A PROPOSAL FOR ODP-DRILLING ON THE AUSTRALIAN CONTINENTAL MARGIN IN THE OTWAY BASIN/WEST TASMANIA REGION

by

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FOREWORD

This mature proposal for ODP-drilling on the Otway Basin margin, Australia, follows from the preliminary proposal by J.C. Branson (BMR), presented in 'Site proposals for scientific ocean drilling in the Australasian region, Consortium of Ocean Geosciences Publication No. 2, (December 1984). Branson's sites WTM 1-5 are closely related to our proposed ODP sites as follows:-

proposed site OT1	approx. WTM2
proposed site OT2	approx. WTM3
proposed site OT2(a)	approx. WTM1
proposed site OT3	approx. WTM5
new site OT4	

BMR multichannel seismic data obtained on 'Rig Seismic' Cruise 48 (1985) is at present being processed and it is possible that further potential sites will be identified on those lines.

We note that this proposal goes hand-in-hand with that of Hinz & Dostmann (1985) for ODP drilling on the South Tasman Rise.

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SCIENTIFIC OBJECTIVES

The southern margin of Australia (and the Otway Basin region) is a classical passive continental margin which exhibits the effects of considerable crustal extension and transform/transfer fault movements. Sediment cover ranges from moderate (8000 metres or more) beneath the continental shelf and upper slope, to relatively thin on the lower slope and rise. The lower slope region is frequently regarded as a magnetic quiet zone. It is here possible for drilling to penetrate sediments in all three stages of basin development i.e. pre-rift, syn-rift and infra-rift, and post-brakeup.

Modern multichannel seismic reflection data collected by the Australian Bureau of Mineral Resources (backed with information collected by the petroleum industry and BGR, West Germany) enable spectacular cross-sections of the margin to be drawn. During the early extensional phase, basement blocks were mildly to strongly rotated on a deep decollement surface which shallows at the abyssal plain. The boundary between slope and abyssal plain is marked by a suite of these blocks which form en-echelon structural and morphological ridges. Preliminary dating of a dredge haul indicates that Palaeozoic blocks persist oceanward to the foot-of-slope, but the origin of ridges in the remainder of the magnetic quiet zone remains enigmatic. The decollement, and blocks of (?)continental crust in abyssal water depths, bear analogy to the Galicia Margin (Leg 103; Boillot, Winterer & Meyer, 1985).

The seismic stratigraphy of the deepwater Otway Basin (as extrapolated from ties to exploration wells on the shelf) bears some similarity to that of the South Tasman Rise, indicating that the two features may have been juxtaposed prior to breakup. Such a concept needs to be tested: it is crucial to our understanding of the breakup of Australia/Antarctica, since the South Tasman Rise is conventionally shown in its present position throughout the rifting and breakup process. We consider the mechanism and subsidence of the margin to be a major unknown which could be elucidated by determining the facies of the 'rift-fill' sequences. The principal problems to be addressed are:

(1) The dating and the nature of Australian/Antarctic rifting and breakup.
- Was this a multistage, multirate, process or a single event?
- Could oceanic crust have been formed by the Early Cretaceous?
- Where is the ocean/continent boundary?
- What is the nature of the decollement surface?

(2) The environments of deposition associated with rifting and breakup.
- Were the rift-fill facies largely fluvial-lacustrine or could they have been bathyal marine?
- What were the effects of Late Cretaceous wrenching on the rift-fill sequences?
- Did the uplifted outer margin of the Otway Basin create a shallow stable sea for deposition of the Palaeogene prograded sequences?
- What were the effects of Eocene wrenching, created by continental contact of the Australian and Antarctic plates along the western margin of Tasmania?

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(3) Dating of the regional seismic unconformities

- Which of these are due to tectonics, and which are of eustatic origin?
- This is a type area for preparation of global sealevel curves (Vail & others, 1977).

(4) Detailed biostratigraphical control

- World-wide correlation of Cenozoic sealevel changes.
- Obtain high-latitude plankton-biogeographic record, particularly for the Late Cretaceous and Palaeogene.

PROPOSED SITE LOCATIONS AND ALTERNATIVE SITES

We propose four non-reentry sites and one alternative site, with an estimated drilling time for four sites of 43 days. If all four sites were drilled the history of development of this part of the Australian margin, and indeed the conjugate Antarctic margin, would be well understood. The nature and age of basement and of the overlying sedimentary sequences could be used in establishing a strongly based model for two-stage breakup with both extensional and wrench components. All sites would add considerably to our knowledge of high-latitude faunas, palaeoenvironment and palaeoclimate.

Site OT1 (40°48.5's, 141°50.2'E; water depth 4130 m)

This site is on the outermost of a series of high blocks which dip back toward the land. The hole should penetrate largely Paleogene and Cretaceous sedimentary rocks and bottom in basement. Whether the basement is continental or oceanic, how old the overlying sediments are, and what water depths they were laid down in, are questions of wide relevance in the process of continental margin development.

Site OT2 (40°30.4'S, 142°01.2'E; water depth 3907 m)

This site is on the second high block up from the abyssal plain which, like the outermost block, dips landward. The hole should penetrate more Neogene sequence than OT1, and a rather different Paleogene and Cretaceous sequence. It is believed that it will bottom in Early Cretaceous non-marine clastic sediments, but it is possible that these may be of Palaeozoic age. The site is complementary to OT1 in establishing the process of continental margin development before, during and after Australia/Antarctia breakup. Site OT2A is a rather similar alternative.

Site OT3 (40°40.0'S, 142°46.0'E; water depth 3226 m)

This site higher on the lower slope is designed to investigate a suite of apparently similar Late Cretaceous to Eocene prograding sequences, which appear to have been laid down slowly in very similar shelfal water depths during slow marginal subsidence. These sequences with their numerous unconformities should help refine curves of global sea-level changes, developed largely on this margin. Furthermore, their history will add considerably to the story of margin development revealed by Sites OT1 and OT2.

Site OT4 (41°26.9'S, 142°01.9'E; water depth 4750 m)

This site on the abyssal plain south of the Otway Basin, is an absolutely key hole in the unravelling of the development of this region. We predict that it will penetrate a thick Cretaceous sequence overlying Early Cretaceous oceanic basement. If we are correct, this would place the first phase of breakup much earlier than proposed by earlier workers. The overlying sequences must be of great interest, palaeoceanographically and palaeontologically.

BACKGROUND INFORMATION

Data

Forty-five exploration wells have been drilled in the Otway Basin of which 16 are offshore (Figure 1). Most are available on open file within BMR. The sparsely cored DSDP Site 282 (Kennett, Houtz, & others, 1974) lies in the deepwater southeastern extremity of the basin, but in a similar structural/stratigraphic setting to the region of the proposed ODP sites.

Regional multichannel seismic data have been collected over the shelf and deepwater areas by BMR (1982 GSI, Survey 40 & 1985 'Rig Seismic', Survey 48 cruises). Shell lines ('Petrel' survey) are available as 2-fold optical stack sections with the key lines reprocessed and migrated (Figure 6).

Regional sparker data (BMR Continental Margins Survey, 1970-73) and, seismic detailing by the petroleum industry are also available (Figure 7). Lamont-Doherty ('Eltanin' Legs 47 & 55) single channel monitor records provide reasonable control at abyssal depths.

Structure and Tectonics

The southern margin of Australia is underlain by a band of extensional basins, almost 2000 km in length (inluding the Bremer, Eyre, Great Australian Bight, Duntroon, and Otway Basins) which developed in Jurassic and Early Cretaceous times, as a precursor to breakup of the Australian-Antarctic supercontinent (Figures 8 & 9).

Breakup was originally dated as early Eocene (anomaly 22, 52 m.y.) by Weissel & Hayes (1972), but more recently Cande & Mutter (1982) have revised the identification of magnetic anomalies and conclude that margin formation commenced in the Santonian (Anomaly 34, 90 m.y.). This is coincident with the onset of seafloor spreading in the Tasman Sea (Weissel & Hayes, 1977). Cande & Mutter (1982) postulate a period of slow spreading from 90 to 43 m.y. ago, followed by more normal spreading rates to the present.

The revised spreading history is more in accord with the findings of Willcox (1978) and studies currently being completed by Willcox & Symonds (in prep.) which, on the basis of stratigraphic evidence, postulate that:

- Cretaceous sediments (and not Eocene sediments) lie directly on oceanic

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basement in the Great Australian Bight. The oldest basement may, in fact, be of Early Cretaceous age (e.g. Site OT4).

- Marine conditions became established in the Great Australian Bight and Otway Basins in the Late Cretaceous, suggesting breakup and thermal subsidence of the margin in the Late Cretaceous (although a eustatic highstand could have produced a similar effect).

In the southeastern Otway Basin region the breakup process appears to have been complicated by considerable crustal extension during the early rift-phase, together with wrenching episodes in the Late Cretaceous and again within the Eocene (Figure 10), due to left-lateral movement of the Australian and Antarctic Plates.

Blocks of possible continental crust, rotated on a deep decollement surface, now appear to form a series of en echelon ridges in abyssal depths. Their continental affinity is supported by recent dredging of Palaeozoic metasediments ('Rig Seismic', 1985) and their stratified appearance on migrated seismic sections (Figure 11).

Recently, stratigraphic considerations (Hinz, Willcox et al., 1985; Hinz & Dostmann, 1985; also Robertson et al., 1978) have led to suggestions that the southeastern Otway Basin and the South Tasman Rise were juxtaposed until about Eocene time (Figure 12).

Stratigraphy

The Otway Basin stratigraphic column is shown in Figure 13.

The most effective seismic correlation to deep water has been made using BMR Line 40-22/23 through the exploration well, Prawn No. 1 (Figure 10). We consider that the stratigraphic ages and facies interpretations made on this line are broadly applicable to the deepwater Otway basin as a whole, and are consistent with the revised breakup history.

Our interpretation shows fourteen well-defined unconformities (U1 to U14) in the southeast Otway Basin, many of which separate distinctive seismic sequences. On the adjacent BMR Line 40-21/24, extending westwards from Clam No. 1, a further four mild unconformities are evident in the Early Tertiary progradational units. The ages, characteristics and tectonic significance of the sequences bounded by U1 to U14 are given in Figure 14.

Geohistory

The mechanism for margin rifting and subsidence, and its timing, is a largely unknown factor in the Otway Basin region. The seismic stratigraphy, and the supposed slow passage of the Southeast Indian Ocean spreading ridge eastward along this part of the margin, may indicate that it was at relatively shallow depths until the mid-Oligocene. However, the possibility remains that the infrarift sediments were deposited under bathyal conditions (2600 m) and this needs to be resolved by drilling.

In Figures 15, 16 & 17 we show synthetic geohistory plots at proposed ODP Site 2 on BMR seismic line 40-23 prepared using a program provided by D.A. Falvey. Three options are explored:

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Option 1 - continental/shallow marine infrarift sedimentation.
Option 2 - bathyal infrarift sedimentation with 'transpressional' uplift in the Late Cretaceous.
Option 3 - as option 1, but with 500 m erosion in Late Cretaceous, and 100 m erosion in mid-Oligocene.

Palaeoceanography and Biostratigraphy

The progressive separation of Antarctica and Australia provides a situation where climate and latitude have varied with time, but latitudes have been high throughout Cretaceous and Paleogene times.

The biostratigraphic control on our limited records of geohistorical and biohistorical changes in the Australia-Antarctica spreading area during the critical Late Cretaceous-Early Tertiary interval has been less than adequate. Carefully cored sections in appropriate oceanic facies will clarify the following:

(i) Cross-correlation between high-latitude and low-latitude (i.e. 'standard') biostratigraphic systems;

(ii) Cross-correlation between oceanic and neritic successions including marginal marine dinoflagellate successions;

(iii) Cross-correlation between marine and non-marine - principally terrestrial palynomorph - successions.

There are two additional matters. One is that an analysis of the early record of separation will bear on the arrival of the Australian fauna. The other is the entrenched belief that the Australian climate, landscape and biotas changed progressively as Australia drifted north - a shibboleth to some, misleadingly simplistic to others, and in need of testing.

ANALOGUES

The Otway Basin margin of Australia is similar in some respects to the Armorican margin of Biscay and the Galicia margin which was drilled on Leg 103 (Roberts & Montadert, 1980; Boillot, Winterer & Meyer, 1985). Under the lower continental slope in the Otway Basin, several tilted blocks of possible Cretaceous syn-rift and Palaeozoic basement rocks, appear to bottom on a listric fault and/or decollement surface. This is similar to the 'S' surface shown by Roberts & Montadert (1980) on seismic profiles south of Goban Spur. Sediments immediately overlying the Otway Basin decollement may be penetrated in proposed sites OT1 and OT2. It is of interest to know if this deep reflector represents the ductile/brittle crustal boundary, or a metamorphic boundary, or is simply a substratum of syn-rift sediments as on the Galicia margin.

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ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: OT1 OTWAY BASIN
(Figs. 1, 2, 6, 18) BMR 40-24: SP520
NW Tasmania Australia

General Area: Otway Basin Continental margin
Position: 40°48.5'S, 141°50.2'E
Alternate Site:

General Objective: Continental margin development during two-stage breakup of Australia/Antarctica

Thematic Panel interest: LITHP, SOHP, TECP
Regional Panel interest: IO-RP, SO-RP

Specific Objectives:

- Test basement age and nature (continental or oceanic) in a magnetic quiet zone on outermost high block
- Investigate nature, age and paleowater depths of overlying sediments
- Monitor the biofacies changes in a new ocean in high paleolatitudes
- Provide an important local record of presumably worldwide sea-level changes in the Cretaceous and Tertiary

Background Information:

Regional Data:

Seismic profiles: BMR 1982 multichannel radiopositioned; Shell Petrel 1973 & BMR 1985 multichannel satellite positioned.

Other data: BMR 1970-72 (6-fold) satellite positioned

Site Survey Data - Conducted by: BMR

Date: May 1982

Main results: Thin Cainozoic pelagic cover and Tertiary and Late Cretaceous sequences over ?Pz basement.

Operational Considerations

Water Depth: (m) 4130 **Sed. Thickness: (m)** 970 **Total penetration: (m)** 1000

HPC Yes **Double HPC** ____ **Rotary Drill** Yes **Single Bit** Yes **Reentry** No

Nature of sediments/rock anticipated: 40 m Neogene ooze; 330m Paleogene shallow marine sediments; 600 m Cretaceous non-marine and marine clastics; 30 m Pz basement

Weather conditions/window: Exposed westerly

Territorial jurisdiction: Australia, Tasmania Adjacent Area

Other: Drilling time estimated as 11 days

Special requirements (Staffing, instrumentation, etc.)

Wireline logs

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Rev.

ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: OT2, OTWAY BASIN
(Figs. 1, 3, 6)
BMR 40-23 : SP 1080

General Area: Otway Basin continental margin
Position: 40°30.4'S, 142°01.2'E
Alternate Site: OT2A

General Objective: Continental margin development during two-stage breakup of Australia/Antarctica

Thematic Panel interest: LITHP, SOHP, TECP
Regional Panel interest: IO-RP, SO-RP

Specific Objectives:

- Test nature and age (Cretaceous or basement) of high block away from margin
- Investigate nature of sedimentary sequence
- Provide data for palaeo-environment models
- Study Austral Cretaceous and Paleogene fossil faunas
- Provide an important local record of presumably world-wide sea-level changes in the Cretaceous and Tertiary

Background Information:

Regional Data:

Seismic profiles: BMR 1982 multichannel, radio positioned; Shell Petrel 1973 & BMR 1985 multichannel satellite positioning

Other data: BMR 1971 (6-fold), satellite positioned

Site Survey Data - Conducted by: BMR

Date: May 1982

Main results: Seaward tapered edge of a shallow basin; sequences can be traced into adjacent areas

Operational Considerations

Water Depth: (m) 3907 **Sed. Thickness: (m)** 1000 **Total penetration: (m)** 1000

HPC Yes **Double HPC** _____ **Rotary Drill** Yes **Single Bit** Yes **Reentry** No

Nature of sediments/rock anticipated: 200 m Neogene ooze; 360 m Paleogene shallow marine clastics; 340 m Late Cretaceous shallow marine clastic sediments; 100 m E. Cretaceous non-marine clastics.

Weather conditions/window: exposed, westerly weather

Territorial jurisdiction: Australia, Tasmania Adjacent Area

Other: Drilling time estimated as 11 days

Special requirements (Staffing, instrumentation, etc.)

Wireline logs

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ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: OT2A, OTWAY BASIN (Figs. 1,3,6,18)
BMR 40-24:SP 1080

General Area: NW Tasmania, Australia
Otway Basin continental margin

Position: 40°44.4'S, 142°17.2'E

Alternate Site:

General Objective: Continental margin development during two-stage breakup of Australia/Antarctica

Thematic Panel interest: LITHP, SOHP, TECP

Regional Panel interest: IO-RP, SO-RP

Specific Objectives:

- Test nature and age (Cretaceous or basement) of high block away from margin
- Investigate nature of sedimentary sequence
- Provide data for paleo-environment models
- Study Austral Cretaceous and Paleogene fossil faunas
- Provide an important local record of presumably world-wide sea-level changes in the Cretaceous and Tertiary.

Background Information:

Regional Data:

Seismic profiles: BMR 1982 multichannel, radiopositioned
Shell 1973 & BMR 1985 multichannel, satellite positioned

Other data: BMR 1971 (6-fold), satellite positioned

Site Survey Data - Conducted by: BMR

Date: May 1982

Main results: Seaward tapered edge of a shallow basin; sequences can be traced into adjacent areas.

Operational Considerations

Water Depth: (m) 3974 **Sed. Thickness: (m)** 1100 **Total penetration: (m)** 1100

HPC Yes **Double HPC** _____ **Rotary Drill** Yes **Single Bit** Yes **Reentry** No

Nature of sediments/rock anticipated: 220 m Neogene ooze; 530 m Paleogene shallow marine clastics; 290 m Late Cret. shallow marine clastics; 60 m E. Cret non-marine clastics.

Weather conditions/window: Exposed westerly weather.
Australia; Tasmania adjacent area

Territorial jurisdiction:

Other: Drilling time estimated as 11 days

Special requirements (Staffing, instrumentation, etc.)

Wireline logs

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ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: OT3, OTWAY BASIN (Figs. 1, 4, 6, 18) BMR 40-24: SP 1700

General Area: NW Tasmania, Australia
Position: 40°40.0'S, 142°46.0'E
Alternate Site:

General Objective: Continental margin development during two-stage breakup of Australia/Antarctica

Thematic Panel interest: SOHP, TECP
Regional Panel interest: IO-RP, SO-RP

Specific Objectives:

- Study changes in sediment type and date unconformities in prograding Late Cretaceous and Paleogene sequences. Why so little sinking over such a long period?
- Obtain detailed biostratigraphic data for use in world-wide correlation of Cretaceous and Paleogene sea-level changes and establishment of high-latitude plankton-biogeographic record.

Background Information:

Regional Data:

Seismic profiles: BMR 1982 multichannel , radiopositioned, Shell Petrel 1973 & BMR 1985 multichannel, satellite positioned

Other data: BMR 1971-73 (6-fold) satellite positioned

Site Survey Data - Conducted by: BMR

Date: May 1982

Main results: Older sequences open to the seafloor which present no hydrocarbon trap risk

Operational Considerations

Water Depth: (m) 3226 **Sed. Thickness: (m)** 1000 **Total penetration: (m)** 1000

HPC Yes **Double HPC** ____ **Rotary Drill** Yes **Single Bit** Yes **Reentry** No

Nature of sediments/rock anticipated: 100 m Neogene ooze; 120 m Eocene shelf clastics; 240 m E. Eocene shelf clastics; 330 m Paleocene shelf clastics; 220 m L. Cret shelf clastics.

Weather conditions/window: High swell, open to westerly gales

Territorial jurisdiction: Australia, Tasmania Adjacent Area

Other: Drilling time estimated as 10 days.

Special requirements (Staffing, instrumentation, etc.)

Wireline logs

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ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: OT4, OTWAY BASIN (Figs. 1, 5, 6)
Eltanin 47 : Day 110, 1555

General Area: W. Tasmania, Australia
Abyssal plain off Otway Basin

Position: 41°26.9'S, 142°01.9'E

Alternate Site:

General Objective: Dating and nature of Australian/Antarctic two-stage rifting and breakup.

Thematic Panel interest: LITHP, SOHP, TECP

Regional Panel interest: IORP, SORP

Specific Objectives:

1. Nature and age of presumed oldest oceanic crust in the region
2. Environments of deposition of overlying sediments-bathyal or shallow marine?
3. Detailed high-latitude biogeographic record of Cretaceous and Paleogene sequences

Background Information:

Regional Data:

Seismic profiles: Eltanin Legs 47 & 55

Other data:

Site Survey Data - Conducted by: Lamont-Doherty Eltanin Leg 47.

Date: 1971

Main results: The continental rise ends in a flat, sedimented area of depressed oceanic basement of possible Early Cretaceous age about 100 km wide on which this site is located.

Operational Considerations

Water Depth: (m) 4750 **Sed. Thickness: (m)** 730 **Total penetration: (m)** 800

HPC Yes **Double HPC** ____ **Rotary Drill** Yes **Single Bit** Yes **Reentry** No

Nature of sediments/rock anticipated: 180 m Cainozoic ooze, 100 m Late Cretaceous marine clastics, 450 m Early Cretaceous marine or non-marine clastics, 70 m ?oceanic basement

Weather conditions/window: Exposed westerly weather

Territorial jurisdiction: Australia; Tasmania adjacent area

Other: Drilling time estimated as 11 days

Special requirements (Staffing, instrumentation, etc.) Wireline logs.

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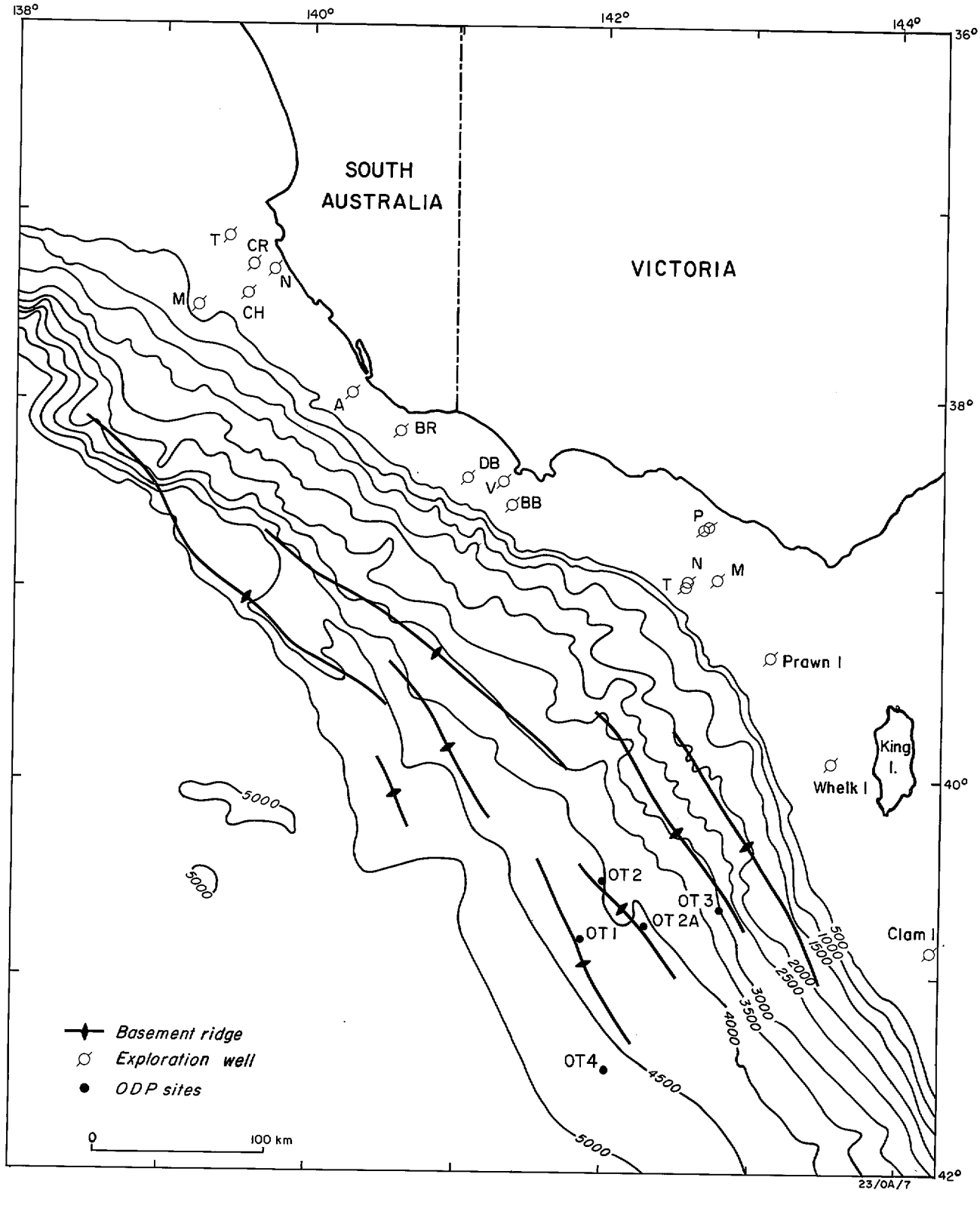

Figure 1. Bathymetry of Otway Basin showing basement ridges and proposed ODP sites.

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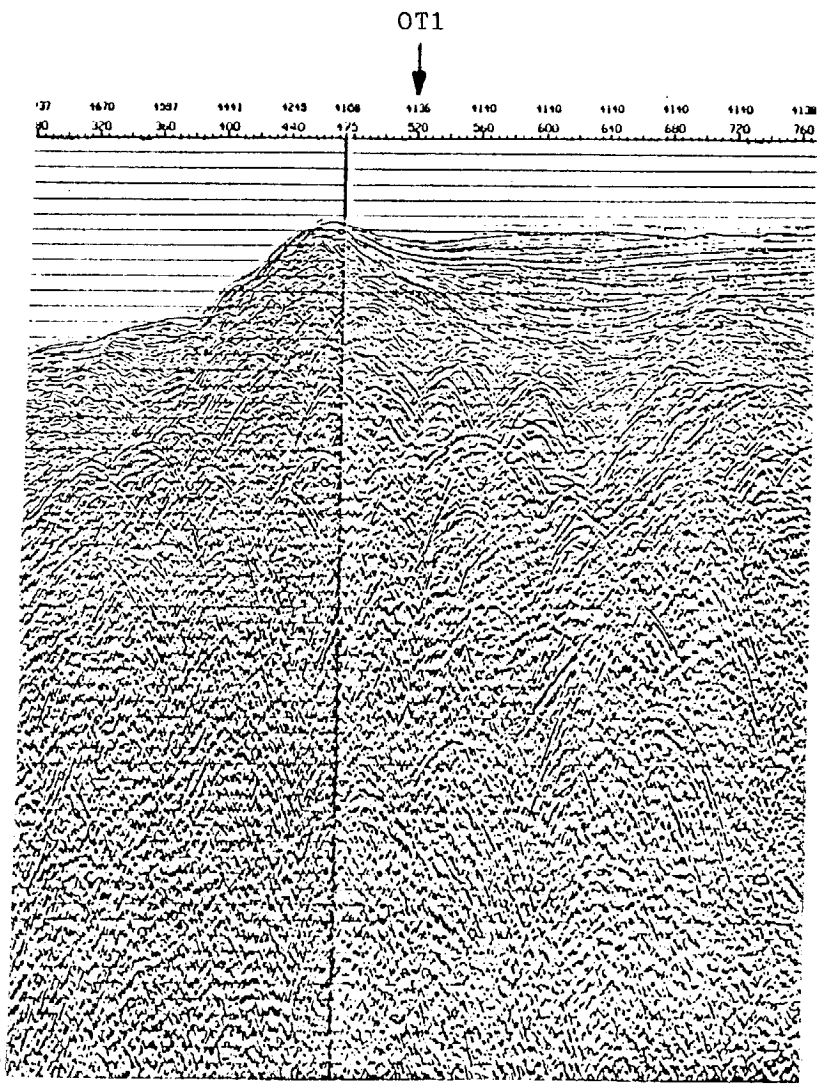
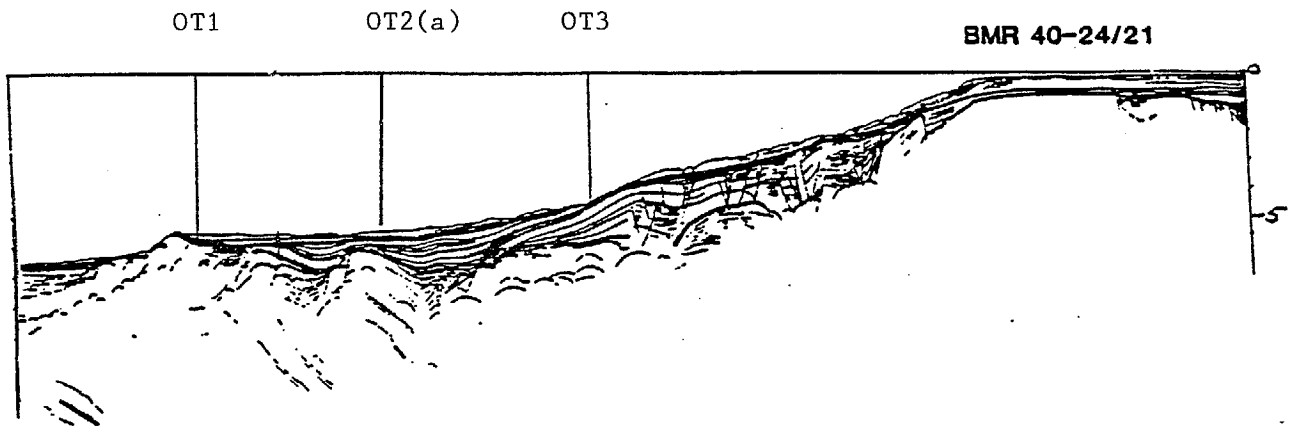
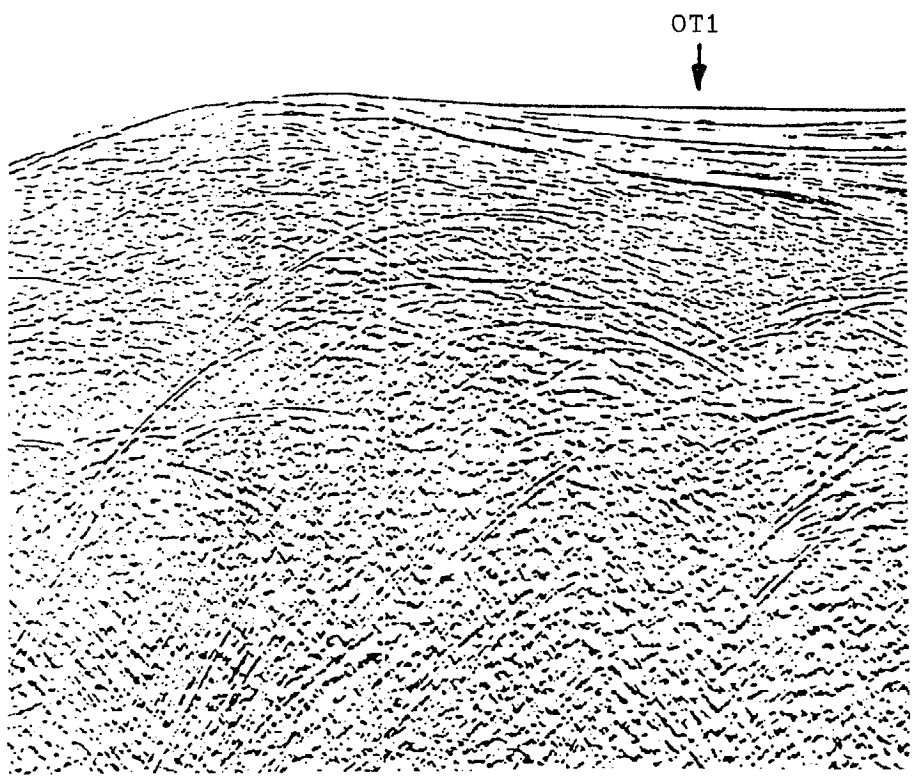
Figure 2. Seismic section showing proposed Site OT1 and line drawing of BMR40-24/21.







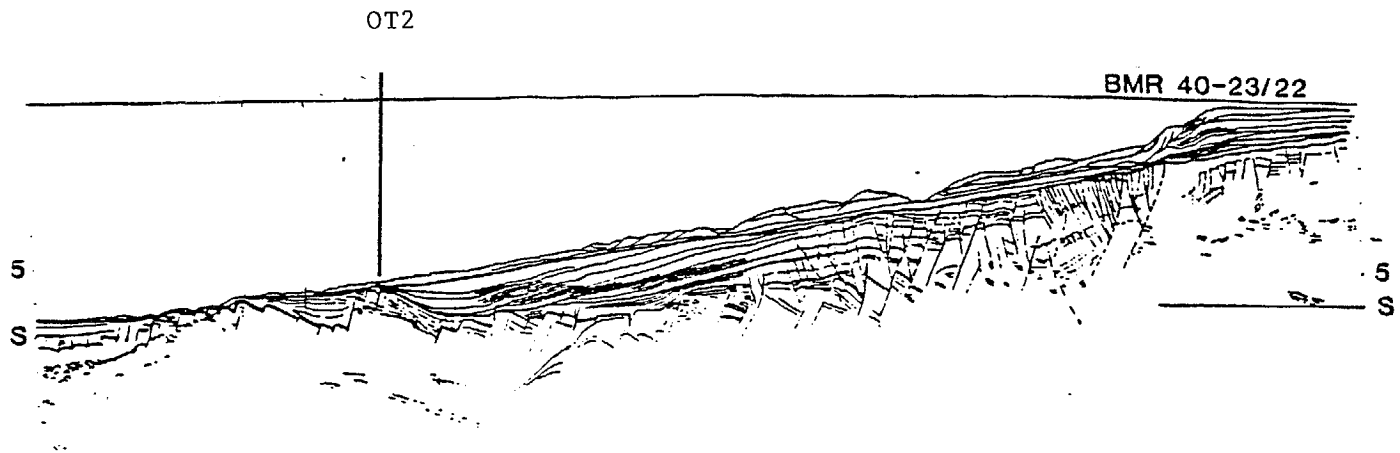
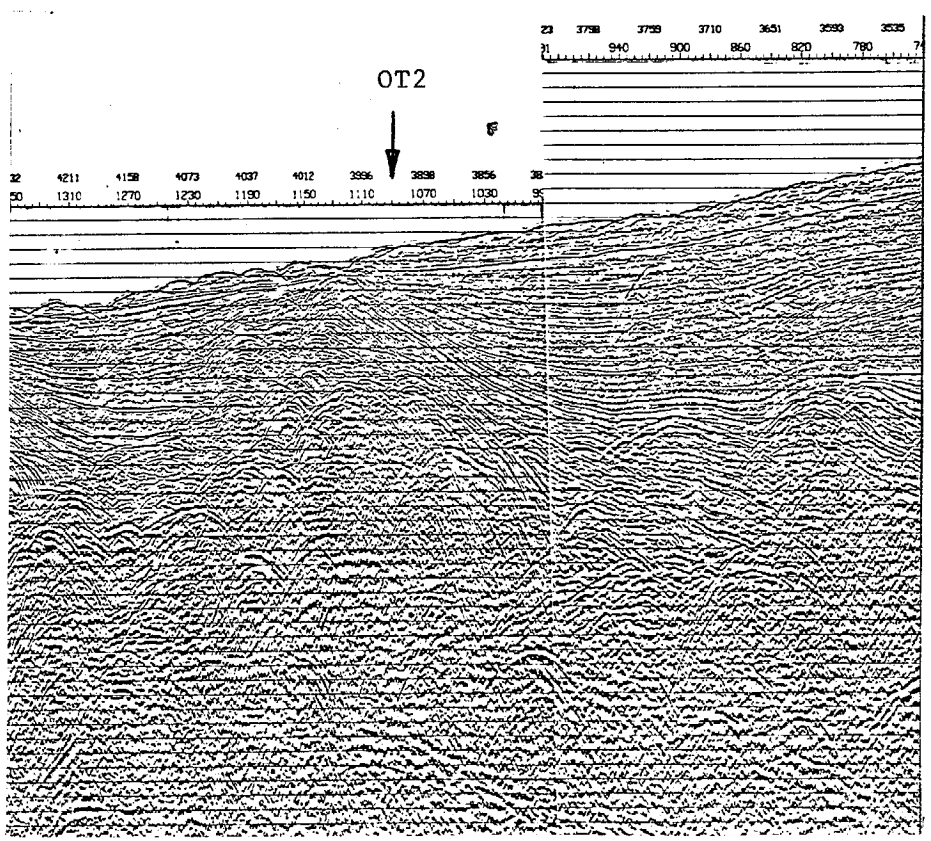
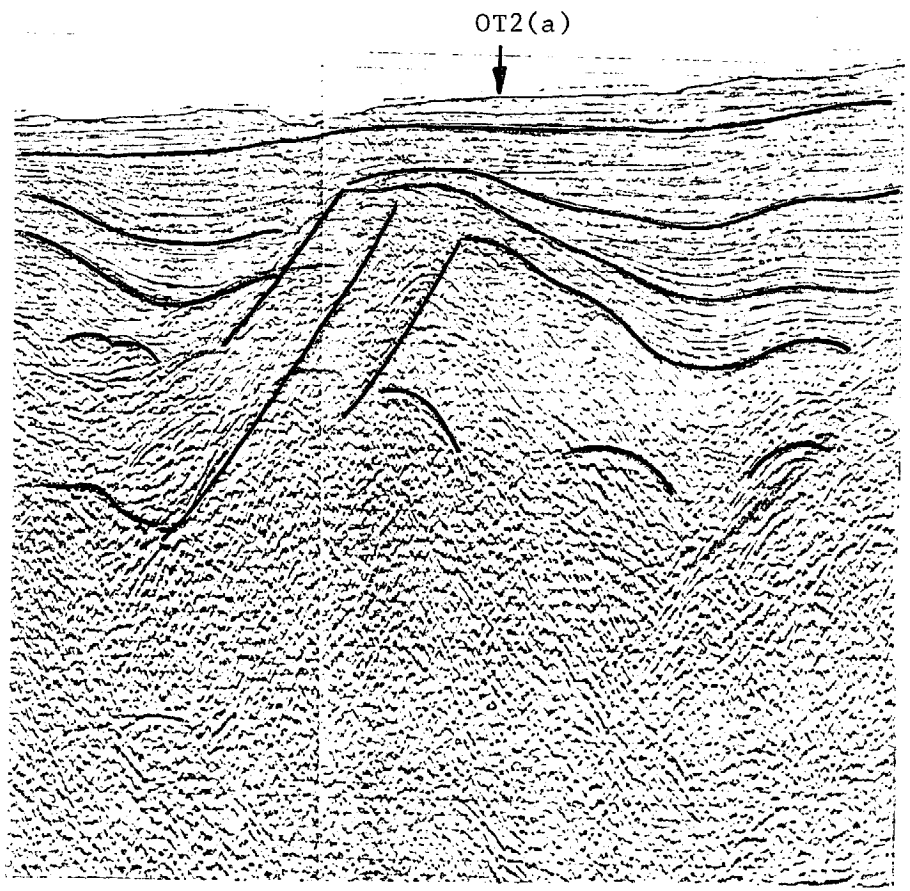


Figure 3. Seismic sections showing proposed Site OT2 and alternative Site OT2(a) and line drawing of BMR40-23/22.





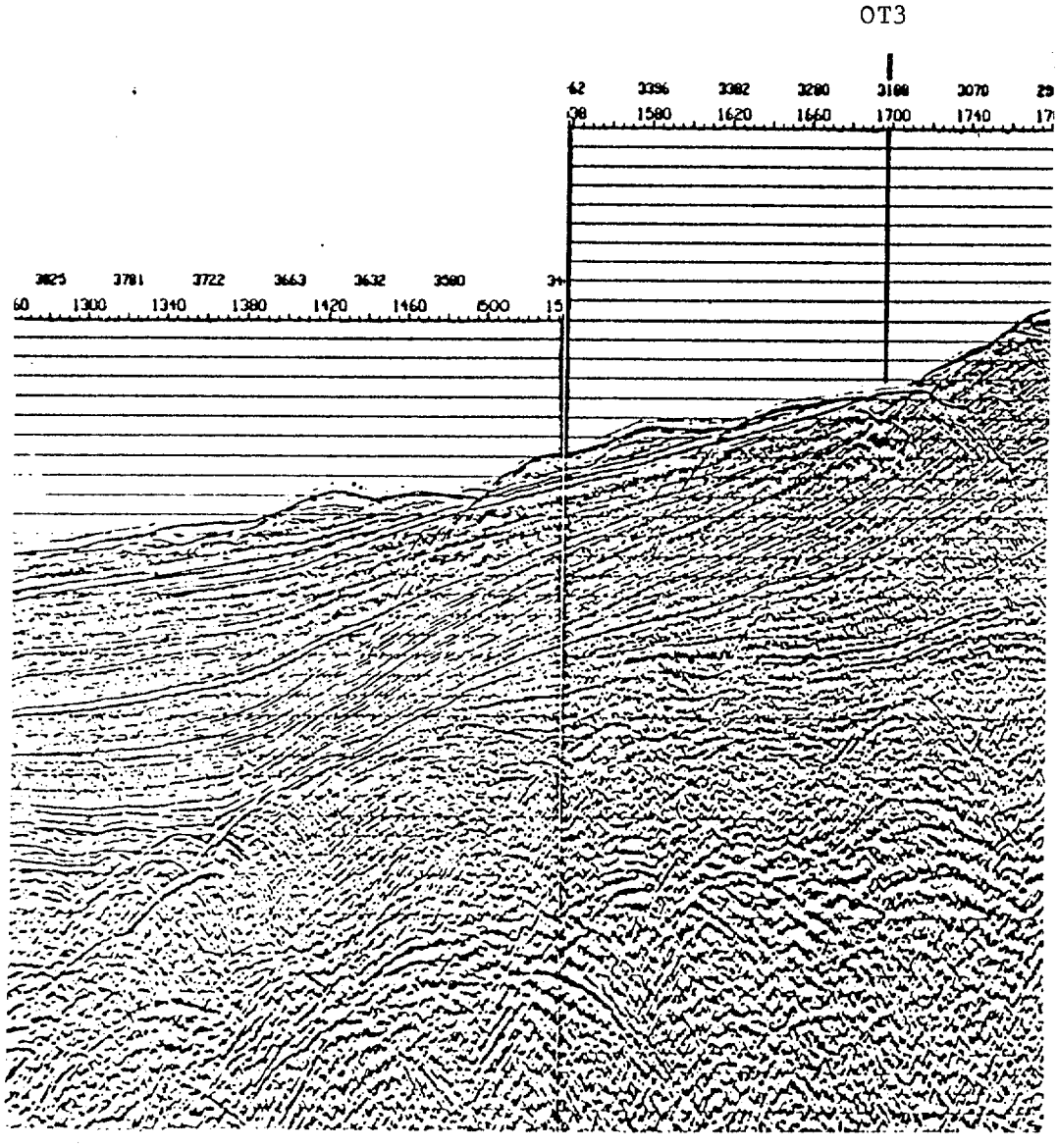


Figure 4. Seismic section showing proposed Site OT3.

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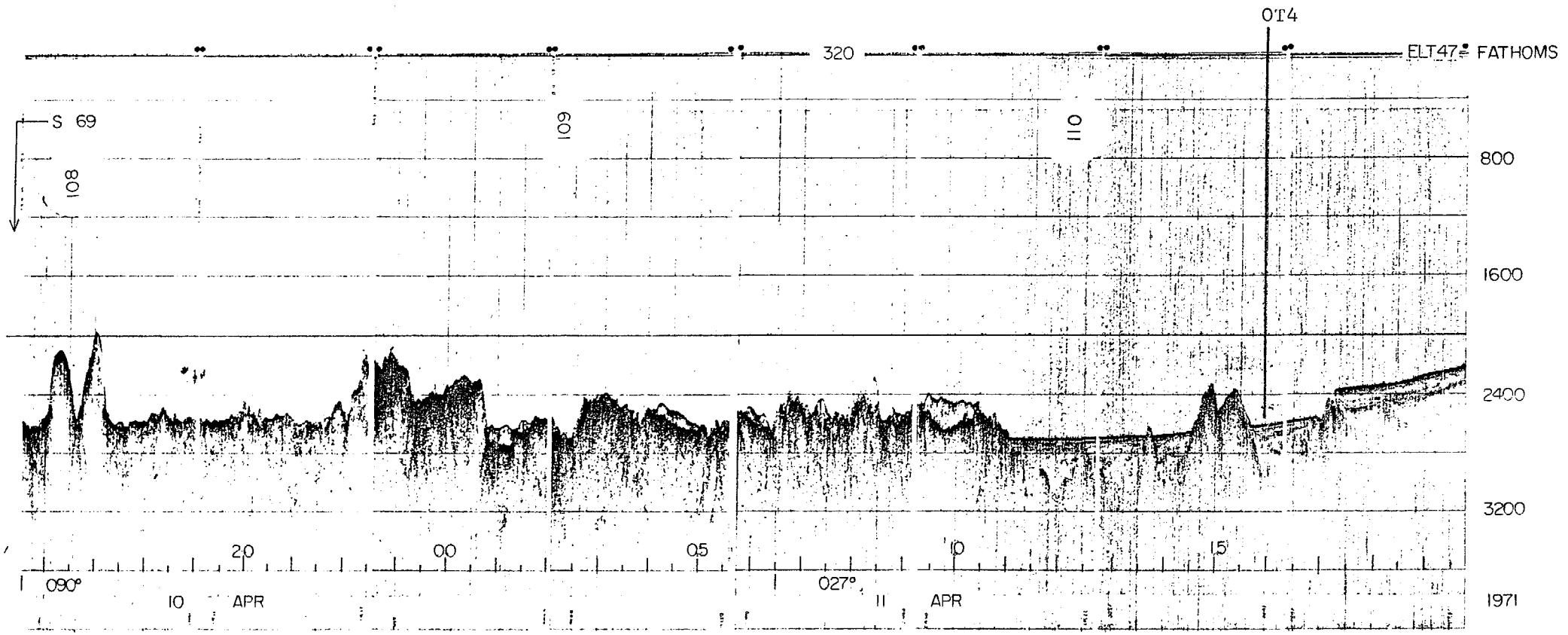


Figure 5. Seismic section showing proposed Site OT4 (Eltanin 47)

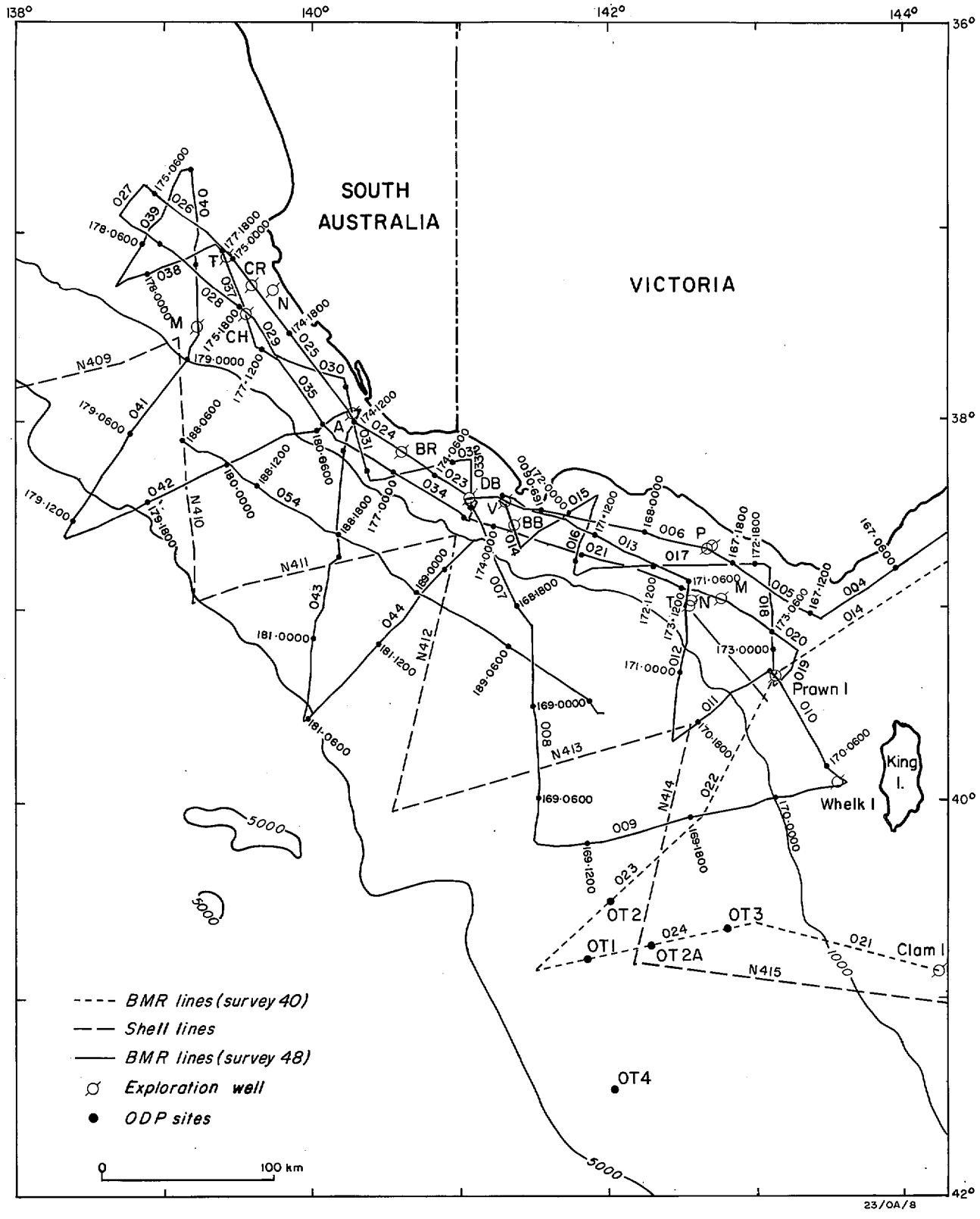


Figure 6. Coverage of high-quality regional and deepwater seismic survey lines, location of exploration wells, and proposed ODP Sites.

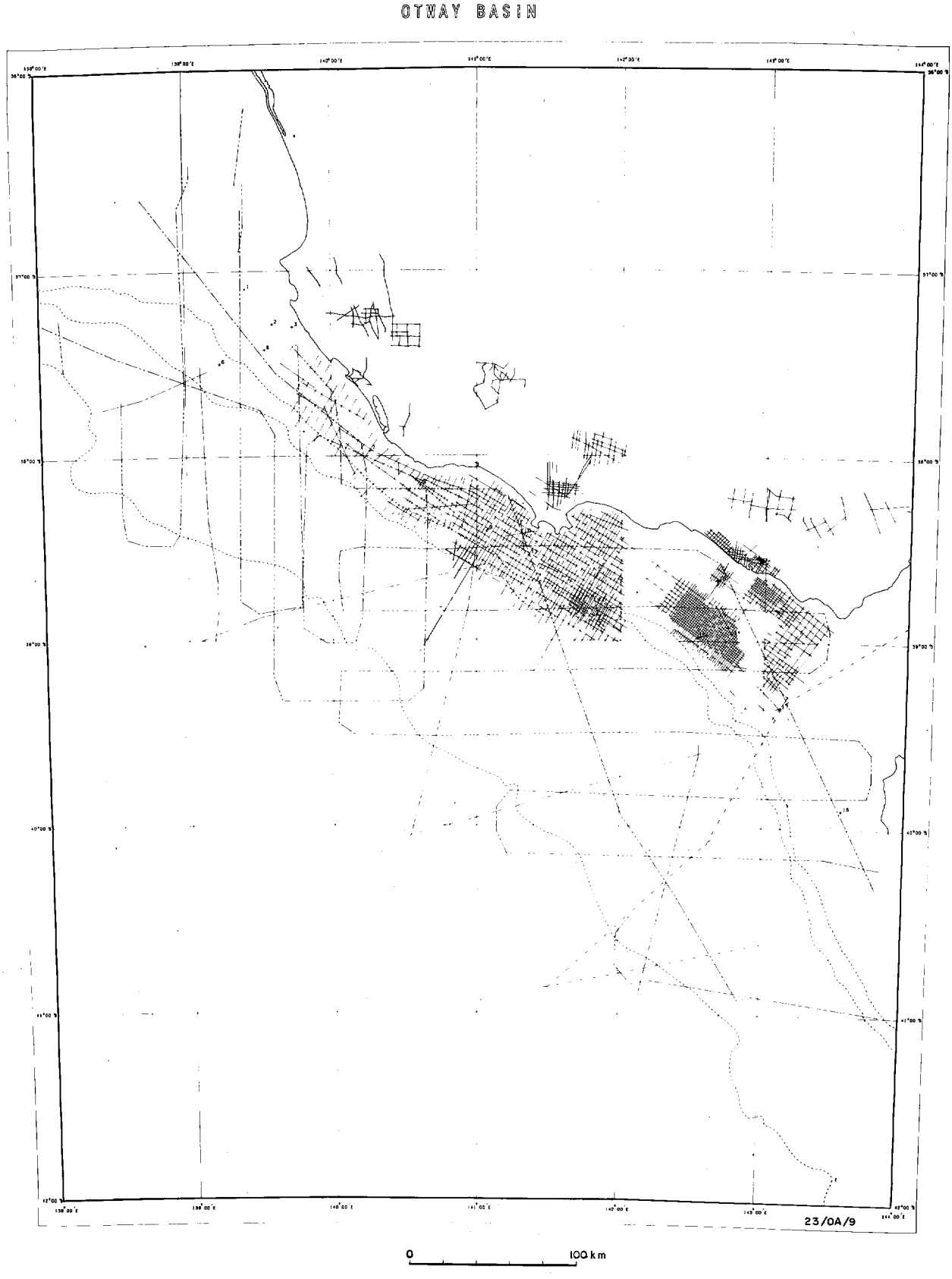


Figure 7. General coverage of seismic survey lines, including detailing in exploration areas.

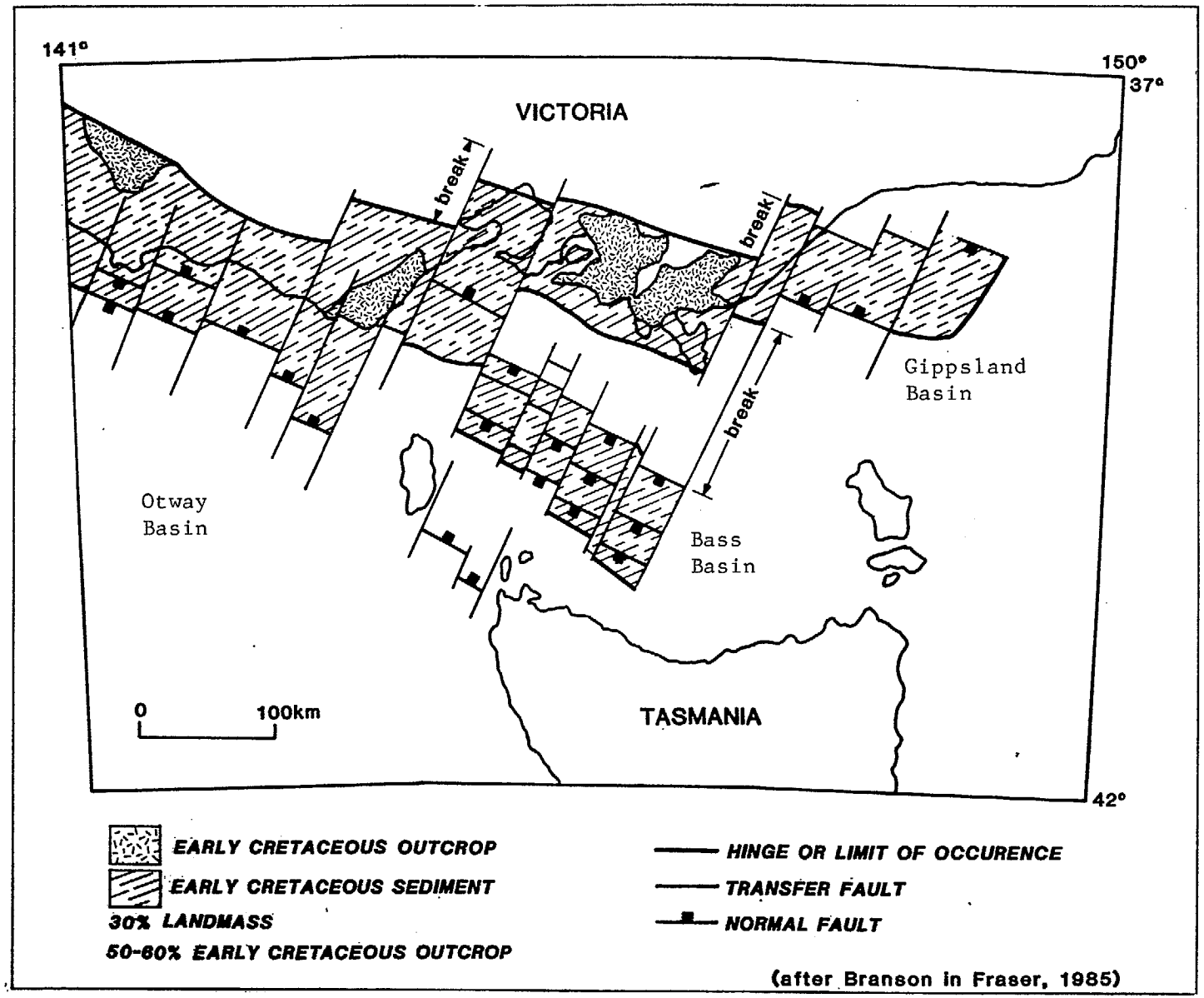


FIGURE 8
Map of Early Cretaceous
extensional basins across
Bass Strait

23

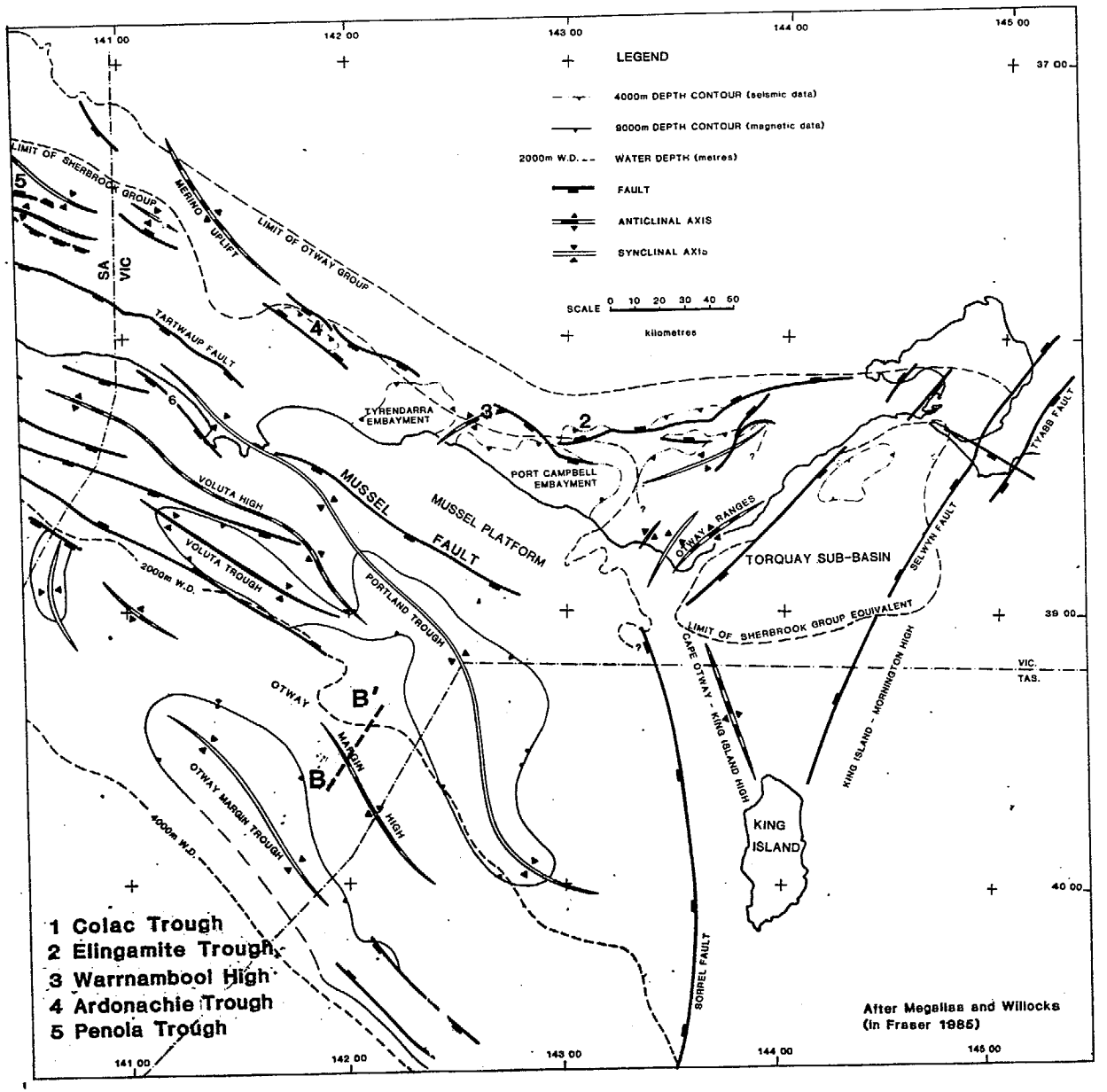


FIGURE 9
Major Basement Structural Elements

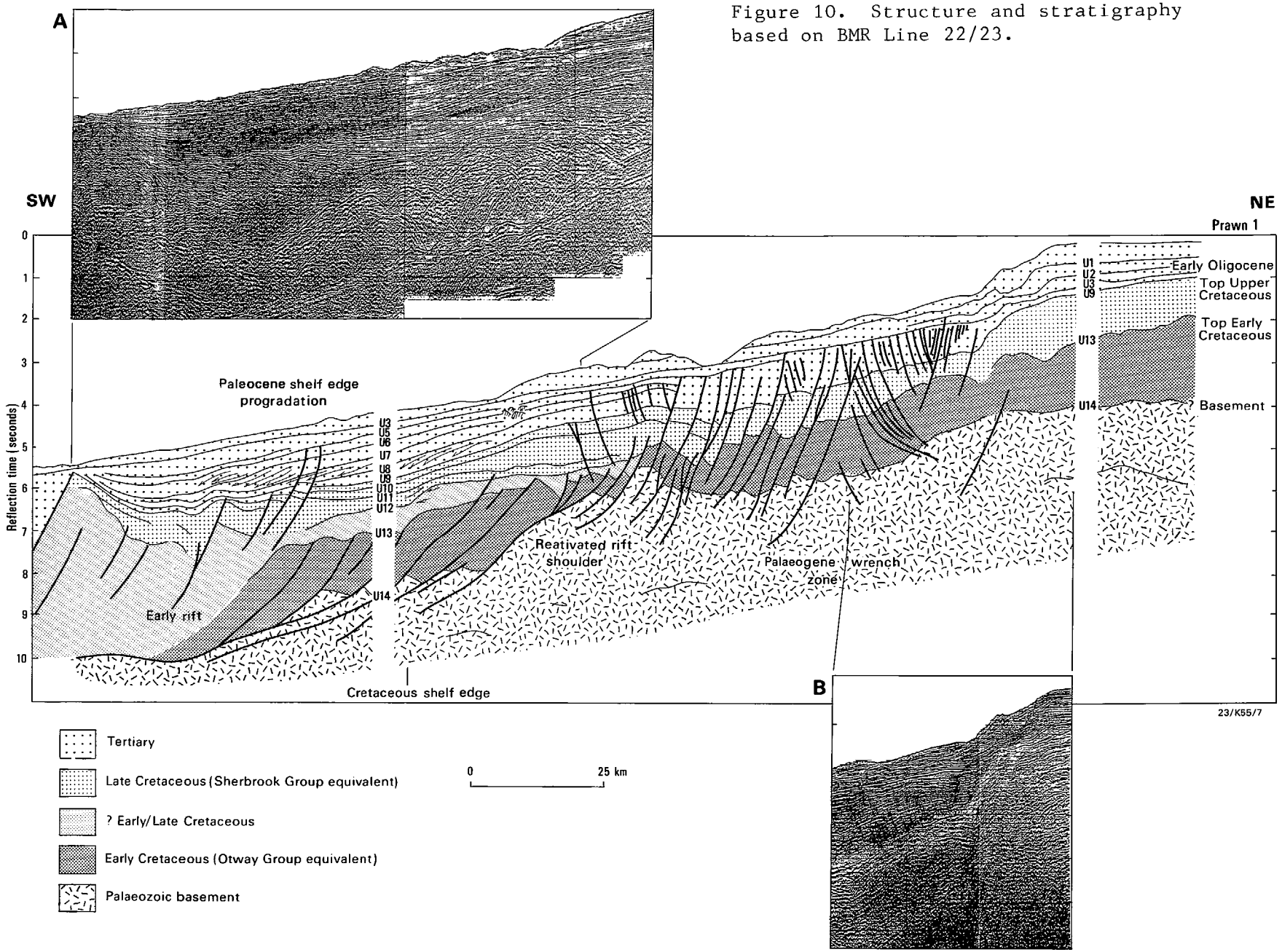


Figure 10. Structure and stratigraphy based on BMR Line 22/23.

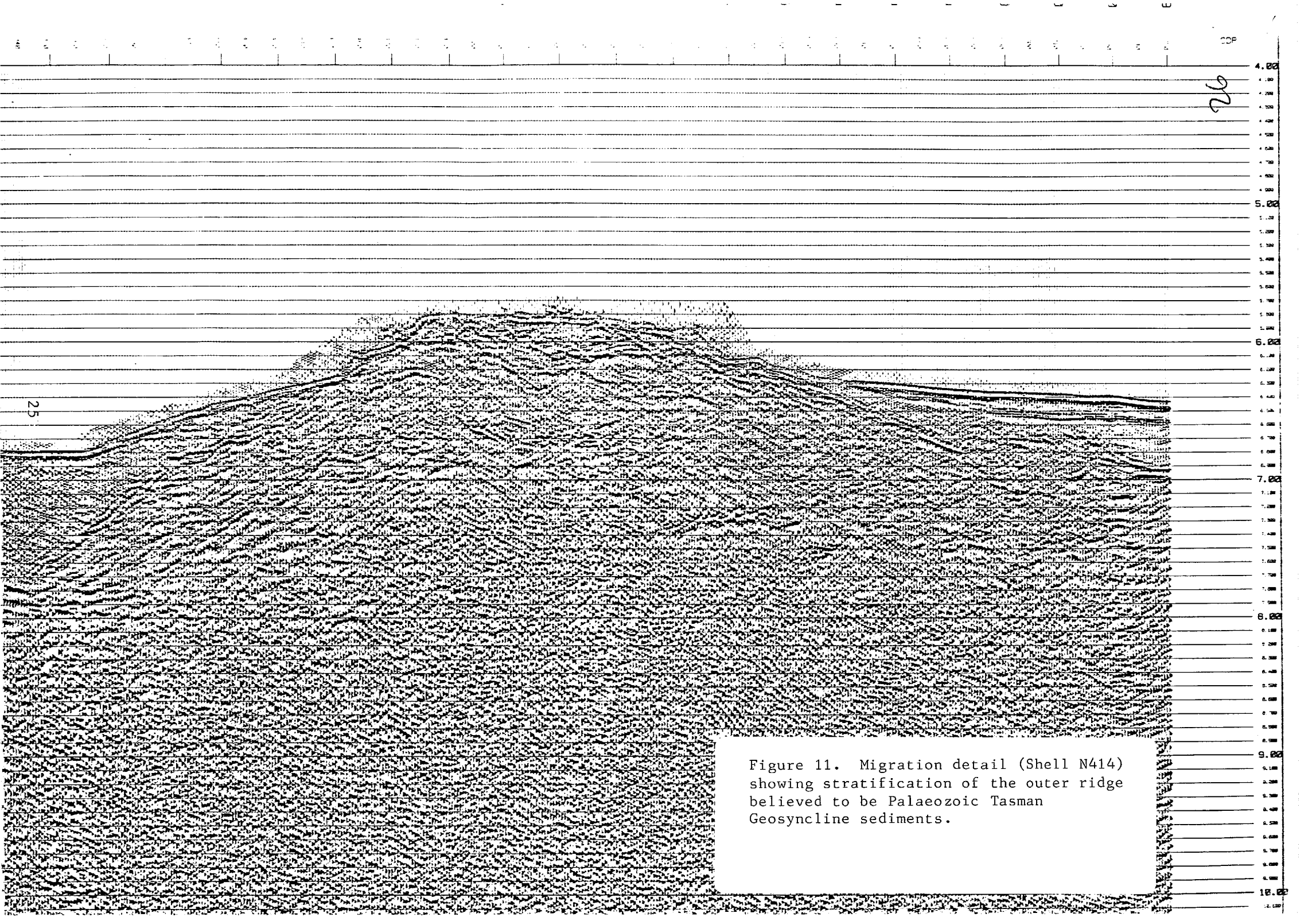


Figure 11. Migration detail (Shell N414) showing stratification of the outer ridge believed to be Palaeozoic Tasman Geosyncline sediments.

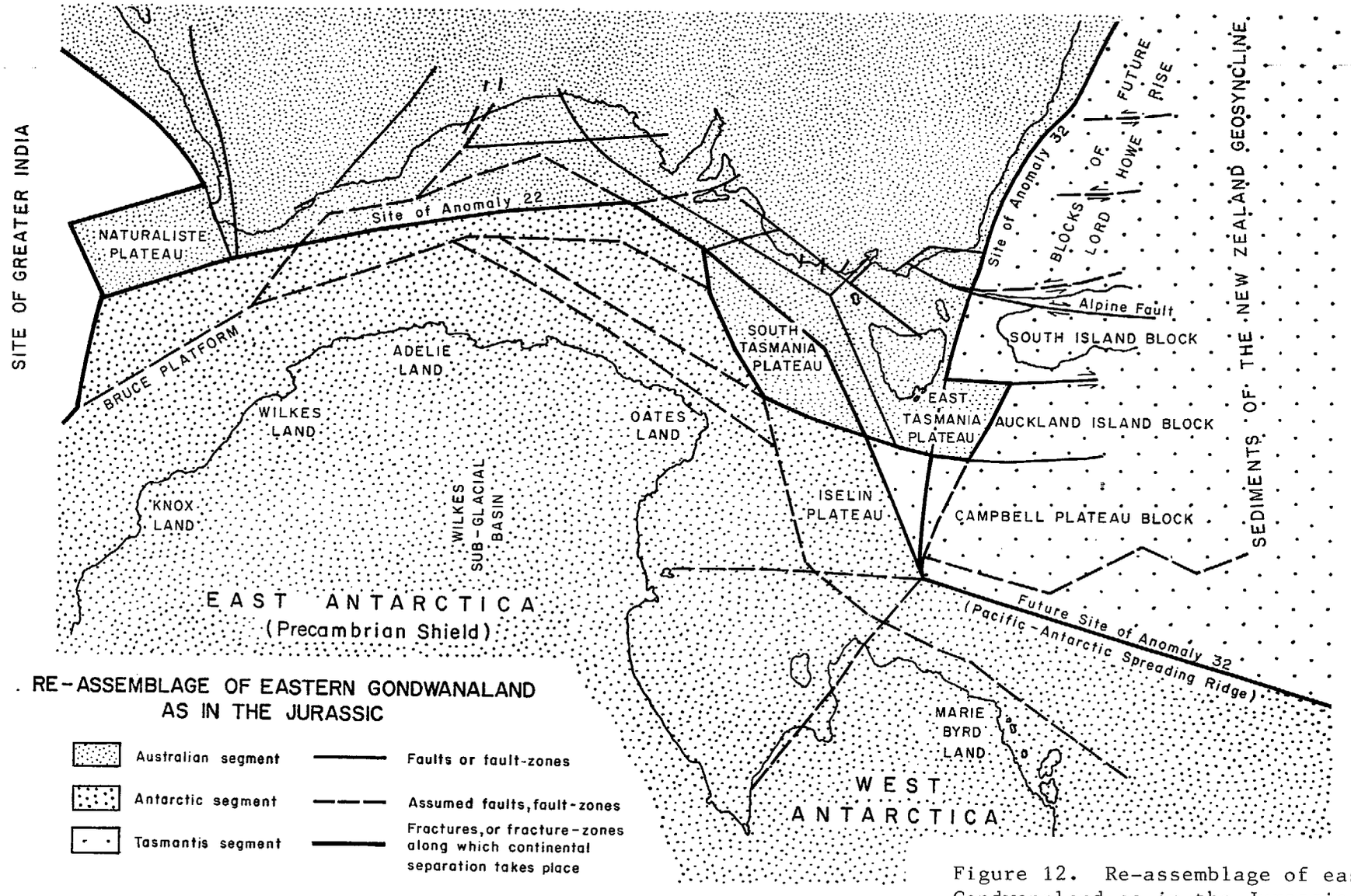
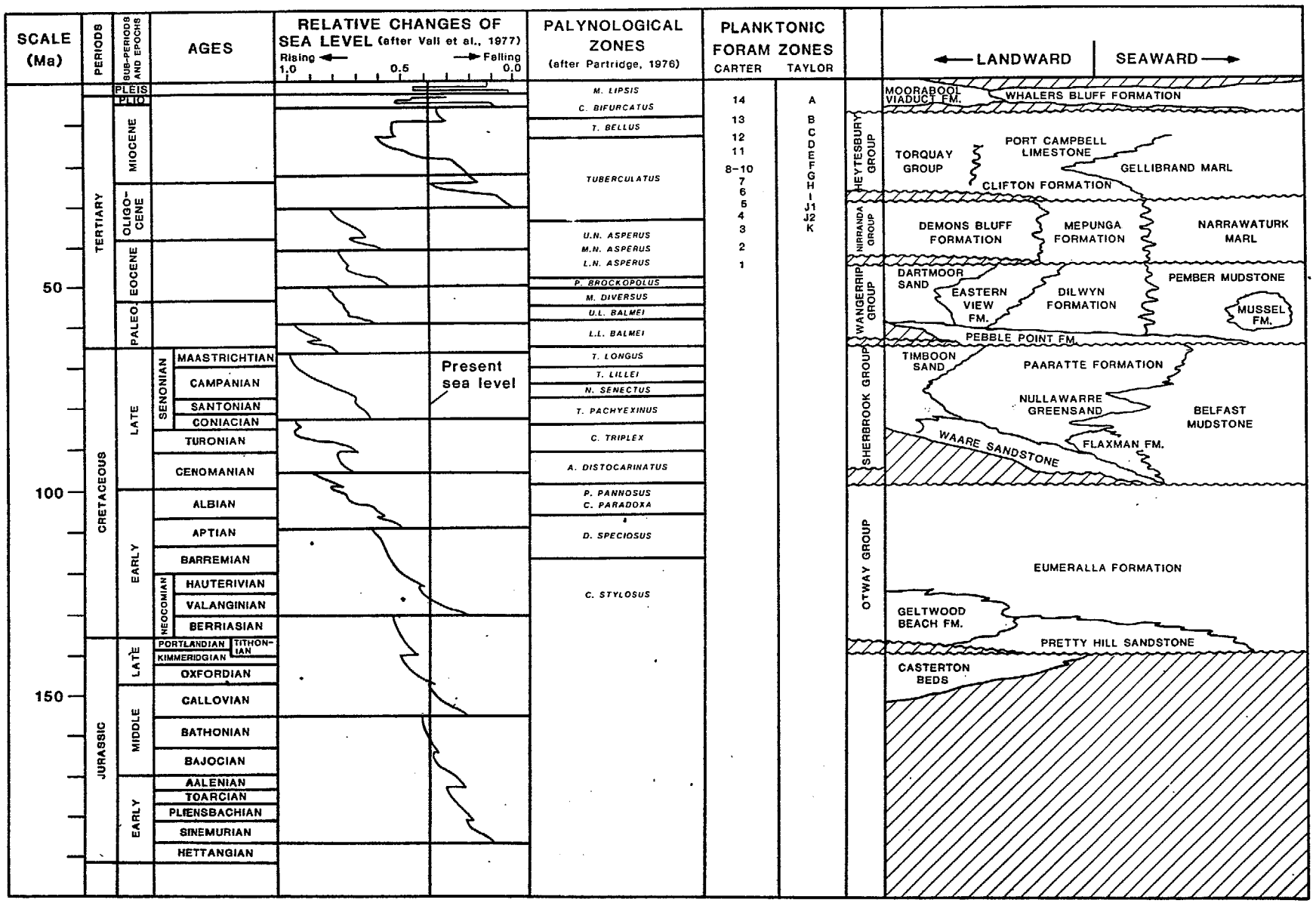


Figure 12. Re-assemblage of eastern Gondwanaland as in the Jurassic.



After Thompson in Fraser 1985

FIGURE 13
Otway Basin Stratigraphic Column

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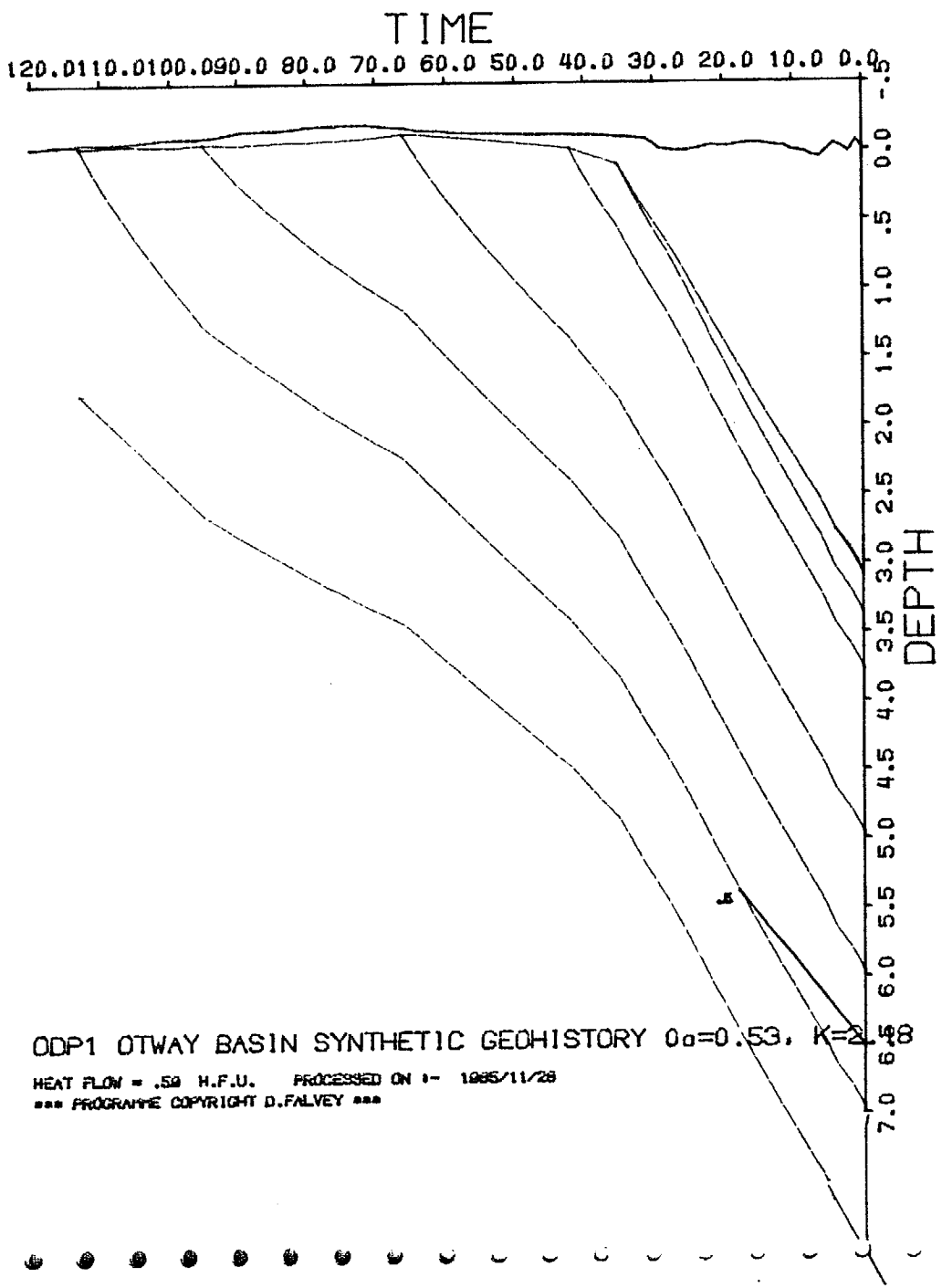


Figure 15. Deepwater (4000 m) Otway Basin Synthetic Geohistory:

Option 1 - continental/shallow marine infrarift sedimentation.

Horizons - Seabed
Mid Oligocene unconformity
Mid Eocene unconformity
Top Cretaceous unconformity
?Cenomanian unconformity
?Albian unconformity
Top Basement

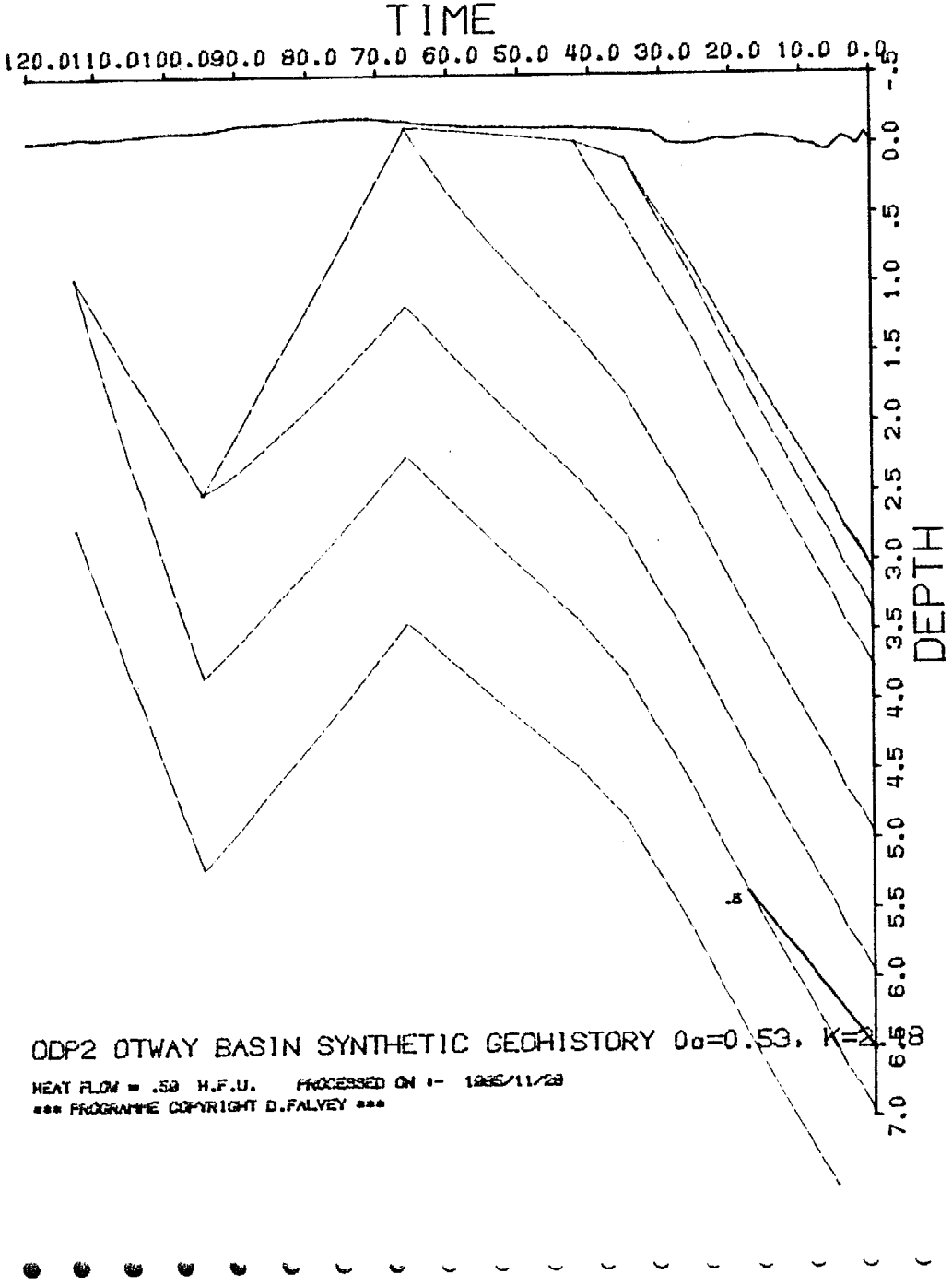


Figure 16. Deepwater (4000 m) Otway Basin Synthetic Geohistory:

Option 2 – bathyal infrarift sedimentation with 'transpressional' uplift in the Late Cretaceous.

Horizons – Seabed
Mid Oligocene unconformity
Mid Eocene unconformity
Top Cretaceous unconformity
?Cenomanian unconformity
?Albian unconformity
Top Basement

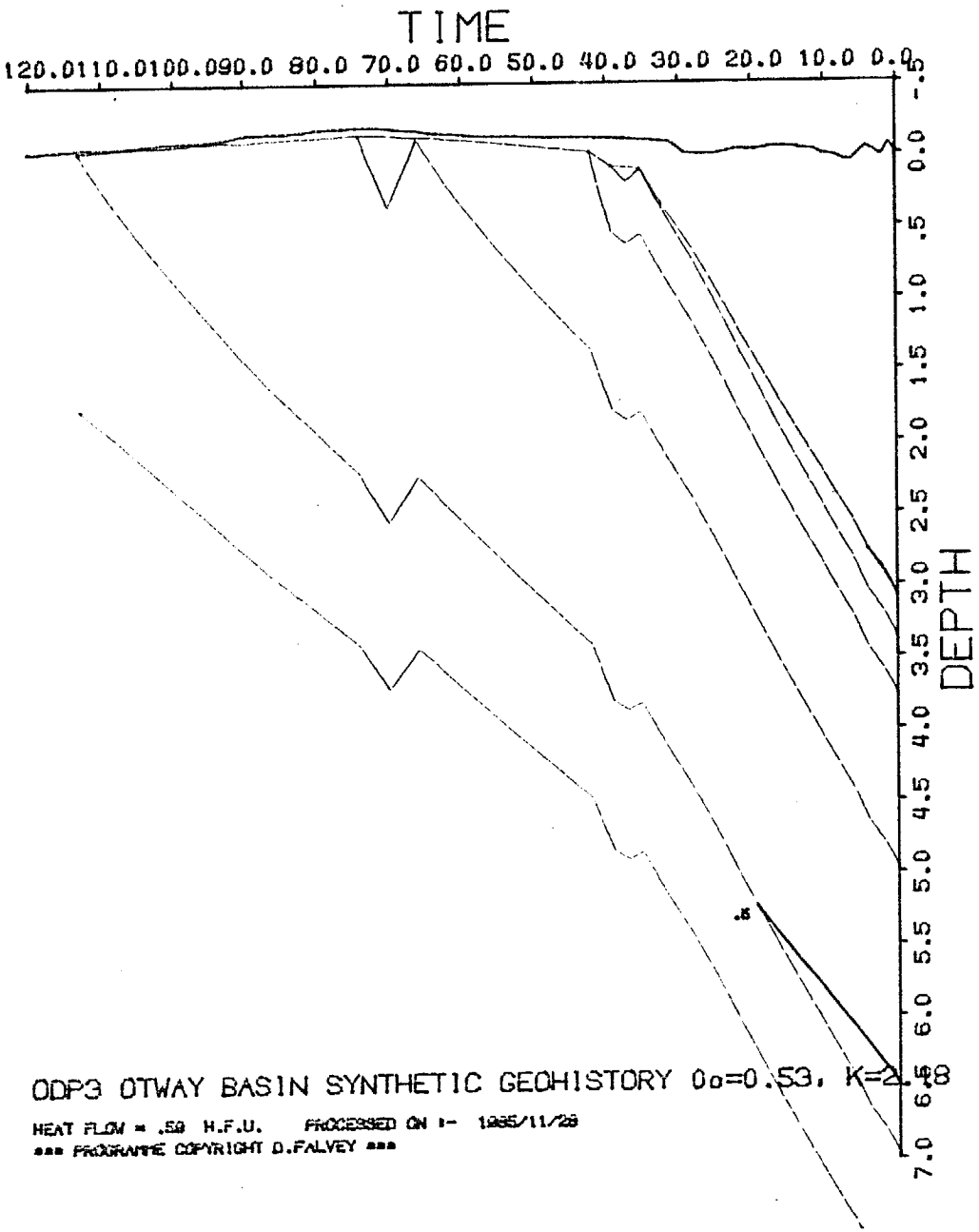


Figure 17. Deepwater (4000 m) Otway Basin Synthetic Geohistory:

Option 3 – as option 1 (Fig. 15), but with 500 m erosion in Late Cretaceous, and 100 m erosion in mid-Oligocene.

Horizons – Seabed
Mid Oligocene unconformity
Mid Eocene unconformity
Top Cretaceous unconformity
?Cenomanian unconformity
?Albian unconformity
Top Basement

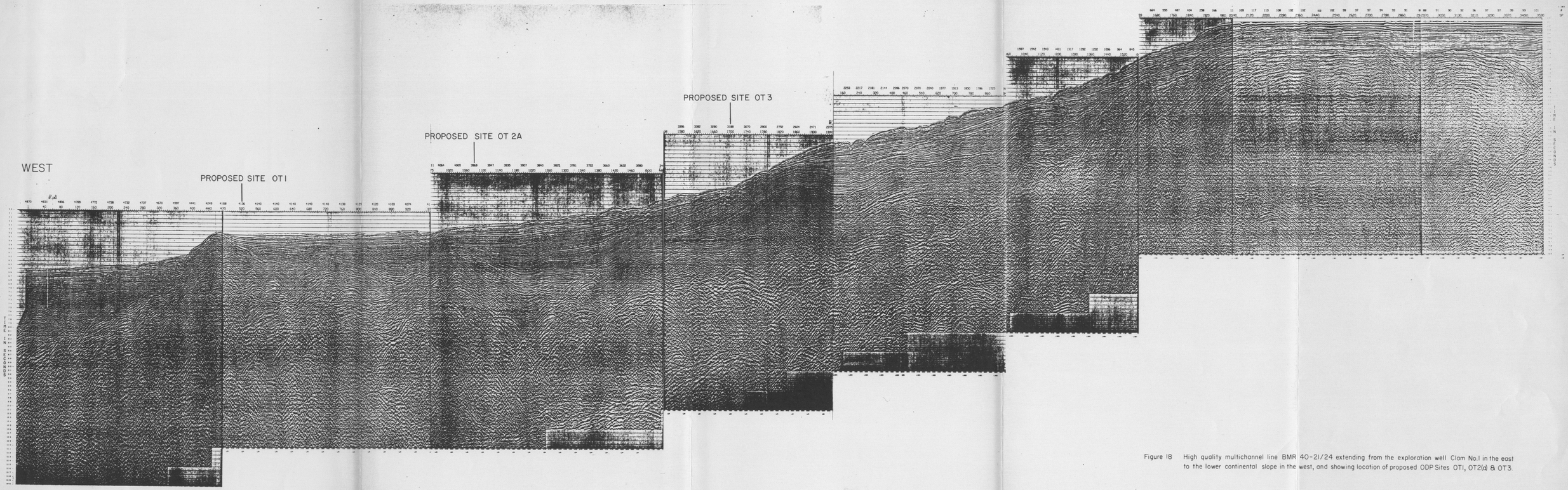


Figure 18 High quality multichannel line BMR 40-21/24 extending from the exploration well Clam No.1 in the east to the lower continental slope in the west, and showing location of proposed ODP Sites OT1, OT2(a) & OT3.

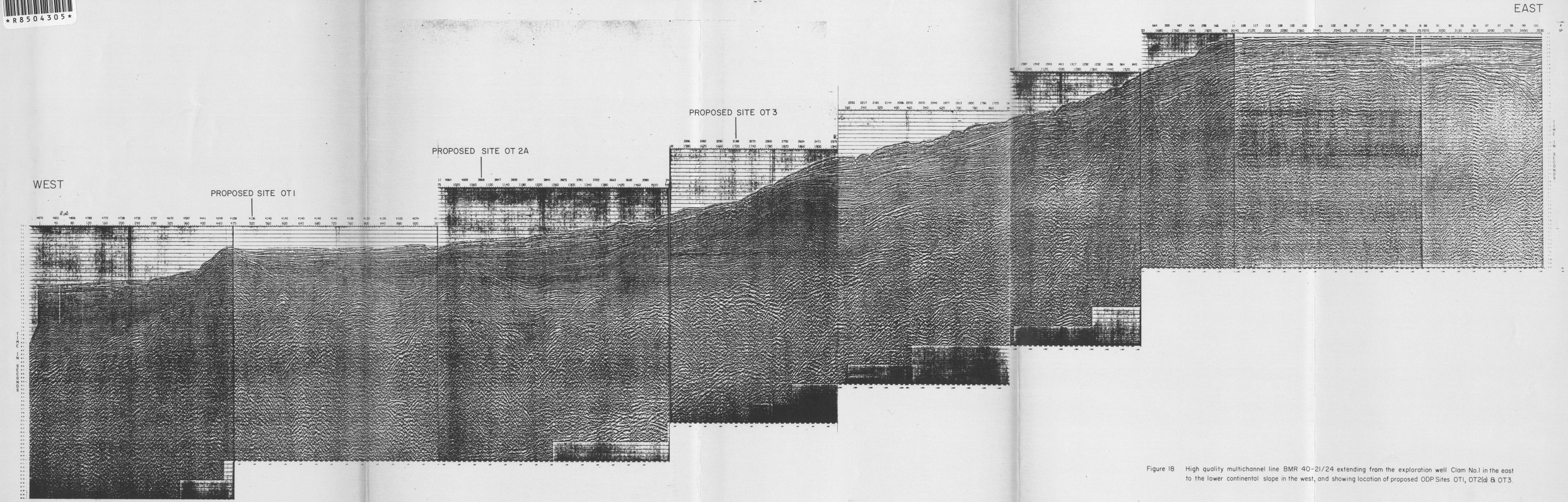
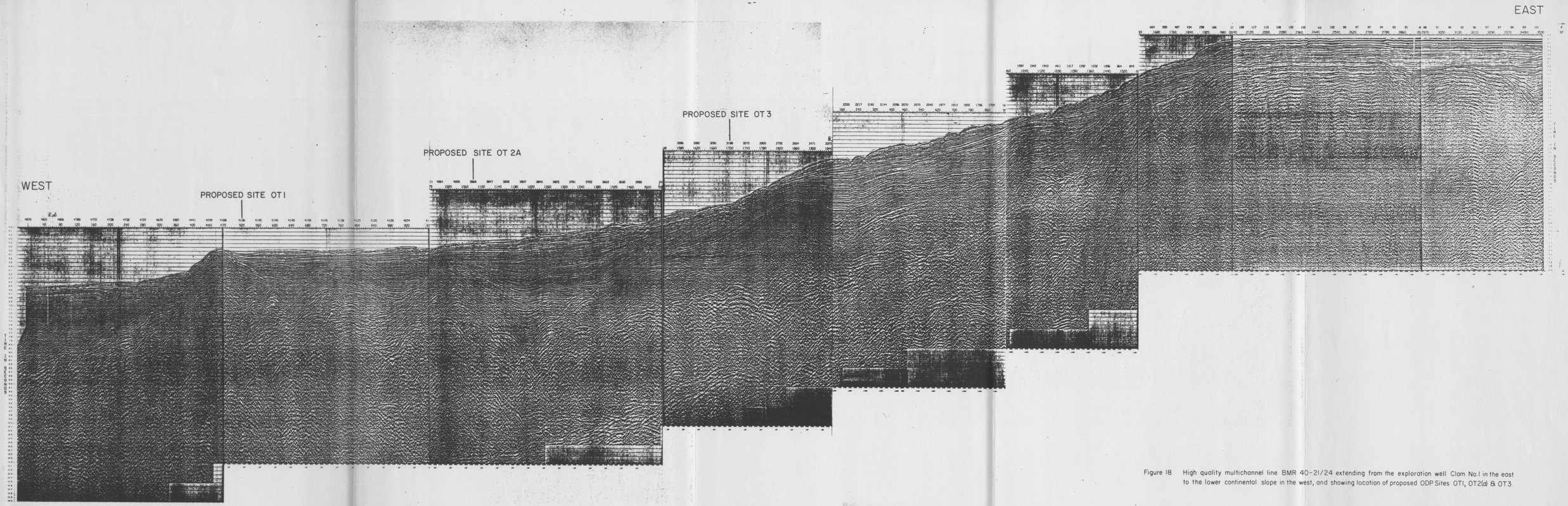


Figure 18 High quality multichannel line BMR 40-21/24 extending from the exploration well Clam No.1 in the east to the lower continental slope in the west, and showing location of proposed ODP Sites OT1, OT2(a) & OT3.



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