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EAST OTWAY BASIN SEISMIC SURVEY
VICTORIA
1967

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SUMMARY

A reconnaissance seismic reflection and refraction survey in the East Otway Basin, Victoria, was carried out by the Bureau of Mineral Resources from mid-February to mid-June 1967. The objective of the survey was to determine whether the gravity low areas of the Torquay Embayment and Port Phillip Sub-Basin in the eastern part of the Otway Basin contain thick Cretaceous sediments like those which had shown potential hydrocarbon source and reservoir characteristics in the western part of the Otway Basin.

Nine reflection and five refraction traverses were recorded in the gravity low areas of the Barwon Trough and Port Phillip Sub-basin. Single-coverage reflection results of variable quality were obtained. Evidence for the presence of Tertiary section is provided by shallow reflections of good to fair quality, but the evidence for Cretaceous sediments is tenuous because of the poor quality of the deeper reflections, some of which may be multiples. The presence of several faults, onlappings and pinch-outs is also indicated. The refraction results are considered unreliable because of the difficulty of interpreting the discontinuous profiles and because of the mapped and suspected faults and pinch-outs in the sections.

The seismic data suggest the presence of about 520 m of Tertiary and 1450 m of Cretaceous sediments near the gravity minimum in the Barwon Trough, about 370 m of Tertiary and 670 m of Cretaceous sediments in the southwestern flank, and about 1000 m of sedimentary section on the south-eastern flank of the Port Phillip Sub-basin gravity low.

Additional seismic reflection surveys using multiple coverage and digital processing techniques designed to improve signal-to-noise ratio are recommended to confirm the presence of Cretaceous sediments and map possible petroleum trap structures in the area.

1. INTRODUCTION

The Bureau of Mineral Resources (BMR) carried out a seismic reflection and refraction survey in the eastern part of the Otway Basin, in Victoria, during the period February to June 1967.

The seismic survey was proposed after a review by BMR in 1966 of the existing geological and geophysical data in the Otway Basin in southeast South Australia and southwest Victoria (Reynolds, 1971). The review indicated that some areas of the basin - including the East Otway Basin, consisting of the Torquay Embayment and Port Phillip Sub-basin - remained relatively unexplored for petroleum. It was suspected that in the eastern part of the basin, areas of gravity low contain thick Cretaceous sediments like those present in most of the wells drilled in other parts of the basin, mainly in the west, which had potential hydrocarbon source and reservoir characteristics though not commercial quantities of hydrocarbons. The seismic reflection and refraction program in the East Otway Basin was made to investigate the thickness and structure of the sedimentary basin and in particular to investigate the possible occurrence of Upper Cretaceous sediments.

Since the BMR survey in 1967, two geophysical surveys have been made in the landward area of the East Otway Basin: an aeromagnetic survey (Shell, 1970) to investigate the structure and depth of the basement, and the Paraparap seismic survey (Pursuit, 1972) to investigate the thickness and structure of the basal Cretaceous sandstone. The results of the BMR survey have been interpreted here in the light of this more recent information.

The survey area was a closely settled rural area where seismic traverses were located mainly along roads and across farming properties. Survey progress was hampered by access problems, shot-point restoration work, and inclement weather in the latter part of the survey. Details of survey staff, equipment, and operational statistics are given in Appendixes 1 and 2.

2. GEOLOGY

The area under review forms the eastern part of the Otway Basin, which is a Mesozoic-Cainozoic sedimentary and volcanic accumulation extending for some 480 km between Lacepede Bay in eastern South Australia and Mornington Peninsula on the eastern side of the Port Phillip Bay in Victoria (Plate 1). The basin is bounded on the northwest by the Padthaway Horst, a Palaeozoic basement ridge, and on the east by the Selwyn Fault which separates it from the basement outcrops in Mornington Peninsula. The northern limit of the basin is mostly obscured by basalt plains and recent deposits, and is assumed to be a line through Hamilton and Geelong following a discontinuous zone of steep gravity gradients (Richards, 1963). The landward boundary on the south is the coastline of southeast South Australia and southwest Victoria, but there are indications from marine geophysical surveys that the basin extends well south of the 100 fathom (200 m) line on the continental shelf (Reynolds, 1971).

The structural and geological history of the basin west of the Otway Ranges has been discussed in detail by McQueen (1961), Leslie (1966), White (1968), Reynolds (1967, 1971) and Wopfner & Douglas (1971) and that of the Torquay Embayment, east of the Otway Ranges, by Stach (1961) and Pursuit (1972). A brief summary of the above studies follows.

Sedimentation in the basin as a whole commenced during the Upper Jurassic or Lower Cretaceous within an east-west zone lying transverse to the trends of the older Palaeozoic Tasman Geosyncline. After the deposition of the Lower Cretaceous Otway Group the basin was divided by differential uplift, accompanied by faulting, into a series of sub-basins, embayments, and structurally high ridges (Plate 1), which are, from west to east: Penola Trough/Gambier Sub-basin, Dartmoor Ridge/Casterton Uplift, Tyrendarra Embayment, Warrnambool High, Port Campbell Embayment, Otway Ranges Uplift, Torquay Embayment, Bellarine High, and Port Phillip Sub-basin. Sedimentation was probably continuous throughout Cretaceous and Tertiary times in the deeper parts of the basin, where a sedimentary section of some 6000 to 7500 m is preserved, while in the other parts it was interrupted and controlled by structural movements giving rise to marked variation in local stratigraphy. The sub-basins and embayments thus contain thick sections of Cretaceous and Tertiary sediments whereas in the structurally high areas Cretaceous rocks are exposed or are covered by only thin Tertiary sediments.

In the eastern part of the basin, the Torquay Embayment is covered, for the most part, by thin superficial deposits of Pliocene and younger fluviatile sand and clay, and by basalt flows of Pliocene age. The older Tertiary formations are, however, well exposed in coastal cliffs and parts of stream valleys. The deeper subsurface geology is known mostly from the few shallow shafts, bores, and exploratory wells, and a generalized stratigraphic sequence in the area based on this information is shown along with some borehole data in Plate 2. From the well data and the seismic survey by Oil Development N.L. in 1960, Stach (1961) constructed a generalized Jurassic surface map (Plate 3), on the basis of which he divided the Torquay Embayment area into three subsurface features: the Anglesea Trough, the Torquay Horst, and the Barwon Trough. These features have been suggested to be the result of block faulting, initiated during or after a period of emergence in post-Jurassic Mesozoic times with movements continuing at intervals along the fault lines during Tertiary times. Most of the Port Phillip Sub-basin is covered by Port Phillip Bay, and only a part extends onshore, in Mornington Peninsula, where it is covered by Quaternary coastal deposits.

The major lineaments in the East Otway Basin are the Selwyn Fault and other suspected faults which bound the series of horsts and troughs. The dominant trend of these lineaments is northeast, yet important but less pronounced trends are also seen normal to this direction. Other subsurface structural features of the basin are limited close folding associated with faults, and broad fold structures and flexures reflecting the accommodation of younger sediments to fault movements at depth or draping over pre-existing structural highs.

The stratigraphic columns in Plate 2 indicate that the subsurface stratigraphy in the Torquay Embayment area consists predominantly of Cretaceous sediments in the southwestern part and of Tertiary sediments in the north and northeast. The Lower Cretaceous seems to be missing from the Torquay Horst and Bellarine High areas, where the thin veneer of Tertiary sediments directly overlies the Jurassic (unit T) sediments. In the Anglesea Trough area the Otway Group (Lower Cretaceous) consists mainly of lacustrine sandstone, siltstone, and shales. The group is estimated to be more than 3000 m thick although no wells in the area have penetrated through these sediments. Late Upper Cretaceous sedimentation in this area is represented by the Eastern View Coal Measures, a continental coal-bearing sequence the deposition of which continued through to the Paleocene. The Tertiary marine deposits consist mainly of the Boonah Sandstone and Demon's Bluff Formation (sandstone and siltstone) and range in thickness from 0 to 750 m in the southern part of the area. All the Tertiary formations in the East Otway Basin are exposed at the surface and are covered in the northern part by an extensive Quaternary lava flow of varying thickness (max. 34 m).

The downthrow along the bounding fault is believed to be much greater in the Anglesea Trough than on the northeastern side of the Torquay Horst, because at least 600 m of Tertiary sediments older than those represented in the northeast are known from surface exposures and wells drilled in the Anglesea Trough. Earlier seismic surveys in the area support this observation (Stach, 1961).

No stratigraphic information is available in the Port Phillip Sub-basin as most of it is covered by water and no bores have been drilled in the area.

In the Otway Basin as a whole, hydrocarbon shows have been reported from within the Otway Group of sediments in the several wells drilled, but no commercial quantities of petroleum have so far been found. Certain sections of the Otway Group, especially the Pretty Hills Sandstone/Geltwood Beach Formation, show good reservoir characteristics. However, the wells drilled in the Torquay Embayment area have not penetrated through the Eumeralla Formation and discovered the presence of the Pretty Hills Sandstone/ Geltwood Beach Formation. The traps in these horizons are expected to be formed by faulting and folding as well as pinch-outs against structurally high areas. The Tertiary sediments, on the other hand, have shown no presence of hydrocarbons in the East Otway Basin.

It is therefore considered necessary to investigate the thickness and structure of the Cretaceous sediments and the possible presence of basal sandstones in the Otway Group in order to assess the petroleum potential of the basin.

3. OTHER GEOPHYSICAL WORK

Prior to the survey reported here, magnetic and seismic surveys in the landward areas of the Otway Basin had been restricted because of the widespread near-surface basaltic cover, which generally confused the magnetic interpretation and increased the seismic surface noise and limited deep penetration of seismic energy. However, experimental seismic surveys by BMR between 1956 and 1965 had shown that good reflections could be obtained in volcanic covered areas of the Otway Basin by using large charges of explosives and multiple shot and geophone patterns (Lodwick & Vale, 1958; Rait, 1966; Schwing & Moss, in prep.) and by using 'Vibroseis', long in-line source and detector patterns, and multiple compositing (SSL, 1965). Recent exploratory seismic surveys in the basin using explosives (Pursuit, 1972), 'Thumper' (Shell, 1972a), and 'Vibroseis' (Shell, 1972b) and multiple-coverage techniques have supported these findings.

In the land areas of the East Otway Basin prior to the BMR survey in 1967 there was good gravity coverage but no magnetic and only one seismic survey had been made. Since then aeromagnetic coverage of most of the Otway Basin, including the eastern part, and another land seismic survey in the Torquay Embayment have been made. The area covered by these surveys is shown in Plate 4, and the main findings are discussed below.

Aeromagnetic

Aeromagnetic coverage of most of the landward area of the Otway Basin, including the Otway Ranges, Torquay Embayment, and parts of Port Phillip Bay, has been obtained for Shell (1970). The resulting magnetic basement contour map (Plate 5) shows:

- an extended and relatively wide low zone, depths 2.5-3.5 km, under the Otway Ranges. It seems to continue eastwards as a narrow elongate low zone into Port Phillip Bay.
- sharp rising of the magnetic basement to 1.0 km depth south of the Anglesea coastline and to surface in the vicinity of the Selwyn Fault.

On the basis of geological evidence and Bouguer anomalies (Plate 6) the magnetic basement seems to conform to the Palaeozoic basement (base of the sediments) along the northern margin of the basin, in the Port Phillip Bay and Selwyn Fault areas. But it shows a wide low in the Otway Ranges area, where the Bouguer anomalies show a high. This may mean that the magnetic and Palaeozoic basements are different or that the interpretation of magnetic data is questionable in the Otway Ranges area.

In the offshore extension of Torquay Embayment, aeromagnetic coverage was obtained by Haematite (1965a). The magnetic anomalies in this area show:

- a confused pattern east of the projected eastern margin i.e. Selwyn Fault, reflecting shallow basement,
- sharp elongate features striking north to northeast along the Torquay coast indicating near-surface basalt or ferruginous sand and faulting along the coast, and
- a broad low southeast of Torquay indicating a small basin filled with about 1500 m of sediments.

Gravity

The Bouguer anomaly map of the East Otway Basin, reproduced in Plate 6, is based on the data from BMR (Gunson & Williams, 1965) and Frome-Broken Hill Pty Ltd (Richards, 1963) surveys. The anomalies show general correlation with subsurface geologic structural features interpreted from the bore-hole and surface data. The pattern is dominated by a west to east series of highs and lows elongated northeast parallel to the Selwyn Fault, the major structural lineament in the area. The eastern edge of the basin is sharply defined by a steep gravity gradient (5 mGal/km) along the Selwyn Fault separating the area of low gravity in Port Phillip Bay from that of high gravity (max. +20 mGal) over the basement outcrops in Mornington Peninsula. The northern margin of the basin is, however, only roughly outlined by a discontinuous zone of generally positive anomalies along the northern part of the map. The elongate highs in the west and centre reflect the basement ridges (or horsts) of the Otway Ranges and Bellarine High respectively, whereas the gravity lows in between the highs outline the Barwon Trough and Port Phillip Sub-basin areas. There is very little indication of the Anglesea Trough and Torquay Horst in the gravity pattern. Gravity gradients of 3 mGal/km and steeper on either side of the Bellarine High indicate the presence of northeast-trending faults which separate it from the Barwon Trough on the west and the Port Phillip Sub-basin on the east.

It is estimated from the excess of about 18 mGal of the gravity anomalies in the Bellarine High over those in the Barwon Trough on the west and in the Port Phillip Sub-basin on the east that the sediments in the trough and sub-basin areas are about 2000 m thicker than those in the Bellarine Peninsula, assuming a density contrast of 0.2 between the sediments and the basement.

The overall pattern of the gravity anomalies in the East Otway Basin is devoid of any marked coastward regional gradient typical of coastal areas and attributable to the thinning of the sialic crust towards the oceans. The lack of a steep gradient is probably due to the masking effect of the sediments in the basin area (Wiebenga, 1957) and to the position of the continental margin being south of King Island rather than close to the Torquay coastline (Cameron & Pinchin, 1974).

Seismic

The Torquay seismic survey was made by Oil Development N.L. in 1960 in the onshore areas of the Torquay Embayment between Anglesea and Torquay (Plate 4). The results, which have been discussed by Stach (1961), indicate the presence of more than 600 m of post-Jurassic sediments in the Anglesea Trough. Across the Torquay Horst and Barwon Trough, the deepest-reflection corresponds closely in depth to the top of the Jurassic as determined by bores located close to some traverses. However, to the southeast of a proposed fault between the Torquay Horst and Anglesea Trough, a sequence of much deeper reflections becomes sharply evident in the seismic sections. In the vicinity of Anglesea the series of deeper reflections extends down to about 1500 m below sea level. In the area north and northeast of Anglesea, the deeper reflections show an upward rise at an angle of several degrees towards the NNE and a consequent wedging of the overlying section in this direction. As no reflections from horizons deeper than the top of Jurassic could be o obtained in the area of the Torquay Horst and Barwon Trough, deeper reflections in the Anglesea Trough were believed to have originated from Lower Cretaceous sediments between the Jurassic basement floor and the Eastern View Coal Measures. Since then, an exploratory oil well, Anglesea

No. 1, drilled by O.D.N.L. (Dellenbach, 1965) had detected about 2500 m of Lower Cretaceous sediments below the Coal Measures.

Haematite (1965b) carried out a seismic survey using single as well as 3-fold CDP coverage on the offshore area of the Otway Basin between Cape Grim and Cape Jaffa. Three reflecting horizons could be mapped over most of the area: 1) near the top of the basement, 2) at the base of Tertiary, and 3) within Lower Tertiary. The results in the offshore area of the Torquay Embayment indicate that the Tertiary sequence is about 2100 m thick, with the maximum accumulation about 30 km offshore from Anglesea. The northwest flank of the embayment is marked by two strike faults which were probably active during the Tertiary. This assumption is supported by the fact that, downdip from the east fault, the older beds show accentuated dip and the succeeding younger beds thicken appreciably. Displacements along these faults range up to 600 m. Several low relief features with structural closure are also indicated in the area. The basement contour map indicates the presence of an additional 1800 m of Mesozoic sediments, but the general configuration of the basement appears similar to that of the Tertiary horizon. The folding is more accentuated with depth and the faulting has a larger displacement at the lower horizons. The results thus indicate that the Torquay Embayment, though lacking in features with sufficient structural closure, offers good prospects for oil accumulation by means of stratigraphic traps.

A seismic survey using multiple coverage was made for Shell (1966) in the offshore area of the Otway Basin which included the offshore parts of the Torquay Embayment and the Port Phillip Sub-basin. Two horizons, A and B, were mapped in most of the area. Horizon A can be correlated in the western part of the basin with a calcareous unit at the base of the Heytesbury Group (Oligocene section) in onshore wells. In some areas, it onlaps onto a strong underlying reflection that is considered to represent the top of the Wangerrip Group (Paleocene-Eocene). Horizon B was an attempt to map a surface of major unconformity at the base of the Tertiary. These horizons indicate the general structure of the Tertiary section. The lack of reflections below the Tertiary may imply a uniform lithologic section but is in contrast to their presence in the Cretaceous section recorded in the onshore areas of the Torquay Embayment (Stach, 1961). There is no evidence for or against the presence of Upper Cretaceous sediments in the offshore area.

Additional seismic studies were made by Shell (1967) to define in detail the prospective areas indicated by the earlier survey in 1966. They consisted of refraction as well as reflection surveying and reprocessing of the earlier data. The results of the velocity profiles in the offshore areas of the Torquay Embayment indicate that a 550-900 m thick layer of velocity

1675-2130 m/s overlies a layer of higher velocity, 3350-3650 m/s. The velocity of the lower layer increases with depth and attains a value of 4580-4880 m/s at about 1500 m, which has been estimated to be the depth of the magnetic basement in this general area. However, a velocity profile shot in an area of shallow basement recorded a velocity of only 3950 m/s at a depth of 460 m. Good reflections were seen at times less than 1.0 s. Horizon A in this area is believed to represent the base of the Heytesbury Group (base of Oligocene) which is absent in Anglesea No. 1 Well. The deeper horizon, B, is conformable with A, correlates with a level about 300 m above the postulated top of the Otway Group in the Anglesea No. 1 Well, and probably originates from within the Eastern View Coal Measures. This horizon also appears to correlate with the base of the low-velocity refraction layer. A still deeper phantom horizon, T, based on poor-quality reflections, has also been mapped in the Torquay Embayment area. It appears to rise gradually towards the north, where it is finally truncated by Horizon B. As the offshore area is separated from the Anglesea No. 1 Well by a major fault parallel to the coastline near Torquay and is affected by pronounced wedging of deeper sediments, the above stratigraphic correlations of the reflectors and refractors in the Torquay Embayment area are not considered reliable.

A land seismic survey using multiple-pattern and multiple-coverage techniques was carried out for Pursuit (1972) to determine the structure and thickness of the basal Cretaceous sandstone in an area about 30 km southwest of Geelong and adjacent to the BMR survey. Four horizons - A, B, D, and E - were mapped. Horizons A and B, which are of poor quality, have been related to a coal/sand sequence and to another density change within the Eumeralla Formation (Otway Group) at the Hindhaugh Creek No. 1 Well. Horizons D and E are the top and bottom of the deepest band of primary events of generally good quality which are mappable all over the area surveyed and are considered similar in appearance to the events originating from the basal Cretaceous sandstone section farther west in the basin. If projected northwards with the dip shown in the seismic sections, these events would emerge approximately near the basement outcrop. Therefore, this band of energy is considered to be from the Pretty Hills Sandstone/Geltwood Beach Formation. A rapid loss of these events northwards indicates a wedging-out of the Pretty Hills Sandstone/Geltwood Beach Formation or a facies change, possibly to the conglomerate seen immediately overlying basement in outcrop. The D and E horizon maps indicate that the basal Cretaceous sandstones occur in the area at depths between 1300 and 3400 m and range in thickness between 200 and 450 m.

In summary, the geophysical surveys prior to the BMR survey defined the areas of gravity lows in the Barwon Trough and the Port Phillip Sub-basin which may contain thick Cretaceous sediments like those that had shown potential source and reservoir characteristics in the western part of the Otway Basin, and suggested that seismic methods could provide information about such sediments in these areas.

4. OBJECTIVES AND PROGRAM

OBJECTIVES

The main objective of the seismic survey was to investigate the structure and thickness of sediments, particularly Cretaceous, in the gravity low areas of the East Otway Basin, and the relationship of sediments in terms of their velocities and thicknesses between the low (graben) and high (horst) areas.

Specifically, the following areas were proposed to be investigated:

- Barwon Trough
- Bellarine High
- Port Phillip Sub-basin
- Anglesea Trough
- Colac Trough, northwest of Otway Ranges

PROGRAM

The following work, consisting of continuous reflection and refraction profiling along the traverses shown in Plate 4, was carried out:

Barwon Trough area

- Traverse A, consisting of reflection between SP100-120 and refraction between SP80A-124A. This E-W traverse was made to investigate the main part of the gravity low area and the transition from the low to the Bellarine High area across the Leopold Fault.
- Traverse C, consisting of reflection between SP292½-307½. This N-S traverse was made to investigate the low area west of the Leopold Fault.
- Traverse D, consisting of refraction between SP1500-1511. This N-S traverse was made to investigate the high area east of the Leopold Fault.

- Traverse B, consisting of reflection between SP512-521. This E-W traverse was made to investigate the northern extension of the gravity low area.

Port Phillip Sub-Basin area

- Traverse S, consisting of reflection between SP782-801½. This approximately E-W traverse was made to investigate the transition between the Port Phillip Sub-basin and the Bellarine High areas.
- Traverse Q, consisting of reflection between SP600½-701½. This NE-SW traverse was made to investigate the southwestern flank of the Port Phillip Sub-basin area.
- Traverses U, V and X, consisting of reflection between SP998-1000, SP1196½-1200 and SP1299½ respectively. These short traverses were made to investigate the southern and southwestern margins of the Port Phillip Sub-basin area.
- Traverse W, consisting of refraction between SP1999-2004. This N-S traverse was made to measure the velocity of volcanic rocks in the Mornington Peninsula near the Selwyn Fault.

Anglesea Trough-Barwon Trough coastal area

- Traverse R, consisting of reflection between SP3098-3101½ and refraction between SP3074-3134. This NE-SW traverse was made to investigate the relationship of sediments between the Barwon Trough and Anglesea Trough areas.

Because of time limitation the Colac Trough area was not surveyed.

5. FIELD WORK AND RESULTS

FIELD WORK

As most of the survey area was closely settled seismic traverses were near roads, farms, and private dwellings. Because of access and shooting difficulties in the developed area, the traverses could not be completed as planned; some of them had to be disconnected, some shortened in length, and some reoriented. The field techniques used had to be modified accordingly.

Experimental tests

In order to determine the optimum parameters for reflection recording, a noise test was carried out at SP109 on Traverse A. On the noise spread record in Plate 7, three kinds of events have been identified: S, the reflection signals; R, the refractions; and N, the unwanted noise. The f-k diagram, shown in the lower part of the Plate 7, suggested that a frequency cut-off of 22 Hz and a wavenumber cut-off of 26 cycles per 1000 m could effectively filter out the noise. Therefore an electrical filter of 18 Hz and a spatial filter with a shot pattern of 5 holes 7.6 m apart, and a geophone pattern of 24 in 2 rows of 12 in line with rows 6.7 m apart, geophones 3 m apart, were generally used for reflection recording. Occasionally, shot patterns of 7 holes 6 m apart, or 9 holes 3.8 m apart, were used instead.

Reflection technique

Charge size was usually 2.3 kg per hole, but varied from 0.6 kg to 4.5 kg per hole depending on the proximity of the shot to buildings. The optimum shooting depths were determined from uphole tests. In the Bellarine Peninsula, where the weathered layer was about 12.2 m thick, the shots were fired at 18.3 m depth. Around Lake Connewarre and along the sea shore where the water table was only a few metres deep, the charges were placed at 3-5 m below the surface.

For continuous reflection profiling, mainly short spreads, 274 m long, were used in order to record the shallow reflections present in the area. Only single-coverage recordings were made.

Refraction technique

Refraction profiles were recorded on 2195-m spreads with geophone stations placed 91.5 m apart. At each station, four 4.5-Hz geophones were laid 6.7 m apart perpendicular to the traverse. Depending on the accessibility and shooting limitations along the traverse, the shots were fired either at fixed locations at the ends of the traverse and the spread moved in between (e.g. Traverses D and W), or at increasing offset from a fixed spread along the traverse (e.g. Traverses A and R).

Weathering corrections

Weathered layer information necessary to calculate the weathering corrections was obtained from shallow refraction probes at about 3-km intervals along the traverses. For this shallow refraction work, single geophones at 6-m spacing were generally used. But in the low-lying areas where the weathering layer was expected to be thin, geophones were placed at 3-m intervals close to the shot and at 9-m intervals at large distances from the shot.

Velocity information

An expanded spread centred at SP298 on Traverse C was recorded using 549-m spreads in an attempt to determine vertical velocities in the Barwon Trough area. The data recorded (see Plate 8) were of poor quality at offsets greater than 600 m possibly because of interference from the nearby Leopold Fault zone and the random noise and could not be used for a reliable $T^2:X^2$ determination of velocities. These data were, however, used along with other reflection data along Traverse C for a t:$\triangle$t analysis for determining moveout corrections and vertical velocities. The time-depth curve based on this analysis is shown in Plate 9 along with two other time-depth curves obtained from well-shooting in the basin area. As the t:$\triangle$t plot showed large scatter, the former curve is not considered reliable.

RESULTS

The overall quality of the reflection sections has generally been poor mainly because of interference by a high level of random noise possibly generated by the near-surface basalt layers in the area. The moveout corrections that have been applied are based on the t: ' t data from the pickable events along each traverse. As the scatter in the t: '·t plots were rather large, the corrections have been inadequate as shown by the poor continuity and the curvatures present in the shallow reflection events in the seismic sections.

Barwon Trough area

The reflection results along Traverses A and C in the main part of the Barwon Trough and along Traverse B in its northern extension are shown in Plates 10, 11 and 12 respectively. Traverses A and C cross each other at right angles.

Along Traverse A, the quality of the shallow reflections ranges from good/fair in the west to poor in the east. The character of the reflections changes across the Leopold Fault which crosses the traverse near SP110. West of the fault, a series of almost continuous reflections can be seen down to 0.35 s at SP100 and to 1.00 s at SP107 and indicate a thickening of the section eastwards. Along the Leopold Fault and another postulated fault near SP117, the sedimentary section is shown to be upthrown to the east by a maximum of about 250 m.

A very strong reflection close to the surface and higher-velocity first-breaks between SP100-103 represent the basalt layer met in shot-holes in this area. A fair-quality reflection, B, at about 0.2 s (168 m) at SP100 is identified as the unconformity surface at the base of Tertiary sediments which was met at 216.4 m in the Connewarre Bore (Reynolds, 1971) near the western end of the Lake Connewarre, about 3.5 km southwest of SP100. The reflection B is much closer to the surface at the eastern end of Traverse A and may represent the base of Tertiary sediments reached at 17.6 m in the Bellarine No. 1 Bore (Reynolds, 1971) drilled about 6 km northeast of SP120.

There is some indication, though poor, of the presence of sediments down to a poor reflection C at about 1.0-1.15 s west of the Leopold Fault, at about 1.0 s near SP115, and at about 0.8 s near SP120. This reflection C may represent the Palaeozoic basement in this area.

Along Traverse C, the quality of reflection is fair/good on the northern side of the Leopold Fault and poor on the south, and their character on the northern side is similar to that of the reflections on the western part of Traverse A. The reflections B and C, which have been correlated from Traverse A, are of better quality here and represent more clearly the unconformity surfaces at the base of Tertiary sediments and at the top of the Palaeozoic basement. The maximum thickness of sediments is estimated to be about 520 m of Tertiary and about 1450 of Cretaceous at SP306 in the area of gravity minimum of the Barwon Trough. The reflection data on the southern part of Traverse C do not suggest the presence of a Jurassic surface with southerly dips as postulated by Stach (1961) and shown north of Lake Connewarre in Plate 3.

Both sections, Traverses A and C, show several steeply dipping events such as diffractions and reflected refractions caused by subsurface faults in the area.

The section along Traverse B (Plate 12) is of poor quality and shows one fair/poor reflection between 0.1 and 0.2 s indicating a very thin (max. 150 m) sedimentary section in the northern extension of the Barwon Trough. Because of the poor quality of the data, it is difficult to interpret whether this reflection represents the horizon B or C. The nearest bore, Woornyalook No. 1 (Reynolds, 1971), about 8 km northeast of SP521, did not reach the base of Tertiary at 109.8 m.

Because of operational difficulties in the area, a simple reversed refraction profile could not be obtained along Traverse A. Sometimes the shot and at other times the recording spread had to be moved for increasing the offset in order to record deeper refractions. Because of the faulting and pinch-out indicated by the reflection data along the traverse and the discontinuity in the refraction data recorded, the interpretation of the data has been difficult, and the values for the velocities and depths are considered unreliable. However, the depth of the shallow refractor (305 m) is in general agreement with the average depth of the reflector B west of the Leopold Fault.

The first-break refraction data from the expanded spread at SP298 (see Plate 8) have been plotted in Plate 13. An analysis of these data indicates a layer with velocity 2830 m/s at 270 m, which depth is about 185 m above the horizon B along Traverse C.

The refraction data recorded along Traverse D are shown in Plate 14. The data have been interpreted in terms of four layers of velocities 2380, 2560, and 4600 m/s. The depths to the refractors at SP1500, the southern end of the traverse, have been estimated to be about 365, 365, and 1350 m respectively and differ significantly from those of the reflections identified at SP115 on Traverse A. The refractors show southerly dips contrary to the gravity gradient along Traverse D.

Port Phillip Sub-basin area

As the major part of the sub-basin gravity low area lies over the waters of Port Phillip Bay, Traverses S, Q, U, V, and X were recorded to investigate the land-covered southwestern and southern flanks of the low. The reflection sections along Traverses S and Q are shown in Plate 15 and along the Traverses U, V, and X in Plate 16.

The section along Traverse S shows poor data northwest of SP786. Between SP786-801, a band of fair/good quality reflections show dipping and thickening of sediments towards southeast, i.e. towards Port Phillip Bay. The good reflection at the base of this band is considered to correspond to horizon B at the base of Tertiary in the Barwon Trough area. The reflections above B may represent the coal seams, probably belonging to the Eastern View Coal Measures (Paleocene), which were met at 183 and 244 m in Queenscliff No. 7 Bore (Reynolds, 1971) located about 1 km north of SP790½. There is some indication of the presence of a fault - the Bellarine Fault, suspected from surface geology - at SP108, though the younger sediments above the horizon B show no clear break but only a change in dips. On the southeast side of the fault, fair/poor quality reflections can be seen below the horizon B down to the times of about 1.1 s (about 1200 m). Thus the presence of up to 370 m of Tertiary and 670 m of Cretaceous sediments is indicated near SP798; but some of the deeper reflections may be multiples, and the Cretaceous section may not be as thick as this. On the northwest side of the fault, there is a very poor indication of a reflection of about 0.6 s.

Traverse Q, which is close to the eastern end of Traverse S (SP801), shows a similar reflection section, with horizon B at 0.4 s (365 m) and poor events down to only 0.8 s (about 760 m).

The sections along Traverse U and X are of poor quality and do not give any indication of the thickness of sediments at the southern flank of the low area. The Traverse V section shows fair quality reflections dipping gently (about 5°) to the northwest between 0.7 and 1.0 s and indicates about 1000 m of sediments at the southeastern flank of the low. From the character of the reflections, it is difficult to say whether they represent the base of Tertiary or horizons within the Cretaceous.

The refraction profile recorded along Traverse W, shown in Plate 17, indicates the presence of a 3100 m/s refractor at 35 to 100 m. This may represent a weathered basalt layer which crops out in an area about 2 km from SP1999.

Anglesea Trough/Barwon Trough coastal areas

The reflection data in this area were recorded only between SP3098-3101 of Traverse R because of operational difficulties and shortage of time. The data shown in Plate 18 are of very poor quality and show no identifiable reflections.

Owing to the difficulties in moving the spreads, the refraction data were recorded on fixed spreads between SP3098-3104. Shots were fired at increasing offsets to a maximum of 16.8 km in attempts to record refractions from deep Cretaceous and basement horizons. Because of the short length of the refraction profile recorded from each shot and the discontinuous coverage, the interpretation of the data has been difficult. Three main layers with velocities of 1770, 3540, and 4790 m/s have been suggested and the refractor depths have been estimated to be about 110 and 550 m respectively. The deeper refractor of velocity 4790 m/s probably corresponds to the top of the Lower Cretaceous Otway Group, which is at 535.5 m in the Anglesea No. 1 Well (Dellenbach, 1965) near SP3095. There is a suggestion of possible faulting in the section, with downthrown side on the southwest.

6. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The quality of the reflection sections, obtained using only single-coverage techniques, ranged from fair to poor. It was adversely affected by the presence of steeply dipping events that have the appearance of diffractions and reflected refractions, and by random noise possibly generated by the near-surface basaltic cover in most of the area surveyed.

The presence of Tertiary section is supported by good/fair quality shallow reflections on most of the traverses. However, the evidence for the Cretaceous sediments is tenuous because of the poor quality of the deeper reflections, some of which may be multiples.

The seismic sections indicate that thicker sediments are present in the Barwon Trough and Port Phillip Sub-basin gravity low areas than in the adjacent gravity high areas. The thicknesses of the sediments have been estimated to be about 520 m for the Tertiary and 1450 m for the Cretaceous near the gravity minimum in the Barwon Trough. The thickness estimates are 370 m for the Tertiary and 670 m for the Cretaceous sediments on the south-western flank and about 1000 m for the combined sediments on the south-eastern flank of the Port Phillip Sub-basin gravity low. The seismic data also indicate onlapping, pinch-outs, and faults in some areas.

The interpretation of the refraction data has been difficult because of the discontinuous nature of the profiles recorded and the presence of faulting and pinch-outs mapped and suspected along the traverses. The refraction results are therefore not considered reliable.

Recommendations

Additional seismic reflection work, using multiple coverage and digital processing techniques, is recommended in order to obtain better quality seismic sections in the area. This is necessary

- to confirm the presence of a Cretaceous sedimentary section suggested by the reconnaissance survey in the gravity low areas, and
- to map in detail the possible petroleum trap structures - faults and pinch-outs - indicated along the margins of the trough areas.

Continuous reflection profiling along traverses on a closed grid would be required for the detailed mapping.

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APPENDIX 1

STAFF, EQUIPMENT AND VEHICLES

1. Staff

Supervisor	C.S. Robertson
Party Leader	J.C. Branson
Geophysicist	D.H. Tucker
Observer	R. Krege
Clerk	B. Beaman
Shooter	H. Pelz
Driller	B. Findlay
	A. Zoska
	J. Keunen
Drilling Assistants	K. Reine
	R. Bryce
Mechanics	E. McIntosh
	N. Gaston
Surveyor	I. Sutherland (Dept of the Interior).
Wages hands	13

2. Equipment

Magnetic Recorder	Electro-Tech DS7-7
Seismic amplifiers	T.I. 8000 "Explorer"
Oscillograph	S.I.E. TRO6 and VT6
Geophones (Reflection)	Electo Tech EVS23 (900)
" (Refraction)	" " 4.5 Hz (104)
Geophone cables	Vector 2000 ft
Transceivers	Traeger TM3 (3)
	Pye VHF (3)
Printing machine	Metam 20

Equipment (cont)

Drilling rigs	Mayhew 1000 (2)
	Carey (1)
Workshop	Fitted on Bedford RLHC3 chassis, with alternator, compressor, greasing unit, air and oxy. welders, bench grinders, hand tools.

3. Vehicles

Function	Type
Party Leader's	Falcon station wagon
Recording truck	International B120 4 x 4, 1-ton utility
Utility	International AB120 4 x 4, 1-ton utility
Personnel carrier	Land-Rover station wagon
" "	" " " "
Cable-geophone	Land-Rover LWB utility
vehicles	" " " "
Flat-top truck	Bedford RLHC3, 4 x 4
Workshop truck	" " "
Flat-top tanker	" " "
" " "	" " "
Shooter's tanker	" " "
Round "	" " "
Mayhew rig	International R190 4 x 4
" "	" " "
Carey rig	Bedford RLHC3, 4 x 4
Office caravan	Carapark, tendem axle
Explosives trailer	4-wheel trailer 14' x 7'
Drill spares trailer	" " " "

APPENDIX 2

OPERATIONAL STATISTICS

1. General

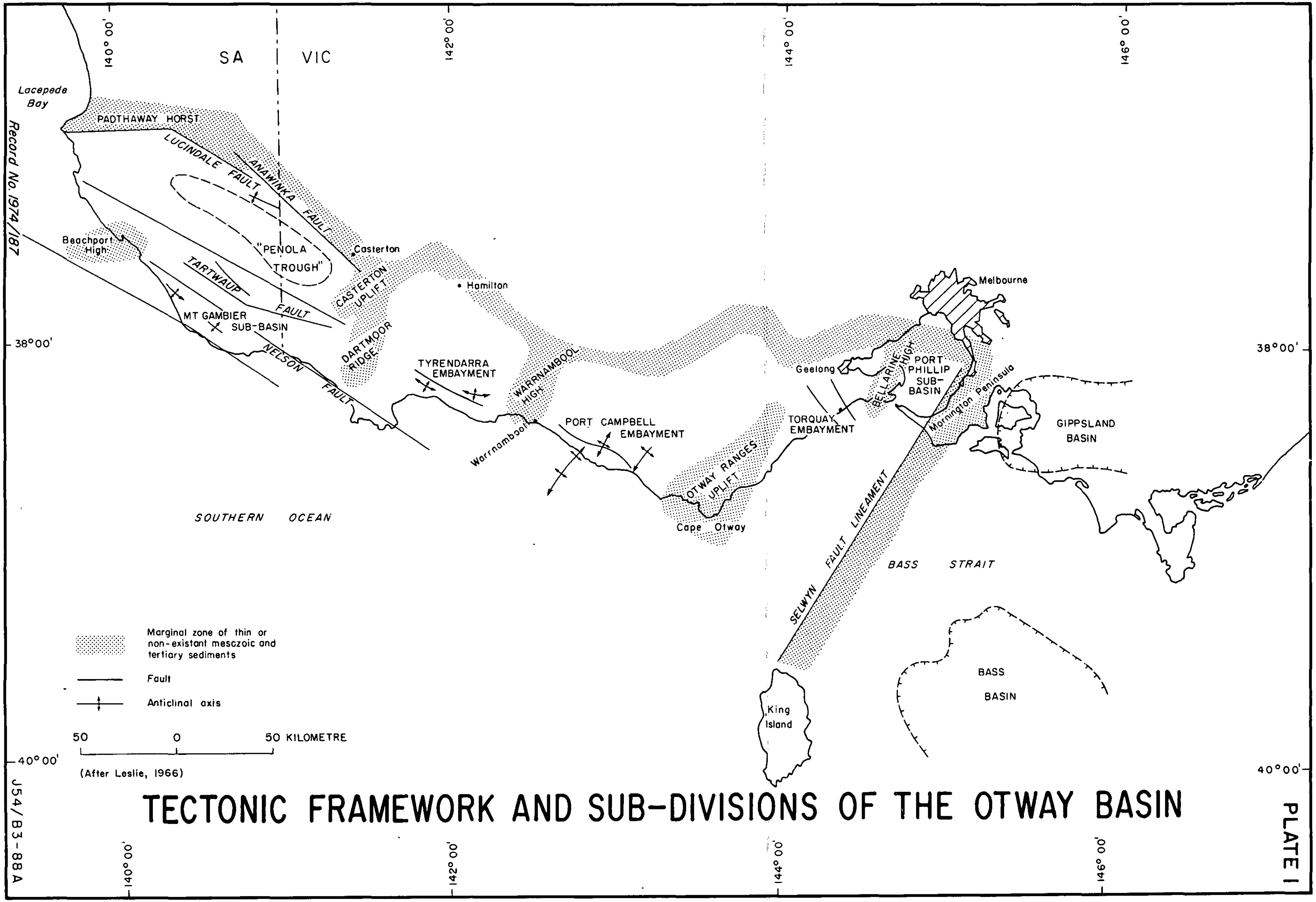
Sedimentary Basin	East Otway Basin
Area of Survey	Geelong, Queenscliff, Portsea-Sorrento, Anglesea
Survey commenced	20 February 1967
Survey terminated	15 June 1967
Length of traverse surveyed	90 km
Length of traverse shot	85 km
Topographic survey control	Geelong Sewerage Trust bench marks.
	A.L.C.O.A. trig stations.
	Low Water Mark Williamstown
Total depth drilled	19 684 m
Total number of holes	1502
Explosives used	6800 kg Geophex
	910 kg ammonium nitrate
Datum levels for corrections	-3m L.W. (Williamstown)
	+30.5m L.W. (")
Weathering Velocity	760 m/s
Subweathering Velocity	1830 m/s
	1710 m/s
Static corrections method	Uphole times checked by first-breaks
Source of t: t analysis	Traverse A, C, S
Shot-point interval	274 m

2. Reflection shooting data

Geophone group interval	22.9 m
Geophone patterns	24 geophones with 3 m spacing connected in 2 rows of 3.7 m with 9 m between rows
Shot-hole pattern	3 holes at 12 m, or 5 holes at 7.6 m or 7 holes at 6 m or 9 holes at 3.8 m in line parallel to the traverse
Number of shot-points shot	150
Length traversed	61 km
Common shooting depth	12-18 m
Common charge size	11.5 kg
Usual recording filters	18-125 K
Usual playback filters	33-72 K

3. Refraction shooting data

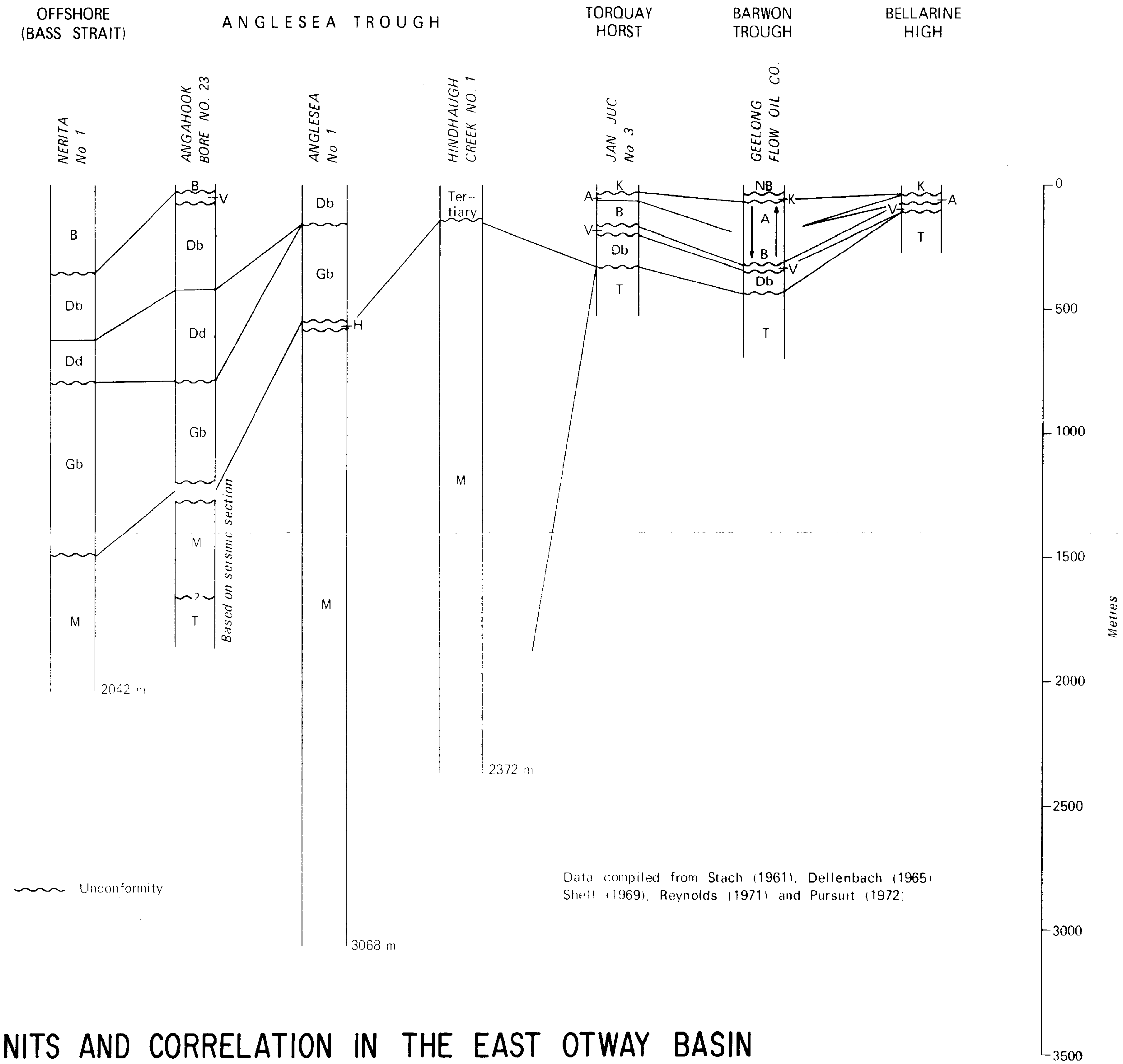
Geophone group interval	91.5 m
Geophone pattern	4 per trace in line perpendicular to traverse, spacing 6.7 m
Number of shot-points shot	33
Number of refraction traverses	4
Charge size	23-545 kg
Usual recording filters	Nil
Usual playback filters	0-40 K
Maximum shot-geophone distance	15.3 km
Weathering control	Reflection shooting data and shallow refraction shots.



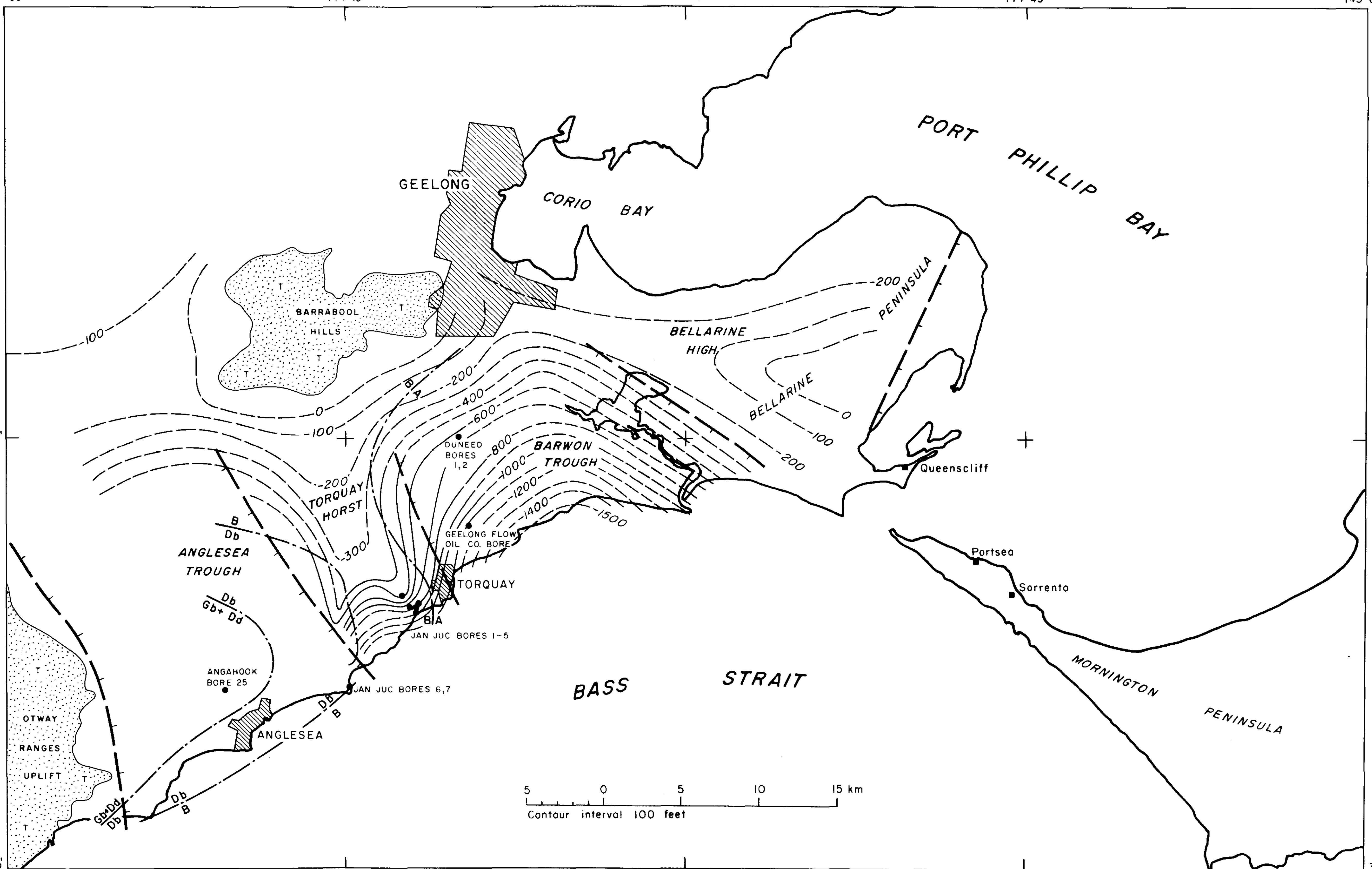
TECTONIC FRAMEWORK AND SUB-DIVISIONS OF THE OTWAY BASIN

PLATE I

AGE	STRATIGRAPHIC NAME		EQUIVALENT BMR UNIT	LITHOLOGY
PLIOCENE	NEWER BASALT (NB)			Basalt flows
	KALIMNAN (K)			Sands, clays
MIOCENE	BALCOMBIAN		A	Marls, limestones
MIOCENE-OLIGOCENE	TORQUAY GROUP		B	Calcareous sands and clays, limestone
EOCENE-PALEOCENE	BASIC VOLCANICS (V)			Volcanics
	DEMON'S BLUFF FORMATION		Db	Siltstones, greywackes, shales, sands
	BOONAH SANDSTONE		Dd	Sandstone
PALEOCENE-UPPER CRETACEOUS	EASTERN VIEW COAL MEASURES		Gb	Lignitic clays and sands with brown coal seams
UPPER CRETACEOUS	OTWAY GROUP	WAARRE FORMATION	J H	Quartzites with carbonaceous and coaly horizons
LOWER CRETACEOUS	OTWAY GROUP	EUMERALLA FORMATION	M	Mudstones, silts with subordinate sands, coals near top
	OTWAY GROUP	GELTWOOD BEACH FM PRETTY HILL SANDSTONE	P R	Lithic sandstones interbedded with shale and silt
L. CRETACEOUS-U. JURASSIC	UNNAMED		T	Conglomerate, sandstone, shale, part carbonaceous, basalt lava flows
PALAEOZOIC	BASEMENT			Tasman geosynclinal rocks



LITHOSTRATIGRAPHIC UNITS AND CORRELATION IN THE EAST OTWAY BASIN



A 'Balcombian'
B Torquay Group
Db Demon's Bluff Formation
Dd Boonah Sandstone
Gb Eastern View Coal Measures
T Exposed 'Jurassic' Rocks

Approximate boundaries between older tertiary stratigraphic units beneath younger superficial deposits

Subsurface contours on top of 'Jurassic'. O-sea level
Full lines based on subsurface controls
Broken lines are assumed positions

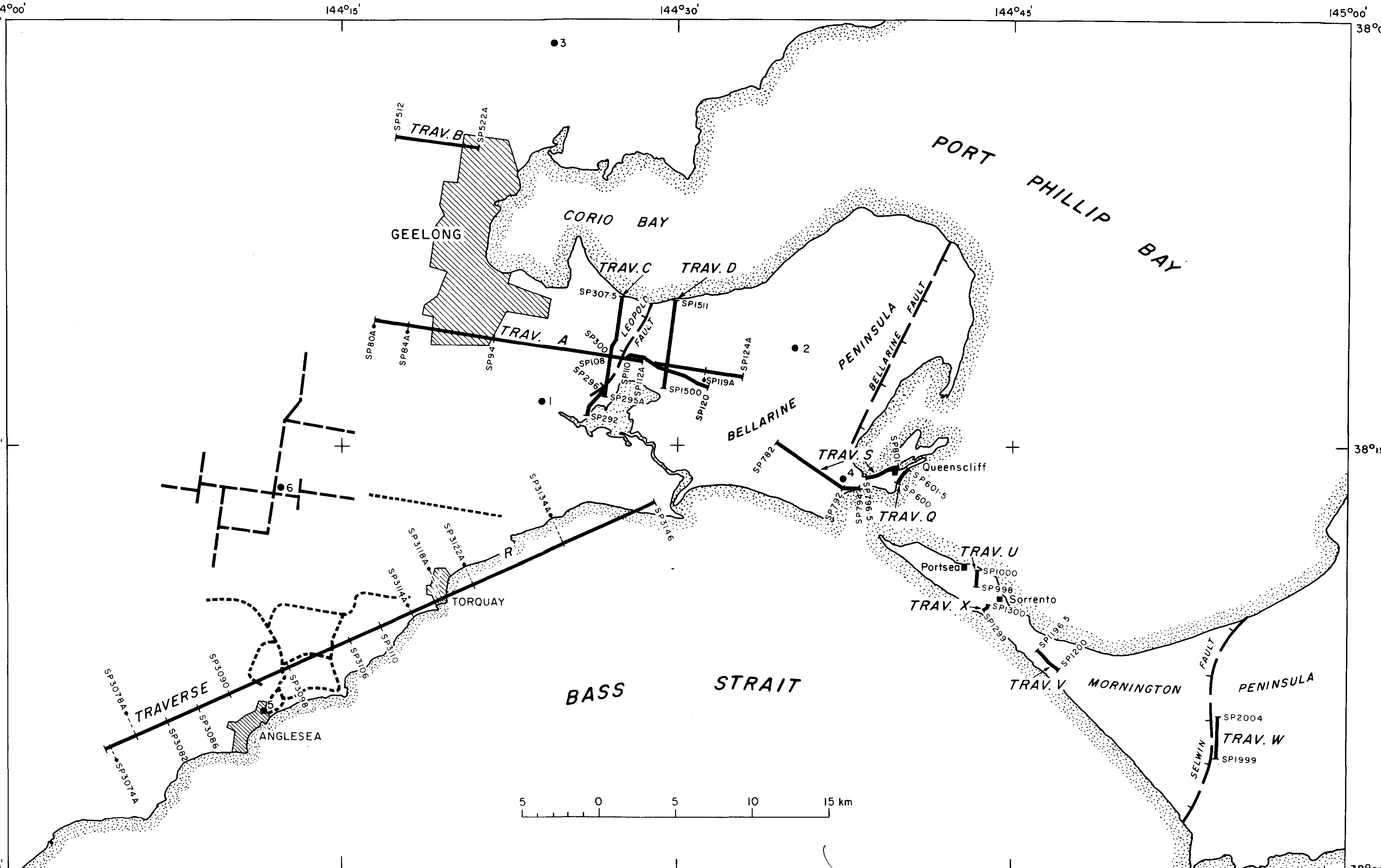
Fault

Deeper subsurface control from well data

STRUCTURAL FEATURES OF THE TORQUAY EMBAYMENT AREA

Record No. 1974/187 (After Stach, 1961)

J55/B3-25



SEISMIC COVERAGE

▬	*Seismic traverse (BMR)*
— —	*Seismic traverse (Pursuit Oil N L)*
-----	*Seismic traverse (Oil Development N L)*

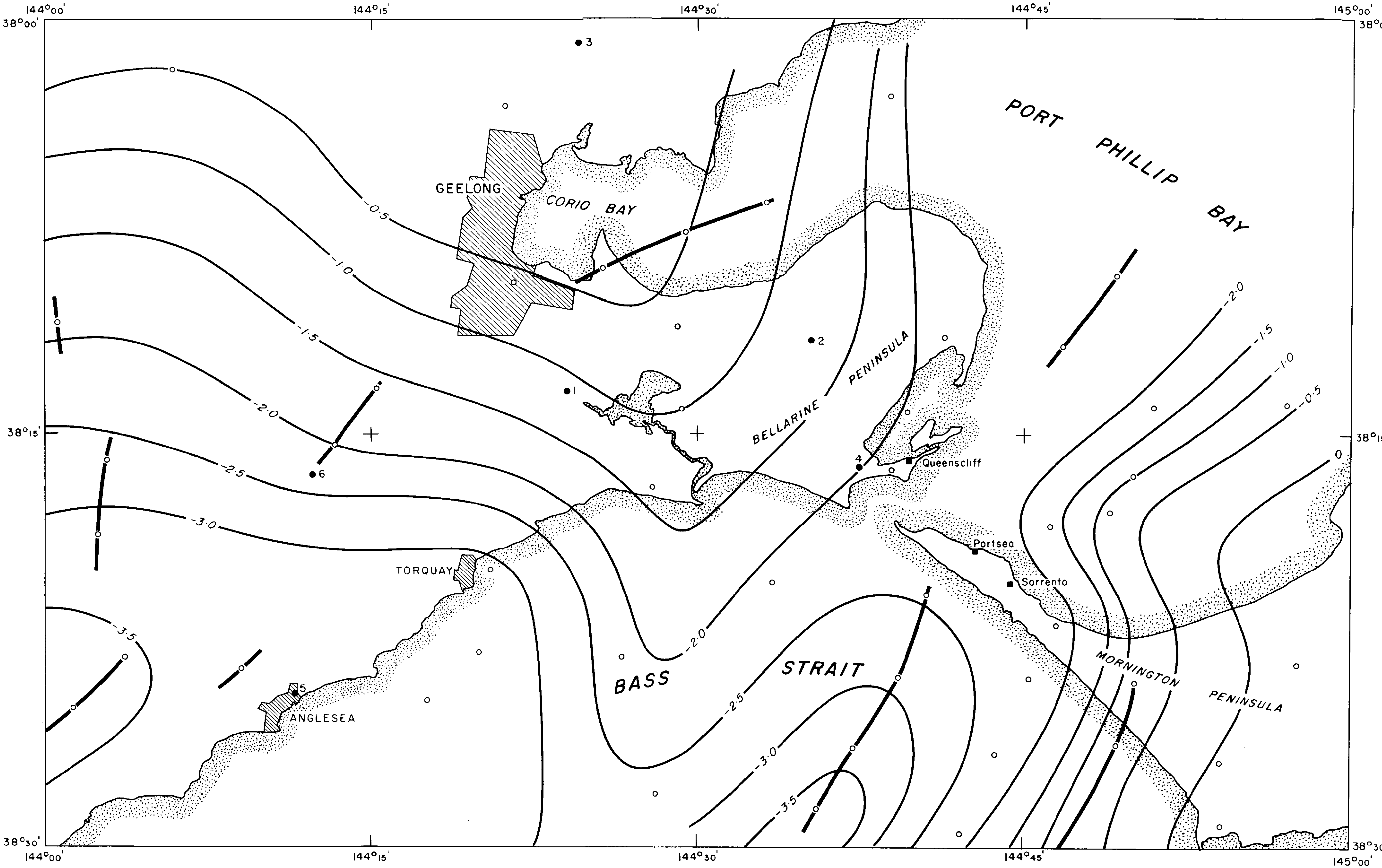
MAGNETIC COVERAGE — COMPLETE

GRAVITY COVERAGE — COMPLETE

● *Bore or well locations*

1 *Connewarre*
2 *Bellarine No. 1*
3 *Woornyalook No. 1*
4 *Queenscliff No. 7*
5 *Anglesea No. 1*
6 *Hindhaugh Creek No. 1*

LOCATION OF TRAVERSES



● Bore or well locations
1 Connewarre
2 Bellarine No. 1
3 Woornyalook No. 1
4 Queenscliff No. 7
5 Anglesea No. 1
6 Hindhaugh Creek No. 1

○ Depth estimates

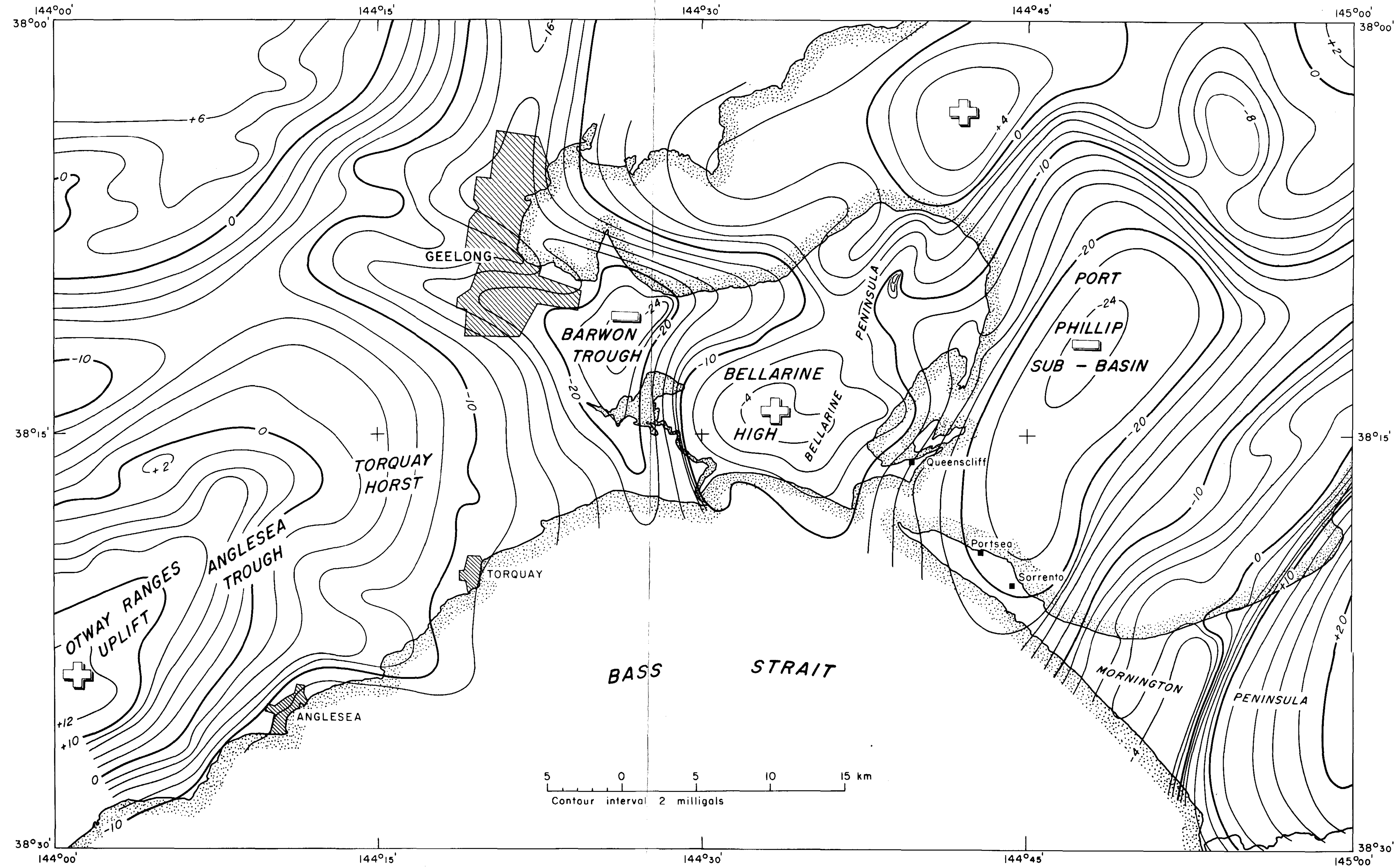
Anomaly axis

(Ref: Shell, 1970)

5 0 5 10 15 km

Contour interval 0·5 kilometre

MAGNETIC BASEMENT CONTOUR MAP



For the calculation of Bouger anomalies 2·2 g/cm³ has been adopted as an average rock density

Geophysical field data from BMR regional and underwater gravity surveys in 1957/58 and Frome-Broken Hill Co. Pty Ltd in 1962

TORQUAY HORST – *Represents geological structural features*

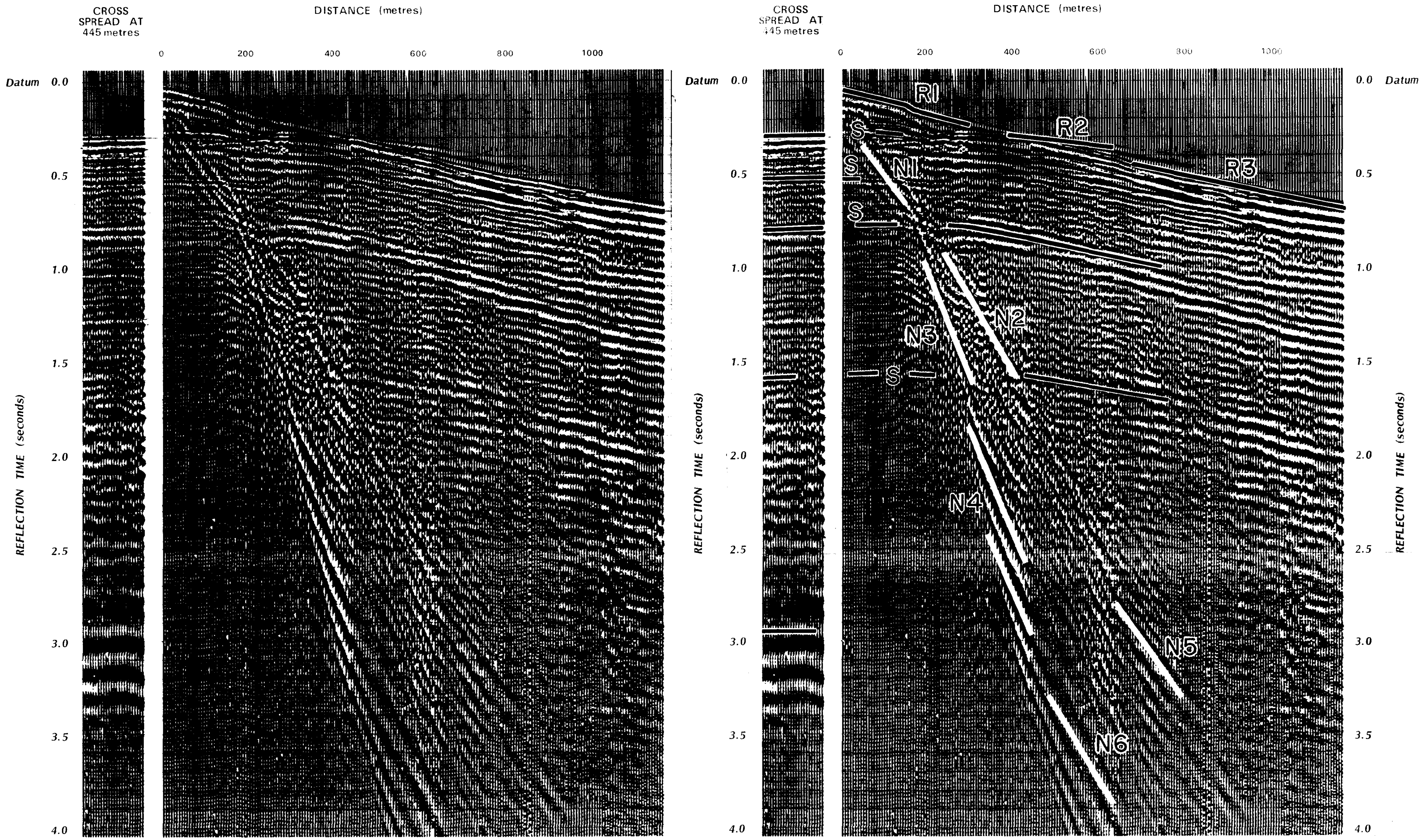
'High' anomaly

'Low' anomaly

BOUGUER ANOMALY MAP

Record No. 1974/187

J55/B3-28



RECORD SECTION

RECORDING INFORMATION

Magnetic recorder: DS7–7
Amplifiers : 8000 TI Explorer
Prefilters: Nil
Filters : Out
AGC : Nil
Geophones : EVS 2B, 20 Hz
Geophone station interval: 6 m
Geophone pattern: Bunched

Shot-hole pattern:
Single
Depth 6–12 m
Charge 4.5 kg

PLAYBACK INFORMATION

Filters: Out
AGC : S
Compositing: Nil

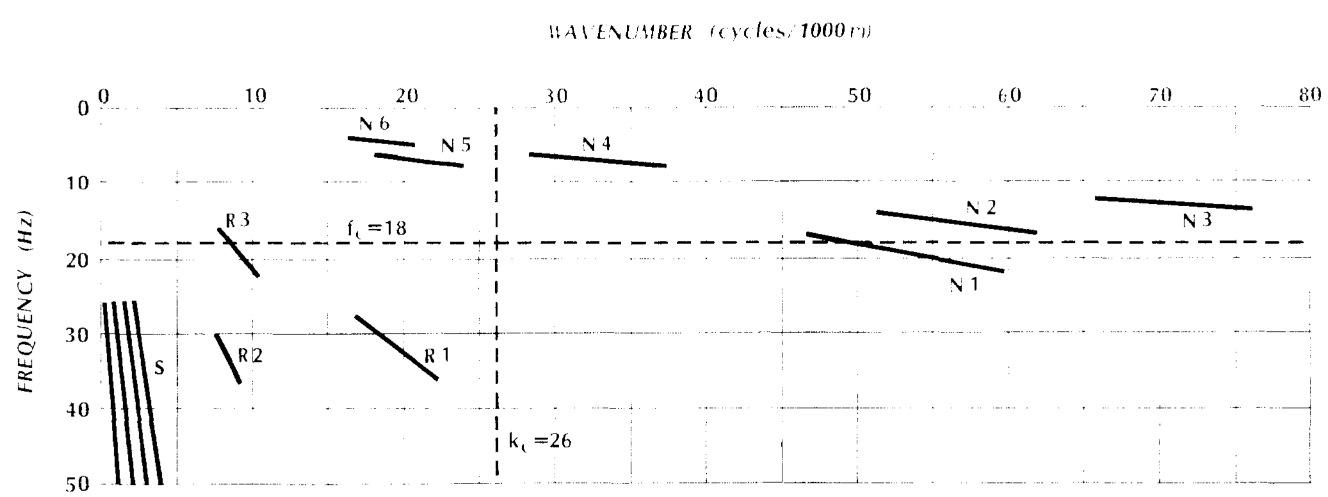
VELOCITY INFORMATION

Nil

HORIZONTAL SCALE

As indicated

EAST OTWAY BASIN SEISMIC SURVEY, 1967 NOISE TEST TRAVERSE A SP109 N

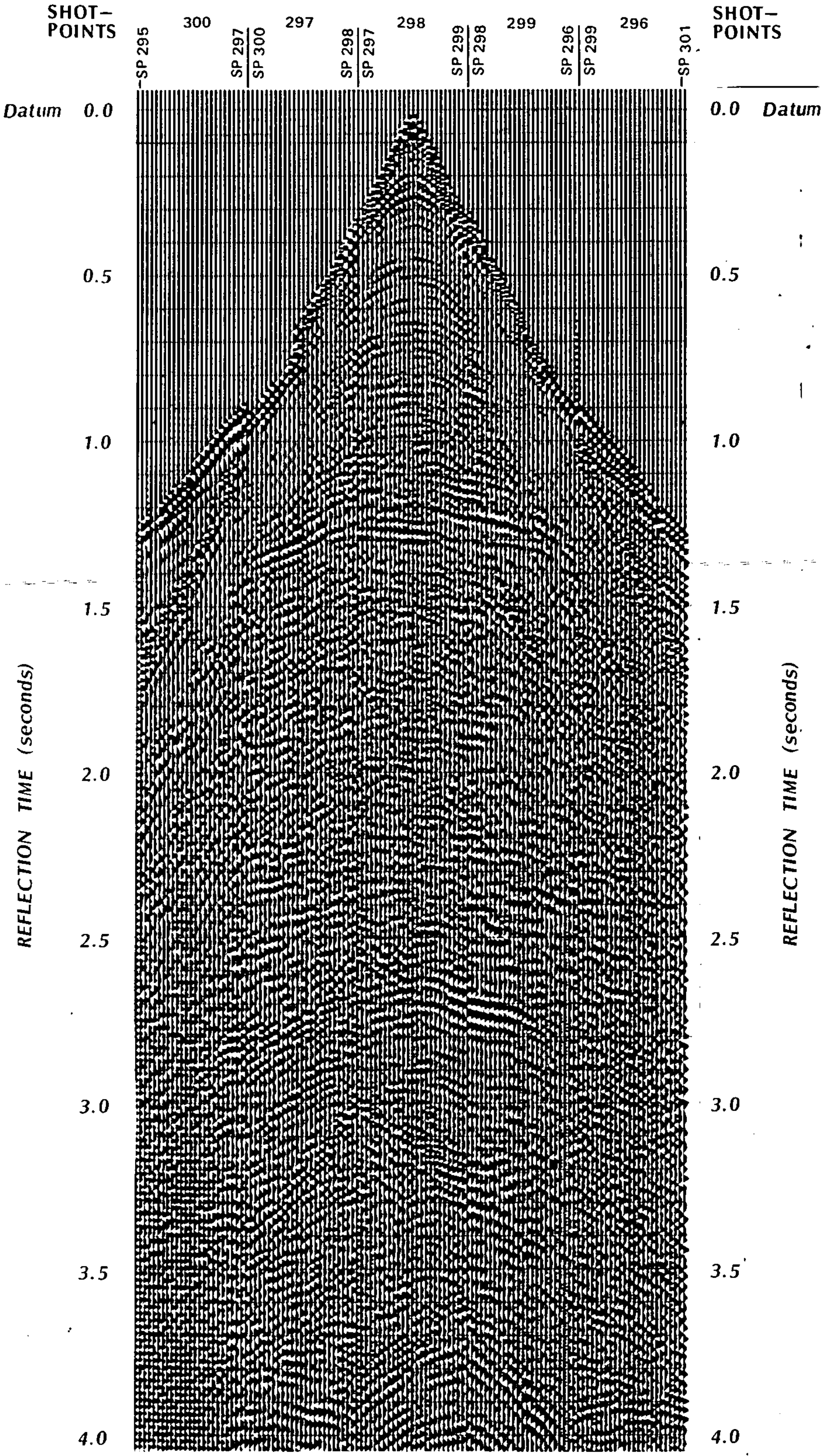


Record No. 1974/187

J55/B3–33

Plate 8

CORRECTED RECORD SECTION



RECORDING INFORMATION

Magnetic recorder: DS7-7
Amplifiers : 8000 TI Explorer
Prefilters : Nil
Filters : K18-K125
AGC : Medium
Geophones : EVS 2B, 20 Hz
Geophone station interval: 22.8 m
Geophone pattern:
24/trace in 2 rows of 12 in line
Rows 6.7 m apart
Geophones 4.3 m apart
Shot-hole pattern
5 holes in line 12.2 m offset
Holes 7.6 m apart
Charge varied (1-7 kg)
Depth 3-18.3 m

PLAYBACK INFORMATION

Filters: 33-72
AGC : S
Compositing: Nil

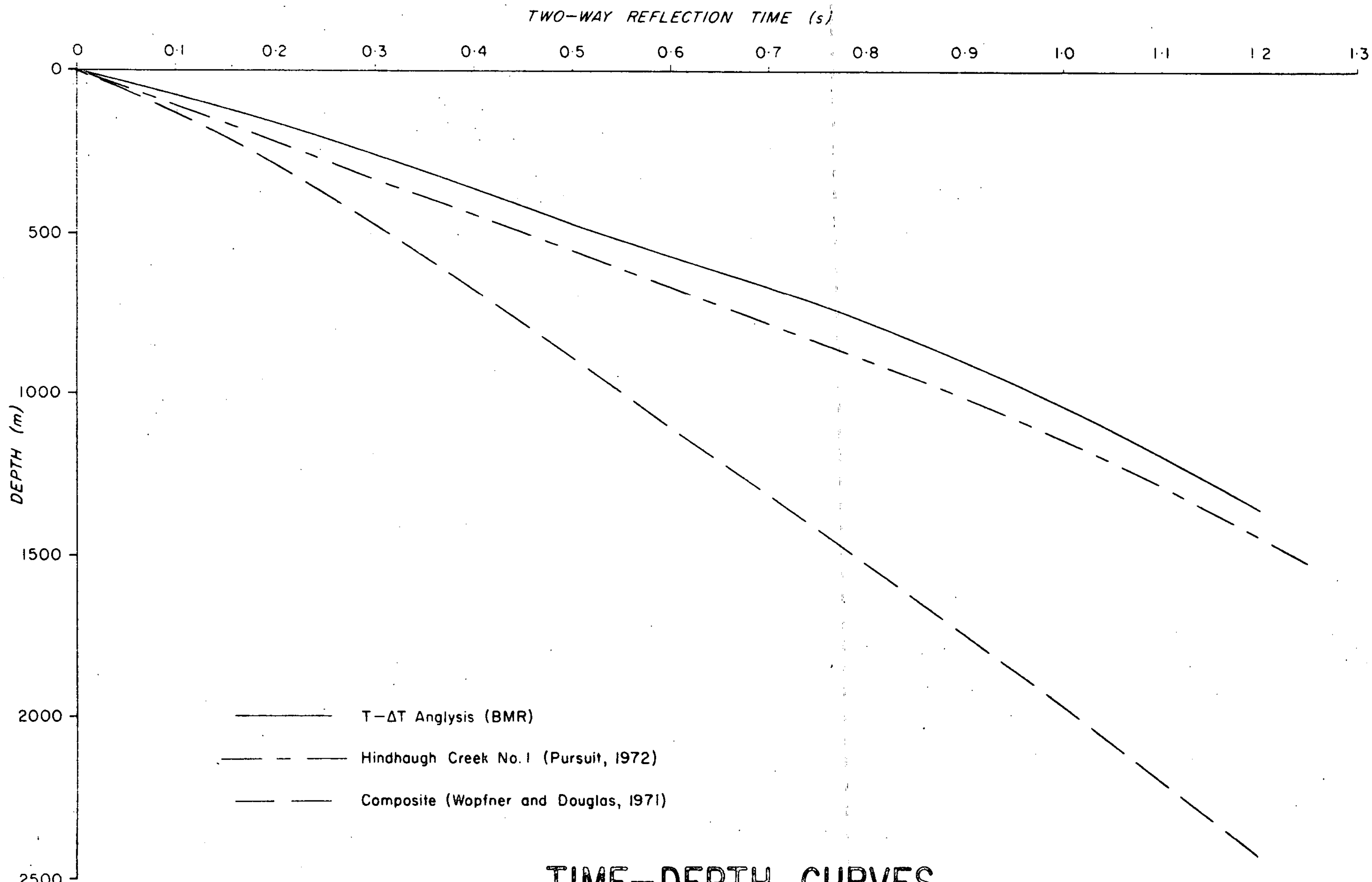
VELOCITY INFORMATION

Nil

HORIZONTAL SCALE

0 274 549 823 1000 metres

EAST OTWAY BASIN SEISMIC SURVEY, 1967 EXPANDED SPREAD centred on SP298 TRAVERSE C



TIME–DEPTH CURVES

J55/B3–32 A

PLATE 9

CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic recorder DS7 7
Amplifiers . 8000 TI Explorer
Prefilters : Nil
Filters : K18–K125
AGC : Medium
Geophones EVS 2B, 20 Hz
Geophone station interval 22.8 m
Geophone pattern
24 trace in 2 rows of 12 in line
Rows 6.7 m apart
Geophones 3 m apart
Shot hole pattern
Varied

PLAYBACK INFORMATION

Filters: K31–K78
AGC : S
Compositing. Nil

VELOCITY INFORMATION

t:Δt analysis

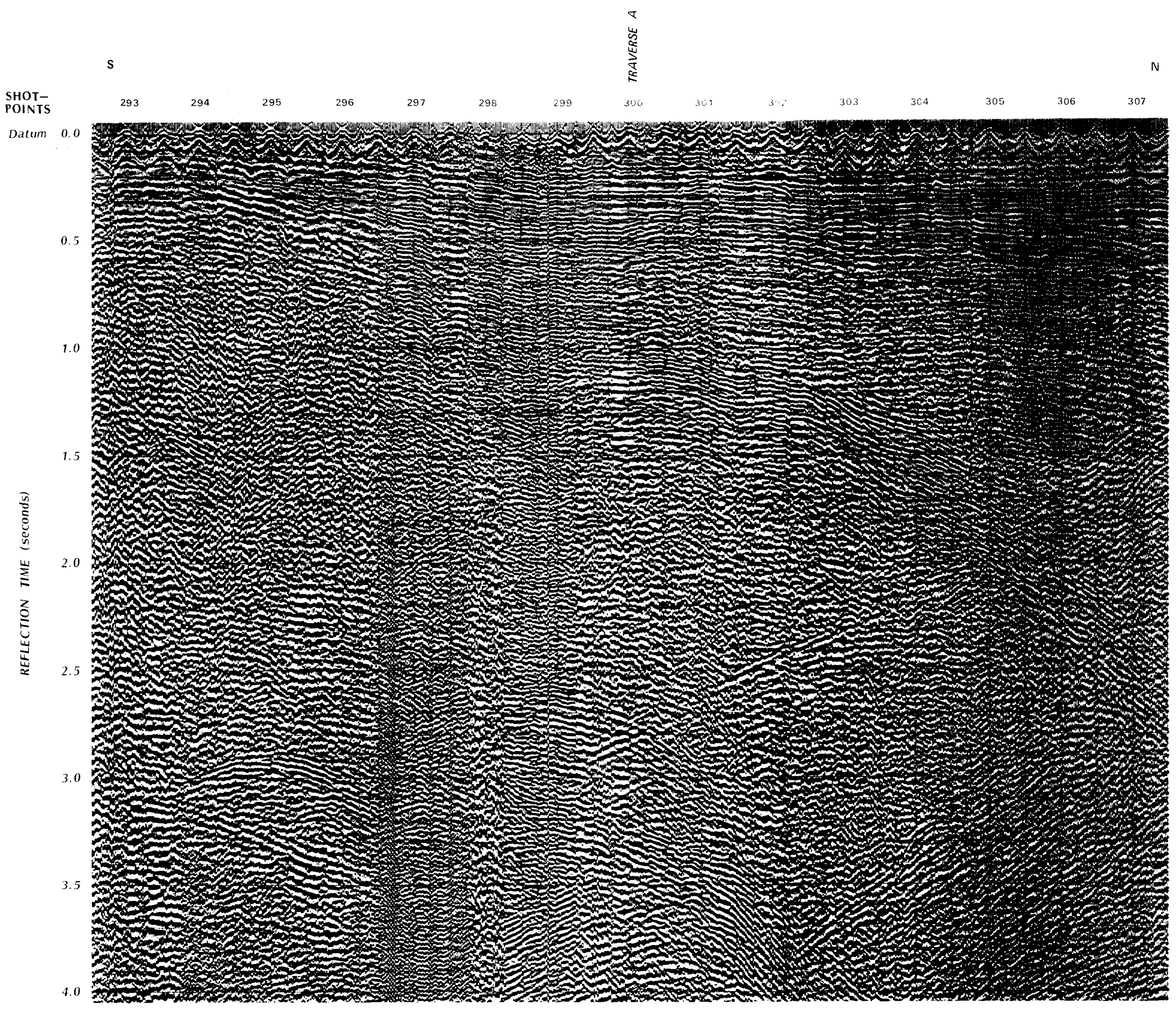
HORIZONTAL SCALE

0 274 549 823 1000 metres

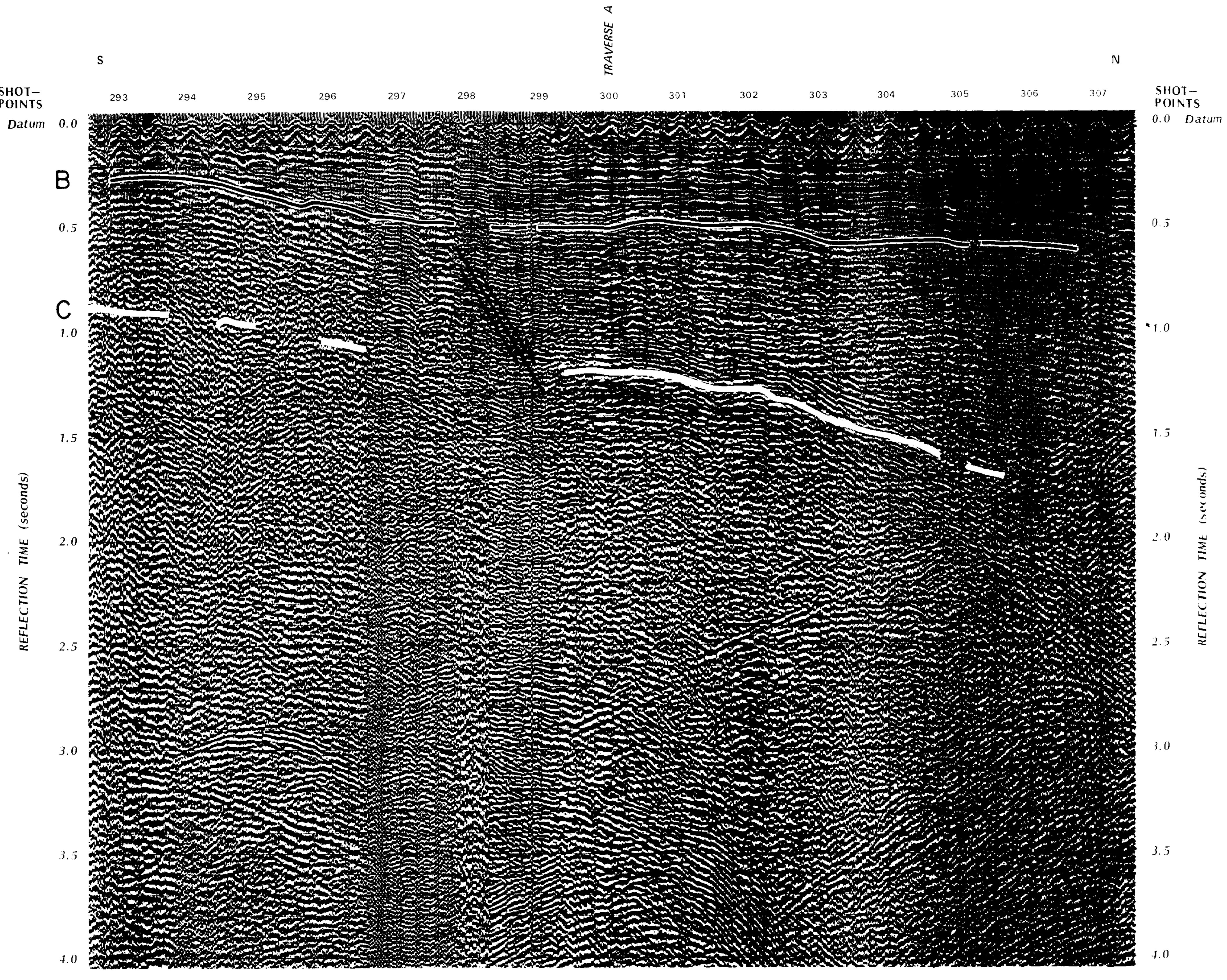
EAST OTWAY BASIN SEISMIC SURVEY, 1967 TRAVERSE A

Record No. 1974/187

J55/B3-35



Record No. 1974/187



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic recorder DS7 7
Amplifiers 8000 TI Explorer
Prefilters Nil
Filters K18 K125
AGC Medium
Geophones EVS 2B 20 Hz
Geophone station interval 22.8 m
Geophone pattern
24 trace in 2 rows of 12 in line
Rows 6.7 m apart
Geophones 3 m apart
Shot hole pattern
5 holes in line
Holes 7.6 m apart
Charge 5x1 kg
Depth varied

PLAYBACK INFORMATION

Filters 1 31 1 78
AGC S
Compositing Nil

VELOCITY INFORMATION

t Δt analysis

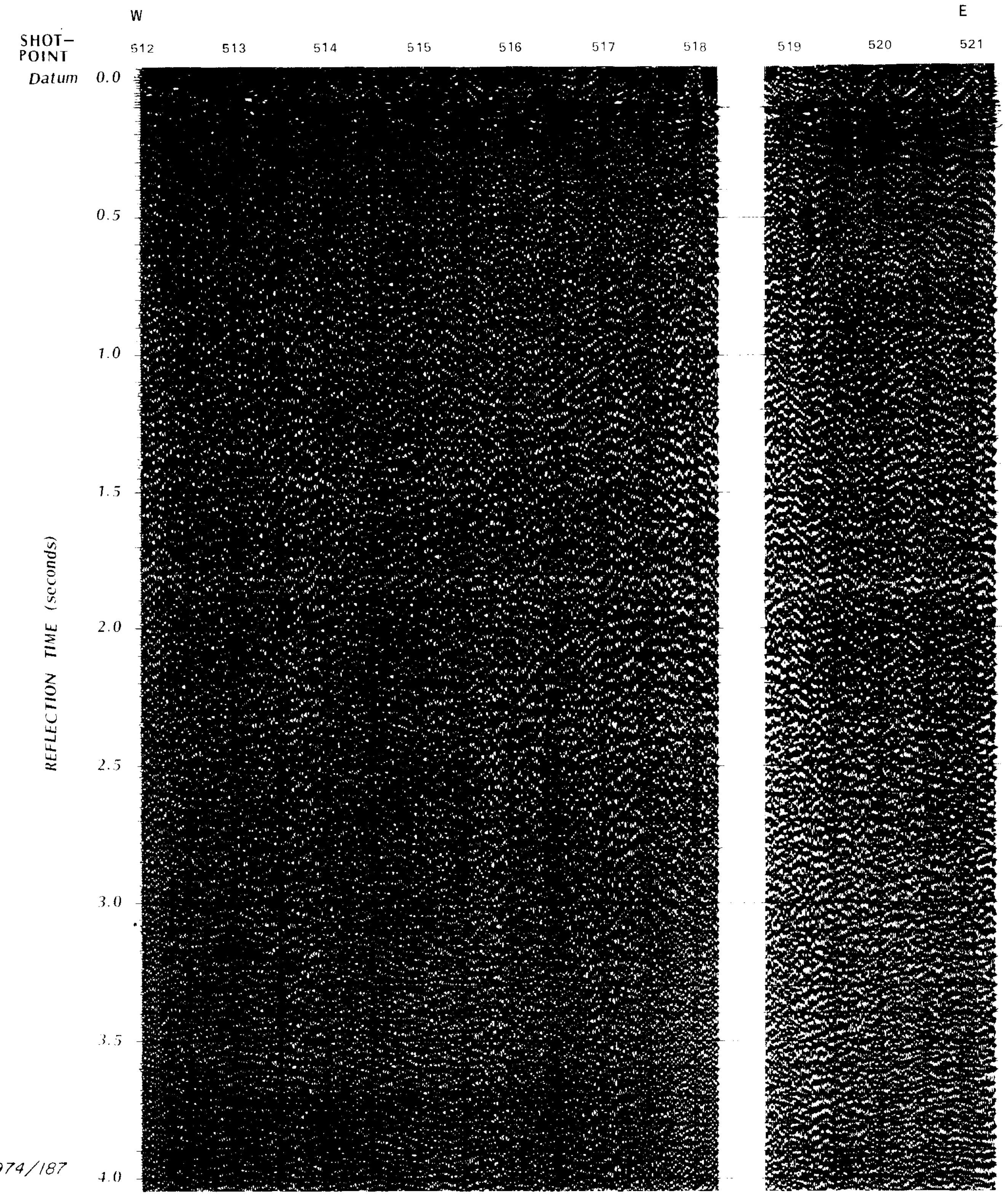
HORIZONTAL SCALE

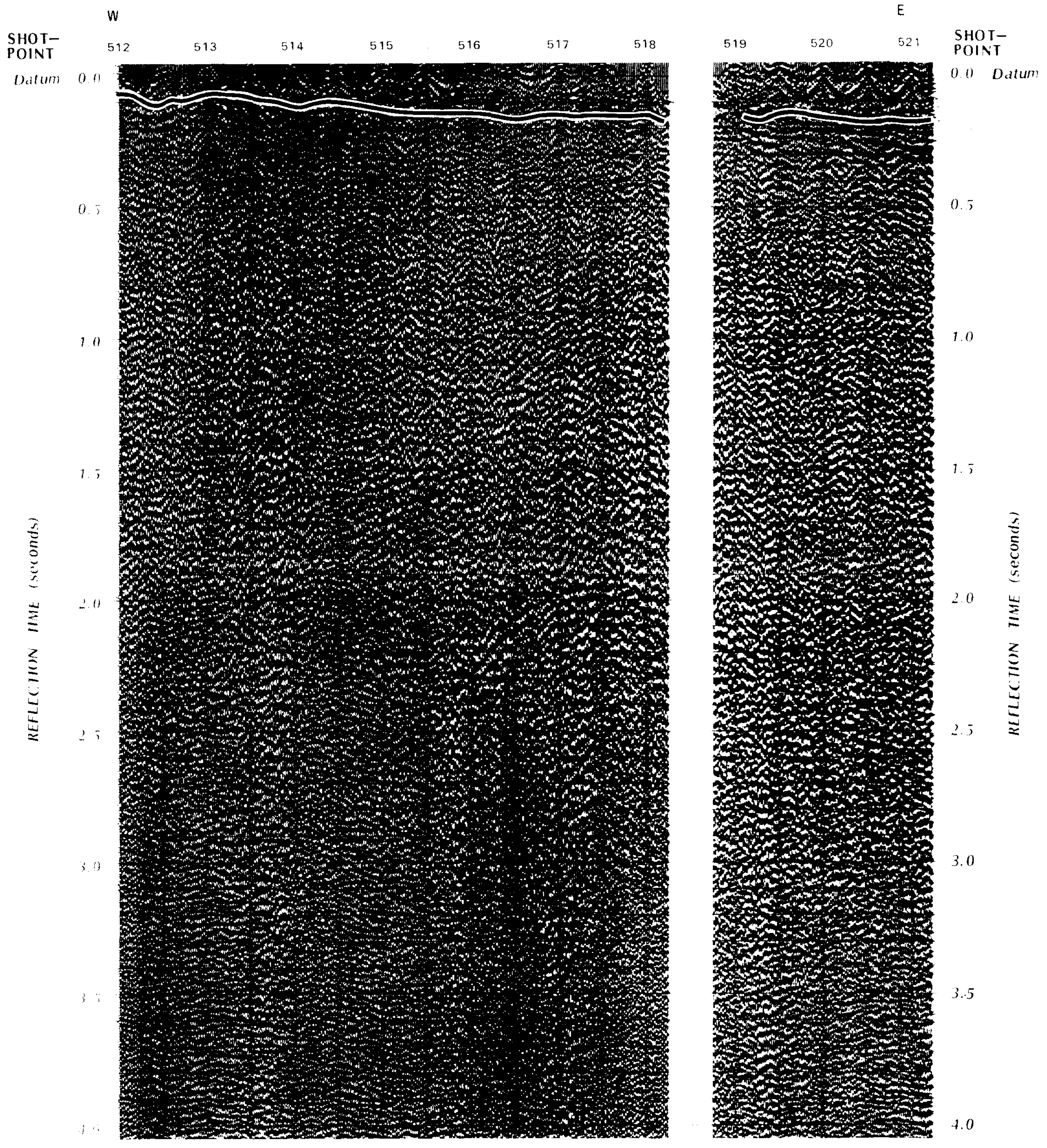
274 549 823 1000 metres

EAST OTWAY BASIN SEISMIC SURVEY, 1967 TRAVERSE C

J55/B3-37

CORRECTED RECORD SECTION





RECORDING INFORMATION

Magnetic recorder: DS7 7
Amplifiers: 8000 TI Explorer
Prefilters: Nil
Filters: K14 K125
AGC: Medium
Geophones: EVS 2B, 20 Hz
Geophone station interval: 22.8 m
Geophone pattern:
24 trace in 2 rows of 12 in line
Rows 6.7 m apart
Geophones 3 m apart
Shot hole pattern
5 holes in line
Holes 7.6 m apart
Charge 5 x 4.5 kg
Depth varied

PLAYBACK INFORMATION

Filters: 1/31 1/78
AGC: S
Compositing: Nil

VELOCITY INFORMATION

t : Δt analysis

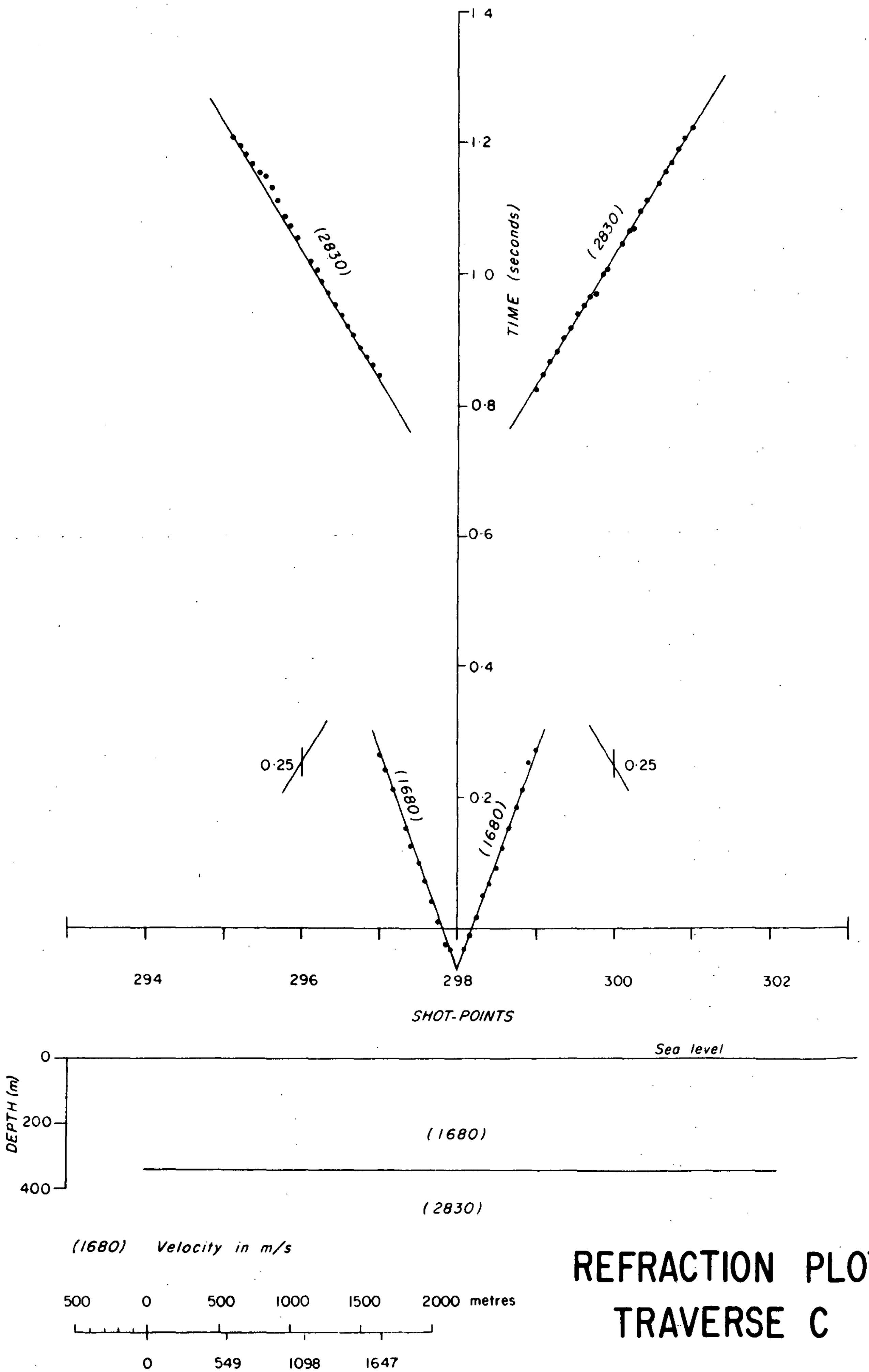
HORIZONTAL SCALE

0 274 549 823 1000 metres

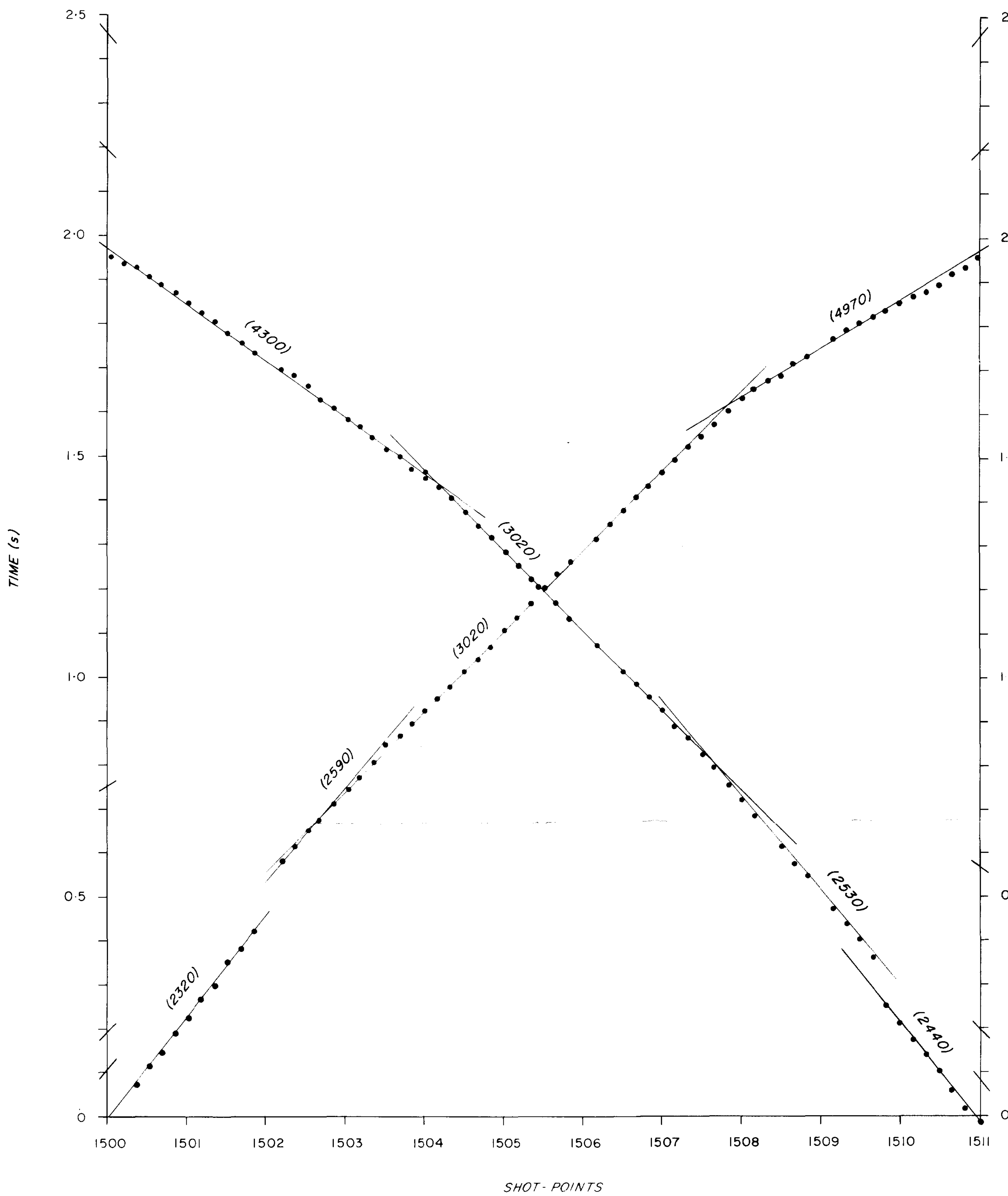
EAST OTWAY BASIN SEISMIC SURVEY, 1967 TRAVERSE B

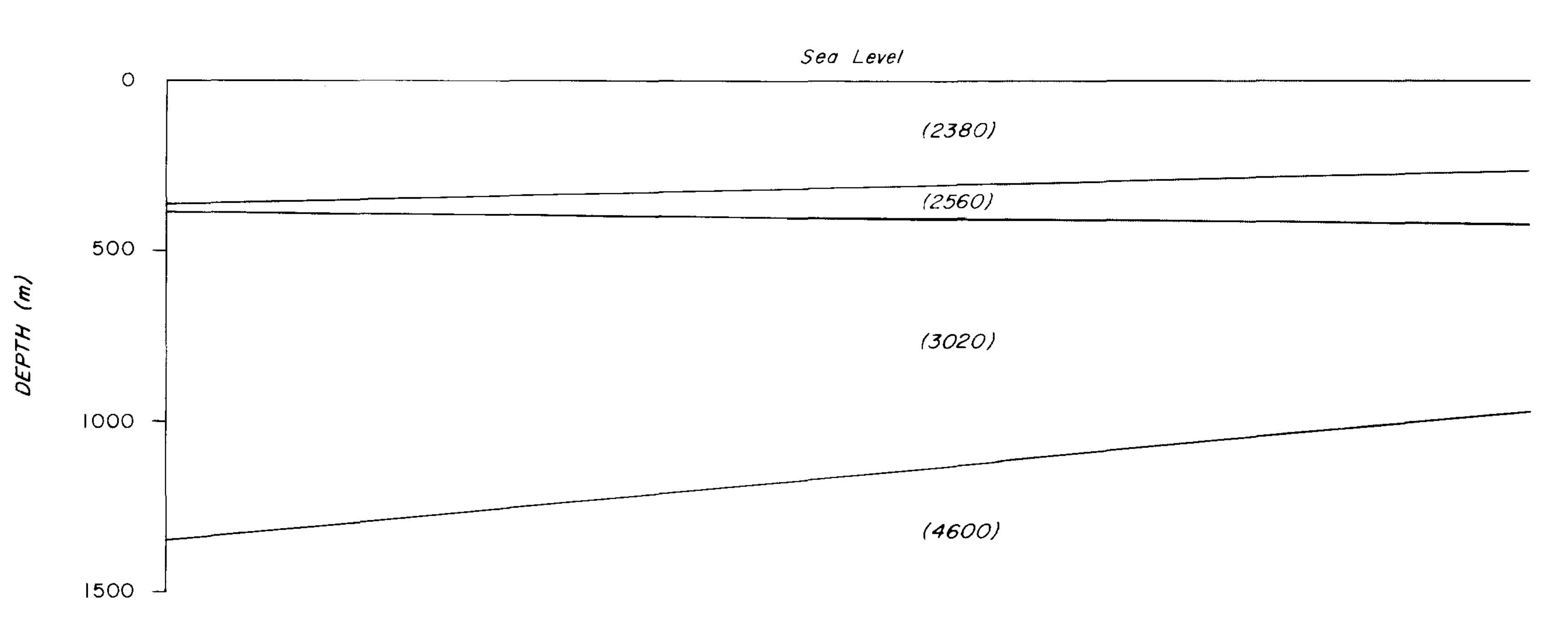
J55/B3-36

Record No. 1974/187



REFRACTION PLOT TRAVERSE C





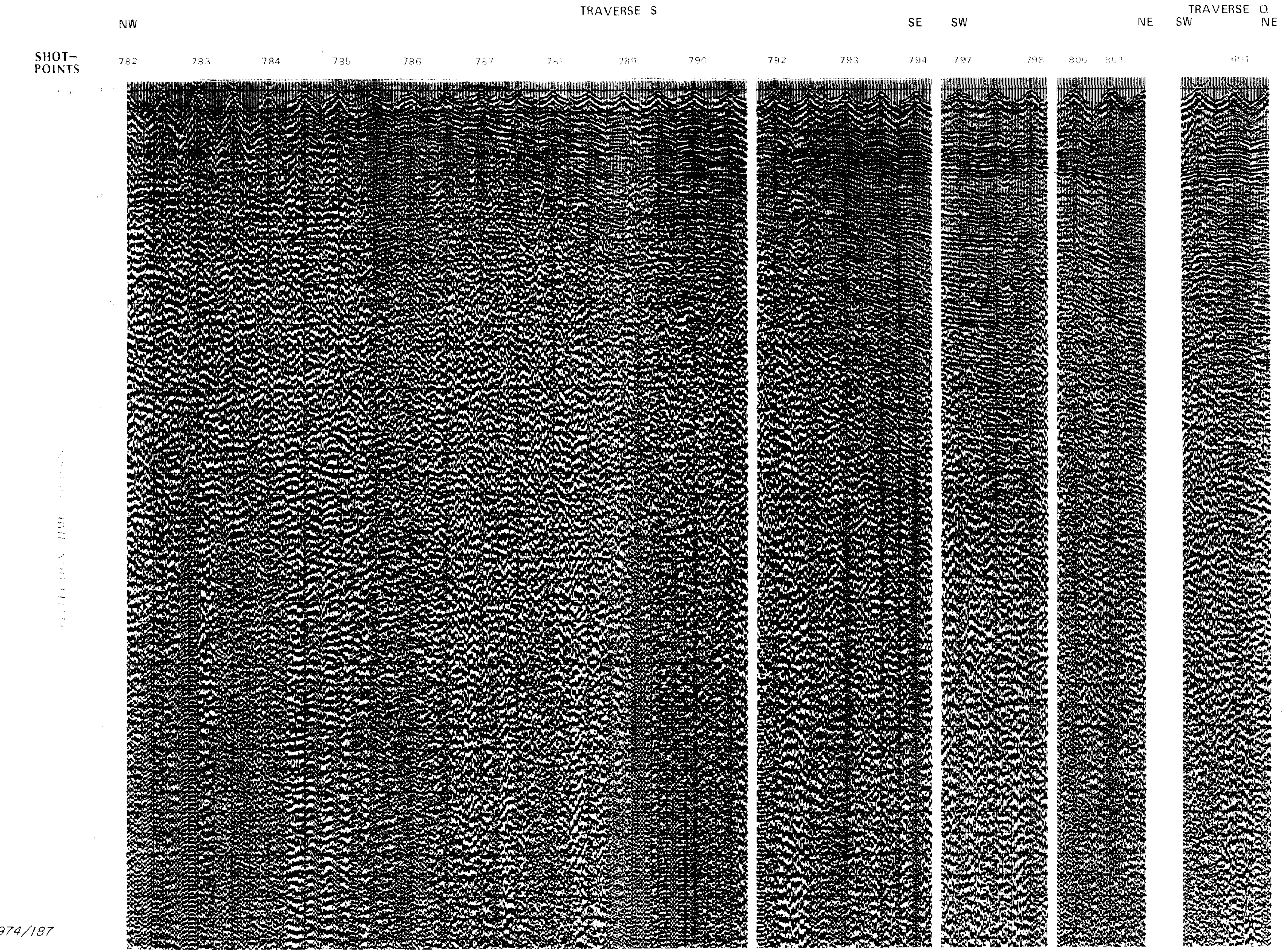
(2560) Velocity in m/s

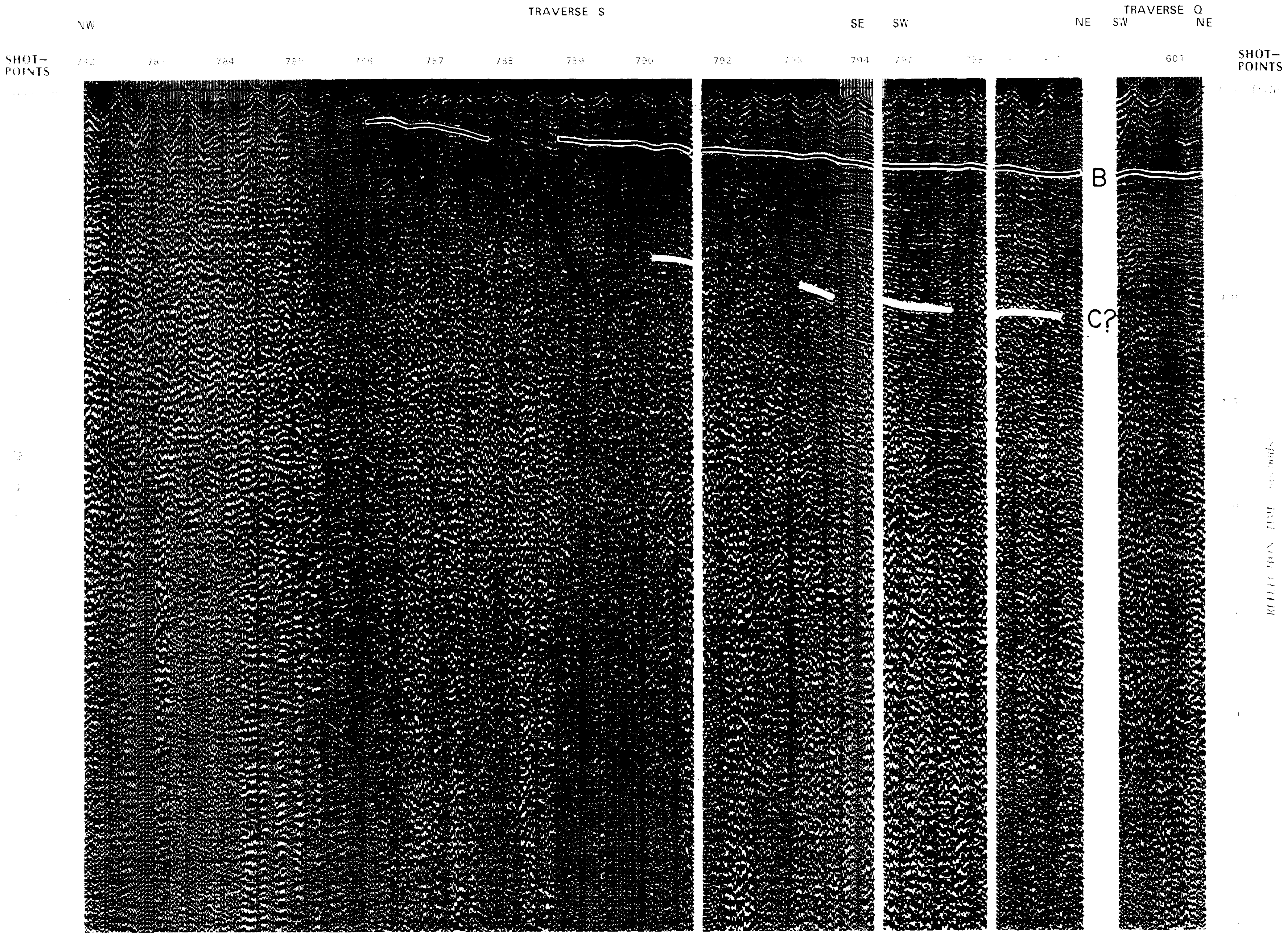
METRES
600 0 600 1200 metres
0 549 1098

J55/B3-29

REFRACTION PLOT TRAVERSE D

PLATE 14





CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic recorder: DS7 7
Amplifiers : 8000 TI Explorer
Prefilters : Nil
Filters : K14 K125
AGC : Medium
Geophones : EVS 2B 20 Hz
Geophone station interval: 22.8 m
Geophone pattern:
24 trace in 2 rows in line
Rows 6.7 m apart
Geophones 3 m apart
Shot hole pattern:
Varied

PLAYBACK INFORMATION

Filters: K33 K72
AGC : S
Compositing: Nil

VELOCITY INFORMATION

t:Δt analysis

HORIZONTAL SCALE

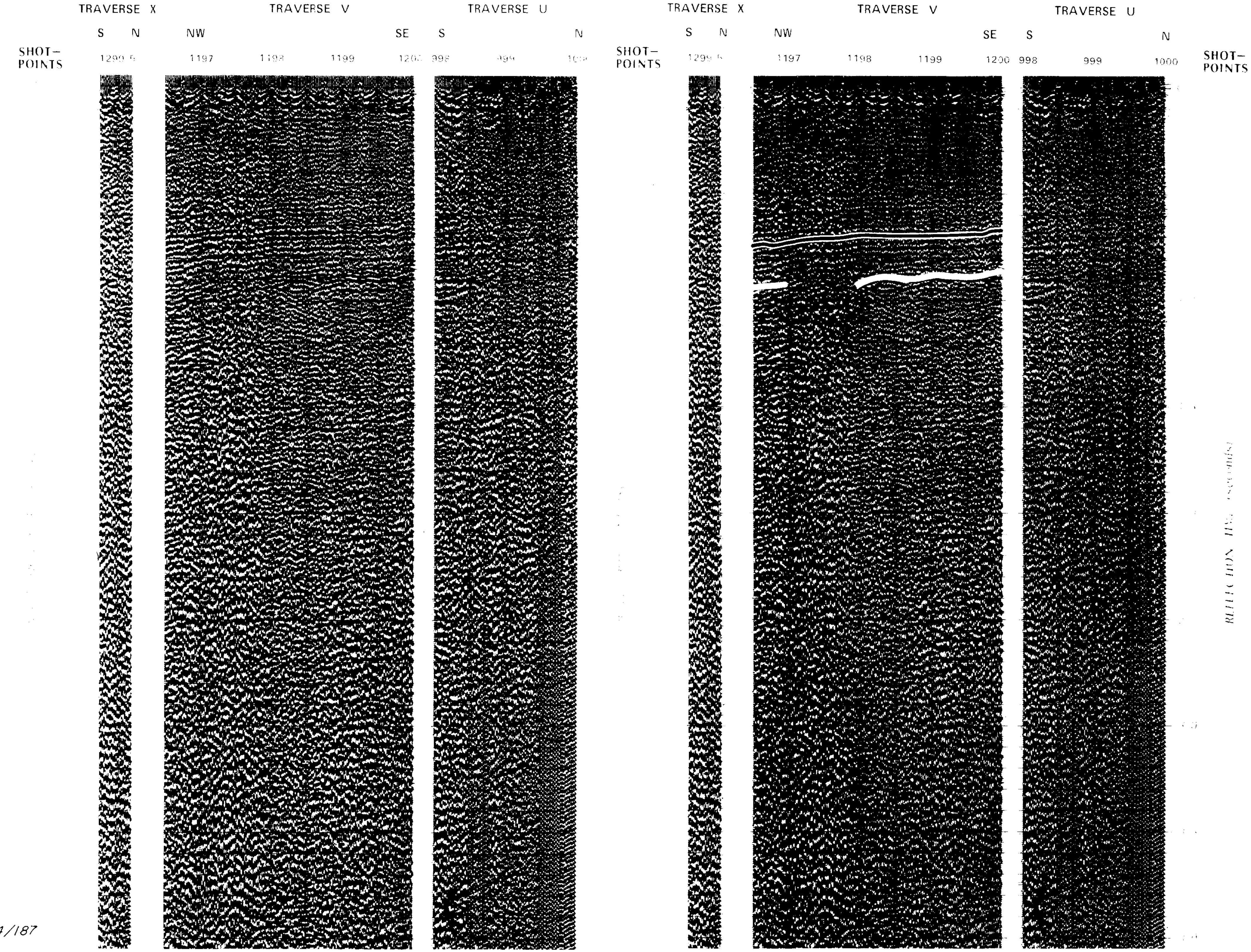
0 274 549 823 1000 metres

EAST OTWAY BASIN SEISMIC SURVEY, 1967 TRAVERSES S AND Q

Record No 1974/197

J55/B3-39

CORRECTED RECORD SECTION



RECORDING INFORMATION

Magnetic recorder DS7 7
Amplifiers 8000 TI Explorer
Prefilters Nil
Filters K14 K125
AGC Medium
Geophones EVS 2B 20 Hz
Geophone station interval 22 8 m
Geophone pattern
24 trace in 2 rows of 12 in line
Rows 6 7 m apart
Geophones 3 m apart
Shot hole pattern
Varied

PLAYBACK INFORMATION

Filters 1 31 1 78
AGC S
Compositing Nil

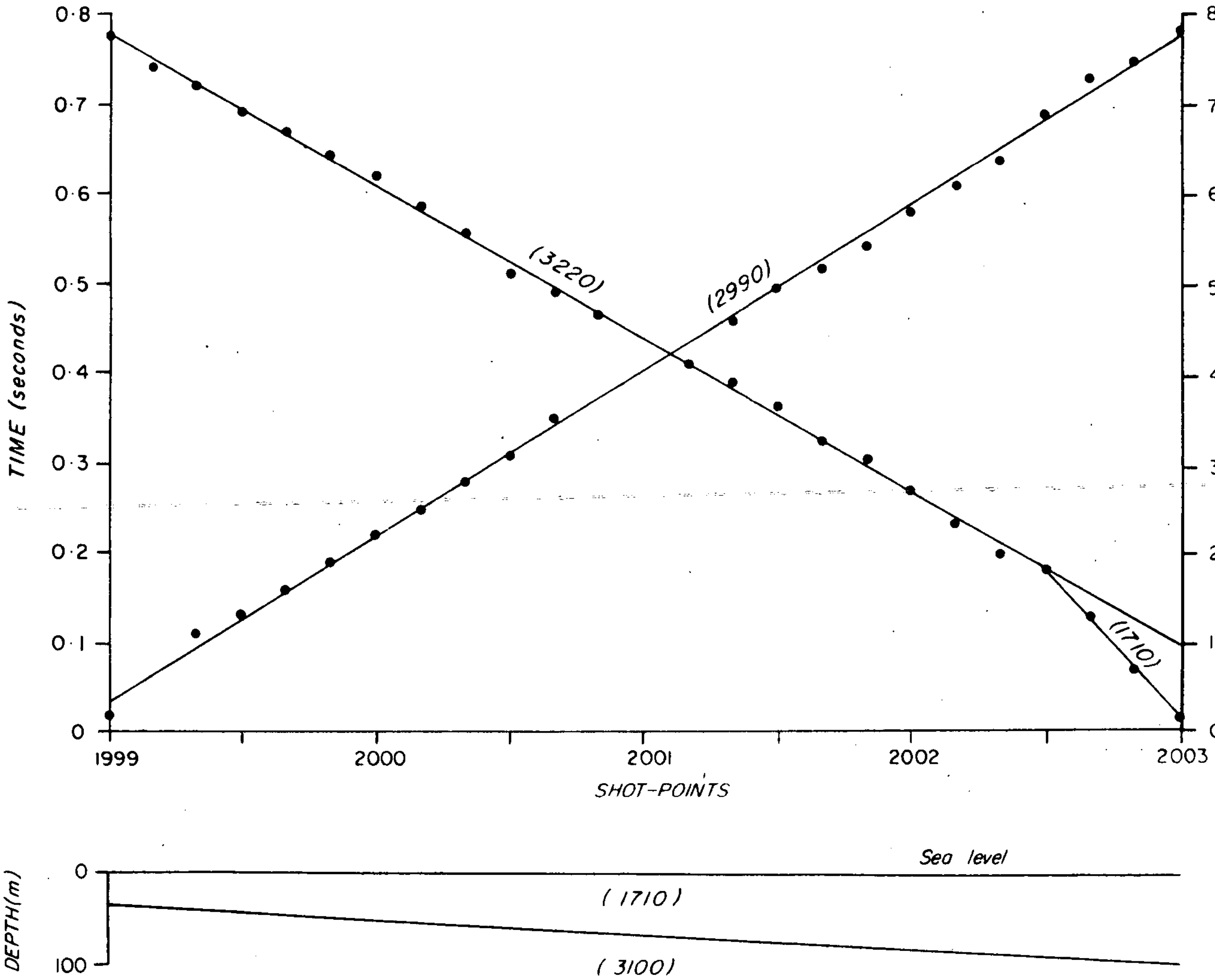
VELOCITY INFORMATION

t Δt analysis

HORIZONTAL SCALE

0 274 549 [illegible] metres

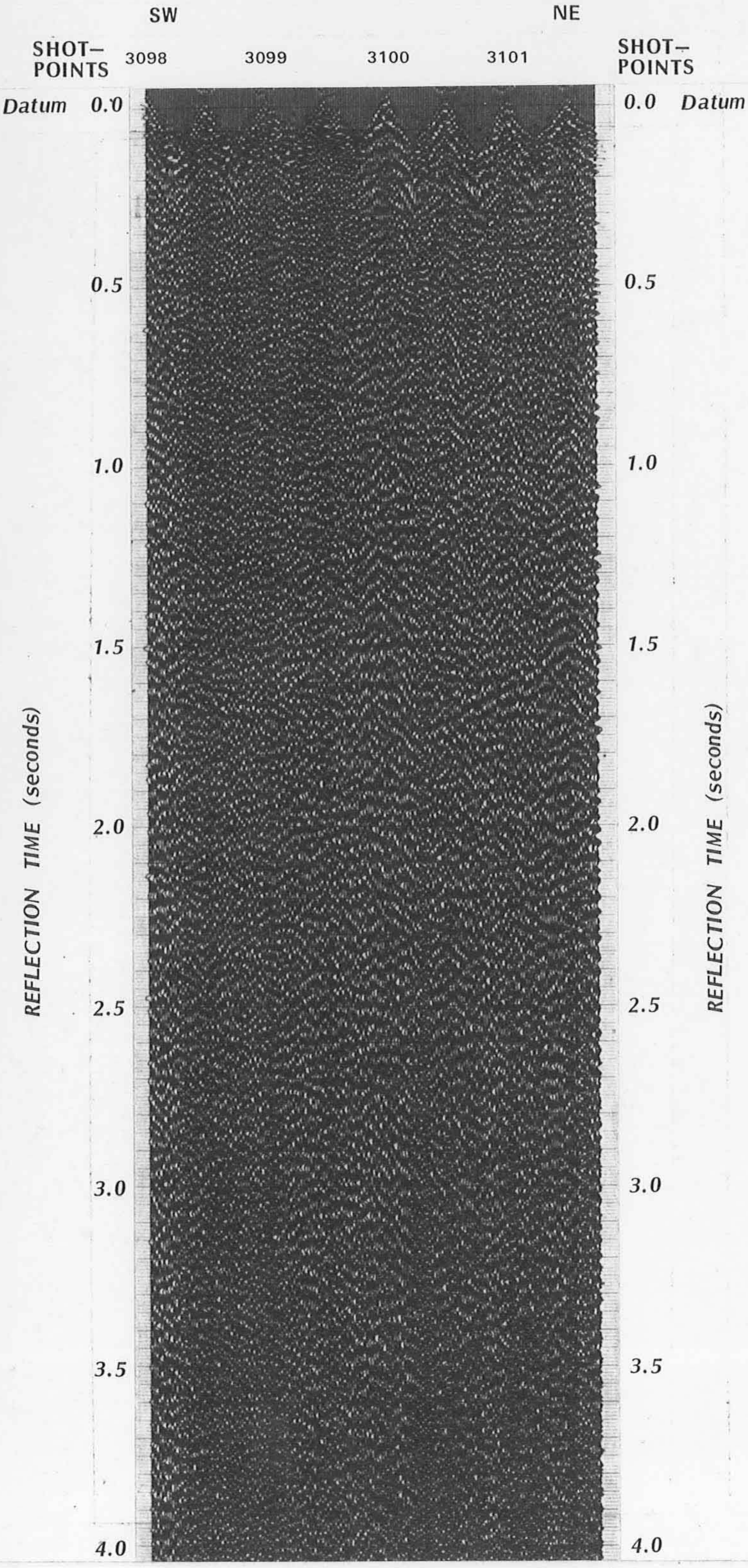
EAST OTWAY BASIN SEISMIC SURVEY, 1967 TRAVERSES X, V AND U



(1710) Velocity in m/s

200	0	200	400	600	METRES
	0	274·5		549	FEET

REFRACTION PLOT TRAVERSE W



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic recorder: DS7–7
Amplifiers : 8000 TI Explorer
Prefilters: Nil
Filters : K14–K125
AGC : Medium
Geophones : EVS 2B, 20 Hz
Geophone station interval: 22.8 m
Geophone pattern:
24/trace in 2 rows of 12 in line
Rows 1 m apart
Geophones 3 m apart
Shot–hole pattern:
Varied

PLAYBACK INFORMATION

Filters: 1/20–1/60
AGC : S
Compositing: Nil

VELOCITY INFORMATION

t:Δt analysis

HORIZONTAL SCALE

0 274 549 823 1000 metres

EAST OTWAY BASIN SEISMIC SURVEY, 1967 TRAVERSE R

Record No. 1974/187

J55/B3-38A