ERLDUNDA SEISMIC SURVEY

OIL PERMIT 78

NORTHERN TERRITORY OF AUSTRALIA

FOR

EXOIL (N.S.W.) PTY. LTD.

Perry House, Elizabeth Street, Brisbane, Queensland.

BY

GEOPHYSICAL ASSOCIATES PTY. LTD.

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August, 1964.

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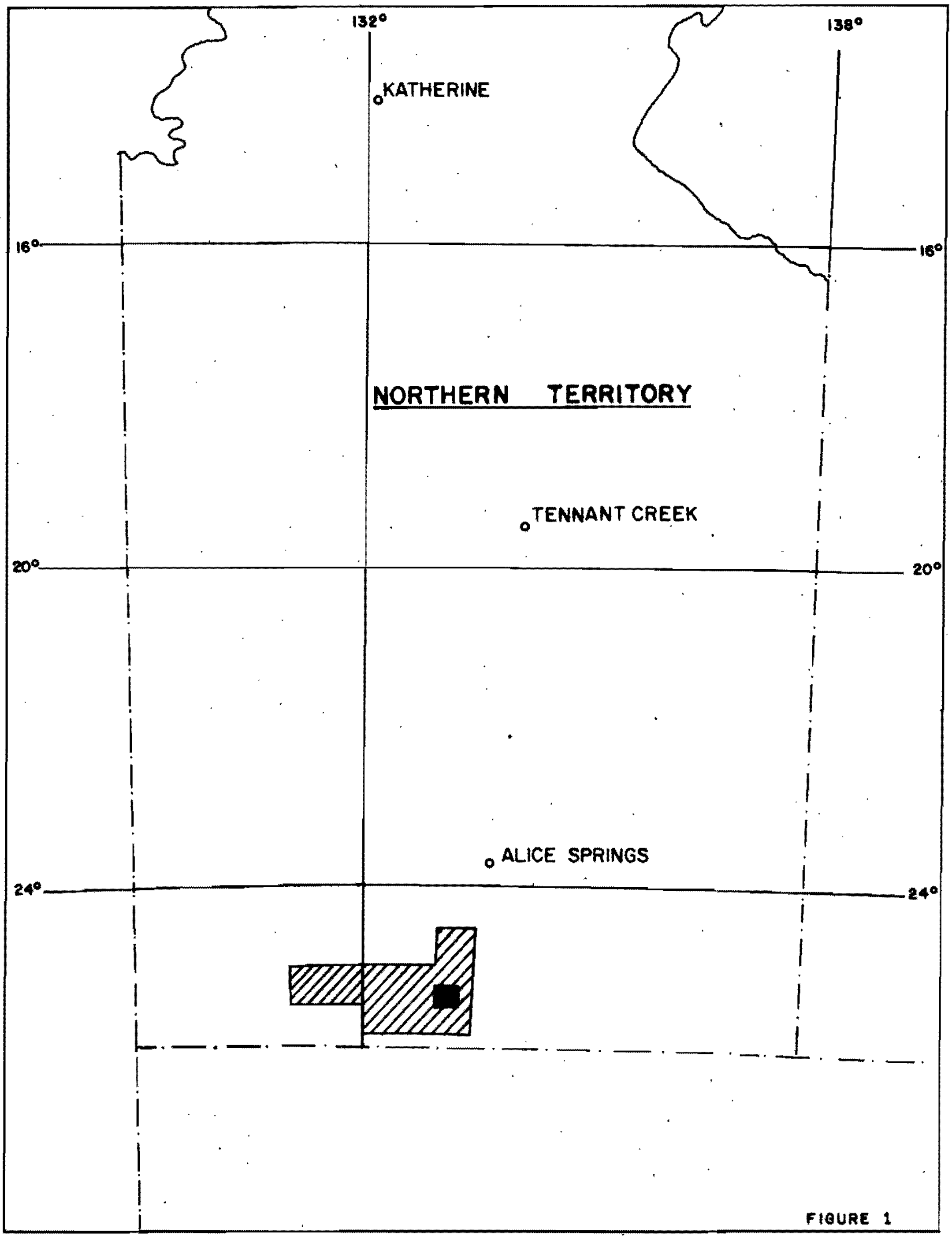
ABSTRACT

A reflection seismic survey was conducted in the Erldunda area, Oil Permit 78, N.T. for Exoil (N.S.W.) Pty. Ltd. by Geophysical Associates Pty. Ltd. The work commenced on 16th June and was completed on 7th August, 1964.

The initial programme was assigned to provide quantitative information on the depth and distribution of sediments in selected areas of Oil Permit 78, with additional programme to be assigned if preliminary results were favourable.

The survey has revealed a major domal anticline cresting near SP 152 about 6 miles south of Erldunda homestead on the Alice Springs-Adelaide highway. The feature is believed to be due to the intrusion of salt and to be of sufficient interest to warrant a deep test. Two anomalies of secondary interest, located 4 miles and 9 miles east of Erldunda homestead, and also believed to be due to salt intrusion, were noted in the reconnaissance shooting but were not detailed.



— LOCALITY PLAT —

ERLDUNDA SEISMIC SURVEY

O.P. 78 N.T.

INTRODUCTION

Oil Permit 78 is located in the Amadeus Basin of the Northern Territory. It comprises 9,005 square miles, and is situated roughly between 24° 30' and 25° 50' South Latitude, and 131° and 133° East Longitude. (Figure 1) The campsite was located one mile east of Erldunda homestead approximately 130 miles south of Alice Springs on the Alice Springs-Adelaide highway.

The terrain is gently undulating and rises gradually to the north and south of Erldunda homestead. Sand dunes are prevalent in the area, running in a general north-south direction, and reaching a height of 20 to 30 ft. Vegetation is sparse, consisting mainly of spinifex and mulga.

Approximately 30 points of rain fell during the period of operations, and strong northerly winds were common during the months of July and August. Sand tyres and bulldozed trails were required for efficient operations when shooting away from well-defined tracks.

An interpretation of the data was carried out in the field office and progress reports were submitted bi-monthly. A crew leave period from July 3 to July 24 was utilized to further evaluate the data obtained, and to plan additional programme.

The nearest significant petroleum test wells are the Alice No. 1 and the Mereenie No. 1, located in Oil Permits 43 and 56 respectively, both having occurrences of hydrocarbons in the Cambrian and/or Ordovician sections. Previous geophysical work in Oil Permit 78 includes a regional helicopter survey by the Bureau of Mineral Resources between 1959 and 1961, and a semi-detailed aeromagnetic survey over the eastern part of Oil Permit 78 by Aero Service Limited for Exoil (N.S.W.) Pty. Ltd. in 1963.

PURPOSE OF INVESTIGATION

The purpose of the survey was fourfold:

1. To provide quantitative information on the depth and distribution of sediments in selected areas of Oil Permit 78 where (a) prospective Paleozoic and Upper Proterozoic sediments are masked by recent sands and flat-lying Mesozoic sediments and (b) volcanics were not indicated to exist by the Charlotte Waters Aeromagnetic Survey.

2. Investigate two major basement highs, and a minor sedimentary structure, disclosed by the Charlotte Waters Aeromagnetic Survey.

3. Detail any significant structures encountered by the regional seismic lines.

4. Investigate a gravity minima revealed by the Bureau of Mineral Resources regional gravity survey, 1959-1961.

REGIONAL GEOLOGY

Ordovician, Cambrian, and Upper Proterozoic sediments of the Amadeus Basin outcrop in several ranges in the northern part of Oil Permit 78. South of these ranges the older rocks are covered by Quarternary sands and Mesozoic and Permian sediments of the Great Artesian Basin onlapping from the east. In the immediate southeast corner of the Permit, Archean rocks of the Arunta complex outcrop and mark the southern limits of Amadeus and Great Artesian sedimentation.

The large ranges and general uplift in the north are not considered to have resulted in a separate depositional basin to the south, but rather it is believed structural deformation took place mainly in Post-Ordovician (probably Devonian) times; i.e., after deposition of Upper Proterozoic and Lower Paleozoic sediments, and is the result of diapiric movement of Upper Proterozoic Bitter Springs evaporites. In view of this, it would appear that the Lower Paleozoic and Upper Proterozoic rocks throughout Oil Permit 78 were deposited under conditions of continuous sedimentation with the main part of the Amadeus Basin to the north.

Geophysical evidence indicates a relatively undisturbed shelfal remnant of the Amadeus Basin obtaining thicknesses up to 10,000 ft lying between the Mt. Sunday Range and the outcropping Arunta Complex to the south. This 'residual' basinal area has been traced northeast into Oil Permit 72 where geophysical evidence has substantiated its existence.

Cambro-Ordovician and Upper Proterozoic sediments, in addition to their occurrence in outcrops in the north of Oil Permit 78, have been observed in outcrop at the Kingston Range on the south flank of the basin in Oil Permit 72. Their continuation beneath the Quarternary, Mesozoic and Permian cover into Oil Permit 78 is thereby anticipated.

The complete sequence of Upper Proterozoic sediments of the Amadeus type have been observed outcropping in Oil Permit 78. Of the various formations, the Bitter Springs is probably of greatest interest as possible source rock. The Pertatataka Formation, which is predominantly shale in the northern Amadeus area, becomes increasingly carbonaceous to the south and may be of greater interest as a source rock due to its increased algae content.

The Arumbera sandstone, main reservoir rock in the Upper Proterozoic-Cambrian sequence, is not likely present this far south. The Pertaoorta Formation, a carbonate-shale-sandstone facies constituting the main body of Cambrian sedimentation, doubtlessly provides ample source material for possible generation of commercial quantities of petroleum.

Thin beds of Ordovician sandstones, correlating to the Pacoota and Horn Valley Formations, overlie the Cambrian rocks and could provide significant reservoirs.

The small thicknesses of Permian and Mesozoic sediments onlapping from the east provide little interest to petroleum exploration.

Prepared by S.S. Chambers

RESULTS

The results of the preliminary shooting on Lines 1,2 and 3 are presented as geologic cross-sections (Plates 1,2,3) which have been prepared by Mr. S.S. Chambers of Exoil (N.S.W.) Pty.Ltd. Horizon identification was accomplished with the aid of velocity determination based on delta T analysis of the principal reflecting events. The interpretation of the cross-sections incorporate known surface geology in the area with seismic information from the respective seismic lines.

The results of detail shooting on Lines 4 through 10, and that portion of Line 1 from SP 135 south to SP 24, are presented as time contour maps at the Upper Ordovician, Lower Ordovician, and Lower Cambrian levels (Plates 5,6,7). An isochron from the Lower Ordovician to the Lower Cambrian is included (Plate 9). A typical cross section (Line 4) of this detail shooting is also included with this report (Plate 4).

Before cross-sections and contour maps are discussed a brief description of data quality and velocity information is made.

Qualitative Analysis of Reflection Events

Three events have been carried continuously on the record sections. The shallowest of these, designated Upper Ordovician, has over-all poor continuity and poor character, but has local areas of relatively good continuity. The second event, believed to be Lower Ordovician, has consistently good character and may be readily correlated throughout the area. The deepest event, Lower Cambrian, is of fair continuity but lacks distinctive character. This event lies immediately above the Lower Cambrian-Upper Proterozoic Unconformity and all seismic energy below this level indicates complex geology. Since the shallowest event never attains a depth greater than 2,000 feet, the three events encompass most of the relatively undisturbed sedimentary section lying above the Unconformity.

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.

Typical of the results obtained, with their suggested geologic correlation, are noted below:

Reflection	S.P. No.	2T	delta T	V(Ft/sec)
	40	.357	.044	9700
A	41	.353	.043	9800
	42	.353	.041	10,100
Average:		.354		9900 (10,000)
	40	.808	.012	12,700
B	41	.805	.011	13,100
	42	.811	.011	13,100
	43	.815	.011	13,100
Average:		.810		13,000
	40	.954	.010	12,700
C	41	.953	.009	13,300
	42	.959	.009	13,300
	43	.959	.009	13,300
Average:		.956		13,100

Reflection Time	V	Depth	Interval Velocity	Geologic Correlation
			10,000	Upper Devonian-Carboniferous
.354	10,000	1750		
			15,400	Upper Ordovician
.810	13,000	5250		
			13,700	Lower Ordovocian-Upper Cambrian
.956	13,100	6250		
			19,000	Lower Cambrian-Upper Proterozoic

Geologic Cross-sections

The reconnaissance lines were assigned to check magnetic basement highs and gravity minima apparent on the Aero Service Ltd. aeromagnetic survey and the Bureau of Mineral Resources gravity survey in the area, as well as to provide quantitative regional control on the subsurface. The geologic cross-sections compiled from the seismic reconnaissance lines generally confirm the aeromagnetic survey with respect to depth of section, but not the gravity minima with respect to the inferred presence of diapiric salt.

The cross-sections indicate a regional thickening of section to the west particularly in the Lower Ordovician-Upper Cambrian sediments. For example, from SP 73, Line 2, west to SP 138, Line 1, there is 1200 ft of thickening in these particular sediments with regional west dip.

The Upper Ordovician on Line 2 has variation in local thickness from a maximum of 5600 ft at SP 105 to a minimum of approximately 1800 ft at SP 125. This considerable variation appears to be caused by intrusion of salt through this section.

The south portion of Line 1 indicates approximately the same thickness of sediments (6,600 ft) above the unconformity as noted at the east end of Line 2. There is an increase in total section to the north to SP 138. North of this point there is a marked loss of Upper Ordovician, culminating north of SP 167 where a series of near vertical faults have resulted in a loss of about 3500 ft of Upper Ordovician and Lower Ordovician-Upper Cambrian sediments.

Line 3, north of the intersection with Line 2, shows a continuous loss of Upper Ordovician and Lower Ordovician-Upper Cambrian sediments to SP 90 where salt intrusion has possibly occurred.

Three major anomalies are apparent on the geologic sections. The most important, centering at SP 152 on Line 1, shows approximately 3000 ft of north closure and 1800 ft of south closure; this structure was later detailed in part. The two other anomalies are located on Line 2 and crest at SPs 125 and 110. It is believed that Lower Cambrian and/or Upper Proterozoic salt movement has been instrumental in producing all three structures.

Detailed Area

Detail shooting on the major anomaly discovered on Line 1 has indicated a northwest-southeast trending structure. Full closure on the structure has not been determined except on the northeast flank where 3000 ft of dip is indicated. Approximately 500 ft of northwest dip, 1800 ft of south dip, and 900 ft of southwest dip, have also been demonstrated. The total areal extent of the structure has not been determined but is at least 50 square miles.

The Upper Ordovician Horizon drapes over the deeper horizons indicating a loss of Upper Ordovician section over the crest of the structure and an increase in Upper Ordovician sediments on the flanks. The Lower Ordovician Horizon exhibits the maximum structural closure on the anticline. The Lower Ordovician to Lower Cambrian Isochron shows thickening of Lower Ordovician-Upper Cambrian sediments (approximately 150 ft) on the crest of the structure and thinning on the flanks.

Seismic data below the Lower Cambrian shows poor continuity with dips unconformable to the younger beds, indicating a complex geology. It was not possible to reliably map the basement which is considered to be the base of the Upper Proterozoic in this area.

CONCLUSIONS

It is believed that the structural anomaly cresting at SP 152 on Line 1 has good possibilities for oil and/or gas accumulation and a deep test is recommended. Estimated depth to economic basement is approximately 6000 ft.

In the event of encouraging results from the recommended deep test, the significance of the anomalous structures at SPs 125 and 110 on Line 2 would be greatly enhanced. It is recommended that detail coverage should then be programmed to fully delineate these features.

GEOPHYSICAL ASSOCIATES PTY. LTD.

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 a triangulation station located approximately 1 mile northeast of Erldunda homestead. 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 features such as property lines, roads, fences, bores, and to Erldunda homestead. Planimetric base maps were supplied by Exoil (N.S.W.) Pty. Ltd.

Steel fence posts, with the shot point stamped on a metal tag, were set out at approximately 5 mile intervals and at all line intersections to permanently mark shot point locations.

Drilling

Single holes were drilled to a depth of 110 to 125 ft and pattern holes to a depth of 80 to 110 ft. Air was used primarily as a drilling method, with water injection used as an alternative when near-surface conditions necessitated its use. Surface casing was set when loose sand near the surface was present. The casing was recovered after shooting of the hole.

Drilling conditions were fair throughout most of the area. Loose sand on the north ends of Lines 1 and 3 necessitated the use of water and drilling additives. Sand dunes in the detail area could be negotiated with sand tyres and did not appreciably slow production.

Shooting

Single shot holes, with the charge size varying from 5 to 80 lbs, were used throughout most of the area. Three and five hole patterns, drilled to a depth of 80 to 110 ft, and spaced at 50 ft intervals, were shot when record quality deteriorated, or for greater efficiency when larger charges were required. Record quality did not show a sufficient improvement with the pattern holes to justify adopting pattern holes as a standard technique for all shot locations. All shot holes were tamped with dirt, which precluded the possibility of a second shot in most holes.

Recording

Recording was accomplished using Southwestern Industrial Electronics GA-33 reflection-refraction amplifiers, an RO-22A oscillograph, and an MR-4E FM magnetic tape system.

The continuous interlocking profile technique was used with 1760 ft spacing on the reconnaissance lines and 1320 ft spacing on the detail programme. The first four miles of the reconnaissance programme was shot with 1320 ft spreads and then increased to 1760 ft when satisfactory data seemed assured. Twelve S.I.E. Type S-16 geophones were spread in line at intervals of 12.2 ft. The far traces were laid across the adjacent shot points to obtain full sub-surface coverage (Figure 2). Trace spacing was kept constant on all spreads, including those where it occasionally became necessary to use a shot point interval of less than normal length. The end traces which could be extended past the adjacent shot point were not recorded on the tape and paper records.

Monitor seismograms were recorded with no mixing, a double section 20 cps low band pass filter, and a single section 90 cps high band pass filter. All shots were taken using fast AVC and 50-70% gain, depending on wind conditions.

Unmixed playbacks from the magnetic tapes were made in the field with a double section 20 cps filter on the low side and a single section 65 cps on the high. Mixed (25% Bi-directional) playbacks were made on some of the detail shooting where wind noise was prevalent.

Unmixed, variable density-galvo record sections were prepared for the reconnaissance shooting. Record sections for the detail shooting were mixed.

COMPUTATION

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

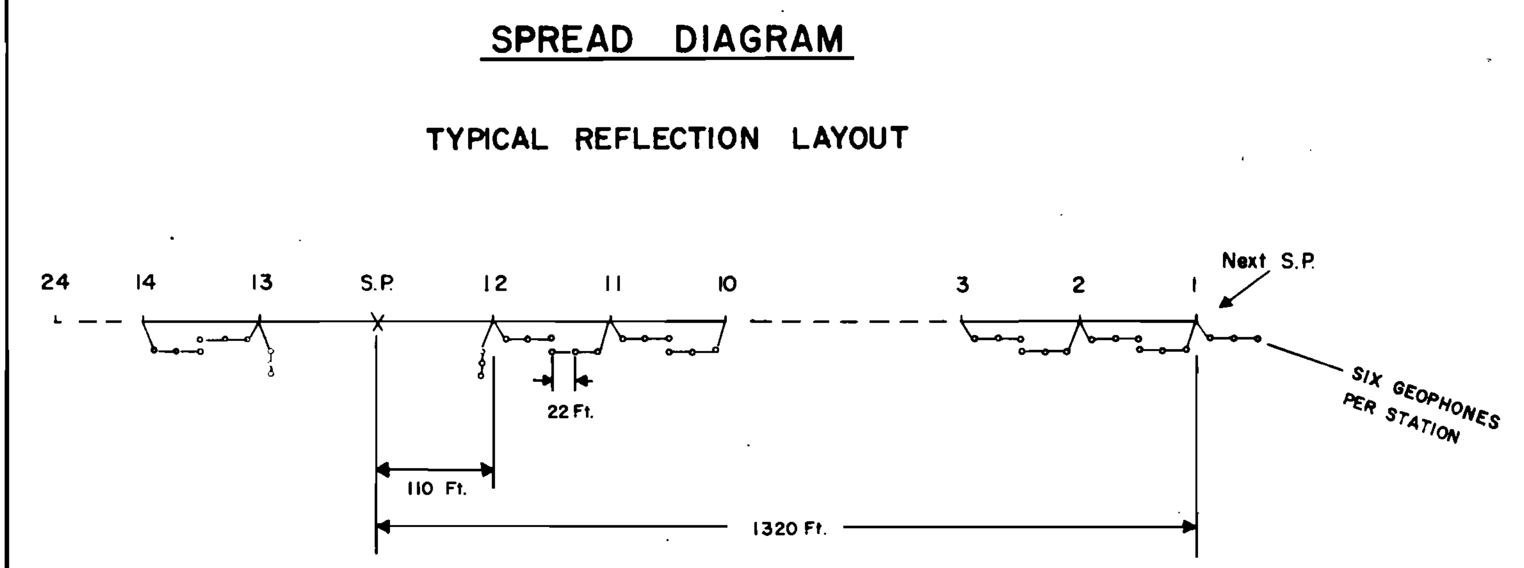

SPREAD DIAGRAM
TYPICAL REFLECTION LAYOUT
24
14
13
S.P.
12
11
10
3
2
1
Next S.P.
22 Ft.
110 Ft.
1320 Ft.
SIX GEOPHONES PER STATION

FIGURE 2

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

Tc = total correction

Es = surface elevation

W = depth to top of charge

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. Their common travel paths could thus be adjusted to datum by application of the resultant static correction.

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

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

H = depth from base of shot to velocity interface

T2 = datum velocity interface time

Tuh= uphole time

V1 = velocity above interface

V2 = velocity to datum

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

Total correction was then computed using the formula:

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

First arrival plots indicated shallow weathering of approximately 30 ft on most shot points. An intermediate velocity of 6000 ft/sec was found on the plots and this was used in conjunction with 10,000 ft/sec when computing weathering. Relatively deep weathering, i.e. the depth to the 6,000-10,000 ft/sec interface, was found on the north ends of Lines 1 and 3, reaching a depth of approximately 500 ft.

Individual trace corrections 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 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	P. Webb
Drilling Supervisor	G.E. Thompson
Driller	G. Robinson
Driller	M.M. Sweedman

The basic crew comprised 22 men. In addition to the key personnel noted above, fourteen men were employed as:

Shooter	1
Rodman	1
Chainman	1
Recording helpers	4
Drilling helpers	2
Supply truck driver	1
Cook	1
Cook's helper	1
Mechanic	1
Mechanic's helper	1

Supervisors

Exoil (N.S.W.) Pty. Ltd.	S.S. Chambers
Geophysical Associates Pty. Ltd.	J.H.B. Campbell

APPENDIX III

Equipment

Automotive

8 F-750 Fords, 4 or 6 wheel drive, equipped with winch, 3 Land Rovers with 4 wheel drive.

Recording

1 Recording truck with airconditioned 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. oscillograph
1 S.I.E. MR-4E (FM) magnetic tape system
450 S.I.E. reflection geophones, S-16, 18 cps
1 Multicap blaster
1 Portable blaster
3 Road cables 1760 ft
3 Portable cables 1320 ft

Shooting

1 Land Rover

Drilling

2 Mayhew 1000 air-water combination drills
2 Water trucks mounted with a stake sided, flat bed 1000 gallon tank

Surveying

1 Land Rover
1 Transit
1 Alidade and plane table

Supply

1 Stake truck

Office

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 an 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 Data	16 June, 1964
Completion Date	7 August, 1964
Hours Moving	17
Hours Field	271
Hours Driving	49
Total Recording Hours	320
Days Worked	33
Holes Shot	346
Total Shots	353
Miles Traversed	99.8
Pounds Dynamite Used	14,175
Average Charge Size (lbs)	40
Detonators Used	529
Tapes Used	352
Holes Drilled	410
Total Footage Drilled	47,035
Hours Drilling (Two drills)	549
Hours Driving (Two drills)	99
Total Drill Hours	648
Average Penetration (ft/hr/drill)	86
Bits Used:	
4½" Tri-Cone Rock	15
5 5/8" Tri-Cone Rock	0
4½" Inserts	42
5 5/8" Starter	9
Sacks Mud Used	3
Sacks Chaff Used	4
Bulldozer Hours:	
Work	93.5
Standby	5.5
Time Lost Due to Weather	0
Time Lost Due to Equipment Failure	0