HALE AREA SEISMIC SURVEY

OIL PERMIT 75
NORTHERN TERRITORY OF AUSTRALIA

FOR

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BY

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Radenja - Hale

March, 1965.

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STATISTICAL DATA

Starting Date	27 October, 1964
Completion Date	8 December, 1964
Hours Moving	32
Hours Field	328
Hours Driving	80
Total Recording Hours	440
Days Worked	40
Holes Shot	352
Total Shots	373
Miles Traversed	86
Pounds Dynamite Used	10,790
Average Charge Size (lbs)	29
Detonators Used	2789
Tapes Used	372
Holes Drilled	2859
Total Footage Drilled	71,000
Hours Drilling (2 drills)	582.5
Hours Driving (2 drills)	142.0
Total Drill Hours	724.5
Average Penetration (ft/hr/drill)	122
Bits Used:	
$4\frac{1}{2}$" Tri-cone Rock	4
$5\frac{5}{8}$" Tri-cone Rock	0
$4\frac{1}{2}$" Insert	24
$5\frac{5}{8}$" Starter	18
Sacks Mud Used	0
Sacks Chaff Used	0
Bulldozer Hours	
Clough	240 (approximate)
Continental Rubber	220
Hours Lost Due to Weather	0
Hours Lost Due to Equipment Failure	0

ABSTRACT

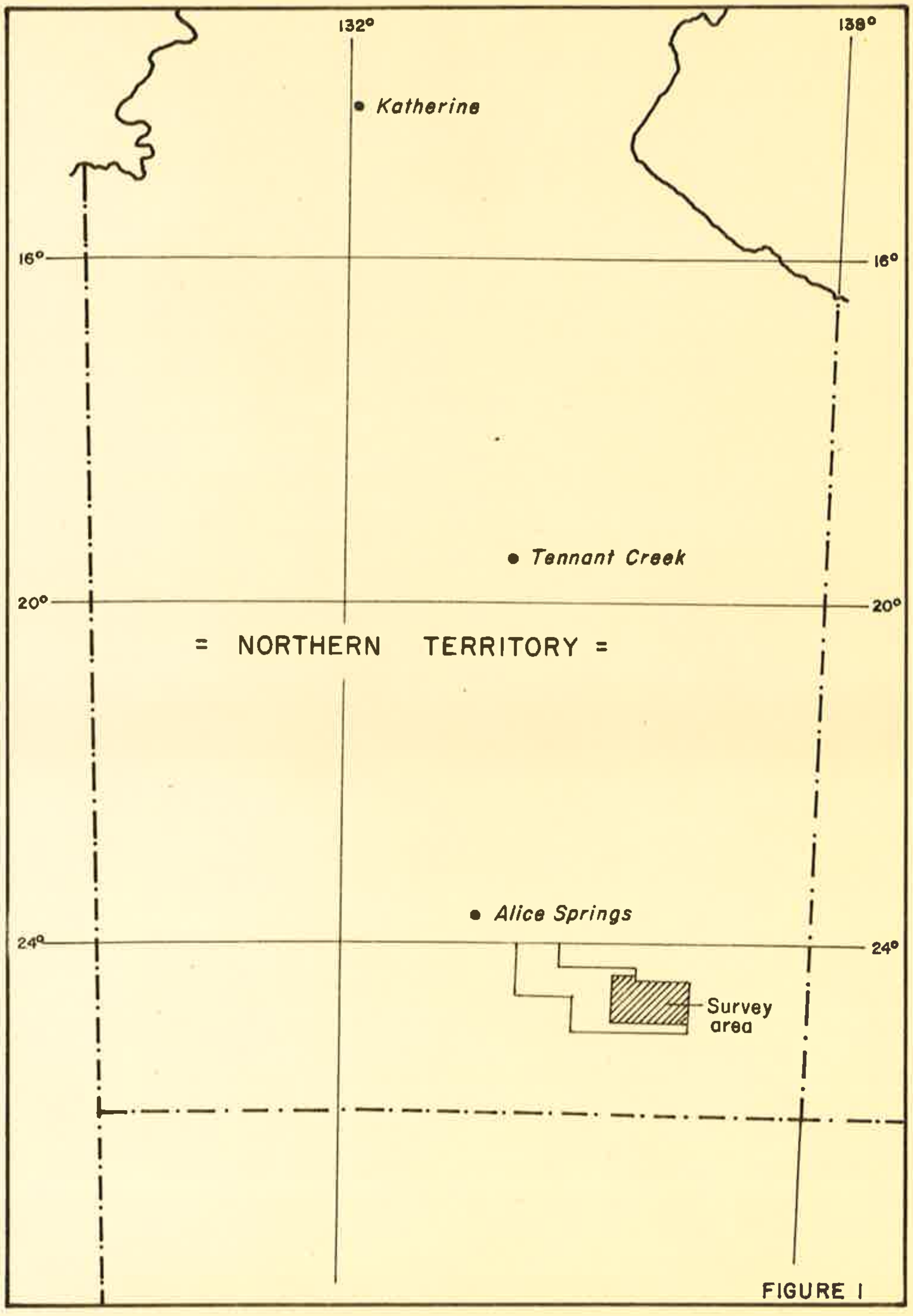
A reflection seismic survey was conducted in the Hale Area, Oil Permit 75, of the Northern Territory of Australia, by Geophysical Associates Pty. Ltd. for Flamingo Petroleum Pty. Ltd. The survey commenced on 27 October, 1964 and was completed on 8 December, 1964.

Programme was assigned to provide qualitative and quantitative information on the depth and distribution of sediments in the Permit, and to investigate anomalies indicated by previous seismic and aeromagnetic surveys.

Completion of the reconnaissance work has indicated that future operations using conventional shooting methods will require at least three shot hole drills and four water trucks in order to obtain optimum seismic results. The seismic lines would be most advantageously placed running approximately north-south, parallel to the sand dunes. East-west tie lines (traversing the sand dunes) should be kept to a minimum.

The survey has shown considerable variation in near-surface velocities and velocities at depth. These velocity variations have made it necessary to compute several move-out curves for dynamic corrections for playback sections.

The record sections indicate regional southeast dip, generally conformable with the increase in depth of sediments indicated on the aeromagnetic surveys. Numerous faults, with relatively small vertical displacement, are indicated on the record sections. Unconformities are indicated below the Cretaceous-(Jurassic ?) and (Triassic ?) - Permian levels in the east part of the Permit. An area approximately six miles long on the East-West traverse (Line 1) could possibly contain major structural development and should be included in future detail programming.



LOCALITY PLAT

HALE AREA SEISMIC SURVEY
O.P. 75 N.T.

INTRODUCTION

A reflection seismic survey was conducted in the Hale Area, Oil Permit 75, in the Northern Territory of Australia by Geophysical Associates Pty. Ltd. for Flamingo Petroleum Pty. Ltd. Field work commenced on 27 October, 1964 and was completed on 8 December, 1964.

Oil Permit 75 is centred approximately 180 miles south-east of Alice Springs (Fig. 1). Access to the area may be gained by following a track via Santa Teresa Mission to Alhambra Homestead. From the homestead a track through Steele's Gap provides access to the west part of the area. An alternate track from Alice Springs via Newbury Homestead roughly follows the Hale River and provides access to the east-central portion. The Permit lies within the area bounded by 134°15' and 136°24'10" east longitude, and 24° to 25° south latitude.

The terrain is characterized by numerous northwest-southeast trending sand dunes approximately 20 to 30 ft in height. Flood-outs of the Hale and Todd Rivers occur within the area. Two large mesas are situated east of the Hale River flood-out and provide the major relief. Vegetation is sparse, centralized for the most part along the river flood plains, and consists chiefly of eucalyptus trees and mulga.

Weather during the summer months is hot and dry, and strong winds are prevalent, particularly in the afternoon. The crew was able to increase efficiency by starting work at five in the morning.

A bulldozer is necessary for all seismic lines running normal to the sand dunes and to provide access to lines shot parallel to the dunes. Sand tyres are recommended for all vehicles other than light four wheel drive units.

A preliminary interpretation was carried out in the field office and progress reports were submitted bi-monthly. Additional programme was assigned to give the greatest possible reconnaissance coverage in the time available.

The nearest significant petroleum tests are the Alice No. 1 and Ooraminna No. 1 wells located in the Amadeus Basin in Oil Permit 43. The Alice No. 1 well had a significant oil show in the Cambrian and the Ooraminna No. 1 flowed gas from the Upper Proterozoic at the rate of 14,000 cubic ft per day.

Previous geophysical work in the area includes two gravity surveys in 1960 and 1961, aeromagnetic surveys in 1962 and 1963-64, and seismic work in the west portion in 1961 and 1963.

PURPOSE OF INVESTIGATION

The purpose of the survey was to:

1. Traverse a structural high in the west part of the permit area on Lines G and H (shot points G-55 to H-62), indicated by the Todd River Seismic Survey conducted by Namco in 1963.

2. Traverse a prominent aeromagnetic high revealed in Oil Permit 75 by the Todd River Aeromagnetic Survey conducted by Aero Services Ltd. in 1964.

3. Provide regional control on the depth and distribution of sediments over an east-west distance of 50 miles through the centre of the permit, tying the Namco work to the central and eastern parts of the permit area.

4. Traverse the western edges of a large graben indicated by the Todd River Aeromagnetic Survey.

5. Investigate the area for any subsurface structures that could be later detailed for a satisfactory location for a deep stratigraphic test.

REGIONAL GEOLOGY

Both Amadeus Basin and Great Artesian Basin sediments occur in Oil Permit 75. The outcropping Amadeus Basin sediments are confined to the northwest part of the permit. The Amadeus Basin sediments are covered by Mesozoic sediments of the Great Artesian Basin over the rest of the survey area. These sediments are, in turn, mostly masked by aeolian sand deposits which leaves a featureless surface with few clues to the underlying geology.

The outcrops of the Amadeus Basin sediments in the northwest have been mapped by various geologists. They have all mapped a generally normal Upper Proterozoic and Cambrian section which includes outcrops of Bitter Springs, Areyonga, Pertatataka and Arumbera Formations, and limestone and shale sequences of Cambrian age. The limestone and shale sequences correlate, in part at least, to the Goyder, Jay Creek and Hugh River members of the Pertaoorta Formation at Ooraminna. Numerous algae inclusions have been observed in these limestones in the Phillipson Pound area (northwest O.P. 75). A total of 2150 ft of shale and limestone section believed of Cambrian age was measured at the farthest south major outcrop; i.e., at Steele's Gap.

Above the Cambrian limestone and shale sequence at Steele's Gap a 2000 ft sandstone section has been measured. Wulff of Frome Broken Hill (1959) has called it Pertnjara, which is a non-marine (?) Upper Devonian Sandstone. Madden of Mines Administration has termed it the PulyaPulya Sandstone and has assigned it to the Upper Cambrian because of its conformity with the underlying carbonate section and because of the occurrence of scolithid burrows. No fossils have been found which would confirm its age identity.

Southeast and east of Steele's Gap outcrop is restricted to isolated patches of Mesozoic siltstones and sandstones and Permian (?) glacials belonging to the Great Artesian Basin. Velocities obtained in delta T analysis from Namco's Seismic Survey (1963) indicate that about 2000 ft of these lower velocity sediments exist in the western part of the survey area.

Malcom's Bore, drilled near the southwest corner of the permit area, has been reported to have penetrated 600 ft of Cretaceous sediments overlying Lower Permian non-marine sandstones which occur from 600 ft to the total depth of approximately 1800 ft (Spriggs).

Jurassic and Triassic sediments as well as Cretaceous and Permian occur in the deeper parts of the Artesian Basin and may well be present in the eastern part of Oil Permit 75 where aeromagnetic surveys reveal up to 15,000 ft of sedimentary section.

The Triassic is often conformable with the Permian, forming sub-basins which are in turn covered disconformably by a relatively thin and uniform blanket of Jurassic and Cretaceous sediments, the latter of which defines the extent of the Great Artesian Basin.

Outcrops of Cretaceous shales and sandstones observed in two large mesas in the central permit area reveal flat dips; hence, no appreciable variation in thickness of Cretaceous sediments can be anticipated in the survey area.

Evidence for believing Cambrian sediments extend throughout most of the survey area has been indicated by previous geophysical work. The sandstones overlying the Cambrian could provide good reservoir for Cambrian source rock.

Although Permian rocks in the area would likely be nonmarine, they have proven productive at Gidgealpa. The possible existence of marine Permian sediments in the deeper sedimentary areas to the south could provide source material for hydrocarbon accumulation in regionally up-dip areas such as Oil Permit 75.

It is not anticipated that any Triassic or Jurassic rocks that might exist or any Cretaceous rocks could be more than mildly prospective for oil and gas.

Prepared by S.S. Chambers

PREVIOUS GEOPHYSICAL INFORMATION

The first geophysical work done within the present boundaries of Oil Permit 75 was a helicopter gravity survey carried out (firstly) by Mines Administration Pty. Ltd. for Flamingo Petroleum Pty. Ltd. in the area of the previous Oil Permit 54 in 1960, and (secondly) by the Bureau of Mineral Resources over the rest of the area in 1961.

In 1961 Geoseismic (Australia) Limited conducted reconnaissance seismic work over the Camel Flat Syncline and along the Steele's Gap to Andado Road.

In 1962 the Bureau of Mineral Resources covered the area with five mile east-west control as part of the Simpson Desert Aeromagnetic Survey.

In 1963 Namco International Inc. shot north-south regional lines in the area south of Steele's Gap.

In late 1963 and 1964 Aero Services Limited carried out a semi-detailed aeromagnetic survey over the whole of the permit area lying south of latitude 24°23'00" S. Their reduction and interpretation incorporated the results of the B.M.R. traverses.

The regional gravity work indicated strong northwest regional dip in the area south of Steele's Gap. Later seismic work indicated southeast regional dip. It is felt that changes in basement composition distorted the gravity results and that aeromagnetics has been a better tool in determining the depth of sediments in this area.

The Namco seismic shooting in 1963 indicated a minimum of 4000 ft of section which would appear (from delta T analysis) to be comprised of Mesozoic, Upper Palaeozoic and Cambrian-Ordovician sediments. The results of the seismic survey were used to assist in the interpretation of the aeromagnetic data in 1964. The aeromagnetic interpretation reveals a similar amount of sedimentary section in the area of seismic control but shows a considerable increase (up to 15,000 ft) in thickness of sediments towards the eastern end of the permit area.

OPERATIONAL PROBLEMS AND EXPERIMENTATION

The Hale Area has proven sufficiently difficult to require special operational and interpretational techniques to obtain satisfactory results. A brief resume of the problems encountered in this survey and their suggested solutions may prove helpful in future operations.

Field

Drilling in the area presented many problems. Difficulties encountered in traversing Line 1 normal to the sand dunes and long water hauls for all lines forced the drillers to drill exclusively with air. An attempt was made to drill for water in the sand dune area at Namco shot point H-63. The hole was drilled to 180 ft and no water was encountered.

Water-bore control through the permit area indicates that water should be encountered in most places at approximately 250 ft. Thus, a third drill and a more concentrated programme would justify water wells and reduce the economic necessity to drill exclusively with air. Results could be greatly improved for reasons as described further.

By drilling exclusively with air, loose sand at the surface made penetration into the underlying clays or shales difficult. On Line 1, most shot holes were shot at depths of less than 20 ft using pattern holes at these locations. On Line 2, which was shot along the Hale River, drilling conditions improved locally and many of the shot holes were drilled to the desired depth of 40 to 60 ft. Clay or shale was normally penetrated at around 30 ft and record quality was much improved where holes greater than this depth could be obtained. On the east portion of Line 1 a hard (laterite ?) formation near the surface, underlain by loose sand, again made it difficult to drill holes to desired depths.

A considerable amount of low frequency noise, particularly from shallow holes, interferes with reflected energy in the area. Thus, the use of pattern holes improved record quality and these were drilled at most locations. Three and five hole in-line patterns with the holes at 50 ft intervals were used where holes could be drilled into clay or shale. Nine and sixteen hole box patterns (with the box rotated at an angle of 45 degrees to the direction of the line) and the holes at 30 or 50 ft intervals were used in most cases where the surface sand could not be completely penetrated. In the areas of hard drilling (laterite ?) it was considered more important to attempt to get at least one hole to a good shooting depth rather than to shoot a shallow pattern. Consequently, shallow patterns less than 30 ft deep were drilled only when the driller had difficulty in penetrating loose sand at the surface.

In summary, pattern holes are desirable in the area. They were found to provide cancellation of a great deal of the low frequency noise and to allow more efficient use of primary energy due to higher frequency of input energy from smaller charges in each hole. A five hole in-line pattern with holes at 30 ft intervals drilled to a depth of at least 40 ft and using 2½ lbs of explosives in each hole could be expected to yield useful seismograms. In order to drill these pattern holes to desired depths, a minimum of three seismic drills are considered necessary to retain an economic rate of production. Water-injection is believed to be the best method of drilling the shot holes and it is anticipated that at least four water trucks would be needed because of the long water hauls involved. Loose sand encountered in many of the shot holes may necessitate the use of a string of five inch surface casing (recoverable) in order to penetrate the sand efficiently. The holes should be pre-loaded in this case before the casing is pulled.

Since the seismic lines shot parallel to the trend of the dunes were found to be much superior to those which crossed them, future programme should be assigned with a minimum amount of traverses normal to these features. The regularity of the strike of the dunes in the area would make this type of programme quite feasible.

Interpretation

Field playback records were of an unsatisfactory quality in view of:-

(1) A very low signal to noise ratio.

(2) Extremely low near-surface velocities causing abnormally high normal move-outs, thus making correlation of otherwise good near-surface reflections indistinguishable.

(3) The lack of a persistently strong deep reflector from which static corrections could be computed for playback purposes.

The problem was then threefold:-

(a) To determine a filter that would eliminate much of the noise while retaining most of the reflected energy.

(b) To compute proper normal move-out curves, which would allow

(c) Accurate static corrections to be determined from shallow reflection events on playback sections after normal move-out corrections had been applied.

If these three steps could be accomplished it might then be possible to improve presentation still further by experimentation with gain and mixing.

(a) Filtering:

Shot point 87 was chosen for filter experimentation because:-

(i) It contained good reflection data.

(ii) It appeared to contain above-average noise.

(iii) It was central to the survey area.

The tape was replayed using all the main filter settings contained by the P.M.R. playback centre in Brisbane. It was determined that a 2/38 filter on the low side and a 2/65 filter on the high side produced the best results. This filter setting was henceforth used for all playback operations.

(b) Normal Move-Out:

Determination of a suitable velocity function was difficult. From first breaks it was observed that near-surface velocities in general decreased from approximately 7000 ft/sec at the west end of the survey area to approximately 5500 ft/sec at the southeast end. In addition, the thickness of this low velocity material increased to the southeast and, from delta T analysis, it was found that the average velocity to a one second reflection time at the south end of Line 2 was only approximately 8000 ft/sec. These prominent lateral velocity variations in the upper 3000 ft of sedimentary section made it necessary to compute several velocity functions for different parts of the area, experimenting with each individual one to test its applicability before proceeding with the next. In all, six normal move-out curves were computed for the south half of Line 2. (The normal move-out curves for various segments of the line are recorded on the correction sheets forwarded to Flamingo Petroleum Pty. Ltd.).

The north part of Line 2 was played back using the normal move-out curve which showed maximum trace corrections. The results of this portion of Line 2 were good. The same normal move-out was then used to produce record sections for all of Lines 1 and 3. Results on Line 1 are considered poor to fair; on Line 3, fair.

(c) Static Corrections:

Static corrections were calculated for the above playbacks by pro-rating between total-time corrections for hole traces of adjacent shot points. This procedure had the advantage of correcting for regional variations in elevation and near-surface velocities while at the same time avoiding the necessity of applying questionable interpretation into the first playbacks from poor quality field records.

The first playbacks on straight filtering with pro-rated static corrections and reasonably accurate dynamic corrections applied, constituted much improved data from which -

1. The effect of trace-to-trace topographic and near-surface velocity changes could be assessed, and

2. Trace-to-trace static corrections could be computed using the better shallow reflectors.

Approximate 2 mile segments from both the west half of Line 1 and the south half of Line 2 were chosen for experimentation with static corrections. Both mixed and unmixed sections were played back for these segments using static corrections calculated, in the main, from strong shallow reflectors.

The unmixed corrected playbacks did not show sufficient improvement to warrant the extra expense of the operation. The mixed playbacks, using a higher gain, were not successful in improving the quality of the data for interpretational purposes, although the records appeared to be better in some instances. It was decided then that trace-to-trace time differentials due to topographic and velocity changes were not a problem - as would be expected from the generally flat terrain and uniform shot hole logs.

The pro-rata method of computing static corrections for the whole area proved quite successful, although it did introduce some artificial line-ups and misties between end traces of adjacent shot points. These phenomena could be avoided somewhat in future surveys by using more constant shot hole parameters.

RESULTS

The results of the reconnaissance shooting have been presented as reduced scale record sections (Plates 2, 3, 4), with the more prominent reflections shown with a series of black dots. Two horizons which exhibited the best continuity are designated A (Base of Cretaceous) and B (unidentified).

Contour maps have not been presented with this report. Lines 1 and 2, which are approximately 49 and 37 miles long respectively, intersect roughly at their centres and do not lend themselves to meaningful contour maps. Lack of continuity of reflected energy and poor reflection character would make any correlation across these long reconnaissance lines of doubtful value.

The following discussion is a resume of the velocity information obtained and a description of the structural features revealed on each record section.

Velocities

Average and interval velocities have been computed for 4 widely separated and representative shot points in the Hale Area in order to indicate the variations in velocities encountered. The results are as follows:

Line 1, SP 2

Reflection	Time (2 way)	NMO	Average Velocity	Interval Velocity	Depth
1.	291	050	7300		1060
				9200	
2.	498	023	8050		2010
				11,450	
3.	699	015	9050		3160

Line 2, SP 211

Reflection	Time (2 way)	NMO	Average Velocity	Interval Velocity	Depth
1.	368	066	5500		1010
				11,700	
2.	684	018	8350		2860
				10,500	
3.	1141	009	9200		5250
				11,200	
4.	1232	008	9350		5760

Line 2, SP 321

Reflection	Time (2 way)	NMO	Average Velocity	Interval Velocity	Depth
1.	392	062	5500		1080
				9500	
2.	489	043	6300		1540
				8300	
3.	759	023	7020		2660
				9400	
4.	1010	015	7600		3840

Line 3, SP 364

Reflection	Time (2 way)	NMO	Average Velocity	Interval Velocity	Depth
1.	395	062	5740		1130
				7800	
2.	500	043	6160		1540
				8950	
3.	728	024	7025		2560
				9550	
4.	1429	009	8250		5900

It will be noted that SP 2 on Line 1, and SP 211 on Line 2 have similar interval velocities for a portion of the section. These velocities (11,300 ft/sec as an average) may be indicative of the Upper Devonian Pertnjara Formation. SP 364 on Line 3 and SP 321 on Line 2 also have similar interval velocities for a portion of the section (9500 ft/sec as an average) which may be indicative of Mesozoic or of Lower Permian formations.

Structural Analysis

Velocities derived from delta T analysis, and the record sections, indicate that more lower velocity and probably younger Mesozoic sediments have been deposited in the east and south of the area. The unconformities apparent on the record sections are believed to be at the base of Cretaceous - (Jurassic ?) and (Triassic ?) - Permian formations. Horizons below the upper unconformity have not reflected with any continuity of energy return and cannot be reliably defined. The best continuity of deeper reflections occurs in the north and west where it is thought Amadeus Basin sediments occur, overlain by a relatively thin mantle of Mesozoic sediments. The depth of the section has greatly increased to the east and south, confirming the aeromagnetic surveys which indicated a sedimentary section of up to 15,000 ft in the southeast part of the area.

The record section of the west portion of Line 1 (Plate 2), between Namco SPs G-55 and H-60, was of generally poor quality and cannot be said to confirm or refute the presence of an anticlinal nose indicated by the previous survey. The numerous fault indications are interpreted as normal faults producing horsts and grabens with small vertical displacements.

The faults between SPs 70 and 82 correspond generally to the steep gradient on the total magnetic intensity map. The magnetic basement depth contours also increase from ± 5000 ft to ± 10,000 ft across this area but there are no strongly dipping seismic reflectors in this zone. Evidence of a greater section is not found until east of SP 105 where deeper reflected energy progressively becomes more abundant.

Dips in the deeper portion of the eastern end of Line 1 are unconformable with the relatively strong shallow reflection A, which is probably the base of Cretaceous. The variations in rates of dip are possibly indicative of the Cretaceous - (Jurassic ?) and (Triassic ?)- Permian unconformities.

Slight reversals in the otherwise gentle east dip along Line 1 occur between SPs 36 to 39, 53 to 58, and 93 to 91. Of greater interest for possible future detail work is the area between SPs 138 and 163 where strong westward dipping segments create several anomalous features. This region is also in proximity to the N-S trending anticlinal axis mapped from surface geological studies.

Line 2 (Plate 3) indicates south dip at all reflecting levels with the exception of flat-lying beds between SPs 169 to 194 and 282 to 296.

In detail, this is not in agreement with the configuration of the magnetic basement since the south end of Line 2 might be expected to be flat or dipping to the northeast. The magnetic basement contouring is very generalized, however, and in a regional sense the north end of Line 2 is over a higher basement surface than the south.

Unconformities are evident below the prominent shallow events and also at depth. Indicative of the different rates of dip are the computed rates of south dip (using velocities from delta T analysis) for the southernmost six miles of the line. The most shallow event dips at approximately 35 ft per mile while the deepest continuous reflection over the same interval dips at 200 ft to the mile.

The shallow reflectors on the south portion of Line 2 are not continuous over long distances, possibly because of minor structural faults or facies changes. Normal faulting has been indicated at SPs 168 and 220, and a reverse fault at SP 202. In all cases the vertical displacement is apparently small.

Line 3 (Plate 4) also has evident unconformities below the shallow horizon and at the approximate record time of 1.5 sec. With the exception of an anomalous segment at 1.0 sec on SP 361, the section is dipping strongly southward.

Of the three traverses, Line 3 is situated in an area of the deepest magnetic basement, and in confirmation of this, it exhibits the deepest reflected energy. The additional section possibly represents Lower Palaeozoic sediments which are suspected to be present in the southeast corner of the permit.

CONCLUSIONS

To increase the efficiency of the seismic field operations the crew should be enlarged to include at least three drilling units and four water trucks. It is believed that this will permit shooting the desired number of pattern holes at the optimum recording depth. Seismic lines should be programmed, wherever possible, to run parallel to the sand dunes with the tie lines traversing the dunes kept to a minimum.

Considerable difficulty was experienced with changes in normal move-out times and this phenomenon should be closely inspected in subsequent work. It might be expected, however, that as the programme progresses south towards the Great Artesian Basin both the near and sub-surface velocities may become more consistent.

The record sections reveal a regional dip toward the southeast with Mesozoic sediments also increasing in thickness in that direction. Basically, this confirms the magnetic basement interpretation of a basinal area of up to 15,000 ft of section developing in the southeast corner of the permit.

Unconformities are evident which are probably Cretaceous - (Jurassic ?) and (Triassic ?) - Permian in age. Lower Palaeozoic sediments may be forming part of the thicker section found on the south end of Line 3 although the delta T analysis failed to yield any velocities correlating to formations of this age.

No structures of sufficient interest to warrant a deep test were found on the reconnaissance lines. However, an anomalous area of possible major significance between SPs 138 and 163 on Line 1 is considered worthy of additional detail surveying. Future programming is also recommended for the southeast corner of the permit which probably contains the greatest thickness of prospective sedimentary section.

GEOPHYSICAL ASSOCIATES PTY. LTD.

J.H.B. Campbell

APPENDIX I

FIELD PROCEDURE

Surveying

Cronaflex base maps on a 1" = 1 mile scale were provided by Flamingo Petroleum Pty. Ltd. These maps were prepared by Aero Service Ltd. from semi-controlled photomosaics. They included all topographical and geographical features including astrofix stations and bench marks. The only surveyed bench marks existing in the area were Northern Territory Administration survey points established on the Steele's Gap to Andado track where Namco's Line G was shot. Several astrofix stations were located in the central part of the permit area.

All lines were surveyed using a K & E alidade and plane table. Elevation control was established from Namco's shot point G-55 which, in turn, had been tied to survey points along the Steele's Gap to Andado track. A check was obtained when Namco's shot point G-55 tied well to their shot point H-60 along Line 1. If the Northern Territory Administration surveying is reasonably accurate this vertical control should be more accurate with respect to mean sea level than the barometric elevations which accompany the astrofix stations.

Horizontal control was obtained by tying in to a Northern Territory Administration survey point near Namco's shot point G-55 and the astrofix stations NMC 87 and NMC 85 in the Hale flood-out area. In addition, prominent surface features were surveyed and plotted on plane table sheets for future reference.

A magnetic declination of $5^{\circ}21'$ east was used. All lines were double run to ensure vertical closure. It is considered that surveying is accurate to within $\pm$ 5' vertical and $\pm$300' horizontal.

Steel fence posts, with the shot point numbers stamped on a metal tag, were set out at approximately 2 mile intervals and at line intersections to permanently mark the shot point locations.

Drilling

The problems encountered in drilling in the area have been discussed under Operational Problems and Experimentation. It is considered that the attainment of consistent quality of the seismograms is dependent on drilling uniform shot holes at favourable depths, and since this was frequently not possible in the area special attention should be given the problem.

Shooting

Considerable variation in charge size was used in the area due to variable surface and weather conditions. Charge sizes ranged from 2.5 to 60 pounds per shot hole with the average being approximately 30 pounds. When possible, the charge was distributed in pattern holes in order to achieve better penetration.

The shooter was not always able to load the shot holes to their drilled depth due to loose sand falling in the hole. Charges were tamped with dirt precluding second shots in most locations.

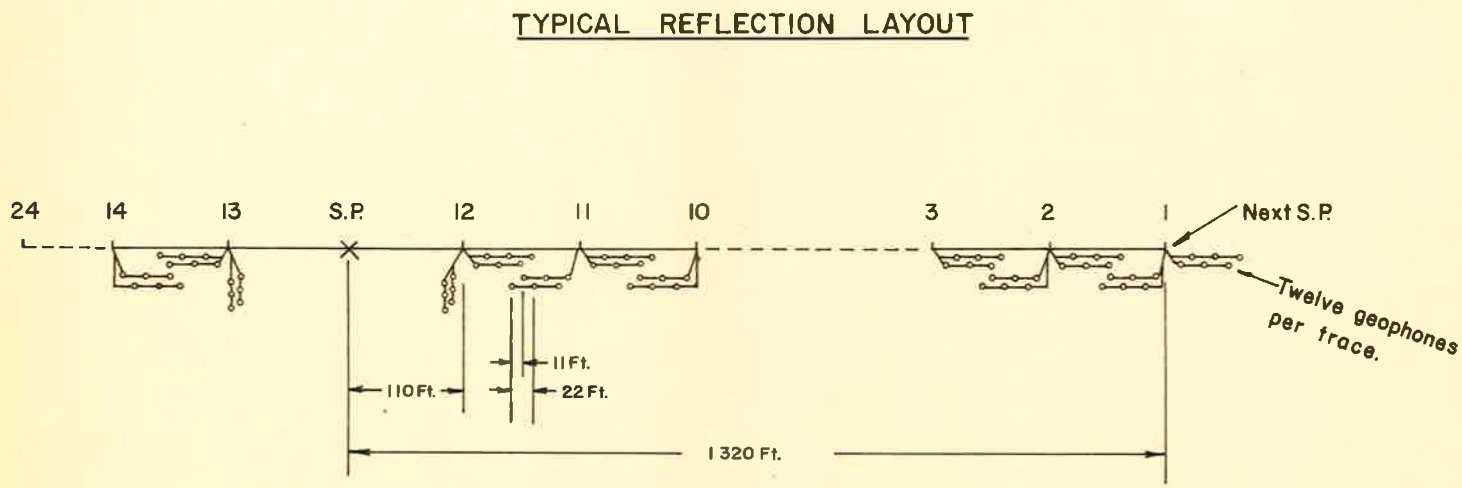
Recording

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

The continuous interlocking profile technique was used with 1320 ft spacing. Twelve S.I.E. Type S-16 geophones were spread in line at 11 ft intervals (Fig 2). The far traces were laid across adjacent shot points to obtain full subsurface coverage. The geophone groups nearest the shot hole were grouped to reduce the effect of hole noise. 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 or paper records.

Monitor seismograms were recorded with no mixing, a double section 20 cps high band pass filter, and a single section 90 cps low band pass filter. All shots were taken using fast AVC and 50 - 70% gain depending on field conditions. Field playbacks were made using a double section 20 cps filter on the low side and a single section 65 cps filter on the high side. An unmixed playback and a 25% bi-directionally mixed playback were made from each field tape.

Unmixed variable density-galvo record sections, with pro-rated static corrections and dynamic corrections applied, were prepared from the field tapes. A mixed variable density-galvo record section was prepared for the south portion of Line 2.



TYPICAL REFLECTION LAYOUT
24
14
13
S.P.
12
11
10
3
2
1
Next S.P.
Twelve geophones per trace.
110 Ft.
11 Ft.
22 Ft.
1320 Ft.

FIGURE 2

COMPUTATION

The reflection seismograms were computed to a datum of 800 ft above mean sea level using a velocity to datum of 7000 ft/sec. When weathering was not indicated on the first arrival plots, records were corrected to datum with a standard uphole computation using the formula:

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

Tc = total correction
Es = surface elevation
W = depth to top of charge
D = datum plane elevation
Vo = velocity to datum
Tuh = uphole time

When first break plots indicated that the shot had been taken in the weathered zone, a weathering velocity of 3000 ft/sec was used with a datum velocity of 7000 ft/sec. The depth to the 3000 ft/sec - 7000 ft/sec interface was computed using the formula:

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

H = depth from shot to velocity interface
T2 = datum velocity intercept time
Tuh = uphole time
V1 = weathering velocity
V2 = datum velocity
sin i = V1/V2 (Snell's Law)

Total correction was then computed using the formula:

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

Corrections for end-trace time ties for the common spreads between adjacent shot points were computed by interchanging the two uphole times and averaging the shot elevation correction times. The common travel paths could thus be adjusted to datum by application of the resultant static correction.

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	J. Hamilton
Driller	P. Lademan

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

Flamingo Petroleum 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, 4 wheel drive
1 Toyota, 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. RO-22A 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 1000 gallon flatbed tanks

Surveying

1 Land Rover
1 Transit
1 Alidade and plane table

Supply

1 Supply truck

Office

1 Airconditioned caravan complete with office equipment including dip plotter and printer

Camp

1 Kitchen caravan with detachable storage and dining tents
1 Airconditioned utility caravan with shower and wash facilities and 4 bunks
2 Airconditioned 8 man sleeping caravans
1 Workshop 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

1 Tent with sleeping accommodation for 6 men