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SOUTHERN CARNARVON BASIN
SEISMIC SURVEY, WA 1964
(TRAVERSE C, GASCOYNE JUNCTION)

by

R.J.H. VALENTINE and A. TURPIE

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SUMMARY

From 1st September to 27th November 1964, Seismic Party No. 2 of the Bureau of Mineral Resources conducted a survey in the Carnarvon Basin along a line running forty miles west from Gascoyne Junction. Its purpose was to investigate the regional structure associated with the southern extension of the Wandagee Gravity Ridge at this latitude and to obtain information concerning the Palaeozoic sediments in the area.

Reflection and refraction techniques were used on both sides of the Ridge. The reflection results varied from good at the eastern end of the line, over the Permian outcrops in the central part of the Merlinleigh Basin, to poor in the western portion of the Merlinleigh Basin and in the Gascoyne Basin.

Refraction work identified three refractors in the Gascoyne Basin and three refractors in the Merlinleigh Basin. Profiling was carried out on refractors in both basins. Shallow refraction work was done in the neighbourhood of the contact between the two basins.

Results are poor and difficult to interpret on the eastern flank of the main gravity 'high'. The sedimentary section dips gently away from both sides of this disturbed region.

A bore hole at about the gravity maximum and just west of the Permian/Cretaceous contact encountered probable Silurian or Ordovician rocks at 350 feet. A reflection that correlates with a refractor having a velocity of 20,100 ft/s indicates possible metamorphic or igneous basement at a depth of about 5000 ft under this point.

Reflections thought to be primary were obtained to a maximum depth of about 10,000 ft in the Merlinleigh Basin.

1. INTRODUCTION

From September 1st to November 27th 1964, Seismic Party No. 2 of the Bureau of Mineral Resources (BMR) made a seismic survey along a line running 40 miles west from Gascoyne Junction. This survey was part of a regional survey of the southern part of the Carnarvon Basin, with the particular objectives of investigating the regional structure associated with the southern extension of the Wandagee Gravity Ridge at this latitude and of obtaining information concerning the Palaeozoic sediments in the area.

Access to the area was along the main Carnarvon Gascoyne Junction road, on a flat plain bordering the Gascoyne River. The traverse (Traverse C) was confined to this plain, and its location is shown in Plates 1 and 2.

Vegetation west of the Permian-Cretaceous contact consists of medium to thick scrub; the Permian outcrop is a fairly open plain. To the south of the area are ridges of high sand dunes.

2. GEOLOGY

The Carnarvon Basin covers an area of about 100 miles in width extending south from the North West Cape for about 500 miles to the Murchison River. Condon (1956), acting on the results of a regional gravity survey made by the BMR (Chamberlain, Dooley, & Vale, 1954), together with the results of geological surveys and drilling, suggested that the Carnarvon Basin may be divided into several sub-basins separated by basement ridges. The present report is concerned with a traverse crossing the Wandagee Ridge, which separates the Gascoyne and Merlinleigh sub-basins.

The Wandagee Ridge was investigated in the vicinity of Wandagee Hill by Western Australian Petroleum Pty Ltd (WAPET) using seismic reflection techniques (Dennison *et al*, 1962). The eastern margin was interpreted as fault bounded. Drilling of the Wandagee No. 1 and Quail No. 1 wells, which were situated on either side of the proposed fault, proved that there was a displacement of the Silurian Dirk Hartog Dolomite of about 8500 ft down to the east. Condon interpreted the eastern flank of the Wandagee Ridge as an angle of rest unconformity. In both interpretations, a displacement of this order would be valid.

The following description of the stratigraphy of the Carnarvon Basin is based mainly on work done by geologists of the BMR (Konecki *et al*, 1958) and WAPET (McWhae *et al*, 1958).

The Gascoyne Basin is largely covered by Mesozoic and Cainozoic sands and limestones, and only on the lower Murchison River where the Tumblagooda Sandstone crops out against the flanks of the Ajana Inlier do Palaeozoic sediments occur on the surface. The age of the Tumblagooda Sandstone is in doubt; however, a similar sandstone sequence, underlying the Silurian Dirk-Hartog Dolomite in the Dirk Hartog 17B Bore with an apparently transitional and conformable contact, was correlated with the Tumblagooda Sandstone (McWhae *et al*, 1958), which would restrict the age of the Tumblagooda Sandstone to Silurian or earlier.

The Silurian Dirk Hartog Dolomite has been identified in several wells and bores in the Gascoyne Basin. In addition, several water bores between Ajana and Carnarvon have been interpreted as penetrating the Dirk Hartog Dolomite and the Tumblagooda Sandstone (McWhae *et al.*, 1958; Konecki *et al.*, 1958), but these interpretations are doubtful as they are based mainly on lithological similarities. However, it would appear from the work carried out by the BMR in the Southern Carnarvon Basin in 1963-1964 (Bow & Turpie, 1964; Raitt & Turpie, 1965) and from the available bore hole information, that the Dirk Hartog Dolomite exists throughout most of the southern part of the Gascoyne Basin.

Devonian, Permian, and possibly Carboniferous sediments have been penetrated in wells and bores in several places within the Gascoyne Basin.

The Mesozoic and Cainozoic section south of Carnarvon in the Gascoyne Basin does not appear to exceed 2500 ft, whereas the maximum depth of sedimentary section in the area according to the interpretation of the gravity and aeromagnetic surveys could be of the order of 15,000 ft. Thus a considerable section of Palaeozoic or earlier age sediments must exist.

The Merlinleigh Basin is a Palaeozoic basin of mainly Permian outcrop with Carboniferous and Devonian sediments cropping out on its eastern margin. Evidence of pre-Devonian rocks within the Merlinleigh Basin comes from the Quail No. 1 well situated 80 miles north-east of Carnarvon, which penetrated both Dirk Hartog Dolomite and Tumblagooda Sandstone (Pearson, 1964), and it would appear that both these sequences exist in the Merlinleigh Basin, but at considerably greater depth than in the Gascoyne Basin.

In a section through the Carnarvon Basin, Condon (1963) estimates the depth of section in the Merlinleigh Basin (25 miles north of the latitude of Gascoyne Junction) as greater than 20,000 ft. Aeromagnetic interpretation gives a maximum depth to basement at the same latitude of about 10,000 ft (J.H. Quilty, pers. comm.).

The following is a summary of the stratigraphy encountered in the area of the traverse as adapted from Playford and Johnstone (1959).

Lithological succession in the southern part of the
Carnarvon Basin

Age	Maximum (ft) Thickness	Lithology	Location
Tertiary	1900	Calcarenite limestone and some minor sandstone near coast, thin Eocene sandstone near eastern margin.	Gascoyne Basin
Cretaceous	2500	Calcarenite, shale, and siltstone with basal sandstone	Gascoyne Basin; very limited in Merlinleigh Basin.
Permian	14,000	Shale, siltstone, sub-greywacke, sandstone, and limestone with marine glacials at base.	Merlinleigh Basin; Warroora No. 1 well (Gascoyne Basin).
Kennedy Group	2550		
Byro Group	4461		
Wooramel Group	879		
Callytharra Formation	870		
Lyons Group	4600	Limestone, sub-greywacke, siltstone, and limestone	Eastern margin of Merlinleigh Basin; Quail No. 1 well; Wandagee No. 1 well; Warroora No. 1 well?
Carboniferous	2300		
Devonian	4700	Sandstone, limestone, siltstone, and sub-greywacke.	Eastern margin of Merlinleigh Basin; Quail No. 1 Well; Wandagee No. 1 Well.
Silurian	2500	Limestone and dolomite.	Quail No. 1 well; Wandagee No. 1 Well; Dirk Hartog No. 17B Well;
? Ordovician	3500+	Sandstone, siltstone, and sub-greywacke	Lower Murchison River, Gascoyne Basin; Quail No. 1 Well; Wandagee No. 1 Well; Dirk Hartog No. 17B well.

3. PREVIOUS GEOPHYSICAL WORK

Regional gravity surveys have been made over the Carnarvon Basin by the BMR (Chamberlain, Dooley, & Vale, 1954) with stations at 5-mile intervals along most of the major roads and tracks. An interpretation of this work by F.J.G. Neumann (pers.comm.) on a section running through Pelican Hill bore and Wandagee No.1 well gives a depth to crystalline basement over the Wandagee Ridge of 5000 ft and shows the strata within the Gascoyne Basin to be flat-lying, whereas to the east in the Merlinleigh Basin a maximum depth of section of about 25,000 ft is indicated.

Total magnetic intensity surveys were carried out by the BMR, and an interpretation by J.H. Quilty (pers.comm.) shows the same general picture as the gravity interpretation, except that the Merlinleigh Basin is considered to be shallower at the latitude of Wandagee Hill (about 15,000 ft), and the Wandagee Ridge is somewhat deeper (about 7500 ft).

Prior to 1963 all seismic work in the Carnarvon Basin was north of the Gascoyne River, where surveys were made by the BMR (Smith, 1962) and WAPET (Hoelscher *et al*, 1962; Dennison *et al*, 1962). In general, results showed that reflected energy could be obtained within both the Gascoyne and Merlinleigh Basins (18 seismometers per trace at 14-ft intervals and 16 shot-holes in a diamond pattern in the Gascoyne Basin; single holes and 9 seismometers at 14-ft intervals in the Merlinleigh Basin). According to Dennison *et al* (1962), severe multiple problems were encountered in both the Gascoyne and Merlinleigh Basins. In the Gascoyne Basin multiples generated at the base of the Cretaceous almost completely obscure deeper events. In the Merlinleigh Basin a velocity profile suggested that events appearing after 0.675 second (about the top of the Callytharra Formation) were not primary.

Refraction work near Wandagee Hill (Dennison *et al*, 1962) and in the Salt Marsh area (Hoelscher *et al*, 1962) found several refractors, which are listed below together with the results of the BMR Traverse A (Bow & Turpie, 1964) and the results of the velocity logs from the Quail No.1 and Wandagee No.1 wells (Pearson, 1964; Pudovskis, 1962).

Velocity (ft/s)	Depth (ft below M.S.L.)	Geological interpretation
1. <u>West of the Permian/Cretaceous contact (Gascoyne Basin)</u>		
(a) <u>Hoelscher et al (1962) Salt Marsh Project</u>		
<u>Refraction velocities (Approximate lat. 24°S)</u>		
15,500	1500 - 2000	Lower Lyons Group
20,500	4500 - 5000	?Moogoovee Limestone(C) or ?Dirk Hartog Dolomite or ?Precambrian basement

(b) Dennison et al (1962) Wandagee Hill South ProjectRefraction velocities (Approximate lat. 24°S)

15,450 (attenuating)	350	Top of the Devonian in Wandagee No. 1
17,000	1350	Dirk Hartog Dolomite
20,000	6000	Crystalline basement

(c) Well completion report, Wandagee No. 1Continuous velocity log (Approximate lat. 24°S)

11,000 - 12,000	350	Gneudna Formation (D)
12,000 - 13,000	700	Nanyarra Greywacke (D)
14,000 - 19,000	1100	Dirk Hartog Dolomite
14,000	2400	Tumblagooda Sandstone

(d) Bow and Turpie (1964) Traverse ARefraction velocities (Approximate lat. 26°40'S)

11,600 - 12,700	0 - 1100	?Permian/?Devonian
14,500 - 19,400	200- 2800	Dirk Hartog Dolomite
13,350 - 14,700	0- 3800	Tumblagooda Sandstone

2. East of the Permian/Cretaceous contact (Merlinleigh Basin)(a) Dennison et al (1962) Wandagee Hill South ProjectRefraction velocities (Approximate lat. 24°S)

14,400	2000	?Mallens Greywacke (P)
17,000 - 17,700	3000	Lower Permian or Carboniferous limestone
20,000	6000	Crystalline basement or massive Palaeozoic limestone.

(b) Well completion report, Quail No. 1Continuous velocity log. (Approximate lat. 24°S)

15,000 - 16,000	1943	Lyons Group
16,000 - 19,000	6892	Carboniferous
17,000	8892	Devonian
20,000 - 17,500	10,518	Dirk Hartog Dolomite Tumblagooda Sandstone

During 1963 the BMR conducted a survey across the southern part of the Carnarvon Basin approximately along latitude $26^{\circ}40'$. Reflection methods were not successful, but by using refraction probes indications of the regional structure within the Gascoyne and Coolcalalaya Basin were obtained (Bow & Turpie, 1964). In the same year work was carried out in the Byro Basin, a Palaeozoic basin of Permian outcrop lying to the south of the Merlinleigh Basin. Reflection profiling gave good results across the Bogadi Syncline, and a refraction probe indicated a depth of section of about 10,000 ft (Turpie, 1964).

4. OBJECTIVES

The general geological objectives of the seismic work to be carried out in the southern part of the Carnarvon Basin were:

1. To investigate the extent and thickness of Palaeozoic sedimentation in the Carnarvon Basin south of the Gascoyne River.
2. To investigate the sub-basinal structure of this area with particular attention to the possible division of the Basin by a basement ridge beneath the Ajana - Wandagee gravity ridge.
3. To disclose major structure and structural trends within the sedimentary section and the tectonic relationships of such structure to the basement relief.
4. To estimate the depth of crystalline basement at critical locations and compare results with gravity and magnetic interpretations.

Within these broad objectives, Traverse C was designed specifically to investigate:

- a. The extent to which Palaeozoic sediments are present in and continuous between the Gascoyne and Merlinleigh Basins at the latitude of Gascoyne Junction.
- b. The structural relationship between the Permian and Cretaceous sediments, which are in unconformable contact in outcrop west of Gascoyne Junction, and whether Palaeozoic sediments are deposited over a basement ridge to form a continuous structure with only minor associated faulting or whether there is major faulting associated with the unconformity and gravity ridge.

5. PROGRAMME

Proposed programme

The programme designed to attain these objectives was as follows:

1. To shoot, at the ends of the traverse, two reflection tests with six geophones (22 ft apart) per trace. A deep hole (200 to 300 ft) should be drilled and shot to obtain best depth and charge.

- 2a. If usable reflections were obtained 40 miles of traverse was to be shot west from Gascoyne Junction.
- 2b. If usable reflections were not obtained noise tests were to be shot and geophones and hole arrays designed from the noise tests were to be tried to obtain usable reflections. The arrays of holes and geophones may have to be different on either side of the Permian/Cretaceous contact. If usable reflections were obtained, then the Traverse outlined in 2a was to be completed.
3. If usable reflections were obtained, extended spread velocity shoots were to be carried out at points where good reflections were obtained on both sides of the Permian/Cretaceous contact to distinguish multiples from primary reflections and to obtain vertical velocity distributions.
4. Refraction probes were to be carried out on both sides of the contact to attempt to obtain a correlation of age with depth, by comparison with known refractor velocities elsewhere in the basin. These probes were to be made along the reflection traverse, if a sufficient length was found to be free from faulting, otherwise consideration was to be given to running the probes in a north-south direction. Reflection shooting was also to be recorded on any cross-traverse, if usable reflections were obtained.
5. If usable reflections were not obtained by the end of the first two weeks as in 2b, then continuous refraction profiling was to be used on good markers (as determined in 4) to determine structure over the ridge. -traverse

Programme carried out

In the area of Permian outcrop, reflection tests to determine optimum charge, depth, and instrument settings were made at SP352, using single holes and recording with a normal reflection spread with 6 geophones, 22 ft apart, per trace. An uphole shoot from 210 ft was also done.

Fair to good reflections were obtained in these tests and organised surface noise did not seem to be a major problem. However, there was room for improvement and a noise recording was made, eastwards from SP352, over a maximum shot-to-geophone distance of 4620 ft and including a transverse spread.

Using the information obtained from the noise recording, several simple hole-patterns were designed and shot into different geophone patterns varying one parameter at a time. The improvement obtained from a 3-hole pattern was not thought to be sufficient to justify its use, but it was thought desirable to increase the geophone group. Continuous reflection profiling was carried out using single holes and 12 geophones, 11 ft apart, per trace, from SP384 to SP350 and on a short cross-traverse CX6.

An extended spread velocity shoot was centred on SP367 with a maximum shot-to-geophone distance of 6600 ft.

Possible faults were interpreted at SP359 and SP364 and high effort correlation shots were made on either side of each of these possible faults using 144 geophones per trace for four traces in an attempt to improve the character of the signal so that it could be correlated across the fault.

As the Permian/Cretaceous contact was approached from the east, record quality deteriorated sharply west of SP351. It was attempted to improve the reflection quality by using larger numbers of geophones and shot-holes. The value of the cut-off wave number was systematically reduced by increasing the length of the geophone group (to a maximum of 24 geophones, 22 ft apart, per trace). The arrangement used in profiling from SP345 to SP334B was 5 holes, 60 ft apart, and 24 geophones, 22 ft apart, per trace.

In the area of Cretaceous outcrop to the west, tests to determine optimum charge, depth, and instrument settings were made at SP306B; the tests included an uphole shoot from 240-ft. They were followed by a noise recording and the comparison of the results of various in-line shot-hole and geophone patterns. As a result, a pattern of 3 holes, 50 ft apart, was used with groups of 24 geophones, 22 ft apart, in traversing from SP334B to SP320B. The traverse was not continued further west because of lack of time.

Also in the area of Cretaceous outcrop to the west, a refraction probe (recorded between SP313B and SP333B with a maximum shot-to-geophone distance of 36,000 ft) penetrated to a refractor having a velocity of 20,100 ft/s at depth of about 5000 ft. Because of the poor quality of the reflection section obtained here and in the region of the contact, continuous refraction profiling was carried out on the 20,100 ft/s refractor with intermittent profiling on a shallow 18,160 to 18,750 ft/s refractor, and it was attempted to follow these refractors into the region of the contact.

Returning to the area of Permian outcrop to the east, a refraction probe (recorded between SP364 and SP384, with a maximum shot-to-geophone distance of 36,000 ft), penetrated only to a 15,400 ft/s refractor at a depth of about 3000 ft. The method of 'correlation shooting' had given no definite result, and in order to examine further the possibility of faulting within the Merlinleigh Basin, the 15,400 ft/s refractor was continuously recorded and it was attempted to follow this refractor into the area of the contact.

At this stage, towards the end of the survey, still very little was known concerning the section of the traverse between SP337B and SP348, an area which was fairly critical to any theory of the structural relationship at the contact. It was decided to attempt a maximum effort to record reflections over this part of the traverse. In the time available it was thought that seven deep holes or 36 shallow holes with 36 geophones per trace, in a three-fold common-depth-point stack was the maximum effort which would allow sufficient coverage. An expanded spread shoot was conducted, shooting both seven deep holes in line and 36 shallow holes in a diamond pattern into 36 geophones per trace in a square pattern, in order to compare the relative effectiveness of the two hole patterns and the effectiveness of the geophone pattern and to look for windows in the noise which might indicate a desirable offset for the common-depth-point shooting. Some additional velocity information was also desired.

In addition to the above seismic programme the following associated programme was carried out during the period of the survey:

- (a) Gravity was measured along all the seismic traverses of the 1963 & 1964 surveys, readings being taken at every shot-point.
- (b) A deep hole (370 ft) was drilled at SP335B and a core was taken to try to determine the nature and age of the shallow 18,160-ft/s refractor in the Gascoyne Basin.

6. RESULTS

Reflection - Merlinleigh Basin

Noise shoot. The results of the noise shoot at SP352 were :

Main noise event: velocity 5000 to 6000 ft/s; wave number values 4.5 to 5.5 per 1000 ft.

Main signal: wave number less than 1 per 1000 ft

Shallow refractors and possible signal: wave number 2.5 to 3.0 per 1000 ft.

The organised longitudinal noise was not pronounced and there was no indication of any transverse noise on the transverse spread.

Record quality. The reflection record quality in the Merlinleigh Basin is variable. In the east the quality is good down to about $1\frac{1}{2}$ seconds but gradually deteriorates west of SP365. From SP 350 to SP 337B there is little continuity of signal. From the reflection tests conducted at SP 349 and SP 347, it was found that record quality could be improved by increasing the number of shot-holes and geophones and by decreasing the value of Kc, the cut-off wave number. Various patterns of shot-holes and geophones were tried in the area, and those adopted were 24 geophones in line at 22 ft spacing (Kc 1) and five holes in line at 60 ft spacing (Kc 1.7). Using these patterns a section was recorded from SP 350 to SP 337 giving poor to fair reflections.

Discontinuities. Sharp changes were noted in the sub-weathering velocity at SP 359 and SP 363.

A change occurred in the average vertical velocity near SP 346. This is evidenced by strong curvature on the shallow reflectors immediately to the east, as seen in the corrected playback section and no curvature in reflections at a similar time immediately to the west.

A major discontinuity existed at SP 337B, in reflection quality, general character of the record, and in sub-weathering velocity.

Extended-spread velocity shoot. The record quality of the velocity shoot centred on SP 367 was fair, although a noise event originating from the shot-point with a velocity of 4000 to 5000 ft/s interfered with the weaker signals. The results were as follows :

Reflector	To (ms)	V _a (ft/s)	V _i (ft/s)	Depth (ft)
1	346	10,120	1500	1750
2	422	10,990	14,000	2340
3	814	12,430	15,050	5050
4	907	12,700	18,750	5780
5	1014	13,330	11,700	6780
6	1108	13,190	16,900	7310
7	1250	13,610	17,300	8500
8	1526	14,820		10,000

Common-depth point recording. The original shot at SP 349 had been recorded using 5 holes, 80 ft deep and 40 ft apart, in line into groups of 12 geophones, 12½ ft apart, in line per trace. The shot recorded with 5 deep holes into 36 geophones in a square pattern (6 x 6 with rows and lines 22 ft apart) was an improvement on the original shot. The shallow 36-hole diamond pattern shot into the same 36 geophone pattern gave a noticeable improvement over the 5 deep holes. Mixing gave a further improvement.

It was therefore decided to use the shallow 36-hole diamond pattern and 36 geophones in a square for the common-depth-point shooting.

Zero offset gave best results and split-spread shooting was therefore used.

The common-depth-point stacked section stretched from SP339 to SP345½. Reflection quality is mainly 'no reflections' to 'poor' with a group of 'fair' events with steep west dip at times greater than 2.5 seconds.

Reflection - Gascoyne Basin

Noise shoot and reflection tests. The results of the noise shoot and the reflection tests made at SP 306B and SP 308B showed that longitudinal noise was much stronger in the Gascoyne Basin than in the Merlinleigh Basin, and that the main noise trends had wave numbers of from 3 to 12½ per 1000 ft, whereas the only recorded signal had a wave number of 1.5 per 1000 ft. The reflection tests, based on the noise shoot, indicated that the optimum patterns were 3 holes, 50 ft apart, in line and 24 geophones, 22 ft apart, in line, similar to those found for the western part of the Merlinleigh Basin.

Record quality. A reflection traverse was shot from SP 320B to SP 337B to join up with the section from the Merlinleigh Basin. In general, results are fair with continuous signal recorded from the two horizons shown in Plate 3.

Refraction - Gascoyne Basin

The refraction probe in the Gascoyne Basin was shot to give reciprocal times over a maximum shot-to-geophone distance of 36,000 ft in the forward and reverse directions, between SP 333 and SP 313. The results are tabulated below :

Refractor	V apparent (ft/s)	Shot-to-geophone distance (ft)
<u>Forward</u>	V ₁	0 - 1800
	V ₂	1800 - 28,800
	V ₃	28,800 - 36,000
<u>Reverse</u>	V ₁	0 - 5400
	V ₂	5400 - 28,000
	V ₃	28,800 - 36,000

The energy from refractor V₂ was attenuated rapidly and was associated with a series of later phases of similar attenuation and slightly lower apparent velocity. This family of events was unpickable for recordings beyond 16,200 ft from the shot but caused interference to the arrivals from the apparently massive refractor V₃ up to 28,800 ft from the shot.

Profiling was carried out on refractors V₂ and V₃ and the true velocities and depths of the refractors are listed below:

Shot-point	Refractor	True velocity (ft/s)	Depth (ft)
320	V ₂	18,750	650
320	V ₃	20,100	5400
330	V ₂	18,160	450
330	V ₃	20,100	4700

Possibly owing to the unconsolidated and sandy nature of the surface, heavy charges had to be used in conjunction with high-gain settings (see Appendix B).

It was preferred, if possible, to keep shooting west of the Permian/Cretaceous contact so that there might be some chance of the refracted wave travelling in the same refractor over its whole path. The traverse was limited to the west by the Gascoyne River and two-way coverage could not be obtained with V₃ as a first event. Initially a profile was shot using a maximum shot-to-geophone distance of 12,400 ft in the reverse direction and 37,800 ft in the forward direction, relying on the attenuation of V₂ to be able to pick V₃ in the reverse direction as a second event. However, the two intercept profiles obtained could not be matched, and it was thought that two different refractors had been recorded in the forward and reverse directions.

The reverse profile was reshot using a maximum shot-to-geophone distance of 28,800 ft and shooting from the eastern side of the Permian/Cretaceous contact from shot-points 341B and 345B. The profile obtained was almost the same as the previous reverse profile. It was found possible to match the two profiles by postulating a change in true velocity of refractor V_3 from 20,100 ft/s to 18,000 ft/s in the region of SP 330B.

The first events in the basement shot recorded over a maximum shot-to-geophone distance of 64,000 ft appeared to have a similar velocity and delay to the apparently massive refractor V_3 .

Refraction - Permian/Cretaceous contact

The discontinuity observed at SP 337 B in the reflection section was investigated using shallow refraction techniques. A shallow 18,160 ft/s refractor was followed from the west up to SP 336B, where it lay about 350 ft below the surface. From the east a refractor of true velocity 11,540 ft/s was followed up to SP 338B. From SP 338B to SP 337B the interpretation was difficult, but it would appear that the first arrivals resulted from a refractor of velocity about 15,000 ft/s dipping steeply eastwards.

Refraction - Merlinleigh Basin

The refraction probe in the Merlinleigh Basin was conducted between SP 384 and SP 364 because reflection work had shown the underlying strata to be flat and free from faulting.

The results are tabulated below:

Refractor	True velocity (ft/s)	Shot-to-geophone distance (ft)	Depth to refractor (ft)
V_1	10,000	0 - 4200	100
V_2	11,000	4200 - 14,100	1000
V_3	15,600	14,100 - 36,000	2500

Profiling was carried out on V_3 , the 15,400-ft/s refractor, from SP 376 to SP 339 using a maximum shot-to-geophone distance of 28,800 ft decreasing to 14,400 ft as the profile shallowed to the west. Computations on the records of this profile have yet to be completed, but it would appear that two velocity changes occur along the profile, from 15,400 ft/s to 15,600 ft/s and then to 15,000 ft/s.

Core hole

The deep hole drilled at SP 335B to a total depth of 370 ft passed through coarse sands and clays to 210 ft and continued to a total hole depth in coarse sandstone. A core was taken from between 360 and 370 ft. This core was examined, in the Geological Branch of the BMR, for forams, ostracods, and conodonts with negative results. However, lithologically the core answers the description of the top of the Tumblagooda Sandstone at the transition to the Dirk Hartog Dolomite.

J.M. Dickins suggests (pers.comm.) that whereas it does not resemble any other outcropping formation it is similar to the upper part of the Tumblagooda Sandstone in outcrop and the lower part of the Dirk Hartog Dolomite in bores.

The results of the uphole shoot conducted in the core hole are as follows :

Depth (ft)	Interval velocity (ft/s)
0 - 85	4100
85 - 230	8050
230 - 350	9600

Gravity work

The reduced gravity values, measured at shot-points along the traverse, are plotted in Plate 3.

7. INTERPRETATION

The interpretation of the results will be discussed in three sections as suggested by the tectonic units covered by the traverse: (a) Gascoyne Basin, (b) Merlinleigh Basin, and (c) Contact of the Gascoyne and Merlinleigh Basins.

Gascoyne Basin

The depth and attitude of the two horizons picked on the reflection section from the Gascoyne Basin can be seen in Plate 3. The dip as computed from the shallow reflection horizon was 2°, with strike approximately north.

It would appear from the high velocity of V_2 that the refractor belongs to the Palaeozoic section. The rapid attenuation associated with the refractor is reminiscent of the rapid energy decay associated with the refractors at Coburn, Tamalá, and Carnarvon, which were interpreted as being within the Dirk Hartog Dolomite (Bow & Turpie, 1964; Raitt & Turpie, 1965).

It would appear unlikely that V_2 could belong to the Permian sediments as no high-speed refractor with a similar velocity was recorded in the refraction work in the Merlinleigh Basin.

The interpretation of V_2 is fundamental to the interpretation of the underlying events, both refraction and reflection, for it indicates the possible thickness of the sedimentary section and the possible geological formations comprising it. By interpreting V_2 as the Dirk Hartog Dolomite, the underlying strata is limited in age to Silurian or earlier. The apparently massive refractor V_3 (20,100 ft/s) is interpreted as metamorphic basement, the intervening 5000 ft between it and V_2 being taken up by the Dirk Hartog Dolomite, which varies in thickness from 2425 ft on Dirk Hartog Island (McWhae *et al.*, 1958) to 1100 ft in Quail No.1 well (Pearson, 1964), and the Tumblagooda Sandstone of which the thickness from the measured section is given as 3500 ft plus. Both these formations are known to underlie the younger Palaeozoics in the Wandagee No.1 and Quail No.1 wells.

Merlinleigh Basin

Reflection record quality and angles of dip are variable within the Merlinleigh Basin. The reflection horizons down to one second were flat from SP 382 to SP 364 and dipped east at 6° between SP 364 and SP 358; the dip flattened out at SP 358, but the reflections continued to dip eastwards at 2° until SP 353. The shallower reflection horizons show an anticline with apex beneath SP 353. From SP 351 to 337B record quality varied from 'no reflection' to fair. From SP 340B to SP 337B the record quality is almost 'no reflection', and the dip of the beds cannot be distinguished.

Faulting is suspected at SP 359 and SP 364 because of deterioration in record quality, change in sub-weathering velocity, and diffraction patterns centred on SP 364. At SP 346 faulting was suspected because of a sharp change in vertical velocity evident from the change in move-out on the shallow reflector at this point.

An unconformity is evident at about 1 second (7000 ft) in the vicinity of SP 367. It is best seen on the cross-traverse CX6, where the angular unconformity appears more marked. To the west the record quality deteriorates and the unconformity does not show as a continuous feature. According to Condon (1962) the maximum thickness of the Permian section below the Kennedy Group, in the southern part of the Kennedy Range 1:250,000 map area is 6878 feet. According to the velocity shoot at SP 367 the unconformity occurs at 7310 ft and is interpreted as being at the base of the Lyons Group.

The refraction horizon V_3 in the Merlinleigh Basin lying at about 2500 ft below datum is interpreted as arising from within the Lyons Group, thus the overlying sediments would belong to the Lyons, Wooramel, and Byro Groups. The refraction probe between SP 364 and SP 384 did not appear to penetrate below the Permian section.

Contact of the Gascoyne and Merlinleigh Basins

The Gascoyne and Merlinleigh Basins appear to be separated by a major discontinuity at SP 337B. This discontinuity is at about the Permian/Cretaceous contact, which is associated with the western edge of the Kennedy Ranges further north and which may be a continuation of the fault or unconformity that bounds the eastern edge of the Wandagee Ridge in the vicinity of Wandagee Hill. The discontinuity is identified on the surface by the change in vegetation from medium scrub in the west to the open plain country in the east and in the geophysical work by the discontinuity of reflection and refraction events, and by the change in the gravity gradient as measured along the traverse. Both gravity and seismic results indicate a complex structure at the contact and a few miles to the east. There appear to be similarities to the structure examined by WAPET at the latitude of Wandagee Hill (Dennison et al, 1962).

8. CONCLUSIONS

West of Gascoyne Junction the Gascoyne Basin has a depth to metamorphic basement of at least 5000 ft immediately west of the Permian/Cretaceous contact.

The geological section in the Gascoyne Basin in the area of Traverse C comprises Palaeozoic sediments of the Silurian and pre-Silurian sequences under a thin section of Mesozoic sediments.

The Merlinleigh Basin at this latitude and in the area of the traverse contains at least 10,000 ft of relatively flat-lying sediments.

Faulting, within the Palaeozoic sequence in the Merlinleigh Basin more than four miles east of the Permian/Cretaceous contact and in the area of the traverse, appears to be relatively minor.

Record quality was too poor to draw definite conclusions concerning the structure at the contact and immediately to the east, but an anticline structure was demonstrated about five miles east of the contact.

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APPENDIX A
Staff and equipment

Staff

Party leader	:	J. Valentine
Geophysicists	:	J. Raitt B. Jones
Surveyors	:	J. Ritchie P. Pullinen
Clerk	:	I. Walker
Observer	:	R. Krege
Shooter	:	B. Arcus
Senior driller	:	K. Suehle
Driller	:	J. Keunen W. Whitburn L. Keast
Mechanic	:	E. McIntosh

Equipment

Seismic amplifiers	:	Texas Instruments 8000 (Explorer)
Seismic oscillograph:		SIE TRO6
Magnetic recorder	:	Electro-Tech DS 7/700
Geophones	:	Electro-Tech 4.5-c/s (26 x 4) Electro-Tech 20-c/s (126 x 6)
Drills	:	1 Mayhew 1000 2 Carey

APPENDIX BOperational Data

Sedimentary basin : Carnarvon
 Area : Gascoyne Junction
 Camp established : 1st September 1964
 Shooting commenced : 2nd September 1964
 Miles surveyed : 54
 Total footage drilled : 46,624
 Explosives used : 22,405 lb Geophex.
 No. of reflection spreads shot : 80
 No. of C.D.P. shots : 23
 Number of refraction spreads shot : 68
 Miles traversed refraction : 31 (on three horizons)
 Datum for correction : 400 ft
 Weathering velocity : 3000 ft/s
 Reflection static correction method : Reciprocal time method
 Refraction weathering control : Depth of weathering as established from reflection

Normal reflection techniques

	<u>Merlinleigh Basin</u>		<u>Gascoyne Basin</u>
	West of SP 351	East of SP 351	
Shot-point interval (ft)	1800	1800	1800
Geophone station interval (ft)	150	150	150
Shot-hole pattern	5 in line @ 60 ft	single	3 @ 50 ft
Charge (lb)	100	60	150
Depth (ft)	80	80	100
Geophone group	24 @ 22 ft	6 @ 22 ft	24 @ 22ft
Filters : Record	18K - 125K	18K - 125K	18K - 125K
Playback	27K - 92K	27K - 92K	27K - 92K
AGC	1/1/125	1/1/125	1/1/125
Sensitivity	Max.	Max.	Max.

Normal refraction techniques

Geophone station spacing: 300 ft

Geophone group: 4 x 4.5 - c/s geophones

Filter: 0 - 40K

Charge size: 100 - 2000 lb

Shot-to-geophone distance: 0 - 64000 ft

Gains and charges used over varying shot-to-geophone distances :

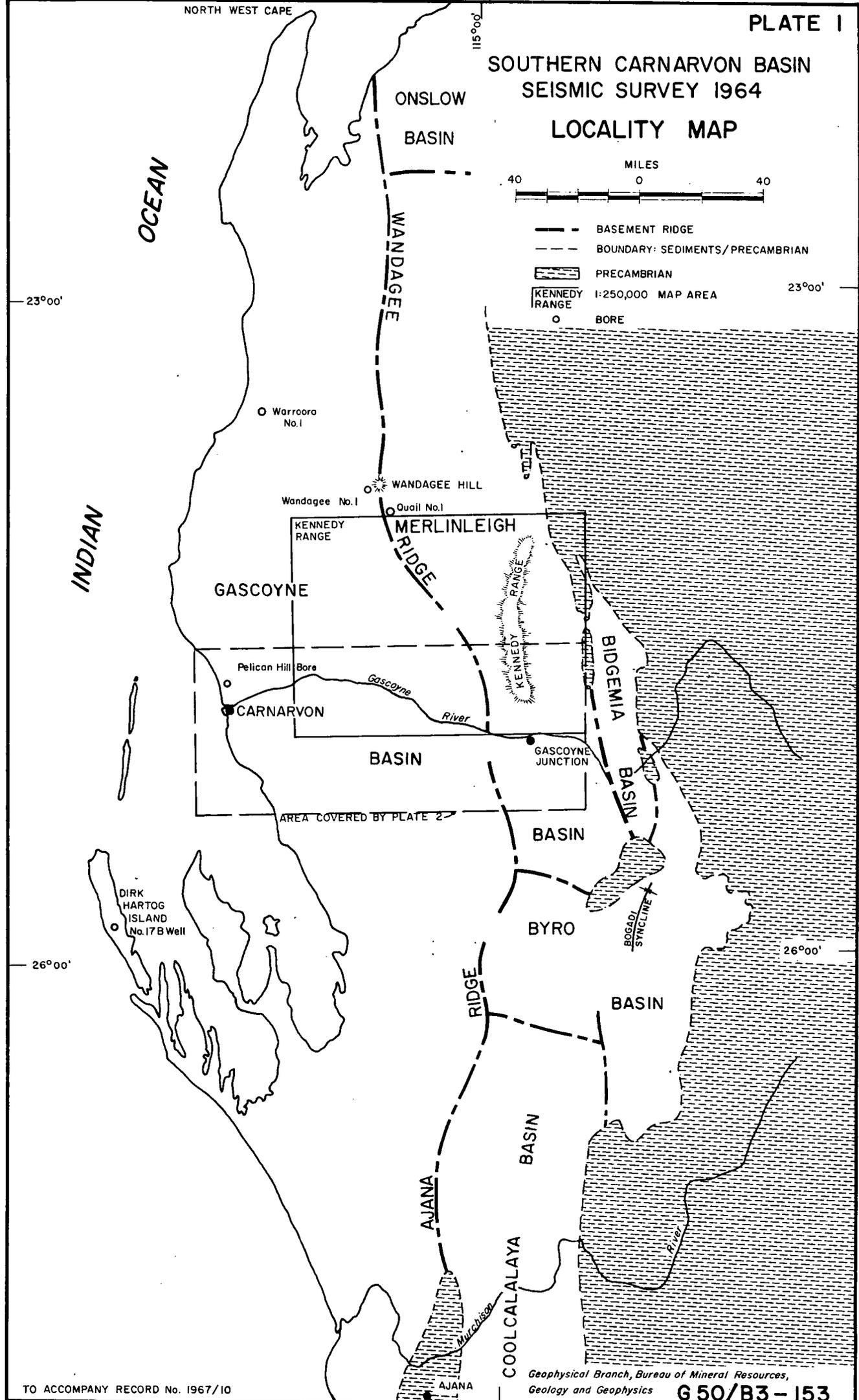
<u>Charge (lb)</u>	<u>Gain (db)</u>	<u>Shot-to-geophone distances (ft)</u>
130	- 60, - 33 ²	0 - 7200
200	- 33, - 30	7200 - 14400
200	- 30	14400 - 21600
280	- 27	21600 - 28800
372	- 27, - 23	28800 - 36000

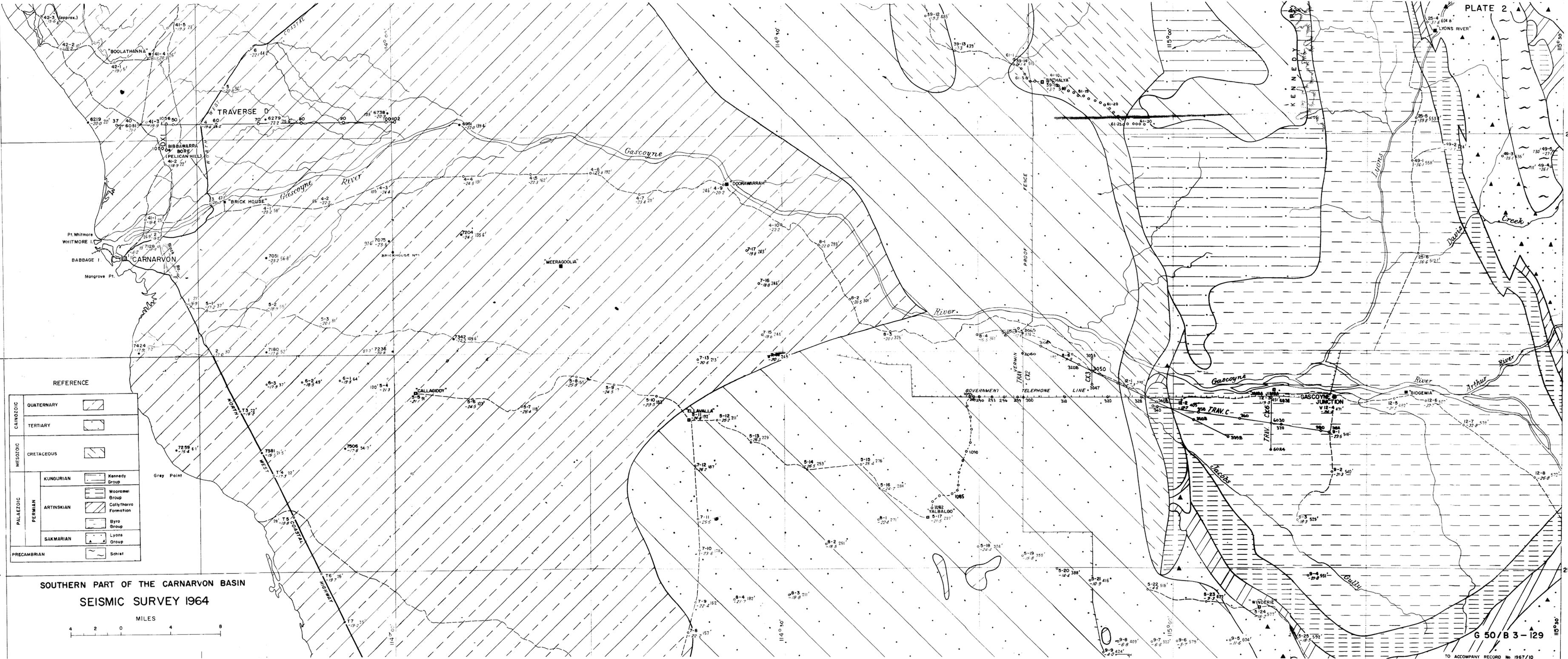
Common-depth-point technique

Shot-point interval	300 ft
Charge	90 lb
Depth	15 ft
Geophone station interval	300 ft
Filters: Record	18K - 125K
Playback	22K - 92K
AGC	1/1/80
Sensitivity	Max.

SOUTHERN CARNARVON BASIN
SEISMIC SURVEY 1964

LOCALITY MAP

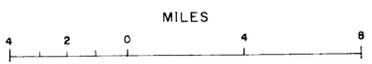




REFERENCE

CAINOZOIC	QUATERNARY	[Symbol]	
	TERTIARY	[Symbol]	
MESOZOIC	CRETACEOUS	[Symbol]	
PALAEZOIC	PERMIAN	KUNGURIAN	Kennedy Group
		ARTINSKIAN	Wooramei Group Calytharro Formation
	SAKMARIAN	Byro Group	
		Lyons Group	
PRECAMBRIAN	Schist		

SOUTHERN PART OF THE CARNARVON BASIN
SEISMIC SURVEY 1964



G 50/B 3-129

TO ACCOMPANY RECORD No. 1967/10

