BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT 191

BMR MICROFORM MF69

OFFICER BASIN SEISMIC, GRAVITY, MAGNETIC, AND RADIOMETRIC SURVEY, WESTERN AUSTRALIA, 1972

by

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DEPARTMENT OF NATIONAL DEVELOPMENT

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Published for the Bureau of Mineral Resources, Geology and Geophysics by the Australian Government Publishing Service

Copies of the plates in this report can be obtained from:

Copy Service, Government Printer (Production),
P.O. Box 84, Canberra, A.C.T. 2600.

ABSTRACT

The Bureau of Mineral Resources made a seismic, gravity, magnetic and radiometric survey in the Western Australian part of the Officer Basin in 1972, on a northeast traverse between the Yilgarn and Musgrave Blocks. The survey comprised a series of depth probes using refraction and single to twelve-fold CDP reflection recording. The other geophysical measurements were taken at 1-km intervals mainly along the seismic traverse.

A model of the geology and structure between the Yilgarn and Musgrave Blocks was obtained from the integrated interpretation of the BMR and earlier surveys. The model shows that there are three main rock sequences: Phanerozoic sediments up to 1300 m thick, Proterozoic sediments up to 5700 m thick, and an underlying layered sequence in the southwest, of unknown nature, but which probably consists of igneous and metamorphic rocks up to 12000 m thick and may be distinct from basement of the Yilgarn Block. It is possible that the rocks may comprise metasediments intruded by basic rocks.

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SUMMARY

The Bureau of Mineral Resources made a seismic, gravity, magnetic, and radiometric survey in the Western Australian part of the Officer Basin between July and December 1972. The aim of the survey was to obtain subsurface information on the composition and structure of the basin between its contacts with the Yilgarn and Musgrave Blocks.

The seismic work was done along a northeast traverse roughly following the Warburton Range Road and consisted of a series of refraction and single and multiple-fold reflection probes located along the central and southwest parts of the basin. Expanded spreads were recorded in three locations for vertical velocity control and identification of primary reflections. Gravity, magnetic, and radiometric measurements were made at about 1-km intervals along the seismic traverse, on short cross-traverses, and along the Emu Road near the southern boundary of the basin.

Reflection quality varied from good to very poor over the area surveyed, depending greatly on the surface conditions. The refraction arrivals were generally of fair to good quality but were complicated by interference from arrivals through shallow high-velocity stringers, and in the central part of the basin from second arrivals from deep high-velocity layers. Expanded spreads provided fair overall vertical velocity control, but the accuracy of the calculations was reduced by poor continuity and small moveout on the reflections and the presence of other interfering events. The seismic data were analogue and digitally processed to improve signal-to-noise ratio.

A cross-section model of the geological composition and structure of the basin along the traverse between the Yilgarn and Musgrave Blocks has been obtained from the integrated interpretation of the data obtained during this and earlier geological and

geophysical surveys. The model shows that there are three main rock sequences: Phanerozoic sediments up to 1300 m thick, Proterozoic sediments up to 5700 m thick, giving a maximum sedimentary thickness of 7000 m, and an underlying layered sequence whose nature is unknown, but which probably consists of igneous and metamorphic rocks up to 12000 m thick and may be distinct from basement of the Yilgarn Block. Reflections were recorded from the latter sequence with lateral continuity up to 4 km and to depths up to 12500 m.

The three major groups of rocks are separated by surfaces of unconformity A and B, are bounded below by surface C, and have been identified on the basis of velocities and depths obtained from the seismic data.

Surface A corresponds to a basalt layer, the Lower Cambrian Table Hill Volcanics, which forms the base of the Phanerozoic sediments and overlies up to 5700 m of Proterozoic sediments. This layer has been correlated with a good reflector, Horizon A, and a refractor of velocity 5100-5430 m/s. The overlying sediments are flat-lying, thickest (about 1300 m) in the centre of the basin, and thinning out gradually towards the margins.

Surface B lies between two distinct rock sequences, the upper with interval velocities of 3300-5700 m/s, and the lower with interval velocities of 6000-6500 m/s. The upper layer correlates with the 5000-m sequence of upper Adelaidean sediments exposed on the southern flank of the Musgrave Block. This sequence is estimated to be about 5700 m thick in the centre of the basin and thins out rapidly towards the southwest in the area where its basal unit, the Robert Beds, is exposed north of the seismic traverse. The lower rock sequence probably comprises layered igneous and metamorphic rocks.

Surface C is believed to be the interface between the layered igneous and metamorphic rocks and underlying basement relatively free of reflections. No refractions were recorded from the boundary and its position has been postulated as the downward limit of primary reflections on the seismic sections. The rocks between surfaces B and C, estimated to be about 12 000 m thick in the southwest, are of unknown nature, but are believed to comprise a layered suite of igneous and metamorphic rocks. It is possible that they are metasediments intruded by basic sills and dykes.

Folding and faulting of these layered basement rocks near the southwest margin of the basin is suggested by numerous diffraction and reflected-refraction events on the seismic records in the area. Seismic and magnetic evidence suggests that the contact between these basement rocks and the Yilgarn Block may be a fault with a vertical displacement of about 8000 m. There is no appreciable gravity expression of the margin between this layered basement sequence and the Yilgarn Block, indicating that the rocks have similar bulk densities.

Most gravity features could not be interpreted in terms of sedimentary thickness variations or structure alone, and substantial basement density variations are proposed to simulate the main gravity features. A gravity high in the southwest and an associated intense magnetic anomaly may be explained by a basic intrusive body within the basement, about 12 000 m wide and 7000 m deep, from which a narrow vertical dyke extends to within about 1500 m of the surface.

INTRODUCTION

The Bureau of Mineral Resources (BMR) made a seismic, gravity, magnetic, and radiometric survey in the Western Australian part of the Officer Basin during July to December 1972. The work was part of a combined geological and geophysical investigation conducted by BMR in co-operation with the Geological Survey of Western Australia (GSWA), and began with geological mapping in 1970.

The basin area is largely covered by recent sand and soil deposits. Permian and Cretaceous outcrops occur over a large area and are nearly horizontal so that information on the Proterozoic sediments which constitute the bulk of the basin fill has been limited. Outcrops are sparse, widely spaced, and deeply weathered, and there is a lack of reliable age data. Geological mapping and several widely spaced stratigraphic holes have given a fragmentary picture of the basin stratigraphy.

Previous geophysical surveys in the Officer Basin include a reconnaissance helicopter gravity survey and a seismic survey by BMR, and a gravity survey, an aeromagnetic survey, and seismic surveys by Hunt Oil Co. Aeromagnetic data suggested depths to magnetic basement varying from about 6000 m in the northeast to about 2000 m and shallower towards the southwest. Depths interpreted from the gravity data generally agreed with the magnetic depths in the northeast and central parts but were deeper by about 2000 m in the southwest. A seismic refraction profile in the northeast near Warburton Mission (Pl. 1)* recorded a high-velocity refractor, whose depth was close to that interpreted from the gravity and magnetic results and defined the structure of the northeastern margin of the basin. However, the seismic reflection surveying south and southwest of Warburton Mission provided little information about the sediments deeper than a good seismic reflector, Horizon A, which corresponds to a

* Since this report was first microfilmed, more information has become available. Consequently, Plate 1 has been updated. The new version now appears as Pl. 45 on Fiche 4.

basalt layer, the Lower Cambrian Table Hill Volcanics. No seismic surveying or stratigraphic drilling had been made in the central and southwestern parts of the basin. The interpretations of the reconnaissance gravity and magnetic results in these areas were inconsistent and of questionable reliability. Seismic surveying and detailed gravity and magnetic measurements were necessary to assist in the determination of the nature and structure of the basin sediments and particularly to determine the structure of the southwest margin of the basin.

The seismic, gravity, magnetic, and radiometric work described in this report was made on a northeast line between an area of extensive seismic surveying by Hunt Oil Co. southwest of Warburton Mission and the northeast limit of the exposed Yilgarn Block near Lake Throssell (Pl. 1). The seismic work consisted of a series of combined reflection and refraction profiles close to the Warburton Range Road for ease of access and operations. Single and up to 12-fold CDP reflection coverage and refraction profiles with offsets up to 32 km were recorded. The seismic work was intended to be a reconnaissance study, and with the available time and effort continuous profiling between the area of the Hunt Oil Co. seismic surveys and the Yilgarn Block would have been impracticable; the length and spacing of the profiles were decided from assessment of results during the survey to obtain maximum information about the regional features of the basin, in particular over the southwest margin where seismic work had not previously been attempted. Gravity readings were taken at 1-km spacing along the Warburton Range Road from near Lake Throssel for 214 km towards Warburton Mission and on short traverses across the Warburton Range Road traverse. Readings were also taken for 136 km along the Emu Road between Yeo Lake and Neale Junction, near the southern boundary of the basin in W.A., to assist in extending the interpretation of the basin structure to an area south of the proposed seismic traverse. Magnetic and radiometric measurements were made in addition to the gravity observations at most stations.

Operational reports on the seismic survey (Harrison, 1973) and on the gravity, magnetic, and radiometric survey (Zadoroznyj, 1973) provide details of staff, equipment, operational statistics, and preliminary results.

BMR did shallow stratigraphic drilling concurrently with the geophysical work, the location of the drill-holes being decided as the geophysical results were assessed. Details are given by Jackson, Van de Graaff, & Boegli (1975).

In 1978 BHP drilled four shallow stratigraphic holes near the centre of THROSSELL* (R. Irvine, BHP, pers. comm., 1979). Granite or gneiss were intersected at depths less than 110 m below the surface. These drilling results were considered in the interpretation of deep reflections in THROSSELL.

GEOLOGY

Between 1916 and 1966 several geological investigations were made in the Officer Basin. The main work was a combined geological, geophysical, and drilling operation by the Hunt Oil - Placid Oil - Exoil, consortium during 1961-66 (Jackson, 1966a). The early geological and geophysical results indicated that the basin was an elongated asymmetrical depression aligned northwest, the deeper part being closer to its northeast flank and filled with about 450 m of Phanerozoic rocks unconformably overlying about 5500 m of Proterozoic rocks. Owing to the Proterozoic age of the bulk of the sediments, the consortium rejected the basin as a poor petroleum prospect. Little attention was paid to detailed mapping and study of the surface exposures in the basin area until BMR began in 1970 a program of geological mapping on a 1:250 000 scale in conjunction with GSWA. A preliminary reconnaissance of the basin was made in 1970 (Jackson, 1971) and systematic mapping was done during 1971-72. Results of these surveys have been reported by Lowry, Jackson, van de Graaff, & Kennewell (1972) and Krieg, Jackson, & Van de Graaff (in press) and details are to be published in the explanatory notes for the twenty 1:250 000 sheet areas.

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

The following description of the geology is largely taken from Krieg et al. (1976). The Officer Basin has been defined as the geological unit bounded by the Yilgarn Block on the west, the Musgrave Block on the north and the Gawler Block on the southeast. It is about 800 km long and 200 km wide. The Western Australian part of the basin, shown in Plate 1, underlies about 250 000 km^2 of the Gibson and Great Victoria Deserts and is a poorly delineated, northwest-trending structural depression containing a little-known sequence of essentially undisturbed Proterozoic and Phanerozoic sediments. Its northwest margin towards the Canning and Bangemall Basins is hidden by younger deposits, but the margin with the Canning Basin may correspond to a subsurface basement ridge defined by regional gravity data (Anketell Gravity Ridge, Pl. 1). The southern flank is covered by Cretaceous and Tertiary rocks of the Eucla Basin.

Stratigraphy

Knowledge of the basin stratigraphy is poor because of the widespread mantle of recent superficial deposits, the horizontal attitude of extensive Mesozoic and Palaeozoic cover, and sparse Proterozoic outcrops. The stratigraphy has been recently redefined by Krieg et al. (1976) and its correlation across the basin is shown in Plate 2.

Precambrian igneous and metamorphic rocks are exposed in the Musgrave and Yilgarn Blocks at the basin's northeast and southwest margins respectively. Also near the southwest margin, granite and gneiss have been intersected at shallow depths in drill-holes in central THROSSELL, during exploration by BHP (R. Irvine, BHP, pers. comm., 1978) (Fig. 1). The sediment fill of the basin has been divided into three groups: the Proterozoic, the Lower Palaeozoic, and the Upper Palaeozoic and Mesozoic. The Palaeozoic and younger sediments have a combined maximum thickness of about 700 m whereas the geological and previous geophysical data suggested an estimated 5000 m of Proterozoic sediments.

Proterozoic A Precambrian sedimentary sequence about 5000 m thick is poorly exposed along the southern edge of the Musgrave Block (Pl. 1). The sequence consists of Townsend Quartzite, Lefroy Beds, Lupton Beds, and an unnamed unit of fine-grained clastic sediments. The Townsend Quartzite, the base of which corresponds to a widespread angular unconformity, has been provisionally adopted by Lowry et al. (1972) as the basal unit of the basin. The sequence in Western Australia is broadly comparable with a better exposed, better defined Adelaidean succession along the southern edge of the Musgrave Block in South Australia.

Rocks of probable Proterozoic age were intersected in several wells drilled by Hunt Oil Co. (Jackson, 1966a) and also crop out in several diapirs in the northwest. Hunt Oil Co. Yowalga No. 2, the deepest well (depth 990 m), penetrated 143 m into the Babbagoola Beds composed of sandstone, siltstone, shale, and dolomite (Jackson, 1966b). Primitive microfossils suggest an earliest Cambrian age. Browne Nos. 1 and 2 wells were drilled on diapiric structures and intersected interbedded dolomitic limestone, calcareous shale, anhydrite, and gypsum (Browne Beds). The Woolnough Hills and Madley diapirs in the northwest part of the basin contain evaporitic core material (Woolnough Beds, Madley Beds) flanked by stromatolitic dolomite, siltstone and, sandstone of probable Adelaidean age (Jackson & Van de Graaff, in prep.). The diapirs intrude Permian and younger rocks at the surface.

The stratigraphic level of the Babbagoola and Browne Beds and the evaporites in the diapirs and their interrelations are indefinite.

Proterozoic sediments and intrusives shown on the Tectonic Map of Australia and New Guinea 1971 as part of the Bangemall Basin crop out extensively to the west of the Officer Basin in the area between Lake Carnegie northwards to about 23°S (Pl. 1). The sediments are east-striking slightly-folded shallow-marine deposits intruded by basic sills and dykes (Mack & Herrmann, 1965) with a mimumum age of 1050 m.y. (W. Compston,

pers. comm.). Recent studies by Hall & Goode (1978) have shown that two distinctive sedimentary basins of early Proterozoic and mid-Proterozoic age (Nabberu and Bangemall, respectively) are present in this area. The thickness and easterly extent of these rocks beneath the western part of the Officer Basin and their stratigraphic and structural relations to the Proterozoic units described above are largely unknown.

Lower Palaeozoic The basal unit of the Phanerozoic sequence is the Lower Cambrian Table Hill Volcanics. This basalt layer, about 100 m thick, was intersected in widely separated drill-holes, viz. Hunt Oil Co. Lennis No. 1 and Yowalga No. 2 (Jackson, 1966a, 1966b) and BMR Westwood No. 1 (Jackson et al., 1975), and can be associated with a good seismic reflection over a large area of the basin. In outcrop, in well sequence, and from seismic evidence the basalt overlies older rocks with angular unconformity. It is in turn overlain unconformably by about 400 m of Cambro-Ordovician shallow-water marine sandstones (Lennis Sandstone and Wanna Beds).

Upper Palaeozoic and Mesozoic Lower Permian glacial, fluvial, and lacustrine deposits (Paterson Formation) form an extensive flat-lying sequence up to 600 m thick. Fossiliferous shallow-marine Lower Cretaceous clastics (Samuel Formation and Bejah Claystone), about 150 m thick, overlie the Paterson Formation in the north and west.

Structure

The Permian and younger sediments are mostly flat-lying. Dips in the older sediments along the west and south flanks of the basin are about 5^{o} whereas in the northeast, along the southern edge of the Musgrave Block, they are commonly between 20^{o} and 45^{o}. The seismic reflection surveys have indicated two types of anticlinal structures in the basin, both of which occur mainly in the Proterozoic section. They are domal anticlines formed by diapiric intrusion, and gentle flexures probably caused by subsidence and readjustment by faulting of basement rocks. Photogeological

studies indicate some regional faults, including the Westwood Fault (Pl. 1). From the aeromagnetic results, Jackson (1966a) inferred large subsurface faults bounding what was believed to be the deepest part of the basin.

PREVIOUS GEOPHYSICAL INVESTIGATIONS

The first major geophysical work in the Officer Basin was done by BMR in the northern part during 1960-62 and comprised reconnaissance gravity, aeromagnetic, and seismic surveys. During 1961-66 the Hunt Oil-Placid Oil-Exoil consortium conducted a large geophysical program in the northeastern part of the basin with reconnaissance aeromagnetic coverage, semi-detailed gravity and seismic surveys, culminating in stratigraphic drilling in 1966, after which operations ceased because sediments and basalt, both considered then to be Proterozoic, were found at shallow depths. All the earlier geophysical work has been reviewed by Jackson (1966a), Turpie (1967), and Pinchin & Mathur (1972).

Aeromagnetic surveys

Three aeromagnetic surveys have been made over the basin. Three isolated lines were flown by BMR in 1960 west of Musgrave Block (Goodeve, 1961). In 1961 Hunt Oil Co. made an aeromagnetic survey, with northeast lines spaced 48 km apart, over most of the basin (Jackson, 1966a). The depth to magnetic basement contours from this survey are reproduced in Plate 3. The contours must be considered questionable as they are based on interpolations across a flight-line spacing of 48 km, and extensive basalts in the area may have an unknown effect on the depth computations.

The main feature of the map is a deep basin with its axis trending northwest and with the deepest areas, 5700-6000 m, near its northeast flank. Shallower sub-basinal areas are indicated in southeast YOWALGA* and southwest NEALE. The strong gradients in northeast and southwest YOWALGA have been interpreted as representing major basement faults. The magnetic basement depths in the northeast part of the basin appear to correspond with horizons interpreted from seismic and gravity data. In southwest NEALE, where the magnetic basement depths are interpreted to be about 2000 m, Lowry et al. (1972) have mapped outcrops of acid igneous and metamorphic rocks.

The Hunt Oil Co. magnetic basement depths in north and west BROWNE and in north BENTLEY are generally 1500 m shallower than those interpreted from a more detailed survey in the north by Union Oil Development Corporation and Kern County Land Company in 1965 (Lynch, 1965).

During 1976-78, BMR obtained aeromagnetic coverage of the Officer Basin, under contract, with lines flown at 3 km spacing. Detailed interpretation has not been made, but there are indications of magnetic sources at less than 250 m over much of THROSSELL (D.H. Tucker, BMR, pers. comm., 1978). BHP measured detailed magnetics in a small area of central THROSSELL in 1978, and obtained similar depths (R. Irvine, BHP, pers. comm., 1979).

Gravity surveys

Extensive gravity coverage of the basin area has been obtained. A Bouguer anomaly map based on BMR helicopter gravity surveys in 1962 (Lonsdale & Flavelle, 1968) and in 1972 (Fraser, 1973a), and semi-detailed surveys by Hunt Oil Co. during 1963-65 (Bazhaw & Jackson, 1965) is reproduced in Plate 4. The contours show mismatch along the boundary between the BMR and Hunt Oil Co. surveys because different densities were used for the Bouguer corrections. A positive anomaly area in the northeast corresponds to the Musgrave Block, and the steep gradient along its southwest edge marks the northeast margin of the basin. The northwest-

trending high in BENTLEY is the southern part of the Anketell Gravity Ridge, which roughly corresponds to a magnetic basement ridge (Goodeve, 1961) and may reflect a subsurface basement ridge separating the Officer Basin from the Canning Basin in the north-east. Within the basin there are three marked low (-80 mGal) areas; in southeast BROWNE, northwest WAIGEN, and northwest and west LENNIS. The first two correspond to magnetic basement lows, and the third to a broad magnetic plateau. The lows in BROWNE and LENNIS are separated by a narrow gravity ridge which roughly runs along the Warburton Range Road. Another marked feature on the map is an L-shaped gravity ridge which runs from northwest YOWALGA and into WESTWOOD and then westwards along the centre of THROSSELL in the western part of the basin. Fraser (1973b) considers that the gravity features in the basin area are similar to those on the shield area in Western Australia, and generally reflect intra-basement density variations. However, the broad east-trending high in THROSSELL is of different orientation to the gravity features on the shield and on this basis Fraser attributes the anomaly to either a basement rise or a dense intrusive body interbedded with or cutting across the sediments.

Seismic surveys

Seismic reflection and refraction surveys were made in the northern part of the Officer Basin by BMR in 1961-62 (Turpie, 1967), and in the northeastern part by Hunt Oil Co. during 1963-65 (Jackson, 1966a). The locations of the various traverses are shown in Plate 1. Reflection surveys required large patterns of geophones and shot-holes to obtain useful reflection information and CDP multiple coverage generally gave improved data. The recording parameters used for both reflection and refraction work have been summarized by Pinchin & Mathur (1972). The main refractors recorded from the previous surveys, together with their possible relation to stratigraphy and lithology are shown in Table 1. Velocities derived from the sonic log in Yowalga No. 2 well are given in Table 2.

TABLE 1. POSSIBLE CORRELATION OF REFRACTORS MEASURED DURING 1961-66

Giles-Carnegie (BMR)		Warburton (Hunt Oil Co.)		Age of rocks and formation	Lithology
Refractor velocity (m/s)	Depth below datum measured at the refraction profiles (m)	Refractor velocity (m/s)	Depth below datum (m)		
2680-3125	150	-	-	Mesozoic	Sandstone, siltstone, claystone and, porcellanite
3050-3350	150-550	2600	456	Lower Permian (Paterson Formation)	Sandstone
3540	910	-	-	Cambro-Ordovician (Lennis Sandstone)	Brick-red arkosic sandstone
				UNCONFORMITY - HORIZON A	
4980-5180	610-1710	5120	730	Lower Cambrian (Table Hill Volcanics)	Basalt
				(UNCONFORMITY)	
5550-6080	610-2800	5680	3205	Upper Proterozoic	Sandstone, shale, dolomite, siltstone, limestone, gypsum
6250	4390-5700	6520	5900	?Proterozoic or ?Archaean basement	?Sandstone, shale, dolomite or ?granite, gneiss

Note: The datum levels for the surveys were: Giles-Carnegie 487 m ASL, Warburton 457 m ASL

TABLE 2. VELOCITIES OF ROCKS DERIVED FROM SONIC LOG IN YOWALGA NO. 2 WELL.

Age of rocks and Formation	Lithology	Depth Interval (m)	Velocity (m/s)
Mesozoic	sandstone, siltstone, claystone, and porcellanite	7.6 - 94.5	1520-3050
Lower Permian (Paterson Formation)	sandstone	94.5 - 406.9	2440-3350
Cambro-Ordovician (Lennis Sandstone)	Brick-red arkosic sandstone	406.9 - 728.5	2740-3350
Lower Cambrian (Table Hill Volcanics)	basalt - ?weathered	728.5 - 737	4200
	- unweathered	737 - 845.8	5140-5600
Upper Proterozoic (Babbagoola Beds)	sandstone and shale	845.8 - 887	3200-4570
	dolomite	887 - 893	5490-7000
	sandstone, siltstone, and shale	893 - 989.4	2900-3660

The Giles-Carnegie seismic survey by BMR during 1961-62 (Turpie, 1967) 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 spaced about 48 km apart. Fair-quality reflections were obtained using multiple-shot and multiple-geophone patterns. Refraction velocities of identifiable sediments near their outcrops and depths to various refractors and reflectors near the northeast flank of the basin were measured during the survey. The refraction results indicated a thickness of sediments varying from 4390 to 5700 m over most of the traverse. Reflection results from the Lake Keene traverse (Turpie, 1967, pl. 1) in the northwest indicated a possible sedimentary thickness of 12 000 m. Two main refractors were recorded over most of the traverse (Table 1). A refractor with velocity 3050-3350 m/s was interpreted to be close to the base of the Permian and a refractor with velocity 4980-5180 m/s was interpreted to be close to the top of the Proterozoic sequence. A refractor with velocity 6250 m/s was recorded at several locations and was tentatively interpreted to originate from the top of igneous or metamorphic basement by correlation with velocities measured on outcropping basement. The recent dating of the Table Hills Volcanics as Lower Cambrian has required slight changes to ages assigned to the refractors by Turpie (1967), (Table 1).

Four seismic surveys were made for Hunt Oil Co. during 1961-66: the 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 the 'Thumper' weight-dropping technique and 6-fold coverage (Mickleberry, 1966a, 1966b). Some limited direct comparisons of the three techniques were made and the 'Thumper' appeared to give the best data, so that this method was used for most of the seismic work.

Some refraction work was done during the Warburton Survey. On line MM a reversed refraction profile was recorded between two shot-points 32 km apart. The refractor velocities and depths are shown in Table 1. The deepest refractor had a velocity of 6520 m/s and depth 5900 m. First-breaks were recorded to an offset of 4500 m but beyond this, later phases were picked up to 1 second after the presumed first breaks. Mickleberry (1966a) has shown that considerable structure exists along the traverse, throwing doubt on the accuracy of the refractor velocity and depth results, which were calculated assuming flat refractors. On line AA the 6520 m/s refractor was followed continuously from Warburton Mission for 30 km to the southwest where it reached a depth of 6000 m, indicating a monocline at the basin's northeast margin.

The Yowalga Survey consisted of 19 lines varying in length from 13 to 38 km. On almost all lines there was a strong shallow reflection, Horizon A, at times 0.3 to 1.1 s (depths 350 to 1500 m). Hunt Oil Co. also picked a deeper reflection, Horizon B, at times 0.75 to 1.8 s (1030 m to 3150 m). This reflection is generally continuous over only a short distance and normally is one of a broad band of reflections with conformable dips, so it is very doubtful that Hunt followed the same event over all lines. Horizon A is characterized by strong angular unconformity below the reflection, with deeper reflections truncating against the event. Many sections show sporadic reflections to the end of the 3-s records (max. depth 7000 m), most of which appear to be primaries, although there is a general lack of continuous reflections below Horizon A. Based on well logs and velocity data from the survey, Horizon A has been correlated to the basalt layer, the Table Hill Volcanics (of Lower Cambrian age on the basis of latest dating results), in Hunt Oil Co. Yowalga No. 2 and Lennis No. 1 wells. A synthetic seismogram derived from the sonic log at Yowalga No. 2 using BMR computer program SEISSYN also shows a strong event from the top of the basalt (Pinchin & Mathur, 1972). In Browne Nos. 1 and 2 wells evaporites were met at the projected level of Horizon A, suggesting that diapiric intrusions have pierced the basalt.

A fair to good-quality reflection corresponding to a refractor of velocity 4980-5180 m/s (Table 1) was recorded on most lines of the Giles-Carnegie survey to the north of the Yowalga survey area. On the basis of refractor velocity, reflection times, and evidence of angular unconformity below the horizon, it can probably be correlated with Horizon A on the Yowalga survey.

Many Yowalga lines have good indications of structure. Typically Horizon A shows gentle flexing, but the unconformable sequence below is strongly folded, and on some lines there are structures at Horizon B which appear to be intrusive domes. It appears that massive salt movement with diapiric and decollement folding has occurred within the Proterozoic sequence. The seismic and gravity evidence for this movement is given in detail by Jackson (1966a) and Turpie (1967). It is notable on nearly all Yowalga lines that below the strongly folded sequence there are nearly-horizontal reflections at times varying from 1.5 to 2.9 s (about 2700 to 6500 m). These reflections may represent the lower limit of the sequence containing evaporites. A seismic section line 12-E showing most of these features is shown in Plate 5. In the North Lennis survey reflections were recorded to 3 s on most lines. Folding appears to be much gentler here, perhaps indicating less disturbance or a thinner salt sequence in this area.

Velocity information was obtained from expanded spreads on the various surveys: on lines 13-C and 39-A, Yowalga survey (Mickleberry, 1966a), line 49-Y on the Lennis survey (Mickleberry, 1966b), and Mount Beadell traverse, Giles-Carnegie survey (Turpie, 1967). The results are summarized by Turpie (1967).

Electrical Survey

An electrical resistivity survey was made in 1971 on the southwest margin of the basin (Pl. 1) for the Public Works Department, Western Australia (Australian Groundwater Consultants,

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

Summary

Northeast sections across the basin and along the lines of the proposed traverse had been given by Jackson (1966a) and Pinchin & Mathur (1972), summarizing the results of the previous geological and geophysical surveys. The Officer Basin was interpreted to be an asymmetrical basin, aligned northwest, with the deepest part (about 6000 m) in the northeast close to the Musgrave Block. Basement shallowed abruptly by about 2000 m midway between the Musgrave and Yilgarn Blocks and then shallowed gradually to form an extensive shallow platform to the southwest. In the northeast the basin's subsurface structure has been defined by seismic reflection and refraction surveys and drilling by Hunt Oil Co. In the central and southwest parts no seismic work had been done and the basin subsurface structure had been defined only by the magnetic depth to basement. The magnetic results are considered to be of questionable reliability because of the large distance between flight lines (48 km). Interpretation of the reconnaissance gravity results gave a depth to basement in the southwest about 2000 m greater than that from the magnetic interpretation.

Seismic work was considered necessary to obtain reliable subsurface information about the nature and structure of the sediments in the central and southwestern parts of the Officer Basin.

OBJECTIVES AND PROGRAM

The aim of the seismic, gravity, and magnetic surveys was to obtain subsurface information along a northeast line across the Officer Basin, between its margins south of Lake Throssell, where the basement rocks are exposed, and west of Warburton Mission, where substantial geological and geophysical data had already been collected. The specific objectives were:

To define the southwest margin of the basin where seismic and detailed gravity, magnetic, and radiometric work had not previously been attempted.

To obtain a reliable configuration of the basement of the basin.

To determine the structure, thickness, and seismic velocity of sedimentary layers in the basin.

To record detailed gravity data on traverses along and away from the seismic lines for additional support to and extension of seismic interpretation.

Seismic program

The details of the seismic program proposed and the program carried out are given in the operational report on the survey by Harrison (1973). A summary of operational statistics is also included in that report.

The seismic program consisted of a series of combined refraction and reflection probes with the first probe located near the centre of the basin southwest of the area of previous Hunt Oil Co. seismic surveys. Subsequent probes were recorded farther to the southwest. The general location of the seismic

lines shot during the period of survey, from July to end of November, 1972, are shown in Plate 1, and the details are shown in Plate 6. A list of the recording carried out is given in Appendix 1. The layout of spreads and corresponding subsurface coverage for the reflection recording is given in Plate 9. The recording consisted of experimentation, reflection and refraction probes, vertical velocity determination, true dip determination, deep crustal recording, and Geoflex comparison tests.

Experimentation An up-hole shoot and noise test were conducted near the presumed centre of the basin as planned. Single coverage was then recorded at SPs 589-601 to determine the best recording and shooting parameters; records shot with different geophone and shot-hole patterns, shot-depths, and geophone station intervals were compared. A further two up-hole shoots were recorded at SPs 377 and 399 to determine the best shooting depth and near-surface velocity and weathering information in those areas.

Reflection and refraction probes The first probe was recorded near the centre of the basin as planned. 6-fold CDP coverage was recorded at SPs 607-610$^{10/12}$ and a reversed refraction profile, 32 km long, was recorded between SPs 551 and 612. Continuous 6-fold CDP and some 12-fold CDP coverage was recorded at SPs 369-379 and 336-339. A reversed refraction profile 23 km long was recorded between SPs 332 and 375. Seven more short reflection and/or refraction probes were recorded farther southwest between SPs 100 and 304 to obtain information on the southwest margin of the basin. The reflection coverage was 1-3 fold and the refraction profiles were up to 6480 m long.

It would have been preferable to have recorded some reflection coverage along one or more of the Hunt Oil Co. lines west of Warburton Mission to enable direct comparison of reflection data, but time did not allow this.

Vertical velocity determination Three expanded spreads were recorded centred at SPs 263, 375, and 610 to determine the vertical velocity distribution and to identify primary and multiple reflections.

True dip determination Three single-coverage cross-traverses were recorded at SPs 302, 375, and 610 to obtain true dip at intervals along the profile surveyed.

Deep crustal recording Large shots fired at Mount Fitton, S.A. and Kunanalling, W.A. were recorded on two perpendicular spreads at SP 375 to obtain deep crustal refraction data as part of an Australia-wide deep crustal survey. Deep crustal reflection shots were later fired to obtain supplementary reflection data at the refraction recording location. The results of the deep crustal refraction and reflection recording will be reported separately.

Geoflex comparison shots Four Geoflex shots using different Geoflex arrays and one dynamite shot were recorded at SPs 613-614 to determine whether shooting with Geoflex as explosive source would be advantageous. The tests were limited because of the lack of a suitable vehicle to tow the Geoflex plough. Party trucks were used initially but were later committed to other tasks.

Gravity, magnetic, and radiometric program

Gravity, magnetic, and radiometric observations were made at 1-km intervals along the Warburton Range Road from the vicinity of Lake Throssell for 214 km towards the Warburton Mission, on short traverses across the Warburton Range Road traverse, and at most seismic shot-points. These observations provided data supplementary to the concurrent seismic survey. Gravity, magnetic, and radiometric measurements were also made at 1-km intervals along the Emu Road between Lake Yeo and Neale

Junction near the southern boundary of the Officer Basin. Operational details for the gravity survey are given by Zadoroznyj (1973). Station locations are shown in Plates 7 and 8.

SEISMIC DATA RECORDING AND PROCESSING

Data Recording

The recording system used on the survey was a PT-700, PMR-20 analogue FM system. Two PMR-20 magnetic recorders were used: a 6-s recorder for reflection shooting and a 24-s recorder for long-range refraction and deep crustal reflection recording. A remote radio firing unit, designed in BMR, transmitted time-break and up-hole times for refraction and CDP reflection coverage. In the latter recording it saves considerable time usually required to run a communication cable between shooting truck and recorder. AGC and programmed gain were both used but AGC was generally necessary because of variable ground coupling of shots and geophones. Comprehensive daily, weekly, and monthly equipment tests were made using established test procedures as described by Hemphill & Brown (1972).

Up-hole Shoots Up-hole shoots were recorded during the survey to provide information about the near-surface layers. Up-hole times were plotted against charge depth to determine velocities and thicknesses of near-surface layers. A reflection split-spread was recorded at the same time to test reflection quality to select the optimum shooting depth. The first experiment on the survey was an up-hole shoot at SP 600 in a hole 80 m deep. The information obtained was incomplete as the first charge stuck at 50 m, but the first-break times on the reflection spread indicated that the weathered layer was about 70 m thick. Another up-hole shoot was recorded at SP 599 in a 100-m hole. The up-hole times and the first-breaks on the reflection spread showed that the weathered layer was also about 70 m thick there. First-breaks from reflection and refraction records indicated that the weath-

ered layer varied in thickness from 25 m to 120 m between SPs 555 and 612 (Pl. 42). Further up-hole shoots at SPs 399 and 377 were recorded to obtain near-surface information and to determine the optimum shooting depth in those areas.

Noise test and determination of geophone-and shot-hole patterns

It would have been uneconomical to drill all shot-holes through the thick weathered layer, so further experiments were made to determine whether useful reflection quality could be obtained by firing shots within the weathered layer and attenuating shot-generated noise by using patterns of geophones and shot-holes. A noise test was recorded at SP 5998/12 with hole depth 22-30 m. Plate 10 shows the unfiltered record section, indicating the main noise events, with a frequency/wave-number diagram below the section. One of the transverse spreads was recorded with 8 geophones spaced at 6 m perpendicular to the spread to attenuate longitudinal noise. The records show that both longitudinal and transverse coherent noise were serious problems. All noise events, except No. 1, had frequencies between 14 and 40 Hz. No signal events are discernible on the records and their frequency range of 20-40Hz has been estimated from reflection records. The noise events at times down to 1.5 s have frequencies and wave-numbers which decrease with increasing offset, whereas below 1.5 s the noise appears to be independent of offset.

To attenuate most of the coherent noise events, the following geophone patterns and recording filters were considered to be appropriate on the basis of the frequency/wave-number diagram:

- grouping of 16 geophones in line with 6-m spacing for cancellation of longitudinal noise. The cut-off wave-number for this group is 5 cycles/1000 m.

- grouping of 3 geophones, spaced 14 m apart perpendicular to the traverse for cancellation of tranverse noise. The cut-off wave-number for this group is 12 cycles/ 1000 m.

- 16 Hz, 12 dB/octave low-cut and 100 Hz, 36 dB/octave high-cut filters.

A 20 Hz, 12 dB/octave low-cut filter and a 78 Hz, 36 dB/octave filter on playback were generally found most suitable. The effects of the recording and playback filters on the noise test records are shown in Plate 11. Considerations of available equipment and need for reasonable production rate limited the number of geophones/trace to 48. The geophone pattern thus selected was 48/trace in 3 rows of 16 geophones in line, geophones spaced 6 m apart and rows spaced 14 m apart perpendicular to the line. A shot-hole pattern of 25 holes consisting of 5 rows of 5 holes in line, with holes and rows 20 m apart was selected; it gave a cut-off wave-number of 5 cycles/1000 m for both longitudinal and tranverse noise.

Single-coverage shots were recorded between SPs 589 and 610 to test the effectiveness of the selected shot-hole and geophone patterns, to determine optimum hole depths, geophone station intervals, and to test the reflection quality in this area and to see if the number of holes in the pattern could be reduced for operational reasons. At SP 599 single shots below the weathered layer were compared with a 25-hole pattern, with hole depth 4.5 m. The single-shot records showed higher frequency but their overall record quality was comparable. SPs 598-600 were shot with both the shallow 25-hole pattern and a 5-hole pattern consisting of 5 holes in line spaced 20 m, depth 25 m. The 25-hole shallow pattern gave better record quality than the 5-hole deeper pattern (Pl. 23). The records here showed some noise events of wave-number 4-7 cycles/1000 m not seen on the noise test. At SPs 375-397 single holes to 30 m gave better record quality than 25-hole patterns, depth 4.5 m, and 30-m holes

of the reflection recording. Near-surface information indicated that between SPs 201 and 399 the weathered layer varied in thickness from about 10 to 75 m (Pl. 42), but was generally less than 30 m thick so that shots over this area were generally fired below the weathered layers. The number of 30-m holes varied from 1 to 5 per shot depending on drilling capability and production rate. Several comparisons of spreads with 45-m and 90-m geophone station intervals indicated that the shorter interval would give better reflection continuity. This interval was therefore used for all reflection recording. The geophone pattern of 48/trace and the shot-hole patterns discussed above generally gave good attenuation of shot-generated noise throughout the survey.

Expanded spreads Expanded spreads were recorded centred at SPs 263, 375, and 610 using the method described by Musgrave (1962), (Pls. 12, 13, and 14). They were placed where single-coverage records indicated reflection quality was better than elsewhere. In the first and third set-ups an 11-spread arrangement was used, and in the second a 9-spread arrangement. These lengths were considered appropriate to enable accurate measurements of moveout on deeper reflectors as the moveout was usually small because of the high velocities in the section. The expanded spreads provided data on vertical velocities, were very useful in distinguishing multiples from primary events, and also showed that the selected geophone and shot-hole patterns were effective in cancelling coherent noise over a large range of offset distances. At SP 610 multiples were found to interfere with primaries although their amplitude was lower. The moveout differences between interfering multiples and primaries were used to design CDP spread offsets and geophone station intervals using the principles discussed by Mayne (1962). For CDP recording at SPs 607-610^{10}/12, a 0-135-1170 m spread was chosen. A larger offset than 135 m would have given greater multiple attenuation, but would have degraded a good reflection at about 0.5 s.

Reflection recording The shot and spread locations and corresponding subsurface coverage are illustrated in Plate 9. Three CDP coverage probes were recorded using a spread 0-135-1170 m. The 6-fold CDP probe at SPs 607-610^{10}/12 was recorded with 25-hole patterns and the 6-12 fold CDP probes at SPs 369-379 and 336-339 were recorded using a shot-pattern of 3 holes spaced 40 m in line, depth 30 m. The 12-fold coverage was obtained on these probes by recording into some spreads from both ends and shooting twice in some holes. The second shots in the holes were shallower but gave records of comparable quality to the deeper shots. In other areas the reflection coverage was 1-3 fold, the multiple coverage obtained by shooting into spreads from various offsets to minimize shifting of spreads. In some areas such as dry salt lakes, single coverage was sufficient to obtain good records probably owing to good ground coupling of shots and geophones.

Refraction depth probes Refraction depth probes were recorded at intervals along the traverse. The method used consisted of recording spreads between two fixed shot-points, the distance between which was estimated to be large enough to allow recording of arrivals from the deepest refractor of interest. The two larger probes had maximum offsets of 32 and 23 km, and the other had offsets between 2.16 and 4.32 km.

On the larger probes, charge sizes were increased with increasing offset in order to try to record the same phase of a particular refraction arrival on adjacent records. Charge sizes varied from 7 to 1800 kg. Linear gain was compared with AGC in the recordings. Linear gain records appeared to show fine detail of higher-frequency legs better than AGC shots, but AGC was found to be necessary to prevent saturation on the early part of a record which could distort later arrivals. The geophone pattern used consisted of four 4.5-Hz geophones placed 6 m apart in a line perpendicular to the traverse. Geophones were buried to reduce the effect of wind noise, but periods of strong wind still

delayed shooting. At long offsets, problems were experienced in receiving radio-time breaks because of intervening sand dunes and occasional atmospheric interference. Geophone station intervals used were 90 and 180 m and adjacent spreads were overlapped by 2-3 geophone stations.

Refraction probes at SP 399 recorded the velocity of a shallow basalt layer and at SPs 384-390 estimated the southwest limit of the basalt. The probe at SPs 100-107 recorded the velocity of shallow basement on the Yilgarn Block.

Weathering control The up-hole correction method was inapplicable over most of the traverse area because shots were fired within the weathered layer. The use of first-break times from CDP and single-coverage spreads to obtain weathering data was not very successful because it was usually difficult to record first arrivals from the sub-weathered layer owing to the presence of thin near-surface high-velocity stringers, and because of high attenuation of first-breaks with increasing offset. The first-breaks on the reflection records could have been improved by increasing the early gain but this would have resulted in loss of shallow reflection information caused by saturation of the amplifiers. Special weathering shots were recorded over some parts of the first reflection/refraction probe (SPs 551-612) with a high early gain to give better first-breaks. The shots had to be recorded with a 0-540-1080 m spread to avoid recording shallow high-velocity thin layers at offsets less than 540 m. Overlapping spreads in reverse directions were used to calculate weathering corrections using the shot and geophone delay-time method. In other areas, time did not permit special weathering shots, and first-break times from reflection shots provided the only data for corrections.

Geoflex comparison shots A split-spread was recorded centred at SP 613 using one dynamite shot and two Geoflex shots (Pl. 24). The dynamite shot was fired in a 25-hole shot pattern with hole depth 4 m. The Geoflex shots consisted of 4 x 100-m and 2 x 200-m

strands parallel to the traverse with 20-m strand spacing. At SP 614, an offset Geoflex array with 3 x 200-m strands was recorded by the same spread to give six traces of common subsurface with the split-spread records. It was difficult to plough the Geoflex to the recommended depth of about 0.5 m because of the hard ground surface and in some places the Geoflex was only about 0.1 m deep, and consequently air-waves generated by the shots reduced the record quality. The limited tests showed that the shortest Goeflex array gave comparable record quality to the dynamite shot and the offset shot at SP 614 appeared to enhance reflections down to about 2 s. Geoflex shooting would almost certainly be more productive than drilling large patterns of shot-holes.

Analogue data processing

All seismic data were recorded on magnetic tapes and were processed using the BMR MS-42 playback system. The final analogue reflection and refraction sections are presented in Plates 12 to 27.

Normal moveout corrections Initial normal moveout corrections were applied to reflection records using the velocity data from the three expanded spreads recorded during the survey. The playback sections were examined for residual moveout and new corrections were made where necessary. Usually these corrections were satisfactory and were used for the final sections. The various velocity functions used for correction, A, B, etc. are indicated on the sections and the functions are shown in Plate 28. Several functions were needed because velocities varied significantly, in general increasing towards the southwest.

Elevation and weathering corrections Elevation corrections were not made because the survey area had gentle relief. Overall the elevations ranged from 372 to 476 m ASL. Variations in the thickness of the weathered layer were, however, a serious problem.

These variations are illustrated in Plate 42 which is a profile of the near-surface layers based on refraction and reflection first-break and other data. The weathered layer is the shallowest layer on the profile.

In the area of the CDP probe at SPs 607-610^{10}/12, for example, the weathering thickness varied erratically from 65 to 120 m. At SPs 607-610^{10}/12 some effort was made to find a method of obtaining reliable weathering corrections to achieve proper stacking of the multiple-fold reflection data. The first-breaks on the reflection records here were poor and gave unreliable weathering data. An attempt was made to derive corrections from the variations on a strong reflection at 0.5 s after applying NMO and dip corrections to the CDP single-coverage records. Average reflection times were found from the sets of 12 common surface point traces and corrections were deduced by lining up these average times. The reflection times on the single-coverage records after correction still showed large scatter so that the corrections were unreliable. Special weathering shots were fired to obtain weathering data and the corrections improved the quality of the 6-fold stacked section.

At the other two CDP probes at SPs 369-379 and 336-339, time did not permit special weathering shots, and the only weathering information was obtained from the poor first-breaks on the reflection records. A further problem in the former area was the presence of two low-velocity layers. In these areas the stacked sections using corrected records were worse than those using uncorrected records. The 1-3 fold coverage reflection sections and the refraction sections were not corrected because of lack of reliable weathering data.

Filter settings Reflection sections were usually played back using several filter settings and the most effective settings were selected for the final sections. The frequency pass-bands generally used were 20-78 Hz. The filter slopes were normally 12

dB/octave on the low-cut and 36 dB/octave on the high-cut. On single coverage at SPs 391-392, large improvement in signal-to-noise ratio was obtained on a section with a pass-band of 20-78 Hz and a 24 dB/octave slope on the low-cut compared with the 12 dB slope.

The short refraction probes were recorded on pass-bands out-60 or out-100 Hz and the same filter was used on playback. The large-scale refraction probes at SPs 551-612 and 332-375 were recorded using the 24-s PMR-20. The quarter-speed tapes were played out on a pass-band 16-220 Hz to give an effective band width of 4-55 Hz. Other effective pass-band widths of 12.5-55 and 32.5-55 Hz were used on playback in an attempt to clarify possible later arrivals.

Optical processing All reflection sections were analysed using the BMR Laser-Scan equipment. The two-dimensional and one-dimensional Fourier transforms of the sections were photographed; the former gave information on dip content and frquencies of an entire section, and the latter a frequency profile across a section. The frequency information was a useful guide in choosing band-pass filters for digital processing. Pie-slice filtering was used to remove steep-dipping events on sections at SPs 261-268 and 251-256. This resulted in greater continuity on near-horizontal events. The processing therefore indicated that digital velocity filtering could be useful.

Digital processing All the reflection and some refraction data were processed digitally under contract by Geophysical Service Incorporated (GSI), Sydney. The 6-s reflection magnetic tapes were transcribed from analogue to digital mode with a 2-ms sampling rate and data were resampled at 4 ms before processing. The 24-s (quarter-speed) refraction tapes were transcribed at a 1-ms sampling rate giving effective 4-ms samples. The main processes generally applied to the reflection data were:

1. Trace equalization

2. Normal moveout correction. Velocity analyses were made to derive the corrections. Nine constant-velocity stacks were made using CDP and expanded spread data. The records were stacked with a range of velocities and the average velocities for particular reflection times were estimated from the reflection quality after stack.

3. Time-variant deconvolution. Records between SPs 607 and $610^{10}/12$ were deconvolved using 12, 18, 24, and 36-point operators for several frequency pass-bands. A 24-point operator was selected for all reflection data.

4. Time-variant frequency filtering. Thirteen filter tests were made in different areas to enable the design of optimum playback filters. In each test 24 traces were played back with various pass-bands.

5. Automatic residual statics. Used for CDP data between SPs 336 and $610^{10}/12$. The process lines up a good reflection on single coverage to improve stacked data.

6. Time-variant scaling. Similar to Programmed Gain Control on analogue playback.

7. Coherence scaling. A mild process where coherent events are scaled up and random noise scaled down.

Digital processing generally improved the records. The processes giving most improvement were trace equalization, time-variant deconvolution, and time-variant filtering. Several sections showed considerable improvement in signal-to-noise ratio and reflection continuity. The analogue and digitally processed sections are compared for four areas in Plates 15, 17, 18, and 20. On the 6-fold CDP at SPs 607-$610^{10}/12$ (Pl. 15), automatic

residual statics lining up the 0.9-s reflection also improved deeper reflections after stack. The cross-traverse at SP 610 (Pl. 15) showed improvement as a result of deconvolution and filtering. At SPs 391-397 (Pl. 17) time-variant filtering improved the section quality.

On the 1-12 fold CDP at SPs 369-379 (Pl. 18) processes 1, 3, 4, and 5 have improved reflection quality so that reflections can be followed farther southwest in the zone of poor record quality. The cross-traverse at SP 375 (Pl. 18) shows marked improvement. The single coverage at SPs 301-303 and on the cross-traverse at SP 302 (Pl. 20) show many line-ups on the analogue sections. Deconvolution simplified the reflections, giving a clearer, more easily interpretable section. On several sections digital processing did not show improvement and appears to have degraded some reflections. Velocity filtering, auto-correlation, and retro-correlation were additional processes that were tried, but were not found to be very useful for the Officer Basin data.

Refraction probes SPs 551-612 and 332-375 were deconvolved and band-pass filtered with the aim of sharpening refraction arrivals and distinguishing interfering arrivals. Marginal improvement was obtained on the former section, and the latter section was degraded by the processing.

GRAVITY, MAGNETIC, AND RADIOMETRIC DATA PROCESSING

The gravity, magnetic, and radiometric profiles along the Warburton Range Road and Emu Road traverses are shown in Plates 29 and 30, respectively.

The gravity data were processed digitally using standard BMR programs to obtain Bouguer anomalies suitable for interpretation. A Bouguer density of 2.2 gm/cm^3 was used in the reductions, this being the value adopted for the Gravity Map of Australia.

The vertical magnetic intensity value for each station was obtained by averaging the three readings taken at each station and then making an adjustment for the regional variation as indicated on the BMR 1:10 000 000 map of vertical magnetic intensity over Australia for the epoch 1970.0. Because of the large scatters in readings at some stations (sometimes over 1000 nT), quantitative analyses of the profiles have not been attempted.

SEISMIC DATA ANALYSIS AND RESULTS

Reflection data analysis

Velocity analysis The three expanded spreads recorded during the survey were analysed using the $T^2 - X^2$ method (Musgrave, 1962). The record sections with and without primary reflections marked are shown in Plates 12, 13, and 14. Computer program VELSPRED (Pettifer, 1972) was used to derive velocity information. The average and interval velocities derived are shown in Plates 31 and 32, respectively.

The reliability of the computed velocities is variable, depending on the quality of reflections picked and the accuracy of the moveout measurements. The maximum offsets for the expanded spreads were chosen to be large, about 4.5 km, because of small moveouts seen on deeper reflections. The spread recorded at SP 610 (Pl. 14) shows fair-quality reflections and sufficient moveout for reliable measurements. The spread at SP 375 (Pl. 13) shows overall poor-quality data with no reflection at larger offsets. The section is complicated by apparent opposite dips on adjacent records because it was recorded on dipping subsurface. Reflections could be followed better on the right side of the section, and these times were corrected for dip and used for $T^2 - X^2$ analysis. The moveouts were small and the results are consid-

ered unreliable. The data at SP 263 (Pl. 12) are of reasonable quality though deeper parts of the section show interfering dipping events. The moveout on the reflections is small as the velocities are higher in this area.

Additional velocity information was obtained through digital processing by GSI of multiple-fold CDP reflection and expanded-spread records using constant velocity stacks. In this process multiple-fold data at each of 24 common depth points are corrected for NMO with each of 10 or more different constant velocities, and are then stacked. The stacked sections are then displayed. The best estimate for the average velocity to a particular reflection is the velocity which gives the best reflection quality after stacking. Nine analyses were made: two using 6-fold CDP records between SPs 607 and $610^{10}/12$ and four with 6-12 fold CDP records between SPs 336 and 379; and each of the three expanded spreads was also analysed as a 9-11 fold CDP.

The digital analyses using the expanded spreads gave better results than the CDP, probably because the offsets on the expanded spreads are longer so that moveouts are larger and the stack is more effective in cancelling interfering noise. The stacks using CDP spreads generally gave no useful results for the deep reflections and only the expanded spread results are presented (Pl. 31). The accuracy of the average velocity estimates derived from the digital analysis is considered to be lower than for those obtained by $T^2 - X^2$ analysis of analogue expanded spread records. The reason appears to be that velocities in the section are high, moveout varies slowly with velocity, and reflection quality on the stacks does not have a sharp maximum as velocity varies. At SP 375, however, the digital processing provided a reasonable velocity estimate where the data quality was too poor to successfully apply $T^2 - X^2$ analysis on analogue records. This velocity estimate was important for deriving interval velocities and interpreting basin structure.

The average velocity was found to increase steadily towards the southwest of the traverse. The interval velocities within 3000 m of the surface show increases from 2800 to 4500 m/s at SP 610, from 3300 to 5900 at SP 375, but are steady at 5800 m/s at SP 263 (Pl. 32).

Time-depth conversion Events were picked on the reflection records and the times converted to depth using the time-depth curves shown in Plate 33. Time-depth conversion was made for the intervals SPs 234-304, 336-399, and 551-613 using the time-depth graphs at SPs 263, 375, and 610, respectively. The events were plotted as an unmigrated depth section (Pl. 34), excluding multiple reflections suggested by velocity analyses but not distinguishing between reflections, and possible reflected refractions and diffractions at this stage.

Migration Events with apparent dips greater than 5^{o} in the cross-section (Pl. 34) were migrated. In the southwest part of the traverse where high dips occur, the velocities are high and probably do not increase much with depth, so that events were migrated assuming a constant velocity medium. Several steeply-dipping curved events between SPs 246 and 256 show dips of about 14^{o}-38^{o} and migrate a considerable distance away from the recording location. They may be diffraction events arising from possible fault zones. These events did not migrate to a point as would have been expected for diffractions, but this may have been due to the shortness of the reflection coverage, lateral velocity variations in the section, and weathering effects.

Diffraction analysis Diffraction curves were generated by computer, assuming linear increase of average velocity with depth. Two sets of curves were made for two different velocity functions which are the probable upper and lower limits of the velocity in the southwest part of the traverse. Several steeply dipping curved events between SPs 249 and 375 match the shape of the theoretical curves if their sources are displaced some distance horizontally from the recording location. The estimated source

locations roughly match the positions to which some of these events were earlier migrated. Many of these sources fall within vertical zones between SPs 240 and 270 (Pl. 43), which are therefore considered to be possible fault zones.

The long straight events between SPs 251 and 268 did not fit the theoretical curves and may be reflected refractions.

True dip determinations The recording spreads were placed along the main road through the area for ease of operations, and therefore their bearings vary by up to 50^{o} (Pl. 43). Three cross-traverses were recorded to measure the true dips at different locations. The true dip and its direction were calculated from the apparent dips along the main traverse and cross-traverses using stereographic projection. The apparent dips were found using the unmigrated reflection times and the interval velocities (Pl. 32). The results are shown in Table 3. Apparent dips on the main traverses were generally less than 20^{o} and usually differed from the true dips by only a few degrees. Another reason for recording the cross-traverses was to determine whether events recorded on the main traverse were vertical reflections or reflections from the side.

Reflection Results

Data quality The processed reflection record sections are presented in Plates 12-24. The reflection quality was variable over the area surveyed and appeared to depend greatly on the surface conditions; the quality was good to fair over dry salt lakes, fair to poor over Cretaceous outcrops, and very poor over sand dunes or sandy country.

TABLE 3. TRUE DIP INFORMATION.

SHOT-POINT	TWO-WAY TIME (s)	DIP ON MAIN TRAVERSE	DIP ON CROSS-TRAVERSE	TRUE DIP	DIP DIRECTION (AZIMUTH)
610	0.5 to 2.9	4°	1°	4°	096
375	1.7	12°	8°30'	14°	088
	2.1	10°30'	5°20'	12°	081
	2.4	9°	6°20'	11°	088
	3.1	22°	7°20'	23°	070
302	2.2	17°30'	3°10'	18°	034
	2.75	6°20'	4°15'	8°	068
	3.0	7°20'	10°30'	12°30'	078
	3.6	4°15'	10°30'	11°30'	135

Factors influencing reflection data quality Several factors influenced the quality of the reflection data:

1. Strong coherent noise generated when shots were fired within the weathered layer. This was a problem mainly between SPs 587 and 614 where the weathered layer was up to 120 m thick. Shots had to be fired within the layer as it would have been uneconomical to drill all shot-holes below the layer.

2. Random noise was generally high in the area.

3. Surface conditions, type of outcrops, and presence of sand-dunes.

4. Large variations in the thickness of the weathered layer over short distances made reflections appear discontinuous in some places and the effectiveness of CDP stacking was reduced owing to lack of reliable weathering data for corrections.

The foregoing analysis of the reflection data distinguished reflections and probable diffraction and reflected refraction events. The migrated reflection data are presented in Plate 43. Detailed results of the individual probes are given below.

SPs 589-610 Single coverage between SPs 589 and 610 was of fair to poor quality (Pl. 16). 6-fold CDP coverage at SPs 607-610^{10}/12 (Pl. 15) was of much better quality and compared favourably with the good-quality reflection data obtained west of Warburton Mission by Hunt Oil Co. using weight-dropping techniques and 6-fold CDP.

Reflections recorded over SPs 607-610^{10}/12 (Pl. 15) at 0.5, 0.75, 0.9, 1.35, 1.6, and 2.85 s at SP 610 are identified as primaries from the expanded spread analysis at SP 610. There are additional weaker primaries at 1.1, 1.5, 3.3, and 3.8 s, and there are possible reflections down to the end of the 4.5 s records. The 0.5-s reflection is strong but discontinuous, and the reflector may be faulted. The section below this reflection shows some evidence of angular unconformity. The 0.75 and 0.9-s reflections are close together but are considered to be two distinct reflections on the basis of their different overall character and their amplitudes. These reflections have conformable dips and show indications of gentle flexing. On the cross-traverse at SP 610, there is clear evidence for an angular unconformity at 2.85 s. Reflections above 2.85 s are nearly horizontal while reflections at or below 2.85 s have a dip of about 4^{o} to the southeast. There is good evidence on this cross-traverse for primary reflections down to 4.5 s.

SPs 391-399 The single coverage between SPs 391 and 399 (Pl. 17) was recorded over an area of basalt subcrop. The record quality is very poor possibly because of low-energy transmission through the basalt, which gave a strong reflection, Horizon A, on Hunt Oil Co. surveys. The signal-to-noise ratio was much improved by digital band-pass filtering (Pl. 17) and reflection events were identified between 0.4 and 0.9 s, at 2.2, 2.3, and 2.5 s, and several strong line-ups can be seen below 3.4 s.

SPs $368^{10}/12$-379 The 6-12 fold CDP section between SPs $368^{10}/12$ and 379 (Pl. 18) is of fair to poor quality on the northeast half of the probe, and very poor in the southwest where low-frequency random noise seems to predominate. Reflections can be seen in the northeast part of the section near SP 375 between 0.2 and 0.5 s and at 0.95, 1.75, 2.1, and 2.4 s at SP 375, and they can only be followed with some difficulty to the southwest. The latter three events had similar northeast dips of about 14° whereas the shallower events show dips of about 2° northeast. A strong series of events occurs between about 3.0 s and 3.6 s at SP 375 with dip about 20° northeast. These events are most likely normal reflections because they match near-horizontal events on the cross-traverse at SP 375 (Pl. 18). These events are intersected by a family of curved southwesterly-dipping events between 3.3 and 3.7 s at SP 375, which matched theoretical diffraction curves. No reflections can be followed confidently across a poor-quality zone between SPs 369 and 373. The record quality below 0.5 s deteriorates abruptly southwest of SP 374. A possible explanation is that a fault may extend through the section in this area. A more likely explanation is that record quality has deteriorated owing to a change in near-surface conditions. Sand dunes and sandy soil became more prominent southwest of SP 374. Also 6-12 fold CDP recorded at SPs 336-339 near sand dunes is of very low quality (Pl. 19). There is some evidence of a fault between SPs 372 and 373 as the 0.5 s reflection is disturbed there.

SPs 336-339 The 6-12 fold CDP coverage at SPs 336-339 was recorded near sand dunes and gave poor-quality records (Pl. 19). Doubtful reflections can be picked between 0.3 and 2.8 s.

SPs 301-303 The four short 1-3 fold CDP probes between SPs 246 and 303 were of good to fair quality with reflections recorded down to 4 s. Sections SPs 301-303 (Pl. 20) and 261-268 (Pl. 21) were recorded near or on dry salt lakes where shot and geophone to ground coupling was excellent.

At SPs 301-303 (Pl. 20) strong events were recorded at 1.9, 2.1, 2.7, 2.9, 3.5, and 4.0 s at SP 303. The first two events and that at 4.0 s have northeast dips of about 20^{o}, but the other events are nearly horizontal. These events could be correlated with gently-dipping events on a cross-traverse at SP 302 (Pl. 20), and they seem to be normal reflections. Other weaker events with dips about 20^{o} northeast intersect the near-horizontal events between 2.7 and 3.6 s; their corresponding events on the cross-traverse also dip about 20^{o}. After migration, the weaker events no longer intersect the near-horizontal events. These could be reflections from the limb of a syncline, although this is indefinite. They could alternatively be reflected refractions from a discontinuity.

SPs 261-268 Numerous reflections can be seen at SPs 261-268 (Pl. 21). Two horizontal reflections at 1.65 (SP 263-264) and 2.65 s are identified as primaries on the expanded spread at SP 263 (Pl. 12). Other reflections at 1.1 to 1.6 s dip northeast. Weak discontinuous near-horizontal events were picked down to 4.4 s. It is doubtful whether any reflections below 2.7 s are primaries, because they cannot be seen on the fair-quality expanded spread at SP 263. Numerous straight events have steep northeast dips $24\text{-}29^{o}$ on the records below 1 s, some of which are recorded over the entire section. These events appear to be too steep to be reflections and are interpreted as reflected refractions from a possible fault boundary. When these events are migrated, they

are displaced southwest of the traverse but cannot be meaningfully correlated with the horizontal reflections.

SPs 251-256 Reflections with small northeast dips were picked at 0.7, 1.8, 2.7, 2.8, 3.0, and 3.6 s near SP 254 (Pl. 21). They were of fair to poor quality only and not very continuous. The reflection at 2.8 s is the strongest, most continuous event. Straight events with steep dip (about 22^{o}) interfered with the reflections between 2.2 and 2.7 s and are interpreted as reflected refractions. Other curved events could be matched with theoretical diffraction curves.

SPs 246-249 The records here are complicated (Pl. 21). Short horizontal reflector segments were picked at 2.15, 2.3, 2.6, 3.7, and 4.0 s at SP 246. They are difficult to follow over more than about one record. The most prominent events have slight curvature and have steep northeast or southwest dips, in places intersecting the horizontal events. They occur at times 1.2, 1.6, 2.2, 2.25, 2.4, and 2.75 s at SP 247. These events matched theoretical diffractions for sources beyond the reflection spreads.

SPs 201-236 1-2 fold coverage here shows some line-ups but no reliable reflections (Pl. 22). The records at SPs 201-204 are the noisiest on the traverse. These shots were recorded only about 12 km away from outcropping basement rocks of the Yilgarn Block and the noise was probably produced by scattering in the crystalline basement. Several low-amplitude curved events on the records are probably diffractions from fault boundaries.

Reflection Correlation Correlation of reflections between traverses based on reflection characteristics such as amplitude, frequency, and envelope was difficult because of variable data

quality and distance between probes; one such possible correlation can however be made for a pair of conformable reflectors recorded at 2.2 and 2.5 s at SP 391, 2.1 and 2.4 s at SP 375, and 1.9 and 2.15 s at SP 303.

Refraction data analysis

All probes except SPs 551-612 were analysed using computer program REFRAN. This program computes depths, velocities, and dips, assuming flat-dipping interfaces.

It was expected that in the area of the probe SPs 551-612, thin layers of high-velocity basalt may overlie sediments of lower velocity. In such an area, reflections can be recorded from all interfaces, but refractions only from the interfaces where the lower medium has a higher velocity. In such cases the analysis of refraction data using multiple-layer formulae gives erroneous depths to the layers and ignores the presence of any interfaces with velocity inversions. Therefore, in this area a different approach involving a combined analysis of refraction and reflection data was used to arrive at a subsurface model. Assuming that a refraction and a reflection originated from the same interface at a particular depth, the average velocity of the section above was calculated from reflection time, refractor velocity, and the intercept time (see Appendix 2 for relevant formulae) and compared with that obtained from expanded spread analysis (Pl. 31). In this way, all the refractors, except the shallowest one (considered to be too shallow for clear identification as a reflection on the records), could be matched with five of the reflecting interfaces where the computed and the observed average velocities showed agreement within 15% (Table 4). In the above analysis, each interface was assumed to be horizontal, as the dip between SPs 551 and 612 was less than 3^{o}, and the mean of the refractor velocities in the two opposite directions was used.

For both reflection and refraction arrivals the first-peak was picked. The measured two-way reflection times and refraction intercept times are estimated to be higher than the true first arrivals by about the same ratio so that the matching calculations were not affected.

TABLE 4. RESULTS OF COMBINED ANALYSIS OF REFLECTION AND REFRACTION DATA, SP 612.

Reflection data		Refraction data		Average velocity (m/s) (computed)	Difference in average velocity (%)
Two-way time (s)	Average velocity (m/s)	Refractor velocity (m/s)	Intercept time (s)		
-	-	2940	0.125	-	-
0.47	2750	4145	0.380	2440	12.7
0.76	3380	5430	0.550	3747	9.7
0.90	3540	-	-	-	-
1.11	3650	5310	0.80	3681	0.8
1.35	3800	-	-	-	-
1.52	3900	5570	1.025	4110	5.2
1.60	3950	-	-	-	-
2.85	4750	6000	1.750	4736	0.3

Refraction Results

The record sections for the two main depth probes are shown in Plates 25, 26, and 27. The time-distance plots with the deduced models for all probes are presented in Plates 35 to 41. First arrivals on all probes were of good to fair quality and generally the peak after the first-break was timed. Later

arrivals could not be seen on the short probes. On the longest probe, SPs 551-612, the pattern of arrivals was more complicated than on the other probes. Four velocity layers were picked at different offsets. The three at higher offsets had similar velocities and the arrivals interfered in several places. Arrival with velocity 5530 m/s (Pl. 25) is rapidly attenuated with increasing offset and timing of its first leg is uncertain. Arrival with velocity 5640 m/s is recorded over a large distance (Pl. 25). Two facts, however, indicate that a phase close to the first leg has been recorded as the first break: Firstly, the spread SPs 576-580 was recorded on 0 dB gain whereas the adjacent records had -10 dB gain. Although the first arrival is saturated there is no evidence of weaker earlier legs. Secondly, the last spread at SPs 559-551 recorded the largest charge (4536 kg) shot on the probe, and adjacent spread 1350 kg shot. Again there is no evidence of weaker earlier legs.

SPs 551-612 The subsurface model deduced from the above analysis is shown in Plate 35.

The refractors with velocities 5430 and 5310 m/s are inferred to be thin layers on the basis of the interval velocity information derived from the average velocities and reflection times (Pl. 32). The interval velocity between the 0.47 s and 0.9 s reflections was 4400 m/s and between the 0.9 s and 1.52 s reflections was 4500 m/s. The arrivals from the 5430 m/s refractor show strong attenuation with distance (Pls. 25 and 26) and indicate that it is probably a thin layer. The strong reflection at 0.9 s does not match with a refractor. It could be a reflection from the base of the 5430 m/s refractor below which interval velocity data indicate a velocity inversion. The thickness of the refractor is estimated to be 350 m using the reflection times of 0.76 and 0.9 s and the refractor velocity.

The 2940 m/s refractor appears to correspond to the sub-weathered layer. The 5570 m/s and 6000 m/s refractors are considered to be massive refractors based on interval velocities (Pl. 32) and the low attenuation of the arrivals with increasing offset.

SPs 332-375 The refraction probe at SPs 332-375 (Pl. 27) was analysed using both the REFRAN program and by matching with reflection data at SP 375 using the above method. Table 5 shows the results of the latter analysis.

TABLE 5. RESULTS OF COMBINED ANALYSIS OF REFLECTION AND REFRACTION DATA, SP 375.

Reflection data		Refraction data		Average velocity (m/s) (computed)	Difference in average velocity (%)
Two-way time (s)	Average velocity (m/s)	Refractor velocity (m/s)	Intercept time (s)		
-	-	3110	.025	-	-
-	-	4360	.075	-	-
0.49	3700	6110	.375	3930	6.3

Other reflections at 0.2-0.4 s at SP 375 and at 0.25 -0.3 s at SP 335 could not be matched with refractors. Average velocities for these were not available from reflection data. The reflections 0.2-0.4 s at SP 375 did not match shallow

refractors using average velocities estimated from the refractor thicknesses and velocities.

The depth to the 6110 m/s refractor is 962 m calculated from the computed average velocity and this agrees with the depth from the REFRAN program (1047 m) within 9%. The results using the REFRAN program are shown in Plate 36.

SPs 201-304 Between SPs 201 and 304 a shallow high-velocity refractor was recorded on each of the four short refraction probes (Pls. 37-40). The velocity of the refractor varies from 6000 to 6200 m/s and its depth from 200 to 300 m. Other shallower refractors were recorded, and details are given in Plate 42 which is a near-surface profile over the traverse.

Refractor velocities over subcropping basalt and igneous basement Between SPs 397 and 399 the refractor velocity of subcropping basalt was measured at SP 399 to be 5400 m/s and at 397 to be 5700 m/s (see Pl. 42).

Between SPs 100 and 107 a refractor of velocity 6000 m/s of depth 45 m was recorded in the area of the Yilgarn Block. Acid igneous rocks crop out near SP 105.

Correlation of refractor and interval velocities Refractor velocities have been included in the interval velocity plot, Plate 32. At SPs 263, 375, and 610 the refractor velocities are in reasonable agreement with the interval velocity data where a refractor and an underlying sequence could be correlated confidently.

Shallow refraction information First-breaks from single-coverage and CDP reflection records, from special weathering shots, and from short refraction probes were analysed to obtain velocities and thicknesses of near-surface layers over the basin. The results are shown in Plate 42, together with information from

up-hole shoots, up-hole times on reflection records, and geological logs from several deep shot-holes and stratigraphic holes. This cross-section shows in detail the nature and structure of shallow weathering and sub-weathering layers along the seismic traverse. The detailed results from BMR Westwood Nos. 1 and 2 and Throssell No. 1 stratigraphic holes are given by Jackson et al. (1975). In the northeast only, the sub-weathering information has been recorded from special weathering shots over most of the line. In the southwest between SPs 100 and 399, four layers were usually recorded with velocity ranges 860-2000, 2155-3250, 4360-4940, and 5905-6200 m/s. At SP 377 a 94-m shot-hole intersected a dolomitic layer at 93 m, close to the depth of a 4500 m/s layer estimated from reflection first-break analysis. Several important results have come from the near-surface profile. The Babbagoola Beds, not seen anywhere in outcrop in the basin and known only from Hunt Oil Co. Yowalga No. 2 well, were intersected in a shot-hole at SP 377 and in BMR Throssell No. 1. The Table Hill Volcanics not seen in outcrop in the central and southwestern parts of the basin were intersected in a shot-hole at SP 399 and in BMR Westwood No. 1. Shallow refraction shots indicated the basalt does not subcrop south of SP 390. Also the refractor velocities of subcropping basalt at SPs 399 and 397 allow a correlation with a refractor of velocity 5430 m/s recorded to the northeast at SPs 551-612. The latter refractor had been inferred to be a thin layer on the basis of the interval velocities (Pl. 32) and the high attenuation of the refraction arrivals with increasing offset. In the southwest, layers shallower than the 5900-6200 m/s refractor appear to be generally flat-lying and unconformable with the deeper refractor.

GRAVITY, MAGNETIC, AND RADIOMETRIC RESULTS

Warburton Range Road traverse

Gravity As seen in Plate 29, the detailed gravity profile has an overall shape similar to that interpolated from the reconnaissance data. However, it shows short-wavelength variations not seen in the reconnaissance data. For instance, the detailed data reveal local Bouguer anomaly highs near stations 5090 and 5198, and show the southwestern slope of the high D (Pl. 29) to be steeper than expected from the reconnaissance data. The principal features of the profile are two large highs B and D, and a low C between them. Other features are a small high within low C, and a small sharp high A at the southwestern end of the traverse.

The profiles along the cross-traverses together with the reconnaissance gravity results indicate more fully the extents and trends of the Bouguer anomaly features B,C, and D on the main traverse (Pl. 4). Feature B is a broad easterly-trending gravity high; feature D is a northerly-trending gravity high; and feature C is an easterly-trending gravity trough immediately north of high B. The cross-traverse running southwards from main traverse station 5150 reveals an intense gravity low with a minimum Bouguer anomaly value almost 25 mGal lower than the value at 5150.

Magnetic The main features of the magnetic profile (Pl. 29) are a narrow anomaly of high amplitude near station 5065 and a sharp change in magnetic level near station 5140. Other anomalies of varying amplitude and wavelength are also revealed. The large variations in readings at some stations indicate near-surface concentrations of highly magnetic material.

Radiometric The average radiometric value is fairly uniform in the southwestern part of the profile but increases slightly northeast of station 5050. Short-wavelength variations are of higher amplitude in the northeastern half of the profile.

Emu Road traverse

Gravity The detailed profile is similar in overall shape to that derived from the reconnaissance data (Pl. 30). Features brought out by the detailed work include a small low, about 10 km wide, near station 7060 and a steep slope at the eastern end of the profile. Apart from the large-amplitude low at the eastern end of the profile the Bouguer values are fairly uniform.

Magnetic The magnetic profile (Pl. 30) has several small-amplitude peaks, and rises slightly in level from station 7000 to about 7060. The profile is otherwise smooth, unlike the profile along the Warburton Range Road traverse.

Radiometric The average level of the radiometric values is fairly uniform along the profile, though superimposed on it can be seen high-frequency variations in the radioactivity, especially near the centre of the profile.

INTERPRETATION

Seismic reflection and refraction results have given subsurface information about the thickness and structure of sediments within the Officer Basin and have allowed the interpretation of the basin's southwest margin. Details of the seismic interpretation are shown in Plate 43. Detailed gravity and magnetic results near the seismic traverse support the seismic interpretation and have assisted in providing subsurface information over gaps in the seismic coverage. A proposed structural model of the Officer Basin along a northeast line between the Yilgarn and Musgrave Blocks is shown in Plate 44. It is based on BMR seismic, gravity, and magnetic results, Hunt Oil Co. seismic results, BMR and Hunt Oil Co. drilling, and geological mapping.

Seismic interpretation

Three major unconformities are interpreted on the basis of velocities and depths obtained from the seismic data (Pl. 43).

Surface A is the base of the Phanerozoic sediments corresponding to a basalt layer, the Lower Cambrian Table Hill Volcanics. The layer was intersected in Hunt Oil Co. Yowalga No. 2 and Lennis No. 1, and BMR Westwood No. 1, and corresponds to a strong reflection, Horizon A, recorded on Hunt Oil Co. surveys to the northeast. It also corresponds to a refractor of velocity 5120 m/s on Hunt Oil Co. Warburton Survey line MM. On the BMR traverse between SPs 551 and 612 this horizon has been correlated with a thin refractor of velocity 5430 m/s and a strong reflection at SPs 607-610^{10}/12 at about 0.75 s. The thickness of this layer at SP 610 is estimated from reflection data to be about 350 m. The refractor velocity is close to other estimates of the basalt velocity, viz. 5400-5700 m/s refractor velocity at SPs 397-399 on subcropping basalt (Pl. 42) and 5140-5600 m/s from the sonic log in Yowalga No. 2 (Table 2). The basalt overlies older rocks with angular unconformity as seen in well intersections and on Hunt Oil Co. reflection records. On the BMR refraction probe at SPs 551-612 the 5430 m/s refractor appears to be unconformable to underlying refractors although the unconformity is not apparent on the reflection records at SPs 607-610^{10}/12.

Surface B is the boundary between two distinct rock sequences which corresponds to a major regional unconformity. The upper sequence comprises Adelaidean sediments of the Officer Basin, and the lower is unknown, but is probably a layered suite of igneous and metamorphic rocks. Evidence for this is discussed later. On the southern flank of the Musgrave Block a Proterozoic sedimentary sequence of estimated 5000 m thickness has been mapped, and its basal unit, the Townsend Quartzite, overlies the lower sequence with an angular unconformity (Lowry et al., 1972). On Hunt Oil Co. refraction profile AA a refractor of velocity 6520 m/s was recorded close to the surface at Warburton Mission and at about 6000 m depth about 40 km to the southwest. Nearly all reflection lines of the Yowalga seismic survey showed a strongly-folded sequence below which there are near-horizontal reflections at times varying from 1.5 to 2.9 s i.e. about 2700 to 6500 m (Pl. 5). Such a reflection on line 53-K has a depth close

to that of the 6520 m/s refractor (Pl. 43). The BMR refraction probes mapped a refractor with velocities between 5985 and 6200 m/s at varying depths in the central and southwest parts of the basin: at 6900 m near SP 612, at about 1000 m near SP 375 and at depths less than 300 m southwest of SP 301. All of these refraction profiles recorded shallower refractors of lower velocities which overlie the high-velocity refractor with angular unconformity (Pls. 42 and 43). Furthermore, the high-velocity refractor marks a boundary between two sequences of significantly different interval velocity (Pl. 32), with interval velocities above the refractor of 2800-5700 m/s and interval velocities below the refractor of 5900-6500 m/s.

The refractor and interval velocities are in the same range, suggesting that the refractor represents the top of a thick high-velocity sequence. Clear evidence for two unconformable rock sequences is given by the cross-traverse at SP 610 (Pl. 15). The reflection at 2.75 s was correlated to the 6000 m/s refractor (Table 4) and marks the boundary between two sequences of unconformable reflectors. Reflections above 2.75 s have almost zero dip on the cross-traverse whereas reflections at or below 2.75 s have an apparent dip of about 4^{o} to the southeast. This unconformity was not apparent on the main traverse SPs 607-610^{1}/12. The high-velocity refractors have therefore been correlated over the basin as an unconformity surface. In the northern part of the basin, the Giles-Carnegie survey (Turpie, 1967) recorded a refractor of velocity 6250 m/s at maximum depth of 5700 m, and there are indications of reflections down to the end of some of the 3.5 s records (depths about 8000 m). It thus appears that unconformity surface B is present in that area also. The overall shape of the boundary matches that of the Hunt Oil Co. aeromagnetic depth to basement profile (Pl. 43) although the depths differ considerably.

Surface C is the interface between a layered sequence, probably comprising igneous and metamorphic rocks, and underlying basement which lacks reflections. No clear reflections or refractions could usually be identified as representing the top of the underlying basement. The base of the layered sequence between SPs 244 and 614 has therefore been shown in Plate 43 as roughly the downward limit of possible primary reflections seen on the sections. At SP 263 the fair-quality expanded spread (Pl. 12) recorded two primary reflections at 1.65 and 2.65 s. The latter reflection is believed to represent the top of the older igneous or metamorphic basement as there are no reflections at later times. In the southwest, the reflection records at SPs 235-236 and 201-205 show no reliable reflection events, and the section beneath these two areas may therefore be all metamorphic or igneous rocks distinct from the layered rocks.

The above unconformities divide the rocks in the basin into three major groups.

1. Surface to interface A. This sequence is correlated with Palaeozoic and Mesozoic sediments, a flat-lying relatively undisturbed sequence. It is thickest in the central part of the basin (about 1300 m at SP 612) and thins out towards its margins. In addition, a thin sequence of Permian or Cretaceous rocks has been mapped overlying most of the basin (Krieg et al., 1976).

2. Interface A to interface B. On the southern flank of the Musgrave Block, this section correlates with a 5000-m thick exposed sequence of southwesterly-dipping sandstone, siltstone, and tillite. Its correlation with similar rocks in South Australia shows that these rocks are probably Adelaidean. Hunt Oil Co. Yowalga No. 2 and Browne Nos. 1 and 2 were drilled into part of this sequence and penetrated the evaporite-bearing Babbagoola and Browne Beds. The Hunt Oil Co. well data and reflection results in the northeast part of the basin indicated the presence of several salt domes and folds that were probably caused by salt movement within this sequence (Jackson, 1966a and Turpie, 1967). In the central and southwest parts of the basin BMR seismic, stratigraphic drilling, and geological results have

provided limited but useful information about this sequence. Its maximum thickness is estimated to be 5700 m. Between SPs 551 and 612, two flat-lying refractors of velocities 5310 and 5570 m/s were recorded at depths 2100 and 2900 m within this sequence. At SPs 607-610^{10}/12 reflections were also recorded from these interfaces as well as from others within this section. On the Hunt Oil Co. refraction probe line MM a refractor of velocity 5680 m/s at depth about 3200 m was recorded within the sequence.

The evaporite-bearing Babbagoola Beds, intersected in Hunt Oil Co. Yowalga No. 2 are not seen anywhere in outcrop in the basin, but they appear to have been intersected at shallow depth in the southwest in a seismic shot-hole at SP 377 and in BMR Throssell No. 1 (Pl. 42), (Jackson et al., 1975). A flat-lying refractor of velocity 4360-4940 m/s may correlate with the top of the Babbagoola Beds intersected at 93 m at SP 377 (Pl. 42). The refractor was recorded on profiles to the southwest between SPs 201 and 240. The refractor is 30-200 m deep and appears to be undisturbed. The Townsend Quartzite, the basal layer of the sequence, probably directly overlies unconformity B, so that near SP 302 the quartzite might be expected at 300 m or shallower. This is possible because the Robert Beds, a lateral equivalent of the Townsend Quartzite, are exposed about 30 km due north of SP 302 (Pl. 1), (Jackson & Van de Graaff, in prep.).

3. Interface B to interface C. The evidence for the presence of this rock sequence comes mainly from BMR seismic reflection results in the southwest. Events of variable amplitude, continuity, dip, and curvature can be seen down to about 4.5 s, i.e. a depth of about 12 500 m, on reflection records at probes between SPs 244 and 612 (Pl. 34). Some of these have been identified as primary reflections, some diffractions and reflected refractions. The correlation of the reflection events between the probes is uncertain, but some folding and faulting of the rock is interpreted, as shown in the southwest part of the section (Pl. 43). At SPs 607-610^{10}/12 reflections indicate the presence of layered rocks. at least as deep as 10 000 m. In the northeast part of the basin, the Hunt Oil Co. reflection data which were

recorded to only 2.9 s provide no information below interface B.

This layered sequence of rocks is interpreted to comprise igneous and metamorphic rocks, possibly distinct and younger than crystalline basement of the Yilgarn Block, which it adjoins. The evidence for this interpretation comes from seismic interval velocities, magnetic information and stratigraphic drilling results. The refractor velocities and interval velocities of the sequence are in the range 6000-6500 m/s, which seem too high for unmetamorphosed siliciclastic sediments. The magnetic basement is shallow (less than 300 m deep) in eastern THROSSELL near the seismic traverses, which suggests igneous and metamorphic rocks are shallow. Stratigraphic drilling by BHP in 1978 intersected granite and gneiss at depths of 38 to 109 m in four holes near central THROSSELL, about 60 km west of the seismic traverses (Fig. 1) (R. Irvine, BHP, pers. comm., 1979). The drill-holes and the seismic traverses both lie in an easterly trending province with fairly uniform magnetic anomaly and gravity anomaly patterns. But the reflections recorded may not tie to the igneous rocks in the drill-holes, because true dip information (Table 3), indicates reflectors dip at 8^{o}-23^{o} approximately east. If these dips are projected to the surface, the layered sequence thins out east of the drill-holes.

The possibility of recording continuous reflections from within igneous and metamorphic basement has been demonstrated in several parts of the world, for example, Oliver et al. (1976), (reflections continuous up to 16 km), Oliver (1978), and Smithson et al. (1977), and in Australia by Moss & Dooley (1973), and Mathur (1974).

The layered basement may be distinct from the Yilgarn Block, because no reflections were recorded on two traverses (SPs 201-205 and 234 - 240) located over the Yilgarn Block (see Pl. 22). The contact between the two basement types could be a faulted zone between SPs 240 and 244, with a vertical displacement of about 8 km (see Pl. 43).

Gravity and magnetic interpretation

Warburton Range Road traverse BMR computer program GRAV2D was used to simulate the gravity profiles for a series of test models which were derived from the seismically-determined regional structure of the Officer Basin (Pl. 43). The simulated gravity profile for each model was compared with the observed profile across the Officer Basin (compiled from the results of the BMR work and a detailed gravity survey by Hunt Oil Co.); modifications were then made to the model to improve the correlation between the simulated and observed gravity profiles. The final model thus obtained (Pl. 44) yields a simulated gravity profile close to that observed and is broadly consistent with the seismic evidence. All gravity features are attributed to density variations within the upper 20 km of the crust. This is approximately equal to the thickness of the upper crustal layer over the Yilgarn Block (Mathur, 1974). The densities of basement rocks are based on known densities of common crystalline rock types (Jakosky, 1950). The densities of sedimentary layers were estimated from seismic velocity measurements using Nafe-Drake curves (Talwani, Sutton, & Worzel, 1959).

An analysis of the gravity results relative to seismic evidence indicates that most gravity features cannot be properly interpreted in terms of sedimentary thickness variations or sedimentary structure alone; substantial basement density variations must be proposed to simulate most gravity features.

The seismic results in the southwest indicate a steeply dipping contact 8 km in vertical extent between SPs 240 and 244 (Pl. 44), which separates the layered metamorphic and igneous basement from the basement rocks of the Yilgarn Block. Fair-quality reflections were recorded at SPs 244-270 but no reliable reflections were recorded at SPs 201-240. The lack of reflections could indicate that basement rocks are homogeneous in this area, but it could also be caused by a variation in near-surface conditions or other causes affecting reflection quality so that the proposed fault is indefinite. Near the proposed fault pos-

ition there is an abrupt increase in level of about 600 nT in the vertical magnetic intensity towards the southwest (Pl. 44). The level change could be interpreted to correspond to a change of magnetic susceptibility of rocks near the surface and possibly at depth; in this case possibly caused by juxtaposition of two different basement rock types. This would require that basement to the southwest has in this area a magnetite content greater than that of the layered basement rocks to the northeast.

The near-surface model (Pl. 42) shows that between SPs 399 and 244 a persistent flat-lying refractor of velocity 4360-4940 m/s was recorded and this refractor probably correlates with the Proterozoic Babbagoola Beds. The refractor was about 120 m below the surface at SP 244, but was not recorded on refraction profiles at SPs 201-240 to the southwest. A fault between SPs 240 and 244 could explain the absence of the refractor on these probes. The postulated fault has no appreciable expression in the gravity profile (Pl. 44). The absence of any Bouguer anomaly variation across the margin indicates that the layered basement has a bulk density very close to that of the Yilgarn Block. This is supported by the high seismic velocity of the former rocks (6000-6500 m/s), which indicates a high bulk density of about 2.7 gm/cm^3. These basement rocks are represented by Body 10 in the model and extend right across the section beneath the Officer Basin.

The densities of the other bodies in the model have been contrasted with the density of these rocks.

High B (Pl. 44) corresponds to a broad easterly-trending Bouguer anomaly high in THROSSELL, which is revealed by the reconnaissance gravity results (Fraser, 1973a). The trend of this high differs markedly from the overall north to northwesterly trend of gravity highs over the Yilgarn Block. The feature is attributed to a dense body within the basement (Body 2).

Low C is centred over a 4-km deep basement depression. The feature, however, is attributed to a granitic body within the basement (Body 3) as the basement depression is calculated to contribute only about 2 mGal to the gravity low assuming a basement/sediment density contrast of 0.01 gm/cm^3. Within low C is a local high which appears to be derived from a near-surface source. It has been attributed to a body of dense rock (Body 11), perhaps weakly magnetic basalt filling a depression in an old erosion surface. The erosion surface is assumed to be horizon B in the seismic section, which is believed to represent a major regional unconformity.

High D is at least partly caused by dense rocks near the surface. It is of large amplitude and is flanked to the west by a steep gradient. Furthermore, it coincides with an intense local magnetic anomaly, the source of which has been estimated to be no deeper than about 1 km (D. Hsu, pers. comm.). Seismic results between SPs 300 and 399 indicate that layered basement rocks rise in this area. The reflection profile at SPs 369-379 recorded several reflections with dip about 22^o northeast underlying reflections with dip about 15^o. It appears from gravity modelling that the source of high D (and the local magnetic anomaly) must be narrow and largely confined to the area between the seismic lines west and east of the high, i.e. between probes at SP 339 and SP 369. The gravity feature is simulated by a basic intrusive body (Body 4) some 12 km wide and at a depth of 7 km from which a narrow vertical dyke extends to a depth of approximately 1500 m. A dense magnetic body of this geometry accounts for the observed gravity and magnetic features, and is consistent with the seismic results.

The Bouguer anomaly values fall gradually northeastwards from high D, apparently reflecting the increasing thickness of lower-density sediments (Bodies 8 and 9) revealed by the

seismic work. Bouguer anomaly depression E, southwest of the northeast basin margin, cannot be explained by the model based on Hunt Oil Co. seismic results and is therefore attributed to low-density granite in the basement (Body 6). The small gravity high south-west of feature E represents the tip of a gravity spur in western TALBOT (Pl. 4). No attempt has been made to simulate the feature as it may be caused by an anomalous body southeast of the profile line.

The steep basement rise at the northeast margin of the basin (Jackson, 1966a) coincides with an intense Bouguer anomaly gradient. Notwithstanding this coincidence, gravity analysis suggests that the basement rise contributes only partly to the Bouguer anomaly gradient and that a major component of the gravity increase results from an appreciable increase in density between the basement of the Officer Basin and the Musgrave Block (Body 7).

The narrow, high-amplitude high A at the southwestern end of the profile indicates a thin body with a high density contrast near the surface. It lies on the Yilgarn Block and is attributed to a basic dyke or a greenstone belt.

Emu Road traverse No interpretative model along the Emu Road traverse has been attempted because subsurface information is not available near the traverse. The traverse is over what Lowry et al. (1972) have suggested is a thin layer of Permian sediments over a thicker sequence of Proterozoic sediments. The short-wavelength variations in the Bouguer anomaly profile may be due to variations in the thickness of the lighter Permian sediments. The intense low at the end of the profile may indicate a considerable thickening of the lighter sediments or, alternatively, a change to a more acid basement. In the latter case, the slope of the anomaly suggests that basement is no more than 8 km from the

surface. The great difference between the two magnetic profiles (Pls. 29, 30) shows that the magnetic properties of the surface formations along the Warburton Range Road are very different from those along the Emu Road and may indicate a different type of deposition or different stages of erosion.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The basalt layer, the Lower Cambrian Table Hills Volcanics, is about 1260 m deep near the centre of the basin at SP 612 and shallows gently to subcrop near SP 399. Its southwest limit is at about SP 390.

The total thickness of the sedimentary pile in a northeast line between the Musgrave and Yilgarn Blocks is estimated to be up to 7000 m. The sedimentary section thins rapidly to the southwest, from 7000 m at SP 614 to about 1600 m at SP 399, and then shelves and finally thins out about 15 km southwest of SP 201, where basement crops out. The Phanerozoic sediments have an approximate maximum thickness of 1300 m near SP 612 and Proterozoic sediments are up to 5700 m thick. Southwest of SP 399 the section consists almost entirely of Proterozoic sediments with only a thin cover of Permian rocks or recent sand and soil. This picture is in broad agreement with that which resulted from the Hunt Oil Co. exploration program, where the basin was considered to be an asymmetrical trough with the deepest part, 6000 m, close to the Musgrave Block, thinning to a shallow shelf 2000 m and shallower in the southwest.

The Proterozoic sediments have a maximum thickness of 6200 m in the northeast and thin to a shallow platform in the southwest, near Lake Throssell. They are probably the lateral equivalents of a 5000-m thick sequence of probable Adelaidean age, which crops out on the southwest flank of the Musgrave Block. The basal unit of the latter sequence is the Townsend Quartzite.

An unusual feature of the area is that in the southwest numerous reflections with continuity up to 4 km and depths up to 12500 m have been recorded beneath the Proterozoic sediments. The presence of reflections suggests a layered sequence, whose identity is unknown, but which probably comprises igneous and metamorphic rocks. It is possible that these rocks comprise metasediments intruded by basic rocks.

There is evidence of considerable faulting within the layered basement rocks in the southwest near Lake Throssell. Seismic and magnetic evidence suggests that the margin between the layered basement and the Yilgarn Block may be formed by a fault with a vertical separation of about 8000 m, but this is not definite. Across the proposed margin, there is no appreciable gravity expression and the shallow refraction velocities, are nearly the same, suggesting that the bulk density does not vary.

Most gravity features could not be interpreted in terms of sedimentary thickness variations or structure alone and substantial basement density variations were proposed to simulate the main gravity features.

Seismic, gravity, and magnetic results indicate that there may be a basic intrusion within the basement in the southwest, about 12 000 m wide and 7000 m deep, with an associated narrow vertical dyke which extends to within 1500 m of the surface.

Recommendations

Stratigraphic drilling of 2 or 3 holes to depths of about 300 m between SPs 201 and 300 is recommended to ascertain the nature and structure of rocks below a shallow high-velocity (about 6000 m/s) refractor at the southwest margin of the basin. The structure postulated at this margin is speculative.

Further reflection profiling preferably using multiple-fold techniques would be valuable to fill the gaps in the seismic traverse between SPs 240 and 614 and in the northeast where Hunt Oil Co. recorded only to 3 s reflection time. The poor petroleum prospect of the area does not, however, warrant a large expensive seismic reflection program. A program of stratigraphic drilling as suggested above would be a relatively inexpensive way of

obtaining key information for a better definition of the south-west margin of the basin. For further seismic exploration in the Officer Basin, particularly towards the South Australian border where there may be thicker Palaeozoic sequences, multiple-fold CDP reflection probes and refraction depth probes would both be recommended. A surface technique has advantages for reflection work as the weathered layer may be over 100 m thick in places, and there is a shortage of water supplies in the area for shot-hole drilling.

Two refractors associated with major unconformity surfaces A and B in Plate 44 appear to have both been recorded over widely separated parts of the basin. Mapping of these refractors by refraction depth probes may allow a rapid reconnaissance of unexplored areas of the basin.

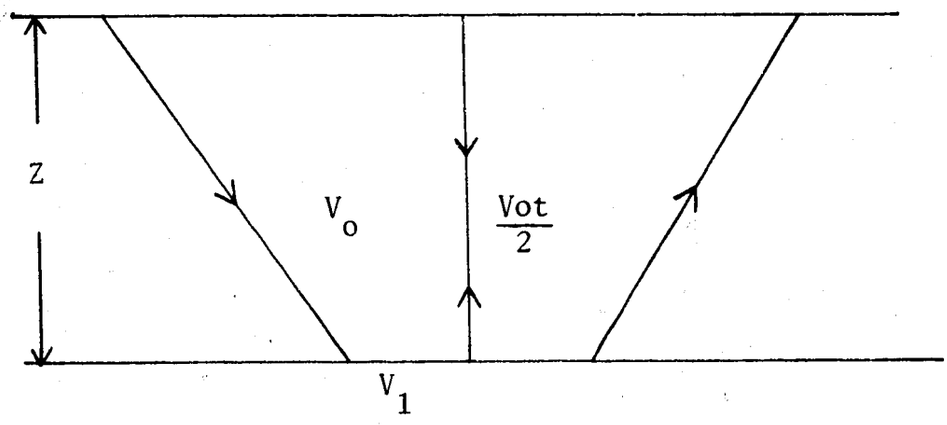
APPENDIX 1. SEISMIC RECORDING SUMMARY

Recording	Technique	Shot-points	Remarks
Up-hole shoot	Reflection	600	First recording of survey.
		599	Hole, depth 100 m, recorded because hole at SP 600 collapsed to 50 m
Noise test	Reflection	599 8/12	
Up-hole shoot	Reflection	399	First recording in new area. Basalt encountered at 30 m
		377	To determine if basalt present, and near-surface information. Basalt not found to maximum depth 94 m
Multiple coverage	Reflection	$610^{10}/12$-607	6-fold CDP coverage
		379-368 $^{10}/12$	Up to 12-fold CDP coverage
		339-336	Up to 12-fold CDP coverage
		268-261	1-2 fold CDP coverage
		255-251	1-2 fold CDP coverage
		249-244	1-3 fold CDP coverage
		205-201	1-2 fold CDP coverage
Single coverage	Reflection	601-597	Experiments with various recording, geophone, shot-hole, and spread parameters
		610, 589	Test of record quality

Recording	Technique	Shot-points	Remarks
		397, 392-391	Test record quality with several recording and shot-hole parameters
		377-375	
		303-301	Preview of recording conditions and record quality
		236-235	
Refraction depth probe	Refraction	612-551	
		304-300	Preview recording
		240-234	Preview recording
		375-332	
		205-201	
		270-262	
		107-100	Recorded to obtain refractor velocity of shallow basement
Expanded spread	Reflection	615-605	
		379-371	
		267-259	
Cross-traverse	Reflection	610, 375 and 302	To obtain true dip information
Deep crustal	Reflection	375	Two perpendicular spreads, charges 3600 and 4200 kg, 24 s of data recorded
	Refraction	375	Two perpendicular spreads recorded shots from Mt Fitton, S.A. and Kunanalling, W.A.

Recording	Technique	Shot-points	Remarks
Geoflex tests	Reflection	614-613	Comparison of several spread and Geoflex arrays and dynamite shot

APPENDIX 2. COMBINED ANALYSIS OF REFLECTION AND REFRACTION DATA



In a two-layer case, where the refraction and the reflection have been recorded from an interface, the depth of the interface Z is given by

$$Z = \frac{Vot}{2} \qquad (1)$$

where V_o = average velocity to the reflector

t = two-way reflection time

and also

$$Z = \frac{T}{2} \cdot \frac{V_o V_1}{\sqrt{V_1^2 - V_o^2}} \qquad (2)$$

where T = intercept time

V_1 = velocity of the refractor

Equating the two formulas,

$$\frac{V_o t}{2} = \frac{T}{2} \cdot \frac{V_o V_1}{\sqrt{V_1^2 - V_o^2}}$$

or

$$V_o = V_1 \sqrt{1 - \frac{T^2}{t^2}} \qquad (3)$$

Thus, the average velocity of the section above the interface calculated using equation (3) should be the same as that obtained from $T^2 - X^2$ analysis of the expanded spread data.

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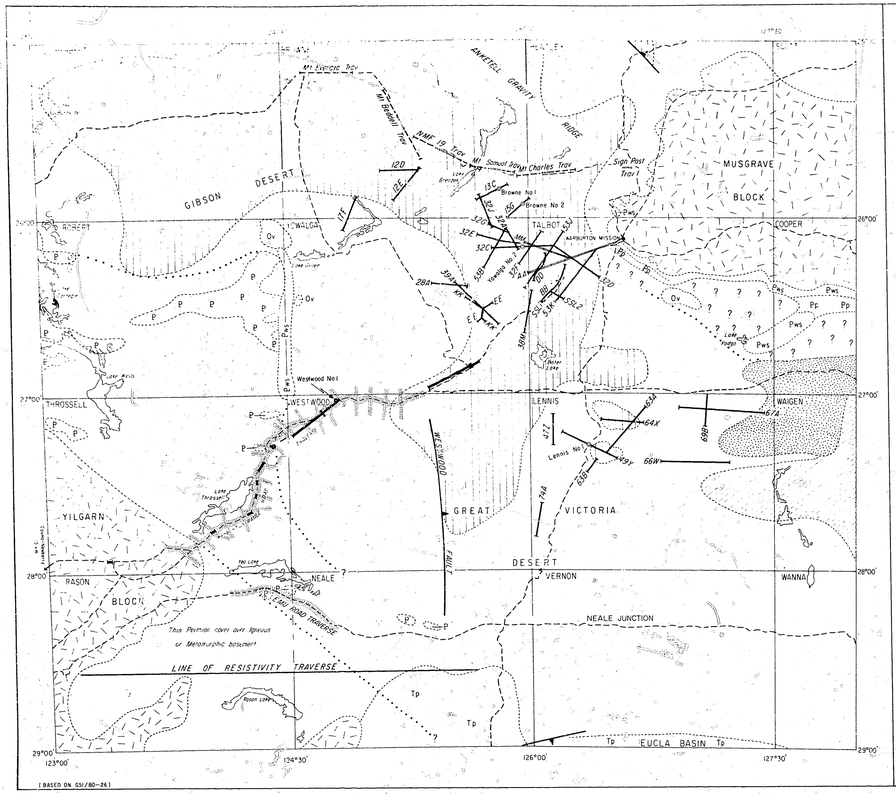
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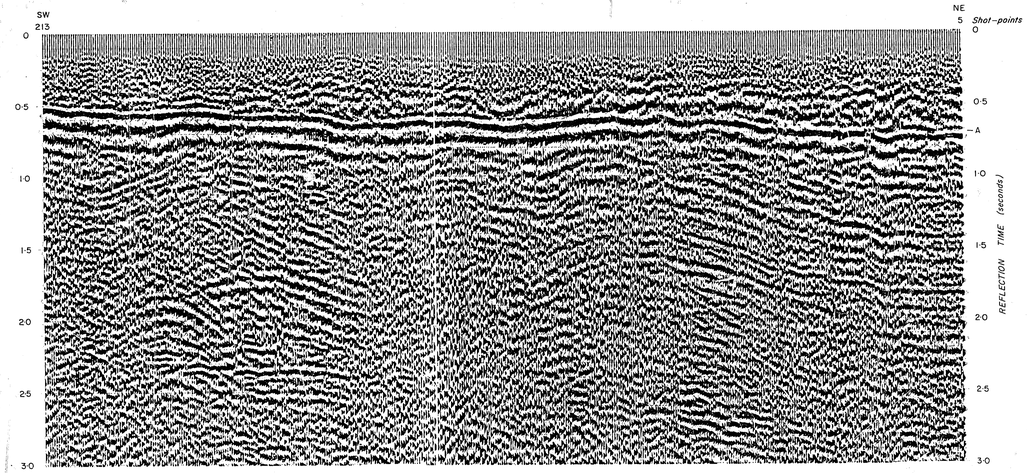
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GIBSON DESERT
MUSGRAVE BLOCK
GREAT VICTORIA DESERT
YILGARN BLOCK
ANKATELL GRAVITY RIDGE
Mt Russell Trav
NME 19 Trav
Mt Samuel Trav
Charles Trav
Sign Post Trail
Browne No 1
Browne No 2
Townsite No 1
Westwood No 1
Lennis No 1
Waigen No 1
Line of Section
Line of Traverse
Low Traverse
Line of Resistivity Traverse
Neale Junction
Eucla Basin
Rason Lake
Lake Burnside
Lake Connelly
Lake Yeo
Lake Throssell
Lake Raeside
Lake Disappointment
Lake Miranda
Lake Carnegie
Lake Wells
Lake Dora
Lake Hope
Lake Lefroy
Lake Cowan
Lake Dundas
Lake Barlee
Lake Minigwal
Lake Rason
Lake Hall
Lake Tobin
Lake Gregory
Lake Mackay
Lake Macdonald
Lake Amadeus
Lake Neale
Lake Throssell



NOTE: details of spread and recording parameters are given by Mickleberry (1966a)

LEGEND

A Hunt Oil Co horizon

500 0 500 1000 1500metres

PLATE 5 REFLECTION SECTION, LINE 12-E, HUNT OIL CO.

G51/B3-51

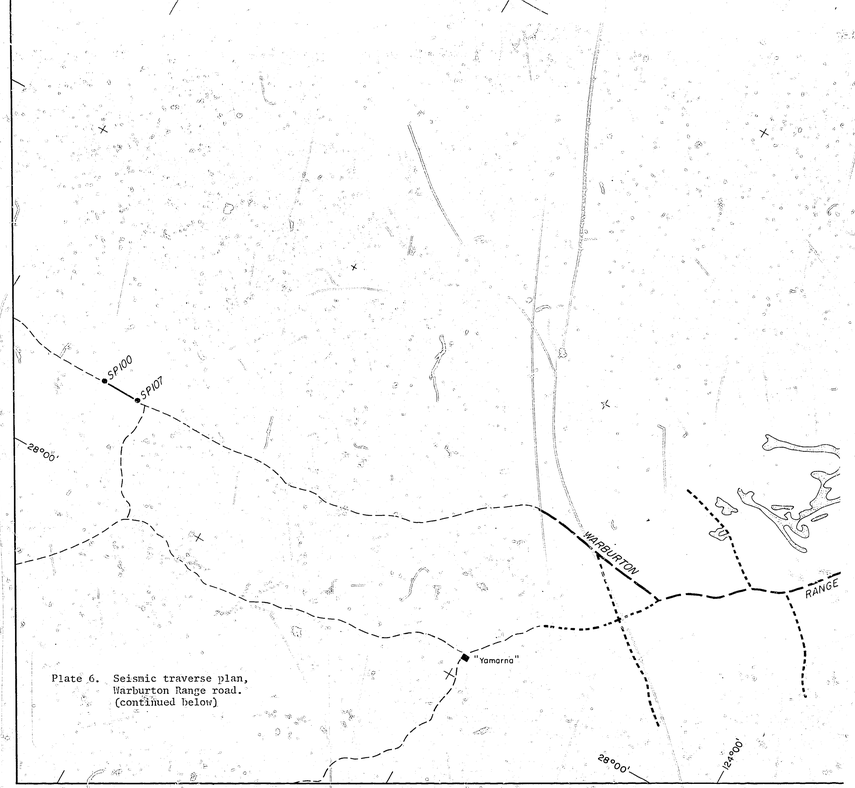


Plate 6. Seismic traverse plan, Warburton Range road. (continued below)

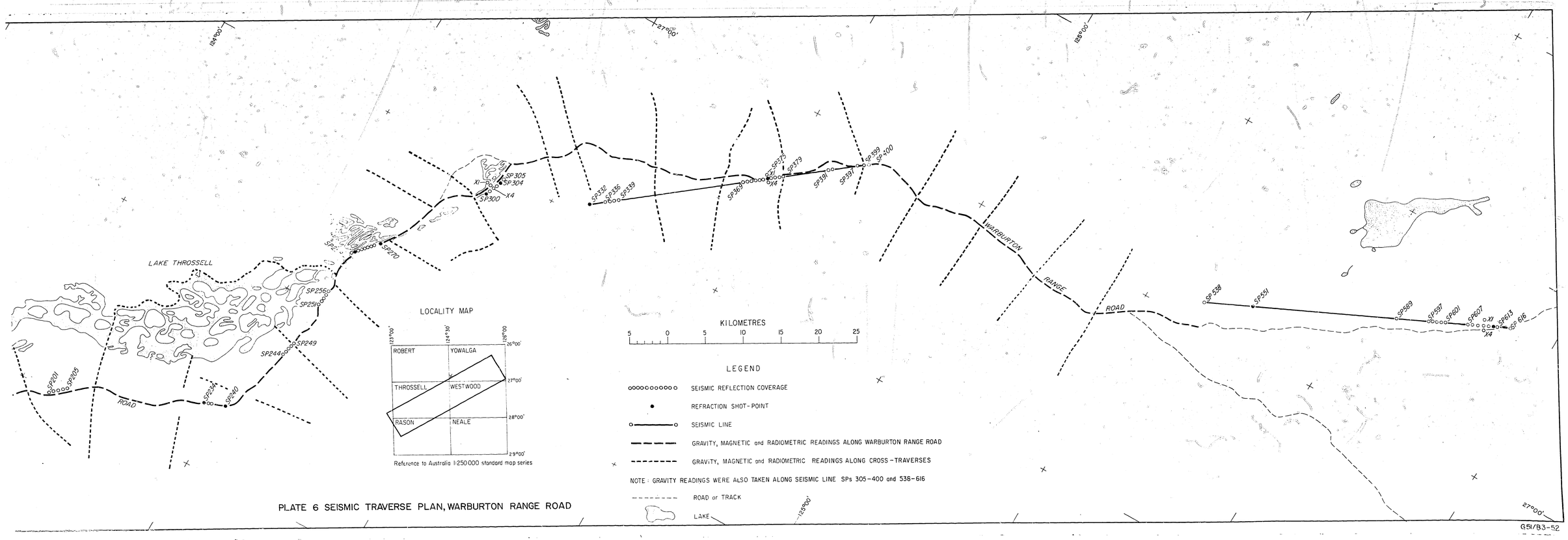


PLATE 6 SEISMIC TRAVERSE PLAN, WARBURTON RANGE ROAD

G51/B3-52

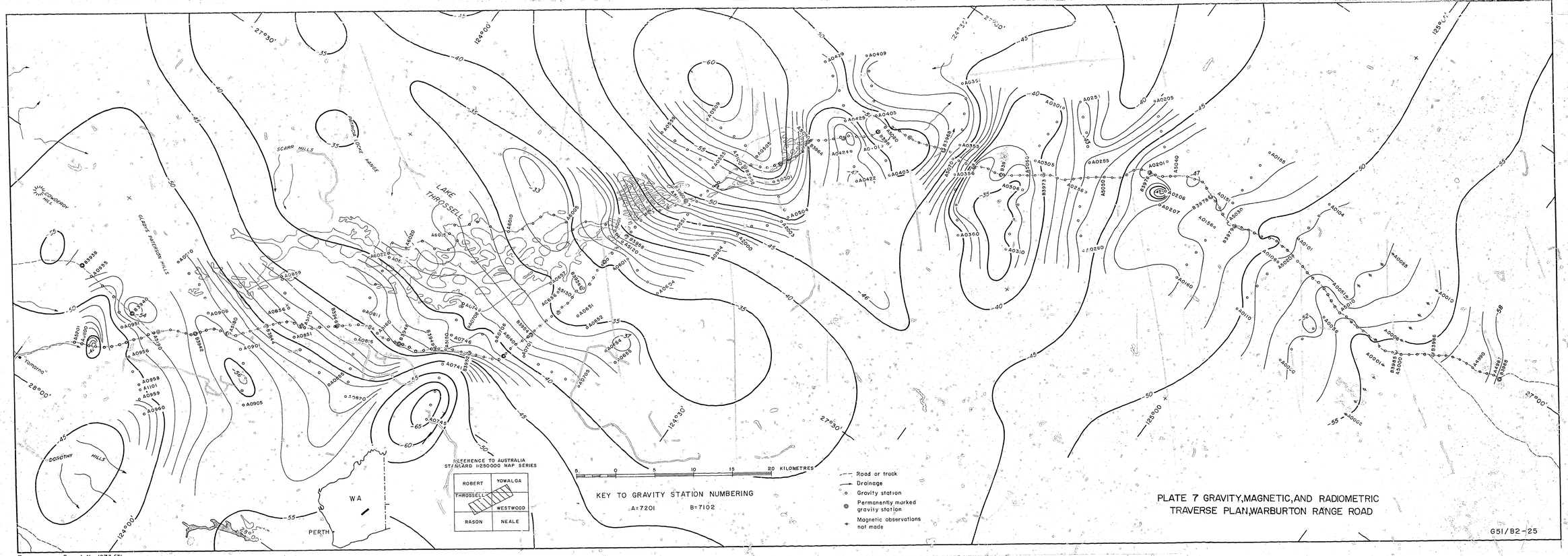


PLATE 7 GRAVITY, MAGNETIC, AND RADIOMETRIC TRAVERSE PLAN, WARBURTON RANGE ROAD

G51/82-25

To accompany Record No 1973/71

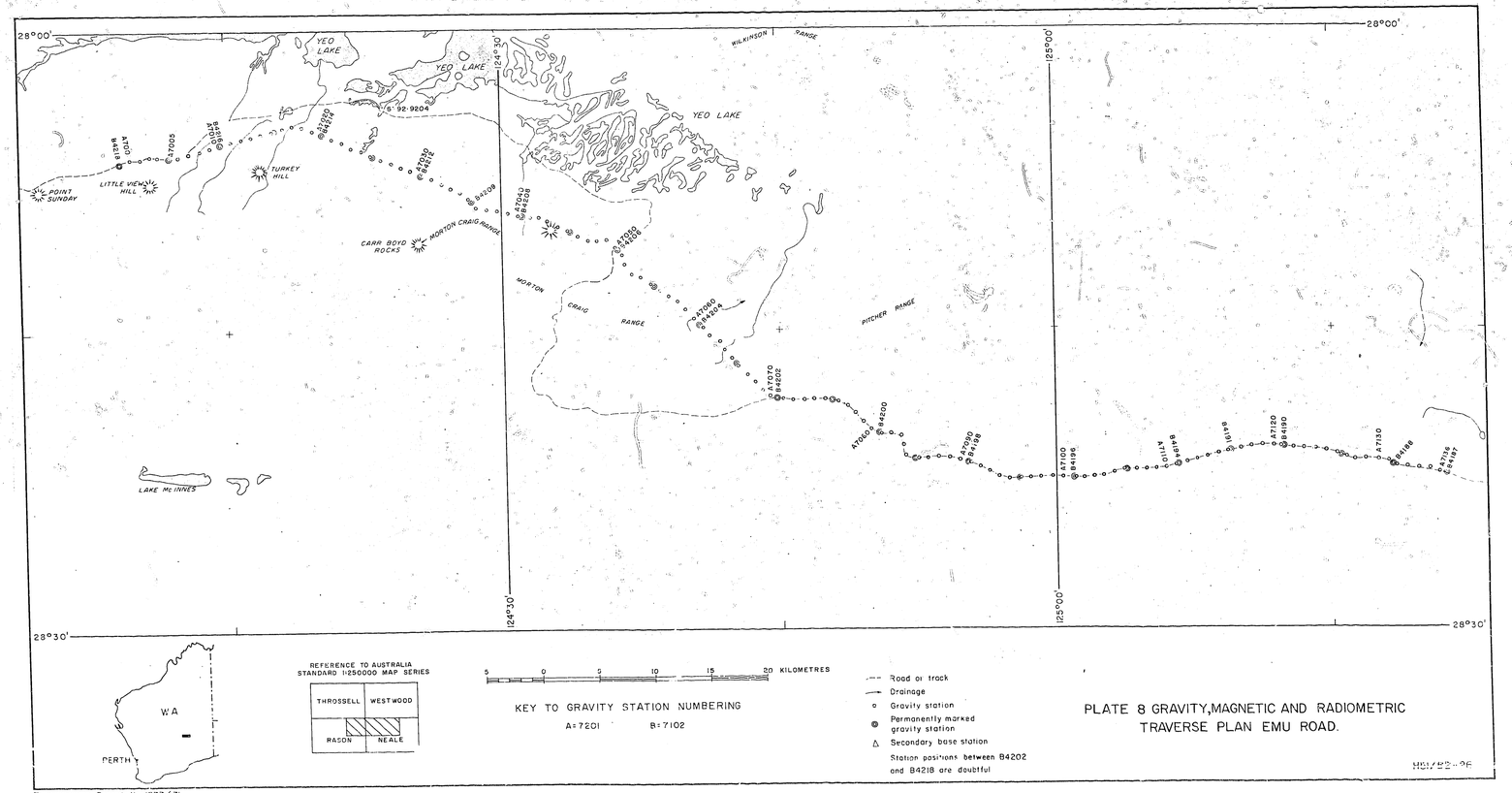
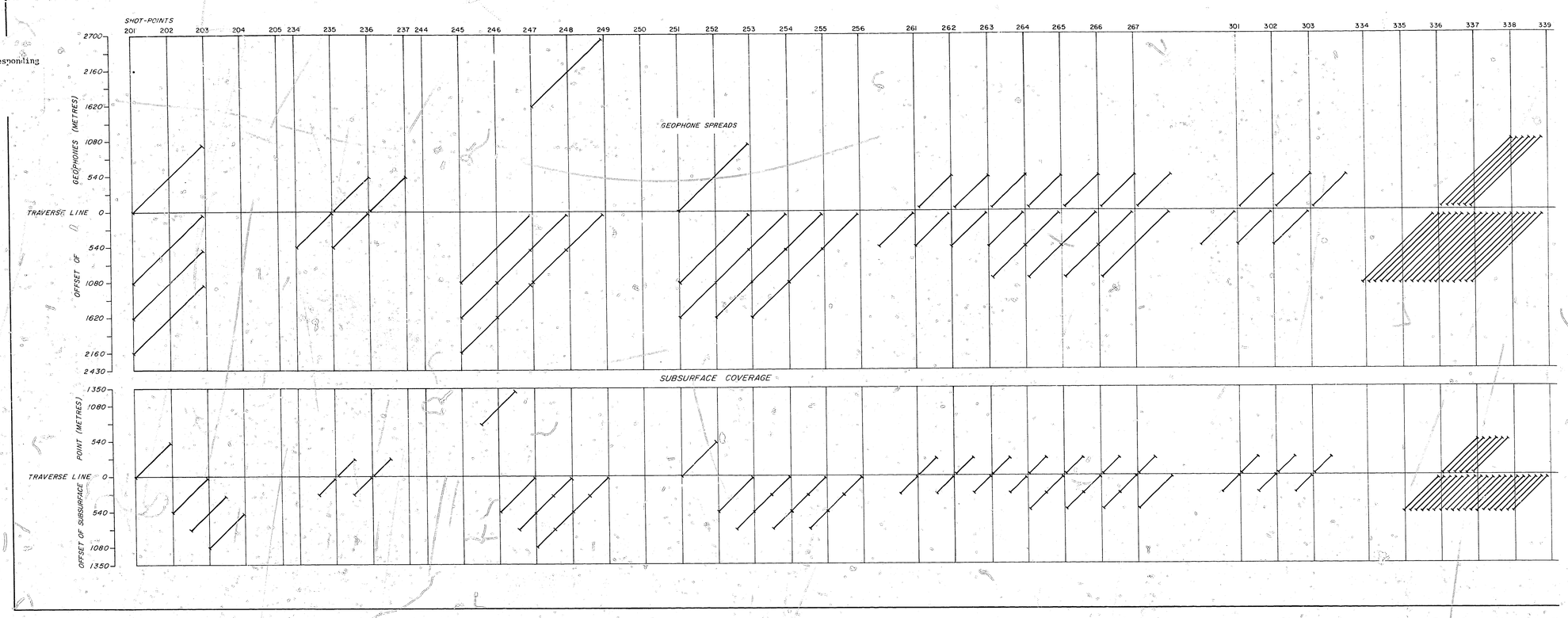


PLATE 8 GRAVITY, MAGNETIC AND RADIOMETRIC TRAVERSE PLAN EMU ROAD.

To accompany Record No 1973/71

Plate 9. Geophone spreads and corresponding subsurface coverage.
(continued below)



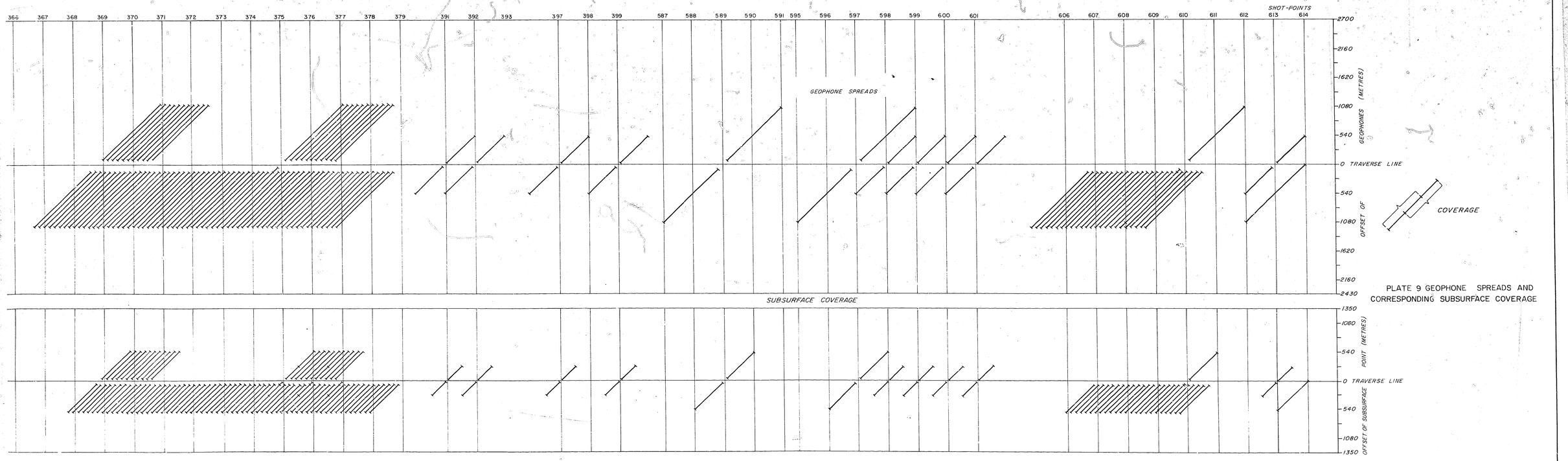
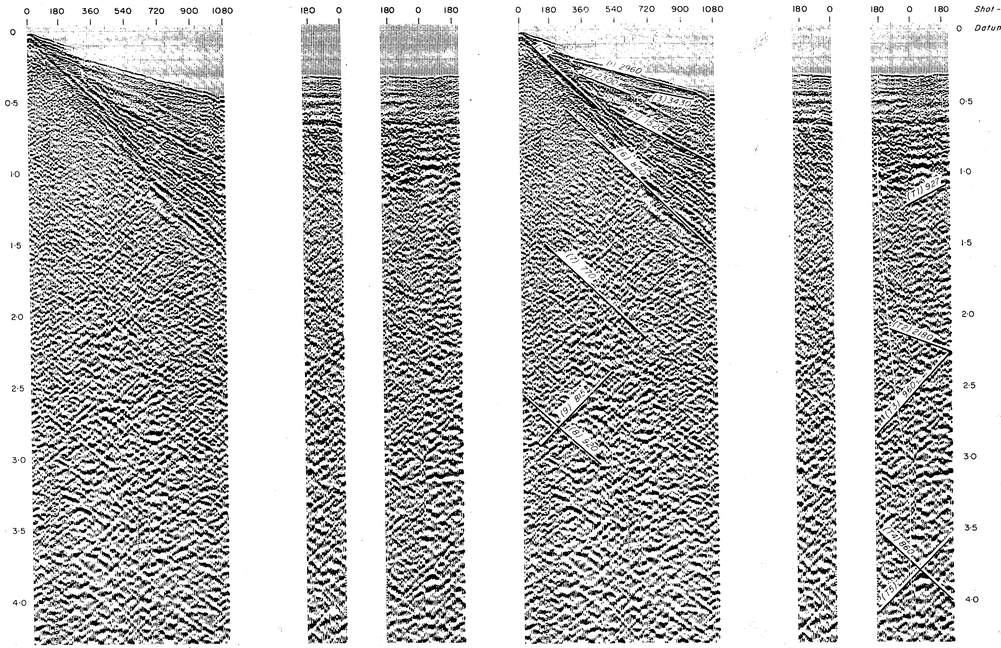


PLATE 9 GEOPHONE SPREADS AND CORRESPONDING SUBSURFACE COVERAGE

G51/B3-53



UNCORRECTED
RECORD SECTION

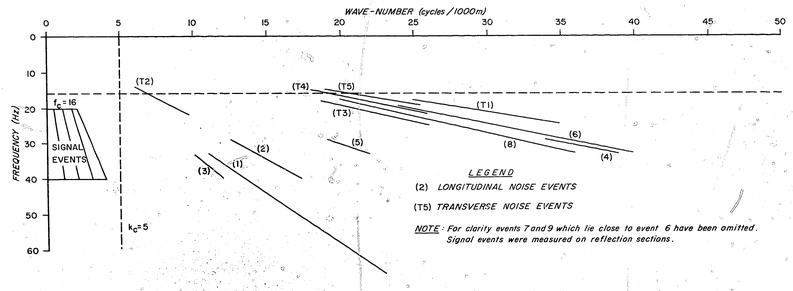
RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : Out
Programmed gain :
Function : A
Geophones : HSJ-14 Hz
Geophone station interval : 9m
Geophone pattern :
(a) and (c) 8/trace, bunched
(b) 8/trace spaced 6m perpendicular to line
Shot-hole pattern :
Single
Depth 23-30m
Charge 9kg
PLAYBACK INFORMATION
Filters : Out
AGC : SS
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

VELOCITY INFORMATION
Nil

HORIZONTAL SCALE
As indicated

PLATE 10 NOISE TEST, SP 599 8/12-UNFILTERED RECORD SECTIONS AND f-k DIAGRAM

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42



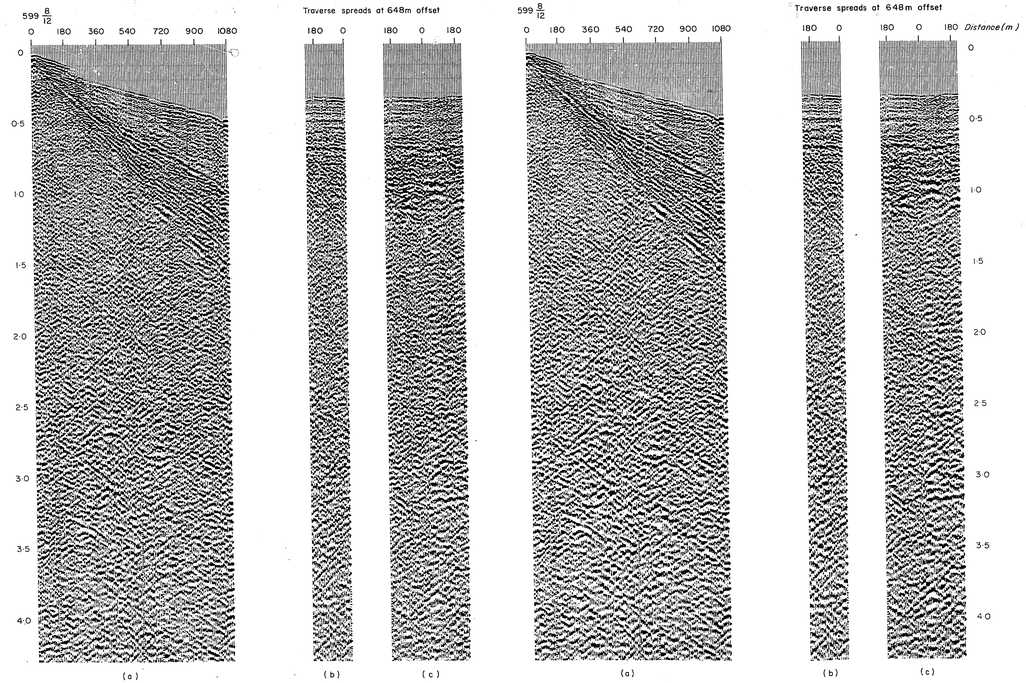
LEGEND

(2) *LONGITUDINAL NOISE EVENTS*

(T5) *TRANSVERSE NOISE EVENTS*

NOTE : For clarity events 7 and 9 which lie close to event 6 have been omitted. Signal events were measured on reflection sections.

G51/83-56



Playback filters : LL20-KK78

Playback filters : L16-KK100

UNCORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : Out
Programmed gain :
Function : A
Geophones : HSJ-14 Hz
Geophone station interval : 9m
Geophone pattern : (a) and (c) 8/trace, bunched
(b) 8/trace spaced 6m perpendicular to line
Shot-hole pattern :
Single
Depth 23-30m
Charge 9kg
PLAYBACK INFORMATION
Filters : See below section
AGC : SS
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

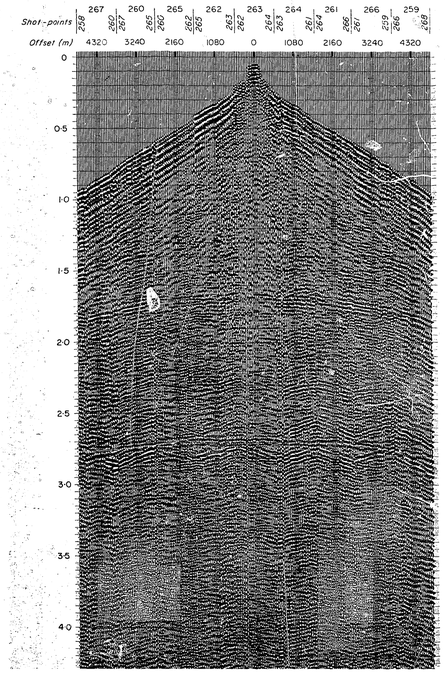
VELOCITY INFORMATION
Nil

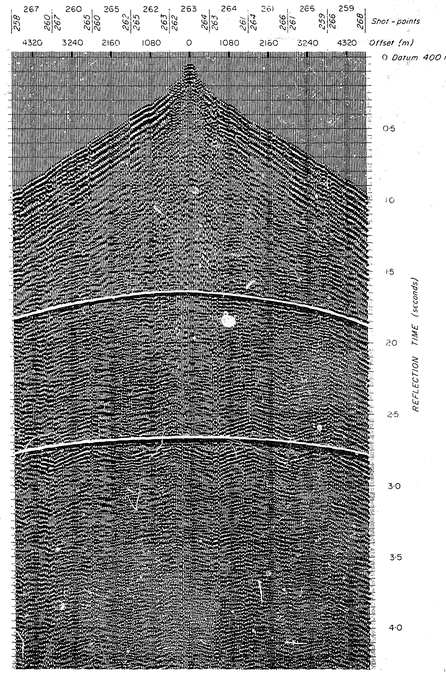
HORIZONTAL SCALE
As indicated

PLATE 11 NOISE TEST, SP 599 8/12-FILTERED RECORD SECTIONS

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-57





UNCORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
AGC : SS
Gain initial : Varies
Final : -10
Geophones : HSJ-14 Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line. Geophones 6m apart. Rows 14m apart.
Shot-hole pattern : 3 holes in one row of 3 in line. Holes 40m apart. Depth 19-30m. Total charge 1·5-7 kg.
PLAYBACK INFORMATION
Filters : L25-KK60
AGC : Off
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

VELOCITY INFORMATION
Nil

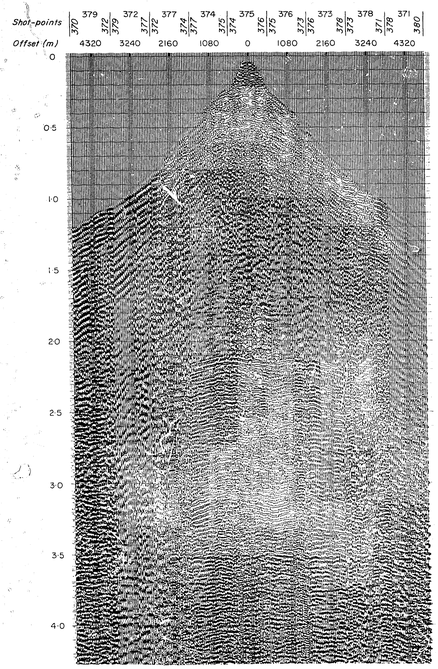
HORIZONTAL SCALE

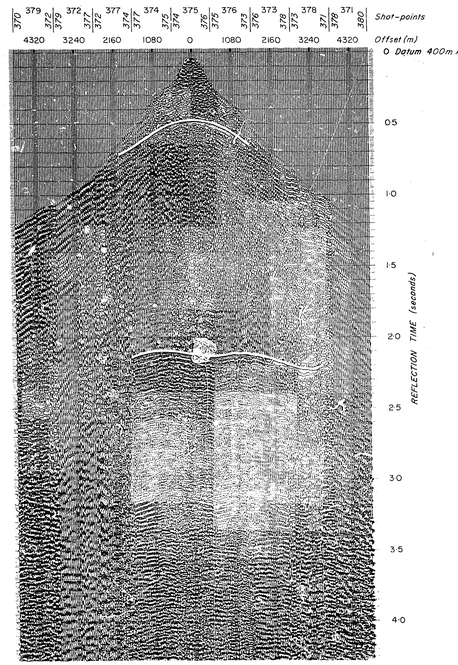
1000 0 1000 2000 3000 metres

PLATE 12. EXPANDED SPREAD, SP 263

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-58





UNCORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
Programmed gain :
Function : A
Geophones : HSJ-14 Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line
Geophones 6m apart
Rows 14m apart
Shot-hole pattern : 5 holes in one row of 5 in line
Holes 40m apart
Depth 15-30m
Total charge 27-114kg
PLAYBACK INFORMATION
Filters : L31-KK78
AGC : SS
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

VELOCITY INFORMATION
Nil

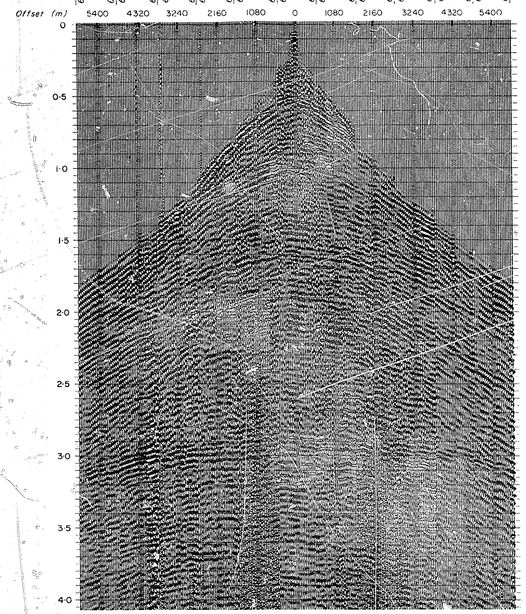
HORIZONTAL SCALE

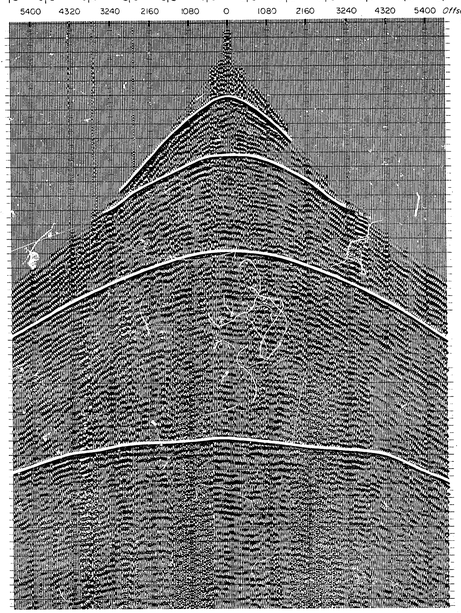
1000 0 1000 2000 3000 metres

PLATE 13. EXPANDED SPREAD, SP 375.

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-59





UNCORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : LI6-KK100
AGC : SS
Gain initial : Varies
Final : -10
Geophones : HSJ-14Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line. Geophones 6m apart. Rows 14m apart.
Shot-hole pattern : 25 holes in 5 rows of 5 in line. Holes 20m apart. Rows 20m apart. Depth 4·5m. Total charge 25-113kg.
PLAYBACK INFORMATION
Filters : LL20-KK78
AGC : SS
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

VELOCITY INFORMATION
Nil

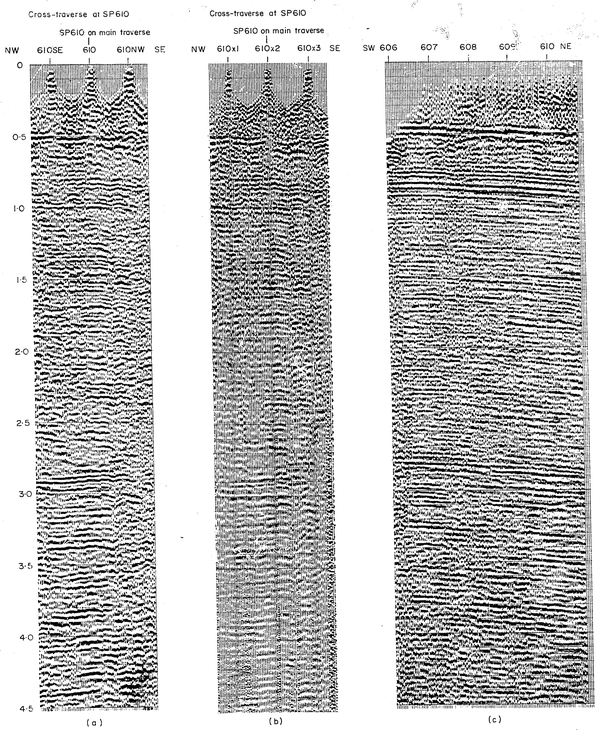
HORIZONTAL SCALE

1000 0 1000 2000 3000metres

PLATE 14 EXPANDED SPREAD, SP610.

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42

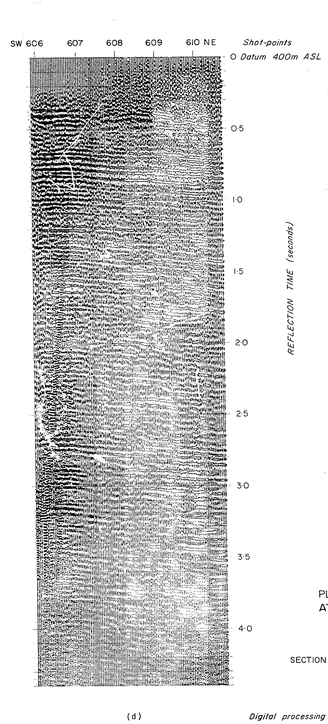
G51/83-60



(a)
24 point time-variant deconvolution
Time-variant scaling
Coherence scaling
Time-variant filtering

(b)
None

(c)
24 point time-variant deconvolution
Time-variant scaling
Automatic residual statics
Time-variant frequency filtering



(d)
None

Digital processing

CORRECTED
RECORD SECTION

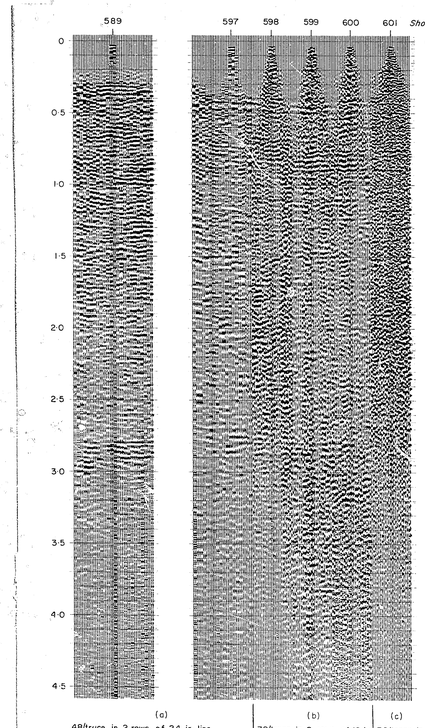
RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : LI6-KK100
AGC : SS
Gain initial : Varies
Final : -10
Geophones : HSJ-14Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line. Geophones 6m apart. Rows 14 m apart.
Shot-hole pattern : 25 holes in 5 rows of 5 in line. Holes 20m apart. Rows 20m apart. Depth 4·5m. Total charge 23-50kg.
PLAYBACK INFORMATION
ANALOGUE PROCESSING :(b)and(d)
AGC : Off
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : (a)and(b) Nil. (c)and(d) 6-fold stack.
Filters : LL20-KK78
DIGITAL PROCESSING (a)and(c) see below section
VELOCITY INFORMATION
Expanded spread at SP 610, Function B'.
HORIZONTAL SCALE

500 0 500 1000 1500metres
0 540 1080

PLATE 15 REFLECTION SECTIONS, SPS 607-610½ AND CROSS-TRAVERSE AT SP 610 WITH COMPARISON BETWEEN ANALOGUE DIGITAL PROCESSING

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-61



(a)
48/trace in 2 rows of 24 in line
Geophones 6m apart
Rows 14m apart

(b)
32/trace in 2 rows of 16 in line. Geophones 6m apart. Rows 8 m apart.

(c)
32/trace in 4 rows of 8 in line. Geophones 6m apart. Rows 8m apart

Geophone pattern

CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : LI6-KK100
AGC : (a) SS (b)and(c) PG function A
Gain initial : Varies
Final : -10
Geophones : HSJ-14Hz
Geophone station interval : (a) 90m (b) and(c)45m
Geophone pattern : See below sections

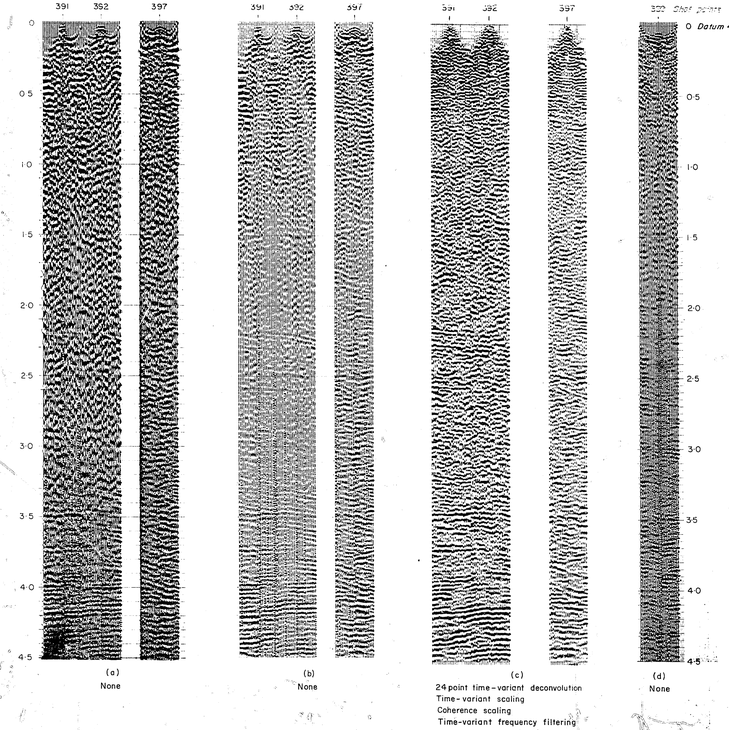
Shot-hole pattern : (a)and(b) 25 holes in rows of 5 in line. Holes 20m apart, rows 20m apart. Depth 4·5m. Total charge 25kg (c) 5 holes 20m apart in line. Depth 20m. Charge 25kg.
PLAYBACK INFORMATION
Filters : LL20-KK78
AGC : (a) Off (b) and(c) SS
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing :
(a) Each trace played out twice
(b) and (c) Nil
VELOCITY INFORMATION
Expanded spread at SP610
Function B'
HORIZONTAL SCALE

500 0 500 1000 1500metres
0 540 1080

PLATE 16 REFLECTION SECTIONS, SPS 589-601

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-62



CORRECTED
RECORD SECTION

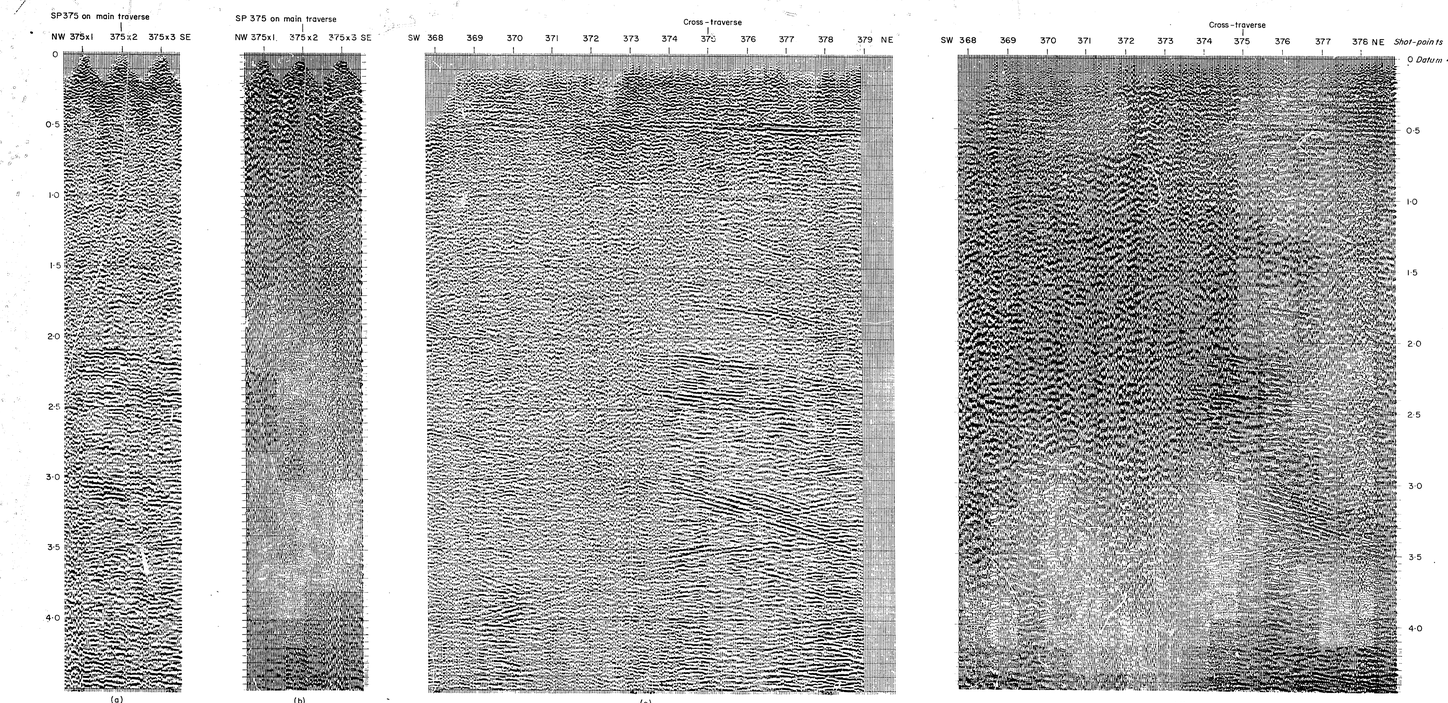
RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
AGC : SS
Gain initial : Varies
Final : -10
Geophones : HSJ-14 Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line. Geophones 6m apart. Rows 14m apart.
Shot-hole pattern : SP 399 and 397 single hole, depths 10 and 30m. SP 392 and 391 25 holes in 5 rows of 5 in line. Holes 20m apart. Depth 4·5m Total charge 14-25kg.
PLAYBACK INFORMATION
ANALOGUE PROCESSING : (a), (b) and (d)
AGC : Off
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil
Filters : (a) L20-KK78 (b) and (d) LL20-KK78
DIGITAL PROCESSING : (c) See below section
VELOCITY INFORMATION
Expanded spread at SP 610
Function B'
HORIZONTAL SCALE

500 0 500 1000 1500 metres
0 540 1080

PLATE 17 REFLECTION SECTIONS, SPS 391-399 WITH COMPARISON BETWEEN ANALOGUE AND DIGITAL PROCESSING.

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-63



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
AGC : (a) and (b) SS, (c) and (d) SS or programmed
Gain initial : Varies gain, Function A
Final : -10
Geophones : HSJ-14 Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line. Geophones 6m apart. Rows 14m apart.
Shot-hole pattern : 3 holes 40m apart in line. Depth 17-30m Total charge 14-45kg

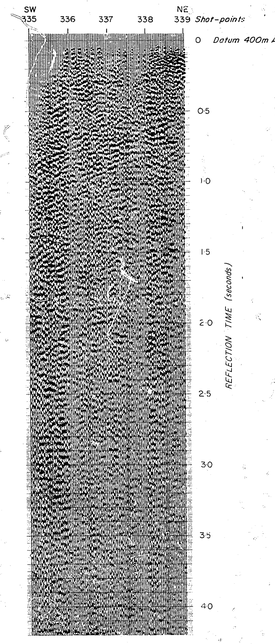
PLAYBACK INFORMATION
ANALOGUE PROCESSING : (b) and (d)
AGC : (b) Off, (d) SS
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : (a) and (b) Nil. (c) and (d) Up to 12-fold CDP stack.
Filters : L20-KK78
DIGITAL PROCESSING : (a) and (c) see below section
VELOCITY INFORMATION
Expanded spreads SP 610 and 375, Function C.
HORIZONTAL SCALE

500 0 500 1000 1500 metres
0 540 1080

PLATE 18 REFLECTION SECTIONS, SPS 368½-379 AND CROSS-TRAVERSE AT SP 375 WITH COMPARISON BETWEEN ANALOGUE AND DIGITAL PROCESSING.

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-64



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
AGC : SS
Gain initial : Varies
Final : -10
Geophones : HSJ-14Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line. Geophones 6m apart. Rows 14m apart.
Shot-hole pattern : 3 holes 40m apart in line Depth 17-30m
Total charge 41kg

PLAYBACK INFORMATION
Filters : LL20-KK78
AGC : SS
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Up to 12 fold CDP stack

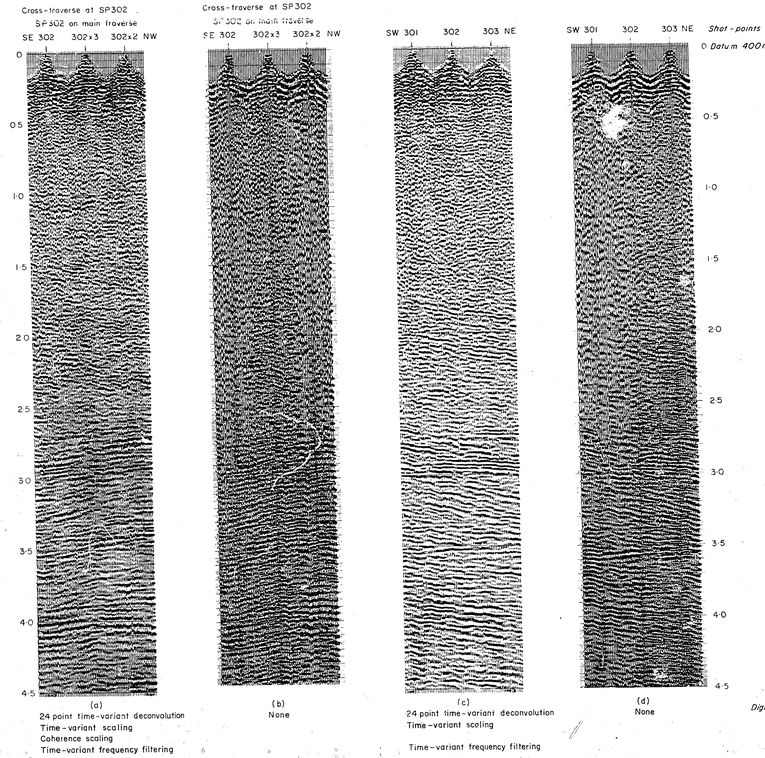
VELOCITY INFORMATION
Expanded spreads at SP 610 and 375
Function C
HORIZONTAL SCALE

500 0 500 1000 1500metres
0 540 1080

PLATE 19. REFLECTION SECTION, SPS 335-339.

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-65A



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
AGC : SS
Gain initial : Varies
Final : -10
Geophones : HSJ-14Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line. Geophones 6m apart. Rows 14m apart.
Shot-hole pattern : 25 holes in 5 rows of 5 in line. Holes 20m apart. Rows 20m apart. Depth 4m. Total charge 20-46kg.
PLAYBACK INFORMATION
ANALOGUE PROCESSING : (b)and(d)
AGC : Off
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil
Filters : L20-KK78
DIGITAL PROCESSING : (a)and(c) See below sections
VELOCITY INFORMATION
Expanded spreads at SP 610 and 375
Function C
HORIZONTAL SCALE

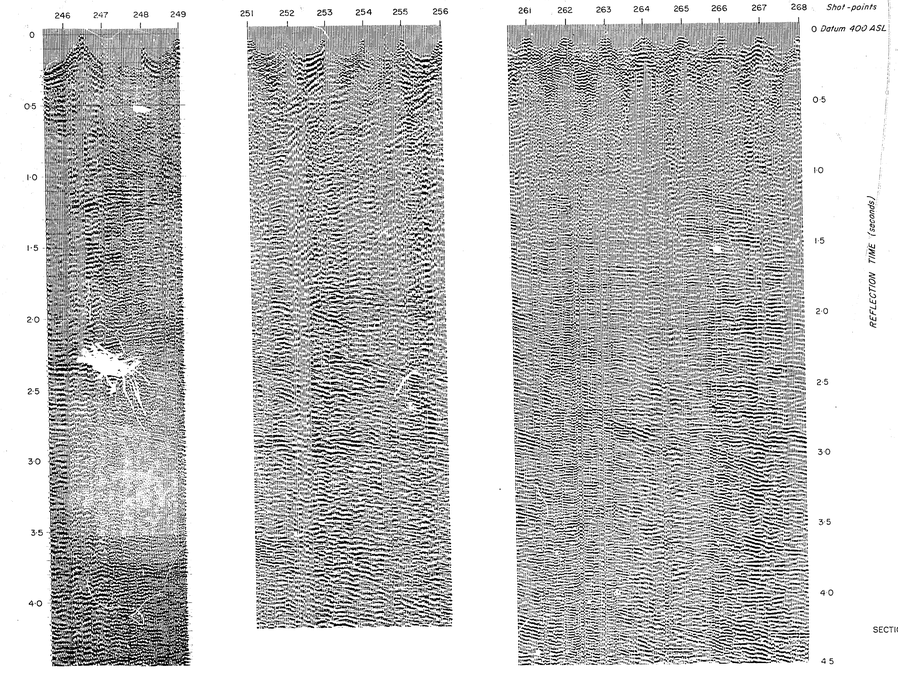
500 0 500 1000 1500metres
0 540 1080

PLATE 20 REFLECTION SECTIONS, SPS 301-303 AND CROSS-TRAVERSE AT SP 302 WITH COMPARISON BETWEEN ANALOGUE AND DIGITAL PROCESSING

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

Digital processing

G51/83-66



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
AGC : SS
Gain initial : Varies
Final : -10
Geophones : HSJ-14Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line. Geophones 6m apart. Rows 14m apart.
Shot-hole pattern : 3 holes 40m apart in line or 2 holes 80m apart in line. Depth 17-30m. Total charge 1·5-21kg.
PLAYBACK INFORMATION
Filters : LL20-KK78
AGC : Off
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

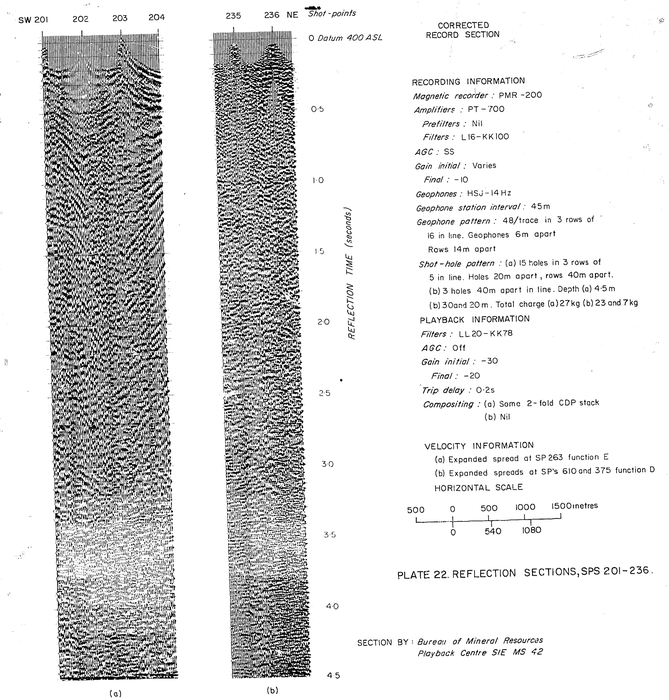
VELOCITY INFORMATION
Expanded spread at SP 263
Function E
HORIZONTAL SCALE

500 0 500 1000 1500metres
0 540 1080

PLATE 21 REFLECTION SECTIONS, SPS 246-268

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-67



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-200
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
AGC : SS
Gain initial : Varies
Final : -10
Geophones : HSJ-14Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of 16 in line. Geophones 6m apart Rows 14m apart
Shot-hole pattern : (a) 15 holes in 3 rows of 5 in line. Holes 20m apart, rows 40m apart. (b) 3 holes 40m apart in line. Depth (a) 4·5m (b) 3and 20m. Total charge (a) 27kg (b) 23 and 7kg
PLAYBACK INFORMATION
Filters : LL20-KK78
AGC : Off
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : (a) Some 2-fold CDP stack (b) Nil

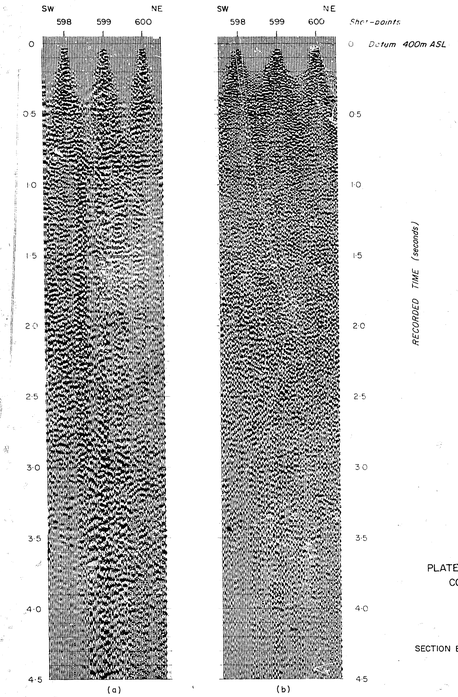
VELOCITY INFORMATION
(a) Expanded spread at SP 263 function E
(b) Expanded spreads at SP's 610 and 375 function D
HORIZONTAL SCALE

500 0 500 1000 1500metres
0 540 1080

PLATE 22. REFLECTION SECTIONS, SPS 201-236.

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/83-68



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
Programmed gain :
Function : A
Geophones : HSJ-14Hz
Geophone station interval : 45m
Geophone pattern : (a) 32/trace in 2 rows of 16 in line
(b) 32/trace in 4 rows of 8 in line
Geophones 6m apart. Rows 8m apart
Shot-hole pattern : (a) 25 holes in 5 rows of 5 in line
Holes 20m apart and rows 20m apart. Depth 4·5m.
Total charge 25kg.(b) 5 holes spaced 20m apart in line. Depth 20-30m. Total charge 25kg
PLAYBACK INFORMATION
Filters : LL20-KK78
AGC : SS
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

VELOCITY INFORMATION
Function A

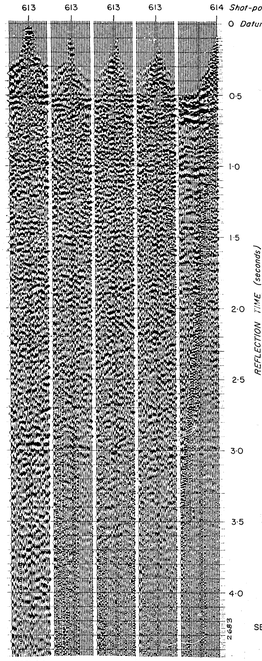
HORIZONTAL SCALE

500 0 500 1000 1500metres
0 540 1080

PLATE 23 REFLECTION SECTIONS,SPS 598-600-
COMPARISON OF SHOT-HOLE PARAMETERS.

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/B3-69



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20
Amplifiers : PT-700
Prefilters : Nil
Filters : L16-KK100
AGC :
Gain initial : Variet
Final : -10
Geophones : HSJ-14Hz
Geophone station interval : 45m
Geophone pattern : 48/trace in 3 rows of
16 in line. Geophones 6m apart.
Rows 14m apart
Shot-hole pattern : (a) 25 holes in 5 rows of
5 in line. Holes 20m apart and rows 20m apart.
Depth 4m. Total charge 22·7 kg. (b),(c),(d) &(e)
rows of geoflex parallel to traverse. Rows 20m apart.
Number and length of rows given below sections.
PLAYBACK INFORMATION
Filters : L25-KK78
AGC : SS
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

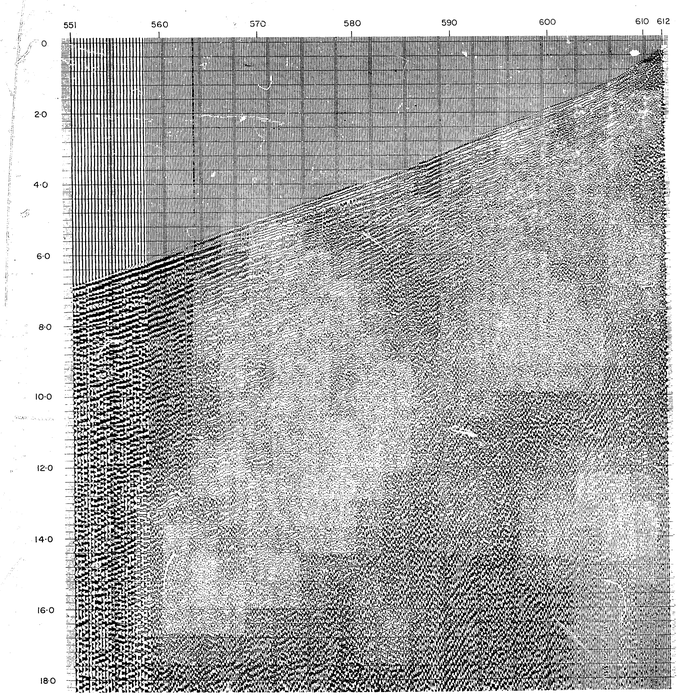
VELOCITY INFORMATION
Expanded spread at SP 510
Function B'
HORIZONTAL SCALE

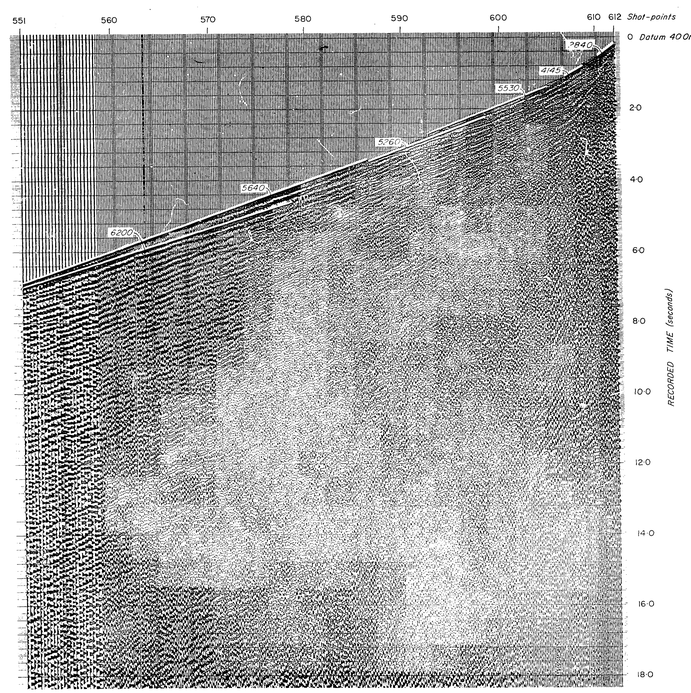
500 0 500 1000 1500metres
0 540 1080

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

PLATE 24 REFLECTION SECTIONS,SPS 613-614
GEOFLEX COMPARISON TESTS

G51/B3-70A





UNCORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20 (24s)
Amplifiers : PT-700
Prefilters : Nil
Filters : Out-KK60
AGC : SS
Gain initial : 0 to -20
Final : 0 to -20
Geophones : 4·5Hz
Geophone station interval : 90m and 180m
Geophone pattern :
4/trace in one line perpendicular to traverse
Geophones 6m apart in line
Shot-hole pattern :
1-23 holes in rows perpendicular to traverse
Depth 30m
Total charge 44-4536kg
PLAYBACK INFORMATION
Filters : L16-KK220
AGC : 011
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

VELOCITY INFORMATION
Nil

HORIZONTAL SCALE

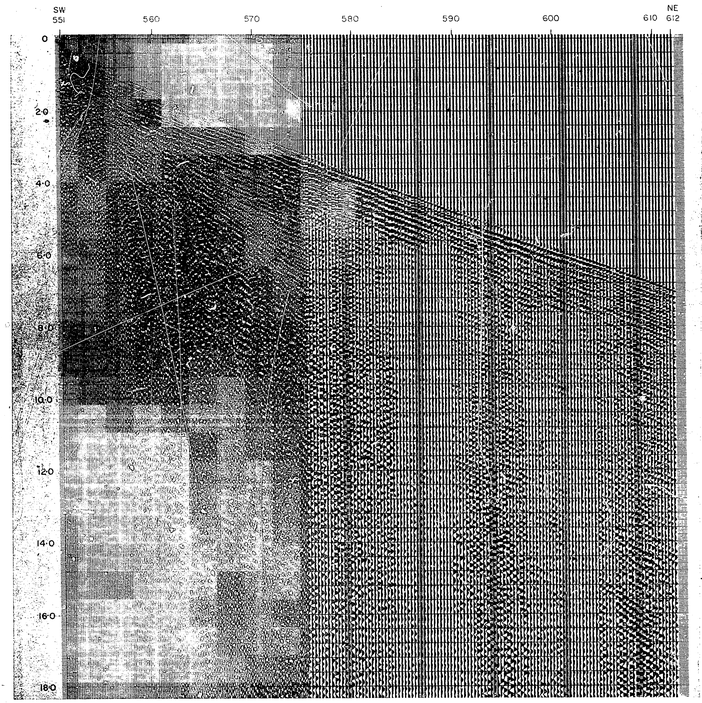
2000 0 2000 4000 6000 metres

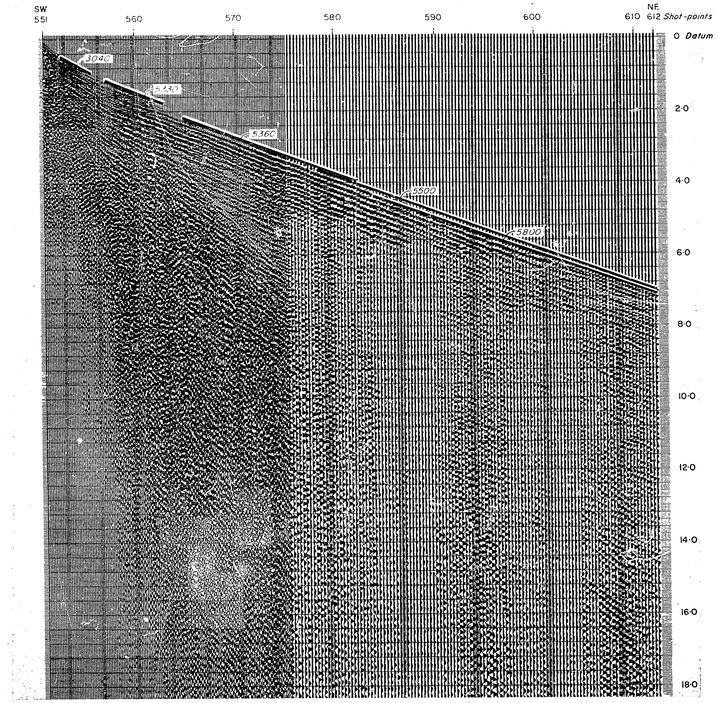
LEGEND
5640 One-way refractor velocity (m/s)

PLATE 25 REFRACTION SECTION,SP 612.

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/B3-71





UNCORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic recorder : PMR-20 (24s)
Amplifiers : PT-700
Prefilters : Nil
Filters : Out-KK60
AGC : SS
Gain initial : Varies
Final : -10 to -40
Geophones : 4·5 Hz
Geophone station interval : 90m and 180m
Geophone pattern :
4/trace in one line perpendicular to traverse
Geophones 6m apart in line
Shot-hole pattern :
1-20 holes in rows perpendicular to traverse
Depth 30m
Total charge 22·7-1445 kg
PLAYBACK INFORMATION
Filters : L16-KK220
AGC : Off
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

VELOCITY INFORMATION
Nil

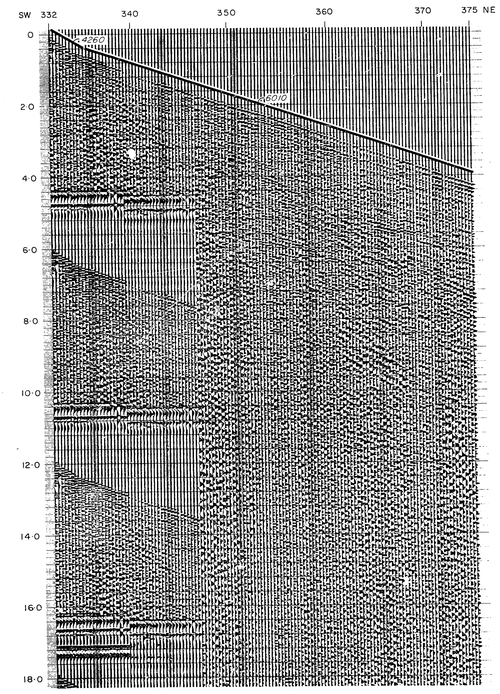
HORIZONTAL SCALE
2000 0 2000 4000 6000 metres

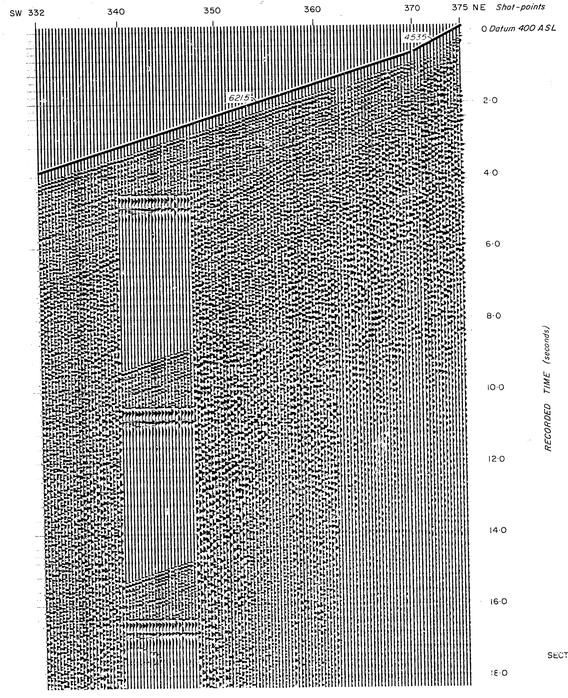
LEGEND
5500 One-way refractor velocity (m/s)

PLATE 26 REFRACTION SECTION, SP 551

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/B3-54





UNCORRECTED
RECORD SECTION

PLATE 27

RECORDING INFORMATION
Magnetic recorder : PMR-20 (24s)
Amplifiers : PT-700
Prefilters : Nil
Filters : Out-KK100
AGC : SS
Gain initial : Varies
Final : -10
Geophones : 4·5 Hz
Geophone station interval : 180m
Geophone pattern :
4/trace in one line perpendicular to traverse
Geophones 6m apart in line
Shot-hole pattern :
1-10 holes in rows perpendicular to traverse
Depth 30m
Total charge 91-1820 kg
PLAYBACK INFORMATION
Filters : L16-KK220
AGC : Off
Gain initial : -30
Final : -20
Trip delay : 0·2s
Compositing : Nil

VELOCITY INFORMATION
Nil

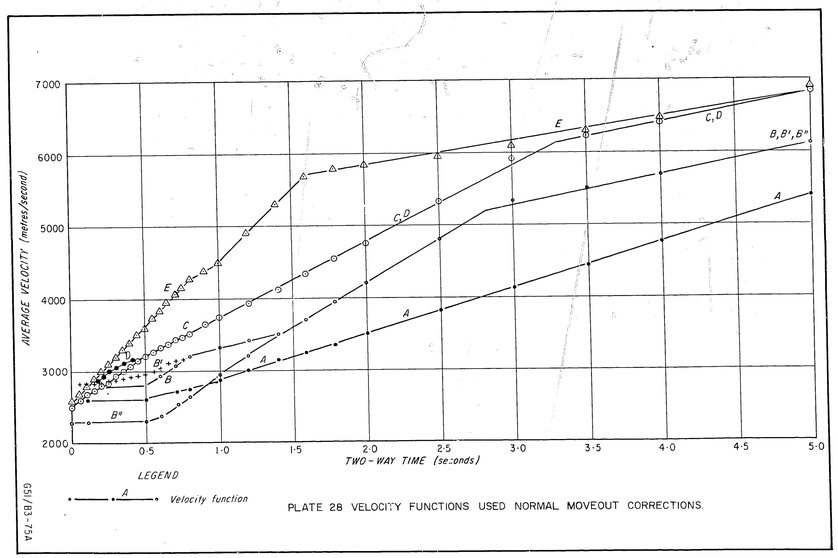
HORIZONTAL SCALE
2000 0 2000 4000 6000 metres

LEGEND
6215 One-way refractor velocity (m/s)

PLATE 27 REFLECTION SECTIONS, SPS 332 AND 375.

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

G51/B3-55



G51/B3-75A

PLATE 28 VELOCITY FUNCTIONS USED NORMAL MOVEOUT CORRECTIONS.

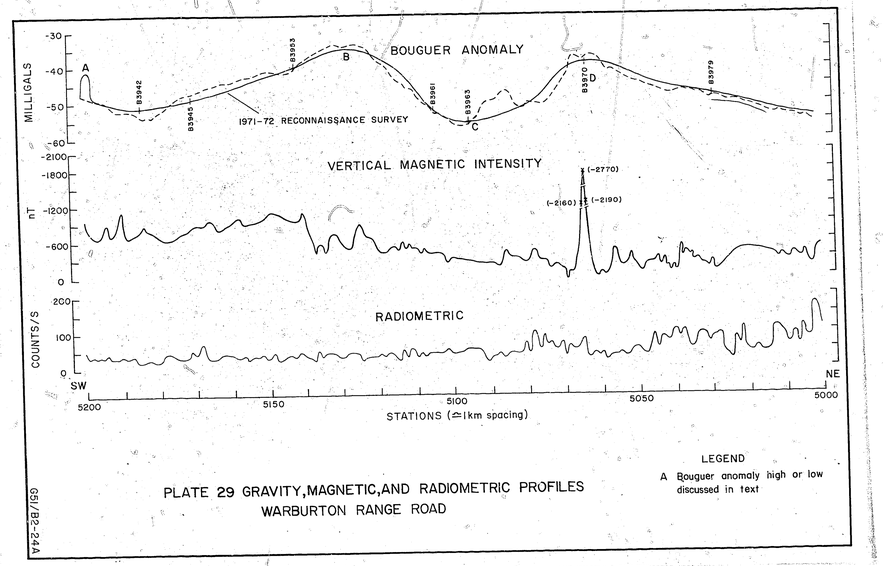


PLATE 29 GRAVITY, MAGNETIC, AND RADIOMETRIC PROFILES
WARBURTON RANGE ROAD

LEGEND
A Bouguer anomaly high or low discussed in text

GSI/82-24A

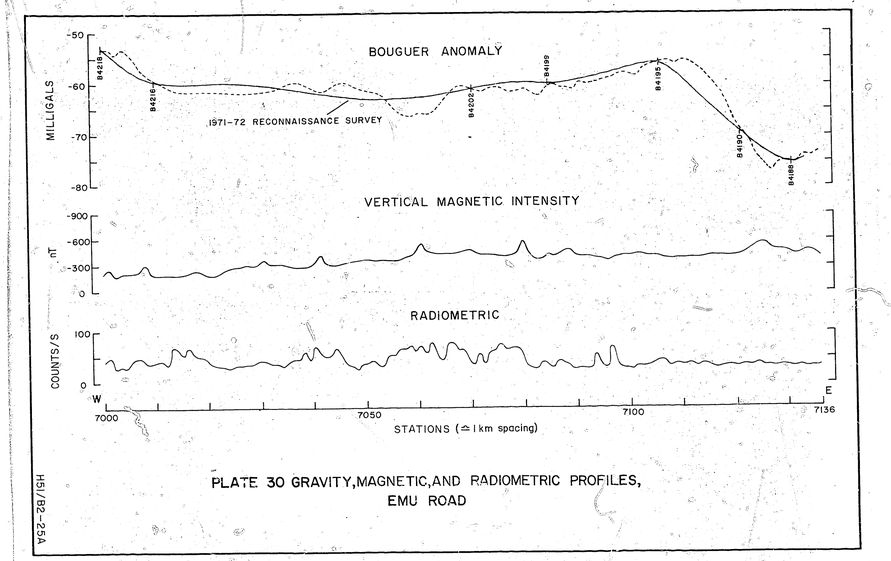


PLATE 30 GRAVITY, MAGNETIC, AND RADIOMETRIC PROFILES,
EMU ROAD

GSI/82-25A

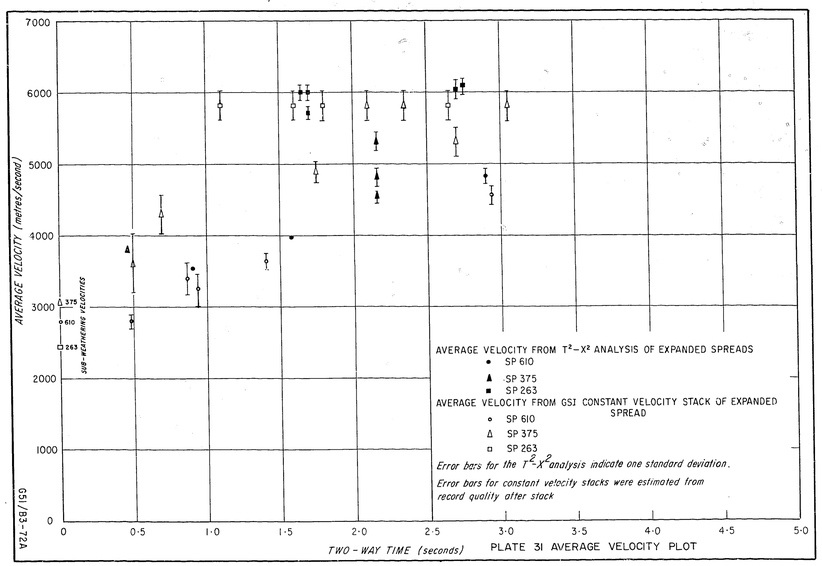


PLATE 31 AVERAGE VELOCITY PLOT

GSI/83-72A

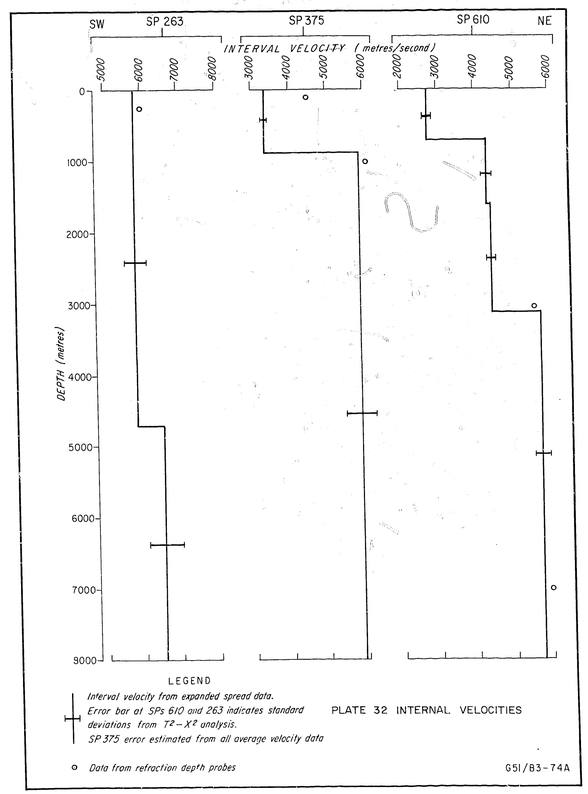


PLATE 32 INTERNAL VELOCITIES

GSI/83-74A

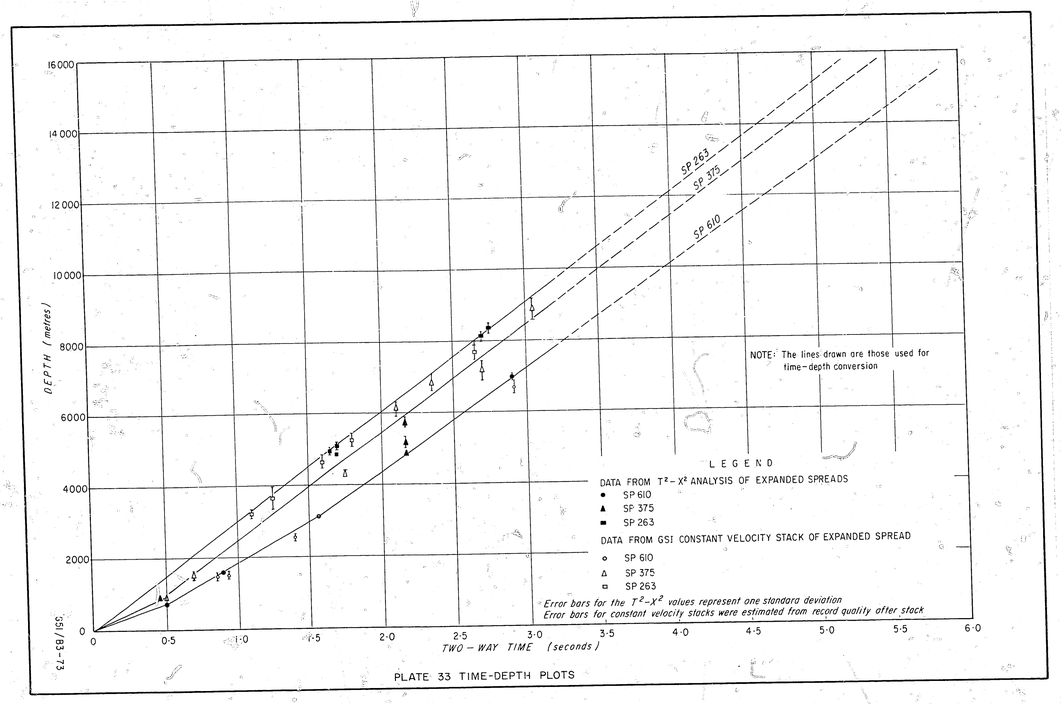


PLATE 33 TIME-DEPTH PLOTS

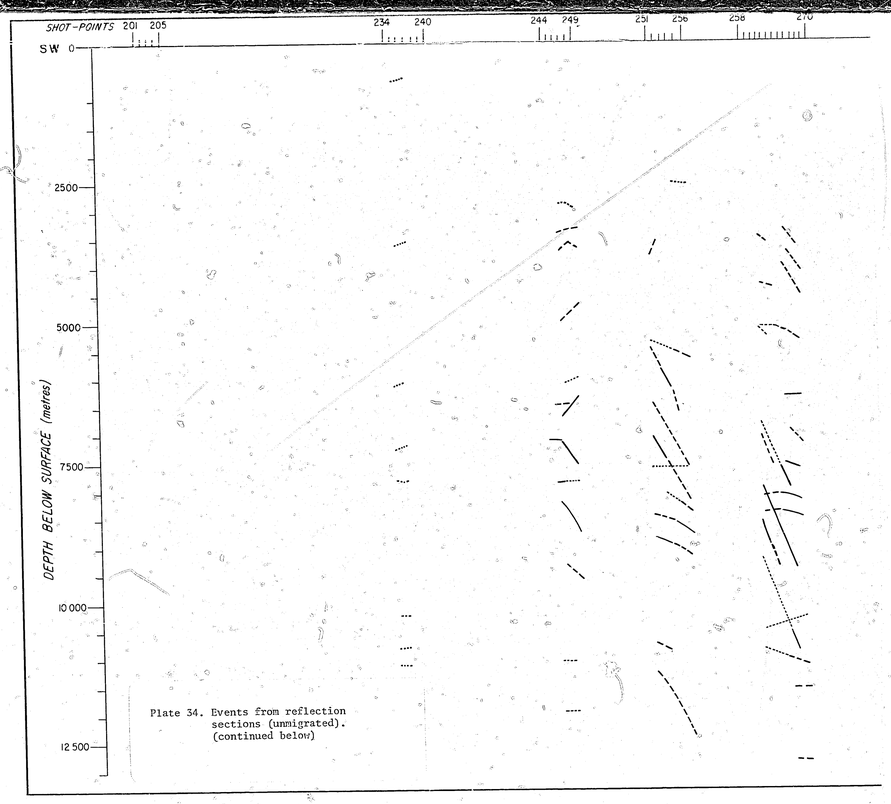


Plate 34. Events from reflection sections (unmigrated). (continued below)

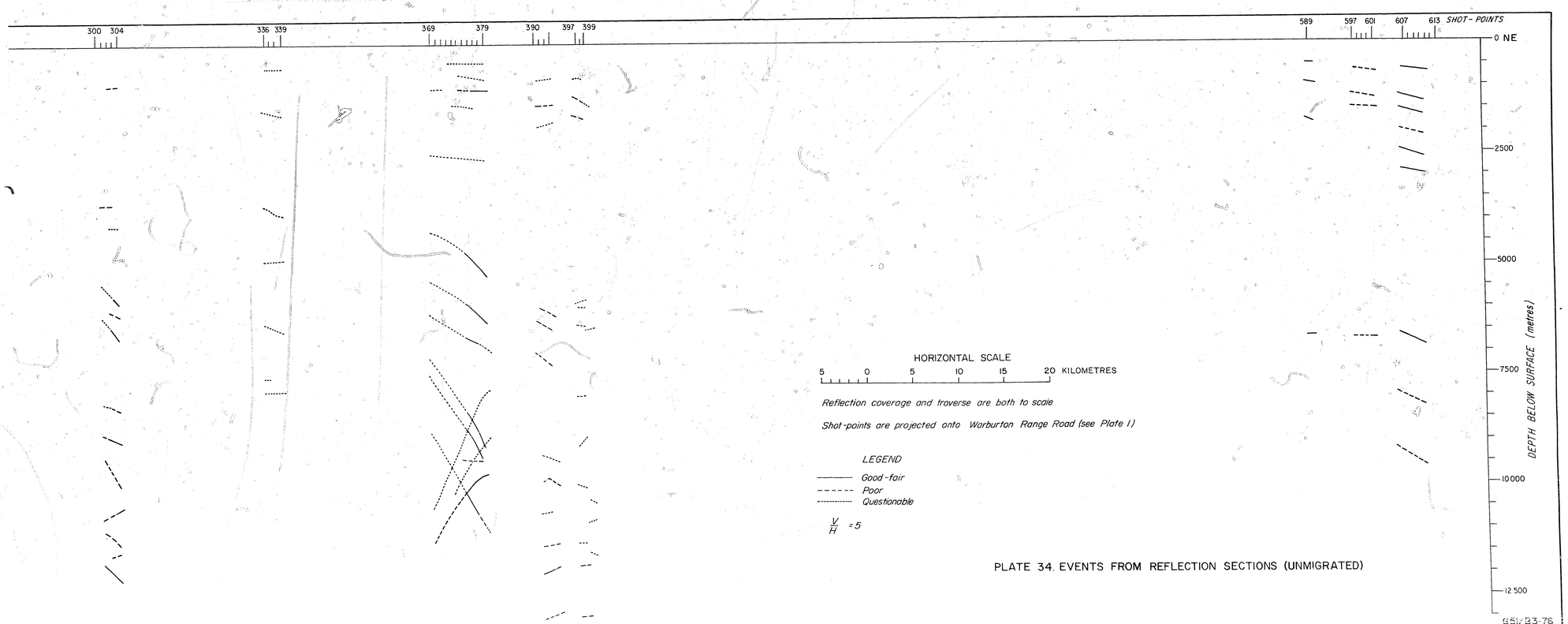


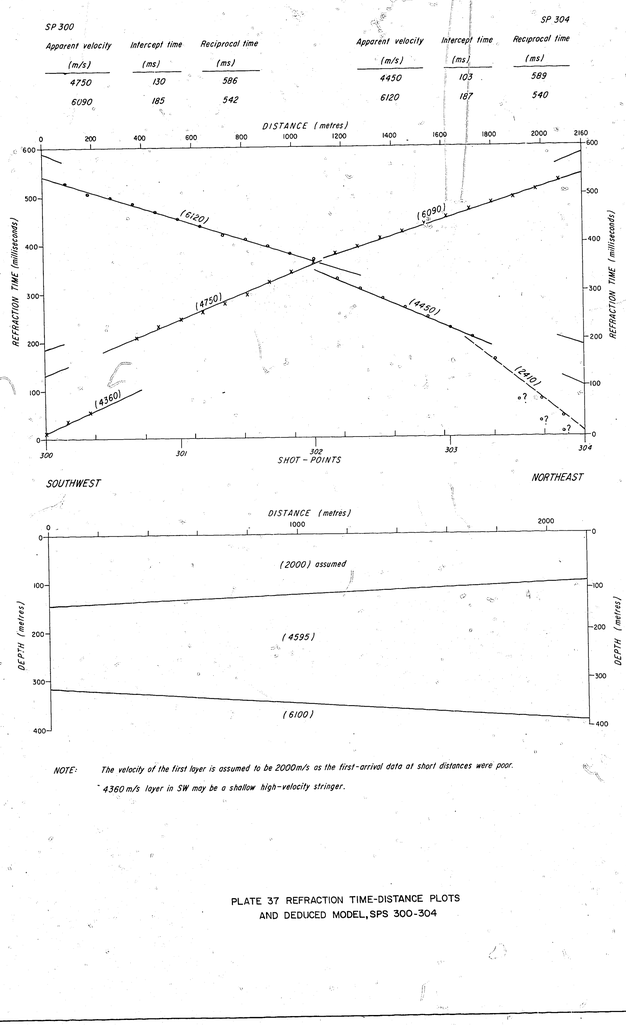
PLATE 34. EVENTS FROM REFLECTION SECTIONS (UNMIGRATED)

PLATE 35 REFRACTION TIME-DISTANCE PLOTS AND DEDUCED MODEL, SPS 551-612

G51/B3-77 R

PLATE 36 REFRACTION TIME-DISTANCE PLOTS AND DEDUCED MODEL, SPS 332-375

G51/B3-78R



NOTE: The velocity of the first layer is assumed to be 2000m/s as the first-arrival data at short distances were poor.
4360 m/s layer in SW may be a shallow high-velocity stringer.

PLATE 37 REFRACTION TIME-DISTANCE PLOTS AND DEDUCED MODEL, SPS 300-304

G51/83-79R

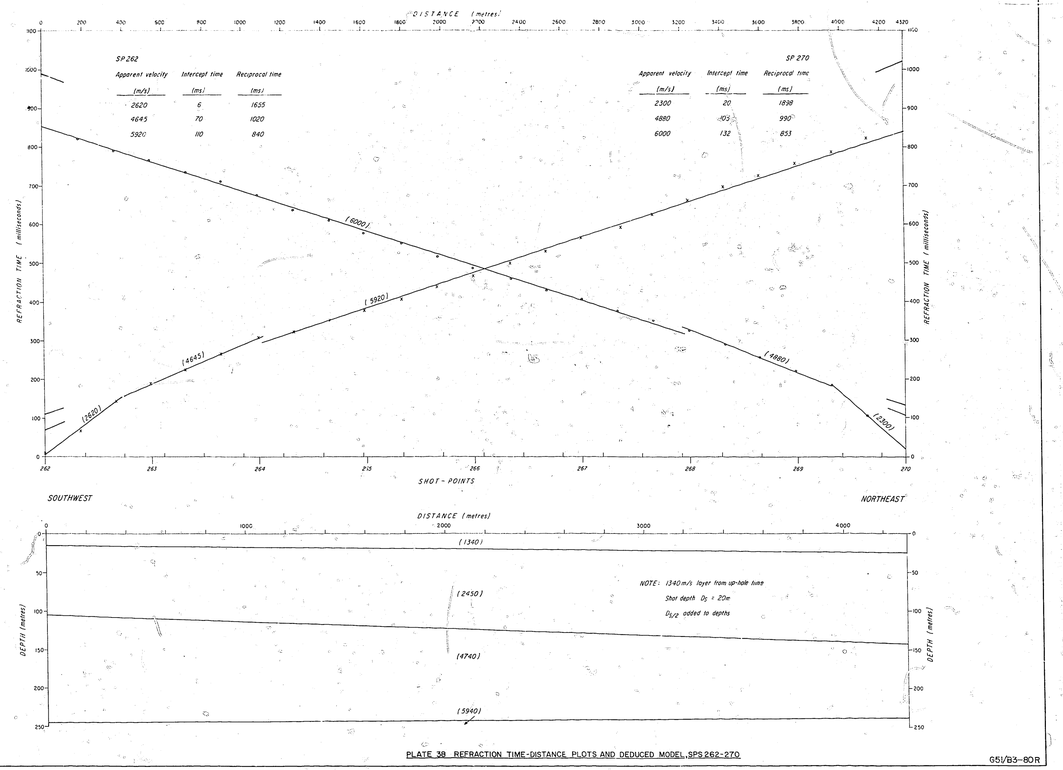


PLATE 38 REFRACTION TIME-DISTANCE PLOTS AND DEDUCED MODEL, SPS 262-270

G51/83-80R

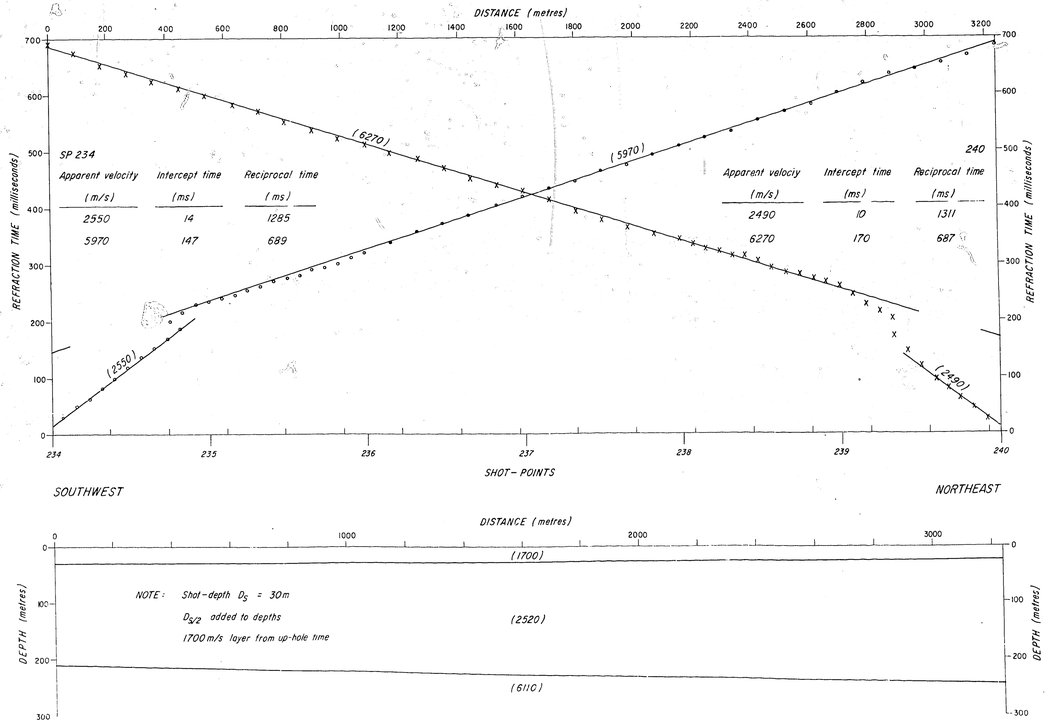


PLATE 39 REFRACTION TIME-DISTANCE PLOTS AND DEDUCED MODEL, SPS 234-240

G51/83-81R

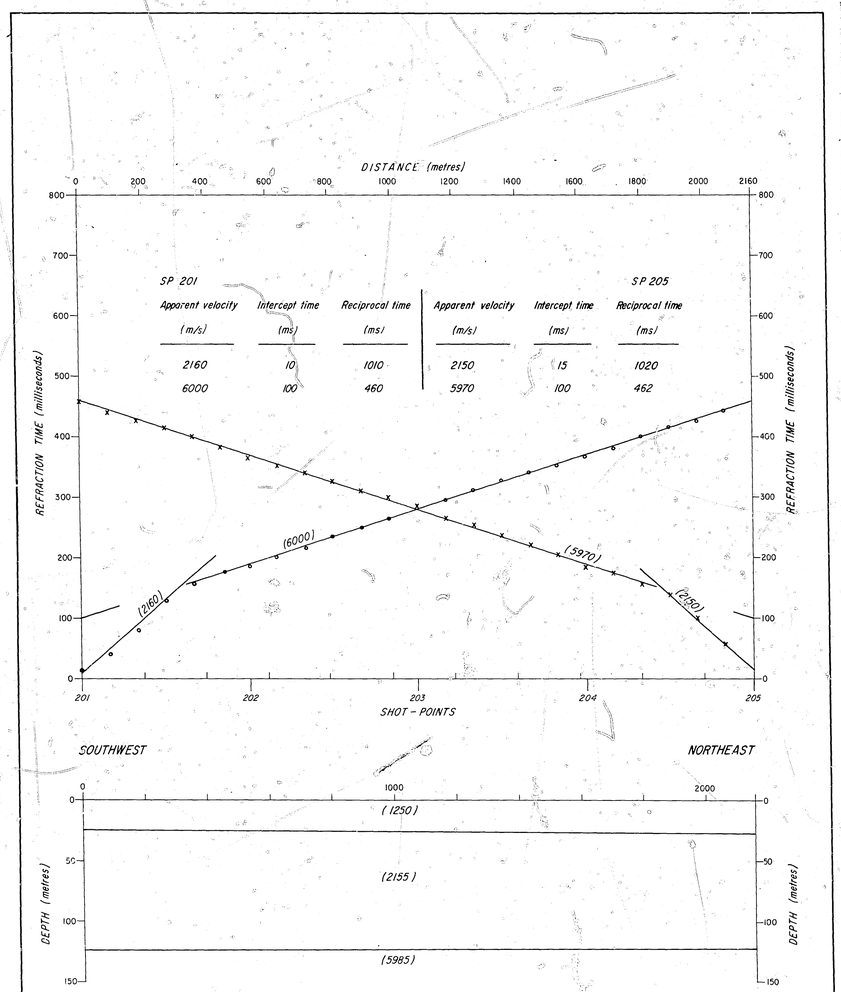


PLATE 40 REFRACTION TIME-DISTANCE PLOTS
AND DEDUCED MODEL, SPS 201-205

G51/B3-82R

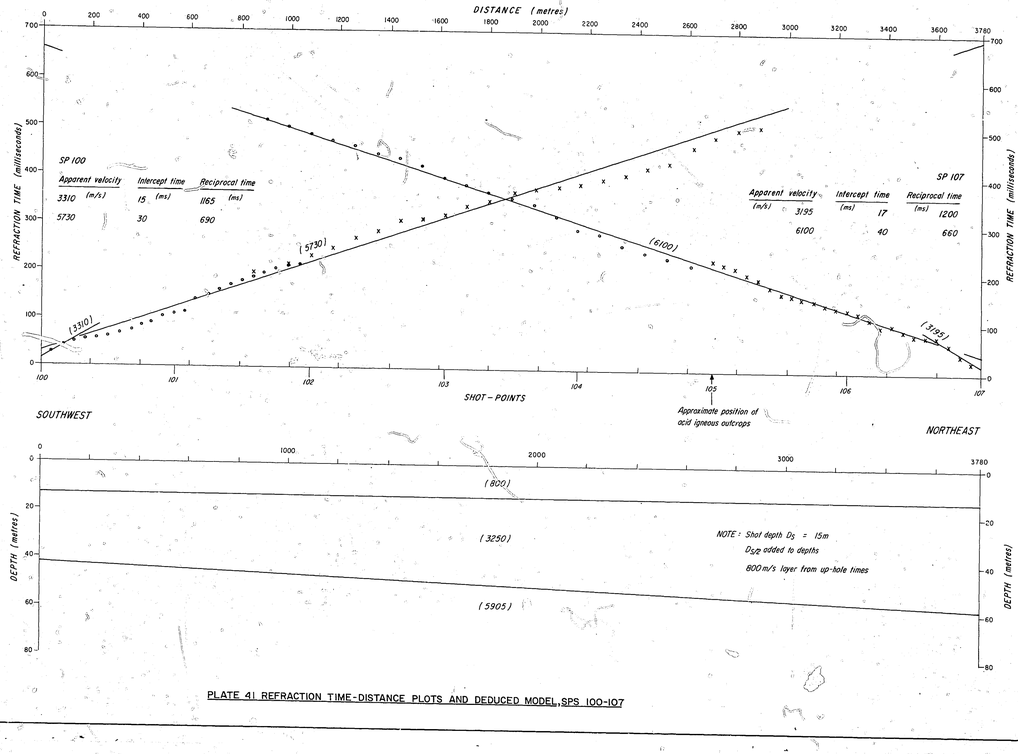


PLATE 41 REFRACTION TIME-DISTANCE PLOTS AND DEDUCED MODEL, SPS 100-107

G51/D3-83R

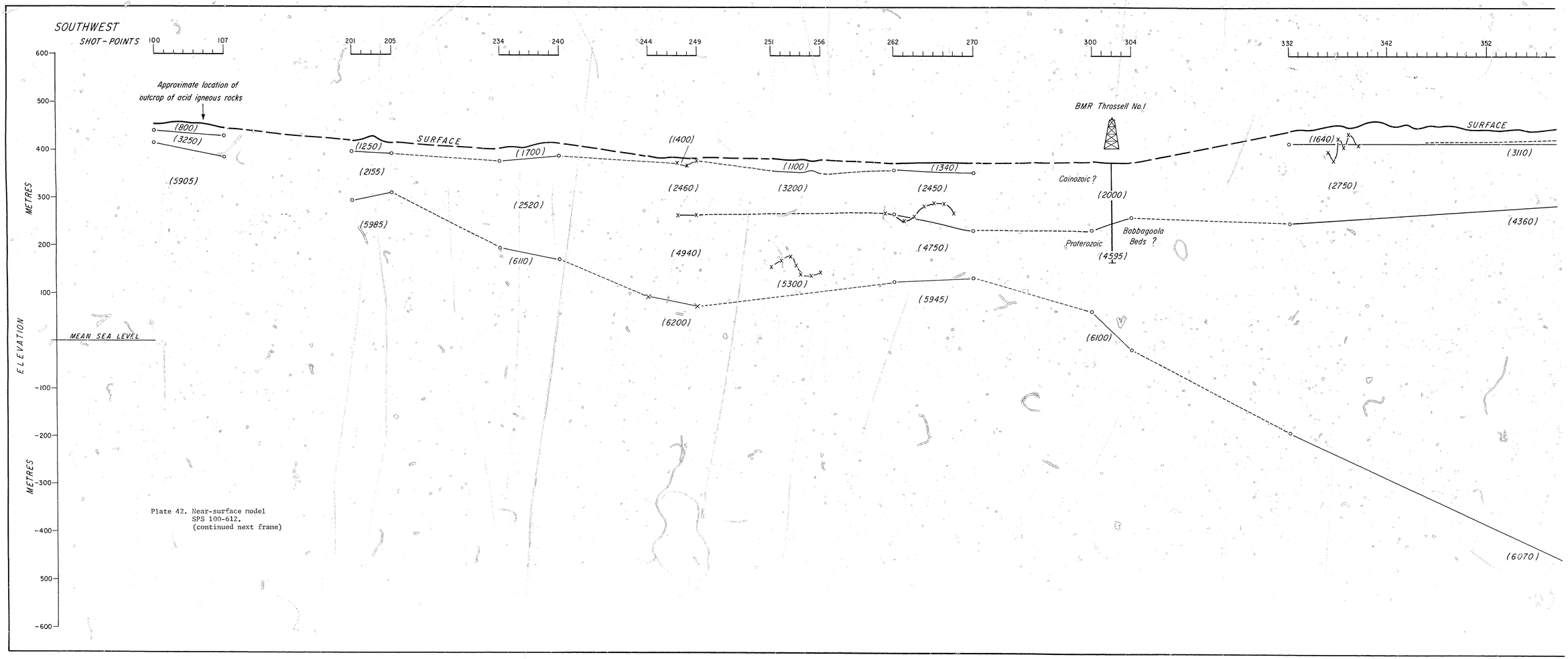


Plate 42. Near-surface model SPS 100-612.
(continued next frame)

NORTHEAST

SHOT-POINTS

362 372 382 392 399 550 560 570 580 590 600 612

BMR Westwood No.2

BMR Westwood No.1

(1470) 1430 2325 3350 (4500) Dolomitic layer

Babbagoola Beds Proterozoic

Cambro-Ordovician

(2000) (4490) Lower Cambrian

(5690) 1340 (5400) Base of basalt

SURFACE

(1300)

530 920 1430 Lower Permian (2600)

(2690–3370)

(5430)

Depth 1285m below surface at SP 612

? ? ? ? (4145)

MEAN SEA LEVEL

600 500 400 300 200 100 0 -100 -200 -300 -400 -500 -600

METRES

ELEVATION

TRAVERSE SCALE

5 0 5 10 KILOMETRES

5400 0 5400 10 800 METRES

(4500) Refractor velocity (metres/second)

1430 Velocity from up-hole shoot (metres/second)

o Point from refraction probe

S Point from special weathering shot

X Point from reflection first-breaks

---------- Interpreted correlation of refractor between recorded traverses

Paterson Formation

Lennis Sandstone

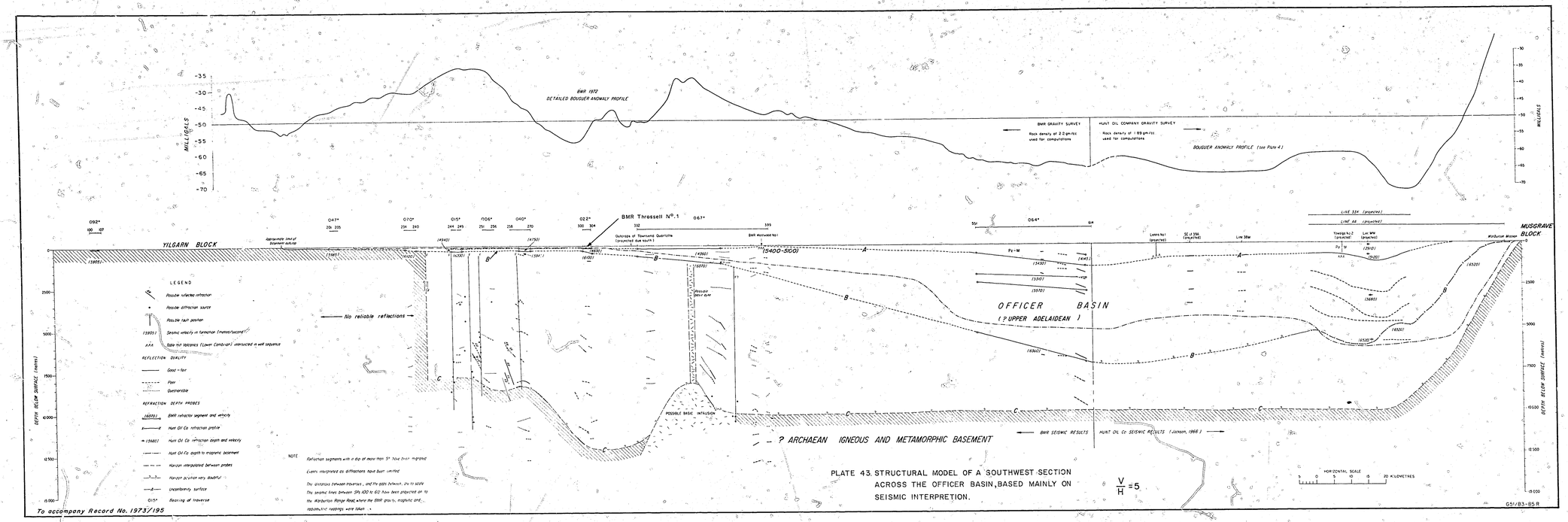
Table Hill Volcanics

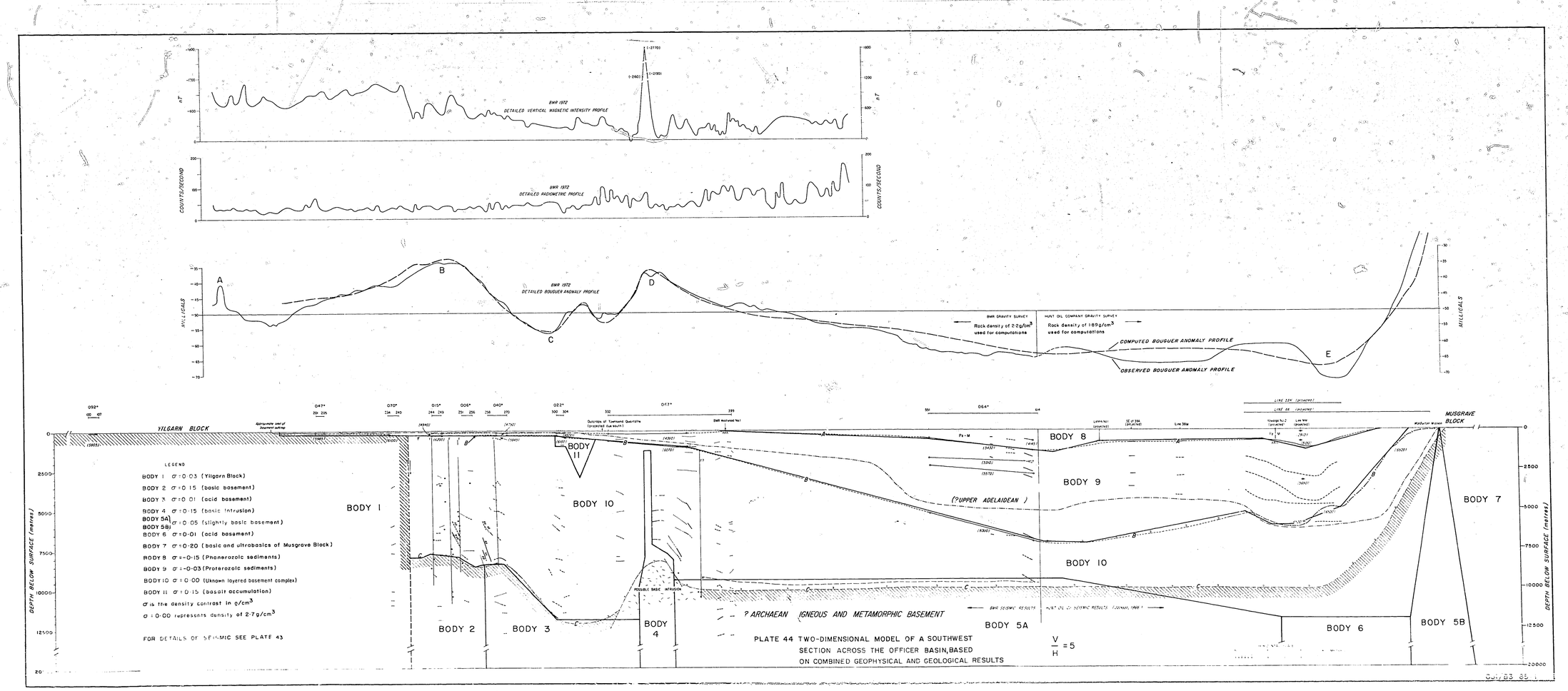
Horizontal scale is correct only on traverse lines. Distance between spreads is not to scale

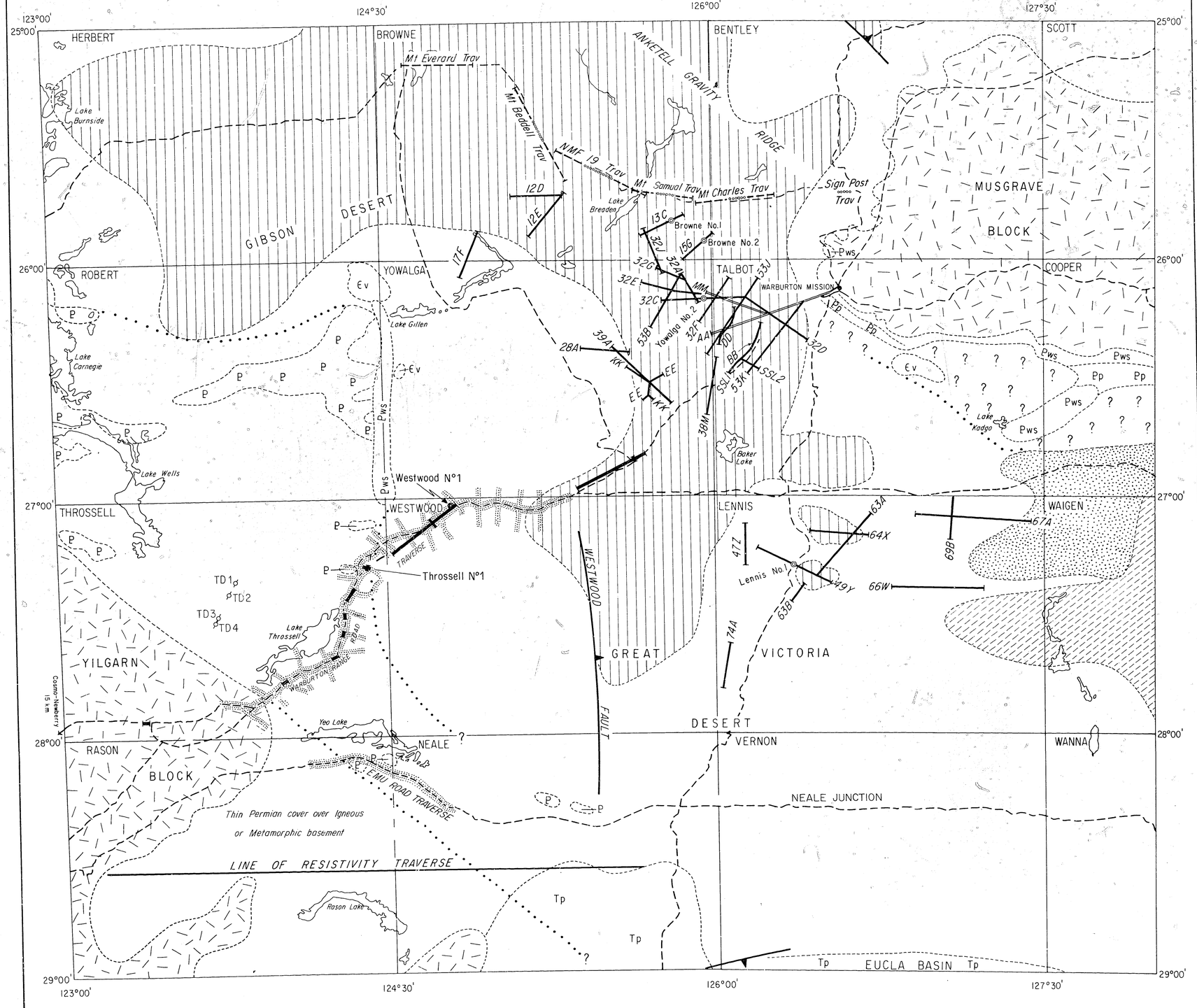
Geology from stratigraphic wells and deep shot-holes. (Jackson, Van De Graaff & Boegli, in prep.)

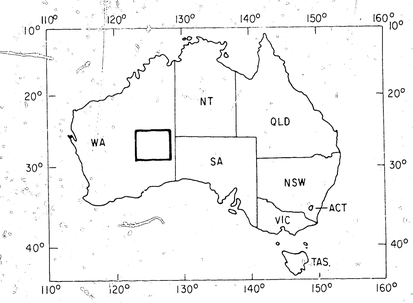
PLATE 42 NEAR-SURFACE MODEL, SPS100-612

G51/B3-84


BMR 1972
DETAILED BOUGUER ANOMALY PROFILE
MILLIGALS
BMR GRAVITY SURVEY
Rock density of 2.2 gm/cc used for computations
HUNT OIL COMPANY GRAVITY SURVEY
Rock density of 1.89 gm/cc used for computations
BOUGUER ANOMALY PROFILE (see Plate 42)
BMR Throssell No.1
YILGARN BLOCK
MUSGRAVE BLOCK
OFFICER BASIN
(? UPPER ADELAIDEAN)
No reliable reflections
POSSIBLE BASIC INTRUSION
? ARCHAEAN IGNEOUS AND METAMORPHIC BASEMENT
BMR SEISMIC RESULTS
HUNT OIL Co SEISMIC RESULTS (Jackson, 1966)
DEPTH BELOW SURFACE (metres)
HORIZONTAL SCALE
0 5 10 15 20 KILOMETRES
LEGEND
Possible reflective refraction
Possible diffraction source
Possible fault position
Seismic velocity in formation (metres/second)
Gabbro and Volcanics (Lower Cambrian) intersected in well sequence
REFLECTION QUALITY
Good - fair
Poor
Questionable
REFRACTION DEPTH PROBES
BMR refraction segment and velocity
Hunt Oil Co refraction profile
Hunt Oil Co refraction depth and velocity
Hunt Oil Co depth to magnetic basement
Horizon interpolated between probes
Horizon position very doubtful
Unconformity surface
Bearing of traverse
NOTE
Reflection segments with a dip of more than 5° have been migrated.
Events interpreted as diffractions have been omitted.
The divisions between traverses, and the gaps between, are to scale.
The seismic lines between SP's 400 to 610 have been projected on to the Warburton Range Road, where the BMR gravity, magnetic and radiometric readings were taken.
PLATE 43 STRUCTURAL MODEL OF A SOUTHWEST SECTION ACROSS THE OFFICER BASIN, BASED MAINLY ON SEISMIC INTERPRETION.
V/H = 5
To accompany Record No. 1973/195
G51/83-85 R


BMR 1972
DETAILED VERTICAL MAGNETIC INTENSITY PROFILE
nT
BMR 1972
DETAILED RADIOMETRIC PROFILE
COUNTS/SECOND
BMR 1972
DETAILED BOUGUER ANOMALY PROFILE
MILLIGALS
COMPUTED BOUGUER ANOMALY PROFILE
OBSERVED BOUGUER ANOMALY PROFILE
BMR GRAVITY SURVEY
Rock density of 2.2 g/cm³ used for computations
HUNT OIL COMPANY GRAVITY SURVEY
Rock density of 1.89 g/cm³ used for computations
BMR Throssell No.1
YILGARN BLOCK
MUSGRAVE BLOCK
(? UPPER ADELAIDEAN)
? ARCHAEAN IGNEOUS AND METAMORPHIC BASEMENT
BMR SEISMIC RESULTS
HUNT OIL Co SEISMIC RESULTS (Jackson, 1966)
DEPTH BELOW SURFACE (metres)
LEGEND
BODY 1 σ = 0·03 (Yilgarn Block)
BODY 2 σ = 0·15 (basic basement)
BODY 3 σ = 0·01 (acid basement)
BODY 4 σ = 0·15 (basic intrusion)
BODY 5A σ = 0·05 (slightly basic basement)
BODY 5B
BODY 6 σ = 0·01 (acid basement)
BODY 7 σ = 0·20 (basic and ultrabasics of Musgrave Block)
BODY 8 σ = 0·15 (Phanerozoic sediments)
BODY 9 σ = -0·03 (Proterozoic sediments)
BODY 10 σ = 0·00 (Unknown layered basement complex)
BODY 11 σ = 0·15 (basalt accumulation)
σ is the density contrast in g/cm³
σ = 0·00 represents density of 2·7 g/cm³
FOR DETAILS OF SEISMIC SEE PLATE 43
PLATE 44 TWO-DIMENSIONAL MODEL OF A SOUTHWEST SECTION ACROSS THE OFFICER BASIN, BASED ON COMBINED GEOPHYSICAL AND GEOLOGICAL RESULTS
V/H = 5
G51/83-85 I





LEGEND

Tp	Plumridge Beds	MIOCENE
	Bejah Claystone and Samuel Formation	CRETACEOUS
	Paterson Formation	PERMIAN
	Wanna Beds	CAMBRIAN
	Lennis Sandstone	CAMBRIAN
Ev	Table Hill Volcanics	CAMBRIAN
P	Undivided	PROTEROZOIC
Pws	Townsend Quartzite Robert Beds (in west)	PROTEROZOIC
Pp	Lupton Beds and Lefroy Beds	PROTEROZOIC
?	Geology uncertain	PROTEROZOIC
	Igneous or metamorphic rocks	PRECAMBRIAN

- Geological boundary (position approximate)
- Inferred subsurface continuation of boundary
- Fault
- Well (dry)
- BHP Stratigraphic holes, 1978
- Road or track
- RASON 1:250 000 Sheet area
- BMR refraction line 1961-62
- BMR reflection line 1961-62
- Hunt Oil refraction line
- Hunt Oil reflection line
- BMR seismic line 1972
- BMR detailed gravity, magnetic and radiometric traverse, 1972

Source of geological information: Lowry et al., 1972
M.J. Jackson, 1973 (pers. comm.)

KILOMETRES
10 0 50 100

PLATE 45 SURFACE GEOLOGY AND LOCATION MAP.

(BASED ON G51/80-26)

G51/83-47