FINAL REPORT

CAPE ARNHEM SEISMIC SURVEY

Arnhem - Gove

AUSTRALIA

MARINE SEISMOGRAPH SURVEY

for

FARMOUT DRILLERS N. L.

by

WESTERN GEOPHYSICAL COMPANY OF AMERICA

PARTY 86

AUGUST 1964

INTERPRETATION BY: C. R. RICHARD

SUPERVISOR: F. J. DI GIULIO

Western

CONTENTS

CAPE ARNHEM SEISMIC SURVEY

I. GENERAL INFORMATION

A. Location of Crew

Because of the short duration of the survey a base of operations was not established for the field crew within the survey area. Interpretative and playback offices were located in Shreveport, Louisiana, U. S. A.

B. Dates of Project

Shooting program began: May 12, 1964

Shooting program completed: May 15, 1964

C. Location of Area

The surveyed area, consisting of three seismic lines, is located in the western part of the Gulf of Carpentaria. The area lies between Cape Arnhem and Cape Grey and extends eastward to 137° 57' east longitude. The three lines fall within the southern part of O. P. 99 (part 1) and the northern part of O. P. 98. See Plate I for a geographical location of the area.

D. Purposes of Assignment

The survey had the following objectives:

1. To determine the thickness and subsurface conformation of the Mesozoic and Tertiary sediments.
2. To obtain information on the regional configuration of the basement surface.

3. If possible, to provide evidence of the presence of Cambrian rocks in the sedimentary section.

E. Surveying

1. Permits

All necessary permits for the survey were obtained by the client.

2. Procedure

Because of the unavailability of radio-location equipment it was necessary to navigate by gyro compass and time interval.

Shot point interval was determined by time interval and cable-towing pressure. Actual time intervals were observed for 600 meter and 1200 meter pull-ups on several points and an average time noted for the different pull-ups. These average times were used for pull-ups except when wind conditions necessitated minor changes.

For a detailed discussion of the proposed survey plan and the actual survey results refer to Supplement I.

3. Location of Points on Maps

Geographical coordinates from sun or star fixes were obtained near shot points 100 and 185 of line A, 47 of line B and 77 of line C. Using these coordinates, and the coordinates of the ends of the lines as shown on the field program map, individual shot point locations were estimated by a pro rata method.

II. RECORDING

A. Major Boat Equipment

1. Recording Boat - OIL CREEK - an 86 foot steel hull vessel powered by two 6-110 General Motors diesel engines and especially constructed and equipped for use as a geophysical recording boat. Its special equipment consists of radar, ship-to-ship and ship-to-shore radio, fathometer, and a power reel capable of handling 8000 feet of floating geophone cable.

2. Shooting Boat - BLUFF CREEK - a 90 foot steel hull vessel of similar design and construction to the "OIL CREEK". In addition to the necessary shooting equipment, it has the essential navigational equipment and a fathometer. It has a full load capacity of 200,000 pounds of marine explosives.

B. Methods

The normal two-boat suspended charge operation was followed throughout the survey. In this method of operation, the shooting boat cruises parallel to the detector cable, and drops the charge opposite the center buoy, at a distance of approximately 300 feet. After the shooting boat has moved away, the charge, which is suspended from three to five feet below the surface for optimum effect, is detonated electronically.

C. Cable

The marine dual purpose cable (of Western design) is effectively two cables, a long cable and a short cable, and for convenience will be discussed as two separate cables. The long cable consists of 24 groups of detectors uniformly spaced 100 meters (328 feet) apart except at the center where groups 12 and 13 are 150 meters (492 feet) apart. The short cable groups are uniformly spaced 50 meters apart from group 1 through group 24. Each group is composed of two pressure sensitive seismometers spaced 6 feet apart. Short cable groups 1, 3, 5, 7, 9, 11, 14, 16, 18, 20, 22 and 24 are common, respectively, to long cable groups 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18.

Normally the seismometers sink approximately 14 feet below the surface when the cable is at rest (in shooting position). An approximate 1% decrease in effective cable length results. See Plate II for schematic diagram of this cable.

D. Dual Recording - Multiple Subsurface Coverage

Through use of the special dual purpose cable it is possible to make two simultaneous 24-trace recordings at each shot point on tape and/or paper. One recording covers the entire length of the cable (2400 meters) while the other covers one half of the cable length (1200 meters).

In this survey magnetic tapes and monitor records were made with the long cable at every shot point. Monitor records and tapes were made on the short cable at those shot points which were spaced 600 meters apart. Both long and short cable FL monitors are recorded on 25 centimeter paper with the short cable record appearing on the top half and the long cable record on the bottom half of the paper. On the 600 meter spacing, filtered field playback records were also made from both long and short cable tapes. On the 1200 meter shot point spacing, where no short cable tapes were made, a filtered short cable record was recorded above the long cable monitor. In addition to these monitors filtered field playbacks were made from the long spread tapes.

The 600 meter pull-up distance yielded 200% subsurface coverage by the long cable and 100% coverage by the short cable. The 1200 meter spacing yielded 100% coverage on the long cable only.

The entire line A was shot with 600 meter shot point spacing. Line C was shot west from shot points 1 through 26 to allow use of 600 meter shot spacing as far as adequate reflecting section was observed. The remainder of line C and all of line B were shot with 1200 meter shot point spacing.

E. Reversing Plugs

In order to shoot line A from Cape Arnhem east and yet obtain records tying together with east on the right, it was necessary to use reversing plugs. A recorded check on the orientation of the cable is provided by the position of the time break. It appears on trace 2 of the monitor records when the reversing plugs were not in use and on trace 23 when they were used.

F. Explosive Charges

Charge sizes of 16-2/3 and 25 pounds of marine explosive were used in the survey. The resulting average charge size was 21.07 pounds. The charges were suspended from three to five feet below the surface.

G. Instrumentation

Western-Techno magnetic tape recorders were used to record tapes at each shot position. The tapes were recorded at full speed through the broad-band FL filter and were monitored on 25 centimeter paper.

Western FA-32 amplifiers equipped with variable automatic gain control and plug-in type filters were standard equipment both in field recording and in magnetic tape playback.

A Bendix fathometer was employed to record water depths at each recording boat position. Water depths are permanently recorded, in fathoms, on the paper fathometer tapes.

In the Shreveport Compositing Center the long spread field tapes were stacked to 200% on all the shot points involved in the 600 meter spacing. The stacked tapes, as well as all 100% coverage tapes, were played back through the CEP filter, which had been chosen from samples as the most suitable filter for this area. The tapes were played back in an unmixed circuit. Medium AVC was used on practically all records in the area.

Plate III shows amplitude response characteristics of the FL and CEP filters.

III. COMPUTING

A. Specific Methods

Each field record was labelled giving spread, cable, and recording information for future reference.

Spread distances were computed from water arrival times recorded, through special water break amplifiers, on the lower part of the monitor records. A water velocity of 5000 feet per second was used in these computations. The eight water arrival traces represent long cable groups 1, 4, 7, 10, 15, 18, 21 and 24.

Magnetic tape playback records were corrected to a sea level reference plane by raising the shot and detectors to the surface at water velocity and by applying the appropriate filter lag. A typical correction would be:

FL tape lag ----------------------	-.012 seconds
CEP playback filter lag -----------	-.007 seconds
Depth of shot correction (at 5 feet)--	+.001 seconds
Depth of geophone correction-------	+.003 seconds
Net correction -------------	-.015 seconds

B. Velocities

A water velocity of 5000 feet per second was used for correcting the charge and geophone to sea level.

The velocity used in selection of the proper cam for dynamic correction was determined by a scatter plot type of Delta T analysis made from the filtered field records of the short cable. Normal moveout from the best reflections was plotted against two way time. An average curve was drawn from these plots and used to select the appropriate moveout cams for both long and short cable tapes.

Dynamic corrections in the playback process were made using Western's 117/45B standard velocity function for the long cable tapes. The cam break time varied from .240 to .500 seconds over the area. The short cable tapes were corrected by using Western's LA 2400 series cam with a variation in cam break time from .300 to .450 seconds. A record from a scribe tape appears on the right side of each record section. This scribe, with the cam break designated, shows the moveout removed at any selected time on the record.

C. Presentation of Data

Fully corrected Western Dual Display (DD) record sections (variable density superimposed on normal squiggle traces) were prepared from the playbacks of the stacked tapes and from playbacks of those field tapes which were used for 100% coverage. Complete sets of quarter size (2.5 inches per second) prints were furnished the client on micro-writ paper.

On those shot points spaced at 600 meters, the alternate long spread tapes were played back to make the 100% long cable record sections.

IV. MAPS

A. Base Maps

Base maps were constructed on Cronaflex film at a scale of 1:100,000 from the small scale field program map. As previously stated, the shot points were evenly spaced between the star and sun fixes provided by the field crew. To facilitate printing and reproduction, the final base maps were constructed on two plates (map 1 and map 2). Final maps were made on film prints of these base maps.

B. Maps Submitted

1. Reflection Horizon (Upper Proterozoic) ?-average time - .515 seconds
2. Depths to High Speed Refractor (Upper Proterozoic)?
3. Water Depth Map

V. INTERPRETATION

A. Reflection and Multiple Identification

Prior to the construction of the reflection horizon map, the 100% long cable record sections were examined for events with excess curvature. These events were identified as multiple energy and were marked with a blue pencil. Events with comparatively little or no curvature were identified as true reflections and were marked with an orange pencil.

B. Construction of Maps

1. Reflection Horizon (Upper Proterozoic)?

The Reflection Horizon map is based upon a fairly continuous reflection event which is present in that part of the area east of shot points 57 and 38 of lines A and C respectively. West of shot point 57 of line A the reflection is obscured by the first arrivals and is too shallow to map. West of shot point 38 of line C a questionable phantom was indicated to shot point 47 where the dip segments become too poor to map.

This horizon, mapped in two-way time, ranges from .300 to .730 seconds and may possibly represent a reflection near the top of the Upper Proterozoic.

2. Depths to High Speed Refractor (Upper Proterozoic)?

An examination of the first arrivals of the long cable field monitor records indicated a shallow high velocity refractor. It was decided to compute the depths to this formation by the refraction method. Using Heiland's * formula ($d = {}^{t}o/2 \cdot V_2 \cdot \tan i$) depths were computed from velocities and intercept times on those points where the high velocity refractor was indicated. The V_1 and V_2 velocities (and intercept times) from the reverse and forward sides of each record were averaged for depth computation.

To facilitate the handling of the numerous profiles a standard computation form (assuming the cable to be of average and constant length and the shot point offset to be uniform) was constructed and used for plotting actual times versus these average distances. Depth computations were also made on these forms.

Although the depths computed by the above described method are reasonably accurate and sufficiently indicative of the overall dip of the refractor, local fluctuations in depth make contouring of the map impractical. These local fluctuations may be attributed to the imposed limitations of the method of computation and to the inability to measure an accurate V_2 velocity where the depth of the refractor was too great to record refracted arrivals on more than three of the traces. The latter condition is

*C. A. Heiland, Geophysical Exploration, 509 (1946) noted on the east end of line A.

It is also quite possible that some, if not all of the depth fluctuation shown by the refraction computations may be indicative of an irregular refracting surface.

C. General Data Quality

On the short cable recordings reflection quality ranged from fair to very poor where there was sufficient reflecting section. Because of interference by the first arrivals in the shallow reflecting section, the quality of the reflections, in general, was considerably poorer on the long cable records. However, the 200% stacked sections (made from long cable tapes) showed a considerable improvement over the 100% long cable recordings. This is especially true on the extreme east end of line C where the deepest part of the reflecting section is observed.

1. Line A - From shot point 57 to approximately shot point 100 the quality of the reflection mapped is considered poor. Here the reflection is very shallow and interference from first arrivals is evident. From this point east the reflection gradually deepens, resulting in a general improvement in data quality. From shot point 165 east to the end of the line, reflection quality is fair.

2. Line B - The filtered short cable field records were used as an aid in correlation of the reflections on the long

spread record sections.

The extreme north end of line B was N. G. As a result, the relationship between shot point 6 and the east end of line A is questionable. From shot point 6 south to the fault mapped between shot point 14 and 15, the data quality is very poor to questionable. South of this fault the mapped reflection becomes stronger and ranges between poor and very poor to the south end of the line. An exception occurs between shot points 34 and 42 where the data are questionable.

3. Line C - The data quality on line C is fair from shot point 1 west to shot point 30. From shot point 30 to shot point 38 the reflection quality is poor. From shot point 38 to shot point 47 the questionable phantom is based upon scattered dip segments. From this point west the scattered dip segments are too sparse to provide a reliable phantom.

D. Faulting

Two small down-to-the-south faults were mapped on line B. The fault between shot points 14 and 15 is very poor to questionable. The second fault, between shot points 16 and 17, is considered to be poor. The displacement on both faults is based upon possible correlations of reflected energy bands. The small down-to-the-north fault indicated between shot points 20 and 21 is questionable.

The fair to poor fault mapped near shot point 30 of line C is based upon interruption of dip and a possible correlation. Other possible faults occuring in the area are indicated with no displacement on the reflection map.

E. Structural Discussion

1. Regional Geology

The Gulf of Carpentaria occupies an area of continental shelf which extends northward to the foothills of the New Guinea Highlands.

Pre-Cambrian rocks flank the western and southwestern margins of the Gulf and separate this area from the lower Palaeozoic sediments of the Georgina Basin. Mesozoic beds outcrop extensively on the eastern and southeastern margins of the Gulf. In some areas along the north coast of the Northern Territory the section consists of lower Cretaceous sediments, thickening seaward, which either directly overlay basement rocks or ~~their~~ thin developments of Jurassic sands. In the Queensland portion of the Gulf a maximum thickness of 3,000 feet is assigned to the mainland Cretaceous. The Tertiary here consists of approximately 400 feet of terrest~~e~~rial sediments.

2. Structure

a. Reflection Horizon (Upper Proterozoic)?

On the parts of the area covered by the Reflection

Horizon map the dips are generally to the east on lines A and C, and to the south on line B. However, local dip reversals were observed in several places. On line A approximately .040 seconds of fair to poor west dip was measured from shot point 65 to 61. Other slight reversals were noted near the eastern end of the line.

On line B a slight amount of north dip was mapped near shot point 14; however, the reflection here is rather questionable. Near shot point 40 approximately .020 seconds of north dip is based upon a questionable projection.

A small arch is suggested at the intersection of lines B and C. The arch is supported by a fair reflection event on line C and by very poor data on line B. Another small arch, located on line C near shot point 33, is formed by poor west dip into the fault situated near shot point 30.

b. <u>Depths to High Speed Refractor (Upper Proterozoic)?</u>

The depths to the high velocity refractor show 750 feet of east dip across line A from shot point 5 to shot point 184. Similarly, 530 feet of east dip is shown on line C from shot point 120 to shot point 58. Slight west dip was noted on the inshore ends of both lines A and C.

F. Conclusions

Very little geologic section was measured over the surveyed area. The maximum thickness of section is seen in the extreme southeastern corner of the area and is estimated to be 2000 to 2500 feet.

Regionally, basement is expected to conform closely to the reflection horizon as mapped.

VI. STATISTICAL DATA

Number of Locations Shot:	
600 Meter Spacing	211
1200 Meter Spacing	159
Total	370
Pounds of Explosive Used	7858
Number of Shots	373
Number of Caps Used	376
Number of Boosters Used	374
Average Charge per Shot	21.07 pounds

Resident Staff Personnel

V. C. Boyd, Jr.	Supervisor
J. A. Dees	Operations Manager and Seismologist
A. C. McEachern	Operations Coordinator
J. E. Dawson	Observer
K. Caillouet	Observer
J. B. Hebert	Shooter
D. Suteliffe	Shooter

SUPPLEMENT I

VII. Discussion of Survey Procedure

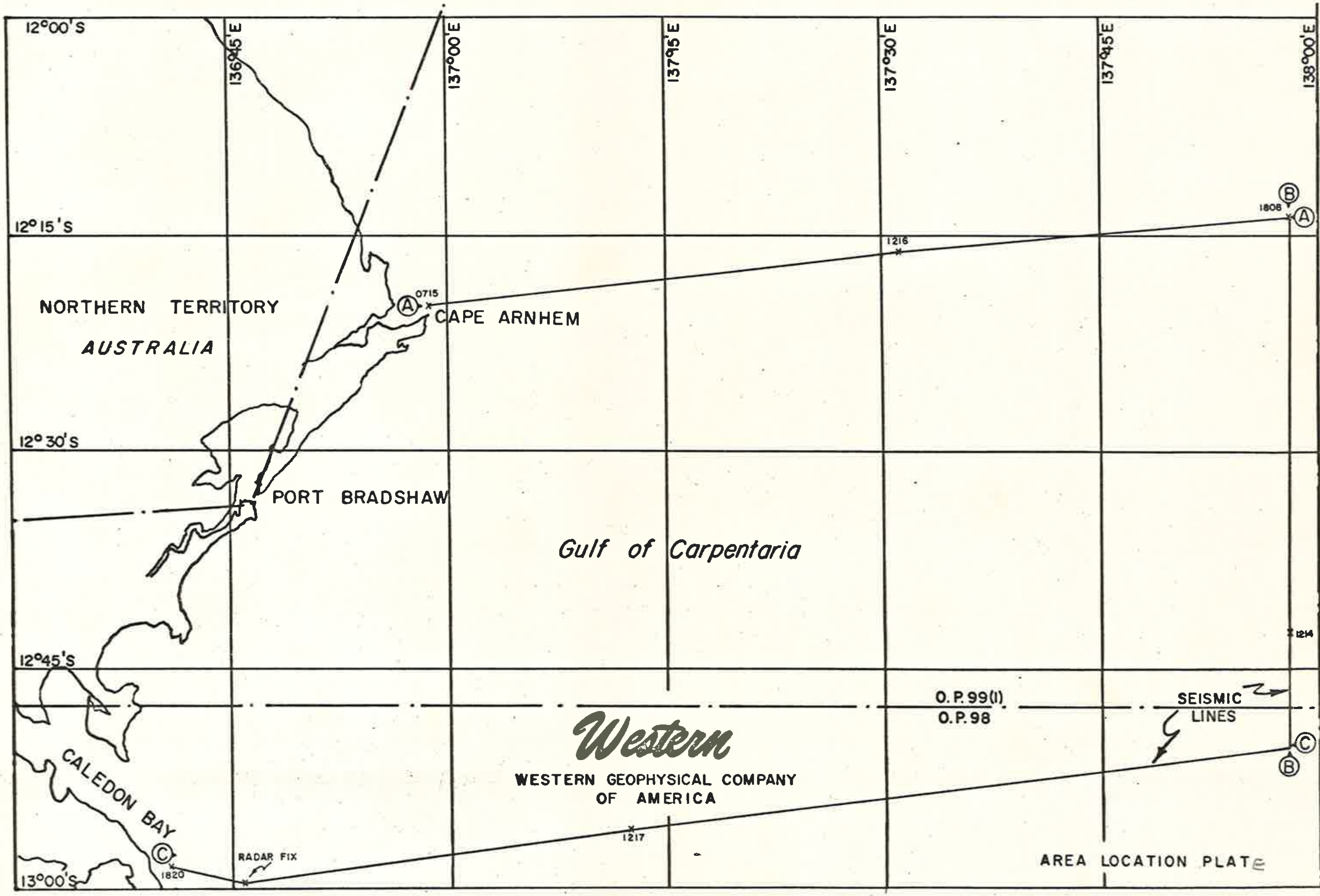
Because Raydist equipment was not available in time for the commencement of the operation, it was necessary to navigate by using gyro compass bearings and time intervals measured with a stop watch.

The original plan was to begin line A opposite Cape Arnhem at a latitude of approximately 12°21' South and proceed due east, at 600 meter spacing, for a distance of about 70 statute miles to the 138 degree meridian. From this point shooting was to proceed south on line B, at 1200 meter spacing, for a distance of about 44 statute miles to the 13 degree parallel of south latitude. Shooting would then be temporarily suspended and a marker buoy was to be placed at this point. Line C was to be shot from Cape Grey due east along the 13 degree parallel for a distance of about 86 miles back to the marker buoy on the 138 degree meridian.

Both ends of lines A and C were to be located by star fixes. However, the readings at the western ends of both lines failed to provide an accurate fix, and the one at the eastern end of line A was considered only accurate to within 3 miles by the navigator. Possibly, the failure to obtain accurate star readings resulted from the abnormal refraction which apparently is a problem in these latitudes. Because of these failures and the negative seismic results of lines A and B, the boats turned west from the south end of line B and shot line C west to a point opposite Cape Grey, thus providing optimum control of shot-point spacing and line ties.

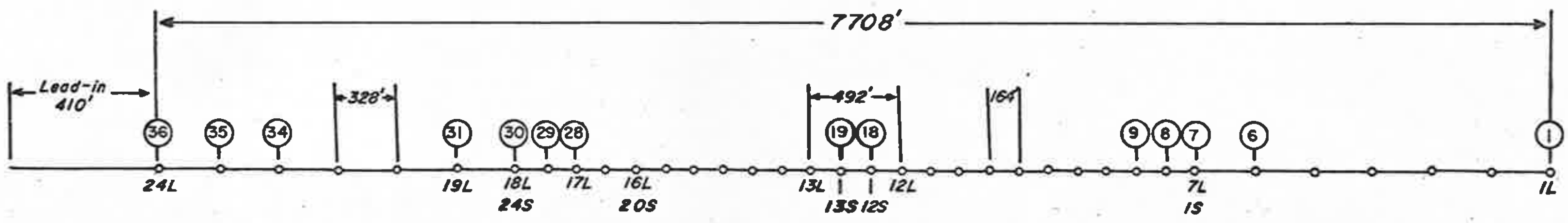
Due to rough seas and 25-35 miles per hour winds, the seismic boats drifted north of the intended due east course of line A. This drift was discovered when a latitudinal sun fix was obtained near shot point 100 of this line. An attempt was made to compensate for the drift by altering the course from here to the east end of the line. However, as a result of the northward drift, the three seismic lines formed a parallelogram rather than the proposed rectangle.

To control the shot point spacing as much as possible a plastic bag, partially filled with water, was dropped from the recording boat after each shot. By observing these bags an approximate running time was determined for the 600 and 1200 meter pull-ups by the recording boat. For the 600 meter spacing on lines A and C, a running time of 3 minutes was used. On the 1200 meter spacing of line C a time interval of 5-1/2 minutes was used. Because the boats were travelling into the wind, a running time of 6 minutes was used for the 1200 meter spacing of line B.



12°00'S
12°15'S
12°30'S
12°45'S
13°00'S
136°45'E
137°00'E
137°15'E
137°30'E
137°45'E
138°00'E
NORTHERN TERRITORY
AUSTRALIA
CAPE ARNHEM
PORT BRADSHAW
CALEDON BAY
Gulf of Carpentaria
A
B
C
0715
1216
1808
1214
1217
1820
RADAR FIX
O.P. 99(1)
O.P. 98
SEISMIC
LINES
Western
WESTERN GEOPHYSICAL COMPANY
OF AMERICA
AREA LOCATION PLATE
PLATE I

CABLE DIAGRAM



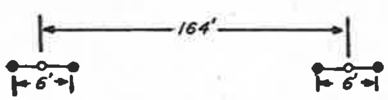
(36) Denotes cable group.

24L Denotes long cable group — Uniformly spaced except at center.

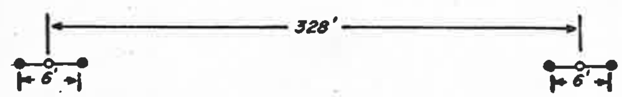
24S Denotes short cable group — Uniformly spaced.

o Denotes group center.

● Denotes seismometer.



Seismometer group layout in Short Cable



Seismometer group layout in Long Cable

PLATE II

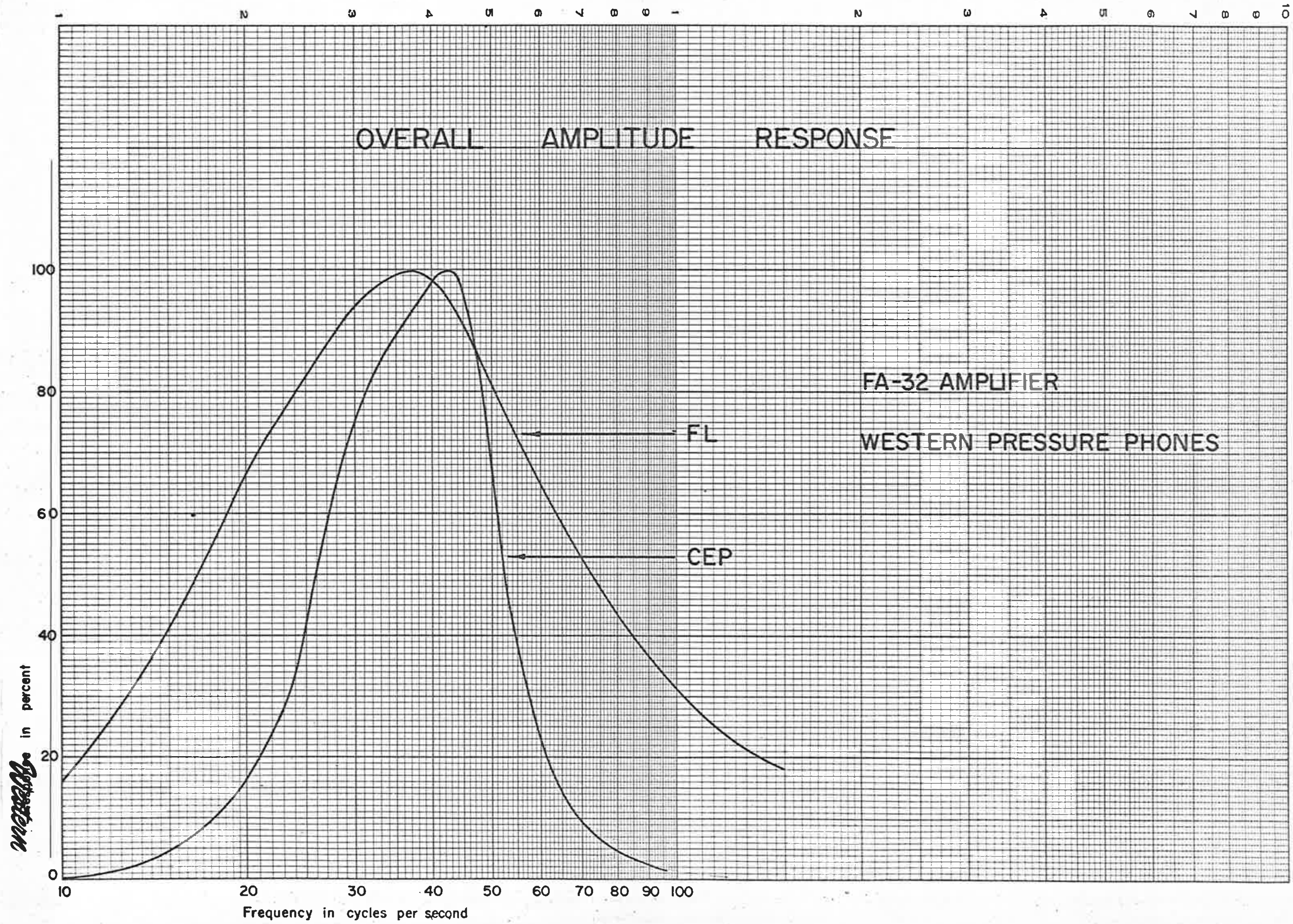

OVERALL AMPLITUDE RESPONSE
FA-32 AMPLIFIER
WESTERN PRESSURE PHONES
FL
CEP
100
80
60
40
20
0
in percent
10
20
30
40
50
60
70
80
90
100
Frequency in cycles per second

PLATE III

WESTERN GEOPHYSICAL
DIVISION OF LITTON INDUSTRIES

DYNAMIC CORRECTION CURVES

for

WESTERN TAPE TRANSPORT MODEL B-A26-2 M024

FARMOUT DRILLERS N.L.
CAPE ARNHEM SEISMIC SURVEY

Date	Velocity Function	Spread	Cam	Multiplier	Elevator	Break Time	Computed By
		2000'	LA 2400	1.0	0	.370	
		3900'	117/45B	2.0	0	.480	
	•	2000'	(Average of scatter plot from short cable.)				

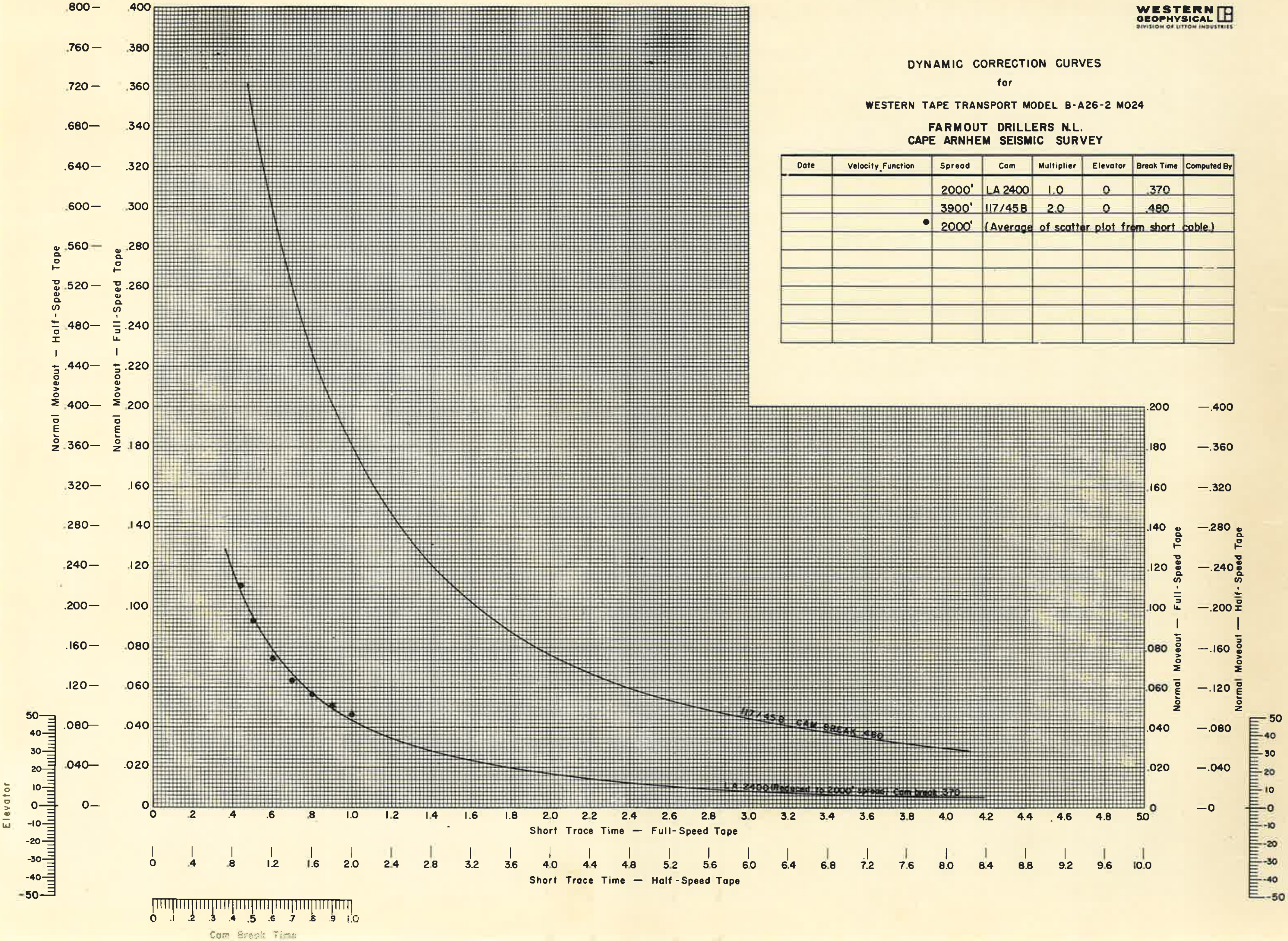
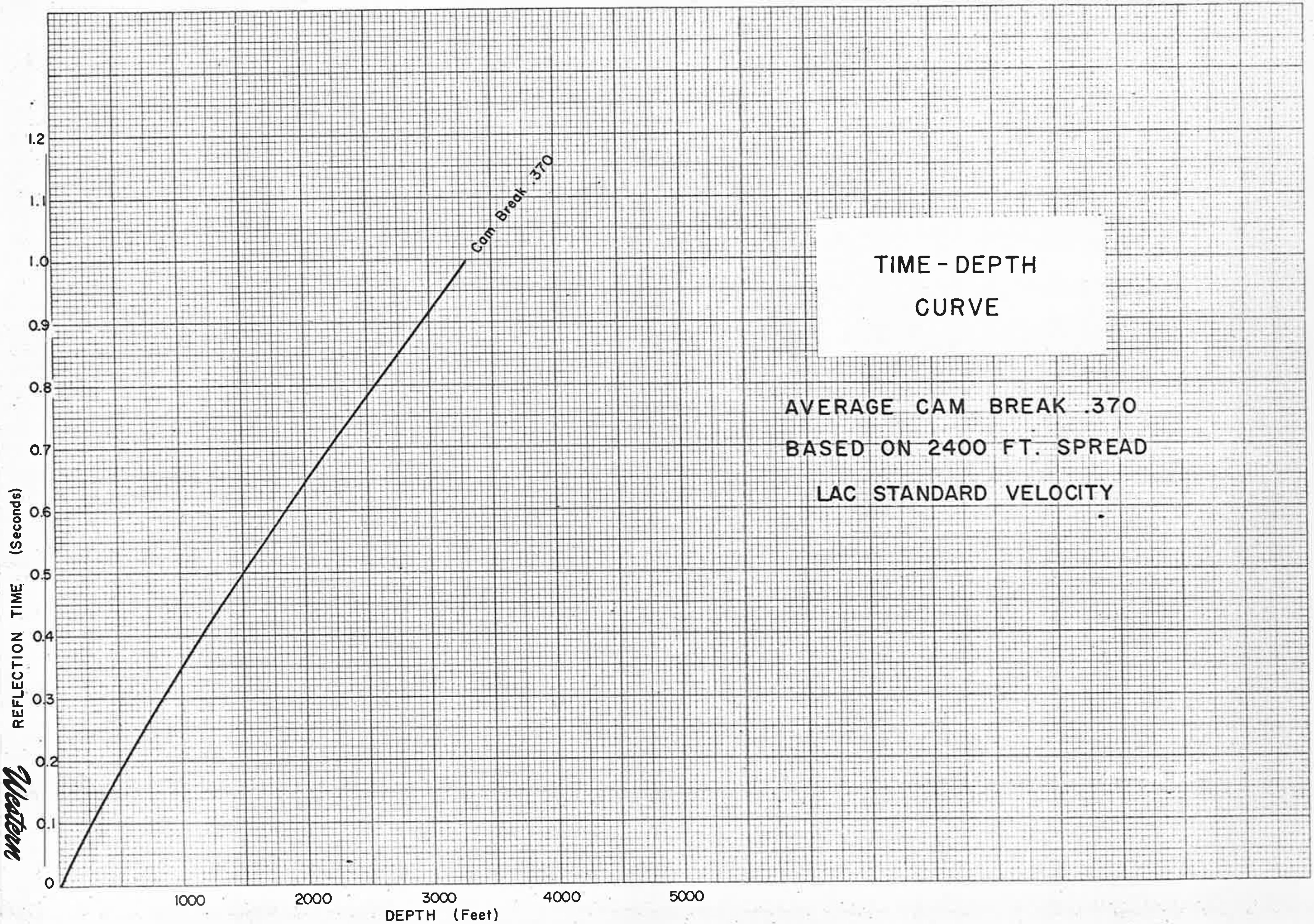


PLATE IV



Western

PLATE X

ADDENDUM TO REPORT

1. **Address of Operator**

   291 George Street, Sydney, N.S.W.

2. **Address of Contractor**

   933 North La Brea Avenue, Los Angles 38,
   California, U.S.A.

3. Total number of miles traversed = 198.75

4. **Previous Geophysical Work**

   In 1955 Adastra-Hunting Geophysics Ltd. carried out a broad reconnaissance aeromagnetic survey of the Gulf of Carpentaria for Frome-Broken Hill Co. Pty. Ltd. Then in 1958 the Bureau of Mineral Resources carried out a regional underwater gravity survey in the coastal regions of the Gulf. Aero Service Ltd. followed the earlier survey of the Gulf with a more intensive reconnaissance aeromagnetic survey for Delhi Australian Petroleum Ltd. in 1962. It was the results of this latter survey which first drew attention to the prospect area.

5. **Annex 1**

   One set Dual Display record sections (variable density and squiggle trace) as follows:-

(cont.)

				Coverage
Line A	SP 3	to	SP 41	200% stacked
	43	"	77	" "
	79	"	113	" "
	115	"	149	" "
	151	"	185	" "
Line B	SP 20	to	SP 1	100% Long Cable
	40	"	21	" " "
	66	"	41	" " "
Line C	31	"	2	" " "
	49	"	32	" " "
	68	"	50	" " "
	87	"	69	" " "
	106	"	88	" " "
	125	"	107	" " "
	26	"	2	200% stacked

PR64/30