DEPARTMENT OF ~~NATIONAL RESOURCES~~ NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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Record 1978/110

A REVIEW OF PETROLEUM EXPLORATION AND PROSPECTS IN THE GIPPSLAND BASIN

by

C.S. ROBERTSON, K.L. LOCKWOOD, E. NICHOLAS and H. SOEBARKAH

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ABSTRACT

Petroleum exploration carried out in the Gippsland Basin up to February 1976 has been reviewed to provide a current assessment of knowledge of the basin and to determine the need for further exploration.

The Gippsland Basin is a Late Mesozoic to Cainozoic Basin located mainly offshore in the northeastern portion of Bass Strait, between the mainland of Australia and Tasmania. It is roughly triangular in shape, being narrowest onshore in Victoria to the northwest and broadening towards the edge of the continental slope to the southeast. It contains up to 4500 m of fluvio-deltaic and marine sediments which have been subjected to faulting, drape folding, and channel erosion.

The Gippsland Basin has been by far the most prolific petroleum producing basin in Australia, with initial reserves of more than 300×10^6 m^3 of oil and 200×10^9 m^3 of natural gas at 31 March 1977. The basin has been actively explored geophysically since the early 1960s and all of the larger and more obvious structures have been drilled. The basin still has some exploration potential at deeper levels than the main Eocene producing zones, but detailed seismic mapping of deeper horizons is difficult and requires the best seismic technology available.

It seems likely that the greater part of the recoverable petroleum in the basin has already been found, but there is some potential for further discoveries.

INTRODUCTION

This Record is a summary of petroleum exploration and prospects in the Gippsland Basin, which is located mainly offshore from the southeastern coast of Victoria.

The Gippsland Basin underlies an area of 63 000 km^2 to the 200 m bathymetric contour and contains up to 4500 m of Late Mesozoic and Cainozoic sediments. The oldest part of the sequence, of Late Jurassic and Early Cretaceous age, was deposited in an east-west rift which Hocking (1972) named the Strzelecki Basin. These sediments crop out onshore at the western end of the Gippsland Basin but have been intersected by only a few near-shore wells in the offshore area where the rift has been defined by geophysical exploration. In this review the Late Jurassic and Early Cretaceous sequence is regarded as part of the Gippsland Basin and 'Strzelecki Basin' is used informally as a term of convenience.

The summary is mainly based on published and non-confidential unpublished information available up to February 1976. Some later information has been included in figures and tables. Much of the unpublished information is derived from the final reports of petroleum exploration company operations subsidised by the Commonwealth Government under the Petroleum Search Subsidy Act 1959-73 (PSSA). Under the terms of that Act the final reports on individual geophysical or drilling operations are available to the public. Some basic (non-interpretative) data from unsubsidised offshore operations is available to the public under the provisions of the Petroleum (Submerged Lands) Act (P(SL)A).

GEOLOGY

GENERAL

A bibliography of the large volume of literature covering the geology of the Gippsland Basin was published by the Geological Survey of Victoria in 1973 (Thomson, et al, 1973) as a first step in a reappraisal of the basin. The bibliography includes reference to many unpublished works. The most recent comprehensive reviews of the Gippsland Basin are by Threlfall et al (1976) and Colman (1976).

The onshore part of the basin in Victoria was mapped at 1:250 000 scale between 1966 and 1972. All five sheet areas are published, three in a provisional form. Mapping at 1:63 360 scale was carried out in 1969 and 1970. Eight maps at this scale have been published.

Two major factors which have stimulated interest in the stratigraphy of the onshore area have been the economically important deposit of brown coal in the Latrobe Valley, and the recovery of oil in 1924 from a well drilled for water at Lakes Entrance.

In the offshore area, much geological information has resulted from petroleum exploration, particularly that by the partnership entered into in 1964 between Broken Hill Proprietary Limited's subsidiary Haematite Explorations Proprietary Limited (later known as Hematite Petroleum Proprietary Limited) and Esso Exploration Australia Inc.

Drilling operations both onshore and offshore are listed in Appendices 1a and 1b, and a map showing simplified geology and the location of petroleum exploration wells is presented as Plate 1.

The bibliography contains a selection of the more important references, and is not intended to be comprehensive.

BASIN SETTING

The Gippsland Basin has a roughly triangular shape, being narrowest onshore to the northwest and broadening offshore to the southeast. The northern boundary is an unconformable contact between basin sediments and rocks of the Tasman Fold Belt, and the northwestern boundary with the Otway Basin is the Selwyn Fault on Mornington Peninsula (Fig. 1). The southwestern boundary is partly an exposed or subsea unconformable contact between basin sediments and basement rocks on the northeastern flank of a southeast-trending elevated area of basement, the Bassian Rise, which separates the Gippsland Basin from the Bass Basin, and partly the crest of the rise where it is covered by sediments. The eastern boundary (and offshore limit) of the basin is undefined. Basin sediments extend beyond the shelf break which is located near the 200 m bathymetric contour. The basin consists of an east-trending central deep trough separated from northern and southern platforms by bounding faults.

The 'Strzelecki Basin' (Hocking, 1972) is an east-west rift bounded on the west by the Palaeozoic rocks of the Mornington Peninsula and extending from Westernport Bay eastwards at least to the shelf break (Fig.1). It is ancestral to the central deep basin.

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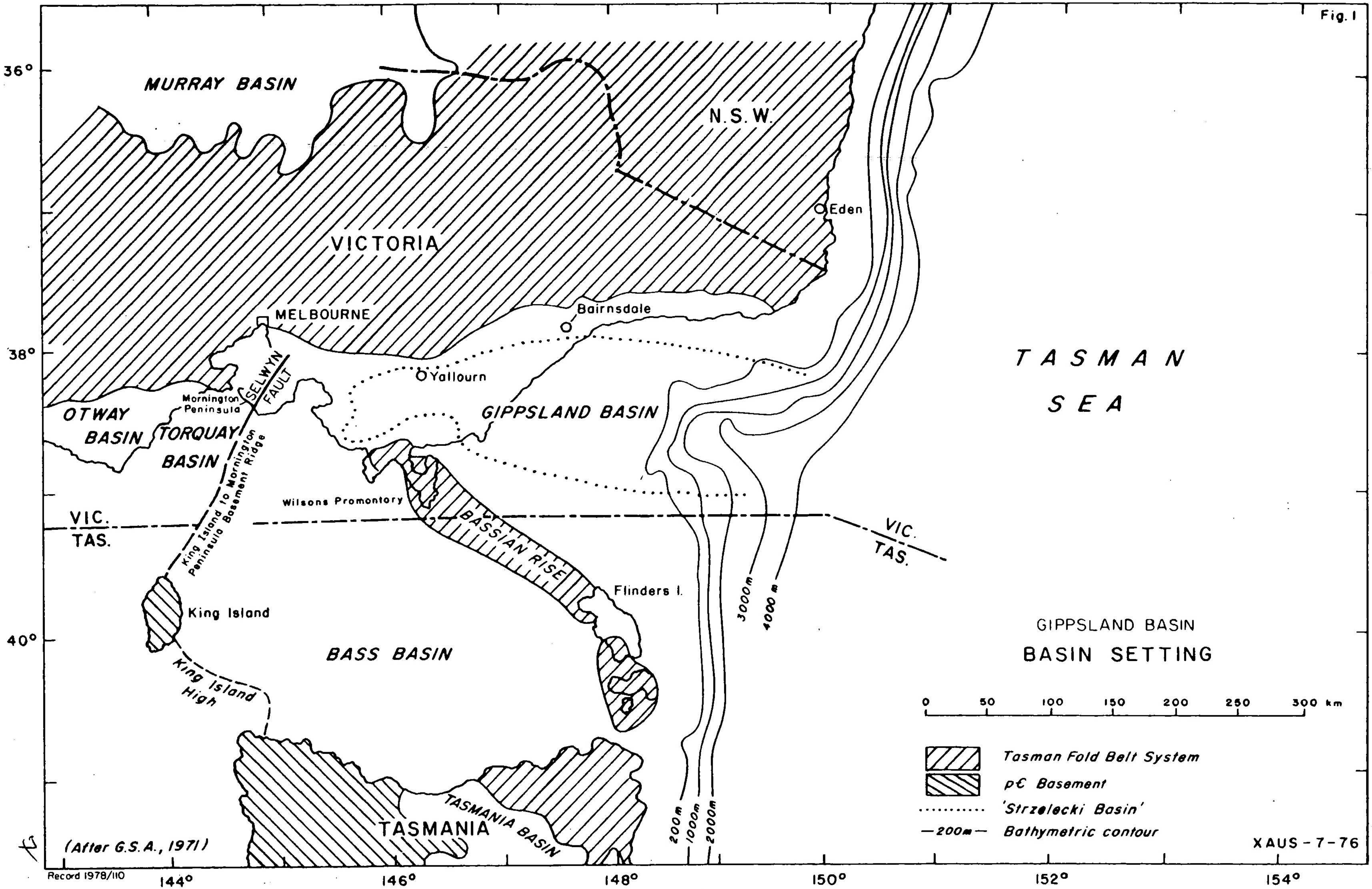

GIPPSLAND BASIN

BASIN SETTING

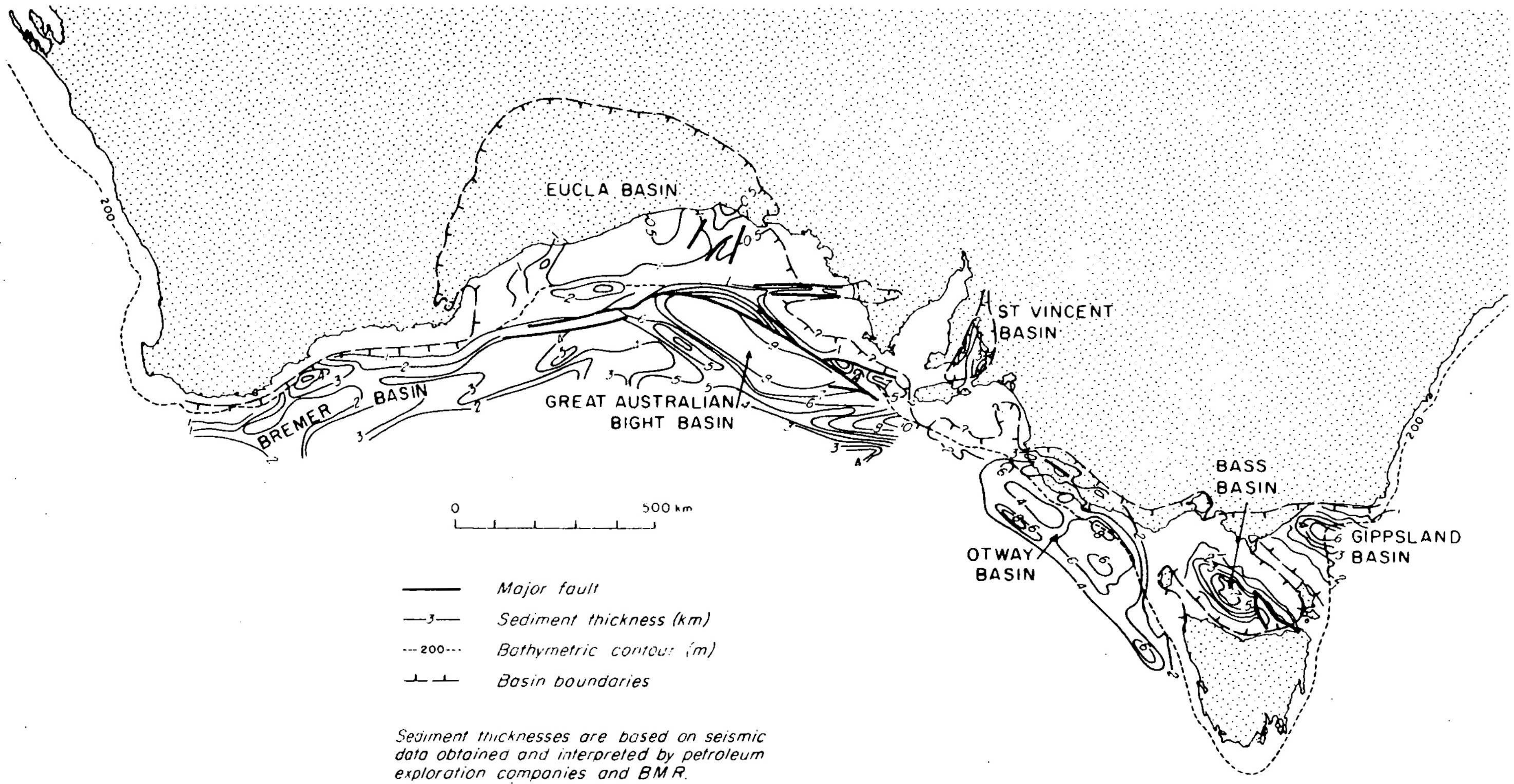

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Fig 1A Generalised total sediment thickness, southern Australian region.

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GEOLOGICAL HISTORY

The evolution of the Gippsland Basin has been discussed by Weeks and Hopkins (1967), Richards and Hipkins (1969), Griffiths (1971), Hocking (1972), Elliott (1972), Gunn (1975), Threlfall and others (1976) and Colman (1976). In terms of plate tectonics, the development of the basin has variously been attributed to two separate phases of continent separation along new plate boundaries. The first of these was the separation of the Lord Howe Rise and New Zealand from eastern Australia from about 80 m.y. to 60 m.y. B.P. The second was the separation of Antarctica from southern Australia, which began about 45 m.y. ago and which is still in progress.

Burke and Dewey (1973) cited the Gippsland Basin as one of numerous examples throughout the world of rift valleys which developed as arms of radiating, triple rift valley systems. According to these authors, rifts extending northeast and south from a point east of the Gippsland Basin developed into a crustal spreading ridge which gave rise to the separation from Australia of the Lord Howe Rise and New Zealand, while the third rift or arm of the 'triple junction' extending westward remained as a 'failed arm' or 'aulacogen'. This developed into the Gippsland Basin.

Gunn (1975) supported this basic concept, but pointed out that it is the 'Strzelecki Basin' rather than the overlying Gippsland Basin which should be identified as the 'failed arm'. The 'Strzelecki Basin' developed as a half-graben in the Late Jurassic and Early Cretaceous. The major subsidence occurred along the southern fault system, and deposition was accompanied by volcanism. Up to 3500 m of fluviatile sediments of the Strzelecki Group were deposited, derived predominantly from a northern source. Seismic evidence along the northern and southern margins of the basin indicates that this sequence is more intensely deformed than the overlying sequence, and where intersected in offshore wells, the top of the Strzelecki Group is marked by an angular unconformity.

The non-marine sediments of the Strzelecki Group were evidently deposited during the tensional, rifting stage of continental break-up which preceded the sea floor spreading which opened up the Tasman Sea. Based on the evidence of ocean floor magnetic lineations (Hayes and Ringis, 1973) sea floor spreading is believed to have taken place between 80 and 60 m.y. B.P. (Late Cretaceous to Early Paleocene). These dates are compatible with the recovery of Upper Cretaceous marine shales from the Deep Sea Drilling Program Site 283 (Geotimes, 1973) (Figure 1A).

The next major period of basin development took place between the Late Cretaceous and the Late Eocene, with the deposition of up to 5000 m of fluviodeltaic clastics and coal of the Latrobe Group. Subsidence began at the eastern end of the 'Strzelecki Basin' as a result of northwest-trending normal faulting and tilting of basement fault blocks. Deposition, which was initially accompanied by volcanism, moved westwards with time and continued without a major break until the end of the Eocene. The area of sedimentation expanded rapidly in the Late Eocene to cover most of the present day basin. The volcanism was most common in the central deep basin, and was associated with the tilting of basement fault blocks.

Threlfall and others (1976) consider that the development of the Gippsland Basin (including the Strzelecki Group) is attributable to the movement of the Tasmanian continental block relative to Australia and Antarctica during the break-up of Gondwanaland. They propose that the relative movement of the Tasmanian block to the southwest created a tensional system in which two separate depressions, the Gippsland and Bass Basins, were formed by crustal thinning. They concede that the separation of Australia and the Lord Howe Rise-New Zealand continental mass may have had some bearing on the structural complexities of the Lower Cretaceous rocks, but consider that the effect of this separation 'is not particularly evident from the data available in the Gippsland Basin'.

The same authors recognise two distinct structural styles within the basin: basin-forming normal faults active principally from Early Cretaceous to Early Eocene, and on echelon anticlines and shear faults generated during the Late Eocene-Early Oligocene and Late Miocene (Fig. 2). The basin-forming faults are ascribed to the tensional regime resulting from the southwest movement of Tasmania and the rotation of Antarctica away from Australia. Presumably the shear faults and the anticlines which developed between them were produced by the same tensional regime, although Threlfall and others are not specific on this point.

It is tempting to postulate that the initial east-west rifting which resulted in the deposition of the Strzelecki Group is attributable to events preceding and connected with the opening of the Tasman Sea, while the later development of shear faults and anticlines in the Gippsland Basin was related to the separation of Antarctica and Australia. Evidence for such a postulate is largely circumstantial, the ages of the two types of

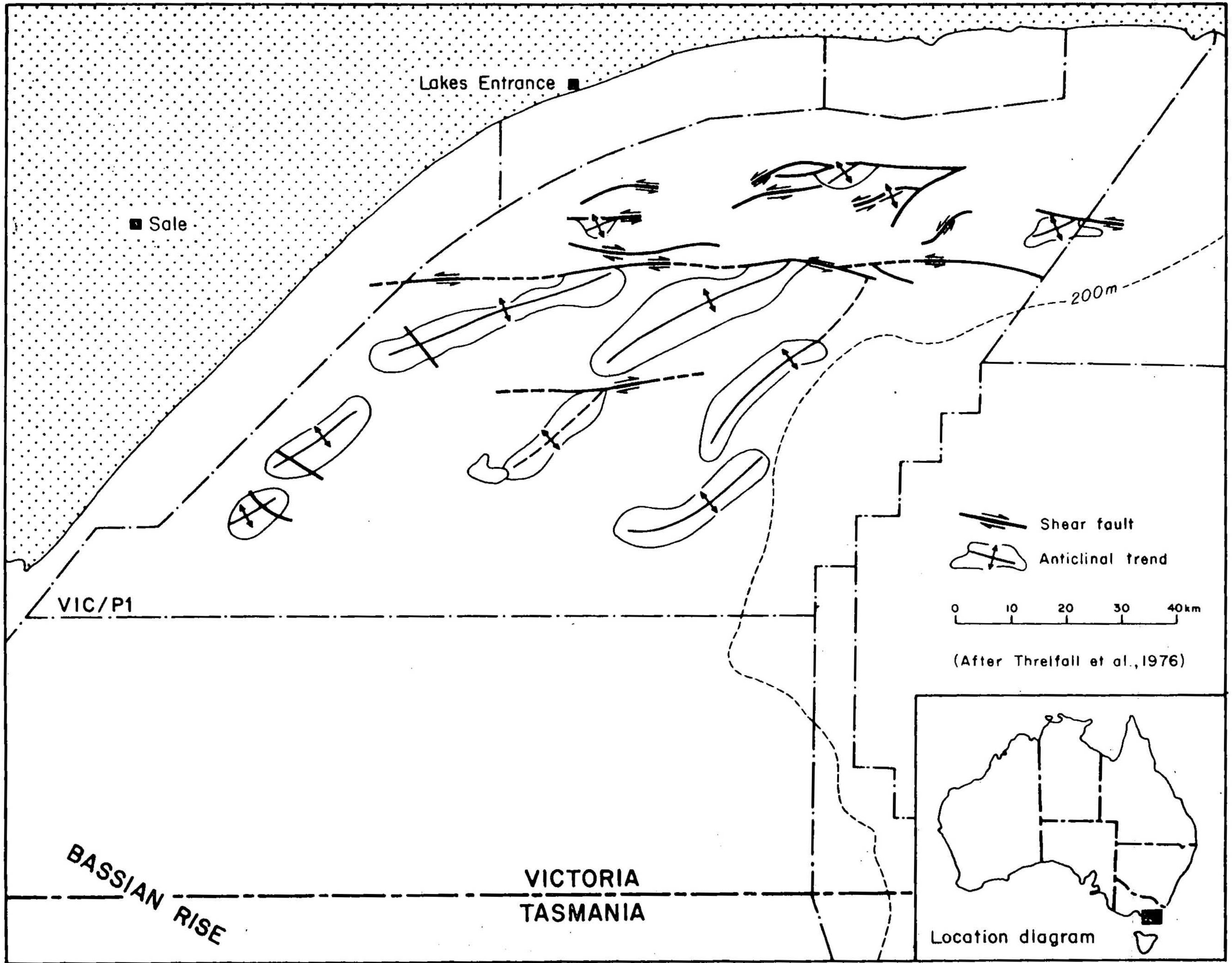

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Fig. 2 Late Eocene - Early Oligocene and Late Miocene anticlines and shear faults.

faults in the Gippsland Basin being consistent with known dates of plate tectonic events related to the separation of Australia from Lord Howe Rise-New Zealand and Antarctica respectively.

The Latrobe Group is characterised by an almost basin-wide unconformity at the top and by large-scale channels of several ages. While there is no evidence for the existence of open-marine conditions during the deposition of the group, there is evidence for marginal marine conditions in the form of discrete dinoflagellate ingressions. These were described by Partridge (1976) (Figure 6) and related to eustatic tycles, within the context of a relative overall rise in sea level during the Paleocene and Eocene. In a chronographic section (Figure 7) Partridge shows the distribution of a series of sedimentary sequences within the Latrobe Group as a function of geological time. The section shows each sequence onlapping the basin margins at its base and being truncated towards the margins at its top, and also a general landward encroachment towards the northwest. The landward encroachment is accompanied by the development of an increasingly more widespread area of non-deposition on the seaward, southeasterly, side. It is suggested that the apparent non-deposition of fine-grained sediments may have been due to the removal of such sediments by the action of strong currents on the shallow Gippsland shelf. The concept that fine-grained sediments were being supplied but were by-passing the shelf during this time is supported by the finding of fine-grained terrigenous sediments of Paleocene and Eocene age in the DSDP Site 283 (Fig. 1A) in the Tasman Sea. Partridge therefore considers that the unconformity at the top of the Latrobe Group should be regarded as being as much the result of non-deposition as of erosion, and that where erosion occurred it was associated with the large-scale channelling during major low stands of sea-level in the Early and Middle Eocene. These channels will be discussed further under the heading 'Stratigraphy'.

Sedimentation in the Middle to Late Eocene was widespread on the southern platform of the basin and onshore on the northern platform, but restricted to the westernmost part of the central basin.

Marine conditons were established over the basin in the Early Oligocene during the continuing overall marine transgression. Sediment type changed from the mainly coarse-grained clastics of the

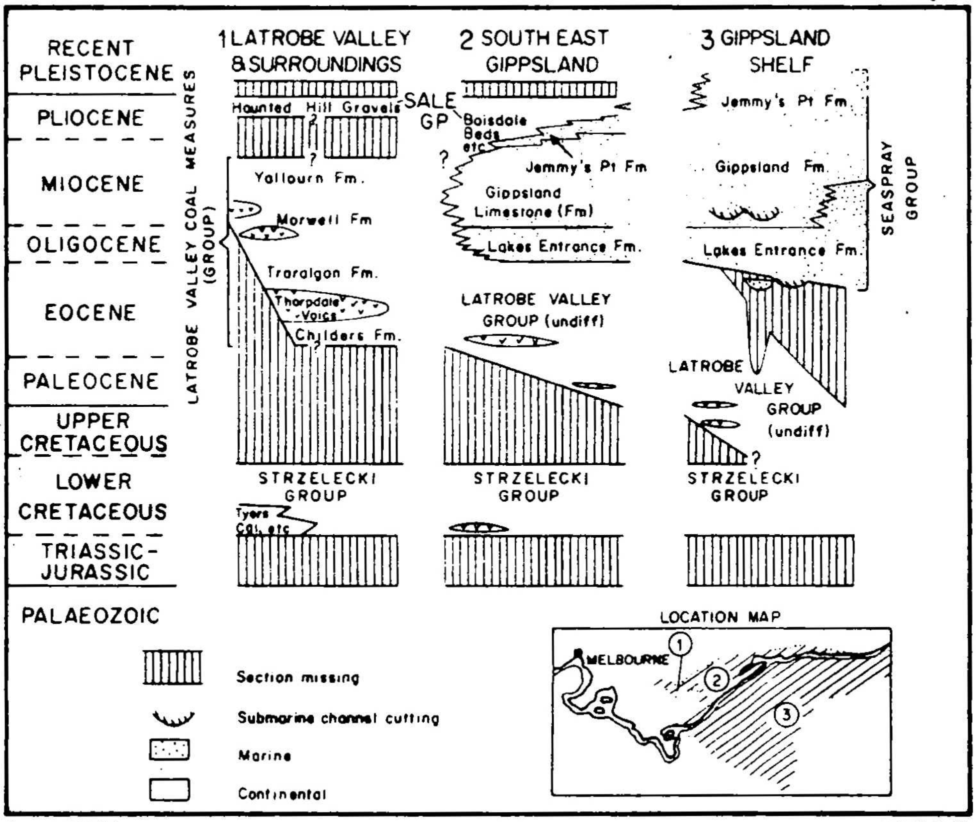
Latrobe Group to the calcareous shale and marl of the Lakes Entrance Formation. The marine shale was deposited in a narrow wedge around the basin margins, only a thin veneer of pelagic shale being deposited in the basin centre. Late in the Early Oligocene a drop in sea-level caused erosion of the shale on the margins, over most anticlinal crests and perhaps in the youngest of the Eocene channels. With a renewed rise in sea level deposition of shale and marl continued through the Middle and Late Oligocene and, offshore, into the Early Miocene, onlapping the basin margins and structural 'highs'.

During the Miocene there was a gradual change in sedimentation from the shale and marl of the Lakes Entrance Formation to the bryozoan limestone and marl of the Gippsland Limestone. Upper Miocene limestone formed the present continental shelf and slope within the area of the basin.

The Miocene sequence is characterised offshore by two major depositional features which are described by Threlfall et al., (1976). A massive linear slump zone occurs on the southern platform, and complex channelling is evident over the remainder of the basin. The northwest-trending slump zone can be traced seismically for more than 130 km. It was formed when a northerly-prograding wedge of marls and limestones slumped towards the basin centre during structural movement which activated the south-bounding fault. Structural movements and sea-level changes were responsible for the complex submarine channels. The heads of the channels are filled with a coarse mixture of skeletal fragments and sand grains and the middle and distal portions are filled mainly by micritic limestone with low porosity. The micritic limestone presents problems in seismic mapping of underlying strata because of its very high velocity compared to that of the surrounding rocks.

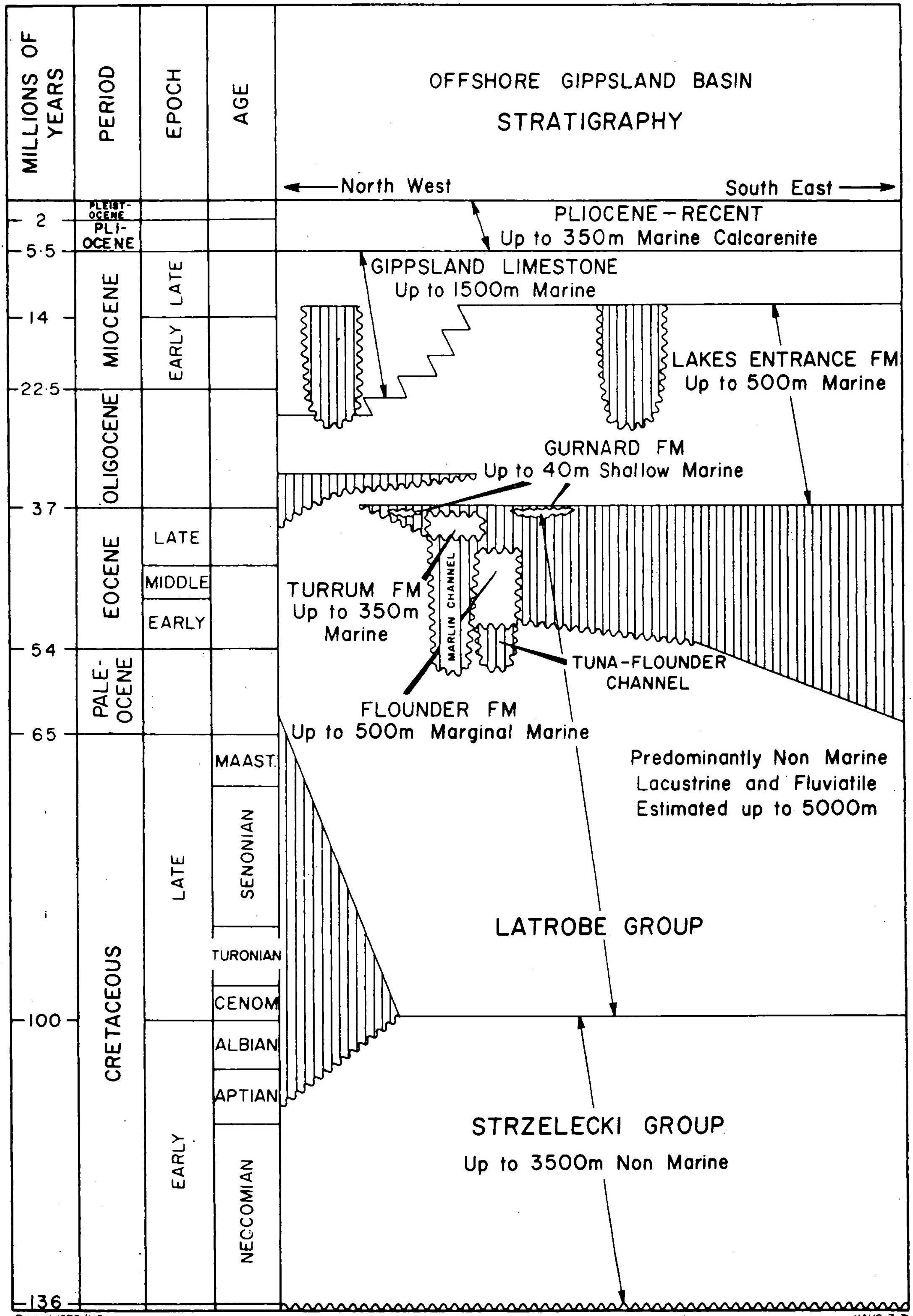
Mention has already been made of structural deformation in the Gippsland Basin from late Eocene to Miocene. This deformation was related to east-west strike-slip faults, as a result of which large en echelon anticlines were developed between continuous fault zones. Strike slip movement occurred in the Late Eocene to Oligocene, and in the Late Miocene, and during each period the movement was accompanied by the intrusion and extrusion of mafic igneous rocks and the rejuvenation of some of the older, basin-forming faults.

Fig. 3



Record 1978/110 Stratigraphic Chart, Gippsland Basin (after Hocking, 1972) XAUS-7-47

Fig. 4



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(After Threlfall et al., 1976)

The final episode in the development of the Gippsland Basin was a period of marine regression and a return to continental clastic sedimentation in southeastern Gippsland. Marine sedimentation continued on the continental shelf. The highland region north of the basin and the South Gippsland Hills along the western margin were uplifted during the Kosciusko uplift in the Late Pliocene and structures around the northern edges of the basin were rejuvenated. Many plunged eastward as a result of basinward tilting.

STRATIGRAPHY

This section is based mainly on James and Evans (1971), Threlfall and others (1976), and Partridge (1976) who present the sequence for the offshore area; and on a number of authors, principally Gloe (1967), Traill (1968), Hocking (1972), Haskell (1972), and Coman (1976) for the onshore part of the the basin. It includes a brief treatment of several stratigraphic units which have been recognised by some authors as separating the Strzelecki Group from the Latrobe Valley Coal Measures, and by others as formations within the coal measures sequence, and indicates some of the contradictions contained in the literature in relation to these units.

Figures 3 and 4 show the stratigraphy presented by Hocking (1972), and Threlfall and others (1976). Figure 5 shows geological cross-sections after James and Evans (1971) and Beddoes (1973).

Knowledge of time-stratigraphic relationships in the Gippsland Basin was derived from the recognition of spore-pollen assemblages in the Late Cretaceous to Eocene non-marine and marginal marine interval, and of planktonic foraminiferal zonules in the Oligocene to Pliocene marine sequence. Seismic data, and electrical log data in areas of close well control, have also contributed to the understanding of the stratigraphy.

The Cretaceous spore-pollen zones are derived from zones proposed by Dettman and Playford (1969), and the planktonic foraminiferal zonules are a refinement of those originally defined by Taylor (1966) for Barracouta No. 1 well. The spore-pollen zones are described by Stover and Evans (1973), and Stover and Partridge (1973). Partridge (1976) presents the recent changes that have been made to the zonation and gives a recent correlation of the zones with the International

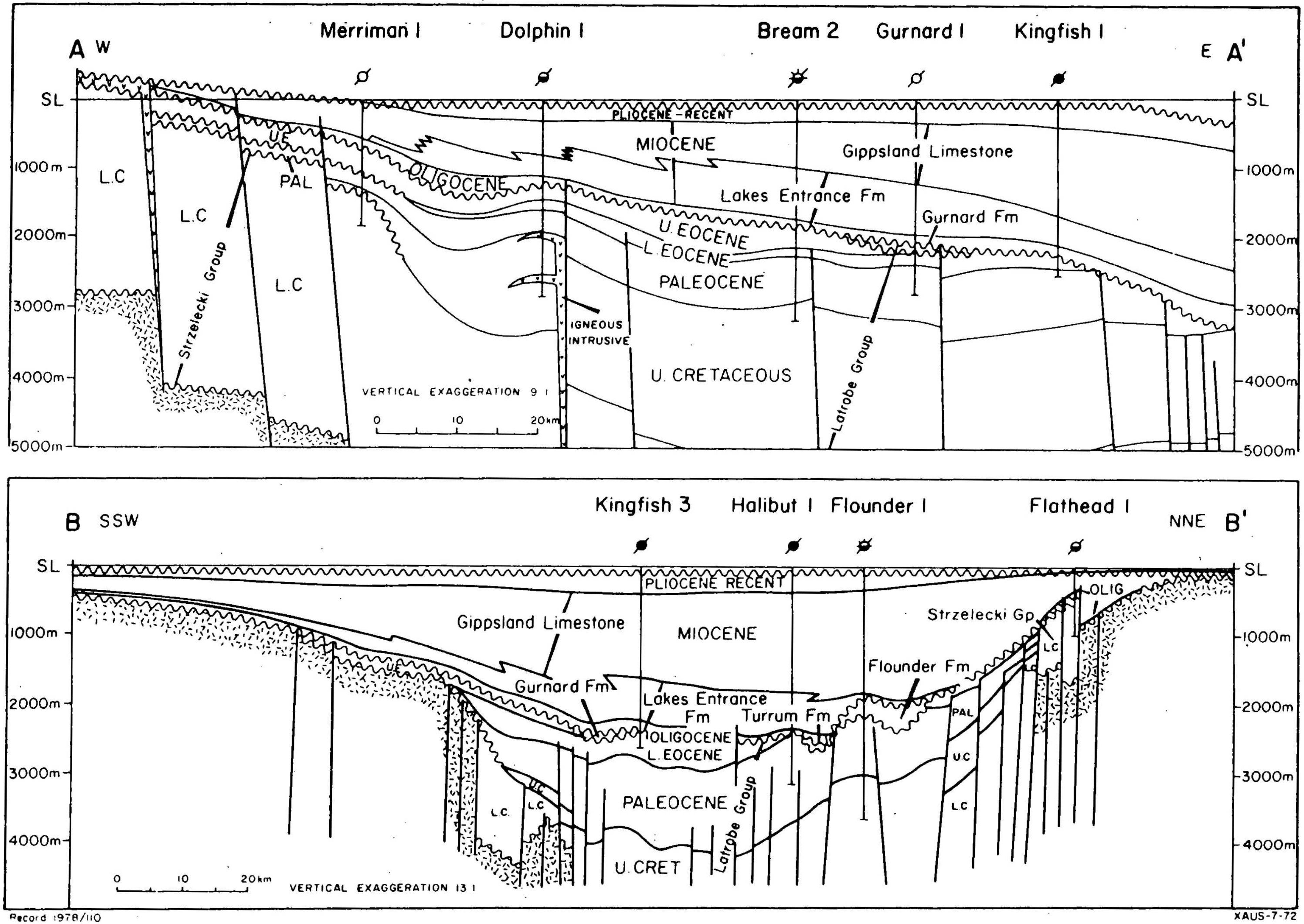
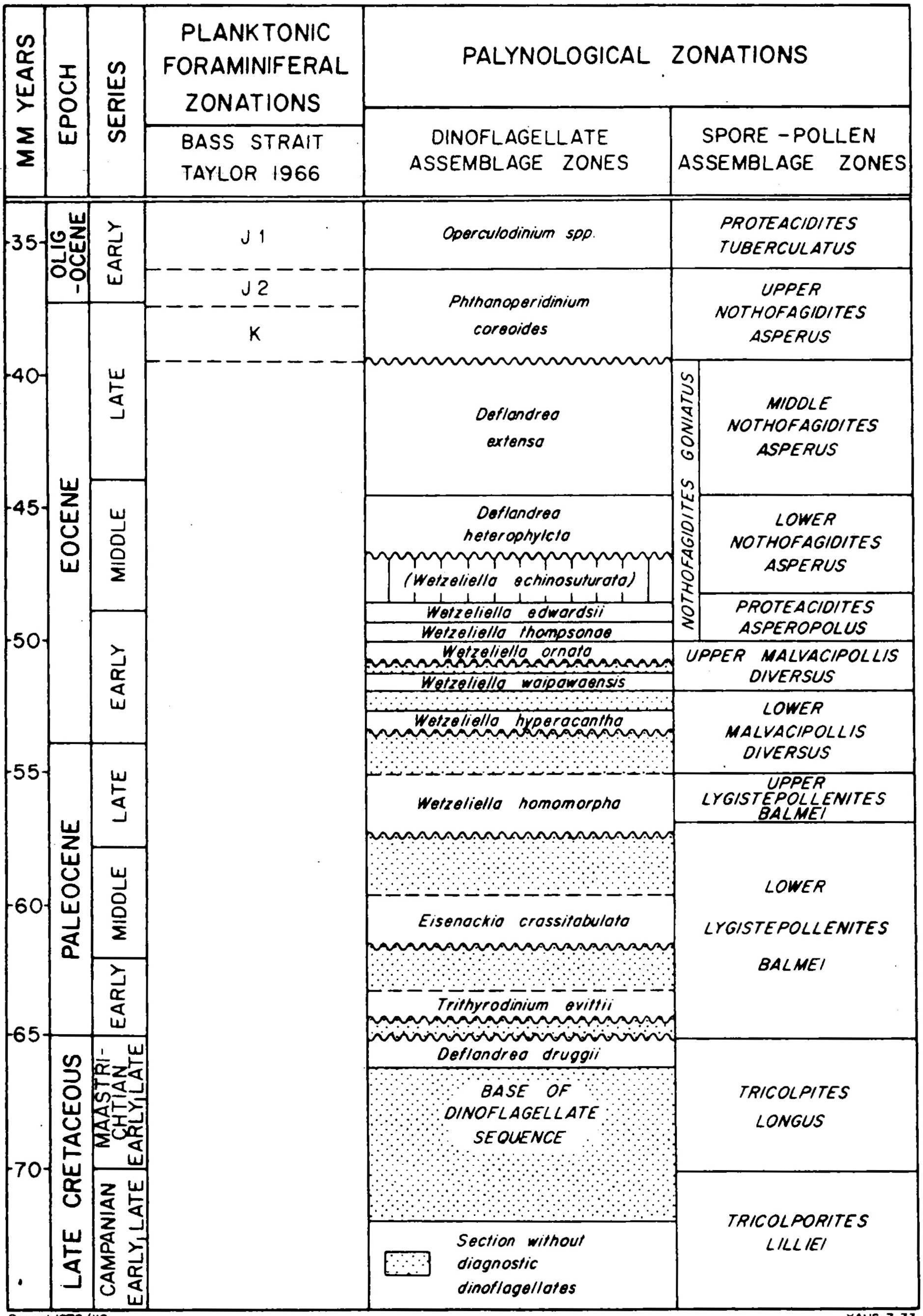


Fig. 5 Geological Cross Sections – Offshore Gippsland Basin (After James and Evans, 1971 and Beddoes, 1973)

Fig. 6



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

(After Partridge, 1976)

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Geological Time Scale (Fig. 6). The changes, 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 recognises a series of dinoflagellate assemblage zones in the Latrobe Group (Fig. 6). The zones represent discrete ingressions of dinoflagellates and are interpreted as indicative or rises in sea level. The zones are widespread, covering areas up to 2500 km^2. The dinoflagellate assemblages which are also recorded from the Otway Basin and from New Zealand in sequences dated by planktonic foraminifera provided the correlation with the International Time Scale. Figure 7 is Partridge's chronographic section for the Gippsland Basin based on the spore-pollen, dinoflagellate, and planktonic forminiferal zones.

Seismic data (Steele, 1976) have been used for the recognition of discrete time-stratigraphic units within the Latrobe Group and overlying Lakes Entrance Formation through the application of the concept of sequences as defined by Vail et al., (1975). A sequence is defined as a time-stratigraphic unit that is bounded by unconformities, or their correlative conformities, at its top and base. The seismic sequences recognised in the Latrobe Group and Lakes Entrance Formation have been tied into the palynological and foraminiferal zones at the well control.

Basement Basement rocks are exposed onshore to the north and west of the basin, and offshore where they form islands along the Bassian Rise. They comprise Ordovician and Silurian rocks of the north-trending Tasman Fold Belt overlain by Devonian to Early Carboniferous red-beds. Non-marine sediments of Permian age are also exposed to the north of the basin and have been intersected in one onshore well, Duck Bay No. 1.

The Tasman Fold Belt sequence consists of folded and slightly metamorphosed sediments of Ordovician and Silurian age which were deformed and intruded by massive granites and granodiorites during the Devonian Tabberabberan Orogeny. The overlying post-orogenic Devonian-Carboniferous red-beds, comprise conglomerate, sandstone, and pebbly mudstone with interbedded rhyolite, rhyodacite and trachyte.

Onshore, basement has been intersected by a number of wells north of latitude 38°45'S, but offshore it has been reached by only four wells located on the southern margin. Groper No. 1, Bluebone No. 1, and Mullet No. 1 bottomed in granite, and Groper No. 2 in red siltstone, presumed to be Devonian to Carboniferous in age.

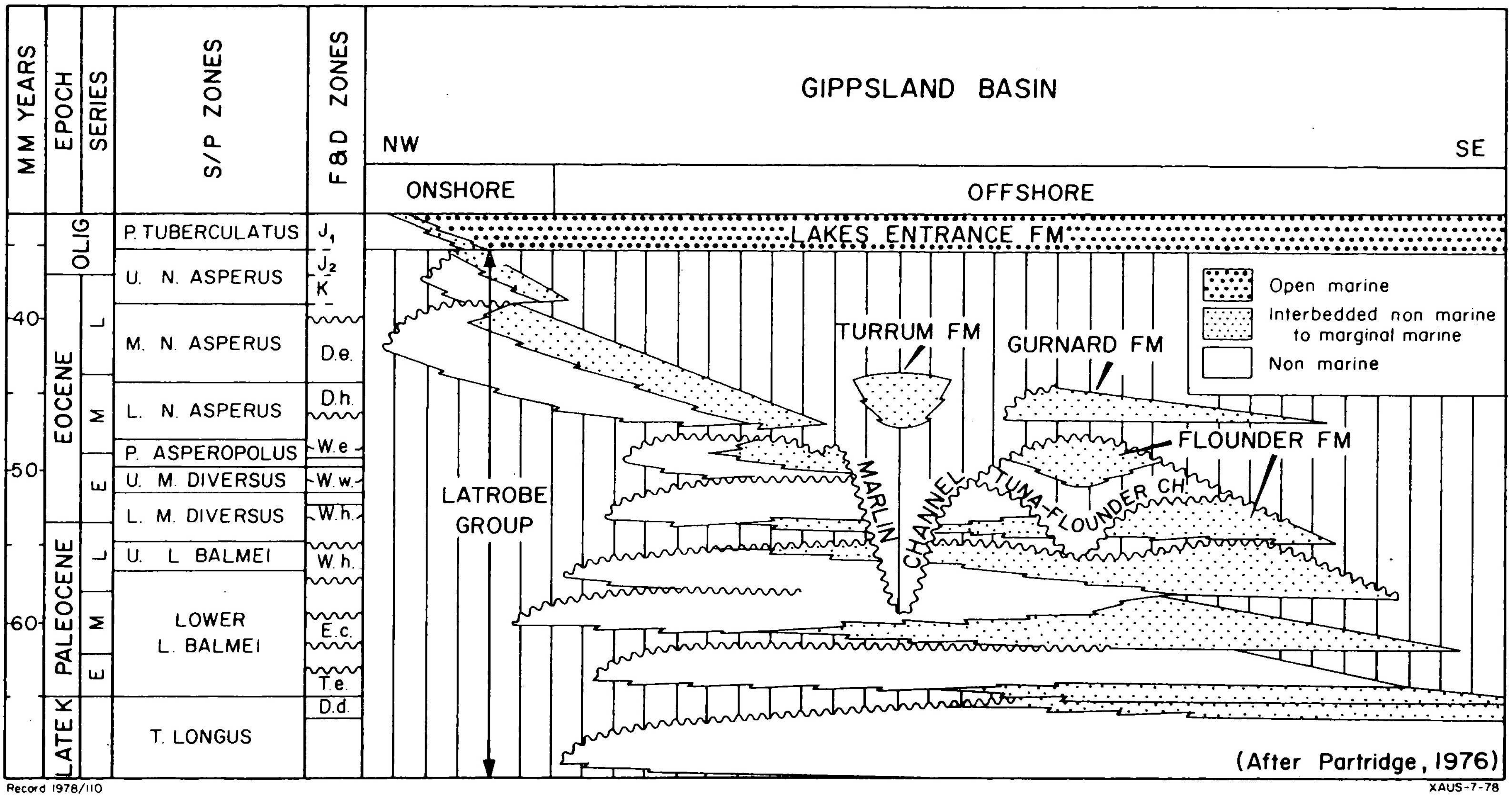

Fig. 7 Chronographic section Gippsland Basin

The aeromagnetic data suggest that the character of the basement underlying the centre of the basin is similar to that already described, except in the area of the Bream structure where a large magnetic anomaly is indicative of a deep mafic intrusive.

Strzelecki Group The group was originally defined by Medwell (1954) as a Jurassic unit. Palynological evidence has since dated it as mainly Neocomian to Albian but it contains some Late Jurassic sediments. The Group crops out onshore (Pl. 1), and has been penetrated offshore in Emperor No. 1 (159 m), Flathead No. 1 (589 m), Wahoo No. 1 (154 m), Golden Beach No. 1A (610 m), Perch No. 1 (1354 m), and possibly in Moray No. 1 (745 m). The maximum thickness of the Group is unknown. The sequence comprises non-marine sandstone with interbedded siltstone, mudstone, claystone, and minor coal. The sandstone is predominantly medium-grained, feldspathic and volcanolithic with abundant kaolinitic and chloritic clay matrix and minor calcareous cement, and is mainly impermeable. The Group appears to have resulted from rapid deposition on a steadily subsiding fluvial plain. The Tyers Conglomerate and associated quartzose sandstone units at the base of the sequence were derived from the adjacent Palaeozoic craton. Basal Early Cretaceous volcanics about 100 m thick composed of chloritised basalts and minor tuff occur in the sub-surface near the northern margin of the basin about 30 km west of Lakes Entrance and constitute a major source for the overlying sediments.

Latrobe Valley Group This term is used by Hocking (1972) to include the offshore Latrobe Group of Esso and its stratigraphic equivalent onshore in southeast Gippsland (Fig. 2). He describes the depositional environment as an extensive, aggrading fluvial plain and an adjacent high-constructive delta system nearer the present shelf edge........... Sediment supply was primarily from the north but also from the southwest. The group shows an overall increase in deltaic facies to the southeast and a similar vertical facies changes due to the transgressive nature of the sequence. Onshore and offshore in the Gippsland coastal area, the sequences encountered broadly comprise an upper mainly sandstone section representing lower fluvial plain and sub-aerial delta plain facies, overlying fluvial and deltaic swamp deposits including coal and carbonaceous mudstone. Offshore, toward the edge of the Gippsland Shelf, the sequence in the Halibut field (Franklin and Clifton, 1971) consists of distributary and interdistributary (including lacustrine) deposits of the delta plain.

Threlfall and others (1976) describe three time-rock units in the Latrobe Group:

(i) Late Cretaceous

The late Cretaceous sequence consists of shale, minor coal and poorly-sorted sandstone, and is non-marine where penetrated. The unit progressively onlaps the Early Cretaceous Strzelecki Group unconformity surface towards the basin margins where in Emperor No. 1, Perch No. 1, and Moray No. 1 only the youngest Upper Cretaceous sediments are present. It is possible that Lower and Upper Cretaceous sequences could be conformable in the centre of the basin - in Tuna No. 1 the spore and pollen assemblages in the Late Cretaceous sediments at total depth were interpreted to have Early Cretaceous affinities. Late Cretaceous marine shale was recovered from the Joides Hole 283 in the Tasman Sea (Fig. 1A) indicating the presence of a shoreline along the east coast of Australia and Tasmania at this time.

(ii) Paleocene to Early Eocene

Sediments of this age reach a maximum thickness of 1500 m in the centre of the basin. Encroachment of the shoreline from the southeast produced a zone of progradation and palaeoslope development which can be distinguished on northwest-trending seimsic sections in the southeastern part of the basin. Little or no sediment accumulated beyond this zone owing to non-deposition and erosion. The Kingfish, Bonita, Albacore, Mackerel and Stonefish wells located from southwest to northeast along the encroaching shoreline intersected stacked sequences of beach, shoreface and offshore sediments. The non-marine sediments were deposited in alluvial and delta-plain environments with the main direction of stream flow and sediment transport being from the northwest to the southeast. Carbonaceous shales and coals are interbedded with sandstones of point-bar and braided stream origin.

(iii) Early-Late Eocene

During the Early-Late Eocene there was a reduction of normal fault movement in the basin and a general slowing down in the rate of sediment accumulation. Latrobe Group sediments of this age reach a maximum

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thickness of 700 m. Braided stream and point bar sandstones and coal make up a higher percentage of the sequence than in the underlying units, particularly in the northeast.

During the Early Eocene in the northeastern part of the basin a roughly southeast-trending channel was cut into the top of the Latrobe Group to a maximum depth of about 650 m. The channel is termed the Tuna-Flounder channel and the sediments that fill it, the Flounder Formation (after Flounder No. 1). The lower part of the formation is a massive sandstone which is interpreted as a 'grainflow' deposit that both cut and partly filled the channel. The upper part of the Flounder Formation is a shaly, micaceous, pyritic siltstone which is interpreted as a prograding estuarine deposit which filled the channel during continued subsidence of the area in the Middle and Late Eocene. .

Further channelling occurred in the northeastern area in the latest Eocene following the tectonic events that produced the en echelon anticlines and shear faults discussed previously. Erosion occurred on the crests of the anticlines and on the basin margins, and drainage systems trapped by the tectonic events cut the Marlin Channel, probably by subaerial erosion in the upper reaches but by subsea erosion in the middle and lower reaches.

The channel trends southeasterly and eroded the Flounder Formation in addition to the Latrobe Group. The Turrum Formation, named after Turrum No. 1 (Appendix 3), fills the Marlin Channel and has been mapped from seismic data. It reaches 300 m in thickness and in Turrum No. 1 consists of dark grey-brown shale with rare coarse clastic interbeds. Benthonic and rare pelagic foraminifera occur in the formation which is interpreted as a marine deposit that filled the channel during continuing marine inundation of the basin in the Late Eocene. In contrast to the Tuna-Flounder Channel the original clastic material in the erosional channel has not been preserved.

The Gurnard Formation (named after Gurnard No. 1) is a Late Eocene unit which occurs sporadically in the eastern two-thirds of the basin. It comprises up to about 35 m of glauconitic, very fine-grained sandstone, siltstone, and mudstone, containing assorted pebbles, which is interpreted as a shallow marine facies deposited on the eroded Latrobe Group surface during the continuing rise in sea level and northwesterly migration of the shoreline in the Late Eocene.

Haskell (1972) uses the term Latrobe Group for the Late Cretaceous to Eocene sequence onshore and describes two formations in the pre-Eocene part of the sequence.

Golden Beach Formation Haskell proposed this name for a sequence which in various well completion reports had either wholly or partially been included informally in the Strzelecki Group as the Golden Beach Beds or Formation. The type section is that intersected between 1707 m and 2377 m in Golden Beach No. 1A. Other wells which intersected the formation are Colliers Hill No. 1, Dutson Downs No. 1 and Golden Beach West No. 1. The formation consists of medium to coarse-grained sandstone with interbedded siltstone and mudstone. Palynological evidence indicates a Late Cretaceous (Cenomanian to Turonian) age (Dettman 1966a, 1970) and a non-marine depositional environment. The sandstone beds are up to 30 m thick and are locally cross bedded.

Traill (1968) proposed the term Barracouta Sandstone for a Late Cretaceous sequence of similar lithology to the Golden Beach Formation encountered in Barracouta No. 1A which he stated also occurs in the offshore wells Cod 1A, Marlin 1A, Golden Beach 1A and the onshore wells Merriman No. 1, Lake Reeve No. 1, North Seaspray No. 1, Golden Beach West No. 1, Dutson Downs No. 1, and Hollands Landing No. 1. Comparison of Haskell's and Traill's papers indicate that the two terms were proposed for the same interval. James and Evans (1971) state that palynological evidence subsequent to Traill's work does not support his recognition of the Barracouta Sandstone as a formation in the offshore area.

Childers Formation This term has been applied to a predominantly sandstone unit that crops out in the west Gippsland highlands in the Warragul 1:250 000 Sheet area (Geol. Surv. Vic., 1966) where it is dated as Oligocene, and separated from the overlying Latrobe Valley Coal Measures by a basalt unit, the Thorpdale Volcanics. In the absence of the Thorpdale Volcanics which thin eastwards in the subsurface the Childers Formation does not appear to be lithologically distinct from the overlying coal measures. There is confusion in the literature with respect to the age and lithology of this unit. Traill (1968) describes it as a series of brackish water clays and slates, and Haskell (1972) describes this formation in the sub-surface in the coastal area as a predominantly sandstone unit overlying the Golden Beach Formation,

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and cites the sequences between 1449 and 1715 m in Golden Beach West No. 1 as typical of the formation. This unit contains micro flora of Paleocene age (Dettmann 1966 a & b). Hocking (1972) gives the age of the formation as Eocene.

Traralgon, Morwell and Yallourn Formations Hocking (1972) considers the Traralgon Formation in the Latrobe Valley and surroundings as the time equivalent of the Latrobe Valley Group in coastal Gippsland, and the Morwell and Yallourn Formations as the non-marine time equivalents of the marine Lakes Entrance Formation and Gippsland Limestone respectively. Boutakoff (1955) describes the Morwell and Yallourn (Groups) as consisting of 'thick brown coals with subordinate clays passing eastwards into gravels and sandstones'.

Latrobe Valley Coal Measures Hocking (1972) confines the use of this term to the coal measures of Eocene to Miocene age in the Latrobe Valley and surroundings. He gives the unit group status, and recognises the five formations shown in Figure 3 and described briefly in the foregoing. Haskell (1972) on the other hand, regards the coal measures as a formation comprising the Eocene part of the Latrobe Group, and divides the pre-Eocene part into the Golden Beach Formation and the Childers Formation.

Colman (1976), in a review of the onshore part of the basin uses Hocking's classification, but uses the term Latrobe Group for the two sequences referred to by Hocking as Latrobe Valley Group and Latrobe Valley Coal Measures.

Lakes Entrance Formation This unit was mapped in the subsurface onshore as a sequence of basal gravels and sands, a glauconitic sandstone member and a micaceous marl. It is of Oligocene age and up to 230 m thick (Crespin, 1943; Boutakoff, 1955; Carter, 1964). It comprises the Colquhoun Gravel Member, the Greensand Member, and the Micaceous Marl Member of Hocking and Taylor, (1964). Offshore (James and Evans, 1971) the name is applied to a sequence of marine mudstone up to 455 m thick which overlies the Latrobe Group. The mudstone is usually olive-green and contains a variable amount of argillaceous and calcareous material, and abundant bryozoal fragments, foraminifera, pyrite and galuconite. The boundary with the overlying Gippsland Formation is gradational, lying within the Oligocene onshore, and within the Miocene offshore in the centre of the basin.

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Gippsland Limestone Onshore the formation comprises up to 900 m of Miocene limestone and marl overlying the Lakes Entrance Formation. Offshore the formation reaches a thickness of up to 1500 m and mainly consists of limestone, calcarenite and marl. The sediments infilling the Miocene sub-marine canyons are also considered part of this formation. These are mainly calcareous mudstone with subordinate micritic limestone, but in the area of the Barracouta field there is a quartz-carbonate sand unit which is interpreted as possibly a channel-head facies (Esso, 1966).

Jemmy's Point Formation Hocking (1972) uses the term for a late Miocene to early Pliocene sequence of glauconitic-limonitic sandstone and siltstone in southeast Gippsland. Offshore the youngest sedimentary unit consists of a largely calcarenite sequence up to 300 m thick (Franklin & Clifton, 1971; James and Evans, 1971) which Hocking also assigns, although tentatively, to the Jemmy's Point Formation.

Hocking (Fig. 2) includes the three formations just described in the Seaspray Group.

Sale Group Hocking (1972) describes this group as representing the final phase of the major transgressive/regressive cycle which produced the sedimentary fill of the Gippsland Basin and the return to continental clastic sedimentation in southern Gippsland. He includes the Plio/Pleistocene Haunted Hill Gravels, and Pliocene Boisdale Beds (Fig. 3) with a combined thickness of up to 260 m, as typical units (Jenkin, 1968).

Quaternary sediments A relatively thin veneer of Quaternary sediments was deposited across southeast Gippsland after a period of extensive erosion (Jenkin, 1968).

GEOPHYSICAL EXPLORATION

The earliest geophysical surveys in the Gippsland Basin were carried out by BMR. Gravity surveys by BMR began in 1948 and continued in limited areas until 1961. Aeromagnetic surveys by BMR covered most of the onshore basin and a significant part of the offshore basin by 1956. BMR further investigated gravity and magnetic anomalies by small scale seismic

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surveys until the early 1960's since when most of the work has been carried out by petroleum exploration companies.

During the 1960's the emphasis of geophysical activity moved from onshore to offshore. The surveys also became larger in scale and coverage, and increased in technical complexity. Numerous marine seismic surveys were carried out between 1963 and 1975. Important offshore petroleum reserves were discovered and exploited during the period.

Geophysical activity onshore has declined from the levels experienced in the early 1960's. Only one minor seismic survey and one regional gravity survey (by BMR) have been undertaken this decade, and the latter was not specifically directed at petroleum objectives.

This section will describe the history of geophysical operations in the Gippsland Basin, and review their results on a regional scale.

MAGNETIC SURVEYS

The locations of magnetic surveys in the Gippsland Basin are indicated on Plate 2. Individual surveys are also listed in Appendix 2 and are cross-referenced to the map by means of map key numbers.

Airborne magnetic surveys by BMR (McCarthy, 1952; Goodeve, 1956) had covered the onshore areas of the basin and most of the near offshore areas by 1956. Individual flight lines have not been indicated on Plate 2 for this detailed work but flight lines were oriented north-south and spaced 1.6 km apart. Flight altitude was 300 m. Offshore aeromagnetic coverage was extended by Haematite Explorations during 1960-61 into the central Gippsland Basin. This work was part of a large survey covering much of Bass Strait and extending west into South Australian waters (Haematite, 1965). An aeromagnetic survey in 1967 for Magellan Petroleum was undertaken in deeper water along the outer shelf and upper continental slope, but details are unavailable.

Magnetic data have been collected in the offshore Gippsland Basin during marine geophysical surveys from 1968 to 1973, and results from parts of three surveys are available under PSSA. These consisted of two surveys by Magellan (East Gippsland and Tasman-Bass Strait), and one by Esso Exploration (the G69A survey, see Appendix 2).

Regional magnetic traverses in deep water were undertaken during Esso's G71A survey, the BMR Continental Margin geophysical survey of 1971-72, and the Shell Deepwater Scientific survey of 1972-73.

<u>Results</u> Quilty (1965) has documented the results of the BMR aeromagnetic surveys. Contours of depth to magnetic basement for the onshore and near offshore parts of the basin in Plate 3 have been taken from his interpretation. In the area immediately northeast of the Kent Group, the contours depend on the company's interpretation of the results of Haematite's survey (Haematite, 1965). The good agreement between these two interpretations along the common survey boundary has permitted presentation of continuous contours across the boundary area between the two surveys in Plate 3.

Results shown for the ramainder of the Gippsland Basin are adapted from a report available under PSSA (Magellan, 1969). Magnetic intensities measured at sea level during a marine seismic survey were recomputed using the method of upward continuation to a plane 300 m above sea level, and integrated with magnetic intensities measured at that altitude during a previous aeromagnetic survey. This enabled a more complete definition of the anomaly pattern to be made than was possible using marine magnetic or aeromagnetic data alone. However both survey areas were narrowly confined so that optimum definition of anomalies may not have been achieved. Because no significant overlap existed between Magellan's results and those described previously, the two sets of data are presented as separate sets of contours on Plate 3. General agreement between them is observed between 39^{o}S and 40^{o}S. Magnetic results from later marine surveys are mostly presented in company reports in profile form, and interpreted depths to magnetic basement are not available.

A strong magnetic contrast between basin sediments and Palaeozoic rocks was observed around the onshore basin boundary, together with a tendency for Palaeozoic tectonic axes, as expressed by magnetic anomalies, to continue across the boundary beneath the basin. Maximum basin thickness was indicated in an east-west trough extending from the coast to the 200 metre isobath. A large area of shallow magnetic basement was indicated over the eastern part of the Victorian offshore area, extending to 40 km south of the coast. The presence of basalt flows within the sedimentary section in the western onshore area reduced the reliability of some basement depth estimates, but the presence of an easterly-plunging anticlinal basement feature intersecting the coast near 38^{o}30'S was indicated.

To the south and southwest of the area of deepest basinal development, magnetic basement gently shallows, and represents a set of ridges with interfingering embayments of sediment which thin toward the southwest.

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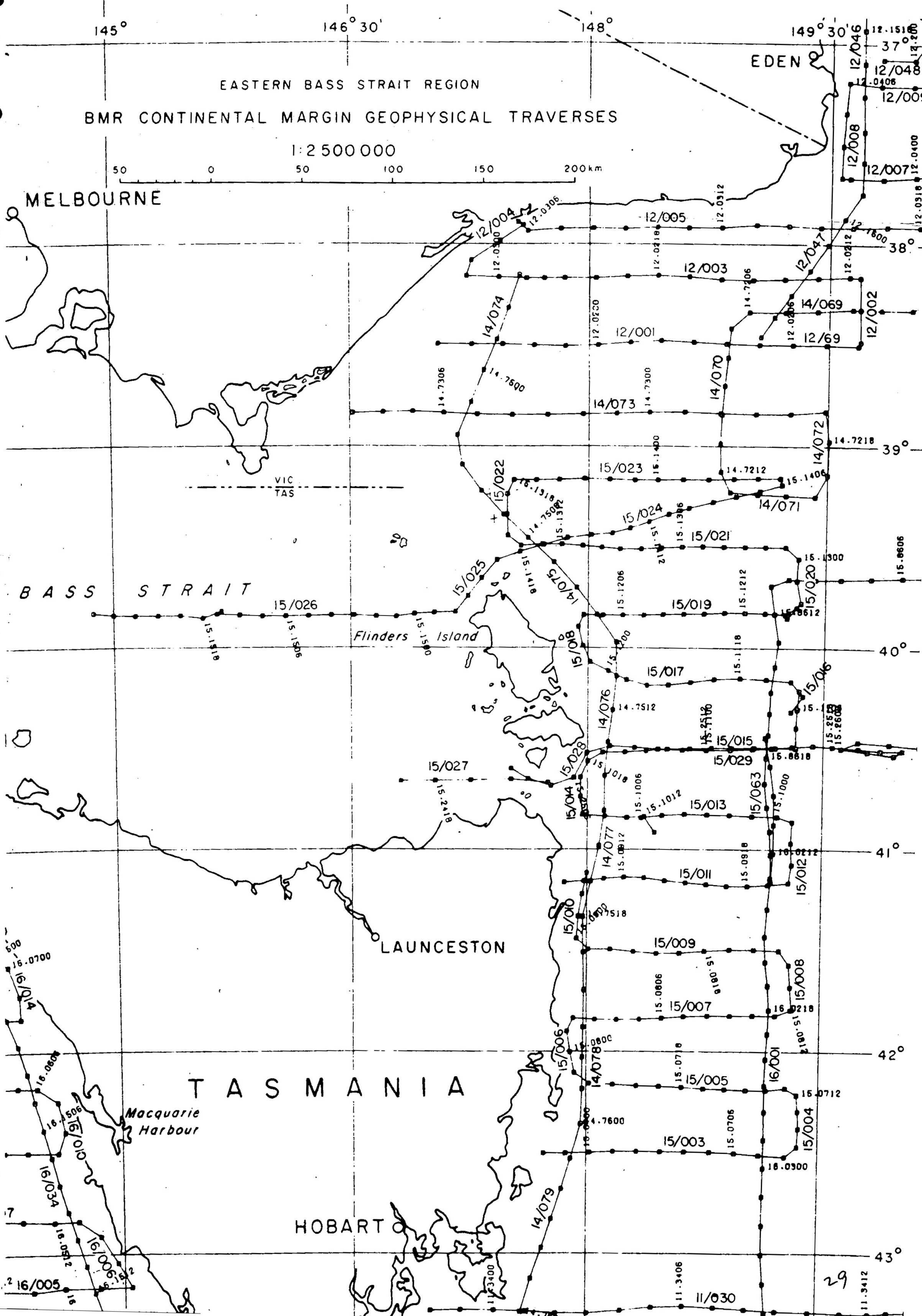
EASTERN BASS STRAIT REGION
BMR CONTINENTAL MARGIN GEOPHYSICAL TRAVERSES
1:2 500 000
50 0 50 100 150 200km
145°
146° 30'
148°
149° 30'
37°
38°
39°
40°
41°
42°
43°
EDEN
MELBOURNE
VIC
TAS
BASS STRAIT
Flinders Island
TASMANIA
LAUNCESTON
HOBART
Macquarie
Harbour
12/004
12/005
12/003
12/001
12/002
12/69
12/007
12/008
12/046
12/047
12/048
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14/073
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15/012
15/010
15/009
15/008
15/007
15/006
14/078
15/005
16/001
15/004
15/003
14/079
11/030
16/014
16/010
16/034
16/006
16/005

The Gippsland Basin is bordered along its entire southwest margin by a region of shallow or outcropping basement rocks known as the Bassian Rise. Although short wavelength, high amplitude anomalies, typical of shallow basement were mapped near Wilson's Promontory and Flinders Island, the Bassian Rise produces no intense magnetic anomalies along much of its length.

Magnetic results have suggested that areas of significant sediment thickness may exist in deep water around the rim of the Bass Canyon, which is the name given to the prominent northwesterly-trending embayment of deep water in eastern Bass Strait between 38°30' and 39°S, and on the continental slope to the south. A total sediment isopach map would be preferable to a basement depth map for the presentation of results in rapidly varying water depths, but Plate 3 permits the following general observations:

On the north wall of the Bass Canyon, sediment thickness indicated by the magnetic data ranges from 3 to 5 km in water depths of 1 to 2 km. Survey coverage is sparse at the canyon head, but the presence of 1 to 2.5 km of sediment is indicated. Up to 4 km of sediment may be present on the western wall. This sediment distribution is consistent with an erosional origin for the canyon. Further south at about 39°20'S, a graben containing a maximum of 4 km of sediment in water depth of 1 km exists (Pl. 3). In general, the shape of the magnetic basement surface in the area of the slope appears complex, relative to that in the shelf area. However, this apparent complexity may simply be due to the fact that the contours are based on a larger number of depth estimates in the slope area.

Cameron and Pinchin (1974) have interpreted the results of BMR Continental Margin geophysical traverses (Fig. 8) as indicating the presence of a line of intrusive features which have strong magnetic expression. This line extends from NSW to south of latitude 40°S, and cuts across the trend of the Bass Canyon. The emplacement of the intrusives within the continental slope during Jurassic time, as a consequence of rifting of Gondwanaland, has been postulated by Cameron and Pinchin.

GRAVITY SURVEYS

Geophysical exploration in the Gippsland Basin began in 1948, with the initiation of a series of gravity surveys by BMR. Neumann (1974) has summarised the work and results for the period 1948-1961. Principal objectives were the location of coal deposits and the delineation of structure in coal-producing area. Details of gravity surveys in the Gippsland Basin are given in Appendix 2, but not all individual surveys for the period covered by Neuman have been listed. For additional details the reader is referred to Thyer and Williams (1948), Dooley (1952), Dooley and Mulder (1953), Neumann (1951, 1960), Lonsdale (1963), and Neumann and Lonsdale (1973).

In 1966 a small gravity survey was conducted for Woodside (Lakes Entrance) Oil Co. immediately east of Lake Wellington over a seismically-defined high at the level of the Latrobe Valley Coal Measures. No significant gravity anomaly was mapped.

The other gravity surveys conducted in the Gippsland Basin were regional surveys. In 1973-74, a regional helicopter survey by BMR covered the onshore areas with gravity stations on an 11 km grid (Zadoroznyj, 1976, in prep.). Offshore, gravity data were collected along the traverses of the BMR Continental Margin geophysical survey (Cameron and Pinchin, 1974; Branson, 1974) and by Shell Development (Australia) in their Deepwater Scientific survey, 1972-73.

Results Bouguer anomalies over onshore areas, and free air anomalies over offshore areas are presented in Plate 4, which is a preliminary version of a comprehensive and current gravity map now in preparation by BMR. Descriptions of the onshore gravity features have been given in detail by Neumann (1974) and on a regional scale by Zadoroznyj (1975).

A large closed gravity 'low' along the coast northeast of Wilson's Promontory is a prominent feature of the map. It partly coincides with, but does not extend as far to the southeast as, a magnetically indicated basement depression (Pl. 3). Displacement of the gravity 'low' relative to this depression may be due to the countervailing positive gravity effect associated with crustal thinning to the southeast.

Other prominent features are a north-aligned gravity ridge over the slope area south of 39°S; a 'high' of similar magnitude seen in the extreme northeast corner of Plate 4; and the deep gravity trough which separates these two areas of positive gravity anomalies. This last feature is largely caused by the negative effect of deep water in the Bass Canyon, while the positive areas are parts of a much longer belt present around much of the Australian continental margin. The presence of the positive belt has been attributed to the combination of two effects; deep-lying

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mantle material becoming more shallow to seaward, and the layer of sea water becoming thicker to seaward. However, the line of intrusive bodies described in the preceeding section closely coincides with the gravity ridge and dense intrusives may contribute to the increase in gravity values.

SEISMIC SURVEYS

Plate 5 shows locations of those seismic surveys for which results are publicly available. The density of seismic coverage is higher than that shown, but the results of some surveys remain confidential and have not therefore been illustrated. Individual surveys may be identified by the map key numbers which refer to Appendix 2. For those surveys which were subsidised under the Petroleum Search Subsidy Act 1959-73 (and which have a PSSA file number as reference in Appendix 2) final reports, which may include interpretative material, are available in addition to basic data. For unsubsidised surveys (which have a P(SL)A file number and no PSSA number as reference in Appendix 2) final reports and interpretative data are not normally publicly available, but basic survey data are available if release has been approved by the relevant authorities in accordance with the Petroleum (Submerged Lands) Act 1967-1974. Data from some portions of surveys listed in Appendix 2 may not be publicly available.

Land surveys The earliest seismic surveys in the Gippsland Basin were done by BMR during the 1950's. Commonly these surveys involved a limited number of traverses recorded over gravity and/or magnetic anomalies to test for the presence of closed structures. In some cases structures were confirmed (Garrett, 1955), but not in others (Vale, 1952). Combined reflection and refraction traverses, whose objectives were related to both oil and coal exploration, were later recorded (Lodwick and Moss, 1959; Fowler, 1961). Reduced ambiguity of interpretation resulted from this dual technique approach, and the presence of a great thickness of pre-Tertiary section was indicated in the Latrobe Valley.

The first reflection seismic surveys by geophysical contractors were undertaken for Woodside (Lakes Entrance) Oil Company, beginning in 1960, in the vicinity of Lake Wellington. A drilling location was recommended after two such surveys, and drilling results subsequently confirmed the presence of very thick Jurassic section.

One dip reversal, suggested by the Woodside work, was more closely investigated by Arco Ltd during a survey in 1962. This survey also extended seismic coverage east from Lake Wellington to Lakes Entrance, and to the southwest in an area inshore from the Ninety Mile Beach. Refraction traverses formed part of this work. Closure was confirmed on at least one structure.

Other minor surveys, using the refraction and single coverage reflection seismic techniques, were undertaken onshore in the extreme west and east of the basin for A.P.M. Development and W.Y.P. Development respectively.

Of greater interest were two surveys which involved the application of higher multiplicity of coverage (600% CDP) to explosive reflection work in 1964, and the use of the Vibroseis energy source for reflection work in 1965. The first of these surveys, near the coast south of Sale for Arco Ltd, achieved a significant gain in record quality compared to previous results, but no continuous horizon could be mapped below the Tertiary. The second, by Woodside (Lakes Entrance) Oil along the coastal region to the southwest of Lake Wellington, resulted in data quality sufficient for the mapping of two small closed structures associated with a positive gravity anomaly. Multiples generated at the coal horizons were attenuated to a degree and this enabled some valid pre-Tertiary dip to be observed, but no continuous pre-Tertiary events could be mapped.

<u>Marine surveys</u> Following assessments of the prospectivity of the onshore Gippsland Basin in the early 1960's exploration was largely diverted to the offshore areas, where considerable thicknesses of sedimentary section had already been established from aeromagnetic surveys (see section on magnetic surveys).

The first marine seismic survey was undertaken for Arco Ltd in a narrow near-shore strip parallel to the Ninety Mile Beach, in 1962. The objectives of this reconnaissance survey were to test for offshore extensions of known structural trends, and determine sediment thickness. These objectives were realised from the fair to good quality results obtained for the Tertiary section. The detector cable was designed to allow two records of each shot to be made, using different spread lengths.

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However, the first extensive reconnaissance marine seismic survey was done in 1963, for the operating company Haematite Explorations (later Hematite Petroleum). The detector cable was of similar design to that used the previous year, and permitted some discrimination against multiple reflections on the criterion of large moveout. Several structures with considerable area and vertical closure were mapped, as were large areas in the northeast and extreme western parts of the basin where thin Tertiary section was interpreted to be resting directly on shallow basement.

Following its farm-in agreement with Haematite (see Section 4), Esso proceeded with an exploration program in the central part of the offshore Gippsland Basin, beginning with the Gippsland Shelf seismic survey of 1964. Good results from this multiple (600%) coverage survey, together with some well control, led to a basic understanding of the nature of potential hydrocarbon traps in the area. A notable discovery was the palaeocanyon trending southeast from Lakes Entrance which was subsequently found to be a critical element in trap formation. Several structures were mapped.

Following the discovery of the Barracouta field in 1965 the area surrounding it became ineligible for subsidy and the seven marine seismic surveys in the Gippsland Basin listed in Table 1, which were undertaken during the period 1966-69, were only partly subsidised. Data from survey lines shot between 1965 and March 1972 inside certain circular areas ('excluded circles' around petroleum discoveries), whose centres and radii are given in Table 1 and which are shown in Plate 1, are not publicly available through the Petroleum Search Subsidy Act 1959-73. Confidential data from unsubsidized surveys are held by the Designated Authority in Victoria and by BMR. Basic data from unsubsidised surveys in some areas have been released to the public under the provisions of the Petroleum (Submerged Lands) Act 1967-74. Because of the restrictions on the availability of some data, the following discussion of seismic survey results is not based on all seismic lines surveyed.

The second survey undertaken by the Esso/Haematite partnership, the Eastern Bass Strait survey of 1966, had multiple objectives. These were to investigate stratigraphic trap potential around the basin margin by collecting single coverage seismic data, and to use the multiple coverage technique to detail structures already discovered. At least three features were upgraded to prospect status, and additional new leads were discovered. Rapid lateral facies changes associated with channel filling were interpreted as the cause of complex velocity variations, but fair quality data were obtained.

The next survey by Esso, entitled the EC-67 survey, explored the stratigraphic trap potential in the southwest of the basin by application of digital recording and computer processing technology. The improvement in data quality and resulting confidence in interpretation ensured the continued adherence by the operator to these techniques. A higher multiplicity (1200%) and an alternative energy source ('Aquapulse') were subsequently coupled to the new digital technology during the EH-68 and G69A Surveys. The limit of the Latrobe Group to the southwest was precisely defined by such work, but no stratigraphic traps could be defined.

TABLE 1.

PARTLY SUBSIDIZED MARINE SEISMIC SURVEYS IN THE GIPPSLAND BASIN, AND THE RADII AND CENTRES OF EXCLUDING CIRCLES AFFECTING DATA AVAILABILITY FOR EACH SURVEY. (See Pl. 1).

Survey name	BMR file no.	Radii & centres of excluding circles
Eastern Bass Strait	PSSA 66/11070	20 mi Barracouta Nos. 1 & 2
EC - 67	PSSA 67/11184	40 mi Barracouta Nos. 1 & 2 and 30 mi Kingfish No. 1
*Sole Structure	PSSA 67/11187	40 mi Marlin No. 1
EH - 68	PSSA 68/3015	40 mi Barracouta No. 2 and 50 mi Kingfish Nos. 2 & 3
East Gippsland	PSSA 68/3049 and P(SL)A 68/1	50 mi Kingfish No. 1 and 50 mi Halibut No. 1
G 69 A	PSSA 68/3058 and P(SL)A 69/4	40 mi Barracouta Nos. 1 & 2 and 50 mi Kingfish No. 1
Tasman - Bass Strait	PSSA 69/3023 and P(SL)A 69/11	50 mi Kingfish No. 1 and 50 mi Halibut No. 1

* Final report on entire survey is now available.

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Other operators have been active in the more distal parts of the basin. Shell Development in 1965 explored the northeastern area with the objective of defining the thickness of, and the northern limits of, the basin sediments. Four-fold multiplicity of coverage produced good quality results, and led to the conclusion that Tertiary sediments overlie Palaeozoic basement on the northeastern margin of the basin. Closed structurally high areas were mapped and interpreted as basement topographic features of low prospectivity. The Sole structure, located near the western extent of this early reconnaissance survey (see Sole No. 1 well, Pl. 1), was subsequently detailed in 1967 during a major sparker survey, which was notable for the contemporaneous shipboard interpretation of unprocessed data undertaken. Limited closure was mapped at the Latrobe Group level. Reconnaissance seismic work also indicated the presence of a large central, structurally high area in the extreme east of the Gippsland Basin.

Seismic exploration in deeper water south and east of the central part of the basin began in 1968 when Magellan Petroleum conducted a survey along the outer edge of the continental shelf and partly onto the slope. Both dynamic and static time corrections were applied in novel ways during processing of the data to allow for relatively sharp changes in water layer thickness. A velocity inversion was found to be associated with the presence of substantial thicknesses of Latrobe Group sediments. A closed structure was mapped at the top of this formation in water depths of 100-120 m, near the Victoria-Tasmania border. Basement reflections of poor reliability were mapped and found to correspond reasonably well in depth with interpreted magnetic basement.

As part of a much larger seismic survey, Magellan in 1969 made use of a single coverage sparker reconnaissance technique in an attempt to extend knowledge of section thickness and basin configuration to the eastern boundary of the Gippsland Basin. The survey also included CDP seismic reflection work to define in more detail the closed structure located in the previous year. While the latter objective was realised, and a structural trap confirmed, the eastern boundary of the basin remained undefined, because results indicated that sediments extended beyond the limits of the survey.

The Sailfish seismic survey of 1970 on behalf of N.S.W. Oil and Gas Company covered in more detail a deep water area initially explored by Magellan in the southeastern corner of the basin. Some refraction work was attempted during this survey, but it achieved little success due to sonabuoy failure. However reflection traverses located a number of anomalous features which were diagnosed, from fairly good quality data, as reefal in origin, a conclusion shown to be erroneous by a later drill test which intersected pyroclastic rocks at the expected reef level.

Two regional surveys, by Shell Development and BMR, recorded seismic and other geophysical data along widely spaced traverses in and near the Gippsland Basin (see Fig. 8 and Pl. 5). The seismic survey by BMR using a sparker energy source achieved poorer energy penetration than the Shell survey with airguns. The higher technology effort on the Shell survey produced fair quality results indicating that continental-type basement in the slope area forms a series of linear north-trending step-faulted blocks, supporting occasional wedges of landward dipping continental sediments. At the base of the slope, basement character changes, suggesting an oceanic-type basement beneath the abyssal sea-floor sediments. It appears that the basin boundary to the east occurs in the mid to lower slope area where ponding of sediments in discrete wedges is common. A more precise definition of the eastern Gippsland Basin offshore boundary could be derived from further study of the seismic traverses of both this Shell survey and the BMR Continental Margin survey.

Regional results Regional seismic depth contours, which summarise some of the results of seismic exploration for petroleum in the Gippsland Basin, are presented in Plate 6, at a scale of 1:500 000. The principal horizon chosen for presentation, while often loosely referred to as 'the top of the Latrobe' is the unconformity surface at the top of the Latrobe Group. A stratigraphic definition is given in Chapter 2. The horizon is strongly diachronous.

This horizon is chosen for presentation because it is the interface between overlying cap rocks of the Lakes Entrance Formation, and the underlying reservoir rocks of the Latrobe Group, which together constitute the most economically important hydrocarbon play in the basin. A coarse contour interval of 250 m has been used for the offshore areas in Plate 6, so that not all significant structures are outlined by the contour pattern. However structural names have been included to indicate locations of structures of major interest. Some details of the nature of potential hydrocarbon traps will be given in the next section of this study. The top of the Latrobe Group has been mapped reliably by operating companies in much greater detail than shown. Potential stratigraphic traps have been located within the Latrobe Group, and the history of small scale eustatic Tertiary sea level changes has been determined (Steele, 1976) from high resolution seismic data.

Channel cutting and filling are known to have occurred during the period of deposition of the Latrobe Group, but most channels were partly or wholly filled with intra-Latrobe sediments by the time the Lakes Entrance Formation was laid down. An important exception is the Marlin Channel, which is evident from the contours of Plate 6. It reaches at least as far seaward as the 200 m isobath, near $38^{o}30'$S. Channel fill material of Eocene to Miocene age plays an important role in providing a flanking seal for the Marlin Field.

In two areas the Latrobe Group persists down the continental slope to the 1 000 m isobath, and beyond, but its southeastern limit cannot be readily determined from the petroleum exploration data alone, which has been confined to the upper slope and shelf area.

The onshore contours shown on Plate 6 define the attitude of the top of the Latrobe Valley Coal Measures (see Chapter 2). In contrast to the offshore horizon discussed above, that shown for the onshore area can be considered isochronous. In some localities the contour map was constructed from good quality reflections from a coal horizon, but in other areas the horizon has been 'phantomed'. Contour interval onshore is 200 m.

It should be noted that contours have been drawn from a variety of sources during the compilation of Plate 6. While different operating companies have mapped what appears to be the same horizon in different areas, correlation must be made with caution. Boundaries where uncertainties may arise have been indicated on Plate 6.

<u>Seismic velocity variations</u> The factor causing most problems in the seismic mapping of structures has been the existence of strong horizontal velocity gradients near the base of the Gippsland Formation. The velocity variations have been of sufficient magnitude to mask or distort valid structures, or to falsely indicate the presence of structures at deeper levels. McEvoy (1974) has described the geological causes of these velocity gradients, and the techniques adopted by Esso for limiting their effect on seismic mapping.

Limestones of the Gippsland Formation were deposited in channels eroded into shales of the immediately underlying Lakes Entrance Formation. Locally, a seismic velocity difference of one to two thousand metres per second between limestones and shales occurs at many channel boundaries. Since channels lie over most of the major structures of interest, severe distortion of the seismic time expression of such structures results. Simple conversion to depth using NMO-derived velocities conserves this distortion. Instead, it is necessary to compute a suite of corrected velocities using true velocities determined at well sites as a standard and allowing for channel size and distribution, and velocities of infill material.

PETROLEUM POTENTIAL

The Gippsland Basin has been discussed as a hydrocarbon province by many authors. Wales (1969) Griffith & Hodgson (1971), Hocking (1972), Beddoes (1973), Threlfall and others (1976) are the main references used in the compilation of this chapter.

HISTORY OF PETROLEUM EXPLORATION

The offshore Gippsland Basin is Australia's major oil and gas producing province. No major discovery has been made in the onshore area.

Interest in the petroleum potential of the onshore Gippsland Basin dates back to about 1886 when a test bore was drilled near an alleged oil seep near Toongabbie (Poll, 1975). However, serious petroleum exploration began after the discovery of minor oil and gas in Lake Bunga No. 1 bore drilled by Lakes Entrance Development Co. Pty Ltd near Lakes Entrance in 1924. Subsequent drilling in the area delineated two oil pools from which about 10 000 barrels of 15^{o} A.P.I. oil were produced in 32 years. The State Department of Mines and several small companies participated in this venture.

Since the Lakes Entrance discovery about 125 wells have been drilled in the onshore area - mainly concentrated in a long narrow coastal strip and with about half located near Lakes Entrance (Plates 1 & 1A). There have been no significant indications of hydrocarbons. The modern phase of this activity began with the formation of Woodside (Lakes Entrance) Oil Co N.L. in 1954. Since that time this company and its associates have been the major onshore title holders, drilling 41 wells since 1955.

Offshore exploration began with the aeromagnetic surveys carried out by BMR between 1951 and 1956, but the major effort was initiated in 1960 when Broken Hill Pty Co Ltd., acting on the advice of a consultant Lewis G. Weekes acquired exploration permits covering a large part of the offshore area. BHP then formed a subsidiary company, Haematite Exploration Pty Ltd (later Hematite Petroleum Pty Ltd) which became the permit holder, and in 1964, Esso obtained farm-in rights to the permits. The partnership made the first offshore discovery in February 1965 when gas was discovered in Esso Gippsland Shelf No. 1 (later renamed Barracouta No. 1), Australia's first offshore well. The Marlin gas and oil field was discovered in 1966, and the Halibut and Kingfish oil fields in 1967.

Gas production began from the Barracouta field in March 1969 and from the Marlin field in November 1969, and oil production from the Halibut and Kingfish fields in March 1970 and April 1971 respectively. Oil production from the Barracouta field bagan in October 1969. Three other fields discovered by Esso/BHP, the Mackerel oil field and the Snapper gas and Tuna oil and gas fields have been declared commercial, but are not as yet producing.

Esso/BHP have drilled 64 exploration and step-out wells (Appendix 1a) in the offshore Gippsland Basin up to February 1976.

Between 1967 and 1971 Woodside (Lakes Entrance) Oil Company N.L. and associates drilled four wells in the offshore strip adjacent to the coast. One of the wells, Golden Beach 1A drilled in 1967 was a gas discovery, but the field has not been developed for production. N.S.W. Oil and Gas N.L,. and Shell Development Australia Pty Ltd have each drilled one offshore well without success.

Appendices 1a and 1b list the wells drilled in the basin, Figure 9 shows well locations and Appendix 3 includes the stratigraphic sequences and lithologies penetrated by selected wells which have produced either commercially significant hydrocarbons or significant shows.

Table 2 and Figure 11 give details of the petroleum exploration permits and production licences in force at 31 December 1976.

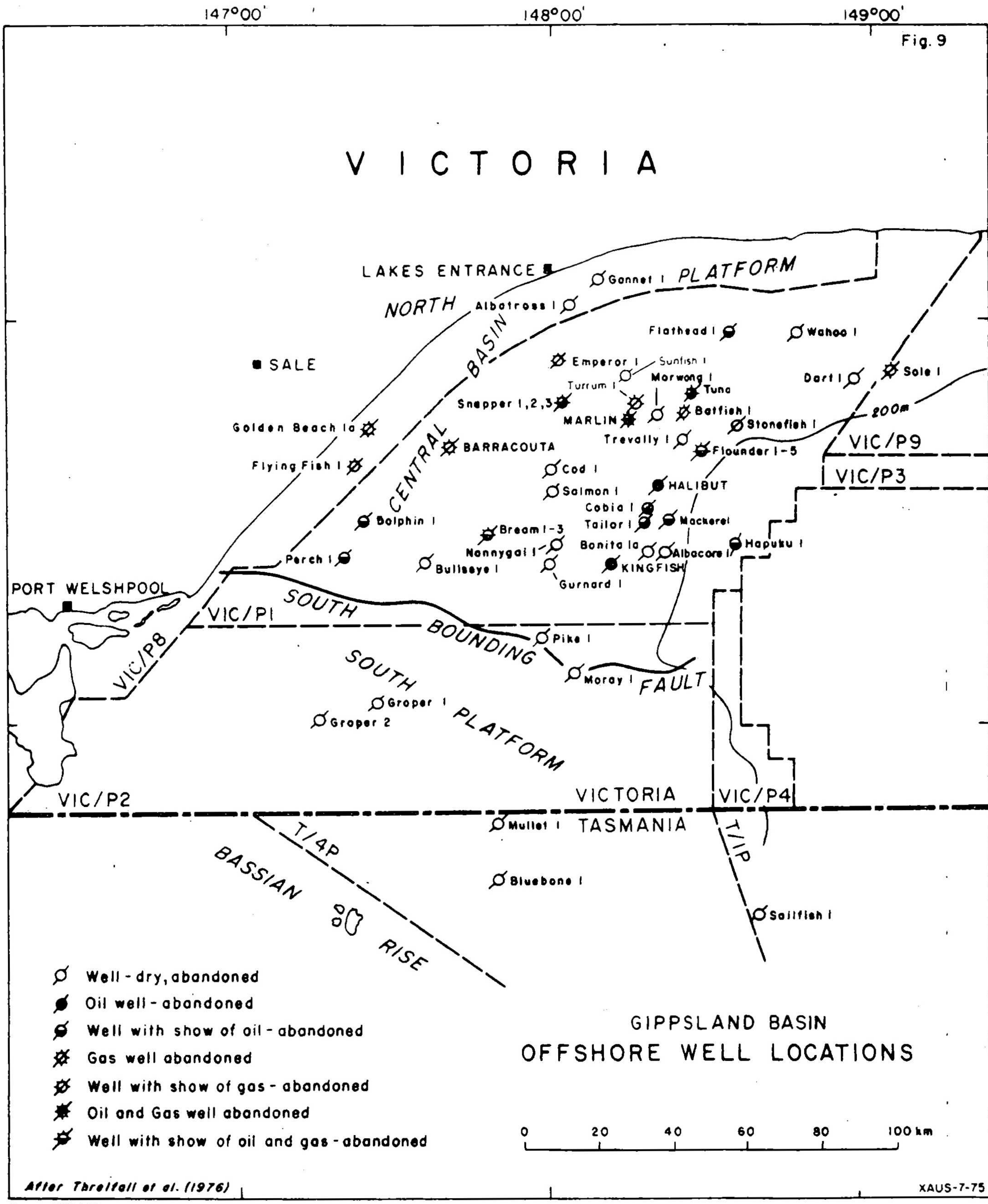
GIPPSLAND BASIN

PRODUCTION LICENCES FOR PETROLEUM, EXPLORATION PERMITS FOR PETROLEUM, PETROLEUM EXPLORATION PERMITS, 31 DECEMBER 1976

Type of Authority	Number	Tenement Holder	Blocks	Licence Area	Date of Expiry
Production Licence for Petroleum	Vic/L1	Hematite Petroleum Pty Ltd., and Esso Exploration and Production Australia Inc.	4	Barracouta Field	31-3-88
	Vic/L2		5	Barracouta Field	31-3-88
	Vic/L3		5	Marlin Field	31-3-88
	Vic/L4		4	Marlin Field	31-3-88
	Vic/L5		5	Halibut Field	13-5-89
	Vic/L6		4	Halibut Field	13-5-89
	Vic/L7		5	Kingfish Field	17-7-89
	Vic/L8		4	Kingfish Field	17-7-89
	Vic/L9		4	Tuna Field	27-2-95
	Vic/L10		4	Snapper Field	23-10-95
	Vic/L11		2	Flounder Field	22-12-95
	Vic/L12		1	Flounder Field	22-12-95
Exploration Permit	Vic/P1	Hematite Petroleum Pty Ltd	57		23-10-79
	Vic/P8	Woodside Oil N.L., Planet Exploration Company Pty Ltd., Australian Oil and Gas Corporation Ltd., Continental Oil Company of Australia Ltd., Woodside Petroleum Development Pty Ltd	8		9-9-81

NOTES

Petroleum Exploration Permit 89 (P.E.P. 89) expired 31-12-1976 - no application for extension
The Mackerel Field is included in Vic/L5



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SOURCE, RESERVOIR AND CAP ROCKS

The interbedded sandstone, siltstone, carbonaceous shale and coal of the Latrobe Group contain both the source and reservoir rocks for the hydrocarbons and the Gippsland Shelf.

The major hydrocarbon accumulations are trapped at the erosional surface at the top of the Latrobe Group. The reservoirs are highly porous and permeable, usually massive sandstones predominantly of Eocene age, and the cap rock is provided by the mudstone and marl of the Lakes Entrance Formation, and by the channel-fill sediments. Other accumulations occur in reservoir sands of early Eocene, Palaeocene and Late Cretaceous age within the Latrobe Group, which in these cases are capped by shale within the fluvio-deltaic sequence.

The reservoir rocks in the onshore Lakes Entrance oil field occur in the basal part of the Lakes Entrance Formation, in the Colquhoun Gravels and the overlying Greensand Members. The reservoirs are capped by the micaceous marl unit which comprises the top member of the formation. Sands which occur in this unit also contain occasional oil smears. The oil is thought to have originated in the Latrobe Group.

It has been established that the hydrocarbons were formed by the diagenesis of land plant material (waxy leaf cuticle, pollen, spore coatings) associated with the carbonaceous sediments and coal in the Latrobe Group (Brooks & Smith, 1967, 1969; Brooks, 1970; Powell & McKirdy, 1976). Brooks (1970) states that in sediments containing such material 'petroleum does not form unless the increasing temperature accompanying deeper burial has been sufficient to alter brown coals to high-volatile bituminous coals with carbon contents near 80 percent.'

Hocking considers that most of the Gippsland Shelf hydrocarbon accumulations have migrated only a short distance from source to reservoirs, and that the generation and subsequent migration took place during the late Eocene to early Oligocene. In support of a short migration he quotes a table of Brooks & Smith (1969) reproduced below, which shows that the paraffins of higher molecular weight in oils from the Gippsland Basin fields, and in solvent extracts of the deeply buried offshore coals were of similar molecular distribution.

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Relative percentages of n-alkanes in the C19-C29 range in coal and oil from the Gippsland Basin

(Brooks & Smith, 1969)

Carbon number	19	20	21	22	23	24	25	26	27	28	29
Coal at 7500 ft (2287.4 m) (Marlin No. 1)	9.3	10.2	11.9	13.4	12.4	11.3	10.3	7.6	6.7	4.2	2.9
Oil at 7590 ft (2314.8 m) (Kingfish No. 1)	11.7	11.4	11.0	12.0	12.8	10.7	9.6	7.5	6.8	3.9	2.8

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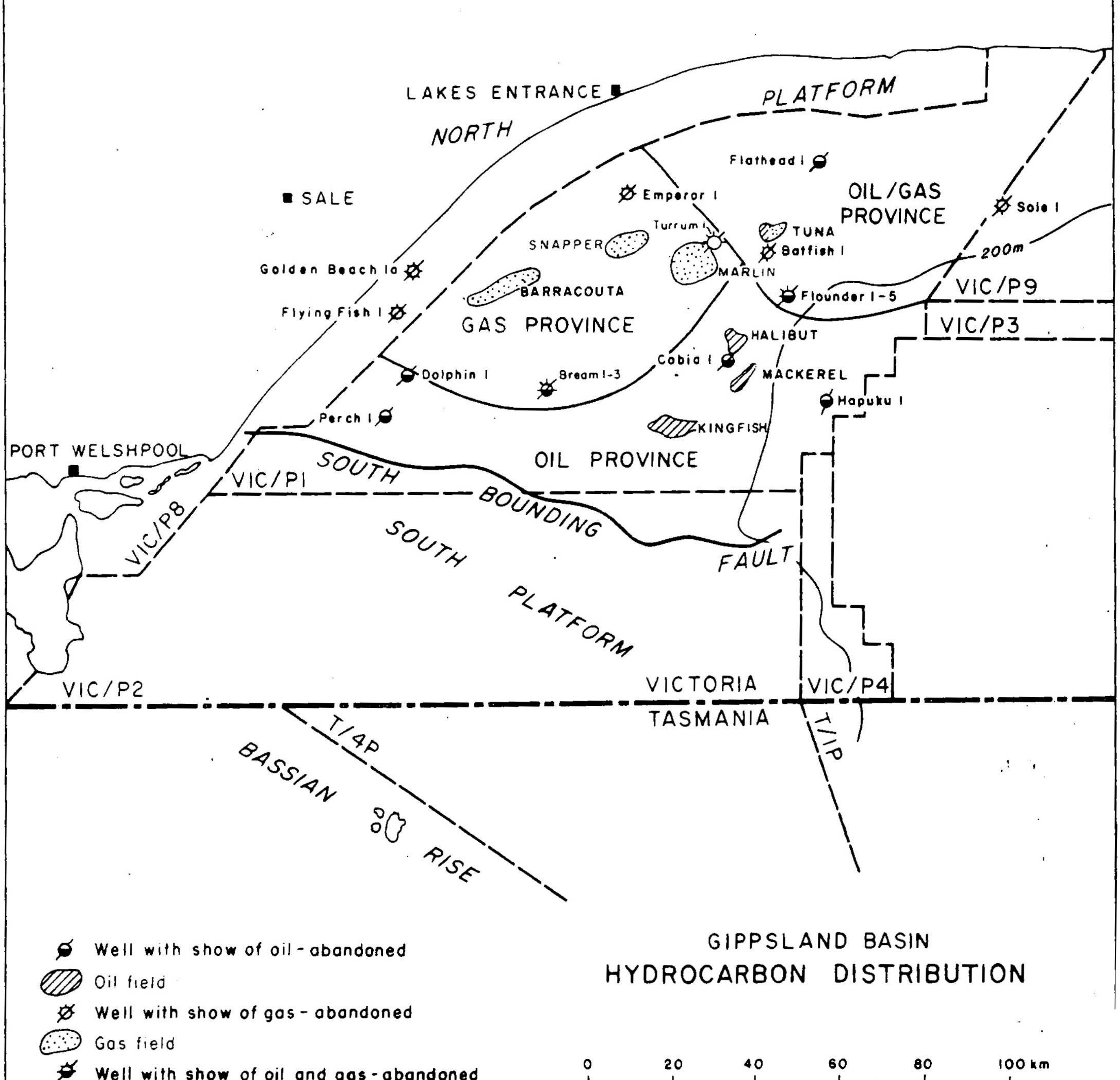
Fig. 10



GIPPSLAND BASIN
HYDROCARBON DISTRIBUTION

After Threlfall et al. (1976)

XAUS-7-139

Record 1978/110

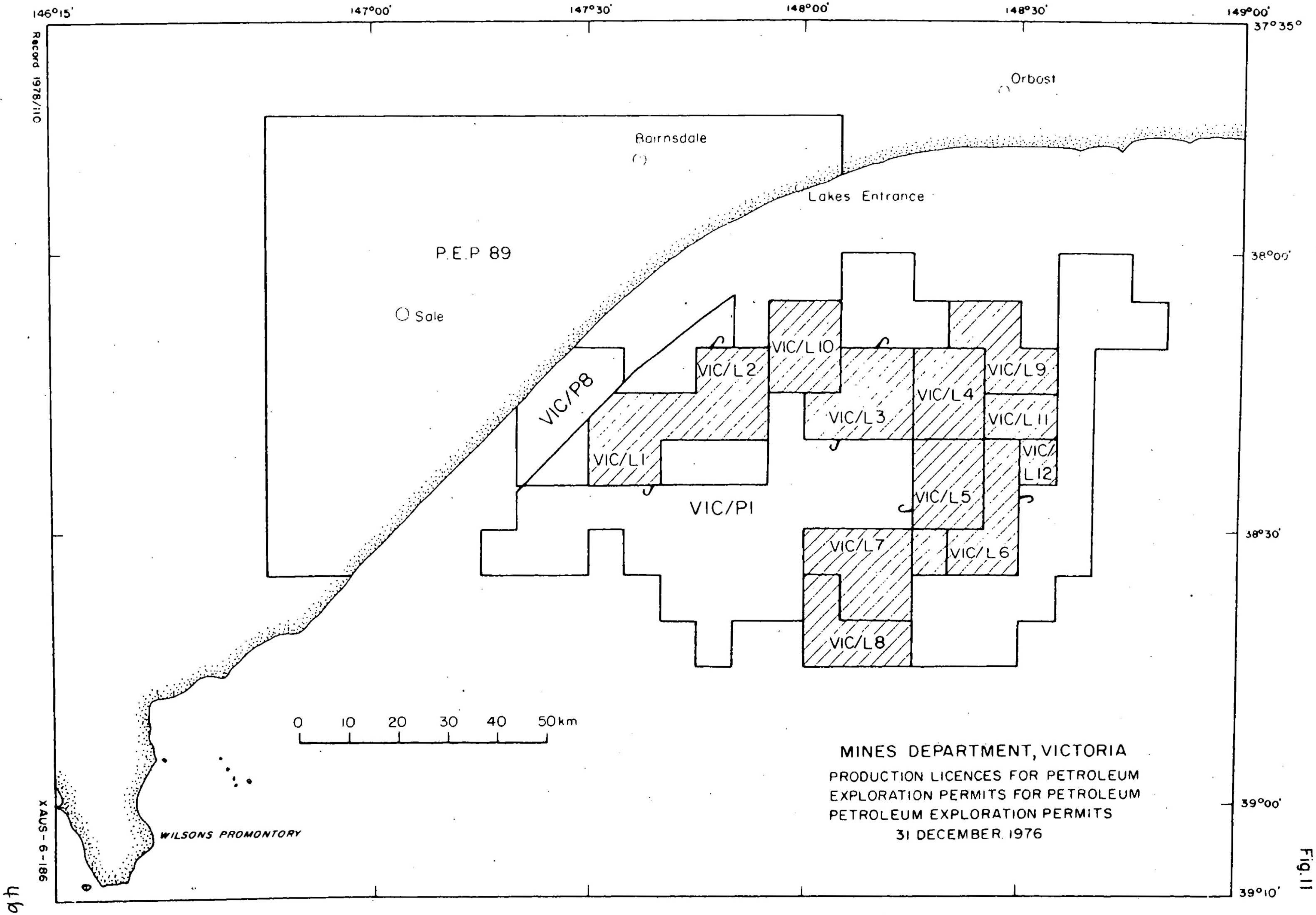


Fig.11

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Threlfall and others (1976) have delineated three hydrocarbon provinces in the offshore Gippsland Basin: a gas province in the north and northwest; an oil province in the southwest, and an oil and gas province in the northeast (Fig. 10).

The gas province closely approximates to the areal distribution of non-marine Latrobe Group sediments of Eocene age. The main source of the gas is thought to be the coal which occurs prolifically, in seams up to 30 m thick.

In the oil province all the major oil accumulations are paraffinic in composition. The oil in the Perch and Dolphin structures in napthenic. Source rock studies have indicated that the paraffinic oils were derived mainly from Latrobe Group coals and non-marine shales of Late Cretaceous and Paleocene age. The napthenic composition of the Perch and Dolphin accumulations suggests a marine source although the oil may have originally been paraffinic and subsequently altered. The overlying Oligocene and Miocene margin shales and marls have poor source rock potential because of a low organic content.

The oil and gas province contains the Tuna and Flounder fields and the minor accumulations in the Sole and Batfish structures. From the point of view of hydrocarbon accumulation the province was physically separated from the rest of the basin by uplift during the Early Eocene and the blocking effect of the Marlin channel. The intra-Latrobe Group oil in the Tuna and Flounder fields in paraffinic and thought to have originated in the non-marine Paleocene and Late Cretaceous Latrobe Group. The source of the gas and minor oil at the top of the Latrobe Group in Tuna is thought to be the estuarine shale of the Tuna-Flounder channel-fill (immediately underlying the reservoir sand). The small volumes of gas which occur in Paleocene sand within the Latrobe Group in the Sole and Batfish structures are thought to have originated in sediments in the immediate vicinity of the structures.

HYDROCARBON TRAPS

Hocking (1972) discusses the hydrocarbon traps in the offshore petroleum province. The traps are primarily structural, occurring as culminations along the major anticlinal axes of the Cainozoic fold belt in the offshore part of the central basin (Figs. 2 and 10, Pl. 6).

The largest culminations seem to be located along the Barracouta-Snapper and Marlin-Tuna anticlinal trends. Those in the deeper part of the basin tend to be smaller, probably because smaller basement fault blocks resulted from the more rapid collapse of the outer part of the craton, and because of the dissection of the structures by submarine channelling.

Wales (1969) discusses the effect of fluid movement in the basin on its petroleum potential contending that movement of both connate and meteoric water must have undergone several reversals since the deposition of the Latrobe Group; increased formation pressure during depositional phases tending to drive fluids flankwards out of the basin, and periods of uplift and erosion producing the opposite effect. The most basinward fluid traps such as Marlin, Tuna, and Kingfish would have been the least affected, being the furthest from the influence of meteoric water movements. In addition these structures were well placed for early burial beneath the sealing mudstone of the Lakes Entrance Formation. Those closer to the basin margins such as Barracouta and Golden Beach would have lost hydrocarbons, both through the effect of meteoric water movement, and because the acquisition of cap rock occurred later.

The apparent lack of hydrocarbon accumulations in the onshore structures is attributed to the basinward tilting of the structures during the Kosciusko uplift, and the associated flushing by meteoric waters entering aquifer sands within the Latrobe Valley Coal Measures at outcrop on the basin margins.

The oil in the onshore Lakes Entrance field occurs in a stratigraphic trap which is discussed in some detail by Boutakoff (1964). The boundary between the Colquhoun gravels and sands and the glauconitic sandstone of the Greensand Member is gradational. The glauconitic sandstone seems to form irregular pockets of a shoe-string like maze, mainly in the upper, sandier part of the Colquhoun Gravel Member, and these pockets appear to connect to form a continuous layer below the capping marls. Porosity and permeability is characteristically extremely variable and the sandstone is often very tight and unproductive. The sands and gravels of the Colquhoun Gravel Member are by contrast very porous and permeable and water filled, the artesian water moving down-dip mainly through the basal gravels.

It appears that oil floating on the artesian water was trapped in the glauconitic sandstone where a sufficiently porous and permeable patch was continuous with the Colquhoun gravels. Presumably, before the influx of fresh water, the sands and gravels of the Colquhoun Gravel Member must have contained much more oil and gas than the glauconitic sandstone, in contrast to the present situation where the oil is trapped in the unit that is less amenable to water flushing. The fact that the water is commonly associated with gas reflects the fact that gas can move up-dip over the moving water in the Colquhoun Gravel Member. The only oil associated with the artesian water is confined to floating 'rafts' and scattered smears.

Threlfall and others (1976) summarise the factors which have combined to control the migration and pooling of hydrocarbons in the offshore Gippsland Basin:

'1. an interconnecting system of porous and permeable sandstones laid down by stream channels trending in a northwest direction;

2. northwest-trending normal faults with anticlines subsequently superimposed approximately at right angles;

3. regional west dip of the Latrobe Group due to the combined effects of the Early Eocene uplift and isostatic adjustment due to sediment loading in the west; and

4. blanket seal of Oligocene and Miocene shales and marls'

Hydrocarbons migrated laterally through the porous and permeable sands in the Latrobe Group, and vertically up the normal faults which offset the intra-Latrobe Group sealing shales, into the culminations along the major anticlinal trends to be trapped at the top of the Latrobe Group by the overlying marine shales and marls. Where intra-Latrobe Group shales were thick and extensive enough to prevent such movement between fault blocks, the hydrocarbons accumulated in the reservoir sands within the Latrobe Group as in the Tuna and Flounder fields.

The regional westerly dip of the Late Cretaceous and Paleocene source beds facilitate the movement of oil to the top of the Latrobe Group. Variation in the properties of the oil in the Kingfish field suggests that migration is still continuing.

Meteoric waters entering aquifers in the Latrobe Group cropping out onshore provide a strong water drive in the major hydrocarbon reservoirs at the top of the Latrobe Group.

OIL AND GAS FIELDS

Griffith and Hodgson (1971) and Threlfall and others (1976) present Esso/BHP's interpretation of the geology of the Barracouta, Marlin, Kingfish, and Halibut fields, and the Kingfish field is described in detail by Bein and others (1973). Colman (1973 & 1976) discusses the Lakes Entrance and Golden Beach fields. Beddoes (1973) tabulates information on the oil and gas fields in the basin and further information on some of the exploration wells drilled in them is available in subsidized well completion reports (PSSA). This section is based on the sources cited. The location of the fields is shown on Figure 10. Table 3 shows petroleum reserves in the Gippsland Basin as at 31 March 1977. Reservoir data are summarised in Tables 4 and 5.

Barracouta oil and gas field The Barracouta structure mapped on the top Latrobe Group unconformity surface is a closed northeast-trending anticline about 20 km long and 4 km wide. It is cut by a northwest-trending normal fault downthrown to the southwest. The gas is produced from Eocene sands of the Latrobe Group (N. goniatus zone) immediately below the unconformity. Cap rock is the marine mudstone of the Oligocene Lakes Entrance Formation. Oil is produced from intra-Latrobe Group sands of Eocene age (M. diversus zone) some 275 m below the gas/water contact of the gas reservoir. The oil is in a structure which is conformable with that mapped on the unconformity surface, but which has independent closure. The oil is trapped by a seal of interbedded shale and coal.

The Latrobe Group sediments within the Barracouta field comprise massive, areally extensive sandstones, alternating with shale and coal. The principal sands of the oil and gas reservoirs are interpreted as braided stream deposits.

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TABLE 3

ESTIMATES OF THE RECOVERABLE, PROVED PLUS PROBABLE, PETROLEUM RESERVES IN THE GIPPSLAND BASIN AS AT 31.3.77

	INITIAL RESERVES				CUMULATIVE PRODUCTION				CURRENT (REMAINING) RESERVES			
	Hydrocarbon liquids ($x10^6 m^3$)				Hydrocarbon liquids ($x10^6 m^3$)				Hydrocarbon liquids ($x10^6 m^3$)			
		Natural Gas Liquids (NGL)				Natural Gas Liquids (NGL)				Natural Gas liquids (NGL)		
FIELDS	Crude Oil	Well Condensate & Plant Products	Liquified Petroleum Gas(LPG)	Natural (Sales) Gas ($x10^9 m^3$)	Crude Oil	Condensate	Liquified Petroleum Gas(LPG)	Natural (Sales) Gas ($x10^9 m^3$)	Crude Oil	Condensate	Liquified Petroleum Gas(LPG)	Natural (Sales) Gas ($x10^9 m^3$)
* Barracouta, Halibut, Kingfish, Mackerel, Marlin, Tuna, Snapper	306.53	27.50	74.25	219.82	127.67	1.59	12.24	14.23	178.86	25.91	62.01	205.59
** Bream, Flounder, Golden Beach, Turrum, Cobia	11.53	4.53	7.55	36.71								

Definitions

Proved reserves: Those reserves established by drilling in a reservoir of known lateral extent, and included within an arbitrary radius of one mile from a well bore.

Probable reserves: Those reserves established in a reservoir beyond the radius of one mile from a well and reasonably assumed to be contained within the limits of the reservoir as indicated by seismic and geological control.

Sales gas: Raw gas obtained from the well after processing to remove condensate and LPG, and CO_2 in excess of 3%.

N.B.

B.H.P. Press statement released during editing of this review:-

Additional reserves Kingfish field - 27.02 x $10^6 m^3$ oil

Revised estimate of reserves for Mackerel field - 60.41 x $10^6 m^3$ oil

Reserves for Cobia plus West Kingfish fields - 47.69 x $10^6 m^3$ oil (approx)

CURRENT CRUDE OIL RESERVES BASS STRAIT - 317.97 x $10^6 m^3$

Notes

* Indicates the initial and current reserves of those fields which have been declared commercial and combines both the Proved and Probable reserves.

** Indicates those theoretically recoverable reserves which are either: geologically proved but considered uneconomic under present conditions, or are awaiting further appraisal and, therefore, subject to major revisions.

Source of information-Department of Mines, Victoria.

Prepared from THE PETROLEUM NEWSLETTER No. 69, Petroleum Technology Section, BMR.

TABLE 4 SUMMARY OF DATA, PRODUCING FIELDS GIPPSLAND BASIN (after Threlfall and others, 1976)

FIELD	RESERVOIR NAME	HYDROCARBONS	GRAVITY °API at 15.6°C	RESERVOIR CHARACTERISTICS			INITIAL RESERVOIR CONDITIONS	
				POROSITY %	PERMEABILITY (md)	WATER SATURATION %	TEMPERATURE °C	PRESSURE kPa
BARRACOUTA	N-1 (N-1.1,N-1.2)	Gas	-	18-26	1000	average 20	76	11 644 (1129 m subsea)
	N-4	Oil	-	-	-	-	-	-
	M-1	Oil	61	2-25	1000	25-35	90	14 000 (1388 m subsea)
HALIBUT	M-1	Oil	43	15-27	1000	average 17	104	23 529 (2349 m subsea)
KINGFISH	M-1 (M-1.1 to M-1.7)	Oil	47.5	18-21 (range of averages)	50-1000 (range of averages)	11-42 (range of averages)	102	22 758 (2288 m subsea)

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TABLE 4 (cont'd)

FIELD	RESERVOIR NAME	HYDROCARBONS	GRAVITY ^{o}API at 15.6^{o}C	RESERVOIR CHARACTERISTICS: POROSITY %	RESERVOIR CHARACTERISTICS: PERMEABILITY (md)	RESERVOIR CHARACTERISTICS: WATER SATURATION %	INITIAL RESERVOIR CONDITIONS: TEMPERATURE ^{o}C	INITIAL RESERVOIR CONDITIONS: PRESSURE kPa
	N-1	Gas	-	15-27	1000	18-25	76	15 482
MARLIN	M-1	Oil & Gas	-	-	-	-	-	(1510 m subsea)

<u>Notes</u>

Each reservoir is identified both according to the first letter of its spore-pollen assemblage zonation and the order of downward occurrence within that zone. Zones are: <u>Nothofagidites goniatus</u> - Late Eocene; <u>Malvacipollis diversus</u> - Early Eocene; <u>Lygistipollenites balmei</u> - Palaeocene, and <u>Tricoleporites lilliei</u> - Late Cretaceous.

TABLE 5 SUMMARY OF DATA, NON-PRODUCING FIELDS GIPPSLAND BASIN

FIELD	RESERVOIR NAME or STRATIGRAPHIC LOCATION	HYDROCARBONS	GRAVITY °API at 15.6°C	RESERVOIR CHARACTERISTICS: POROSITY %	RESERVOIR CHARACTERISTICS: PERMEABILITY (md)	RESERVOIR CHARACTERISTICS: WATER SATURATION %	INITIAL RESERVOIR CONDITIONS: TEMPERATURE °C	INITIAL RESERVOIR CONDITIONS: PRESSURE kPa
SNAPPER	N-1(Top Latrobe Gp)	Gas & Oil	39	Good	Good	-	-	-
TUNA	Top Latrobe Gp	Gas		Good	Good	-	-	-
	T-1(Intra-Latrobe Gp)	Oil & gas	High gravity oil	-	-	-	-	-
GOLDEN BEACH	Top Latrobe Gp	Gas	-	average 33.3	average 226	-	-	-
LAKES ENTRANCE	Base Lakes Entrance Fm (Colquhoun Gravels and Greensand Mbr)	Oil	15.7	36-37	average less than about 10	70-85	28.9	4 134 (365.5 m)

TABLE 5 (con'd)

FIELD	RESERVOIR NAME or STRATIGRAPHIC LOCATION	HYDROCARBONS	GRAVITY °API at 15.6°C	RESERVOIR CHARACTERISTICS			INITIAL RESERVOIR CONDITIONS	
				POROSITY %	PERMEABILITY (md)	WATER SATURATION %	TEMPERATURE °C	PRESSURE kPa
TURRUM	Intra-Latrobe Group	Gas & Oil	57.8	18	5-12 (core analysis, but better permeability indicated by production test)	-	98.9 (2171.7m)	c22560.8 (2171.7m)

Note

Main references; Beddoes (1973) Threlfall 2nd others, 1976 and Colman, 1976

Marlin gas field The Marlin structure mapped on the Latrobe Group unconformity surface is a broad feature slightly elongated in a northwesterly direction with a maximum vertical closure of 275 m over an area of 140 km^2. The northeast flank of the structure is truncated by the northwest-trending Marlin Channel.

Gas production is from Eocene sands in the Latrobe Group (N. goniatus- and M. diversus zones) immediately below the unconformity. A non-commercial oil accumulation occurs below the gas column.

Kingfish oil field Mapped on the Latrobe Group unconformity surface, the Kingfish structure is a large east-trending anticline with an areal closure at the oil/water contact of about 65 km^2 and a vertical closure of some 90 m measured at the crest of the structure just south of one of the two production platforms, the Kingfish B platform. The structural configuration of the enclosed sediments down to approximately the top of the L. balmei zone is that of a westerly plunging anticlinal nose. Log correlations between wells indicate an unconformity surface at this level. Production is from Early Eocene sands (M. diversus zone) at the top of the Latrobe Group.

A detailed stratigraphic analysis of the sediments in the reservoir has permitted the recognition of three distinct depositional phases: The earliest, progradational phase, represented by massive braided stream sandstones; an aggradational phase represented by massive medium-grained to pebbly braided stream sandstones and associated flood-plain deposits, and a final phase of marine transgression represented by clastic sediments of marginal marine origin. The youngest sequence is restricted to the western part of the field, the sediments of the progradational and aggradational phases making up the bulk of the stratigraphic sequence in the field.

Halibut-Cobia oil field The Halibut field produces from Early Eocene sands (M. diversus zone) at the top of the Latrobe Group. Mapped on the top Latrobe Group unconformity, the Halibut structure is an eroded remnant of a southeast-plunging anticline, the now-eroded crest of which lay some 11 km northeast of the present field. The Lakes Entrance Formation was deposited on the deeply eroded surface of the Latrobe group. A saddle separates the Halibut field in the northeast

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from the non-producing Cobia field in the southwest, the lowest part of the saddle being close to the oil/water contact. Cobia No. 1, the only well drilled prior to February 1976 in the Cobia field, discovered a net oil pay of 5.5 m also in Eocene sediments at the top of the Latrobe Group.

The Halibut field reservoir has been subdivided into ten stratigraphic units based on the cyclical nature of the interbedded sandstone, shale and coal sequences. The subdivisios have been used as a reliable basis for the calculation of the distribution and size of produceable oil reserves. Development wells from the Halibut platform were designed to drain the reservoir sands just downdip from their truncated edge at the unconformity surface. The number of wells drilled into each individual sandstone unit was determined by the proportion of reserves calculated for it. Careful production planning, designed to cause a uniform encroachment of the water table across the reservoir is expected to result in a high recovery of oil from the field.

Turrum field The presence of significant gas and oil accumulations has been proven in intra-Latrobe Group sands of Paleocene age below the Marlin field. The Paleocene intra-Latrobe Group section of the Marlin structure is designated the Turrum field. Mapped at the level of the Paleocene sands (Esso, 1973a) the Marlin structure is dissected by northwest-trending faults, downthrown to the southwest, into four distinct fault blocks designated A, B, C and D. Marlin No. 1 (Appendix 3) and Marlin A-6 (development well drilled from the Marlin A platform) drilled in the C Block found 22 m and 43 m of net gas reservoir respectively in Paleocene sands. The platform well also encountered 6 m of net oil sand. Marlin No. A-24 (Appendix 3) was drilled from the Marlin A platform below the Eocene productive horizons to test the Paleocene sands in the D Block. The Well encountered 76 m of net gas sands in fifteen zones and a 1.5 m gas cap at a deeper level. Reserves in the Turrum field are subject to major revision (Table 3).

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Mackerel, Tuna and Snapper fields Commercial reserves have been found in the Mackerel oil field, the Tuna oil and gas field, and the Snapper gas field. In all three fields hydrocarbons are trapped beneath the unconformity at the top of the Latrobe Group, but in the Tuna field the commercially significant accumulation is in the T-1 (T. lilliei zone) intra - Latrobe Groups oil reservoir which occurs in a Late Cretaceous sequence about 610 m below the unconformity. Production licences have been granted for each field (Table 2) and production is expected to start from the Mackerel field in the early part of 1978, and from the Tuna field about a year later.

Bream and Flounder fields Only limited information is publicly available on the Bream gas and Founder oil fields. Oil shows were encountered in Flounder Nos 1, 2 and 3 wells and gas, condensate, and oil shows in thin sands between 1712 and 2271 m in Flounder No. 4. Bream Nos 2 and 3 encountered oil and gas shows. Reserves for the two fields are included in the category which is subject to major revision (Table 3). A production licence has been granted for the Flounder field (Table 2).

Golden Beach gas field This field is located offshore close to the coast in VIC/P8. Mapped on the top Latrobe Group unconformity, the structure is an east-trending anticline which is separated by a saddle from the onshore Baragwanath Anticline (Pl. 1). The discovery well Golden Beach No. 1A encountered gas between 614 and 633 m at the top of the Latrobe Group with a gross and net thickness of 20 m. The gas produced on testing was virtually pure methane, with a calculated open flow potential of 0.8 $m^3 \times 10^6$ per day. Development of the field is not considered economic at the present time.

Lakes Entrance oil field The trapping mechanism in this field has already been discussed in some detail. The oil accumulation occurs in an area of about 15 km^2 and lies at a depth between 300 and 380 m. Production from the field ceased in 1956.

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PROSPECTIVITY - OFFSHORE

Central deep basin area This area which lies mainly in petroleum exploration permit VIC/P1 (Fig. 9) has proved to be the most prospective part of the Gippsland Basin, containing all the commercial fields discovered to date. It remains by far the most prospective part of the basin as far as future discoveries are concerned.

In the first phase of exploration the targets were structural traps mapped on the top Latrobe Group unconformity, the prospective horizons being Eocene sands at the top of the Latrobe Group, immediately below the unconformity. Exploration has now reached the stage when the most favourable of these traps have been tested, and attentionover the past few years has been directed towards deeper horizons within the Latrobe Group. Commercially significant discoveries have been made in intra-Latrobe Group sands of Paleocene age in the Turrum and Flounder fields, and Late Cretaceous age in the Tuna field. Exploration of these deeper levels is hampered by the lack of good basin-wide structural control.

The prospectivity of the eastern part of the area which extends into water depths in excess of 200 m, has yet to be evaluated. Over much of it, the Latrobe Group probably comprises only Late Cretaceous sediments. Hapuku No 1, the only well drilled in the area, was located in 323 m of water and encountered oil shows in a section below 2815 m in reservoir rocks of varying quality.

Southern platform area This section covers the area between the South Bounding Fault and the Bassian Rise and coincides roughly with the petroleum exploration titles Vic/P2 & P4 and parts of T/1P and 4P (Fig. 9).

The most prospective unit in the area is considered to be the Latrobe Group which is of Eocene age south of the South Bounding Fault, and pinches out on the Bassian Rise. Present seismic coverage indicates that there are very few structural traps in this part of the basin and exploration drilling to date has been to test primarily stratigraphic traps. Wells drilled are Pike No. 1 and Moray No. 1 on the downthrown northern side of the South Bounding Fault, Groper Nos 1 and 2, Mullet No. 1, and Bluebone No. 1 on stratigraphic pinchouts of the Latrobe Group onto the Bassian Rise, and Sailfish No. 1 on a postulated biohermal reef near the edge of the continental shelf.

Groper Nos 1 and 2 (Esso 1969 a & b) were located near the up-dip pinchout of the Latrobe Group onto the Bassian Rise, top and bottom seals being provided by the Lakes Entrance Formation and granitic basement respectively.

Groper No. 2 drilled up-dip from the first well penetrated sands in the Latrobe Group with excellent reservoir characteristics.

The Lakes Entrance Formation comprising mudstone with minor glauconitic skeletal limestone appears to form an excellent seal in the Groper area. A possibly larger limestone content in the area near to the pinchout of the Latrobe Group with consequent increase in porosity and reduction in sealing capacity was tentatively advanced by the operator after the drilling of the well as an explanation for the lack of hydrocarbons.

Mullet No. 1 and Bluebone No. 1 located on two separate stratigraphic plays to the northeast of the Groper wells were equally unsuccessful.

In Bluebone No. 1 the Latrobe Group comprised interbedded silty sandstone and mudstone, the sands having only moderate porosity and poor permeability. The Lakes Entrance Formation had a higher sandstone content than in Mullet No. 1, consisting mainly of argillaceous, glauconitic sandstone with minor sandy mudstone. Core analysis indicated 40 percent porosity.

Sailfish No. 1 (N.S.W. Oil and Gas Company N.L., 1971) was drilled in the shallower water part of T/1P, most of which lies in water depths greater than 180 m. The well was drilled as a test of one of a group of seismic anomalies which were interpreted as possible Miocene reefs. However in Sailfish No. 1 the anomaly proved to be due to the presence of 180 m of pyroclastic rocks of Miocene or younger age. The well was abandoned in the volcanic section, so that the presence or absence of the Latrobe Group was not established.

In summary, the drilling results in the southern Gippsland Basin have not been encouraging. The results of the wells drilled to test stratigraphic traps along the u-dip pinchout of the Latrobe Group onto the Bassian Rise suggest the possibility that the Lakes Entrance

Formation may not have provided adequate top seal for any hydrocarbons generated. The lithology of the Latrobe Group penetrated in the wells also indicates a low source rock potential.

The results of the Sailfish well strongly suggest that the untested seismic anomalies in that area are due to the presence of volcanic rocks and not to reef development. However the potential of the Latrobe Group has yet to be tested.

The lack of success in the southern area is reflected in Company reliquishments of permit areas. All the acreage held in VIC/P4 and T/1P was surrendered in 1974, together with that part of T/4P which was held in the Gippsland Basin. All the acreage held in VIC/P2 was surrended in October 1976. Prospectivity of the southern platform area is regarded as fairly low.

Northern platform area The prospectivity of this area is limited by the rapid northward thinning and shallowing of the Latrobe Group against the strongly faulted northern margins (Fig. 5). There is a greater probability of water flushing than in the central deep basin area. However the possibility that structural traps could have received hydrocarbons by up-dip migration from the deeper basinal areas means that small but commercially significant discoveries may be made, although drilling results have not been encouraging. Six wells have been drilled in the area (Fig. 9): Albatross No. 1 and Gannet No. 1 located near the coast in VIC/P8; Flathead No. 1, Wahoo No. 1, and Dart No. 1 farther east in VIC/P1, and Sole No. 1 the most easterly well in the basin located in VIC/P9 in a water depth of 129 m. Sole No. 1 discovered significant but non-commercial gas in intra-Latrobe Group Paleocene sands. VIC/P9 in which Sole No. 1 was drilled, was surrendered by the operating company in December 1975, as was most of VIC/P8. Oil shows were reported in the Flathead No. 1 well, but no oil produced on testing. The Flathead well intersected less than 10 m of Latrobe Group sediments.

PROSPECTIVITY-ONSHORE

Latrobe Group Drilling results in the onshore area, where a large number of wells have penetrated the prospective zone at the top of the Latrobe Group, indicate that the lack of hydrocarbons in this zone is due to flushing by meteoric waters. In Duck Bay No. 1 located due north of Lake Victoria electric log analysis indicated 100 percent water saturation after small gas shows were recorded during drilling. Brackish water with small amounts of dissolved methane was produced in Dutson Downs No. 1 on drill-stem testing. Similarly in Seaspray No. 1 testing of zones in the upper part of the Latrobe Group where gas shows were recorded during drilling, produced only fresh water. In Golden Beach West No. 1, gas-cut fresh water was obtained in the upper zone, and tests of deeper zones in the Latrobe Group produced only fresh water.

Strzelecki Group Indications of hydrocarbons have been rare in the Strzelecki Group which has been fully penetrated by only one well, Duck Bay No. 1 near the northern margin of the Strzelecki Basin. Wellington Park No. 1 located south of Lake Wellington in the deeper basin drilled 2635 m of Strzelecki Group without reaching the base. In this well there were indications of oil in a sand recovered in a core at 2251 m but drill-stem testing was unsuccessful. The sand had a porosity of 5.8 percent and a permeability less than one millidarcy. Drillstem tests at deeper levels recovered brackish formation water containing a small amount of methane in zones of low porosity and permeability and with some fracturing. In North Seaspray No. 1 a sand, which the well completion report placed in the Strzelecki Group, produced wet gas at a rate of 1400 to 2800 cubic metres per day. The net thickness of the sand was only 1.2 m and it was not recognized in the follow-up well, North Seaspray No. 2. Oil and gas shows of dubious reliability were recorded in Woodside Nos 1 and 2.

Seaspray Group The reservoir rocks in the Lakes Entrance oil and gas field which occur in the basal part of the Lakes Entrance Formation have been discussed in the section on source, reservoir and cap rocks. Oil shows have been recorded from the equivalent part of the formation in Colquhoun Nos. 1 and 4 and the Gippsland Oil Co. wells 1 and 3 in the outer parts of the Lakes Entrance area (Pl. 1A). Minor gas shows have been recorded in the Gippsland Limestone in Duck Bay No. 1 and Pelican Point No. 1 located to the southwest of the Lakes Entrance area.

The prospectivity of the onshore part of the Gippsland Basin is considered to be low.

FUTURE EXPLORATION RECOMMENDED.

GEOPHYSICAL

The attitude of magnetic basement beneath the Gippsland Basin is well known from the large scale airborne and seaborne magnetic surveys which have been undertaken there. At the present advanced state of exploration of the basin there is no justification for further large scale magnetic surveys. However the collection of magnetic data during the course of future seismic surveys may help differentiate between volcanic buildups and reefal developments particularly near the eastern basin margin of the basin, although experience to date indicates that the intrasedimentary pyroclastics have little magnetic expression.

Gravity coverage over the basin is quite sparse, consisting of only a few widely spaced traverses from the BMR Continental Margin survey. The principal features of the offshore gravity field have been established however, and preliminary interpretations of these are in reasonable agreement with interpretations of other geophysical surveys. There is in existence a large body of good quality seismic data. Hence detailed marine gravity surveys are not required at the present stage of petroleum exploration. Some further confirmatory regional gravity traverses could be useful in establishing the structural framework of the region.

The southeastern boundary of the Gippsland Basin is not well known. In particular the limit of the economically significant Latrope Group remains unmapped. A thorough appraisal of all available geophysical data in the east of the basin is required, leading to recommendations on locating further geophysical traverses. It would be desirable for further work, perhaps by BMR or academic organisations, to include seismic refraction work to determine the depth and dip of intra-crustal discontinuities at several localities on the continental slope. The results of such work would help to eliminate the ambiguities inherent in interpreting the gravity anomalies observed and would perhaps assist in analysis of the chain of possibly intrusive features near the edge of the continental shelf referred to in Chapter 3 (Cameron and Pinchin, 1974).

GEOLOGICAL

Exploration results to date suggest that the major effort should continue to be made in the central basin, and that it should be directed particularly towards further evaluation of the intra-Latrobe Group sequence. This sequence is stratigraphically very complicated, consisting of many minor sequences which are separated by boundaries which may be unconformities in some locations but may grade laterally into boundaries with concordant beds above and below. These minor sequences commonly exhibit onlapping, offlapping, prograding, and channelling. Lithological trends may cut across time-stratigraphic sequence boundaries. Fortunately, improved seismic data and interpretational techniques should allow better mapping of time-stratigraphic units and extrapolation of well data away from wells in the future (Steele, 1976), so that potential hydrocarbon traps within the Latrobe Group may be better defined after careful study.

In the southeastern Gippsland Basin consideration should be given to the drilling of a well on the structure delineated by Magellan's Tasman-Bass Strait seismic survey (Chapter 3) to obtain stratigraphic control on the Latrope Group and some indication of its hydrocarbon potential in this part of the basin.

CONCLUSIONS

The more prospective areas of the Gippsland Basin have been extensively explored and it seems likely that the greater part of the recoverable petroleum in the basin has already been discovered. Nevertheless, further exploration could lead to the discovery of moderate additional reserves.

The central deep portion of the basin has proved to be the most prospective part, with production from Eocene sands near the top of the Latrobe Group. The most favourable prospects in this play have now been tested. Some commercially significant discoveries have been made in deeper intra-Latrope Group sands of Palaeocene age in the central part of the basin. Probably the best prospects for future discoveries lie in further detailed investigation of these deeper sands.

The eastern margin of the basin near the edge of the continental shelf has so far been only sparsely drilled. The few wells drilled have not been very encouraging, but the area cannot be said to lack potential without further exploration.

The southern portion of the basin, south of the South Bounding Fault, lacks structural traps. The lack of success in drilling a number of primarily stratigraphic traps in this part of the basin has seriously downgraded the area.

Similarly, the prospects of the northern portion of the basin, including the onshore area, appear to be poor. The prospective zone at the top of the Latrobe Group has been extensively tested onshore and it appears that the lack of hydrocarbons is due to flushing by meteoric waters.

Geophysical exploration of the basin has been extensive. Future needs are primarily for more high technology seismic surveying to locate and map potential petroleum traps in the deeper sands of the Latrobe Group in the central deep part of the basin. From a more academic point of view, there is a need to complete the regional gravity coverage of the offshore portion of the basin and perhaps to undertake crustal studies of the continental slope region on the eastern edge of the basin.

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APPENDIX 1a

PETROLEUM EXPLORATION WELLS

GIPPSLAND BASIN

COMPANY Well name BMR file no. (if subsidised)	Latitide South Longitude East o	'	"	1:250 000 Sheet area	Elevation (m) GL/WD DF/KB/RT	Date spudded TD reached	Total depth (m)	Status Remarks
ALLIANCE OIL DEVELOPMENT AUSTRALIA N.L.								
Tarwin Meadows No. 1	38	43	26	J55-10	7.6	7-6-65	1202	PA
	145	51	36		11.0	26-7-65		
ARCO LTD								
Bellbird No. 1	38	12	54	J55-11	132	18-11-63	762	PA
	147	00	45		134.4	11-12-63		
Carr's Creek No. 1	38	17	32	J55-11	23.7	23-3-63	1679	PA
BMR file 63/1306	147	15	55		27	9-4-63		
Duck Bay No. 1	37	56	45	J55-7	20.7	15-2-64	1292	PA
BMR file 64/4614	147	39	56		24	26-2-64		
Merriman No. 1	38	20	52	J55-11	20.4	21-2-63	1830	PA
BMR file 63/1301	147	10	43		23.8	17-3-63		
North Seaspray No. 1	38	17	38	J55-11	23.5	21-11-62	1524	PA
BMR file 62/1305	147	12	13		26.8	13-12-62		
Seaspray No. 1	38	19	39	J55-11	29.6	20-1-64	1693	PA
BMR file 64/4002	147	09	43		32.9	1-2-64		
South Longford No. 1	38	11	54	J55-11	92.6	14-12-63	3795	PA
	147	05	46		94.2	7-1-64		
Southwest Bairnsdale No. 1	37	52	06	J55-7	68.6	8-1-63	1197	PA
BMR file 63/1224	147	21	58		71.9	13-2-63		
ARCO LTD - WOODSIDE (LAKE ENTRANCE) OIL COMPANY N.L. (now Woodside OIL N.L.)								
Wellington Park No. 1	38	08	25	J55-11	0.6	6-12-61	3661	PA
BMR file 62/1077	147	22	30		6.4	3-4-62		
AUSTRALIAN PAPER MANUFACTURERS PTY LTD								
Rosedale No. 1	38	08	00	J55-10	53.6	27-3-60	1779	PA
BMR file 62/1035	146	47	00		56.7	10-5-60		
BOC OF AUSTRALIA LTD								
Golden Beach No. 1	38	15	30	J55-11	WD 18	4-4-67	420	PA
	147	25	21			28-4-67		
Golden Beach No. 1A	38	15	33	J55-11	WD 18	3-5-67	2937	PA
	147	25	20			17-7-67		Gas well
ENDEAVOUR OIL N.L.								
Albatross No. 1	37	57	40	J55-7	43.3	30-6-70	1256	PA
	148	03	00		9.7	14-7-70		
Gannet No. 1	37	54	21	J55-7	39.0	19-7-70	1459	PA
	148	08	09		9.7	28-7-70		
ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC								
Albacore No. 1	38	34	00	J55-11	102.4	6-5-70	3257	PA
	148	19	54		30.2	4-6-70		
Barracouta No. 1								
(Gippsland Shelf No. 1)	36	16	41	J55-11	45.7	27-12-64	2652	PA
BMR file 64/4124	147	42	45		9.4	31-5-65	Gas well	
Barracouta No. 2	38	17	58	J55-11	46.0	8-6-65	1223	PA
(Gippsland Shelf No. 2)	147	40	26		9.4	5-7-65	Gas well	
Barracouta No. 3	38	19	19	J55-11	44.2	3-8-69	2942	PA
								Oil shows below gas reservoir
Batfish No. 1	38	13	14	J55-11	68.0	6-4-70	2975	PA
	148	24	13		9.4	28-5-70		Minor gas & condensate shows
Bluebone No. 1	39	24	24	J55-15	48.1	26-9-69	605	PA
BMR file 69/2029	147	50	53		9.4	1-10-69		
Bonita No. 1	38	33	47	J55-11	79.8	15-10-69	152	PA
	148	17	09		30.1	22-10-69		Technical trouble
Bonita No. 1A	70' NE of Bonita No. 1			J55-11	80.7	22-10-69	3179	PA
					30.1	13-11-69		
Bream No. 1	38	31	09	J55-11	57.9	20-1-69	241	PA
	147	47	45		9.4	22-1-69		Technical trouble
Bream No. 2	38	31	21	J55-11	58.2	24-2-69	3248	PA
	147	47	53		9.4	17-4-69		Hydrocarbon shows

* Key to abbreviations is given at the end of Appendix 1a

COMPANY Well name BMR file no. (if subsidised)	Latitide South Longitude East o	'	"	1:250 000 Sheet area	Elevation (m) GL/WD DF/KB/RT	Date spudded TD reached	Total depth (m)	Status Remarks
ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC contd.								
Bream No. 3	38	30	47	J55-11	59.1	16-11-70	3356	PA
	148	10	34		28.3	10.1-70		
Bullseye No. 1	38	35	30	J55-11	58.5	24-11-73	2369	PA
	147	33	59		9.7	3-12-73		
Cobia No. 1	38	27	27	J55-11	73.0	4-8-72	1771	PA
BMR file 72/2703	148	17	01		9.8	24-8-72		Oil well
Cod No. 1	38	21	43	J55-11	9.4	20-9-65	2908	
(Gippsland Shelf No. 3)	147	58	33		61.5	15-11-65		
Dart No. 1	38	08	13	J55-12	121.3	16-11-73	1219	PA
	148	55	27		9.7	22-11-73		
Dolphin No. 1	38	29	32	J55-11	39.6	28-9-67	2884	PA
	147	22	43		9.4	21-11-67		Oil shows
Emperor No. 1	38	05	59	J55-11	56.7	5-6-70	1995	PA
	148	00	13		9.4	28-6-70		Gas shows
Flathead No. 1	38	01	21	J55-12	52.7	30-4-69	1065	PA
	148	32	04		9.4	15-5-69		
Flounder No. 1	38	18	52	J55-11	87.5	10-7-68	3578	Abandoned
	148	25	29		28.3	24-8-68		due to high pressure. Oil shows
Flounder No. 2	38	19	18	J55-11	99.3	19-2-69	2841	PA
	148	26	43		30.1	28-3-69		Oil shows
Flounder No. 3	38	18	58	J55-11	110.6	26-4-69	2565	PA
	148	28	23		30.1	12-5-69		Oil shows
Flounder No. 4	38	27	27	J55-11	119.5	28-12-72	2623	PA
	148	29	45		9.8	24-1-73		Oil & gas shows
Flounder No. 5	38	18	24	J55-11	99	2-2-75	2607	PA
	148	26	56		9	14-2-75		
Groper No. 1	38	56	20	J55-11	57.9	18-12-68	1030	PA
	147	24	56		9.4	10-1-69		
Groper No. 2	38	58	40	J55-11	130.7	12-11-69	1249	PA
BMR file 69/2028	147	14	12		133.8	0-1-70		
Gurnard No. 1	38	35	33	J55-11	69.4	3-10-69	2964	PA
	147	58	38		9.7	30-10-69		
Halibut No. 1	38	23	56	J55-11	71.9	19-6-67	3051	PA
	148	18	59		9.4	29-8-67		Oil well
Hapuku No. 1	38	33	21	J55-11	379.5	7-7-75	3650	PA
	148	32	56		8.5	1-9-75		Oil shows
Kingfish No. 1	38	35	58	J55-11	72.8	9-4-67	2576	PA
	148	12	35		9.4	29-5-67		Oil well
Kingfish No. 2	38	35	55	J55-11	76.2	28-11-67	2445	PA
	148	10	13		9.4	25-1-68		Oil well
Kingfish No. 3	38	35	07	J55-11	74.1	2-2-68	2529	PA
	148	06	07		9.4	28-2-68		Oil well
Kingfish No. 4	38	35	55	J55-11	75.6	25-10-73	2509	PA
	148	05	45		9.7	11-11-73		Oil well.
Kingfish No. 5	38	34	45	J55-11	78.9	16-5-74	2512	PA
	148	14	30		9.8	2-6-74		
Kingfish No. 6	38	35	40	J55-11	79	1-1-75	2556	PA
	148	13	59		9	24-1-75		
Mackerel No. 1	38	28	54	J55-11	98.1	27-3-69	3049	PA
	148	21	26		30.1	13-4-69		Oil shows
Mackerel No. 2	38	29	14	J55-11	119.5	13-2-72	2592	PA
	148	20	18		9.8	18-3-72		
Mackerel No. 3	38	28	28	J55-11	98.8	1-4-72	2633	PA
	148	21	45		8.9	18-4-72		
Mackerel No. 4	38	30	52	J55-11	83.2	11-2-73	2652	PA
	148	21	55		9.7	10-5-73		Oil shows
Marlin No. 1	38	14	03	J55-11	60.0	5-12-65	2586	PA
(Gippsland Shelf No. 4)	148	13	33		9.4	3-2-66		Oil and gas well
BMR file 65/4183								
Marlin No. 2	38	15	59	J55-11	57.3	31-5-66	3050	PA
(Gippsland Shelf No. 5)	148	10	45		9.4	25-8-66		Gas well
Marlin No. 3	38	14	44	J55-11	59.7	16-12-66	1782	PA
	148	10	16		9.4	9-1-67		

COMPANY Well name BMR file no. (if subsidised)	Latitide South Longitude East o	'	"	1:250 000 Sheet area	Elevation (m) GL/WD DF/KB/RT	Date spudded TD reached	Total depth (m)	Status Remarks
ESSO EXPLORATION AND PRODUCTION AUSTRALIA INC contd.								
Marlin No. 4	38	14	24	J55-11	61.3	5-10-73	2621	PA
BMR file 73/216	148	16	03		9.7	21-10-73		Gas and condensate shows
Marlin A-6	38	13	56	J55-11	58.7	22-8-68	3306	Gas well development well and deeper pool test
	148	13	16		24.7	22-11-68		
Marlin A-24	38	13	55	J55-11	58.5	16-5-73	3349	Suspended as gas well
BMR file 73/209	148	13	10		25.0	15-6-73		
Moray No. 1	38	51	48	J55-11	75.6	15-6-72	2670	PA
	148	03	21		8.9	9-7-72		
Morwong No. 1	38	13	43	J55-11	63.4	10-12-72	2439	PA
BMR file 72/3225	148	18	45		9.8	25-12-72		
Mullet No. 1	39	13	02	J55-15	53.3	9-1-69	751	PA
	147	51	22		9.7	16-1-69		
Nannygai No. 1	38	33	10	J55-11	68.6	9-7-72	3019	PA
	147	59	43		9.8	31-7-72		
Perch No. 1	38	34	37	J55-11	42.1	13-3-68	2867	PA
	147	19	24		9.4	2-5-68		
Pike No. 1	38	46	30	J55-11	73.8	16-7-73	2134	PA
	147	56	59		9.7	25-7-73		
Salmon No. 1	38	25	16	J55-11	64.0	13-1-69	3007	PA
	147	59	15		30.1	16-2-69		
Snapper No. 1	38	12	03	J55-11	54.9	9-5-68	3755	PA
	148	00	49		10.0	9-12-68		Oil and gas well
Snapper No. 2	38	11	16	J55-11	53.3	16-6-69	3051	PA
	148	02	37		9.4	23-7-69		Oil and gas show
Snapper No. 3	38	12	45	J55-11	56.7	24-11-69	3211	PA
	147	59	11		9.4	22-1-70		Oil and gas well
Stonefish No. 1	38	15	03	J55-11	114.9	26.7.73	3184	PA
	148	33	36		9.7	25-8-73		
Sunfish No. 1	38	08	26	J55-11	24.0	7-2-74	766	PA
	148	13	38		3.0	26-2-74		
Tailor No. 1	38	29	45	J55-11	76.5	5-11-69	2590	PA
	148	16	25		9.4	20-11-69		Oil show
Trevally No. 1	38	17	23	J55-11	56.7	28-1-70	2284	PA
	148	23	40		9.4	16-2-70		
Tuna No. 1	38	10	25	J55-11	60.4	7-5-68	3641	PA
	148	25	03		9.4	12-10-68		Oil and gas well
Tuna No. 2	38	10	52	J55-11	59.4	31-10-68	2761	PA
	148	23	14		9.4	5-12-68		Oil and gas well
Tuna No. 3	38	10	10	J55-11	64	18-2-70	2819	PA
	148	26	50		9.4	2-4-70		Oil and gas well
Turrum No. 1	38	12	10	J55-11	58	19-5-69	3057	PA
	148	14	41		30.1	26-6-69		
Turrum No. 2	38	14	39	J55-11	61	5-6-74	2672	PA
	148	14	56		9.8	8-7-74		Oil and gas show
Wahoo No. 1	38	01	42	J55-11	74.6	27-5-69	746	PA
	148	44	48		9.4	11-6-69		
HALLIDAY ENTERPRISES PTY LTD								
Crossroads No. 1	38	19	39	J55-11	-	19-5-71	1040	PA
	147	09	42		-	3-6-71		
East Reeve No. 1	38	05	50	J55-11	1.5	19-9-71	1524	PA
	147	32	57		5.5	25-1-72		
Keystone No. 1	38	19	39	J55-11	29.6	8-2-72	1960	PA
	147	09	21		34.8	18-2-72		
West Seacombe No. 1	38	08	08	J55-11	6.1	31-12-71	1766	PA
	147	25	18		11.0	1-1-72		

COMPANY Well name BMR file no. (if subsidesed)	Latitide South Longitude East o	 '	 "	1:250 000 Sheet area	Elevation (m) GL/WD DF/KB/RT	Date spudded TD reached	Total depth (m)	Status Remarks
N.S.W. OIL AND GAS CO N.L.								
Flying Fish No. 1	38	20	51	J55-11	26.2	7-11-71	1987	PA
	147	21	52		10.3	29-11-71		
Sailfish No. 1	39	27	24	J55-16	84.7	12-10-71	1422	PA
BMR file 71/472	148	37	54		95.4	2-11-71		
SHELL DEVELOPMENT (AUSTRALIA) PTY LTD								
Sole No. 1	38	07	01	J55-12	128.9	28-1-73	1129	PA
	149	02	04		9.7	8-2-73		Gas shows
WOODSIDE (LAKES ENTRANCE) OIL COMPANY N.L. (Now WOODSIDE OIL N.L.)								
No. 1	38	35	34	J55-10	7.9	1955	1831	PA
	146	56	10					
No. 2	38	37	32	J55-10	7.9	1957	2701	PA
	146	53	52					
No. 3	38	37	35	J55-10	-	1956	1824	PA
	146	53	45		-			
No. 4	38	40	11	J55-10	2.1	1957	821	PA
	146	50	25					
Colliers Hill No. 1	38	11	56	J55-11	284.7	9-1-70	1711	PA
	147	17	30		34.0	3-2-70		
Dutson Downs No. 1	38	12	00	J55-11	4.8	8-3-66	1862	PA
	147	21	45		1.5	10-4-66		
Golden Beach West No. 1	38	14	55	J55-11	8.8	11-9-65	2290	PA
	147	21	23		8.5	28-10-65		
Hedley No. 1(W.L.3)	38	39	00	J55-10	12.1	1958	1223	PA
O.C. No. 6	146	32	30					
Lakes Entrance No. 1	37	52	00	J55-7	52.1	28-3-66	422	PA
	147	59	42		49.6	6-4-66		
Lake Reeve No. 1	38	19	42	J55-11	5.1	23-3-65	2022	PA
	147	15	20		1.5	26-4-65		
North Seaspray No. 2	38	17	58	J55-11	27.1	2-2-65	1633	PA
	147	12	25		23.4	28-3-65		
Salt Lake No. 1	38	26	53	J55-11	19.2	12-4-70	1644	PA
	147	05	12		23.1	7-5-70		
Seacombe South No. 1	38	08	30	J55-11	-	4-11-70	361	PA
	147	29	12		-	12-11-70		
Spoon Bay No. 1	38	04	56	J55-11	-	9-10-70	1400	PA
	147	27	57		-	30-10-70		
St Margarets Island No. 1	38	38	16	J55-10	7.9	29-1-66	1422	PA
BMR file 65/4185	146	50	05		4.5	18-2-66		
Sunday Island No. 1	38	42	19	J55-10	6.4	19-11-65	1830	PA
BMR file 65/4180	146	40	11		6.0			
Wellington Park No. 2	38	08	08	J55-11	-	16-3-70	1258	PA
	147	20	55		-	2-4-70		
Woodside South No. 1	38	34	25	J55-10	14.0	30-5-65	1774	PA
BMR file 65/4159	146	54	30		10.3	11-7-65		

Abbreviations

- TD - Total depth
- RT - Rotary table
- KB - Kelly bushing
- DF - Derrick floor
- GL - Ground level
- WD - Water depth (offshore)
- PA - Plugged and abandoned
- C - approximately

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APPENDIX 1b

GEOLOGICAL AND OTHER SHALLOW DRILLING, GIPPSLAND BASIN

COMPANY	Well Name	Latitude South/Longitude East °	'	" / °	'	"	Elevation GL/KB (m)	Date Spudded T.D. reached	Total depth T.D. (m)
AMALGAMATED OIL SYNDICATE	No. 1 (Old Goon Nure)	c37	59	00/ 147	33	00	28	1931	893
ARCO LTD	East Lake Tyers No. 1	37	50	38/ 148	07	33	3/4	8.10.62 18.10.62	470
	East Nowa No. 1	37	47	47/ 148	09	42	60/62	21.10.62 26.10.62	364
FROME LAKES PTY LTD	No. 1 (Gippsland)	c38	35	00/ 146	53	00	-	1956	518
	No. 1A "	c38	33	51/ 146	52	54	10	1956	598
	No. 2 "	38	38	30/ 146	46	00	3	1956	473
	No. 3 "	38	35	16/ 146	50	10	9	1956	572
	No. 4 "	37	59	53/ 147	09	10	37	1956	553
	No. 5 " (No. 6)	37	52	54/ 147	32	03	76	1957	472
	Darriman No. 1	38	27	04/ 147	00	30	35	1955	1442
LAKE WELLINGTON OIL WELLS	No. 1 (Glencoe)	38	13	00/ 147	14	00	53		676
MIDFIELD OIL COMPANY	No. 1 (Glencoe South)	38	13	43/ 147	08	34	?		293
OIL SEARCH LTD	No. 1 (Bengworden)	37	57	26/ 147	25	11	32		282
	No. 2 "	37	57	27/ 147	27	51	22		331
	No. 1 (Bravo Plant)	37	51	30/ 147	25	24	85	?	86
	No. 2 " "	"	"	" "	"	"	"	?	93
	No. 3 (Steam Drill)	37	53	12/ 147	27	52	58	?	441
SIGNAL HILL EXPLORATION	No. 1	c38	14	27/ 147	19	17	28		699
TANGIL-POINT ADDIS COMPANY	No. 1	c38	14	27/ 147	06	24	76		439
	No. 2	c38	15	26/ 147	09	38	8		841
TEXLAND OIL COMPANY	Glencoe No. 1	c38	12	45/ 147	12	51	?		331
VALVE OIL WELLS	No. 1 (Pelican Point)	c38	00	51/ 147	37	30	3	1929-1933	704

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VICTORIAN STATE DEPT. OF MINES	Bairnsdale									
	No. 3 (Cobbler's Creek)	c37	52	17/	147	36	36	6	1938	275
	No. 4 (Forge Creek)	c37	54	51/	147	37	30	30	1939	436
	No. 5 (Eagle Point)	c37	54	00/	147	40	43	3	1939	473
	Bengworden South									
	No. 1 (Holland's Landing)	c38	03	36/	147	27	51	3	1940	1220
	Boole Poole									
	No. 1 (Sperm Whale Head)	c37	51	26/	147	40	43	3	1939	948
	Bungdalaguah									
	No. 1	c37	58	56/	146	52	18	21	1938	185
	No. 2	c37	57	27/	147	03	12	20	1938	198
	No. 3	c38	05	06/	147	01	04	6	1938	201
	Coongulmerang									
	No. 1	c37	53	12/	147	24	40	56	1933	288
	No. 2	c37	48	57/	147	26	45	48	1933	195
	No. 3 (Tom's Creek)	c37	53	45/	147	22	32	?		367
	Darriman									
	No. 3	c38	24	54/	146	58	56	30	1929	368
	No. 4	c38	27	27/	147	04	16	30	1937	381
	Dulungalong									
	No. 1	c38	12	45/	147	23	26	-	1937	493
	Giffard									
	No. 14	c38	23	00/	147	11	20	4	1937	488
	Glencoe									
	No. 1	c38	11	54/	147	06	24	81	1924	112
	No. 2	c38	11	54/	147	06	24	44	1929	289
	No. 3	"	"	"	"	"	"	71	1930	71
	No. 4	"	"	"	"	"	"	62	1930	105
	No. 5	"	"	"	"	"	"	55	1930	165

VICTORIAN STATE DEPT. OF MINES
contd.

<u>Glencoe</u> contd.								
No. 6	c38	12	45/ 147	08	32	34	1930	199
No. 7	c38	11	03/ 147	09	36			421
No. 8	c38	09	21/ 147	12	48	3	1937	428
<u>Glencoe South</u>								
No. 2	c38	17	04/ 147	02	45	188	1932	281
<u>Goon Nure</u>								
No. 1 (Romawi)	c37	58	18/ 147	36	24	30	1938	989
<u>Meerlieu</u>								
No. 1	c37	56	26/ 147	17	12	31	1936	368
<u>Moormurng</u>								
No. 1	c37	51	30/147	27	52	53	1932	311
<u>Nindoo</u>								
No. 1	c37	51	30/ 147	16	00	61	1936	162
<u>Nuntin</u>								
No. 1	c38	00	51/ 147	06	24	12	1937	443
No. 2 (Lake Kakydra)	c38	00	15/ 147	11	44	1	1939	1085
<u>Seacombe</u>								
No. 1	c38	05	57/ 147	27	56	3	1937	478
<u>Stradbroke</u>								
No. 14 (Monkey Creek)	c38	19	33/ 147	00	34		1930	464
No. 15	c38	17	00/ 146	58	56		1930	197
No. 16 (Merriman's Creek)	c38	17	50/ 147	02	04		1931	450
<u>Stratford</u>								
No. 1	c37	54	03/ 147	07	25	90	1936	203
<u>Woodside</u>								
No. 5	c38	28	18/ 146	56	48		1926	95
No. 6	"	"	"	"	"		1926	100

VICTORIAN STATE DEPT. OF MINES contd.	<u>Wulla Wullock</u>								
	No. 2	c38	00	17/ 147	04	52		1937	433
	<u>Wurruk Wurruk</u>								
	No. 1 (Sale)	c38	05	00/ 147	02	08	9	1941	980
	<u>Yeerung</u>								
	No. 1	c38	00	00/ 147	14	56	7	1936	410
WESTRALIAN OIL LTD	No. 1 (Yarram)	c38	33	18/ 146	37	20	27	1957	571
AUSTRAL OIL SYNDICATE	Foster's (Bore) No. 1	c37	52	08/ 147	59	59	28	1936	384
	Imray (Bore) No. 1	c37	52	02/ 147	59	47	41	1939-40	388
DOME OIL AND MINERALS SYNDICATE N.L.	Dome Frome No. 1 (Lake Tyers No. 1)	37	47	25/ 148	00	55	39	1957	172
	Dome Frome No. 5 (Ekberg No. 1)	37	30	00/ 148	11	00	-	1959	378
(Dome Frome No. 2-4 see FROME LAKES OIL CO.)									
(East End Bore No. 1, see LAKES OIL LTD)									
A.E. EKBERG	Ekberg No. 1 - Dome Frome No. 5								
FROME LAKES OIL CO. (-F.L.P.L.)	No. 8 (Ballong) - Dome Frome No. 2	37	46	47/ 148	02	45	15	1958	170
	No. 9 (Tarra Tarra) - Dome Frome No. 3								
	No. 10 (Ballong) - Dome Frome No. 4	c37	48	00/ 148	04	00	42	1958	396
GIPPSLAND OIL CO. LTD	No. 1	c37	51	50/ 147	51	00	71	28.2.39	536
	No. 2	c37	51	50/ 147	51	00	62	30.11.39	337
	No. 3 (Nungurner)	c37	51	50/ 147	51	00	60		443

KALIMNA OIL CO. LTD	No. 1	37	53	20/ 147	57	08	1	1929	449
	No. 2	37	52	08/ 147	57	52	46	-	428
LAKES ENTRANCE DEVELOPMENT CO. PTY LTD	No. 1 (Lake Bunga)	37	51	22/ 148	02	21	2	1924	370
	No. 2	37	52	21/ 148	00	47	9	1927	389
LAKES OIL LTD	No. 1 (-East End Bore No. 1)	37	48	04/ 148	21	14	3	1959	375
LAKE VIEW COMPANY	No. 1	37	51	34/ 148	01	39	43		368
	No. 2	37	52	03/ 148	00	21	53		409
	No. 3	37	52	15/ 147	59	42	25		392
MIDFIELD OIL COMPANY	No. 1	37	51	45/ 148	00	21	60		398
	No. 2	37	51	57/ 148	00	18	52		403
MIDWEST COMPANY	No. 1	37	51	51/ 147	59	42	55		402
	No. 2	37	51	51/ 147	59	42	39		1036
OIL SEARCH LTD	Mac's Oil Well No. 1	37	52	40/ 147	59	36	12		399
	" " " No. 2	c37	52	34/ 147	59	23	15		395
	" " " No. 3	c37	52	37/ 147	59	21	9		399
	No. 1	37	51	54/ 147	58	37	40		389
	No. 2	37	52	00/ 147	58	31	43		402
	No. 3	37	51	54/ 148	00	50	35		399
POINT ADDIS COMPANY	No. 1	c37	53	12/ 147	50	21	1	1929	442
	No. 2	c37	50	39/ 147	50	20	1	1930	289
	No. 3	c37	52	25/ 148	00	03	8	1930	378
	No. 4	c37	52	00/ 147	59	21	61	1931	411
S.A. OIL WELLS COMPANY	No. 1	c37	50	48/ 147	57	13	56		381
	No. 2	c37	51	54/ 148	00	00	46		398
	No. 3	c37	51	54/ 147	58	03	50		411
	No. 4	c37	51	45/ 147	59	55	42		382
	No. 5	c37	51	35/ 147	57	58	42		402
	No. 6	c37	51	51/ 147	59	55	29		382
	No. 7	c37	51	07/ 147	59	57	26		382
	No. 8	c37	52	00/ 148	00	00	43	1932	389

TANGIL NO. 1 COMPANY	No. 1	c37	51	40/ 148	00	01	59		387
	No. 2	c37	51	46/ 147	59	18	53		385
TANGIL NO. 2 COMPANY	No. 1	c37	51	35/ 148	00	21	70		415
TEXLAND OIL COMPANY	Houghton's No. 1	c37	51	51/ 148	00	02	49		388
VICTORIAN STATE DEPT. OF MINES	*Bumberrah No. 3	c37	52	51/ 147	49	17	1	1931	374
	Colquhoun No. 1	c37	52	57/ 147	58	10	2	1928	428
	" No. 2	c37	51	30/ 147	56	40	18	1930	297
	" No. 3	c37	53	12/ 147	53	28	1	1940	443
	" No. 4	c37	53	31/ 147	58	18	4	1940	460
	" No. 5	c37	52	18/ 147	56	29	3	1940	382
	" No. 6	c37	52	25/ 147	57	21	53	1940	444
	" No. 7	c37	52	03/ 148	02	26	1	1940	372
	" No. 8	c37	51	40/ 147	58	47	1	1940-41	355
	" No. 9	c37	52	28/ 148	01	21	2	1941	379
	" No. 10	c37	52	03/ 148	00	08	42	1941	421
	" No. 11	c37	50	57/ 147	59	58	60	1941	377
	Colquhoun North No. 1	c37	48	57/ 147	54	40	30		201
WOODSIDE (LAKES ENTRANCE) OIL COMPANY N.L. (now Woodside Oil N.L.)	No. 7 (-Oilco, No. 1)	37	51	49/ 146	57	53	42	1957	422
UNKNOWN	Cobden's Bore	c37	52	00/ 148	04	00	6		459

APPENDIX 2

GEOPHYSICAL SURVEYS

Magnetic surveys

Map key no. (Plate 2)	Survey name and type	Year	Operator	Contractor	Survey altitude	Traverse spacing km	Total traverse length km	Reference
1	Gippsland Basin airborne magnetic	1951-52 & 1956	BMR	-	1000'	1.6		BMR Recs. 1952/14 and 1956/116 BMR Report 95
2	Bass St. Encounter Bay airborne magnetic	1960 1961	Haematite Exploration	Aero Service " "	1000' 2000'	48-80 3-20	2400	PSSA 62/1711 and PSSA publication no. 60
3	East Gippsland Basin seismic and magnetic	1968	Magellan	Western Geophysical	Sea Level (S.L.)	5	1020	PSSA 68/3049
4	Gippsland G69A seismic and magnetic	1968-69	Esso Australia	Western Geophysical	S.L.	10	438	PSSA 68/3058
5	Tasman-Bass St. seismic & magnetic	1969	Magellan	Teledyne	S.L.	4	2590	PSSA 69/3023
6	Shell Deepwater Scientific	1972-73	Shell Development (Australia)	Seismograph Services Ltd	S.L.	50	10904	P(SL)A 72/30
7	BMR Continental Margin geophysical	1970-73	BMR	Compagnie Generale de Geophysique	S.L.	35		BMR Records 1974/15 and 1974/98

Gravity Surveys

Survey name	Year	Operator	Contractor	Traverse spacing km	Station spacing km	No. of stations	Reference
Morwell Anticline	1948	BMR	-	1.0	0.2	189	BMR Record 1948/81
East Gippsland	1949 1951	Lakes Oil BMR	R.H. Ray	Various	0.8	1892	BMR Records 1952/13 and 1953/77
Yallourn-Morwell -Traralgon	1950	BMR	-	Various	0.8	240	BMR Record 1951/10
Longford	1960	BMR	-	2-4	0.4	63	BMR Record 1963/106
Gormandale	1960-61	BMR	-	2-4	0.4	208	BMR Record 1973/86
Gippsland Basin	1948-61		(Summary of early surveys)				BMR Record 1974/160
Stockyard Hill	1966	Woodside (Lakes Entrance)	Wongala Geophysical	0.5	0.5	312	PSSA 66/4823
BMR Continental Margin geophysical	1970-73	BMR	Compagnie Generale de Geopnysique	50	-	-	BMR Records 1974/15
Shell Deepwater Scientific	1972-73	Shell Development (Australia)	Seismograph Service Ltd	75	-	-	P(SL)A 72/30
Reconnaissance Helicopter surveys	1973-74	BMR	Wongola Geophysical	11	11	7658	BMR Record in preparation

APPENDIX 2 (Cont.)

Land seismic surveys

Map Key No. (Plate 5)	Survey name and type	Year	Operator	Contractor	Energy Source	No. of km surveyed	CDP coverage %	Reference
1	Avon area reflection	1952	BMR	-	Explosives		100	BMR Record 1952/35
2	Darriman area reflection	1954	BMR	-	Explosives		100	BMR Report 19
3	Latrobe Valley experimental reflection & refraction	1958	BMR	-	Explosives		100	BMR Record 1959/151
4	East Gippsland reflection	1960	Woodside (Lakes Entrance)	Austral Geoprospectors	Explosives	134	100	PSSA 62/1507
5	Rosedale reflection & refraction	1961	BMR	-	Explosives	29	100	BMR Record 61/165
6	Lake Wellington	1961	Woodside (Lakes Entrance)	Austral Geoprospectors	Explosives	218	100	PSSA 62/1552
7	Lakes Entrance reflection and refraction	1962	Arco Ltd	Austral Geoprospectors	Explosives		100	PSSA 62/1591
8	Gormandale refraction	1963	A.P.M. Development	Austral Geoprospectors	Explosives	13.4	-	PSSA 63/1547
9	Seaspray reflection	1964	Arco Ltd	Namco	Explosives	95	600	PSSA 64/4521
10	Woodside Paynesville reflection	1965	Woodside (Lakes Entrance)	Seismograph Services Ltd	Vibroseis	100	1000	PSSA 64/4573
				Namco	Explosives	210	600	
11	Toongabbie reflection and refraction	1968	A.P.M. Developments	GAPL	Explosives	35	100	PSSA 68/3022
12	Bemm River refraction	1970	W.Y.P.	Geosurveys	Explosives	29	-	PSSA 70/768
13	Ninety Mile Beach	1962-63	Arco Ltd	Western Geophysical	Explosives	-	100-200	PSSA 62/1640
14	Gippsland-Bass St. - Anglesea-S.A.	1963	Haematite	Western Geophysical	Explosives	1610	100-200	PSSA 62/1645
15	Gippsland Shelf	1964	Esso Australia	Western Geophysical	Explosives	1030 130	600 100	PSSA 64/4550
16	Offshore Gippsland Basin	1965	Shell Development	Geophysical Services International (GSI)	Explosives	1000	400	PSSA 65/11045
17	Eastern Bass St.	1966	Esso Australia	GSI	Explosives	3590	100-600	PSSA 66/11070
18	Gippsland EC-67	1967	Esso Australia	GSI	Explosives & Airguns	750	600	PSSA 67/11184
19	Sole Structure	1967	Shell Development	Compagnie de Generale Geophysique	Sparker	320	100	PSSA 67/11187

APPENDIX 2 (Cont)

Land seismic surveys

Map Key No. (Plate 5)	Survey name and type	Year	Operator	Contractor	Energy source	No. of km surveyed	CDP coverage %	Reference
1	Avon area reflection	1952	BMR	-	Explosives		100	BMR Record 1952/35
2	Darriman area reflection	1954	BMR	-	Explosives		100	BMR Report 19
3	Latrobe Valley experimental reflection & refraction	1958	BMR	-	Explosives		100	BMR Record 1959/151
4	East Gippsland reflection	1960	Woodside (Lakes Entrance)	Austral Geoprospectors	Explosives	134	100	PSSA 62/1507
5	Rosedale reflection & refraction	1961	BMR	-	Explosives	29	100	BMR Racord 61/165
6	Lake Wellington	1961	Woodside (Lakes Entrance)	Austral Geoprospectors	Explosives	218	100	PSSA 62/1552
7	Lakes Entrance reflection and refraction	1962	Arco Ltd	Austral Geoprospectors	Explosives		100	PSSA 62/1591
8	Gormandale refraction	1963	A.P.M. Development	Austral Geoprospectors	Explosives	13.4	-	PSSA 63/1547
9	Seaspray reflection	1964	Arco Ltd	Namco	Explosives	95	600	PSSA 64/4521
10	Woodside Paynesville reflection	1965	Woodside (Lakes Entrance)	Seismograph Services Ltd	Vibroseis	100	1000	PSSA 64/4573
				Namco	Explosives	210	600	
11	Toongabbie reflection and refraction	1968	A.P.M. Developments	GAPL	Explosives	35	100	PSSA 68/3022
12	Bemm River refraction	1970	W.Y.P.	Geosurveys	Explosives	29	-	PSSA 70/768

Marine seismic surveys

Map Key No. (Plate 5)	Survey name and type	Year	Operator	Contractor	Energy source	No. of km surveyed	CDP coverage %	Reference
13	Ninety Mile Beach	1962-63	Arco Ltd	Western Geophysical	Explosives	-	100-200	PSSA 62/1640
14	Gippsland-Bass St. - Anglesea-S.A.	1963	Haematite	Western Geophysical	Explosives	1610	100-200	PSSA 62/1645
15	Gippsland Shelf	1964	Esso Australia	Western Geophysical	Explosives	1030 130	600 100	PSSA 64/4550
16	Offshore Gippsland Basin	1965	Shell Development	Geophysical Services International (GSI)	Explosives	1000	400	PSSA 65/11045
17	Eastern Bass St.	1966	Esso Australia	GSI	Explosives	3590	100-600	PSSA 66/11070
18	Gippsland EC-67	1967	Esso Australia	GSI	Explosives & Airguns	750	600	PSSA 67/11184
19	Sole Structure	1967	Shell Development	Compagnie de Generale Geophysique	Sparker	320	100	PSSA 67/11187
20	Gippsland EH-68	1968	Esso Australia	Western Geophysical	Aquapulse	1126	1200	PSSA 68/3015
21	East Gippsland Basin seismic and magnetic	1968	Magellan	Western Geophysical	Aquapulse	226 555	1200 1200	PSSA 68/3049 P(SL)A 68/1
22	Gippsland G69A seismic and magnetic	1968-1969	Esso Australia	Western Geophysical	Aquapulse	438 2570	1200 1200	PSSA 68/3058 P(SL)A 69/4
23	Tasman-Bass St. seismic and magnetic	1969	Magellan	Teledyne	Sparker & Airguns	3000 229	100-2400 100-2400	PSSA 69/3023 P(SL)A 69/11
24	Sailfish reflection and refraction	1970	N.S.W. Oil & Gas	Teledyne	Sparker Airguns	174 530	100 2400	PSSA 70/884
25	Gippsland Basin	1970	Shell Development	GSI	Airguns	860	2400	P(SL)A 70/10
26	Shell Deepwater Scientific	1972-1973	Shell Development	Seismograph Services Ltd	Airguns	10,904	2400	P(SL)A 72/30
27	Gippsland G73A	1973	Esso Australia	GSI	Airguns	618	2400	P(SL)A 73/14
28	1973 Seismic Survey	1973	Shell Development	GSI	Airguns	515	2400	P(SL)A 73/19
29	Northeast Furneaux	1973	Magellan	GSI	Airguns	208	2400	PSSA 73/225
30	Gippsland G74A	1974-1975	Esso Australia	GSI	Airguns	2926	4800	P(SL)A 74/15
31	BMR Continental Margin geophysical	1970-1973	BMR	CGG	Sparker		100	BMR Record 1974/98

STRATIGRAPHIC TABLES, GIPPSLAND BASIN WELLS APPENDIX 3

BARRACOUTA NO. 1 X

AGE	UNIT	Depth (m)	K.B.	Thickness (m)		LITHOLOGY
	Sea level	9				
	Sea floor	45				
MIOCENE	Gippsland Fm.	?		763	234-797	Marl, grey to olive grey, fossiliferous, soft, massive glauconitic dense Limestone, grey, skeletal, fossiliferous, glauconitic, pyritic and hard.
					797-940	Sandstone, grey, friable, fairly porous and permeable fossiliferous farily well sorted and quartzose with subrounded to rounded grains set in a calcareous matrix. Limestone, sandy or calcareous sandstone, but carbonate dominant. Marl, as above minor percentage.
	?Lakes Entrance Fm.				940-997	Marl, olive to dark grey, very fossiliferous and glauconitic, pyritic with scattered quartz grains.
OLIGOCENE	Lakes Entrance Fm.	997	57		997-1054	Shale, calcareous, green-grey, olive-grey, glauconitic, fossiliferous, pyritic with random quartz grains. Lithologically distinct from the section from 940-997 m and ties with the seismic top. Palaeontological disconformity at 940.
UPPER EOCENE	Latrobe Gp.	1054	585		1054-1639	Sand, clear-milky, light grey, medium grained, rounded well sorted quartz. Unconsolidated and extremely porous with minor coal fragments and muscovite flakes. Sandstone, as above but finer grained and slightly dolomitic in places. Coal, brown and black. Siltstone, brown-grey, finely pyritic, micaceous and very carbonaceous. Shale (minor) brown-grey, argillaceous dense and grades into siltstone as above.
UPPER CRETACEOUS	"	1639	1013		1639-1739	Siltstone, grey to black, carbonaceous, micaceous and pyritic. Shale, green grey to dark grey grading into siltstone as above. Sandstone, grey, very fine to medium grained, subangular to subrounded, soft, friable, carbonaceous, dolomitic in spots. Minor medium to coarse quartz grains. Coal, thin bands, brown to black.
					1739-2059	Sandstone, grey, green grey to brown grey, very fine to medium angular to subrounded, 95% clean quartz. Minor coal fragments mica flakes and a few lithic fragments. Siltstone, brown-grey carbonaceous and micaceous, finely pyritic grading into shale as below. Shale, grey and green grey, dense carbonaceous and micaceous. Coal, dense, black with good conchoidal fracture.
					0 2~~9~~59-2140	Same lithology as for 1739-2059 m but sands are coarser, up to pebble conglomerate in grainsize and angular to subangular. Quartz makes up about 95% of the sandstone
					2140-2213	As for 2059-2140 m but sandstones have kaolinitic matrix
					2213-2652	As for 2059-2140 but matrix appears to be weathered feldspar. Quartz 85-90%, feldspar 5-10%, coal fragments, trace of mica, dark rock fragments and pyrite.
			TD	2652		

Notes

1) First well drilled in the offshore Gippsland Basin and first offshore discovery with 108 m of gas column logged in the top of the Eocene Latrobe Gp.
2) The calcareous sandstone unit from 797-940 m within the Gippsland Fm. had not been encountered in onshore wells.
3) The section from 940 to 997 m could be included in the Lakes Entrance Fm. on palaeontological control but is lithologically distinct from the underlying section (997-1054m) and the prominent electric and sonic log marker at 997 m coincides with an extensive mappable seismic reflection.
4) The Upper Cretaceous section is lithologically distinct from the Strzelecki Gp. sediments seen onshore and appears devoid of marine fauna although formation water salinities are very high.

ESSO (1964)

BLUEBONE NO. 1

AGE	UNIT	Depth (m)K.B.	Thickness(m)		LITHOLOGY
PLIO-PLEISTOCENE	-	Sea Floor	?		Sampling of the cuttings was not carried out until 381m.
MIOCENE	Gippsland Formation	?	81+	381-462	Marls - light grey green, soft, glauconitic in part slightly pyritic with a trace of fossils. Skeletal limestones - light grey, white, unconsolidated moderately well sorted, glauconitic. Trace quartz, unconsolidated medium to coarse grained, angular to rounded. Limestones - light grey, firm to hard, argillaceous, glauconitic with abundant fossiliferous debris, dolomitic, massive.
OLIGOCENE	Lakes Entrance Fm.	462	60	462-522	Sandstones - dark grey-green and calcareous, strongly argillaceous and glauconitic; generally massive with minor lamination. The sand grains are poorly sorted, fine to coarse grained, angular to rounded. Mica is abundant and fossils are common. Mudstones - similar to above but having much more than 50% silty material.
EOCENE	Latrobe Group	522	69	522-591	Sandstones - grey-white, medium to coarse grained, poorly to moderately sorted; in part conglomeratic and pebbly, unconsolidated, with clay matrix. Poor permeability. Mudstone - light brown to dark brown, weakly laminated to massive, soft to perm, weakly carbonaceous and micaceous-sandy in part. No porosity or permeability.
DEVONIAN	-	591	13+	591-594	Weathered zone composed of weathered feldspars and amphiboles and quartz from the underlying granites; clayey.
				594-605	Granite - grey; weakly fractured with infillings of chlorite. Crystalloblastic with coarse grained quartz, plagioclase and orthoclase. Biotite and dark green amphiboles are present as accessories; pegmatitic with very coarse grained prophyroblastic quartz in microcline ground mass.

T.D. 605

Notes. A comparable thickness and facies of the Gippsland Formation was penetrated by Mullet No. 1. The possible age of the formation is not known other than that it is of Miocene age.
The Lakes Entrance Formation in Bluebone No. 1 has, from an insepection of the samples and interpretation of the gamma ray log, a greater sand content than was found in this formation in Mullet No. 1.
Core analysis showed the formation to have 40% porosity.
No hydrocarbons were detected, in the Latrobe Group, the formation being water flushed.

Esso (1970)

COBIA NO. 1

AGE	UNIT	Depth (m)K.B.	Thickness(m)		LITHOLOGY
PLIO-PLEISTOCENE	-	Sea Floor	152 approx		
MIOCENE	Gippsland Formation	?	2134 approx	259-866	Limestone - grey and brown loosely consolidated with forminifera and shell fragments, sandy in part.
				866-1817	Marl - grey-white, soft to firm, fossiliferous, trace glauconite and pyrite, minor interbeds of brown, dense limestone.
				1817-2232	Marl - as above. Shale - grey, soft to firm, calcareous, fossiliferous, traces of pyrite and glauconite.
OLIGOCENE	Lakes Entrance Fm.	2232	150	2232-2341	Shale - grey, soft to firm, bentonitic, trace pyrite and fine grained sand. Marl - as above.
				2341-2382	Shale - grey, silty, micaceous, fossiliferous, traces of fine grained sand, very glauconitic at base.
EOCENE	Latrobe Group Gurnard Fm.	2382	212+ 3	2382-2385	Siltstone - grey-green, and olive green, very argillaceous with disseminated sand grains and abundant glauconite and pyrite.
	Latrobe Group	2385	40	2385-2594	Shale - grey, silty Siltstone - tan, firm very glauconitic.
PALEOCENE	"	2425	169+		Sandstone - white to tan, very fine to coarse grained, occasionally glauconitic and pyritic in part. Coal - minor interbeds, black, brittle, conchoidal fractures.

T.D. 2594

Notes. A 22.5m oil column, from the base of the Gurnard Formation (2385m) to the oil-water contact (2407m), was discovered in the Cobia No. 1 well. The oil-bearing sands do not appear to be continuous with sands in either Halibut or Mackerel and appear to be of a depositional type which is typically of limited areal extent. Hydrocarbon pooling would appear to be contemporaneous with that at both Mackerel and Halibut.

Esso (1972)

DUCK BAY NO. 1

AGE	UNIT	Depth (m)K.B.	Thickness(m)		LITHOLOGY
UPPER PLIOCENE PLEISTOCENE	Haunted Hills Gravels and/or Lake Wellington Formation	3	88	12-91	Sand, light grey to yellow, fine to coarse grained; Gravel; Clay, yellow to grey; and Lignite - non-marine.
LOWER PLIOCENE	Jemmy's Point Fm.	91	30	91-122	Sand, fine to medium grained, with occasional coarse grains, sub-rounded; Fossils, predominantly Bryozoan, but with abundant Gastropoda, Pelecypoda and Foraminifera; and Marl, medium grey silty, very fossiliferous, glauconitic. The sand and fossils occupy the upper half of the unit and grade downward into the marl. The fossils, except for the smaller forms, appear to have been thoroughly fragmented by wave action .
UPPER MIOCENE	Tambo River Fm	122	6	122-128	Marl, medium grey, silty, very fossiliferous
MIOCENE	Gippsland Limestone	128	451	128-155	Marl, medium grey-brown, glauconitic, silty poorly consolidated, very fossiliferous.
				155-309	Limestone, white, yellow and light brown, finely crystalline to fine-grained, very fossiliferous and often coquinoidal in upper half, friable to slightly hard, very porous in upper half, argillaceous and tight in lower half, slightly glauconitic.
				309-411	Interbedded Limestone as above and Marl, grey to grey green, friable, slightly glauconitic.
				411-579	Claystone, light to medium grey, soft and sticky, slightly fossiliferous and glauconitic, calcareous; and minor Marl, grey to grey green, friable.
OLIGOCENE	Lake Entrance Fm.	579	117	579-667	Claystone, light to medium grey, slightly fossiliferous and glauconitic, calcareous; and Marl, medium grey to grey green, friable.
				667-683	Shale, brown green and grey green, firm, moderately to very glauconitic and pyritic, fossiliferous, floating coarse sand grains common.
				683-696	Sand, dark green grey to medium brown, fine to coarse grained, glauconitic and pyritic, good to fair porosity, slightly argillaceous and micaceous, occasional carbonaceous material, gradational downward into ligneous sand.
LOWER OLIGOCENE TO UPPER EOCENE	Latrobe Valley Coal Measures	696	122	696-818	Sand, fine to very coarse-grained; and Gravel, unconsolidated, mostly sub-angular grains, clean to very ligneous, fair to very good porosity; Brown Coal, brittle to soft, partly silty and shaly; and clay (or Claystone).

DUCK BAY NO. 1 (cont.)

AGE	UNIT	Depth (m)K.B.	Thickness(m)		LITHOLOGY
LOWER CRETACEOUS	Strzelecki Group	818	150	818-968	Shale-Mudstone, dark green grey to dark brown, compact, often silty, carbonaceous; and silt-stone, light grey to light brown, argillaceous, carbonaceous, micaceous. From 945m to 968m in the cuttings become very clayey and the lithology in this interval may more correctly be called claystone.
LOWER PERMIAN(?)	Volcanics (Un-named)	968	99	968-1067	The major rock type in this section is dark green, highly altered basalt. Tuff, breccia and volcanic ash were seen in core number 5, in which the recovery was only 0.52m, and as a minor constituent of the cuttings.
LOWER PERMIAN	Un-named	1067	190	1067-1257	Predominantly Sandstone, white to light grey, very fine to fine grained with occasional medium size grains, white argillaceous (ser-icitic) matrix, friable to slightly hard, generally tight, carbonaceous flakes, and laminations common, slightly micaceous; with minor Shale, dark brown and medium grey; and Siltstone, light grey, partly slightly dolomitic. The age of these sediments has been determined by the identification of spores in core number 6 at 1127m-1130m. No marine fossils have been found in these sediments, and judging by the presence of carbonaceous materials, it is probable that the sequence is non marine in origin. The presence of phosphatic pellets in core number 6 probably indicates a depositional environment with stagnant reducing conditions.
ORDOVICIAN	Ordovician Undifferentiated	1257	35	1257-1292	Slate, dark grey, metallic luster, dense, hard, well developed cleavage, partly silty, slightly pyritic; Siltstone, siliceous, hard, slightly argillaceous and Sandstone, medium to dark grey, fine grained, siliceous, very hard, The cores are cut by numerous milky white to light grey quartz veins 1/8" to 1/4" thick, and thin veins of black chert filling fractures.

T.D. 1292 (Schlumberger)

Notes 1) Several small gas shows were recorded in the Gippsland Limestone and in the top of the Latrobe Valley Coal Measures. The electrical and other logs indicate that these shows originated from porous zones with 100% water saturation.

2) No gas shows were recorded in the Lower Cretaceous or Upper Palaeozoic. The Strzelecki Group was completely lacking in reservoir beds, and the Upper Palaeozoic section contained only very thin porous beds having at the best about 20% porosity.

Arco Ltd. (1964)

GROPER NO. 2

AGE	UNIT	Depth (m)K.B.	Thickness(m)		LITHOLOGY
PLIO-PLEISTOCENE	-	Sea Floor	?		Cuttings samples were not recovered until at 472m.
MIOCENE	Gippsland Formation	?	215	472-527	Coquina - white to pink skeletal debris of bryozoal fragments, echinoid spines and foraminifera; sandy in part, poorly to moderately sorted. Mudstone-grey-green; thin minor interbeds of moderately hard fossiliferous and glauconitic mudstone.
				527-545	Sandstones - Quartzose, unconsolidated, well rounded moderately sorted; minor skeletal debris. Coquina - pink and white, slightly glauconitic, as above.
				545-670	Coquina - as above; with minor interbeds of grey-green glauconitic mudstone.
				670-687	Mudstone - green, soft to moderately hard, fossiliferous (bryozoans and foraminifera) glauconitic, slightly calcareous, non fissile.
OLIGOCENE	Lakes Entrance Fm.	687	75	687-725	Marl - white, very glauconitic, very soft to moderately hard, fossiliferous.
				725-760	Mudstone - green-grey, massive, poorly bedded, glauconitic, and calcareous. Very fossiliferous and burrowed. Pyrite nodules common. This unit becomes more glauconitic towards the base.
				760-762	Greensand - green, extremely glauconitic and sandy quartzose, fine to coarse-grained, subrounded to well rounded, moderately friable to firm.
EOCENE	Latrobe Group	762	79	762-842	Sandstones - greyish, quartzose, medium to coarse grained, poorly to moderately well sorted, subangular to subrounded with good to excellent porosities and permeabilities. Pyrite is common and slight carbonaceous material is present. Siltstone - dark brown, carbonaceous pyritic (disseminated and nodular) Slightly sandy and micaceous. Clays - white to grey, firm, kaolinitic, pyritic, blocky.

GROPER NO. 2 (Cont.)

AGE	UNIT	Depth (m)K.B.	Thickness(m)		LITHOLOGY
*DEVONIAN	Avon River Group? Weathered Zone	842	33+ 16	842-858	A weathered basement zone was encountered in this interval; and consisted of a dark red-brown firm plastic clay.
	Unweathered Zone	858	17+	858-875	Siltstone - dark red-brown, very hard and dense; poor laminations dip at approximately $5^{o}-10^{o}$. Minor fine sandy beds show scour and fill and poor rippling.

T.D. 876

Notes The contact between the Gippsland Formation and the underlying Lakes Entrance Formation is tentatively placed at 687m and is based on the electric log interpretation and cuttings analysis.

Much of the Gippsland Formation containing sandy coquinas and friable sands, is very permeable. The equivalent section in Groper No. 1 is generally impermeable with no development of porous sandstone intervals.

The presence of a 1.8m thick basal 'greensand' in the Lakes Entrance Formation in Groper No. 2 indicates that reworking of the Latrobe sands occurred during the Oligocene transgression.

The Lakes Entrance Formation at Groper No. 2, except possibly for the thin basal sand, is seen to act as a good top soil of the Latrobe sediments.

The Latrobe Group was the anticipate pay zone. No hydrocarbons were detected, the formation containing only water.

* This formation was quite unexpected. Study of the thin section has suggested that the unit shows affinities with the Late Devonian Avon River Group found in south eastern Victoria. No fossils were found in samples of this rock. The relationship of the formation to the Devonian Granites found along the trend from Wilson's Promentory to Flinders Island is unknown.

Esso (1970)

AGE	UNIT	Depth (m) K.B.	Thickness (m)	MARL	LITHOLOGY
	Sea level	9			
	Sea floor	60			
MIOCENE	Gippsland Fm.	232	1066	232-323	dstone, light grey fine to coarse poorly sorted gillaceous calcareous, glauconitic and fossiliferous. ithic and quartz fragments in a marl matrix.
				323-533	Sandstone as above with sandy marl and argillaceous calcarenite.
				533-1055	Sandy marl, light grey calcareous and fossiliferous.
				1055-1299	Marl mudstone light grey calcareous soft and fossiliferous.
OLIGOCENE	Lakes Entrance Fm.	1298	80	1299-1378	Mudstone, light grey soft, calcareous and fossiliferous. Trace of shale and brown silty mudstone. Glauconitic at base.
EOCENE	Latrobe Gp.	1378	600	1378-1478	Sandstone, light grey, quartzose very fine to coarse poorly sorted with finely disseminated pyritic and carbonaceous flecks.
					Very glauconitic in top part and generally not calcareous. Minor brown shale and coal.
				1478-1978	Sandstone, grey, fine to very coarse porous and permeable interbedded with dolomite bands, dark brown shale and siltstone, and black coal.
UPPER CRETACEOUS	"	1978	608	1978-2512	Interbedded sandstone, siltstone, shale, coal and dolomite. Sandstone is grey white quartzose dominantly fine grained subangular and fairly well sorted with some disseminated glauconite and a variable white clay matrix. Dolomite is light to medoum brown crypotocrystalline dense, hard and contains some dolomitic sandstone.
				2512-1586	Dominantly sandstone with minor interbedded siltstone and coal. Sandstone is light grey quartzose fine to very coarse poorly sorted. Porosity and permeability low as a result of kaolinitic matrix

Notes 1) First significant discovery of oil in the Latrobe Gp.16 m of gross oil sand from 1558-1574m was logged. Production test from 1561-1566 produced 1182 bpd of 51^{o}-53^{o}oil.

2) First significant gas show in the Upper Cretaceous section. Gross gas column of 180 m was logged from 2149-1329 m. Production test through perforations from 2290-2309m and 2257-2276m flowed at a maximum rate of 10.9 MMCFD + condensate at 39bbl/MMCFG.

3) Stratigraphy is essentially the same as Barracouta No. 1 but Miocene section is complete and 305 m thicker in Marlin No. 1. Palaeontological evidence indicates that the Middle Miocene in Marlin No. 1 is 152m higher than in Barracouta No. 1 suggesting local structural growth at Marlin No.1 ESSO(1965)

MARLIN NO. A-24

AGE	UNIT	Depth(m) K.B.	Thickness(m)		LITHOLOGY
EOCENE	Latrobe Gp.	1582 MD 1393 TVD	590		Interbedded pyritic siltstone and carbonaceous shale, scattered interbeds of sandstone, coal beds.
PALEOCENE	"	2368 MD	744	2368-2624	Interbedded carbonaceous siltstone and fine grained sandstone, minor shale and coal beds.
				2624-3310	Interbedded carbonaceous shale and siltstone and sandstone, numerous coal beds; sands are gas-bearing to 3173m, oil-bearing from 3310-3234m, and water-bearing below that.
				3310-3349	Interbedded micaceous pyritic siltstone and silty clay-choked tight sandstone.
		3354 TD 2727 TVD			

Notes 1) The well confirmed the presence of gas and oil in the 'D' fault block immediately to the south of the Marlin Platform. 78m of net gas and 16m of net oil sand between 2161 and 2603m

2) Apart from the gas sand at 2161m which is not present in other Marlin field wells the Paleocene section is similar to that found in Marlin 1, 2 and A6 wells. ESSO (1973)

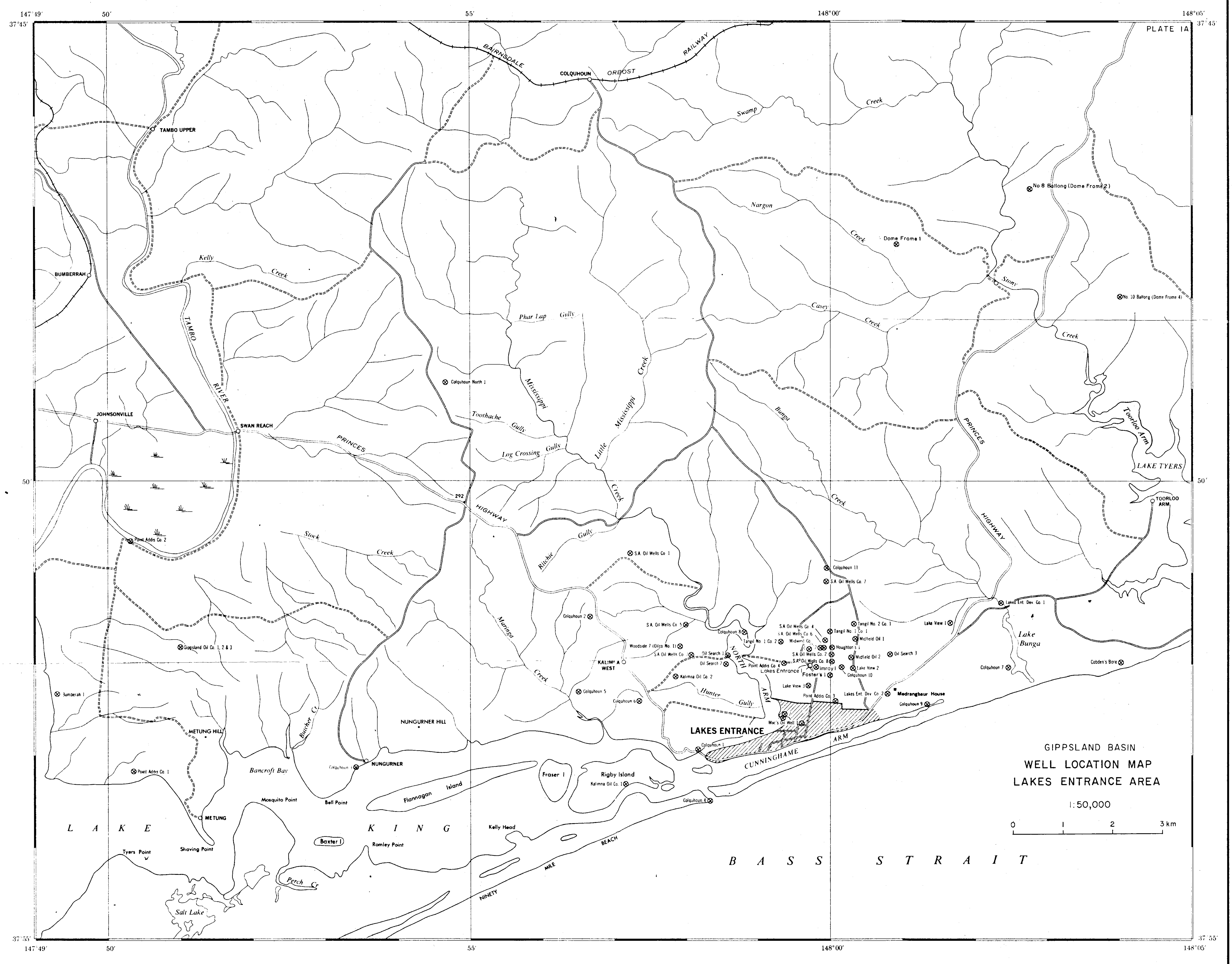
SAILFISH NO. 1

AGE	UNIT	Depth (m)K.B.	Thickness(m)		LITHOLOGY
RECENT- PLEISTOCENE	Sea floor		?		Sea floor samples comprised undifferentiated calcarenite and skeletal limestones
MIOCENE	Gippsland Formation	?	978+	260-1237	Mainly marls
MIOCENE OR EARLIER	Unnamed volcanics	1237	184+	1237-1271 1271-2031	Weathered basic volcanics Dominantly dark green volcanics

T.D. 231

Notes No hydrocarbons were encountered in the well and none were indicated by the electric logs.

N.S.W. Oil and Gas Company N.L. (1972)



(Based on XAUS-1-119) Record 1978/110

XAUS-7-52

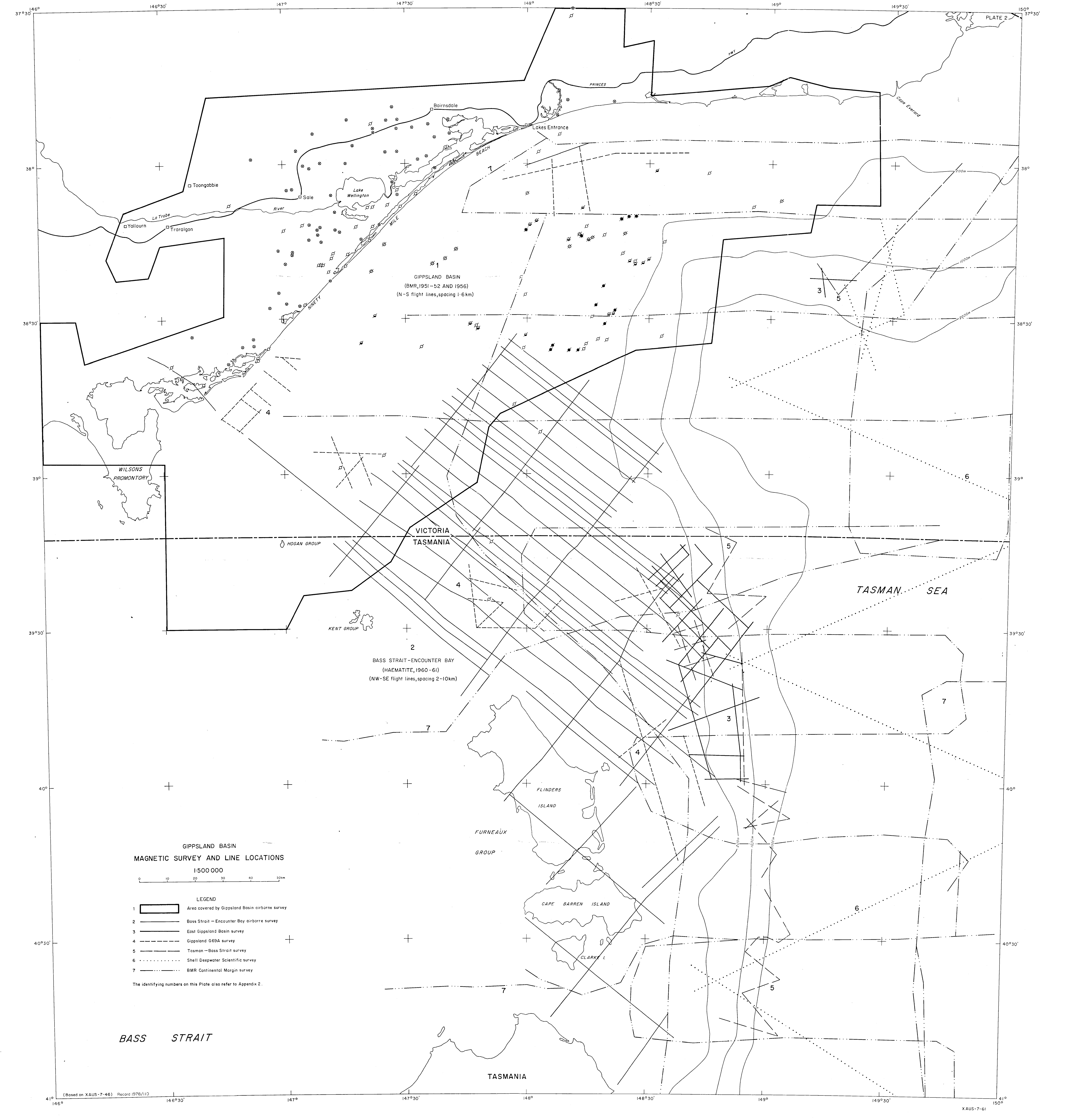
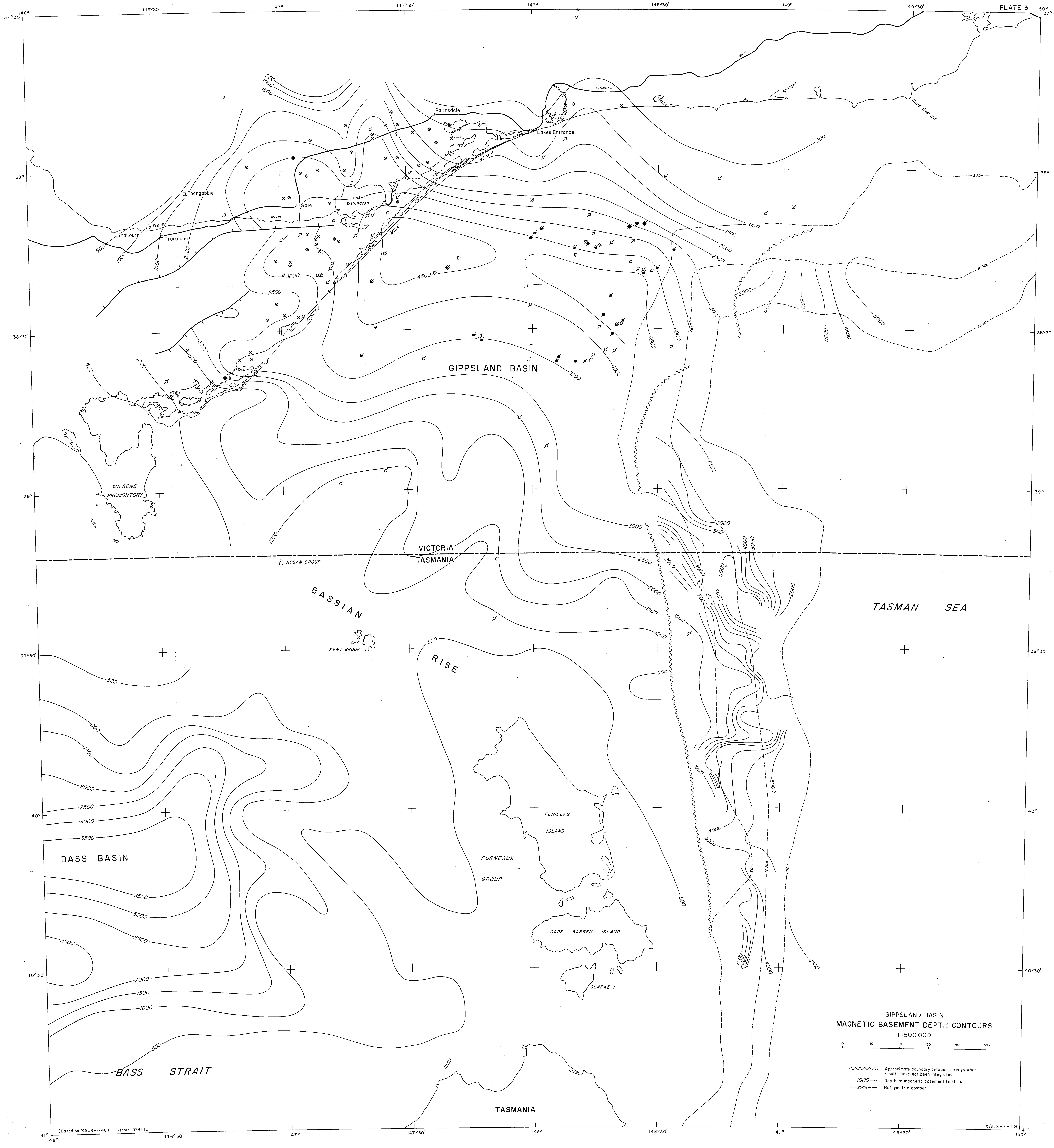


PLATE 2
GIPPSLAND BASIN
MAGNETIC SURVEY AND LINE LOCATIONS
1:500 000
0 10 20 30 40 50km
LEGEND
1 Area covered by Gippsland Basin airborne survey
2 Bass Strait — Encounter Bay airborne survey
3 East Gippsland Basin survey
4 Gippsland G69A survey
5 Tasman — Bass Strait survey
6 Shell Deepwater Scientific survey
7 BMR Continental Margin survey
The identifying numbers on this Plate also refer to Appendix 2.
1
GIPPSLAND BASIN
(BMR, 1951–52 AND 1956)
(N-S flight lines, spacing 1·6 km)
2
BASS STRAIT–ENCOUNTER BAY
(HAEMATITE, 1960-61)
(NW-SE flight lines, spacing 2-10km)
Bairnsdale
Lakes Entrance
Toongabbie
Sale
Lake Wellington
Yallourn
Traralgon
La Trobe River
NINETY MILE BEACH
PRINCES HWY
Cape Everard
WILSONS PROMONTORY
VICTORIA
TASMANIA
HOGAN GROUP
KENT GROUP
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN ISLAND
CLARKE I.
TASMAN SEA
BASS STRAIT
TASMANIA
200m
1000m
2000m
37°30'
38°
38°30'
39°
39°30'
40°
40°30'
41°
146°
146°30'
147°
147°30'
148°
148°30'
149°
149°30'
150°
(Based on XAUS-7-46) Record 1978/113
XAUS-7-61

PLATE 3


GIPPSLAND BASIN
VICTORIA
TASMANIA
BASSIAN RISE
TASMAN SEA
BASS BASIN
BASS STRAIT
Bairnsdale
Lakes Entrance
Sale
Lake Wellington
Toongabbie
Traralgon
Yallourn
La Trobe River
PRINCES HWY
NINETY MILE BEACH
Cape Everard
WILSONS PROMONTORY
HOGAN GROUP
KENT GROUP
FURNEAUX GROUP
FLINDERS ISLAND
CAPE BARREN ISLAND
CLARKE I.
GIPPSLAND BASIN
MAGNETIC BASEMENT DEPTH CONTOURS
1:500 000
Approximate boundary between surveys whose results have not been integrated
1000 Depth to magnetic basement (metres)
200m Bathymetric contour
(Based on XAUS-7-46) Record 1978/110
XAUS-7-58

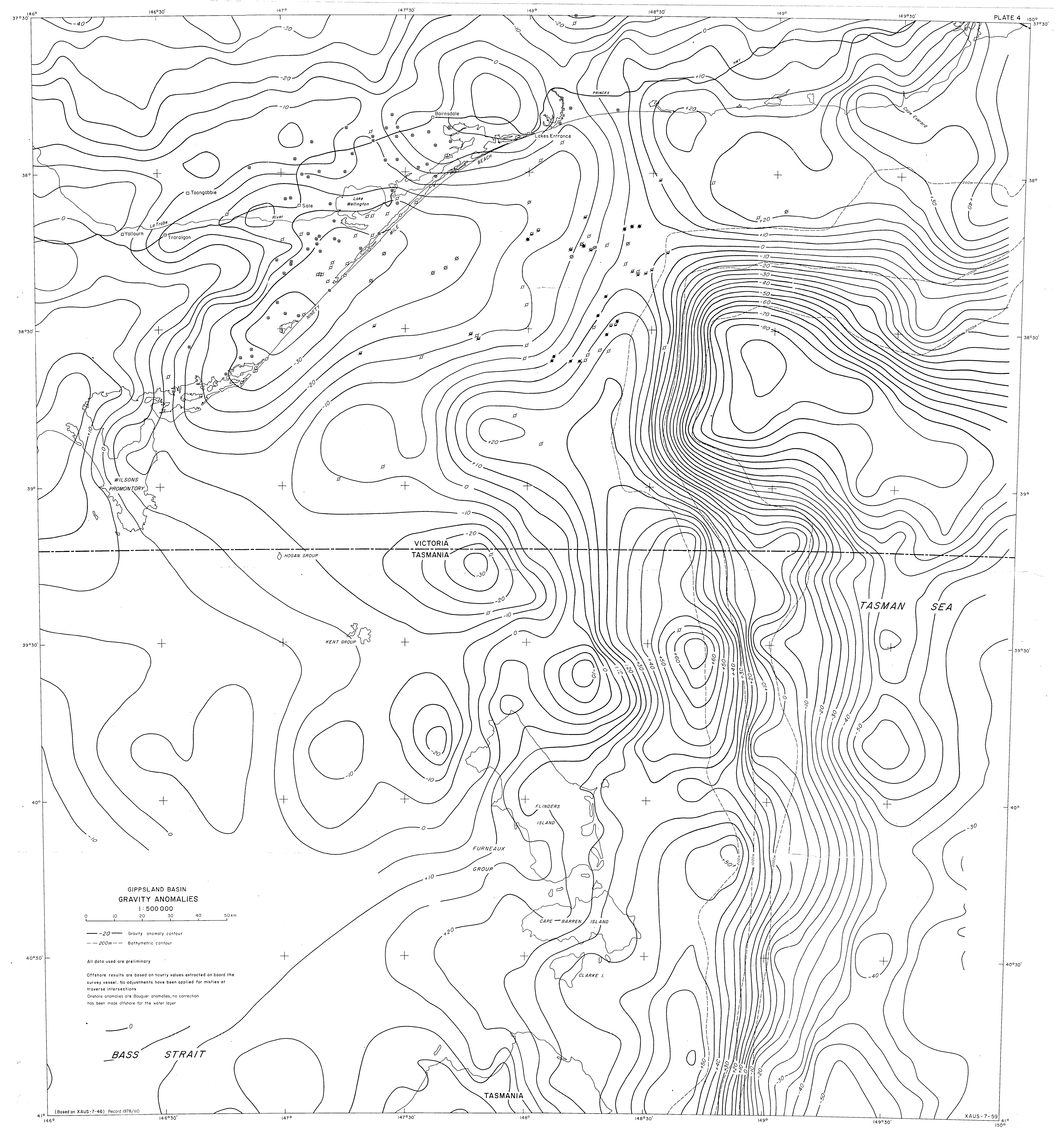
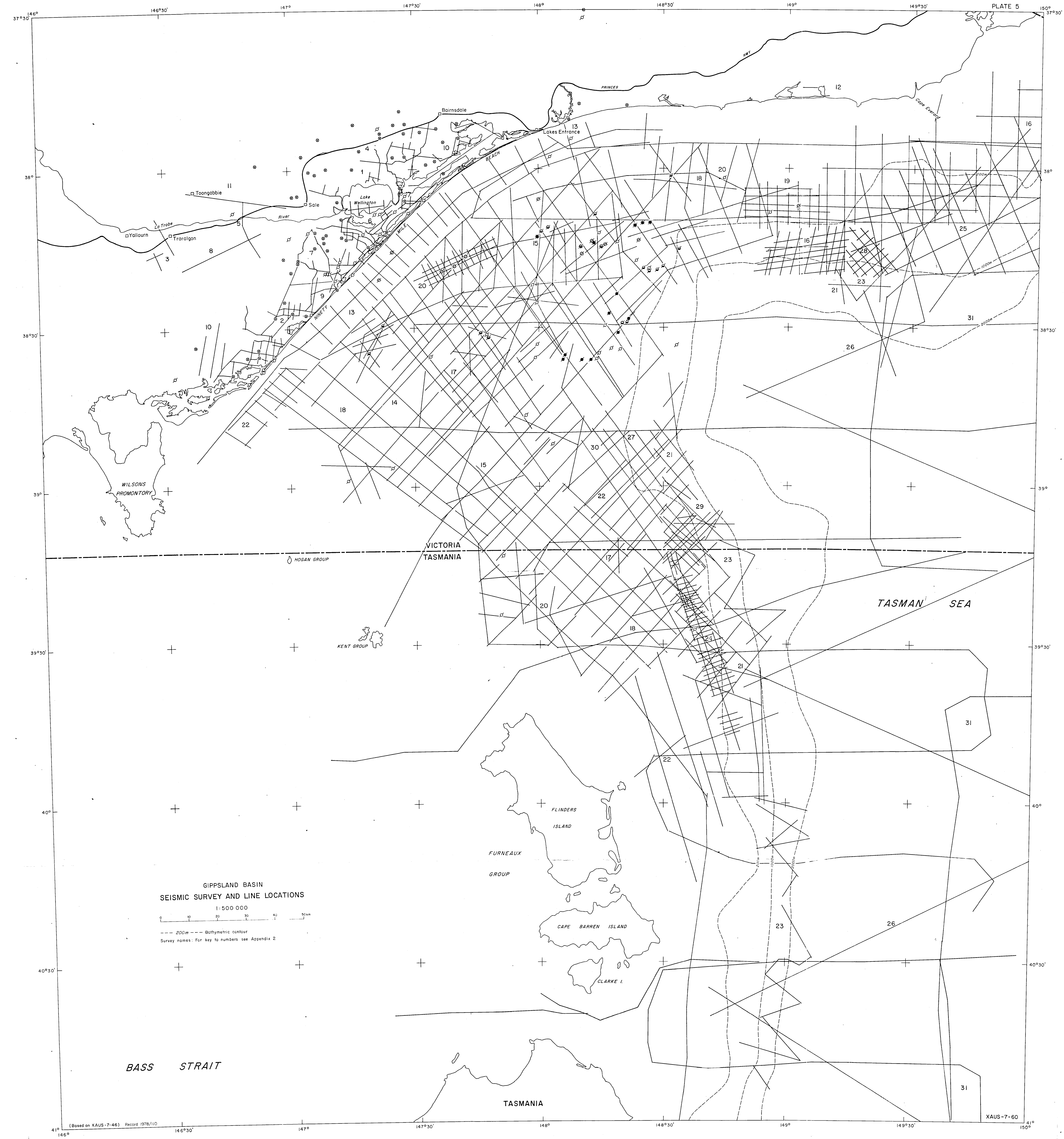


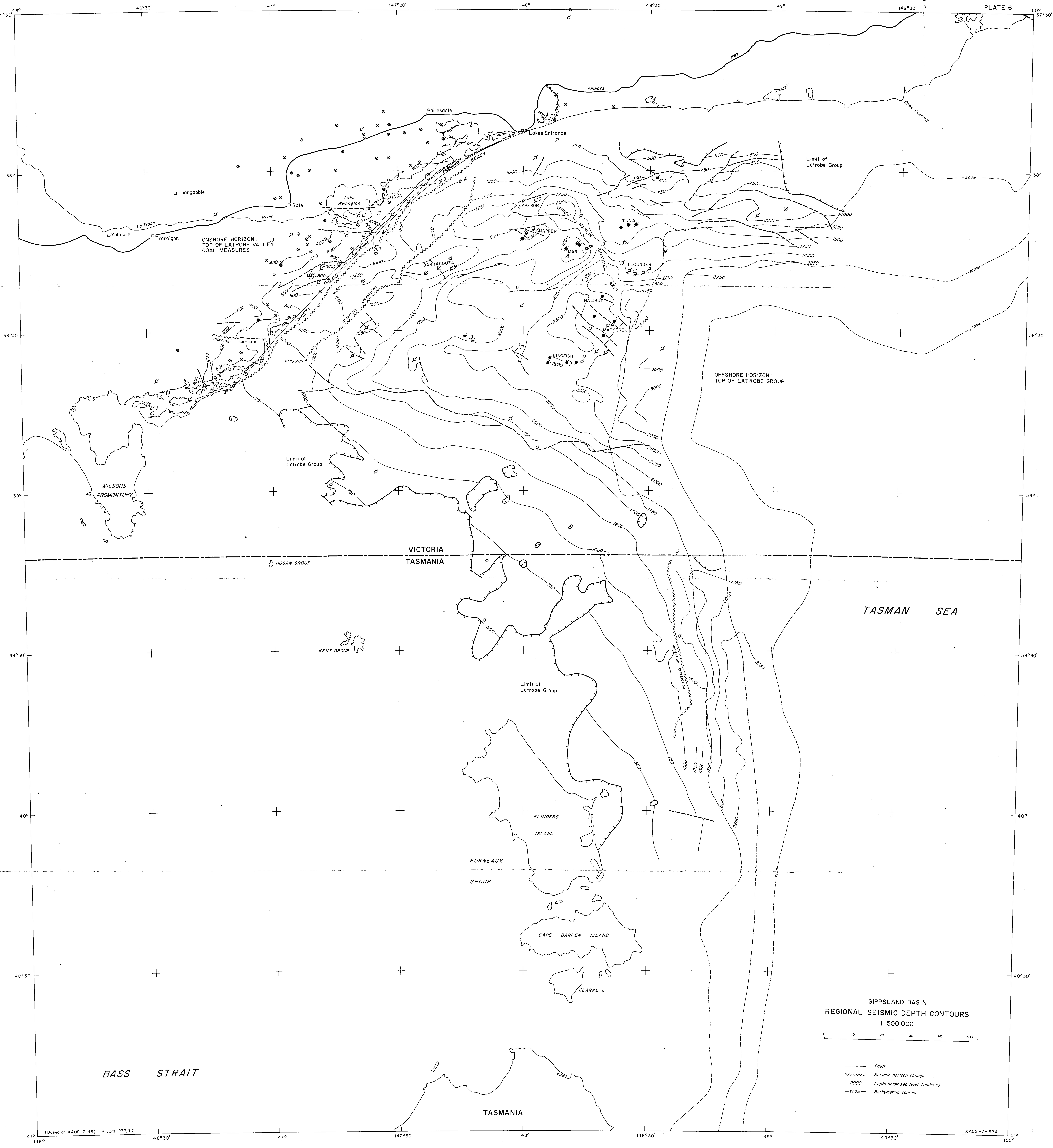
PLATE 4
GIPPSLAND BASIN
GRAVITY ANOMALIES
1:500 000
0 10 20 30 40 50 km
—20— Gravity anomaly contour
— —200m— — Bathymetric contour
All data used are preliminary
Offshore results are based on hourly values extracted on board the survey vessel. No adjustments have been applied for misties at traverse intersections
Onshore anomalies are Bouguer anomalies, no correction has been made offshore for the water layer
VICTORIA
TASMANIA
TASMAN SEA
BASS STRAIT
WILSONS PROMONTORY
HOGAN GROUP
KENT GROUP
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN ISLAND
CLARKE I.
Bairnsdale
Lakes Entrance
Toongabbie
Sale
Lake Wellington
Yallourn
Traralgon
La Trobe River
NINETY MILE BEACH
PRINCES HWY
Cape Everard
(Based on XAUS-7-46) Record 1978/110
XAUS-7-59

PLATE 5



GIPPSLAND BASIN
SEISMIC SURVEY AND LINE LOCATIONS
1:500 000
0 10 20 30 40 50km
--- 200m --- Bathymetric contour
Survey names: For key to numbers see Appendix 2
Bairnsdale
Lakes Entrance
Toongabbie
Sale
Lake Wellington
Yallourn
Traralgon
La Trobe
River
NINETY
MILE
BEACH
PRINCES
HWY
Cape Everard
WILSONS PROMONTORY
VICTORIA
TASMANIA
HOGAN GROUP
KENT GROUP
TASMAN SEA
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN ISLAND
CLARKE I.
BASS STRAIT
TASMANIA
146°
146°30'
147°
147°30'
148°
148°30'
149°
149°30'
150°
37°30'
38°
38°30'
39°
39°30'
40°
40°30'
41°
(Based on XAUS-7-46) Record 1978/110
XAUS-7-60

PLATE 6


GIPPSLAND BASIN
REGIONAL SEISMIC DEPTH CONTOURS
1:500 000
Fault
Seismic horizon change
2000 Depth below sea level (metres)
200m Bathymetric contour
ONSHORE HORIZON: TOP OF LATROBE VALLEY COAL MEASURES
OFFSHORE HORIZON: TOP OF LATROBE GROUP
Limit of Latrobe Group
Bairnsdale
Lakes Entrance
Sale
Toongabbie
Yallourn
Traralgon
Lake Wellington
La Trobe River
PRINCES HWY
Cape Everard
NINETY MILE BEACH
uncertain correlation
EMPEROR
SNAPPER
APPROX. MARLIN CHANNEL AXIS
MARLIN
TUNA
FLOUNDER
BARRACOUTA
HALIBUT
MACKEREL
KINGFISH
WILSONS PROMONTORY
VICTORIA
TASMANIA
HOGAN GROUP
KENT GROUP
TASMAN SEA
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN ISLAND
CLARKE I.
BASS STRAIT
TASMANIA
(Based on XAUS-7-46) Record 1978/110
XAUS-7-62A