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NINBING - BURT

SEISMIC SURVEY

BONAPARTE GULF BASIN

NORTHERN TERRITORY

O.P. 3

for

ALLIANCE OIL DEVELOPMENT AUSTRALIA N.L.

UNITED GEOPHYSICAL

FINAL REPORT

THE NINBING - BURT SEISMOGRAPH SURVEY - PART TWO

O. P. 3, NORTHERN TERRITORY

average Port Keats
Waterloo.

Conducted for

ALLIANCE OIL DEVELOPMENT AUSTRALIA N. L.

100 Collins Street,

Melbourne, Victoria.

by

UNITED GEOPHYSICAL CORPORATION

113 Eagle Street,

Brisbane, Queensland.

January 1964

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LIST OF ENCLOSURES

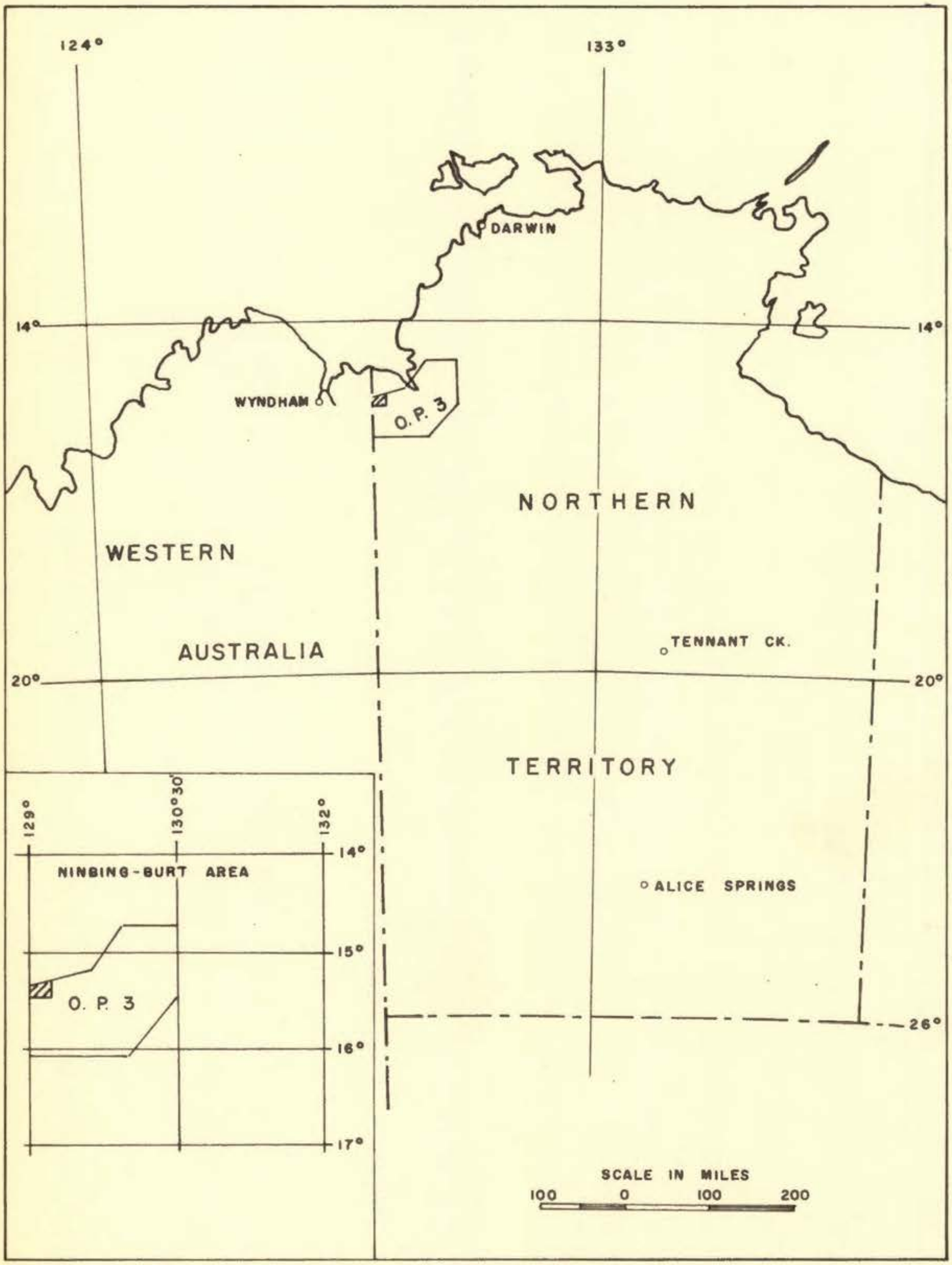


Fig. 1 LOCALITY MAP

INTRODUCTION

The Ninbing-Burt Seismograph Survey - Part Two was conducted on O.P. 3, Northern Territory, by United Geophysical Corporation, 113 Eagle Street, Brisbane, on behalf of Alliance Oil Development Australia N.L., 100 Collins Street, Melbourne. The survey commenced on 2nd September, 1963 and was completed on 15th October, 1963. Both refraction and continuous profiling methods were used in the survey.

O.P. 3 is held by Westralian Oil Limited; Alliance Oil Development Australia N.L. holds a 37½ percent interest in the permit and Alliance Petroleum Australia N.L. holds a 12½ percent interest.

LOCATION

The area covered by the Ninbing-Burt Seismograph Survey - Part Two is located in the northern part of O.P. 3. The reflection traverses are situated to the north and east of the Spirit Hill Well No. 1; several traverses overlap traverses conducted during the 1960 and 1962 seismic surveys.

Refraction Line E is located immediately north of the Spirit Hill Well No. 1 and extends from the Northern Territory - Western Australia boundary (S57°E) to a point approximately 4 miles southeast of the well.

Refraction Line F is located in the center of the area surveyed and extends from the boundary of O.P. 3 and O.P. 2 (S57°30'E) to a point about three miles southeast of the Legune track.

OBJECTIVES

The purposes of the survey were:

1. To further study the structure of the Burt Range embayment and to determine the thickness of the sedimentary sequence present within it.
2. To delineate reliable drilling locations on structures or close to wedge-outs which could form traps for hydrocarbon accumulation.
3. To obtain more reliable geophysical control of structure encountered in other geophysical surveys.

GEOGRAPHY

Access to the area is by track from the C.S.I.R.O. Kimberly Research Station.

Elevations within the survey area varied from 90 feet to 240 feet above sea level. The Burt Range embayment is flanked by steep-sided Precambrian ridges; the area covered by the survey, however is reasonably level but traversed by numerous, deep gullies.

A bulldozer was required for line clearing although the density of timber varied greatly.

Heavy rainfall is restricted to the tropical "wet season" but scattered showers of short duration can be expected from late October onwards.

GEOLOGY

The Bonaparte Gulf Sedimentary basin is located in the Darwin-Wyndham area of northwestern Australia. That portion of the basin which extends onto the Australian mainland is divided into two embayments by a northeast trending Precambrian ridge known as the Pincombe Range. The Carlton embayment is situated to the west and the Burt Range embayment to the east of this basement high. The seismic survey covered in this report is located within the Burt Range embayment.

Structurally, the basin developed as a result of downwarping, accompanied by faulting along the margins, of a portion of the Precambrian shield. The movements were apparently initiated in early Cambrian time and continued, with some interruptions, at least until Permian time.

The basement sediments consist essentially of flat-lying Upper Proterozoic quartzite, sandstone and siltstone with some shale; Lower Cambrian volcanics occur sporadically around the southern rim of the basin and locally may constitute effective basement.

Carboniferous, Upper Devonian and Ordovician-Cambrian sediments, approximately 9,000 feet in total thickness, outcrop at the southern and western margins of the Carlton embayment; within the deeper part of the embayment the thickness of sediments is believed to be in excess of 15,000 feet.

The outcropping strata of the Burt Range embayment are of Upper and Lower Carboniferous and Upper Devonian age. Cambrian-Ordovician sediments which are present in the Carlton embayment have not been recognized in this area. The seismic survey carried out by the Bureau of Mineral Resources in 1956 suggested that more than 6,000 feet of sediments might be present to the north of the Spirit Hill area. The present survey, however, indicates that in this area basement may occur at 5,000 feet. In this event a thinner section can be expected in the southern part of the embayment.

The outcropping sediments of the Burt Range embayment consist predominantly of sandstone and conglomerate with some limestone and shale. The data obtained from surface geological mapping and from the Spirit Hill Well No. 1 indicate that, in the subsurface, facies changes can be expected in the older sediments.

The Burt Range embayment is bounded to the east by the high angle Cockatoo Fault which has a displacement (west block down) of the order of 5,000 feet. This major fault is flanked on the west for two miles by a series of faults which merge with the major fracture and have displacements of up to 1,200 feet. Faulting, associated with the Pincombe Range high may be present on the western margin of the embayment.

PREVIOUS GEOPHYSICAL WORK

A regional gravity survey was carried out within the Bonaparte Gulf Basin by the Bureau of Mineral Resources in 1956. The Bouger Anomaly map accompanying the record of this survey (B.M.R. Records 1959 No. 20) incorporates the results of a marine gravity survey carried out by the Bureau in 1958, together with the data of a joint gravity survey of a portion of the Keep River area which was undertaken previously by Associated Australian Oilfileds N.L. and Westralian Oil Limited.

Additional reconnaissance gravity work was carried out in the Carlton embayment by Mines Administration Pty. Limited for Gulf Oil Syndicate during 1959. In the same year Mines Administration Pty. Limited also conducted a limited gravity survey within the Burt Range embayment on behalf of Westralian Oil Ltd.

In 1961, Oil Development N.L. (now Alliance Oil Development Australia N.L.) carried out a close pattern gravity survey of the Carlton embayment. Gravity stations were established at half mile intervals on a three mile square grid. This survey incorporated sufficient points in common with the previous reconnaissance survey to permit the regional correlation of all surveys.

A seismic survey undertaken by the Bureau of Mineral Resources in 1956 attempted to obtain a continuous profile across the Carlton embayment but no reflections were obtained over the northeastern half of this traverse. The program carried out by the Bureau in 1956 also included several short traverses across the Burt Range embayment.

During 1960 further seismic exploration of the Burt Range embayment was conducted on behalf of Oil Development N.L. The objective of this work was the delineation of the anticlinal structure on which the Spirit Hill Well No. 1 was drilled and the exploration of the deeper part of the basin.

In 1962 Oil Development N.L. conducted a long seismic reflection traverse in a SE-NW direction across the Carlton embayment, a small amount of detailed reflection survey in the vicinity of one of the gravity anomalies outlined in

1961 and some refraction shooting. The 1962 program also included several reflection traverses to the northwest of the Spirit Hill Well No. 1.

During 1963 further seismic exploration of the Carlton embayment was conducted on behalf of Alliance Oil Development N.L. The purpose of this work was to further study the structure of the deeper part of the embayment and to delineate suitable drilling locations. The program, consisting of four refraction lines and detailed reflection survey was concentrated in the area southeast of the Alliance Bonaparte Well No. 1. The results of this survey are discussed in "The Ninbing-Burt Seismograph Survey - Part One".

EQUIPMENT

1. Vehicles:

   1 Ford F600 Recording Truck with Cable Reels.

   1 Ford F600 Shooting Truck with Water Tank.

   1 Ford F250 Shooting Truck.

   2 Ford F800 Drill Trucks with Mayhew "1000" Air-Water Drills.

   2 Ford F600 Water Trucks.

   1 Ford F600 Supply/Water Truck.

   1 Dodge 5 ton Shop Truck.

   2 Willys Jeeps for Surveyor and Recorders.

   1 Land Rover for Party Chief.

2. Instruments:

1 set of Carter instruments for magnetic tape recording with 24 seismic information channels plus time break, uphole and timing traces.

24 United 1-38 Frequency Modulation Amplifiers.

1 United 5-30E Camera.

1 United Magnetic Tape Transport.

18 United 1 -27 Refraction Amplifiers.

1 United 5-30 Camera.

1 set of reflection cables (24 takeouts).

1 set of refraction cables (18 takeouts).

312 Hall-Sears Model HSJ reflection geophones.

24 ELI refraction geophones.

3 AWA frequency modulation radio transceivers.

PERSONNEL

Party Chief	T.J.Greer
Assistant Party Chief	I.G.Weiske
Chief Computer	M.Giles
Computer	T.J.Mulholland
Observer	A.Swann
Assistant Observer	C.Smitheringale
Drillers	R.Moy and A.B.Dore
Shooters	R.Strange and K.Robinson
Surveyors	W.T.Purcell and J.Oakley
Driller-Mechanic	A.C.Schloss

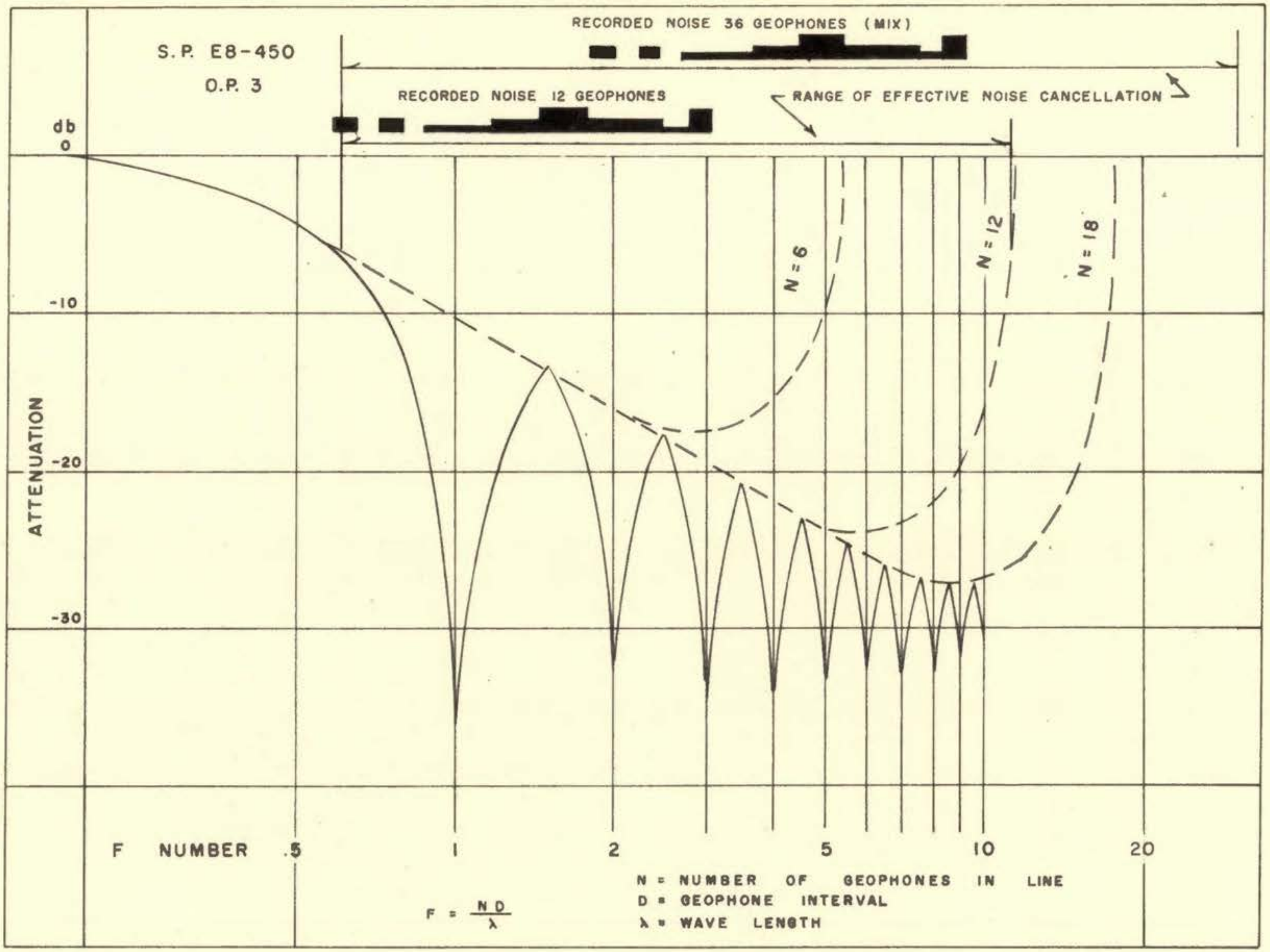

RECORDED NOISE 36 GEOPHONES (MIX)
S.P. E8-450
O.P. 3
RECORDED NOISE 12 GEOPHONES
RANGE OF EFFECTIVE NOISE CANCELLATION
db
0
-10
-20
-30
ATTENUATION
N = 6
N = 12
N = 18
F NUMBER .5
1
2
5
10
20
N = NUMBER OF GEOPHONES IN LINE
D = GEOPHONE INTERVAL
λ = WAVE LENGTH
F = ND/λ

Fig. 5

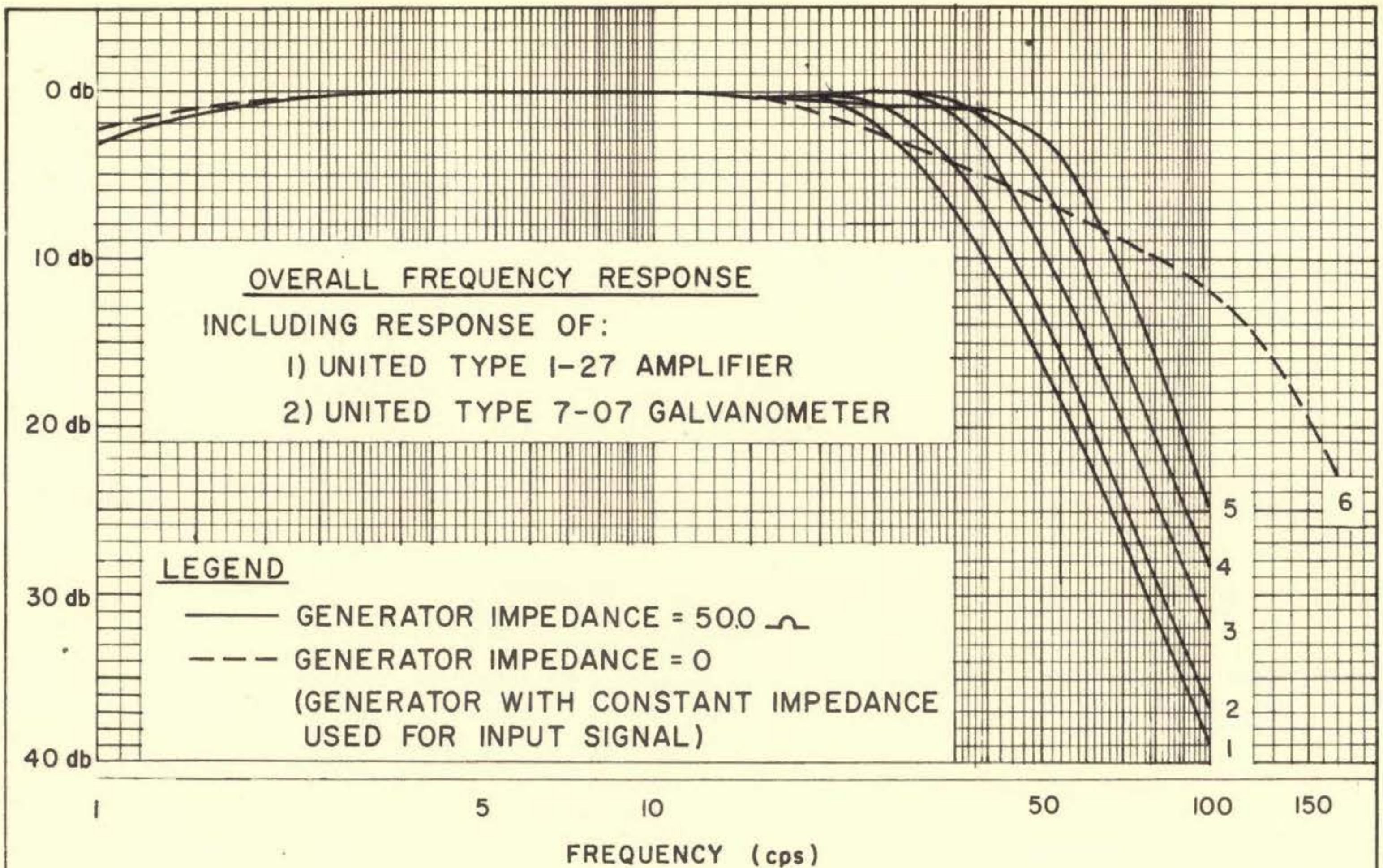


Fig. 3

FREQUENCY RESPONSE CURVES FOR

UNITED 1-27 REFRACTION AMPLIFIER

Mechanic	R. Ashton
Cook	E.H.R. Lake

Sixteen additional men were employed. This was a continuous operation: the number of men in the field at any given time was 23, the remainder being on rest leave.

CAMP

All operations were conducted from a portable camp which was moved twice in order to keep driving time between the camp and the field party to a minimum. The camp consisted of the following:

1 Kitchen caravan, completely outfitted

1 Office caravan

1 Shower caravan

1 Water supply trailer

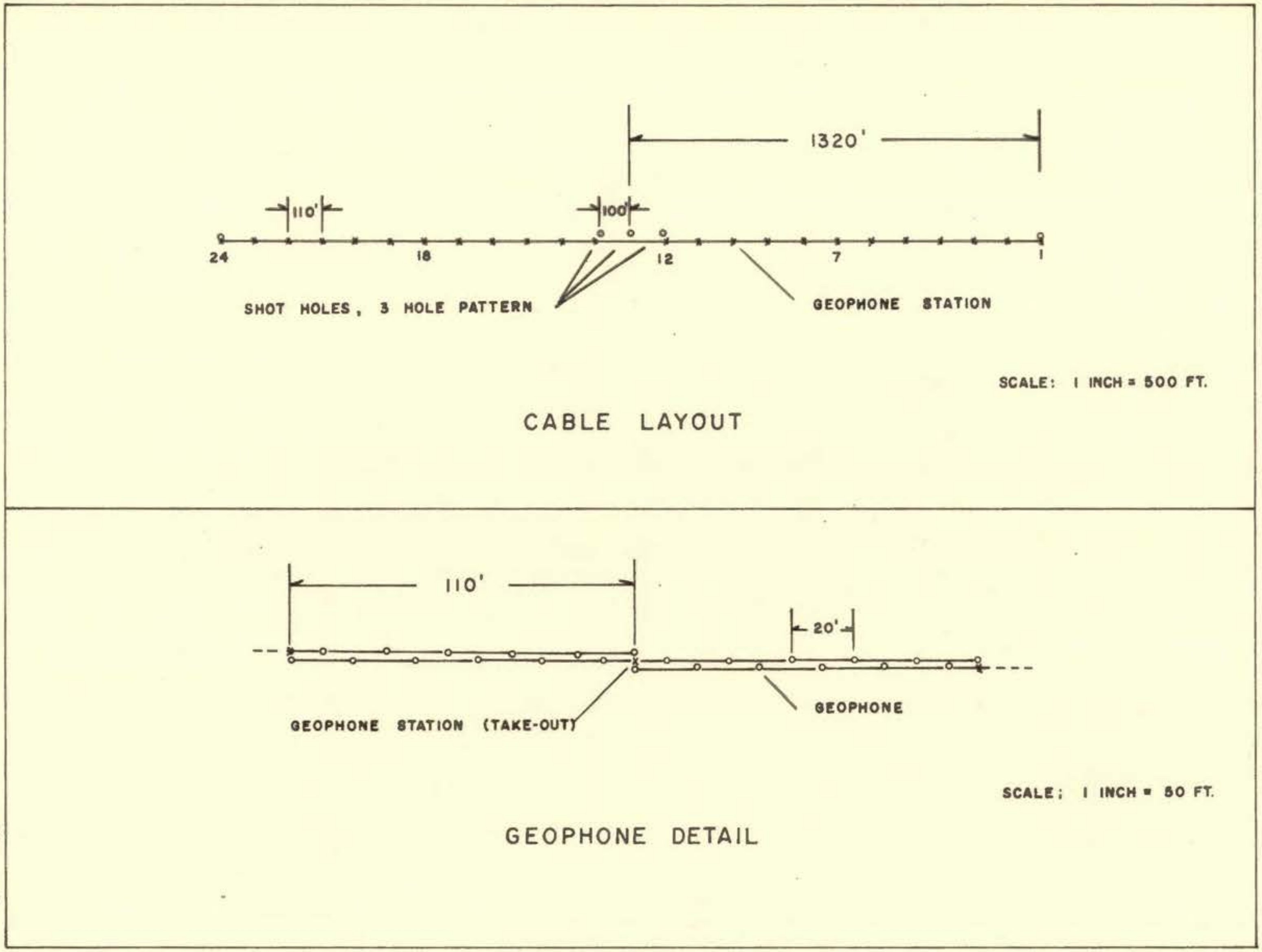
1 Large screened canvas dining tent

12 12 foot by 12 foot canvas sleeping tents

1 15 KW Diesel generator for electricity

OPERATIONAL DATA

1. Survey Control: Vertical and horizontal control was based on the following shot points of the survey conducted by General Geophysical in 1962: Line EC,



1320'
110'
100'
24
18
12
7
1
SHOT HOLES, 3 HOLE PATTERN
GEOPHONE STATION
SCALE: 1 INCH = 500 FT.
CABLE LAYOUT
110'
20'
GEOPHONE STATION (TAKE-OUT)
GEOPHONE
SCALE; 1 INCH = 50 FT.
GEOPHONE DETAIL

Fig. 2

S.P. 45; Line ND, S.P. 5; S.P.'s 0, 20 and 26 on Line NB. As noted in the Ninbing-Burt Seismograph Survey Part I, all reduced levels in this survey are approximately 57 feet high. Horizontal distances were measured with a surveyor's chain and checked with stadia reading.

Every fifth shot point was marked by a steel fence post to which an aluminium identification tag was attached.

2. <u>Drilling</u>: Two Mayhew "1000" shot hole drills equipped for water drilling, air drilling, or air drilling with water injection were used. Throughout most of the area, drilling presented no difficulties and the drills proved to be adequately powered for the type of work required of them. Most of the drilling was done with air but it was necessary to drill several holes with water. To cover this eventuality one water truck was assigned to each drill.

A total of 19½ hours were lost in making minor repairs to the drills and water trucks. These repairs were scheduled so as not to delay the recording operations.

3. <u>Shooting and Recording</u>: A. <u>Refraction</u>

ELI refraction geophones were used in conjunction with United 1-27 refraction amplifiers and a United

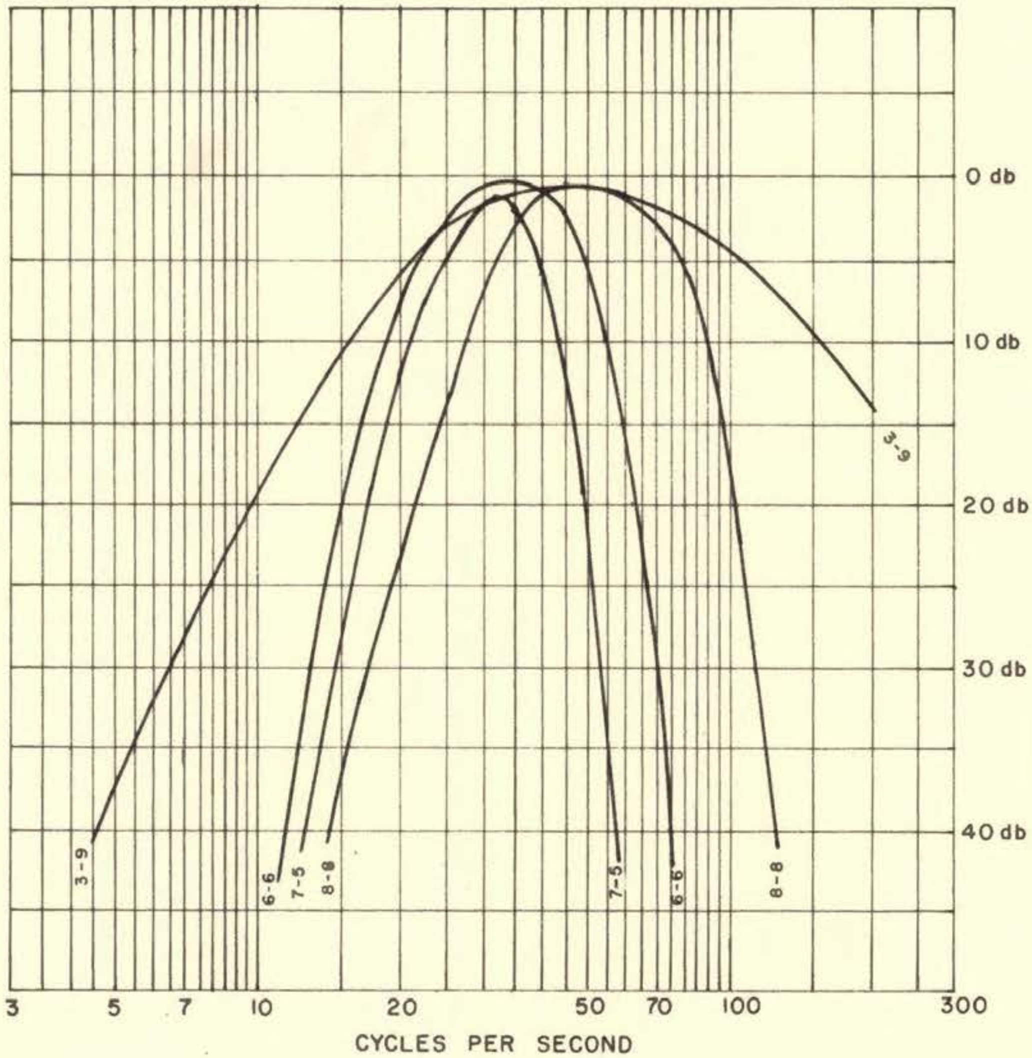
Model 5-30 camera. AWA frequency modulation radio transceivers with truck mounted 50 foot telescopic antennas, were used for communications purposes and to give time break and uphole signals.

An ammonium nitrate-fuel oil mixture primed with high velocity dynamite was used for all except the smallest charges. Since the ammonium nitrate (Anfo-X) must remain absolutely dry, and most holes contained some water at varying depths, only relatively shallow shot holes were used. The use of shallow holes made necessary an increase in the size of charge required but the overall explosive costs remained lower than if all-dymamite charges had been used.

Eighteen geophone positions per spread were used in most cases, with a spacing of 600 feet between geophones. With a single geophone position overlap between spreads, this resulted in a total spread length of 10,200 feet. A single ELI geophone was used at each position.

The lowest available filter setting (F-1) was used for the regular refraction shots.

Four hours of operating time were lost due to strong winds giving an adverse signal to noise ratio.



FREQUENCY RESPONSE CURVES OF SELECTED FILTERS FOR

UNITED I-38 REFLECTION AMPLIFIERS

Fig. 4

B. Reflection

On the first reflection line (Line E-8) of this survey, a Carter set of instruments was employed. On all subsequent reflection lines, United 1-38 frequency modulation amplifiers with a United Model 5-30E camera and United magnetic tape transport were used.

All recordings were made "wide band" using a 28-56 cps playback filter on the Carter instruments. With the 1-38 amplifiers a 3-9 (18-110 cps) recording filter was used. Interpretation was from playbacks with 40 per cent mix and the 6-6 (21-51 cps) filter.

Twelve Hall-Sears HSJ geophones laid "in-line" at 20 foot intervals were employed at each reflection geophone position. The interval between geophone positions was 110 feet; this gave a spread length of 1320 feet.

The majority of records were shot with a single charge of 20 pounds but a considerable number were shot with three hole patterns using charges of 5 pounds in each hole. The patterns were "in-line" with intervals of 100 feet between shot holes.

A noise analysis was shot at S.P. E8-450. The results indicated that 12 geophones per trace gave only 6 db. of attenuation for the longer wavelengths.

For 36 geophones per trace (12 on the ground plus bi-lateral mixing) at least 15 db. of attenuation was noted for all the coherent noise it was possible to measure. The noise study showed frequencies ranging from 30 to 53 cycles per second, which indicated that attenuation by means of filtering was impractical. Considerable additional random noise was evident. The general quality of field records indicated that, despite the attenuation achieved by the geophone pattern, considerable additional multiplicity was needed.

There was no lost operating time during the reflection program.

COMPUTATION PROCEDURE

A. Refraction: As both refraction lines (Lines E and F) were also detailed by reflection shooting, separate weathering spreads were not shot. The geophone corrections were taken as interpolated values of the nearest reflection shot point t_g's. The shot point corrections for shots below the base of the weathering were calculated using the shot to datum distance and a velocity of 9,000 ft/sec. For shots in the weathering, a weathering velocity of 2,250 ft/sec. was used to correct for the travel path from shot to the base of the weathering. To this was added the correction from the base of the low velocity layer to the datum, calculated using the 9,000 ft/sec. velocity. The depth to the base of the weathering was calculated from the shot depths and uphole times of the relevant refraction shot point.

Slotnick's method was used in interpreting the results of the refraction profiles. This method, which is largely graphical, is explained in detail in Geophysics; Vol. XV, No. 2, April 1950 (M.M. Slotnick; "A Graphical Method for the Interpretation of Refraction Profile Data"). Having taken into consideration the dip of the refractors and the lack of good velocity control for the area, this was felt to be the best applicable interpretation method.

B. Reflection; Standard uphole computing methods were used to correct records to a sea level datum. A weathering correction was not applied as the hole depth generally ensured that the shot was below the weathered layer. A velocity of 9,000 ft/sec. was used as the sub-weathering velocity.

INTERPRETATION OF RESULTS

A. Refraction. Line E. Only shallow refraction information was obtained along this line. It is possible that high velocity intrusive material is masking the deeper refractors. The very shallow refractors show a southeast component of dip near the northwest end of the line, a northwest component of dip over the central portion of the line, and no dip on the southeast part of the line. Between S.P.'s 14 and 15 there is a fault of undetermined magnitude with downthrow to the southeast. Southeast of S.P. 15 there is a small section of high velocity material apparently at shallow depth which, however, was not completely evaluated by this shooting programme. Northwest from the fault, between S.P.'s 14 and 15, there is a high velocity (18,700 ft/sec.) refractor which dips (northwest component of dip) from -200 feet to -2,800 feet in the vicinity of geophone position No. 38. Northwest of geophone position No. 38 this refractor drops into a graben bounded on the northwest at geophone position No. 25 by a fault with about 1,600 feet of throw. From this fault northwestward to the end of the line the high velocity refractor has a northwest component of dip with possibly a fault, downthrown to the northwest, near S.P. 11.

The results of the refraction shooting agrees well with the reflection shooting along the same line. The reflection seismograms record events arriving much later than could be expected from the deepest recorded refractors.

Line F. There are two faults along this line, one between S.P.'s 12 and 13 and another two miles further to the southeast. The shallow refractors all have a northwest component of dip and range down to 2,000 feet below sea level. On the southeast half of this line the 18,900 ft/sec. refractor averages 4,200 feet below sea level.

On the northwestern portion of this line a peculiarity exists with regard to the high velocity refractor. On the shot out of S.P. 15 the apparent velocity changes from 15,800 ft/sec. to 18,400 ft/sec. near S.P. 11. On the shot out of S.P. 13 the apparent velocity changes from 12,600 ft/sec. to 18,400 ft/sec. also near S.P. 11. This would seem to indicate that the refractor of 15,800 ft/sec. apparent velocity was skipped over on the shorter shot. One explanation for this phenomenon is that the interface between the refractors of 12,600 ft/sec. and 15,800 ft/sec. apparent velocities is either at the same depth or below the top of an intrusion of material with an apparent velocity of 18,400 ft/sec. Thus on the long shot the 15,800 ft/sec. velocity was picked up in an area where the intrusive material was absent, but on the short shot the intrusion masked the medium velocity.

Another possible interpretation for this segment of line is that the 12,900/15,800 ft/sec. interface dips steeply toward the west between S.P.'s 12 and 13. In such a case, the component of dip along Line F for this interface would be of the order of 20 degrees. The reflection records in this area do not substantiate such steep dip although, admittedly, the reflection data in the area is rather poor.

A. Reflection. The results of the reflection shooting are presented in the form of plotted cross sections, variable area sections and a sub-surface time contour map. The interpretation was based on paper playbacks and the mapped horizon was plotted on the variable area sections.

The mapped horizon is denoted as "Horizon A". The information obtained from the Spirit Hill Well No. 1 suggests that the horizon occurs within the Lower Carboniferous section..

Record quality varied from good to very poor, with poor continuity at all levels.

At the eastern side of the prospect Horizon "A" dips to the west, away from the Cockatoo Fault. (Not shown on the map, but is just to the east of the surveyed area.) There are also two faults in this area which accelerate this dropping off. There is a small "high" between these faults at the intersection of Lines E-11 and NB, but there is no positive evidence of closure to the east.

East of the Spirit Hill Well No. 1 there is a fault which, in conjunction with the Cockatoo Fault, forms a graben in the southeast corner of the area surveyed. The upthrown block of the western side of the graben, and closer to the Spirit Hill Well No. 1, contains a "high" butting against this fault. The present survey did not extend far enough to the south to establish whether closure also exists in that direction.

Northeast of the Spirit Hill well there is another "high" along Line N-6 between Lines E-10 and E-11 with east closure against the fault. This feature is apparently also present in the deeper formations. There is fair evidence that this is part of a "high" trend which continues northward into the adjoining O.P. 2 area.

Near the western edge of the area surveyed there is a graben with steady southwest dip along its axis. Strangely, the upthrown block forming the northwest boundary of this graben dips to the northeast, in the opposite direction to that of the bottom of the graben. Horizon "A" continues to rise to the southwest of this upthrown block which extends also into Western Australia. It is quite likely that the block is associated with the Pincombe Range Precambrian high which outcrops to the southwest in Western Australia.

CONCLUSIONS AND RECOMMENDATIONS

The results of the seismic program indicate that the "high" on Line N-6 between Lines E-10 and E-11 has the best prospects of forming a petroleum trap. The two other most likely locations, near the Spirit Hill Well No. 1 and at the intersection of Lines E-11 and NB, would require further detailing to assure that closure exists in all directions.

The area south of the Spirit Hill Well. No. 1 warrants further investigation.

The refraction method gave only shallow information; this is apparently due to the presence of high velocity intrusives in this area. The reflection and refraction data were compatible. It appears that the high velocity material was intruded along a plane of weakness between two distinct formations. The high velocity layer would naturally also hinder any reflection energy. The noise level generated by conventional shooting techniques is not excessive in this area but, since the energy level is for several reasons very low, the energy to noise ratio is very low. The energy is low due to poor energy transmitting layers at the shot point and geophones, the presence of the intermediate high velocity layer, and the probable lack of other strong velocity interfaces to act as reflectors.

Any further seismic work in this area should rely mainly on the reflection method. Much higher multiplicity either in the form of more geophones, more shot holes, common depth point techniques or any combinations of these should be used in any future work.

Respectfully submitted,

T.J. Greer

T.J.Greer,
Party Chief.

H.D.Gray

H.D.Gray,
Supervisor.

Brisbane, Queensland
31 January 1964

UNITED GEOPHYSICAL

SUMMARY OF STATISTICS

	Refraction	Reflection	Total
Recorders:			
Driving Time (hours)	17.5	59	76.5
Standby Time (hours)	3.5	3.5	7
Field Time (hours)	75.8	225.7	301.5
Total Time (hours)	96.8	288.2	385
Number of Profiles	54	259	313
Number of Shots	56	301	357
Average Depth of Charges (feet)	28	73	-
Dynamite Used	4,905	6,542	11,447
Ammonium Nitrate Used (lbs.)	19,915	-	19,915
Detonators Used	345	749	1,094
Sub-Surface Coverage (ft.)	112,208 (surface)	343,262	-

Drills:

No. 1564	
Driving Time (hours)	63.7
Standby Time (hours)	5
Field Time (hours)	290.8
Total Time (hours)	359.5
Number of Holes	472
Footage Drilled	21,494
Footage per Drilling Hour	74.0
Footage per Total Hour	59.8

Drill No. 1565	
Driving Time (hours)	80.5
Standby Time (hours)	4
Field Time (hours)	319
Total Time (hours)	403.5
Number of Holes	457
Footage Drilled	24,481
Footage per Drilling Hour	76.8
Footage per Total Hour	60.7

Materials Used:

Insert Bits	124
Rock Bits	30

Bulldozer:

Total Hours	505

General:	Refraction	Reflection	Total
10 Hour Working Days	9.675	28.825	38.5
Profiles per Day	5.6	9.0	8.1
Dynamite per Profile (lbs.)	91.0	25.2	-
Dynamite per Shot (lbs.)	87.6	21.7	-
Anfo-X per Profile (lbs.)	369	-	-
Anfo-X per Shot (lbs.)	356	-	-

REFERENCES

McWHAE, J.R.H.; PLAYFORD, P.E.; LINDNER, A.W.; GLENISTER, B.F.; BALME, B.E.	The Stratigraphy of Western Australia.
NETTLETON, L.L.	Geophysical Prospecting for Oil.
ROBERTSON, C.S.	Preliminary Report on a Seismic Survey in the Bonaparte Gulf Area (1956).
SLOTNICK, M.M.	A Graphical Method for the Interpretation of Refraction Profile Data. <u>Geophysics</u>, Vol. XV, No. 2, April 1950.
SPRIGG, R.C.; DENNISON, R.G.	Report of a Seismic Survey of the Spirit Hill Area, Northern Territory (1960).
TAYLOR, P.	Reinterpretation Report of Reflection Seismic Surveys Spirit Hill Area, O.P. 3 . Northern Territory (1963).
TINLINE, R.J.	Final Report Spirit Hill Seismic Survey (1963).