BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

RECORD 1988/38

DEFINITION OF THE CONTINENTAL MARGIN USING U.N. CONVENTION ON THE LAW OF THE SEA (ARTICLE 76), USING ITS APPLICATIONS TO AUSTRALIA.

BY

P.A. SYMONDS AND J.B. WILLCOX

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BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

Division of Marine Geosciences
and Petroleum Geology

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FORWARD

This manuscript was prepared to accompany a presentation in the Marine Geography Study Group (S12) at the 26th Congress of the International Geographical Union, August 21 -26, 1988, University of Sydney. It is derived from publications of Symonds & Willcox (in press) and Willcox & Symonds (in prep.).

We acknowledge the contribution made to this study by the late John C. Branson, who prepared Figures 4 to 9.

CONTENTS

ABSTRACT

Under the U.N. Convention on the Law of the Sea a coastal state has sovereign rights over its 'Legal Continental Shelf'(LCS) for the purposes of exploring and exploiting the natural resources of its seabed and subsoil. The LCS is considered to extend throughout the natural prolongation of the land territory to the outer edge of the continental margin, which, where it extends beyond the 200 nautical mile limit (Exclusive Economic Zone - EEZ), is defined by a two part formula based on measurements from foot-of-continental-slope(FCS) reference points. In order to fully apply this section of Article 76 both bathymetric and sediment thickness information are required.

The most precise determination of the FCS can be obtained from echo sounder profiles, although contours of 'spot' water depth data can give an approximate position. Regardless of the type of bathymetric data used the recognition of a relatively imprecise geomorphic feature such as the FCS will always be a matter of interpretation, particularly on complex margins containing terraces and plateaus associated with several significant changes in gradient. Application of the sediment thickness part of the formula is fraught with practical difficulties, such as - a worldwide sparsity of direct sediment thickness measurements (drilling); highly irregular sediment distribution on some continental margins; and uncertainties in distinguishing 'true' crystalline basement on seismic sections. Improved seismic resolution and penetration has meant that in many areas "yesterday's basement is today's sedimentary section". Furthermore, inaccuracies in determining sediment thicknesses from seismic data can amount to 10 or 20% owing to uncertainties in the propagation velocity of the seismic signal.

The area of a LCS around Australia and its territories would be approximately 11.9 million km^2 (about 1.5 times the area of the continent itself, and one of the largest in the world), or approximately 14.8 million km^2 if the Australian Antarctic Territory was included. Eight regions of this shelf, totalling more than 3 million km^2 in area, would extend beyond an EEZ. Sediment thicknesses greater than 2000m - sufficient to have generated hydrocarbons from any potential source rocks - occur in six of these areas; namely, Lord Howe Rise, South Tasman Rise, Great Australian Bight, Naturaliste Plateau, Exmouth/Wallaby Plateaus and Kerguelen Plateau. At present, the application of Article 76 to the Australian margin is mainly dependent on the definition of the outer edge of the continental margin by a line 60 nautical miles beyond the FCS - the so-called Hedberg line. Due to the sporadic distribution and poor quality of seismic data beyond the slope it is only possible to construct a sediment thickness related edge-of-margin line around approximately 15% of the Australian margin. On current understanding this places most of the remote parts of the Australian margin with possible resource potential, within a LCS. The only significant exception to this is in the Great Australian Bight, on the southern margin, where it may be possible to place a greater area of thick sediment within a LCS if the seismic data existed to allow the sediment thickness formula to be applied.

INTRODUCTION

Two major types of geological province cover the surface of the globe - the continents and the oceans - each of which is floored by crust (lithosphere) with characteristic lithological, geochemical, and physical properties. The boundary between these provinces, marks the outer-most limit of natural prolongation of a continent, and hence the land territory of coastal state, which is commonly viewed as the **absolute** limit of any reasonable claim that a coastal state could make for sovereign rights to explore and exploit the natural resources of the deep seabed and subsoil. Therefore, the definition of the extent of the 'geological' continental margin has become increasingly important to the international community as technology is developed to explore the resources of deep-water regions. However, the geological complexity and transitional nature of the ocean/continent boundary zone make it difficult to accurately define on a map.

Several indirect means of estimating its position are available, but these generally result in the mapping of a boundary zone rather than a precise line. Such methods involve:

- the general relationship of parts of the continental margin to various isobaths
- the physiography of the margin, which is related to the crustal types, its subsidence history, structural style and sediment supply
- the gravity field, from which an general estimate of crustal thickness, and possibly crustal type, can be obtained
- the seismic velocity structure of the crust as determined by refraction and wide-angle reflection studies
- the termination of linear, seafloor spreading magnetic anomalies, which are related to the formation of oceanic crust, commonly in the general vicinity of the ocean/continent boundary
- legal definitions based on distances from baselines, water depth, morphology, sediment thickness, and combinations of these factors.

Substantial international agreement on formulae used to define the boundaries of national jurisdiction over the sea and seabed was obtained in 1982 when the U.N. Convention on the Law of the Sea was adopted at the eleventh session of the Third United Nations Conference on the Law of the Sea. The Convention, which covers jurisdiction of over 100 million square kilometres of ocean, was arrived at following deliberation at a series of conferences stemming from the Truman Proclamation of 1945.

In this report we briefly examine the definition of Australia's continental margin using water depth (i.e. isobaths and physiographic provinces) and gravity data; we then discuss the legalistic approach to defining a continental margin and 'legal continental shelf' (LCS), and point out some of the problems involved in the application of these formulae; and finally we examine the implications of the legal definitions to defining the Australian margin and LCS, and to Australia's offshore resources.

DEFINITION OF THE CONTINENTAL MARGIN USING PHYSICAL PARAMETERS

Morphology of a continental margin

The seafloor around the continents consists typically of a **continental shelf**, which dips gently away from the coast to a relatively well defined shelf edge or shelf break, beyond which a relatively steeper slope - the **continental slope** - dips away to the deep ocean floor or **abyssal plain** (Figs. 1 & 2a). Water depths at the shelf break and foot of slope are typically in the ranges 150-200 metres and 3500-5500 metres, respectively. The boundary between the foot of slope and the abyssal plain is in many places obscured by an apron of sediment known as the **continental rise**. This has a low gradient and in some areas, such as offshore Ireland and in the Great Australian Bight, can extend for several hundred kilometres. The total width of the continental shelf, slope, and rise can vary from a few tens of kilometres to 200 km or more. The configuration described above - shelf, slope, rise and abyssal plain - can be further complicated by major areas of low gradient which are referred to as **terraces and plateaus** (Fig. 2b). The term plateau is usually reserved for features which are separated from the shelf and upper slope by a significant bathymetric trough (for example, Queensland Plateau and Queensland Trough, Fig. 1), though in some instances it is used to describe major plateau-like features within the deep ocean (for example, Ontong-Java Plateau and Kerguelen Plateau, Fig. 1). The term terrace refers to a decrease in gradient on the continental slope, and generally lacks a trough on its landward side (for example, Ceduna Terrace, Fig. 1). Further significant features on and beyond the continental margin are the ocean rises and ridges (for example, Lord Howe Rise and Broken Ridge, Fig. 1) and the numerous seamounts, seamount chains and guyots, which occur on the abyssal plains (for example, the Tasmantid Chain in the Tasman Basin, Fig. 1).

Use of bathymetry: Australian example

The bathymetry around Australia and its territories (Fig. 1) has been obtained by hydrographic surveys conducted by the Royal Australian Navy and from systematic geophysical and geological surveys by the Bureau of Mineral Resources (BMR). This information has been supplemented by regional studies carried out by international oil companies, and by numerous overseas institutes, such as Lamont-Doherty Geological Observatory. More detailed information has been collected during oil industry geophysical surveys and as part of BMR research projects. For the purpose of defining the continental margin of Australia, the most significant contribution comes from the 140 000 km of systematic geophysical traverses recorded by the BMR in 1970-73, during the Continental Margin Survey (Fig. 3). These data form the basis of the generalised bathymetric maps for the Eastern, Southern and Western margins of Australia shown in Figures 4, 5 and 6. The more detailed bathymetric contour maps (based on a triangular contouring technique) presented in Plates 3, 5, 7, 9, 11, 13 and 15 are based totally on BMR data. The bathymetric map of the Kerguelen Plateau region (Plate 16) comes from Houtz & others (1977). A new bathymetric map of this area has just become available (Schlich & others, 1987), and includes data from the most recent French and BMR research cruises in the region. It has not been used to define the continental margin in this report, but a generalised version of it is shown in the insert in Figure 1.

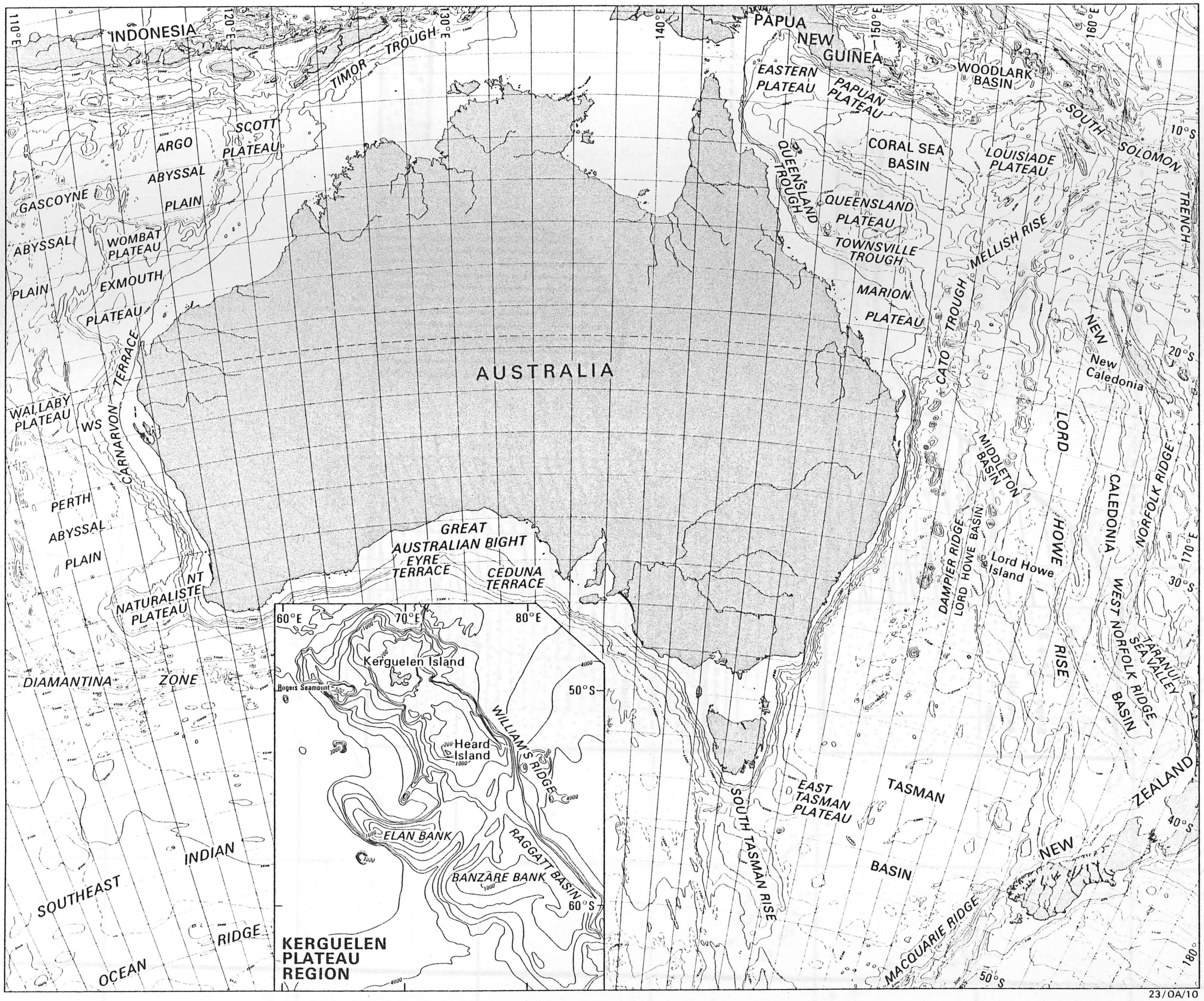

Figure 1. Bathymetry of the Australian and Kerguelen Plateau regions showing main physiographic features (isobaths in metres). Based on Plate-Tectonic Map of the Circum-Pacific Region, Southwest Quadrant base map (AAPG, 1978); Houtz & others (1977); Ramsay, Colwell & others (1985). NT = Naturaliste Trough, WS = Wallaby Saddle.

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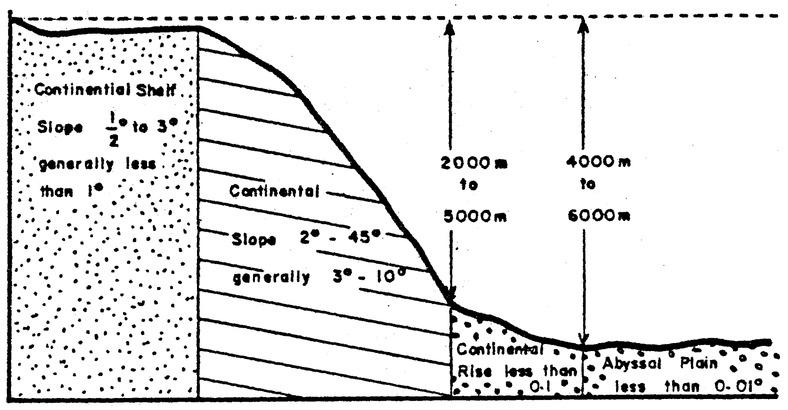
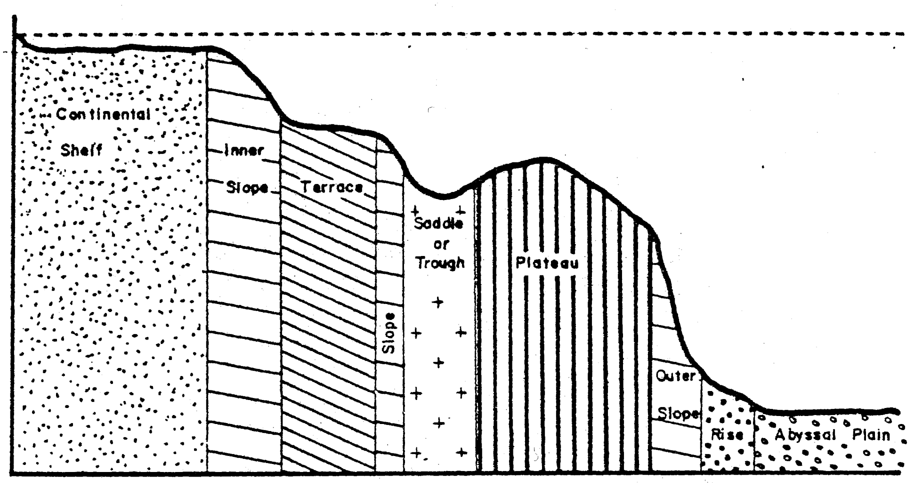


Simple Form



Complex Form

Figure 2.
Generalised cross-section of water bottom topography across a continental margin. Hachuring is consistent with that on Figures 7, 8 & 9.

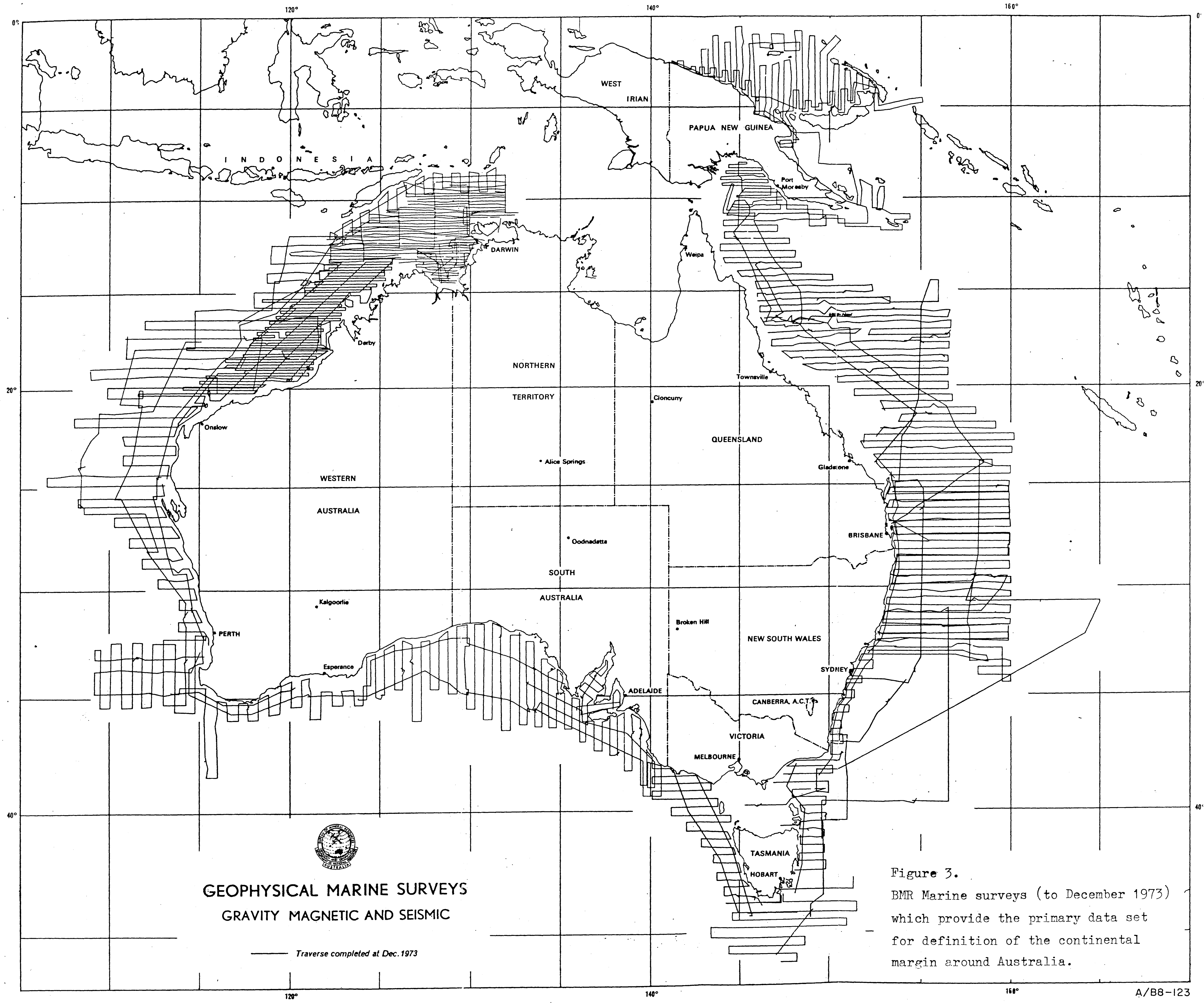


Figure 3.
BMR Marine surveys (to December 1973) which provide the primary data set for definition of the continental margin around Australia.

The 200, 2500 and 4000 m contours shown in Figures 4, 5 and 6 are regarded as the three most significant and useful isobaths for defining the continental margin. Many continental shelves around the world show a distinct change in slope at about 200 m water depth. This point - the shelf break - is often adequately defined by the 200 m isobath, although local variations in its depth are fairly common. Clearly the 200 m isobath is an important demarcation line which, despite rapid technical advances, still marks the seaward limit of relatively easy, and currently economic, exploitation of subsea resources.

At the second preparatory meeting of the United Nations Seabed Committee in 1971 a number of proposals were put forward on seabed limits, which included a depth limit of 2500 m. The northern Atlantic deep ocean basin becomes shallower than 2500 m to the north of a line between Nova Scotia and southern Ireland, and hence this isobath is a significant one off Europe and North America. Around the Australian margin the 2500 m isobath occurs in the middle of the continental slope and outlines most major marginal plateaus.

A third isobath of 4000 m outlines all the major ocean basins and approximates the base of the continental slope over about 50% of the Australian margin.

Around Australia the 200 m isobath lies within 200 nautical miles (370 km; the width of an Exclusive Economic Zone, see below) of the Australian coastline. In several places the area between the coast and the 200 m isobath widens to form an extensive continental shelf: such areas occur east of Mackay in Queensland, in Bass Strait, in the Great Australian Bight, along the northwestern coast north of Barrow Island, and in the Arafura Sea/Gulf of Carpentaria region (not represented in Figs. 4, 5 and 6, but see Fig. 1), where a continuous continental shelf occurs between Australia and Irian-Jaya. Elsewhere around the Australian margin the 200 m isobath lies within 50 nautical miles (93 km) of the coast.

In tropical waters off the east coast of Australia, the Great Barrier Reef marks the outer limit of the continental shelf, which approximately coincides with the 200 m isobath. Beyond the shelf on the adjacent marginal plateaus and terraces, isolated reefal platforms form elevated areas covered by less than 200 m water. At similar latitudes off the northwestern coast there is no barrier reef, but isolated shoals and reefs occur near the shelf break at Rowley Shoals, and Scott and Ashmore Reefs.

The 2500 m isobath forms an almost continuous line around the Australian continent and often extends well over 200 nautical miles from the coastline. In the northeast, this isobath circumscribes the Queensland and Eastern Plateaus. In the Tasman Sea it only occurs a short distance offshore, but it also forms a separate outline to bathymetric features further east, such as parts of the Dampier Ridge and the major Lord Howe Rise/Kenn Plateau feature. South and east of Tasmania the 2500 m isobath defines two prominent marginal plateaus - the East Tasman (or Cascade) Plateau and South Tasman Rise. It circumscribes similar plateaus/terraces on the southern Australian margin - the Ceduna and Eyre Terraces - and on the western margin off Perth, Barrow Island and Scott Reef - the Naturaliste, Exmouth and Scott Plateaus, respectively. In the north,

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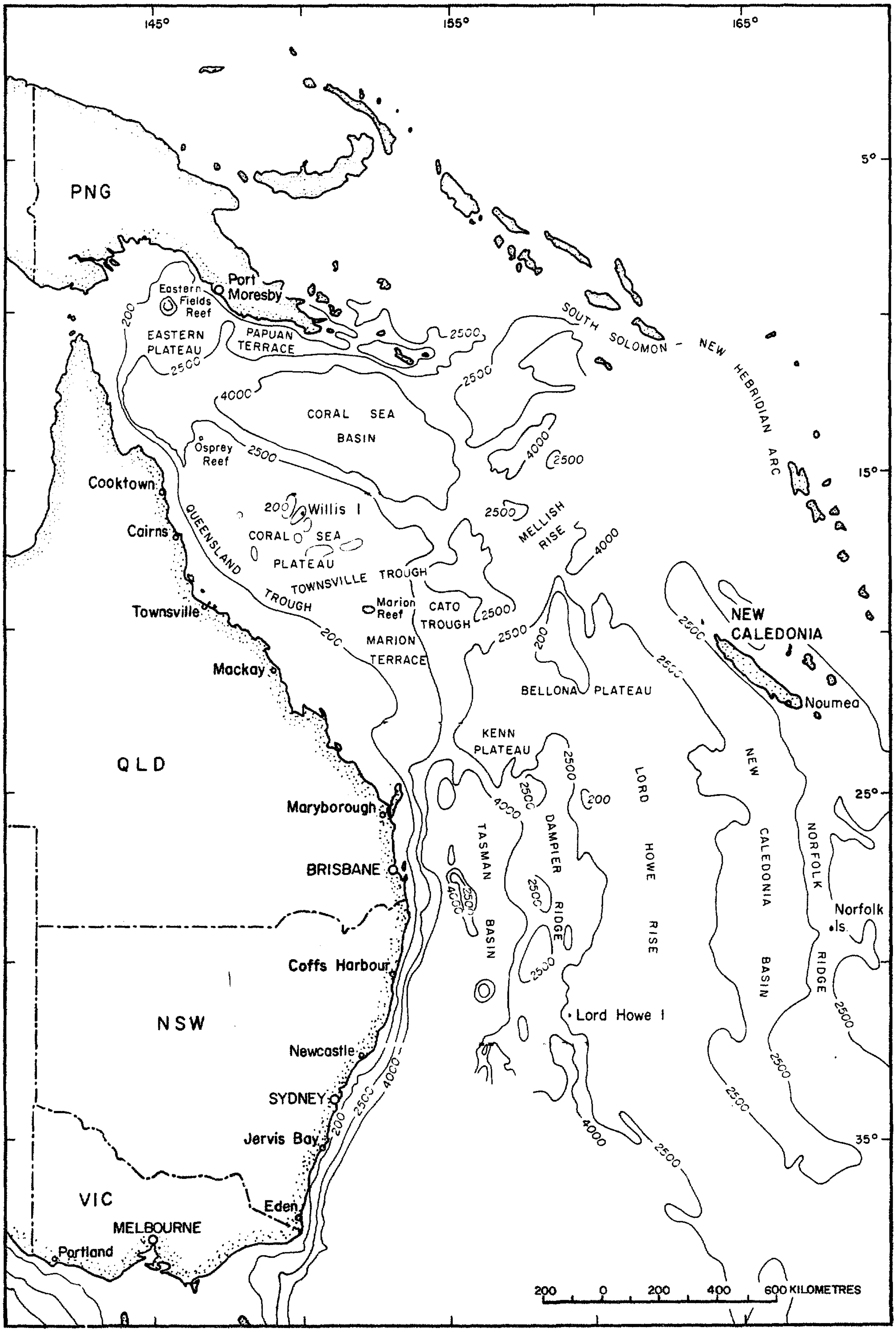

BASED ON A/BO-70A

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Figure 4.
Generalised bathymetry of Australia's Eastern Margin showing physiographic features. Contours in metres.
NB. Coral Sea Plateau = Queensland Plateau.

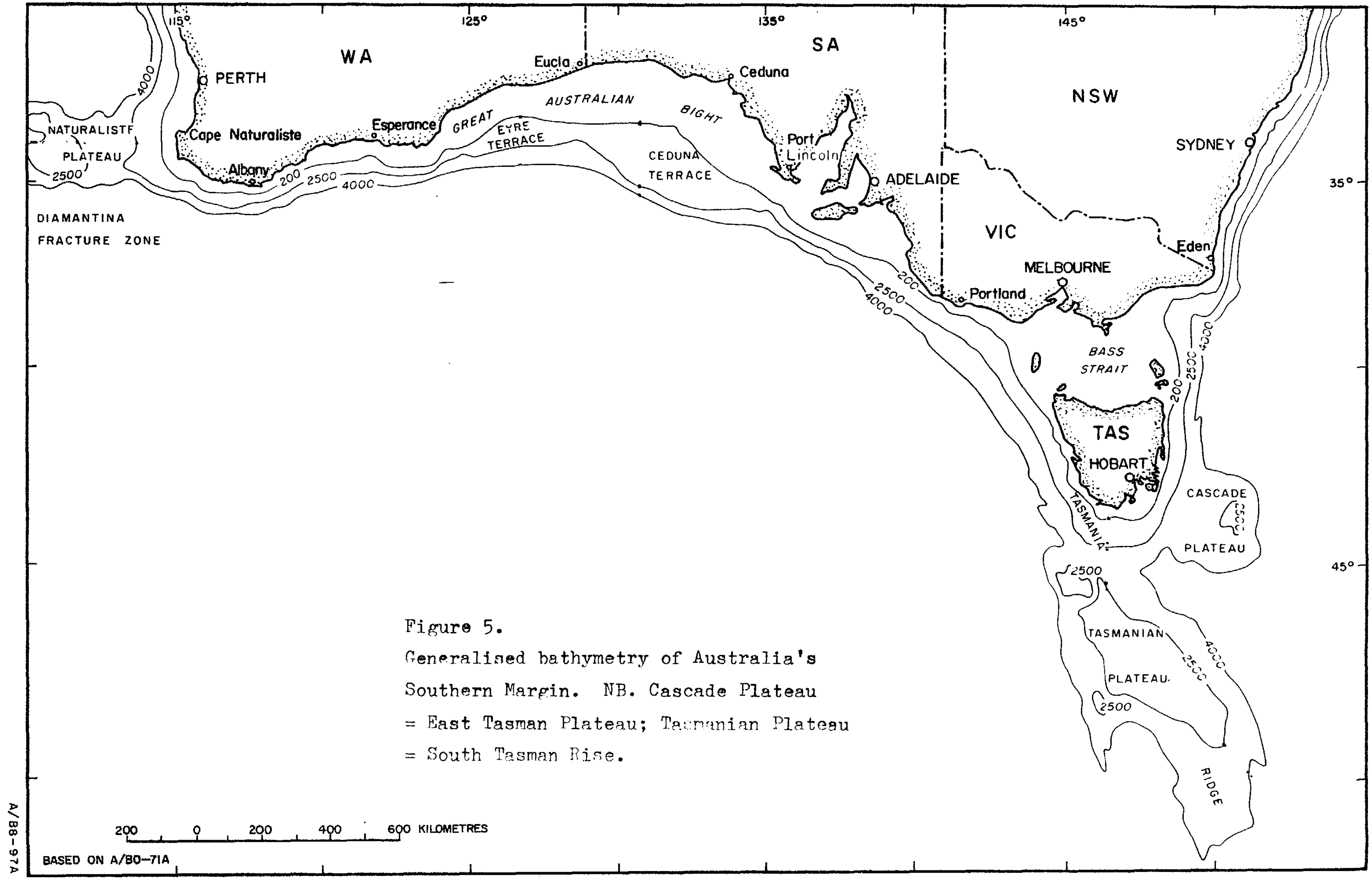

Figure 5.
Generalised bathymetry of Australia's Southern Margin. NB. Cascade Plateau = East Tasman Plateau; Tasmanian Plateau = South Tasman Rise.

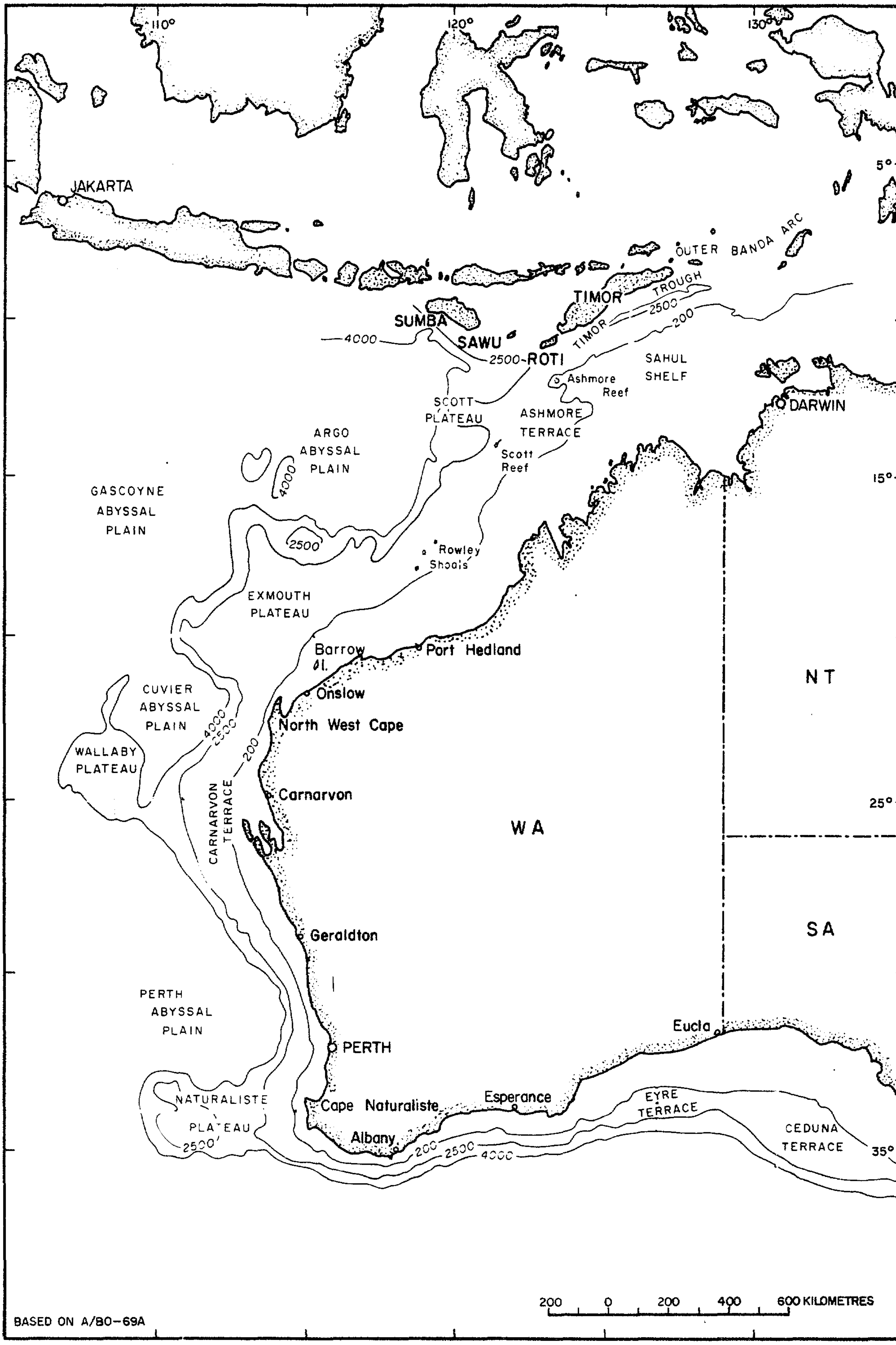

Figure 6.

Generalised bathymetry of Australia's Western and Northwestern Margins.

between the islands of the Outer Banda Arc and the Sahul Shelf, part of the floor of the Timor Trough is outlined by the 2500 m isobath.

The major ocean basins of the Coral Sea, Tasman Sea, Great Australian Bight and Indian Ocean are all outlined by the 4000 m isobath. All the marginal plateau regions outlined by the 2500 m isobath are also circumscribed by the 4000 m isobath, as is a further deep water marginal plateau off Carnarvon, Western Australia - the Wallaby Plateau. The 4000 m isobath does not form a continuous connection between the Coral Sea and Tasman Basins, and between the Outer Banda Arc and the Argo Abyssal Plain region; however, on many parts of the margin it is a crude approximation to the edge of the continent.

Use of physiographic provinces: Australian example

Figures 7, 8 and 9 show the nine primary physiographic provinces into which the Australian margin can be subdivided. These are based on the seven morphological units given in Figure 2, plus the categories of ridges and seamounts/guyots. The outer limit of the data set, which consists primarily of cross-sections from the BMR's Continental Margin Survey, is shown by a dashed line.

Although any physiographic province can occur over a range of water depths, its underlying geological structure is in many cases similar. Thus, in general terms, it is possible to relate the province type to crustal structure, and hence use this information as a guide to the extent of the continental crust. For example, the continental shelves and slopes are invariably part of the continent, and the plateaus and terraces within the slopes are, in most cases, large areas of continental crust which have subsided during the process of continental rifting and breakup (Fig. 10). There are a few instances around the world where marginal plateaus appear to be, at least in part, composed of unusually thick oceanic crust, such as the outer Voring Plateau off Norway. Such an origin has also been proposed for the Naturaliste, Wallaby and Scott Plateaus off Western Australian, but this is still a subject of debate and investigation. It is.widely accepted that many mid-ocean plateaus around the world are composed of thick oceanic crust - Iceland, for example. This is not the case for the Dampier Ridge and Lord Howe Rise features off eastern Australia, but there is recent evidence to indicate that at least part of the Kerguelen Plateau may have formed in this way.

Use of gravity data: Australian example

The gravity data which is routinely collected during BMR marine surveys (Fig. 3) can be used to provide a guide to changes in crustal thickness and the possible limit of continental crust. Regional variations in the free-air gravity anomalies (Symonds and Willcox, 1976) reflect changes in the density and thickness of the crustal column. If assumptions are made regarding the densities of water, sediment, crust and mantle - based either on average values or drilling results - and if the crustal thickness is known from seismic studies, at at least one location, then a simple crustal cross-section can be computed.

In Figure 11 we show such a crustal profile along a north-south transect through the Eyre Terrace region in the Great Australian Bight.

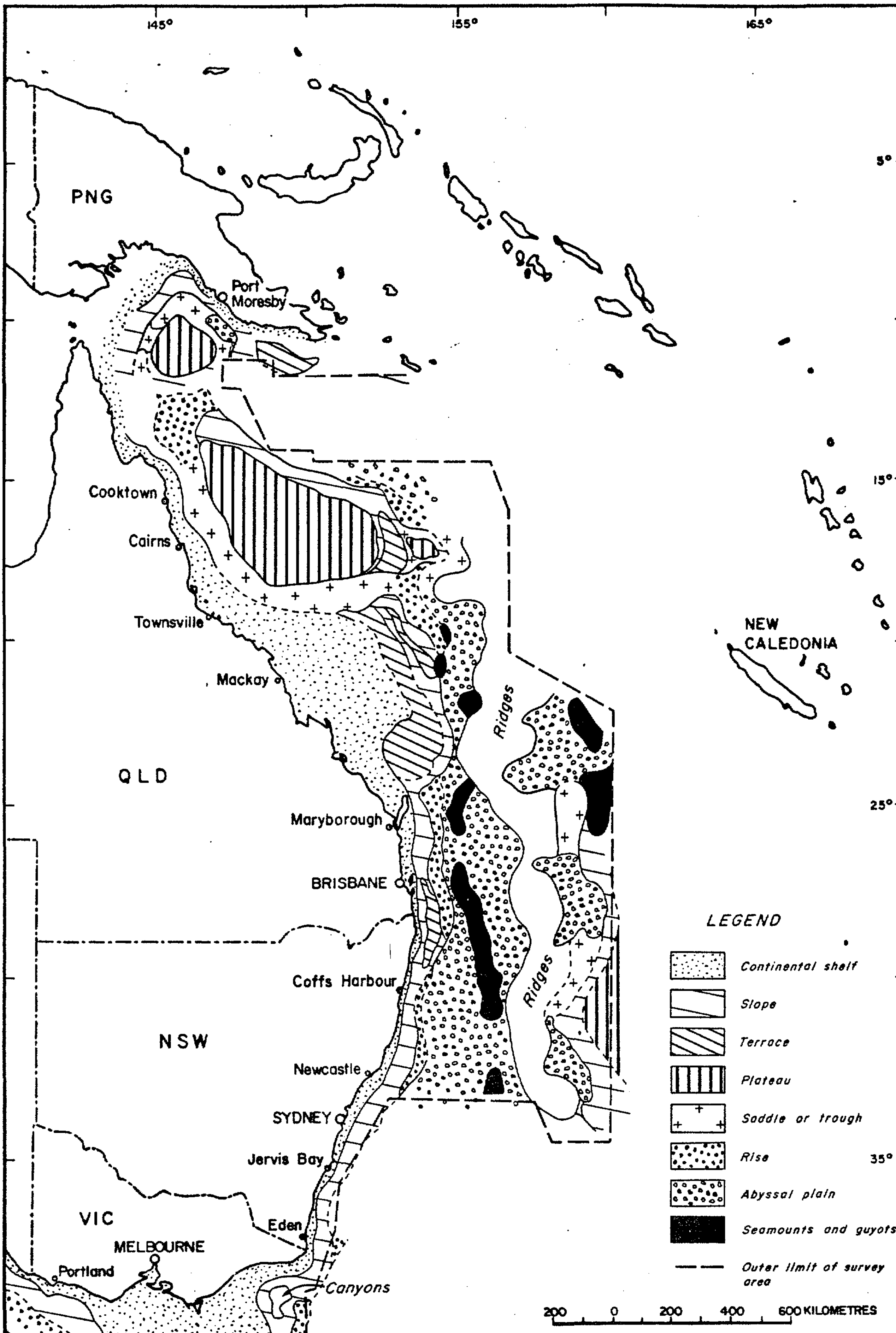

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Figure 7.
Physiographic provinces of Australia's Eastern Margin.

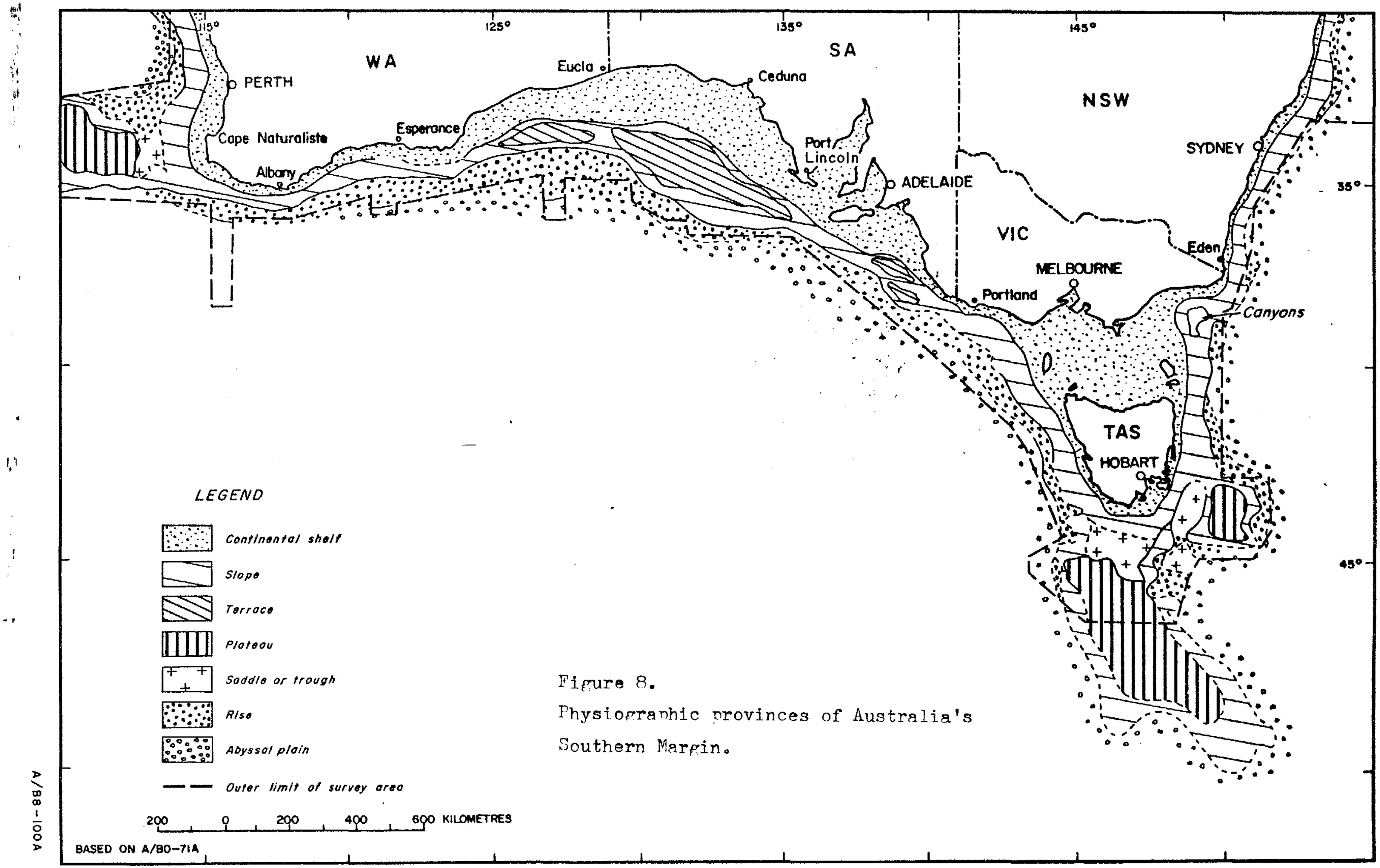

Figure 8.
Physiographic provinces of Australia's Southern Margin.

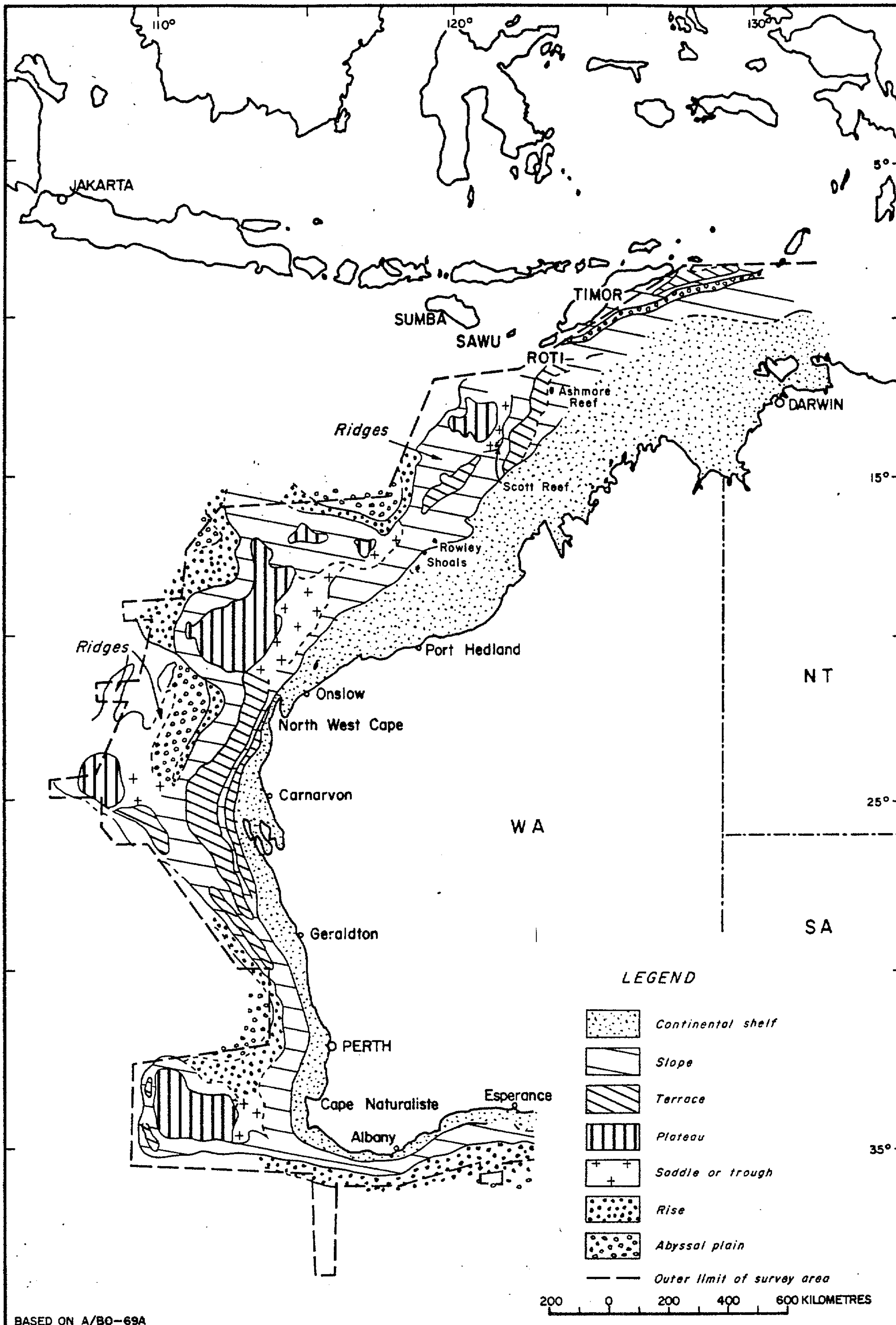

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Figure 9.
Physiographic provinces of Australia's
Western and Northwestern Margins.

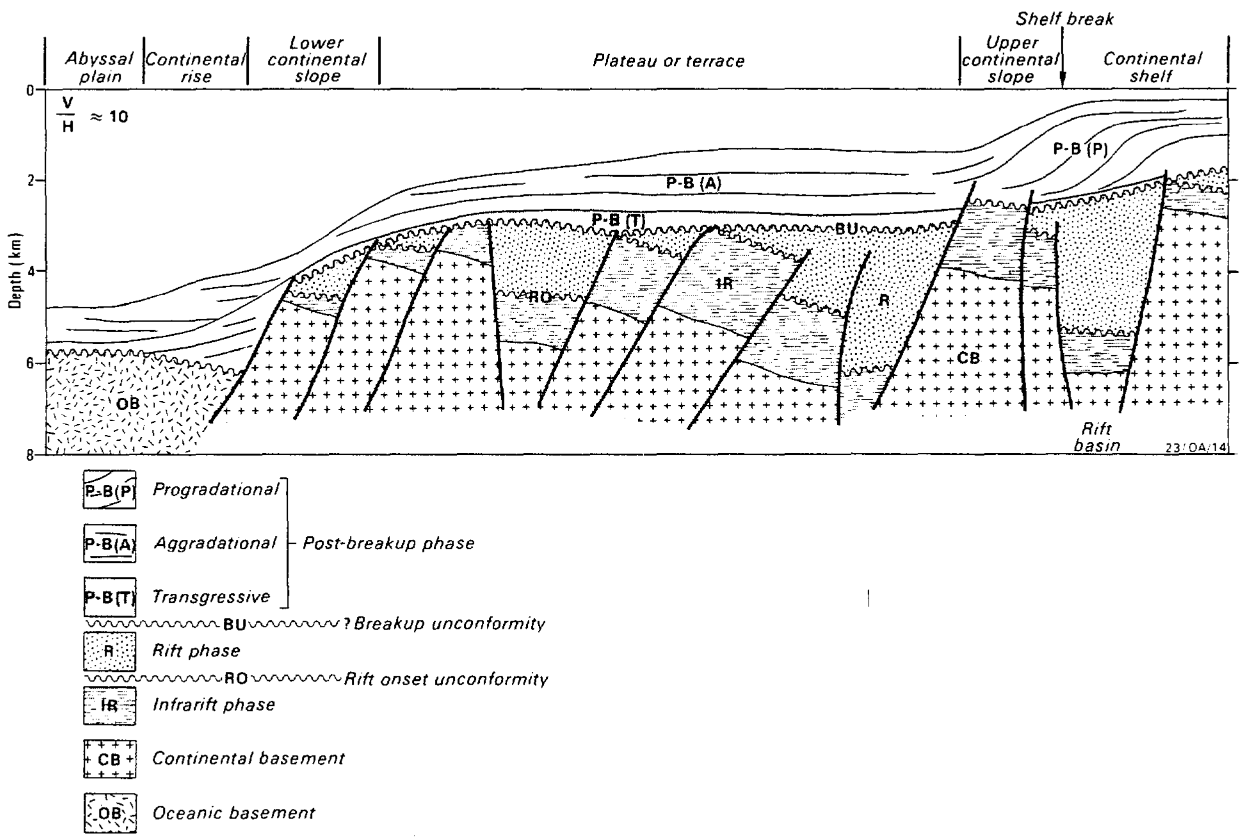

Figure 10. Schematic section illustrating the general form of an 'Australian-type' passive continental margin. Shows the main phases of stucturing and sedimentation - infrarift, rift and post-breakup, based on the nomenclature of Falvey & Mutter (1981).

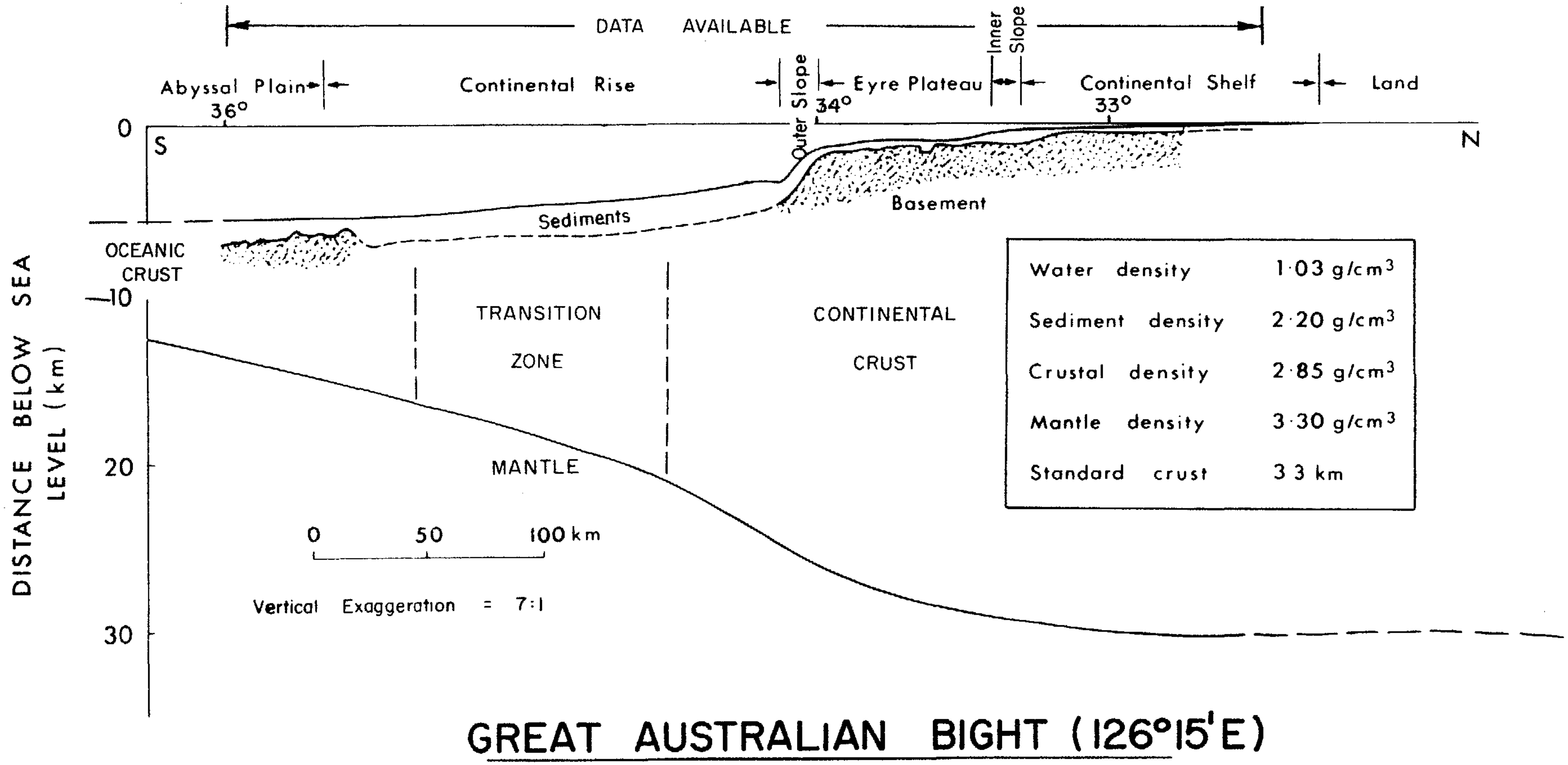

Figure 11.
Variation in crustal thickness along a north-south transect in the Eyre Terrace region, Great Australian Bight.

The computation is based on regional gravity data collected by BMR, and assumed density values. The profile suggests that the edge of the continent lies within a 'transition zone' (crust 15-20km thick) beneath the continental rise.

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This indicates that the crust thins from a known 33 km near the coast to approximately 12 km (including water), on the abyssal plain. A 'transition zone' (thickness range about 15-20 km) separates crust of typical continental thickness to its north from crust of typical oceanic thickness to its south. On this basis, the *'natural prolongation of the continent'* could be regarded as extending into the transition zone which underlies the continental rise.

In some areas the 'ocean/continent' boundary can be more precisely positioned from a large magnetic anomaly which is generated by the juxtaposition of the differently magnetised oceanic and continental crustal columns. Also, the linear seafloor spreading magnetic anomaly pattern, which is a characteristic of oceanic crust, can sometimes be traced to near the ocean/continent boundary, thus providing another indicator of the outer limit of the continent.

The precise location of the ocean/continent boundary can be directly identified in a few locations around the world, including Australia, using modern high-penetration marine seismic reflection sections. As the seismic reflection method improves and is more commonly used in deep crustal studies over continental margins, and as our knowledge of the deep structure of margins increases, direct determination of the limits of continental crust will become more commonplace.

DEFINITION OF A CONTINENTAL MARGIN USING 'LEGAL METHODS'

Historical background

Australia has been a party to the United Nations' Conferences on the Law of Sea since 1963, and present claims to the 'continental shelf' around Australia and its territories are largely based on the deliberations of these conferences. It is of interest to outline the historical background that led up to the various conventions and the ultimate agreement over jurisdiction, which was adopted in 1982 at the eleventh session of the Third United Nations' Conference on the Law of the Sea. This historical background is summarised in Tables 1 and 2.

The Dutch lawyer, Hugo Grotius, is usually given credit for making the first legal statement on the law of the sea (Ross, 1979; Table 1). In 1609, he published his *Mare Liberum*, or concept of the freedom of the seas, in which he declared that nations are essentially free to use the sea for whatever purpose they wish as long as this use does not interfere with another nations use of the sea. It was also realised that in order to give a coastal state some control over the adjacent waters, a zone of territorial sea needed to be established. This territorial sea was generally accepted as being 3 nautical miles in width; that is, the distance which cannons of the day could fire. The right of free passage and exploitation on the high seas beyond this territory belonged to everyone. This situation remained largely unchallenged until the 1940's when many of the newly formed nations began to recognise that the resources of the oceans, particularly fisheries and mineral resources, were not inexhaustible.

Table 1
Sea laws, a chronology (from UN Cronicle, 1982)

1609	A Dutchman, Hugo Grotius, one of the "fathers" of international law, publishes a chapter of his treatise ((De Jure Praedae)) (On the Law of Prize and Booty), in which the resources of the sea, considered inexhaustible, are said to be open for unrestricted use by all nations.
1958	First United Nations Conference on the Law of the Sea: 86 States meet in Geneva and adopt four international conventions covering the territorial sea, the high seas, the continental shelf and fishing and conservation of living resources.
1960	Second United Nations Conference on the Law of the of the Sea fails to produce any substantive agreement on the limits of the territorial zone and fishing rights.
1967	Ambassador Arvid Pardo of Malta tells the United Nations General Assembly's First Committee that technological and other changes in the world require the international community to address the matter of laws governing the seas beyond national jurisdiction. A 35-member ((ad hoc)) committee is set up by the Assembly to study the matter.
1968	The ad hoc committee grows to 41 members and is renamed - committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor Beyond the Limits of National Jurisdiction.

The Truman Proclamations and United Nations Conferences of 1958 and 1960.

In 1945, President Truman of the United States established a national policy on natural resources of the seabed and its subsoil (the Truman Proclamations). The United States believed that:

> 'exercise of jurisdiction over the natural resources of the subsoil and sea bed of the continental shelf by the contiguous nation is reasonable and just, since the effectiveness of measures to utilize or conserve these resources would be contingent upon cooperation and protection from the shore, since the continental shelf may be regarded as an extension of the land-mass of the coastal nation and thus naturally appurtenant to it, since these resources frequently form a seaward extension of a pool or deposit lying within the territory, and since self-protection compels the coastal nation to keep close watch over activities off its shores which are of the nature necessary for utilization of these resources' (U.S. Government, 1945).

Such a policy would provide the United States with control of non-living sources of petroleum and minerals on the continental shelf. In a further proclamation relating specifically to fisheries, the United States government maintained a right to establish and regulate fisheries conservation zones within the high secs contiguous with its territory. The character of the high seas in which such zones were established was to be unaltered in relation to free and unimpeded navigation. These proclamations did not change the concept of a 3-mile territorial sea; for example, foreign fishing beyond the 3-mile limit. However, a claim was being made on ownership of the seafloor and subsea. The Truman Proclamations led to a unilateral extension of jurisdiction and sovereignty over the sea, seabed and subsoil by some nations eager to protect their resources. For example, in 1952, Chile, Ecuador and Peru extended their sovereignty out to 2000 nautical miles from their coastlines. Such actions clearly pointed to the need to set up an international convention for control of the seas. This was pursued in 1958 and 1960 at the United Nations Conferences on the Law of the Sea, which led to basic conventions on:

- Territorial seas and contiguous zones
- Continental shelves
- High seas
- Fishing and conservation of living resources of the high seas.

The conventions established the concept of 'baselines' (Ross, 1979, p.44) for measuring the width of the territorial sea, but in fact set no figure on this width (many states claimed 3 miles).

The most obvious points of controversy to arise from these early conferences were:

- the undefined width of the territorial sea
- the 200-metre depth contour defining the outer limit of the continental shelf, which in many areas had little to do with the morphological or geological characteristics of the shelf,
- and the exploitability concept, which could enable technologically advanced nations to mine in superjacent waters, perhaps even the deep ocean basins.

Table 2. The Conference (from UN Chronicle, 1982)

1970	As a result of the Sea Bed Committee's work the General Assembly adopts a **Declaration of Principles Governing the Sea-Bed and Ocean Floor, and the Subsoil Thereof, beyond the Limits of National Jurisdiction.** These areas are declared the "common heritage of mankind" The Assembly also decides to convene the Third United Nations Conference on the Law of the Sea.
1971-1973	The Sea-Bed Committee, enlarged to 91 members, acts as the Preparation Committee for the Conference. Puts out a 6-volume report in 1973.
1973 December	First session (organizational) of the Conference elects its officers, begins work on rules of procedure. Hamilton Shirley Amerasinghe of Sri Lanka is President of the Conference.
1974 June-August	Second session, Caracas. Adopts rules of procedure; 115 countries speak in general debate. First attempt to deal with alternate August texts submitted by Preparatory Committee.
1975 March-May	Third session, Geneva. A "single negotiating text" produced by Committee Chairmen, sets out in treaty language the provisions to be included.
1976 March-May	Fourth session, New York. The results of negotiations set out in a "revised single negotiating text".
1976 August-Sept.	Fifth session. Further progress in some areas, impasse on how deep-sea mining should be organized and regulated.
1977 May-July	Sixth session, New York. An "informal composite negotiating text"continuing deliberations.
1978 March-April July-August	Seventh session, Geneva. Seven negotiating groups created to tackle "hard core" differences.
1979 March-April July-August	Eighth session, New York. First revision of the 1977 negotiating text emerges. Decision taken to complete work on Convention by April 1980. July-August
1980 March-April July-August	Ninth session, first New York, then Geneva. "Informal text" of Draft Convention produced. Plans to hold final session in 1981.
1981	Tenth session, New York. First official text of Draft

March-April	Convention issued. Jamaica and Federal Republic of Germany chosen as seats April for the International Sea-Bed Authority and the International Tribunal for the Law of the Sea respectively. United States cites difficulties in sea-bed provisions. "Final decision-making session" set for 1982.
1982 8 March-April	Eleventh session, New York. The rules of procedure, "all efforts at reaching general agreement" having been exhausted, the Conference votes on a number of amendments to the Draft Convention. At the end, at the request of the United States, there is a recorded vote. The Convention is adopted by 130 votes to 4 against, with 17 abstentions on 30 April.
1982 July- 13 Aug. (Perhaps to 20 Aug.)	23-member Drafting Committee (either New York or Geneva) to 12 meet to put together the final consolidated text.
1982 22-24 Sept.	Twelfth session, New York. To approve the Drafting Committee's work.
1982 Early December	Signing ceremony in Caracas, Venezuela.

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Conferences leading to the 1982 agreement

During the 1960's and early 1970's technological advances were made in fields such as deep offshore drilling and this made the need for a settlement on the 'exploitability issue' all the more pressing. The impetus for renewed activity came in 1967 with a speech at the U.N. General Assembly by Ambassador Dr. A. Pardo of Malta. He envisaged a treaty to make the deep ocean floor, beyond the limits of national jurisdiction - "*the common heritage of mankind*". This led to almost unanimous support and to the setting up of a committee to study the peaceful uses of the seabed and deep ocean floor. A resolution was eventually passed to reconvene the conferences on the Law of Sea, and this second burst of activity commenced in 1974 (Table 2).

The Law of the Sea Conferences of 1974 and 1975 produced a draft treaty which was not voted upon. It was generally agreed that territorial seas would be extended to 12 miles and that an economic resource zone out to 200 miles would be established. In the 1976 and 1977 conferences, further negotiating texts were drafted but controversy continued, particularly with regard to ocean mining and the powers to be conferred on a proposal seabed authority. The 1978 conference focussed on the problem of a 200-mile exclusive economic zone (EEZ). Some landlocked and disadvantaged nations felt that they should share in the resources of the EEZ's, while some of the more advantaged nations, with margins wider than 200 miles, sought means of extension. Formulas were devised for defining the continental margin (continental shelf, slope and rise) where it extends beyond 200 nautical miles.

A 'revised Informal Composite Negotiating Text' (A/Conf. 62/S.P. 10/Rev. 1) was produced in 1979 and defines a 'legal continental shelf' (the geological shelf, slope and rise) in terms of the so-called 'Irish Formula', but prohibits its extension more than 350 nautical miles from the coast or 100 nautical miles from the 2500 m isobath, whichever is the greater. The final stages in the preparation of a draft convention took place during a series of conferences between 1980 and 1982 (Table 2). At the eleventh session the Convention was adopted following a vote, and at the twelve session, in September 1982, approval was given to the drafting committee's work. The signing ceremony was held in Caracas, Venezuela, in December 1982.

Definitions - U.N. Convention on the Law of the Sea (Article 76)

An important aspect of the U.N. Convention on the Law of the Sea is the definition of a 'Legal Continental Shelf'(LCS) (Article 76 of the Convention; see Appendix), which is quite distinct from the morphological continental shelf. A coastal state has sovereign rights over its LCS for the purposes of exploring and exploiting the natural resources of its seabed and subsoil. The full text of Article 76 is included in the Appendix and its main points are:

. The LCS of a coastal State comprises the seabed and subsoil ..... throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles .....

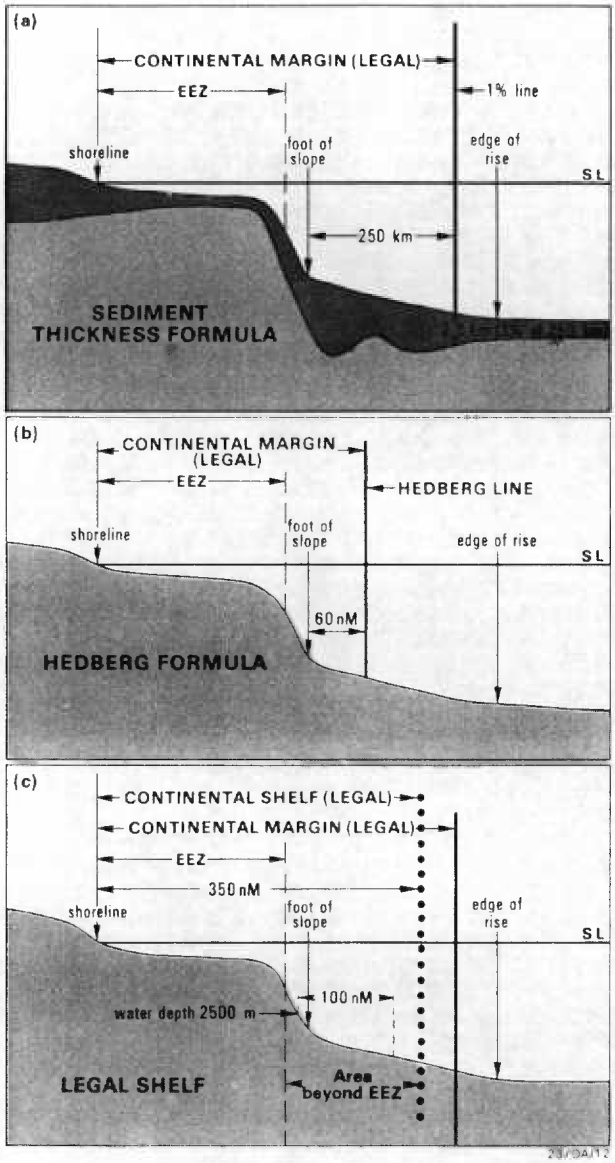

Figure 12. Definition of the Legal Continental Margin and Legal Continental Shelf (a) 1 per cent sediment thickness formula defining the outer edge of the continental margin (b) Hedberg Line defining the outer edge of the continental margin (c) cutoff lines limiting the continental shelf to 350 n.m. from baselines, or 100 n.m. from 2500m isobath.

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- Where the continental margin extends beyond the 200 nautical mile limit (EEZ) its outer edge is defined by the so-called Irish Formula, which is in two parts:

(1) A line delineated by the outermost fixed points at which the thickness of sedimentary rocks is at least 1% of the shortest distance from the foot of the continental slope (sediment thickness formula, Fig. 12a),

(2) A line not more than 60 nautical miles from the foot of the continental slope (Hedberg Line, Fig. 12b).

- The legally defined outer edge of the continental margin is cut back by a formula, which is also in two parts, to give the outer limits of the LCS beyond the EEZ.

(1) A line not exceeding 350 nautical miles from the territorial sea baselines (Fig. 12c),

(2) a line not exceeding 100 nautical miles from the 2500 metre isobath (Fig. 12c).

Problems in appling the legal definitions

The main problems arising with the application of Article 76 of the Convention relate to the definition or the outer edge of the continental margin using the two-part, so-called Irish formula. Both parts of this formula require the identification of a foot-of-continental-slope, which is 'defined' within Article 76 as ' the point of maximum change in the gradient at its base'. As stated by Hedberg (1976), the continental slope is probably the single most impressive and extensive feature of the earth's surface, with a linear extent of 300,000 km on the ocean floor and a height of as much as several kilometres. However, the base of this slope is still difficult to define precisely enough in many places for it to serve as a political boundary in its own right. The recognition of a FCS will always be a matter of interpretation, particularly on complex margins containing terraces and plateaus associated with several significant changes in gradient. The most precise determination of the FCS can be obtained from echo sounder and seismic profiles. Contoured bathymetric charts derived from either 'spot' water depth data, or from automated swath mapping systems such as SEABEAM, can often be used to locate an approximate FCS position. Swath sidescan imaging techniques such as GLORIA and SEAMARC can also be used, but the location of a FCS on these data can often be difficult and highly interpretive.

Application of the sediment thickness part of the Irish formula is fraught with practical problems which have long been recognised by geoscientists, and which have been discussed in some detail by Hedberg (1979). The main difficulties are as follows:

- the worldwide sparsity of direct sediment thickness measurements determined by drilling. Because of the enormous costs involved in drilling in even moderate water depths , this situation is unlikely to change. Also the Deep Sea Drilling Program showed

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that on the flanks of deep ocean basins in particular, it is very difficult, and perhaps impossible in some areas, to be sure that true igneous basement has been reached. Basement could easily be confused with younger extrusive and intrusive igneous bodies, or a thick, layered basalt/volcaniclastic sequence.

- highly irregular sediment distribution occurs on some continental margins making a linear representation of a specific thickness relation with respect to the FCS very difficult.

- there can be great uncertainities in distinguishing 'true' crystalline basement on seismic sections. For example, thick seaward-dipping reflector wedges on the outer Voring Plateau off Norway (Hinz, 1981; Mutter & others, 1982) form part of a 'basement' complex, which is now known by drilling to be composed of interbedded lava flows and volcaniclastic sediments (Fig. 14a) (DSDP Leg 104 Shipboard Scientific Party, 1986). Also, on the Goban Spur-Irish Sea margin of the eastern north Atlantic oceanic basalts have been drilled overlying rifted continental basement rocks (Fig. 14b) (Graciansky & others, 1985). On other margins these continental blocks could be composed, in part, of sedimentary rocks, which could easily be interpreted as part of oceanic basement.

- improved seismic resolution and penetration has meant that in many areas "yesterday's basement is today's sedimentary section". For example, Figure 15 shows part of a high quality BMR stacked seismic section across the southern margin of Australia. On this data basement would be interpreted to occur at B3 level; however, on older seismic data of lesser quality it has been variously interpreted at both B1 and B2 levels. Obviously, this would make a significant difference to the location of the 1% sediment thickness line, and thus the outer limit of the continental margin. Significantly, it could affect the area of prospective sediment that Australia could claim under the Convention.

- inaccuracies in determining sediment thickness from seismic data can amount to as much as 10-20% owing to uncertainties in calculating, or estimating, the propogation velocity of the seismic signal through the sedmentary section.

- it compounds two uncertainties - sediment thickness and the location of the FCS.

Taking the above problems into account, the part of the Irish formula that uses a point 60 n.m. beyond the FCS (the so-called Hedberg line) to define the outer edge of a continental margin is probably the easiest and most practical way of applying Article 76. The collection of high quality seismic reflection data over continental margins is an excellent way to ensure the optimum application of Article 76, as it provides the possibility of acquiring the necessary bathymetric and sediment thickness information, at the same time as the information needed for an assessment of the resource potential of the margin.

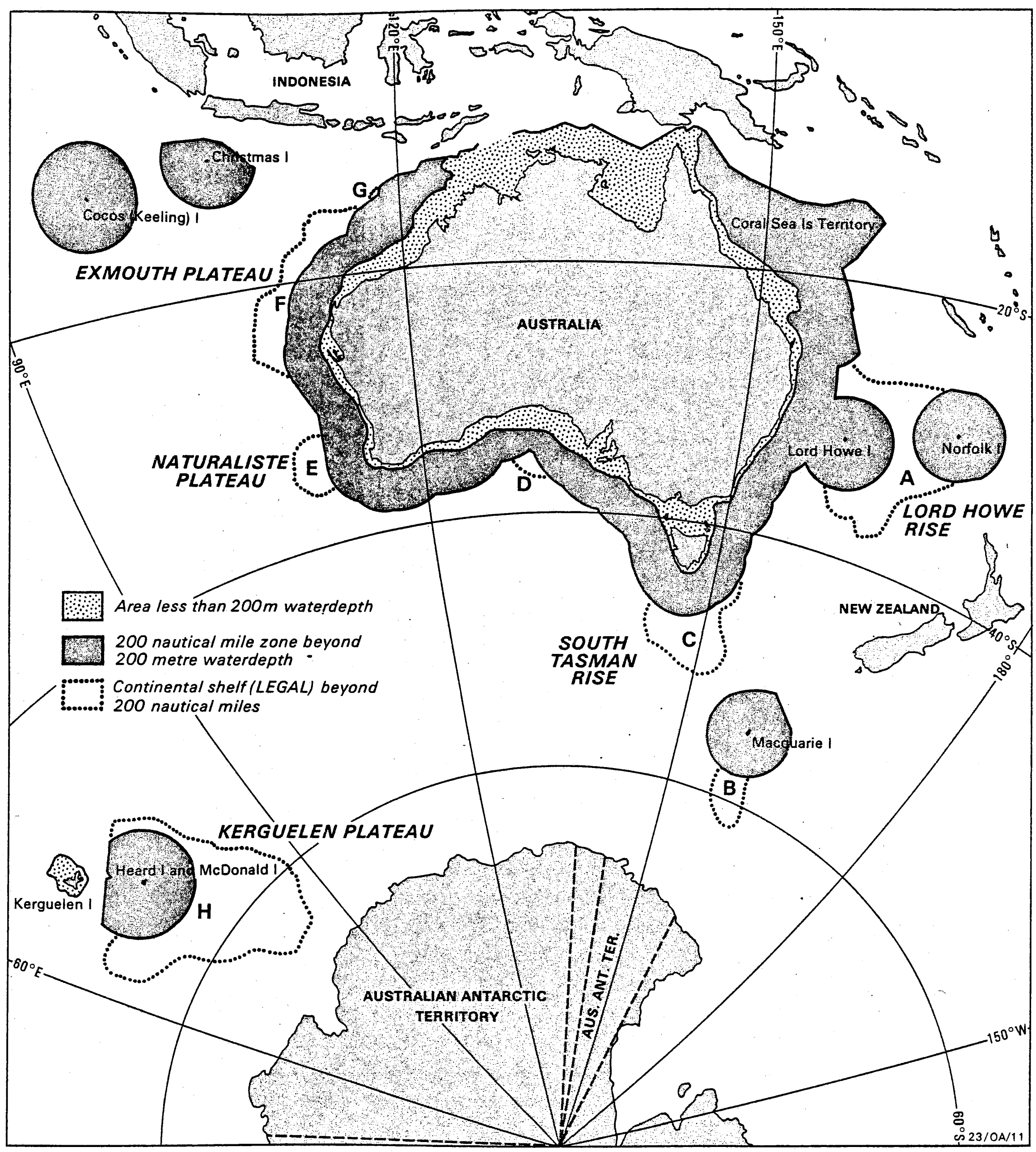
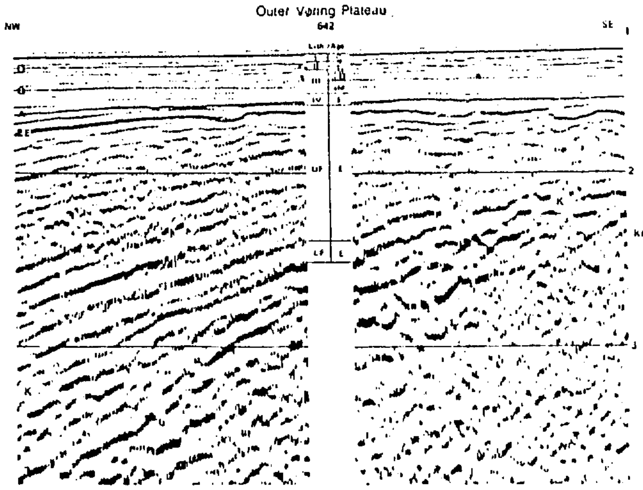


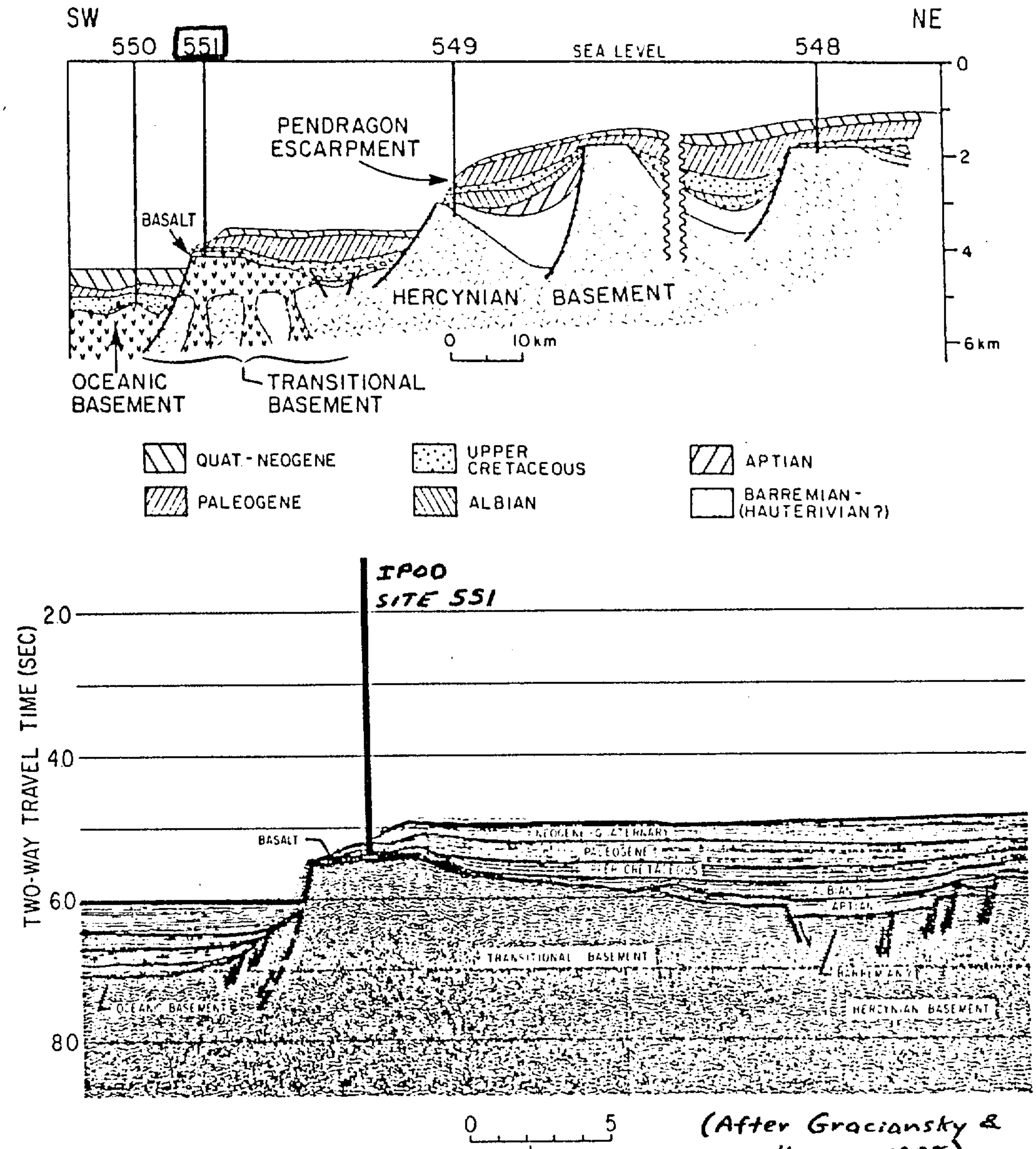
Figure 15. Approximate limits of 200 nautical mile EEZ and Legal Continental Shelf around Australia and its territories. The geomorphic shelf (<200m water depth) is stippled; the area of an EEZ beyond the geomorphic shelf is dark grey; the limit of a Legal Continental shelf beyond an EEZ is indicated by the dotted line. Also shows the labelling used in the text for the various legal continental shelf regions (A to H) beyond an EEZ.

(a)



(After DSDP Leg 104 Shipboard Scientific Party, 1986)

(b)



(After Graciansky & others, 1985)

Figure 14. (a) Depth-migrated seismic section across the outer Voring Plateau showing the seaward-dipping reflector sequence and DSDP site 642. This sequence consists of volcanic lava flows and forms the upper part of the basement complex in this area.
(b) Schematic section and seismic section across Goban Spur showing oceanic basalt overlying continental basement at DSDP site 551.

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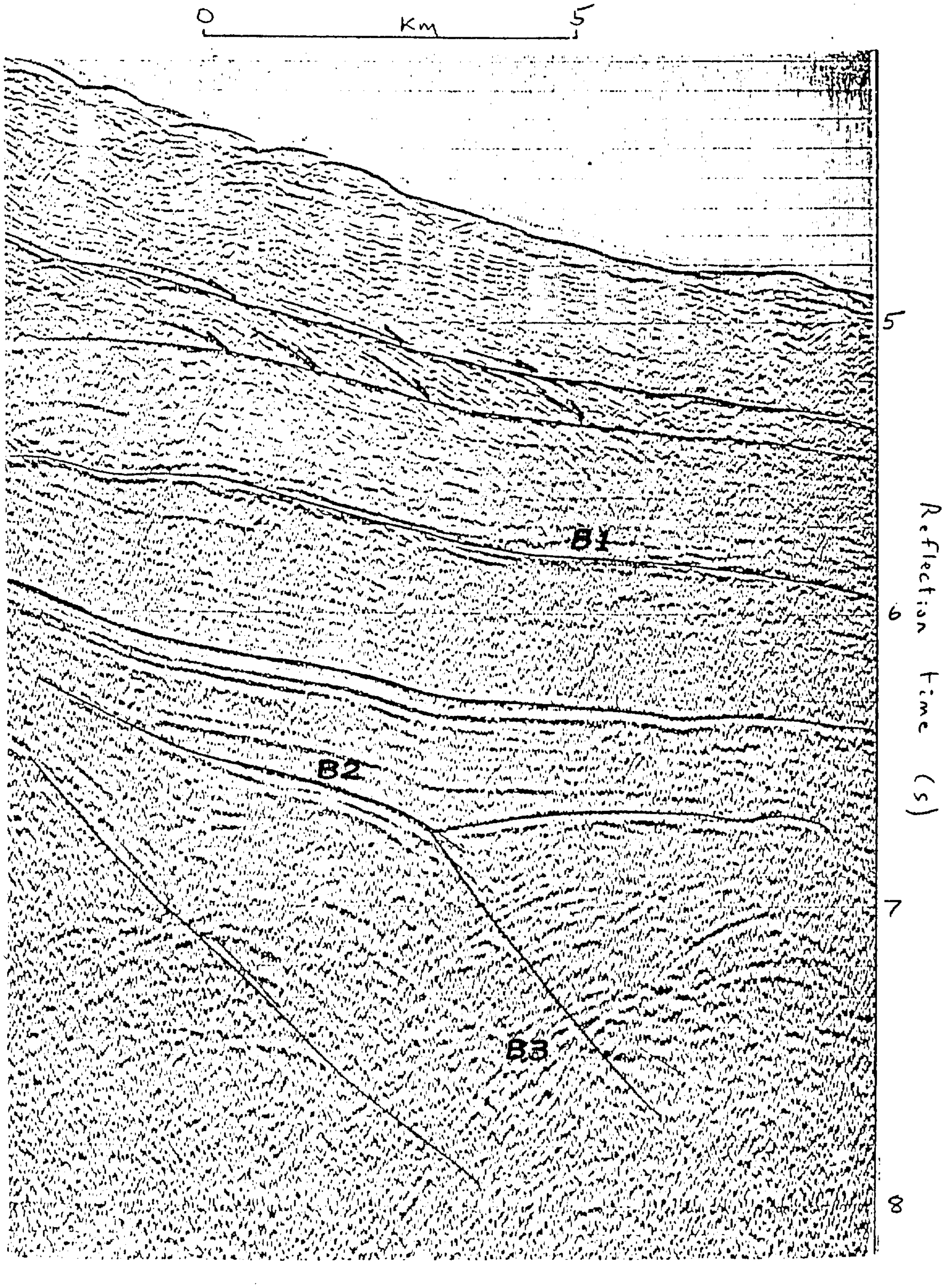

Figure 15. Stacked BMR 1986 seismic reflection profile across the southern Australian margin south of the Eyre Terrace. Shows interpretations of basement level using this data (B3), and on older poorer quality seismic data (B1 and B2).

The Australian situation

The Australian continental margin covers an area of about 5.5 x 10^6 km^2, which is about 65% of the area of the continent itself. Almost half consists of continental slope, including marginal plateaus, terraces and rises, most of which resulted from passive margin tectonism related to the rifting and dispersal of Gondwanaland.

An Australian Exclusive Economic Zone

In 1982 many nations of the world reached an agreement on jurisdiction of the worlds' oceans by adopting the U.N. Convention on the Law of the Sea (United Nations, 1983). Australia has since signed, but not ratified the Convention.

In accord with the Convention, Australia could proclaim an 'Exclusive Economic Zone' (EEZ), over which it has the rights to explore and exploit living and non-living resources of the seabed, subsoil and superjacent waters. The EEZ extends for a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured (Figs. 12 & 13). The EEZ delimitation is essentially formed by a suite of arcs of 200 nautical mile(n.m.) radius around Australia and its island territories. The total area enclosed is about 8.6 million square kilometres (Table 3). In regions where the EEZ's (and 'legal continental shelves') of adjacent states overlap the seabed boundary is subject to negotiation (see footnote to Table 3).

Australia has not declared a full EEZ, but in 1979 it did establish a 200 n.m. Australian Fishing Zone.

Australia's Legal Continental Shelf

Due to the sporadic distribution and poor quality of seismic data beyond the foot of the slope it is only possible to construct a sediment thickness line around approximately 15% of the Australian margin. The application of the Irish Formula around Australia is thus at present dependent mainly on the Hedberg Line. The appropriate formulae used to define the Legal Continental Shelf around Australia and its territories is indicated in Figures 16, 17 & 18 by letters, as follows:

E = EEZ (200 n. miles)
H = Hedberg line
X = 350 n.m. cutoff
Y = 2500 m.isobath + 100 n.m. cutoff
N = negotiated boundary
M = median line.

Maps showing the distribution of the fundamental parameters required for detailed application of these formulae around Australia and its territories are included as Plates 1 to 17. The plates are reductions of the 1:2,500,000 scale simple conic maps on which the basic data was originally plotted.

Eight regions of the Legal Continental Shelf of Australia and its

APPROXIMATE AREA STATISTICS (10^6 KM^2)

AUSTRALIAN LANDMASS		7.8
CONTINENTAL SHELF (GEOMORPHOLOGICAL)		2.0
EEZ	AUSTRALIA + LORD HOWE OVERLAP	6.7
	AUSTRALIA + ISLAND TERRITORIES ✸	8.6
	AUSTRALIA + ISLAND TERRITORIES + AAT ●	11.1
LEGAL CONTINENTAL SHELF BEYOND EEZ	SOUTH TO AAT	3.3
	SOUTH TO EEZ AROUND AAT	3.7
TOTAL LEGAL CONTINENTAL SHELF	AUSTRALIA + TERRITORIES, SOUTH TO AAT	11.9
	AUSTRALIA + TERRITORIES, SOUTH TO EEZ AROUND AAT	12.3
	AUSTRALIA + TERRITORIES + EEZ AROUND AAT	14.8

✸ NORFOLK, MACQUARIE, CHRISTMAS, COCOS AND HEARD ISLANDS

● AUSTRALIAN ANTARCTIC TERRITORY

Table 3.

Note: A negotiated seabed boundary separates Australia (and/or terrirories) from Indonesia (except for East Timor), Papua New Guinea, and the French territories of the New Caledonia region and Kerguelen Island. Negotiations are currently underway with New Zealand and Indonesia.

territories lie beyond an EEZ (Figs. 13, 16, 17 & 18):

A - Lord Howe Rise
B - Macquarie Ridge
C - South Tasman Rise
D - Great Australian Bight
E - Naturaliste Plateau
F - Exmouth/Wallaby Plateaus
G - Argo Abyssal Plain
H - Kerguelen Plateau

IMPLICATIONS FOR AUSTRALIAN OFFSHORE RESOURCES

It is recognised that continental margins, which make up 15% of this ocean area, provide the most favourable major prospects for petroleum, in that they are often associated with great thicknesses of organic rich sediment. The style of sedimentation and tectonics associated with the margins has favoured the deposition of reservoir rocks, as well as the development of structural and stratigraphic traps. In the past, nearly all offshore hydrocarbon production has come from oceanward extensions of known structures and producing fields on shore. In fact today about a quarter of the world's daily oil production comes from this continental shelf area. Gradual depletion of these areas and accompanying escalation in oil prices will eventually entice explorers to search for large fields in the more remote and deep water regions. Such a situation may be particularly relevant to Australia with its vast area of continental shelf and marginal plateaus (Fig. 1), particularly if decline of the Gippsland Basin oil and gas fields is not rapidly offset by new discoveries in the onshore and nearshore basins. It is thus important for Australia, and indeed all coastal states, that jurisdiction over the offshore area be wisely and promptly resolved, and this was necessarily one of the main concerns in the Law of the Sea negotiations.

A qualitative assessment of potential within a LCS

There is little doubt that the Australian slope, and several of the plateau features, have been sites for deposition of substantial thicknesses of sediments. The rift-stage sediment is up to 10 km thick in places, and being largely of fluvial-deltaic origin it has the potential to generate hydrocarbons, particularly gas. The post-breakup sequence is predominantly clastic carbonate; however, it commonly includes a basal marine transgressive unit which could generate oil in areas where it is deeply buried. We consider that the most obvious deep water depocentres are the troughs lying between the upper continental slope and the Exmouth, Scott, and Queensland Plateaus. These are hence areas of high potential. The presence of probable marine sequences within the rift phase sediment underlying the Great Australian Bight and Carnarvon Terrace also indicate fair to good source rock potential for these areas. The potential of other sections of the margin - particularly the South Tasmania Rise, Kenn Plateau, Marion Plateau, Osprey Embayment, and other parts of the east coast, are largely unknown owing to a lack of good quality survey data, although this has been redressed somewhat in recent years by BMR's Continental Margins Program.

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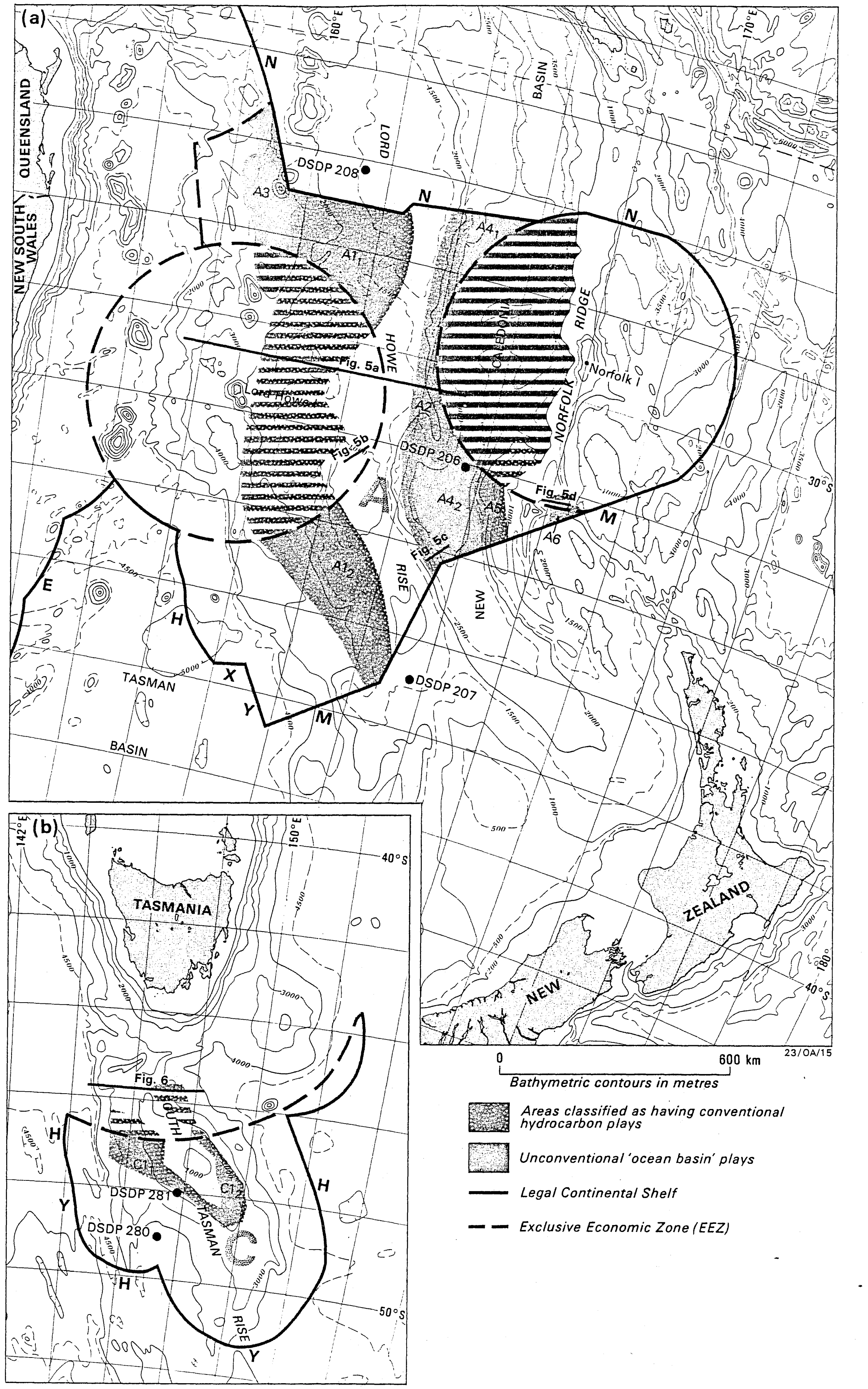


Figure 16.
An EEZ and Legal Continental Shelf in the Lord Howe Rise Region (A) and the South Tasman Rise Region (C) (After Symonds & Willcox in press). E,H,X,Y,N & M indicate the appropriate formulae/means used to define the Legal Continental Shelf, as discussed in the text. DSDP 206, 207, 208 and 281 are Deep Sea Drilling Project (DSDP) sites. Areas labelled $A1_1$, $A1_2$ etc. are referred to in Symonds & Willcox (in press), and correspond to areas in Tables 4 and 5 - e.g. areas $A1_1 + A1_2$ make up the western Lord Howe Rise and area A5 is the West Norfolk Ridge. The heavy lines labelled Fig. 5a etc. show the locations of seismic data presented in Symonds & Willcox (in press).

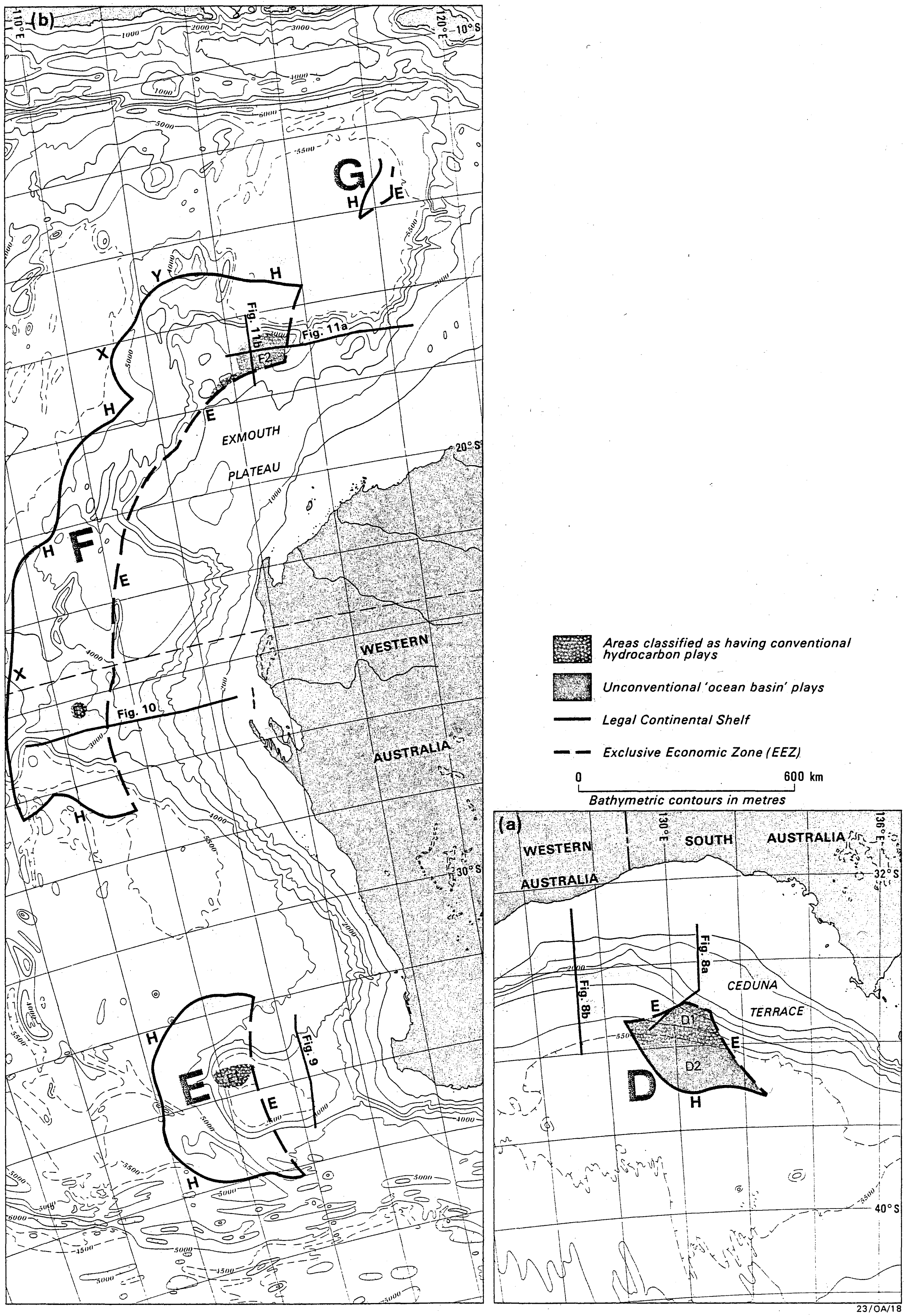


Figure 17. An EEZ and Legal Continental Shelf in the Great Australian Bight Region (D), the Naturaliste Plateau Region (E), Wallaby/Exmouth Plateau Region (F) and Argo Abyssal Plain Region (G) (After Symonds & Willcox in press). Other labelling as for Fig. 16.

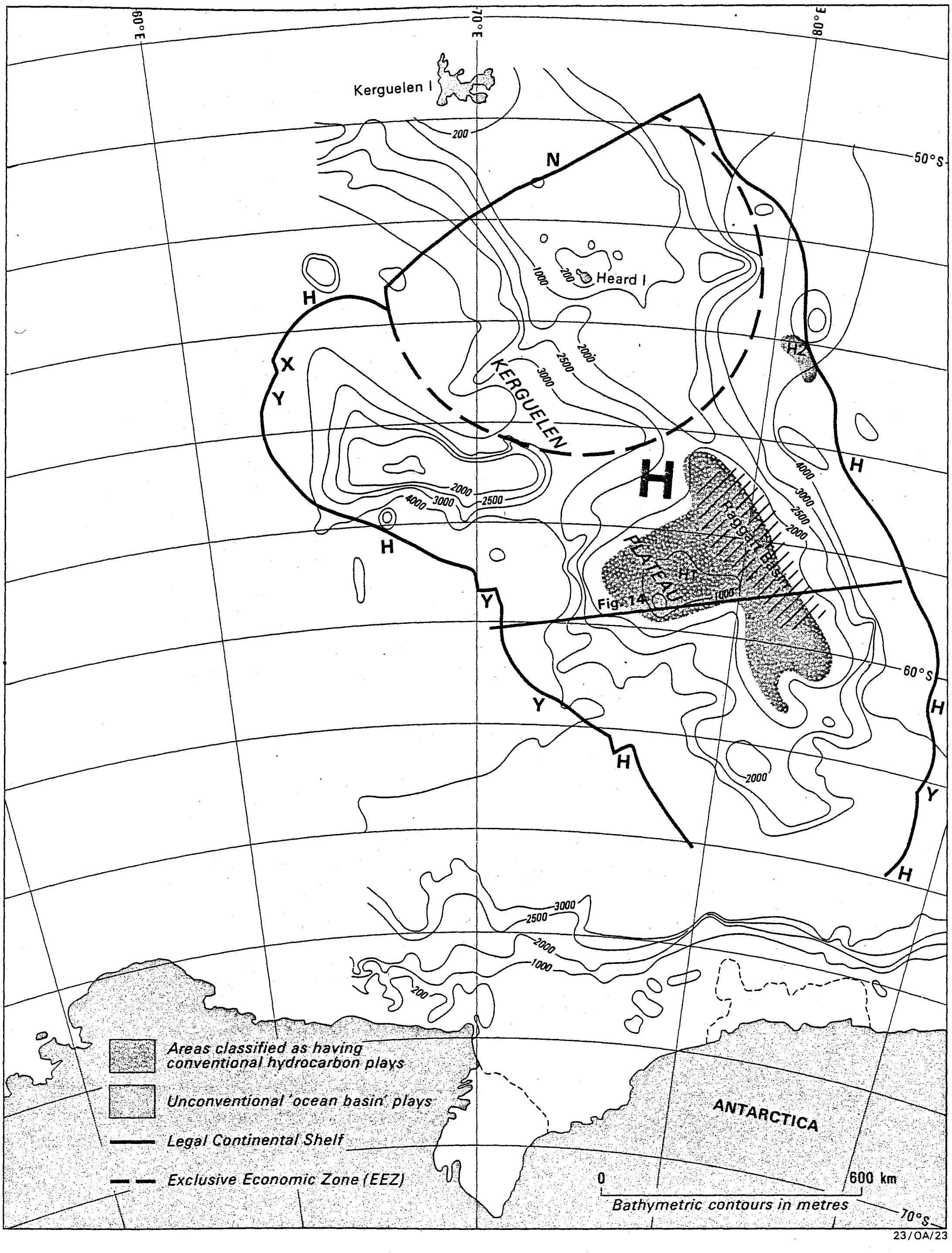


Figure 18. An EEZ and Legal Continental Shelf in the Kerguelen Plateau Region (H) (After Symonds & Willcox in press). Other labelling as for Fig. 16. Also shows location of the recently discovered Raggatt Basin (Ramsay, Colwell & others, 1985).

Most areas of the margin with relatively high potential fall within an EEZ; however, there are five major exceptions which warrant further discussion (Fig. 13):-

Area C: South Tasmania Rise Most of this large feature lies beyond the EEZ in water 1000 to 4000 m deep. Deep sea drilling results indicate that the rise is of continental origin. A tentative interpretation of seismic data across the rise suggests that it consists of a central, probably Palaeozoic, core flanked by extensional basins with up to 6000 m of sediment. The pre-breakup sequence, which is faulted, probably consists of Cretaceous fluvial-deltaic sediments with associated volcanics. The prospectivity of the South Tasmania Rise has generally been regarded as poor, but further surveys are required to determine the nature and extent of sediments within the extensional basins before a more accurate assessment of its prospectivity can be made. With water depths of around 2500 to 3000 m the basins cannot be regarded as anything but very long-term prospects.

The Article 76 formulae will cause Australia to lose about 20% of the South Tasmania Rise, however, this is in water depths greater than 2500 m.

Area D: Slope and Rise of Ceduna Terrace A small portion of the slope and rise of the Ceduna Terrace lies beyond an EEZ. **This area, which may have some long-term prospectivity, will lie within an Australian LCS defined by the Article 76 formulae.**

Area E: Naturaliste Plateau About 50% of the Naturaliste Plateau lies beyond an EEZ in water 2200 to 5000 m deep. Like the Wallaby Plateau its origin is uncertain, but the weight of evidence at the moment tends to favour it being a continental feature. In places pre-breakup strata up to 2000 m thick lie between major basement blocks of probable crystalline composition. The prospectivity of the Naturaliste Plateau is generally regarded as poor, although until we know more about the nature of the pre-breakup sediments this is difficult to substantiate.

Application of Article 76 to this area enables Australia to claim all of the Naturaliste Plateau.

Area F: Wallaby Plateau Nearly the whole of the Wallaby Plateau lies beyond the EEZ in water 2200 to 4500 m deep. The dredging of basalts and volcaniclastic sediments from its margins adds weight to the theory that the feature is an oceanic upgrowth, which could be considered to be unprospective for petroleum. Even if the Wallaby Plateau is a continental feature its prospectivity could only be rated as poor owing to an apparent lack of significant thicknesses of source and reservoir rocks.

Application of Article 76 to this area enables Australia to claim all but the western margin of the Wallaby Plateau.

Area F: Northwest Exmouth Plateau About 20% of the area of prospective sediment on the Exmouth Plateau lies beyond an EEZ in water 1800 to 3000 m deep. This includes the small Wombat Plateau which has an area of 3000 km^2, and from which samples of a Traissic to Middle Jurassic coal measure sequence have been dredged (von Stackelberg et al., 1980). The northwest Exmouth Plateau is underlain by numerous fault-blocks of probable Triassic age. Although the Jurassic and younger strata are thinner than elsewhere on the Plateau this does not significantly affect the prospectivity of the Triassic blocks themselves. In fact, palaeogeographic considerations suggest that Triassic depositional environments may have been more marine in the north and northwest, thus favouring deposition of liptinitic oil bearing kerogens. Probable higher heatflow associated with intrusions and rift-valley formation along the northwest margin may also be a favourable factor.

Application of Article 76 to this area enables Australia to claim jurisdiction over the entire Exmouth Plateau.

In addition to the above, there are parts of the continental margins of Australia's territories which also lie beyond an EEZ:

Area A: Lord Howe Rise and Dampier Ridge About 50% of Australia's claimable territory on Lord Howe Rise and Dampier Ridge lies beyond an EEZ, in water depths ranging from about 1000 to 4500 m. Much of this corresponds to areas of probable Palaeozoic and igneous basement which are considered of low prospectivity. However, areas of thicker sediment and rift-basins on the western flank of the Rise may have reasonable long-term potential. **Application of Article 76 leads to no significant losses of prospective territory.**

Area A: Norfolk Ridge The Norfolk Ridge appears to be a volcanic feature. The small area of the West Norfolk Ridge to which Australia lays claim includes a sedimentary basin up to 2000 m thick (probably of low prospectivity) which is **adequately encompassed by Article 76.**

Area B: Macquarie Ridge This is an oceanic feature, thought to be composed entirely of basaltic rocks, which is thus **considered completely unprospective for petroleum.**

Area H: Kerguelen Plateau The Kerguelen Plateau is a major topographic high in the southern Indian Ocean adjacent to, but apparently separated from, Antarctica. The Plateau rises about 3700 m above the deep ocean floor and extends along a NW-SE trend for 2000 km. Australia's claim to the southern part of the plateau stems from the presence of Heard and McDonald Islands which are Australian territory. About 70% of the area to which Australia lays claim lies beyond an EEZ.

A reconnaissance geophysical survey of the Plateau region, conducted by Lamont-Doherty Geological Observatory, led Houtz & others (1977) to conclude that the Kerguelen Plateau (or at least a portion of it) is an uplifted part of a Mesozoic ocean basin.

Examination of the Houtz et al. (1977) paper, and recent work by BMR's *Rig Seismic* and ODP drilling, leads us to the opinion that the data on the at least the southern part of the Plateau (seismic reflection, shallow refraction, gravity, magnetic, and sampling) do not necessarily warrant the conclusion that it is a piece of uplifted ocean basin. Another origin that has been put forward for the Plateau is that it formed as volcanic buildup related to a hot spot. In particular, we believe that its structural style, relatively thick sediment cover and the lack of a mechanism for uplift of Mesozoic ocean floor, lend at least as much support to an initial continental origin, although it has undoubtedly experienced episodes of intense volcanic activity. Houtz & others (1977) consider that truncation of magnetic lineations in the southern ocean by the northeast margin of the Kerguelen Plateau is easier to explain if the Plateau were oceanic. However, a similar situation exists along the southern margin of the Australian continent. We feel that there is some evidence to suggest that the magnetic lineation pattern adjacent to both of these regions may have been misidentified and the apparent conflict may arise from a more complex rifting and seafloor history for the Southern Ocean region.

We currently rate the Plateau as having fair prospectivity, and note that Article 76 should enable Australia to claim the entire southern part of the Kerguelen Plateau.

We conclude that application of Article 76 of the Convention would allow Australia to claim nearly all prospective territory around its margin. Australia's only major loss may be the southern portion of the South Tasmania Rise, which appears to be underlain by prospective rift phase sediments. The loss of the western extremity of the Wallaby Plateau is of little consequence owing to its low prospectivity rating.

A quantitative assessment of potential beyond an EEZ

The 200 n.m. line, which defines Australia's Fisheries Zone and lies beyond areas covered by most oil exploration surveys, is frequently conceived to be the limit of national interest. However, significant areas of the Legal Continental Shelf lie beyond the EEZ and may have mineral potential which could be expoited into the next century. Although the areas are remote, the water depths, though considerable, are not in all places greater than for the marginal plateaus and slopes within the EEZ.

As mentioned previously eight regions of a Legal Continental Shelf of Australia and its territories would lie beyond a EEZ. Although seismic data over most of these regions is sparse and of varied quality, it is apparent that areas of relatively thick sediment, with at least some hydrocarbon potential, occur within all except Macquarie Ridge and the Argo Abyssal Plain. These two features are composed of oceanic crust and have only a thin sediment cover in which hydrocarbons are unlikely to have been generated; thus, these two regions do not warrant further consideration in this report. Owing to a lack of deep drilling in all eight regions, our understanding of lithologies and depositional environments has to be inferred from the seismic stratigraphy, and by analogy either with better known areas of similar geological style, or in places with contiguous areas within an EEZ. The prospective areas within each region are labelled A1, A2, A3 .... etc. on Figures 16, 17, & 18.

Our evaluaton of the six areas beyond the EEZ, with significant sediment accumulation (namely: areas A, C, D, E, F & H; Fig. 13), indicates that they may be grouped into two major categories. Firstly, there are the areas where sediments have been deposited in structurally controlled basins - mainly grabens and half-grabens. By analogy with better explored areas we envisage that their sediment fill is mostly overlain unconformably by a thin sequence of shallow to deep marine sediments. These are referred to on Figures 16, 17, & 18 as areas having **conventional hydrocarbon plays**. Secondly, there are areas of turbidite and pelagic sediments deposited in, or on the flanks of, deep ocean basins. Such basins are generally floored by oceanic crust and are referred to as areas of **unconventional ocean basin plays**.

In the following discussion, which is taken from a more detailed study by Symonds & Willcox (in press), we seek to use the somewhat sporadically distributed data to assess basin development in these remote areas. As a first approximation, and as a means of obtaining a relative rating between these areas, we have gauged potential hydrocarbon recovery by using the 'yardstick' for evaluation of poorly explored basins given by Klemme (1975; based on a statistical analysis of world-wide recovery figures), our sediment volume calculations (Table 4), and our geological consideration of the most appropriate Klemme basin type (Table 5). The results, expressed in kilolitres x 10^9 per km^3 of sediment, and billions of barrels per km^3, are presented in Table 5 as a rough estimate of **'most likely' recovery**. It should be noted that the recovery figures for the New Caledonia Basin and southern Kerguelen Plateau incorporate Middle East (Klemme basin type closed, extra continental) rates, which are most probably unrealistically large.

The speculative rating given in Table 5 is a somewhat intuitive estimate of hydrocarbon prospectivity based on the sum total of our knowledge of the areas. On the basis of existing information there are no areas beyond the EEZ that can be rated as better than 'fair'. The prospectivity of the deep-ocean basin areas is essentially 'unknown'.

The recovery figures (Table 5) provide an indication of the relative importance of the remote areas, in terms of their total potential to have produced hydrocarbons. This is not to say that such hydrocarbons have actually been generated, or that any mechanism exists for their concentration into viable traps. Most of these areas are in deep-water and it is unlikely that anything other than 'giant' fields (say 500 million barrels) would be worth exploiting. The question then arises as to whether such giant traps could be recognised, particularly over the enormous areas involved.

Two areas of intermediate water depth, which are within range of current exploration drilling technology, stand out as having relatively large recovery figures : these are, the western Lord Howe Rise (most likely estimate of 0.56 x 10^9 kilolitres or 3.5 billion barrels) and the southern Kerguelen Plateau (0.9x10^9 kilolitres or 5.98 billion barrels). These areas are considered to be continental in origin, to have stratigraphy and structure related to passive continental margin evolution, and to contain petroleum plays of a kind that have been tested elsewhere in the world.

The basins on western Lord Howe Rise and the southern Kerguelen Plateau are considered to be mainly of Klemme types - cratonic rift and intermediate extracontinental - which on a world-wide basis have a 50% chance of providing commercial production and also a 50% chance that giant fields could be present. However, the authors coonsider that the

Table 4.

EFFECTIVE SEDIMENT AREAS / VOLUMES FOR FEATURES BEYOND EEZ

ZONE	FEATURE		MOST LIKELY AREA ($10^3 KM^2$)	MOST LIKELY VOLUME ($10^3 KM^3$)
A	W. LORD HOWE R.		40	100 ✱
	E. LORD HOWE R.		40	100 ✱
	MIDDLETON B.		25	62
	NEW CALEDONIA B.		43	129 ✱
	W. NORFOLK R.		2	5
	TARANUI SEA V.		2	6
C	S. TASMAN R.		19	57
D	GREAT AUST. BIGHT	MID-SLOPE	21	73
		LO. SLOPE & BASIN	29	131 ✱
E	NATURALISTE PL.		5	10
F	WALLABY PL.		2	5
	NW EXMOUTH PL.		13	38
H	S. KERG-UELEN PL.	CREST	66	165 ✱
		E. SLOPE	4	10
	GIPPSLAND B.		13	70-75

" CONVENTIONAL" PLAYS

"UNCONVENTIONAL"(DEEPWATER) PLAYS

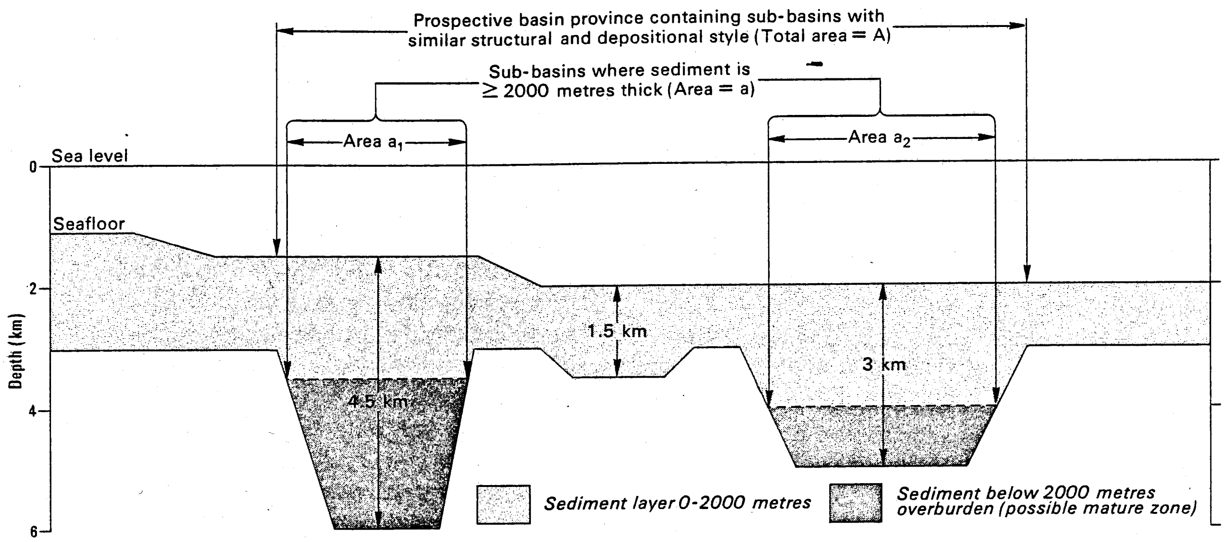
✱ EFFECTIVE SED. VOLUME >100,000 KM^3

<u>Note</u>: 'unconventional plays' are types of potential hydrocarbon entrapment that have not been widely explored to date.
The concept of 'effective sediment volume' is illustrated in Figure 19.

REGION	AREA NAME		BASIN TYPE	MOST LIKELY RECOVERY		SPECULATIVE RATING
				KILOLITRES ($X10^9$)	BARRELS ($X10^9$)	
A	W.LORD HOWE RISE		RIFT	0.56	3.50	FAIR
	E. LORD HOWE RISE		PULL-APART	0.16	1.00	FAIR-POOR
	MIDDLETON BASIN		OPEN,EXTRA CONTINENTAL	0.25	1.55	UNKNOWN
	NEW CALEDONIA BASIN		CLOSED,EXTRA CONTINENTAL	0.77	4.84	UNKNOWN
	WEST NORFOLK RIDGE		PULL- APART RIFT	0.02	0.11	FAIR-POOR
	TARANUI SEA VALLEY		INTERMONTANE	0.41	2.60	FAIR
C	SOUTH TASMAN RISE		RIFT	0.32	2.00	FAIR
D	GREAT AUST. BIGHT	MID SLOPE	PULL-APART	0.12	0.73	POOR
		BASIN FLOOR	OPEN, EXTRA CONTINENTAL OR PULL APART	0.16	1.02	UNKNOWN
E	NATURALISTE PLATEAU		? RIFT	0.06	0.35	POOR
F	WALLABY PLATEAU		RIFT/PULL -APART	0.02	0.11	POOR/NIL
	NW EXMOUTH PLATEAU		RIFT/PULL -APART	0.14	0.86	FAIR-POOR
H	SOUTHERN KEGUELEN PLATEAU		RIFT OR CLOSED, EXTRA CONTIN.	0.95	5.98	FAIR-POOR
		E.SLOPE	OPEN EXTRA CONTINENTAL PULL-APART	0.04	0.25	UNKNOWN

Note: The potential hydrocarbon recovery figures indicate the relative importance of the areas: the absolute values should not be quoted without detailed discussion of the method of calculation and their meaning (Symonds & Willcox, in press).

Table 5: 'Potential hydrocarbon recovery' and rating for areas beyond and EEZ.



Estimation of effective sediment volume, assuming sub-basins have similar dimensions:

- Total area of basin province = A
- Total area of all sub-basins ($\geq$ 2000 metres sediment) = a
  Area a = $a_1 + a_2$ = 54% A (in this example only)
- Average sediment thickness in sub-basins = 3.750 km
- Approximate sediment volume ($\geq$ 2000 metres) = 3.750a km^3

Note: This volume calculation has only been applied where sub-basins are approximately equidimensional (e.g. Western Lord Howe Rise). The estimate is then within about 20% of the true volume ($4.500a_1 + 3.000a_2$) if all individual sub-basins could have been mapped. In a real situation ratio a/A is estimated from available data.

23/OA/30

Figure 19. Method of calculating effective sediment volume of an area containing a number of structurally related basins, such as beneath the western Lord Howe Rise (After Symonds & Willcox in press). Method was used in some areas during the derivation of Tables 5 and 6.

western Lord Howe Rise basins, although promising in terms of total potential recovery, mey be individually less attractive as they are mainly small in both area and volume. The accumulation of any large and commercially viable fields could have been restricted by relatively small quantities of source rock. For most of the area we may be faced with an 'all or nothing' situation; that is, either modest-sized fields may potentially be present in most grabens, or these grabens could all be barren. The larger grabens and basins maybe somewhat more promising : both the diapiric structures in the basin northeast of Lord Howe Island (Roeser & others, 1985), and possible Mesozoic infrarift sequences in fault-blocks southeast of Lord Howe Island (Whitworth and Willox, 1985) warrant further surveys. Taken as a whole we regard the western Lord Howe Rise basins as having fair potential (Table 5).

The southern Kerguelen Plateau presents a similar problem to Lord Howe Rise, in that we are aware of a vast volume of sediment which has the potential to have reached maturity, but that we have no knowledge of the way in which any hydrocarbons may have migrated and become trapped. The area is enormous, and understanding of the geology in its infancy. Two specific problems relate to the southern Kerguelen Plateau : the presence of volcanogenic detritus in some of the plateau's Tertiary sequences, which could destroy the permeability of potential reservoirs; and the Tertiary faulting, which is common in some places, could have prevented the sealing of any traps. The greatest disincentive to exploration is, of course, the remoteness of the region. With our meagre knowledge, we rate the petroleum potential of the southern Kerguelen Plateau as fair - poor, with a large component of the unknown.

Two other areas which yield significant recovery figures are the South Tasman Rise (most likely estimate of 0.32×10^9 kilolitres or 2.0 billion barrels) and the eastern 'progradative' margin of Lord Howe Rise (0.16×10^9 kilolites or 1.0 billion barrels). Although small yields of thermogonically derived hydrocarbons have been recovered from the surface sediments of the South Tasman Rise (Whiticar & others, 1985), indicating active hydrocarbon generation in the past and/or present, the seismic data show abundant volcanics in the rift basins which could downgrade reservoir potential. Both the eastern Lord Howe Rise and the South Tasman Rise are considered to have fair - poor potential.

Of the very deep-water, deep ocean basin areas, the New Caledonia Basin appears to be the most significant. However, as this is interpreted as being of a Klemme basin type that includes the Middle East basins its recovery potential is probably unrealistically large. The other deep-water areas which yield viable recovery figures are the Middleton Basin and the lower slope and basin floor in the Great Australian Bight. The exploration potential of basins of this type, which lie in such deep water, is a totally unknown factor.

Any assessment of the kind presented in this paper has a tendency to emphasise the regions which generally have a large area and volume of sediment, and which thus give large recovery figures. However, in terms of exploration success, the relatively small, potentially high-yield areas, should not be dismissed. The most notable of these is the Taranui Sea Valley on the Norfolk Ridge, which appears to be a Klemme type Intermontane Basin. The relatively thick (4000 m) sediments, and apparent structural complexity of the Taranui Sea Valley section, together with the intermediate water depths (2000 m), enhance the prospectivity of this feature.

Although some readers may be sceptical of the volumetric/basin analogue approach used in this study, it is probably the only useful tool which will enable us to rank the potential hydrocarbon recovery of Australia's remote regions. It is clear that, in terms of the recovery figures, the western flank of Lord Howe Rise and the very remote southern Kerguelen Plateau are the most important regions beyond an EEZ. Despite our reservations regarding basin size, the western Lord Howe Rise is ranked highest. This is because an equivalent-sized prospective area also lies within the EEZ. The South Tasman Rise and eastern flank of Lord Howe Rise warrant farther examination, and small, potentially high-yield features such as the Taranui Sea Valley may prove to be valuable.

Since the early 1960s, the worldwide rate of discovery of petroleum has been in apparent decline, although this has been the period of greatest exploration activity. This decline is not a result of finding fewer fields, but fewer 'super-giants,' which account for 50% of all oil discovered to date. Furthermore, the contribution that 'giant' fields are making to total discoveries also appears to be less significant. Although the petroleum resources of Australia are comparatively small by world standards, the exploration trends and discovery rates have still tended to follow those for the rest of the world. It seems probable that if further giant fields are to be discovered, our attention should, in part, be drawn to the deeper-water regions. It is important to recognised that although exploration of the remote regions is unlikely to be viable in the present economic climate, they may well provide Australia with a strategic resource into the next century.

CONCLUSION

Continental margins may best be defined by systematic seismic surveying from continental shelf-break to abyssal plain. If the 'sediment thickness formula' as well as the 'Hedberg formula' is to be applied, it is essential to unequivocally identify crystalline basement. This will generally require the use of a high power seismic system of the type now operating on BMR's R/V Rig Seismic.

Around about 90% of Australia, the continental margin has been defined by a reliably constructed Hedberg Line. However, only 15% of the margin can be defined by the sediment thickness formula using data of the present quality.

The definition of Australia's legal continental shelf, using the formula specified in Article 76, allows Australia to claim nearly all the territory which is considered to have resource potential. The most significant omission is the southern part of the South Tasman Rise which contains some extensional sedimentary basins (in 2000+ m water depths) which may have long-term potential. Also lost, is a small deep-water (4000+ m) portion of the Great Australian Bight Basin which underlies the continental rise in the Eyre/Ceduna Terrace region. The western flank of the Wallaby Plateau, which also lies beyond a legal continental shelf, is considered to have little economic significance.

Our consideration of the resource potential of areas beyond an EEZ (using basin analogy and effective sediment volume) leads to the conclusion that the southern Kerguelen Plateau and the western flank of Lord Howe Rise have the highest potential hydrocarbon recovery. However, this is not to say that any hydrocarbons would necessarily be trapped in 'giant' fields - an essential element if such accumulations were to be economically viable.

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Appendix: United Nations Law of the Sea Convention Article 76

Article 76

Definition of the continental shelf

1. The continental shelf of a coastal State comprises the sea-bed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance.

2. The continental shelf of a coastal State shall not extend beyond the limits provided for in paragraphs 4 to 6.

3. The continental margin comprises the submerged prolongation of the landmass of the coastal State, and consists of the sea-bed and subsoil of the shelf, the slope and the rise. It does not include the deep ocean floor with its oceanic ridges or the subsoil thereof.

4. (a) For the pruposes of this Convention, the coastal State shall establish the outer edge of the continental margin wherever the margin extends beyond 200 nautical miles from the baselines from which

the breadth of the territorial sea is measured, by either:

(i) a line delineated in accordance with paragraph 7 by reference to the outermost fixed points at each of which the thickness of the sedimentary rocks is at least 1 per cent of the shortest distance from such point to the foot of the continental slope; or

(ii) a line delineated in accordance with paragraph 7 by reference to fixed points not more than 60 nautical miles from the foot of the continental slope.

(b) In the absence of evidence to the contrary, the foot of the continental slope shall be determined as the point of maximum change in the gradient at its base.

5. The fixed points comprising the line of the outer limits of the continental shelf on the sea-bed, drawn in accordance with paragraph 4 (a) (i) and (ii), either shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured or shall not exceed 100 nautical miles from the 2,500 metre isobath, which is a line connecting the depth of 2,500 metres.

6. Notwithstanding the provisions of paragraph 5, on submarine ridges, the outer limit of the continental shelf shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured. This paragraph does not apply to submarine elevations that are natural components of the continental margin, such as its plateaux, rises caps, banks and spurs.

7. The coastal State shall delineate the outer limits of its continental shelf, where that shelf extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by straight lines not exceeding 60 nautical miles in length, connecting fixed points, defined by co-ordinates of latitude and longitude.

8. Information on the limits of the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured shall be submitted by the coastal State to the Commission on the Limits of the Continental Shelf set up under Annex II on the basis of equitable geographical representation. The Commission shall make recommendtions to coastal States on matters related to the establishment of the outer limits of their continental shelf. The limits of the shelf established by a coastal State on the basis of these recommendations shall be final and binding.

9. The coastal State shall deposit with the Secretary-General of the United Nations charts and relevant information, including geodetic data, permanently describing he outer limits of its continental shelf. The Secretary-General shall give due publicity thereto.

10. The provisions of this article are without prejudice to the question of delimitation of the continental shelf between States with opposite or adjacent coasts.

PLATES

The following 17 plates comprise a legend and basic database maps of the continental margin of Australia and its territories which show the position ofthe 'foot of continental slope', 'edge of continental rise', and the edge of the continental margin as defined by the 'Hedberg Line' and the 'Irish formula' (strictly the sediment thickness formula).

Plates 2 - 15 show the seven areas of the Australian margin (except for the Arafura Sea/Gulf of Carpentaria) and are based largely on the 140 000 km of seismic data from the BMR Continental Margin Survey (1970-73). These maps are in pairs - the first showing the actual 'picks' on the seismic lines; the second showing the relationship to a simplified bathymetry.

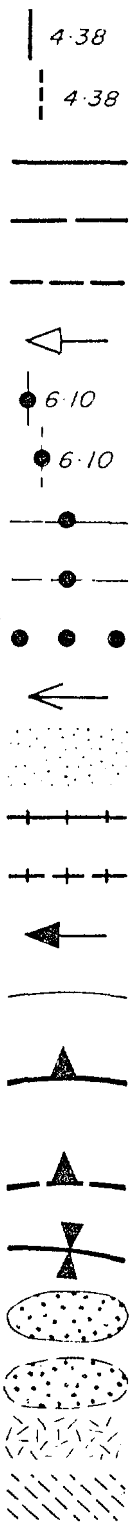
Plate 16, the Kerguelen Plateau region, is based on the contour map (in fathoms) of Hayes (1975) and some widely spaced seismic control data. It shows the approximate position of the foot of slope, edge of rise, and the Hedberg Line. Also shown are the 200 m mile line around Kerguelen Island and the Heard/McDonald Islands, and two of the cut-offs, namely lines 100 m miles and 60 m miles beyond the 1400 fathom isobath (approx. 2500 m) - used in LOS negotiations. Note that only the '100 n mile beyond 2500 m isobath' cutoff was eventually used in Article 76.

Plate 17 is a similar map for the Kerguelen Plateau - Antarctica region.

Plate	1	Continental margin data legend	
	2	Coral Sea area	- tracks
	3		- bathymetry
	4	Tasman Sea area	- tracks
	5		- bathymetry
	6	Tasmania area	- tracks
	7		- bathymetry
	8	Gt. Aust. Bight area	- tracks
	9		- bathymetry
	10	South Western margins	- tracks
	11		- bathymetry
	12	North Western margins	- tracks
	13		- bathymetry
	14	Timor Trough area	- tracks
	15		- bathymetry
	16	Kerguelen Plateau region	
	17	Kerguelen Plateau - Antarctica region	

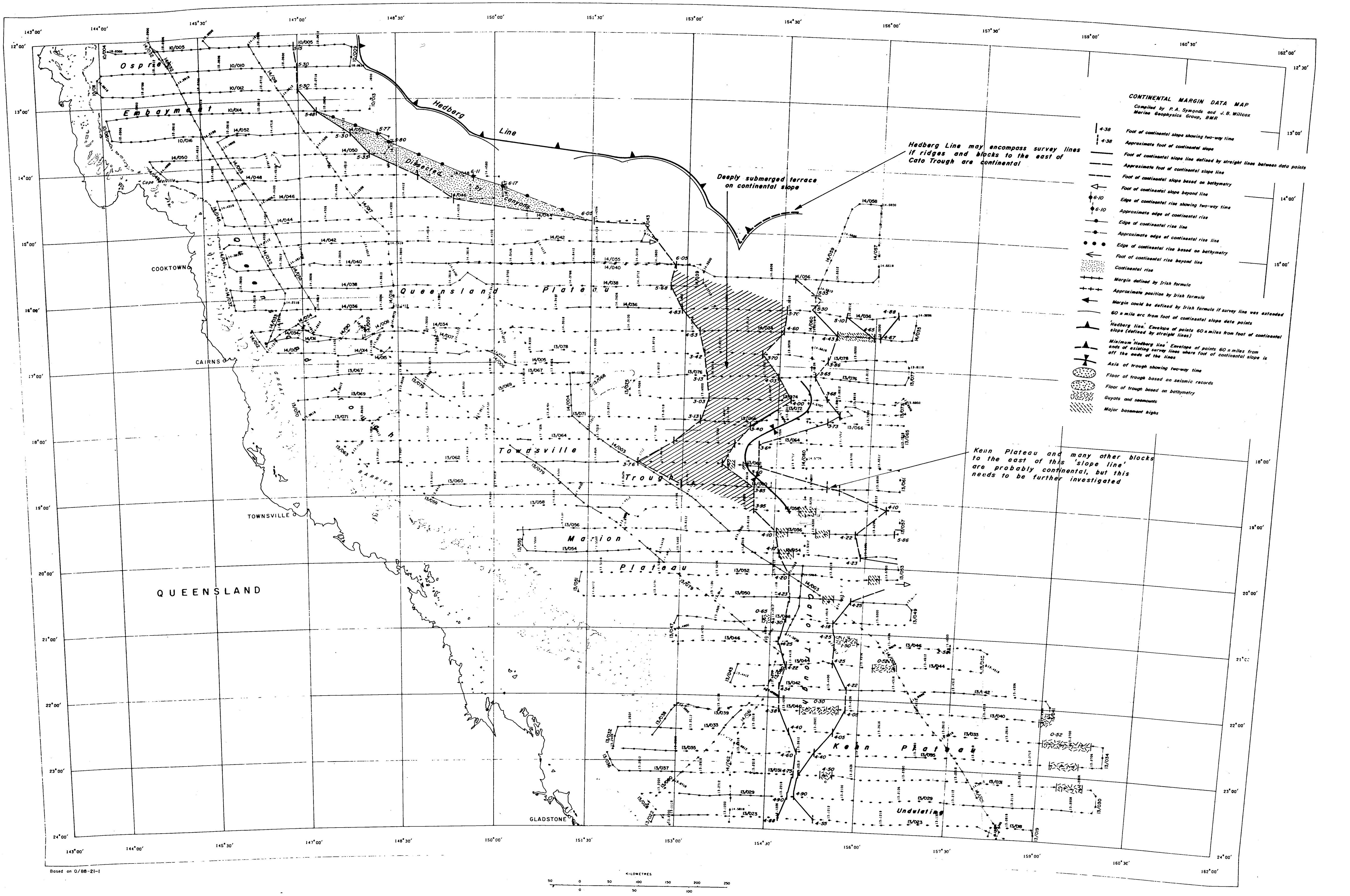
CONTINENTAL MARGIN DATA MAP

Compiled by P. A. Symonds and J. B. Willcox
Marine Geophysics Group, BMR



- Foot of continental slope showing two-way time
- Approximate foot of continental slope
- Foot of continental slope line defined by straight lines between data points
- Approximate foot of continental slope line
- Foot of continental slope based on bathymetry
- Foot of continental slope beyond line
- Edge of continental rise showing two-way time
- Approximate edge of continental rise
- Edge of continental rise line
- Approximate edge of continental rise line
- Edge of continental rise based on bathymetry
- Foot of continental rise beyond line
- Continental rise
- Margin defined by Irish formula
- Approximate position by Irish formula
- Margin could be defined by Irish formula if survey line was extended
- 60 n mile arc from foot of continental slope data points
- 'Hedberg line' Envelope of points 60 n miles from foot of continental slope (defined by straight lines)
- Minimum 'Hedberg line'. Envelope of points 60 n miles from ends of existing survey lines where foot of continental slope is off the ends of the lines
- Axis of trough showing two-way time
- Floor of trough based on seismic records
- Floor of trough based on bathymetry
- Guyots and seamounts
- Major basement highs

Plate 1.



AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

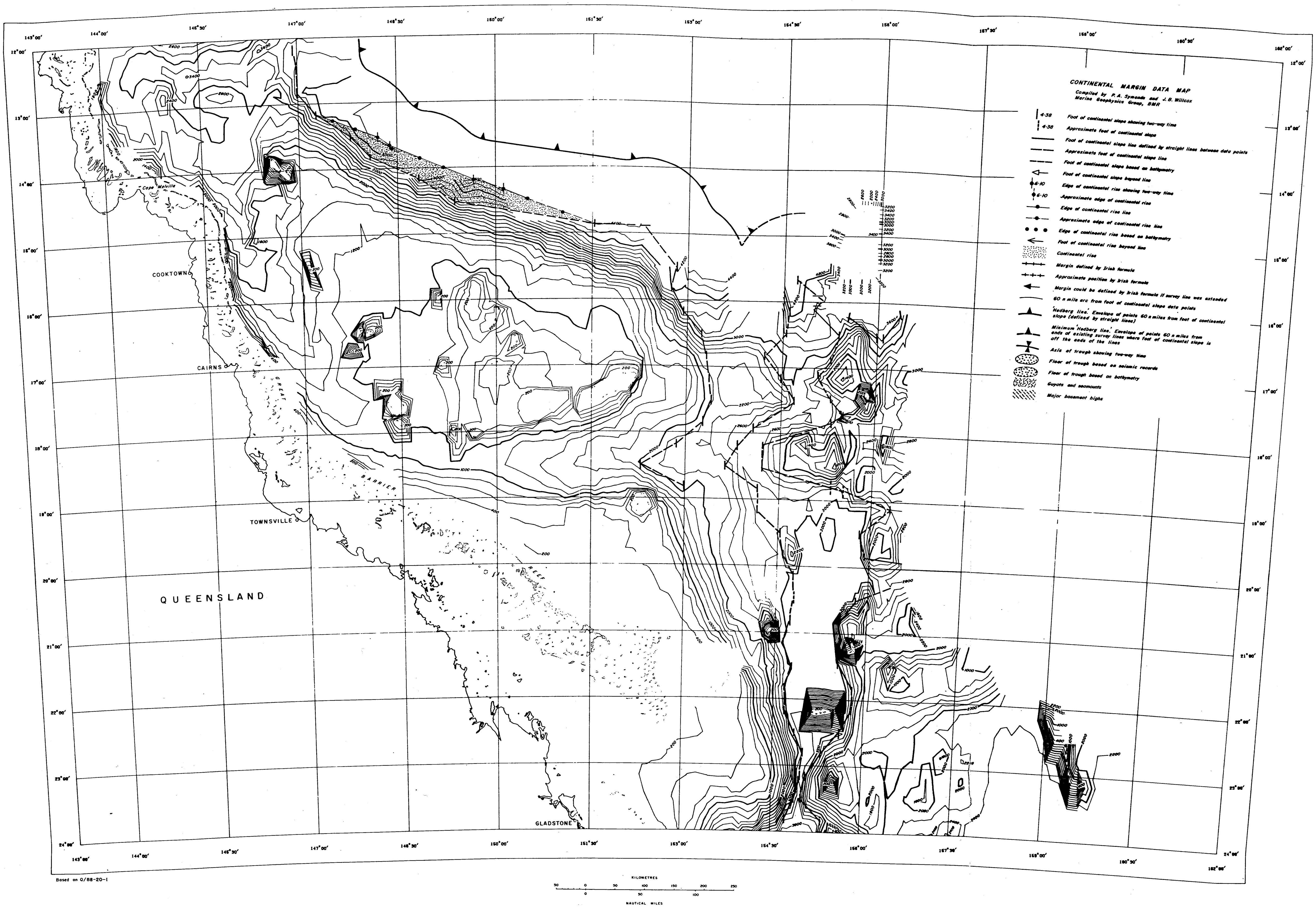
B.M.R. 1970-73 MARINE SURVEYS

TRACK CHART

CORAL SEA

Plate 2.

Q/88-100



Based on Q/88-20-1

AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

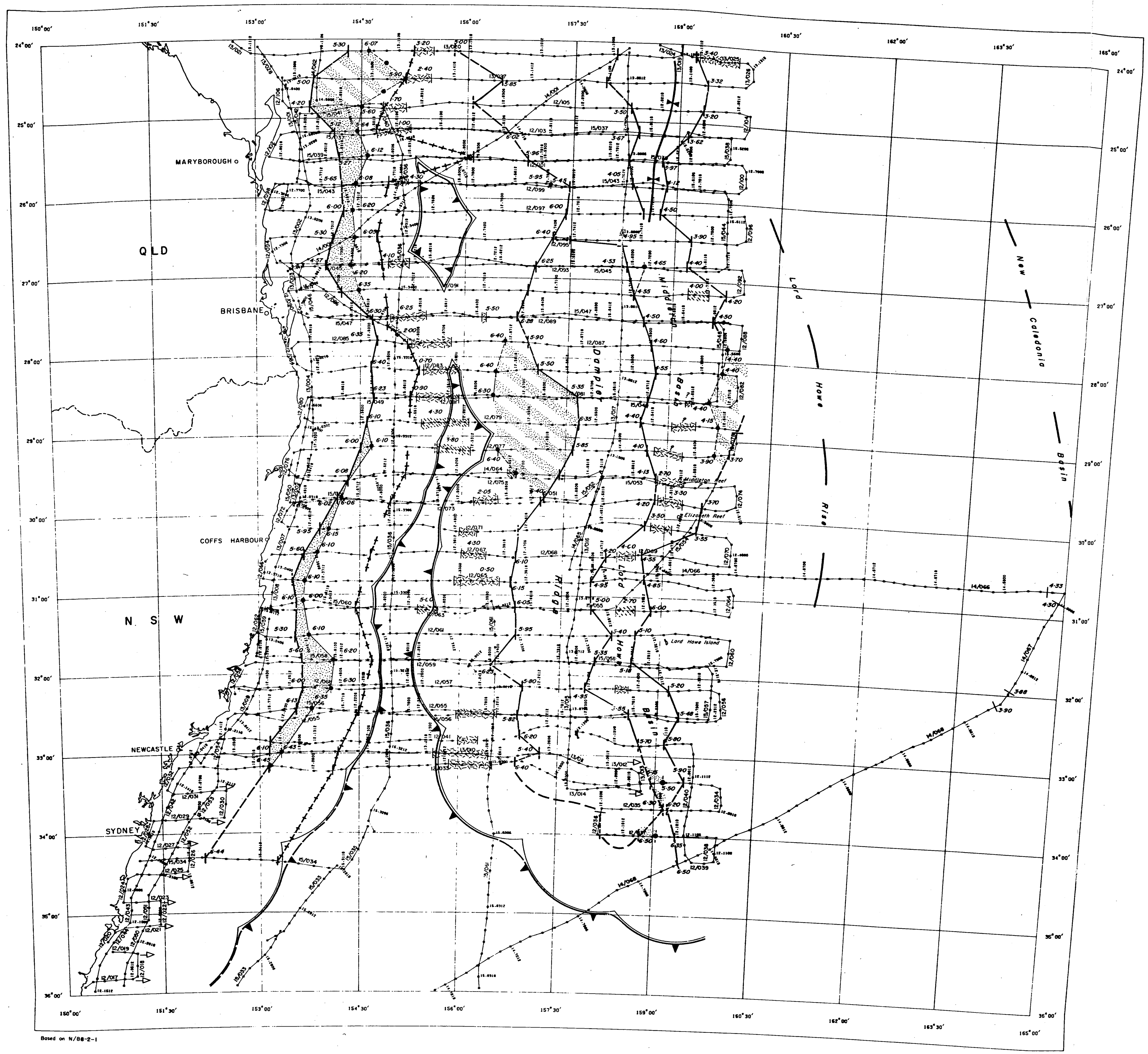
WATER DEPTH (METRES)

Contour interval 200 metres
Water velocity assumed constant at 1500 m/s

CORAL SEA

Plate 3.

Q/88-101



Based on N/88-2-1

AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0 AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

TRACK CHART

TASMAN SEA

Plate 4.

N/88-10

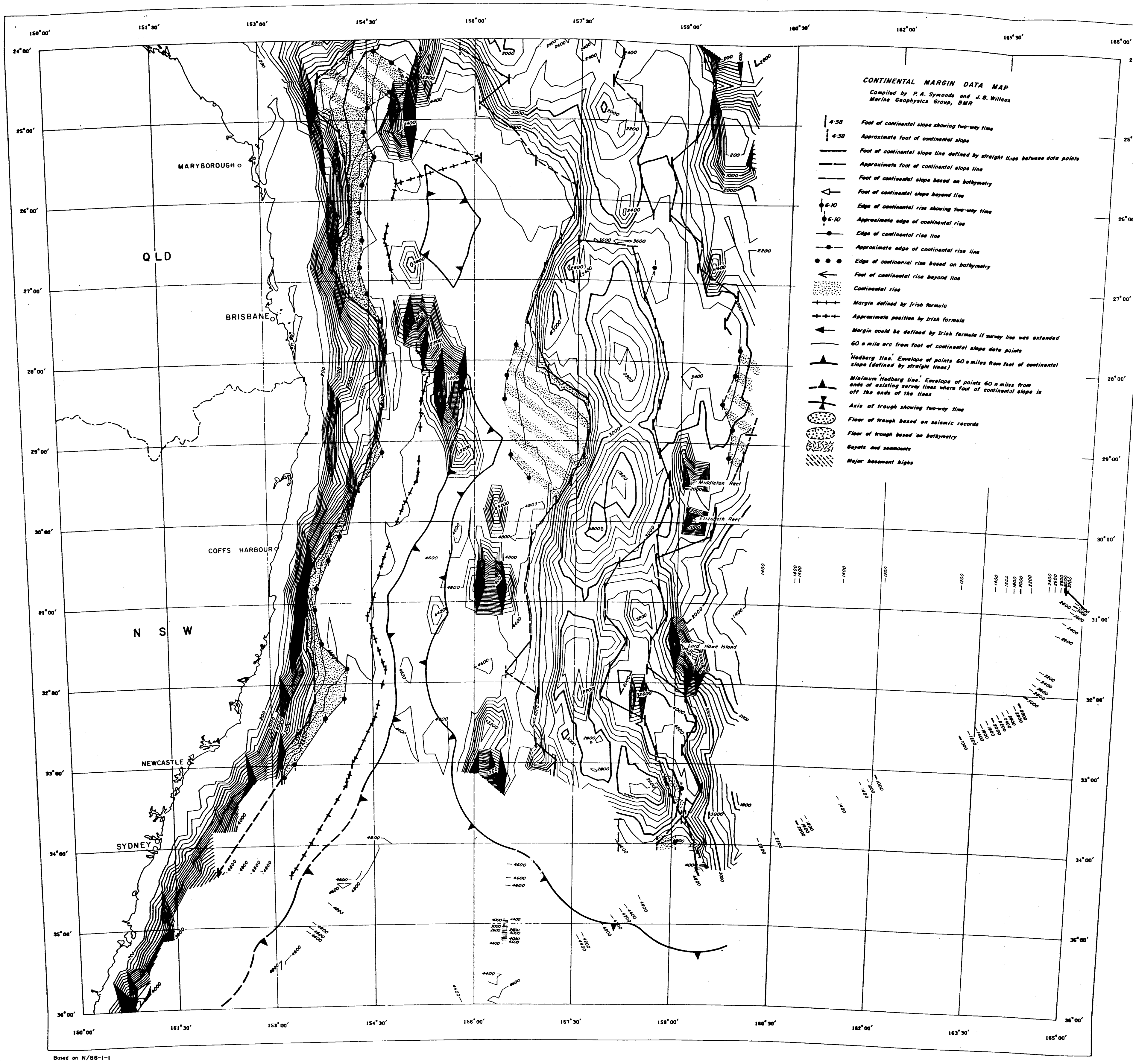
KILOMETRES

50 0 50 100 150 200 250

0 50 100

NAUTICAL MILES

Contour interval



AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

WATER DEPTH (METRES)

KILOMETRES 50 0 50 100 150 200 250

NAUTICAL MILES 0 50 100

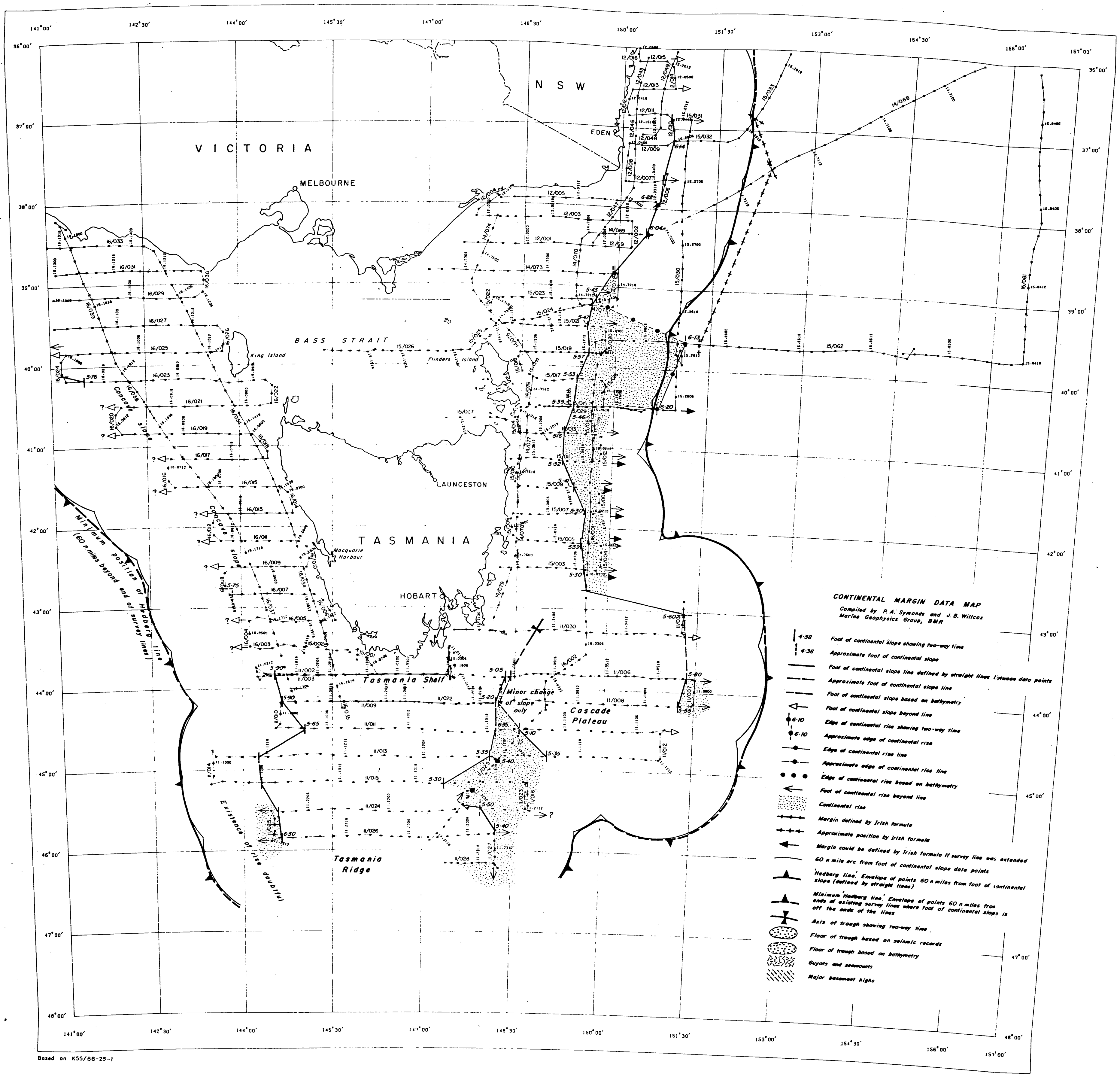
Contour interval 200 metres

Water velocity assumed constant at 1500 m/s

TASMAN SEA

Plate 5.

N/88-11



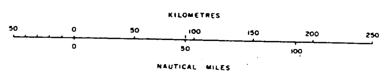
AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

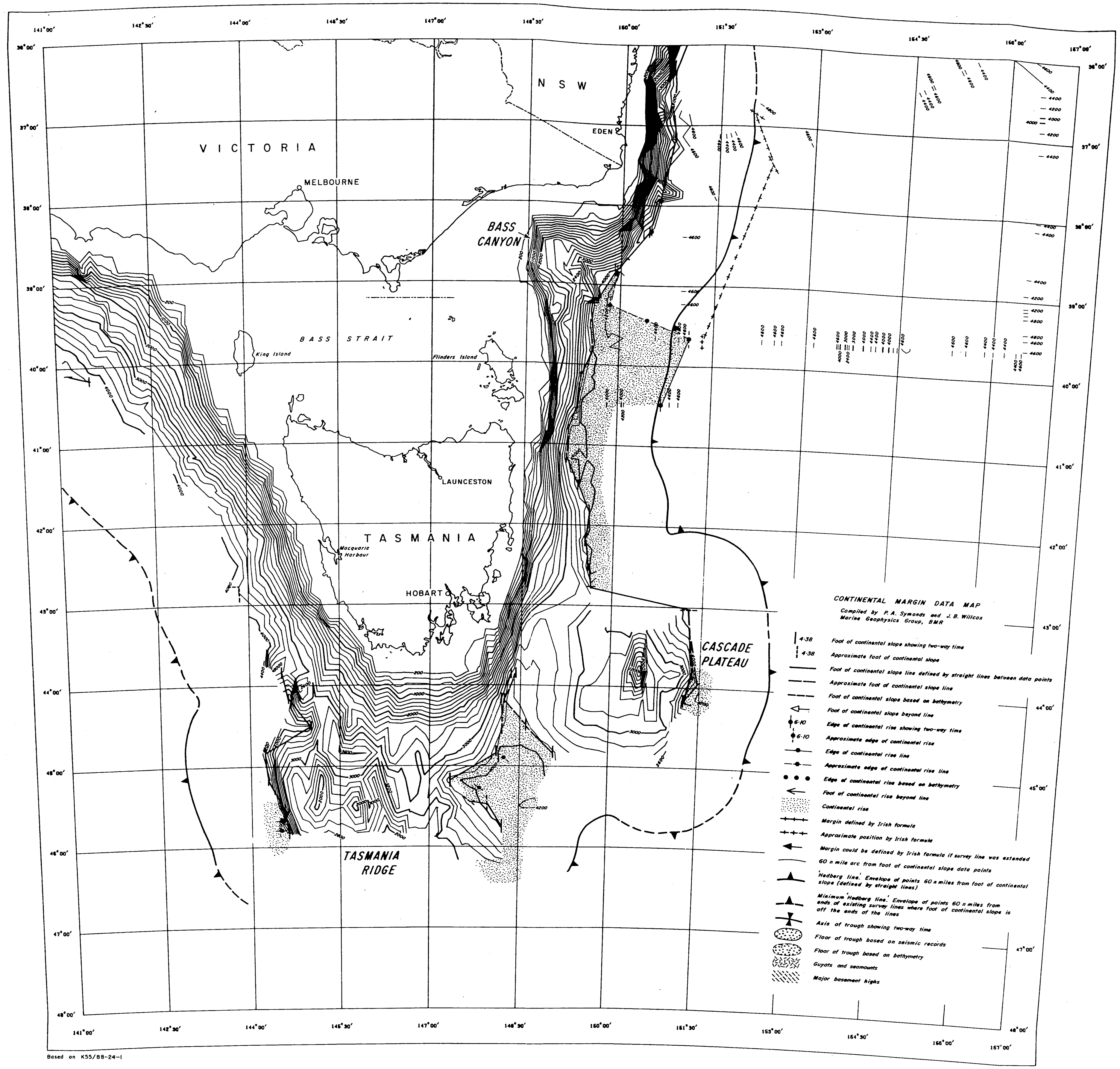
TRACK CHART

TASMANIA

Plate 6.



K55/88-37



AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B M R 1970-73 MARINE SURVEYS

TASMANIA

WATER DEPTH (METRES)

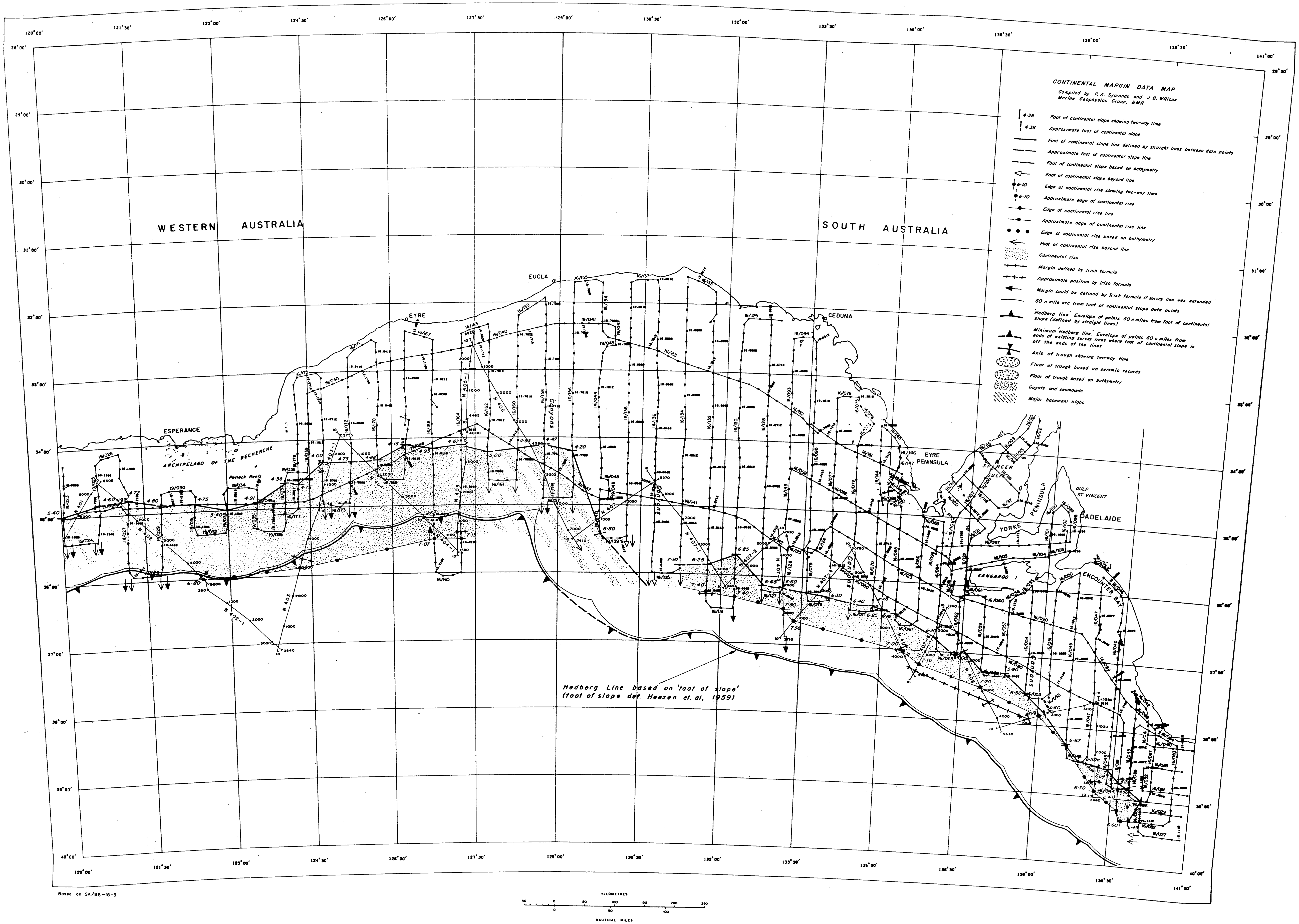
Plate 7.

K55/88-38

KILOMETRES
50 0 50 100 150 200 250
0 50 100
NAUTICAL MILES

Contour interval : 200 metres

Water velocity assumed constant at 1500 m/s



AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0 AND 36° 0 SOUTH

B M R 1970-73 MARINE SURVEYS

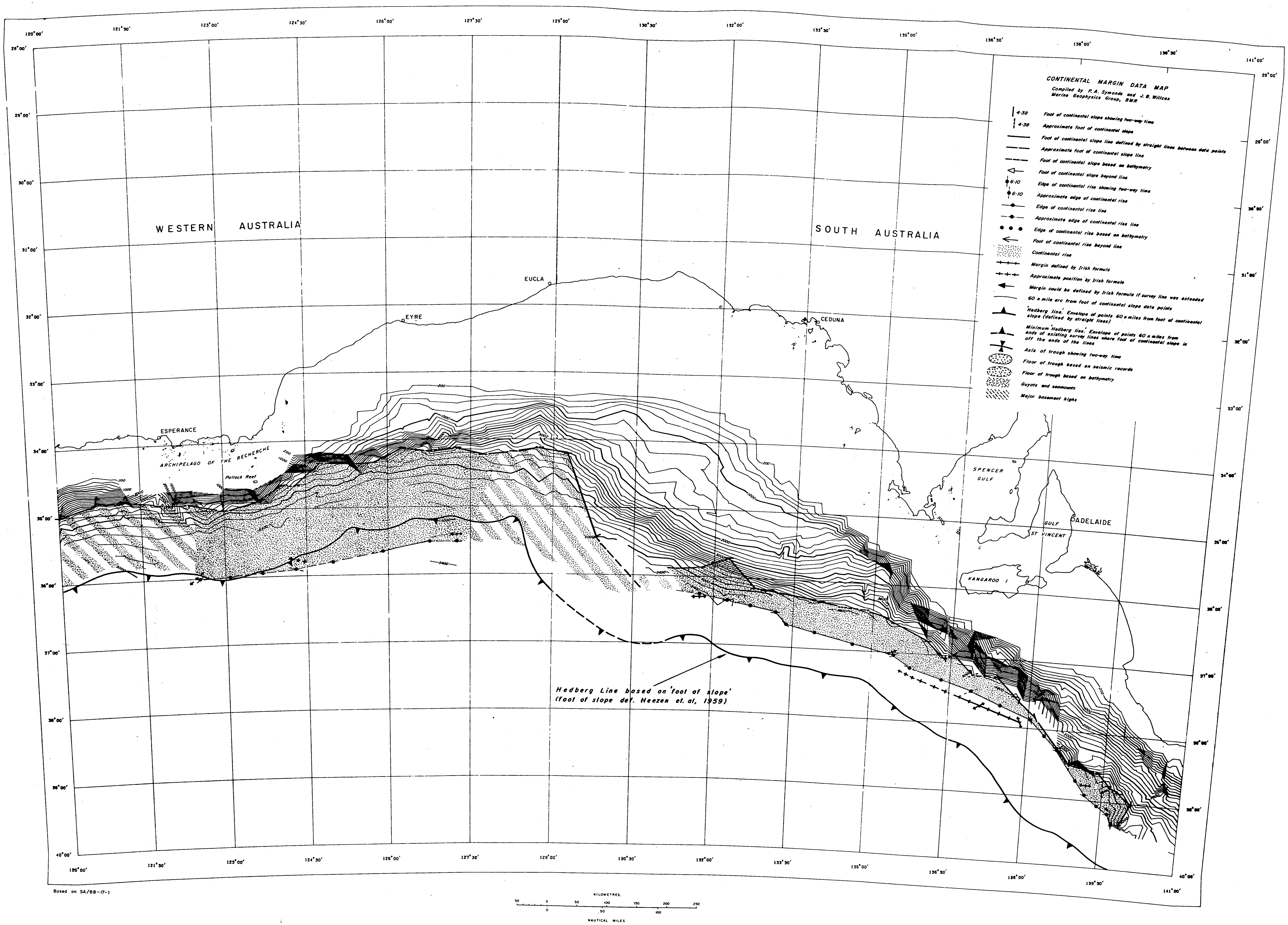
Tracks by Shell ('Petrel')

TRACK CHART

GREAT AUSTRALIAN BIGHT

Plate 8.

SA/88-44



AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

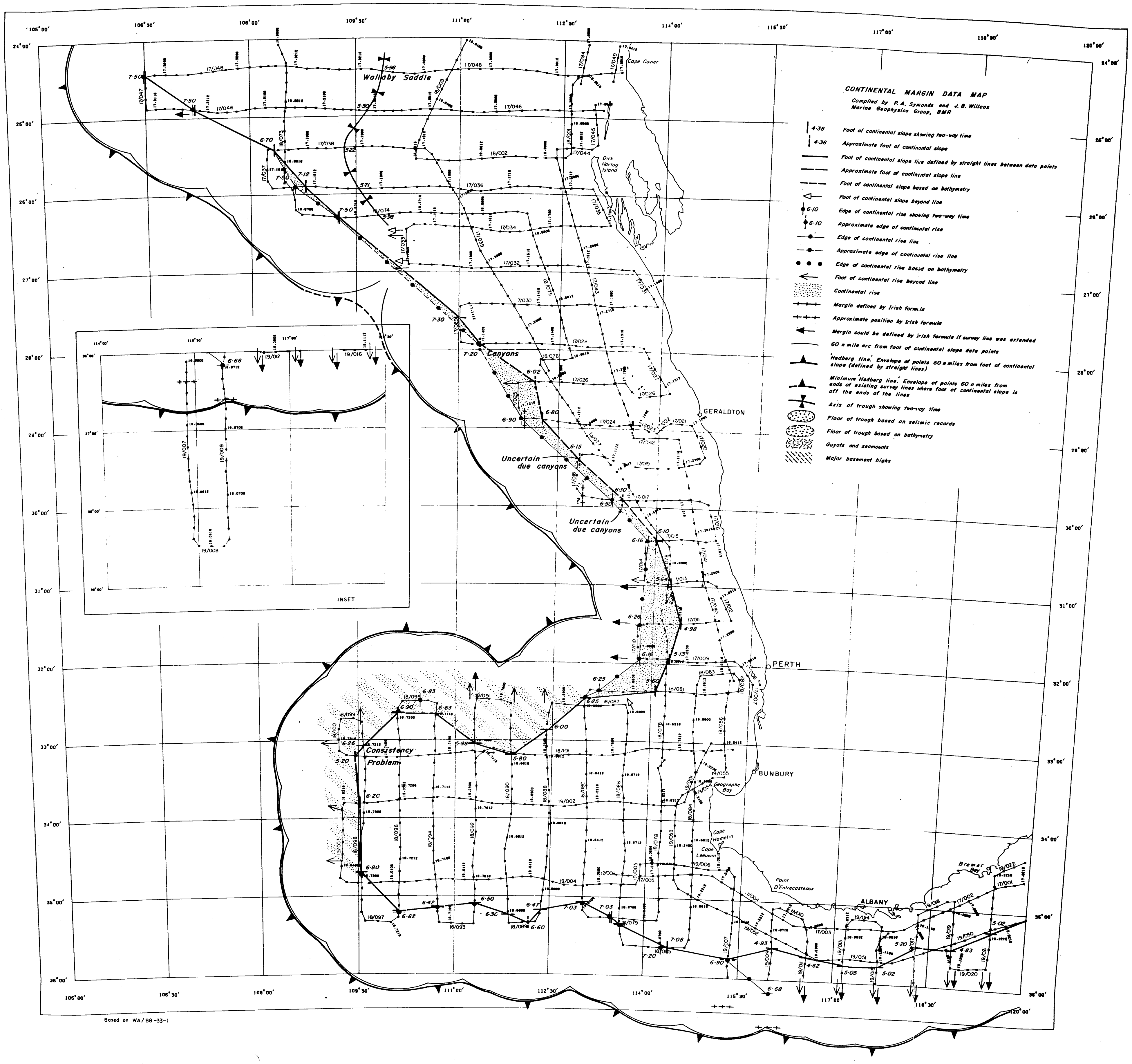
WATER DEPTH (METRES)

Contour interval 200 metres
Water velocity assumed constant at 1500 m/s

GREAT AUSTRALIAN BIGHT

Plate 9.

SA/88-45



AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

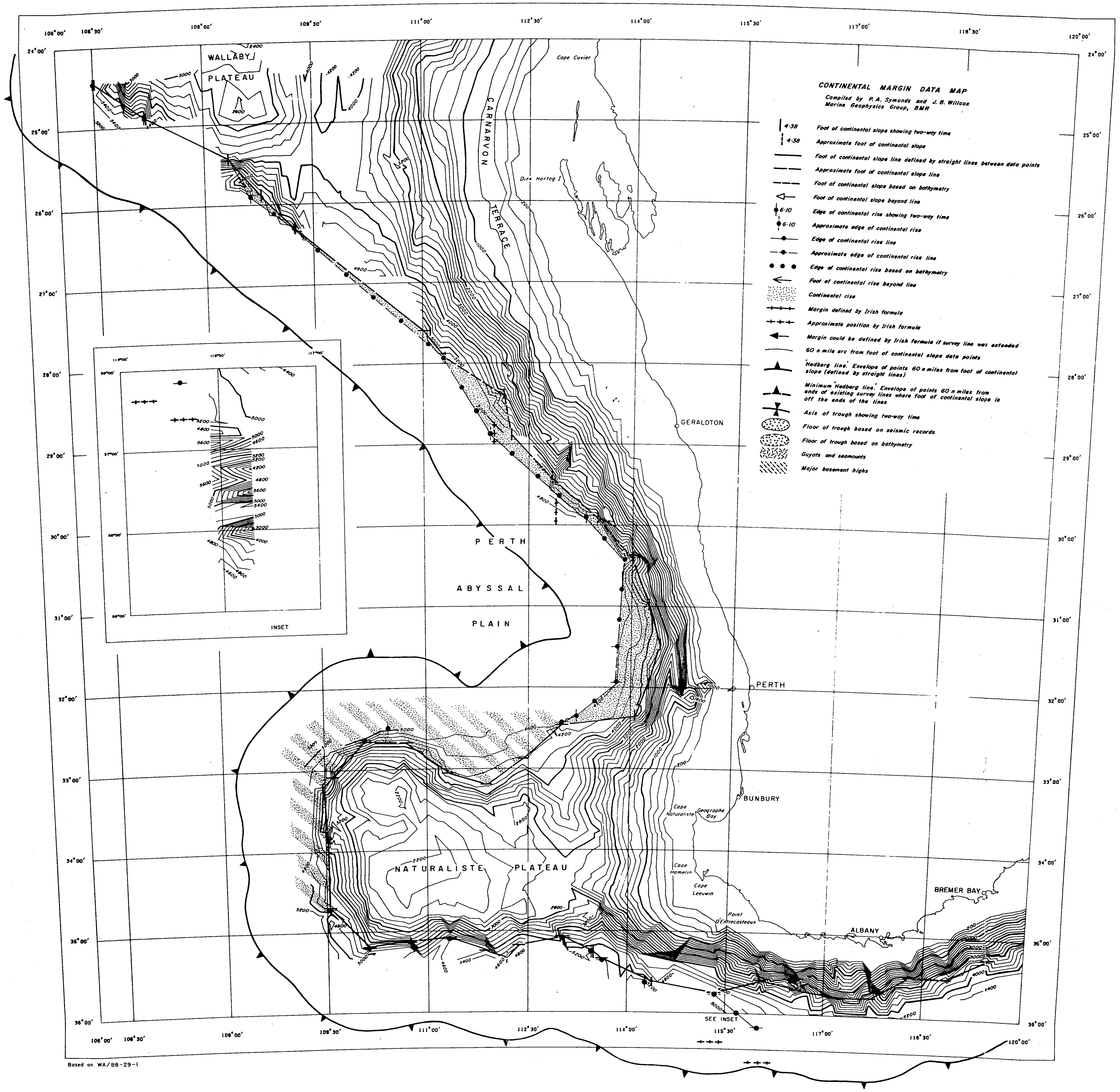
SOUTHWESTERN MARGINS

TRACK CHART

KILOMETRES 50 0 50 100 150 200 250
NAUTICAL MILES 0 50 100

Plate 10.

WA/B8-269



AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B M R 1970-73 MARINE SURVEYS

SOUTH WESTERN MARGINS

WATER DEPTH (METRES)

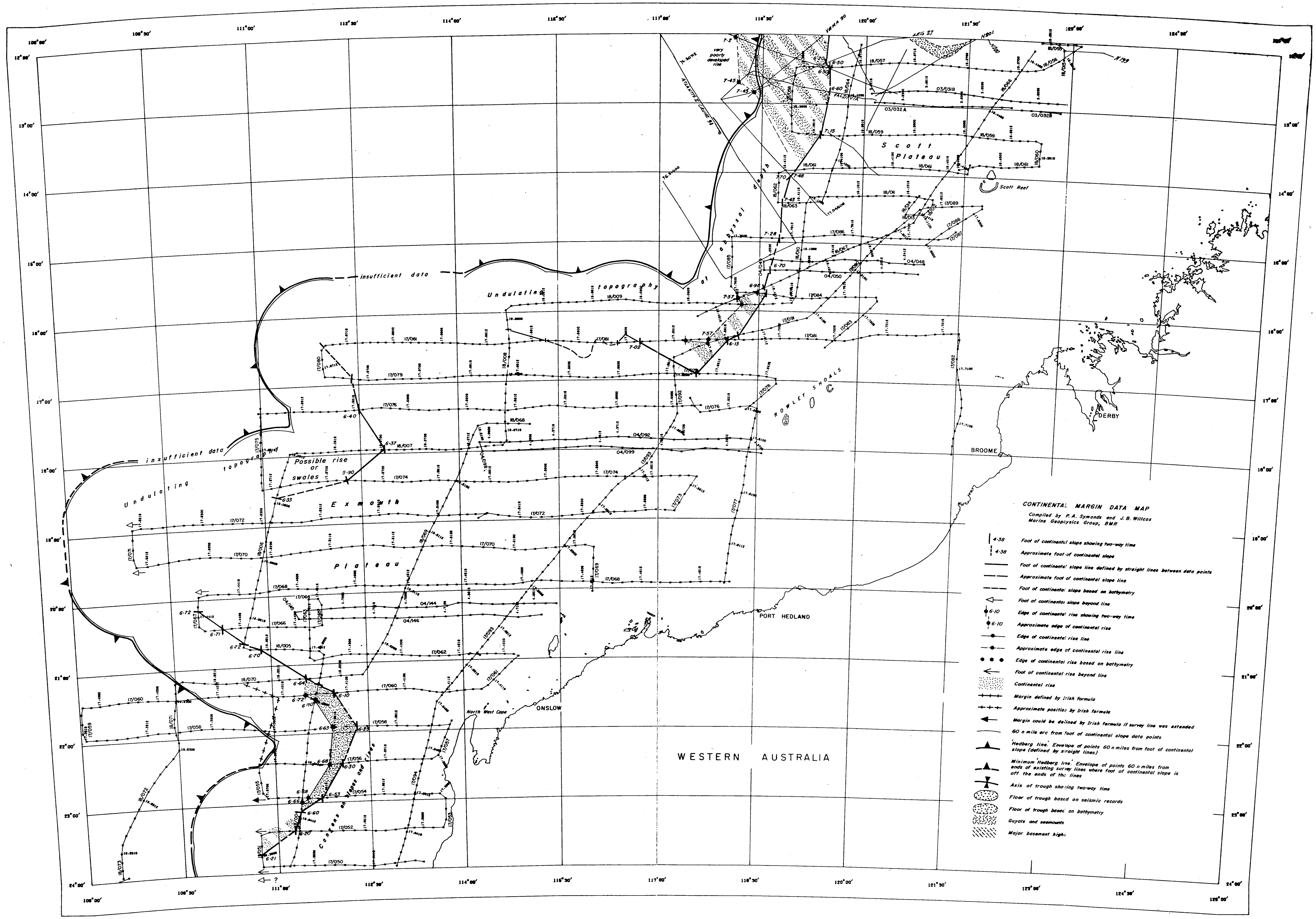
Plate 11.

KILOMETRES 50 0 50 100 150 200 250
NAUTICAL MILES 0 50 100

Contour interval : 200 metres

Water velocity assumed constant at 1500m/s

WA/B8-270



Based on WA/88-34-1

AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

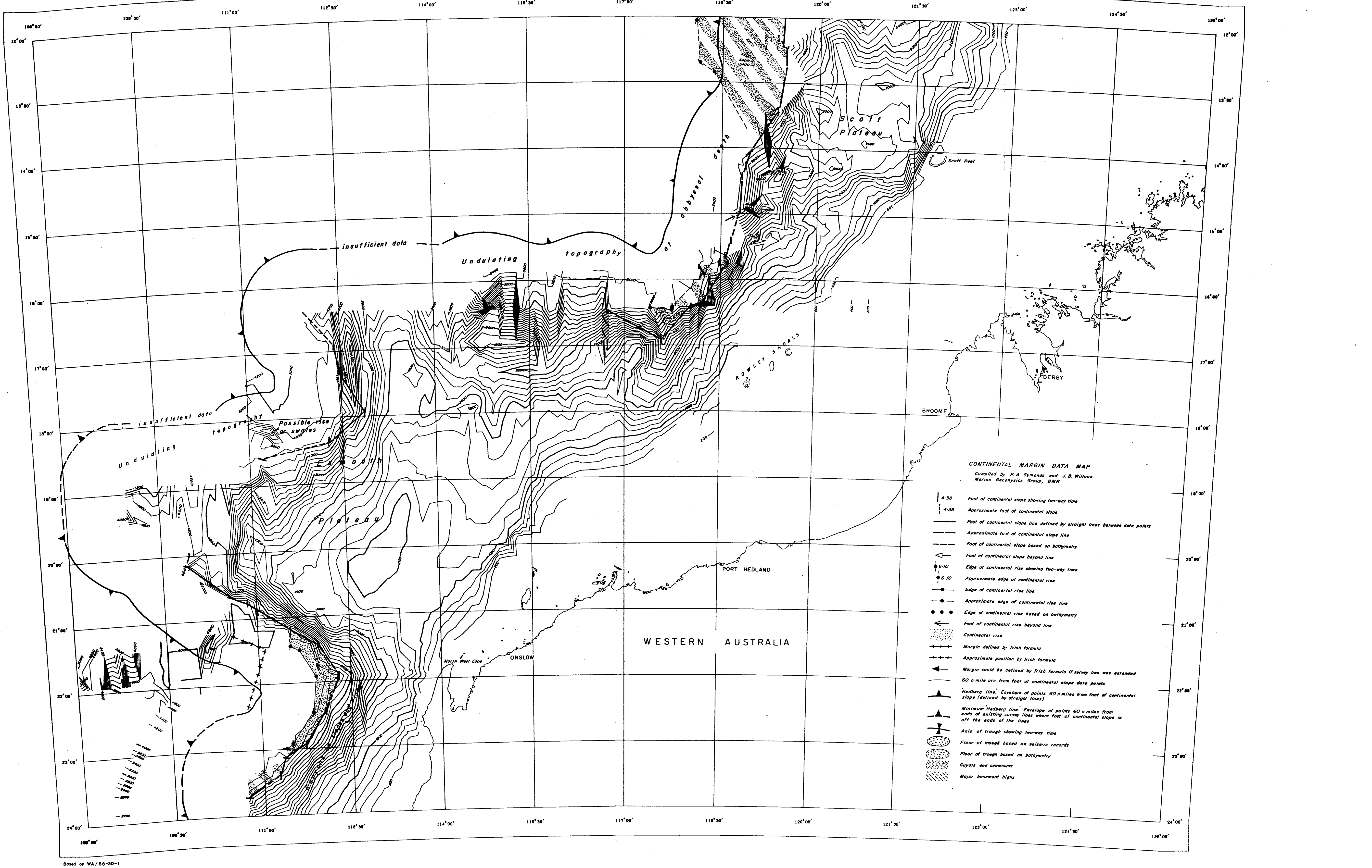
TRACK CHART

KILOMETRES 50 0 50 100 150 200 250
NAUTICAL MILES 0 50 100

NORTH WESTERN MARGINS

Plate 12.

WA/88-271



AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

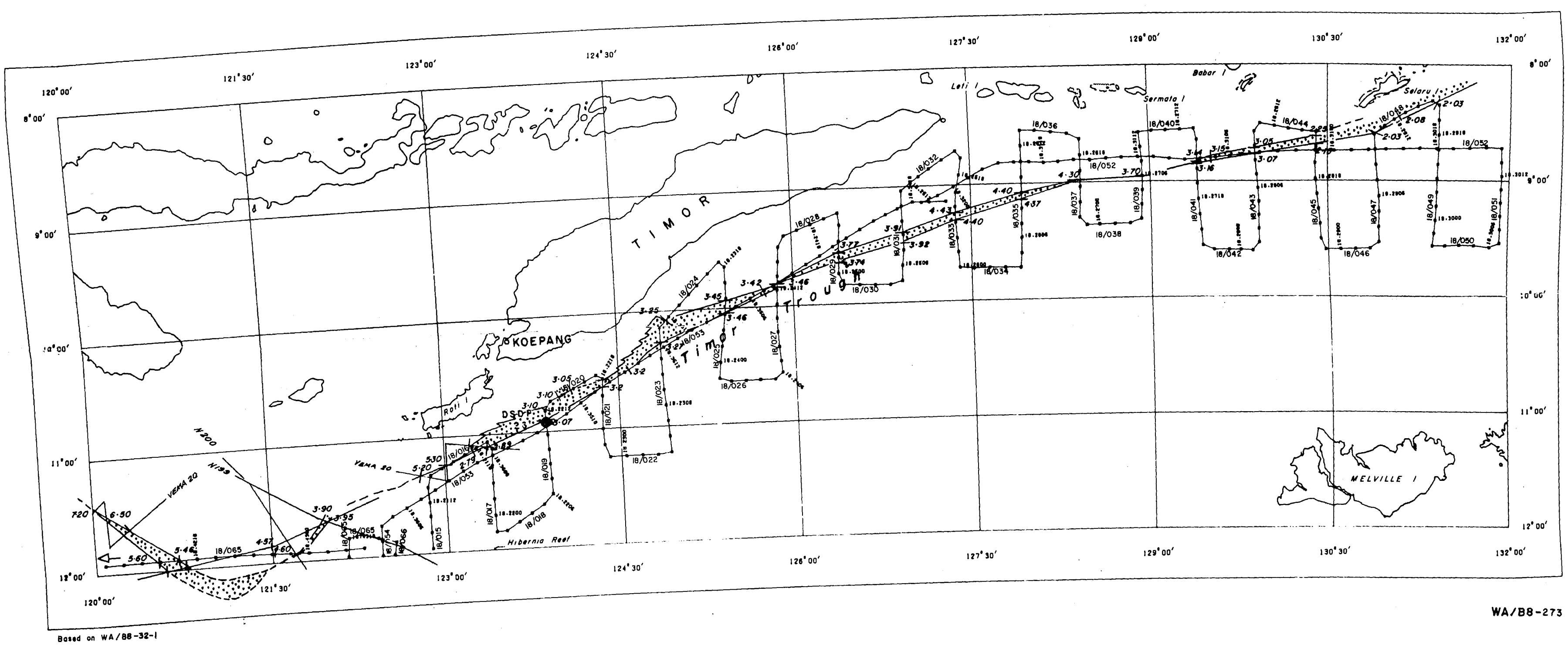
WATER DEPTH (METRES)

KILOMETRES
NAUTICAL MILES
Contour interval 200 metres
Water velocity assumed constant at 1500 m/s

NORTH WESTERN MARGINS

Plate 13.

WA/88-272



Based on WA/B8-32-1

WA/B8-273

AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

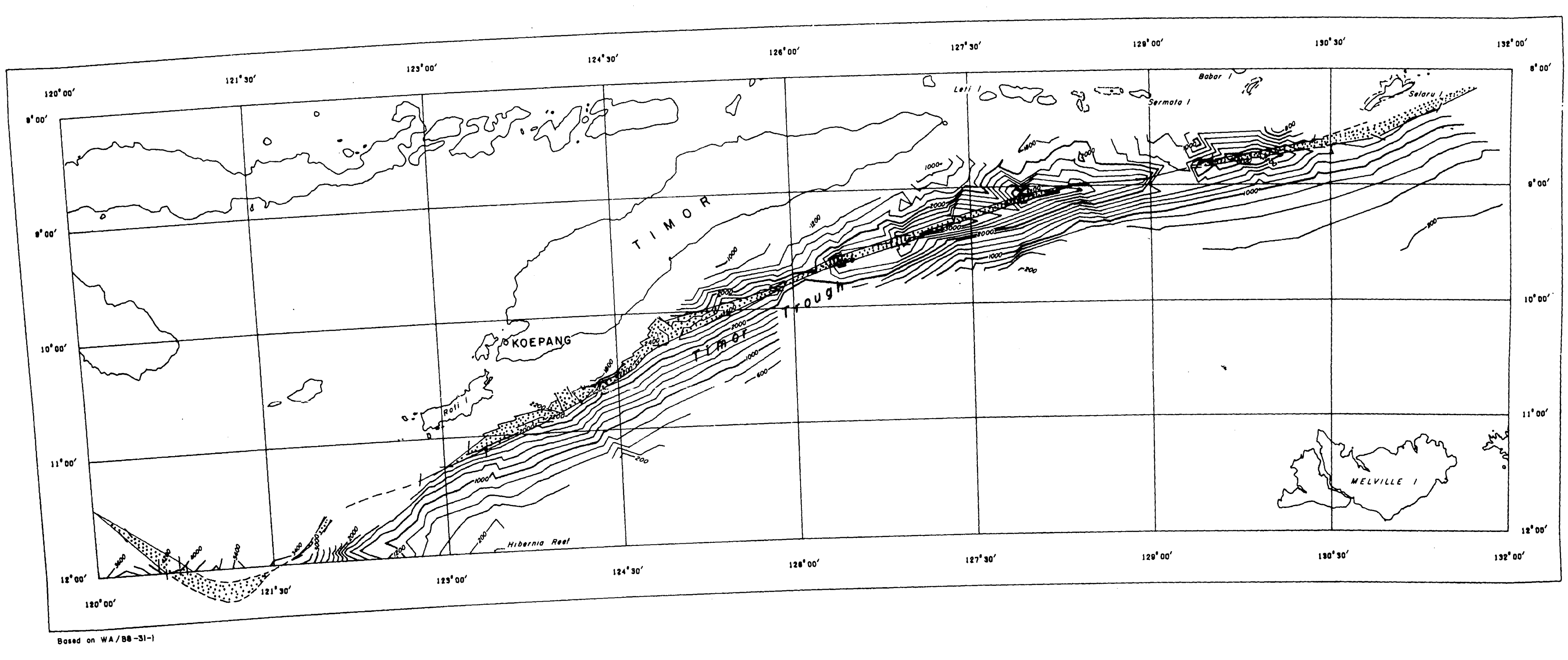
TRACK CHART

KILOMETRES 50 0 50 100 150 200 250
NAUTICAL MILES 0 30 100

CONTINENTAL MARGIN DATA MAP

Compiled by P.A. Symonds and J.B. Willcox
Marine Geophysics Group, BMR

- 4·38 — Foot of continental slope showing two-way time
- 4·38 — Approximate foot of continental slope
- Foot of continental slope line defined by straight lines between data points
- Approximate foot of continental slope line
- Foot of continental slope based on bathymetry
- Foot of continental slope beyond line
- 6·10 — Edge of continental rise showing two-way time
- 6·10 — Approximate edge of continental rise
- Edge of continental rise line
- Approximate edge of continental rise line
- Edge of continental rise based on bathymetry
- Foot of continental rise beyond line
- Continental rise
- Margin defined by Irish formula
- Approximate position by Irish formula
- Margin could be defined by Irish formula if survey line was extended
- 60 n mile arc from foot of continental slope data points
- 'Hedberg line.' Envelope of points 60 n miles from foot of continental slope (defined by straight lines)
- Minimum 'Hedberg line.' Envelope of points 60 n miles from ends of existing survey lines where foot of continental slope is off the ends of the lines
- Axis of trough showing two-way time
- Floor of trough based on seismic records
- Floor of trough based on bathymetry
- Guyots and seamounts
- Major basement highs



Based on WA/B8-31-1

AUSTRALIAN NATIONAL SPHEROID
SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18° 0' AND 36° 0' SOUTH

B.M.R. 1970-73 MARINE SURVEYS

TIMOR TROUGH

WATER DEPTH (METRES)

KILOMETRES 50 0 50 100 150 200 250
NAUTICAL MILES 0 50 100

Contour interval 200 metres
Water velocity assumed constant at 1500 m/s

Plates 14/15.

WA/B8-274

Plate 14

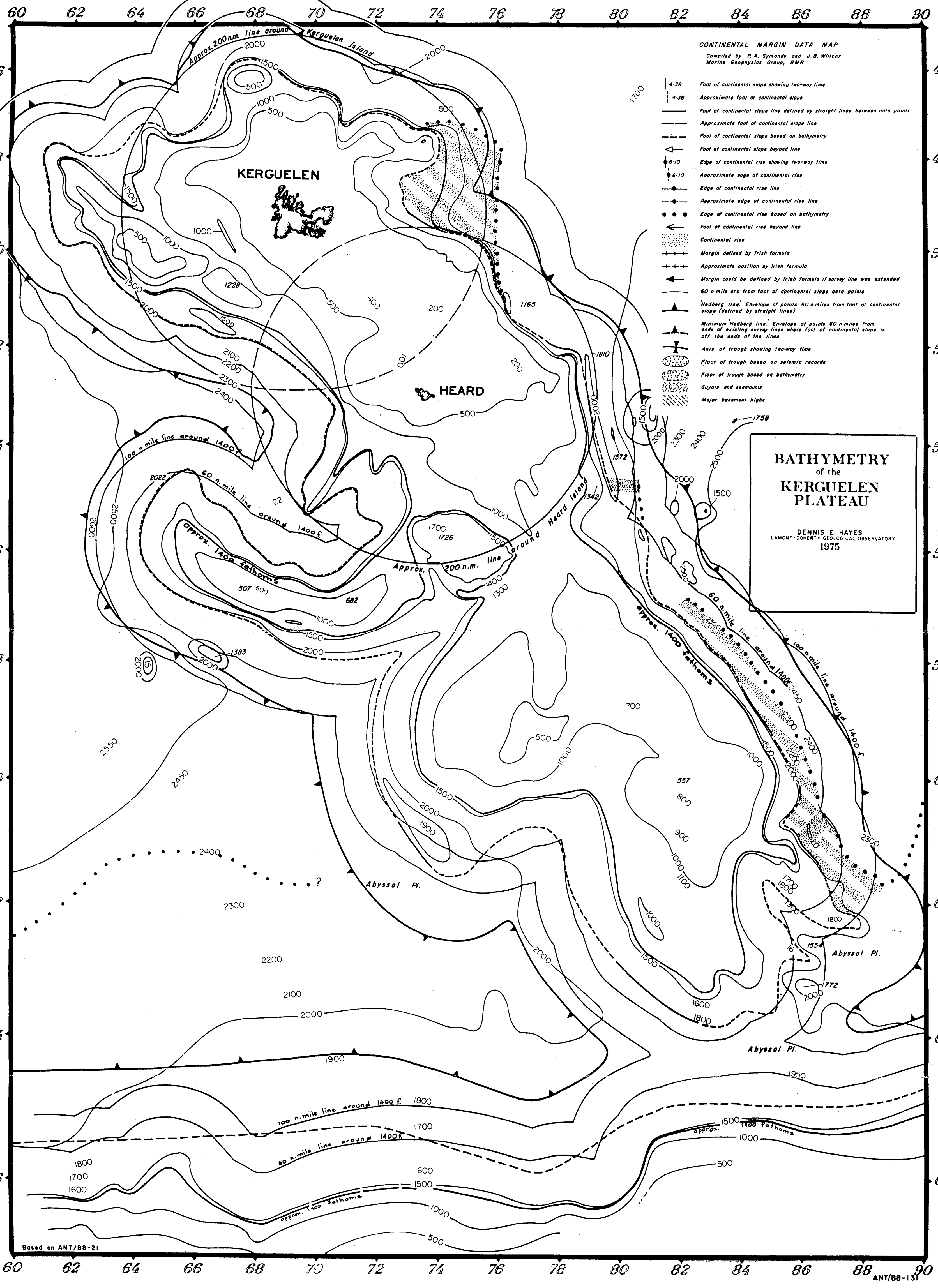
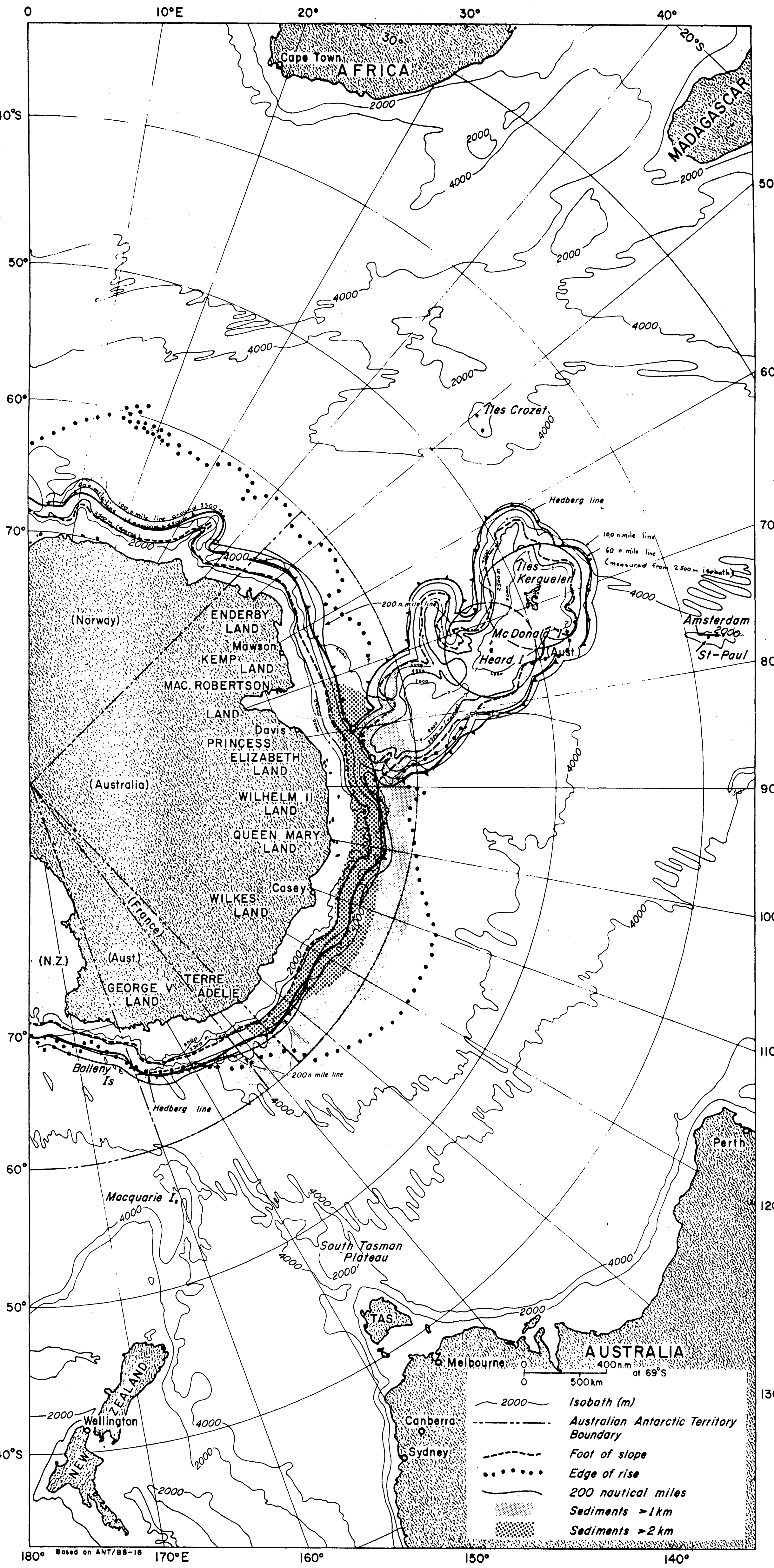


Plate 16.



AFRICA
Cape Town
MADAGASCAR
Îles Crozet
Îles Kerguelen
McDonald I.
Heard I.
(Aust.)
Amsterdam
St-Paul
Hedberg line
100 n.mile line
60 n.mile line
(measured from 2500 m. isobath)
200 n.mile line
(Norway)
ENDERBY LAND
Mawson
KEMP LAND
MAC. ROBERTSON LAND
Davis
PRINCESS ELIZABETH LAND
(Australia)
WILHELM II LAND
QUEEN MARY LAND
Casey
WILKES LAND
(France)
(N.Z.)
(Aust.)
GEORGE V LAND
TERRE ADELIE
Balleny Is
Macquarie I.
South Tasman Plateau
TAS.
Melbourne
Canberra
Sydney
Perth
AUSTRALIA
NEW ZEALAND
Wellington
400 n.m at 69°S
500 km
2000 Isobath (m)
Australian Antarctic Territory Boundary
Foot of slope
Edge of rise
200 nautical miles
Sediments >1 km
Sediments >2 km
Based on ANT/88-18

Plate 17.