COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF
NATIONAL DEVELOPMENT

BUREAU OF MINERAL
RESOURCES, GEOLOGY
AND GEOPHYSICS

Record No. 1972/111

BMR PROPOSALS FOR DRILL SITES FOR LEGS XXVIII AND XXIX OF THE DEEP SEA DRILLING PROJECT

by

P.A. Symonds and P.J. Cameron

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ILLUSTRATIONS

SUMMARY

The Bureau of Mineral Resources has prepared recommendations for five sites, which could be drilled during Legs XXVIII and XXIV of the Deep Sea Drilling Project, being managed by the Scripps Institution of Oceanography.

The sites have been selected on the basis of recent marine geophysical surveys by BMR. They are all in places where the sediments are thin enough for the drill to reach underlying basement rocks, and where stratigraphic information on the basement will be of greatest value to tectonic and evolutionary geological studies of the eastern Australian region.

1. INTRODUCTION

Leg XXI of the Deep Sea Drilling Project provided much information on the age and biostratigraphy of some of the ridges, marginal basins, and plateaus in the southwest Pacific. However, the results also posed many questions about the tectonic and sedimentary history of this complex region, and some of these can be answered only by further drilling in the area.

Since December 1970, BMR has completed about 71 000 nautical miles of a planned 80 000 nautical mile systematic seismic, magnetic, and gravity survey of the Australian continental margin. Only the traversing south of Tasmania and in the Tasman Sea is relevant to Legs XXVIII and XXIX of the Deep Sea Drilling Project (Plate 1).

This report contains proposals for five drill sites - two on Leg XXVIII and three on Leg XXIX. The bathymetric features on which the sites are located are the Tasmania Ridge, the Cascade Plateau (Plate 2), the Tasman Basin (Plate 6), and the Dampier Ridge (Plate 5). These have been chosen because of their importance in any accurate morphological reconstruction and tectonic evolution of the region. The exact drill site locations are based on the results of BMR seismic traverses, using criteria such as water depth and sediment thickness.

2. LEG XXVIII SITES BMR 1 AND 2 - SOUTHERN TASMANIA AREA

The proposed drill sites are situated on BMR survey lines, as indicated on the traverse map given in Plate 1. The relation of the sites to the bathymetric features is shown in the bathymetric map (Plate 2).

Regional Setting

Results from the surveying south of Tasmania indicate that the area off the continental shelf may be divided into three major bathymetric features. The Tasmania Ridge, separated by a narrow channel from the continental slope, extends directly south of Tasmania and out of the survey area. The Cascade Plateau (new name proposed) lies southeast of Tasmania and is separated from the ridge by a broad sediment-filled channel which trends south and then southeast around the plateau.

BMR 1: Tasmania Ridge — 45° 50'S, 145° 50'E.
Water Depth 2 700 metres.

The Tasmania Ridge lies at a depth of 2 500 to 3 500 metres and is marked by numerous topographic highs, which give it a rugged outline. Sediment thickness is very variable on the ridge, and thick sediments typically occur in small pockets between basement highs. Evidence for at least two separate periods of deposition is apparent in some of these pockets. Topographic changes in basement on the ridge do not generally affect the magnetic field. This suggests that the ridge does not have an oceanic basement, and may be submerged continental material.

Aims of BMR 1

Little previous work has been conducted on the ridge, and a drill hole could give important basic information on its age, composition, and origin.

Knowledge of the age and type of sediment on the ridge would be valuable in determining the sediment source. Also, evidence of the time of initial separation of Antarctica and Australia may be apparent in the column. This could take the form of a transgression from non-marine to marine sedimentation.

The proposed drill site is on a line of continuous seismic, magnetic, and gravity data. The site was selected because sediment thickness here should allow easy penetration to basement. The seismic section indicates some 400 metres of sediment at the site (Plate 3).

BMR 2: Cascade Plateau — 43° 50'S, 151° 02'E.
Water Depth 2 700 metres.

The Cascade Plateau, to the southeast of Tasmania, is a broad, roughly circular, plateau area at a depth of 2 000 to 3 000 metres. Thick sediments (approximately 1 km) cover most of the plateau, but this decreases on the eastern edge to a depth that would allow a drill to penetrate to basement. Its proximity to Tasmania suggests that the plateau may be submerged continental material.

Aims of BMR 2

As in the case of the Tasmania Ridge, little is known about the Cascade Plateau; again, a drill hole could give basic information on the plateau's age, composition, and possible origin.

The Plateau forms a lobe on the southeastern corner of the Australian plate and as such should be important in an accurate reconstruction of the area. In reconstructions of the southwest Pacific available at the present time, for example by Griffiths & Varne (1972), no account is given of this plateau. Its relation to Lord Howe Rise is unknown. Comparison of the sedimentary section from the plateau and from Lord Howe Rise (e.g. from the Deep Sea Drill Site 207) could determine whether both these areas have received sediment from the same source, and may indicate a date for the separation of these masses.

The site selected is on a line of continuous seismic, magnetic, and gravity data. It is in an area of low relief, and sediment thickness at the site is approximately 400 metres (Plate 4).

3. LEG XXIX SITES BMR 3, 4, AND 5 - TASMAN SEA AREA

Recent morphological reconstructions of the region, and the results of Leg XXI, suggest several places where more data are required in order to obtain a reasonable tectonic history of the Tasman Sea area. The following deep sea drilling site proposals are aimed at three such places in the hope that the information obtained would provide constraints on any speculative models of the evolution of the area.

The morphological reconstruction and evolutionary model for the Tasman Sea area proposed by Griffiths & Varne (1972) is consistent with most of the known geological and geophysical data and is therefore accepted as providing a general tectonic history of the area. Mutter & Symonds of BMR (in prep.) arrive at a similar tectonic history, which is summarized below.

Mutter & Symonds (in prep.) tentatively suggest that the Tasman Basin was formed in two discrete stages. The initial stage was due to sea-floor spreading from about 80 to 60 m.y. B.P. (Hayes & Ringis, 1972) creating a triangular rift between Australia and the southern part of Lord Howe Rise. The oceanic crust created by this stage now exists as the swale and abyssal hill province of the central and southern Tasman Basin. In response to the spreading a rift developed between Australia and the northern part of Lord Howe Rise, which may have been a marginal plateau at this time. The second stage was the result of the 'differential spreading of Australia and the Campbell Plateau from Antarctica during the Tertiary', leading to 'the establishment of a zone of transcurrent displacement through New Zealand' (Griffiths & Varne, 1972, p.86), namely the Alpine Fault. This produced further rifting between Australia and Lord Howe Rise, thus forming the 'oceanic' basement beneath the present abyssal plain as the rise moved northeast with respect to Australia. Mutter & Symonds (in prep.) suggest that the Mellish Rise may have been formed as a result of igneous activity in a zone of transcurrent displacement resulting from the northeasterly movement of the northern end of Lord Howe Rise. That is, the Mellish Rise may be the northern equivalent of the Alpine Fault. During the second stage of rifting, the Dampier Ridge, which probably formed as an intrusive complex in the initial rift between Lord Howe Rise and Australia, also moved northeast with respect to Australia in a similar manner to Lord Howe Rise. This movement may have been responsible for some rifting between the Dampier Ridge and the rise.

BMR 3 and 4: Tasman Basin

Two sites are proposed in the Tasman Basin. Ideally, both should be drilled in order to test the hypothesis of dual stage evolution; however, either one would provide a great deal of information on the area.

BMR 3 Abyssal Plain - 37° 24.7'S, 152° 28.6'E.
- Water Depth 4 725 metres

BMR 4 Swale Area - 36° 28.1'S, 154° 37.7'E.
- Water Depth 4 390 metres

The proposed drill holes are situated on line 68 (BMR survey 14), which has continuous seismic and magnetic coverage. Gravity data were also recorded continuously, but on much of the line the quality was poor owing to the roughness of the sea. The position of this line and other BMR traverses is shown in Plate 1. BMR 3 and 4 are also situated about 10 nautical miles from two Eltanin lines.

Regional Setting

The relation of the drill sites to regional structural and bathymetric features is shown in Plates 5 and 6, respectively.

The Tasman Basin is the flat-lying area between the base of the eastern Australian continental slope and the western margin of the Dampier Ridge, north of latitude 33°S, and between the base of the slope and the western margin of Lord Howe Rise, south of latitude 33°S. The basin ranges in width from about 250 kilometres north of 33°S to more than 1 250 kilometres south of 33°S, and in depth from 4 500 to 5 200 metres.

The regional magnetic field in the northern part of the Tasman Basin is characterized by small, irregular closures of the zero and +100 gammas residual magnetic contours, which exhibit a vague north-northeast trend. Ringis (1970) and Hayes & Ringis (1972) describe magnetic lineations trending about 330° in the southern part of the basin between 34°S and 40°S. Hayes & Ringis (1972) state that 'the magnetic lineations are distributed in a bilaterally symmetric fashion about a highly disrupted basement ridge, which also trends NW' . During the last fifteen years quite a deal has been written on the Tasman Basin. The earlier papers such as Standard (1961), Conolly (1969), and Van der Linden (1970) deal mainly with the morphology of the northern and central areas of the basin, and Eade & Van der Linden (1970) discuss the Quaternary stratigraphy and sedimentation in the North Tasman Basin. Later papers and abstracts such as Cullen (1970), Ringis (1970), Griffiths (1971), Packham & Falvey (1971), Vogt & Conolly (1971), Griffiths & Varne (1972), and Hayes & Ringis (1972) mainly discuss the structure and evolution of the Tasman Basin in the light of the regional tectonics of the Tasman Sea area. Using seismic refraction studies Shor, Kirk & Menard (1971) arrive at a crustal thickness of 5 to 6 km for the north Tasman Basin.

Local Setting

The Tasman Basin can be divided into two provinces: the flat abyssal plain and the abyssal hills area. The abyssal plain, which is about 250 km wide, extends south from 24°S, paralleling the continental shelf. The abyssal hills province, which occurs south of 33°S, is a 'triangular area of abyssal hills and ridges lying between the Lord Howe Rise and the Tasman Abyssal Plain' (Conolly, 1969).

The abyssal plain north of about 33°S consists of an average of 1 km of sediment overlying rugged to undulating oceanic basement. A number of low abyssal hills occur in this area. South of 33°S the basement surface dips gently towards the shelf, and sediment thickness ranges from about 1 km on its eastern margin to 2 km or more at the base of the slope. Throughout the abyssal plain the top 500 m of sediment is often characterized by very good reflectors on the seismic sections - these are probably recent turbidites.

The character of the abyssal hills province appears to be largely controlled by the northwest-trending basement ridge described by Hayes & Ringis (1972). West of the ridge the basement surface, which appears to be slightly less rugged than that of the abyssal plain, dips gently west; the thickness of the relatively transparent sediment cover ranges from about 500 m to 1 km. East of the ridge the basement surface is more rugged with no consistent dip, and abyssal hills are common; The sediment thickness is usually less that 1 km.

Throughout much of the central and northern Tasman Basin, particularly in the abyssal plain province, a relatively prominent, but sometimes disrupted, reflector is often visible on the seismic sections about half way between the sea floor and the basement surface. This is shown as the blue reflector on sketched seismic section B-B' (Plate 7). Two drill holes have been proposed in the Tasman Basin to elucidate differences in both the nature of the basement and the seismic characteristics of the sediment between the two provinces, and how these factors relate to the origins of the provinces.

Plates 8 and 9 are copies of seismic sections showing the locations of BMR 3 and 4, respectively. They indicate that at BMR 3 there is about 750 m of sediments overlying rugged to undulating basement and at BMR 4 there is about 650 m of sediments overlying relatively smooth basement.

Aims of BMR 3

BMR 3 has been selected to supply the following information:

(a) Age of basement, using biostratigraphic information.

(b) Character and composition of the basement.

(c) Age and composition of the sediments.

(d) Rate of turbidite deposition in the area.

(e) Age and nature of the prominent central reflector described above.

If most of these aims were met by the drill hole the following would result:

(i) A better understanding of the origin of the abyssal plain; e.g. whether the basement in this area formed at a ridge (Hayes & Ringis, 1972) or as the result of rifting.

(ii) A biostratigraphic check on the age of basement deduced by Hayes & Ringis (1972) from magnetic lineations about a basement ridge.

(iii) An age for the formation of the Tasman Basin.

(iv) A check for the presence of the late Oligocene to mid Eocene break in sedimentation found at other sites in the Tasman-Coral region on Leg XXI of the Deep Sea Drilling Project.

Aims of BMR 4

BMR 4 has been selected to supply the following information:

(a) Age of basement, using biostratigraphic information.

(b) Character and composition of the basement.

(c) Age and composition of the sediments.

(d) Rate of pelagic deposition in the area.

If most of these aims were met by the drill hole the following would result:

(i) A better understanding of the origin of the abyssal hills area.

(ii) A biostratigraphic check on the age of basement deduced by Hayes & Ringis (1972) from magnetic lineations about a basement ridge.

(iii) An age for the formation of this part of the Tasman Basin. Is it the same age as the abyssal plain?

(iv) A check for the presence of the late Oligocene to mid Eocene gap in the sedimentary record found at other drill sites in the Tasman-Coral Sea region on Leg XXI.

BMR 5: Dampier Ridge - Lat. 30° 49.5' to 31° 49.9'S.
- Long. 157° 51.8' to 157° 40.7'E.
- Water Depth 2 980–2 540 metres.

The proposed drill hole is situated on line 58 (BMR survey 15), which has continuous seismic, gravity, and magnetic coverage. The distribution of other traverse lines is shown in Plate 1.

Regional Setting

The relation of the drill site to regional structural and bathymetric features is shown in Plates 2 and 3 respectively. The Dampier Ridge, which lies between latitude 26° 30' and 32° 30', is an approximately north-south trending ridge about 100 km wide and 1 800 metres below sea level, at its highest point. The ridge markes the eastern margin of the north Tasman Basin and is separated from the foothills of Lord Howe Rise by the Lord Howe and Middleton Basins (Plate 7).

The ridge is associated with a broad, positive 100-200 gamma north-south trending residual magnetic anomaly, on which are superimposed shorter wavelength anomalies, up to +400 gammas, associated with shallow or exposed basement.

Until recently, little was known of the Dampier Ridge owing to lack of seismic information; however, a few authors have referred to it. Van der Linden (1967) proposed the name 'Dampier Ridge' for the structure and Van der Linden (1969) suggested that it may be an extinct or dormant mid-ocean ridge. Van der Linden (1970) referred to 'the youthfulness of the ridge' and Cullen (1970) raised a number of objections to Van der Linden's suggestion that the Dampier Ridge may be an extinct mid-ocean ridge. Using continuous gravity measurements Woodward & Hunt (1971) calculated a crustal thickness of 20 km beneath the Dampier Ridge.

Local Setting

The Dampier Ridge is marked by relatively rugged and occasionally exposed basement, which is overlain by an average of 600 metres of sediments, with a maximum of 1 km in basement lows (assuming a velocity of 2 km/s for the sediments). The upper 200-300 metres of sediments is usually more transparent than the underlying sediments. The character of the seismic records suggests that the basement is probably volcanic - the ridge may be a large intrusive complex. West of the ridge no abrupt contact can be seen between the basement of the Dampier Ridge and that of the abyssal plain; east of the ridge the basement surface disappears under the Lord Howe and Middleton Basins (Plate 7).

Plate 10 is a copy of a seismic section showing the location of BMR 5. It indicates that at this site the sedimentary thickness ranges from about 500 to 700 metres and that the basement surface is relatively smooth.

Aims of BMR 5

BMR 5 has been selected to supply the following information;

(a) Age of basement, using biostratigraphic information

(b) Character and composition of basement

(c) Age and composition of the sediments

(d) Rate of pelagic deposition in the area.

If most of these aims were met by the drill hole the following would result:

(i) A better understanding of the origin of the Dampier Ridge, which is difficult to account for by any simple explanation of the tectonics of the area. Some of the possibilities are:

A. A piece of uplifted abyssal plain.

B. An extinct mid-ocean ridge.

C. A piece of submerged subcontinental crust left behind as Lord Howe Rise separated from Australia.

D. An intrusive complex formed in the initial rift between Lord Howe Rise and Australia (perhaps similar to those in the African rift system, e.g. Ruwenzori). The authors favour the latter origin.

(ii) Limitations on the age of the northern part of the Tasman Basin, thus allowing a more detailed history of the separation of Lord Howe Rise and Australia to be built up.

Note: Throughout the report sedimentary thicknesses have been calculated using an assumed velocity of 2 km/s.

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PLATE 1

PROPOSALS FOR LOCATIONS OF DRILLING SITES

LEGS XXVIII & XXIX

OF THE DEEP SEA DRILLING PROJECT

MERCATOR PROJECTION

0° 25° 50°

100 0 100 200 300 400 500

KILOMETRES

SCALE 1 : 10,000,000 AT EQUATOR

135° 140° 145° 150° 155° 160° 165° 170°

0° 5° 10° 15° 20° 25° 30° 35° 40° 45° 50°

WEST IRIAN

NEW GUINEA

PAPUA

QUEENSLAND

NEW SOUTH WALES

VICTORIA

SOUTH AUSTRALIA

TASMANIA

Momote Kavieng Vanimo Wewak Rabaul Nauru Ocean Island Buka Aropa Wabag Goroka Lae Daru Port Moresby Observatory Honiara Gurney Gove Weipa Cooktown Wallis Island Croydon Ingham Townsville Weonarah Mount Isa Mackay Winton Boulia Alpha Noumea Marvborough Birdsville Quilpie Roma Oodnadatta Eromanga Eromanga Thoobburra Moree Norfolk Island Grafton Bourke Woomera Wilcannia Broken Hill Newcastle Condobolin SYDNEY Mildura Renmark Parafield ADELAIDE CANBERRA Albury Warracknabeal MELBOURNE Foolangi Observatory BRISBANE Burnie Launceston Zeehan HOBART Cambridge

LEG XXX

LEG XXVIII

LEG XXIX

209 210 208 206 207

BMR 1 BMR 2 BMR 3 BMR 4 BMR 5

A A' B B'

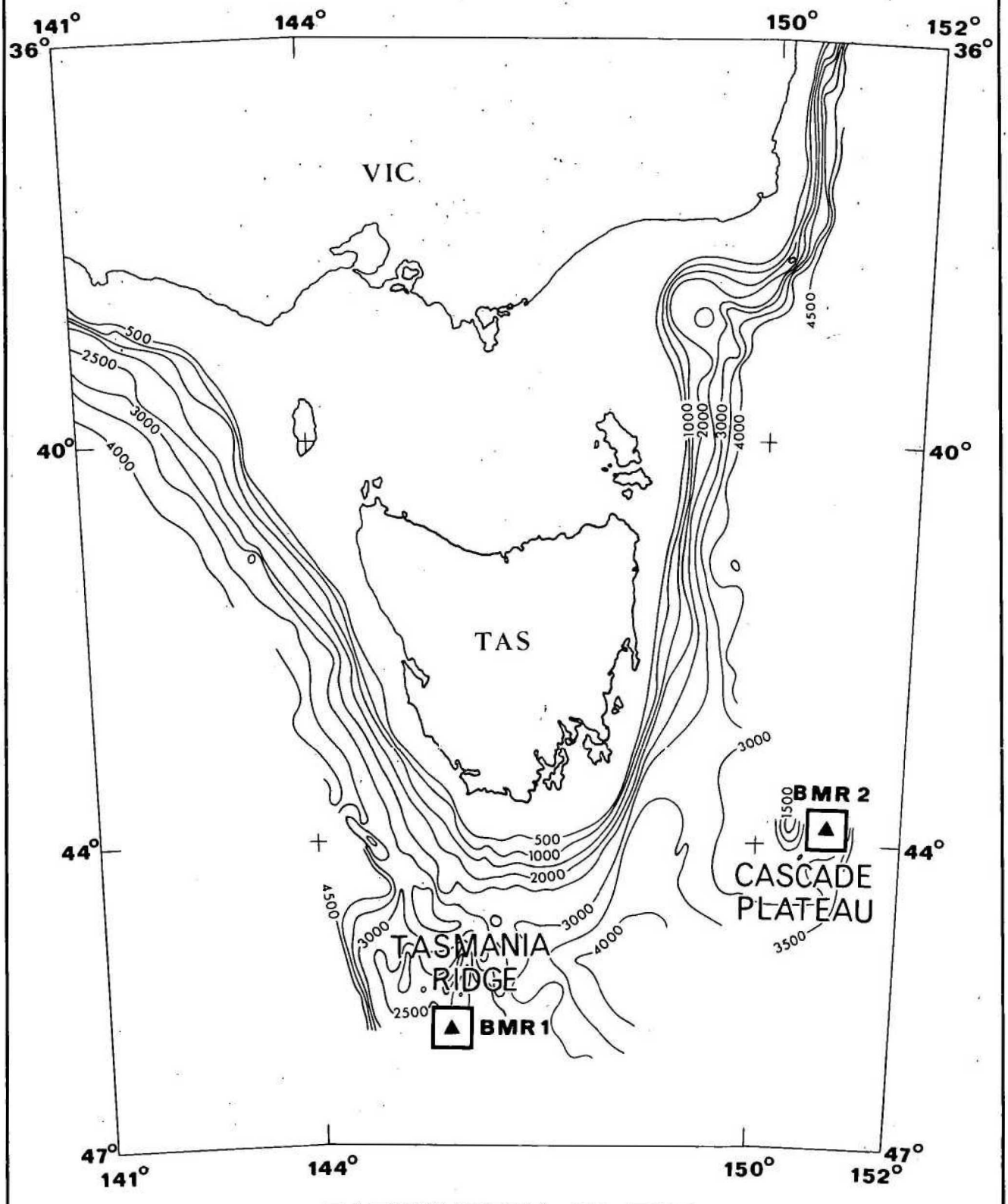
LEGEND

- JOIDES sites completed on Leg XXI
- BMR proposal for drill site on Leg XXVIII
- BMR proposal for drill site on Leg XXIX
- BMR traverses 1970-1972

A/B8-13-1

To accompany Record No. 1972/111

PLATE 2



BATHYMETRY OF THE TASMANIAN AREA

100 0 100 200 300 400 500 600 KILOMETRES

Contour interval 500 metres

▲ BMR proposal for drill site on Leg XXVIII

To accompany Record No. 1972/111

K55/B8-3A

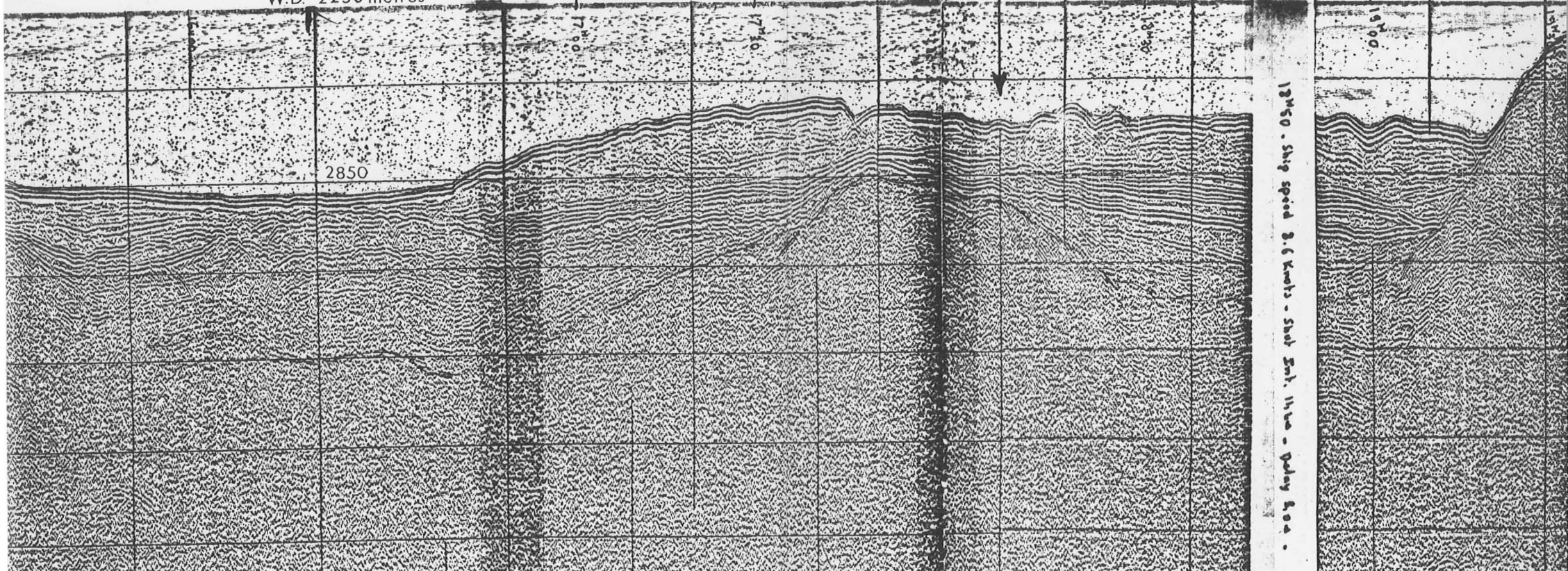


PLATE 3

To accompany Record No. 1972/111

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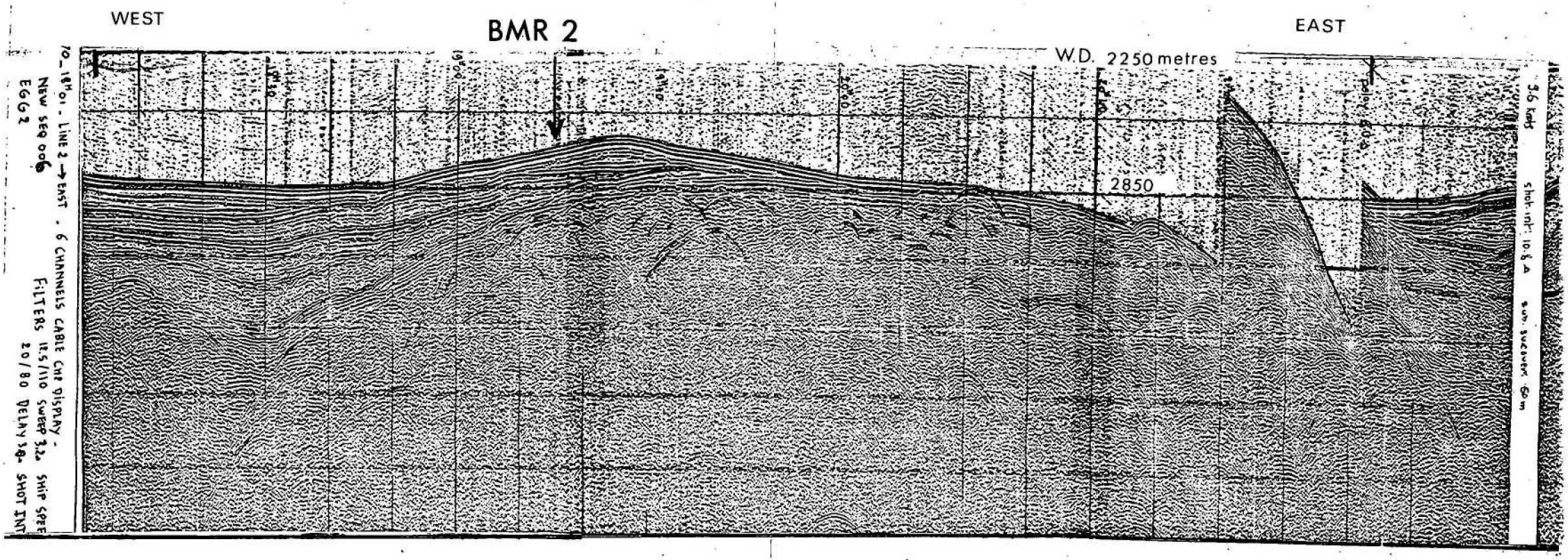

PLATE 4

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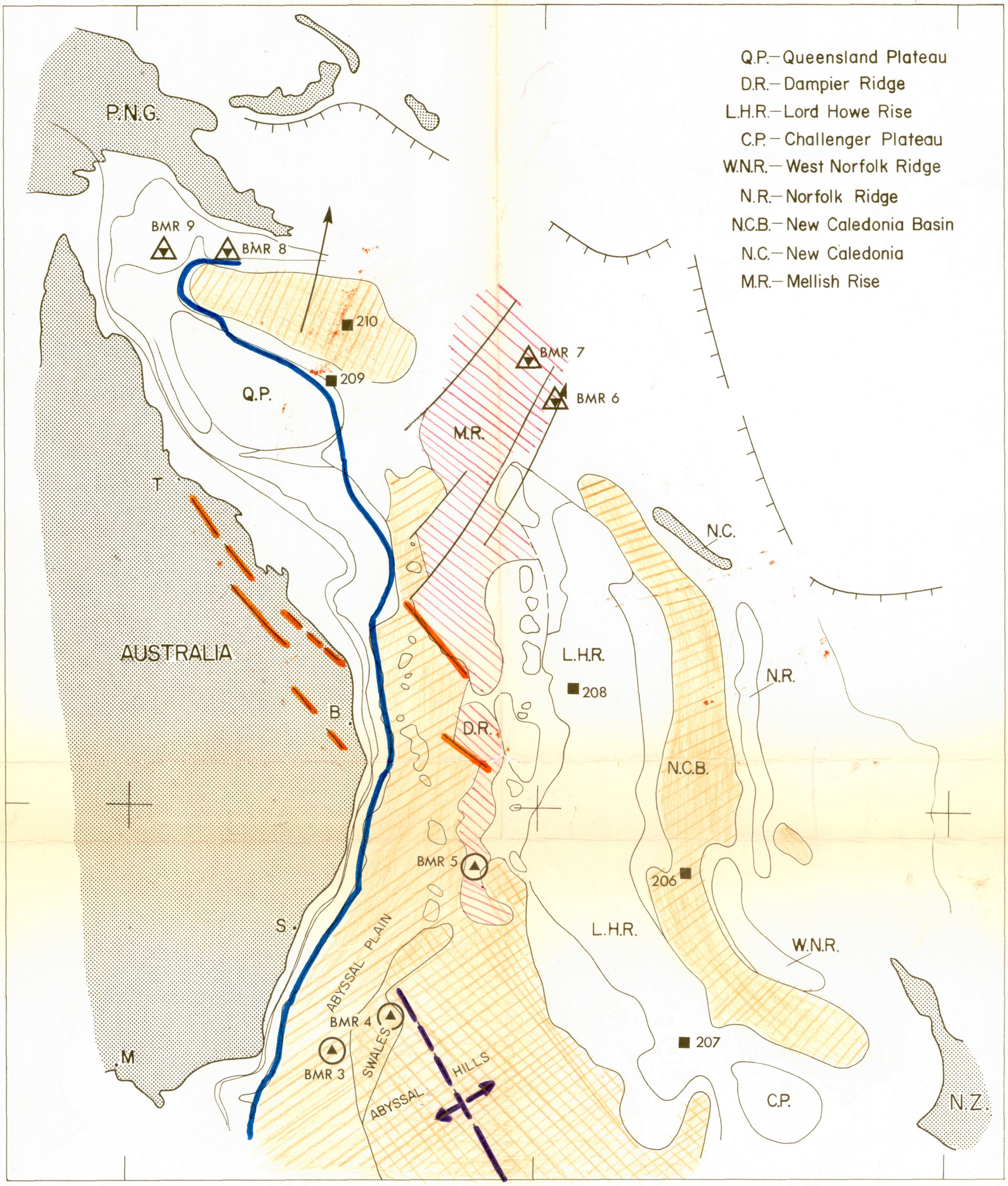
To accompany Record No. 1972/111



STRUCTURAL MAP
EASTERN AUSTRALIAN MARGIN

■ JOIDES sites completed on Leg XXI

BMR proposal for drill site on Leg XXIX

BMR proposal for drill site on Leg XXX

Ocean Basin

Sub-Continental Crust

Sub-Oceanic Crust (Igneous activity in fracture zone)

Base of Continental Slope

Fracture zone

Trench

Extinct spreading centre

Tasman Geosyncline trends

To accompany Record No. 1972/111

PLATE 6

BATHYMETRY OF THE SOUTHWEST PACIFIC
LOCATION OF DRILLING SITES AS PROPOSED BY BMR

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA SAN DIEGO

MERCATOR PROJECTION
CONTOURS IN KILOMETERS
CORRECTED FOR SOUND VELOCITY

Prepared by
T.E. Chase, D.E. Karig, D.A. Newhouse, and I.L. Taylor
under the general direction of H.W. Menard

March, 1968

Based on results of NOVA expedition, 1967, and earlier soundings compiled by Australian Hydrographic Office, New Zealand Oceanographic Institute, O.R.S.T.O.M., New Caledonia, U.S. Naval Oceanographic Office and contours by J.W. Brodie, J.R. Conolly, R.L. Fisher, G.B. Udintsev, and E.L. Winterer.

MILES

HORIZONTAL SCALE BETWEEN
20° - 25° LATITUDE SOUTH

0 100 200 300

ABOVE SEA LEVEL
0-1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8 PLUS

Color Separation by C.L. Buffington
Chart Preparation assisted by W. Crocker, J. Crouch, A.J. Henry, L. Hydock, L. Mason, V. Moore, J. Pelagano, M. Schoenbechler, S.M. Smith, A. Turner, and S. Wang

AUSTRALIA

LEGEND

- JOIDES sites completed on Leg XXI
- BMR proposal for drill site on Leg XXIX
- BMR proposal for drill site on Leg XXX
- Major strutural lineament
- Faults interpreted from BMR seismic and aeromagnetic surveys

NEW GUINEA
NEW BRITAIN TRENCH
SOLOMON ISLANDS
SOLOMON RISE
CAPE JOHNSON TROUGH
VITIAZ
SANTA CRUZ ISLANDS
WOODLARK BASIN
PAPUA PLATEAU
BMR 9
BMR 8
POCKLINGTON TROUGH
SOUTH SOLOMON TRENCH
INDISPENSABLE REEFS
NEW HEBRIDES TRENCH
CORAL SEA BASIN
210
209
208
206
BMR 7
BMR 6
BMR 5
BMR 4
BMR 3
GREAT BARRIER REEF
OSPREY REEF
BOUGAINVILLE REEF
MOORE REEF
DIANE BANK
HOLMES REEF
FLORA REEF
FLINDERS REEF
MALAY REEF
KENNINGTON REEF
LIMOU REEF
QUEENSLAND PLATEAU
MELLISH RISE
MELLISH REEF
D'ENTRECASTEAUX FRACTURE ZONE
HEBRIDES TRENCH
MARION REEF
CHESTERFIELD GROUP
NEW CALEDONIA BASIN
LOYALTY ISLANDS
FREDERICK REEF
KENN REEF
SWAIN REEFS
FAIRWAY REEF
SOUTH BELLONA REEF
NOVA BANK
ARGO BANK
KELSO BANK
CAPEL BANK
LORD HOWE RISE
RECORDER GUYOT
MORETON SEAMOUNT
BRISBANE GUYOT
QUEENSLAND GUYOT
BRITANNIA GUYOTS
STRADBROKE GUYOT
MIDDLETON REEF
ELIZABETH REEF
NORFOLK RIDGE
WANGANELLA BANK
DERWENT HUNTER GUYOT
BARCOO BANK
TAUPO BANK
TASMAN ABYSSAL PLAIN
TASMAN BASIN
GASCOYNE SEAMOUNT
Brisbane
Sydney

140° 145° 150° 155° 160° 165° 170°
10° 15° 20° 25° 30° 35°

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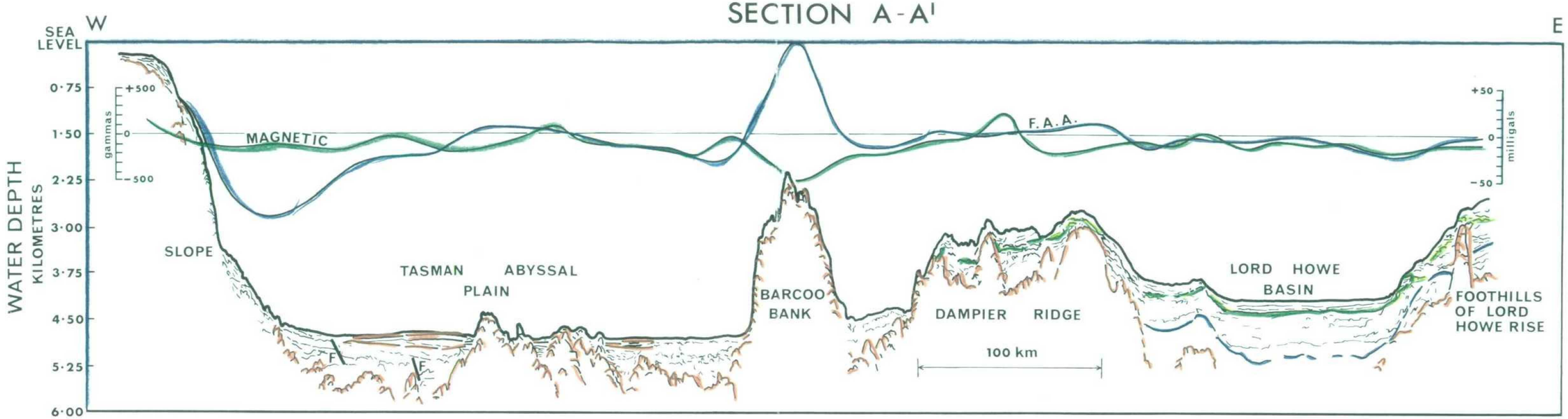
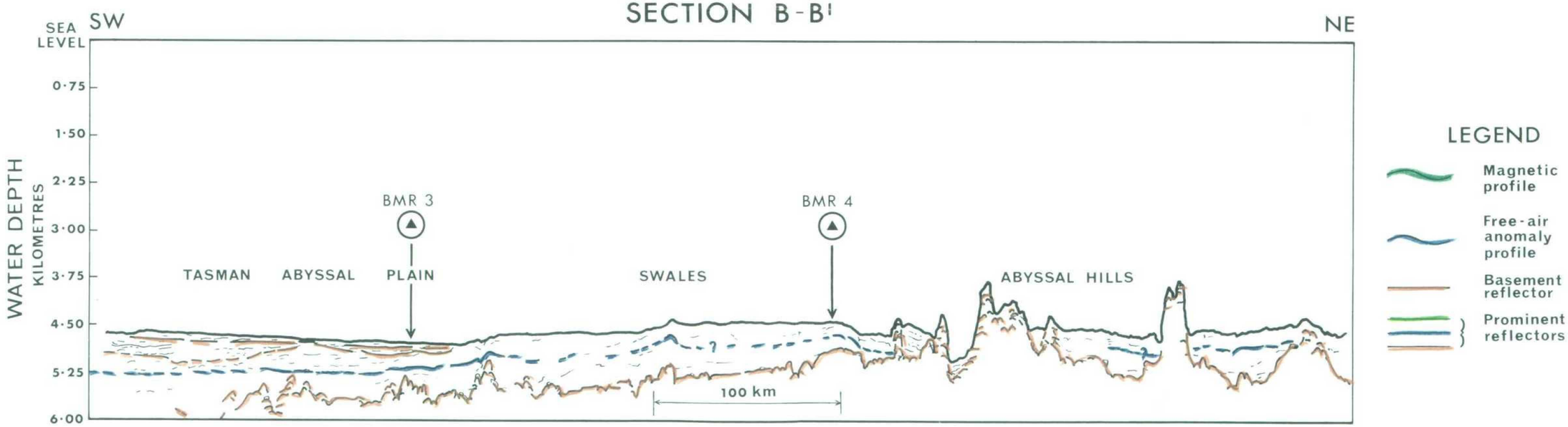
SECTION A-A¹



SECTION B-B¹



SKETCHED SEISMIC SECTIONS
showing locations of proposed sites BMR 3 and BMR 4

To accompany Record No. 1972/111

G85/3-174

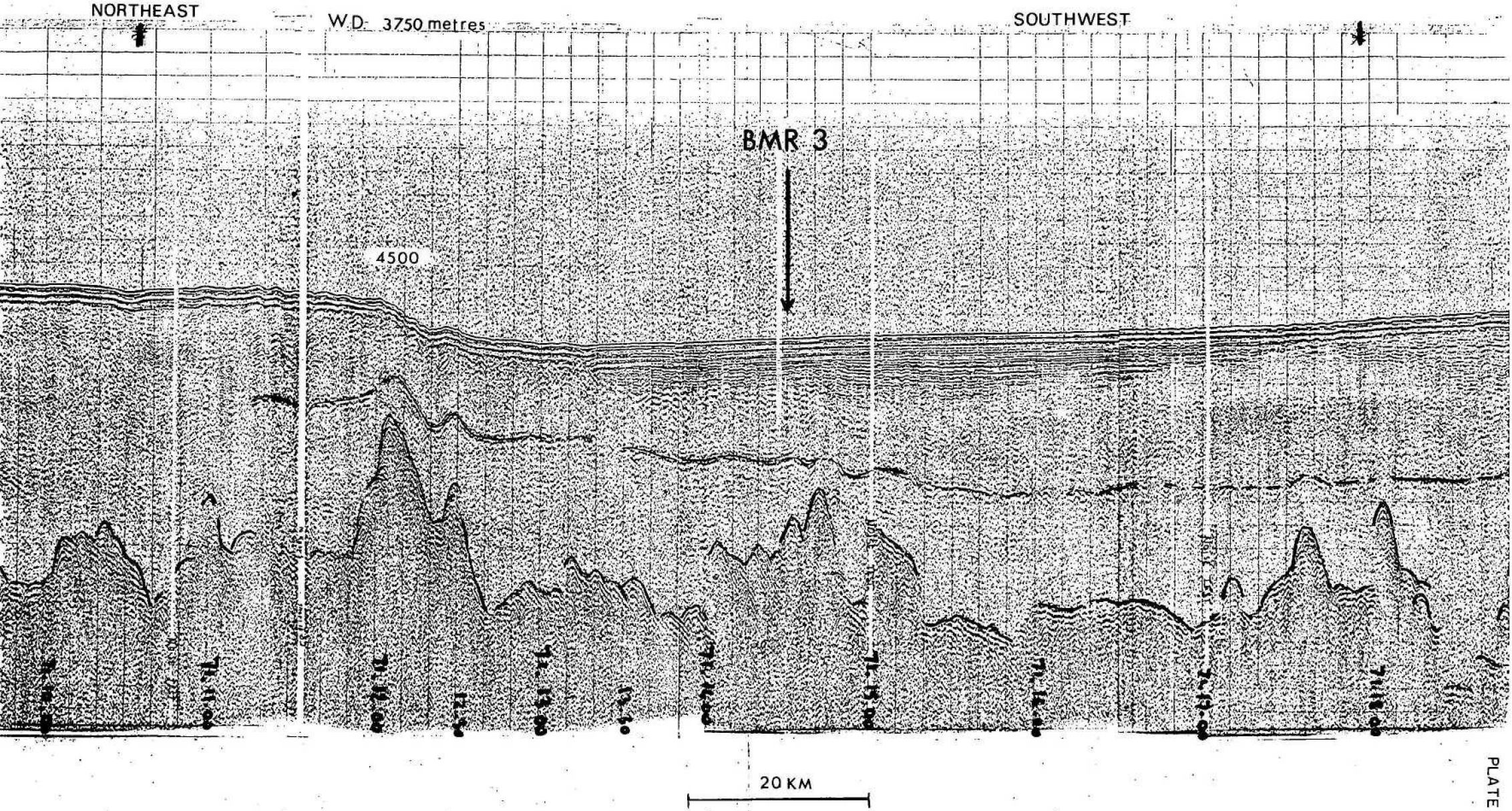
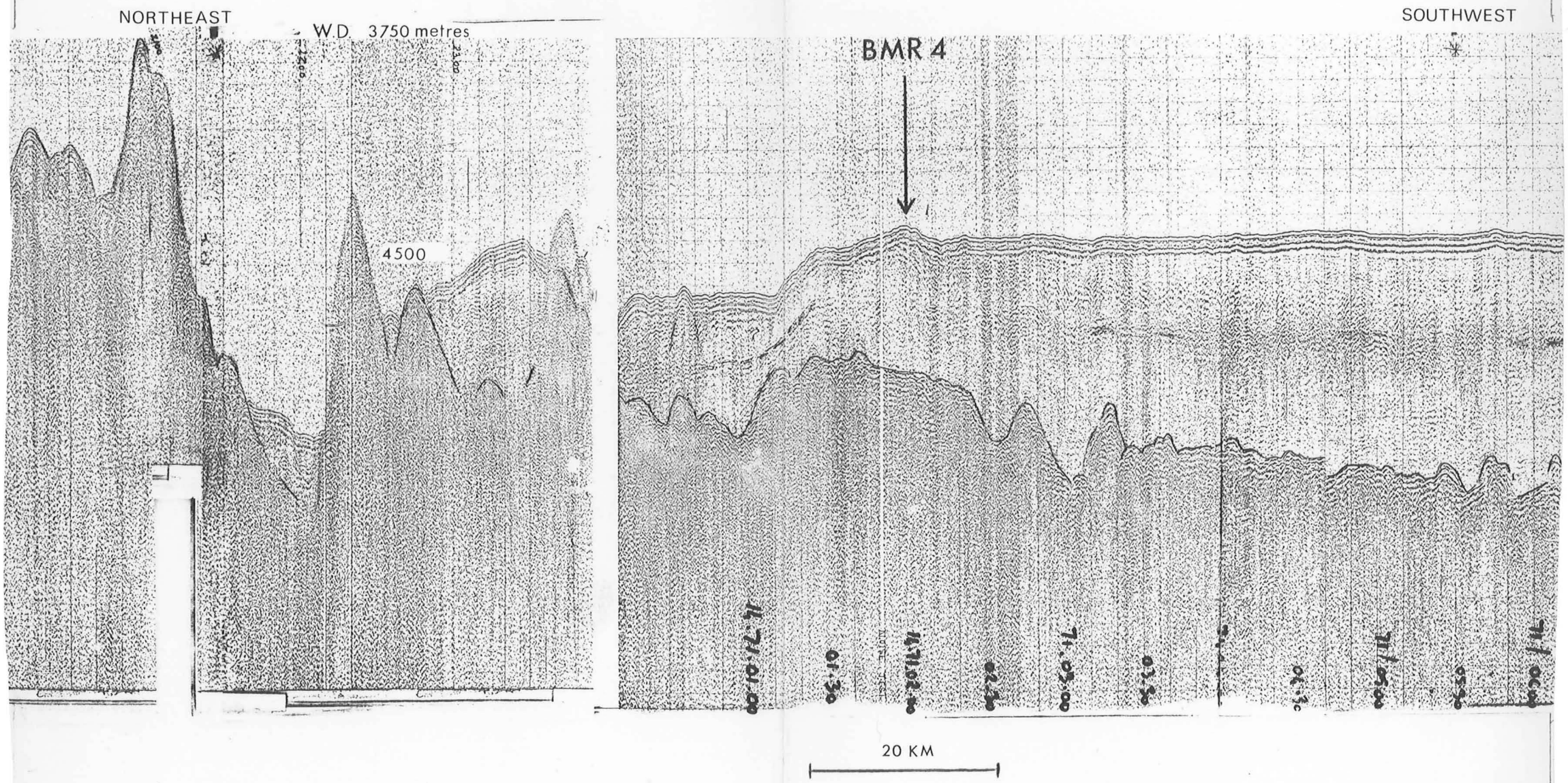
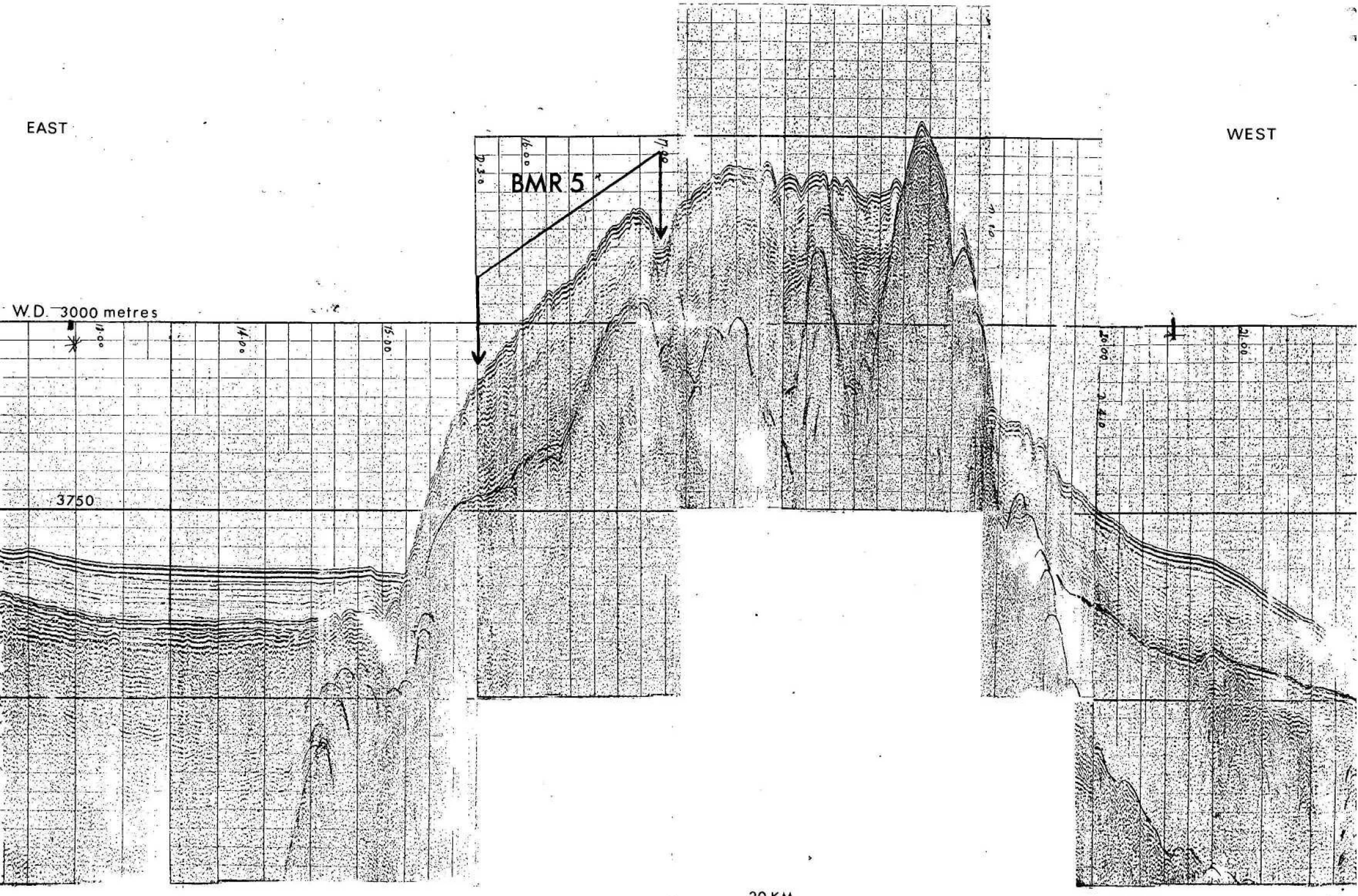


PLATE 8

To accompany Record No. 1972/111

A/B3-4A


NORTHEAST
W.D. 3750 metres
4500
BMR 4
SOUTHWEST
20 KM



To accompany Record No. 1972/111

A/B3-6

PLATE 10