Copy 3

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1972/95

PRESURVEY REPORT ON OFFICER BASIN SEISMIC SURVEY, W.A. 1972

by

J. Pinchin and S.P. Mathur

Record 1972/95

PRESURVEY REPORT ON OFFICER BASIN SEISMIC SURVEY, W.A. 1972

by

J. Pinchin and S.P. Mathur

CONTENTS

2

SUMMARY

Current geological surface mapping of the Officer Basin, W.A., by BMR has given an incomplete picture because the area is largely covered by flat-lying Permian fluvioglacials or lateritized Cretaceous rocks and the outcrops give no indication of the structure and composition of the sediments in most of the basin. The geological boundaries within the basin and at its margins are ill-defined, and the only reliable shallow subsurface information available from geophysical and well data is along the northern part of the basin near Warburton Mission.

A seismic survey in the Officer Basin, W.A., is planned to operate from mid-July to December 1972. The survey is to be conducted along a NE-SW line roughly following the road between Lake Throssell and Warburton Mission at the two margins of the basin. It will consist of a series of combined refraction and reflection probes located along the road. The operations will start with two probes near the centre of the basin, and the location of subsequent probes will depend on the progressive assessment of results. The results will be tied to those from the earlier seismic surveys in the northern part of the basin.

1. INTRODUCTION

A seismic survey across the southwest part of the Officer Basin in Western Australia is planned during mid-July to December 1972 as part of an integrated geological and geophysical investigation which commenced with geological mapping in 1970. The survey will provide subsurface information about the geological composition and structure of the basin to supplement the geological data obtained from sparse, widely scattered and deeply weathered surface rock exposures in the area. The survey is proposed to be a combined reflection and refraction operation along a NE-SW line roughly following the road between Lake Throssell and Warburton Mission (see Plate 1), covering a distance of about 350 km. This line has been chosen because (1) the field operations and logistics will be easiest along the road, which is one of the main routes through the area, (2) the resulting data would provide a subsurface coverage across the basin between its well-defined southwest and northeast edges where the Precambrian basement outcrops are exposed, and (3) a substantial amount of seismic data is already available to the west of Warburton Mission as shown in Plate 1.

The region under survey, referred to as the Officer Basin, W.A., covers an area of about 240 000 sq km and forms the western two-thirds of a Proterozoic-Phanerozoic sedimentary basin which occupies parts of Western Australia and South Australia. Much of the area underlies the Gibson and Great Victoria Deserts and is a flat, arid, monotonous series of sand dunes and plains, occasionally broken by residual erosional features and minor elevation changes. Access to the survey area is by two graded roads to Warburton Mission, one northeast from Laverton and the other north from Rawlinna on the Transcontinental Railway.

The climate of the area is that of a hot, dry inland desert with an average annual rainfall of less than 20 cm. Summer maximum temperatures (December to February) exceed 38°C while winter minimum temperatures are often around 4°C with an occasional frost. The vegetation is typically drought-resistant desert forms whose density and growth is controlled by soil conditions and rainfall. The drainage in the area is a relict system with numerous dry salt lakes. Surface water is almost non-existent except after heavy rains. A small volume of water exists semi-permanently in rock holes. Obtaining enough water for both drilling and domestic needs of the seismic party may be a problem despite earlier finds in widely scattered boreholes.

2. GEOLOGY

General

Since 1916 several geological investigations into the Officer Basin W.A. have been made by various workers. The most important of these has been a combined geological, geophysical, and drilling operation during 1961-66 by Hunt Oil Company (Jackson, 1966b) after which that company rejected the basin as a poor prospect for oil exploration owing to the Proterozoic age of the bulk of the sediments. Only recently systematic geological mapping of the basin on a 1:250 000 scale has been done by BMR in co-operation with the Geological Survey of Western Australia. A preliminary reappraisal of the geology of the basin was made in 1970 by Jackson (1971), and systematic mapping in 1971 by Lowry, Jackson, van der Graaff & Kennewell (1972).

The Officer Basin, the western part of which is shown in Plate 1, has been defined as the deep, elongated structural depression bounded by the Yilgarn Block on the west, the Musgrave Block on the northeast, and the Gawler Platform on the southeast. It is separated from the Canning Basin on the northwest by a subsurface basement ridge postulated and defined by gravity (Warri Gravity Ridge) and its southern flank is covered by the Tertiary rocks of the Eucla Basin. The earlier geological and geophysical investigations indicate that the basin is an elongated and asymmetrical structural depression aligned NW-SE with the deeper part closer to its northeast flank, and that the sediments in the western part are composed of a thick (5 500 m) Proterozoic sequence capped by a thin (about 450 m) veneer of Palaeozoic and Mesozoic rocks.

The western part is in contrast to the eastern part of the basin in South Australia, where it consists of a thin Proterozoic section (900 m) overlain by a thick (4 000 m) sequence of Palaeozoic rocks.

The results of geological mapping in the Officer Basin, W.A., in 1970 and 1971 combined with the earlier subsurface data from exploratory wells have been discussed by Lowry et al. (1972). The surface geology is shown in Plate 1 and the stratigraphic correlation in the area of the proposed survey is given in Table 1.

Stratigraphy

Most of the rock exposures in the basin belong to an undifferentiated Permian glaciofluvial sequence. Pre-Permian sediments and volcanics are also exposed in some areas. Along the proposed seismic traverse, two-

6

thirds of the distance from the southwest edge of Lake Throssell is covered by Permian sandstone which has weathered to sand dunes and plains. The remaining third on the northeast is covered by lateritized Cretaceous rolling plains and rises which are also deeply weathered and are underlain by claystone.

The Proterozoic and Phanerozoic sediments in the basin are believed by Jackson (1971) to overlie a Precambrian basement withihich in most areas consists of crystalline igneous and metamorphic rocks. The basement crops out only at the northeast and southwest margins of the basin.

The Proterozoic sequence consists of Townsend Quartzite, a quartzite and sandstone unit deposited in a littoral to sublittoral environment; Lefroy Beds, a shallow marine siltstone and fine-grained sandstone; Lupton Beds, a glacial conglomerate and sandstone; and the Browne and Babbagoola Beds, intersected in Browne and Yowalga Wells (Jackson, 1966b), which consist of interbedded limestone, shale, anhydrite, gypsum, salt, and sandstone. The later two are possibly the same Upper Proterozoic unit, and probably form the core of diapirs in this area.

The Officer or Table Hill Volcanics, mainly a basalt layer ranging in thickness from 26 to 118 m, overlies the Proterozoic sediments with an angular unconformity in the northeast margin of the basin and in the Browne Nos 1 and 2 wells. It correlates well with a good seismic reflector over much of the area surveyed in the northeast. When correctly dated, the basalt layer could provide a good time marker as well as a key seismic horizon if present in the rest of the basin.

Lennis Sandstone (uncertain age), a reddish fine-to-medium grained sandstone; Paterson Formation (Lower Permian), a poorly sorted conglomerate, sandstone, and claystone; and Samuel Formation and Bejah Claystone (Lower Cretaceous), a shallow marine series of sandstone and claystone, lie above the volcanics, all separated by unconformities. Lampe Beds (Lower Tertiary) occur only as isolated thin cappings on mesas and rises in the western and central parts of the basin.

Structure

The Mesozoic and younger sediments in the Officer Basin W.A., are mostly flat-lying. Dips in the older sediments along the west and south flanks are around 5° whereas along the northeast flank they range from 20° to 45°. Photogeological studies indicate the presence of some regional

6

faults, including the Westwood Fault. From the aeromagnetic results, Jackson (1966b) infers large subsurface faults bounding the deepest part of the basin on the northeast as well as local faulting in other areas. Seismic data indicate two types of anticlinal structures in the basin, both of which are present mainly in Proterozoic sections: (1) domal anticlines formed by diapiric intrusion, and (2) gentle flexures probably caused by subsidence and readjustment by faulting of basement rocks.

3. PREVIOUS GEOPHYSICAL INVESTIGATIONS

Magnetic

A large scale reconnaissance aeromagnetic survey was carried out in the Officer Basin for Hunt Oil Company in 1961 (Jackson, 1966b). The resulting magnetic basement contour map is reproduced as Plate 2. The main feature of the map is a deep basin with its axis trending NW-SE and the deepest areas (5700-6000 m) near its northeastern flank in the northeast of YOWALGA and northwest of WAIGEN*. Shallower sub-basinal areas are indicated in the southeast parts of YOWALGA and southwest part of NEALE. These basement contours must be regarded as questionable since (1) they are based on interpolations across a flight-line spacing of 48 km, and (2) the Officer and Table Hill Volcanics or other shallow basalts may extend over a large area and be sufficiently thick and shallow to have an unknown effect on basement depth calculations. Nevertheless, the depths in the northeastern part of the basin are in agreement with those computed from other geophysical data whereas those in the southwestern part of the basin are not, as the surface geology and near-surface resistivity measurements indicate higher resistivity (basement) rocks to be at or relatively close (about 160 m) to the surface.

Gravity

A Bouguer anomaly map based on regional gravity surveys by BMR in 1962 and 1972 to date, and a semi-detailed survey by Hunt Oil Company during 1963-65, is reproduced here as Plate 3. The contours show mismatch along the boundary between the BMR and Hunt surveys as the anomalies have been computed using different densities for Bouguer correction. The northeastern edge of the basin is marked by a positive anomaly area representing the Musgrave Block and the Warri Gravity Ridge representing a subsurface basement feature. A steep gravity gradient to the southwest indicates the northeast flank of the basin beyond which the

---

* In this report the names of 1:250 000 Sheet areas are written in capital letters to distinguish them from ordinary place names.

anomalies show three marked low (-80 mgal) areas: the first in the southeast of BROWNE, the second in the northwest of WAIGEN, and the third in the northwest of LENNIS. The first two correspond to lows in the magnetic basement, but the third to a magnetic basement ridge. The proposed line of seismic traverse runs along a minor gravity ridge area between the lows in BROWNE and LENNIS.

The preliminary Bouguer anomaly contours from the 1972 BMR survey indicate an L-shaped gravity ridge running from the northwest of YOWALGA into WESTWOOD and to the centre of THROSSELL. There is a sharp local gravity high in the centre of ROBERT, and to the west of this a low of -70 mgal marks the edge of a deeper feature extending into the area to the west of the map.

Seismic

Seismic reflection and refraction surveys have been made in the northern part of the Officer Basin by BMR in 1961-62 (Turpie, 1967), and in the northeastern part by the Hunt Oil Company in 1963-65 (Jackson, 1966b). The locations of the various traverses are shown in Plate 1 and the recording parameters are summarized in Tables 2 and 3.

The BMR survey was conducted along a traverse between the Musgrave Block in the east and the north end of the Yilgarn Block in the west, with refraction and reflection probes located about 48 km apart. Fair quality reflections were obtained using multiple-shot and multiple-geophone patterns. Refractor velocities of identifiable sediments near their outcrops and depths to various refractors and reflectors near the northeastern flank of the basin, were measured during this survey. The velocity information together with a tentative relationship to stratigraphy and lithology, as known at that time, is summarized in Table 4. Two refractors could be followed over most of the area surveyed. The deeper of the two probably represents the basement.

Three types of reflection seismic surveys were carried out for the Hunt Oil Company: Babbagoola Survey using 'Vibroseis' and single to 10-fold coverage (Kendall & Hartley, 1964), Warburton Survey using explosives and 6- fold coverage (Campbell, 1964) and Yowalga and North Lennis Surveys using 'Thumper' and 6-fold coverage (Mickleberry, 1966a, 1966b). Of these, the 'Thi nper' surveys were the most successful; an example is shown in Plate 4. Some refraction profiles were also shot to provide basement control near the northeastern edge of the basin. A good reflector, called Horizon A, was mapped over most of the survey areas while another reflector, called Horizon B, about 0.5 sec below and unconformable with A, was also mapped in Yowalga and North Lennis survey areas. The reflector B was stronger in areas where A was weaker. Several seismic sections show evidence of angular unconformity immediately below A. Some weak and discontinuous reflections below B can be seen in the Yowalga and North Lennis areas, and show gentle folding. The absence or poor quality of reflections below A, and B where mapped, may be due to poor penetration of seismic energy into deeper sections and/or greater interference from energy scattered by near-surface lateritized Cretaceous rock.

Four expanded spreads were shot for velocity information.

1. Mt Beadell (BMR)
2. Yowalga 13-C (Hunt Oil Company)
3. Lennis 49-Y (Hunt Oil Company)
4. Warburton S-S (Hunt Oil Company)

The Warburton line S-S gave no useful results. The Mount Beadell, Yowalga 13-C, and Lennis 49-Y recordings gave very similar velocities to the depths at which the reflections were identifiable. Below a two-way reflection time of 1.4 seconds the curves begin to diverge. The reflections below this time become weak and hard to correlate. The curve shown in Plate 5, derived from the Mount Beadell expanded spread (Turpie, 1967), is a good average sample.

Based on well logs and this velocity function, the Horizon A has been correlated to the basalt layer (Officer Volcanics) in Yowalga No. 2 and Lennis No. 1 wells. A synthetic seismogram derived from the sonic log at Yowalga No. 2 using the BMR computer program SEISSYN also shows a strong event from the top of the basalt layer (see overlay in Plate 4). However, in Browne No. 1 and No. 2 wells evaporites were met at the projected level of Horizon A. Here the reflections are weak and suggest that diapiric intrusions have pierced through the basaltic layer. Horizon B has not been intersected by any wells and cannot be correlated with a geological boundary.

Electrical

An electrical resistivity survey was made in 1971 near Squeakers Hill on the southwestern margin of the basin (Plate 1) for the Public Works Department, Western Australia (Australian Groundwater Consultants Pty

9

Ltd, 1971). The results indicate that a 160 m thick low-resistivity (30 to 100 ohm-metres) layer overlies are of higher (over 1000 ohm-metres) resistivity and imply that igneous and metamorphic rocks (basement) are quite shallow in this area.

Results

The results, of the geological and geophysical operations in the Officer Basin W.A. to date, have been summarized in Plate 6. The geological cross-section shown has been postulated by Lowry et al. (1972) on the basis of surface data from the outcrops and subsurface data from the exploratory wells in the area. The geological well data have been projected from distances up to 70 km away. The magnetic basement profile and the seismic horizons are based on the Hunt Oil Company surveys (Jackson, 1966b). The model of the gravity basement profile shown has been computed using a reasonable density contrast of 0.2 g/cm^3 between the sediments and the basement rocks. In the northeastern part of the basin the computed basement depths are in fair agreement with those obtained from other geophysical data, whereas in the southwestern part they are not. The Bouguer gravity anomalies at the true well locations are lower (-82 mgal) than those shown along the profile and may reflect greater thickness of basin sediments or the presence of massive salt domes.

4. OBJECTIVES AND PROGRAM

The purpose of the proposed seismic survey is to obtain subsurface information along a NE-SW line across the Officer Basin W.A. between its margins near Lake Throssell where the basement rocks are exposed and Warburton Mission where a considerable amount of geological and geophysical information exists. In particular, the objectives are:

1. To define the southwest and northeast margins of the basin.
2. To obtain a reliable configuration of the basement of the basin.
3. To determine the structure, thickness, and seismic velocity of the sedimentary layers in the basin.

The seismic survey party will leave Canberra on or about 20 June, operate in the basin for about five months (providing about 100 operating days), and return to Canberra on or about 20 December 1972. As this period is not sufficient for continuous recording of seismic data along the Laverton-Warburton Mission road from one edge of the basin to the other, a distance of about 320 km, it is proposed that the data be recorded in a series of refraction and reflection probes at intervals along the road.

The operations are planned to start near the centre of the basin (Traverse 1, Plate 1) and consist of:

1. Noise test, uphole shoot, and expanded spread to determine optimum shooting and recording parameters and subsurface velocity distribution - Time estimated 5 days.
2. CDP reflection and reversed refraction profiles, using comprehensive techniques (see Appendix 1), to record shallow and deep horizons including the basement (about 5000 m deep estimated from aeromagnetic and gravity measurements) - Time required 20 days.

Similar reflection and refraction profiles will be recorded along Traverse 2. The location and spacing of subsequent probes along the road, for additional information on reflectors and refractors as well as changing recording parameters and subsurface velocity distributions, will depend on the assessment of the results as the survey progresses. The seismic results will be related to those from the Hunt Oil Company seismic surveys in the northeastern part of the basin. It is also possible that some of the probes may be located towards the area of the gravity low in the northwest of LENNIS if the time and program permit.

The BMR is planning to drill a 300 m stratigraphic hole in an area along the road near the southwestern margin of the basin, where the seismic data would indicate the basement to be within this depth. Such a hole should allow correlation between the seismic horizons and the lithology in that area.

Gravity, magnetic, and radiometric measurements will also be made at 1 to 2 km intervals along the Laverton-Warburton Mission road as well as on 20 km long cross-traverses spaced 10 km apart along the road. The gravity observations will provide greater definition of the anomalies in the area of seismic traverse whereas the magnetic and radiometric data, which may be obtained with little additional effort, may provide additional information to assist in the overall interpretation.

A list of the personnel and equipment constituting the Seismic Survey Party is given in Appendix 2.

5. REFERENCES AND SELECTED BIBLIOGRAPHY

AUSTRALIAN GROUNDWATER CONSULTANTS PTY, 1971 - Water resources investigation, Poseidon Nickel Venture. Report for Public Works Department, W.A. No. 146F (unpubl.).

BAZHAW, W.O., & JACKSON, P.R., 1965a - Lennis-Breaden gravity survey, Officer Basin, Western Australia for Hunt Oil Company. Bur. Miner. Resour. Aust. Petrol. Search Subs. Act. Rep. (unpubl.).

BAZHAW, W.O., & JACKSON, P.R., 1965b - Neale Junction land magnetic survey, Officer Basin, W.A. for Hunt Oil Company. Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. (unpubl.).

BROD, R.J., 1962 - Aeromagnetic interpretation (Officer Basin) W.A., Geophysical Associates International, for Hunt Oil Company (unpubl.).

CAMPBELL, J.H.B., 1964 - Warburton seismic survey, W.A. Geophysical Associates International, for Hunt Oil Company. Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. (unpubl.).

DANIELS, J.L., 1969a - Explanatory notes on the Bentley 1:250 000 Geological Sheet, W.A. Geol. Surv. W. Aust. Rec. 1969/13 (unpubl.).

DANIELS, J.L., 1969b - Explanatory notes on the Scott 1:250 000 Geological Sheet, W.A. Geol. Surv. W. A. Rec. 1969/17 (unpubl.).

DANIELS, J.L., 1971a - Explanatory notes on the Talbot 1:250 000 Geological Sheet, W.A. Geol. Surv. W. Aust. Rec.

DANIELS, J.L., 1971b - Explanatory notes on the Cooper 1:250 000 Geological Sheet, W.A. Geol. Surv. W. Aust. Rec.

FAIRBRIDGE, R.A., 1967 - The hydrology of the Scott, Cooper, Bently and Talbot 1:250 000 Sheets, Geol. Surv. W. Aust. Rec. 1968/6 (unpubl.).

FLETCHER, R.W., 1933 - Summary of the petrological report on the rocks from the Warburton area. Ann. Rep. Dep. Min. W. Aust. 1932.

12

FORBES, B.G., 1968 - Officer-Eucla Basin-geological reconnaissance. Geol. Surv. S. Aust. Rep. 67/97 (unpubl.).

GEOPHOTO 1963a - Geomorphic evaluation of the Officer Basin area, Geophoto Services Inc., report for Hunt Oil Company. (unpubl.).

GEOPHOTO 1963b - Photogeological evaluation of the Gibson Desert Area, W.A., including petroleum permits 205^{h}, 260^{h}, and 207^{h}, Geophoto Services Inc., report for Alliance Petroleum N.L. (unpubl.).

JACKSON, M.J., 1971 - Notes on a Geological Reconnaissance of the Officer Basin, W.A., 1970. Bur. Miner. Resour. Aust. Rec. 1971/5 (unpubl.).

JACKSON, P.R., 1966a - Hunt Oil-Placid Oil, Well completion report No. 2 Yowalga. Hunt Oil Co. Report (unpubl.).

JACKSON, P.R., 1966b - Geology and review of exploration, Officer Basin, W.A. Hunt Oil Co., Report (unpubl.).

KENDALL, T.L., and HARTLEY, D.A., 1964 - Babbagoola vibroseis seismic survey, Seismograph Service Ltd. for Hunt Oil Company. Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. (unpubl.).

KRIEG, G.W., 1966 - Officer Basin - Geological reconnaissance. Geol. Surv. S. Aust. Rep. 63/61 (unpubl.).

LESLIE, R.B., 1961 - Geology of the Gibson Desert, W.A. Frome-Broken Hill Co., Pty Ltd. Rep. No. 3000-G-38 (unpubl.).

LONSDALE, G.F., & FLAVELLE, A.J., 1968 - Amadeus and South Canning Basins Gravity Survey, Northern Territory and Western Australia 1962. Bur. Miner. Resour. Rep. 133.

LOWRY, D.C., 1970 - Explanatory notes on the Jubilee 1:250 000 Geological Sheet, W.A. Geol. Surv. W.A. Rec. 1969/24

LOWRY, D.C., 1971 - Geological reconnaissance of the Officer Basin, 1970, W.A. Geol. Surv. Rec. 1971/6 (unpubl.).

LOWRY, D.C., JACKSON, M.J., VAN der GRAAFF, W.J.E., KENNEWELL, P.J., 1972 - Preliminary results of geological mapping in the Officer Basin, W.A. 1971. Bur. Miner. Resour. Aust. Rec. (in prep.).

LYNCH, V.M., 1965 - Airborne magnetometer survey of the Gibson Desert area. Union Oil Co., of California. Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. (unpubl.).

MICKLEBERRY, R.K., 1966a - North Lennis Seismic Survey, Western Australia. Report by Ray Geophysics (Australia) Pty Ltd for Hunt Oil Co. (unpubl.).

MICKLEBERRY, R.K., 1966b - Yowalga Seismic Survey, Western Australia. Report by Ray Geophysics (Australia) Pty Ltd for Hunt Oil. Co. (unpubl.).

MOORCROFT, E., 1967 - Seismic Reflections, refraction and gravity survey, Eastern Officer Basin, 1966. Min. Rev. Dep. Min. S. Aust. 126 (June, 1967).

MUMME, I.A., 1963 - Geophysical survey of the Officer Basin, South Australia. Trans. Roy. Soc. S. Aust., 87.

NAMCO INTERNATIONAL, 1962 - Seismic survey report - Mabel Creek area - South Australia and Western Australia. Namco International Inc. Report for Exoil Pty Ltd. (unpubl.).

SHIELS, O.J., 1961 - The petroleum prospects of the Officer Basin, South Australia and Western Australia. Report for Exoil Pty Ltd. (unpubl.).

SHOREY, D.J., 1966 - Serpentine Lakes reconnaissance seismic survey. Seismograph Service Ltd, report to Continental Oil Co. (unpubl.).

SOFOULIS, J., 1962 - Water supplies, Warburton Range and adjoining areas. Ann. Rep. Dep. Min. W. Aust. 1961.

STEENLAND, N.C., 1965 - An airborne magnetometer survey of the Western Officer Basin, oil exploration lease O.E.L. 28, South Australia. Adastra Hunting Geophysics Pty Ltd, and Geophysical Associates Pty Ltd, for Exoil Pty Ltd, Bur. Miner. Resour. Aust. Petrol. Search Subs. Act Rep. (unpubl.).

TALBOT, H.W.B., and CLARKE, E. de C., 1917 - A geological reconnaissance of the country between Laverton and the South Australian Border. Bull. Geol. Surv. W. Aust., 75.

TURPIE, A., 1967 - Giles - Carnegie seismic survey, Western Australia. Bur. Miner. Resour. Aust. Rec. 1967/123. (unpubl.).

VALE, K.R., and SMITH, E.R., 1961 - The "Depth-Probing" Tech ique using Seismic Refraction Methods. Bur. Miner. Resour. Aust. Rec. 1961/79. (unpubl.).

WATSON, S.J., 1963 - Giles-Carnegie seismic traverse, W.A., and S.A., 1961. Bur. Miner. Resour. Aust. Rec. 1963/7. (unpubl.).

WEBB, E.A., 1965 - Will Officer and Amadeus Basins both be productive? World Oil, 160(7), 160-5.

WELLS, A.T., 1963 - Reconnaissance geology by helicopter in the Gibson Desert, W.A. Bur. Miner. Resour. Aust. Rec. 1963/59 (unpubl.).

WILSON, R.B., 1967 - Woolnough Hills and Madley diapiric structures, Gibson Desert, W.A., A.P.E.A. J. 1967.

15

APPENDIX 1: Proposed seismic techniques

Refraction

The general method of refraction profiling is to record from two fixed shot-points (A and B in Plate 7-1) into geophones laid out along the line between them. The shot-points should be far enough apart to record the arrivals from the deepest refractor. This produces two continuous and reversed time-distance plots as shown in the Plate 7-1. From the intercept times and the apparent velocities, the depths to the refractor at A and B can be calculated using standard formulae based on the assumption that the refractor is a horizontal or uniformly dipping plane interface.

The travel-time curves are usually based on first arrivals of refracted waves, and the time intercepts and velocities derived represent only the conditions along the parts of the interface from which the refractions have been recorded and at the shot-point. If the refractor has a varying dip, an uneven surface or a varying velocity, the above method would result in erroneous depths. It would then be necessary to obtain first arrival refractions from the remaining part of the interface by shooting additional shots (A_1, A_2, A_3, ... B_1, B_2, B_3..........) beyond A and B and recording on spreads offset by a distance greater than the critical distance for the refractor, as illustrated in Plate 7-2. A realistic profile of the refracting interface is then obtained by computing depths from all geophone positions using the geophone delay-time method described by Vale & Smith (1961).

The initial refraction traverse at the centre of the basin will require a distance from A to B of about 26 km, since the basement depth is interpreted from gravity and aeromagnetic data to be about 5000 m in this area and the critical distance is computed to be 22 km. It is suggested that each spread of 24 geophone stations overlap by 3 stations for each shot to tie-in arrival times from the different shots. Station spacing should be 90 m for the general refraction method and 180 m for the continuous profiling on the basement since the latter spacing would still provide sufficient detail and halve the number of shots required.

It is estimated that the refraction traverse at the centre of the basin will require 30 shots, 8 200 kg of dynamite, and 7 days' work for the general method; and additionally 14 shots, 9 500 kg of dynamite, and 4 days' work for the continuous profile on the basement.

Other traverses in the basin would follow the same techniques, but where the basement is shallower, shorter distances and fewer shots would be involved.

Reflection

The BMR and Hunt Oil Company seismic results suggest that large shot and geophone patterns and possibly a 6-fold common-depth-point (C.D.P.) technique will be required to produce good reflections, particularly in the areas of lateritized Cretaceous outcrop. As there were no geologically significant reflections shallower than Horizon "A" (average two-way time 0.5 seconds), a geophone station spacing of 90 m is proposed. However, the following experiments will be done at the start and at intervals throughout the survey, and shooting and recording parameters will be selected accordingly.

	Experiment	Purpose
1.	Noise Test	Wavelength and velocity of shot-generated noise, design of geophone and shot arrays, station spacing, offset, and spread layout.
2.	Uphole Shoot	Depth and velocity of weathered layer, best shot depth.
3.	Reflection Quality Tests	Shot and geophone pattern and charge size selection.
4.	Expanded Spread	Velocity-depth information, identification of multiples, and selection of offset distances.
5.	Experimental C.D.P.	Multiplicity of coverage, assessment of signal-to-noise ratio for coherent and random noise.

17

APPENDIX 2: Proposed Staff and Equipment

STAFF

Party Leader	P.L. Harrison
Geophysicists	J. Pinchin E.J. Riesz (part-time) R.A.P. Garnett (part-time) A. Hogan (part-time)
Surveyor	1 (under contract from Department of the Interior)
Observers	L.E. Hemphill (part-time) A. Martindale
Assistant Observer	J. Walker (part-time)
Party Clerk	I. Betts
Shooters	R.D.E. Cherry S.J. Wilcox
Mechanic	E. McIntosh
Wages Hands	1 Cook 1 Cook's Offsider 1 Wages Mechanic 8 Field Hands
(ex Petroleum Technology Section)	
Toolpusher	E. Cherry
Drillers	E. Lodwick E. Reid
Drill Assistant	1
Field Hands	3

EQUIPMENT

Seismic Amplifers	SIE PT-700
Magnetic Recorder	SIE PMR-20
Camera	SIE TRO-6

Geophones	Hall Sears HS-J, 14Hz (total 1200) reflection Hall Sears HS-1, 4.5 Hz (total 200) refraction
Cables	12 x 2000 ft, 2 x 450 ft weathering cables
Recording Truck	Bedford 5 ton 4 x 4
Shooting Truck	Bedford 5 ton 4 x 4 Water Tanker
Workshop Truck	Bedford 5 ton 4 x 4
Flat Top Trucks	Bedford 5 ton 4 x 4, ... 2
Water Tankers	Bedford 5 ton 4 x 4, ... 4
Personnel Carrier	Land Rover Panel Van, L.W.B., ... 1
Personnel Carriers	Toyota Land Cruiser Station Wagon, L.W.B., ... 2
Geophone Carriers	Land Rover Ute, L.W.B. 3
Stores Runs	International C1300, 1 ton 4 x 4
Office Caravan	4 wheel trailer
Kitchen Caravan	" " "
Ablutions Caravan	" " "
Explosives Magazine	" " "
Workshop Trailer	" " "
Generator Trailer	" " " special
General Purpose Trailer	" " " 2
Drill Trailer	" " " 1
Drilling Rigs	Mayhew 1000, 1 .... 1 Foxmobile 2
Drill Tanker	Leyland Comet

19

Table 1. Correlation Diagram of Stratigraphic Units

AGE				WESTERN MARGIN	LENNIS WELL NO. 1 (HUNT OIL COMPANY)	YOWALGA WELL NO. 2 (HUNT OIL COMPANY)	BROWNE WELL NO. 1 (HUNT OIL COMPANY)	NORTHWESTERN MARGIN (WARBURTON AREA)
PHANEROZOIC	CAINOZOIC	Pleistocene						
		Pliocene						
		Miocene						
		Oligocene						
		Eocene						
	MESOZOIC	Cretaceous		Lampe Beds (3m)				
		Lower Cretaceous		Bejah Claystone (27m)				
				Samuel Formation (300m)	Samuel Formation (136m)	Samuel Formation (90m)	Samuel Formation (87m)	Samuel Formation
		Jurassic						
		Triassic						
	PALAEOZOIC	Lower Permian		Paterson Formation (600m)	Paterson Formation (52m)	Paterson Formation (316m)	Paterson Formation (50m)	Paterson Formation
		Carboniferous						
		Devonian						
		Silurian		Unnamed volcanics & siliclastics on N/E Robert Sheet	Lennis Sandstone (425m)	Lennis Sandstone (322m)		
		Ordovician			Officer Volcanics	Officer Volcanics (117m)		Table Hill Volcanics (26m)
		Cambrian			? ?			
PRE-CAMBRIAN	PROTEROZOIC	Upper	Adelaidean		? ? ?	Babbagoola Beds (143m)	Browne Beds (251m)	Lupton Beds (240m) Lefroy Beds (200m)
		Middle			?	?	?	Townsend Quartzite (255m)
			Carpentarian	Bangemall Basin Sediments (9000m)	? ? ?	? ? ?	? ? ?	Sedimentary, metamorphic, and igneous rocks of Musgrave Block
		Lower (GSWA)	Lower (BMR)		? ? ?	? ? ?	? ? ?	
	ARCHAEAN			Igneous and metamorphic rocks of Yilgarn Block	? ?	? ?	? ?	

Key

- Contact conformable
- Contact unconformable to disconformable
- Contact unconformable to disconformable, level uncertain
- Nature and stratigraphic level of contact uncertain
- // Hiatus
- ? Sequence unknown

Note: Approximate thickness of unit given in bracket where known.

(After Lowry et al., 1972)

Table 2. Summary of recording parameters used in seismic refraction surveys 1961-66

Traverse	Maximum X-distance	Refractor Velocity at max.distance	Depth of Refractor	Maximum Charge Size	Minimum X-distance	Refractor Velocity at min.distance	Depth of Refractor	Minimum Charge Size	Comments
Mount Charles (BMR)	20 km	5360 m/s	580 m	164 kg	1.5 km	5360 m/s	580 m	9 kg	
Mount Samuel (BMR)	19 km	5750 m/s	2840 m	260 kg	1.1 km	3470 m/s	316 m	18 kg	2nd event at max. distance
NMF - 19 (BMR)	24.5 km	6460 m/s	5680 m	190 kg	0.8 km	3160 m/s	252 m	9 kg	2nd event at max. distance
Mount Beadell (BMR)	25.6 km	6460 m/s	4420 m	820 kg	0.8 km	3380 m/s	252 m	9 kg	
Lake Keene (BMR)	10.5 km	6230 m/s	1580 m	91 kg	0.4 km	3350 m/s	63 m	9 kg	
Warburton A-A (Hunt Oil)	28 km	6750 m/s	6400 m	920 kg	0.4 km	6750 m/s	0 m	136 kg	Refractor followed to surface, later events picked at larger distances
Warburton M-M (Hunt Oil)	32 km	6750 m/s	6100 m	920 kg	0.8 km	3010 m/s	188 m	2 kg	Later events picked at larger distances.

Table 3. Summary of recording parameters used in seismic reflection surveys, 1961-66

Survey	Line	Coverage	Shot Pattern	Shot Depth	Charge Size	Geophone Pattern	Geophone Type	Station Interval	Offset	Section Quality
Giles-Carnegie (BMR)	Mt Charles	Single fold	one hole	16-31 m	2 - 5 kg	6 in line cover 35 m	EVS 2B	35 m	Split Spread	Poor
	Mt Samuel	"	"	21-27 m	2 - 5 kg	-"-	"	"	"	Poor
	NMF (1961) 19	"	"	23-37 m	2 - 5 kg	-"-	"	"	"	Poor
	NMF (1962) 19	"	7 in line over 83 m	25 m	7 x $1\frac{1}{4}$ = 9 kg	24 in rectangle (4 rows) 35m x 35 m	"	"	"	Poor/Fair
	NMF (1962) 19	"	36 in diamond 70 m on each side	4 m	36 x $\frac{1}{3}$ = 12 kg	24 in rectangle (4 rows) 35m x 35m	"	"	"	Fair
	Mt Beadell (1962)	"	Single	25 m	5 kg	6 in line over 35 m	"	"	"	Fair/Poor
		"	9 in diamond 31m on each side	2 m	9 x 1.1/8= 10 kg	"	"	"	"	Fair
	Mt Beadell (1962)	" "	36 in diamond 70 m on each side	4 m	36 x $\frac{1}{3}$ = 12 kg	24 in rectangle (4 rows) 35m x 35m	"	"	"	Fair/Good
	Mt Everard	"	36 "	4 m	36 x 1.1/8 = 41 kg	"	"	47 m	"	Fair/Good
WARBURTON (Hunt Oil)	BB	"	Single	25-35 m	23 - 50 kg	16 in line over 80 m	HS L-1	35 m	156-3120 m	Poor
	27th parallel		Single	"	"	"	"	"	Split Spread	Fair
	DD	6 fold	"	35 m	$13\frac{1}{2}$-77 Kg	"	"	70 m	"	Poor/Fair
BABBAGOOLA* (Hunt Oil)	1	Single Fold	20 over 528 m	0	Vibroseis	400 over area of 195 x 65 m	HS-J	41 m	1320-2640 ,m	Poor/Fair
YOWALGA (Hunt Oil)	All lines	6 fold	64 drops on two parallel 135 m lines separated by 65 m	0	Thumper	192 in parallelogram 330 m x 60 m	EVS-3A	135 m	355-1670 m	Fair/Good
LENNIS (Hunt Oil)	All lines	6 fold	48 drops on two parallel 190 m lines separated by 65 m	0	Thumper	144-288 in parallelogram 330 m x 60 m	EVS-3A	135 m	395-1700 m	Fair/Good

* Many experimental techniques were used during the vibroseis survey, including up to 10 fold C.D.P., but only one example is given, the other results were comparable.

Table 4. Correlation of Refraction Velocities Measured During 1961-66

Giles-Carnegie (BMR)	Babbagoola (Hunt Oil)	Warburton (Hunt Oil)	Age	Lithology
V_w = 978 m/s	V_w = 782 m/s, D_w = 13 m		Quaternary	Weathered layer laterite and red-brown clayey soils.
High velocity stringers in weathered layer 2610 m/s.			Tertiary	Bedded white chalcedony marly chalcedonic breccia sandy siliceous limestone.
V_e = 1960 - 2940 m/s	V_e = 2080 m/s	V_e = 2040 m/s	Cretaceous	Sand Shale Gravel
3260 - 3590 m/s		3110 m/s	Permian	Sandstone
				(UNCONFORMITY) (HORIZON 'A')
5310 - 5540 m/s		5470 m/s	Lower Palaeozoic to Upper Proterozoic	Volcanics or Limestone Shale Gypsum Dolomite
5920 - 6690 m/s		6000 m/s (6950 m/s) 6690 m/s	Proterozoic to Archaean (?) Basement	Sandstone Shale Dolomite etc. to Granite, Gneiss etc.

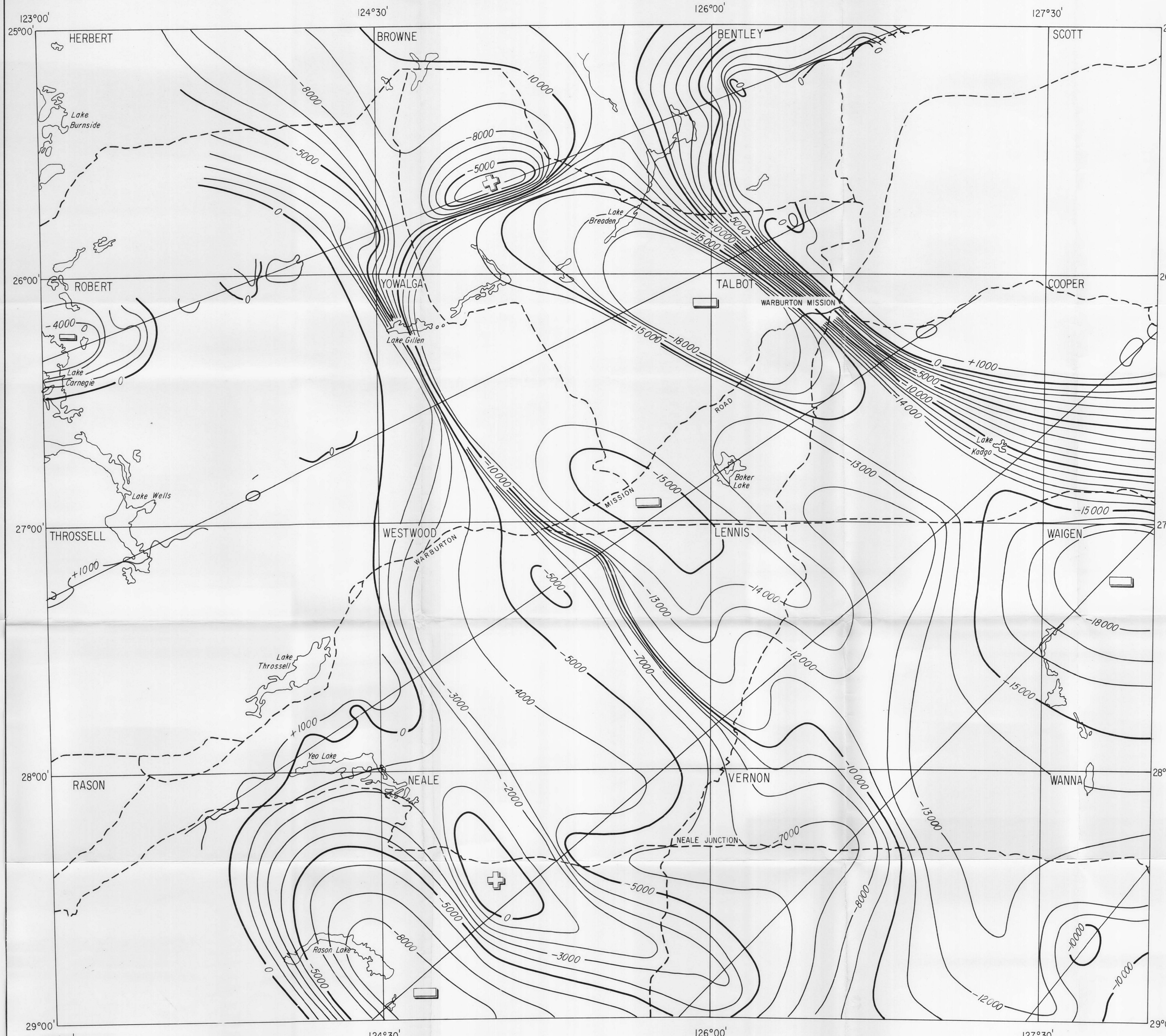
PLATE I

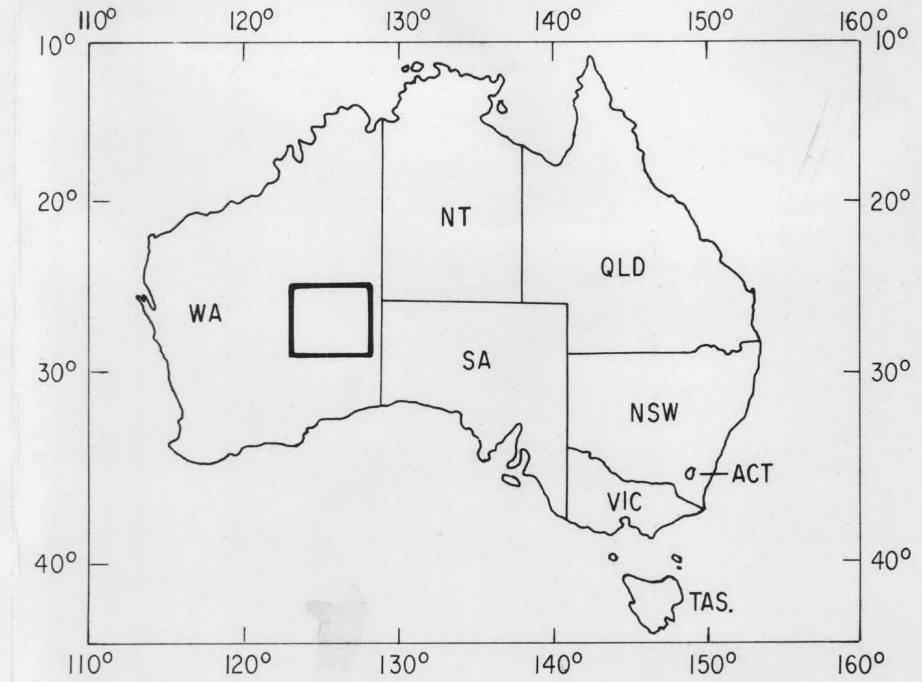
SURFACE GEOLOGY AND LOCATION MAP

(BASED ON G51/B0-26) To accompany Record No 1972/95

G51/B3-32

PLATE 2





LEGEND

MAGNETIC BASEMENT CONTOURS (interval 1000ft) (Datum: sea level) from Hunt Oil Company (Jackson, 1966b)

ROAD OR TRACK

FLIGHT LINE

BASEMENT 'HIGH'

BASEMENT 'LOW'

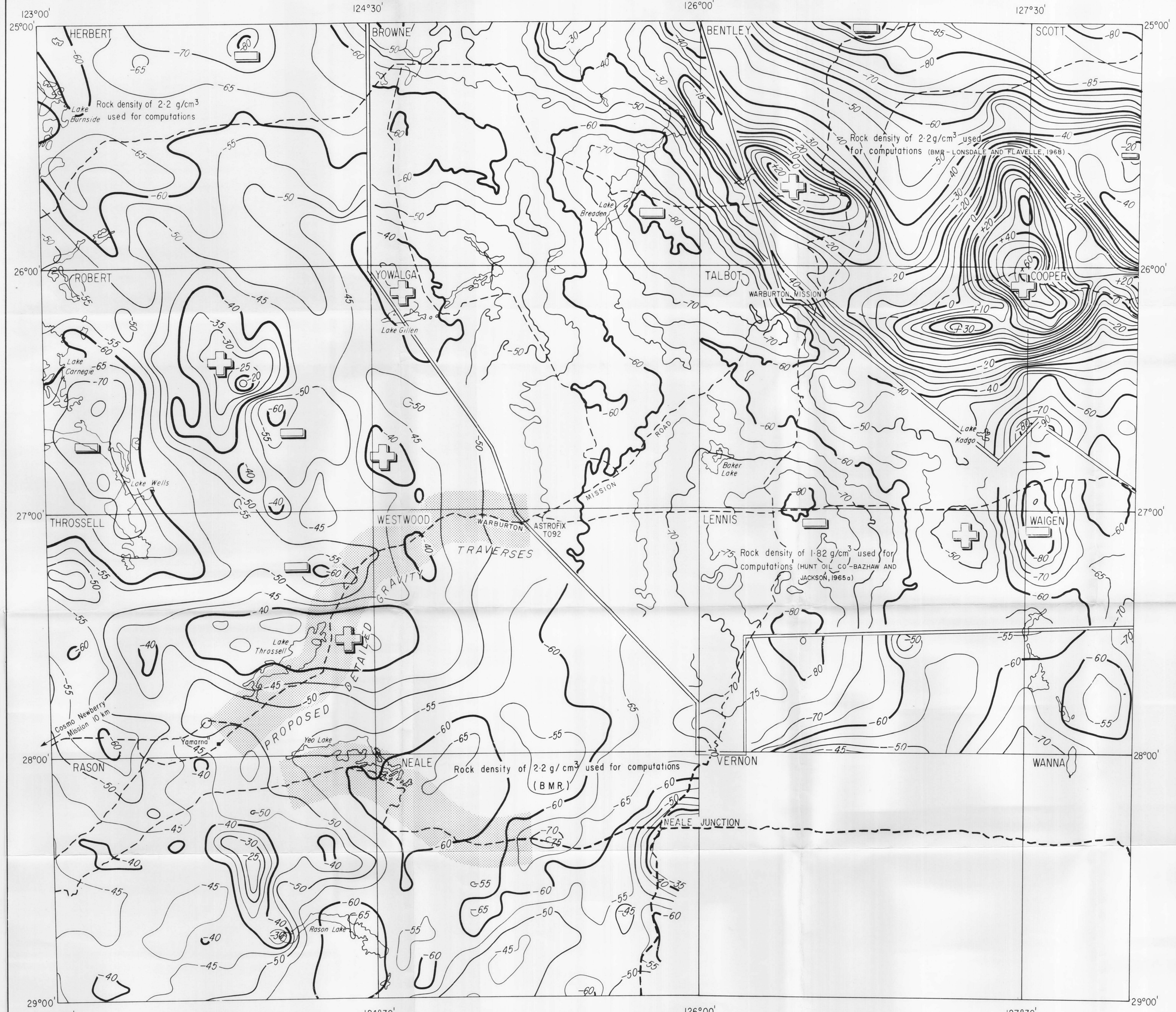
MAGNETIC BASEMENT CONTOUR MAP

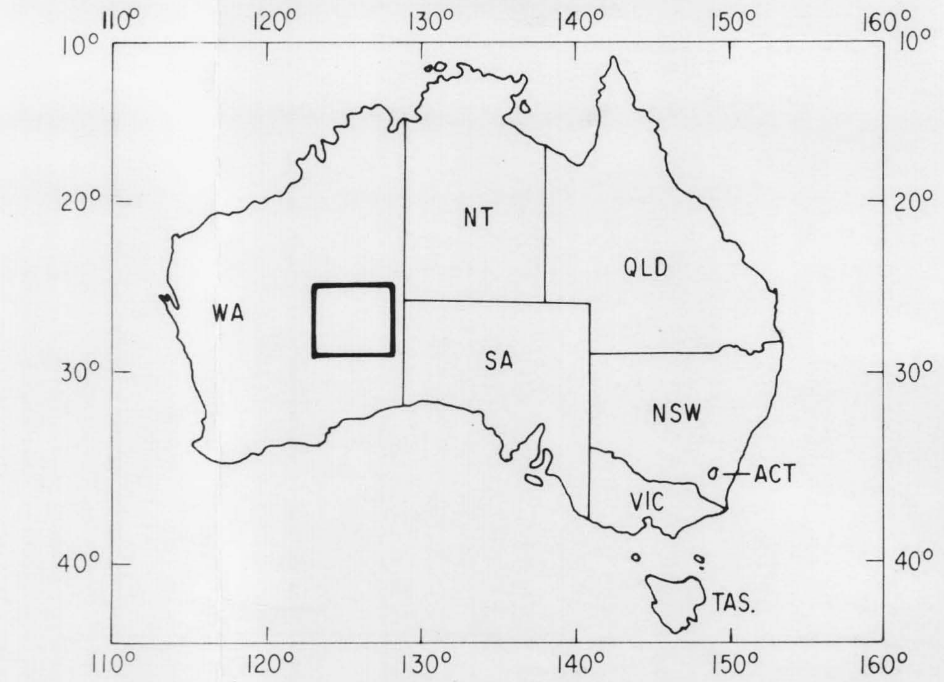
SCALE

10 0 10 20 30 40 50 60 70 80 90 100 110 KILOMETRES

(BASED ON G51/B0-26) *To accompany Record No 1972/95*

After Hunt Oil Co., 1966. G51/B3-33





LEGEND

BOUGUER ANOMALY CONTOURS (interval 5 mgal)

DENSITY CHANGE BOUNDARY

GRAVITY 'HIGH'

GRAVITY 'LOW'

HUNT OIL Co. GRAVITY TRAVERSE

BMR PROPOSED DETAILED GRAVITY SURVEY, 1972

BOUGUER ANOMALY CONTOUR MAP

SCALE

10 0 10 20 30 40 50 60 70 80 90 100 110 KILOMETRES

(BASED ON G51/B0-26) *To accompany Record No 1972/95*

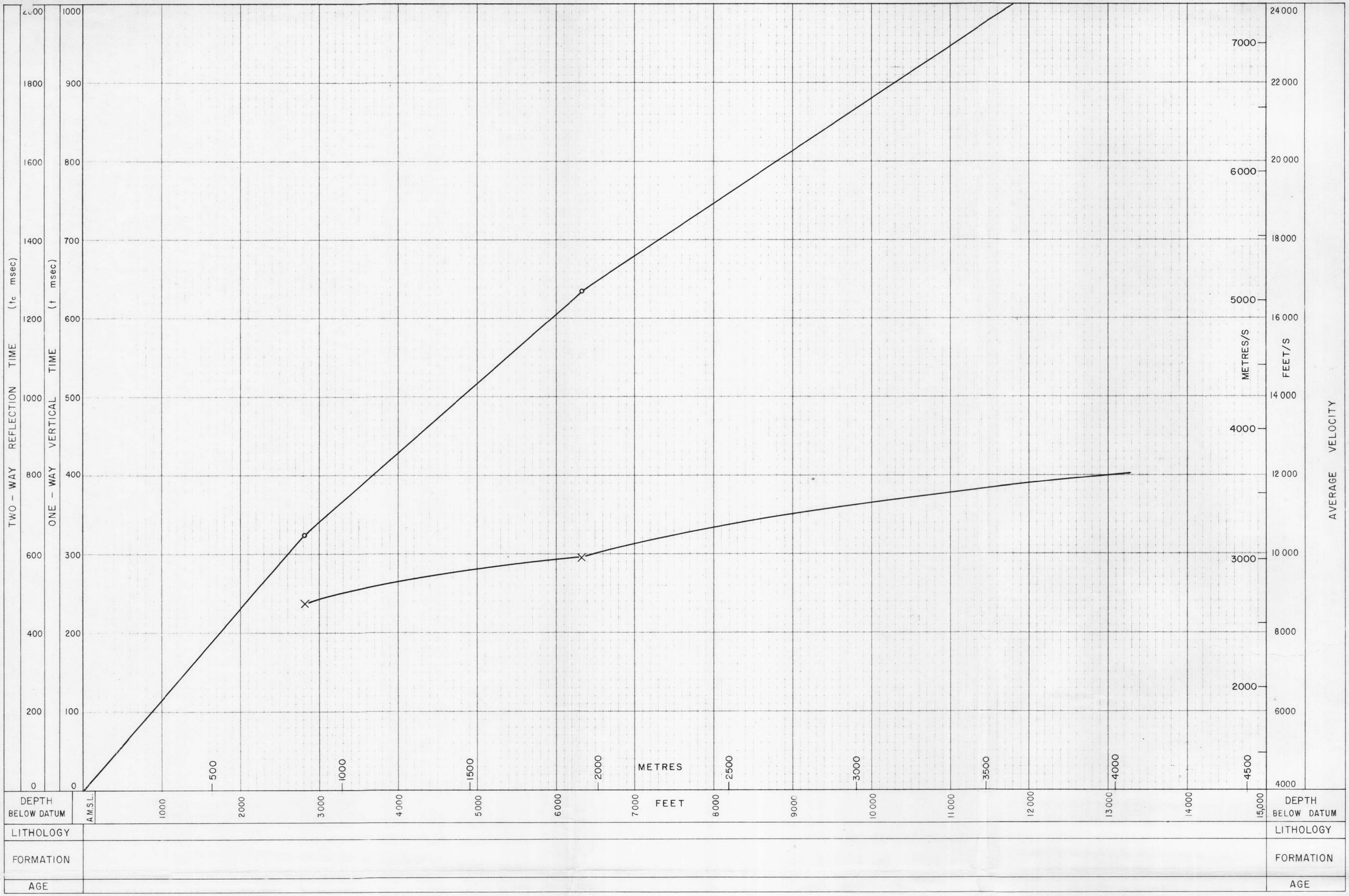
G51/B3-34

HUNT OIL Co. — RAY GEOPHYSICAL SEISMIC LINE 32-C (Mickleberry, 1966b)

To accompany Record No 1972/95

G51/B3-36

PLATE 5



(Based on G 85/3-21)

LITHOLOGY

Time / depth curve (t - d)

Average velocity (Va)

Sandstone

Siltstone

Shale

Limestone

To accompany Record No 1972/95

VELOCITY AND TIME VERSUS DEPTH

AREA MOUNT BEADELL (GILES-CARNEGIE, 1962) (AFTER TURPIE, 1967)

Basis Extended spread velocity shoot (estimated below 6340 ft)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

G51/B3-39

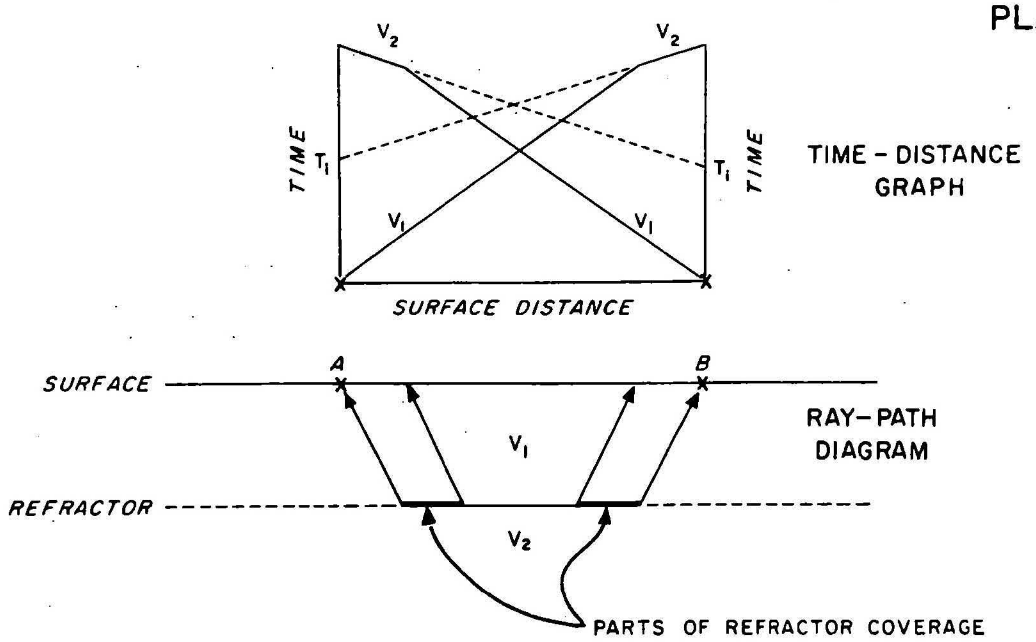
INTERPRETATIVE CROSS-SECTION

ACROSS THE OFFICER BASIN, WA

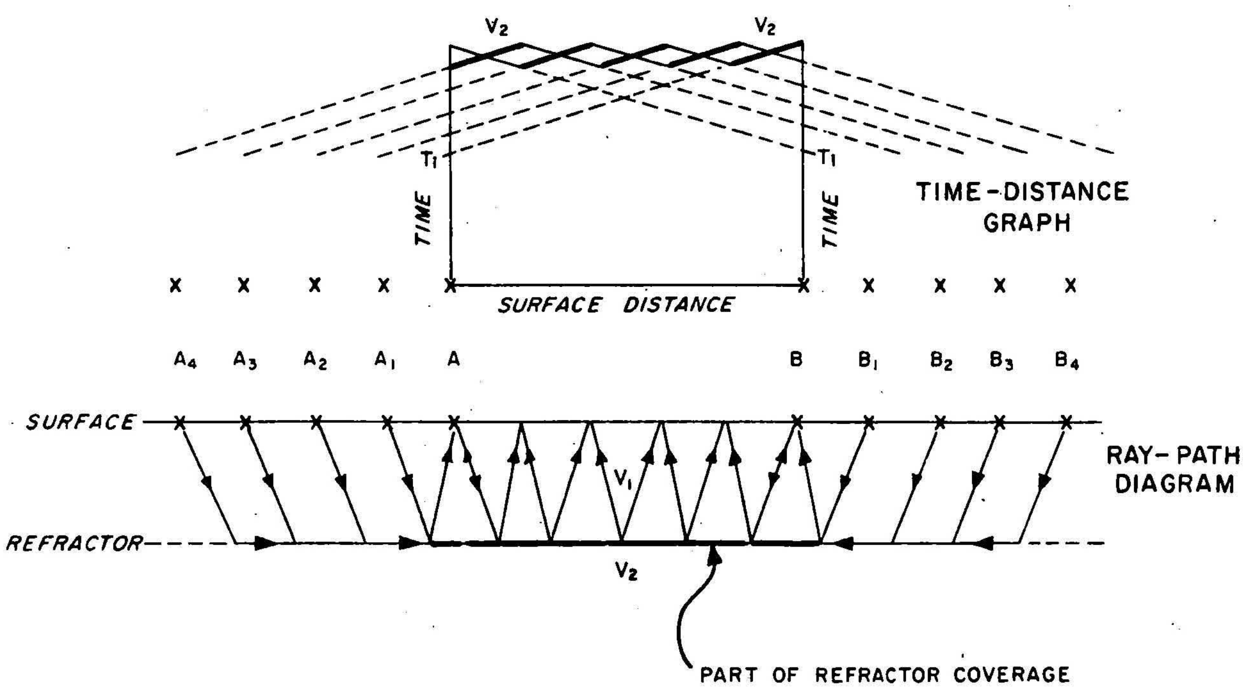
To accompany Record No 1972/95

G51/B3-35

PLATE 7



1. General type of refraction profile
(two layer case)



2. Continuous profile on one refractor
(two layer case)

PROPOSED REFRACTION TECHNIQUES

To accompany Record No 1972/95

G51/B3-38A