(Opik, Carter, & Noakes, 1959)
LAWN HILL	(Carter & Opik, 1961)

Bureau Records have been issued on the following 1:250,000 map areas:

MOUNT YOUNG	(Plumb & Paine, 1962)
CALVERT HILLS	(Firman, 1959)
MOUNT DRUMMOND	(Smith & Roberts, 1960)
HODGSON DOWNS	(Dunn, 1962)
BAUHINIA DOWNS	(Smith, 1962)
ROBINSON RIVER	(Yates, 1962)
TANUMBIRINI	(Paine, 1962)
RANKEN	(Randal & Brown, 1962a)
AVON DOWNS	(Randal & Brown, 1962b)

Lower and Upper Proterozoic rocks crop out in the area traversed by the gravity survey. These beds are overlain by relatively thin, discontinuous Cambrian sediments and volcanics, and also by Mesozoic and Tertiary sediments (Lloyd, 1963). From the area south of Newcastle Waters, Lower Proterozoic rocks extend to the western-most end of the gravity traverse near station No. L128.

Low-grade metamorphosed sediments, volcanics, and intrusives (Murphy Metamorphics) of Lower Proterozoic age occur in the north-west portion of MOUNT DRUMMOND.

Unmetamorphosed sediments and volcanics of Lower Proterozoic age crop out on the southern wing of the South Nicholson Basin, which occurs as a smaller basin feature east-north-east across MOUNT DRUMMOND into the area of LAWN HILL. On LAWN HILL a small outcrop of granite, the Weberra Granite, is known.

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* Locality references in capital letters (e.g. CALVERT HILLS) refer, in this Record, to the names of the Australia 1:250,000 map areas. The boundaries of these areas are superimposed as a grid in Plates 1, 2, 3, and 5.

TABLE 1

STRATIGRAPHIC SEQUENCE, McARTHUR AND GEORGINA BASIN AREAS

Age	Lithology	Formation or Group	Bedding
Quaternary	Alluvials	-	Horizontal
Tertiary	Laterite Brunette Limestone	-	"
Mesozoic	Sandstone Mudstone Conglomerate	-	"
	UNCONFORMITY		
Palaeozoic (Cambrian)	Limestone	Tindall Limestone	
	Sandstone	Bukalara Sandstone	Sub-horizontal
	Volcanics	Nutwood Downs Volcanics	
	UNCONFORMITY		
Upper Proterozoic	Dolomite	Karns Dolomite	Gentle dipping
	Sandstone	Masterton Sandstone	
	Sandstone and Siltstone with Volcanics	Drummond Group Roper Group Gold Creek Volcanics	
	STRONG UNCONFORMITY		
	Limestone Dolomite Siltstone, Sandstone	Wollogorang and McArthur Group	Steeper folding and anticlinal structure
	Acid to basic lava	Peters Creek Volcanics	
	Conglomerate	Westmoreland Conglomerate	
	Sandstone	Tawallah Formation	Faulting mainly along Basin margins
	Volcanics	Cliffdale Volcanics	
	UNCONFORMITY		
Lower Proterozoic	Unmetamorphosed sediments and volcanics	Lawn Hill Formation	Much folded and intruded
	Low-grade metamorphosed sediments with intrusions	Murphy Metamorphics	
Igneous Rocks	Granite	Nicholson Granite (of Upper or Lower Proterozoic age)	
	Granite	Weberra Granite	

The Cliffdale Volcanics, now considered as Upper Proterozoic, occur in an east-striking belt and are closely associated with the Nicholson Granite on WESTMORELAND and CALVERT HILLS west of stations No.L21 to L22. The age of the Cliffdale Volcanics and that of the Nicholson Granite have not been conclusively established. Earlier, both were considered as being of Lower Proterozoic age but as they do not appear to have been involved in the tectonic movements that deformed the Lower Proterozoic Lawn Hill Formation farther south, they are now regarded as Upper Proterozoic. The Nicholson Granite probably intrudes the Cliffdale Volcanics, but they could be also co-magnetic. Both are basement rocks to younger Upper Proterozoic strata.

Upper Proterozoic rocks crop out on the gravity traverse from station No.L24 north-westward to station No.L59, and from station No.L72 westward to station No.L90. They also occur intermittently between stations No.L90 and L100.

The Upper Proterozoic sequence consists of sediments and volcanics, being intruded by intermediate to acid dykes. The sediments have been deposited in broad shallow basins. They overlie the Lower Proterozoic rocks with strong unconformity.

The oldest outcropping Upper Proterozoic rocks, including Tawallah Formation, Westmoreland Conglomerate, and Peters Creek Volcanics, consist of sandstone and conglomerate with acid to basic lava flows. Westmoreland Conglomerate and Peters Creek Volcanics occur north of the Nicholson Granite on WESTMORELAND and CALVERT HILLS (Plate 3). Tawallah Formation crops out on BAUHINIA DOWNS near stations No.L82 and L83.

This sequence is overlain by a limestone-dolomite, siltstone, and sandstone sequence known as McArthur Group on BAUHINIA DOWNS and as Wollogorang Formation on CALVERT HILLS and WESTMORELAND.

The McArthur Group-Wollogorang Formation is unconformably overlain by the Roper Group-Drummond Group rock sequence. These groups consist of siltstone and sandstone together with volcanics (Gold Creek Volcanics) which occur on ROBINSON RIVER and CALVERT HILLS. These rocks in turn are overlain by the Masterton Sandstone and finally by the Karns Dolomite, which is probably also of Proterozoic age and crops out on ROBINSON RIVER and CALVERT HILLS.

In the area of the McArthur Basin a maximum thickness in the Upper Proterozoic rocks ranging from 30,000 to 35,000 ft occurs on BAUHINIA DOWNS, where these rocks form a structural ridge marked by steep faults. On BAUHINIA DOWNS and also on WALLHALLOW the folding trends north.

The margins of the Upper Proterozoic basins are formed by ridges that are composed of Lower Proterozoic rocks. Changes in lithology and thickness occur across these ridges but correlation is still possible. In places Upper Proterozoic sediments show direct derivation from the ridges.

The east-north-east-striking South Nicholson Basin covers a major part of MOUNT DRUMMOND and LAWN HILL (Plate 1) and also the southern part of CALVERT HILLS and WESTMORELAND.

The western basin margin is formed by Murphy Metamorphics of Lower Proterozoic age and the north margin is the Cliffdale Volcanics-Nicholson Granite ridge. North of this ridge, the dips in the beds decrease rapidly over a short distance to sub-horizontal bedding, with the exception of a few anticlinal structures in the Wollogorang Formation.

Dipping angles within the Upper Proterozoic rocks range up to 50 degrees with an average of about 15 degrees. Where the rocks have been affected by faulting, dips steepen to vertical and in places strata are overturned.

Faulting is strongly developed within the Upper Proterozoic beds and in some places it parallels the basin margins, e.g. Emu Fault (Plate 3). A north-west fault direction is prominently expressed in Mallapunyah and Calvert Faults, which traverse BAUHINIA DOWNS and CALVERT HILLS respectively.

The Proterozoic rocks are unconformably blanketed with a widespread sub-horizontal sandstone of Lower to Middle Cambrian age, the Bukalara Sandstone. This sandstone forms a dissected plateau over a large part of CALVERT HILLS and extends into ROBINSON RIVER and BAUHINIA DOWNS. Farther east this plateau is formed by Upper Proterozoic rocks. The eastern edge of the plateau is marked by a rise in elevations between stations No. L31 and L34 to 700 ft above sea level. The highest altitudes near the centre of this plateau occur in the north-western part of CALVERT HILLS, where elevation exceeds 1000 ft. As a physiographic unit the plateau forms the north-eastern portion of the Barkly Tableland. It has also been referred to as the Carpentaria Block (Whitehouse, 1954).

Cambrian sediments and volcanics extend from this block into the north-eastern part of WALLHALLOW.

Widespread Mesozoic sediments, consisting of sandstone, mudstone, and conglomerate, form most of the Barkly Tableland between stations No.L100 and L121 east of Beetaloo. These beds occur in a shallow basin extending south-east, west, and north-west of Daly Waters. Recent examinations of Cretaceous strata deposited in this basin area show non-marine plant-bearing sandstone and shale of early Cretaceous age being continuous over a large portion of the Northern Territory. This development is quite distinct from that which predominated in the inland sea of Lower Cretaceous time over the Great Artesian Basin of Queensland (Skwarko, 1963) and in the area of the Carpentaria Basin.

In the Carpentaria Basin east of Doomadgee Mission the presence of Mesozoic beds of Cretaceous age is indicated in a number of wells drilled in recent years by private companies in the search for oil. These wells are listed in Table 2, and the results obtained from drilling in the area between Mornington Island and Weipa are correlated in Plate 4. Mesozoic sediments have been shown to increase gradually in thickness easterly from Doomadgee Mission, where they are 200 ft thick (as indicated by a shallow water-bore), towards Normanton (Robertson and Moss, 1959). In the Karumba well, basement rocks have been intersected at 2360 ft after penetrating Mesozoic beds under a veneer of Tertiary strata 129 ft thick (Plate 4). According to the seismic data the thickness of Mesozoic beds between Normanton and Burketown remains fairly constant (Robertson and Moss, 1959).

TABLE 2

WELLS DRILLED IN SEARCH FOR OIL

GEORGINA BASIN AND GULF OF CARPENTARIA AREA

Name and position	Company	Year when completed	Total depth (ft)	Basement lithology
Mornington Island				
No.1 Long. 139° 15' 27" Lat. 16° 32' 44"	Delhi-Santos (Terpstra & Evans, 1962)	1961	2764	Granite
No.2 Long. 139° 31' 11" Lat. 16° 29' 13"	Delhi-Santos (Harrison, Greer, & Gibson, 1961)		3000	"
Weipa				
Long. 141° 55' 5" Lat. 12° 43' 0"	Zinc Corp. (B.M.R., 1960b)	1957	3243	Metamorphosed basement rock
Karumba				
Long. 140° 52' 21.9" Lat. 17° 24' 36.6"	A.A.O. (B.M.R., 1960a)	1958	2364	Granitised quartzite
Wyaaba				
Long 141° 37' 22" Lat. 16° 29' 30"	Frome-Broken Hill A.A.O., and Assoc. Freney (B.M.R., 1960b)	1957	2822	Quartz greenstone derived from gabbro
Lake Nash				
Long. 137° 53' 20" Lat. 20° 54' 18"	Amalgam. Petroleum N.L. (Mines Administration, 1963a)	1963	1316	Quartzite (Proterozoic?)
Morestone				
Long. 138° 30' 50" Lat. 19° 34' 15"	Amalgam. Petroleum N.L. (Mines Administration, 1963b)	1963	2504	(ending in red sandstone, basement not reached)

Mesozoic beds in the Gulf of Carpentaria area are lithologically similar to those known from the Great Artesian Basin farther south. They include predominantly marine dark shales of Lower Cretaceous (Aptian and Albian) age, which are contained in the Blackdown (Roma) and Normanton (Tambo) Formations. These strata are overlain by Upper Cretaceous Winton beds, which are non-marine on the western side of York Peninsula, becoming more marine westerly in the Mornington Island area.

Marine limestone of younger Tertiary age has been described from BRUNETTE DOWNS and ALROY, between Rockhampton Downs and Anthony Lagoon. This Brunette Limestone, as it has been named, is richly fossiliferous, having been deposited in shallow water of marine, lagoonal, or brackish environment, probably during the course of a small marine transgression near the end of the Miocene period (Lloyd, 1963).

Quaternary sands blanket the Normanton to Burketown area and recent alluvial deposits are widespread in the river valleys and along the fringes of the Gulf of Carpentaria.

The composition of the basement below the sediments in the area of the Carpentaria Basin is probably complex. Drilling data listed in Table 2 show basement lithology of considerable diversity at various bore locations, e.g. granite, granitised quartzite, metamorphic rock, and greenstone derived from gabbro. Intrusions in the basement ranging from acidic to basic rock types probably cause lateral density changes of considerable magnitude.

4. PREVIOUS SURVEYS

In the area north and east of Burketown the first geophysical work was an aeromagnetic survey flown in 1955 by Adastra Hunting Geophysics Limited over Frome-Broken Hill Company's permit area. The purpose of this survey was to provide general geological and structural information.

Following this aeromagnetic survey, gravity investigations were made by Frome-Broken Hill Pty Ltd and Mines Administration Pty Ltd and by the Bureau of Mineral Resources. During 1958 the Bureau conducted an underwater gravity-meter survey on the waters of the Gulf of Carpentaria, in which stations were read at roughly 20-mile intervals (Williams and Waterlander, 1958).

In the second half of 1958 the Bureau also made a seismic survey over certain prominent gravity 'high' anomalies indicated by these earlier surveys. It was hoped that at least the major gravity anomaly features, which occur east of the Gulf of Carpentaria, would be related to the presence of structures associated with sediments suitable for oil accumulation. However, seismic results and subsequent drilling showed that the gravity anomalies referred to were mainly caused by lateral density variations due to complex lithology of the basement (Robertson and Moss, 1959), as confirmed by drilling (Table 2).

From the 15th May to the 20th June 1959 the Bureau of Mineral Resources made a regional gravity survey using a commercial airline (Radeski, 1962). Isolated gravity stations were observed at 20 homestead airstrips throughout the area discussed in this Record.

During 1951 staff from Sydney University made gravity observations at 10-mile intervals along the Barkly Highway, traversing the central part of the Georgina Basin from Cloncurry via Mount Isa and Camooweal to Tennant Creek (Marshall and Narain, 1954). Paulin altimeters were used for determining station elevations and a Worden gravity meter for gravity readings.

Where applicable the results of the Bureau's 1959 regional survey and the gravity data available from various private companies and Sydney University have been integrated into the gravity anomaly contour plan shown in Plate 2.

Gravity variations, mainly in the form of symmetrical Bouguer anomalies of positive sign, have been described as the principal results of the 1951 survey by Marshall and Narain (op. cit.). In analysing the results of the survey, they concluded that no immediate explanation for the gravity anomalies measured can be obtained from the geology revealed by rock outcrops. Flat-lying or sub-horizontal beds of Lower Palaeozoic age occur over the whole extent of the area traversed during 1951. Consequently, the distinct gravity anomalies observed between Camooweal and Tennant Creek were related by Marshall & Narain (op. cit.) to probable folding in Lower and Middle Proterozoic beds, which it is suggested are overlain unconformably by the Upper Proterozoic and Cambrian sediments in the Georgina Basin.

5. OBJECTIVES OF THE SURVEY

From a consideration of the facts dealt with in Sections 3 and 4 the following main objectives of the 1959/60 survey can be stated:

(a) To supplement the regional gravity anomaly picture available in the northern portion of Australia by traversing a region in which little geophysical work had been done.

(b) To assist the geological survey over the area by providing basic gravity data of some value in the assessment of major structure and in the evaluation of basin-type areas delineated as a result of the geological investigations,

(c) To establish gravity data in the area immediately south of the Gulf of Carpentaria which would throw some light on a possible extension of highly folded and intruded Precambrian rocks contained in the Cloncurry Fold Belt farther south; these Precambrian rocks are known from earlier surveys (Gibb, in preparation) to be associated with very pronounced and unusual gravity anomaly features.

(d) To make a gravity tie from the Bureau's pendulum station No.55 at Cloncurry to Normanton Airport for the purpose of re-examining the accuracy of two observed gravity values obtained as a result of two previous surveys. There was a discrepancy of 0.5 mgal in the readings taken at the Normanton Airport gravity station by L. Williams in 1958 and by Radeski (1962).

6. FIELD PROCEDURE AND REDUCTIONS

Field procedure

Gravity readings taken along the Normanton to Daly Waters traverse were tied to the Bureau's pendulum stations No. 55, Cloncurry (978,650.7 mgal) and No.33, Daly Waters (978,388.6 mgal) which had been observed during 1950-51 (Dooley et al., 1961). In the meanwhile the pendulum station values have been adjusted; revised data have been established (Dooley, in press). The adjusted values are as follows: Cloncurry pendulum station (978,651.4 mgal), Daly Waters pendulum station (978,388.5 mgal). Thus a small correction should be made to the values given in this Record; however, this is not enough to affect the conclusions.

The Normanton Airport gravity station was tied to the Cloncurry pendulum station by observing 20 intermediate stations, from five to 17 miles apart, along the road between Cloncurry and Normanton. These stations were temporarily marked, but not levelled. Station descriptions are available for future use.

Stations on the traverse between Normanton and Burketown have been levelled but not permanently marked. These stations were identified in the field by using station descriptions and air photographs. Station elevations were measured by conventional spirit levelling, and are referred to mean sea level.

Along the major portion of the traverses extending from Burketown to Daly Waters all gravity stations were permanently marked and station heights were determined by conventional levelling by the Commonwealth Department of the Interior.

A Heiland gravity meter No.58 was used during the course of the 1959 survey. The thermostat temperature was constantly set at 47.2°C, corresponding to approximately 117°F. Batteries required for heating the instrument were charged daily with the aid of a generator driven by the truck engine.

Notwithstanding the temperature control, the performance of the meter in the field was not entirely satisfactory owing to its irregular drift. There appeared to be a relation between the rate of drift and variations in the outside air temperature, and it was obvious that the drift-rate of the meter was more regular for outside temperatures below 100°F.

In order to avoid periods of extreme heat, readings were taken during the early morning hours when possible. The time interval between two repeat readings taken at any particular station was normally within one hour.

Inside the vehicle the gravity meter was mounted in a shock-absorbing cradle to avoid mechanical jolting of the instrument when traversing rough sections of the road, difficult creek crossings, etc. However, this did not prevent occasional 'jumps' in the readings. During the course of the survey there were about 10 variations or 'jumps' in the readings, ranging from two to three scale divisions and leading to increased as well as decreased reading results. In addition one maximum 'jump' of about six scale divisions occurred.

In order to minimise the unpredictable element from the time-drift behaviour of the gravity meter (see Appendix B for detail), each station of the gravity traverse was read three times, using the 'two-up-one-back' method as reading procedure. This method includes readings to be taken in the following order of stations numbers:

One-two; One-two-three; two-three-four; three-four-five; etc.

Reductions

For each station the meter readings were corrected for instrument drift and irregular 'jumps' by plotting a drift curve based on the results of the repeated readings (see above).

The drift-corrected readings were then converted to milligals by using an instrument calibration factor of 0.1104 mgal/ scale division. This calibration factor was determined prior to the field survey by calibrating the meter between gravity stations at Brenock Park and Kallista near Melbourne (Victoria).

The converted readings were then adjusted to the previous work conducted in Queensland and to the Cloncurry and Daly Waters pendulum stations, referred to above. Misclosures were adjusted to give the final observed gravity value of each gravity-meter station. Corrections for latitude and station altitude above mean sea level were then applied to obtain the Bouguer anomaly value of each station.

Bouguer anomaly values were first computed using a crustal density of 2.67 g/cm^3. For the purpose of this Record, Bouguer anomaly values were also computed using densities of 2.2 g/cm^3 and 1.9 g/cm^3. The variations in the gravity anomaly curve that result from the adoption of different densities are shown graphically in Plate 6. On the low-lying areas these variations are almost negligible, but on areas of high topography the gravity reductions with higher densities lead to considerably lower Bouguer anomaly values.

In the section of relatively steep topographic rise between stations No.L31 and L34 the Bouguer values have been also computed using a density as high as 3.45 g/cm^3. This method was used to examine further the possible gravity effect of extremely dense rocks of basic-type volcanics, which frequently occur near the surface in the area of the Barkly Tableland (Carpentaria Block).

The final results of the gravity work have been presented in the form of gravity contours in Plates 2 and 5.

A cross-section of the traverse extending from Normanton (Karumba Well) into the area of Newcastle Waters has been added (see Plate 6) in order to illustrate the correlation between gravity, topography, and geology.

Bouguer anomaly values used in the contouring in Plates 2 and 5 are those obtained by adopting a rock density of 1.9 g/cm^3. To show a possible relation between the Normanton-to-Daly-Waters gravity data with those of a wider area, the scattered gravity results obtained from various field surveys have been integrated into a regional gravity anomaly contour plan (Plate 2).

Owing to the paucity of gravity stations over most of the area, contouring was attempted only in a broad manner with the intention to show possible trends in the anomalies and major features of more-regional extension. Therefore, it should be clearly understood that the gravity anomaly pattern shown in Plates 2 and 5 is provisional and that it could be considerably altered as more information based on denser station coverage becomes available. However, it is felt that even at this stage the attempt to recognise prominent trends and major closed anomaly features was justified.

7. DESCRIPTION OF RESULTS

The results of the gravity work show a general decrease in Bouguer anomaly values westwards along the traverse between Normanton and Newcastle Waters, with distinct gravity 'lows' superimposed in the sections of the profiles between Nicholson and Robinson Rivers and also near O.T. Downs and Beetaloo (see Plate 6). The decrease westerly in the reduced gravity values is expressed as a regional gravity gradient of approximately 0.1 mgal/mile.

From the correlation of gravity and topography shown in Plate 6, it is apparent that in a general way the topographically high areas of the Barkly Tableland have lower Bouguer anomalies than the low-lying region of the coastal plains.

The highest gravity anomalies are near station No. GS 21, near the eastern end of the traverse in the area immediately south-east of Burketown. Station No. GS 21 has a Bouguer anomaly value of +41.3 mgal when reduced with 1.9 g/cm^3 density, and of +40.8 mgal when reduced with 2.67 g/cm^3 density.

The plan of the integrated gravity contours (Plate 2) shows a closed gravity anomaly of east-north-easterly strike direction in the area south of Burketown, the amount of the closure being about 20 mgal. For convenience this anomaly is referred to as the 'Burketown High'.

Plate 2 also shows that the 'Burketown High' forms a portion of a much wider area of relatively high gravity anomaly that follows broadly the fringes of the Gulf of Carpentaria, and also includes the somewhat irregular anomalies measured by Frome-Broken Hill at stations on islands in the Gulf area, e.g. Mornington Island, Bentinck Island. North-east of the 'Burketown High' a group of gravity 'high' anomalies was located by earlier surveys on the eastern coast of the Gulf of Carpentaria.

Farther south of the 'Burketown High', regional gravity stations established on DONORS HILL and DOBBYN include Wondoola (+8.7 mgal), Lorraine (+13.8 mgal), and Kamileroi (+29.1 mgal). These relatively high values form a gravity ridge of mainly north-north-east strike, which falls in line with the group of distinct gravity anomaly features measured in the area of the Cloncurry Fold Belt (Gibb, in preparation).

A broad gravity depression was traversed during the course of the 1959 survey in the area extending west from Westmoreland Homestead to Robinson River. This anomaly is terminated in the west by a sharp rise in gravity on the banks of the Robinson River.

The plan of the integrated gravity values (Plate 2) shows a possible southerly extension of low gravity values into the area of the South Nicholson Basin, where comparatively low readings were obtained by Radeski (1962) e.g. those at Creswell Downs (-25.9 mgal), Brunette Downs (-23.1 mgal), and Alexandria (-46.1 mgal).

In the area between the Robinson and McArthur Rivers a major gravity 'high' extends roughly from station No.L59 (+11.5 mgal) westwards to station No. L77 (+9.5 mgal). This anomaly of mainly north-east strike direction might also be closed, although it is not possible at this stage to determine the total amount of the closure. The stations established during the course of the 1959 survey are mainly marginal to this anomaly. The comparatively high reading by Radeski during the course of the 1959 regional gravity survey at Mallapunyah (+11.9 mgal) might be indicative of a south-westerly extension of the anomaly between the Robinson and McArthur Rivers. The feature might even extend farther south-west into the area near Eva Downs, where a Bouguer anomaly of +7.4 mgal has been measured.

Westwards from McArthur River a sharp gravity 'low' located at stations No.L84 (-13.0 mgal) and L85 (-12.6 mgal) is terminated further west by a gravity 'high' of comparable sharp variation, which was observed at stations No.L88 (+2.9 mgal) and L89 (+2.9 mgal).

Near the western end of the gravity traverse and east-north-east of Newcastle Waters two gravity 'lows' have been measured, a smaller one centred at O.T. Downs and a larger one at Beetaloo respectively.

These low anomalies are separated by a gravity 'high' of comparable magnitude that might extend from the main gravity traverse north-westwards into the area around Nutwood Downs.

8. INTERPRETATION OF RESULTS

Geophysical problem

Basically, gravity Bouguer anomalies are caused by density contrasts between various geological formations, for example, geological basins containing sedimentary rocks bounded by elevated complexes of older and denser rocks.

In highly folded, faulted, and intruded areas such as the Amadeus Basin (Langron, 1962; Lonsdale and Flavelle, 1963) it is virtually impossible to explain the gravity anomalies solely in terms of sedimentary basins or troughs. A major part of the gravity variations must be attributed to density variations within the Precambrian basement. Similarly, over the fold belt exposed east of about longitude 139°E in the southern part of the area shown in Plate 1, intensive gravity variations have been observed (Plate 2). These anomalies have a pronounced northerly trend.

West of this, the anomalies are less-intense and broader and have no pronounced trend. The flat-lying Cambrian sediments indicate that this area has remained stable at least since the early Palaeozoic; the different pattern of the gravity anomalies suggests that it was tectonically less-active even in Proterozoic times, and that it forms a different geological province from the fold-belt.

Although the gravity data are much sparser north of latitude 21°S it is postulated that this division into two distinct geological provinces persists northwards to the traverse under discussion. Accordingly, the gravity anomalies west of about station No. L26 have been interpreted as due mainly to thickness of the Cambrian sediments. This interpretation is tentative, but seems the most-reasonable one to adopt at this stage. However, it should be realised that almost certainly some gravity variation arises from density contrasts within the basement. In particular, the regional decrease westwards probably has a deep-seated origin associated with isostatic compensation.

The initial approach to problems relating to the geological explanation of Bouguer anomaly features is normally attempted by way of correlating gravity contour trends, prominent gravity gradients, and major closed-anomaly features with observed geological data.

As a general rule, sedimentary rocks are less dense than igneous and metamorphic rocks of more compact texture. Sediments of younger geological age are frequently more porous and less dense than older strata, which after deposition have become denser by compaction and chemical infiltration, causing e.g. silicification.

In the surveyed area, rock densities have been determined of a limited number of surface specimens collected in the vicinity of Nutwood Downs (Lonsdale, 1963). More density data would be desirable in order to evaluate better the gravity results available at this stage; the density values listed in Table 3 might not be entirely typical for the whole extent of formation outcrops, and surface specimens frequently do not give a representative value for the density at depth. In Table 3 the results of density determinations are listed in the order of increasing values.

Density data listed show that geologically young sandstones are relatively low in density and become gradually denser with increasing age, e.g.

Sandstone	Density (g/cm^3)
Cretaceous	1.75
Lower Cambrian Bukalara	2.23
Upper Proterozoic	2.50

TABLE 3

ROCK DENSITIES, NUTWOOD DOWNS AREA

Rock type	BMR specimen No.	Age	Density (g/cm^3)
Sandstone (very porous)	6005	Cretaceous	1.75
Bukalara Sandstone	6027	Lower Cambrian	2.23
Sandstone	6011	Upper Proterozoic	2.50
Siltstone	6024	" "	2.51
Shale	6025	" "	2.56
Tindall Limestone	6004	Middle Cambrian	2.72
Nutwood Downs Basalt	6003	Lower Cambrian	2.98

NOTE:

Specimens used for density determinations were on loan from the Geological Branch of the Bureau of Mineral Resources. They were collected by geologists from outcrops in the vicinity of Nutwood Downs Station and submitted to Footscray Laboratory for density determination by Lonsdale (1963).

Limestone formations are generally known to be denser than sandstone. Accordingly the density of Middle Cambrian Tindall Limestone was found to be 2.72 g/cm^3.

Highest density values for rocks occurring in the area traversed can be expected from basic and ultra-basic volcanics. As an example, the density of Nutwood Downs Basalt was determined as 2.98 g/cm^3.

No density data are available from the rocks that compose the basement complex. From experience it is known that metamorphic rocks affected by basic intrusions are denser than the various types of sediments. Consequently, densities of Lower Proterozoic metamorphics in the area investigated can be estimated to range from 2.75 to 2.85 g/cm^3.

For the purpose of geological interpretation of gravity anomalies over basin-type areas of the region traversed, a density contrast between sediments and the underlying basement within the range from 0.25 to 0.3 g/cm^3 has been adopted. The results of the analysis are shown in Plate 6.

While basement rocks can be considered generally to be denser than overlying sediments, major granitic intrusions would tend to decrease gravity readings. This could be suggested from the area of the Nicholson Granite, which might protrude deep into the sub-basement as an intrusive body of 2.65 g/cm^3 density.

Interpretation in detail

From a consideration of the known geological data and the descriptions of gravity results dealt with in Sections 3 and 7, the gravity anomaly picture obtained from the 1959-60 and earlier surveys in the area has been interpreted as follows :

(a) High anomaly in the eastern portion of the surveyed area, including the 'Burketown High'. The high gravity anomaly features in the eastern portion of the 1959-60 survey between Normanton and Westmoreland Homestead occur in an area of outcropping Cainozoic and Mesozoic beds, which are horizontally deposited and, for that reason, do not offer any explanation for the anomalies. However, immediately south of latitude 18 degrees south, i.e. in the region south of Doomadgee Mission, a large complex of Precambrian rocks has been described (Carter and Brooks, 1960). The oldest Precambrian rocks in the area form a zone of uplift which lies a little west of longitude 140 degrees east and follows a submeridional strike direction near the middle portion of the Cloncurry Fold Belt. This belt occurs between longitude 139 degrees and 142 degrees, being composed of metamorphosed lavas, gneiss, schist, and migmatite, associated with numerous intrusions of metadolerite, amphibolites, and major masses of granite. This is a fold belt and from the very nature of the lithology prevailing here, it has been concluded (Gibb, in preparation) that a wide range of rock densities must exist within the Precambrian rock complex in this particular area.

Positive gravity variations of considerable magnitude can be expected from the denser metamorphic and basic igneous rocks, whereas more-negative anomalies would be caused by acidic granite protruding deep into the lighter basement or sub-basement. In fact, the results of various gravity surveys conducted over western Queensland during recent years disclosed distinct gravity anomalies of positive and negative sign following submeridional trends and extending from the area between Mount Isa and Cloncurry southerly into the area near latitude 24 degrees, where Precambrian rocks entirely disappear beneath a blanket of Mesozoic strata, mainly deposited in the Great Artesian Basin of Queensland.

As the high anomalies in the area westwards from Normanton appear to be connected by a gravity ridge extending south to the anomalies of the Cloncurry area, the most-reasonable explanation would be to expect a corresponding extension under Mesozoic cover beds of the Precambrian rock complex. However, the fact that the 'Burketown High' elongates east-north-east might indicate a somewhat different development in the Precambrian rocks, which might follow the fringes of the Carpentaria Gulf.

(b) <u>Gravity 'low' between Westmoreland and Robinson River.</u> In the area south of Westmoreland Homestead the relatively low readings obtained on stations No.L21 to L26 probably indicate an easterly extension of the Nicholson Granite, which crops out about 20 miles west of station No. L21. Low readings observed on the section of the gravity traverse extending westwards from station No.L27 to L56 are probably caused by a thickening at depth of the Upper Proterozoic rocks that occur in this portion of the McArthur Basin.

Assuming a density contrast of 0.25 g/cm^3 between the sediments and the basement rocks a thickness of about 12,000 ft of sediments could be expected in this particular area. Naturally this figure must be considered highly conjectural because of the scant gravity data available at this stage.

An attempt was made to apply the method of Nettleton (1940) for density determination over the rise in topography between station No.L31 and L34 with altitudes of 186 ft and 629 ft respectively. These gravity observations were taken across a fault that occurs west of Wollogorang and brings Gold Creek Volcanics and Peters Creek Volcanics nearer to the surface in the area west of the fault (see Plate 6). The Bouguer values plotted with this particular part of the anomaly curve were reduced by applying density values of 1.9, 2.2, 2.67, and 3.45 g/cm^3. This form of analysis assists in distinguishing under favourable circumstances between gravity anomalies caused by subsurface density variations and those produced by topographic features. It is also used to determine the density of rocks that compose the topographic feature. As can be seen in Plate 6, the bulge in the anomaly curve between stations No. L31 and L34 decreases with higher densities applied in reducing the gravity data. Finally a straight line downwards appears when the density of 3.45 g/cm^3 is used. The gravity stations involved are far apart and not ideally placed for a density traverse, but the results suggest that relatively dense rock types can be expected to occur near the surface in the area immediately west of the fault mentioned. This finding agrees with the geological situation where basic volcanic rocks compose a plateau-like feature west of the fault.

The rise in the gravity readings along the western bank of the Robinson River can be interpreted as a major fault.

(c) <u>Gravity 'high' between Robinson and McArthur Rivers.</u> In the area between station No.L59 west of Robinson River and station No. L77 on the western bank of the McArthur River relatively high gravity readings have been obtained in an area that forms a portion of the coastal plains and lies in the north-western portion of ROBINSON RIVER and in the north-eastern portion of BAUHINIA DOWNS. Surface beds are mainly Cainozoic depositions underlain by Cambrian Bukalara Sandstone, which in turn may be underlain by Upper Proterozoic strata. High gravity readings suggest the existence of relatively shallow Lower Proterozoic basement, overlain by Upper Proterozoic sediments probably not more than 4000 ft thick (see Plate 6). According to gravity data the suggested ridge in the Lower Proterozoic beds might extend southerly or south-westerly into the area near Eva Downs.

(d) Gravity variations west of McArthur River. Upper Proterozoic rocks in the area immediately west of McArthur River were extensively deformed and uplifted before Cambrian times. Structurally these beds, which include the Roper Group, McArthur Group, and Tawalla Formation, form a ridge marked along the edges by steep faults such as Emu and Mallapunyah Faults.

This ridge in itself is known to be faulted. One possible interpretation of the gravity data is to postulate a granitic intrusion at depth in the area around stations No. L84 and L85, where the relatively-low Bouguer anomaly values of -12.6 and -13.0 mgal have been measured.

In the western-most portion of the 1959 traverse, i.e. in the area extending west of the Mallapunyah Fault to the Stuart Highway, surface depositions include alluvials and horizontally-bedded Mesozoic strata.

In the Nutwood Downs area Lower Cretaceous sandstone, siltstone, and conglomerate are underlain by Middle Cambrian Tindall Limestone and Lower Cambrian Nutwood Downs Volcanics together with Bukalara Sandstone. These Palaeozoic beds, having been weakly folded and faulted, compose an almost-undeformed veneer overlying more-intensely-folded Upper Proterozoic rocks (Paine, 1962). Accordingly, the low gravity anomalies described earlier, from the area near O.T. Downs and Beetaloo respectively, are interpreted as most-probably caused by a thickening in the folded Upper Proterozoic beds. Assuming a density contrast between the sediments and the basement of 0.3 g/cm^3, the depth to the basement might be about 7000 ft near Beetaloo, and might reach about 4000 ft near O.T. Downs (Plate 6).

Gravity results obtained along the 1960 traverse east and north-east of Daly Waters and near Nutwood Downs have been discussed by Lonsdale (1963), who concludes that local anomaly features can be reasonably explained as being caused either by gravel beds on the surface or by variation in the thickness of the Nutwood Downs Volcanics. The relatively high readings obtained between stations No.L104 and L110 might indicate a shallow ridge composed of high-density Lower Proterozoic rocks. This ridge might extend north-north-westerly from the main traverse into the Nutwood Downs area, where similar high readings were obtained near the end of the 1960 traverse south of Nutwood Downs.

9. CONCLUSIONS AND RECOMMENDATIONS

The low gravity anomalies in the western part of the traverse have been interpreted as Cambrian sedimentary basins. On the other hand relatively high gravity readings have been interpreted as either high-standing block-type structure or specific Precambrian lithology, as in the low-lying eastern portion of the surveyed region, i.e. around the fringes of the Carpentaria Gulf.

It is recommended that the area be investigated in more detail, preferably using the helicopter field procedure developed by the Bureau of Mineral Resources during recent years. Gravity data sufficiently close-spaced with a regular grid pattern of station locations would undoubtedly improve the knowledge of the geological setting of the area covered.

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APPENDIX 'A'

STAFF

Bureau of Mineral Resources

J. van Son, geophysicist, party leader from 10th August-9th September 1959.

A. Radeski, assistant geophysicist, party leader from 9th September - 23rd November 1959.

A. Douglas, geophysicist, party leader during September 1960, supervised by the Resident Geologist stationed at Darwin.

W.G. Carter, field assistant from 10th August - 23rd November 1959.

Department of the Interior

H. McCutken, surveyor in charge of the Topographic Party.

APPENDIX 'B'

Equipment and vehicles:

(a) 1959

Heiland gravity meter No. 58

Calibration Factor: 0.1104 mgal/scale division, thermostat controlled, metal-spring-type instrument.

Heating temperature set during the course of the field work at 117° Fahrenheit = 47.2°C.

Performance of the Heiland meter No. 58

The behaviour of the Heiland gravity meter No. 58 was not entirely satisfactory. Irregular drift rates were frequent. The meter was extremely sensitive to mechanical shocks such as those experienced while travelling over rough portions of the road. 'Jumps' in the readings occurred at irregular intervals.

The majority of the daily drift curves indicate a rise in the readings of the instrument during the morning hours until a time ranging between 1.00 p.m. to 3.00 p.m. After this period the readings decrease. Consequently it may be deduced that the rate of drift of the Heiland meter No. 58 is directly influenced by variations in the outside temperature, as this variation in the readings corresponds to the normal daily temperature variation. However, mechanical shocks, as mentioned above, add an unpredictable factor to the time-drift behaviour of the meter.

12-V generator with voltage regulator and ammeter

The generator used for re-charging the batteries was mounted under the bonnet of one of the trucks and was driven by the truck engine.

The generator became faulty for periods during the course of the field work.

Two 12-V batteries

These batteries were used for keeping the gravity meter at constant temperature.

Radio-Equipment - Traeger unit

Standard-type 59/M/10

The performance of the radio-unit was satisfactory throughout the period of the survey; radio communication was maintained with the Royal Flying Doctor Base, Cloncurry at all times.

Camping equipment

Standard-type - satisfactory.

Two 'International Harvester' 1-ton trucks

4 x 4 - type AA120 - SWB

The vehicles were equipped with additional petrol tanks and water tanks.

Petrol tank capacity

85 and 35 gallons respectively giving the party a travelling range of about 300 miles between supply bases.

Water tank capacity

35 gallons each.

Petrol Consumption

12.5 m.p.g. on bitumen roads

8.0 m.p.g. on bush tracks

The performance of the vehicles was satisfactory throughout. Minor repairs, e.g. to door locks, electrical system, steering wheel bushings, etc. became necessary after the party had travelled over rough sections of the road.

(b) 1960

Worden gravity meter No. 260. Temperature-compensated quartz-system instrument. Calibration factor: 0.10785 mgal/scale division, performance satisfactory.

APPENDIX 'C'

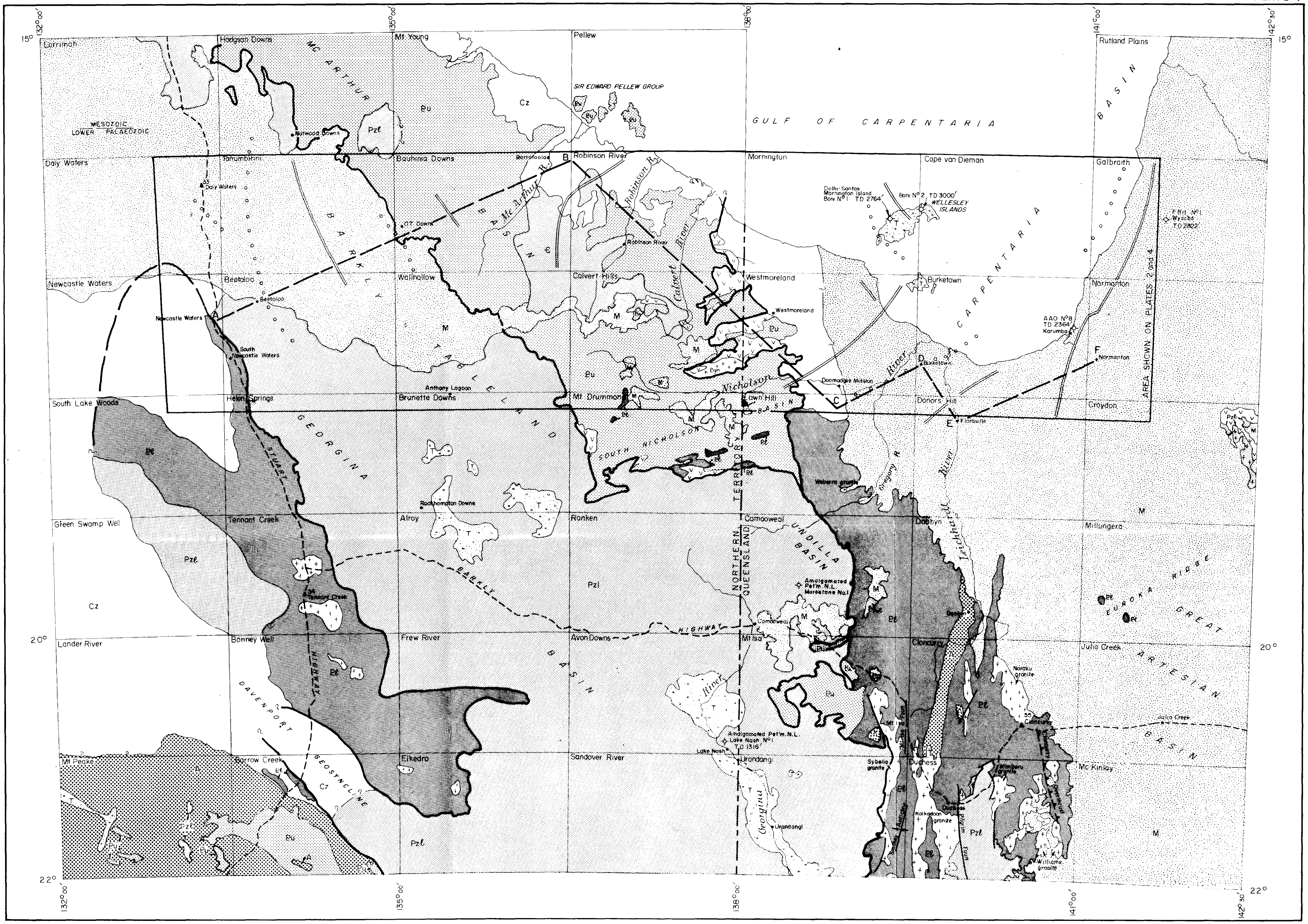
SURVEY STATISTICS

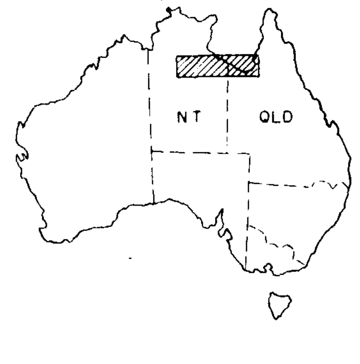
(a) 1959

Party departed Melbourne	10th August
Arrived Cloncurry	24th August
Commenced gravity-tie at Cloncurry pendulum station	28th August
Completed gravity-tie at Normanton Airport	7th September
Completed readings between Normanton and Burketown	18th September
Completed traverse at Daly Waters pendulum station	13th November
Returned to Melbourne	23rd November
New gravity stations established	205 stations
Total length of traverse	1035 miles

(b) 1960

Duration of field work	22nd and 23rd September, 1960
New gravity stations established	19 stations
Length of traverse from Daly Waters to a point 20 miles beyond Nutwood Downs	65 miles





Cz	Cainozoic
T	Tertiary
M	Mesozoic
€ Pzℓ	Cambrian and/or undifferentiated Palaeozoic
Ꝑu	Upper Proterozoic
Ꝑℓ	Lower Proterozoic
A	Archaean (with granite included)
v v v	Volcanics (undifferentiated)
Ꝑgn + +	Nicholson Granite

═══	Gravity 'high' anomaly axis
° ° ° ° °	Gravity 'low' anomaly axis
Alroy	BMR 1:250 000 map area
▲55	BMR pendulum station
A — F	Cross-section (Plate 6)
━━━	Geological basin boundary
✧	Well
——	Fault

NORMANTON TO DALY WATERS RECONNAISSANCE GRAVITY SURVEY, NT AND QLD (1959-1960)

REGIONAL GEOLOGY

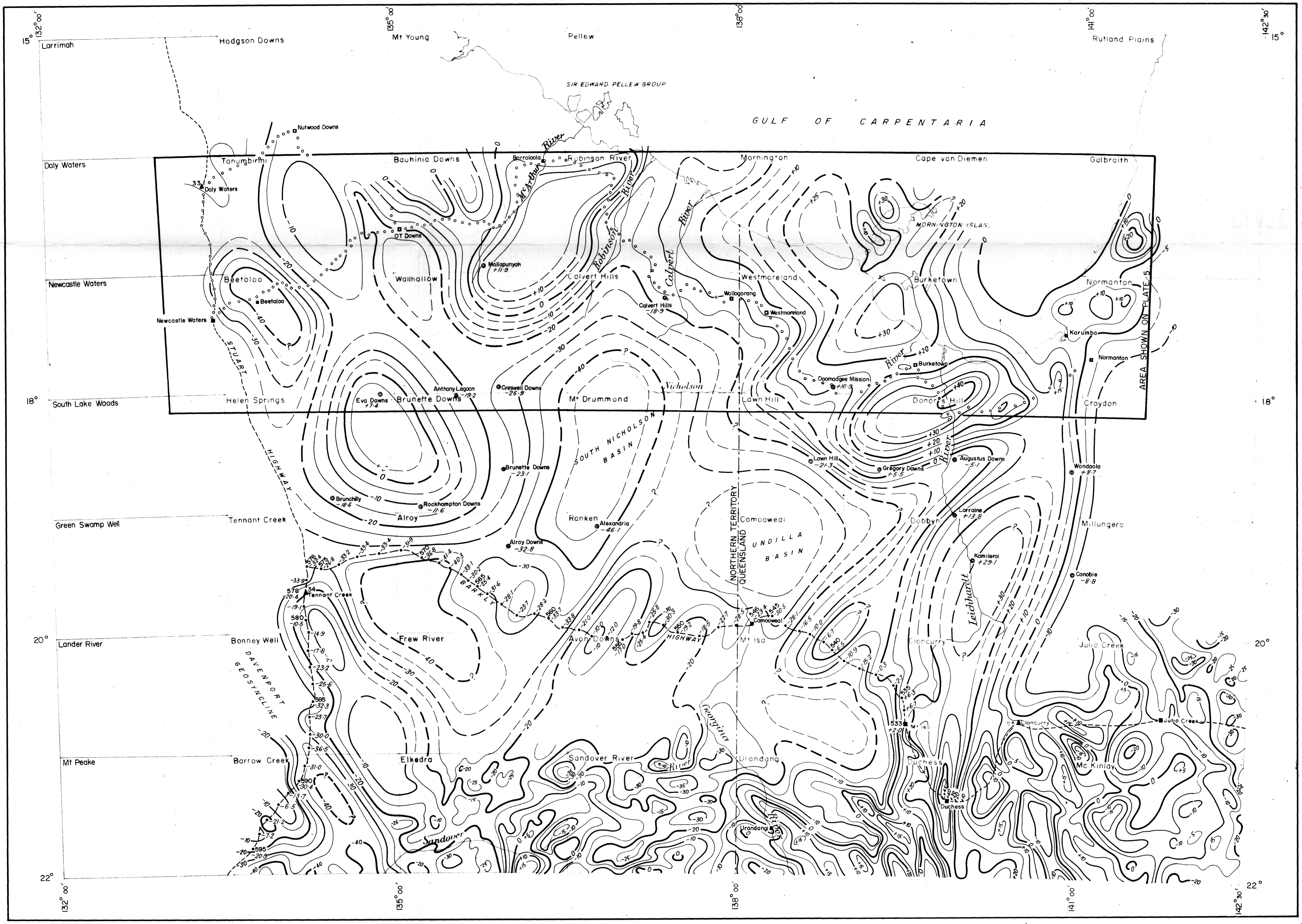
SCALE IN MILES

40 0 40 80 120 160

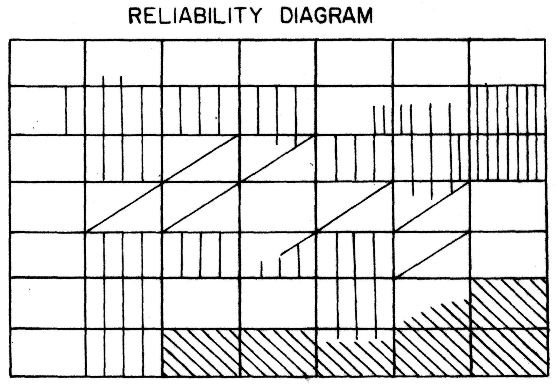
Based on BMR tectonic map 40 miles to 1 inch and later information

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E53/B2-24

To accompany Record No 1964/131



RELIABILITY DIAGRAM



LEGEND

- HELICOPTER GRID COVERAGE BY BMR
- GROUND AND UNDERWATER TRAVERSES BY BMR
- GROUND TRAVERSES BY PRIVATE COMPANIES
- WIDELY DISPERSED GRAVITY STATIONS ON AIR STRIPS BY BMR

- Alroy — BMR 1:250,000 map area
- ▲55 — BMR pendulum station
- ○ — BMR gravity station (traverse from Normanton to Daly Waters and Nutwood Downs)
- ⊙ — BMR gravity station (observed on airstrip)
- • — Gravity station (Sydney University)
- ▪ — Named place

NORMANTON TO DALY WATERS
RECONNAISSANCE GRAVITY SURVEY, NT AND QLD (1959-1960)
BOUGUER ANOMALIES
INTEGRATED WITH ADJOINING SURVEYS

SCALE IN MILES

40 0 40 80 120 160

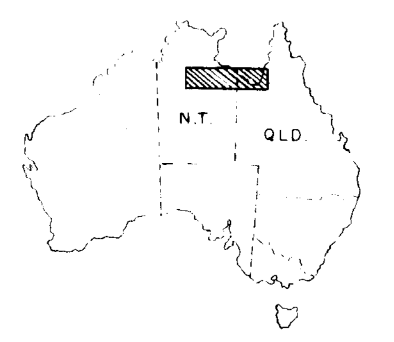
Based on BMR tectonic map 40 miles to 1 inch

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

E 53/B2-25-1

To accompany Record N°1964/131

LOCATION



COMPILED DECEMBER 1961

LEGEND

- CAINOZOIC
- T — TERTIARY
- M — MESOZOIC
- CAMBRIAN (Є) AND/OR UNDIFF. LOWER PALAEOZOIC (PzL)
- UNDIFF. UPPER PROTEROZOIC (Pu); DRUMMOND GROUP (Pudr)
- UNDIFF. LOWER PROTEROZOIC (PL); MURPHY METAMORPHICS (PLm)
- VOLCANICS: GOLD CREEK VOLCANICS (Pug); PETERS CREEK " (Pup); CLIFFDALE " (Puf)
- NICHOLSON GRANITE (Pgn)
- MAJOR FAULT
- B.M.R. GRAVITY STATION
- B.M.R. GRAVITY STATION (UNDERWATER)
- GRAVITY STATION (PRIVATE COMPANY)
- 139' — ELEVATION ABOVE M.S.L
- +8.5 — BOUGUER ANOMALY (MILLIGALS) REDUCED WITH 1·9 g/cm³ DENSITY
- (+8.4) — " " " " " 2·67 " "
- WELL DRILLED FOR PETROLEUM
- ▲33 — BMR PENDULUM STATION
- BEETALOO — BMR 1:250,000 MAP AREA
- RIVER (NON-PERENNIAL)
- CROSS-SECTION A-F (PLATE 6)

NORMANTON TO DALY WATERS RECONNAISSANCE GRAVITY SURVEY, NT AND QLD (1959-1960)

GEOLOGY AND GRAVITY STATIONS

MILES 16 0 16 32 48 64 80 MILES

KILOMETRES 25 0 25 50 75 100 125 KILOMETRES

MAP DATA

TRANSVERSE MERCATOR PROJECTION, AUSTRALIA SERIES.

CONTROL AND PLANIMETRY AFTER DEPARTMENT OF THE INTERIOR 4-MILE GRAVITY SURFACE-CONTROL MAPS.

BMR GEOLOGICAL MAP - 1961 (unpublished)

BOUGUER ANOMALIES ARE BASED ON THE OBSERVED GRAVITY VALUES OF THE FOLLOWING B M R PENDULUM STATIONS:

No 33 DALY WATERS .... 978,388·6 MILLIGALS.

No 55 CLONCURRY .... 978,650·7 MILLIGALS.

FOR THE CALCULATION OF BOUGUER ANOMALIES 1·9 and 2·67 g/cm³ HAS BEEN ADOPTED AS AN AVERAGE ROCK DENSITY

GRAVITY DATA AFTER FOLLOWING SURVEYS:

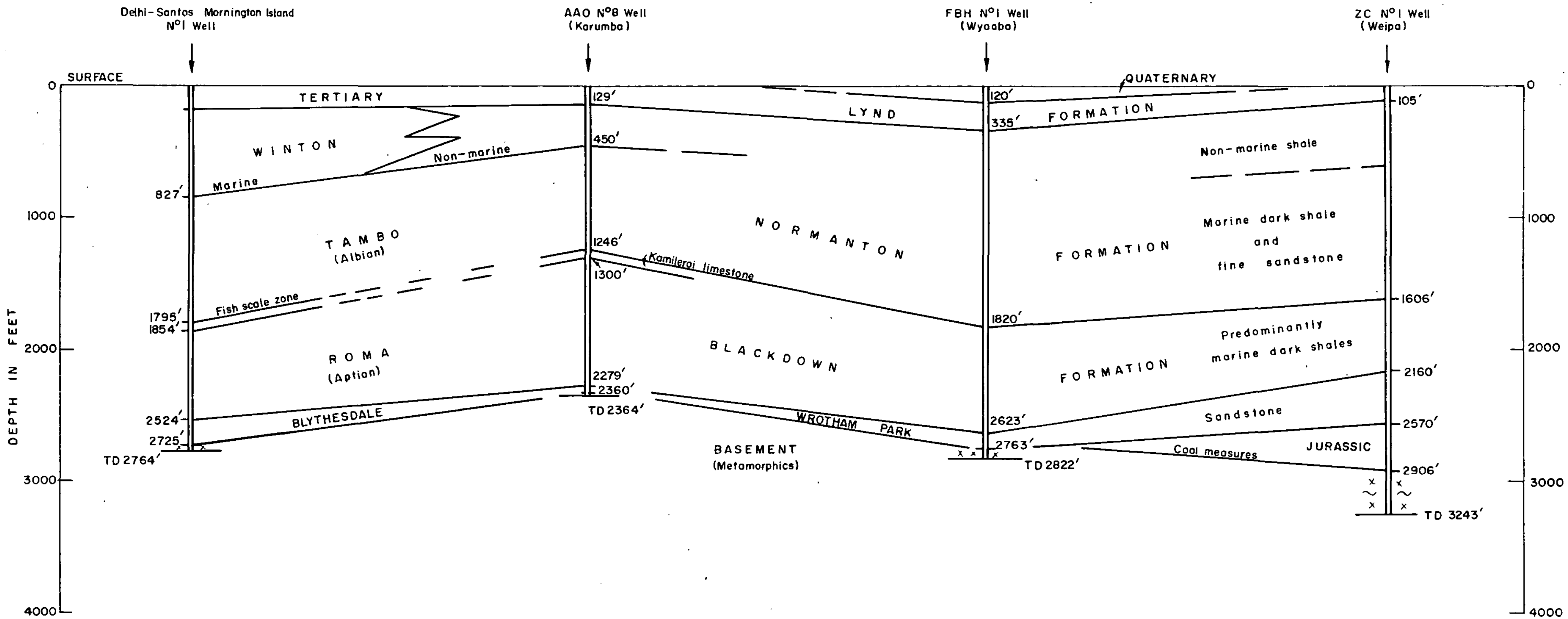
B M R UNDERWATER GRAVITY SURVEY IN 1958,

B M R GRAVITY FIELD SURVEY IN 1959,

MINES ADMIN. PTY LTD SURVEY 1956, AND FROME-BROKEN HILL SURVEY 1956-57.

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS **E53/B2-21**

To accompany Record No 1964/131



Vertical scale : as shown
Horizontal scale : arbitary

Reference : Terpstra & Evans (1962)
Harrison, Greer & Gibson (1961)
BMR (1960a, 1960b)

NORMANTON TO DALY WATERS
CARPENTARIA GULF AREA, QLD
STRATIGRAPHIC CORRELATION CHART

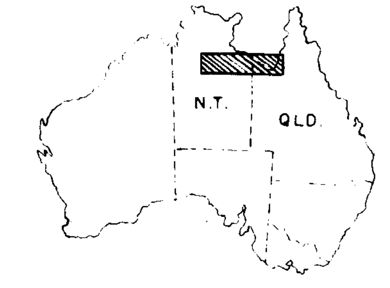
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

E53/B2-23

PLATE 4

To accompany Record N° 1964/131

LOCATION



Compiled December 1961

LEGEND

- BEETALOO — BMR 1:250,000 MAP AREA
- RIVER (NON-PERENNIAL)
- ▲ 33 — BMR PENDULUM STATION
- MAJOR FAULT
- BMR GRAVITY STATION (TRAVERSE FROM NORMANTON TO DALY WATERS AND NUTWOOD DOWNS)
- B.M.R. GRAVITY STATION (OBSERVED ON AIRSTRIP)
- B.M.R. GRAVITY STATION (UNDERWATER)
- GRAVITY STATION (PRIVATE COMPANY)
- ELEVATION ABOVE M.S.L.
- BOUGUER ANOMALY (MILLIGALS)
- ISOGALS (INTERVAL 5 MILLIGALS)
- 'HIGH' ANOMALY
- 'LOW' ANOMALY

NORMANTON TO DALY WATERS
RECONNAISSANCE GRAVITY SURVEY, NT AND QLD (1959-1960)
BOUGUER ANOMALIES

MILES 16 0 16 32 48 64 80 MILES

KILOMETRES 25 0 25 50 75 100 125 KILOMETRES

MAP DATA

TRANSVERSE MERCATOR PROJECTION, AUSTRALIA SERIES.

CONTROL AND PLANIMETRY AFTER DEPARTMENT OF THE INTERIOR 4-MILE GRAVITY SURFACE CONTROL MAPS.

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

Nº 33 DALY WATERS .... 978,388·6 MILLIGALS.

Nº 55 CLONCURRY .... 978,650·7 MILLIGALS.

FOR THE CALCULATION OF BOUGUER ANOMALIES 1·9 g/cm^3 HAS BEEN ADOPTED AS AN AVERAGE ROCK DENSITY.

GRAVITY DATA AFTER FOLLOWING SURVEYS:

B.M.R. UNDERWATER GRAVITY SURVEY IN 1958,

B.M.R. GRAVITY FIELD SURVEY IN 1959,

MINES ADMIN. PTY. LTD. SURVEY 1956, AND FROME-BROKEN HILL SURVEY 1956-57.

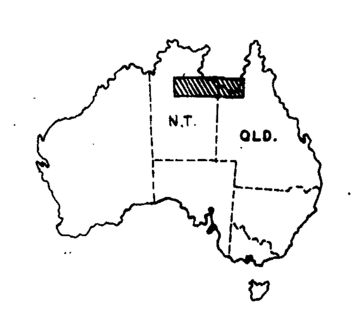
To accompany Record Nº 1964/131

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

E53/B2-22

PLATE 6

LOCATION



NORMANTON TO DALY WATERS

RECONNAISSANCE GRAVITY SURVEY (1959-1960)

CARPENTARIA GULF-BARKLY TABLELAND AREA, NT AND QLD

CORRELATION OF GRAVITY, TOPOGRAPHY, AND GEOLOGY

(CROSS-SECTION A-B-C-D-E-F)

MILES 16 0 16 32 48 64 80 MILES

KILOMETRES 25 0 25 50 75 100 125 KILOMETRES

VERTICAL SCALES AS SHOWN

LEGEND

Cz CAINOZOIC
M MESOZOIC
€b CAMBRIAN/BUKALARA SANDSTONE
Pzl LOWER PALAEOZOIC

POSITION OF LOWER PROTEROZOIC ESTIMATED FROM GRAVITY ANOMALIES SHOWN THUS:

GEOLOGICALLY SUGGESTED, HIGHLY FOLDED LOWER PROTEROZOIC SHOWN THUS:

σ ASSUMED ROCK DENSITY (g/cm^3)

UPPER PROTEROZOIC

Pu UPPER PROTEROZOIC UNDIFFERENTIATED
Pun KARNS DOLOMITE
Pum MASTERTON SANDSTONE
Pug GOLD CREEK VOLCANICS
Pudr DRUMMOND GROUP
Puro ROPER GROUP
Puh WOLLOGORANG FORMATION
Pumc MC ARTHUR GROUP
Pup PETERS CREEK VOLCANICS
Puw WESTMORELAND CONGLOMERATE
Put TAWALLAH FORMATION

LOWER PROTEROZOIC

Plc CLIFFDALE VOLCANICS
Pll LAWN HILL FORMATION
Plm MURPHY METAMORPHICS

Pgn NICHOLSON GRANITE

COMPILED JANUARY 1962

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E 53/B2-20

To accompany Record No 1964/131