R/B 68/55

Rept.Bk.No. 68/55
G.S. No. 4206

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

PETROLEUM RESOURCES DIVISION

HELICOPTER GRAVITY SURVEY OF AREAS MARGINAL TO THE WESTERN GREAT ARTESIAN BASIN

by

J. McG. HALL
GEOPHYSICIST
SEISMIC GEOPHYSICS SECTION

and

I.J. TOWNSEND
GEOLOGIST
PETROLEUM SECTION

D.M. 573/69

22nd April, 1969

RIB 68/55

DEPARTMENT OF MINES
SOUTH AUSTRALIA

HELICOPTER GRAVITY SURVEY OF AREAS MARGINAL TO THE WESTERN GREAT ARTESIAN BASIN

by

J. McG. HALL
GEOPHYSICIST
SEISMIC SECTION.

and

I.J. TOWNSEND
GEOLOGIST
PETROLEUM SECTION

CONTENTS | PAGE

Rpt.Bk.No. 68/55
G.S. No. 4206
D.M. No. 573/69

22nd April, 1969.

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rpt.Bk.No. 68/55
G.S. No. 4206
D.M. No. 573/69

HELICOPTER GRAVITY SURVEY OF AREAS MARGINAL TO THE WESTERN GREAT ARTESIAN BASIN

ABSTRACT

A helicopter survey was conducted between the southwestern margin of the Great Artesian Basin and the eastern Officer Basin on a 4 mile by 4 mile grid (1 station per 16 square miles) between the 21st of May and the 8th of July 1968.

The results outlined a general easterly to northeasterly trend in the western portion of the area, abutting a general northerly trend to the east of the area at the Basin margin.

A number of anomalies were outlined by the survey; the positive ones are thought to be associated with near surface crystalline basement and the negative anomalies are assumed to be associated with Palaeozoic sedimentary basins.

INTRODUCTION

A helicopter gravity survey was conducted between the 21st of May and 8th of July, 1968, in the Coober Pedy - Oodnadatta area of South Australia covering the WARRINA and MURLOOCOPPIE 1:250,000 military sheets, the northern halves of COOBER PEDY and BILLAKALINA and the southern half of WINTINNA. Ties were made to two B.M.R. isogal stations, one directly at William Creek and the other indirectly at Oodnadatta by tying to a previous Mines Department gravity survey.

The survey was carried out to extend the geological knowledge of the area, at present limited to outcrops around the margins, and to aid in planning further exploration work as part of an oil search programme.

Geographically, the area can be divided into several different types of country. West of the Coober Pedy - Alice Springs road the area is fairly flat and heavily timbered with mulga scrub. To the east the Peake and Denison and Mount

Margaret Ranges rise some 1100 feet above the plains. These plains are generally alluvial flats with small sand dunes, interdunal clay pans, and undulating gibber plains. In the northern area and around Coober Pedy the topography is table top or mesa type country with the Stuart Ranges extending north from Coober Pedy and covering much of MURLOOCOPPIE. The remainder of the area consists of gibber plains and successions of sand dunes.

GEOLOGY

The area surveyed covers some 21,000 square miles of the southwestern portion of the Great Artesian Basin and areas marginal to it. The northeastern portion of the surveyed area consists of Mesozoic sediments thickening to the east.

The OODNADATTA sheet and a map of the Peake and Denison Ranges (Reyner, 1955) are the only geological maps available for the survey area. The OODNADATTA sheet has been included in this report as it is one of the few sources of geological information and the southern 1/3 of the sheet was covered by a ground survey in 1967 by the Department of Mines to complete it as a Bouguer gravity map.

The relatively few known geological outcrops have also been used in interpreting the gravity map, e.g. the granite outcrop at Mount Woods.

Information from the few wells drilled in the survey area, together with seismic and gravity data, has been used in forming a subsurface picture in certain areas such as around Mount Toondina, the Arckaringa basin, Boorthanna trough, the Lake Phillipson trough and the Mount Willoughby trough.

PREVIOUS GEOPHYSICS

Seismic

The only seismic work carried out in the area was conducted by the S.A. Department of Mines in several surveys in 1961, 1963, 1964 and 1968. Seismic work was begun in late 1963 around Mt.Toondina after the discovery of Permian outcrop by Freytag (1964). Reflection and refraction work in this area which led to the drilling of a stratigraphic well, Cootanoorina No. 1, has been described by Moorcroft (1964).

Late in 1964 a series of refraction depth probes with a limited amount of continuous reflection profiling was carried out along the Stuart Highway between Welbourn Hill and Coober Pedy and east to Anna Creek. Further reconnaissance work was carried out northwards to link up with the work in the Mt. Toondina area (Milton, 1964a and b).

Seismic work was continued in 1968 in the Boorthanna trough and indicated possible sedimentary sections of up to 8,000 feet to basement. Experimental work near Mt. Willoughby showed some 3,000 feet of sediments on the northern flank of the gravity low.

Gravity

In conjunction with the Departmental seismic work in the area, gravity readings were taken over all seismic traverses. Apart from this, no previous gravity work has been done.

Although notpart of this survey, the Bouguer anomaly map of OODNADATTA has been included in this report; the Bouguer map of the four 1-mile sheets in the southwest corner has not previously been reported. This area was covered by the Department of Mines in 1967. The remainder of OODNADATTA was surveyed by Wongela Geophysical Pty. Ltd. as part of their Dalhousie helicopter gravity survey for French Petroleum Co. Australia Pty. Ltd.

Aeromagnetic

An aeromagnetic survey of most of the area was flown for the leaseholders in 1961-62, and a small section in the west in 1968 for the S.A. Department of Mines.

RESULTS OF THE SURVEY

Figure 1 shows the Bouguer anomaly contours of the helicopter survey and the OODNADATTA 1:250,000 sheet. It is contoured at 5 m.gal. intervals and was reduced from a 1:1,000,000 map to approximately 20 miles to the inch.

A near-surface density of 1.9 gm/cc has been assumed to correct the field results so that a direct tie can be made to the Dalhousie survey. Both surveys have been tied to the B.M.R. isogal station at Oodnadatta. In addition to Figure 1 contoured at 5 milligal intervals, the six 1:250,000 scale maps contoured at 2 milligal intervals are included for greater definition of individual structures.

The Bouguer anomaly map shows several anomalies which can be correlated with known geological features. These include the Peake and Denison gravity high and the Mt. Woods gravity high, both associated with basement outcrops, and gravity lows associated with the Palaeozoic Boorthanna trough and Archaringa basin.

There are many anomalies in areas where little is known of the detailed geological structure, particularly in the western half of the area. Comparison with anomalies over known structures suggests the presence of several previously unknown basins and areas of shallow basement.

Figure 2 shows the names and positions of the principal gravity features to be discussed in this report, several of which were not known before this survey. Positive anomalies have been numbered and negative anomalies lettered for the purpose of subsequent discussion.

Anomaly 1. Peake and Denison gravity high

This is a N.N.W. trending positive anomaly in the eastern part of the area outlining the Peake and Denison Ranges.

Anomaly 2. Wintinna gravity high

This anomaly is a N.E. trending gravity ridge in south-west WINTINNA. The name was proposed by Wongela Geophysical Pty. Ltd. in their interpretation of the Dalhousie Gravity Survey. With the new gravity data on the southern half of WINTINNA the gravity high is located further to the west than outlined in plate 4 of the Dalhousie Gravity Survey report.

Anomaly 3. Mt. Woods gravity high

Anomaly 3 is a small gravity high on BILLAKALINA coincident with the crystalline basement outcrop of Mt. Woods.

Anomaly 4. Coober Pedy gravity ridge

The Coober Pedy gravity ridge is the name proposed for a large east-west gravity high over the northern half of COOBER PEDY. A low gravity "saddle" separates this anomaly from the Mt. Woods gravity high.

Anomaly 5. Mabel Creek gravity high

Slightly smaller than the Coober Pedy ridge, this is an ENE-WSW trending positive anomaly west of Mabel Creek Homestead on MURLOOCOPPIE.

The above five anomalies are all thought to be due to shallow crystalline basement as there is evidence of outcrop at both Mount Woods and the Peake and Denison Ranges. By their similarity the other 3 anomalies are initially interpreted as near surface crystalline basement.

Of more interest to the oil exploration programme in this area are the negative gravity anomalies. In several cases these anomalies outline areas known, from geological, geophysical, or well information, to be Palaeozoic basins. Extrapolation to similar anomalies over unknown areas suggests the presence of several other sedimentary basins within the survey area.

Anomaly A. Boorthanna gravity low

The existence of the Boorthanna trough was known prior to the survey. The Boorthanna gravity low trending parallel to, and west of, the Peake and Denison Ranges outlines the known limits of the trough. The presence of thick sediments was first realised by Chugg (1956) and Ludbrook (1961) and the trough was subsequently named by Wopfner (1964).

Anomaly B. Wattiwarriganna gravity low

This is a gravity low south of the Boorthanna trough. Department of Mines seismic work in 1968 showed a deepening sedimentary section in the area covered by this gravity low.

Anomaly C. Arckaringa gravity low

This gravity low appears to be part of a large regional low called the Murloocoppie gravity depression and is coincident with the Arckaringa basin in southwest OODNADATTA. The basin was first referred to by Sprigg (1961) and named the Arckaringa sub-basin by Freytag (1964).

Anomaly D. Beviss gravity low

Adjacent to the Arckaringa low, the area covered by this anomaly is as yet completely unexplored.

Anomaly E. Oodnadatta gravity low

Lying on OODNADATTA, this anomaly has been discussed by Wongela Geophysical in their report on the Dalhousie helicopter survey.

Anomaly F. Karkaro gravity low

This anomaly is on eastern MURLOOCOPPIE and is part of the larger Murloocoppie gravity depression. To date little is known of the anomaly but it is to be investigated by the Department of Mines Seismic party during 1969.

Anomaly G. Mt. Willoughby gravity low

This is a narrow negative anomaly trending NE-SW and is again possibly part of the Murloocoppie depression. It was first detected by the S.A. Department of Mines seismic party (Milton, 1964a) and will be further investigated in 1969.

Anomaly H. Wallira gravity low

Both this anomaly and anomaly J are on the extreme southern edge of the survey area so that their southern limits have not been accurately defined. Anomaly H trends east-west and is bounded to the north by the Coober Pedy gravity ridge. It will be investigated by the Department of Mines seismic party in 1969.

Anomaly J. Lake Phillipson gravity low

One of the few anomalous areas for which geological information is available, the Lake Phillipson gravity low is coincident with a basin containing a thick Permian section (2973 ft.) intersected in the Lake Phillipson bore.

GEOLOGICAL INTERPRETATION (QUALITATIVE)

The interpretation has been made using all available information such as the gravity, aeromagnetic, geological and seismic information.

Gravity Highs

The Peake and Denison high is coincident with the ranges which consist of early Precambrian metamorphics and migmatites, Adelaidean sediments with volcanics and intrusive granites.

The inlier is bounded by faulting near Albeguckina and this eastern fault extends south along the eastern side of the range. The western fault can be traced from the northern tip south to about latitude 28°35'S, but is absent in an east-west seismic line further south which was shot easterly to Permian outcrop.

This gravity high is interpreted as a horst structure to the north and a west tilted fault block to the south.

The Mount Woods gravity high (3) coincides with crystalline basement in outcrop at Mount Woods indicating the reason for the 30 milligal anomaly. This is probably associated with the large east-west gravity high at Coober Pedy (4) indicating again near-surface crystalline basement.

Similarly the Mabel Creek gravity high appears to arise from near-surface basement and this is supported by the aeromagnetic interpretation for MURLOOCOPPIE.

The large positive anomaly on the Wintinna Sheet (2) may be associated with basement outcrop at Ammaroodinna Hill on the EVERARD sheet. This evidence points to the Wintinna high being near-surface crystalline basement, but the aeromagnetic interpretation in this region shows the magnetic basement to be at a depth of about 4,500 feet. On this evidence the gravity high appears to be different from others in the surveyed area as they all have magnetic basement highs associated with them. If the aeromagnetic interpretation is correct, an alternative explanation must be proposed for the Wintinna high. The situation could arise from a dense carbonate mass similar to that intersected in Cootanoorina No. 1 well where Devonian Dolomites have a .25 gms/cc greater density than the overlying sediments. A body of dense carbonates would produce a gravity high and also satisfy the magnetic basement low.

This interpretation is tentative and further work is required to work out the relationships. Since many interpretations are possible the near-surface crystalline basement model has been used in the quantitative interpretation as it is the simplest.

Gravity Lows

The Boorthanna trough is approximately outlined by the gravity low (anomaly A).

Interpretation of the steep gradient, between this and the Peake and Denison anomaly, as a fault, is supported by an east-west seismic line at Mount Toondina and geological evidence.

The Seismic Section of the S.A. Department of Mines worked in the Boorthanna trough area during the 1968 field season and it is interesting to note that in the region of the Warrangarrana structure (W), an east-west gravity profile conforms with the configuration of a deep seismic reflector.

This reflector originates from the top of the Devonian dolomites intersected in the S.A.G. Cootanooorina No. 1 well. The density contrast of .25 gms/cc., between these Devonian dolomites and the overlying sediments is thought to contribute largely to the gravity. This horizon is also a good seismic reflector, hence the similarity in gravity and deep seismic profiles.

Reflections differ markedly to the south in the Boorthanna trough and in the Wattiwarriganna low (anomaly B) indicating a possible facies change or wedge out between the northern and southern Boorthanna trough.

Separated from the Boorthanna trough by a small gravity rise is the Arckaringa basin. S.A.G. Cootanoorina No. 1 was drilled at the edge of the gravity basin near the gravity rise and intersected some 2,300 ft. of Permian to Permo-Carboniferous sediments. A greater thickness would therefore be expected towards the centre of the gravity trough and seismic work north-west of Mt. Toondina confirms a deeper section in this direction.

As Cootanoorina No. 1 well was drilled on the gravity rise, and intersected the above sediments, it is reasonable to assume that these two basins were connected in Permian times. The Arckaringa basin was probably connected also to the Beviss gravity low (anomaly D) which appears to be a Palaeozoic basin from the Bouguer map.

Anomalies C, D, E and F and perhaps G are all gravity lows forming part of a large northeast trending gravity depression named the Murloocoppie gravity depression. This gravity depression is the first indication that there may have been interconnection between the Officer and Pedirka basins in Palaeozoic times.

Wongela Geophysical in their Dalhousie survey interpreted the Oodnadatta gravity low (E) as a sediment filled graben from gravity and geological evidence (see Wongela report).

Anomaly F, the Karkaro gravity low was previously unknown, but from the Bouger map is a possible Palaeozoic basin and will be the area upon which the S.A. Department of Mines seismic party will be focussing much attention in the present 1969 field season.

The Wallira gravity trough (H) is adjacent to and south of the Coober Pedy ridge. The steep gradient between them is interpreted as being caused by a fault, as both gravity profiles and aeromagnetic results suggest faulting and there is surface expression of the fault to the west on the Wallira 1 mile sheet and the adjacent Karari sheet which is on TALLARINGA. The fault has been named the "Karari fault" and the Coober Pedy ridge is the upfaulted side. The Wallira trough was also unknown prior to the survey and requires much more work to confirm depths and to determine the age of sediments contained therein.

Much more is known of anomaly (J) the Lake Phillipson trough, as the Lake Phillipson bore intersected a thick Permian section. The southern limits of this trough or basin are not known but the gravity programme for 1969 includes the southern half of the COOBER PEDY sheet so the Lake Phillipson trough will be discussed in more detail in a future report.

QUANTITATIVE INTERPRETATION

A quantitative interpretation has been made on selected anomalies in the area using generalised geometrical shapes as models (Nettleton, 1942).

1. Mt. Willoughby area

a. Profile JK (fig. 3A)

This profile crosses the centre of the Mt. Willoughby trough and ends on the Wintinna gravity high. The profile bearing is 322°.

It is assumed that the trough contains Permian sediments (density 2.3 gms/cc) resting on basement rocks with a density contrast of .4 gms/cc, these basement rocks being faulted upwards almost to the surface over the Wintinna high. Because of the probable presence of rocks with an average density of 2.7 gms/cc between surface and datum, the Bouguer gravity has been recomputed over the Wintinna high using an elevation correction factor of .06 mgals/foot. This results in a 25 m.gal anomaly across the fault believed to be the cause of the marked gravity gradient northwest of Mt. Willoughby; a depth to basement in the centre of the Mt. Willoughby trough of 7,200 feet below sea level has been computed from this anomaly.

b. Profile GH (fig. 3B)

Profile GH crosses the eastern end of the Mt. Willoughby trough at a bearing of 332°. Across this profile, the anomaly due to the trough is 20 m.gals, giving a depth to basement of 9,900 feet and a depth below sea level of about 9,000 feet.

The depths to basement on these profiles are considerably in excess of those predicted on aeromagnetic evidence suggesting that a density contrast greater than .4 gms/cc. exists between the basement and overlying sediments.

2. Boorthanna trough

a. Profile LM (fig. 3C)

This is an east-west profile through the Warrinna Railway Station. The anomaly is interpreted as being caused by the density contrast between Mesozoic and Palaeozoic sediments on the west and Proterozoic rocks of the Peake and Denison Ranges on the east, the contact being assumed to be a simple vertical fault. Density determinations on rock samples and cores have suggested a density contrast of .25 gm/cc. across the fault. There is an anomaly across this profile of 26 mgals assuming a Bouguer density of 1.9 gm/cc. Over the Peake and Denison Ranges, a more likely figure would be 2.7 gm/cc. reducing the anomaly to 23 mgals. From this, a depth to basement west of the fault of 7,200 feet (relative to M.S.L.) has been computed. The fault is 8 miles west of Warrina R.S. and has no surface expression.

b. Profile RS (fig. 4A)

Profile RS is an east-west profile crossing the Warrangarrana structure and extending onto the Peake and Denison Ranges. It is similar to LM in showing a major fault on the west of the Ranges, but in addition reflects the Warrangarrana seismic structure. The same adjustments to the Bouguer density must be made on the eastern end of the profile as for LM, resulting in an anomaly of 20 mgals and a depth to basement west of the fault of 6,300 feet (relative to M.S.L). This agrees with the depth to the deepest seismic reflector off the Warrangarrana structure (Milton 1969).

3. <u>Coober Pedy area</u>

a. Profile AB (fig. 4B)

This profile crosses the Karkaro gravity low and extends onto the Mabel Creek gravity ridge. It is believed that the Mabel Creek high is caused by near-surface basement rocks with a density of 2.7 gm/cc which was used for recalculating the Bouguer gravity in this area. After adjustment there is an anomaly of 33 mgals across the profile, assumed to be caused by a density contrast of .4 gm/cc between assumed Permian sediments in the area coincident with the Karkaro gravity low and basement rocks indicated by the Mabel Creek gravity ridge. From this anomaly, a depth to basement of 6,500 feet below sea level has been calculated over the presumed deepest part of the basin outlined by the Karkaro gravity low.

b. Profile ON (fig. 4C)

This is a north-south profile across the Wallira gravity low with an anomaly of 50 mgals across the Karari fault (after adjustment to the Bouguer gravity over the Coober Pedy gravity ridge). The depth to basement estimate for the centre of the Wallira gravity low is 8,000 ft.

CONCLUSIONS

The survey has revealed a number of positive anomalies which are associated with basement outcrop; other positive anomalies are assumed to be associated with near surface crystalline basement. The only exception is perhaps the Wintinna gravity high which is interpreted as a dense body of possible carbonate on the scanty evidence available.

All of the negative anomalies are interpreted as basins and as the known basins in the surveyed area contain Palaeozoic sediments it is probable that the unknown basins contain similar sediments.

These conclusions, based on broad generalisations show that a great deal more work must be done to understand the area more fully.

Seismic work has been planned by the S.A. Department of Mines for the 1969 field season to cover the Karkaro low and Wallira low to help in the interpretation of each basin.

The survey revealed other interesting areas for petroleum search besides the Karkaro and Wallira gravity lows. These include the Murloocoppie gravity depression containing several other basins, the Boorthanna trough, the Lake Phillipson trough, the Mount Willoughby trough and maybe even the Wintinna structure as yet unexplored.

J. McG. Hall

J.McG. HALL
GEOPHYSICIST
SEISMIC GEOPHYSICS SECTION

I. J. TOWNSEND
GEOLOGIST
PETROLEUM SECTION

J.McGH. IJT:JMM
22/4/69.

REFERENCES

ALLCHURCH, P.D., and WOPFNER, H., 1967. South Australian Government Cootanoorina No. 1 Well Completion Report. Geol. Surv. S.Aust. (unpub.).

CHUGG, R.I., 1957. Hydrology of portion of the Great Artesian Basin, near the Peake and Denison Ranges. Geol. Surv. S.Aust. Rpt. of Invest. No. 10.

FREYTAG, I.B., 1964. Summary of Recent Investigations in the Mt. Toondina area of the Arckaringa Sub-basin. Geol. Surv. S.Aust. (Unpub.).

__________ 1965. Mt. Toondina Beds - Permian Sediments in a Probable Piercement Structure. Trans. Roy. Soc. S.Aust. Vol. 89.

HASTIE, L.M., and WALKER, D.G., 1962. Two methods of Gravity Traversing using Helicopters. Bur. Min. Res. Aust. Rec. 1962/134.

INGALL, L.N., and LONSDALE, G.F., 1964. Dalhousie Helicopter Gravity Surveys for F.P.C.(A). Wongela Geophysical Pty. Ltd. (unpub.).

LUDBROOK, N.H., 1961. Permian to Cretaceous Subsurface Stratigraphy between Lake Phillipson and the Peake and Denison Ranges South Australia. Trans. Roy. Soc. S.Aust. Vol.85.

MILTON, B.E., 1964a. Seismic Refraction Depth Probes and Profiles: Welbourn Hill to Coober Pedy. Geol. Surv. S.Aust. (unpub.).

__________ 1964b. Seismic Refraction Depth Probes and Profiles: Coober Pedy to Anna Creek. Geol. Surv. S.Aust. (unpub.)

__________ 1969c. Geophysical Investigation of the Warrangarrana Structure Northern Boorthanna Trough. Geol. Surv. S.Aust. Quart. Geol. Notes No. 29

MOORCROFT, E., 1964. Geophysical Investigation, Mt. Toondina Area. Geol. Surv. S.Aust. Quart. Geol. Notes No. 12.

NETTLETON, L.L., 1942. Gravity and Magnetic Calculations. Geophysics, Vol. VII, 1942.

REYNER, M.L., 1955. Geology of the Peake and Denison Region. Geol. Surv. S.Aust. Rept. of Invest. No. 6.

SMITH, A.E., 1951. Graphical Adjustment by Least Squares. Geophysics, Vol. XV, 1951.

SPRIGG, R.C., 1961. On the Structural Evolution of the Great Artesian Basin. Aust. Petrol. Expl. Assoc. Papers presented at the 1961 Conference (Melbourne).

WOPFNER, H., 1964. Permian-Jurassic History of the Western Great Artesian Basin. Trans. Roy. Soc. S.Aust. Vol. 88.

APPENDIX A

SURVEY STATISTICS

Period of Survey: 21st May - 8th July, 1968.

Area covered: 3½ 4-mile geological sheets (21,000 sq.miles)

New 4-mile grid stations: 1445.

Cost per station : $24.

Ties to other gravity stations:		
	B.M.R. (Isogal Station 6793.9308)	1
	S.A. Department of Mines	4
	Wongela (Dalhousie survey)	1

Helicopter gravity flights:	35½ days
Helicopter on other work:	4½
Helicopter unserviceable:	6
Unproductive camp moves	½
Bad weather:	2
Total days on survey	48½

APPENDIX B

INSTRUMENTS

1. Gravity meters:

Sharpe No. 190-G (geodetic)

World Wide No. 38 (non-geodetic)

Both meters were calibrated before the survey on the B.M.R. calibration range in Adelaide. Another calibration run was made with the Sharpe after the survey.

The World Wide instrument was carried in case of trouble with the Sharpe and was not used.

Calibration factor of the Sharpe was .1057 m.gal/div.

Observed gravity values are based on the B.M.R. isogal station number 6793.9308 at William Creek with an Observed Gravity value of 979226.61 m.gals.

2. Microbarometers:

Askanias number 530512 and 530518 calibrated in millimetres of mercury.

Mechanisms Ltd. Type 2016, calibrated in millibars.

APPENDIX C

REDUCTION OF RESULTS

1. Determination of Observed Gravity

Drift curves were drawn for each flight from the repeated readings at cell centures. The difference in value between each station and the theoretical value at the cell centure at the same time was calculated. These differences were converted to milligals using the calibration factor of .1057 m.gals/div. The observed gravity differences between cell centres and tie stations were plotted on a loop closure diagram and the misclosures adjusted by a graphical least squares method (Smith, 1951). From the adjusted observed gravity differences, the observed gravity for all stations was calculated using the B.M.R. isogal station at William Creek as a base

2. Determination of Elevation

Two barometers were read during each flight, one at the control station at 10 minute intervals and the other with the gravity readings. The differences in barometric readings between stations were corrected for diurnal variations using the base instrument and converted to elevation differences with the formula of Babinet:

$$h = K \frac{Bo - B}{Bo + B}$$

$$\text{and } K = 16000\left(\left(1 + \frac{2(t_o + t_1)}{1000}\right)\right)$$

where h = difference in height between two stations (metres)

B_o, B = barometric readings at each station (millimetres of Hg)

t_o, t_1 = air temperature at each station (^oC)

The elevation differences were finally corrected for humidity.

Loop misclosures in elevation were adjusted by the same least squares process used to adjust the observed gravity values.

All elevations were tied to Department of Lands bench marks in the area and Department of Mines Seismic Survey traverses.

3. Determination of Station Position

The position of each gravity station was transferred to 1:250,000 scale photo-centre base maps by the use of proportional dividers. Station latitudes were scaled off these maps to .1 minutes of latitude.

4. Reduction of Results

The adjusted observed gravity, elevation, and station latitudes were entered in an Olivetti Programma 101 computer which had been programmed to compute and print out the Bouguer gravity values for six different surface densities. To enable ties to surrounding gravity surveys to be made, the

Bouguer gravity corresponding to a near-surface density of 1.9 gm/cc. was used for plotting and contouring on 1:250,000 scale maps at 2 milligal intervals and 1:1,000,000 scale maps at 5 milligal intervals.

5. Accuracy

(a) Observed Gravity:

Maximum loop misclosure:	.34 m.gals.
Average loop misclosure:	.08 m.gals.
Standard deviation of closure errors:	.07 m.gals.

(b) Elevation:

Maximum loop misclosure:	37 feet
average loop misclosure:	11 feet
Standard deviation of closure errors:	8 feet

(c) Latitude:

All stations marked accurately on photographs. Latitudes measured to .1 minutes of latitude.

APPENDIX D

OPERATIONAL PROCEDURE

The survey was carried out using the "cell" method described by Hastie and Walker (1962). A station spacing of 4 miles was used, the area being divided into rectangular cells, generally 20 miles by 36 miles and containing 45 stations. Normally, one cell was covered each day in four loops of eleven stations each. Loops were flown in 1½ to 2 hours with the cell centre as the base station for the microbarometer and gravity meter drift checks and helicopter refuelling point. During each loop, a check reading was taken at one station of an adjoining cell; these tie stations and all the cell centres were permanently marked with star pickets.

Ties were made to seismic stations and Lands Department bench marks for elevation and gravity control.

APPENDIX E

PERSONNEL AND VEHICLES

S.A. Department of Mines

Party Chief:	J. McG. Hall
Meter Operators:	J. McG. Hall I.S. Rowan I.J. Townsend
Mechanic:	C.J. Van der May.

Australian Helicopters

Pilots:	A. Dewhurst A. Peters
Engineers:	I. Gill L. Smith.

Ground Vehicles

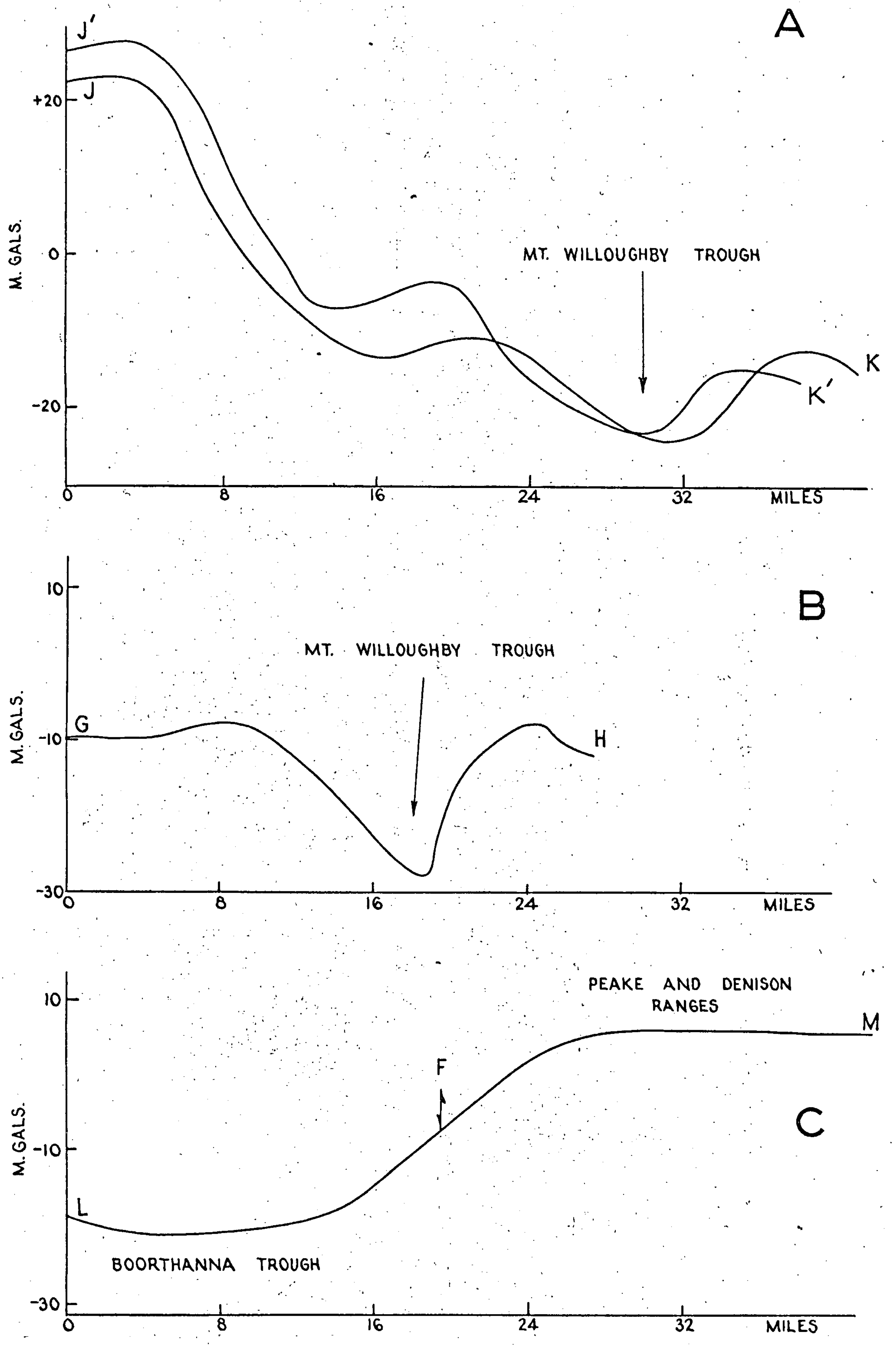
One L.W.B. 4-wheel drive Land Rover

One 4-wheel drive International AB 160

One 4-wheel drive International AA 120

Aircraft

Australian Helicopters Pty. Ltd. Bell 47G, registration VH-SJA, was used throughout.

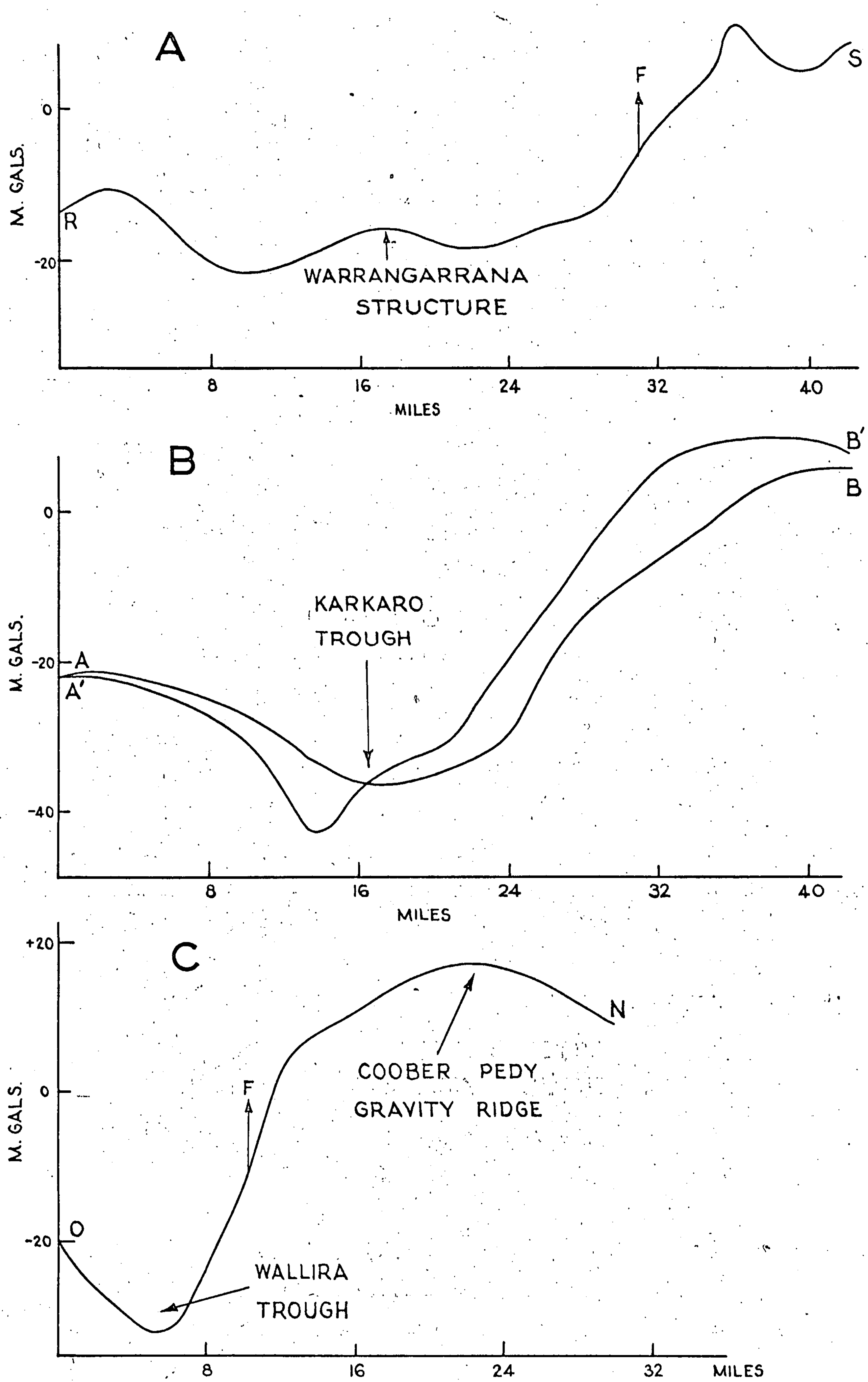


Warrina and Wintinna 1:250,000 sheets.

FIG. 3

DEPARTMENT OF MINES — SOUTH AUSTRALIA

PETROLEUM	*Drn.* J.H.	S.W. PORTION OF GREAT ARTESIAN BASIN AND MARGINS GRAVITY PROFILES	**SCALE:** Graphical
	Tcd. R.J.		S7218 Bab + de
	Ckd. E.B.T.		
	Exd.		**DATE:** 14th. April '69



Warrina, Murloocoppie and Coober Pedy 1:250,000 sheets

FIG. 4

DEPARTMENT OF MINES — SOUTH AUSTRALIA

PETROLEUM	Drn. J.H.	S.W. PORTION OF GREAT ARTESIAN BASIN AND MARGINS GRAVITY PROFILES	SCALE: Graphical
	Tcd. R.A.J.		S7219 Bab+de
	Ckd. E.B.T.		
	Exd.		DATE: 11th. April '69