COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1964/116

WINTON SEISMIC SURVEY,

QUEENSLAND 1960

by

C.S. ROBERTSON

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SUMMARY

Towards the end of 1960, the Bureau of Mineral Resources, Geology and Geophysics made a brief seismic survey in the Winton area of Queensland to resolve an apparent contradiction between the interpretations of gravity and aeromagnetic results previously obtained in the area. Gravity and aeromagnetic results both suggested the occurrence of a large fault or fault zone about 20 miles north-west of Winton, but the gravity and aeromagnetic interpretations differed regarding the direction of throw of the fault. A nine-mile seismic reflection traverse was surveyed across the supposed fault. The seismic results indicate the presence of a large fault or monoclinal fold with downthrown side north-west as suggested by the gravity values and also a smaller fault or monocline about two miles south-east with downthrown side south-east. The variations in thickness of Mesozoic rocks caused by these features were insufficient to explain the observed Bouguer gravity anomaly values, but the seismic results left open the possibility that there may be a considerable thickness of pre-Mesozoic sediments north-west of the main monocline or fault. It is postulated that the steep gravity gradient observed may be due to a large fault whose main movement took place in pre-Mesozoic times. Indications are that there is 5000 to 6000 ft of Mesozoic sediments in the area.

1. INTRODUCTION

From 28th November to 9th December 1960, the Bureau of Mineral Resources, Geology and Geophysics did a brief seismic reflection survey about 20 miles north-west of Winton in the Great Artesian Basin, Queensland. The object of the survey was to resolve an apparent contradiction between interpretations of gravity and aeromagnetic results previously obtained in the area. Gravity and aeromagnetic results both suggested the occurrence of a large fault or fault zone with a south-west to north-east strike, but the interpretations differed on the direction of throw. A seismic reflection traverse about nine miles long was surveyed along the Winton-Cloncurry road, which runs in a north-westerly direction, so as to cross the supposed fault.

The seismic traverse was situated on a lease area held by Magellan Petroleum Corporation. The aeromagnetic survey was made in 1956 by Adastra Hunting Geophysics Pty Ltd for Catawba Corporation, the previous holder of the Authority to Prospect. The position of the seismic traverse in relation to total magnetic intensity contours is shown in Plate 2. The results of a gravity survey made in 1959 (Magellan, 1961) are shown in Plate 3. Prior to the Bureau's 1960 survey, no seismic work had been done in the Winton area.

2. GEOLOGY

In the Winton area of the Great Artesian Basin, a thin cover of Tertiary sandstone (eroded away in many places) overlies blue clay of the Winton Formation. The geology sequence at depth is :

Age		Formation
Tertiary		Eyrian Formation
	Rolling Downs Group	Winton Formation (shale)
		Tambo Formation (shale)
		Roma Formation (shale)
Cretaceous		
		Transition Beds
		Mooga Sandstone
	Blythesdale Group	Fossil Wood Beds
Jurassic		Gubberamunda Sandstone
		Boxvale Sandstone
Triassic	Bundamba Group	Evergreen Shale
		Precipice Sandstone

Whitehouse (1954, p.10) considers that in bores the lacustrine Winton Formation, which at Winton is 1050 ft thick (Mott, 1960), is readily distinguished from the marine Tambo Formation owing to the '...increase in sandstone members...' in the Winton Formation. Until recently there was some doubt regarding the geological ages of various formation in the Blythesdale Group. Recent palaeontological evidence, especially from microfloral studies, has shown that the Transition Beds of the Blythesdale Group are Cretaceous and the remaining units of the Group are Jurassic.

The Blythesdale Group/Roma Formation boundary is lithologically abrupt. The Mooga Sandstone in the Blythesdale Group is the uppermost aquifer of the Great Artesian Basin, but useful water is produced by sub-artesian bores from sandy beds within the Rolling Downs Group. A structural contour plan by Whitehouse (op.cit. Fig.17) indicates that the boundary between the Roma Formation and the Transition Beds of the Blythesdale Group is about 2700 ft below sea level at Winton, but only about 1500 ft below sea level in the region of Corfield, 52 miles north-east of Winton.

Winton No.2 bore was drilled to a depth of 4010 ft at Winton township in 1960 to supplement the town water supply. A simplified driller's log for this bore is shown below :

Depth (ft)	Rock type
67-91	Clay with sand and gravel
91-213	Blue clay or mudstone with coal bands
213-309	Blue and yellow mudstone and clay with coal bands.
309-439	Blue mudstone
439-1529	Blue silty mudstone with a few hard banks
1529-3295	Mudstone with hard shale bands
3295-3716	Muddy or silty sandstone
3716-4016	Sandstone

This bore was logged electrically by the Bureau of Mineral Resources in 1960 using a Widco 10,000-ft logger (Jesson & Radeski, 1961). The same year the Bureau also logged Corfield No.1 bore which was initially drilled as a water bore for the Winton Shire Council and later deepened to granitic basement (4300 ft) at the request of Magellan Petroleum Corporation (Jewell, 1960). It was found from the electrical logs that the formations penetrated by the bores are uniformly thicker at Winton than at Corfield by about about 40 percent.

Little information is available on the pre-Mesozoic rocks in the Winton area because of the scarcity of bores drilled below the artesian strata. It is not known whether the granitic basement rocks encountered in Corfield No.1 bore extend over the whole area or whether pre-Mesozoic sediments may be present in some areas.

3. FIELD WORK

The Bureau's No.1 seismic party commenced field work on Monday 28th November and finished on Friday 9th December 1960. Field progress was mainly restricted by the fact that water for drilling had to be carted about 20 miles from Winton. Two drilling rigs were employed, both of which used fluid for drilling but only two water tenders were available so that much time was lost by the rigs while waiting for water. The formations drilled were soft, consisting mainly of clay and shale, and penetration rate was good. The best shooting depth was found to be 150 ft but it was not possible to drill all holes to this depth because of the limited time available. The majority of holes were drilled to about 100 ft. Shooting at this depth usually gave satisfactory results.

The normal split-spread method of continuous reflection profiling was used. Shot-points were a quarter of a mile apart along the side of the Winton-Cloncurry road.

The survey was conducted by geophysicist C.S. Robertson (party leader) assisted by six staff members of the Bureau and six wages employees. A surveyor was provided by the Department of the Interior. The staff members and the main items of equipment are listed in Appendix A. Recording parameters and statistics relating to the survey are set out in Appendix B.

4. RESULTS

The results of the seismic traverse are shown in the form of a corrected variable-density cross-section (Plate 4). Reflection quality varied from poor, as at the south-eastern end, to moderately good, as at the north-western end. The quality of reflections deteriorated greatly beyond about 1.2 sec in the south-eastern half of the traverse and beyond about 1.5 sec in the north-western half. A number of reflections can be correlated continuously over distances of several miles and these give a good indication of subsurface structure to a depth of about 5000 or 6000 ft from the surface.

In the absence of any seismic velocity information in the Winton area from boreholes or more-extensive seismic surveys, the velocity distribution used by the Bureau in the Quilpie- Eromanga area was applied to the 1960 Winton traverse. This velocity distribution is shown in Plate 5 and was derived from $t:\Delta t$ analysis made from previous surveys in the area (Bigg-Wither & Morton, 1962). Using this velocity distribution the normal spread correction move-out effect was satisfactorily removed from the records in producing the corrected cross-section by means of the variable-intensity plotter. This is an indication that the velocity distribution assumed is a good approximation to reality, at least to reflection times of 1.5 sec.

It is evident from the corrected record cross-section (Plate 4) that the reflections indicate conformable sediments with slight to moderate dips down to a depth of about 6000 ft. It is likely that these are the Mesozoic sediments of the Great Artesian Basin, and they will be referred to as such, although elsewhere in this Basin, the Mesozoic Artesian sediments are underlain by conformable Permian sediments, which could be present here also. These sediments show a pronounced structural feature between Shot-points 14 and 23. There is a structural 'high' with culmination in the vicinity of Shot-point 20. Reflections obtained at Shot-points 21, 22, and 23 indicate a fairly steep component of dip to the north-west, suggesting an increase in depth of Mesozoic sediments from about 4700 ft at Shot-point 21 to 5500 ft at Shot-point 24. Although some reflections from a depth of about 4000 ft appear to be continuously correlatable from Shot-points 21 to 23, it is not certain whether the increase in depth is due to a fold or to faulting. The sloping events recorded at Shot-points 22 and 23 and on the north-western end of the spread at Shot-point 21 are possibly diffractions from the ends of reflectors on the upthrown side of a fault a few hundred feet north-west of Shot-point 21.

South-east of Shot-point 21 reflections indicate that the Mesozoic sediments are more or less horizontal in the direction of the traverse to about Shot-point 16. Reflections recorded at Shot-point 16 indicate about 30 msec of south-easterly dip, whereas reflections recorded at Shot-point 15 are somewhat confusing because of indications of both horizontal and south-easterly dipping events. The record from Shot-point 14 also indicates nearly horizontal sediments but the deepest reflections on this record and on those from shot-points farther south-east are seen to occur about 0.1 sec later than those from Shot-points 16 and 17. It appears from these facts that in the vicinity of Shot-points 15 and 16 there is a fault or monoclinal fold whose downthrown side is to the south-east. Because of the confused nature of the reflections or diffracted events recorded, it is not possible to correlate events from Shot-point 16 to Shot-point 14 and hence determine accurately the vertical displacement caused by the fault or fold. However, it is estimated that the vertical displacement across this structural feature below the main reflection band is of the order of 500 ft (0.1 sec reflection time).

As already stated, events from below the conformable strata, which were indicated to a depth of 5000 to 6000 ft, were very poor, especially on the south-eastern half of the traverse. Between Shot-points 1 and 22 no definite reflections were recorded beyond about 1.3 sec. There were a few more-or-less horizontal events that could be multiple reflections. Between Shot-points 9 and 15 some poor events with steep slope towards the north-western end of the traverse were also recorded. These events are certainly indistinct, but in some cases they do appear to correlate well between two or more adjacent records. However, they could not be interpreted reliably as reflections indicating north-westerly component of dip in deep sediments. Some of these sloping events may represent diffraction patterns, whereas others may merely be 'chance line-ups'.

On the north-western half of the traverse beyond Shot-point 23, events recorded later than 1.5 sec are much more common and are usually more or less horizontal. Some of them can be correlated from one record to the next, but they always exhibit a lower signal-to-noise ratio than the majority of the shallower reflections assumed to come from Mesozoic sediments. The deep events may well be multiple reflections. They may also be genuine reflections indicating the presence of sediments to a depth of at least 12,000 ft (2.5 sec). The seismic results are thus inconclusive regarding the existence, of pre-Mesozoic sediments.

The relief in the Mesozoic sediments as indicated by the seismic results is not sufficient to account for the gravity anomaly along the traverse. The Bouguer gravity anomalies range from -10 mgal at the south-east end of the seismic traverse to -28 mgal at the north-western end (Plate 3). If we ignore the probable fault near Shot-points 15 and 16, which appears to have a throw of about 500 ft to the south-east and hence in the opposite direction to the gravity anomaly, the only substantial relief in the Mesozoic sediments is caused by the fault or monocline near Shot-point 23, with a downward displacement of about 800 ft to the north-west. Assuming a density contrast as much as 0.4 g/cm^3 between Mesozoic sediments and pre-Mesozoic basement, the change in gravity anomaly owing to the increased thickness of Mesozoic sediments would only be about 4 mgal, which is far short of the 18 mgal observed from one end of the traverse to the other. The major part of the gravity anomaly must be due either to a marked horizontal density change in basement material or to strong structural relief within the basement complex or to both of these causes.

One plausible explanation for the gravity gradient and the seismic results is that a considerable thickness of pre-Mesozoic sediments may be present only at the north-western end of the seismic traverse. In the vicinity of Shot-point 23 there is possibly a major fault whose main displacement took place in pre-Mesozoic times, resulting in the deposition of a thick trough of sediments to the north-west. The fault movement evidently continued beyond the end of the Palaeozoic era resulting in either monoclinal folding or faulting of the Mesozoic sediments as observed.

It is not clear how the aeromagnetic results can be explained in terms of this theory. These results indicate a zone of steep magnetic intensity gradient trending in a north-easterly direction more or less parallel to the gravity gradient, with total magnetic intensity increasing to the north-west. The magnetic contour map (Plate 2) has been interpreted (Magellan, 1961) as indicating the existence of a major fault at the south-eastern edge of the zone of steep magnetic gradient, i.e. cutting the seismic traverse near its north-western end. Because magnetic gradients observed south-east of the supposed fault are much gentler and depth estimates much deeper, it was postulated that magnetic basement is covered by a greater thickness of sediments in this region i.e. the downthrow side of the fault was to the south-east.

There is no seismic indication of the existence of a major fault or other structure near the north-western end of the traverse. However, the zone of steep magnetic anomaly is centred several miles beyond the end of the seismic traverse. If any structural reason for the magnetic gradient exists, it may well be located beyond the seismic traverse. The magnetic gradient may on the other hand be caused by a lateral change in basement material or even a change from granite to sediments rich in magnetite or sediments with interbedded lava flows below the Mesozoic sediments. Quilty (pers. comm.) has commented that it appears likely that the magnetic anomaly is derived from a totally different structure to that which gives rise to the gravity gradient and probably relates to a fault or contact in the basement situated about five miles north-west of the end of the traverse.

5. CONCLUSIONS

The Winton seismic traverse indicated the presence of about 5000 to 6000 ft of conformable sediments believed to be of Mesozoic age. These sediments are affected by a monocline or fault that intersects the seismic traverse near the centre of a steep gravity gradient with decreasing values of Bouguer anomaly towards the north-west. The seismic results indicated a vertical displacement of about 800 ft, the lower side being to the north-west. A smaller structural feature, which might be a fault or monocline, was also indicated about two miles south-east of the main feature. Displacement of the Mesozoic sediments at the smaller feature could not be determined with certainty, but appears to be of the order of 500 ft, the downthrown side being to the south-east.

Owing to the lack of definite reflections, there is no evidence for the existence, or otherwise, of pre-Mesozoic sediments south-east of the main structural feature mentioned above. Many more-or-less horizontal events were recorded north-west of the main monocline or fault. These may have been multiple reflections, or true reflections indicating the presence of a considerable thickness of pre-Mesozoic sediments, extending to a depth of at least 12,000 ft. The most reasonable explanation of both seismic and gravity results would seem to be that there is a major fault in pre-Mesozoic rocks near Shot-point 23 with downthrown side to the north-west. This fault is reflected by a monocline or fault with less displacement in the overlying Mesozoic sediments. The seismic traverse did not extend far enough to the north-west to be of much assistance in interpreting the aeromagnetic results.

6. REFERENCES

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APPENDIX A

STAFF AND EQUIPMENT

STAFF:

Party leader	:	C.S. Robertson
Surveyor	:	N. Wilson
Observer	:	L. Vliecenthart
Shooter	:	E. Cherry
Drillers	:	B. Findlay, J. Lambert
Mechanic	:	H. Robertson

EQUIPMENT

Seismic amplifiers	:	TIC 621
Seismic oscillograph	:	TIC 50 trace
Magnetic recorder	:	Electro-Tech DS.7
Geophones	:	TIC, 20 c/s and 6 c/s
Drills	:	1 Failing 750, 1 Carey
Water tankers	:	1 International, 700 gallon 1 Bedford, 700 gallon
Shooting truck	:	Bedford, 700 gallon

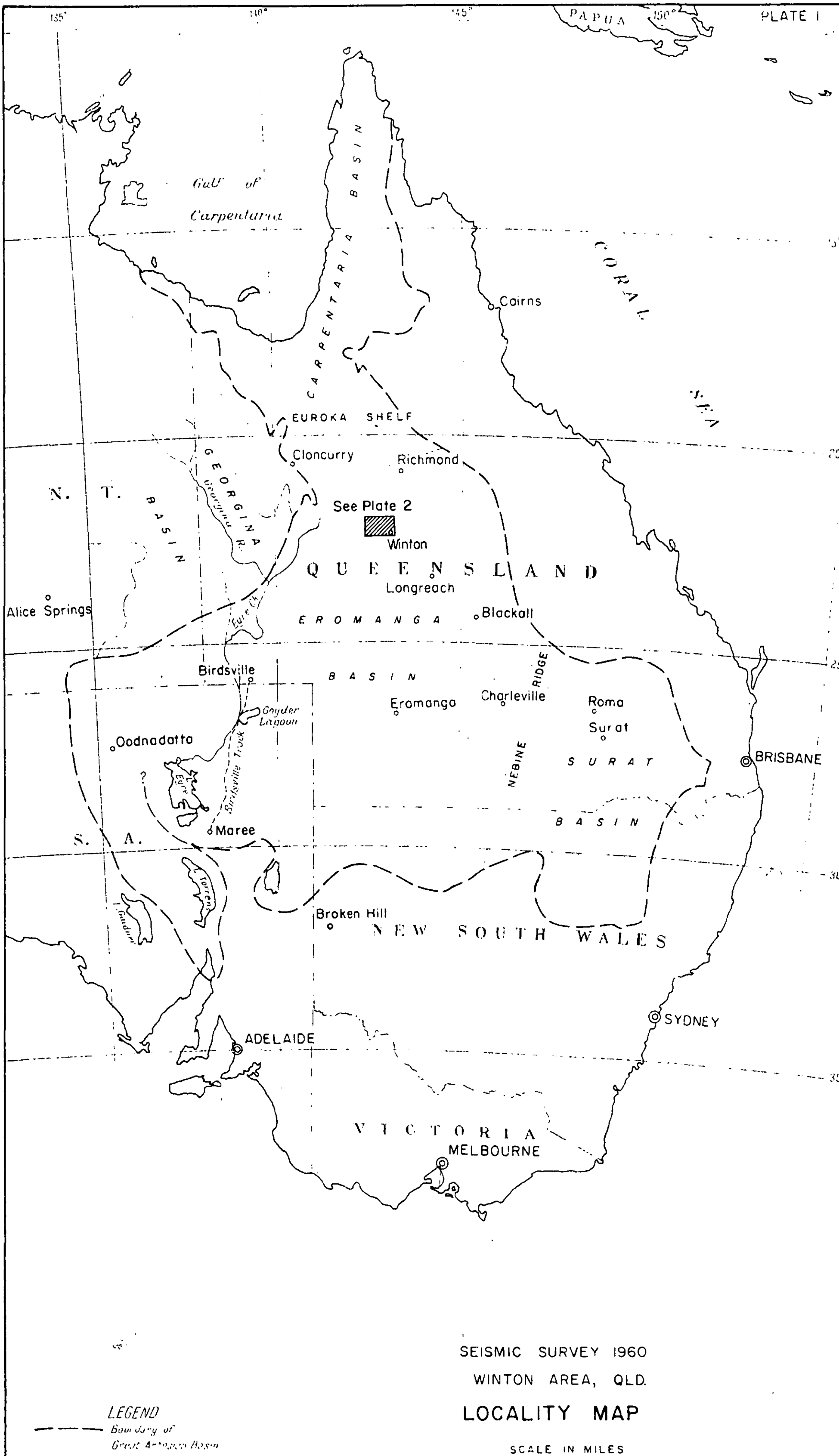
APPENDIX B

TABLE OF OPERATIONS

Sedimentary basin	:	Great Artesian
Area	:	Winton
Accommodation	:	Hotel Winton
Surveying commenced	:	28/11/60
Drilling commenced	:	28/11/60
Shooting commenced	:	29/11/60
Miles Surveyed	:	$8\frac{1}{2}$
Topographic survey control	:	Horizontal and vertical from main-road bench marks
Total footage drilled	:	4944
Explosives used	:	1304 lb
Datum level for corrections	:	500 ft above sea level
Weathering velocity	:	2000 ft/sec
Sub-weathering velocity	:	6000 ft/sec
Source of velocity distribution	:	$t:\Delta t$ analysis

REFLECTION SHOOTING DATA:

Shot point interval	:	1320 ft
Geophone group	:	six 20-c/s geophones at 22-ft spacings
Geophone group interval	:	110 ft
Holes shot	:	34
Miles traversed:	:	$8\frac{1}{2}$
Common shooting depths	:	105-150 ft
Usual recording filter	:	L2H2
Usual playback filter	:	L2H4
Common charge sizes	:	20 lb
Weathering corrections	:	After Vale (1960)
Grading system	:	After Gaby (1947)



SEISMIC SURVEY 1960

WINTON AREA, QLD.

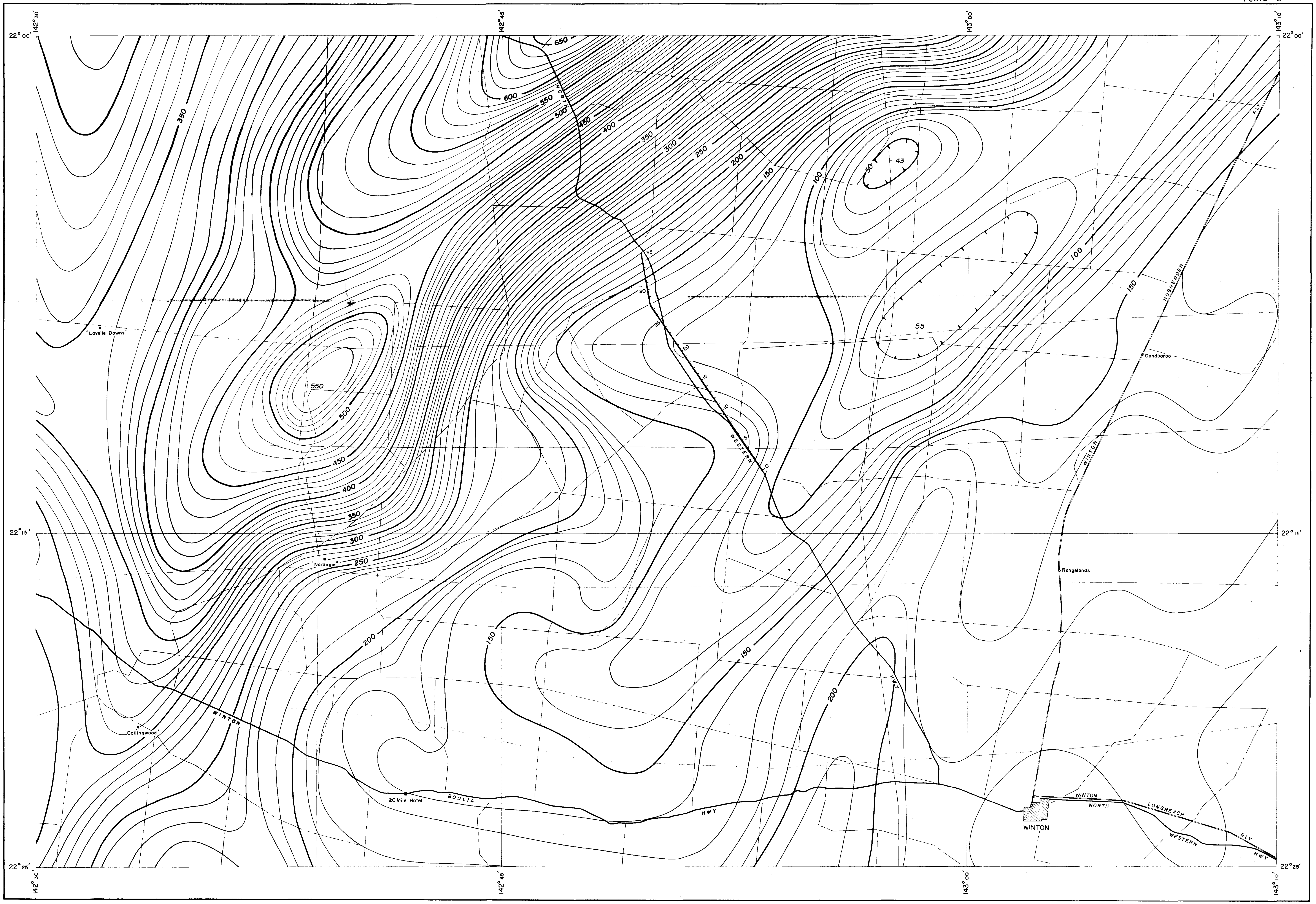
LOCALITY MAP

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G 295-49

TO ACCOMPANY RECORD No 1964/116

Ex 296-2

PLATE 2



LEGEND

- Road
- Railway
- Homestead
- Seismic traverse (30)
- Flight-line
- Gravity survey line
- 200 Isogams
- Magnetic 'low'

EXPLANATION

Computed Regional Variation +9·6 gammas/mile to the north (geog)
(Space Gradient) Applied +1·7 gammas/mile to the east (geog)

MAP DATA

Planimetric detail based on Division of National Mapping photo scale compilation, Winton sheet.
Magnetic information after Catawba Corporation sheet 10 of Authority 62 P (North Winton)

TOTAL MAGNETIC INTENSITY

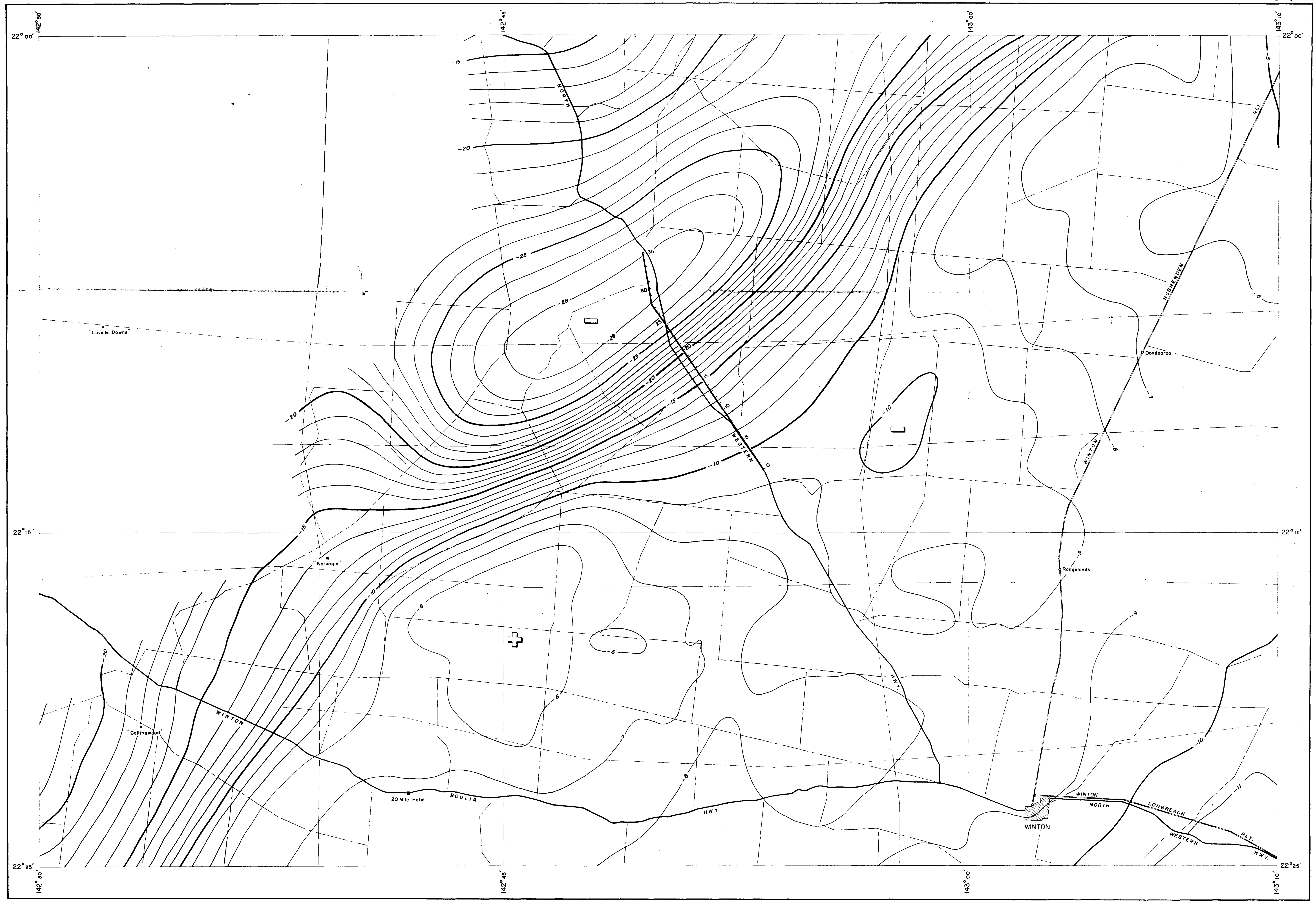
SCALE IN MILES

2 0 2 4 6 8

CONTOUR INTERVAL 10 GAMMAS

SEISMIC SURVEY 1960, WINTON, QLD.

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. F 54/B 3-51
To Accompany Record No 1964/116



BOUGUER ANOMALIES

LEGEND

- Road
- Railway
- Homestead
- Seismic traverse
- Flight-line
- Gravity survey line
- -20 Isogals
- 'High' anomaly
- 'Low' anomaly

EXPLANATION

Relative Bouguer anomalies are based on the observed gravity values at following B.M.R. pendulum stations:

No. 54 Longreach 978,798·80 milligals

No. 57-4 978,718·75 milligals

For the calculation of Bouguer anomalies 1·9 g/cm^3 has been adopted as an average rock density.

MAP DATA

Planimetric detail based on Division of National Mapping photo scale compilation, Winton sheet.

Gravity information after Magellan Petroleum Corp. sheets 4 and 5 of Authority 62 P (North Winton)

SCALE IN MILES

2 0 2 4 6 8

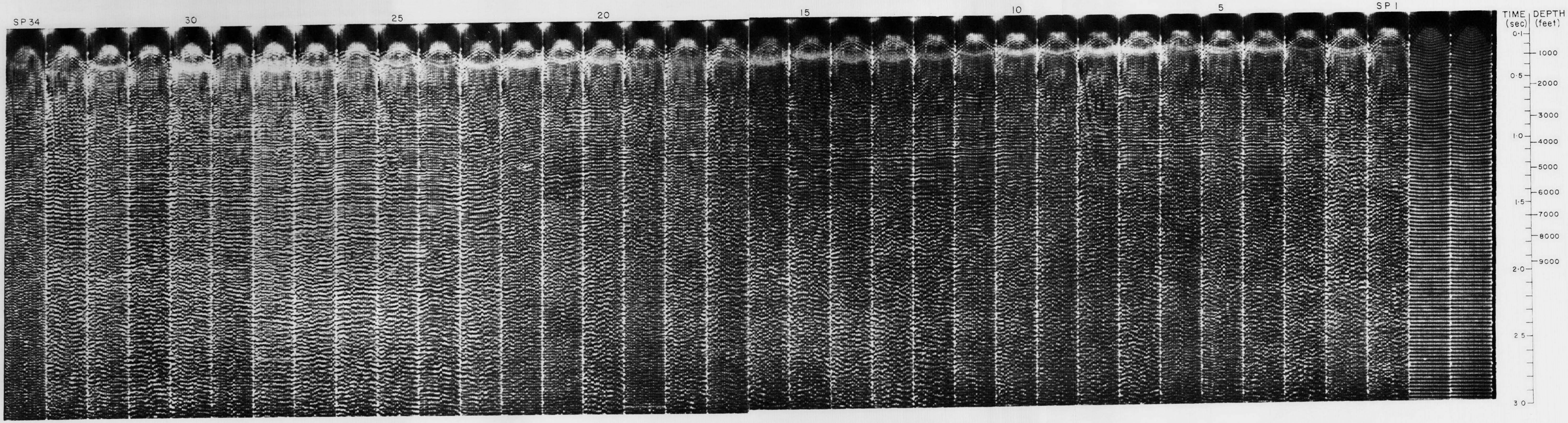
CONTOUR INTERVAL 1 MILLIGAL

SEISMIC SURVEY 1960, WINTON, QLD.

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. F54/B3-52

To Accompany Record No 1964/116

PLATE 4



VARIABLE INTENSITY CROSS-SECTION

TRAVERSE A

HORIZONTAL SCALE IN MILES

0 ¼ ½ ¾ 1

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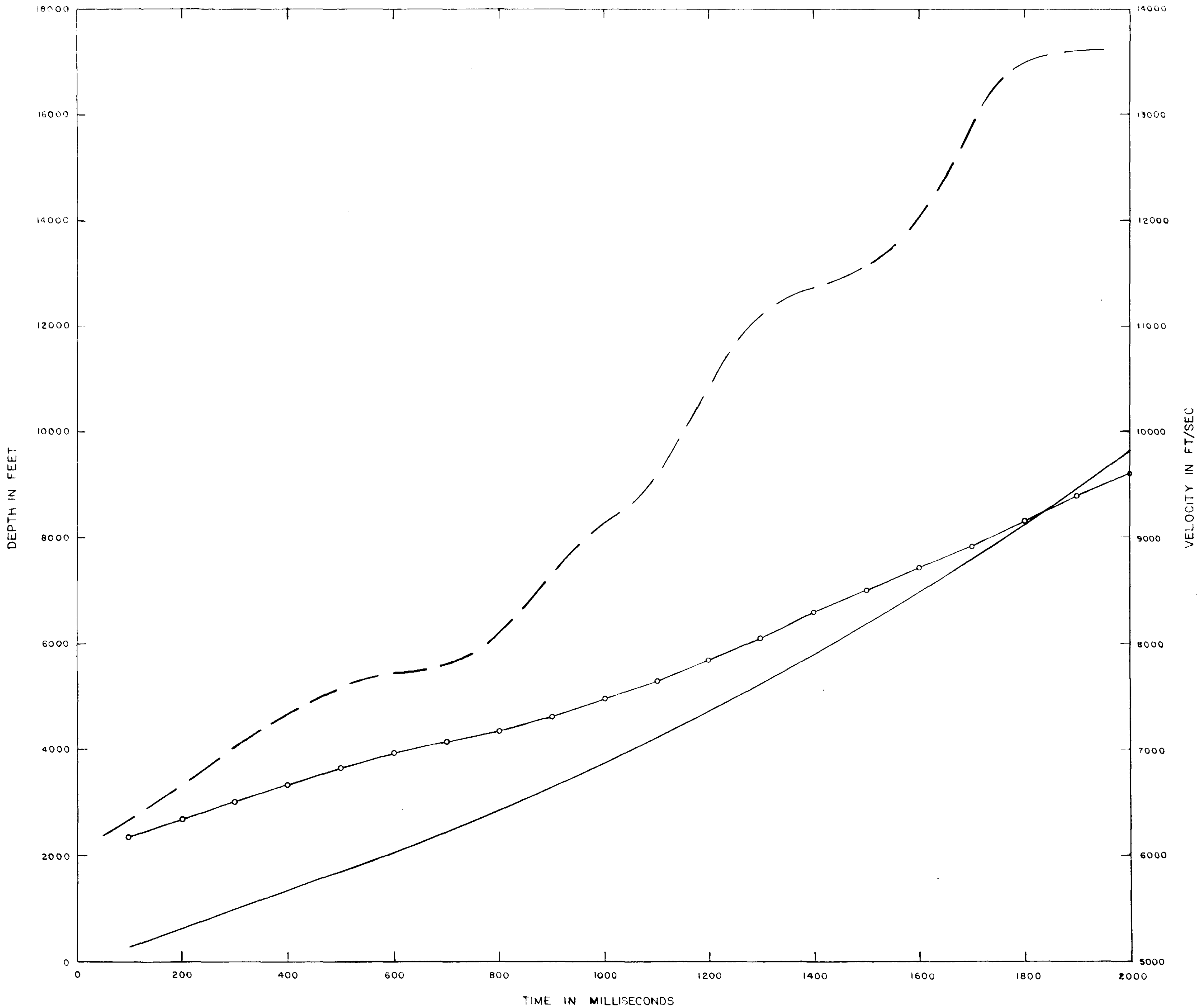
TO ACCOMPANY RECORD No 1964/116



LEGEND

DEPTH

AVERAGE VELOCITY

INTERVAL "

SEISMIC REFLECTION SURVEY, WINTON AREA, QUEENSLAND

ASSUMED CURVES RELATING DEPTH, AVERAGE AND INTERVAL VELOCITIES WITH TIME DERIVED FROM t:Δt ANALYSES OF REFLECTIONS OBTAINED IN THE QUILPIE AND HADDON DOWNS (SA) AREAS