1973/107
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DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/107

ASPECTS OF THE STRUCTURE AND TECTONIC HISTORY OF THE CONTINENTAL MARGIN OF NORTHERN QUEENSLAND

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PLATES

SUMMARY

Some seismically inactive continental margins include plateaus of large areal extent lying at depths intermediate between shelf and open sea-floor. These plateaus, as in the case of the Coral Sea Plateau, are underlain by crust of continental-type thickness and are believed to have submerged to their present position by a complex process involving aseismic crustal thinning and the maintenance of isostatic equilibrium (Falvey, 1972).

A study of the continental margin of northern Queensland using the multisensor data from 20 000 miles of BMR traversing, together with the recent JOIDES drilling results, has suggested a theory concerning the tectonic evolution of the region. Subsidence of the marginal plateaus is suggested to be closely related to the opening of the Coral Sea in mid-Eocene time. This, in turn, is thought to have been the result of large-scale movements influenced by spreading centres in the south Tasman Sea and the rifting of Australia from Antarctica.

Subsidence of the Coral Sea Plateau has occurred in three stages. The present morphology of the plateau and marginal troughs is influenced by structural lineations of the Tasman Geosyncline.

1. INTRODUCTION

As part of its two-year program of marine geophysical reconnaissance on the continental margin of Australia, the Bureau of Mineral Resources surveyed an area of marginal plateaus and troughs which form the continental margin of Queensland. Some 20 000 nautical miles of traversing was carried out on a systematic grid of east-west lines spaced 20 nautical miles apart (Plate 1). Continuous bathymetric and seismic profiling with simultaneous gravity and magnetic sensing was maintained 24 hours per day. Navigation was by satellite/sonar Doppler at all times so that an accuracy of about 1 nautical mile was generally achieved.

The contour maps given here were produced by hand contouring of values sampled at an interval of one hour, i.e. approximately 10 nautical miles. Both the sample values and the corresponding position data are, at this stage, preliminary. Some smoothing of the contours was found necessary for the production of the plates. Seismic profiles shown are single-channel, unprocessed sections photographed from original sections obtained on board ship.

The object of this report is to present some of the data obtained during BMR's marine geophysical survey of Australia's continental margin, and to give a preliminary interpretation of the data.

2. PHYSIOGRAPHIC UNITS

The bathymetric contours of Plate 2 delineate the basic morphology of the area. Contour interval is 500 metres, with the 200-metre isobath included to define the outer edge of the continental shelf.

The two major units are the marginal plateaus. The larger of these is the Coral Sea Plateau defined roughly by the 1500-metre isobath and lying between 13°30'S and 18°00'S. The plateau has a very flat surface, gently deepening to the northwest toward Osprey Reef. The surface is broken by many reefs and banks which originate on the flat plateau surface and rise in steep sided structures to about sea level. The existence of such features has been interpreted in the past (Fairbridge, 1950), as an indication that the plateau has sunk from close to sea level down to its present elevation - the reef growth is assumed to have kept pace with the subsidence. Using this observation one can suggest a subsidence of up to 1000 metres for the Coral Sea Plateau.

The Marion Plateau is a triangular shaped terrace lying south of 19°00'S. It has an average depth of about 400 metres and contains one large reef - Marion Reef.

The Coral Sea Plateau is separated from the continental shelf by the Queensland Trough. The trough is parallel to the coast and hence to the dominant structural grain of the Tasman Geosyncline in northern Queensland.

The Townsville Trough, which separates the Coral Sea Plateau from the Marion Plateau, has an east-west trend and is therefore nearly normal in trend to the Tasman Geosyncline. No clue to the origin of this trough is seen in the continental geology.

East of the plateaus the dominant physiographic trend becomes north-south. The Cato Trough is a deep, flat-floored oceanic trough originating at the head of the Tasman Basin and extending north to the latitude of the Townsville Trough. In the south of the trough Wreck Reef is located on a conical structure similar to the guyots of the Tasman Sea.

In the east of the survey area is a semi-continuous rise. The topography of the rise is rugged in detail with many conflicting trends.

Between the rise and the Nova-Argo Bank to the south a small ocean basin that will be referred to as the Nova-Argo Basin connects with a chain of basins located on the western flank of the Lord Howe Rise.

3. REGIONAL STRUCTURES

The set of seismic reflection profiles given in Plates 3 to 5 illustrate the structural setting and nature of several of the major physiographic units in the area.

Section A

Section A is on the western margin of the Cato Trough in the region of Frederick Reef. Clear reflections can be seen in the trough from more than 1.0 sec below seabed, and weak reflections continue to 1.5 sec. Sedimentary sequence here exceeds 1500 metres and could be up to 2000 metres. Sediments are very flat-lying except where they turn up against the rugged structures in the west and east* forming a very sharp contact. On both the east and west sides the basement structure of the trough shows high-angle faulting suggestive of rifting.

Section B

Section B shows sediments in the Nova-Argo Basin west of Nova-Argo Bank. Sediments here are at least 2000 metres thick and form two sequences - an upper stratified and a lower opaque layer. The basin sediments pinch out against the Nova-Argo Bank over a distance of 10 nautical miles.

In both this basin and the Cato Trough, the igneous basement must lie at 4.5 to 5.0 kilometres below sea level, and this implies a quasi-oceanic thickness of crust in both basins. In addition, the large thickness of sediment accumulated in these areas, remote from major sources of supply, suggests that the basins are quite old; perhaps earliest Tertiary.

Section C

Section C crosses the Queensland Trough at latitude 15°50'S. On the edge of the Coral Sea Plateau, faulting in the basement has downthrown sediments into the trough resulting in reshaping and slumping of sediments on the trough's eastern flank. Sediments in the trough

* not shown on this profile

itself are more than 1000 metres thick and show some disturbances in their bedding. On the eastern flank of the trough is a large structure, apparently an intrusion. The vertical exaggeration (40:1) makes it look deceptively sharp - its true dimensions are about 1 kilometre high by 4 kilometres wide. The structure may therefore be a fault block.

Faulting on the eastern margin of the trough and disturbance in the sediments implies a tectonic origin for the Queensland Trough.

Section D

Section D is taken from the Coral Sea Plateau east of 150°30'E on latitude 15°50'S. Throughout most of the plateau, as illustrated by this section, there is a clear limit to the sedimentary sequence, marked by a strong basal reflector; this horizon will be referred to as H1. H1 is faulted at the top of the slope into the Coral Sea Basin. Within the sedimentary column is a second major horizon, conformable with the lower sequence but unconformable with the upper sequence. This horizon will be referred to as H2.

The location of JOIDES drill site 209 of Leg XXI is shown. Results from this hole (Deep Sea Drilling Project, 1972) indicate that this site has deepened from mid-Eocene, with replacement of terrigenous by pelagic deposition. Two breaks in deposition are present; one from upper Eocene to upper Oligocene and a second from mid-Miocene to mid-Pliocene. From its depth in the section, compared with JOIDES information, it is possible that H2 corresponds to the Eocene/Oligocene break. The Miocene hiatus is very high in the JOIDES hole and does not show on the reflection record.

The unusual feature of beds dipping from above into H2 is probably the result of deep sea current influence on pelagic sedimentation.

Section E

Section E, on the western side of the Coral Sea Plateau, illustrates that sediments on the western side are generally thinner than those on the east and also shows the development of a poorly reflecting layer as an upper sequence of plateau sedimentation.

Section F

Section F lies in the north of the Coral Sea Plateau at 14°30'S. H1 is clear again and the upper poorly-reflecting layer is well developed. The horizon which marks the base of this layer will be referred to as H3. On the eastern side of the section is an intrusive structure which originates from below H1. This structure shows no magnetic anomaly and is possibly diapiric rather than an igneous intrusion.

Section G

Section G shows the heavily intruded nature of the eastern rise structure. Sediments are very thin and ponded in local depressions.

In Plate 6 an attempt has been made to draw together the line-by-line interpretation of the seismic results into a plan map. Only the major, regional features are illustrated.

The eastern rise structure shows numerous intrusives. Major faulting across the general trend is also present. The rise appears to be a linear zone of strongly fractured, oceanic crust.

The western margin of the Cato Trough has an en echelon structure, which supports the suggestion that it is a rift feature.

Faulting on both sides of the Queensland Trough shows it to be a graben with a band of intrusives along most of its length. No major faulting is apparent in the Townsville Trough and it is not possible to postulate how this feature originated.

On the plateaus the areal distribution of horizons H1, H2, and H3 have been shown. The limit of the occurrence of H1 as an identifiable horizon describes roughly the shape of the plateaus. In the troughs the reflecting event giving rise to H1 is probably present but is buried so deeply that it gives no observable reflection record. H2 follows the outer margin of the plateau and also roughly marks the area of thickest sediments on the plateau. The distribution of H2 suggests that the force which shaped the sediments above H2 may have been a large contour current. The occurrence of the upper transparent layer, as marked by the areal extent of H3, is restricted largely to the north of the plateau.

4. GRAVITY FIELD

The gravity field variation in the region is presented as free-air anomalies in Plate 7 and as Bouguer anomalies in Plate 8. The density used for Bouguer reduction was 2.2 g/cm^3.

If the free-air anomaly map and the physiographic map are compared it is apparent that most of the variation in free-air anomaly is related to topography. Thus the sharply elevated structures such as Wreck Reef, Nova-Argo Bank, and the eastern rise show strong positive anomalies, and the troughs and basins show a negative effect. Such a behavior in the free-air anomalies indicates that the small sharp topographic features lack isostatic compensation (which is generally true in most oceanic areas). However, the Coral Sea Plateau, a feature some 400 by 700 kilometres in extent shows dominantly positive free-air anomalies, and these cannot be related simply to a topographic effect. This feature ought to be large enough to be regionally compensated, but the persistently positive anomalies indicate that it lacks compensation. Subsidence of the plateau as a complete crustal unit by about 450 metres would bring the plateau to its minimum energy state found in isostatic compensation and expressed as zero average free-air anomaly.

If the Bouguer density has been chosen well, then the gravity effect of horizontal variations in the water/sediment interface should be eliminated, and the long-wavelength component of the Bouguer anomalies should reflect variations in the base of the crust. If this is the case then it appears that neither the Queensland Trough nor the Townsville Trough has much expression in the base of the crust; that is, they are essentially shallow features of the upper crust.

As a rough guide to crustal thickness in the region one can take the areas with Bouguer anomaly less than 80 milligals as having continental thickness (greater than about 25 kilometres), and those with anomalies greater than 160 milligals as having ocean thickness (less than about 15 kilometres). Areas of oceanic thickness are thus the Cato Trough and Nova-Argo Basin, plus the southern Coral Sea Basin. Continental crust underlies the plateaus, and the southern end of the eastern rise which may be a continental fragment.

5. RELATION TO STRUCTURES OF QUEENSLAND AND CORAL SEA

In Plate 9 the continental margin of northern Queensland is shown in its regional setting. The dominant structural lineaments of the Tasman Geosyncline in northern Queensland have been indicated and an attempt has been made to extend these into the continental areas offshore. The Queensland Trough is considered to lie in a structural depression of the geosyncline. This trend has been extended south, roughly parallel to the geosynclinal trends, to join with the Capricorn Basin. A structural high trending along the western margin of the Coral Sea Plateau, first recognized by Falvey (1972), has been extended south to include the Swain Reefs structure. The other two lineaments are believed to be further extensions of the geosynclinal trends and are drawn assuming parallelism with the other trends.

Oceanic trends have been determined partly from results of the subject survey, and partly by inspection of the bathymetric chart of Mammerickx, Chase, Smith and Taylor (1971). These trends are generally normal to those on the continent, and one connects with the Townsville Trough. This latter trend was recognized by Cullen (1970), and if oceanic processes have resulted in the formation of the Townsville Trough this may explain why the trough has no expression in the onshore geology.

The major ocean basins, together with the major offshore continental blocks, have been indicated. Also shown is the system of trenches which ring the region.

6. POSSIBLE TECTONIC EVOLUTION

In most reconstructions of the southwest margin of Gondwanaland, e.g. Griffiths (1971), it is assumed that Lord Howe Rise has moved northeast away from a position adjacent to the Australian continent. This movement is related to the breakup of Australia and Antarctica around the mid-Eocene. The southern end of Lord Howe Rise is thought to have moved along the Alpine Fault of New Zealand, but movement of the northern end generally lacks a similar well defined trend. It is suggested here that the southernmost of the oceanic lineament shown in Plate 9 marks the line of movement of the northern end of Lord Howe Rise.

It is possible, then, that the Mellish Rise, which forms a zone of rugged linear features within the delineated oceanic trends, is a fossil fracture zone, active during the movement of Lord Howe Rise.

With an active trench system developed in the Solomons and New Hebrides, a tensional environment was established between these island chains and the stable Australian Continental mass. Within this environment ocean basins formed by rifting and extension. Following formation of the Coral Sea Basin, some time before mid-Eocene (Deep Sea Drilling Project, 1972), the areas which now form the marginal plateaus began to subside. There is a clear association between formation of a new ocean and plateau subsidence, and a discussion of the possible processes involved is given in Falvey (1972).

Subsidence of the Coral Sea Plateau appears to have been achieved by a three-stage process: firstly, marginal subsidence along the outer edge of the plateau in the area marked by the thickest sediments; secondly, vertical subsidence of the plateau as a complete unit; and thirdly, trough formation. The first stage may have taken place during the initial rifting of the Coral Sea before mid-Eocene, the second may have proceeded from mid-Eocene onward after the Coral Sea was well developed, and the third may have been a mid-Miocene event. The last event correlates with the time of orogenic emergence in Papua (Thompson, 1967), and corresponds to the second depositional break on the plateau (Deep Sea Drilling Project, 1972).

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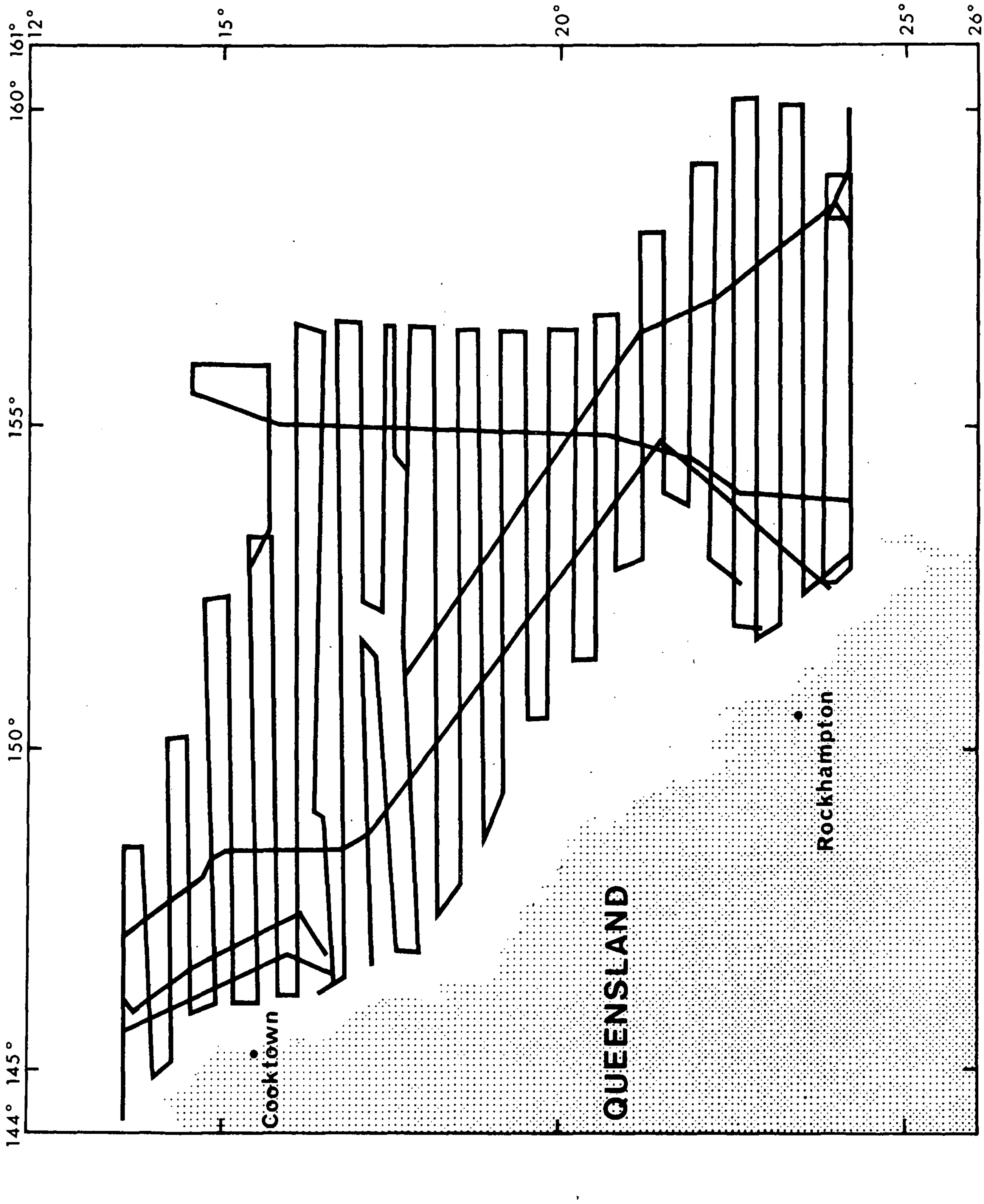
PLATE 1



ASPECTS OF STRUCTURE AND TECTONIC HISTORY OF
THE CONTINENTAL MARGIN OF NORTHERN QUEENSLAND

TRAVERSE PLAN

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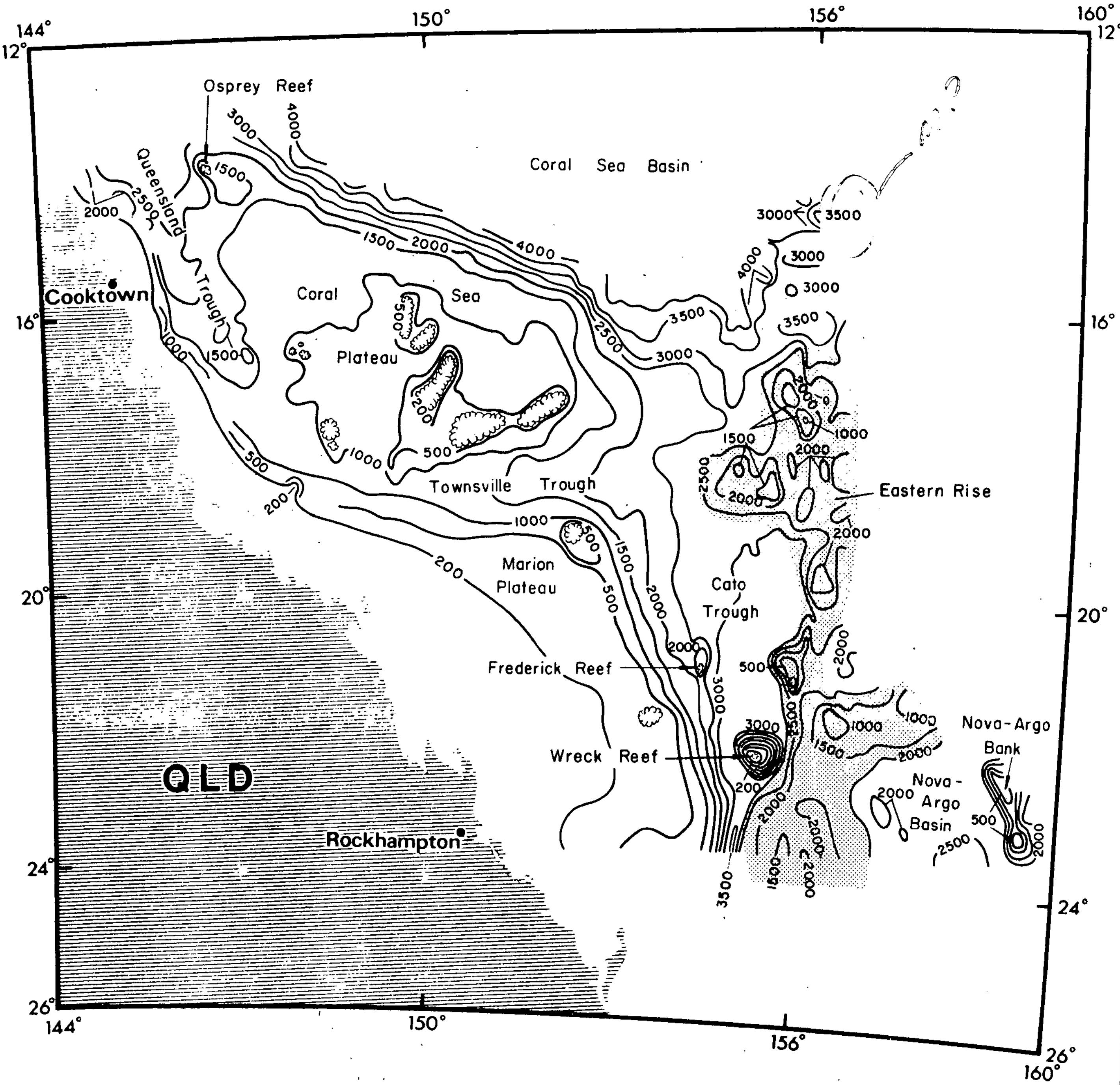
To accompany Record No. 1973/107

Q/B8-16A



PHYSIOGRAPHY

100 0 200 400 600 Km

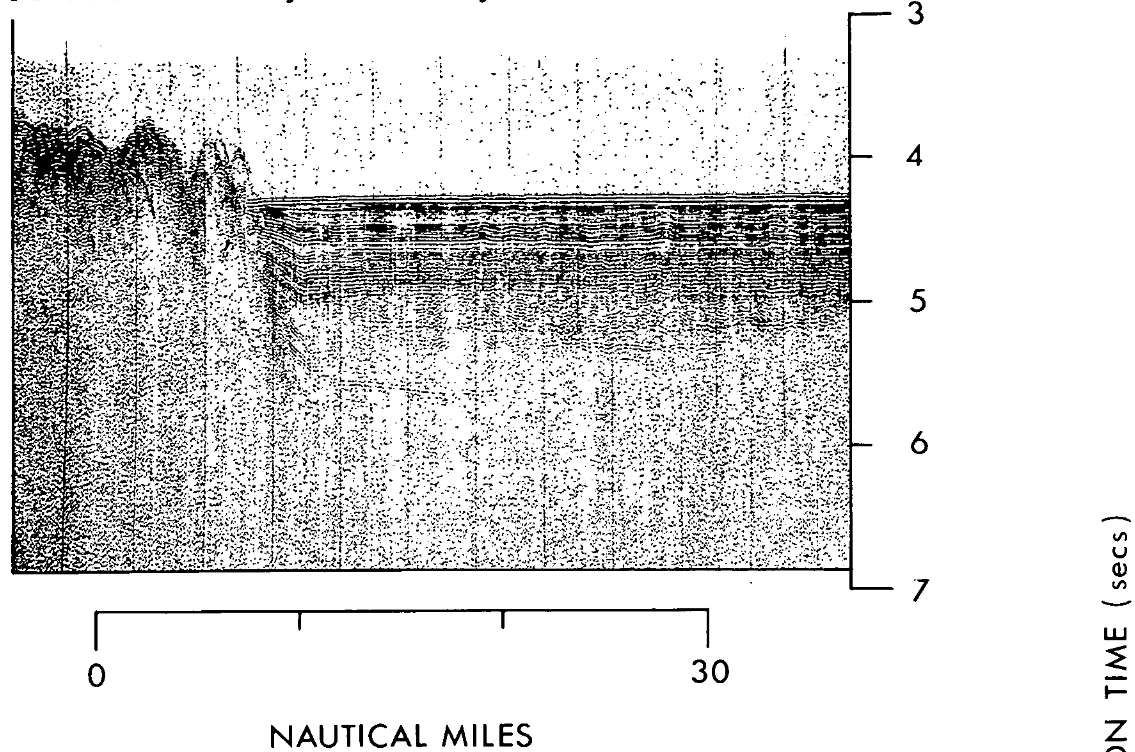
LEGEND

Reef

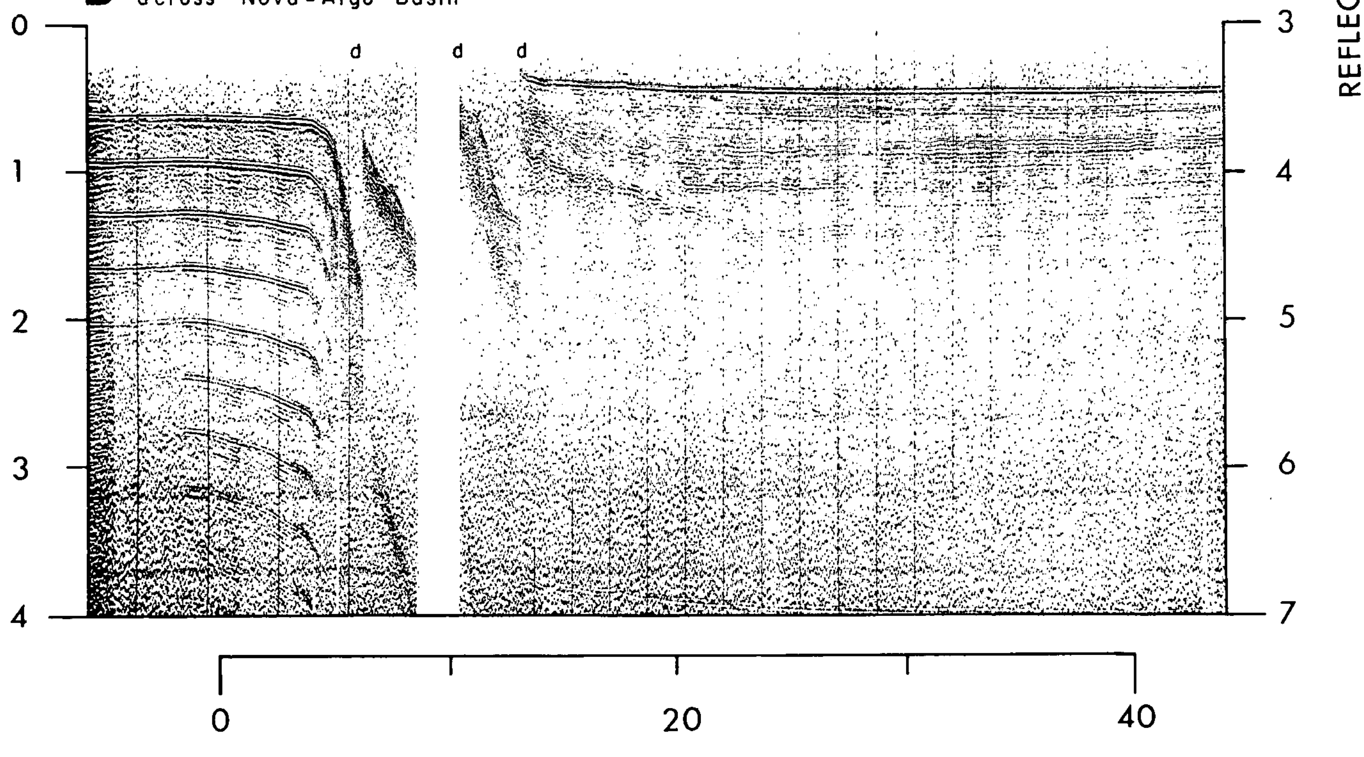
To accompany Record No. 1973/107

Q/B8-14A

A - across Cato Trough (Western Margin)



B - across Nova - Argo Basin



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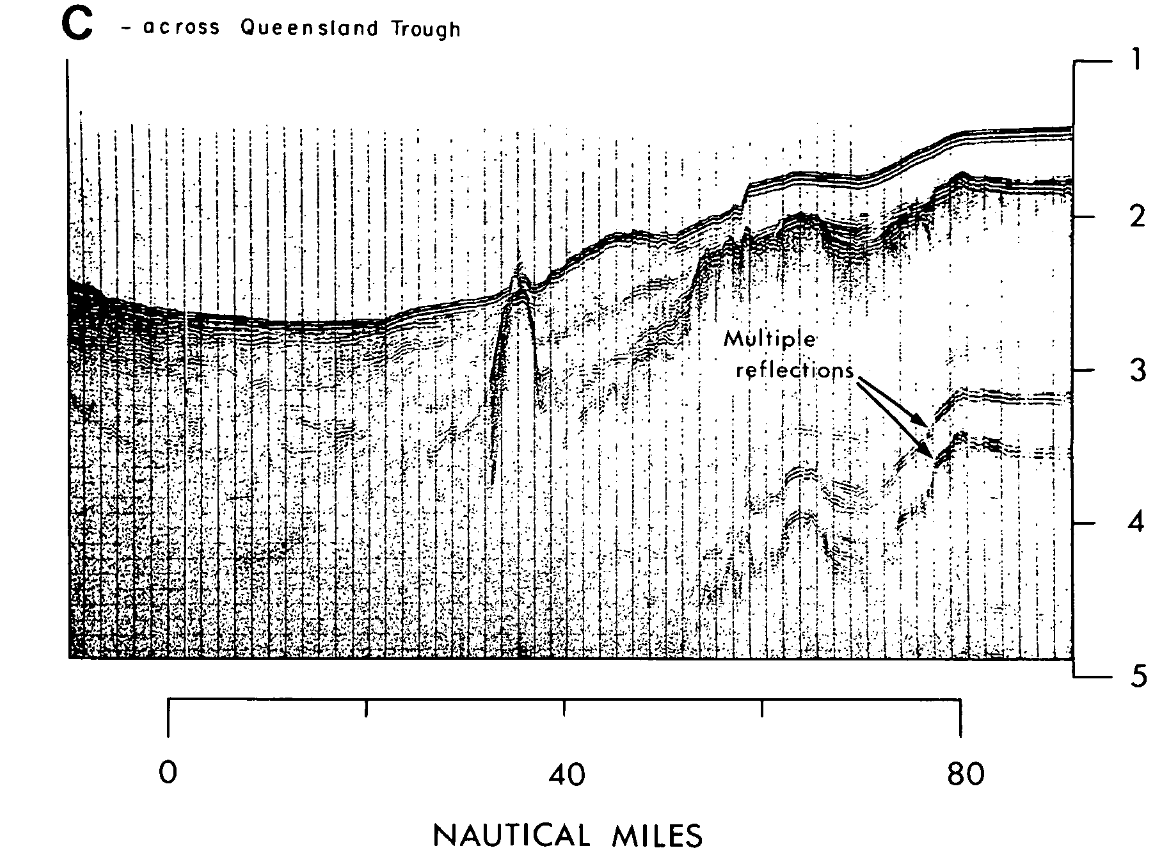
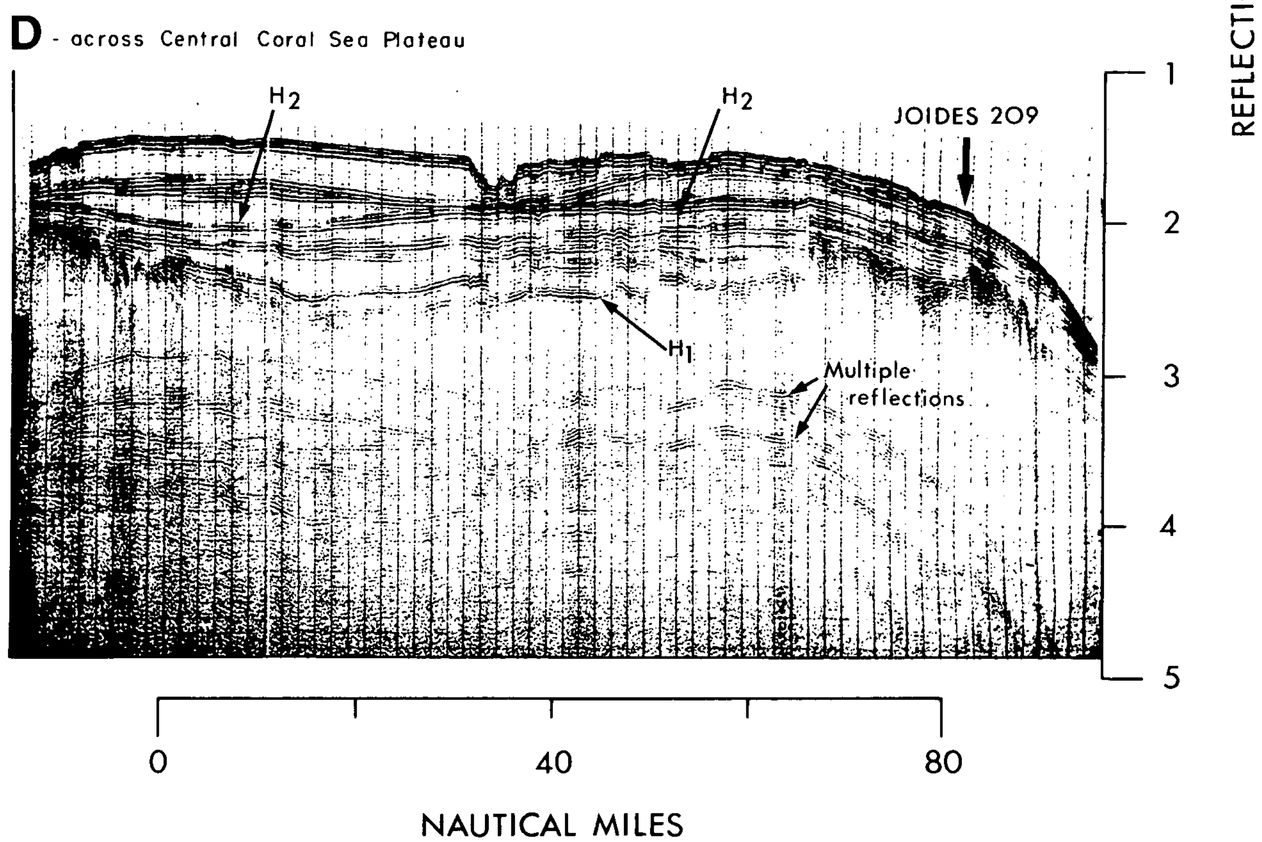
SEISMIC SECTIONS

To accompany Record No. 1973/107

Q/B8-17A

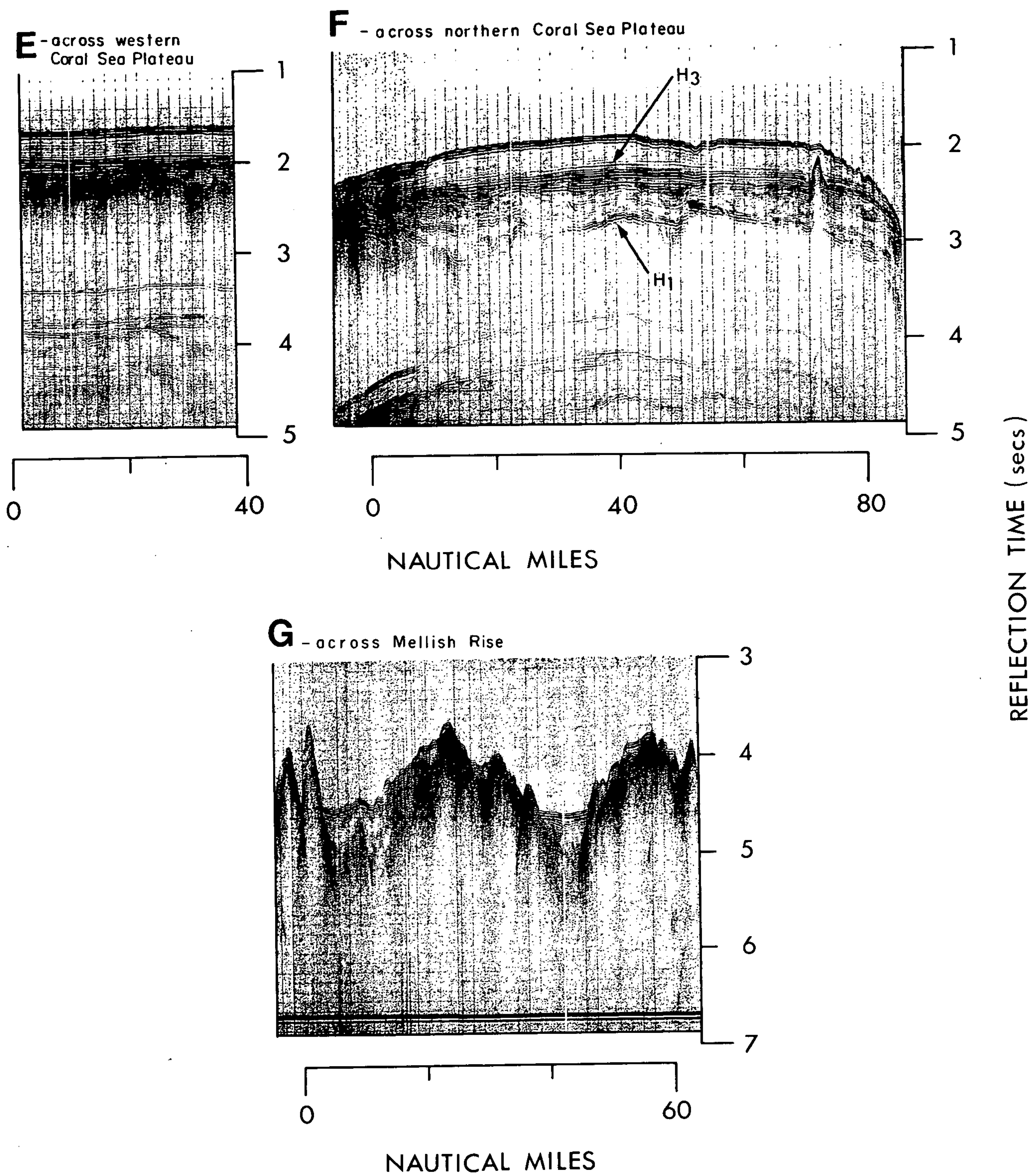




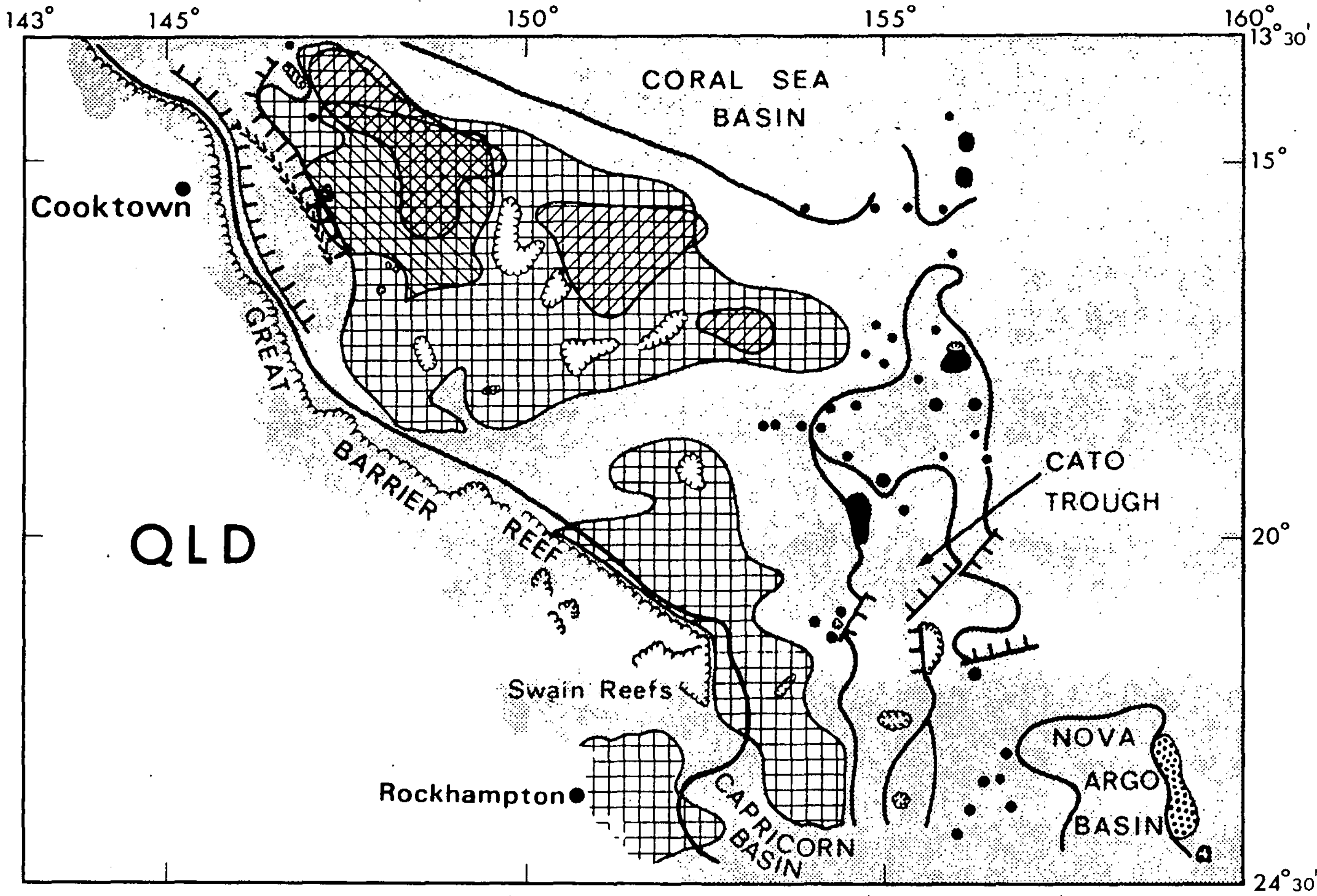
SEISMIC SECTIONS

To accompany Record No. 1973/107

Q/B8-18A



SEISMIC SECTIONS



LEGEND

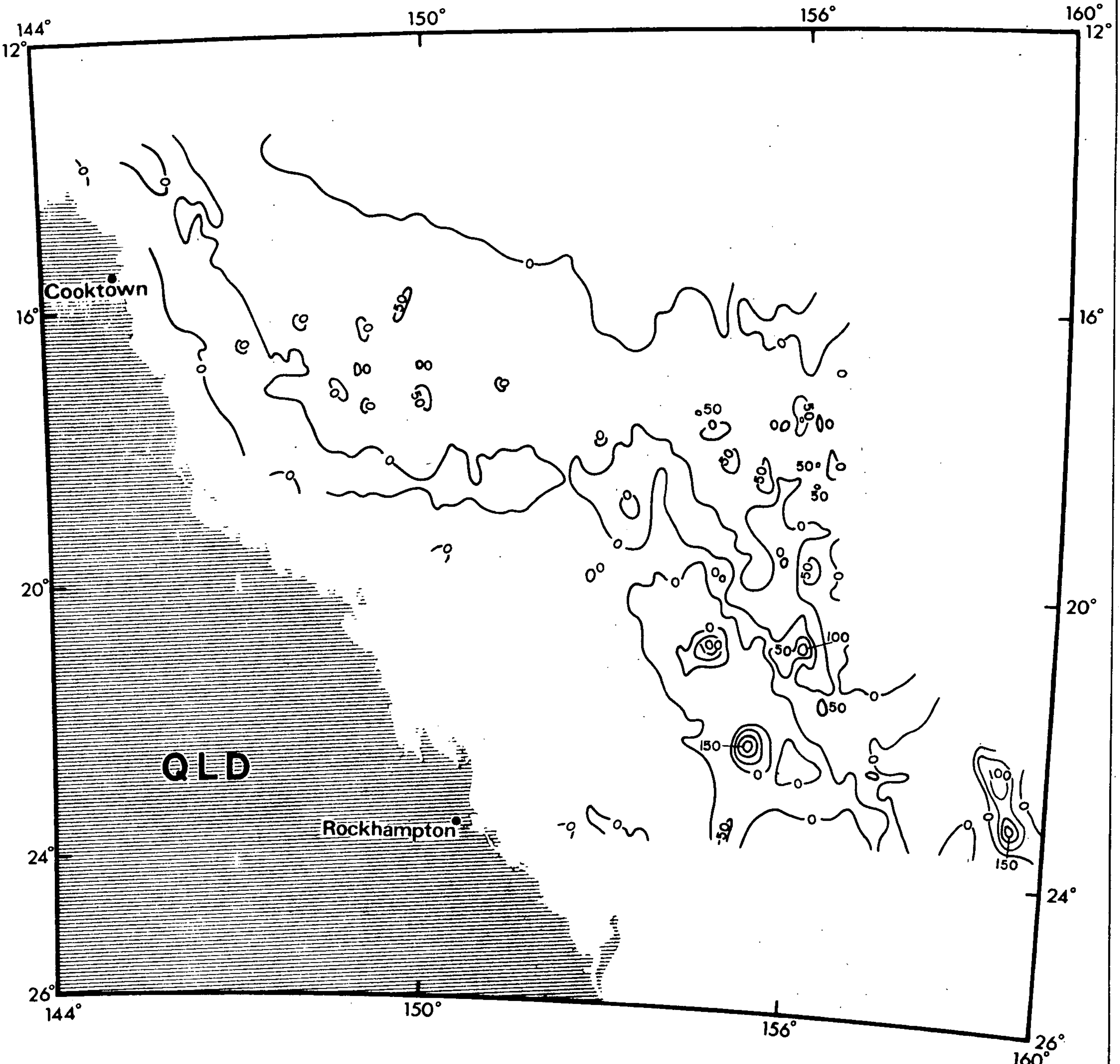
- H1 seismic reflecting horizon
- H2 seismic reflecting horizon
- H3 seismic reflecting horizon
- Guyot
- Structural boundary
- Major fault
- Intrusion
- Reef
- >>>>>>>>> Linear intrusion

REGIONAL STRUCTURES

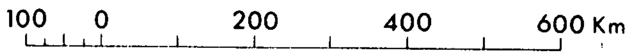
SCALE

100 0 100 200 300 400 500 600 KILOMETRES

PLATE 7



FREE-AIR ANOMALIES



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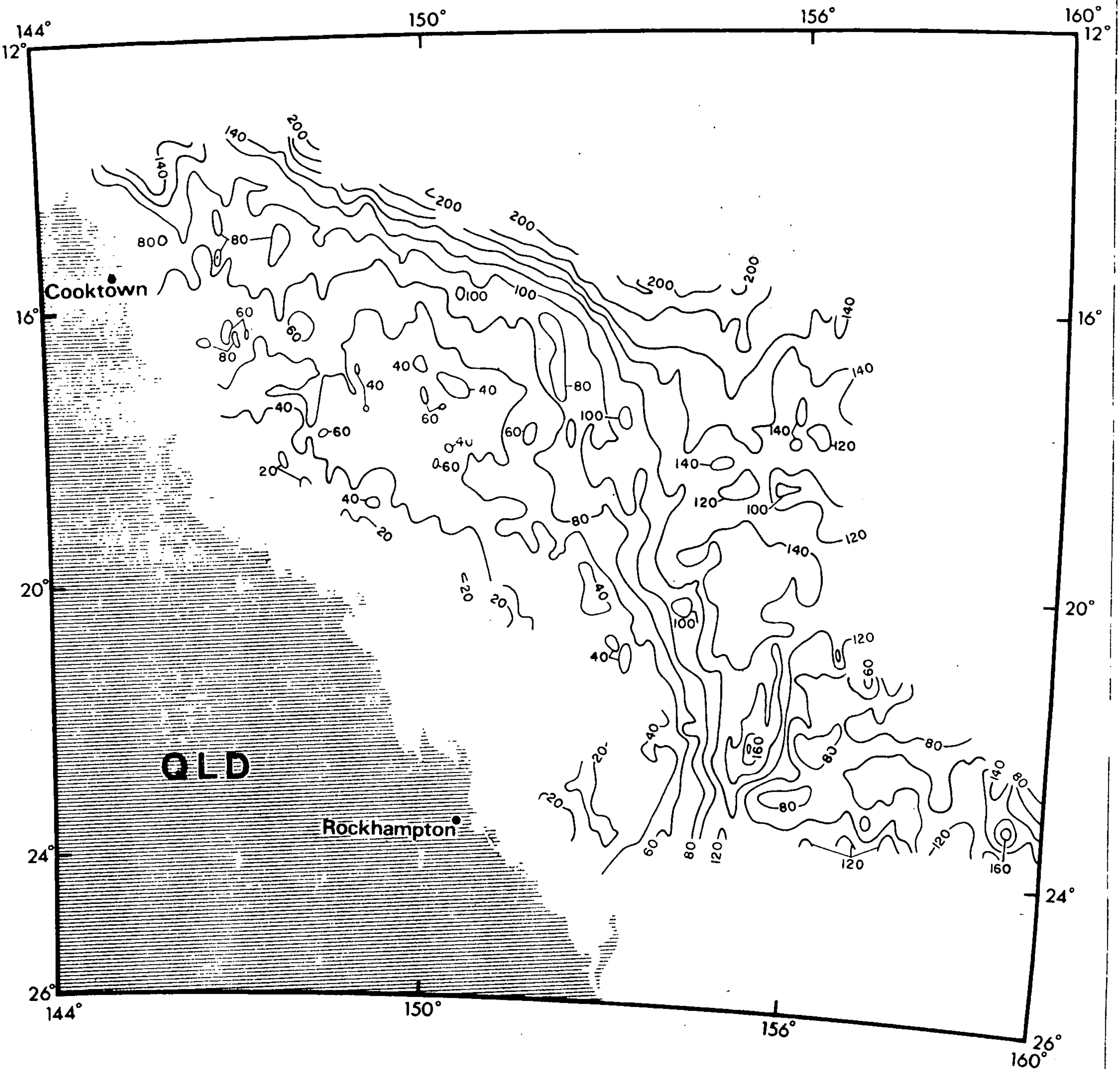

BOUGUER ANOMALIES

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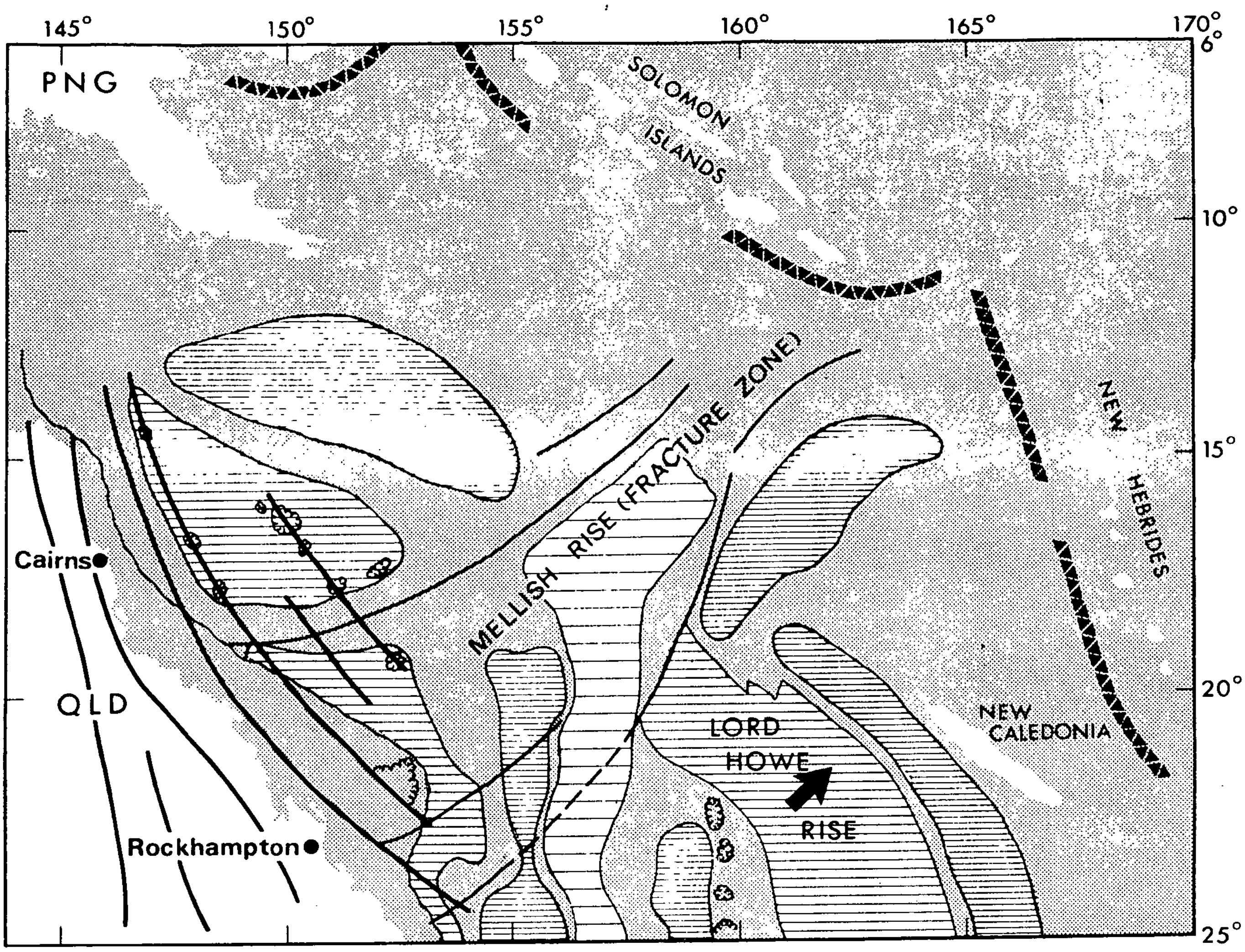

LEGEND

	Oceanic rise		Continental structural trend
	Submerged continental block		Oceanic structural trend
	Ocean basin		Edge of continental shelf
			Reef
	Trench		Direction of movement of Lord Howe Rise

STRUCTURAL SETTING OF QLD CONTINENTAL MARGIN

SCALE

100 0 200 400 600 800 KILOMETRES

To accompany Record No. 1973/107

Q/B8-12A