COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Petroleum Search Subsidy Acts

PUBLICATION No. 63

Dalhousie Gravity Survey South Australia, 1963

BY

FRENCH PETROLEUM COMPANY (AUSTRALIA) PTY LIMITED

Issued under the Authority of the Hon. David Fairbairn
Minister for National Development
1965

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

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

SECRETARY: SIR HAROLD RAGGATT, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

DIRECTOR: J. M. RAYNER

THIS REPORT WAS PREPARED FOR PUBLICATION IN THE PETROLEUM EXPLORATION BRANCH

ASSISTANT DIRECTOR: M. A. CONDON

Published by the Bureau of Mineral Resources, Geology and Geophysics

Canberra A.C.T.

FOREWORD

Under the Petroleum Search Subsidy Act 1959-1961, agreements relating to subsidized operations provide that the information obtained may be published by the Commonwealth Government six months after the completion of field work.

The Bureau of Mineral Resources, Geology and Geophysics is required, on behalf of the Department of National Development, to examine the applications, maintain surveillance of the operations and in due course publish the results. The growth of the exploration effort has greatly increased the number of subsidized projects and this increase has led to delays in publishing the results of operations.

The detailed results of subsidized operations may be examined at the offices of the Bureau of Mineral Resources in Canberra and Melbourne (after the agreed period) and copies of the reports may be purchased.

This Publication deals with a helicopter gravity survey conducted by Wongela Geophysical Pty Ltd over an area in the northern part of South Australia. It contains information furnished by French Petroleum Company (Australia) Pty Limited and edited in the Petroleum Exploration Branch of the Bureau of Mineral Resources. The final report, dated 31st January, 1964, was written by L.N. Ingall and G.F. Lonsdale of Wongela Geophysical Pty Ltd. The methods employed in the survey and the results obtained are presented in detail.

J.M. RAYNER
DIRECTOR

CONTENTS

ILLUSTRATIONS

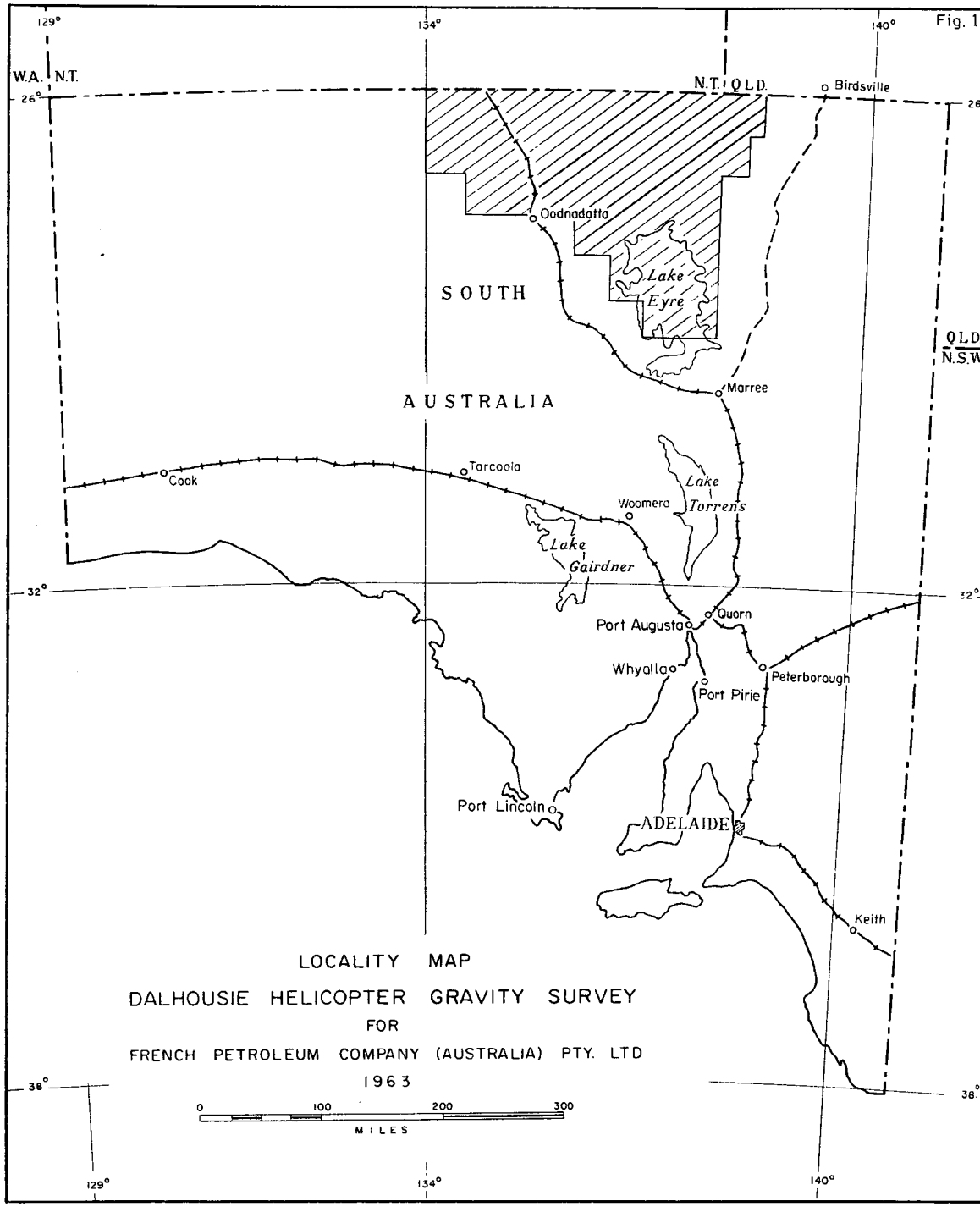


Fig. 1
129°
134°
140°
W.A.
N.T.
N.T.
QLD.
Birdsville
26°
Oodnadatta
Lake
Eyre
SOUTH
AUSTRALIA
QLD.
N.S.W.
Marree
Cook
Tarcoola
Woomera
Lake
Torrens
Lake
Gairdner
32°
Port Augusta
Quorn
Whyalla
Port Pirie
Peterborough
Port Lincoln
ADELAIDE
Keith
38°
LOCALITY MAP
DALHOUSIE HELICOPTER GRAVITY SURVEY
FOR
FRENCH PETROLEUM COMPANY (AUSTRALIA) PTY. LTD
1963
0
100
200
300
MILES

SUMMARY

Wongela Geophysical Pty Ltd conducted a helicopter gravity survey for the French Petroleum Company (Australia) Pty Limited in northern South Australia during the period 22nd August to 21st November, 1963, and established 2204 new gravity stations. The area surveyed is in Oil Exploration Licences Nos 20 and 21, and originally covered 34,000 square miles. This area was increased to 35,500 square miles to fill in a gap between the subject survey and the Delhi Alton Downs survey farther east. The work is tied to previous reconnaissance gravity surveys in Central Australia and completes the gravity coverage of the Simpson Desert.

The survey was carried out to determine the extent of Palaeozoic sedimentation in the area and in particular to determine whether Amadeus Basin sediments extend into the survey area. These sediments are masked in the area by relatively flat-lying Mesozoic and more recent sediments. The younger sediments have much the same thickness and density throughout the survey area, and for this reason their contribution to variations in the anomaly field is small. Hence the variations in the anomaly field are thought to be due mainly to density contrasts in the basement and between the basement and pre-Mesozoic sediments.

The survey results have defined some major geological structural units. These are described and discussed individually in the text of the report. Of particular interest is the Dalhousie Gravity Depression which probably represents a large area of pre-Permian sedimentation, about 8000 feet in thickness. To the east of this feature is a platform area which was probably fairly stable and high standing during pre-Permian time in which period it received only a thin cover of sediments. It is probable that since early Permian times the area has been depressed relative to the area of the Dalhousie Gravity Depression and the area farther west, and has received extensive Permian and Mesozoic sedimentation, the sediments thickening towards the east.

INTRODUCTION

The area surveyed is in South Australian Oil Exploration Licences Nos 20 and 21 and covers 35,500 square miles, bounded by latitudes 26°00' and 29°00' South and longitudes 134°00' and 138°00' East. Wongela Geophysical Pty Ltd established 2204 new gravity stations in the period 22nd August to 21st November, 1963 for the French Petroleum Company (Australia) Pty Limited.

The survey is tied to existing gravity surveys bordering the area in Queensland, Central, and South Australia, and completes the gravity coverage of the Simpson Desert.

One of the prime objectives of the survey was to determine the extent of Palaeozoic sedimentation in the area; and in particular to determine whether the Amadeus Basin sediments extend into the survey area. These sediments are masked in the area by relatively flat-lying Mesozoic and more recent sediments. These younger sediments have much the same thickness and density throughout the survey area and for this reason their contributions to variations in the anomaly field are small. The variations in the anomaly field are thought to be due mainly to density contrasts in the basement itself and between the basement and pre-Mesozoic sediments.

The survey area includes the southern part of the Simpson Desert, Lake Eyre North and much dissected gibber country. The area is arid, and the average annual rainfall is less than five inches.

The South Simpson Desert is characterized by north-north-west striking sand dunes up to eighty feet high. The western faces of the dunes are generally gently dipping and the eastern faces are avalanched. The frequency of occurrence of the dunes varies from as many as ten per mile to as few as three per mile. The interdune corridors are generally sandy with occasional flat claypans. Spinifex grows abundantly both on the dunes and in the corridors. Elevations range from near sea level to a few hundred feet above sea level.

Lake Eyre North has salt deposits which probably reach a maximum thickness of twelve inches in the south-eastern lobe of the lake known as Madigan Gulf. The salt is restricted to the southern quarter of the lake and most of the lake surface has a very thin dry crust overlying mud. At the time of flying the lake (November, 1963), surface water was confined to the south-western lobe, and near the mouths of Cooper's Creek and the Warburton River. Elevations over the lake surface varied from forty feet below sea level at the northern end to fifty feet below sea level in Madigan Gulf.

The country to the west of the Simpson Desert is characterized by tableland-like topography, well dissected and with many mesas of Mesozoic age. Duricrust deposits are extensive. The elevations rise gradually from about one hundred feet above sea level on the western fringe of the South Simpson Desert to over twelve hundred feet in the north-western corner of the survey area. The plains in this area are liberally covered with gibbers and ironstone patches. Vegetation in the area is much more abundant than in the desert to the east.

Access throughout the area ranged from very difficult in the desert and lake areas to moderately difficult in the duricrust area which flanked the western side of the Desert.

The French Petroleum Company (Australia) Pty Limited carried out exploration work in the area prior to the initiation of the subject gravity survey. This work included photogeology and seismic reflection and refraction surveys. Delhi Australian Petroleum Limited had already done aeromagnetic work in the area.

The gravity work was programmed to aid in the resolution of the large scale geological units and structural features. A grid four miles by four miles was selected for the work, except in the area between the subject survey and the Alton Downs survey. In this latter area a grid size seven miles by seven miles was considered adequate for determining the gravity anomaly pattern.

GEOLOGY

The survey area is in the extreme western part of the Great Artesian Basin, an extensive sedimentary basin of Mesozoic age. The sediments deposited in this basin in the survey area are mainly Jurassic and Cretaceous sandstones and conglomerates. They are relatively flat lying and information from water bores indicates that they increase in thickness towards the east.

East of longitude 136°E. and north of Lake Eyre North in the survey area, the Mesozoic sediments are obscured by sand of the Simpson Desert. Over Lake Eyre North and the adjacent area the Mesozoic sediments are covered by recent salt, loam, and clay deposits.

In the vicinity of the survey area the Great Artesian Basin overlaps several Proterozoic and Palaeozoic sedimentary basins: the Amadeus Basin to the north-west, the Officer Basin to the west, and the Torrens Basin to the south. The extent of these basins beneath the Mesozoic deposits is largely unknown and it is possible that they may extend into the survey area. Hence, appreciable thicknesses of Proterozoic and Palaeozoic sediments are possible in the survey area. Recent drilling has established the presence of oil in sediments in the Amadeus Basin, and it is thus very important to determine whether the south-eastern margin of the Amadeus Basin lies within the survey area. Porous sediments associated with basin margins can be expected in this area, and the prospects of hydrocarbon accumulation in structural traps and stratigraphic "wedge-outs" within these sediments are very good.

Archaean and Lower Proterozoic rocks crop out in two areas adjacent to the survey area. In the area west of ABMINGA*, Archaean rocks of the Musgrave Block separate the sediments of the Amadeus Basin to the north from those of the Officer Basin to the south, whilst in the area south of OODNADATTA, Archaean and Lower and Upper Proterozoic rocks form the core of the Peake and Denison Ranges.

Comparatively little is known of the structure of the area, apart from that outlined above. Surface geology as mapped from aerial photographs shows some gentle folding in the Oodnadatta area, but this does not necessarily bear any relationship to the structure of the underlying rocks.

---

* Throughout this report individual 1:250,000 map areas will be denoted by capital letters, e.g. ALBERGA, whilst locations will be shown in small type, e.g. Abminga.

PREVIOUS GEOPHYSICAL SURVEYS

Gravity Surveys

The initial gravity work in the surveyed and adjoining areas was carried out in 1951 when the Commonwealth Bureau of Mineral Resources, Geology and Geophysics, established a pendulum station at Oodnadatta (Dooley, et al., 1961, 1962).

The first gravity traverse in the survey area was also carried out in 1951 by members of the University of Sydney Department of Geology and Geophysics, who made gravity readings along the railway line from Wall Creek to Marree during regional gravity investigations in the eastern and central parts of Australia (Marshall and Narain, 1954). The results of this traverse show small variation in the Bouguer anomaly values from Wall Creek to Oodnadatta. However, south of Oodnadatta the anomaly values increase towards Algebuckina before decreasing again towards the southern margin of the survey area. It was suggested that this anomaly increase might be caused by an upward swell in Proterozoic rocks, outcrops of which are known locally to pierce the Mesozoic sedimentary veneer.

In 1953 the South Australian Department of Mines conducted a regional gravity and magnetic survey along roads and tracks in between the Commonwealth Railway and the main Alice Springs to Adelaide highway; and between the South Australia-Northern Territory border and Oodnadatta (Knapman, 1953). The survey was intended as a guide to bedrock structure and its relationship to the younger beds of the Great Artesian Basin with special reference to the limits of the artesian waters. The gravity results reveal the presence of a gravity "high" passing eastwards through De Rose Hill and Tieyon Homestead towards Abminga. It is flanked to the south, near Granite Downs Homestead, by a gravity "low". Knapman suggested that the gravity "high" is produced by rocks of the Archaean Musgrave Block either in outcrop or at shallow depth, and that the general decrease in gravity values from Tieyon Homestead towards Abminga represents a thickening sedimentary section. He also suggested that this "low" in the vicinity of Granite Downs Homestead where the Musgrave Block consists mainly of granite gneiss extensively intruded by basic dykes, is due to a thickening of the sialic crust, apparently associated with the edge of the Musgrave Block.

The South Australian Department of Mines carried out a second gravity survey in the area during 1960 and took gravity readings along a traverse between Mirra Mitta Bore on the Birdsville Track and Oodnadatta (Pegum, 1961). This survey formed the first phase of a Mines Department geophysical programme in the area to determine the geological structure and potential for hydrocarbon accumulation. The results indicate the presence of a north-south trending gravity "low" twenty miles wide and immediately east of Mount Dutton. East of the "low" the anomalies are irregular but the Bouguer anomaly values gradually decrease towards Cowarie, after which point they become more positive towards Mirra Mitta Bore. Pegum suggested that the "low" east of Mount Dutton is produced by Palaeozoic sediments beneath the Mesozoic deposits. The irregularities in the decreasing Bouguer gravity values east of this "low" may reflect variations in the basement topography.

In 1962 the Bureau of Mineral Resources made a series of gravity observations along the railway line between the Alice Springs and Oodnadatta pendulum stations as part of the regional gravity network of Australia.

Several gravity surveys have been carried out in the area adjoining the survey area. Mines Administration Pty Ltd carried out the first of these surveys in 1960 on behalf of Flamingo Petroleum Pty Ltd in the area north of Wall Creek (Burbury, 1960). The gravity

results suggested that dense Precambrian basement rocks lie close to the surface and that it is unlikely that unmetamorphosed Upper Proterozoic or Lower Palaeozoic sediments of the Amadeus Basin occur below the Mesozoic sediments. The results also suggested that the major gravity variations observed are due to structure and density contrasts within the basement.

Also in 1960, Geosurveys of Australia Limited conducted a gravity survey in the Andado area, north of the subject survey area (Denton and Dennison, 1962).

Mines Administration Pty Ltd also conducted a gravity survey in 1961 on behalf of Associated Freney Oil Fields N.L. in the eastern part of the Simpson Desert in O.P. 36, N.T., north-west of Poeppels Corner (Burbury, 1961). Most of the gravity anomaly features found on the survey are considered to be due to density contrasts within the basement. However, the anomalies also suggest a thinning in the sedimentary section from about 7000 feet near Poeppels Corner to about 3300 feet in the north-western corner of the permit area.

In 1961, the Bureau of Mineral Resources carried out gravity surveys in two adjoining areas. The first of these was over the eastern part of the Amadeus Basin in the area north of the north-western portion of the subject survey area (Langron, 1962). Two gravity troughs trending east-west and separated by a gravity ridge were partially delineated in this part of the basin. No definite gravity evidence for the easterly termination of the basin was found.

The second survey by the Bureau of Mineral Resources in 1961 was carried out in the area north and east of Poeppels Corner (Lonsdale, 1962). The western margin of this survey adjoins the Associated Freney survey. In this area the Great Artesian Basin overlaps northwards onto the Boulia Shelf. The Bouguer anomalies in the part of the area immediately to the north-east of Poeppels Corner are considered to be principally related to variations in the basement topography and hence the two major adjacent features - the Annandale gravity "low" and the gravity "high" midway between Poeppels Corner and Birdsville - are considered to represent areas of thick sediment and shallow basement respectively.

In 1962, Geoseismic (Australia) Pty Limited conducted a gravity survey for Beach Petroleum N.L. in O.P. 57, N.T., north of the Dalhousie survey area. Their objective was to locate geological structures of significance in the search for petroleum (Sprigg and Stackler, 1963). This survey adjoined the Associated Freney survey to the east and the Geosurveys survey to the west. The report suggests that the gravity anomalies in this area are related in many cases to basement topography. Sedimentary thicknesses are thought to vary between 10,000 and 20,000 feet. A gravity "high" on the southern margin of the area is thought to be due to the broad Dalhousie Anticline whilst a gravity "low" which flanks this "high" to the west may represent the Mount Dare Syncline.

Later in 1962, Geophysical Service International (G.S.I.) carried out a gravity survey on behalf of Delhi Australian Petroleum Ltd in the area south of Birdsville but not extending as far west as Poeppels Corner (Delhi Australian Petroleum Ltd, 1963). The results reveal that the area of positive anomalies found earlier mid-way between Poeppels Corner and Birdsville joins the northernmost portion of a large gravity "high" developed farther to the south and which is flanked to the west by a partially delineated gravity "low" on the western margin of the area. The report concludes that the large positive gravity anomalies are due to density contrasts within the basement.

Magnetic Surveys

The South Australian Department of Mines (Knapman, 1953) observed variations in vertical magnetic intensity during the 1953 survey in the far north of South Australia. The results suggest an increasing depth to basement between Granite Downs Homestead and Lambina Homestead, and between 32 and 62 miles north of Oodnadatta on the road to Abminga. Between Oodnadatta and Lambina the results indicated a deep basement. The report noted some correlation between gravity and magnetic variations between Tieyon Homestead and Abminga, increases in the Bouguer anomaly values being associated with increases in the vertical magnetic intensity values.

Aero Service Limited flew an aeromagnetic survey for Delhi Australian Petroleum Ltd in 1961-62. The survey covered that part of the Great Artesian Basin in north-eastern South Australia (Delhi Australian Petroleum Ltd, 1962).

The results of the survey indicate a general increase in the depth to basement towards the north-east. The results indicated two large areas of shallow basement (less than 2000 feet below sea level) in the subject survey area - one in the north-west and south-west of ALBERGA extending into north WINTINNA, the other extending eastwards from eastern WARRINA into the south-west of LAKE EYRE and northwards as two lobes into the east and south of OODNADATTA. The results also indicated three large areas of deep basement (more than 12,000 feet below sea level) in the subject survey area - one in the south-west of DALHOUSIE, another in the north-east of DALHOUSIE and the north-west of POOLOWANNA, and the third in the south-west of POOLOWANNA. A further area of moderately deep basement (more than 10,000 feet below sea level) was indicated in the south-west of NOOLYE-ANA.

Seismic Surveys

The South Australian Department of Mines has recently conducted seismic work in the Macumba region of OODNADATTA. The results available to date reveal variations in the thickness of the Mesozoic and Permian sediments, but provide no detailed information on the nature or structure of the pre-Permian rocks.

The Compagnie Generale de Geophysique (C.G.G.) recently completed a reflection and refraction survey for the French Petroleum Company (Australia) Pty Limited in the area east of Pedirka and extending across the Simpson Desert towards Birdsville. Although the final results of the survey are not yet available, the preliminary results indicate that the Mesozoic sediments are faulted or monoclinally folded to form a series of terraces increasing in depth to the east. At each flexure there also appears to be a corresponding thickening of the "P-Z" time interval. This interval is identified as the Permian sequence in the Witcherrie No. 1 Well, and the seismic data indicate that the sequence terminates to the west near Mt Crispe. The Permian sequence at Witcherrie No. 1 is underlain by a refractor with a velocity of 4200 metres/second. This refractor is identified in the well as a marker in the Finke "Series" of probable Middle Palaeozoic age, and the seismic data indicate that the Finke "Series" terminates about 15 miles east of the Witcherrie well.

The Finke "Series" are underlain at Witcherrie No. 1 by a quartzite of Lower Palaeozoic or Proterozoic age. This bed correlates with a refractor of velocity 5350 metres/second. The velocity of this marker is 5800 metres/second across the fault mapped just east of Witcherrie No. 1, and at Purni No. 1 Well the marker correlates with a calcareous shale.

RESULTS OF THE SURVEY

Introduction

The Bouguer anomaly contours of the surveyed and surrounding areas based on a density of 1.9 g/cm and drawn on a scale of 1:2,000,000 are shown on Plate 1.

Plate 2 shows the Bouguer anomaly contours of the surveyed and immediately adjacent areas on a scale of 1:2,000,000 and is primarily included in this report to present the results of two traverses in the southern part of the surveyed area: from south-eastern LAKE EYRE to the Birdsville Track and from western LAKE EYRE to the railway line at William Creek. The individual 1:250,000 gravity plans of the survey area are available for inspection at the Bureau of Mineral Resources, Canberra.

The Bouguer anomaly values throughout the survey area are almost entirely negative ranging from a minimum value of - 64.7 mgals at station 1327 in central DALHOUSIE to a maximum value of +8.6 mgals at station 1993 in south-eastern LAKE EYRE.

Two distinct areas of anomaly form are apparent in the survey area, the line separating the two being aligned in a south-south-easterly direction from southern McDILLS to eastern OODNADATTA, then swinging west-south-west to west-central OODNADATTA after which it appears to resume the south-south-easterly trend. To the west of this line the anomaly pattern shows certain distinct trend directions; a north-easterly trend in the west of the area and a north-north-westerly trend in the east. The anomalies are more negative in this area than to the east of the dividing line and the gravity "lows" are generally bordered by steep gradients. To the east of the dividing line the anomalies, in addition to being more positive, are more irregular, being without obvious trend directions and the anomaly variations are gentle, there being virtually no steep gradients.

The northern extent of this dividing line is not so clear but from southern McDILLS the line appears to swing west into eastern CHARLOTTE WATERS thence north-east into west-central HALE RIVER from whence it swings into a north-north-west direction.

The surveyed and surrounding areas have been divided into several units on the basis of the gravity results to form an extension of the division suggested as a result of previous surveys (Lonsdale and Flavelle, 1963; Barlow, 1964). The names and boundaries of several previously defined units are shown on Plate 1 together with those of new or re-defined units which are described below. The numbers of these new or redefined features are also shown on Plate 1.

Alberga Gravity High (Feature 1)

The gravity high region as originally defined by Lonsdale and Flavelle (1963) was suggested to extend north-east through north-eastern ABMINGA into CHARLOTTE WATERS. However, the results of this survey indicate that the feature does not extend into CHARLOTTE WATERS but terminates in northern ABMINGA.

Abminga Gravity Depression (Feature 2)

This name is suggested for an east to north-east elongated gravity low region lying to the south of the Alberga Gravity High and extending north-east across ABMINGA.

An embayment of this gravity depression (Feature 3) extends eastwards into northern WINTINNA. The southern and western limits of the gravity depression are unknown.

Wintinna Gravity High (Feature 4)

This name is suggested for a gravity "high" developed in central WINTINNA; the southern and western extents are unknown.

Hamilton Gravity High (Feature 6)

This irregularly shaped gravity high region extends from south-eastern ABMINGA into south-western DALHOUSIE and north-western OODNADATTA. The gravity "high" is bounded to the north-west by the Abminga Gravity Depression, whilst to the south-west it is separated from the Wintinna Gravity High by a narrow region of low gravity values (Feature 5) extending south-east from Feature 3.

Oodnadatta Gravity Low (Feature 7)

This is a north to north-west elongated gravity "low" bounded by steep gravity gradients and extending from central to north-western OODNADATTA.

Dalhousie Gravity Depression (Feature 8)

This gravity low region extends from northern OODNADATTA through western DALHOUSIE and lies to the east of the Hamilton Gravity High from which it is separated by a steep gradient. To the south the gravity depression is separated by a low ridge from the Oodnadatta Gravity Low, whilst to the north the major portion of the depression is similarly separated from the Abminga Gravity Depression. However, a shallow extension of the gravity depression (Feature 9) is suggested to continue to the west-north-west towards the Ayers Rock Gravity Depression.

McDills Gravity Platform (Feature 10)

This gravity platform was originally defined by Barlow (1964) as a feature in southern HALE RIVER, eastern CHARLOTTE WATERS, McDILLS, and extending into southern and eastern SIMPSON DESERT SOUTH and western BIRDSVILLE. As a result of this survey the gravity platform has been shown to extend to the south into north-eastern DALHOUSIE, north-eastern OODNADATTA, northern and central POOLOWANNA and western PANDIE PANDIE.

Noolyeana Gravity Swell (Feature 11)

This is the name given to a gravity "high" extending north-north-west from northern LAKE EYRE to north-western NOOLYEANA, thence east through northern NOOLYEANA and southern POOLOWANNA into southern PANDIE PANDIE and northern GASON whence it extends north through central and northern PANDIE PANDIE into southern BIRDSVILLE. A gravity spur (Feature 12) extends from the gravity swell in a north-north-westerly direction from north-western NOOLYEANA across eastern DALHOUSIE into southern McDILLS, whilst another spur (Feature 13) extends west from western NOOLYEANA into eastern OODNADATTA.

Muloorina Gravity Swell (Feature 14)

This is the name proposed for a gravity high region suggested to extend south-east from southern OODNADATTA across eastern WARRINA, southern LAKE EYRE, northern CURDIMURKA, southern and central KOPPERAMANNA, MARREE and CALLABONNA. The gravity information over parts of this feature is sparse and additional data are necessary to confirm its extent. Two culminations are known on the gravity "swell", one in east-central WARRINA, the other in west-central MARREE. The western, southern, and eastern extents of the feature are not known.

Cowarie Gravity Depression (Feature 15)

This is the name proposed for a gravity low region which is suggested to extend in a south-easterly direction from east-central NOOLYEANA across south-western GASON and north-eastern KOPPERAMANNA into western STRZELECKI and thence north-east into south-eastern INNAMINCKA and farther east. Gravity control is sparse over parts of this feature particularly in GASON and KOPPERAMANNA. More data are needed to delineate the feature more accurately.

The feature may extend into south-western INNAMINCKA and eastern GASON (Feature 16) and may also extend south from south-eastern NOOLYEANA into eastern LAKE EYRE (Feature 17) and thence north-west into north-western LAKE EYRE, south-western NOOLYEANA, and south-eastern OODNADATTA (Feature 18).

INTERPRETATION OF RESULTS

In this section the qualitative interpretation of each of the described gravity features will be discussed before regional and quantitative interpretations are attempted.

Alberga Gravity High (Feature 1)

It is considered that the high gravity values associated with this feature are produced by the presence of metamorphic or igneous basement rocks of the Musgrave Block at shallow depth. This concept is supported by the aeromagnetic evidence. It is further considered that these basement rocks are basic or ultrabasic in composition, thus providing a density contrast between these rocks and the acidic igneous rocks farther north which are associated with a gravity low region (Lonsdale and Flavelle, 1963).

Abminga Gravity Depression (Feature 2)

This gravity depression is in an area in which outcrops of acid metamorphic and igneous rocks are known (near Granite Downs Homestead), together with outcrops of Proterozoic sediments. The density contrast between these rock types and the more dense basic igneous rocks of the Musgrave Block is the most likely explanation of this large negative gravity anomaly. Marshall and Narain (1954) note many instances which support the conclusion that gravity observations over acid igneous rocks generally show negative Bouguer anomalies.

The aeromagnetic evidence in this area suggests near surface basement rocks in the west, becoming deeper to the north-east where the gravity becomes more positive.

It is suggested that this gravity depression is produced by a north-east trending geosyncline, possibly forming part of a large sedimentary area extending farther to the west.

This latter area could be linked with the Officer Basin, in which thick sediments have been postulated on the basis of aeromagnetic results (Quilty and Goodeve, 1958). It is further suggested that the major thickness of sediments in this geosyncline was deposited in the Proterozoic period and that these sediments were extensively metamorphosed by granitic or more basic intrusions near and beyond the western margin of the survey area. It is possible, however, that the sediments postulated to give rise to the north-eastern portion of the gravity depression are not extensively metamorphosed, and this is supported by the aeromagnetic evidence. Some outcrops of Lower Palaeozoic sediments are known on what is thought to be the margin of the Officer Basin, and it is possible that unmetamorphosed sediments of this age, deposited during the final stages of sedimentation in the geosyncline, may be present in the area of the gravity depression.

The gravity embayment, Feature 3, may be produced by thick sediments in a small trough related to the postulated geosyncline.

Wintinna Gravity High (Feature 4)

This gravity "high" occurs in an area in which the aeromagnetic evidence suggests a magnetic basement about 6000 feet deep. It is tentatively suggested that this gravity feature may be produced by a basic or ultrabasic igneous body at this depth, or by high density sedimentary rocks, for example limestone or dolomite, at more shallow depth.

Hamilton Gravity High (Feature 6)

This gravity "high" also occurs in an area in which the aeromagnetic evidence suggests a fairly deep magnetic basement, and an explanation is postulated for this feature similar to that postulated for the Wintinna Gravity High.

The Hamilton Gravity High is separated from the Wintinna Gravity High by a narrow region of low gravity values, Feature 5. This gravity "low" could be produced by low density sediments associated with the small trough which may produce Feature 3, if the two gravity "highs" are produced by high density sediments; or it may be produced by acidic igneous or metamorphic rocks, lower in density than the basic igneous bodies which may be present at depth beneath the two gravity "highs".

Oodnadatta Gravity Low (Feature 7)

This gravity "low", bounded by steep gradients, suggests a fault-bounded depressed area, i.e. a "graben-like" structure.

The aeromagnetic evidence indicates that the magnetic basement in the area of this gravity feature is relatively deep and forms a south-south-east trending embayment of a large depressed area farther north. This embayment in the magnetic basement becomes shallower towards the south-south-east and is bounded by steep sides.

The results suggest that this gravity "low" is produced either by a thick accumulation of sediments now possibly metamorphosed in a "graben-like" structure, or by the intrusion of an acid-igneous body of low magnetic susceptibility into an elongate, possibly fault-controlled, zone of structural weakness.

Dalhousie Gravity Depression (Feature 8)

This gravity depression occurs in an area in which the aeromagnetic evidence is indicative of deep magnetic basement (12,000 feet) which suggests that thick sediments are present in this area.

Further evidence is provided by a C.G.G. seismic traverse for the French Petroleum Company (Australia) Pty Limited, which crosses this gravity feature in an east-north-easterly direction. The seismic results in this area indicate that about 2300 feet of sediments of probable Mesozoic and Permian age overlie up to about 3000 feet of Middle Palaeozoic sediments which overlie an unknown thickness of sediments, Lower Palaeozoic or Proterozoic in age.

This sequence of sedimentary rocks was investigated by a stratigraphic well - Witcherrie No. 1 - of the French Petroleum Company (Australia) Pty Limited. The following sequence was observed:

Depth Interval (feet)	Formation	Age
50 - 370	Tambo Formation	Jurassic-Cretaceous
370 - 396	Toolebuc Member	
396 - 910	Roma Formation	
910 - 1037	Transition Beds	
1037 - 1819	Mooga Sandstone	
1819 - 2150	Crown Point "Series"	Permian
2150 - 3838	Finke "Series"	Middle/Upper Palaeozoic (Devonian/Carboniferous?)
3838 - 4803	quartzite	Lower Palaeozoic/Proterozoic

(Depths measured from the kelly bushing, elevation 285 feet)

A qualitative appraisal of the available evidence leads to the conclusion that the Dalhousie Gravity Depression is produced by a thick accumulation of sediments of Palaeozoic and/or Proterozoic age. There appears to be no evidence for any increase in the thickness of the Mesozoic sediments compared with the probable thicknesses of these sediments in the adjacent areas. Furthermore, it would appear that whilst the major sedimentary thickness is confined to the western part of DALHOUSIE, a portion of the sedimentary sequence is more extensive, occurring in northern OODNADATTA and also extending to the north-west towards the Amadeus Basin and forming Feature 9.

McDills Gravity Platform (Feature 10)

The western boundary of this gravity "platform", as outlined in the introduction to the discussion of the gravity results, forms a part of a most important gravity anomaly boundary in this area, separating strongly negative anomalies in the west from gentle,

undulating near-positive anomalies to the east. This gravity feature boundary is considered to represent a most important structural boundary: the eastern boundary of extensive and thick pre-Permian sedimentation in the survey area.

This hypothesis is supported by the seismic and drilling evidence available to date which indicates that the Middle/Upper Palaeozoic sediments terminate eastward of this line and that the underlying Lower Palaeozoic or Proterozoic sediments are thinning rapidly eastwards from the line.

The results suggest that the gravity "platform" represents an area which was fairly stable and high standing during the pre-Permian period, in which time it probably received only a thin cover of sediments. It seems probable that since early Permian times this area has been depressed relative to the area to the west and that several thousand feet of Permian and Mesozoic sediments are present in the area. This thickness of sediments is indicated by the aeromagnetic evidence.

Noolyeana Gravity Swell (Feature 11)

This extensive gravity "high" forms the southern boundary of the McDills Gravity Platform and, in the west, a portion of the structural boundary which has been suggested to represent the eastern limit of thick pre-Permian sedimentation.

A part of the gravity "swell" - the spur extending north-north-west across eastern DALHOUSIE - was investigated by a stratigraphic well, Purni No. 1, drilled by the French Petroleum Company (Australia) Pty Limited. The following sequence was observed:

Depth Interval (feet)	Formation	Age
381 - 1560	Winton Formation	Jurassic-Cretaceous
1560 - 2570	Tambo Formation	
2570 - 3218	Roma Formation	
3218 - 3360	Transition Beds	
3360 - 4220	Mooga Sandstone	
4220 - 4650	Gubberamunda Sandstone	
4650 - 5860	(?) Crown Point "Series"	Permian
5860 - 6168	calcareous shale	Lower Palaeozoic/Proterozoic(?)

(Depths measured from the kelly bushing, elevation 255 feet)

The absence of the Finke "Series" and the Lower Palaeozoic or Proterozoic quartzite penetrated in Witcherrie No. 1 Well strengthens the structural boundary hypothesis put forward above. The age of the calcareous shale is not known.

The part of the gravity "swell" lying in eastern OODNADATTA corresponds with an area in which the magnetic basement is indicated to approach the surface. Farther to the east, however, the aeromagnetic results suggest a depth to the magnetic basement of up to 12,000 feet in the area of the gravity "swell". The gravity feature may represent high density sediments, or, more probably, the intrusion of higher density rocks into the basement.

Muloorina Gravity Swell (Feature 14)

This gravity "swell" is probably produced by the presence of metamorphic basement rocks at shallow depth. Outcrops of these rocks are known in the Peake and Denison Ranges which coincide with a gravity culmination. In addition, over the portion of the gravity "swell" for which aeromagnetic data are available a comparatively shallow magnetic basement is indicated.

Cowarie Gravity Depression (Feature 15)

In the discussion on the Noolyeana Gravity Swell it was considered probable that the gravity feature was produced by density contrasts within the basement rather than by a thinning in the sedimentary section.

In analysing the Cowarie Gravity Depression the possibility of a similar cause must be borne in mind. However, in view of the drilling results of Innamincka No. 1 (5600 feet of probable Devonian red-beds beneath 7000 feet of Mesozoic sediments) and Gidgealpa No. 1 (more than 2000 feet of Cambrian dolomite, limestone, and shale beneath less than 11,000 feet of Permian and Mesozoic sediments), it is considered feasible that the part of the Cowarie Gravity Depression in INNAMINCKA and northern STRZELECKI may be produced, at least partially, by several thousand feet of Middle and Lower Palaeozoic sediments. If this hypothesis is correct then it is further possible that the gravity "lows" in north-eastern and south-western GASON and eastern NOOLYEANA may be produced by local "pockets" of Lower or Middle Palaeozoic sediments. However, it is more probable that the NOOLYEANA gravity "lows" together with Features 17 and 18 are produced by intrabasement density contrasts.

Quantitative Appraisal - Dalhousie Gravity Depression

A quantitative appraisal of the Dalhousie Gravity Depression has been attempted along the line of the C.G.G. seismic traverse, using these results together with the results of the Witcherrie No. 1 and Purni No. 1 wells (Plate 3). The line of the section is shown on Plate 2.

The gravity effects of the Mesozoic and Permian sediments, contrasted with the quartzite encountered in Witcherrie No. 1 Well, were calculated from the seismic data using the densities listed in Appendix 6 and utilizing the two layer formula:

$$g_z = 12.77 \sigma h$$

where g_z = gravity effect of the upper layer,

σ = density contrast between the upper and lower layers, and

h = thickness of the upper layer in kilo feet.

The effect of these sediments was then removed from the observed Bouguer anomaly profile giving Corrected Profile No. 1.

Using the same formula, the gravity effect of the Finke "Series" contrasted with the quartzite was calculated for the thickness of the former beds encountered in Witcherrie No. 1 Well and this effect was removed from Corrected Profile No. 1 at this point. Regional curve No. 1 was then drawn on Corrected Profile No. 1 to pass through this point. The difference between these two curves was taken to represent the gravity effect of the Finke "Series" contrasted with the quartzite and, utilizing the above formula, the thickness of the Finke "Series" along the profile was calculated and was plotted on the geological profile.

It was then assumed that the quartzite is underlain by basement rocks having a density of 2.8 g/cm . Utilizing the above formula and the information on the variation in thickness of the Mesozoic, Permian, and Finke "Series" along the profile, the gravity effects of these sediments contrasted with the basement were calculated and removed from the observed Bouguer anomaly profile to give Corrected Profile No. 2. A straight-line regional curve, No. 2, was then drawn on Corrected Profile No. 2 and the difference between these curves was taken to represent the gravity effect of the quartzite contrasted with the basement. The thickness of the quartzite was then calculated using the above formula and plotted on the geological profile.

The seismic results indicated that the Finke "Series" thinned and disappeared between the sites of Witcherrie No. 1 and Purni No. 1 wells. This observation was confirmed by their absence in Purni No. 1. The seismic results also indicated that the nature of the rocks below the sediments of the Finke "Series" was different to the east and to the west of a fault just east of Witcherrie No. 1. These two formations were investigated by the two wells and it was found that the underlying formation to the west is quartzite whilst to the east it is calcareous shale. No density data are available yet for the calcareous shale. However, it is understood that a value of 2.4 g/cm would be reasonable and hence for that portion of the profile east of the fault the difference between Corrected Profile No. 2 and regional curve No. 2 has been taken to represent the gravity effect of the calcareous shale contrasted with a basement of density 2.8 g/cm .

On the geological profile the quartzite and calcareous shale are each shown directly in contact with the basement on their respective sides of the fault. Whilst it is more likely that one of these formations overlies the other, no attempt has been made to illustrate this in the section because of the lack of information on their relative ages.

Assuming a density of 2.8 g/cm for the basement, then, along the line of the profile, a maximum thickness of 8400 feet of pre-Permian sediments is present approximately 20 miles west of Witcherrie No. 1. Furthermore, along the line of the profile maximum thicknesses of 4200 feet for the Finke "Series", 8200 feet for the quartzite, and 2300 feet for the calcareous shale have been calculated.

A small intrabasement granitic intrusion has been suggested, in association with a known fault just to the west of Purni No. 1 well site, to explain a small gravity low feature associated with the Corrected Profiles.

Regional Appraisal

The two distinct areas of anomaly form noted in the introduction to the results of the survey have led to the postulation of a distinct structural break along their common margin.

It is considered that the area to the west may be grouped with the "Amadeus Province", an extensive area of thick Proterozoic and Palaeozoic sedimentation. In this area a number of dominantly east-west trending geosynclines were active at different times along separate but sub-parallel axes. The western portion of the survey area includes the eastern extremity of a postulated geosyncline which produces the Abminga Gravity Depression, but lies mainly on the south-eastern margin of the "Amadeus Province". As such, this latter area probably was subject to both deposition and erosion during Proterozoic and Palaeozoic times and received a lesser thickness of sediments than in the geosynclinal areas, with both condensation and discontinuity of sequence. The presence of probable Middle Palaeozoic sediments overlying quartzite of (?) Proterozoic age in Witcherrie No. 1 Well suggests that sedimentation in the area of the Dalhousie Gravity Depression occurred during at least two separate periods. Sedimentation in the area of the Oodnadatta Gravity Low may have taken place during one or both of these periods. However, it seems likely that in the Oodnadatta area, the sedimentation may have been considerably influenced and affected by movement between north-west trending faults.

During this period of sedimentation in the "Amadeus Province", the eastern portion of the survey area formed part of a probable high-standing block extending to the south and east of the survey area. However, during part of the pre-Upper Palaeozoic period, thin sediments were deposited in this eastern area, though the sediments may be mainly associated with pre-Upper Palaeozoic sedimentation in areas other than the "Amadeus Province". In Carboniferous or early Permian time this eastern area was depressed relative to the "Amadeus Province", a movement which probably continued throughout the Mesozoic period and led to the deposition of thick Permian to Cretaceous sediments in the area. These sediments overlap onto the margin of the "Amadeus Province".

The potential for hydrocarbon accumulation in the survey area would appear to be largely associated with the extent and structure of Lower and Middle Palaeozoic sediments. Sediments of this age are known in the areas of the Dalhousie Gravity Depression and between the areas of the Oodnadatta Gravity Low and the Abminga Gravity Depression (?Ordovician sediments were encountered at shallow depth in the Santoodna well). Thick sediments of this age may also be present in the area between the Dalhousie Gravity Depression and the Ayers Rock Gravity Depression, and in eastern NOOLYEANA because of the association of the Cowarie Gravity Depression with thick Lower and Middle Palaeozoic sediments in the Innamincka and Gidgealpa areas.

Thick Lower and Middle Palaeozoic sediments are unlikely elsewhere in the survey area, although in the eastern part of the area, the probable association of Bouguer anomalies largely with intrabasement density variations makes an assessment of the lateral or vertical extent of these sediments difficult.

CONCLUSIONS

As a result of this gravity survey the presence of pre-Permian sediments in three different depositional areas has been suggested; the probable eastern limit of thick pre-Permian sedimentation in the survey area has been delineated; and the presence of Permian and Mesozoic sediments on a large platform area indicated.

The Dalhousie Gravity Depression probably represents the principal area of pre-Permian sedimentation in the survey area. Detailed analysis of a gravity profile coincident with the C.G.G. seismic traverse leads to the postulation of up to 8400 feet of pre-Permian

sediments in this area. Whilst the major sedimentary thickness is confined to the western part of DALHOUSIE, a portion of the sedimentary sequence appears to be more extensive, extending into northern OODNADATTA and also extending north-westwards towards the Amadeus Basin.

To the west of the Dalhousie Gravity Depression and separated from it by the Hamilton Gravity High is the Abminga Gravity Depression. It is suggested that this feature is produced by a north-east trending geosyncline, possibly forming part of the nearby Officer Basin. The major thickness of sediments in the geosyncline was probably deposited during the Proterozoic period and has been extensively metamorphosed. Lower Palaeozoic sediments, deposited during the final stage of sedimentation in the geosyncline, may be present in the area of the gravity depression.

The Oodnadatta Gravity Low to the south of the Dalhousie Gravity Depression could be produced either by a thick accumulation of sediments, now possibly metamorphosed, in a "graben-like" structure, or by the intrusion of an acid-igneous body into an elongate, possibly fault-controlled, zone of structural weakness.

A steep gravity gradient aligned in a general north-south direction and forming the eastern boundaries of the Dalhousie Gravity Depression and the Oodnadatta Gravity Low is considered to form the eastern boundary of thick pre-Permian sedimentation in the survey area. This conclusion is based on the differing form of the Bouguer anomalies to the east and west of the gradient together with structural information gained from the C.G.G. seismic traverse.

To the east of this gravity gradient is an area which is considered as having been relatively stable and high standing during the pre-Permian period, when it probably received only a thin cover of sediments. However, it would appear that since early Permian times this area has been depressed relative to the area to the west and that several thousand feet of Permian and Mesozoic sediments have been deposited in the area. Several small sub-circular gravity "lows" in this area may represent "pockets" of thick Permian or, possibly, pre-Permian sediments, or alternatively areas of granitic intrusion into the basement. In the extreme south of this area, in southern Lake Eyre, more positive Bouguer anomalies indicate a thinning sedimentary section.

REFERENCES

BARLOW, B.C.,	1964:	Georgina Basin reconnaissance gravity survey using helicopters, N.T. and Qld, 1960-61. Bur.Min.Resour.Aust.Rec. (in preparation).
BURBURY, J.E.,	1960:	Report on gravity surveys in Oil Permits 34 and 42, N.T. Unpublished report for Flamingo Petroleum Pty Ltd.
BURBURY, J.E.,	1961:	Report on gravity survey in Oil Permit 36, N.T. Unpublished report for Associated Freney Oil Fields N.L.
DELHI AUSTRALIAN PETROLEUM LTD,	1962:	Interpretation of airborne magnetometer survey in South Australia (Unpubl.).

DELHI AUSTRALIAN PETROLEUM LTD,	1963:	Interpretation of reconnaissance gravity survey, Alton Downs area, Qld and S.A. (Unpubl.).
DENTON, E.R., and DENNISON, R.G.,	1962:	Report of a gravity survey in the Andado area, N.T. Unpublished report for Geosurveys of Australia Ltd.
DOOLEY, J.C.,	1962:	Australian gravity network adjustment, 1962. Bur. Min. Resour. Aust. Rec. 1962/141 (Unpubl.).
DOOLEY, J.C., McCARTHY, E., KEATING, W.D., MADDERN, C.A., and WILLIAMS, L.W.,	1961:	Pendulum measurements of gravity in Australia, 1950-51. Bur. Min. Resour. Aust. Bull. 46.
HASTIE, L.M., and WALKER, D.G.,	1962:	Two methods of gravity traversing using helicopters. Bur. Min. Resour. Aust. Rec. 1962/134 (Unpubl.).
KNAPMAN, W.H.,	1953:	Gravity and magnetic traverses in the far north of South Australia. S.A. Dept of Mines Rep. 215/53.
LANGRON, W.J.,	1962:	Amadeus Basin reconnaissance gravity survey using helicopters, N.T., 1961. Bur. Min. Resour. Aust. Rec. 1962/24 (Unpubl.).
LONSDALE, G.F.,	1962:	Great Artesian Basin reconnaissance gravity survey using helicopters, Qld, 1961. Bur. Min. Resour. Aust. Rec. 1962/14 (Unpubl.).
LONSDALE, G.F., and FLAVELLE, A.J.,	1963:	Amadeus Basin and South Canning Basin reconnaissance gravity survey using helicopters, N.T. and W.A., 1962. Bur. Min. Resour. Aust. Rec. 1963/152 (Unpubl.).
MARSHALL, C.E., and NARAIN, H.,	1954:	Regional gravity investigations in the eastern and central Commonwealth. University of Sydney Dept Geology and Geophysics Memoir 1954/2.
PEGUM, D.M.,	1961:	A gravity survey from the Birdsville Track to Oodnadatta. S.A. Dept of Mines Rep. 1202/60.

QUILTY, J.H., and GOODEVE, P.E.,	1958:	Reconnaissance airborne magnetic survey of the Eucla Basin, southern Australia. Bur. Min. Resour. Aust. Rec. 1958/87 (Unpubl.).
SMITH, A.E.,	1951:	Graphical adjustment by least squares. Geophysics, 15, 1951.
SPRIGG, R.C., and STACKLER, W.F.,	1963:	Report on a gravity survey, Simpson Desert-Oil Permit 57, N.T. (Hale River gravity survey). Unpublished report for Beach Petroleum N.L.
VALE, K.R.,	1962:	Reconnaissance gravity surveys using helicopters for oil search in Australia. Bur. Min. Resour. Aust. Rec. 1962/130 (Unpubl.).

APPENDIX 1

SURVEY STATISTICS

DALHOUSIE GRAVITY SURVEY

Period of survey	22nd August - 21st November, 1963
New 4-mile grid stations	2134
New 7-mile grid stations	23
Other new stations	47
Total new stations	2204
Total chargeable readings	2387

Ties to previous gravity survey:

B.M.R.	7
G.S.I.	3
Mines Administration	1
Beach Petroleum N.L.	2
S.A. Dept of Mines	1
University of Sydney	1
Total ties to previous gravity surveys	15

Time spent on survey:

	Days
Helicopter gravity flights	62
Sundays	13
Helicopter unserviceable	13
Moving	3 1/2
Inclement weather	1/2
Total days on survey	92

APPENDIX 2

GRAVITY SURVEY INSTRUMENTS

DALHOUSIE GRAVITY SURVEY

Gravity Meters

Worden No. 581

Sharpe No. 154

Both meters were calibrated prior to use on the BMR Calibration Range in Brisbane. A check calibration run was made during the survey when the accepted scale value of the Worden was used to check the scale value of the Sharpe.

Calibration Results

Instrument	Date	Value (mgal/Div.)
Worden No. 581	12. 8.63	0.09714
Sharpe No. 154	28. 9.63	0.11010
Worden No. 581	15.10.63	0.09714
Sharpe No. 154	15.10.63	0.11010
Worden No. 581	3.12.63	0.09714

Observed gravity values are based on the gravity value of the BMR Pendulum Station at Oodnadatta. This station has an observed gravity value of 979,100.0 milligals.

Elevation Measuring Equipment

Instruments: Mechanisms Ltd Type No. 2016, Serial Nos 506, 507, 508.

Type No. 2016A, Serial No. 306.
(calibrated in millimeters of mercury)

APPENDIX 3

REDUCTION OF RESULTS

DALHOUSIE GRAVITY SURVEY

At the conclusion of a flight the observer in the helicopter has in his possession a pricked photograph, a gravity meter reading and a barometer reading for each station occupied during the flight. In addition, for stations at which readings were taken on more than one occasion on the flight, for example cell centres, he has the appropriate number of gravity meter and barometric readings.

Determination of Observed Gravity Value

A drift curve is drawn from the repeat readings at control stations and the difference in gravity meter reading between any station and the theoretical reading at the control point at that same time is calculated. This difference is converted to milligals using the calibration factor of the gravity meter. The differences in milligals between control stations, for example between cell centres and corner tie stations using the cell method, are plotted on a gravity loop closure diagram. On completion of the survey a graphical method of least squares adjustment (Smith, 1951) is used to resolve any misclosures. Observed gravity values are then calculated for all control stations, and hence all stations, using the observed gravity value of the Bureau of Mineral Resources pendulum station at Oodnadatta, 979,100.0 milligals.

Determination of Elevation Value

During the course of each flight two barometers are read, one on landing at each station, the other at a control station, usually the cell centre of the flight, at ten-minute intervals. Both barometers are calibrated in millimeters of mercury. The difference in barometric reading at each station is calculated with respect to the reading at the previous station. Likewise the change in barometric reading of the base instrument for the same time interval is calculated, and by subtraction, the change in barometric field reading found with respect to the change in the diurnal over the same period. This figure is related to the elevation difference between the two stations.

One conversion formula is that of Babinet which is :

$$Z = K \frac{B_o - B}{B_o + B}$$

where Z = difference in height between the two stations,

B_o, B = Barometric readings at the lower and upper stations respectively,

t_o, t = Air temperature at the lower and upper stations respectively,

$$K \text{ (in meters)} = 16000 \left(1 + 2 \left(\frac{t_o\,^{\circ}C + t\,^{\circ}C}{1000}\right)\right)$$

On this survey the difference in millimeters of mercury is converted to a difference in feet using the conversion factor one millimeter of mercury = 36.7 feet. This figure is applicable to the barometric conditions encountered in the subject survey area. The elevation difference is finally corrected for temperature and humidity.

The difference in elevation between control stations is plotted on an elevation loop closure diagram. A graphical method of least squares adjustment (Smith, 1951) is used to resolve any misclosures in the loops and to adjust the values to the known elevations of tie points.

Elevation data in the surveyed and adjoining areas are based on two systems: Mean Sea Level, Brisbane; and the Commonwealth Railways datum. The former is used locally by the Bureau of Mineral Resources, Mines Administration Pty Ltd, and Geophysical Service International, and the latter by the Compagnie Generale de Geophysique, the French Petroleum Company (Australia) Pty Limited, the South Australian Department of Mines, and the Railways Department.

For the subject survey it was decided to refer all elevations to Mean Sea Level, Brisbane.

The Chief Surveyor, Department of the Interior, has advised that the Alice Springs town datum is within one-half foot of Mean Sea Level, Brisbane. The town datum is derived from the Commonwealth Railway datum, and is Commonwealth Railways datum plus 100 feet. The local Railway datum, operative between Ooraminna and Alice Springs is 101 feet below Mean Sea Level Port Augusta, indicating that Mean Sea Level Brisbane is one foot below Mean Sea Level Port Augusta. The correction factors to be applied to railway elevations for the interval Marree - Alice Springs are tabulated below.

Section	To bring to M.S.L. Port Augusta subtract	To bring to M.S.L. Brisbane subtract
Marree - Mile Post 785	104.3 feet	103 feet
M.P. 785 - Ooraminna	102.8 feet	102 feet
Ooraminna - Alice Springs	101.1 feet	100 feet

Latitude and Longitude Determination

The position of each gravity station is transferred on to 1:250,000 photocentre compilation base maps by the use of proportional dividers. For two map areas - ABMINGA and WINTINNA - photocentre compilations are not available, and in these areas the gravity stations are plotted onto the mosaics and then transferred onto 1:250,000 photogeological base maps by feature identification using proportional dividers. Scaling graticules are then used to determine the latitude and longitude of each station.

Accuracy

Observed Gravity : Maximum loop misclosure 0.3 mgal

Average loop misclosure 0.05 mgal

However, all observed gravity values are considered accurate to within 0.1 mgal.

Elevation	: Maximum loop misclosure 36 feet Average loop misclosure 8 feet Station elevations considered accurate to within 10 feet, equivalent to 0.7 mgal.
Latitude	: Pin pricks accurate: Latitude within 0.1 minute of arc = 0.1 mgal. On Lake Eyre points were positioned by 'dead reckoning'. (See Appendix 4). Latitudes within 1/2 mile = 0.5 minute of arc = 0.5 mgal.
Standard Deviation all stations except Lake Eyre	: $= \sqrt{0.01 + 0.49 + 0.01} = \sqrt{0.51} = 0.7$ mgal.
Standard Deviation Lake Eyre Stations	: $= \sqrt{0.01 + 0.49 + 0.25} = \sqrt{0.75} = 0.9$ mgal.

APPENDIX 4

OPERATIONAL PROCEDURE

DALHOUSIE GRAVITY SURVEY

The survey was patterned after the type of survey conducted for some years by the Bureau of Mineral Resources. This is the "cell" method of surveying. (Hastie and Walker, 1962). Gravity stations are observed on a grid of a size designed for best and most economic resolution of the geological units in the area. A helicopter is used for transportation of the gravity meter and microbarometer, and ground support is provided by mobile camps and wheeled equipment.

The observations are carried out in blocks or "cells". Each "cell" is an area normally covered by one helicopter in one day. The helicopter flies loops of stations beginning and ending at the centre of the "cell".

On the Dalhousie Survey a four-mile by four-mile grid was laid out (one station per sixteen square miles) and the "cell" size adopted was six hundred and fifty square miles. This area enclosed forty-four gravity stations and on a normal day the crew observed one cell area in four loops of eleven stations each. The cell centre is used as the control point for the gravity meter and microbarometer drift control, as well as a refuelling point for the helicopter. Each of the four loops was flown in an elapsed time of one and one-half to two hours. Adjacent cell areas were tied at two common points and then the points and the cell centres were marked with a steel stake. A numbered aluminium tag was attached to each marked stake.

The gravity meter observations were controlled by repeat readings at cell centres at intervals of less than two hours. The gravity values were carried from cell area to cell area by means of the two common tie points for adjacent cells. Ties were made for gravity comparison purposes to previous gravity surveys both in the surveyed and in the surrounding areas.

The microbarometer observations were controlled by using a base barometer to read diurnal fluctuations. In addition, numerous ties were made to spirit-levelled bench marks. These are along the Commonwealth Railway Line from Marree to Alice Springs; the Birdsville Track from Marree to Birdsville; a traverse from Mirra Mitta Bore on the Birdsville Track to Mt Dutton Station on the Commonwealth Railway Line; the C.G.G. seismic traverse from Pedirka to Birdsville; South Australian Department of Mines seismic traverses in the Macumba region; Commonwealth Department of Interior traverses in the Kulgera-Andado area; and G.S.I. traverses in the Alton Downs area.

The special problems associated with Lake Eyre North necessitated different operational techniques. Recent flooding in the Lake Eyre area made the aerial photographs taken over the lake in 1948 unusable. As it was impracticable to re-photograph the Lake prior to the survey, the crew devised an alternative method of navigation over the Lake, using a modified form of "line" flying (Hastie and Walker, 1962).

A Cessna aircraft dropped markers at one-mile intervals across the lake while maintaining a fixed heading and speed. The average width of the lake is forty miles and flight path recovery was achieved by identifying the landfall and departure points on aerial photographs.

The helicopter followed the marker "runs" and gravity stations were established at every fourth marker.

The survey was hampered by the softness of the lake surface in its northern and eastern parts and by the frequent dust storms which blew up with little warning.

It is interesting to note that thick dust deposits are present in the central part of the lake.

APPENDIX 5

WONGELA PERSONNEL

DALHOUSIE GRAVITY SURVEY

Party Supervisor	-	L.N. Ingall
Party Chief	-	L.N. Ingall (to 2nd September) G.F. Lonsdale (from 2nd September)
Party Manager	-	M. Brulhart
Meter Operators	-	F.S. Clements G.L. Devlin (from 2nd September) G.C. Phipps (29th September to 12th October)
Computer	-	A. Molloy
Cook	-	T. Taylor and five field staff - mechanics, assistant cook, etc.

AUSTRALIAN HELICOPTER PERSONNEL

Pilot	-	J.T. Ferguson
Engineer	-	J.P. Hilferty

PARTY VEHICLES

4-wheel drive Land Rover L.W.B.	(1)
4-wheel drive Toyota Land Cruiser	(1)
4-wheel drive Toyota	(1)
4-wheel drive Ford F-750	(2)

PARTY AIRCRAFT

Australian Helicopters Pty Ltd Hughes 269A VH-IHB used almost exclusively throughout survey.

Additional helicopters were hired from:

Helicopter Utilities Pty Ltd - Bell 47G - VH-UTB one day only (4th October).

Helicop-Air Pty Ltd - Hughes 269A - VH-IHA for last week of survey in Lake Eyre area.

Cessnas were chartered as required from:

Barrier Air Taxis Pty Ltd, Broken Hill, N.S.W. - Cessna 205.

South Australian Air Taxis Pty Ltd, Adelaide, S.A. - Cessna 180,185.

APPENDIX 6

DENSITY DATA

DALHOUSIE GRAVITY SURVEY

Locality	Depth Below Surface (feet)	Age	Formation	No. of Samples	Average Density (g/cm^3)
Mt Heard and Mt Crispe	0- 330	Recent-Tertiary		31	2.12
Witcherrie No. 1	1820-1900	Permian	Crown Point "Series"	10	2.30
Witcherrie No. 1	2300-3600	M. Palaeozoic	Finke "Series"	31	2.03
Witcherrie No. 1	3800-4500	L. Palaeozoic or Proterozoic	quartzite	16	2.52

(Note: Density values of cores from Purni No. 1 Well were not available in time for this report).

APPENDIX 7

ADDITIONAL DATA FILED IN THE

BUREAU OF MINERAL RESOURCES

The following additional data relating to the Dalhousie Gravity Survey have been filed in the Bureau of Mineral Resources, Canberra, and are available for reference:

(i) Table of Principal Facts — 54 pp.

(ii) Maps

(a) Geological Map, — Scale 1" = 40 miles

(b) Aeromagnetic Map, — Scale 1:1,000,000

(c) Bouguer Anomaly Maps, — Scale 1:250,000

Oodnadatta

Lake Eyre

Wintinna

Abminga

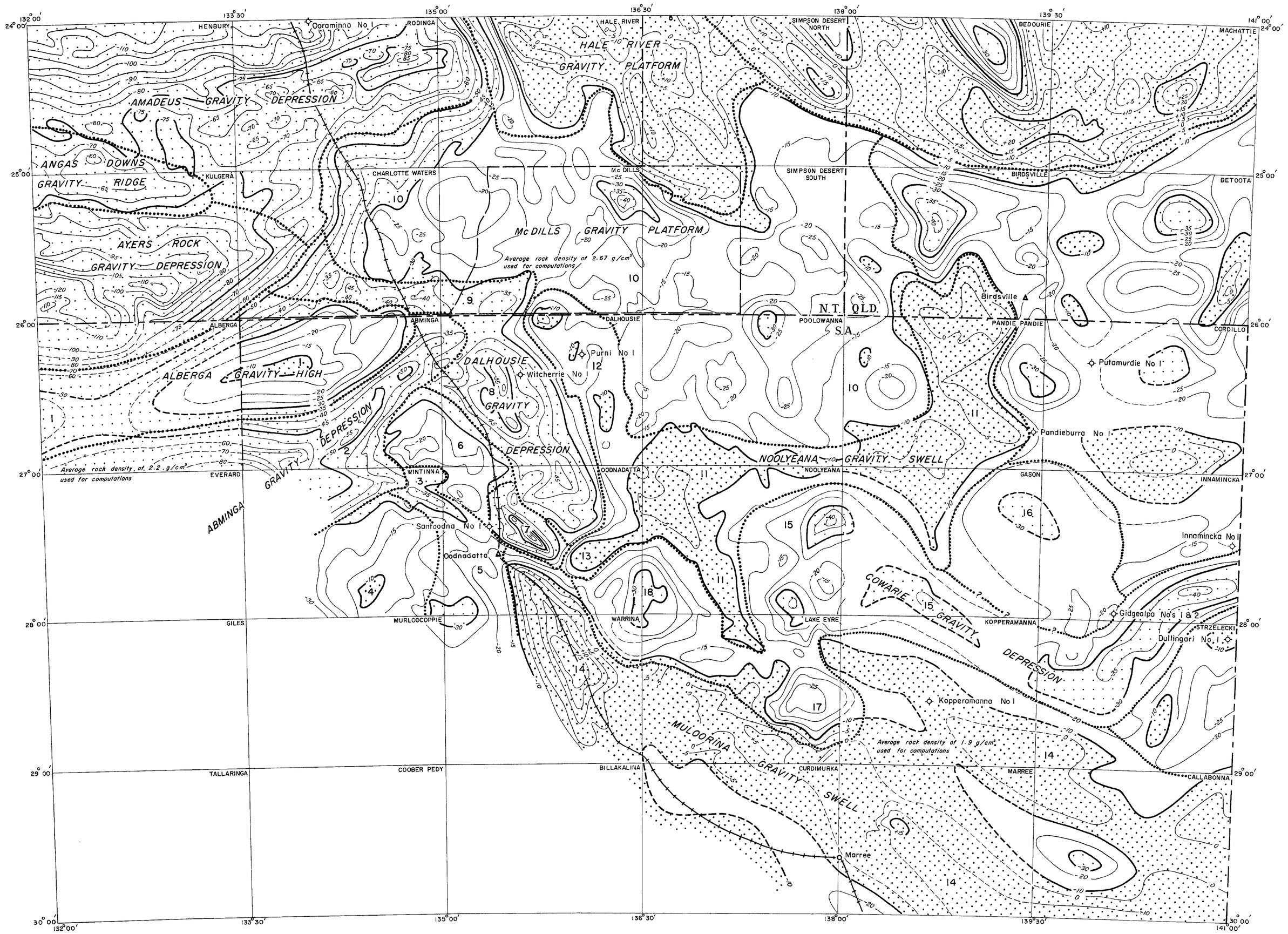
Poolowanna

Dalhousie

Pandie Pandie

Noolyeana

Plate 1



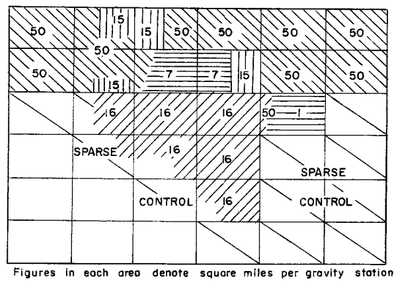
REFERENCE

+5	Isogals, values in milligals	4	Anomaly number
	Gravity high anomaly		Feature boundary
	Gravity low anomaly		Abandoned well
△	B.M.R. pendulum station		Railway
ABMINGA	1:250,000 map area		State boundary

GRAVITY

SURVEY	METHOD
Helicopter by Wongela.	Regular grid coverage, air photography, barometric levelling.
Helicopter by B.M.R.	" " "
Helicopter by Flamingo, Papuan Apinaipi.	" " "
Semi detailed ground trav. by Geosurveys, Beach, and Delhi.	Conventional & barometric levelling, Some helicopter traverses.
Ground traverses by Geosurveys, S A Mines Dept. and University of Sydney.	Widely dispersed traverses, conv. and barometric levelling, astrofixes.

RELIABILITY DIAGRAM



Figures in each area denote square miles per gravity station

DALHOUSIE HELICOPTER GRAVITY SURVEY

SOUTH AUSTRALIA

BOUGUER ANOMALIES

Scale 1: 2,000,000

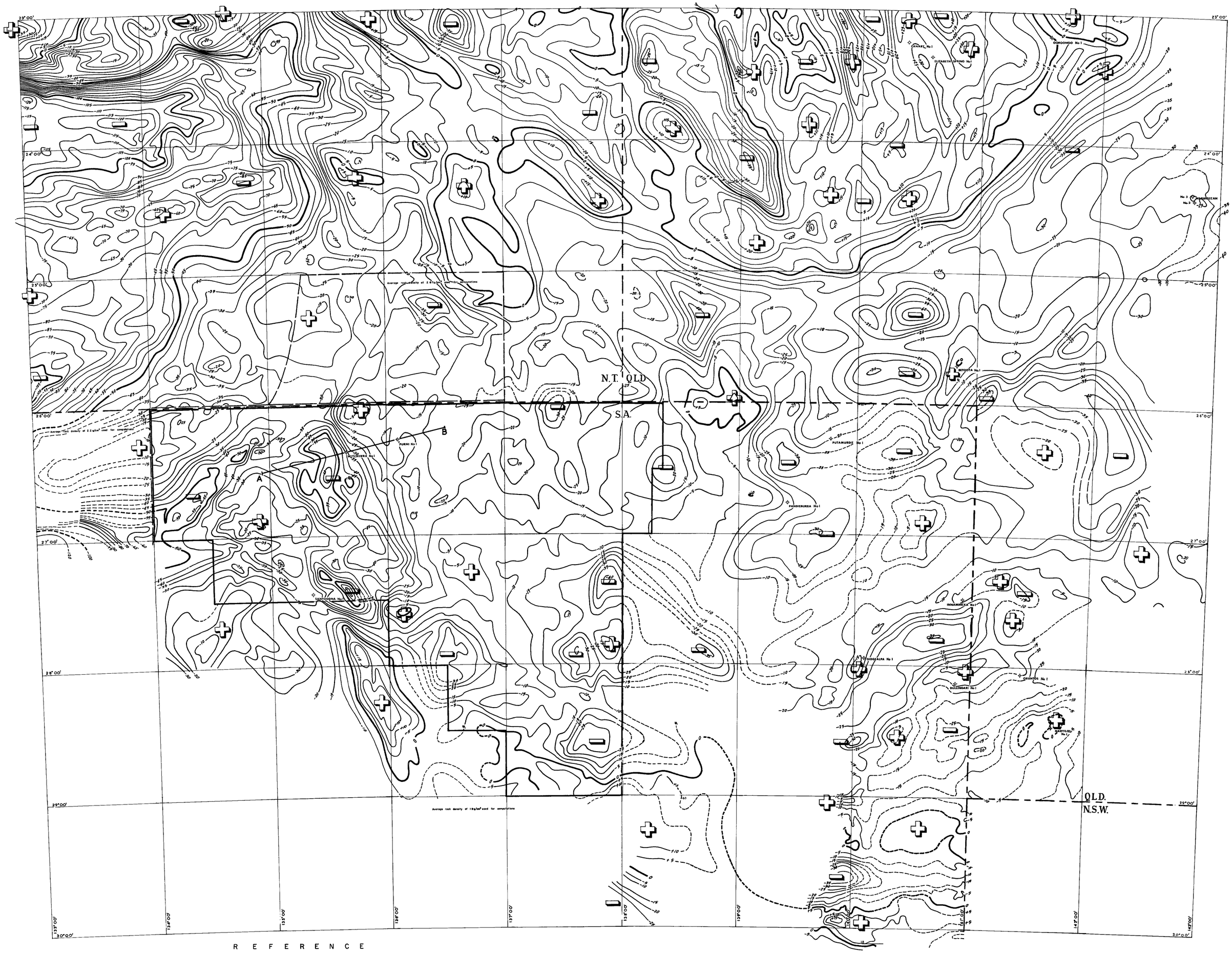
25 0 25 50 75

MILES

1963

KC

Plate 2



REFERENCE

- Isogals, values in milligals
- Gravity high anomaly
- Gravity low anomaly
- Line of profile
- Abandoned well
- Boundary of Dalhousie gravity survey
- State boundary

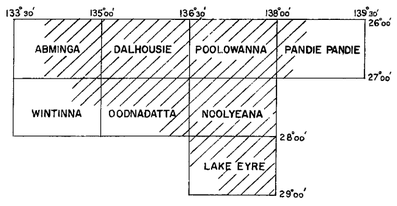
EXPLANATION

Relative Bouguer anomalies are based on the observed gravity value of the following BMR pendulum stations:

No 36 Oodnadatta 979,100·0 milligals
No 35 Alice Springs 978,653·7 milligals
No 57 Birdsville 979,003·7 milligals

Elevation correction factor 0·06982 mgal/ft.
Elevation datum M.S.L. Brisbane

GRAVITY SURVEY AREA



DALHOUSIE HELICOPTER GRAVITY SURVEY

SOUTH AUSTRALIA

BOUGUER ANOMALIES

(INCLUDING DATA FROM ADJACENT SURVEYS, AS COMPILED AND CONTOURED BY FRENCH PETROLEUM COMPANY (AUST.) PTY. LTD.)

Scale 1: 2,000,000

25 0 25 50 75

MILES

1963

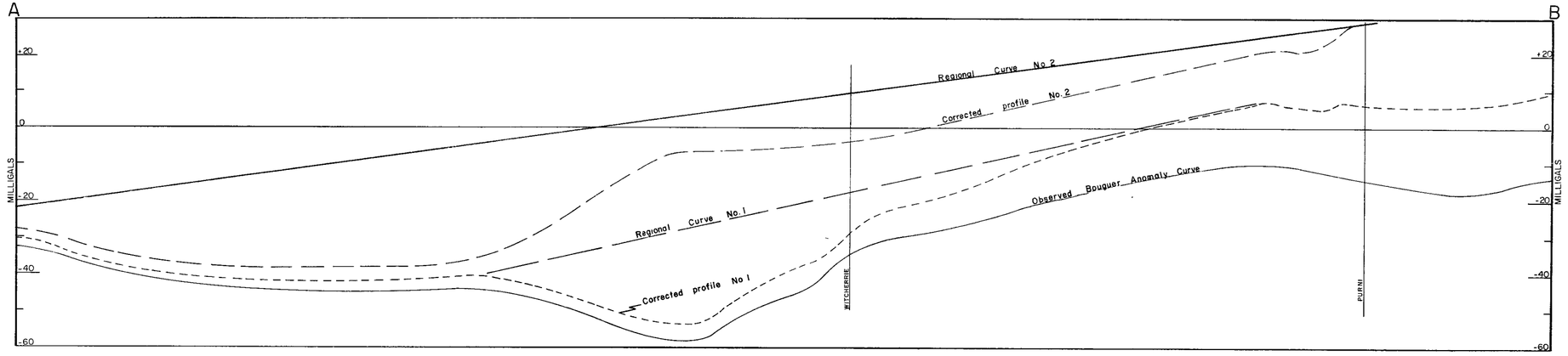


Plate 3

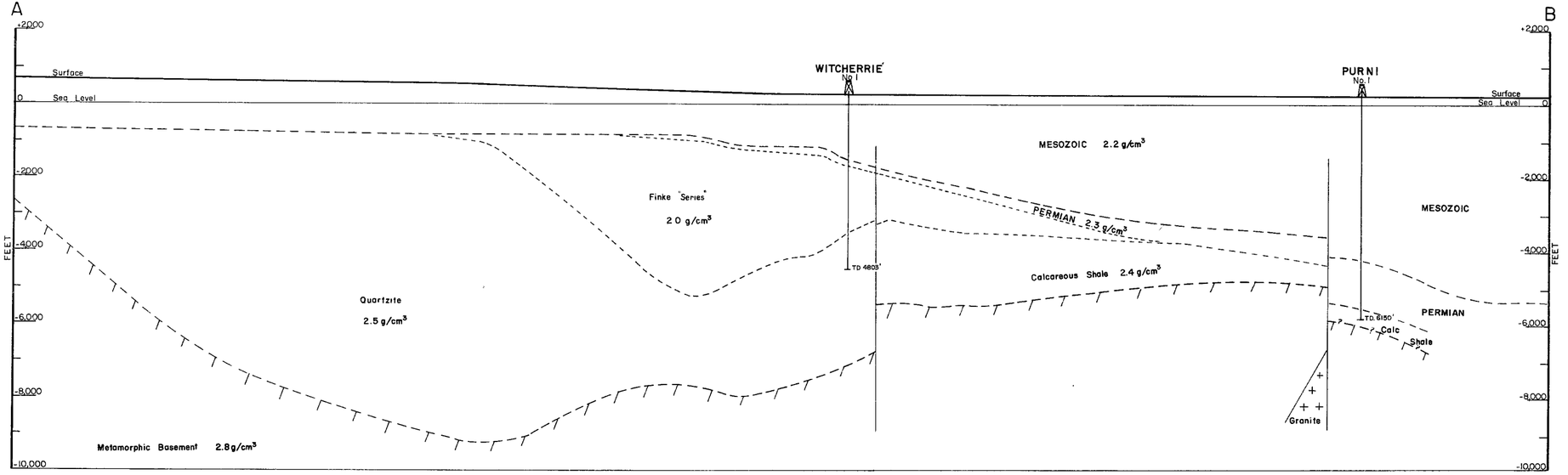
DALHOUSIE HELICOPTER GRAVITY SURVEY

PROFILE A-B

WONGELA GEOPHYSICAL PTY LTD

Date. 1963

Horizontal · 1/250,000
Vertical 1/24,000



Sedimentary thickness calculated by means of the 2 layer formula

$\Delta g = 12.77 \sigma h$

Where Δg = Gravity effect due to the upper layer

σ = Density contrast between the upper and lower layers.

h = Thickness of the upper layer in kilo feet