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# REPORT ON

# GIRALIA-BULLARA SEISMIC REFLECTION TRAVERSE, WESTERN AUSTRALIA.



by

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This report covers the results of a seismic reflection traverse on portion of the Giralia anticline which has been mapped in Mesozoic and Tertiary rocks in the North-West basin. This basin lies in the North-West District of Western Australia between the coast and the 116th east meridian, and is otherwise bounded by latitudes 21°30' South and 26°30' South.

The work constitutes a part of a general programme of investigation which the Bureau of Mineral Resources, Geology and Geophysics, has been carrying out on Permit areas held by Ampol Petroleum Ltd. in this area. The Australian Mining and Smelting Company also holds a Temporary Reservation over the area for prospecting for evaporites. Geologists of the Bureau have during the past three years been carrying out geological mapping in the basin. It contains Palaeozoic rocks which outcrop mostly on the eastern portion and Mesozoic and Tertiary rocks which overlap the Palaeozoics on the west. The existence of anticlinal structures in the Mesozoic and Tertiary rocks has been known for many years but they have never before been mapped in detail. These structures have large dimensions, being many tens of miles long and have up to 1,500' ± of closure in the near surface rocks. Dr. Schneeberger, Supervising Geologist of the Bureau, has expressed three alternatives to the tectonic nature of the major structures and the task of the seismic survey was to determine, if possible, which of these structural conditions actually existed. The three alternatives were expressed as follow :-

(1) It is assumed that the Palaeozoic sediments are developed in at least the same thickness as measured in outcrop sections farther east. They are faulted in a similar fault pattern as they are near the eastern margin of the basin. The folding of the Mesozoic-Tertiary sediments, which overlie the Palaeozoic rocks unconformably, is a reflection of the block-faulting of the Devonian-Permian sequence in depth. This should result in a seismic reflection picture in two independent sets of dips, the higher set appertaining to the folded Mesozoic-Tertiary sequence, the deeper one to the block-faulted Palaeozoic strata.

(2) The Palaeozoic and Mesozoic-Tertiary sediments are harmoniously folded, although insipient folding movements might have taken place in pre-Mesozoic time. Dips in the younger strata should in this case be of approximately the same magnitude as those in the Palaeozoic beds. A deep-seated basement core might, however, be present, but would presumably be out of reach of the seismic investigation.

(3) The Cape Range and Giralia structures contain basement cores (buried hills), flanked and partly overlapped by Palaeozoic sediments. Similar to other well known structures of this type, differential compaction would be an essential factor for their origin. The steep zones in the Mesozoic-Tertiary sequence would in this case be caused by faulting in the basement complex. A solution of this alternative should be possible with refraction shooting, provided the Palaeozoic cover of the basement ridge is not too thick.

The seismic traverse described herein lies along the main road joining Giralia and Bullara homesteads and crosses the northern end of the Giralia structure. Plate 1 shows the layout of the traverse with the appropriate shot point numbers. Tests were made with shooting in shot holes and also by air shooting. The latter method proved most successful and was used for most of the work. In addition, a refraction spread was shot along the axis of the anticline. Insufficient refraction work was done, however, to determine whether or not the structure had a relatively shallow basement core as suggested in alternative (3). Reflections were relatively abundant and clear above a depth of approximately 2,500' and it seems likely that this corresponds to the Mesozoic and Tertiary rocks. Below this depth there is strong evidence of an unconformity, although the number and quality of the deeper reflections were not as good as the shallow ones. The cross section is described in detail below but first it is considered desirable to discuss briefly such technical matters as the interpretation technique and the symbols used in plotting results.

## Technical Matters.

The reflections have been graded according to a system described by P. P. Gaby (1947). Each reflection is graded twice. The first grading indicates the degree of certainty that the event is a reflection and takes into account the strength of the reflected energy, its duration and what is known as essential copy, i.e., the extent to which the character of the event is repeated from trace to trace across the record. The second grade indicates the accuracy of recorded dips and takes into account the deviations from the exact "line-up" from trace to trace across the record. There are four grades of certainty, good, fair, poor and questionable, represented respectively by G, F, P and R, and three grades of accuracy, good, fair and poor, represented respectively by G, F and P; thus a reflection graded as G.P. shows that the certainty is good but the accuracy is poor. The grading is shown on each reflection plotted in the cross section, and it is emphasised in the plotting where an unbroken line means good accuracy, a line with a single break means fair accuracy, three breaks means poor accuracy. In addition, a line of alternate dashes and dots means a questionable reflection. By this means the reader can assess the relative importance of each individual reflection. The reflection times corrected to a datum of approximately 100' above sea level are also shown on each reflection plotted.

The cross section is plotted in depth, i.e., the reflection times have been multiplied by the appropriate velocity to convert them into depths. The depths have been calculated and the tangents of the calculated angle of depth is marked on one end of the line indicating the reflection. A positive tangent means west dip and a negative tangent means east dip. These dips have been taken into account when plotting and the reflections are shown in the positions from which they appear to come if it is assumed that the section is normal to the strike of the reflecting horizon and that the velocity is uniform. A correction has been made for elevation effects. The shooting technique, in which the shot points were off-set by 2,400' normal to the traverse from the ends of the geophone spreads, did not provide the necessary data for making weathering corrections but special shooting to obtain this data was not considered justified for this traverse. Velocities used for the depth plotting have a probable error of ± 10 per cent, but this can have little effect on the structural picture obtained as an error of 10 per cent in relief is not important at this stage.

Phantom horizons have not been constructed but this could be done readily from the data available once the necessary zones were selected. The normal method of constructing a phantom horizon is to calculate the mean of all the dips within a chosen zone weighted according to accuracy grade. The phantom is drawn so that it follows the mean dip from point to point. This method is particularly valuable where there is not sufficient continuity of reflections to indicate the structure fully.

<u>Discussion of Results.</u>

Generally, across the section the shallow data are abundant and good, particularly in the zone between 2,000' and 3,000' with notable exceptions in the regions between shot points 6 and 8 and immediately to the west of shot point 24. The reflecting horizons conform generally with the surface structures. Below this zone there is good evidence of an unconformity, but the number and the quality of the reflections are not as good as in the zone above. The upper part of the section above the unconformity is believed to correspond to Mesozoic and Tertiary rocks which are separated from underlying Palaeozoic rocks by the unconformity.

The following is a detailed description of the section from east to west. Between shot points 40 and 34 the reflecting horizons are dipping slightly to the west and the shallow and deep horizons appear conformable. To the west of shot point 34 at about 2,750' deep an unconformity becomes apparent. Immediately below the unconformity between shot points 34 and 27 the reflecting horizons are dipping about 6° to the west, and at about 4° to the east between shot points 27 and 1, thus forming a syncline with its axis near shot point 27. The reflecting horizons above the unconformity are relatively flat and slightly synclinal. At about 4,000' under shot points 27, 26, 1 and 2 a second unconformity is suggested as the beds below that depth are dipping much more gently than those immediately above. From shot point 2 to shot point 6 the unconformities are not apparent and all beds continue either flat or with slight westerly dips, the most significant exception being the reflection under shot point 5 with different phases at 1.945 and 1.973 seconds respectively, which was actually recorded from shot point 11. It ~~showed~~ dips at about 55° and its significance in indicating faulting will be discussed later. From shot point 6 to the west side of shot point 7 there is a complete absence of reasonable quality data and this also indicates faulting. From shot point 8 westward the shallow reflections are conformable with surface dips including the steep dips which were noted between shot points 7 and 8. Shot point 14 coincides with the axis of the anticline with gentle east dips east of it and west dips to the west. To the west of shot point 8 the first high grade deep reflections, i.e., from below the major unconformity, are recorded from shot point 10 and they show westerly dips in contrast to the easterly dips of the shallow horizons above them. Below a depth of approximately 4,000' these westerly dips continue to shot point 16 which appears to be on the axis of a syncline. At a depth of between 3,000' and 4,000', however, the beds appear relatively flat and may be unconformable with both the shallow anticline and the deeper syncline. From shot point 20 westward the quality of the records was poor and a considerable amount of conflicting data is shown. However, the unconformity between the deeper and shallow zones is still apparent. Shot points 41 and 42 were not shot and shot point 45 gave no reflections whatever. A further seven miles westward three experimental shot points, A, B and C, were fired. The dips above 3,000' differ slightly from those below, but the evidence of an unconformity is not conclusive. There appears to be a reversal in dip in the deeper beds which suggests the presence of a syncline centred at shot point B.

Summary and Conclusions.

In relating these results to the main object of the survey, namely, the nature of the structure underlying the Giralia anticline, it is seen that :-

(a) A shallow anticline corresponding to the Giralia anticline and conformable with the surface geology exists to a depth of approximately 3,000'.

(b) There is a marked unconformity below this depth where there is actually a syncline underlying the shallow anticline.

(c) There is an absence of reflections beneath shot points 6 to 8 which is marked in the surface geology as an area of steep dips, and the absence of reflections is considered to be evidence of faulting.

It is thus possible to offer the following comments on the alternatives to the tectonic nature of the structure. The surface structure is not repeated at depth and the Palaeozoic and Mesozoic-Tertiary sediments are not harmoniously folded. There is no obvious relation between the deep and shallow structures. It is not possible to say from the seismic evidence whether or not the zone of steep dips on the eastern flank is caused by a deep-seated fault. Indications at present suggest that the steep dips may be underlain by a deeper fault or a series of faults confined to a relatively narrow region. This is suggested by the absence of reflections, a normal feature of a fault zone, and the steeply dipping reflection below shot point 5 that was recorded from shot point 11. This could possibly be a reflection from a fault plane which may have been misplotted due to errors inherent in the plotting technique and in the velocity assumptions. Such evidence as there is suggests that there may be a fault dipping at approximately 55° to the west below the area of steep dips but its exact location cannot be determined. Further evidence on this question might be obtained from refraction shooting which would involve north-south (strike) profiles each side of the supposed fault to obtain the depths to prominent refraction horizons which could be correlated and east-west profiles across the supposed fault to determine possible throw. The seismic results to date are not adequate to determine whether or not the Giralia structure has a basement core. The results from a refraction traverse approximately along the axis of the structure revealed a refractor with a velocity of greater than 20,000' per second at a depth which appears to be between 5,000' and 6,000'. This might be a part of the Palaeozoic sedimentary section, for example, a very dense limestone, but also it might be Pre-Cambrian basement. Until such time as velocities are measured in situ on the various Mesozoic, Palaeozoic and basement rocks it is not possible to offer an opinion as to the true identity of this refractor.

In conclusion it is pointed out that the results of the present traverse demonstrate clearly that the investigation of the area for possible oil-bearing structures and with a view to the selection of drilling sites cannot be completed without a considerable additional amount of seismic work.

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Melbourne.
November, 1951.

Reference : Gaby, Phil. P., "Grading System for Seismic Reflections and Correlations," Geophysics, Vol. XII, No.4, 1949.

Distribution :

1. Under Secretary for Mines, Western Australia.
2. Chief Geologist.
3.) General Manager, Ampol Petroleum Ltd.
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GIRALIA RANGE TRAVERSE "A"
S.P.15
S.P.14
S.P.13
S.P.12
S.P.11
S.P.10
S.P.9
S.P.8
S.P.7
S.P.6
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SEISMOGRAPH SURVEY
CROSS-SECTION
TRAVERSE "A" GIRALIA RANGE
N.W. BASIN - W.A.
SCALE 1 INCH = 500 FEET
DATE 16 NOV. 1951 SIGNED K.R. VALE
ALL SHOT POINTS OFFSET 2400'
PROFILE BASED ON AIR-SHOOTING
PRELIMINARY SECTION ONLY

22°35'
22°40'
22°45'
114°05'
114°10'
114°15'
114°20'
CENTIPEDE
CENTIPEDE BORE
GIRALIA H.
LEGEND
SHOT POINT
AIR SHOT POINT
GRAVITY STATION
FENCE
TELEGRAPH
TRACK
WATERCOURSE
BORE
TRIG STATION
HOUSE
GEOPHYSICIST
DATE
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G.98-8