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SUBMERGED SHORELINES AND CHANNELS ON THE EAST AUSTRALIAN CONTINENTAL SHELF BETWEEN SANDY CAPE AND CAPE MORETON: HEAVY-MINERAL PROSPECTS

by

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SUMMARY

A detailed study of new bathymetric data has been undertaken with the objective of locating submerged shorelines and other features on the continental shelf, which may be associated with deposits of heavy minerals. The most widespread fossil shoreline occurs close to the edge of the shelf at a depth of 110 m. Less persistent changes of slope, some of which can be traced for several tens of kilometres, occur at depths ranging from 19 to 54 m. Extensive shallow linear depressions parallel to the present-day coastline were also identified in water depths of about 60 m; these represent submerged coastal lake systems.

Some reworking of beach dunes and their associated heavy-mineral seams must have occurred during the transgression of the sea. However, seams at lower levels in the ancient beach profiles may have been preserved, particularly if the rise in sea level was rapid, while heavy minerals in the higher dunes may have been redistributed to form blanket deposits. The latter are unlikely to include high-grade seams.

The linear depressions running along the inner shelf have trapped large volumes of sediment; they would form a secondary target in an exploration program, but the prospects of finding high-grade concentrations of heavy minerals do not appear to be good.

INTRODUCTION

Accurately positioned and closely spaced sounding lines across the continental shelf between the 20-m and 300-m isobaths recently obtained by the Division of National Mapping provide an important new source of data on the detailed physiography of the shelf. A study of the original echograms has been carried out with the objective of delineating features which may be related to submerged shorelines and other features possibly associated with deposits of heavy minerals.

The bathymetric survey of the continental shelf being carried out by contractors for the Division of National Mapping started in Queensland waters in mid-1971. The first of the original echograms made available for study by BMR were recorded during the first contract, Raydist chains 1, 4, and 5, and cover the continental shelf from Sandy Cape which is the northern tip of Fraser Island, to Cape Moreton near Brisbane, a distance of 260 km. In the southern half of this area, from Cape Moreton to Double Island Point (25°57'S), E-W sounding lines were spaced 1.5 km apart; from Double Island Point to Sandy Cape the interval was increased to 3 km, except for limited areas where the 1.5-km spacing was retained. A few diagonal tie-lines were also run (Fig. 1).

The contractors for this part of the survey, Australian Maritime Surveys, employed an Edo echosounder consisting of a Model 578 recorder and a Model 480 transducer. This instrument used a 38 KHz acoustic source with a peak power output of 150 W and a pulse length of 1 ms or 1.5 ms. The straight-line recorder had a sweep of 65 feet or 65 fathoms (20 m or 119 m) over a paper width of 15.5 cm. Scale was adjustable in four steps down to 280 fm (512 m). At the ships speeds and paper feed rate employed during the survey, vertical exaggeration of scale on the echograms is about x45 on the foot scale and x15 on the fathom scale. Use of the foot scale was restricted to the inshore end of the traverses in water depths less than 35 m.

The quality of the echograms was usually good, although identification of small-scale irregularities of the sea bed was sometimes made difficult by undulations of the trace caused by sea state.

The contractors were required to carry out bar checks twice daily, and to maintain sounding accuracy within plus or minus 1 percent. Depths were corrected to Mean Sea Level, the normal topographic map datum, rather than to the datum used on Australian and British Admiralty charts, which is close to Lower Water Springs; in the context of this work, the difference between the two is not significant.

Positioning was carried out by Raydist, a medium-range radio system in which the phases of two continuous-wave signals are compared. Under the terms of the contract, positioning accuracy was required to average 100 m, seldom to exceed 200 m, and never to exceed 300 m. Data compiled by the Instrument Division of the U.S. Coast and Geodetic Survey indicate that the Raydist system achieves a much higher order of accuracy than this, and there is no evidence to suggest that positioning errors exceeded those specified.

REGIONAL MORPHOLOGY

The shelf break zone

Off Sandy Cape the continental shelf is 22 km wide, broadening southwards to a maximum width of 78 km between Double Island Point and Noosa Heads, and then narrowing again to 48 km at 27°S, the southern margin of the area (Fig. 2). If Moreton Island is considered to be part of the continent, the shelf is only 20 km wide at this point. These distances are measured from the shoreline to the 200-m bathymetric contour, and are usually slightly greater than those measured to shelf break, in so far as the latter can be identified. The shelf break, which is the point where an increase in gradient at the outer edge of the essentially flat continental shelf marks the commencement of the continental slope, is at a depth of 60 to 90 m off Fraser Island, but to the south it is difficult to delineate with any accuracy; south of Fraser Island there is a gradual increase in gradient between 110 and 170 m, but the first marked steepening does not occur until a depth of 220 to 300 m is reached. The changes in depth and character of the shelf break over the relatively small area covered by this survey are illustrated by three representative profiles shown in Figure 3. Even where the shelf break is clearly defined, as in line 153, there is a further increase in slope in deeper water, marking the top of the continental slope proper and in this case a deep-water terrace is present. Thus everywhere along this stretch of continental margin there is a zone, usually poorly defined, separating the true continental shelf from the true continental slope. Marshall (1972), using data from widely spaced but deeper-water bathymetric profiles and the Hydrographic Office Oceanic Soundings Sheets, tentatively describes this zone as a marginal plateau or upper continental slope and states that its seaward margin is as deep as 600 m off the southern part of Fraser Island. Soundings used in the present study do not extend below 300 m, and although further steepening may occur in deeper water, almost all the profiles examined show some increase in gradient at about 250 m.

As noted by Marshall (1972) in this area, and on the Northwest Shelf by Jones (in press), the depth and character of the shelf/slope boundary bear no relation to the terraces and notches associated with Pleistocene low sea levels which maintain an almost constant depth.

The deeply submerged terrace on the upper continental slope, well displayed in line 153 (Fig. 3), can be recognized over much of the area and maintains a fairly constant depth. Its inner edge ranges from 210 to 274 m, and its outer edge, which coincides with the top of the true continental slope, ranges from 240 m to over 300 m (600 m according to Marshall, 1972). Seismic evidence shows that this terrace is structurally controlled; its surface is formed by the outcrop of a prominent reflector which can be traced sub-surface landwards under a thickening prism of sediment (Fig. 4). It is unlikely that this terrace is in any way connected with erosional processes associated with low sea levels.

Submarine canyons

East of Noosa Heads, the upper continental slope is dissected by a submarine canyon, here named the Noosa Canyon. The head of the Noosa Canyon was crossed by one of the offshore tie-lines at 26.33°S, 153.85°E; it presents the typical steep-walled flat-floored profile of these features and at this point the floor is 27 m below the rim which is at a depth of 183 m. It is the only canyon in the region whose head reaches as far up slope as the edge of the shelf, although at least two others heading in deeper water have been identified off Fraser Island by Marshall (1972). It is likely that they all form part of a single system.

Channels on the shelf

There appear to be no major channels related to an ancient subaerial drainage system crossing the shelf from west to east. The orientation of the sounding traverses is not favourable for locating linear E-W features, but the traverses are sufficiently closely spaced and there are enough tie-lines to make it extremely improbable that any significant channels were missed. A number of shallow linear depressions are present, the most important of which follows a sinuous course roughly parallel to the coast for a distance of 45 km between Double Island Point and Noosa Heads (Pl. 1 & Fig. 2). It is a very subdued feature several kilometres wide and its axis is nowhere more than 5 m below the level of the adjoining shelf. The axis of the trough maintains an almost constant depth close to 60 m over its length, and there is little doubt that it represents a drowned coastal channel, lagoon, or swamp similar to those along the present-day coast. The other depressions mapped are similar in general characteristics, except for the rather short channel at the entrance to Moreton Bay, which is probably related to erosion by the Brisbane River during a period of lowered sea level.

Banks on the shelf

North Gardner Bank, Gardner Bank, and Barwon Bank rise a maximum of 30 m above the general level of the surrounding shelf, and have least water depths over them of 22 to 26 m. In addition to these, a number of other elevated areas are of significant extent (Fig. 2). All are very subdued features rising only a few metres above the surrounding shelf. Barwon Bank is one of several low irregular ridges which run for considerable distances parallel to the edge of the shelf, close to the break in slope. The shallow seismic profiles obtained by BMR in 1970 in this area normally achieved little penetration beneath the ridges which apparently consist of banks of poorly stratified coarse sand and shells.

SUBMERGED SHORELINES

Apart from local areas of rough topography formed by the banks and shelf-edge ridges described above, most of the area of the continental shelf consists of a smooth almost flat surface standing between 50 and 70 m below sea level. Gradients on this broad terrace are commonly 1:1000 or less, but on both its landward and seaward sides one or more narrow linear zones of relatively steep gradient are aligned more or less parallel to the coast. There is a high probability that these features represent drowned shorelines formed during periods of static sea level which occurred in the transgressive and regressive cycles of the Quaternary. Most are probably associated with still-stands of sea level during the last (Holocene) transgression as it seems unlikely that such features in unconsolidated shelf sediments would escape obliteration by erosion and sedimentation if formed earlier. As it is, their surface expression on the present-day sea floor is usually very subdued, and the gradients are extremely low. The three forms they commonly present in profile are diagrammatically illustrated, with exaggerated vertical scale, in Figure 5. In the case of profiles A and B, the inshore limit of the lower terrace, or the base of the change of slope, is fairly clearly defined. However, in the case of C there is a gradual change of gradient extending over a considerable distance and it is not possible to delineate this feature accurately.

The distribution of the changes of slope identified in the profiles examined is shown in Plate 1. The deepest of these features is also the most persistent; it maintains a depth of 104 to 118 m over the whole area and is recognizable everywhere except for a small region east of Noosa Heads and close to Gardner Bank. It can be seen in each of the three profiles across the edge of the shelf illustrated in Figure 2. East of Noosa Heads the shelf-edge topography is modified by Noosa Canyon which accounts for the absence of the notch; in the Gardner Bank area the shelf-edge is steep and rough and the single well-defined notch at about 110 m splits into several poorly defined features above and below this depth.

None of the changes of slope in shallower waters is as persistent as the 110-m notch, although several can be traced for considerable distances. Off Fraser Island two prominent changes of slope each extend for about 70 km, virtually without a break; the deeper ranges in depth from 37 to 49 m and the shallower from 19 to 22 m. South of Double Island Point, the shallower change in slope reappears and can be traced for a further 45 km in water depths of 21 to 26 m. In the same area an extensive deeper change in slope is present at depths of 48 to 54 m in two areas over an aggregate distance of 80 km. In addition to these, several changes of slope are locally present at intermediate depths making a correlation of individual linear features difficult and the drawing of conclusions regarding warping of the shelf hazardous.

PROSPECTS FOR HEAVY-MINERAL DEPOSITS

The area of shelf described lies off the northern part of the east Australian coastal mineral sands province, but there is no evidence as yet that submarine deposits are present in this region. The pioneering offshore exploration work of Planet Metals Ltd during the late 1960s did not extend north of Southport, 100 km south of Cape Moreton. This company has reported that over 375 million tons of sand averaging 0.20 to 0.22 percent rutile plus zircon have been outlined by drilling off the central coast and a further 500 million tons indicated (Brown, 1971). Full descriptions have not been published, but there are apparently two types of deposit; a blanket type of unknown extent in which heavy minerals are present in the top 1.5 to 4.5 m overlying barren sand; and a seam type 3 to 4.5 m thick, 120 to 490 m wide, and up to 4.9 km long, which underlies 3 to 4.5 m of generally barren sand. Both types of deposit lie in water depths of about 30 m; it is assumed that they are associated with a fossil beach, but the company has not revealed whether this feature has any surface expression on the sea floor.

It is not known how and to what extent any heavy-mineral deposits which may have been associated with beaches now submerged would have been modified during and after the transgression of the sea. Clearly the wind-concentrated deposits at considerable elevations in the high dunes behind the present coast have no counterparts offshore; if such high dunes existed they were completely destroyed during the transgression, and their heavy-mineral content redistributed, as there is no vestige of these large features preserved on the present-day shelf. In addition, concentrating processes controlling the distribution of the onshore deposits are strongly influenced by rocky headlands of the modern coastline which form efficient sediment traps. The Holocene transgression took place across the flat featureless sediment-mantled continental shelf where there were no such coastline irregularities.

However, beach dunes must have been present along the ancient coastlines and with a rapid rise of sea level these would stand a chance of at least partial preservation. It is difficult to envisage conditions under which some reworking and down grading of heavy-mineral seams in the upper part of the beach profile would not have occurred, but deposits at lower levels could well have been unaffected.

In the absence of any subsurface information from drilling, conclusions on the offshore heavy-mineral prospects must be speculative. However, it is reasonable to predict that in the area of the submerged shorelines there are rather extensive blanket deposits, probably of low grade, which represent the reworked heavy-mineral seams formerly held in the high dunes and in the upper part of the beach dunes. In the same areas, higher-grade seams originally occurring at lower levels in the ancient beach profiles may be preserved more or less unaltered.

Another possible target is the series of shallow linear depressions on the inner shelf. Presumably these must have formed coastal swamps and lakes on the landward side of the beach dune system during the period of lowered sea level. With rising sea level and landward movement of the paralic sediment wedge, including the beach dunes and contained heavy minerals, these depressions would have formed efficient sediment traps. Local concentrations of heavy minerals may have been formed by current scour, but it is not easy to reconstruct a situation in which large high-grade deposits could have formed.

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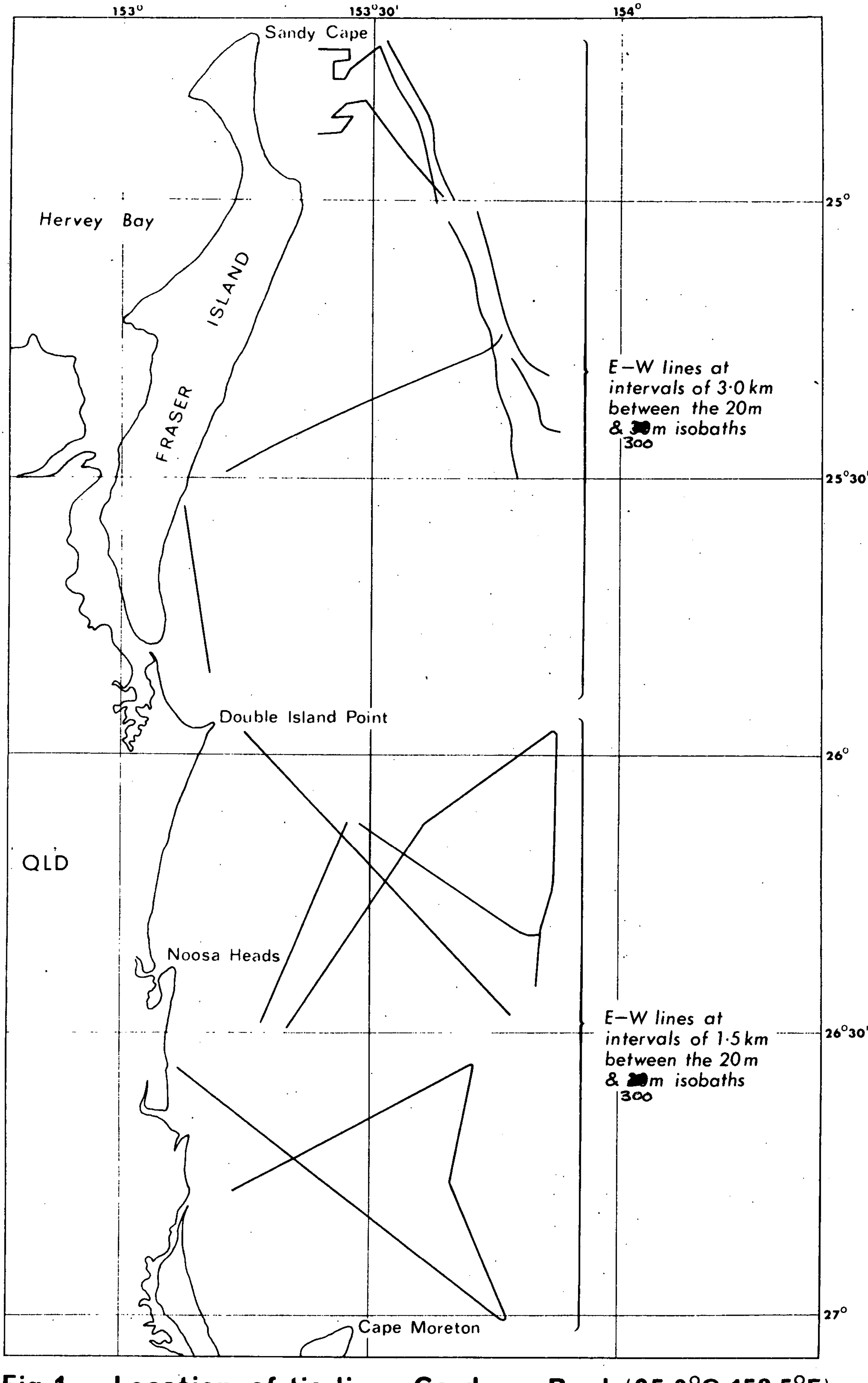

Fig.1 Location of tie-lines. Gardner-Bank (25·0°S, 153·5°E) was surveyed at 1·5-km line spacing

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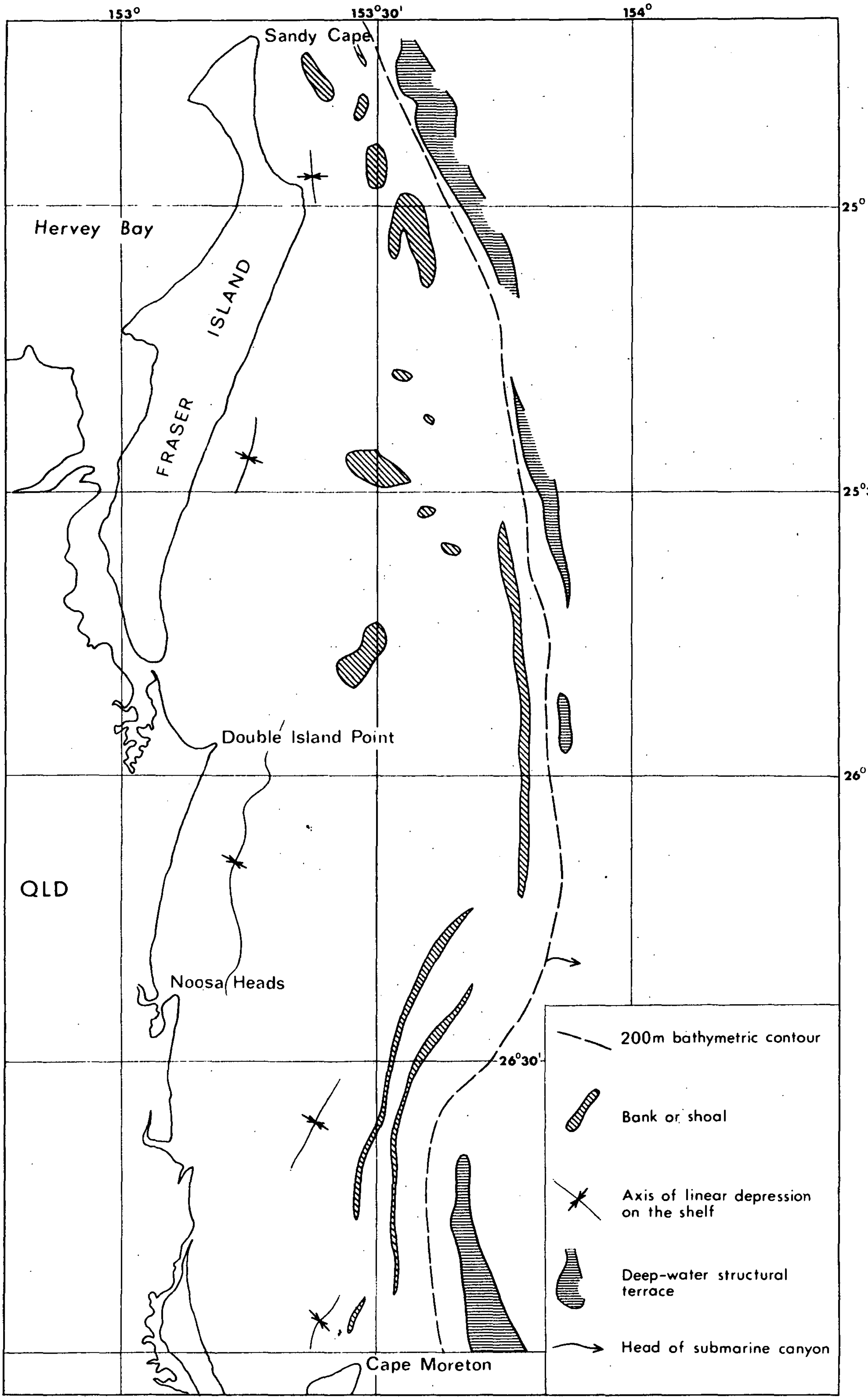

Fig. 2 Major morphological features of the shelf and upper slope

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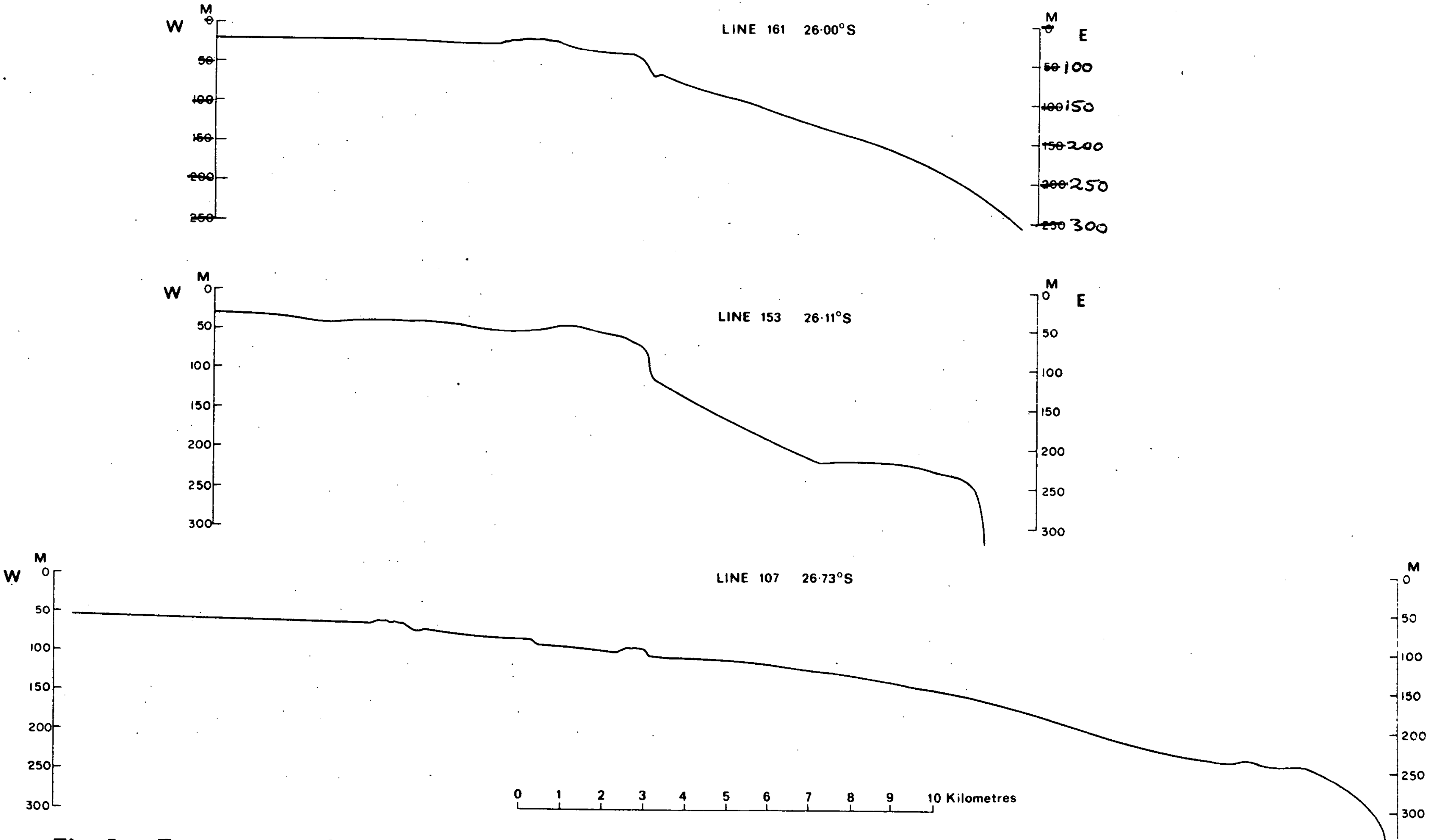

Fig. 3 Representative east–west profiles across the continental shelf

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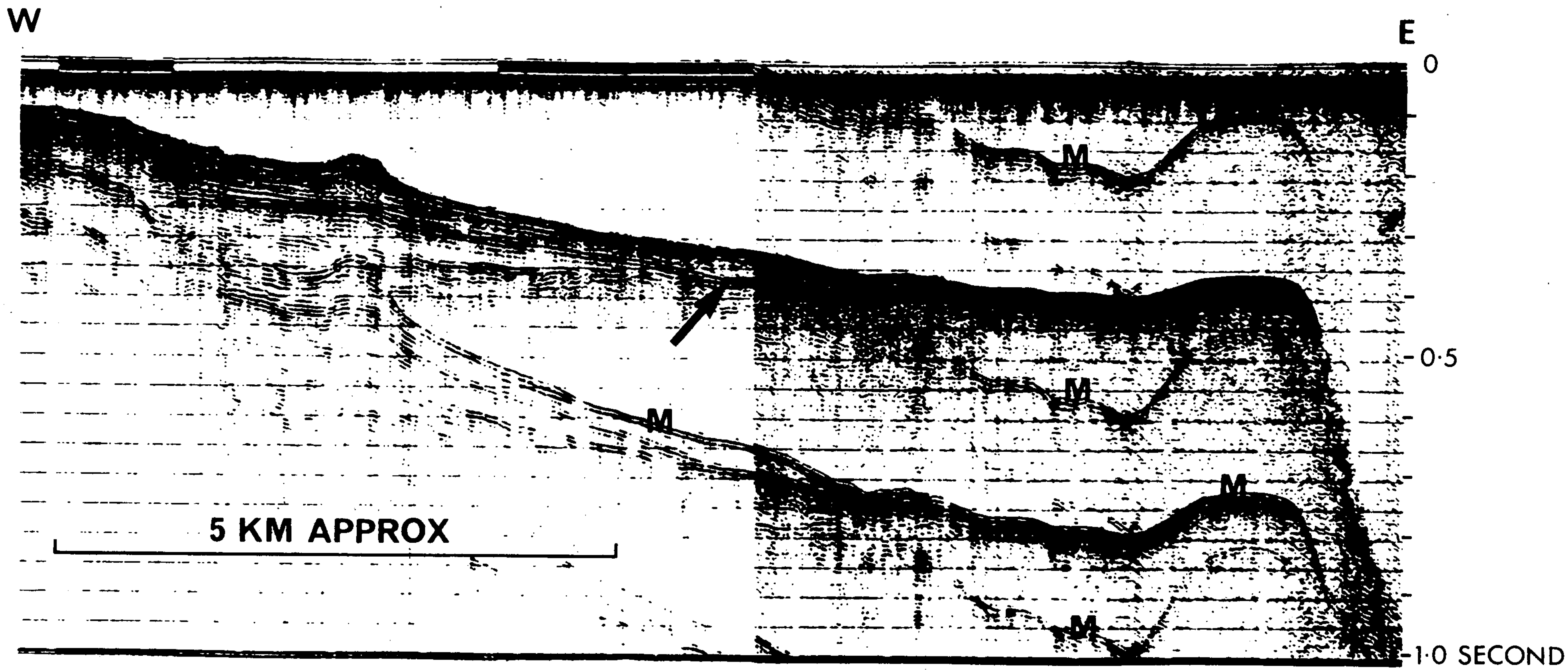

Fig 4 East–West seismic profile across the edge of the shelf at about 25°S Arrowed reflector crops out on the sea floor at the right hand side of the section. Prominent multiples are indicated by "M"

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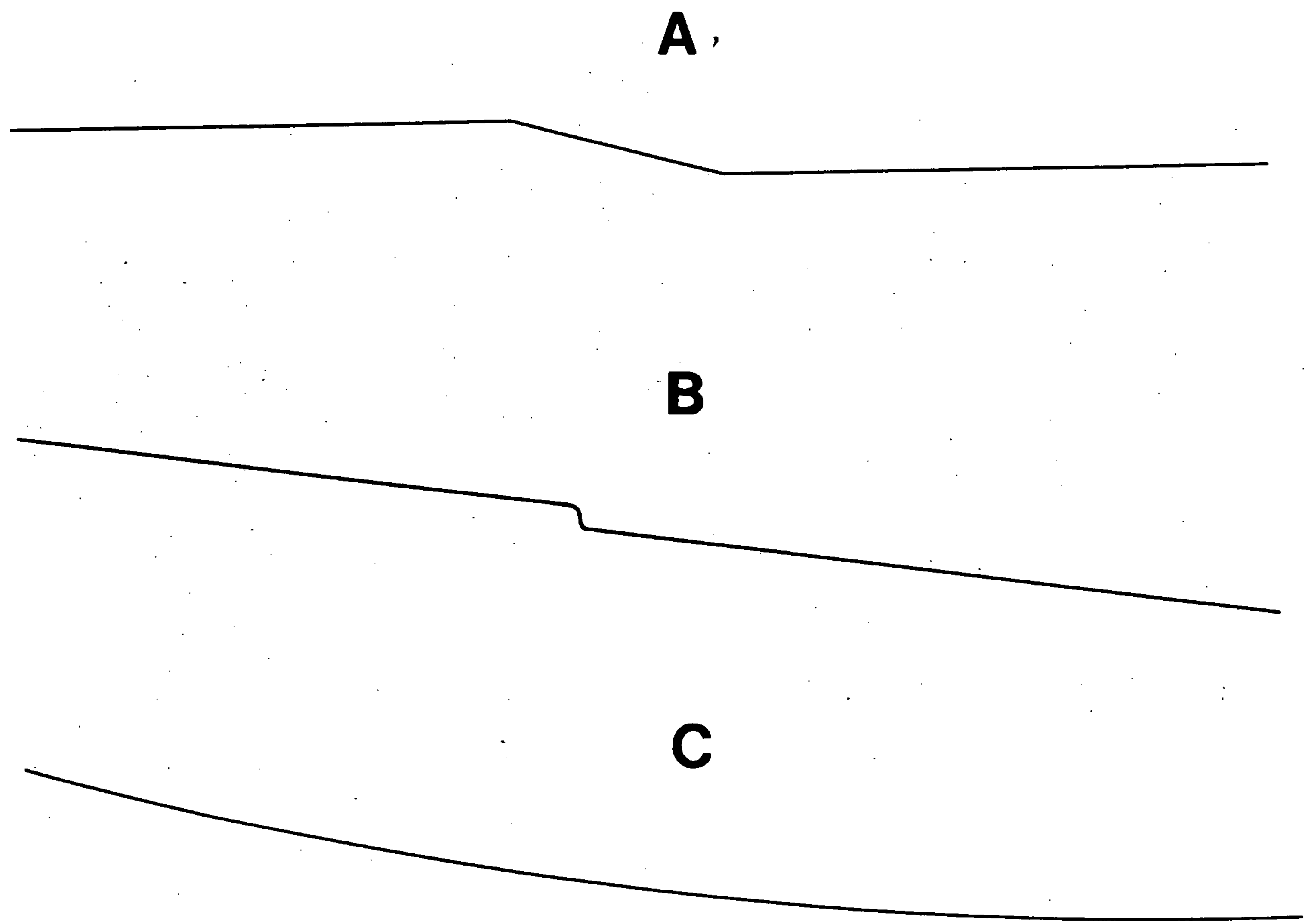

Fig. 5 Diagrammatic profiles illustrating the three basic types of feature interpreted as submerged shorelines

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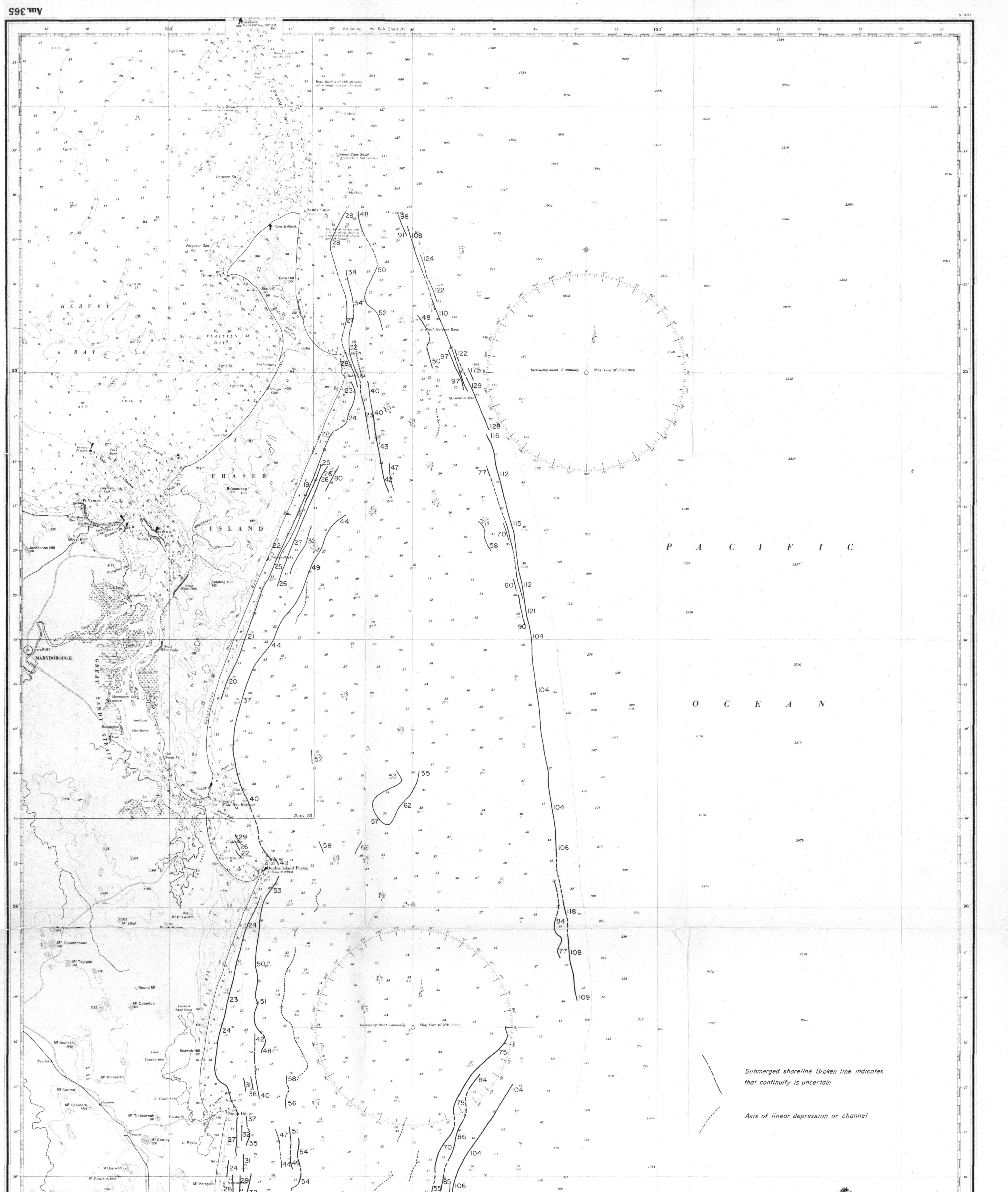

PLATE I DISTRIBUTION OF SUBMERGED SHORELINES SHOWING DEPTH TO BASE OF CHANGE OF SLOPE IN METRES.
CHART SOUNDINGS ARE IN FATHOMS

To accompany Record 1973/46