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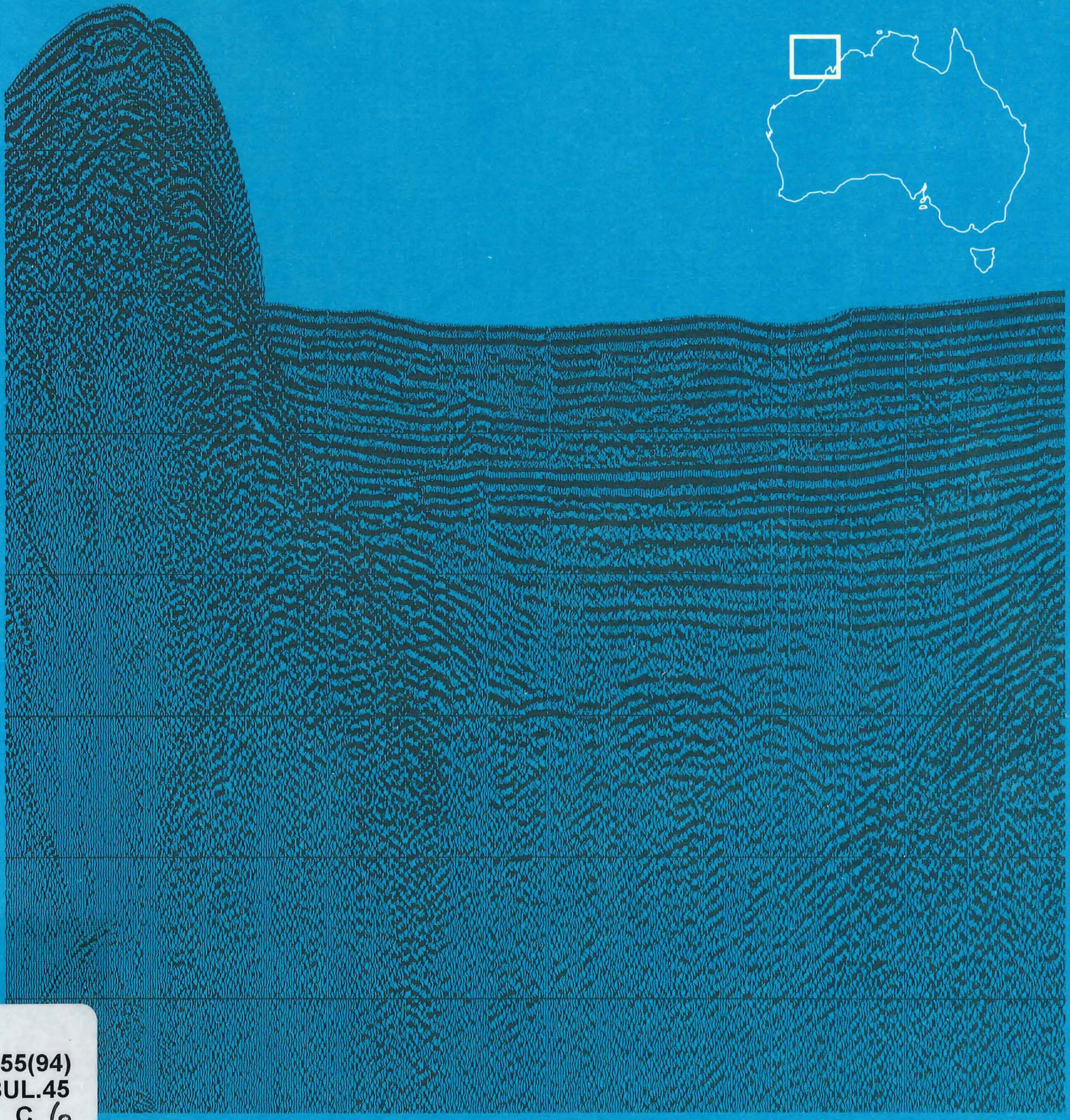

DEPARTMENT OF NATIONAL DEVELOPMENT & ENERGY
BUREAU OF MINERAL RESOURCES, GEOLOGY
AND GEOPHYSICS

BULLETIN 213

Geology of the Scott Plateau and Rowley Terrace, off northwestern Australia

H. M. J. STAGG & N. F. EXON

With an appendix on the foraminifera recovered
from a core sample, by D. J. BELFORD

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ABSTRACT

The Scott Plateau and the adjacent Rowley Terrace occupy an area of about 160 000 km^2 in water depths ranging from 300 to 3500 m off Australia's Northwest Shelf. The Scott Plateau forms a subsided western margin to the Browse Basin. For much of the time between the Permian and Late Jurassic, the plateau was probably higher than the adjoining basins, shedding sediment into the Browse Basin to the east and the Rowley Sub-basin to the south. Since break-up of the continental margin in the Callovian, the plateau has gradually subsided to its present depth of 1000-3500 m, and is now covered by a blanket of Upper Cretaceous and Cainozoic sediments, mainly carbonates, averaging 1 km in thickness. Seismic, magnetic, and gravity data indicate that, over most of the plateau, basement of possible Kimberley Block equivalents is probably no more than 2 to 4 km below the seabed.

The southern part of the Scott Plateau and the Rowley Terrace are underlain by the Rowley Sub-basin. The Rowley Sub-basin is a pull-apart basin that trends east-northeast and contains largely Mesozoic sediments; it differs from other pull-apart basins of the Northwest Shelf because it is only mildly deformed. The basin probably contains at least 6 km of pre-break-up Mesozoic and Palaeozoic rocks, overlain by a post-break-up sequence that has an average thickness of 1.5 to 2 km, thinning to zero at the top of the continental slope.

The hydrocarbon potential of the Scott Plateau appears to be only fair. The highest potential appears to be in the Scott Plateau Saddle, which may have suitable source, reservoir, and cap rocks, and structural and stratigraphic traps. Over much of the plateau, the potential hydrocarbon-bearing rocks are probably no younger than Palaeozoic, and are unlikely to be more than 2 to 4 km thick; any hydrocarbons generated in them would probably have been lost during the prolonged emergence and erosion that preceded break-up.

The hydrocarbon potential of the Rowley Sub-basin cannot be regarded as high. The thickness of the sediments in the sub-basin is adequate for hydrocarbons to be generated, but drilling at East Mermaid No. 1 indicated a possible lack of suitable source rocks. In addition, the lack of structure in all but the deeper parts of the sub-basin must downgrade prospects.

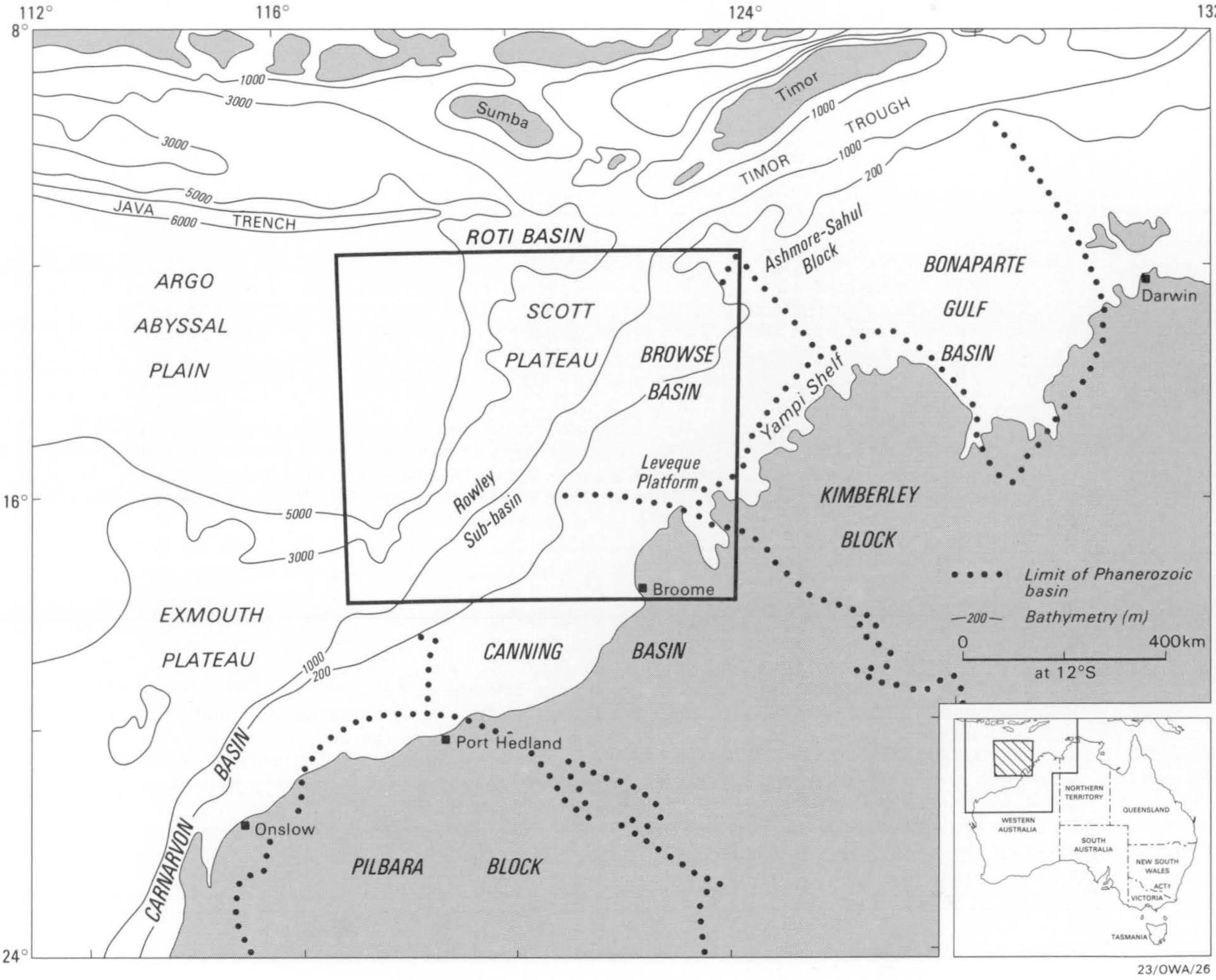


Fig. 1. Regional setting of the Scott Plateau and Rowley Sub-basin.

INTRODUCTION

The northeasterly trending Scott Plateau (Fig. 1) lies oceanward of Australia's Northwest Shelf and northwest of the Kimberly Block, and is considered to extend from the foot of the upper continental slope, at a water depth of between 1000 and 2000 m, to the 3500 m isobath (Fig. 1, Plate 3). Its area is about 80 000 km^2, which is half that of the Exmouth Plateau to the south and roughly that of Tasmania. The total area studied extends from the shelf break to the Argo Abyssal Plain in the west, and to the Roti Basin (the bathymetric depression connecting the Java Trench with the Timor Trough) in the north, and is about 200 000 km^2. The Scott Plateau has an average water depth of about 2500 m, which is similar to the depths of the Wallaby and Naturaliste Plateaux but about 1000 m deeper than the Exmouth Plateau. The plateau is underlain by the outer parts of the Browse Basin and the northern Canning Basin (Fig.1).

The regional geology of the Scott Plateau has been deduced largely from a study of seismic profiles which can be tied into well-known areas of the Browse and Canning Basins. Further information has come from bottom samples on the plateau, deep-sea drill cores in the Argo Abyssal Plain, and seismic refraction, magnetic, gravity, and bathymetric data. As the plateau lies offshore from the Scott Reef gas field, special consideration has been given to its hydrocarbon potential.

GEOSCIENTIFIC SURVEYS

Nine geophysical surveys have traversed the Scott Plateau and Rowley Terrace (Table 1), but the data from only five of them—totalling about 13 000 km—have been used in this study. The tracks of these five surveys are shown in Plate 1.

Direct geological information in the area is sparse; drilling is limited to petroleum exploration wells on the Northwest Shelf and the JOIDES Deep Sea Drilling Project (DSDP) Site 261 on the Argo Abyssal Plain (Plate 1). Additional information has come from short cores obtained by the Lamont-Doherty Geological Observatory's RV *Vema* and RV *Robert Conrad* between 1965 and 1971 (Table 9), and dredge, piston-core, and boomerang-core samples obtained by RV *Valdivia* of the Bundesanstalt für Geowissenschaften und Rohstoffe in 1977 over the northwest Scott Plateau (Table 8); core and dredge localities are shown in Plate 2.

PREVIOUS PUBLICATIONS

Papers discussing the geology of the northwest Australian continental margin, and others discussing the geology specifically of the Scott Plateau and provinces adjacent to it, are reviewed below.

Northwest continental margin

Falvey & Veevers (1974) discussed the physiography of the Scott and Exmouth Plateaux and Wharton Basin, and produced a bathymetric map making use of all available data. Branson (1974) and Hogan & Jacobson (1975) reviewed geophysical results from the western and northwestern margins of Australia respectively. Veevers, Falvey, Hawkins, & Ludwig (1974) used seismic data collected by Lamont-Doherty Geological Observatory and HMAS *Diamantina* to review the structure and stratigraphy of the northwest margin. Veevers & Johnstone (1974) compared the stratigraphy and structure of Australia's western continental margin with that of the adjacent deep ocean floor, and Veevers & Heirtzler (1974) outlined the tectonic and geomorphic history of the same area, using the information from DSDP sites in the Wharton Basin and available seismic data. Powell (1976) published a major review of the entire northwest continental margin of Australia. Veevers & Cotterill (1978) reviewed the geology and history of the western margin of Australia and suggested that the Scott Plateau is an epilith* or volcanic excrescence; Stagg & Exon (1979) contested this view, regarding the plateau as a foundered continental block.

Scott Plateau

Until recently the Scott Plateau had received only passing mentions in regional reviews. Stagg (1977) compiled structure, isopach, and potential field maps of the Scott Plateau, and Stagg (1978) reviewed the geology and history of the plateau. Hinz & others (1978) studied the northwest Scott Plateau and the area from the Scott Plateau to the Java Trench, using seismic data and geological samples collected by RV *Valdivia.*

Provinces adjacent to the Scott Plateau

The Scott Plateau study area is bounded to the northeast by the Timor Trough and Bonaparte Gulf Basin, and to the southwest by the Exmouth Plateau. The most recent reviews of these areas were by Warris (1973) in the Timor Sea, Laws & Kraus (1974) in the Bonaparte Gulf Basin, and Exon & Willcox (1978, 1980) on the Exmouth Plateau.

The eastern and southern margins of the study area are underlain by the Browse Basin and by the Rowley Sub-basin of the Canning Basin respectively. The offshore Canning Basin was reviewed by Challinor (1970), who only briefly mentioned the Rowley Sub-basin, and, more recently, by Warris (1976). The Browse Basin was initially reviewed by Halse & Hayes (1971), and later by Lofting, Crostella, & Halse (1975) and Crostella (1976). Allen, Pearce, & Gardner (1978) published a major review of the Browse Basin, and we have made considerable use of their work.

Falvey (1972) interpreted northeast-trending magnetic lineations on the Argo Abyssal Plain west of the Scott Plateau as indicating the onset of seafloor spreading in this region. Deep-sea drilling results from Site 261 (Veevers, Heirtzler, & others, 1974), and a comparison of the lineations with standard seafloor-spreading anomalies from the Pacific Ocean (Larson, 1975), showed that the oldest lineation is of Late Jurassic age.

The drilling of DSDP Site 261 (Veevers, Heirtzler, & others, 1974), and geophysical profiling eleswhere (Heirtzler & others, 1978; Hinz & others, 1978), have shown that oceanic basement beneath the Argo Abyssal Plain is overlain by at least 400 m of Upper Jurassic and Cretaceous claystone and marl, and 200 m of Neogene carbonate. Cook, Veevers, Heirtzler, & Cameron (1978) discussed diapir-like structures on the plain, which they suggested may have been induced by salt diapirism. Lancelot & Embley (1977) regarded the structures as diapirs, but did not believe them to be salt-cored

* Veevers & Cotterill (1978, p. 340) proposed the term 'epilith' for an upgrowth of oceanic crust that developed after continental break-up.

TABLE 1. SEISMIC SURVEYS OVER THE SCOTT PLATEAU AND ROWLEY TERRACE

Year	*Organisation*	*Ship*	*Seismic source*	*Recording*	*Display*	*Processing*	*Comments*	*Line km used in this study*
1967	BMR (Australia)	*Wyrallah*	21 kJ-sparker	Single-channel analogue	EGG electrostatic recorder	NA	Inadequate penetration	
1968	BMR (Australia)	*Robray 1*	21 kJ-sparker	Single-channel analogue	EGG electrostatic recorder	NA	Inadequate penetration	
1971	*Shell International Petroleum Mij. (Netherlands)	*Petrel*	Airguns (6.4 l)	24-channel digital	2-fold CDP stack with no move-out corrections produced on-line by an optical method. Also variable area (processed)	Inshore ends of each line processed—24-fold CDP stack with deconvolution and time-variant filtering after stack. Variable area display	Both 2-fold and 24-fold stacks are good-quality records	1980
1971	Lamont-Doherty Geological Observatory (USA)	*Vema*	Airgun (0.83 l)	Single-channel analogue	Lamont-designed electrostatic recorders	NA	Inadequate penetration	
1972	*Gulf Research and Development Co. (USA)	*Gulfrex*	Aquapulse	24-channel digital	Variable area	24-fold CDP stack with deconvolution and time-variant filtering after stack. All lines processed	Good-quality records	1740
1972	*BMR (Australia)	*Hamme/ Lady Christine*	120 kJ sparker	6-channel analogue	EPC electrostatic recorder	About 60% of lines have been digitally processed (6-fold stack). Variable area display	Fair to good quality for BMR Continental Margin Survey data. Processed data are fair quality	6150
1972	JOIDES (USA)	*Glomar Challenger*	Airguns (0.5 l)	Single-channel analogue	Electrostatic recorders	NA	Inadequate penetration	
1976	*Woods Hole Oceanographic Institution (USA)	*Atlantis II*	Airguns (2.0 l)	Single-channel analogue	Hewlett-Packard electrostatic recorder	NA	Fair quality—similar to unprocessed BMR 1972 records	1700
1977	*BGR (West Germany)	*Valdivia*	Airguns (18.0 l)	24-channel digital; single-channel analogue	24-channel recorded on EPC electrostatic recorders. Single-channel recorded on Edo-Western electrostatic recorder. Near-trace gathers variable area	Near-trace gathers only	Fair to good quality	1460

* Results of these surveys used in this study.
NA = not applicable.

ACKNOWLEDGEMENTS

We acknowledge the use of seismic profiles recorded by Shell International Petroleum Mij. (1972), Gulf Research and Development Co. (1973), Woods Hole Oceanographic Institution, and the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR). We are also indebted to various staff members of Woodside Petroleum Pty Ltd and the Bureau of Mineral Resources with whom we have had useful discussions.

The illustrations were drawn by a BMR cartographic team, comprising R. Anderson, C. Fitzgerald, I. Hartig, A. Jaensch, and A. Murray, led by J. Convine.

REGIONAL SETTING

The Scott Plateau is the most northerly of the marginal plateaux off Western Australia, lying on the northern edge of the Australian plate. It is bordered by the Roti Basin to the north, the Northwest Shelf to the south and east, the Rowley Terrace to the south and the Argo Abyssal Plain (North Australian Basin) to the west.

REGIONAL GEOLOGY

The study area includes the western margin of the Browse Basin and the northern part of the Rowley Sub-basin of the Canning Basin (Fig. 1). Petroleum exploration permits in the Browse Basin are presently held by the Northwest Shelf Joint Venture, and exploration—both seismic and drilling—is continuing. Allen & others (1978) have published an excellent account of the geology and hydrocarbon potential of the Browse Basin; the major results of their study are summarised here.

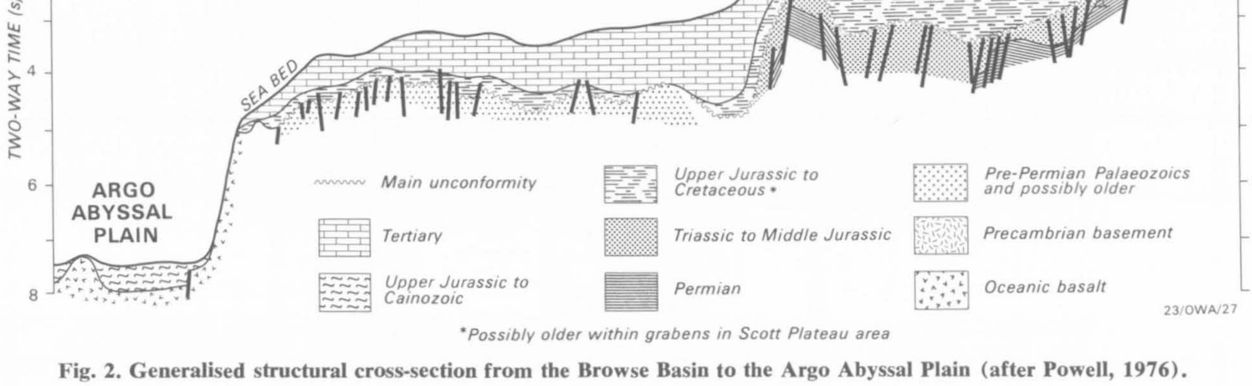
The *Rowley Sub-basin*, a Mesozoic to Cainozoic depocentre of the offshore Canning Basin, is relatively poorly known, especially in the deep-water areas. Only one exploration well (East Mermaid No. 1) has been drilled in the sub-basin, and this well bottomed in Lower Jurassic rock. To date, the deep-water Rowley Sub-basin has rated only brief mentions in published reports on the area. These reports include those by Challinor (1970) and Warris (1976). In part, Warris (1976) wrote:

> 'The Rowley Sub-basin constitutes a major depositional wedge which attains up to 6000 m of Mesozoic and Tertiary sediments in the area of the Rowley Shoals. The sub-basin is bounded to the south by the Bedout High, to the east by the Leveque Shelf and Platform and dips to the north-west into the abyssal depths of the Indian Ocean.'

The *Browse Basin* originated as an intracratonic basin in response to tensional movements, and subsequently developed into a mature Atlantic-type marginal basin. It is a northeasterly oriented basin lying offshore from the Kimberley Block; it is bounded to the north and south by the Ashmore-Sahul Block and Leveque Platform respectively, and to the west by the Scott Plateau. To the southwest it appears to be continuous with the Rowley Sub-basin.

The Browse Basin (Fig. 2) consists of Upper Carboniferous/Lower Permian to Quaternary sediments, which are estimated to be more than 11 km thick in the central basin and are probably underlain by older Palaeozoic and Precambrian rocks. A major Middle to Late Jurassic unconformity divides the sedimentary section into pre-break-up and post-break-up series, which Allen & others (1978) have referred to as the Lower and Upper Series respectively.

Little is known of the Permian to Triassic section owing to a lack of well control. On the eastern basin margin, paralic Permian clay and silt were deposited over an old erosion surface and progressively lapped eastwards onto Precambrian basement. Late Permian regression was followed by the deposition of non-marine sand along the southeastern basin margin. Regional lithological and faunal associations indicate the existence of an epicontinental sea in communication with Tethys to the north during this period. Subsequent uplift and erosion removed much of the Upper Permian sequence, leaving an erosional wedge-out along the margin. A more complete section is probably present in the centre of the basin.



*Possibly older within grabens in Scott Plateau area

Fig. 2. Generalised structural cross-section from the Browse Basin to the Argo Abyssal Plain (after Powell, 1976).

A stratigraphic break between Permian and Upper Triassic rocks throughout the basin indicates significant tectonic movement. Well and seismic data suggest that Triassic rocks are confined to the area between the Prudhoe Terrace and the Scott Plateau (Fig. 2). Lower and Middle Triassic rocks are present in the central basin, where marine upper Ladinian rocks are the oldest yet drilled. In the Late Triassic, fine-grained sand and dolomite with interbedded clay accumulated in a paralic environment. Dipmeter plots at Scott Reef indicate, at least locally, that a sedimentary source existed in the northwest, perhaps in the Scott Plateau area. This sedimentary phase was terminated by a major period of uplift and block-faulting which affected different parts of the basin at various times from the latest Triassic to the late Early Jurassic.

Lower to Middle Jurassic rocks are interpreted as covering the same area as the Triassic rocks. They comprise red beds, sandstone, siltstone, and claystone with local coal beds that were deposited in a widespread fluvio-deltaic environment subject to minor marine incursions. The final period of uplift and faulting was associated with break-up of the margin in the early Late Jurassic. This marked the end of deposition of the Lower Series sediments.

Upper Series sedimentation began in the early Late Jurassic in the central basin, where a marine influence increases upwards in the section. At the end of the Jurassic, local regression resulted in the deposition of interbedded estuarine and deltaic sands, silts and clays, at least along the eastern flank of the basin. Deposition of these sediments continued into the early Neocomian.

A transgression in the late Neocomian influenced the deposition of nearshore sand on the Yampi Shelf, and shelf clay—grading locally to minor silt, sand, and

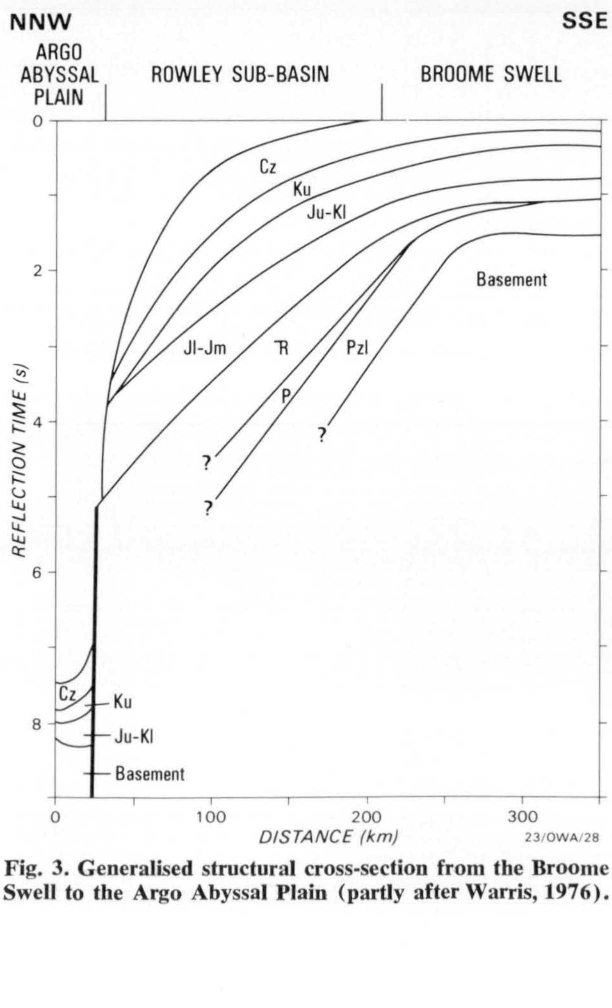


Fig. 3. Generalised structural cross-section from the Broome Swell to the Argo Abyssal Plain (partly after Warris, 1976).

carbonate—in the central basin. Palaeontological information indicates that fully open-marine conditions were established by the Turonian, and that the point of maximum transgression was reached in the Santonian. Upper Cretaceous rocks include claystone and marl in the eastern basin, and calcilutite in the west. Calcilutite deposition continued in the west until the beginning of the Tertiary, but massive littoral and continental sands were deposited along the eastern flank of the basin after the sea regressed in the Campanian.

Lower Tertiary sediments—including thick sands with interbedded coal and carbonate—were deposited in a largely non-marine environment. A major eustatic fall of sea level in the Oligocene is reflected as a stratigraphic break in all wells, except those at Scott Reef. With the advance of the sea in the Miocene, transgressive sand was succeeded by a prograding wedge of carbonate that reaches its maximum thickness (3400 m) at the outer edge of the present-day shelf.

HYDROCARBON GEOLOGY

Logs of three petroleum exploration wells drilled on the Scott Reef Trend (Fig. 2, Plate 16), on the Yampi Shelf (Fig. 2), and in the Rowley Sub-basin (Figs. 1 and 3) are shown in Figures 4, 5, and 6. A north-south correlation of wells from the Ashmore-Sahul Block to the Rowley Sub-basin is shown in Figure 7. This summary of the hydrocarbon geology of the Browse Basin is based on the paper by Allen & others (1978).

Most exploratory drilling in the Browse Basin has been carried out on the eastern margin of the basin where water depths are shallowest. With the introduction of a deep-water drilling vessel in 1977, a new phase of exploration has commenced in the central part of the basin. Scott Reef Nos. 1 (Fig. 4) and 2A have been drilled on the western margin of the basin in the shallow waters of Scott Reef, and so far these have been the only wells to encounter a significant hydrocarbon accumulation. Scott Reef No. 1 discovered gas/condensate in sediments of Late Triassic and Early to Middle Jurassic ages. Scott Reef No. 2A, a step-out well completed in 1977, confirmed the presence of gas/condensate in Middle Jurassic reservoirs.

Drilling and seismic data indicate that suitable traps and source, reservoir, and seal rocks exist within the basin. The thick Upper Series transgressive claystone, and the Lower Series claystone of Triassic and Early to Middle Jurassic age, are considered to be suitable source rocks. The principal reservoir rocks lie in the Lower to Middle Jurassic rift-valley sediments, which include fluvio-deltaic and paralic sandstones and shallow-marine carbonate. The reservoir rocks also include the Upper Series basal sandstone, which is probably in communication with the Triassic and Jurassic source beds. Thick sandstone on the eastern flank of the basin has good reservoir potential, but has no vertical seal where drilled. The regional seal over most of the basin is provided by thick claystone of the Upper Jurassic to mid-Upper Cretaceous transgressive sequence. Fault blocks developed during pre-break-up tectonism provide the best potential traps.

Little is known of the hydrocarbon geology of the Rowley Sub-basin. The one well drilled in the sub-basin, East Mermaid No. 1 (Fig. 6), encountered no hydrocarbons whatsoever, and the paucity of hydrocarbon shows from other wells in the Canning Basin is not encouraging. The hydrocarbon potential of the Rowley Sub-basin is evaluated in more detail on p. 43.

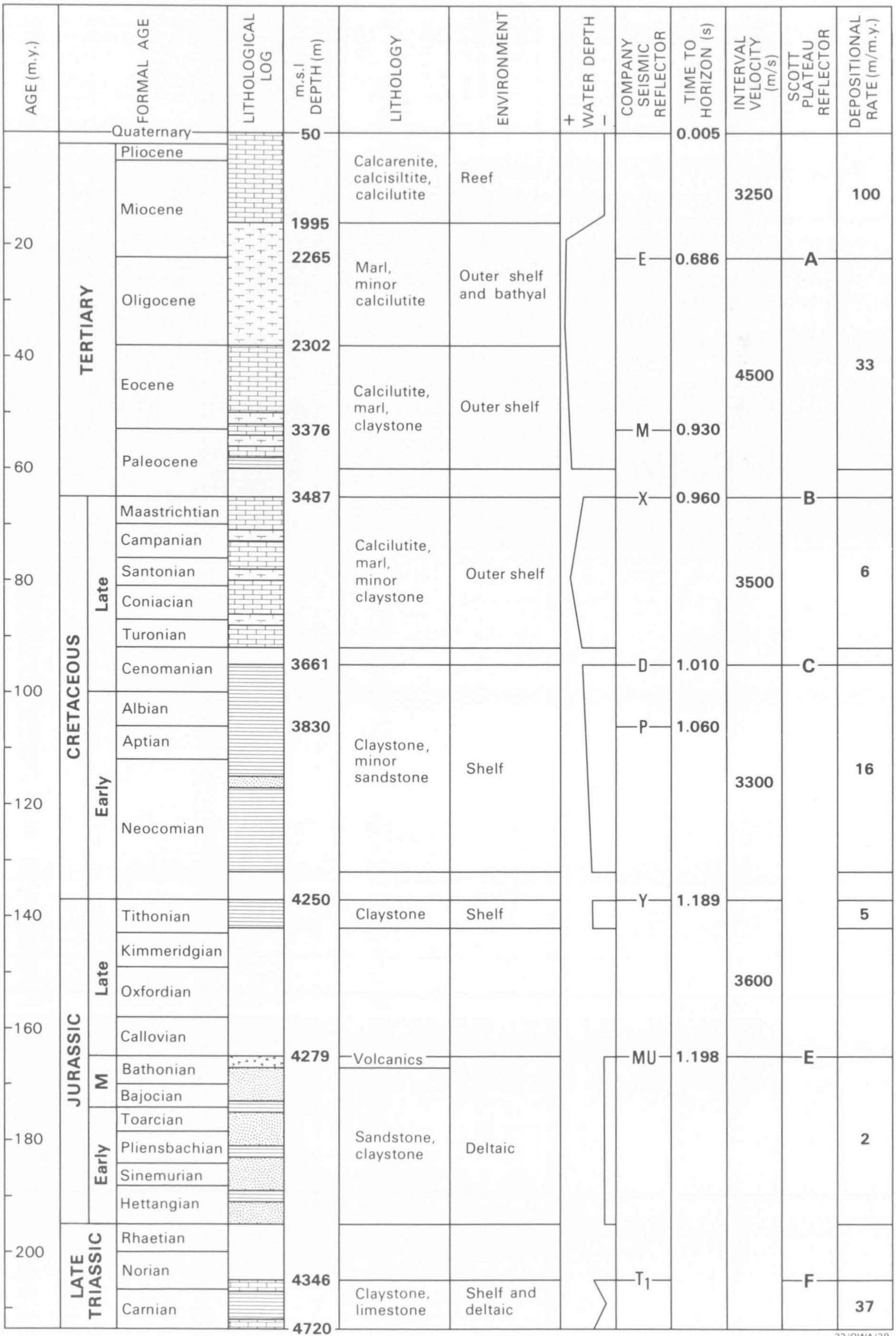
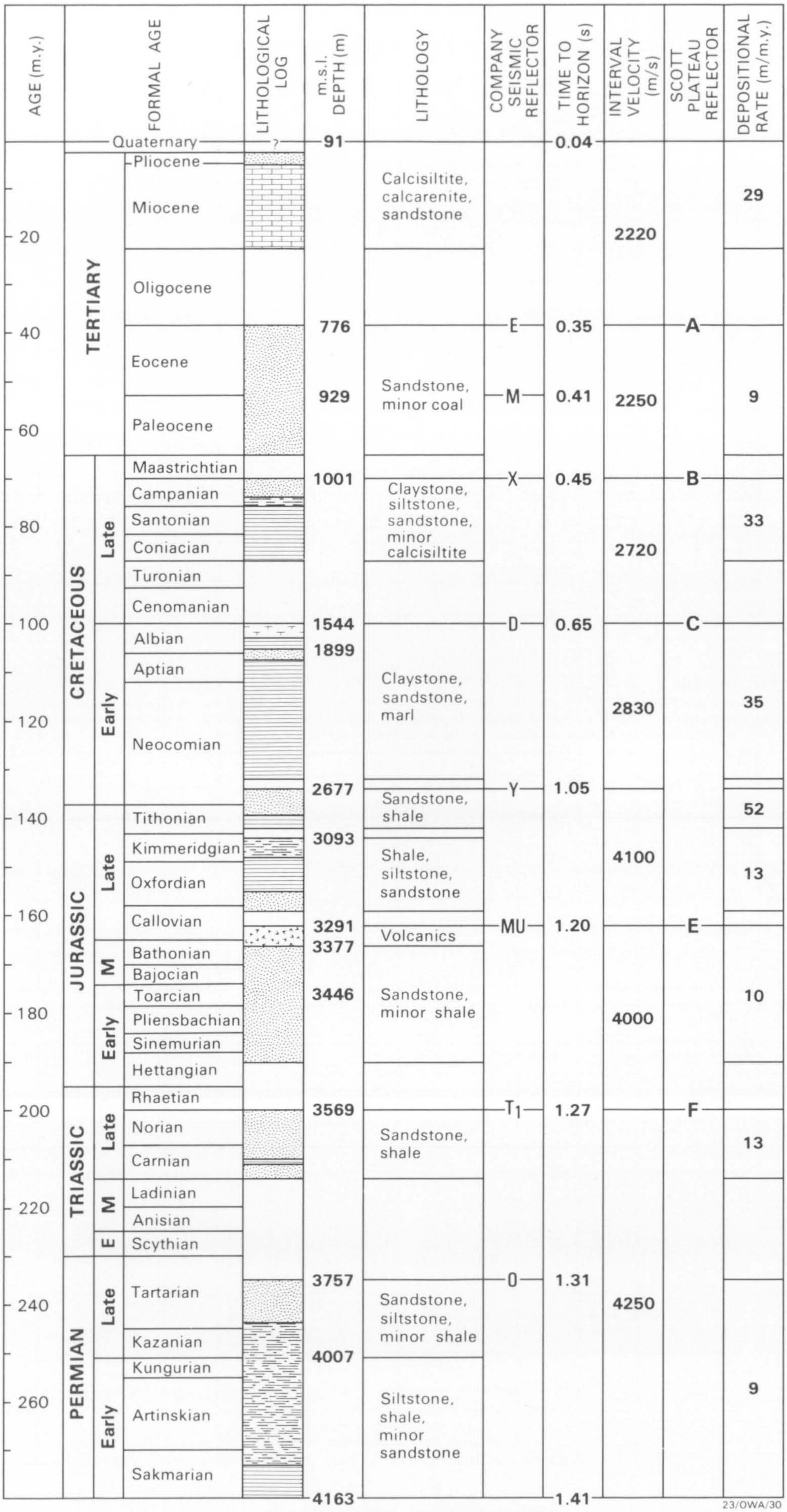
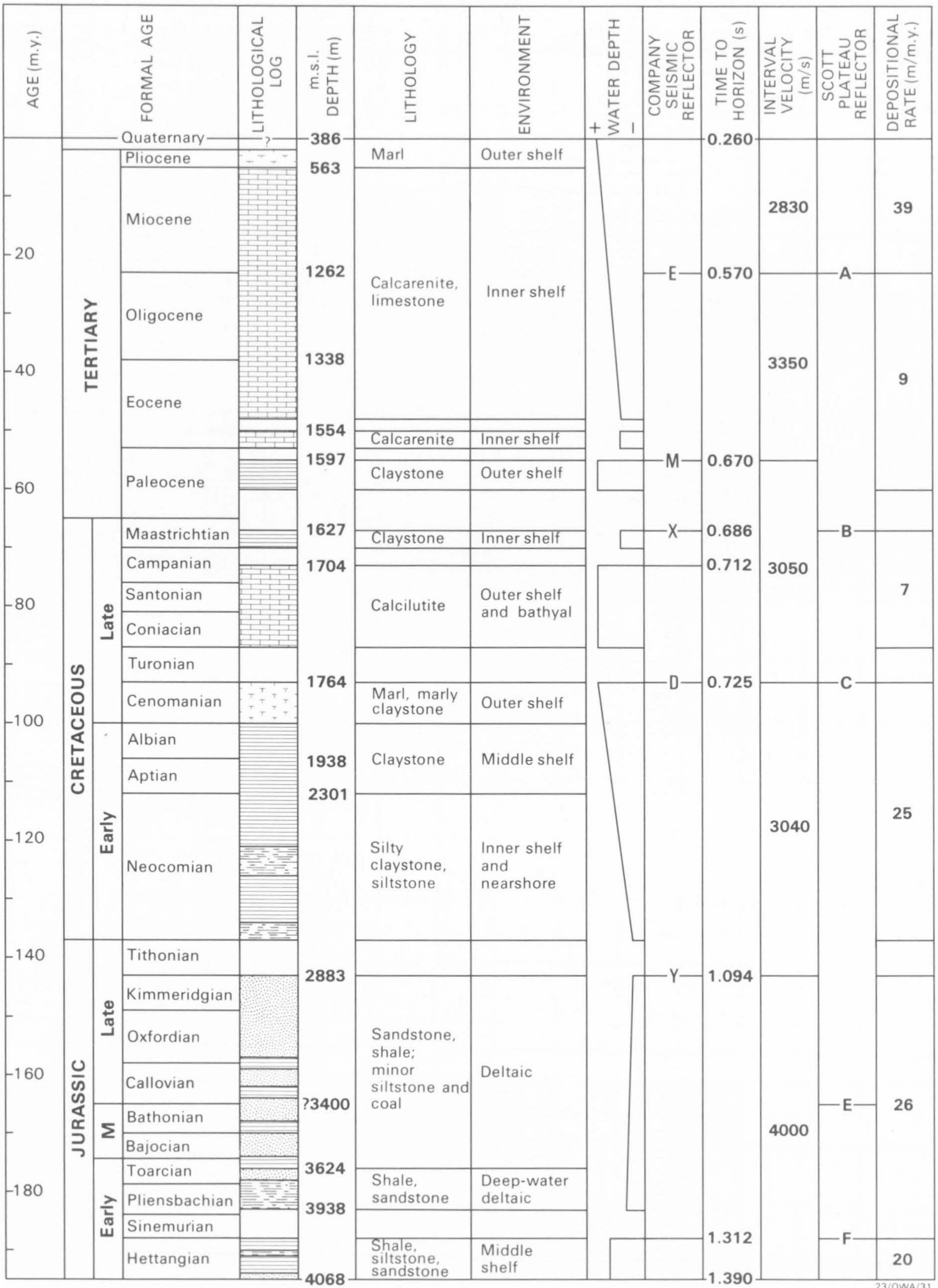


Fig. 4. BOC Scott Reef No. 1 well log.



For reference see Figure 7

Fig. 5. BOC Yampi No. 1 well log.



For reference see Figure 7

Fig. 6. Shell East Mermaid No. 1 well log.

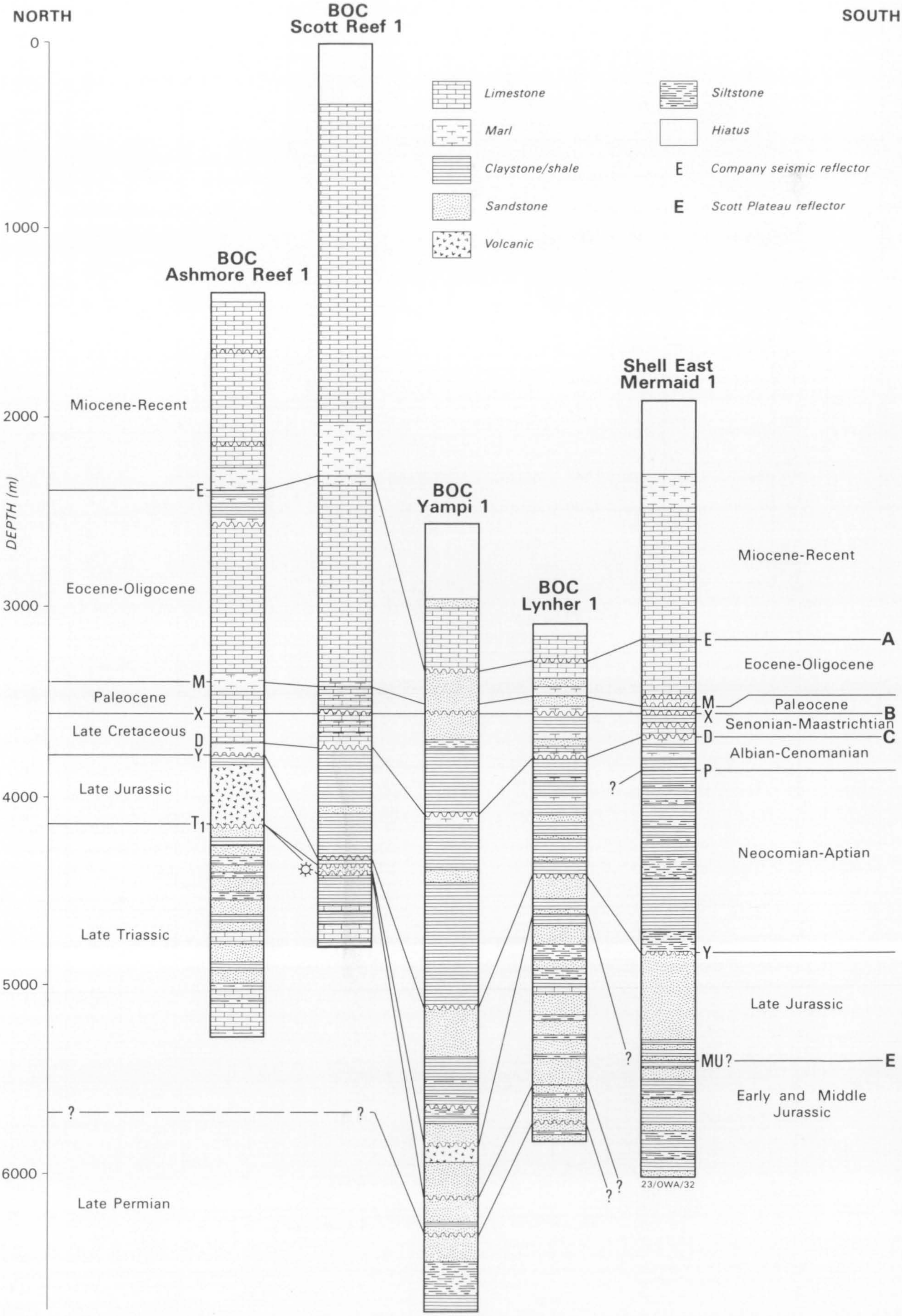


Fig. 7. Well correlation diagram, Ashmore Reef No. 1 to East Mermaid No. 1 (nomenclature after Woodside Petroleum Development Pty Ltd).

PHYSIOGRAPHY

The Scott Plateau occupies an area of about 80 000 km^2 in water depths ranging from 1000 to 3500 m off Australia's Northwest Shelf (Plates 3 and 4). The lower continental slope forms well-defined boundaries to the plateau on its western and northern margins, and the upper continental slope bounds it to the east. To the northeast and southwest the plateau narrows gradually and merges with the broad, gently inclined upper and middle continental slope west of Ashmore Reef and northwest of the Rowley Shoals. We take the northern boundary to be at about 12°10′S and the southern boundary at about 15°50′S.

The shallowest parts of the plateau, other than its eastern margin, are the Scott Plateau Dome and Wilson Spur, where water depths are about 2000 and 1800 m respectively. The northern part of the plateau is separated from the Ashmore Terrace by the arcuate, northeast-trending Scott Plateau Saddle (minimum water depth 2180 m), which connects the Roti Basin in the north and the Bowers Canyon in the southwest.

The western margin of the plateau is deeply incised by canyons. Oates Canyon lies north of Wilson Spur between large fault blocks west of the Scott Plateau Dome, and debouches northwestward onto the Argo Abyssal Plain. Slopes are steeper than 30° on the southwest flank of the canyon. Farther south is the major Bowers Canyon, which originates on the upper slope—southwest of Scott Reef—and debouches westward onto the Argo Abyssal Plain.

The upper slope encompasses two major terraces: Ashmore Terrace in the north between Ashmore and Scott Reefs, lying in water depths of 200 to 1000 m; and Rowley Terrace in the south, lying in water depths of 300 to 3000 m. We have somewhat arbitrarily separated the Rowley Terrace from the Scott Plateau at about 15°50′S, although the Rowley Terrace might equally be considered as extending as far north as 14°30′S. The southwestern Rowley Terrace is separated from Emu Spur of the northeast Exmouth Plateau by the north-trending Swan Canyon.

The lower slope below the Scott Plateau extends from the 3500 to 5000 m isobaths with gradients ranging from 2° to 7°. Below the Rowley Terrace, the lower slope is much steeper; gradients of up to 20° have been recorded. The continental rise lies in water depths of 5000 to 5500 m, and ranges in width from 15 km in the south to 70 km in the north.

West of the Scott Plateau is the Argo Abyssal Plain, where water depths are greater than 5500 m. The deepest part (5730 m) is in the southeast near the continental margin. The plain is generally flat with a gentle southeasterly slope of about 0.02°.

GRAVITY AND MAGNETIC INTERPRETATION

The definitions of free-air anomaly, Bouguer anomaly, and magnetic anomaly as used in this Bulletin are outlined in Appendix 1. Previous investigations of the gravity and magnetic fields in the area have been made by Hogan & Jacobson (1975), and of the gravity field by Symonds & Willcox (1976). Stagg (1978) used gravity data to test a structural model for the Scott Plateau.

The contour maps of free-air, Bouguer, and magnetic anomalies (Plates 5, 7, and 9) have been compiled by machine-contouring the surface of minimum curvature (Briggs, 1974). The bulk of the data has come from the BMR Continental Margin Survey (Compagnie Générale de Géophysique, 1975); supplementary data have come from the Gulf Research and Development Co. (1973) and Woods Hole Oceanographic Institution surveys. Gravity data were sampled at a one-minute interval of ship-time, and magnetic data at a five-minute interval. The nearshore sections of the Bouguer anomaly map (southeast of a line from 12°30′S, 124°E, to 18°S, 118°E) have been hand-contoured from the 1968 BMR data.

Geodetic parameters describing the Earth's gravity field have been derived from satellite and terrestrial gravity observations by Gaposchkin & Lambeck (1971). From their data, we estimate that the height of the geoid in the Scott Plateau area ranges from about 30 m in the southwest to about 60 m in the northeast. The corresponding range in average free-air anomaly is from 50 to 100 μm.s^{-2}. Such regional gravity variations probably result from broad density variations in the mantle, and consequently have little bearing on the geological interpretation of the data. However, they must be considered if average free-air anomaly values are used as an indication of the degree of isostatic equilibrium.

Where the gradient of the seabed is uniformly low, as on the Northwest Shelf, the Bouguer and free-air anomaly contours have similar patterns. In contrast, where the gradient of the seabed is high, as on the continental slopes, the free-air anomalies show local correlation with water depth, whereas the Bouguer anomalies typically exhibit a prominently monoclinal gradient that is the result of crustal thinning. On continental margins, free-air anomalies provide more information than Bouguer anomalies, although considerable caution should be exercised in their interpretation. Complicating factors in the free-air anomaly include the opposing gravity effects due to deepening of the seabed and thinning of the crust. Where the seabed gradient is steep and the crustal thickness varies abruptly, these features combine to give the well-known 'edge-effect', typically seen as a gravity ridge at the top of a slope and a gravity trough at its foot. The marked gravity expression of the edge-effect leads to masking of some minor gravity features; this is particularly so over the steep slopes below the Rowley Terrace and the Scott Plateau, and to a lesser extent over the upper slope above the Scott Plateau.

GRAVITY AND MAGNETIC MAPS

Interpretation of the free-air anomalies (Plates 5 and 6) is complicated by the effects of abrupt variations in water depth across the Scott Plateau. Only in the north—over the Scott Plateau Dome—and on the shallower parts of the Rowley Terrace are water depths sufficiently uniform for edge-effects to be negligible. Over the northern Scott Plateau the average free-air anomaly is in the range +200 to +300 μm.s^{-2} (see the northern three profiles in Plate 6). Allowing for the +50 to +100 μm.s^{-2} regional effect, this leaves a residual of +100 to +250 μm.s^{-2}, suggesting that the plateau would need to subside slightly to attain isostatic equilibrium.

The positive residual anomaly values of the Northwest Shelf are probably accounted for by the rapid accumulation of sands since the Miocene without compensating crustal sudsidence (Symonds & Willcox, 1976). A similar explanation may apply for the positive values on the shallower parts of the Rowley Terrace.

Over the Scott Plateau, anomaly features with wavelengths of 100 km and less can be directly related to basement and seabed features which have not been individually compensated. Minor anomalies (seen best in the profile map, Plate 6) are probably related to variations in basement relief and to the intrusions which are evident at shallow levels in some seismic sections.

Free-air anomaly values are generally negative over the southern half of the Scott Plateau and the deeper parts of the Rowley Terrace. Gravity modelling studies indicate that this may be partly due to a slight westward thickening of the crust on the eastern side of the ocean/continent boundary. However, the negative anomaly values are mainly due to the edge-effect associated with the steep continental slope. A northwesterly offset in the gravity trough at about 15°40'S, 118°50'E is not reflected in the bathymetry, and may be due to a dislocation caused by transform faulting. More subtle indications of northeast and northwest trends can be distinguished in the vicinity of the lower slope north of 15°S, although some of these may be artefacts of the contouring process. If these trends are real, then they support the hypothesis that the lower slope beneath the Scott Plateau is underlain by narrow segments of rifted crust offset by transform faults.

Bouguer anomalies (Plates 7 and 8) reveal little additional information. On the Northwest Shelf, the anomaly features reflect the major structures of the area—lows over the Browse Basin and offshore Canning Basin, and a high over the Leveque Platform. The gentle gradient between the Northwest Shelf and the Scott Plateau and Rowley Terrace indicates that there is little change in crustal thickness. There are no expressions of major structural changes at the shelf edge; this is in agreement with our interpretation of the seismic data, which indicates that the shelf break is the expression of the foreset beds of a wedge of prograding sediments. The major feature in the Bouguer anomaly field is the steep gradient over the lower slope, which can be attributed to crustal thinning and a density increase at the ocean/continent boundary. Variations in crustal thickness are examined on p. 12.

The magnetic data are presented as a map and profiles in Plates 9 and 10 respectively. The magnetic field can be separated into a number of distinct units which are broadly related to the main structural features.

The most prominent magnetic feature is a strong positive anomaly of up to 700 nT which overlies the lower continental slope. This anomaly is most intense where the slope is steepest, and is probably due to the susceptibility contrast between juxtaposed oceanic and continental crust. The continuity of this anomaly is broken only twice between the northern Scott Plateau and the northeastern Exmouth Plateau: over the Swan Canyon in the southwest, a weak negative anomaly separates positive peaks of 650-700nT; and over the distal end of Bowers Canyon, an intense east-west-trending trough of amplitude −300 nT separates positive peaks of 350-450 nT. The Swan Canyon anomaly is probably related to a right-angle bend in the ocean/continent boundary in that area. Seismic data indicate that the Bowers Canyon anomaly may be related to volcanic sheets and mounds beneath the break-up unconformity, and to downthrow of magnetic basement under the western end of the canyon.

Magnetic field anomalies over the northern half of the Scott Plateau are of low amplitude and long wavelength. Although the long wavelengths of features suggest that magnetic basement is up to 6 km below sea level, acoustic basement is quite shallow except under the northern margin of the plateau and the Scott Plateau Saddle. The likely explanation is that acoustic basement represents the top of a Precambrian and lower Palaeozoic section that overlies magnetic basement; estimates of the depth to magnetic basement (see below) indicate a varying thickness (0-3 km) of Precambrian and lower Palaeozoic section overlying a weakly magnetic basement that may be composed of Kimberley Block equivalents.

Contouring of the 1968 BMR magnetic data (not included in Plate 9) shows that the Browse Basin is characterised by generally negative low-amplitude anomalies which have no discernible trends. The extension of this anomaly pattern to the west-southwest of Ashmore Reef reflects a possible extension of Browse Basin sediments in this direction, as indicated by the seismic data. The Browse Basin magnetic signature is terminated to the west by a series of magnetic highs and lows over the Seringapatam Trend (a major northeast to east-northeast-trending basement high underlying the eastern Scott Plateau and Ashmore Terrace; Plates 16 and 24, line 18/61), confirming the seismic interpretation that the Seringapatam Trend forms the effective western limit to the Browse Basin.

The southern half of the plateau is characterised by several positive anomaly features, up to 450 nT in relief, in an overall positive magnetic field. Acoustic basement appears to be shallow, and the southern edge of the area of postitive anomalies is probably the northern limit of the Rowley Sub-basin. The Rowley Sub-basin is overlain by east-trending magnetic anomaly features with amplitudes of −300 nT in the northern part of the sub-basin; the prominent easterly trend may be partly due to the proximity of the ocean/continent boundary, which also has an easterly trend in the area (Plate 16). The broad negative anomalies of the Rowley Sub-basin are terminated to the east-southeast by the Broome Swell (Plate 16), and to the east and northeast by a complex of positive and negative anomaly features that may reflect-basement complexities at the junction of the Rowley Sub-basin and the offshore part of the Fitzroy Graben.

ESTIMATES OF DEPTH TO MAGNETIC BASEMENT

The magnetic data from a number of Continental Margin Survey lines were subjected to computer analysis by the technique of Werner deconvolution (Hsu & Tilbury, 1977) in an attempt to determine the configuration of magnetic basement under the Scott Plateau.

For the most part, the depth estimates are poor and enable only broad generalisations to be made about magnetic basement configurations. Under most of the plateau, the depth to magnetic basement appears to vary from 2 to 4 km below sea level (0-3 km below the

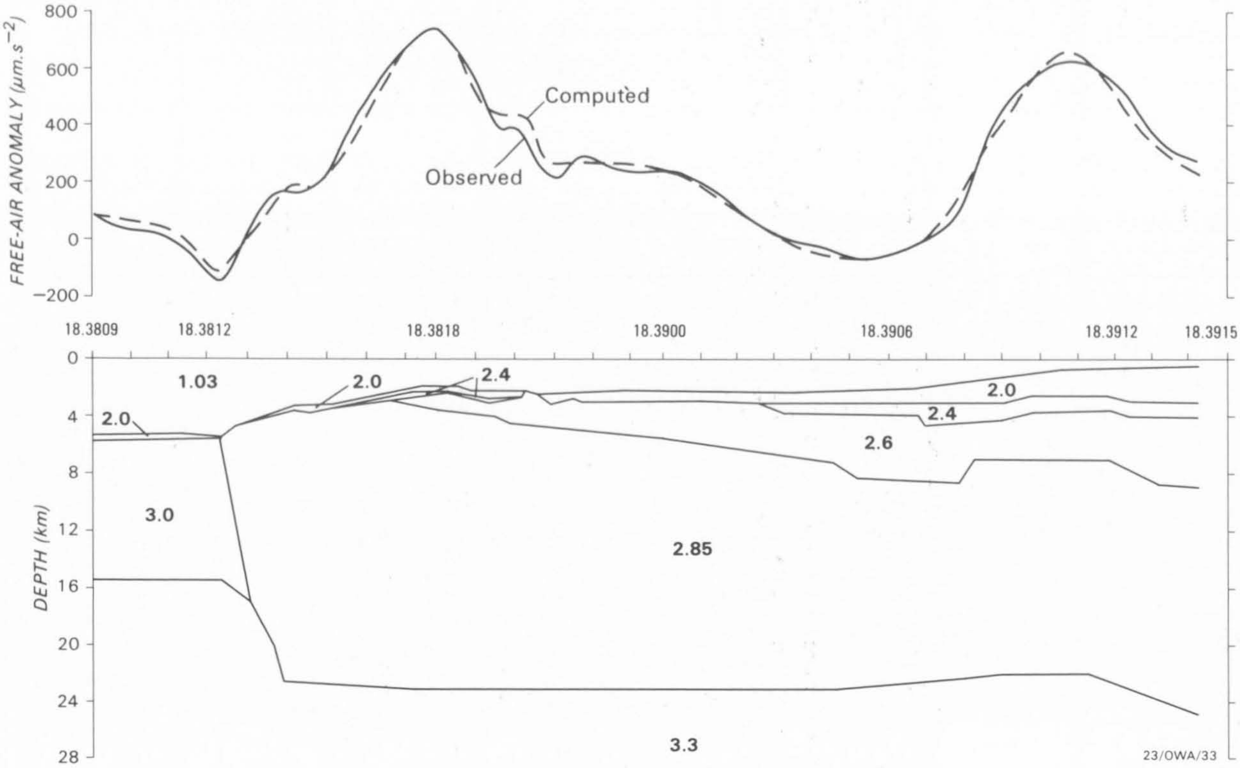


Fig. 8. Computed two-dimensional gravity model across the Scott Plateau (BMR line 18/59); densities are in tonnes/cubic metre.

break-up unconformity). On the outer margin, where basement probably crops out, depth estimates coincide roughly with the seabed. The greatest thicknesses of sediment appear to be under the eastern side of the Scott Plateau Saddle (about 6 km) and beneath the Rowley Terrace (at least 6 km).

GRAVITY MODELS

Two-dimensional gravity models across the Scott Plateau (line 18/59; Fig. 8) and the Rowley Sub-basin (line 17/81; Fig. 9) have been computed to test the compatibility of our seismic interpretation with the available gravity data, and to determine the approximate shape of the crust/mantle interface. The densities of the sedimentary layers (Table 2) are those used by Exon & Willcox (1978), except that the 2.0/2.4 t.m^{-3} interface is placed at our Horizon C—not at Exon & Willcox's Horizon D, which we were unable to map. Crust and mantle densities are assumed to be standard. The density value assumed for oceanic crust (3.0 t.m^{-3}) is that used by Exon & Willcox (1978).

The profile of magnetic basement (density interface 2.6/2.85 t.m^{-3}) was interpreted from estimates of the depth to magnetic basement derived from BMR data, and from a contour map of the depth to magnetic basement compiled by Shell International Petroleum Mij. (1972), based on data recorded by the MV *Petrel* in 1971. A first approximation of the crust/mantle interface was computed from the free-air anomaly values on the assumption that the crust beneath the nearby onshore areas is of standard continental type, is 33 km thick, and has zero free-air anomaly. Francis & Raitt (1967; Table 3) computed the depth to the base of the crust at a sonobuoy refraction station in the eastern Argo Abyssal Plain, 60 km from the western end of line 18/59; this thickness (14 km) has been used as a tie-point for the depth of the mantle at the western end of each model.

The most poorly known parameters in the models are the depths of the magnetic basement and mantle surfaces. However, by making minor adjustments to these two interfaces in the models, we closely matched

TABLE 2. DENSITIES USED IN GRAVITY MODELS

Layer	*Density (t.m^{-3})*
Sea water	1.03
Upper Cretaceous (Horizon C) to Recent	2.0
Triassic to mid-Cretaceous	2.4
Palaeozoic	2.6
Basement (continental)	2.85
Basement (oceanic)	3.0
Mantle	3.3

TABLE 3. SUMMARY OF VELOCITY AND DEPTH INFORMATION FROM REFRACTION STATION 59 OF FRANCIS & RAITT (1967) IN THE EASTERN ARGO ABYSSAL PLAIN

Location of probe: 13°31′S, 118°26′E

Velocity (km/sec)	*Thickness (km)*	*Total depth (km)*
1.5	5.67	5.67
2.15	0.56	6.23
4.89	0.8	7.03
6.61	7.0	14.03
8.09		

the observed and computed gravity data, so we are confident that the models represent the structure.

Several features are readily apparent in both models. On line 18/59 (Fig. 8) there are considerable thicknesses of sedimentary rock beneath the Ashmore Terrace (8 km) and the Scott Plateau Saddle (6 km). On the Scott Plateau, magnetic basement shallows from 4 km below the seabed in the east to 2 km in the west. No attempt was made to simulate short-wavelength anomalies on the crest of the plateau, as the reflection seismic data indicate that structural relief on the acoustic and magnetic basement surfaces is complex. Perturbations in the basement surface of about 1 km relief would be sufficient to account for these anomalies.

The model suggests that crustral structure is fairly normal for a margin of this type. The crust thins seaward at a rate of 1 in 15, from 25 or 26 km under the Ashmore Terrace to 22 km under the upper slope. The crust under the Scott Plateau has a fairly uniform thickness of 23 km as far as the lower slope, from where it thins oceanward at a rate of 1 in 2.8 to about 15 km under the Argo Abyssal Plain.

The fit between observed and computed gravity data is also good for line 17/81 across the outer margin of the Rowley Sub-basin (Fig. 9). However, the line is not at right-angles to the regional geological strike, and the assumption of two-dimensionality is probably not wholly applicable. This may cause some distortion in the computed crust/mantle interface at the deep-water end of the model. As with line 18/59, the least-known parameters are the magnetic basement and the crust/mantle interfaces.

The three uppermost bodies in the model correspond to the sedimentary section in the Rowley Sub-basin. These sediments are more than 7 km thick within a basement depression 50 km wide. West of this depression, the basement shallows gradually and crops out beneath the lower slope. East of the depression, the basement shallows at about the same rate as the seabed, and is overlain by a fairly constant 5-6 km of sediments. Crustal thicknesses are similar to those for the Scott Plateau—about 24 km under the deep-water part of the terrace, increasing to about 27 km under the Northwest Shelf.

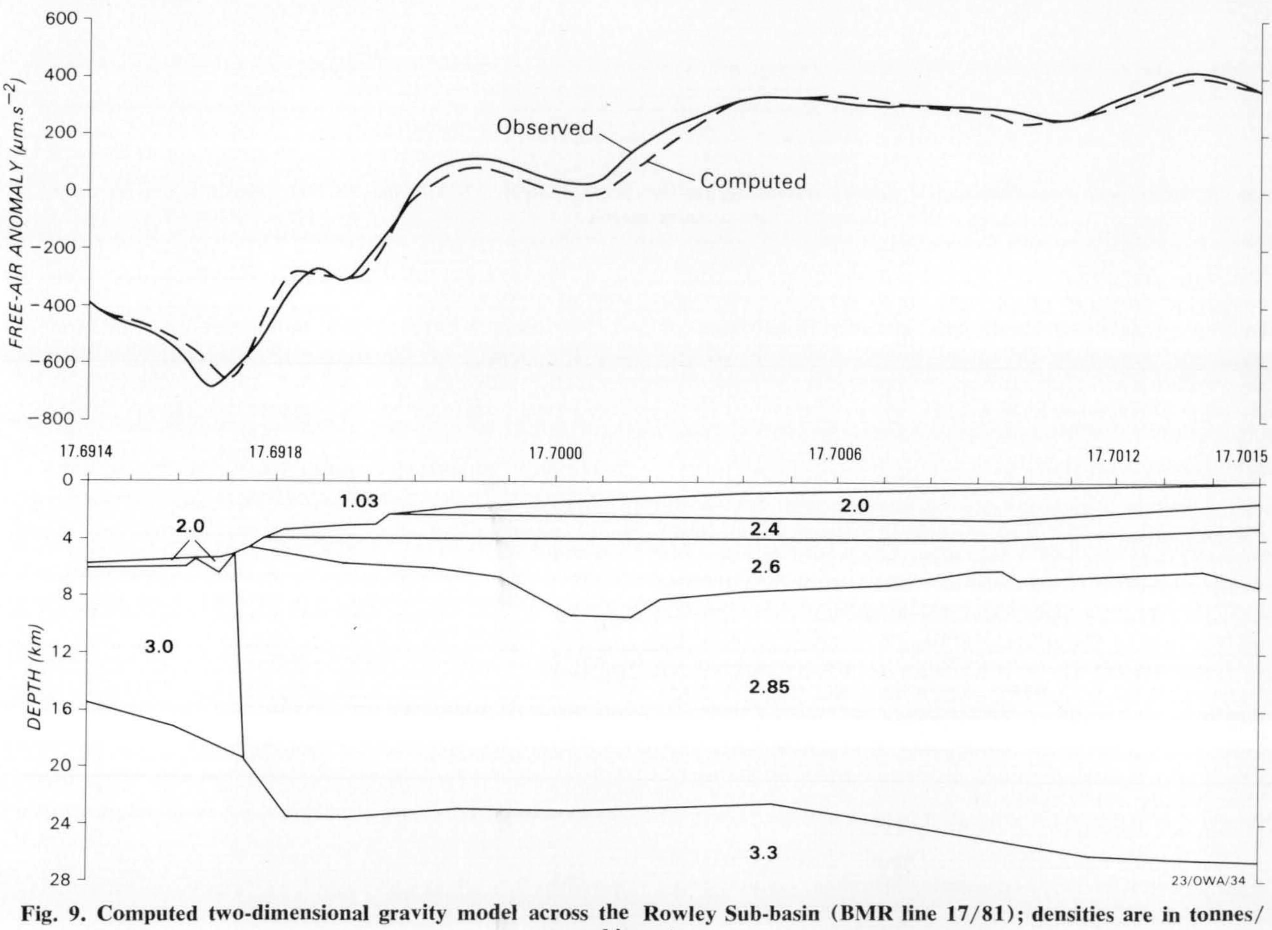


Fig. 9. Computed two-dimensional gravity model across the Rowley Sub-basin (BMR line 17/81); densities are in tonnes/cubic metre.

SEISMIC HORIZONS AND INTERVALS

Stratigraphic information on the sequences underlying the Scott Plateau and Rowley Terrace is based partly on tentative seismic ties to company wells on the Northwest Shelf, and partly on a regional comparison of the seismic stratigraphy with that of the Exmouth Plateau to the southwest. Stratigraphic nomenclature on the Scott Plateau is complicated by the existence of two large sedimentary basins in the study area—the Browse Basin in the north, and the offshore part of the Canning Basin in the south. Although the two basins appear to be connected via the margin of the structural Leveque Shelf (Plate 16), there are marked differences in reflector characteristics (particularly of the deeper reflections) between the two basins. Despite these differences, we are fairly confident in tracing the major unconformities from basin to basin, and our confidence

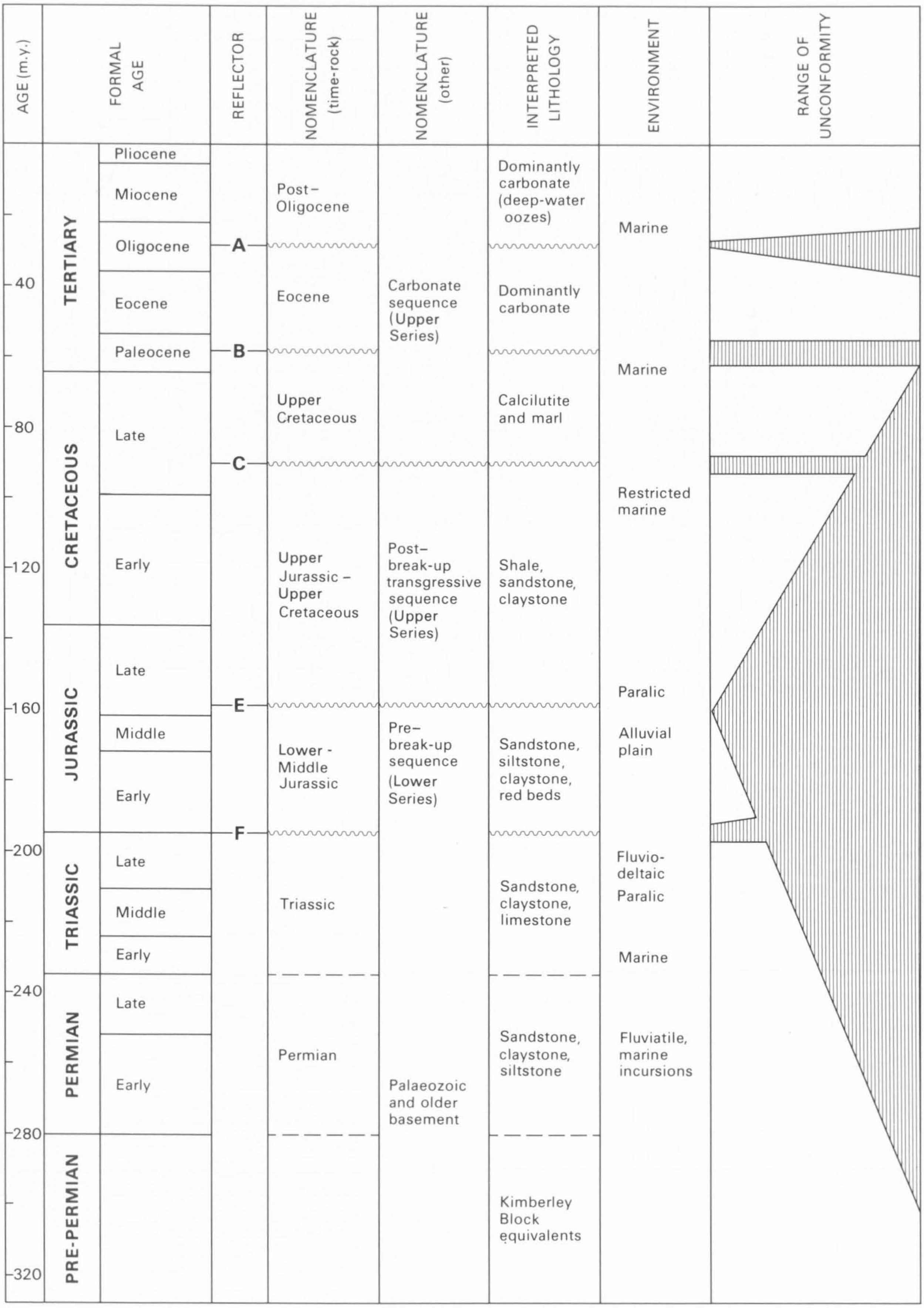


Fig. 10. Interpreted stratigraphy, mapped unconformities, and probable ranges of hiatuses on the Scott Plateau and Rowley Terrace.

TABLE 4. CHARACTERISTICS AND PROBABLE AGES OF SEISMIC REFLECTORS

Horizon	*Probable age*	*Scott Plateau*	*Scott Plateau Saddle to Ashmore Terrace*	*Rowley Terrace*	*Argo Abyssal Plain*
A	Oligocene	Mild angular unconformity near top of well-stratified zone, and at base of semitransparent zone	Prominent unconformity within thick well-stratified section. Overlies slumped beds in Scott Plateau Saddle. Underlies prograded beds on Ashmore Terrace	Within or near top of stratified zone with slightly more transparent beds above. Underlies major zone of prograding with possible thin prograded beds beneath	Strong conformable reflector near top of stratified zone; underlies a semitransparent sequence
B	Base Tertiary—probably early Paleocene	Strong reflector at base of stratified zone, overlying a zone of extensive small-scale slumping	As for Scott Plateau, with some slumped beds above	As for Scott Plateau	Not identified
C	Late Cretaceous—probably Turonian on Scott Plateau and Coniacian on Argo Abyssal Plain	Strong reflector below slumped beds showing excellent continuity; overlies thin weakly stratified zone	As for Scott Plateau	As for Scott Plateau, but overlies thick semitransparent zone	Strong reflector at base of stratified zone overlying thick semitransparent zone
E	Late Middle to early Late Jurassic (Callovian). May be as young as Late Jurassic on Rowley Terrace	Prominent angular unconformity. Marks upper limit of most faulting. Generally overlies acoustic basement of probable pre-Permian age over most of the plateau	Prominent to gentle angular unconformity. Upper limit of most faulting. Underlying section varies from non-stratified (Scott Plateau Saddle) to well stratified (Ashmore Terrace)	Slight unconformity at margins of Rowley Sub-basin; generally conformable in centre of basin. Underlies major semitransparent zone. Upper limit of mild faulting	See Basement, below
F	?Late Triassic	Not definitely identified	Not identified	Strong continuous reflector. Unconformable on basin margins; generally conformable in basin centre. Generally lies 0.8-1.2 s below Horizon E	Not applicable
Basement	Probably Precambrian on Scott Plateau and Rowley Terrace. Late Jurassic and younger on Argo Abyssal Plain	Envelope of diffractions, especially along western margin. Probably Kimberley Block equivalent or volcanics contemporaneous with break-up	Not identified	Not identified	Strong continuous smooth reflector, or envelope of diffractions. Top of oceanic layer 2

is reinforced by tentative ties to Bedout No. 1 (latitude 18°14.667'S, longitude 19°23.383'E, south of the study area), Lynher No. 1, Scott Reef No. 1, and Ashmore Reef No. 1 wells (Plate 1).

Sedimentary units and sequences are referred to by their interpreted ages, because no rock units have been named in the wholly offshore Browse Basin, and few units have been named in the offshore part of the Canning Basin. The characteristics and probable ages of seismic reflectors are shown in Table 4, and the interpreted ranges of unconformities are shown in Figure 10. Four unconformities (Horizons E, C, B, and A) have been mapped over the entire area, and contour maps of the depths of these horizons are included in Plates 12-15. Stagg (1977) constructed contour maps of the time-depths of these same reflectors.

Horizon E is the most prominent unconformity visible under most of the plateau. Its age range can be determined only on the Northwest Shelf, where it is dated as late Middle to early Late Jurassic, corresponding to the period of continental break-up. It probably has the same age range over the eastern margin of the Scott Plateau, in the Rowley Sub-basin, where the sedimentary section appears to be fairly complete.

On the central and western Scott Plateau, the hiatus was probably of much greater duration: Allen & others (1978) considered that the pre-Horizon E sequence is no younger than Permian, whereas on some structural highs the sequence immediately overlying Horizon E is as young as Late Cretaceous to Eocene (Stagg, 1978).

The seismic characteristics of Horizon E and the underlying Lower Series vary from area to area. On the Ashmore Terrace, and especially along Gulf Lines AU-28 to Au-32, Horizon E is only a slight unconformity, little disturbed by faulting, at the top of a well-stratified sequence. It shows similar characteristics over much of the Rowley Sub-basin (Fig. 12), but is more extensively faulted at the margins of the sub-basin. On the eastern margin of the Scott Plateau, Horizon E is a more distinct unconformity dislocated by quite extensive block-faulting of the underlying sequence. The central and outer Scott Plateau apparently remained at or above sea level throughout much of the period preceeding break-up of the margin; here Horizon E is a well-marked erosional surface on the structural highs, little displaced by the numerous faults, and a moderately prominent angular unconformity in the ponds of sediment within the depressions in the erosional surface (Plate 24, line 18/61). The underlying sequence is poorly stratified, other than in the depressions, indicating that it is probably much older than the Lower Series to the east (probably pre-Permian); the basal ponded sediment within the depressions is probably of Early to Middle Jurassic age.

The only unconformity older than Horizon E that we can identify with any confidence is labelled as Horizon F. It probably corresponds to a major episode of tectonism that lasted from the Late Triassic to Early Jurassic, and resulted in some uplift and erosion of the pre-break-up rift-valley sequence. We are most confident of our identification of this reflector in the Rowley Sub-basin, where it forms a distinct horizon that is mildly unconformable in places (Fig. 12). Faulting at this level is more evident than it is at the break-up Horizon E, although displacements are mostly minor. A strong, faulted reflector under part of the northern Scott Plateau has been picked as Horizon F, although its identification is tentative.

Horizon C shows the most consistent character throughout the area, appearing as a continous, strong reflector that separates an underlying semitransparent zone from an overlying well-stratified zone (Figs. 11 and 23). Interval E-C ranges in thickness from 1800 m under the southeast Scott Plateau to 400 m and less on the central and outer plateau. Only where this interval is thin does it lose its characteristic semitransparent character. Well ties, and comparison with a similar reflector over most of the western margin of Australia, identify Horizon C as being of Turonian to Coniacian age, and lying at the base of a Toolonga Calcilutite equivalent (the basal unit of the Upper Cretaceous-Tertiary carbonate sequence).

The post-Horizon C section contains several unconformities, mainly within the upper part of the section near the shelf edge. Two of these unconformities—Horizons B and A—are regionally continuous, and were mapped over the entire area. Tentative well ties, and ties to BOC of Australia Ltd (BOCAL) seismic lines, indicate that the unconformities are of Paleocene and Oligocene ages, respectively. The origin of neither unconformity is well understood at present, but the most likely alternatives are erosion due to deep ocean currents or to carbonate dissolution; however, a shallow-water wave-erosional origin cannot be ruled out in some places.

Both Horizons B and A have distinctive seismic characters. Horizon B is typically a strong reflector overlying a thin sequence which shows small-scale yet widespread slumping (Figs. 12 and 23). Horizon A is a prominent unconformity near the middle of the Tertiary section. On the central and outer Scott Plateau and the Argo Abyssal Plain it lies at or near the top of a well-stratified sequence, and underlies a semitransparent sequence. On the inner margin of the plateau the unconformity generally deepens, and the overlying sequence becomes well-stratified (Fig. 11). Beneath the Northwest Shelf and the Rowley Terrace, Horizon A lies at the base of a major prograded sequence (Plate 24, line 18/61), but in a few places on the shelf there are indications of a thin prograded sequence beneath the unconformity.

INTERVAL VELOCITIES

Several problems were encountered in deriving a set of interval velocities for use in time-to-depth conversion. Briefly, these were:

1. The only exploration wells in the area have been drilled on the Northwest Shelf, and almost invariably on structural highs where the sedimentary intervals are usally thinner, and hence probably of lower velocity, than in adjacent areas. Interval velocities determined from these wells are therefore not usually representative of velocities over the study area as a whole.

2. Most of the nine sonobuoys deployed in the area during the BMR Continental Margin Survey recorded poor-quality data. Although refractors were identified, it was difficult to tie them to a particular geological horizon. During cruise 93/14 of the *Atlantis II*, a sonobuoy was deployed over the Argo Abyssal Plain. This recorded an excellent refraction from the oceanic third layer, but nothing shallower. However, analysis of wide-angle reflection data from all the sonobuoys was of considerable use in velocity determinations.

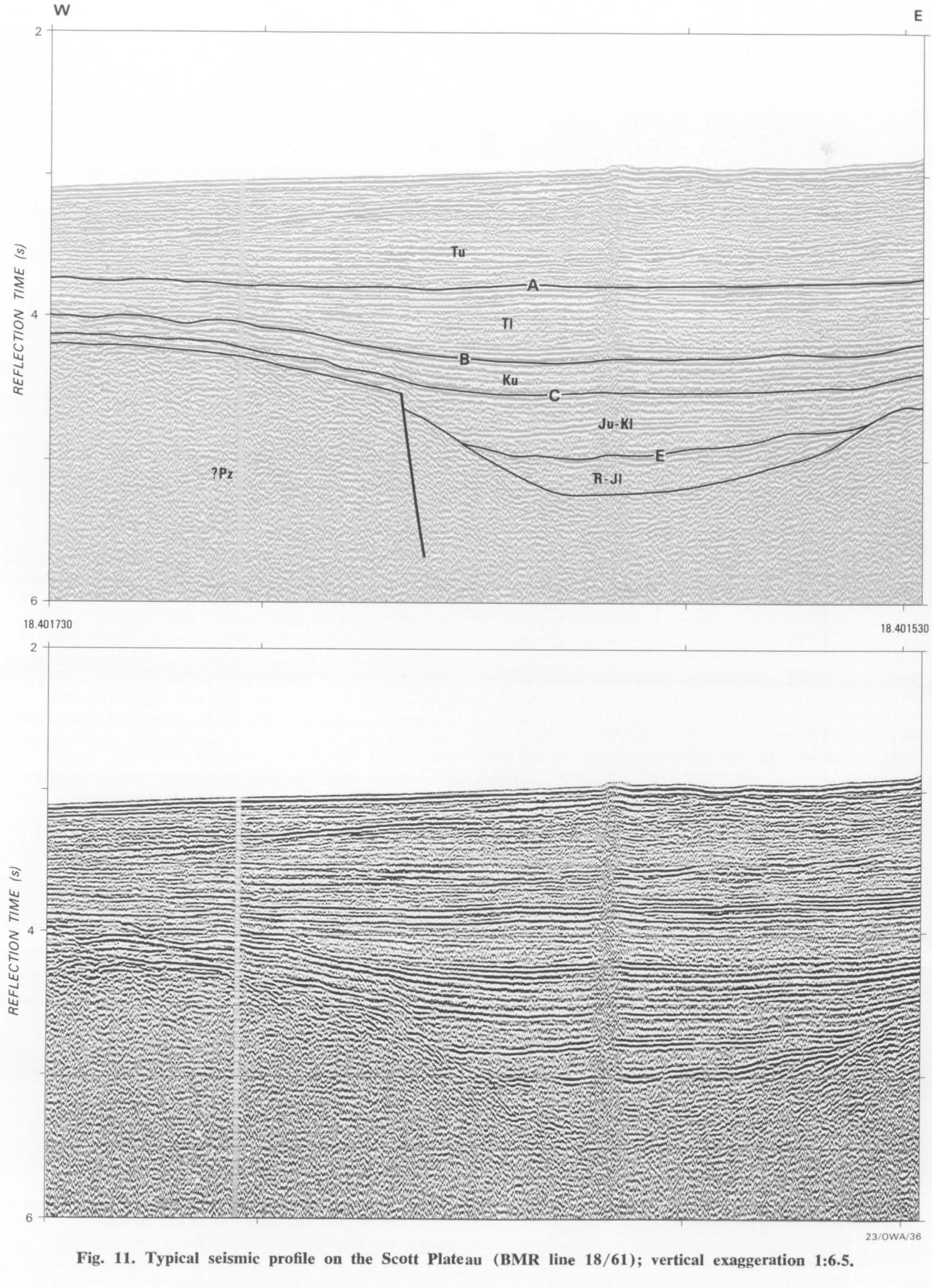


Fig. 11. Typical seismic profile on the Scott Plateau (BMR line 18/61); vertical exaggeration 1:6.5.

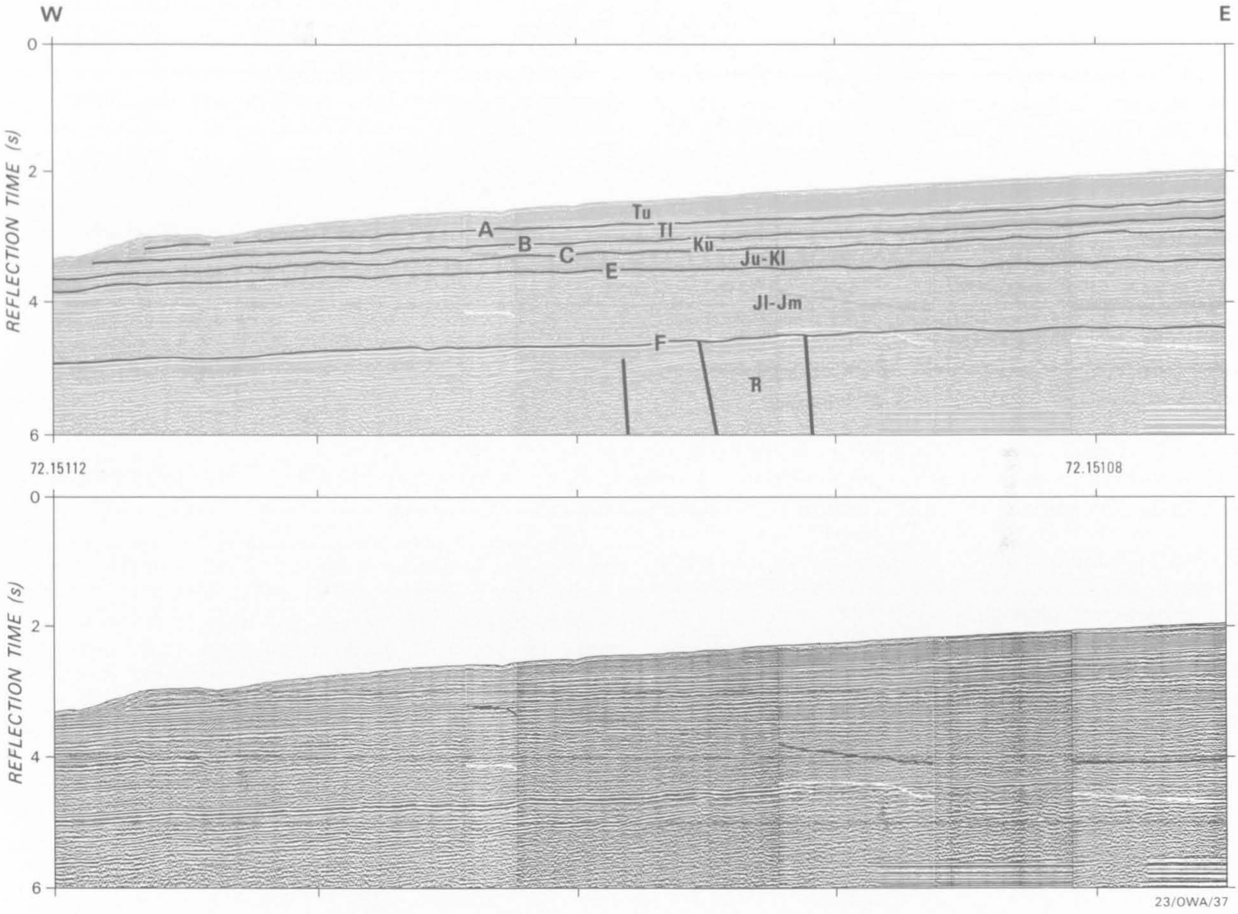


Fig. 12. Typical seismic profile on the Rowley Terrace (Gulf line Au-26); vertical exaggeration 1:4.0.

3. The variation in sediment type in proceeding from a neritic environment (Northwest Shelf), through a bathyal environment (Scott Plateau), to an abyssal environment (Argo Abyssal Plain) must be associated with lateral velocity changes within particular seismic intervals.

4. The large variation in thickness of particular sedimentary intervals (2000 m to 100 m for the post-Oligocene section) produces lateral velocity variations as a result of differing degrees of compaction.

The only widespread velocity information came from the root-mean-square processing velocities obtained from BMR seismic lines processed by Geophysical Service International. Although interval velocities obtained from these processing velocities may be only a rough approximation to true interval velocities, we believe that comparison of processing velocities with known true velocities in a particular area might enable a general correlation to be made. It was found that average interval velocities compiled from the seismic processing were close to those obtained from wells and wide-angle sonobuoy reflections. About 70 sets of processing velocity analyses in various water depths were reduced to interval velocities by the method of Dix (1955).

Two important results came from the analysis of velocities. Firstly, the interval velocities—particularly the seabed-Horizon A velocity—vary inversely with water depth. Secondly, velocities from any particular range of water depths are consistent.

Because of the large variation in velocity of a particular seismic interval (1850 $m.s^{-1}$ to 2600 $m.s^{-1}$ for interval A-seabed) we were unable to use constant interval velocities over the entire area. Combining the various data sources has enabled us to compile a table of velocities (Table 5). Within each of the three bathymetric provinces (Northwest Shelf, Scott Plateau, Argo Abyssal Plain; Plate 11), we have assumed constant velocity for each interval. We have assumed that the variations in interval velocity between these areas—over the upper and lower slopes—are linear.

TABLE 5. SEISMIC INTERVAL VELOCITIES ($m.s^{-1}$) USED IN TIME-DEPTH CONVERSION IN THE ASHMORE TERRACE, SCOTT PLATEAU, AND ARGO ABYSSAL PLAIN COMPARED WITH CENTRAL BROWSE BASIN INTERVAL VELOCITIES

Horizon	*Ashmore Terrace*	*Scott Plateau*	*Argo Abyssal Plain*	*Central Browse Basin*
Sea level				
	1500	1500	1500	1500
Seabed				
	2600	1850	1850	2750
A				
	3000	2250	2200	3400
B				
	3000	2500	2200	3600
C				
	3000	2700	2200	3300–4000
E				
Source	Exploration wells, processing velocities	Sonobuoy wide-angle reflections, processing velocities	Sonobuoy wide-angle reflections, DSDP Site 261	Allen & others (1978)

STRUCTURE

The structural features of the sedimentary basins of the adjacent Northwest Shelf have been described in detail by Challinor (1970), Halse & Hayes (1971), and Allen & others (1978). To date, the structure of the Scott Plateau has been discussed briefly by Veevers, Falvey, & others (1974) and Veevers & Cotterill (1978), and in more detail by Stagg (1978) and Hinz & others (1978). The following analysis is more comprehensive and detailed than any published hitherto.

Northwest-trending structural lineaments are common over much of Western Australia, being reflected in the Kimberley, Pilbara, and Yilgarn Blocks and the deformed Proterozoic sequences between them. The lineaments are Precambrian in age, and Palaeozoic and Mesozoic structures in the onshore intracratonic Canning Basin reflect to some extent the underlying grain. Structural lineaments on the northwest Australian margin, particularly in the Carnarvon and Browse Basins, are dominated by northeast structural trends which probably formed in the Mesozoic during the rifting of Gondwanaland.

Falvey (1972) identified northeast-trending magnetic lineations in the Argo Abyssal Plain, which Falvey & Veevers (1974) interpreted to be the result of seafloor spreading. Larson (1975) correlated the magnetic lineations with a Late Jurassic magnetic-reversal sequence, which is consistent with the dating of oceanic basement at DSDP Site 261 as Oxfordian (Veevers & Heirtzler, 1974). Based on computed spreading rates, break-up has been calculated (Veevers & Heirtzler, 1974) as taking place in the Callovian (early Late Jurassic).

The study area is structurally diverse, and can best be discussed in terms of six structural elements. These are:

—Ashmore Terrace,

—Scott Plateau Saddle and northeast Scott Plateau,

—central and northern Scott Plateau,

—northwest Scott Plateau,

—southeast Scott Plateau and Leveque Shelf,

—Rowley Sub-basin and southern margin of the Scott Plateau.

ASHMORE TERRACE

The Ashmore Terrace is a poorly defined upper-slope terrace (Plate 3) underlain by the western and northwestern Browse Basin. Company seismic data indicate a series of closed and faulted pre-break-up, northeast-trending structural highs lying along the Scott Reef and Seringapatam Trends (Plate 16). These deep structures are barely visible on the BMR seismic lines used in this study, owing to insufficient penetration and the masking effect of reverberations set up in the water column and within the strongly reflecting, high-velocity, flat-lying carbonates which constitute the top 1 to 2 seconds of the section.

The most prominent feature in our seismic data is the pronounced prograding in the post-Horizon A (post-Oligocene) sediments. The prograded part of the section is about 20-25 km wide, and the sediments attain a maximum thickness of about 1000 m. Just beyond the distal edge of the prograded sediments a zone of slumping about 10 km wide underlies the upper slope. The position of the upper slope is controlled by the distal edge of the prograded sediments and does not appear to be related to any major faulting.

Local minor unconformities are evident in the post-Horizon A section; these show greatest angular discordance near the western edge of the terrace, where Recent sediments lap on to an undulating surface. Probable buried reef structures in the Miocene and younger section indicate shallow-marine environments. The uppermost reflectors in the section crop out at the western edge of the terrace where seabed gradients are about 1°. This, together with the marked angularity of some reflectors with the seabed, supports Jones's (1973) conclusion that the shelf is presently an area of non-deposition of sediment. Minor faulting is present in the Tertiary section, particularly at the northern end of the terrace, but throws are generally small.

SCOTT PLATEAU SADDLE AND NORTHEAST SCOTT PLATEAU

The Scott Plateau Saddle roughly marks the western limit of the Mesozoic sedimentary rocks of the Browse Basin. Oil company seismic data indicate that the Mesozoic rocks thin westwards over shallowing basement of probable pre-Permian age at the southern end of the saddle (see also fig. 4 in Allen & others, 1978).

At the southern end of the Scott Plateau Saddle to the west of Scott Reef, the Lower Series section immediately below Horizon E is probably of Palaeozoic or Precambrian age (Fig. 11). These rocks appear to be extensively faulted, although individual faults are difficult to identify because of peneplanation of the palaeotopographic highs. In general, the Lower Series returns little coherent reflected energy, although there are indications of steeply dipping events to the west of the Seringapatam Trend. The magnetic data indicate that about 4-6 km of Palaeozoic section may overlie magnetic basement in the Scott Plateau Saddle. Possible Triassic and Jurassic sedimentary rocks are ponded in depressions on the basement surface; they are rarely more than a few hundred metres thick, and probably consist of fluvial and lacustrine sands eroded from the adjacent high areas.

The Mesozoic Lower Series section thickens northwards and becomes more widespread. Stratified fault-blocks of possible Triassic and Jurassic age are evident on BMR line 18/59 (Plate 24). The throws of the faults are generally small, and rarely attain 200 ms (about 200 m). Upper Series deposition commenced in the valleys between the fault-blocks and transgressed to cover the blocks by the Late Cretaceous.

The interpreted Lower Series Mesozoic sediments are thickest at the northern end of the Scott Plateau Saddle, where a minimum of 2 to 2.5 s of well-stratified section is present. Within this section, normal antithetic faults with westerly downthrows—generally less than 200 m—are evident beneath the upper slope on BMR line 18/57 (Fig. 13). Although our tying of horizons between seismic lines here is uncertain, it appears that horizons as young as Horizon C (Upper Cretaceous) and perhaps Horizon B (base Tertiary) have been displaced by the faulting. The magnetic anomaly data suggest that the Lower Series sequence may be in communication with that of the northern Browse Basin.

The Upper Series section under the Scott Plateau Saddle has an average thickness of 1.5 km in the south, and thins to a few hundred metres in the north, where slopes become steeper. The Upper Jurassic to mid-

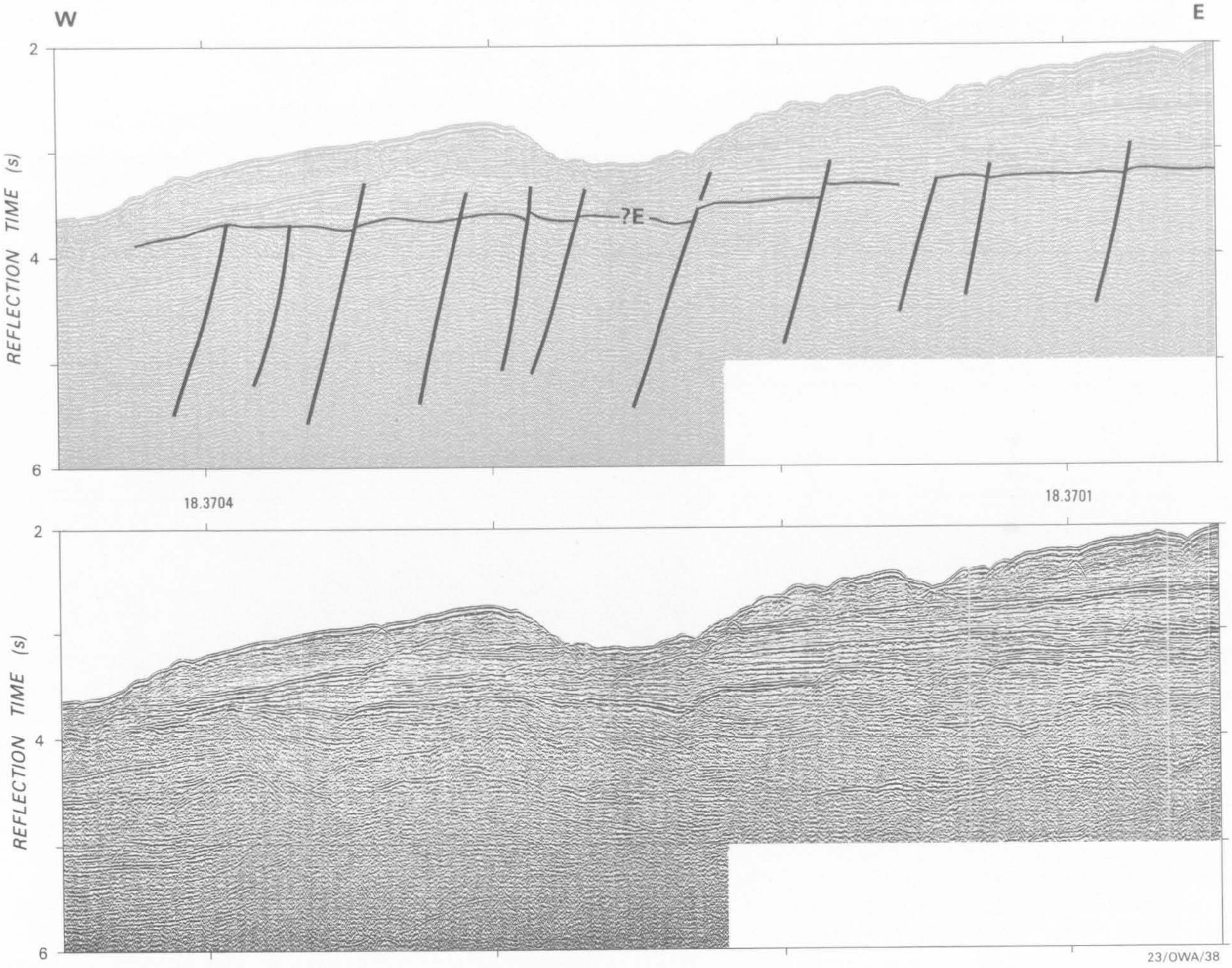


Fig. 13. Seismic profile across the fault zone on the northeastern Scott Plateau (BMR line 18/57); vertical exaggeration 1:6.4.

Cretaceous section (interval E to C) is rarely more than a few hundred metres thick and characteristically laps onto the Palaeozoic basement highs. Most of these highs were not covered by sediment until Late Cretaceous time, indicating either that sediments were in short supply or that parts of the plateau remained near sea level until the Late Cretaceous. The latter possibility was suggested by Stagg (1978), and also by Allen & others (1978, p. 31), who considered that: 'The transgression had spread across much of the subsiding Scott Plateau by the Late Jurassic-Early Cretaceous time, although parts of it may have remained exposed until the Late Cretaceous . . .'

Most of the Upper Series section is Late Cretaceous (Coniacian) and younger (cf. Plates 17 and 22). As on the Ashmore Terrace, these sediments are usually flat-lying, although angular unconformities are present in the upper part of the section, especially near the base of the upper slope.

CENTRAL AND NORTHERN SCOTT PLATEAU

Structurally, the central Scott Plateau is probably the least deformed part of the study area (Fig. 14; Plate 24, line 18/61). It is underlain by a dome of rocks that typically show chaotic reflections or are reflection-free. We believe that this seismic character indicates that the rocks are probably Palaeozoic and older. Volcanics probably make up a significant part of the section, especially near the break-up unconformity. The original topography has been reduced by peneplanation, indicating that, before break-up, at least this part of the plateau was at or above sea level, shedding sediments into the adjacent areas. Significantly, dipmeter data in Scott Reef No. 1 suggest that the Scott Plateau provided a sedimentary source in the western Browse Basin (Allen & others, 1978). Small erosional depressions and shallow grabens within the peneplaned surface are filled with probable Triassic and Jurassic fluvial and lacustrine sands. Faults are apparent in the Lower Series; trends are difficult to determine, but from the limited amount of data available they appear to be east-northeasterly on the eastern side of the central plateau, and west-northwesterly on the northern and western sides.

The Upper Series sedimentary cover has an average thickness of 1 km over most of the central Scott Plateau (Plate 21), thinning to a few hundred metres in the west. As under the Scott Plateau Saddle to the east, most of this section is post-Horizon C (Late Cretaceous and younger; Plate 22). The thin sequence between Horizons B and C (Late Cretaceous) typically contains widespread but small-scale slump structures which have facilitated the picking of Horizon B in areas where ties are dubious. The Tertiary section is typically flat-lying and well-stratified, and contains several minor unconformities, principally below Horizon A. Although most

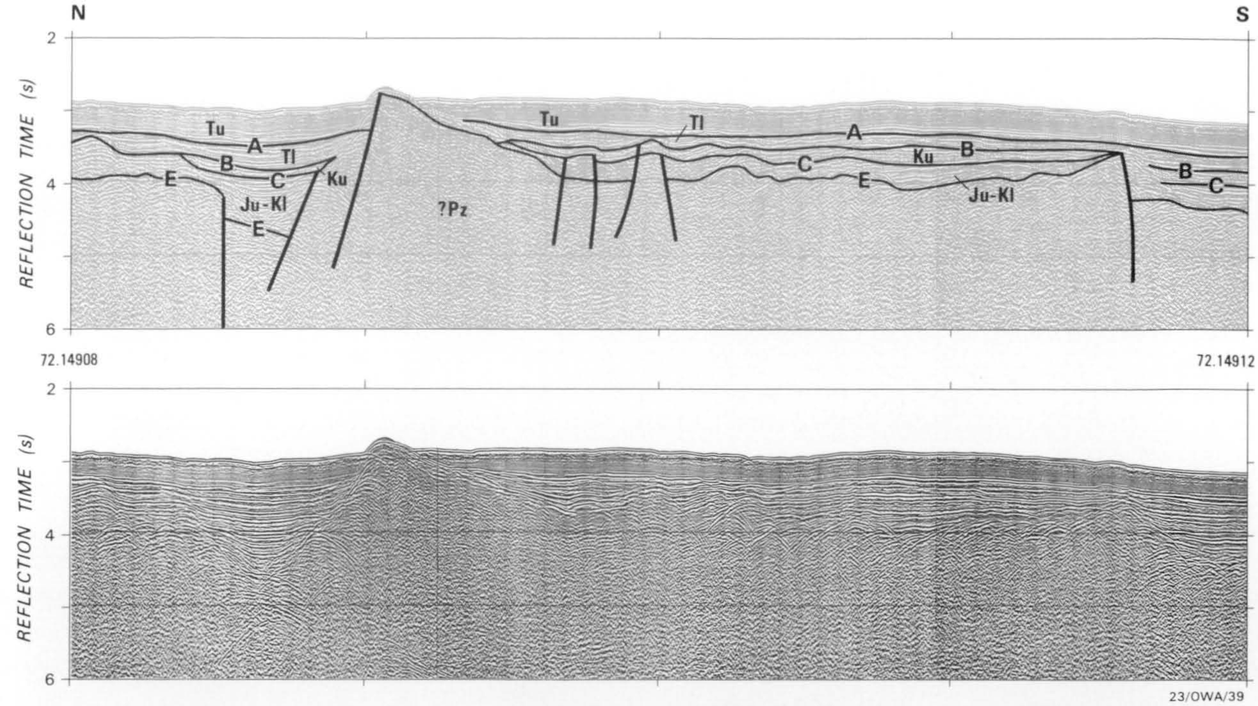


Fig. 14. Interpreted seismic profile on the Scott Plateau Dome (Gulf line Au-4); vertical exaggeration 1:4.3.

of this interval is flat-lying, channelling and lensing are evident at about the level of Horizon A. Such channels may be the result of strong local currents in deep water, but a shallow-water origin cannot be ruled out. Some minor faults extending to about the level of Horizon A are probably related to continuing subsidence and other epeirogenic movements of the plateau in the Tertiary.

NORTHWEST SCOTT PLATEAU

This area of the Scott Plateau is certainly the most complex structurally. Despite the relatively high concentration of survey lines here, our interpretation is far from definitive because the lines are from four different surveys and most were sited with little or no regard to the location of previous work. Consequently, despite the concentration of data, many of the more complex and important features are still inadequately surveyed and there is a lack of good ties to better-known areas.

The structural complexity reflects the highly fractured nature of the crust to the north of the Scott Plateau. Hinz & others (1978) tentatively concluded that continental crust continues to the north of the plateau, perhaps as far as the Roti Basin. The structure of the northwest Scott Plateau may have been affected to some degree by collision processes in the Roti Basin. Although we disagree with Veevers & Cotterill (1978), who have proposed that the bulk of the Scott Plateau is an epilith, we do not discount the possibility that the area to the north is underlain by an epilith.

To the north of the Scott Plateau Dome, the thickness of the stratified Lower Series section generally increases. Centred on about 12°40′S, 120°30′E is an isolated pocket of thick possible Mesozoic sedimentary rocks mentioned by Stagg (1978). Although our tie of horizons in this pocket is tentative, we are fairly confident of our pick of the break-up unconformity. Below this unconformity (Fig. 15), up to 2 seconds of well to poorly stratified section are evident. The deepest unconformity visible in this pocket is a strong, though discontinuous reflector offset by up to 1 km by normal faults with the downthrown blocks apparently to the northeast. We have tentatively labelled this reflector as Horizon F, because its relation to Horizon E is similar to that between Horizons F and E south of the Scott Plateau. Many of the faults at Horizon F level were reactivated during break-up, resulting in significant offsets of Horizon E. The interval between Horizons F and E is well layered, although more transparent than adjacent intervals, and the lowest beds in the interval lap on to reflector F. The Upper Series section thins from about 1 km on the northern side of the Scott Plateau Dome to a few hundred metres and less on the northern plateau margin.

To the northwest and northeast, this sedimentary pocket is bounded by basement highs which crop out on the seabed. Whether these sedimentary rocks continue into the Roti Basin, and whether they are continuous with thick Mesozoic rocks under the northern end of the Scott Plateau Saddle, cannot be determined from the available data.

Structure in the northwest corner of the Scott Plateau is controlled by large-scale block-faulting which has resulted in the development of the northwest-trending Oates Canyon. Within the uplifted fault-blocks, Horizon E is a prominent unconformity, which apparently resulted from the subaerial erosion of a well-stratified dipping sedimentary section at least 2 km thick (Fig. 16). This section overlies an acoustic basement which shallows to the south and immediately underlies Horizon E south of Oates Canyon.

The similarity between the uplifted fault-blocks adjacent to Oates Canyon and fault-bounded blocks underlying Emu and Echidna Spurs on the northeast Exmouth Plateau is remarkable, and similar origins must be considered likely. At both places, a thick stratified sequence underlies a flat unconformity which was apparently formed in shallow water and today lies about 2000-2300 m below sea level. Exon & Willcox (1980) considered the blocks underlying Emu Spur to

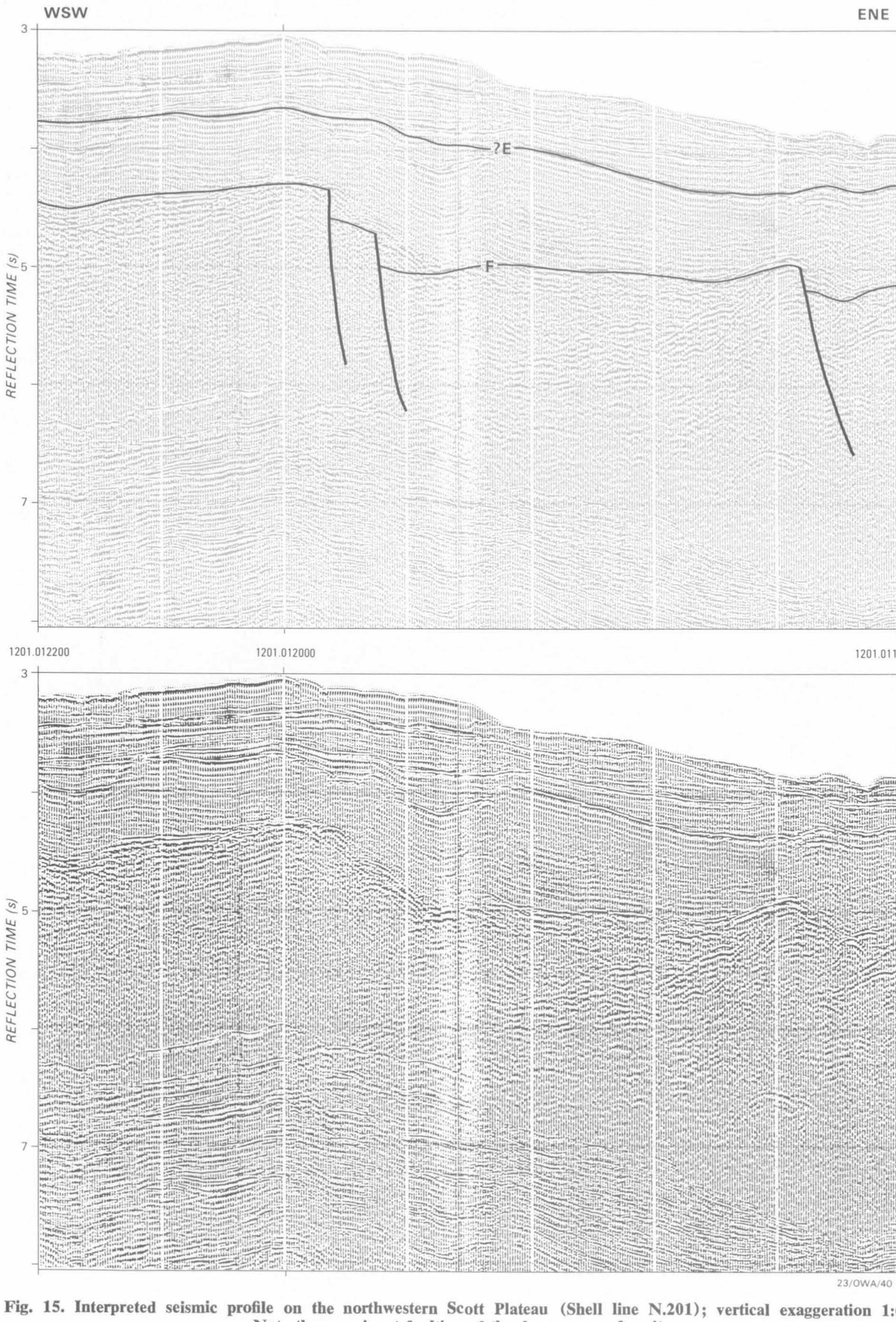


Fig. 15. Interpreted seismic profile on the northwestern Scott Plateau (Shell line N.201); vertical exaggeration 1:6.5. Note the prominent faulting of the deeper unconformity.

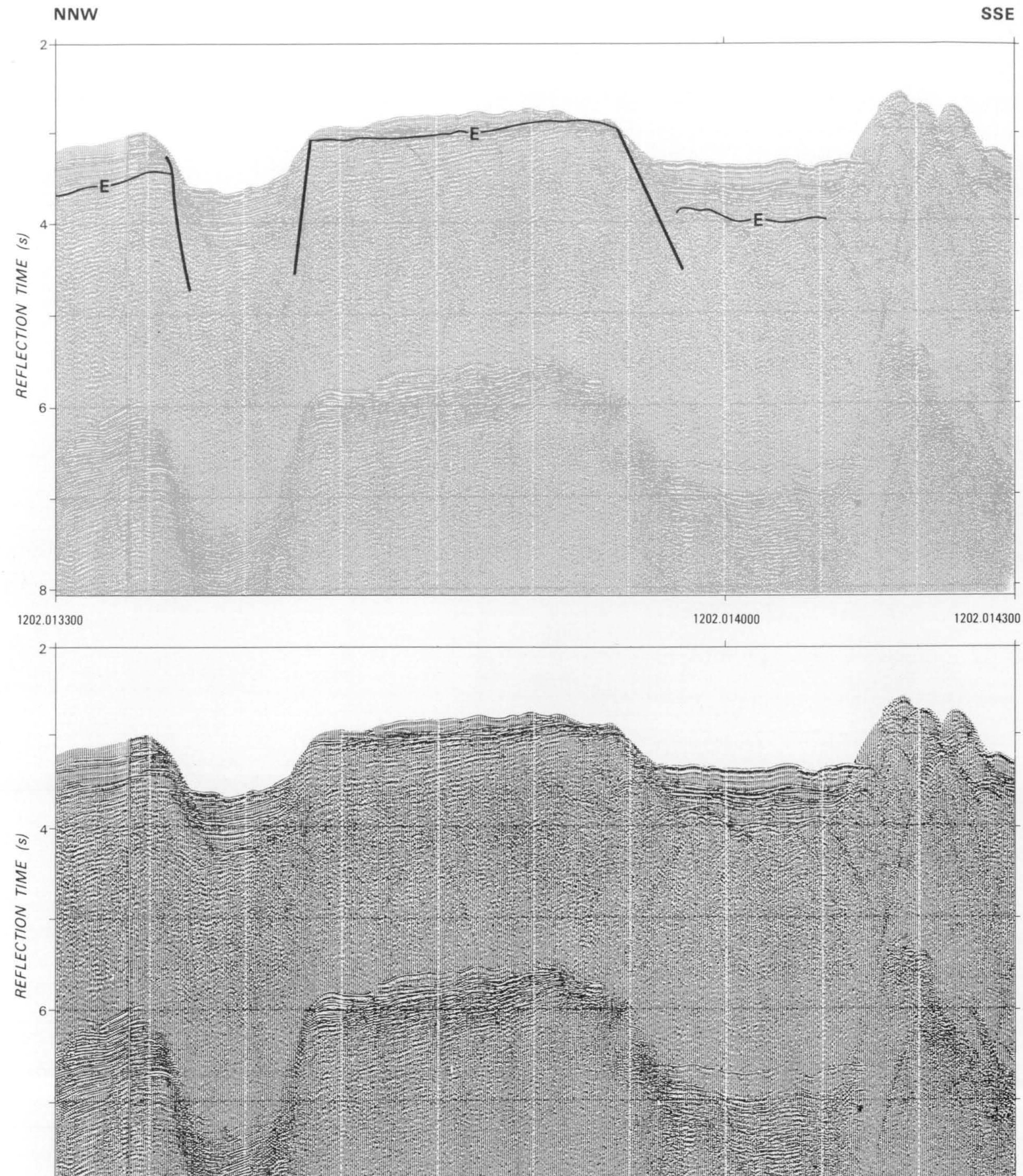


Fig. 16. Interpreted seismic profile on the northwestern Scott Plateau (Shell line N.202); vertical exaggeration 1:5.8. Note the fault-block with the planed-off break-up unconformity overlying a dipping stratified section in the centre of the profile. The protruding structure on the right of the section has strong magnetic expression and is probably of igneous origin.

be wave-cut platforms upon which post-Miocene carbonates have been deposited. They also suggested that the Lower Tertiary sediments were stripped from the Emu Spur blocks during uplift of the Exmouth Plateau Arch in the Eocene and early Miocene.

Coring of an Oates Canyon fault-block by the RV *Valdivia* recovered a sample of Campanian calcareous marl from the post-Horizon E section (Hinz & others, 1978). Tests on this sample indicate that deposition was in a bathyal environment, which implies that Tertiary uplift and erosion did not occur—so the paucity of sediments on the blocks above Horizon E may be due to strong currents acting around isolated and relatively elevated depositional sites.

The northwest margin is one of the few places on the Scott Plateau where fault trends can be determined with confidence. The prominent trends are northwest to west-northwest, and are possibly the expressions of

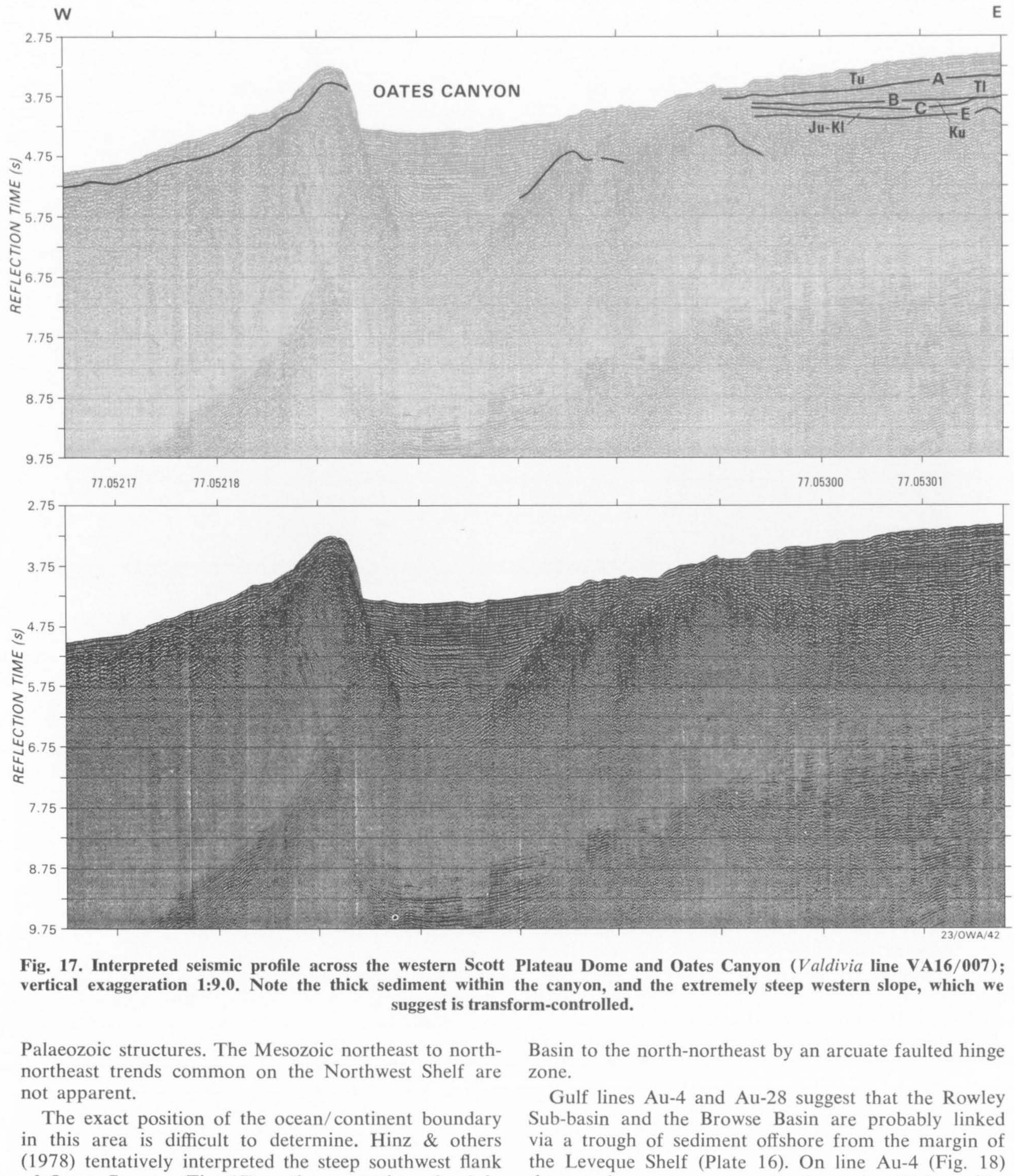


Fig. 17. Interpreted seismic profile across the western Scott Plateau Dome and Oates Canyon (*Valdivia* line VA16/007); vertical exaggeration 1:9.0. Note the thick sediment within the canyon, and the extremely steep western slope, which we suggest is transform-controlled.

Palaeozoic structures. The Mesozoic northeast to north-northeast trends common on the Northwest Shelf are not apparent.

The exact position of the ocean/continent boundary in this area is difficult to determine. Hinz & others (1978) tentatively interpreted the steep southwest flank of Oates Canyon (Fig. 17) as the expression of a left-lateral transform fault, which they named the North Wilson Transform. Volcanic extrusion along this fault may account for the abundant volcanics dredged in this locality, and for the difficulty in determining the type of crust to the north.

SOUTHEAST SCOTT PLATEAU AND LEVEQUE SHELF

The Leveque Shelf is a stable westerly and north-westerly extension of the Leveque Platform (Plate 16), an area of shallow basement which separates the Browse Basin from the offshore Canning Basin. It is separated from the Rowley Sub-basin to the west and the Browse Basin to the north-northeast by an arcuate faulted hinge zone.

Gulf lines Au-4 and Au-28 suggest that the Rowley Sub-basin and the Browse Basin are probably linked via a trough of sediment offshore from the margin of the Leveque Shelf (Plate 16). On line Au-4 (Fig. 18) the trough appears as a gentle depression 50 km wide, principally in the Lower Series (pre-Horizon E) section. The depression contains at least 7 km of Mesozoic and Cainozoic sedimentary fill.

The northwest margin of the Leveque Shelf is down-faulted to the north, and acoustic basement plunges north or northwest beneath a thickening sedimentary section. To the northwest of this margin of the Leveque Shelf, acoustic basement presumably shallows across a fault or hinge zone beneath the upper continental slope, and Horizon E lies above rocks of probable Palaeozoic age on the southeast Scott Plateau.

A Late Triassic palaeoenvironment map prepared by Allen & others (1978, fig. 6) indicates that before

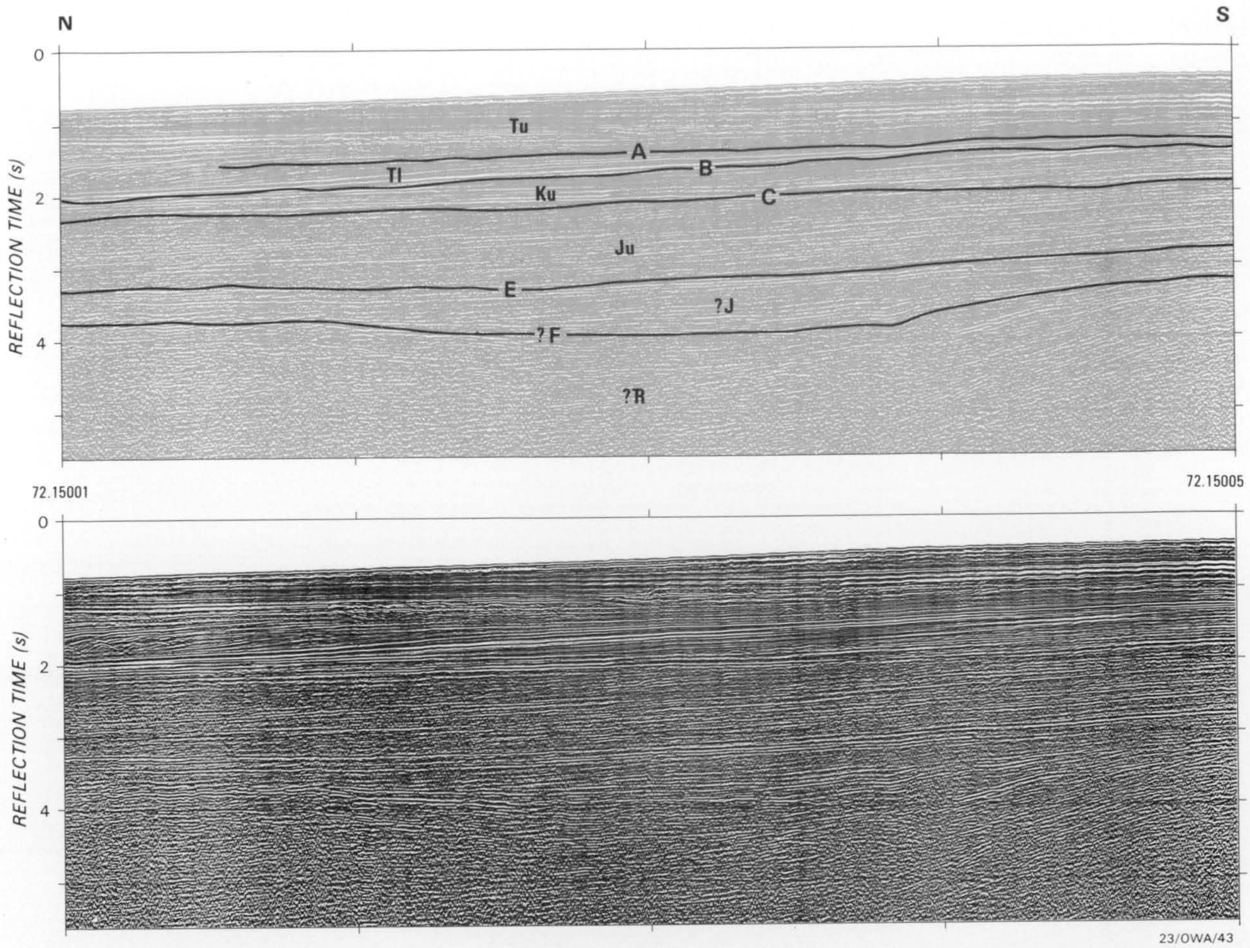


Fig. 18. Interpreted seismic profile across the downwarp joining the Browse Basin and the Rowley Sub-basin northwest of the Leveque Shelf (Gulf line Au-4); vertical exaggeration 1:4.4. The downwarp has little expression above Horizon E.

Horizon F time the area presently underlain by the southeast Scott Plateau and Leveque Shelf was possibly a fluvio-deltaic plain draining to the northeast through the Browse Basin. On line Au-4 (Fig. 18) the pre-Horizon F reflections are strong but have poor continuity, which according to Sangree & Widmier (1977) indicates likely fluvial conditions. Between Horizons F and E is a 700 m thick Lower and Middle Jurassic sedimentary sequence, which laps on to Horizon F within the trough. Allen & others (1978) concluded that these sediments were deposited on an alluvial plain, and consist of red beds at the base, succeeded by Middle Jurassic sandstone, siltstone, and claystone with local coal beds and carbonaceous material.

There is little thickening of Upper Series sediments into the trough. This section may be conveniently divided into two intervals, pre-Horizon C and post-Horizon C, on the basis of seismic character. The interval between Horizons E and C is characterised by its generally semitransparent appearance, although it has distinct lateral variations in character. Deposition of this interval—the Upper Series transgressive sequence—commenced in the slight residual depression in Horizon E, but later transgressed to completely blanket the break-up surface. The sequence thins over a high on the western flank of the trough before thickening into an oblique progradational sequence that extends to the upper slope. Line density is insufficient to determine the lateral limits of this probable deltaic sequence, although it can be inferred from the direction of prograding that the sedimentary source was to the southeast. The delta front is indistinct: the youngest foreset beds grade laterally into an almost completely transparent sequence of probable deep-water shale.

The well-stratified post-Horizon C section is similar to though thinner than the corresponding sequence to the north of Scott Reef (Plate 22). The sediment supply was probably more limited here, and sigmoidal prograding of the post-Oligocene section is less pronounced than to the north. Slump structures with relief of up to 300 m are prominent at the seaward limit of the prograding.

ROWLEY SUB-BASIN AND SOUTHERN MARGIN OF THE SCOTT PLATEAU

The Rowley Sub-basin is an east-northeast-trending, mainly Mesozoic basin connecting with the Beagle Sub-basin to the southwest, and probably with the Browse Basin to the northeast. It underlies the Northwest Shelf, Rowley Terrace, and southern Scott Plateau in water less than 100 m to 3500 m deep. It is separated from the Bedout Sub-basin (southern offshore Canning Basin) by the Bedout High, and from the offshore extension of the northwest-trending Fitzroy Graben by a poorly defined hinge. Most of the sub-basin is only sparsely covered by seismic surveys, especially in the deeper-water part, oceanward of Rowley Shoals. The quality of the available data is generally good, allowing

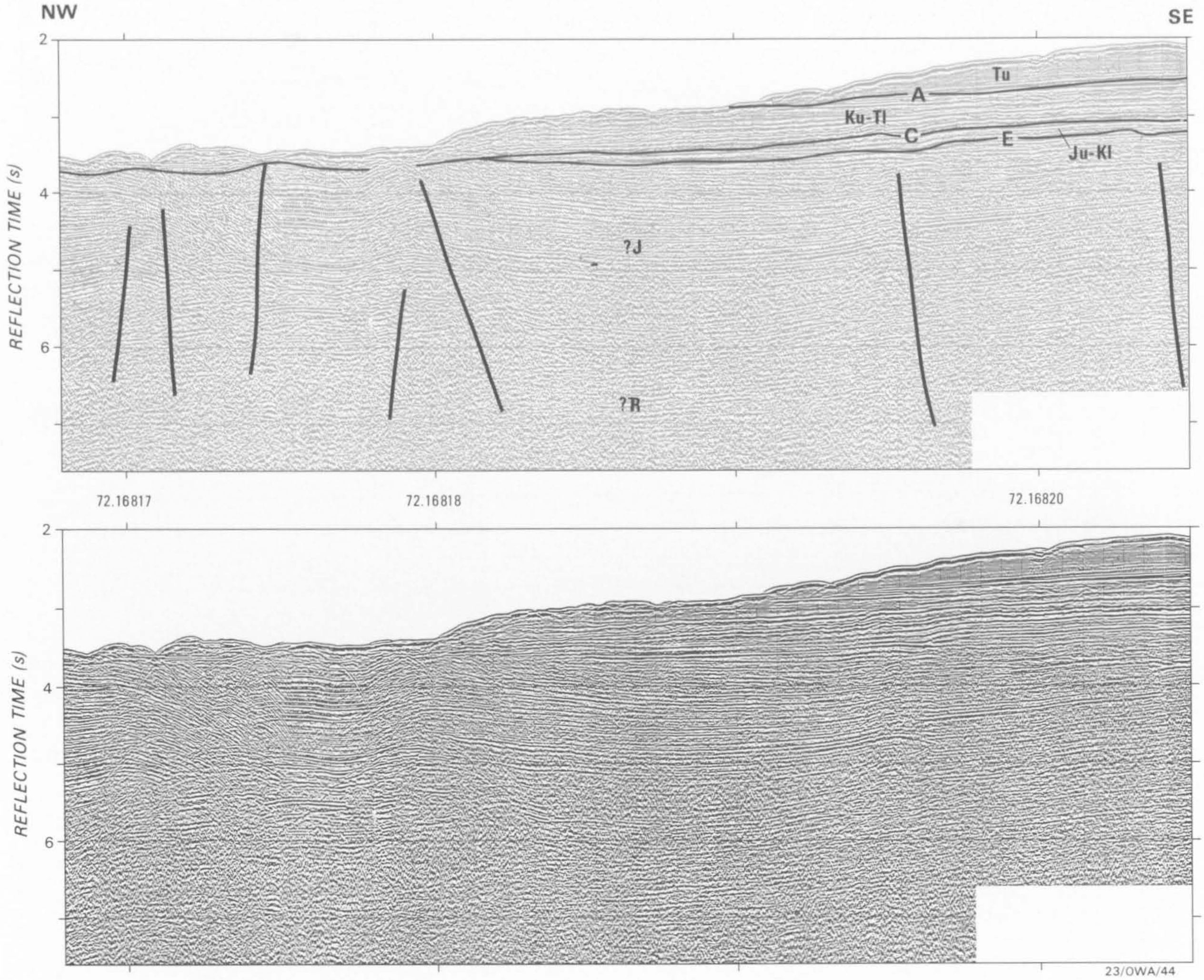


Fig. 19. Interpreted seismic profile across the southwestern Rowley Sub-basin (Gulf line Au-8); vertical exaggeration 1:4.0. Upper Series sediments are thin, and the thick Lower Series section is extensively faulted.

us to define the northern limits of the sub-basin and revealing some large structures along its margins.

We define the eastern margin of the Rowley Sub-basin as the fault zone associated with the western margin of the Leveque Shelf. To the west of the bounding faults, sediments (particularly those of the Lower Series) thicken gradually towards the centre of the sub-basin.

Along the eastern margin of the sub-basin, the angular discordance across the interpreted break-up unconformity is only slight. This discordance decreases basinwards, and the rocks are probably entirely conformable in the centre. More obvious than the break-up unconformity is Horizon F of probable Late Triassic age. This horizon is a prominent angular unconformity under the eastern margin of the sub-basin, and a strong continuous reflector conformable with the underlying section in the central part. The Lower to Middle Jurassic interval E-F is 1.5-2.0 km thick, and is probably underlain by a similar thickness of Triassic rocks. The centre of the sub-basin is little disturbed by faulting; only minor dislocations are evident, principally in the pre-Horizon F section. The intensity of faulting generally increases towards the western margin of the sub-basin, but throws are mostly minor.

The margins of the Rowley Sub-basin are structurally complex, in contrast to the almost structureless nature of its centre. The margin in the southwest, adjacent to the Beagle Sub-basin of the Carnarvon Basin, is dominated by intense block-faulting up to the level of Horizon E (Fig. 19), and is structurally similar to the block-faulted Exmouth Plateau. Some large-scale folding is also apparent (Fig. 20).

The northwest margin facing the Argo Abyssal Plain was sharply cleaved at the time of rifting (Fig. 21), leaving about 2.5 km of vertical section—ranging in age from Cretaceous to probable Palaeozoic—exposed on the steep (15-20°) continental slope. The orientation of the western and northern margins of the Rowley Sub-basin (Plate 16) suggests that only the northwest corner of the basin was rifted away.

The northern margin of the Rowley Sub-basin is difficult to delineate owing to the paucity of north-south profiles in the area. Profiles across this margin show a distinct and quite abrupt change in the seismic character of Horizon E and the underlying sequence, probably reflecting a northwards change from Mesozoic to Palaeozoic rocks in the pre-Horizon E section. We have taken this transition as defining the northern margin of the Rowley Sub-basin. The abrupt variation in seismic character suggests that the margin is faulted, in contrast to the southern margin, which appears to take the form of a hinge zone. This implies that the Rowley Sub-basin has the form of a broad complex

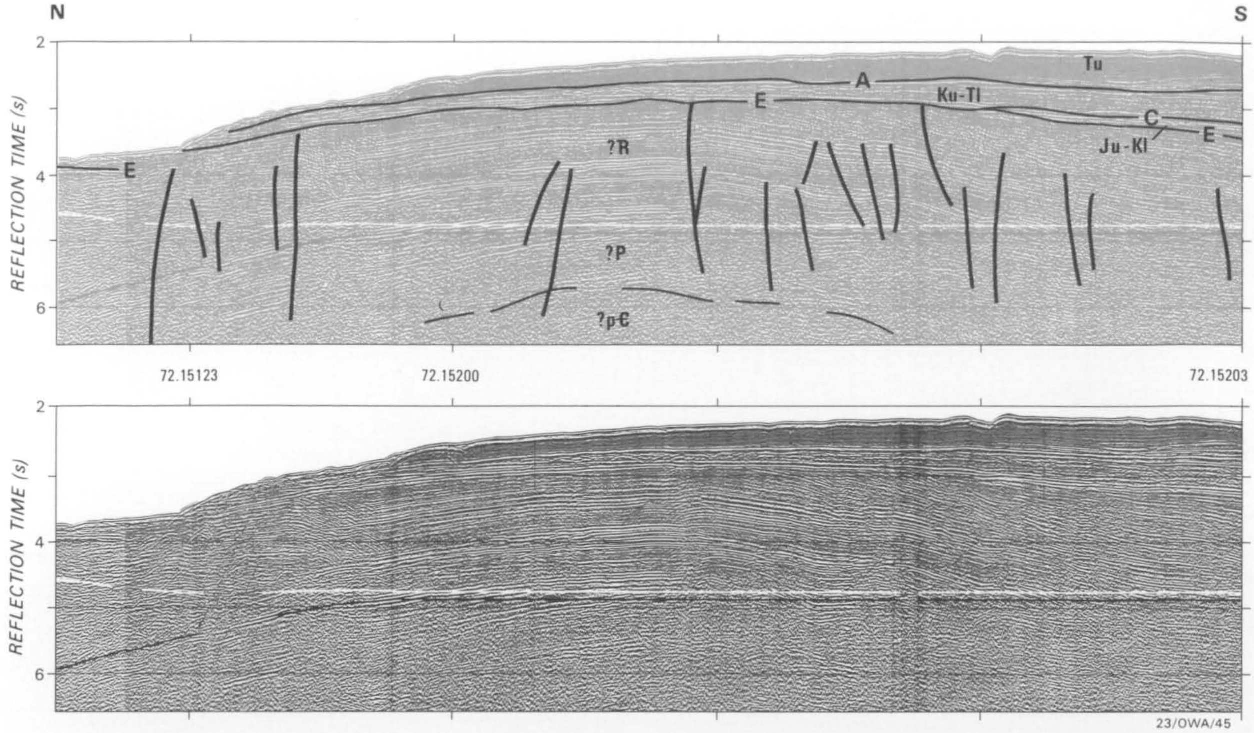


Fig. 20. Interpreted seismic profile across a faulted broad anticline in the southwestern Rowley Sub-basin (Gulf line Au-25); vertical exaggeration 1:3.8. In common with Emu Spur and parts of the northwest Scott Plateau, the main unconformity appears to be planed-off and is now about 2000 m below sea level.

half-graben bounded by a hinge to the south and faults in the north. Subsidence of the basin appears to have been gradual as evinced by the thick, flat-lying, and undisturbed sedimentary fill and the increasing northerly dip of reflectors with depth.

Set partly into the Palaeozoic basement of the southern Scott Plateau, and probably separated from the Rowley Sub-basin to the south by a major fault, is a deep sedimentary embayment occupying an area of about 5000 km^2 (Plate 16; Figs. 22 and 23). The sedimentary fill is tentatively correlated with the Triassic and Jurassic sequences of adjacent areas. The seismic data along Shell line N.206 (Fig. 22) indicate that the embayment contains 6 to 7 km of well-stratified, faulted, and folded sedimentary rocks between Horizon E and acoustic basement. On this line, Horizon E is flat-lying and of similar appearance to Horizon E at the top of fault-blocks underlying Emu Spur and the northwest Scott Plateau, though at a considerably greater depth (3300 m, compard with 2000-2300 m). The northern end of this embayment appears on Shell line N.205 (Fig. 23) as a half-graben, 30 km wide within probable Permo-Triassic and Palaeozoic rocks, and contains at least 3 km of Triassic and Jurassic sedimentary rocks beneath the faulted eastern margin.

Upper Series sedimentation in the centre of the Rowley Sub-basin consists of about 2 km of Cretaceous and Tertiary shale, sandstone, and carbonate (Plate 21). Deeper reflections tend to be masked by the highly reflecting beds in the Tertiary section. The Upper Series transgressive sequence (interval E to C) is quite thin (about 500 m in the centre of the basin; Plate 17) and tends to pinch out near the top of the continental slope. Reflectors within the E to C interval are mostly weak, and lap on to Horizon E at the base of the sequence. The carbonate sequence (post-Horizon C), which dominates the Upper Series in the Rowley Sub-basin, comprises a thin Upper Cretaceous and Eocene section and a thicker (about 1000 m) post-Oligocene section which is prograded and slumped. The post-Horizon C sequence pinches out at the top of the continental slope (Plate 22) and all Tertiary and younger beds are exposed to the sea.

SUMMARY OF STRUCTURAL FEATURES

The composite map showing gross structural features (Plate 16) has been compiled from the seismic data used in this study, together with data in deep-water areas from Heirtzler & others (1978) and Hinz & others (1978). We have briefly summarised below the salient features of this map.

The Scott Plateau is composed principally of a core of Palaeozoic and older rocks. Much of this core was reduced by peneplanation before break-up, and it is now covered by a flat-lying Upper Series sedimentary blanket averaging 1 km in thickness. The Upper Series is mainly Late Cretaceous and younger in age, and predominantly of carbonate composition. Lower Series Mesozoic sedimentary rocks appear to be confined to pockets and shallow grabens within the Palaeozoic erosion surface. Igneous rocks contemporaneous with margin break-up are probably abundant—as basalt flows, tuffs, and intrusives. Faulting and fracturing of the central Scott Plateau is evident, but most faults appear to be related to Palaeozoic structures rather than to margin break-up.

The western margin of the plateau coincides with the transition to the oceanic crust of the Argo Abyssal Plain. This margin has a general northerly orientation and typically has the form of a scarp 1 to 1.5 km high. The northern margin of the plateau is a complex

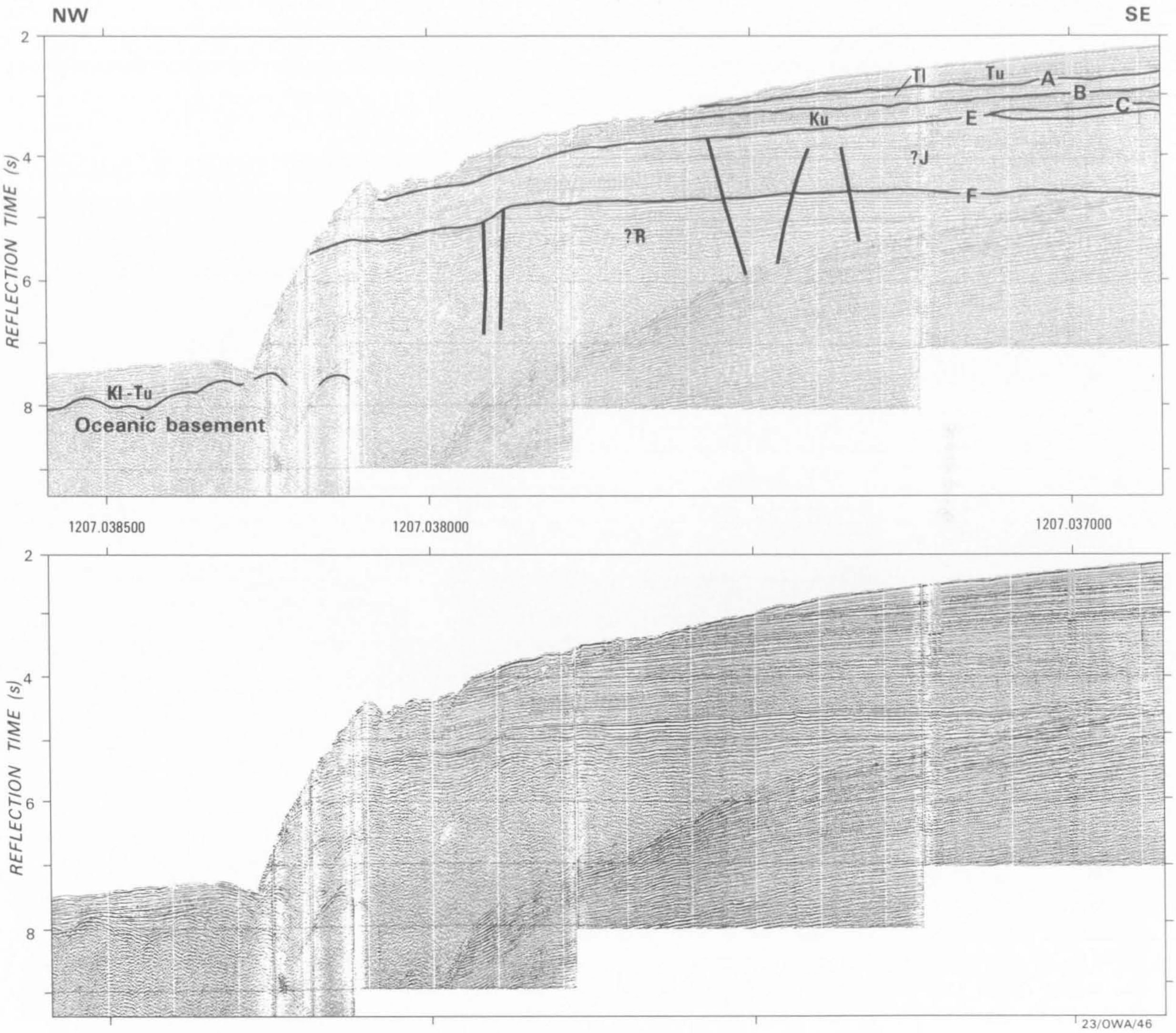


Fig. 21. Interpreted seismic profile across the northwestern margin of the Rowley Sub-basin with the Argo Abyssal Plain on the left (Shell line N.207); vertical exaggeration 1:6.2.

area dominated by planed-off, well-stratified fault-blocks.

Basement appears to deepen from the Scott Plateau eastwards into the Browse Basin. The Lower Series Mesozoic section of the Browse Basin probably pinches out between basement and a thick (2000 to 3000 m) Upper Series sedimentary section. Basement also deepens beneath the trough connecting the Browse Basin with the Rowley Sub-basin.

South of the Scott Plateau, the Rowley Sub-basin has developed over the deep offshore extension of the Palaeozoic Fitzroy Graben. The Rowley Sub-basin differs from the other Mesozoic pull-apart basins of the Northwest Shelf because it is only mildly deformed, except at its margins. It contains in excess of 8 km of flat-lying sedimentary rocks, and appears to take the form of a northward-dipping half-graben faulted against the southern margin of the Scott Plateau.

STRATIGRAPHY

Seismic reflection profiles, such as those shown in Plates 24 and 25, show that many stratigraphic intervals under the Scott Plateau are continuous with, and apparently similar to, those present in the known parts of the Browse Basin and the offshore Canning Basin. Using the seismic information (including interval velocities) over the plateau, and data from nearby petroleum exploration wells and DSDP drilling, we have been able to make several inferences about the sequences present on the Scott Plateau (Fig. 24). A short program of bottom sampling (Hinz & others, 1978) provided some support for these inferences.

Note that much of what is written below is speculative, and only deep stratigraphic drilling or petroleum exploration drilling can provide final answers to the many unresolved questions about the plateau.

BASEMENT

The seismically opaque rocks which are regarded as acoustic basement in this Bulletin probably include Precambrian and lower Palaeozoic rocks. They have been drilled only along the eastern margins of the Browse and Canning Basins, so any discussion of basement rock types under the Scott Plateau and

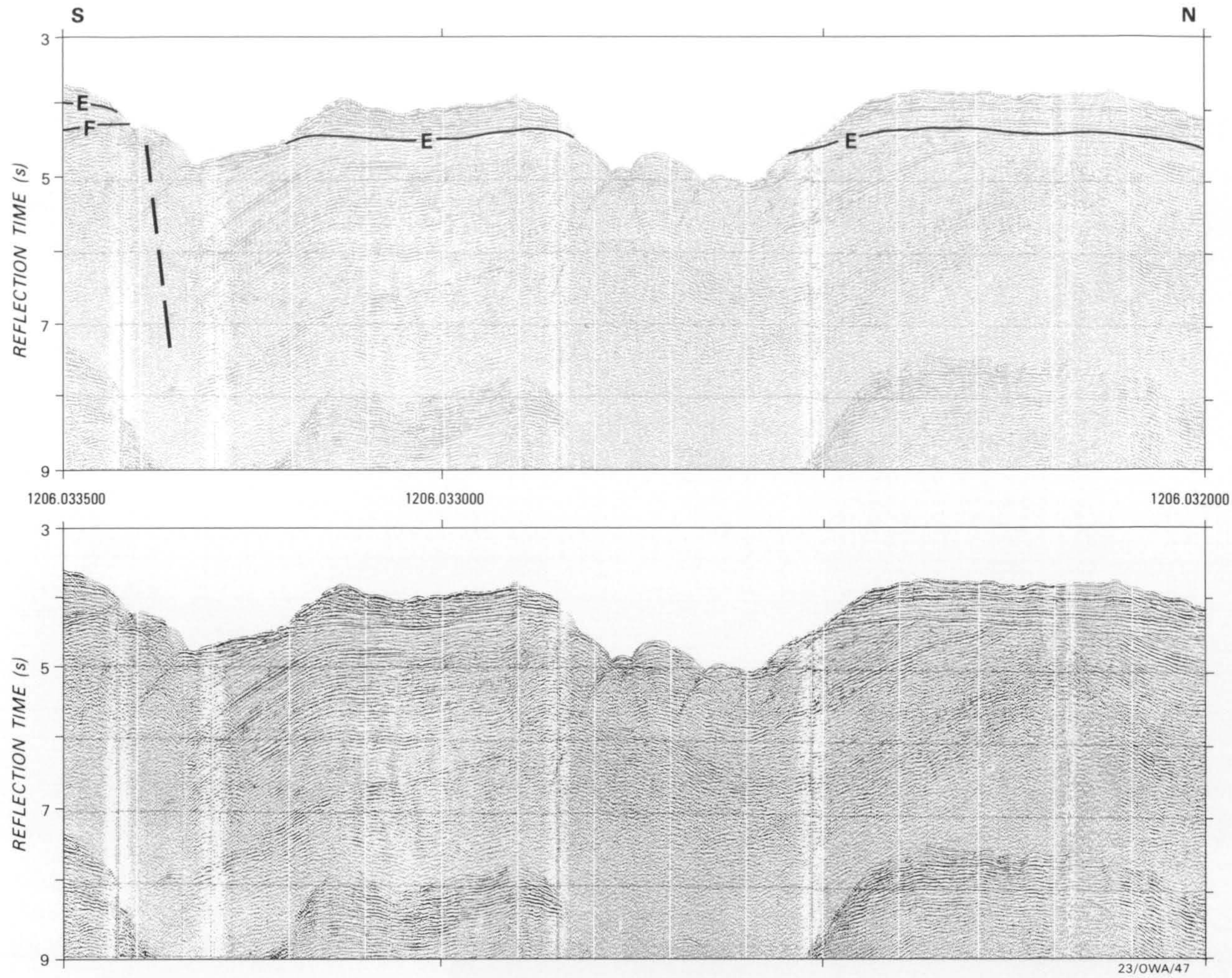


Fig. 22. Interpreted seismic profile across the sedimentary embayment north of the Rowley Sub-basin (Shell line N.206); vertical exaggeration 1:6.2. Note the planed-off main unconformity (here about 3300 m below sea level), and the large fault at the left which appears to separate the embayment from the Rowley Sub-basin.

Rowley Terrace necessitates long-distance extrapolation. If basement here is similar to the rocks making up the Kimberley Block, it should consist largely of plutonic and metamorphic rocks overlain by deformed sedimentary and minor volcanic rocks (Veevers, 1967). It apparently crops out at a number of places on the margins of the plateau (Plates 24 and 25) but has not been sampled.

Gravity data indicate that the thickness of the crust under the Plateau ranges from 22 to 25 km. This thickness range, and the lack of oceanic-type magnetic anomalies, suggest that the plateau is underlain by continental crust. The long wavelengths of low-amplitude anomalies in the basement suggest that true magnetic basement lies at considerable depth (6-7 km), and that the basement rocks are only weakly magnetised. Minor local anomalies are probably related to basement relief, shallow intrusions, or volcanic flows.

Acoustic basement lies 0-3 km below the seabed on the plateau, but is much deeper below the Browse Basin to the east and below the Rowley Terrace to the south.

Allen & others (1978) considered that 'widespread stripping of uplifted, pre-Permian Palaeozoic rocks may have occurred along the flanks of the Browse Basin. Permian sediments locally covered an old eroded surface and extended shorewards over Precambrian basement (Rob Roy No. 1*). Subsequent uplift formed an erosional wedgeout of Lower Permian sediments along the eastern margin of the basin (Rob Roy No. 1, Prudhoe No. 1†). Basinward the section is more complete and Upper Permian sediments should be preserved'. Upper Palaeozoic rocks may make up part of the section shown as basement at the eastern end of the northern seismic profiles in Plate 25.

LOWER SERIES

Permian

Allen & others (1978) described the Lower Permian rocks from wells along the eastern flank of the Browse Basin as largely paralic claystone and siltstone with a few limestone interbeds. In the Late Permian a regression led to the deposition of non-marine sandstone in the southeast, but marine limestone was deposited in the Sahul Shoals area far to the north, suggesting that the Browse Basin was an epicontinental sea connected to Tethys.

Lacepede No. 1A, in the offshore Canning Basin, penetrated Lower Permian siltstone and shale in the Fitzroy Graben, and Lynher No. 1 penetrated Upper Permian sandstone on the Leveque Shelf (Warris,

* Located at latitude 13°58.267'S, longitude 124°11.950'E.
† Located at latitude 13°44.933'S, longitude 123°51.850'E.

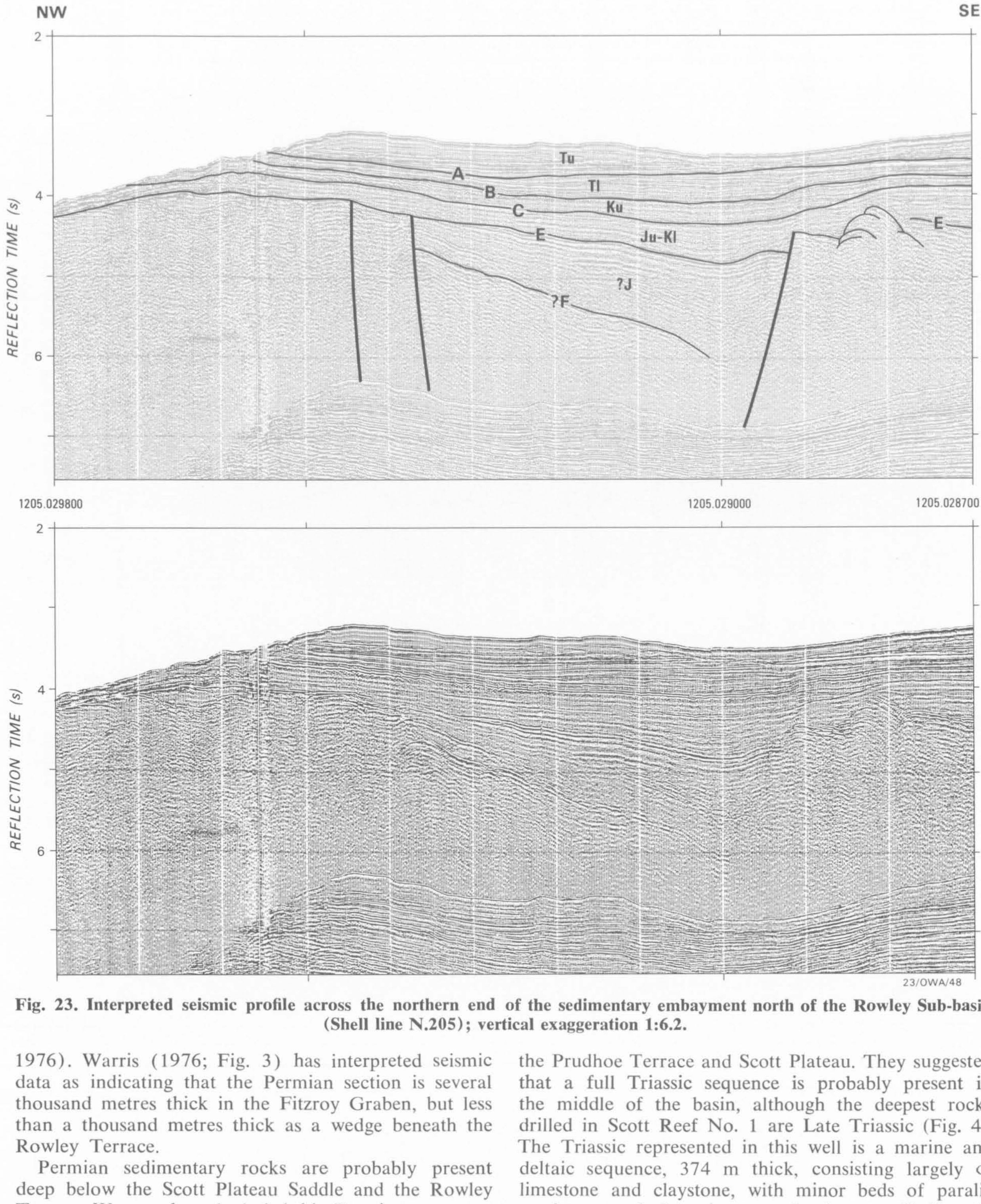


Fig. 23. Interpreted seismic profile across the northern end of the sedimentary embayment north of the Rowley Sub-basin (Shell line N.205); vertical exaggeration 1:6.2.

1976). Warris (1976; Fig. 3) has interpreted seismic data as indicating that the Permian section is several thousand metres thick in the Fitzroy Graben, but less than a thousand metres thick as a wedge beneath the Rowley Terrace.

Permian sedimentary rocks are probably present deep below the Scott Plateau Saddle and the Rowley Terrace. We may have included thin Permian sequences within the acoustic basement on the plateau, but we tend to agree with the view of Allen & others (1978) that most of the basement is pre-Permian in age.

A stratigraphic break between the Permian and Upper Triassic rocks in Lynher No. 1 and Yampi No. 1 indicates significant tectonic movement near the end of the Permian or in the Early Triassic (Allen & others, 1978).

Triassic

In the Browse Basin, Allen & others (1978) interpreted the Triassic section as being confined between the Prudhoe Terrace and Scott Plateau. They suggested that a full Triassic sequence is probably present in the middle of the basin, although the deepest rocks drilled in Scott Reef No. 1 are Late Triassic (Fig. 4). The Triassic represented in this well is a marine and deltaic sequence, 374 m thick, consisting largely of limestone and claystone, with minor beds of paralic sandstone and dolomite towards the top. Shelf sedimentation continued north of the Browse Basin until the latest Triassic when regressive sandstone accumulated. Fluvio-deltaic sandstone and shale characterise the Late Triassic in the east and south of the basin (Yampi No. 1 and Lynher No. 1).

In the offshore Canning Basin, several hundred metres of Upper Triassic sandstone and shale have been penetrated in Lynher No. 1 on the Leveque Shelf, and in Bedout No. 1 in the Bedout Sub-basin, where they overlie volcanics (Warris, 1976). From seismic information, Warris (1976, fig. 3) suggested that at least a thousand metres of Triassic rocks are present in

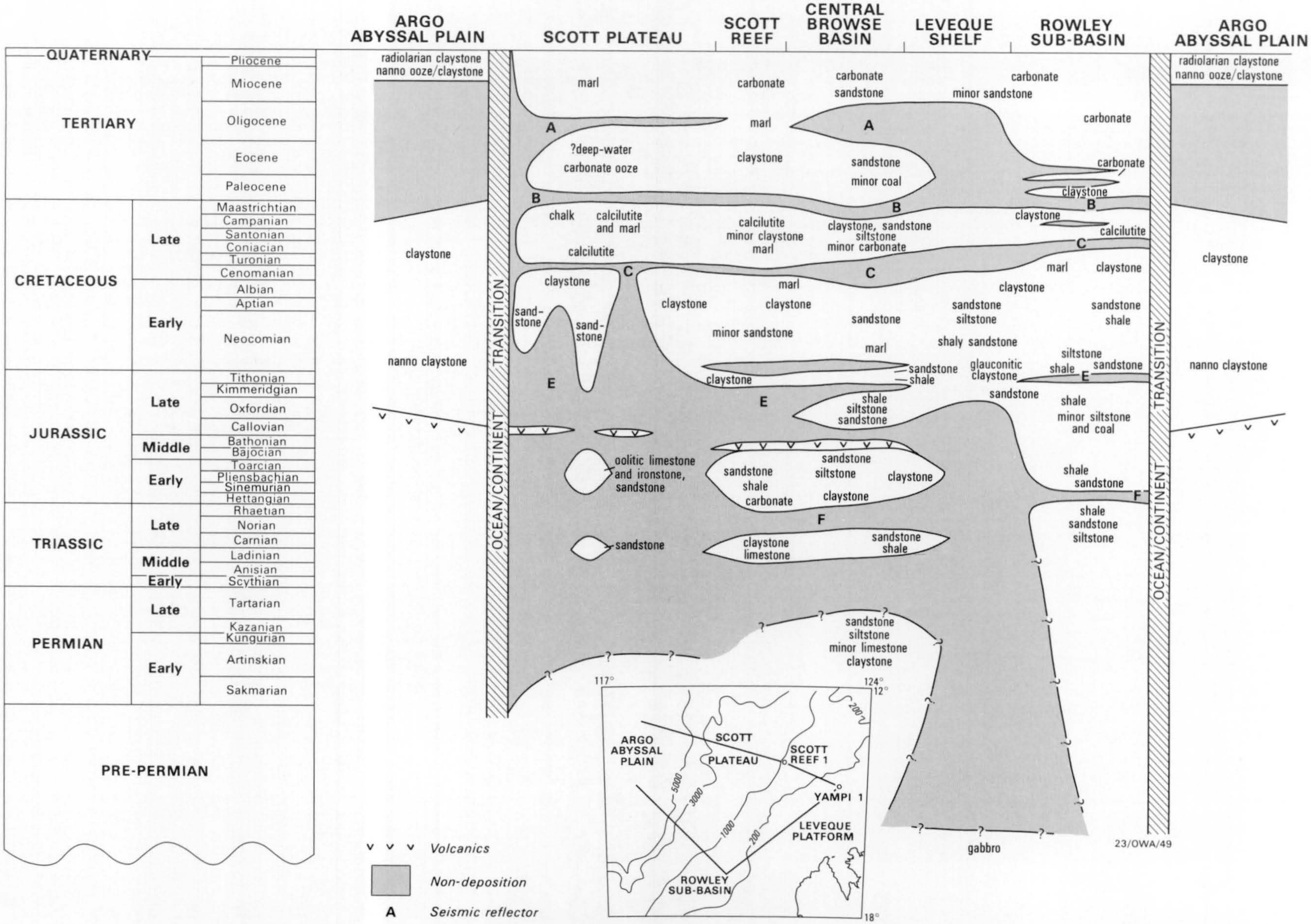


Fig. 24. Generalised lithostratigraphic diagram: Argo Abyssal Plain/Scott Plateau/Scott Reef/central Browse Basin/Leveque Shelf/Rowley Sub-basin/Argo Abyssal Plain. Based on Veevers, Heirtzler, & others (1974) for the Argo Abyssal Plain; authors' interpretation for the Scott Plateau; the logs of Scott Reef No. 1, Yampi No. 1, and Lynher No. 1, and Allen & others (1978) for Scott Reef, central Browse Basin, and Leveque Shelf; and authors' interpretation and the log of East Mermaid No. 1 for the Rowley Sub-basin.

a wedge beneath the Rowley Terrace, but that elsewhere in the offshore Canning Basin the Triassic sequence is much thinner. He indicated that the Permo-Triassic sequence is essentially conformable, but that there is a major Late Triassic unconformity. His study suggests that most of the Rowley Sub-basin sequence consists of Lower Triassic correlatives ofthe marine Blina Shale and the continental Erskine Sandstone.

Our seismic data suggest that 2000 m of bedded rocks underlie the Horizon F unconformity beneath parts of the Scott Plateau Saddle, and that the section is considerably thicker beneath the Rowley Terrace (Plate 24); a large part of this sequence is probably of Triassic age. The Permo-Triassic section is thin or absent on the Scott Plateau Dome, which was probably above sea level at the time, shedding material into adjacent areas. Dipmeter plots in the Upper Triassic section in Scott Reef No. 1 suggest that the sediment was derived from the Scott Plateau area (Allen & others, 1978).

Lower to Middle Jurassic (sequence F-E)

Seismic ties to exploration wells suggest that the sequence between Horizons F and E is of Early to Middle Jurassic age. This well-stratified sequence is thickest in the Scott Plateau Saddle and the Rowley Sub-basin; it may be present on the northwest margin of the plateau, but is virtually absent from the Scott Plateau Dome.

In the Browse Basin this sequence is preserved (and was probably deposited) in a northeast-trending trough whose axis lies east of Scott Reef (Allen & others, 1978). It is thin in Scott Reef No. 1, but is about 900 m thick in Lynher No. 1, on the Leveque Shelf, south of the Browse Basin (Fig. 7). A depocentre with a sequence more than 1000 m thick is present north of Caswell No. 1, and another with a sequence more than 3000 m thick is present west of Lynher No. 1 (Allen & others, 1978, fig. 12). The sequence is probably absent from the Ashmore Terrace in the north and the Yampi Shelf in the east, and is thin to absent on the Scott Plateau Dome.

The Browse Basin sequence generally consists of Lower Jurassic reddish brown claystone and siltstone, probably laid down on an alluvial plain, and Middle Jurassic sandstone, siltstone, and claystone with minor coal, laid down in a fluvio-deltaic environment. However, in Scott Reef No. 2A, marine Lower Jurassic carbonate, sandstone, and shale are overlain by non-marine Middle Jurassic sandstone and shale (Allen & others, 1978). Sandstones are generally coarser-grained along the eastern margin of the basin, but dipmeter readings in Scott Reef No. 1 suggest that the Scott Plateau was the source of some of the sediments. Basic lavas are interbedded with sedimentary rocks in Lombardina No. 1 (Lower Jurassic), and in Scott Reef No. 1, Yampi No. 1, and possibly Ashmore Reef No. 1 (Middle Jurassic). These volcanics appear to be related to the rifting that preceded the break-up of this part of Gondwanaland.

In the offshore Canning Basin the Lower to Middle Jurassic sequence unconformably overlies upper Palaeozoic to Triassic rocks, but there is little sign of an unconformity above it (Warris, 1976). It is present in all wells except those of the northeast margin. The known sequence consists of the fluvio-deltaic Middle to Upper Jurassic Wallal Sandstone, which contains shaly red beds towards its base in Bedout No. 1. No volcanics have yet been found in the Canning Basin.

The present study of seismic data shows that the equivalent of this sequence is as much as 1000 m thick in the Scott Plateau Saddle, and probably 2000 m thick in the southern Rowley Sub-basin, but occurs only as thin deposits in isolated fault-bounded pockets on the Scott Plateau Dome (Plate 24). The sequence is extensively faulted in the Scott Plateau Saddle, Browse Basin, and western and northern margins of the Rowley Sub-basin, but is virtually undisturbed in the central Rowley Sub-basin.

Rocks were dredged from below Horizon E at five stations on the southern and southwestern walls of Oates Canyon (stations 2-4 and 12-13 in Plate 2) and at one station on the northern Scott Plateau (station 40 in Plate 2) during a cruise of RV *Valdivia* (Hinz & others, 1978). The samples from three of the stations came from well-bedded sequences, and the other three from seismically opaque material. Despite this, all stations vielded similar material (Table 8)—various combinations of altered aphanitic basalt, and vesicular and amygdaloidal basalt, volcanic breccia, and tuff. A little oolitic ironstone came from one station, and a little oolitic limestone from another.

Veevers & Cotterill (1978) considered that the Scott Plateau is a Late Jurassic epilith (see footnote, p. 1), and the above dredging results provide superficial support for this view. However, Hinz & others (1978), Stagg & Exon (1979), and we believe that the dredge hauls are not representative of the well-stratified sequences, from which resistant volcanics were selectively sampled rather than softer detrital sediments. The seismically opaque sequences may, however, consist almost entirely of volcanics. We equate the volcanics with the rift-valley volcanics in the Browse Basin wells, rather than regarding them as oceanic extrusions.

From a study of magnetic lineations, Larson (1975) showed that the zone of break-up was immediately to the west of the Scott Plateau, so it is not surprising that volcanics are apparently more abundant on the Scott Plateau than in the Browse Basin. The presence of oolites in the dredge haul suggests that at least some of the volcanics were laid down in shallow water.

The depocentres in Early and Middle Jurassic time lay between the present coastline and Scott Plateau, and are filled with as much as 3000 m of fluvio-deltaic and shallow-marine shale, siltstone, and sandstone. The Scott Plateau Dome lay near sea level; the higher parts of it were eroded while local depressions in it were depositional sites. As rifting progressed before the break-up of Gondwanaland, a suite of volcanic flows and pyroclastics erupted on the Scott Plateau, the Ashmore-Sahul Block, and the Scott Reef Trend.

UPPER SERIES

Upper Jurassic to lower Upper Cretaceous (sequence E-C)

Seismic correlation suggests that the Scott Plateau sequence between Horizons E and C represents the Upper Jurassic to Upper Cretaceous detrital sequence which is present right around the Western Australian margin. DSDP 261, on the Argo Abyssal Plain (Veevers, Heirtzler, & others, 1974), indicated that Horizon E—the break-up unconformity—is of Callovian age.

On the Argo Abyssal Plain, basement consists of oceanic basalt, of which 47 m was drilled in DSDP 261 (Fig. 25): a 10 m basalt still, overlying several

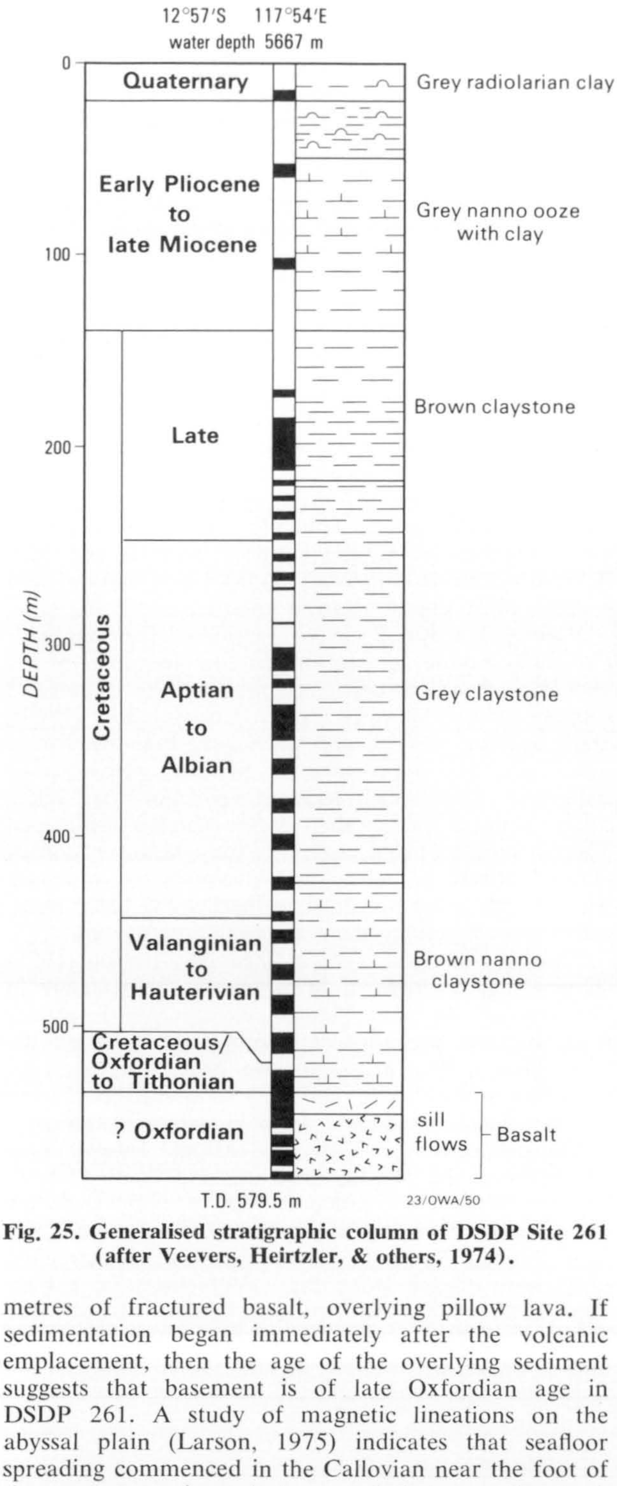


Fig. 25. Generalised stratigraphic column of DSDP Site 261 (after Veevers, Heirtzler, & others, 1974).

metres of fractured basalt, overlying pillow lava. If sedimentation began immediately after the volcanic emplacement, then the age of the overlying sediment suggests that basement is of late Oxfordian age in DSDP 261. A study of magnetic lineations on the abyssal plain (Larson, 1975) indicates that seafloor spreading commenced in the Callovian near the foot of the present continental slope, and that spreading took place at about 4.4 cm/year. Based on this spreading rate, the basalt poised on the lip of the Java Trench is of Kimmeridgian age.

As much as 2000 m of this sequence was deposited in the Browse Basin (Allen & others, 1978). In the early Late Jurassic, sandstone, siltstone, shale and mudstone were laid down in a fluvio-deltaic and restricted marine environment between the dry land areas of the Scott Plateau and the Yampi Shelf. By the latest Jurassic, the Scott Plateau had sunk largely below sea level; estuarine and deltaic claystone, siltstone, and sandstone in the east give way to shelf sandstone and siltstone in the west. Similar conditions persisted across the area until the early Late Cretaceous, when marl became an additional sediment type.

In the offshore Canning Basin the Upper Jurassic sequence is generally about 300 m thick and consists of equivalents of the Alexander Formation and Jarlemai Siltstone, both of which contain marine shale, siltstone, and sandstone (Warris, 1976). The overlying Lower to lower Upper Cretaceous sequence is about 500 m thick in the east but thickens to about 800 m in the Rowley Sub-basin. It consists of marine shale, siltstone, and sandstone. The thickest Upper Jurassic to lower Upper Cretaceous sequence yet drilled is that at East Mermaid No. 1, in the southeast Rowley Sub-basin: almost 600 m of deltaic sandstone and shale of Late Jurassic age, about 1000 m of Lower Cretaceous shelf claystone and siltstone, and about 100 m of Cenomanian outer shelf marl and marly claystone (Fig. 6).

On the Scott Plateau and in the Rowley Sub-basin, the E-C interval is characteristically acoustically semi-transparent. It is draped over irregularities in the break-up unconformity (Horizon E), and is little disturbed by faulting, except on the outer margins of the area and in the Scott Plateau Saddle (Plates 24 and 25). The isopach map (Plate 17) indicates that the sequence is thickest along a northeast trend through Scott Reef, and that major depocentres lay northwest of Lynher No. 1 and west of Yampi No. 1 (Allen & others, 1978, fig. 13). Thicknesses range from 0 to 400 m on the Scott Plateau Dome and from 0 to 800 m in the Rowley Sub-basin (Table 6). The sequence is generally truncated by the continental slope (Plate 24); on the abyssal plain the equivalent sequence, dated from DSDP 261, is several hundred metres thick.

Average depositional rates for the interval are between 10 and 30 m/m.y. in the east and south, about 4 m/m.y on the Scott Plateau Dome, and 11 m/m.y. in the Rowley Sub-basin (Table 7).

The sequence on the abyssal plain (Hinz & others, 1978) rests directly on oceanic basement, which is typically smooth; occasional rugged highs are generally older than the sediment, which is obviously draped over them. However, a few basement highs disturb the surrounding sediments and may be later intrusions.

In DSDP 261 (Veevers, Heirtzler, & others, 1974) the sequence is 390 m thick and consists of two distinct intervals. The lower interval is 323 m thick and consists of brown nanno claystone overlain by a grey claystone (Fig. 25) and contains poor and monotonous faunas. The nanno claystone is only intermittently calcareous; the highest calcareous content is at the base. It is probably a pelagic sediment laid down in a gradually deepening environment; when the seabed subsided below the carbonate-compensation depth in the early Aptian, radiolaria-rich grey claystone was deposited in place of the nanno claystone. The upper interval, 67 m thick, consists of zeolitic claystone with very little calcium carbonate and was apparently laid down below the carbonate compensation depth. It contains arenaceous foraminifera of Late Cretaceous (Coniacian or younger) age and is thus a time equivalent of the lower part of the C-B sequence on the Scott Plateau. According to our interpretation (Fig. 26), which is based on seismic character, Horizon C immediately overlies this zeolitic claystone. If our interpretation is correct, then Horizon C must be younger on the abyssal plain (post-Coniacian) than on the Scott Plateau (Turonian).

Veevers, Heirtzler, & others (1974) described sequence E-C as a major transparent layer from the

TABLE 6. THICKNESSES IN METRES OF THE MAPPED SEISMIC SEQUENCES

Seismic sequence	*Approximate age*	*DSDP 261*	*Scott Plateau Dome*[1]	*Rowley Sub-basin*[2]	*Scott Reef No. 1*	*Yampi No. 1*	*East Mermaid No. 1*
A–seabed	Miocene-Recent	140	400 (200-500)[4]	850 (300-1000)	2215	685	876
B–A	Paleocene-Oligocene		200 (200-300)	250 (200-400)	1222	225	365
C–B	Late Cretaceous		250 (0-300)	500 (200-800)	175	543	137
E–C	Late Jurassic-early Late Cretaceous[3]	390	200 (0-400)	350 (0-800)	618	1747	?1636
F–E	Early to Middle Jurassic		?1500	1700 (1500-2000)	67	278	?538
C–seabed	Late Cretaceous-Recent	140	800 (500-1000)	1300 (500-2000)	3611	1453	1378
E–seabed	Late Jurassic-Recent		1500 (500-3000)	1500 (500-2500)	4229	3200	?3014

1 Area centred on 13°S, 121°E.
2 Area centred on 17°S, 119°E.
3 ?Late Jurassic to middle Late Cretaceous in DSDP 261.
4 All figures in parentheses for Scott Plateau Dome and Rowley Sub-basin indicate the ranges of thicknesses of the sequences in the area mapped for this Bulletin.

TABLE 7. SEDIMENTATION RATES IN METRES PER MILLION YEARS FOR THE MAPPED SEISMIC SEQUENCES

Seismic sequence	*Approximate age*	*DSDP 261*	*Scott Plateau Dome*[1]	*Rowley Sub-basin*[2]	*Scott Reef No. 1*	*Yampi No. 1*	*East Mermaid No. 1*
A–seabed	Miocene-Recent	14	20	30	100	30	40
B–A	Paleocene-Oligocene		10	13	33	9	9
C–B	Late Cretaceous		10	20	6	33	7
E–C	Late Jurassic-early Late Cretaceous[3]	6	4	11	13	29	?25
F–E	Early to Middle Jurassic		?40	50	2	10	?10
C–seabed	Late Cretaceous-Recent	3	10	14	40	18	22
E–seabed	Late Jurassic-Recent		9	9	30	20	?18

1 Area centred on 13°S, 121°E.
2 Area centred on 17°S, 119°E.
3 ?Late Jurassic to middle Late Cretaceous in DSDP 261.

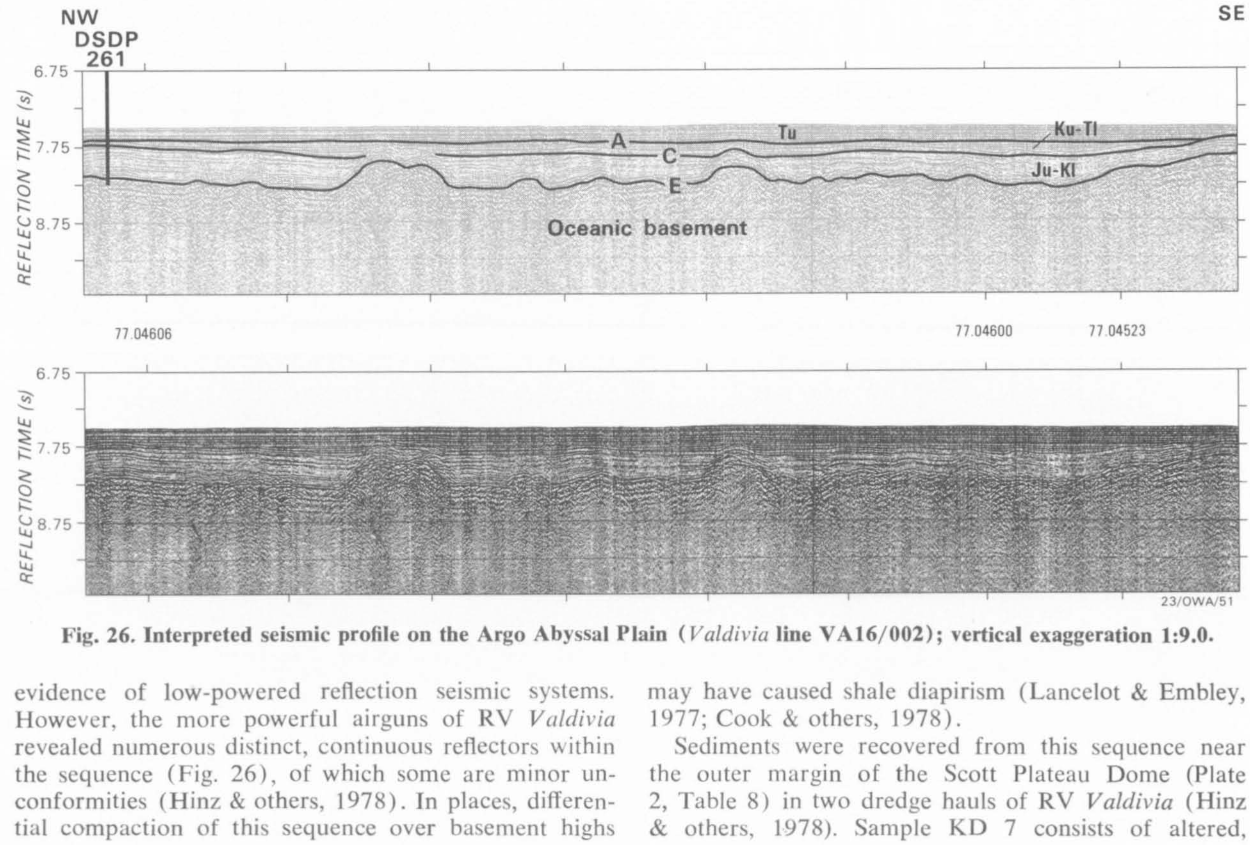


Fig. 26. Interpreted seismic profile on the Argo Abyssal Plain (*Valdivia* line VA16/002); vertical exaggeration 1:9.0.

evidence of low-powered reflection seismic systems. However, the more powerful airguns of RV *Valdivia* revealed numerous distinct, continuous reflectors within the sequence (Fig. 26), of which some are minor unconformities (Hinz & others, 1978). In places, differential compaction of this sequence over basement highs may have caused shale diapirism (Lancelot & Embley, 1977; Cook & others, 1978).

Sediments were recovered from this sequence near the outer margin of the Scott Plateau Dome (Plate 2, Table 8) in two dredge hauls of RV *Valdivia* (Hinz & others, 1978). Sample KD 7 consists of altered,

TABLE 8. *VALDIVIA* GEOLOGICAL STATIONS
(after Hinz & others, 1978)

Area	Station (Plate 2)	Apparatus	Bottom contact begins (decimal degrees) Lat. (°S)	Long. (°E)	Water depth (m)	Bottom slope	Recovery	Age	Seismic Interval	Short description
Southern Oates Canyon	1	KL	13.2084	120.0660	2000	1°	101 cm	Late Cretaceous	C-B	White marl
	2	KD	13.1150	120.0994	2947–2242	20°	6 kg	?Jurassic. Early Pleistocene	pre-E	Amygdaloidal basalt 80% Silicified chalk, Mn crusts 20%
	3	KD	13.1057	120.0801	2587–2040	20°	80 kg	?Jurassic	pre-E	Basalt, some amygdaloidal 90% Volcanic breccia, Mn crusts 10%
	4	KD	13.1439	120.0887	2318–1933	20°	50 kg	?Jurassic	pre-E	Amygdaloidal basalt Mn crusts
Northern Oates Canyon	7	KD	12.9091	120.2290	2480–2421	20°	65 kg	?Late Jurassic	E-C	Soft brown bioturbated sandy siltstone with rare shelly fossil impressions, fossil wood
Southwestern Oates Canyon	11	KD	12.8115	119.8687	3090–3058	5°	200 kg	Late Jurassic	E-C	Soft brown bioturbated siltstone with rare shelly fossil impressions. Minor calcareous sandstone
	12	KD	12.8956	119.9224	3178–3195	30°	6 kg	?Jurassic	pre-E	Basalt, fine tuff, very minor oolitic ironstone
	13	KD	12.9064	119.8761	2380–2050	30°	200 kg	?Jurassic	pre-E	Basalt, some amygdaloidal 70% Breccia 5% Tuff 20% Limestone, some oolitic 2% Mn nodules 3%
Northern Scott Plateau	29	BL	12.3676	121.1599	3250	0°	100 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	30	BL	12.3687	121.1558	3290	0°	103 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	31	BL	12.3691	121.1493	3290	0°	104 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	32	BL	12.3692	121.1376	3260	0°	100 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	33	BL	12.3681	121.1290	3240	0°	103 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	34	BL	12.3658	121.0665	3270	0°	95 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	35	BL	12.3651	121.0544	3290	0°	103 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	36	BL	12.3656	121.0411	3280	0°	103 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	37	BL	12.3660	121.0291	3210	0°	100 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	38	BL	12.3661	121.0186	3180	0°	101 cm	Quaternary	A-seabed	Light grey calcareous silty mud with forams
	40	KD	12.3639	120.9619	3039–2900	0°	5 kg	?Jurassic	pre-E	Basalt, calcareous breccia, fine tuff

KL = Piston corer, KD = Chain dredge, BL = Boomerang corer.

bioturbated yellowish brown siltstone, silty sandstone, and sandstone, commonly coated or impregnated with manganese: the siltstone contains rare pelecypod impressions and silicified wood, and abundant open burrows; the sandstone is commonly phosphatic; and the macrofauna yields a Middle Triassic to Late Cretaceous age. Sample KD 11 is somewhat finer-grained, consisting largely of siltstone, but is otherwise similar to sample KD 7; the macrofauna consists of ammonites, pelecypods, scaphopods, and *Lingula,* and the microfauna of marine dinoflagellates and hystrichospheres; both macrofauna and microfauna yield a Late Jurassic age (von Stackelberg & others, 1978).

As pointed out by Hinz & others (1978), the presence of ammonites and radiolaria shows that the Scott Plateau area was connected to the open sea, and the association of wood, phosphate, and ooids suggests shallow-marine deposition. The paucity of the molluscan fauna and the solution of shelly carbonate (all the shelly fossils occur as impressions) point to a restricted marine environment.

In summary, the Late Jurassic to early Late Cretaceous interval was a period of steady subsidence. The thickest accumulation was in the Browse Basin and Rowley Sub-basin, where environments changed from fluvio-deltaic and restricted shelf in the early Late Jurassic to a more open shelf thereafter. The Scott Plateau was initially exposed, but subsidence set in after the Callovian break-up of Gondwanaland, and restricted-marine sediments were laid down in the latest Jurassic and Early Cretaceous. The newly formed oceanic crust west of the plateau subsided fairly rapidly, and pelagic sediments accumulated there.

Upper Cretaceous (sequence C-B)

Seismic correlations indicate that the sequence between Horizons C and B on the Scott Plateau is the Late Cretaceous carbonate and marl sequence which overlies detrital sediments right along the Western Australian margin. Horizon C is the most distinctive reflector in the area, and Horizon B is also characteristic, so the seismic ties back to wells on the shelf are considered reliable.

In the Browse Basin the dominant lithologies are claystone and marl in the east, and calcilutite in the west (Allen & others, 1978). Thicknesses generally range from 200 to 500 m, but reach 1000 m. A northeast-trending depocentre lay east of Scott Reef. Palaeoenvironments range from coastal plain and marginal marine in the east, to inner and middle shelf in the centre, and outer shelf to upper slope in the west; dry land lay well seaward of the present shoreline (Allen & others, 1978, fig. 11).

In the offshore Canning Basin the characteristic rock types are calcilutite and marl, and the sequence is generally less than 500 m thick (Warris, 1976). East Mermaid No. 1 penetrated 60 m of Senonian calcilutite laid down in outer shelf and slope environments, and 77 m of Maastrichtian claystone laid down in an inner shelf environment (Fig. 6).

On the Scott Plateau and in the Rowley Sub-basin the lower part of the sequence is fairly transparent acoustically, but typically contains numerous small diffractions, whereas the upper part is distinctly layered and essentially undeformed. We interpret the lower sequence as calcilutite which underwent some mass movement, and the upper sequence as interbedded calcilutite and marl on the Scott Plateau and claystone in the Rowley Sub-basin. The C-B sequence is generally conformable on the E-C sequence, and is little disturbed by faulting, except in the Scott Plateau Saddle and on the outer margins of the plateau (Plates 24 and 25). On steeper slopes there is evidence of slumping in the form of rapid thickening and thinning of the sequence and of shallow glide-planes. The isopach map (Plate 18) indicates that the sequence thickens eastward from zero beneath the continental slope, to 500 m or more in the east where there must have been a chain of depocentres. The sequence averages 250 m thick on the Scott Plateau, and 500 m thick in the Rowley Sub-basin. Average depositional rates for the interval lie between 10 and 20 m/m.y. over most of the area, but reach 30 m/m.y. or more on the Yampi Shelf (Table 7).

The distribution of sequence C-B on the Argo Abyssal Plain is unclear. As noted previously for the sequence E to C, we interpret Horizon C as being younger on the abyssal plain (post-Coniacian) than on the plateau (Turonian); according to this interpretation, sequence C-B was not penetrated in DSDP 261, and consequently we have not attempted to draw isopachs for it in Plate 18.

Sediments from within the C-B sequence were cored by Hinz & others (1978). Core KL1 (Table 8), which came from a well-bedded sequence above Horizon C in the southern Oates Canyon in a water depth of 2000 m, consists of white marl with a calcium carbonate content of 50 percent. It contains abundant planktic foraminifera and coccoliths, and is of early to middle Campanian age (Appendix 2). The excellent preservation of the foraminifera suggests that deposition was above the lysocline, and the overwhelming predominance of planktic over benthic foraminifera suggests deposition in bathyal depths.

Thus the Late Cretaceous environment of the Scott Plateau complements that in the Browse and Canning Basins; that is, the water deepened towards the northwest of the area. The water on the plateau had deepened from shallow marine in the earliest Cretaceous to bathyal in the Campanian, and the change from detrital deposition to the deposition of carbonate and marl appears to have been synchronous with that elsewhere off Western Australia (cf. Veevers & Johnstone, 1974). Core KL1 suggests that water depths on the plateau in the Late Cretaceous were similar to present-day depths, which implies that most of the subsidence of the plateau (ca. 2000 m) took place in the Cretaceous. This agrees with the interpretation that marked increases in foraminiferal population and planktic/benthic ratios in Browse Basin wells indicate the development of fully marine conditions during the Turonian (Allen & others, 1978).

Paleocene to Oligocene (sequence B-A)

The sequence on the Scott Plateau lying between Horizons B and A appears to correlate with the upper Paleocene and Eocene sequences in the wells on the Northwest Shelf. The early Paleocene and Oligocene unconformities which bound this sequence are widespread both on the shelf (Powell, 1976; Quilty, 1977) and abyssal plain (Davies, Weser, Luyendyk, & Kidd, 1975). The sequence is missing at DSDP 261 (Veevers, Heirtzler, & others, 1974) which was drilled on a basement high, but is probably present on much of the Argo Abyssal Plain.

In the Browse Basin the thickness of this interval averages about 300 m, but reaches a maximum (more than 1200 m) in the Scott Reef area (Plate 19), which is the only area wher marine sedimentation continued through the Oligocene. Non-marine sandstone characterises the eastern and south central parts of the basin, and middle and outer shelf carbonate the south and west (Allen & others, 1978).

In the offshore Canning Basin the sequence is generally thinner than in the Browse Basin, and consists of carbonate, marl, and claystone (Warris, 1976). The bounding unconformities are well-developed in most of the basin, but in East Mermaid No. 1 there is no Oligocene unconformity. In this well the sequence consists of 30 m of Paleocene inner shelf claystone and 335 m of Eocene and Oligocene inner shelf calcarenite and limestone (Fig. 6).

The seismic records show that this interval is generally well-stratified, and is prograded under the eastern Rowley Terrace. Only under the outer margins of the Scott Plateau is it affected by faulting. On steep slopes, slumping of the interval is indicated by low-angle glide-planes and rapid changes in thickness (Plate 24).

On the Argo Abyssal Plain (Fig. 26) Horizons B and C apparently coincide so the sequence between Horizons C and A is probably the B-A sequence. It is well-bedded, conformable with the overlying sediments, and unconformable with the sequence underlying Horizon C. Its seismic character suggests that it is lithologically similar to the overlying sequence, which consists of nanno ooze and nanno clay with a few calcareous turbidites in DSDP 261 (Veevers, Heirtzler, & others, 1974).

The B-A sequence is thickest near Scott and Ashmore Reefs and northeast of Rowley Shoals (Plate 19), which probably represent original depocentres. On most of the Scott Plateau and Rowley Terrace the sequence is uniform in thickness, averaging 250 m, but it is truncated by the outer continental slope. It is absent in the northern Argo Abyssal Plain, but in the southern abyssal plain it is generally thicker than 200 m, and reaches a maximum of more than 400 m. Average depositional rates are 10 to 20 m/m.y. in most of the area, including the southern Argo Abyssal Plain, and more than 30 m/m.y. in Scott Reef No. 1 (Table 7).

There is no direct evidence of the nature of this stratigraphic interval under the Scott Plateau, but available information enables us to infer that the sediments were laid down in bathyal depths and consist of pelagic carbonate and marl. The shallowest water in the area studied was probably in the southeast, where prograded carbonate apparently formed the outer edge of the continental shelf (Plate 24, line 17/81). The height of the topset beds above the foreset beds is about 100 m, so water depths beyond the shelf edge were probably everywhere greater than 300 m.

Miocene to Recent (sequence A-seabed)

Seismic ties to wells on the Northwest Shelf and to DSDP 261 on the Argo Abyssal Plain indicate that the age of the sequence between Horizon A and the seabed is Miocene to Recent throughout the area.

In the Browse Basin, interval A-seabed was a period of basin-wide carbonate sedimentation (Allen & others, 1978). After the Oligocene regression, the sea advanced landward, basal Miocene sand was deposited locally, and a carbonate wedge prograded westward. This wedge thickens toward the shelf edge, and reaches a maximum thickness of 2215 m in Scott Reef No. 1 (Fig. 4), where there is no Oligocene unconformity. In various places, reefs are apparent in the seismic sections; these are probably equivalent to the essentially reefal sequence at Scott Reef. Calcarenite predominates, but calcisiltite, dolomite, and marl are present in many wells.

In the offshore Canning Basin this sequence is generally unconformable on older Tertiary sediments (Warris, 1976). It consists largely of carbonate and thickens seaward to the outer shelf margin. The thickest sequence drilled—in East Mermaid No. 1, where there is no Oligocene unconformity—comprises 700 m of Miocene inner shelf calcarenite and limestone overlain by 177 m of Pliocene and Quaternary outer shelf marl (Fig. 6).

The seismic profiles (Plates 24 and 25) show that there is a major change in reflector configuration in the sequence beneath the upper continental slope. Southeast of the slope the lower part of the sequence is markedly prograded to the northwest, whereas its upper part is parallel-bedded. Wherever the slope is steep the parallel beds are truncated by the seabed. The prograded and parallel-bedded parts of the sequence both average 1000 m in thickness. Seaward of the upper slope the sequence is represented by a wedge of generally parallel-bedded sediment which is about 700 m thick at the foot of the upper slope, but thins westward to about 300 m on the Scott Plateau, where parallel-bedded sediments are interbedded with acoustically transparent sediments. The sequence is truncated by the lower slope, except in the north where the slope is less (Plate 24).

The isopach map (Plate 20) also shows that the sequence is thick below the shelf edge, thins abruptly below and beyond the upper slope, and is generally thin on the Scott Plateau and Rowley Terrace. It is thin or absent on the lower slope, but thickens from about 100 m in the northern Argo Abyssal Plain to more than 400 m in the south (cf. Cook & others, 1978).

On the shelf, shelly calcarenites and gravels consisting of relict organic material predominate, but finer-grained sediments replace them on the outer shelf margin (Jones, 1973). Farther offshore, the few surface samples suggest that the main lithologies are marl and foraminiferal ooze on the Scott Plateau and Rowley Terrace, and siliceous clay on the Argo Abyssal Plain (Tables 8 and 9). In DSDP 261 in the northern part of the abyssal plain, the A-seabed sequence consists of 19 m of Quaternary siliceous clay, and 123 m of Miocene and Pliocene nanno ooze and nanno-rich ooze with siliceous clay at the top, which Veevers, Heirtzler, & others (1974) regarded as mainly pelagic, and a few calcareous turbidites.

We interpret the available data on Miocene to Recent sedimentation as follows. The lower, prograded part of sequence A-seabed represents the wedge of Miocene shelf calcarenite which built outwards everywhere on the Northwest Shelf at this time. It formed during the worldwide period of low sea level in the late Oligocene and Miocene, which followed the generally high sea levels of the Palaeogene (see Vail, Mitchum, & Thompson, 1977). The sea transgressed well eastward thereafter, and the overlying parallel-bedded part of the sequence represents the deep-water equivalents of the sediments on the Northwest Shelf.

TABLE 9. CORES OBTAINED BY RV *VEMA* (V) AND RV *ROBERT CONRAD* (RC)*

Station (Plate 2) and date	*Area*	*Location Lat. (°S)*	*Location Long. (°E)*	*Water depth (m)*	*Recovery (cm)*	*Description*
V24-187 1967	Roti Basin	11°43′	120°12′	4266	482	Foraminiferal marl and chalk; lamination and slump and slide structures. Yellowish green to light grey
RC14-64 1971	Northwest Shelf	14°15′	123°17′	154	1110	Sandy foraminiferal ooze with occasional Mn micronodules. Coarse fraction consists of foraminifera, molluscs, echinoid spines, sponge spicules
RC14-65 1971		13°28′	125°00′	106	105	0-20 cm: coral-pteropod shell hash ooze; olive-grey to olive-brown. 20-105 cm: foraminiferal-pteropod shell hash ooze; greenish grey
V28-342 1971	Scott Plateau	14°06′	120°30′	2730	762	Interbedded foraminiferal marl and foraminiferal marl-ooze. 0-70 cm: greyish orange. 70-762 cm: light olive-grey
RC14-63 1971		15°12′	119°27′	2838	1007	Alternating foraminiferal ooze, foraminiferal marl-ooze, foraminiferal marl, and marl. 0-58 cm: yellowish brown. 58-1007 cm: grey tones
V28-345 1971	Rowley Terrace	17°40′	117°57′	1904	771	0-10 cm: orange foraminiferal ooze. 10-229 cm: brown foraminiferal marl-ooze. 229-505 cm: greenish grey foraminiferal marl-ooze grading to foraminiferal chalk-ooze. 505-771 cm: yellowish brown to olive-grey foraminiferal marl-ooze
V20-155 1965	Argo Abyssal Plain	13°00′	118°13′	5658	1220	Diatomaceous lutite and silty lutite; foraminifera and Mn micronodules at some levels. Yellowish brown above 76 cm, grey tones below
V28-343 1971		12°19′	118°18′	5404	1160	Interbedded clay, radiolarian clay, diatomaceous clay, and volcanic ash; Mn micronodules common. 0-78 cm: brown tones. 78-998 cm: grey tones. 998-1160 cm: mainly brown tones
V28-344 1971		14°38′	117°57.5′	5658	1790	Interbedded clay, diatomaceous ooze, radiolarian clay-ooze, foraminiferal-radiolarian ooze, marl, foraminiferal-pteropod ooze, diatomaceous clay, and foraminiferal ooze. Rare Mn micronodules. 0-310 cm: yellowish brown. 310-1790 cm: grey tones

* Core descriptions by the staff of Lamont-Doherty Geological Observatory, USA.

Current erosion and slumping along the upper slope has carried sediment into deeper water, forming the wedge at its foot.

On the Scott Plateau the whole of interval A-seabed sedimentation was in relatively deep water with a strong pelagic influence, though the parallel-bedded sediments, which are the analogues of the parallel-bedded sediments on the shelf, were probably laid down in shallower water than the acoustically transparent ones.

Storm and current action are apparently important in the area. The shelf sediments are coarse and mud-free, whereas the plateau and abyssal plain sediments include a great deal of mud, presumably derived from the Australian mainland. The truncation of the sediments on the upper slope, and the reworking of the plateau sediments discussed by Shafik (1978) and Zobel (1978), are also related to current action. The presence of large manganese nodules and outcrops of ancient sedimentary rocks on the outer margin of the Scott Plateau (Hinz & others, 1978) suggests strong current action in 2000 m and more of water.

The lower continental slope is virtually free of superficial sediment, except in the far north where the slope is more gentle. The slope is probably swept clean by contour currents runing to the north. The removed sediment has made its way to the Argo Abyssal Plain, where the thickest sequence lies in the gentle basement depression in the south mapped by Cook & others (1978). This thick sequence probably consists largely of calcareous turbidites derived from Swan Canyon, Bowers Canyon, and other lesser canyons in between. The thin sequence present in DSDP 261, in the north, is largely of pelagic origin.

GEOLOGICAL HISTORY

The geological evolution of the Scott Plateau area is illustrated in the schematic cross-sections of Figure 27 (based on BMR seismic profile 18/61), and in the palaeogeographic sketches of Figure 28. The interpretation relies heavily on drill and seismic information from the adjacent shelf areas (Powell, 1976; Allen & others, 1978; Warris, 1976) and the Argo Abyssal Plain (Veevers, Heirtzler, & others, 1974).

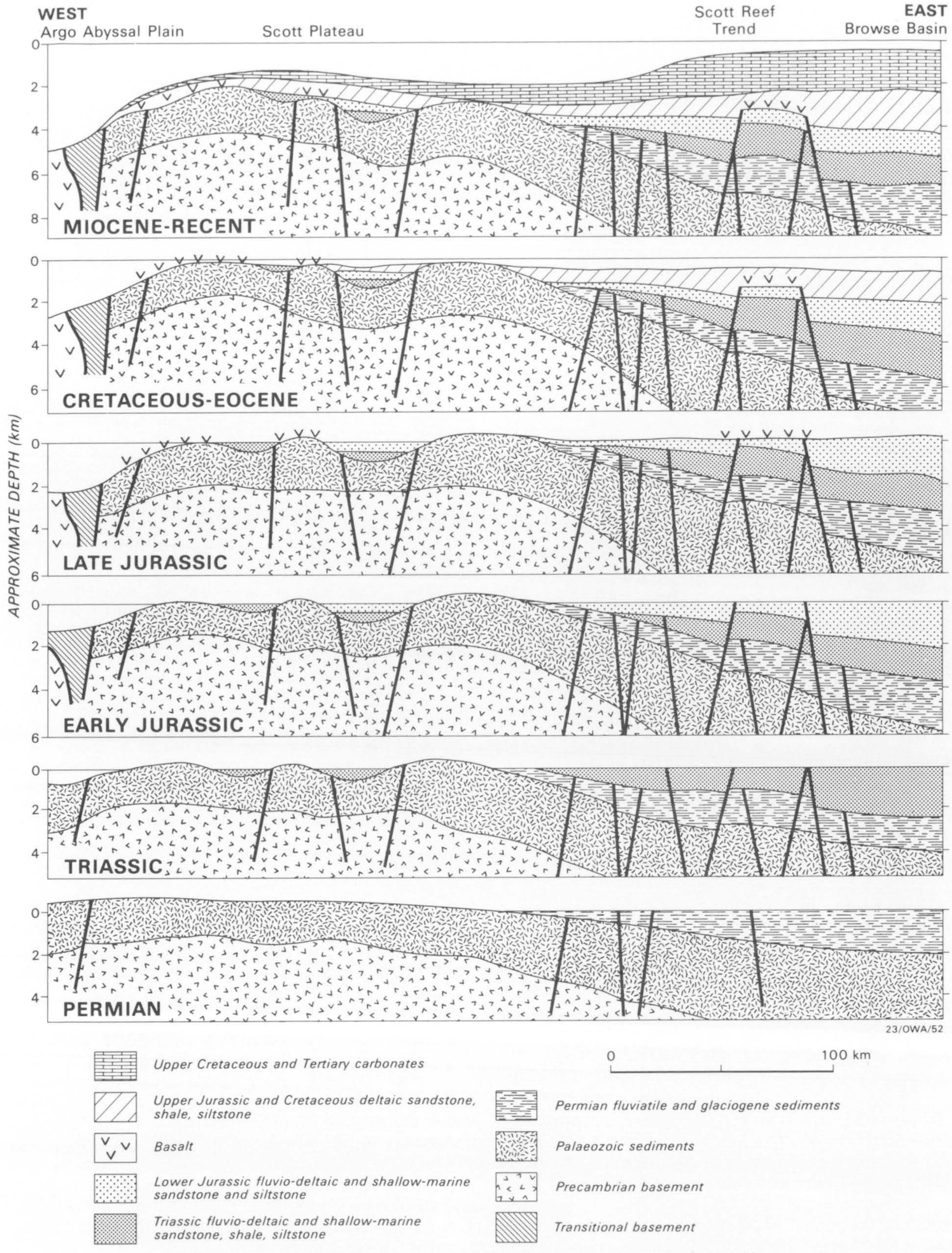


Fig. 27. Schematic cross-sections showing the structural evolution of the Scott Plateau area.

PRE-PERMIAN

Magnetic and gravity evidence suggest that the Scott Plateau is underlain by continental crust, a view espoused by Allen & others (1978) and Stagg & Exon (1979). If so, then—by analogy with the Kimberley Block to the east—the Scott Plateau and Rowley Terrace are probably underlain by a variety of Proterozoic granites, volcanics, and metamorphosed sedimentary rocks. In contrast, Veevers & Cotterill (1978) and Veevers (1979) suggested that the Scott Plateau is an epilith (see footnote, p. 1).

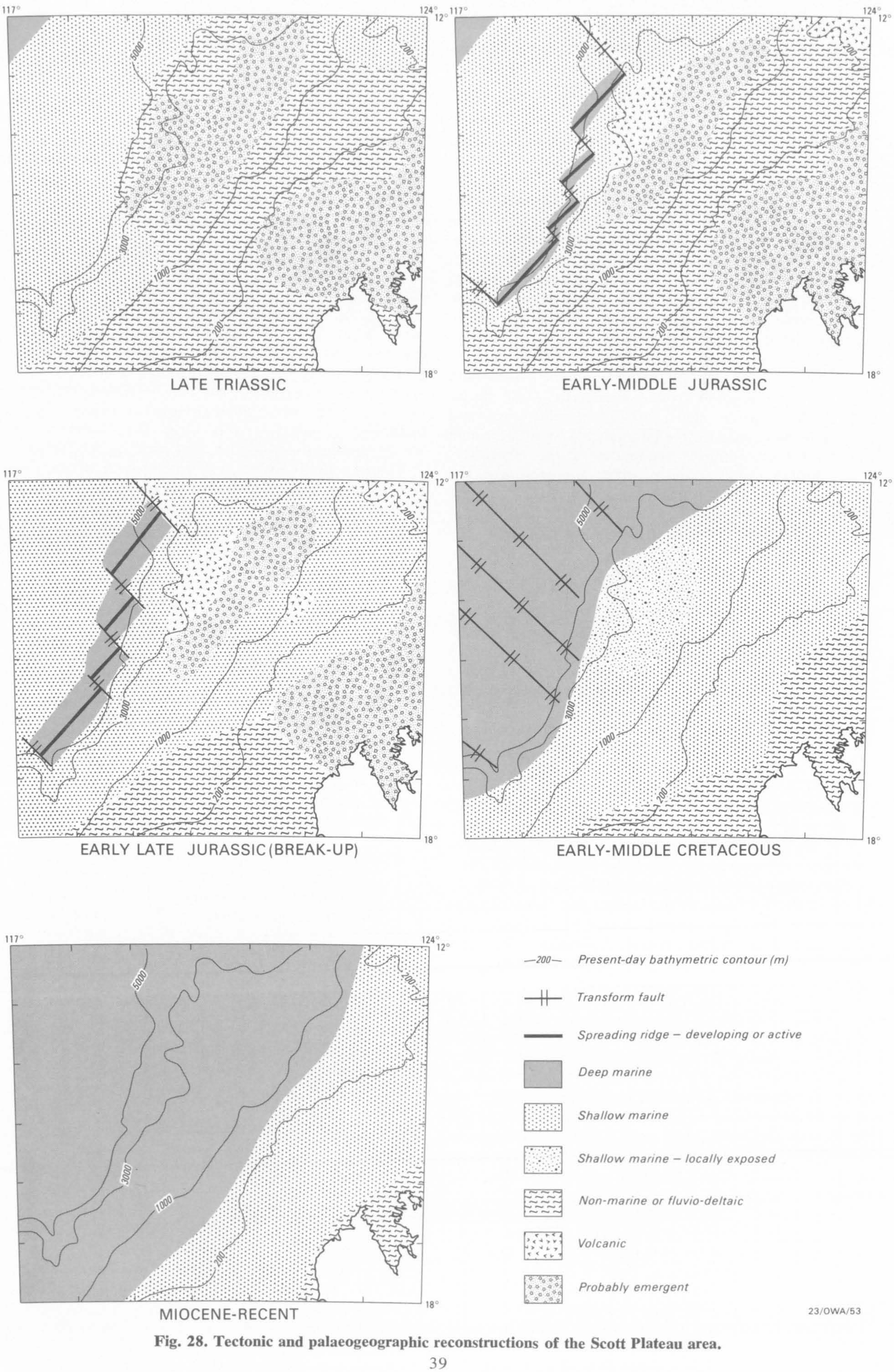


Fig. 28. Tectonic and palaeogeographic reconstructions of the Scott Plateau area.

In the Precambrian the Kimberley Block was alternately elevated and depressed, and the area beneath the Canning Basin was probably elevated. Sedimentation commenced in the Bonaparte Gulf Basin to the north in the Cambrian, and in the Canning Basin to the south in the Ordovician (Playford & others, 1975). Lower Palaeozoic sediments may have accumulated in the Browse Basin (Allen & others, 1978) and in the Scott Plateau area.

The separation of Gondwanaland and Eurasia in the middle Palaeozoic may have led to the formation of the Petrel Sub-basin in the Bonaparte Gulf Basin and the Fitzroy Graben in the Canning Basin (Laws & Kraus, 1974), and may also have initiated the west-northwest to northwest-trending faults of the outer Scott Plateau.

A marine transgression in the Early Devonian appears to reflect the formation of a broad trough seaward of and parallel to the present Western Australian landmass (Powell, 1976). Lower Devonian evaporites precipitated in the Bonaparte Gulf Basin, but shallow-marine shale, siltstone, sandstone, and carbonate more generally characterise Lower Devonian to Lower Carboniferous sequences of the Northwest Shelf. A widespread period of uplift and erosion in the Late Carboniferous was probably the first phase of the rifting of eastern Gondwanaland, which culminated in continental break-up in the Jurassic-Cretaceous.

PERMIAN TO MIDDLE JURASSIC (LOWER SERIES)

From Permian to Middle Jurassic time, rift-valley sediments were deposited in a northeast-trending depocentre (the Browse and offshore Canning Basins) bounded by the Kimberley Block and the Broome Swell to the east and by a continental landmass which included the Scott Plateau to the west. The abundance of marine sedimentary rocks suggests that the Browse Basin was connected to the Tethys Sea to the north. As rifting progressed, numerous northeast-trending normal faults developed, of which some were rejuvenated several times before this part of Gondwanaland broke up in the Late Jurassic.

The depocentre was formed by uplift of its eastern and western margins in the Late Carboniferous, and glaciers may have capped the uplands of the Kimberley Block in the Early Permian. During the Permian, probably more than a thousand metres of glacigene and other detrital sediments were laid down in the axial part of the Browse Basin and in the Rowley Sub-basin. Marine and paralic sands, silts, muds, and carbonates dominated the Early Permian, and may have transgressed onto Precambrian basement on the flanks of the depocentre. During a Late Permian regression, fluvial sands were the characteristic sediments. Subsequent uplift (in the Late Permian or Early Triassic) caused an erosional wedge-out of Lower Permian sediments along the eastern side of the Browse Basin and the Rowley Sub-basin, and probably along the eastern side of the Scott Plateau. In deeper parts of the depocentre Upper Permian rocks are probably still preserved.

In the Early Triassic, the sea transgressed from the north, and thereafter steadily shallowed. In the deeper parts of the depocentre, sedimentation was probably continuous from Permian to Triassic time, and a full sequence of Triassic shale, siltstone, and sandstone up to 2000 m thick may be present; but around the margins of the depocentre, Upper Triassic sediments were deposited directly on Permian rocks. At that time the continental shelf lay to the north; delta-front and paralic sands, muds, and carbonates were laid down in the central Browse Basin, and fluvio-deltaic sand and mud were deposited around its margins (Allen & others, 1978) and in the Rowley Sub-basin. The Scott Plateau was essentially an erosional area in the Triassic, but pockets of fluvial sediments were probably deposited in local depressions.

Triassic sedimentation was terminated by a major episode of faulting, uplift, and erosion that lasted from the end of the Triassic until early in the Jurassic in the Canning, Browse, and Bonaparte Gulf Basins. These movements took place along the eastern margins of the Browse Basin and Rowley Sub-basin in the Triassic, but much later (late Early Jurassic) in the Scott Reef area. Northeast-trending normal faults developed in the central Browse Basin and along the eastern edge of the Scott Plateau, but were confined to the western margin of the Rowley Sub-basin. Movements on the outer Scott Plateau followed the old northwest trends. At this time the Ashmore-Sahul Block, previously a depositional area, was uplifted.

Thermal uplift of an arch to the west of the depocentre, along which break-up would later occur, had probably begun by the Early Jurassic, and the Browse Basin and Rowley Sub-basin could be regarded as 'extra-arch basins' (Veevers & Cotterill, 1978). However, this caused little change in the depocentre. Sedimentation began with the deposition of reddish brown fluvial silt and mud unconformably on Triassic rocks. This soon gave way to the depostion of fluvio-deltaic sand, silt, mud, and coal measures. The Lower and Middle Jurassic sequence is up to 1000 m thick in the central Browse Basin, 3000 m thick west of the Leveque Shelf, and 2000 m thick in the Rowley Sub-basin. Basic lavas poured out during the later stages of rifting in the late Middle and early Late Jurassic are interbedded with sediments on the Ashmore-Sahul Block, on the Scott Plateau, and in the Browse Basin. On the Scott Plateau, thick sequences of sediments and volcanics were probably confined to local depressions.

When this area of Gondwanaland broke up in the early Late Jurassic, there was a great deal of movement on northeasterly trending faults in the Bonaparte Gulf, Browse, and Carnarvon Basins. The zone of rupture passed west of Scott Plateau, and probably consisted of a number of northeast-trending fractures and northwest-trending transform faults, which constructed a composite margin oriented north-south. On the Scott Plateau a complex pattern of blocks bounded by northeast and northwest-trending normal faults developed. Northeast-trending normal faults along the western margin of the Rowley Sub-basin were also active at this time.

LATE JURASSIC TO RECENT (UPPER SERIES)

A major marine transgression took place as the northwest Australian margin sank after break-up in the Callovian (160 m.y. ago); by the Late Cretaceous the outer margin was in bathyal depths. In the Cainozoic, shelf carbonate built out across the Browse Basin and Rowley Sub-basin, but pelagic sedimentation continued over the Scott Plateau and outer Rowley Terrace. More than 5000 m of Upper Series sediments accumulated in the central Browse Basin (Allen & others, 1978, figs. 13 and 14), but, except for isolated areas, less than 1000 m accumulated on the Scott Plateau (Plate 21). The Scott Plateau had subsided about 2000 m by Late Cretaceous time, but has sunk little since.

Deltaic deposition was continuous through the Middle and Late Jurassic in the southeastern half of the Rowley Sub-basin, while in the northwestern half of the sub-basin there was a probable change from a fluvio-deltaic to shallow-marine environment. Sedimentation recommenced during the early Late Jurassic in the central part of the Browse Basin and spread radially outward; the initial deposits were fluvio-deltaic sediments deposited in a restricted embayment but, as the Scott Plateau sank, normal detrital shelf sedimentation gradually spread over basin and plateau. From the Early Cretaceous, mud and silt were deposited on a broad shelf which covered much of the Browse Basin and Rowley Sub-basin, and mud was probably deposited over the Scott Plateau. In the Late Jurassic and Early Cretaceous, 2500 m of sediment accumulated in a broad northeast-trending depocentre east of Scott Reef (Allen & others, 1978, fig. 13), and up to 2000 m of sediment accumulated in the northeastern Rowley Sub-basin. In contrast, less than 500 m of sediment was laid down over the Scott Plateau and in the outer Rowley Sub-basin.

Few of the old faults were active during the Late Jurassic and Early Cretaceous, and pre-existing horst blocks were covered by Upper Series sediments. However, some movement is evident in the Scott Plateau Saddle, and considerable movement took place along the outer edge of the continent, where fault-blocks adjusted to their new position adjacent to low-lying oceanic crust to the west. This crust was generated through most of the Late Jurassic (Larson, 1975), and was overlain by several hundred metres of Late Jurassic and Early Cretaceous abyssal clay.

In the early Late Cretaceous, detrital sedimentation gave way to carbonate sedimentation, in common with the rest of the west Australian margin (Veevers & Johnstone, 1974). During the Late Cretaceous, coastal-plain and marginal-marine clay and marl were laid down in the eastern Browse Basin, and outer shelf and bathyal marl and calcilutite were laid down in the western Browse Basin and the Rowley Sub-basin. Bathyal calcilutite and marl were deposited on the Scott Plateau, and clay on the abyssal plain to the west. Sediment thicknesses exceed 900 m in a depocentre northeast of Seringapatam Reef, but are less than 500 m in the outer Rowley Sub-basin and on the Scott Plateau, and are probably absent on the abyssal plain.

A break in deposition in the early Paleocene coincided with subaerial erosion in the east, and probably with carbonate solution in deep water in the west. During the remainder of the Paleocene and Eocene, non-marine sandstone was deposited in the east, shelf clay and marl prograded northwestward in the Rowley Sub-basin, middle and outer shelf carbonate was deposited in the southern and western Browse Basin, and marl and calcilutite were probably the dominant deposits on the Scott Plateau. Deep-sea ooze and clay and interbedded turbidites were deposited on the abyssal plain. In the major Palaeogene depocentre trending northeast through Scott Reef, sediment thicknesses exceed 1200 m, but in the outer Rowley Sub-basin and on Scott Plateau they are only about 300 m. The thickest sequence on the abyssal plain (400 m +) lies off the Rowley Terrace, and is probably composed of sediments deposited by turbidity currents from the south and east.

The worldwide Oligocene regression caused a break in sedimentation in much of the Browse Basin, but not in the Scott Reef or Rowley Shoals area. A synchronous break in the deeper-water areas to the west may have been caused by the solution or erosion of carbonate by a strong cold current related to Antarctic cooling (Davies & others, 1975). In Miocene to Recent time, the Northwest Shelf was built up by 1000 to 2000 m of prograding carbonates, and reefs developed at the edge of this carbonate platform. Bathyal marls were laid down in the outer Rowley Sub-basin and on the Scott Plateau, where sediment thicknesses are generally less than 400 m. Siliceous clays and turbidites accumulated on the abyssal plain, where the thickest sequence—comprising more than 400 m of sediment—was laid down off the Rowley Terrace.

HYDROCARBON GEOLOGY

This assessment of the hydrocarbon potential of the Scott Plateau and Rowley Terrace is in general agreement with that of Willcox (1981), who reviewed the prospectiveness of all Australian marginal plateaux. Possible structural plays on the Scott Plateau and in the Rowley Sub-basin are shown in Figure 29, and an assessment of the hydrocarbon prospectiveness is shown in Plate 23.

The Scott Plateau forms the western margin of the Browse Basin, in which—despite the discovery of a gas/condensate field at Scott Reef (Allen & others, 1978), and of oil and gas shows in Caswell No. 1—exploration has proved generally disappointing. The Browse Basin is a marginal tensional basin containing up to 10 km of Upper Carboniferous to Cainozoic sediments, including proven Mesozoic source rocks. Hydrocarbons have generally been found within the fluvio-deltaic sandstones of the Lower Series, which are sealed by Upper Jurassic and Lower Cretaceous transgressive shales of the Upper Series.

In the Scott Reef field, hydrocarbons were discovered in Lower Series sandstones of Late Triassic and Early to Middle Jurassic ages, which are separated by an angular unconformity of Norian to Rhaetian age. Their porosity is about 15 percent and permeability low. The reservoir section is sealed by Upper Jurassic claystone. Gas flows from three horizons in Scott Reef No. 1 were 9.8 MM scfd and 18.2 MM scfd on 1-inch surface chokes, and 11.0 MM scfd on a ½-inch surface choke. Condensate flowed at rates of up to 20 bbl per day. The oil and gas shows in Caswell No. 1 also occurred in the Lower Series.

The Rowley Terrace forms the western margin of the Canning Basin. Both Upper and Lower Series are thick, but structural traps appear to be rare. East Mermaid No. 1 well, the only well yet drilled on the terrace, encountered minor gas shows in the Cretaceous sequence, but the sandstones of the Lower Series were filled with saline water.

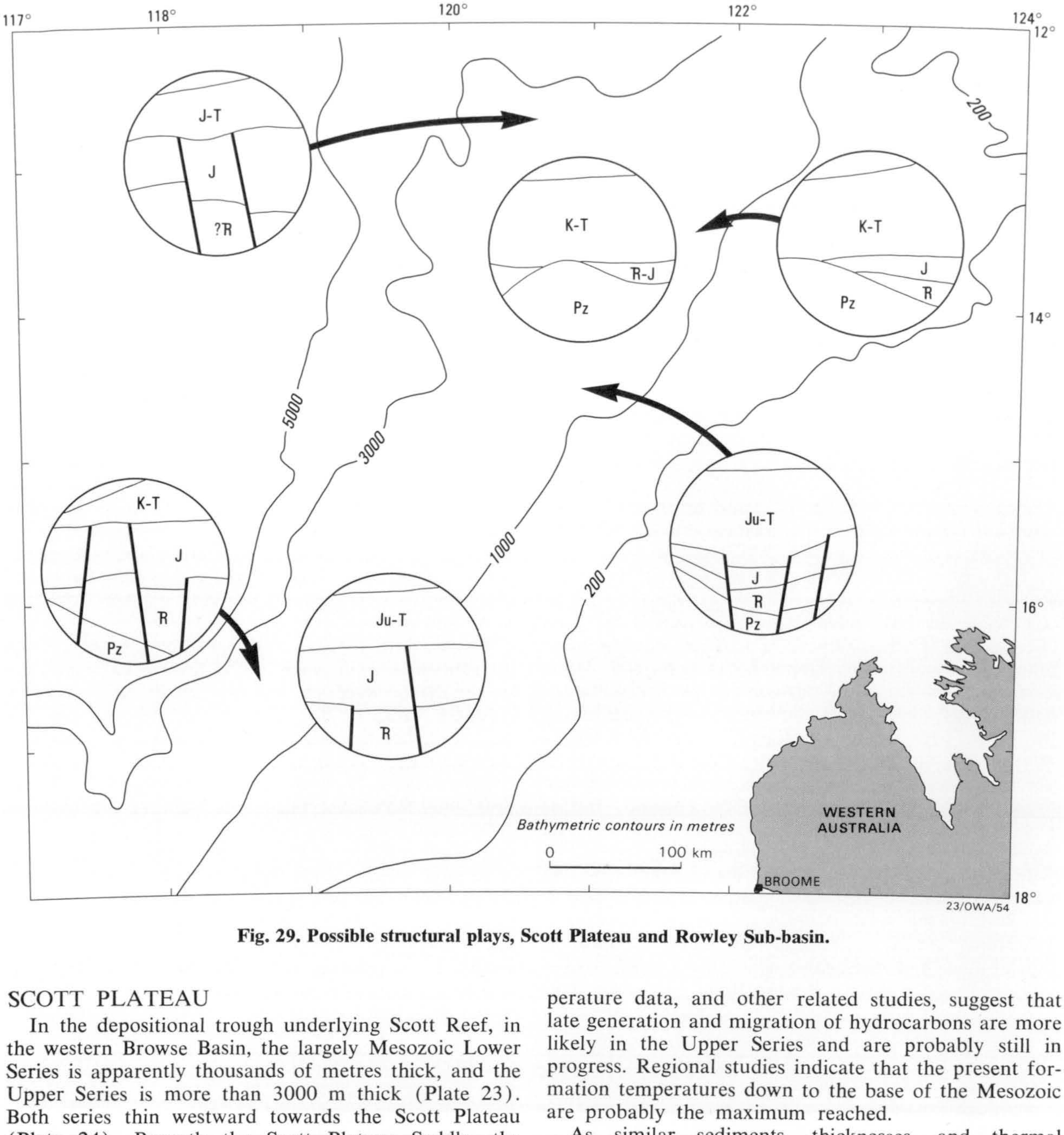


Fig. 29. Possible structural plays, Scott Plateau and Rowley Sub-basin.

SCOTT PLATEAU

In the depositional trough underlying Scott Reef, in the western Browse Basin, the largely Mesozoic Lower Series is apparently thousands of metres thick, and the Upper Series is more than 3000 m thick (Plate 23). Both series thin westward towards the Scott Plateau (Plate 24). Beneath the Scott Plateau Saddle, the Lower Series is still generally thick, and the Upper Series has a thickness of 1000-2000 m. The Lower Series is faulted out against the eastern side of the Scott Plateau Dome, where the Upper Series generally rests on basement and is less than 1000 m thick.

There appears to be no lack of suitable source rocks in either the Lower or Upper Series in the Browse Basin, about which Allen & others (1978) made several observations. They considered that the thick Upper Series claystones and the interbedded Triassic and Lower to Middle Jurassic claystones of the Lower Series provide ample source rock potential for hydrocarbons. The marine Upper Jurassic and Lower Cretaceous intervals rich in sapropel and cuticle apparently represent the best potential source rocks for oil and gas, but an assessment of the more deeply buried Triassic and Lower to Middle Jurassic rocks is incomplete owing to a lack of data. However, extrapolation of well temperature data, and other related studies, suggest that late generation and migration of hydrocarbons are more likely in the Upper Series and are probably still in progress. Regional studies indicate that the present formation temperatures down to the base of the Mesozoic are probably the maximum reached.

As similar sediments, thicknesses, and thermal gradients probably prevail beneath the Scott Plateau Saddle, the foregoing observations can be applied to that area also.

If thermal gradients are similar to those on the Northwest Shelf (ca 2.7°C/100 m according to Exon & Willcox, 1980, table 8), and the normally accepted maturity/temperature criteria are applied, then (1) no hydrocarbons could have been generated in the region under less than 1500 m of overburden, (2) the zone of mature oil generation would be between 2500 m and 4500 m deep, and (3) only gas and condensate would be produced at greater depths. This suggests that the zone of mature oil generation covers (1) Triassic, Jurassic, and Early Cretaceous rocks where the Tertiary sequence is thick—as it is beneath Scott Reef and farther east; (2) only Lower Series rocks beneath the Scott Plateau Saddle; and (3) only rocks deep in the basement beneath the Scott Plateau Dome.

The seismic records show that faulting is generally confined to the Lower Series, where displacements of hundreds of metres occur (Plate 24). There is no evidence of compression in the basin (Allen & others, 1978), and normal faults formed under a tensional regime which ended in the Early Jurassic. The Scott Plateau was apparently above sea level before break-up, shedding sediment into the shallow-marine Browse Basin to the east. After break-up it began to sink, and was in bathyal depths by the Late Cretaceous. This sinking was greater than that of the eastern areas, and the slope upward from basin to plateau must have diminished accordingly. The necessary flexing rejuvenated a few older faults, but displacements are seldom evident in Tertiary sediments. Any hydrocarbons generated before break-up probably escaped up the numerous normal faults. Hydrocarbons generated in the Lower Series after break-up would probably migrate to the break-up unconformity, and would then move up-dip in the general directions indicated by the arrows in Plate 23. Any hydrocarbons generated in the Upper Series would follow similar paths.

At present, hydrocarbons could be generated from the Lower Series as far west as the 1000 m contour of Upper Series overburden. Hydrocarbons are unlikely to be generated from the Upper Series where the overburden is less than 1500 m thick, so hydrocarbons from Upper Jurassic and Lower Cretaceous source rocks can be expected only east of the axis of the Scott Plateau Saddle.

The regional highs near the thick sedimentary sequences between the edge of the shelf and the Scott Plateau Saddle (Plate 23) are of considerable interest. The hydrocarbon prospectiveness map indicates the existence of suitable easterly hydrocarbon migration paths toward the shelf and the Scott Reef Trend, and also of westerly migration paths towards particular structural highs such as A (water depth 2200 m), B (2000 m), C (1000 m), and D (1600 m). Highs on the Scott Plateau Dome such as E, F, and G (2000 m) would be prospective if hydrocarbon has migrated 50 km or more up-dip.

Lower Series reservoir rocks in the Scott Plateau Saddle are probably similar to those of Scott Reef, consisting of deltaic and shelf sandstone and limestone of Triassic and Jurassic age. As this area probably formed the western margin of the basin immediately after break-up in the early Late Jurassic (Allen & others, 1978), and sank steadily thereafter, the break-up unconformity may well be overlain by fluvial and shallow-marine sandstones. Further sinking would have capped the sandstones with marine shale, which our seismic interpretation indicates is hundreds of metres thick.

The area beneath and near the Scott Plateau Dome appears to be less prospective than the saddle. The best targets appear to be shallow-marine sandstones of the Upper Series resting on basement and laid down as the plateau subsided below sea level in the Late Jurassic; any hydrocarbons would have been derived from underlying basement rocks or from the east. Other possible targets are Lower Series sandstones in horsts, which could have derived their hydrocarbons from deep adjacent grabens (Plate 24). In both environments, caprocks would be Upper Series shales. It should be noted here that dredging has suggested that a large part of the Lower Series on the outer plateau might consist of unprospective volcanics (Hinz & others, 1978).

ROWLEY SUB-BASIN

Both Lower and Upper Series are generally thick in the Rowley Sub-basin, where magnetic data suggest that the total sedimentary section is as much as 9 km thick (Willcox, 1981). Seismic sections indicate that the Lower Series is more than 3000 m thick, and that the Upper Series is more than 2000 m thick in a north-northeast-trending zone through Rowley Shoals (Plates 21 and 23), thinning toward the lower continental slope. Faulting is confined to the Lower Series, and was apparently caused by tension that developed during rifting before break-up; extensive faulting is confined to the margins of the Rowley Sub-basin.

The fact that East Mermaid No. 1 well, sited on a broad dome, had only minor gas shows suggests that there may be a lack of suitable source rocks in the Rowley Sub-basin. The zone of mature oil generation is probably similar to that in the north, lying between 2500 and 4500 m below the seabed, so that sediment thickness is adequate.

Hydrocarbons generated before break-up probably would have escaped to the surface in the more faulted areas, but may be preserved in the widespread undeformed areas. Hydrocarbons generated in both the Lower and Upper Series since the Late Cretaceous are likely to have migrated up-dip in a generally south-easterly direction. Dips are gentle; closer spacing of seismic lines is generally needed to define local highs although one broad high (I) in 2000 m of water has been roughly defined.

Suitable reservoir sandstones were penetrated in the generally regressive shallow-marine Jurassic part of the Lower Series in East Mermaid No. 1 (Fig. 6). Porosities are about 20 percent and the sandstones were full of water. No suitable reservoir rocks were penetrated in the Upper Series. Potential cap-rocks include shales within the Jurassic sequence, and unconformably overlying Lower Cretaceous claystone.

Possible targets in the Rowley Sub-basin are broad highs, and possibly large fault-blocks in the Lower Series.

CONCLUSIONS

The best hydrocarbon prospects in the area are probably below and near the Scott Plateau Saddle, where (1) source rocks are probably present, (2) depth of burial has been adequate to generate hydrocarbons, and (3) broad old highs are present. Fault-bounded structures are confined to the Lower Series. Suitable sandstone reservoirs may be confined to the Lower Series, and to basal sandstones of the Upper Series resting on the break-up unconformity. Local seals are provided by shales in the Lower Series, and a regional seal by Upper Jurassic and Lower Cretaceous shales. Water depths range from 1000 to more than 2000 m.

The Rowley Sub-basin appears to be less prospective than the Scott Plateau Saddle, largely because East Mermaid No. 1 indicated a possible lack of suitable source rocks. Depth of burial has certainly been adequate to generate hydrocarbons, but a lack of anticlinal closures, and the fact that faulting in the Lower Series is confined to limited areas, suggest that adequate structural traps would be difficult to find. However, any such structures would have existed throughout the Tertiary and would have been capable of trapping any migrating hydrocarbons. Suitable reservoir sandstones are present in the Lower Series, and interbedded shales could form a regional seal.

The hydrocarbon prospects of the Scott Plateau Dome and adjacent areas appear to be low, because Upper Series rocks directly overlie Lower Palaeozoic or older basement rocks, and are relatively thin. Hydrocarbons may have migrated into broad highs from the Scott Plateau Saddle, and, in some areas, horsts containing Lower Series sediments may be targets.

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APPENDIX 1

Computation of free-air, Bouguer, and magnetic anomalies

The free-air gravity anomaly is computed by applying latitude and Eötvös correction (Glicken, 1962) to the observed gravity data:

$$G_{FAA} = G_{OBS} - 978.049\ (1 + 0.0052884 \sin^2 \phi - 0.000005 \sin^2 2\phi) + 7.5\ V_e$$

where G_{FAA} = free air gravity anomaly (Gal)
G_{OBS} = observed gravity (Gal)
ϕ = latitude
V_e = eastward component of velocity (knots).

In the Bouguer gravity anomaly a further correction has been applied to eliminate the gravity effect caused by variations in water depth. The water layer of density 1.03 $t.m^{-3}$ has been rounded to 1.0 $t.m^{-3}$ and replaced with a layer of density 2.20 $t.m^{-3}$.

$$G_{BA} = G_{FAA} + 2\pi G\ \Delta\rho\ d$$

where G_{BA} = Bouguer anomaly
G = Universal Gravitational Constant
$\Delta\rho$ = difference in density between sea water and sediments—assumed to be 1.20 $t.m^{-3}$
d = water depth in metres.

Ordinarily, magnetic anomalies are computed as the difference between the measured total magnetic field, corrected for diurnal variation, and the International Geomagnetic Reference Field (IGRF). However, recent studies at BMR by Petkovic & Whitworth (1975) have shown the time terms of the IGRF to be considerably in error in the Australian region, and they derived a more closely fitting regional field. This is termed the Australian Geomagnetic Reference Field (AGRF), which has been used for the computation of magnetic anomalies in this Bulletin.

magnetic anomaly = observed total magnetic field − diurnal − AGRF

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APPENDIX 2

Late Cretaceous planktic foraminifera in *Valdivia* core KL1 from the Scott Plateau, off northwestern Australia

D. J. Belford

This account records the planktic foraminifera from the only core of Late Cretaceous age taken during the *Valdivia* cruise in 1977 off northwestern Australia—core KL1 from latitude 13.2084°S, longitude 120.0660°E, in a water depth of 2000 m near the southern edge of Oates Canyon, in the Scott Plateau (Fig. A1). Initially, only samples from the top and bottom of the core were available, but subsequently small samples throughout the core were examined. The fauna proved to be uniform throughout. Although most samples also contain Recent planktic species introduced as contaminants during cutting of the core, no reworked material is evident.

In the following annotated alphabetical list of foraminifera identified in core KL1, each species is accompanied by a reference to the plate in which it is figured in this paper, and by the original reference. All figured specimens are deposited in the Commonwealth Palaeontological Collection, held at the Bureau of Mineral Resources, Canberra, Australia, under numbers CPC 19075 to 19118.

ANNOTATED CHECK LIST

Genus **GLOBIGERINELLOIDES** Cushman & Ten Dam, 1948

Globigerinelloides asperus asperus (Ehrenberg, 1854)

Plate A1, figs. 1-4

Globigerinelloides asperus asperus (Ehrenberg, 1854): *Phanerostomum asperum* Ehrenberg, 1854, p. 23, pl.

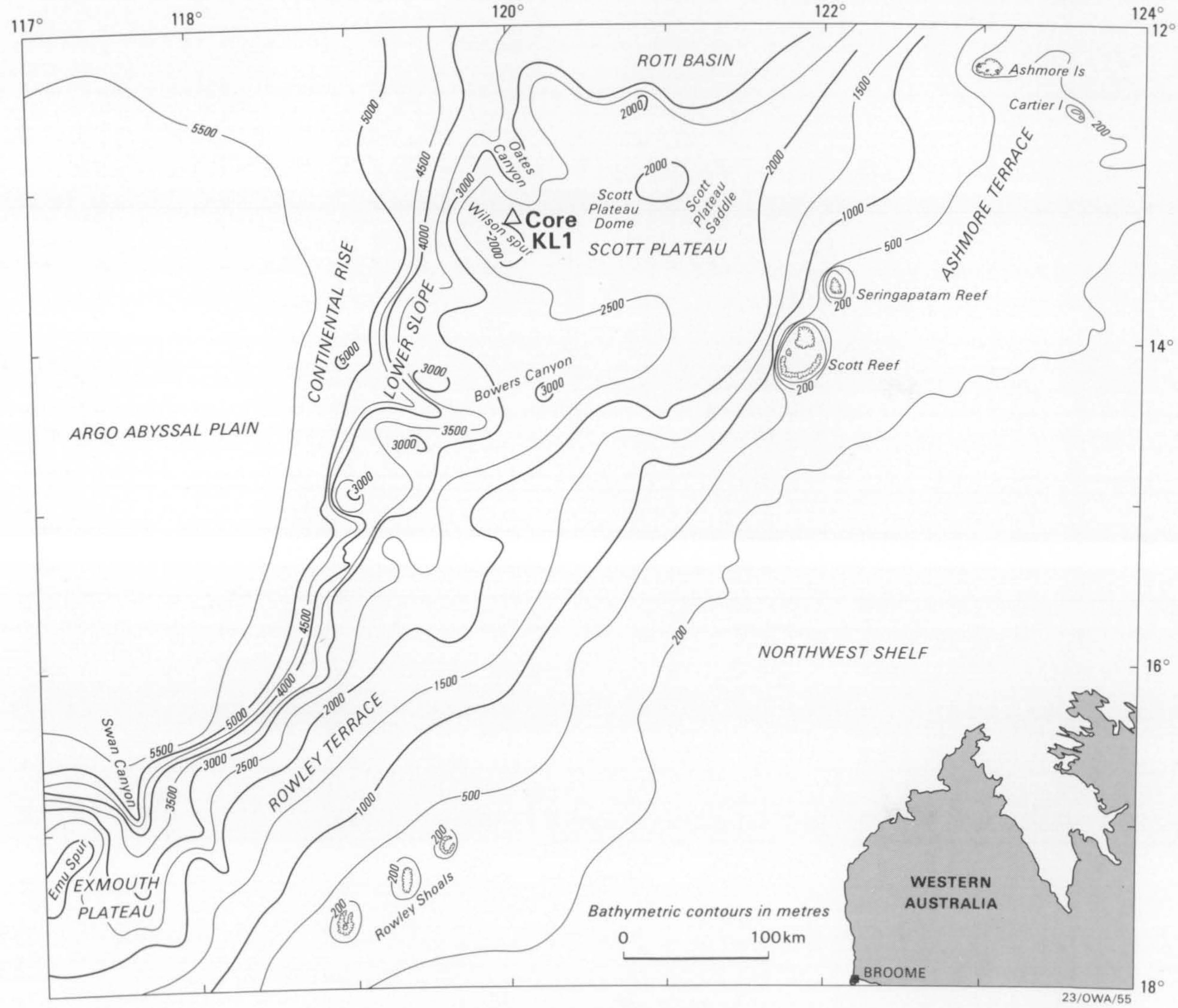

Fig. A1. Location of core KL1.

30, figs. 26a-b; pl. 32, fig. 24; pl. 32, fig. 42 (fide Ellis & Messina, 1940, et seq.).

Abundant well-preserved finely spinose or pustulose specimens of *Globigerinelloides* with seven to eight chambers in the last whorl are referred to *G. asperus asperus.* Barr (1968), after examining Ehrenberg's collection, figured specimens of *G. asperus asperus* which the *Valdivia* specimens closely resemble. Pessagno (1967), in order to stabilise the taxonomy of this species, selected as lectotype for *G. asperus asperus* the specimen illustrated by Ehrenberg in plate 30, figures 26a-b. However, Barr (1972) stated that he had been unable to locate this specimen, and had some doubts that it still existed. Frerichs, Atherton, & Shive (1975) figured specimens of *G. asperus* which those from the *Valdivia* material closely resemble.

The *Valdivia* specimens also resemble *G. ehrenbergi* (Barr, 1961) in having seven to eight chambers in the last whorl, and in the compression of the test; *G. ehrenbergi* was described as having a finely hispid surface. Herb (1974) figured as *G. ehrenbergi* (Barr) specimens which are very similar to those from the *Valdivia* material. Both van Hinte (1963) and Pessagno (1967) placed *G. ehrenbergi* in the synonymy of *G. asperus.*

Sliter (1968) omitted *G. asperus* from discussion, noting the inadequate original descriptions. However, the illustrations mentioned by Sliter were of specimens which Ehrenberg figured as *Rotalia aspera* and which Pessagno (1967) stated could not be placed with certainty in *Globigerinelloides.* The concept of *G. asperus asperus* used here follows the usage of such papers as Barr (1968, 1972) and Pessagno (1967).

Globigerinelloides messinae messinae (Brönnimann, 1952)
Plate A1, figs. 5-10

Globigerinelloides messinae messinae (Brönnimann, 1952): *Globigerinella messinae messinae* Brönnimann, 1952, p. 42, pl. 1, figs. 6-7; text-figs. 20a-i; k-q.

Berggren (1962) has discussed the development of the *Globigerinelloides* lineage, and has shown infraspecific variation in *G. messinae messinae.* Most of the *Valdivia* specimens have a bipartite aperture; some specimens also have an irregularly developed smooth-walled bulla-like final chamber. No indications of the development of a biserial chamber series have been observed. Dain, *in* Subbotina (1953), discussed the development of a bipartite aperture in forms referred to *G. aspera*; Berggren (1962) referred these specimens to *G. messinae.*

Specimens of *G. messinae messinae* from the *Valdivia* material have slightly curved sutures, and in this respect differ from most illustrated specimens of this taxon. However, in illustrating the infraspecific variation of the species, Berggren (1962) showed specimens with curved sutures.

Pessagno (1967) placed *G. messinae* in the synonymy of *G. volutus* (White), and also noted that the types of *G. volutus* are missing. This suggested synonymy is based on the comparison of specimens from the Mendez Shale at the type locality for *G. volutus* with types of *G. messinae.* Until the status of *G. volutus* is formalised by the selection of a neotype, I propose to retain the name *G. messinae* for specimens from the *Valdivia* material of the kind illustrated.

The specimen figured by Quilty (1978) as *Globigerinelloides alvarezi* Eternod Olvera resembles those here placed in *G. messinae messinae*, but has a smooth test surface and a relatively smaller last chamber.

Genus **GLOBOTRUNCANA** Cushman, 1927

Globotruncana arca (Cushman, 1926)
Plate A1, figs. 11-15

Globotruncana arca (Cushman, 1926): *Pulvinulina arca* Cushman, 1926, p. 23, pl. 3, figs. 1a-c.

This is the most abundant species in the fauna from the *Valdivia* material. The specimens are large, have a dorsal surface more convex than the ventral surface, are distinctly double-keeled, and have a broad carinal band and well-developed tegillum.

Globotruncana churchi Martin, 1964
Plate A1, figs. 16-18; Plate A2, figs. 1-3

Globotruncana churchi Martin, 1964, p. 79, pl. 9, figs. 5a-c.

Specimens placed here are not as convex dorsally as the holotype, but have the raised ridge formed by the spiral sutures that Martin (1964) described as a characteristic of the species. In the convexity of their dorsal surfaces the *Valdivia* specimens resemble those figured by Douglas (1969, pl. 8, figs. 1a-c, 2a-c). Martin (1964) described the ventral surface as convex, but the holotype as figured has a flat ventral surface. Douglas (1969) described the species as biconvex, but noted that the ventral surface is commonly slightly concave. Specimens from the *Valdivia* material have a flat or slightly concave ventral surface.

Globotruncana coronata Bolli, 1945
Plate A3, figs. 1-6

Globotruncana coronata Bolli, 1945: *Globotruncana lapparenti* Brotzen *subsp. coronata* Bolli, 1945, p. 233, pl. 9, figs. 14-15; text-fig. 1, 21-22.

This name is used here for some rare large specimens, in accordance with usage in numerous publications; the name was originally applied to specimens observed only in thin section. Van Hinte (1963) discussed the nomenclature of this group, particularly in relation to *G. angusticarinata* Gandolfi, and to the possible synonymy of *G. coronata* with *G. angusticarinata.* The *Valdivia* specimens are not conspecific with that figured by van Hinte (1963) as *G. (G.) renzi angusticarinata*, which is more distinctly biconvex and has more prominently curved ventral sutures. Barr (1972) also figured a specimen with prominently curved ventral sutures as *G. angusticarinata.*

Van Hinte (1963) described *G. 'coronata'* (his usage) as lacking pustules on the ventral surface; in this respect the *Valdivia* specimens differ, having fine pustules particularly on the early chambers of the last whorl, but in other respects are very similar. Herb (1974) figured as *G. coronata* Bolli a specimen very similar to the *Valdivia* specimens; this specimen is also pustulose on the ventral surface.

Others who have figured *G. coronata* specimens similar to the *Valdivia* forms are Vasilenko (1961), Herm (1962), Douglas (1969), and Barr (1972).

Globotruncana fornicata fornicata Plummer, 1931
Plate A3, figs. 7-12

Globotruncana fornicata fornicata Plummer, 1931: *Globotruncana fornicata* Plummer, 1931, p. 198, pl. 13, figs. 4a-c, 5, 6.

This is a common element among the globotruncanid species in the *Valdivia* material.

Globotruncana fornicata Plummer **manaurensis** Gandolfi, 1955

Plate A3, figs. 13-17

Globotruncana fornicata Plummer *manaurensis* Gandolfi, 1955, p. 41, pl. 2, figs. 1a-c; text-fig. 9, 1a-c, 2a-c.

This subspecies is distinguished from *G. fornicata fornicata* mainly by its more convex dorsal surface and narrow peripheral band. The specimens here referred to this subspecies agree well with the original figures and description given by Gandolfi (1955) and with the specimen figured by Barr (1972). Some specimens have very prominently curved to angled ventral sutures and are similar in ventral view to *G. angusticarinata* Gandolfi, which Barr (1972) regarded as the direct ancestor of *G. fornicata manaurensis.*

Globotruncana fresnoensis Martin, 1964

Plate A4, figs. 1-3

Globotruncana fresnoensis Martin, 1964, p. 80, pl. 9, figs. 8a-d.

Rare specimens in core KL1 closely resemble this species in their biconvex test and prominently curved ventral sutures, but do not have inflated dorsal chambers as described for *G. fresnoensis.* The cross-section illustrated by Martin (1964) does not show this feature clearly. Takayanagi (1965) figured as *G. coronata* Bolli specimens which may be referable to *G. fresnoensis.* A specimen figured by Barr (1972) as *G.* aff. *G. coronata* Bolli is also similar to *G. fresnoensis.* Douglas (1969) placed *G. fresnoensis* in the synonymy of *G. marginata* (Reuss). However, *G. marginata* has radial ventral sutures, unlike the strongly curved horse-shoe-shaped sutures of *G. fresnoensis*, which—as shown by the section figured by Martin (1964)—does not have the distinctly inflated chambers of *G. marginata. G. fresnoensis* seems to be closer to *G. lapparenti bulloides* Vogler, which Douglas also suggested may be synonymous with *G. marginata. G. fresnoensis* is here retained as a distinct taxon.

Globotruncana fundiconulosa Subbotina, 1953

Plate A4, figs. 4-6

Globotruncana fundiconulosa Subbotina, 1953, p. 200, pl. 14, figs. 1a-c, 2a-c, 3a-c, 4a-c; pl. 15, figs. 1a-b, 2a-b.

Rare large planoconvex specimens with a wide umbilicus, an acute umbilical rim, two closely spaced keels, and a pustulose test surface are referred to *G. fundiconulosa.* The specimens agree well with Subbotina's description and figures, particularly with the holotype and original no. 5150. Berggren (1962) placed *G. wiedenmayeri wiedenmayeri* Gandolfi and *G. wiedenmayeri magdalenaensis* Gandolfi in the synonymy of *G. fundiconulosa*; Douglas (1969) considered *G. wiedenmayeri wiedenmayeri* to be synonymous with *G. gansseri* (Bolli). Pessagno (1967) placed *G. fundiconulosa* in the synonymy of *G. concavata* (Brotzen), but *fundiconulosa* lacks the distinctly concave dorsal surface of *concavata.* A smaller five-chambered specimen figured by Subbotina (original no. 5153), which in ventral view does resemble *G. concavata*, has a slightly convex dorsal surface. *G. fundiconulosa* is here retained as a distinct taxon; it has more chambers per whorl than *G. concavata*, is more weakly double-keeled, and has a wider umbilicus.

Globotruncana linneiana (d'Orbigny, 1839)

Plate A4, figs. 7-11

Globotruncata linneiana (d'Orbigny, 1839): *Rosalina linneiana* d'Orbigny, 1839, p. 101, fide Ellis & Messina, 1940 et seq.

Small forms with flat parallel dorsal and ventral surfaces, broad marginal band bounded by distinct keels, prominently curved ventral sutures, and usually six chambers in the whorl are referred to *G. linneiana.* Occasional specimens have a more convex dorsal surface.

Globotruncana morozovae Vasilenko, 1961

Plate A4, figs. 12-16

Globotruncana morozovae Vasilenko, 1961, p. 161, pl. 36, figs. 2, 3a-d, 4a-d.

Specimens referred here to *Globotruncana morozovae* agree well with the original description and figures, but show some variation in the convexity of the dorsal surface; not all specimens are as convex as the holotype. *G. churchi* Martin is similar in dorsal and side views, but *G. morozovae* has narrower more elongate dorsal chambers. Douglas (1969) recorded *G. morozovae* from the Late Cretaceous of California; one specimen illustrated is distinctly pustulose on the early chambers of the last whorl, a feature not observed on any of the *Valdivia* specimens. Takayanagi (1965) also recorded from the Late Cretaceous of California one specimen of *G. morozovae* which the *Valdivia* specimens closely resemble.

Globotruncana putahensis Takayanagi, 1965

Plate A5, figs. 1-3

Globotruncana putahensis Takayanagi, 1965, p. 221, pl. 27, figs. 2a-c.

Rare specimens in the *Valdivia* material agree very closely with the description and illustrations of the holotype of *G. putahensis*; they have slightly convex dorsal and markedly convex ventral surfaces, a double keel becoming weakly developed on the later chambers, and a pustulose ventral surface. Other specimens (Pl. A5, figs. 4-7) may be compared with *G. putahensis*, but are more evenly biconvex and lack the pustulose test surface.

Douglas (1969) placed *G. putahensis* in the synonymy of *G. stuartiformis* Dalbiez, stating that the holotype of *G. putahensis* has a wide imperforate margin but is single-keeled throughout. Two of the specimens figured by Douglas as *G. stuartiformis* have a wide imperforate margin, and ventral chambers ornamented by a transverse series of pustules, giving the appearance of a keel; the third specimen (figured by Douglas & Sliter, 1966, as *G. rosetta*) has a pustulose margin. The holotype of *G. stuartiformis* has an acute margin with a well-developed single keel, and so do the specimens figured by Olsson (1964), El-Naggar (1966), and Barr (1972). In my opinion the specimens figured by Douglas (1969) as *G. stuartiformis* should not be referred to this species.

As noted by Takayanagi (1965), *G. putahensis* resembles *G. rosetta* in having closely spaced keels that have fused into a single keel on the later chambers. Olsson (1964), who discussed the development of keels in *G. rosetta*, observed specimens whose later chambers have become single-keeled, and also specimens on which the two keels continue through all chambers but become progressively more closely spaced.

Takayanagi (1965) referred to the possibility that a specimen figured by Edgell (1957) as *G. elevata elevata* (Brotzen) is referable to *G. putahensis*. I have examined this specimen; it is weakly double-keeled on the early chambers of the last whorl, but its later chambers have a single keel. In my opinion it is not referable to *G. putahensis*: the sutures on its ventral side are raised; its ventral surface is smooth; and its dorsal chambers are not as narrow and elongate as those of *G. putahensis*. The specimen figured by Edgell seems to be closer to the *G. rosetta* group; *G. putahensis*, which is retained here as a distinct taxon, also is considered to be referable to the *G. rosetta* group, and could well be regarded as a subspecies of *G. rosetta*.

Globotruncana tricarinata (Quereau, 1893)
Plate A5, figs. 8-12

Globotruncana tricarinata (Quereau, 1893): *Pulvinulina tricarinata* Quereau, 1893, p. 89, pl. 5, fig. 3a.

In an attempt to clarify the taxonomic status of *G. tricarinata*, Pessagno (1967) designated one of Quereau's specimens as lectotype, and regarded *G. tricarinata* as a synonym of *G. linneiana*; however, the name *G. tricarinata* continues to be used. Pessagno regarded most specimens assigned to *G. tricarinata* as either referable to *G. linneiana*, or transitional between *G. linneiana* and *G. ventricosa*; it is in the latter sense that the name is used here, for rare *Valdivia* specimens with broadly spaced peripheral keels and a raised thickened umbilical margin forming a 'third keel'.

Globotruncana ventricosa White, 1928
Plate A5, figs. 13-17

Globotruncana ventricosa White, 1928: *Globotruncana canaliculata* var. *ventricosa* White, 1928, p. 284, pl. 38, figs. 5a-c.

Specimens from the *Valdivia* material characterised by an almost flat dorsal surface, convex ventral surface, distinct double keel, raised curved dorsal sutures, and slightly curved depressed ventral sutures are referred to *G. ventricosa*.

Globotruncana vescicarinata sp. nov.
Plate A2, figs. 4-13

A full description of this taxon is given after the check list.

Globotruncana sp.
Plate A6, figs. 1-3

Rare small double-keeled specimens in core KL1 have not been referred to any described species. These specimens have a flat or slightly convex ventral surface and a markedly convex dorsal surface; generally six chambers in the last whorl; and spinose keels and dorsal sutures. These may be referable to the *G. arca* group, but also resemble some published figures of specimens referred to *G. fornicata*.

Genus **HEDBERGELLA** Brönnimann & Brown, 1958

Hedbergella holmdelensis Olsson, 1964
Plate A6, figs. 4-9

Hedbergella holmdelensis Olsson, 1964, p. 160, pl. 1, figs. 1a-c, 2a-c.

Specimens referred to *H. holmdelensis* usually have five chambers in the last whorl, but occasional specimens (Pl. A6, figs. 7-9) have four to four-and-a-half chambers, with a large smooth final chamber and distinct lip over the umbilicus. In other respects the *Valdivia* specimens agree well with the description and figures of *H. holmdelensis*; they have a compressed low trochospiral test and finely perforate wall. The specimen of *H. holmdelensis* figured by Quilty (1978) is much more coarsely hispid than specimens from the *Valdivia* material.

Hedbergella monmouthensis (Olsson, 1960)
Plate A6, figs. 10-15

Hedbergella monmouthensis (Olsson, 1960): *Globorotalia monmouthensis* Olsson, 1960, p. 47, pl. 9, figs. 22-24.

Rare specimens from the *Valdivia* material are referred to *H. monmouthensis*. The specimens are small, low, and trochospiral; the last whorl has five chambers, which increase rapidly in size, and the test surface is finely hispid. Sliter (1976) figured specimens from the southwestern Atlantic Ocean which are similar to the *Valdivia* specimens.

Genus **HETEROHELIX** Ehrenberg, 1843

Heterohelix striata (Ehrenberg, 1840)
Plate A6, figs. 16-17

Heterohelix striata (Ehrenberg, 1840): *Textularia striata* Ehrenberg 1840, p. 135, pl. 4, figs. 1*a*, 1*a*', 2*a*, 3*a*, 9*a*.

H. striata occurs rarely among the heterohelicid specimens in the *Valdivia* material. The tests have a lobate margin on the later chambers, and have a distinctly striate ornament either extending over the entire test or with the last one or two chambers smooth. The specimen of *H. striata* s.s. figured by Quilty (1978) closely resembles those from the *Valdivia* material.

Heterohelix sp.
Plate A6, figs. 18-22

Specimens placed here are difficult to refer definitely to any described species. Sliter (1976) figured as *H. pulchra* specimens which have faint to distinct discontinuous striae; the *Valdivia* specimens are similar to these, but are not as lobate. *H. pulchra* as originally figured is smooth, and so are the specimens figured by Govindan (1972). Sliter (1968) figured finely striate to smooth specimens as *H. pulchra*, and so did Douglas (1969). Govindan (1972) noted that many specimens which he referred to *H. globulosa* (Ehrenberg) had faint longitudinal striations or longitudinal alignment of pores. Quilty (1978) figured as *H. striata* form β specimens which have a similar ornament to the *Valdivia* specimens, but have a much more rapidly expanding test.

Genus **SCHACKOINA** Thalmann, 1932

Schackoina sp.
Plate A6, figs. 23-26

Very rare specimens of this genus in the *Valdivia* material cannot be referred definitely to any described species. Some specimens (Pl. A6, figs. 25-26) resemble *S. cenomana cenomana* (Schacko) in having four chambers in the last whorl and a single tubulospine on each chamber, but the chambers are not as compressed as in *S. cenomana cenomana*. Larger specimens have a broad last chamber with two tubulospines, one on each side of the median plane. These differ from *S. cushmani* Barr in lacking the third tubulospine in the median plane. *S. cenomana bicornis* Reichel has a more compressed and elongate final chamber extending into irregularly developed tubulospines. The *Valdivia* specimens differ from *S. multispinata* Lalicker in lacking multiple irregularly developed tubulospines.

DESCRIPTION OF NEW SPECIES

Genus **GLOBOTRUNCANA** Cushman, 1927

Globotruncana vescicarinata sp. nov.

(Pl. A2, figs. 4-13)

Material examined: 64 specimens.
Derivation of name: From the Latin *vescus,* weak thin; and *carinatus*, keeled, referring to the nature of the keels.

Diagnosis: A species of *Globotruncana* that is characterised by two closely spaced keels on early chambers coalescing into one keel on the later chambers; seven to eight chambers in the last whorl; narrow elongate dorsal chambers; and a pustulose ventral surface.

Description: Test trochoid; dorsal surface slightly to distinctly convex; ventral surface markedly convex. Chambers arranged in about three whorls, increasing slowly in size as added; seven to eight chambers in last whorl. Equatorial periphery circular, slightly to distinctly lobate, with two closely spaced beaded keels on early chambers of last whorl, coalescing into single keel over last two or three chambers. Sutures on dorsal side raised, beaded, curved, prominently reflexed; chambers narrow, elongate. Sutures on ventral side obscure on early chambers of last whorl, later slightly curved, depressed. Dorsal surface smooth except for raised sutures; ventral surface markedly and coarsely hispid except for last chamber in some specimens. Umbilicus wide, open, deep; tegillae well developed. Aperture interiomarginal, umbilical; a high-arched opening.

Dimensions:	*Max. diameter (mm)*	*Min. diameter (mm)*	*Height (mm)*
Holotype	0.76	0.66	0.50
Paratype A	0.66	0.56	0.46
Paratype B	0.65	0.58	0.46
Paratype C	0.75	0.66	0.46

Occurrence: Holotype (CPC 19084) and paratypes A to C (CPC 19085 to 19087) from a depth of 100 cm in core KL1 taken at latitude 13.2084°S, longitude 120.0660°E, Scott Plateau, in a water depth of 2000 m. Unfigured paratypes are deposited in the Commonwealth Palaeontological Collection under number CPC 19088; additional unfigured paratypes are deposited in the ESCAP Fossil Reference Collection held at the Bureau of Mineral Resources under number E 747.

Remarks: G. vescicarinata sp. nov. is similar to *G. concavata cyrenaica* Barr in having two keels on the early chambers on the last whorl and a single keel on the last two to three chambers, and in the coarsely hispid ventral surface. However, its double keel is less prominent than that of *G. concavata cyrenaica*; it has more chambers in the last whorl; it has narrower more elongate dorsal chambers; and it has a slightly to distinctly convex dorsal surface. Because of the last feature *G. vescicarinata* is thought not to be related to the *concavata* group; its relationships to other described species are not known.

AGE SIGNIFICANCE OF THE FAUNA

Globotruncana arca

Published records indicate that this species occurs in the Campanian and Maastrichtian in various areas of the world. Takayanagi (1965) reviewed records of its occurrence to that time, and noted that the lower limit of its range was not settled.

Globotruncana churchi

Martin (1964) described this species from Santonian and Campanian beds in Fresno County, California. Douglas & Sliter (1966) also recorded *G. churchi* from Santonian to Campanian at several Californian localities, but Douglas (1969) observed it only from middle to late Campanian beds of northern California.

Globotruncana coronata

The concept of the taxon to which this name is given has been discussed in the previous section. Herb (1974) recorded *G. coronata* from the Coniacian and Santonian of the Naturaliste Plateau. Herm (1962) recorded similar specimens from the early and basal late Campanian. Douglas (1969) noted that *G. coronata* is generally considered an index of the late Turonian to Santonian, but noted the possibility of it extending into the Campanian. Barr (1972) recorded the species from the latest Turonian to Santonian of Libya. Takayanagi (1965) also noted that most records are restricted to the Turonian-Santonian, but recorded occurrences in the middle Campanian of Europe and North Africa and the Campanian of California.

Globotruncana fornicata fornicata

The subspecies is recorded mainly within the interval Santonian-Maastrichtian in a world-wide distribution. Takayanagi (1965) recorded this species from the late Turonian to late Coniacian of California, and also listed several other Turonian to Coniacian occurrences; he concluded that the range is (?late) Turonian to Maastrichtian, but that it was not common before the Santonian. Douglas & Sliter (1966) stated that the record from the Turonian by Takayanagi was based on a misidentification.

Globotruncana fornicata manaurensis

This subspecies was originally described from the Coniacian of northeastern Colombia. Barr (1972) assessed the range in Libya as Santonian to mid-Campanian. Salaj (1969) gave a similar range in Tunisia.

Globotruncana fresnoensis

This species was originally described from the Santonian-Campanian of Fresno County, California. Takayanagi (1965) recorded specimens referred to *G. coronata* from the late Turonian to early Santonian of California; the figured specimen is very similar to *G. fresnoensis.*

Globotruncana fundiconulosa

This species occurs in the Campanian and Maastrichtian of the northern Caucasus and Turkmenia. The subspecies *G. wiedenmayeri wiedenmayeri* Gandolfi and *G. wiednmayeri magdalenaensis* Gandolfi, placed by Berggren (1962) in the synonymy of *G. fundiconulosa,* also occur in the Campanian. Pessagno (1967) placed *G. fundiconulosa* in the synonymy of *G. concavata*, generally regarded as a Coniacian-Santonian index species; this synonymy, if accepted, would extend the range of *G. concavata* into the Maastrichtian.

Globotruncana linneiana

Published records show that this species has a worldwide distribution in the Campanian and Maastrichtian.

Globotruncana morozovae

This species occurs in the Campanian and Maastrichtian of the USSR. Douglas (1969) recorded it in the lower Campanian and possibly upper Santonian beds of California. Takayanagi (1965) recorded one specimen from the Funks Formation, which he showed as ranging from early Coniacian to early Santonian.

Globotruncana putahensis

This species has been described from the Forbes Formation (Campanian) of California.

Globotruncana tricarinata

As interpreted here, this species occurs in Campanian and Maastrichtian beds over a wide geographic range.

Globotruncana ventricosa

A species with both a wide geographic distribution and long stratigraphic range, *G. ventricosa* is recorded from at least late Turonian to Maastrichtian, but more commonly from Santonian to Maastrichtian.

Globigerinelloides asperus asperus

Recorded throughout the Senonian, this subspecies also extends into the Maastrichtian in some areas (e.g., Barr, 1972). Barr also recorded *G. ehrenbergi* occurring in the late Coniacian; the possible synonymy of *G. ehrenbergi* with *G. asperus asperus* does not affect stratigraphic conclusions.

Globigerinelloides messinae messinae

Brönnimann (1952) originally recorded this subspecies from the Turonian to Senonian and the Maastrichtian of Trinidad. Several publications have since referred to its occurrence at different levels within the interval late Santonian to Maastrichtian.

Hedbergella holmdelensis

Olsson (1964) originally described this species from the early Maastrichtian of New Jersey. Other records are from the late Campanian and early Maastrichtian of California (Sliter, 1968); from the Campanian and Maastrichtian of California (Douglas, 1969); from the early Maastrichtian of Libya (Barr, 1972); from the Campanian of Wyoming (Frerichs, Atherton, & Shive, 1975); and rarely from the Campanian and Maastrichtian of DSDP Site 327A (Sliter, 1976).

Hedbergella monmouthensis

Olsson (1960) originally described this species from the Maastrichtian of New Jersey. It has since been recorded from the Campanian to Maastrichtian of California (Sliter, 1968), Campanian of northern California (Douglas, 1969), and Campanian to Maastrichtian of DSDP Site 327A (Sliter, 1976), but is more abundant in the Maastrichtian.

Heterohelix striata

This is a wide ranging species occurring through the Campanian and Maastrichtian.

Indicated age of the Valdivia *core*

The foregoing recorded stratigraphic ranges indicate a Campanian age, probably early to middle Campanian, for the *Valdivia* core.

GENERAL COMMENTS

The Campanian fauna from the Scott Plateau adds to our knowledge of the Late Cretaceous planktic fauna of the Western Australian and Northwest Shelf areas, where previous investigations have been those of Edgell (1957, 1962; describing faunas ranging from Cenomanian to Maastrichtian), Belford (1960; Santonian to early Campanian), Wright & Apthorpe (1976; Maastrichtian), and Quilty (1978; Santonian). The *Valdivia* fauna is the most diverse and well-preserved Campanian fauna yet recorded.

The well-preserved *Valdivia* fauna contrasts with that found in Upper Cretaceous sediments at the nearby DSDP Site 261 (Argo Abyssal Plain), which contained only benthic agglutinated foraminifera (Krasheninnikov, 1974; Bolli, 1974). This faunal difference reflects the depth difference between the two sites: 2000 m for the *Valdivia* core, and 5667 m (corrected) for Site 261; sediments at Site 261 are zeolite clays thought to have been deposited below the lysocline. Core 6 at DSDP Site 260, on the Gascoyne Abyssal Plain, contains reworked planktic foraminifera of different ages (Krasheninnikov, 1974). Veevers & Johnstone (1974) concluded that Santonian and younger carbonate sediments at Site 212, in the Wharton Basin, represent displaced sediments originally deposited above the carbonate compensation depth; the same explanation could well apply to the planktic fauna from Site 260. Veevers & Johnstone took the 4 km isobath as a rough boundary between oceanic and continental crust; both Sites 260 and 261 are about 150 km oceanward of this boundary. The *Valdivia* core was taken on the continental margin.

Stagg & Exon (this Bulletin) interpreted seismic profiles across the Scott Plateau as showing sediment overlying an eroded and faulted lower Palaeozoic and Precambrian basement. The sampling reported by Hinz & others (1978), and the geophysical studies reported by Stagg & Exon suggest that basement on the outer margin of the plateau is overlain by lower Mesozoic volcanics related to rifting before break-up (see Veevers & Johnstone, 1974). These volcanics are overlain by Upper Jurassic and Lower Cretaceous shallow-marine detrital sediments, which are in turn overlain by the Upper Cretaceous carbonates discussed here. Seismic interpretation suggests that these carbonates cover most of the plateau to a thickness of 150 m or more, and that hundreds of metres of younger carbonates commonly overlie them. They crop out at numerous places, and outcrops must have existed along the steep outer margin of the plateau ever since they were deposited, so source sediments would have been readily available for the reworked carbonates found in deeper water.

Sediments containing Late Cretaceous and younger foraminifera from mid-Pacific seamounts (Hamilton, 1954)—the peaks of a basaltic submarine range whose tops lie in water depths between 1300 and 2100 m—are probably similar to those laid down on the Scott Plateau.

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PLATE A1

Fig.	
1-4	*Globigerinelloides asperus asperus* (Ehrenberg) 1-2, CPC 19075: 1, side view; 2, edge view; both ×120. 3-4, CPC 19076: 3, side view; 4, edge view; both ×120.
5-10	*Globigerinelloides messinae messinae* (Brönnimann). 5-6, CPC 19077: 5, side view; 6, edge view; both ×120. 7-8, CPC 19078: 7, side view; 8, edge view; both ×120. 9-10, CPC 19079: 9, side view; 10, edge view; both ×120.
11-15	*Globotruncana arca* (Cushman) 11-13, CPC 19080: 11, ventral view; 12, dorsal view; 13, edge view; all ×80. 14-15, CPC 19081: 14, ventral view; 15, edge view; both ×80.
16-18	*Globotruncana churchi* Martin CPC 19082: 16, ventral view; 17, dorsal view; 18, edge view; all ×80.

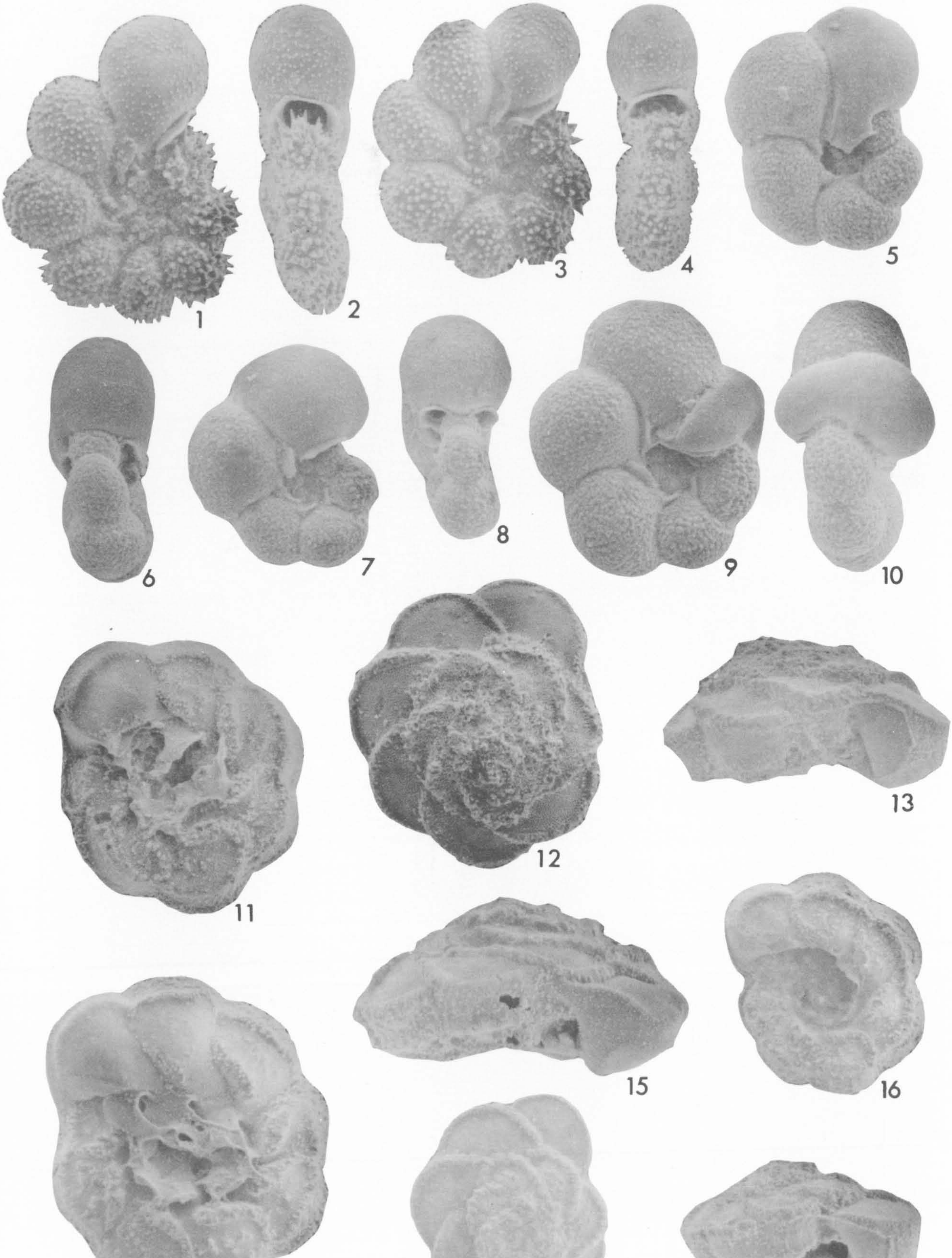
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PLATE A2

Fig.

1-3 *Globotruncana churchi* Martin

CPC 19083: 1, ventral view; 2, dorsal view; 3, edge view; all ×80.

4-13 *Globotruncana vescicarinata* sp. nov.

4-6, holotype, CPC 19084: 4, ventral view; 5, dorsal view; 6, edge view; all ×80.
7-9, paratype A, CPC 19085: 7, ventral view; 8, dorsal view; 9, edge view; all ×80.
10-11, paratype B, CPC 19086: 10, ventral view; 11, edge view; both ×80.
12-13, paratype C, CPC 19087: 12, ventral view; 13, edge view; both ×80.

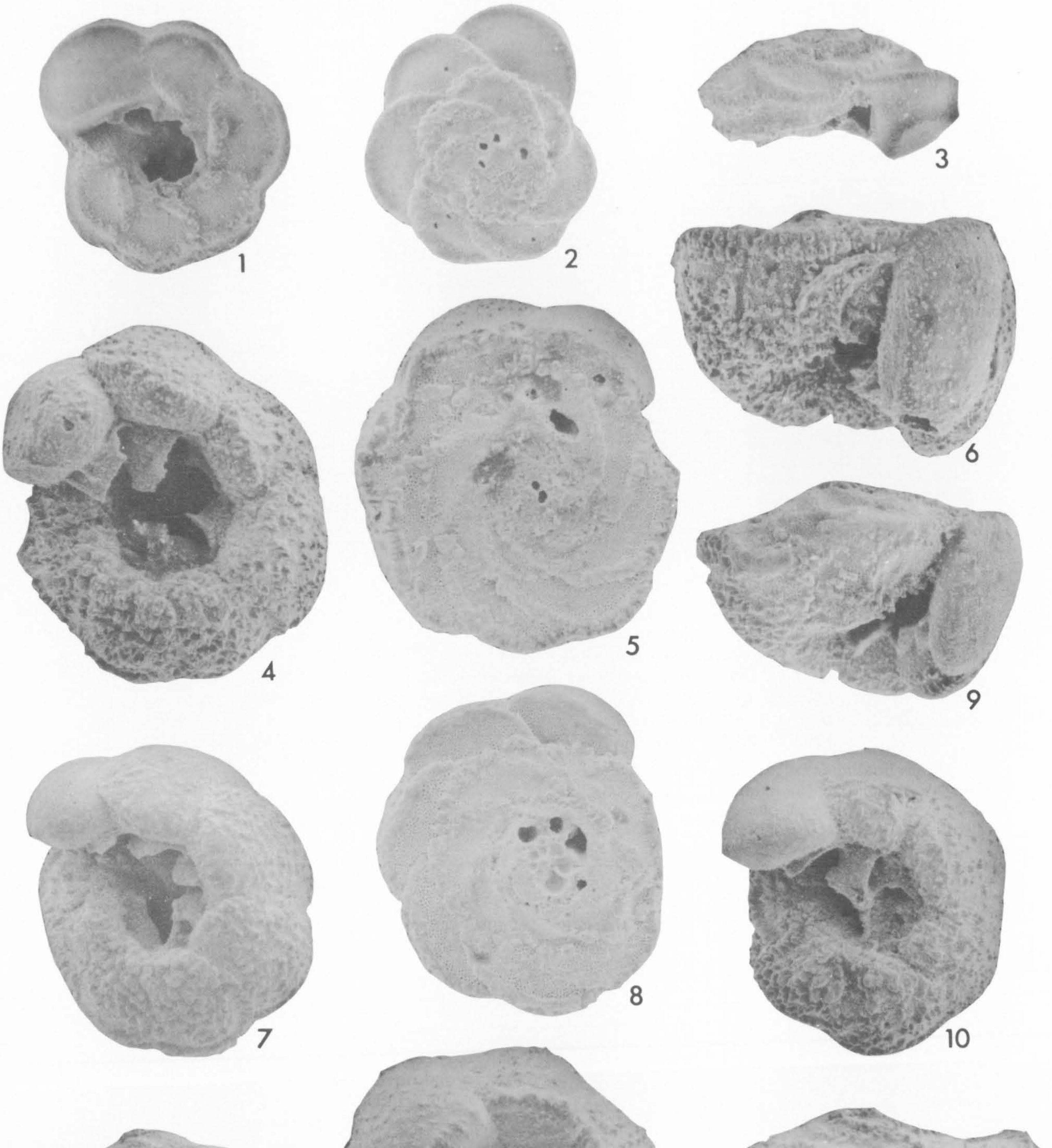
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PLATE A3

Fig.

1-6 *Globotruncana coronata* Bolli

1-3; CPC 19089: 1, ventral view; 2, dorsal view; 3, edge view; all ×80.
4-6, CPC 19090: 4, ventral view; 5, dorsal view; 6, edge view; all ×80.

7-12 *Globotruncana fornicata fornicata* Plummer

7-9, CPC 19091: 7, ventral view; 8, dorsal view; 9, edge view; all ×80.
10-12, CPC 19092: 10, ventral view; 11, dorsal view; 12, edge view; all ×80.

13-17 *Globotruncana fornicata* Plummer *manaurensis* Gandolfi

13-15, CPC 19093: 13, ventral view; 14, dorsal view; 15, edge view; all ×80.
16-17, CPC 19094: 16, ventral view; 17, edge view; both ×80.

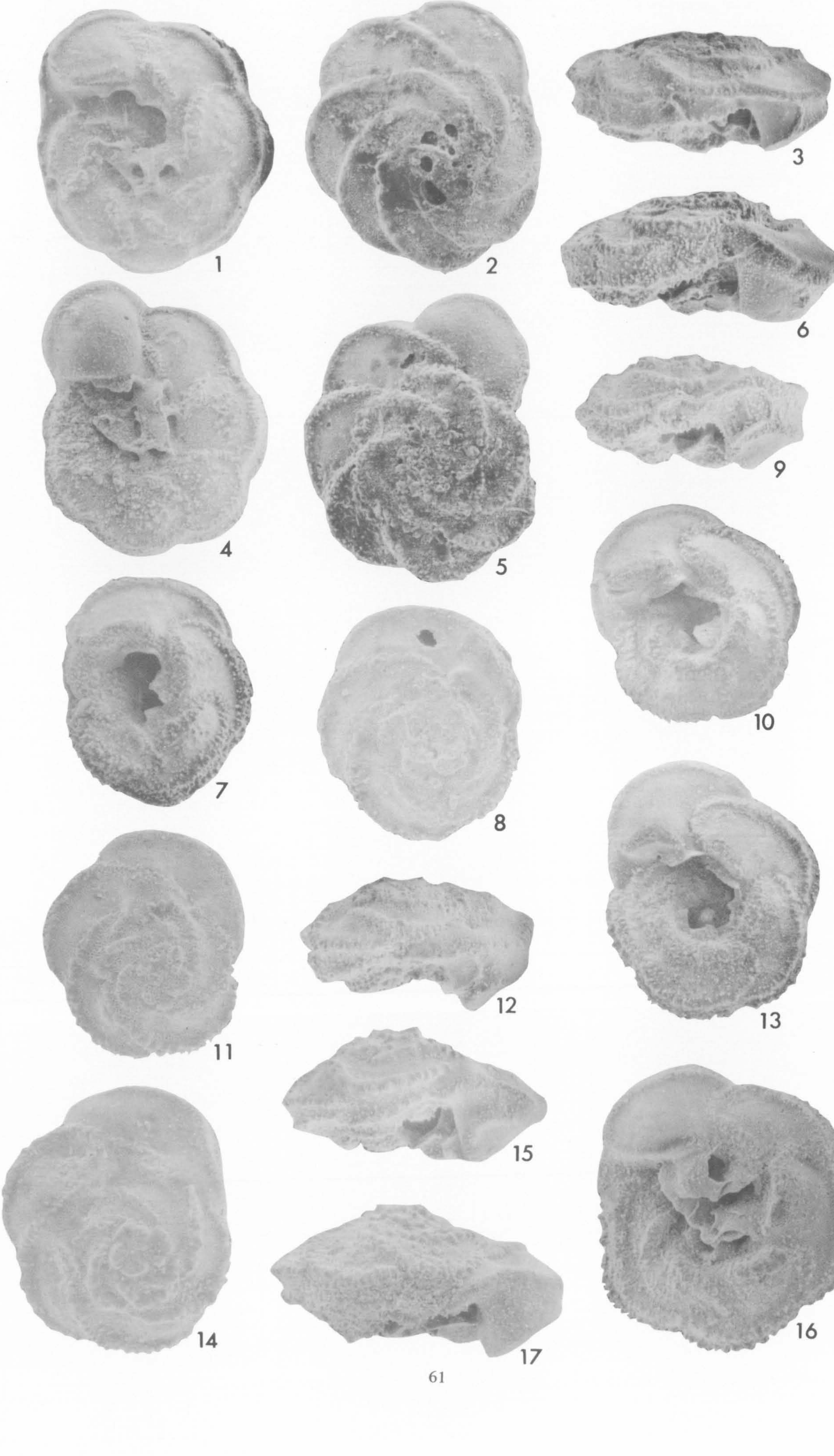
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PLATE A4

Fig.	
1-3	*Globotruncana fresnoensis* Martin CPC 19095: 1, ventral view; 2, dorsal view; 3, edge view; all ×80.
4-6	*Globotruncana fundiconulosa* Subbotina CPC 19096: 4, ventral view; 5, dorsal view; 6, edge view; all ×80.
7-11	*Globotruncana linneiana* (d'Orbigny) 7-9, CPC 19097: 7, ventral view; 8, dorsal view; 9, edge view; all ×80. 10-11, CPC 19098: 10, ventral view; 11, edge view; both ×80.
12-16	*Globotruncana morozovae* Vasilenko 12-14, CPC 19099: 12, ventral view; 13, dorsal view; 14, edge view; all ×80. 15-16, CPC 19100: 15, ventral view; 16, edge view; both ×80.

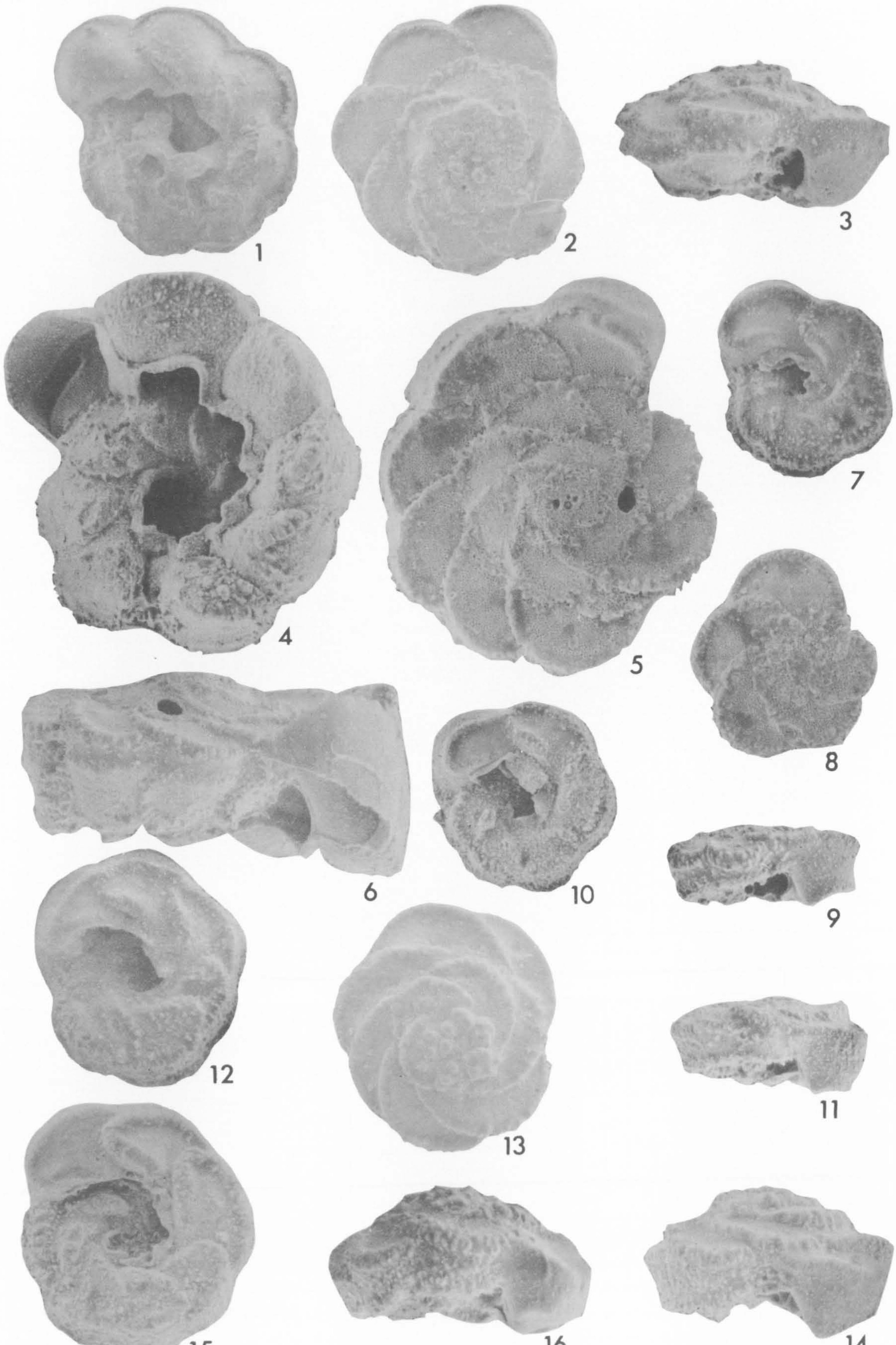
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PLATE A5

Fig.

1-3 *Globotruncana putahensis* Takayanagi

CPC 19101: 1, ventral view; 2, dorsal view; 3, edge view; all x 80.

4-7 *Globotruncana* cf. *putahensis* Takayanagi

4-6, CPC 19102: 4, ventral view; 5, dorsal view; 6, edge view; all ×80.
7, CPC 19103: ventral view, ×80.

8-12 *Globotruncana tricarinata* (Quereau)

8-10, CPC 19104: 8, ventral view; 9, dorsal view; 10, edge view; all ×80.
11-12, CPC 19105: 11, ventral view; 12, edge view; both ×80.

13-17 *Globotruncana ventricosa* White

13-15, CPC 19106: 13, ventral view; 14, dorsal view; 15, edge view; all ×80.
16-17, CPC 19107: 16, ventral view; 17, edge view; both ×80.

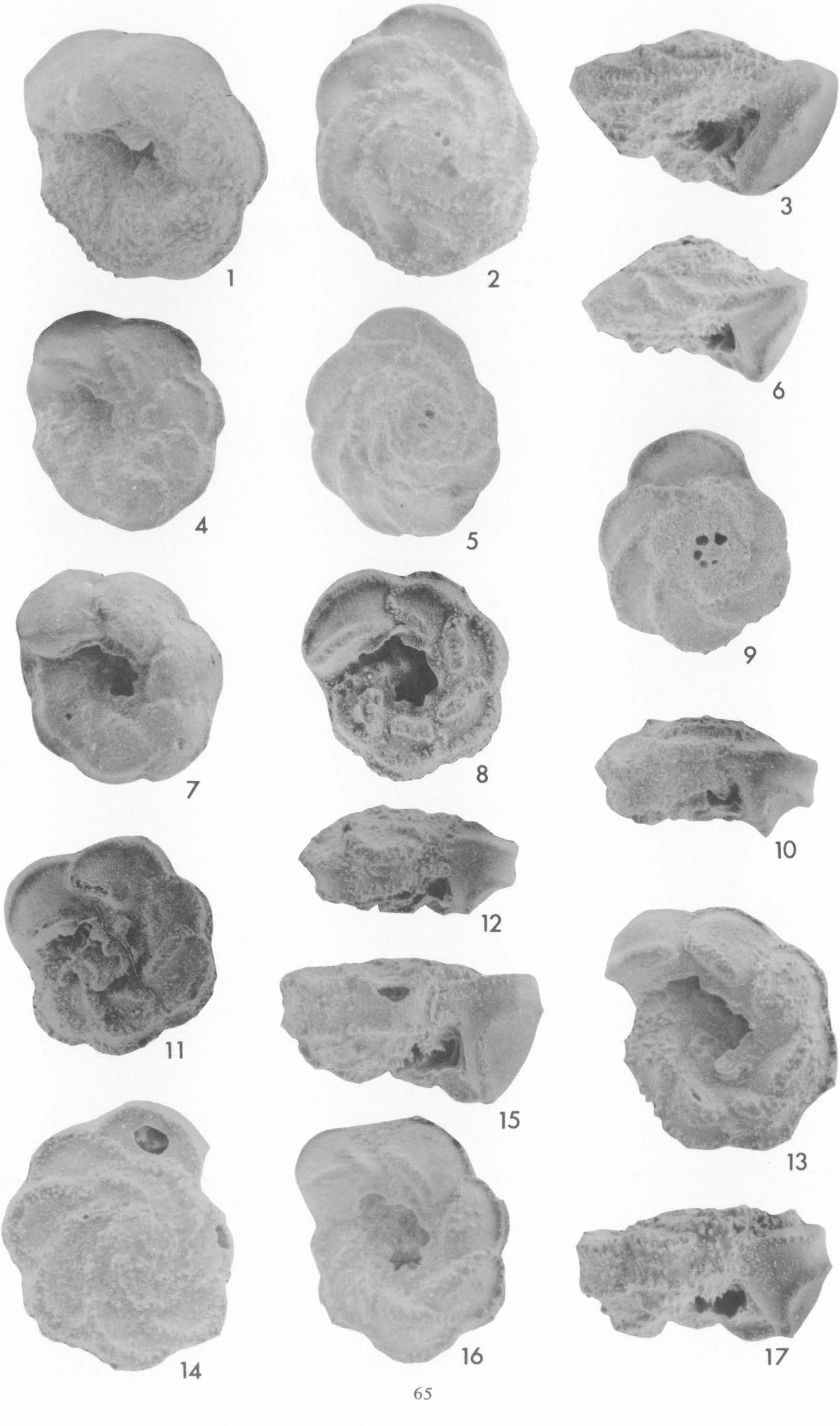
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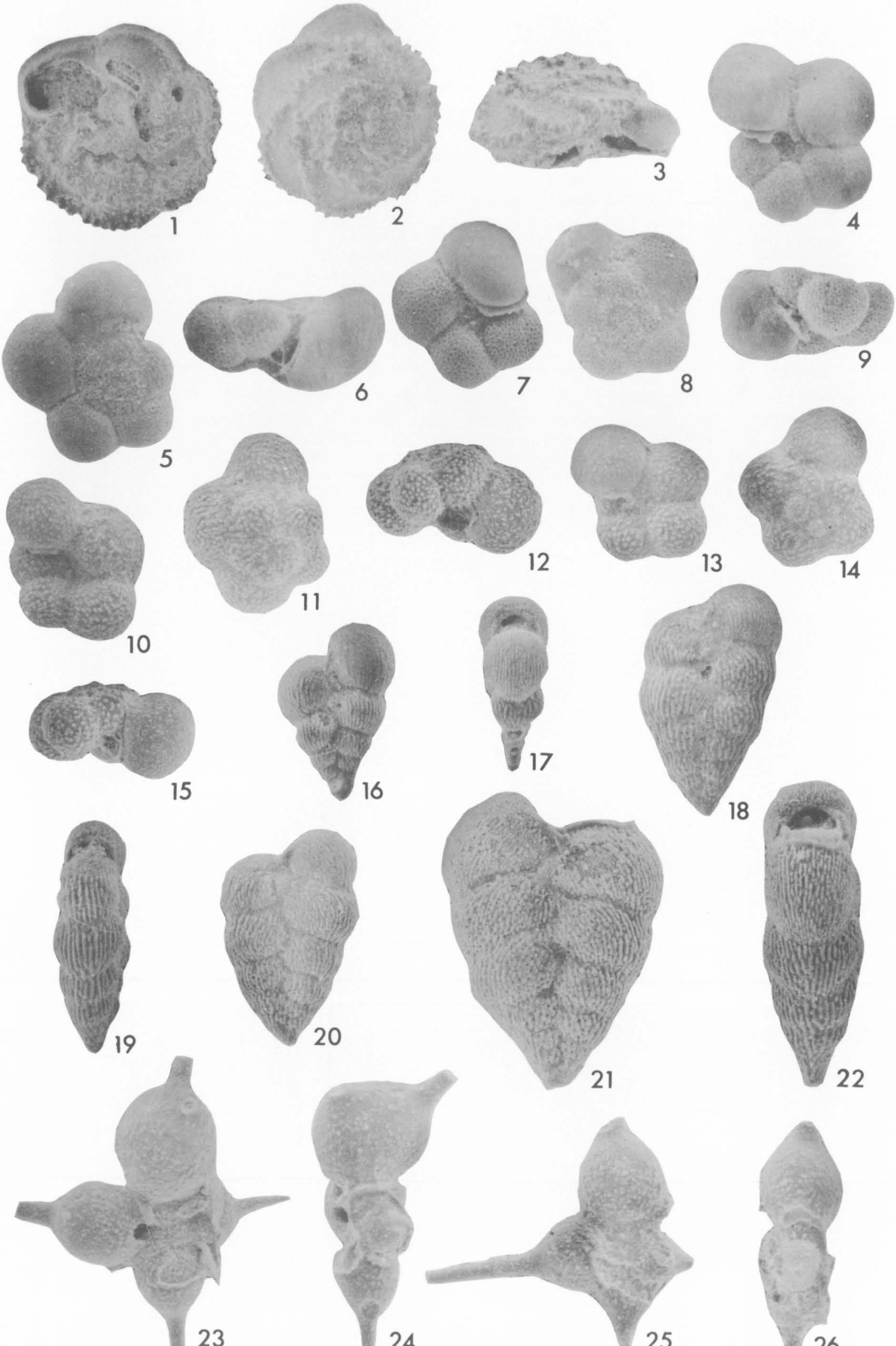
PLATE A6

Fig.	
1-3	*Globotruncana* sp. CPC 19108: 1 ventral view; 2, dorsal view; 3, edge view; all ×80.
4-9	*Hedbergella holmdelensis* Olsson 4-6, CPC 19109: 4, ventral view; 5, dorsal view; 6, edge view; all ×150. 7-9, CPC 19110: 7, ventral view; 8, dorsal view; 9, edge view; all ×150.
10-15	*Hedbergella monmouthensis* (Olsson) 10-12, CPC 19111: 10, ventral view; 11, dorsal view; 12, edge view; all ×150. 13-15, CPC 19112; 13, ventral view; 14, dorsal view; 15, edge view; all ×150.
16-17	*Heterohelix striata* (Ehrenberg) CPC 19113: 16, side view; 17, edge view; both ×150.
18-22	*Heterohelix* sp. 18-19, CPC 19114: 18, side view; 19, edge view; both ×150. 20, CPC 19115: side view, ×150. 21-22, CPC 19116: 21, side view; 22, edge view; both ×150.
23-26	*Schackoina* sp. 23-24, CPC 19117: 23, side view; 24, edge view; both ×100. 25-26, CPC 19118: 25, side view; 26, edge view; both ×100.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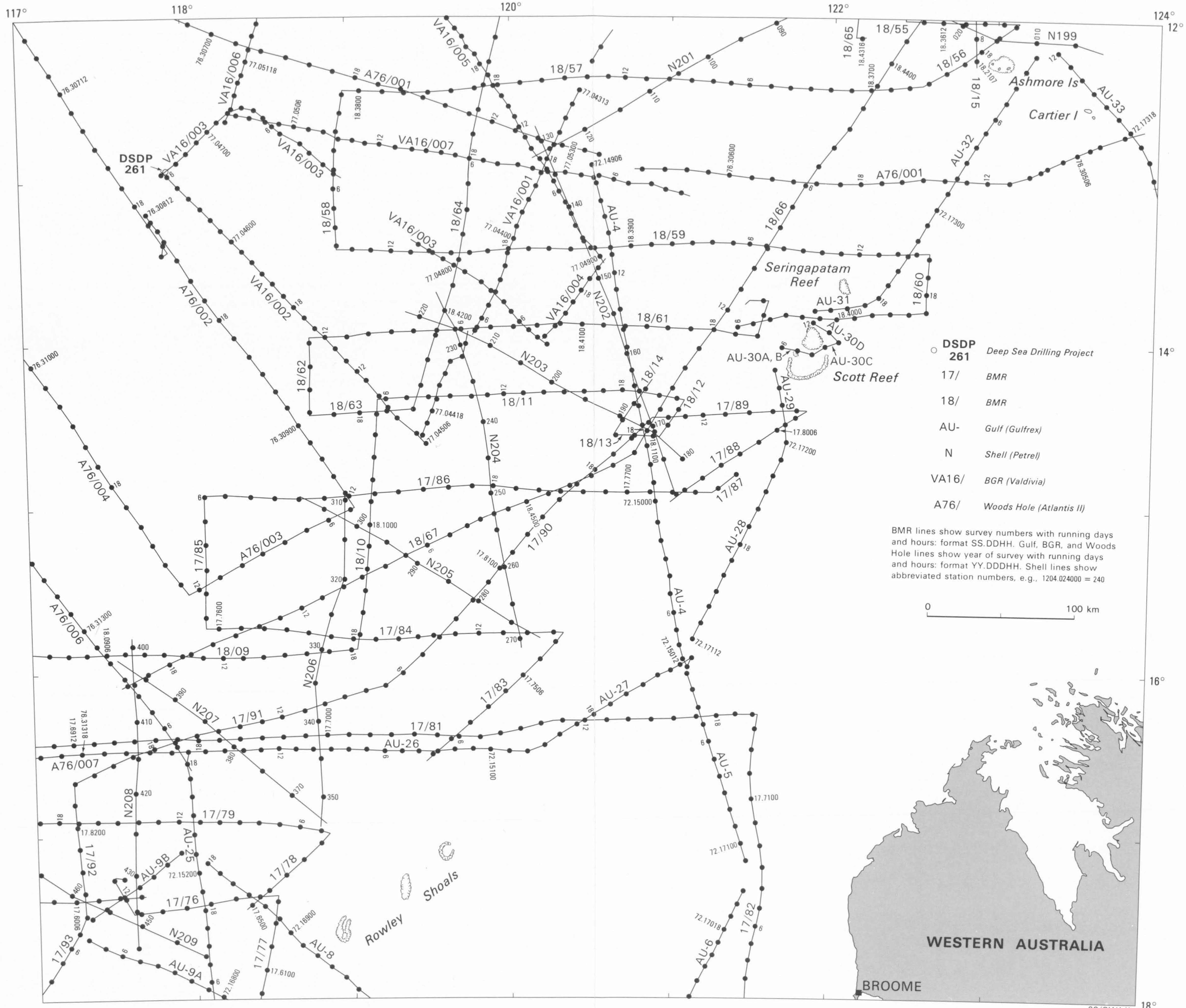
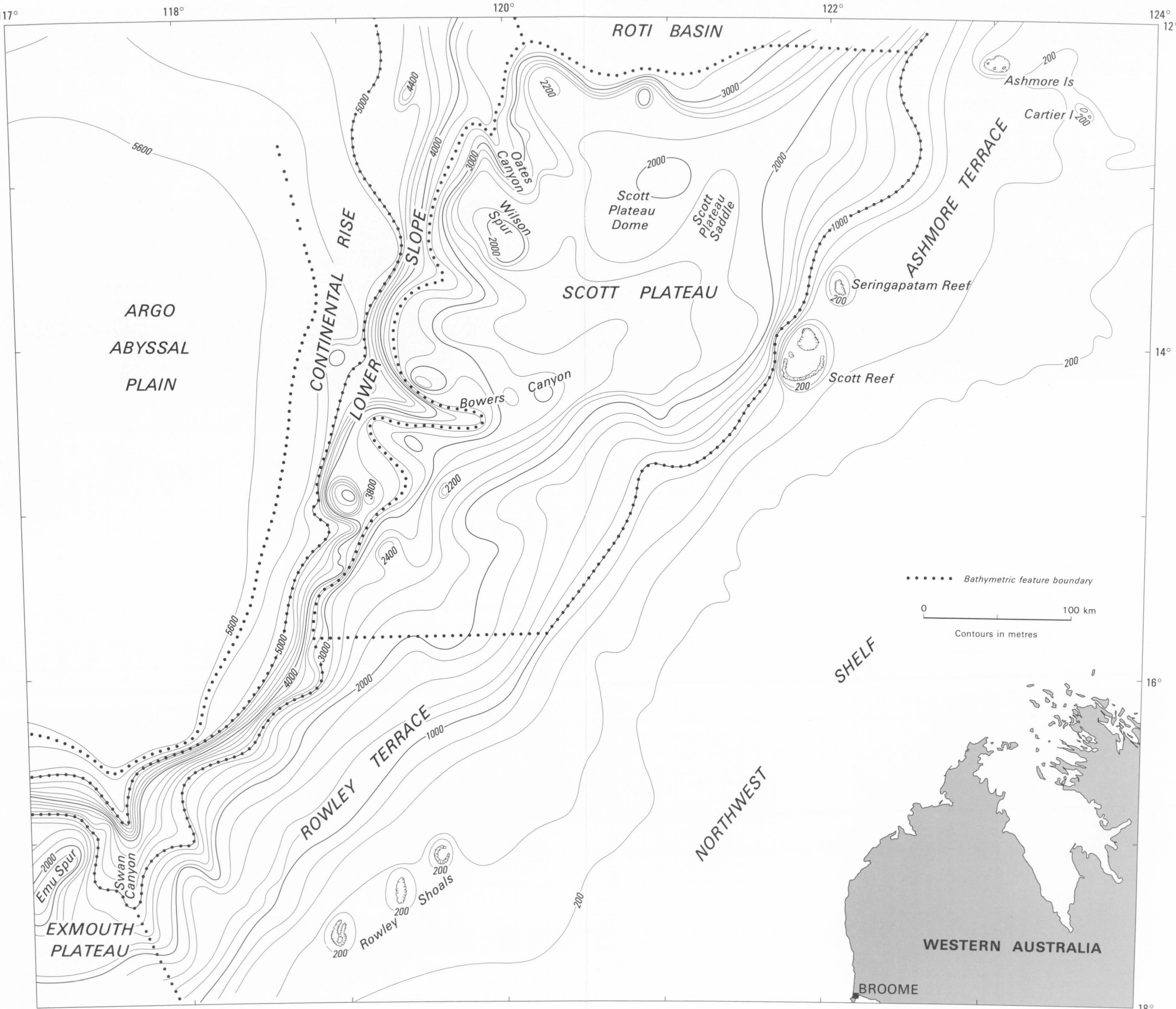


SHIPS' TRACKS

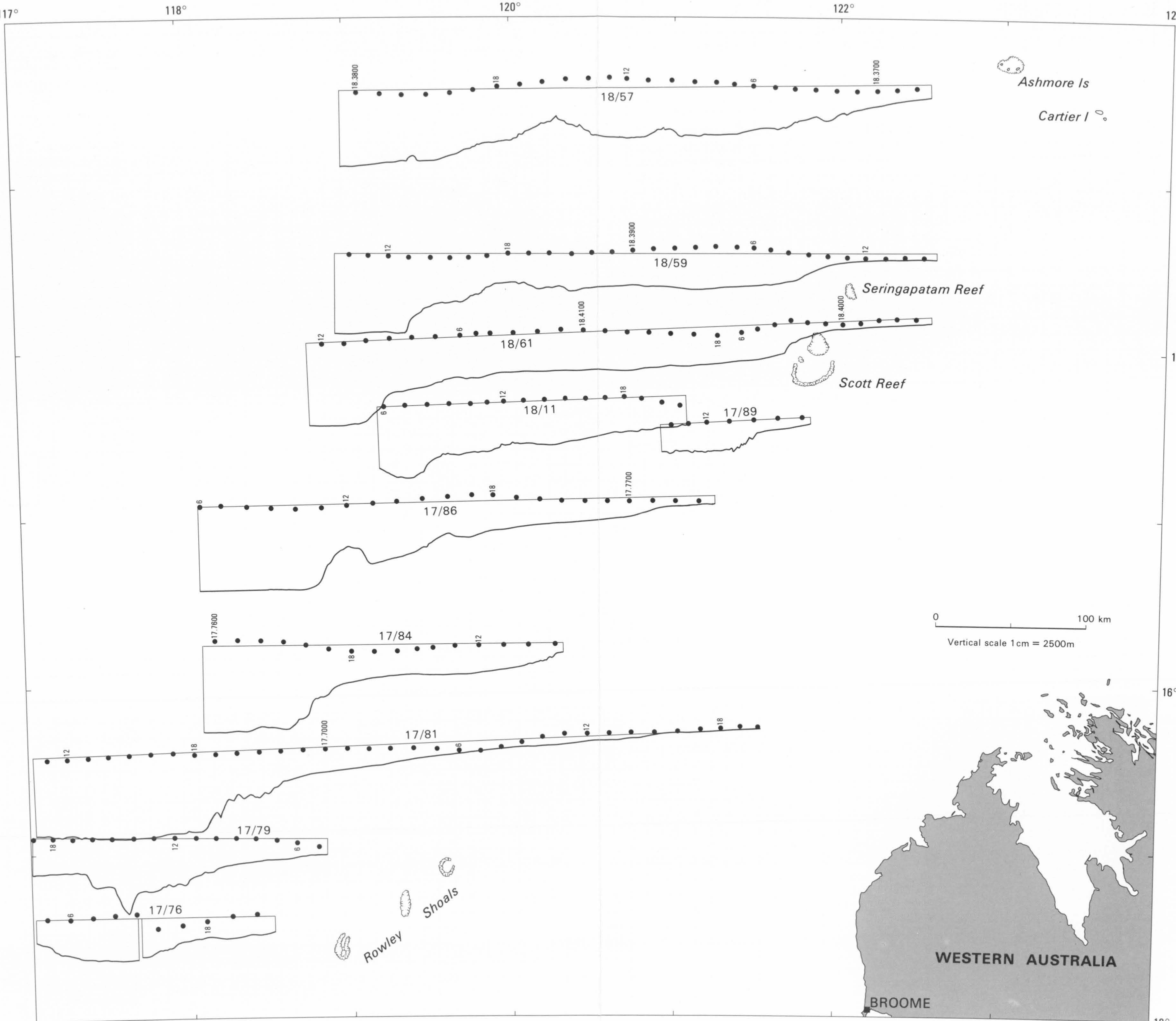
PLATE 2

CORE STATIONS, DREDGE STATIONS, AND KEY TO ILLUSTRATED SEISMIC PROFILES AND GRAVITY MODELS



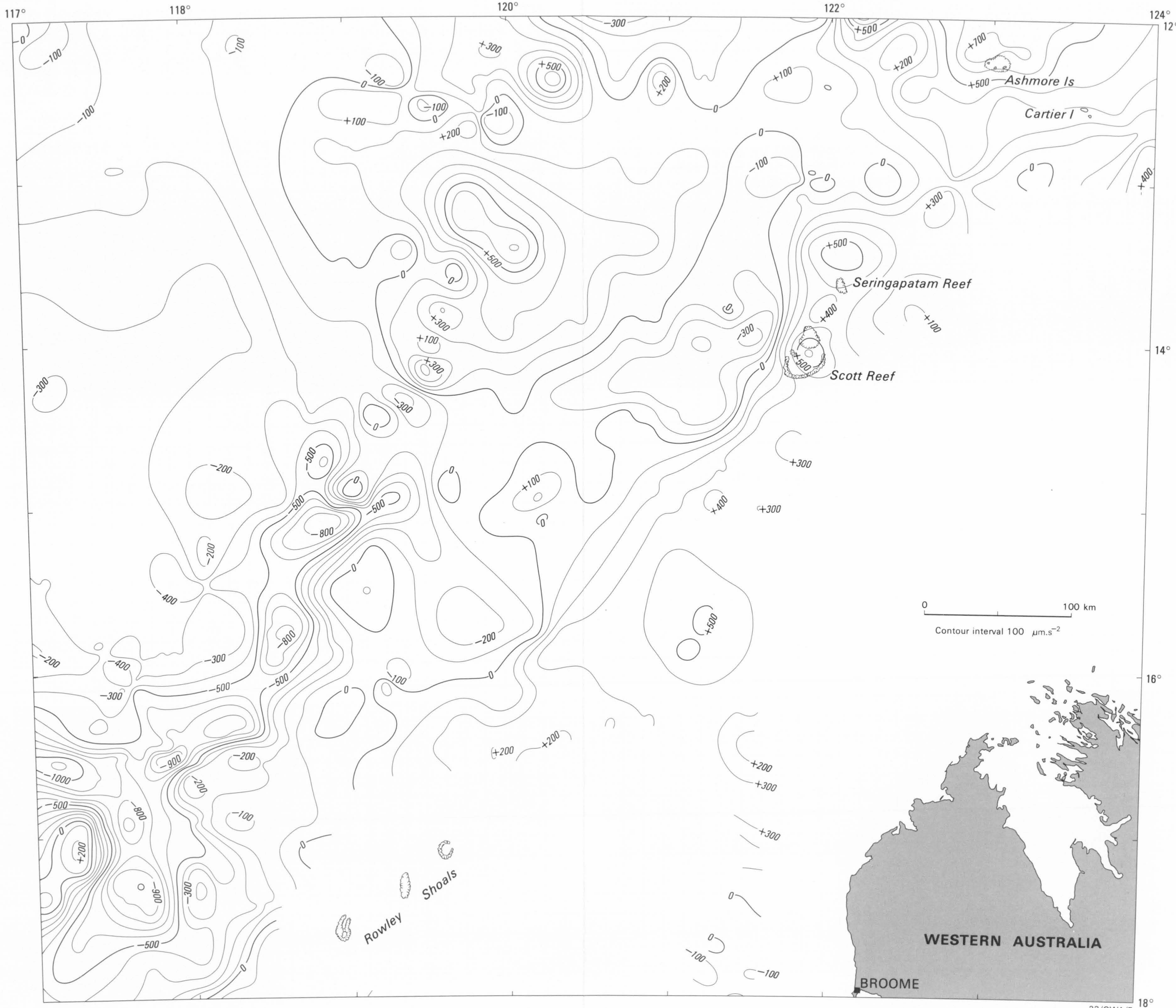
BATHYMETRIC FEATURES

23/OWA/3



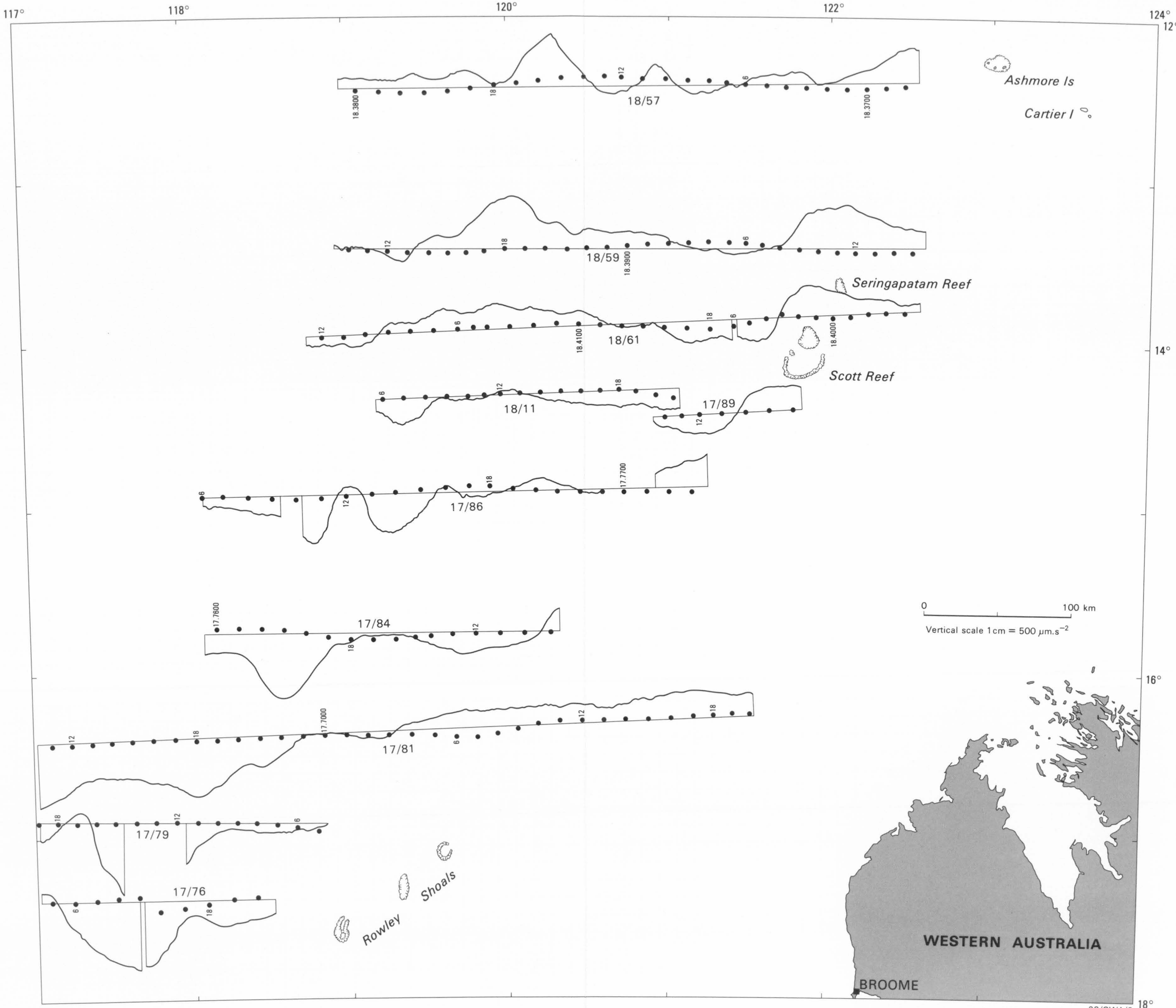
BATHYMETRIC PROFILES

23/OWA/4

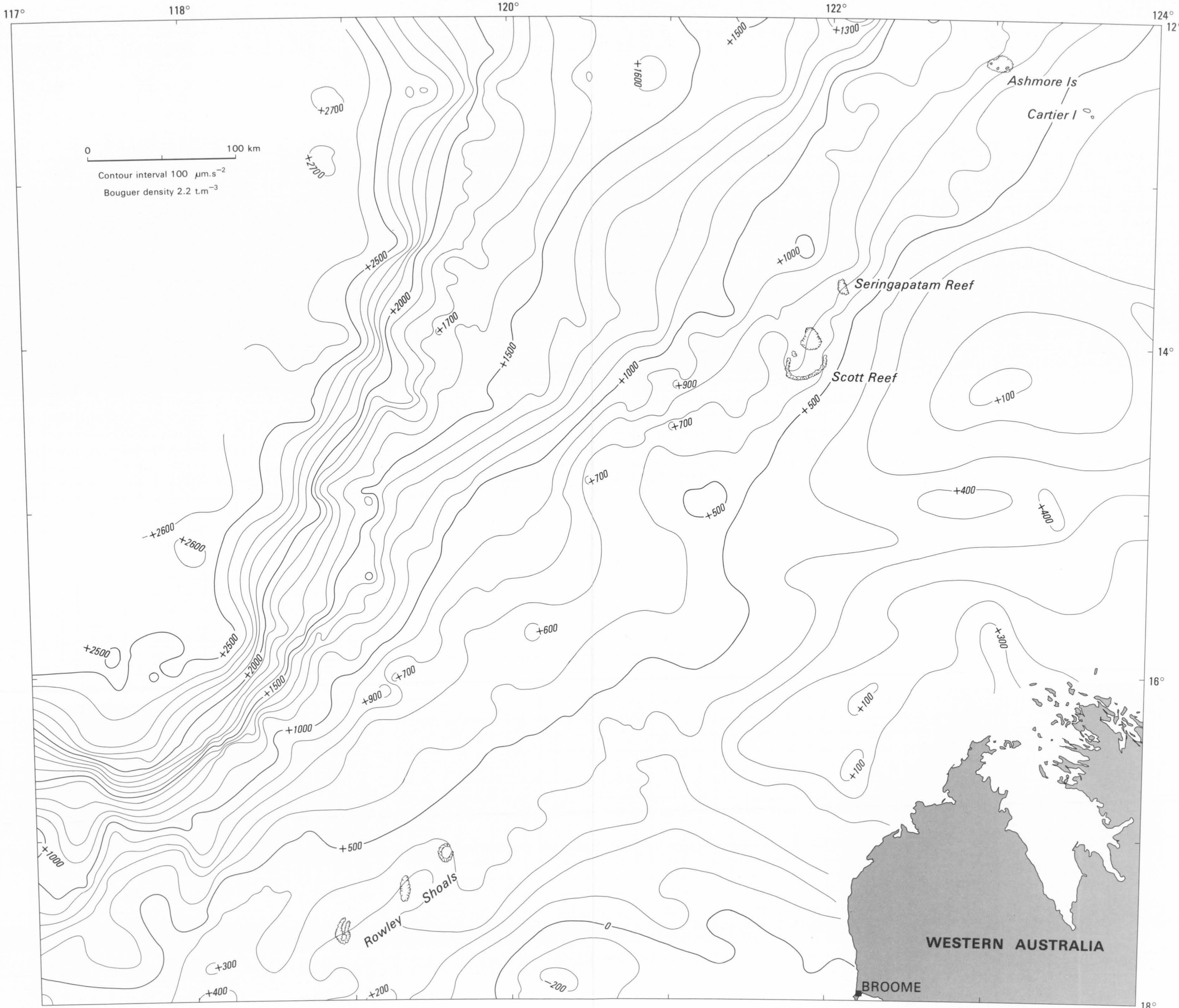


FREE-AIR ANOMALIES

23/OWA/5

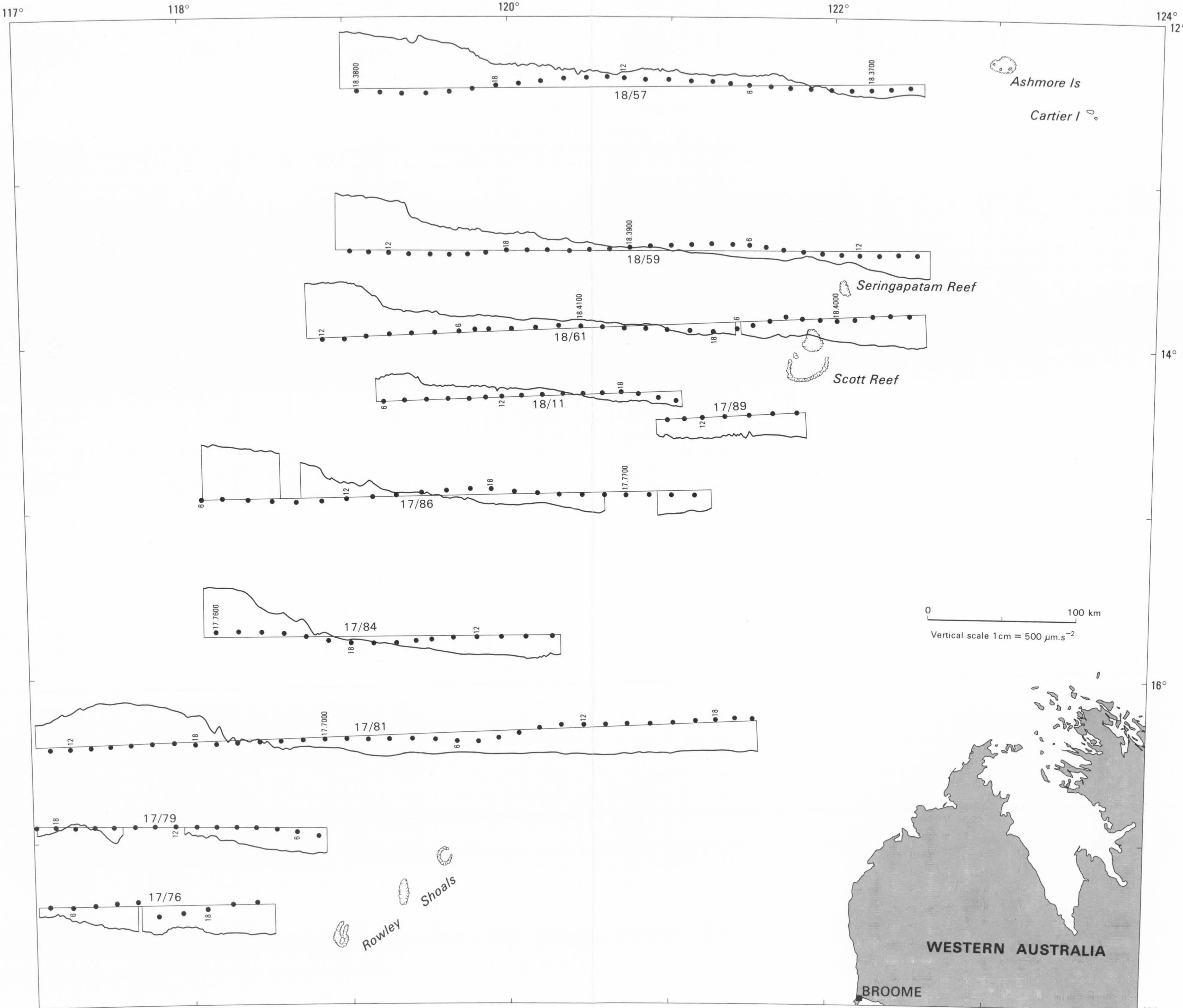


FREE-AIR ANOMALY PROFILES

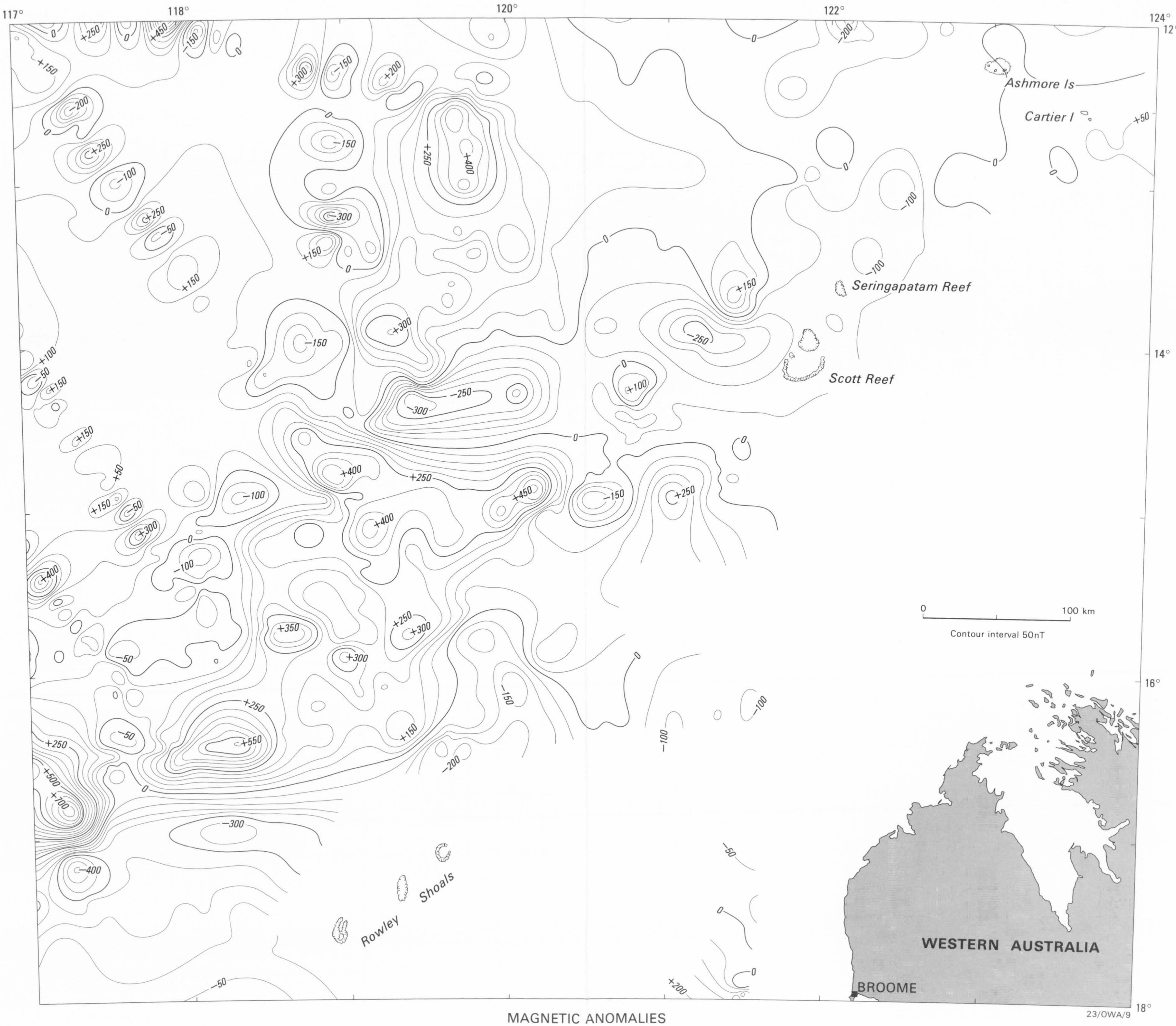


BOUGUER ANOMALIES

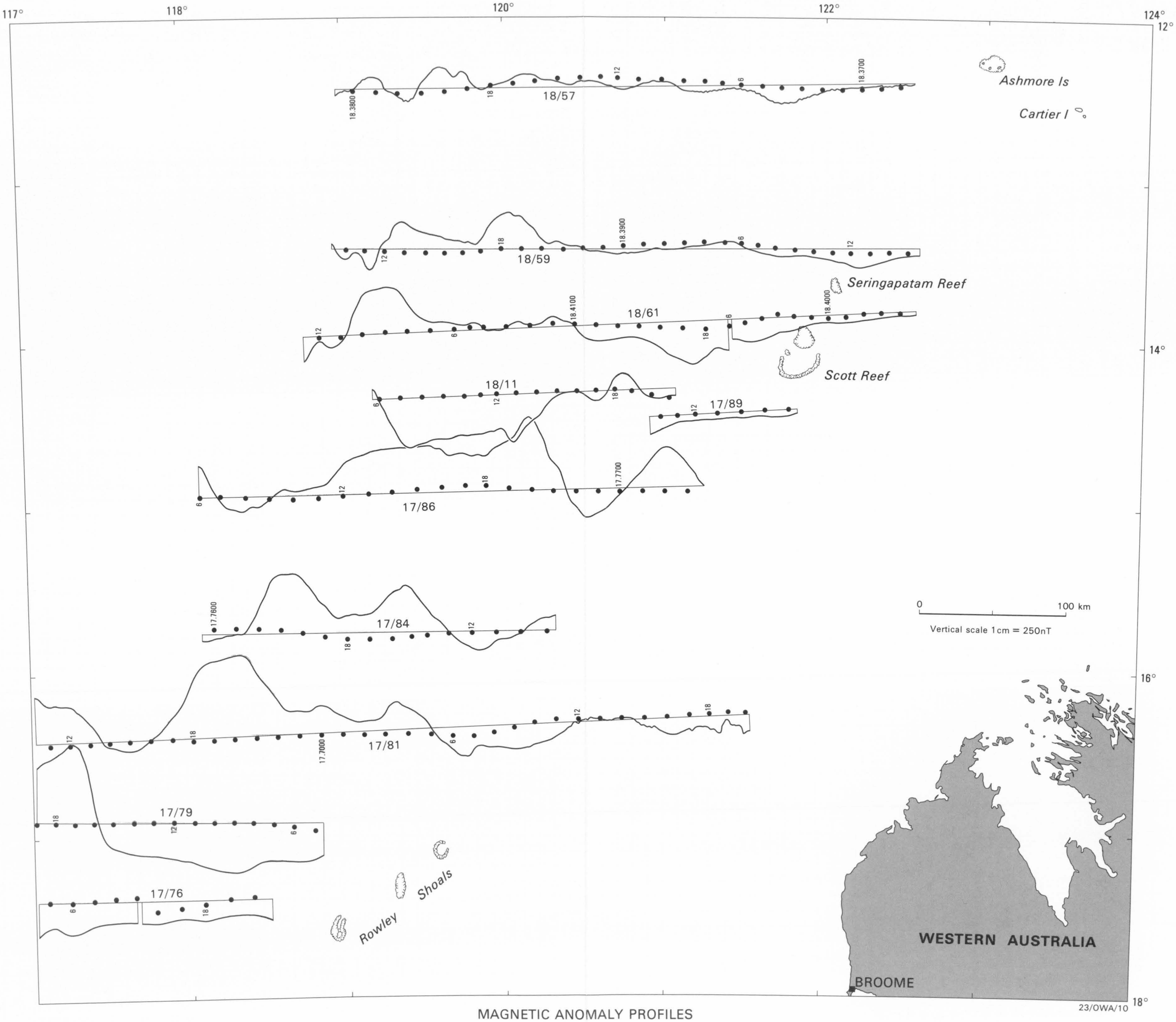
23/OWA/7



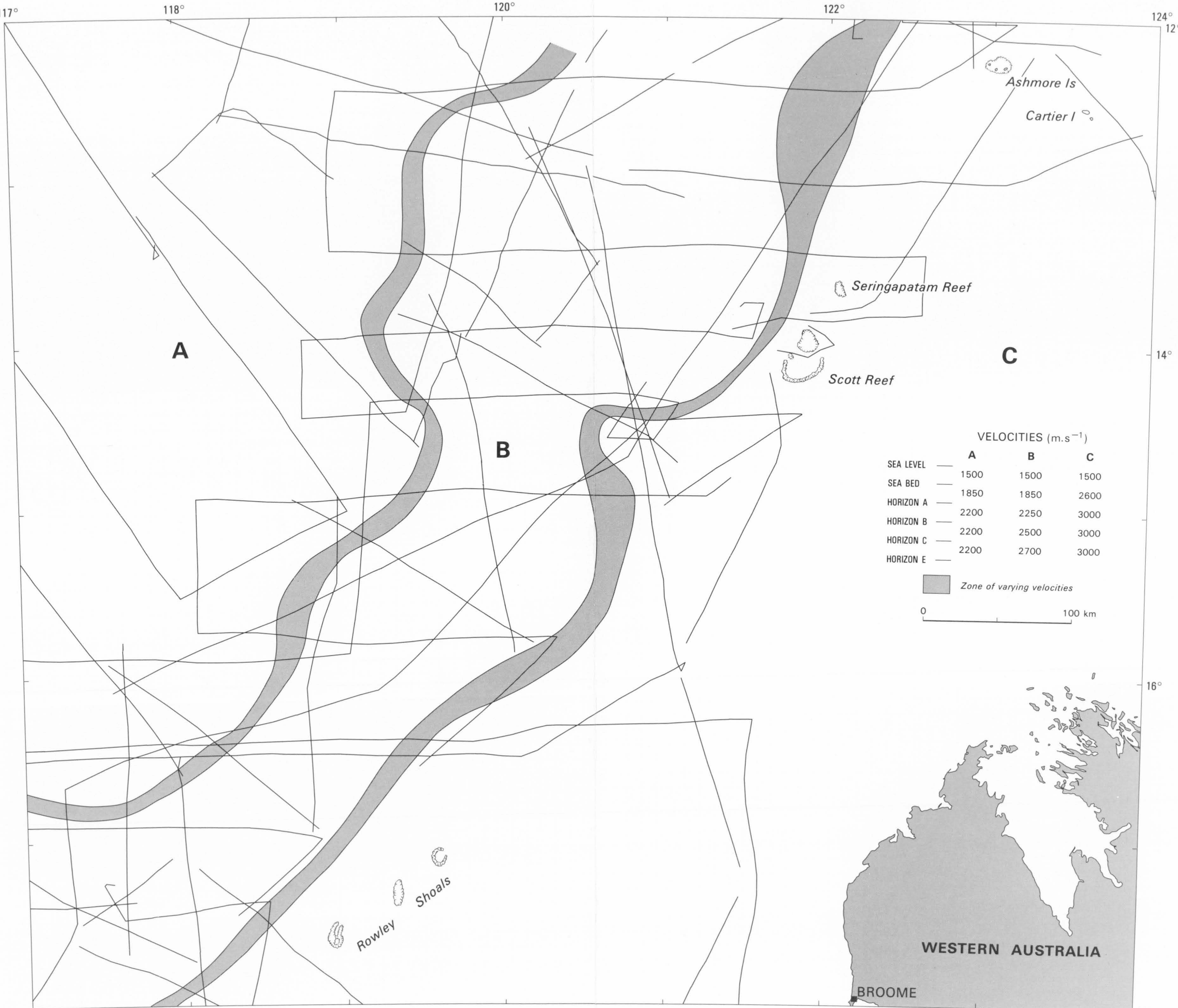
BOUGUER ANOMALY PROFILES



MAGNETIC ANOMALIES



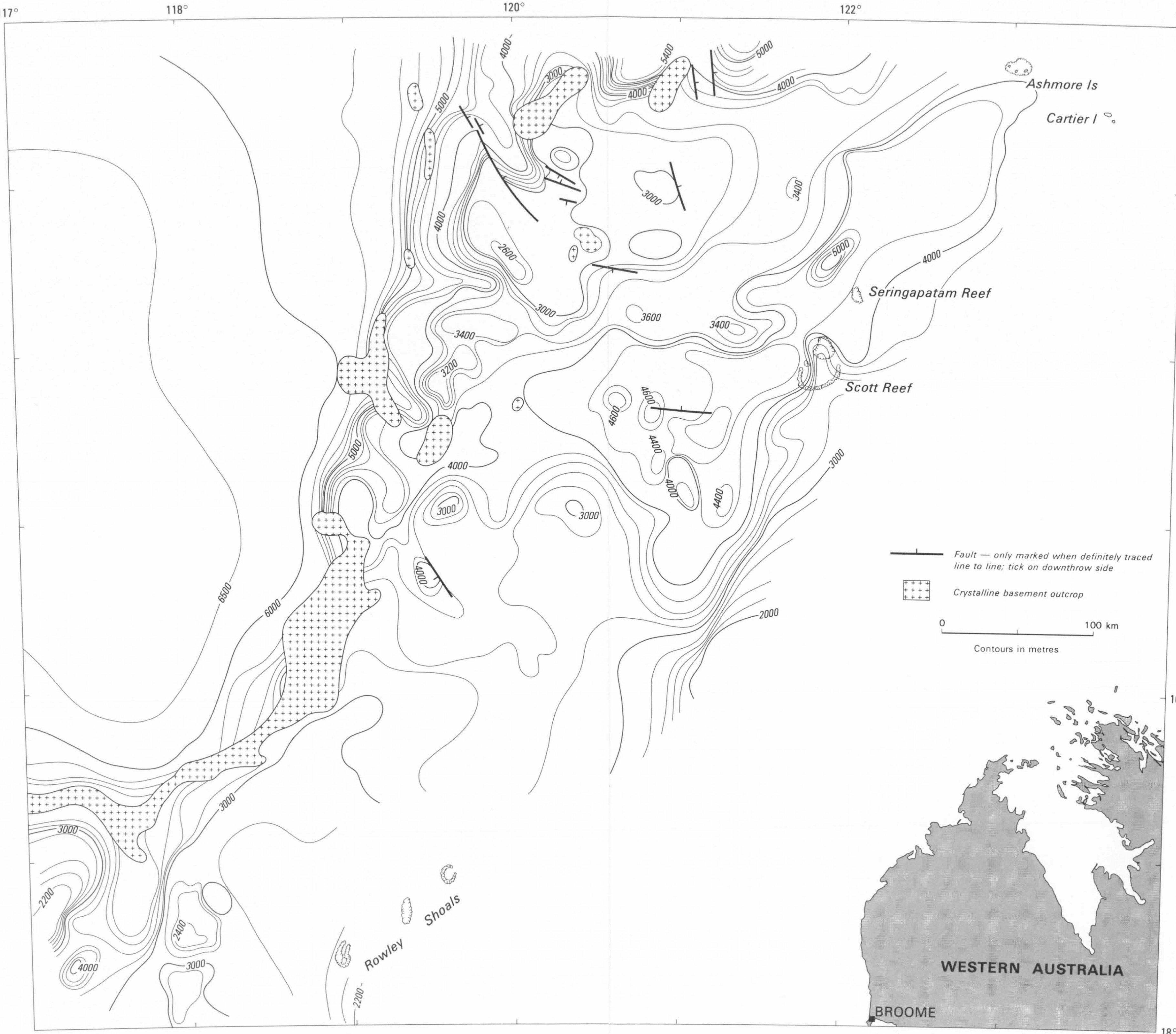
MAGNETIC ANOMALY PROFILES



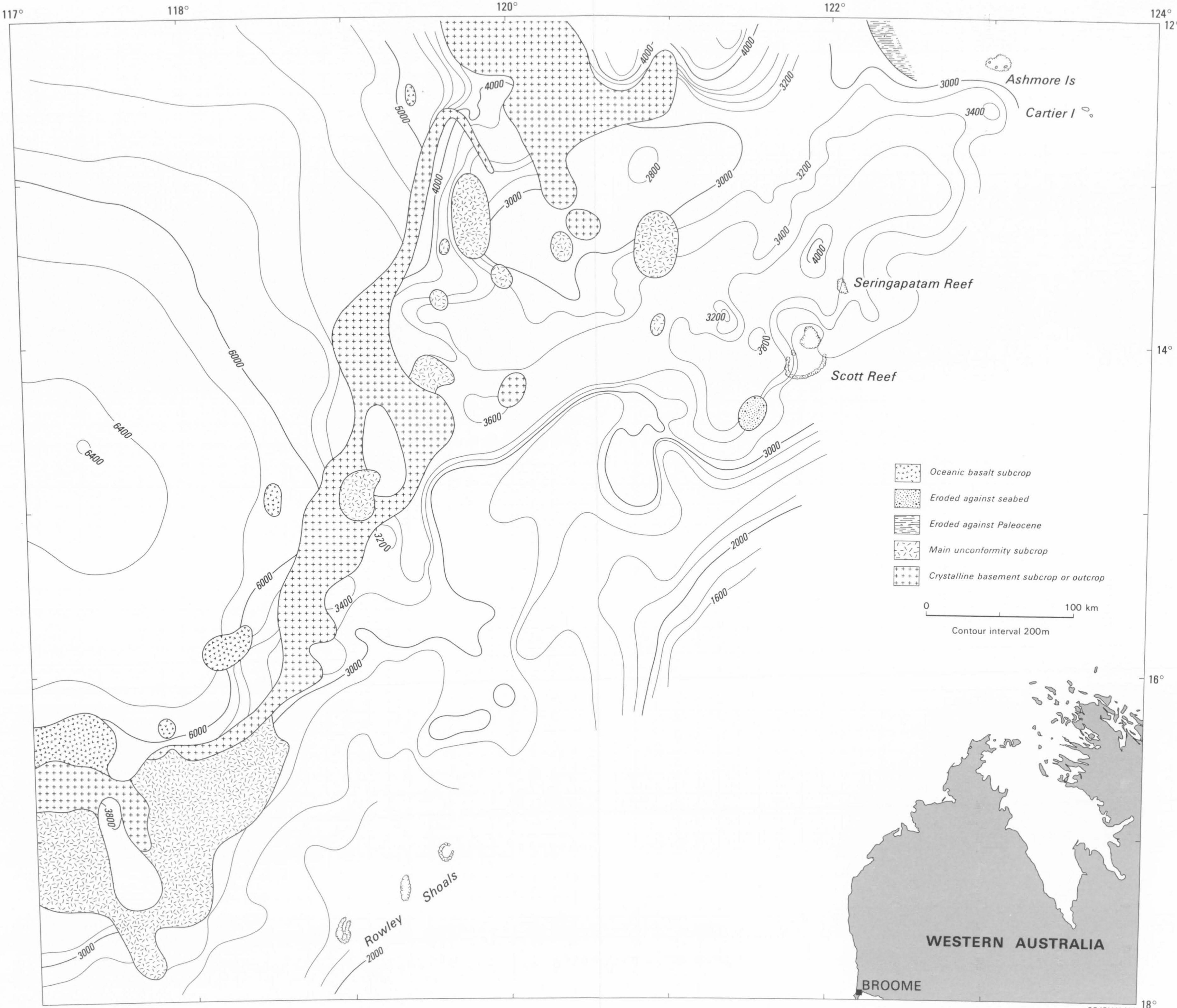
	A	B	C
SEA LEVEL	1500	1500	1500
SEA BED	1850	1850	2600
HORIZON A	2200	2250	3000
HORIZON B	2200	2500	3000
HORIZON C	2200	2700	3000
HORIZON E			

DISTRIBUTION OF INTERVAL VELOCITIES USED IN TIME-DEPTH CONVERSION

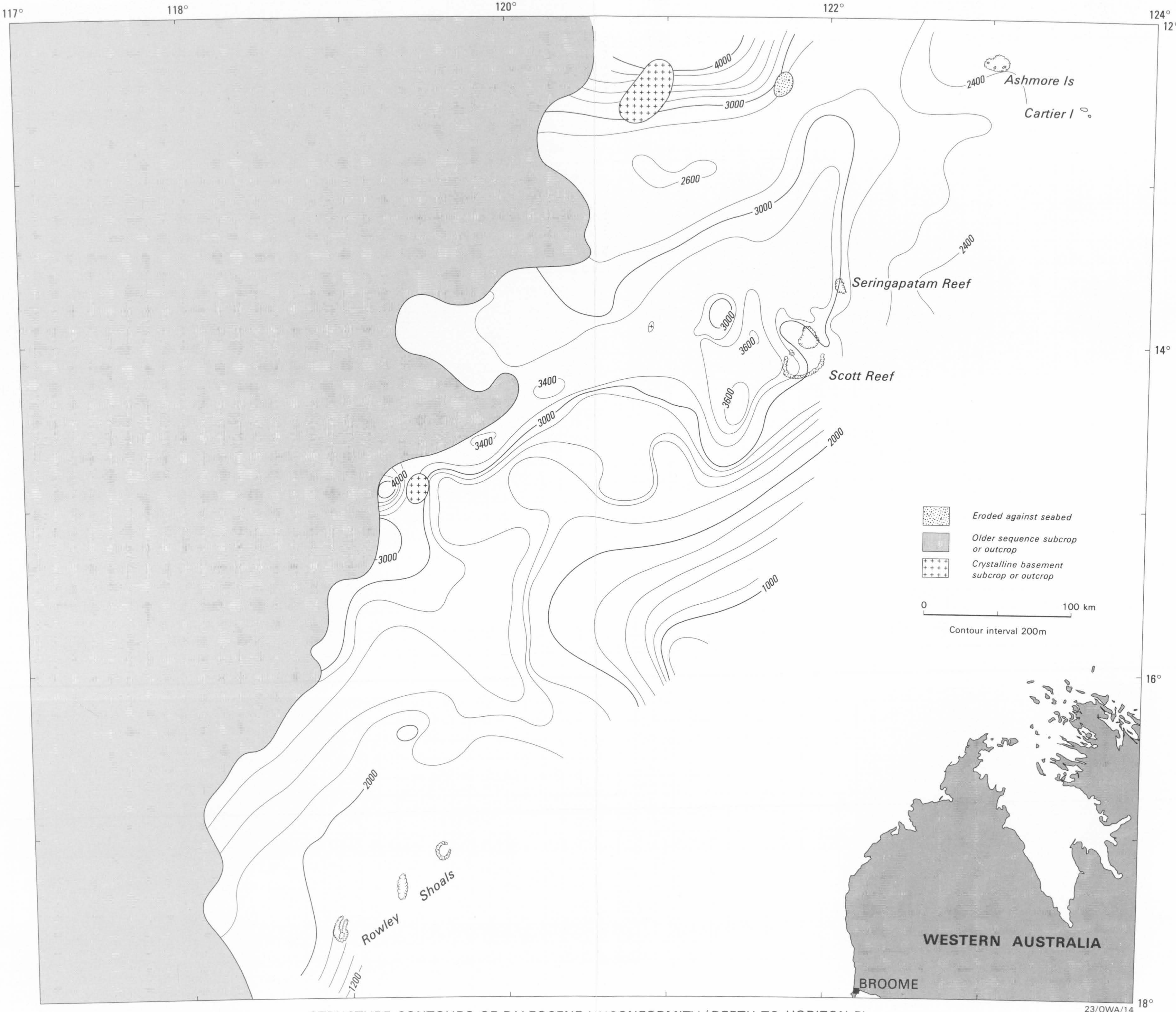
23/OWA/11



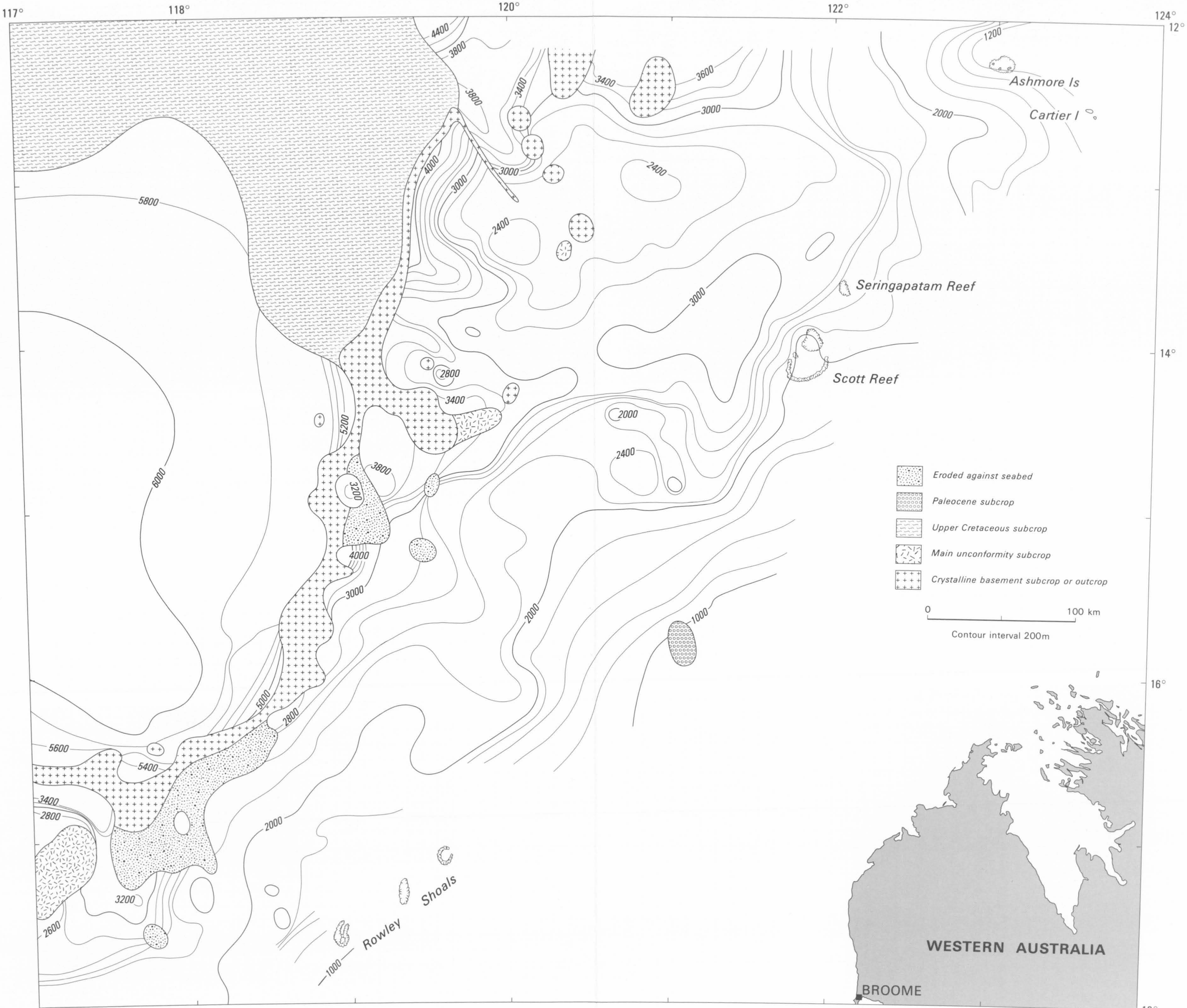
GENERALISED STRUCTURE CONTOURS OF MAIN UNCONFORMITY (DEPTH TO HORIZON E)



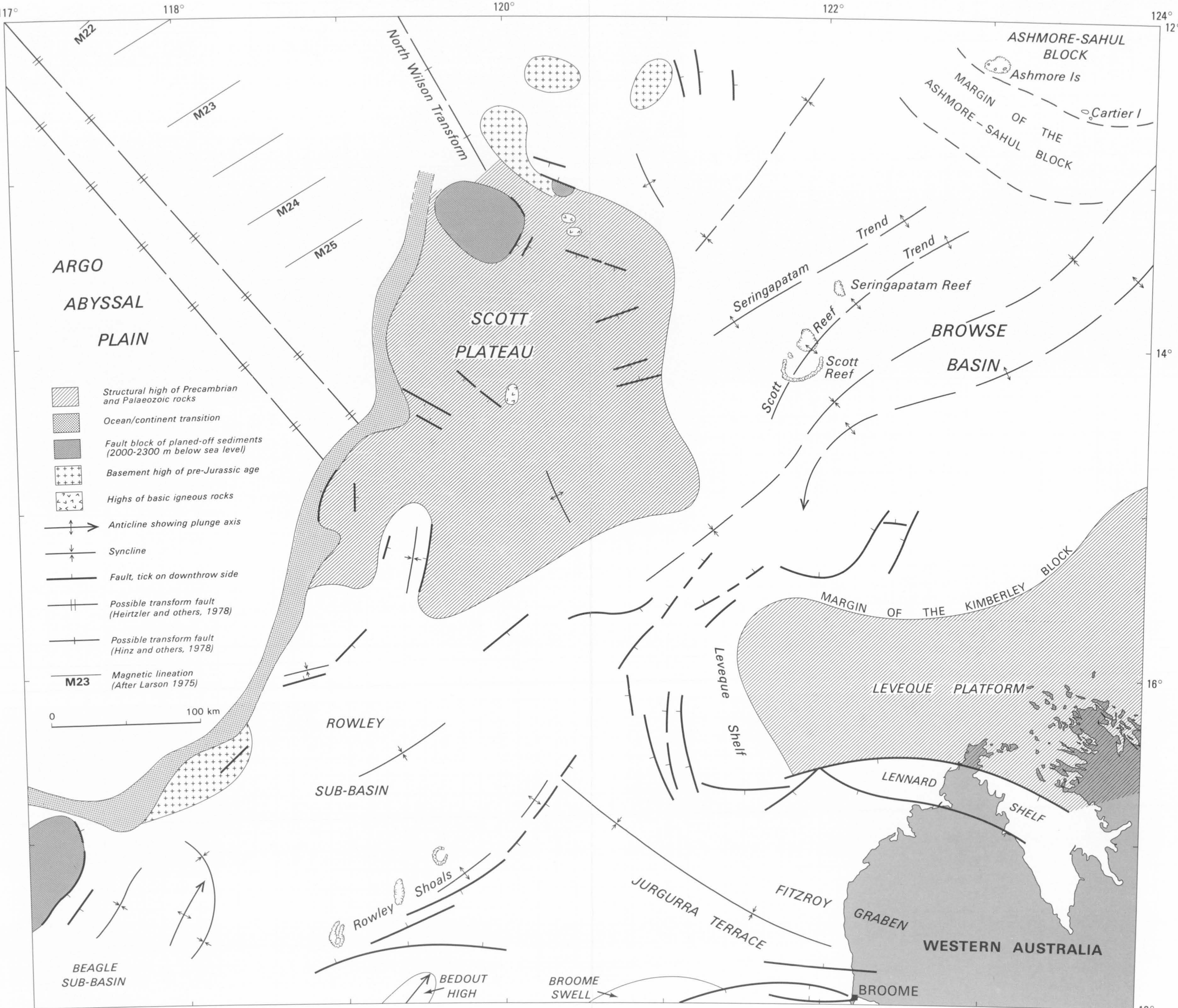
STRUCTURE CONTOURS OF LATE CRETACEOUS REFLECTOR (DEPTH TO HORIZON C)



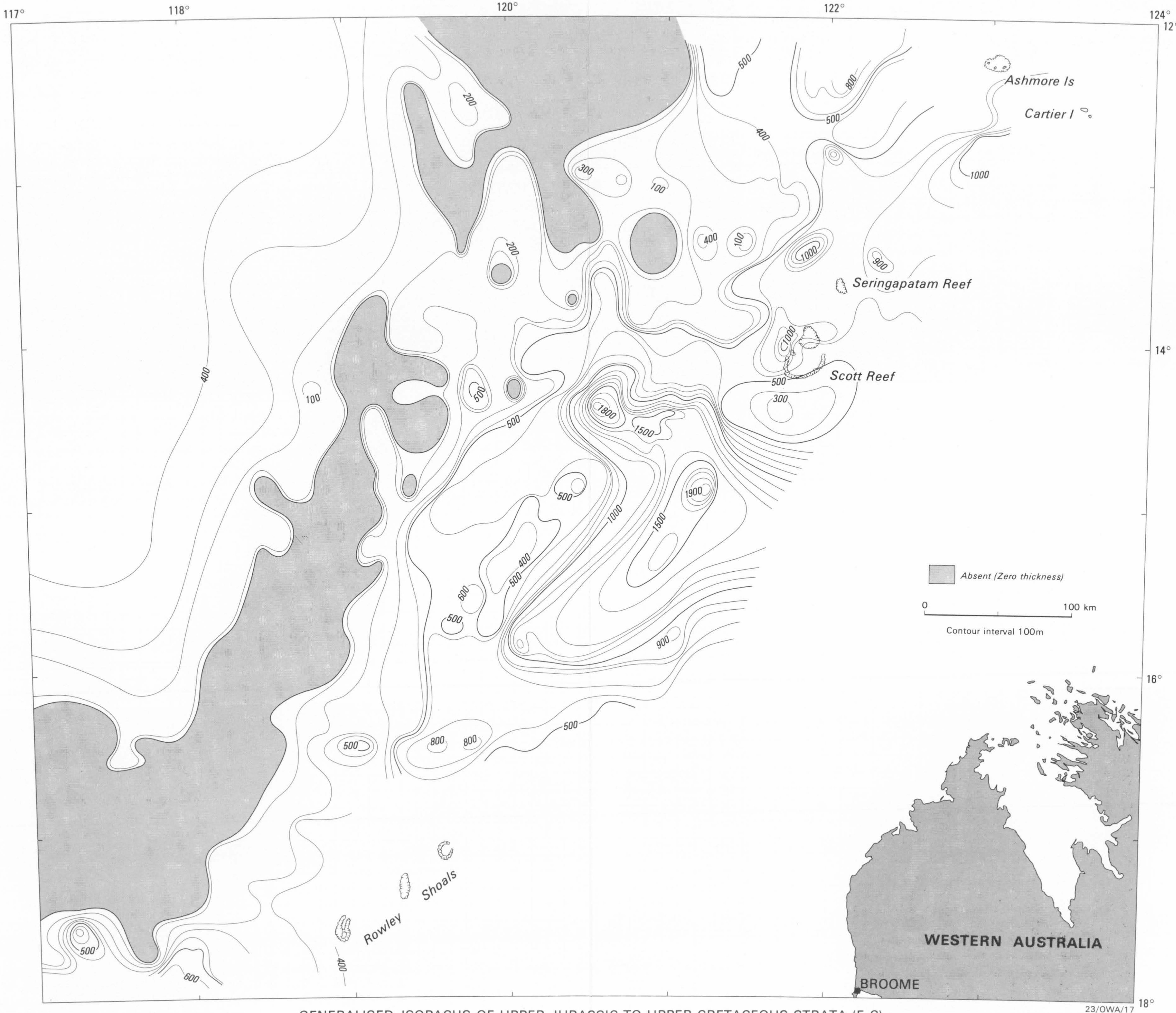
STRUCTURE CONTOURS OF PALEOCENE UNCONFORMITY (DEPTH TO HORIZON B)



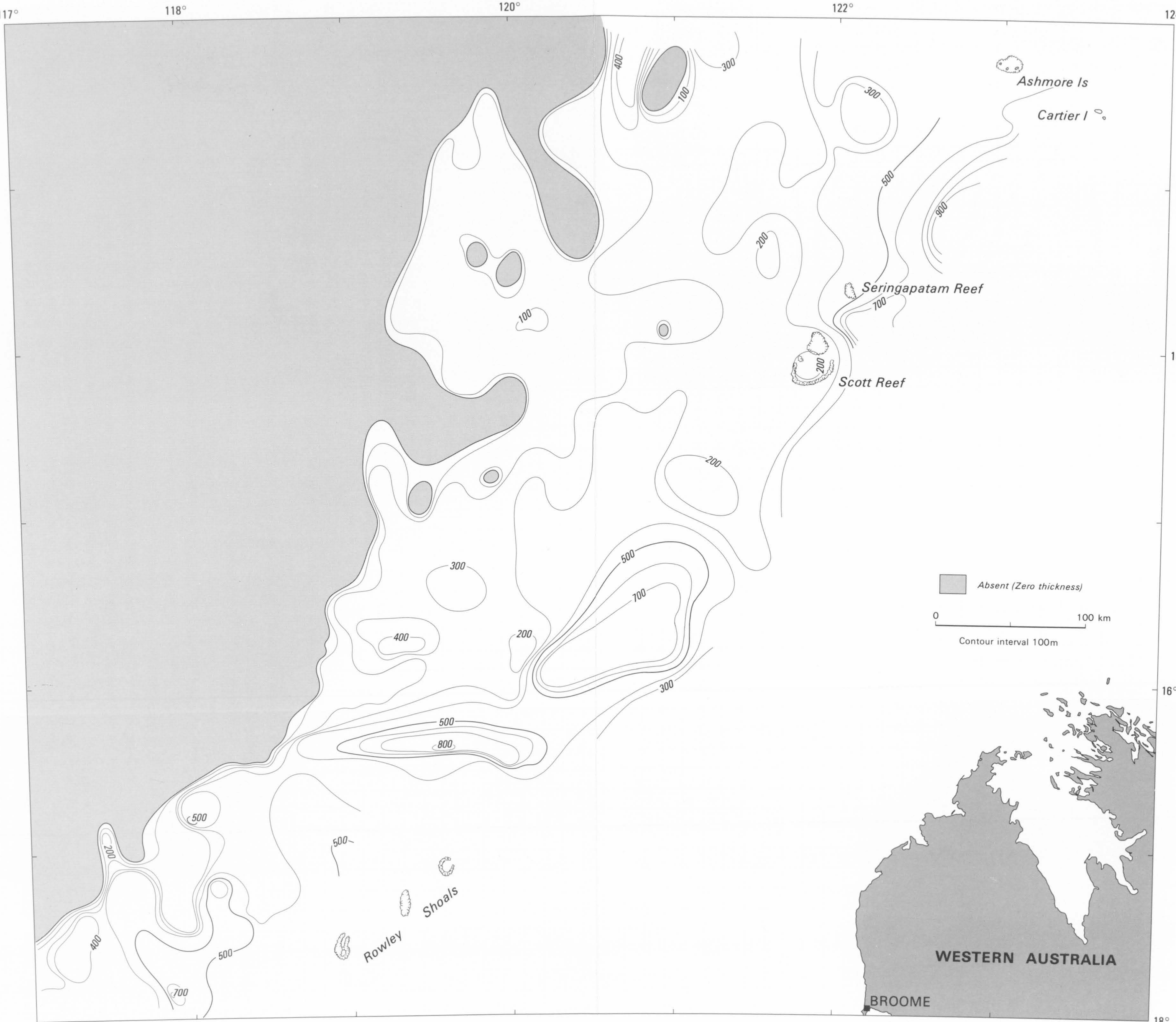
STRUCTURE CONTOURS OF OLIGOCENE UNCONFORMITY (DEPTH TO HORIZON A)



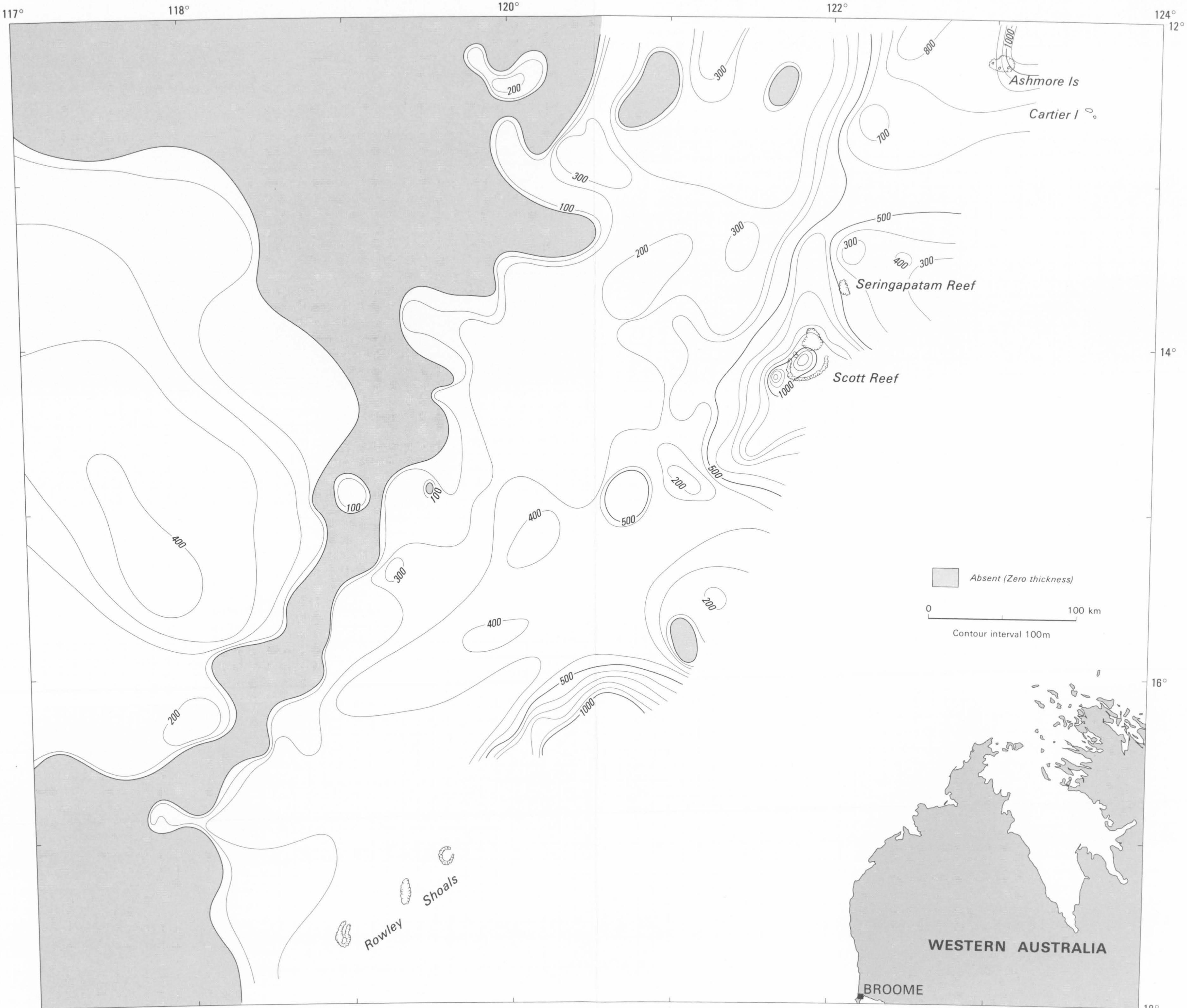
STRUCTURAL ELEMENTS BENEATH THE BREAK-UP UNCONFORMITY



GENERALISED ISOPACHS OF UPPER JURASSIC TO UPPER CRETACEOUS STRATA (E-C)

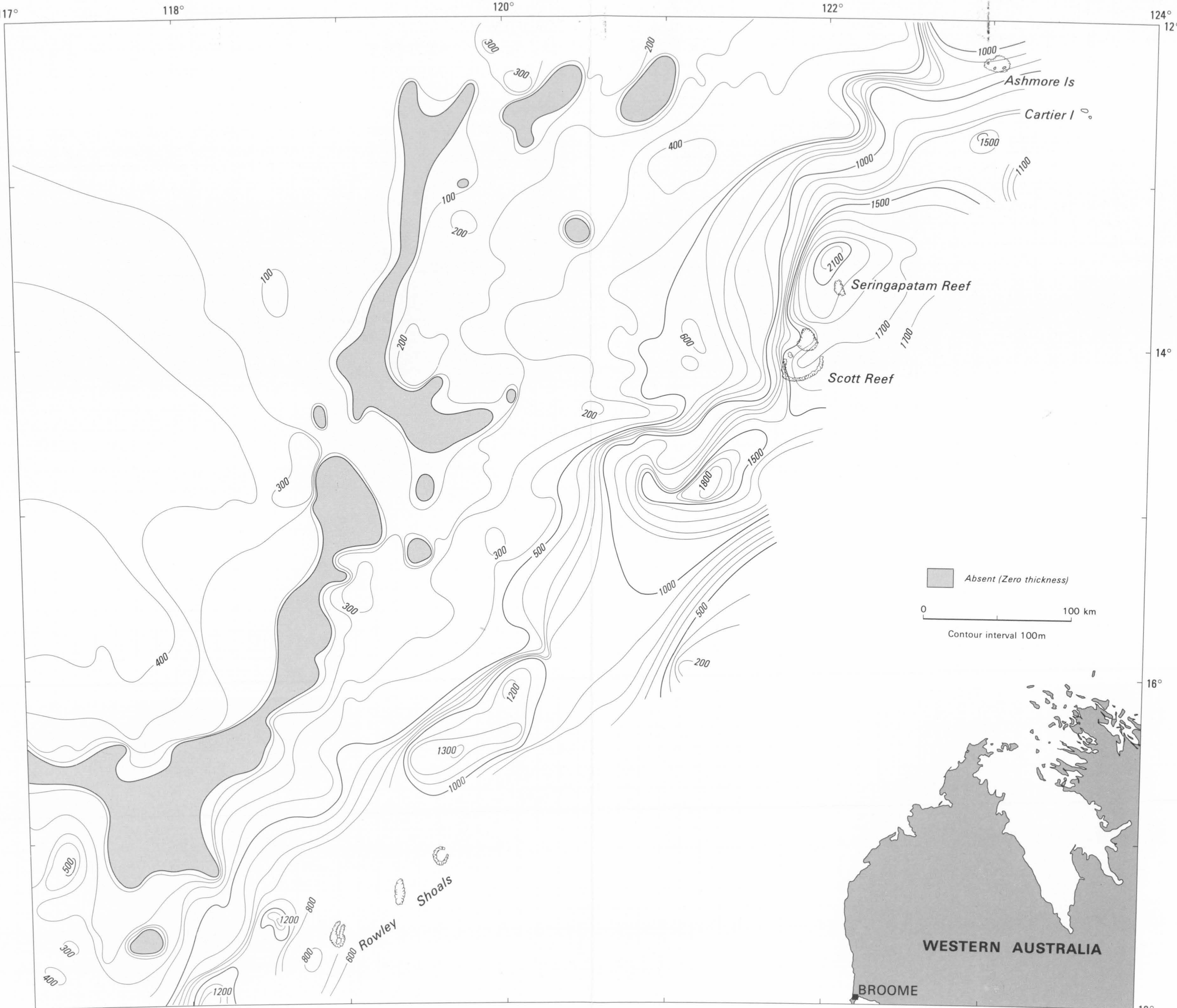


ISOPACHS OF UPPER CRETACEOUS STRATA (C-B)



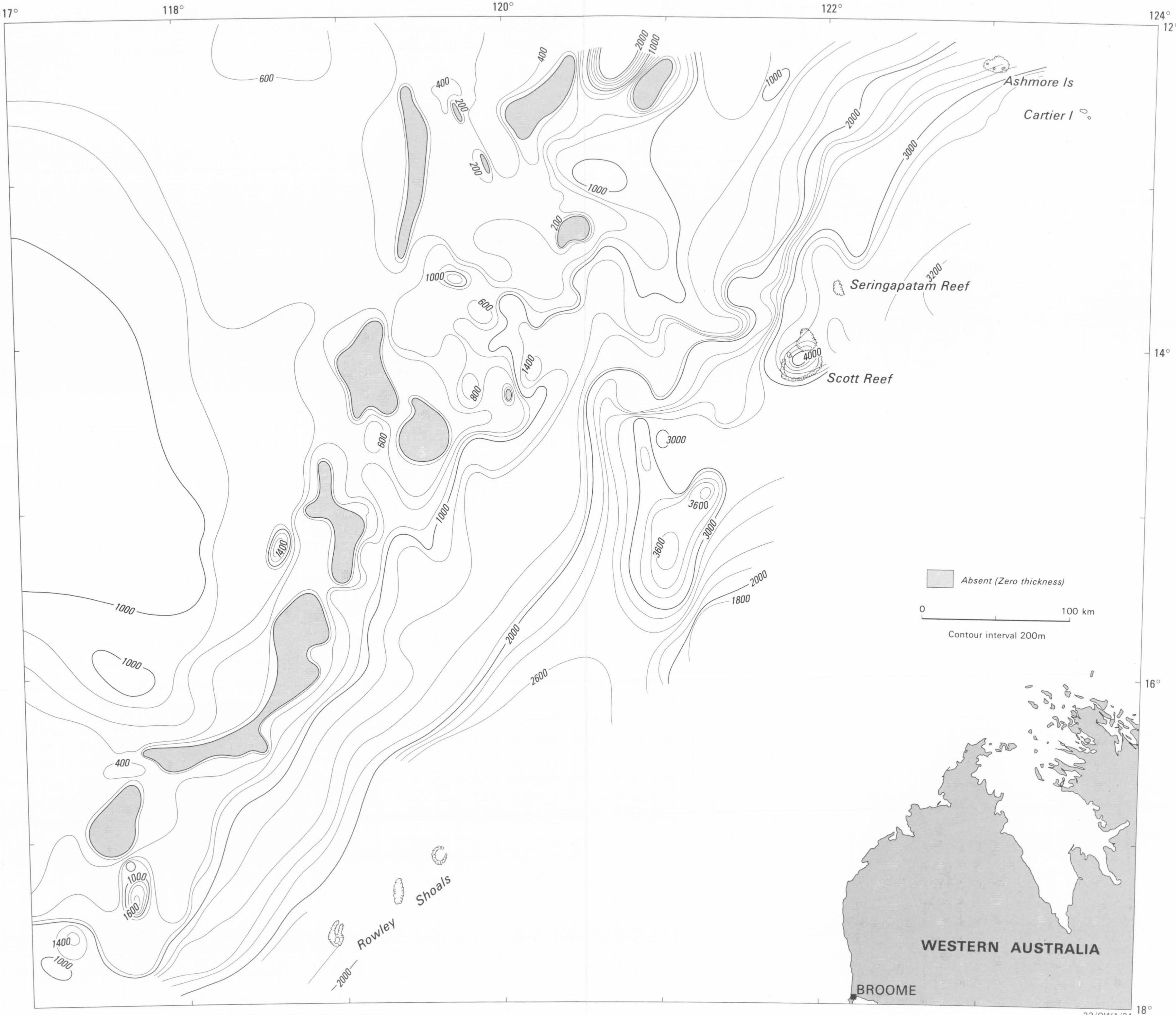
ISOPACHS OF EOCENE TO OLIGOCENE STRATA (B-A)

23/OWA/19

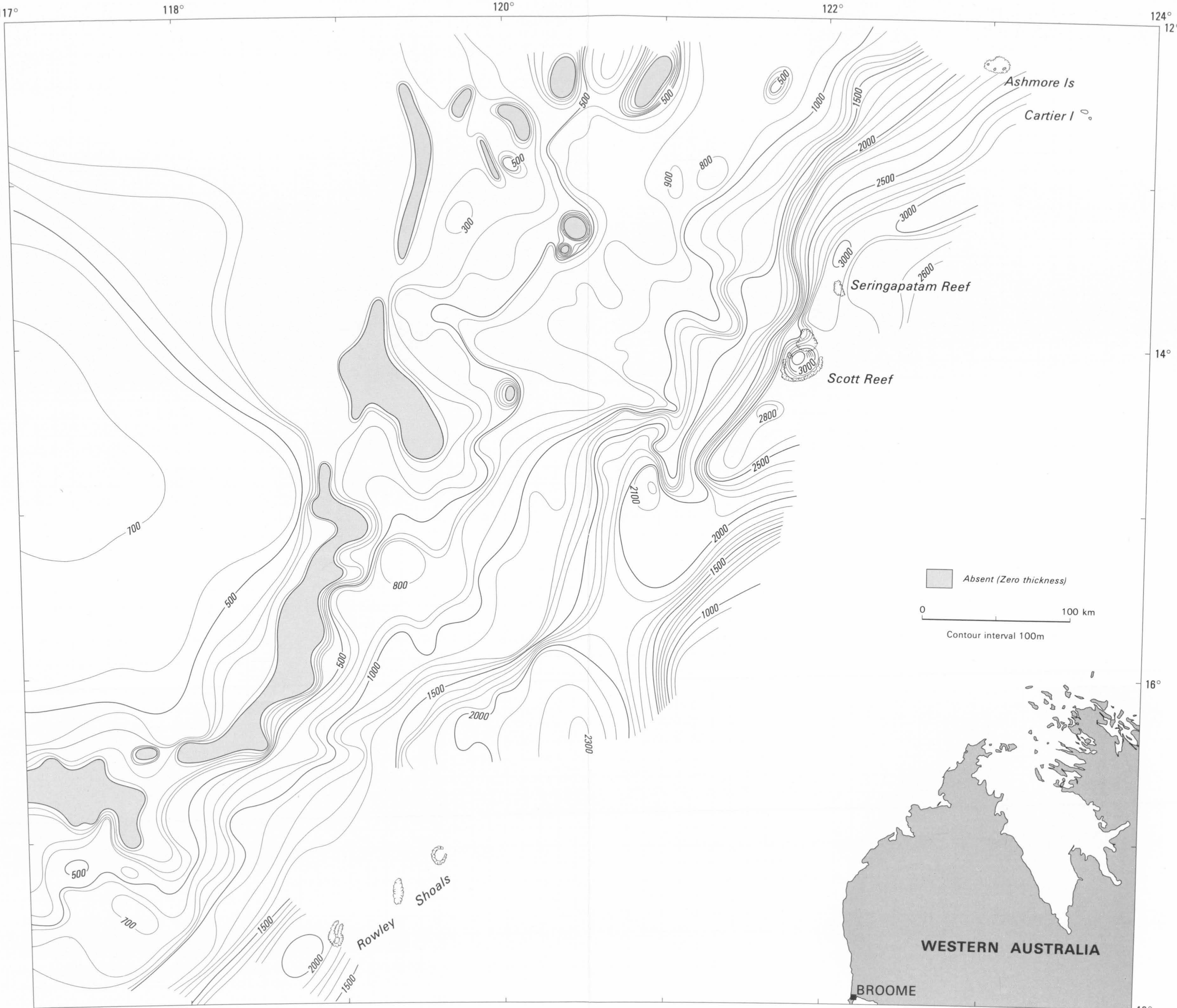


ISOPACHS OF MIOCENE TO RECENT STRATA (A – SEABED)

23/OWA/20

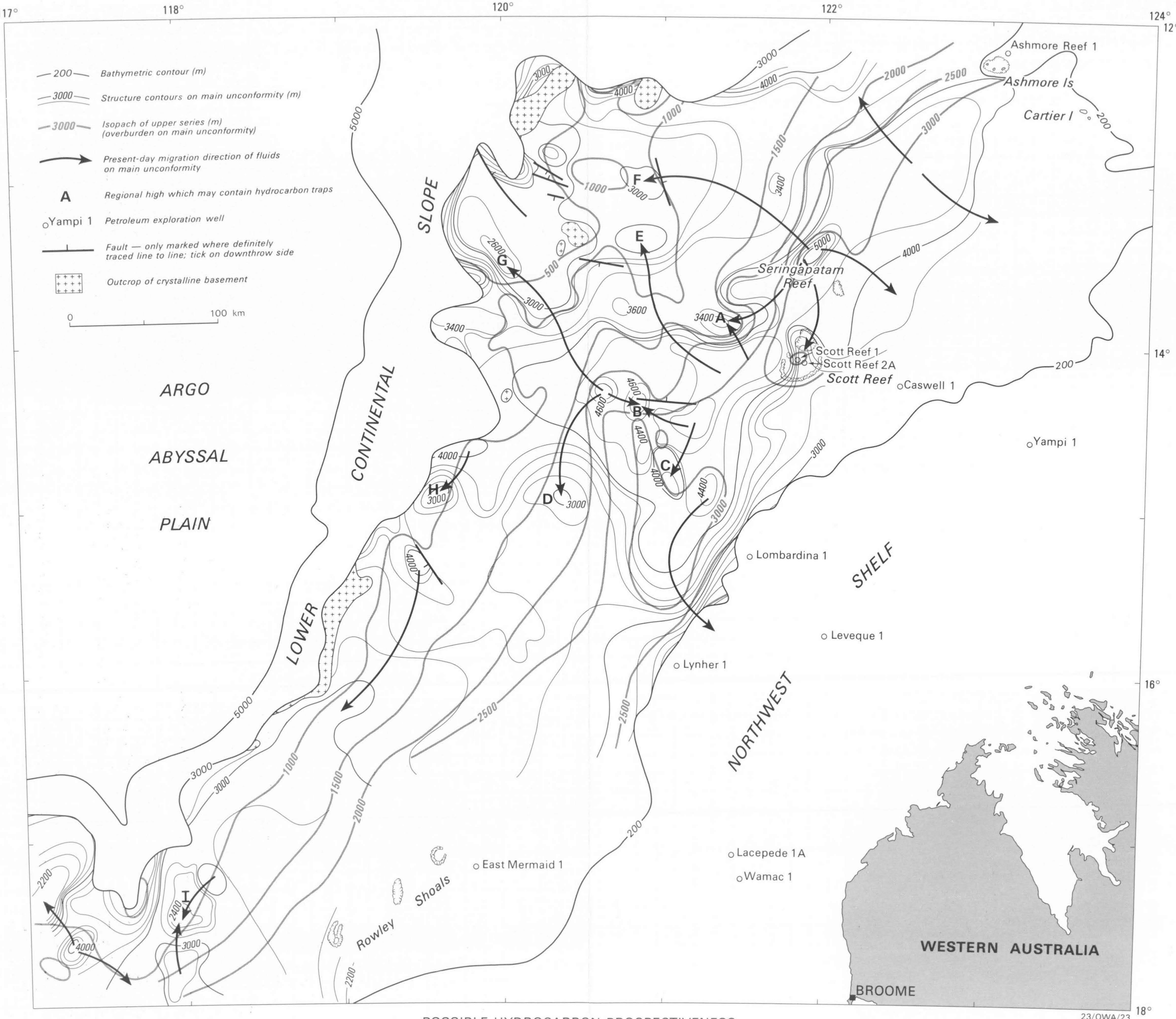


GENERALISED ISOPACHS OF UPPER JURASSIC TO RECENT STRATA — THE UPPER SERIES (E – SEABED)

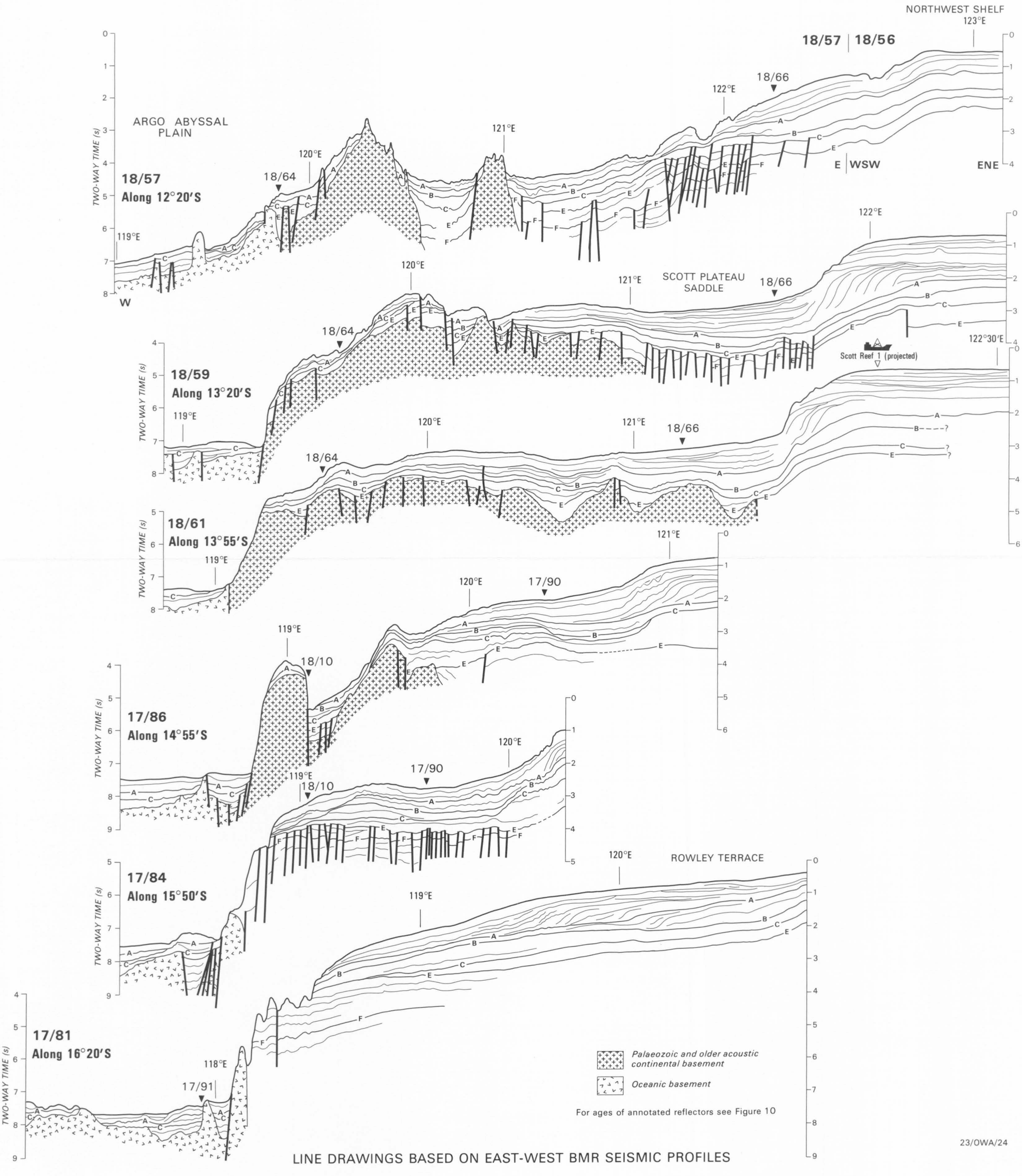


ISOPACHS OF UPPER CRETACEOUS TO RECENT CARBONATE STRATA (C – SEABED)

23/OWA/22



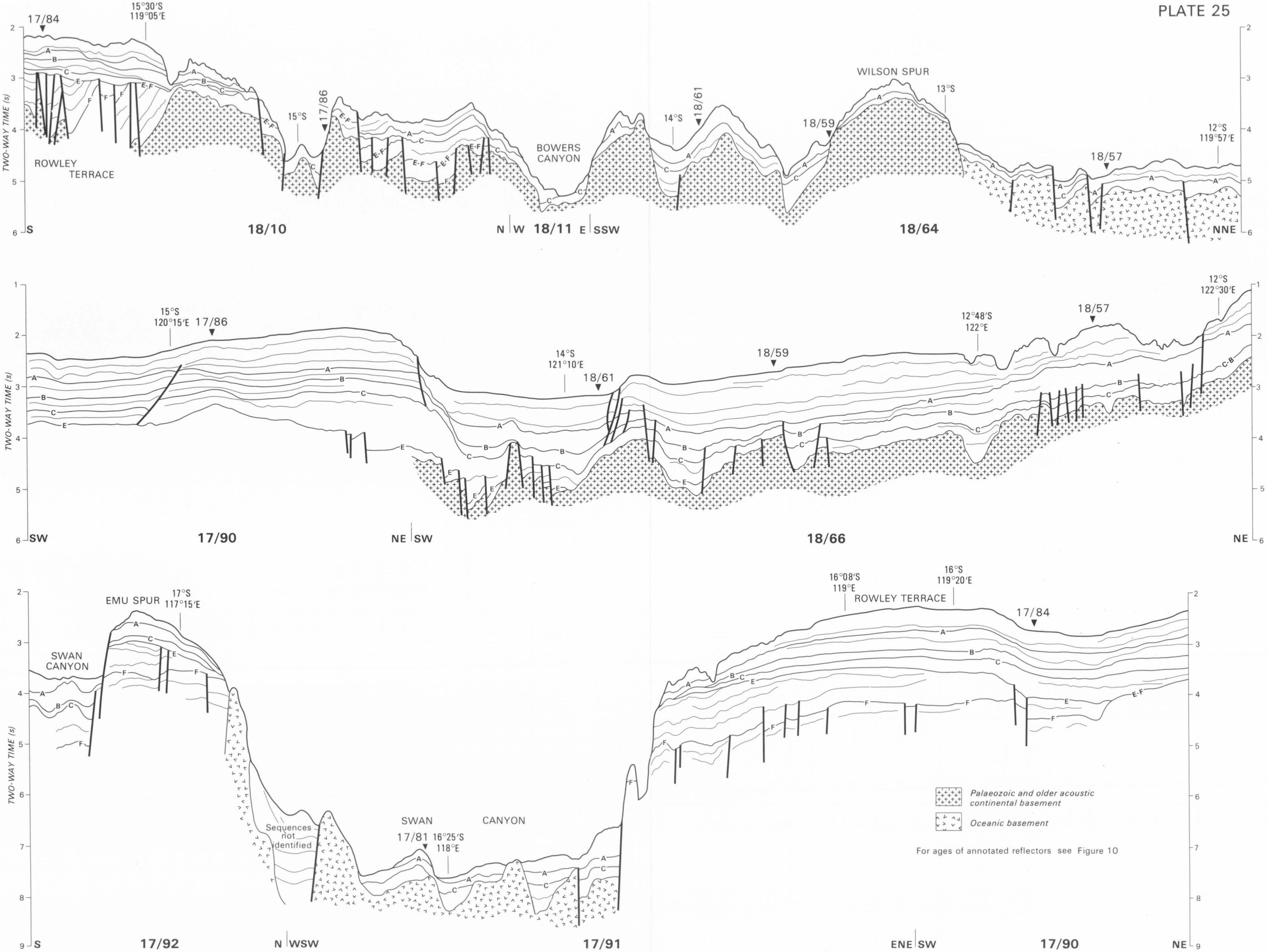
POSSIBLE HYDROCARBON PROSPECTIVENESS



LINE DRAWINGS BASED ON EAST-WEST BMR SEISMIC PROFILES

23/OWA/24

PLATE 25



LINE DRAWINGS BASED ON NORTH-SOUTH BMR SEISMIC PROFILES