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MT. CHARLOTTE SEISMIC SURVEY

OIL PERMIT 72

Finke - Wallara

NORTHERN TERRITORY

OF AUSTRALIA

FOR

FINKE OIL COMPANY PTY. LTD.

Perry House, Elizabeth Street, Brisbane, Queensland

GEOPHYSICAL ASSOCIATES PTY. LTD.

85 Eagle Street, Brisbane, Queensland

June, 1964.

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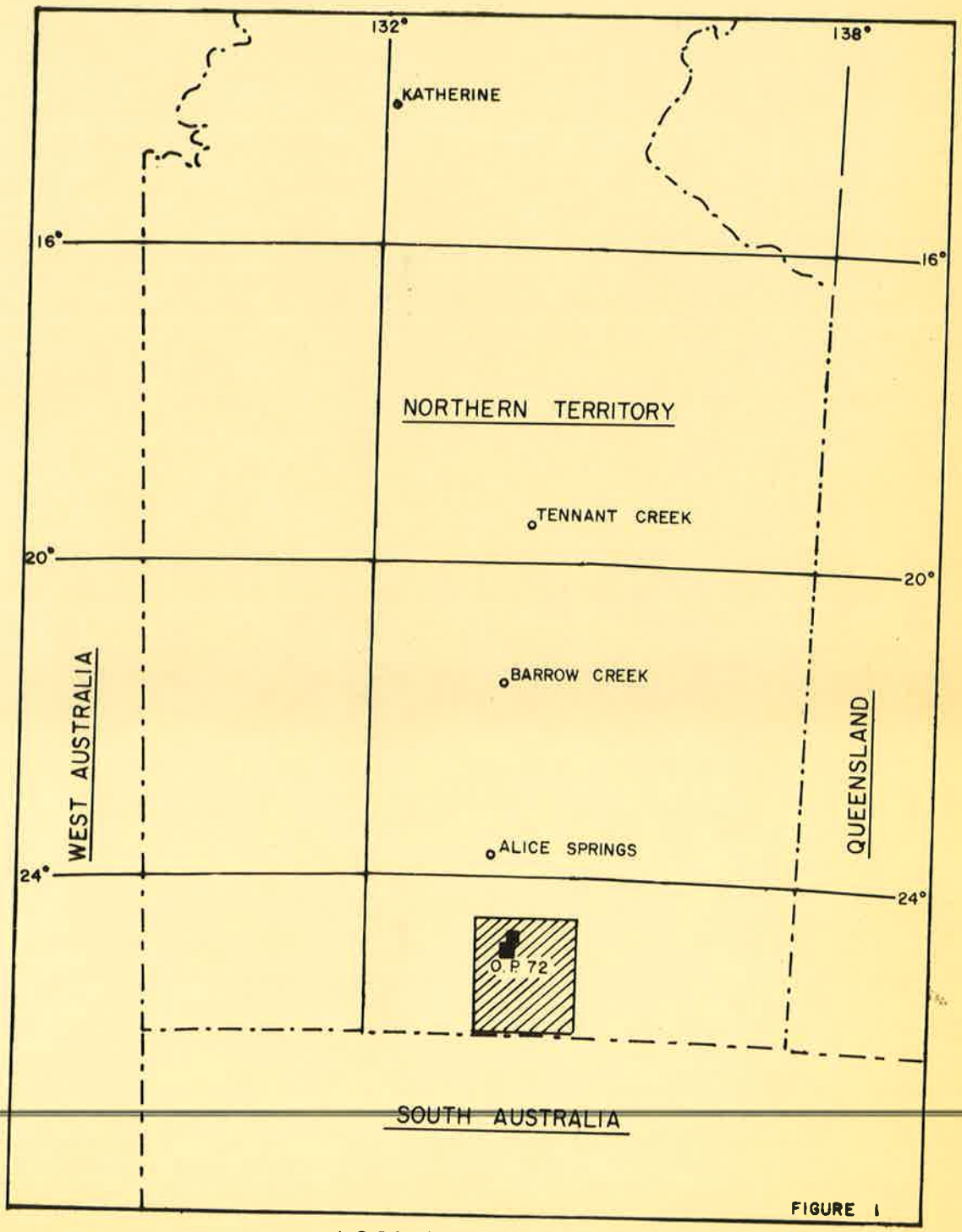
ABSTRACT

A reflection seismic survey was conducted in the Mt. Charlotte Area, Oil Permit 72, N.T. for Finke Oil Company Pty. Ltd. by Geophysical Associates Pty. Ltd. The work was started on 22nd April and completed on 15th June, 1964.

The initial lines were assigned to delineate an anomaly evident from the BMR Mt. Charlotte reflection traverse. This feature, however, proved to be in an area of complex faulting and of small areal extent; at this time it is considered to be of secondary interest.

A 50 mile reconnaissance line run from the Mt. Charlotte Range south to Mt. Watt in the Black Hills Range revealed a major structural anomaly centrally located in the basin just north of the Finke River. The feature was subsequently detailed and appears to be of sufficient interest to warrant a deep test. Farther north, an additional large anticline believed to be formed by Upper Proterozoic salt movement was noted on the reconnaissance line but was not detailed. South of the Finke River, several relatively minor features, associated with faulting, were also detected in the vicinity of a prominent aeromagnetic high revealed by the Charlotte Waters Aeromagnetic Survey.



LOCALITY PLAT

MT. CHARLOTTE SEISMIC SURVEY

O.P. 72 N.T.

INTRODUCTION

Oil Permit 72 is situated in the Amadeus Basin approximately midway along the southern boundary of the Northern Territory (Figure 1). The Mt. Charlotte Area, near Maryvale Station, is located 80 miles south of Alice Springs and west of the Alice Springs - Port Augusta railway. Access into the area is via the Finke River road from Alice Springs or via a track running east from the Alice Springs - Adelaide highway to Deep Well.

Sand dunes, up to 60 ft in height and running in a general north-south direction, are prevalent in the area. Areas where dunes are not present are mantled with sand, with vegetation consisting mainly of spinifex and eucalyptus trees. The topography, when not controlled by dunes, is gently rolling and sloping down to the valleys of the Hugh River and the Finke River.

Approximately 150 points of rain fell while the crew was in the area. The rain served to pack the sand making the trails easier to negotiate. However, it was necessary for all vehicles other than Land Rovers to use sand tyres.

An interpretation of the data was carried out in the field office and progress reports were submitted fortnightly. A crew leave period from 24 through 31 May was utilized to further evaluate the data obtained to that date and to plan additional detail programme.

The nearest petroleum test wells are the Alice No. 1 and the Mereenie No. 1, located in Oil Permits 43 and 56 respectively, both having significant occurrences of hydrocarbons in the Cambrian and Ordovician sections. Previous geophysical work in Oil Permit 72 includes a reflection and refraction programme carried out south of Mt. Charlotte by the BMR in 1962, helicopter gravity surveys in 1960 and 1961, and a semi-detailed aeromagnetic survey over the whole of the permit area in 1963.

PURPOSE OF INVESTIGATION

The purpose of the survey was threefold:

1. To detail a prominent subsurface structure revealed in the Mt. Charlotte Reflection Profile shot by the Bureau of Mineral Resources during their survey work in 1962. It was thought that the pronounced structural anomaly, characterized by a large hemispherical 'inclusion', and significant thinning over the feature, was possibly due to reef development or salt intrusion and was thus of great interest.

2. To give regional control on the depth and distribution of prospective Upper Proterozoic, Cambrian and Lower Ordovician sediments in the relatively deep and undisturbed sedimentary trough extending northeast to southwest through O.P. 72 between the Mt. Charlotte and Black Hills Ranges. In addition, regional control would be used to examine the area for new subsurface structures of a drillable nature that could be detailed with further seismic work.

3. To traverse and evaluate the most prominent magnetic basement high indicated in O.P. 72 by the Charlotte Waters Aeromagnetic Survey.

REGIONAL GEOLOGY

Units of the Amadeus Basin sequence have been recognised in O.P. 72. These beds outcrop in the north and northwest of the Permit and are overlapped by sediments of the Great Artesian Basin to the east and southeast. In the south of the area these younger beds rest directly on Archean granites and metamorphics.

The Proterozoic Sequence begins with the Heavitree Quartzite which is not seen outcropping in O.P. 72 but it may have a restricted occurrence at depth.

The overlying Bitter Springs Limestone outcrops in the extreme north of O.P. 72 with the southern limit of deposition probably being in the vicinity of the Black Hills Range. The Bitter Springs Limestone has been mapped with the Pioneer Formation, a variable sequence of sandstones, conglomerates, siltstones, shales, limestones and dolomites, approximating to the Areyonga Formation of the Amadeus type section. The so-called Pioneer Formation has been found in anticlinal cores near Mt. Burrell, about 8 miles slightly south of west from Rodinga.

At Mt. Kingston, in the Black Hills Range, a sequence of clastics some 2,500 ft thick have been attributed to the Pertatataka Formation. Limestones at the top of this sequence may belong to the Cambrian Jay Creek Limestone since the intervening Arumbera Formation is thought to be missing in the Black Hills Range.

The Paleozoic sequence begins with the Arumbera Formation, represented by a thick section of sandstones and conglomerates in the Mt. Burrell Anticlinorium but probably missing in the south.

In the Mt. Charlotte Anticline, about 12 miles slightly west of south of Rodinga, the Pertaoorta Formation outcrops. In the Amadeus Basin this formation has been divided into the Hugh River Shale, the Jay Creek Limestone and the Goyder Formation. In O.P. 72, this subdivision is not practicable since the dominance of carbonate versus clastic beds varies from section to section. The formation attains a thickness of 3,900 ft in the Ocraminna Anticline 50 miles to the north but thins southwards to about 2,000 ft at Mt. Charlotte.

The Ordovician section, Larapinta Group, is made up of the following formations:

1. The Pacoota Sandstone is fossiliferous and about 100 ft thick. It consists of fine grained, clean, well-sorted quartzitic sandstone, often silicified.

2. The Horn Valley Formation of fossiliferous limestones, siltstones and shales are not known in O.P. 72. In the Mt. Charlotte Anticline a sandstone succession of 300-400 ft, disconformably overlying upper Pertaoorta beds, has been equated to the Horn Valley Formation.

3. The Stairway Sandstone consists of finely cross-bedded white sandstones with abundant trilobite trails.

4. The Stokes Formation is not known in O.P. 72.

The Mereenie Sandstone of the central Amadeus Basin is not differentiated this far east but is included with the overlying Pertnjara Formation which consists mainly of impure sandstones and outcrops in the north of O.P. 72. The thickness of the formation there is unknown.

Unconformably overlying Pre-Permian rocks are the sediments of the Great Artesian Basin. These sediments are not considered important to oil exploration in the Finke Area but thicknesses of Permian sediments sufficient to be of interest may occur near the eastern boundary of the Permit. They consist of the Finke River beds which are glacial sediments made up of boulders, cobbles, and pebbles in a massive sandy clay matrix; the Jurassic De Souza Sandstone overlies the Finke River beds and is typically a brown, thin current-bedded, friable, ferruginous, quartz sandstone. A sequence of shale, claystone, and fine-grained sandstone unconformably overlies the De Souza Sandstone and has been named the Rumbalara Shale and assigned a Cretaceous age.

Prepared by E.A. Webb

RESULTS

The seismic reflection programme is divided into three parts (see Plate 5, Shot Point Location Map). The first, designated Prospect 2, consists of six detail lines tied to the BMR Mt. Charlotte profile. This work was followed by a reconnaissance line starting near Mt. Charlotte and running south to the vicinity of Mt. Watt (Line 7). The final programme (Prospect 1) was planned to delineate a prominent anomaly revealed on Line 7. The following discussion will include the results obtained from these traverses preceded by assessments of reflection quality and horizon velocities.

Qualitative Analysis of Reflection Events

Four main reflecting events can be correlated with comparative ease across the greater part of the basin. The summation of the intervals between these reflections comprise most of the total section, since the shallowest reflection never attains a depth greater than 2,000 ft and the deepest reflection appears to represent basement. The sharpness of the reflections indicate well-defined lithological boundaries and their continuity and notable lack of intermediate reflections suggest an almost entire marine section.

Velocity Analysis

Horizon identification in the area was established from a knowledge of regional geology and the correlation of known velocities in other parts of the Amadeus Basin to velocities derived from delta T analysis for prominent reflection intervals. One-half mile velocity profiles were shot for this purpose north and south from SP 130, Line 7 (Plate 3). The location was selected because of the flat dips, relatively flat terrain, and the good quality of the reflections noted in the area. The results of the survey are tabulated below together with formation identifications provided by S.S. Chambers.

Reflection Time (1000' datum)	Average Velocity	Interval Velocity	Depth (from 1000' datum)	Assumed Formation
Datum to				
.359	10,600		1900	Pertnjara Stairway
		14,200		
.480	11,500		2760	
		12,100		Lower Ordovician-Upper Cambrian
.799	11,750		4700	
		19,300		Lower Cambrian - Upper Proterozoic
1.076	13,700		7380	
				Basement

Reconnaissance Line

The whole of the reconnaissance traverse (Line 7), less the part included with detailed shooting, is presented as a geologic cross section (Plate 4). Time data has been converted to depth using velocities derived from delta T analysis. Reflection continuity was poor over part of the traverse and the interpretation of the results is questionable where noted.

The northern portion of the section terminates at SP 53 in the Mt. Charlotte Range. The southern flank of a large structure is shown between SPs 53 and 60 associated with a possible down to the north thrust fault. It is probable that a salt intrusion created the anomaly.

Farther south, in the vicinity of SP 73, there is a major structure which also appears to be caused by movement of Upper Proterozoic salt. Cambrian and Ordovician sediments are uplifted conformably above the salt mass. This structure has approximately 1000 ft of closure to the north and south with indications on the north flank of minor down to the north thrust faults. The feature is also exhibited in this report on the playback cross section of Line 7 (Plate 1). It was not detailed in preference to the major anomaly to the south (Prospect 1).

The southern portion, SPs 136 to 201, terminates about 2 miles north of Mt. Watt in the Black Hills Range. There is evidence along this section of a series of faults (possibly thrust) in the Upper Proterozoic causing a major unconformity at that level with compensating changes in thickness in the Upper Proterozoic to Pertnjara interval. South from SP 193 the Basement horizon rises uniformly and steeply towards Mt. Watt.

Prospect 1

Detailed seismic shooting north of the Finke River has outlined an anomaly at least 20 square miles in area. Closure has been mapped on all flanks at or near an unconformity level believed to be Lower Cambrian, with minimum measured closure on the structure of about 550 ft. Maximum closure to the north and east is approximately 1400 ft (Plate 7).

A shallow event of presumed Ordovician age, believed to be the Stairway Sandstone, is not conformable to the Lower Cambrian. The crest of the structure on the Ordovician is 2 miles north of the Lower Cambrian high, exhibiting approximately 140 ft of closure (Plate 6). There is a considerable gain in thickness of Ordovician and/or Cambrian sediments off the structure to the north, increasing from about 1900 ft to 3700 ft (Plate 8).

The feature is possibly associated with an old basement high which may have had its origin prior to Upper Proterozoic deposition but which appears to have undergone its greatest movement during the Lower Cambrian orogenic period. The old high possibly formed an island in the lower part of the Upper Cambrian and Lower Ordovician seas causing the sediments of these ages to drape over its top and thicken off its flanks. This would have resulted in the evident decreasing closure on the sediments as one proceeds higher in the section. (Plates 1 and 2).

There is some evidence (see Plate 1) that structural growth may have been intensified by lateral salt movement in the Lower Cambrian to Basement sedimentary interval. This would account for the thickened section between SPs 96 and 100 and would suggest that the small fault at SP 96 is actually a rupture zone marking the northern limit of the salt layer. The almost circular shape of this structure at the Lower Cambrian level (Plate 7) lends feasibility to this postulation.

Prospect 2

Detailing of the anomaly noted on the BMR Mt. Charlotte reflection traverse indicates an area of complex faulting. A reflection believed near the top of the Upper Proterozoic indicates a structural high with the crest at SP 43. The structure is faulted

on the north flank (downthrown to the north approximately 500 ft) and has a minimum of 750 ft of south closure. A shallow horizon, probably Ordovician, indicates an anticlinal high trending north-south with measured closure of at least 50 ft centred 1 mile south of SP 43. The areal extent of the anomaly is small, less than 5 square miles, and the structure is considered to be of secondary interest (Plates 9-11).

Conclusions

It is believed that the structural anomaly in Prospect 1 has good possibilities for oil and gas accumulation and a deep test is recommended at SP 93. At this point closure exists on the Ordovician and any Cambrian which may be present, as well as the Upper Proterozoic. Estimated depth to basement is approximately 7800 ft.

In the event of encouraging results from the above test drilling the significance of the anticlinal features in Prospect 2 and north of Prospect 1 at SP 73 would be greatly enhanced. It is recommended that detail coverage should then be programmed to fully delineate the latter feature.

GEOPHYSICAL ASSOCIATES PTY. LTD.

J.H.B. Campbell

J.H.B. Campbell

APPENDIX I

FIELD PROCEDURE

Surveying

All lines were surveyed with a K & E alidade and plane table with traverses plotted to a scale of 1 inch = 1 mile. Elevation control was established from the BMR Mt. Charlotte seismic traverse (SPs 412, 414-420) and from the bench mark and triangulation station on Mt. Charlotte. Elevation ties were obtained by the closed loop method, or by double running. Misties did not exceed plus or minus 3 ft.

Horizontal traverse control was established by the closed loop method and ties to existing topographic features such as property lines, roads, fences and bores. Detailed planimetric base maps, drawn from air photos, were supplied by Finke Oil Company.

Steel fence posts, with the shot point number stamped on a metal tag, were set at 5 mile intervals to permanently mark shot point locations along the reconnaissance line. Within the detail areas, posts were set at the line intersections (Plate 5).

Drilling

Single holes were drilled to depths of 95-150 ft and pattern holes were drilled to depths of 20-125 ft. Drilling in the detail area southeast of Mt. Charlotte, Prospect 2, was quite difficult due to the thick unconsolidated sand and gravel deposits on and near the surface. Air drilling with water injection was used primarily as a drilling method as water was difficult to obtain in the area. Large and numerous sand dunes caused slow progress in traversing the lines.

Air drilling on the north-south reconnaissance line was fair except in the vicinity of the Finke River. Thick layers of sand and gravel were encountered in the river valley which necessitated the use of water and drilling mud.

Near-surface conditions in the detail area immediately north and west of the Finke River, Prospect 1, were also poor. Numerous and extensive sand dunes in this area made traversing the lines

difficult and slow.

Shooting

Experimental shooting was conducted at the start of the survey in an endeavour to improve the data. This consisted of pattern holes, 3 in line, 30-50 ft apart and 80-150 ft deep, 5 and 9 hole box patterns, at 50 ft intervals and 50-100 ft in depth, and 16 hole box patterns, at 30 ft intervals and a 20 ft depth. This experimentation produced only a slight improvement over the single hole shooting technique of 10-30 lbs of Geophex at 80-150 ft. Consequently single holes were used primarily throughout the area. However, three hole in-line patterns were shot to gain efficiency over a single detonation when large charges were required.

Preloading by the drill crews was necessary in areas where sand holes had a tendency to cave. All charges were tamped with dirt.

Recording

Recording was accomplished using Southwestern Industrial Electronic GA-33 reflection-refraction amplifiers, a 50 channel oscillograph and an MR-4E FM magnetic tape system.

The continuous interlocking profile technique was used with 1760 ft spacing on the reconnaissance line and 1320 ft spacing on the detail work. The shot point to near geophone offset distance, and intervals between geophone group centres, were 110 and 146.6 ft respectively on the 1320 and 1760 ft spread lengths. Twelve S.I.E. Type S-16 geophones were spaced in line at intervals of 12.2 ft. The far traces were laid across the adjacent shot points to obtain full subsurface coverage (Figure 2). Trace spacing was kept constant on all spreads, including those where it occasionally became necessary to lay a shot point interval with less than the normal length. The end traces which would have extended past the adjacent shot point were not recorded on the tape or paper records.

Monitor seismograms were recorded with no mixing, a double section 20 cps low band pass filter and no high band pass filtering (SP 1-27) or a single section 90 cps filter (SP 28-302). All shots were taken using fast AVC and gain set at 50 - 70%, depending on wind conditions. Unmixed playbacks from

SPREAD DIAGRAM

TYPICAL REFLECTION LAYOUT

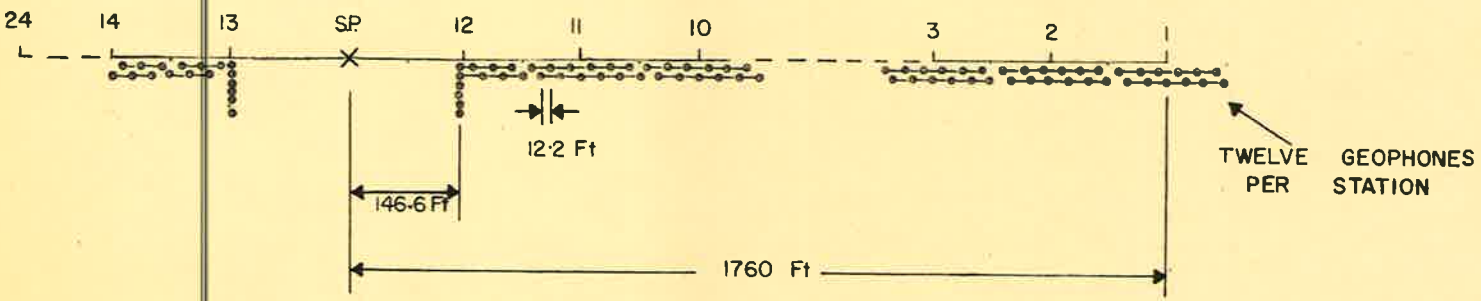


FIGURE 2

the magnetic tape were made with a double section 20 cps filter on the low side and a single section 65 on the high.

An unmixed, variable density galvo record section was prepared for each traverse. Line 8 and a portion of Line 7 are included with this report (Plates 1 and 2).

COMPUTATION

The reflection seismograms were computed to a 1000 ft datum above mean sea level using the standard uphole method and a velocity to datum of 10,000 ft/sec.

$$Tc = 2\,\frac{(Es-W-D)}{Vo} + Tuh$$ where:

Tc = total correction

Es = surface elevation

W = shot depth

D = datum plane elevation

Tuh = uphole time

Vo = velocity to datum

Corrections for end trace time ties for the common spread between two adjacent shot points were computed by interchanging the two uphole times and averaging the shot elevation-to-datum correction times. The computed surface to datum travel times at the shot points were thus applied as the static correction to the corresponding surface to datum portion of the end trace travel path.

First arrivals were plotted for all shot points and weathering was computed using the formula:

$$H = \frac{(T2 - Tuh)}{2 \cos i}$$ where:

H = depth from base of shot to velocity interface

T2 = datum velocity interface time

Tuh = uphole time

V1 = velocity above interface

sin i = V1/V2 (Snell's Law)

V2 = velocity to datum

Total correction is then computed using the formula:

$$Tc = \frac{2H}{V1} + \frac{2(Es - W - H - D)}{V2} + Tuh$$

First arrival plots indicated shallow weathering of approximately 30 ft on most shot points, with a horizontal velocity varying from 10,000 to 13,000 ft/sec. An intermediate velocity of 6,000 ft/sec was found on many of the plots and this was used in conjunction with the 10,000 ft/sec velocity when computing weathering.

Corrections to individual traces for record section presentations were entered on forms supplied by Pacific Magnetic Reductions, Brisbane. Corrected times for centre traces, relative to a zero time break, were taken from the computed field seismograms. From the inspection of several strong representative reflections, static corrections were applied to traces which exhibited consistently lower or higher irregularities caused by weathering or elevation changes across the spread. Dynamic corrections were made from normal move-out curves constructed from delta T analysis. The horizontal scale was determined by employing the average vertical velocity to the Lower Cambrian reflection and setting the two dimensions to approximately a one to one ratio.

APPENDIX II

Personnel

Party Chief	R.C. Philbrick
Seismologist	B.B. Hudson
Computer	P. Kazoks
Observer	R.N. Ehrler
Surveyor	D.A. Worrall
Drilling Supervisor	G.E. Thompson
Driller	D.M. Clark
Driller	M.M. Sweedman

The basic crew comprised twenty-two men. In addition to the key personnel listed above, fourteen men were employed as:

Shooter	1
Rodman	1
Chainman	1
Recording Helpers	4
Drill Helpers	2
Supply Truck Driver	1
Cook	1
Cook's Helper	1
Mechanic	1
Mechanic's Helper	1

Supervisors

Finke Oil Company Pty. Ltd. . . S.S. Chambers

Geophysical Associates Pty. Ltd. J.H.B. Campbell

APPENDIX III

Automotive

8 F-750 Fords, 4 or 6 wheel drive equipped with winch and large sand tyres

3 Land Rovers, 4 wheel drive

Recording

1 Recording truck with air-conditioned instrument cab

1 Cable truck with Squirter cable handler and geophone storage

1 Set 24 channel S.I.E. GA-33 amplifiers

1 50 channel S.I.E. camera

1 S.I.E. MR-4E (FM) magnetic tape system

450 S.I.E. reflection geophones type S-16, 18 cps

1 Multicap blaster

1 Portable blaster

3 Road cables 1760 ft

3 Portable cables 1320 ft

Shooting

1 Shooting truck (Land Rover)

Drilling

2 Mayhew heavy duty 1,000 air-water combination drills

2 Water trucks mounted with a stake sided, flat bed, 1000 gallon tank plus two 800 gallon portable tanks for additional capacity.

Surveying

1 Land Rover

1 Transit (K & E)

1 Alidade and plane table (K & E)

2 Survey rods

Supply

1 Stake truck

Office

1 Land Rover

1 Trailer complete with office equipment including dip plotter and printer.

Camp

1 Kitchen trailer with detachable storage and dining tents

1 Utility trailer with shower and wash facilities and 4 bunks

1 Work shop trailer mounted on F-750 Ford with electric and acetylene welders and complete set of power and hand tools

2 Diesel generators, 15 KW, trailer mounted

3 Six man sleeping tents with beds

APPENDIX IV

Statistical Data

Starting Date	22 April, 1964
Completion Date	15 June, 1964
Hours Moving	25
Holidays	20
Driving Time	98
Field Time	342
Total Crew Hours	485
Time Lost	0
Total Hours Drilling (2 drills)	728
Total Hours Driving Time (2 drills)	176
Total Hours Recording	342
Holes Shot	323
Number of Shots	377
Magnetic Tapes Used	371
Miles Surveyed	87.75
Holes Drilled	713
Footage Drilled	56,540
Average Hole Depth (ft)	125
Average Penetration (ft/hr/drill)	76
Pounds Explosive Used	16,195
Average Charge Size	40
Caps Used	933
Bits Used:	
Starter 5 5/8"	16
Insert 4 1/2"	126
Rock 5 5/8"	1
Rock 4 1/2"	11
Drilling Mud Used (100 lb bags)	44
Lost Circulation Material Used (bags)	16