COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Petroleum Search Subsidy Acts

PUBLICATION No. 67

SUMMARY OF DATA AND RESULTS

GREAT ARTESIAN BASIN, QUEENSLAND AND SOUTH AUSTRALIA

Alton Downs Gravity Survey

Birdsville—Lake Frome Gravity Survey

OF

DELHI AUSTRALIAN PETROLEUM LTD

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: R. W. BOSWELL

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

DIRECTOR: J. M. RAYNER

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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 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 office of the Bureau of Mineral Resources in Canberra (after the agreed period) and copies of the reports may be purchased.

In order to make the main results of operations available early, short summaries are being prepared for publication. These will be grouped by area and date of completion as far as practicable. Drilling projects and geophysical projects will be grouped separately. In due course, full reports will be published concerning those operations which have produced the more important new data.

This Publication contains summaries of data and results of two geophysical operations undertaken in the Great Artesian Basin, Queensland and South Australia: Alton Downs Gravity Survey, and Birdsville - Lake Frome Gravity Survey. The information has been abstracted by the Petroleum Exploration Branch of the Bureau of Mineral Resources from final reports furnished by Delhi Australian Petroleum Ltd.

J.M. RAYNER
DIRECTOR

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ALTON DOWNS GRAVITY SURVEY

by

DELHI AUSTRALIAN PETROLEUM LTD

SUMMARY OF DATA AND RESULTS

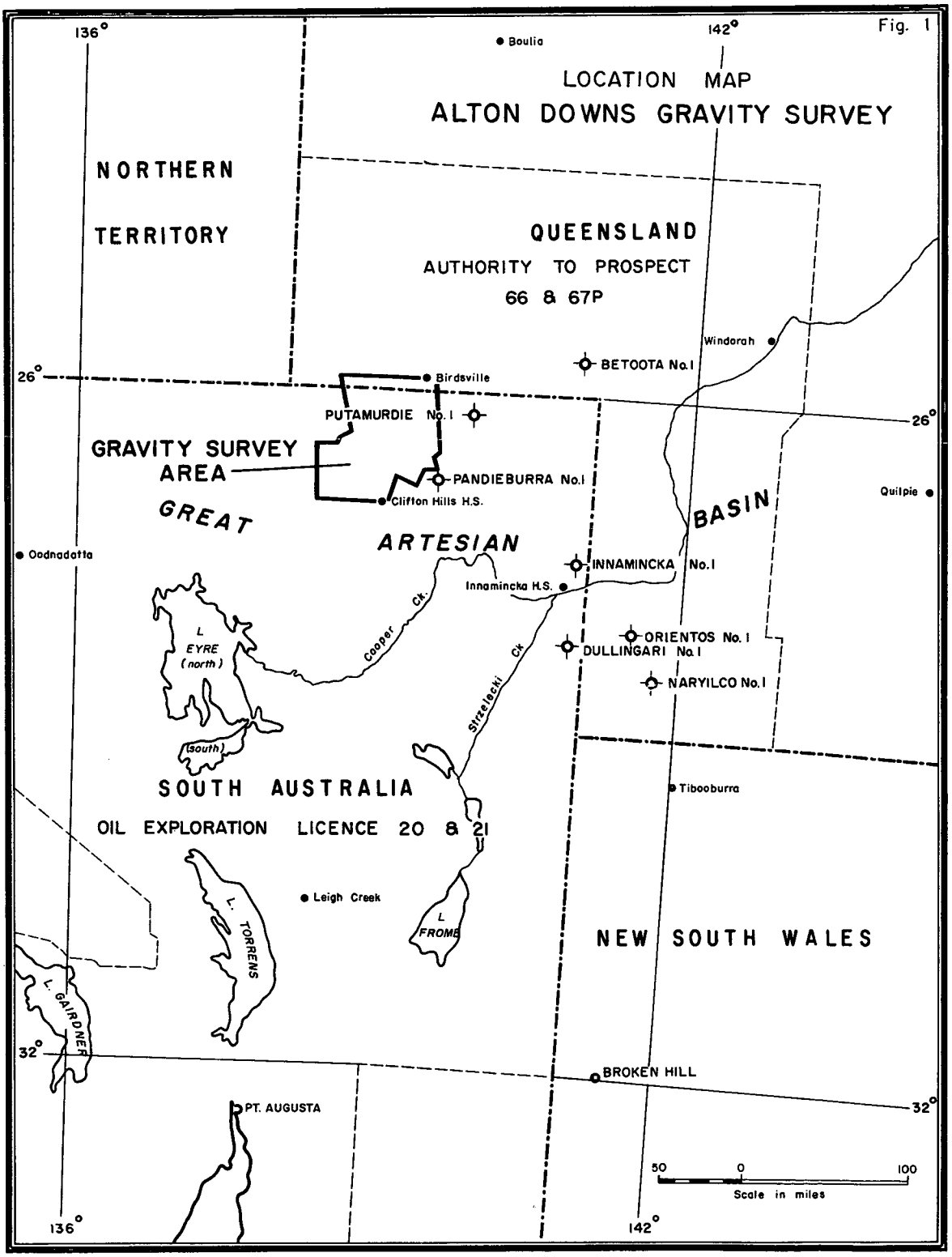
Fig. 1
LOCATION MAP
ALTON DOWNS GRAVITY SURVEY
136°
142°
Boulia
NORTHERN
TERRITORY
QUEENSLAND
AUTHORITY TO PROSPECT
66 & 67P
Windorah
BETOOTA No.1
26°
Birdsville
PUTAMURDIE No. 1
GRAVITY SURVEY
AREA
PANDIEBURRA No.1
Clifton Hills H.S.
GREAT
ARTESIAN
BASIN
Quilpie
Oodnadatta
INNAMINCKA No.1
Innamincka H.S.
Cooper Ck.
L
EYRE
(north)
(south)
Strzelecki Ck.
ORIENTOS No. 1
DULLINGARI No.1
NARYILCO No.1
SOUTH AUSTRALIA
OIL EXPLORATION LICENCE 20 & 21
Tibooburra
Leigh Creek
L. TORRENS
L
FROME
NEW SOUTH WALES
L. GAIRDNER
32°
BROKEN HILL
PT. AUGUSTA
50
0
100
Scale in miles

ALTON DOWNS GRAVITY SURVEY

SUMMARY OF DATA AND RESULTS*

SUMMARY

A gravity survey of 3883 stations covering an area of 4000 square miles was conducted in southern Queensland and northern South Australia by Geophysical Service International's Party 662 for Delhi Australian Petroleum Ltd, from July to December, 1962. Most of the gravity stations were approximately one-half mile apart, but 824 were one-quarter mile stations. In general, stations were set in a four by fifteen-mile grid, although in some areas, particularly in the south-eastern portion of the survey, closer control was established.

The survey was designed to determine the major gravity anomalies in the prospect area, and to seek structural leads in an area almost devoid of outcrop.

Fifteen gravity anomalies of significance were discovered, eight of which are related to basement topography while the remainder indicate features within the sedimentary section. Computed sedimentary thicknesses ranging from 3500 feet to 21,500 feet were obtained. Seven major anomalies related to basement features are recommended for further detailed geophysical investigation.

In this summary, the results of the survey are presented on the Bouguer gravity map at a scale of 1:250,000.

The geophysical operation undertaken in the Alton Downs area of the Great Artesian Basin, Queensland and South Australia, was subsidized under the Petroleum Search Subsidy Act 1959-1961.

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* Abstracted from: Final Report "Interpretation of Reconnaissance Gravity Survey, Alton Downs Area, Queensland and South Australia," by R.A. Geyer, Geophysical Service International, March, 1963.

METHODS OF OPERATION

General Data

Operator:	Delhi Australian Petroleum Ltd, 32 Grenfell Street, Adelaide, S.A.
Contractor:	Geophysical Service International
Location:	Oil Exploration Licences Nos 20 and 21, issued by the State of South Australia; Authorities to Prospect Nos 66P and 67P, issued by the State of Queensland. Survey area south-west of Birdsville, Queensland, and bounded by latitudes 25° 55' and 27° 00' South, longitudes 138° 15' and 139° 30' East.
Basin:	Great Artesian
Tenement Holder:	Delhi Australian Petroleum Ltd and Santos Limited

Field Operations

Date survey commenced:	7th July, 1962
Date survey completed:	19th December, 1962
Total field party work time:	1369.75 hours
Coverage:	3883 gravity stations over an area of 4000 square miles
Average density of gravity stations:	0.97 station per square mile

Equipment

Gravity Meters:	Worden No. 317 Worden No. 342
Surveying instruments:	Keuffel and Esser transits
Vehicles:	Five Landrovers; One 7-ton Bedford supply truck
Camp:	One air-conditioned office caravan; Tented camp for 13 men.

GEOLOGY

by

Delhi Australian Petroleum Ltd

General

With the exception of some small areas of "gibbers" representing weathered duricrust, the Alton Downs area is blanketed by sand and soil and, as a consequence, any surface expression of geological structure is confined to drainage anomalies. The meagre

knowledge of the stratigraphy of the area is inferred from water bores along the Marree-Birdsville Track, and other widely scattered water bores and test wells, from outcrops in the Amadeus Basin region, and from data compiled into regional subsurface geological maps. From these sources of information a general stratigraphic column for the Alton Downs area has been derived.

Stratigraphy

Rocks of the Lower Cretaceous Winton, Tambo, and Roma Formations and the Transition Zone are likely to attain an aggregate thickness of 4800 feet, and to be underlain by 700 feet of Upper Jurassic Blythesdale Group sediments. Below the Blythesdale, the Walloon Formation of Middle Jurassic age is expected to be of the order of 500 feet thick. Below the Jurassic there may be some 500 feet of Triassic sediments resting on a thick sequence of Permian and older Palaeozoic rocks. From aeromagnetic data the "true" (magnetic) basement, very generally, occurs at depths of 12,000 feet and more in this area. A thickness for the Palaeozoic strata of 5500 feet can thus be postulated, subtracting the 6500 feet of Mesozoic sediments, and assuming Palaeozoic sediments of essentially no magnetic susceptibility. It is quite likely that in addition to Permian, the Palaeozoic sequence may include rocks of Devonian, Ordovician, and Cambrian ages, as suggested by studies of the many thousands of feet of beds of these ages present in the Amadeus Basin to the north-west.

GEOPHYSICS

by

Delhi Australian Petroleum Ltd

General

Both aeromagnetic and seismic surveys covered all parts of the Alton Downs area prior to the 1962 gravity survey. The Innamincka-Betoota reconnaissance airborne magnetometer survey flown in 1961 included this area in a regional mapping programme. The Clifton Hills seismic survey, conducted in part concurrently with the gravity survey, overlapped the eastern half of the gravity survey area.

A comparison of the Bouguer anomaly map and the total magnetic intensity map shows a fairly good correlation in as much as the areas of greater depth to basement on the latter map agree well with the location of the strongest negative Bouguer anomalies, and indicated structural anomalies often coincide. Computations of depth to basement made on these negative anomalies give figures which are in agreement with those on the total magnetic intensity map. The Bouguer anomaly map shows a close correlation also with the seismic contour maps on the 'C' and 'Z' horizons. On the seismic maps the location and strike of the axes of the major folds agree remarkably well with the main positive and negative Bouguer anomalies in the overlap area. In this regard, particularly, the gravity method is shown to be a reliable tool in this area for the detection of structural leads prior to the more costly mapping in detail by the seismic method.

FIELD PROCEDURES

General

Surveying was begun at horizontal and vertical control points in Birdsville. These were National Mapping Astrofix NMA 41 and bench mark 50/57 (elevation 161.00 feet,

Queensland Level Datum). A control line of one-quarter mile stations was double-surveyed south along the Birdsville Track to station 333. All other stations were surveyed in a series of closed loops extending away from the control line, tied and adjusted to South Australian Department of Lands tellurometer stations where possible.

The observed gravity datum is based on an adopted value of 979,103.59 milligals for the BMR pendulum station at Birdsville (this value, 100 milligals greater than the BMR value, was assigned so that all Bouguer values of this survey would be positive). Observed values for 120 other gravity base stations were determined from two or more measurements of the difference between adjacent bases in overlapping "drifts" (i.e., for bases A, B, C, ... gravity meter readings in the sequence ABABCBC.....). These base stations were set in closed loops with the closure error prorated. The average closure error of the 29 loops involved was 0.026 milligal, without regard to sign.

Sand dunes afford the only significant topographic relief in the survey area. A density profile over one dune indicated an average density of 1.8 gm/cm^3. However, in keeping with prior BMR experience in the Great Artesian Basin, an average surface-material density of 1.9 gm/cm^3 was adopted. The Bouguer gravity values were calculated with the corresponding elevation correction factor, 0.06982 milligal per foot.

INTERPRETATION METHODS

General

Both profile analysis and contour migration* methods were used to interpret the Bouguer gravity map in terms of its geological significance. Profiles were drawn approximately normal to the prevailing strike of the gravity anomalies to facilitate both their qualitative and quantitative study. Anomalies found on the profiles were corroborated by contour migration before they were accepted as being real, geologically. Their axes were then plotted on the geologic summary map.

The major emphasis in interpreting the geological significance of the anomalies on the Bouguer gravity map was to classify them in terms of their origin - such as intra-basement features, basement topography, and structure or igneous intrusions in the sedimentary section. Pertinent information from the aeromagnetic map was also used as corroborative evidence in this phase of the interpretation.

Bouguer Gravity Map

A half-milligal contour interval was used except where the gradient was so steep as to necessitate a 1-milligal interval. There is evidence in the configuration of the gravity contours for a number of major structures that are confined to the sedimentary section. These include large anticlines, structural noses, and individual faults, as well as horst and graben systems. In addition, by a comparative study of the aeromagnetic map, several gravity anomalies indicative of structure in the section that could also be controlled to a major extent by basement topography were defined.

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* Contour migration is essentially the same as the fictitious contour method described in "Introduction to Geophysical Prospecting", by M.B. Dobrin, p. 244, McGraw-Hill Book Company, Inc., New York, 1960 (second edition).

There is also corroborative evidence in the gravity data for areas where the aeromagnetic data indicate the basement is deep, particularly near the eastern boundary of the survey. The deeper portions of the basement appear to be interrupted at a number of places by local basement uplifts. Some of these appear to control major structural features in the overlying sedimentary section.

Aeromagnetic Map

Several magnetic anomalies of intrabasement origin dominate this map. One occurs along the eastern boundary of the survey and was used for a depth-to-basement determination in this area. It centres near the axis of a major negative gravity anomaly.

A depth-to-basement computation on this negative gravity anomaly, assuming an average difference in density between the basement rocks and the sedimentary section of 0.1 gm/cm^3, yields a value of approximately three miles. This figure is in reasonable agreement with that obtained by computing the depth-to-basement on the aeromagnetic anomaly.

RESULTS

General

The purpose of the report was to interpret the geological significance of the various types of gravity anomalies mapped by the survey. Evidence available from the aeromagnetic survey and density data of key geological formations was also considered in preparing this interpretation.

The significant geological features of the area and their relationships as interpreted from the gravity survey and additional aeromagnetic and density data are shown on the geologic summary map. These include major positive and negative structural axes, faults and fault-systems.

The Bouguer gravity map of the survey area shows at least two large positive gravity anomalies believed to be caused primarily by density contrasts within the basement. Each of these anomalies is associated with a well-defined positive magnetic anomaly which is also of intrabasement origin. The first is a regional anomaly situated in the centre of the survey area; the second occurs near the southern central part of the area. In addition, there is a positive, intrabasement, magnetic anomaly with no associated positive gravity anomaly. It is near the central part of the eastern boundary.

There is evidence in the configuration of the Bouguer gravity contours along the eastern and western boundaries for two major synclines. However, profile analysis indicates the western one may in part be a pseudo-negative effect caused by the adjoining positive, intrabasement, gravity anomaly.

A number of positive structural axes are shown on the geologic summary map. These were interpreted from those positive gravity anomalies believed to be caused by either structure in the section or basement uplift, considering also the magnetic information.

A series of fault type anomalies including horst and graben systems also appear on the summary map. Additional gravity information would be required over these anomalies before a more definitive quantitative interpretation as to depth and displacement could be made.

It is evident from the interpretation that additional information regarding the density of key formations in the survey area is necessary before a more quantitative interpretation can be made of the geological significance of the gravity anomalies. It would then be possible to give a more direct answer as to the depth to basement, the thickness of the sedimentary section in various parts of the survey area, and the displacement of the faults.

ADDITIONAL DATA FILED IN THE BUREAU OF MINERAL RESOURCES

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

(i)	Final Report, by R.A. Geyer	14 pp.
	Appendix A: Field operations	6 pp.
	Appendix B: Geology and geophysics, by Delhi Australian Petroleum Ltd	2 pp.
(ii)	Geologic summary map (1" = 10,000 ft)	2 sheets
(iii)	Representative Bouguer profiles	1 sheet
(iv)	Station location map, showing station numbers, elevations, and station locations	9 sheets
(v)	Computation sheets, showing station numbers, elevations, observed gravity values, latitude corrections, elevation corrections, and Bouguer values	
(vi)	Topographic survey field sheets	
(vii)	Gravity meter field notes	

BIRDSVILLE - LAKE FROME GRAVITY SURVEY

by

DELHI AUSTRALIAN PETROLEUM LTD

SUMMARY OF DATA AND RESULTS

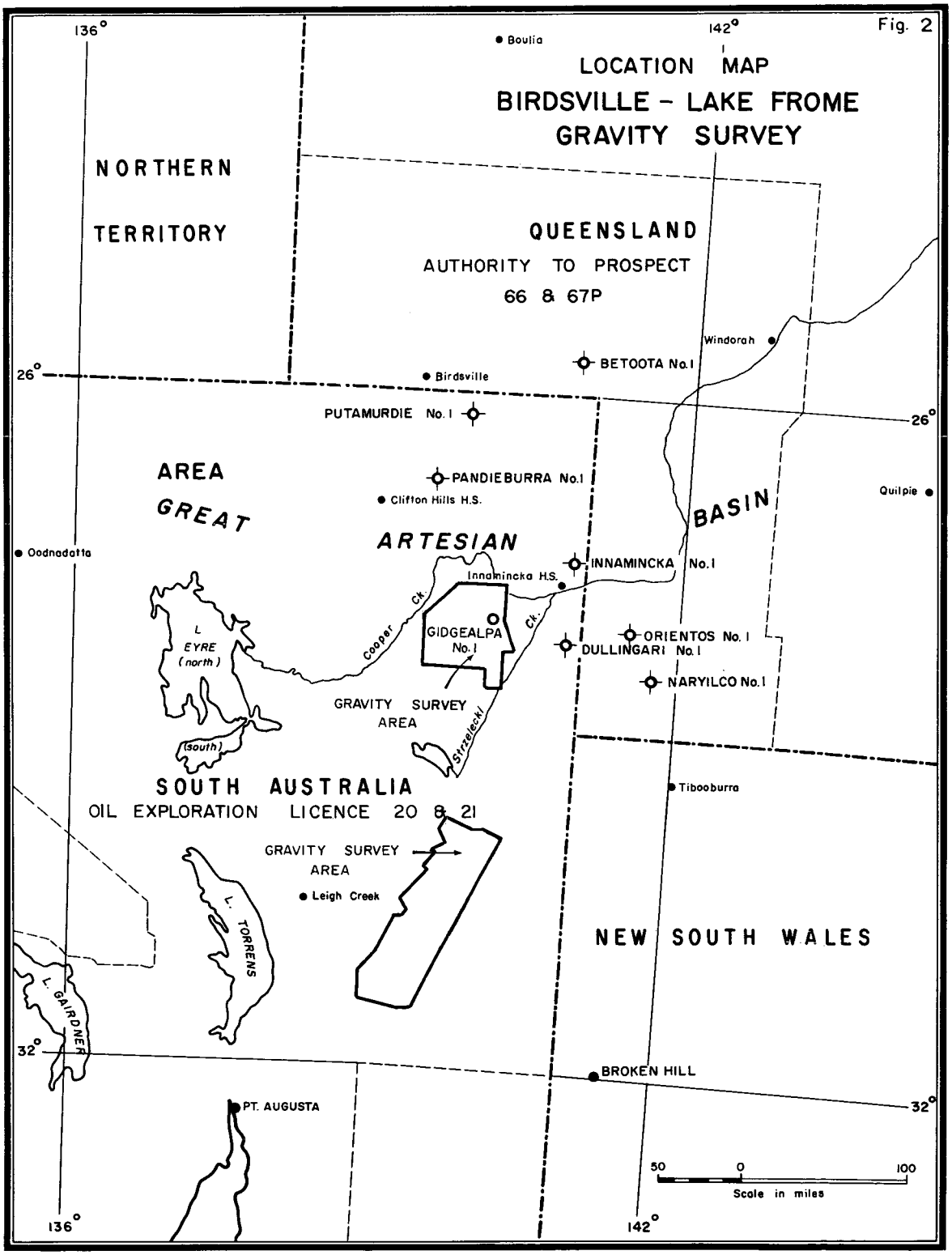
Fig. 2
LOCATION MAP
BIRDSVILLE - LAKE FROME
GRAVITY SURVEY
136°
142°
Boulia
NORTHERN
TERRITORY
QUEENSLAND
AUTHORITY TO PROSPECT
66 & 67P
Windorah
BETOOTA No.1
26°
Birdsville
PUTAMURDIE No. 1
PANDIEBURRA No.1
Clifton Hills H.S.
AREA
GREAT
ARTESIAN
BASIN
Quilpie
Oodnadatta
INNAMINCKA No.1
Innamincka H.S.
Cooper Ck.
L EYRE (north)
GIDGEALPA No. 1
Ck.
ORIENTOS No. 1
DULLINGARI No.1
NARYILCO No.1
GRAVITY SURVEY AREA
Strzelecki
(south)
SOUTH AUSTRALIA
OIL EXPLORATION LICENCE 20 & 21
Tibooburra
GRAVITY SURVEY AREA
Leigh Creek
L. TORRENS
L. GAIRDNER
NEW SOUTH WALES
32°
BROKEN HILL
PT. AUGUSTA
50 0 100
Scale in miles

BIRDSVILLE - LAKE FROME GRAVITY SURVEY

SUMMARY OF DATA AND RESULTS*

SUMMARY

A gravity survey of two areas in the Birdsville - Lake Frome region of the Great Artesian Basin was conducted by Geophysical Service International's Party 662 for Delhi Australian Petroleum Ltd, during the period April to October, 1963.

In the first survey, over the Lake Frome area of eastern South Australia, gravity observations were taken at 2870 stations that formed loops of approximately five by ten-mile dimensions, and were spaced at one-half mile intervals along trails and fence lines. Thirty-four anomalies were outlined, including features of interest to petroleum exploration, and features such as intrusive material, that might limit the prospective areas. Some of the more interesting anomalies indicate regions where 5000 to 15,000 feet of sediments may overlie the basement. Vertical magnetic intensity measurements were recorded at the gravity stations, and the results were used to aid the gravity interpretation.

The second survey was made over the Gidgealpa area in north-eastern South Australia, where both gravity and magnetic observations were taken on 1189 one-half mile stations located in an estimated area of approximately 2000 square miles. Eighteen anomalies were outlined. Nowhere was the sedimentary section computed to be less than 6000 feet. Of particular interest is a large gravity "high" anomaly that appears to outline the structure upon which the Gidgealpa gas field is located.

The vertical magnetic intensity contours show that some of the magnetic anomalies cannot be correlated directly with gravity anomalies. The variance between gravity and magnetic anomalies is discussed in general terms, and it is concluded that:

(i) Magnetic estimations of deep basement are valid;

(ii) Gravity anomalies reflect mainly Permian-Cambrian topography and shallow density anomalies; and

(iii) The major negative gravity anomalies indicate thickening of sediments.

The geophysical operation undertaken in the Birdsville - Lake Frome area of the Great Artesian Basin, South Australia, was subsidized under the Petroleum Search Subsidy Act 1959-1961.

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* Abstracted from: Final Report "Birdsville - Lake Frome Gravity Survey, Parts I and II", by N. Harding, M.L. Brown, and R.A. Geyer, Geophysical Service International, November, 1963.

METHODS OF OPERATION

General Data

Operator:	Delhi Australian Petroleum Ltd, 32 Grenfell Street, Adelaide, S.A.
Contractor:	Geophysical Service International
Location:	Oil Exploration Licences Nos 20 and 21, issued by the State of South Australia. Lake Frome area - bounded by latitudes 29° 45' and 31° 30' South, longitudes 139° 00' and 140° 30' East. Gidgealpa area - bounded by latitudes 27° 30' and 28° 30' South, longitudes 139° 25' and 140° 20' East.
Basin:	Great Artesian
Tenement Holder:	Delhi Australian Petroleum Ltd and Santos Limited

Field Operations

Date survey commenced:	3rd April, 1963
Date survey completed:	11th October, 1963
Total field party work time:	1338.75 hours
Coverage:	4059 gravity stations over an area of 6750 square miles
Average density of gravity stations:	0.6 station per square mile

Equipment

Gravity Meters:	Worden No. 317 Worden No. 342
Surveying instruments:	Keuffel and Esser transits
Vehicles:	Six Landrovers; One 4 x 4 Bedford supply truck
Camp:	One air-conditioned office caravan; Tented camp for 15 men.

GEOLOGY

by

Delhi Australian Petroleum Ltd

Lake Frome Area

Objective of survey:

The Lake Frome portion of the Birdsville-Lake Frome Gravity Survey was designed as a means of confirming the existence and determining the extent of a postulated structural trough adjacent to the eastern flank of the northern Flinders Ranges, and to detect leads to possible structural traps for hydrocarbons which might be mapped further by seismic methods.

Prior geological information:

Extensive areas of outcrop of very thick (up to 20,000 feet) Lower and Middle Cambrian marine sediments occur along the eastern flank of the northern Flinders Ranges, within the south-western margin of the survey area. Meagre structural indications from a few aeromagnetic profiles and scattered shallow water bores have suggested that a deep structural depression parallel to and immediately east of the ranges is present. The presence of Cambrian sediments in the downwarp is indicated by regional stratigraphic studies which show that marine sedimentation was widespread during the Cambrian period, with shorelines far from the area under consideration.

Gidgealpa Area

Objective of survey:

The primary objective of the survey in the Gidgealpa area was to acquire basic gravity and ground magnetic information in an area believed to have considerable potential for hydrocarbons. At the time the survey was undertaken the area was one in which only reconnaissance aeromagnetic and seismic surveys had been carried out. A deep off-structure stratigraphic test was being drilled at the time the survey was initiated and conducted. It was expected that the gravity and ground magnetic information in conjunction with the previous geophysical data, and data resulting from the drilling of the Gidgealpa No. 1 Well, would provide a means for more reliable mapping of the subsurface structural and stratigraphic features of this area.

Prior geological information:

Previously drilled wells nearest to the survey area are the Delhi-Frome-Santos Innamincka No. 1 Well located 60 miles to the north-west of Gidgealpa No. 1 and the Delhi-Santos Dullingari No. 1 Well located 50 miles to the south-east. Reconnaissance reflection and refraction seismic surveys had related the sedimentary column as encountered in these wells to the present survey area and, in conjunction with reconnaissance aeromagnetic data, indicated that a thick sequence of Permian and older Palaeozoic sediments is of widespread occurrence in this region.

Conclusions regarding the stratigraphy of the Permian sediments in the region of the gravity and ground magnetic survey were based primarily on the results of the two wells previously mentioned, both of which encountered interbedded sandstones, shales, and coals of Permian age. At least some of the shales appear to be of marine origin, although this is not proven, and the section in general appears to be representative of a fluctuating marginal-to-marine environment, and to bear a favourable aspect for the generation and accumulation of hydrocarbons.

With regard to pre-Permian sediments in the general Gidgealpa area it was expected that marine units of Lower Palaeozoic age would be present, but it was impossible to predict their age or nature. At Innamincka No. 1, red-beds of probable Devonian age, and more than 5000 feet thick, were encountered below the Permian. At Dullingari No. 1, marine shales of Ordovician age, and in excess of 2000 feet stratigraphic thickness, were found to underlie the Permian sequence. Widespread Lower Palaeozoic marine sedimentation is believed to have occurred across the north-eastern portions of South Australia, based on studies of sediments of these ages which occur in outcrop in the northern Flinders Ranges of South Australia, the Mootwingee area of north-western New South Wales, and the Amadeus and Georgina regions of the Northern Territory and Queensland.

Gidgealpa No. 1 Well penetrated 6942 feet of Mesozoic sediments, 1000 feet of Permian, 420 feet of undifferentiated Palaeozoic sediments, and 4004 feet of Cambrian sediments to total depth of 13,114 feet. In the Cambrian section, Middle Cambrian rocks are thrust over Upper Cambrian, which continue in downward sequence into Middle Cambrian at total depth.

Gidgealpa No. 2, located two miles west of No. 1 Well, and near the axis of the anticline, found volcanic rocks immediately underlying the Permian sediments and these were penetrated for 2152 feet to total depth at 9020 feet. Gidgealpa No. 2 was completed as the discovery well of the Gidgealpa gas field, with a calculated absolute open flow potential of 29.5 million cubic feet of gas per day from Permian sands.

FIELD PROCEDURES

Lake Frome Area

Vertical control was initiated at Reaphook Hill trigonometrical station with an elevation of 1272 feet (M.S.L. Port Augusta). National Mapping Astrofixes NMA 37 and NMA/E/54 provided the horizontal control.

The observed gravity base network was composed of seventy-six bases forming sixteen base loops with an average misclosure of less than $\pm$ 0.02 milligal. Misclosure errors were prorated. Observed values for bases were determined from two or more measurements of the difference between adjacent bases in overlapping "drifts" (i.e., for bases A, B, C, ... gravity meter readings in the sequence ABABCBC) and are relative to an assumed value of 500.00 milligals for Base A. A tie to a pendulum station was not deemed practical. With the exception of the foothills of the Flinders Ranges along the western side of the prospect, the terrain is generally flat. Only two suitable gravity meter density profiles were obtained in the area. Both yielded a density of 2.0 gm/cm^3 indicative of an elevation correction factor of 0.06854 milligal per foot. No surface rock samples were submitted.

Gidgealpa Area

The entire prospect is dominated by north-south oriented sand dunes spaced at approximately one-half mile intervals. These rough-surfaced dunes rise 30 to 60 feet above the general terrain which has little relief. A large percentage of the surveying was along seismic lines with station spacing at one-half mile intervals. The majority of the lines were oriented in a north-south direction because of the sand dunes. Accessibility and anomalous conditions were the criteria used to decide loop sizes.

The horizontal and vertical datum originated on United Geophysical Corporation Shot Point L-110, which has an established elevation of 168.00 feet. The horizontal control for Shot Point L-110 was derived from the Delhi Australian Petroleum Ltd Gidgealpa No. 1 astrofix, located 820 feet from this shot point on a bearing of $064^{o}05'$ True. The vertical datum was derived by United Geophysical Corporation seismic survey, using as a base datum the value of Innamincka No. 1 Well : 401.68 feet (L.W.O.S.T. = 0' Port Adelaide). This well had previously been tied by a level traverse to the Marree-Birdsville 1883 Railway Survey.

A network of 41 bases was established from an adopted value of 200.00 milligals for Base A located on station No. 8. Two or more measurements of the observed gravity difference between adjacent bases were taken by use of overlapping "drifts" (i.e. ABAB, where A and B are readings on two distinct points used as base locations). The nine base loops' average misclosure was $\pm$ 0.027 milligal. The errors were prorated in proportion to the number of bases on the loop.

When running stations, "drift" was determined from readings on previously established bases at not more than two and one-half hour intervals. The drift corrections were applied in proportion to time.

One density profile was run which indicated an elevation correction factor of 0.06982 milligal per foot, corresponding to a density of 1.9 gm/cm^3.

INTERPRETATION METHODS

Lake Frome Area

The interpretation of the Bouguer gravity maps was made using profile analysis and contour migration methods. Gravity and magnetic profiles were drawn perpendicular to the gravity contours.

An attempt was made to classify each anomaly's source as to its geological origin, based on the combined evidence from the gravity, magnetic, and density data.

Because of the extremely steep gradient in several parts of the area, a 1.0 milligal contour interval was used. The Bouguer gravity maps show a wide range of anomaly types from large circular anomalies associated with basement geology to small, sharp, irregular shaped contour variations due to shallow intrusions or near-surface sedimentary density contrasts.

The magnetic maps made it possible to eliminate from further consideration the entire northern quarter of the surveyed area - the part dominated by intrusives and flows. The general basement configuration can be seen from depths to basement computed from the magnetic anomalies. Magnetic depth determinations in the south-western part of of the map were not made because of the absence of suitable anomalies.

Gidgealpa Area

Profile analysis was used to interpret the Bouguer gravity map. Profiles were drawn approximately normal to the prevailing strike of the gravity anomalies to facilitate their qualitative and quantitative study. The gravity and magnetic maps were used to trace out the axes shown on the geologic summary map.

Because of the steep gravity gradient along the eastern side of the central anticlinal axes, a contour interval of one milligal was chosen. The gravity map substantiates evidence shown on the magnetic map for large areas where the basement is relatively deep such as in the north-western and south-eastern sections.

RESULTS

Lake Frome Area

The results of the survey are presented in this summary on two maps: Bouguer gravity map, and magnetic map, each drawn at a scale of 1:250,000.

The examination and interpretation of all data obtained from the survey indicate that the Lake Frome area can be divided into three provinces: (i) an area in the south-western part bounded on the east by a major fault and on the west by the northern Flinders Ranges, (ii) the north-eastern part containing very shallow intrusions of igneous plugs and flows into the sedimentary section, and (iii) a basin area having a maximum thickness of sediments of about three miles.

Thirty-four anomalies are drawn on the geologic summary map. Their interpretations are based upon profiles drawn perpendicular to the gravity contours and by contour migration. A density contrast of 0.2 gm/cm^3 was used to compute maximum depths to the top of the geological feature causing the anomaly. Specific gravity determinations made by the Australian Mineral Development Laboratories on top Lower Cambrian (Billy Creek) and Lower Cambrian (Parara) specimen rocks, resulted in densities of 2.60 and 2.78 gm/cm^3, density contrast of 0.18 gm/cm^3. These rocks crop out along the eastern flank of the northern Flinders Ranges. It is also thought that the Billy Creek Formation is overlain by 200 to 300 feet of limestone (probable density of 2.6 to 2.7) and a very thick Middle Cambrian section of sands (probable density of 2.4), resulting in a probable density contrast between Middle Cambrian and top Lower Cambrian of 0.2 gm/cm^3.

Gidgealpa Area

The results of this survey are presented on the following maps (scale 1:250,000) Bouguer gravity map; and magnetic map.

The geologic summary map shows the significant geological features of the area as interpreted from the gravity and magnetic maps. These features are major positive and negative structural axes, faults, and fault systems; a total of 18 gravity anomalies are drawn on the map.

The most striking characteristic of the magnetic map is the enormous regional extent of the magnetic positive anomaly which dominates at least 60 percent of the surveyed area. This great elliptical-shaped anomaly has its symmetry interrupted in only two places, by a deep basement fault which runs northeast-southwest across it, breaking its axial continuity at 27^{o} 57' S, 140^{o} 00' E, and by the large magnetic negative with its axis at approximately 28^{o} 13' S, and 140^{o} 13' E. Because of the relatively gentle magnetic gradients over the entire map, except on the eastern flank of the huge magnetic positive, it can safely be concluded from the magnetic data alone that (i) the basement is at considerable depth, or (ii) the properties of the Precambrian rocks in general change very gradually horizontally.

An inspection of the Bouguer gravity map and a subsequent comparison of its anomalous areas with those of the magnetic map reveal that in general there is a minimum correlation. From this fact, it can be concluded that many of the positive and negative gravity anomalies originate entirely from horizontal density contrasts within the sedimentary section. Specific gravity determinations of cores (1-17) from Gidgealpa No. 1 revealed that positive density contrasts do exist in the section.

The Bouguer gravity map shows a major anticlinal axis running northeast-southwest across the central part of the area. Gravity lows of considerable areal extent flank the sides of this axis. Profile B-B' was selected to cross the axis perpendicularly. This major positive gravity anomaly is no doubt associated with the Gidgealpa structure. Its trend coincides very nearly with the crest of the structure.

The positive gravity anomalies vary in amplitude from three milligals to 16 milligals. As an objective test, depths were calculated on all significant positive anomalies using symmetrical models of two dimensional prisms and circular cylinders and a conservative positive density contrast of 0.2 gm/cm^{3}. No depth was shallower than 6000 feet.

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DELHI AUSTRALIAN PETROLEUM LTD, 1961b: D.F.S. Innamincka No. 1 Well, South Australia. Bur. Min. Resour. Aust. Petrol. Search Subs. Acts Publ. 9.

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SKEELS, D.C., 1962 : An approximate solution of the problem of maximum depth in gravity interpretation. Society of Exploration Geophysicists, 32nd International Meeting, Calgary, Alberta.

VACQUIER, V., STEENLAND, N.C., HENDERSON, R.G., and ZIETZ, I., 1951 : Interpretation of aeromagnetic maps. Geol. Soc. Amer. Mem. 47.

ADDITIONAL DATA FILED IN THE BUREAU OF MINERAL RESOURCES

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

Lake Frome Area

(i)	Final Report, by N. Harding and R.A. Geyer		12 pp.
	Appendix A: Field operations		9 pp.
	Appendix B: Geological summary, by Delhi Australian Petroleum Ltd		3 pp.
	Appendix C: Table of Principal Facts		6 pp.
(ii)	Bouguer gravity map,	(1" = 5000 ft)	6 sheets
(iii)	Magnetic anomaly map,	(1" = 5000 ft)	6 sheets
(iv)	Geologic summary map,	(1" = 10,000 ft)	3 sheets
(v)	Station location and elevation map,	(1" = 5000 ft)	6 sheets
(vi)	Density profile results		1 sheet
(vii)	One-mile photo mosaics showing 100 permanently marked stations		1 sheet

Gidgealpa Area

(i)	Final Report, by M.L. Brown and R.A. Geyer	11 pp.
	Appendix A: Field operations	6 pp.
	Appendix B: Geological summary, by Delhi Australian Petroleum Ltd	8 pp.
	Appendix C: Correlation of geophysical data, by M. Mazzolini	5 pp.
	Appendix D: Table of Principal Facts	10 pp.
(ii)	Geologic summary map, (1" = 10,000 ft)	1 sheet
(iii)	Station location and elevation map, (1" = 5000 ft)	4 sheets
(iv)	Density profile results	1 sheet
(v)	Gravity profile B-B'	1 sheet
(vi)	Topographic survey notes	
(vii)	Magnetometer calculation sheets	
(viii)	Gravity meter drift and dial corrections	
(ix)	Gravity meter drift curves	
(x)	Bouguer calculation sheets	

PLATE I

QUEENSLAND
SOUTH AUSTRALIA

BIRDSVILLE

TI/1493

TI/1492

TI/1805

TI/1492

DELHI AUSTRALIAN PETROLEUM LTD.

ALTON DOWNS GRAVITY SURVEY
SOUTH AUSTRALIA AND QUEENSLAND

BOUGUER GRAVITY MAP

SCALE 1 : 250,000

0 5 10 15 MILES

CONTOUR INTERVAL 0.5 MILLIGAL

GEOPHYSICAL SERVICE INTERNATIONAL

PARTY NO. 662 — PARTY CHIEF: L. WERLE

INTERPRETATION: R A GEYER — DATE: MARCH, 1963

FIELD WORK DONE JULY - DECEMBER 1962

MAP PROJECTION, POLYCONIC

LOCATION

INDEX

LEGEND

Gravity Station with Bouguer value less in milligals stacked, station number underneath.

Horizontal control point, all except NMA 41 are U.S. Dept. of Lands Tellurometer Stations.

Bouguer gravity contours, at one-half milligal intervals.

Positive Anomaly.

Negative Anomaly.

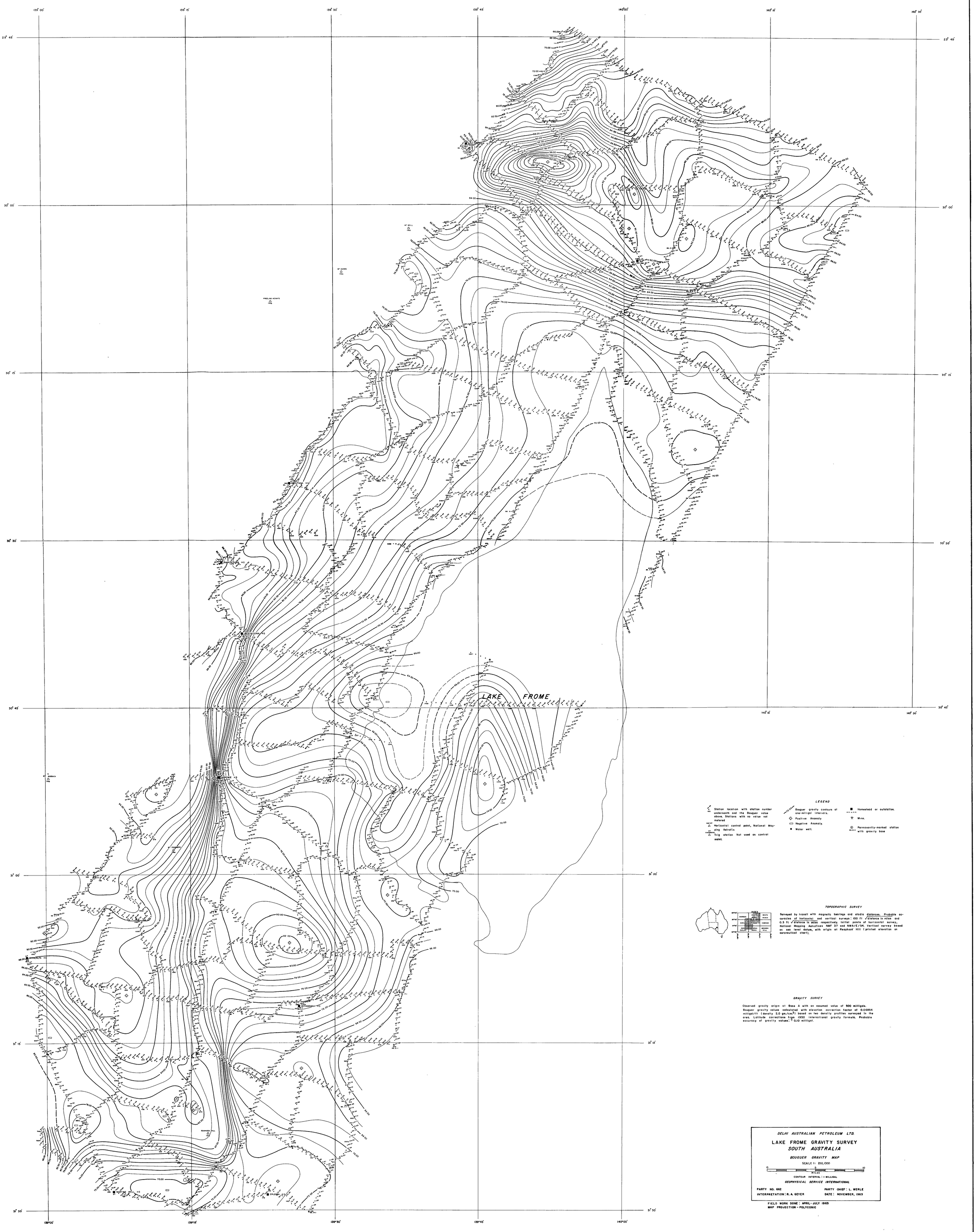
TOPOGRAPHIC SURVEY

Surveyed by transit with magnetic bearings and stadia distances. Probable accuracy of horizontal survey: 100 ft. Elevations to nearest foot. Probable accuracy of vertical survey: 0.3 ft. Reference to initial point of horizontal survey, National Mapping Astrefix NMA 41 at Birdsville, with ties to U.S. Dept. of Lands Tellurometer Stations. Vertical survey based on elevation of 181.00 ft. for BM 30/57 at Birdsville (Queensland Level Datum).

GRAVITY SURVEY

Observed gravity datum based on adopted value of 979.103.9 milligals for Birdsville Pendulum Station. Bouguer gravity values calculated with elevation correction factor of 0.06982 milligal/ft., based on adopted rock density of 1.9 gm/cm^3. Latitude corrections from 1930 International gravity formula. Probable accuracy of gravity values: ± 0.10 milligal.

PLATE 2



LEGEND

- Station location with station number underneath and the Bouguer value above. Stations with no value not metered
- Horizontal control point, National Mapping Astrofix
- Trig station Not used as control point.
- Bouguer gravity contours at one-milligal intervals.
- Positive Anomaly
- Negative Anomaly.
- Water well.
- Homestead or outstation.
- Mine.
- Permanently-marked station with gravity base

TOPOGRAPHIC SURVEY

Surveyed by transit with magnetic bearings and stadia distances. Probable accuracies of horizontal and vertical surveys: 100 ft $\sqrt{\text{distance in miles}}$ and 0.3 ft $\sqrt{\text{distance in miles}}$ respectively. Initial points of horizontal survey, National Mapping Astrofixes NMF 37 and NMA/E/54. Vertical survey based on sea level datum, with origin at Reaphook Hill (printed elevation on aeronautical chart).

GRAVITY SURVEY

Observed gravity origin at Base A with an assumed value of 500 milligals.
Bouguer gravity values calculated with elevation correction factor of 0.06854 milligal/ft (density 2.0 gm./cm^3) based on two density profiles surveyed in the area. Latitude corrections from 1930 International gravity formula. Probable accuracy of gravity values: $\pm$ 0.10 milligal.

DELHI AUSTRALIAN PETROLEUM LTD.

LAKE FROME GRAVITY SURVEY
SOUTH AUSTRALIA

BOUGUER GRAVITY MAP

SCALE 1: 250,000

0 5 10
MILES

CONTOUR INTERVAL: 1 MILLIGAL

GEOPHYSICAL SERVICE INTERNATIONAL

PARTY NO. 662 — PARTY CHIEF: L. WERLE
INTERPRETATION: R. A. GEYER — DATE: NOVEMBER, 1963

FIELD WORK DONE: APRIL - JULY 1963
MAP PROJECTION - POLYCONIC

PLATE 3

139° 00' 139° 15' 139° 30' 139° 45' 140° 00' 140° 15' 140° 30'

29° 45' 30° 00' 30° 15' 30° 30' 30° 45' 31° 00' 31° 15' 31° 30'

LAKE FROME

MT ADAMS TRIG

FREELING HEIGHTS TRIG

MT CHAMBERS TRIG

PEARMOOR HILL TRIG

RIVERSLEIGH HS

BARKLY DOWNS HS

MOUNTAINS HS

MOUNTAIN HS

MINNIELAPA HS

MOUNTAIN HS

MOUNTAIN HS

ERUDGERE

ROEBUCK BORE

LEGEND

- Station location with station number underneath and relative magnetic value, vertical component, posted above. Stations with no value not metered
- Horizontal control points, National Mapping Astrofix
- Trig station. Not used as control point.
- Magnetic vertical intensity. Contour lines at 50-gamma intervals.
- Positive Anomaly.
- Negative Anomaly.
- Water well.
- Homestead or outstation
- Mine
- Permanently-marked station with gravity base.

LOCATION

INDEX

TOPOGRAPHIC SURVEY

Positioning by transit with magnetic bearings and stadia distances, initial points of horizontal survey, National Mapping Astrofixes NAF 37 and NMA/E/54. Probable horizontal accuracy: 100 ft $\sqrt{}$ distance in miles.

MAGNETIC SURVEY

All observed magnetic values relative to an assumed value of 1000 gammas at Magnetometer Base "A". Observed values corrected for normal regional deviation of 14.3 gammas per mile, N.G.E. (BMR Report No. 62). Apparent accuracy of magnetic values: $\pm$ 6 gammas

DELHI AUSTRALIAN PETROLEUM LTD.

LAKE FROME GRAVITY SURVEY
SOUTH AUSTRALIA

MAGNETIC MAP

SCALE 1 : 250,000

0 5 10

MILES

CONTOUR INTERVAL 20 GAMMA

GEOPHYSICAL SERVICE INTERNATIONAL

PARTY NO. 662 PARTY CHIEF: L. WERLE

INTERPRETATION: R. A. GEYER DATE: NOVEMBER, 1963.

FIELD WORK DONE: APRIL - JULY 1963

MAP PROJECTION - POLYCONIC

PLATE 4

139° 30′ 139° 45′ 140° 00′ 140° 15′

27° 30′ 27° 45′ 28° 00′ 28° 15′ 28° 30′

DELHI AUSTRALIAN PETROLEUM LTD.

GRAVITY & MAGNETIC SURVEYS

BIRDSVILLE - LAKE FROME AREA SOUTH AUSTRALIA

BOUGUER GRAVITY MAP

SCALE 1 : 250,000

0 5 10

MILES

CONTOUR INTERVAL 1 MILLIGAL

GEOPHYSICAL SERVICE INTERNATIONAL

PARTY NO. 662 PARTY CHIEF : L. WERLE

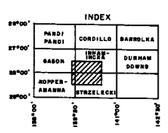
INTERPRETATION : R. A. GEYER DATE : MARCH, 1964

FIELD WORK DONE : AUGUST - OCTOBER, 1963

MAP PROJECTION : POLYCONIC

LOCATION

INDEX



TOPOGRAPHIC SURVEY

Surveyed by transit with magnetic bearings and stadia distances. Probable accuracies of horizontal and vertical surveys : 100 ft. √distance in miles and 0.3 ft.√distance in miles respectively. Initial points of both horizontal and vertical survey, United Geophysical shot point L-110. Previously established elevation of L-110, 168.00 feet.

Most of seismic shot point locations omitted to prevent crowding of data.

70.97 / 503 Station location with station number underneath and the Bouguer value above stations.

NMH 170 △ Horizontal control point, National Mapping Astrofix.

LEGEND

Gravity bases marked with iron pickets. Number underneath, double circle indicates permanently marked station.

Positive Anomaly.

Negative Anomaly.

Dry Hole.

68.00 Bouguer gravity contours at 1 milligal intervals.

128 United Geophysical shot point and line number.

GRAVITY SURVEY

Observed gravity origin at Base "A" with an assumed value of 200.00 milligals. Bouguer gravity values calculated with elevation correction factor of 0.06982 milligal/ft. (density 1.9 gm./cm.^{3}) based on one density profile surveyed in the area. Latitude corrections from 1930 international gravity formula. Probable accuracy of gravity values: ± 0.10 milligal.

PLATE 5

139° 30′ 139° 45′ 140° 00′ 140° 15′

27° 30′ 27° 45′ 28° 00′ 28° 15′ 28° 30′

DELHI AUSTRALIAN PETROLEUM LTD.

GRAVITY & MAGNETIC SURVEYS

BIRDSVILLE - LAKE FROME AREA SOUTH AUSTRALIA

MAGNETIC MAP

SCALE 1 : 250,000

0 5 10

MILES

CONTOUR INTERVAL . 25 GAMMA

GEOPHYSICAL SERVICE INTERNATIONAL

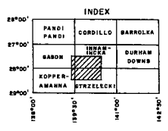
PARTY NO. 662 PARTY CHIEF : L. WERLE

INTERPRETATION R. A GEYER DATE : MARCH, 1964

FIELD WORK DONE : AUGUST - OCTOBER, 1963

MAP PROJECTION : POLYCONIC

LOCATION



TOPOGRAPHIC SURVEY

Positioning by transit with magnetic bearings and stadia distances. Initial points of horizontal survey, United Geophysical shot point L-110. Probable horizontal accuracy : 100 ft. √distance in miles

Most of seismic shot point locations omitted to prevent crowding of data.

1764 / 420 Station location with station number underneath and relative magnetic value, vertical component, posted above.

NMK170 △ Horizontal control points, National Mapping Astrofix.

LEGEND

85 °G Gravity bases marked with iron pickets Number underneath double circle indicates permanently marked station.

Positive Anomaly.

Negative Anomaly

Dry Hole

-1800 Magnetic vertical intensity contour lines at 25 gamma intervals.

186 United Geophysical shot point and line number.

MAGNETIC SURVEY

All observed magnetic values relative to an assumed value of 1000 gammas at Magnetometer Base "A" located 400 feet south of density profile Station No.11. Observed values corrected for normal regional deviation derived from BMR Report No 62, "Isomagnetic Maps of Australia."

Probable accuracy of magnetic values : ± 10 gammas.