COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM SEARCH SUBSIDY ACTS

Publication No. 38

BARLEE GRAVITY SURVEY, WESTERN AUSTRALIA, 1959

BY

WEST AUSTRALIAN PETROLEUM PTY LIMITED

Issued under the Authority of Senator the Hon. Sir William Spooner,
Minister for National Development

1964

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

Minister: SENATOR THE HON. SIR WILLIAM SPOONER, K.C.M.G., M.M.

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 Geophysical Branch

Acting Chief Geophysicist: L. S. PRIOR

FOREWORD

In 1959 the Commonwealth Government enacted the Petroleum Search Subsidy Act 1959. This Act enables companies that drill for new stratigraphic information, or carry out geophysical or bore-hole surveys in search of petroleum to be subsidized for the cost of the operation, provided the operation is approved by the Minister for National Development.

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.

A gravity survey was carried out under the Petroleum Search Subsidy Act 1959 in the Barlee area of the Canning Basin of Western Australia by West Australian Petroleum Pty Limited. This publication deals with that survey and contains the information furnished by West Australian Petroleum Pty Limited.

The final report was submitted in two parts :

(i) a geological report by D. Johnstone, Geophysical Supervisor of West Australian Petroleum Pty Limited, and

(ii) an interpretation report by B.S. Gamill and N.C. Steenland of Gravity Meter Exploration Company, Houston, Texas, U.S.A.

These reports were collated and edited in the Geophysical Branch of the Bureau of Mineral Resources.

CONTENTS

ILLUSTRATIONS

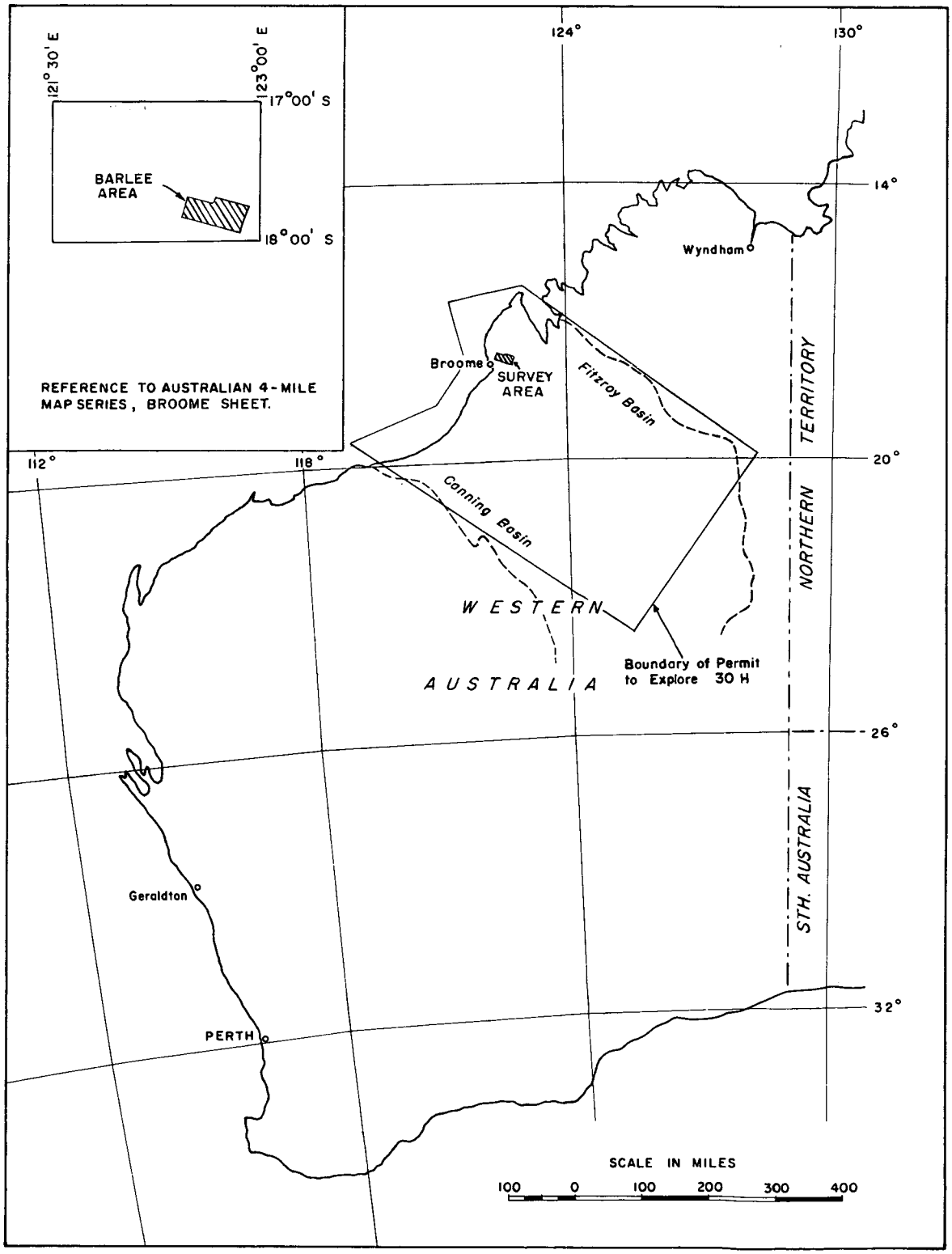


Fig. 1. LOCALITY MAP

SUMMARY

A detailed gravity survey was carried out in the Barlee area of the Canning Basin of Western Australia during the period 31st August, 1959 to 31st October, 1959, by West Australian Petroleum Pty Limited. The gravity observations were made by L.J. Starkey of Mines Administration Pty Limited and the gravity data were reduced and interpreted by Gravity Meter Exploration Company.

A location for a proposed test well had been selected on a complex faulted anticline defined by previous seismic surveys. The objective of the gravity survey was to evaluate the possibility of a salt intrusion being associated with the structure.

Analysis of the gravity data in conjunction with the results of previous geological and geophysical investigations shows no evidence of domed salt within the detailed survey area, although the presence of a regionally uniform thickness of bedded salt is not precluded. It is recommended that the test well be drilled deeper than 7000 feet in order to determine the nature of older, denser sediments which may be present in significant thickness.

INTRODUCTION

A detailed gravity survey was carried out in the Barlee area of the Canning Basin, Western Australia, by West Australian Petroleum Pty Limited during the period 31st August, 1959 to 31st October, 1959. The survey area (see Fig. 1) is located 35 miles east-north-east of Broome and forms part of Permit to Explore 30H. Extensive seismic refraction and reflection surveys in the Barlee area had defined a complex, faulted anticline upon which a location for a proposed test well had been chosen.

The penetration of 1747 feet of rock salt in Frome Rocks No. 1 Well, (Elliott, 1962), located approximately 65 miles to the east-south-east, indicated the desirability of employing a geophysical technique capable of indicating the extent of the salt mass. As there appeared to be insufficient contrast between the velocities of the rock salt and the surrounding sediments, the seismic refraction method was believed to be unsuitable; it was therefore decided to conduct a detailed gravity survey at Frome Rocks to see if it would indicate :

(i) The presence of salt,

(ii) the shape and extent of the salt, and

(iii) the optimum gravity grid to achieve these results.

This survey was completed on 12th May, 1959. Gravity Meter Exploration Company, of Houston, Texas, U.S.A., interpreted the gravity data and some of their conclusions were :

(i) "The presence of substantial salt masses can be determined by gravity surveys and the quantitative evaluation of the mass is feasible".

(ii) "Faulting of the section above 5000 feet caused substantial and easily detectable gravity anomalies".

(iii) "Salt masses apparently interrupt regional anticlinal trends".

(iv) The optimum gravity grid should be "parallel lines of stations spaced one mile apart along which stations are to be made at an approximate interval of one-third mile".

It was therefore decided to carry out a detailed gravity survey in the Barlee area about the proposed well location [1] to investigate the possibility of there being a salt intrusion associated with the structure. The results of this survey, together with the results of previous investigations of the Barlee area, were studied by Gravity Meter Exploration Company and their report is included in this Publication.

---

(1) Footnote by Bureau of Mineral Resources:

Since this completion report was written, Barlee No. 1 Well has been drilled to total depth of 8101 feet. The report on this operation has been published by the Bureau in P.S.S.A. Publication No. 16 - Barlee No. 1 Well Completion Report of West Australian Petroleum Pty Limited.

GEOLOGY

by

D. Johnstone

West Australian Petroleum Pty Limited

The Canning Basin covers 175,000 square miles of the northern part of Western Australia between the Precambrian Kimberley and Pilbara Blocks. The Canning Basin is subdivided into the Fitzroy Basin, whose southern boundary is the Dampier Fault and that part of the Fenton Fault south-east of Nerrima, and the South Canning Basin. The northernmost structural province of the Fitzroy Basin is the Lennard Shelf adjacent to the Precambrian Shield. The north-west-trending Jurgurra Terrace is the southernmost unit of the Fitzroy Basin, and it is separated from the deep Fitzroy Trough to the north by the Fenton Fault and its north-west continuation, and from the shallow South Canning Basin to the south by the Dampier Fault.

The sediments cropping out on the Lennard Shelf are mainly Ordovician, Devonian, and Lower Carboniferous, whereas those cropping out in the Fitzroy Trough are mainly Permian with some Triassic and Cretaceous in the north-west. Drilling has penetrated Upper Carboniferous sediments, and geophysical surveys suggest that the thickness of the sedimentary rocks in the Fitzroy Trough is between 20,000 and 30,000 feet. As exposures are poor in the South Canning Basin, the stratigraphy has been ascertained from several wells and seismic surveys; the known sequence of Ordovician, Permian, Jurassic, and Cretaceous rocks does not exceed 7000 feet.

The only outcrops on the Jurgurra Terrace are small, isolated exposures of Permian, Jurassic, and Cretaceous rocks in the eastern part of the terrace in the vicinity of Frome Rocks and Jurgurra Creek, and exposures of Cretaceous near Broome and 15 miles east of Barlee. The surface of the Barlee area consists of sand derived from the underlying Cretaceous rocks. The nearest points of stratigraphic control are the Broome water bores, Roebuck Bay No. 1 Well (30 miles south-south-west) and Fraser River No. 1 Well (40 miles north-east). Roebuck Bay No. 1 encountered Ordovician strata at 3660 feet and is located in the shallow South Canning Basin south of the Dampier Fault. Fraser River No. 1 reached its total depth of 10,144 feet in the Upper Carboniferous sequence and is in the deep Fitzroy Trough. Although aeromagnetic, gravity, seismic refraction, and seismic reflection surveys have been conducted at Barlee and a reflection line was shot to tie the area into Roebuck Bay No. 1, the stratigraphy at Barlee can be predicted only with a small degree of confidence.

FIELD PROCEDURES

The detailed gravity survey covered an area of approximately 277 square miles, gravity meter measurements being made at stations at intervals of 27 chains on 23 traverses spaced 0.9 to 1.7 miles apart and oriented 015^{o} to 025^{o}. The traverses were cleared by bulldozer and the gravity stations located by theodolite and chain survey. Levelling of the traverses was done with an optical level and staff.

The horizontal and vertical control datum for the topographic survey was Station No. 2275 (R.L. 109.1 ft above M.S.L.) of the earlier, less detailed gravity survey made by Ray Geophysics (Australia) Pty Ltd, for which the horizontal survey datum was Cooke's Pillar, Broome, and the vertical survey datum was the Bureau of Mineral Resources bench mark at Yeeda Homestead.

A Worden gravity meter (Serial No. 207), owned by Mines Administration Pty Limited of Brisbane, Queensland, was operated by L.J. Starkey, Geophysicist of that Company. The datum used was the Ray Station No. 2275 with an observed gravity value of 978,521.4 mgal which, in turn, was based on the value of 978,541.5 mgal at the south-eastern corner of the hangar at Broome airport established by Muckenfuss of Woods Hole Oceanographic Institute.

DISCUSSION OF RESULTS

by
B.S. Gamill and N.C. Steenland

Gravity Meter Exploration Company

Data analysed

The geological and geophysical data listed below were furnished by West Australian Petroleum Pty Limited for integrated analysis :

(i) Geological data including composite well logs from Fraser River No. 1, Roebuck Bay No. 1, Frome Rocks Nos 1 and 2 Wells, and associated geological cross-sections.

(ii) Gravity data consisting of Bouguer and residual gravity maps of a reconnaissance gravity survey carried out by Ray Geophysics (Australia) Pty Ltd during 1956, and gravity meter field sheets and topographical survey data from the Barlee Gravity Survey carried out by L.J. Starkey, of Mines Administration Pty Limited during 1959.

(iii) Seismic data from surveys conducted by Geophysical Service International S.A. including seismic structure maps of the 17,700-ft/sec refraction horizon; reflection horizons 'B' and 'C'; and seismic structure sections.

(iv) Aeromagnetic data from the Canning Basin Aeromagnetic Survey, carried out by World Wide Aerial Surveys (Aust.) Pty Limited during 1955 and interpreted by Gravity Meter Exploration Company, including local basement structure map; basement map, and total magnetic intensity map.

Bouguer Gravity Map (Plate 1)

The Ray reconnaissance gravity coverage consisted essentially of north-south lines spaced four to eight miles apart and east-west lines spaced three to six miles apart. Additional lines followed existing roads and tracks. Station spacing approximated one-half mile on all lines. Observed data north of the Great Northern Highway were reduced with an elevation correction factor of 0.070 mgal/ft, corresponding to a surface density of 1.88 g/cc while to the south a factor of 0.072 mgal/ft, corresponding to a surface density of 1.73 g/cc was used. The data are of generally satisfactory quality.

The detailed survey covered an area of approximately 277 square miles and consisted of 23 lines of stations spaced 0.9 to 1.7 miles apart oriented between 015^{o} and 025^{o}.

Station spacing was a uniform 27 chains on all lines. The gravity data, as distinct from the survey data, were reduced by Gravity Meter Exploration Company from field notes with the usual corrections for latitude and elevation. The gravity meter sensitivity used was 0.10135 mgal per scale division, (see Appendix 1), as determined by the manufacturer. An elevation correction factor of 0.070 mgal/ft was used throughout the survey after a study of density profiles on several of the detailed lines. The resulting Bouguer gravity values are tied to the Ray datum, posted to 0.01 mgal, and contoured at 0.2-mgal intervals.

The combined gravity surveys give adequate regional and local control for this analysis. Observed contours over the Barlee area define a sharp, westerly-trending, maximal nose of 5 to 10-mgal amplitude with local closures of 1.0 mgal. This nose is approximately over the Barlee seismic structure, and local closures roughly coincide with seismic Anomalies 'A' and 'J'. Westward, the maximal nose plunges sharply into a minimal saddle centred approximately over the western flank of Refraction Anomaly 'D'. Farther westward in the vicinity of the coast, an easterly-trending maximal nose complements the Barlee gravity feature and forms the westerly flank of the minimal saddle. East of the area of the detailed survey, the axis of the Barlee gravity nose swings northward, and the feature becomes considerably broader. South of the maximal axis, a narrow minimal reversal with local closures of 1.0 and 3.0 mgal trends from east to west and merges with the minimal saddle at Refraction Anomaly 'D'. North of the saddle a broad ovate, east-west-trending minimum dominates the north-westerly quadrant of the Ray reconnaissance survey. The northern flank of this feature and the southern flank of the southerly minimal axis rise steeply along uniform gradients to the edges of the map.

Grid Residual Map (Plate 2)

Grid-residual calculations are made with a three-ring system using the formula :

$$G_r = G_o + 0.09380\,(G_1 + \ldots . G_4) - 0.06250$$

$$(G_{21} + \ldots . G_{24}) - 0.14065\,(G_{31} + \ldots . G_{38})$$

Centre points are on a one-mile grid, oriented approximately parallel to the lines of the detailed gravity survey. Results are contoured at an interval which approximates 0.2 mgal.

The map (Plate 2) shows a continuous maximum with sharp local closures of 1.0 to 3.0 mgal trending along the axis of the maximal nose shown by the Bouguer gravity contours. Minima of 1.0 to 2.0 mgal flank the positive trend, and locally, sharply embay the maximal contours. A trend of subround maxima of 0.8 to 1.2 mgal parallels the axial maximum along the southerly limits of the detailed survey.

The primary function of grid-residual calculations is to separate certain anomalies from others which can either be much sharper or broader. The extent to which anomalies of one class can be resolved from others is dependent primarily upon the choice of grid spacing. One factor that limits the usefulness of this method is the purely mechanical operation of the calculations or its inability to adjust to conditions such as a change or reversal in a regional gradient. From this it follows that some amount of all anomalies is included in the grid-residual anomalies.

Grid-residual anomalies cannot be used directly for quantitative analysis. They are particularly useful, however, for confirming results obtained by pure residual methods if the

grid spacing is correctly chosen to emphasize these anomalies. The grid-residual serves in this case as a guide in selecting the proper "regional" to separate the Bouguer gravity into residual and regional components.

INTERPRETATION

by

B.S. Gamill and N.C. Steenland

Gravity Meter Exploration Company

Geological considerations

Consideration of the geological-geophysical data and the relations demonstrated at Frome Rocks gives rise to the following working hypothesis of regional geological history. However, alternative explanations seem equally likely for some events.

(i) On the Bouguer gravity maps, the alternating maximal and minimal axes over both the Barlee and Frome Rocks areas suggest regional anticlinal and synclinal trends. In the Frome Rocks interpretation it was postulated that these features represented regionally faulted, continuous strike folds along which salt domes were presumed to have formed. Minimal saddles interrupting the regional maximal axes were interpreted as the gravitational expressions of the suspected salt masses. These assumptions appear to be still valid.

(ii) Folding occurred during middle-to-late Palaeozoic, probably during Carboniferous time. Faulting and salt flowage, where present, presumably occurred synchronously judging from the close inter-relations of structure, faulting, and intrusive salt.

(iii) Permian sediments were involved in continued folding, at least along the Frome Rocks-Barlee trend where gently dipping Permian beds unconformably overlie steeply dipping Devonian sediments in the Frome Rocks No. 2 Well. A similar relation is possible at Barlee, at least along the anticlinal crest where a pre-Permian unconformity is mildly suggested by the deeper reflections on seismic Line Q.

Pre-interpretational considerations

Basement rocks are indicated by seismic survey at a depth of 9000 to 13,000 feet below the proposed site of the Barlee No. 1 Well, (Pudovskis, 1961). Aeromagnetic interpretation indicates by two depth estimates that basement material rises above a depth of 8000 feet near the site; although this basement depth figure is to some degree in conflict locally with other data, the general form is entirely reasonable. The coincidence of a local basement "high" with the overlying structure merits attention.

The possibility of regional gravity features being due to intrabasement density contrasts has been considered. If such is the case, an east-west-trending, horizontal cylinder

with a density contrast of 0.25 g/cc and a cross-sectional area of 7.2 square miles (a diameter of 3.0 miles), centred at a depth of 4.5 miles (top at 3.0 miles) below the proposed location would produce the anomaly. A proportionally larger cross-sectional area would be required to account for the greater and wider gravity anomaly to the east. The body would be entirely absent below the minimal gravity saddle near seismic Anomaly 'D'. On the other hand, a density contrast of 0.10 g/cc assigned to a long body of lenticular cross-section in the 7000 to 12,000 feet depth range gives an identical result. Such a body may be a wedge of denser, older sediments, perhaps even including a barrier reef core grown over and around a basement "high". The demonstrated coincidence of structure and gravity anomalies in the Barlee and Frome Rocks areas suggests this latter possibility. Furthermore, seismic data at Reflection Anomalies 'C' and 'K', although weak and uncorrelated, do show a broad, shallow structure similar in form and outline to a long lenticular body such as drawn on Plate 6.

The interpretation of gravity is therefore based upon the assumption of a direct relation between gravity and structure, which presupposes that the major density contrasts occur within the sedimentary rocks. Any predicted structures must satisfy the conditions prescribed by the other geophysical and geological data.

Gravity interpretation

The Bouguer gravity is interpreted to consist of components attributed to shallow and moderately deep origins. From the density-depth relations of sediments and salt shown by Plate 3, it is obvious that an appreciable mass of intrusive salt in the sedimentary sequence would produce a recognizable gravity "low". The detailed gravity survey shows no evidence of such a thickened salt mass in the area of the proposed well. This does not preclude the presence of a regionally uniform thickness of salt, with no lateral density variations, underlying the detailed survey area. The Ray reconnaissance gravity data show a pronounced minimal saddle centred some 24 miles west of the detailed survey near the westerly edge of Refraction Anomaly 'D'. This saddle is equivalent to a 10-mgal "low" superimposed on a hypothetical gravity maximum; this 10-mgal "low" is interpreted as being caused by intrusive salt.

The Map of Fault Anomalies (Plate 4) shows residual gravity anomalies which have been derived by graphical methods and which are of such a nature that they could originate from faulted structures. These anomalies have been contoured at a contour interval of 0.25 mgal. The contours show a continuous positive anomaly of 0.25 to 2.0 mgal trending west-north-westerly through the central area. Parallel trends of elongated and subround anomalies of 0.25 to 1.5 mgal are present over the northerly and southerly structural flanks. The distribution of maxima is similar to that of the Grid Residual map.

From past experience it seems doubtful that sufficient lateral density variations occur in the flat-lying post-Permian beds above the unconformity, (seismic phantom horizon 'B', at -2000 ft) to produce the anomalies. The nature of the anomalies indicates a maximum depth of some 4000 feet to their origin. Perhaps the anomalies represent shallow faulting; if so, they could be due to a fault system consisting of horsts and grabens over and parallel to the Barlee seismic structures, as shown on Plate 4. A similar, but simpler, fault system at Frome Rocks is largely confirmed by seismic methods. Barlee seismic data are interpreted, however, as showing a series of parallel, north-westerly-trending, down-to-the-east, normal faults transversely cutting the structure (Plate 7). Seismic and gravity results are, therefore, in fundamental conflict. Gravity alone cannot discriminate between faulting and other conditions that result in sharp, lateral variations of density, such as steep dip. The faults interpreted from gravity results are made with this reservation.

The Corrected Observed Gravity Map (Plate 5) shows Bouguer gravity contours after removal of components attributed to the possible faulted structures discussed above. The resulting comparatively gentle anomalies are, in general, attributed to regional structure. The steep westerly decrease in gravity, which terminates the maximal nose west of Reflection Anomaly 'A', is interpreted as the fringe of a gravity "low" caused by a possible salt mass underlying the westerly limits of Refraction Anomaly 'D'.

The Geologic-Gravity Section (Plate 6) shows a compilation of gravity, seismic, and aeromagnetic data along Line 15 of the detailed survey. It shows a geological representation of the structure based on the gravity interpretation. The cross-hatched zone shows the cross-section area of an anomalous mass whose effect would account for the corrected-observed component of the gravity. The body, assumed to be very long, is convex (upward) and is concordant with seismic phantom horizon 'C'. The cross-hatched outline consists partly of "basement" rocks from the aeromagnetic interpretation, and partly of older sediments; the basement rocks and the older sediments probably have approximately equal densities of about 2.7 g/cc. The form of the cross-hatched area is based on the assumption of a density contrast of 0.1 g/cc; therefore the density of overlying sediments is assumed to be 2.6 g/cc. Any mass of older sediments or basement material projecting appreciably above the regional basement configuration and surrounded by less dense sediments would produce a recognizable positive anomaly.

The structural interpretation proposes a pre-Permian unconformity at approximately -4500 feet. It is hypothesized that Carboniferous uplift exposed the crest of the structure to erosion. Permian sediments were then deposited unconformably over the truncated Carboniferous beds on the flanks of the structure and directly on pre-Upper Carboniferous beds across the crest of the structure. The processes of differential compaction and some salt flowage may have contributed to the total deformation. The postulated pre-Permian unconformity is restricted to the zone of structural deformation.

The Summary Map (Plate 7) illustrates the interpretive results of the gravity surveys. On the map are collated fault interpretations from seismic and gravity data, outlines of local structural anomalies, structural and gravity axes, the outline of a possible salt mass, and the outline of the basement structure at Barlee from the aeromagnetic interpretation. Plate 7 has been referred to in the previous paragraphs, so it is not necessary to discuss it further.

CONCLUSIONS

by

B.S. Gamill and N.C. Steenland

Gravity Meter Exploration Company

From the foregoing analysis, it is concluded that no appreciable mass of intrusive salt underlies the area of the detailed survey. A possible intrusive salt mass is indicated west of Refraction Anomaly 'D'; the low density of this mass causes the steep westerly gravity decrease in the western portion of the detailed survey. There may, however, be a uniform thickness of bedded salt at depth under the Barlee structure.

Structure in the younger horizons, as interpreted from gravity data, may be related at depth to a core of basement and older, denser sediments which may in turn include a buried reef of Precambrian or early Palaeozoic age associated locally with the basement "high". A density contrast of 0.10 g/cc for such a body lying at a depth of 7000 to 12,000 feet would closely account for the Corrected Observed Gravity anomaly.

The proposal that a well to test the Barlee structure should be located at Reflection Anomaly 'J' is supported by the gravity interpretation. Further, it is recommended that the well be drilled into the postulated older, denser sediments to ascertain their nature. It is expected that such a well would have to be deeper than 7000 feet.

REFERENCES

ELLIOTT, R.M.L., 1962: Geological report, Frome Rocks No. 1 Well, of West Australian Petroleum Pty Limited. Bur. Min. Resour. Aust. Petrol. Search Subs. Acts Publ. 8.

PUDOVSKIS, V., 1961: Geological report, Barlee No. 1 Well, of West Australian Petroleum Pty Limited. Bur. Min. Resour. Aust. Petrol. Search Subs. Acts Publ. 16.

APPENDIX 1

Calibration of Gravity Meter

Worden gravity meter No. 207 was checked against calibration stations in Brisbane, Queensland, before and after the Barlee gravity survey. The stations occupied for this calibration were stations later occupied by the Bureau of Mineral Resources in establishing a standard calibration range in Brisbane on 6th January, 1960; namely, B.M.R. Stations M.A. 1 and B.C.S. 2.

The difference in observed gravity between these two stations, determined by the Bureau of Mineral Resources, is 59.15 mgal. The differences in scale divisions between these stations, determined with Worden meter No. 207, were :

15th September, 1959: 587.8 scale divisions
9th November, 1959: 587.7 scale divisions

These values give a mean scale value of 0.10064 mgal per scale division.

APPENDIX 2

Additional data filed in the Bureau of Mineral Resources

The following additional data have been filed in the Bureau of Mineral Resources and are available for reference :

(i) Complete set of gravity meter field sheets compiled by L.J. Starkey, Geophysicist, Mines Administration Pty Limited.

(ii) Complete set of gravity meter field sheets re-compiled by Gravity Meter Exploration Company.

(iii) Complete set of gravity computation sheets compiled by Gravity Meter Exploration Company.

(iv) List of permanently marked gravity stations.

SEISMIC ANOMALY 'D'
SEISMIC ANOMALY 'A'
SEISMIC ANOMALY 'J'
ALSO FENTON REFRACTION LINE
ALSO FENTON REFRACTION LINE 'F'
From BROOME GREAT NORTHERN HIGHWAY
TO DERBY
LINE 1
LINE 5
LINE 10
LINE 15
LINE 20
122° 30'
122° 35'
122° 40'
122° 45'
122° 50'
17° 45'
17° 50'
17° 55'
2,770,000
2,760,000
2,750,000
2,745,000
DATE OF SURVEY OCTOBER, 1959
ELEVATION CORRECTION FACTOR 0·07 MILLIGALS / FOOT.
GRAVITY:
Reference Datum
(a) Barlee Gravity Survey
R.H.R Station 2275
Observed gravity value 978521·4 milligals
(b) R.H Ray Survey.
South-east corner of hangar at Broome Airport
Observed gravity value 978541·5 milligals
which established by Muckenfuss
Accuracy. 0 1 milligals
SURVEYING:
Reference Datum Horizontal and Vertical Control
(a) Barlee Gravity Survey.
R.H Ray station 2275 with an elevation
of 109·1 feet above MEAN SEA LEVEL.
(b) R.H Ray Survey:
Horizontal: Cooke's Pillar, Broome
8,229,290' N, 1,630,585' E
Vertical. B.M.R bench mark at Yeeda Hmstd.
(Tweedie, 1953)
Accuracy. Horizontal: Locations correct to within 1 ft per every
5000 ft of each 6 mile x 1 mile loop
Vertical: Within 0·5 ft. within each 6 mile x 1 mile loop
Method. Bearings - Theodolite
Distance - Chain
Elevation - Level and staff
SCALE
0 1 2 MILES
MONUMENTED STATION
R.H.RAY MONUMENTED STATION
GRAVITY MINIMUM
LOCALITY
BROOME
DERBY
Derby
Broome
LA GRANGE
MT. ANDERSON
17°
18°
19°
REVISIONS
WEST AUSTRALIAN PETROLEUM PTY LIMITED
PORTIONS OF BROOME SHEETS 5 & 6
PERMIT TO EXPLORE 30 H
BARLEE GRAVITY SURVEY
FIELD DATA FURNISHED BY WAPET
CANNING BASIN, AUSTRALIA
BOUGUER GRAVITY MAP
CONTOUR INTERVAL 0.2 MILLIGAL
ELEVATION FACTOR 0.07 MG/FT
DATA REDUCED AND CONTOURED BY
GRAVITY METER EXPLORATION COMPANY
HOUSTON TEXAS
2 FEBRUARY 1960
DR BY F.B.
TR BY F.B
CH BY D.J.
DATE
SCALE
PLATE I

122° 30′ 122° 35′ 122° 40′ 122° 45′ 122° 50′

17° 45′ 17° 50′ 17° 55′

2,750,000 2,745,000

SEISMIC ANOMALY 'D'

SEISMIC ANOMALY 'C'

SEISMIC ANOMALY 'A'

ALSO FENTON REFRACTION LINE 'A'

ALSO FENTON REFRACTION LINE 'Y'

FROM BROOME GREAT NORTHERN HIGHWAY

TO DERBY

SCALE

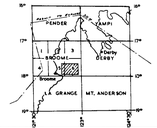
0 1 2 MILES

WCR 224 MONUMENTED STATION

2765 R.H.BAY MONUMENTED STATION

GRAVITY MINIMUM

LOCALITY



REVISIONS	WEST AUSTRALIAN PETROLEUM PTY. LIMITED
	PORTIONS OF BROOME SHEETS S.A.S. PERMIT TO EXPLORE 30

BARLEE GRAVITY SURVEY

FIELD DATA FURNISHED BY WAPET

CANNING BASIN, AUSTRALIA

GRID RESIDUAL MAP

CONTOUR INTERVAL 0·2 MILLIGAL

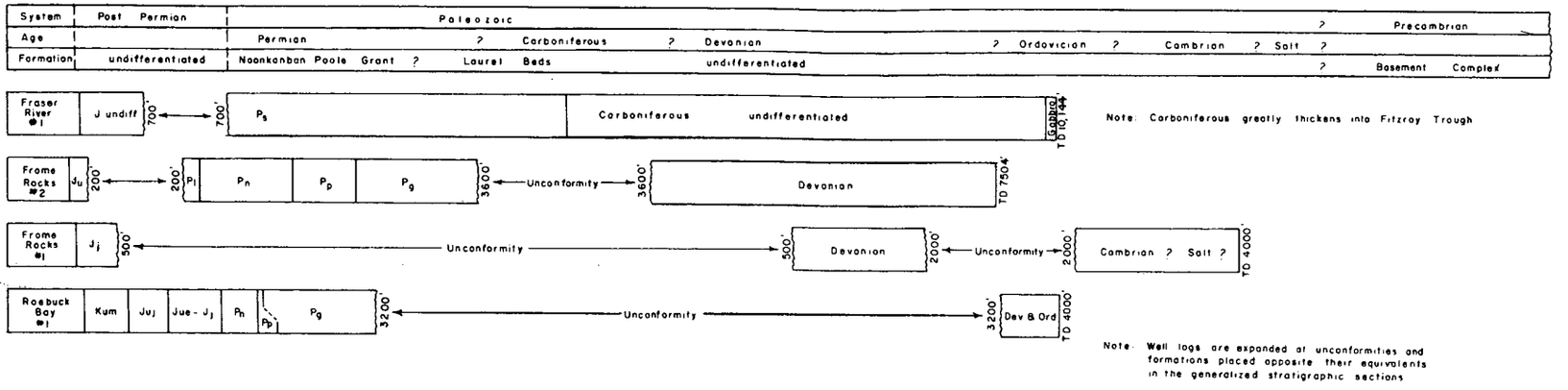
DATA REDUCED AND CONTOURED BY

GRAVITY METER EXPLORATION COMPANY

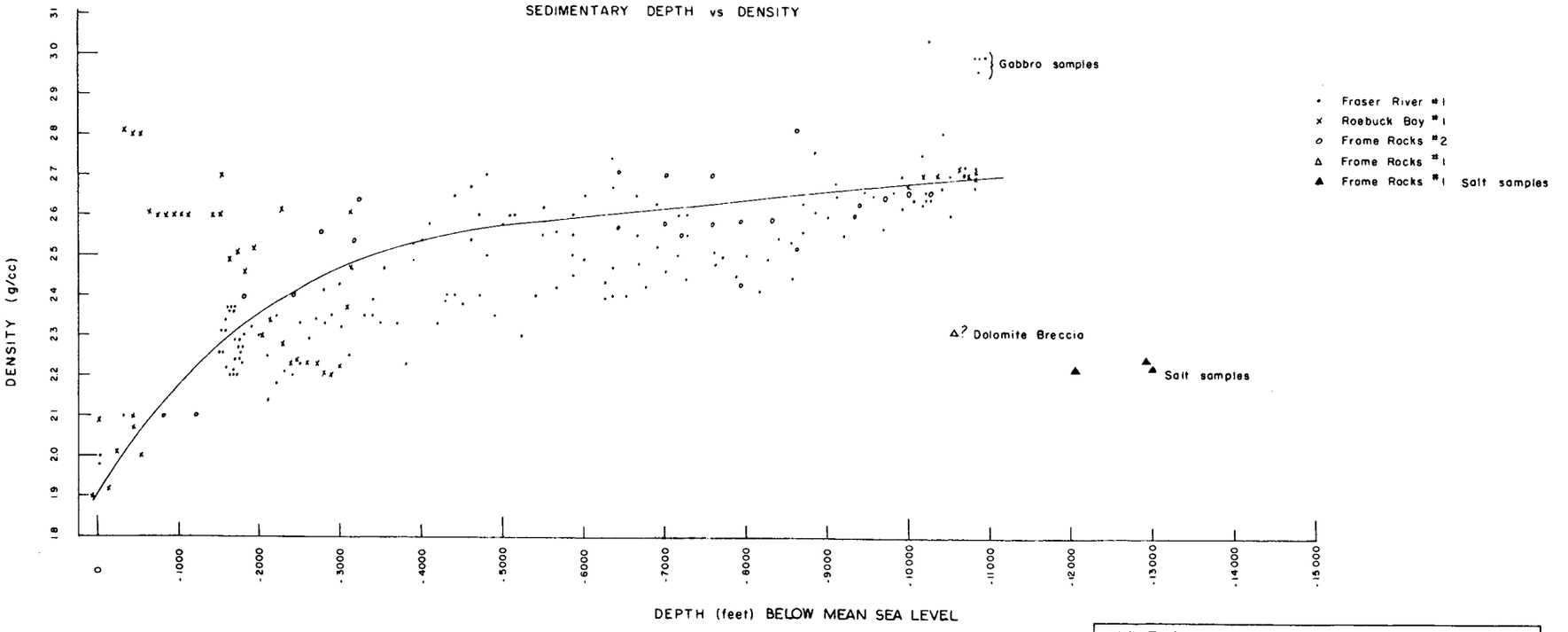
HOUSTON TEXAS 2 FEBRUARY 1960

DR. BY P.S.	DATE	SCALE	PLATE 2
CH. BY P.S.			
CH. BY D.T.			

GENERALIZED STRATIGRAPHIC SECTION FOR REGION SURROUNDING BARLEE PROSPECT
SUBSURFACE CORRELATION



SEDIMENTARY DEPTH vs DENSITY



WEST AUSTRALIAN PETROLEUM PTY LIMITED

CANNING BASIN AUSTRALIA

SEDIMENTARY DENSITIES

GRAVITY METER EXPLORATION COMPANY
HOUSTON TEXAS

PLATE 3

2 FEBRUARY 1960

122°30′ 122°35′ 122°40′ 122°45′ 122°50′

17°45′ 17°50′ 17°55′

2,770,000 2,760,000 2,750,000 2,745,000

565,000 570,000 580,000 590,000 600,000 610,000 615,000

ALSO FAULTING INTERPRETED LINE 'B'

ALSO FAULTING INTERPRETED LINE 'A'

SEISMIC ANOMALY 'D'

SEISMIC ANOMALY 'A'

SEISMIC ANOMALY 'J'

From BROOME GREAT NORTHERN HIGHWAY

GRAVITY MINIMUM

SCALE

0 1 2 MILES

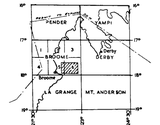
MONUMENTED STATION

B.M.R.M.P. MONUMENTED STATION

FAULT - PROBABLE

FAULT - POSSIBLE

LOCALITY



REVISIONS	WEST AUSTRALIAN PETROLEUM PTY. LIMITED
	PORTIONS OF BROOME SHEETS 5 & 6 — PERMIT TO EXPLORE 301H

BARLEE GRAVITY SURVEY

FIELD DATA FURNISHED BY WAPET

CANNING BASIN, AUSTRALIA

MAP OF FAULT ANOMALIES

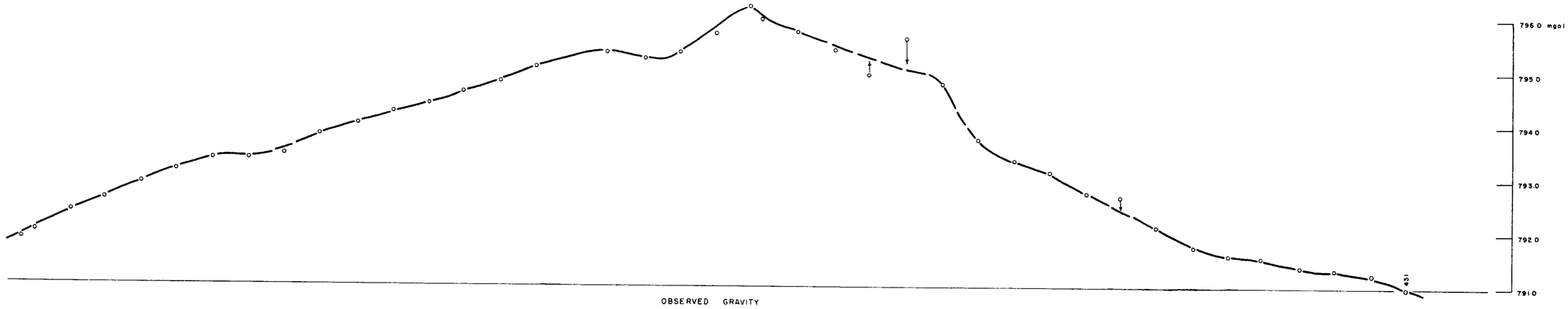
CONTOUR INTERVAL 0.25 MILLIGAL

FAULTS AT 3000 FEET APPROX

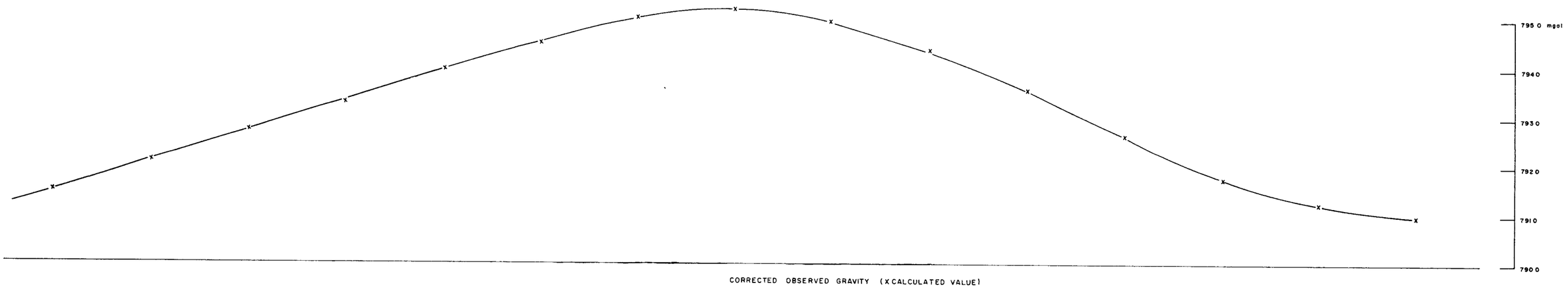
DATA REDUCED AND CONTOURED BY
GRAVITY METER EXPLORATION COMPANY
HOUSTON TEXAS
2 FEBRUARY 1960

DR. BY F.S.	DATE	SCALE	PLATE 4
CH. BY P.S.			
DR. BY D.T.			

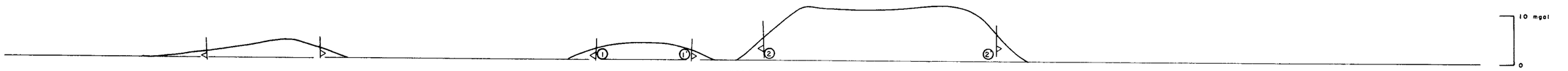
122° 30'
122° 35'
122° 40'
122° 45'
122° 50'
17° 45'
17° 50'
17° 55'
SEISMIC ANOMALY 'D'
SEISMIC ANOMALY 'A'
SEISMIC ANOMALY 'J'
ALSO FENTON REFRACTION LINE 'X'
ALSO FENTON REFRACTION LINE 'Y'
From BROOME GREAT NORTHERN HIGHWAY
TO DERBY
LINE 1
LINE 5
LINE 10
LINE 15
LINE 20
782.0
783.0
784.0
785.0
786.0
787.0
788.0
789.0
790.0
791.0
792.0
793.0
794.0
795.0
796.0
SCALE
0 1 2 MILES
WGB 228 MONUMENTED STATION
3766 R H RAY MONUMENTED STATION
LOCALITY
PENDER
YAMPI
BROOME
DERBY
Derby
Broome
LA GRANGE
MT. ANDERSON
PERMIT TO EXPLORE 30 H
REVISIONS
WEST AUSTRALIAN PETROLEUM PTY LIMITED
PORTIONS OF BROOME SHEETS 5 & 6
PERMIT TO EXPLORE 30 H
BARLEE GRAVITY SURVEY
FIELD DATA FURNISHED BY WAPET
CANNING BASIN, AUSTRALIA
CORRECTED OBSERVED GRAVITY MAP
CONTOUR INTERVAL 10 MILLIGAL
DATA REDUCED AND CONTOURED BY
GRAVITY METER EXPLORATION COMPANY
HOUSTON TEXAS
2 FEBRUARY 1960
DR BY F.B.
TR BY F.B.
CH BY D.J.
DATE
SCALE
PLATE 5



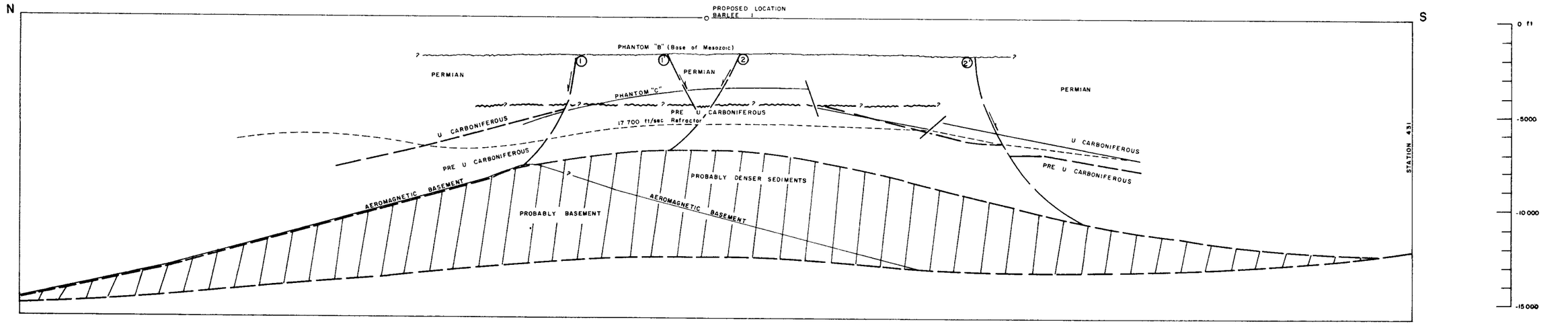
OBSERVED GRAVITY



CORRECTED OBSERVED GRAVITY (X CALCULATED VALUE)



POSITIVE RESIDUAL GRAVITY



ALONG LINE 15

SCALE
0 2 MILES

WEST AUSTRALIAN PETROLEUM PTY LIMITED

BARLEE AREA
GEOLOGIC-GRAVITY SECTION
CANNING BASIN AUSTRALIA

GRAVITY METER EXPLORATION COMPANY
HOUSTON TEXAS 2 FEBRUARY 1960

PLATE 6

INDIAN OCEAN

POSSIBLE SALT MASS

REFRACTION ANOMALY "D"

REFLECTION ANOMALY "A"

PROPOSED LOCATION BARLEE #1

REFLECTION ANOMALY "J"

REFLECTION ANOMALY "K"

REFLECTION ANOMALY "C"

-1000'

-2000'

-3000'

-4000'

GREAT NORTHERN HIGHWAY

BROOME

ROEBUCK BAY

LINE OF PROFILE

OUTLINE OF DETAILED SURVEY

17°30'

17°45'

18°00'

122°15'

122°30'

122°45'

123°00'

123°15'

FAULT FROM GRAVITY DATA AT 3000 FT APPROX.

FAULT FROM SEISMIC DATA AT 4000-6000 FT APPROX

STRUCTURAL ANOMALY FROM REFLECTION SEISMIC DATA

STRUCTURAL ANOMALY FROM REFRACTION SEISMIC DATA

POSSIBLE SALT MASS

STRUCTURAL AXIS FROM SEISMIC DATA

GRAVITY AXIS

LOCAL BASEMENT STRUCTURE FROM AEROMAGNETICS

SCALE

0 1 2 MILES

WEST AUSTRALIAN PETROLEUM PTY LIMITED

GRAVITY METER SURVEYS

BARLEE AREA

CANNING BASIN AUSTRALIA

BROOME SHEETS 5 & 6

SUMMARY MAP

INTERPRETATION BY

GRAVITY METER EXPLORATION COMPANY

HOUSTON TEXAS 2 FEBRUARY 1960

DATE	SCALE	PLATE 7