Rept. Bk. No. 61/116 G.S. No. 3293 D.M. 1679/64



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# DEPARTMENT OF MINES SOUTH AUSTRALIA

GEOLOGICAL SURVEY

PETROLEUM EXPLORATION DIVISION

PRELIMINARY REPORT ON A SEISMIC REFRACTION AND REFLECTION SURVEY IN THE WOOLTANA AREA OF THE FROME EMBAYMENT 1964

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P. W. Taylor Geophysicist SEISMIC GEOPHYSICS SECTION

28th October, 1965

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by

### P. W. Taylor Geophysicist SEISMIC GEOPHYSICS SECTION

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# PRELIMINARY REPORT ON A SEISMIC REFRACTION AND REFLECTION SURVEY IN THE WOOLTANA AREA OF THE FROME EMBAYMENT 1964

#### SUMMARY

The survey delineates the subsurface extension eastward of the Early Proterozoic formations of the eastern Flinders Ranges, thereby indicating the economic basement for oil exploration in the area.

It also indicates the western termination of the Transition beds in the area, by wedge out against the rising basement.

#### INTRODUCTION

A refraction and reflection seismic survey was carried out by the Department in the Wooltana area of the Frome Embayment in July, 1963 as part of the general exploration of the Great Artesian Basin in South Australia.

This report deals with the PC line which runs from position  $30^{\circ}$  11: 44\*S,  $139^{\circ}$  27: 36\*E at shot point PC 32 W for about 27 miles east to shot point PC 82. The western extremity of the line is situated about  $\frac{2}{2}$  mile northwest of Paralana homestead and 1 mile east of the outcropping Early Proterozoic formations of the eastern margin of the Flinders Range.

Refraction coverage extended the whole length of the line for the deepest refractor, and depth probes were shot for all refractors at positions centered on shot points PC 78, 28, 11 and PC 37 W. Total reverse coverage of the deep refractor was not obtained because of difficulties caused by rain in the area.

Continuous reflection coverage was shot from PJ 24 to PC 53. The quality of the records varied from poor to fair.

#### RDFRACTION INTERPRETATION METHODS

The interpretation of the refraction records has been made difficult by the absence of reverse coverage over much of the section, also by the poor quality of the records at the eastern end of the line.

In view of these difficulties, where possible, three methods of interpretation were used and the results plotted together to provide a check against one another.

#### Method I

This method was used at those points on the section where depth probes provided coverage of all refractors. Starting at the shallowest interface:-

$$\frac{d_1}{2(v_1^2 - v_2^2)^{\frac{3}{2}}}$$

where  $d_1$  = thickness of 1st refractor  $T_1$  = intercept time " "  $V_1$  = velocity " "  $V_0$  = velocity of medium above refractor

The thickness of the next refractor was then calculated from:--

$$T_{2} = 2d_{1} \frac{(v_{2}^{2} - v_{0}^{2})^{2}}{v_{2}v_{0}} + 2d_{2} \frac{(v_{2}^{2} - v_{1}^{2})^{2}}{v_{2}v_{1}}$$

where  $T_2 =$  intercept time of 2nd refractor

 $V_2 =$  velocity  $\gamma_1$ d<sub>2</sub> = thickness  $\gamma_2$ 

For the third refractor :-

$$T_{3} = 2d_{1} \frac{(v_{3}^{2} - v_{0}^{2})}{v_{3} v_{0}} + \frac{2d_{2}(v_{3}^{2} - v_{1}^{2})^{2}}{v_{3} v_{1}} + \frac{2d_{3}(v_{3}^{2} - v_{2}^{2})^{2}}{v_{3} v_{2}}$$

Where  $T_{ij}$  = intercept time of 3rd refractor

- V) = velocity = •
  - d<sub>3</sub> = thickness " " "

The depth points were plotted beneath the appropriate shot points and marked thus X

#### Nethed II

This method was used where there were points of inflexion on the time distance curves giving the critical distances and times for the deeper refractor. The formula used was:-

where

d = depth of refractor

x = critical distance

S = horisontal distance between shot point and point on refractor from which oritical distance

energy comes.

 $V_1$  = velocity of refractor

V = average velocity deva to refractor

The calculation was done in two stages. First an approximate value of  $V_{a}$  was calculated by dividing the critical distance by the critical time.



This was put into formula (1) and an approximate value for d obtained. Using d and  $\frac{1}{2} \times_{0}^{-}$  the value of 1 was calculated and from this and the critical time a more accurate value of  $V_{a}^{-}$ calculated. This was again put into (1) and a new value of d calculated. It was found that a third repetition of the calculation produced no significant change in the depth value, so the process was not taken beyond the second approximation. The offset distance was then calculated from (2) and the depth point plotted at the offset distance and marked thus  $\bigcirc$ 

#### Mothod III

The intercept time was again used in this method but each refractor was reduced to a two layer problem by using the average velocity to refractor calculated in Nethod II and averaged along the traverse. The formula used:-

$$D = \frac{T_1 \quad V_a}{2 \cos i}$$

where

т <sub>і</sub>	Ħ	intercept time
V <sub>a</sub>	*	average velocity to refractor
v <sub>r</sub>	n	velocity of refractor
1	ų	angle whose sine is $\frac{Va}{V_{r}}$
đ	n	depth of refractor

The depth points were plotted \_\_\_\_\_ under the appropriate shot points.

#### INTERPRETATION

The interpretation shows the following structure. First there is a layer, velocity  $5,000^{1}/\text{sec.}$  to  $5,600^{1}/\text{sec.}$  with a base that lies about 200° above datum (300° above M.S.L.) at the western end of the line, which dips irregularly to the east. At the eastern end of the traverse the depth of the base is about 500° below datum. Next below we have a layer of volocity  $6500^{1}$ /sec to  $8000^{1}$ /sec whose base is about 200' below datum at the western end of the traverse and which dips at about 2<sup>0</sup> to the east to shot point P0 7 where it reaches a depth of 1700'. From here it continues level to the eastern end of the line.

East of shot point PC 7 a layer of velocity 14,000<sup>1</sup>/sec to 15,000<sup>1</sup>/sec lies beneath the 6,000<sup>1</sup>/sec layer. Its base dips at  $1\frac{1}{7}^{\circ}$  from about 2,000' at PC 7 to 4,000' at PC 62. From here it rises slightly to about 3,500' at the eastern end of the line. The western end of this layer appears to wedge out against the deepest refractor at PC 7.

The top of the deepest refractor lies at 200' below datum at the western end of the line. It dips at angles  $1\frac{1}{2}^{0}$ to 2° to a maximum depth of about 4000', at 90 62, from whence it rises slightly to 3,500' at the end of the line. The velocity is about 16,500<sup>1</sup>/sec at the shallow western end. At PC 7 the velocity is about 19,000 /sec and continues approximately at this value to the sastern end of the line.

The velocity and depth values given above are affected by the lack of information from reverse coverage and cannot be given an accuracy higher than  $\pm 10\%$  of the indicated values.

It is possible that the deep refractor shown on the section may not be a single continuous formation. More detailed shooting would be necessary to resolve this.

### Reflection Interpretation

Continuous reflection profiles were shot in the central part of the traverse between PC 24 and PC 53.

The records are of poor to fair quality. No pronounced dips are shown on the cross section. The two strongest bands of energy are control at .5 secs and .75 secs two way time.

A T - AT examination of the records leads to the conclusion that events below the .75 sec energy band are

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multiples of earlier events.

#### Correlation of Refraction and Reflection Work

The equivalent two way reflection time of the 14,000 / sec refractor and the 19,000 /sec refractor were calculated from their depths and average velocity to the refractor for points between PC 22 and PC 57 and plotted on the reflection cross section. The shallower layer was plotted thus, x, and the deeper layer thus,  $(\underline{x})$ 

It will be seen that they fall respectively within the .5 sec. and .75 sec energy bands. Taking into account the uncertainty of depth and velocity of the refractors they correlate well with the reflection section.

#### Correlation of Seismic and Geological horizons

The 14,000<sup>1</sup>/sec refractor lies at a depth of about 1700<sup>4</sup> below datum. This is in the region of the depth of the "C" horizon of the Great Artesian Basin which the Petroleum Geology Section has mapped at about 1600<sup>4</sup> at a point coinciding with the eastern end of the traverse. The "C" horizon is a seismic event, occurring at the top of the "Transitional Beds" which lie between the Gretaceous Roma beds and the Jurassic Mooga Equivalent beds.

The proximity of the outcropping Early Proterezoic formations of the eastern margin of the Flinders Range to the shallow eastward dipping high velocity refractor at the western end of the traverse leads to the strong presumption that this refractor is the subsurface continuation of those formations. If this is so it represents the economic basement for petroleum exploration.

P.W. Toylar C. P. W. Taylor fuik Geophysicist SEISMIC GEOPHYSICS SECTION

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#### Sorrelation of Refraction and Reflection Work

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The equivalent two way reflection time of the 14,000 / sec refractor and the 19,000 /sec refractor were calculated from their depths and average velocity to the refractor for points between PC 22 and PG 57 and plotted on the reflection cross section. The shallower layer was plotted thus, x, and the deeper layer thus,  $(\bar{x})$ 

It will be seen that they fall respectively within the .5 sec. and .75 sec energy bands. Taking into account the uncertainty of depth and velocity of the refractors they correlate well with the reflection section.

#### Correlation of Seismic and Geological Horizons

Due to the lack of any deep bores in this area any attempt to correlate the seismic events with geological horizons must be approached with caution. The refractor with a velocity of 14,000 ft./sec. has been interpreted to lie at a depth of about 1700 ft. This depth may be in error due to velocity inversions. In this area the 'G' reflector occurs at approximately this depth, but the relatively high velocity makes it unlikely that the refractor does in fact coincide with the 'G'. A more possible correlation is with an unconformity at the base of the Mesozoic. This view is supported by the probable lack of section between the base of the marine cretaceous and the pre-cretaceous sediments.

The refractor of velocity 19,000 ft./sec. presents similar problems with regard to the correlation. Decause of the large number of reflections recorded from beneath this refractor it is suggested that it represents a sedimentary horizon rather than a true basement. There is no direct evidence as to the nature of this horizon but it is possible that it represents a Cambrian Limestone or a sedimentary member of the upper Adelaidean. Velocity analyses of the reflection records in the area have failed adequately to derive the velocity distributions, and much doubt still exists as to the validity of many of the deep reflections. It is considered however that at least some of these reflections can be identified as primaries thus thending credence to the supposition of a fairly thick sedimentary section. At present it would seem that a deep hole is required in order to give adequate geological control to the seismic events.

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