OCEAN DRILLING PROGRAM

LEG 133 SCIENTIFIC PROSPECTUS

NORTHEAST AUSTRALIAN MARGIN

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ABSTRACT

Five physiographic regions define offshore northeastern Australia: the platforms of the Great Barrier Reef and the Queensland and Marion plateaus, and the basins of the Queensland and Townsville troughs. Drilling off northeastern Australia will allow detailed study of the evolution of these carbonate platforms and adjacent basins. Leg 133 will sample Oligocene to Holocene sediments at 12 sites along 2 transects. Specific objectives are:

1. To define the sedimentary response to global sea-level change in the Late Cenozoic and, in particular, the Quaternary.

2. To define the influences of paleochemistry, paleoclimate, and paleoceanography on the initiation, growth, and demise of carbonate platforms, particularly the Great Barrier Reef.

This information will have a substantial impact on our understanding of the mechanisms and causes of natural climatic change.

Subsidiary objectives include the following:

1. To define slope-to-basin stratigraphic and facies variations on both sides of rift basins.

2. To define the diagenetic history and processes operating on pure carbonate and mixed carbonate/siliciclastic margins.

Leg 133 will leave Guam on 10 August 1990 and terminate in Townsville, Australia, on 11 October 11 1990.

NORTHEAST AUSTRALIA - REGIONAL SETTING

The passive continental margin off northeastern Australia extends over a distance of some 2000 km and an area of 930,000 km^2. It comprises the coast and shelf occupied by the Great Barrier Reef and a number of carbonate-dominated marginal plateaus and troughs (Fig. 1). This section describes the physiography and geology of this margin.

Onshore Geology

The coastal regions of Queensland are underlain by rocks of the Paleozoic Tasman Fold Belt, which extends from Tasmania in the south to Papua New Guinea in the north (Brown et al., 1968). The western border of the fold belt consists of Precambrian metamorphics which, in the north at least, are separated from the Paleozoic sediments to the east by a major fault - the Palmerville Fault (Willmott et al., 1973) (Fig. 2). "Geosynclinal" sedimentation commenced in the Early Devonian in the Hodgkinson Basin and continued through to the Carboniferous, interrupted by a number of orogenies.

Relative to the width of the New England and Lachlan fold belts to the south, an extensive area of the Tasman Fold Belt in northern Queensland appears to be absent. This has led to the interpretation that the missing Middle-Upper Paleozoic rocks lie beneath the Queensland Plateau (Ewing et al., 1970).

Packham (1973) interpreted the development of the eastern Australian region in terms of a stepwise easterly growth of the continent outward from the Precambrian nucleus by development and accretion of Andean-type continental margins during the Ordovician-Permian. The easternmost portion of the fold belt off southeastern Australia has since been dismembered by seafloor spreading in the Tasman Sea during the Late Cretaceous.

The Mesozoic-Holocene geological history of Queensland is one of terrestrial to marginal marine sedimentation in basins and troughs bordering the Queensland coast. A major hiatus is present in all onshore basins separating Lower Cretaceous sediments from upper Tertiary-Holocene terrestrial deposits, which infill depressions in the old land surface. The only known possible Upper Cretaceous deposits are found in the offshore Capricorn Basin (Ericson, 1976). A thick section of nonmarine sediments was deposited during the early Tertiary in the Hillsborough Basin, and similar age sediments containing oil shales are found near Gladstone (Fig. 2). In the Capricorn Basin this sequence is unconformably overlain by upper Oligocene marginal-marine quartzose sands, which are in turn overlain by a Miocene-Holocene marine calcareous shelf facies, including coral reefs.

Offshore Physiography

The area of interest for Leg 133 (Fig. 1) is the southwestern part of the Coral Sea, seaward of the Great Barrier Reef. The main regional physiographic elements are the Great Barrier Reef and adjacent slope, the Queensland and Marion plateaus, the Queensland and Townsville troughs, the Cato Trough, and the Capricorn Channel (Figs. 1, 2).

The continental shelf is dominated by the Great Barrier Reef and reaches a maximum width of about 350 km in the southernmost part of the region at about 22°S. The shelf break occurs at 100-200 m. The slope of the Great Barrier Reef is steeply dipping and canyoned in the northern part of the area, particularly adjacent to the Ribbon Reefs marking the outer reef edge north of Cairns; the slope decreases in the vicinity of Townsville and becomes very gentle adjacent to the Marion Plateau.

The Queensland Plateau is the largest marginal plateau of the Australian continental margin, being nearly twice as large as the Exmouth Plateau. The plateau is roughly triangular with its western margin striking north-northwest, its northeastern margin facing the Coral Sea Basin and striking northwest, and its southern margin striking east-west. The western and southern margins are both bounded by linear troughs. Many valleys and canyons lead from the plateau surface into the bounding troughs and the Coral Sea Basin. The plateau surface lies at a depth of 1100 m, and away from reef areas is generally very smooth and flat. It exhibits a very gentle northwest tilt, its surface being most deeply submerged around Osprey Reef. Fairbridge (1950) observed that the Queensland Plateau reefs grow from as much as 1500 m below sea level, well beyond the normal ecological limit of reef growth, and this led him to suggest that the plateau had subsided to its present depth from an initial elevation close to sea level, with reef growth keeping pace with subsidence.

The Queensland Trough occupies the region between the continental shelf and the Queensland Plateau between 14°S and 17°30'S, adjacent to the Great Barrier Reef. Its western margin is much steeper than its eastern margin, with gradients up to 1:3 (at 15°S). The trough has a smooth, flat floor that gently deepens to the north-northwest from about 1100 m at its junction with the Townsville Trough. It joins the Osprey Embayment region at a depth of about 300 m between the Queensland and Eastern plateaus. The strike of the trough is that of the dominant structural grain of the Tasman Fold Belt in northern Queensland (Hill and Denmead, 1960).

The Townsville Trough has no clear relation to any known structure onshore, being roughly perpendicular to the main Tasman Fold Belt trend. Falvey (1972) suggested that part of the trough appears to be an offshore continuation of onshore Devonian to Carboniferous trends. Mutter (1977) pointed out that it is equally possible that the trough reflects trends such as those of the Mellish Rise to the east. The trough has a symmetric U-shaped profile that is maintained over most of its length. At its eastern end, at about 154°E, a bifurcation sends one branch south into the Cato Trough and the other winding sinuously north into the Coral Sea Basin. Mutter (1977) speculated that sediment derived from the Queensland Plateau or mainland Queensland could reach the deep ocean floor via the Townsville Trough.

The 77,000-km^2 area of the Marion Plateau lies directly east of the central Great Barrier Reef and is bounded along its northern margin by the Townsville Trough and along its eastern margin by the Cato Trough (Figs. 1, 2). The present plateau surface forms a deeper water extension of the Australian continental shelf, with water depths ranging from 100 m along the western border to 500 m along the eastern margin. At present, reef growth is restricted to Marion Reef on the northeastern corner and Saumarez Reef at the southeastern extremity of the plateau (Fig. 1). The plateau may be considered to extend south of Saumarez Reef to include the Capricorn Channel area (Marshall, 1977). Its eastern margin is formed by the slope leading down to the Cato Trough. This margin has a moderate grade and is cut by numerous canyons.

Offshore Stratigraphic Control

The most important sources of stratigraphic control in the region are the industry and scientific wells drilled at Anchor Cay, Michaelmas Cay, Aquarius 1, Capricorn 1A, Wreck Island-1, and Heron Island, and at DSDP Sites 209, 210, and 287 (Fig. 2).

The Anchor Cay No. 1 well was drilled to a depth of 3623.5 m (11,888 ft) by Tenneco-Signal in 1969. Two major unconformities representing the late Oligocene and the middle to late Miocene separate three carbonate sequences (i.e., temperate Eocene limestones, subtropical upper Oligocene to lower Miocene limestones, and tropical upper Miocene-Pliocene limestones). The Quaternary section is composed of mixed prograding fluvioclastics and carbonates.

Wreck Island-1, in the Capricorn Basin, reached a total depth of 579 m after penetrating 31 m of siliceous volcanic conglomerates. The most significant result was the identification of Miocene carbonates and clastics -- proof of a Tertiary marine basin in the area. Two industry exploration wells (Capricorn 1A and Aquarius 1) were drilled in the

Capricorn Basin, adjacent to the southern Marion Plateau (Fig. 2). Basement consists of Cretaceous volcanics in Capricorn 1A (at 1710 m) and indurated ?Paleozoic shale and siltstone in Aquarius 1 (at 2658 m). In both wells, basement is overlain in turn by Paleocene to mid-Oligocene basal polymictic conglomerate and arkosic red beds, by shallow-marine glauconitic and carbonaceous sandstones, and by Miocene to Holocene claystone and marl (Fig. 3) (Ericson, 1976). The most important deep-sea geological data are the three drill sites of the Deep Sea Drilling Project (DSDP), drilled during Legs 21 and 30. DSDP Site 209 was drilled on the eastern Queensland Plateau in 1428 m of water and penetrated three lithologic units (Fig. 3). It bottomed in upper bathyal to neritic upper middle Eocene glauconite-bearing bioclastic and foraminifer-rich sediment. The overlying unit (uppermost middle to upper Eocene) is composed of terrigenous detritus and foraminiferal ooze, indicating subsidence of the margin. A major hiatus represents the late Eocene to late Oligocene and is probably the result of nondeposition and/or slight submarine erosion. This was followed by further subsidence to the present mid-bathyal depths and the deposition of almost pure foraminifer and nannofossil ooze from the late Oligocene to the present, although with a period of nondeposition or erosion during the middle Miocene.

The most important points to emerge from the data are:

1. The site clearly records the history of subsidence of the Queensland Plateau from shallow water (neritic) in the late middle Eocene to the present depth at the site of 1428 m (mid-bathyal).

2. Sediments are dominantly foraminifer ooze throughout with terrigenous content in the cores decreasing in the upper units, particularly in the middle to upper Eocene.

3. A major period of nondeposition or submarine erosion spans most of the Oligocene. After this hiatus the sedimentary regime is almost purely pelagic carbonate ooze.

4. The effects of submarine current activity are well recorded.

The Eocene/Oligocene hiatus has been attributed to submarine erosion caused by either a major change in circulation patterns following the final separation of Australia from Antarctica in the early Eocene (Kennett et al., 1972), or by the commencement of a significant equatorial circulation pattern (Taylor and Falvey, 1977). Winnowing is evident in the post-hiatus sediments, suggesting bottom-current activity. Depositional patterns (Mutter, 1977; Taylor and Falvey, 1977) also suggest the influence of currents on sedimentation.

DSDP Sites 210 and 287 in the central Coral Sea Basin penetrated essentially the same lithologic sequences. The more complete section was intersected at Site 210. The bottom part of the section is composed of lower to upper Eocene detrital clays and biogenic pelagic sediment that accumulated above the foraminifer solution depth. The clays are thought to have been derived from high-grade metamorphics and volcanics to the west (Burns et al., 1973). Deposition was interrupted in the late Eocene to early Oligocene by an erosional/nondepositional hiatus that is of regional extent and was caused by a marine bottom-water current (Kennett et al., 1972; Edwards, 1975). Mid-Oligocene nannofossil oozes were deposited near the carbonate compensation depth and overlie the unconformity;

these were followed by a late Oligocene to early Miocene period of nondeposition and/or erosion. Overlying this unconformity is a lower-middle Miocene abyssal clay that indicates deepening of the seafloor to below the carbonate compensation depth. The clays are thought to have been derived from the Papuan area to the northwest (Burns et al., 1973). During the late Miocene to late Pleistocene, turbidity currents deposited graded cycles of silt and clay with the sediment again being derived from sources in Papua New Guinea.

Nearly 700 core and dredge stations have been occupied over the northeast Australian margin, mostly by the Australian Bureau of Mineral Resources (BMR). They show that the deep-water parts of the margin are currently receiving pelagic sedimentation. Some areas near the Great Barrier Reef and near large reefs on the Queensland Plateau currently receive reef-derived debris. The Coral Sea and the troughs between the Gulf of Papua, the Eastern Plateau, and the Papuan Plateau receive terrigenous sediment at present, largely deposited as turbidites. Along the slope of the Great Barrier Reef, low-sea-level sedimentation is dominantly siliciclastic.

Tectonostratigraphic Framework

Townsville and Queensland Troughs

Structural style and seismic-sequence geometries determined from the 1985/87 BMR and industry data are consistent with the following tectonic history:

Pre-Breakup Development - Jurassic to Early Cretaceous

In the Jurassic to Early Cretaceous the northeast Australian continental margin, incorporating the present marginal plateaus and parts of Papua New Guinea, lay adjacent to the Pacific Plate. Continental to marginal-marine sediments of this age were deposited throughout the region in intracratonic downwarps (e.g., Laura Basin and the older part of the Papuan Basin). One of these elongate troughs of "infrarift" basins may have extended along the Queensland Trough and into the Townsville Trough to form the locus of future rifting. During the Early to Late Cretaceous (pre-Cenomanian) and possibly during the Late Jurassic (syn-rift phase), northwest-southwest extension resulted in the low-angle normal faulting and block rotation that initiated the Townsville Trough rift basin. Associated wrenching, and possible transtensional pull-apart basin development produced the Queensland Trough. The tectonism was probably accompanied by uplift in adjacent regions and by volcanism.

Continental Breakup - Late Cretaceous to Paleocene

In the Late Cretaceous, prior to the Paleocene-Eocene opening of the Coral Sea Basin, a northeast-southwest extensional event was probably superimposed on the region, resulting in reactivation and overprinting of the older basin-forming structures. During the period of Cretaceous extension/rift tectonism, continental, marginal-marine, and perhaps areas of very restricted shallow-marine sediments were deposited in developing half-grabens of the Townsville Trough. From the Late Cretaceous to early Paleocene (late rift phase), movement on the normal faults continued, but at a greatly reduced level. Some of the tilt blocks were capped and buried by late-rift-phase sediments, which exhibit flexural drape and thinning over the block corners. Increased marine influence in the Townsville Trough probably followed Campanian breakup and seafloor spreading in the Tasman Basin and Cato Trough. Restricted shallow-marine sediments were deposited in the center of the Townsville Trough, grading to marginal-marine and continental sedimentation on its flanks and on the adjacent emergent Queensland and Marion plateaus.

Post-Breakup Subsidence - Paleocene to Oligocene

During the Paleocene to Eocene episode of seafloor spreading in the Coral Sea Basin to the north, only minor reactivation and structuring occurred in the Townsville Trough, enhancing flexural and compaction drape in the early post-breakup sediments. At this time, partially restricted shallow-marine conditions probably existed in the trough, with paralic to shallow-shelf environments on the trough margins. In post-middle Eocene time, slow regional subsidence during the post-breakup sag phase of continental margin development resulted in shallow-marine conditions being established on the Queensland and Marion plateaus, although parts of both these features were probably still emergent until at least the end of the Eocene. During the middle to late Eocene, the Townsville Trough received neritic to deep-water high- and low-energy deposits, which probably consisted mainly of terrigenous and calcareous turbidites. During the early Oligocene a widespread unconformity resulted from the initiation of a significant equatorial circulation pattern over the subsiding margin and basins, as reflected by a widespread unconformity (Taylor and Falvey, 1977). In post-early Oligocene times, as a consequence of subsidence, pelagic ooze, turbidites, and slump deposits became the major components of trough sedimentation.

Carbonate Platforms

The Great Barrier Reef

The major geological characteristics of the Great Barrier Reef are summarized in schematic form in Figure 4. In the northern Great Barrier Reef and Gulf of Papua, the occurrence of subsurface reefs are well documented by seismic data and drill holes (Tanner, 1969; Tallis, 1975). Miocene reefs occur in the subsurface of the Gulf of Papua and Pliocene reefs and Miocene limestones containing algal rhodoliths occur at the northern end of the Great Barrier Reef (Marshall, 1983) in Anchor Cay 1. Seismic data acquired by BMR (Davies et al., 1989) in the northern area confirm both the presence of buried reefs and the existence of a thick reef section. Our seismic data indicate that a major reef structure occurs in the continental-slope sequence on the western margin of the Pandora Trough between Portlock and Boot Reefs. The data show that these modern reefs are constructed on a more extensive Miocene and Pliocene reef complex as thick as 1.5 km. Therefore, in the northern Great Barrier Reef and Gulf of Papua, seismic and drill-hole data indicate that a reef sequence of varying thickness and age started to develop in the Miocene.

On the outer continental shelf of the central Great Barrier Reef region, the 250-300-m-thick reef complex (Fig. 5) is composed of a series of reef slices separated by low-sea-levelgenerated unconformities (Davies, 1983; Symonds et al., 1983). The reef complex forms only the uppermost part of a thick outer-shelf sequence that is dominated by prograding fluviodeltaic and onlapping slope sediments overlying a rifted basement (Symonds et al., 1983). The reef thickness and a tie to DSDP Site 209 in the Coral Sea indicate a probable Pliocene age for initiation of reef growth in this region. A borehole on Michaelmas Cay (Fig. 3) shows 100 m of (?)Pliocene-Pleistocene reef facies overlying siliciclastic sediments.

The boreholes on Heron Island and Wreck Bay (Fig. 3) at the southern end of the Great Barrier Reef show that less than 150 m of reef overlies quartz sand, and that reef growth began in the Pliocene-Pleistocene (Lloyd, 1973; Palmieri, 1971,1974; Chaproniere 1984).

The principal conclusions derived from studies of the Great Barrier Reef carbonate platform are that the reef sequence thins dramatically and the age of initial reef growth becomes younger from north to south. The Great Barrier Reef is a mixed carbonate-siliciclastic province, with reefs forming a discontinuous wedge largely enclosed within terrigenous fluviodeltaic deposits.

Queensland Plateau

The Queensland Plateau (Fig. 2) is the largest marginal plateau of the Australian continental margin, extending over an area of about 154,000 km^2. It is one of the largest features of its type in the world and is approximately the same size as the Bahama Platform. Approximately half of the plateau surface lies above the 1,000 m isobath, with living reef systems at or near present sea level forming 10% to 15% of the surface. The largest modern reef complexes are Tregrosse and Lihou reefs, lying along the southern margin of the plateau (Fig. 1). Both these complexes are nearly 100 km long from east to west and 50 to 25 km wide, respectively, from north to south. The other major areas of modern reef growth are the Coringa, Willis, and Diana complexes, which are aligned north to south in the center of the plateau, and the large isolated pinnacles of Flinders, Holmes, Bougainville, and Osprey reefs, which lie along the western margin of the plateau (Fig. 1). In addition, drowned reefs have been reported from at least 25 different locations (Taylor, 1977; Mutter, 1977; Mutter and Karner, 1980; Davies et al., 1989). Away from reef areas, the plateau surface is generally smooth and slopes northward. A distinct terrace at approximately 450 to 500 m depths occurs between Willis and Diana reefs, and also between Tregrosse, Lihou, and Coringa reefs.

The major characteristics of the Queensland Plateau carbonate platform, as deduced from analysis of extensive air-gun and sparker seismic data combined with sampling data, are summarized on schematic sections across the plateau (Fig. 6). The ages of the stratigraphic sequences visible on the seismic data have been deduced by correlation with DSDP Site 209 (Burns et al., 1973), located on the northeastern margin of the plateau.

Basement on the Queensland Plateau is represented by a series of fault blocks, composed probably of Paleozoic rocks, which form a basement surface that dips northeast toward the Coral Sea Basin (Mutter, 1977; Taylor, 1977). Basement beneath the western one-third of the plateau is progressively downfaulted toward the Queensland Trough (Fig.

6). South of Tregrosse and Lihou reefs, the basement surface slopes gently south toward the northern boundary fault of the Townsville Trough. Large parts of the basement surface were exposed and planated during the Cretaceous-Oligocene. From the early Eocene, this surface was progressively submerged and overlain, first by shallow-marine siliciclastic sediments and then by deeper water pelagic sediments (Burns et al., 1973). A period of nondeposition or submarine erosion occurred from the late Eocene until the late Oligocene The sedimentary sequence reflects constant gradual subsidence until the late Miocene, followed by an increased subsidence rate until the present.

Along the western margin of the Queensland Plateau, steep-sided pinnacles 1-2 km across rise from depths of as much as 1,200 m to within 10 m of sea level. Dredged samples indicate that the flanks of these features are composed of reefal framework containing Miocene-Pliocene larger foraminifers (Davies et al., 1989). Seismic data show that at least some of these pinnacles have developed on the raised corners of fault blocks.

In addition to the carbonate buildups on the plateau margins noted earlier, seismic data indicate that a thick carbonate-platform sequence was deposited on the central part of the plateau. At least two phases of separate but superimposed reef and periplatform facies (QR1 and QR2; Fig. 6) form the core of the carbonate platforms. Dredge samples from this complex on the southern slope of the Queensland Plateau between 1,000 and 1,300 m depth consist of middle Miocene to Pliocene reefal material (Davies et al., 1989). The presence of shallow-water sediments at these depths confirms that there has been unusually rapid subsidence of the plateau since the middle Miocene. The deeper water areas between reef complexes are the sites of hemipelagic sedimentation.

A terrace that occurs at 450 to 500 m depths represents the end of QR2 reef growth (Fig. 6). A third, more restricted phase of reef growth (QR3) developed on this surface, with associated periplatform sedimentation in front of the reef. This reefal platform grew to sea level, and, as a result of relative sea-level rise, now forms another terrace at approximately 50 m depth.

The most recent reef complexes (QR4) developed on the 50-m terrace and are even more restricted than previous phases. Descriptions of the modern coral faunas (Orme, 1977) suggest that the modern reefs are oceanic equivalents of high-energy reefs present in the Great Barrier Reef. It is therefore likely that throughout their evolution, the different phases of Queensland Plateau reef development have all been products of high-energy oceanic conditions as a result of their exposed oceanic location.

Marion Plateau

Little detailed subsurface structure and facies distribution information exists for the Marion Plateau (Mutter and Karner, 1980). The plateau is bounded on three sides by rifts: the Cato Trough to the east, the Townsville Trough to the north, and a series of north-south-oriented, narrow half-grabens that separate the plateau from the continent to the west (Fig. 6). During the Tertiary, siliciclastic shelf sediments prograded eastward across these half-grabens and onto the western Marion Plateau. The most northern of these half-grabens appears to join the confluence of the Townsville and Queensland troughs. Therefore, the Marion Plateau formed a separate marginal plateau during the early Tertiary. To the south, the Marion Plateau is separated from the Capricorn Basin by a northwest-trending basement ridge (the Swains Reef High; see Fig. 2).

The basement beneath the Marion Plateau is a planated surface that dips gently toward the northeast. The only disruption to this surface occurs in the northeast corner of the plateau, where a basement high forms the pedestal on which Marion Reef developed. Basement beneath the plateau margins is steeply downfaulted into the troughs to the north and east. The slope sequences on the northern and eastern margins of the plateau are both onlapping and progradational. Small reef complexes overlie some of these progradational sequences along the northern margin.

The basement surface was completely transgressed during the (?)early Miocene, resulting in development of an extensive carbonate platform (MR1; see Fig. 6). The top of this platform presently lies at 450 to 500 m depth. Shelf-edge barrier reefs (Fig. 6) and platform reefs separated by lagoons and interreef areas (Fig. 6) can be identified over the northwestern two-thirds of the platform. Barrier reefs formed a distinct rimmed margin only along the northern edge of the plateau. The second phase of platform development (MR2) was more restricted and was confined to the southern one-third of the plateau. This phase was initiated at a level considerably below the top of the earlier phase. The top of the MR2 platform presently lies at 350 to 400 m below sea level. The third phase of reef growth on the Marion Plateau (MR3) is represented by small platform areas that have grown on the 350- to 400-m surface. Toward the southern Marion Plateau, part of the Great Barrier Reef overlies the third phase of carbonate platform growth. The final, very restricted, phase of growth on the Marion Plateau (MR4) is represented by Marion and Saumarez reefs. Therefore, the successive phases of carbonate platform growth have been progressively more restricted in area (Fig. 6).

At present, the top of the Marion Plateau is swept by moderately strong currents with the result that, away from the areas of modern reef growth, only thin hemipelagic sediments are accumulating in restricted areas.

Principal Post-rift Factors Affecting the Stratigraphic and Sedimentological Evolution of Northeast Australia

Subsidence

Quantitative subsidence data have been derived from geohistory analysis (Van Hinte, 1978; Falvey and Deighton, 1982) of Anchor Cay 1, DSDP Site 209, Capricorn 1A, and Aquarius 1 (Fig. 7). The subsidence data from these wells indicate that northeast Australia has not subsided wholly as a result of uniform post-rift thermal cooling, but that subsidence pulses have occurred at different times.

The pre-Eocene portion of the subsidence curve for Anchor Cay 1, at the northern end of the Great Barrier Reef (Fig. 6) , is not reproduced here, as it is difficult to ascertain how much section has been removed at the major unconformity (Fig. 7A). The accelerated subsidence of 50 m/m.y. that affected this region in the Miocene (25-5 Ma) increased to 140 m/m.y. in the Pliocene (Fig. 7A).

DSDP Site 209 provides the only source of quantitative subsidence data for the Queensland Plateau. The subsidence history of the plateau at this site was characterized by progressively increased rates of subsidence (Fig. 7B). An initial slow rate (20 m/m.y.) was succeeded by a markedly increased rate (40 m/m.y.) after the middle Miocene (11 Ma).

The geohistory curves for Aquarius 1 (Fig. 7C) and Capricorn 1A show similar subsidence patterns. A Cretaceous to mid-Oligocene (88-30 Ma) slow subsidence phase (20 m/m.y.) was succeeded by increased subsidence (75 m/m.y.) until the middle Miocene (11 Ma). Decreased subsidence followed by uplift during the late Miocene and early Pliocene was succeeded by a final increased subsidence pulse (75 m/m.y.) from the mid-Pliocene.

Plate Motion and Paleoclimate/Paleoceanography

Hotspot (Duncan, 1981; Wellman, 1983) and magnetostratigraphic studies (Idnurm, 1985, 1986) provide a reconstruction of Indian-Australian Plate movement through the Cenozoic. These studies show that since the end of the Eocene, when northeast Australia was located between 20°S and 44°S, the region has moved almost directly northward to its present location between 9°S and 24°S. On this basis the Cenozoic paleolatitudes for the northeast Australia region may be determined (Fig. 8). This latitudinal motion would have resulted in profound climatic changes along the east Australian shelf, particularly because plate movement was essentially normal to developing climatic zones. Since surface-water temperatures are critical to carbonate-platform development, we have examined data primarily derived from geochemical and petrographic analyses of DSDP cores from the western Pacific and produced a synthesis describing Cenozoic surface-water temperature variability for the northeast Australian region (Fig. 9). This oceanic surface-water temperature curve for northeast Australia allows us to draw the following conclusions:

1. Temperatures in the earliest middle Eocene were briefly warm enough for coral reef growth. Corroboration is provided by the identification of early middle Eocene larger foraminifers from the northwestern margin of the Queensland Plateau (Chaproniere, 1984), indicating sea surface temperatures of 18°-27°C (Murray, 1973).

2. Temperatures from the late middle Eocene to the middle early Miocene were not conducive to tropical carbonate-platform development. Climates at paleolatitudes of 23°-46°S were probably temperate or cool temperate, and accordingly there would have been no significant coral reef growth.

3. During the early Miocene, the northeast Australia region was bathed in surface waters marginal for supporting coral reefs (i.e., probably comparable to those off northern New South Wales and southern Queensland today). While some reef growth may have been possible in the extreme north, it is most likely that prolific growth throughout much of the northern region began with the initiation of tropical climatic conditions in the early middle Miocene.

4. The late Miocene climatic cooling would have prevented extensive reef growth in the southern part of the region, situated near the subtropical/tropical climatic boundary.

5. During the Pliocene, temperatures suitable for reef growth extended into the southern parts of the northeast Australian province.

The paleoclimatic and paleoceanographic data substantiate and refine the major conclusions deduced from plate-motion studies. The consequences of this interpretation are that the Great Barrier Reef tropical shelf carbonate facies are thinner and younger to the south and overlie temperate facies (Davies et al., 1987); that reefs grew first in the north, probably within the developing foreland basin; that this early reef growth was closely followed by reef growth on the Queensland and Marion plateaus; and that reefal development occurred later in the central and southern Great Barrier Reef. Facies diachroneity must be a fundamental factor in platform evolution where plate motion has produced movement either toward or away from the tropics.

The above conclusions can be tested by a comparison of present-day facies variations along the east Australian margin with the vertical facies sequence observed in cores from the Gulf of Papua. The present-day sediment distribution on the east Australian outer continental shelf is composed of three distinct facies (Marshall and Davies, 1978), which contain a clear climate-related signature:

1. Tropical carbonate and clastic sediments, dominated by coral and *Halimeda* debris, north of 24°S.

2. Subtropical rhodolith/encrusting foraminifer/bryozoan facies between 24°S and 28°S, with bioherms dominated by this association occurring over large parts of the outer shelf.

3. Temperate, branching bryozoan/foraminifer/mollusc facies south of 28°S.

A similar facies sequence occurs vertically in the Borabi No. 1 drill hole (Fig. 3) in the Gulf of Papua (Fig. 1). This sequence shows the development from a temperate open shelf in the Eocene and Oligocene, to a subtropical shallow outer shelf in the early Miocene, to a tropical reef-dominated shelf in the middle Miocene, and finally to a fluvioclastic-dominated shelf in the Pliocene. The vertical carbonate facies variations mirror those that occur laterally on the present-day shelf and that are clearly climate related. Horizontal plate motion, with its attendant climatic and oceanographic effects, has therefore exerted a fundamental control on the sedimentary evolution of northeast Australia (Davies et al., 1987).

Further refinements arise from a consideration of local physical and chemical oceanographic factors. The progressive development of the east Australian current would have intensified from the early-middle Miocene (15-20 Ma), as the northern edge of the Australian craton began to disrupt the strong equatorial current flow (Kennett et al., 1985). Continuing northward plate motion, the elevation of New Guinea, and the closure of the east Indonesian seaway in the late Miocene would have further restricted westerly current flow and caused diversion of warm tropical waters to the south into the northeast Australia region.

Sea-Level Variation

The effects of sea-level variation on carbonate-platform development have been established by detailed analysis of the nature and distribution of siliciclastic and carbonate facies on the central Great Barrier Reef shelf.

High-sea-level deposition on the central Great Barrier Reef shelf occurred either as progradation of prodeltaic sediments on the inner shelf, primarily concentrated on wave-dominated deltas; or as aggradation of the middle to outer shelf as a result of reef growth and inter-reef sedimentation (Fig. 10A). Reef facies reflect both the high physical energy of the system and the transgressive/stillstand history of the Quaternary sea-level rises (Marshall and Davies, 1982, 1984; Davies, 1983; Davies and Hopley, 1983; Davies et al., 1985). The reefs are composite features, composed of stacked reef facies that grew as a consequence of successive high-sea-level growth phases, separated by unconformities representing low-sea-level erosion. The high physical energy of the reef environment restricted reef expansion to the leeward or backreef direction.

In the inter-reef areas on the middle to outer shelf, high-sea-level platform aggradation is represented by bioherms (Davies and Marshall, 1985), biostromes, and a sediment blanket of varying thickness (from <1 to 10 m) deposited on the previously exposed shelf surface. This sediment blanket is composed of a lower, terrigenous (mud- and quartz-rich; carbonate-poor), transgressive facies, and an upper, carbonate-rich (less mud; little quartz), stillstand facies (based on studies in progress). At the present time, after 10,000 yr of transgression and stillstand, there has been little high-sea-level progradation of coastal terrigenous facies onto the inner shelf. It seems likely that the terrigenous/carbonate facies couplet that occurs over wide areas of the middle to outer shelf is probably representative of high-sea-level sedimentation on the Great Barrier Reef platform throughout most of the Pliocene-Pleistocene.

Low-sea-level sedimentation occurred both as aggradation of fluvial sediments on the middle to outer shelf (Fig. 10B), and as progradational shelf-edge deltas composed of terrigenous sand and sandy mud beneath the outer shelf and upper slope (Fig. 5).

Periods of rising and high sea level in the central Great Barrier Reef were therefore characterized by both reefal and inter-reef carbonate deposition, with restriction of siliciclastic deposition largely to the inner shelf. In contrast, periods of falling and low sea level were characterized by fluvial or shallow-marine siliciclastic deposition, with siliciclastic progradation on the present upper slope. The marginal plateaus are essentially isolated from terrigenous input, and accordingly their facies response to sea-level variation must have been different. Although high-sea-level periods in these areas are also marked by carbonate aggradation, low-sea-level periods are characterized by unconformities representing exposure of the previous reef surfaces. This response to sea-level variation can be used to interpret the evolutionary history of the Cenozoic sequences on the marginal plateaus by attributing unconformities within the carbonate platforms to low-sea-level episodes, and reef sequences to periods of high sea level. In the absence of a specific Cenozoic sea-level curve for northeast Australia, the global sea-level curve proposed by Haq and others (1987) can be used. On this basis, episodes of reef growth during the early-middle Miocene (QR1, MR1 -- see Fig. 6), the middle to late Miocene (QR2, MR2), the Pliocene-Pleistocene (QR3, MR3), and the Quaternary (QR4, MR4) are separated by unconformities representing erosion during the late middle Miocene (1-2), latest Miocene (2-3), and the Quaternary (3-4).

LEG 133 CRUISE OBJECTIVES

Scientific drilling off the northeast Australian margin has two primary objectives:

1. To define the sedimentary response to global sea-level changes in the Late Cenozoic and Quaternary. Two approaches will be applied through the study of shelf-margin progradational/onlap sequences and marginal-plateau reef stratigraphy. Along the margins of the Great Barrier Reef, low-sea-level, shelf-edge, deltaic, siliciclastic progradative and middle and top-of-slope fans alternate with high-sea-level onlapping sequences and are overlain by high- and low-sea-level aggradational couplets correlated to periods of reef growth. These sedimentary sequences are clearly visible on seismic sections and drilling will provide the ground truth essential for testing the major tenets of the global sea-level hypothesis. Sites on the upper slope close to the margin hinge will define a shallow-water sea-level signal, whereas those on the lower slope and in the Queensland Trough will define the related shelf-to-basin stratigraphy and deep-water sea-level signature.

    Sites proposed for the Queensland and Marion plateaus will drill into Miocene and Pliocene reefs, which grew in oceanic situations. An absolute eustatic sea-level fall of 150-200 m in the middle to late Miocene has recently been defined from these reefs (Pigram et al., submitted).

2. To define the influence of paleochemistry, paleoclimate, and paleoceanography on the initiation, growth, and demise of carbonate platforms, and the effect of shifting from temperate to tropical latitudes (or vice versa) as a result of plate motion, on the biological and lithological facies types (the "Darwin Point"; Grigg and Epp, 1989) in an environment analogous to the Jurassic eastern margin of the U.S.A. These objectives are best achieved in pure carbonates where the climatic and oceanographic signatures are well preserved. Sites are proposed on the Queensland and Marion plateaus aimed at the Neogene and Pliocene-Pleistocene reefal and periplatform sequences. Sites in the adjacent troughs will define the relationship of facies to climate and oceanography throughout the late Paleogene and Neogene.

In addition to the primary objectives, the drill sites have been chosen (1) to define the slope-to-basin variations on both sides of a rift basin in order to evaluate facies and stratigraphic models of passive-margin evolution; and (2) to define the diagenetic history of contrasting mixed carbonate/siliciclastic and pure carbonate margins in an environment undersaturated with respect to aragonite and high-magnesium calcite at relatively shallow water depths.

Drill sites have been located along two transects: one oriented east-west across the Queensland Trough (Fig. 11) and the other north-south across the Townsville Trough (Fig. 12).

Queensland Trough Transect

The schematic section in Figure 11 is based on a series of tied east-west seismic profiles that extend across the Queensland Trough from the Great Barrier slope to the western flank of the Queensland Plateau. The section illustrates the general structural style of the trough and its margins. Shallow (1.7 s TWT) planated basement tilt blocks occur beneath the western Queensland Plateau (CDP 200-1100) and are bounded by relatively steep, westerly dipping rotational normal faults. Half grabens formed by these blocks contain easterly dipping ?Upper Cretaceous syn-rift sections up to about 800 m thick. The tilt blocks, and in some places the syn-rift section, were eroded during the formation of the Paleocene "breakup" unconformity, which corresponds to the commencement of seafloor spreading in the Coral Sea Basin to the northeast. Beneath the eastern flank of the Queensland Trough (CDP 1400-1700), the dip of the faults bounding the tilt blocks switches to the east, and the corresponding syn- and pre-rift sections dip to the west. Complex faulting beneath the eastern part of the trough (CDP 1700-2000) may be related to wrenching and indicates that strike-slip movement probably played an important part in the development of the trough. A large planated basement block in the center of the trough (CDP 2000-2300) appears to be bounded by a major near-vertical fault on its eastern flank and a series of smaller high-angle normal faults on its western flank that progressively down-step basement to the west. This high can be identified on seismic data both north and south along the strike of the trough. West of this high, sediment thickness could be as much as 3000 m. In the center of the trough (CDP 2600-2900) another major half graben containing ?Cretaceous pre- and syn-rift sections occurs at a depth of 3.1 s TWT. Both this section and the underlying basement tilt block are planated by the Paleocene "breakup" unconformity. The western flank of the high is formed by a complex vertical fault system. Another planated basement high occurs beneath the western flank of the trough (CDP 3600-3800) at a depth of 2.9 s TWT, and is bounded by high-angle faults. A broad anticline formed by flexural and compaction drape over this block extends to quite high levels (upper Miocene) within the section. The thickest sedimentary section within the trough occurs beneath its western flank, where it may be over 4000 m thick.

Pre-Oligocene mounds or buildups occur on the flanks of highs beneath the western part of the Queensland Trough, and are draped by the overlying Oligocene and upper Miocene section. Similar buildups also occur on basement highs on the western margin of the Queensland Plateau between proposed Sites NEA-6 and -8. A major lower middle Miocene buildup occurs on top of the large basement high in the center of the trough (CDP 2000-2300), associated with a substantial debris apron extending westward into the deeper part of the trough. There is a marked change in depositional style across the upper middle Miocene unconformity from essentially conformable sequences to onlapping basin-fill sequences. On the western flank of the trough the Pliocene-Pleistocene section displays strong downlapping character and thins eastward. The thickest part of this section occurs in the prograding wedge beneath the slope of the Great Barrier Reef at Sites NEA-1 to -3.

The relatively thin Miocene and younger section covering the western Queensland Plateau (Site NEA-8) thins dramatically westward. The complexity of the sequence stratigraphy in the vicinity of Site NEA-6 is apparently a result of the interaction between trough and plateau depositional processes.

Townsville Trough Transect

Most of the schematic section in Figure 12 is based on two tied seismic profiles that extend across the Townsville Trough from the Queensland Plateau in the north to the Marion Plateau in the south. The northernmost part of the section in the vicinity of Site NEA-10A is entirely schematic, and is based on a combination of seismic profiles. The section illustrates the general structural style of the Townsville Trough and places Sites NEA-10A, -11, -13, and -14 within a regional structural and stratigraphic framework.

The northern margin of the Townsville Trough is underlain by a relatively flat "basement" platform, which exhibits small-throw, down-to-the-north normal faults beneath the southern Queensland Plateau. In places, southward-dipping reflectors occur within the "basement" platform and may represent Paleozoic metasediments or pre-rift Mesozoic section. On this section the southern edge of the platform is basically a hinged margin that dips into the Townsville Trough and is associated only with minor down-to-basin faulting (time 269.2100-2200). Large tilt blocks, some with eroded and planated corners, occur beneath the main depocenter of the trough, which is about 70 km wide. Beneath the northern part of the trough a large tilt block up to 12 km across (time 269.2150-2330) is bounded by several relatively steep northward-dipping rotational normal faults. The half graben to the south of this block contains a southward-dipping ?Upper Cretaceous syn-rift section up to about 1500 m thick. A switch in the direction of faulting occurs about a complex fault zone (transfer fault/accommodation zone) beneath the center of the trough (time 269.2330-2340). Fault blocks to the south of this zone are bounded by southward-dipping normal faults, and this style extends beneath the northern flank of the Marion Plateau. Thus on this schematic section the southern margin of the Townsville Trough is also a hinged or dip-slope margin formed by northward-tilted "basement" blocks bounded by southward-dipping rotational normal faults. The ?Upper Cretaceous syn-rift section is considerably thicker beneath the southern part of the trough -- up to 3000 m (1.6 s TWT) thick. Broad anticlines related to flexural and compaction drape over tilt blocks, and the edges of the bounding "basement" platforms, particularly on the Queensland Plateau side, can in places extend to quite high levels (lower Miocene) within the section (e.g., time 269.2150-2230).

The sedimentary fill within the Townsville Trough can be broadly divided into three main units: (1) an ?Upper Cretaceous syn-rift section, which is restricted to the half grabens (as described above); (2) a Paleocene-Eocene post-breakup section, which generally onlaps the syn-rift section and the flanks of the bounding "basement" platforms; and (3) an upper Oligocene to Holocene section, which covers both the trough and the adjacent platforms. The Paleocene-Eocene section is basically a basin-fill unit, which has a relatively uniform, conformable reflection character throughout the trough. It can be up to about 2000 m thick beneath the center of the trough. The overlying ?upper Oligocene to Holocene unit is much more variable in reflection character, both across the trough and up through the section. In the center of the trough, where it can be up to 2000 m thick, this unit commonly contains chaotic, mounded, and channeled facies, particularly toward its base, suggesting that along-trough depositional processes have been important during post-late Oligocene time. A possible lower Miocene shelf edge is evident beneath the southern part of the Townsville Trough (day 270 194.26), and the top of the main shelf edge sequence appears to correspond to the base of the "debris" facies in front of the carbonate platform at Site NEA-14. That is, the carbonate platform beneath the northern Marion Plateau (~ CDP 24 on section) appears to have built up on the inner edge of a lower

Miocene shelf. The post-platform facies in this area have a prominent downlapping character and may correspond to a late Miocene-Pliocene period of current-controlled contourite deposition. An apparently older phase (late Oligocene-early Miocene) of carbonate platform development is evident beneath the southern slope of the Queensland Plateau on the northern flank of the Townsville Trough (time 269.1740-1840), and Site NEA-11 should intersect the distal facies shed into the trough in front of this platform. On the schematic section, the southern edge of the oldest part of the carbonate platform that forms the base to the modern Tregrosse reefal platform is shown. The back-platform facies east of the western edge of a younger portion of this platform will be drilled at Site NEA-10A. This is illustrated conceptionally on the northern end of the schematic profile (Fig. 12).

SITE OBJECTIVES

NEA-1

To determine the composition and origin of the most landward of the prograding and aggrading units beneath the upper slope terrace, and to define the sea-level signal within them.

NEA-2

To determine the composition and origin of the prograding and aggrading units beneath the outer part of the upper slope. This hole, in conjunction with NEA-1, will calibrate the abrupt seismic facies variations evident on the seismic lines.

NEA-3

To determine the nature of the most distal portions of the progradational and aggradational units beneath the upper slope terrace. To determine the age and origin of the eight seismic sequences at this site. This hole, in conjunction with NEA-1 and NEA-2, will allow the investigation of a complete shelf-margin series of prograding units.

NEA-4

To define and evaluate the relationship between lower slope carbonate/siliciclastic fan facies and the more proximal facies found at Sites NEA-1 to NEA-3, and to relate that to the sea-level signature extracted from Sites NEA-1 to -3.

NEA-5

To obtain a complete basinal section for paleoceanographic history and to correlate basin-fill response between the continental margin and the Queensland Plateau.

NEA-6

To understand slope processes in an exclusively carbonate system and to determine the age of the reef platform and timing of the onset of pelagic sedimentation. To determine the sea level, oceanographic, and climatic control in the Pliocene-Pleistocene periplatform sediments shedding from the western margin of the Queensland Plateau.

NEA-8

To sample the periplatform sequence and to determine the sea level and climatic signals for comparison with Sites NEA-1 to NEA-3. To determine the timing and mode of origin of the uppermost reef horizons.

NEA-9A

To determine the composition and origin of the slope units immediately seaward of the Neogene carbonates of the southern margin of the Queensland Plateau. To compare the history and processes operative on the mixed carbonate/siliciclastic continental margin sites.

NEA-10A/1 and -10A/2

To determine the origin of platform-top carbonates, the history of drowning, and the paleoclimatic signal in the overlying periplatform ooze.

NEA-11

To obtain stratigraphic and age data to tie event stratigraphy in the Townsville Trough. Furthermore, to obtain paleoclimatic data on the change from temperate to tropical climates as Australia drifted north in the Neogene. To determine the age and origin of carbonate deposition on the Queensland Plateau.

NEA-13

To determine the nature and age of the buildups on the northern edge of the Marion Plateau, the minimum position and timing of the middle Miocene sea-level fall, and to determine the cause(s) of demise of these buildups.

NEA-14

To establish the composition and age of the forereef, the downlapping and onlapping sediments that overlie the platform, and to establish the cause and timing of the demise of the platform. To establish the paleoclimatic history and the facies response to climatic variation and the initiation of boundary-current activity. To determine the composition and age of the pre-reef sediments.

DRILLING PLAN

Sites approved by the JOIDES Pollution Prevention and Safety Panel for drilling on Leg 133 are shown in Tables 1 and 2. The site occupation schedule is shown in Table 3. This schedule is designed noting (1) the need to drill the platform sequences before the basin sequence in the Townsville Trough, and (2) the logistical advantage of coring the western slope of the Queensland Trough at the end of the cruise, thus reducing the transit time to Townsville.

Leg 133 is scheduled to depart from Guam on 10 August 1990. Drilling operations will begin on 16 August at NEA-8. From there the ship will proceed to NEA-10A/1, -10A/2, -13, -14, -11, -6, -5, -4, -1, -2, and -3 (see Table 3). In accordance with JOIDES policy, logging (i.e., the standard Schlumberger logs plus the formation microscanner, or FMS) is currently planned for all sites drilled >400 mbsf; in addition, selected logs will be run at other sites of interest. Vertical seismic profiles (VSP) are scheduled for Sites NEA-2 and -11, and the wireline packer will be run at Sites NEA-10A/1 and -10A/2 (and possibly also at Site NEA-13). However, this program may need to be revised if more vertical seismic profiling is considered necessary, drilling difficulties are encountered, and/or additional water samples are required. In addition, a prototype of the Vibra Percussive Corer (VPC) system, currently under development by the ODP Engineering and Drilling Operations Department, will also be tested at one or more sites. The ship will arrive in Townsville on October 11.

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FIGURE CAPTIONS

Figure 1. Locality map showing the main bathymetric features of the northeast Australian margin and the proposed Leg 133 drill sites. Bathymetry in meters.

Figure 2. Map showing the major structural features offshore of northeast Australia. The location of exploration and other drill holes are shown as follows: BB = Borabi; P = Pasca; AC = Anchor Cay; M = Michaelmas Cay; AQ = Aquarius-1; CP = Capricorn-1A; W = Wreck Island-1; H = Heron Island. Bathymetry in meters.

Figure 3. Summary lithostratigraphic logs from drill holes shown in Figure 2. **A.** Gulf of Papua. **B.** Great Barrier Reef. **C.** Queensland Plateau. **D.** Capricorn Basin.

Figure 4. Schematic section showing the generalized structure and sedimentary geometry of the Great Barrier Reef provinces. Note that MR1 and MR2 refer to different phases of reef growth beneath the Marion Plateau as shown in Figure 5. **A.** Northern province. **B.** Central province. **C.** Southern province.

Figure 5. Carbonate-terrigenous facies geometry on the upper slope and outer shelf of the central Great Barrier Reef. **A.** Sparker seismic record in the vicinity of Sites NEA-1 to -4 showing a submerged reef at the seabed (R) and siliciclastic prograding units (P2-P4). **B.** Aquapulse seismic section showing the position of the outer shelf sequences, particularly the two lower prograding units P1 and P2, with respect to underlying basement.

Figure 6. Schematic sections showing generalized structure and sedimentary sequences. QR1 to QR4 and MR1 to MR4 denote phases of carbonate platform growth on the Queensland and Marion plateaus. Symbols and legend as for Figure 4. **A.** Eastern Plateau. **B, C.** Queensland Plateau. **D, E.** Marion Plateau.

Figure 7. Geohistory plots for wells in the northeast Australian region. Location of drill holes is shown in Figure 2; summary logs appear in Figure 3. **A.** Anchor Cay-1 (northern Great Barrier Reef). **B.** DSDP Site 209 (Queensland Plateau). **C.** Aquarius 1A (southern Great Barrier Reef region).

Figure 8. Projected latitudinal movement of the northeast Australian region through the Cenozoic, based on hotspot and paleomagnetic data. The northern boundary corresponds to Anchor Cay (latitude 9°30'S), and the southern boundary to Heron Island (latitude 24°S).

Figure 9. Envelope of surface-water temperature variation for the Great Barrier Reef region throughout the Cenozoic, obtained from oxygen isotope data. M1 through M4 represent stages of carbonate platform growth on the Marion Plateau (Feary et al., in press).

Figure 10. Schematic sections illustrating sea-level control on the structural and sedimentary geometry of the shelf facies along the slope of the Great Barrier Reef in the vicinity of Sites NEA-1 to -3. Note the predominance of siliciclastics in the low-sea-level situation. **A.** High sea level. **B.** Low sea level.

Figure 11. Schematic transect across the Queensland Trough compiled from BMR lines 75/037, 75/038, 75/039, 75/040, 75/041, and 75/042.

Figure 12. Schematic transect across the Townsville Trough compiled from BMR lines 50/002, 75/007, 75/027, and 75/057.

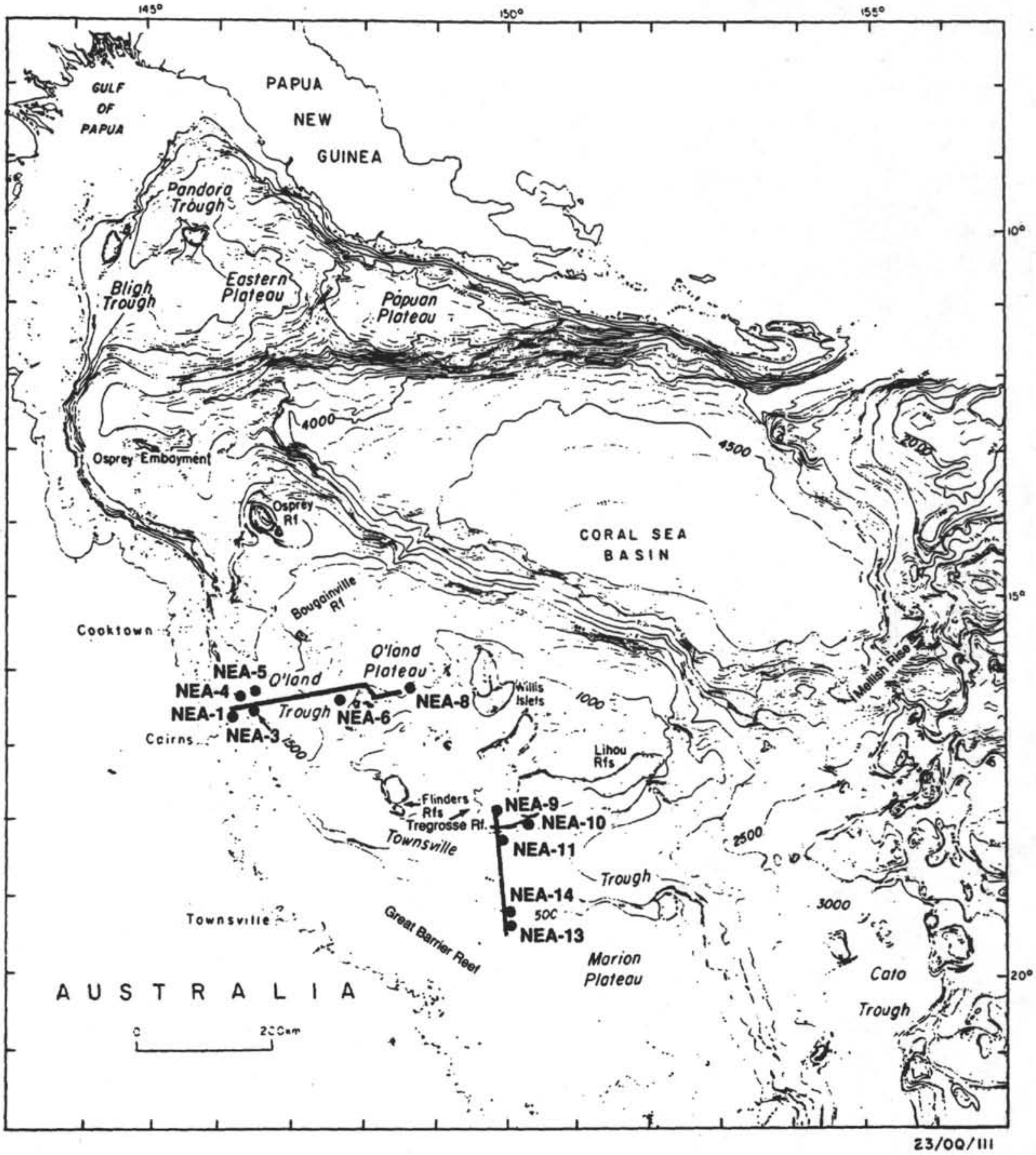
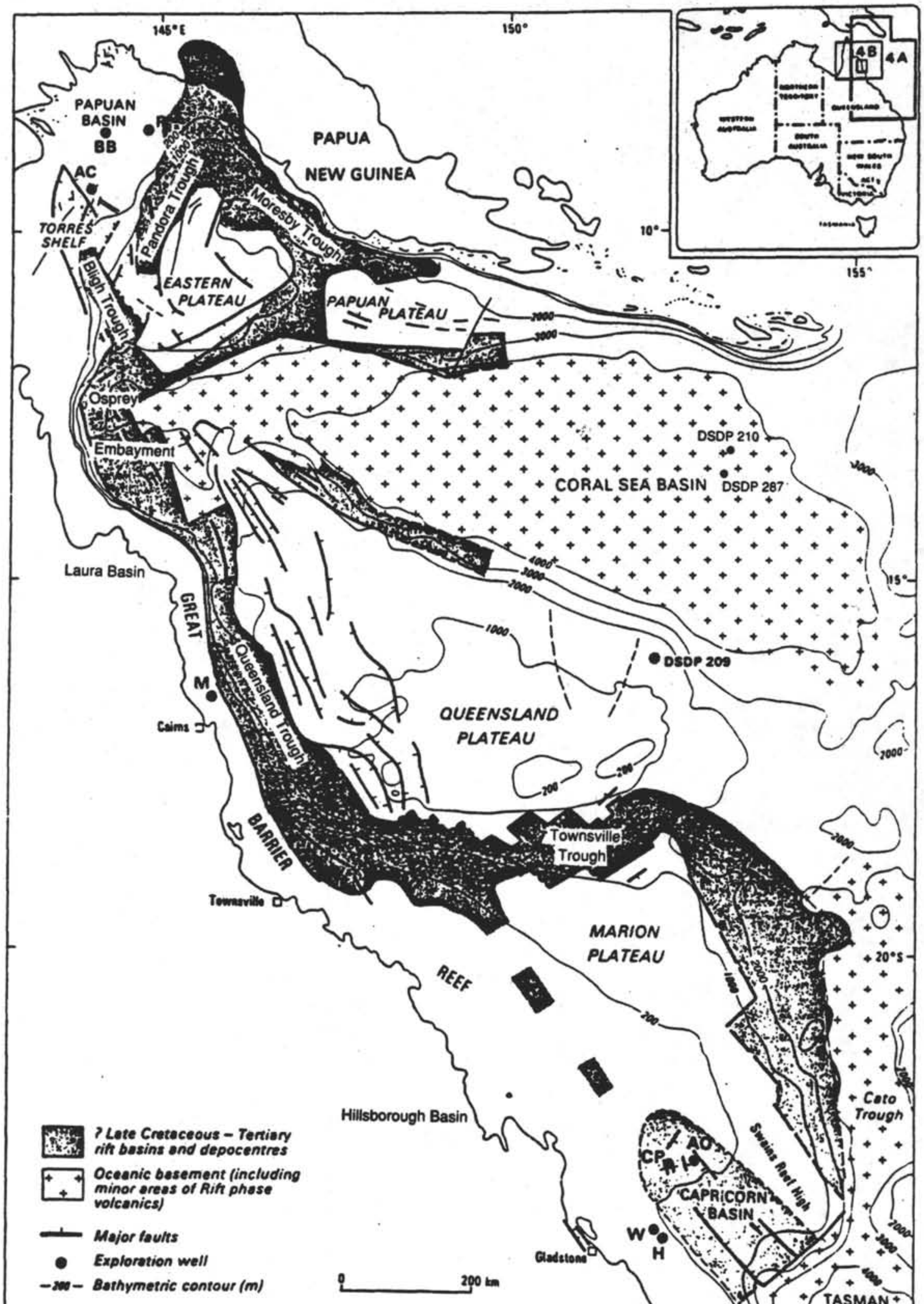

145°
150°
155°
10°
15°
20°
GULF OF PAPUA
PAPUA NEW GUINEA
Pandora Trough
Bligh Trough
Eastern Plateau
Papuan Plateau
4000
4500
2000
Osprey Embayment
Osprey Rf
CORAL SEA BASIN
Bougainville Rf
Cooktown
O'land Plateau
NEA-5
NEA-4
NEA-1
NEA-3
O'land Trough
NEA-6
NEA-8
Willis Islets
1000
Mellish Rise
Cairns
1500
Lihou Rfs
Flinders Rfs
Tregrosse Rf.
NEA-9
NEA-10
NEA-11
Townsville Trough
2500
NEA-14
500
NEA-13
3000
Townsville
Great Barrier Reef
Marion Plateau
Cato Trough
AUSTRALIA
23/OQ/111

Figure 1.



145°E
150°
155°
10°
15°
20°S
PAPUAN BASIN
BB
AC
TORRES SHELF
Pandora Trough
Moresby Trough
Bligh Trough
EASTERN PLATEAU
PAPUA NEW GUINEA
PAPUAN PLATEAU
Osprey
Embayment
CORAL SEA BASIN
DSDP 210
DSDP 287
DSDP 209
Laura Basin
GREAT
BARRIER
REEF
M
Cairns
Queensland Trough
QUEENSLAND PLATEAU
Townsville Trough
Townsville
MARION PLATEAU
Cato Trough
Swains Reef High
Hillsborough Basin
CP
AO
CAPRICORN BASIN
W
H
Gladstone
TASMAN BASIN
4B
4A
? Late Cretaceous – Tertiary rift basins and depocentres
Oceanic basement (including minor areas of Rift phase volcanics)
Major faults
Exploration well
Bathymetric contour (m)
0
200 km
23/OQ/31

Figure 2.

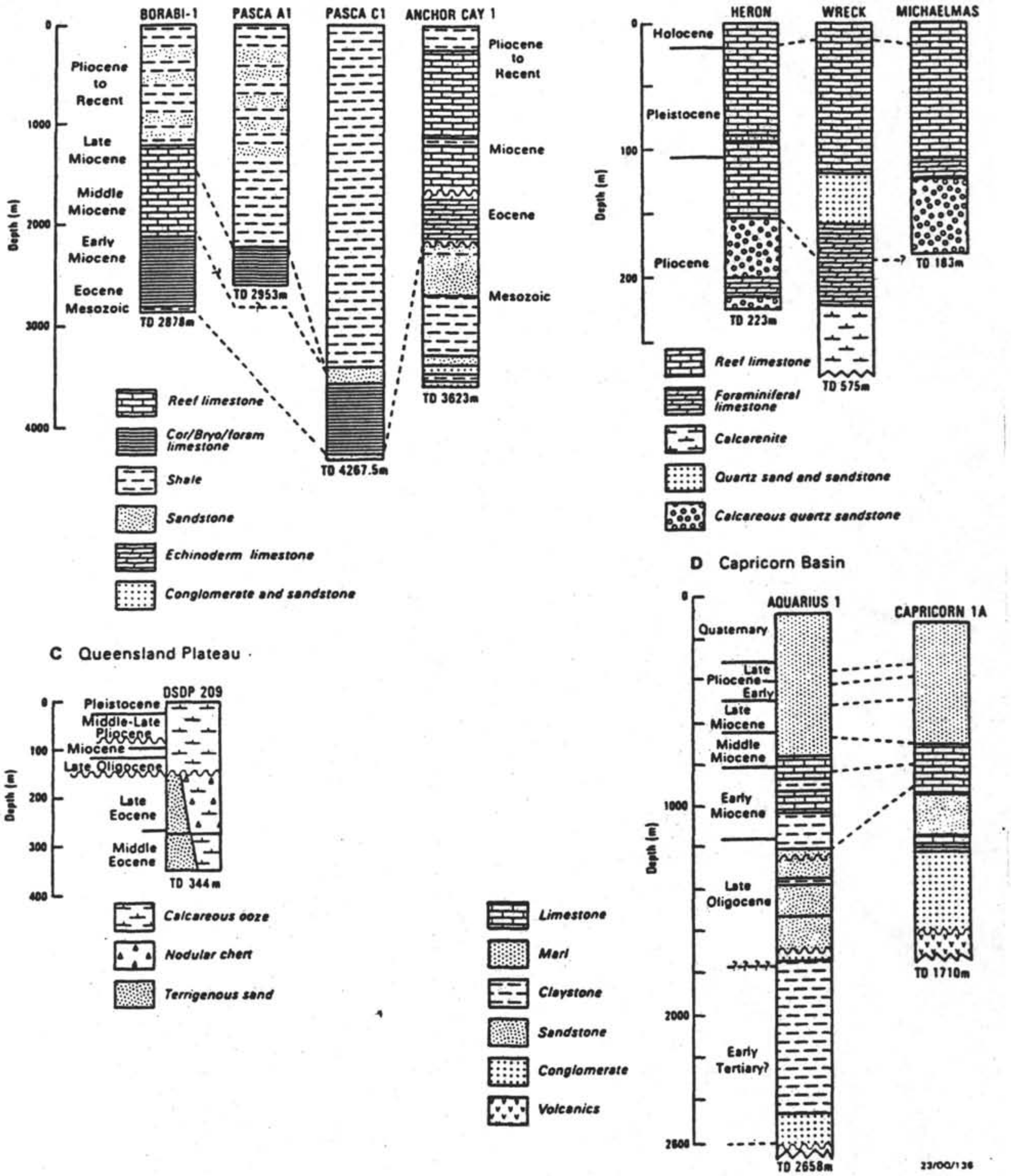

BORABI-1
PASCA A1
PASCA C1
ANCHOR CAY 1
Depth (m)
0
1000
2000
3000
4000
Pliocene to Recent
Late Miocene
Middle Miocene
Early Miocene
Eocene
Mesozoic
TD 2878m
TD 2953m
TD 4267.5m
TD 3623m
Miocene
Reef limestone
Cor/Bryo/foram limestone
Shale
Sandstone
Echinoderm limestone
Conglomerate and sandstone
HERON
WRECK
MICHAELMAS
0
100
200
Holocene
Pleistocene
Pliocene
TD 223m
TD 575m
TD 183m
Foraminiferal limestone
Calcarenite
Quartz sand and sandstone
Calcareous quartz sandstone
C Queensland Plateau
DSDP 209
Pleistocene
Middle-Late Pliocene
Miocene
Late Oligocene
Late Eocene
Middle Eocene
TD 344m
300
400
Calcareous ooze
Nodular chert
Terrigenous sand
D Capricorn Basin
AQUARIUS 1
CAPRICORN 1A
Quaternary
Late
Pliocene
Early
Late Miocene
Middle Miocene
Early Miocene
Late Oligocene
Early Tertiary?
2600
TD 2658m
TD 1710m
Limestone
Marl
Claystone
Conglomerate
Volcanics
23/OO/136

Figure 3.

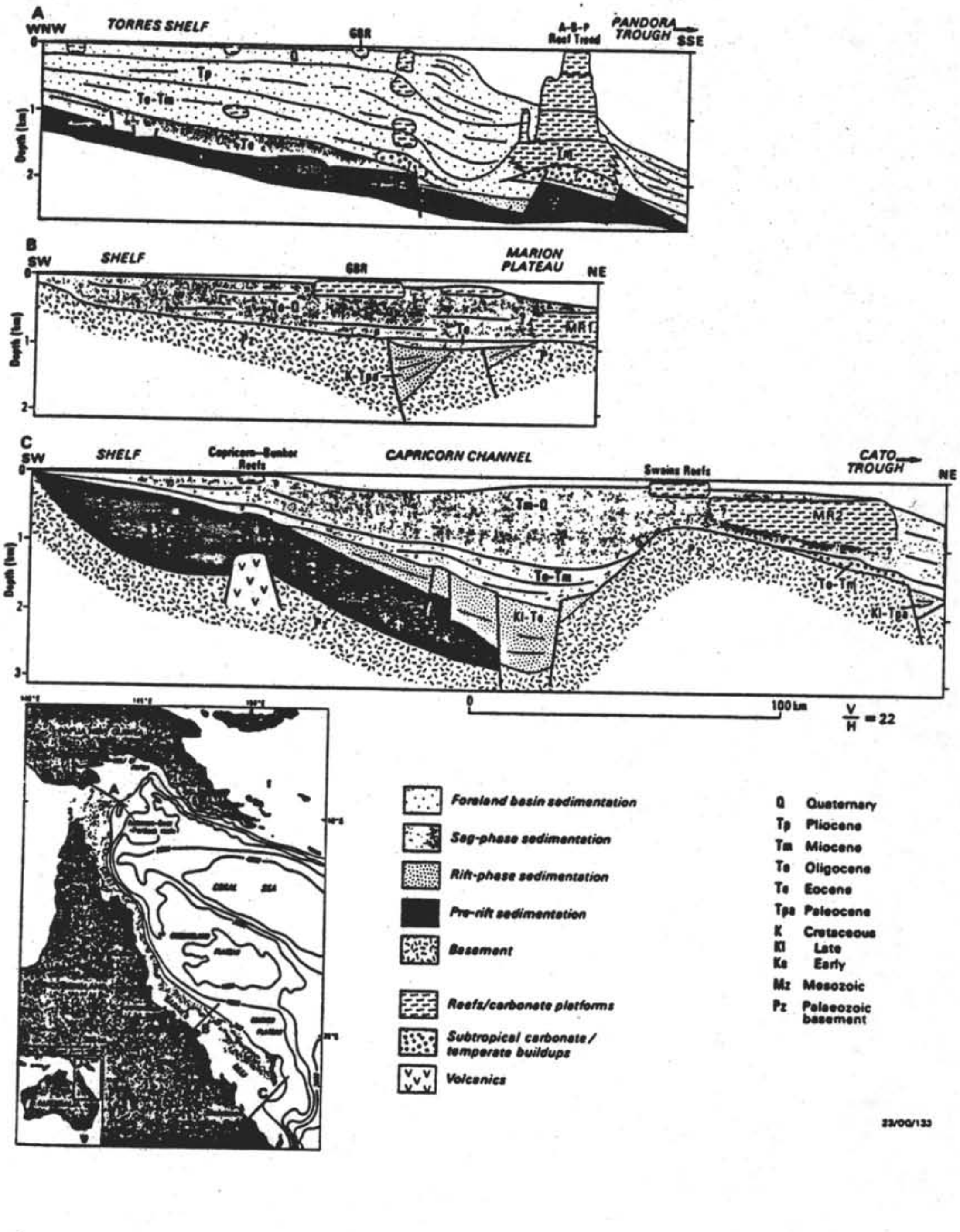

A
WNW
TORRES SHELF
GBR
PANDORA TROUGH
SSE
Tp
Te-Tm
Depth (km)
B
SW
SHELF
GBR
MARION PLATEAU
NE
Pz
C
SW
SHELF
CAPRICORN CHANNEL
Swains Reefs
CATO TROUGH
NE
Tm-Q
MR2
Te-Tm
Kl-Te
Pz
0
100 km
V/H = 22
Foreland basin sedimentation
Sag-phase sedimentation
Rift-phase sedimentation
Pre-rift sedimentation
Basement
Reefs/carbonate platforms
Subtropical carbonate / temperate buildups
Volcanics
Q Quaternary
Tp Pliocene
Tm Miocene
To Oligocene
Te Eocene
Tpa Paleocene
K Cretaceous
Kl Late
Ke Early
Mz Mesozoic
Pz Palaeozoic basement
23/OQ/133

Figure 4.

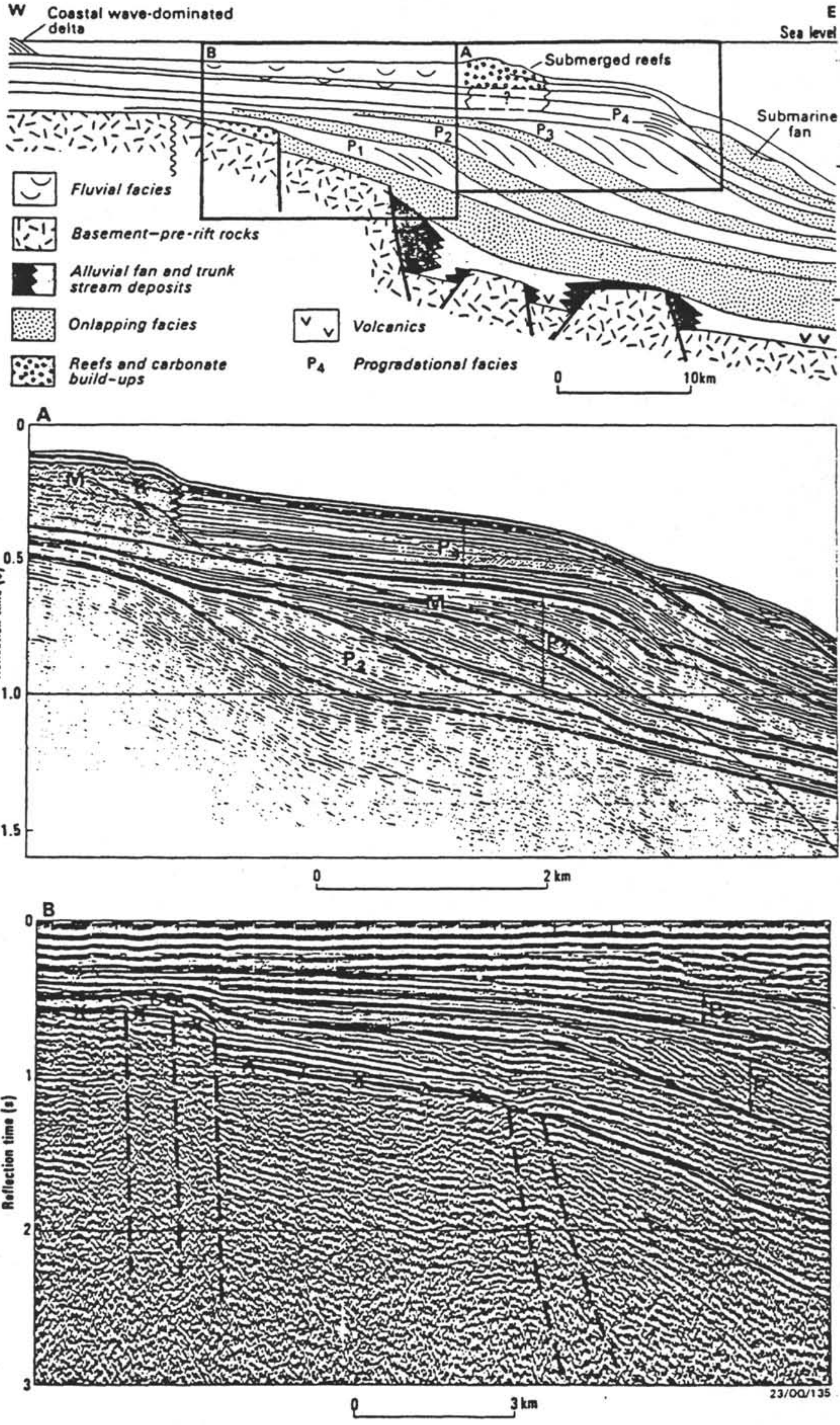

W
Coastal wave-dominated delta
E
Sea level
B
A
Submerged reefs
P4
P3
P2
P1
Submarine fan
-1
-2
Depth (km)
Fluvial facies
Basement–pre-rift rocks
Alluvial fan and trunk stream deposits
Onlapping facies
Reefs and carbonate build-ups
Volcanics
P4 Progradational facies
0
10km
A
0
0.5
1.0
1.5
Reflection time (s)
0
2 km
B
0
1
2
3
Reflection time (s)
0
3 km
23/00/135

Figure 5.

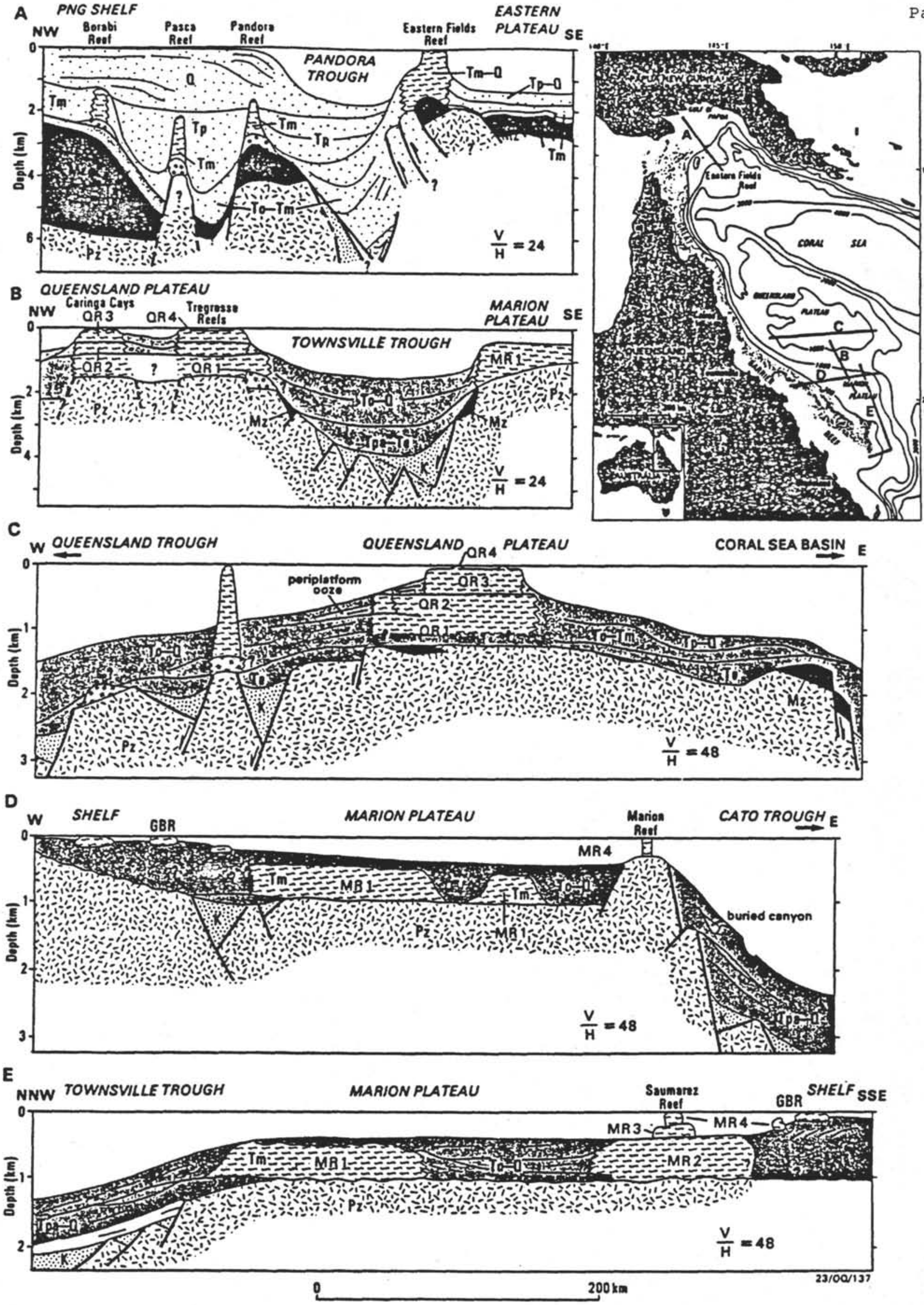

A
PNG SHELF
NW
Borabi Reef
Pasca Reef
Pandora Reef
Eastern Fields Reef
EASTERN PLATEAU
SE
PANDORA TROUGH
Depth (km)
V/H = 24
B
QUEENSLAND PLATEAU
Caringa Cays
Tregrosse Reefs
MARION PLATEAU
TOWNSVILLE TROUGH
V/H = 24
C
W
QUEENSLAND TROUGH
QUEENSLAND PLATEAU
CORAL SEA BASIN
E
periplatform ooze
V/H = 48
D
SHELF
GBR
MARION PLATEAU
Marion Reef
CATO TROUGH
buried canyon
V/H = 48
E
NNW
TOWNSVILLE TROUGH
MARION PLATEAU
Saumarez Reef
GBR
SHELF
SSE
V/H = 48
0
200 km
23/OQ/137
CORAL SEA
Eastern Fields Reef

Figure 6.

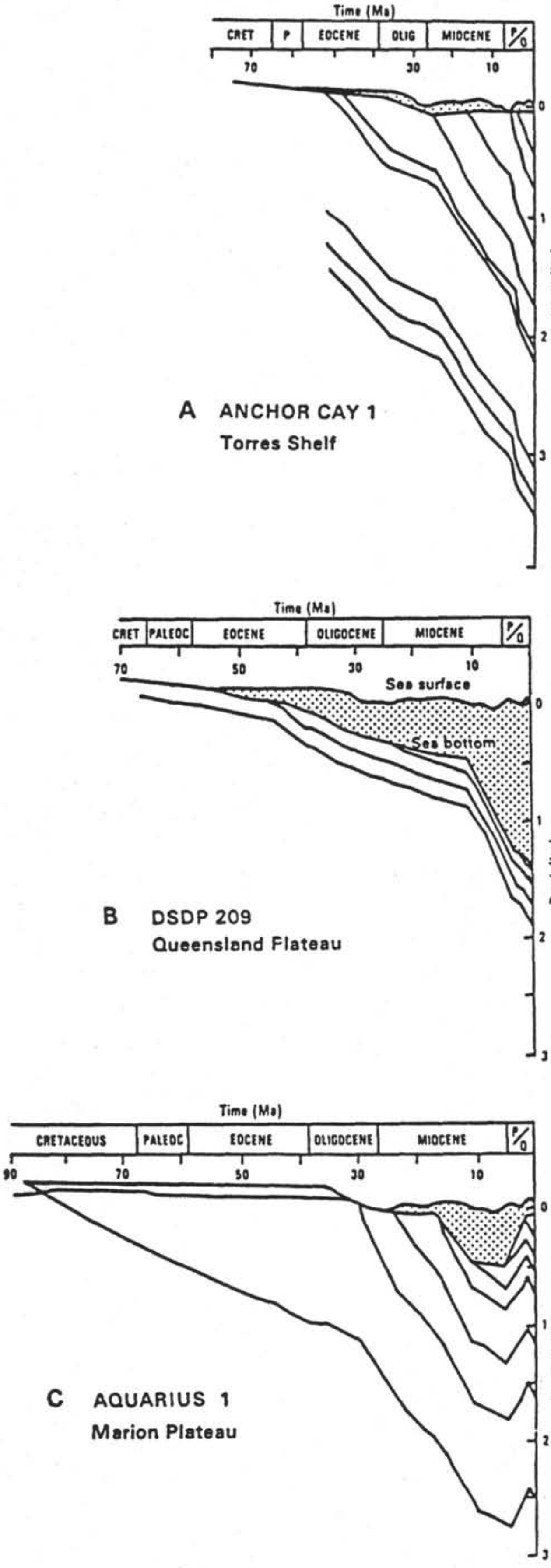

Time (Ma)
CRET
P
EOCENE
OLIG
MIOCENE
P/Q
70
30
10
0
1
2
3
Depth (km)
A ANCHOR CAY 1
Torres Shelf
Time (Ma)
CRET
PALEOC
EOCENE
OLIGOCENE
MIOCENE
P/Q
70
50
30
10
Sea surface
Sea bottom
0
1
2
3
Depth (km)
B DSDP 209
Queensland Plateau
Time (Ma)
CRETACEOUS
PALEOC
EOCENE
OLIGOCENE
MIOCENE
P/Q
90
70
50
30
10
0
1
2
3
Depth (km)
C AQUARIUS 1
Marion Plateau

Figure 7.

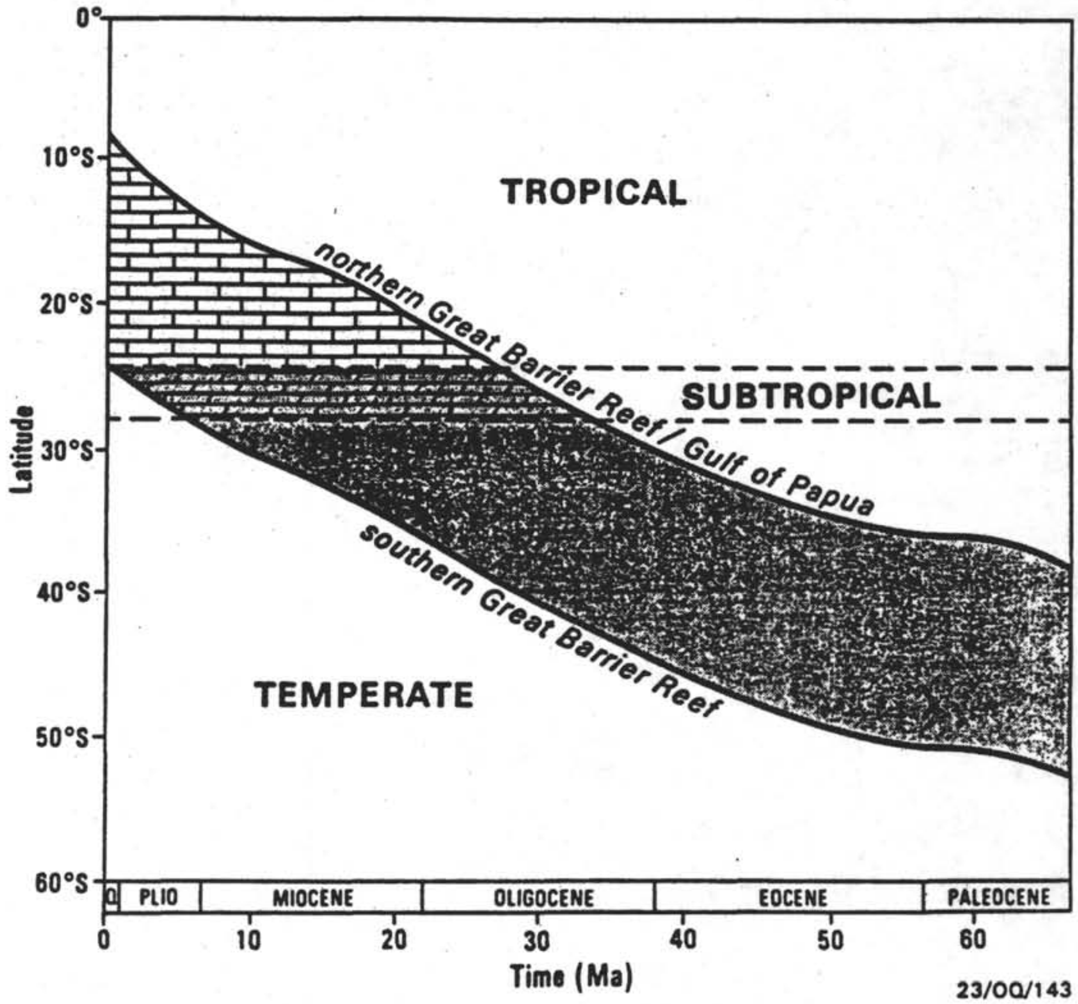

0°
10°S
20°S
30°S
40°S
50°S
60°S
Latitude
TROPICAL
SUBTROPICAL
TEMPERATE
northern Great Barrier Reef / Gulf of Papua
southern Great Barrier Reef
Q
PLIO
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
0
10
20
30
40
50
60
Time (Ma)
23/OQ/143

Figure 8.

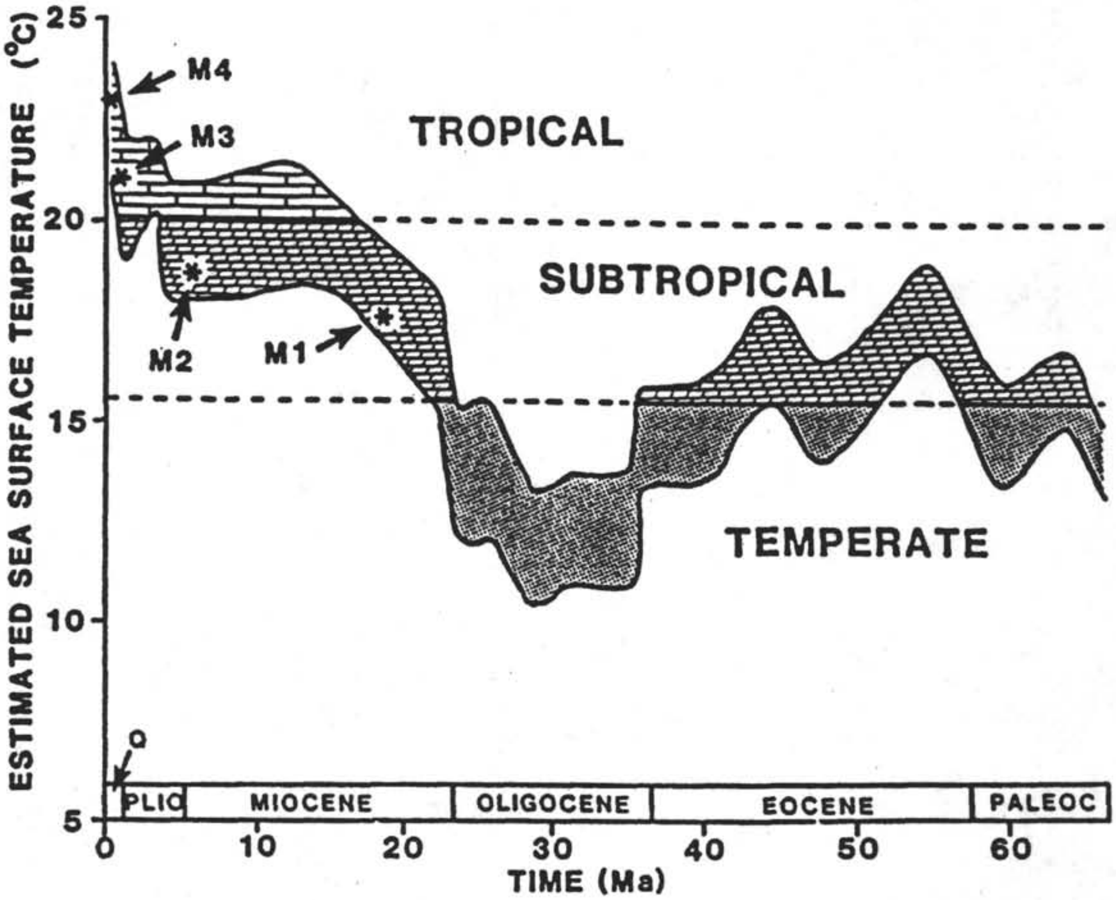

ESTIMATED SEA SURFACE TEMPERATURE (°C)
25
20
15
10
5
M4
M3
M2
M1
Q
TROPICAL
SUBTROPICAL
TEMPERATE
PLIO
MIOCENE
OLIGOCENE
EOCENE
PALEOC
0
10
20
30
40
50
60
TIME (Ma)

Figure 9.

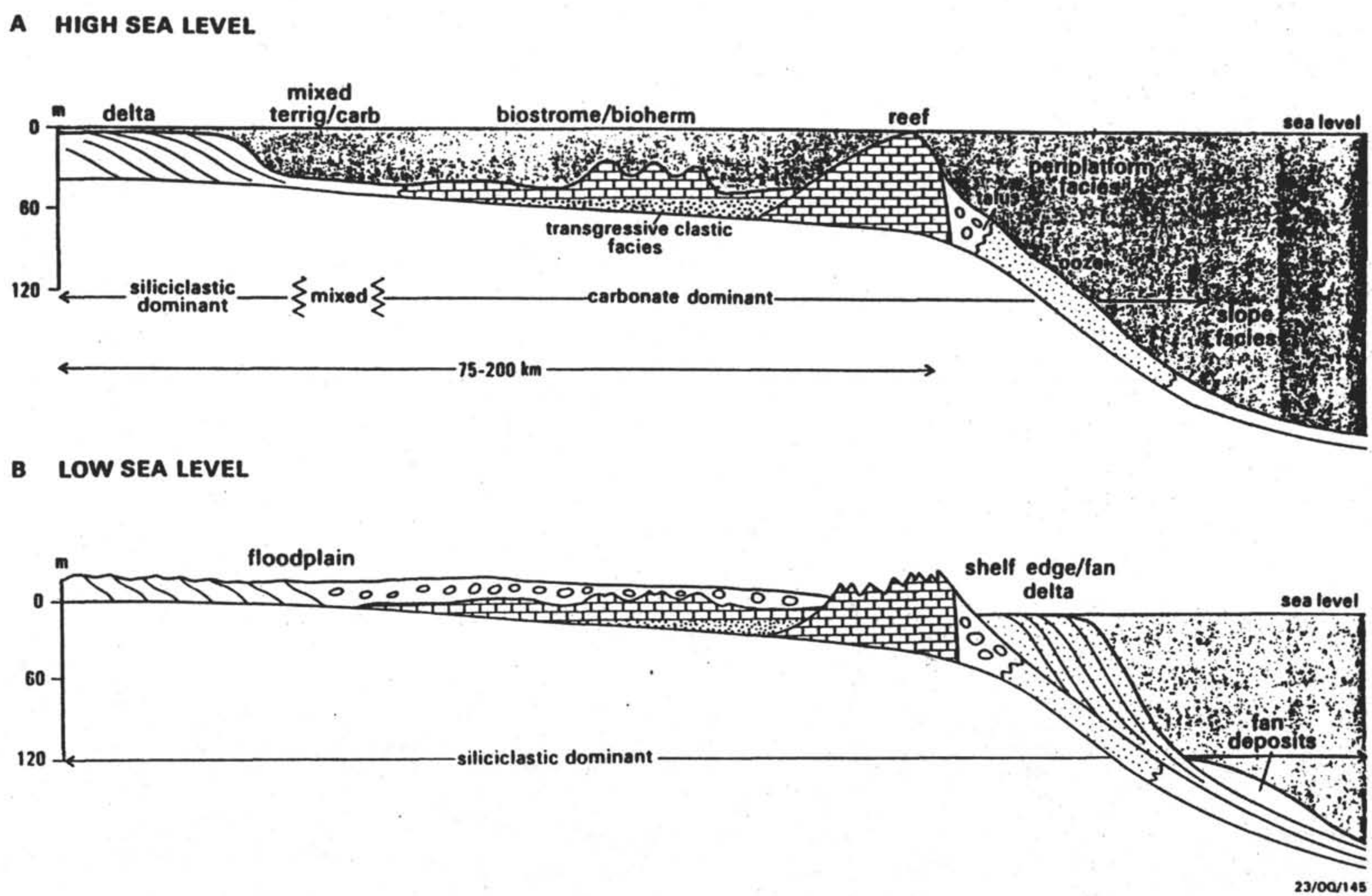
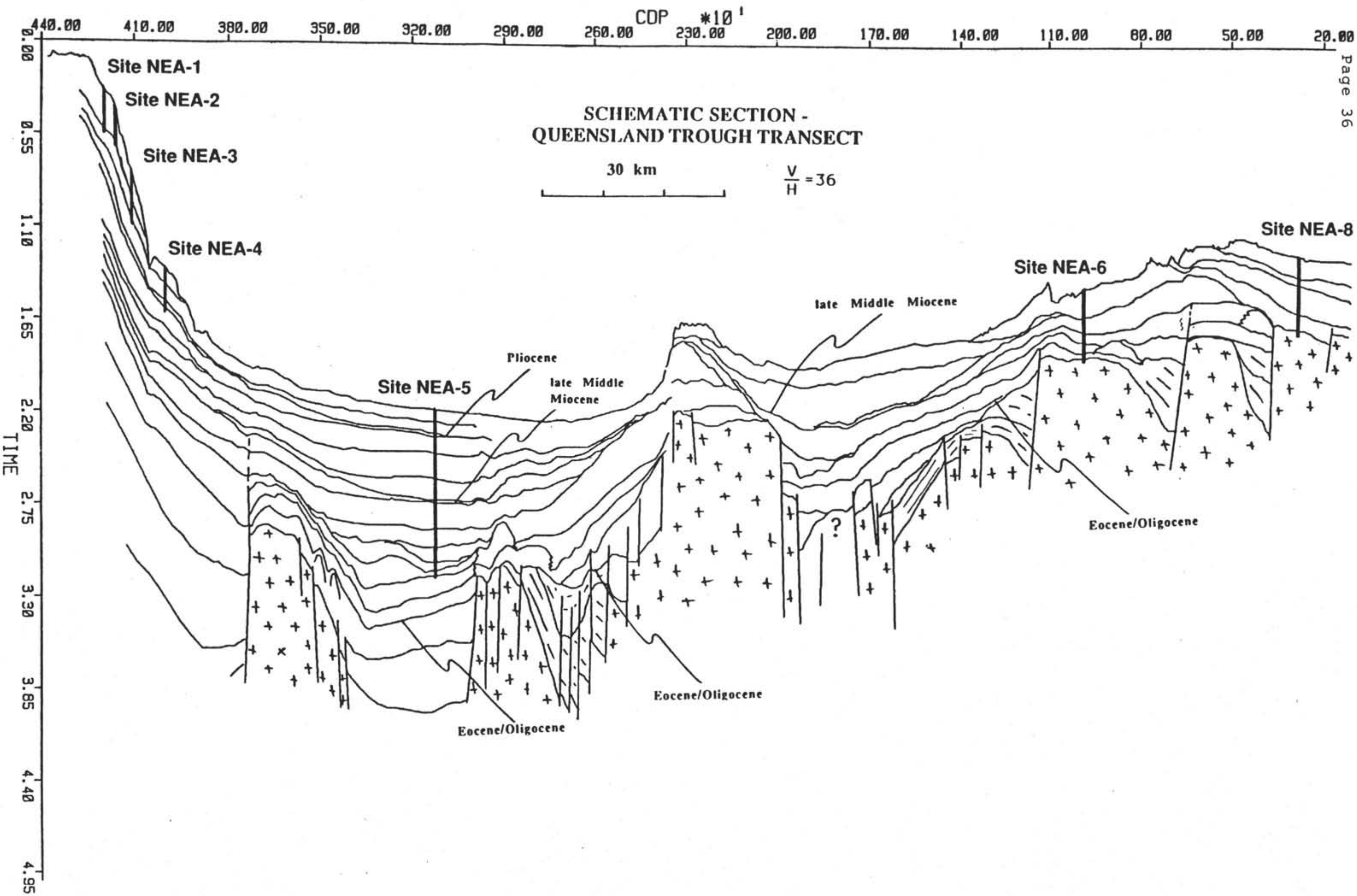

A HIGH SEA LEVEL
m
0
60
120
delta
mixed
terrig/carb
biostrome/bioherm
reef
sea level
periplatform
facies
talus
ooze
transgressive clastic
facies
siliciclastic
dominant
mixed
carbonate dominant
slope
facies
75-200 km
B LOW SEA LEVEL
m
0
60
120
floodplain
shelf edge/fan
delta
sea level
fan
deposits
siliciclastic dominant
23/00/145

Figure 10.



CDP *10[1]
440.00
410.00
380.00
350.00
320.00
290.00
260.00
230.00
200.00
170.00
140.00
110.00
80.00
50.00
20.00
Page 36
TIME
0.00
0.55
1.10
1.65
2.20
2.75
3.30
3.85
4.40
4.95
SCHEMATIC SECTION -
QUEENSLAND TROUGH TRANSECT
30 km
V/H = 36
Site NEA-1
Site NEA-2
Site NEA-3
Site NEA-4
Site NEA-5
Site NEA-6
Site NEA-8
Pliocene
late Middle Miocene
late Middle Miocene
Eocene/Oligocene
Eocene/Oligocene
Eocene/Oligocene
?

Figure 11.

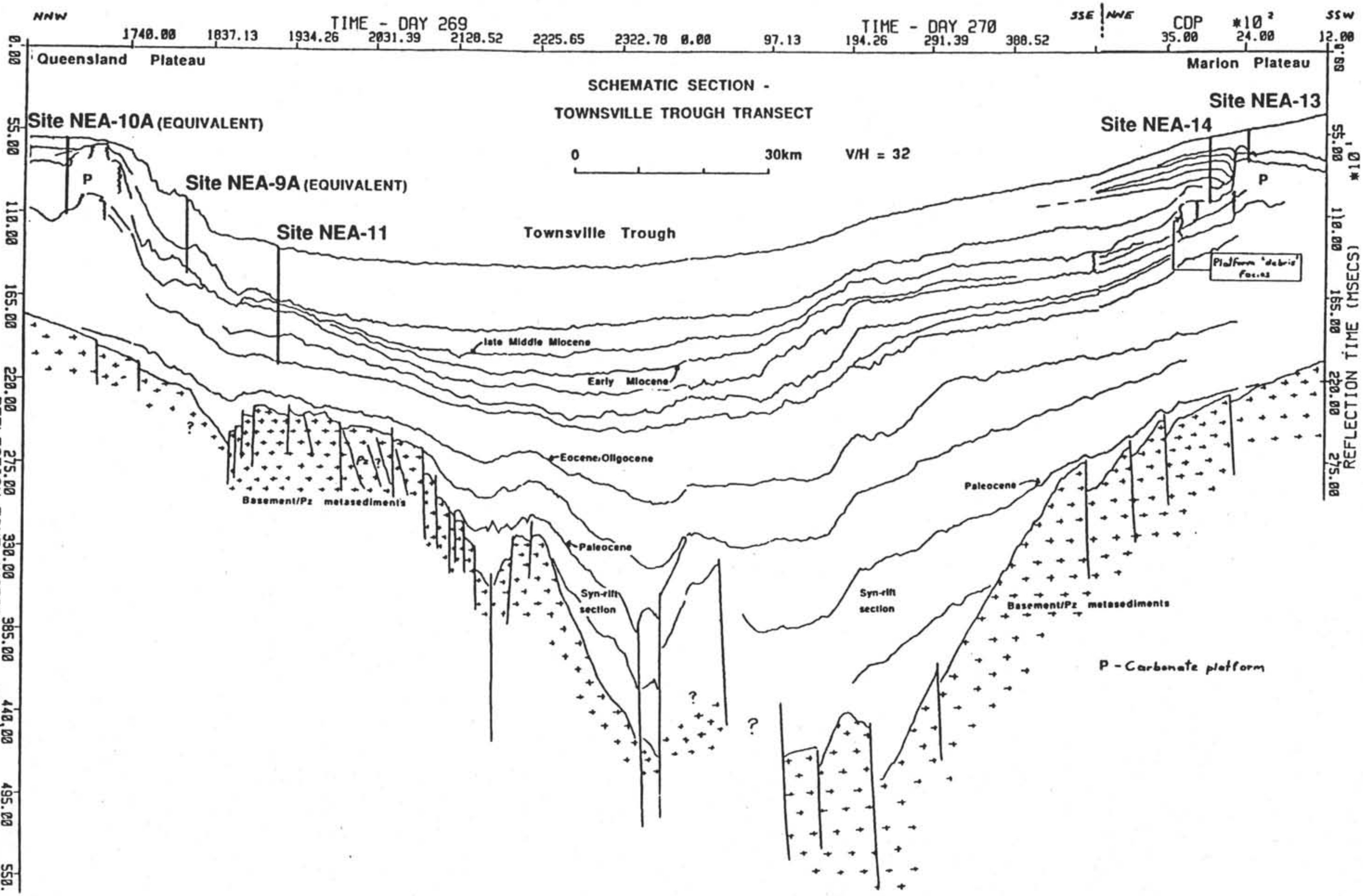

NNW
TIME - DAY 269
1740.00 1837.13 1934.26 2031.39 2128.52 2225.65 2322.78 0.00 97.13
TIME - DAY 270
194.26 291.39 388.52
SSE NWE
CDP *10 ²
35.00 24.00 12.00
SSW
Queensland Plateau
Marion Plateau
SCHEMATIC SECTION -
TOWNSVILLE TROUGH TRANSECT
0 30km V/H = 32
Site NEA-10A (EQUIVALENT)
Site NEA-9A (EQUIVALENT)
Site NEA-11
Site NEA-14
Site NEA-13
Townsville Trough
P
Platform 'debris' facies
late Middle Miocene
Early Miocene
Eocene/Oligocene
Paleocene
Basement/Pz metasediments
Syn-rift section
P - Carbonate platform
REFLECTION TIME (MSECS) *10¹
0.00 55.00 110.00 165.00 220.00 275.00 330.00 385.00 440.00 495.00 550.

Figure 12.

TABLE 1
LEG 133 DRILL SITES

Site	Location	Water depth (m)	Total penetration (mbsf)	Time estimate (days) Drilling	Logging	Total
NEA-1	16°38.6'S 146°17.3'E	206	400	1.8	0.5	2.3
NEA-2	16°38.3'S 146°18.3'E	272	400	2.2	1.2	3.4
NEA-3	16°37.3'S 146°19.6'E	555	400	2.0	0.5	2.5
NEA-4	16°25.3'S 146°12.7'E	960	400	2.4	1.1	3.5
NEA-5	16°36.96'S 146°47.07'E	1638	1011	7.7	1.5	9.2
NEA-6	16°26.7'S 147°45.8'E	1000	390	3.1	1.0	4.1
NEA-8	16°31.1'S 148°09.4'E	934	400	2.9	1.0	3.9
NEA-9A[a]	18°03.7'S 150°02.6'E	739	500	3.5	1.1	4.6
NEA-10A/1	17°48.8'S 149°36.3'E	455	300	2.4	1.2	3.6
NEA-10A/2	17°50.0'S 149°30.9'E	505	500	3.1	1.4	4.5
NEA-11	18°09.5'S 149°45.5'E	1005	700	5.4	1.4	6.8
NEA-13	19°12.0'S 150°00.6'E	426	250	2.2	0.7	2.9
NEA-14	19°09.0'S 149°59.5'E	456	400	2.8	0.9	3.7

[a]Note that Site NEA-9A is of secondary priority and is not included in the drilling schedule shown in Table 3.

TABLE 2
SITE LOCATIONS ON SITE SURVEY SEISMIC LINES
(APPROVED BY POLLUTION PREVENTION AND SAFETY PANEL)

Site	Line/Part	CDP	TD
NEA-1	43 L *	6391	400 mbsf
	43 T	10107	
NEA-2	43 J *	5429	400 mbsf
	43 T	10244	
NEA-3	43 T *	10445	400 mbsf
NEA-4	45P1 A *	463	400 mbsf
	46 Q	2380	
NEA-4 (alt.)	45P2 E *	1084	400 mbsf
	46 Q	2322	
NEA-5	41 A	468	
	41 K *	5865	1011mbsf[1]
NEA-6	39 A *	798	390 mbsf[2]
	39 C	2853	
NEA-8	37 C *	3062	400 mbsf
NEA-9A	59 I *	3668	500 mbsf
	59 M	5572	
NEA-10A/1	57 C	1647	
	57 G *	4068	300 mbsf
NEA-10A/2	57 I *	5802	500 mbsf

NEA-11	30	E *	1235	700 mbsf
	30	K	2235	
NEA-13	27	A *	312	250 mbsf
	27	M	4848	
NEA-14	27	C	1028	
	27	Q *	6630	400 mbsf

Note: Asterisks (*) indicate site positions recorded as approved in the minutes of the JOIDES Pollution Prevention and Safety Panel (PPSP).

[1]Cleared by PPSP to 1100 mbsf.
[2]Cleared by PPSP to 400 mbsf.

TABLE 3
LEG 133 - NORTHEAST AUSTRALIA
PROPOSED SITE OCCUPATION SCHEDULE

DATE	TIME ON STATION	TRANSIT
Leg 133 departs Guam - 10 August 1990		
Transit Guam to NEA-8		6.5 days
Start drilling NEA-8: 16 August	3.9 days	
Transit to NEA-10A/1: 20 August		0.5 days
Start drilling NEA-10A/1: 20 August	3.6 days	

Start drilling NEA-10A/2: 24 August	4.5 days	
Transit to NEA-13: 28 August		0.5 days
Start drilling NEA-13: 29 August	2.9 days	
Start drilling NEA-14: 1 September	3.7 days	
Transit to NEA-11: 4 September		0.5 days
Start drilling NEA-11: 5 September	6.8 days	
Transit to NEA-6: 10 September		0.5 days
Start drilling NEA-6: 11 September	4.1 days	
Transit to NEA-5: 15 September		0.75 days
Start drilling NEA-5: 16 September	9.2 days	
Transit to NEA-4: 25 September		0.25 days
Start drilling NEA-4: 25 September	3.5 days	
Transit to NEA-1: 29 September		0.5 days
Start drilling NEA-1: 29 September	2.3 days	

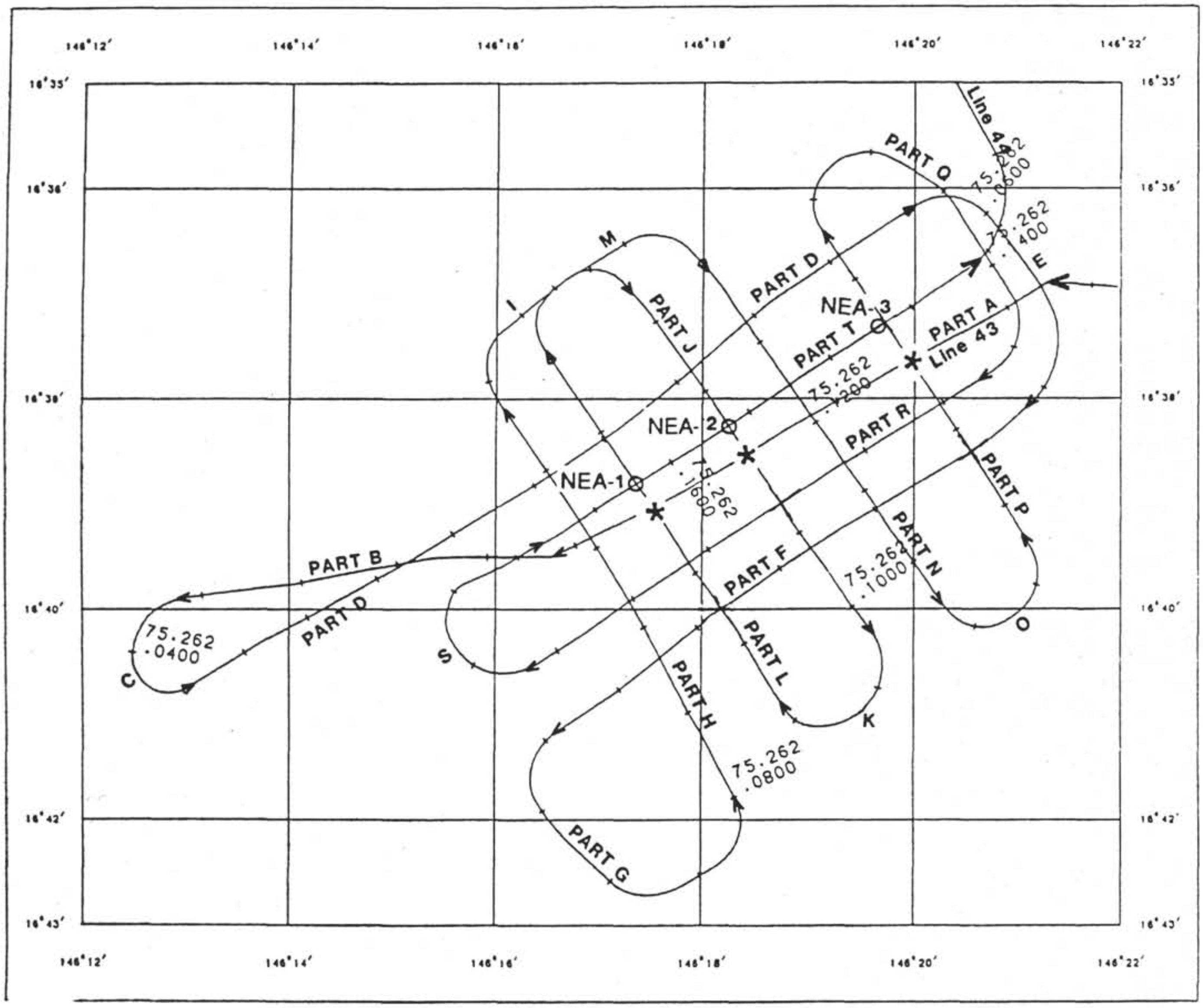
Start drilling NEA-2: 3 October	3.4 days	

Start drilling NEA-3: 7 October	2.5 days	
Transit to Townsville 10 October		1.5 days
Arrive Townsville 11 October		

Note: Transit times assume ship speed of 10 knots.

SCALE 1:100000

EDITION OF 1989/03/23



AUSTRALIAN NATIONAL SPHEROID
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

TRACK MAP

COMPUTER DRAWN AT THE DIVISION OF
MARINE GEOSCIENCES & PETROLEUM GEOLOGY

KILOMETRES 2 0 2 4 6 8

1 0 1 2 3 4 NAUTICAL MILES

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS AUSTRALIA

SITE: NEA-1

PRIORITY: 1

POSITION: 16°38.6'S
146°17.3'E

JURISDICTION: Australia

WATER DEPTH: 206 m

SEDIMENT THICKNESS: >2 s TWT

PROPOSED DRILLING PROGRAM: APC/XCB to 400 mbsf (oriented cores).

SEISMIC RECORD: BMR Line 75/043 (part L), CDP 6391; Line 75/043 (part T), CDP 10107.

LOGGING: Limited standard Schlumberger suite.

OBJECTIVES:

1. To determine the age and facies of the most proximal portions of the aggradational and progradational units immediately in front of the present day Great Barrier Reef.

2. To determine the relationship between sea level and depositional facies in order to extract the sea-level signature.

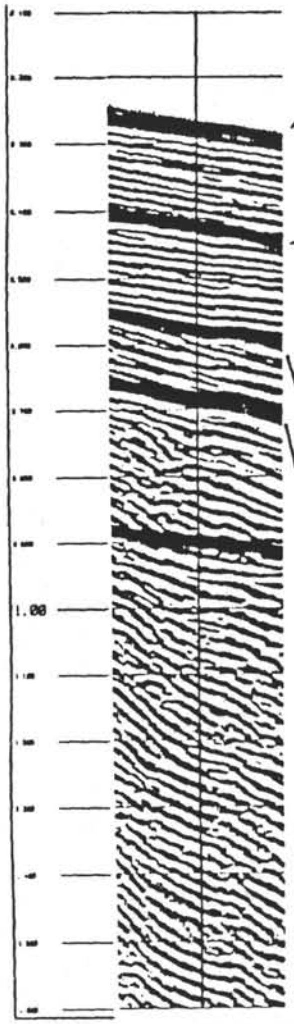
3. To determine the timing and factors controlling the initiation of reef growth on the central Great Barrier Reef.

4. To understand the factors controlling the transition from progradative to aggradative depositional geometries.

NATURE OF SEDIMENTS/ROCKS ANTICIPATED:

Pliocene-Quaternary siliciclastic and carbonate sediment (0-234 mbsf)
uppermost Miocene to Pliocene siliciclastic sediment (234-400 mbsf)

GRAPHIC SUMMARY: SITE NEA 1



Key Reflectors	Depth (m)	Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
	0–100	Quaternary	1.54	interbedded finegrained siliciclastic & carbonate sediments; possibly some hardgrounds	upper slope	63 m/my	high resolution sealevel signature from siliciclastic /carbonate couplets
H4	200	[127] Pliocene and Pleistocene [234]	1.94	siliciclastic sand and mud with increasing carbonate content toward the top	outer shelf to shelf edge	54 m/my	initiation of shallow water carbonate sedimentation
H6	300	Pliocene	1.94	siliciclastic sand and mud; low carbonate content	shelf edge fan delta	51 m/my	
H10	400	[336] latest Miocene to Pliocene	2.05	as above	as above		
	500	TD					

SITE: NEA-2

PRIORITY: 1

POSITION: 16°38.3'S
146°18.3'E

JURISDICTION: Australia

WATER DEPTH: 272 m

SEDIMENT THICKNESS: > 2 s TWT

PROPOSED DRILLING PROGRAM: APC/XCB to 400 mbsf (oriented cores); one water sample (WSTP) every 100 m.

SEISMIC RECORD: BMR line 75/043 (part J), CDP 5429; Line 75/043 (part T), CDP 10244.

LOGGING: Standard Schlumberger suite; vertical seismic profile (VSP).

OBJECTIVES:

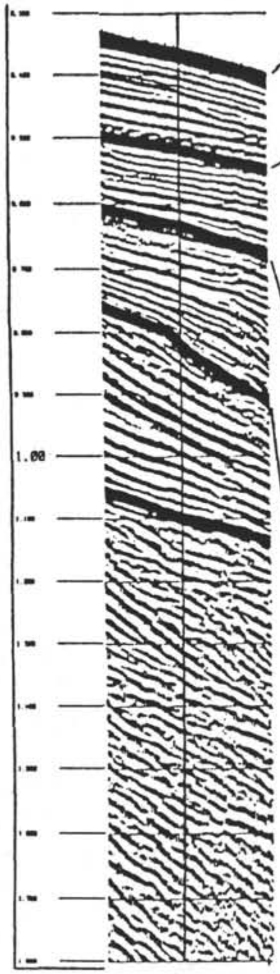
1. To determine the age and facies of the central portions of the aggradational and progradational units immediately in front of the present-day Great Barrier Reef.
2. To determine the relationship between sea level and depositional facies in order to extract the sea-level signature.
3. To determine the timing and factors controlling the initiation of reef growth on the central Great Barrier Reef.
4. To understand the factors controlling the transition from progradative to aggradative depositional geometries.

NATURE OF SEDIMENTS/ROCKS ANTICIPATED:

Pliocene-Quaternary interbedded siliciclastic/carbonate sediment (0-233 mbsf)
uppermost Miocene to Pliocene siliciclastic sediment (233-400 mbsf)

GRAPHIC SUMMARY: SITE NEA 2

Key Reflectors



Depth (m)	Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
0 – H4	Quaternary	1.61	interbedded finegrained silici. & carb. sediments.	upper slope	62 m/my	high resol. sealevel signature in siliciclastic/carbonate couplets
H4 – 100 – 200 – H6	[124] Pliocene to Pleistocene	1.98	siliciclastic sand and mud with increasing carbonate content toward the top.	fluviodeltaic - outer shelf to shelf edge	55 m/my	initiation of shallow water carbonate sedimentation
H6 – 300 – 400	[233] Latest Miocene to Pliocene	2.65	siliciclastic sand and minor mud	shelf edge fan delta	50 m/my	sand-prone topsets and upper foresets
H10 TD – 500	[432]					

SITE: NEA-3

PRIORITY: 1

POSITION: 16°37.3'S
146°19.6'E

JURISDICTION: Australia

WATER DEPTH: 555 m

SEDIMENT THICKNESS: > 2 s TWT

PROPOSED DRILLING PROGRAM: APC/XCB to 400 m (oriented cores).

SEISMIC RECORD: BMR line 75/043 (part T), CDP 10445.

LOGGING: Limited standard Schlumberger suite.

OBJECTIVES:

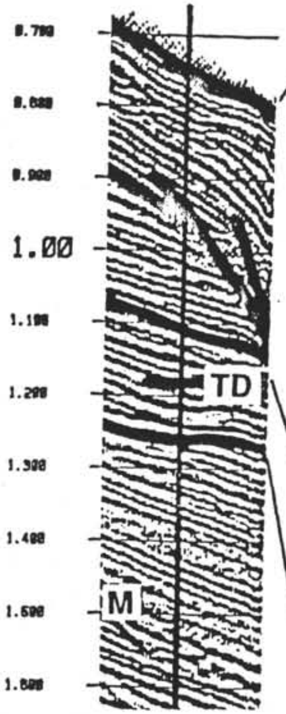
1. To determine the age and facies of the most distal portions of the progradational units in front of the present-day Great Barrier Reef.
2. To determine the relationship between sea level and depositional facies in order to extract the sea-level signature.
3. To determine the timing and factors controlling the initiation of reef growth on the central Great Barrier Reef.
4. To determine the nature of the deeper water condensed section equivalent to the aggradational package deposited closer to shore.

NATURE OF SEDIMENT/ROCKS ANTICIPATED:

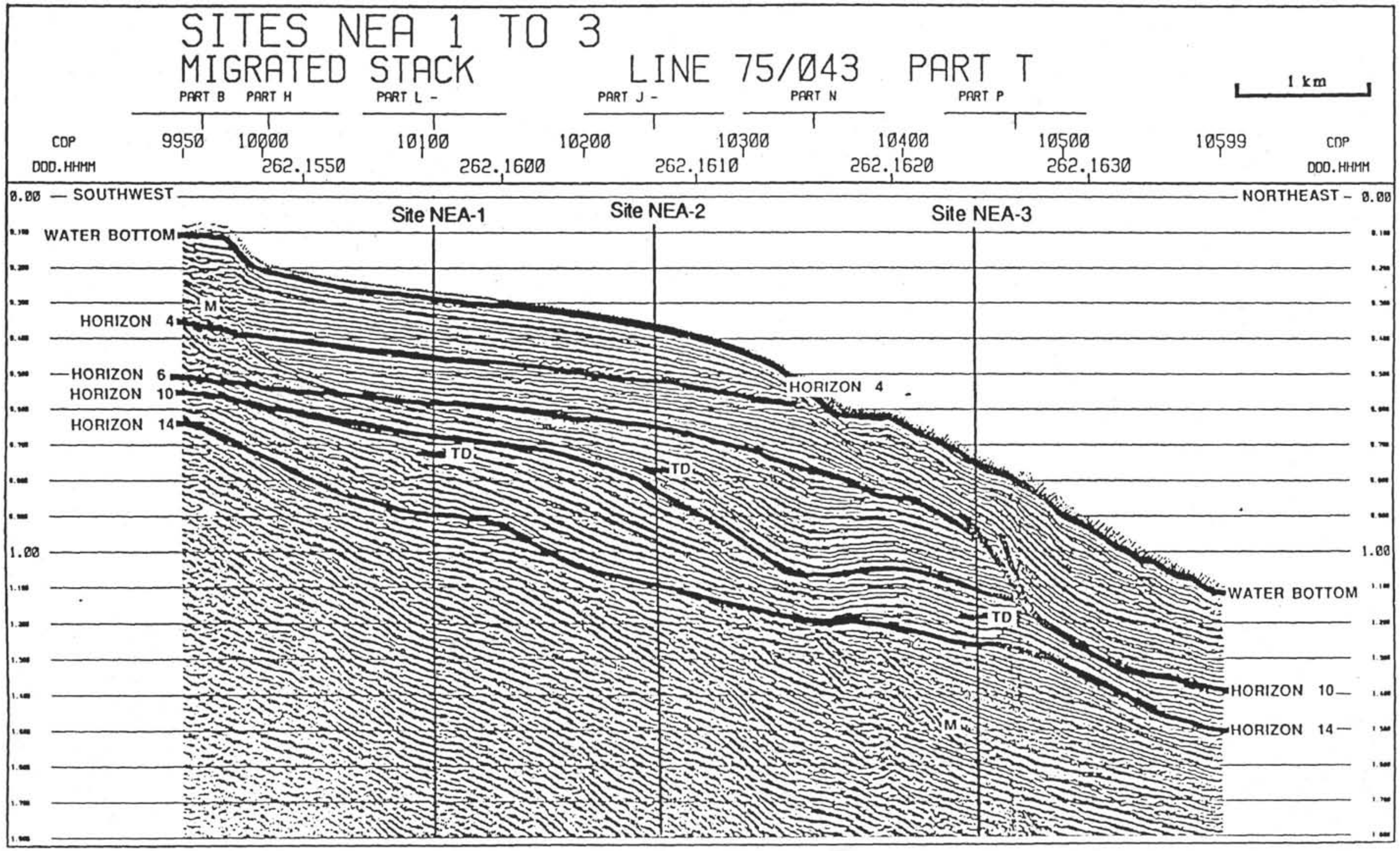
uppermost Pliocene-Quaternary interbedded siliciclastic and carbonate sediment with slumps present (0-186 mbsf)
Pliocene siliciclastic sediment (186-326 mbsf)
uppermost Miocene to Pliocene siliciclastic mud (326-400 mbsf)

GRAPHIC SUMMARY: SITE NEA 3

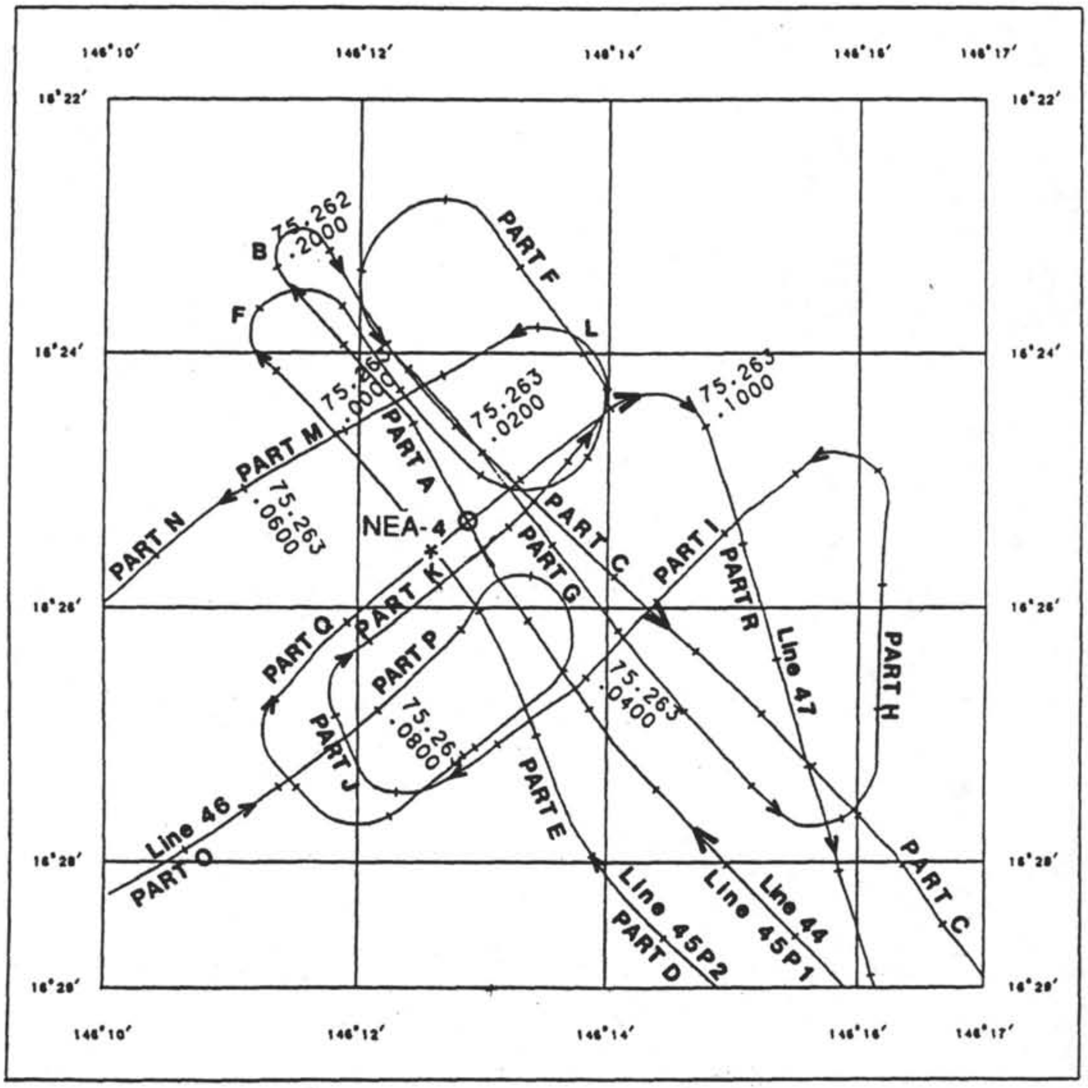
Key Reflectors



Depth (m)	Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
0–100	Latest Pliocene to Quaternary	1.59	interbedded siliciclastic and carbonate sand and mud.	upper slope - hemipelagic	50 m/my	upper part of section is slumped - some parts of section missing. Sequence contains 1 or more slump surfaces
100	[99]	1.92				
H6 200	[186] Pliocene	2.00	siliciclastic mud.	upper slope - hemipelagic	56 m/my	distal progadation mud-prone bottomsets
300 H10	[326] Latest Miocene to Pliocene	2.09	siliciclastic mud.	upper slope - hemipelagic	50 m/my	as above
400 TD H14	[439]					
500						


SITES NEA 1 TO 3
MIGRATED STACK
LINE 75/Ø43 PART T
1 km
PART B
PART H
PART L -
PART J -
PART N
PART P
CDP
DDD.HHMM
9950
10000
10100
10200
10300
10400
10500
10599
262.1550
262.1600
262.1610
262.1620
262.1630
Ø.ØØ
SOUTHWEST
NORTHEAST
Site NEA-1
Site NEA-2
Site NEA-3
WATER BOTTOM
M
HORIZON 4
HORIZON 6
HORIZON 10
HORIZON 14
TD
1.ØØ
HORIZON 10
HORIZON 14

SCALE 1:100000 EDITION OF 1989/03/23



* ALTERNATE SITE

TRACK MAP

AUSTRALIAN NATIONAL SPHEROID
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

SITE: NEA-4

PRIORITY: 1

POSITION: 16°25.3'S
146°12.7'E

JURISDICTION: Australia

WATER DEPTH: 960 m

SEDIMENT THICKNESS: >2 s TWT

PROPOSED DRILLING PROGRAM: APC/XCB to 400 mbsf (oriented cores); one water sample (WSTP) every 100 m.

SEISMIC RECORD: BMR line 75/045 Part 1 (part A), CDP 463; adjacent line 75/046 (part Q), CDP 2380.

LOGGING: Standard Schlumberger suite.

OBJECTIVES:

1. To determine the age and facies of a lower slope fan in front of the present-day Great Barrier Reef.

2. By comparison with Sites NEA-1 to -3, to determine the sea-level signature preserved in lower slope facies.

3. To examine fan processes on the lower slope in a mixed siliciclastic/carbonate depositional system.

NATURE OF SEDIMENTS/ROCKS ANTICIPATED:

uppermost Miocene-Quaternary interbedded siliciclastic and carbonate sands and muds (0-400 mbsf)

SITE: NEA-4 (alternate)

PRIORITY: 2

POSITION: 16°25.6'S
146°12.6'E

JURISDICTION: Australia

WATER DEPTH: 917 m

SEDIMENT THICKNESS: >2 s TWT

PROPOSED DRILLING PROGRAM: APC/XCB to 400 mbsf (oriented cores); one water sample (WSTP) every 100 m.

SEISMIC RECORD: BMR line 75/045 Part 2 (part E), CDP 1084; line 75/046 (part Q), CDP 2322.

LOGGING: Standard Schlumberger suite.

OBJECTIVES:

1. To determine the age and facies of a lower slope fan in front of the present-day Great Barrier Reef.

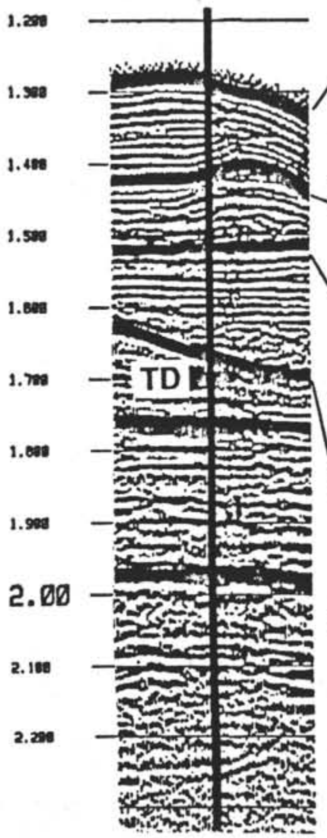
2. By comparison with Sites NEA-1 to -3, to determine the sea-level signature preserved in lower slope facies.

3. To examine fan processes on the lower slope in a mixed siliciclastic/carbonate depositional system.

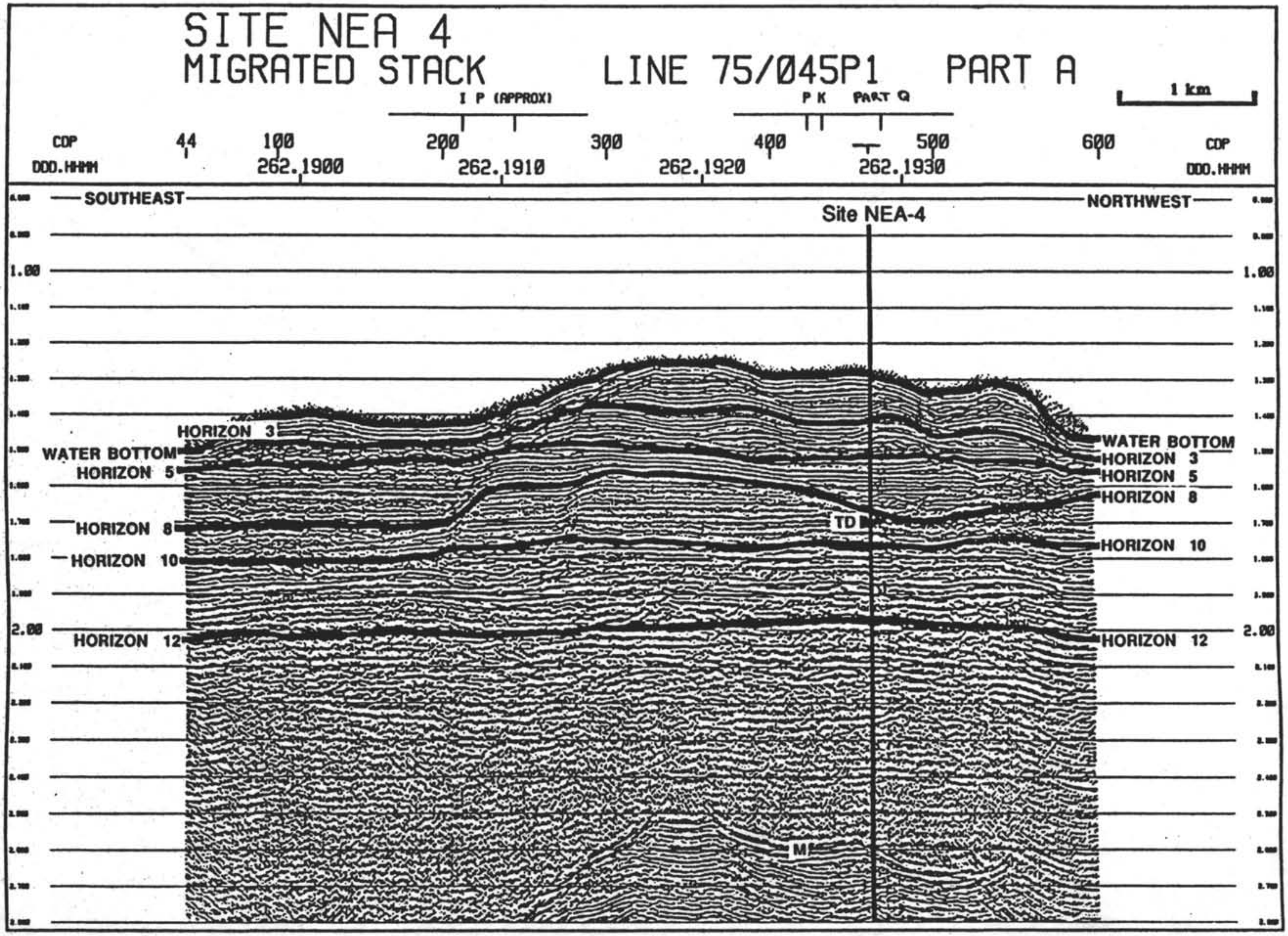
NATURE OF SEDIMENTS/ROCKS ANTICIPATED:

uppermost Miocene-Quaternary interbedded siliciclastic and carbonate sands and muds (0-400 mbsf)

GRAPHIC SUMMARY: SITE NEA 4



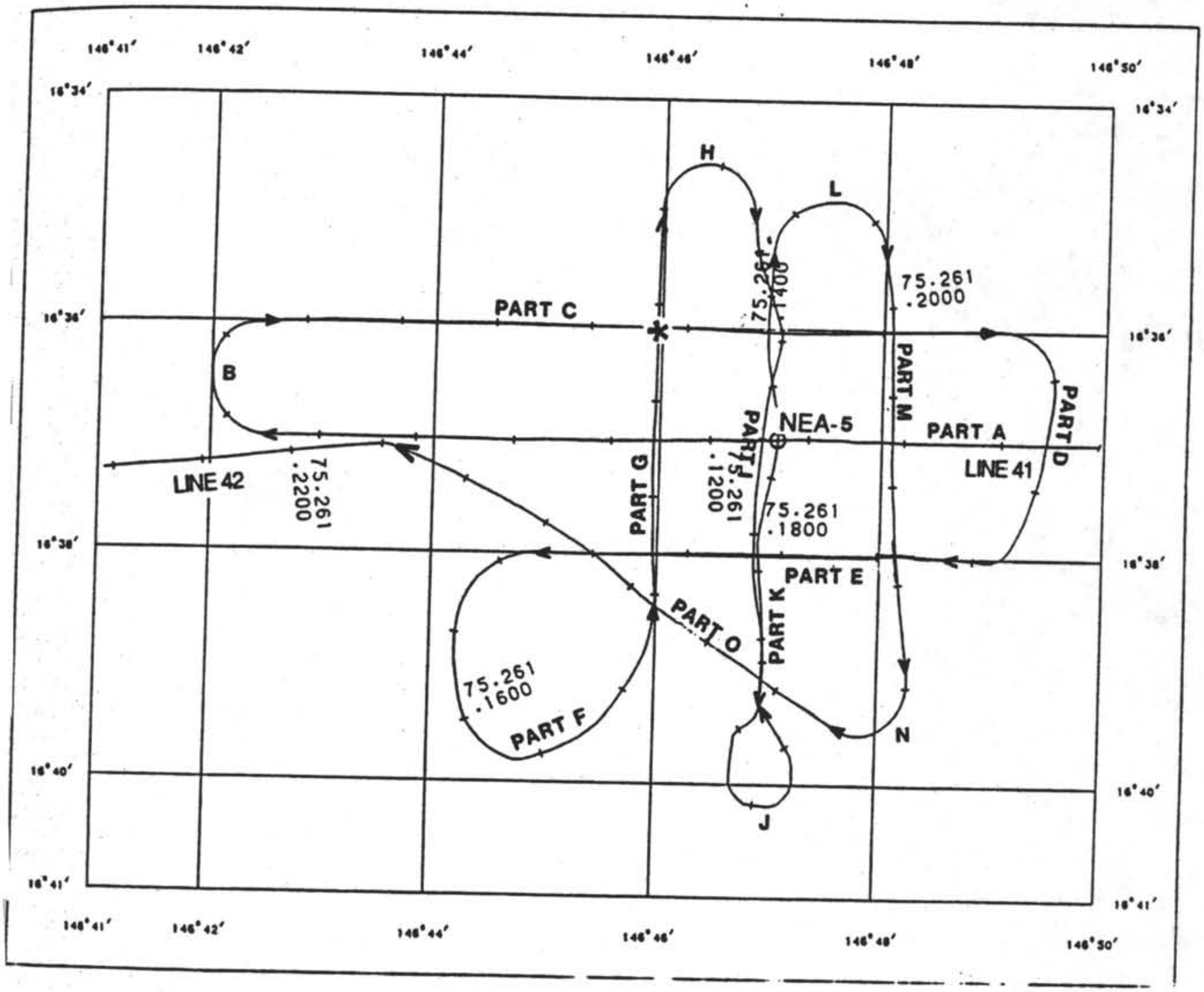
Key Reflectors	Depth (m)	Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
	0	latest Pliocene to Quaternary	1.56	carbonate mud draped over siliciclastic & carbonate sand to mud	pelagic ooze over lower slope fan deposits	43 m/my	both coarser channel deposits and fine grained 'levee' deposits should be represented
H3	100	[113] Pliocene	1.56	siliciclastic & carbonate sand to mud	lower slope fan	35 m/my	
H5	200	[183] Pliocene	1.86	siliciclastic & carbonate sand to mud	lower slope fan	35 m/my	
H8	300	[318] latest Miocene to Pliocene	1.86 / 2.23	siliciclastic & carbonate sand to mud	lower slope fan	30 m/my	
TD	400						
H10		[445]					
	500						



SITE NEA 4
MIGRATED STACK
LINE 75/Ø45P1
PART A
1 km
I P (APPROX)
P K
PART Q
CDP
DDD.HHHH
44
1ØØ
2ØØ
3ØØ
4ØØ
5ØØ
6ØØ
262.19ØØ
262.191Ø
262.192Ø
262.193Ø
SOUTHEAST
NORTHWEST
Site NEA-4
1.ØØ
2.ØØ
HORIZON 3
WATER BOTTOM
HORIZON 5
HORIZON 8
HORIZON 10
HORIZON 12
TD
M
WATER BOTTOM
HORIZON 3
HORIZON 5
HORIZON 8
HORIZON 10
HORIZON 12

SCALE 1:100000

EDITION OF 1989/03/23



AUSTRALIAN NATIONAL SPHEROID
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

TRACK MAP

SITE: NEA-5

PRIORITY: 1

POSITION: 16°36.96'S
146°47.07'E

JURISDICTION: Australia

WATER DEPTH: 1638 m

SEDIMENT THICKNESS: >4 s TWT

PROPOSED DRILLING PROGRAM: First APC to 100 mbsf (oriented cores); second APC/XCB to 400 mbsf; RCB from 400 to 1011 mbsf .

SEISMIC RECORD: BMR line 75/041 (part A), CDP 468; line 75/041 (part K), CDP 5865.

LOGGING: Standard Schlumberger suite.

OBJECTIVES:

1. To derive the age and facies of basinal sediments.
2. To derive a sea-level signature in a deep-basin setting, and to relate this signature to that obtained from a shelf-margin setting at Sites NEA-1 to -4.
3. To derive a high-resolution paleoceanographic record reflecting Late Cenozoic climatic variation.

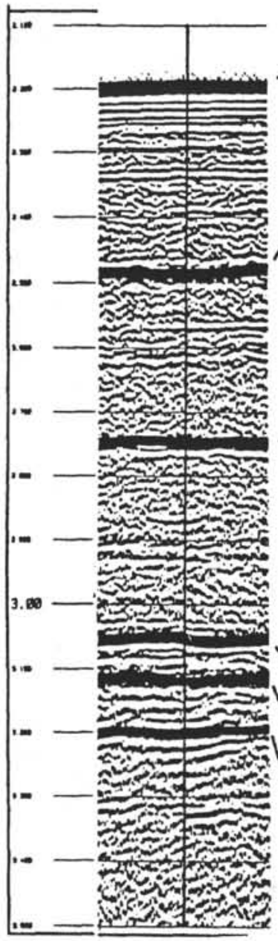
NATURE OF SEDIMENT/ROCKS ANTICIPATED:

middle Miocene to Holocene interbedded siliciclastic and carbonate pelagic sands and muds (0-785 mbsf)

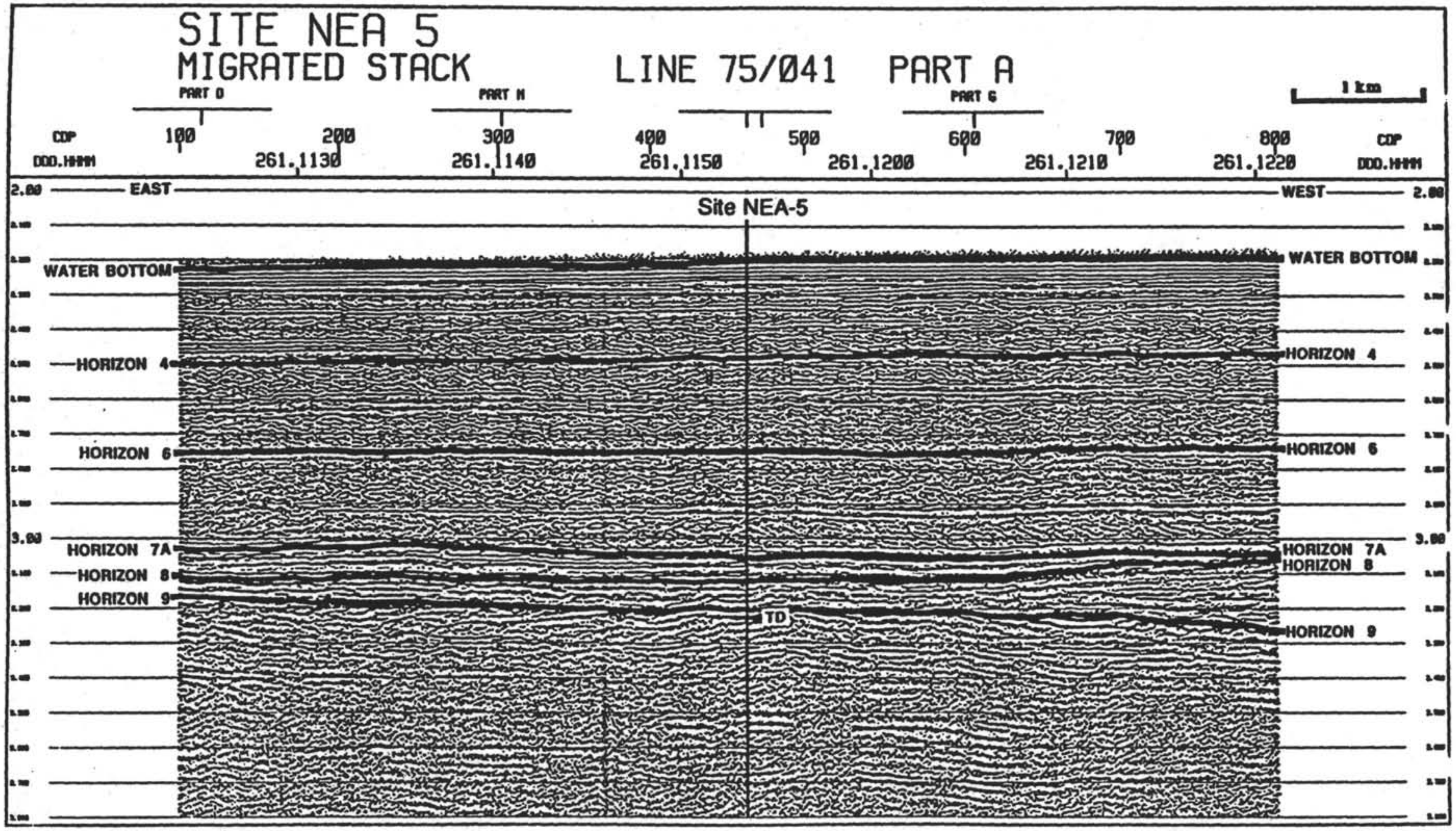
lower Miocene shallow-marine siliciclastic and carbonate sandstone and mudstone (785-869 mbsf)

Oligocene to lower Miocene shallow-marine siliciclastic sandstone and mudstone (869-1011 mbsf)

GRAPHIC SUMMARY: SITE NEA 5

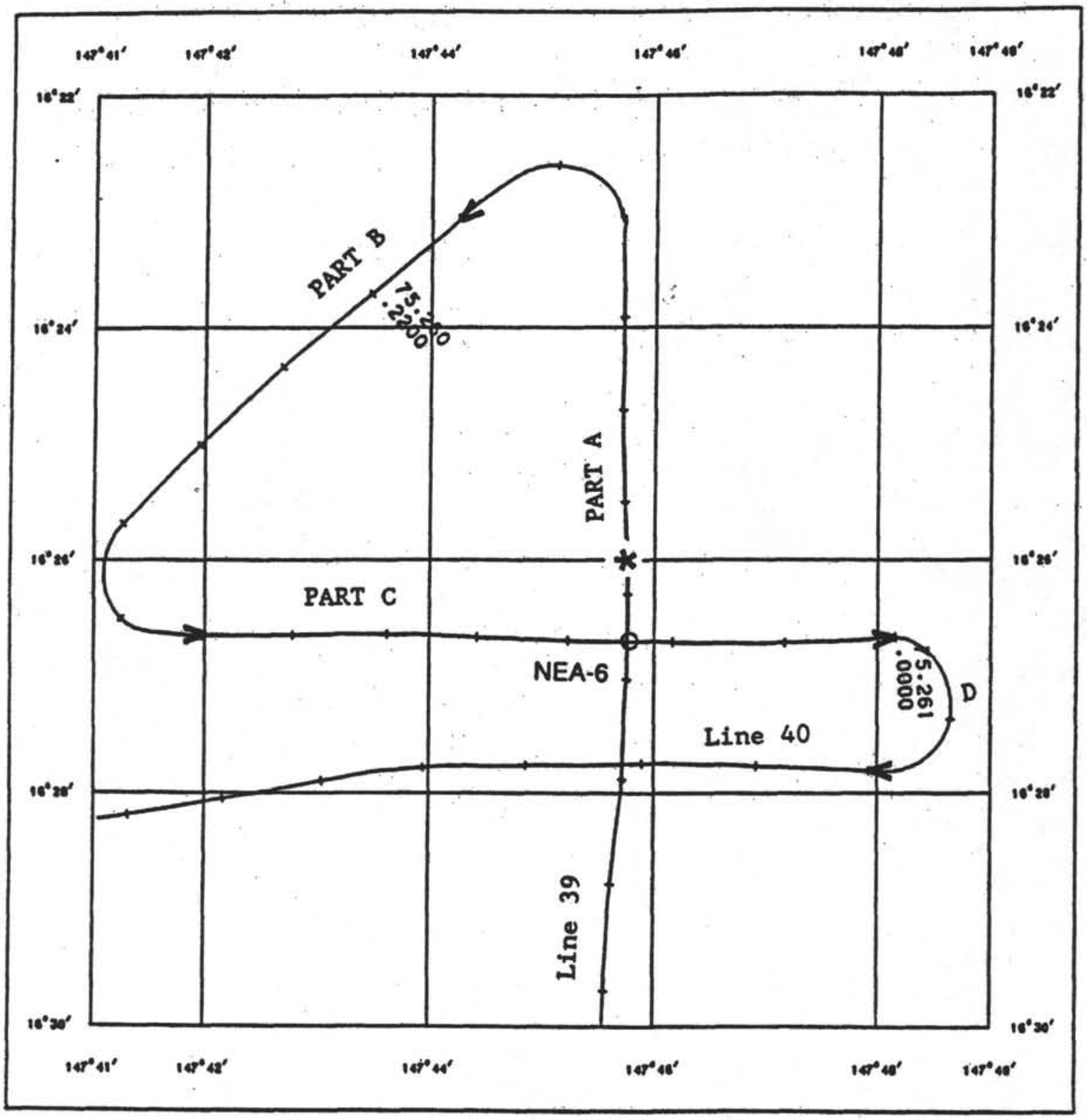


Key Reflectors	Depth (m)	Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
	0	Pliocene to Recent	1.6	mixed siliciclastic and carbonate sand and mud	pelagic	34 m/my	deep trough fill
H4	100	[112] Late Miocene	2.3	mixed siliciclastic and carbonate sand and mud	pelagic	52 m/my	trough fill will show interaction of lateral and longitude supply
H6	200, 300, 400	[422] Middle and Late Miocene	2.4	mixed siliciclastic and carbonate sand and mud	hemipelagic to pelagic	60 m/my	trough fill
H7A	500, 600, 700	[785] Early Miocene	2.8	siliciclastic & carbonate sandstone & mudstone	shallow marine	17 m/my	
H8	800	[869] Oligocene to Early Miocene	2.85	siliciclastic sandstone and mudstone	shallow marine	20 m/my	
H9	900, 1000, 1100	TD [1011]					


SITE NEA 5
MIGRATED STACK
LINE 75/Ø41 PART A
PART D
PART H
PART G
1 km
CDP
DDD.HHMM
1ØØ
2ØØ
3ØØ
4ØØ
5ØØ
6ØØ
7ØØ
8ØØ
261.113Ø
261.114Ø
261.115Ø
261.12ØØ
261.121Ø
261.122Ø
CDP
DDD.HHMM
2.ØØ
EAST
WEST
2.ØØ
Site NEA-5
WATER BOTTOM
WATER BOTTOM
HORIZON 4
HORIZON 4
HORIZON 6
HORIZON 6
3.ØØ
HORIZON 7A
HORIZON 8
HORIZON 9
3.ØØ
HORIZON 7A
HORIZON 8
TD
HORIZON 9

SCALE 1:100000

EDITION OF 1989/03/17



AUSTRALIAN NATIONAL SPHEROID
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

TRACK MAP

SITE: NEA-6

PRIORITY: 1

POSITION: 16°26.7'S
147°45.8'E

JURISDICTION: Australia

WATER DEPTH: 1000 m

SEDIMENT THICKNESS: 365 m

PROPOSED DRILLING PROGRAM: APC/XCB to 266 mbsf; RCB from 266 to 390 mbsf.

SEISMIC RECORD: BMR line 75/039 (part A), CDP 798; line 75/039 (part C), CDP 2853.

LOGGING: Standard Schlumberger suite.

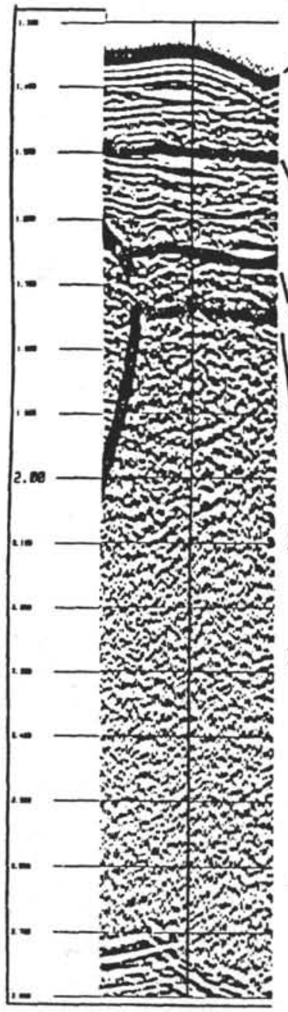
OBJECTIVES:

1. To determine the age and facies of upper slope deposits adjacent to a plateau-margin reefal buildup.
2. To determine the paleoceanographic and paleoclimatic signal within a periplatform system.
3. To understand slope processes in an exclusively carbonate depositional system.
4. To determine the composition and age of basement.

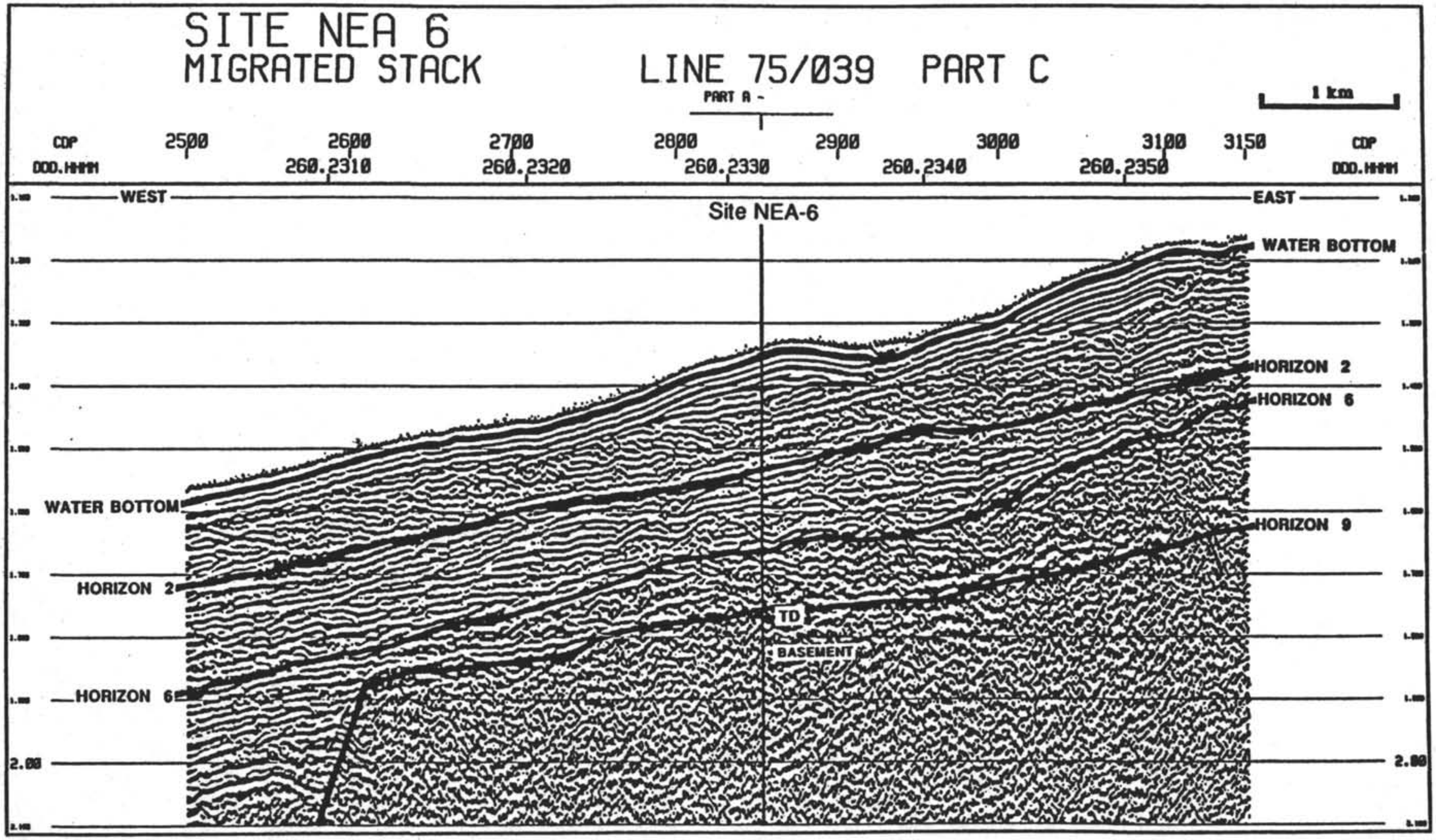
NATURE OF SEDIMENT/ROCKS ANTICIPATED:

Quaternary current-winnowed carbonate sand and mud (0-62 mbsf)
middle Miocene-Pliocene periplatform sands and muds, probably with a gravel component and possibly containing gaps (62-266 mbsf)
uppermost Oligocene to lower Miocene carbonate sands and gravels in a debris apron (266-365 mbsf)
Paleozoic(?) metasedimentary detritus (365-390 mbsf)

GRAPHIC SUMMARY: SITE NEA 6

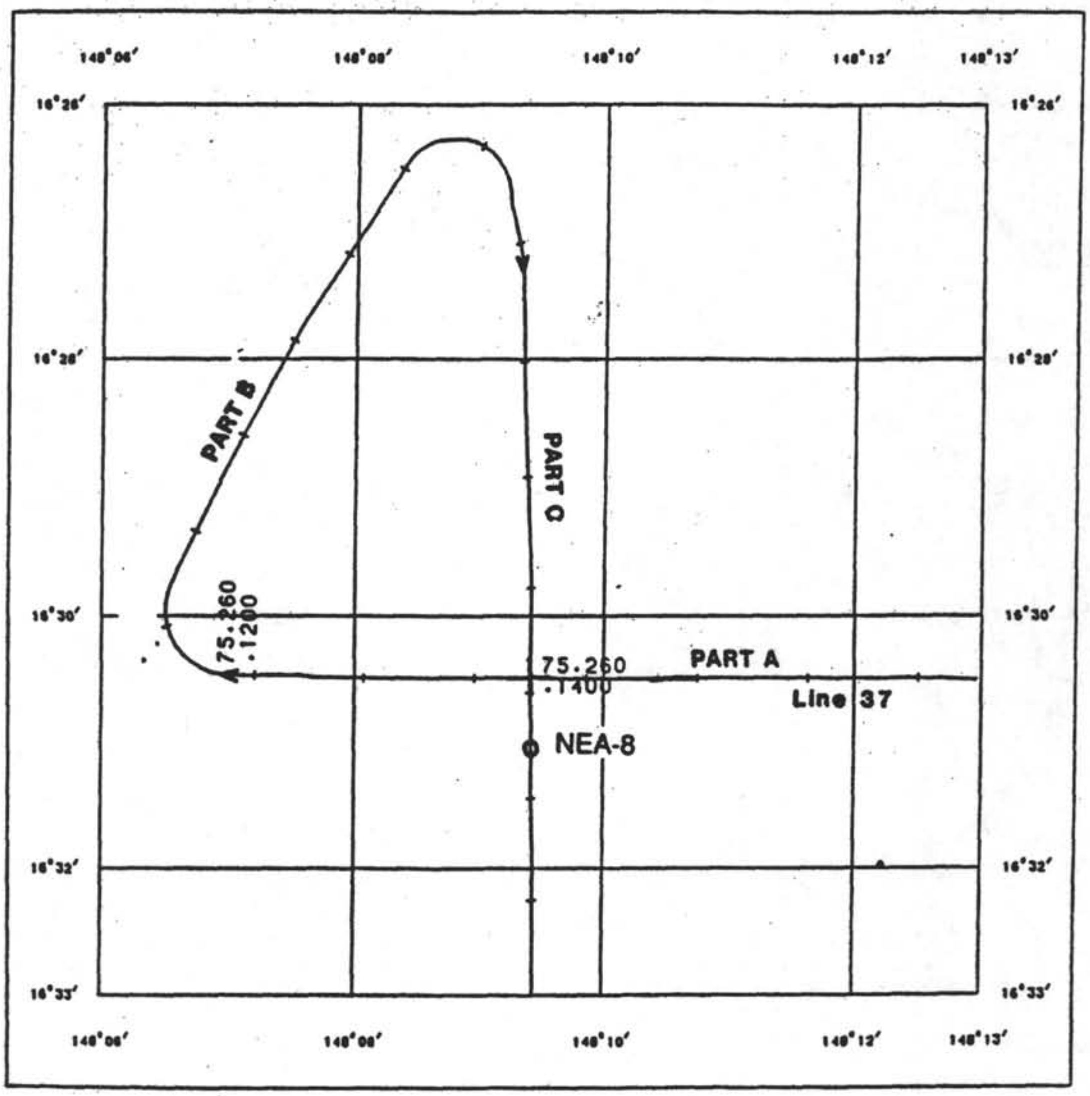


Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
Quaternary	1.55	current winnowed carbonate sand and mud	pelagic plateau slope	21.0 m/my	?contourite
[62] latest Miocene and Pliocene	1.75	interbedded carbonate sand and mud possibly with some gravel beds	pelagic toe of slope	17.5 m/my	periplatform deposits
[149] ?Late Miocene	1.8	as above but with more gravel	pelagic	9 m/my	periplatform deposits
[203] late Early to Middle Miocene	2.1	carbonate gravel, sand	hemipelagic midslope	10.5 m/my	periplatform deposits
[266] latest Oligocene to Early Miocene	2.2	rudstone, wackestone and packstone	carbonate platform slope	12.5 m/my	debris apron
[365] ?Palaeozoic		low grade metasediments			basement
TD [390]					


SITE NEA 6
MIGRATED STACK
LINE 75/039 PART C
PART A -
1 km
CDP
DDD.HHMM
2500
2600
2700
2800
2900
3000
3100
3150
260.2310
260.2320
260.2330
260.2340
260.2350
WEST
EAST
Site NEA-6
WATER BOTTOM
HORIZON 2
HORIZON 6
HORIZON 9
TD
BASEMENT
2.00

SCALE 1:100000

EDITION OF 1989/03/17



AUSTRALIAN NATIONAL SPHEROID
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

TRACK MAP

SITE: NEA-8 PRIORITY: 1

POSITION: 16°31.1'S
148°9.4'E

JURISDICTION: Australia

WATER DEPTH: 934 m

SEDIMENT THICKNESS: 399 m

PROPOSED DRILLING PROGRAM: APC/XCB to 400 mbsf (oriented cores).

SEISMIC RECORD: BMR line 75/037 (part C), CDP 3062.

LOGGING: Standard Schlumberger suite.

OBJECTIVES:

1. To determine the age and facies of periplatform deposits adjacent to a plateau-margin reefal buildup.

2. To determine the sea level, paleoceanographic, and paleoclimatic signal within a periplatform system.

3. To understand plateau processes in an exclusively carbonate depositional system.

4. To determine the composition and age of basement.

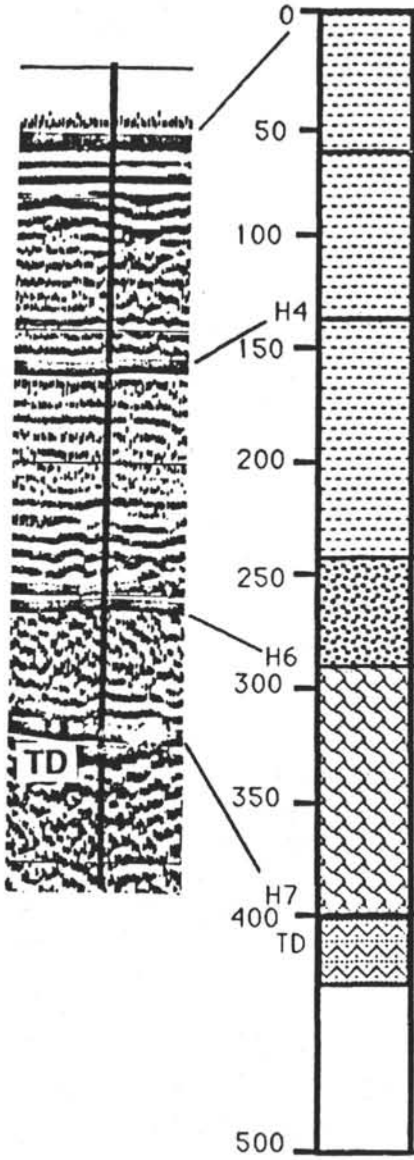
NATURE OF SEDIMENT/ROCK ANTICIPATED:

uppermost Oligocene to Quaternary periplatform sands and muds, possibly with some minor gravel beds (0-399 mbsf)

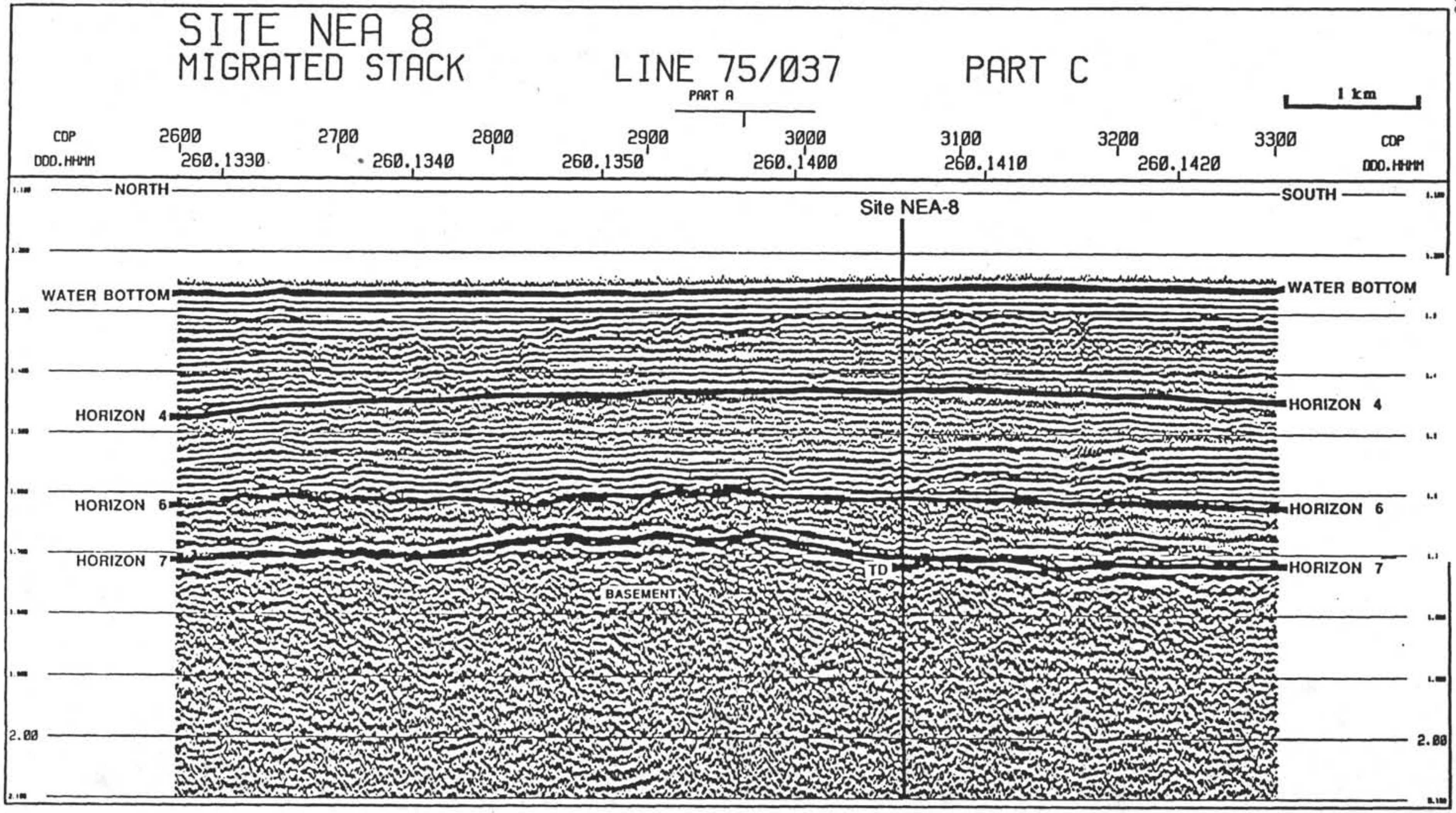
Paleozoic(?) metasedimentary detritus (399-400 mbsf)

GRAPHIC SUMMARY: SITE NEA 8

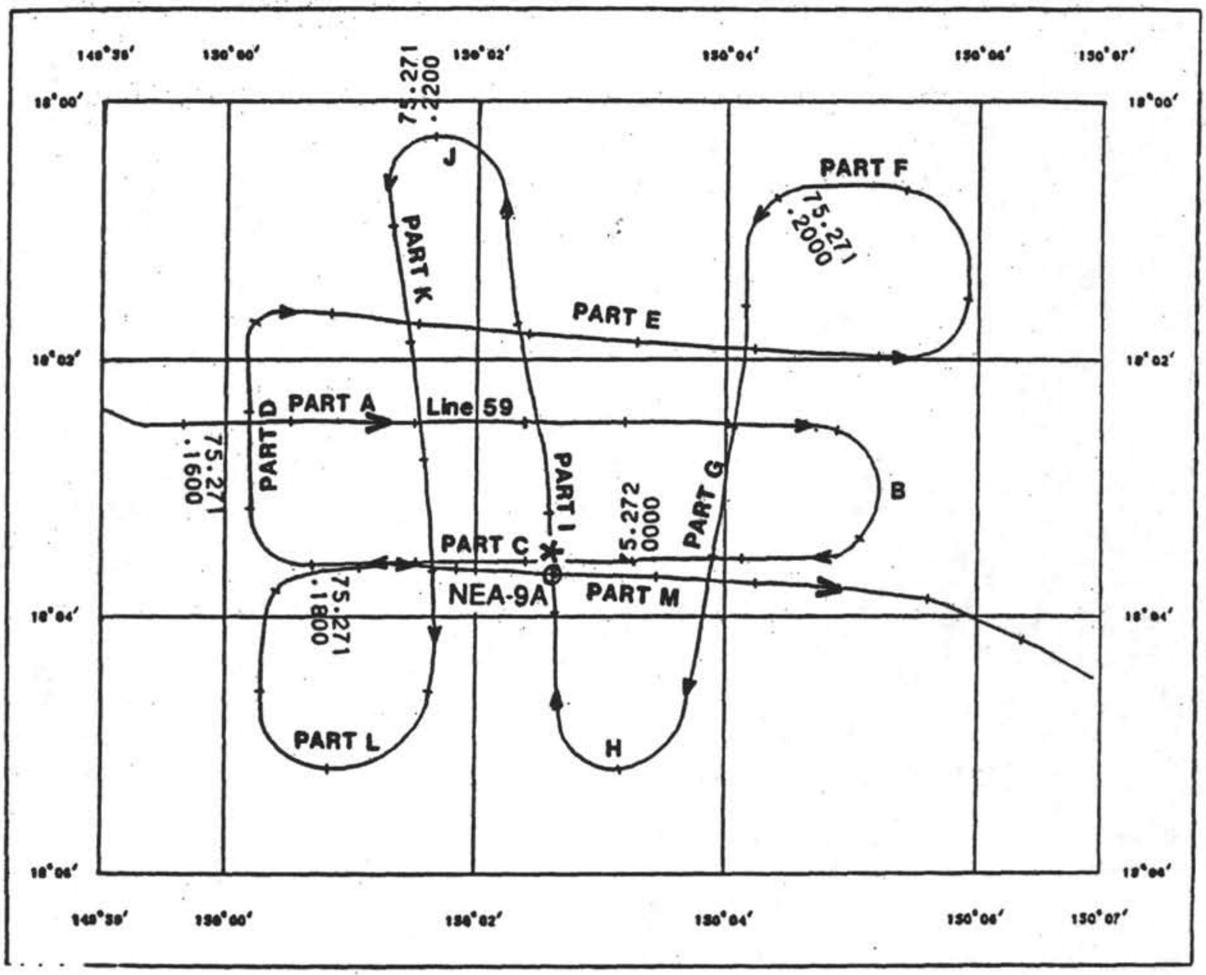
Key Reflectors



Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
Pliocene to Recent	1.55	sand and mud	pelagic plateau outer margin	21.0 m/my	periplatform sediments
[62] latest Miocene to Pliocene	1.6	sand and mud	as above	8 m/my	periplatform sediments
[138] Late Miocene	1.7	sand and mud		20 m/my	periplatform sediments
[240] Middle Miocene	1.8	sand and mud with gravel beds and possible hardgrounds		7 m/my	
[292] latest Oligocene to Early Miocene	2.0	gravel, sand and mud		5 m/my	
[400] ?Palaeozoic		low grade metasediment			basement


SITE NEA 8
MIGRATED STACK
LINE 75/037
PART C
PART A
1 km
CDP
DDD.HHMM
2600
2700
2800
2900
3000
3100
3200
3300
260.1330
260.1340
260.1350
260.1400
260.1410
260.1420
NORTH
SOUTH
Site NEA-8
WATER BOTTOM
WATER BOTTOM
HORIZON 4
HORIZON 4
HORIZON 6
HORIZON 6
HORIZON 7
HORIZON 7
TD
BASEMENT
2.00
2.00

SCALE 1:100000 EDITION OF 1989/03/17



AUSTRALIAN NATIONAL SPHEROID
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

TRACK MAP

SITE: NEA-9A

PRIORITY: 2

POSITION: 18°03.7'S
150°02.6'E

JURISDICTION: Australia

WATER DEPTH: 739 m

SEDIMENT THICKNESS: 1100 m

PROPOSED DRILLING PROGRAM: APC/XCB to 265 mbsf; RCB from 265 to 500 mbsf.

SEISMIC RECORD: BMR line 75/059 (part I), CDP 3668; line 75/059 (part M), CDP 5572.

LOGGING: Standard Schlumberger suite.

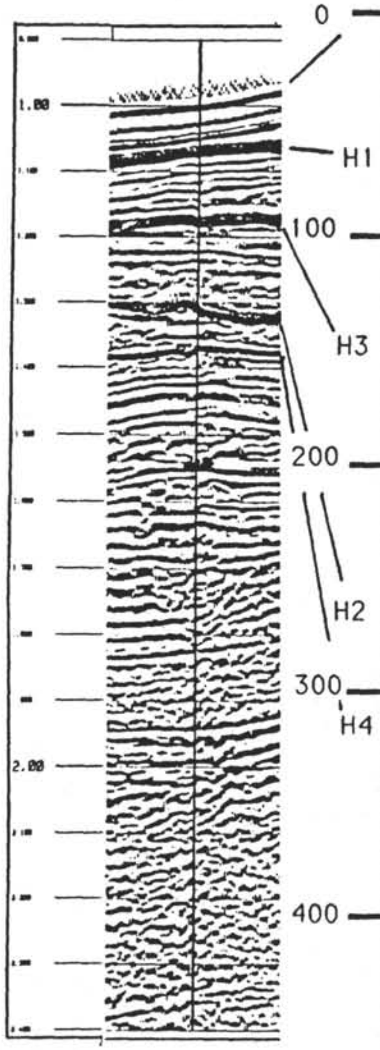
OBJECTIVES:

1. To determine the age and facies of periplatform and fore-reef sequences on the margin of a carbonate platform complex.
2. To determine the late Miocene to Holocene paleoceanographic signal in the periplatform ooze.
3. To establish the relationship between sea level fluctuations and bank-derived carbonate facies.
4. To determine the late Cenozoic carbonate saturation history within the region.
5. To analyze the "backstepping" history of the shallow carbonate banks of the Queensland Plateau.
6. To determine the diagenetic signal contained within periplatform sediments; in particular, to establish the stability regimes of high-magnesium calcite and aragonite within the platform-margin environment.

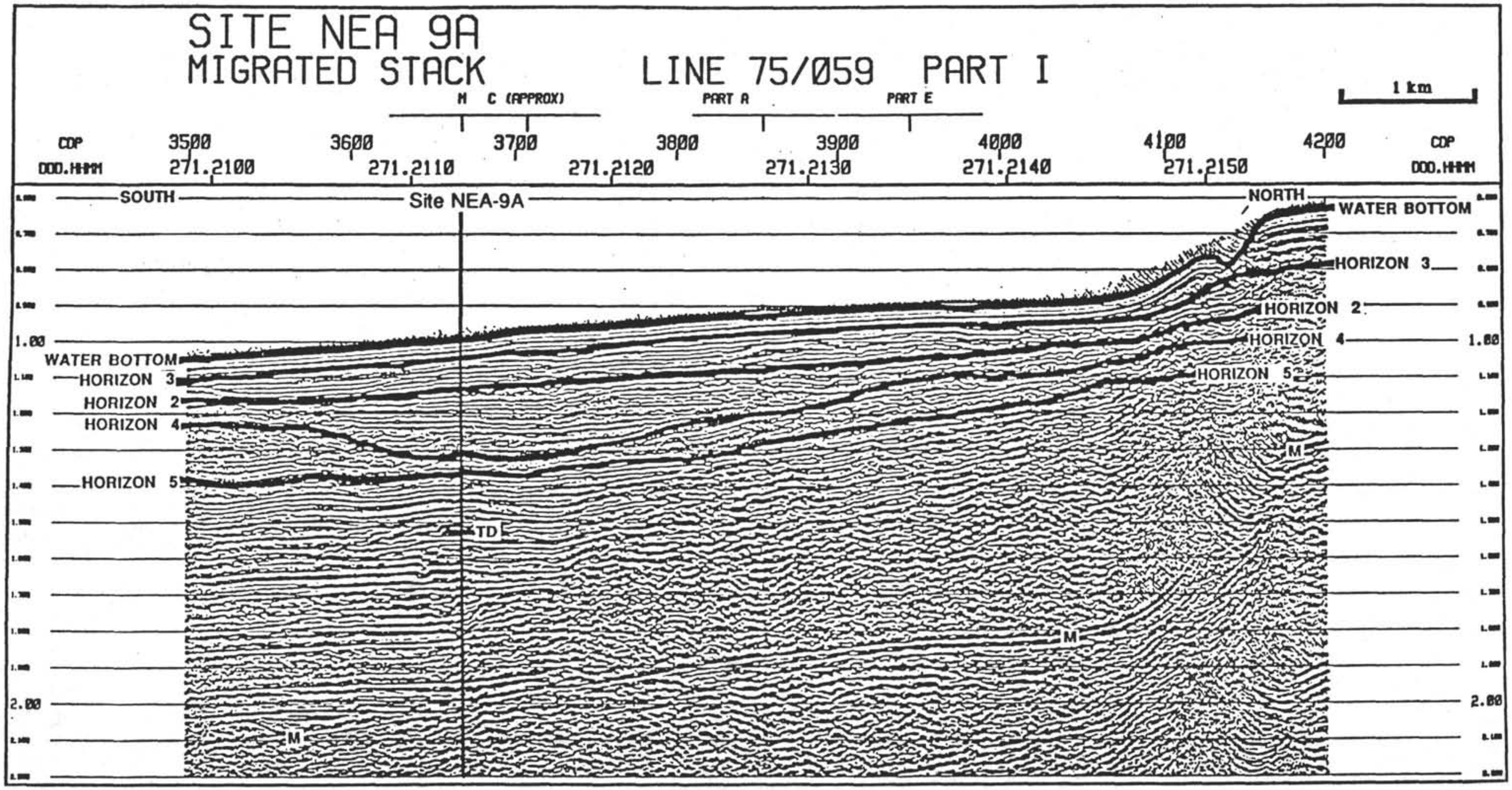
NATURE OF SEDIMENT/ROCK ANTICIPATED:

Pliocene to Holocene periplatform ooze (0-265 mbsf)
Miocene rudstone, wackestone, and packstone, fining upward (265-500 mbsf)

GRAPHIC SUMMARY: SITE NEA 9A

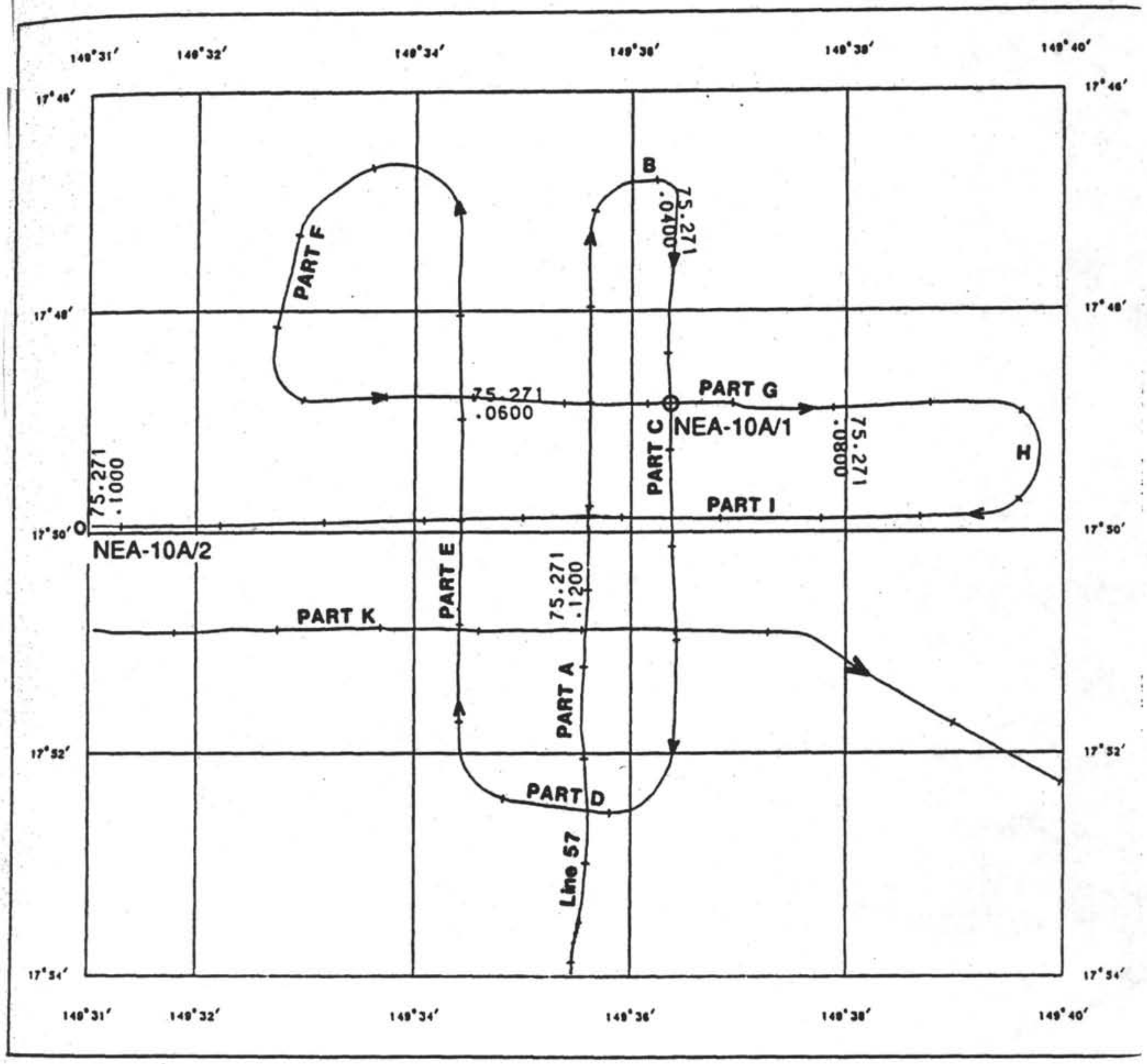


Depth (m)	Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
0	Quaternary	1.65	carbonate sand & mud	periplatform ooze	30 m/my	
100	[66] Pliocene to Pliestocene	1.65	carbonate sand & mud	periplatform ooze	30 m/my	
200	[149] Pliocene	1.65	carbonate sand & mud	periplatform ooze	35 m/my	
300	[265] latest Miocene	1.65	wackestone/ packstone	reef slope	20 m/my	
400	[315] Early Miocene	2.4	rudstone, packstone & wackestone	reef slope	25 m/my	section subjected to cementation
500 TD						


SITE NEA 9A
MIGRATED STACK
LINE 75/Ø59 PART I
M C (APPROX)
PART A
PART E
1 km
CDP
DDD.HHHH
35ØØ
36ØØ
37ØØ
38ØØ
39ØØ
4ØØØ
41ØØ
42ØØ
271.21ØØ
271.211Ø
271.212Ø
271.213Ø
271.214Ø
271.215Ø
SOUTH
Site NEA-9A
NORTH
WATER BOTTOM
HORIZON 3
HORIZON 2
HORIZON 4
HORIZON 5
TD
M
1.ØØ
2.ØØ

SCALE 1:100000

EDITION OF 1989/03/23



AUSTRALIAN NATIONAL SPHEROID
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

TRACK MAP

SITE: NEA-10A /1

PRIORITY: 1

POSITION: 17°48.8'S
149°36.3'E

JURISDICTION: Australia

WATER DEPTH: 455 m

SEDIMENT THICKNESS: 1500 m

PROPOSED DRILLING PROGRAM: APC/XCB to 200 mbsf; RCB from 200 to 300 mbsf; possible wireline packer.

SEISMIC RECORD: BMR line 75/057 (part C), CDP 1647; line 75/057 (part G), CDP 4068.

LOGGING: Limited standard Schlumberger suite.

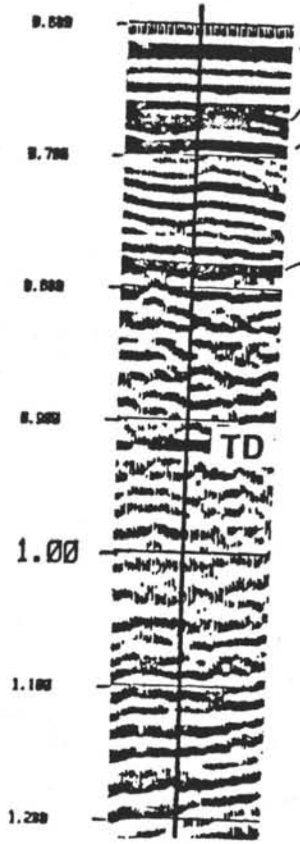
OBJECTIVES:

1. To determine the age and facies of periplatform and reef sequences toward the margin of a carbonate platform complex.
2. To determine the Oligocene to Holocene paleoceanographic and paleoclimatic signal in the reef and periplatform sequences.
3. To analyze the "backstepping" history of the shallow carbonate banks of the Queensland Plateau.
4. To establish the relationship between sea-level fluctuations and bank-derived carbonate facies.
5. To determine the late Cenozoic carbonate saturation history within the region.
6. To determine the diagenetic signal contained within periplatform sediments; in particular, to establish the stability regimes of high-magnesium calcite and aragonite within the platform-margin environment.

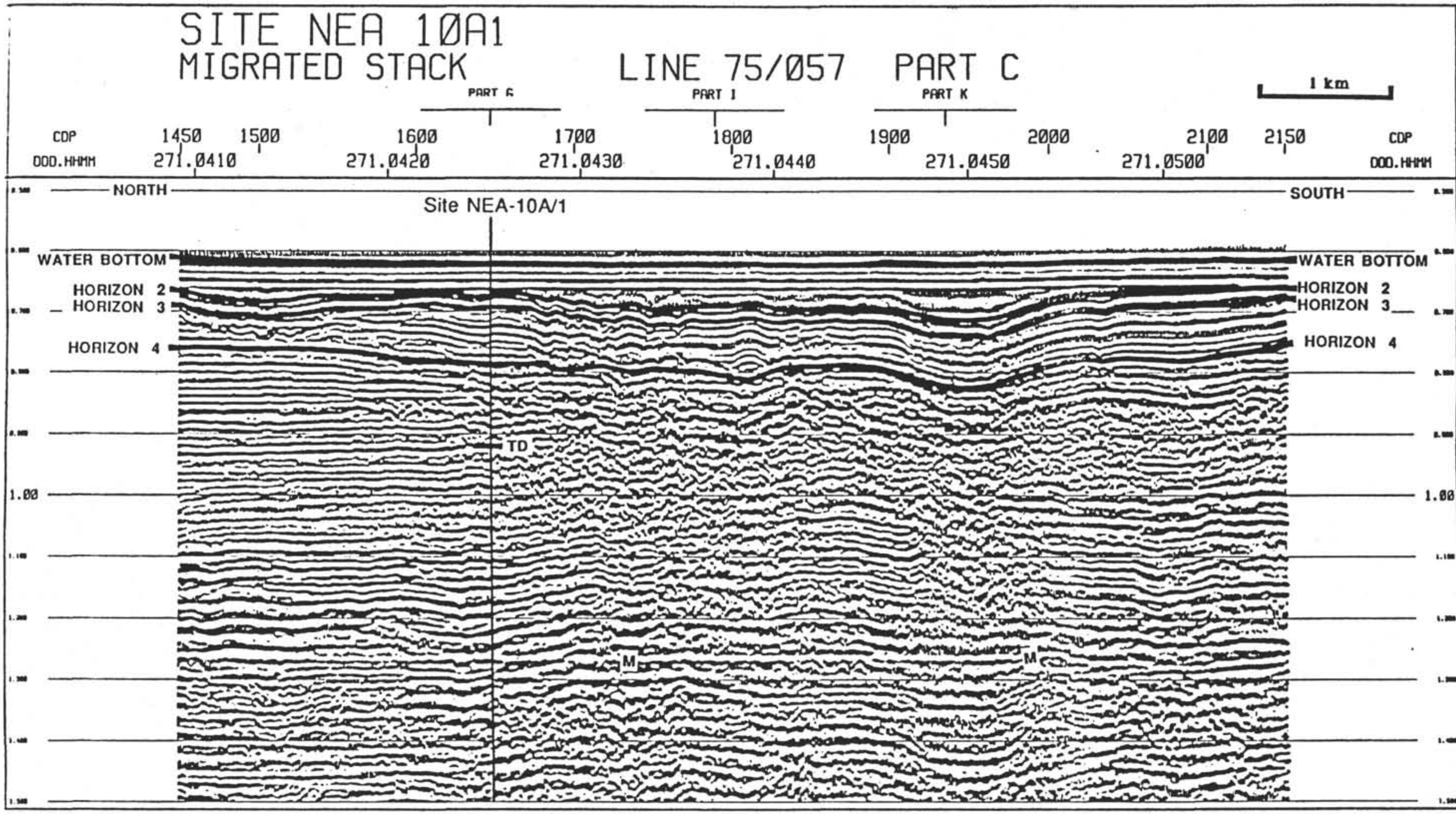
NATURE OF SEDIMENT/ROCKS ANTICIPATED:

uppermost Miocene to Holocene periplatform ooze (0-64 mbsf)
upper Miocene carbonate gravel, sand, and mud (64-120 mbsf)
lower Miocene grainstone, packstone, and wackestone (120-300 mbsf)

GRAPHIC SUMMARY: SITE NEA 10A1



Key Reflectors	Depth (m)	Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
	0	Quaternary	1.6	carbonate sand & mud	periplatform ooze	25	
H2		[44] latest Miocene to Pliocene	1.6	carbonate sand & mud	periplatform ooze	25 m/my	?hardground - submarine cement
H3	100	[64] Late Miocene	1.6	carbonate gravel, sand & mud	back reef/lagoon	15 m/my	
H4	200	[120] late Early Miocene	2.4	grainstone, packestone & wackestone	?lagoon	25 m/my	section may have been subject to freshwater diagenesis
H5	300	TD					
	400						
	500						


SITE NEA 10Ø A1
MIGRATED STACK
LINE 75/Ø57 PART C
1 km
PART G
PART I
PART K
CDP
1450 1500 1600 1700 1800 1900 2000 2100 2150
DDD.HHMM
271.Ø410 271.Ø420 271.Ø430 271.Ø440 271.Ø450 271.Ø500
NORTH
SOUTH
Site NEA-10A/1
WATER BOTTOM
HORIZON 2
HORIZON 3
HORIZON 4
TD
M
1.ØØ

SITE: NEA-10A/2

PRIORITY: 1

POSITION: 17°50.0'S
149°30.9'E

JURISDICTION: Australia

WATER DEPTH: 505 m

SEDIMENT THICKNESS: >1500 m

PROPOSED DRILLING PROGRAM: APC/XCB to 120 mbsf (oriented cores); RCB from 120 to 500 mbsf; possible wireline packer.

SEISMIC RECORD: BMR line 75/057 (part I), CDP 5802.

LOGGING: Standard Schlumberger suite.

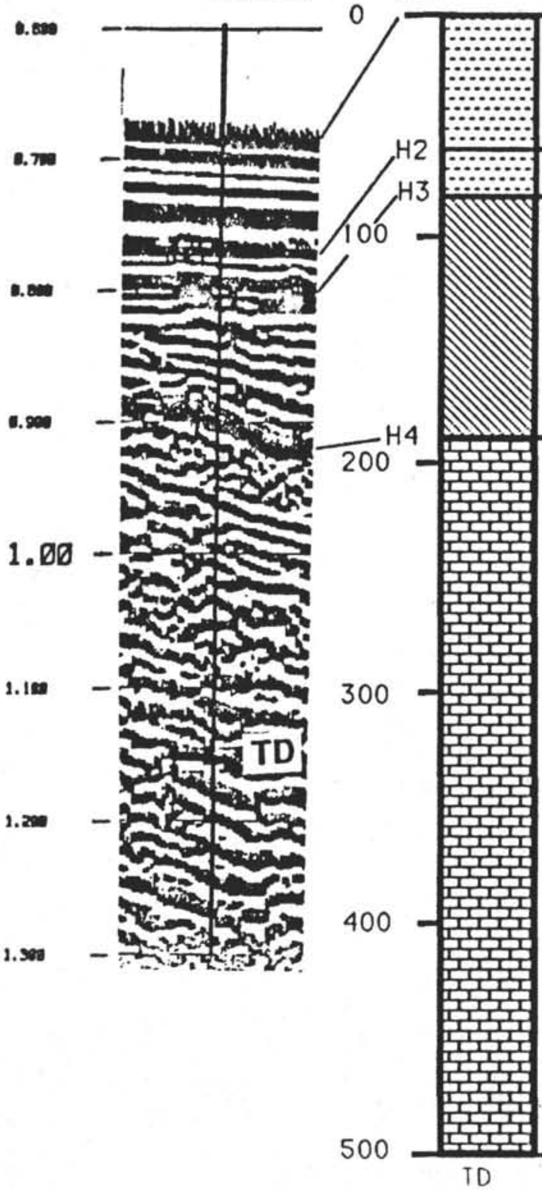
OBJECTIVES:

1. To determine the age and facies of periplatform and reef sequences toward the margin of a carbonate platform complex.
2. To determine the Oligocene to Holocene paleoceanographic and paleoclimatic signal in the reef and periplatform sequences.
3. To analyze the "backstepping" history of the shallow carbonate banks of the Queensland Plateau.
4. To establish the relationship between sea-level fluctuations and bank-derived carbonate facies.
5. To determine the late Cenozoic carbonate saturation history within the region.
6. To determine the diagenetic signal contained within periplatform sediments; in particular, to establish the stability regimes of high-magnesium calcite and aragonite within the platform-margin environment.

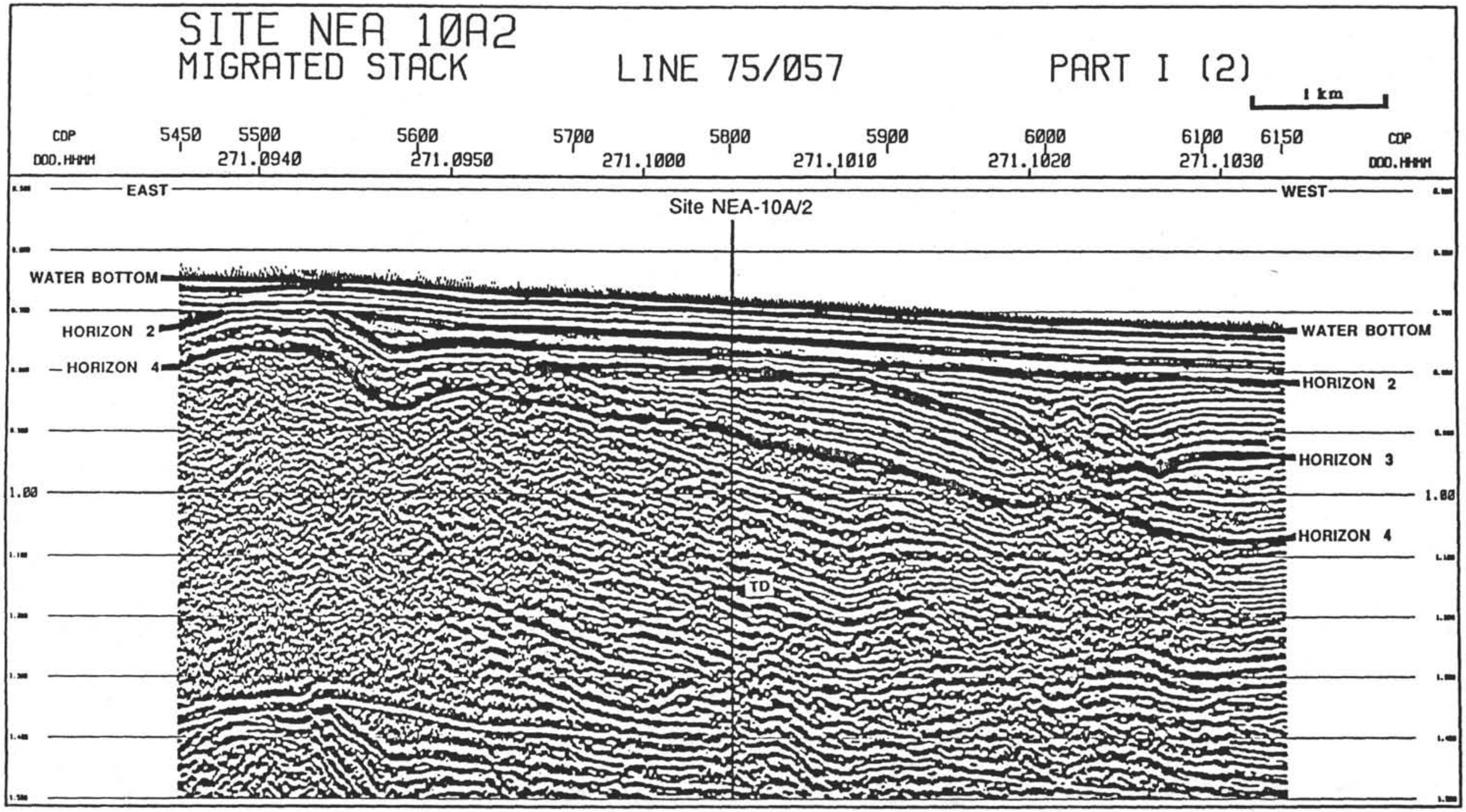
NATURE OF SEDIMENT/ROCKS ANTICIPATED:

Pliocene to Holocene periplatform ooze (0-81 mbsf)
upper Miocene carbonate gravel, sand, and mud (81-188 mbsf)
lower Miocene grainstone, packstone, and wackestone (188-500 mbsf)

GRAPHIC SUMMARY: SITE NEA 10A2

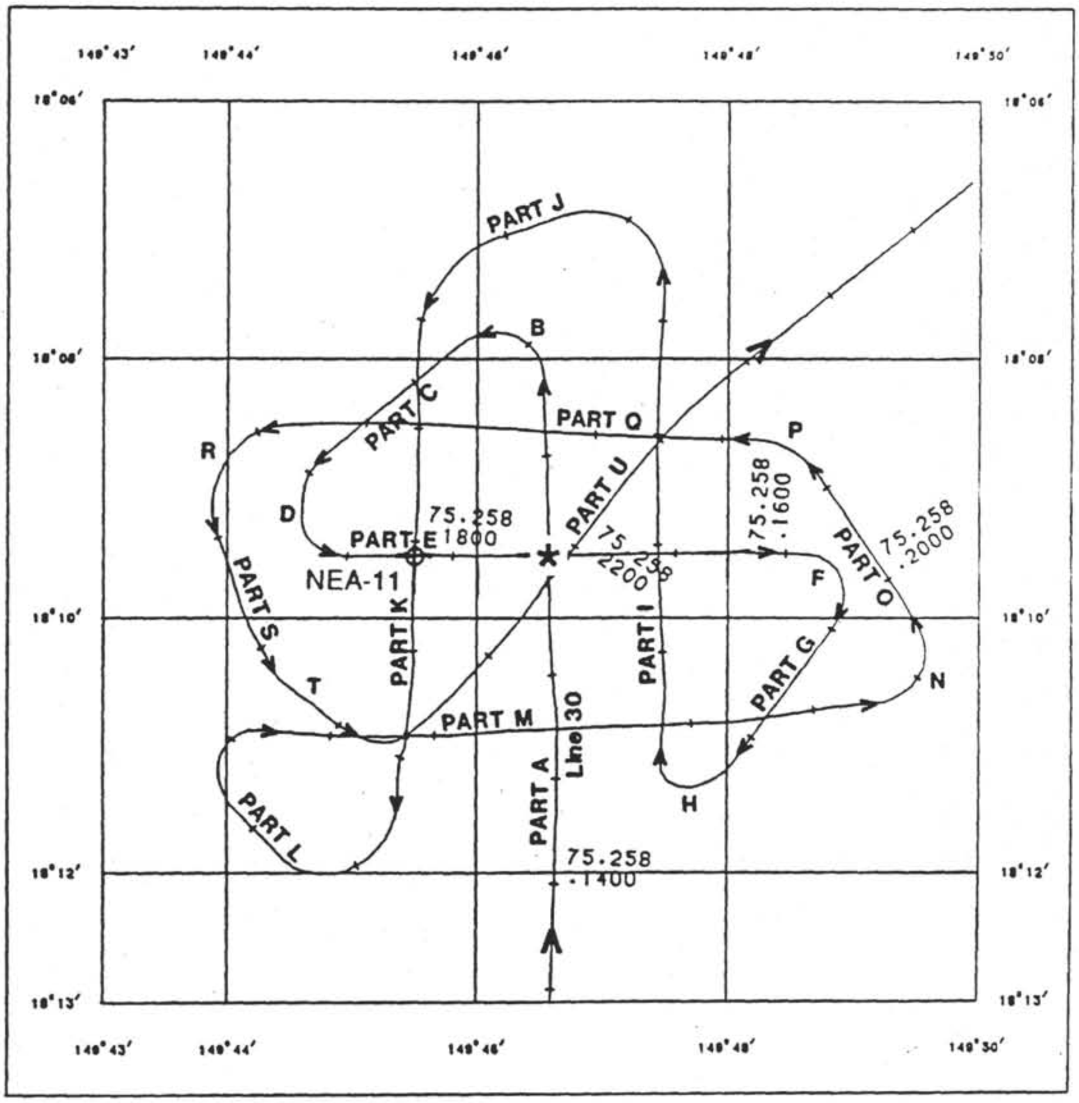


Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
Quaternary Pliocene	1.65	carbonate sand & mud	periplatform ooze	30 m/my	
[60]	1.65	as above	periplatform ooze		
[81] Late Miocene	2.15	grainstone & packstone	prograding reef slope	20 m/my	
[188] [258] Early Miocene	2.15 2.5	wackestone, packstone & mudstone	carbonate platform		section may have been subjected to freshwater diagenesis


SITE NEA 10A2
MIGRATED STACK
LINE 75/057
PART I (2)
1 km
CDP
DDD.HHMM
5450
5500
5600
5700
5800
5900
6000
6100
6150
271.0940
271.0950
271.1000
271.1010
271.1020
271.1030
EAST
WEST
Site NEA-10A/2
WATER BOTTOM
HORIZON 2
HORIZON 3
HORIZON 4
1.00
TD

SCALE 1:100000

EDITION OF 1999/03/29



AUSTRALIAN NATIONAL SPHEROID
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

TRACK MAP

SITE: NEA-11

PRIORITY: 1

POSITION: 18°09.5'S
149°45.5'E

JURISDICTION: Australia

WATER DEPTH: 1005 m

SEDIMENT THICKNESS: 1500 m

PROPOSED DRILLING PROGRAM: First APC to 200 mbsf (oriented cores); APC/XCB to 405 mbsf; RCB from 405 to 700 mbsf.

SEISMIC RECORD: BMR line 75/030 (part E), CDP 1235; line 75/030 (part K), CDP 2235.

LOGGING: Standard Schlumberger suite; vertical seismic profile (VSP).

OBJECTIVES:

1. To determine the age and facies of a lower slope sequence adjacent to the Queensland Plateau.

2. To understand the interaction between carbonate-platform-margin-dominated processes (e.g., sediment gravity flows) and trough pelagic and contourite-dominated depositional processes, particularly as a function of sea level.

3. To derive a high-resolution paleoceanographic record reflecting late Cenozoic climatic variation.

NATURE OF SEDIMENT/ROCKS ANTICIPATED:

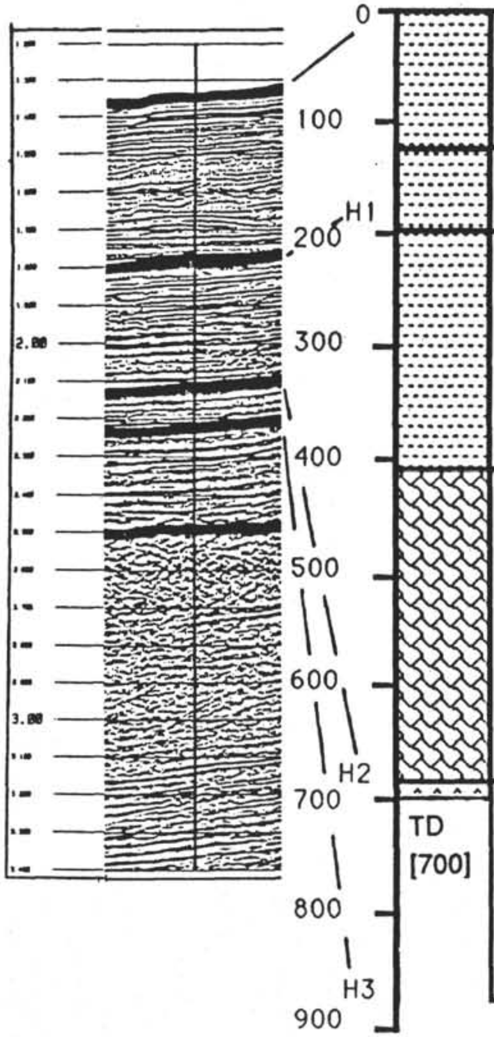
upper Miocene to Holocene periplatform gravel, sand, and mud (0-405 mbsf)

lower to middle Miocene platform-debris-apron rudstone, wackestone, and packstone (405-681 mbsf)

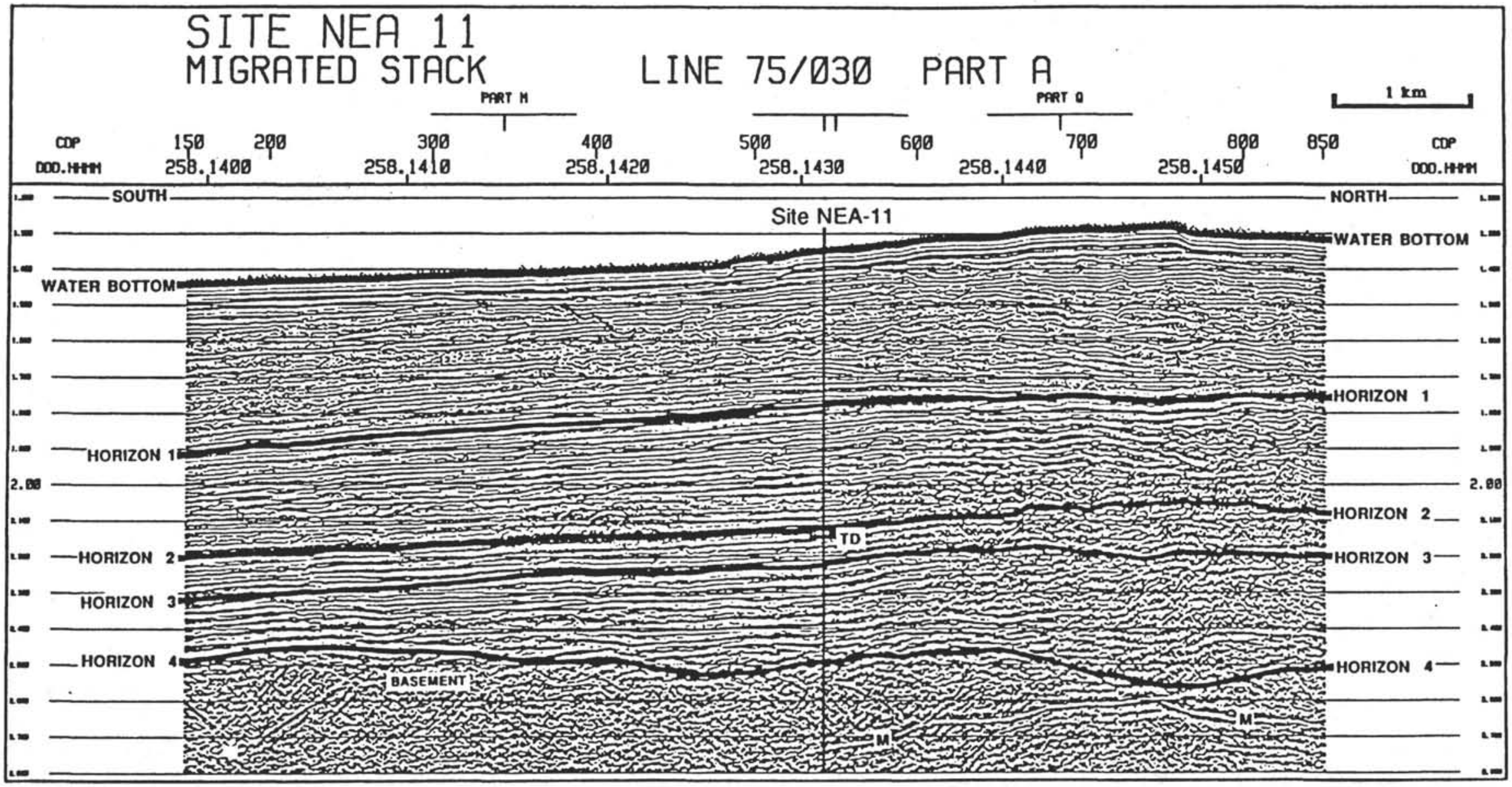
Oligocene(?) to lower Miocene shallow-marine siliciclastic sandstone and mudstone, possibly with wackestone interbeds toward the top (681-700 mbsf)

GRAPHIC SUMMARY: SITE NEA 11

Key Reflectors | Depth (m)



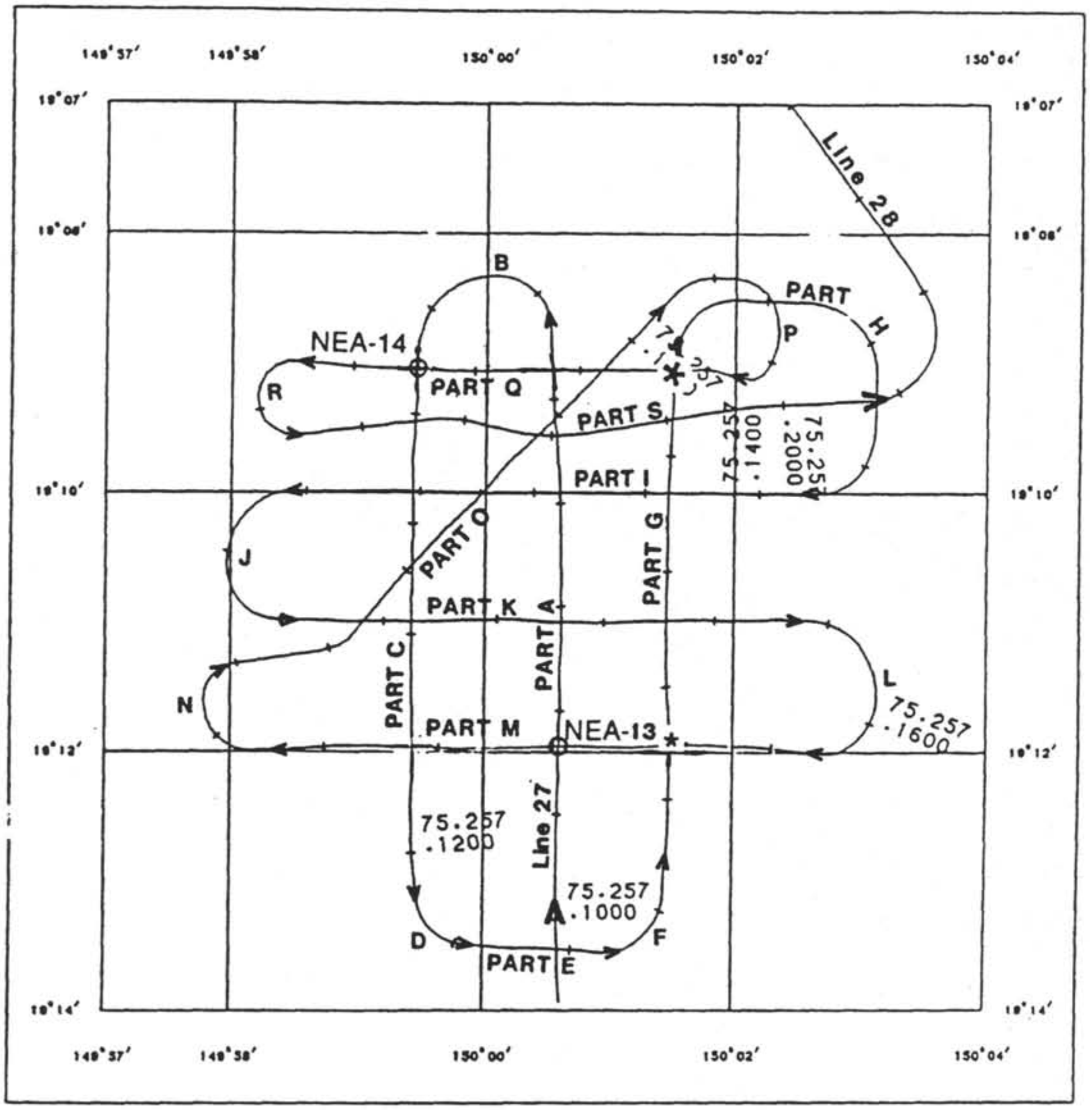
Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
Late Pliocene to Recent	1.90	interbedded carbonate sand and mud /ooze	pelagic - outer slope of plateau	45 m/my	periplatform carbonates
[135] Pliocene	2.0	as above /ooze	pelagic	40 m/my	as above
[195] Late Miocene	2.1	as above/ooze	pelagic	35 m/my	as above
[405] Early to Middle Miocene	2.3	wackestone, packstone	mid slope	25 m/my	distal carbonate platform apron
[681] ?Oligocene to Early Miocene	3.0	siliciclastic sandstone, mudstone and wackestone	shallow marine	20 m/my	



SITE NEA 11
MIGRATED STACK
LINE 75/030 PART A
PART M
PART Q
1 km
CDP
DDD.HHMM
150 200 300 400 500 600 700 800 850
258.1400 258.1410 258.1420 258.1430 258.1440 258.1450
SOUTH
NORTH
Site NEA-11
WATER BOTTOM
WATER BOTTOM
HORIZON 1
HORIZON 1
HORIZON 2
HORIZON 2
HORIZON 3
HORIZON 3
HORIZON 4
HORIZON 4
BASEMENT
TD
M
M
2.00
2.00

SCALE 1:100000

EDITION OF 1989/03/30



AUSTRALIAN NATIONAL SPHEROID
UNIVERSAL MERCATOR (SPHERE)
WITH NATURAL SCALE CORRECT
AT LATITUDE 33 00

TRACK MAP

SITE: NEA-13

PRIORITY: 1

POSITION: 19°12.0'S
150° 0.6'E

JURISDICTION: Australia

WATER DEPTH: 426 m

SEDIMENT THICKNESS: 2500 m

PROPOSED DRILLING PROGRAM: APC/XCB to 110 mbsf; RCB from 110 to 250 mbsf; possible wireline packer.

SEISMIC RECORD: BMR line 75/027 (part A), CDP 312; line 75/027 (part M), CDP 4848.

LOGGING: No logging currently planned.

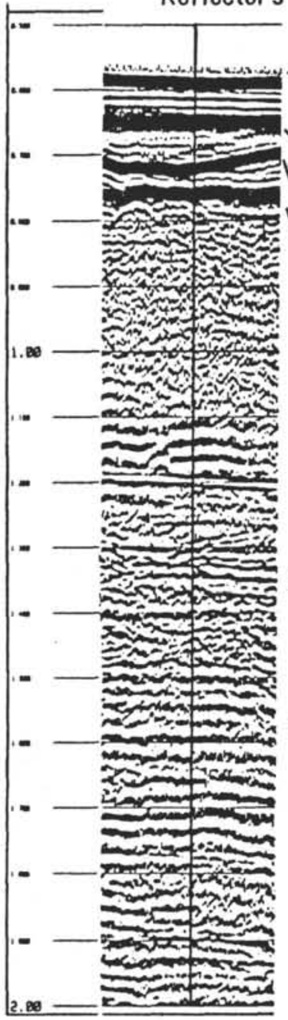
OBJECTIVES:

1. Determine the minimum position and timing of the middle Miocene eustatic highstand.
2. Determine the nature and age of two phases of carbonate platform growth, thereby defining the paleoclimatic and paleoceanographic regimes at two times during the Neogene.
3. Determine the cause and timing of the demise of two phases of carbonate platform accretion, as a key to understanding the controls on carbonate platform development.
4. Determine the nature and age of the sequence overlying the carbonate platforms, in order to understand the paleoclimatic and paleoceanographic regime at a time when carbonate platform facies were not deposited.

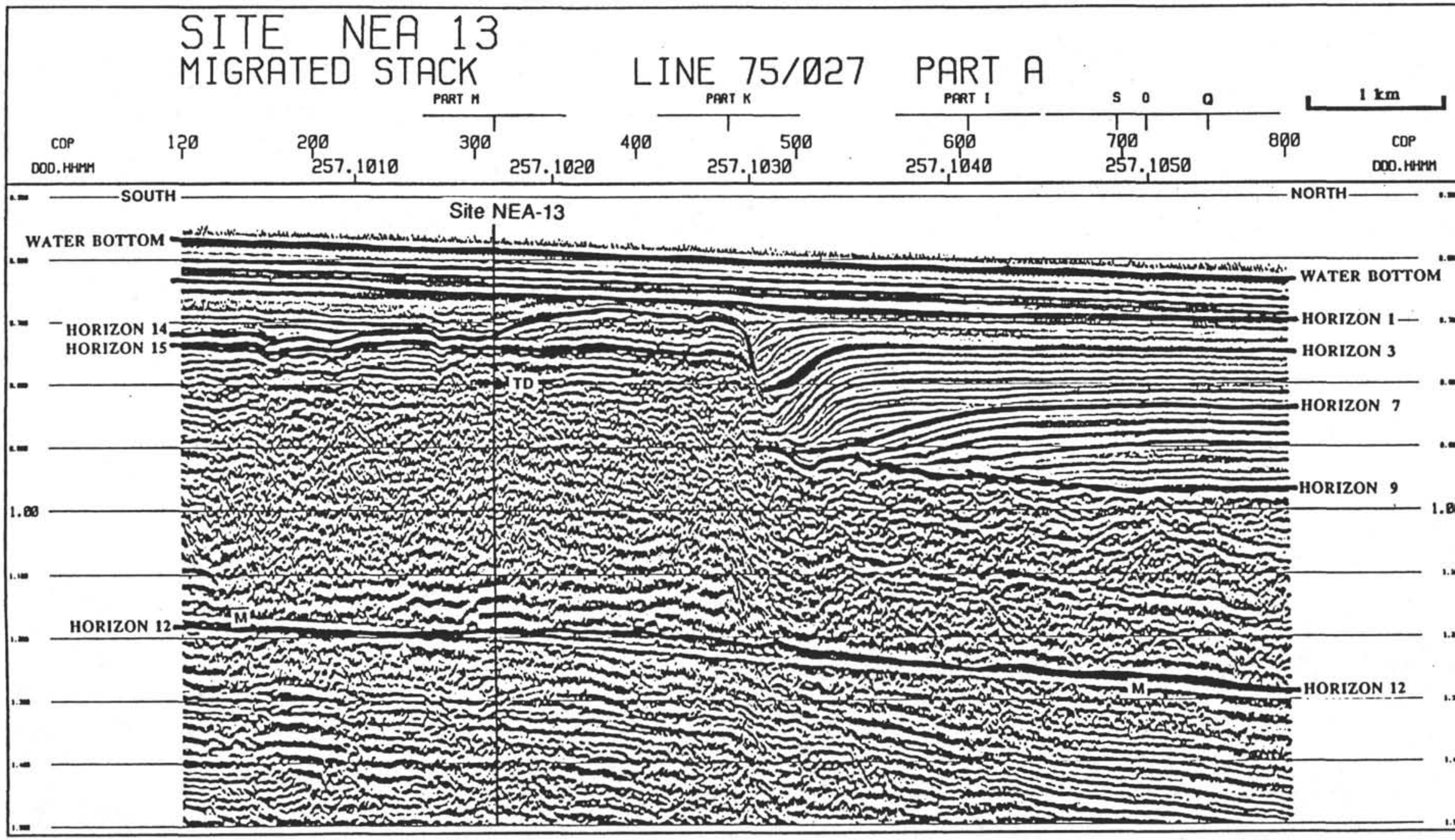
NATURE OF SEDIMENT/ROCK ANTICIPATED:

Pliocene/Pleistocene current-winnowed periplatform sediment (0-110 mbsf)
upper(?) Miocene to Pliocene *in-situ* and detrital carbonate mound facies, probably warm subtropical to tropical (110-135 mbsf)
Major unconformity
upper lower to lower middle Miocene subtropical carbonate mound facies (135-250 mbsf)

GRAPHIC SUMMARY: SITE NEA 13



Key Reflectors	Depth (m)	Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
H1	0–110	Pliocene to Recent [110]	1.60	interbedded sandstone/gravel and packstone/grainstone	hemipelagic - plateau outer margin	21.0 m/my	condensed section subject to current winnowing. Coarse, cemented, lag deposits.
H14	110–135	?Late Miocene to Pliocene [135]	2.15	packstone/grainstone	backreef	9.0 m/my	may have been subject to freshwater diagenesis
H15	135–250	Early Miocene [250]	2.50	boundstone/packstone/grainstone	reef to backreef or lagoon		
	TD						



SITE NEA 13
MIGRATED STACK
LINE 75/027 PART A
PART M
PART K
PART I
S O Q
1 km
CDP
DDD.HHMM
120
200
300
400
500
600
700
800
257.1010
257.1020
257.1030
257.1040
257.1050
SOUTH
NORTH
Site NEA-13
WATER BOTTOM
HORIZON 14
HORIZON 15
TD
HORIZON 1
HORIZON 3
HORIZON 7
HORIZON 9
1.00
HORIZON 12
M

SITE: NEA-14

PRIORITY: 1

POSITION: 19°9.0'S
149°59.5'E

JURISDICTION: Australia

WATER DEPTH: 456 m

SEDIMENT THICKNESS: 2500 m

PROPOSED DRILLING PROGRAM: First APC to 55 mbsf (oriented cores); APC/XCB to 295 mbsf; RCB from 295 to 400 mbsf.

SEISMIC RECORD: BMR line 75/027 (part C), CDP 1028; line 75/027 (part Q), CDP 6630.

LOGGING: Standard Schlumberger suite.

OBJECTIVES:

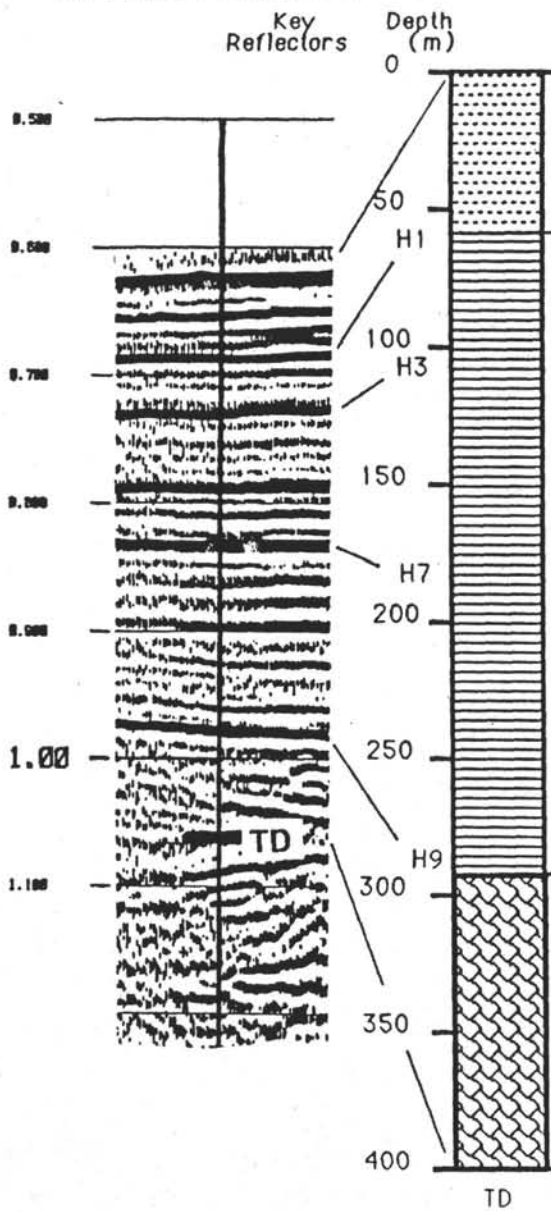
1. Determine the cause and timing of the demise of the oldest phase of carbonate platform accretion, as a key to understanding the controls on carbonate platform development.

2. Determine the nature and age of the periplatform sequence deposited throughout much of the Neogene, both during and between periods of carbonate platform growth. This sequence will contain a record of the paleoclimatic and paleoceanographic factors controlling carbonate platform development from the upper lower Miocene, including the transition from subtropical to tropical climates.

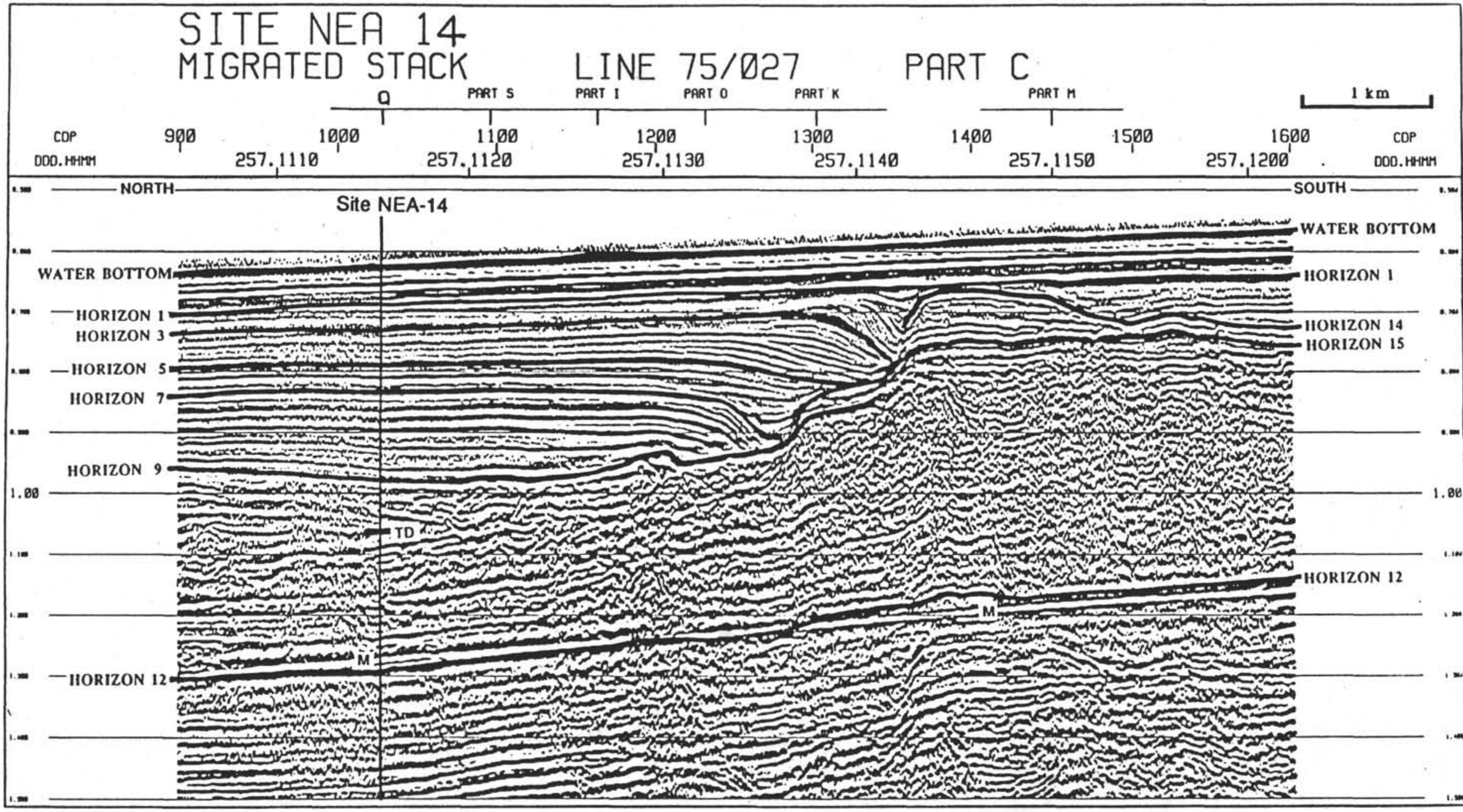
NATURE OF SEDIMENT/ROCKS ANTICIPATED:

Pliocene-Pleistocene periplatform ooze (0-55 mbsf)
uppermost(?) Miocene to Pliocene periplatform sediment (55-295 mbsf)
Major unconformity
lower Miocene subtropical carbonate platform detritus (295-400 mbsf)

GRAPHIC SUMMARY: SITE NEA 14



Age	Velocity (km/sec)	Lithology	Paleoenvironment	Sedim. Rate	Comments
Pliocene to Recent	1.60	mud/ooze	pelagic - plateau outer margin	27.5 m/my	
[55] [101] Late Miocene and [178] Pliocene	1.80	mudstone/ wackestone	top of slope - adjacent to carbonate platform margin	24.5 m/my	downlapping / onlapping contourite package
[295] Early Miocene	2.50	rudstone/ wackestone/ packstone	carbonate platform debris apron		


SITE NEA 14
MIGRATED STACK
LINE 75/027
PART C
Q
PART S
PART I
PART O
PART K
PART M
1 km
CDP
DDD.HHMM
900
1000
1100
1200
1300
1400
1500
1600
257.1110
257.1120
257.1130
257.1140
257.1150
257.1200
NORTH
SOUTH
Site NEA-14
WATER BOTTOM
HORIZON 1
HORIZON 3
HORIZON 5
HORIZON 7
HORIZON 9
HORIZON 12
HORIZON 14
HORIZON 15
TD
M
1.00

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