DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/41

GRAVITY SURVEY OF THE VALLEYS OF THE GOULBURN AND OVENS RIVERS, VICTORIA 1972

by

G.R. Pettifer

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SUMMARY

As part of a geophysical investigation of the Goulburn River valley system for the Mines Department of Victoria and the State Rivers & Water Supply Commission, a gravity survey of 942 stations and covering 3200 square kilometres, was carried out around Shepparton by the Bureau of Mineral Resources in 1972. The survey was an extension of a previous survey in 1971. A preliminary Bouguer anomaly map is presented and a report of survey operations is given. The geological discussion of the results will be given in the final report on completion of the 1973 extension of the survey.

A small gravity traverse across the Ovens River valley near Wangaratta was carried out at the request of the Mines Department to determine whether the gravity method could indicate the depth to the base of the alluvium. The result revealed a gravity low associated with the river valley. The gravity anomaly is too large to be accounted for by the known thickness of the Quaternary alluvium.

1. INTRODUCTION

The Bureau of Mineral Resources (BMR) is conducting a geophysical study of the Goulburn River valley system using seismic, resistivity, and gravity methods in conjunction with the Mines Department of Victoria and the State Rivers & Water Supply Commission (SRWSC). This report gives an operational account of the regional gravity survey by BMR in February 1972 as an extension of a previous survey (Taylor, Hill, & Pettifer, (in prep.)) carried out in 1971. The results of the gravity survey indicate that further work is required for a complete interpretation, and hence no interpretation is attempted at present. A preliminary Bouguer anomaly map is presented.

The area covered by the 1971-1972 surveys is 4600 square kilometres and the total number of regional gravity stations is 1256, 942 of which were occupied in 1972. The average station density is one station per 3.7 square kilometres. The field work was done in February 1972 by a party consisting of G.R. Pettifer (geophysicist) and L. Kerec (draftsman).

A small gravity survey was also conducted for the Mines Department across the Ovens River valley from Glenrowan to Springhurst. The Mines Department is conducting a drilling program in the Ovens valley to find the areas of thickest alluvium. It was hoped that the gravity method would reveal such areas because of the low density of alluvial fill.

The assistance of Mr Alex Weston and the staff of the SRWSC survey office at Numurkah in supplying level information for the Goulburn River valley survey area is gratefully acknowledged.

2. SURVEY METHOD

The Goulburn River valley survey was conducted using two gravity meters and two vehicles. The survey station network was approximately a square grid so the standard techniques used in BMR helicopter gravity surveys (Hastie & Walker, 1962) were used. Plate 1 shows the station location and survey network used. Two base stations were used for the survey. These were established by tying to the Benalla Isogal station. The observed gravity values of these two base stations were taken as fixed for computation of the survey results. Stations were located at road intersections near a fence post in one corner. Ground elevations were taken from SRWSC 0.3 metre contour plans of the survey area. In areas where contour plans were not available SRWSC benchmarks were occupied. All heights were corrected to the Australian Height Datum. A base map was compiled at 1:100 000 scale by L. Kerec in the field.

For the Goulburn River valley survey three detailed traverses across outcrops on the margin of the valley were carried out in an attempt to measure the density of the outcrop material by the technique of obtaining a Bouguer anomaly which has the least correlation with topography (Nettleton, 1939). The traverses were carried out over the Silurian sandstones of Mount Scobie, the granite of Waggarandall Ranges, and the Cambrian chert and basic volcanics (greenstones) of Mount Major near Dookie.

Appendix 1 contains a summary of survey information for the Goulburn valley survey. During the survey, rock samples were collected and density and seismic velocity measurements were made in the Mines Department and BMR laboratories. Appendix 2 summarizes the density and seismic velocity information and the results of the three detailed gravity traverses.

For the Ovens River valley gravity work a tie was made to the Benalla Isogal station. Stations were located on Department of Lands, Victorian Railways, and SRWSC benchmarks, and on Mines Department boreholes.

3. COMPUTATIONAL PROCEDURE

For the Goulburn valley surveys the 1972 and 1971 survey results were combined and computed using the standard GRAVHTS gravity reduction program, which makes a least-squares adjustment of misclosure errors and produces a magnetic tape of observed gravity values. Station co-ordinates were taken from the 1:100 000 base map and converted to latitude and longitude using program PHOTOMAP. The heights and latitudes and longitudes were then combined with the observed gravity through the program AMENDS to produce Bouguer anomalies. Appendix 1 gives a summary of computation data and Plate 1 shows initial and least-squares adjusted misclosures. The preliminary Bouguer anomalies calculated for a density of 2.0 g/cm^3 are shown in Plate 2.

4. GEOLOGY OF OVENS RIVER VALLEY

The geology, gravity station locations, borehole logs, and Bouguer anomaly contours of the Ovens River valley area are shown in Plate 4. The Palaeozoic basement underlying the Ovens valley at Wangaratta consists of Silurian-Devonian granite; to the north and south of the granite extrusions, Ordovician mudstones and sandstone occur. Laceby No. 2 borehole (L2, Plate 4) penetrated 167 metres of Permian-Carboniferous glacial sediments which fill the northerly trending Ovens valley graben (Central Planning Authority, 1949).

The graben is bounded on the east and west by the Devonian and Silurian granite outcrops. The borehole evidence from Laceby 2 and the occurrence of Permian outcrops on the northern fringes of the river sediments suggest possible large thicknesses of Permian rocks beneath the Quaternary alluvial deposits. The density of the Permian rocks (Table 2, Appendix 2) is very hard to determine as the deposits are unconsolidated at the top of the sequence but become gradually silicified at depth. The Quaternary alluvial deposits reach a depth of roughly 120 metres (Plate 4).

5. GRAVITY RESULTS - OVENS RIVER VALLEY

The gravity results suggest an east-west trend which cuts across the strike of the Ovens valley graben and the Quaternary river valley. The observed gravity low of 9 mGal is too large to be accounted for by 120 metres of low-density alluvium, assuming a maximum density contrast of 0.7 g/cm^3. Granite from the Warby Range (Plate 4) has a density of 2.6 g/cm^3 (Appendix 2). A possible explanation for the east-west trend of the gravity anomaly is that the Ordovician mudstone and sandstone are sufficiently metamorphosed to be denser than the granite. The limited station coverage suggests that the gravity trends parallel the mapped contact of the Ordovician and the granite, and it would appear that this contact is the predominent influence on the gravity field in this area. Because of this it is considered that further gravity coverage will not achieve the desired objective of defining the thickness alluvium in the Ovens valley. The deep lead would probably be best located by deep seismic refraction and resistivity probing.

6. REFERENCES

CENTRAL PLANNING AUTHORITY, 1949 - Physiography geology and mineral resources. Upper Murray region - Resources Survey. Prelim. Rep.

HASTIE, L.M. & WALKER, O.G., 1962 - Two methods of gravity traversing with helicopters. Bur. Miner. Resour. Aust. Rec. 1962/34 (unpubl.).

NETTLETON, L.L., 1939 - Determination of density for reduction of gravimeter observations. Geophysics, 4(2), 176-183.

TAYLOR, F.J., HILL, P.J. & PETTIFER, G.R., (in prep.) - Goulburn Valley (Victoria) groundwater survey. Bur. Miner. Resour. Aust. Rec.

APPENDIX 1: GOULBURN VALLEY SURVEY DATA

Time of survey		February 1972	
Personnel		G.R. Pettifer (geophysicist) L. Kerec (draughtsman)	
Vehicles		Toyota 4 wheel drive; Holden Panel Van	
Survey base office		Numurkah SRWSC Survey Office	
BMR Survey Number		7206	
Survey based on Benalla Isogal		Station No. 6793.9302 May 1965 Isogal Value 979814.12 milligals	
Base stations (fixed nodes)		Station No. 7106.9000 May 1965 Isogal Value 979804.68 milligals	
		Station No. 7206.0604 May 1965 Value 979830.37 milligals	
Meter (calibration factor)		Sharpe Canadian No. 145 (0.1066)	
		Worden No. 260 (0.1088)	
Area of survey 1971-72		4600 sq km	
Total No. of stations		1265	
Station density		1 station/3.7 sq km	
Equivalent grid		1.92 km x 1.92 km	
New stations 1972		942	
Number of free nodes		48	
Number of gravity loops		92	
Misclosures (in mGal)		Initial	Adjusted
	Mean	0.07	0.01
	Std Devn	0.07	0.01
	Maximum	0.23	0.05
Adjustments	Mean	0.00 mGal	
	Std Devn	0.04 mGal	
	Maximum	0.14 mGal	
Errors (in mGal)	Height	0.05	
	Latitude	0.05	
	Base Stn	0.02	
	Misclosure	0.03	
	Total	0.08	

APPENDIX 2: DENSITY INFORMATION

In the Goulburn River valley survey three detailed gravity traverses were conducted over inliers of Palaeozoic basement rocks, which form hills on the margins of the valley. The eastern limit is marked by the Silurian granite of the Waggarandall Ranges and the Cambrian chert and greenstone of the Mount Major area near Dookie. In the southwest of the survey area the limit of the present Goulburn valley is marked by the Silurian sandstone and mudstone at Mount Scobie. Traverses were carried out on these three separate outcrops.

The traverses over the Waggarandall granite and Mount Major greenstone and chert showed high-frequency anomalies which could not be attributed to local topographic relief and hence were unsuitable for analysis for density information purposes. The profile over Mount Scobie showed a smooth variation with height, and Plate 5 shows the location and results of the Mount Scobie detailed traverse.

The coefficient of correlation for linear regression shows that the anomaly due to Mount Scobie is reduced to a minimum for density values 2.5 to 2.6 g/cm^3. The correlation coefficient of Bouguer anomaly and topography shows zero correlation at a Bouguer density of 2.5 g/cm^3. Samples from Mount Scobie have density values measured at between 2.4 and 2.5 g/cm^3. The results of the detailed traverse show that the surface sampling is biased towards lower density values and that the true value of density of the Silurian sediments is at least 2.5 g/cm^3 around Mount Scobie. The results of the Ovens River survey also suggest that the Ordovician rocks are denser than the Silurian granite (2.6 g/cm^3, see Table 2 below).

Table 1 shows the densities and seismic velocities of samples taken from the surface outcrops in the Goulburn Valley area. Table 2 presents the data for the Ovens Valley region.

TABLE 1 - DENSITIES AND SEISMIC VELOCITIES MEASURED ON SURFACE SAMPLES FROM THE GOULBURN VALLEY

Locality	Rock description	Density g/cm^3	Seismic velocity km/
DOOKIE	Cambrian chert, fresh	2.66	6.0 - 6.3
	Cambrian dolerite (slightly weathered) 2.98	2.98	5.9 - 6.5
	Cambrian basalt, fresh	2.96	5.5 - 6.4
MT SCOBIE	Silurian quartz sandstone	2.4 - 2.5	2.6 - 3.9
WAGGARANDALL	Silurian biotite granodiorite (slightly weathered)	2.62	4.5 - 4.6
TUNGAMAH	Ordovician medium-grained sandstone	2.59	3.3 - 3.6
	Ordovician hornfels	2.57 - 2.63	4.2 - 4.6

TABLE 2 - DENSITIES AND SEISMIC VELOCITIES MEASURED BY SURFACE SAMPLES FROM THE OVENS VALLEY

Locality	Rock description	Density g/cm^3	Seismic velocity km/s
WARBY RANGE	Silurian granite, moderately weathered	2.60	5.2 - 5.4
WANGARATTA 4	Palaeozoic mudstone	2.30	-
LACEBY 3	Lower Carboniferous mudstone	2.49	-
LACEBY 4	Permian pebbles	2.62	-
	Permian mixture	2.11	-

PLATE 1

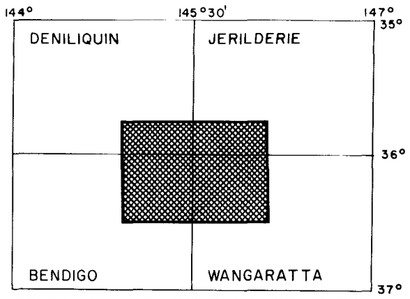
144°45' 145°00' 145°15' 145°30' 145°45' 146°00'

35°45' 36°00' 36°15' 36°30'

Mathoura
HWY
COBB
MURRAY RIVER
Tocumwal
Cobram
MURRAY VALLEY HIGHWAY
MURRAY RIVER
Broken
Picola
Barmah
Nathalia
Moama
ECHUCA
GOULBURN HIGHWAY
Numurkah
FIXED NODE
Katamatite
Boosey
Nine Mile Creek
GOULBURN VALLEY HIGHWAY
WAGGARANDAL RANGES
Tongala
Kyabram
MOUNT SCOBIE
MERRIGUM
Girgarre
Mooroopna
SHEPPARTON
MOUNT MAJOR
Katandra
Spine Lodge Creek
MIDLAND HIGHWAY
Stanhope
Tatura
The Salt Lake
Green Lake
Lake Cooper
Honeysuckle Ck
Broken River
FIXED NODE
BENALLA ISOGAL 6793·9302

CC1 B3670 · CC2 B3820 · CC3 A0016 · CC4 A0961 · CC5 B2470 · CC6 B2620 · CC7 A0060 · CC8 A0940 · CC9 B1225 · CC10 B9000 · CC11 A0111 · CC12 A0301 · CC13 A0293 · CC14 B4825 · CC15 A0200 · CC16 A0535 · CC17 A0527 · CC18 A0558 · CC19 A0253 · CC20 A0761 · CC21 A0753 · CC22 A0792 · CC23 A0598

TP B3090 · TP B3050 · TP B3200 · TP A0030 · TP A0083 · TP B1890 · TP B1845 · TP B1810 · TP A0160 · TP A0412 · TP A0404 · TP A0381 · TP A0233 · TP A0204 · TP A0678 · TP A0686 · TP A0663 · TP A0471 · TP A0845 · TP A0843 · TP A0835 · TP A0824 · TP A0844 · TP A0604 · TP B1100 · TP B1255



REFERENCE TO AUSTRALIA STANDARD 1:250,000 MAP SERIES ; DENILIQUIN JERILDERIE , BENDIGO , WANGARATTA.

ADJUSTMENT BASED ON;

7106·9000	979,804·68	FIXED NODE
7206·0604	979,830·37	
6793·9302	979,814·12	2°ISOGAL STATION

· GRAVITY STATION

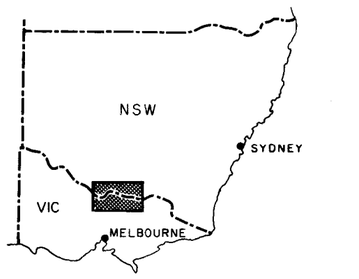
TP ⊡ TIE POINT

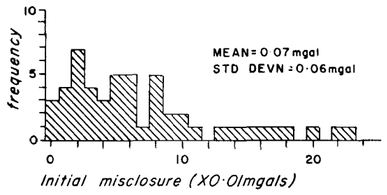
CC8 ⊡ CELL CENTRE & NUMBER

+0·13 — INITIAL VALUE (mgals)

(+0·00) — LEAST SQUARES ADJUSTED VALUE IN BRACKETS

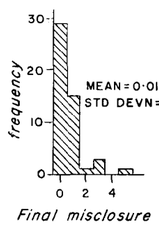
A=7206 B=7106



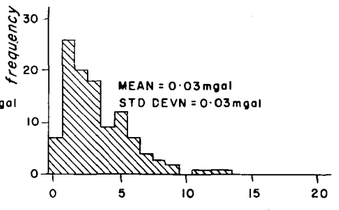


Initial misclosure (X0·01mgals)

BUILT-UP AREA
HIGHWAY
SECOND CLASS ROAD
RAILWAY WITH STATION
LAKE, RIVER OR STREAM
MARSH OR SWAMP
STATE BOUNDARY
NAMED PLACE



Final misclosure (X 0·01mgals)



Least squares network adjustments (X0·01mgals)

GOULBURN VALLEY REGIONAL GRAVITY SURVEYS 1971 AND 1972

LOOP CLOSURE DIAGRAM

5 0 5 10 15 20 KILOMETRES

5 0 5 10 15 MILES

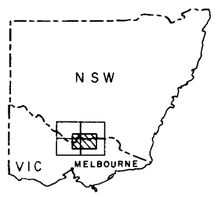
GOULBURN VALLEY SURVEYS
7106 & 7206
(NETWORK ADJUSTMENTS)
&
(LOOP MISCLOSURES)

To accompany Record No. 1973/41

J55/B2-111

PLATE 2

(Based on J55/80-26)



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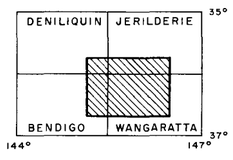
STANDARD 1:250000 MAP SERIES



- Lake, river or stream
- Marsh or swamp
- Hill feature
- Highway
- Secondary road
- Built-up area
- Named place
- Railway, with station
- State boundary

-10 Isogal

'High' anomaly

'Low' anomaly

For the calculation of Bouguer anomalies 2·0 g/cm has been used as an average rock density

5 0 5 10 15 20 25 30 KILOMETRES

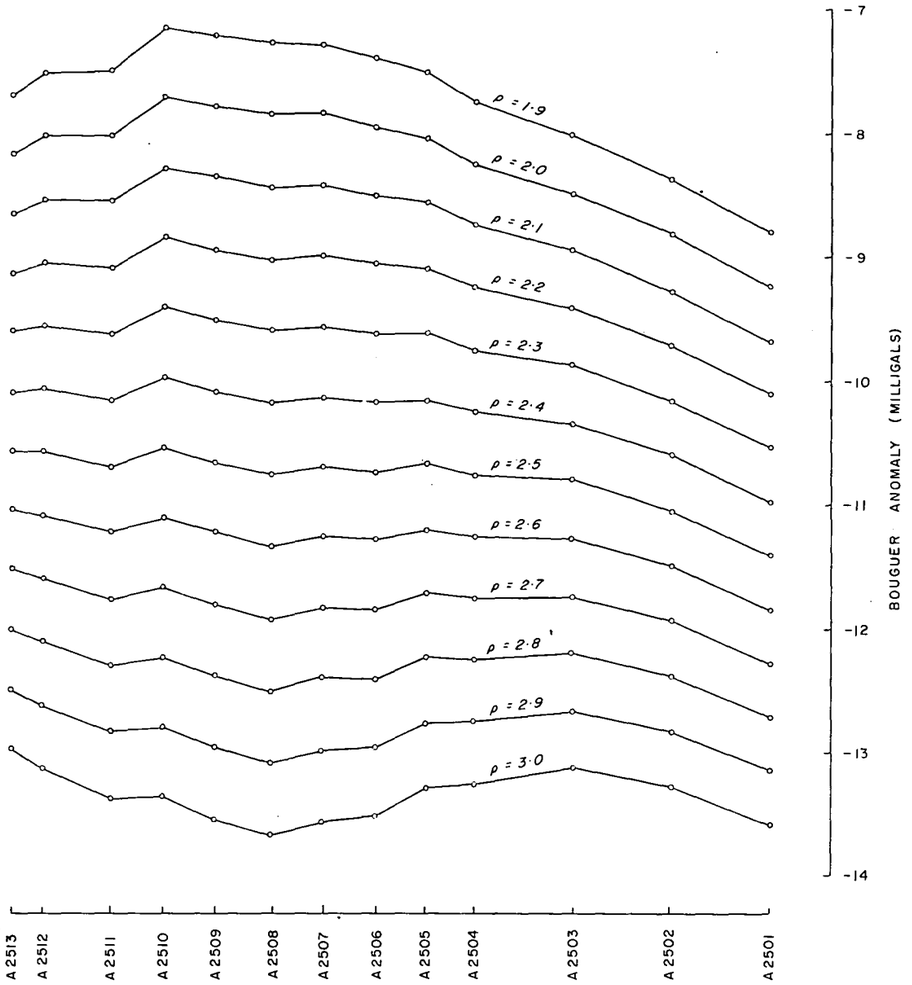
5 0 5 10 15 MILES

Contour interval 1 milligal

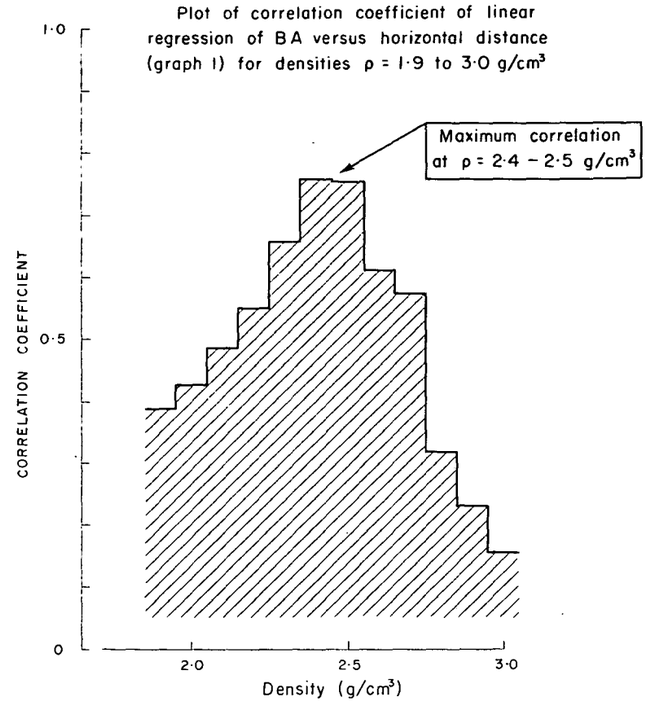
PRELIMINARY BOUGUER ANOMALIES

GRAPH 1

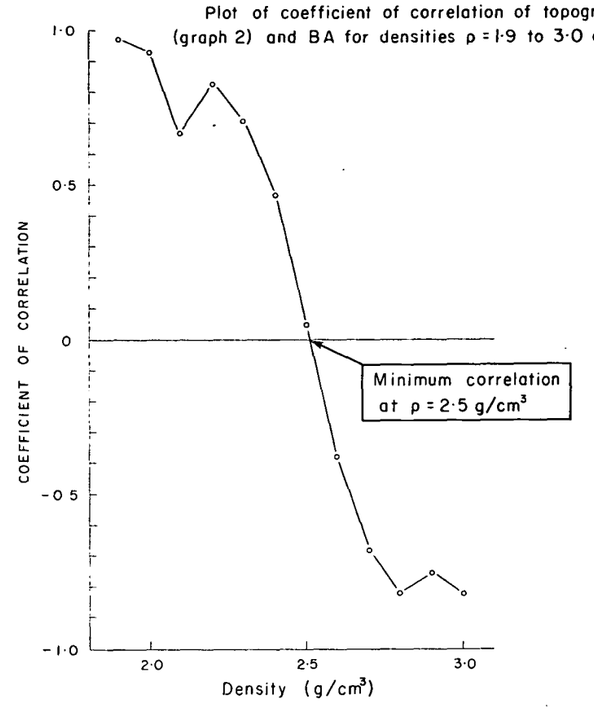
Plot of BA at densities ρ = 1·9 to 3·0 g/cm³



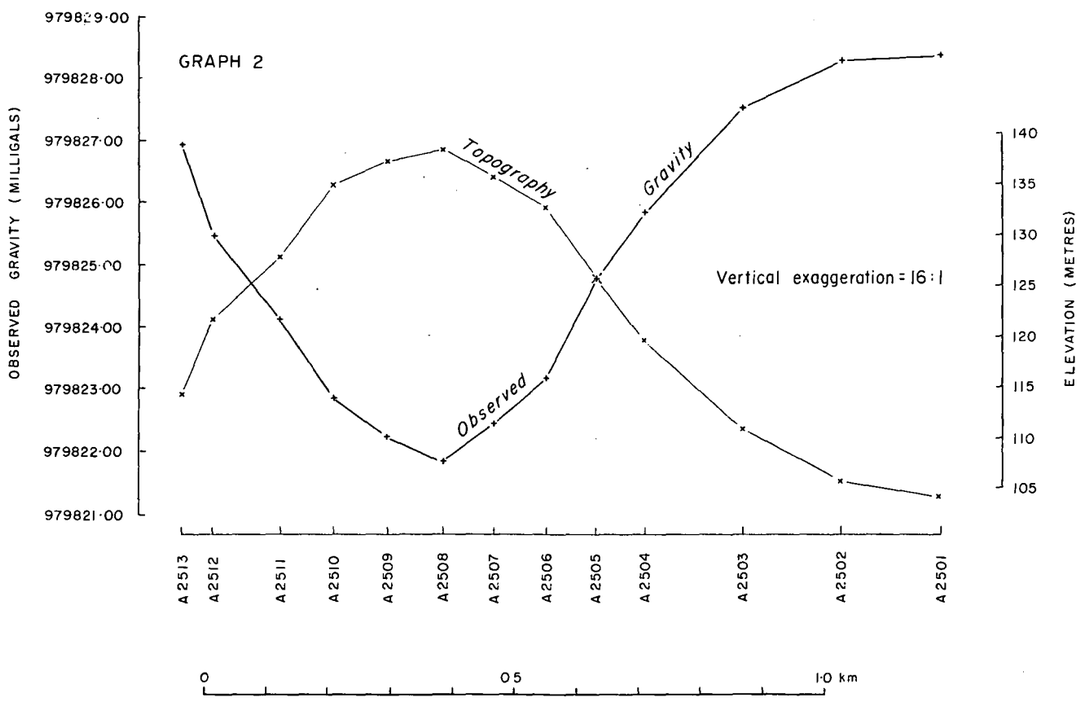
Plot of correlation coefficient of linear regression of BA versus horizontal distance (graph 1) for densities ρ = 1·9 to 3·0 g/cm³



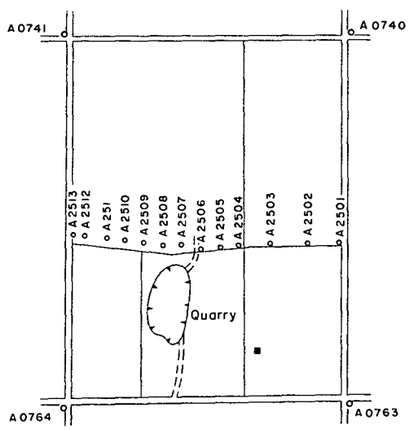
Plot of coefficient of correlation of topography (graph 2) and BA for densities ρ = 1·9 to 3·0 g/cm³



GRAPH 2



LOCATION DIAGRAM



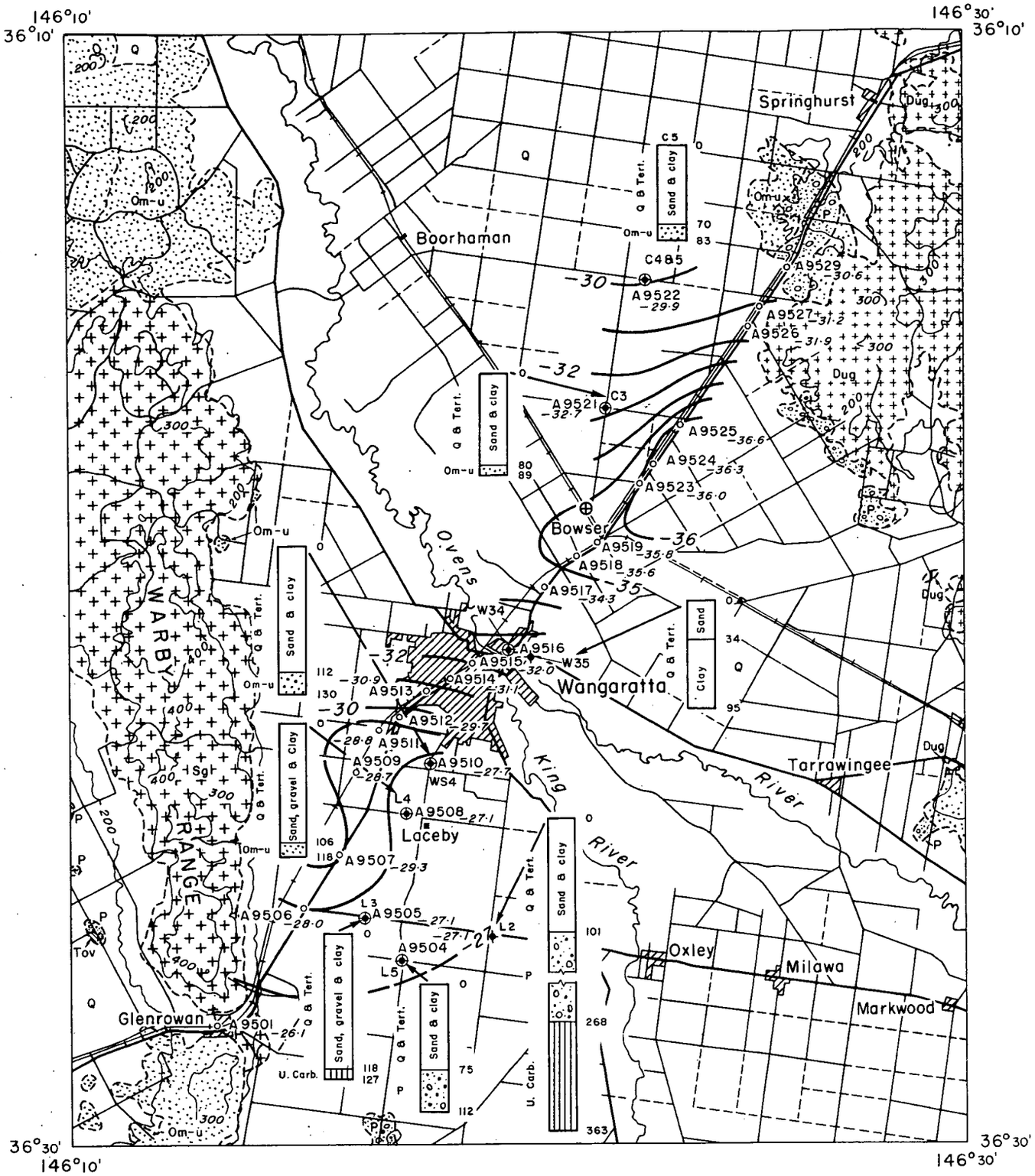
A = 7206

MOUNT SCOBIE DETAILED TRAVERSE

To accompany Record No. 1973/41

J55/B2-115

PLATE 4

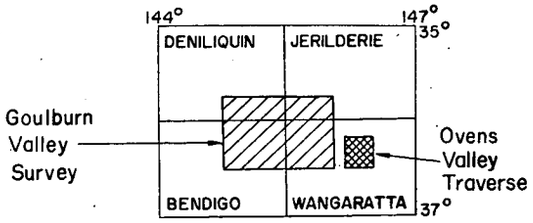


OVENS VALLEY GRAVITY TRAVERSE 1972

2 0 2 4 6 8 10 12 KILOMETRES

2 0 2 4 6 MILES

LOCATION DIAGRAM



Average rock density of 2·0 g/cm^3 used for computations

A = 7206

Geological information taken from Wangaratta, Sheet No. SJ55-2, Geological Survey of Victoria provisional edition 1968

LEGEND

GRAVITY

- A9505 — Gravity station & number
- -27·1 — Bouguer anomaly (milligals)
- -30 — Isogal (Inferred)
- Borehole
- L — Laceby
- W — Wangaratta
- WS — Wangaratta South
- C — Carraragarmungee
- Proposed borehole
- Gravity station at borehole
- 118/127 — Borehole log (depth in metres)

TOPOGRAPHY

- Principal or secondary road
- Minor road
- Vehicular track
- Railway, station
- Built-up area
- Named place
- River or stream
- -400- Contour with value (metres)

GEOLOGY

- Geological boundary
- Q — Quaternary (alluvial deposits)
- Tov — Tertiary (older basic volcanics)
- P — Permian (glacial deposits)
- Upper Carboniferous (?)
- Dug — Devonian (granite)
- Sgr — Silurian (granite)
- Om-u — Ordovician (sandstone & mudstone)

To accompany Record No. 1973/41

J55/B2-112