COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM SEARCH SUBSIDY ACTS

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TAMBO-AUGATHELLA AEROMAGNETIC AND GRAVITY SURVEYS, QUEENSLAND, 1959-1960

BY

MAGELLAN PETROLEUM CORPORATION

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

An aeromagnetic survey and a gravity survey were carried out under the Petroleum Search Subsidy Act 1959 in the Tambo-Augathella area of Queensland by Magellan Petroleum Corporation. This Publication deals with the results of these surveys and contains information furnished by Magellan Petroleum Corporation.

The final report of the aeromagnetic survey was submitted in two parts:

(i) a geological report and review of the interpretation, by H.I. Harris, Chief Geologist, Magellan Petroleum Corporation, and

(ii) a report on the geophysical interpretation of the survey results, by W.B. Agocs, R.R. Har nan, and C.E. Curtis of Aero Service Corporation.

The final report on the gravity survey was also submitted in two parts:

(i) a general report, by H.I. Harris, and

(ii) a report by Karl W. Abel, of Century Geophysical Corporation, dealing specifically with the interpretation.

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

J.M. RAYNER
DIRECTOR

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ILLUSTRATIONS

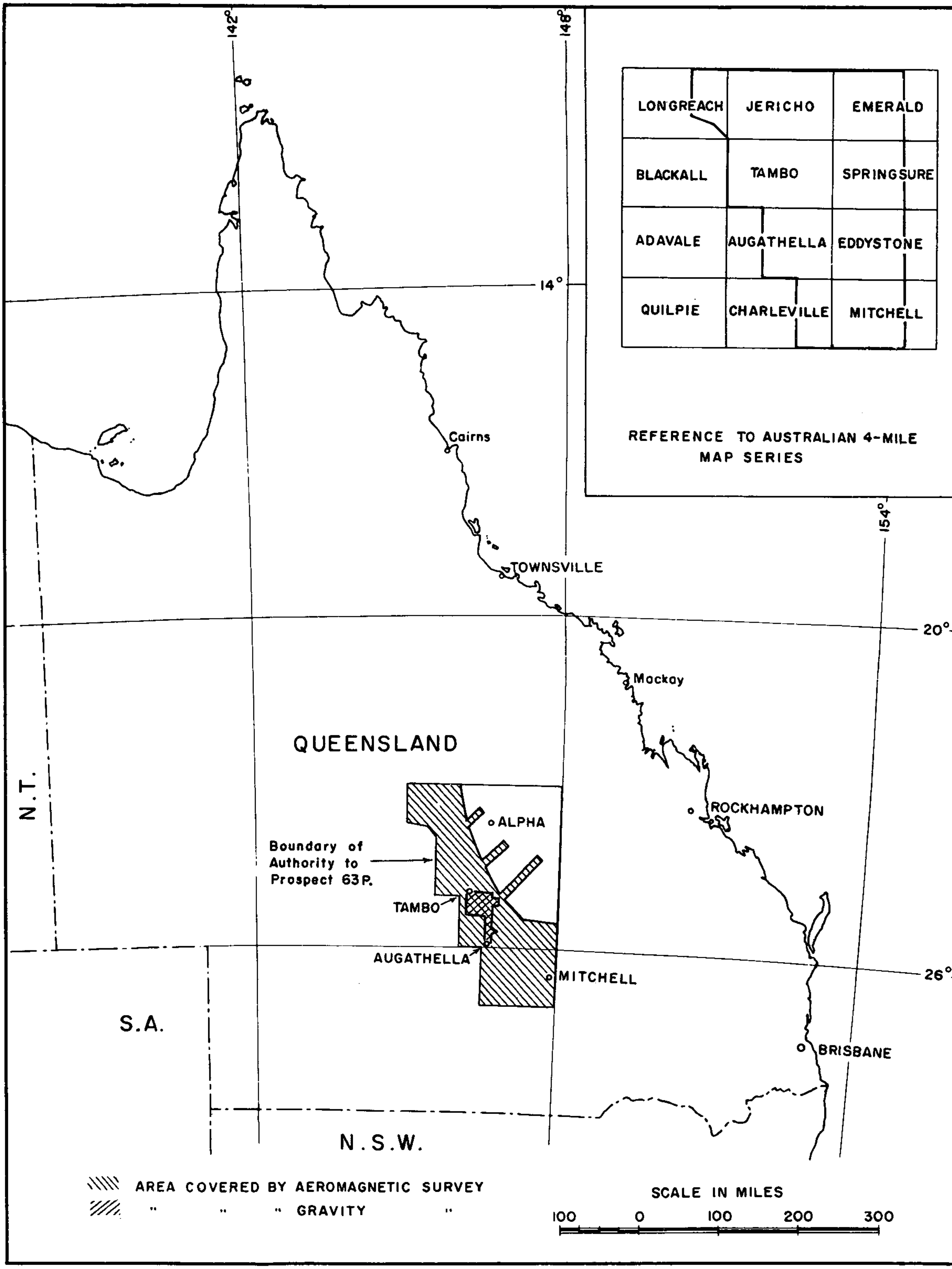

Fig. I. LOCALITY MAP

SUMMARY

An aeromagnetic survey and a gravity survey were carried out for Magellan Petroleum Corporation in the Tambo-Augathella area of Queensland in 1959-1960. The results of the aeromagnetic survey were reduced, studied, and interpreted by Aero Service Corporation, who had subcontracted Adastra Airways Pty Ltd, to provide the aircraft and also the flying personnel and associated ground staff. The gravity survey was done by Century Geophysical Corporation.

The main objectives of the two surveys were to delineate the thickness of the sedimentary rocks, and to investigate the major geological structures in the area.

The results of the aeromagnetic survey suggested the presence of several structures in the basement rocks. The Nebine Ridge appeared to be quite shallow over most of the area; major east-west trending faults were indicated. The results of the gravity survey did not fully agree with the results of the aeromagnetic survey. The gravity results indicate a central basinal feature bounded on the west by a platform, but the aeromagnetic results indicate deep basement on the north-west and only a few thousand feet of sediments to the south and east. These conflicting results indicate that some additional control, as would be obtained from wells drilled for stratigraphic information, is necessary for evaluation of the respective surveys.

INTRODUCTION

Magellan Petroleum Corporation was granted Authority to Prospect 63P[1] (see Fig.1) by the Queensland Department of Mines. To initiate the exploration of the subsurface of that portion of the prospect which forms part of the Great Artesian Basin, Magellan Petroleum Corporation engaged Aero Service Corporation, of Philadelphia, Pennsylvania, U.S.A., to carry out an aeromagnetic survey of approximately 25,250 square miles. The area covered by this survey is shown in Figure 1. Aero Service Corporation subcontracted Adastra Airways Pty Ltd, of Mascot, New South Wales, to provide the aircraft, a converted Catalina, and also the flying personnel and associated ground staff. The flying was carried out between 9th August and 10th October, 1959.

After the aeromagnetic survey had been completed, a gravity survey was undertaken during the period 1st January to 31st March, 1960, for Magellan Petroleum Corporation by Century Geophysical Corporation, of Tulsa, Oklahoma, U.S.A. The area selected for the gravity survey covered about 1000 square miles and was one in which the aeromagnetic results had indicated a moderate to thick sequence of sediments. The location (see Fig.1) of the gravity survey was between Tambo and Augathella.

The objectives of the airborne magnetometer survey were as follows:

(i) To determine the configuration of the crystalline basement and possible variations in its structure and composition. This would include information as to the depth to the crystalline basement, basement rock type, basement-controlled structure, faults, uplifts, and zones where extrusive and intrusive rocks occur at, or near, the surface.

(ii) To determine the thicknesses of the unmetamorphosed sedimentary rocks. The Mesozoic beds which underlie about two-thirds of the south-western part of the prospect effectively mask the Palaeozoic beds. It was understood that the survey would not indicate the ratio of Mesozoic to pre-Mesozoic, unmetamorphosed sediments, but it was hoped that a large thickness of sedimentary rocks would probably indicate that Palaeozoic sediments formed part of the sequence.

The purpose of the gravity survey was to obtain information on the thickness and distribution of the sedimentary rocks, particularly the Palaeozoic sequence, and to detect any intermediate to large structural features, worthy of further investigation by the seismic reflection method.

GEOLOGY

by

H.I. Harris

Magellan Petroleum Corporation

The area surveyed by the aerial magnetometer (see Fig. 1) had as its eastern boundary the Palaeozoic-Mesozoic outcrop which forms the eastern margin of the Great Artesian Basin.

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(1) Footnote: Authority to Prospect 63P was later re-issued as part of Authority to Prospect 80P, for a five-year term commencing 1st April, 1960.

The gravity survey covered a small portion of the aeromagnetic survey area. Cretaceous shales of the Roma Formation and Cretaceous-Jurassic sandstones of the Blythesdale Group dip gently to the west in the survey area. These sediments comprise the lower part of the sedimentary sequence in the Great Artesian Basin.

There is no evidence at the surface of folding in the Mesozoic rocks, except for some anomalous drainage patterns which may be an expression of very gentle warping.

Only the stratigraphic sequence from the surface to the uppermost aquifer (presumably an upper member of the Blythesdale Group) is well known. South Pacific Pty Ltd No. 1 (Birkhead) Well drilled about 22 miles north of Tambo, encountered a clastic, continental facies of Permian rocks lying on steeply dipping, indurated Palaeozoic rocks possibly of Carboniferous age. At Mitchell in the south-eastern corner of the survey area, Mesozoic sediments lie directly on metamorphic rocks. No deep drilling has been done in the Tambo-Augathella area and the section below the Mesozoic rocks is unknown.

Before the surveys commenced, all available geological data were reviewed and basement depths as recorded in water bores were used to prepare Figure 2, which is an interpretation of basement relief in the survey area. Control for this interpretation is reasonable only in the south-eastern corner of the map; elsewhere it is poor. The zone of shallow basement near Mitchell (Fig. 2) may be an extension of the Nebine Ridge (Whitehouse, 1945).

Photogeological mapping by Shell (Qld) Development Pty Ltd was reviewed by geologists of Magellan Petroleum Corporation, but no changes of regional significance were made.

A map (Fig. 3) has been prepared to show fold axes and faults, in both Mesozoic and pre-Mesozoic rocks. The subsurface contour map (Fig. 4) on the highest aquifer, (probably sandstones of the Blythesdale Group), was prepared from water bore records. This map confirms the gentle westerly dip of the Mesozoic sequence. The composite stratigraphic column (Fig. 5) was compiled from various sources, using maximum known thicknesses of Mesozoic stratigraphic units in the Great Artesian Basin and Palaeozoic units exposed on its north-eastern margin west and south-west of the Anakie "High". The section from S.P.L. No. 1 (Birkhead) to Mitchell Bore (Fig. 6) illustrates an interpretation of the regional stratigraphy of the survey area.

On the western flank of the Anakie "High", Permian sandstones and shales dip gently beneath the Mesozoic sequence of the Great Artesian Basin. Carboniferous and Devonian sediments on the south-western flank of the Anakie "High" are folded and faulted. Therefore unconformity between the Permian sequence and the Carboniferous - Devonian sequence seems probable.

The gravity anomalies recorded are regarded as either reflections of structure within a Carboniferous - Devonian sequence or compositional variations in pre-Devonian basement. The gravity anomaly near the western edge of the survey area is attributed to density changes in the pre-Devonian metamorphic or igneous rocks.

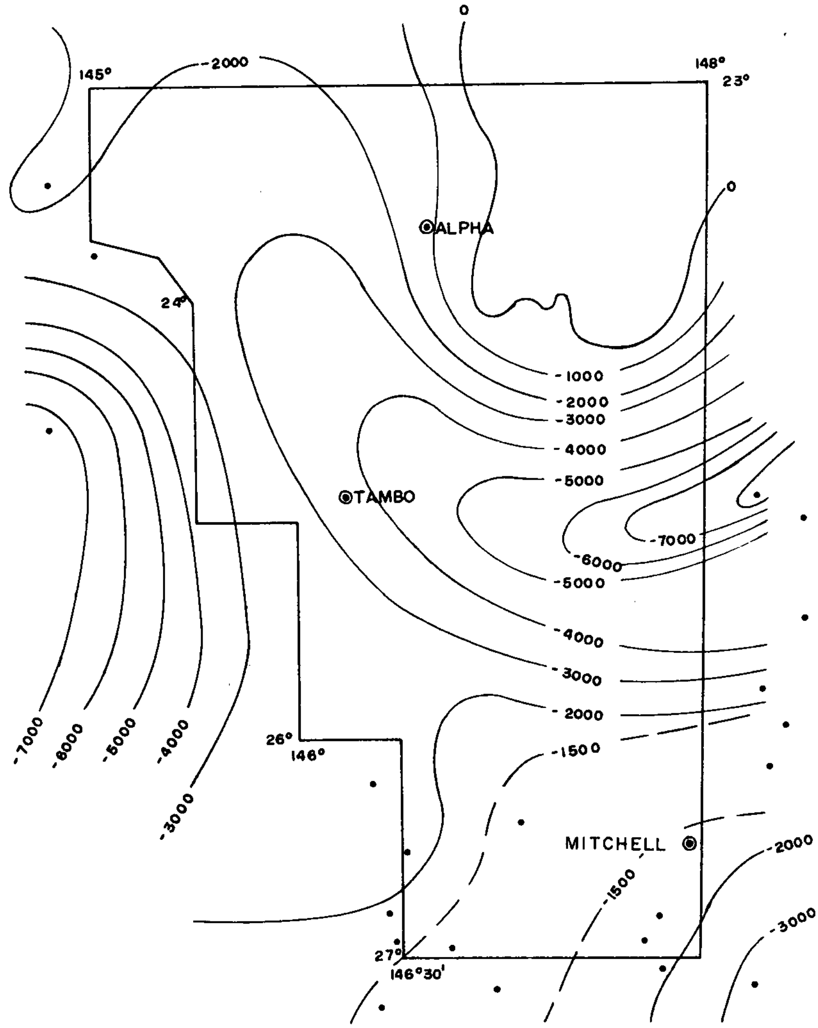
OPERATIONAL PROCEDURE FOR THE AEROMAGNETIC SURVEY

by

H.I. Harris

The profiles were spaced at approximately 3-mile intervals. Tie-lines, at right-angles to the profiles, were spaced at approximately 15-mile intervals. Perimeter control lines were flown along the boundaries of the survey area. Most navigation was made using R.A.A.F. and National Mapping photo-maps at a scale of 1 : 250,000 and 1 : 150,000 with

Fig. 2



MAGELLAN PETROLEUM CORPORATION

DEPTH TO BASEMENT
63-P AREA
Contour interval: 500 and 1000 feet.

◉ Town
• Bore hole
Source of data :- Queensland Irrigation and Water Supply Comm.

SCALE
0 20 40 80
MILES

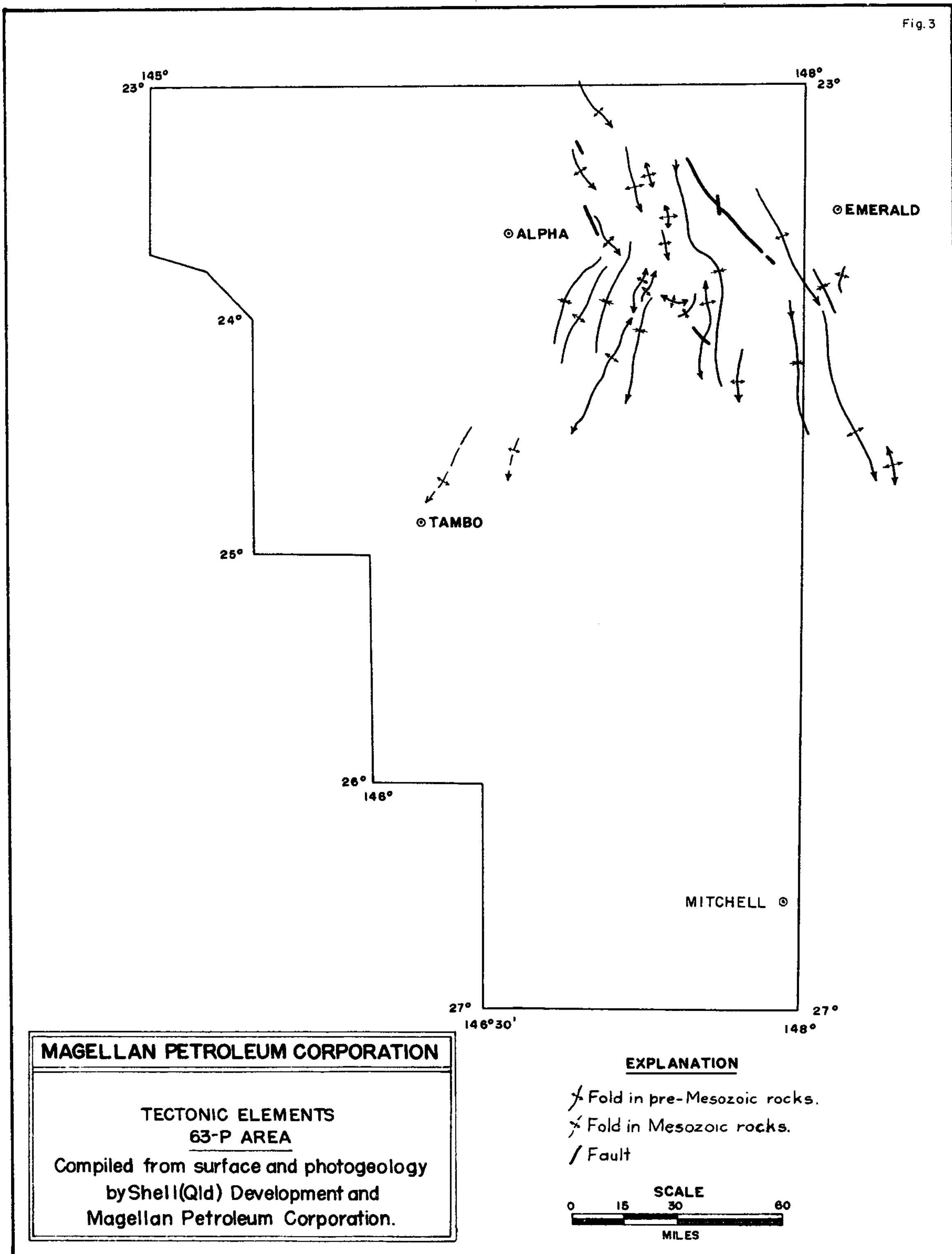
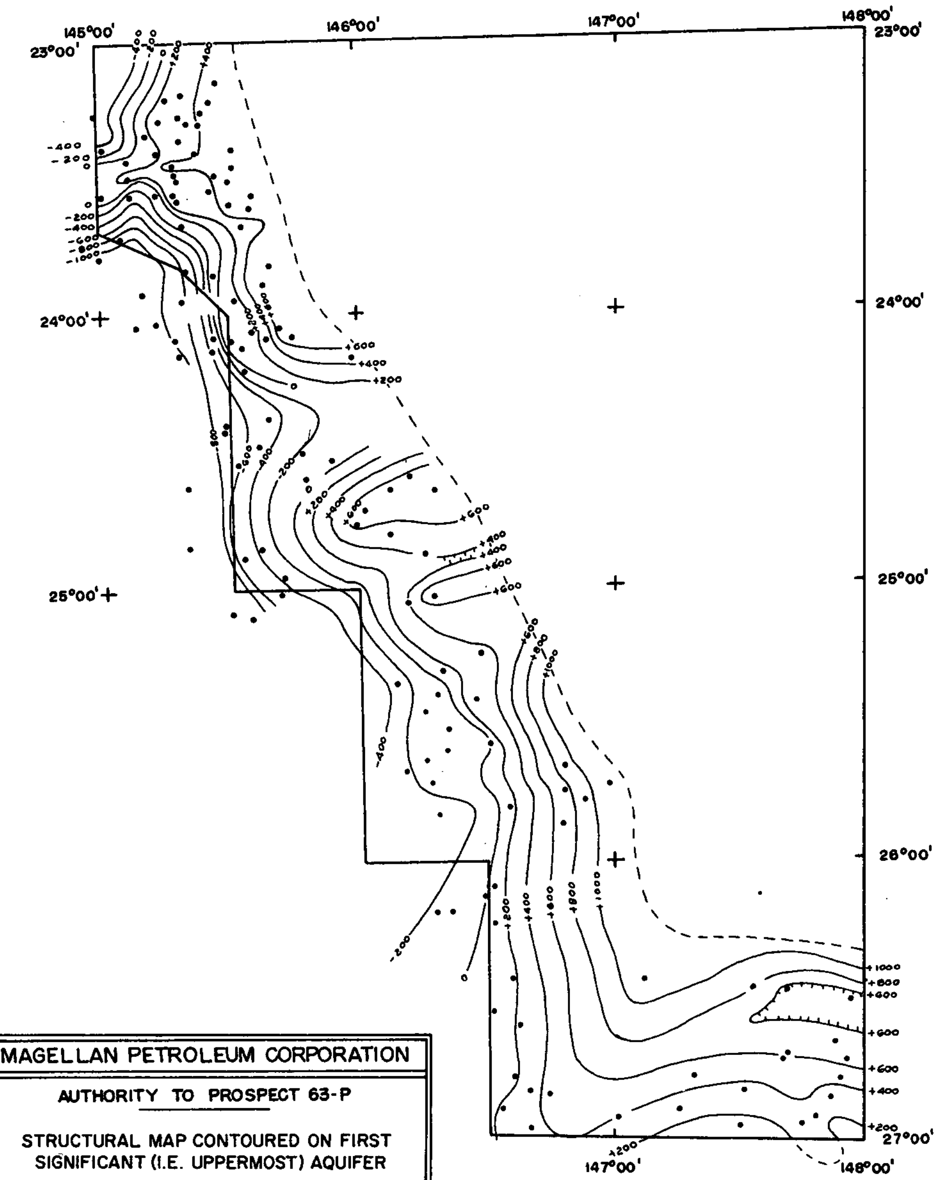


Fig. 3
145°
23°
148°
23°
24°
25°
26°
146°
27°
146°30'
27°
148°
⊙ ALPHA
⊙ EMERALD
⊙ TAMBO
MITCHELL ⊙
MAGELLAN PETROLEUM CORPORATION
TECTONIC ELEMENTS
63-P AREA
Compiled from surface and photogeology
by Shell (Qld) Development and
Magellan Petroleum Corporation.
EXPLANATION
Fold in pre-Mesozoic rocks.
Fold in Mesozoic rocks.
Fault
SCALE
0 15 30 60
MILES

Fig. 4



MAGELLAN PETROLEUM CORPORATION

AUTHORITY TO PROSPECT 63-P

STRUCTURAL MAP CONTOURED ON FIRST SIGNIFICANT (I.E. UPPERMOST) AQUIFER

DATUM-SEA LEVEL

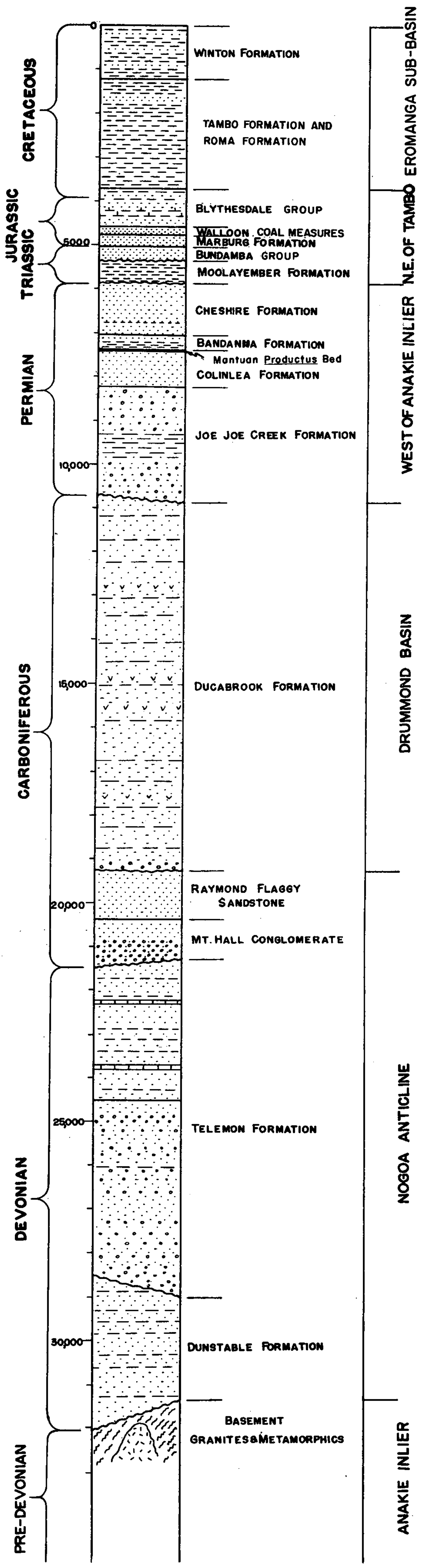
• CONTROL POINT

SCALE

0 16 32 64

MILES

Fig. 5



Source: Shell (Qld.) Development Pty. Ltd.
Reports filed at Queensland Geological Survey.

MAGELLAN PETROLEUM CORPORATION

COMPOSITE STRATIGRAPHIC COLUMN

SCALE
0 1000 2000 4000
FEET

predetermined flight paths delineated and flown. Air photographs at a scale of 1 : 25,000 and 1 : 50,000 were used for the final compilation. The camera used for flight-path recovery was a 35 mm single-frame camera which continuously photographed the flight path of the aircraft.

The magnetometer used was a Gulf Mark III total-field self-orienting saturable-core fluxgate magnetometer with a Leeds and Northrup Speedomax continuous chart recorder. The detector head of the magnetometer was housed in a "bird" which was towed below and behind the aircraft. The magnetometer sensitivity was 600-gamma full-scale deflection with a maximum permissible noise level of two-gamma envelope and drift less than five gammas per hour. Before the survey began, the magnetometer sensitivity was calibrated by means of a Helmholtz coil and the effect of aircraft magnetization was compensated for by adjustments made while flying clover-leaf patterns at a constant altitude over a known, identifiable point until the recorded field intensity, when flying on any cardinal heading, was constant within the specification of two gammas.

The flying altitude was 2500 feet above sea level. The actual terrain clearance of the aircraft was continuously recorded by an APN-1 radio altimeter and an Esterline Angus continuous-recording graphic recorder. Barometric variations were obtained from Government weather and airport radio stations both at the beginning of each flight and during flight. The aircraft was based at Longreach and later at Charleville.

Daily magnetic storm variations were continuously recorded by a Gulf total-field saturable-core fluxgate storm monitor. The operation of this equipment is similar to that of the airborne magnetometer except that, whereas the airborne instrument is equipped with orienting fluxgates, the storm monitor has only a detector fluxgate, which is manually aligned parallel to the earth's total field and records any variation of this field with time. Any variation which has a non-linear variation greater than five gammas in five minutes cannot be adjusted on the airborne magnetometer record, and all flights during which storm variations exceeded this specification were considered void.

All survey records were synchronized every four seconds by use of an intervalometer which produced fiducials on the magnetic record, the altimeter record, and the vertical camera film. The magnetic storm monitor record was correlated with the airborne magnetic record by use of time checks and the constant chart speed of the recording apparatus. The United States Government Radio Station WWV was monitored as a time standard for synchronization of all records.

RESULTS AND INTERPRETATION OF THE AEROMAGNETIC SURVEY

by

W.B. Agocs, R.R. Hartman, and C.E. Curtis

Aero Service Corporation

Data Compilation

The first step in the final compilation was the plotting of the actual flight paths on the maps of the area. The film image of the flight path was studied at the reference marks (fiducials), and corresponding points transferred to aerial mosaics of the area. The exact location of the flight traverse was thus tied to the ground with a positional error of less than one-tenth inch at the scale of the maps used.

The magnetic profiles were then reduced to a common datum. This involved making corrections for diurnal variation, instrument drift, and any minor changes due to different headings. The instrument drift and heading error were generally negligible, the latter because the aircraft was magnetically compensated, but the compilation technique used incorporates an automatic correction for drift and heading.

The corrections required to adjust the profiles to a common datum were made by relating the profiles along the traverses to the profiles along a series of control lines flown at right angles to the traverses, and spaced fifteen miles apart. The photographic method was used to find the points of intersection between the traverses and control lines. A statistical analysis of the pairs of apparent field intensity values recorded at the intersections was made to determine the relative magnetic level of each traverse.

The normal regional variation was subtracted from the aeromagnetic maps using the values listed in the Tables of the Carnegie Institution of Washington (Vestine et al.,1948) as a basis.

After the data were adjusted to a common datum, the arbitrary reference datum to be used on the entire survey was placed on the magnetometer chart, and the anomaly variation determined.

The aeromagnetic data were recorded at a constant chart speed of three inches per minute. This chart speed was chosen to give a horizontal scale approximately equal to the map scale at which data were to be compiled. In order to position the data at their exact scale position a transcriber was used. The interval between fiducial positions on the map was compared with the interval between the corresponding fiducials on the magnetic chart. The scale was adjusted so that the distance on the chart was converted to equal the corresponding distance on the map. The magnetic intensity level contour positions were then plotted along the flight paths and the contours drawn. In this process, the exact magnetic gradients were mapped along the flight lines, and the only interpolation was between flight lines.

This was followed by checking the preliminary or manuscript magnetic map. Level errors would be obvious from a "herring-bone" pattern in the contours, and the purpose of this checking was to determine continuity and actual positioning of contours, and to check the accuracy of the interpolation of magnetic features.

Finally, the magnetic contours were traced on linen, and contour values, borders, trim lines, co-ordinates, planimetric detail, and the title were added.

Interpretation Methods

The magnetic data were plotted on nine separate sheets at a scale of 1 : 126,720 (1 inch = 2 miles), using a contour interval of 10 gammas. Spot depths to magnetic basement were calculated from the data, and the interpretation in the form of basement contours, faults, etc., were superimposed on the magnetic contours. These individual sheets were assembled into a single map (Pl. 1). The planimetric and magnetic data are shown in black, and the interpretation in green. The individual sheets, bounded by one degree lines of latitude and longitude were numbered, and can still be identified. Copies of the nine original sheets have been filed in the Bureau of Mineral Resources and are available for inspection.

The results of the survey are discussed in two parts. The first part is based on the results from Sheets 1, 2, 3, 4, and 4A. The second part is based on the results from Sheets 5, 6, 7, and 8.

Key indices are given for the anomalous features or structures, the first part of the index is the number of the sheet and the second part is a letter referring to the feature.

All depths are based on sea level datum. The anticlinal and synclinal symbols are used here to represent positive and negative structural features as interpreted from the magnetic anomalies. They do not necessarily have the same meaning as if they appeared on a geological map.

"Geological contacts", which represent basement susceptibility contrasts, have been indicated on Plate 1 as a line with small hachures on one side.

Depth to basement was calculated by measuring the horizontal widths of the magnetic gradients of individual anomalies. For anomalies that were reasonably isolated and could be compared with the theoretical anomalies included in "Interpretation of Aeromagnetic Maps" (Vacquier et al., 1951), calculations were based on the method described in that publication. Most of the magnetic anomalies in the survey area were interpreted by this method.

Additional depth estimates were computed where a recognizable magnetic gradient occurs which is not associated with a theoretical-type anomaly, by measuring the width of the gradient and assuming it to be approximately equal to the depth of the source. Examples of this are the two depths of the order of 15,000 feet in the south-western part of Sheet 3, and the depth of 4400 feet in the south-eastern corner of Sheet 8. Such depth estimates are more tenuous than those derived by comparison with theoretical anomalies.

The contours on the postulated basement surface are based on the estimates of depth to basement.

Fault interpretation was based on a variety of criteria; an offset in an elongate anomaly or series of anomalies which, in the judgment of the geophysicist, would normally have carried through, may be attributed to horizontal displacement. A persistent, straight or gently curving gradient or a long, straight boundary between contrasting magnetic zones (as on Sheet 7) may be attributed to vertical faulting. An abrupt discontinuity in depth estimates (as in the central part of Sheet 3) may also be explained by vertical faulting. These criteria may also appear in combination, lending greater weight to the interpretation.

The most frequent source of the anomalous magnetic field is magnetite. Usually, basic rocks contain more magnetite than acidic rocks. The magnetite content of a rock largely controls its susceptibility, and the amplitude of an anomaly produced by a body is proportional to the susceptibility. Therefore, in this interpretation, areas of very gentle magnetic relief were attributed to rocks of acidic composition.

Contacts between rock units are based on the presence of contrasting magnetic patterns, dimensions of individual anomalies, their comparative amplitudes, shapes, and orientations. On Sheet 1, Plate 1, for example, rock contacts are postulated separating two broad zones of small magnetic relief from the rest of the area of that sheet, which is dominated by relatively strong and abrupt magnetic anomalies.

<u>Qualitative Analysis</u> Sheets 1, 2, 3, 4, and 4-A.

The northern half of the survey, constituting Sheets 1, 2, 3, 4, and 4-A, exhibits a rather erratic magnetic pattern. Most of the anomalies are roughly circular in shape, and many exhibit numerous slight pulls or trends. The general trend is from north-east to south-west, but this is interrupted by many local, abrupt changes.

With some exceptions, the anomalies become broader and less intense from east to west. This changing character is due to the basement being at a greater depth in the western region away from the crystalline rocks cropping out in the eastern region.

A basement contact which has been inferred from the magnetics, extends generally in a south-easterly direction across the sheets, with the exception of an area near the centre of Sheet 1, where it is interrupted by a south-westward projecting salient of the basement. This contact is shown by a hachured line on the interpretation map. The magnetic characteristics of the basement rocks to the east of the contact indicate that the basement is intermediate to basic in composition, and probably well-metamorphosed. To the west of this contact, the basement probably consists of a more granitic rock type. The magnetic trends here are less pronounced; hence, it is believed that a lower grade of metamorphism occurred.

A major fault, 1-B, 2-B, is indicated striking east-west across the central parts of Sheets 1 and 2. It is believed to continue also across the three-line band of reconnaissance profiles extending north-east from the centre of Sheet 2. It is located to the south-west of the two massive negative anomalies on the above band, and there develops a south-east trend. This fault is believed to be down-thrown to the south. Extending south-westward from the centre of this fault on Sheet 1, is a second fault, 1-G, which is believed to control, or at least partially control, the aforementioned basement salient occurring to the west.

The extreme complexity of the magnetic pattern in this area suggests the presence of more extensive faulting than has been shown previously. Additional possible zones of faulting have been indicated on the magnetic interpretation map trending south-east across the north-central part of Sheet 1 and east to west in the south-central part of Sheet 1. These faults have not been considered in the representation of the basement structure because of the difficulty in locating their exact positions.

A major fault, 3-A, 4-A, extends south-westward across Sheets 3 and 4. This fault is also believed to be down-thrown to the south. The trend is normal to the major structural features indicated by the outcropping igneous-metamorphic complex to the east. Many of the features occurring in the basin show a pronounced variance from the trends indicated in this complex, and it appears as though they may be controlled by the fault system which has been indicated on these maps in some detail.

Another fault, labelled 3-C, is located near the centre of Sheet 3. It is terminated near fault 3-A, and is based mainly on a rather abrupt change in the depths to basement. Fault 4-D is shown in the extreme south-eastern corner of Sheet 4. It is believed to be down-thrown to the north, and constitutes the southern limit of a graben-like structure which occurs between this fault and fault 3-A, 4-A.

Quantitative Interpretation Sheets 1, 2, 3, 4, and 4A.

The depths to basement on Sheets 1, 2, 3, 4, and 4-A support the observation that many of the major trends run counter to the regional strike observed in the igneous-metamorphic complex to the east.

In the northern half of Sheet 1, north of fault 1-B, a deep basin develops, the basement of which is believed to be about 7000 feet below sea level. Questionable depths in excess of 10,000 feet have been estimated near the central portion of this basin. A small anomaly, 1-C, on the north-eastern flank of the basin, has a source which lies at a very shallow depth. This anomaly, which could be caused by a small intrusive plug, effectively confuses the magnetic pattern in this area. The basement contact shown on the interpretation map relates this possible intrusion to the relatively basic rocks to the east. It is believed that faulting may be present along the eastern side of the basin. The basin is also interrupted by a small salient, 1-A, developing in the extreme north-west corner of the area. The southern boundary of this basin is terminated by the major fault 1-B.

In the north-eastern part of Sheet 1 and in the northern part of Sheet 2, there is a positive zone, the basement of which is about 2000 feet below sea level. East and west of this positive zone, the elevations of the basement are about 4000 feet below sea level. South of this positive zone, the depths to basement become gradually greater approaching fault 1-B, 2-B, and in the area indicated by 1-D the level of the basement may be greater than 5000 feet below sea level.

At 1-E, the nose of the aforementioned "high" in the north-east corner of Sheet 1 extends south-westward and is believed to be offset by the south-flanking fault.

South of the fault, in the extreme western part of Sheet 1, a high zone which may be a possible extension of 1-E, is indicated by 1-F. The depth to basement here is probably less than 3000 feet below sea level and, as shown on the magnetic interpretation map, this structure is believed to be controlled along its northern and eastern flanks by faulting (1-B, 2-B, and 1-G). East of the south-west striking fault 1-G is a basin area, 1-H, where the depth to basement is believed to exceed 10,000 feet below sea level. Occasional deep values have been determined on the north-eastern end of this structure (at 1-K) which are also in excess of 10,000 feet below sea level. The validity of these depth estimates is highly questionable; therefore, they have been disregarded in contouring the basement depths. These values may result from sub-basement facies changes in the crystalline rocks.

The general trends of this basin, the fault 1-G, and the "high" 1-F to the west, are not consistent with the structural trends of the remaining area of the survey. However, the basin, 1-H, may actually be only a small re-entrant of the larger basin area occurring to the west.

The remainder of Sheet 1 and Sheet 2 is dominated by three small structures of small area. The basement dips gently westward from the eastern side of the magnetic control on Sheet 2, where it is believed to be at a depth of around 4500 feet, to approximately 7000 feet in a small basin area located at 2-C, then rises again to a "high" of about 5200 feet at 1-J. This high zone and the complementary low to the east are based on limited evidence and may actually be a broad, gently dipping or shelf-like feature on the eastern flank of the major basin 1-H. Depth estimates on the profile band to the east range from 1000 to 1500 feet below sea level.

South of 1-J, the basement again drops to a possible maximum depth of 9500 feet. Here again, this information is based on limited evidence, especially on the western and south-western sides.

As described in the qualitative analysis, the anomalies on Sheet 3 are broad and very low in amplitude, indicating a generally deep basin. However, superimposed on these anomalies are some smaller, sharp anomalies whose origins lie at shallow depths. This magnetic pattern may be explained in two ways:

(i) Due to a structural "high" within the basement, as shown at feature 3-B on the interpretation map (Pl. 1), or

(ii) Due to a magnetic horizon within the sedimentary rocks, such as either a ferrous deposit or a shallow tabular body of intrusive or extrusive origin. The south-western side of structure 3-B is controlled by fault 3-C, which is down-thrown to the south-west. As previously stated, fault 3-C is based mainly on the large disparity between depths to the north-east and south-west. If the shallow depths to the north-east of this fault are caused by a source within the sedimentary rocks, then the actual basement would not include 3-B or the lower closure immediately to the north-east. Although these features have been shown as basement closures on the interpretation map, it is not known at this time which of these alternate hypotheses should take precedence.

Fault 3-C also forms the northern limit of wedge-shaped basin zone 3-D where depths in excess of 10,000 feet below sea level are indicated. Although this zone is flanked to the south by fault 3-A, it is an integral part of the major basin in the south-eastern part of the sheet.

The broad gradients south of fault 3-A are a reflection of this deep basin, which is believed to be in excess of 15,000 feet at the south-western extremity of the survey on this sheet.

On Sheet 4, the basement rises gently to the east, where two 'nosings' or salient-like features, 4-B and 4-C, are observed at the eastern limit of the magnetic control. They are separated by the north-eastern extension developing from the basin delineated on Sheet 3.

The Birkhead well, located on the northern flank of 4-C and drilled to a depth of 5186 feet, entered what is believed to be the basement rock at a depth of 5040 feet below the surface. Depths in this area are supported by this basement test.

A second band of reconnaissance profiles extends north-eastward from the "high" located at Birkhead. A magnetic control is insufficient to determine accurate depths but, near the centre of this band, the depth is found to be approximately 3500 feet below sea level. The character of the magnetic contours between the "high" located at Birkhead and this depth is indicative of a rather deep basement. However, no quantitative information as to depth could be obtained in this area. Towards the north-eastern end of this reconnaissance band, depth estimates of about 5500 to 6000 feet below sea level are obtained, indicating the presence of a small basin in this area. On the extreme north-eastern end of this band, depths to basement are believed to be about 1500 feet below sea level.

The basement dips to the south-west from the area of the "high" located at Birkhead to depths in excess of 7000 feet near Tambo in the south-western corner of Sheet 4. In the south-western corner of Sheet 3, the magnetic gradients produce numerous extremely large depth values. These depths are probably due to sub-basement anomalies and they may represent the depth to Precambrian rock beneath the metamorphosed Palaeozoic rocks. If the latter is true, then the depths would indicate a thickness of Palaeozoic rocks greater than 10,000 feet in this area. Geological reports state that the Middle Palaeozoic is highly metamorphosed on the eastern side of the Great Artesian Basin.

Features 1-D and 4-E are significant in that they may reflect minor basement relief or flexures in the sedimentary rocks. The relief of these features is likely to be from fifty feet to a few hundred feet, and is not shown in the basement contours.

On Sheet 4-A, three traverses are mapped and extend north-eastward from the limits of the survey into the igneous-metamorphic complex to the east. At the north-eastern end of these lines, the depths give surface indications. The depth estimates gradually become greater toward the centre of the magnetic control on this sheet. A small anomaly occurs near the centre of the southernmost of the traverses and is indicative of surface volcanic rock. The geological map shows Tertiary volcanics occurring in this area. On either side of this immediate zone, the depth to basement is difficult to determine because of broad anomalies which are insufficiently delineated by the limited magnetic control. However, it is believed that the depth to basement is in excess of 1000 feet, with the exception of a possible structure of indeterminate trend located towards the southern end of the central traverse, where a depth to the basement of 800 feet was recorded. From here the basement slopes gradually south-west to a point near the south-western corner of this sheet, where a depth to basement of approximately 5000 feet below sea level is obtained. This depth may be excessively great compared with indications in this vicinity on Sheets 5 and 6, where depths are less than 3000 feet below sea level. For this reason this depth has not been considered in contouring.

Qualitative Analysis Sheets 5, 6, 7, and 8.

These four sheets are characterized by broad, low-amplitude anomalies of 40 to 50 gammas, on which are superimposed sharper anomalies of 50 to 250 gammas. These sharp anomalies occur at random throughout the area covered by these sheets. In general, the magnetic pattern is complex with no persistent trends, with the exception of the area over the Nebine Ridge where some south to south-west continuity is developed. This continuity is expressed by a broad, roughly circular zone of relatively high amplitude, sharp anomalies occurring in the south-central part of Sheet 6 and extending into the north-central part of Sheet 8. The zone may be the magnetic expression of a relatively basic rock at a shallow depth. A basement contact delineates this zone on Sheet 6 and continues south-westward across Sheet 8. The magnetic control indicates that this zone may be interrupted and, in fact, may consist of three separate entities. This zone of anomalies occurs over the Nebine Ridge.

Two fault systems have been mapped on these sheets trending east to north-east. The first of these faults occurs in the north-west corner of Sheet 5 and is labelled 5-A. It continues into the northern block where it is labelled 4-D. This fault is down-thrown to the north and terminates the deeper part of the basin mapped on Sheet 4 and in the extreme north-west corner of Sheet 5. A second fault parallel to this one is shown extending from the south central part of Sheet 5. This fault is labelled 5-B, 6-A, and is down-thrown to the north. It comprises the southern limit of a series of magnetic and structural trends generally parallel to the igneous-metamorphic complex to the east. A third possible fault which may coincide with a basement contact is shown as 5-C, located in the south-central part of Sheet 5, and may be a north-westward continuation of fault 7-A, which trends north-westward across Sheet 7. Both 5-C and 7-A have been mapped as faults on the basis of discontinuity in the magnetic trend and the character of the magnetics themselves. Depth information does not completely support the existence of these faults. As previously stated, this zone may be a basement contact. South-west of fault 7-A, the rock type constituting the basement is probably similar to that beneath the Nebine Ridge and also on the eastern half of Sheet 4 and on Sheet 2. The possibility exists that the small closure 7-D, shown in the extreme south-western corner of Sheet 7, is a continuation of the Nebine Ridge which is offset to the north-west by faulting. However, termination of magnetic control to the south precludes the possibility of determining the exact nature of the Nebine Ridge in this area. It seems probable that the Nebine Ridge continues south of this fault, showing no offset.

Quantitative Interpretation   Sheets 5, 6, 7, and 8.

In the north-central part of Sheet 5, there is a south-west trending positive zone, 5-D, at a probable depth of less than 1000 feet below sea level. Progressing southward from this "high", a south-eastward trending negative, 5-E, has been delineated, and depths in excess of 5000 feet below sea level are obtained.

Immediately to the south-west of this feature is a positive closure, 5-F, with a maximum depth to the crest of about 2000 feet below sea level. This feature is indicated as having a closure of approximately 2000 feet, although this estimate may be excessive. South-westward from this positive closure, the basement slopes gradually down to a maximum depth which may be in excess of 10,000 feet below sea level in the south-western corner of Sheet 5.

South of the major fault 5-B, 6-A, and north of the Nebine Ridge, the structure, as delineated on the interpretation map, continues in a general trend from north-west to south-east. In the south-east corner of Sheet 5, and extending down into Sheet 7, a small negative zone, 5-G, occurs. This may be a continuation of zone 5-E located to the north of the fault. Zone 5-G has a maximum depth slightly in excess of 3000 feet. Two other significant features, 7-B and 8-A, have been outlined on Sheets 7 and 8 in the basin lying between faults 7-A and 5-B, 6A. 7-B is a positive zone with a closure probably greater than 2000 feet and the basement at the crest of the closure approximately at sea level. This closure may be due to an intrusive plug. A shallow basin, 8-A, is located immediately south-east of this "high" where a maximum depth of about 3200 feet below sea level occurs. The area of the basin mapped on these sheets is generally delineated by the 2000 - foot contour south of fault 5-B, 6-A.

The south-eastern boundary of this basin approximately follows the Nebine Ridge. The crest of this ridge is above sea level in the areas 6-B and 8-B. Elevations of the crest as much as 1000 feet above sea level occur in both of these areas and the small structural saddle occurring between 6-B and 8-B probably does not exceed 2000 feet. A small salient extending from this ridge and trending eastward toward the town of Mitchell indicates the presence of a positive area over which the Mitchell Bore was drilled. Closure is not indicated over this positive zone due to the termination of the magnetic control to the east. North of this positive zone, and extending along the eastern margin of the survey area, the basin becomes deeper and a maximum depth of 5000 feet below sea level was recorded in the south-east corner of Sheet 6. Again, termination of the magnetic control does not permit delineation of the remainder of this basin. 8-E, located within this basin to the north of Mitchell, is indicative of surface or near-surface volcanic material. South of Mitchell, the basement slopes down to a maximum of 7000 feet below sea level, again along the survey boundary. This basin is indicated by 8-C. A second small basin, 8-D, also reaches approximately 7000 feet below sea level. These two basins are separated by a small ridge at a maximum depth of about 5000 feet below sea level.

Progressing westward from feature 8-D, the basement rises rather sharply to the Nebine Ridge.

West of the fault 7-A, a high closure, 7-D, has been delineated on the interpretation map with the maximum elevation of the source being approximately sea level. This feature trends approximately north-eastward parallel to the Nebine Ridge. To the north-west of this closure the basement drops off gradually to a maximum of about 3000 feet below sea level along the western boundary of the survey.

From this limited area of study, evidence seems to place additional significance on the erratic anomalous pattern, as stated below.

The very complex fault system or systems located on Sheets 1 and 2, the associated shifts in the magnetic anomaly pattern, and the superposition of small amplitude anomalies of small area on broad features in the zone encompassed by Sheets 5 and 7, can be interpreted as resulting from two or more tectonic elements.

With regard to the two sets of anomalous trends in the northern block of four sheets, it is observed that one set runs approximately parallel with the trend of the crystalline outcrop to the east of the survey area, while the other set is approximately at right angles to it. At fault 3-A, 4-A, and again at fault 5-B, 6-A, a second fault, in each case, truncates the major north-east to south-west trending fault. This may be indicative of the relative ages of these two tectonic events. That is, the earlier event created structures which are transverse to the trend observed in the crystalline complex, and the more recent event was responsible for structures parallel to the crystalline complex and, possibly, for the structure of the crystalline complex itself. The intense metamorphism of the Palaeozoic rocks on the eastern side of the Great Artesian Basin could be attributed to this latter set of forces.

Summary and Conclusions

The structures discussed in this interpretation probably occur, in most cases, in the basement; to be considered as petroleum prospects they must be reflected in the overlying sedimentary rocks.

The following features appear to be the most promising:

(i) The major faults trending generally east-west. These seem to be the most prominent controlling factors in the area.

(ii) Feature 1-F, an elongate structure trending north-east along the western side of Sheet 1.

(iii) The possibility of a small high closure at feature 1-J trending north-south in the south-east corner of Sheet 1.

(iv) Feature 3-B, providing it is basement controlled. However, as shown above, this feature may be due to a magnetic horizon within the sedimentary rocks.

(v) Additional structures which could be located by other geophysical methods on the nosing associated with 4-C where two wells have been drilled.

(vi) The possibility that feature 5-F, even though it seems at this time to be an intruded mass, may have associated structures in the form of a flexure over it.

(vii) The Nebine Ridge as indicated is quite shallow over most of the survey area; however, some parts may be of interest, such as the suggestion of structure in the contours south of 6-B.

(viii) The possibility that the zone between 8-C and 8-D may be significant, though rather limited control and some near surface anomalies have obscured the exact nature of the structure.

(ix) The minor indications of a closure on the extreme western edge of Sheet 7, west of fault 7-A. This feature again may be in the sedimentary rocks in the form of a magnetic horizon, in which case the possibility of a structure within the sedimentary rocks is severely curtailed.

OPERATIONAL PROCEDURE FOR THE GRAVITY SURVEY

by

Karl W. Abel

Century Geophysical Corporation

Operational Procedure

For the gravity survey of the area, a general reconnaissance pattern was used. Nearly all the traverses were along roads, tracks, and fire-breaks. Approximately 75 percent of the region is open downs country. The country east of the Tambo-Augathella road is heavily wooded and hilly. The area was readily accessible using four-wheel-drive equipment.

Two Zeiss automatic levels equipped with compasses were used for the surveying. A levelling accuracy of $0.3\sqrt{m}$ ft, where m is the length of the traverse in miles, was maintained throughout the survey. The misclosure in elevation was distributed along each traverse. Elevation datum was established from Department of the Interior bench marks at Tambo and Augathella. Horizontal control was established from two astro-stations, namely a State astro-station in Tambo and a National Mapping astro-station in Augathella. A "double run" control line from Tambo to Augathella was established at the beginning of the survey and all loops were related to this control line.

1449 gravity stations were established, each of which is marked with a 2" x 4" aluminium tag. Permanent stations, which were set approximately 8 miles apart, were marked with iron bolts 24" long driven in the ground approximately 18" or placed on a main road bench mark. Sketch plans and station descriptions were prepared.

"World-Wide" gravity meters Nos 29 and 38 were used. They were calibrated on Bureau of Mineral Resources Stations in Brisbane. The gravity values are based on pendulm stations at Roma and Longreach.

Base loops were run so that loop closures could be made. The drift of the gravity meter was distributed on a linear time scale, the meter normally being checked at base stations every two hours. The computations of the basic data were made in the field office in Tambo and in Tulsa, Oklahoma.

DENSITY DETERMINATIONS AND REDUCTION OF RESULTS OF THE GRAVITY SURVEY

by

H.I. Harris

Density Determinations

The gravity method is based on the measurement of small variations in the earth's gravitational field caused by lateral changes in mass distribution. In interpreting the gravity data, it is necessary to know the density of the various rocks.

No rock samples from the area were sent for density determinations. However, the following density determinations had already been made on samples from other parts of the Great Artesian Basin, including some from South Australia, and were available from information supplied by the Bureau of Mineral Resources.

Rock Densities in the Great Artesian Basin

1. F.-B.H. Wyabba No. 1 Well, 1957

Carpentaria Region, Northern Queensland

Specimen No.	Type/Formation	Depth (feet)	Density (g/cc)
(i)	Grey shale, Tambo Formation (?)	1155 - 1156	1.93
(ii)	Carbonaceous grey shale, Tambo Formation	1692 - 1693	1.93
(iii)	Dark greyish mudstone, (shale), Roma Formation	2229 - 2230	2.12
(iv)	Greyish, fine-grained sandstone, Blythesdale Group	2634 - 2635	2.27

2. Haddon Downs Well No. 1, 1958

South-west Great Artesian Basin, South Australia

(v)	Soft greyish-greenish clay	400	1.92
(vi)	Soft greyish-greenish clay	443	1.76
(vii)	Soft greyish-greenish clay	463	1.82
(viii)	Soft greyish-greenish clay	511	1.80
(ix)	Grey-greenish sandy clay	533	1.83
(x)	As above, with carbonaceous plant remnants	553	1.67
(xi)	Soft grey-greenish clay	574	1.94

3. Density profile in vicinity of Haddon Downs Well

(xii)	Formation composed of sandstone and shale with white and coloured siltstone		1.9
(xiii)	"Duricrust" layer, silicified shale		2.4

The average density of the Mesozoic rocks in the Tambo-Augathella area is likely to be similar to the average density of the Mesozoic rocks found in the Wyabba and Haddon Downs Wells. The density of the rocks below the Mesozoic rocks in the area covered by the gravity survey is not known; however, it is reasonable to assume that it is greater than that of the Mesozoic rocks.

Reduction of Results

Latitude corrections were determined from the formula based on the International Ellipsoid.

The Bouguer correction factor was 0.07 milligal per foot (mgal/ft) which corresponds to a rock density of 1.9 g/cc. The elevation correction applied was a combination of the Bouguer correction and the free-air correction.

The gravity data were reduced and plotted and they are shown as Bouguer anomaly contours on Plate 2 with contour values in milligals and a contour interval of 0.2 mgal. A milligal is equivalent to approximately one millionth of the earth's normal gravity. The geographical co-ordinates, principal towns, and permanent gravity meter stations are shown on the map. Local anomalous areas are designated by numbers for reference purposes.

The following information has been filed in the Bureau of Mineral Resources, and is available for reference:

(i) Gravity meter data computation sheets and drift curves.

(ii) Locality plans and descriptions of all base and permanent stations.

(iii) Gravity base value map and control traverse from Winton to Roma.

(iv) Elevation loop closure map.

(v) Tables of Principal Facts for all gravity stations.

(vi) Bouguer anomaly contours on a scale 1 : 48,000 (5 sheets).

INTERPRETATION OF THE GRAVITY SURVEY

by

Karl W. Abel

Introduction [2]

The basic assumption made in this interpretation is that gravity maxima are indications of the uplift of land areas. [3] This assumption holds true except where a low density stratum, such as salt, is a factor in structural movement. The results of the North Winton Gravity Survey, Queensland, 1959, (Magellan Petroleum Corporation, P.S.S.A. Publication No. 30) were compared with the results of a previous aeromagnetic survey in that area, and the comparison raised some doubt as to the validity of the above assumption.

The interpretation of this survey was made without the aid of any auxiliary information, such as structural data, geological map, or magnetic coverage. Further interpretation should be made when more information is available.

The method of interpretation is dictated by the degree of control achieved. It was felt that only deep-seated anomalies which cover a large area were worthy of consideration as "prospects". Consequently, a reconnaissance or regional survey was run in which some of the loops were as large as 5 x 7 miles. In general, this type of control will detect all anomalies which are the result of density contrasts at deeper levels or which cover a large area. Such large loops however, will not delineate precisely the anomalous areas. The maximum anomalous areas are outlined on Plate 2. Some of the anomalies may show composite effects of smaller structural features. It was considered more logical to outline the larger of the maximum anomalous areas than to attempt to outline the small individual components within them.

The fact that an anomaly covers a large area does not necessarily indicate a deep density contrast. In fact, one of the weaknesses of a survey involving large loops is the lack of resolving power with respect to individual, local anomalies. Thus, two or more anomalies having small areas may have a combined effect which simulates the effect of one large anomaly.

One criterion of the depth of the density contrast from which an anomaly originates is the sharpness of the anomaly. Small, sharp anomalies must necessarily be caused only by masses at shallow depth. Consequently, if anomalies originating at relatively shallow depths

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(2) Footnote by the Bureau of Mineral Resources:

In this section, the results of the gravity survey are discussed by Karl W. Abel. His interpretation was made before the results of the aeromagnetic survey were known.

In the next section H.I. Harris discusses the results of both geophysical surveys. He gives possible reasons for any contradictions where the magnetic and gravity surveys do not produce mutually supporting results.

(3) Footnote by the Bureau of Mineral Resources:

It should be pointed out that gravity anomalies arise also from other causes e.g. density contrasts in the basement and in the sedimentary rocks of the basin. These factors are referred to by the same author elsewhere in this report.

are to be discriminated against, small loops with a resultant high density of stations are dictated. These small loops would not aid in detecting any additional anomalies of large magnitude, but would permit the interpreter to discern anomalies of shallow origin.

The limitations of the gravity method in defining subsurface structures have been described fully in an article by Skeels (1947) which indicates how widely different mass distribution can result in the same gravity anomaly. There is a need for other information aside from the gravity data to reduce the ambiguity which, at this stage, is inevitable in the interpretation.

Residual or derivative maps were not computed. The large loops result in a smoothing of the contours over the anomalies and tend, therefore, to make all anomalies appear to be of regional character. The separation of regional from local anomalies is an impossibility when there is no standard as to what constitutes regional and what constitutes local anomalies.

It is true that a residual map can be constructed from any contour map. The residual map will show closed contours in those areas in which the Bouguer anomaly map shows only noses and changes of gradient. These closures may have more meaning to a geologist and there may be a tendency to rely upon this map rather than the original Bouguer anomaly map from which the residual map was constructed. Also, the residual method does not discriminate between controlled and uncontrolled contours. Consequently, the computed map may indicate resolution not defined on the Bouguer anomaly map. The limitations of the residual method may be disregarded and much of the value of the survey may accordingly be lost. A second derivative map would be technically incorrect since it resolves anomalies of small area and consequently demands close spacing of the gravity stations.

<u>Regional Features</u>

The central portion of the district covered by the survey is dominated by a regional minimum. This portion is characterized by anomalies of relatively low magnitude extending over large areas, whereas the flanks of the surveyed area are characterized by relatively sharp anomalies of high magnitude. These sharp anomalies are typical of those in areas where the basement is at a relatively shallow depth of 4000 to 5000 feet, and the large magnitude of some of these anomalies may be an indication of density difference within the basement and not related to structure.

It was felt that an optimistic attitude should be maintained and, unless evidence is produced to disprove this opinion, all anomalous areas should be considered as structural features. In particular, the relatively small change in gravity gradient in the central portion is considered as indicating the deepest part of a basinal configuration.

The strong maximum area covering Prospects No. 1, grade C [4], and No. 2, grade A, are taken as representing an anticline or platform area. The strong gradient in a narrow zone parallel to the -24 milligal contour and the steep gradient at the position of Tambo may be caused by extremely steep dip or by faulting.

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(4) <u>Footnote:</u>

The anomalous areas have been designated by numbers for reference purposes and by the grades A,B, and C to indicate the relative value of each anomaly, with A being the strongest grade.

Local Prospects

In addition to those anomalies which have been indicated, there are other maximum anomalies of lower magnitude. At this stage of exploration it is felt that only the more prominent anomalous areas should be defined.

Prospect No. 1, grade C, and Prospect No. 2, grade A, combine to form a large maximum area along the western edge of the survey. Prospect No. 1, grade C, is much weaker than Prospect No. 2, grade A, but has sufficient magnitude to warrant consideration as a separate anomaly. Prospect No. 2, grade A, is not completely defined. Its magnitude is such that it may be the result of changes in density in the basement. The very marked change in gradient occurring along the -24 milligal contour on the eastern side of the prospect may indicate faulting, down-thrown to the east.

Prospect No. 3, grade B, covers a large area. This fact, coupled with its regularity, indicates that this anomaly is caused either by a large mass or by a high density contrast at great depth.

Prospect No. 4, incomplete, has been shown with two asterisks indicating the probable centres of individual anomalies whose overlapping effect results in the large anomaly as indicated on Plate 2. The sharpness of the changes in gradient, as indicated by the asterisks, indicates a much shallower or smaller mass causing this anomaly than the mass causing Prospect No. 3, grade B.

Prospect No. 5, grade C, is the anomaly of lowest magnitude indicated on Plate 2. Some of the magnitude of this anomaly is masked by its position relative to a large area of low gravity. A profile drawn east-west through Prospects No. 5, grade C, and No. 6, grade C, indicates a deviation from an assumed regional gravity of approximately 0.5 milligal. This type of anomaly may be more promising because it could be caused by density changes within the sedimentary rocks.

Prospect No. 6, grade C, is comparable to the previous anomaly, but is somewhat larger both in magnitude and in area.

Prospect No. 7, grade A, has been given the higher grade because of its magnitude.

Prospect No. 8, incomplete, Prospect No. 9, incomplete, and Prospect No. 10, incomplete, are all strong leads along the borders of the survey. These are merely indications of the most prominent anomalies along the borders of the survey but are not sufficiently detailed to outline fully any anomalous area. Additional indications of probable but less attractive anomalies occur such as those immediately south and north of Prospect No. 4, grade C.

Conclusions

The regional pattern is dominated by the large minimum area which prevails throughout the central part of the survey and indicates a basinal configuration. The most promising area in which to start a seismic survey would be the one covered by Prospects No. 5, No. 6, and No 7. After such a survey, this interpretation of the gravity work should be reviewed.

GENERAL DISCUSSION OF RESULTS

by

H.I. Harris

Aeromagnetic Survey

The interpreting geophysicists conclude that at least two distinct tectonic events are represented in the survey area. These are expressed by off-setting fault systems. The younger tectonic event may have produced the present trends in the crystalline complex outcropping to the east of the survey area.

A further broad generalization which canbe made is that the greatest thicknesses of sediments accumulated in grabens and over down-faulted basement blocks.

Water bore records indicate that in the south-eastern corner of the area, depth to basement as calculated from aeromagnetic data is more than twice the actual depth. It is unlikely that this order of error is consistent throughout the area. The geophysicists have pointed out that in some places the depth estimates are very poorly controlled, and in those places where control is particularly poor, contouring has not been attempted. Doubts concerning depth estimates are attributable to the possibility of the presence of igneous rocks within the sedimentary sequence, possible compositional changes in the crystalline basement, and possible confusion of metamorphosed Palaeozoic rocks with the upper unmetamorphosed sedimentary rocks. In the area south of Mitchell, the basement is interpreted to drop rather sharply to beyond 7000 feet below sea level. However, information from bores indicates relatively thin sediments (less than 3000 feet) throughout the extreme south-eastern corner of the area surveyed. From the Mitchell Bore it is known that "basement" at Mitchell is a phyllite which was probably originally a shale. It thus appears that in this area the magnetometer is measuring the depth to the contact of the metamorphic rocks on igneous rock. It may well be that many of the indicated areas of thick sedimentary rocks include metamorphosed Palaeozoic rocks.

Faulting indicated by the magnetometer survey is interesting in that the east-west trend shown by several of the major faults is not known in the Carboniferous and younger rocks. From Figure 3, in which known tectonic elements are shown, the east-west trends are clearly older than Carboniferous. Thus it is probable that the east-west faults shown by the magnetometer are faults in the basement. Basement, in this case, would include all rocks older than Middle Devonian. The north and north-east trending faults are probably pre-Permian.

The delineation of the Nebine Ridge by the airborne magnetometer compares favourably with the basement map drawn from information from bores (Fig. 2). However, as only a very thin veneer of sedimentary rocks overlies basement along the Nebine Ridge, even slight changes in the mineralogy of the basement could cause an incorrect interpretation to be made. In this case, the basement under the Nebine Ridge apparently changes very little.

The subsurface contour map on the uppermost aquifer (Fig. 4) shows a regional gentle westward dip of an upper member of the Blythesdale Group. Therefore, faults indicated by the magnetometer are older than the deposition of the Blythesdale Group.

Confident interpretation of this aerial magnetometer survey has not been possible but basic data have been recorded and contoured, and an interpretation offered. It is known that the basic readings made by the magnetometer reflect anomalies due to regional variations in the rocks but our knowledge of these rocks is very scanty at present. As a result, we are sure this interpretation should be reviewed in the light of any new drilling or geophysical work in this part of the Great Artesian Basin.

Gravity Survey

The limited coverage of the gravity survey does not permit regional comparison with the aeromagnetic survey. However, the strong gravity change on the eastern flank of Prospect 2-A which Karl W. Abel suggests may be attributed to faulting, partly corresponds with the "possible fault zone" on the magnetic map (see Pl. 1).

The gravity anomaly "Prospect No. 4" on Plate 2, the magnetic anomaly 5-D on Plate 1, and the erosional embayment in the escarpment formed by sandstones of the Blythesdale Group, all suggest a fold plunging gently to the south-west.

Despite this limited agreement, there remains a basic disagreement in the attainment of the chief objective of the two surveys, namely the assessment of the thickness of the sedimentary rocks in the area. The gravity results indicate a central basinal feature bounded on the west by a platform, but the aeromagnetic results indicate deep basement on the north-west and only a few thousand feet of sedimentary rocks in the south and east. These conflicting results indicate that some additional control, as would be obtained from a well drilled for stratigraphic information, is necessary for evaluation of the respective surveys.

It is becoming more apparent, with continuing geophysical work in parts of the Great Artesian Basin, that magnetic and gravity results do not show mutually supporting results. [5] Interpretation of aeromagnetic data may be hampered by the effects of near-surface granites with extremely low magnetic susceptibilities which produce low, broad anomalies. In the case of gravity surveys, the basic assumption that the deeper the rocks, the higher the density may not be applicable in this region. Indurated sedimentary rocks may have a higher density than granite or schist, and their presence would indicate a "high" although, in fact, the crystalline basement might be relatively deep. Under these conditions a "low" would actually represent shallow crystalline rocks.

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(5) Footnote by Bureau of Mineral Resources:

See also discussion of this problem in "North Winton Gravity Survey, Queensland, 1959" by Magellan Petroleum Corporation.

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APPENDIX 1

PERSONNEL

Aeromagnetic Survey

Aero Service Corporation

W.G. Agocs	-	Chief Geologist-Geophysicist	)	Interpretation
			)	
R.R. Hartman	-	Geologist-Geophysicist	)	Staff
			)	
C.E. Curtis	-	Geologist-Geophysicist	)	Philadelphia, U.S.A.
R.N. Lambert	-	Project Manager		
J.M. Schmunk	-	Project and Electronics Engineer		

Adastra Airways Pty Ltd

K.A. Rowlands	-	First Pilot
B. Sellick	-	Co-Pilot
A. Tidey	-	Navigator
R. Cozens	-	Aircraft Maintenance Engineer
M.Y. Miller	-	Chief Electronic Technician
L. Snape	-	Technician

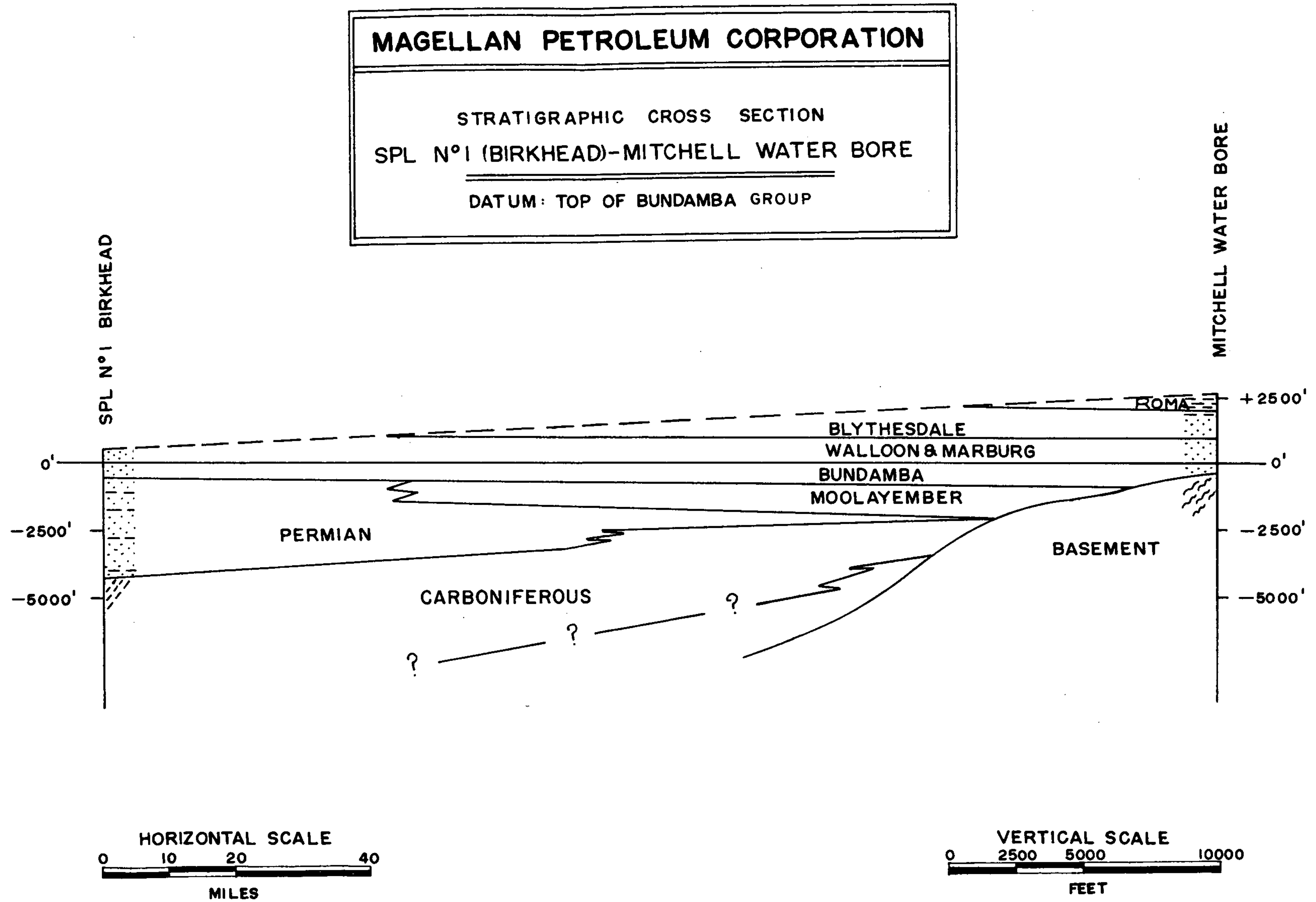
Gravity Survey

H.I. Harris	-	Chief Geologist, Magellan Petroleum Corporation
K.W. Abel	-	Geophysical Interpreter, in Tulsa, Oklahoma, for Century Geophysical Corporation
E.P. Lane	-	Party Chief, Century Geophysical Corporation
R.E. Brettell	-	Assistant Party Chief, Century Geophysical Corporation

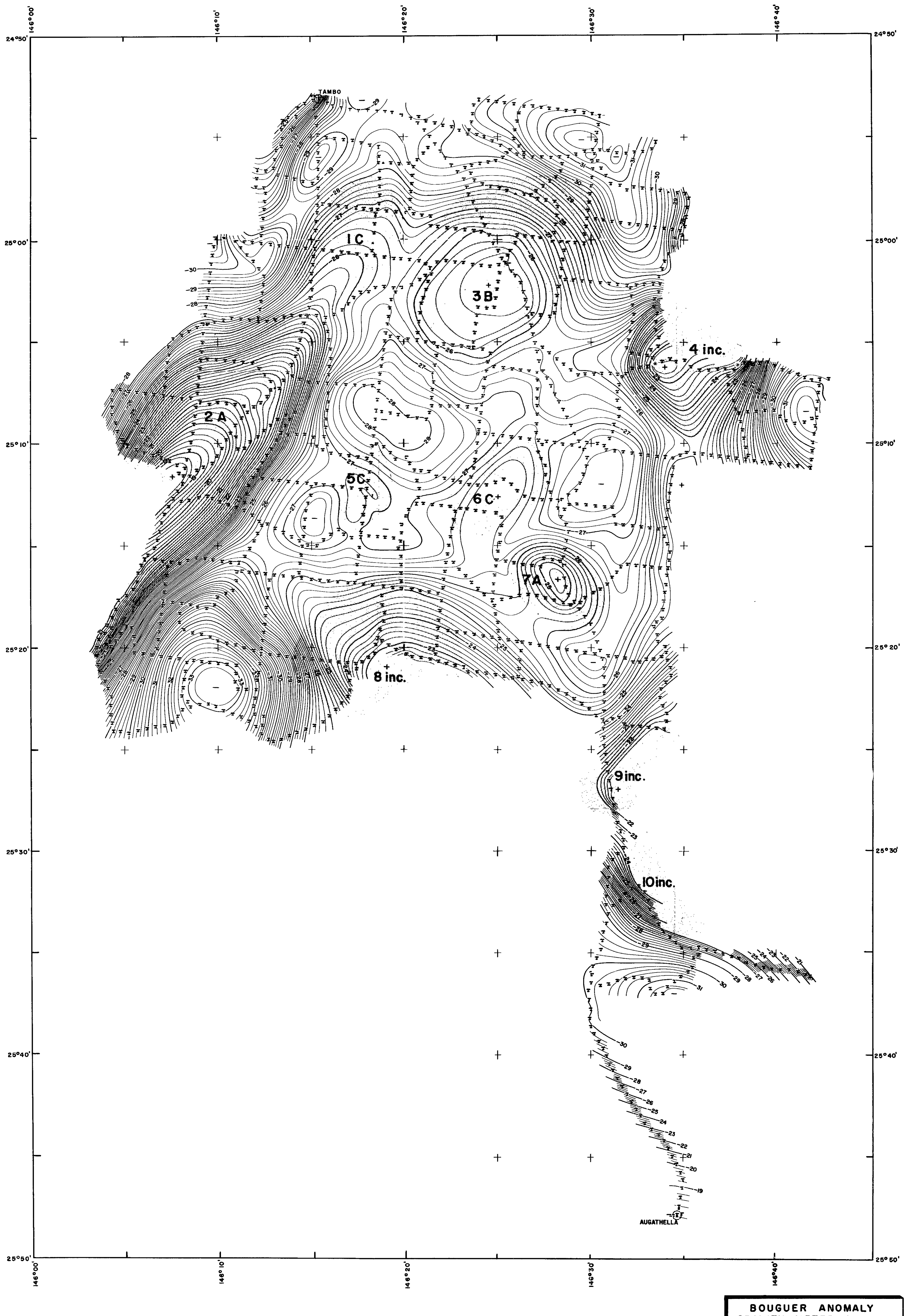
Other employees working for Magellan Petroleum Corporation but supervised by Century Geophysical Corporation personnel were:

C. Rush	-	Surveyor
D. Worrall	-	Surveyor
A. Brosch	-	Meter Operator

Fig.6


MAGELLAN PETROLEUM CORPORATION
STRATIGRAPHIC CROSS SECTION
SPL N°1 (BIRKHEAD)-MITCHELL WATER BORE
DATUM: TOP OF BUNDAMBA GROUP
SPL N°1 BIRKHEAD
MITCHELL WATER BORE
ROMA
BLYTHESDALE
WALLOON & MARBURG
BUNDAMBA
MOOLAYEMBER
PERMIAN
CARBONIFEROUS
BASEMENT
?
?
?
+2500'
0'
0'
-2500'
-2500'
-5000'
-5000'
HORIZONTAL SCALE
0 10 20 40
MILES
VERTICAL SCALE
0 2500 5000 10000
FEET

TAMBO-AUGATHELLA AREA, QUEENSLAND
AEROMAGNETIC SURVEY 1959 BY MAGELLAN PETROLEUM CORPORATION
TOTAL MAGNETIC INTENSITY
AND
INTERPRETATION
SCALE
MILES 8 0 8 16 24 32 40 MILES
CONTOUR INTERVALS
MAGNETIC: 10 GAMMAS. DEPTH: 1000 FEET
LOCALITY MAP
QLD.
Brisbane
8°
M.N.
T.N.
SHEET INDEX
1 2 3 4 4A 5 6 7 8
23°00' S
24°00' S
25°00' S
26°00' S
27°00' S
145°00' E
146°00' E
147°00' E
148°00' E
LEGEND
MAGNETIC DATA
Magnetic contours
Flight line with fiducial position
Magnetic "low"
INTERPRETATION DATA
Probable depth contour } below sea level
Possible depth contour
Probable fault
Possible fault
Basement contact
Possible contact
Structural axis, anticline
Structural axis, syncline
1000 Depth estimate, below sea level
+1000 Depth estimate, above sea level
NOTES
This map is a composite of sheets originally prepared by Aero Service Corporation at a scale of one inch to two miles.
Survey Flown :- August - October 1959.
Survey Contractor :- Aero Service Corporation.
Flight Altitude :- 2500 feet above mean sea level i.e. approximately 1000 feet above mean ground level.
Flight line Spacing :- 3 miles.
Planimetric Detail :- After Royal Australian Survey Corps four-mile maps of the area.
Prepared for Lithographic reproduction in Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics, Melbourne.
POSSIBLE FAULT ZONE
PROBABLE FAULT
BARCALDINE
JERICHO
BLACKALL
TAMBO
AUGATHELLA
MORVEN
MUNGALLALA
MITCHELL



3
2
1
1 2 3 4 5 MILES

LEGEND

○ GRAVITY STATION
-153 RELATIVE BOUGUER ANOMALY
100 STATION NUMBER
⌧ PERMANENT STATION
● BASE STATION
▲ ASTRONOMICAL STATION
+ GRAVITY HIGH ANOMALY
— GRAVITY LOW ANOMALY

MAP DATA

PROJECTION: TRANSVERSE MERCATOR

CONTROL: STATE AND NATIONAL MAPPING ASTRONOMICAL STATIONS DEPARTMENT OF THE INTERIOR AND STATE BENCH MARKS

DETAIL: GRID AND GRATICULE COMPUTED AND COMPILED BY CENTURY GEOPHYSICAL CORP. FIELD OFFICE. GRAVITY STATION LOCATIONS PLOTTED FROM STADIA DISTANCES, AND MAGNETIC BEARINGS
HORIZONTAL ACCURACY: 100 FT × $\sqrt{m}$ (m = LENGTH OF TRAVERSE IN MILES)
LEVELING ACCURACY: 0.5 FT × $\sqrt{m}$ (m = LENGTH OF TRAVERSE IN MILES)

ELEVATION DATUM: M. S. L. (QUEENSLAND STATE DATUM). DATUM ESTABLISHED FROM DEPARTMENT OF THE INTERIOR BENCH MARKS AND ELEVATIONS ESTABLISHED WITH RESPECT TO STATE DATUM. MISTIES PRORATED ALONG TRAVERSE

RESPONSIBILITY

GEOLOGICAL REPORT .... H. I. HARRIS
INTERPRETATION AND FINAL REPORT .... KARL ABEL
FIELD WORK, COMPUTING AND MAPPING .... E. P. LANE

EXPLANATION

RELATIVE BOUGUER ANOMALIES ARE BASED ON THE VALUES OF THE FOLLOWING B.M.R. STATIONS:
PENDULUM STATION NO. 54 – LONGREACH QLD. – 978,789.80 MILLIGALS
PENDULUM STATION NO. 59 – ROMA QLD. – 978,978.50 MILLIGALS

AN AVERAGE DENSITY OF 2.0 HAS BEEN ASSUMED FOR ROCKS BETWEEN STATION SITE AND SEA LEVEL IN REDUCTION OF GRAVITY VALUES.

BOUGUER ANOMALY
GRAVITY METER SURVEY
AUTHORITY 63-P (TAMBO-AUGATHELLA)
AUSTRALIA
FOR
MAGELLAN PETROLEUM CORP.
CONTOUR INT. = 0.20 MILLIGALS
SCALE = 1:253,440
GEOPHYSICAL CORPORATION
TULSA, OKLAHOMA
JUNE, 1960