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INTERPRETATION

of the

MADIGAN TROUGH AREA

O.P. 57, NORTHERN TERRITORY

by

R. D. Drayton

for

GEOSURVEYS OF AUSTRALIA PTY. LTD.

1969/1

INTRODUCTION

A review of the geophysical information available for the Madigan Trough area in O.P. 57 Northern Territory was made in the period November 26th to December 20th.

After relating the magnetic and gravity information to regional geological features, and plotting values on representative lines of the seismic network the border of the Arunta Block zone was selected for detailed seismic interpretation. The contoured maps of the seismic one way times, and the conclusions drawn from them forms the basis of this report.

All the reports available in Geosurveys files were consulted during the course of this investigation. The reader is referred to the report by R.M. Hoogenraad, "1967 Simpson Desert Gravity Survey, Oil Permit 57, Northern Territory." p. 18 for a comprehensive list of the references available.

MAGNETIC INTERPRETATION

(see Attachment No. 1)

The main feature of the magnetic basement map is the basin under the Simpson Desert (see Attachment No. 2). It has long been recognised that the deep magnetic basement occurs well beneath the base of Upper Palaeozoic sediments. Originally in this region the hope of mappable Lower Palaeozoic formations similar to those in the Adelaide and Amadeus Geosynclines was the target for oil exploration. But the limited amount of drilling undertaken in the region of the Simpson Desert has indicated the presence of steeply dipping sediments beneath the Permian. The steeply dipping sediments are probably folded Upper Proterozoic and Lower Palaeozoic series, though as yet the only direct evidence of the presence of Lower Palaeozoic formation are age datings from the bottom hole cores in Mokari No. 1 and Poonarunna No. 1.

The magnetic basement then is most likely within the Proterozoic or perhaps the top of the Archean. The only current explanation of the discrepancy between the rather gently dipping magnetic basement contours and the steep dips of higher non magnetic sediments has been postulated on the basis of observations in the Amadeus where "Décollement Folding" of younger beds over more rigid older formations occurs.

The overall result of these preliminary findings focussed attention on the Upper Palaeozoic Permian and Finke Formations as potential targets in this region. So far only one well has been drilled as a Permian test, Mokari No. 1. These sediments mask the direction of the magnetic anomaly trends associated with the Lower Palaeozoic and Proterozoic rocks. Quite plainly, to the north of Lake Eyre the N.N.W.-S.S.E. trend parallel to the Peake and Dennison Ranges to the west becomes much more diffuse in areas where Permian and Finke sediments subcrop beneath the thick Mesozoic cover. (see Attachment 1).

Gradually interest has shifted away from the large Simpson Desert Magnetic Basement low to magnetic basement basins (and also gravity lows) bordering this central feature: such features as the Pedirka Basin, the Eringa Trough and the Madigan Trough. I would suggest much more interest should be shown in the southern extensions of the Casuarina Trough in O.P. 57, but more later.

The McDills No. 1 Well has demonstrated the development of a promising Lower Palaeozoic sequence. Rather than search for elusive complexly folded Cambro-Ordovician structures in the Simpson Desert Magnetic Basement low, the extension of these formations in bordering lows should be delineated.

MADIGAN TROUGH

Hale River No. 1 provided a valuable calibration point for the magnetic basement depth interpretation map made before the well was drilled. Two anomalies within a 10 mile radius of the well were suitable for depth estimates. (see Enclosure 6). Both values 4,000 feet and 4,700 feet indicate the Proterozoic (?) volcanic sequence drilled below 4,700 feet could be considered as magnetic basement.

Another depth estimate in the centre of the Madigan Trough gave 7,000 feet as the depth to magnetic basement.

GRAVITY INTERPRETATION

(see attachment 3)

The principal density contrast in this region occurs between the Upper Palaeozoic infill sands of the Permian, Permo-Carboniferous and the Devonian, and the underlying Palaeozoic and/or Proterozoic. Since the thickness of the Mesozoic sediments varies only gradually over large distances with only very minor facies changes, their contribution to the gravitational field changes only gradually on a regional scale. Hence variations in the Bouguer Anomaly probably represent variations in the overall density of the Pre-Mesozoic Formations.

The Simpson Desert Magnetic low is a Bouguer Anomaly High zone with small amplitude variations in values. Seismic shooting has confirmed that these variations are due mainly to variations in the topography of the Pre-Mesozoic unconformity. The Bouguer Anomaly in this zone is extremely useful for delineating the structure and relative topography of the Permian sediments. For example, the "Border Anticline" is well defined on the gravity map.

Surrounding the gravity high are a series of gravity lows, the Pedirka Basin, Eringa Trough, Madigan Trough and the Casuarina Trough. These features have a developed Permian, Permio-Carboniferous and perhaps Devonian sequence. McDills No. 1 highlights the possibility of Lower Palaeozoic formations in these structurally depressed areas.

MADIGAN TROUGH

The gravity anomaly extends farther north than the magnetic low. Both are elongate to the west. Assuming a density contrast of 0.6 between the Mesozoic - Upper Palaeozoic (2.1) and the Basement (2.7), and assuming a fault contact to the edge of the Trough, using the formula -

$$g_1 \text{ milligals} = 12.77 \times 0.6 \times L \text{ (in thousands of feet)}$$
$$24 = 12.77 \times 0.6 \times L$$
$$L = \frac{40}{12.77} = 3.2$$

gives the depth to the density contrast as at least 3,000 feet deeper in the Madigan Trough than at Hale River No. 1 on the Arunta Block. Using a lower density contrast increases the depth: 0.4 gives 4,700 feet.

		Hale River No. 1 (feet)	Madigan Trough (feet)
Magnetic Basement depth		4,700	7,000
Gravity computations	0.6	4,700	7,900
	0.4	4,700	9,400

In the case of the gravity values the deeper value refers to the top of the units of higher density, that is Basement or Cambrian-Ordovician. The Magnetic values however refer to a magnetic basement at 7,000 feet, which would normally be considered economic basement within the limits of accuracy of the magnetic basement calculation.

SELECTION OF THE AREA TO BE STUDIED

The Madigan Trough area is covered with a detailed network of continuous in-line reflection traverses. The seismic contractor Austral GeoProspectors, supplied maps of the "C" and "P" horizon. The location of Hale River No. 1 was chosen by Amerada Petroleum Corporation of Australia Ltd., taking into account the interpretation of the geophysical information available.

Since the well was drilled no further re-interpretation has been attempted. Besides incorporating the results of this well into the network, it was thought possible that horizons beneath the Permian could also be mapped.

A brief look at the Border Anticline was also requested, to help determine the amount of closure and the position of the top of the structure.

R E S U L T S

The following horizons were mapped at a scale of 1:250,000 -

"C" Transition Beds
"P" Pre-Mesozoic Unconformity
"F" Top of the Finke Beds
"Z" Base of the Finke Beds
"X" Phantom Horizon.

The identification of the "F" and "Z" horizons depends critically on the geological interpretation of Hale River No. 1 and the record character of the seismic lines. The "X" will be discussed later.

VELOCITY CONTROL (see Appendix I)

The lack of adequate velocity control is amazing. Three velocity spreads were shot in the immediate area.

2K-200
2AJ-288
2K-107

None of these, or other spreads to the south and west were extended far enough to enable the velocity of particular distinctive refractors to be known and tied to reflection horizons. Correlation from one velocity spread to another depends completely on record character. The only control point is Hale River No. 1, where a Velocity Survey was shot. The well was drilled on the Arunta Block, however, and it is not very easy to correlate across the boundary into another geological province.

Because of the particular character of the "C" and "P" horizons it is not too difficult to recognise them. In an effort to extract as much information from the velocity spreads as was possible the table of interval velocities was computed and listed with Geo Prospectors T^2-X^2 analyses. It was hoped that particular interval velocities may characterise various reflection intervals (see Appendix I).

"C"

Throughout the Simpson Desert-Eromanga Basin area the character of this reflection is amazingly consistent and needs no further definition.

"P"

The "P" horizon is a strong relatively high frequency event associated with the velocity inversion resulting from the sand and coal of the Permian. In this area, especially towards the centre and on the flanks of the Madigan Trough there is a distinctive character first noted further south. The "P" thickens by the addition of high energy cycles above the one being picked. The only geological explanation that seemsconsistent, is that the Permian sequence has been truncated by erosion before the Mesozoic sediments were deposited. In this case the Permian thickness is greater in the Madigan Trough because it was preserved in a slowly sinking area, with erosion exposing older beds proceeding toward the basin edge.

On line 3B near shotpoint 40, the reflection character seems to indicate the Mesozoic formations were deposited transgressively on the older surface. This could mean the Permian is overlain by a sandy contact in this area.

"F"

The distinctive Permian velocity inversion provided an approximate means of determining the "P" - "F" interval but it cannot be defined any more precisely than to within 2 or 3 cycles. Fortunately, once the cycle chosen was followed, it seemed often to be a strong event and in some places to be an unconformity.

The "F" horizon was computed at Hale River No. 1 from the depth and the results of the velocity survey and tied to the velocity spreads 2K-107 and 2K-200. Much better velocity control is needed. See later for recommendations.

One source of doubt has been the lithological descriptions of the Finke or Devonian-Carboniferous encountered in the well. (Note the error in picking the top of this Formation in the composite well log. From the evidence of all logs, especially the gamma ray, it should be 4,520 not 4,550 feet). It does not correlate lithologically with the Devonian-Carboniferous further west. What else could it be? It has been accepted as the Devonian-Carboniferous in this interpretation.

"Z"

As the base of the predominantly infill sand sequence of the Upper Palaeozoic, the "Z" can usually be distinguished by the use of long offsets. But without such control it has been necessary to follow a strong low frequency event which was calibrated at Hale River No. 1. The overall picture of the "Z" map is consistent with the "F", "P" and "C". The crucial area for the definition of the "Z" horizon by character is the loop 2Z, 2G, 3A, and 2K. More than one solution is possible.

QUALITY OF SECTIONS

The quality of the "C" and "P" horizons varies from fair to good. A recent playback of part of line 2Z, applying deconvolution techniques has enhanced the record character of the deeper events, which for the most part are generally poor to fair. Many of the cross-sections indicates that all sections need to be carefully checked for assembly misties after playback. On line 2Y there is a cumulative error of at least 50 milliseconds in less than 16 shotpoints.

DISCUSSION OF MAPS

"C" The overall configuration of the "C" map (see Attachment 4) is the same as those of the underlying horizons, but smoother and with less relief. There are the two features of interest on the eastern flank of the Madigan Trough, Spinifex and Corridor, as well as the fault controlled nose of the Border Anticline to the south.

The quality of the "C" is poor on the top of the Spinifex structure. The horizon picked could be one cycle too high, which if so would decrease the closure, and in line with the "P" map suggests this feature should be considered as a nose.

The Corridor Structure is not closed, though here again, it has been contoured without relying on the results of line 2Y. This line has to be re-assembled for major errors have been made in compiling the section with regard to the datum.

These two structures seem to be associated with intersection of two major faults defining the border of the Arunta Block.

<u>"P"</u> This map is similar to the "C", but with a steeper gradient on the flanks of the trough. The Spinifex nose, and the Corridor Structure (with doubtful one cycle closure) stand out as the two most obvious features (see Attachment 5).

<u>"F"</u> The lack of velocity control limits the extent over which this horizon could be followed with confidence. I am sure two or three offset shots would enable this area to be understood in relation to McDills to the east and Mokari to the south (see Attachment 6).

<u>"Z"</u> Again the Spinifex and Corridor structures stand out as the focal points. (see Attachment 7).

STRUCTURE

The structure of the Horizons followed is dependent on the deeper structural configuration.

For this reason an attempt was made to follow an "X" horizon phantom visible as a strong reflection event beneath the "Z" which occurs in the vicinity of the Hale River Fault and the Arunta Fault. The "X" map represents the shape of the formation beneath the "Z". The phantom event occurs as a strong signal on various parts of the sections. Correlation between such points is extremely subjective to say the least. All multiples on the record were identified before picking this event.

This map shows fault control as the dominating feature of the structure, especially the Arunta Fault lineament. The question still remains. What is beneath the "Z" horizon? (see Attachment 8).

PRE-Z GEOLOGY

The "X" horizon suggests the occurrence of layered sediments preserved along the two major faults which define the boundary of the Arunta Block. Are these sediments the layered volcanics encountered in Hale River No. 1, or Proterozoic or Lower Palaeozoic rocks?

If the depth estimate of the magnetic basement in the Madigan Trough of 7,000 feet is stressed, it would follow the sediments are probably Proterozoic layered volcanics. Using a vertical velocity of 9,000'/s for the "Z" horizon, the "Z" map indicates the Madigan Trough is 9,000 feet deep, which agrees well with the approximate gravity interpretation of the depth using a density contrast of 0.4. The gravity calculation does not indicate the depth of magnetic rocks, but of more dense formations. There is some chance that such Lower Palaeozoic sediments may be present in the Madigan Trough and on the eastern flank beneath the Spinifex and Corridor structures.

This question could be fairly cheaply resolved.

RECOMMENDATIONS

Step 1. Shoot at least two offset shots, to determine the refraction velocity of the underlying sediments. Note it is necessary that the offset or refraction probe should be shot out until high speed events of the order of 20,000 feet per second are recorded for at least 4,000 feet. If only lower horizontal velocities are recorded it is necessary to shoot to at least 30,000 feet.

<u>Suggested programme</u>:

Offset on Spinifex line 2K from SP 135 to 150

Offset on Corridor line 2K from SP 97 to 82

Offset at Hale River No. 1 line 3X from SP 240 to 251 and also to obtain velocity control to help tie with McDills and Mokari.

Offset line 2C from SP 40 to 65

Offset line 2D from SP 65 to 80.

If velocities significantly different from the probe at Hale River No. 1 are obtained, or more than one refractor beneath the Z can be determined then -

<u>Step 2</u>. Playback the following lines with DECONVOLUTION to enable the closure on the Spinifex and Corridor Structures to be determined with greater reliability especially at deeper levels.

line 2Y SP 150 - 82
line 2Z SP 130 - 174, (175 - 191 has been replayed)
SP 192 - 235
line 3N SP 120 - 180
line 3K SP 45 - 165
line 3A SP 135 - 200

A total of 367 SP's at $16 per shotpoint cost $5,900.

<u>Step 3</u>. If the area proves to be of interest playback the following sections to tie with McDills and Mokari.

line 2A SP 1 - 135
line JJ SP 30 - 100
line AB SP 218 - 260 Recompute static corrections trace by trace for line AB shotpoints.

A total of 247 SP's at $16 per shotpoint cost $4,000.

RESULTS - BORDER ANTICLINE

(see Attachment 9) A & B.

Amerada line 2C SP16 nearly ties with FPC(A) line AA SP 1254. This enables the datum of the two surveys at this point to be compared and the character and picking of the "P" to be evaluated.

On the FPC(A) sections two extremely high frequency events can be distinguished above the first cycle of the main energetic event of two or three cycles. The top high frequency event has been picked as the "P".

On the Amerada sections these high frequency events cannot usually be distinguished. The first energetic cycle has been followed as the "P".

Allowing for the difference in "P" and the datum the structure was contoured on the FPC(A) map. (see Attachments 9A - 9B).-
Maps A and B are two different character correlations. I consider A the most probable interpretation with the top of the structure straddling the border.

RECOMMENDATION

If a reflection crew was in the area, a crestal line would aid in detailing the structure, but no further geophysical work needs to be done at present. A decision about drilling must be made in the light of the age of the structure and the history of the reservoir.

CASUARINE TROUGH
RECOMMENDATION

The magnetic basement map of Aeroservice indicate depths of 10,000 feet or more sediment to the west of McDills No. 1 (see Attachment 2). The Emery Seismic Survey has shown an extensive Upper Palaeozoic and probably Lower

Palaeozoic trough which has not yet been drilled. This southwestern corner of the lease which can be considered as the northern extension of the Eringa Trough or the southern extension of the Casuarina Trough, needs at least two or three refraction probes, and a reconnaissance seismic reflection survey to evaluate this untested section. Close to the railway line, and comparatively good surface conditions make this area attractive if structures can be traced in the gently dipping sediments. Gravity and magnetic highs just north of the border in the southwestern corner of the area may have large structural significance within this proven area of Upper and Lower Palaeozoic section. Such a reconnaissance survey would enable the refractions offsets further east in the Madigan Trough area to be shot cheaply and without undue positioning costs.

<u>R. D. DRAYTON</u>

February, 1969.

APPENDIX I.

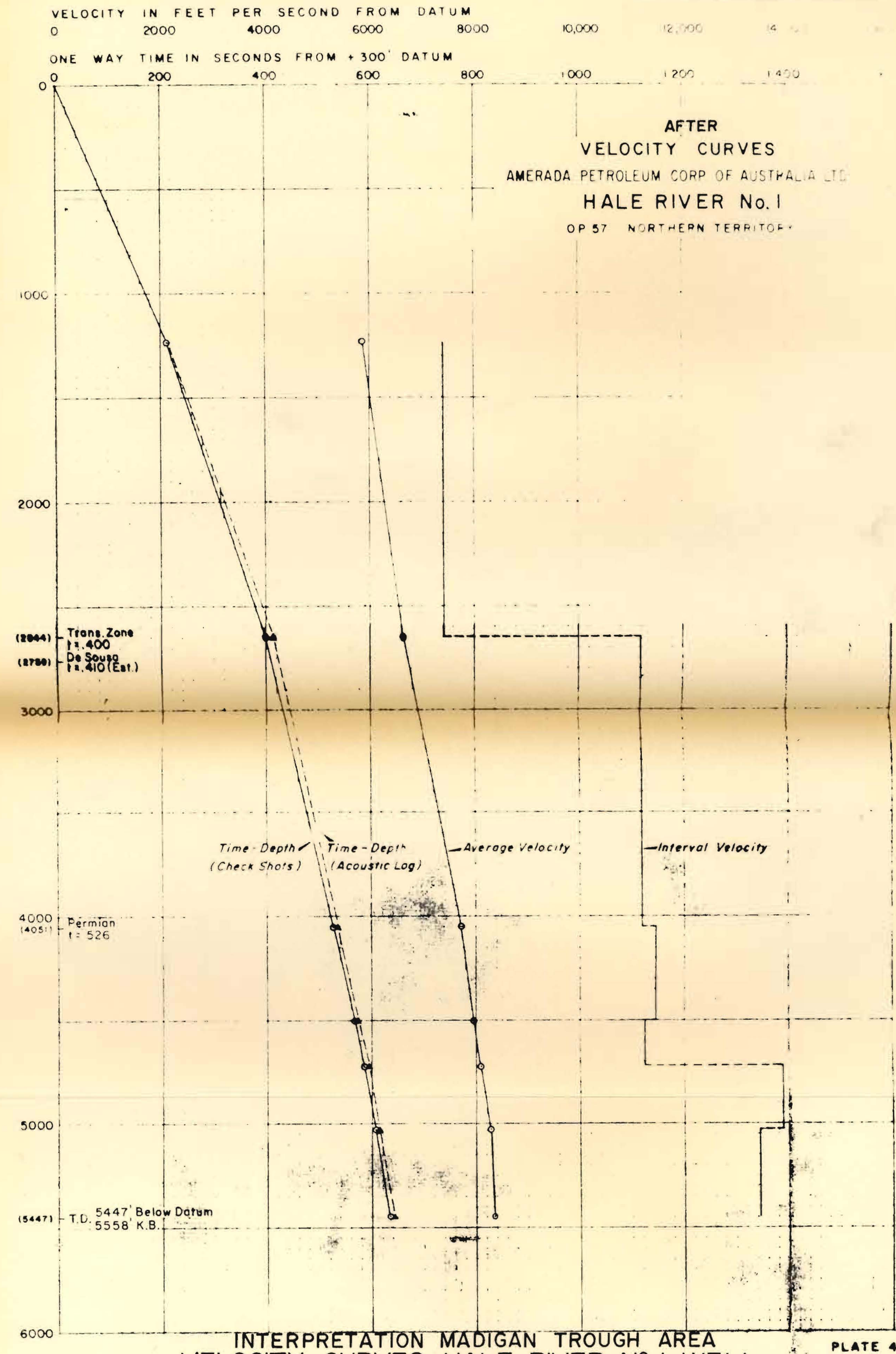
INTERVAL VELOCITIES

Expanded Spreads

Line - S.P. Horizon	To	Ts	Velocity	Depth	Int.T.	Int.D.	Int.V.
2AJ-288							
C	.931	.465	6,750'/s	3,139'	.465	3,139'	6,750'/s
P	1.169	.585	7,850'/s	4,592'	.120	1,453'	12,100'/s
? Base P	1.269	.635	7,750'/s	5,309'	.050	717'	14,340'/s
2G - 54							
C	1.409	.705	7,700'/s	5,428'	.705	5,428'	7,700'/s
P	1.777	.889	9,500'/s	8,445'	.184	3,017'	16,550'/s
Base?	2.070	1.035	9,600'/s	9,936'	.146	1,491'	10,200'/s
2K-200							
C	.610	.305	6,370'/s	1,943'	.305	1,943'	6,370'/s
P	.705	.352	7,110'/s	2,503'	.047	560'	11,930'/s
F	.814	.407	7,290'/s	2,967'	.055	464'	8,450'/s
	1.048	.524	8,670'/s	4,533'	.117	1,566'	13,380'/s
	1.432	.716	9,650'/s	6,909'	.192	2,376'	12,230'/s
	1.820	.910	10,290'/s	9,364'	.194	2,455'	12,780'/s
	2.045	1.022	10,840'/s	11,078'	.112	1,714'	15,300'/s
	2.783	1.392	11,540'/s	16,064'	.370	4,986'	13,500'/s
2C-64							
C	1.215	.608	7,090'/s	4,311'	.608	4,311'	7,090'/s
P	1.520	.760	7,900'/s	6,004'	.152	1,693'	11,150'/s
	1.660	.830	8,000'/s	6,640'	.070	636'	9,100'/s

Expanded Spreads
(continued)

Line - S.P. Horizon	To	Ts	Velocity	Depth	Int.T.	Int.D.	Int.V.
2K-107							
C	1.205	.602	7,330'/s	4,416'	.602	4,416'	7,330'/s
P	1.500	.750	8,570'/s	6,427'	.148	2,011'	13,580'/s
F	1.646	.823	8,710'/s	7,168'	.073	741'	10,130'/s
	1.812	.906	9,030'/s	8,182'	.083	1,014'	12,200'/s
	2.131	1.066	10,820'/s	11,523'	.160	3,341'	20,100'/s
3R-237							
P?	.545	.273	6,760'/s	1,845'	.273	1,845'	6,760'/s
	.660	.330	6,470'/s	2,135'	.057	290'	5,080'/s
	1.058	.529	7,360'/s	3,893'	.199	1,758'	8,830'/s
	1.290	.645	7,130'/s	4,598'	.116	705'	6,080'/s
McDills No. 1							
C	.530	.265	6,650'/s	1,762'	.265	1,762'	6,650'/s
P	.663	.332	7,190'/s	2,387'	.057	625'	10,960'/s
	.856	.428	8,090'/s	3,460'	.096	1,073'	11,180'/s
Multiple ?	1.483	.742	8,120'/s	6,025'	.314	2,565'	



INTERPRETATION MADIGAN TROUGH AREA
VELOCITY CURVES HALE RIVER Nº I WELL

PLATE 4

ON BEHALF OF
BEACH PETROLEUM N.L.
BY
GEOSURVEYS OF AUST. PTY. LTD

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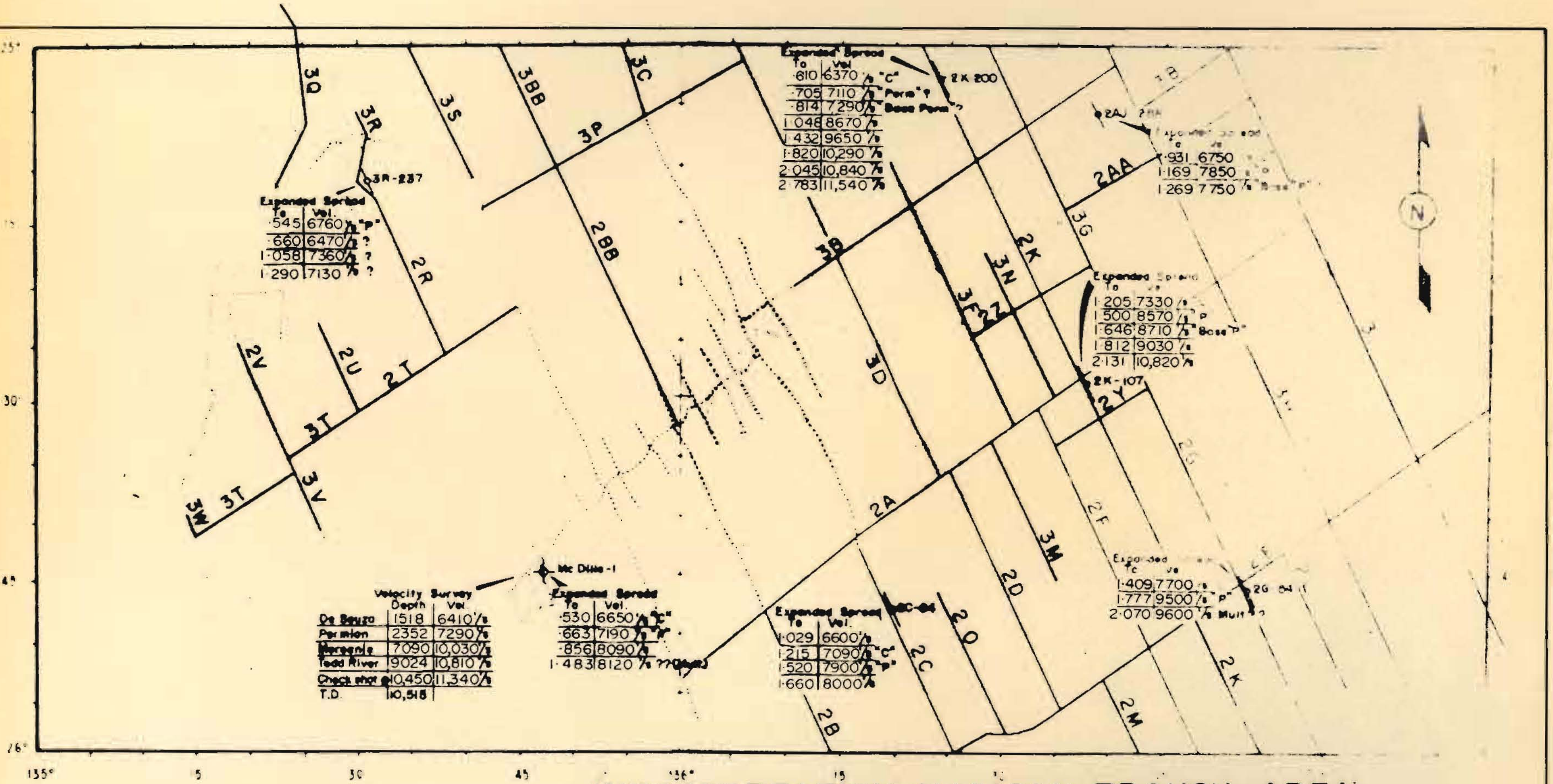
BP 737



INTERPRETATION MADIGAN TROUGH AREA

EXPANDED SPREADS

ON BEHALF OF

BEACH PETROLEUM N.L.

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AFTER PLATE III
OP 57

SIMPSON DESERT 'A' SEISMIC SURVEY

EXPANDED SPREADS

——— This survey.

.... Previous shooting by Beach.

REPORT N° 1969/1 APPENDIX I

BP 738