COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT No. 133

Amadeus and South Canning Basins Gravity Survey, Northern Territory and Western Australia 1962

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G. F. LONSDALE AND A. J. FLAVELLE

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MINISTER: THE HON. DAVID FAIRBAIRN, D.F.C., M.P.

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SUMMARY

During 1962 the Bureau of Mineral Resources conducted a reconnaissance gravity survey in the Amadeus and South Canning Basins of the Northern Territory and Western Australia, using helicopters.

This survey covered eighteen 1:250,000 map areas, of which three had previously been partially covered by helicopter gravity surveys, and established over 3000 new gravity stations.

The results of the survey indicate the boundaries of the Amadeus Basin and the South Canning Basin, suggest the presence of thick sediments in two other areas (those of the Cobb Gravity Depression and the Gibson Gravity Depression), and indicate an area of extensive crustal thickening south of the Amadeus Basin.

1. INTRODUCTION

This Report describes the results of a reconnaissance gravity survey in the Amadeus and South Canning Basins of the Northern Territory and Western Australia during 1962 by the Bureau of Mineral Resources (BMR). The area surveyed is shown in Plate 1.

The first gravity work in the survey area was done in 1951 when a regional gravity traverse was read between Alice Springs and Ayers Rock (Marshall & Narain, 1954). In 1957 a combined gravity and geological survey was conducted in the south-central part of the Canning Basin, north of the present survey area, and a ground traverse was made south-east of the Canning Stock Route along part of the northern margin of the survey area (Flavelle & Goodspeed, 1962). A ground traverse was also made during 1957 between Alice Springs and Giles. In 1959 a gravity station was established at Giles during a regional gravity survey (Radeski, 1962). In 1960 a reconnaissance gravity survey was carried out in the northern part of the Canning Basin (Flavelle & Goodspeed, op. cit.) and another survey north-east of Alice Springs commenced the coverage of the Georgina Basin and the marginal areas of the Amadeus and Great Artesian Basins (Barlow, 1966). Also in 1960 the Flamingo Petroleum Corporation did a gravity survey over parts of HALE RIVER*, RODINGA, and CHARLOTTE WATERS (Burbury, 1960). Geosurveys of Australia Ltd made a gravity survey in the Andado area on McDILLS and the South Australian Mines Department made a gravity survey of the Officer Basin (Mumme, 1961). The eastern half of the Amadeus Basin was surveyed by the 1961 Helicopter Gravity Party (Langron, 1962). In 1962 Geoseismic (Australia) Ltd made a gravity survey over parts of McDILLS and SIMPSON DESERT SOUTH for Beach Petroleum N.L. (Beach Petroleum, 1963).

The gravity coverage of the Amadeus Basin, including its eastern marginal area, was completed during the 1962 survey. The coverage was extended west to investigate the relation between the Amadeus Basin, the South Canning Basin to the north-west, and the Officer Basin to the south-west during pre-Mesozoic times.

The survey area comprised the following 1:250,000 map areas: HERBERT, MADLEY, BROWNE, WARRI, BENTLEY, COBB, SCOTT, RAWLINSON, MACDONALD, PETERMANN RANGES, BLOODS RANGE, MOUNT RENNIE, AYERS ROCK, LAKE AMADEUS, MOUNT LIEBIG, HALE RIVER, ILLOGWA CREEK, and ALCOOTA.

On this survey the 'cell' method of flying was used for the first time, in place of the 'line' method previously used, the readings being taken on a approximate 7 x 7 mile grid as before (Hastie & Walker, 1962).

In addition to the reconnaissance work, a gravity tie was made between Alice Springs and Wiluna Pendulum Stations (Van Son, 1966), and a gravity traverse (Flight 'B') was made from the Woolnough Hills across MORRIS and RYAN to the north-west of MACDONALD to test the extent of a gravity 'low' feature, the South Canning Basin Gravity Depression (Plate 4) described from an earlier survey (Flavelle & Goodspeed, 1962); some more-detailed gravity work was carried out in the area of the Woolnough Hills over suspected salt-dome structures (Flavelle, unpublished data).

In this Report the discussion on that part of the survey made in Western Australia was written by G.F. Lonsdale; the discussion on the Northern Territory part was written by A.J. Flavelle.

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* Throughout this Report the individual 1:250,000 map areas will be denoted by capital letters, e.g. BENTLEY, whilst locations will be shown in small type, e.g. Giles.

2. GEOLOGY

A geological sketch map of the area is shown in Plate 2. This map is based on the 'Tectonic Map of Australia' (Bureau of Mineral Resources, 1960) and Bureau of Mineral Resources 1:250,000 geological maps, including some information derived from the results of field mapping during 1962 (Wells, 1962a and 1962b; Forman, 1962).

The main survey area extends westward from the central part of the Amadeus Basin towards the southern margin of the South Canning Basin and the north-western margin of the Officer Basin.

The Amadeus Basin is defined as the down-folded and faulted area of Upper Proterozoic and Palaeozoic sediments in central Australia (Wells, Forman, & Ranford, 1962), extending from HALE RIVER to MOUNT RENNIE and BLOODS RANGE. The Palaeozoic sediments extend as far west as the Western Australian border and the Proterozoic sediments continue into RAWLINSON and east MACDONALD before becoming obscured by Permian and younger sediments.

The Amadeus Basin is bounded on the north by Archaean metamorphic and igneous rocks of the Arunta Block, which are known to extend as far west as north-east MACDONALD, and on the south by Archaean crystalline rocks of the Musgrave Block, including basic and ultrabasic igneous rocks, which extend from north-west ABMINGA as far west as east BENTLEY before becoming obscured by Permian and younger sediments. A nickel orebody has been worked in these rocks near Mount Davies.

The major sedimentary structures within the Amadeus Basin were formed by tectonic movements initiated during Ordovican times and culminating in Upper Palaeozoic times. Sedimentary structure does not appear to have been caused by movements originating within the basement (McNaughton, 1962; F.J. Moss, personal communication) and it is postulated by McNaughton that the structures were caused by horizontal stresses reacting on sediments of differing physical properties. In particular it is postulated that the incompetency of the Upper Proterozoic Bitter Springs Limestone has been a major factor in the forming of the sedimentary structures of the basin. This hypothesis is supported by the occurrence of diapiric structures in the basin in which the mobile material appears to originate from the Bitter Springs Limestone. A number of possible diapiric structures have been mapped on LAKE AMADEUS (Wells, 1962a).

The Permian and younger sediments which crop out west of the Amadeus Basin largely obscure the relation between the Amadeus Basin and the South Canning and Officer Basins. However, there are some important exposures of pre-Permian rocks in this part of the survey area (Plate 2).

At the Woolnough Hills, a central core of sheared massive gypsum is surrounded by four concentric units of unconformable sedimentary rocks. Moving outwards from the gypsum core, the ages of the sediments are Upper Proterozoic, Permian, ?Jurassic, and Cretaceous. The domal structure is considered to be of diapiric origin, formed by the upward piercement of some plastic evaporite medium (Veevers & Wells, 1959; Leslie, 1961; Wells, 1962b). The age of the original evaporite bed must be Upper Proterozoic or older and in order to produce diapiric movements this bed must have been overlain at the time of movement by at least 15,000 to 18,000 ft of sediments (F.J.G. Neumann, personal communication).

In the north-east of MADLEY and 15 miles west-south-west of the Woolnough Hills a second diapiric structure has been mapped (Wells, 1962b). This structure is elongated in an easterly direction but is otherwise similar to that of the Woolnough Hills.

At Constance Headland, in the north-west of MADLEY, sandstone and conglomerate of Proterozoic age have been mapped (Wells, 1962b).

About 3000 ft of Palaeozoic sediments overlying about 12,000 ft of ?Upper Proterozoic sediments crop out in the Iragana Hills on the west of COBB (Wells, 1962b and personal communication). These sediments are not metamorphosed. A large fault is present at the eastern side of the Iragana Hills and has been traced several miles to the south-south-east.

A domal structure occurs in Permian rocks near this fault about 35 miles south-east of the Iragana Hills, but no pre-Permian rocks are visible (Wells, 1962b).

Near the Bedford Range, on BENTLEY, outcrops of quartzite, amphibolite, and muscovite-schist have been noted (Wells, 1962b).

The remainder of the survey area consisted of two smaller areas on the eastern margin of the Amadeus Basin, one south-east of Alice Springs (ILLOGWA CREEK and HALE RIVER) and the other north of Alice Springs (ALCOOTA).

The geology over the area south-east of Alice Springs is obscured in places by the sand of the Simpson Desert. Archaean rocks of the Arunta Block crop out over a large part of ILLOGWA CREEK but farther south there are outcrops of Upper Proterozoic and Palaeozoic rocks in the north-west of HALE RIVER extending south-west into RODINGA. These rocks are covered farther south-east by Mesozoic sediments. This area is important in determining the relation between the eastern part of the Amadeus Basin, the Georgina Basin, and the Great Artesian Basin.

ALCOOTA is marginal to the Ngalia Trough to the west and the Georgina Basin to the north-east. Outcrops consist mainly of Upper Proterozoic sediments and Archaean metamorphic and crystalline rocks.

3. PREVIOUS GEOPHYSICAL WORK

Gravity surveys

A resume of previous gravity work carried out in the survey area has been made above (Page 1).

In the Western Australia part of the survey area it was considered that the Anketell Gravity Ridge (Flavelle & Goodspeed, 1962) would extend south-east into WARRI, and that the South Canning Basin Gravity Depression east of this ridge might also extend into the survey area.

In the Northern Territory part of the main survey area it was suggested that the dominant features would be the continuation of the two intense east-west-trending gravity 'lows', separated by a platform, found in the eastern part of the Amadeus Basin (Langron, 1962).

On ALCOOTA it was considered that over outcrops of the metamorphic basement the gravity level would be higher than over outcrops of Upper Proterozoic rocks and that the Georgina Basin in the north-east and the Ngalia Trough in the south-east would be associated with low gravity values.

It was suggested that on ILLOGWA CREEK and HALE RIVER the gravity values would, in general, increase towards the east, although it was possible that the gravity 'low' in the east of ALICE SPRINGS might extend across ILLOGWA CREEK to north-west HAY RIVER.

Aeromagnetic surveys

In 1958, during a BMR aeromagnetic survey over the Great Artesian Basin (Jewell, 1960), profiles were flown from Dajarra to Alice Springs and to The Curralulla River and from Alice Springs to Broken Hill. These profiles are disturbed in their western portions, indicating a shallow magnetic basement there. The estimate of magnetic basement depth in the north of ILLOGWA CREEK is 700 ft; in the east of HALE RIVER the estimated basement depth is 2300 ft.

In 1960 an aeromagnetic survey was made in the area south-west of Alice Springs (Goodeve, 1961). The profiles crossing the main part of the survey area are shown in Plate 3. In the Northern Territory the profiles are generally relatively flat, becoming disturbed south-west of Ayers Rock where an extensive north-west-trending fault has been postulated on the basis of photo-interpretation (Wells, Forman, & Ranford, 1961). The profiles are very disturbed over outcrops of Archaean rocks near Mount Davies in South Australia and near Giles and the Blackstone Range in Western Australia. The profiles are also very disturbed in the south-west of SCOTT, and a suggested belt of disturbance extending from north WARRI to north TALBOT has been indicated by shading in Plate 3.

The Hunt and Placid Oil Companies have recently made an aeromagnetic reconnaissance survey south-west of Giles but their results are not yet available.

Seismic surveys

The only seismic work in the survey area was done by BMR in 1961 and 1962 along the road from Giles to Carnegie (Watson, 1963; Turpie, 1967).

In 1961, refraction spreads were laid near outcrops to obtain data on refraction velocity values in typical subsurface materials; these velocities were used in identifying refractors encountered between 'Signpost' and Mount Beadell (Plate 2). Interpretations of the results west of 'Signpost' suggested a series of ?post-Proterozoic sediments thickening towards the west with a maximum thickness (so far recorded) of 5000 ft at Mount Beadell. No refractor that could be identified with basement was recorded west of 'Signpost'. A rise in the ?Proterozoic floor was suggested near the eastern margin of BROWNE.

During the 1962 seismic work possible basement (high-velocity) refractors were recorded at depths of about 12,000 ft at Mound Beadell and of about 4000 ft at Lake Keene (Turpie, 1967).

4. DISCUSSION OF GRAVITY RESULTS

Plate 4 shows the preliminary Bouguer-anomaly contours of the surveyed and surrounding areas based on a density of 2.2 g/cm^3 and drawn on a scale of 40 miles to the inch. The individual 1:250,000 gravity plans of the surveyed area have not been included with this Report.

The Bouguer-anomaly values throughout the survey area are almost entirely negative, becoming positive only in BENTLEY and south-west SCOTT (where the maximum value of +60.9 mgal was recorded at Station 1741), north-east MOUNT RENNIE, north-west MOUNT LIEBIG, north-east ILLOGWA CREEK, and central and south-east HALE RIVER. The minimum Bouguer value, -148.5 mgal, was recorded on central MOUNT LIEBIG at Station 2507.

The main survey area and its adjacent areas have been divided into several units on the basis of the gravity results. These units, which are outlined by hachuring in Plate 4, have been further subdivided into their more important features, which are listed below, the feature numbers being also shown in Plate 4.

Gibson Gravity Depression

This is the name given to the gravity 'low' region in the west of the survey area. It extends over HERBERT, MADLEY, west WARRI, and BROWNE (except the north-east corner) and continues northwards into RUNTON.

Feature No.	Description	Name
1	Gravity 'low' in north HERBERT and south MADLEY extending into BROWNE.	Herbert Gravity Sub-Depression.
2	Gravity 'high' extending from south-west WARRI to north-west MADLEY.	Madley Gravity Swell
3	Gravity 'low' in north-east MADLEY and north-west WARRI extending into RUNTON.	Runton Gravity Sub-Depression.
4	Gravity 'low' in north-west WARRI.	Woolnough Hills Gravity Low.
5	Gravity 'high' in south-west BROWNE.	
6	Gravity 'low' in south-east BROWNE.	Mount Samuel Gravity Low.

Warri Gravity Ridge

This is a belt of gravity 'highs' extending in a south-easterly direction across the survey area, where it crosses WARRI, north-east BROWNE, and west BENTLEY. The belt probably forms the south-easterly continuation of Feature 10, the Anketell Gravity Ridge (Flavelle & Goodspeed, 1962).

Feature No.	Description	Name
7	Elongated gravity 'high' in south-west BENTLEY.	Mount Charles Gravity High.
8	Gravity 'high' in central WARRI.	
9	Gravity 'high' in central and north-east MORRIS.	Patience Well Gravity High.

South Canning Basin Gravity Depression (Feature 11)

This gravity 'low' area is shown extending over URAL, west WILSON, south PERVICAL and south-west HELENA. However, the gravity coverage over the feature is very sparse. The extent of the feature to the north, west, and east has been discussed by Flavelle and Goodspeed (1962). To the south the feature appears to be separated from Features 14 and 15 by a gravity saddle between Features 9 and 12.

Barons Gravity Plateau

This gravity 'high' region extends north and north-east from north-west RAWLINSON and north-east COBB through south-east RYAN, west and north MACDONALD, north-east Ryan and thence probably north and east, being split by the Stansmore Gravity Trough (Flavelle & Goodspeed, 1962). However, the gravity coverage in this area is very sparse. The name is derived from the Barons Range in west MACDONALD.

Feature No.	Description	Name
12	Northerly-elongate gravity 'high' in east WILSON and extending south-west into north RYAN.	Wilson Gravity High (Flavelle & Goodspeed, 1962).
13	Gravity 'high' in south-east RYAN extending into west RAWLINSON and south-west MACDONALD.	

Cobb Gravity Depression

This is the name given to the gravity 'low' that extends south-east from RYAN through COBB and north BENTLEY into north SCOTT. The gravity feature terminates in the extreme west of PETERMANN RANGES.

Feature No.	Description	Name
14	Gravity 'low' in central RYAN.	East Ryan Gravity Low.
15	Gravity 'low' in west RYAN and east MORRIS	West Ryan Gravity Low.
16	Gravity 'low' in south COBB.	
17	Gravity 'low' extending from south-east COBB to north-west SCOTT.	Three Hills Gravity Low.
18	Gravity 'low' in north-east SCOTT.	

Blackstone Gravity Plateau

This is a gravity 'high' region in the south of the survey area in south-east BENTLEY and south SCOTT and extending into south PETERMANN RANGES and north MANN (Mumme, 1961). The name is derived from the Blackstone Range in north COOPER.

Feature No.	Description	Name
19	Local gravity 'low' in south SCOTT.	
20	Gravity 'high' in south-east BENTLEY and south-west SCOTT extending south.	Barrow Range Gravity High.
21	Gravity 'high' in south-east SCOTT, south PETERMANN RANGES, and north MANN.	Mount Davies Gravity High.

Feature No.	Description	Name
22	Gravity shelf on north margin of Feature 21 in south-west PETERMANN RANGES.	

Ayers Rock Gravity Depression

This is a gravity 'low' region mainly in south AYERS ROCK and south KULGERA with an embayment extending into north PETERMANN RANGES and a narrow extension suggested towards south MANN (Mumme, 1961).

Feature No.	Description	Name
23	Elongate gravity 'low' extending north-west from Feature 24 towards north PETERMANN RANGES.	Katamala Gravity Embayment.
24	Deep gravity 'low' in south AYERS ROCK extending east into south KULGERA.	Musgrave Gravity Trough.
25	Narrow elongate gravity 'low' suggested to extend south-west from Feature 24 towards south MANN.	

Alberga Gravity High

This gravity 'high' region lies south of the Ayers Rock Gravity Depression and is probably separated from it by a steep gravity gradient. The gravity coverage over the feature is generally sparse, except in the north-east. The ground traverses shown were done by the South Australia Department of Mines (South Australia Department of Mines, 1957; Mumme, 1961).

Feature No.	Description	Name
26	West-south-west elongate gravity 'high' extending from west ALBERGA to south-west WOODROFFE.	
27	Gravity 'high' in north ABMINGA extending west into ALBERGA and north-east into FINKE.	

Angas Downs Gravity Ridge (Feature 28)

This is an east-elongated gravity 'high' that extends from north KULGERA and south-west HENBURY to north-east PETERMANN RANGES and south-east BLOODS RANGE. It was originally named the Angas Downs Gravity Platform (Langron, 1962), but has been renamed as a result of the 1962 gravity work, which defined it more clearly.

Bloods Range Gravity High (Feature 29)

This is the name given to the gravity 'high' region in east RAWLINSON and north-east SCOTT extending east into BLOODS RANGE. It is separated by small gravity 'low' areas from Feature 13 of the Barons Gravity Plateau and from the Angas Downs Gravity Ridge.

Amadeus Gravity Depression

This is the gravity 'low' region that extends westward from south ALICE SPRINGS and north RODINGA to south MACDONALD and north RAWLINSON. To the south it is bounded by the Angas Downs Gravity Ridge and to the west by the Barons Gravity Plateau.

Feature No.	Description	Name
30	Extensive gravity trough roughly enclosed by the -100 mgal contour extending westwards from south ALICE SPRINGS to south-east MOUNT RENNIE.	Mount Liebig Gravity Trough.
31	Gravity re-entrant south-west of Feature 30 extending into north-east RAWLINSON.	
32	Gravity re-entrant west of Feature 30 extending into south MACDONALD and north RAWLINSON.	
32A	Small gravity 'low' at tip of Feature 32.	
33	Gravity re-entrant on north-west margin of Feature 32 in west-central MACDONALD.	

Papunya Gravity Ridge (Feature 35)

This is the east-trending line of high gravity values that extends from north MOUNT RENNIE to north-west ALICE SPRINGS. It is separated from the Amadeus Gravity Depression by a strong gravity gradient, Feature 34.

The major gravity anomalies detected on the marginal areas of ALCOOTA, ILLOGWA CREEK, and HALE RIVER are all extensions of previously known and described features (Barlow, 1966) with the exception of Feature 36.

Feature No.	Description	Name
36	Gravity 'low' extending west from ALCOOTA.	
37	Gravity ridge trending south-east across ALCOOTA, HUCKITTA, ILLOGWA CREEK, HAY RIVER, and SIMPSON DESERT NORTH.	Lake Caroline Gravity Ridge.
38	Closed gravity 'low' having its major expression in north-west HAY RIVER and extending into north-east ILLOGWA CREEK.	Hay River Gravity Low.
39	Gravity platform extending from SIMPSON DESERT NORTH into HALE RIVER and ILLOGWA CREEK.	Hale River Gravity Platform.
40	Gravity platform area in McDILLS, south HALE RIVER, east FINKE, and extending into south-west SIMPSON DESERT SOUTH.	McDills Gravity Platform.
41	Gravity 'low' in east RODINGA extending into west HALE RIVER.	East Rodinga Gravity Low.

5. INTERPRETATION OF GRAVITY RESULTS

Gibson Gravity Depression

The Gibson Gravity Depression appears to consist of two gravity sub-depressions, the Herbert Gravity Sub-depression (Feature 1) and the Runton Gravity Sub-depression (Feature 3), separated by a belt of higher gravity values, the Madley Gravity Swell (Feature 2).

The Warri and Anketell Gravity Ridges bound these features to the east and north, but their extent west is unknown and it is possible that the two gravity sub-depressions may be connected. To the south, the Herbert Gravity Sub-depression appears to be bounded by an area of higher gravity values centred on Feature 5 in south-west BROWNE, though it is connected in the south-east to the Mount Samuel Gravity Low, Feature 6, which extends beyond the survey area. Additional gravity work is necessary north, west, and south of the known area of the Gibson Gravity Depression to completely delineate these features.

The Runton Gravity Sub-depression, Feature 3, in considered to be an area of thick sediments. Diapiric structures are known in two localities within the area of this feature: the Woolnough Hills Diapir in north-west WARRI and the Madley Diapirs in north-east MADLEY. These structures are associated with low gravity values, particularly the former which is associated with a pronounced gravity 'low', the Woolnough Hills Gravity Low, Feature 4. Although it is likely that these low gravity values can be attributed in part to the presence of a thick salt mass in this area, they are probably mainly attributable to thick sediments, since the sedimentary thickness associated with salt-dome structures is known to average at least 15,000 to 18,000 ft (F.J.G. Neumann, personal communication).

It is considered likely that a similar thickness of sediments is associated with the Herbert Gravity Sub-depression, Feature 1, since the gravity values of these two gravity sub-depressions are of similar magnitude. To test this suggestion a seismic refraction traverse was shot at Lake Keene (Plate 2) in south MADLEY and north HERBERT (Turpie, 1967), and a high-velocity (19,000 ft/s) refractor was recorded at a depth of about 4000 ft. If this high-velocity refractor represents the igneous or metamorphic basement then it can be shown by the use of the plate formula (see page 17) that the density contrast between the sediments and this basement is about 0.6 g/cm^3.

If the basement is granitic, as is suggested at Mount Beadell, then the average sedimentary density must be about 2.0 g/cm^3. This is much lower than the density value of 2.3 g/cm^3 suggested for the sediments at Mount Beadell (see page 18). However, this figure becomes feasible if thick Cretaceous sediments are present in the area, but this seems most unlikely. If the sediments have the same density as at Mount Beadell then the basement density becomes 2.9 g/cm^3, indicative of basic or ultrabasic rocks. However, the existence of such rocks beneath the sediments over the large area of the Herbert Gravity Sub-depression appears most unlikely. The Warri Gravity Ridge would also need to be related to these rock types whereas it will be suggested later as being related to granitic or metamorphic rocks. An alternative theory, which is preferred at this stage, is that the high-velocity refractor recorded at a depth of 4000 ft is a limestone or dolomite bed included in a thicker sedimentary sequence.

The Madley Gravity Swell which separates the two gravity sub-depressions is probably produced by a basement uplift or ridge between these two areas of suggested thick sediments.

To the south-east the Herbert Gravity Sub-depression is connected to the Mount Samuel Gravity Low, Feature 6, which itself extends farther south-east beyond the survey area. Thick sediments have been indicated by the seismic work in the area of this 'low', and these sediments may be connected to those postulated in the Officer Basin farther south-east (Quilty & Goodeve, 1958).

Warri Gravity Ridge

This series of gravity 'highs' appears to form the south-eastern extension of the Anketell Gravity Ridge (Flavelle & Goodspeed, 1962) and coincides with a possible structural feature (Plate 3) revealed by BMR's aeromagnetic results (Goodeve, 1961).

The gravity values of Features 8 to 10 are lower than those found by Flavelle and Goodspeed but that of the Mount Charles Gravity High, Feature 7, is of a similar magnitude.

Traced from the north-west the ridge appears to divide, one branch turning north of east towards the north-west of RYAN. The writers suggest that this branch continues into RYAN to join Feature 12 and thus separates Feature 14 and 15 from Feature 11. The other branch continues towards the south-east beyond the margin of the survey area.

No outcrops older than Mesozic are known in the survey area over this series of gravity 'highs'. However, to the north-west beyond the survey area the gravity 'highs' are associated with outcrops of granitic and metamorphic rocks; it seems most probable that a similar association exists in the survey area, with these rocks forming a ridge at shallow depth beneath the sedimentary rocks and approaching the surface most closely in the area of the Mount Charles Gravity High. This interpretation is in agreement with aeromagnetic results. The Mount Charles Gravity High is discussed further in the cross-section analysis (Chapter 6).

South Canning Basin Gravity Depression

This gravity feature has been further defined by the results of Flight 'B', mentioned in Chapter 1 and marked in Plate 4, but the coverage is still very sparse. The feature is the southernmost extension of the Canning Basin and is terminated by the Warri Gravity Ridge on the South-west, the Barons Gravity Plateau on the south-east, and the suggested link between Features 9 and 12 in north-west RYAN.

Barons Gravity Plateau

This gravity 'high' region in interpreted as being produced by the presence of high-density rocks at shallow depth beneath a more recent sedimentary cover. The high-density rocks are probably largely metamorphic, and possibly an extension of the Archaean Arunta Block, which crops out farther north-east.

The ?metamorphic rocks probably approach the surface most closely in the area of the Wilson Gravity High (Feature 12). This feature extends west into north RYAN and may continue into north MORRIS to join Feature 9 as indicated above. The uncertainty is due to the very limited gravity coverage over this area.

Cobb Gravity Depression

The limited and diverse geological information on the area covered by the Cobb Gravity Depression makes it somewhat difficult to interpret the depression in an entirely satisfactory manner.

The East and West Ryan Gravity Lows (Features 14 and 15) lie in an area in which sparse outcrops of Mesozoic and Permian sediments are known. Similar rocks crop out in the area of Feature 16, but in addition, on the north-west flank of the feature in the area of the Iragana Hills about 15,000 ft of unmetamorphosed sediments have been observed as noted earlier.

Plate 2 indicates that Precambrian rocks crop out over most of the area of the Three Hills Gravity Low, Feature 17, and over the entire area of Feature 18. In the north-west of Feature 17, sparse outcrops of Mesozoic and Palaeozoic rocks are known. On the south-west flank of this feature, near the Bedford Range, outcrops of metamorphic rocks have been observed.

During investigation into the Archaean rock types which might be associated with Feature 18, the authors consulted a BMR 1:250,000 geological sketch map of SCOTT. This map indicates that the area between the extreme north and the south-central part of SCOTT is devoid of known rock outcrops and hence that there is no geological information in the area of Feature 18.

A similar lack of geological information applies to the area of Archaean rocks indicated to coincide with Feature 17. Consequently, over this feature the only geological information is that of the sparse sedimentary rock outcrops in the north-west and the metamorphic rocks in the south-west.

Aeromagnetic profiles which cross Features 16 and 17 are shown in Plate 3. The profiles are flat and smooth across these features, with much higher values farther south and near Giles. This is indicative of a deep magnetic basement such as is found in an area of thick sediments or, possibly, an area of granite which has a very low ferro-magnesian mineral content.

One aeromagnetic flight-line crosses the Bedford Range and shows little disturbance. This suggests that the metamorphic rocks, and in particular the amphibolite, are of local occurrence only and that any associated igneous rocks have a low magnetic susceptibility.

A density determination made on a sample of the amphibolite from the Bedford Range (BMR sample BE2) gave a value of 3.05 g/cm^3. This high density value supports the suggested limited extent of the amphibolite, because a large mass of these rocks would cause a much higher Bouguer-anomaly value in this area.

It is not impossible that Features 17 and 18 are produced by granite masses, and that the granite masses gave rise to the metamorphic rocks noted in the Bedford Range. These granite masses would require very deep roots in order to explain the associated intensely-low gravity features. As indicated earlier these granite masses must have a very low ferro-magnesian mineral content, lower than that found in the granite and prophyry that crop out at Giles.

The presence of 15,000 ft of unmetamorphosed sediments in the Iragana Hills on the north-west flank of Feature 16 leads to the postulate that this gravity 'low' is produced by thick sediments.

If it is to be suggested that Features 17 and 18 can be similarly explained it is necessary first to adequately explain the metamorphic rocks of the Bedford Range. It is possible that these rocks could have been produced by the metamorphism of sediments by a sill-like acid igneous body or a series of dykes. These may have been intruded (or extruded) in association with the igneous activity farther south in south-east BENTLEY, and it is suggested that they are so thin as to have negligible effect on the magnetic profile. It may also be worth noting that the Bedford Range lies on the northward extension of the Barrow Range Gravity High, Feature 20.

It has been postulated that Feature 16 is produced by thick sediments; the apparent unity of the features of the Cobb Gravity Depression coupled with the lack of positive geological evidence and the inconclusive aeromagnetic evidence leads to the tentative interpretation of Features 17 and 18 as also being produced by thick sediments. Owing to the similar lack of geological evidence, Features 14 and 15 are also tentatively interpreted as areas of thick sediments. Thus the Cobb Gravity Depression is interpreted as an arcuate area of thick sediments.

Blackstone Gravity Plateau

This gravity 'high' region is considered to be produced by basic and ultrabasic igneous rocks and metasediments that form a portion of the Musgrave Block.

The Mount Davies Gravity High, Feature 21, in the south-east of SCOTT coincides with an outcrop of basic and ultrabasic igneous rocks in which a nickel orebody has been worked.

No information on rock exposures is available for the extreme south-eastern corner of BENTLEY and south-western corner of SCOTT where the Barrow Range Gravity High, Feature 20, reaches its known maximum gravity value. However, on the north-western flank of this feature exposures of amphibolite, basalt, porphyry, and several other igneous rock types are known (Wells, 1962b), and it seems probable that an ultrabasic mass may be present farther south-east.

It is probable that Feature 20 is a continuation of Feature 21 but additional gravity work in north COOPER is necessary to confirm this. If so, then a continuation of the nickel-bearing orebody into the central area of Feature 20 is possible.

The gravity shelf, Feature 22, north of the Mount Davies Gravity High, is interpreted as an area of near-surface intermediate to basic igneous rocks.

Feature 19 in south SCOTT is interpreted as being produced by a granitic intrusion or thick metasediments on the margin of the basin igneous rock mass.

The strong gravity gradient that separates these two comparatively-low gravity features from the Barrow Range Gravity High and the Mount Davies Gravity High is considered to be produced by the horizontal density contrast between the basic and ultrabasic igneous rock to the south and the more acidic igneous rocks and metasediments farther north.

The relation between the Warri Gravity Ridge and the Blackstone Gravity Plateau is not clear. There appears to be a distinct break between Features 7 and 20 on the gravity plan; the geological information available also suggests that these two units should be considered separately.

Ayers Rock Gravity Depression

The main feature of the depression is the Musgrave Gravity Trough, Feature 24. The geology of the area between the Musgrave Ranges and Ayers Rock is not well known. However, granite of the Musgrave Ranges crops out immediately south of the negative culmination.

In the absence of any comprehensive geological mapping of the area it is considered likely that the Gravity Trough is caused by a thickening of the less-dense acidic igneous rocks. However, thick sediments might also be present in this area.

Two minor gravity embayments (Features 23 and 25) extend north-west and south-west respectively from the Musgrave Gravity Trough. Feature 23 trends north-west across PETERMANN RANGES with a minor extension trending north-north-west towards BLOODS RANGE. This feature occurs in an area (Scanvic, 1961; Forman 1962) where the Dean Quartzite (Heavitree Quartzite) and some Ordovician sediments rest on basement rocks of Lower Proterozoic or Archaean age. In this area the basement rocks include numerous granitic intrusions. It is assumed therefore that the basement rocks that underlie the area represented by Feature 23 are less-dense than the basement rocks, including basalt, exposed on BLOODS RANGE. Consequently, therefore, the basement rocks over the entire area must have considerable horizontal density variation. In addition Feature 23 might also represent a narrow trough of Proterozoic sediments of 2000-4000 (or more) feet thickness.

Feature 25 occurs on MANN and WOODROFFE. It is defined by a small number of stations and appears to be a south-westerly extension of the Musgrave Gravity Trough.

Alberga Gravity High

It is considered that the high gravity values of Features 26 and 27 are produced by basic and ultrabasic igneous rocks near the surface. Additional gravity work would be necessary to define the features more clearly, but they appear to form the northern margin of the Officer Basin.

Angas Downs Gravity Ridge

This line of gravity 'highs' (Feature 28) separates the Amadeus Gravity Depression from the Ayers Rock Gravity Depression.

It is probable that the Angas Downs Gravity Ridge is produced by near-surface basement rocks. These rocks might be similar to the Lower Proterozoic rocks associated with the Bloods Range Gravity High (see below).

The Angas Downs Gravity Ridge forms the southern boundary of the Amadeus Gravity Depression and its northern margin is presumed therefore to indicate the southern limit of thick sediments in the Amadeus Basin. As the gravity gradient that separates the Amadeus Gravity Depression from the Angas Downs Gravity Ridge is not very steep, the thinning of the Amadeus sediments in this direction must be gradual.

Bloods Range Gravity High

This gravity 'high' (Feature 29) coincides with an outcrop area of Upper Proterozoic Dean Quartzite that rests unconformably on Lower Proterozoic metasediments, granite, and thick basalt (Scanvic, 1961; Forman, 1962).

It is possible that these Lower Proterozoic rocks extend in a north-westerly direction beneath a thin cover of more-recent sedimentary rocks to produce the Barons Gravity Plateau.

Amadeus Gravity Depression

The main feature of this gravity depression is the Mount Liebig Gravity Trough, Feature 30, which represents the thick sediments of the Amadeus Basin (Langron, 1962). The station coverage of the area was sufficient to completely delineate the feature and, therefore, presumably the extent of the thick sediments of the Amadeus Basin. The most negative part of the feature occurs on MOUNT LIEBIG, corresponding therefore with the thickest sediments in the Basin.

The gravity coverage is such that only the larger sedimentary features stand out on the gravity pattern. These in general are postulated to represent the basement configuration, i.e. total sedimentary depth; on this basis the correlation between gravity and geology is good. Extra stations were read over some interesting geological structures, and in these places the sedimentary structure showed up on the anomaly map. For instance a small relatively negative anomaly occurred on the Johnson Hill structure (Plate 4) which is believed to be of diapiric origin (Wells, Forman, & Ranford, 1962).

Therefore on a regional scale the Bouguer-anomaly map delineates the extent of the Basin whilst any small-scale gravity features that occur within Feature 30 are most probably caused by sedimentary structures.

Three extensions (Features 31, 32, and 33) of the Mount Liebig Gravity Trough have been mapped. They extend across MOUNT RENNIE into MACDONALD and RAWLINSON and presumably represent westerly extensions of the thick sediments of the Amadeus Basin. At the tip of Feature 32 is an isolated 'low', Feature 32A, which corresponds with a 'pocket' of Palaeozoic sediments immediately north of the Robert Fault (Plate 2).

Papunya Gravity Ridge

This line of gravity 'highs' (Feature 35) extending from north-west ALICE SPRINGS westwards to MOUNT RENNIE is produced by crystalline rocks near the southern margin of the Arunta Block.

The shart gravity gradient, Feature 34, separating the Papunya Gravity Ridge from the Amadeus Gravity Depression is one of the most prominent features expressed in the gravity-anomaly picture of the whole surveyed area. It extends from central ALICE SPRINGS to central MOUNT RENNIE, a distance of about 310 miles. Since the gradient is possibly caused in the main by the density contrast between the light sediments of the Amadeus Basin and the denser crystalline rocks of the Arunta Block (Langron, 1962), the dissipation of the gradient on MOUNT RENNIE can be regarded as consistent with the thinning of sediments (Wells, Forman, & Ranford, 1962) in this area.

It is possible that the Barons Gravity Plateau forms an extension of the Papunya Gravity Ridge. More detailed gravity coverage of the south of WEBB would be necessary to confirm this.

ALCOOTA and surrounding map areas

The gravity 'high' along the south-western edge of ALCOOTA appears to be a continuation of Feature 35. A gravity 'high' region in the south-east of ALCOOTA, Feature 37, appears to form the north-westerly termination of a gravity ridge that extends south-east.

The gravity pattern north-east of ALCOOTA, which represents sediments of the Georgina Basin, does not appear to be controlled by any major trends; i.e. the Bouguer anomalies are not regular in direction. This irregular pattern extends onto the north-east corner of ALCOOTA, which suggests that the sediments of the Georgina Basin extend into the area from the east.

Readings made on the western edge of ALCOOTA suggest that a gravity 'low' (Feature 36) develops on NAPPERBY. Isolated readings on NAPPERBY and MOUNT DOREEN (Radeski, 1962) suggest that the feature is extensive. The negative anomaly is probably caused by the sediments of the Ngalia Trough.

ILLOGWA CREEK and HALE RIVER and surrounding map areas

Certain areas on ILLOGWA CREEK and HALE RIVER were not covered during the 1960 and 1961 helicopter gravity surveys. The area covered by the 1962 survey filled in the gap between previous BMR surveys and private-company data supplied by Flamingo Petroleum Pty Ltd.

All the major gravity features in the area have already been partially mapped by previous surveys. Features 37, 38, and 39 have been described by Barlow (1966) and appear to form the south-western portion of an extensive gravity plateau. Features 37 and 39 probably represent near-surface basement rocks, and in places are correlated with outcropping crystalline rocks.

The McDills Gravity Platform, Feature 40, lies south-west of this gravity plateau and probably represents an area of thicker sediments. It has been mainly outlined by private company gravity work (Geosurveys of Australia Ltd, 1960; Beach Petroleum N.L., 1963). Feature 40 extends south-west into the Alberga Gravity High.

The East Rodinga Gravity Low, Feature 41, extends into the extreme western portion of HALE RIVER. The gravity 'low' coincides with a small basin of Palaeozoic sediments on RODINGA and the extension of this basin onto HALE RIVER is thus indicated to be marginal only. This small basin is situated within the area of the Amadeus Gravity Depression.

6. CROSS-SECTION ANALYSIS

Two cross-sections have been analysed in the Western Australian part of the survey area. These cross-sections, the positions of which are indicated in Plate 4, are shown in Plate 5.

Cross-section A-E was drawn to investigate sedimentary thickness and density across the Cobb Gravity Depression and the south-eastern part of the Gibson Gravity Depression.

On this cross-section, in the region of C, a regional-gravity curve was drawn and a superimposed anomaly was isolated. In order to investigate this residual anomaly a second cross-section, F-G, was drawn passing through C and perpendicular to the trend of the gravity anomaly, and the graphical regional anomaly was removed.

It was assumed that the regional Bouguer-anomaly curve is produced solely by the contrast between low-density sediments and higher-density basement rocks which are at roughly 12,000-ft depth at A (Mount Beadell) and at less than 250-ft depth at 'Signpost' near C. It was also assumed that the average density of both rock units is constant.

The value of the density contrast between these two units was investigated using the plate formula:

$$\Delta g = 12.77h\Delta d$$

where Δg = the gravity effect due to the upper layer,
Δd = the density contrast between the layers, and
h = the thickness of the upper layer in thousands of feet.

At C, near 'Signpost', h = approximately 0, and the Bouguer anomaly on the graphical regional curve is -16 mgal. Hence the above formula may be re-written as

$$-16 - g_x = 12.77h_x\Delta d$$

where g_x = the anomaly value at a point x, and
h_x = the thickness of the upper layer at this point

If the anomaly value at A (Mount Beadell) and the thickness of the upper layer there (approximately 12,000 ft) are inserted in this formula the density contrast between the two layers is shown to be about 0.3 g/cm^3.

Inserting this density contrast and the value of the Bouguer anomaly at B, the Mount Samuel Gravity Low (Feature 6), into the formula it is shown that the upper sedimentary layer is 18,000 ft thick at that point.

If it is assumed that similar conditions exist across the Cobb Gravity Depression, i.e. a simple two-layer case with a density contrast of 0.3 g/cm^3 between these layers, then it can be similarly shown that the upper sedimentary layer is 25,000 ft thick at D (Feature 16) and 9000 ft thick at E on the margin of Feature 13.

As it might be considered somewhat dubious to assume similar conditions across this part of the survey area, a test calculation using these assumptions was made utilising the available gravity and geological information at the Iragana Hills on the western margin of Feature 16. About 15,000 ft of sediments showing a southward dip of 38 degrees have been measured there (Wells, 1962b and personal communication). This would correspond to a vertical sedimentary thickness of about 12,000 ft. As no basement rocks were observed in this locality the sedimentary thickness could be somewhat greater. Owing to the gravity gradient in this area, it is difficult to choose a Bouguer value for the calculations, but -70 mgal would be a reasonable average value. This value when substituted in the formula corresponds to a thickness of the upper sedimentary layer of 14,500 ft, which is reasonable and in accordance with the known geological conditions. Hence, it is considered that the theoretical figure of 25,000 ft obtained for the thickness of the upper sedimentary layer at D is acceptable geologically.

The residual anomaly obtained by removing the graphical regional anomaly on Cross-section F-G has been compared with the theoretical curve for a number of simple models for buried bodies. The shape of the assumed body was varied within geological feasibility and the gravity effect calculated until the anomaly curve thus obtained was in close agreement with the actual Bouguer anomaly. Although the interpretation is not unique, owing to the ambiguity inherent in all gravity interpretation, the model should contribute useful information on possible geological structure and density distribution.

One model which fits reasonably is shown in Plate 5. It extends from the surface to a depth of 12,000 ft with a density contrast of 0.3 g/cm^3.

The densities of rock samples from this part of the survey area are listed below:

Sample number	Age and type of sample	Locality	Density in g/cm^3 (dry sample)
W1	Cretaceous claystone	32 miles south of Woolnough Hills	1.69
C2	Palaeozoic sandstone	Iragana Hills	2.30
C3	Precambrian sandstone (porosity 31%)	Iragana Hills	2.02 (2.33 water saturated)
W2A	Sheared gypsum	Woolnough Hills	2.26
W2B	Dolomite	Woolnough Hills	2.73
BE4	Porphyritic rhyolite	South-east BENTLEY	2.62
BE5	Porphyritic granite	South BENTLEY	2.58

If it is assumed that the basement refractor identified at a depth of about 12,000ft at Mount Beadell is of granitic composition, for which a density of about 2.6 g/cm^3 is suggested from the list of densities above, and that rocks of similar composition lie beneath the sedimentary rocks throughout the length of the Cross-section A-E (with the exception of the higher-density rocks near 'Signpost'), then the sedimentary rocks would have an average density of about 2.3 g/cm^3. This figure is in reasonably good agreement with the average density of the five sedimentary samples listed above.

Similarly, by using the above assumptions, the density of the rocks which give rise to the residual anomaly near 'Signpost' must be about 2.9 g/cm^3. This high density is indicative of basic or ultrabasic material, which could be similar to that which produces the Blackstone Gravity Plateau farther east.

7. CONCLUSIONS AND RECOMMENDATIONS

The results of the gravity survey have revealed the relation between the Amadeus, South Canning, and Officer Basins, and the presence of two other areas of low Bouguer-anomaly values - the Gibson Gravity Depression and the Cobb Gravity Depression.

The Gibson Gravity Depression lies to the south-west of the postulated ridge of granitic or metamorphic rocks that produce the Warri Gravity Ridge. In its currently-known extent the Gravity Depression consists of two gravity sub-depressions, the Herbert Gravity Sub-depression and the Runton Gravity Sub-depression, separated by the Madley Gravity Swell. The Gravity Depression is interpreted as a region of thick sediments, the thickest sediments being located in the areas of the two gravity sub-depressions. The Woolnough Hills and Madley diapirs, which are situated in the Runton Gravity Sub-depression, suggest a sedimentary thickness of at least 15,000-18,000 ft. A similar sedimentary thickness would appear likely in the Herbert Gravity Sub-depression although a seismic refractor at Lake Keene suggested a shallower basement. However, this refractor may be a limestone or dolomite bed included in a thicker sedimentary sequence. The Herbert Gravity Sub-depression is connected to the south-east to the Mount Samuel Gravity Low which extends south-east beyond the survey area. Thick sediments have been indicated by seismic means in the area of this 'low' and these may be connected to those postulated in the Officer Basin farther south-east.

The available geophysical and geological evidence in the area of the Cobb Gravity Depression indicates that this also is an area of thick sedimentary rocks. From analysis of a cross-section a thickness of 25,000 ft of sediments has been suggested in the south of COBB. It is possible that granitic intrusions having very deep roots and a very low ferro-magnesian mineral content could give rise to the low gravity-anomaly values in the eastern part of the depression. However, this is not considered likely, and the sedimentary hypothesis for the whole of the depression is preferred at this stage. It is considered that some additional geological work should be undertaken on SCOTT with a view to obtaining more information on this problem. The ?sedimentary area represented by the Cobb Gravity Depression is bounded to the south by basic and ultrabasic igneous rocks, either in outcrop or at shallow depth, which produce the Blackstone Gravity Plateau; it is bounded to the south-west and west by the postulated ridge of granitic or metamorphic rocks at shallow depth represented by the Warri Gravity Ridge; and to the north it is probably separated from the sediments of the South Canning Basin Gravity Depression by a postulated ridge of near-surface metamorphic rocks, though this is uncertain owing to the sparse gravity coverage in this area. It is separated from the Amadeus Basin by the area of the Barons Gravity Plateau in which basement ?metamorphic rocks are considered to be present at shallow depth.

From analysis of a cross-section it appears likely that the postulated ridge of granitic or metamorphic rocks, which give rise to the Warri Gravity Ridge, has a core of ultrabasic igneous rocks in the area of the Mount Charles Gravity High in west BENTLEY. These ultrabasic rocks could be similar to those that are considered to produce the Blackstone Gravity Plateau farther east.

It is also possible that a nickel orebody similar to that which has been worked near Mount Davies might be located at shallow depth near the central part of the Barrow Range Gravity High.

The gravity data suggest quite strongly that the thick Palaeozoic sediments of the Amadeus Basin do not extend farther west than MOUNT RENNIE and BLOODS RANGE. The northern and southern margins of the Basin are represented by a gravity gradient and a gravity ridge respectively. Many diapirs and anticlines are represented by residual-gravity minima and this fact could be used to locate by detailed gravity work any such structures masked by sand and alluvium. In fact semi-detailed gravity surveys would be a valuable means of obtaining data on the underlying sedimentary structure and of determining where to place seismic traverses.

The geology of AYERS ROCK and PETERMANN RANGES has not been mapped systematically at the time of writing. The Bouguer-anomaly pattern of the area contains many features of extreme interest. An accurate geological map of the area would aid the interpretation of these anomalies. Of particular interest is the Ayers Rock Gravity Depression within which Bouguer values as low as -135 mgal are obtained.

The gravity pattern on ALCOOTA is interesting in that it includes the extreme eastern edge of an extensive gravity 'low'. The coverage on HALE RIVER, ILLOGWA CREEK, and the eastern half of ALCOOTA did not disclose any new gravity features but served to properly define some features that have already been described.

Further reconnaissance gravity work in the areas adjoining the survey area on the north, the west, and the south would define the western and souther extent of the Gibson Gravity Depression; this might confirm the suggested link between the Gibson Gravity Depression and the Officer Basin, and the postulated separation of the Cobb Gravity Depression from the South Canning Basin Gravity Depression. Additional gravity investigations are also desirable over the gravity 'low' area that extends west from ALBERGA and the Officer Basin.

It is considered that seismic investigations should be made across the postulated sediments that give rise to the Cobb Gravity Depression. These could be made along the roads south of Giles towards both the Blackstone Ranges and Mount Davies, and also along the road west of Giles towards 'Signpost'. It would also be useful to further investigate by seismic means the suggested sedimentary thickness in the Gibson Gravity Depression.

In addition, if the geological mapping of AYERS ROCK fails to indicate conclusively the nature of the structure and the rock-types that give rise to the Ayers Rock Gravity Depression, then it is recommended that a seismic traverse be made across the centre of the depression along the road from north-east AYERS ROCK to north WOODROFFE.

Summing up, the results of the 1962 helicopter gravity survey indicate that:

(a) The Amadeus Basin is separated from the South Canning Basin and from the suggested sediments that give rise to the Cobb Gravity Depression by shallow basement rocks in the area of the Barons Gravity Plateau.

(b) The South Canning Basin is separated from the suggested sediments of the Cobb Gravity Depression by a ridge of basement rocks aligned east-west across north RYAN; this ridge thus marks the southern limit of the Canning Basin.

(c) The South Canning Basin and the suggested sediments that give rise to the Cobb Gravity Depression are separated from the suggested sediments of the Gibson Gravity Depression, in which the Woolnough Hills diapir is situated, by a ridge of granitic or metamorphic rocks that gives rise to the Warri Gravity Ridge. In addition, the gravity results suggest that the sediments of the Gibson Gravity Depression may be connected to the south-east to the Officer Basin.

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*Surveys subsidised under Petroleum Search Subsidy Acts.

APPENDIX A - PARTY PERSONNEL

Bureau of Mineral Resources

Party Leader:	A.J. Flavelle
Geophysicists:	L.M. Hastie
	M.A. Reid (left party 15/6/62)
	J.S. Davies (left party 4/7/62)
	G.F. Lonsdale (21/6/62 - 16/8/62)
	R.A. Gibb (joined party 11/8/62)
Technical assistants:	W. Lowndes (joined party 18/6/62)
	P. Campbell (joined party 21/6/62)
Draftsmen:	E. Krams-Steins
	G. Knapp-Stein
Mechanic:	C. Bannerman
Cook:	C. Howard
Cook's offsider:	C. Robinson
Field assistants:	W. Bannerman
	G. Corder
	F. de Vere
	K. Kirby
	D. Locke
	I. Thomas

Ansett-ANA

Ansett-ANA supplied a crew of five - three pilots and two engineers drawn from the following personnel:

Pilots:	J. Ferguson
	R. Larder
	R. Jones
	P. Hunt
	J.C. Pain
	D. Newell
Engineers:	L. Taylor
	J. Morvell
	K. Harvey
	D. King
	R. Annand

APPENDIX B - EQUIPMENT

Gravity meters

Meter	Calibration factor (mgal/scale div.)
Master Worden No. 548	0.10954
Worden No. 169	0.1058

Microbarometers

Mechanisms Ltd No. 294/62	
317/62	
318/62	
Askania	No. 5112387
	5112395
	531306
	531333

Vehicles

International AA120, 4 x 4 (1-ton utilities)	C.89944
	C.90122
	C.90126
	C.89985 (replacement vehicle)
	C.89987 (replacement vehicle)
Bedford 3-ton truck, 4 x 4	C.10675
	C.10678
	C.93795
	ZSU 016
Bedford tanker, 4 x 4	C.10684
	ZSU 014
Bombardier J5, tracked vehicle:	ZSW 022
	ZSW 023
Four-wheel flat-top trailer:	C.67752
Two-wheel generator trailer:	C.57867
Tracked (T6) trailer:	ZTL 059
	ZTL 060

Helicopters (Ansett-ANA)

Bell 47J	VH-INF
	VH-INN

APPENDIX C - SURVEY STATISTICS

Survey period 28 May-28 September 1962	
Number of gravity flying-days	124
Total gravity flying-time	814.35 hours
Average gravity flying-time per gravity flying-day	6.6 hours
Number of new stations established	3056
Average number of new stations per gravity flying-day	25
Average number of new stations per gravity flying-hour	3.8
Number of days survey period	123
Sundays	17
Total available helicopter days (two helicopters)	212

Helicopter usage, days

Gravity flying		124
U/S (breakdown and servicing)		49½
U/S (weather)		9
Transit flights, geological flights, not required etc.		29½
	Total	212

Note

Gravity flying-day	:	A full day of flying by the helicopter for the purpose of gravity observations.
Gravity flying-time	:	The amount of time spent by the helicopter in the air between events which occur on a gravity flight, usually from engine start to touch down.
Gravity flying-hour	:	One hour of gravity flying-time.
New station	:	A point at which a gravity observation is made for the first time.
Transit flight	:	A flight by the helicopter for the purpose of transiting from one point to another, usually from one camp to another, without any gravity observations being made en route.
Geological flight	:	A flight made solely for geological purposes.

APPENDIX D - PARTY TIMETABLE

Period	Camp sites	1:250,000 sheet flown
28 May-1 July	Carnegie Homestead and additional fly camps	HERBERT, MADLEY, BROWNE, WARRI
2 July-26 August	Giles Meteorological Station and additional fly camps	COBB, BENTLEY, SCOTT, RAWLINSON, MACDONALD, MOUNT RENNIE, MOUNT LIEBIG
27 August-13 September	Ayers Rock and additional fly camps	BLOODS RANGE, PETERMANN RANGES, LAKE AMADEUS, AYERS ROCK
14-28 September	Alice Springs and additional fly camps	HALE RIVER, ILLOGWA CREEK, ALCOOTA

APPENDIX E - OPERATIONAL CONDITIONS

Conditions during June, July, and August 1962 were extremely difficult. In the Western Australian survey area permanent water could be obtained only at Giles. Consequently the main camp for the western part of the area had to be sited at Carnegie Homestead.

The road and general access conditions in the Western Australian area left much to be desired, and it was a constant struggle to maintain adequate ground transport facilities for the party. Tracked vehicles were used with considerable success for the positioning of aviation spirit.

On moving eastwards into the Northern Territory the operational conditions experienced by the party showed a marked improvement. This could be attributed to better access facilities in the area and more comfortable camping sites. The most difficult areas to cover were MOUNT RENNIE and BLOODS RANGE. In both areas access was limited and in addition the operation was hampered by rain while MOUNT RENNIE was being traversed.

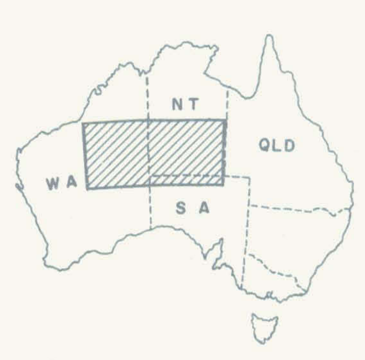
Tracked transport was used to position fuel on one occasion (BLOODS RANGE). Subsequent events which occurred whilst positioning fuel on LAKE AMADEUS showed that tracked transport should also have been used in this area. Information given to the party by BMR geologists suggested that the track on LAKE AMADEUS was in good order. However, recent heavy winds had reduced it to a sand-covered trail across the dunes.

It was originally believed that conditions on the north-west edge of the Simpson Desert would be difficult, but it was subsequently found that the construction of new tracks in the area rendered the positioning of aviation spirit a simple matter.

PLATE 4

Based on G 69-475-0

LOCATION



Compiled March 1963.

LEGEND

Isogals, values in milligals

▲ 35 BMR gravity pendulum station

BMR gravity reading of aerodrome

Ryan BMR 4-mile gravity map area

9 Anomaly feature number

Feature boundary

A----B Cross-section line

Ground traverse in area of sparse control

Flight "B"

Bouguer anomalies are based on the observed gravity values at BMR pendulum stations:

No. 22	Wiluna	978,954·4 milligals
No. 23	Mundiwindi	978,745·9 "
No. 26	Port Hedland	978,646·0 "
No. 27	Anna Plains	978,624·9 "
No. 29	Halls Creek	978,463·0 "
No. 35	Alice Springs	978,653·7 "
No. 36	Oodnadatta	979,100·0 "
No. 57	Birdsville	979,003·7 "

Elevation datum: Queensland State and M.S.L. Derby

BOUGUER ANOMALY VALUES IN MILLIGALS

+80 to +60	-40 to -60
+60 to +40	-60 to -80
+40 to +20	-80 to -100
+20 to 0	-100 to -120
0 to -20	-120 to -140
-20 to -40	-140 to -160

AMADEUS BASIN - SOUTH CANNING BASIN RECONNAISSANCE GRAVITY SURVEY USING HELICOPTERS NT AND WA 1962

BOUGUER ANOMALIES

SCALE IN MILES

40 0 40 80 120

Reference: Division of National Mapping 40 miles to 1 inch topographic map

Contour interval 5 milligals

RELIABILITY DIAGRAM

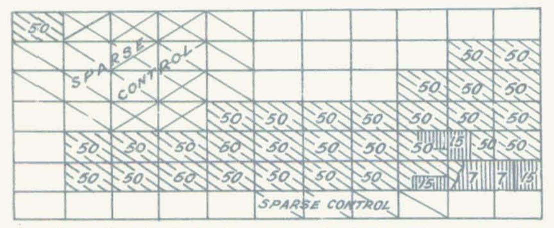


FIGURE IN EACH AREA DENOTES SQUARE MILES PER GRAVITY STATION

BOUGUER ANOMALY CONTOURS (ISOGALS) ARE BASED ON PRELIMINARY DATA AND MAY BE SUBJECT TO SLIGHT ALTERATIONS.

GRAVITY	
SURVEY	METHOD
Helicopter by BMR	Regular grid coverage, air photography, barometric levelling.
Ground traverses by BMR, WAPET & SA Mines Dept. Scattered BMR helicopter traverses.	Widely dispersed traverses, air photography, conventional & barometric levelling, astrofixes.
Semi-detailed by Flamingo & Papuan Apinaipi, Geosurveys & Beach Petroleum	Helicopter traverses, conventional & barometric levelling. Some ground traveses.

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS G 69-475-1 W.O.

PLATE 5

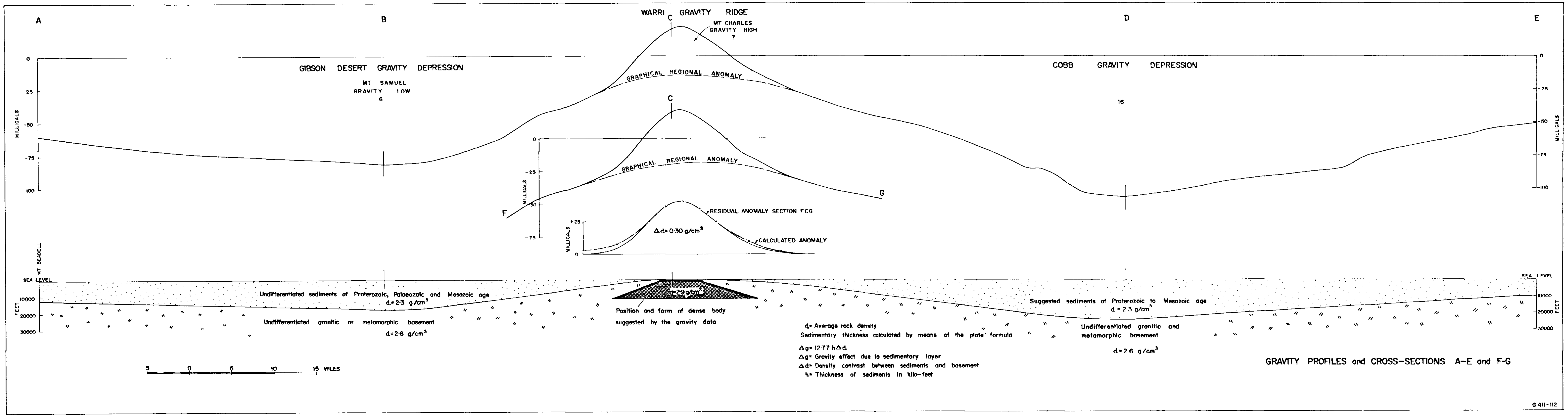

A
B
C
D
E
WARRI GRAVITY RIDGE
MT CHARLES GRAVITY HIGH 7
GIBSON DESERT GRAVITY DEPRESSION
MT SAMUEL GRAVITY LOW 6
COBB GRAVITY DEPRESSION
16
GRAPHICAL REGIONAL ANOMALY
MILLIGALS
F
G
RESIDUAL ANOMALY SECTION FCG
CALCULATED ANOMALY
Δd= 0·30 g/cm³
MT BEADELL
SEA LEVEL
FEET
Undifferentiated sediments of Proterozoic, Palaeozoic and Mesozoic age
d= 2·3 g/cm³
Undifferentiated granitic or metamorphic basement
d=2·6 g/cm³
d=2·9 g/cm³
Position and form of dense body suggested by the gravity data
Suggested sediments of Proterozoic to Mesozoic age
d= 2·3 g/cm³
Undifferentiated granitic and metamorphic basement
d=2·6 g/cm³
d= Average rock density
Sedimentary thickness calculated by means of the plate formula
Δg= 12·77 hΔd
Δg= Gravity effect due to sedimentary layer
Δd= Density contrast between sediments and basement
h= Thickness of sediments in kilo-feet
5 0 5 10 15 MILES
GRAVITY PROFILES and CROSS-SECTIONS A-E and F-G
G 411-112

PLATE I

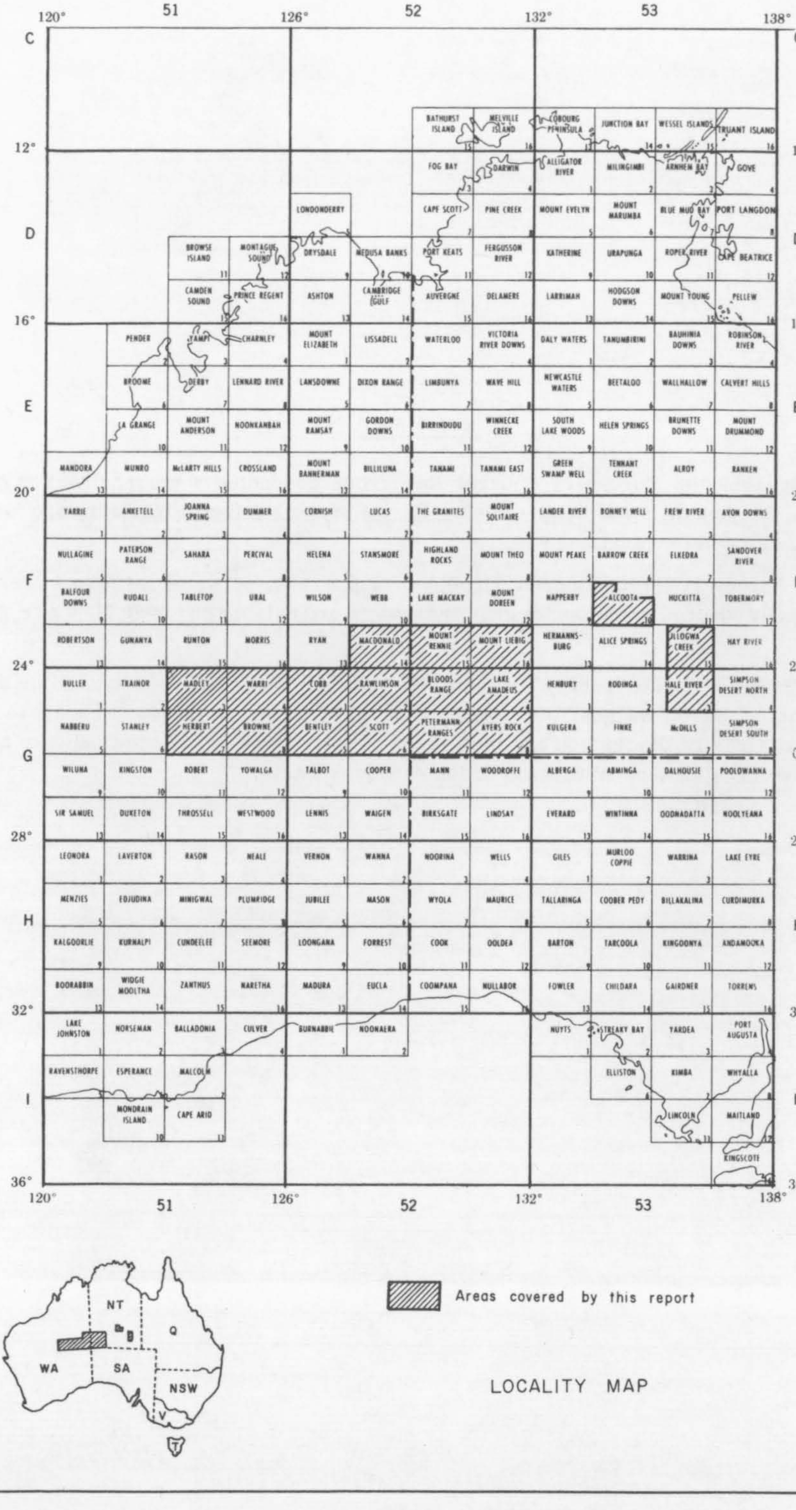
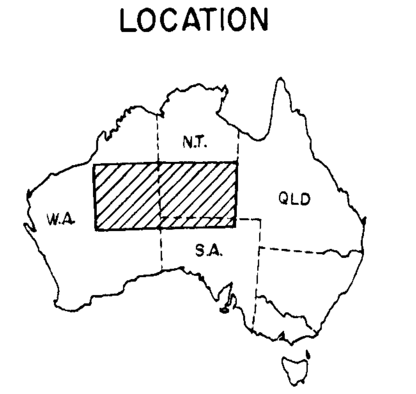

120°
51
126°
52
132°
53
138°
C
12°
D
16°
E
20°
F
24°
G
28°
H
32°
I
36°
BATHURST ISLAND
MELVILLE ISLAND
COBOURG PENINSULA
JUNCTION BAY
WESSEL ISLANDS
TRUANT ISLAND
FOG BAY
DARWIN
ALLIGATOR RIVER
MILINGIMBI
ARNHEM BAY
GOVE
LONDONDERRY
CAPE SCOTT
PINE CREEK
MOUNT EVELYN
MOUNT MARUMBA
BLUE MUD BAY
PORT LANGDON
BROWSE ISLAND
MONTAGUE SOUND
DRYSDALE
MEDUSA BANKS
PORT KEATS
FERGUSSON RIVER
KATHERINE
URAPUNGA
ROPER RIVER
CAPE BEATRICE
CAMDEN SOUND
PRINCE REGENT
ASHTON
CAMBRIDGE GULF
AUVERGNE
DELAMERE
LARRIMAH
HODGSON DOWNS
MOUNT YOUNG
PELLEW
PENDER
YAMPI
CHARNLEY
MOUNT ELIZABETH
LISSADELL
WATERLOO
VICTORIA RIVER DOWNS
DALY WATERS
TANUMBIRINI
BAUHINIA DOWNS
ROBINSON RIVER
BROOME
DERBY
LENNARD RIVER
LANSDOWNE
DIXON RANGE
LIMBUNYA
WAVE HILL
NEWCASTLE WATERS
BEETALOO
WALLHALLOW
CALVERT HILLS
LA GRANGE
MOUNT ANDERSON
NOONKANBAH
MOUNT RAMSAY
GORDON DOWNS
BIRRINDUDU
WINNECKE CREEK
SOUTH LAKE WOODS
HELEN SPRINGS
BRUNETTE DOWNS
MOUNT DRUMMOND
MANDORA
MUNRO
McLARTY HILLS
CROSSLAND
MOUNT BANNERMAN
BILLILUNA
TANAMI
TANAMI EAST
GREEN SWAMP WELL
TENNANT CREEK
ALROY
RANKEN
YARRIE
ANKETELL
JOANNA SPRING
DUMMER
CORNISH
LUCAS
THE GRANITES
MOUNT SOLITAIRE
LANDER RIVER
BONNEY WELL
FREW RIVER
AVON DOWNS
NULLAGINE
PATERSON RANGE
SAHARA
PERCIVAL
HELENA
STANSMORE
HIGHLAND ROCKS
MOUNT THEO
MOUNT PEAKE
BARROW CREEK
ELKEDRA
SANDOVER RIVER
BALFOUR DOWNS
RUDALL
TABLETOP
URAL
WILSON
WEBB
LAKE MACKAY
MOUNT DOREEN
NAPPERBY
ALCOOTA
HUCKITTA
TOBERMORY
ROBERTSON
GUNANYA
RUNTON
MORRIS
RYAN
MACDONALD
MOUNT RENNIE
MOUNT LIEBIG
HERMANNSBURG
ALICE SPRINGS
ILLOGWA CREEK
HAY RIVER
BULLER
TRAINOR
MADLEY
WARRI
COBB
RAWLINSON
BLOODS RANGE
LAKE AMADEUS
HENBURY
RODINGA
HALE RIVER
SIMPSON DESERT NORTH
NABBERU
STANLEY
HERBERT
BROWNE
BENTLEY
SCOTT
PETERMANN RANGES
AYERS ROCK
KULGERA
FINKE
McDILLS
SIMPSON DESERT SOUTH
WILUNA
KINGSTON
ROBERT
YOWALGA
TALBOT
COOPER
MANN
WOODROFFE
ALBERGA
ABMINGA
DALHOUSIE
POOLOWANNA
SIR SAMUEL
DUKETON
THROSSELL
WESTWOOD
LENNIS
WAIGEN
BIRKSGATE
LINDSAY
EVERARD
WINTINNA
OODNADATTA
NOOLYEANA
LEONORA
LAVERTON
RASON
NEALE
VERNON
WANNA
NOORINA
WELLS
GILES
MURLOO COPPIE
WARRINA
LAKE EYRE
MENZIES
EDJUDINA
MINIGWAL
PLUMRIDGE
JUBILEE
MASON
WYOLA
MAURICE
TALLARINGA
COOBER PEDY
BILLAKALINA
CURDIMURKA
KALGOORLIE
KURNALPI
CUNDEELEE
SEEMORE
LOONGANA
FORREST
COOK
OOLDEA
BARTON
TARCOOLA
KINGOONYA
ANDAMOOKA
BOORABBIN
WIDGIE MOOLTHA
ZANTHUS
NARETHA
MADURA
EUCLA
COOMPANA
NULLABOR
FOWLER
CHILDARA
GAIRDNER
TORRENS
LAKE JOHNSTON
NORSEMAN
BALLADONIA
CULVER
BURNABBIE
NOONAERA
NUYTS
STREAKY BAY
YARDEA
PORT AUGUSTA
RAVENSTHORPE
ESPERANCE
MALCOLM
ELLISTON
KIMBA
WHYALLA
MONDRAIN ISLAND
CAPE ARID
LINCOLN
MAITLAND
KINGSCOTE
Areas covered by this report
NT
Q
WA
SA
NSW
V
T
LOCALITY MAP

PLATE 2

Based on G 69-475-0

LOCATION



Cz	Cainozoic
T	Tertiary
M	Mesozoic
Pz Pzu Pzl	Palaeozoic
P Eu Es A	Proterozoic and Archaean
+ +	Granite and porphyry

▲ 35 BMR gravity pendulum station

Kulgera — BMR 1:250,000 gravity map area

Fault
Fault, indefinite

Anticlinal axis

Synclinal axis

State boundary

AMADEUS BASIN — SOUTH CANNING BASIN RECONNAISSANCE GRAVITY SURVEY USING HELICOPTERS NT AND WA 1962

GEOLOGY

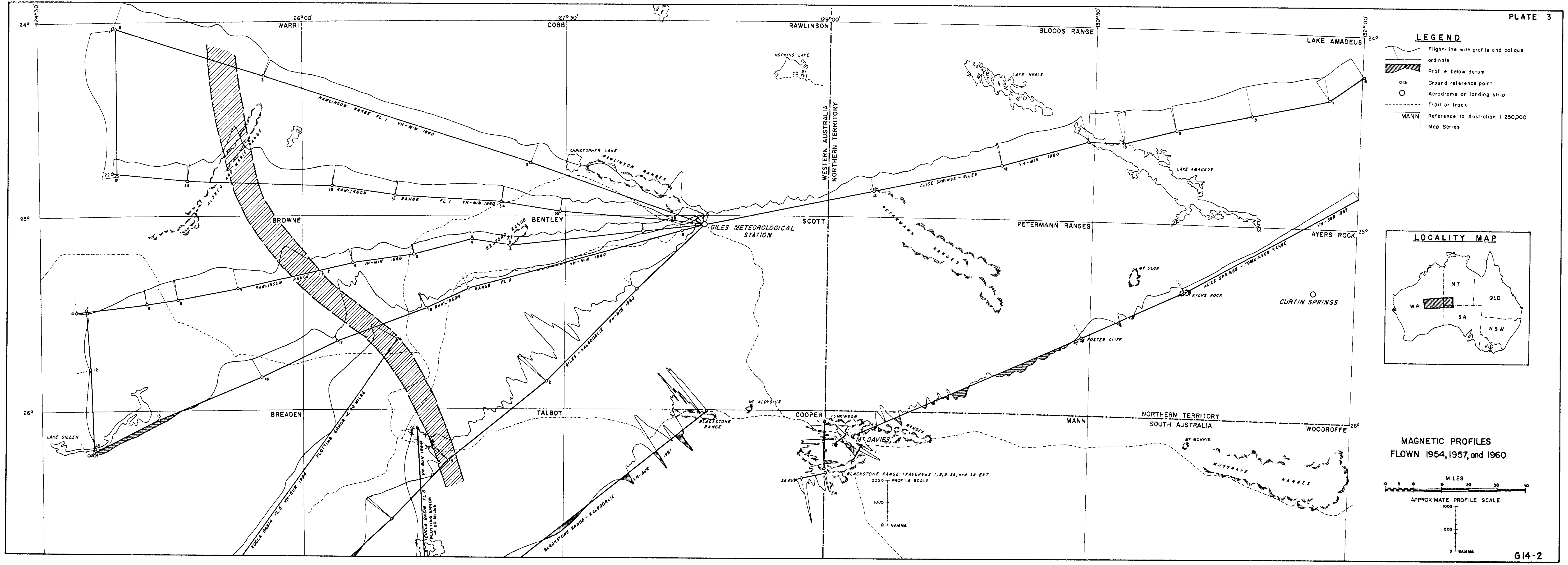
SCALE IN MILES

40 0 40 80 120

Geology based on BMR tectonic map 40 miles to 1 inch and BMR 1:250,000 geological maps

Compiled March 1963

G 69-475



MAGNETIC PROFILES
FLOWN 1954, 1957, and 1960

G14-2