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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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Record 1979/5

A REVIEW OF PETROLEUM EXPLORATION AND PROSPECTS IN THE BASS BASIN

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C.S. Robertson, E. Nicholas and K.L. Lockwood

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CONTENTS

ABSTRACT

Petroleum exploration carried out in the Bass Basin up to October 1976 has been reviewed to provide a current assessment of knowledge of the basin, and to determine the need for future exploration.

The Bass Basin is located on the continental shelf in Bass Strait between the Australian mainland to the north and Tasmania to the south. It is flanked on the northeast by the Kent Group and Flinders Island and on the west by King Island.

The basin contains sediments of Early Cretaceous to Late Tertiary age, the deepest well having been terminated in Early Tertiary strata at 3692 m.

Early Cretaceous to Late Eocene fluvio-deltaic sediments were derived mainly from a southern provenance. Late Eocene and Oligocene marine sediments are mainly fine-grained clastics deposited during a marine transgression from the northwest. Open marine conditions were established during the Miocene, and the Late Tertiary sequence consists mainly of calcarenite and calcareous mudstone.

Development of the Bass Basin appears to have been initiated in the Early Cretaceous during the continental break-up which resulted in the separation of Australia from Antarctica. The major structural deformation occurred during the Early Cretaceous to Early Eocene, but the detailed structure at the deeper levels is still unknown over most of the basin area. Extensive volcanic activity occurred during most of the basin's history.

Seventeen wells have been drilled to date, six of which encountered hydrocarbon shows in the Late Cretaceous to Late Eocene Eastern View Coal Measures. Of these, latter gas in the Pelican structure was the most significant. Drilling results have indicated that the Paleocene and Early Eocene sediments in the Eastern View Coal Measures comprise the most prospective sequence in the basin. However good basinwide structural control is lacking at these levels because of the difficulty experienced in obtaining good quality seismic data from below the coals which overlie them.

Further evaluation of the hydrocarbon potential of the Bass Basin is dependent on the use of the most advanced seismic reflection surveying techniques to improve the resolution of the prospective horizons below the coals in the upper part of the Eastern View Coal Measures.

INTRODUCTION

This review is a summary of the geology, geophysics, and petroleum exploration and prospects, in the Bass Basin. The basin is located mainly offshore in Bass Strait in Victorian and Tasmanian waters. The sedimentary fill ranges in age from Early Cretaceous to Tertiary but the bulk of the sediments was deposited during the Tertiary. The Bass Basin covers an area of about 65 400 km^2.

This summary is based on published and unrestricted unpublished information available up to October 1976. Much of the unpublished information is derived from final reports on petroleum exloration company operations subsidised by the Australian Government under the Petroleum Search Subsidy Act 1959-1973 (PSSA). Under the terms of the Act the final reports of individual geophysical or drilling operations are available to the public. Basic data from a number of unsubsidised offshore operations have also been released to the public under the provisions of the Petroleum (Submerged Lands) Act 1967-1974 (P(SL)A).

GEOLOGY

GENERAL

Knowledge of the geology of the Bass Basin has come mainly from the results of petroleum exploration which has been actively pursued since 1963 by Hematite Petroleum Pty Ltd and Esso Exploration and Production Australia Ltd on Petroleum Exploration Permits held by Hematite. Seventeen wells have been drilled, six of which were subsidised. The wells are listed in Appendix 1, and stratigraphic tables from selected wells are given in Appendix 3.

The published literature on the Bass Basin is relatively meagre. Important references used in the compilation of this chapter are Wallis (1967), Richards and Hopkins (1960), Robinson (1974) and Brown (1976). These and other references related to the basin are given in the Selected Bibliography.

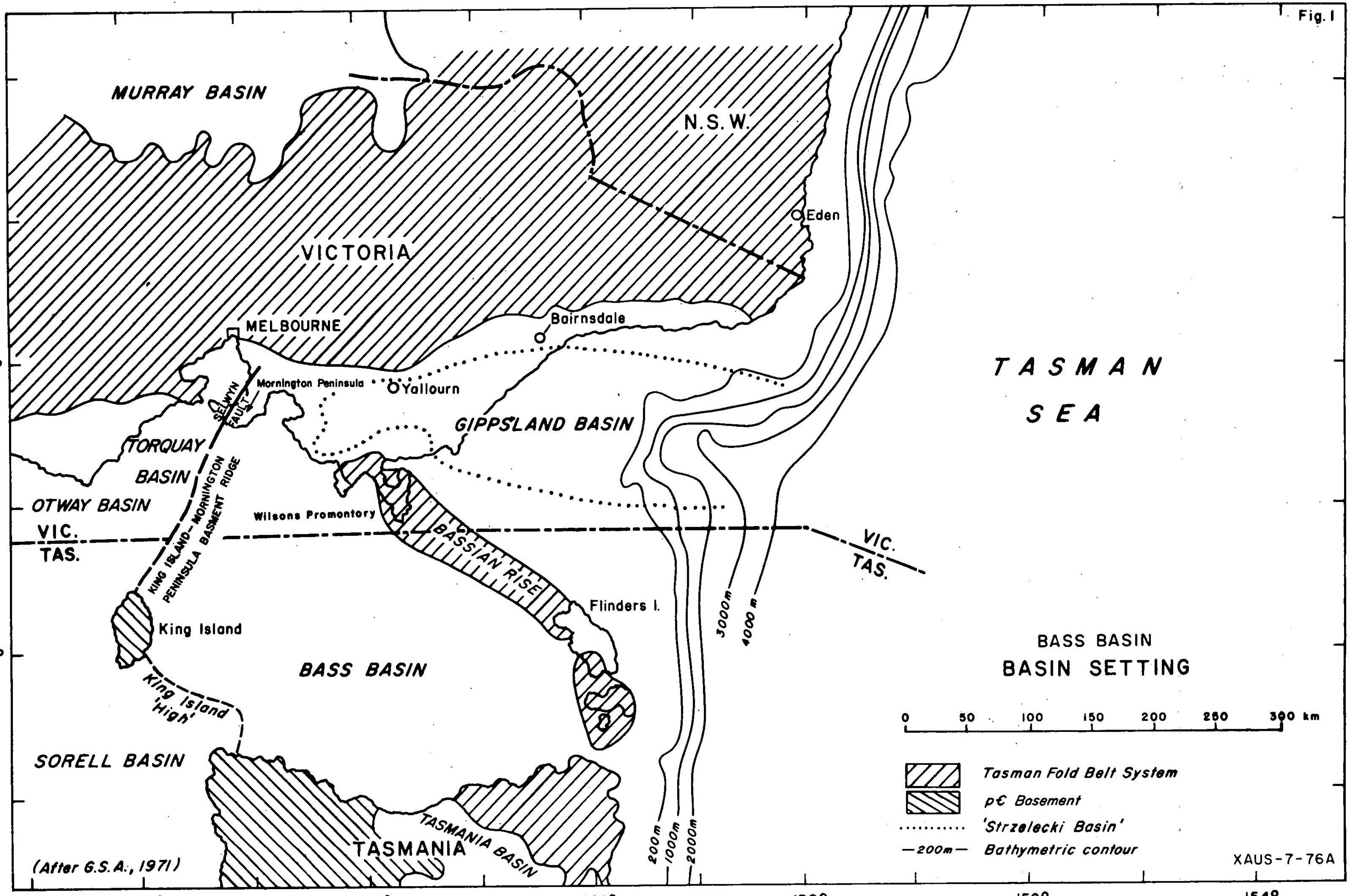
BASIN SETTING

The Bass Basin is a northwest-trending basin located on the continental shelf in Bass Strait (Fig. 1). Water depths over the topographical basin are generally between 30 and 90 m but most of the area which is prospective for hydrocarbons is covered by water deeper than 60 m. The northeastern boundary is taken as the exposed or subsea unconformable contact between basin sediments and basement rocks on the southwestern flank of the Bassian Rise (Fig. 1), ov the crest of the rise where the sediments extend over it into the Gippsland Basin. The southwestern boundary is a basement ridge known as the King Island 'High' which is overlain by a thin sedimentary sequence and which separates the Bass Basin from the Sorell Basin (King Island Sub-basin) (Robertson and others, 1978). Another basement ridge extending from King Island to Mornington Peninsula separates the northwestern part of the Bass Basin from the Torquay Basin and the Otway Basin, although during the Tertiary sedimentation was continuous across this ridge. A fault which forms the northwestern boundary of the basement ridge is probably a seaward extension of the onshore Selwyn Fault (Taylor, 1966). The southern boundary of the basin is an unconformable contact between basin sediments and basement which lies close to the northern coast of Tasmania. The northern boundary is ill-defined, but is here taken as an arbitrary lifne between Mornington Peninsula and Wilsons Promontory.

GEOLOGICAL HISTORY

The Bass Basin is one of a series of late Mesozoic/Tertiary basins located along the southern Australian coastline which, in plate tectonic terms, are postulated to have developed as a result of the separation of Australia from Antarctica.

The geological history of the basin is described by Richards and Hopkins (1969), Robinson (1974), and Brown (1976). The development of the basin is related to plate tectonic theory by Griffiths (1971), Elliott (1972), Robinson (1974) and Gunn (1975).



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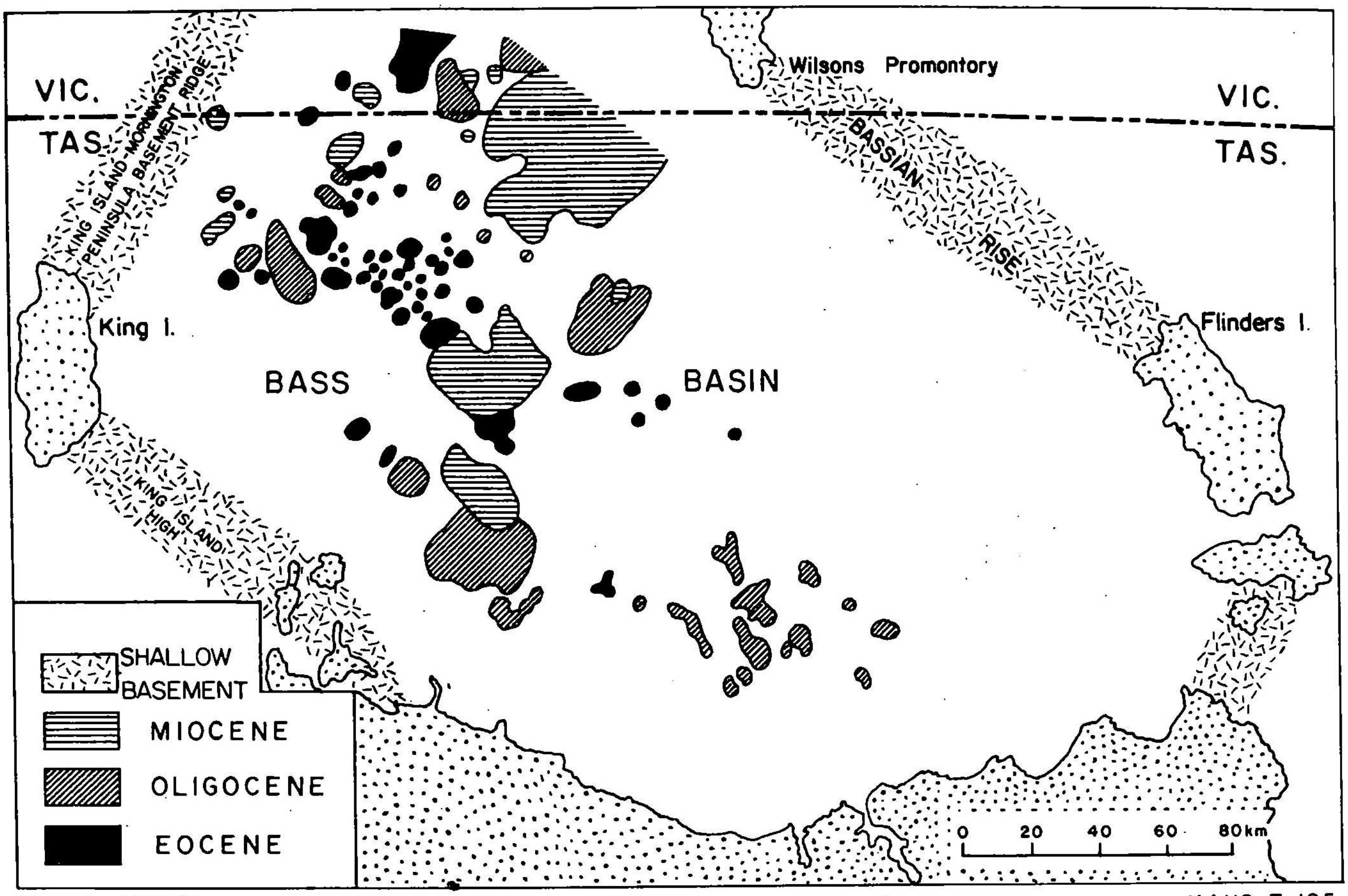
In the Early Cretaceous the basin received rapidly deposited and mainly poorly sorted sediments derived from a southern provenance. The sediments filled rapidly subsiding northwest-trending troughs produced by major fault movements in a northwest oriented tensional regime. Up to 3000 m of Early Cretaceous sediments are estimated to occur in some of these localized linear depressions.

A period of erosion was followed in the Late Cretaceous by reactivation of the Early Cretaceous structures. The distribution and nature of the Late Cretaceous sediments is poorly known, but it appears that the major provenance was to the south with subsidiary sediment sources on the Bassian Rise and the continental mass to the north. This situation continued through the Paleocene. The most southerly well (Durroon No. 1) contains a dominantly arenaceous Paleocene sequence which in the wells to the northwest becomes mainly argillaceous, with thin interbedded sands and rare thin coal seams. The Paleocene appears to have been a tectonically quiet period. Robinson (1974) interprets the basin at this time as a delta plain receiving arenaceous detritus from the south.

Similar conditions persisted into the Early Eocene with an intensification of structural movement. Although in some parts of the basin the sediments were deeply eroded at this time, over much of the area the tectonism produced no dramatic change in relief or depositional environment. Deposition continued through the Eocene with the widespread development of coal swamps which were dissected by actively downcutting streams.

The sea entered the basin from the northwest in the late Eocene, but the first widespread marine transgression was in the Oligocene. The late Eocene and Oligocene sediments are mainly fine-grained clastics laid down under restricted marine conditions. The sequence reaches a thickness of at least 750 m of which at least 600 m were deposited in the Oligocene. Open marine conditions were established in the Miocene when up to 900 m of calcareous mudstone, calcarenite and tuff were deposited conformably on the underlying sequence. In the northern part of the basin shallow-water marine to terrestrial sand, and ferruginous grit and ironstone of Pliocene age is disconformable on the Miocene strata.

Fig. 2



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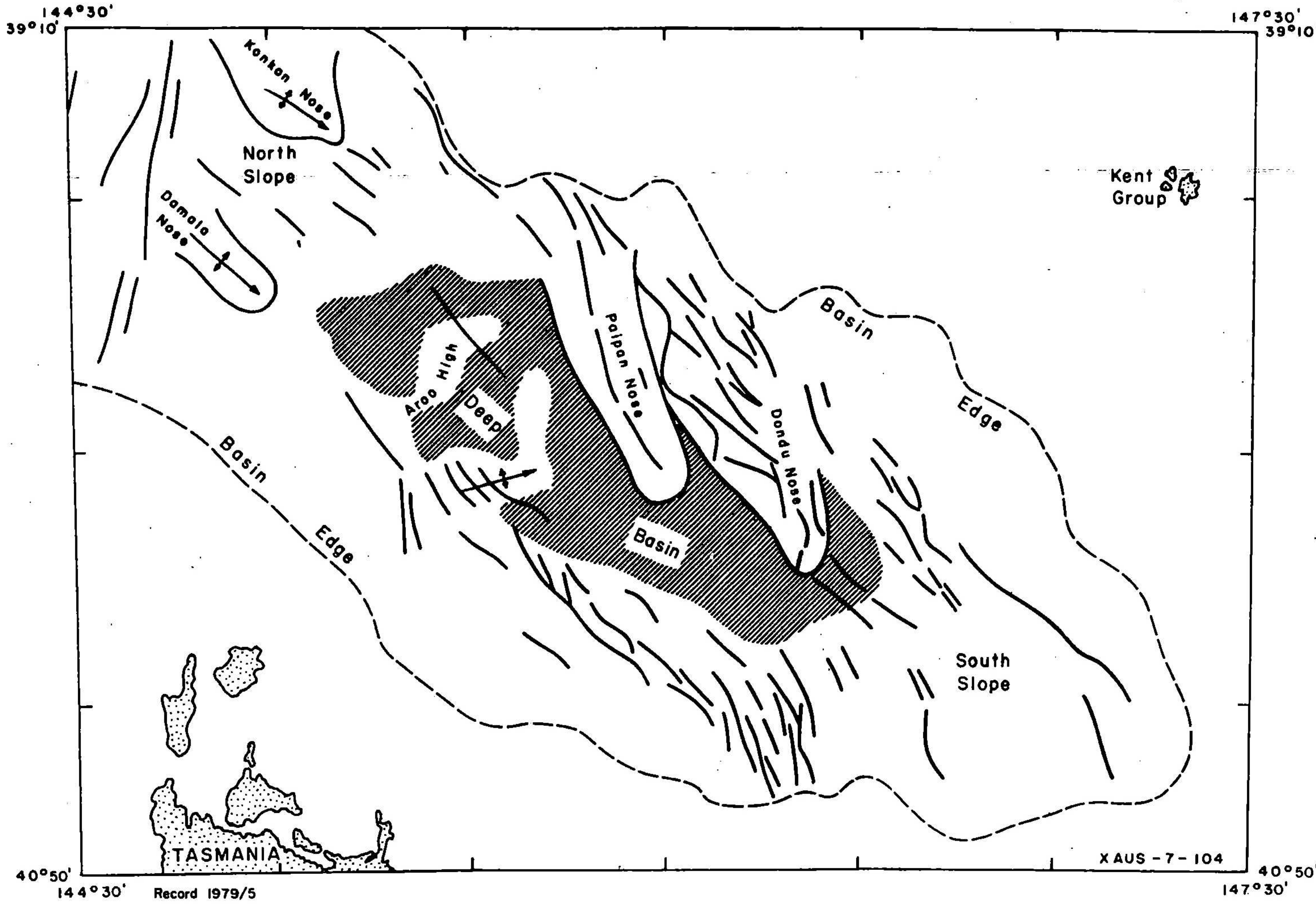
Tertiary Volcanics, Bass Basin (after Robinson 1974)

Fig. 3



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Major structural features, Bass Basin (after Brown 1976)

There was extensive volcanic activity during most of the basin's history and volcanic rocks as indicated by well data and interpreted seismic data, range in age from Late Cretaceous to Late Miocene. The distribution of the interpreted Tertiary volcanics is shown in Figure 2. The incidence of volcanic activity agrees with that reported from adjacent areas in southeastern Victoria and northern Tasmania (Joyce, 1973; Varne, 1973).

STRUCTURE

The structures observed in the Bass Basin fall into three main types (Robinson, 1974): basement-involved fault blocks with onlap and differential compaction of sediment over the upthrown blocks; faulted anticlines; and arches or folds caused by extrusive and intrusive igneous rock. The major structural trends are mainly oriented in a northwest to southeast direction parallel or sub-parallel to the present basin axis.

Three distinct structural provinces are recognised; a southeastern area where the earliest structural growth (Early Cretaceous) occurred, and central and northwestern areas where the structural growth occurred in the Early and Late Tertiary respectively. The structural style varies from tilted fault blocks with major vertical displacement in the southeastern area to low relief, small anticlines and minor faults in the northwestern area.

Brown (1976) presents the major structural elements in the Bass Basin (Figure 3) derived from a map drawn on an horizon within the upper part of the Eastern View Coal Measures (Pl. 4). These structures reflect the last major movements in the basin. By comparison a map drawn on an intra-Eastern View Coal Measures horizon shows a greater intensity of faulting and more anticlinal structures.

STRATIGRAPHY

GENERAL

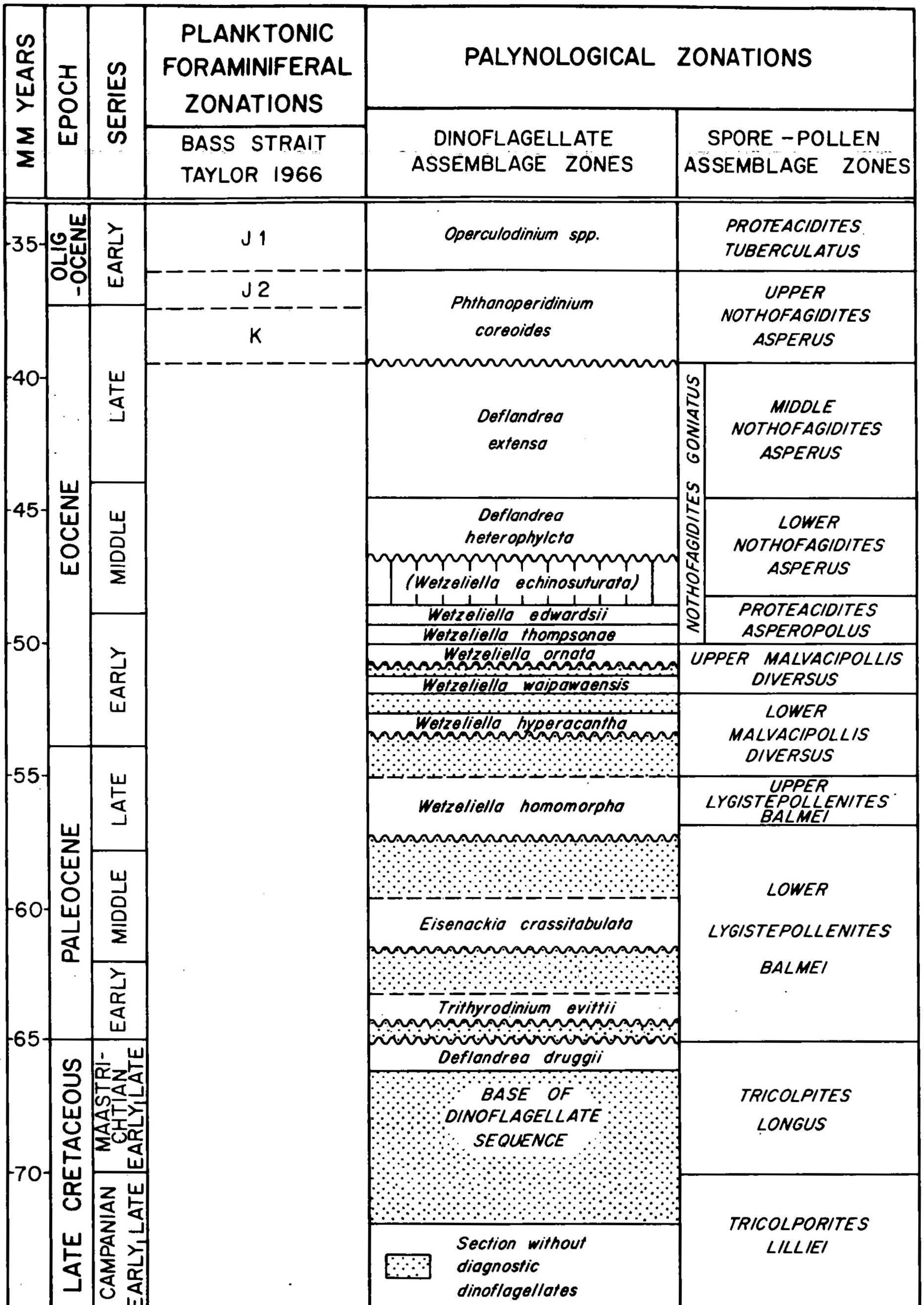
The Bass Basin contains non-marine sediments of Early Cretaceous to Late Eocene age, and a Late Eocene to Recent marine sequence.

The non-marine part of the stratigraphical succession is dated by a series of spore-pollen assemblage zones (Dettmann, 1963; Dettmann and Playford, 1969; Harris, 1970), and the marine sequence by planktonic foraminifera (Taylor in ESSO, 1966; Taylor, 1973). These zones can also be related to the time-rock units in the Otway and Gippsland Basins. Seismic markers have been identified by relating the stronger more continuous seismic events to the faunal and floral zones at the well control. Electric logs have also proved useful in the identification of certain lithological markers.

The most recent published work on the spore-pollen assemblage zones in the Bass Strait basins relates to the Gippsland Basin (Stover and Partridge, 1973; Stover and Evans, 1973; Partridge, 1976). Partridge (1976) presents the recent changes that have been made to the definition of zones and gives the latest correlation of the zones with the Internatonal Geological Time Scale (Fig. 4). The changes (c.f. Fig. 5) including that of the position of the Cretaceous/Tertiary boundary from the base to the top of the T. longus zone, are based on his unpublished work. Partridge also recognizes dinoflagellate assemblage zones, representing discrete ingressions of dinoflagellates and interpreted as indicative of rises in sea level. The dinoflagellate assemblages which are also recorded from the Otway Basin and New Zealand in sequences dated by flanktonic foraminifera provided the correlation with the International Time Scale. In the Bass Basin the Eocene section contains dinoflagellate zones equivalent to those recognized in the Gippsland Basin but with less diverse assemblages. Partridge attributes this difference to the more restricted access of the sea to the barred (Woolnough, 1937) Bass Basin (across the King Island to Mornington Peninsula basement ridge) compared with that to the Gippsland Basin which was open to the ocean at its eastern end from the close of the Cretaceous. Conversely the spore-pollen succession is more complete in the Bass Basin which was not affected by eustatic lows in the Early and early Middle Eocene that are represented by extensive channelling in the Gippsland Basin.

The Bass Basin sequence crops out in coastal sections in the Torquay Embayment (Raggatt and Crespin, 1952, 1955) and was penetrated offshore in Nerita No. 1 and Snail No. 1 petroleum exploration wells. The reader is referred to Abele (1976) for a detailed treatment of the stratigraphy in this area.

Fig. 4



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Correlations of planktonic foraminiferal and palynological zonations of the Gippsland Basin with the Geological Time Scale

(After Partridge, 1976)

The main stratigraphic units recognised in the Bass Basin are the Jurassic and Early Cretaceous Otway Group, the Late Cretaceous to Late Eocene Eastern View Coal Measures (Eastern View Group in ESSO terminology (Robinson (1974)), the Late Eocene to Oligocene Demons Bluff Formation, the the Oligocene to Pliocene Torquay Group. All these units were formally named in the Otway Basin.

JURASSIC - EARLY CRETACEOUS

Otway Group The Otway Group has not been completely penetrated in the Bass Basin or offshore in the Torquay Basin. In the latter basin Nerita No. 1 intersected the Group at 1428 m subsea and penetrated 580 m, and Snail No. 1 intersected it at 875 m subsea and penetrated 349 m. In Snail No. 1 the sequence consisted of lithic kaolinitic sandstone interbedded with carbonaceous siltstone. Onshore in the Torquay Basin, Fergusons Hill No. 1 well (38°37'20", 143°09'41") intersected the Otway Group lying unconformably on steeply dipping rocks of presumed Silurian age.

In the Bass Basin only two wells have intersected the Otway Group. Konkon No. 1 in the northwest penetrated 40 m of lithic sandstone interbedded with weathered volcanics which is tentatively assigned to the Group on lithological evidence only. Durroon No. 1 in the southeast penetrated more than 1200 m of interbedded lithic sandstone and siltstone containing rare thin conglomerate beds and thin coal seams. The palynological evidence indicates that the upper 16 m of this sequence is of Late Albian age and the underlying part Late Aptian. This suggests the possibility of a stratigraphical break. Early Cretaceous microfloras have also been identified in Snail No. 1 and Nerita No. 1.

Late Cretaceous - Late Eocene

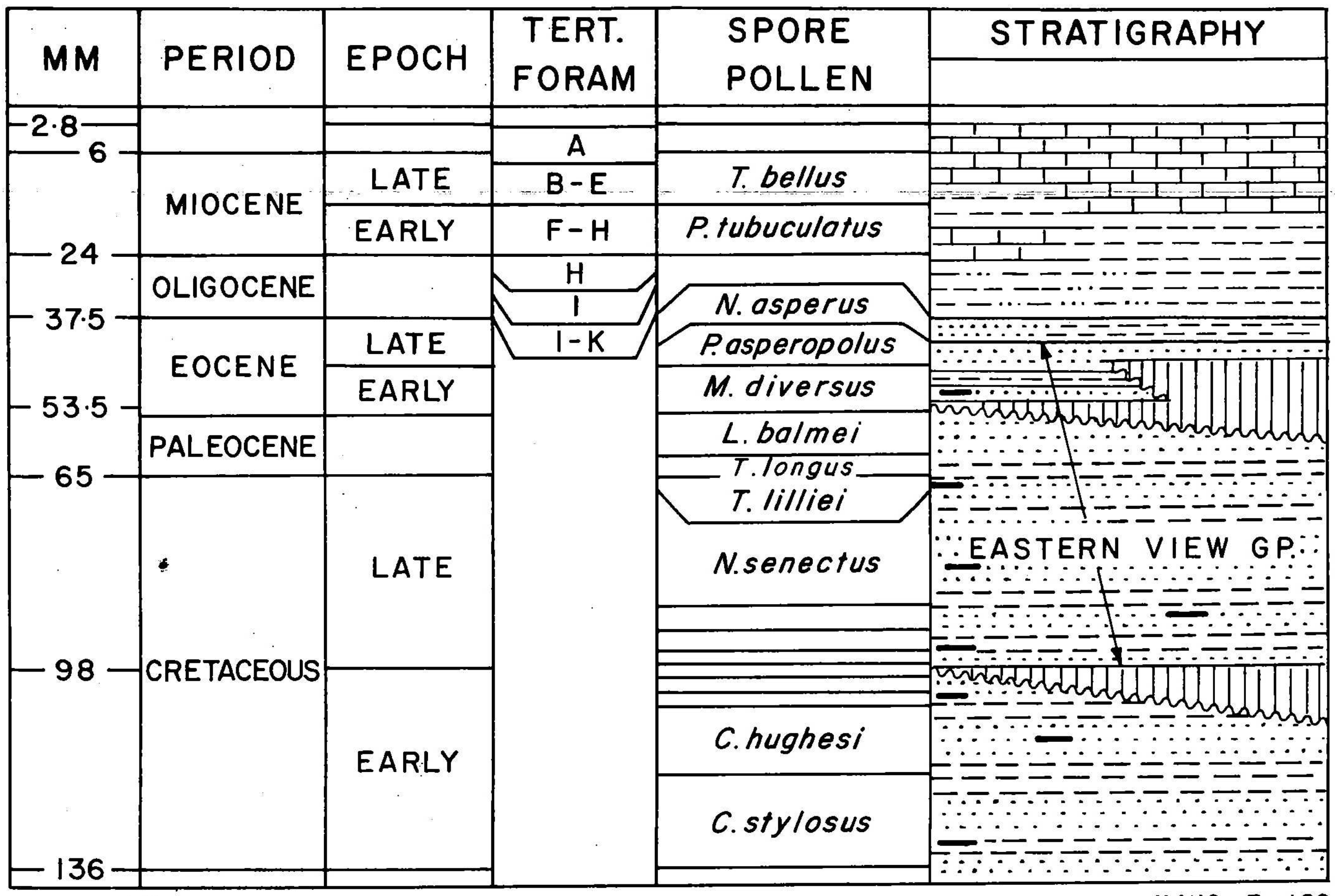
Eastern View Coal Measures The Eastern View Coal Measures were formally defined onshore in the Torquay Basin (Raggatt and Crespin, 1952; 1955). Two sections near Eastern View with a combined thickness of 90 m were designated type sections. The same authors also defined a sandstone unit, the 'Boonah Sandstone' between the Eastern View Coal Measures and the overlying Demons Bluff Formation. Edwards (1962) regarded the coal measures and the sandstone unit as one formation which was designated the Eastern View Formation (Abele, 1968a & b). Offshore, in the Bass Basin Robinson (1974) and Brown (1976) also recognise a sandstone sequence at the top of the Eastern View Coal Measures. Robinson prefers the use of the term 'Eastern View Group' in this area but Brown retains the original terminology which will also be used in this review. The following description of the Eastern View Coal Measures is based on the work of these two authors.

The Eastern View Coal Measures have been traced on seismic sections from the Torquay Basin across the 'King Island to Mornington Peninsula Ridge' into the Bass Basin where they are estimated to reach about 3000 m in thickness. On the basin margins the unit rests unconformably on the Otway Group in Konkon No. 1 and Durroon No. 1, and on basement in Bass No. 3 (Fig. 8). The base of the Eastern View Coal Measures is difficult to trace on seismic sections for any great distance from the well control. Consequently the nature of the lower contact is unknown over a large part of the basin.

Late Cretaceous sediments have been identified in the Bass Basin only in Durroon No. 1 in the southeast, where the sequence consisted of 335 m of carbonaceous shale overlain by 240 m of coarse-grained sandstone interbedded with thin shale. The age of this sequence ranges from Maestrichtian (C. distocarinatus zone) to Cenomanian (T. lilliei zone). It is seen on seismic sections to thicken down-dip from the well to 2500 m in a fault-controlled trough. In the Torquay Basin a Late Cretaceous sequence was identified in Nerita No. 1, comprising 120 m of interbedded fine to coarse-grained sandstone, carbonaceous siltstone and carbonaceous mudstone.

Paleocene sediments have been identified in twelve of the seventeen wells drilled. The L. balmei palynological zone was completely penetrated in Durroon No. 1, Poonboon No. 1 and Bass No. 3. In the latter two wells the lowermost Paleocene Zone, Tricolpites longus, was also identified. Poonboon No. 1 which is located near the centre of the basin penetrated the thickest Paleocene sequence of 620 m. The generalised lithology of the Paleocene

Fig. 5



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Stratigraphic chart, Bass Basin (after Robinson, 1974) sequence consists of interbedded sandstone, siltstone and shale with minor thin coal seams and exhibits a broad facies change from dominantly arenaceous in the southeast to dominantly argillaceous in the northwest.

Early Eocene sediments are lithologically similar to the Paleocene sequence. They are divided into the Lower and Upper M. diversus palynological zones. On earlier palynological zonation (Figure) the base of the Lower M. diversus zone was considered to be the base of the Eocene. However on the new zonation (Figure 4) this zone spans the Paleocene/Eocene boundary. In the Bass Basin there is evidence in some areas of an unconformity of this level. Early Eocene sediments were absent in Durroon No. 1 in the southeastern part of the basin. The well intersected Late Eocene sediments of N. asperus zone age resting unconformably on the Paleocene (L. balmei zone) sequence. In the southern part of the basin the lower M. diversus zone thins from 660 m in Pelican No. 1 to 130 m in Pelican No. 3 located 9 km to the northeast. This zone was 30 m thick in Bass Nos 1 and 3 on the northeastern and southwestern margins.

The upper M. diversus zone exhibits less variation in thickness than the lower zone. The thickest section intersected was 540 m in Cormorant No. 1 but it may reach 1000 m. This unit characteristically contains a higher percentage of coal than any other unit in the Eastern View Coal Measures. Aggregate sections of coal commonly reach a thickness of 60 m, and an individual seam over 25 m thick was penetrated in Dondu No. 1. Linear Sand bodies channel into older sequences and comparison of Bass No. 2 with Bass No. 3 indicates that fewer coal seams are developed on the western than the eastern side of the basin. Facies change makes correlation of individual lithological units difficult even between closely spaced wells.

Middle and Late Eocene sediments of the Eastern View Coal Measures are also distinguished from the underlying sequence on palynological rather than lithological evidence. A maximum thickness of 560 m was intersected by Cormorant No. 1. In the lowermost zone, (P. asperopolus) which spans the Early and Middle Eocene boundary (Figure), coal decreases up the sequence, and the proportion of sandstone in the section increases. The overlying N. asperus zone spans the boundary between the Eastern View Coal Measures and the overlying

Demons Bluff Formation; the boundary being marked by a lithological change from sandstone to shale which is readily distinguishable both on electric logs and seismic sections.

The depositional environment for the Eastern View Coal Measures in the Bass Basin is interpreted as predominantly a delta plain with progradation towards the northwest, and the possibility of a shallow marine incursion from the northwest beginning in the Early Eocene.

Late Eocene-Oligocene

Demons Bluff Formation The Demons Bluff Formation was defined onshore in the Torquay Embayment (Raggatt and Crespin 1952; 1955) as the sequence of sedimentary and volcanic rocks between the top of the Boonah Sandstone and the base of the Jan Juc Formation. Three members: Anglesea Siltstone Member; Addiscott Greywacke Member; and Angahook Member were recognised. However, Abele (1976) grouped the Anglesea Siltstone Member and the Addiscott Greywacke Member into one unit, the Anglesea Member, as was suggested by Edwards (1962), Singleton (1967), and Abele (1968a & b). Typical exposures of the Anglesea Member occur in the coastal cliffs northeast of Anglesea. The contact with the underlying Eastern View Coal Measure is not exposed but where penetrated in bores appears to be conformable and may be gradational. Lithologically, the Anglesea Member is a homogeneous unit described by Abele (1976) as 'brownish black to brownish grey, carbonaceous, pyritic clayey silt to fine sand and silty clay, with abundant paler burrows filled with silt or fine sand, and darker more carbonaceous and clayey streaks'. At Anglesea the unit is about 180 m thick. The Angahook Member by contrast is a lithologically variable unit containing (Abele, 1976) 'basalt, tuff, lapilli tuff and tuff breccia, tuffaceous sediments, quartz sand and gravel, sandy clay and clay'. The type locality is Soapy Rocks at Anglesea. The unit is not laterally extensive, and is mappable only along some parts of the coast. Basalt from an exposure at Aireys Inlet was dated as Late Oligocene - 26.5 to 27 m.y. (Abele and Page, 1974).

In the offshore Torquay Basin the Demons Bluff Formation was 277.8 m thick in Nerita No. 1 and 135.9 m thick in Snail No. 1. Both the Anglesea and Addiscott Members were recognized in the Nerita well, but only the Anglesea Member in Snail No. 1 (Appendix 3).

In the Bass Basin, the Demons Bluff Formation is represented by a lithologically homogeneous shale and siltstone sequence (Appendix 3) which is conformable on the Eastern View Coal Measures and can be traced on seismic sections from the Torquay Basin over the 'King Island to Mornington Peninsula Ridge' where much of the upper part of the sequence has been eroded off.

The lithological uniformity of the formation in the wells is demonstrated in Appendix 3.

Sandstone is rare even in wells located on the basin margins, the only notable sandstone development being in Durroon No. 1. The well sections are dated as Late Eocene (upper to middle N. asperus zone) and foraminifera of the Eocene to Oligocene K and J Zonules have been identified.

OLIGOCENE - PLIOCENE

Torquay Group Raggatt and Crespin (1952, 1955) defined the Torquay Group onshore in the Torquay Basin. It contains two formations, the lower Jan Juc Formation and the upper Puebla Formation. Abele (1970) expanded the definition of both formations and the reader is referred to Abele (1976) for a detailed treatment of the Torquay Group in the Torquay Basin.

The Jan Juc Formation in the type locality at Bird Rock near Torquay consists of interbedded glauconitic marl and glauconitic calcarenite. Further to the southwest the upper part of the formation is represented by the Point Addis Limestone. Although local unconformities occur, particularly with the Angahook Member, the relationship of the Jan Juc Formation with the underlying Demons Bluff Formation is conformable. The fauna includes the pelecypod Glycimeris (Grandaxinea) ornithopetra (Chapman and Singleton) and the echinoid Duncaniaster australiae (Duncan). The foraminifera indicate that in the onshore area the age of the Jan Juc Formation is late Oligocene to very early Miocene.

Offshore in the Torquay Basin the formation was 132.3 m thick in Nerita No. 1 and 193.2 m in Snail No. 1. In Nerita No. 1 the sequence comprises interbedded marl and calcarenite, glauconitic except in the bottom 18 m where pyritic shale is common. The fauna comprises pelecypods, gastropods, bryozoans, echinoids and foraminifera. The Point Addis Limestone Member is 39 m thick, composed mainly of bryozoan, pelecypod, gastropod and echinoid fragments with minor calcareous clay, silt, and marl. The sequence in Snail No. 1 consists of glauconitic claystone and marl interbedded with siltstone, sandstone, and calcarenite.

The Puebla Formation onshore consists mainly of argillaceous sediments (clayey calcareous silt) containing thin limestone beds and discontinuous layers of carbonate concretions. The sequence contains ferruginous burrows, pyrite concretions, gypsum, gastropods and pelecypods.

Several calcareous units characterised by bryozoal limestone (Cellepora Beds, Zeally Limestone, Yellow Bluff Beds) have been recognized in various localities.

Offshore in the Torquay Basin Nerita No. 1 and Snail No. 1 both spudded in the Puebla Formation (Appendix 3).

The Torquay Group onshore reaches a thickness of 103 m (Raggatt and Crespin, 1956) and increases to 636 m in Nerita No. 1 and 557 m in Snail No. 1 offshore in the Torquay Embayment and to 1650 m in the centre of the Bass Basin at Poonboon No. 1.

Equivalents of the Jan Juc and Puebla Formations are recognized in the Bass Basin but the names are not formally applied. The Torquay Group comprises a lower argillaceous section which may be up to 650 m thick and ranges in age from the J to the E foraminiferal zone. This is overlain by a limestone sequence ranging in age from the D to the A foraminiferal zone. The limestone may be up to 760 m thick and is the stratigraphic equivalent of the Gippsland Limestone in the Gippsland Basin and the Port Campbell Limestone of the Otway Basin. Conclusions about the detailed lithological character of the Torquay Group in the Bass Basin are based mainly on electrical log character, the samples collected during drilling being difficult to correlate accurately because of contamination due to rapid penetration rate and cavings. The argillaceous section has been shown to be thinly bedded with many distinctive units that can be easily correlated in the central area of the basin. Volcanic sequences show up on seismic sections on a number of horizons in the Torquay Group.

GEOPHYSICS

Because the basin lies entirely offshore, geophysical methods have played an important role in the exploration of the Bass Basin. Brown (1974) has briefly described the exploration history. The delineation of a large basin containing prospective thicknesses of sediment was achieved by aeromagnetic surveying in 1961, and from 1962 seismic surveys have proceeded more or less annually until 1975. Survey objectives advanced, as the density of seismic coverage increased, from mainly reconnaissance, up to 1967, to semi-detailing and drilling target delineation in the later years.

In this section we describe the important geophysical surveys, and their results.

MAGNETIC SURVEYS

The locations of traverses from five magnetic surveys in the Bass Basin are indicated on Plate 1. The most extensive of the surveys, and the first to be undertaken, was the Bass Strait and Encounter Bay aeromagnetic survey. It was flown in 1961 for Haematite Explorations and had as its main objective the mapping of magnetic basement in the entire Bass Basin region, as well as parts of the Gippsland and Otway Basins (Haematite Explorations, 1965). The contractor for the above survey extended the operation to fly the Andersons Inlet aeromagnetic Survey for Oil Development. This survey consisted of traverses in the coastal area between Phillip Island and Wilsons Promontory.

Not shown on the plate are those widely spaced (50 to 80 km) traverses of the reconnaissance phase of the survey which were undertaken principally to locate areas of shallow basement, and to test operational procedures. Results derived from them became obsolete upon completion of the detailed flight pattern shown. A feature of the operation was the ability to introduce additional traverses, or extend existing ones, over features of interest noted during preliminary examination of the data.

Some of the traverses of BMR's Tasmania aeromagnetic survey are shown in the southern part of the plate. Full details of the work have been given by Finney and Shelly (1966). The particular survey parameters of 18.5 km traverse spacing and 3000 m flight altitude chosen for this work were selected to reduce the amplitude of anomalies arising from surface or near surface magnetic material. Under these conditions, anomalies arising from magnetic bodies deep within the crust were dominant. The results are of little direct interest to the location of prospective areas for petroleum exploration and will not be discussed here.

Other traverses shown on Plate 1 are from marine geophysical surveys. The most extensive of these was the subsidised B69A marine seismic and magnetic survey by Esso Australia in 1969, which was concentrated in the southeastern part of the basin. A single traverse of the BMR Continental Margin geophysical survey extended into the Bass Basin from the east.

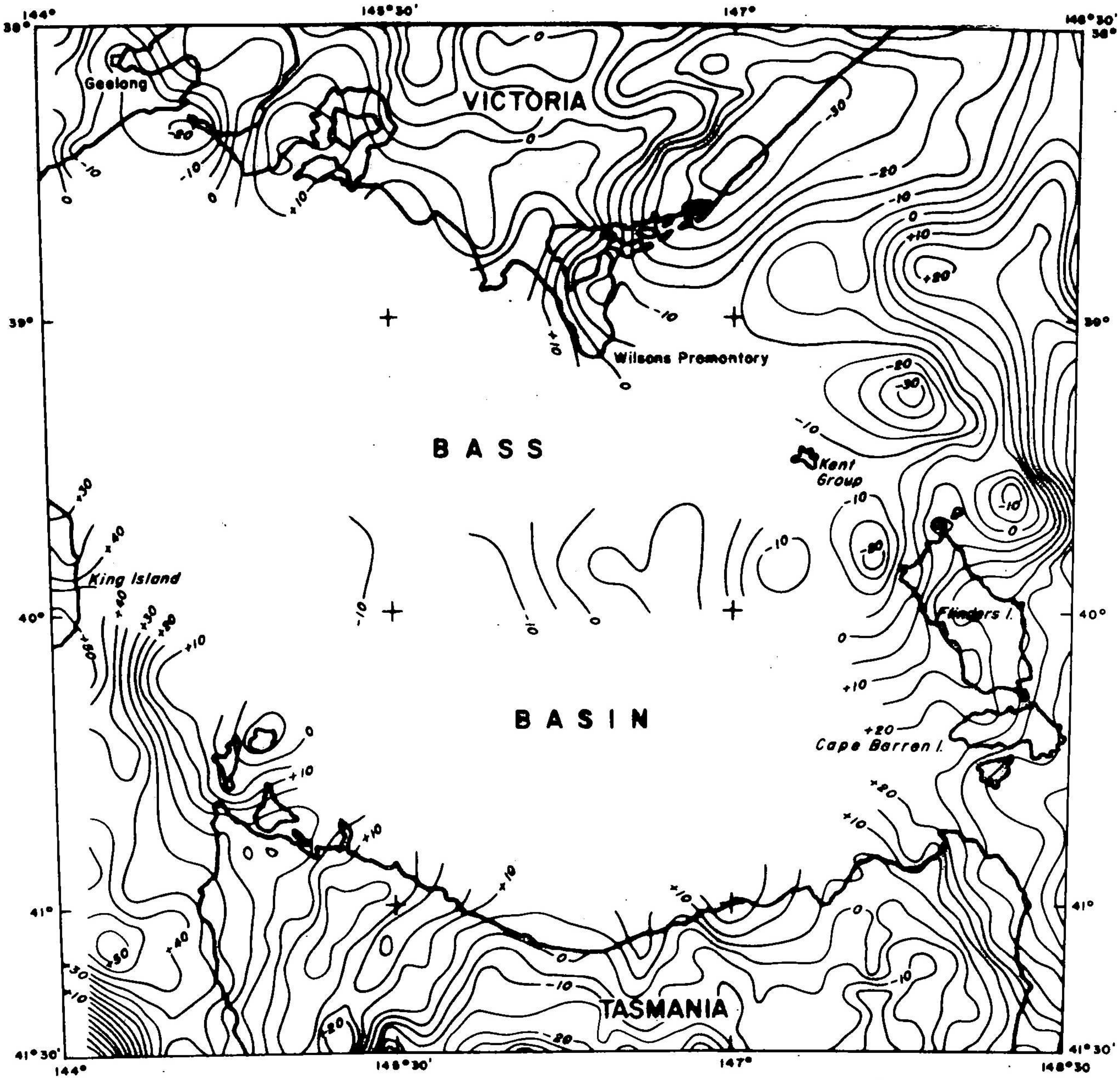
Results Plate 2 shows contours of estimated depth of magnetic basement below sea level in the central part of the basin. These are taken exclusively from the comprehensive Bass Strait and Encounter Bay aeromagnetic survey (Haematite Exploratioons, 1965). No other published depth estimates for the area are known.

It was observed during the early reconnaissance phase of the survey that the granites of the basement ridge which forms the northeastern boundary of the Bass Basin (termed the Bassian Rise) had little magnetic expression. In the southeastern part of the basin the seismic horizon identified as basement from the results of several surveys is generally much deeper and structurally far more complex than the interpreted magnetic horizon (Plate 2). It can be concluded that magnetic anomalies arise from volcanic material within the sedimentary section. Anomalies may also arise from lateral variations in magnetic susceptibility contrast (Esso, 1969).

Near the northern end of the Bassian Rise, just west of Wilsons Promontory, a change in the character of the anomalies was noted, and interpreted as arising from a change in basement rock type.

Some similarities in trend between anomalies offshore from Tasmania west of 146°30', and dolerite dykes and sills in onshore Tasmania were noted. The presence of such intrusives within basement rocks was postulated offshore.

Fig. 6



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BASS BASIN

GRAVITY ANOMALIES

1: 2 500 000

0 100 200 km

In general terms, the results of aeromagnetic surveying of the Bass Basin showed it to be dish-like in shape with the maximum depth to magnetic basement of 3500 m occurring roughly near its centre.

GRAVITY SURVEYS

There is very little gravity coverage within the Bass Basin. Gravity data were collected along the same east-west traverse of BMR's Continental Margin survey as shown in Plate 1. Gravity data are known to have been recorded along another isolated traverse near Wilsons Promontory (Riesz & Moss, 1971) but are unavailable.

Regional gravity coverage around the basin margin is reasonably complete. The mainland to the north, and Flinders and Cape Barren Islands, were covered during the reconnaissance helicopter gravity survey by BMR in 1973 and 1974. The results of this survey, and those of older more detailed surveys, have been interpreted by Zadoroznyj (1975). King Island and the northern coast of Tasmania have been covered during numerous surveys by research students of the University of Tasmania, and by the Tasmanian Geological Survey. Descriptions of some of the more recent surveys have been given by Leaman and others (1973), and Leaman and Symonds (1975).

Gravity anomalies of the region are shown in Figure 6. Near the basin centre, values in the range -10 to +5 mgal are indicated.

SEISMIC SURVEYS

The locations of seismic traverses and surveys in the Bass and Torquay Basins are shown in Plates 3a and 3b, covering the years 1962-69, and 1970-75 respectively. The surveys designated in the legends of Plates 3a and 3b are listed in the appropriate part of Appendix 2, together with information on the date of the survey, the operator, the contractor, the type of energy source used, the number of kilometres surveyed, the degree of multiple coverage and the BMR reference number.

Those surveys with reference numbers prefixed by the letters PSSA in Appendix 2 were subsidised by the Australian Government. Results and interpretations of such surveys are available to the public. Copies of final reports on subsidised surveys may be ordered through the Copy Service, Government Printer (Production), G.P.O. Box 84, Canberra. Basic data (but not interpretative data) from other surveys may be released to the public from time to time in accordance with the Petroleum (Submerged Lands) Act. Information on data released is available from the Designated Authority in the relevant state.

Seismic reconnaissance was first undertaken in the basin in 1962-63 with the aim of verifying the existence of the sedimentary basin indicated by the aeromagnetic survey discussed above, and delineating its shape and size. Although the quality of results obtained with early single-fold coverage work was only fair, these broad objectives were achieved, and structures which might form potential traps for petroleum were indicated. The deepest continuous reflection recorded was tentatively identified as the Base of Tertiary by extrapolation from an onshore drilling result. Deeper reflections were recorded in limited areas near the basin margin.

Anomalous reef-like features were detected on seismic sections from two areas. These areas were further investigated using a 6-fold CDP seismic technique and a site was selected for a well (Bass No. 1) on one of the anomalies. However, the results of drilling were disappointing; the feature proving to be a volcanic sequence.

Other structural leads were delineated by further 6-fold CDP seismic surveying during the Kind Island East survey of 1965. Multiple reflections were successfully attenuated during the processing of results. Tertiary horizons were identified from drilling data and mapped with reliability. Basement reflections were tentatively identified, again in limited areas.

Results of a seismic survey in 1966 confirmed the presence of a basement ridge in an area of shallow magnetic basement between King Island and Tasmania. This ridge forms the southwest margin of the Bass Basin.

The Eastern Bass Strait marine seismic survey in 1966 contributed further reconnaissance data over other relatively shallow basement areas to the northwest and northeast of the deep central basin. The Mornington Peninsula-

King Island Ridge and Bassian Rise were further delineated. The seismic reconnaissance grid was also extended to the southeast. Two structures on the Mornington Peninsula-King Island Ridge were mapped by another seismic survey in 1967, the last survey in the basin to use explosives as the energy source.

Beginning in 1968, significant developments which had been made in the technology of seismic exploration were applied to the Bass Basin. The 'Aquapulse' energy source, 12-fold CDP shooting, and digital recording and processing of the seismic data, were features of three surveys of the period 1968 to '69. Much of the older data was reprocessed to provide a reliable integrated interpretation of old and new data. Important advances in knowledge of the basin where achieved, including the mapping of the Pelican structure. Good quality seismic data indicated the presence in the southeastern part of the basin of more than 6 km of sediments likely to contain fault-controlled structural closures.

Since 1970 airguns have been used exclusively as the seismic energy source in the Bass Basin, in conjunction with higher multiplicities of CDP coverage. Seismic parameters which have varied since that time are airgun capacity, cable length, number of detector groups, and the degree of sophistication of data processing. Exploration objectives have included the detailing of both structural and stratigraphic leads.

Since 1973 effort has been concentrated on deeper stratigraphic levels giving weak reflections. By setting more stringent noise tolerance levels, by increasing energy input, and by applying continuous velocity analysis, some limited improvement in the resolution of deep seismic horizons was achieved. Coal horizons within the Eastern View Coal Measures limited the degree of seismic energy penetration to underlying strata. Some problems were experienced with coherent noise trains, and with velocity anomalies associated with bodies of volcanic rock.

The recent (1975) HB 75 A survey by the same operator was largely concentrated along the southeast and southwest flanks of the basin.

Regional seismic depth contours have been presented for the top of the Eastern View Coal Measures in Plate 4, at a contour interval of 100 metres. The elongate dish-like configuration of the basin is evident. Few structural closures can be discerned.

Names of some wells and structures of interest have been included in the plate as an aid to discussion of petroleum resources elsewhere in this study.

PETROLEUM POTENTIAL

The first petroleum exploration well, Bass No. 1, was drilled in the Bass Basin in 1965 following a period of geophysical evaluation by Haematite Explorations Pty Ltd with aeromagnetic and reconnaissance seismic surveys in 1961 and 1963, and a more detailed seismic survey by Esso Exploration which was completed in 1965.

Seventeen wells were drilled between 1965 and 1974, six of which were subsidised by the Commonwealth Government (Appendix 1). No commercial discoveries of hydrocarbons have been made but there were significant shows in six of the wells drilled and more minor indications in several others, all from within the Eastern View Coal Measures. Robinson (1974) and Brown (1976) discuss the hydrocarbon occurrences and the petroleum potential of the Bass Basin.

HYDROCARBON OCCURRENCES

In Bass No. 3 well 0.82 m^3 of gas and 800 cm^3 of condensate were recovered during a formation interval test (F.I.T.) at a depth of 2055 m (K.B.). The reservoir was a 15 m thick sandstone in the Paleocene L. balmei zone.

In Cormorant No. 1 an F.I.T. at a depth of 1500.6 m (K.B.) recovered 22000 cm^3 of oil from a thin sandstone in the upper part of the Eastern View Coal Measures interpreted to be in the Late Eocene N. asperus zone. Hydrocarbon shows also occurred in four thin sands between 1828 and 2347 m. On testing only 1000 cm^3 and 0.045 m^3 of condensate were recovered from 2007 m and 2345 m respectively.

In Pelican Nos 1 and 2, gas and condensate were recovered during F.I.T.'s of sandstones at various depths within the Early Eocene M. diversus zone. The greatest recovery was in Pelican No. 1 where 3.9 m^3 of gas and 6000 cm^3 of condensate were recovered from a depth of 2551 m.

In Aroo No. 1 there were indications of hydrocarbons at a number of levels within the Paleocene to middle Eocene part of the Eastern View Coal Measures, the most encouraging ones being in the older part of the L. balmei zone. Three F.I.T.'s recovered small amounts of gas.

The Paleocene to Early Eocene section of the Eastern View Coal Measures gave indications of hydrocarbons in other wells during drilling, in the form of fluorescence and cut in cores and cuttings, and of high gas readings on the well site mud logging unit. The strongest indications were in Dondu No. 1, Pelican No. 3 and Poonboon No. 1 from thin sands below 2740 m. At these depths formation waters become relatively fresher, and abnormally high pressures occur locally.

SOURCE, RESERVOIR, AND CAP ROCKS

All the hydrocarbons so far detected in the Bass Basin have been in the Eastern View Coal Measures, most commonly in the Paleocene and Early Eocene parts of the sequence. The interbedded sandstone, siltstone, shale, and coal provide source, reservoir and cap rocks. The source rock potential of the sequence is indicated by the presence of finely disseminated land plant material in the argillaceous sediments, in addition to the presence of coal beds.

Reservoir qualities in wells (PSSA) with hydrocarbon shows

In Bass No. 3 the sandstones in the Eastern View Coal Measures are generally coarse-grained to granular with porosities estimated from the formation density log ranging from 18 to 30 percent, which compares well with measured values from core analysis. Permeability was greatly reduced by abundant clay matrix and measured permeabilities were generaly between 2 and 30 md.

In Aroo No. 1, sandstones in two core samples from the zone with the best hydrocarbon indications (L. balmei) had porosities of 17.6 and 20.8 percent, with corresponding permeabilities of 0.9 and 113 md.

HYDROCARBON TRAPS

The structural style of the Bass Basin has been discussed in the first section of this review. Most of the wells have tested structural traps, and the target horizons have been at various levels within the Eastern View Coal Measures. Bass No. 1 tested a postulated Oligocene carbonate reef which proved to consist of pyroclastics.

Plate 4 shows the structures mapped on the top Eastern View Coal Measures seismic horizon.

DRILLING OPERATIONS

The results of the drilling operations will be discussed separately for four areas (Fig. 4): North Slope and Northern Flank; Southwest Flank; Deep Basin; South Slope. Detailed information will be given only for subsidised wells (PSSA).

North Slope and Northeast Flank. Konkon No. 1 encountered no significant reservoir sands in the prospective section which consisted mainly of carbonaceous shale and siltstone, and coal.

Six wells have been drilled on the northeast flank of the basin, including Bass No. 1 already referred to, which tested a postulated carbonate reef and not a structural trap. This well was the first to be drilled in the basin, and provided the first geological information. A velocity survey run in the well enabled the seismic data to be tied to stratigraphic horizons.

Bass No. 2, Yurongi No. 1, and Dondu No. 1 tested three structural traps located en echelon down-dip on the southeastern end of the northeast flank (Pl. 4); major structural growth being during the Paleocene and Early Eocene. Apart from the minor indications of hydrocarbons previously referred to in Dondu No. 1, which occurred in the L. balmei zone, the wells were all dry holes.

In the Bass No. 2 well 80 percent of the Eastern View Coal Measures comprised reservoir sands with porosities ranging to 34 percent and permeabilities to 190 md; cap rocks were poorly developed, arenaceous sediment dominating the sequence. A seismic unconformity within the M. diversus zone proved to be a sand-on-sand contact, so that although structural closure is mapped at this level there is no effective seal. Similarly the closure mapped at the top of the Eocene may not be sealed because of the development of a thick sequence (100 m) of quartzose sand at the base of the Oligocene. This compares with only 9 m in Bass No. 1 located 50 km to the west. This eastwards increase in same content is also evident in the Eastern View Coal Measures which contain 80 percent sand by comparison with 68 percent in Bass No. 1.

Toolka No. 1A and Cormorant No. 1 were located at the northwestern end of the northeast flank (Pl. 4). The Cormorant anticline is one of the younger structural features which developed in the Oligocene and Miocene at the northwestern end of the basin. The hydrocarbons encountered in this well have already been discussed; the Toolka well was dry. Esso considers that the oil in the Cormorant well may have been generated locally from within the Eastern View Coal Measures, or may have migrated upwards along faults during late Tertiary movements (Brown, 1976).

Southwest Flank The Pelican field which is the only hydrocarbon discovery to date considered to have possible commercial potential is located in this area, together with Bass No. 3 and Narimba No. 1. The Narimba well was dry, but gas shows, already discussed, were encountered in Bass No. 3 - one of the earliest wells drilled in the basin, to establish the stratigraphy and petroleum potential of the sediments on the southwest flank. It was located on a northwest-trending anticline developed from basement through strata of Early to Middle Miocene age. Closure is partly dependent on a fault along the southern flank. Seismic data indicate that the gas sand was penetrated at its structurally highest point. The gas probably occurs in a small reservoir trapped beneath an impermeable shale at the apex of the structure.

Narimba No. 1 tested a closed anticline, on trend and to the northwest of the Pelican structure. The two structures are separated by a small, possibly fault-controlled saddle; the major structural growth was during the Early Eocene and no closure is mapped at the top of the Eastern View Coal Measures. Narimba No. 1 penetrated the stratigraphic section equivalent to the hydrocarbon-bearing sequence in Pelican Nos 1 and 2 but there were no indications of hydrocarbons although good quality reservoir sandstones and interbedded shale cap rock were present. In the well completion report the Company attributes the lack of hydrocarbons to the limited migration of fluids in this part of the basin and the inadequate size of the palaeo-drainage area of the prospect. The high pressure zone below 2800 m in Pelican No. 2 was not encountered in the Narimba well.

Deep Basin Nangkero No. 1 and Poonboon No. 1 were located about 10 km apart at the southeastern end of the Deep Basin on structures which developed during the deposition of the lower Eastern View Coal Measures and exhibit no closure on the top Eastern View Coal Measures seismic horizon (Plate 6). The only hydrocarbons detected were the shows in Poonboon No. 1 referred to previously. Tarook No. 1 which was located about 23 km to the northwest of Poonboon No. 1 was also a dry hole, but in this case the well was drilled on a younger structure with closure on the top Eastern View Coal Measures seismic horizon.

In Nangkero No. 1 sandstone beds with good reservoir potential made up 48 percent of the Eastern View Coal Measures. However the beds were thicker and more numerous in the upper part (N. asperus and P. asperopolus zones), while the sands in the target section (M. diversus and L. balmei zones) were thinly interbedded with siltstone, coal and shale although porosity (25-30 percent) was higher, and clay matrix content lower than in the upper sands. The thinly interbedded nature of these sands may have precluded migration of hydrocarbons into the Nangkero area.

South Slope The only well drilled on the South Slope is Durroon No. 1 which was located on a fault block in which structural growth occurred in the Early to Middle Cretaceous. The Early Cretaceous sequence which was intersected at 1508 m (below M.S.L.) comprised shale, coal, siltstone and sandstone. The sandstone has low porosity and permeability due to clay matrix and abundant sub-angular lithics. The overlying Late Cretaceous and Tertiary sequence including the Late Eocene shale (Demons Bluff Formation equivalent) and Oligocene and Miocene clays, siltstone and marl encountered in other wells in the basin, consists mainly of coarse-grained sandstone in Durroon.

There were no indications of hydrocarbons in the well. This is to be expected in the Tertiary and Late Cretaceous sequence which lacks structural closure and sealing cap rocks. In the Early Cretaceous sequence the sandstones have poor reservoir characteristics although adequate structural closure is present.

Recent Exploration Activity

The Hematite/Esso partnership has drilled no wells in the Bass Basin since 1974, and carried out no geophysical work since January 1976. In 1976, the companies surrendered 90 blocks of the acreage held in T/6P (Fig. 7) and retained an area of 64 blocks which includes the Pelican field. In T/3P one of the two northern permits, 86 blocks of the acreage held were relinguished in August 1976. This reduced the acreage to 85 blocks.

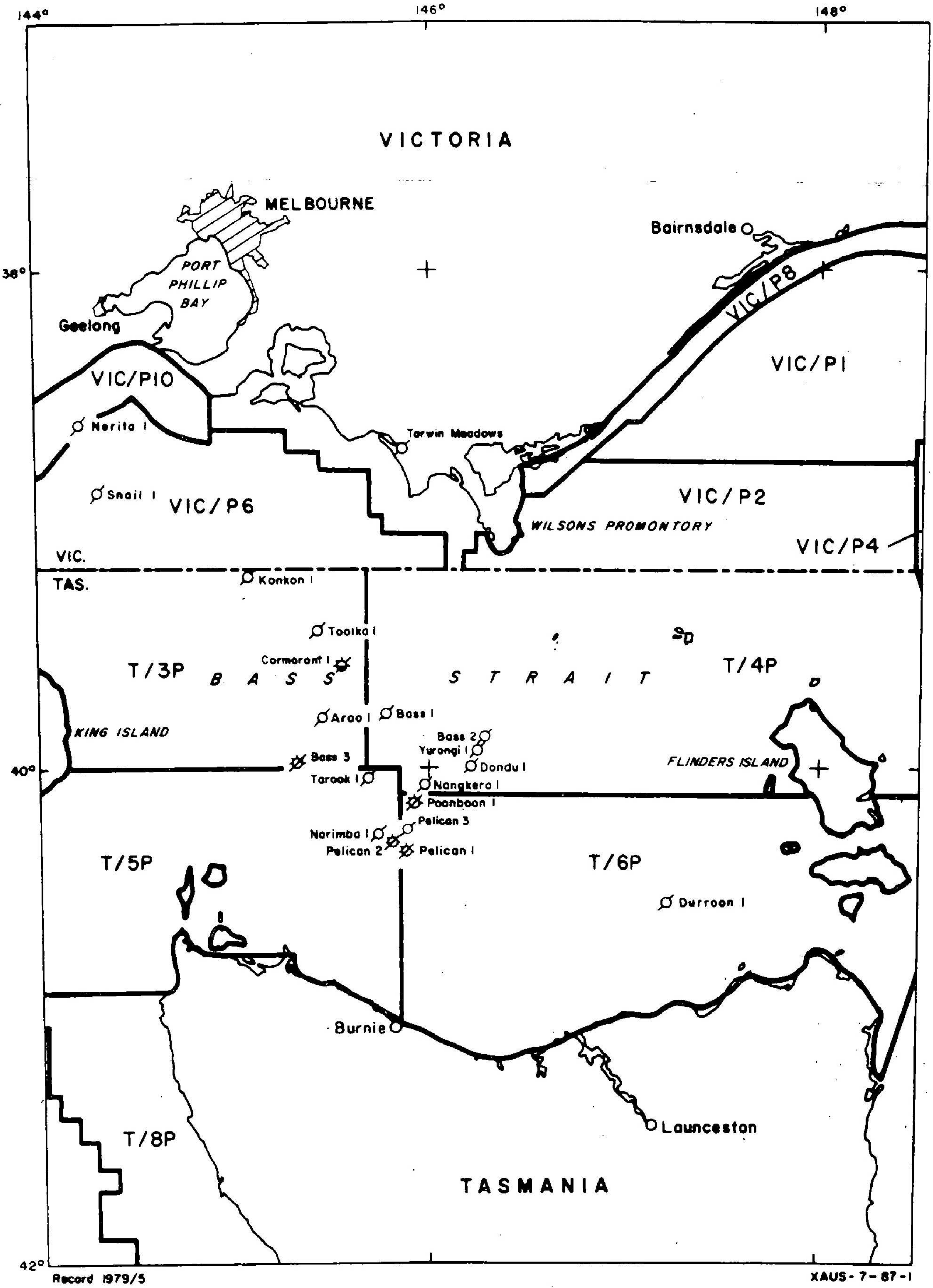
In the remaining northern permit T/4P three as yet untested structures were detailed by the Flinders seismic survey in 1973. Kalperri was mapped as a broad anticline with a minimum closure of 60 m on the intra-Eastern View Coal Measures seismic horizon, and as a narrower structure elongated in a north-westerly direction on the top Eastern View Coal Measures horizon. Jerra Jerra was confirmed as a small fault-controlled closure on the lower horizon, and Paipan was mapped on both horizons as a small closed anticline, but the interpretation of this structure was hampered by the presence of presumed volcanic bodies.

The eastern parts of VIC/P6 and VIC/P10 which cover most of the area occupied by the Torquay Basin were relinquished in 1975 by Hematite (VIC/P6) and IOL Petroleum Ltd (VIC/P10).

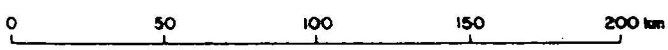
PROSPECTIVITY

Petroleum exploration carried out to date has established the Eastern View Coal Measures as the most prospective sequence in the basin and the Paleocene and Early Eocene L. balmei and M. diversus zones as the most prospective horizons within it. However of the seventeen prospects tested, only one, the Pelican structure, appears to have possible commercial potential.

Fig. 7



BASS BASIN
WELL LOCATIONS AND PERMIT AREAS



Well – dry, abandoned

Gas well – abandoned

Well with show of oil and gas – abandoned

It is now apparent that an earlier optimistic view of the petroleum potential of the Bass Basin which resulted from the establishment of the broad stratigraphic and lithological similarity to the adjacent Gippsland Basin for the Bass wells (1965-67), and the discovery of the possibly commercial Pelican Field (1970), must be drastically revised in the light of subsequent drilling results, and the more detailed knowledge that now exists of the geology of the two basins.

The Bass Basin lacks the major exploration play of the Gippsland Basin which is associated with the unconformity that occurs at the top of the Latrobe Group - the stratigraphic equivalent of the Eastern View Coal Measures. In the Gippsland Basin hydrocarbons are trapped in structural/topographic highs on the unconformity surface, seal being provided by fine-grained marine sediments deposited during the Oligocene.

The unconformity in the Gippsland Basin developed during the general overall marine transgression into the basin from the southeast which began late in the Cretaceous and progressed in a series of pulses related to eustatic cycles (Partridge, 1976). The unconformity is interpreted as being partly due to non-deposition possibly because of non-retention of fine sediments in the basin during the transgressive episodes, and partly to erosion during the periods of low sea level when deep channelling occurred. In contrast, the Bass Basin during the same period was a barred basin with only limited access of the sea from the northwest over the King Island to Mornington Peninsula basement ridge from the Middle to Late Eocene. Sediment was retained in the basin and no unconformity is apparent between the top of the Eastern View Coal Measures and the overlying transgressive Demons Bluff Formation. The periods of channelling in the Gippsland Basin during eustatic lows were in the Bass Basin periods of internal drainage into lacustrine environments. In those parts of the basin where erosion did occur in the Paleocene and Early Eocene it is represented by the unconformity within the Eastern View Coal Measures (M. diversus zone).

The structures which form the hydrocarbon traps on the top Latrobe Group unconformity in the Gippsland Basin were developed in the Late Eocene and Oligocene as a result of East-west shearing. There is no evidence of similar deformation at this time in the Bass Basin where vertical movements seem to have controlled the structural development throughout.

However, although the lack of an analogous major play to that in the Gippsland Basin reduces the prospectivity of the Bass Basin, that prospectivity must still be regarded as fair on present evidence. An assessment of the prospectivity of the deeper part of the Eastern View Coal Measures, which seems to contain the most prospective sediments, has not yet been accomplished. This is due to the lack of good basinwide structural control at this level because of the difficulty in obtaining good quality seismic data from below the coal in the Upper M. diversus zone. The data obtained so far suggest that an increase in structural complexity may occur below an intra-M. diversus zone unconformity which has been interpreted in a number of areas e.g. (Narimba, Pelican, Dondu, Yurongi, and Bass No. 2 (Brown, 1976).

CONCLUSIONS AND RECOMMENDATIONS

The Bass Basin review has indicated that further detailed work will be necessary before a reliable assessment of the petroleum prospectivity of the basin can be made.

A detailed stratigraphic analysis of the Eastern View Coal Measures is recommended, using existing geological and geophysical data, combined with source rock studies.

Future geophysical work in the Bass Basin should be directed towards the location and delineation of structural and stratigraphic traps, particularly below the coal in the Upper M. diversus zone. Only the most advanced technology can significantly improve the resolution of the prospective horizons below these highly reflective coal measures.

The only drilling which can be justified at present is that necessary to establish the reservoir limits and potential of the Pelican field. Future drilling programs must depend on whether the recommended geophysical objective is achieved.

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APPENDIX 1a

PETROLEUM EXPLORATION WELLS,
BASS BASIN

APPENDIX 1a

PETROLEUM EXPLORATION WELLS, BASS BASIN

COMPANY Well Name BMR file no. if subsidised	Latitude South Longitude East			1:250 000 Sheet Area	Elevation (Metres) GL/WD* DF/KB/RT		Date Spudded TD reached			TD (Metres)	Status
ESSO EXPLORATION AUSTRALIA, INC.											
Bass No. 1 BMR file 65/4167	39 145	46 44	18 03	J55-14	WD RT	74.67 9.44	21 8	7 9	65 65	2352	PA
Bass No. 2 BMR file 66/4187	39 146	53 18	09 15	J55-14	WD RT	85.34 9.44	14 21	4 5	66 66	1801	PA
ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC.											
Bass No. 3 BMR file 67/4241	39 145	59 16	51 57	J55-13	WD RT	57.91 9.44	11 29	2 3	67 67	2432	PA
Narimba No. 1 BMR file 73/251	40 145	16 43	18.080 53.581	K55-2	WD KB	77.1 9.8	31 1	8 10	73 73	3354	PA
Cormorant No. 1	39 145	34 31	23 36	J55-14	WD KB	733.15 30.48	10 14	6 7	70 70	3001	PA
Dondu No. 1	39 146	59 13	12 03	J55-14	WD KB	82 9.8	30 28	5 6	73 73	2927	PA
Durroon No. 1	40 147	32 12	4.479 47.463	K55-2	WD DF	68.6 9.8	22 24	10 11	72 72	3024	PA
Konkon No. 1	39 145	12 03	19.584 39.721	J55-13	WD KB	70.1 9.8	13 27	5 5	73 73	1537	PA
Pelican No. 1	40 145	20 50	20 37	K55-2	WD KB	73.15 30.48	19 29	3 4	70 70	3179	PA
Pelican No. 2	40 145	18 40	28 12	K55-2	WD KB	77.72 30.48	28 24	7 8	70 70	3068	PA
Pelican No. 3	40 145	15 51	43.228 50.670	K55-1	WD DF	80.2 9.8	1 13	5 6	72 72	2907	PA
Poonboon No. 1	40 145	08 55	15 01	K55-1	WD DF	78.9 9.8	29 29	8 9	72 72	3266	PA
Tarook No. 1	40 145	02 40	36.95 28.56	K55-1	WD DF	79.6 9.8	3 18	10 10	72 72	2774	PA
Toolka No. 1A	39 145	24 23	35.678 45.108	J55-13	WD KB	78.63 9.75	15 2	1 2	74 74	2715	PA
Yurongi No. 1	39 146	55 15	32 59	J55-14	WD KB	82.9 9.8	3 14	7 7	73 73	2438	PA
HEMATITE PETROLEUM PTY LTD											
Aroo No. 1 BMR file 74/208	39 145	47 26	30.325 47.976	J55-13	WD KB	76.2 10	4 19	3 4	74 74	3692	PA
Nangkero No. 1 BMR file 74/211	40 145	04 58	24.161 41.952	K55-2	WD KB	79.5 10	24 12	4 5	74 74	2877	PA

APPENDIX 1b

PETROLEUM EXPLORATION WELLS, TORQUAY BASIN

HEMATITE PETROLEUM PTY LTD

Snail No. 1 BMR file 72/3159	38 144	53 18	52 10	J55-9	WD DF	81.1 9.8	26 6	11 12	72 72	1235	PA

SHELL DEVELOPMENT (AUST.) PTY LTD

Nerita No. 1 BMR file 67/4258	38 144	37 13	43.2 44.8	J55-9	WD DF	74.67 34.13	1 30	7 7	67 67	2042	PA

*KEY

PA - plugged and abandoned
WD - water depth
GL - ground level
DF - derrick floor
KB - kelly bushing
RT - rotary table
TD - total depth

APPENDIX 2

GEOPHYSICAL SURVEYS

APPENDIX 2

GEOPHYSICAL SURVEYS

Magnetic surveys

Survey name and type	Year	Operator	Contractor	Survey altitude m	Traverse spacing Km	Total traverse length Km	Reference
Bass Strait and Encounter Bay aeromagnetic	1960-61	Haematite Explorations	Aero Service Ltd.	610	3	19000	PSSA pub. 60
Anderson's Inlet aeromagnetic survey	1961	Oil Development	"	610	3	740	PSSA 62/1713
Tasmania aeromagnetic	1966	BMR	-	3050	18		BMR record 1966/139
Bass B69A seismic and magnetic	1969	Esso Australia	Western Geophysical	Sea level (S.L.)	10	1140	PSSA 68/3057
Bass B70A seismic and magnetic	1970-71	Esso Australia	Geophysical Service International (GSI)	S. L.	-	14	P(SL)A 70/2
Bass B71A seismic and magnetic	1971-72	Esso Australia	GSI	S. L.	8	85	P(SL)A 71/4
Continental Margins Geophysical	1971-72	BMR	CGG	S. L.	-	50	BMR Records 1974/15 and 1974/98

APPENDIX 2 (Continued)

Seismic surveys

Survey name and type	Year	Operator	Contractor	Energy Source	Km surveyed	CDP coverage (percent)	Reference
Flinders Island-Kingston seismic (B)	1962-63	Haematite Explorations	Western Geophysical	Explosives	2568	100	PSSA 62/1645
Bass Basin seismic (EB)	1965	Esso Australia	Western Geophysical	Explosives	352	100-600	PSSA 65/4588
King Island East seismic (EK)	1965	Esso Australia	Geophysical Service International (GSI)	Explosives	405	600	PSSA 65/11037
Eastern Bass Strait seismic (ES)	1966	Esso Australia	GSI	Explosives	2480	100-600	PSSA 66/11070
Otway Basin seismic (A)	1966	Shell Development	Western Geophysical	Explosives	1760	600	PSSA 66/11052
PEP 22-D1 seismic (OD)	1966	Shell Development	Western Geophysical	Explosives	750	600	PSSA 66/111124
Offshore Otway Basin seismic (EO)	1966-67	Esso Australia	GSI	Explosives	3800	600	PSSA 66/11121
Bass ED-67 seismic	1967	Esso Australia	GSI	Explosives	343	600	PSSA 67/11196
Venus Bay seismic	1967	Alliance	Compagnie Generale de Geophysique	Sparker	290	100	PSSA 67/11193
Otway EP-67 seismic	1967-68	Esso Australia	GSI	Explosives	1550	600	PSSA 67/11188
Otway ER-68 seismic & magnetic	1968	Esso Australia	Western Geophysical	'Aquapulse'	1780	1200	PSSA 68/3036
Bass EF-68 seismic	1968	Esso Australia	Western Geophysical	'Aquapulse'	630	1200	PSSA 68/3014
Bass B69A seismic	1968-69	Esso Australia	Western Geophysical	'Aquapulse'	1150	1200	PSSA 68/3057
Bass B69B seismic & magnetic	1969	Esso Australia	Western Geophysical	'Aquapulse'	?	1200	P(SL)A 69/1
Cape Paterson seismic	1969	Mid-Eastern	Western Geophysical	'Aquapulse'	235	1200	PSSA 69/3068
Bass B70A seismic & magnetic	1970-71	Esso Australia	GSI	Airguns	2300	2400	P(SL)A 70/2
Bass B71A seismic & magnetic	1971-72	Esso Australia	GSI	Airguns	2100	1200-2400	P(SL)A 71/4
Torquay Embayment (HO) seismic	1971-72	Hematite Petroleum	GSI	Airguns	225	2400	PSSA 71/883
Continental Margins Geophysical (seismic, magnetic and gravity)	1971-72	BMR	CGG	Sparker	50	600	BMR Records 1974/15 and 1974/98
Bass B72A seismic	1972	Esso Australia	GSI	Airguns	1750	4800	P(SL)A 72/12
Flinders seismic (HB 73 A)	1973	Hematite Petroleum	GSI	Airguns	500	2400-4800	PSSA 73/258
Bass HB 75 A	1975	Hematite Petroleum	GSI	Airguns	2132	1200-2400	P(SL)A 75/2

Letters in parentheses in the left hand column denote the prefixes to seismic line numbers for that survey.

APPENDIX 3a

STRATIGRAPHIC TABLES

BASS BASIN WELLS

APPENDIX 3a

STRATIGRAPHIC TABLES, BASS BASIN WELLS

AROO NO. 1

AGE	UNIT	DEPTH KB (m)	THICKNESS (m)	LITHOLOGY
Oligocene-Miocene	Torquay Group	86	1728	Bioclastic calcirudite overlying fossiliferous marl, calcareous siltstone
Eocene-Oligocene	Demons Bluff Formation	1814	235	Glauconitic, calcareous siltstone
Paleocene-Eocene	Eastern View Group	2049	1099	Sandstone, siltstone, shale, mudstone, coal, dolomite
Paleocene or pre-Paleocene	Unnamed	3148	544+	Fresh and weathered volcanic rocks including amygdaloidal basalt; siltstone, sandstone
		3692 T.D.		

Hematite Petroleum Pty Ltd (1974)

NANGKERO NO. 1

AGE	UNIT	DEPTH KB (m)	THICKNESS (m)	LITHOLOGY
Oligocene-Miocene	Torquay Group	89	1662	Bioclastic calcirudite, overlying fossiliferous marl, calcareous siltstone, calcarenite, shale, siltstone, sandstone
Eocene-Oligocene	Demons Bluff Formation	1751	129	Carbonaceous, calcareous siltstone
Paleocene-Eocene	Eastern View Group	1880	997+	Sandstone, siltstone, shale, mudstone, coal, dolomite
		2877 T.D.		

Hematite Petroleum Pty Ltd (1974)

NARIMBA NO. 1

AGE	UNIT	DEPTH KB (m)	THICKNESS (m)	LITHOLOGY
Miocene	Middle Miocene (Seismic Mkr.)	872	503	235 - 710 m Calcarenite, grey to white, soft, abundant shell bryozoan and coral fragments 710-859 m Calcirudite, soft, grey to white, some shell and bryozoan fragments
Oligocene	Oligocene (Seismic Mkr.)	1375	280	859-1451 m Mudstone, grey to grey brown, soft, some bryozoan, foram, and shell fragments, some limestone streaks 1451-1655 m Shale, brown, calcareous, limestone and calcarenite fragments
	'Upper Eocene shale'	1655	138	1655-1793 m Shale, brown, firm, calcareous some large forams, trace pyrite
	Eastern View Group	1793	255	1793-1817 m Siltstone, tan to grey green, hard, dolomitic, pyritic, glauconitic
Eocene	*Proteacidites asperopolus (Seismic Mkr.)	2048	187	1817-2079 m Interbedded sandstone, siltstone, shale, and coal 2079-2089 m Siltstone, brown argillaceous, coaly, dolomitic
	*Upper Malvacipollis diversus (Seism. Mkr.)	2235	296	2089-3354 m Interbedded sandstone, siltstone, shale and coal
	*Lower M. diversus	2531	307	
	*Intra-L.M. diversus (Seis. Mkr.)	2838	516+	Esso (1973)

TD3354

Notes

*Within Eastern View Group

BASS NO. 2

AGE	UNIT	DEPTH KB (m)	THICKNESS (m)		LITHOLOGY
Miocene		81	578	259-660	Coarse Calcarenite: light grey, fine to very coarse grained; made up largely of assorted calcareous fossil debris (bryozoa, echinoids, pelcypods or lamellibranchs and foraminifera).
		660	251	660-910	Calcareous mudstone: light grey-green, very plastic. Abundant foraminifera, echinoids, bryozoa and pelecypod fragments. Abundant grains of glauconite in bottom 6 m.
Oligocene		910	193	910-929	Silty sandstone: light olive grey, very fine - medium grained, calcareous, soft, friable, very glauconitic. Pyrite. Fossiliferous, including foraminifera, bryozoa and pelecypods.
		929	74	929-1003	Silty mudstone: light olive grey, fairly plastic, waxy, micro-micaceous, calcareous and pyritic. Fossils as above.
		1103	100	1003-1103	Silty sandstone: grey and buff, fine and medium grained, angular to rounded, dolomitic, and in part calcareous cement. Abundant glauconite, and pyrite, tuffaceous. Minor mineral fluorescence, dull yellow. Sandstone: Brown-grey, fine-medium grained angular-rounded, unconsolidated. Argillaceous and tuffaceous matrix, with fairly abundant clear mica flakes. Contains sparse foraminifera.
Eocene		1103	67	1103-1170	Very argillaceous siltstone: chocolate brown-grey. Finely disseminated pyrite. Fairly abundant flecks of mica. Non-calcareous, much fine fossiliferous debris locally (dolomitized). Dolomitic siltstone: buff-orange to brown-grey, well cemented. Abundant pyrite.
Eocene-Paleocene	Eastern View Coal Measures	1170	200	1170-1370	Sandstone: light grey, fine to coarse to granule size, generally poorly sorted, angular to sub-rounded grains. In part the interval is pyritic and carbonaceous and locally contains a white kaolinitic matrix; tight in part and has bright yellow mineral fluorescence. Carbonaceous sandy siltstone: dark brown grey-streaked black, well compacted. Abundant carbonaceous plant remains. Very micaceous. Sand occurs in elongate lenses and is disseminated throughout. Coaly streaks up to 0.08 m thick. Argillaceous siltstone (minor): light brown-grey to buff, bentonitic, (tuffaceous?).

AGE	UNIT	DEPTH KB (m)	THICKNESS (m)		LITHOLOGY
Paleocene	Eastern View Coal Measures	*1370	310	1370-1680	Sandstone: grey, very fine to coarse grained but largely in the fine and medium size range. Sorting generally poor. Generally an argillaceous (Kaolinitic) matrix. Many thin discontinuous shaly and carbonaceous laminae. Grades to sandy siltstone locally. The interval contains a few black coal beds which range in thickness up to 1.5 m.
Mesozoic	" "	1680	122	1680-1728	Volcanic rock (altered): Trachyte? vari-coloured, brownish grey greenish blue, tan and grey-blue and green.
				1728-1758	Volcanic rock (relatively unaltered): blue-grey and green, fairly hard, in part. Amorphous vein quartz noted locally throughout this interval.
				1758-1801	Mudstone (altered): (tuffaceous), medium olive grey and bluish grey, hard and dense, faintly banded. Highly fractured.
		T.D. 1801			

Esso (1966)

Notes: No hydrocarbons were encountered in the well.
The Eocene top was 55 m higher than predicted.
*Seismic reflecting horizon

BASS NO. 3

AGE	UNIT	DEPTH KB (m)	THICKNESS (m)		LITHOLOGY
Miocene		220	914+	220-317	Coarse calcarenite to fine calciridite, light grey, composed of loose, calcareous skeletal debris (principally bryozoa with pelyecypods, echinoids, foraminifera and gastropods).
				317-427	Coarse calcarenite to fine calcirudite as above, but light brown to buff.
				427-646	Limestone: light grey, argillaceous, skeletal, micritic, sparsely carbonaceous and glauconitic.
				646-693	Interbedded limestone and marl. Limestone: as above. Marl: grey to grey-green, in part silty, sparsely pyritic, richly fossiliferous. Very soft and plastic.
				693-747	Marl: as above.
				747-1149	Mudstone: dark grey-green, calcareous, in part silty, sparsely micaceous and puritic, very fossiliferous.
Oligocene		1149	285	1149-1305	Mudstone: as above, but becoming more compact and less calcareous.
				1305-1434	Shale: dark grey to dark grey - brown, silty, sparsely pyritic, sparsely carbonaceous with sparsely dissiminated calcareous skeletal debris.
Eocene		1434	998	1434-1443	Sandstone: light brown, argillaceous, very fine grained, sub-angular to sub-rounded, sparsely glauconitic and fossiliferous. Porosity fair, permeability very poor.
				1443-1617	Shale: with minor siltstone. Shale: dark brown, silty, sparsely micaceous and pyritic with sparsely disseminated calcareous skeletal debris. Siltstone: light grey-brown, argillaceous, sparsely micaceous and pyritic.
	Eastern View Coal Measures			1616-1704	Interbedded sandstone, siltstone and shale. Sandstone: light brown, argillaceous, very fine to fine grained, sub-angular to sub-rounded, generally fairly well sorted. Moderately hard. Porosity good, permeability fair to poor. Sandstone: light green, argillaceous, very fine grained, sub-angular to sub-rounded, fairly well sorted, variably glauconitic, sparsely micaceous, friable; porosity fair, permeability poor. Siltstone: light brown to white, sparsely micaceous. Shale: light to dark brown, sparsely micaceous.

------------------------ unconformity ------------------------

AGE	UNIT	DEPTH KB (m)	THICKNESS (m)		LITHOLOGY
	Eastern View Coal Measures			1704-2151	Interbedded sandstone, siltstone and shale, with rare coal seams. Sandstone: light grey, finely pebbly to granular fine to coarse grained, sub-angular to rounded, poorly sorted, generally abundant white clay matrix, sparsely micaceous, carbonaceous and felspathic in part. Moderately hard. Porosity good, permeability generally poor. Sandstone: grey white silty, fine to very fine grained, sub-angular to sub-rounded, generally fairly well sorted, moderately abundant white clay matrix, sparsely micaceous and carbonaceous. Moderately hard, porosity fair, permeability poor. Siltstone: light grey, sparsely micaceous, pyritic and carbonaceous. Shale: light grey to grey brown, sparsely micaceous, pyritic and carbonaceous. Coal: black, brittle, brilliant lustre, irregular to sub-conchoidal fracture.
	" "			2151-2199	Shale with minor sandstone. Shale: dark grey to dark grey-brown, sparsely micaceous. Shale: light grey as above. Sandstone: light grey, silty, fine to very fine grained, as for interval 1702 m-2151 m.
				2199-2387	Interbedded sandstone, siltstone and shale. The sandstones are the same as for interval 1704 m - 2151 m, except for a greater abundance of feldspar and lithic grains and pebbles, principally dark grey shale, light grey quartzite and buff to green volcanics. Siltstone: light brown to light grey, sparsely micaceous, pyritic and carbonaceous. Shale: light to mid-grey, in part silty, sparsely micaceous.
				2387-2432	Interbedded quartzite, recrystallized siltstone and fine grained sandstone and black metamorphosed shale.
		T.D. 2432			

Notes: 1) small non-commerciashow from 2054 m to 2056 m was logged and wireline tested.
2) smic evidence indicaat the gas sand was penetrated at its structurally highest point.

Esso (1967)

APPENDIX 3b

STRATIGRAPHIC TABLES TORQUAY
BASIN WELLS

APPENDIX 3b

STRATIGRAPHIC TABLES, TORQUAY BASIN WELLS

NERITA NO. 1

AGE	UNIT	DEPTH DF (m)	THICKNESS (m)		LITHOLOGY
Late Eocene-Early Miocene	Torquay Group	Sea floor	251		Marl
Early Miocene	?Puebla Formation	109 (Sea floor)			Marl silty, grey, with abundant fine calcareous organic debris (from 1.47 m core taken in the sea-bottom) (Above 188 m cuttings were not obtained)
Middle & Early Oligocene and Late Eocene	Jan Juc Formation Point Addis Limestone Member	188	171	188-227	Bioclastic lime packstone beige to orange very fossiliferous (debris of Lamellibranchs, Gastropods, Echinoids)
				227-259	Marl alternating with bioclastic lime packstone
				259-297	Bioclastic lime grainstone to packstone interbedded with bioclastic lime packstone and quartz sand, and minor marl
				297-360	Marl interbedded with packstone, and packstone
Late Eocene	Demons Bluff Fm.	360	278	360-390	Quartz sand with intercalations of clay and streaks of dolomite
	Anglesea Siltstone Member			390-637	Clay (and claystone approximately below 549 m) usually dark brown and silty
					Shale (between 635 m - 637 m), brown reddish, very silty, sandy, slightly glauconitic and pyritic
Late Eocene	'Boonah Formation'	637	141	637-718	Quartz and interbedded with claystone and few streaks of dolomite and coal
				718-779	Quartz sand interbedded with coal and some streaks of clay
--------	--- Unconformity ---				
Late Cretaceous-Paleocene	Eastern View Coal Measures	779	684	779-865	Quartz sand/conglomerate interbedded with coal and claystone, with very rare streaks of dolomitic sandstone
				865-917	Quartz sand interbedded with claystone; some siltstone intercalations and few coal seams
				917-937	Dolomite/dolomitic siltstone interbedded with quartz sand and some intercalations of siltstone and claystone

AGE	UNIT	DEPTH KB (m)	THICKNESS (m)		LITHOLOGY
				984-1035	Dolomite/dolomitic sandstone/dolomitic siltstone, with some quartz sand and claystone intercalations and few coal seams in lower 9 m
				1035-1124	Quartz sand interbedded with coal/carbonaceous claystone, and with claystone in middle part
				1124-1250	Quartz sandstone interbedded with subordinate coal and carbonaceous claystone
				1250-1330	Quartz sandstone with minor claystone
				1330-1416	Carbonaceous claystone interbedded with subordinate quartz sandstone.
				1416-1462	Quartz sandstone with subordinate carbonaceous Siltstone in upper part
——— Unconformity ———					
Early Cretaceous	Otway Group	1462	580+	1462-1591	Lithic sandstone interbedded with minor siltstone and claystone
				1591-1852	Shale more abundant in 1753 m - 1798 m interval interbedded with minor lithic sandstone and siltstone, some coal seams
				1852-2042	Lithic sandstone with intercalations of minor shale and accessory thin streaks of siltstone. Two beds (about 1.52 m thick) of chert at 1915 m and 1934 m
			T.D. 2044		

*DUNHAM, R. J. (1962): Classification of Carbonate Rocks according to Depositional Texture. Americ. Assoc. Petroleum Geologists, Mem. 1.

Notes: Only minor methane shows were recorded from the Eastern View Coal Measures and the Otway Group.

Three Formation Interval Tests sandstones with good reservoir properties in the Eastern View Coal Measures produced only fresh to brackish water.

Shell (1967)

SNAIL NO. 1

AGE	UNIT	DEPTH KB (m)	THICKNESS (m)		LITHOLOGY
Miocene	Torquay Group	91	551		
	Puebla Formation	91	364	91-455	Largely claystone and marl containing bioclastics with minor siltstone and sandstone. It is presumed to extend to the sea floor although it is not sampfled about 244 m (K.B.)
Late Eocene to Oligocene	Jan Juc Formation	455	193	455-648	Partly glauconitic claystone and marl with interbedded siltstone, calcarenite, sandstone sand and fossiliferous limestone. Two limestone beds are recognised. Well correlation suggests that the upper limestone in Snail No. 1 correlates with the Point Addis Limestone as recognised in Nerita No. 1.
Eocene	Demons Bluff Formation	648	136	648-784	A monotonous, silty, glauconitic claystone sequence. It is to be compared lithologically with the Anglesea Siltstone Member of the onshore section rather than with the Angahook Member.
Eocene to mid-Paleocene	Eastern View Coal Measures	784	98	784-885	Poorly consolidated, clay-choked, glauconitic, marginal marine sandstone with relatively minor beds of carbonaceous claystone, clayey sand and very minor shale and dolomite. A sharp log break and lithological change at 885 m (K.B.) marks the top of the underlying Otway Group.
Early Cretaceous	Otway Group	885	350+	885-1235	Lithic, kaolinitic(?) zeolitic sandstone with a few thin beds of carbonaceous siltstone. Below 1134 m the sandstone appear to be bimodal, having a fine to coarse quartz sand fraction and granule size lithic fraction.
			T.D. 1235		

Hematite (73)

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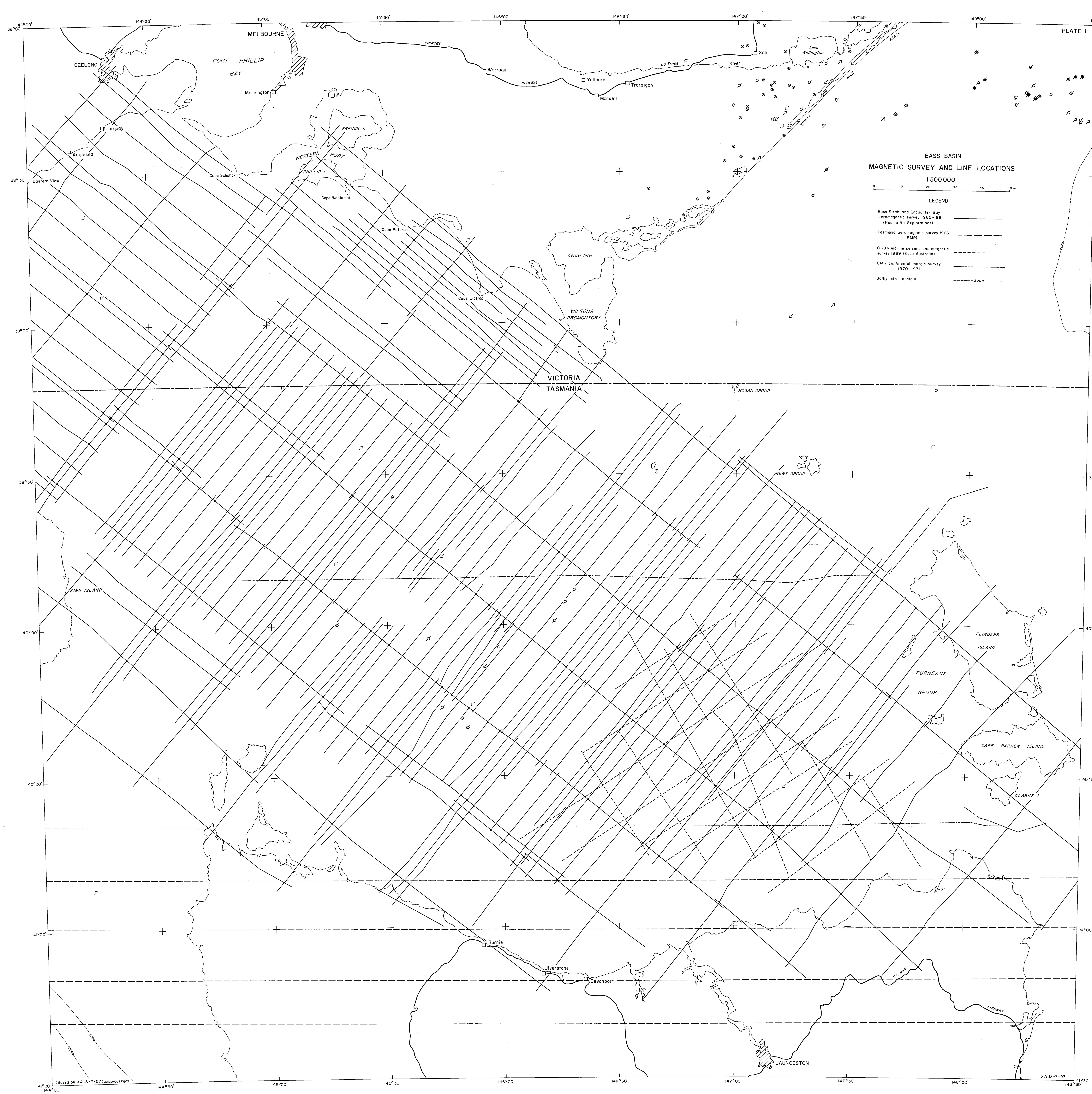
PLATE I
BASS BASIN
MAGNETIC SURVEY AND LINE LOCATIONS
1:500 000
0 10 20 30 40 50km
LEGEND
Bass Strait and Encounter Bay aeromagnetic survey 1960-1961 (Haematite Explorations)
Tasmania aeromagnetic survey 1966 (BMR)
B69A marine seismic and magnetic survey 1969 (Esso Australia)
BMR continental margin survey 1970-1971
Bathymetric contour
200m
MELBOURNE
GEELONG
PORT PHILLIP BAY
Mornington
Torquay
Anglesea
Eastern View
Cape Schanck
WESTERN PORT
FRENCH I.
PHILLIP I.
Cape Woolamai
Cape Paterson
Cape Liptrap
Corner Inlet
WILSONS PROMONTORY
PRINCES
HIGHWAY
Warragul
Yallourn
Morwell
Traralgon
La Trobe
River
Sale
Lake Wellington
NINETY MILE BEACH
VICTORIA
TASMANIA
HOGAN GROUP
KENT GROUP
KING ISLAND
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN ISLAND
CLARKE I.
Burnie
Ulverstone
Devonport
LAUNCESTON
TASMAN HIGHWAY
1000m
(Based on XAUS-7-57) RECORD 1979/5
XAUS-7-93
144°00'
144°30'
145°00'
145°30'
146°00'
146°30'
147°00'
147°30'
148°00'
148°30'
38°00'
38°30'
39°00'
39°30'
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41°00'
41°30'

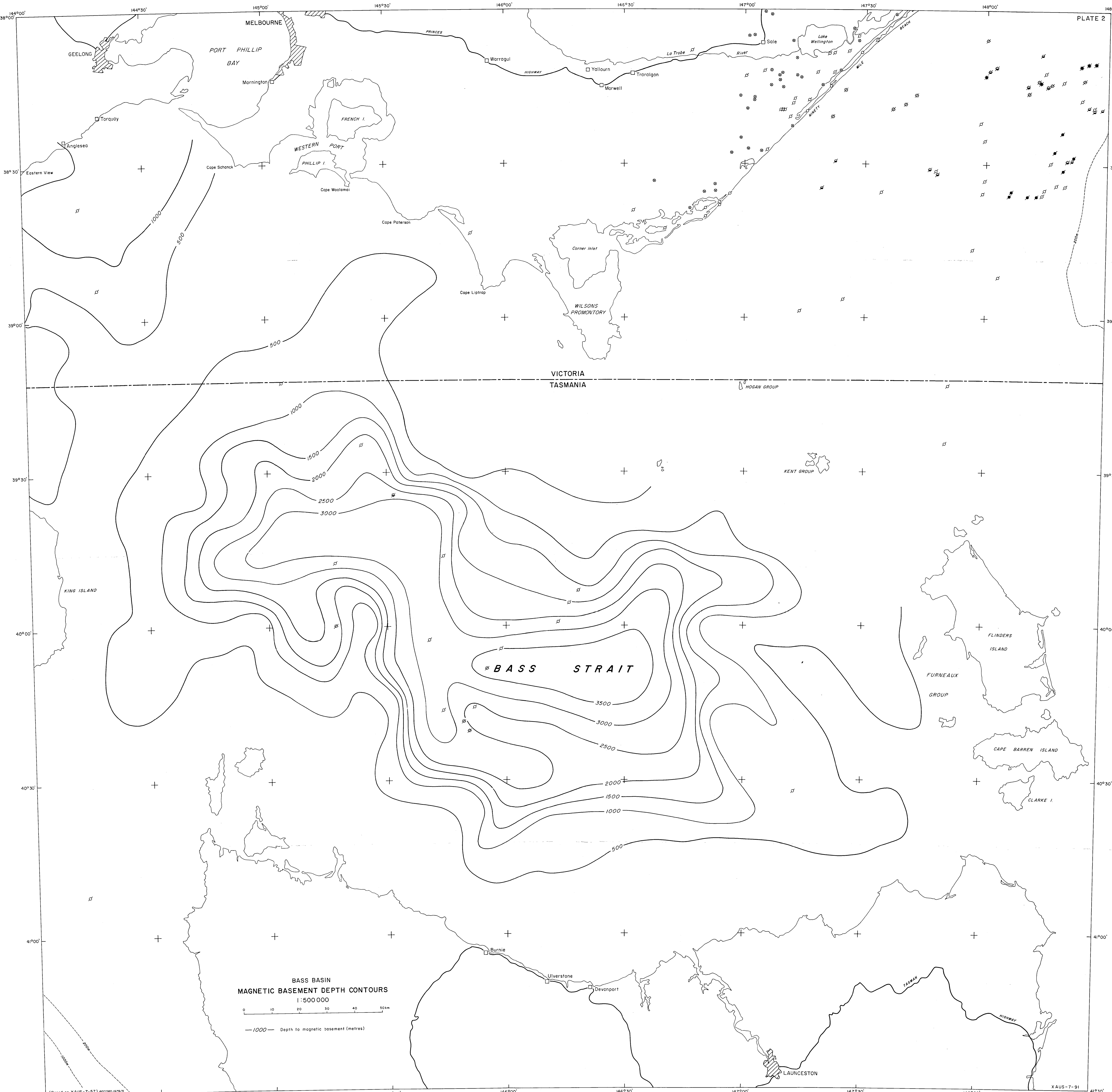
PLATE 2
BASS BASIN
MAGNETIC BASEMENT DEPTH CONTOURS
1:500 000
0 10 20 30 40 50 km
—1000— Depth to magnetic basement (metres)
XAUS-7-91
MELBOURNE
GEELONG
PORT PHILLIP BAY
Mornington
Torquay
Anglesea
Eastern View
Cape Schanck
WESTERN PORT
FRENCH I.
PHILLIP I.
Cape Woolamai
Cape Paterson
Cape Liptrap
Corner Inlet
WILSONS PROMONTORY
Warragul
Yallourn
Morwell
Traralgon
Sale
Lake Wellington
La Trobe River
PRINCES HIGHWAY
NINETY MILE BEACH
VICTORIA
TASMANIA
HOGAN GROUP
KENT GROUP
KING ISLAND
BASS STRAIT
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN ISLAND
CLARKE I.
Burnie
Ulverstone
Devonport
LAUNCESTON
TASMAN HIGHWAY
500
1000
1500
2000
2500
3000
3500
38°00'
38°30'
39°00'
39°30'
40°00'
40°30'
41°00'
41°30'
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148°00'
148°30'

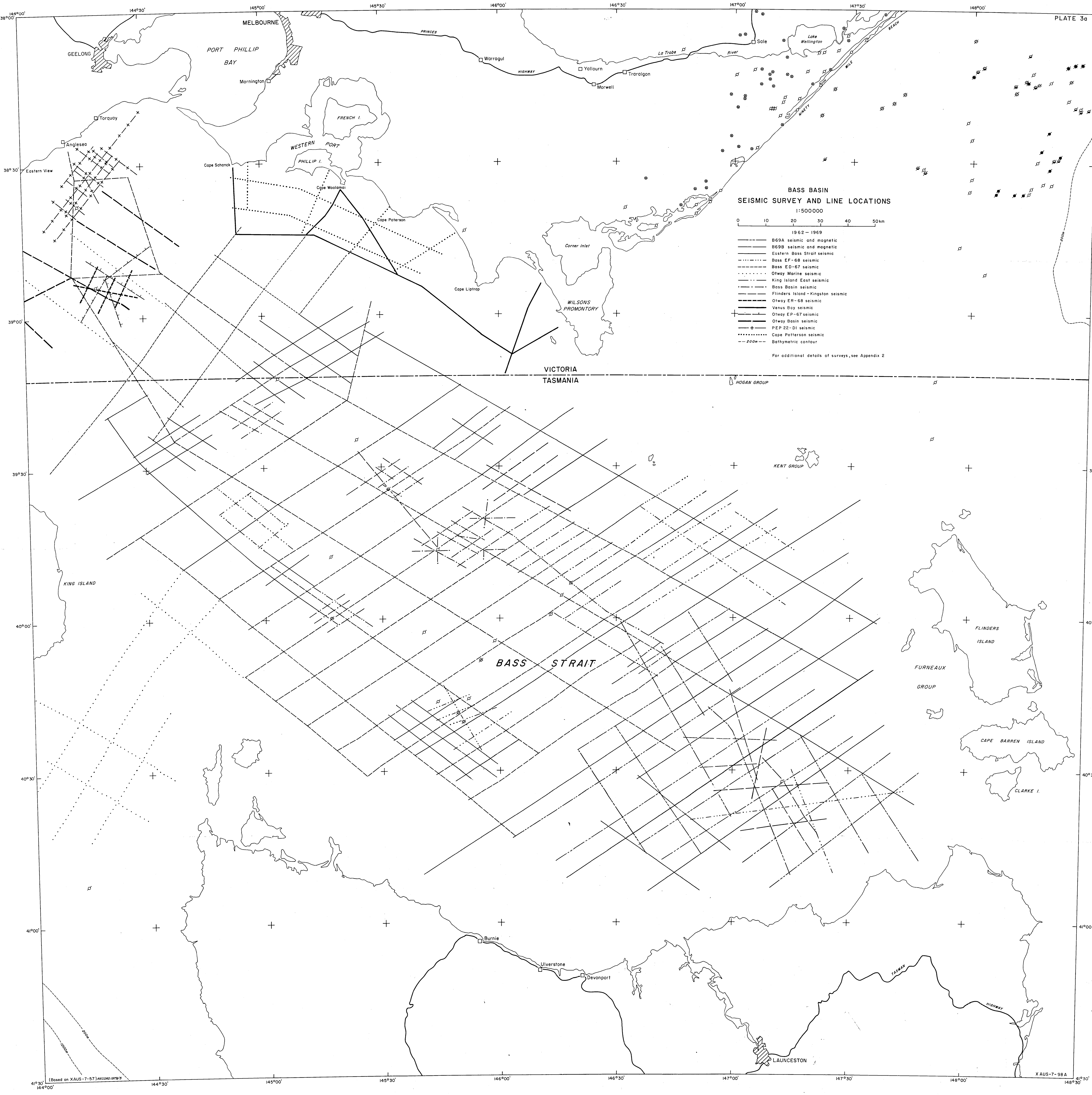


PLATE 3a
MELBOURNE
GEELONG
PORT PHILLIP BAY
Mornington
Torquay
Anglesea
Eastern View
Cape Schanck
WESTERN PORT
FRENCH I.
PHILLIP I.
Cape Woolamai
Cape Paterson
Cape Liptrap
Corner Inlet
WILSONS PROMONTORY
PRINCES HIGHWAY
Warragul
Yallourn
Traralgon
Morwell
La Trobe River
Sale
Lake Wellington
NINETY MILE BEACH
BASS BASIN
SEISMIC SURVEY AND LINE LOCATIONS
1:500000
0 10 20 30 40 50km
1962 – 1969
B69A seismic and magnetic
B69B seismic and magnetic
Eastern Bass Strait seismic
Bass EF-68 seismic
Bass ED-67 seismic
Otway Marine seismic
King Island East seismic
Bass Basin seismic
Flinders Island - Kingston seismic
Otway ER-68 seismic
Venus Bay seismic
Otway EP-67 seismic
Otway Basin seismic
PEP 22-DI seismic
Cape Patterson seismic
200m Bathymetric contour
For additional details of surveys, see Appendix 2
VICTORIA
TASMANIA
HOGAN GROUP
KENT GROUP
KING ISLAND
BASS STRAIT
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN ISLAND
CLARKE I.
Burnie
Ulverstone
Devonport
Launceston
TASMAN HIGHWAY
144°00'
144°30'
145°00'
145°30'
146°00'
146°30'
147°00'
147°30'
148°00'
148°30'
38°00'
38°30'
39°00'
39°30'
40°00'
40°30'
41°00'
41°30'
(Based on XAUS-7-57) RECORD 1973/3
XAUS-7-98A

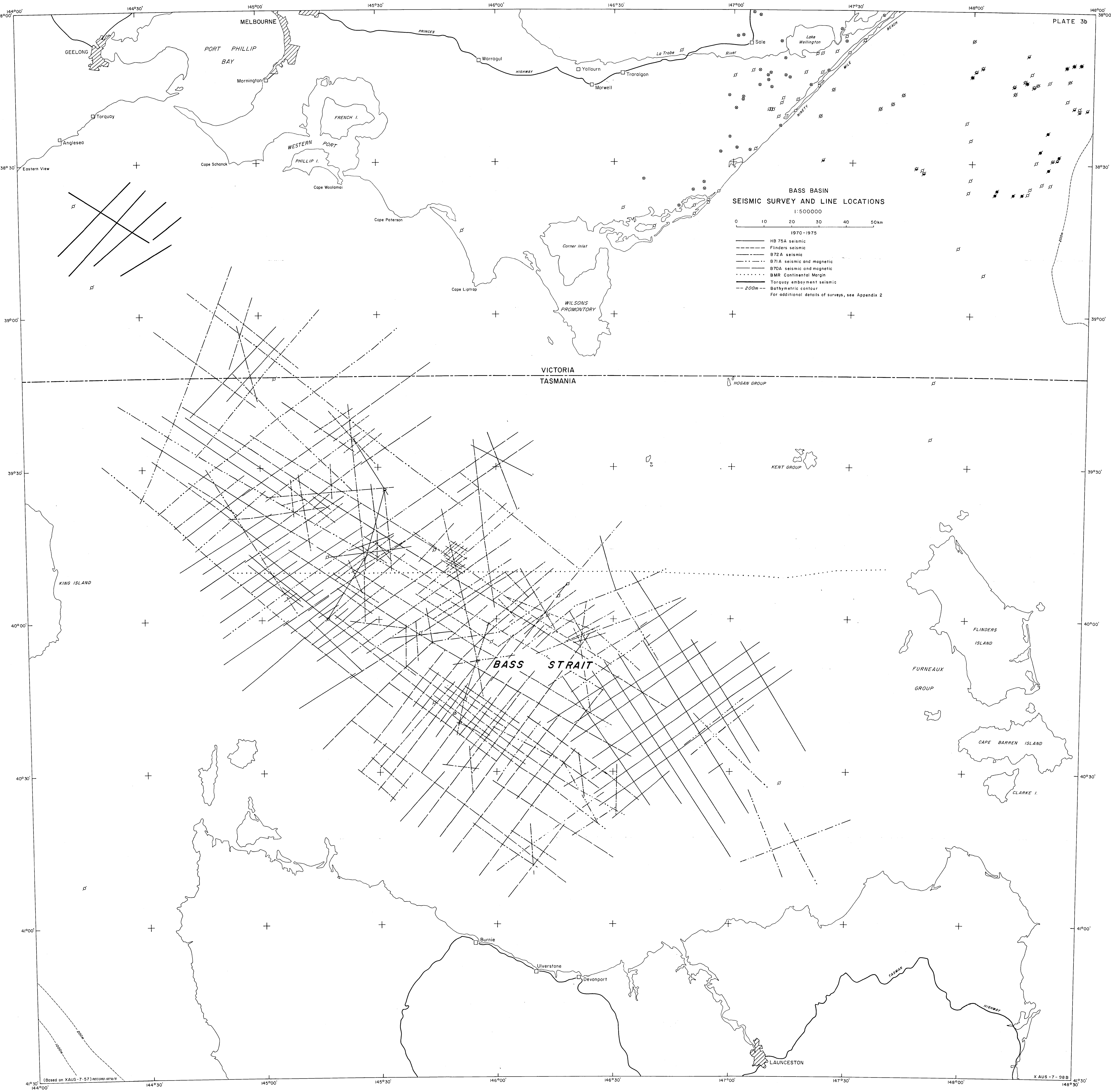


PLATE 3b
BASS BASIN
SEISMIC SURVEY AND LINE LOCATIONS
1:500000
0 10 20 30 40 50km
1970-1975
HB 75A seismic
Flinders seismic
B72A seismic
B71A seismic and magnetic
B70A seismic and magnetic
BMR Continental Margin
Torquay embayment seismic
200m Bathymetric contour
For additional details of surveys, see Appendix 2
MELBOURNE
GEELONG
PORT PHILLIP BAY
Mornington
Torquay
Anglesea
Eastern View
Cape Schanck
WESTERN PORT
FRENCH I.
PHILLIP I.
Cape Woolamai
Cape Paterson
Cape Liptrap
Corner Inlet
WILSONS PROMONTORY
PRINCES
HIGHWAY
Warragul
Yallourn
Traralgon
Morwell
La Trobe
River
Sale
Lake Wellington
NINETY
MILE
BEACH
VICTORIA
TASMANIA
HOGAN GROUP
KENT GROUP
KING ISLAND
BASS STRAIT
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN ISLAND
CLARKE I.
Burnie
Ulverstone
Devonport
LAUNCESTON
TASMAN
HIGHWAY
200m
1000m
(Based on XAUS-7-57) RECORD 1979/5
X AUS-7-98B
144°00'
144°30'
145°00'
145°30'
146°00'
146°30'
147°00'
147°30'
148°00'
148°30'
38°00'
38°30'
39°00'
39°30'
40°00'
40°30'
41°00'
41°30'

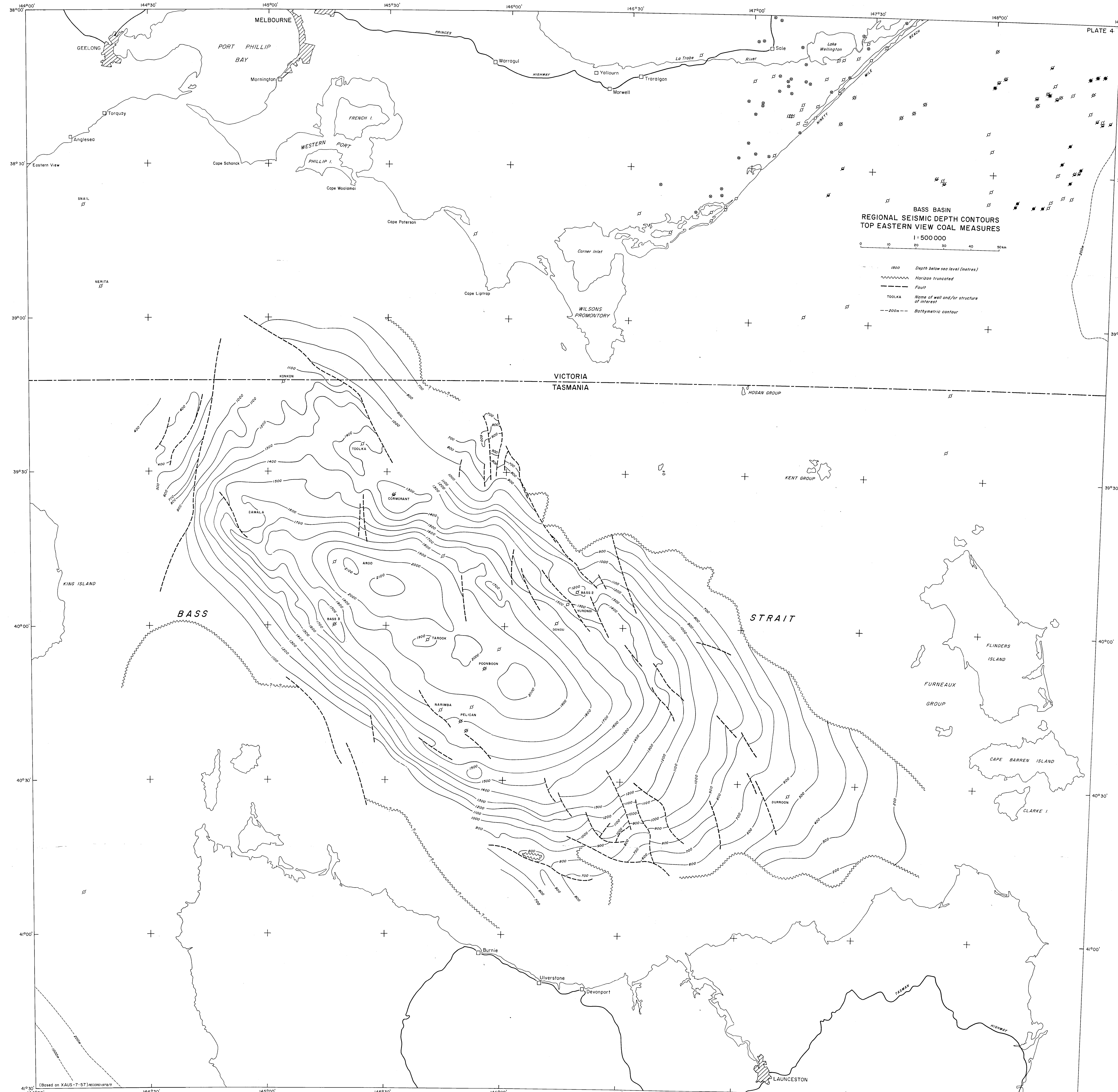
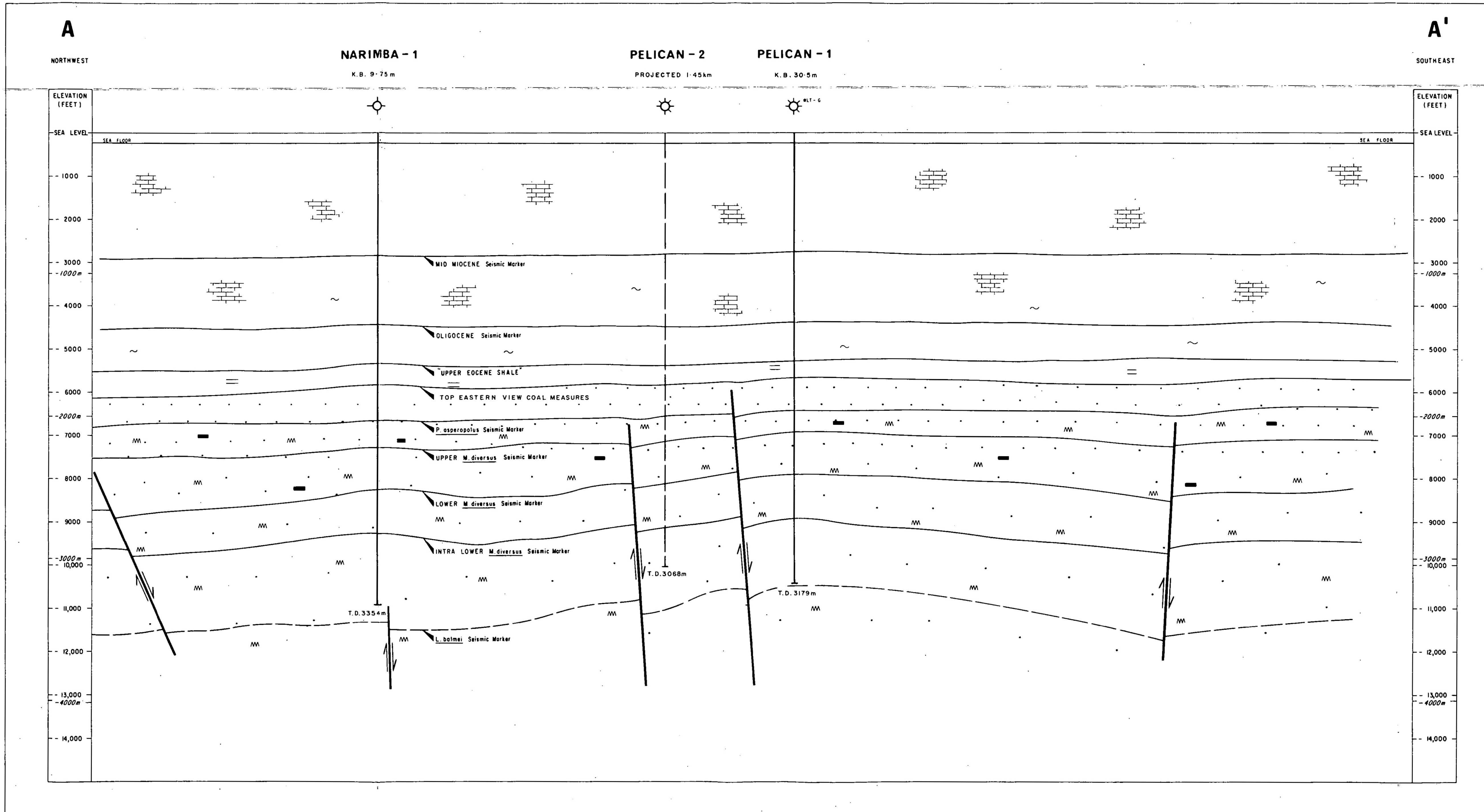
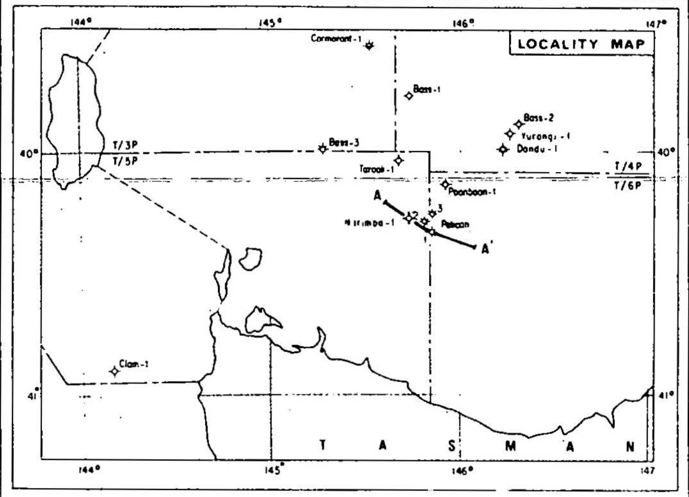


PLATE 4
BASS BASIN
REGIONAL SEISMIC DEPTH CONTOURS
TOP EASTERN VIEW COAL MEASURES
1 : 500 000
0 10 20 30 40 50 km
1500 Depth below sea level (metres)
Horizon truncated
Fault
TOOLKA Name of well and/or structure of interest
--200m-- Bathymetric contour
MELBOURNE
GEELONG
PORT PHILLIP BAY
Mornington
Torquay
Anglesea
Eastern View
Cape Schanck
WESTERN PORT
FRENCH I.
PHILLIP I.
Cape Woolamai
Cape Paterson
Cape Liptrap
Corner Inlet
WILSONS PROMONTORY
PRINCES HIGHWAY
Warragul
Yallourn
Morwell
Traralgon
La Trobe River
Sale
Lake Wellington
NINETY MILE BEACH
SNAIL
NERITA
VICTORIA
TASMANIA
KONKON
HOGAN GROUP
TOOLKA
CORMORANT
ZAMALA
KENT GROUP
KING ISLAND
BASS
STRAIT
ARCO
BASS 3
BASS 2
YURONGI
DONDU
TAROOK
POONBOON
NARIMBA
PELICAN
DURROON
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN ISLAND
CLARKE I.
Burnie
Ulverstone
Devonport
LAUNCESTON
TASMAN HIGHWAY
144°00'
144°30'
145°00'
145°30'
146°00'
146°30'
147°00'
147°30'
148°00'
148°30'
38°00'
38°30'
39°00'
39°30'
40°00'
40°30'
41°00'
41°30'
(Based on XAUS-7-57) RECORD 1979/3
XAUS-7-101



Record 1979/5

VERTICAL EXAGGERATION 4·2 : 1



LEGEND

- LIMESTONE
- SANDSTONE
- MARL
- COAL
- SHALE
- SILTSTONE

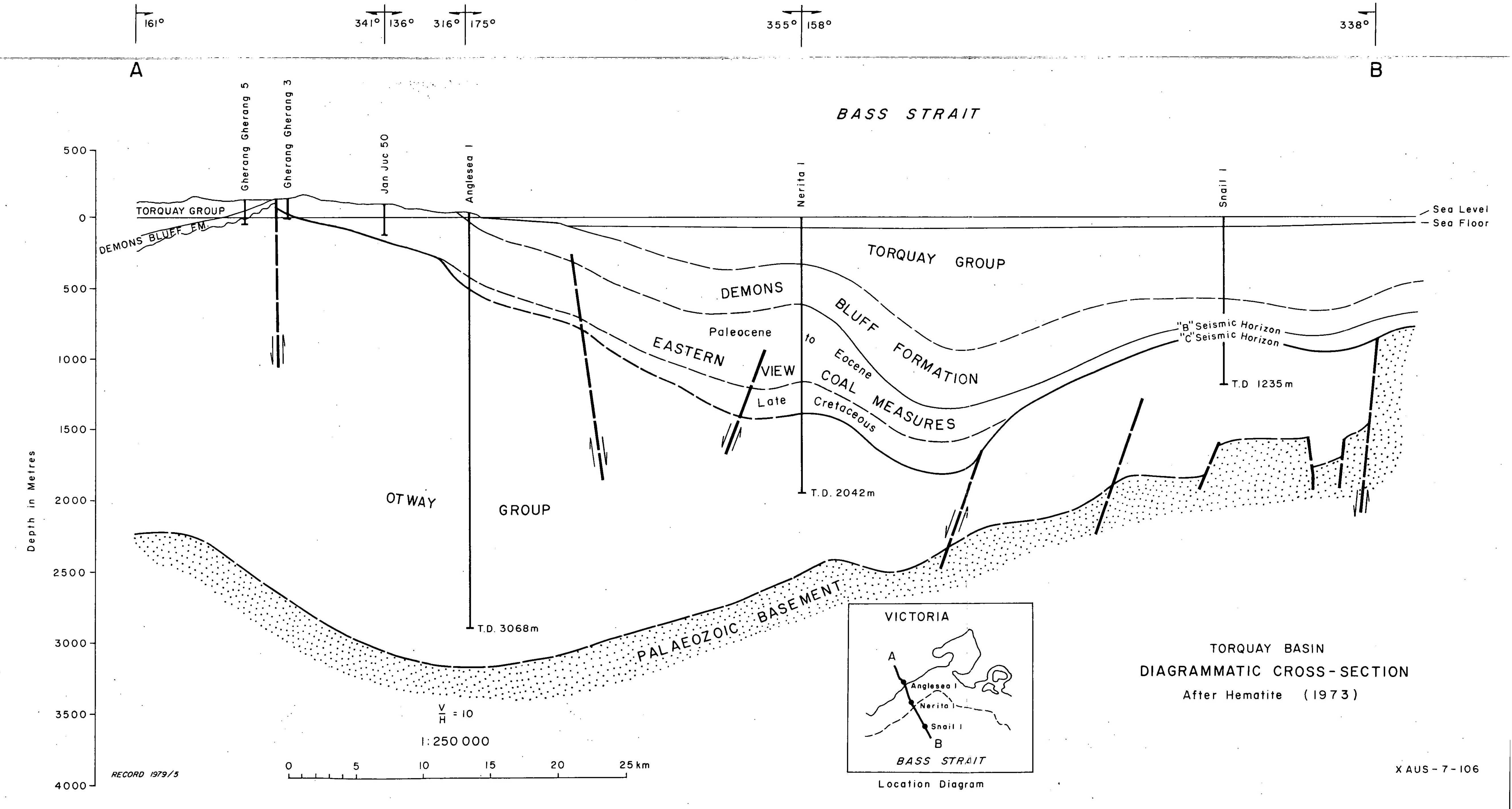
BASS BASIN GEOLOGICAL CROSS-SECTION

0 1 2 3 4 5 km

After ESSO, 1974

X AUS-7-110

PLATE 6



TORQUAY BASIN

DIAGRAMMATIC CROSS-SECTION

After Hematite (1973)

RECORD 1979/5

X AUS-7-106