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OEL 39

MURRAY BASIN

1967 HAMLEY SEISMIC SURVEY

FINAL REPORT

Submitted by

Associated Australian Oilfileds N/L

1967

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Namco Geophysical Co.

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Report No. SA/OEL. 39/351

FINAL REPORT

on the

HAMLEY SEISMIC AND GRAVITY SURVEY

Oil Exploration Licence 39,
South Australia

Submitted to

ASSOCIATED AUSTRALIAN OILFIELDS N.L.

By

Mines Administration Pty. Limited

and

Namco Geophysical Company

ENV. 824

January, 1968.

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ABSTRACT.

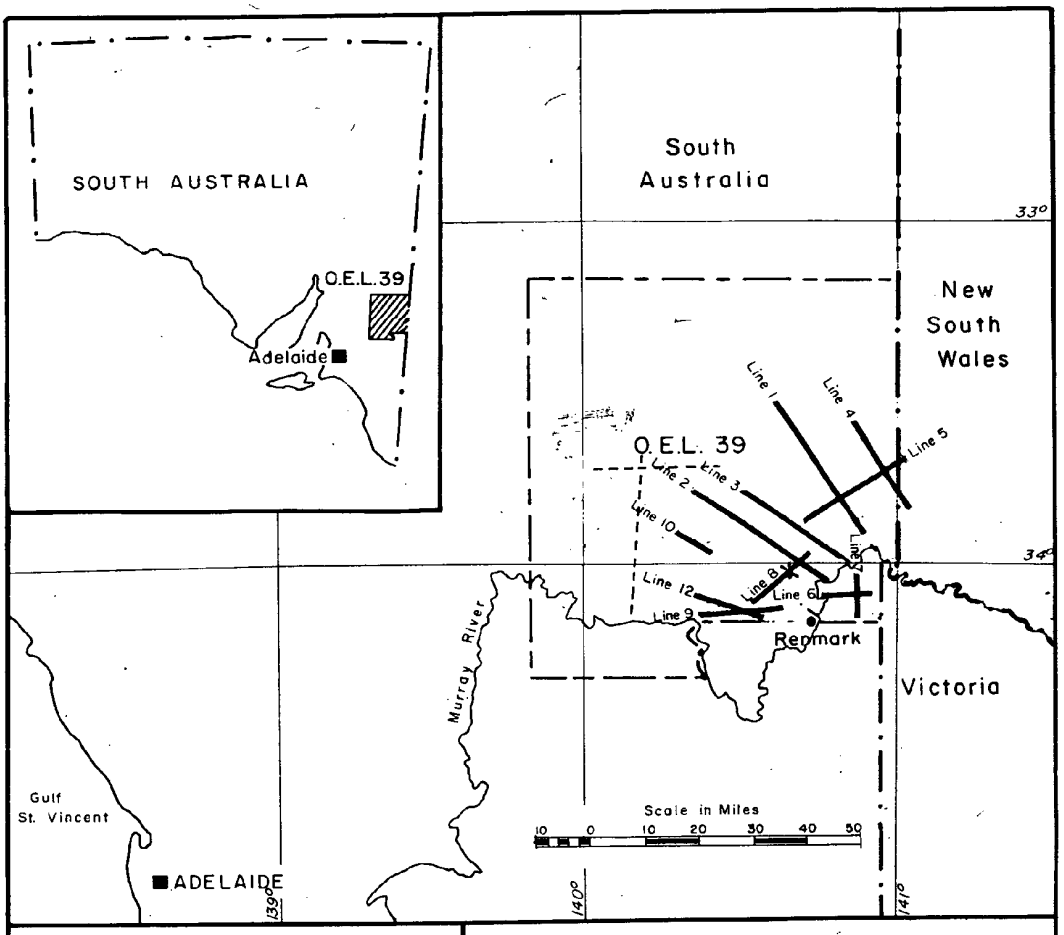
A refraction and reflection seismic survey was conducted during June, July and August 1967 for Associated Australian Oilfields N.L. by Namco Geophysical Company within Oil Exploration Licence 39 in the State of South Australia. A gravity survey by Mines Administration Pty. Limited was combined with the seismic survey.

The objectives of the seismic survey were to obtain additional information on the form and structure of the Renmark Trough and to establish a location for the drilling of a stratigraphic test well to basement in an area underlain by an appreciable thickness of pre-Cretaceous section.

The gravity survey was aimed at determining regional structure in the area west of the main seismic survey.

The refraction profiling was most successful in outlining basinal structural configurations, the definition of two major and several minor fault systems, an appreciation of the velocity distribution and in measuring overall section thicknesses. The single-fold reflection profiling showed improved data quality and gave a better insight to the application of this technique within the area. The data confirm the presence of a major fault-controlled trough with sedimentary section thicknesses exceeding 10,000 feet on the down-thrown side of the Hamley fault. Minor amounts of structural reversal can be inferred at intermediate depths.

The gravity results showed a basement high dividing the Canegrass Lobe into two troughs.



State Boundary

O.E.L. Boundary

Seismic Refraction Line

Gravity Line

ASSOCIATED AUSTRALIAN OILFIELDS N.L.
Oil Exploration Licence 39, S.A.

HAMLEY SEISMIC SURVEY LOCATION MAP

MAP No. 11898	namco GEOPHYSICAL COMPANY.
FILE Loc. M 1	August, 1967

Figure 1

1. INTRODUCTION

1.1 LOCATION

The Hamley Seismic and Gravity Survey was conducted within Oil Exploration Licence 39, in the State of South Australia, for Associated Australian Oilfields N.L. The location map (Figure 1) shows the regional location of the area.

1.2 CONTRACTORS

The seismic contractor was Namco Geophysical Company of Dallas, Texas, U.S.A. with Australian headquarters at 64 Tribune Street, South Brisbane, Queensland. The total survey was supervised, and the gravity survey carried out, by Mines Administration Pty. Limited, 31 Charlotte Street, Brisbane.

1.3 EQUIPMENT AND PERSONNEL

The seismic crew employed one recording unit equipped for magnetic recording, two drills and two shooting trucks. Worden Gravity meter No. 216 was used for the gravity work. Details of equipment and personnel are given in Appendix I and Appendix II respectively. Seismic shooting commenced on 5th June and was completed on the 8th August 1967. The statistical data of the survey are given in Appendix III.

1.4 GEOGRAPHY

The survey area is located on the northwestern flank of the Murray Basin. It is mainly low-rainfall semi-desert with numerous sand hills which are consolidated by scrub and gum trees. Along the course of the Murray River, which isolates the southeast corner of O.E.L. 39, are several irrigation areas. The actual river, with meanders, anabranches, and lagoons, occupies a belt of heavily timbered flood plain, 1 to 3 miles wide. Water is piped inland from the Murray River for stock watering.

1.5 COMMUNICATIONS

Direct road, rail and light aircraft connections are available to Adelaide from Renmark, which is on the Sturt Highway to Mildura. The survey area is reached from Renmark by the Wentworth road, a part sealed and part good quality graded road which follows the northern bank of the Murray northeasterly from Renmark. The area is interlaced with property tracks, seismic line and power line clearings.

2. OBJECTIVES OF THE SURVEY

The objectives of the seismic survey were to obtain additional information on the form and structure of the Renmark Trough and to establish a location for the drilling of a test well to basement in an area underlain by an appreciable thickness of pre-Cretaceous section.

The continuous refraction profiling technique was adopted as the most suitable tool for acquiring the bulk of subsurface information, while the continuous reflection profiling technique was used to provide greater detail and keener insight into subsurface relief at selected locations.

The gravity survey was intended to outline basinal structure in the area west of the Hamley Fault. Metering along the seismic lines was done to compare the gravity results with known structure.

3. GEOLOGY

A detailed review of the geology of the area as known prior to the survey has been given by Swindon (1966).

O.E.L. 39 is on the northwestern flank of the Murray Basin. The seismic survey area is over the main part of the Renmark Trough which is a southwest - northeast trending infrabasin approximately 60 x 25 miles underlying the thin Tertiary section of the Murray Basin proper. The gravity coverage is also over this area and, in addition, extends into the Canegrass Lobe, a little known area of significant pre-Tertiary section associated with, and to the west of, the Renmark Trough.

In the central part of the Renmark Trough previous refraction surveys indicated a maximum sedimentary thickness of over 9,000 feet. At the deepest known point this section was thought to be:

0	- 2000'	Tertiary
2000'	- 4000'	Cretaceous
4000'	- 5000'	Permian
5000'	- 9000'	Permian + possible older Palaeozoics
9000'	+	Metamorphic basement (probably equivalent to the ?Cambrian Kanmantoo Group)

The Renmark Trough is flanked on the southeast by the basement highs in the Lake Victoria and Loxton areas and on the northwest by the Hamley Fault in the south and the Canopus High in the north. The thick sections of the Trough pinch out against these basement highs and on their axes the Tertiary rests directly on basement or on thin Cretaceous sections overlying basement at shallow depths. To the west of the Hamley Fault the pre-Tertiary section extends to the northwest into the Canegrass Lobe which probably contains a maximum of 5,000 feet of section.

The known sedimentary units in the Renmark Trough portion of the Murray Basin are summarised on Table I.

The Tertiary has a probable maximum thickness of 2,000 feet. The upper part is a shallow marine sandstone-marl-limestone section. The lower part is a paralic to non-marine section characterised by quartz sandstones, grits, clays and lignites.

The Cretaceous has a probable maximum thickness of 2,000 - 2,500 feet. It is a mainly marine, siltstone-shale-sandstone sequence. Sandstone becomes more common towards the base and A.O.C. North Renmark No.1 contains a thick basal sand section which appears to be permeable and saltwater filled. Well correlations show that these sands pinch out by onlap on to the northwestern flank of the basement highs on the southeastern flank of the Trough (Enclosure XXII).

The Permian is a shale-siltstone-sandstone sequence. In both the North Renmark and Monash wells the section consists of upper and lower shaly units separated by a sandy middle unit. Log character in North Renmark and test data from Monash show that these sandstones are permeable and saltwater filled (42,449 p.p.m. total salts).

The Permian contains a restricted marine microfauna. The argillaceous sections are characterised by slump structures, irregular lenticles and bands of sandstone and grit and by numerous erratic pebbles and cobbles. In places the mudstones grade into boulder-clay conglomerates. These textural features have been variously taken to indicate glacigene conditions (ice rafting), large scale tectonic slumping and turbidity current effects.

TABLE 1

STRATIGRAPHIC UNITS OF THE WESTERN MURRAY BASIN.

AGE		GROUP	FORMATION	LITHOLOGY	ENVIRONMENT	INTERVAL IN A.O.C. NORTH RENMARK NO.1	THICKNESS IN A.O.C. NORTH RENMARK NO.1
QUATERNARY (60')				Sands and clays.	Aeolian and fluviatile.	0 - 60'	60'
TERTIARY (1740 ft.)	L. Pliocene		Loxton Sands	Unconsolidated yellow and grey sands with minor mudstones.	Marine.	60 - 140'	80'
	U. Miocene - L. Pliocene		Bookpurnong Beds	Siltstones and sandstones, greenish with abundant glauconite.	Marine.	140 - 200'	60'
	Lower Miocene	Murray Group (230')	Pata Limestone	Grey clayey marl, partly recrystallised limestone. Very fossiliferous.	Marine	200 - 250'	50'
			Morgan Limestone	Fine grained cream - yellow and grey bryozoal limestone grading to mainly limestone.	Marine	250 - 450'	200'
			Mannum Formation	Yellow liminitic calcareous sandstones and limestones.	Marine	450 - 530'	80'
	Oligocene	Glenelg Group (176')	Gambier Limestone	Fossiliferous mainly limestone. Very porous. Minor shale bands.	Marine	530 - 656'	126'
			Ettrick Formation	Grey and green sandy clays and marls. Abundant fossils and glauconite.	Marine	656 - 706'	150'

TABLE 1 (contd.)

AGE		GROUP	FORMATION	LITHOLOGY	ENVIRONMENT	INTERVAL IN A.O.C. NORTH RENMARK NO.1	THICKNESS IN A.O.C. NORTH RENMARK NO.1
TERTIARY	Eocene	Knight Group (1094')		Quartz gravels and grits, carbonaceous clays and silts, medium carbonaceous sands, lignites.	Paralic to non-marine.	706 - 1800'	1094'
				UNCONFORMITY			
C R E T A C E O U S (1445')	?Cenomanian - Albian			Greenish grey, very fine to fine sandstones and siltstones with minor mudstones. Spores and fish remains. No foraminifera.	Paralic.	1800 - 2390'	590'
	Aptian		upper unit	Shales and siltstones with minor sandstones, some of which are porous.	Marine.	2390 - 2870'	480'
			lower unit	Interbedded shales, siltstones and sandstones. Some sandstones are coarse and porous. Metamorphic rock erratics.	Marine.	2870 - 3015'	145'
	?Neocomian			Interbedded sandstones and shales. Sandstones are dominant, mainly medium grained and porous. Rare coal lignite.	Apparently no foraminifera. Probably paralic.	3015 - 3245'	230'
				UNCONFORMITY			

TABLE 1: (contd.)

AGE	GROUP	FORMATION	LITHOLOGY	ENVIRONMENT	INTERVAL IN A.O.C. NORTH RENMARK NO.1	THICKNESS IN A.O.C. NORTH RENMARK NO.1
P E R M I A N (773+')	Lower Permian (U. Sakmarian - L. Artinskian)	upper unit	Shales and siltstones, minor tight sandstones. Slump structures and erratic pebbles.	Glacial marine.	3245 - 3430'	185'
		middle unit	Interbedded sandstones, siltstones and shales. Boulder beds in core. Many of the sandstones appear to be porous.	Glacial marine.	3430 - 3785'	355'
		lower unit	Shales and siltstones with minor sandstones including fontainbleau sandstones. Slump structures and erratics.	Glacial marine.	3785 - 4018' (T.D.)	233'
? LOWER PALAEOZOIC			Reddish sands and conglomerates.	No cores, no pre-Permian fossils in cuttings. Identification and age very tentative.	Section in Monash No.1 3320 - 3445' (T.D.)	Thickness in Monash No.1. 125'

Pre-Permian section has not been positively identified. However, cuttings in the lower part of B.P.N.L. Monash No.1 included pinkish sandstones which could possibly have been derived from a Devonian section. It seems probable that pre-Permian is present in the lower part of the thick section in the deeper parts of the Trough. The sedimentary section rests on a metamorphic basement which has been correlated with the ?Cambrian Kanmantoo Group of the Mt. Lofty-Olary Arc.

The structure of the northwestern flank of the Trough is dominated by the Hamley Fault. Previous seismic evidence showed that the total fault - flexure movement across the fault was of the order of 3,000 feet at basement level and 350 - 800 feet at the Cretaceous level.

To the south of the Trough, there is no pre-Cretaceous and the structure is dominated by a number of sinuous, generally north-trending anticlines and synclines which are probably related to basement topography.

Although much of the Tertiary section is marine it is flat-lying and subcrops under a thin veneer of permeable Quaternary sands and clays. Facies changes are known to occur but it is essentially an aquifer section of very low petroleum potential.

The source and reservoir conditions in the Cretaceous appear to be attractive. One source rock analysis from the North Renmark section gave 392 p.p.m. C15+ hydrocarbons. The logs and the test in B.P.N.L. Berri North No.1 show that the sands in the lower part are permeable and saltwater filled (34,400 p.p.m. total solids).

The only source rock analysis from the Permian (from North Renmark No.1) gave 0.23% total organic carbon and 96 p.p.m. C15+ hydrocarbons suggesting only fair source potential. However, reservoir conditions in the known section appear to be good and a test of the middle sand section in B.P.N.L. Monash No.1 gave salt water to within 80 feet of surface.

4. PREVIOUS GEOPHYSICAL EXPLORATION

4.1 AEROMAGNETIC

The area has been covered by a regional aeromagnetic survey and total intensity maps have been prepared by the South Australian Department of Mines.

4.2 GRAVITY

A complete regional coverage is available over the survey area. This coverage has mainly been established by gravity readings taken in association with the reflection and refraction surveys carried out by the South Australian Department of Mines and by company surveys. The regional gravity coverage in O.E.L. 37 to the south of O.E.L. 39 is summarised in the final report of the subsidised Murray Basin Provinces Gravity Survey (Stackler and Sprigg, 1966). Bouguer Anomaly maps of the Renmark and Chowilla 1:250,000 sheets have been prepared by the South Australian Department of Mines (Swindon, 1966, Sheets 1 and 2).

In the Renmark Trough - Canegrass Lobe area there is a close relationship between the Bouguer contours and the basement contours derived from refraction and drilling data.

4.3 SEISMIC

The initial work was carried out by the South Australian Department of Mines (Seedsman, 1963; Seedsman and Kendall, 1964; Kendall, 1965). This work included three long refraction lines: the Monash, Canegrass and Hypurna Lines, which were designed to map basement. The results of these lines and of a number of refraction probes provided the basic data for the previous picture of the form of the Renmark Trough.

During these refraction surveys two main refractors were recognized:

(a) a refractor of approximately 14,000'/sec. velocity which has been correlated with the top of the Permian, and

(b) a refractor of 17,500 - 19,500'/sec. velocity which has been correlated with basement.

The results from the refraction surveys were generally good; only moderate charge sizes were necessary to give good quality data from long offsets.

The main reflection work within O.E.L. 39 is the subsidised Renmark Seismic Survey carried out in 1965 on behalf of Tasman Oil Limited (Geophysical Associates, 1965). This survey provided a regional coverage of the southern end of the Trough.

Two reflectors were mapped:-

"Reflector K" - this was the most consistent reflector and was identified as arising from at or near the top of the sandstone unit in the lower part of the Cretaceous in A.O.C. North Renmark No.1 and in B.P.N.L. Berri North No.1.

"Reflector L" - a less continuously mappable event which was identified as arising from the unconformity at the top of the Permian. As such it is generally equivalent to the 14,000'/sec. refractor recognized on the refraction probes. At Berri North No.1 well it is apparently a basement reflection.

A study of the corrected record sections, particularly on those lines adjacent to the Hamley Fault (e.g. Renmark Survey, Line 3, Shot Points 1 to 10, Line 6, Shot Points 1 to 3), shows an angular unconformity between the Cretaceous and the Permian and confirms the interpretation that the "L" reflection maps the Permian - Cretaceous unconformity rather than the intra-Permian structure.

Discontinuous reflections occur for 100 to 500 milliseconds below Reflector L. On Line 1 and other lines of the Renmark Survey these discontinuous reflections are present down to about 5,000 feet in an area where reliable refraction data from the Monash line indicates a total sedimentary section of over 8,000 feet.

5. FIELD PROCEDURE

5.1 REFRACTION

5.1.1 Line Locations

The refraction profiling in the Hamley Survey took the form of six dip lines across the Renmark Trough, with one axial line along the trough, one line along the southeastern flank, and two detailed profiles over a suspected anomaly. Away from the Renmark Trough, one line was shot northwest of the Hamley Fault towards the Canegrass Lobe. Two short lines normal to one another were located over the area of shallower basement on the south side of the Murray River.

5.1.2 Detector Arrangement

The typical refraction spread consisted of twenty-four detector stations at nine hundred feet intervals, covering 20,700 feet.

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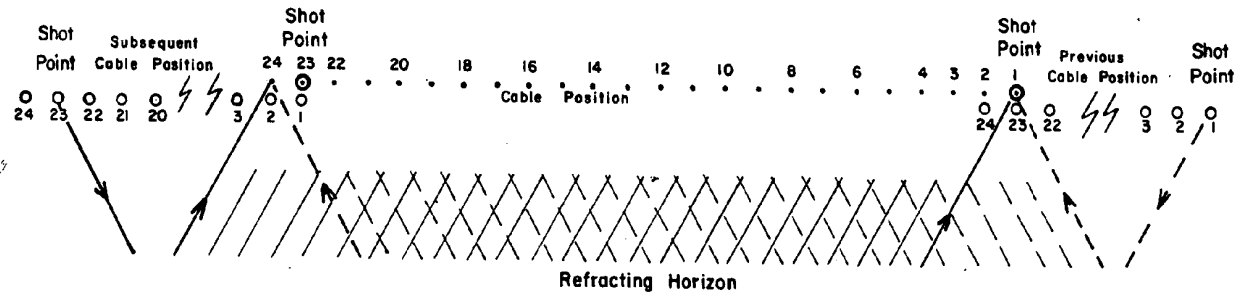
TYPICAL REFRACTION SPREAD



SPREAD DESCRIPTION

Geophones per spread	96.	Normal distance between groups	900ft.
Number of groups	24.	Geophones buried in	10' dia. cluster.
Geophones per group	4.	One group overlap between spreads.	
Spread Length	20,700ft.		

INSTRUMENTS

Geophones	National Geophysical Co.	12LF.	8cps.
Amplifiers	National Geophysical Co.	26AA.	
Camera	National Geophysical Co.	4A.	
Tape Recorder	Techno Model	401B.	

TYPICAL CONDITIONS

Charge Size	50-300lbs.
Hole Depth	60-80feet.
Optimum Filter	3.5-57cps.
A.G.C.	Medium.

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by
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O.E.L. 39 S.A.

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Figure 2a

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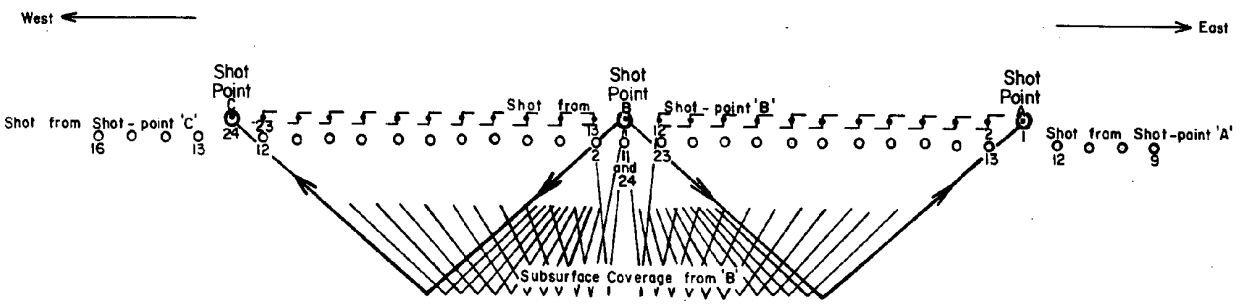
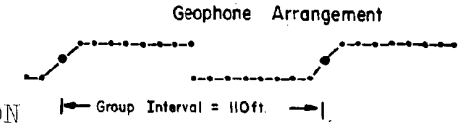
TYPICAL REFLECTION SPREAD





SPREAD DESCRIPTION

Geophones per spread	384.	Normal distance shot-point to centre of nearest group	137ft.
Number of groups	24.		
Geophones per group	16.	Distance between geophones in group	7ft.
Normal distance between groups	112ft.		

INSTRUMENTS

Geophones	Electro-tech, E.V.S.2-20cycle.
Amplifiers	National Geophysical Company 26AA.
Circuits	Unmixed.
Camera	National Geophysical Company, 4A.
Tape Recorder	Techno Model 401B.

TYPICAL CONDITIONS

Charge size	10 - 25lbs.
Hole depth	80 and 20ft.
Optimum filter	18 - 72cps.
A.G.C.	Medium.

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Figure 2b

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Continuity was achieved by a nine hundred feet overlap between spreads, which reduced the surface coverage to 19,800 feet. (See Figure 2a). Group intervals were shortened to improve control around Lines 2, 8, 11 and 13, and when surface conditions limited spread lengths on Lines 6 and 7.

Detector stations were made up of four National Geophysical Company 12 LF geophones, connected in series and buried in a cluster about ten feet in diameter.

5.1.3 Recording

Monitor seismograms and magnetic tape recordings were taken simultaneously through National Geophysical Company, 24 channel Model 26AA amplifiers and preamplifiers, in conjunction with a Techno Model 401B tape recorder and field playback unit. At first, records were taken through a 2.5 to 30 c.p.s. filter peaking at 8 c.p.s. This was later expanded on the high side to a 3.4 to 57 c.p.s. filter with a peak at 17 c.p.s.

The tape recorder was operated at half the normal tape speed (3.75 inches/second instead of 7.5 inches/second).

Variations in cable resistance due to distance were offset by a compensating panel in the instrument complex.

On the closer shots automatic gain control was used and final gain settings were varied along the spread with shot distance, and some nearer geophones disconnected on end of spread shots. Time breaks and uphole signals were transmitted over R.C.A. Super Carfone radios with a 50 watt output.

5.1.4 Shooting

Shots were taken from each end of each spread and at offsets of up to three spread lengths where this was necessary to achieve continuous two-way basement coverage. On the axial line (Line 5) intermediate shots were taken at half-spread intervals to delineate the intermediate velocities, and provide additional velocity information within the Renmark Trough.

Effective charge sizes were 50 pounds at one spread offset, 300 pounds at two spreads offset and 400 pounds at an offset three spreads away from the nearest trace.

When fairly dry holes were available a mixture of "Nitropril" (prilled ammonium nitrate) with 6% diesel oil was used with a small amount of Geophex as a detonating agent.

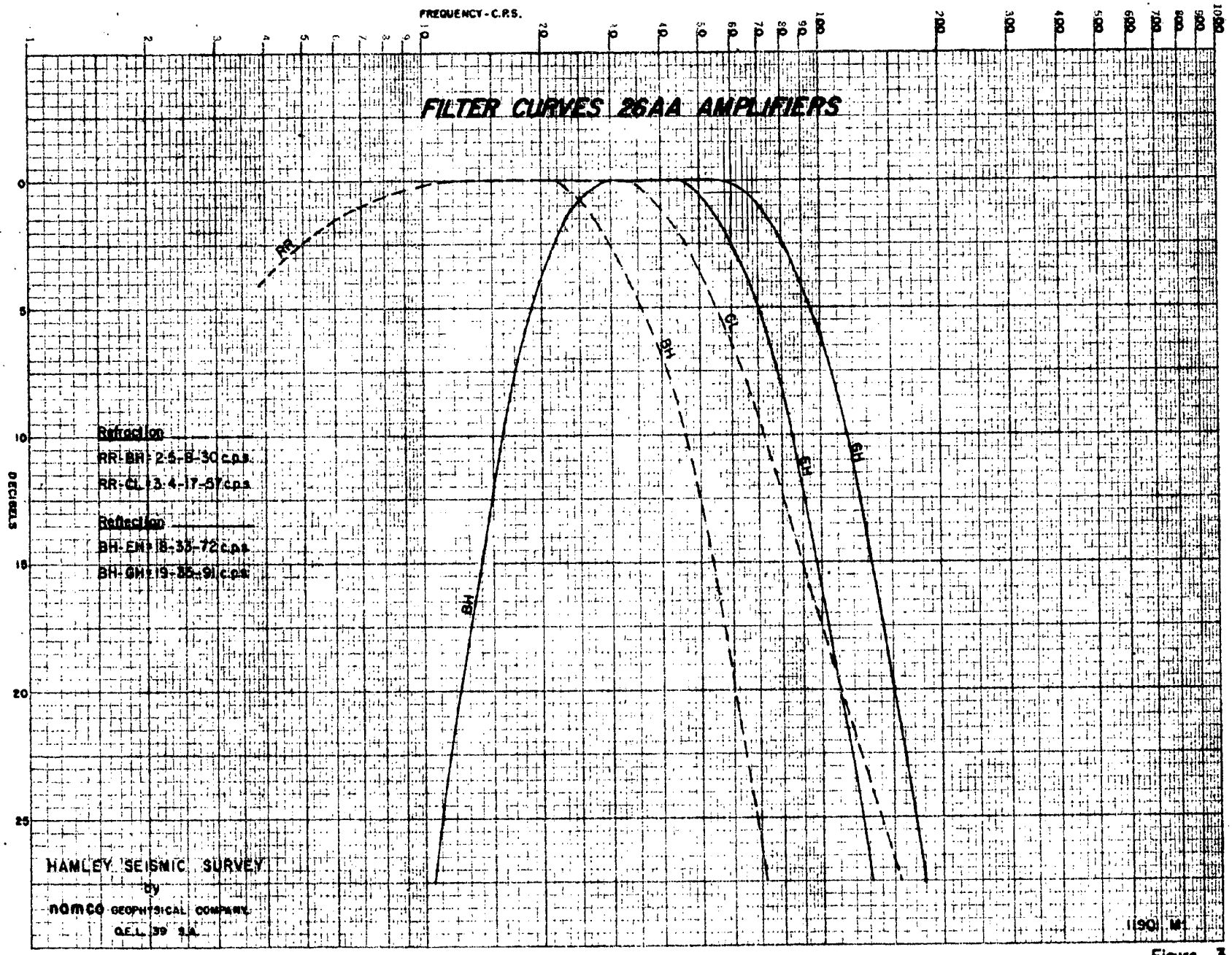

FREQUENCY - C.P.S.
FILTER CURVES 26AA AMPLIFIERS
DECIBELS
0
5
10
15
20
25
RR
BH
CL
EH
GH
Refraction
RR-BR = 2.5-8-30 c.p.s.
RR-CL = 3.4-17-57 c.p.s.
Reflection
BH-EH = 8-33-72 c.p.s.
BH-GH = 19-35-91 c.p.s.
HAMLEY SEISMIC SURVEY
by
nomco GEOPHYSICAL COMPANY
O.E.L. 39 S.A.
1190 M

Figure 3

020

5.1.5 Weathering Spreads

Over a suspected anomaly, where weathering differential was critical, short refraction spreads of 2,400 and 2,700 feet were shot to obtain better weathering control.

5.1.6 Progress

Two radio-equipped shooting trucks and graded lines accounted for a high recording rate of almost a shot per hour and an average of 0.38 miles of subsurface coverage per chargeable recording hour.

5.2 REFLECTION

5.2.1 Type of Spread

An overlapping split layout was used giving a continuous subsurface reflection profile (Figure 2b).

5.2.2 Recording

Results were recorded on magnetic tape through either a 18-72 c.p.s. or a 19-91 c.p.s. filter via 24 Channel National Geophysical Company 26AA amplifiers, and played back through a 24-58 c.p.s. filter. No mixing was used. Tape speed was 7.5 inches/second.

5.2.3 Detector Arrangement

The normal spread length was 1,350 feet over refraction lines to keep a continuous relationship with the refraction group interval of 900 feet. Sixteen (Electro-tech, E.V.S.-2 20 cycle) geophones per trace were used, with a group interval of slightly over 110 feet, and a geophone spacing of 7 feet. Away from refraction lines a 1,320 feet spread was used.

5.2.4 Shooting

Single holes were normally shot at a depth of 60-80 feet, and sixteen hole patterns were drilled to a depth of 20 feet. A charge varying from ten to twentyfive pounds was used in single holes, and forty pounds over a sixteen-hole pattern.

5.2.5 Expanding Spread

Along reflection Line "A" an expanding spread was shot using a system described by Musgrave (1962) giving a 1,320 feet subsurface coverage centred on Shot Point 54. The interpretation is given in Figure 6.

5.3 DRILLING

5.3.1 Equipment

Two air-water combination Mayhew 1000 Drills were used, each with a water tanker. A water tanker/supply truck was available during periods of high water usage.

5.3.2 Drilling Conditions

Drilling mud was needed to obtain open holes and over most of the area to drill below 80 feet. Layers of fine sand at depths as shallow as 30 feet were a constant hinderance. On the deep reflection holes south of the Murray River, circulation losses were severe enough to outstrip water supplies from a third feeder tanker despite the use of drilling mud.

5.3.3 Progress

Though the overall drilling rate was more than adequate for recording progress, the loss of a comfortable drilling lead whilst waiting for line to be cleared sometimes resulted in shallower holes than considered desirable for refraction in an area with weathering problems.

5.4 SURVEYING

5.4.1 Method

All lines were chained. Horizontal and vertical positioning was obtained with a Wild T1 theodolite with compass attachment.

5.4.2 Co-ordinate System

Co-ordinated points of the Engineering and Water Supply Department of South Australia were mainly used, effectively tying the survey to the Australian Transverse Mercator Grid, Zone 6.

5.4.3 Horizontal accuracy

Control points at each end of a forty miles traverse run east-west across the area were used to determine the compass deviation from grid north. This was also checked over a shorter distance between two different control points. A horizontal mis-tie of eight hundred feet was found between the two main control points and an internal mis-tie of sixteen hundred feet also occurred around a traverse of about ninetyfive miles. The only other internal loop of about forty miles of traverse tied within two hundred feet. These misclosures occurred along a mainly east-west direction, minimising the effect on the reduction of gravity readings.

5.4.4 Vertical Accuracy

Due partly to an intermittent mechanical fault an instrument had to be replaced and considerable re-running of lines was needed to attain the required vertical accuracy of within half a foot times the square root of the number of miles of traverse. Elevations were reduced to Mean Sea Level at Port Adelaide through Bench Marks of the South Australian Engineering and Water Supply Department.

5.4.5 Progress

The distance to offset shot points and the extreme difficulty in carrying control across the Murray River led to survey control lagging well behind recording progress. The tying in of offset shot points, correction of vertical misclosures to within gravity standards of accuracy, and the laying out and surveying of the two purely gravity lines took a further six weeks after the completion of the seismic field work.

5.4.6 Permanent Marks

Permanent marks were established at all refraction shot points.

5.5 GRAVITY

5.5.1 Field Procedure

Metering was carried out with a Worden gravity meter, occupying stations at approximately one-half mile intervals. Ties were made at approximately one hour intervals to a previously metered station to measure drift.

5.5.2 Drift

Instrument drift tended to be high, up to 0.3 milligal per hour, but was uniform and predictable. The high rate of drift was attributed to the large changes in ambient temperature: night temperatures were about 30°F. and day temperatures were as high as 80°F. No special effort was made to ensure accurate drift control, but the loop closures showed that no significant errors were caused by instrument drift.

5.5.3 Accuracy

The maximum adjustment in the least squares fitting of the gravity network was 0.03 milligal. The standard deviation was 0.01 milligal. Inaccuracies in elevation and latitude corrections are much larger, and the standard deviation of the Bouguer values is estimated to be about 0.2 mgal.

5.5.4 Datum

The survey was tied to Isogal Station 6491.9133 at Waikerie, using the "May 1965" value of 979654.36 mgal.

5.5.5 Scale Factor

The meter was calibrated over the Adelaide calibration range before and after the survey. The factor was 0.1002 mgal/div. before and 0.1003 mgl/div. after. The 0.1003 figure was used for computation.

6. QUALITY OF DATA

6.1 REFRACTION

6.1.1 General

The use of preamplifiers resulted in good, slightly overshot, refraction records. A very small proportion of poor records was taken. These records occurred when it was not possible to reload holes where there was a sudden change in area energy characteristics. However, in all except two cases, it was possible to relate a strong event back to the first break with satisfactory time ties.

6.1.2 Refractor Identification

The presence of the 16,000'/sec. refractor was often deduced rather than observed. Because of the small velocity contrast with basement a fairly thick interval between this refractor and basement would be required to obtain 16,000'/sec. first arrivals.

6.1.3 Data Accuracy

A small number of poor reversed time checks was noted; these were thought to be due to either weathering or hole fatigue. Such values were not used in depth calculations.

6.2 REFLECTION

Reflection quality varied with topography, as would be expected in sand-hill country. In the Renmark Trough, single and triple sixty feet holes returned only poor to fair quality records, the only persistent reflector being near a two-way time of .750 second. Sixteen-hole patterns at twenty feet showed a dramatic improvement with a clear, almost continuous, Lower Cretaceous (?) reflector at 1.0 second. This solved drilling problems but failed to produce a clear pre-Cretaceous picture. Along the sixteen-hole pattern part of Line "C" there is a reflector at 1.2 seconds with bridgeable gaps, but on nearby Line "D"

this is neither as clear nor as continuous, and gives an impression of being masked by multiples.

7. INTERPRETATION PROCEDURE

7.1 REFRACTION

7.1.1 Reduction to Datum

Travel times were reduced to a plane at sea level using the observed near-surface refraction velocities. A weathering correction obtained from observed uphole times was interpolated from shot point to shot point, then adjusted on an inspection of delay time plots from opposing directions in their surface and subsurface positions (see also 7.1.5).

7.1.2 Velocity Determination

A first approximation of horizontal velocities was made by averaging the apparent velocities appearing on the corrected Time-Distance Plot. A preliminary depth calculation was then made to determine the lateral movement from surface to subsurface position. Then a final velocity was calculated from the convergence or divergence of the delay times from opposite directions. The amount of lateral movement was also influenced by the shape of the opposing delay-time plots.

7.1.3 Delay-Time Concept

Delay-times were derived by subtracting the time required to travel the horizontal distance from shot to detector at the refractor velocity from the total observed travel time. The incorrect assumption that the distance travelled along the refractor is the same as the surface distance is compensated for in the depth calculations.

7.1.4 Depth Calculation

Layer thicknesses were calculated by a standard method derived from Nettleton (1940)(Equation 200), for either the subsurface entrance and emergence points of a ray, or at a midpoint adjusted by the time-depth difference scaled from the averaged delay-time plot. Vertical velocities were assumed to be equal to the horizontal velocity of the overlying refractor.

Delay-time differences were converted to depth differences by the formula -

$$\triangle Z = \triangle td. \frac{Vh . \bar{V}v}{\sqrt{Vh^2 - \bar{V}v^2}}$$

where $\triangle Z$ = Depth difference

$\triangle td$ = Delay-Time difference

Vh = Horizontal velocity of refractor

$\bar{V}v$ = Average vertical velocity to refractor

7.1.5 Weathering Spreads

A further refinement to the reduction to datum was later introduced, when weathering spreads were shot around the intersections of Lines 2, 8, 11 and 13. With the shorter spreads and closer grouping of detector stations, a near-surface refractor of 5,600'/sec. was observed, with an overlying velocity of 2,000'/sec. deduced from uphole times. The refraction lines covered by this control were then re-calculated with a near-surface velocity of 5,600'/sec. and a weathering correction made down to this layer. An attempt was made to correlate these figures with surface elevation and a correction was extrapolated to Lines 9 and 12, believed to be over similar nearsurface conditions. Where reflection spreads coincided with refraction Line 2, an amended weathering correction was made from the more precise weathering depths obtained at the reflection shot points.

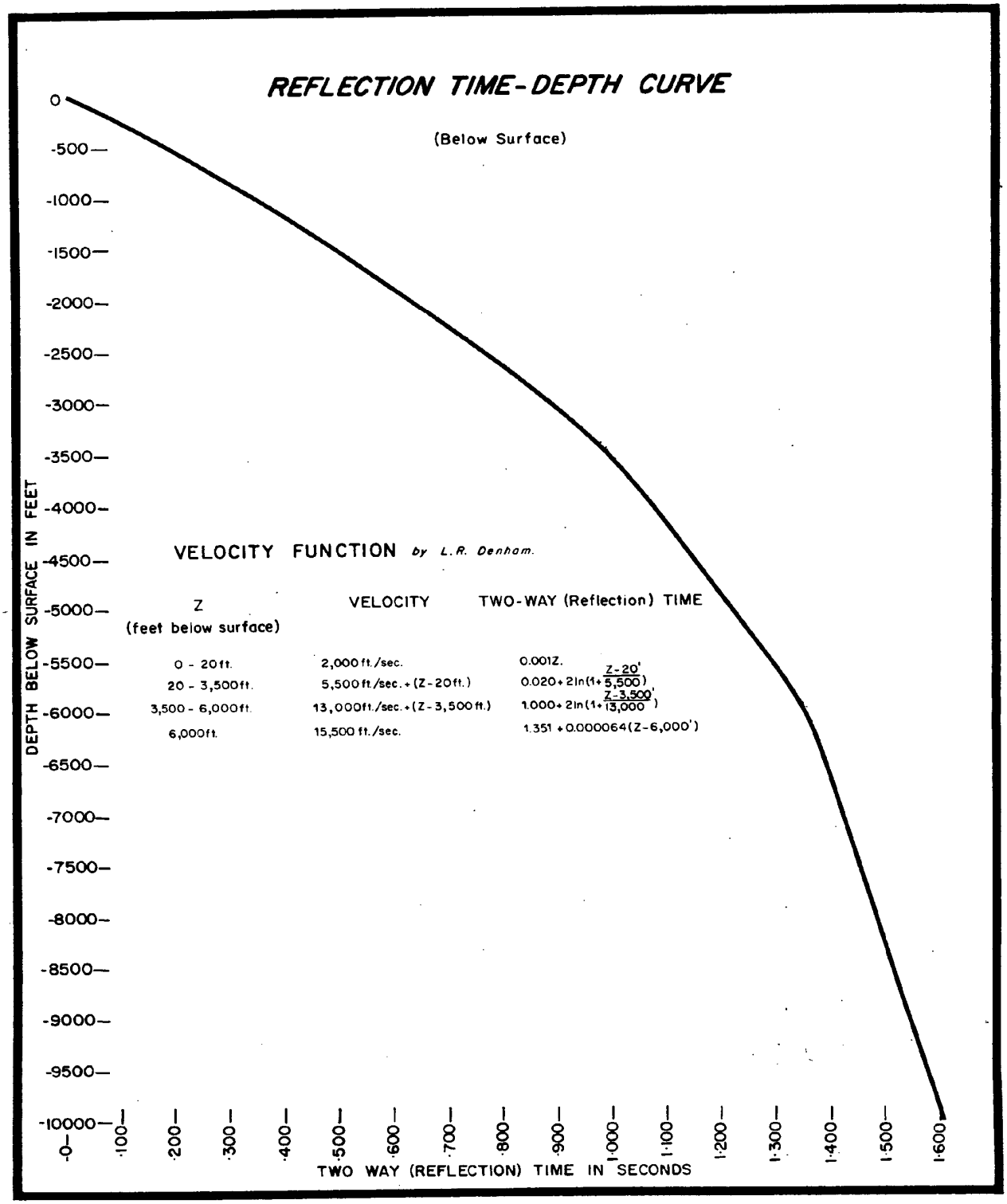
7.2 REFLECTION

7.2.1 Reduction to Datum

Observed reflection times were corrected to sea level using the standard uphole time method, with a correction velocity of 6,000'/sec. When necessary a weathering correction was derived from the first breaks. Any subsequent shots in a hole were corrected to the reference shot by the difference in uphole times.

7.2.2 Normal Moveout

Corrected wiggle trace/variable density record sections were made using a velocity function from a "delta-t" analysis of the reflection records. Below is a velocity function (Figure 4) derived by L.R. Denham at reflection Line "C" and from the expanding spread shot south of the Murray River. Refraction data was used below 3,500 feet, where there are no reliable reflections.



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11902 M1
Figure 4

	Z = 0-20'	
V = 2,000'/sec.		T = 0.001Z
	Z = 20 - 3,500'	
V = 5,500'/sec.+(Z-20')		$T = 0.020+2\ln\left(1+\frac{Z-20'}{5,500}\right)$
	Z = 3,500-6,000'	
V = 13,000'/sec. +(Z-3,500')		$T = 1.000+2\ln\left(1+\frac{Z-3,500'}{13,000}\right)$
	Z = Below 6,000'	
V = 15,500'/sec.		T = 1.351+0.000064(Z-6,000')

Where: Z = Depth below surface

V = Velocity

T = Two-way (Reflection)time in seconds

7.2.3 Corrected Record Sections

Corrected record sections were made through an Electrodynamic Instrument Corporation modified P.B. 50 playback system, using an S.I.E. GA-22 amplifier with an S.I.E. RA-7 camera, A 1/27 to 1/65 filter was used with no A.G.C.

7.2.4 Expanding Spread

A velocity analysis of an expanding spread was made using the procedure outlined by A.W. Musgrave (1962) (see also 8.2.1).

The expanding spread (Enclosure XIX) was shot simultaneously with a"reflection - refraction" spread (Enclosure XX) and conventional continuous split reflection coverage (Enclosure XVI).

7.3 GRAVITY COMPUTATION

The field data was reduced to Bouguer anomalies by Monash University Computer Centre, using the same methods as used in the Katanga Gravity Survey (Denham, 1967). The Bouguer Anomaly print-out forms Enclosure XXIII. An elevation correction density of 2.2 mgals. was used to conform with the South Australian Department of Mines maps of the area, but values for seven densities, ranging from 2.00 to 2.40 gms/ml. are listed. The computer results are filed on tape at Monash University.

The survey was allocated the reference number 6731 by the Bureau of Mineral Resources Regional Gravity Section. In order to combine this number with seismic line and station numbers, and still retain the eight figure station numbers required for the computer input, some contractions of numbers were necessary. These are listed below.

Map Numbering	Computer Numbering		
G1 to G116	6731.0001	to	6731.0116
Line 1, Stations 78 to 289	6731.1078	to	6731.1289
Line 10, Stations 78 to 166	6731.1478	to	6731.1566
Line 2, Stations 176 to 334	6731.2176	to	6731.2334
Line 11, Stations 100 to 122	6731.2500	to	6731.2522
Line 3, Stations 120 to 299	6731.3120	to	6731.3299
Line 12, Stations 100 to 190	6731.3500	to	6731.3590
Line 4, Stations 148 to 255	6731.4148	to	6731.4255
Line 5, Stations 85 to 217	6731.5085	to	6731.5217
Line 6, Stations 78 to 147	6731.6078	to	6731.6147
Line 7, Stations 78 to 145	6731.7078	to	6731.7145
Line 8, Stations 100 to 188	6731.8100	to	6731.8188
Line 9, Stations 78 to 232	6731.9078	to	6731.9232

8. DISCUSSION OF RESULTS

8.1 REFRACTION

8.1.1 General

The results of the survey are summarised in Figure 7a-e and in Enclosure IIa and b.

The full refractor sequence was 5,600'/sec., 7,000'-8,000'/sec., 14,000'/sec., 16,000'/sec. and 18,000'/sec.

In the north the eastern extent of the 14,000'/sec. refractor is defined by a major fault herein called the Chowilla Fault, running from the southeast end of Line 3, north through the junction of Lines 1 and 5. To the west of the Chowilla Fault, the 14,000'/sec. is seen to persist south almost to the Murray River. Northwest of the Hamley Fault the intermediate refractor observed on Lines 1, 3 and 10 is clearly of a higher velocity, but the 14,000'/sec. evidence on Lines 2 and 12 prevents a neat demarcation line.

The 16,000'/sec. refractor though rarely obvious, suggests a boundary between the 6,000' and 6,500' basement contours.

A major assumption has been followed throughout of a basically level 14,000'/sec. to 16,000'/sec. interface.

A difficulty arising from a 16,000'/sec. layer of greatly varying thickness has been the creation of an average vertical velocity to basement gradient, giving depth and delay-time curves of sometimes opposing attitudes.

8.1.2 Reliability of Results

In the following discussion four areas are considered separately -

(a) the Western Renmark Trough, with its eastern boundary a fault running from the southeast end of Line 3, north through the junction of Lines 1 and 5, and its northwestern boundary the Hamley Fault,

(b) the Eastern Renmark Trough, being that part of the trough east of the Chowilla Fault,

(c) northwest of the Hamley Fault, and

(d) south of the Murray River.

(a) The Western Renmark Trough

All lines in this area give clear evidence of a 14,000'/sec. layer. Lines 1 and 5 clearly demonstrate the existence of a 16,000'/sec. refractor though, as always, this disappears as the basement shallows. Line 2 gives weak indications of a 16,000'/sec. refractor with only a small segment visible shot from one direction. Line 3, with deeper section than Line 2, gives improved evidence with two-way control over a 16,000'/sec. segment. Line 9 gives no obvious indications of a 16,000'/sec. layer and this is only deduced from the intersection with Line 12.

(b) The Eastern Renmark Trough

This is covered by the south end of Line 1, the eastern shallow part of Line 5, and Line 4 in its entirety. This area appears to have a character distinct from that of the south-western part of the trough. Here the basement is covered only by a 7,400'/sec. layer in the shallower southern part, with an uncertain intermediate refractor (though obviously higher than 14,000'/sec.) appearing in the northern deeper section. Line 5 is the authority for limiting the southern extent of this extra layer.

(c) Northwest of the Hamley Fault

Here lines 2 and 12 alone show a 14,000'/sec. refractor. Line 10 does display an intermediate refractor but, though uncertain, the velocity of this seems to be greater than 15,000'/sec.

The basement depth on Line 10 has not been confidently allotted. The delay-time plot shows a disturbed, perhaps faulted, basement and there seems to be an increase in penetration near basement with an offset distance increase. The loss of two-way coverage (increased by migration) made an accurate velocity determination impossible. In view of this the depth calculation was made over the greatest possible distance to ensure a genuine basement return and minimise the effects of time loss over a possible fault. On this line only, vertical velocities were assumed to be 5% less than horizontal velocities. As, in addition, the assumed basement velocity is rather low, the result is a shallow but still realistic depth. A strike line running north-east - southwest would be necessary for an accurate depth determination.

The section appears to be thickening to the northwest of this area.

(d) South of the Murray River

Lines 6 and 7 show only a 7,000'/sec. velocity overlying basement, between 2,700' and 3,500' below sea level.

8.1.3 Faults

The Hamley Fault has been clearly defined across Lines 12, 2, 3 and 1 and indicated west of Line 9, and southeast of Line 10. Line 10 seems to disagree with the good reflection evidence of Line R1 (Renmark Seismic Survey) which implies that some fault indication should have been seen on the basement refractor shot from the southeast. At the crossing of Line 1 the Hamley Fault seems to develop into a fault set with the apparent increase in throw.

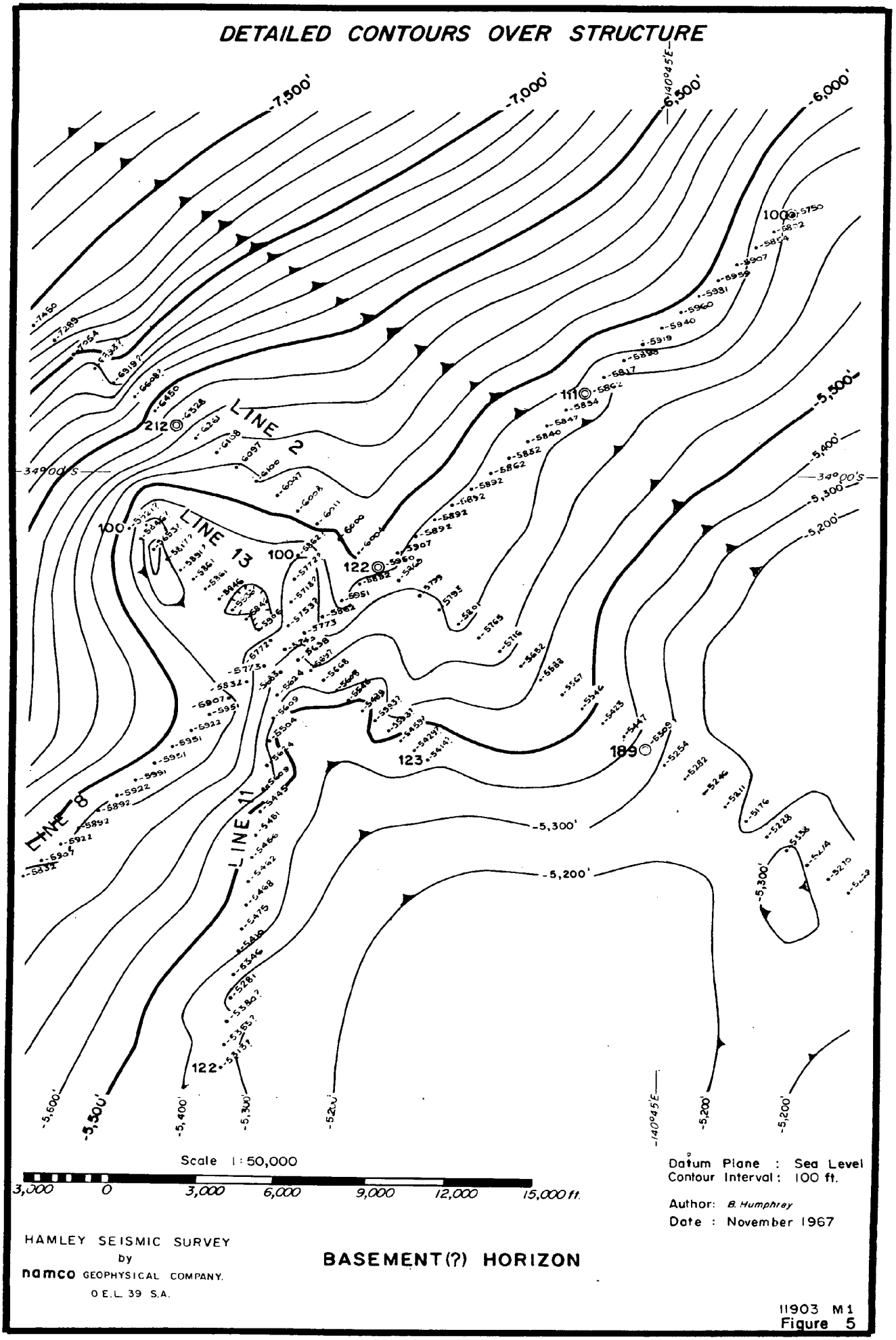
The Chowilla Fault is a major fault, disturbing the character of the eastern flank of the Renmark Trough. It is seen on the southeastern end of Line 3 and at the junction of Lines 1 and 5, and continuity between these points is inferred. This fault is not immediately evident on Line 1 but is unmistakeable on Line 5.

Two small faults, the southeasterly of which is considered doubtful, are shown at the south end of Line 1 and extended westwards to form a small fault complex.

Refraction evidence tends to indicate a narrow zone rather than pinpoint the positions of faults.

8.1.4 Possible Closed Structures

In this section, only points of turnover within the area where a 14,000'/sec. refractor has been demonstrated are mentioned.


DETAILED CONTOURS OVER STRUCTURE
-7,500'
-7,000'
-6,500'
-6,000'
-5,500'
-5,400'
-5,300'
-5,200'
-5,600'
-5,500'
-5,400'
-5,300'
-5,200'
-5,300'
-5,200'
-5,200'
140°45'E
34°00'S
LINE 2
LINE 13
LINE 8
LINE 11
212
111
100
122
123
189
Scale 1:50,000
3,000 0 3,000 6,000 9,000 12,000 15,000 ft.
Datum Plane : Sea Level
Contour Interval : 100 ft.
Author: B. Humphrey
Date : November 1967
HAMLEY SEISMIC SURVEY
by
namco GEOPHYSICAL COMPANY.
O.E.L. 39 S.A.
BASEMENT(?) HORIZON
11903 M1
Figure 5

The only attempt to detail a closed structure was made around the junction of Lines 2, 8, 11 and 13 (Fig. 5). In this area, on the south-eastern limb of the Trough, basement is considered to be too shallow to be able to detect a 16,000'/sec. refractor. There is good data on the 14,000'/sec. refractor and a possible minor closure is developed at the basement level. However the results of Lines 11 and 13 failed to pinpoint its culmination and the southerly closure is problematical.

Indications of reversal on other lines are discussed below:

Line 1. There are two indications of reversal in the 14,000'/sec. refractor, each of about eighty feet: around station 174 and, more doubtfully, at station 204.

Line 2. Areas of interest in the 14,000'/sec. refractor near station 230 were detailed using reflection methods and are discussed under these results. On the upthrown side of the Hamley Fault around station 320 basement turnover with three hundred to four hundred feet of reversal is seen, with no information on the shape of shallower refractors. The southwest plunge from Line 3 and the shallow basement depth make this prospect less attractive.

Line 3. Though a reversal in the 16,000'/sec. refractor is shown at station 237, this is dependent on one way control.

Line 4. There are three possible points of basement turnover between stations 211 and 233, complicated by a vertical velocity change with the thinning and disappearance of the 15,000'/sec. (?) refractor. The 15,000'/sec. (?) refractor gives fair indication of turnover near station 241.

Line 9. At station 185 basement reversal of three hundred feet is shown over a distance of about $1\frac{1}{2}$ miles; this section has already been adjusted for apparent residual weathering, so the structure has been minimised. Basement contours suggest a ridge running through here and the turnover point on Line 12. A reversal of about one hundred and fifty feet is seen at station 128 with a basement depth of 5,600 feet.

Line 12. The basement turnover at station 131 shows about two hundred feet of reversal. In the 14,000'/sec. refractor about fifty feet of reversal is shown at station 116.

8.2 REFLECTION

8.2.1 Line "A"

A clearly identifiable basement reflection level, with gentle undulations at 0.75 seconds show about ten milliseconds of turnover around shot point 54. The only other obvious reflector is about five hundred feet below sea level.

On the Expanding Spread shot concurrently with Line "A", four pickable reflections appear above basement, two of these have the average velocity characteristics of multiples, and a later than basement reflector is identified as a multiple. The results of this analysis (Fig. 6) show an increase of interval velocity with depth from 5,800'/sec. to 8,800'/sec. and the depth calculation gives a basement fifty feet shallower than the refraction interpretation on Line 7. This difference is less than the errors which could be expected with either seismic method.

8.2.2 Line "C"

The deepest reflector, around 1.2 sec., displays a very similar shape to the basement refractor on Line 2, though shallower and with less northwest dip. There is about a hundred feet of reversal at shot points 73 and 76, and about twice this over a stretch enclosing these two points which corresponds with the area of reversal on refraction Line 2 between stations 200 and 213 (Reflection shot points 70 to 78).

The lower Cretaceous (?) reflector, which appears to be somewhat deeper than the 14,000'/sec. refractor, shows very gentle northwest dip with small reversals at shot points 67, 74, 78 and 91. About 0.2 seconds above this a strong, persistent reflection displays a basically level attitude with still milder versions of the reversals in the lower level. The shallower of these two reflections is the "K" reflection and the deeper the "L" reflection of the Renmark Seismic Survey.

A reversal of about 0.015 sec. at shot point 91 at the "K" horizon level coincided with a slight reversal on the 14,000'/sec. refractor (refraction station 230). To evaluate this structure, line D was shot to determine whether north dip were present.

8.2.3 Line "D"

The southern half of the line gives some pre-Cretaceous indications of three hundred to four hundred feet of north dip. The reflector referred to above as lower Cretaceous shows gentle south dip and is paralleled by a strong reflector about 0.2 seconds shallower. This indicates that there is little chance of the reversal noted on Line C being a closed structure; no further shooting was done over this structure.

8.3 GRAVITY

The gravity results are summarised by the Bouguer Anomaly contours shown on Enclosure XXI a and b.

The most striking feature of the gravity results is the expression of the Hamley Fault as a zone of steep Bouguer anomaly gradient with more negative values on the downthrown side of the fault. The Renmark Trough is outlined as a gravity low, with the lowest values at the southwestern end. This area may be the area of thickest Tertiary - Cretaceous section, as well as an area of thick pre-Cretaceous section.

The Chowilla Fault is recognisable as a zone of fairly steep Bouguer Anomaly gradient, but the change in gravity over this fault is only about 7 mgals., whereas the change over the Hamley Fault is about 20 mgals. This difference may be caused by the Hamley Fault extending into the Cretaceous section, while the Chowilla Fault does not. Both faults have comparable throws at basement level.

Lines 6 and 7 show very little Bouguer gradient, in an area where the metamorphic basement is almost completely flat.

West of the Hamley Fault, where there is seismic control the gravity profiles agree in detail with the basement profile. As an example the two crests of the Canopus High on Line 2, at stations 300 and 320, are represented by a double maximum in the Bouguer anomaly, at stations 297 and 322.

From these observations it can be seen that there is good qualitative agreement between basement shape and Bouguer anomaly over the whole of the area covered by the seismic work, and it appears safe to interpret gravity data in the areas with no seismic coverage by identifying Bouguer highs and lows as basement highs and lows.

West of the Canopus High the regional gravity traverses show two major lows separated by a high. These gravity features are all subparallel to the Hamley Fault. The two lows probably represent areas of thick sedimentary section, and the high between them suggests a basement high similar to the Canopus High. Analogy with Bouguer anomalies where there is seismic control over the Canopus High suggests that basement is at about -4000 feet in the deepest parts of the two lows, and at about -1000 ft. over the crest of the high. Thus it is inferred that the pre-Cretaceous pinches out on the flanks of this high and that in the axial area the Tertiary probably rests directly on basement.

9. CONCLUSIONS

9.1 CONTRIBUTIONS TO GEOLOGICAL CONCEPTS

9.1.1 General

The Hamley Seismic Survey has been successful in obtaining greater detail regarding the form of the Renmark Trough and in mapping the general distribution and thickness of the major segments of the sedimentary sequence. It was not successful in locating favourable drilling locations in and adjacent to the Trough. The gravity results appear to have been successful in providing further information on the form and sequence of the Canegrass Lobe.

9.1.2 Structure

The major new structural element located by the survey was the Chowilla Fault which controls the northern part of the eastern flank of the Renmark Trough.

The initial concept was of the Renmark Trough as a half graben feature with the western side controlled by the Hamley Fault and the eastern flank a structural and probable deposition hinge. It was hoped that favourable structural features would be present in this predicted eastern hinge area.

The seismic work has shown that the northern part of the Renmark Trough is a full graben controlled by faults with throws of the order of 5,000 feet at basement level. The unfaulted eastern hinge area is limited to the southern part of the survey and in this zone the structural conditions are not encouraging. There do not appear to be major closures associated with either of the faults.

The southern boundary of the Renmark Trough is beyond the survey area and it is possible that the Trough may continue into that part of Oil Exploration Licence 39 southwest of Kingston-on-Murray.

The gravity data indicates that the Canegrass Lobe consists of two troughs separated by a basement high. This high, which passes through section G92 may have some potential although it is very likely that basement is at less than 1500 feet over the crest and is overlain by the unprospective Tertiary section.

9.1.3 Stratigraphy

The pre-Cretaceous section has a maximum thickness of 7,000 feet in the deepest part of the Trough. It can be divided into an upper layer with a velocity of 14,000 ft/sec. identified as Permian, and a lower layer, presumably pre-Permian, possibly Devonian, with a velocity of about 16,000 ft/sec.

The pre-Permian is basically limited to an axial zone of the Trough about 12 to 15 miles wide where basement depths are greater than about 6000 - 6500 feet. This section thins generally from about 5000 feet in the north to about 2000 feet in the south. Although the data are not conclusive it is probable that this pre-Permian extends, as thin sections, eastwards beyond the Chowilla Fault into the area around the northern half of Line 4 and westwards beyond the Hamley Fault into the area of Lines 10 and 12.

In the axial zone of the Trough the Permian is of the order of 2500 - 3000 feet thick. In the north only thin sections extend beyond the Hamley and Chowilla Faults. In the south the Permian extends onto a "shelf" area between Line 8 and the Murray River. The Permian also extends westward across the southern part of the Hamley Fault into the Canegrass Lobe where the maximum thickness is probably greater than 3000 feet. The gravity data suggest that it pinches out on the flanks of a basement high in the central part of the Lobe.

The seismic data suggest that the Cretaceous does not extend very far into the Canegrass Lobe and that in the central and western parts of this zone the Tertiary rests directly on basement. In the southern axial area of the Trough the Cretaceous is probably 2000 feet thick. It appears to thin to the north.

The major zones of interest in the Cretaceous are associated with the potential reservoir sands at the base of the thicker sections. In the east these are limited by onlap onto rising basement but are probably present wherever the depth to basement is about 2500 - 3000 feet or greater. The basement depths on Lines 6 and 7 and the data from the Department of Mines Refraction Probe A, 18 miles east of Berri, indicate that comparatively thick Cretaceous sections are present in a lobe extending southeast from Renmark, probably into Victoria. This lobe forms a saddle between the basement high in the Loxton area in the south and that in the Lake Victoria area to the north.

The Tertiary section appears to be thickest in the central part of the Trough where the maximum section is probably 1700 - 2000 feet. The thickest section drilled was 1740 feet in A.O.C. North Renmark No.1. The Tertiary thins on the flanks of the Trough.

9.1.4 Drilling Sites

The most promising structure located by the survey was a minor basement feature near the northwest end of Line 13. This high has a problematical closure of about one hundred feet over one square miles in an area where basement depth is 5700 - 6000 feet. Several other very minor reversals were noted.

9.2 VALUE OF SEISMIC AND GRAVITY METHODS

9.2.1 Refraction

The seismic refraction method is an efficient and economical method of structural mapping in the area of the survey, but the comparatively small velocity contrasts and large near surface variations make it unsuitable for detailed mapping of small structures.

9.2.2 Reflection

Reflection shooting can be used for mapping Cretaceous structure, but record quality is not good, and drilling is still a problem. No reliable reflections have been obtained from the pre-Cretaceous section, and it is doubtful whether a practical economic technique for obtaining deep reflections could be evolved.

9.2.3 Gravity

Gravity surveying is an effective reconnaissance method in this area.

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APPENDIX I

EQUIPMENT AND SUPPLIES.

Recording

24 Channel amplifiers (National Geophysical Company Model 26AA) capable of recording either reflections or refractions.

1 Set of refraction pre-amplifiers.

1 Techno Model 401B tape recorder with field playback 2-speed (3.75 and 7.5 inches/sec.) six or twelve seconds recording time, modified for low frequency recording.

100 National Geophysical Company 12LF, 8 cps. refraction geophones.

1 Complete set of refraction cables with take-outs for 200 or 300 metre group intervals, 24 channel.

All recording spare parts and supplies, including photographic papers and chemicals.
1 set of quarter mile reflection cables with C.D.P. capacity.
500 EVS-2, 20 cps., geophones in strings of eight.

3 R.C.A. Super Carfone Radios for time-break and communications.

1 International 160, 4 x 4 recording truck complete with instrument cab and cable reel.

1 Toyota 4 x 4 cable truck, complete with seismometer racks.

Drilling

2 Mayhew 1,000 combination air-water drills, mounted on International R192 4 x 6 trucks, 667 cfm air compressors, Gardner-Denver 5" x 6" water pumps.

2 International 160 4 x 4 water trucks, with 800-gallon flat-bed tanks.

1 International RF190 4 x 6 water truck with 1,200-gallon water tank.

Shooting

2 Toyota 4 x 4 shooting and cable trucks, complete with squirters and seismometer baskets.

1 Explosives magazine.

2 Sets of shooting equipment, including multi-hole blasters.

Surveying

2 International Scout 4 x 4 survey trucks.

1 Complete set survey equipment with Wild T.1 theodolite.

Field Office

1 Office caravan.

1 Complete set of office furniture.

1 Toyota 4 x 4 truck for field administration.

APPENDIX I (contd.)

Camp Equipment

1 Kitchen-shower-diner caravan, completely equipped for messing 25 men.

1 Complete set of tents, bedding, etc., for crew accommodation with provision for visitors.

1 Workshop trailer.

1 Royal Flying Doctor Service radio communications set.

1 Royal Flying Doctor medical kit.

1 Onan power unit

Gravity Survey (Mines Administration Pty. Ltd.)

1 Worden gravity meter, No. 216

1 Short wheel-base Landrover.

Line Clearing (A. Hearne)

1 International TD15A bulldozer.

1 Allis Chalmers HD11 bulldozer.

1 Allis Chalmers grader.

APPENDIX II

PERSONNEL

Party Chief	Bryan Humphrey
Party Manager	D. Mackenzie
Surveyors	G. Cozby (May 26th - June 5th) G. Smith (June 5th - Sept. 10th) B. Robb (July 5th - Aug. 3rd)
Computer	B. Thomas
Observers	J. Lane (June 3rd - July 17th) D. Laing (July 17th - Aug. 8th)
Drillers	W. Johnson J. Withers
Gravity Meter Operator	D.A. Short (Mines Administration Pty. Limited)

Technical and administrative supervision for the contractor was provided by Mr. H.E. Bowman.

Geophysical supervision for the client was provided by Mr. L.R. Denham, Mines Administration Pty. Limited.

The final report was written jointly by H.E. Bowman and B. Humphrey (Namco Geophysical Company) and L.R. Denham and V.G. Swindon (Mines Administration Pty. Limited).

APPENDIX III (contd.)

Average shots per recording field hour	1.24
Total miles of subsurface coverage	16.7
Number of corrected tapes played back (Plus 10 re-played in different filters)	98
Days lost due to holidays	Nil
Days lost due to weather	Nil
Days lost due to equipment failure	Nil
Total pounds of dynamite used	2,470
Total pounds of Ammonium Nitrate used	Nil
Average charge per shot	27.75
Number of holes drilled	825
Total footage drilled	20,825
Average depth of hole, feet	25
Average depth of charge, feet (Midpoint)	24
Total field hours, drilling	228.2
Total driving hours, drilling	42.5
Average footage per field hour	91
Total detonators used	685
Rock bits used	Nil
Insert bits used	15
Starter bits used	3
Total diesel (with Ammonium Nitrate)	Nil
Total bulldozing hours	36.5
Total grader bours	10.0
Drilling Mud used	Nil

Gravity (by Mines Administration Pty. Limited)

Metering commenced	28th July, 1967
Metering completed	30th August 1967
Number of stations metered	525
Number of days metering	23

The following statistics apply to regional gravity lines only:-

Surveying commenced	10th August, 1967
Surveying completed	21st September, 1967
Number of days surveying	12
Bulldozing hours	62.5
Grading hours	38.5

APPENDIX III (contd.)

Average shots per recording field hour	1.24
Total miles of subsurface coverage	16.7
Number of corrected tapes played back (Plus 10 re-played in different filters)	98
Days lost due to holidays	Nil
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Total driving hours, drilling	42.5
Average footage per field hour	91
Total detonators used	685
Rock bits used	Nil
Insert bits used	15
Starter bits used	3
Total diesel (with Ammonium Nitrate)	Nil
Total bulldozing hours	36.5
Total grader bours	10.0
Drilling Mud used	Nil

Gravity (by Mines Administration Pty. Limited)

Metering commenced	28th July, 1967
Metering completed	30th August 1967
Number of stations metered	525
Number of days metering	23

The following statistics apply to regional gravity lines only:-

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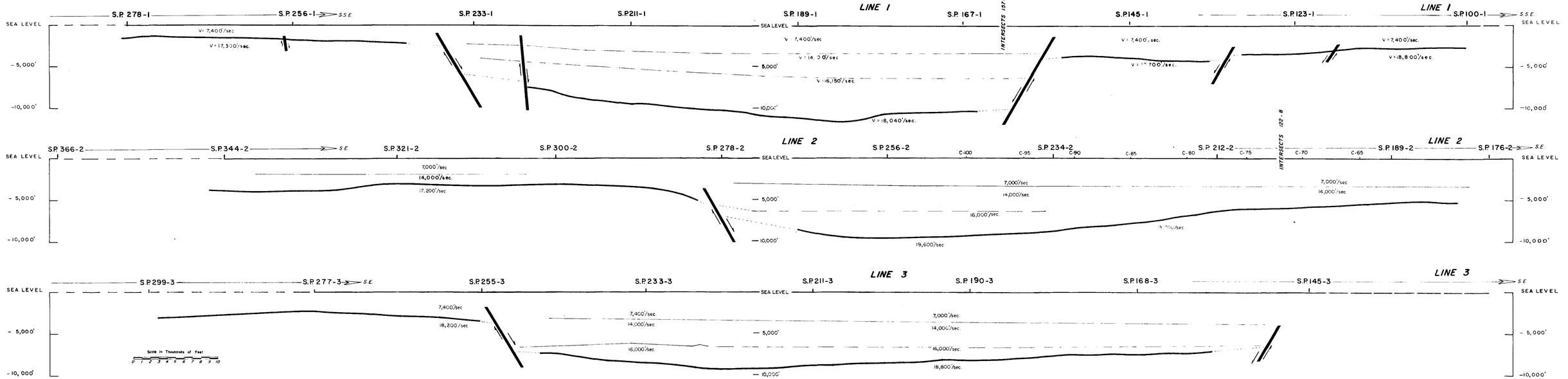
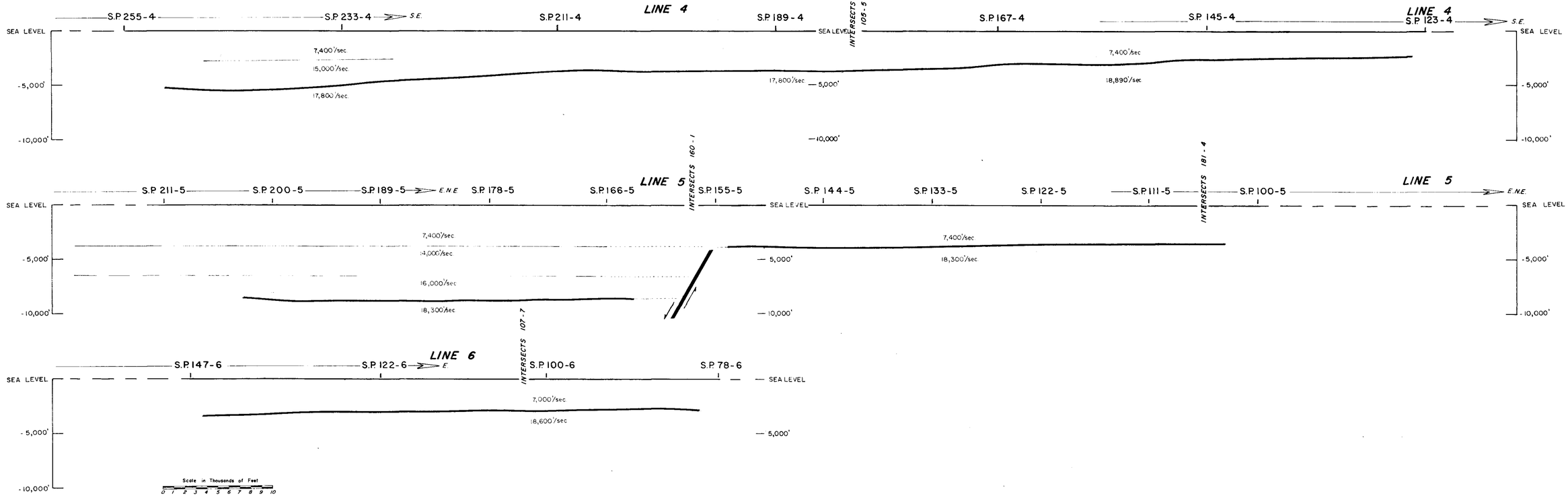


HAMLEY SEISMIC SURVEY
by
namco GEOPHYSICAL COMPANY.
O.E.L. 39 S.A.

CONDENSED DEPTH SECTIONS

REFRACTION
LINES 1,2,3.
11905 M 1

Figure 7a



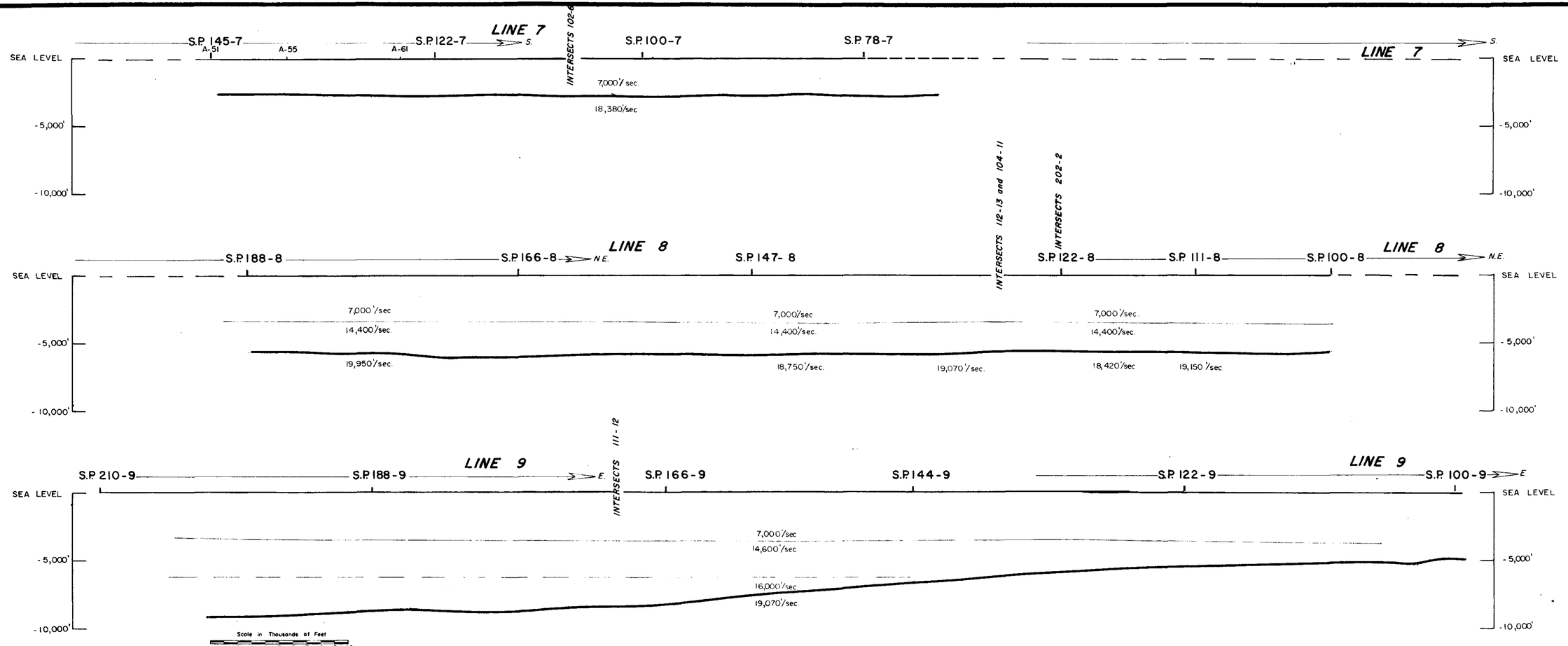
HAMLEY SEISMIC SURVEY
by
namco GEOPHYSICAL COMPANY.
O.E.L. 39 S.A.

CONDENSED DEPTH SECTIONS

REFRACTION
LINES 4,5,6.
11906 M 1

Figure 7b

824-28



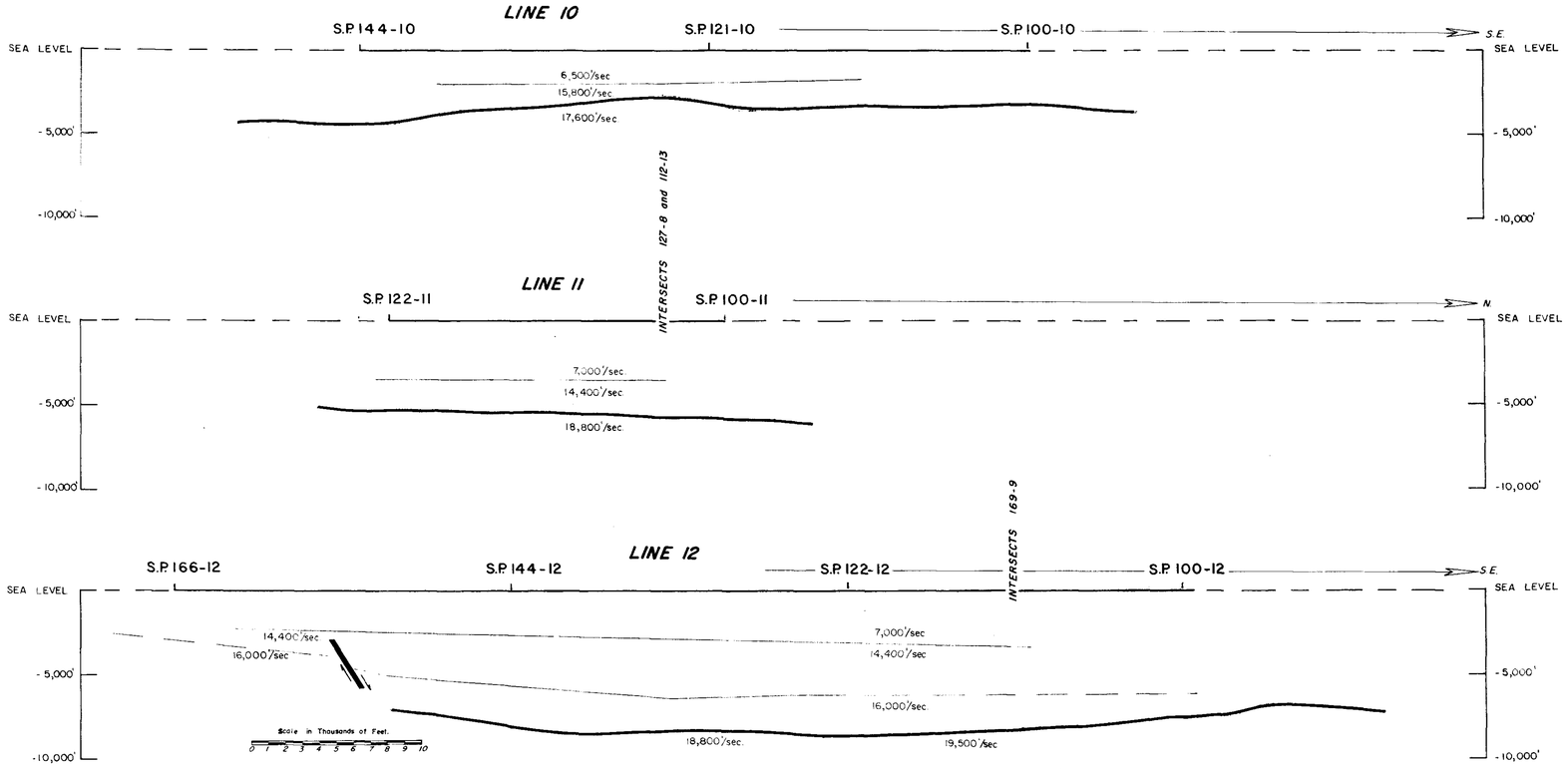
HAMLEY SEISMIC SURVEY
by
namco GEOPHYSICAL COMPANY.
O.E.L. 39 S.A.

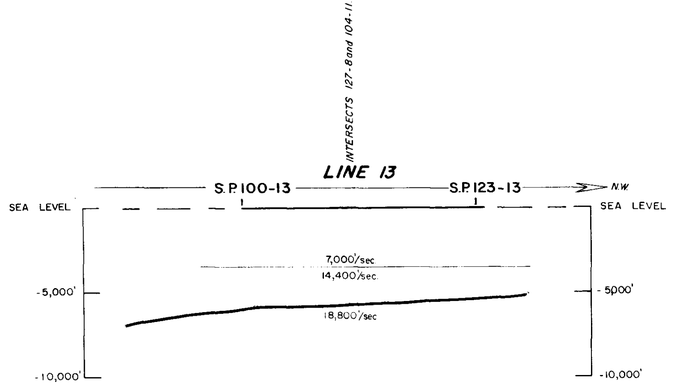
CONDENSED DEPTH SECTIONS

REFRACTION
LINES 7, 8, 9.
11907 M1

Figure 7c

824-26





HAMLEY SEISMIC SURVEY
by
namco GEOPHYSICAL COMPANY
OEL 39 SA

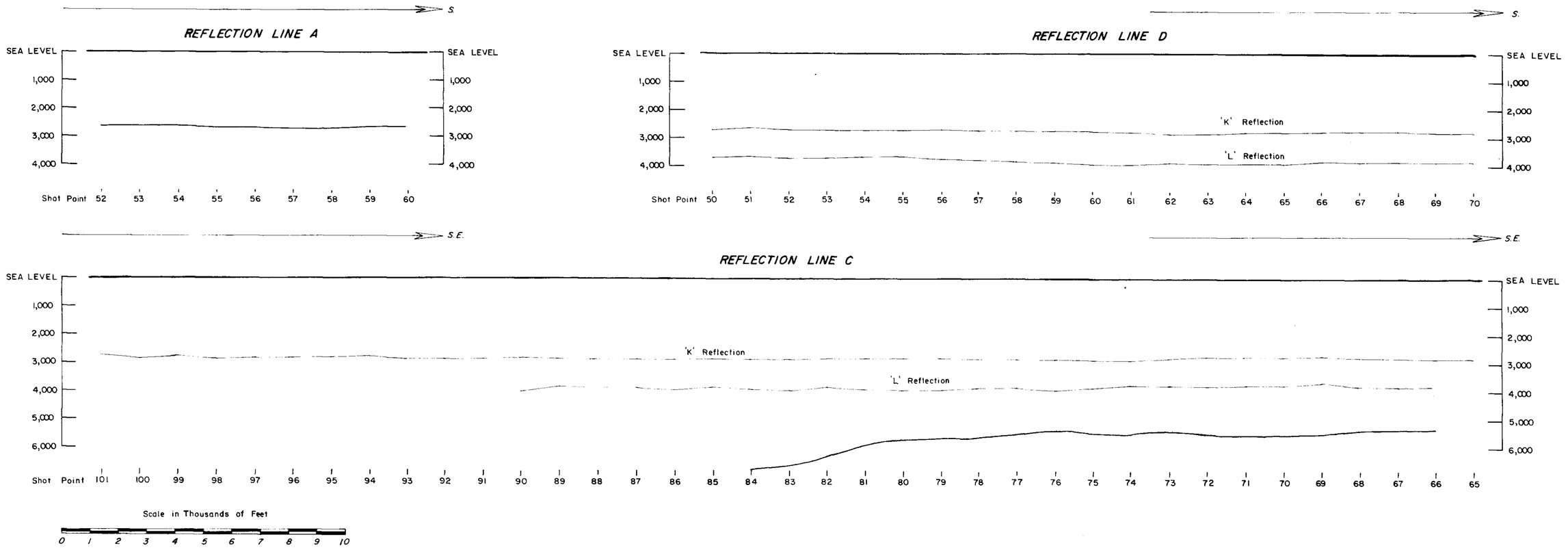
CONDENSED DEPTH SECTIONS

REFRACTION
LINES 10, 11, 12, 13.
11908 M 1

Figure 7d

824-27

CONDENSED DEPTH SECTIONS



HAMLEY SEISMIC SURVEY
by
namco GEOPHYSICAL COMPANY.
O.E.L. 39 S.A.

REFLECTION LINES A, C, D.
11909 M1

Figure 7e

824-25

CANEGRASS LINE

MONASH LINE

LINE 1 · LINE 2 · LINE 3 · LINE 4 · LINE 5 · LINE 6 · LINE 8 · LINE 10

R1 · R2 · R5 · R7

BM 20-774 · BM 9-774 · BM 4-774

MURRAY RIVER

S.A. · VIC.

N. S. W.

33°30' · 33°40' · 33°50' · 34°00'

140°00' · 140°10' · 140°20' · 140°30' · 140°40' · 140°50' · 141°00'

Scale 1:100,000

YARDS · METRE · MILES

SEISMIC SHOT-POINTS

- BEACH PETROLEUM
- SOUTH AUSTRALIAN MINES DEPT. (Reflection)
- RENMARK SEISMIC SURVEY
- HAMLEY SEISMIC SURVEY
- REFRACTION STATION
- REFRACTION SHOT-POINT
- REFLECTION SHOT-POINT
- G1 GRAVITY STATION
- SOUTH AUSTRALIAN MINES DEPT. (Refraction) - Approximate positions only
- SURVEY CONTROL POINT

1	2	3
4	I54/6 Chowilla 5	6

ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE 39 S.A.

HAMLEY SEISMIC SURVEY

SHOT-POINT LOCATION and ELEVATION MAP

Surveyor G. Smith	Date November, 1967	
namco GEOPHYSICAL COMPANY	M.A.P. No. 11910	FILE LOC. M2

ENV 824-1

Enclosure I (a)

S.A.

S.A. VIC.

O.E.L. 39

O.E.L. 37

LINE 2

LINE 13

LINE 11

LINE 8

LINE 12

LINE 9

LINE 7

LINE 6

R1

R2

R3

R4

A.O.C. North Renmark No. 1

Renmark

Murray

No. 3 Lock

Kingston-on-Murray

Lake Bonney

BWOOLPUNDA WATER TOWER

B.P.N.L. Monash No. 1

B.P.N.L. Berri North No. 1

B.P.N.L. Berri South No. 1

Barmera

Berri

Loxton

Yinkanie

Maggea

Scale 1:100,000

1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 YARDS

2000 0 2000 4000 6000 8000 METRES

2 0 2 4 MILES

SEISMIC SHOT-POINTS

- BEACH PETROLEUM
- SOUTH AUSTRALIAN MINES DEPT (Reflection)
- RENMARK SEISMIC SURVEY.
- HAMLEY SEISMIC SURVEY
- REFRACTION STATION
- REFRACTION SHOT-POINT
- REFLECTION SHOT-POINT
- G1 GRAVITY STATION
- SOUTH AUSTRALIAN MINES DEPT (Refraction) – Approximate Positions Only
- SURVEY CONTROL POINT

1	2 154/10 Renmark	3
4	5	6

ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE 39 S.A.

HAMLEY SEISMIC SURVEY

SHOT-POINT LOCATION and ELEVATION MAP

Surveyor G. Smith	Date November, 1967	
namco GEOPHYSICAL COMPANY	MAP No. 1191	FILE LOC. M2

ENV 824-2

Enclosure I (b)

CANEGRASS LINE

NONAWISH

FAULT

Limit of Pre-Cretaceous Sediments

HAMLEY TROUGH

REMMARK TROUGH

Limit of Pre-Cretaceous Sediments

LINE 1

LINE 2

LINE 3

LINE 4

LINE 5

LINE 6

LINE 7

LINE 8

LINE 9

LINE 10

LINE 11

LINE 12

LINE 13

LINE 14

LINE 15

LINE 16

LINE 17

LINE 18

LINE 19

LINE 20

LINE

HAMLEY FAULT

RENMARK TROUGH

S.A.

S.A. VIC.

LINE 1 LINE 2 LINE 3 LINE 4 LINE 5 LINE 6 LINE 7 LINE 8 LINE 9

AOC North Renmark No.1

Renmark 1067 m

Sediments 1979 m

Limit of Pre-Cretaceous Sediments

1372 m

1524 m

1676 m

2591 m

2743 m

2896 m

3048 m

3200 m

762 m

914 m

610 m

O.E.L. 39

O.E.L. 37

Murray

No.3 Lock

Kingston-on-Murray

Lake Bonney

Barmera

Berri

Yinkanie

Loxton

Maggea

B.P.N.L. Monash No.1

B.P.N.L. Berri Extn. No.1

B.P.N.L. Bern South No.1

Loxton Fo... T.D. ~1,650 ft... Basement not r...

'A'

6,700'/2 sec 3,200'

Scale 1:100,000

SEISMIC SHOT-POINTS

- BEACH PETROLEUM
- SOUTH AUSTRALIAN MINES DEPT. (Reflection)
- RENMARK SEISMIC SURVEY
- HAMLEY SEISMIC SURVEY
- REFRACTION STATION
- REFRACTION SHOT-POINT
- REFLECTION SHOT-POINT
- G1 GRAVITY STATION
- SOUTH AUSTRALIAN MINES DEPT. (Refraction) — Approximate Positions Only.

1	2	3
4	5 I54/10 Renmark	6

ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE 39 S.A.

HAMLEY SEISMIC SURVEY

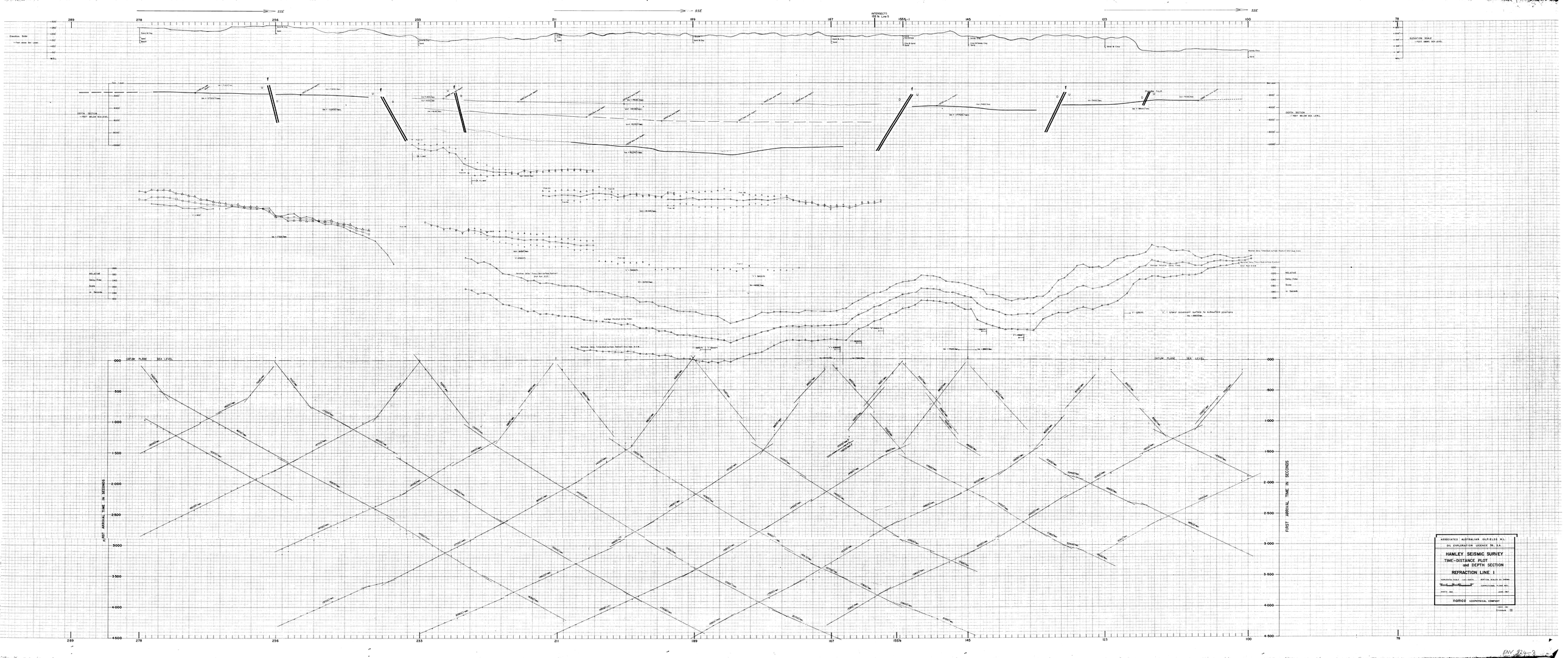
BASEMENT (?) STRUCTURE MAP

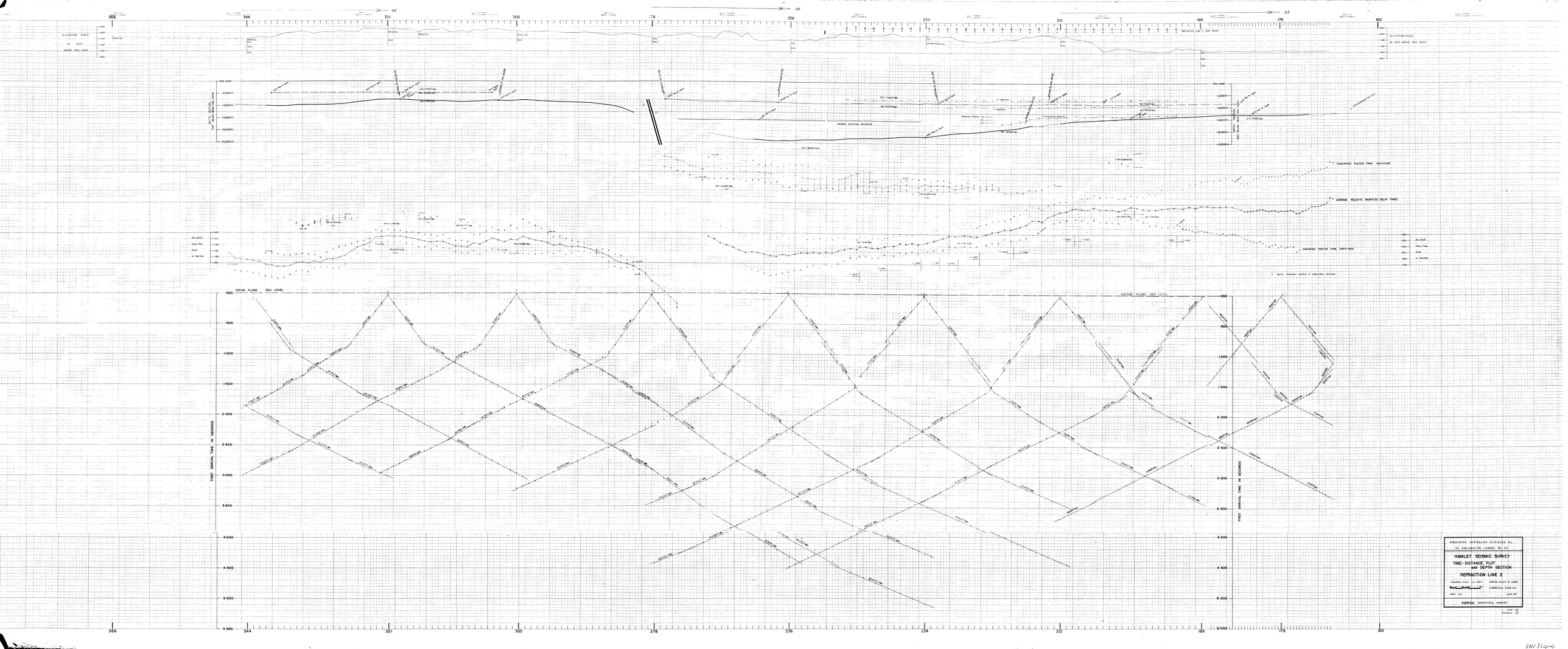
Contour Interval: 500ft Datum Plane: Sea Level

Author B Humphrey	Date November, 1967	
namco GEOPHYSICAL CO.	MAP No. 11313	FILE LOC. M 2

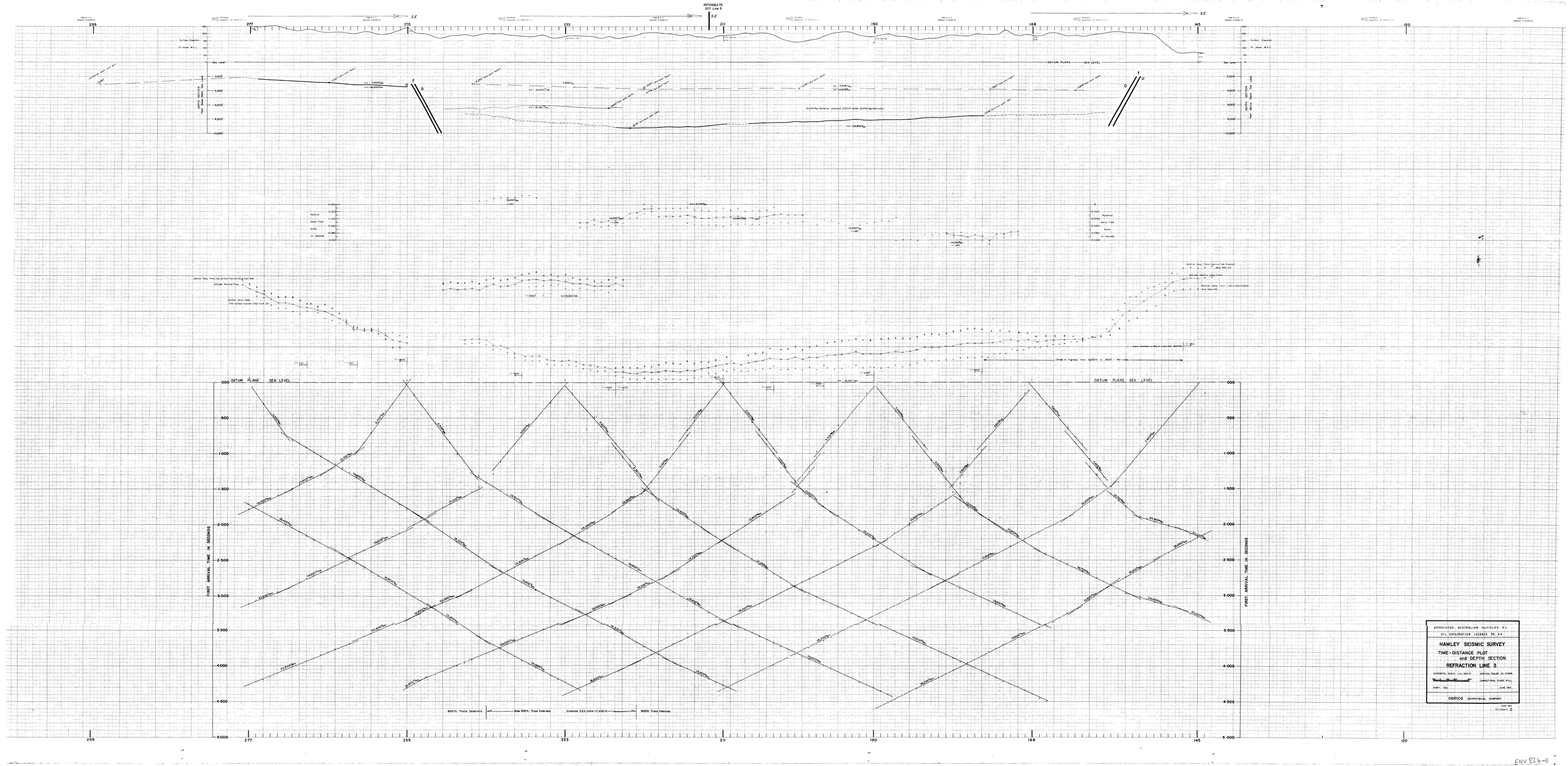
ENV. 824

Enclosure III(b) ENV 824-23

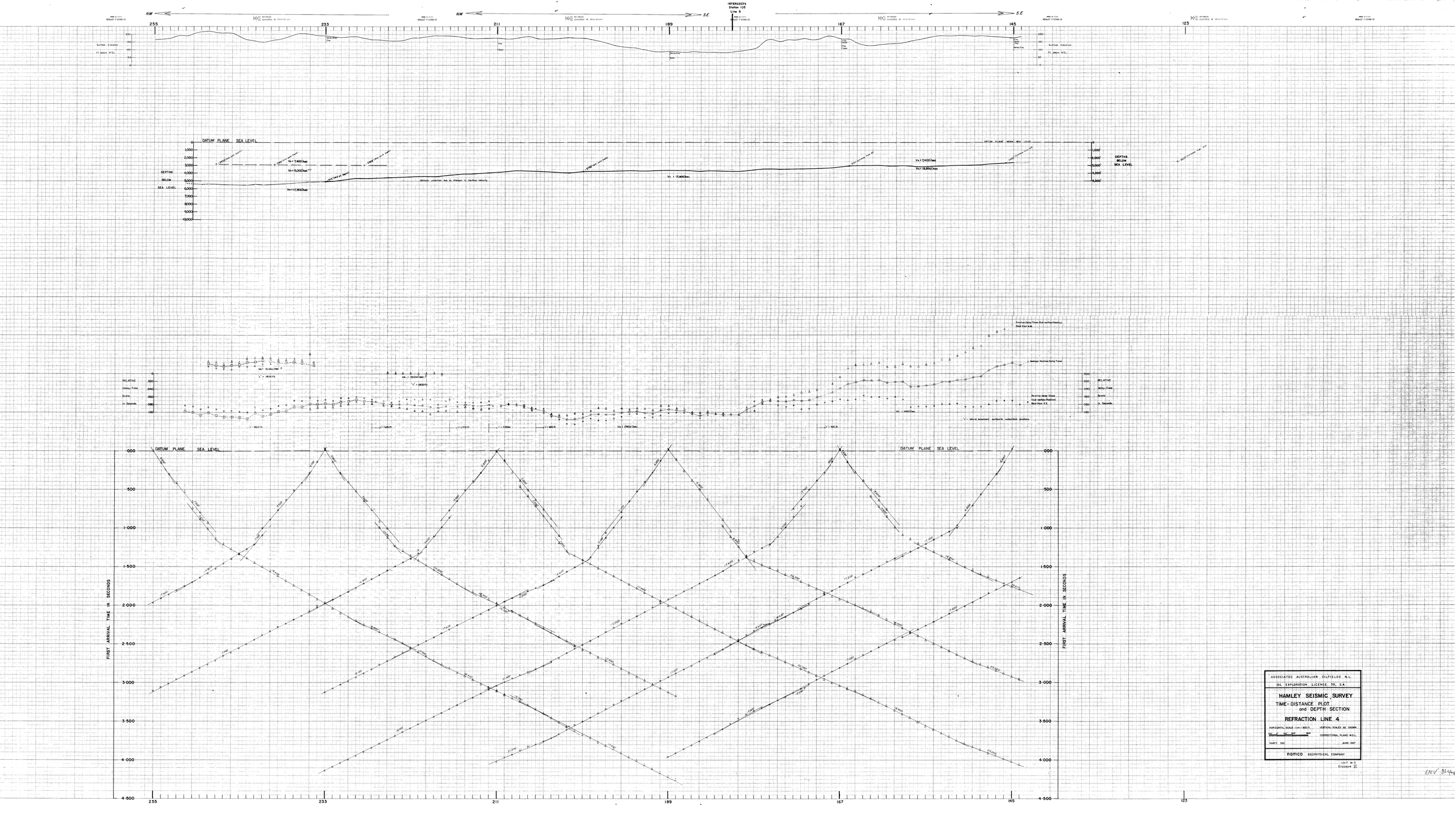

SSE
INTERSECTS (R) N. Line 5
Elevation Scale
1 Inch above Sea Level
ELEVATION SCALE
1 INCH EQUALS 200 FEET ABOVE SEA LEVEL
DEPTH SECTION
FEET BELOW SEA LEVEL
RELATIVE Delay Time Scale In Seconds
DATUM PLANE SEA LEVEL
FIRST ARRIVAL TIME IN SECONDS
ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE No. S.A.
HAMLEY SEISMIC SURVEY
TIME-DISTANCE PLOT and DEPTH SECTION
REFRACTION LINE 1
AUSTRALIA (SOUTH AUSTRALIA)
CONTRACTOR (S) OF PARTY
PARTY NO.
DATE (MO.)
NOMCO GEOPHYSICAL COMPANY
REF. No.
Drawing No.


366
344
321
300
278
256
234
212
189
176
160
SE
ELEVATION SCALE
IN FEET
ABOVE SEA LEVEL
ELEVATION SCALE
IN FEET ABOVE SEA LEVEL
DEPTH BELOW SEA LEVEL
Sea Level
2,000 ft
4,000 ft
6,000 ft
8,000 ft
10,000 ft
RELATIVE
Delay-Time
Scale
in Seconds
DATUM PLANE SEA LEVEL
FIRST ARRIVAL TIME IN SECONDS
000
500
1 000
1 500
2 000
2 500
3 000
3 500
4 000
4 500
5 000
5 500
SUBSURFACE POSITION FROM SOUTH-EAST
SUBSURFACE POSITION FROM NORTH-WEST
AVERAGE RELATIVE MIGRATED DELAY TIMES
ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE No. S.A.
HAMLEY SEISMIC SURVEY
TIME-DISTANCE PLOT
and DEPTH-SECTION
REFRACTION LINE 2
HORIZONTAL SCALE 1 cm = 500 ft
VERTICAL SCALE AS SHOWN
DIMENSIONAL PLANE WILL
PARTY 204
JUNE 1967
Enclosure 12
namco GEOPHYSICAL COMPANY

ENV 2244-4


INTERSECTS
207 Line 5
S.E.
299
277
255
233
211
190
168
145
120
DATUM PLANE SEA LEVEL
Sea Level
Surface Elevation
Ft. above M.S.L.
FIRST ARRIVAL TIME IN SECONDS
DEPTH SECTION
Feet Below Sea Level
Relative Delay Time Scale in Seconds
Minutes Delay Times Calculated from N.W.
Average Reciprocal Times
Smoothed Delay Times
Plot Surface Position Shot from S.E.
Change in migration from 6,000 ft. to 9000 ft. Per Layer
Average Reciprocal Layer Times
Reciprocal Delay Times (sub-surface position) Shot from S.E.
Average movement surface to sub-surface positions
900 ft. Trace Intervals
Note 6300 ft. Trace Intervals
Distance 223-(2441-17,430 ft.
9000 ft. Trace Intervals
ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE 39, S.A.
HAMLEY SEISMIC SURVEY
TIME-DISTANCE PLOT
and DEPTH SECTION
REFRACTION LINE 3
HORIZONTAL SCALE 1 in. = 880 ft.
VERTICAL SCALES AS SHOWN
DIRECTIONAL PLAN N.W.L.
PARTY 336
JUNE 1961
GEOPHYSICAL COMPANY
1338-WZ
Enclosure 12

ENV 824-5



ASSOCIATED AUSTRALIAN OILFIELDS N.L.

OIL EXPLORATION LICENCE 39, S.A.

HAMLEY SEISMIC SURVEY

TIME-DISTANCE PLOT and DEPTH SECTION

REFRACTION LINE 4

HORIZONTAL SCALE 1 cm = 200 Ft. VERTICAL SCALES AS SHOWN

CORRECTIONAL PLANE M.S.L.

PARTY 33C JUNE 1967

namco GEOPHYSICAL COMPANY

UNIT No 9
Enclosure 31

ENV 3146

INTERSECTS 213 Line 3

INTERSECTS 160 Line 1

INTERSECTS 181 Line 4.

WSW

ENE

220 211 200 189 178 166 155 144 133 122 111 100 85

Surface Elevation Ft above M.S.L.

DATUM PLANE SEA LEVEL

DEPTH SECTION FEET BELOW SEA LEVEL.

0000 2500 5000 7500 10,000

Vx = 7400'/sec

Vx = 14,000'/sec ?

Vx = 16,000'/sec ?

Vx = 18,300'/sec

HEADWAVE VARIATION REQUIRES SHOT BELOW REFRACTOR REFRACTION

HORIZONTAL DISTANCE

RELATIVE Delay-Time Scale in Seconds

Relative Delay Times (Subsurface Position) Shot from E.N.E.

Average Relative Delay Time

Vx = 18000'/sec

Z = 7200'

Relative Delay Times (Subsurface Position) Shot from W.S.W.

Vx = 18300'/sec

Z = 2700'

* = Inferred displacement surface to subsurface positions

FIRST ARRIVAL TIME IN SECONDS

000 500 1000 1500 2000 2500 3000 3500 4000 4500

ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE 39, S.A.

HAMLEY SEISMIC SURVEY

TIME-DISTANCE PLOT and DEPTH SECTION

REFRACTION LINE 5

HORIZONTAL SCALE: 1 cm = 500 ft. — VERTICAL SCALES AS SHOWN.

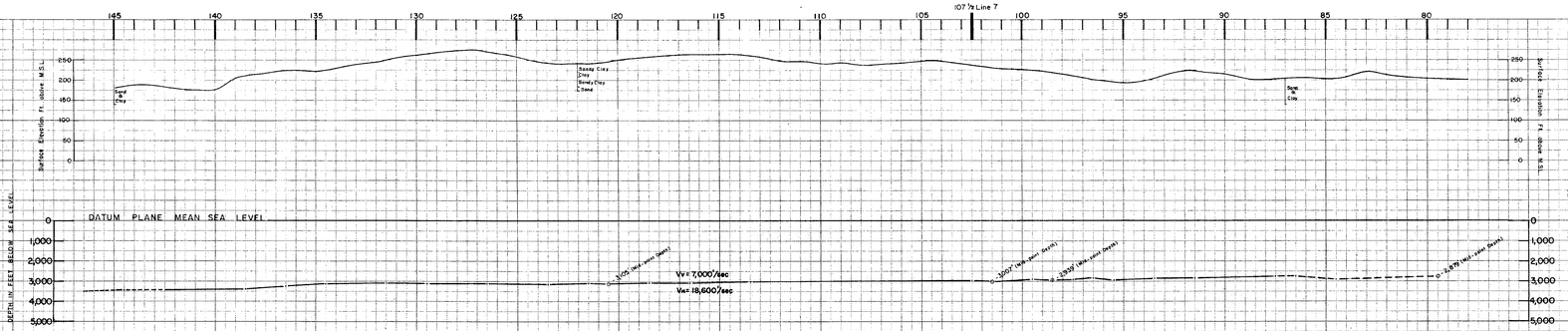
CORRECTIONAL PLANE M.S.L.

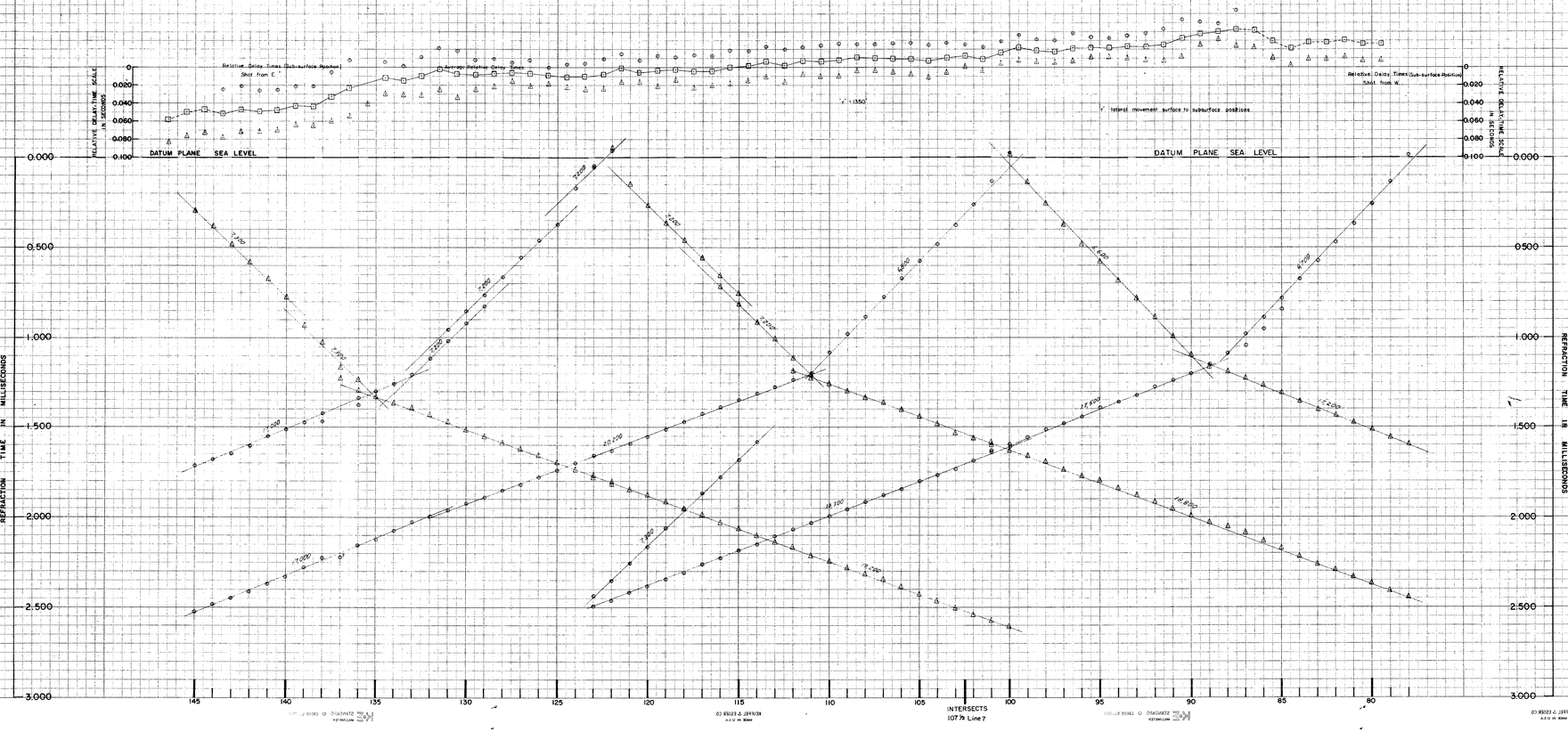
PARTS 352. JUNE 1957.

namco GEOPHYSICAL COMPANY

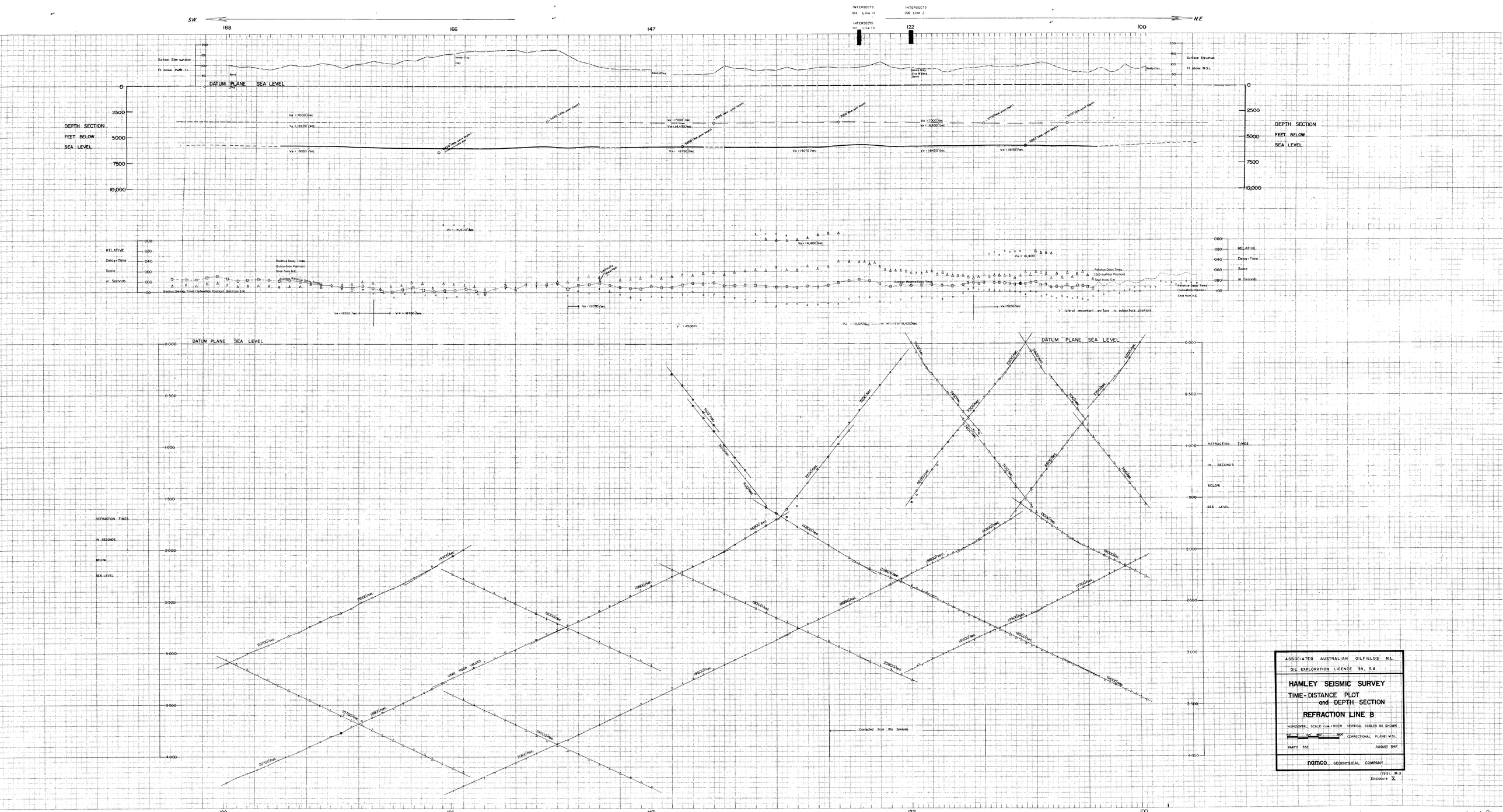
1198 M-3
Enclosure VII

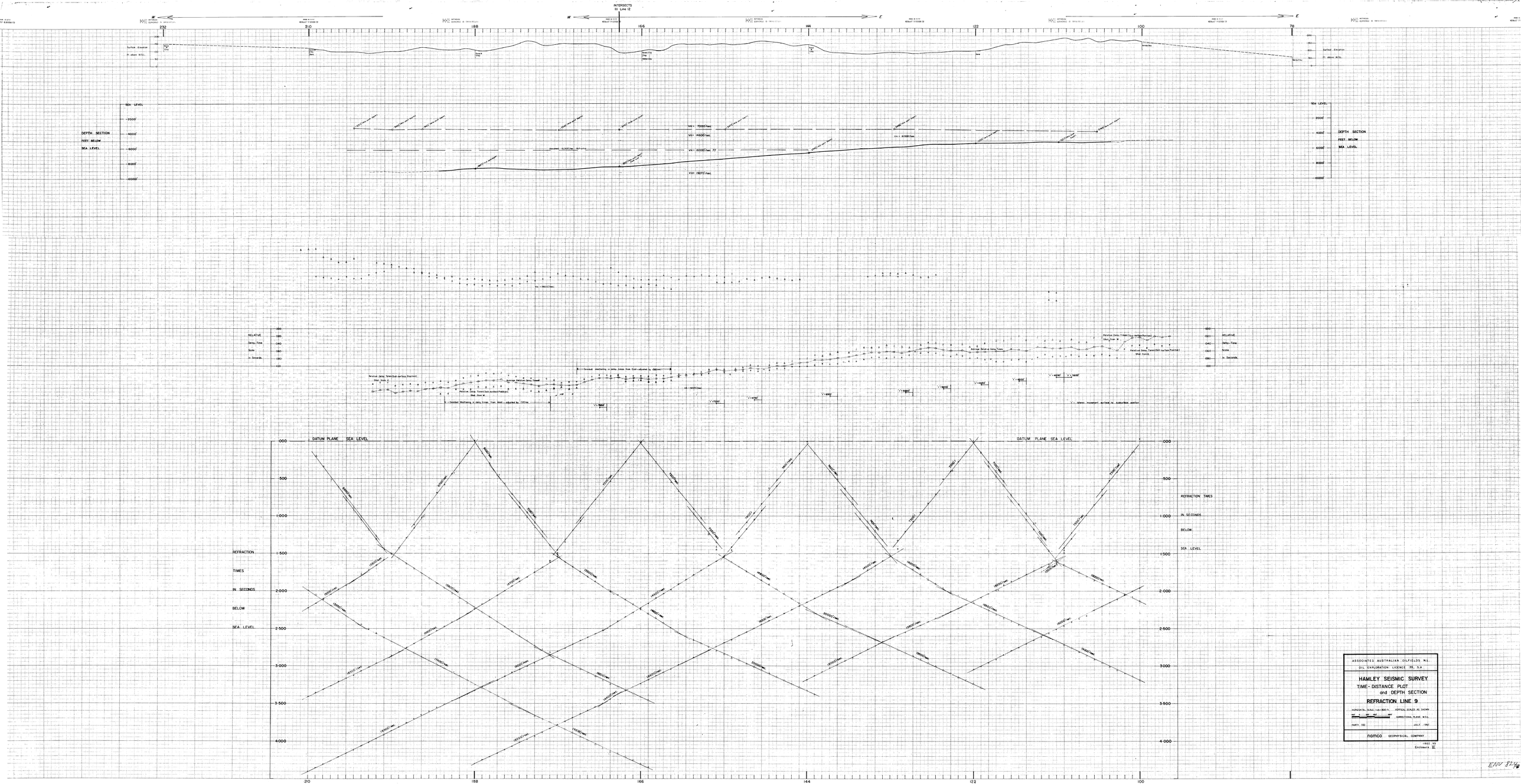
ENV 824-7


W
E
INTERSECTS
107 ½ Line 7
145
140
135
130
125
120
115
110
105
100
95
90
85
80
Surface Elevation Ft. above M.S.L.
250
200
150
100
50
0
Sand & Clay
Sandy Clay
Clay
Sandy Clay
Sand
Sand & Clay
DATUM PLANE MEAN SEA LEVEL
DEPTH IN FEET BELOW SEA LEVEL
0
1,000
2,000
3,000
4,000
5,000
3,105 (Max. depth Datum)
3,007 (Max. depth Datum)
2,939 (Max. depth Datum)
2,879 (Max. depth Datum)
Vv = 7,000'/sec
Va = 18,600'/sec


Relative Delay Times (Sub-surface Position)
Shot from E.
Average Relative Delay Times
Relative Delay Times (Sub-surface Position)
Shot from W.
RELATIVE DELAY-TIME SCALE IN SECONDS
0
0.020
0.040
0.060
0.080
0.100
Y lateral movement surface to subsurface positions
DATUM PLANE SEA LEVEL
REFRACTION TIME IN MILLISECONDS
0.000
0.500
1.000
1.500
2.000
2.500
3.000
7200
7300
7400
7500
7600
7700
7800
7900
8000
8100
8200
8300
8400
8500
8600
8700
8800
8900
9000
9100
9200
9300
9400
9500
9600
9700
9800
9900
10000
10100
10200
10300
10400
10500
10600
10700
10800
10900
11000
11100

N. ← — — —


SW
NE
188
166
147
122
100
INTERSECTS
104 Line 11
INTERSECTS
112 Line 13
INTERSECTS
200 Line 2
Surface Elevation
Ft. above M.S.L.
DATUM PLANE SEA LEVEL
DEPTH SECTION
FEET BELOW
SEA LEVEL
0
2500
5000
7500
10,000
RELATIVE
Delay-Time
Scale
in Seconds
REFRACTION TIMES
IN SECONDS
BELOW
SEA LEVEL
Corrected from Wa Spreads
ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE 39, S.A.
HAMLEY SEISMIC SURVEY
TIME-DISTANCE PLOT
and DEPTH SECTION
REFRACTION LINE 8
HORIZONTAL SCALE 1 cm = 200ft VERTICAL SCALES AS SHOWN
CORRECTIONAL PLANE M.S.L.
PART 8 332
AUGUST 1967
namco GEOPHYSICAL COMPANY
1192 L M-3
Enclosure X


INTERSECTS
III Line 12
W
E
232
210
188
166
144
122
100
78
Surface Elevation
Ft. above M.S.L.
SEA LEVEL
DEPTH SECTION
FEET BELOW
SEA LEVEL
RELATIVE
Delay-Time
Scale
In Seconds
DATUM PLANE SEA LEVEL
REFRACTION
TIMES
IN SECONDS
BELOW
SEA LEVEL
REFRACTION TIMES
IN SECONDS
BELOW
SEA LEVEL
ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE 39, S.A.
HAMLEY SEISMIC SURVEY
TIME-DISTANCE PLOT
and DEPTH SECTION
REFRACTION LINE 9
HORIZONTAL SCALE 1 in. = 800 ft. VERTICAL SCALES AS SHOWN
CORRECTIONS PLANE W.S.L.
PARTY 332 JULY 1962
namco GEOPHYSICAL COMPANY
HALF SIZE
Enclosure XI

S.E

Position of Hamley fault from Line R1 (Remark Seismic Survey)

166 144 121 100 78

Surface Elevation Ft above M.S.L.

+300' +250' +200' +150'

Sandy Clay Sand

Sandy Clay Sand Stone Sand

Sandy Clay Sand

Sandy Clay Sand

Sandy Clay Clay

DEPTH SECTION — FEET BELOW SEA LEVEL

SEA LEVEL

−2000' −4000' −6000' −8000'

MEAN SEA LEVEL

2000' 4000' 6000' 8000'

0 – 4488' (Formerly Proc. 166)

0 – 2975' (Air-shot Data)

2040' (Air-shot Data)

1778' (Bore above Datum)

3492' (Bottom Point 100)

VH = 6500'/sec.

VH = 15800'/sec.

VH = 17600'/sec.

Depths unreliable due to..

Lack of reversed coverage

Disturbed, possibly faulted, basement

Some superficial refraction above basement

Depths believed to be minimum

VH = 15800'/sec.

RELATIVE Delay-Time Scale in Seconds

000 020 040 060 080 100

r' = 7200' r' = 6750'

r' = 6750' r' = 6300'

r' = 6200' r' = 5400'

r' = 5400' r' = 4500'

r' = 4500' r' = 5400'

VH = 17600'/sec.

r' = 5400' r' = 6300'

Average Relative Delay Times

Relative Delay Times (Sub-surface Position) Shot from N.W.

Relative Delay Times (Sub-surface Position) Shot from S.E.

r' = lateral movement surface to subsurface positions

144 121 100

DATUM PLANE SEA LEVEL

FIRST ARRIVAL TIME IN SECONDS

000 500 1·000 1·500 2·000 2·500 3·000 3·500 4·000

7000'/sec.

6500'/sec.

6500'/sec.

15200'/sec.

15700'/sec.

16400'/sec.

16100'/sec.

18400'/sec.

15800'/sec.

17500'/sec.

24400'/sec.

14600'/sec.

19200'/sec.

19100'/sec.

23600'/sec.

19400'/sec.

17200'/sec.

17400'/sec.

18200'/sec.

14600'/sec.

15600'/sec.

ASSOCIATED AUSTRALIAN OILFIELDS N.L.

OIL EXPLORATION LICENCE 39, S.A.

HAMLEY SEISMIC SURVEY

TIME-DISTANCE PLOT and DEPTH SECTION

REFRACTION LINE 10

HORIZONTAL SCALE 1cm.=900M VERTICAL SCALES AS SHOWN

CORRECTIONAL PLANE M.S.L.

PARTY 332 AUGUST 1967

namco GEOPHYSICAL COMPANY

1923 M-3

Enclosure XII

166 144 121 100 78

ENV 824

S. N.

INTERSECTS 127 - 8

122½ 120 115 110 105 100

Surface Elevation Feet above M.S.L.

150 100 50 0

Sandy Clay Sandy Clay Sandy Clay Sand Sand Sandy Clay

DATUM PLANE — MEAN SEA LEVEL

DEPTH SECTION FEET BELOW SEA LEVEL

2500 5000 7500 10,000

7,000'/sec
14,400'/sec
18,800'/sec

Δt = 5.72 m/sec from Sp 1274 Line 8

Relative Delay Times (Sub-surface Position) Shot from S.

Average Relative Delay Times

r = 4,500'

Relative Delay Times (Sub-surface Position) Shot from N.

r = lateral movement surface to subsurface position

RELATIVE Delay-Time Scale in Seconds

000 020 040 060 080 100

REFRACTION TIMES IN SECONDS BELOW SEA LEVEL

3 000 3 500 4 000 4 500 5 000

19,100'/sec

19,800'/sec

ASSOCIATED AUSTRALIAN OILFIELDS N.L.

OIL EXPLORATION LICENCE 39, S.A.

HAMLEY SEISMIC SURVEY

TIME-DISTANCE PLOT and DEPTH SECTION

REFRACTION LINE 11

HORIZONTAL SCALE: 1 cm = 900 ft. VERTICAL SCALES AS SHOWN

900' 0 900' 1800' 3600'

CORRECTIONAL PLANE: M.S.L.

PARTY 332 AUGUST 1967

namco GEOPHYSICAL COMPANY

11924 M-3

Enclosure XIII

ENV 824-13

NW. ← S.E.

INTERSECTS 169 Line 9

190 166 144 122 100

Surface Elevation Ft above M.S.L.

DATUM PLANE SEA LEVEL

DEPTH BELOW SEA LEVEL

0 2500 5000 7500 10,000

Vn = 18,900'/sec

Vn = 16,000'/sec

Vn = 14400'/sec

Vn = 7000'/sec

Vn = 16,000'/sec

Vn = 18900'/sec

Vn = 19750'/sec

8,000'/sec Refractor assumed at 9,000'

RELATIVE Decay Time Scale in Seconds

0.00 0.20 0.40 0.60 0.80 1.00

Vn = 4,400'/sec

Vn = 7000'/sec

Vn = 18,900'/sec

Relative Decay Times (Sub-surface Positions) Shot from N.W.

Average Decay Times

Relative Decay Times (Sub-surface Positions) Shot from S.E.

Vn = 18,900'/sec

Vn = 19,500'/sec

Vertical movement surface to subsurface positions

DATUM PLANE SEA LEVEL

0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000 4.500 5.000 5.500

REFRACTION TIMES IN SECONDS BELOW SEA LEVEL

7000'/sec 8000'/sec 14400'/sec 16000'/sec 17000'/sec 18900'/sec 19500'/sec 20000'/sec

Ref. Data - Intercept Time and Velocity Control

ASSOCIATED AUSTRALIAN OILFIELDS N.L.

OIL EXPLORATION LICENCE 39, S.A.

HAMLEY SEISMIC SURVEY

TIME-DISTANCE PLOT and DEPTH SECTION

REFRACTION LINE 12

HORIZONTAL SCALE 1cm = 500ft. VERTICAL SCALES AS SHOWN

CORRECTIONAL PLANE M.S.L.

PARTY 332 AUGUST 1967

namco GEOPHYSICAL COMPANY

69105 M-3

Enclosure XIV

ENV 824-14

120 115 110 105 100

INTERSECTS
127 Line 8

N.W.

Surface Elevation
Ft. above M.S.L.
100
50
0

Sand & Clay
Sand & Clay
Sand & Clay
Sand Clay
Sand & Clay
Sand & Clay

DATUM PLANE SEA LEVEL

DEPTH BELOW SEA LEVEL
0
2500
5000
7500
10,000

VH = 7,000'/sec.
VH = 14,400'/sec.
5742' from 127 Line 8
VH = 18,800'/sec

RELATIVE Delay-Time Scale in Seconds
000
020
040
060
080
100

Relative Delay Times (Sub-surface Position) Shot from S.E.
Average Relative Delay Times.
VH = 19,000'/sec
r = 8,500'
Relative Delay Times (Sub-surface Position) Shot from N.W.

r : lateral movement surface to subsurface positions

REFRACTION TIMES IN SECONDS BELOW SEA LEVEL
3,000
3,500
4,000

21,000'/sec
20,000'/sec
17,700'/sec.

Trace Interval = 600'

120 115 INTERSECTS 110 105 100
127 Line 8

ASSOCIATED AUSTRALIAN OILFIELDS N.L.

OIL EXPLORATION LICENCE 39, S.A.

HAMLEY SEISMIC SURVEY

TIME-DISTANCE PLOT and DEPTH SECTION

REFRACTION LINE 13

HORIZONTAL SCALE: 1cm. = 600ft. VERTICAL SCALES AS SHOWN
600 0 600 1200 2400
CORRECTIONAL PLANE: M.S.L.

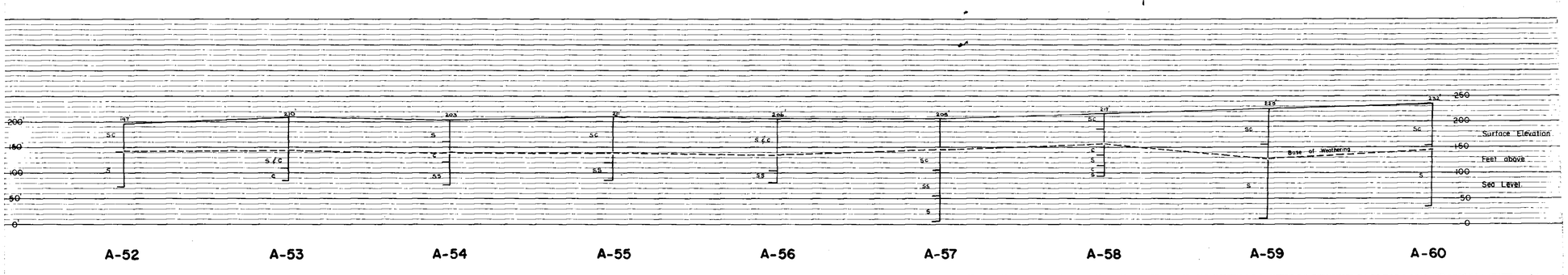
PARTY 332 AUGUST 1967

namco GEOPHYSICAL COMPANY

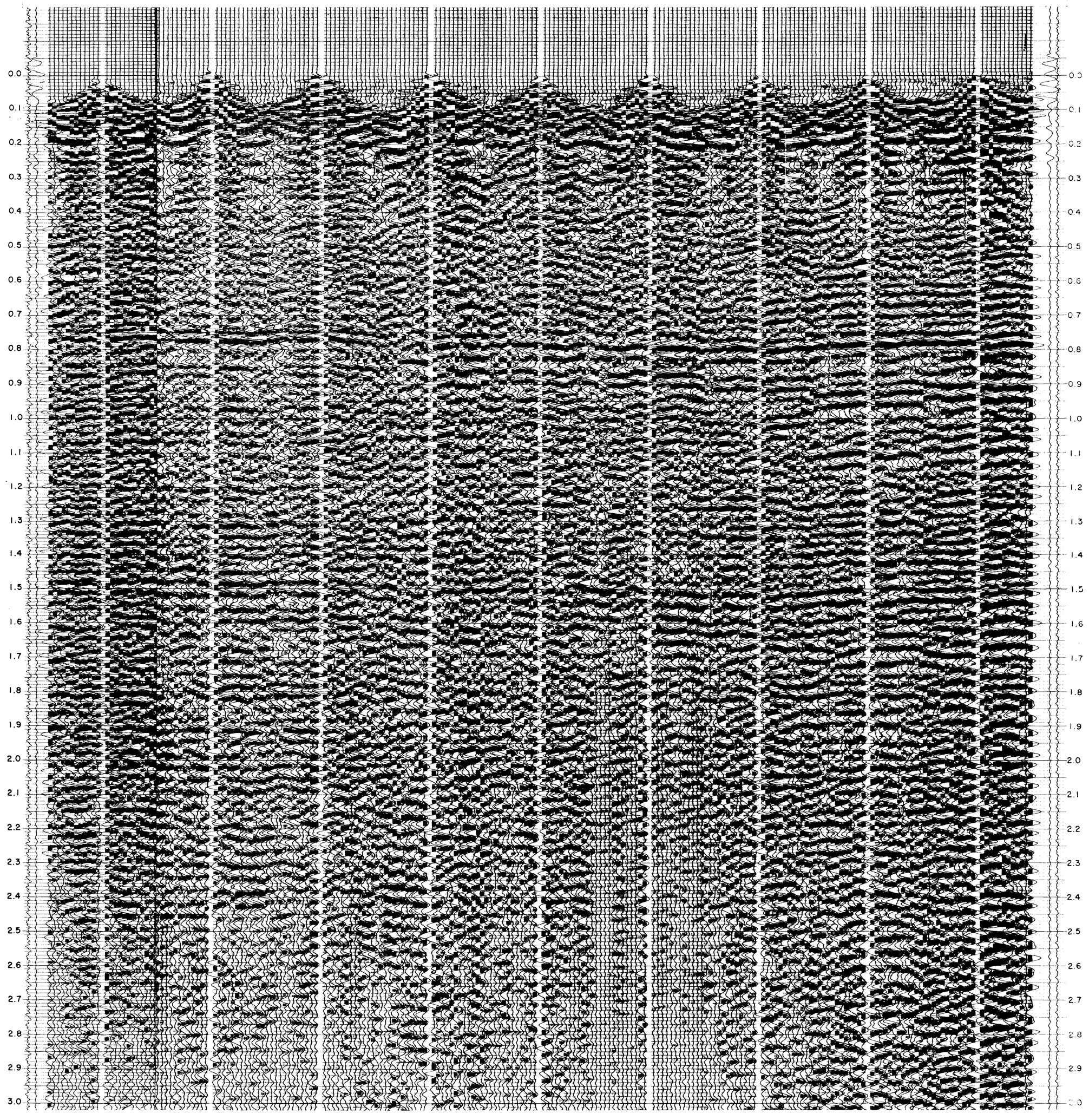
11926 M-3
Enclosure XV

ENV 8245

Enclosure XVI
11927 M4



A-52 A-53 A-54 A-55 A-56 A-57 A-58 A-59 A-60



ASSOCIATED AUSTRALIAN OILFIELDS N.L

HAMLEY SEISMIC SURVEY

O.E.L. 39, S.A. PROJECT

LINE A S.P's 60 - 52

SHOT HOLE LEGEND

C = Clay
G = Gravel
S = Sand
SC = Sandy Clay
SS = Sand Stone
SH = Shale
LS = Lime Stone
RK = Rock

ENV 8246

Datum Mean Sea Level
Correction Velocity 6,000' per second
Velocity Function

TAPE PLAYBACK DATA

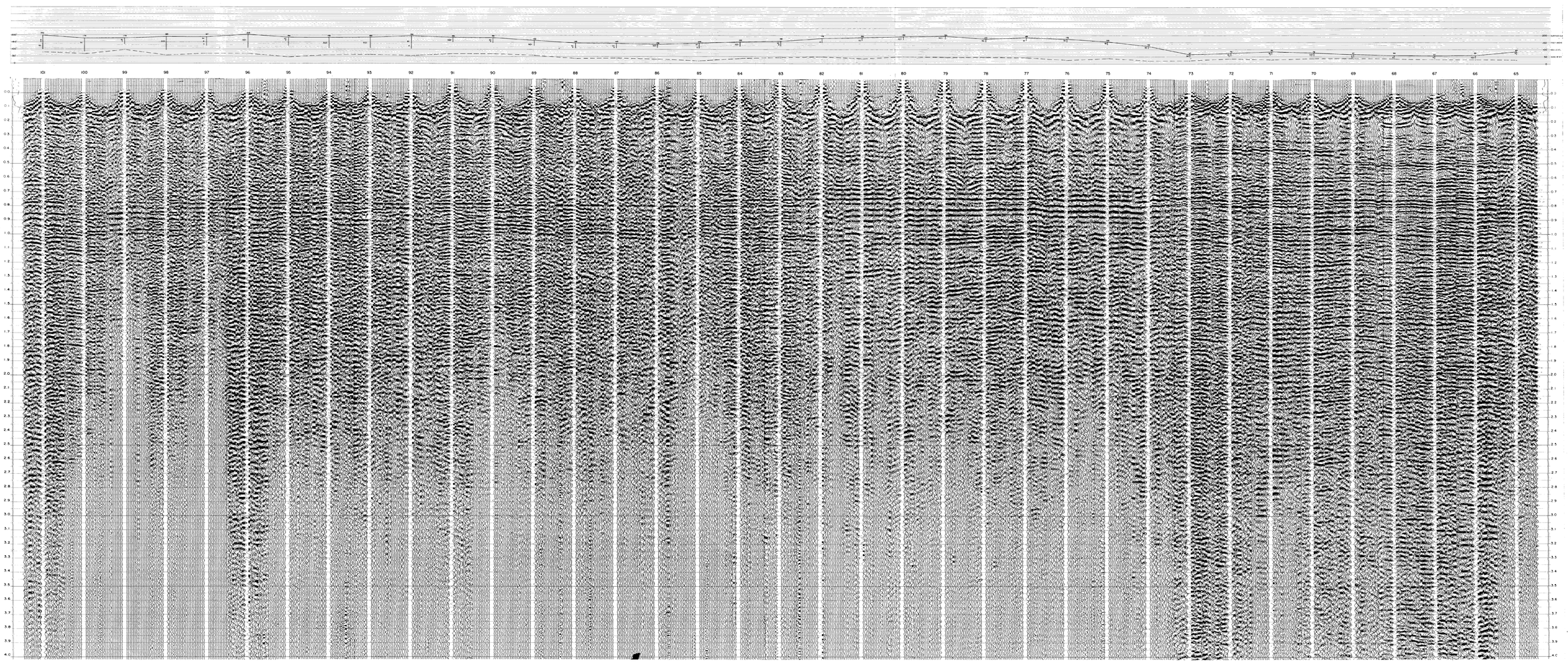
Filter 1/27-1/65 A.V.C. None
Mix None
Vertical Scale As Shown
Horizontal Scale 1320' Spread

TAPE RECORDING DATA

Filter 18-72 A.V.C. Medium
Detectors/Group 8
Group Interval 110'
S.P. Interval 1320'

Records shot by
namco GEOPHYSICAL COMPANY
Party 332

Section by
namco GEOPHYSICAL COMPANY
Date November, 1967



Enclosure XXII
SW - NE

ASSOCIATED AUSTRALIAN OILFIELDS N.L.

HAMLEY SEISMIC SURVEY

O.E.L. 39, S.A. PROJECT

LINE C SP's 65-101

ENV P2247

SHOT HOLE LEGEND
C = Clay
G = Gravel
S = Sand
SC = Sandy Clay
GC = Gravelly Clay
SH = Shale
LS = Lime Stone
RK = Rock

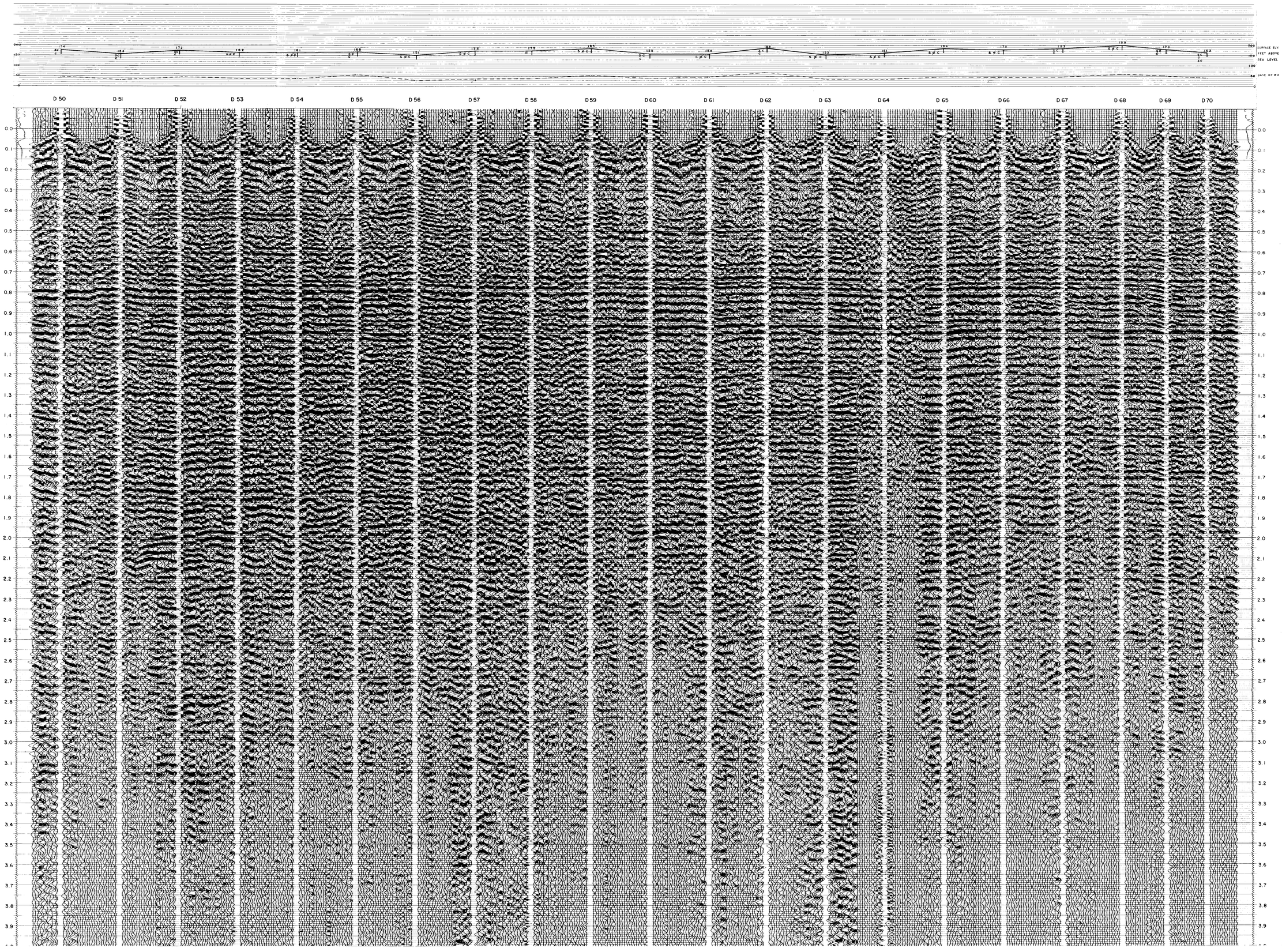
Datum Mean Sea Level
Correction Velocity 6,000' per second
Velocity Function

TAPE PLAYBACK DATA
Filter V27-1/65 AVC None
Mix None
Vertical Scale 4s Sticks
Horizontal Scale 1320' Spread

TAPE RECORDING DATA
Filter 18-72 AVC Medium
Detectors/Group 8
Group Interval 110'/C
S.P. Interval 1320'

Seismic Work by
namco GEOPHYSICAL COMPANY
Party 332

Section by
namco GEOPHYSICAL COMPANY
Date November 1967



Enclosure XVIII
1929 M 4

ASSOCIATED AUSTRALIAN OILFIELDS N.L.

HAMLEY SEISMIC SURVEY

O.E.L. 39, S.A. PROJECT

LINE D S.P's 70 - 50

SHOT HOLE LEGEND

C = Clay
G = Grivel
S = Sand
SC = Sandy Clay
SS = Sand Stone
SH = Shale
LS = Lime Stone
RK = Rock

ENV 8248

Datum Mean Sea Level
Correction Velocity 6,000' per second
Velocity Function

TAPE PLAYBACK DATA

Filter 1/27 - 1/65 AVC None
Mix None
Vertical Scale As Shown
Horizontal Scale 1350' Spread

TAPE RECORDING DATA

Filter 18-72 AVC Medium
Detectors/Group 8
Group Interval 112 1/3'
S.P Interval 1350'

Records shot by

namco GEOPHYSICAL COMPANY

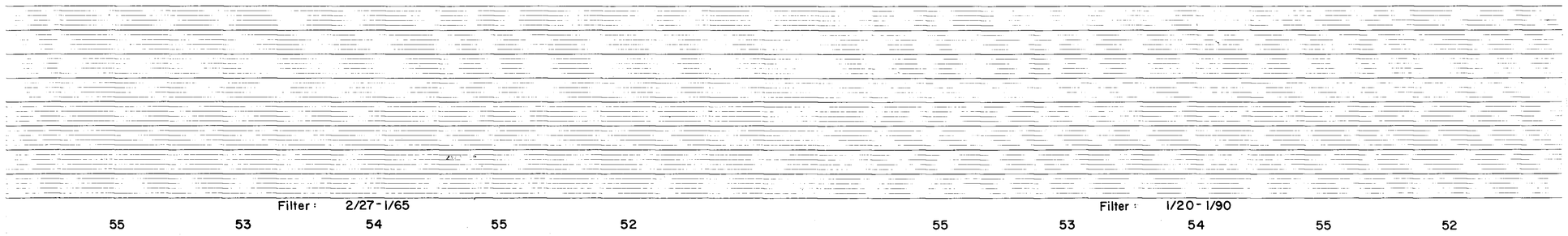
Party 332

Section by

namco GEOPHYSICAL COMPANY

Date November, 1967

Enclosure XIX
1930 M 4

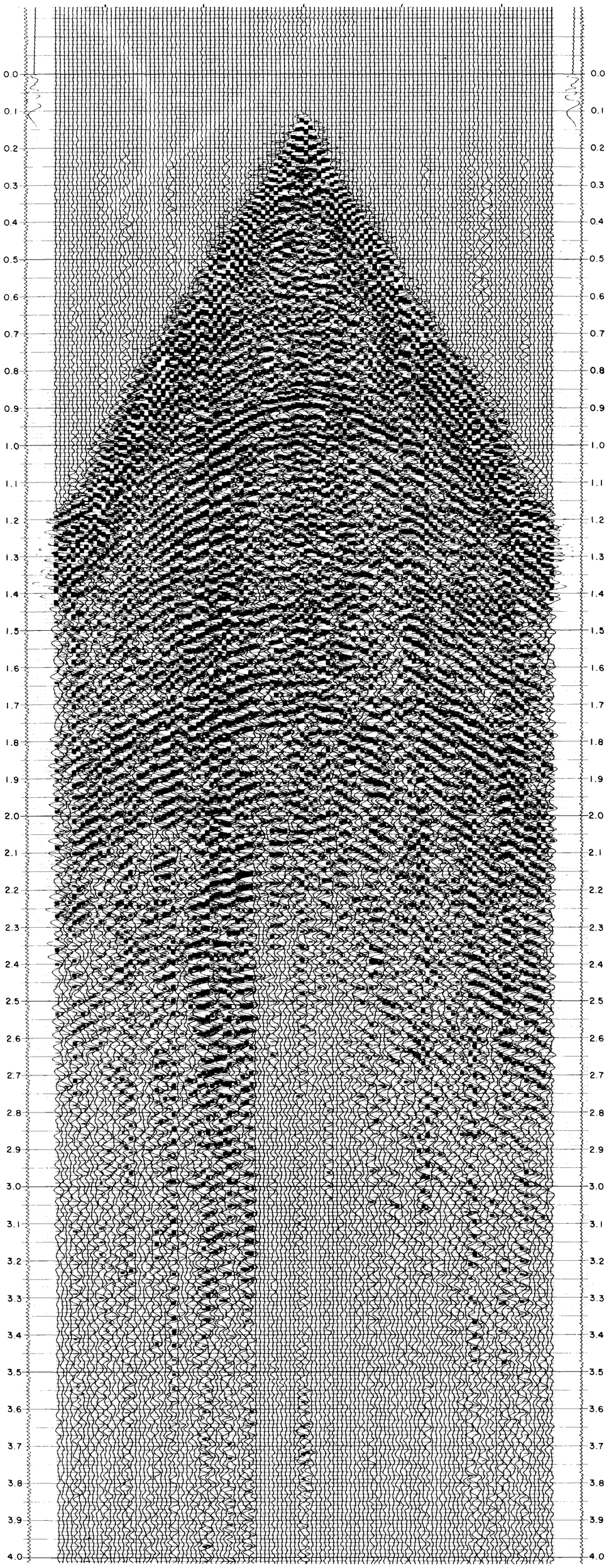


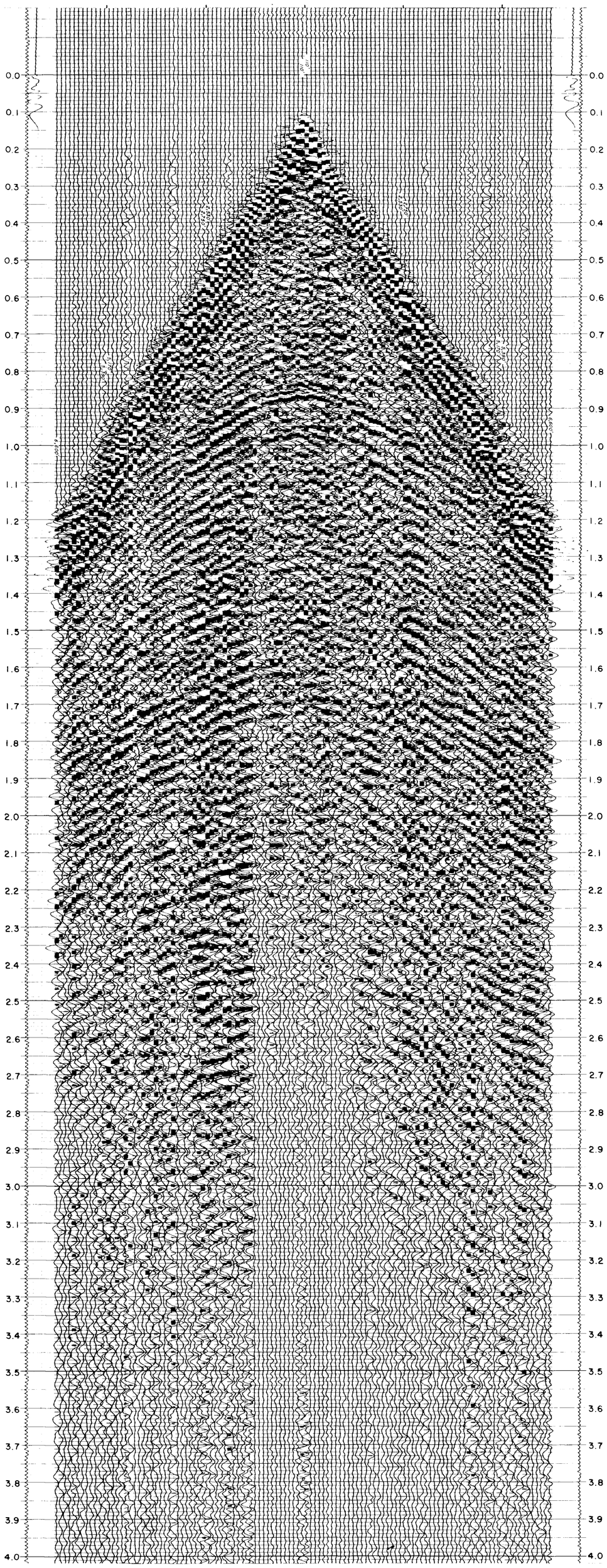
Filter : 2/27 - 1/65

55 53 54 55 52

Filter : 1/20 - 1/90

55 53 54 55 52





ASSOCIATED AUSTRALIAN OILFIELDS N.L.

HAMLEY SEISMIC SURVEY

O.E.L. 39, S.A. PROJECT

LINE A S.P's 54

EXPANDING SPREAD

SHOT HOLE LEGEND

C = Clay
G = Gravel
S = Sand
SC = Sandy Clay
SS = Sand Stone
SH = Shale
LS = Lime Stone
RK = Rock

ENV 82419

Datum Sea Level
Correction Velocity 6,000' per second
Velocity Function

TAPE PLAYBACK DATA

Filter AVC. None
Mix None
Vertical Scale
Horizontal Scale

TAPE RECORDING DATA

Filter 18-33-72 c.p.s. A.V.C. Medium
Detectors/Group 16
Group Interval 112'
S.P Interval 1320'

Records shot by
namco GEOPHYSICAL COMPANY
Party 332

Section by
PACIFIC MAGNETIC REDUCTION PTY. LTD.
Date July, 1967

Enclosure XX
1951 M4

S.P.51 — Filter 2/27-1/65 — 51-53 — 53-55 — 55-57 — 57-59 — 59-61

S.P.51 — Filter 1/27-1/65 — 51-53 — 53-55 — 55-57 — 57-59 — 59-61 — S.P.51

Filter 1/20-1/90 — 51-53 — 53-55 — 55-57 — 57-59 — 59-61

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4.0

ASSOCIATED AUSTRALIAN OILFIELDS N.L.

HAMLEY SEISMIC SURVEY

O.E.L. 39, S.A. PROJECT

LINE A S.P's 51-61

CONTINUOUS REFRACTION PROFILE

SHOT HOLE LEGEND

C = Clay
G = Gravel
S = Sand
SC = Sandy Clay
SS = Sand Stone
SH = Shale
LS = Lime Stone
RK = Rock

ENV 824-20

Datum Sea Level
Correction Velocity 6,000 per second.
Velocity Function

TAPE PLAYBACK DATA

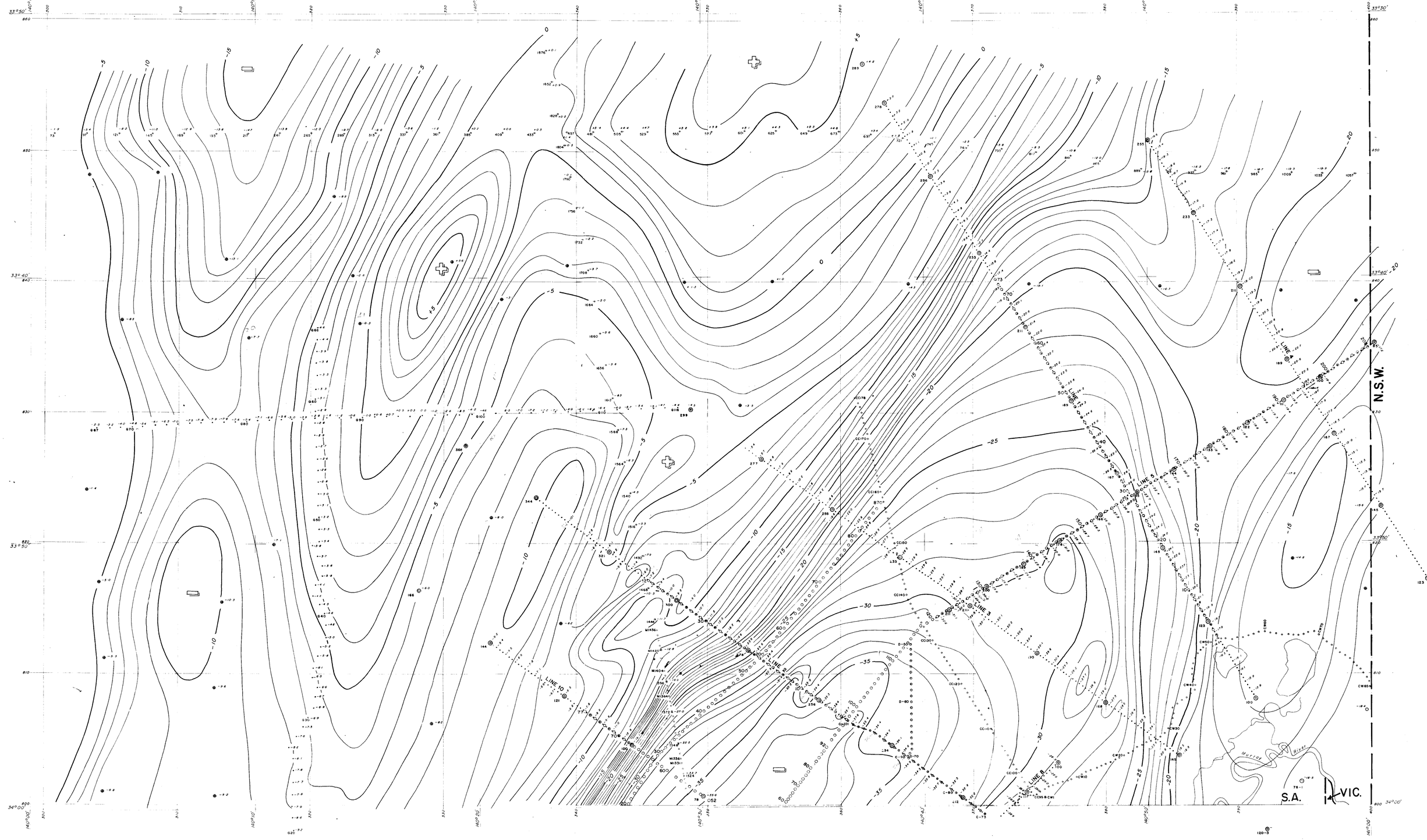
Filter AVC None
Mix None
Vertical Scale
Horizontal Scale

TAPE RECORDING DATA

Filter 18-33-72 cps AVC Medium
Detectors/Group 16
Group Interval 112'
S.P. Interval 1320'

Records shot by
namco GEOPHYSICAL COMPANY
Party 332

Section by
PACIFIC MAGNETIC REDUCTION PTY. LTD.
Date July, 1967



SEISMIC SHOT-POINTS

- BEACH PETROLEUM
- SOUTH AUSTRALIAN MINES DEPT. (Reflection)
- RENMARK SEISMIC SURVEY
- HAMLEY SEISMIC SURVEY
- REFRACTION STATION
- REFRACTION SHOT-POINT
- REFLECTION SHOT-POINT
- GRAVITY STATION
- SOUTH AUSTRALIAN MINES DEPT. (Refraction) – Approximate positions only
- GRAVITY STATION FROM PREVIOUS SURVEYS

1 : 100,000

1	2	3
4	154/6 Chowilla 5	6

ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE 39 S.A.

HAMLEY SEISMIC SURVEY

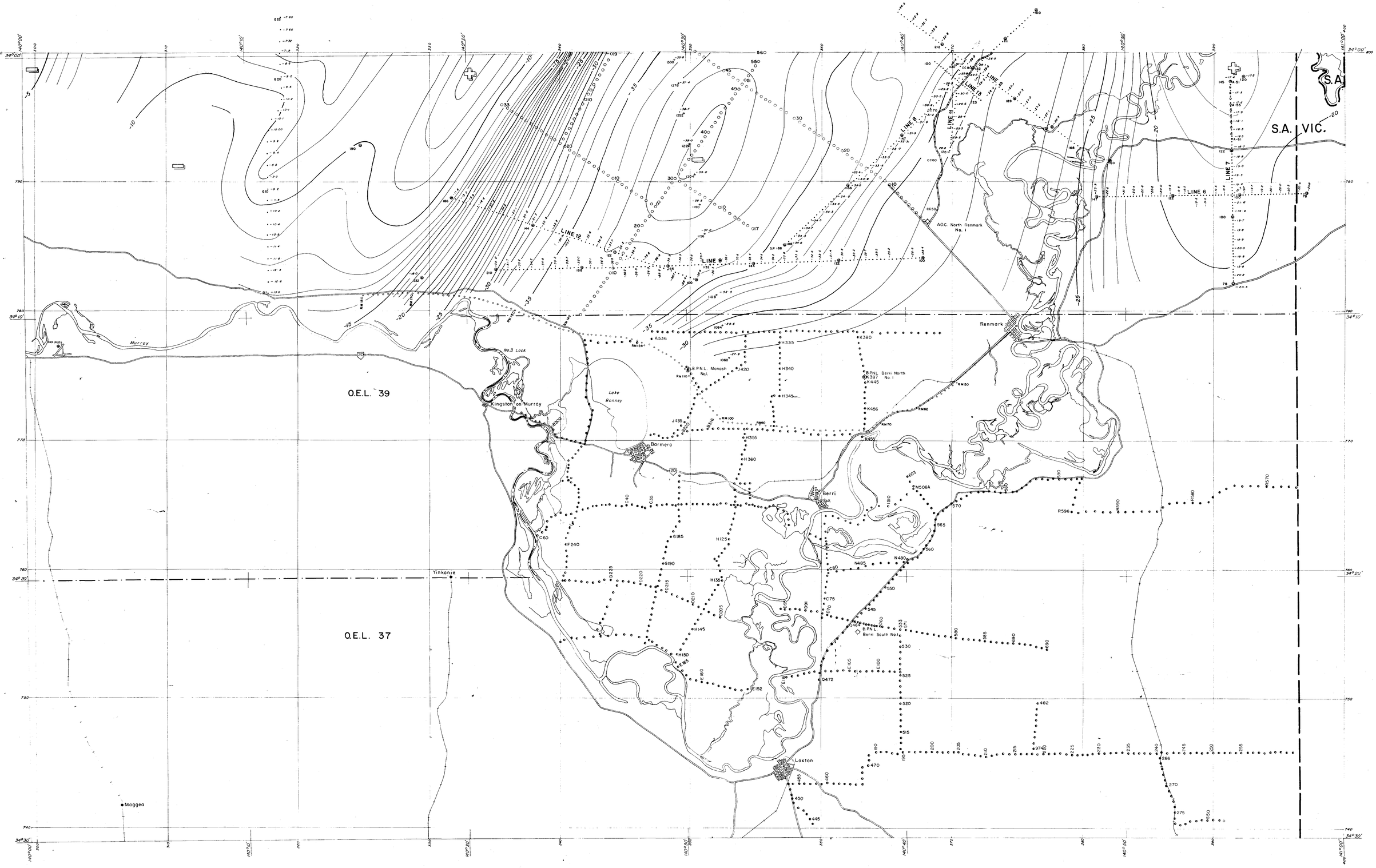
BOUGUER ANOMALY

Author: L.R. DENHAM.	Date: JANUARY, 1968.	
Company: MINAD.	MAP No. 11932	FILE LOC. K.14.

154/6

Enclosure XXI a

ENV 8242



SEISMIC SHOT-POINTS

- BEACH PETROLEUM
- SOUTH AUSTRALIAN MINES DEPT. (Reflection)
- RENMARK SEISMIC SURVEY.
- HAMLEY SEISMIC SURVEY
- REFRACTION STATION
- REFRACTION SHOT-POINT
- REFLECTION SHOT-POINT
- Gt GRAVITY STATION
- SOUTH AUSTRALIAN MINES DEPT. (Refraction)— Approximate Positions Only
- GRAVITY STATION FROM PREVIOUS SURVEYS.

GRAVITY DATA

SURVEY BASED ON STATION 6491.9133 = 979654.36 milligals.

CORRECTION DENSITY 2·2 gm/ml.

1 : 100,000.

1	2 I54/10 Renmark	3
4	5	6

ASSOCIATED AUSTRALIAN OILFIELDS N.L.
OIL EXPLORATION LICENCE 39 S.A.

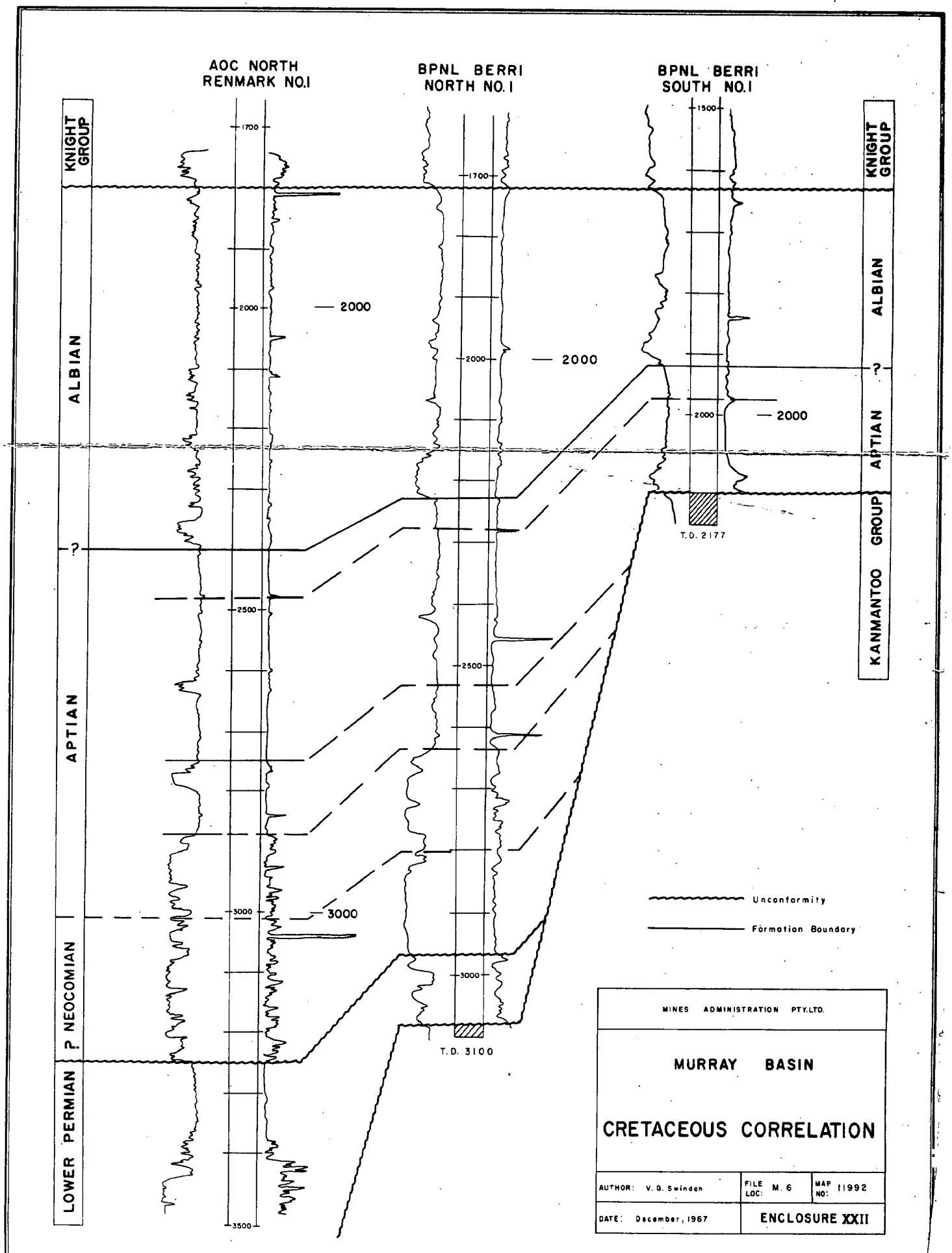
HAMLEY SEISMIC SURVEY

BOUGUER ANOMALY

Author: L.R. DENHAM.	Date: JANUARY, 1968.	
Company: MINAD.	MAP No. 11933	FILE LOC. K.14.

I 54/10

ENCLOSURE XXI b



MINES ADMINISTRATION PTY.LTD.

MURRAY BASIN

CRETACEOUS CORRELATION

AUTHOR: V. G. Swinden	FILE LOC: M. 6	MAP NO: 11992
DATE: December, 1967	ENCLOSURE XXII	