SEISMIC SURVEY REPORT

FOR THE

PORT KEATS AREA

OP NO. 2

NORTHERN TERRITORY

SUBMITTED TO

MINES ADMINISTRATION PTY. LIMITED

By

Douglas F. Warner

AUSTRAL GEO PROSPECTORS PTY. LTD.

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C O N T E N T S

A B S T R A C T

A reconnaissance seismic survey was undertaken in late 1960 on Oil Permit No. 2 (Northern Territory) held by Associated Australian Oilfields N.L.. The work was performed on the peninsula which projects into the Joseph Bonaparte Gulf portion of the Timor Sea, south of Port Keats Mission.

The primary aim of the program was to ascertain the distribution of the Paleozoic sediments south of Port Keats Mission and obtain an estimate of their thickness. Seismic results indicate that approximately 12,500 feet of Paleozoic beds are present in the central part of the area. Although this survey defines only a small zone of deep Paleozoic section, it is possible that the basin extends north and west from the locality worked.

We recommend that reconnaissance offshore seismic shooting and additional gravity work be carried out in this area before deciding on detailed seismic surveys and/or drilling.

F O R E W O R D

All final seismic reports are the products of teamwork. The author is indebted to a number of persons who have made material contributions to this report. He wishes to particularly mention the assistance derived from discussions with D. M. Traves and John Burbury of Mines Administration Pty. Ltd. and with W. E. Hightower and S. S. Chambers of Austral Geo Prospectors Pty. Ltd.

We express our appreciation, also, for the assistance given by Father O'Leary and the staff of Port Keats Mission to crew personnel during the duration of the survey.

Douglas F. Warner.

INTRODUCTION

A reflection seismic survey was conducted in late 1960 in an area which lies south of the Port Keats Mission and on the peninsula which projects into the Joseph Bonaparte Gulf portion of the Timor Sea. The survey was performed by Austral Geo Prospectors for Associated Australian Oilfields N.L. through their management affiliate, Mines Administration Pty. Ltd.

Because of the lack of adequate roads, seismic equipment was driven to Darwin and then moved into the Port Keats area by sea-going barge. The equipment was removed from the project in the same manner at the end of the survey. This accounts for the unusual amount of move time involved in the operation.

Since the nearest supply source was Darwin, N.T., it was necessary to set up a field camp for personnel. Transport of supplies, seismic progress reports, mail, etc. was by either barge or charter airplane from Darwin. An outpost radio provided additional communication by radio-telegrams.

Except for staff personnel and aborigines of the Port Keats Mission, the area is mostly uninhabited. The Mission personnel provided invaluable assistance by furnishing water, certain food supplies, medical help, and emergency radio communications.

The work was carried out during the dry season of northern Australia. Heavy rains during the wet season (December-April) prevent normal operations by flooding the mud flats portion of the Port Keats area.

GEOLOGY

The Port Keats prospect is located in the east-central portion of the Bonaparte Gulf Basin and centres roughly twenty miles west of the north-northeast trending Macadam Range, which marks the western limit of an outcropping segment of the Precambrian shield that forms the core of the Australian continent.

Permian sandstone ridges rise to elevations in excess of two hundred feet above sea level in the centre of the peninsula south of the Port Keats Mission. Elevations drop abruptly to the mud flats in the recently uplifted and emergent creek mouths immediately north and south of the central sandstone ridges, and to the beaches on the periphery of the peninsula where the Permian beds are overlapped by Quaternary and Recent alluvial and littoral deposits. The essential drainage pattern and generalized topographic contours are shown on the shotpoint elevation map (Plate No. II).

One hundred miles to the southwest, near the terminus of the Bonaparte Gulf Basin in the Keep River Inlet area, extensive Paleozoic outcrops allow the measuring of 17,000 feet of sedimentary section. Of particular interest are the relatively thick Devonian and Cambrian limestones which could give rise to persistent or semi-persistent seismic reflections.

Upper Proterozoic sandstones, shales and dolomites are generally not greatly disturbed structurally in the near-by areas, nor are they metamorphosed, which, we assume, permits beds of this age to contribute seismic reflected energy. On the other hand, the older Precambrian beds are mainly metamorphosed and contorted and would not normally be expected to yield seismic reflections.

Gravity surveys in the outcrop zone of the Keep River Inlet conducted by Mines Administration Pty. Limited during the period 1956 to 1958 indicate that gravity interpretations in this area are trustworthy and diagnostic. A scattering of gravity stations has also been occupied in and around the Port Keats Mission peninsula. Although the gravity work in this locality suffers from inadequate density of control, the data nevertheless give much useful information.

Some shallow bores were drilled by the South Australian Government in the vicinity of Port Keats Mission between 1903 and 1911, but no deep exploratory tests in search of oil have ever been drilled in the Bonaparte Gulf Basin.

FIELD PROCEDURES

(a) Drilling:

Since most of the original traverses of the survey were located on the mud flats of the area, two light truck mounted drills (Mayhew 200 and Failing CFD-2) were imported for drilling. These drills were ideal for the lowland country where numerous bogs existed and where the near-surface material was soft or unconsolidated. They were a bit light, however, along ridges where thick, hard sandstone was often encountered. In localities of soft drilling and where long water hauls were necessary, a "one drill, two water truck" drilling unit was often able to obtain more holes than two drills with one water truck each.

Normal shothole depths ranged between 60 and 100 feet. Four deep holes (up to 250 feet) were drilled at the eastern end of Line 3 to check on postulated near-surface basement. The results of these tests were inconclusive.

(b) Recording:

The entire survey was conducted using the continuous profiling method.

Reflection quality was good on some profiles, but, in many instances no reflections were recorded at all. Two factors were recognized which contributed to the spotty results. First, reflection quality generally deteriorated with elevation; that is, the higher the elevation the greater the probability of finding thick sandstone and the faster the velocity of this sandstone the poorer its properties as a shooting medium. Second, abrupt changes occurred in the subsurface, with presumably a complete loss of the reflecting Paleozoic section.

Because of the several zones of records containing poor reflections or even no reflections whatsoever, an unusually large variety of multiple phone arrangements and shot-hole patterns was tried experimentally. In the central portion of Line 1, some improvement was managed through the use of 3 hole patterns; but, where the basic problem was non-reflection (ostensibly as a result of the loss of reflectors), or the basic problem was to initiate downward travelling energy by loading sufficiently deep shotholes in sandstone with sufficiently heavy charges, no improvement was accomplished.

Charges ranged from five pounds in the good reflection area in the central portion of Line 1 to 100 pounds in the sandstone outcrop at the north end of Line 6.

Specimen records in the profiles were ordinarily mixed field play-backs. Mixing was used to advantage in distinguishing between in-phase energy, which was desired, and out-of-phase energy, which was undesired.

Other items of field procedure are outlined in Appendix III of this report.

INTERPRETATION METHODS

The "normal uphole" correction was utilized to convert reflection times to two-way sub-sea times. Insomuch as no velocity control existed in the area and dips were such that analysis of move-out times was not considered a reliable velocity guide, cross-sections were prepared in time. However, a one-to-one scale based on a velocity of 15,000 feet per second was utlized in order that steep dip could be migrated and to give an estimate of the total depth of sedimentary section. Therefore, the depth scale shown on the cross-sections would greatly exaggerate depths of the shallow reflectors and was placed on the section only as a guide to depths of the deeper reflectors.

Reduced scale record sections were prepared by aligning and photographing field records. The record sections were thought to be more diagnostic than plotted cross-sections for the following reasons:

1) Reflection character enabled correlation of certain reflectors across fault zones and across some of the poor reflection zones.
2) The preponderance of high-quality partial reflections over the area carry uninterrupted only on a few traces of each record. We conclude that this type of reflection originates from a sequence of brittle beds which has been extensively fractured. Although the partial reflections can not be carried from record to record and can not be shown on the cross-sections as continuous reflections, they do assist in identifying an angular unconformity.

Only one reflection could be carried over enough of the area to be useful in map presentation. For this reason, only one subsurface contour map, Unidentified Paleozoic (Plate I), was prepared. An approximate outline of the Paleozoic basin is also shown on Plate I.

DETAILED DISCUSSION OF RESULTS

Best results were obtained on the segment of Line 1 (Plates III & IV) which lies between Shotpoints 121 and 61. An examination of this segment reveals the following significant geological considerations.

1) A persistent reflection having fair character stands out. It occurs at 1.248 seconds at Shotpoint 3, is downthrown to the east at Shotpoint 10, then rises gently eastward. This reflection is identified as "P" and heavy-lined on the enclosed sections.

   A deeper and less persistent reflection (1.653 seconds at Shotpoint 3) is also heavy-lined on the cross-sections. Following the two horizons westward, we find that they stop abruptly at Shotpoints 2 and 3 - just as if they "ran into a wall". Upper events persist farther to the west. We take this to mean that the horizons have "bumped into" a Precambrian island or peninsula in the Paleozoic sea.

   One might discredit the above hypothesis by saying that the gap in reflections is caused by shooting problems associated with sandstone found at higher elevations. However, one would be hard pressed to explain why the two strong, fairly persistent deeper reflections disappear abruptly while the more shallow reflectors continue farther to the west.

No more coherent reflections are noted to the west until the western extremity of the line, where one mile of reflection continuity at an intermediate depth suggests the return of basin conditions.

East of Shotpoint 54, we assume that we have again encountered a Precambrian island or northward projecting peninsula of the Paleozoic sea. The cross-section suggests that the island or peninsula here has a west-dipping flank. Since reflections in this locality were poor and also indicated that the Precambrian section was getting very close to the surface, the field crew skipped approximately 3 miles to Shotpoint 74. Recording at this point was performed under conditions which ordinarily would have yielded reflections, but no line-ups were obtained - possibly indicating that Shotpoint 74 is near the culmination of the Precambrian peninsula or island. Another skip of approximately 3 miles was made to Shotpoint 90. There was a return to basin conditions and a semi-persistent reflection vaguely correlatable with the "P" horizon was noted on the eastern end of Line 1.

2) Between Shotpoints 24 and 37 there are some sharply west-dipping partial reflections which define an angular unconformity. At Shotpoint 37 the line makes a right angle bend to the north. Here, to the north of Shotpoint 37, where the traverse is on strike with the beds beneath the angular unconformity, we see our only segments of "Precambrian" continuity.

We would logically associate this angular unconformity with the most drastic change in the section which would be the break-over between the Paleozoic and the Precambrian. Accepting this at face value, we thus have a means of estimating the thickness of the Paleozoic section. Projecting the angular unconformity westward along the line of section to its deepest point, we get a value at Shotpoint 12 of about 1.9 seconds. If we assume a "linear increase with depth" velocity distribution, take an initial instantaneous velocity (Vo) of 7500 feet per second (the sub-weathering horizontal velocity given by the first breaks) and take the refraction velocity (Vz) for the Precambrian as 21,000 feet per second (the limiting instantaneous velocity at depth), we can compute a thickness of 12,500 feet of Paleozoic section. This is roughly commensurate with the thickness of the Paleozoic measured across the outcrop in the Keep River Area, 100 miles to the southwest.

No cross-section was prepared for Line 2 since no reflections were obtained. Data on Line 3 were very poor. Lines 4, 5, and 6 add to the picture as follows:

1) The northern ends of Lines 4 and 6 carry very little information. This is quite likely due to surface conditions of high topography and sandstone. However, if we accept the few reflections present at face value, we must conclude that the Paleozoic basin deepens slightly to the north.

2) The southern portion of Line 6 shows the upper horizon (P) lapping on the lower semi-persistent

horizon at Shotpoint 116. This defines the approximate boundary of the Paleozoic basin at that point. Lines 3 and 5 show no such on-lapping; so, we conclude the southern limits of the basin lie somewhere south of the southern ends of these traverses.

As shown by the reflection contour map (Plate I), we have now outlined a north-south striking arm of the Paleozoic sea, bounded by two northward projecting Precambrian peninsulas. Reconnaissance gravity observations by Mines Administration Pty. Ltd. define a gravity minimum roughly coincident with the basin visualized. No support for the hypothesis of the westernmost Precambrian peninsula is provided by the scattered gravity data, however.

CONCLUSIONS AND RECOMMENDATIONS

If the Paleozoic basin were only of the small dimensions indicated by this limited seismic survey, no further exploration would be economically justifiable: since even if oil were found in quantity, a sufficiently large area could not be developed to make the venture payable in such a remote location. However, it is logical to presume that a commercially interesting thickness of marine Paleozoic extends north and west from the area worked. Consequently, within the confines of Permit No. 2, a sufficiently extensive distribution of marine Paleozoic may exist to justify a large scale exploration program. In planning future programs we would recommend the following:

1) A seismic reconnaissance offshore water program coupled with additional gravity control to attempt to determine the areal extent of the Paleozoic basin.

2) If additional land seismic work is eventually conducted, we strongly urge that standard dip shooting procedures be utilized because of the predominance of high quality partial reflections and the steep dip encountered. Traverses should consist of a grid of straight lines with cross spreads used at each shotpoint. A three-dimensional analysis could be expected to yield benefits which include:

a) Increased resolving power of the survey;

b) earlier recognition of structural problems in preliminary interpretation;

c) a more accurate structural solution in the final interpretation.

The combined seismic water work and gravity survey provides an economical preliminary approach toward further evaluation of the area. If detailed land seismic work is then desired, the benefits of the dip shooting method recommended should more than offset the additional costs of such a program.

Respectfully submitted:

AUSTRAL GEO PROSPECTORS PTY. LTD.

Douglas F. Warner

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Interpretation Supervisor.

July, 1961.

LOCATION, PERSONNEL, AND EQUIPMENT

Crew Headquarters:	Port Keats, N.T.
Party Chief:	S. S. Chambers.
Observer:	J. E. Simpson.
Drillers:	R. Barger, H. Munro.
Surveyor:	B. O. Llewelyn.
Recording Unit:	S.I.E. P-11 seismic system with S.I.E. PMR-6A magnetic recorder mounted on a 1960 International B-162 truck. Shooting truck (1960 Ford F-600) included water tank, explosives storage compartments, and related shooting equipment.
Drill No. 1:	Failing CFD-2 drill mounted on 1960 International 4 x 4 drive truck.
Drill No. 2:	Mayhew 200 drill mounted on 1959 Ford F-600 truck.
Survey Unit:	1960 utility type Land Rover. Watts Microptic Alidade, and related surveying equipment.

STATISTICS

Starting Date, (Leave Brisbane):	19 September, 1960.
Completion Date, (Return Brisbane):	8 December, 1960.
Recording Time:	
Drive to and from field:	115.0 hours
Field:	392.0 hours
Move:	302.0 hours
Holidays:	20.0 hours
Lost due to Weather:	0.0 hours
Lost due to Equipment Failure:	0.0 hours
Holes Shot:	259 holes
Miles of Traverse:	62 miles
Drill Time:	
Drive to and from field:	176.5 hours
Field:	560.0 hours
Move, Standby:	690.0 hours
Holidays:	20.0 hours
Lost due to Weather:	0.0 hours
Lost due to Equipment Failure:	0.0 hours
Holes Drilled:	457 holes
Total Footage:	31,503 feet
Bits Used:	34 4¼" inserted 3 blade bits 4 5 " inserted 3 blade bits 2 4¼" Rock Bits.
Drilling Chemicals Used:	None.

FIELD PROCEDURES

Surveying Control:	Tied to reference markers A.W. 1 & A.W. 2.
Magnetic Declination Used:	3.5 degrees east.
Type Geophones Used:	S.I.E. S16, 18 c.p.s.
Number per Trace:	4
Connection:	Series
Spacing in Group:	30 feet
Number of Channels:	24
Normal Filter Setting:	Tape: 30-90 c.p.s., unmixed Play-back: 30-64 c.p.s., mixed
Spreads Used:	1320 feet
Method Used:	Continuous profiling; single holes, 3 hole patterns, some 5 hole patterns; 45 feet spacing between holes in pattern.
Distance from Shotpoint to Close Geophone Stations:	110 feet
Relation of Far Geophone Stations to Interlocking Shotpoints:	At interlocking shotpoints
Normal Dynamite Charge:	$2\frac{1}{2}$ - $7\frac{1}{2}$ pounds
Operational Difficulties:	Long water hauls slowed down drilling. Long supply hauls from beach to camp; $3\frac{1}{2}$ -4 day round trip required by barge per load of equipment moving in and out of Port Keats.

APPENDIX IV

LIST OF PLATES