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FINAL REPORT

BATHURST ISLAND REFRACTION SURVEY

Conducted for

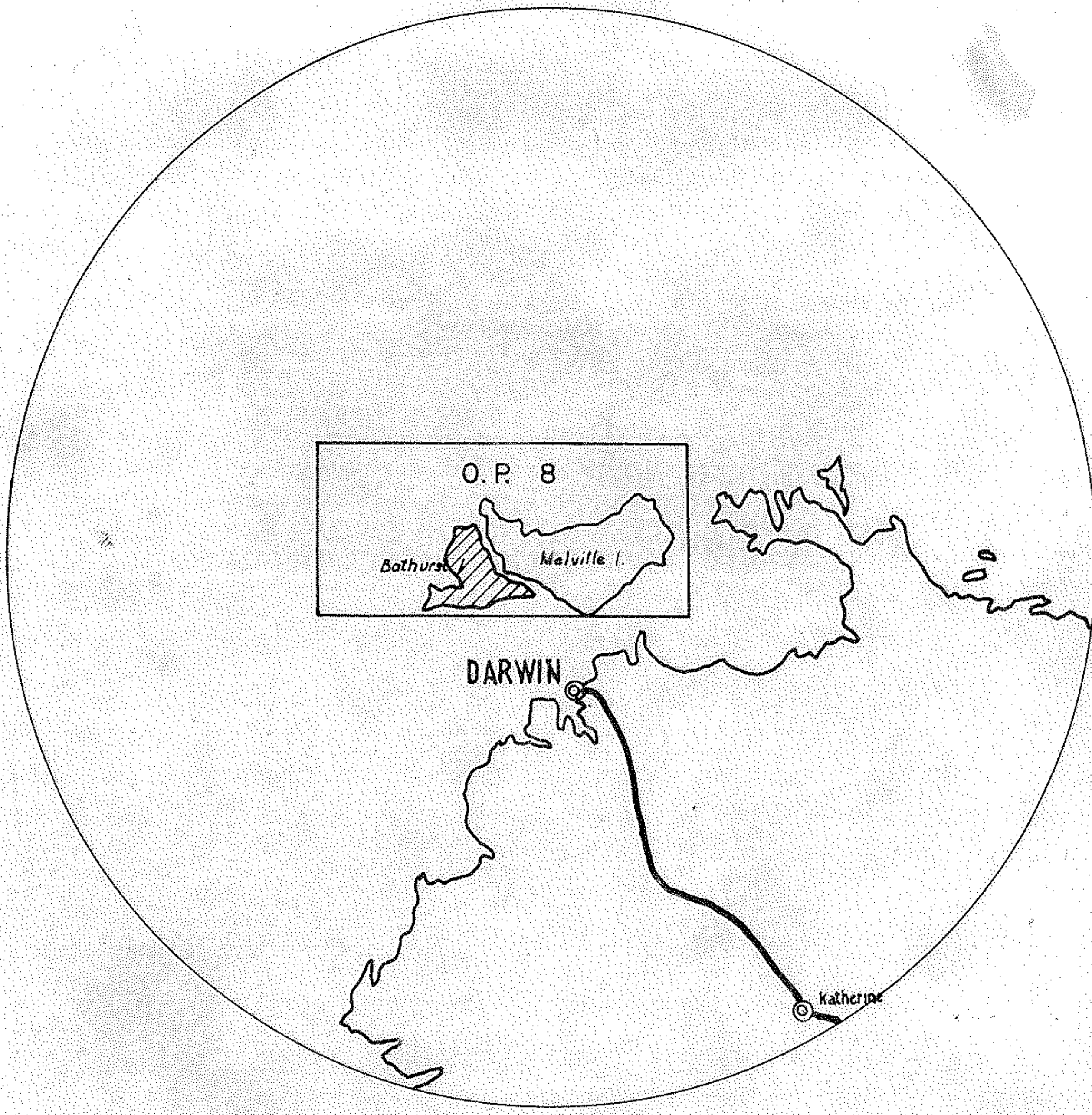
OIL DEVELOPMENT N.L.

By

GENERAL GEOPHYSICAL COMPANY (BAHAMAS) LIMITED

1962

GENERAL GEOPHYSICAL COMPANY



SURVEYED AREA

LOCATION PLAT

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PLATE I

GENERAL GEOPHYSICAL COMPANY

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OBJECTIVE OF SURVEY.

The purpose of the proposed survey is to determine the depth to basement and the regional gradient of the surface of the basement rocks with the object of delineating the thickest section of prospective sediments on the island for reflection seismic survey.

LOCATION.

Bathurst Island lies about 50 miles offshore north westerly from Darwin, Northern Territory. It is contained approximately by latitudes 11° 20' S. to 11° 50' S. and longitudes 130° 02' E. to 130° 38' E.

TOPOGRAPHY, VEGETATION AND CLIMATE.

There was a fair range of elevations from a minimum of 16 ft. to a maximum of 250ft. above sea level in the locations surveyed. Most of the island is of a flat or gently inclining nature but there are a few rather steep slopes.

The vegetation while of a tropical nature is not really dense jungle. Except for the occurrence of a few open savannahs, it is mostly tree covered. The trees are usually of the eucalyptus variety but there are also some palms.

There are no roads as such, but on the south part of the island there are a few trails wide enough for vehicles to travel.

While the survey took place during the winter season, and there was very little precipitation, several small streams were encountered.

EQUIPMENT.

Vehicles:

1	International RF-190, 4x4, equipped with a Failing CFD-1 combination air-water drilling machine.
1	International B-160, 4x4, Recording Truck.
2	Dodge Power Wagons, 4x4, Trucks.
2	Landrovers, 4x4, light vehicles.
1	Jeep, 4x4, light vehicle.
1	Gemco Auger Type Drill.
1	Caterpillar D-8 Bulldozer.

EQUIPMENT.

Instruments:

1 set of GENERAL'S RA-5 Refraction Amplifiers, 24 channels.

1 set of GENERAL'S JMH Reflection Amplifiers.

1 Power and Control Unit for use in conjunction with amplifiers.

1 GENERAL Geocord system of magnetic recording.

3 General Electric F.M. Transceivers operating on 71 megacycles.

120 Hall-Sears Refraction Geophones with 4.5 c.p.s. natural frequency.

288 Hall-Sears Reflection Geophones with a natural frequency of 21 c.p.s.

1 set of Portable Refraction Cables (Vector type) comprised of 24 outlets with a maximum spacing of 650 feet between outlets. The maximum overall spread length was 14,950 feet.

1 set of Portable Reflection Cables having 24 outlets with 146 foot intervals and an overall spread length of 3,500 feet.

Personnel:

Ronald J. TINLINE	-	Seismologist.
John S. FIFE	-	Seismologist.
Floyd PRESTENBACK	-	Observer.
Thomas JONES	-	Observer.
Reginald ULMER	-	Party Manager.
Ralph BEVERIDGE	-	Surveyor.
John KEATING	-	Surveyor.
George McKIGNEY	-	Driller Mechanic.

In addition to the key personnel listed, an average of 6 helpers, 2 cooks and 8 native brushcutters were utilized.

GEOLOGY.

Bathurst Island is situated on the projected regional trend of the eastern edge of the Bonaparte Gulf Basin which consists of Palaeozoic and Mesozoic rocks overlying Proterozoic basement rocks.

Prior to this survey the area of Bathurst Island was known to consist essentially of flatly lying marine Cretaceous sediments which outcrop principally along the south coast of the island and are covered elsewhere by up to 100 feet of

GEOLOGY (Continued).

Tertiary continental sands. Two stratigraphic wells had established a thickness of over 1,000 feet of Cretaceous sediments. Samples of these sediments had also been obtained by auger drilling in places all over the island. Biostratigraphic correlation of these auger samples with the sections penetrated in the wells indicated that the degree of folding or faulting of these sediments was very slight.

Earlier reconnaissance gravity surveys had shown a pronounced and steady drop in gradient westward from the centre of the island. A reasonable explanation of these results was to suppose a rapid thickening of sedimentary section in that direction and the possibility of upper Palaeozoic rocks occurring below the Cretaceous rocks.

The two continuously cored stratigraphic wells both penetrated an extremely uniform section consisting chiefly of mudstone. The refraction profiles all showed only two strongly contrasting velocities. The small variations in the lower velocity indicate a uniform sedimentary refractor - and so conform to the Cretaceous section. The variations in the higher velocity refractor are typical of those expected in Proterozoic rocks. No intermediate velocity corresponding to upper Palaeozoic rocks was recorded.

The refraction results indicate a homogeneous section of marine Cretaceous sediments directly overlying Proterozoic basement rocks. The basement surface has a gentle dip in a north-westerly direction and lies at a depth of from 1,160 feet to 2,980 feet below sea level.

FIELD PROCEDURES.

Surveying:

The survey party normally consisted of two surveyors and two helpers who served as both rodmen and chainmen. At times, additional natives were employed as brush cutters.

All horizontal measurements were established through the use of a surveyor's steel tape calibrated in feet. All such measurements were checked through the use of stadia observations.

All angles, both horizontal and vertical, were measured using either a Watt's Self Levelling Level or a Watt's Theodolite.

All elevations were established using the same instruments. Since no elevation control was available on Bathurst Island, the high tide mark was used as a sea level datum.

Horizontal control was established in relation to existing "Trig" stations located on the island. In addition, solar and astral observations were employed to

FIELD PROCEDURES.

Surveying (Continued):

determine the location and bearing of some of the profiles.

As closed loops did not exist, all elevations and distance measurements were double run to lessen the possibility of error except in the limited zones where base control was available at both ends of the traverses.

A bulldozer was used to establish traverses in the areas where heavy tree cover was encountered.

Drilling:

The drilling crew normally consisted of a driller and one helper.

All the shot holes were drilled using a CFD-1 combination air-water drilling machine mounted on an International RF-190, 4x4, vehicle. Due to the shortage of water near shot point locations, all holes were drilled using the air blast method of rotary drilling. Skidmore-Crooks, insert type drag bits, $4\frac{3}{4}$" in diameter, were used exclusively.

Most shot holes were drilled to a depth of twenty feet where the water table was normally encountered. Due to the shallow holes drilled, multiple holes were necessary to accommodate the large charges. Also, the same position was shot several times necessitating additional holes.

Drilling offered no problems as the rate of penetration was good through the near-surface sands and clays.

Bottom hole samples were taken from each shot point and have been submitted along with this report.

Recording-Shooting:

The recording crew consisted of one observer, one shooter, and eight helpers. The cables, segmented for convenience and ease of handling, were laid out by men using breast cable reels in the exact positions established by the surveying crew.

A normal spread consisted of twenty four stations with a station interval of three hundred feet and an overall spread length of 6,900 feet. However, due to varying conditions, the station intervals were altered to suit the specific needs. A minimum of two stations on adjacent spreads were made common as a check on the timing of the individual records. At each outlet, a group of five Hall-Sears seismometers with a natural frequency response of 4.5 c.p.s., connected in series, were laid out at right angles to the spread. The intervals between geophones were fifteen feet. A diagram of a typical refraction set-up is incorporated in this report.

FIELD PROCEDURES.

Recording - Shooting (Continued):

The recording truck was positioned between stations twelve and thirteen during recording operations. The shooter who was located at the shot point as far as 26,000 feet away maintained contact with the observer through the use of the General Electric FM Transceivers.

The shooter fired the charges with a high voltage blaster upon radioed instructions from the observer. The time breaks were transmitted by radio to be recorded by the recording instruments.

Six inch seismograms were produced incorporating twenty four channels of refracted information, and two channels on which the time breaks were recorded by radio signal and also one channel of 100 c.p.s. information used as a timing check. In addition to the monitor seismograms produced, magnetic recordings were made simultaneously on a standard Techno type tape for future reference and playback.

The recording technique employed was one designed to obtain the optimum first arrivals. With the data recorded on magnetic tapes, they can be played-back to observe later arrival times.

A filter setting of 1.80 - 18.75 was used on the General RA-5 refraction amplifiers. The response curves of these amplifiers are incorporated herewith.

The charge size varied considerably over the project due to the great variances in distances and the differences in energy response encountered. A minimum charge of $2\frac{1}{2}$ pounds and a maximum charge of 450 pounds were used in this project. The explosives used were Geophex gelatin packed in $2\frac{1}{2}$" x 5 pound units.

COMPUTING PROCEDURE.

Time - Distance Plots:

The arrival times as read from the individual records are corrected to a datum of sea level. The elevation correction velocity chosen is the velocity of the proposed Cretaceous section which on the first velocity profile was approximately 6,000 ft./sec. The elevation of the shot point and that of each geophone station was known. Since the depth of the bottom of the hole was also known, the elevation correction was made for the shot and for the geophone. The arrival time adjusted by these amounts produces a corrected time (T_{RC}) for each detector station. Strictly speaking it is not entirely proper to correct only for elevation. If there were marked differences in depth of the near surface material it would be necessary to make a weathering correction. Since, however, this layer is comparatively thin, no appreciable error is introduced by this simplification. The corrected times are plotted versus the distance for each detector and this is done for the energy travelling in both directions. Best fit straight lines are ruled for each directional plot. The average of respective apparent velocities from each direction

Time - Distance Plots (Continued):

gives a good approximation of the true velocity. When there is little dip the depths for each stratigraphic layer are computed as follows:

$$t_1 = \frac{T_1}{2 \cos i} \quad \text{and} \quad d_1 = V_1 t_1$$

$$t_2 = \frac{T_2 - T_1}{2 \cos i_2} \quad \text{and} \quad d_2 = V_2 t_2$$

where the symbols used have the following significance:

T_1 = first intercept on T-D plot.

T_2 = second intercept on T-D plot.

t_1 = vertical time through first layer.

t_2 = vertical time through second layer.

i = critical angle for interface between V_1 and V_2.

d_1 = depth of first layer.

d_2 = depth of second layer.

V_1 = velocity of first layer.

V_2 = velocity of second layer.

Intercept Plots:

The values T_{RC} for each geophone station are subjected to a distance correction X/V_R where X is the detector distance from the shot and V_R is the refractor velocity chosen. This gives the intercept for each trace as:

$$I = T_{RC} - \frac{X}{V_R}$$

These intercept times are plotted on a new cross section. By having different time scale origins for energy in opposite directions, two separated series of points are produced. These points are then migrated at the computed distance of the "offset". This again produces a series of points for energy in each direction. For the portion of the plots with common sub-surface coverage, a new set of points is established exactly half way between the two offset intercept curves. A smooth curve drawn

COMPUTING PROCEDURE.

Intercept Plots (Continued):

through these points is called the average intercept curve (AIC). The time separation between the two offset intercept curves for the portion of common coverage is plotted versus each geophone offset position. A best fit straight line is drawn through these points. The establishment of further AIC points is made possible by the projection of this line in each direction. Through these new points a smooth curve is drawn in continuation of the original AIC. From these various plots the delay times and subsequently the depths for selected points may be computed.

Sample Computation:

Time-Distance Plot:

Using data from Velocity Profile No. 2 -

S.P. 9		
T_1	=	.015
T_2	=	.625
V_1	=	2000ft./sec.(Est.)
V_2	=	6470 ft./sec.
V_3	=	19,200 ft./sec.

ave V_2	=	6400ft./sec.
ave V_3	=	19000ft./sec.
sin i	=	$\frac{2000}{6400}$ = .312
2 cos i	=	1.90
sin i_2	=	$\frac{6400}{19000}$ = .337
2 cos i_2	=	1.88

S.P. 6		
T_1	=	.029
T_2		.619
V_1	=	2000ft./sec.(Est.)
V_2	=	6330 ft./sec.
V_3	=	18,800 ft./sec.

S.P. 9:

$$t_1 = \frac{.015}{1.90} = .008$$

$$d_1 = .008 \times 2000 = 16 \text{ ft.}$$

$$t_2 = \frac{.625 - .015}{1.88} = .325 \text{ sec.}$$

$$d_2 = V_2 t_2 = 2077 \text{ ft.}$$

$$d_1 + d_2 = 2077 + 16 = 2093 \text{ ft.}$$

S.P. 6:

$$t_1 = \frac{.029}{1.90} = .015$$

$$d_1 = V_1 t_1 = 31 \text{ ft.}$$

$$t_2 = \frac{.619 - .029}{1.88} = .314 \text{ sec.}$$

$$d_2 = .314 \times 6400 = 2009 \text{ ft.}$$

$$d_1 + d_2 = 2010 + 30 = 2040 \text{ ft.}$$

Thus elevation of base of Cretaceous is 2,093 ft. below sea level at S.P. 9 and 2,040 ft. below sea level at S.P. 6.

COMPUTING PROCEDURE.

Time-Distance Plot (Continued):

The depth of Tertiary calculation suffers in accuracy by this method. To accurately compute its depth it is necessary to replace the amount of correction that was made for elevation. As this correction was made for both detector and shot end, and as the intercept is at zero distance, it is necessary to add back both the correction for elevation of shot and for elevation of surface plus up-hole time.

For S.P. 9	For S.P. 6
Add Back .003 + 000 + .015 = .018	Add Back .009 + .006 + .015 = .030
$t_1 = \frac{.015 + .018}{1.90} = \frac{.033}{1.90} = .017$	$t_1 = \frac{.029 + .30}{1.90} = \frac{.059}{1.90} = .031$
$d_1 = V_1 t_1 = 35$ ft.	$d_1 = V_1 t_1 = 61$ ft.

Since, however, the depths involved are so small, the error introduced in the computation of total section is not significant and this calculation is not included in the evaluation of it.

Intercept Plot Calculation:

Intercept 9E shot to 6W is .589

Intercept 6W shot to 9E is .598

Average intercept is .594

Arbitrary time 9E is .080 sec. (from A.I.C.)

Arbitrary time 6W is .079 sec. (from A.I.C.)

DIP = .001 sec. (Neglect dip for such a small quantity. As there is no appreciable dip, the delay times are equal at each end).

$\therefore$ Delay time $= \frac{.594}{2} = .297$

Full Separation at 9E	=	.094
Full Separation at 6W	=	.145
Separation Difference	=	.051
Half Separation Difference	=	.026

By the plotting convention used this shows divergence to the right, i.e. from 9E to 6W. Therefore intercept must be increased by .026.

Corrected intercept = .594 + .026 = .620

$\therefore$ Corrected delay time at both 9E and 6W = .310

COMPUTING PROCEDURE.

Intercept Plot Calculation (Continued):

But arbitrary time was .080, so adding .230 to arbitrary time gives delay time (D_t) for any point on AIC.

Thus at S.P. 6 -

AIC = .078 which is a D_t = .230 + .078 = .308

and at S.P. 9 -

AIC = .082 (Est.) which is a D_t = .230 + .082 = .312

Depth is given by:

$$d = \frac{D_t \times V_2}{\cos i_2} \quad \text{and} \quad \sin i_2 = \frac{6{,}400}{19{,}000} = .337$$

At S.P. 6

$$d = \frac{.308 \times 6400}{.942} = 2090$$

At S.P. 9

$$d = \frac{.312 \times 6400}{.942} = 2120$$

RESULTS.

Profile	S.P.	Elev.	Apparent Velocity		True Velocity		Elevation of Base of Cretaceous Below Sea Level	
			Cretaceous	Proterozoic	Cretaceous	Proterozoic	By T-D Plots.	By Intercept
1	1	+ 214	6,075 ft./sec.	18,420 ft./sec.	6,100	18,400	1,690	1,610 Est.
1	5	69	6,060	18,440			1,630	1,640 Est.
2	6	57	6,330	18,800	6,400	19,000	2,040	2,070
2	9	18	6,475	19,200			2,090	2,120 Est.

RESULTS (Continued):

Profile	S.P.	Elev.	Apparent Velocity		True Velocity		Elevation of Base of Cretaceous Below Sea Level	
			Cretaceous	Proterozoic	Cretaceous	Proterozoic	By T-D Plots.	By Intercepts
3	10	51	6,030	19,400	6,100	19,800	1,850	1,890
3	13	71	6,170	20,200			1,990	2,050
4	14	33	6,440	17,230	6,400	17,300	2,940	2,960
4	17	22	6,320	17,290			2,960	2,980
5	18	13	6,350	17,450	6,300	17,400	1,260	1,260
5	21	72	6,220	17,340			1,330	1,290
The following results were obtained by velocity profile extensions:								
1	24	180.5	6,140	19,500	6,100	19,000	1,560	1,470
4	23	35.0	6,470	17,600	6,400	17,300	2,570	2,470
5	22	142.0	6,170	17,700	6,300	17,400	1,270	1,160

DISCUSSION OF RESULTS.

The unconsolidated near surface material is presumably Tertiary. It varies in thickness from 40 ft. to 70 ft. over the 5 locations surveyed. This thickness calculation assumes a velocity of 2,000 ft./sec. The velocity of the next stratum varies from 6,100 to 6,400 ft. per sec. This section has been tentatively identified as Cretaceous. Below this a velocity ranging from 17,300 to 19,800 ft./sec. is encountered. This refractor we believe is of Proterozoic origin. The changes in velocity encountered are considered to represent lithologic changes both in the Cretaceous and the Proterozoic. Reference to the data will show that there is a minimum section of 1,160 ft. at Velocity Profile 5 increasing to a maximum section of 2,980 ft. at Velocity Profile 4. This dip occurs northwesterly over a distance of about 30 miles or at the average rate of about 60 ft. per mile. The westerly dip from Velocity Profile 5 to Velocity Profile 3 is even more gentle being at the rate of about 20 ft. per mile.

In this widely scattered reconnaissance type of program, no interesting features were encountered. There is a possibility that a fault occurs on Profile 1, Spread 1 - 2, 2,000-2,400 ft. from S.P. 1. This feature while it may not be a fault does represent, nevertheless, a sharp dip change on the refractor.

Two methods of determining the "offset" distance for intercept plots were

DISCUSSION OF RESULTS (Continued):

used. In this area the absence of any outstanding features makes it difficult to match the two ground position plots for offset distance. However, we benefit from the following information:

(1) the time distance plots give the actual V_R (refractor correction velocity) which occurs at each velocity profile;

(2) the stratigraphic section appears rather simple as shown by the limited number of velocities. Thus the computation of the theoretical value of the offset is quite easy and very likely the best possible estimate. This is advantageous since the velocity profile gives a limited amount of common coverage and consequently a limited opportunity to match anomalies or interruptions in the intercept plot. The apparent simplicity of the section also indicates that depth calculations may be considered quite reliable.

Certain differences occur between depth computations by the two methods. These may be attributed to the fact that the time-distance depth values result from an overall average velocity line while those from intercept method result from individual trace plots. However, these differences are not more than 110 ft. and so are not significant in the total picture. The mapped depth values are derived from the intercept plot.

Since our program of 5 profiles was not continuous, we cannot say positively that the deep refractor is the same one in all cases. It is, however, in every case the refractor following Cretaceous and is the only one deeper.

When the amplitude of a record is low enough, it may be possible to see events later than the first arrivals. The best opportunity to do this usually has been on records taken at the maximum distance from the shot point. Playbacks of these records were inspected to determine if there was any occurrence of a velocity faster than that shown by first arrivals. In no instance was any such true velocity discovered. There were occurrences of velocities of 40,000 ft./sec. but these obviously are not real and must be attributed to some phenomenon such as diffraction. It might here be noted that time-distance plots sometimes do indicate changing apparent velocities for what we propose to be a single refractor. However, as above, the examination of playbacks at maximum distances does not show any subsequent cycle of the first arrival being crossed by any other greater velocity. Therefore, these changes merely indicate an alteration of dip and not a change of refractor. On the same subject the extension of profile 1 to the east produces for the eastbound energy from S.P.5 to spread 1-24 a velocity of 19,500 ft./sec. and for the westbound energy from S.P.24 to spread 4-5 a velocity of 18,400 ft./sec. The reverse times of these two paths, of course, produce a time tie. The velocity of energy from S.P.24 to spread 4-5 is very nearly the same as that of S.P.1 to spread 4-5. Thus, the spread of 4-5 is on the same refractor whether shot from S.P.1 or S.P.24. And since S.P.5 into spread 1-24 must be on the same refractor as S.P. 24 into 4-5, then S.P. 5 into 1-24 must be the same marker as S.P. 5 into 1-2. The change in apparent velocity (18,440 ft./sec. for

DISCUSSION OF RESULTS (Continued):

S.P. 5 into 1-2, 19,500 ft./sec. for S.P. 5 into 1-24) must then be attributed to change in dip for the spread 1-24. Profile 4 shows an apparent velocity of 21,300 ft./sec. for S.P. 17 shot into S.P. 23 but this is preceded by a velocity of 17,340 ft./sec. and succeeded by a velocity of 17,300 ft./sec. so it must be attributed to structure.

While a remote possibility it was considered possible that a greater velocity could occur at depth and that much greater shooting distances are required to record it. However, available information on Pre-Cambrian in Australia indicates that a velocity of 18,000 to 19,000 ft./sec. is confirmation of basement. Another possibility also is that, if we have reached a Proterozoic strata, there is still a Paleozoic section present which is too thin to produce a first arrival under any conditions. Presumably this situation would not be of interest.

The refractor which we tentatively identify as Proterozoic has a range of 17,300 ft./sec. to 19,800 ft./sec. through the various profiles shot. In summary we believe this refractor to be Proterozoic for the following reasons:

(1) the extension of existing profiles as much as 8,000 ft. farther produced no first arrival evidence of a greater velocity;

(2) the examination of later events on playbacks also did not indicate any such velocity.

The accuracy of depths computed by refraction is limited by certain conditions. Obviously if there are a large number of refractors present, the difficulties of interpretation are enhanced. If one or more refractors should occur as thin beds, they may never reveal themselves as first arrivals. Furthermore if a velocity inversion occurred for a bed of any thickness, it would never show as a refraction. In either of these circumstances, computed depths could be quite inaccurate. However, in a simple section with a limited number of refractors and no velocity inversions, depth calculations are quite reliable.

CONCLUSIONS.

The results indicate the maximum depth of section above tentative Proterozoic for any profile is at the north-west end of the island. Here the depth is 2,980 ft. below sea level at S.P. 17. The minimum section measured was at the south-east end of the island where the depth is 1,160 ft. below sea level at S.P. 22. Bearing in mind that only 5 widely separated profiles have been shot, it still would appear that the shallow section indicated offers little encouragement for further exploration.

REFLECTION RESULTS.

A few reflection profiles were shot during the times that the recording crew was held up by line clearance difficulties, to determine if reflection results were obtainable in the area.

REFLECTION RESULTS (Continued):

Very good seismograms were obtained using single charges of approximately 25 pounds at a depth of from 50 to 60 feet. A station interval of 146 feet in conjunction with the use of six to twelve reflection geophones, Hall-Sears 21 c.p.s., produced a good record. Due to the homogeneous nature of the section, the only reflection recorded was from the basement interface. This reflection is very strong and is continuous and correlative over the area surveyed.

A filter setting 13-75 was utilized with various AGC attack times on all records. Extensive experimentation was not conducted due to the secondary nature of the reflection program.

There appear to be multiple returns based on the observation of deep reflected events which occur at definite and regular time intervals and having the same characteristics of the strong reflection from the interface of the basement. However, since this was not a reflection project, no attempt was made to further prove these to be multiples through the completion of an expanded profile as a basis for a T^2 X^2 evaluation. The reflection profiles are included with this report.

Respectfully submitted,

GENERAL GEOPHYSICAL COMPANY
(BAHAMAS) LIMITED

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Seismologist.

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BRISBANE.

12th September, 1962.

REFERENCES AND ACKNOWLEDGMENTS: -

All Geological Information by H.J. NEWTON of R. Hare and Associates.

Refraction Techniques adapted from the following:

C. HEWITT DIX - "Seismic Prospecting for Oil".

L.L. NETTLETON - "Geophysical Prospecting for Oil".

L.W. GARDNER - "Geophysics" 1959.

STATISTICAL DATA

Commencement Date	-	2nd June, 1962.
Termination Date	-	10th July, 1962.
Number of Holes Shot	-	68 Refraction.
	-	6 Reflection.
Number of Miles Shot	-	23.43
Recording Hours	-	233.75
Average Charge Size	-	101.08 Pounds.
Dynamite Used	-	7,480 Pounds.
Average Hole Depth	-	21.25 Feet.
Caps Used	-	254.
Drills	-	1 Failing CFD-1.
	-	1 Gemco.
Holes Drilled	-	261.
Footage	-	5,545 Feet.
Drill Hours	-	126.5
Average Rate of Penetration	-	43.8 feet per hour.
Rock Bits Used	-	None.
Replacement Bits Used	-	1 Set.
Drilling Mud Used	-	None.

FILTER CURVES
TYPE RA - 5 AMPLIFIER

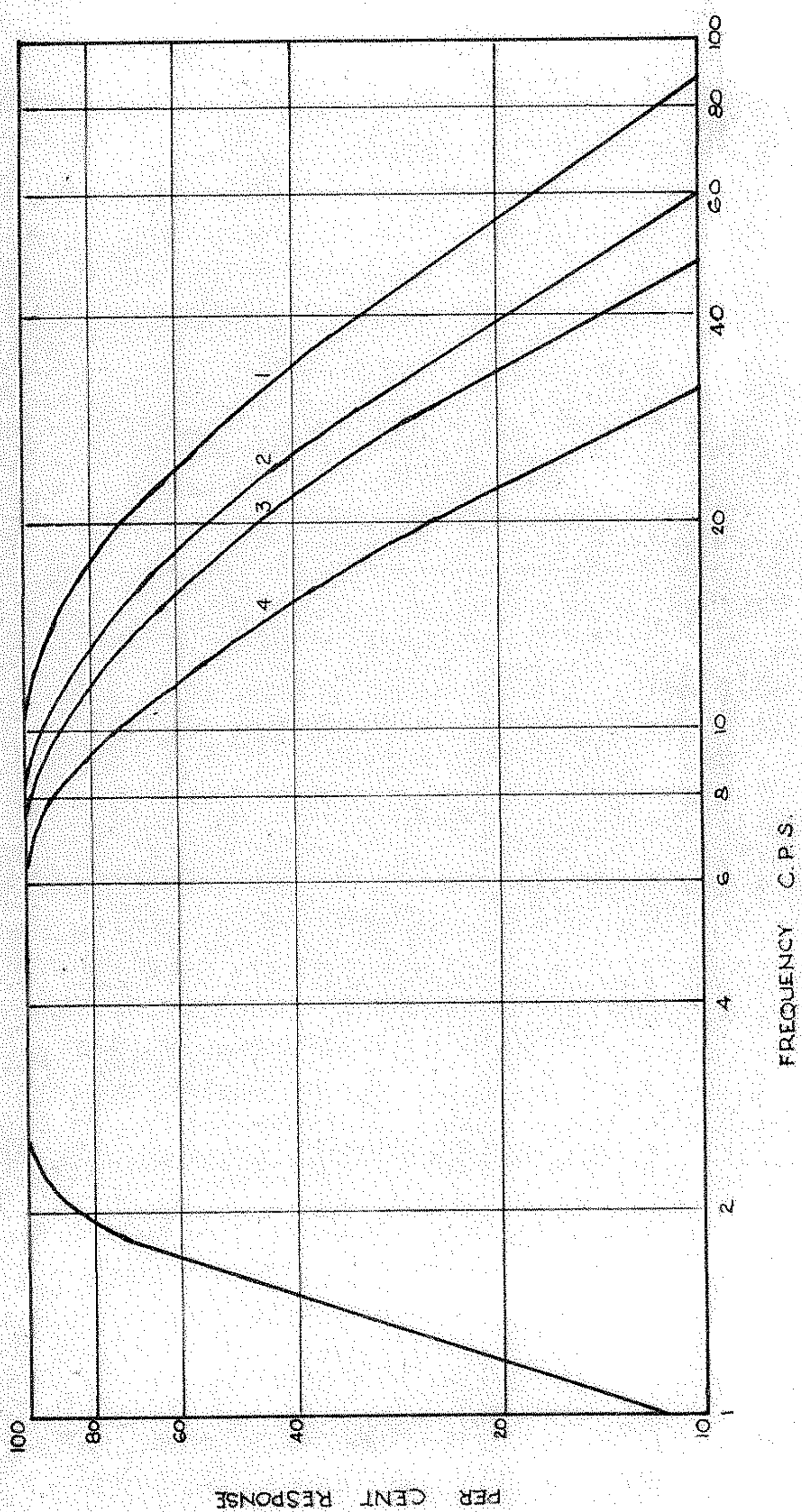
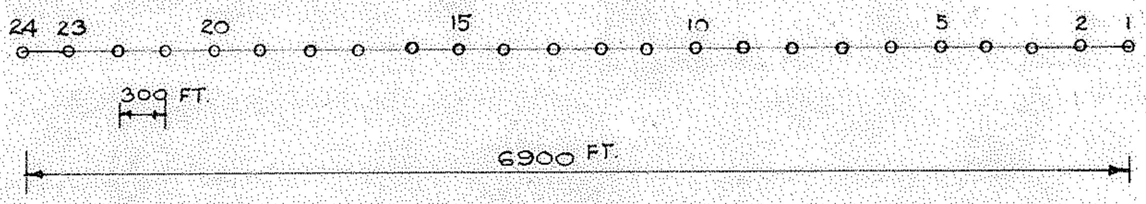
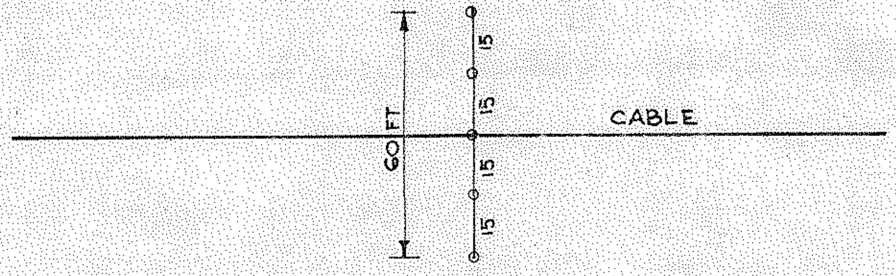


PLATE II

TYPICAL SPREAD LAYOUT



TYPICAL GEOPHONE LAYOUT



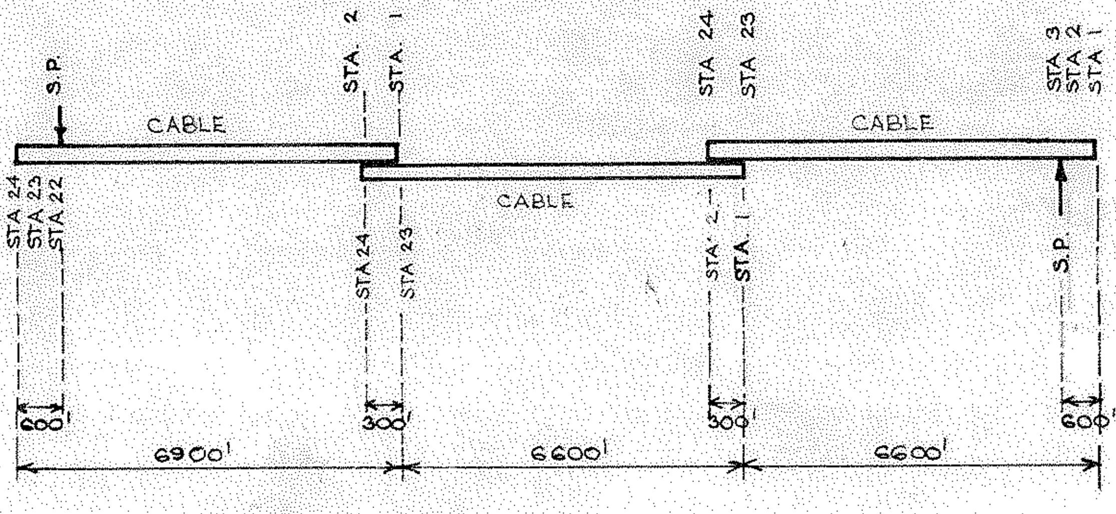
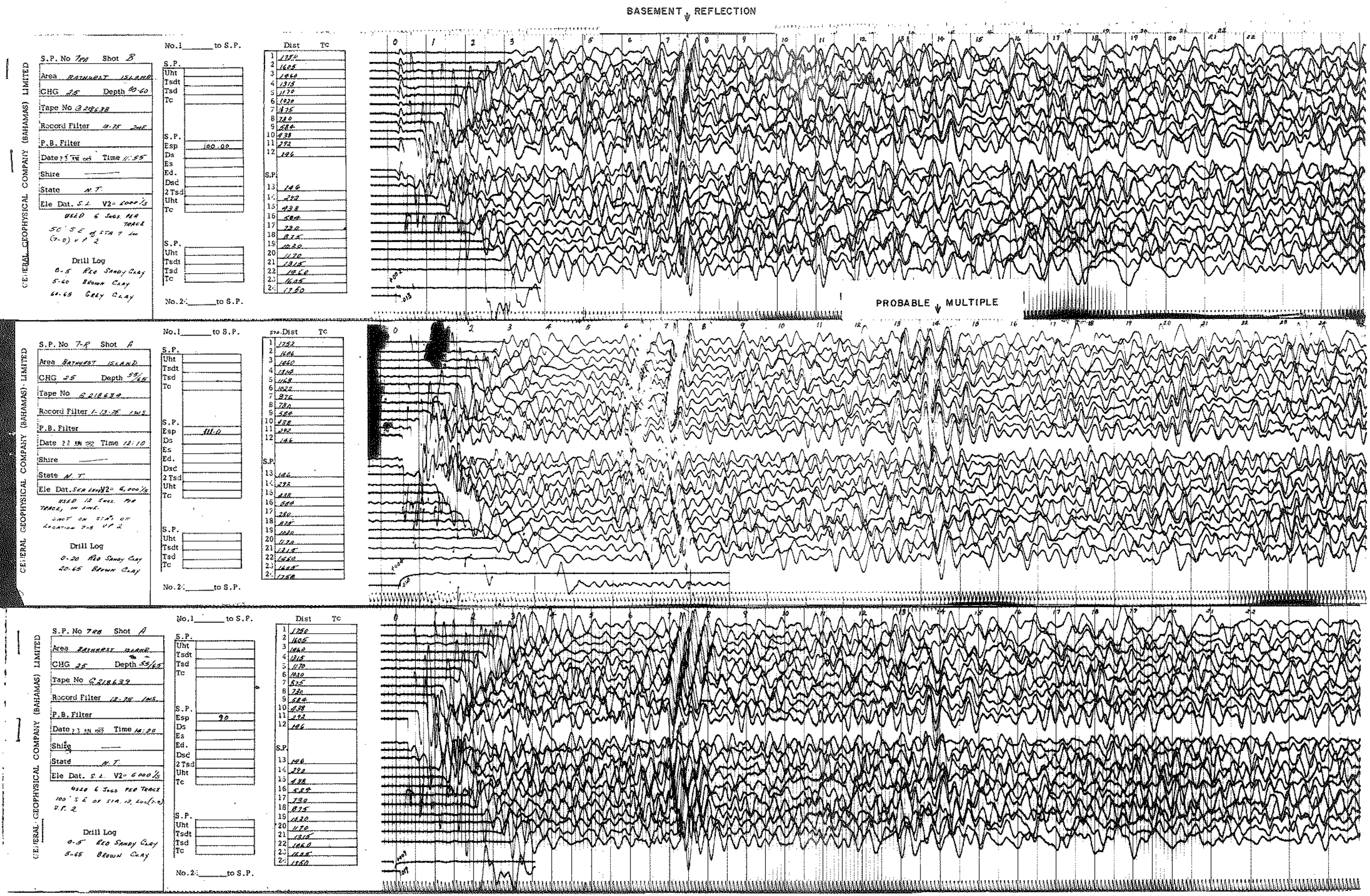
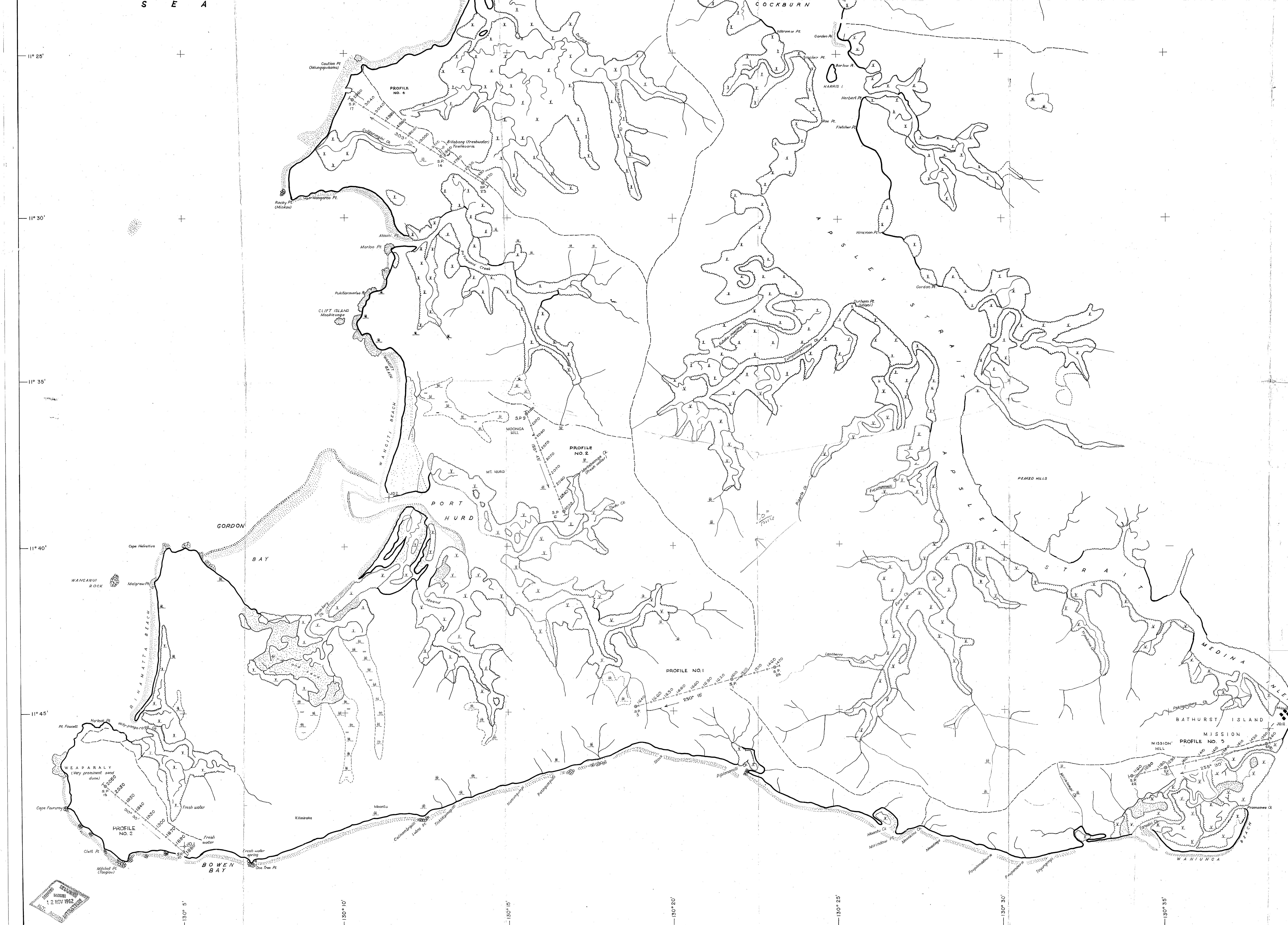


PLATE III

GENERAL GEOPHYSICAL COMPANY



SAMPLE REFLECTION RESULTS



LEGEND

ROADS
REFRACTION TRAVERSES
SHOT POINT LOCATIONS
INTERMEDIATE DEPTH POINTS
"TRIG" STATIONS

SCALE OF MILES

1 ½ 0 1 2 3

OIL DEVELOPMENT N.L.

FINAL MAP

BATHURST ISLAND REFRACTION SURVEY

DEPTH TO

PRE CAMBRIAN

SEA LEVEL DATUM

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R. HARE & ASSOCIATES
TECHNICAL DIRECTORS

12 SEPTEMBER 1962

CONTRACTOR

GENERAL GEOPHYSICAL COMPANY

(BAHAMAS) LIMITED

PE601317A

130° 5'
130° 10'
130° 15'
130° 25'
130° 30'
130° 35'
140° 40'
11° 20'
11° 25'
11° 30'
11° 35'
TIMOR
SEA
ST ASAPH
BAY
PORT
COCKBURN
APSLEY
STRAIT
Brace Pt. (Marlbo)
Tinmile
Deception Pt. (Patchapra)
Murroo Pt.
Caution Pt. (Miungapukamu)
PROFILE NO. 4
S.P. 17
S.P. 14
S.P. 23
303° 10'
Billabong (Freshwater)
Rocky Pt. (Minkau)
Wangaroo Pt.
Atauni Pt.
Marloo Pt.
Pukillormarloo Pt.
CLIFT ISLAND
Mookieuaga
Putuwaminy Creek
Garden Pt.
Interview Pt.
Sinclair Pt.
Barlow Pt.
HARRIS I.
Herbert Pt.
Roe Pt.
Fletcher Pt.
Hinxman Pt.
Gordon Pt.
Durham Pt.