FINAL REPORT

GARDINER RANGE GRAVITY SURVEY

1973 - 1974

O.P. 175 and 178

AMADEUS BASIN

NORTHERN TERRITORY

for

MAGELLAN PETROLEUM AUSTRALIA LTD.

~~PR 74/13B WELL FILE - C~~

BY.

MANDREL INDUSTRIES, INC.

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ABSTRACT

A gravity survey has been conducted for Magellan Petroleum (N.T.) Pty. Ltd. by Mandrel Inductries, Inc. The purpose of the survey was to obtain gravity control on possible concealed faults along anticlines located in the north-western sector of the Amadeus Basin N.T., and also to obtain gravity coverage along seismic lines which present complex interpretative problems, in an area of fault closure prospects. Proximity of the surveyed area to the Mereenie and Palm Valley fields enhances prospects in the area and the gravity results subsequently define objectives for further exploration.

Field operations were carried out between September 24th, 1973 and January 11th, 1974 with a total of 262.6 Km of line being metered, comprising 970 stations.

Bouguer anomaly values were computed on the ComMand processing centre located in Alice Springs.

INTRODUCTION

A gravity survey has been conducted in the northwestern area of the Amadeus Basin N.T. by Mandrel Industries Inc. on behalf of Magellan Petroleum (N.T.) Pty. Ltd.

The survey area is situated about 430 Km (270 miles) west-southwest of Alice Springs in OP 175 and OP 178 and comprises long reconnaissance lines in the region of Mereenie Anticline, Walker Creek Anticline and the Gardiner Ranges (See Figure 2).

The objective of the survey was to yield gravity control on concealed faults located on the flanks of anticlines. The specific areas of interest were:-

(1) the southern flank of Gardiner Range Anticline
(2) the northern flank of Walker Creek Anticline and
(3) the northern flank of Mereenie Anticline

The original program was extended to cover seismic lines GA1 and GA2, and BN to assist in the interpretation of complex records obtained in the Central Amadeus Seismic Survey 1973/74, which was being conducted concurrently. The structures traversed by the lines are considered prospective owing to their proximity to the Mereenie and Palm Valley fields.

Gravity readings were taken using a La Coste and Romberg gravimeter and processed in Alice Springs by the ComMand digital processing centre.

Operations commenced on September 24th, 1973 and were completed on January 11th, 1974. A total of 970 stations were metered over 262 Kms of line.

	Stns	Kms
WW-1	65	18.66
WW-2	77	17.95
WW-3	170	44.06
GA-1	205	56.56
GA-2	314	15.12 + 72.45
4.5	66	17.92
4.5 Ext	20	5.32
BN	53	14.56
Total	970	262.60

LOGISTICS

Field Operations

Operations were conducted from (a) the seismic camp at Mereenie and (b) various fly-camps situated on lines WW-3, GA-2 and WW-1. Support was obtained either from the seismic camp or from the Aboriginal Mission at Areyonga. The survey area is readily accessible via the main road from Alice Springs through Hermannsburg and Areyonga.

Terrain

On lines GA-1, GA-2 (seismic portion), 4.5, 4.5 Ext and BN which had been cleared for seismic program, the terrain was gently undulating and offered no access problems. Line WW-3 was run along the track connecting Areyonga Mission with Tempe Downs homestead and for the most part followed Areyonga and Illara Creeks. On lines WW-2 (Walker Creek) and WW-1 (Centre Creek) where no tracks were available, it was decided to follow the most accessible route. Dozing was carried out on the gravity portion of line GA-2 (see dozing report).

Dozing

A total of 72.45 Kms of line were cleared on line GA-2 (gravity portion). Dozing was carried out by Mr. J. Brisbane who was employed by the seismic crew operating in the Mereenie area. Dozing was necessary here as the line was repeatedly traversed by small creeks and stream beds which made rapid travel impossible.

Weather

During most of the survey the weather was fine. Rain temporarily halted the survey at times during the mid-December to January period.

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SURVEYING

Surveying of the seismic/gravity lines 4.5, 4.5 Ext, GA-1, BN and GA-2 was carried out by surveyors from the seismic crew. For details see seismic report Central Amadeus Seismic Survey (1973) by Mandrel Industries, Inc. On the gravity lines levelling and traversing were carried out by means of a Wild T-16 Theodolite and prismatic compass. Stations were set up at approximately 300 metre intervals using a vehicle odometer. Permanent markers were established at line ends and intersections and consist of 5'9" star pickets bearing metal tags identifiable by line name and station number.

Vertical control was obtained from a survey entitled "Missionary Plain and Mt. Rennie-Ooraminna Seismic and Gravity Surveys, OP 43 and OP 56, N.T., Australia 1965 and 1966" conducted by Geophysical Associates Pty. Ltd. for Magellan Petroleum.

Mereenie No.1 well was used for horizontal control, co-ordinates being supplied to Magellan Petroleum by the Department of Lands. The survey was also tied into Camel's Hump trig station to provide further control. All lines, with the exception of WW-3, were either double shot or tied into loops to provide confirmation of accuracy.

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Due to difficult terrain conditions, it was considered impractical to double run line WW-3. A series of Department of Lands third order Bench Marks are located along the line but the horizontal accuracy of these points is insufficient to provide traverse control. The location of the line was verified against surface geology and topography as taken from aerial photographs and government maps.

Vertical and Horizontal closures are shown by Figures 7 and 8.

Vertical Control:-

GA1 Line	Station (Gravity)	Elevation (Metres)
AS	7185	719.03
BN	7454	729.39

Horizontal Control:-

	Latitude	Longitude
Mereenie No.1 Well	23°58'33"S	131°30'30"E
Camel's Hump Trig	23°46'0.7912"S	131°38'55.4426"

METERING

Readings

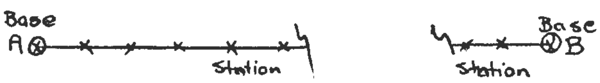
A La Coste and Romberg gravity meter (No.259) was used during the survey. Calibrations were carried out both before and after the survey using the B.M.R. Isogal stations 6091-0135 and 6091-0235 situated north of Alice Springs. The following results were obtained:-

6091-0135/6091-0235

Date	Observed Difference	Actual Difference
Sept. 3 1973	52.09 mgals	52.10 mgals
Jan. 12 1974	52.13 mgals	52.10 mgals

The B.M.R. Isogal station 6111-7534 at Gosses Bluff was used as control for the survey and tied into Station 170 on line WW-3.

All lines were treated as "hanging-lines" and consequently double-run. The reading pattern is shown below:-



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The sequence would be as follows:-

BASE A, STATION, STATION ETC .... BASE B,

BASE A, BASE B, BASE A, BASE B. - thus giving 4 differences between BASE A and BASE B. Base stations were set up where necessary, the first base being re-read within a 3 hour period in order to correct for drift.

Densities

As no suitable locations could be found to run density profiles, fresh rock samples were taken at selected points in the survey area. A complete list of results and observations are tabulated in Appendix V.

Previous density determinations are also listed in Appendix IV for reference. The densities presented on the Interpretation figures are nominal values selected from all values presented here.

Density determinations were made on a centogram balance with an accuracy of ± 0.01 gm. Samples used were 2-300 gms; the density being determined by weighing an air (W_A), in water (W_W) and then calculation $\left(\frac{W_A}{W_A - W_W}\right)$.

Sample	Formation	Density
1	Carmichael Sandstone	2.43
2	Mereenie Sandstone	2.20
3	Hermannsburg Sandstone	2.55
4	Hermannsburg Sandstone	2.30
5	Hermannsburg Sandstone	2.28
G1	Hermannsburg Sandstone	2.09
G2	Hermannsburg Sandstone	2.53
G3	Pacoota Sandstone	2.53
G4	Hermannsburg Sandstone	2.36
G5	Hermannsburg Sandstone	2.22
G6	Carmichael Sandstone	2.25
G7	Mereenie Sandstone	2.30
G8,9	Carmichael Sandstone	2.20 2.26
G10	Mereenie Sandstone	2.52
G11	Stokes Siltstone	2.43
G12	Stokes Siltstone	2.49

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PROCESSING

Gravity data were input to the ComMand processing centre which was situated in Alice Springs.

Survey bearings and distances were used to compute latitudes and departures, for each station and then misclosures were evaluated. Adjusted latitudes and departures were then used for plotting. Observed gravity and elevation (in metres) were input for computation of the Bouguer anomaly at each station. All of the computed data was recorded and retained on magnetic tape.

The ComMand mapping system was employed to give printouts of elevation, observed gravity values, Bouguer values and location in degrees.

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REGIONAL GEOLOGY

The Amadeus Basin is a westerly trending intracratonic depression within the Central Australian Shield (Southern Northern Territory). Present day margins narrow toward eastern and western extremities. The basin is approximately 800 Km by 320 Km covering an area of 150,000 square Km (Figure 1.).

Since its inception in the Early Proterozoic the Amadeus Basin has received in excess of 9,000 m of sediments. The sedimentary section comprises unmetamorphosed marine sediments laid down in the interval between Early Proterozoic and Ordovician times. Subsequent sediments were principally continental deposits; Recent sediments being comparatively thin occur now as outliers. The sedimentary section overlies igneous and metamorphosed basement rocks, which have surface expression as the Arunta Complex along the northern margin of the basin and the Musgrave Complex along the southern margin (Figure 3).

The earliest sediments in the Amadeus Basin probably extended well beyond present margins. These Proterozoic sediments were deposited as a continuous sheet in a shallow, stable, marine environment (Heavitree Quartzite). The development of barred basins and lagoonal environments is inferred from

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the presence of evaporites and carbonate rocks of the Bitter Springs Formation (Figure 5a, 5b). Diastrophism if the Areyonga Movement was accompanied by the development of a 'basinal' province in the southern area of the Amadeus Basin separated from a shelf province to the north, by a medial westerly trending hinge line (Wells et al, 1970). This movement and the Souths Range Movement in the Late Proterozoic uplifted areas to the south which then became the provenances for the subsiding areas.

Sedimentation continued with little tectonic disturbance during the Late Proterozoic, retaining the two distinct environments. The Areyonga and Pertatataka Formations, deposited at this time, have similar lithology, facies distribution and environmental conditions. Two stages of glaciation have been identified in this time, the earlier of the two covering the entire shelf and the later episode being confined to a small subsidiary basin in the northeast. The Petermann Ranges Orogeny re-configured the basin, shifting the axis of deposition to the north. The shelf province appears to have been little disturbed by these intense movements which were localised in the southwest of the basin. The 'basinal'sediments were uplifted as isoclinal and recumbent folds developed and Proterozoic sediments were infolded with basement complex, during Late

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Proterozoic to Early Cambrian times. Overthrusting of the young Proterozoic sediments was accomplished by utilizing the more competent Bitter Springs Formation as a décollement. This movement provided a southern provenance for Cambrian deposition. The Cambrian Pertaoorta Group, unconformably overlying the Proterozoic rocks, comprises marine sands and silts, including a evaporitic member (Chandler Limestone). Carbonate and evaporitic deposition predominated in the northeast and clastics in the remainder of the basin grade coarse to fine from the west to the southeast. Sedimentation during this time shows evidence of a facies change across a median ridge oriented north-south, giving two depositional subdivisions varying from continental to deltaic in the west to marine carbonates and shale in the east.

The Larapinta Group (Figure 5) was laid down from the Late Cambrian to Ordovician, conformably overlying the Pertaoorta Group and the Proterozoic rocks to the south. The depositional pattern indicates a series of transgressions and regressions in an epeiric sea which probably extended beyond the present basin margins.

These shallow marine Ordovician rocks comprise sandstones, siltstones and shales which show true depositional thinning to the south. Ordovician

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sedimentation was brought to a close by the Rodingan Movement (Silurian?), the ensuing environment being principally continental. Desert erosion provided sediments of the Mereenie Formation which is partly shallow marine, partly fluviatile and aeolian. An apron of coarse conglomerates developed at the foothills of the Central MacDonnell Ranges. The Mereenie Formation unconformably overlies the earlier rocks, the majority of sediments probably being deposited during the Devonian.

This phase of deposition was interrupted by the Pertnjara Movement (Late Devonian) which uplifted sediments on the northern margin. Molasse deposits of the Pertnjara Group followed this movement, the sediments accumulating at the base, on the southern flank of the newly formed mountains. The Finke Group was deposited contemporaneously within the basin.

The Alice Springs Orogeny (Foreman et al, 1965) is evidence by folding overthrusting and the formation of nappes, along the northern margin of the basin. This Mid to Late Palaeozoic cycle may have started near the end of the Ordovician and shows increased intensity in the Devonian, activity persisting into the Carboniferous. The two major occurrences of evaporites appear to have provided shearing planes of weakness with detachment of sediments occurring angularly between these planes as

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sediments were overthrust (Foreman and Milligan, 1965). Huge blocks of allochthonous sediments provide evidence of gravity sliding in response to uplifting and overthrusting. The sediments of the Late Palaeozoic depression do not show signs of activity as intense, as that evidenced in the basement complexes to the north. Many of the structures of the depression display an origin in the Palaeozoic. Some folds show crestal thinning in the late Palaeozoic and some diapirs and thrusts may have been initiated as early as the Petermann Ranges Orogeny. The Amadeus area stabilized after the deposition of the Pertnjara Group to serve as provenance for the Permian to Cretaceous sediments of the Simpson and Gibson deserts.

Middle Tertiary fluvial and lacustrine sediments were deposited in ancestral river valleys as the climate became wetter. Tilting and minor faulting accompanied the downwarping of the Lake Eyre area, establishing the present system of internal drainage.

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PREVIOUS GEOPHYSICAL SURVEYS

Method	Year	Survey Notes
Aeromagnetic	1959, 1960	An air magnetometer profile was flown from Alice Springs to Giles by B.M.R.
	1965	Airborne magnetic and radiometric surveying by B.M.R. over the greater part of the entire basin.
Gravity	1951	Regional gravity surveys by Marshall & Narrain.
	1958	A local gravity survey of Gosses Bluff was run by Frome - Broken Hill Co. Pty. Ltd.
	1959, 1960	Further gravity control was added by B.M.R.
	1960, 1961	A local survey was carried out at Mereenie Anticline.
	1961	Magellan ran several long traverses south and west of Alice Springs metering 1261 stations and incorporated previous local work by Frome Broken Hill.

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	1961-1962	B.M.R. helicopter survey on a sevel mile grid spacing (Langron, 1962; Lonsdale and Flavelle, 1963).
Seismic	1961	Amadeus Basin, Southern Margin, Seismic survey, N.T. 1961, B.M.R. Record 1962/167.
	1961	Palm Valley - Hermannsburg Seismic Survey, N.T. 1962, B.M.R. Record 1963/5.
	1962	Namco Geophysical Co. shot over the Alice, Ooraminna and Mereenie prospects for Exoil.
	1962	B.M.R. shot a cross basin profile from the Gardiner Range through Gosses Bluff into the Macdonnell Ranges B.M.R. Record 1964/66.
	1962	Ooraminna Seismic Survey B.M.R. Record 1966/57.
	1964	Magellan shot additional seismic control around Mereenie Anticline (Patch J.R., 1964).

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INTERPRETATION

The Origin of Gravity Anomalies

The Bouguer gravity mapped on a regional scale previous to this survey defines a basinal configuration with the deepest point situated north-east of the Mereenie area (Figure 4).

The regional trend in the area of investigation shows a rise to the southeast. The anomalies which are superimposed on this trend have a shallow origin. These strong near surface effects mask the effect of deeper layers, and gravity anomalies are most pronounced where adjacent beds of strong density contrast have been upturned (Nettleton, 1967). Most anticlines give rise to a gravity high and unless the evaporite sequences (Bitter Springs Formation, Chandler Formation) come close to the surface little expression due to lower densities can be observed on the profiles. Hence the evaluation of postulated salt cores in the anticlines is rendered obscure. Densities assigned to formations in the basin have been listed in Appendix V.

Interpretation diagrams (Figures 9 - 12) have been presented where gravity data covers seismic profiles (Central Amadeus Seismic Survey, 1973/74). Assignment of average densities and approximate formation boundaries has been made to assist in the qualitative evaluation of anomaly sources.

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Discussion of Profiles

Line annotations vary between gravity computer printouts and seismic sections. Equivalent line names are listed below:-

Gravity	Seismic
S4.5	73-1-4.5
S4.5 Ext	73-1-4.5 Ext
BN	73-1-BN
GA-2S	73-1-GA2
GA-1	73-1-GA1

Line S4.5 and S4.5 Ext (Figure 9).

Over the Mereenie Anticline, the truncated beds of Parke Siltstone and Mereenie Sandstone appear to have caused the irregularities on a positive gravity anomaly. The only low is over the Mereenie Sandstone which may be attributed to the contact caused by its lower density. Salt intrusion or the presence of a salt pillow cannot be inferred from the profile and it is assumed, if present, to be masked by the dense rocks above and below any salt.

The large amplitude decrease in gravity on the northern flank of Mereenie Anticline is attributed to the near surface effect of faulting in the Parke Siltstone. The adjacent minor low could be due to alluvial fill or possibly a small syncline in the Pertnjara Group. The latter explanation is favoured as the weathering profile inferred from first breaks on the seismic section does not show a great change in the weathering depth. A gravity high at station 240 correlates with a seismic high in the Pertnjara Group. The general trend across the Wild Eagle Syncline shows a northerly dipping regional gradient which ends in an anomalous downturn on approaching the hills between 4.5 and 4.5 Ext. This downturn in the gravity profile is contrary to the effect expected due to the near surface approach of the dense Parke Siltstone. Unfortunately the terrain prevents a continuous profile being presented. This anomaly seems to be the only area surveyed in which salt intrusion might justifiably be invoked on the basis of the gravity anomaly.

A wedge of salt beneath the northern slope of the syncline could provide the necessary effect to give a negative anomaly. Such intrusion may have expression in the topographic high and the upturning of flanking reflections (on the migrated sections). The 'carry-over' of the migrated reflections gives the appearance of intrusion and perhaps the upturning of sediments, so that the seismic reflection picture under the no data area is to be viewed cautiously. The gravity effect on the northern side of the feature again reflects the density contrasts of beds at the surface. A high-low-high

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sequence along S4.5 Ext characterises the effects of outcropping Parke Siltstone, Mereenie Sandstone and Stokes Siltstone respectively.

Line GA-1 (Figure 10).

Line GA-1(E) shows only a regional trend rising to the east. The Bouguer profile does not reflect the minor variation in depth to the Pertnjara Group. Minor fluctuations possibly have their origin in the near surface layers. A gravity high from stations 205 to 240 coincides with a seismic high.

On GA-1 (W) the seismic reflections deepen to the west. The Bouguer anomaly over the good record area appears to be due to the variations in thickness and weathering of a dense near surface member of the Hermannsburg Sandstone which when truncated(?) near station 320 gives a small negative anomaly. In the poor record area (stations 420 - 480) the profile indicates that there may be either a small rise with overturn of beds or variable weathering densities. However the weathering profile as picked from first breaks on the seismic records shows a considerable deepening of the weathering layer (possibly an old stream channel) with little expression in the Bouguer anomaly. The gravity effect of this deep weathering could possibly mask the expression of an anticline in the deeper horizons which

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would give an anomalous effect of opposite sign. The nett effect would then be the difference of the two opposed effects, having a low amplitude. The sharp rise in the far west is considered to be caused by a combination of basement complex rise and outcropping dense Cambrian rocks.

Line GA-2S (Figure 12)

The Bouguer anomaly along this line does not show the effects of density contrast observed on north-south lines. However, the gravity drops characteristically over the Mereenie Sandstone. A rise in gravity may be observed as the profile crosses the southern flank of Gardiner Range anticline. Small amplitude effects may be related to faulting at depth (Figure 11), and these fault planes may cross the profile with a small trend.

It is possible that the profile may indicate a structural high to the west from the end of the line. The change in slope of the gravity profile is also a point where deep reflections alter. When the outcrop pattern is related to the seismic horizons a fault is inferred which does not seem to have an exceptionally strong gravity effect. The gravity effects on east-west lines are necessarily of lower amplitude than the north-south lines. This is an expression of the east-west trend of the gross structure of the area.

On GA-2 the Stokes Siltstone has a steeply dipping attitude and is also in close lateral proximity along most of the line. Hence the anomalous effects observed on the north-south lines (eg. S4.5) are not as apparent on east-west lines.

Line BN (Figure 11)

Line BN, oriented north-south, exhibits the effect of the outcropping, dense Parkes Siltstone (Stations 140 - 160). To the north the outcropping Mereenie Sandstone is characterised by a low. However the presence of a salt pillow within the core of the anticline could also contribute to this low. Further north the Bouguer profile over the Parkes Siltstone and Hermannsburg Sandstone does not show the usual strong anomalous effects. The sudden variation in gravity on the north end of the line correlates with the extrapolated line of décollement as exhibited by the outcrop rocks situated north of the western end of the Gardiner Range Anticline and slightly east of line BN. The mild disturbance caused to the south of this feature might then be attributed to sheet over thrusting or simply brecciated and contorted beds associated with the fore front of overthrusting from the north.

Line GA-2G

Line GA-2G shows a marked rise in Bouguer anomaly on crossing the boundary between the Mereenie Sandstone and the Parke Siltstone. From here the profile is situated along a valley in which Parke Siltstone outcrops. There are minor fluctuations which probably reflect variations in the Parke Siltstone and there is also some distortion due to inadequate terrain corrections due to limited topgraphic control.

The profile shows a marked increase in slope about station 344 which probably is caused by a thickening of the Parke Siltstone, as a deepening of the seismic section may be inferred from GA-1 going east. Other contributing factors could be an increase of the regional trend, thinning of the Quaternary cover or an increase in the silt/sand ratio of near surface horizons.

Two minor inflections occur at stations 407 and 420, which may be attributed to minor faulting in an area opposite Walker Creek Anticline. Station 440 is at the peak of an exceptionally high frequency anomaly. This reading has been carefully checked and all computations are correct. The anomaly seems far too 'sharp' for the area and as such is thought to be a mistaken field reading. The Bouguer value rise in the vicinity of station 440 may however, be the result of an outcropping fault. Other minor fluctuations in the profile reflect the changes in distance from the outcrop of the Mereenie Sandstone. The anomaly at station 556 is probably due to a fault, the trend of which may be extended from the Gardiner Range.

Line WW-2

Regionally the line shows a rise to the south. Superimposed upon this trend are several low amplitude anomalies. The line was run along a creek bed which was flanked by cliffs on both sides. The cliffs were up to 200 feet high and the creek bed averaged 100 feet in width. Under these conditions an accurate estimate of the terrain corrections to be applied is difficult. It is more than likely that all of the terrain corrections have not been removed. This makes anomalies difficult to understand; especially when they are of low amplitude. Anomalies that fall within this category and which may still be of interest occur near stations 40 and 60. At station 40 the anomaly is on the Hermannsburg Sandstone and could possibly be due to minor arching or more probably a change in surface densities. Near station 60 the profile passes through the bluffs which define the outer edge of the breached Walker Creek Anticline. A possible concealed fault could be inferred from the inflection at station 59. However, this could only be minor when the effect of the outcropping bluffs is considered.

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The profile persists as a strong rising trend into the middle of the anticline. This would suggest the Walker Creek Anticline does not have a large salt core but does not negate the possibility of salt flow at depth to give a small salt pillow.

Line WW-1

This line, located on the western nose of the Walker Creek Anticline, has yielded little information on the structure along the hinge line. Small amplitude anomalies indicate possible faults at stations 5, 36 and 43. The relief exhibited by the seismic horizon mapped by Bowman, 1962, bears little correlation to gravity high or lows. This is only a phantom horizon and consequently, the relief may be doubted. Highs in the gravity which may be of interest occur about stations 7 and 45. Highs may be due to a thickening of the Parke Siltstone and could possibly be related to depressions in the underlying strata. Hence lows in the gravity may indicate underlying highs. Little more can be inferred without reference to better quality seismic profiles.

Line WW-3

This line extends from Areyonga south across the Wild Eagle Syncline to Tempe Downs. The regional trend along this line shows the northerly drop in values observed on the lines to the west. In the south the

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Mereenie Sandstone does not exhibit the low gravity effect observed in the rest of the survey area. This may reflect a facies change in the formation. The Stairway Sandstone also seems to have a stronger gravity effect in this southern area. The Pacoota Sandstone shows a distinct low which may be due in part, to near surface effects of salt flow in the core of the anticline A similar cause for the low at station 26 may also be postulated.

There appears to be a fault contact on or about station 50. A postulated thrust fault would seem to account for this and also the anomalous high between stations 50 and 80. If such a thrust fault exists then the highs of the profile might be due to arching of sediments on the southern slope of Wild Eagle Syncline. The small high between stations 110 and 120 is on the dense Parke Siltstone so probably it is caused by the increase in near surface density. The contact with the Mereenie Sandstone drops into a small characteristic low. The profile passes over the contacts of beds which are steeply dipping to the south on the southern flank of the Gardiner Range. Faults may be postulated at stations 148 and 155. In this area the Stairway and Pacoota Sandstone show unusually strong effects which may be indicative of over thrusting above denser beds. The décollement mapped in surface geology on the northern flank has expression as a small peak centred about

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station 161. The profile then passes over a series of overturned beds. The large drop in Bouguer values at stations 167 to 169 may be the axis of overturning or the location of a shear plane.

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CONCLUSIONS AND RECOMMENDATIONS

Mereenie Anticline

The gravity profile strongly indicates a fault on the northern flank of this structure. It seems possible that a fault trap for hydrocarbon accumulation may abut this feature.

Western Extremity of Gardiner Range

The gravity profile indicates a low on the northern end of S4.5. The regional in this area is also dipping to the north. However the Bouguer gravity usually shows a high over anticlines and also the gravity effect of the Parkes Siltstone towards the outer edge of the syncline is usually an expressed high. The fact that no high is apparent above the regional trend requires the presence of low density layers or intrusions to explain the Bouguer effect. The simplest postulate in keeping with the geology of the area would be an evaporite wedge of low density, located near the surface, possibly terminating as an intrusion up a fault plane. Such a feature could provide a northern closure for noses of sediments on the southern flank of the Gardiner Range. If intrusion has occurred at localised sites along the fault plane then sediments could be locally upturned - providing a hydrocarbon trap. The difficulties in evaluating this anomaly are complicated by the gap in geophysical data coverage directly over the area of interest.

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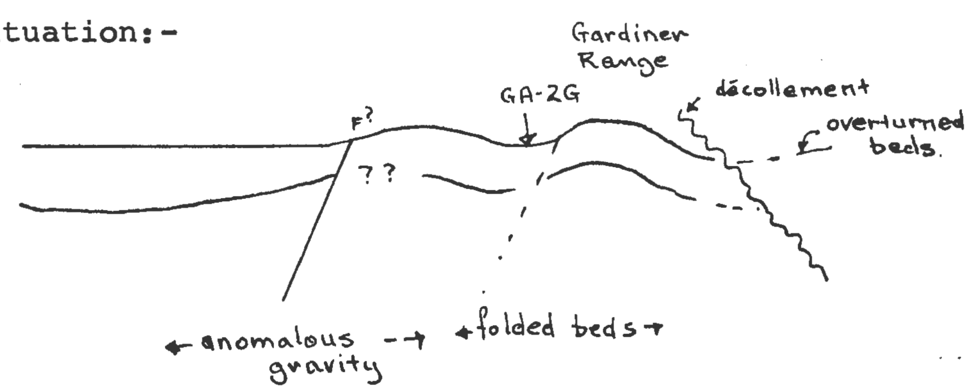
Line GA-1

The gravity data indicates that the western end of GA-1 is a marginal area of the basin. The presence of salt intrusions has not been verified nor completely negated. The poor data area of the seismic record may, however, exhibit some turnover although this may be doubted. The weathering profile plot indicates the gravity correlation to the depth of weathering is low. Hence the gravity effect is again attributed to an origin in near surface layers.

Southern Flank of the Gardiner Range

An east west line is very difficult to assess. The line along the southern flank has no major anomalies; the variation observed being attributed to fluctuations in depth and lateral disposition to the dense near surface layers (Parke Siltstone). From the profile observed on line S4.5 it seems that a gravity line parallel to GA-2G but situated about 3 Km south may define anomalous zones better than GA-2G.

The sketch below indicates the postulated situation:-



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Walker Creek Anticline

No evidence has been found for large throw, concealed faults on the northern flank of this anticline. There may be some arching of sediments, however such a proposition is very speculative on the basis of gravity readings. The line along the crest of Walker Creek Anticline has revealed little on the configuration of the crest. A seismic line combined with the gravity may prove more fruitful.

Areyonga to Tempe Downs

The Areyonga area is quite complex in geological outcrop. There is evidence of overthrusting, shearing and faulting. The outcrop rocks do not have the same gravity effect as in the area to the west. There are faults evident on the southern and northern flanks of the Gardiner Range. To the south the moderate high in the Parkes Siltstone could be due to a broad arching of beds which may be more pronounced at depth. This could be a broader extension of the high observed topographically, between lines S4.5 and S4.5 Ext. On the southern side of Wild Eagle Syncline the gravity anomalies warrant further investigation.

..../31.

Summary

The Gardiner Range Gravity Survey has defined several areas which warrant further investigation. The northern flank of Mereenie Anticline and the northern end of Line S4.5 are of interest as potential hydrocarbon traps. The northern flank in the Tempe Downs Area is of interest for seismic surveying. The southern flank of the topographic high, south of GA-2G is of interest as a reconnaissance area for gravity surveying.

A careful re-evaluation of the outcrop geology with due regard to any postulates concerning faulting or salt intrusion would be warranted in the Areyonga area and the northern end of line S4.5.

R.K. Harrison,
Area Manager,
Mandrel Industries, Inc.

for B. Armstrong,
Party Chief.

S.M. McTaggart,
Interpretation.

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APPENDIX I

Statistics

Number of bases established	66
Number of new stations read	904
Total stations read	970

Kms. surveyed/metered	263 Kms
Number of days worked	101
Travel	16
Down time due to weather	0
Down time waiting on dozer	5

Actual Breakdown

Work	52
Travel	16
Computing	2½
Waiting on dozer	5
Down - weather	1½
Crew break	10
Vehicle maintenance	8½
Scouting	5½
	101

APPENDIX 11

Table of Principal Facts

Bases and Permanently Marked Stations

Line	Station	Latitude	Longitude	Elevation Metres	Observed Gravity M gals.	Bougue Gravit P= 2.42
4.5	Mereenie No.1	23°58'33"	131°30'30"	783.46	978 609.06	-128.39
	191	23°58'34"	131°30'35"	782.90	609.14	-128.44
	221	23°56'41"	131°31'56"	764.38	607.19	-132.12
	240	23°43'8"	131°32'2"	762.04	591.13	-145.30
	281	23°52'56"	131°34'46"	759.99	593.67	-142.4[illegible]
	319	23°50'35"	131°36'33"	759.07	589.60	-144.04
4.5 Ext	100	23°48'58"	131°37'53"	736.22	595.77	-140.82
	138	23°46'37"	131°39'42"	758.28	588.73	-140.69
GA-1	100	23°54'26"	131°40'26"	813.31	584.41	-142.26
	140	23°52'13"	131°38'13"	780.25	587.79	-143.27
	160	23°51'6"	131°37'6"	765.49	588.95	-143.94
	207	23°48'31"	131°34'26"	745.16	589.76	-144.49
	226	23°47'36"	131°33'14"	730.09	591.73	-144.62
	274	23°45'14"	131°30'14"	712.48	591.14	-146.25
	276	23°45'9"	131°30'6"	715.54	590.27	-146.38
	300	23°44'8"	131°28'28"	703.16	590.95	-147.14
	340	23°42'26"	131°25'44"	691.83	592.92	-145.66
	350	23°42'1"	131°25'11"	691.42	591.41	-146.78
	370	23°41'19"	131°23'35"	684.41	591.52	-147.36

Line	Station	Latitude	Longitude	Elevation Metres	Observed Gravity M gals.	Bouguer Gravity P= 2.42
	430	23°39'14"	131°19'7"	678.09	978 589.80	-148.08
	460	23°38'11"	131°17'1"	671.09	590.27	-147.90
	504	23°36'39"	131°13'49"	665.88	599.29	-138.27
BN	100	23°49'1"	131°31'50"	737.20	590.53	-145.91
	157	23°45'51"	131°34'55"	722.36	592.37	-143.64
	204	23°43'5"	131°37'26"	726.27	584.69	-147.45
GA-2S	148	23°47'9"	131°37'4"	748.27	587.40	-144.67
	170	23°48'3"	131°38'36"	744.52	589.34	-144.52
	186	23°48'43"	131°39'42"	737.36	593.11	-142.96
	204	23°49'27"	131°40'57"	728.32	597.75	-141.02
	207	23°49'35"	131°41'9"	727.39	598.55	-140.55
GA-2G	320	23°51'15"	131°41'2"	711.91	604.07	-140.10
	330	23°52'17"	131°42'68"	703.06	607.40	-139.76
	340	23°53'15"	131°43'27"	698.94	609.45	-139.63
	355	23°54'49"	131°45'9"	690.67	614.86	-137.66
	375	23°56'24"	131°47'53"	678.41	621.86	-134.97
	380	23°56'52"	131°48'33"	673.05	624.25	-134.21
	390	23°57'40"	131°49'58"	665.63	627.79	-133.10
	400	23°58'19"	131°51'34"	656.02	631.05	-132.55
	410	23°59'4"	131°52'53"	651.96	634.06	-131.22
	430	24°0'14"	131°56'2"	632.36	641.25	-129.40
	438	24°0'41"	131°57'12"	630.45	642.80	-128.73

Line	Station	Latitude	Longitude	Elevation Metres	Observed Gravity M gals.	Bouguer Gravity P= 2.
	445	24°1'7"	131°58'9"	631.84	978 643.79	-127.95
	465	24°2'20"	132°1'25"	665.05	639.47	-126.74
	480	24°3'16"	132°3'52"	692.25	636.34	-125.28
	495	24°4'34"	132°6'4"	664.93	645.62	-123.12
	510	24°5'59"	132°8'12"	637.46	654.78	-122.22
	525	24°7'17"	132°10'26"	628.72	659.66	-119.63
	530	24°7'43"	132°11'6"	628.55	660.95	-118.65
	537	24°8'16"	132°12'10"	617.01	664.99	-117.82
	550	24°9'46"	132°14'17"	605.26	669.76	-116.39
WW-1	1	24°12'19"	132°0'57"	569.81	687.44	-109.70
	14	24°11'26"	131°58'53"	568.67	685.29	-111.08
	31	24°10'36"	131°56'8"	576.88	681.18	-112.5[illegible]
	33	24°10'26"	131°55'44"	580.09	679.98	-112.92
	42	24°9'54"	131°54'19"	583.76	677.68	-113.85
	57	24°8'38"	131°52'17"	589.01	673.71	-115.31
	65	24°7'55"	131°51'3"	597.86	669.87	-116.52
WW-2	14	24°2'44"	131°56'47"	610.67	651.25	-126.68
	28	24°4'43"	131°56'39"	599.78	658.06	-124.35
	38	24°6'1"	131°56'16"	593.38	664.66	-120.53
	39	24°6'11"	131°56'13"	600.72	663.83	-120.0[illegible]
	46	24°6'55"	131°56'0"	590.07	668.05	-118.84
	52	24°7'27"	131°56'6"	584.65	670.25	-118.35
	64	24°8'50"	131°55'38"	575.12	676.69	-115.44

Line	Station	Latitude	Longitude	Elevation Metres	Observed Gravity M. gals.	Bouguer Gravity P= 2.[illegible]
WW-3	1	24°26'24"	132°25'44"	514.03	978 730.61	-93.94
	29	24°22'26"	132°24'13"	520.99	719.47	-99.17
	54	24°19'49"	132°21'1"	543.44	709.23	-101.81
	55	24°19'46"	132°20'50"	544.76	708.68	-102.02
	63	24°18'45"	132°20'24"	559.19	703.63	-102.9[illegible]
	79	24°16'18"	132°20'16"	545.31	698.62	-108.07
	100	24°13'13"	132°19'9"	567.52	685.56	-113.06
	110	24°11'50"	132°18'35"	603.97	675.83	-113.88
	119	24°10'49"	132°17'37"	590.53	677.70	-113.45
	129	24°9'51"	132°16'15"	595.81	674.13	-114.84
	142	24°8'7"	132°15'32"	604.05	671.46	-113.87
	155	24°6'25"	132°15'7"	631.27	665.58	-112.21
	160	24°5'45"	132°15'23"	639.05	665.13	-110.29
	170	24°4'26"	132°15'27"	661.81	651.84	-117.39

APPENDIX III

Personnel

Meter Operator/Party Chief	B. Armstrong
Surveyor	F. Carlson
Surveyor	B. Richardson
Surveyor/Rodman	M. Bannister
Rodman	D. Jones
Rodman	D. Harkness
Rodman	L. Reid
Rodman	A. Carey
Assistant	S. Martin
Assistant	R. Hoyle

Equipment

2 - 4x4 S.W.B. Toyota Land Cruisers

1 - 4x4 L.W.B. Toyota Land Cruisers

1 - La Coste & Romberg Gravity Meter (No. 259)

1 - Wild T-16 Theodolite

2 - Tents plus camping equipment

APPENDIX IV

Density Samples

Sample Number	Location	Description of Hand Specimen Rocks	Density
1	Rock face in edge of creek on Line WW-2.	Fine grained, red sandstone, grains sub-rounded. Carmichael Sandstone	2.43
2	Station 300, Line GA-2 sandstone outcrop beside road.	Very fine grained sandstone, pale grey with reddish (weathering?) patches, red-brown weathering surface. Mereenie Sandstone.	2.20
3	Station 38, Line WW-2; edge of creek.	Grey-white quartzite, 98% quartz. Weathered surface - very smooth, greyish brown. Hermannsburg Sandstone	2.55
4	Station 39, WW-2	Friable, red sandstone, 30% labile minerals, 1-2% rutile or cassiterite(?) Hermannsburg Sandstone	2.30
5	Station 39, WW-2	Laminated shale, laminae 2"; very fine to medium grained shales with rounded medium sized quartz grains up to 40%. Hermannsburg Sandstone	2.28

Sample Number	Location	Description of Hand Specimen Rocks	Density
G1	North end of Line S4.5, 50 m northeast of station 326.	Medium grained red to pink sandstone; high labile content (40%); interstitial clay. Hermannsburg Sandstone	2.09
G2	East end of Line GA-1, 60 m southeast of station 100.	Medium grained, yellow-red sandstone; labile content 20%, grains subrounded-subangular. Hermannsburg Sandstone	2.53
G3	300 m northeast of station 207, Line BN.	Medium to coarse grained, clean, white sandstone; grains subrounded to subangular; little interstitial material. Pacoota Sandstone	2.53
G4	Station 142, Line BN.	Very fine grained, well-cemented, red-pink sandstone, 5% dark mineral content. Hermannsburg Sandstone.	2.36

Sample Number	Location	Description of Hand Specimen Rocks	Density
G5	South end of S4.5 near station 100.	Fine to medium grained sandstone, 75% quartz, labile content partially weathered out; limonitic weathering surfaces. Hermannsburg Sandstone	2.22
G6	North end of S4.5 Ext. Large boulders of float adjacent to the end of the line.	Very fine grained pink sandstone, minor dark laminae, 90% quartz. Carmichael Sandstone	2.25
G7	3-400 m south of GA-2, station 207.	Very fine grained quartzite (indurated in part). Buff to yellow colour. Mereenie Sandstone	2.30
G8,G9	1,000 m north of station 207, GA-2.	G8. Fine grained sandstone, labile content 20%. Colour: yellow/pink. G9. Very fine grained well cemented sandstone, labile content 20%. Carmichael Sandstone	2.26
G10	100 m northeast of station 207, Line GA-2.	Very coarse white sandstone, grains subrounded to round, little interstitial material, silicified in part. Mereenie Sandstone	2.52

Sample Number	Location	Description of Hand Specimen Rocks	Density
G11	1,600 m north of the east end of GA-2.	Very find grained grey/white sandstone; well cemented, laminated; red-brown weathering surface. Stokes Siltstone(?)	2.43
G12	8 Km east of G11 location along Mereenie to Areyonga road.	Grey siltstone, pink weathering surface, minor organic content (micro.) Stokes Siltstone	2.49

DENSITIES (GA1, 1967)

Formation	Densities	Ave.	Sonic Log
Tertiary	2.09c, 2.10c	2.10c	
Pertnjara Group	2.31c, 2.44c, 2.66c	2.47c	2.25
Mereenie Sandstone	2.39c, 2.15s, 2.39c, 2.42c	2.40c	2.39
Carmichael Sandstone	2.42c, 2.40s, 2.25s, 2.36s, 2.27	2.34s & c	
Stokes Siltstone	2.73c, 2.57c, 2.79c	2.70c	2.40
Stairway Sandstone	15 core samples av. 2.53c 4 surf. samples 2.49s	2.53c 2.49s	2.41
Horn Valley Siltstone	2.46c, 2.68c, 2.64c	2.54c	2.42
Pacoota Sandstone	21 core sample av. 13 surf. samples av.	2.51c 2.47s	2.48
Goyder Formation	6 core samples av. 6 surf. samples av.	2.54c 2.60s	2.62
Jay Creek Limestone	2.74s, 2.59s 2.68c, 2.91c, 2.66c, 2.70c	2.66s 2.70c	
Giles Creek Dolomite	2.63c, 2.78c, 2.76c	2.72c	
Tempe Formation	2.55c	2.55c	2.54
Hugh River Shale	2.69c	2.69c	
Arumbera Sandstone	2.26c, 2.33c	2.29c	2.52
Cleland Sandstone	2.24s 2.44s	2.24s 2.44s	2.32
Pertatataka Formation	2.74c, 2.69c	2.71c	
Bitter Springs Formation	3.04c, 2.83c, 2.83c, 2.77c	2.85c	2.81

s = surface
c = core

LOCATION MAP

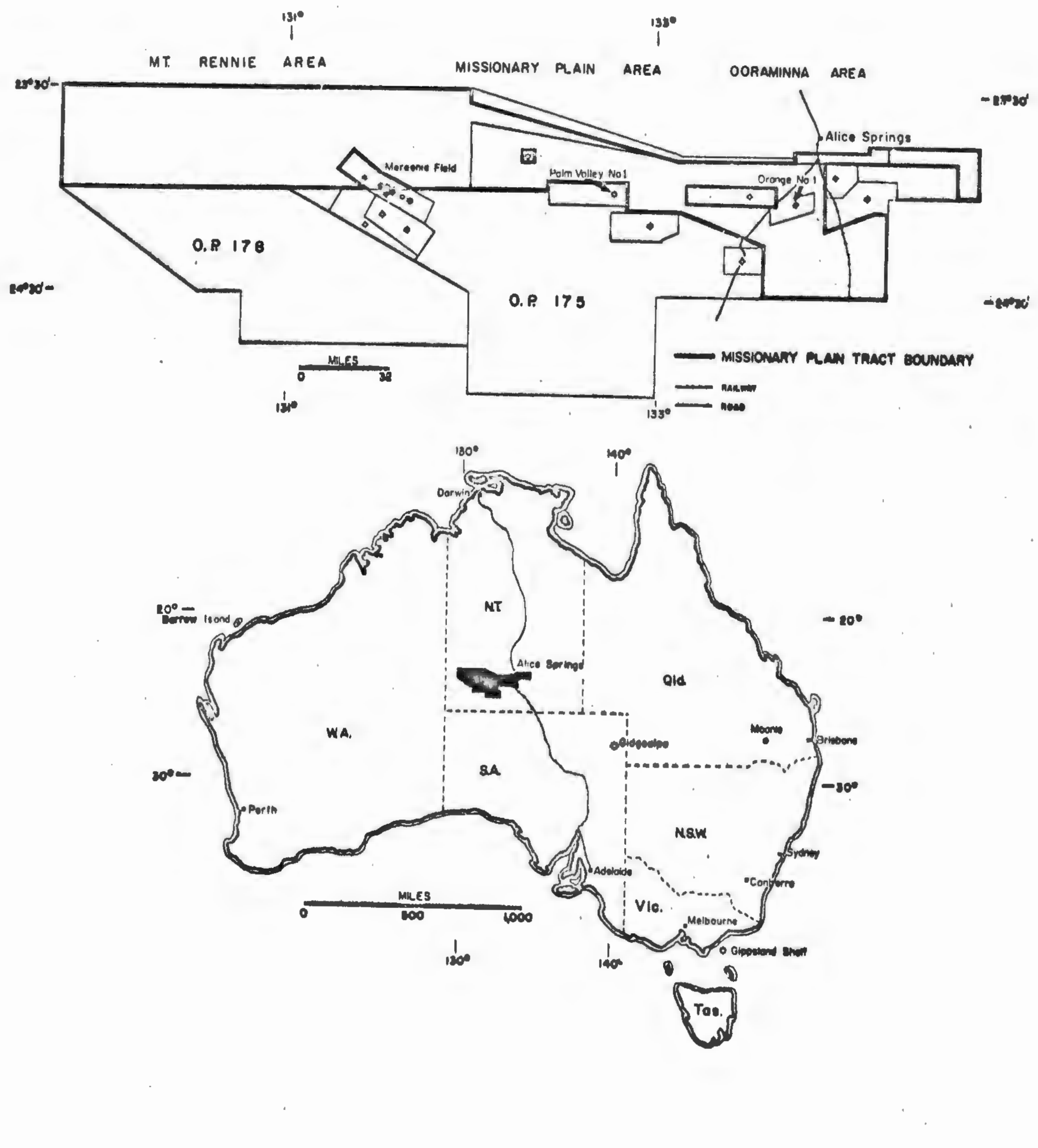
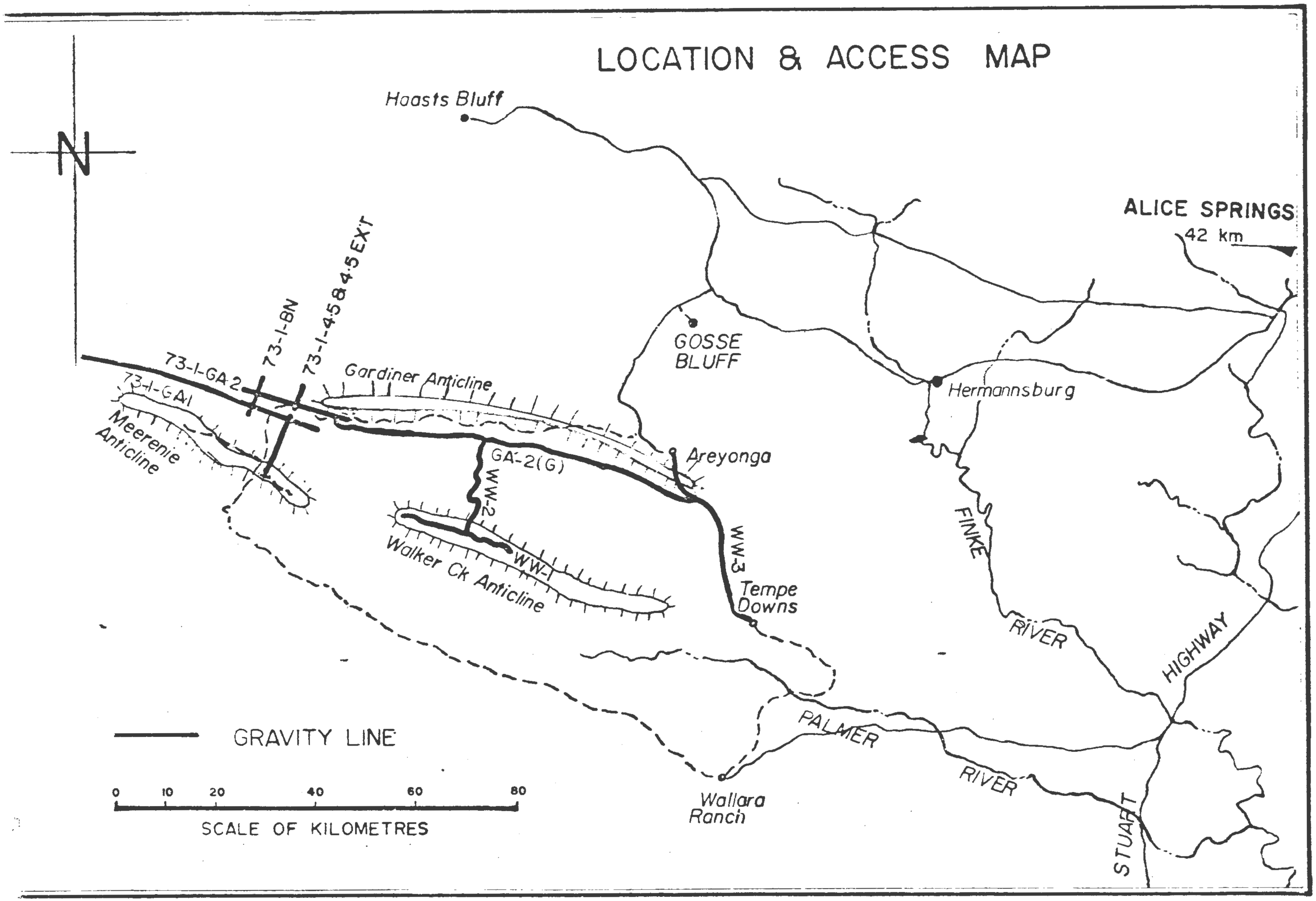
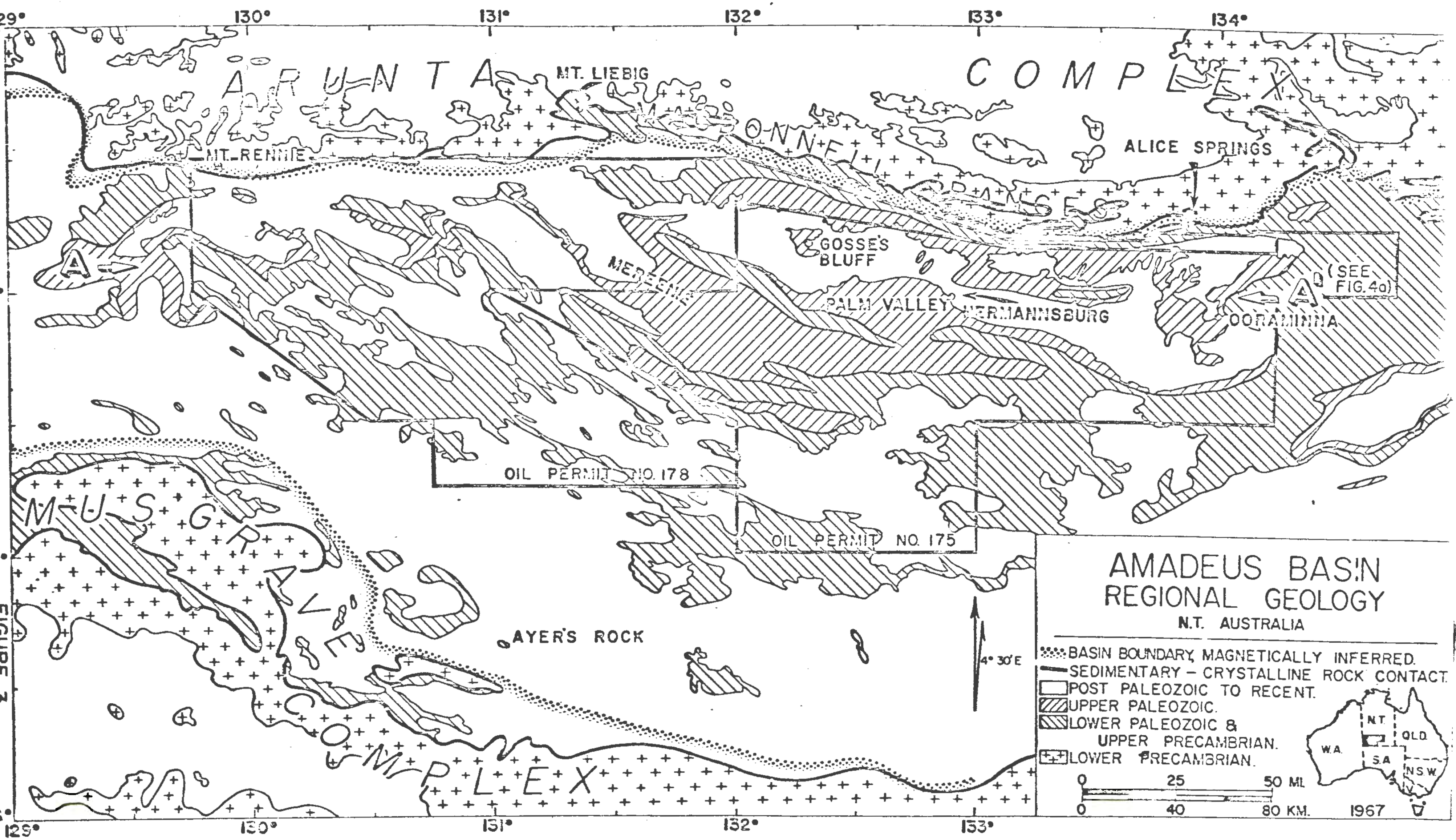


FIGURE 1



LOCATION & ACCESS MAP
N
Haasts Bluff
ALICE SPRINGS
42 km
GOSSE
BLUFF
Hermannsburg
73-I-GA 2
73-I-GA1
73-I-BN
73-I-45&45 EXT
Gardiner Anticline
Meerenie
Anticline
Areyonga
GA-2(G)
WW-2
WW-3
WW-1
Walker Ck Anticline
Tempe
Downs
FINKE
RIVER
HIGHWAY
PALMER
RIVER
STUART
Wallara
Ranch
GRAVITY LINE
0
10
20
40
60
80
SCALE OF KILOMETRES



ARUNTA COMPLEX
MT. LIEBIG
MACDONNELL RANGES
MT. RENNIE
ALICE SPRINGS
GOSSE'S BLUFF
MEREENIE
PALM VALLEY
HERMANNSBURG
OORAMINNA
A
A
(SEE FIG. 4a)
OIL PERMIT NO. 178
OIL PERMIT NO. 175
MUSGRAVE COMPLEX
AYER'S ROCK
4° 30' E
AMADEUS BASIN
REGIONAL GEOLOGY
N.T. AUSTRALIA
BASIN BOUNDARY, MAGNETICALLY INFERRED.
SEDIMENTARY - CRYSTALLINE ROCK CONTACT.
POST PALEOZOIC TO RECENT.
UPPER PALEOZOIC.
LOWER PALEOZOIC & UPPER PRECAMBRIAN.
LOWER PRECAMBRIAN.
0 25 50 ML
0 40 80 KM.
1967
N.T.
QLD.
W.A.
S.A.
N.S.W.
129°
130°
131°
132°
133°
134°
23°
24°
25°

FIGURE 3

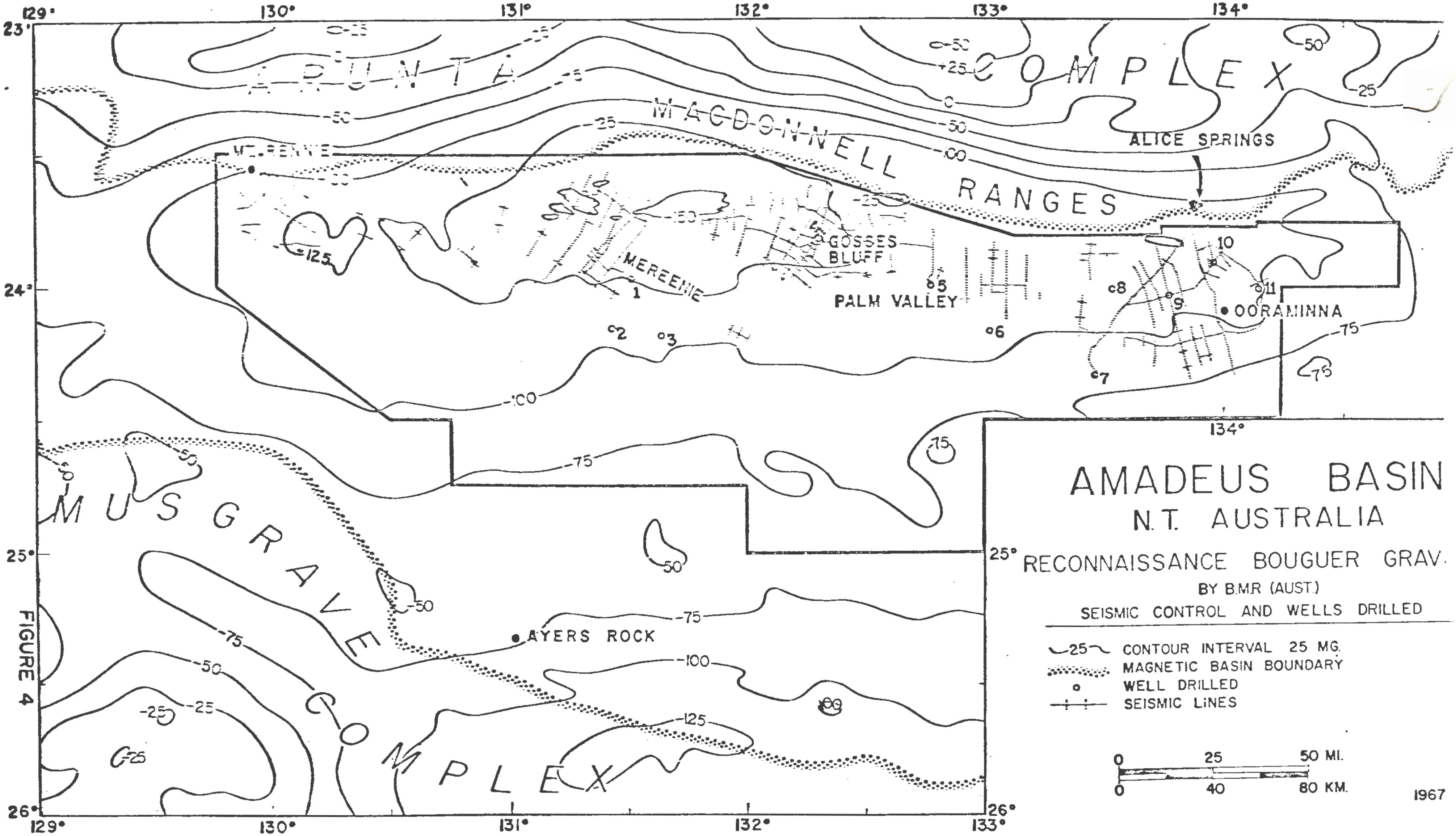
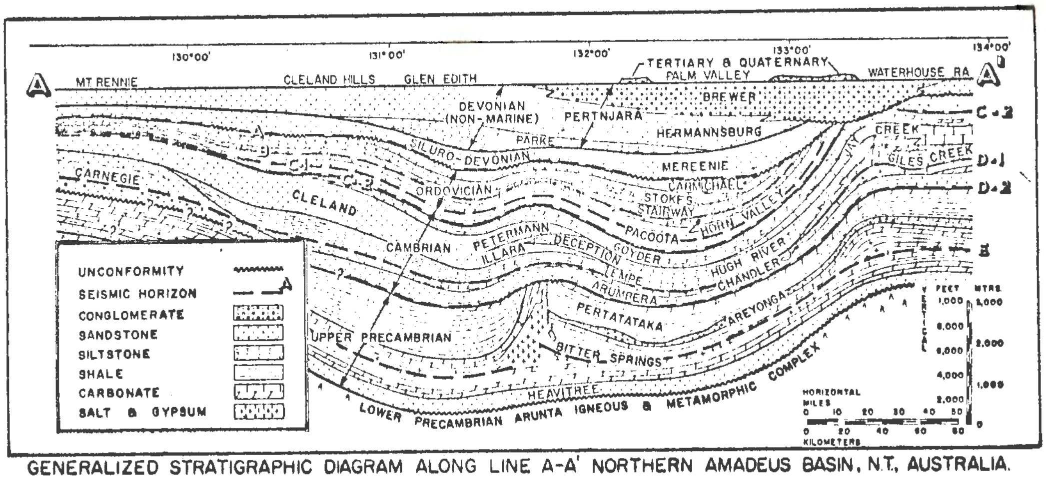


FIGURE 4

HOLES DRILLED

1. MEREENIE FIELD:
   - A — No. 1, 3983'; O. PACOOTA
   - B — EAST No. 1, 4710'; Є. GOYDER
   - C — EAST No. 2, 5175'; Є. GOYDER
   - D — WEST No. 1 5504, Є. GOYDER
   - E — WEST No. 2 5001 O. PACOOTA
   - F — EAST No. 3 4940' O. PACOOTA
   - G — EAST No 4 — DRILLING
2. OCHRE HILL, 3755' PC. BITTER SPRINGS
3. E. JOHNNY'S CREEK, 6344'; PC. BITTER SPRINGS
4. GOSSE'S BLUFF, 4535'; O. STAIRWAY
5. PALM VALLEY, 6658'; O. PACOOTA
6. JAMES RANGE A, 3000'; P.C. BITTER SPRINGS
7. HIGHWAY, 3770'; Є. GILES
8. WATERHOUSE, 3081'; Є. ARUMBER
9. ORANGE, 8886'; Є. ARUMBERA
10. ALICE, 7518'; Є. ARUMBERA
11. OORAMINNA, 6095'



GENERALIZED STRATIGRAPHIC DIAGRAM ALONG LINE A-A' NORTHERN AMADEUS BASIN, N.T., AUSTRALIA.

FIGURE 5a

AGE		ORIGIN	GROUP	FORMATION AND PREDOMINANT LITHOLOGY (WEST)	(EAST)	THICKNESS		AVERAGE MEASURED DENSITY SURFACE	CORE	Average Velocity of Formation Ft/2/m.s.*	REMARKS
TERTIARY TO RECENT		CONTINENTAL		Dune Sd, Gvl, Alluv, Ls, Coal, Silcrete, etc.		0-1000'			2·10	8·0±2·0	
DEVONIAN TO PERMIAN?	NON-MARINE	SYNOROGENIC	PERTNJARA	BREWER Cgl, Ss		0-12000'	12000'			6·0±2·0 (Est)	
		LACUSTRINE		HERMANNSBURG Ss		0-3000'			2·47		
				PARKE Siltst, Ss		0-3000'			2·66		
SILURIAN? TO DEVONIAN		AEOLIAN TO DELTAIC		MEREENIE Ss		600'-2500'	2000'	2·18	2·40	8·9±1·0	HORIZON 'A'
UPPER ORDOVICIAN	MAINLY SHALLOW MARINE (SHELF)	REGRESSIVE MARINE (OSCILLATING)	LARAPINTA	CARMICHAEL Ss, Siltst		0'-500'	3000'	2·34	2·34		
				STOKES Siltst, Sh, Ls		0'-1800'			2·70	8·6±0·7	
MIDDLE ORDOVICIAN				STAIRWAY Ss, Siltst		0'-1830'		2·49	2·63	7·6±2·4	HORIZON 'B'
LOWER ORDOVICIAN		EUXINIC TO TRANSGRESSIVE MARINE		HORN VALLEY Siltst, Sh, Dol		0'-800'			2·64	7·2±1·1	HORIZON 'C-1'
				PACOOTA Ss, Siltst		900'-3500'		2·47	2·51	7·8±1·2	CAMBRIAN REFLECTION HORIZON 'C-2'
UPPER CAMBRIAN		PARALIC AND DELTAIC IN WEST	PERTAOORTA	CLELAND Ss / GOYDER Ss, Dol, Sh		0'-1800'	7000'	2·60	2·54	8·4±1·1	
MIDDLE CAMBRIAN				PETERMANN Ss	JAY CREEK (SHANNON) Ls	2500'-6000'		2·66	2·70	8·8±0·4	
		MARINE CARBONATE AND EVAPORITIC IN EAST		DECEPTION Siltst	HUGH RIVER Siltst				2·69	7·8±1·0	
				ILLARA Ss					2·72		
				TEMPE Sh, Siltst, Ls	GILES CREEK Dol				2·58	8·3±0·8	HORIZON 'D-1'
LOWER CAMBRIAN				CHANDLER Salt, Sh, Ls	TODD RIVER Dol	0'-1000'			(1)	7·7±0·7	
		PARALIC-DELTAIC		ARUMBERA Ss, Siltst		0'-3150'		2·24	2·77 / 2·33	7·8±?	HORIZON 'D-2'
UPPER PRECAMBRIAN (UPPER PROTEROZOIC)		EUXINIC ?		CARNEGIE Ss / PERTATATAKA Sh, Siltst, Dol, Ls		0'-4000'±	7000'		2·71		PRECAMBRIAN REFLECTION HORIZON 'E'
		PERIGLACIAL ?		AREYONGA Sh, Ss, Dol, Cgl							
		EVAPORITIC		BITTER SPRINGS Ls, Dol, Salt, Sh		3000'±			2·68 (1)	10·0±0·8 (Est)	
		TRANSGRESSIVE		HEAVITREE Ss, Siltst, Qtzite		2000'±		2·59			
LOWER PRECAMBRIAN		BASEMENT		ARUNTA IGNEOUS AND METAMORPHIC ROCKS				2·6-3·0			

* FROM SONIC LOGS AND WELL VELOCITY SURVEYS

(1) SALT — 2·2; 7·0'

TABLE 1. SUMMARY OF FORMATIONS, NORTHERN AMADEUS BASIN, AUSTRALIA

FIGURE 5b