THE MARINE GEOLOGY OF THE CAPE YORK PENINSULA

BETWEEN WEIPA AND CAPE FLATTERY,

NORTHERN QUEENSLAND

A Review and Compilation of Existing Data

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SUMMARY

Surveys of the shallow coastal waters of the Cape York Peninsula completed by the Australian Geological Survey Organisation (AGSO) in 1992/1993 form part of the Cape York Land Use Strategy Project (CYPLUS); a joint Commonwealth and Queensland Government initiative to assess the natural resources of the region. The CYPLUS region extends from the entrance of the Mitchell River south of Weipa on the eastern Gulf of Carpentaria coast around to Cooktown on the Great Barrier Reef Lagoon coast, an alongshelf distance of some 1,500km. This report summarises the results of AGSO marine surveys which cover a 1,000 km section of the Cape York Peninsula inner shelf between Weipa and Cape Flattery.

The surveys were conducted in water depths of less than 35m and involved the collection of over 1,000km of high resolution seismic (Uniboom) and side scan sonar trackline, 265 grab samples, and 41 vibrocores. The majority of seismic and side scan sonar lines were run shore-parallel with grab and vibrocore samples taken of representative shoreface and inner shelf environments on the western and eastern sides of the Cape York Peninsula. Radiocarbon dates of selected core samples provided some control on the age structure of the upper 4m of the Holocene sediment sequence. Enhanced LANDSAT thematic mapper datasets were utilised for the preparation of bathymetric coverages and the identification of benthic substrates.

The principal findings of this report highlight the importance of late Quaternary sea level changes on the shallow shelf stratigraphy plus the influence of coastal setting and associated process regimes on contemporary patterns of inner shelf sedimentation. There appears to be little evidence for the accumulation of significant volumes of terrigenous sediment on the present day inner shelf.

The seismic data identify a regionally significant flat-lying reflector shallowly underlying much of the inner shelf in the Gulf of Carpentaria, Endeavour and southern Torres Straits, and Great Barrier Reef Lagoon. This reflector, interpreted as the pre-Holocene shelf surface inundated by the early to mid-Holocene postglacial marine transgression, was sampled in a number of vibrocores and shown to consist of an oxidised, ferruginous sandy clay. The Holocene sequence is comprised of contemporary shoreface and inner shelf sediments which either directly overlie the pre-Holocene surface or early to mid-Holocene transgressive estuarine and relict dune deposits. The age relationships of these units has been confirmed by radiocarbon dates on shell and organic material enclosed within the Holocene sequence. The Holocene sequence typically forms a seaward thinning wedge with a maximum thickness of around 10m at the coast, thinning to less than 0.5m on the inner shelf. Much of the inner shelf covered is characterised by a thin (<1m thick) Holocene sequence. The exception to this general trend occurs in the vicinity of relict river valleys where the Holocene valley fills may be up to 30m thick.

A four part subdivision of the coastal waters of the Cape York Peninsula is proposed on the basis of the relative efficacy of the marine environment to disperse terrigenous sediment supplied to the coast and inner shelf. The study identifies the low wave energy-high terrigenous input eastern Gulf of Carpentaria shelf; the high tidal energy-localised high terrigenous input Endeavour Strait shelf; the low wave energy-high terrigenous input protected embayments of the Great Barrier Reef Lagoon (GBRL); and the high wave energy exposed GBRL shelf. The greatest potential for terrigenous sediment supply to the shelf appears to occur in the low energy Gulf of Carpentaria and protected GBRL embayment settings.

The regional coverage of the surveys necessitates that the findings of this report are preliminary and require confirmation. Recommendations are made for additional surveys to explore the validity of the conclusions presented here and to provide a sensible basis for the formulation of management options for the coast and shallow coastal waters of the Cape York Peninsula.

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1. Introduction

The Cape York Peninsula in Northern Queensland represents one of few remaining sections of the Australian coastline where human activities have had minimal impact on the integrity and stability of the coastal and nearshore ecosystems. Poor access and the relative remoteness of the region have, in the past, protected it from the damaging influences of unplanned development which blight other areas of the Australian coast. This is changing. Interest in the area's natural resources for mining, agriculture and tourism purposes has underlined a lack of information on which to base responsible management and development strategies. The Cape York Land Use Strategy Project (CYPLUS) initiated by the Commonwealth and Queensland Governments is designed to rectify this situation by providing a decision support system to assist in devising management strategies for the region.

The Coastal Geoscience Project of the Australian Geological Survey Organisation (AGSO) undertakes coastal geoscientific mapping and research to provide baseline data for the sustainable development and management of the Australian coastal zone (Burne and Graham, 1995). Since 1992 AGSO has been involved in collecting data on coastal and nearshore environments in the CYPLUS study area, a 1,300km section of the Cape York Peninsula coast extending from the entrance of the Mitchell River south of Weipa in the Gulf of Carpentaria to Cooktown on the eastern Peninsula coast (Fig. 1.1). Onshore data have been compiled into a series of 1:100,000 scale map sheets summarising the late Quaternary geology of the coastal plains of the CYPLUS region. Limited work has been completed on the offshore data set. The offshore data include high resolution seismic reflection profiles, side-scan sonar images, sea bed sediment grab samples, and subsurface sediment vibrocore samples. These data, collected during two field seasons in 1992 and 1993, are reviewed and summarised in this report.

The extent of the marine survey defines the area examined in this report - effectively the shallow coastal waters of the eastern Gulf of Carpentaria north from Weipa, the tidally influenced shelves of Cape York, and the coastal waters from Cape York to Cape Flattery (Fig 1.1). The area extends some 1,000km alongshore and contains a variety of coastal and inner shelf depositional environments. This report represents a step towards the integration of the CYPLUS coastal and nearshore data sets for the purposes of identifying the natural resources and management issues relevant to the coastal zone of the Cape York Peninsula.

1.1 Terms of Reference

The terms of reference for the consultancy were finalised in March 1995 after several meetings between personnel from Coastal & Marine Geosciences (CMG) and the Australian Geological Survey Organisation (AGSO: Coastal Geoscience Project).

The study brief required CMG to:

1. Log vibrocores recovered from the Cape York Peninsula coastal waters by AGSO, characterise facies, interpret depositional environments and select samples for analysis and dating.

2. Merge core interpretations with interpreted seismic data collected by AGSO to assess the Quaternary history of sedimentation in the area.

3. Review data and interpretations contained in publications and theses on the area.

4. Prepare a report summarising the findings of the study.

The consultancy also called for regular meetings between AGSO and CMG staff so as to monitor the project and to identify areas where more information was required or other datasets held by AGSO needed to be accessed.

CMG commenced work in April, 1995, and completed the project by August, 1995. Production of the final report was delayed to allow incorporation of the results of sediment analyses (texture and composition) and radiocarbon dating. The report represents a compilation and interpretation of all data collected by AGSO in the coastal waters of the Cape York Peninsula. The report also contains a bibliography of reports, papers and other publications relevant to the project.

1.2 Report Structure

The body of the report is divided in five main sections; this section outlines the project and summarises the study brief, Section 2 briefly reviews relevant published and unpublished information, Section 3 describes the data sets utilised in the report and a synopsis of how they were assembled, Section 4 summarises the marine geology of the Cape York Peninsula coast between Weipa and Cooktown, and Section 5 contains a discussion of the datasets in terms of the late Quaternary evolution of the region. A summary of the report's principal findings is contained in Section 6.

The marine geology of the CYPLUS area is discussed with reference to regional changes in the coastal and nearshore geology noted by Burne and Graham (1995). Reference articles relevant to the CYPLUS Project plus a complete list of the samples, their location and analyses are contained in Sections 7 and 9 respectively. Working copies of 1:100,000 plans and their accompanying notes have been lodged with the Coastal Geoscience Project (AGSO) for incorporation into GIS coverages for the CYPLUS Project Area.

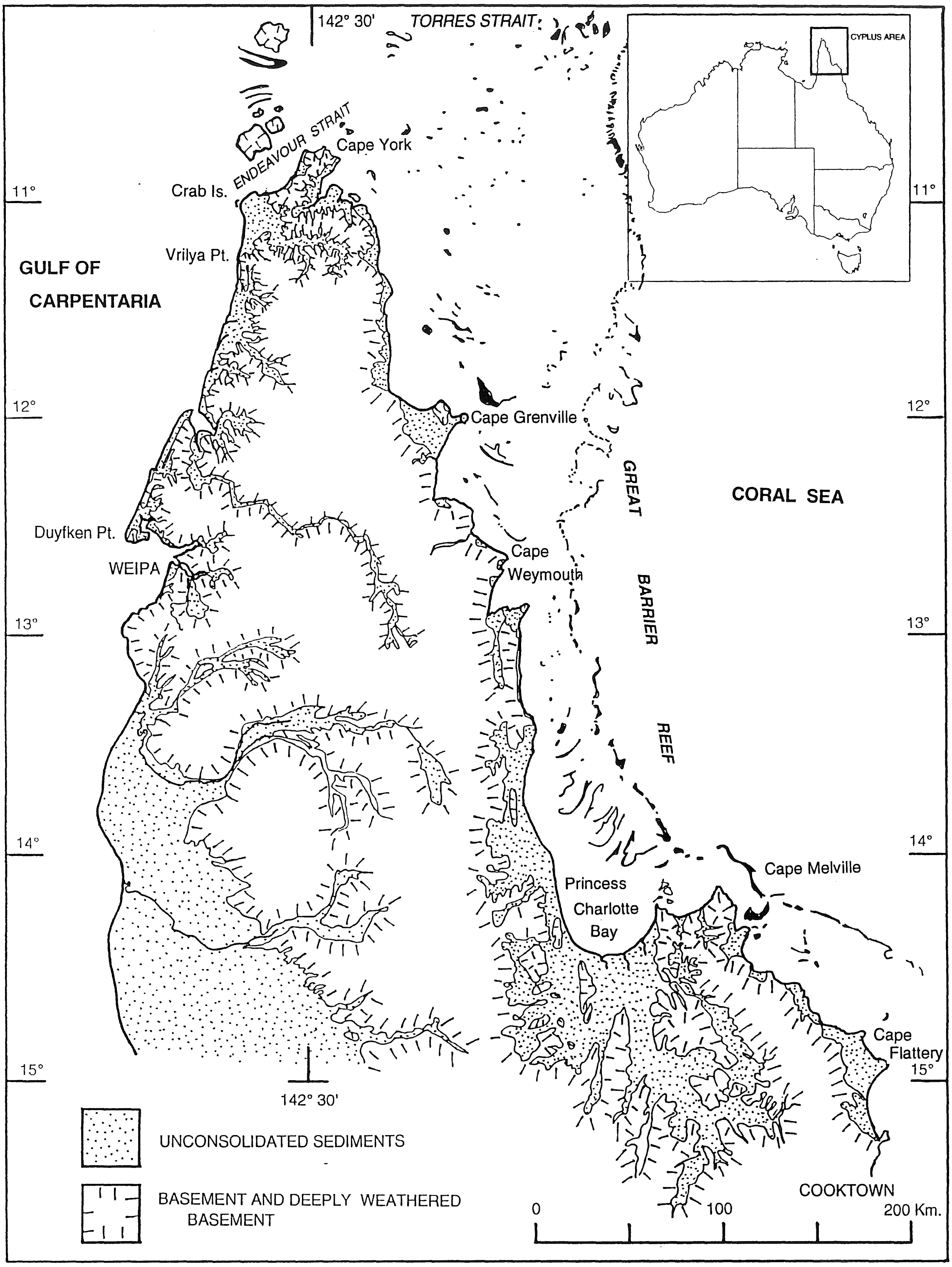


Figure 1. Cape York Peninsula study region, northern Queensland.

2. Previous Work

The CYPLUS Project Area as defined by the present investigation extends from Weipa in the Gulf of Carpentaria to Cape Flattery just north of Cooktown on the eastern Cape York Peninsula. Apart from a few detailed site investigations, large sections of the coast and inner shelf within this area effectively remain unexamined. Reconnaissance marine surveys conducted by AGSO in 1992 and 1993 were designed to provide baseline information over those sections of the inner shelf with little or no data. It is not the intention of this review to provide a detailed discussion of the regional geology, climatology, and oceanography of Cape York Peninsula as this information is adequately covered elsewhere (Maxwell, 1968; Smart et al., 1980; Hopley, 1982; Burne and Graham, 1995). Rather, the emphasis is on a review of previous investigations in the CYPLUS area which have examined nearshore environments and their relationship to the adjacent coastal systems. The following paragraphs provide a regional overview of the coastal waters of the CYPLUS area, a brief review of late Quaternary sea level changes and their impacts on coastal and nearshore environments, and a discussion of published information on shoreface and inner shelf depositional environments within the CYPLUS area.

The coastal waters of the northern Cape York Peninsula can be subdivided into the relatively protected waters of the Gulf of Carpentaria, the tidally influenced shelves of Cape York and southern part of Torres Strait, and the inner shelf of the northern Great Barrier Reef (Fig. 2.1) (Burne and Graham, 1995).

The Gulf of Carpentaria is a large (c.510,000km^2) shallow (60m maximum depth) epeiric sea occupying a broad structural depression identified as the Mesozoic Carpentaria Basin. Terrigenous sediments (alluvial fans) of the Cainozoic Karumba Basin which occupy the Carpentaria Basin crop out extensively onshore and reach an estimated thickness of 400m+ above the Mesozoic basement beneath the Gulf of Carpentaria (Pinchin, 1973; Smart et al., 1980). The occurrence of marine sediments within the Karumba Basin sequence suggests that the Gulf assumed its present configuration around the late Tertiary (Pliocene) (Doutch, 1976; Rhodes, 1980).

Coastal waters in the eastern Gulf experience a mesotidal (2 to 3m range), low wave energy environment. Tidal currents are thought to move in a clockwise direction within the Gulf at velocities of up to 1.5 knots while non-tidal currents are primarily wind generated and in response to northwest winds in summer and southeast winds in winter (Cresswell, 1971; Rhodes, 1980). Significant departures from predicted tide levels by as much as +2m are associated with cyclonic activity in the summer months (Rhodes, 1980). The wave climate is characterised by locally generated wind waves and cyclonic storm waves during the summer monsoon. The remainder of the year is characterised by low waves. Limited observations of wave activity indicate the prevalence of short steep waves with amplitudes less than 2m during the summer and slight seas with wind chop during the winter months (Rhodes, 1980).

The coast is characterised by a low relief hinterland composed of a number of dissected plateau remnants, deep weathering (lateritised) surfaces, alluvial fans, extensive alluvial plains, and prograded coastal barriers of Holocene and Pleistocene age (Smart et al., 1980; Burne and Graham, 1995). North of Weipa, late Quaternary marine deposits infill the lower portions of coastal valleys incised into an early to mid Tertiary lateritised surface (Aurukun surface). River sediments infill the entrances of tidal inlets and prograded beach ridge plains extend along the coast. Offshore, shoreface sands and prodeltaic sandy muds superficially veneer older sediments (pre-Holocene) in water depths of less than 20m. In water depths of between 20 and 60m, relict alluvial sands and gravels commonly crop out on the seafloor. Late Pleistocene lacustrine silts and Holocene marine muds overlie subaerially weathered marine/estuarine deposits in the central and deepest section of the Gulf (>60m water depth) (Torgersen et al., 1985; Jones, 1987; Jones and Torgersen, 1988).

The tidally influenced shelves of Endeavour Strait and southern Torres Strait (Adolphus Channel) form a distinct zone in the northern part of the CYPLUS region (Fig. 2.1). Here the coast changes from one characterised by extensive prograded barrier sequences typical of the eastern Gulf, to one of small bedrock controlled embayments infilled with late Quaternary marine and terrigenous deposits (Burne and Graham, 1995). Offshore, strong tidal currents flowing between the Australian mainland (Cape York), offshore continental islands (Prince of Wales, Mt. Adolphus) and carbonate reefs have swept much of the inner shelf clear of fine sediments, leaving a lag of coarse grained sands and gravels overlying a flat erosional surface. Sediments deposited at the entrance to the straits (eg. Inskip Banks at the western entrance to Endeavour Strait) have been sculpted into extensive tidal shoals (Burne and Graham, 1995). Reworking of tidal shoals in the vicinity of Cape York appears to be in response to a combination of tide and wind generated sea bed currents (Harris et al., 1989; Harris, 1991). The regional significance of tidal currents over this section of the CYPLUS study area is reflected in the widespread distribution of current generated bedforms on the inner shelf and shoreface, low levels of mud (<1%) in the surficial marine sediments, and a strong gradient from terrigenous to carbonate sediments away from the coast (Harris et al., 1991).

The inner shelf of the northern Great Barrier Reef represents the final subdivision of the CYPLUS area coastal waters (Fig. 2.1). The area extends from Newcastle Bay in the north to Cape Flattery in the south, a distance of around 600km. This section of coast incorporates the typical range of coastal (clastic), innershelf (mixed clastic and carbonate) and reef (carbonate) depositional environments to be found in the Great Barrier Reef Lagoon. A description of this region contained in Burne and Graham (1995) is summarised in the following paragraphs.

The Great Barrier Reef Lagoon is defined by the Cape York Peninsula in the west and an almost unbroken line of coral reefs along the continental shelf edge in the east. Proximity of the eastern Highlands to the coast has produced relatively steep and rugged coastal catchments drained by short coastal creeks and rivers. The coastal plain is typically less than 50km wide and comprised of late

Quaternary marine, estuarine, and alluvial deposits. The Great Barrier Reef Lagoon narrows from around 150km in the north to a minimum width of 30km off Cape Melville near the southern limit of the study area. Water depths are at a maximum (50m) in the vicinity of narrow passes between reefs at the shelf edge and decrease gradually towards the mainland.

The eastern Cape York Peninsula experiences a dry winter and wet summer (December to March) with tropical cyclones common during the summer months (January to March). The regional pattern is for SE winds (Trades) to dominate the entire year with light winds (10 to 20km/hr and calms) in the summer months replaced by stronger winds (30 to 40km/hr) during winter (Hopley, 1982). Rainfall is strongly influenced by coastal relief with the isohyets generally paralleling the coast - annual rainfall for the CYPLUS area ranges between 1200 to 2400mm, reaching a maximum at the northern tip of the peninsula. River discharges demonstrate a strong seasonality, with peak wet season discharges 2 to 3 times that of their mean flow. The highest catchment sediment yields are associated with intense cyclonic rains (Hopley, 1984).

Tidal range varies from 3m at Cape York to around 2.5m in the south of the area with significant departures from predicted tides (up to 3m) being due to storm surges generated by the passage of cyclonic depressions (Hopley, 1984). Tidal currents are effective in mobilising lagoon sediments at coastal inlets and narrow passages between coral reefs. The persistent SE airstream generates local wind waves which set up a strong northward littoral drift along exposed sections of coast, mobilising shoreface sediments and resuspending lower shoreface/inner shelf sandy muds. Wind driven currents are believed to be significant for fine grained sediment dispersal across the shelf while cyclones are thought to be the most effective agent for mobilising lagoon and shoreline sediments (Burne and Graham, 1995).

Regional subdivisions of the lagoon bed have recognised a number of shore parallel zones including a steeply sloping nearshore zone in water depths of less than 12m, a relatively featureless gently sloping inner shelf zone from 12m to 35m water depth, and mid to outershelf zones characterised by an irregular sea bed morphology due to the widespread occurrence of coral reefs and *Halimeda* banks. Although the distribution of surfical sediment facies is complex, there is a general gradient from predominantly terrigenous sediments at the coast, through mixed terrigenous-carbonate sediments on the inner-mid shelf, to predominantly carbonate sediments on the mid-outer shelf.

Site specific investigations of a number of the larger embayments (eg. Princess Charlotte Bay and Lloyd Bay; Frankel, 1974; Orme and Flood, 1980; Skjold, 1989; Salama, 1990) have identified fluvially derived muddy sands and sandy muds blanketing the nearshore areas while relict carbonates and terrigenous sediments (sands and gravels), including reworked aeolian sands, shallowly underlie or crop out on the sea floor further offshore. Carbonate sands and gravels accumulate on the seafloor in the vicinity of the shelf edge and mid shelf reefs. Thick (20m+) accumulations of carbonate sands in back reef areas remote from the coast are associated with

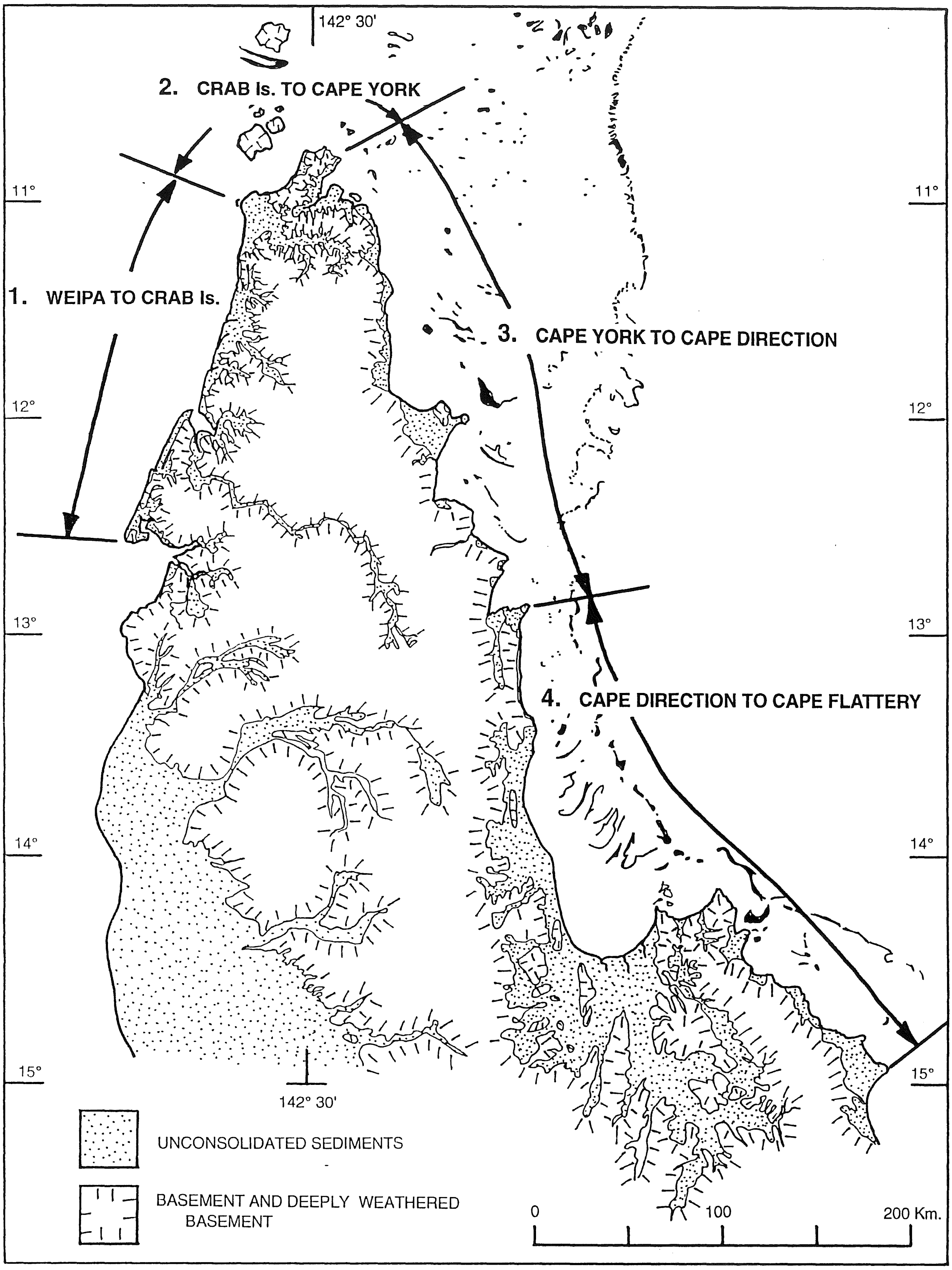


Figure 2.1 Major subdivisions of the Cape York Peninsula study are used in this report.

Halimeda bioherms, or banks. Relict sediments crop out on the sea bed in areas of scour adjacent to channels between midshelf reefs and in those areas of the inner shelf where insufficient contemporary sedimentation has occurred to blanket the older sediments.

Whilst there are clear links between contemporary processes (waves, winds, tides and river discharge) and present day coastal behaviour, regional investigations of the northern Great Barrier Reef, southern Torres Strait and Gulf of Carpentaria have highlighted the role past sea level changes have had on the nature and evolution of coast and shelf environments (Orme et al., 1978a&b; Smart et al., 1980; Hopley, 1982; Chappell et al., 1983; Searle, 1983; Jones and Torgersen, 1988; Harris et al., 1991). Reconstructions of eustatic sea level changes over the past 300,000 years have indicated that sea level oscillated between 20 to 70m below its present position for much of this time and only on a few occasions has it approached or exceeded its present position, the most recent time being around 120,000 years ago (Last Interglacial) when sea level is thought to have been 4 to 5m above its present position (Chappell, 1983; Thom and Murray-Wallace, 1988). The same data show that sea level rose from a Glacial minimum of -130m some 18,000 years ago to its present position around 6,000 years ago (Chappell, 1983). The exact nature of the sea level rise is uncertain with opinion split between a scenario of continuous relative sea level rise in late Pleistocene - Holocene (Thom and Roy, 1985; Hopley, 1987), and a second scenario of episodic sea level rise over the same period (Carter and Johnson, 1986; Larcombe et al, in press).

Radiometric dating of coral reef flats and prograded coastal sequences in northern Queensland provides finer resolution of mid to late Holocene relative sea level changes (Chappell et al., 1982; 1983). These data demonstrate that relative sea level reached a maximum on the inner shelf and mainland coast around 5,500 years ago and since this time has fallen some 2 to 3m in the Gulf of Carpentaria and around 1m on the eastern Cape York Peninsula coast. Local differences in mid to late Holocene relative sea levels are explained in terms of hydro-isostatic loading of the northern Queensland continental shelf following the postglacial marine transgression rather than local tectonic effects (Chappell et al., 1983).

The regional impact of late Quaternary sea level changes on coastal evolution can be seen in the widespread development of prograded barrier deposits of both Pleistocene and Holocene age along the western, northern and eastern coasts of the Cape York Peninsula (Rhodes, 1980; Smart et al., 1980; Chappell and Grindrod, 1984; Graham and Burne, 1995). Offshore, a widespread shallow seismic discontinuity (Reflector A), interpreted as the pre-Holocene landsurface inundated by the postglacial marine transgression, underlies the modern seafloor sediments (Johnson and Searle, 1984). This surface is of regional significance and is recognised throughout the northern Great Barrier Reef (Orme et al., 1978a&b; Nelson, 1980; Searle and Hegarty, 1982; Johnson and Searle, 1984; Skjold, 1988; Salama, 1990), southern Torres Strait (Harris et al., 1991; Holmes et al., 1992a; 1992b), and Gulf of Carpentaria (Bates et al., 1971; Michaelsen, 1994). The seaward extension of many of the coastal valleys can be traced across the present day shelf. The river valleys are incised into the pre-Holocene surface and infilled/overfilled with thick sequences of late Pleistocene-mid Holocene sediments of fluvial and estuarine origin (Johnson et al., 1982; Johnson and Searle, 1984).

A number of detailed investigations of shoreface and inner shelf environments have been completed in the CYPLUS study area. These include exploration for commercial deposits of bauxite on the Weipa inner shelf (Bates et al., 1971; Zwigulis, 1971), an examination of late Pleistocene-Holocene inner shelf deposits of the Gulf of Carpentaria north of Weipa (Michaelsen, 1994), a study of the late Quaternary evolution of the Lloyd Bay area in the northern Great Barrier Reef (Skjold, 1988), and several investigations of the late Quaternary evolution of Princess Charlotte Bay in the southern part of the CYPLUS area (Frankel, 1974; Sahl and Marsden, 1987; Salama, 1990). The data collected by AGSO during the 1992 and 1993 field seasons provides a link, albeit at a reconnaissance level, between these previously examined sections of the shallow coastal waters of the Cape York Peninsula.

Exploration for commercial deposits of bauxite in the Gulf of Carpentaria in the early 1970's involved several marine surveys which included the collection of seismic and drillhole data from shoreface and inner shelf environments offshore of Weipa (Bates et al., 1971; Zwigulis, 1971). The seismic data (Boomer) identified a regional unconformity shallowly underlying the seafloor close to the coast into which were incised numerous river channels. The unconformity was originally interpreted as the offshore extension of the bauxite layer encountered onshore at Weipa, subsequent drilling and radiocarbon dating indicated that the surface represented the contact between pre-Holocene alluvial deposits and more recent Holocene marine muds (Bates et al., 1971; Zwigulis, 1971). Although many of the drillholes were located to the south of the present study area, several holes were drilled within the present study area on the inner shelf north of Duyfken Point (Hole#17A - 26m WD, Hole#18R - 27m WD; Zwigulis, 1971). The drilling shows a southward thickening of the surficial marine sequence (shelly mud) from <1m north of Duyfken Point to 6m+ in Albatross Bay at Weipa. The drilling also demonstrated that the marine muds superficially overlie a stiff-yellow brown clay (Zwigulis, 1971). Subsequent sediment sampling in the eastern Gulf by Jones (1987) has confirmed the generally thin cover of contemporary sediments on the inner shelf north of Weipa.

A detailed examination of the shoreface and inner shelf environments north from Weipa to Vrilya Point was undertaken by Michaelsen (1994). This study utilised part of the dataset collected by AGSO in 1993 and included an interpretation of high resolution seismic reflection (Boomer) and side-scan sonar data and analyses (texture, composition, palynology, radiocarbon dating) of surficial and subsurface (vibrocore) sediment samples. The study identified a seaward thinning wedge of Holocene marine sediments (4m thick at the coast and <1m thick in 33m water depth 27km from the coast) overlying a pre-Holocene surface comprised of an indurated ferruginous clayey sand. The Holocene sequence contains a number of surficial units including modern shore connected sands, inner shelf shelly muds and sands, and shelly shelf-platform palimpsest sands

(Michaelsen, 1994). Vibrocores encountered a variety of early to mid-Holocene estuarine and lacustrine deposits in the shallow subsurface. While the extent of the estuarine and lacustrine units is uncertain (ie. cannot be correlated between core sites), they do preserve a record of the environmental changes which accompanied the postglacial marine transgression. Radiocarbon dating and palynological analyses of selected vibrocore samples show that the early Holocene landsurface consisted of dune deposits and freshwater swamps and a *Myrtaceae* dominated plant community (Michaelsen, 1994). Inundation of the early Holocene landsurface by the rising sea level is recorded in the transition from lacustrine to estuarine (mangrove peats) and, ultimately, a shallow marine environment (Michaelsen, 1994).

The surficial sediments show a complex distribution with modern terrigenous sedimentation (sands and silts) typically restricted to a narrow shoreface zone in less than 15m water depth. Offshore of here, much of the inner shelf surface is mantled by reworked relict alluvial sands and gravels. The inner shelf immediately north of Duyfken Point is irregular and characterised by major palaeotopographic highs related to pre-Holocene outcrops. Further north, the inner shelf sediments have been reworked into a series of asymmetric bedforms (steep south facing slopes) with amplitudes of 1m and wavelengths of up to 1,100m (Michaelsen, 1994; Burne and Graham, 1995). Comparable data for other sections of the western Cape York Peninsula and Cape York coastal waters are described for the first time in this report.

Several detailed investigations have been completed in the larger embayments on the east coast of the Cape York Peninsula (eg. Lloyd Bay and Princess Charlotte Bay). These studies have examined the interplay of terrigenous and carbonate sedimentation within the northern Great Barrier Reef lagoon in response to late Quaternary sea level fluctuations (Frankel, 1971; Skjold, 1988; Salama,1990).

Lloyd Bay is located in the far north of the Cape York Peninsula at the entrance to the Lockhart and Claudie Rivers. Water depths in the bay are less than 20m, increasing to around 40m in the vicinity of the shelf edge reefs located some 50km offshore. Gentle gradients and a subdued sea bed morphology characterise the inshore part of the area. Offshore, shelf relief and bathymetry is highly variable within 20 to 30 kilometres of the reef edge due to the presence of mid shelf platform reefs and extensive *Halimeda* banks. Beach ridges of Pleistocene and Holocene age occur along the bay coast exposed to the prevailing SE winds. Cheniers and mangrove deposits occur along the relatively protected north-facing coast and adjacent to the estuarine inlets (Skjold, 1988). Large dune fields comprised of well sorted siliceous sands occur along the exposed northwestern shore of the bay and at Cape Direction to the east of the bay. Similar dune fields are common elsewhere on the Cape York Peninsula where their formation has been linked to the long term supply of terrigenous sediments to the coast and shelf followed by marine and aeolian reworking in response to late Pleistocene sea level fluctuations (Pye, 1984; Pye and Bowman, 1984; Lees and Yanchou, 1992).

Examination of the late Quaternary depositional environments in the Lloyd Bay area included a high resolution (Boomer) seismic reflection survey supplemented by surficial and subsurface sediment sampling (Skjold, 1988). The study identified a widespread erosional surface shallowly underlying much of the shelf into which is incised the pre-Holocene valley of the Lockhart and Claudie Rivers. The Holocene marine sequence above the seismic disconformity was found to be relatively thin (3 to 4m thick) with the thickest accumulation of late Pleistocene-Holocene sediments (around 30m) occurring within the pre-Holocene river valley (Skjold, 1988).

Skjold (1988) subdivided the Holocene sequence into six main seismic units. The oldest sequence consists of a channel fill deposit graded to a -70m base level of 11,000 years ago over which was deposited a channel fill and mangrove peat facies associated with widespread inundation of the shelf surface to -50m around 10,000 years ago. Transgressive shallow marine and estuarine (mangrove peat) deposits accumulated within the bay as sea level approached -20m some 9,000 years ago - contemporaneous formation of *Halimeda* Banks on the outer shelf commenced around this time. A series of surficial terrigenous and carbonate sequences formed during the final rise and stabilisation of sea level around its present position in the mid-Holocene (Skjold, 1988). Four principal lithologies were recognised: siliclastic sands in the vicinity of Cape Direction, mixed terrigenous-carbonate muds in water depths of less than 30m within the bay which become less muddy and more carbonate rich further offshore, *Halimeda* banks on the outer shelf in water depths of around 25m, and coralgal facies associated with reefs on the mid shelf and outer shelf. The siliclastic sands near Cape Direction were interpreted as Pleistocene aeolian deposits partially reworked by the postglacial marine transgression (Skjold, 1988). Terrigenous sedimentation has dominated the shelf and shoreface environments within the bay throughout the late Pleistocene and Holocene with carbonate sedimentation, particularly the growth of *Halimeda* banks, typifying Holocene sedimentation on the outer shelf (Skjold, 1988).

Similar investigations in Princess Charlotte Bay, a large protected embayment located some 180km further to the south of Lloyd Bay, have identified a comparable sequence of nearshore and inner shelf facies (Frankel, 1971; Salama, 1990). Princess Charlotte Bay is defined by the offshore extension of the Mesozoic Laura Basin and represents the regional base level for the numerous rivers draining the coastal hinterland. Of the four main rivers draining the catchment (North Kennedy, Bizant, Normanby and Marett Rivers), the Kennedy River system has the second highest average annual sediment discharge (c.2.7 million tonnes) of all the northern Queensland rivers (Belperio, 1983a). The coastal plain is comprised of extensive alluvial deposits and prograded coastal sequences of Pleistocene and Holocene age including cheniers, clay dunes, beach ridges and mangrove peats (Chappell and Grindrod, 1984; Burne and Graham, 1995). The adjacent shelf is shallow with water depths greater than 40m being restricted to inter-reef channels at the shelf edge. The shelf varies in width from 20km off Cape Melville at the eastern margin of the bay to a maximum of 80km from within the bay (Salama, 1990). Terrigenous muds cover most of the shelf area with *in situ* shell production forming a significant component of this facies. Resuspension and transport of fine sediments occurs in response to waves in shallow nearshore areas (<11m water depth) and tidal currents in the estuaries. Tidal flows generate offshore transport whereas strong southeast winds transport fine sediments alongshore and out of the bay to the northwest (Sahl and Marsden, 1987). Most of the coarse grained terrigenous sediment reaching the coast is trapped inshore and transported northward by the prevailing longshore currents (Frankel, 1971). Reef derived sediments are locally important in the vicinity of mid shelf and shelf edge reefs while relict sediments occur on the seafloor near current swept passes between the reefs (Frankel, 1971; Salama, 1990).

Seismic, surficial and shallow subsurface sediment data identified an extensive pre-Holocene subaerial surface overlain by a thin (<5m thick) Holocene sequence comprised of transgressive marine (reef, estuarine and shoreline environments) and terrestrial (fluvial and deltaic environments) sediments (Salama, 1990). The Holocene sequence attains a maximum thickness of around 30m in the palaeodrainage channel which extends to the NE across the bay where it connects with the present day Lowry Passage at the shelf edge (Salama, 1990). *Halimeda* banks common in the Lloyd Bay area were not encountered in the Princess Charlotte Bay area.

Previous investigations of the coastal waters of the Cape York Peninsula have provided a limited amount of information on the nature and variability of the depositional environments within the eastern Gulf of Carpentaria and northern Great Barrier Reef Lagoon. The information that is available highlights the impact late Pleistocene sea level changes have had on coastal and nearshore sedimentation as well as the importance of contemporary terrigenous sedimentation to coastal progradation and the development of shoreface and inner shelf facies. The AGSO 1992 and 1993 marine survey data reviewed here provides an important link between the poorly known and better studied sections of the CYPLUS area and, as such, represents an important contribution to the establishment of appropriate management strategies for the variety of coastal settings found around the Cape York Peninsula.

3. Data Sets

A number of data sets collected by AGSO have been utilised in this report. The primary emphasis has been on the correlation of the surficial and subsurface sediment data with the results of the seismic and side-scan sonar surveys. The following sections contain an overview of the relevant data sets and a description of how they have been assembled. This information has been sourced from a variety of unpublished AGSO reports, university theses and published papers.

3.1 Bathymetry

The coastal waters of the Cape York Peninsula are incompletely mapped, poorly charted and without reliable digital coverage (Burne and Graham, 1995). A complete bathymetric coverage of the area was compiled by Mr. Cameron Buchanan (AGSO, Canberra) at 1:100,000 scale using existing nautical charts, reef location maps supplied by the Great Barrier Reef Marine Park Authority, and other available sea bed information. Ms. Heather Rennie (AGSO, Canberra) merged and edited these datasets in an ARCINFO GIS, producing a regular grid (1km spacing) of interpolated water depths from which were prepared a series of 1:100,000 bathymetric maps with a 5m isobath interval.

Regional variations in shelf slope and morphology have been noted from the bathymetric maps compiled for the CYPLUS Project. Details of seabed morphology and water depths in the vicinity of surface (grab) and subsurface (vibrocore) sediment sites have been taken from the original echo sounder, seismic and side-scan sonar records produced in the 1992 and 1993 marine surveys. Water depths are as recorded and no correction has been made for tide or other effects.

3.2 Satellite Thematic Mapping Imagery

A series of benthic substrate coverages have been produced from enhanced LANDSAT Thematic Mapper data sets. Multispectral LANDSAT data has been processed at AGSO to derive a residual representing relative substrate reflectance which is independent of water depth. The algorithm utilises LANDSAT TM bands 1, 2, and 3 in combined colour to delineate substrate features such as sea grasses and sandy substrates which are obscured in the raw data (Bierwirth et al., 1993).

Enhanced images have been compared with available colour aerial photography (1:50,000 scale), surface sediment data, and seismic and side-scan sonar data in an attempt to verify changes in substrate types indicated in the images. Comparison of the data sets was facilitated by overlaying transparencies containing summaries of the marine survey data onto the enhanced LANDSAT TM images (1:100,000 scale).

3.3 Seismic and Side Scan Sonar Surveys

Marine surveys of the coastal waters of the CYPLUS area were completed in October 1992 and October 1993. The aim of the surveys was to provide baseline data on the sediment types, thickness and age structure within shoreface and inner shelf environments of the Cape York Peninsula between Weipa and Cooktown. The 1992 survey was conducted in collaboration with staff of the Queensland Department of Resource Industries from the research vessel "M.V. Hero". The 1993 survey was conducted from the James Cook University 18m research vessel "R.V. James Kirby".

In excess of 1,000km of high resolution seismic reflection and side-scan sonar trackline was completed over the 1992 and 1993 field seasons. The majority of lines were run shore-parallel so as to identify relict drainage patterns extending seaward of the present day coast. A limited number of shore-normal lines were run to assess offshore variations in sediment types and thicknesses. The quality of the records is variable - poor resolution and penetration typify records from the Gulf of Carpentaria, better resolution and penetration was achieved in the Great Barrier Reef Lagoon.

The seismic equipment consisted of a high resolution ORE 3.5kHz subbottom boomer system incorporating a 180 Joule sound source. Maximum subbottom penetrations in sediment of around 50m are possible with this system, however the occurrence of hard layers and bedrock below the seafloor greatly reduce this figure. Side-scan sonar data were collected with a Waverly 100kHz system capable of covering a 150m swath (ie. 75m either side of the boat track) of sea bed. Seismic and side-scan sonar data were recorded on EPC flat bed recorders, the paper records were automatically annotated with event marks (ie. waypoint numbers and time) during the course of the surveys. A hull mounted 200 kHz Furuno echo sounder was run continuously throughout the surveys. Navigation was by shipboard Furuno GPS and an independent Magellan 5000 GPS satellite navigation system (Michaelsen, 1994)

Examination of these data involved preparation of survey tracklines maps at 1:100,000 showing individual line numbers, navigation waypoints, and surface and subsurface sediment sample locations. General features of the sea bed including sediment thickness (seismic data), morphology and texture (side-scan sonar data) were noted and plotted on acetate overlays for each 1:100,000 map sheet. Sediment thicknesses and water depths were determined using an assumed average velocity of sound in water and post glacial sediments of 1,500ms^{-1}. A comparable figure has been used elsewhere in the Cape York region for interpreting shallow marine seismic data (Orme et al, 1978a; Harvey, 1980; Johnson and Searle, 1984; Skjold, 1988). Typical examples of seismic and side-scan sonar records were selected from each area and these are reproduced in Section 4.

3.4 Surface and Subsurface Sediment Samples

Surface seabed samples were collected with the aid of a Van Veen 625cm^2 grab sampler attached to an electric winch. Subsurface seabed samples were collected during the 1993 survey with an electric powered vibrocorer fitted with a disposable 4.5m long, 75mm diameter aluminium barrel. A toughened steel bit and spring steel leafed core catcher was fitted to the barrels to aid penetration and core recovery (Michaelsen, 1994). Core samples were collected during the 1992 survey with a diver operated corer consisting of a pneumatically operated vibrating head, vacuum pump, and 4m length of 50mm diameter disposable aluminium tubing. Corer penetrations and recoveries were consistently higher in the 1992 survey.

A total of 265 grab samples collected in water depths ranging from intertidal to 35m were recovered during the surveys. On recovery, a visual description of sediment colour, texture and composition was made prior to storing the sample in a labelled plastic bag. Sample details including date of collection, water depth, location (latitude and longitude) and sample number were recorded.

A total of 41 vibrocores ranging in length from 0.10m to 4.24m were recovered in water depths of between 2.5m and 32.5m. On recovery, the cores were held upright to facilitate settling of any fine sediments still in suspension in the top of the core barrel while notes were made on core penetration, recovery, nature of sample (if any) retained in the core bit, and general locational information (longitude/latitude, water depth etc.). The cores were cut at 1m intervals, sealed, labelled and stored on board prior to transport back to laboratory facilities for processing.

A standard set of procedures was adopted for processing both grab and core samples at the AGSO laboratory facilities in Canberra. Core samples retained in the aluminium barrels were split longitudinally, logged, resin peeled, and sampled. Resin peels are designed to highlight depositional structures (ie. cross bedding, laminations etc.) in core samples, however the poor results of peels prepared from the 1992 cores meant that no peels were prepared from the 1993 cores. Reference sets of core and grab samples were retained. A number of the cores and grab samples from the Gulf of Carpentaria were analysed at James Cook University (Michaelsen, 1994).

A complete set of core samples and the results of analyses of the grab samples were made available to Coastal & Marine Geosciences in March, 1995. Field descriptions of the grab samples and their analyses (texture and composition) have been reexamined. Reference core samples retained in their original core barrels were relogged and resampled, including cores previously examined by Michaelsen (1994). Core samples were selected for textural and compositional analyses and radiocarbon dating. Textural and compositional analyses were completed at the AGSO Sediment Laboratory, Canberra. Details of the analytical methods outlined below are available in laboratory manuals held at AGSO.

Textural analyses involved determinations of the proportions of Gravel:Sand:Mud (G:S:M) and grainsize distributions of the sand (2mm to 63 micron) and mud (<63 micron) fractions of each sample. Proportions of G:S:M were determined by wet sieving 20gm bulk samples through 2mm and 63 micron sieves and weighing the fractions retained and passing each sieve. Results are expressed in terms of the weight percent of each size fraction normalised against the total sample weight. Sand grainsize distributions were determined by calibrated settling tube. Output from the settling tube includes a histogram of particle size frequency (%weight per phi interval), a table of particle size cumulative and frequency distributions, and calculated moment measures of mean, standard deviation, skewness and kurtosis. Mud (63 to 2 microns) grainsize distributions were calculated by a Sedigraph 5100 X-Ray particle sizer. Compositional analyses involved determinations of the carbonate and non-carbonate component of each sample by the titration method. Samples were processed using a Metrohm 716 Titrino and the results are expressed as the weight percent of carbonate material in each sample.

3.5 Radiocarbon Dating

A total of 18 vibrocore samples was selected for radiocarbon dating and submitted to the Radiocarbon Dating Laboratory, University of Waikato, New Zealand. The purpose of the dating was to establish the time of deposition of the marine, estuarine and terrestrial facies intersected by the cores.

Prior to dispatch, each sample was washed on a 1mm sieve to remove excess fine material, examined under a binocular microscope and described. Material unsuitable for dating (ie. large abraded shell fragments, heavily stained and bored shell fragments) was removed at this stage.

The materials submitted for dating included whole shells, shell fragments, shell hash and organic (plant remains) material. With the possible exception of some of the organic material, none of the shell samples represent *in situ* material. In view of this, the dates obtained on this type of material must be viewed as a maximum age as an indeterminate period of time must have elapsed between the death of the organism(s) and incorporation the shell into the sediments. Although the possible errors associated with dating transported shell material cannot be overlooked (Nielsen and Roy, 1982; Roy, 1991), the purpose of the dates obtained for this report are to provide a general chronostratigraphic framework for the facies recognised in the cores. A partial measure of the reliability of the dates is their correlation with established sea level curves for the region and sensible variations in ages with depth below the sea bed for dates from the same core (ie. no age reversals).

In view of the possible errors associated with the radiocarbon dates on transported shell and organic material, the dates have not been converted to sidereal (calendar) years and are expressed in environmentally corrected C14 years. An environmental correction factor is necessary to account for old C14 in the ocean waters incorporated into contemporary biogenic material. A correction factor of 450+/-35 years has been deducted from all dates of shell material (Gillespie and Polach, 1976).

4. Marine Geology of the CYPLUS Area

The results of the CYPLUS 1992 and 1993 marine surveys are discussed with reference to the regions previously described by Burne and Graham (1995). These regions include the shallow coastal waters north of Weipa in the eastern Gulf of Carpentaria (Section 4.1: Duyfken Point to Crab Island), the tidally influenced shelves of Cape York (Section 4.2: Crab Island to Cape York), and the coastal waters of the Great Barrier Reef Lagoon from Cape York to Cooktown (Sections 4.3 and 4.4; Cape York to Cape Direction, Cape Direction to Cape Flattery respectively).

4.1 Duyfken Point to Crab Island

4.1.1 Bathymetry and Surficial Sea Bed Sediments

The Gulf of Carpentaria forms the western shore of the Cape York Peninsula and here the coast is characterised by extensive prograded barrier systems, tidal inlets infilled by terrigenous sediment, and coastal rivers with highly seasonal discharges and rates of sediment supply. Sea bed slopes are low (<0.01°) with water depths of 10m and 20m commonly occurring 5km and 15km offshore. Regional sea bed slopes are lowest in the far north of the area around Crab Island where the 10m isobath is located some 15km to 20km offshore. The steepest sea bed slopes (0.06°) occur inshore in the vicinity of rocky coastal promontories such as Duyfken and Vrilya Points. Seaward of the barrier coasts, the sea floor has an irregular, concave-up profile with slopes of up to 0.02° inshore of the 10m isobath grading to slopes of less than 0.01° further seaward (Fig. 4.1). There is a clear decrease in sea bed slopes seaward of the 10m isobath (Lines K and L, Figs. 5.9 and 5.10; Michaelsen, 1994). Irregularities in the sea bed morphology between 5m and 20m are, in part, related to sub-tidal bedforms. These bedforms are 1m to 4m high, between 500m to 1200m long, and asymmetric in profile with steep west to southwest facing slopes (Michaelsen, 1994). The asymmetric nature of the bedforms and their occurrence in relatively shallow water depths suggests that they may be the result of offshore sediment movement in response to storm generated sea bed currents (Michaelsen, 1994).

Surficial sea bed sediments range from sands and muddy sands near the coast to sandy gravels and muds further offshore. A review of sea bed sediments between Weipa and Vrilya Point identified a complex pattern of surficial sediments with modern shore-connected sands (shoreface) in water depths of less than 10m and either relict gravels (shells, lithic fragments, lateritic pebbles) or shelly silty sands and sandy silts in deeper water on the inner shelf. Silts and muds cover the sea bed in protected embayments such as Albatross Bay at Weipa (Fig. 4.2) (Michaelsen, 1994).

A summary of regional trends in surface sediment textures and composition between Duyfken Point and Crab Island is presented in Figures 4.3 and 4.4. A ternary plot of the proportions of

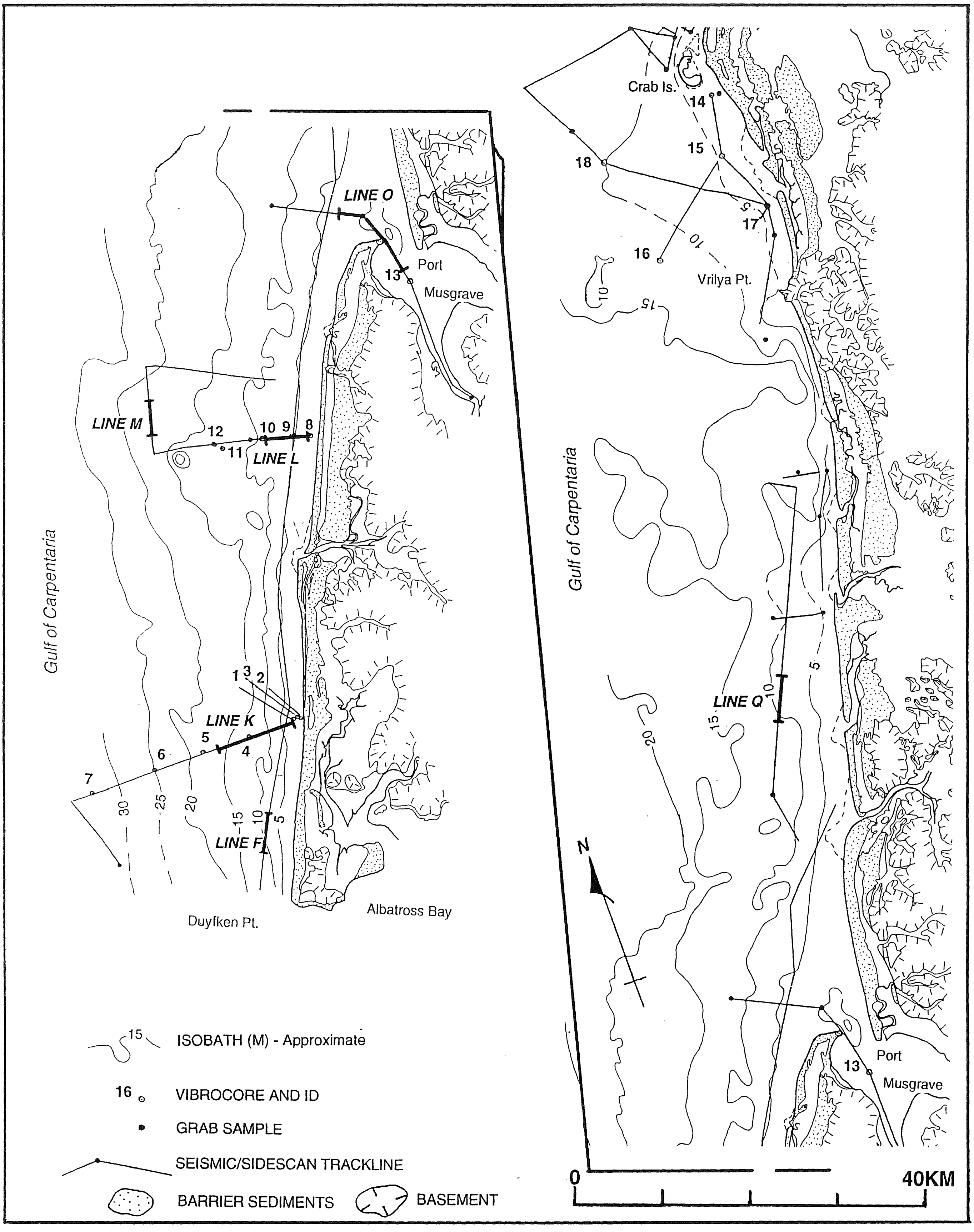


Figure 4.1 Gulf of Carpentaria - Duyfken Point to Crab Island. Figure shows generalised bathymetry, survey tracklines, grab and vibrocore locations. Highlighted sections of tracklines discussed in text. Onshore geology from AGSO coastal mapping program.

Sand:Gravel:Mud demonstrates that the sediments range from muds through to sandy gravels, with the majority of samples falling into the sand and muddy sand fields (Fig. 4.3). The proportion of mud in the surface sediments increases with increasing water depth while no comparable trend can be discerned for the proportion of gravel (Fig. 4.3). The carbonate content shows a clear increase with increasing water depth (Fig. 4.3). Visual inspection of the grab samples confirms that the carbonate is produced by benthic organisms and consists of whole and broken molluscan fragments, gastropods, echinoid spines and tests, ostracods, and foraminiferal tests. An examination of longshore compositional trends suggests a marked drop in the proportion of carbonate in inshore sediments (water depths less than 10m) north of Vrilya Point. To the south of here, inshore sediments have carbonate contents of around 30% while sediments in comparable water depths to the north of the point have carbonate contents of less than 15%. This trend appears to be related to the supply of terrigenous sediment to the coast and shelf by the Jardine River (Fig. 4.1) rather than to a local decrease in carbonate productivity.

Analyses of the sand grainsize distributions of the sea bed sediments are summarised in Figure 4.4. The samples have been grouped on the basis of water depth in an attempt to show the transition from modern shoreface to relict inner shelf sediments. The sand fraction of sea bed sediments in water depths less than 5m is moderately to moderately well sorted and fine to medium grained. Typical modes occur around 1.5 Phi (Medium Sand) and 3.0 Phi (Fine to Very Fine Sand) (Fig. 4.4). Seaward of the 5m isobath the sand fraction becomes coarser, less well sorted, and polymodal. The poorest sorting and coarsest sand size appears to occur in water depths greater than 10m (Fig. 4.4). These data suggest that the transition from modern shoreface sediments to relict inner shelf sediments occurs in water depths of less than 10m, possibly as shallow as 5m. Further sampling is required to confirm this.

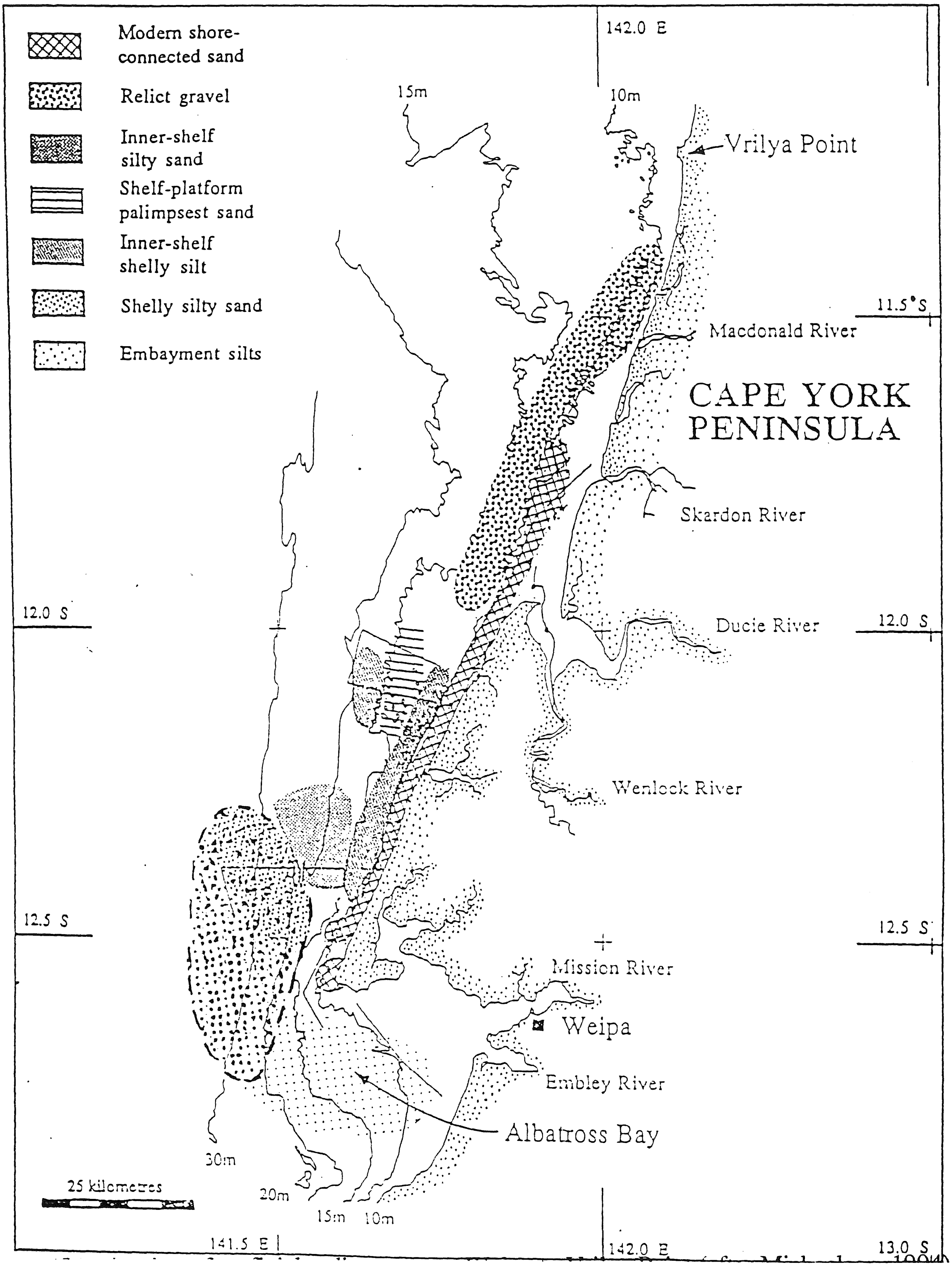


Figure 4.2 Distribution of surficial sediment types, Weipa to Vrilya Point (after Michaelsen, 1994)

Duyfken Pt. to Crab Is.

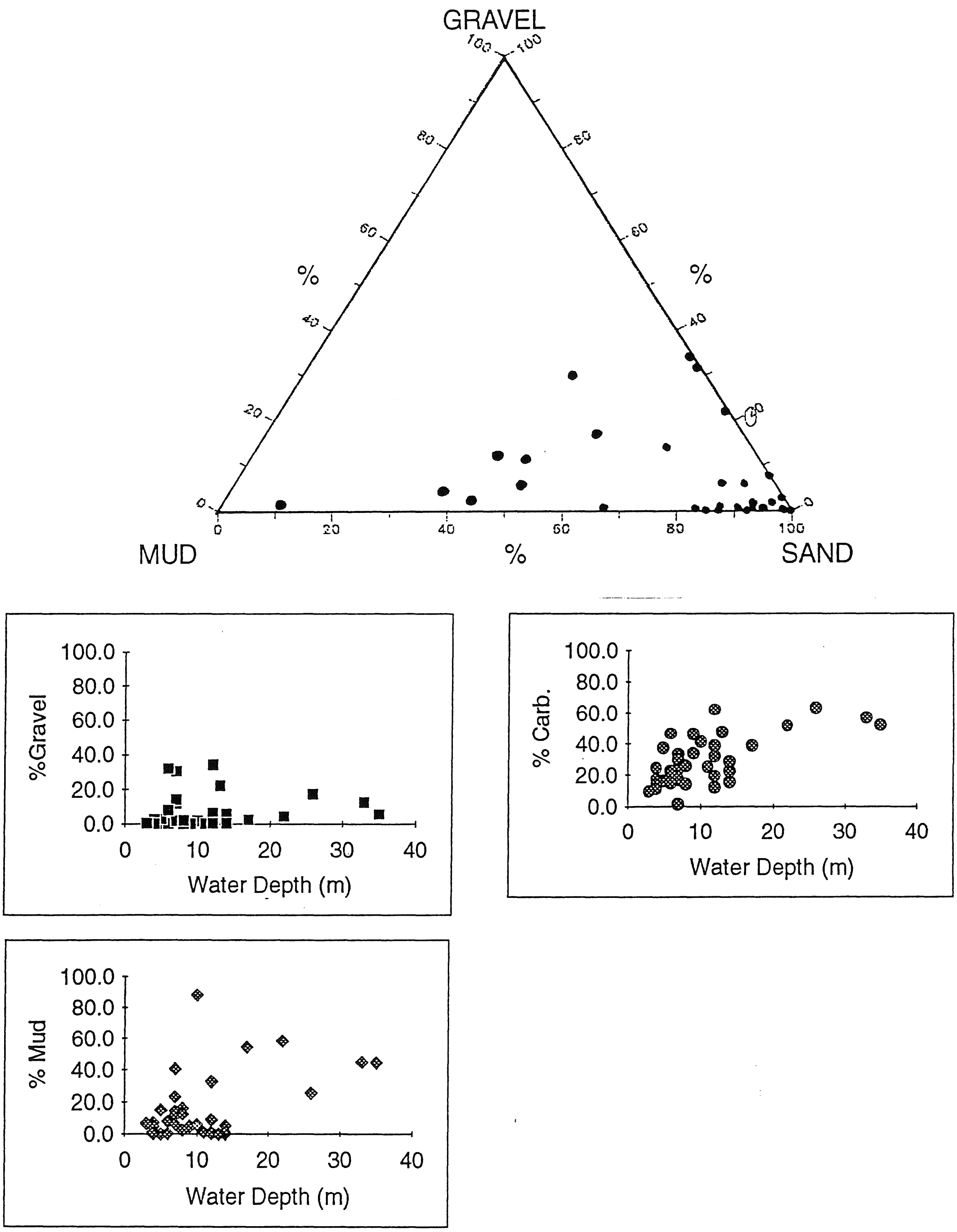


Figure 4.3 Textural characteristics of surficial sea bed sediments - Duyfken Point to Crab Island.

Duyfken Pt. to Crab Is.

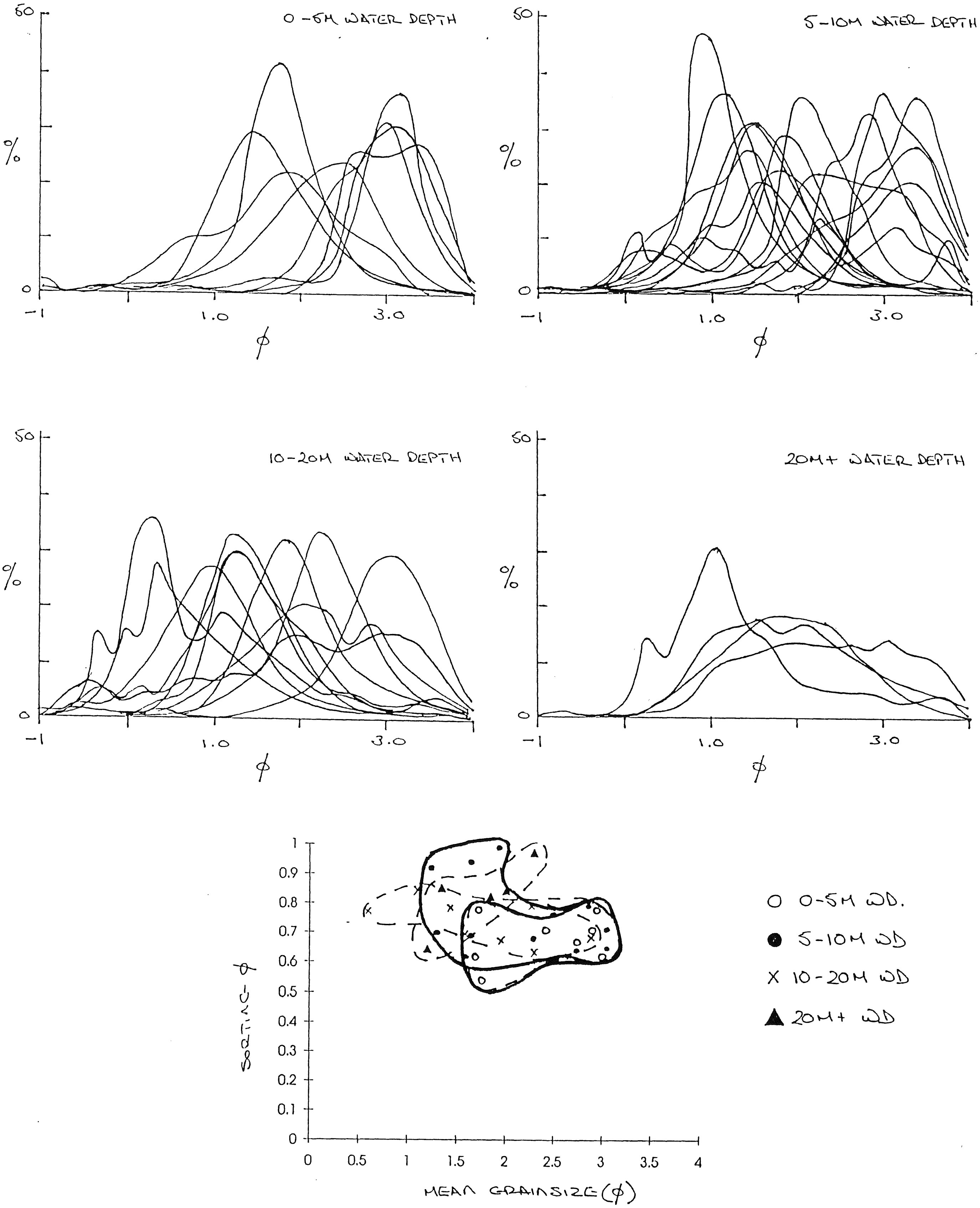


Figure 4.4 Sand grainsize distributions and sorting for surficial sea bed sediments Duyfken Point to Crab Island.

4.1.2 Seismic and Side Scan Sonar Surveys

The distribution of seismic and side scan sonar tracklines is indicated in Figure 4.1 and selected examples are shown in Figures 4.5 to 4.10. The majority of the lines are shore-parallel and in water depths of less than 10m while a number of shore-normal lines occur at intervals along the coast (Fig. 4.1).

The seismic data show the Gulf of Carpentaria sea floor to be broad, shallow and underlain by a prominent subsurface horizon. This horizon, presumed to represent the pre-Holocene land surface, is overlain by a Holocene sequence of estuarine and shallow marine deposits up to 5m thick (Dr. John Marshall, AGSO, pers. comm). The thickest accumulations of Holocene sediments occur as valley fills within the shallow channels incised into the pre-Holocene land surface. Channel fills typically are less than 5m thick, reaching a maximum of around 20m at the entrance to major inlets (eg. Port Musgrave; Fig. 4.5). A complex seismic stratigraphy consisting of at least two (?)Holocene units (progradational clinoform and regularly bedded channel fill sequence) over an irregular (?)pre-Holocene surface characterises the Port Musgrave inlet (Fig. 4.5). Basement (bedrock) outcrops on the sea bed are uncommon except in the vicinity of rocky coastal headlands (Point Duyfken and Vrilya Point). Limited sampling of these outcrops suggests that they are likely to be composed of Tertiary laterites (Bates et al., 1971).

The quality and resolution of the seismic records prevents an accurate determination of Holocene sediment thicknesses over much of the area, particularly seaward of the 10m isobath. It is likely that in these water depths the pre-Holocene surface shallowly underlies and/or crops out on the sea bed. Vibrocore sampling was undertaken to establish the shallow sea bed stratigraphy (Section 4.1.3).

An example of basement outcrop on the sea bed in the southern part of the area northwest of Duyfken Point is shown in Figure 4.6. The outcrop forms a topographic high of around 2m above a sea floor mantled by a relatively thick (up to 5m) sediment sequence. The sediments overlie and infill an irregular surface which has a different acoustic signature to the basement high and presumably represents the pre-Holocene surface (Fig. 4.6). The irregularity of the pre-Holocene surface and variable thickness of the overlying Holocene sequence is demonstrated in two shore-normal lines between Duyfken Point and Port Musgrave (Figs. 4.7 and 4.8). A chaotic acoustic pattern shallowly underlying the sea floor defines an irregular and, in places, channelled surface within 2m to 5m of the sea bed on both lines. Although the records are of insufficient quality to trace the pre-Holocene surface across the entire profiles, they do indicate the variable thickness of the Holocene sequence. Localised thickening of the Holocene sediments is associated with channels in the pre-Holocene substrate and 2m to 3m high bedforms in 5m to 10m water depth on the lower shoreface (Figs. 4.7 and 4.8).

Low amplitude asymmetric bedforms are a common feature of the shallow sea bed between Duyfken Point and Crab Island. The bedforms are readily recognisable in seismic section as they represent areas of minor relief and relatively thick (<5m) sediment on what is an otherwise flat, featureless sea bed (Fig. 4.9). No internal structuring (eg. foresets) was observed in the bedforms. The thin cover of Holocene sediments over the pre-Holocene surface in water depths greater than 10m is shown in Figure 4.10 where a discontinuous reflector immediately below the sea bed defines a Holocene sequence less than 2m thick. A side scan sonar image over the same section of sea bed indicates alternating zones of coarse and fine sediment (Fig. 4.10). In view of the proximity of the pre-Holocene surface to the sea bed in these areas, it is possible that the zones of coarse and fine sediment sediment represent areas of relatively thin (coarse grained gravel lags) and thick (fine sediments) Holocene sediment cover.

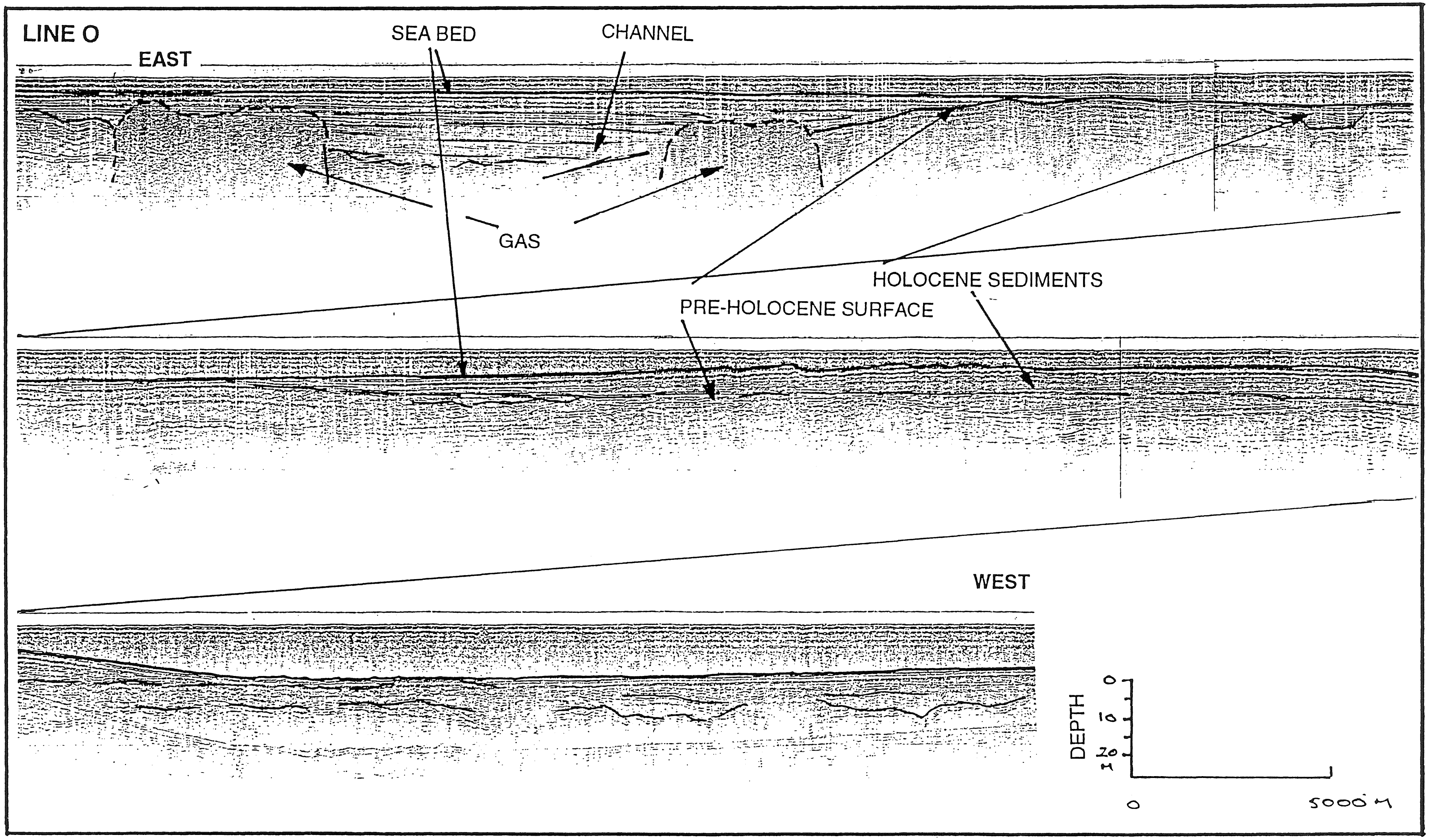


Figure 4.5 Seismic profile along axis of Port Musgrave inlet entrance (Line O; Figure 4.1). Note infilled channels and seaward thinning wedge of sediment (tidal delta) onlapping inner shelf. Pre-Holocene surface is deeply incised inshore and appears to shallowly underlie inner shelf further seawards.

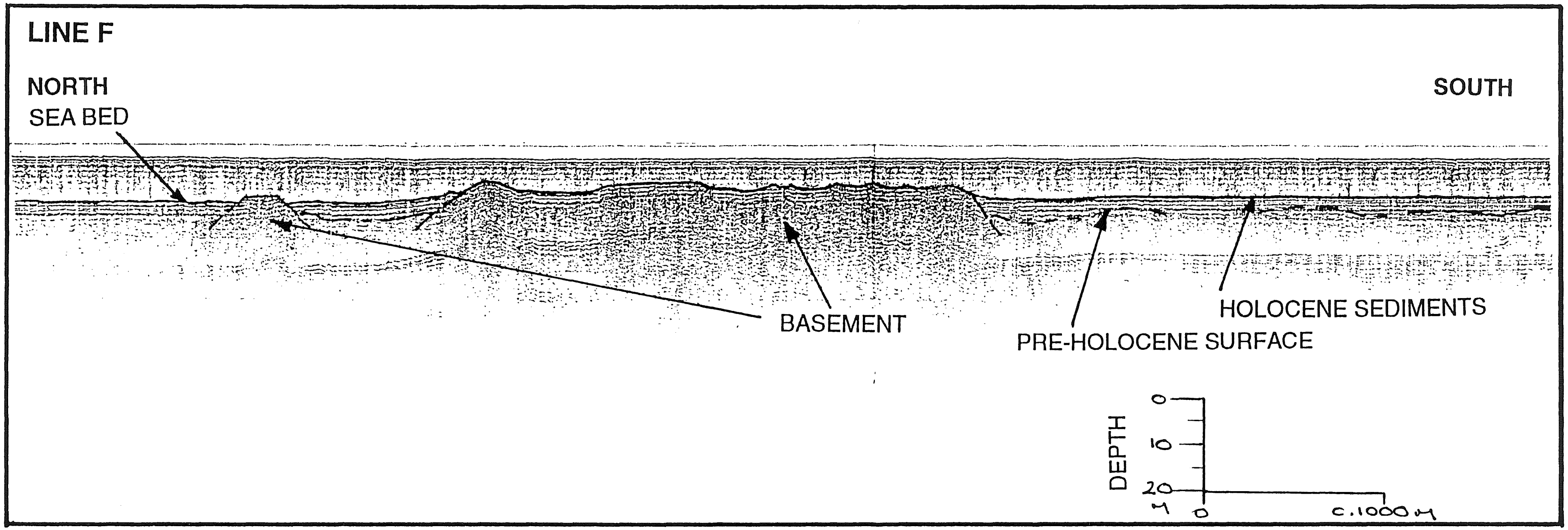


Figure 4.6 Basement outcrop on seabed northeast of Duyfken Point (Line F, Figure 4.1)

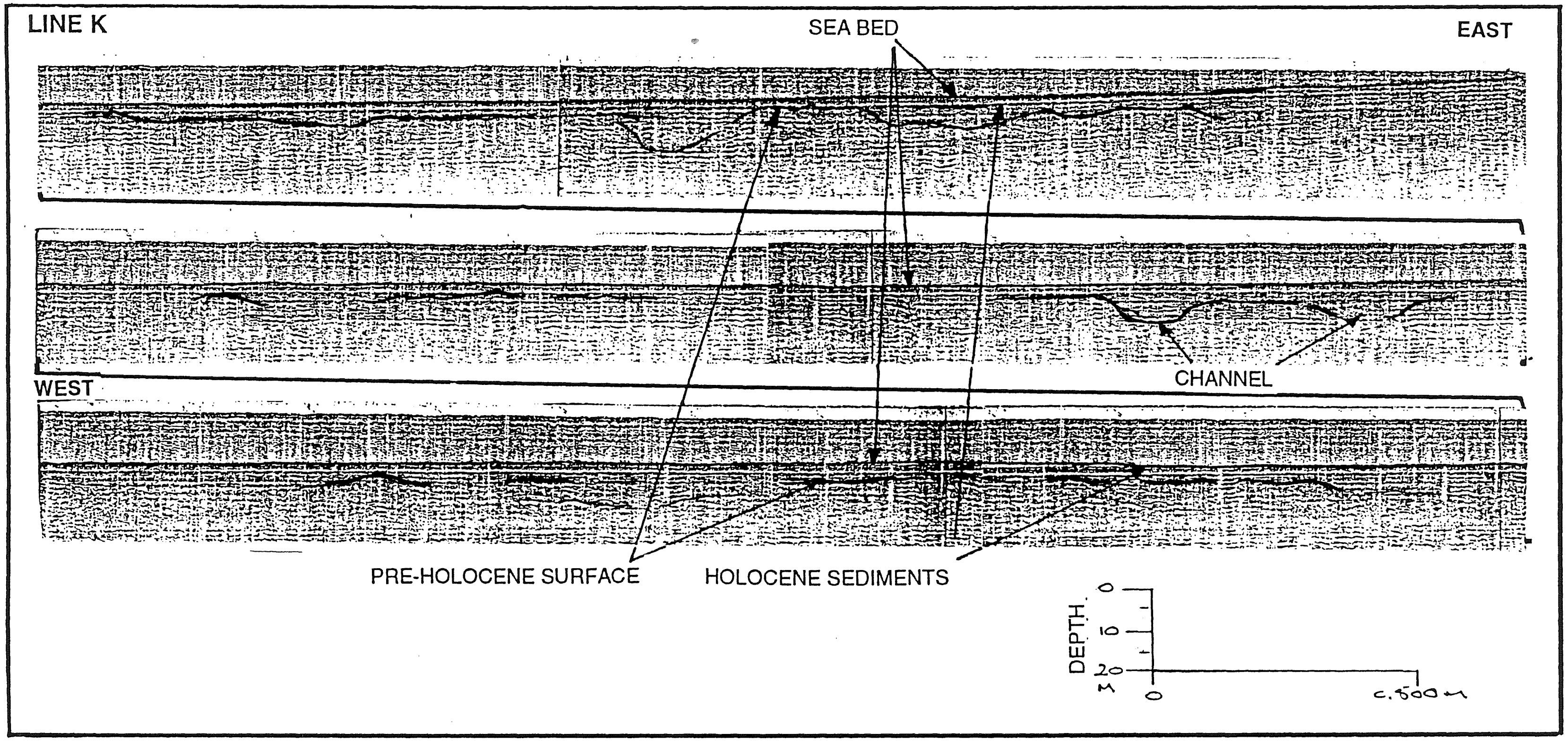


Figure 4.7 Shore normal seismic profile showing poorly defined pre-Holocene surface, channelled in places, underlying gently sloping shoreface profile (Line K, Figure 4.1).

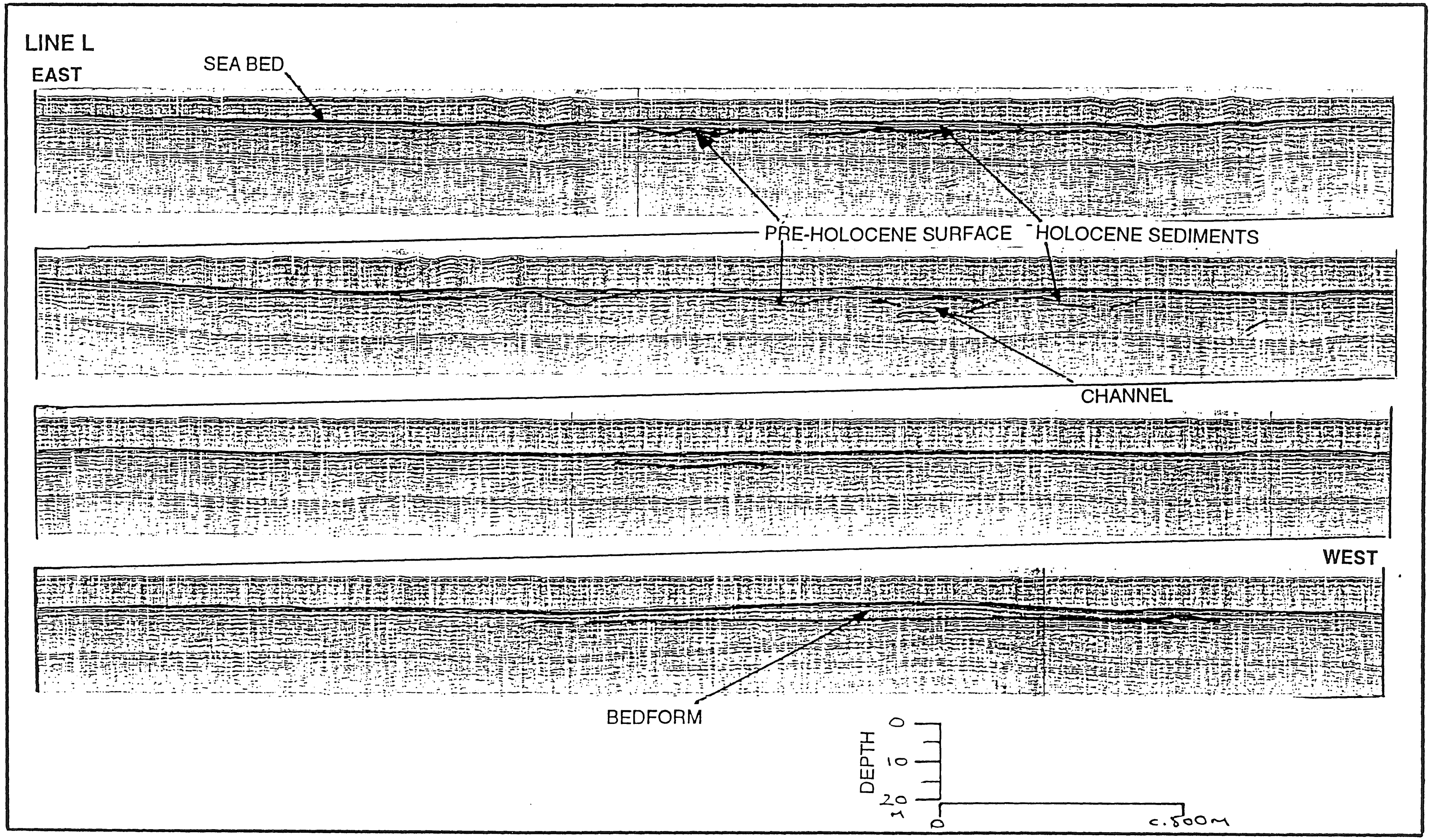


Figure 4.8 Shore normal seismic profile showing poorly defined pre-Holocene surface, channelled in places, underlying gently sloping shoreface profile (Line L, Figure 4.1). Note low amplitude, asymmetric bedform on lower shoreface/inner shelf.

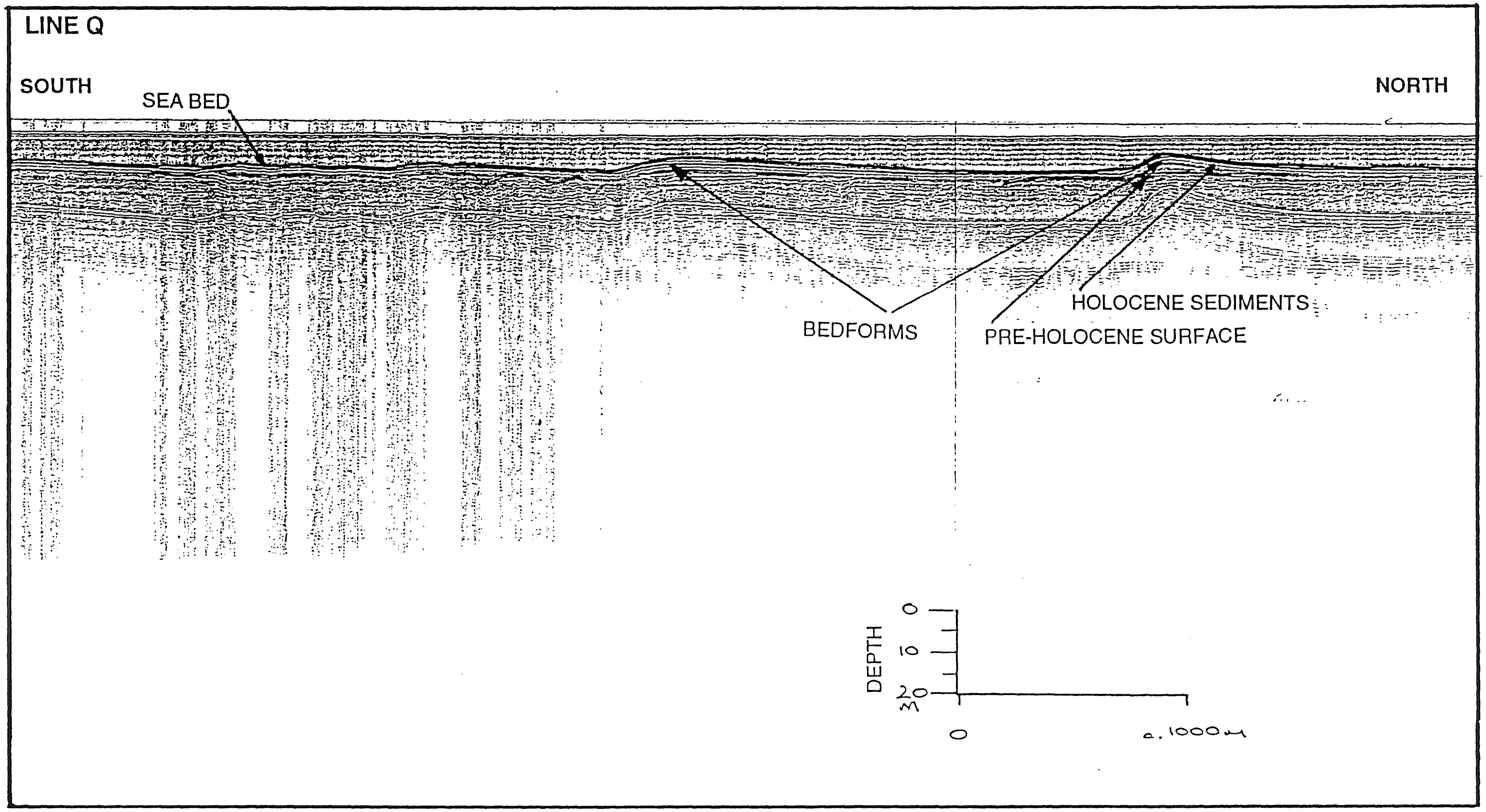


Figure 4.9 Seismic section showing asymmetric bedforms on lower shoreface/inner shelf south of Port Musgrave (Line Q, Figure 4.1). Bedforms appear to be oriented to the "south".

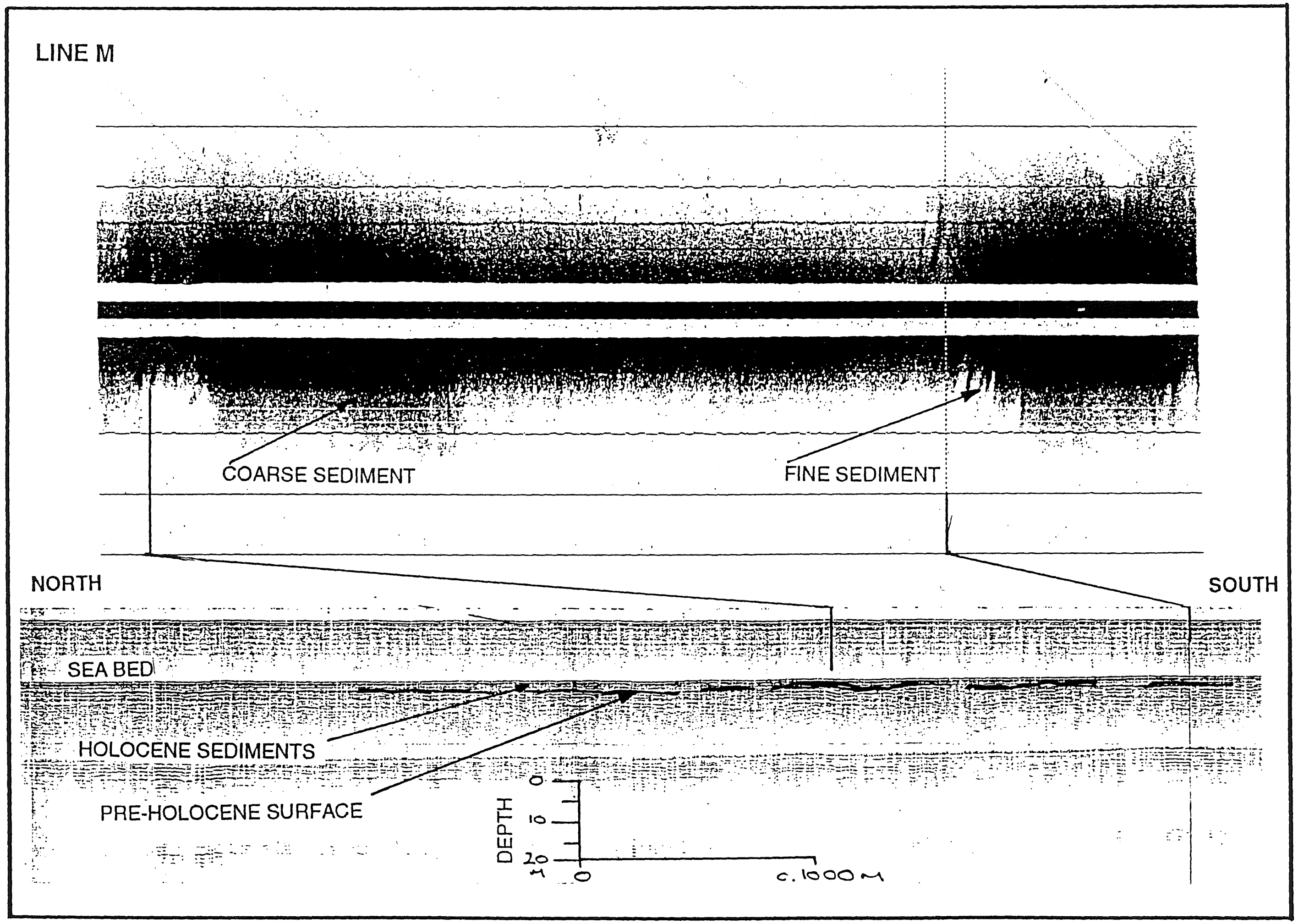


Figure 4.10 Side scan sonar image (upper panel) and seismic section (lower panel) of inner shelf south of Port Musgrave (Line M, Figure 4.1). Side scan image indicates zones of coarse and fine sediment on sea bed, seismic section indicates thin Holocene sequence above pre-Holocene surface over same area.

4.1.3 Vibrocores

Confirmation of the shallow sea bed stratigraphy interpreted from the seismic data required the collection of core (vibrocore) samples. The cores enable calibration of the seismic interpretation and the means by which material necessary for establishing the depositional history of sea bed sediments can be obtained.

A total of 16 cores from 18 sites was recovered from the sea bed between Duyfken Point and Crab Island (Fig. 4.1). Cores were collected on two shore normal transects south of Port Musgrave (VC#1, 2, 3, 4, 5, 6, 7, 8, 9, 10), at the entrance to Port Musgrave (VC#13), and between Crab Island and Vrilya Point (VC#14, 15, 16, 17, 18) (Fig. 4.1). Core recoveries varied from 0.3m to 2.6m and averaged 1.4m. Summary core logs and sample analyses (texture and carbonate) are contained in the Appendix. Summary stratigraphic sections are shown in Figures 4.11 and 4.12.

Cores of the sea bed between Duyfken Point and Port Musgrave encountered a thin (<2m thick) Holocene sequence composed of modern shoreface, inner shelf, and estuarine deposits unconformably overlying a stiff oxidised clayey sand (Fig. 4.11; North and South sections). The shoreface sediments consist of grey-green, fine grained muddy sands with common shelly gravel lags. The gravel is comprised of large molluscan fragments, whole shells and lateritic pebbles. The gravel lags are thickest and best developed immediately above a stiff clayey sand unit which is interpreted as the pre-Holocene land surface (Fig. 4.11; Cores VC#1, VC#2, VC#3, VC#8). The inner shelf facies is a surficial unit characterised by grey-green fine to medium grained shelly muddy sand and sandy mud. This facies displays a high degree of bioturbation (burrows) and commonly contains rounded mud clasts (Fig 4.11; Cores VC#4, VC#5, VC#6, VC#7, VC#10). Unlike the contact between the shoreface facies and the pre-Holocene surface, the basal contact between the inner shelf facies and pre-Holocene alluvial facies is not always marked by a gravel lag (Figs. 4.11; Cores VC#4, VC#5, VC#6, VC#7).

An estuarine facies was encountered beneath shoreface (VC#2) and innershelf (VC#5) deposits on the southernmost core transect (Fig. 4.11). In both cores the estuarine facies is characterised by dark grey to black laminated organic rich muds interbedded with fine to medium grained shelly sands. Maximum thickness of the unit is around 1.3m and it overlies either pre-Holocene alluvium (VC#5) or a moderately well sorted fine grained quartzose sand unit containing no shell (VC#2). The shell-free, well sorted sand facies at the base of VC#2 is interpreted as a relict dune deposit (Fig. 4.11).

The oldest unit encountered in the cores is a stiff, oxidised, mottled yellow to bright orange, ferruginous, alluvial sandy clay to clayey sand. The unit contains no shell and its upper contact with the overlying marine and estuarine units is commonly marked by organic remains (plant roots?). A similar unit was encountered over a large area of the inner shelf off Weipa (Zwigulis, 1971). The alluvial facies appears to form a regional unconformity beneath the sea bed in the eastern Gulf and presumably corresponds to the pre-Holocene surface noted in the seismic records (Section 4.1.2). Vibrocores of the shoreface and inner shelf south of Port Musgrave have confirmed the seismic interpretation that a relatively thin Holocene sequence overlies a pre-Holocene land surface which either shallowly underlies or crops out on the present day sea bed.

Cores in the northernmost part of the area were collected from the shoreface and inner shelf between Vrilya Point and Crab Island (Fig. 4.1). Summary stratigraphic sections are shown in Figure 4.12. A similar suite of marine and estuarine facies to that encountered in the southern part of the area was intersected by the cores between Vrilya Point and Crab Island. Shoreface and inner shelf facies comprised of shelly sands and muddy shelly sands overlie organic-rich estuarine muds and well sorted quartzose dune sands (Fig 4.12; VC#14, VC#15, VC#17, VC#18). Alluvial clayey sands occur at depth inshore (Fig. 4.12; VC#16).

Apart from the broad similarities in facies types and stratigraphic relationships, there are several important differences between the southern and northern parts of the shelf between Duyfken Point and Crab Island. Shoreface and inner shelf facies north of Vrilya Point have relatively low proportions of carbonate when compared with similar deposits further south, a point noted previously from the surficial sediment data. In addition, (interpreted) dune sands were encountered at depth in four of the five cores from the shoreface and inner shelf between Vrilya Point and Crab Island (Fig 4.12; VC#14, VC#15, VC#17, VC#18), suggesting the presence of a relict aeolian sand sheet over a large section of the shelf in the vicinity of Crab Island. Harris (1994) drew a similar conclusion on the probable occurrence of an extensive aeolian sand sheet in the southwestern portion of Torres Strait based on the quartzose nature of sediments in the tidal sand banks.

The coincidence of relatively low proportions of carbonate in shoreface and inner shelf facies north of Vrilya Point and the widespread occurrence of a relict quartzose dune sand unit on the shelf surrounding Crab Island suggests that this section of shelf has received a significant volume of terrigenous sediment throughout the Holocene, presumably from the Jardine River catchment immediately to the east. It is likely that aeolian reworking of the deltaic sediments at glacial low sea levels and during the postglacial marine transgression has been responsible for the formation of the well sorted, shell-free, quartzose sand unit which underlies much of the present day shelf. A similar model has been proposed for the deposition of Holocene coastal dune sequences elsewhere in the Gulf of Carpentaria (Lees et al., 1993; 1995).

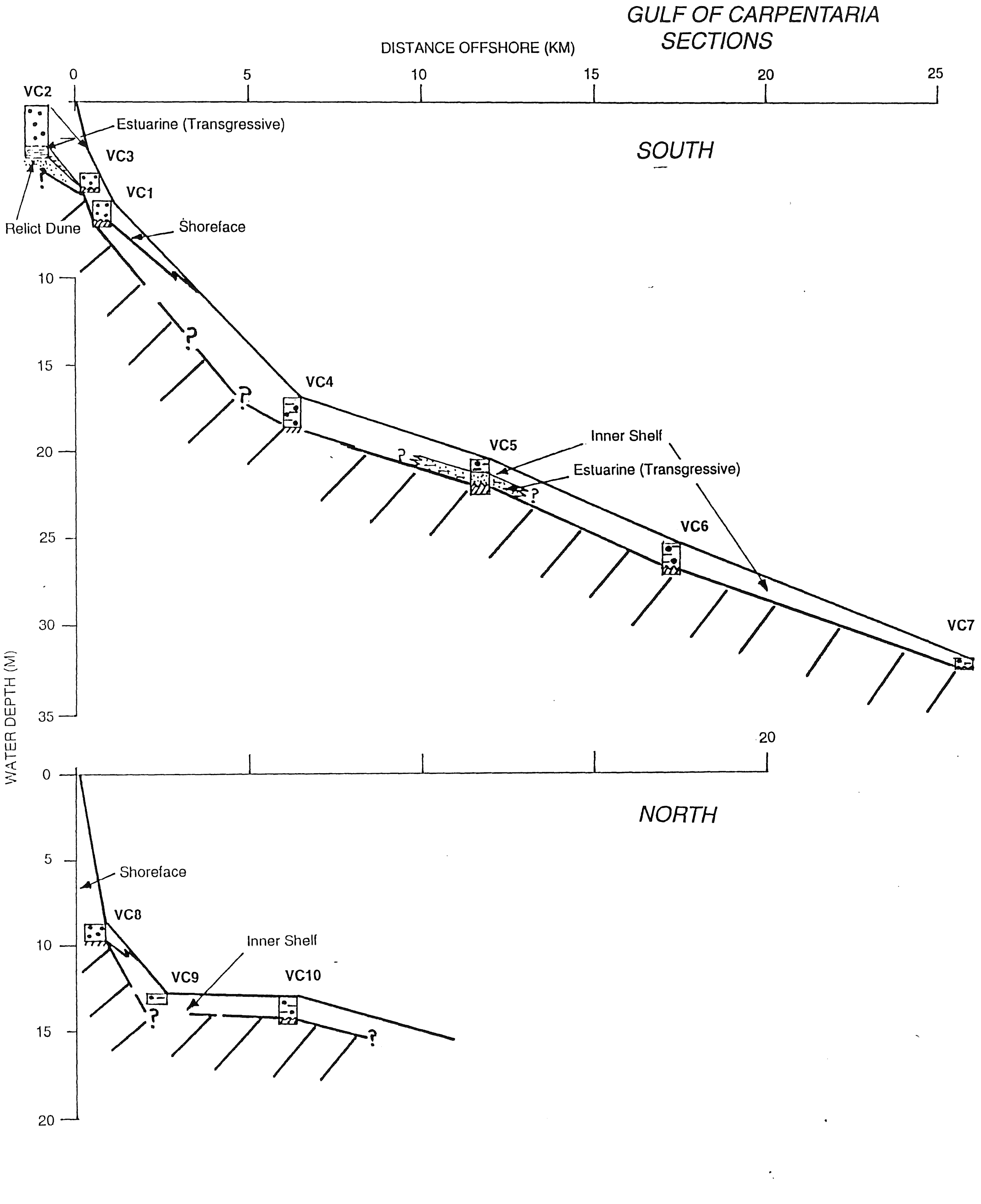


Figure 4.11 Stratigraphic sections for the Gulf of Carpentaria shelf south of Port Musgrave (Lines K and L, Figure 4.1). Note the generally thin Holocene sequence which overlies transgressive estuarine and dune deposits or the pre-Holocene surface (weathered alluvium?). Graphic core logs for each core are shown on the following pages.

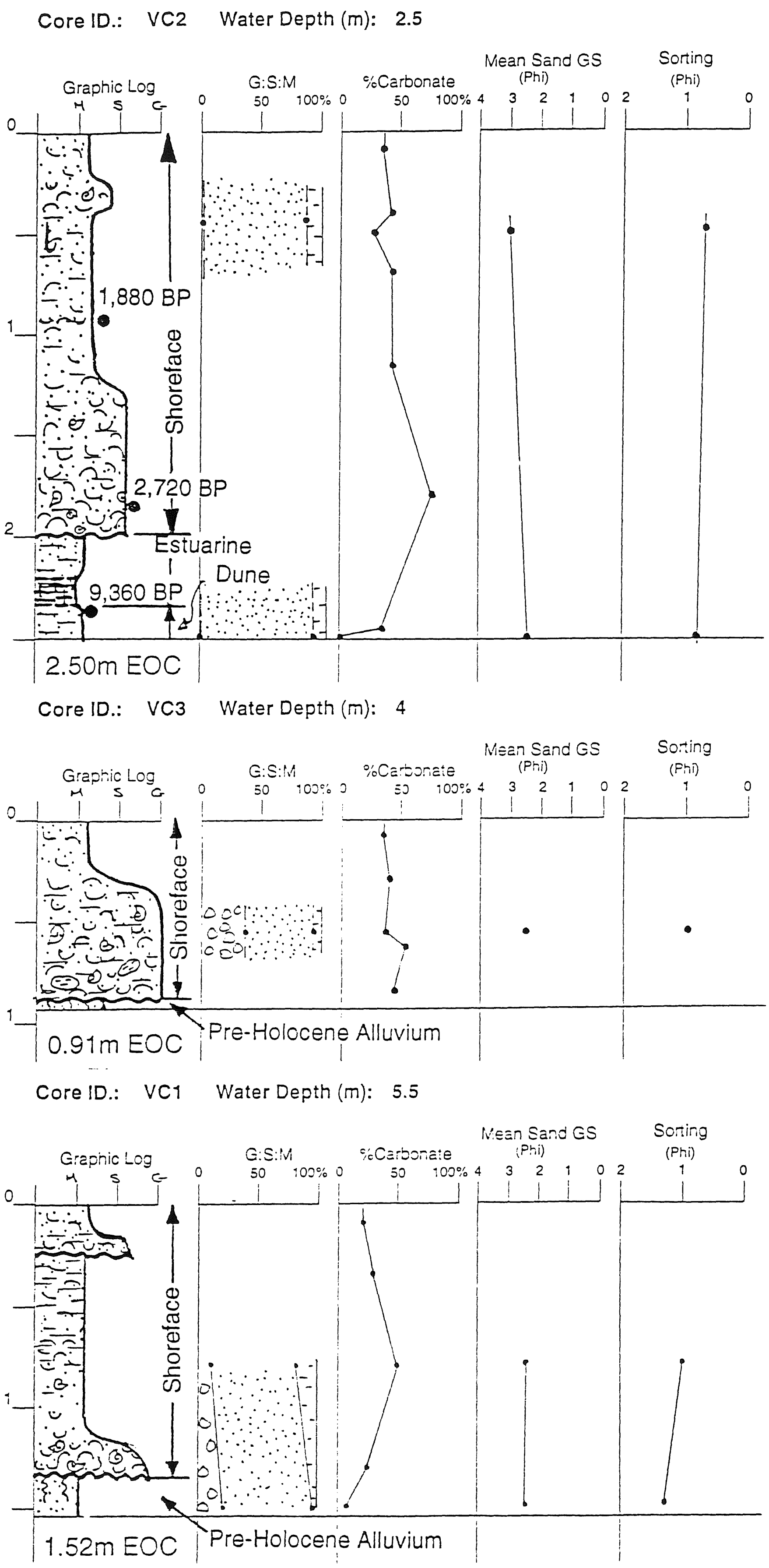
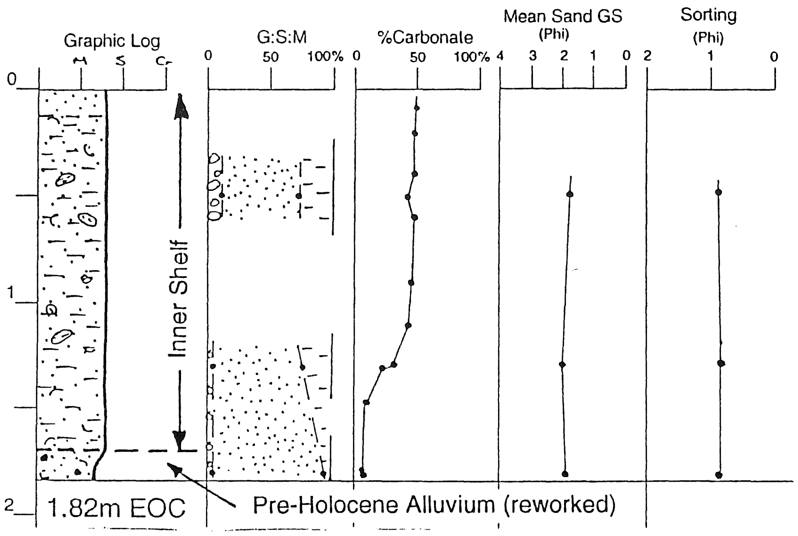
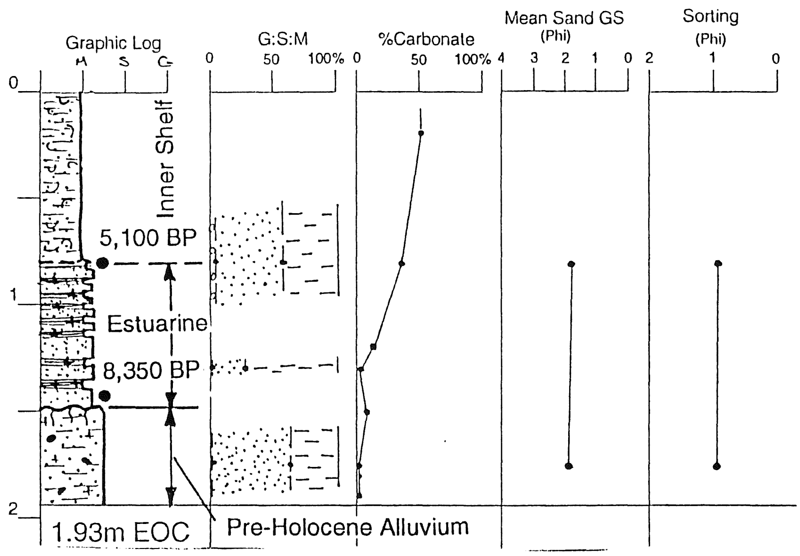


Figure 4.11(contd.) Graphic core logs for cores.

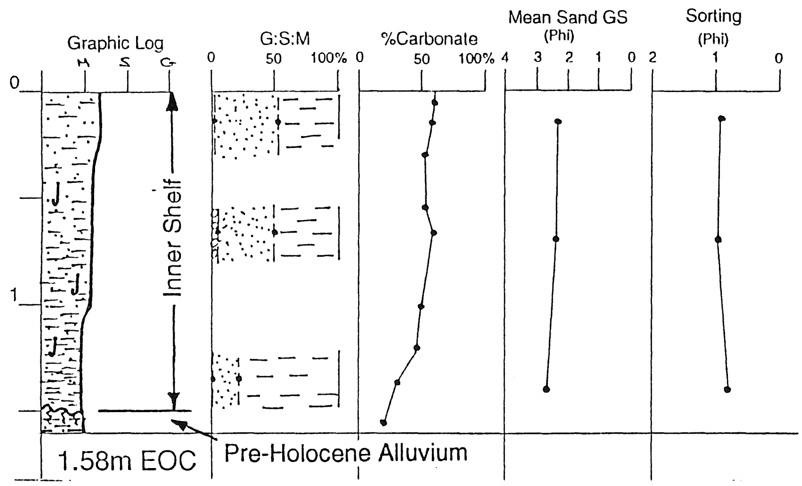
Core ID.: VC4 Water Depth (m): 17



Core ID.: VC5 Water Depth (m): 20.5



Core ID.: VC6 Water Depth (m): 25.5



Core ID.: VC7 Water Depth (m): 32.5

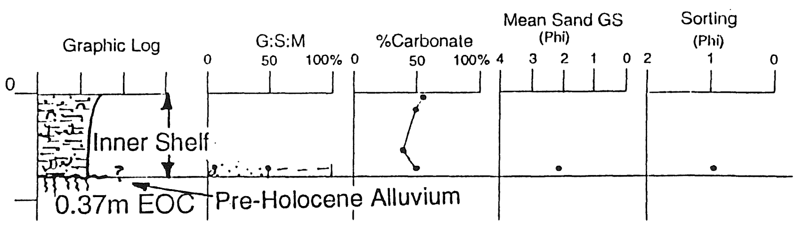


Figure 4.11(contd.) Graphic core logs for cores.

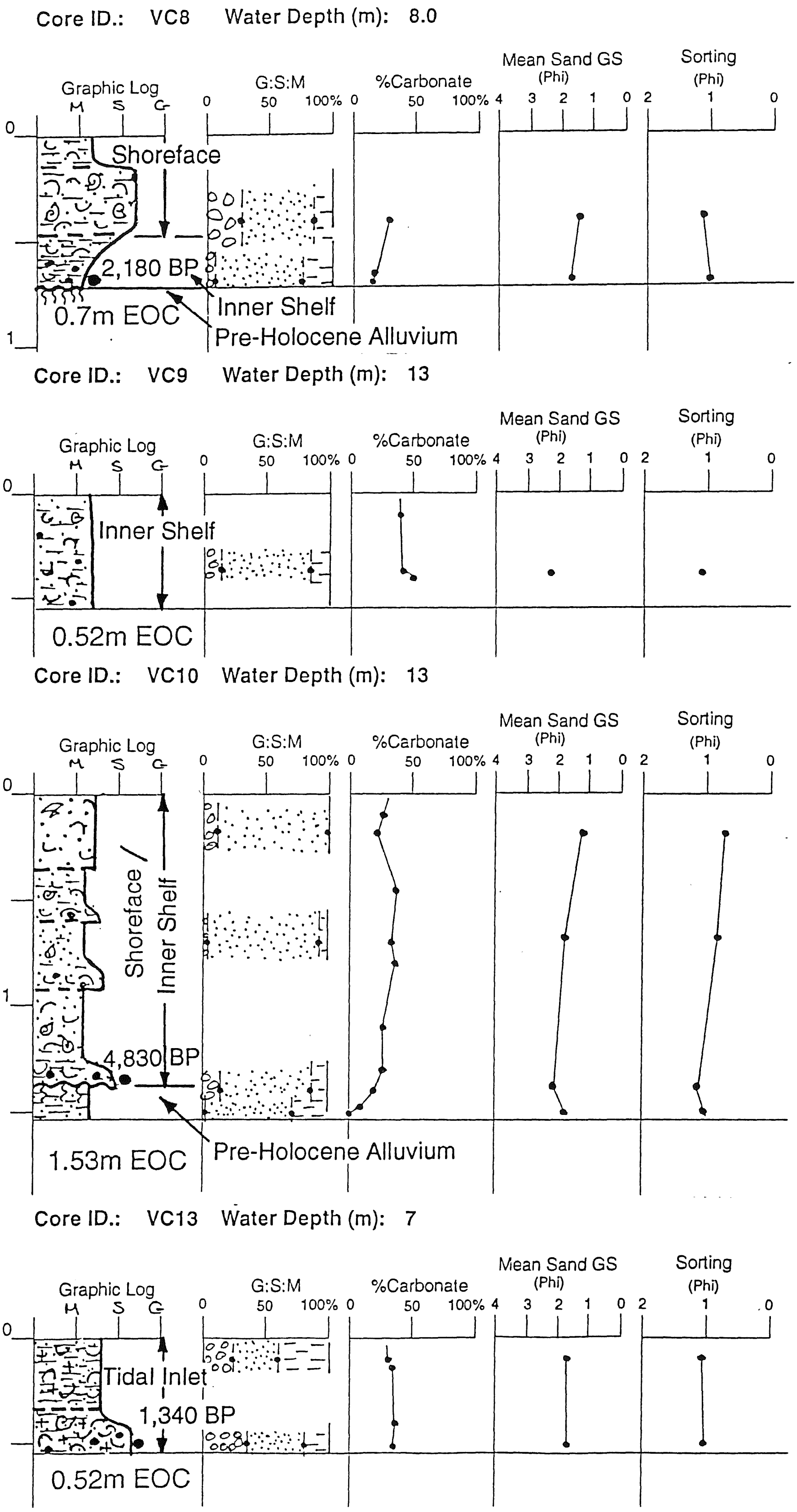


Figure 4.11(contd.) Graphic core logs for cores.

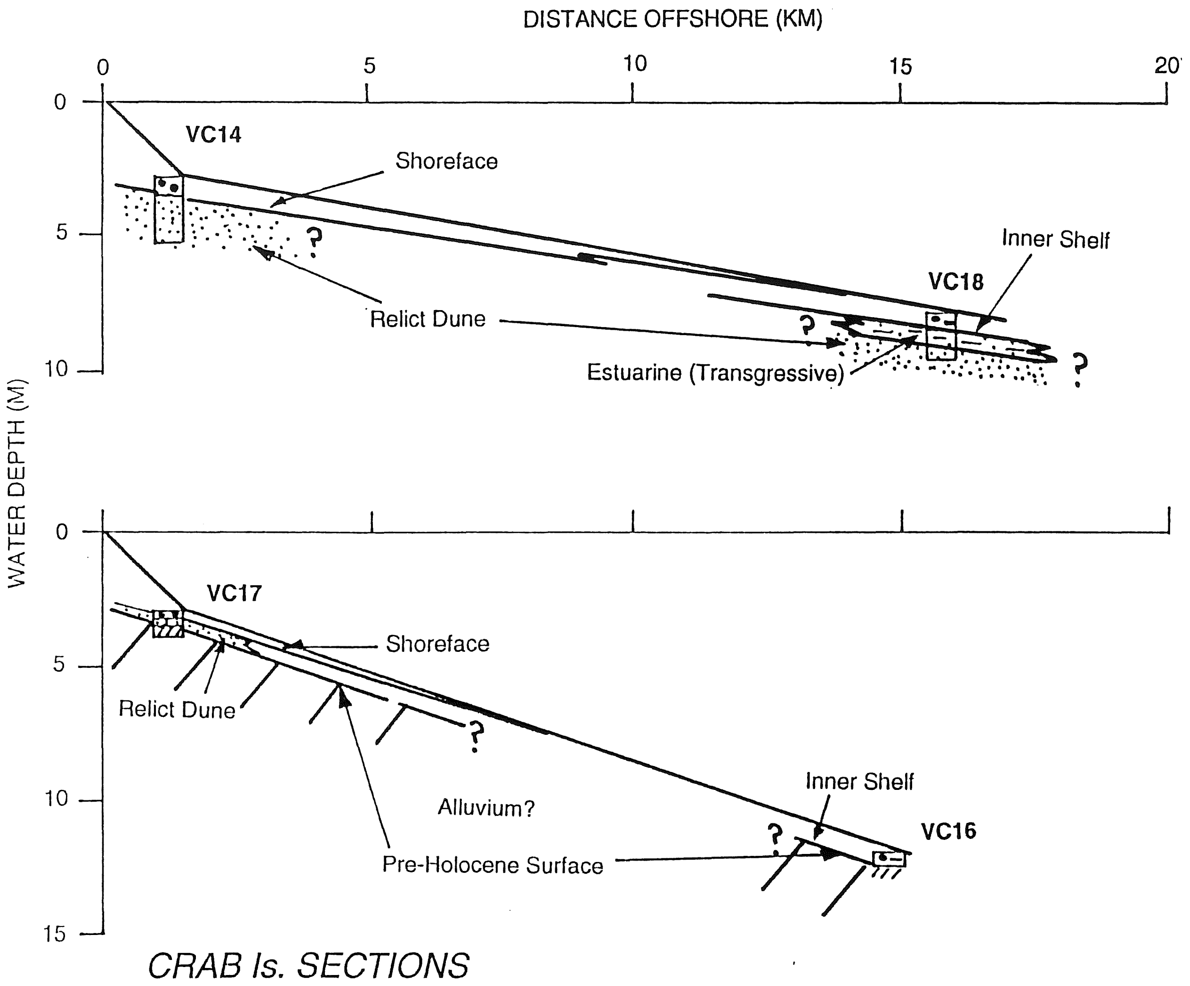


Figure 4.12 Stratigraphic sections for the Gulf of Carpentaria shelf south of Crab Islands (see Figure 4.1). Note the generally thin Holocene sequence which overlies transgressive estuarine and dune deposits or the pre-Holocene surface (weathered alluvium?). The dune sequence appears thicker and more extensive on the line closest to Crab Island (upper section). Graphic core logs for each core are shown on the following pages.

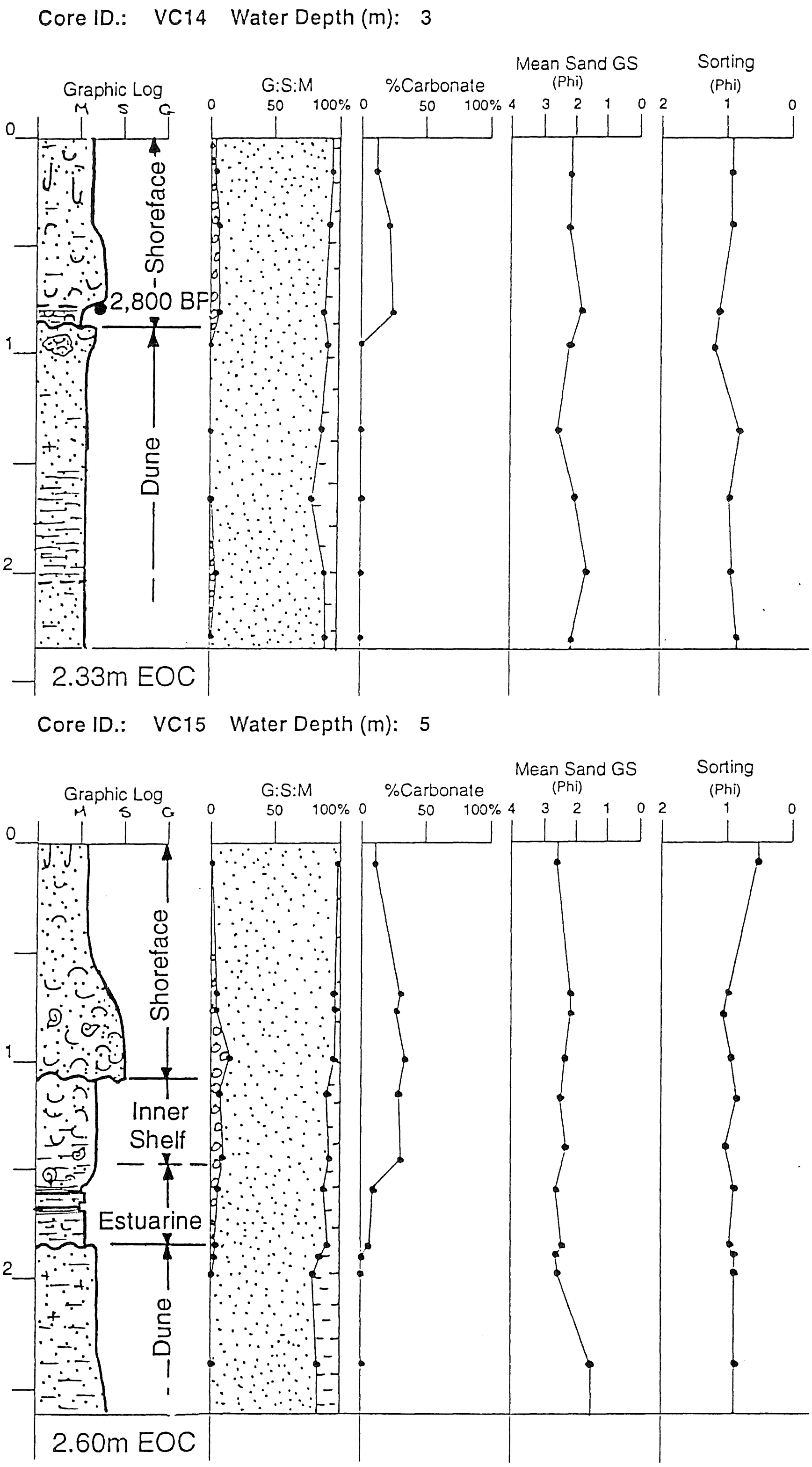


Figure 4.12 (contd.) Graphic core logs.

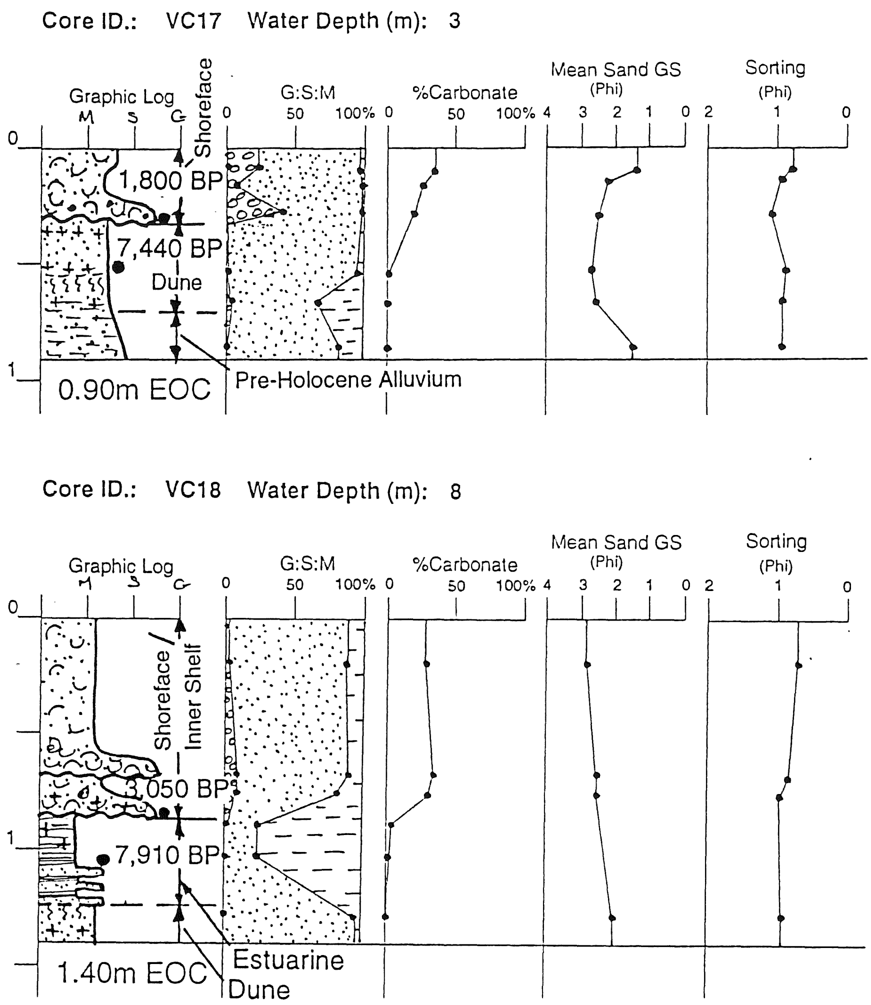


Figure 4.12 (contd.) Graphic core logs.

4.1.4 Radiocarbon Dating

A list of the samples submitted for radiocarbon dating is contained in Table 4.1 and their stratigraphic position is indicated in the graphic core logs (Figs. 4.11 and 4.12). Samples of whole shell and shell hash from contemporary shoreface and inner shelf environments returned radiocarbon ages of less than 5,280 years Before Present (4,830 years B.P. environmentally corrected). Samples of organic fragments from relict estuarine and dune deposits gave radiocarbon ages of between 7,440 and 7,910 years B.P. The youngest date (1,790 years B.P., corrected to 1,340 years B.P.) came from tidal inlet deposits at the entrance to Port Musgrave.

The dates indicate that the mid to late Holocene shoreface and inner shelf facies overlay either early Holocene transgressive dune and estuarine facies or a (interpreted) pre-Holocene subaerial erosion surface of uncertain age. This interpretation is consistent with the ages of shoreface and inner shelf deposits reported in Michaelsen (1994) and the proposed episodes of early Holocene aeolian activity in the Gulf identified by Lees et al. (1993 and 1995).

TABLE 4.1 Radiocarbon Dates - Duyfken Point to Crab Island

CORE ID	LAB. NO.	WATER DEPTH (M)	SAMPLE INTERVAL(M)	MATERIAL	FACIES	REPORTED C14 AGE	ENVIRON. CORRECTED AGE (yrsBP)*
VC 8	Wk 3876	8	0.65 - 0.68	Shell Hash	Inner Shelf	2,630 +/- 270	2,180 +/- 272
VC 10	Wk 3877	13	1.36 - 1.40	Shell Hash	Inner Shelf	5,280 +/- 340	4,830 +/- 342
VC 13	Wk 3878	7	0.45 - 0.50	Whole Shell/ Shell Hash	Tidal Inlet	1,790 +/- 130	1,340 +/- 135
VC 14	Wk 3879	3	0.78 - 0.80	Whole Shell/ Shell Hash	Shoreface	3,250 +/- 200	2,800 +/- 203
VC 17	Wk 3880	3	0.25 - 0.29	Whole Shell/ Shell Hash	Shoreface	2,250 +/- 80	1,800 +/- 87
VC17	Wk 3881	3	0.52 - 0.53	Organics (Wood)	Relict Dune	7,440 +/- 590	7,440 +/- 590
VC 18	Wk 3882	8	0.76 - 0.80	Whole Shell/ Shell Hash	Inner Shelf	3,500 +/- 260	3,050 +/- 262
VC 18	Wk 3883	8	1.02 - 1.06	Organics (Wood)	Estuarine	7,910 +/- 210	7,910 +/- 210

Environmental correction 450 +/- 35 years (Gillespie and Polach, 1976)

4.2 Crab Island to Cape York

4.2.1 Bathymetry and Surficial Sea Bed Sediments

The northern limit of the CYPLUS area between Crab Island and Cape York takes in the tidally influenced shelves of Endeavour Strait and the southern Torres Strait (Fig. 4.13). Strong tidal flows between the Australian mainland and offshore islands in this area are responsible for the reworking of sea bed sediments and formation of extensive submarine tidal deltas (eg. Inskip Banks at the western entrance to Endeavour Strait). The coast to the west of the Jardine River entrance is characterised by prograded barrier deposits and extensive sand shoals and islands (eg. Crab Island). East of the river entrance the coast is characterised by common bedrock outcrops and small embayments infilled with relatively small barrier systems. This longshore variation in late Quaternary sediment volumes identifies the Jardine River as the principal source of terrigenous sediment to the shelf and coast as well as indicating that the net movement of sediment is to the west in response to the prevailing tidal regime.

Regional sea floor slopes increase from west to east with slopes of around 0.04° in the vicinity of Crab Island increasing to 0.18° at Cape York. Sea floor sediments range from sands and gravelly sands close to the coast to shelly muddy sands and sandy gravels further offshore. Alongshore trends indicate that inshore sediments east of the Jardine River entrance tend to be coarser (gravelly) and contain slightly higher proportions of carbonate than sediments west of the river entrance; a pattern consistent with the delivery of higher volumes of terrigenous sediment to the shoreface west of the river entrance.

A summary of the regional trends in sediment texture and composition is presented in Figures 4.14 and 4.15. The ternary plot of Gravel:Sand:Mud proportions demonstrates that many of the surficial sea bed sediments are coarse grained and fall into the sand and gravelly sand fields, very few samples contain significant proportions of mud. The proportion of gravel in sea bed sediments increases with water depth while proportions of mud appear to show the inverse relationship (Fig. 4.14). Carbonate shows a comparable trend to gravel, suggesting that much of the gravel sized material in deeper water is likely to be shell. Visual inspection of the grab samples confirms this observation. The samples contain a variety of coarse grained carbonate material including molluscs, gastropods, coral, and algal (*Halimeda*) fragments. A minor component of bauxitic gravel (pisoliths) also occurs in many of the samples.

The increase in carbonate content with water depth suggest a separation of the shoreface and inner shelf environments wherein the tidal regime effectively prevents delivery of significant quantities of terrigenous sediment to the inner shelf. A similar conclusion can be drawn from the sand grainsize distributions (Figure 4.15). The sands inshore of the 10m isobath display a broad range of textures and sorting (well to moderately sorted, coarse to fine grained) consistent with the delivery of poorly sorted terrigenous sediments to the nearshore. Seaward of the here, the sands display similar sorting but are coarser and with a limited spread of grainsize distributions - medium to coarse sand mode (1.0 Phi) (Fig. 4.15). It must be emphasised that the limited coverage of grab samples in the area underlines the speculative nature of these observations. Further sampling is required.

4.2.2 Seismic and Side Scan Sonar Data

The distribution of seismic and side scan sonar tracklines is indicated in Figure 4.13 and selected examples are shown in Figures 4.16 to 4.19. The character of the shelf between Crab Island and Cape York is dominated by the presence of tidal bedforms, particularly in those areas where there is an abundant supply of sediment (eg. inshore of the 10m isobath west of Jardine River entrance). In areas of reduced sediment supply and strong tidal currents, bedforms are less common and the sea floor is shallowly underlain by a prominent seismic reflector presumed to represent the pre-Holocene land surface.

Tidal bedforms are a common feature of the sea bed to the northwest (Fig. 4.16), north (Fig. 4.17) and northeast (Fig. 4.18) of Crab Island. The bedforms are asymmetric (steep west facing slopes), between 2m to 4m high and best developed in relatively shallow water (5m to 10m) adjacent to the coast. Sidescan sonar images of the shoreface west of the Jardine River entrance indicate a highly mobile sea bed with clearly defined megaripples on the east-facing slopes of large, regularly spaced bedforms (Fig. 4.18). A flat-lying seismic reflector occurs at 2m to 5m below the sea bed throughout the area. East of the Jardine River entrance, tidal bedforms are less common, the Holocene sequence is generally less than 2m thick, and basement outcrops are widespread. The resolution of the seismic data is insufficient to determine the relationship of the pre-Holocene surface to the sea bed east of the Jardine River entrance. Despite this, it is likely that the pre-Holocene surface occurs either at or immediately below the sea bed on the inner shelf in this area. It is not until the eastern limit of the area near Cape York that there is a clear thickening of the Holocene sequence to around 8m above the pre-Holocene surface (Fig. 4.19).

The seismic and sidescan data indicate a clear increase in the volumes of shoreface and inner shelf sediment west of the Jardine River entrance. To the east of here, shoreface and inner shelf sediments form a veneer over the pre-Holocene land surface. A review of the surficial sea bed sediment data is consistent with these observation and supports the view that tidal currents have been effective in redistributing fluvial sediments west from the Jardine River for much of the Holocene. The formation of Crab Island, a sand island at the western entrance of Endeavour Strait, appears to be linked to the westward dispersal of terrigenous sediments during the mid to late Holocene.

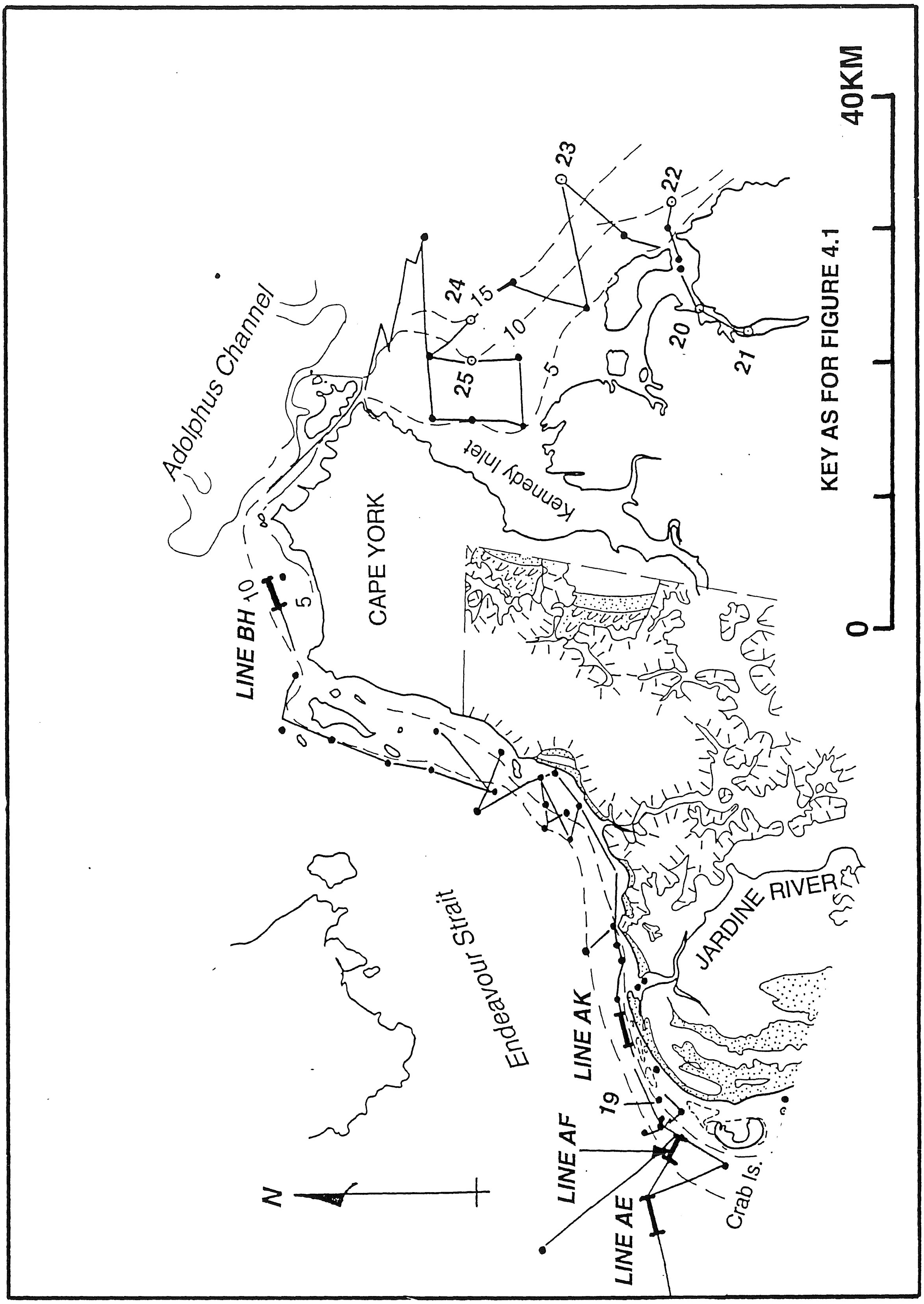


Figure 4.13 Endeavour Strait - Crab Island to Cape York. Figure shows generalised bathymetry, survey tracklines, grab and vibrocore locations. Highlighted sections of tracklines discussed in text. Onshore geology from AGSO coastal mapping program.

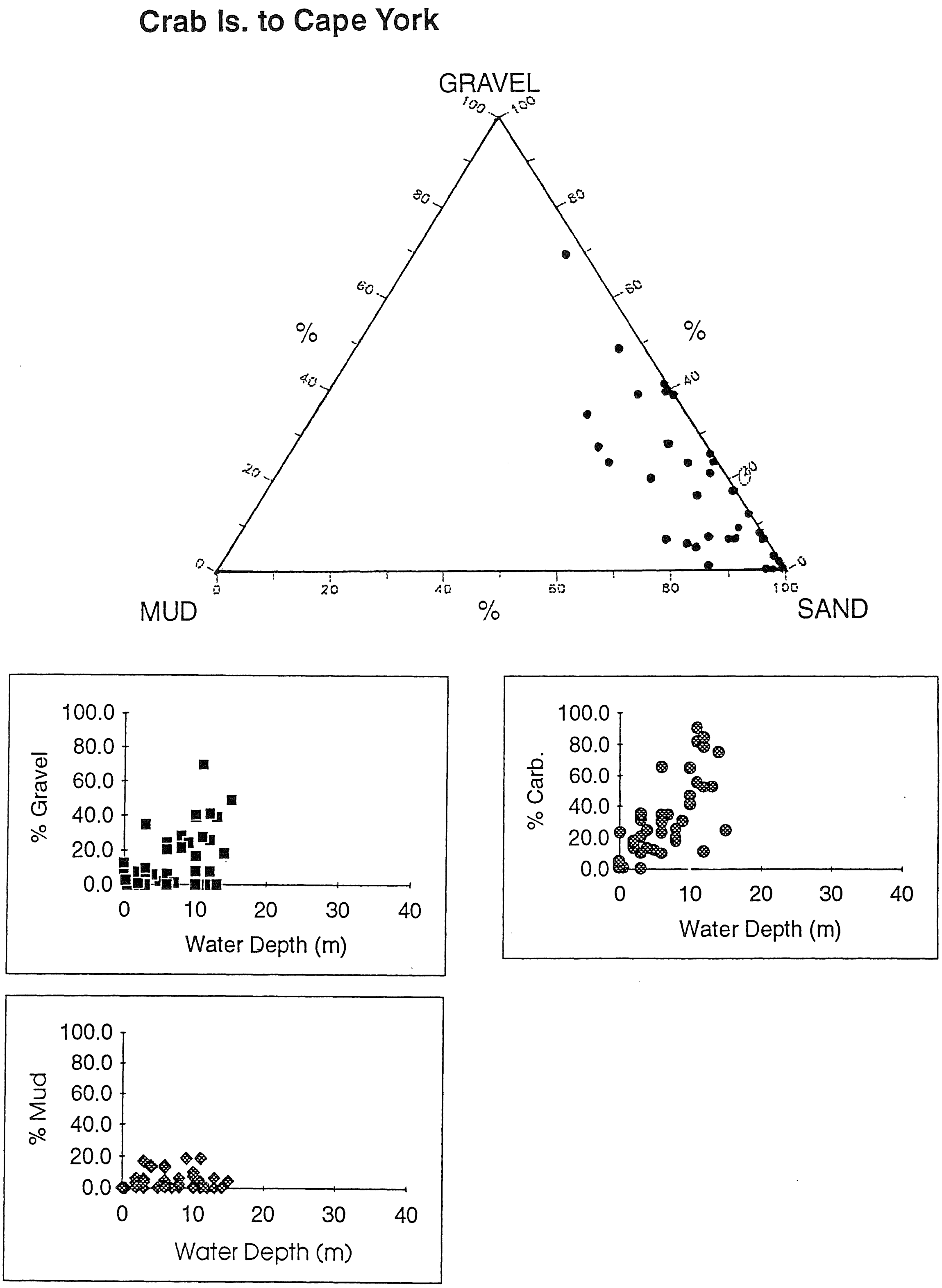


Figure 4.14 Textural characteristics of surficial sea bed sediments - Crab Island to Cape York.

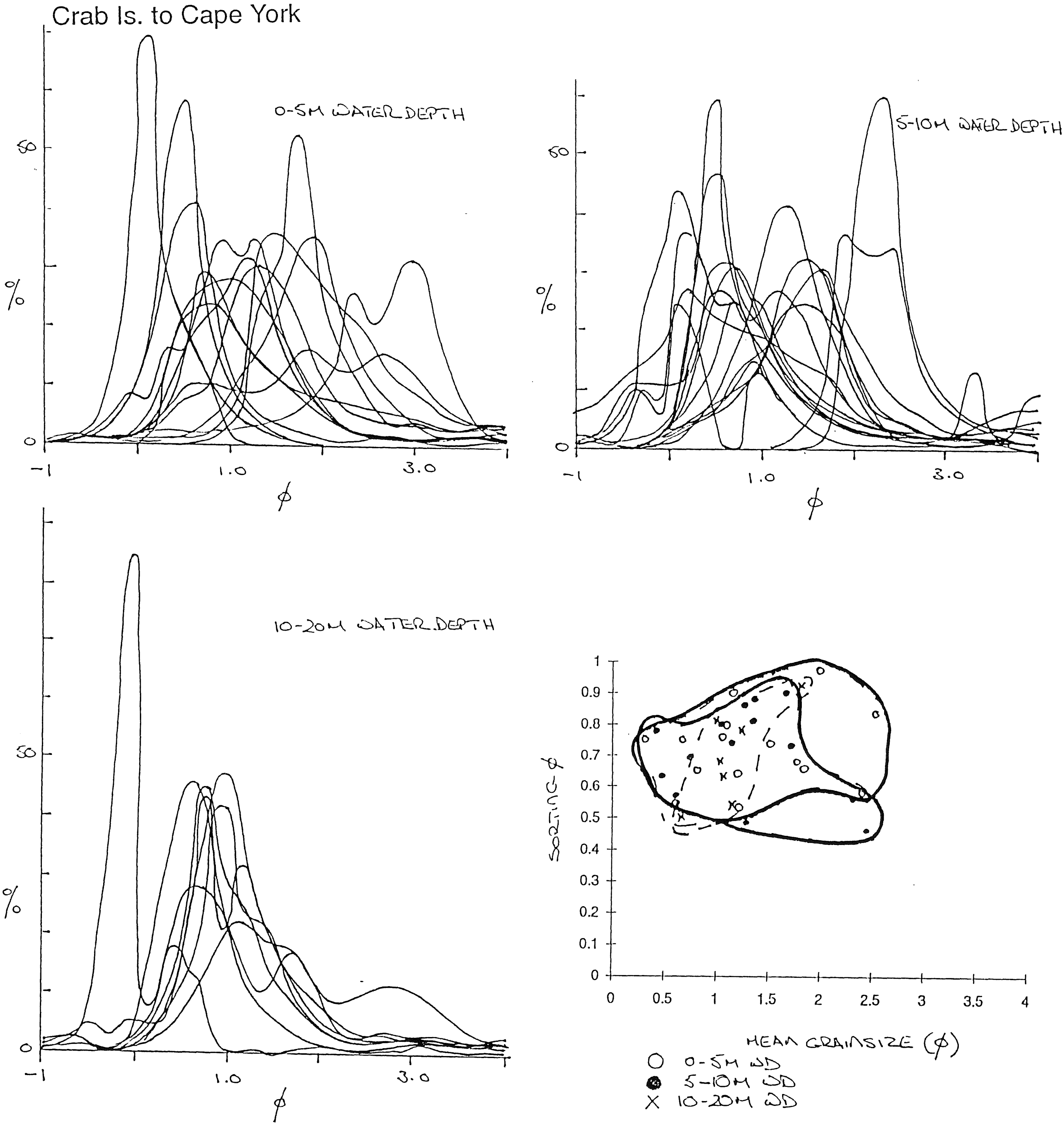


Figure 4.15 Sand grainsize distributions and sorting for surficial sea bed sediments Crab Island to Cape York.

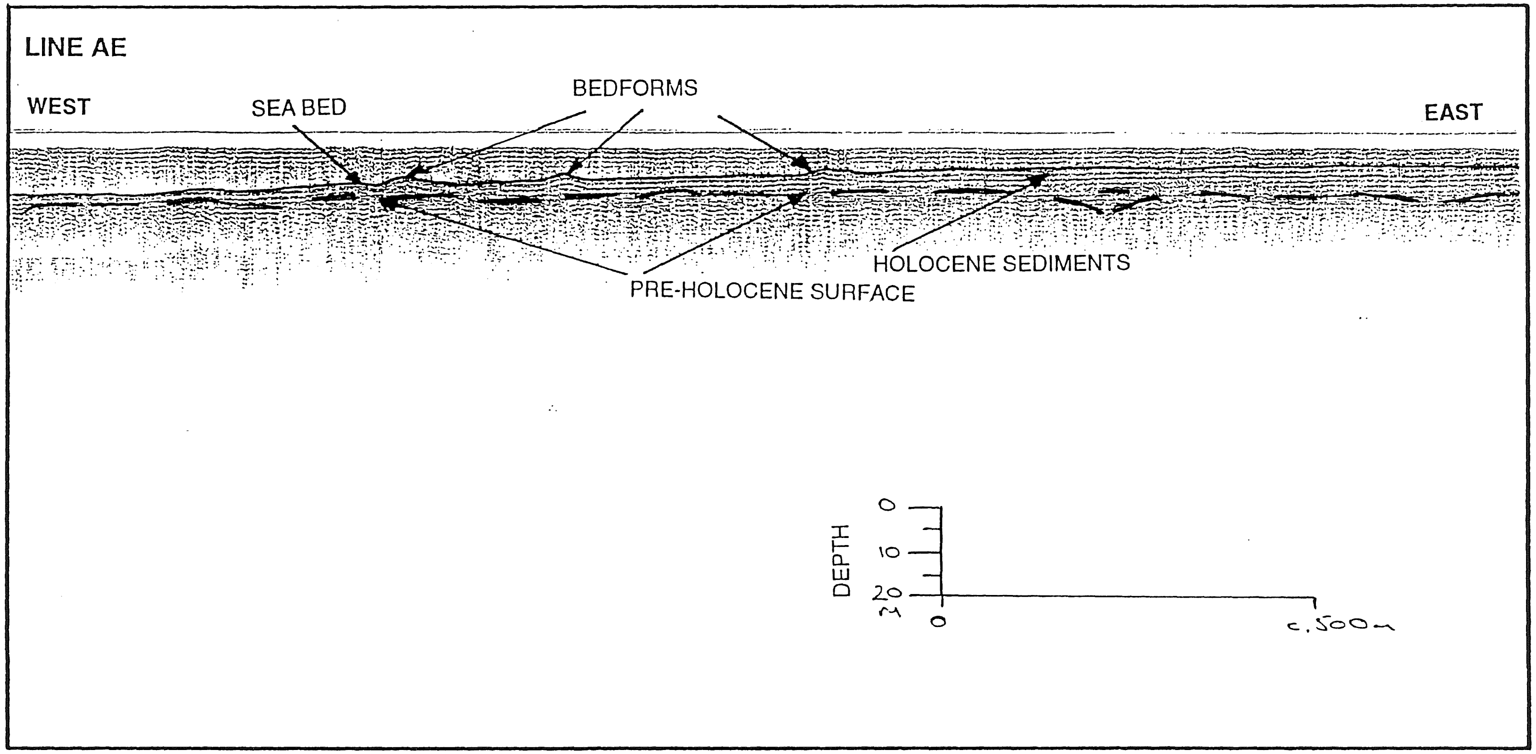


Figure 4.16 Seismic section of inner shelf to the west of Crab Island (Line AE, Figure 4.13). Note subdued asymmetric bedforms (orientation to west) above gently sloping pre-Holocene(?) surface.

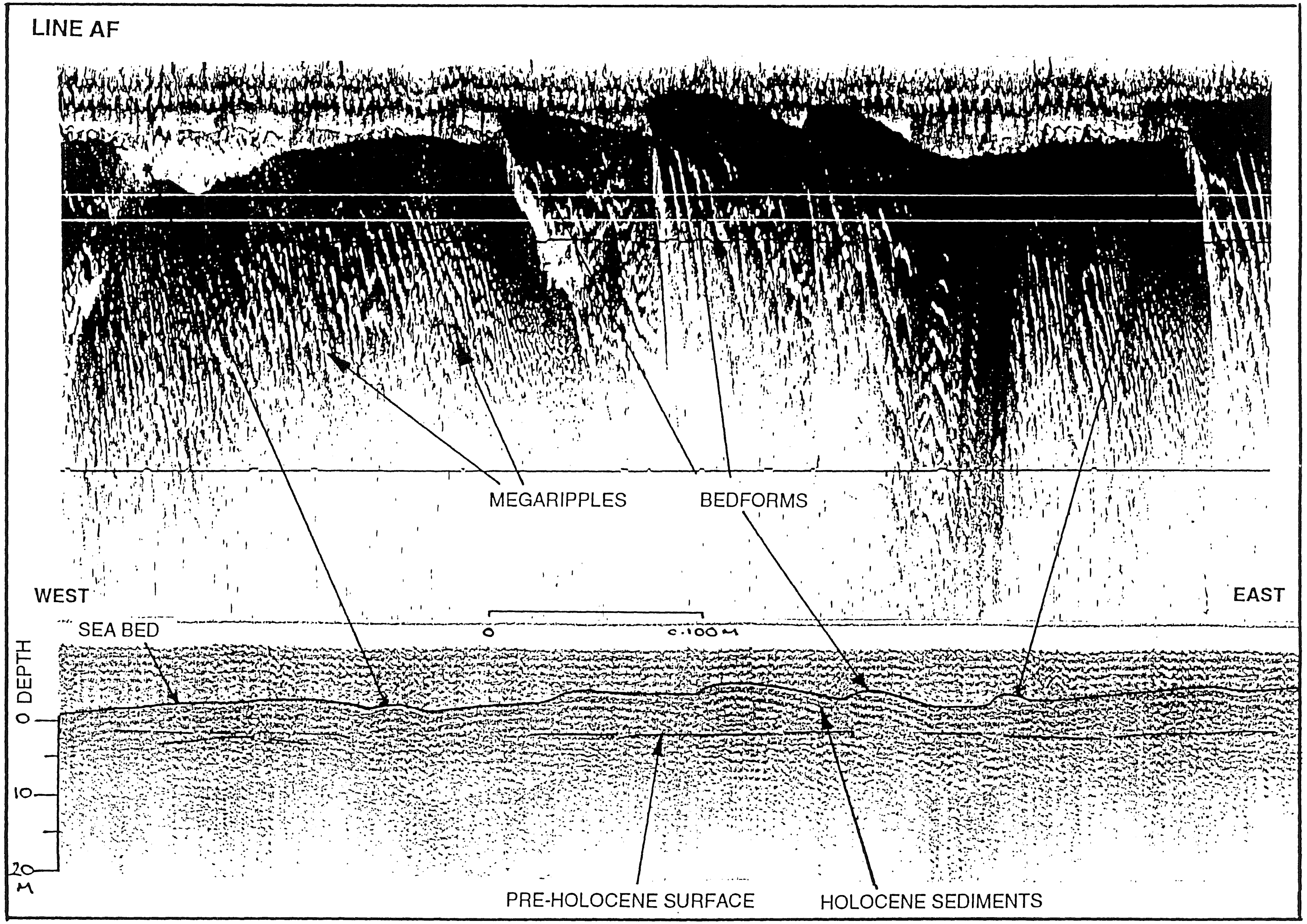


Figure 4.17 Side scan image (upper panel) and seismic section (lower panel) of sea bed immediately to the north of Crab Island (Line AF, Figure 4.13). Figure illustrates a highly mobile sea bed with asymmetric bedforms (oriented to west) mantled with meggaripples. Seismic section indicates irregularly spaced bedforms and a flat-lying reflector (pre-Holocene surface?) some 5m below the sea bed.

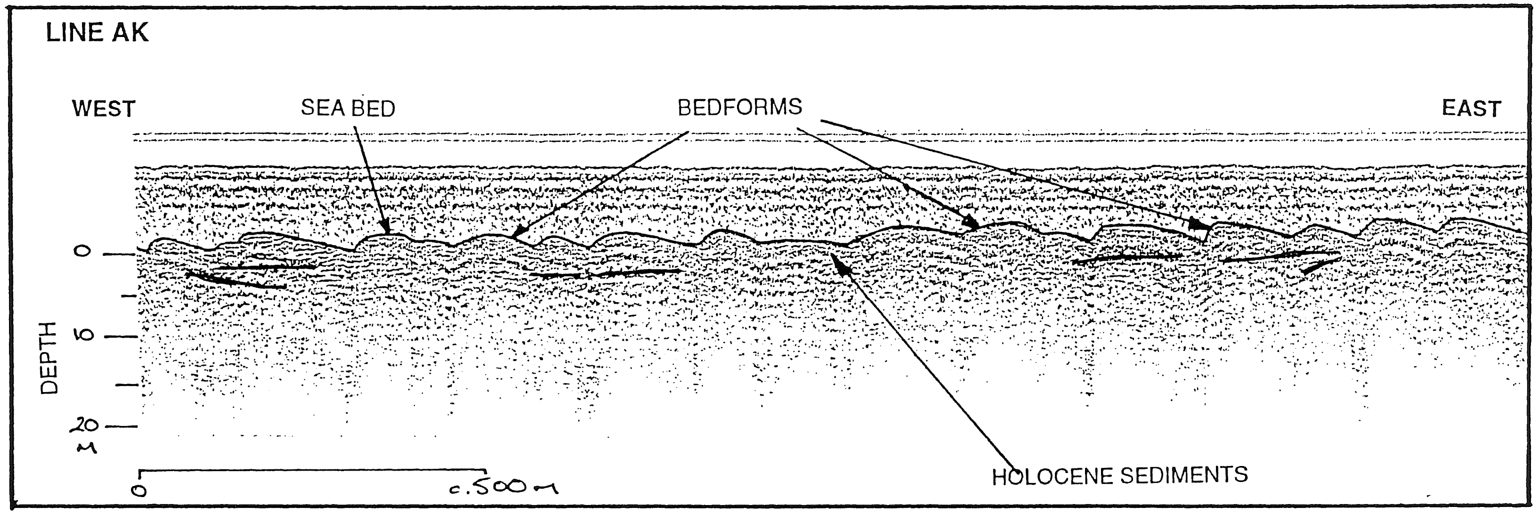


Figure 4.18 Seismic section of shoreface east of Crab Island (Line AK, Figure 4.13). Figure illustrates a highly mobile sea bed with regularly spaced asymmetric bedforms (oriented to west). Poorly defined flat-lying reflector (pre-Holocene surface?) occurs around 3m below the sea bed.

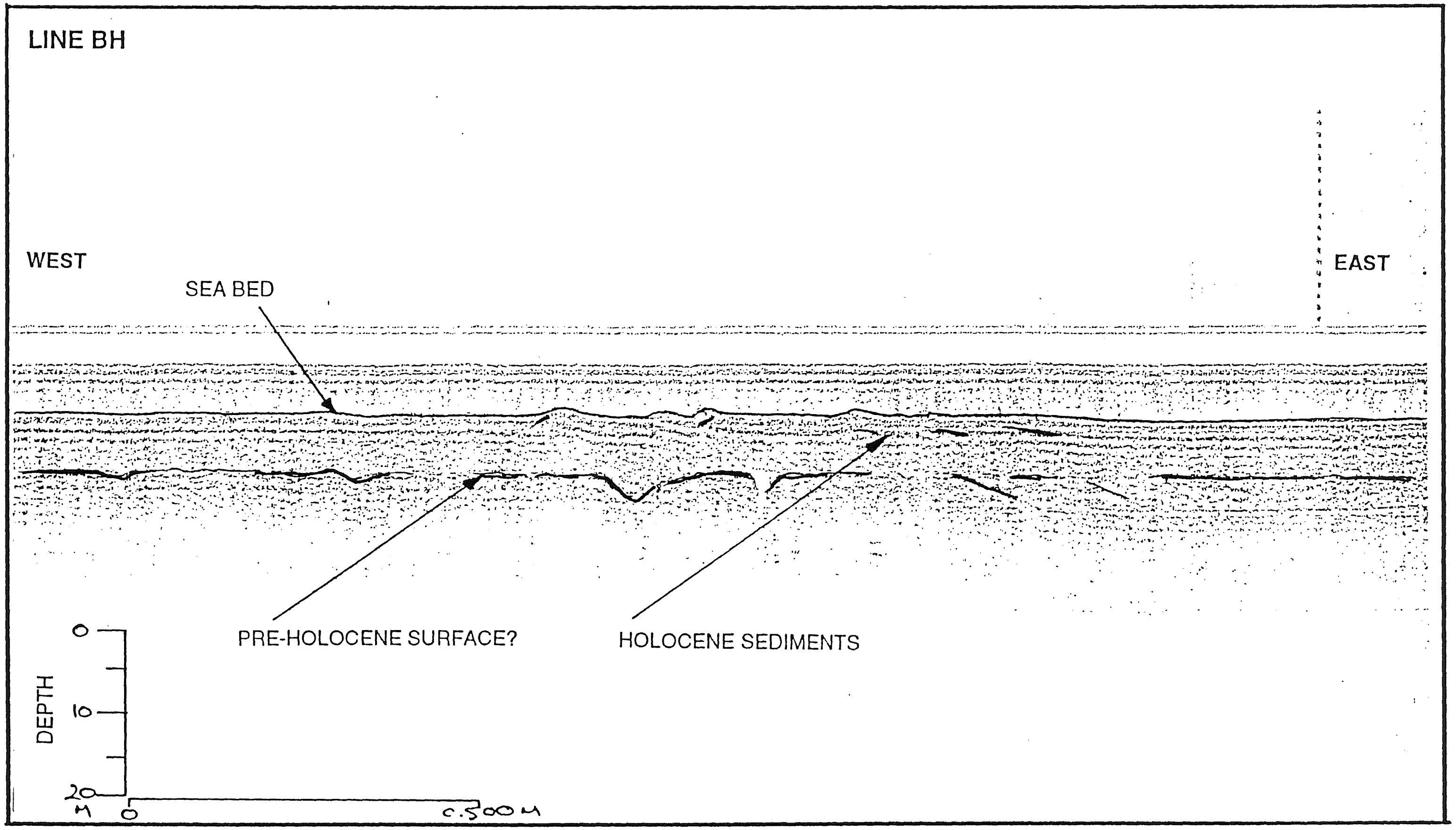


Figure 4.19 Seismic section of shoreface/inner shelf west of Cape York (Line BH, Figure 4.13). Figure illustrates isolated bedforms over a relatively thick Holocene sequence. Flat lying reflector some 7m below the sea bed is presumed to represent the pre-Holocene surface.

4.2.3 Vibrocores

A single vibrocore (VC#19) was collected in 4m water depth from the shoreface north of Crab Island (Fig. 4.20). The core recovered 1.7m of pale olive grey muddy shelly sand containing occasional shell gravel layers. The uniform nature of the subsurface sediments and minor shell gravel layers is consistent with a mobile shoreface environment. No material was selected for radiocarbon dating from this section of the CYPLUS area.

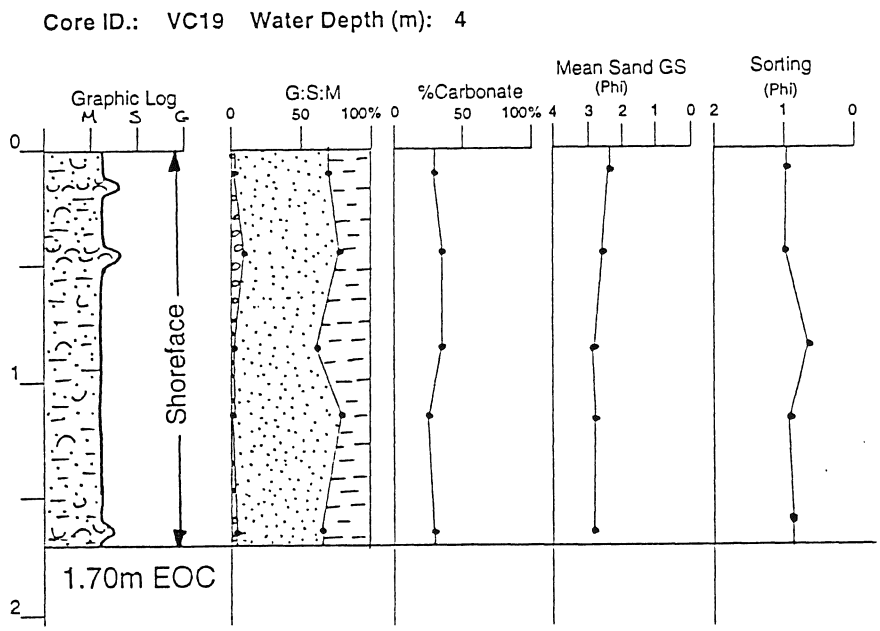


Figure 4.20 Graphic core log for solitary core collected from the shoreface east of Crab Island (see Figure 4.13)

4.3 Cape York to Cape Direction

Three discrete sections of this 260km length of coast were surveyed: Newcastle Bay, Orford Ness to Cape Grenville, and the inner shelf off Lloyd Bay near Cape Direction (Fig. 4.21). The coast from Cape York to Cape Direction consists of protected embayments and estuaries (eg. Kennedy Inlet, Lloyd Bay) separated by sections of bedrock coast with extensive late Quaternary dune deposits (eg. Cape Grenville to Newcastle Bay). Fine grained fluvial sediments accumulate in shoreface and inner shelf environments within the protected embayments at the entrance to the larger river systems. In contrast, exposed sections of the coast have active littoral systems where fine grained sediments are dispersed offshore and alongshelf while coarse grained shoreface sediments are driven northward by the prevailing southeast wave climate. Extensive dune fields commonly occur north of major river entrances (eg. Olive River).

4.3.1 Bathymetry and Surficial Sea Bed Sediments

The sea bed morphology and sediment types are closely related to coastal setting with low sea floor slopes (0.05°, less than 1m per kilometre) and muddy sediments common within the protected embayments (eg. Newcastle Bay and Lloyd Bay) and steeper (0.2°, around 5m per kilometre) sandy sea beds typical of the more exposed sections of shelf (eg. Orford Ness to Cape Grenville). *Halimeda* banks occur on the outer shelf in water depths of around 20m in the southern part of the area off Lloyd Bay. The sea bed in the vicinity of the banks is highly irregular and characterised by coarse carbonate sands.

A feature of the bathymetry between Cape Grenville and Orford Ness is a series of nearshore terraces which occur in water depths of less than 5m offshore of the coastal dune fields. The shoreface in the vicinity of the terraces consist of a concave-up nearshore profile grading from the beach to the terrace surface in 5m water depth, a flat-topped terrace up to 3km wide with common bedforms and sea grass beds, and a steeply dipping slope at the seaward edge of the terrace where water depths increase from 5m up to 15m. Similar sublittoral platforms have been identified offshore of Townsville where they have been described as "flat-topped wedges" and "lenses" of coarse grained coastal deposits (Johnson and Searle, 1984; Facies C2, Fig. 10). The terraces have been interpreted as high energy shallow water deposits produced by wave reworking of terrigenous sediments delivered to the inner shelf (Johnson and Searle, 1984). These features are remarkably similar to the nearshore terraces described by Pickrill (1983) who demonstrated the widespread occurrence of sublittoral platforms off low energy coasts and lake shores. The terraces are interpreted as equilibrium forms produced in response to contemporary wave processes (Pickrill, 1983), a conclusion consistent with the mode of formation proposed by Johnson and Searle (1984).

Surficial sediment textures and composition are summarised for the shelf between Cape York and

Cape Direction in Figures 4.22 and 4.23. A ternary plot of Gravel:Sand:Mud demonstrates a broad range of sea bed sediment types from sands and gravelly sands typical of the exposed coast and *Halimeda* banks, to the muddy sands and muds common in the protected embayments (Fig. 4.22). The proportion of gravel in the sea bed sediments is generally less than 20% while mud contents are clearly depth related. Figure 4.22 indicates a marked increase in the proportion of mud in surficial sediments in water depths greater than 5m. Carbonate shows an increase with increasing water depth, the highest proportions (c.100%) being associated with *Halimeda* banks to the east of Lloyd Bay (Fig. 4.22). With the exception of the *Halimeda* banks, visual inspection of the grab samples identifies benthic organisms as the main carbonate producers (eg. molluscs, gastropods, echinoids, foraminifera). A summary of the sand size distributions indicates considerable overlap in modal sand grainsize and sorting for the various water depth groups - sea bed sediments from water depths less than 5m display the best sorting (Fig. 4.23).

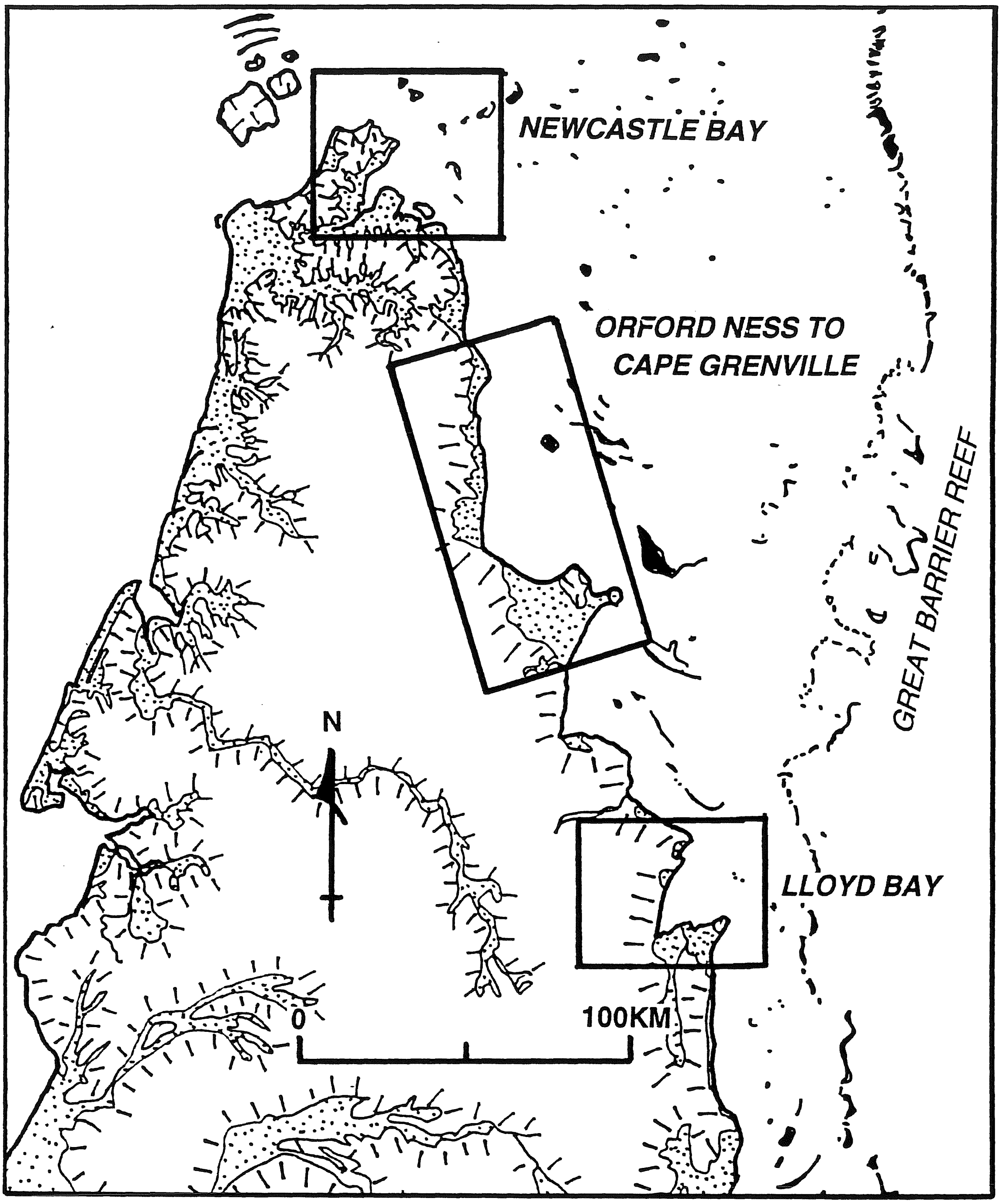


Figure 4.21 Areas surveyed by AGSO in 1992/1993 field programs.

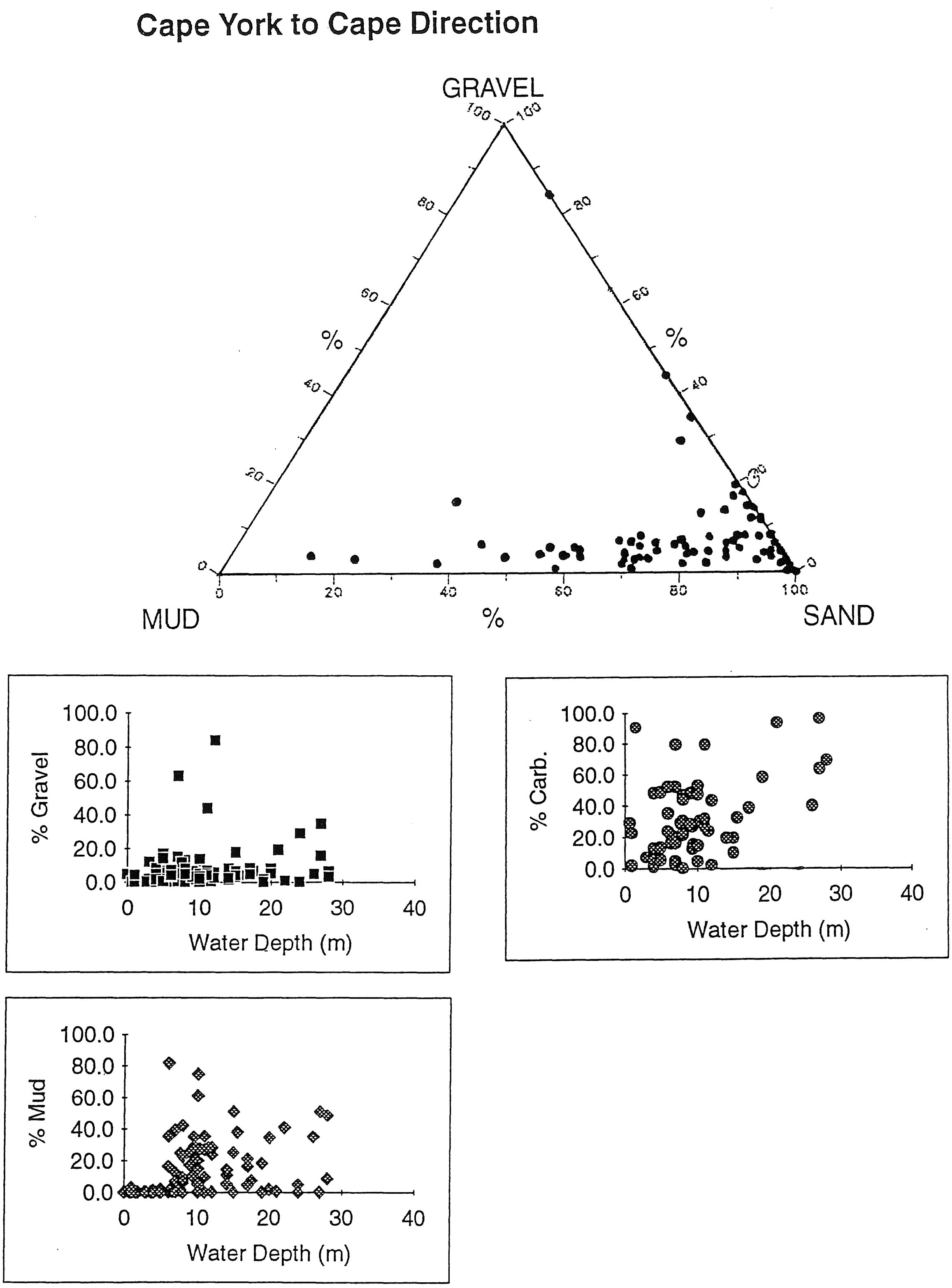


Figure 4.22 Textural characteristics of surficial sea bed sediments - Cape York to Cape Direction.

Cape York to Cape Direction

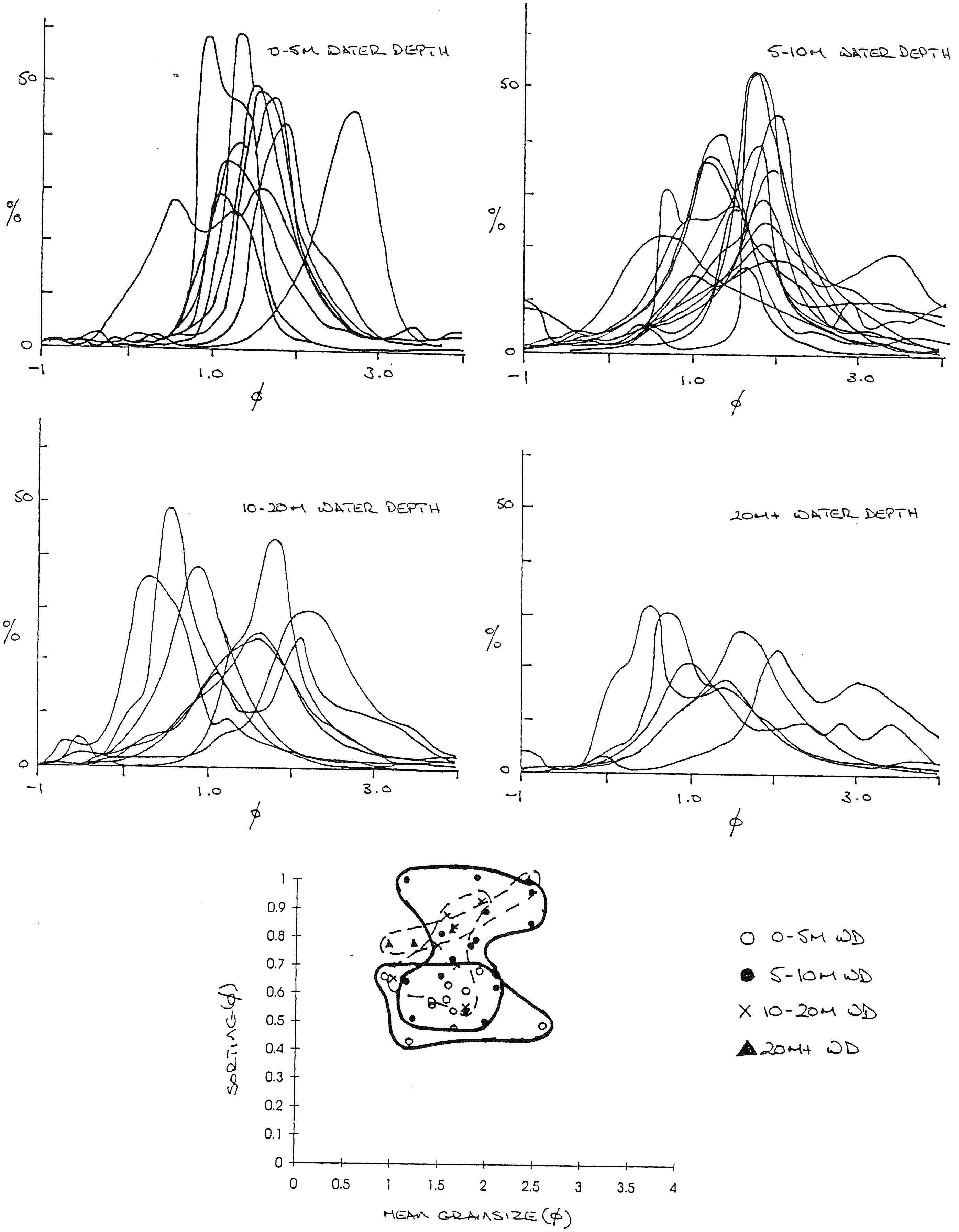


Figure 4.23 Sand grainsize distributions and sorting for surficial sea bed sediments Cape York to Cape Direction.

4.3.2 Seismic and Side Scan Sonar Data

Seismic and side scan sonar tracklines for Newcastle Bay, Newcastle Bay to Cape Grenville, and Lloyd Bay are indicated in Figures 4.24, 4.27 and 4.31 respectively. Selected examples from these areas are shown in Figures 4.25 to 4.26 (Newcastle Bay), Figures 4.28 to 4.30 (Newcastle Bay to Cape Grenville), and Figure 4.32 (Lloyd Bay).

An unpublished review of the seismic results for the nearshore and inner shelf regions of the Great Barrier Reef lagoon has been prepared by Dr. John Marshall (AGSO), the main points of which are summarised in the following paragraph.

The seismic data show much of the Great Barrier Reef shelf to be shallowly underlain by a prominent planar subsurface reflector. The reflector, interpreted as a pre-Holocene subaerial erosion surface, is presumed to be equivalent to a similar feature observed in the Gulf of Carpentaria. On the Great Barrier Reef shelf the erosion surface is relatively planar and occurs within 4m to 15m of the sea bed. Offshore of major coastal rivers the surface is irregular and incised by numerous channels. These channels, cut by rivers into the exposed shelf surface at lower sea levels, have been infilled with estuarine and marine sediments during the subsequent post glacial marine transgression. Sediment thicknesses above the pre-Holocene surface reflect the volume of material delivered to the shelf during the marine transgression and subsequent stillstand. Relatively thick accumulations of sediment inshore can be correlated with areas of high terrigenous sediment input near river entrances. Offshore, thick accumulations of carbonate sand (eg. Halimeda banks) are related to organic production over the same period.

The influence of river channels on shallow shelf stratigraphy is demonstrated in a number of seismic sections from Newcastle Bay (Figs. 4.25 and 4.26). A seismic section across the entrance to Kennedy Inlet in 5m water depth shows a thick (25m) sediment sequence infilling an irregular channelled substrate (Fig. 4.25). The seismic section contains at least two depositional units; a basal unit up to 20m thick characterised by a chaotic acoustic signature and a thinner (5m to 7m thick) surficial unit with a more regular acoustic signature. The irregular (channelled?) nature of the contact between the two units suggests that the surficial unit overlies and infills an older erosion surface. A similar pattern is seen in a shore normal section offshore of the Escape River entrance in the southern part of Newcastle Bay (Fig. 4.26). Here the thickness of the two units is around 10m and the surficial unit infills an irregular and channelled substrate. An isolated 2m high bedform occurs in 15m water depth at the seaward end of the section, indicating the efficacy of tidal currents in mobilising sea bed sediments seaward of the embayment.

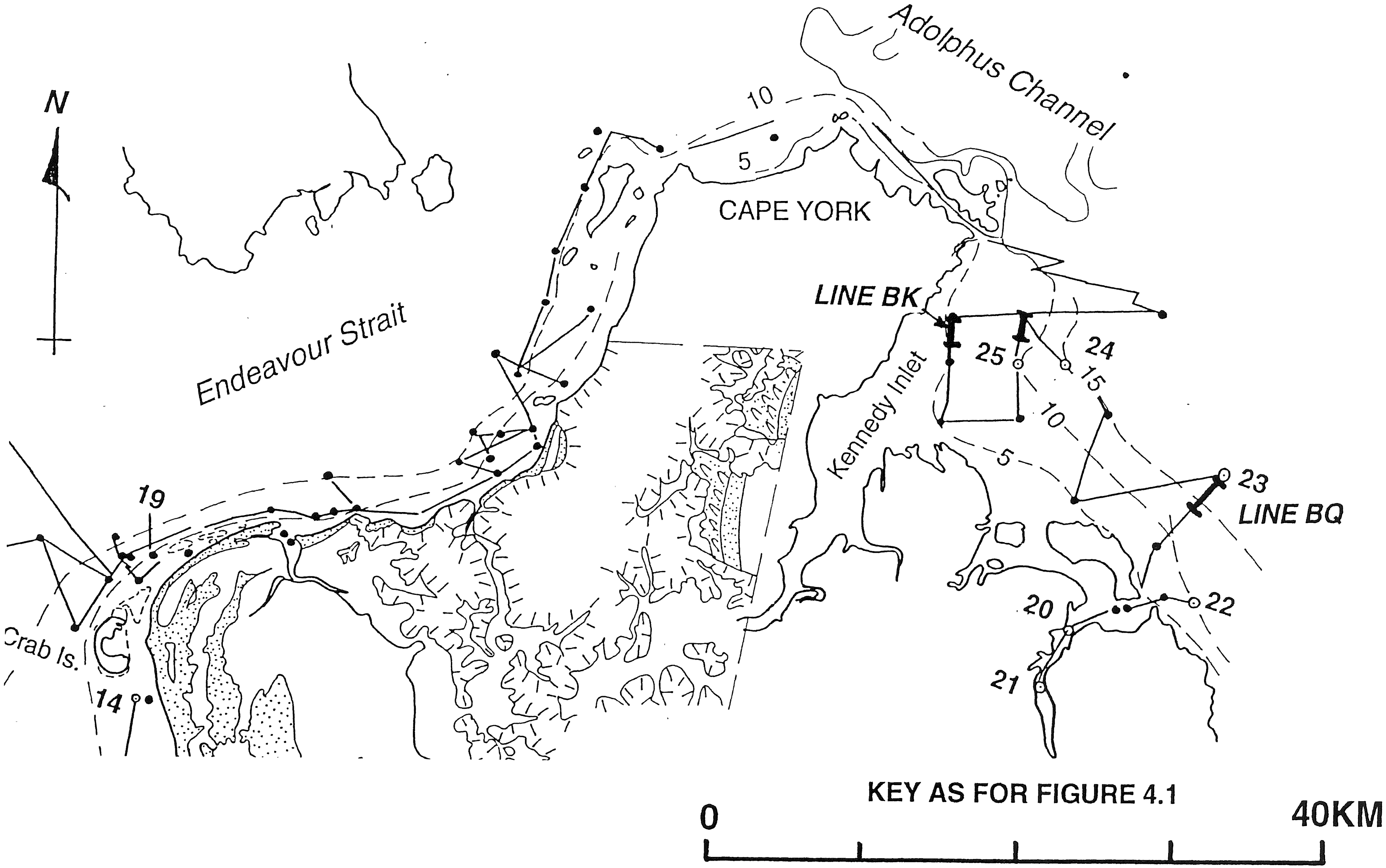
The Shelburne Bay embayment provides another example of the complex shelf stratigraphy encountered in protected embayments along this section of coast (Figs. 4.27 and 4.30). The sea floor is underlain by at least two seismic units, a thin (c.5m thick) surficial unit with a uniform acoustic signature and a thicker (up to 25m thick) basal unit with a chaotic acoustic signature (Fig. 4.28). The contact between the two units is sub-planar and, in places, channelled. The age of the thicker basal unit is uncertain. The unit overlies an undulating seismic reflector at around 30m below the sea bed which may represent either the pre-Holocene surface or some older surface.

The seismic character of exposed sections of the shelf between Newcastle Bay and Cape Grenville differs from that encountered within the protected embayments. In general, the shelf consists of a thin (<2m) surficial sediment unit overlying a relatively planar subsurface reflector (pre-Holocene surface). A notable exception occurs inshore of the 5m isobath off some sections of dune coast where the surficial sediment unit may thicken to 10m to form a nearshore terrace-like feature extending up to 3km offshore and 15km alongshore (Fig. 4.29). The terrace has a planar upper surface and a steeply dipping seaward face, sidescan data show seagrass beds on the terrace upper surface. Internal structures are evident in the terrace in the form of a series of steeply dipping reflectors paralleling the seaward face (Fig. 4.29). Seaward of the terrace water depths increase to 15m and the surficial sediment unit thins to around 2m (Fig. 4.28). A similar feature occurs in deeper water (c.25m) east of Cape Grenville (Fig. 4.30). Here, the terrace-like feature is less than 8m thick and overlies a planar subsurface reflector. Unlike the shallow water example, the terrace east of Cape Grenville has no obvious internal structure.

The probable origin of the terrace features has been discussed previously and the available evidence suggests that the terraces are the product of contemporary littoral processes. The occurrence of submerged spits in relatively deep water at the northern ends of some of the terraces suggests a link between contemporary littoral transport and spit formation. While the seismic data does support these conclusions it is possible that the terraces may contain older sediments at depth (eg. partially reworked dune) which would indicate a more complex mode of formation. Similarly, the formation of the spits may reflect contemporary processes and the influence of inherited sea bed morphology/ geology. Detailed survey data supplemented with dated core samples is required to determine the relative influence of contemporary littoral processes and geological inheritance on the formation of the nearshore terraces and associated submerged spits.

Lloyd Bay is a sediment filled embayment at the southern end of this section of coast. Previous investigations have identified a relatively thin sediment cover over much of the area except in the vicinity of a palaeodrainage channel extending NE across the inner shelf (Skjold, 1988). The channel is infilled with a Holocene sediment sequence some 15m thick comprised of basal transgressive marine and estuarine facies overlain by prograded fluvio-deltaic deposits. Fine grained fluvial muds and sandy muds cover most of the bay floor and adjacent shelf to water depths of around 30m, seawards of here carbonate sediments become dominant (Skjold, 1988). In water depths of around 20m to 25m near the shelf edge thick (25m max.) accumulations of carbonate sand have formed in the lee of the coral reefs (Fig. 4.32). These banks of carbonate sands are bioherms or *in situ* accumulations of carbonate material produced by the calcareous alga *Halimeda*. The banks overlie the planar pre-Holocene and represent some 25m of vertical Holocene sedimentation.

Figure 4.24 Newcastle Bay. Figure shows generalised bathymetry, survey tracklines, grab and vibrocore locations. Highlighted sections of tracklines discussed



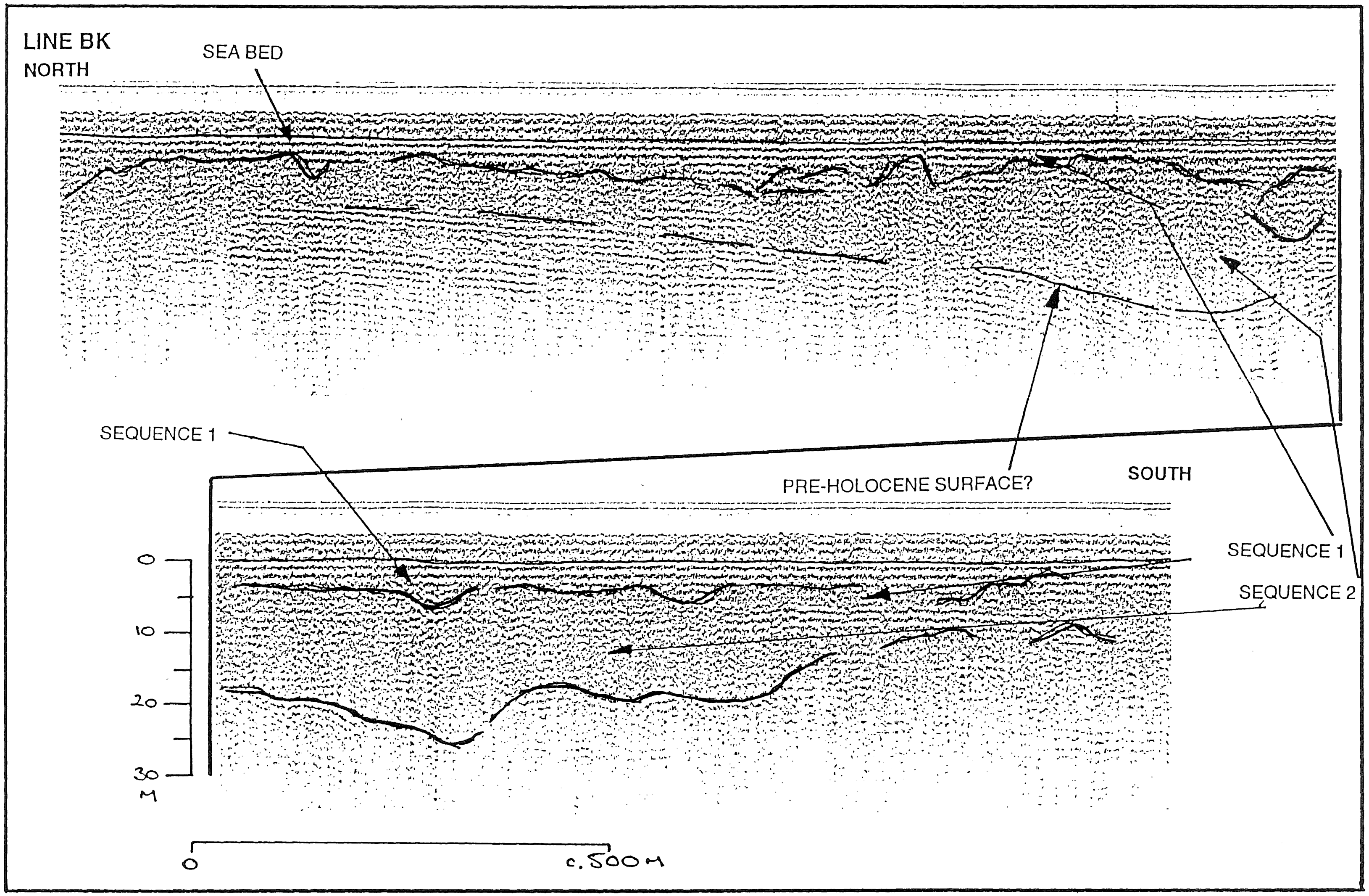


Figure 4.25 Seismic section across the entrance to Kennedy Inlet (Line BK, Figure 4.24). Section shows a considerable thickness of sediment infilling a broad relict valley. At least two seismic sequences can be distinguished; a basal sequence characterised by a chaotic acoustic signature (Sequence 2) which is overlain by thinner surficial unit (Sequence 1).

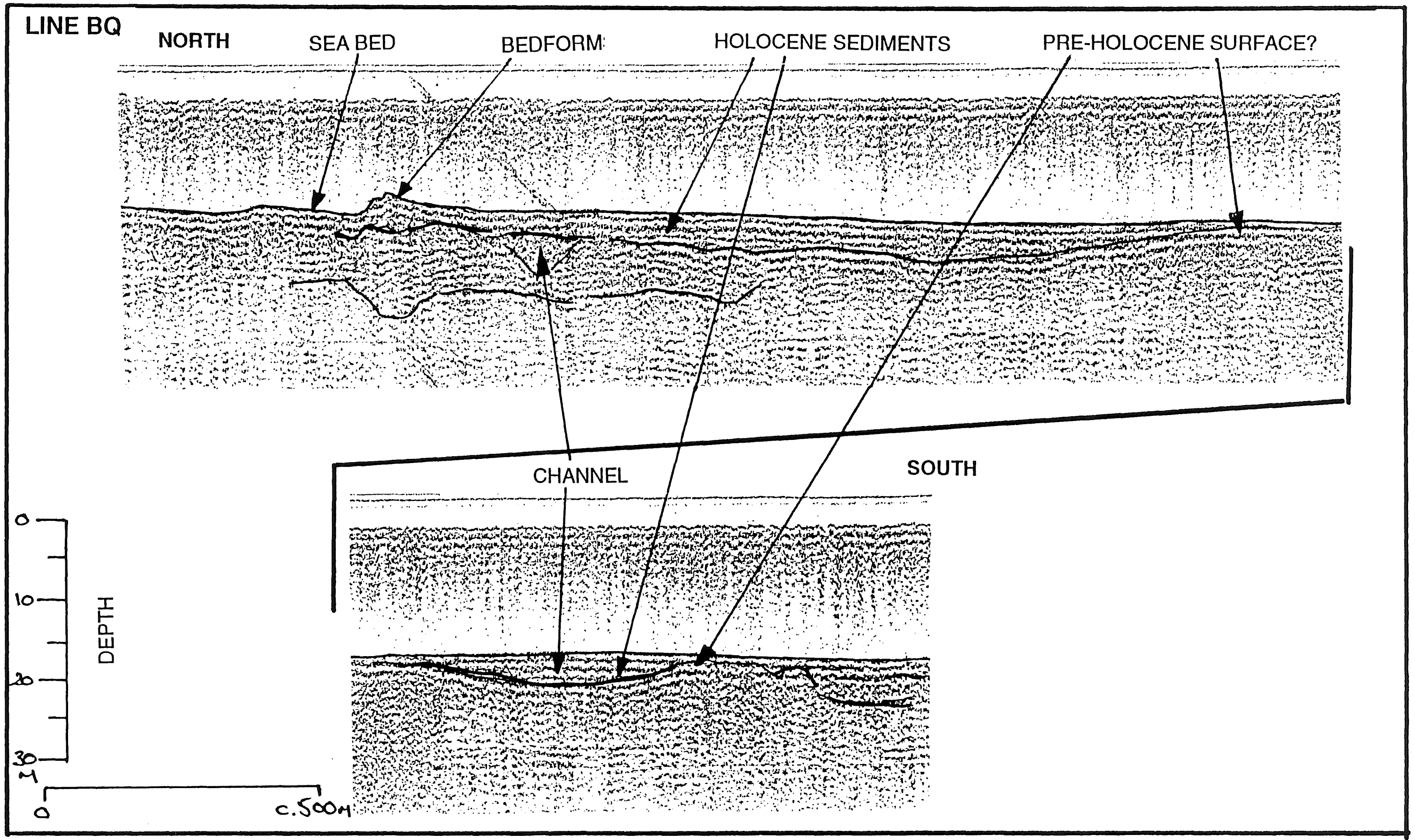


Figure 4.26 Shore-normal seismic section seaward of the Escape River entrance (Line BQ, Figure 4.24). Section shows isolated bedforms at the seward limit of the line and a series of broad channels in the subsurface.

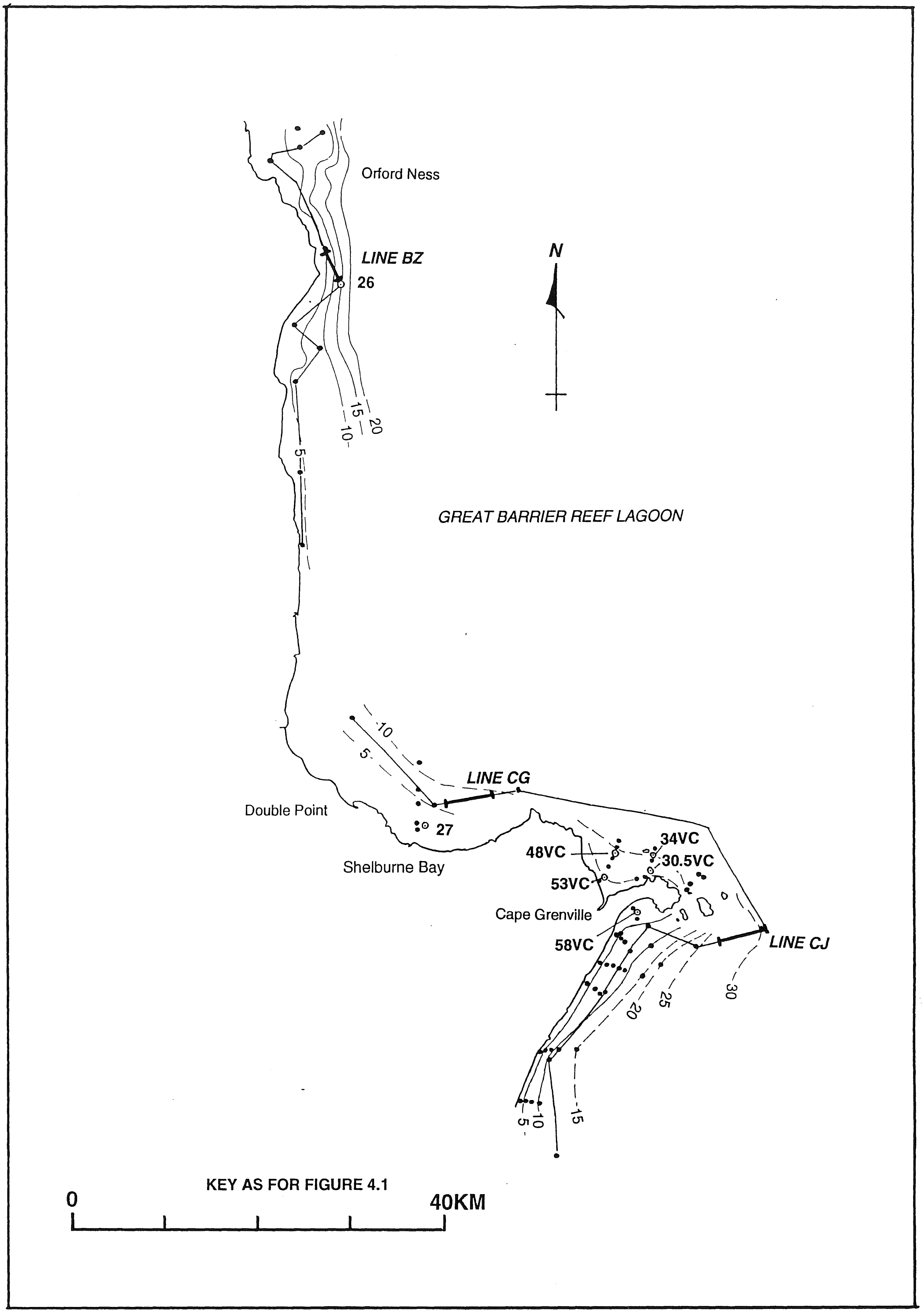


Figure 4.27 Orford Ness to Cape Grenville. Figure shows generalised bathymetry, survey tracklines, grab and vibrocore locations. Highlighted sections of tracklines discussed in text.

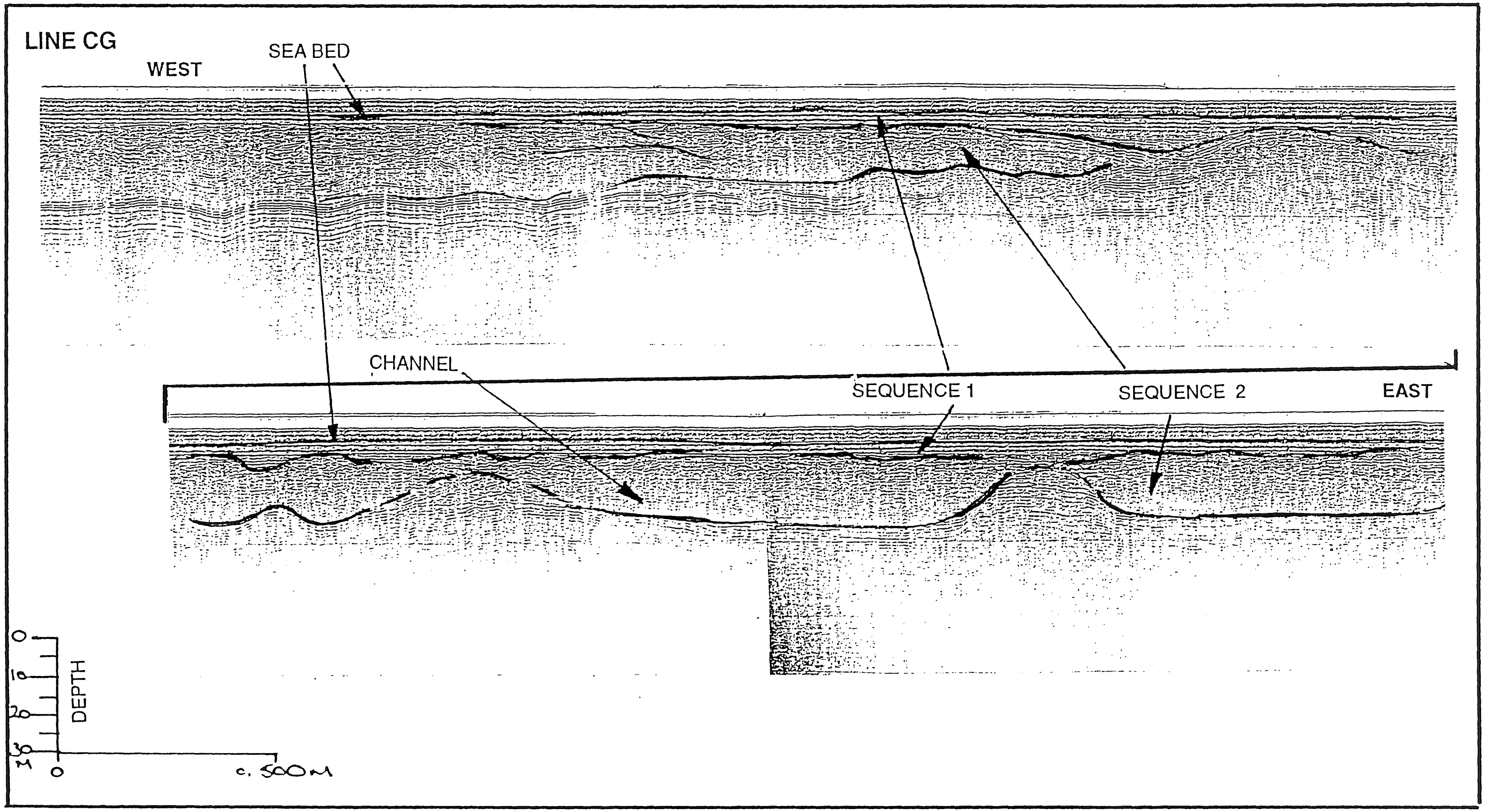


Figure 4.28 Shore parallel seismic section across Shelburne Bay (Line CG, Figure 4.27). Section shows complex seismic stratigraphy (Sequences 1 & 2) with channel-like features overlying a relatively flat substrate with pronounced mounds. Sequence 1 is thought to represent contemporary bayfloor sediments.

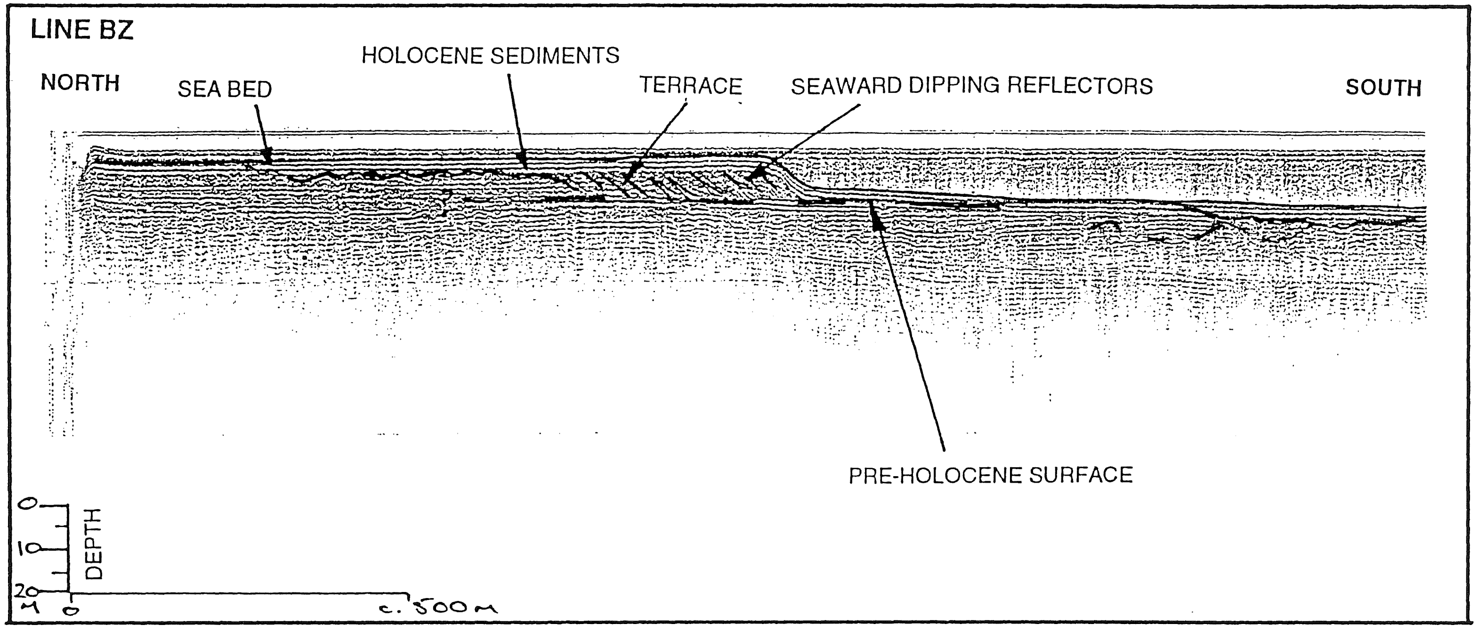


Figure 4.29 Shore-parallel seismic section north of Shelburne Bay (Line BZ, Figure 4.27). Section shows terrace-like feature extending seaward of the coast. Note seaward dipping reflectors within terrace and relatively thin sediment cover on inner shelf immediately seaward of the terrace. See text for discussion.

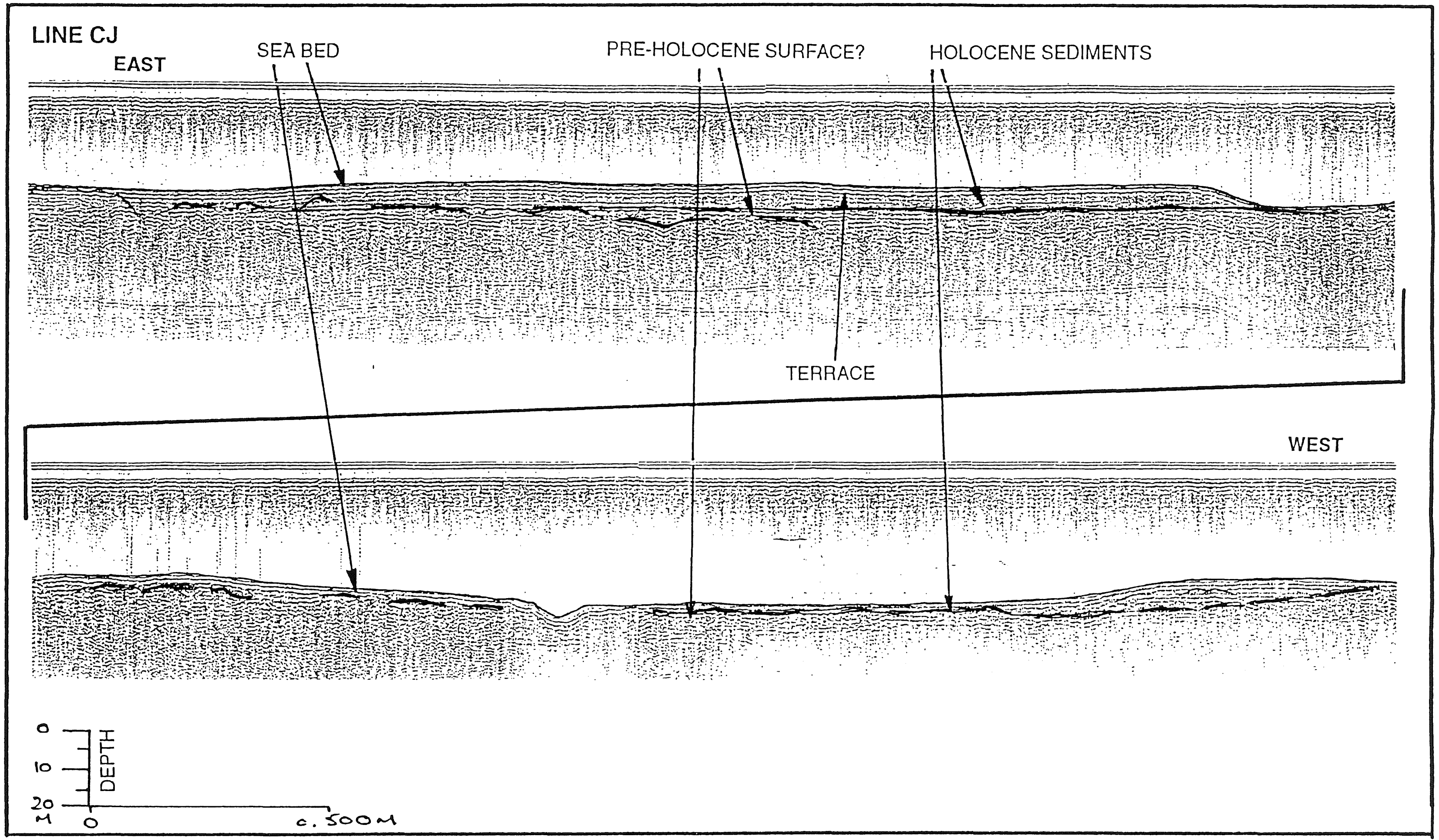


Figure 4.30 Shore-normal seismic section east of Cape Grenville (Line CJ, Figure 4.27). Section shows terrace-like feature overlying a relatively flat subsurface reflector interpreted as the pre-Holocene surface. Note absence of any clear structures within the terrace feature. See text for discussion.

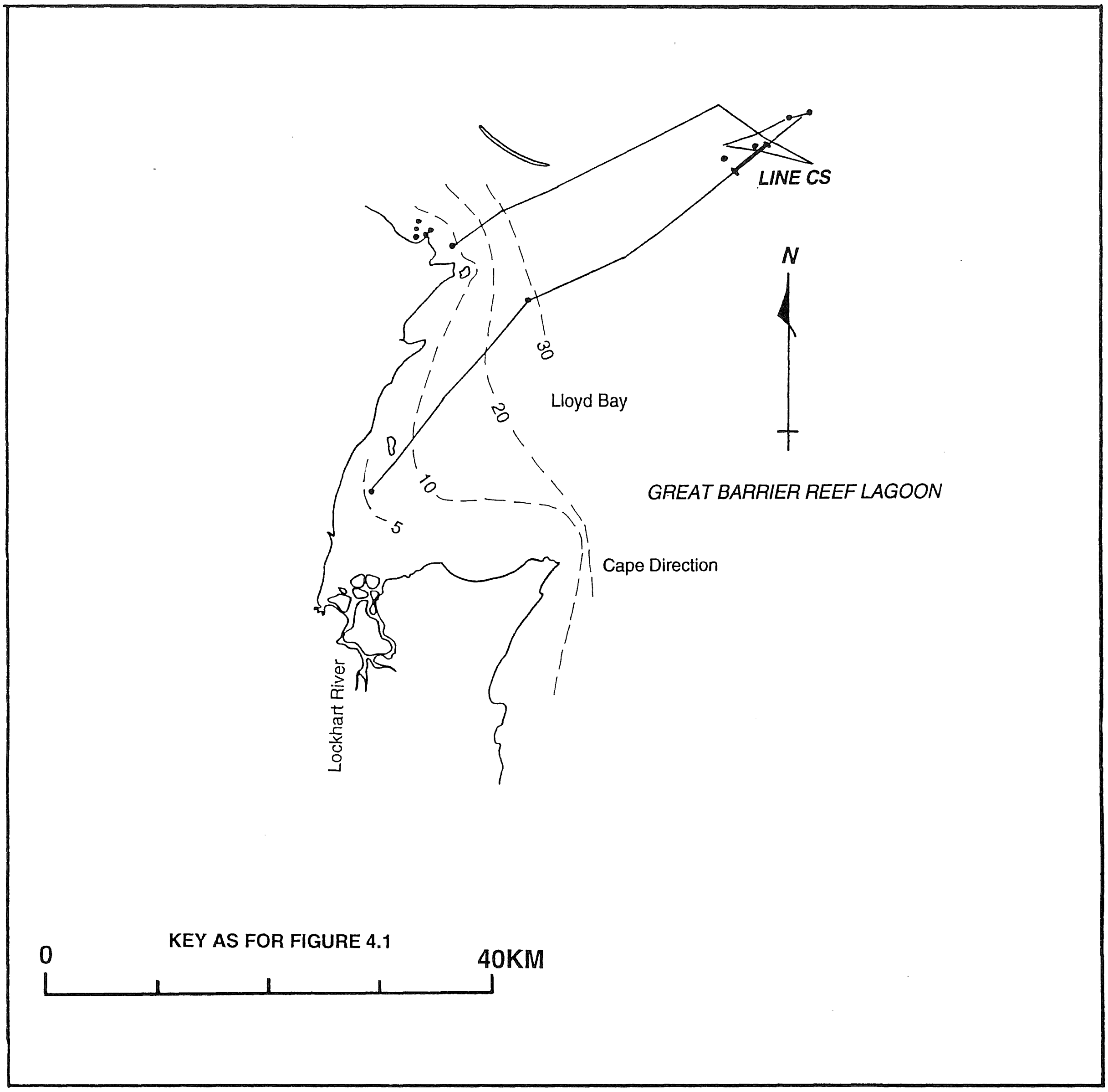


Figure 4.31 Lloyd Bay. Figure shows generalised bathymetry, survey tracklines, grab and vibrocore locations. Highlighted sections of tracklines discussed in text.

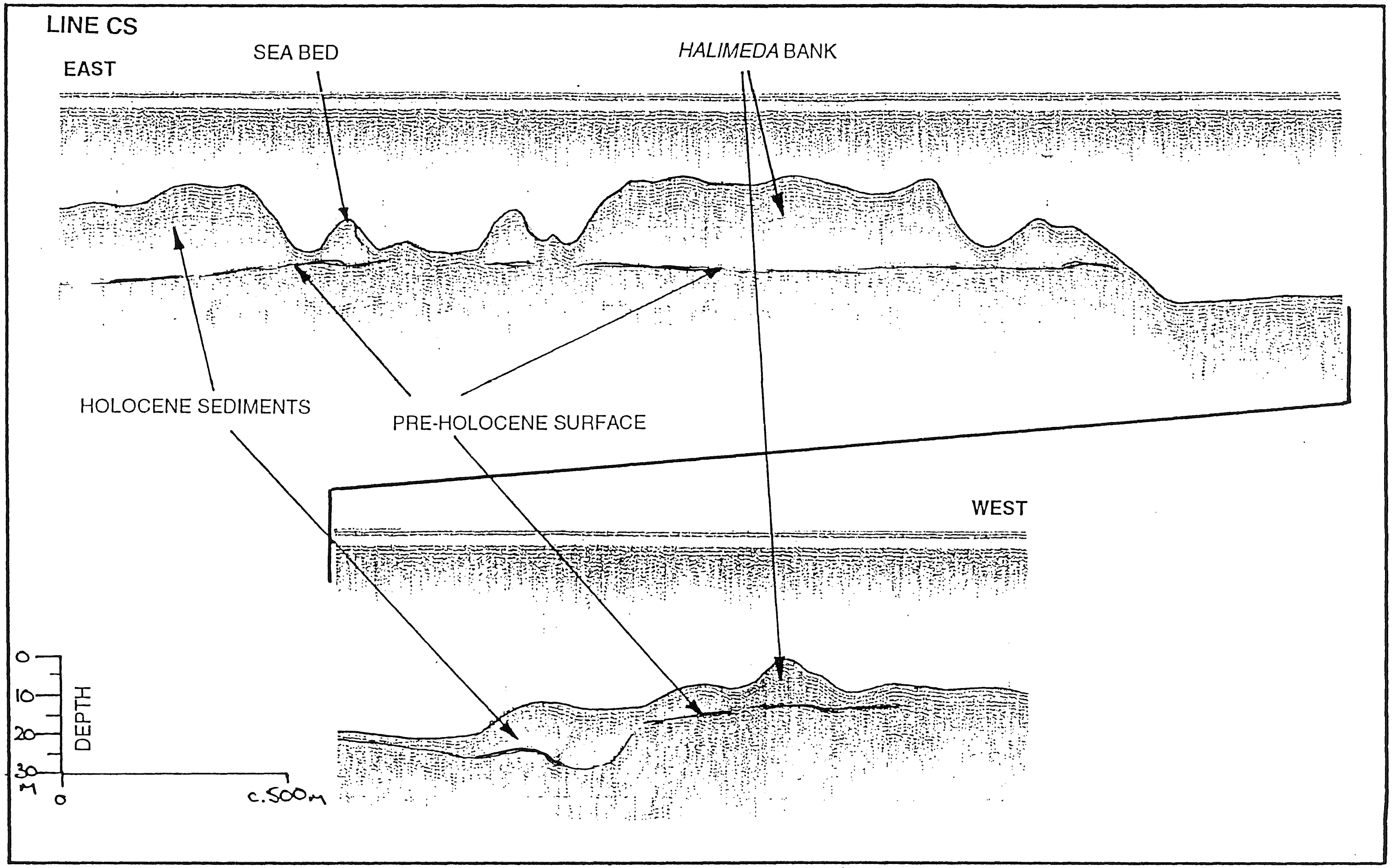


Figure 4.32 Shore-normal seismic section east of Lloyd Bay (Line CS, Figure 4.31). Section shows thick accumulations of carbonate sands associated with *Halimeda* banks on the outer shelf east of Lloyd Bay.

4.3.3 Vibrocores

A total of 13 cores was recovered from the sea bed between Cape York and Cape Direction. No cores were taken in Lloyd Bay due to the detailed seismic and coring survey previously completed by Skjold (1988). Cores were collected on a number of shore normal and shore parallel lines in Newcastle Bay (Fig. 4.24; VC#20, 21, 22, 23, 24, 25) and around Cape Grenville (Fig. 4.27; VC#26, 27, 30.5VC, 34VC, 48VC, 53VC, 58VC). Core recoveries varied from 0.53m to 4.24m and averaged 1.71m. Summary core logs and sample analyses (texture and carbonate) are contained in the Appendix. Summary stratigraphic sections are shown in Figures 4.33, 4.34 and 4.36.

Cores in Newcastle Bay offshore of Kennedy Inlet encountered a thin (<1m thick), muddy, fine to medium sand unit (bay floor facies) overlying a clean, relatively shell-free, white quartzose sand (Fig. 4.33). The clean sand unit contains common plant fragments (roots?) and is interpreted as a superficially reworked dune/shallow estuarine deposit (Fig. 4.33; VC#24, 25). A similar moderately well sorted, slightly shelly sand unit was recovered in a core at the entrance of the Escape River in the south of Newcastle Bay (Fig. 4.34; VC#20). Here, a poorly sorted shelly gravel (tidal inlet facies) less than 0.2m thick overlies a partially indurated (podzol?) sand unit containing a minor amount of shell and common organics (roots and charcoal). The sand unit overlies a stiff gravelly (vein quartz) clayey sand - interpreted as a pre-Holocene fluvial facies. The occurrence of a dune/ reworked dune facies beneath the sea bed in Newcastle Bay is consistent with the widespread distribution of coastal sand dunes north and south of the bay. In view of this, it is possible that much of the bay floor is underlain by an early Holocene transgressive dune facies.

Some support for the widespread occurrence of a quartzose dune sand unit throughout the bay can be seen in VC#22 and VC#23 seaward of the Escape River entrance (Fig. 4.34). The bay floor facies contains low proportions of shell (VC#22; <15%) or a sharp reduction in shell content at depth (VC#23). The occurrence of low carbonate sands may indicate that the bay floor sediments are derived from quartzose (dune?) sands which shallowly underlie the sea bed. Skjold (1988) drew a similar conclusion from a zone of low carbonate, well sorted quartzose sand on the sea bed in the eastern portion of Lloyd Bay.

Several cores were collected in water depths of less than 20m at isolated sites on the shelf between Newcastle Bay and Cape Grenville (Fig. 4.35; VC#26, 27). Core VC#26 is from 17m water depth and seaward of one of the terrace-like features described previously. The seismic data indicated that Holocene sediment thicknesses were likely to be thin (<5m) seaward of the nearshore terraces and this has been confirmed by the core. The core consists of a thin (0.7m) muddy shelly sand unit (inner shelf facies) overlying a stiff, shell-free, clayey sand (pre-Holocene surface - alluvium?) (Fig. 4.35). A core from 3m water depth on the shoreface in Shelburne Bay encountered a 1m thickness of muddy moderately well sorted shelly sand (shoreface facies) overlying an organic rich (leaf and root fragments - mangrove?) muddy sand unit (estuarine facies) (Fig. 4.35; VC#27).

A number of cores were collected around Cape Grenville (Fig. 4.36; 30.5VC, 34VC, 48VC, 53VC, 58VC). Cores to the north and south of the Cape encountered a shelly sand unit (shoreface facies) of variable thickness overlying a shell free, moderately well sorted fine to medium grained quartzose sand unit (Figs 4.36; 48VC, 53VC, 58VC). The basal sand unit is interpreted as a relict dune facies and consists of a well sorted fine quartzose sand with common plant fragments, roots and humic staining. A departure from this general pattern of relatively thin (c.1m thick) shoreface sediments overlying a relict dune unit occurs near the eastern extremity of the Cape (Fig. 4.36; 30.5VC, 34VC). Here, the sea bed is highly irregular and a 17m deep channel separates shoreface sediments from a submerged spit in 5m water depth further offshore. LANDSAT images and aerial photographs indicate that the submerged spit is attached to, and extends to the west from, Cape Grenville. Cores collected from the seaward (34VC) and landward (30.5VC) side of the submerged spit encountered a thick (up to 4m) shelly sand unit (muddy at depth) overlying a relatively shell free, moderately well to well sorted fine to medium sand unit (Fig. 4.36; 30.5VC, 34VC). There is a clear increase in the mud content of the surficial shelly sand unit on the seaward side of the bank (Fig 4.36; 34VC). Samples of the muddy shelly sand unit immediately above the contact with the shell-free unit were selected for radiocarbon dating.

4.3.4 Radiocarbon Dating

A list of the samples submitted for radiocarbon dating is contained in Table 4.2. Samples of whole shell and shell hash from contemporary shoreface and bay floor environments returned radiocarbon ages of less than 5,260 years Before Present (4,810 years B.P. environmentally corrected). Samples of organic fragments from relict estuarine deposits gave a radiocarbon age of 5,300 years B.P.

The oldest dates were obtained from the base of a muddy shelly sand unit in cores 30.5VC (7,030 years B.P.; 6,580 years B.P. corrected) and 34VC (9,640 years B.P.; 9,190 years B.P. corrected) adjacent to a submerged sand spit at Cape Grenville (Table 4.2). These early to mid Holocene ages indicate that the muddy shelly sand unit, initially thought to be shallow marine (inner shelf), is more likely to be a transgressive estuarine/protected bay floor facies. In view of the complex sea bed morphology in the vicinity of the spit, further coring and dating is required to establish the shallow shelf stratigraphy.

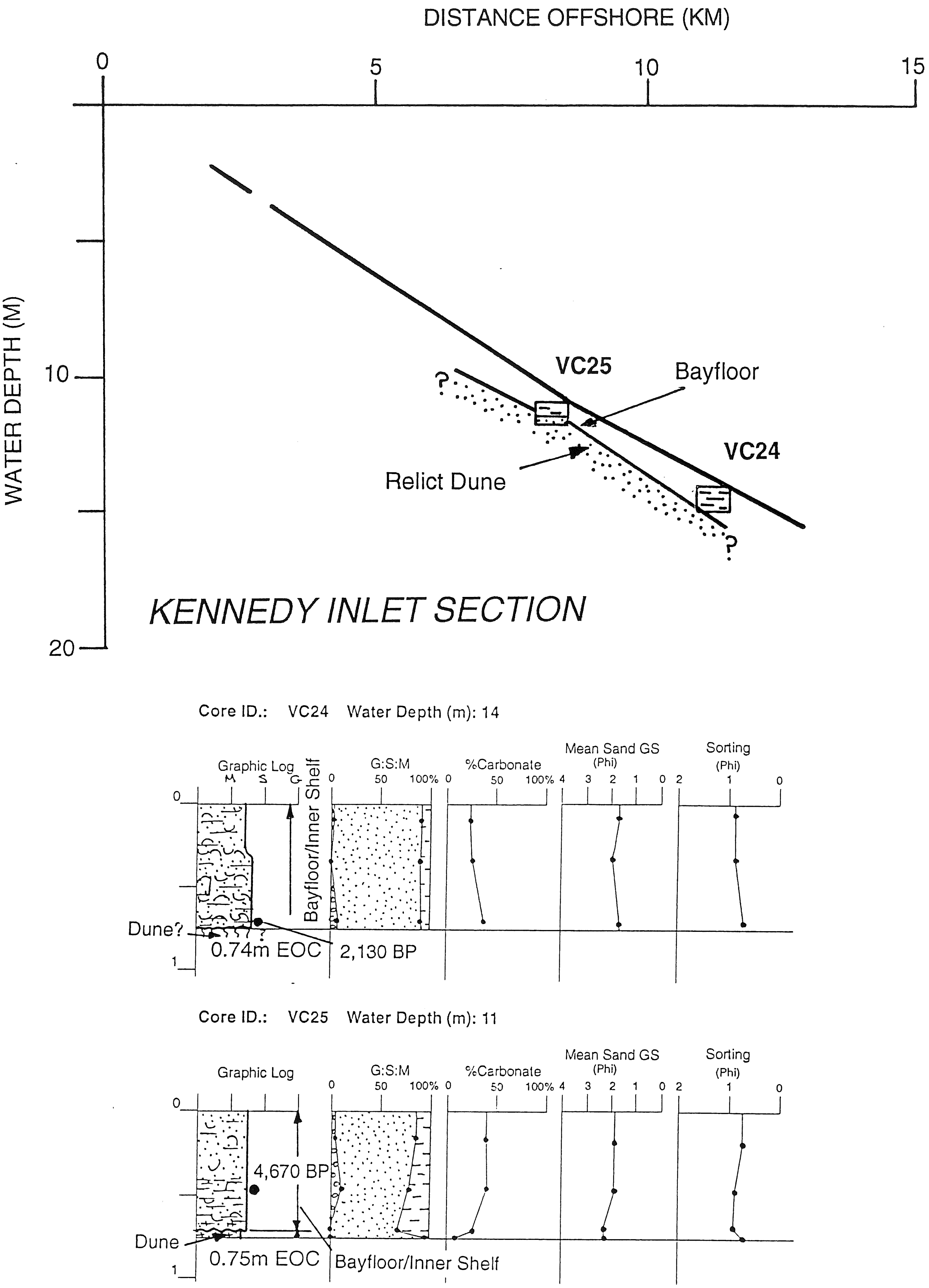


Figure 4.33 Kennedy Inlet (Newcastle Bay) stratigraphic section and graphic logs. Note occurrence of interpreted relict dune unit beneath the bayfloor facies. Core locations shown on Figure 4.24

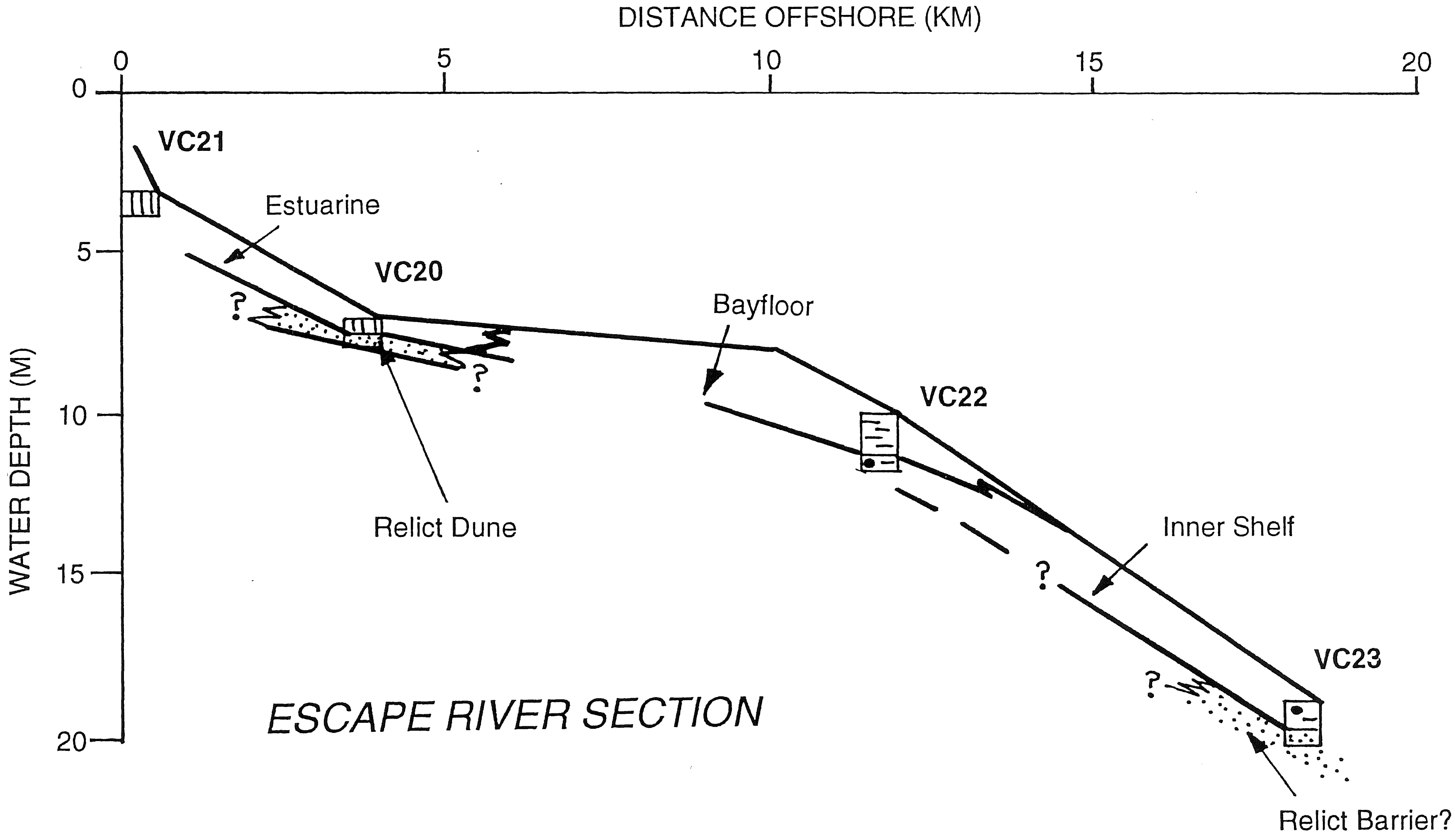


Figure 4.34 Escape River (Newcastle Bay) stratigraphic section. Cores VC20 and VC21 are in inlet channel. Note occurrence of highly quartzose sand facies beneath inlet channel and inner shelf. Core locations shown in Figure 4.24, graphic core logs on following pages.

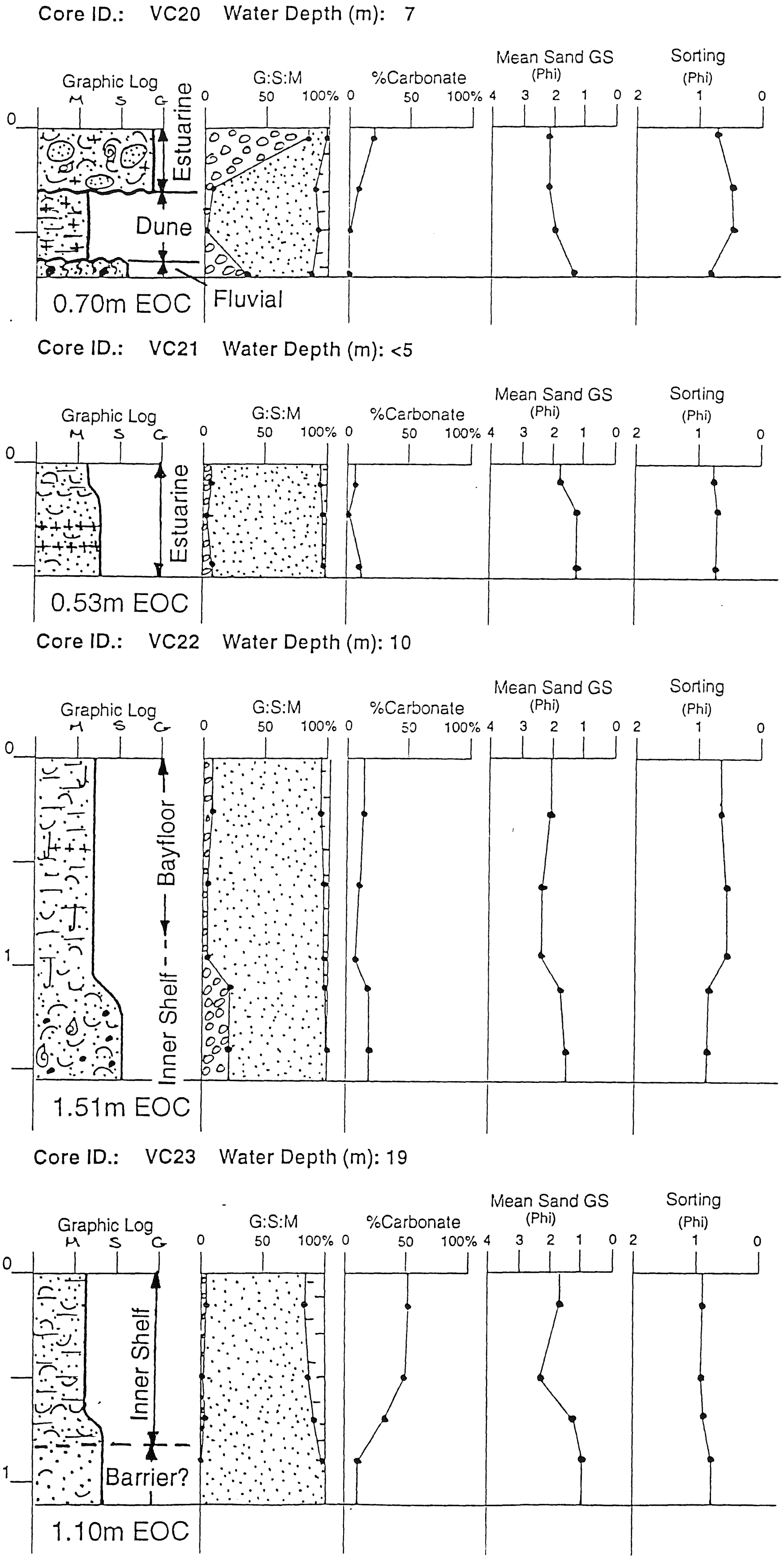


Figure 4.34 (contd.) Graphic core logs for Newcastle Bay vibrocores.

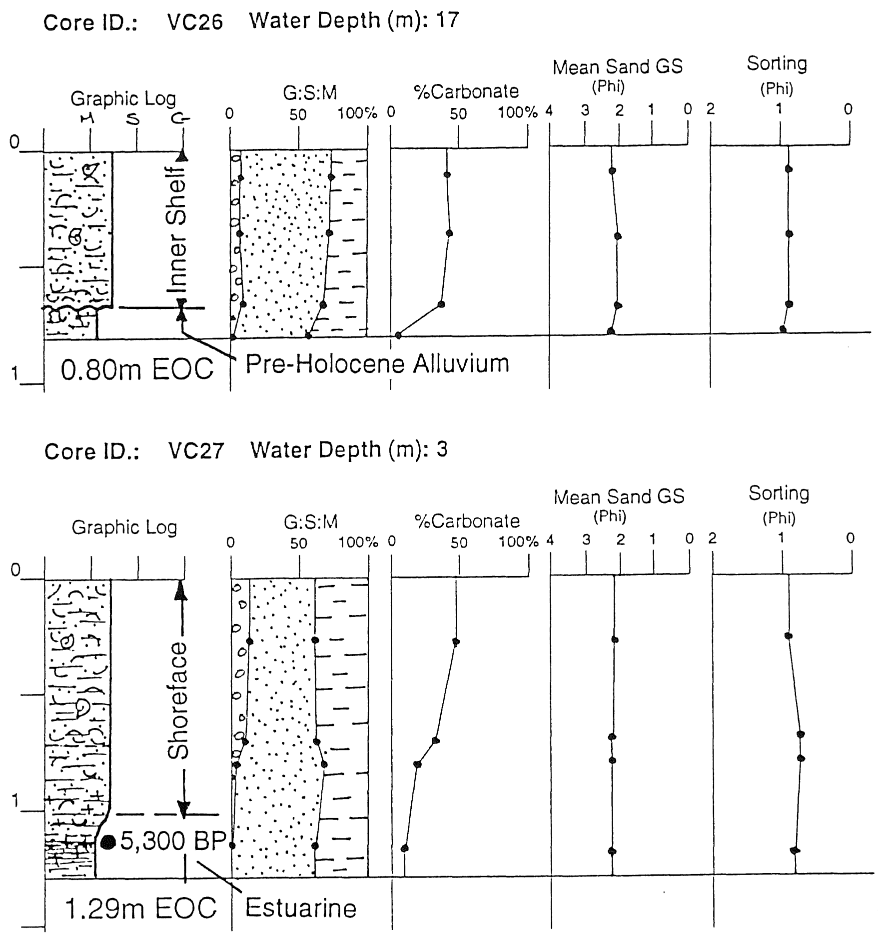


Figure 4.35 Graphic core logs for Orford Ness inner shelf (VC26, Figure 4.27) and Shelburne Bay (VC27, Figure 4.27). See text for discussion.

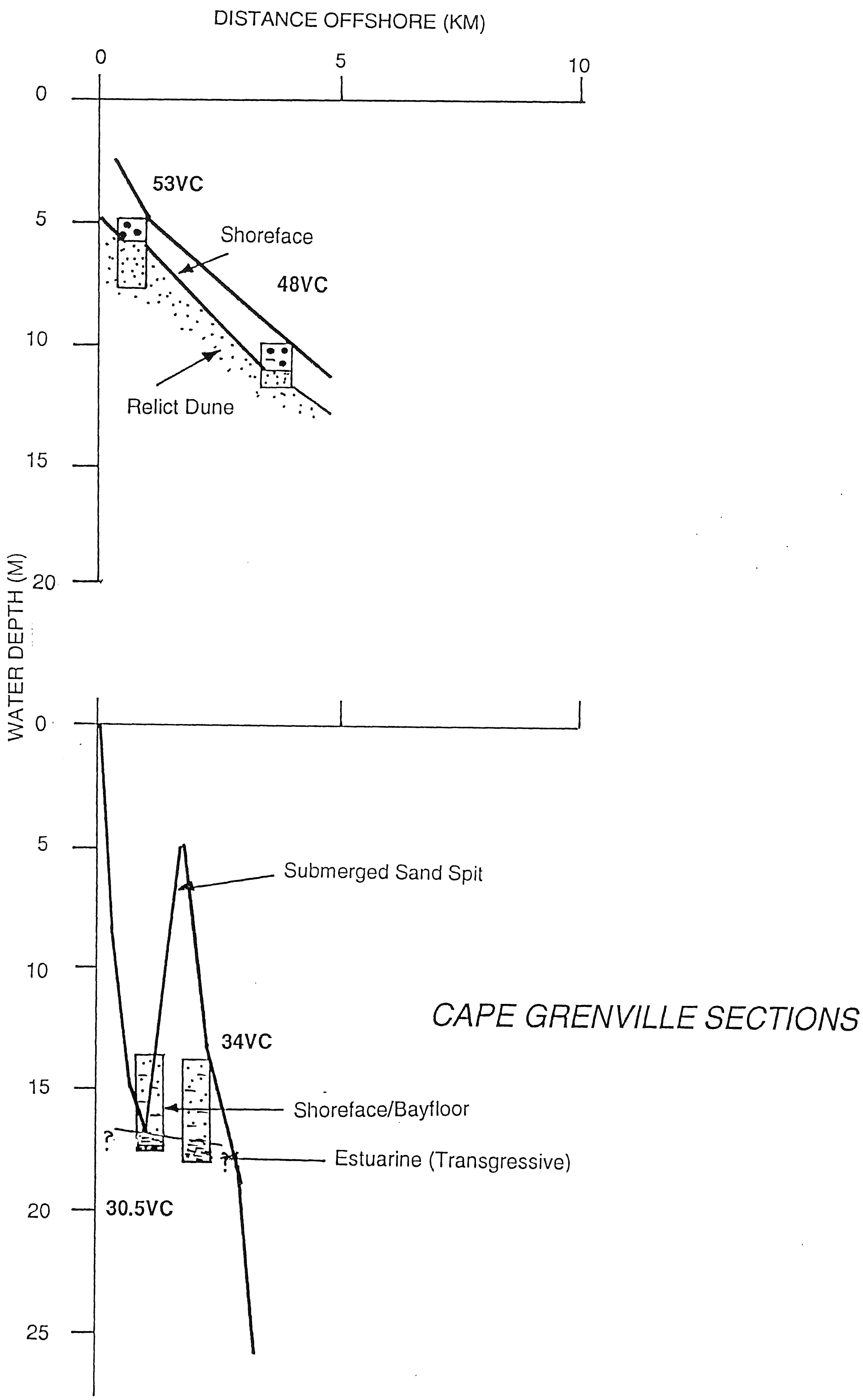


Figure 4.36 Cape Grenville stratigraphic sections. Core locations indicated in Figure 4.27. Top panel shows western section while bottom panel shows section in vicinity of submerged spit near Cape Grenville. Graphic logs on following pages See text for discussion.

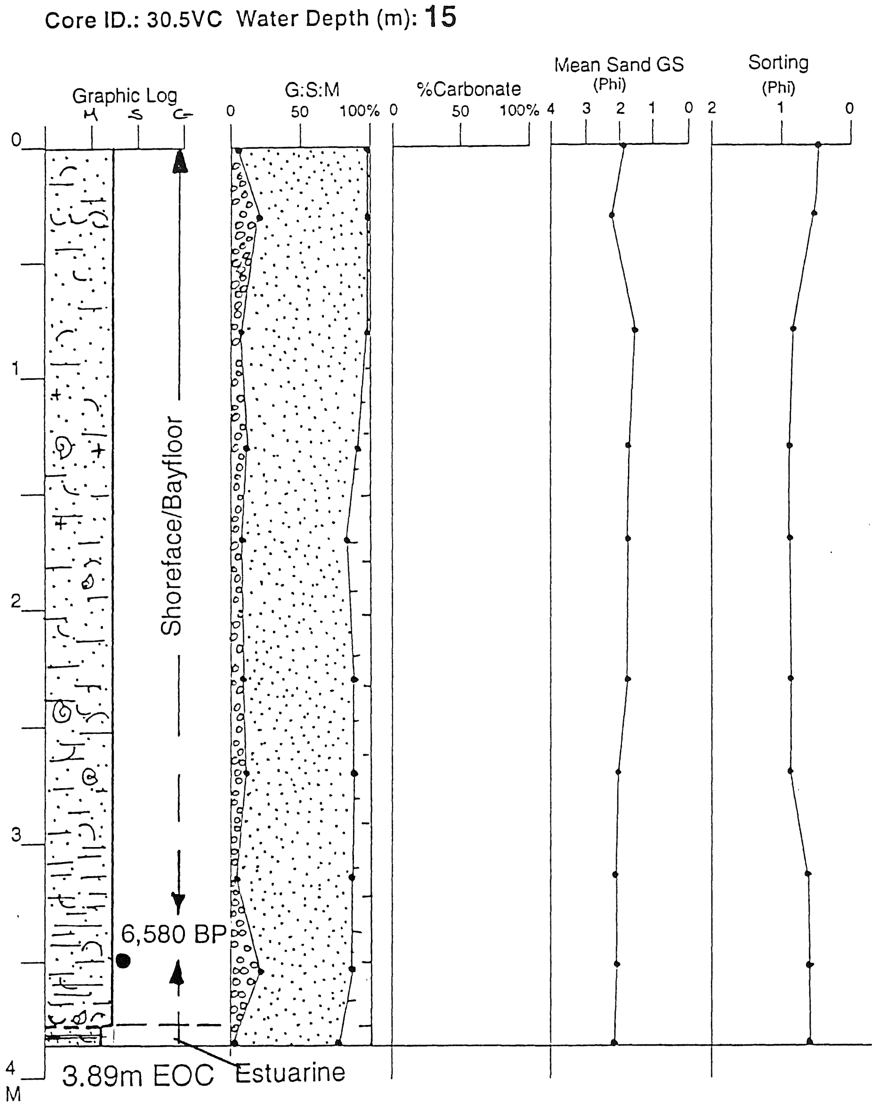
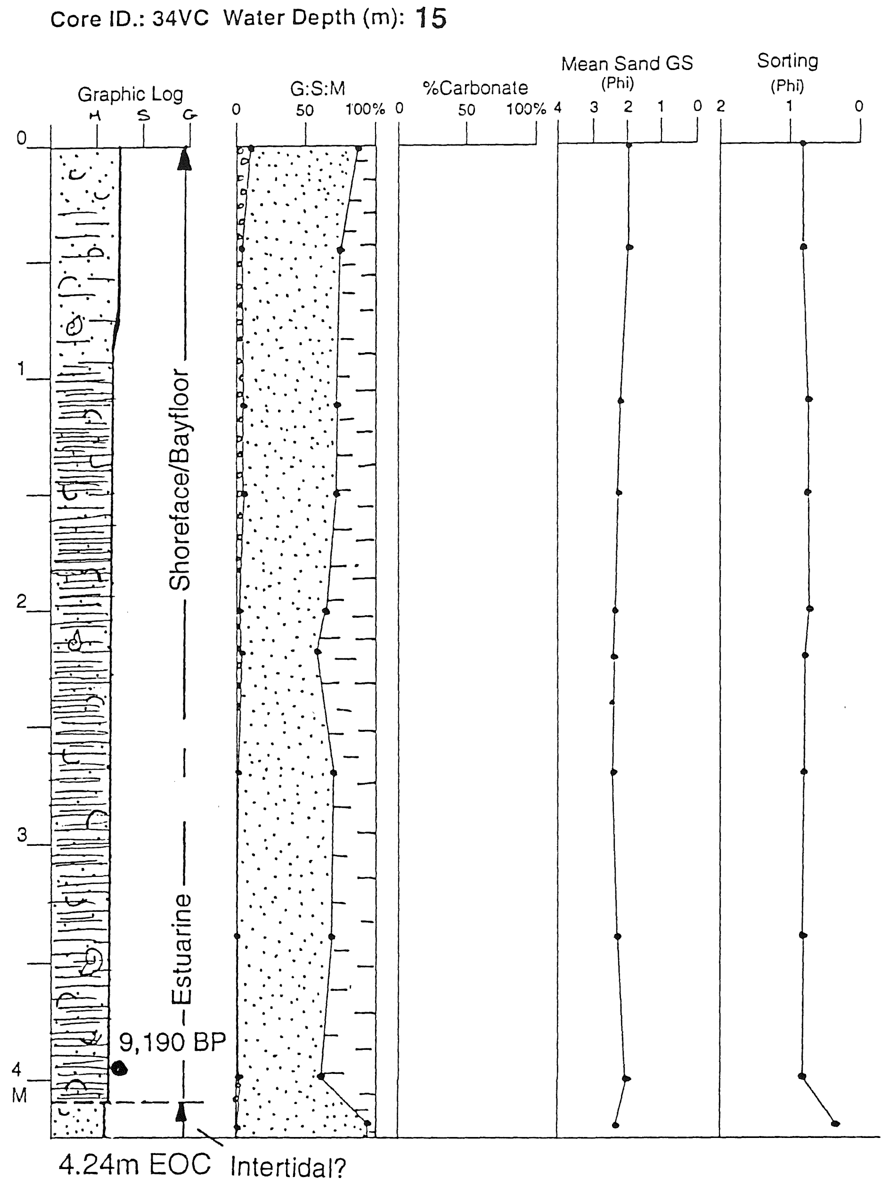


Figure 4.36 (contd.) Graphic core logs for Cape Grenville.



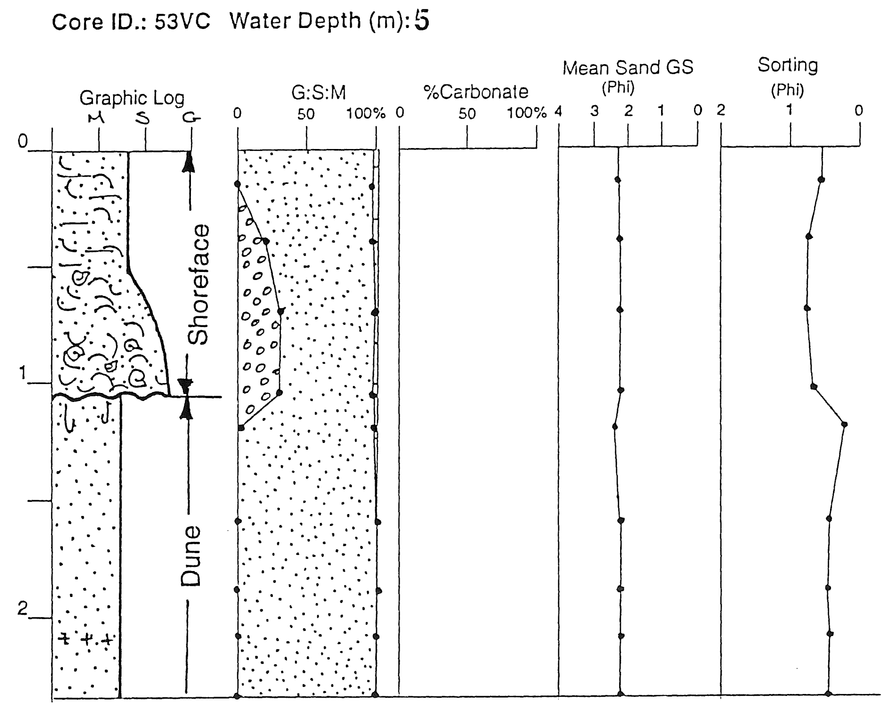
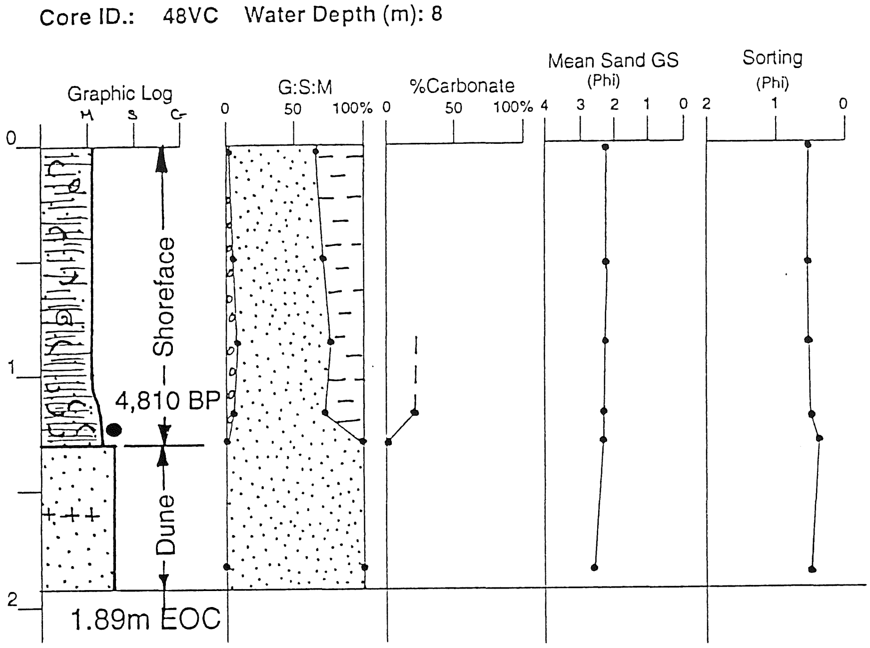


Figure 4.36 (contd.) Graphic core logs for Cape Grenville.



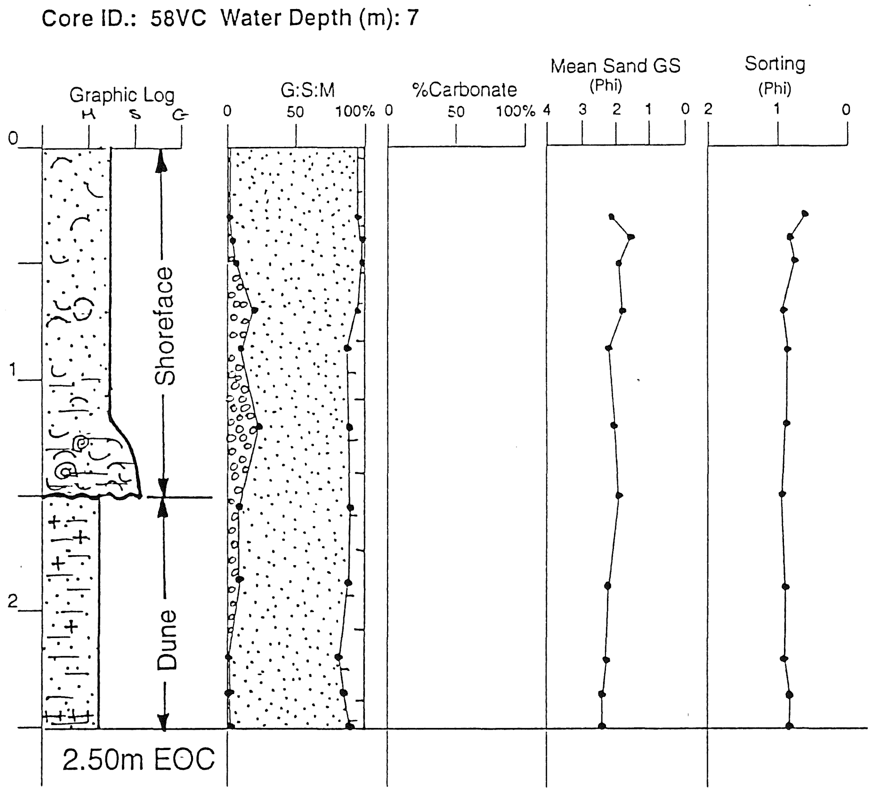


Figure 4.36 (contd.) Graphic core logs for Cape Grenville.

TABLE 4.2 Radiocarbon Dates - Cape York to Cape Direction

CORE ID	LAB. NO.	WATER DEPTH (M)	SAMPLE INTERVAL(M)	MATERIAL	FACIES	REPORTED C14 AGE	ENVIRON. CORRECTED AGE (yrs. BP)*
30.5VC	Wk 3871	c.15	3.40 - 3.50	Shell Hash	Estuarine	7,030 +/- 210	6,580 +/- 213
34VC	Wk 3872	c.15	3.80 - 3.90	Shell Hash	Estuarine	9,640 +/- 290	9,190 +/- 292
48VC	Wk 3873	8	1.10 - 1.20	Shell Hash	Shoreface	5,260 +/- 180	4,810 +/- 183
VC 24	Wk 3884	14	0.65 - 0.70	Shell Hash	Bay Floor	2,580 +/- 210	2,130 +/- 213
VC 25	Wk 3885	11	0.40 - 0.45	Whole Shell & Shell Hash	Bay Floor	5,120 +/- 510	4,670 +/- 511
VC27	Wk 3887	3	1.10 - 1.15	Organics (Mangrove?)	Estuarine	5,300 +/- 360	5,300 +/- 362

Environmental correction 450 +/- 35 years (Gillespie and Polach, 1976)

4.4 Cape Direction to Cape Flattery

The final section of the CYPLUS study area described here extends from Cape Direction to Cape Flattery and includes the relatively protected waters of Princess Charlotte Bay and the more exposed coast between Cape Melville and Cape Flattery (Fig. 4.37). In view of the previous investigations conducted in Princess Charlotte Bay (reviewed in Section 2), much of the survey data was collected in Bathurst Bay and between Cape Melville and Cape Flattery.

Bedrock outcrops dominate the Bathurst Bay coast between Bathurst Head and Cape Melville (Fig. 4.37). Small barrier systems infill bedrock embayments in the east and west while several prograded barrier systems with broad intertidal backbarrier flats occur along the central portion of the bay. To the south of Cape Melville the coast consists of a series of bedrock embayments infilled to varying degrees by late Quaternary terrestrial, aeolian, estuarine and marine deposits (Fig. 4.37). Sections of coast exposed to the prevailing southeast wind and wave climate are characterised by extensive aeolian plains and high energy shorefaces with pronounced northward littoral drift. Low energy intertidal flats and mangroves occur in protected sections of coast in the lee of bedrock headlands.

4.4.1 Bathymetry and Surficial Sea Bed Sediments

The sea floor in Bathurst Bay slopes gently offshore at a gradient of less than 1m per kilometre (0.05°). South of Cape Melville sea bed slopes increase to around 0.1°, reaching a maximum of 0.7° off major coastal promontories such as Cape Flattery where water depths of 25m occur within 2km of the coast. Sea bed sediments range from gravelly shelly muds to sandy muds in the protected waters of Bathurst Bay to gravelly shelly sands on more exposed sections of the shelf south of Cape Melville. The coarsest sea bed sediments (shelly sandy gravels) occur in water depths greater than 20m east of Cape Flattery. Nearshore terraces and associated submerged spits attached to bedrock headlands are common south of Red Point (Fig. 4.37).

Surficial sediment textures and composition are summarised for Bathurst Bay (Bathurst Head to Cape Melville) in Figures 4.38 and 4.39 and Cape Melville to Cape Flattery in Figures 4.40 to 4.41. A ternary plot of Gravel:Sand:Mud proportions in samples from Bathurst Bay shows a limited range of textures (sandy muds and muds) consistent with the low energy bay floor environment (Fig. 4.38). The proportion of mud in the bay floor sediments increases with water depth while carbonate shows the reverse trend. The sea bed between Cape Melville and Cape Flattery is characterised by a range of sediment textures from muds through to gravels (Fig. 4.40) consistent with the low and high energy environments encountered on this section of the shelf. The proportions of gravel, mud and carbonate all show a positive correlation with increasing water depth (Fig. 4.40).

Analyses of the sand grainsize distributions for the two areas are shown in Figures 4.39 and 4.41.

The limited number of samples from Bathurst Bay (n=4) show that the sands are typically poorly sorted and polymodal (1.0Phi and 3.0Phi modes). Sands between Cape Melville and Cape Flattery show a wide range of sorting (well sorted to poorly sorted) and modal grainsizes (coarse to very fine sand) with a weak trend towards finer and better sorted sands inshore and coarser and more poorly sorted sands offshore (Fig. 4.41).

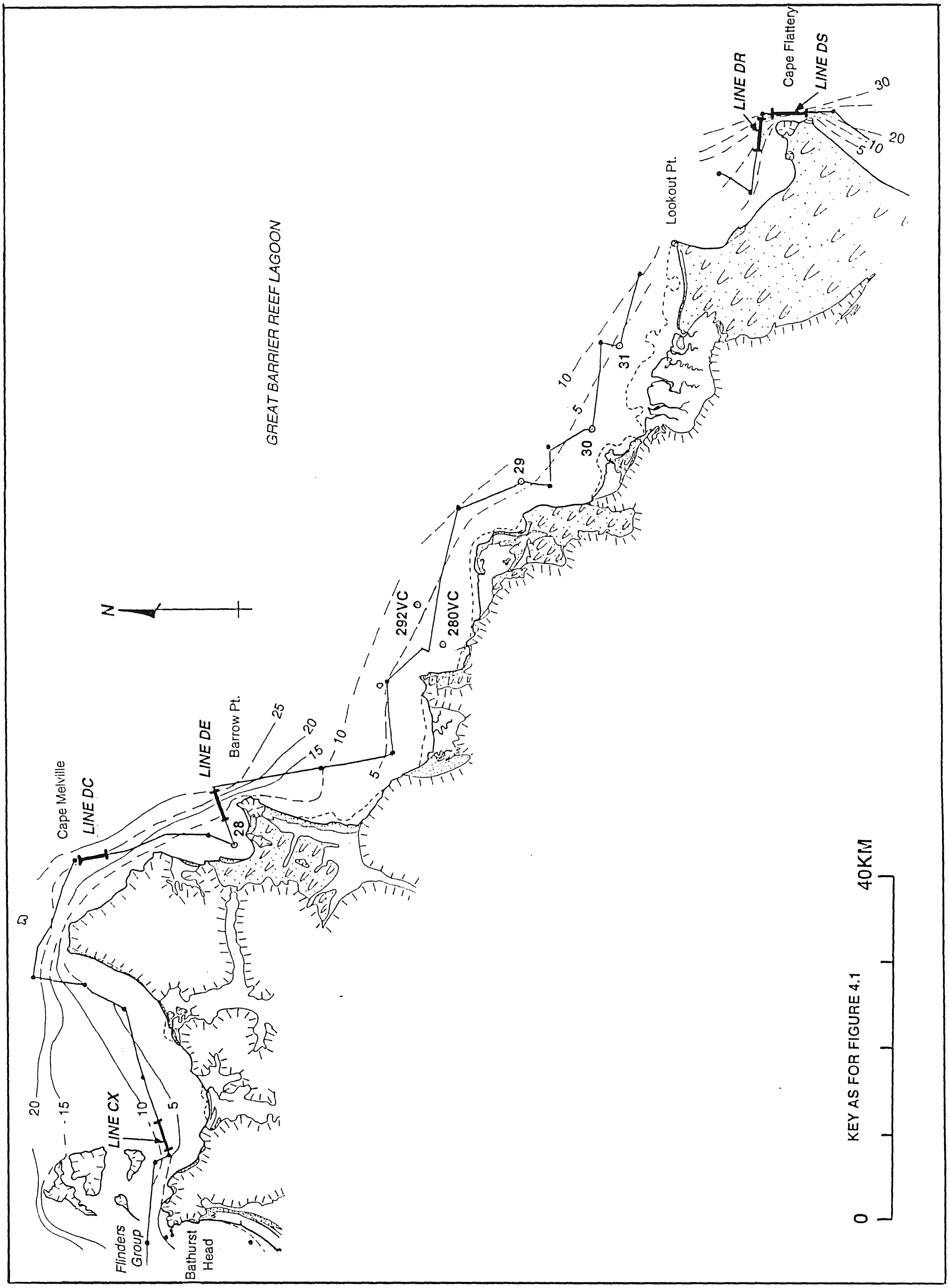


Figure 4.37 Cape Melville to Cape Flattery. Figure shows generalised bathymetry, survey tracklines, grab and vibrocore locations. Highlighted sections of tracklines discussed in text. Onshore geology from AGSO coastal mapping program.

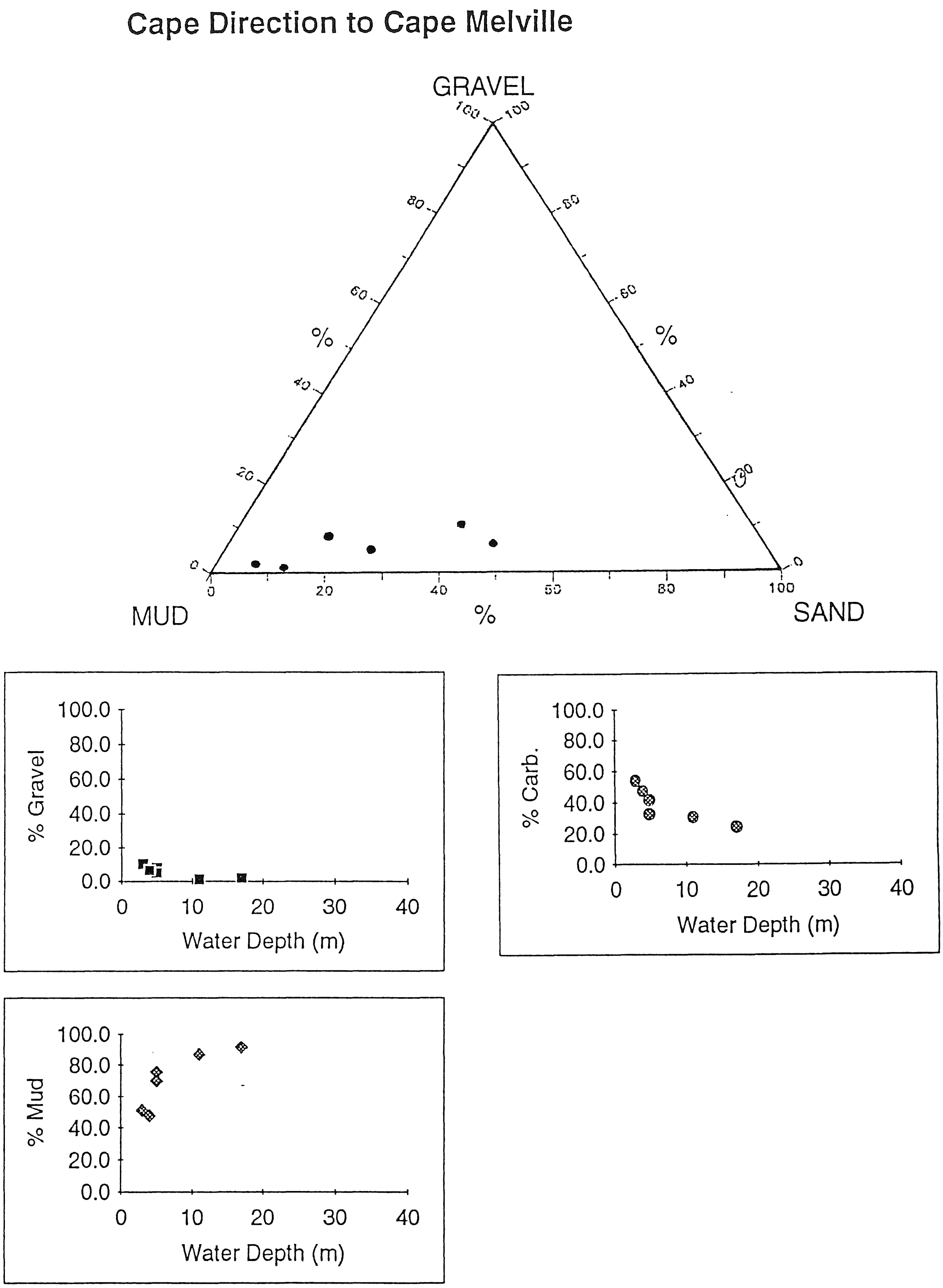


Figure 4.38 Textural characteristics of surficial sea bed sediments - Bathurst Bay, west of Cape Melville.

Cape Direction to Cape Melville

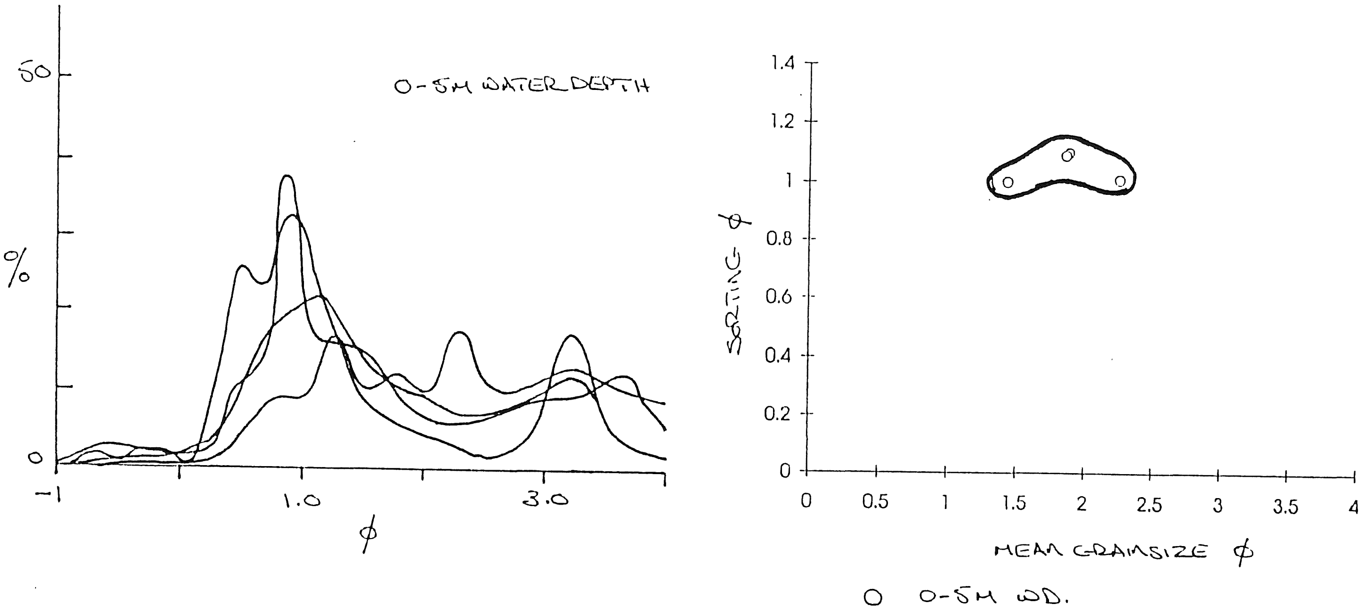


Figure 4.39 Sand grainsize distributions and sorting for surficial sea bed sediments Bathurst Bay, west of Cape Melville.

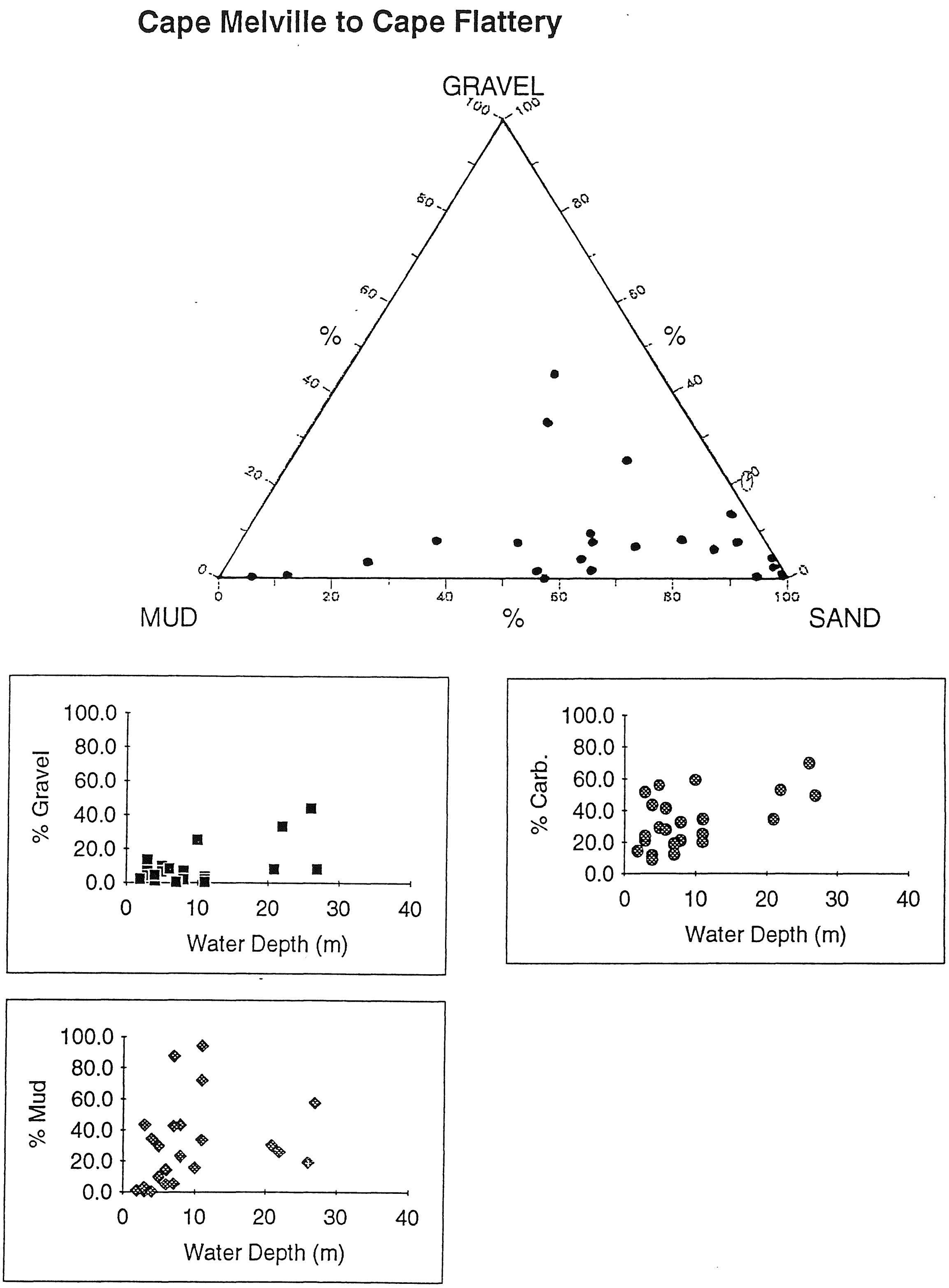


Figure 4.40 Textural characteristics of surficial sea bed sediments - Cape Melville to Cape Flattery.

Cape Melville to Cape Flattery

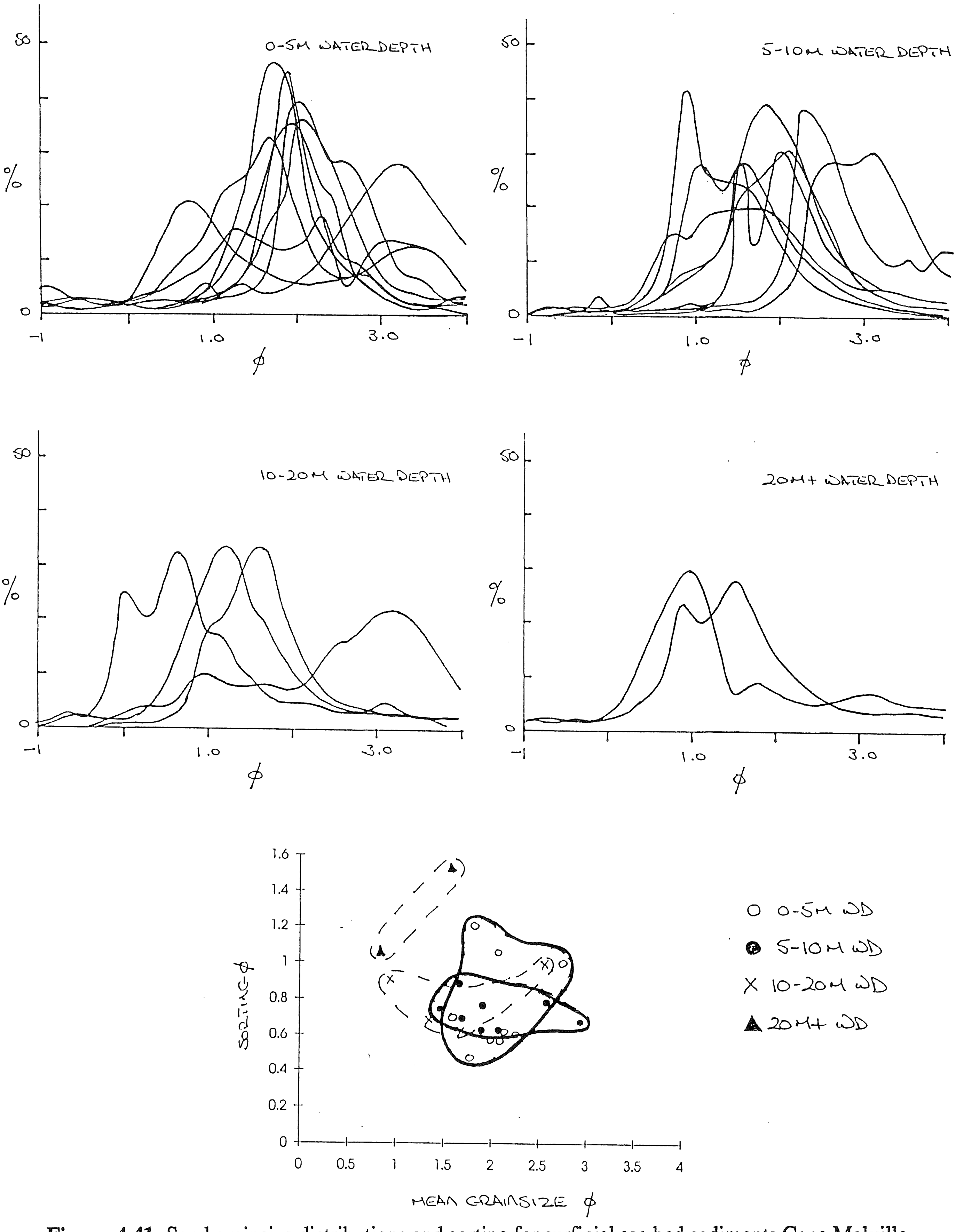


Figure 4.41 Sand grainsize distributions and sorting for surficial sea bed sediments Cape Melville to Cape Flattery.

4.4.2 Seismic and Side Scan Sonar Data

The distribution of seismic and side scan sonar tracklines is indicated in Figure 4.37 and selected examples are shown in Figures 4.42 to 4.46. The seismic data show the Bathurst Bay shelf to be underlain by a channelled seismic unit which thickens towards the central part of the embayment, a pattern consistent with the onshore distribution of present day river channels (Figs. 4.37 and 4.42). Channel-like features incised to a depth of 20m below sea level while the underlying substrate is composed of regular sub-horizontal reflectors. East of Cape Melville the seismic character of the shelf changes and the sea floor consists of a relatively thin (less than 5m thick) surficial unit overlying an irregular subsurface reflector tentatively identified as the pre-Holocene land surface (Fig. 4.43).

The relationship of the pre-Holocene surface to the present day sea bed is clearer in seismic sections to the south Cape Melville. A shore normal line near Barrow Point shows thickening of a surficial seismic unit inshore of the 20m isobath above a well defined subsurface reflector (Fig. 4.44). The prominent subsurface reflector, presumed to represent the pre-Holocene surface, occurs in the shallow subsurface inshore and dips gently seaward where it appears to crop out on the seabed at the toe of the sediment wedge in 15m to 20m water depth. The upper seismic unit forms a 10m thick wedge, or terrace, above the pre-Holocene surface (Fig. 4.44). A similar seismic stratigraphy occurs east of Cape Flattery in the southern part of the area (Fig. 4.45). Here, the surficial sediment wedge is up to 25m thick and extends offshore into water depths of around 25m. The wedge overlies a prominent subsurface reflector (pre-Holocene surface) which shallowly underlies the sea bed further offshore (Fig. 4.45). East of Cape Flattery the pre-Holocene surface is channelled and onlaps the bedrock basement (Fig. 4.46).

The formation of the sublittoral sand platforms, or terraces, appears to be related to contemporary littoral processes (see previous discussion). The location of submerged spits at the northern ends of a number of the nearshore terraces between Cape Flattery and Barrow Point indicates that shoreface sediments transported northward by the prevailing southerly wave climate are currently being deposited in relatively deep water on the inner shelf in the form of submerged, headland-attached spits. Formation of the spits results in shoaling of the sea bed around the headland which facilitates littoral bypassing. Satellite imagery and aerial photography of Cape Flattery show a pronounced submerged spit-like feature extending northwest of the Cape in 5m to 10m water depth. Cores of these features are required to confirm if they have formed during the late Holocene by the offshore accumulation of shoreface sediments or whether they have a complex stratigraphy (ie. older transgressive and *in situ* deposits at depth) indicative of a different mode of evolution.

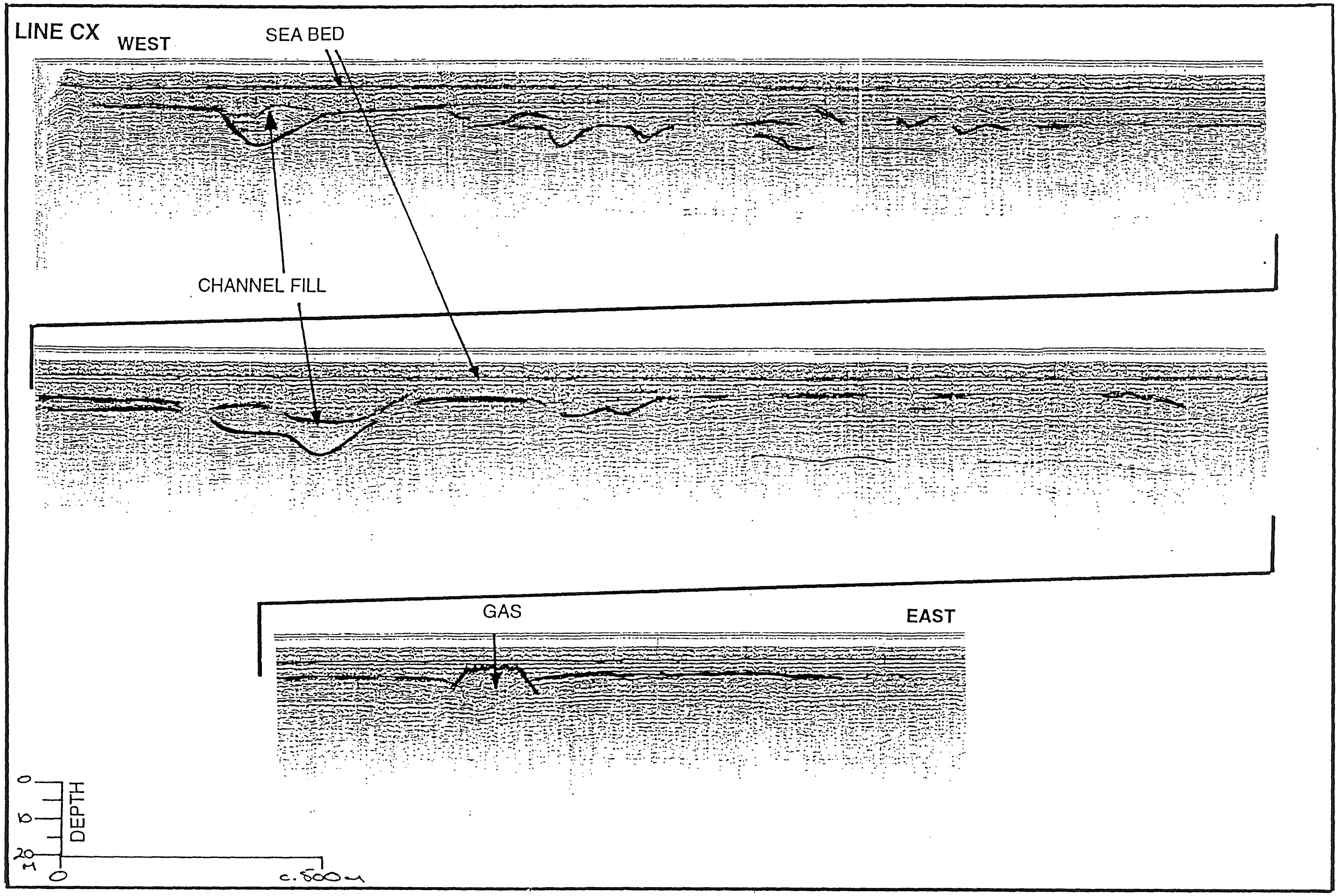


Figure 4.42 Shore parallel seismic section across Bathurst Bay (Line CX, Figure 4.37). Section shows channelled seismic sequence underlying more recent bay floor sediments. See text for discussion.

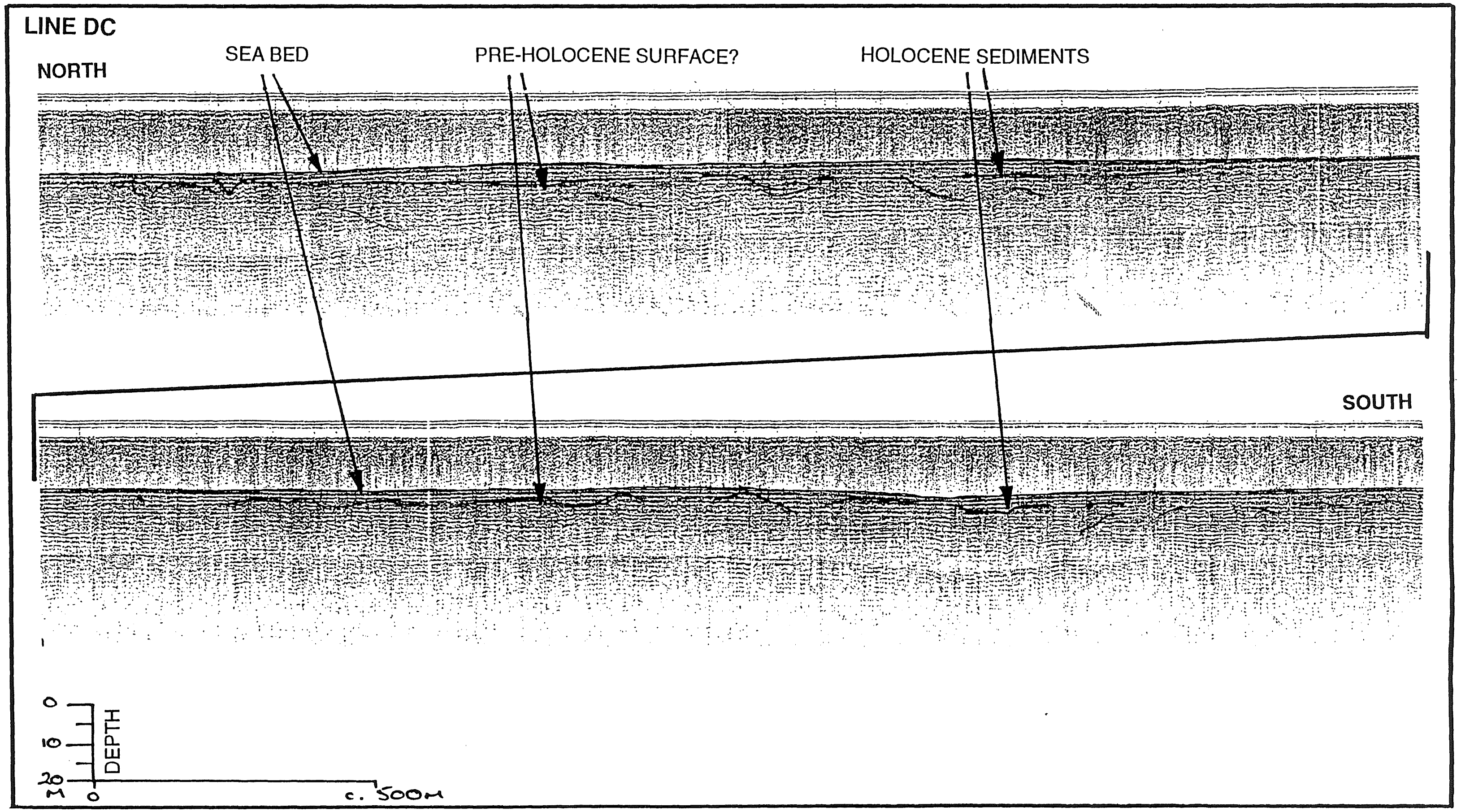


Figure 4.43 Shore parallel seismic section east of Cape Melville (Line DC, Figure 4.37). Section shows relatively thin Holocene sequence above channelled pre-Holocene surface on inner shelf east of Cape. See text for discussion.

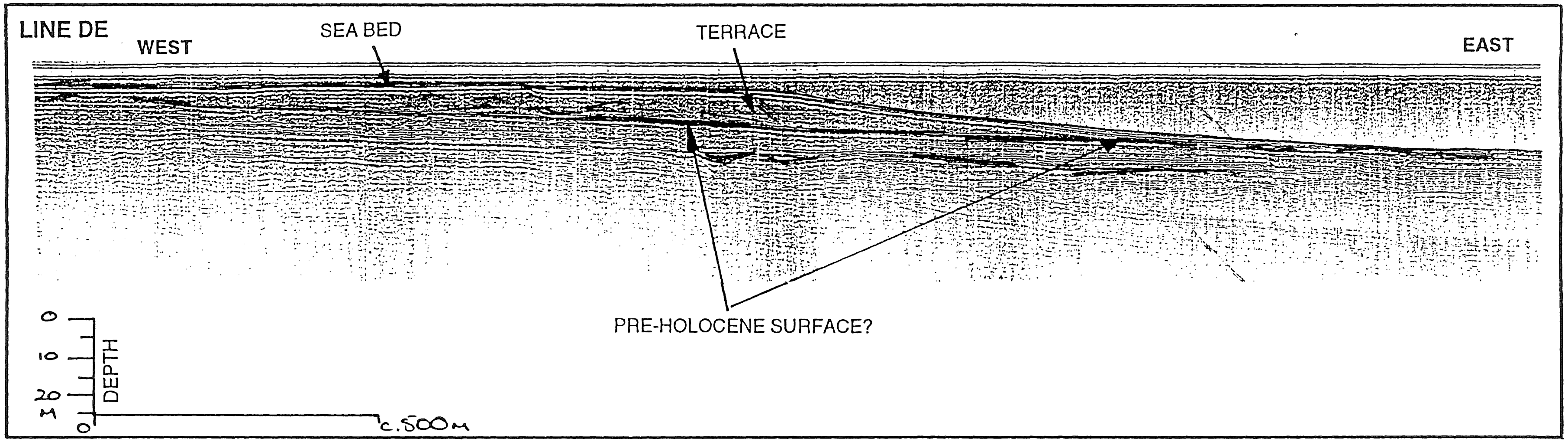


Figure 4.44 Shore normal seismic section north of Barrow Point (Line DE, Figure 4.37). Section shows well developed terrace-like feature extending offshore from coast and grading seaward to the inner shelf. Clearly defined flat-lying subsurface reflector occurs in the shallow subsurface on the inner shelf. See text for discussion.

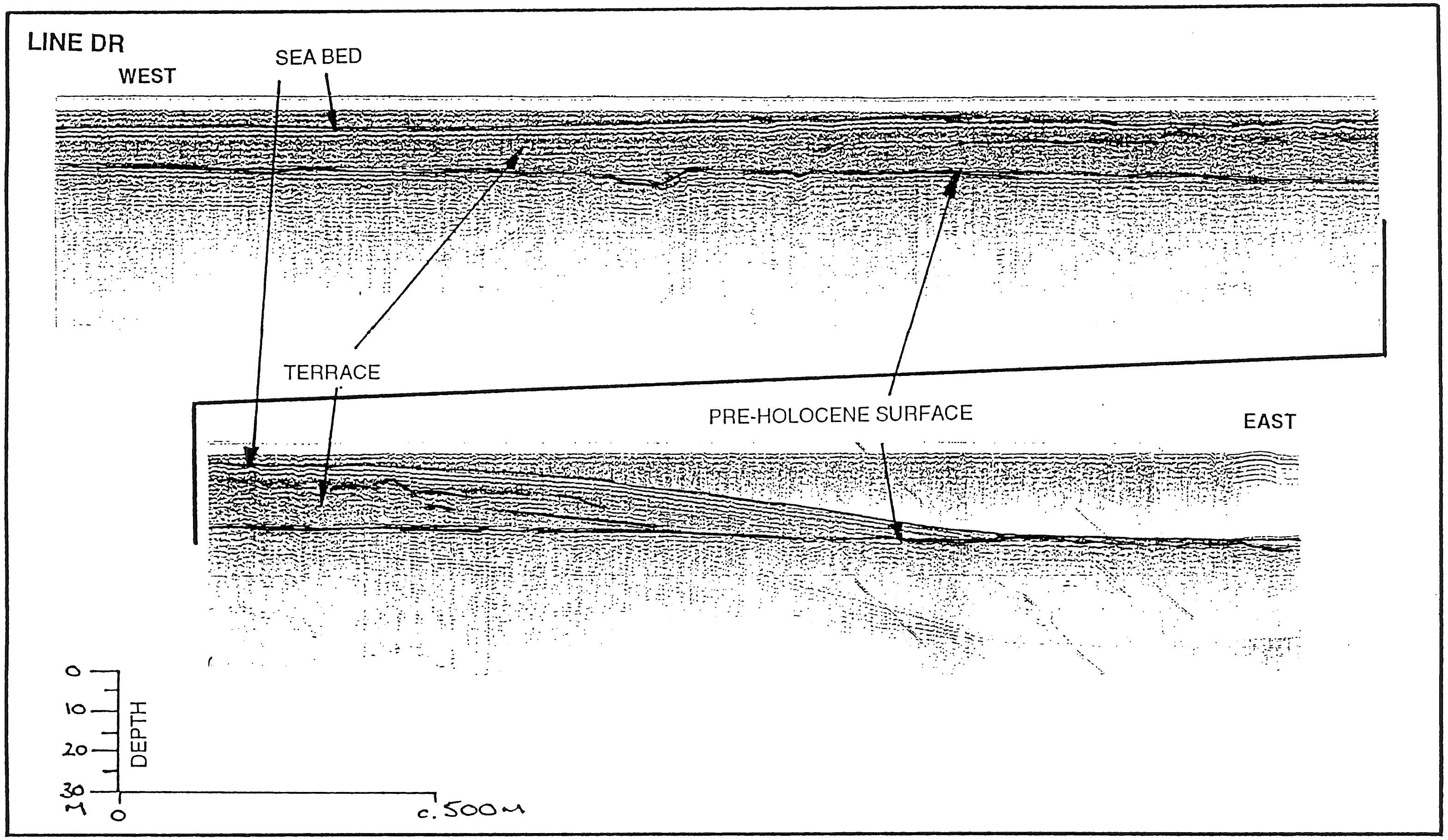


Figure 4.45 Shore normal seismic section north of Cape Flattery (Line DR, Figure 4.37). Section shows well developed terrace-like extending into relatively deep water (c.25m) seaward of the Cape. Satellite imagery indicates connection between terrace and submerged spit in vicinity of Cape Flattery. Clearly defined flat-lying subsurface reflector occurs beneath the terrace and in the shallow subsurface on the inner shelf. See text for discussion.

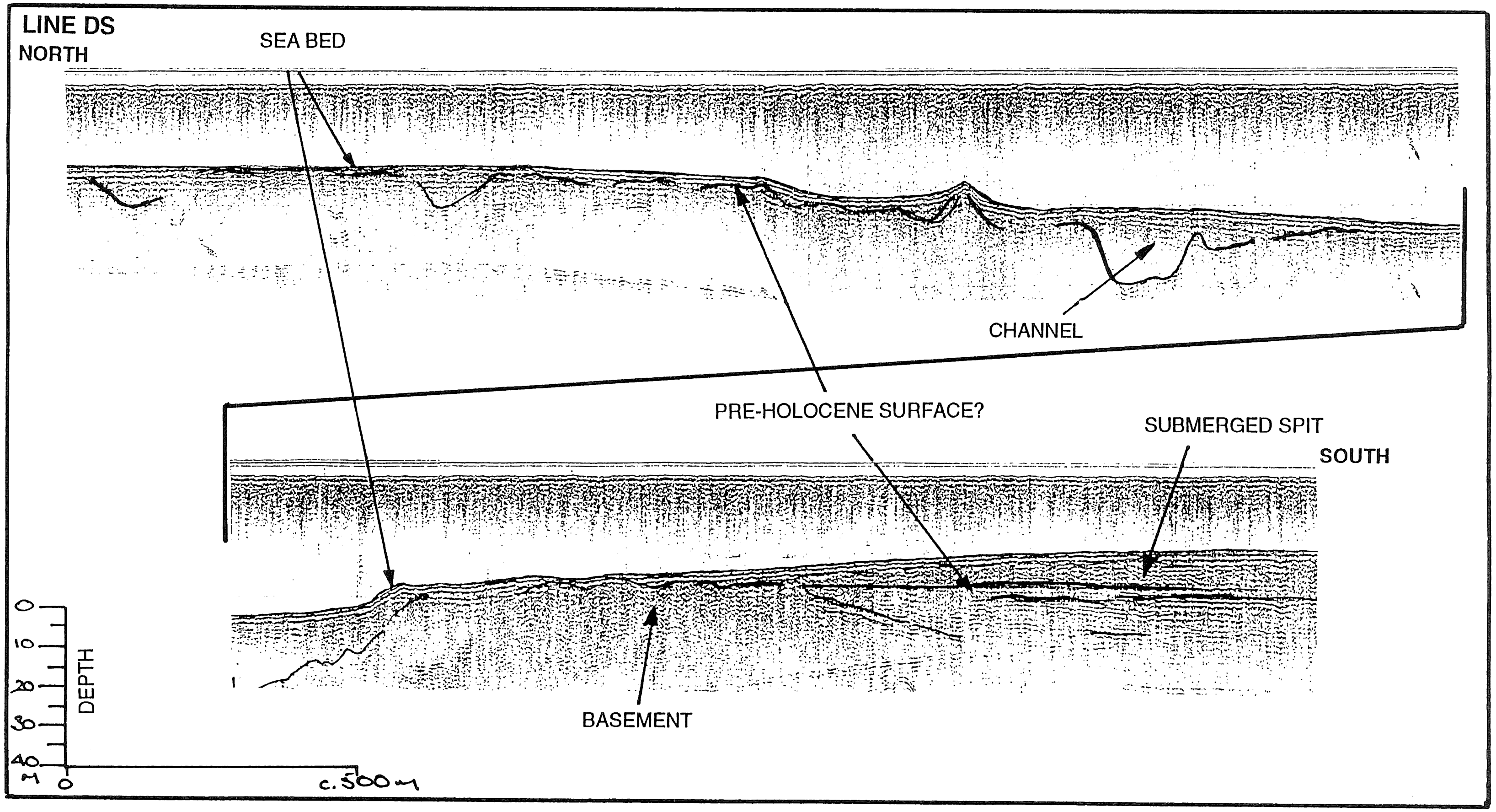


Figure 4.46 Shore parallel seismic section east of Cape Flattery (Line DS, Figure 4.37). Section shows irregular, channelled in places, substrate and basement in the shallow subsurface. Line intersects seaward toe of interpreted submerged spit which extends northwest of the Cape. See text for discussion.

4.4.3 Vibrocores

A total of 5 cores was recovered from 6 sites on the sea bed between Cape Melville and Cape Flattery. Cores were collected inshore of Barrow Point (VC#28) and in water depths of 5m to 10m between Barrow Point and Lookout Point (292VC, 280VC, VC#29, VC#30) (Fig. 4.37). Core recoveries varied from 0.25m to 3.64m and averaged 1.97m. Graphic core logs and a summary stratigraphic section are shown in Figures 4.47 and 4.48.

Embayments protected from the prevailing southeast wind/wave climate between Cape Melville and Cape Flattery are characterised by low energy shorefaces and muddy nearshore sediments. Core VC#28 drilled in a protected shoreface environment north of Barrow Point encountered around 2m of shelly sandy mud (Fig. 4.47). Cores from exposed sections of shelf contain less mud and consist of shelly sands with common carbonate gravel (VC#29, VC#30; Fig. 4.47). The proximity of the pre-Holocene surface to the sea bed over much of this shelf (seismic data) has been confirmed in a number of cores which encountered a stiff oxidised sandy clay less than 0.7m below the sea bed (VC#29, VC#30; Fig. 4.47).

The variable thickness of sediments above the pre-Holocene surface indicated by the seismic data is confirmed in two cores to the east of Red Point (280VC, 292VC; Fig. 4.48). These cores intersected a Holocene sequence in excess of 3.6m thick comprised of shoreface and inner shelf shelly sands which overlie a moderately well sorted, low carbonate, white quartzose sand unit. The quartzose sand unit is interpreted as an early to mid Holocene transgressive dune unit. The contact between the marine and terrestrial dune facies is marked by shelly gravel which possibly represents a lag deposit produced by the marine transgression (Fig. 4.48). The occurrence of relict dune deposits below contemporary inner shelf and shoreface sediments highlights the potential for preservation of older terrestrial deposits on this exposed section of shelf, raising the possibility that some of the nearshore terraces may have formed around a core of transgressive dune sand.

4.4.4 Radiocarbon Dating

A list of the samples submitted for radiocarbon dating is contained in Table 4.3. Two samples of shell hash from shoreface and inner shelf environments returned radiocarbon ages of 4,830 and 6,300 years Before Present respectively (4,380 and 5,850 years B.P. environmentally corrected). The stratigraphic position of the samples is indicated in the graphic logs (Fig. 4.48). The dates confirm a mid to late Holocene age for the marine facies and, indirectly, a probable early to mid Holocene age for the underlying relict dune unit.

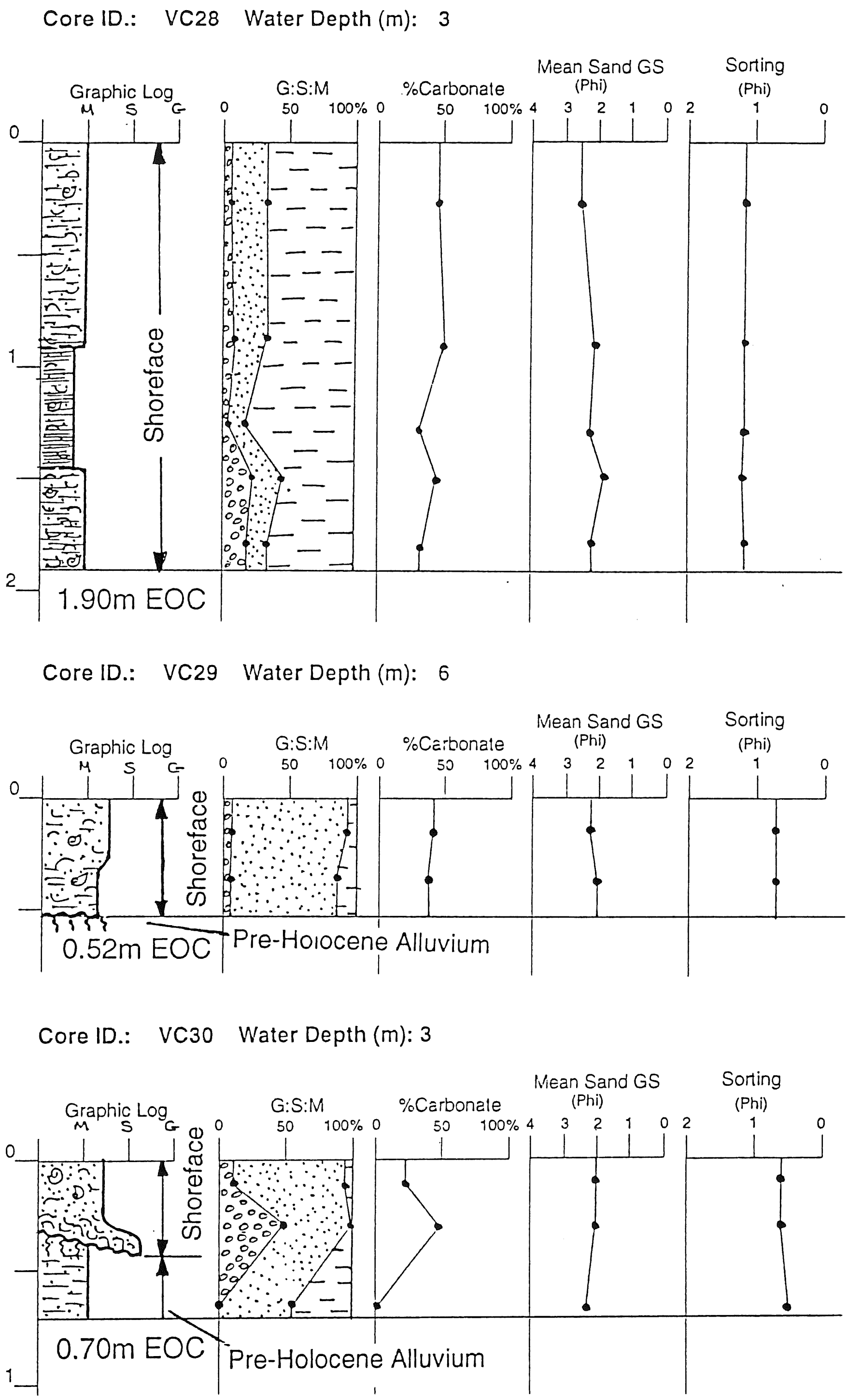


Figure 4.47 Graphic logs for cores collected from selected shoreface environments between Cape Melville and Cape Flattery. See Figure 4.37 for core locations and text for discussion.

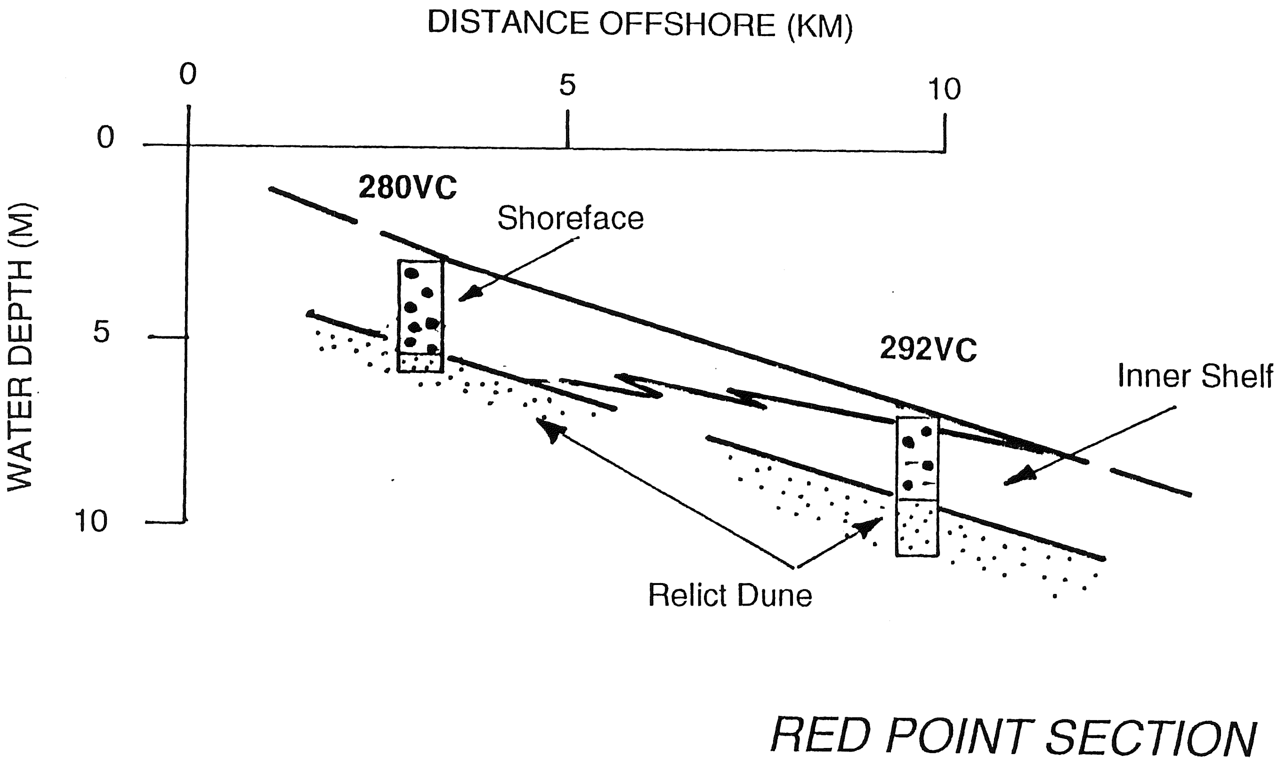
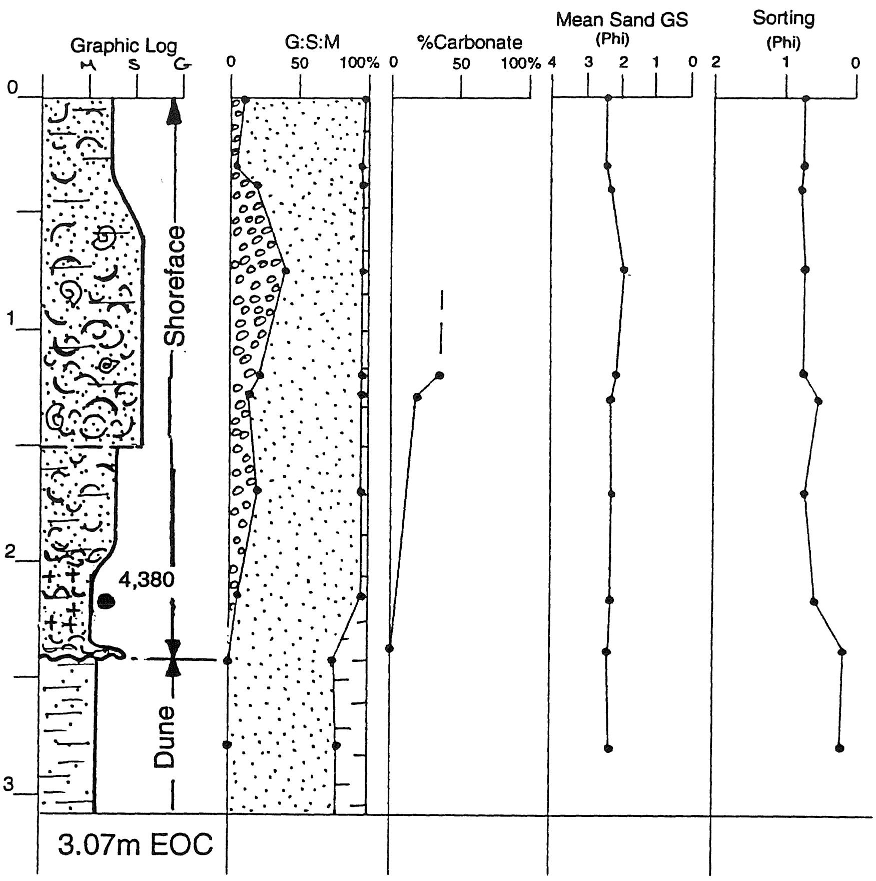


Figure 4.48 Stratigraphic section east of Red Point. Note relict dune unit in shallow subsurface underlying shoreface and inner shelf sediments. Core locations shown in Figure 4.37, graphic logs shown on following pages.

Core ID.: 280VC Water Depth (m): 3



Core ID.: 292VC Water Depth (m): 7

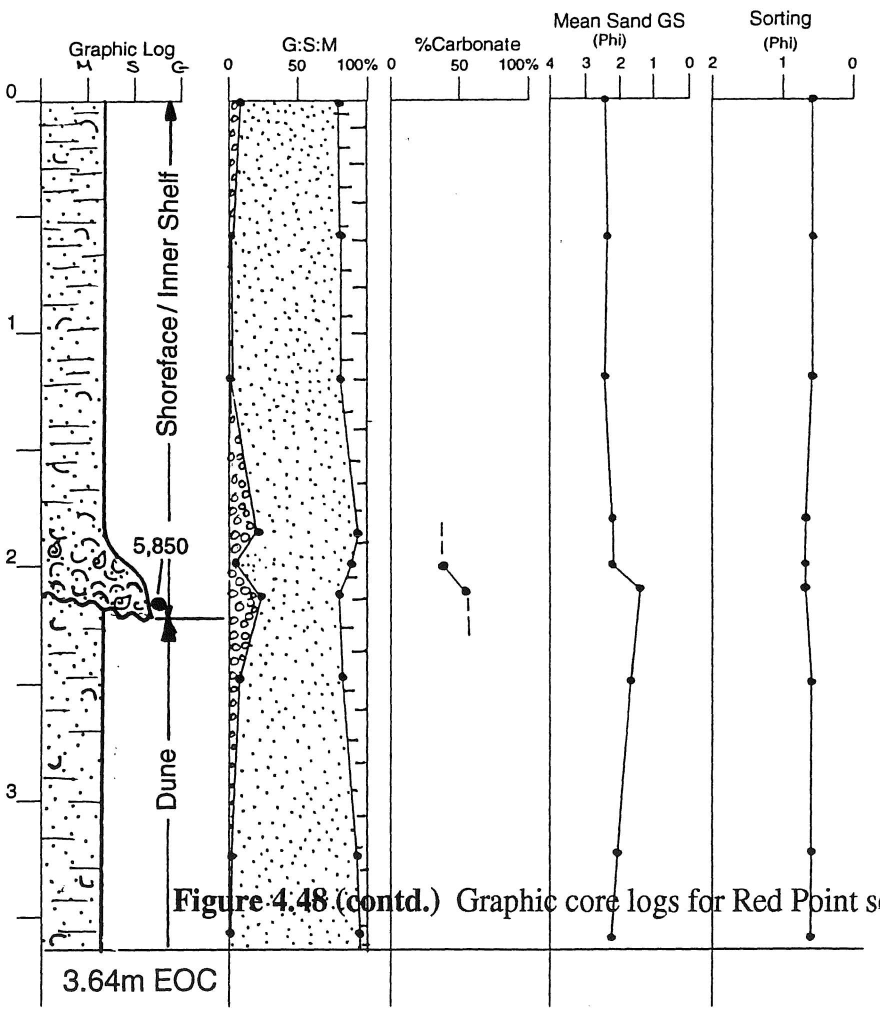


Figure 4.48 (contd.) Graphic core logs for Red Point section.

TABLE 4.3 Radiocarbon Dates - Cape Melville to Cape Flattery

CORE ID	LAB. NO.	WATER DEPTH (M)	SAMPLE INTERVAL(M)	MATERIAL	FACIES	REPORTED C14 AGE	ENVIRON. CORRECTED AGE (yrs. BP)*
280VC	Wk 3874	c.5	2.13 - 2.18	Shell Hash	Shoreface	4,830 +/- 100	4,380 +/- 106
292VC	Wk 3875	c.15	1.90 - 2.00	Shell Hash	Inner Shelf	6,300 +/- 240	5,850 +/- 243

Environmental correction 450 +/- 35 years (Gillespie and Polach, 1976)

5. Discussion

The marine surveys conducted by AGSO in the CYPLUS area have enabled an investigation of both the long-term (Holocene) and contemporary evolution of shoreface and inner shelf environments of the Cape York Peninsula between Weipa and Cooktown. A compilation and review of the various data sets assembled by AGSO (eg. bathymetry, satellite imagery, seismic and sidescan sonar, surficial and subsurface sediment) has confirmed general patterns of regional inner shelf sedimentation published elsewhere (see discussion in Sections 2 and 4) while providing new insights into previously unexamined sections of the Cape York Peninsula shelf. The following discussion reviews the principal findings of the marine surveys and proposes a series of conceptual models highlighting recognisable types of coastal/inner shelf systems in the CYPLUS area.

The original subdivision of the CYPLUS area proposed by Burne and Graham (1995) included the protected waters of the Gulf of Carpentaria, the tidally influenced shelves of Cape York and southern Torres Strait, and the inner shelf of the Great Barrier Reef Lagoon. While it is clear from a review of the available data that there are significant differences between these coastal sectors (Sections 2 and 3), there are some important similarities. The similarities are related to the regional impact late Pleistocene-Holocene sea level changes have had on patterns of marine and terrigenous sedimentation.

A common feature of the Cape York Peninsula shelf is a shallow subsurface seismic reflector which immediately underlies the modern sea bed. The seismic reflector has been identified as the pre-Holocene land surface (Orme et al., 1978a&b; Johnson and Searle, 1984; Jones and Torgersen, 1988; this report) inundated by the postglacial marine transgression. The surface typically occurs with 1m to 2m of the sea bed and consists of a stiff, oxidised, ferruginous clayey sand. The available data suggest that the pre-Holocene surface probably crops out on the sea bed over large areas of the inner shelf seaward of contemporary shoreface deposits.

A sequence of early Holocene transgressive and mid to late Holocene stillstand deposits overlies and infills the pre-Holocene surface. The Holocene sequence generally thins away from the coast and is at it thickest where it infills relict river valleys incised into the pre-Holocene surface. On the Gulf of Carpentaria shelf the relict valleys tend to be broad and shallow (<10m deep), contrasting the more deeply incised valleys on the Great Barrier Reef lagoon shelf (>10m deep). In addition, the seismic data indicate that relict channels on the Great Barrier Reef lagoon shelf appear to contain a series of stacked channel fills, suggesting a long history of valley infilling in response to fluctuating sea levels. Previous investigations of these valley fills have shown that their upper part (limit of vibrocore penetration of around 6m) to consist of estuarine and shallow marine deposits deposited as sea level flooded the exposed shelf during the postglacial marine transgression (Skjold, 1989; Salama, 1990; this report). The best development of the Holocene transgressive valley fill sequences occurs in protected embayments near major coastal rivers (eg. Newcastle Bay, Lloyd bay, Princess Charlotte Bay). Away from these embayments the Holocene sequence rarely exceeds a thickness of 5m and consists of contemporary shoreface and inner shelf sediments overlying either the pre-Holocene land surface or early Holocene transgressive deposits.

A notable exception to the general pattern of a seaward thinning Holocene sediment sequence occurs in the Great Barrier Reef Lagoon where the reef edge comes within 20km of the coast (eg. east of Lloyd Bay). Here, the influence of carbonate as opposed to terrigenous sedimentation is manifest in the thick (25m) accumulations of carbonate sands in the lee of the shelf edge reefs. The carbonate sands have been deposited as bioherms or *in situ* accumulations of carbonate produced by the calcareous algae *Halimeda*. The seismic data show the *Halimeda* banks to have formed above the same pre-Holocene surface identified further inshore and represent mid to late Holocene carbonate deposition following the post glacial marine transgression.

While the influence of carbonate sedimentation near the shelf edge is of interest, the marine surveys reported here have focused on shoreface and inner shelf environments. Proximity to the coast means that these shallow marine environments have/are strongly influenced by terrigenous sediment input, a fact reflected in the high proportions of coarse and fine grained clastic material and relatively low proportions of carbonate in the shoreface sediments. In the Gulf of Carpentaria and Great Barrier Reef Lagoon surficial sediments range from sands and muddy sands on the shoreface to sandy muds and gravels on the inner shelf. Carbonate contents are highly variable and related to the proportions of coarse grained skeletal fragments (eg. molluscs, gastropods, echinoid, forams etc.) incorporated in the sediments. In general, there appears to be a strong gradient in the terrigenous component of surficial marine sediments away from the coast - at a maximum in shoreface deposits and at a minimum on the inner shelf. Investigations of both the Gulf of Carpentaria and Great Barrier Reef Lagoon suggest that very little terrigenous material is deposited on the shelf in water depths beyond 30m (Belperio, 1983; Johnson and Searle, 1984; Jones and Torgersen, 1988). The data reported here supports this conclusion, albeit at a regional level and on the basis of a limited number of samples. There appears to be little evidence for significant transport of coarse <u>and</u> fine grained terrigenous seaward of the inner shelf at present sea level.

A feature of the study area is the thin cover of Holocene sediments over large sections of the inner shelf, particularly away from the transgressive channel-fill sequences described previously. This observation is supported by the common occurrence of relict fluvial gravels and reworked terrestrial dune sands on the inner shelf (Johnson and Searle, 1984; Jones 1986, 1987; Skjold, 1989; this report). While the Holocene sequence is thickest at the coast, it varies between 2m and 0.2m thick over much of the inner shelf (vibrocore data). A similar observation has been made for sections of the Great Barrier Reef Lagoon to the south of the CYPLUS area (Belperio, 1983; Johnson and Searle, 1984). Vibrocores collected by AGSO have identified Holocene shoreface and inner shelf sediments directly overlying either the pre-Holocene land surface or early Holocene terrestrial deposits. The terrestrial deposits consist of moderately well sorted, shell-free, white quartzose sands with common organic fragments (plant remains). The quartz sands are interpreted as aeolian deposits reworked from terrigenous sediments exposed on the shelf at lower sea levels. Radiocarbon dates on organic material contained in these sediments confirms an early Holocene age for these deposits. Shell-free quartzose sands were encountered on the inner shelf in the Gulf of Carpentaria and Great Barrier Reef Lagoon, particularly in areas of significant terrigenous sediment supply during the late Pleistocene and early Holocene (eg. inner shelf west of the Jardine River, inner shelf seaward of the dune coasts between Cape York and Cape Flattery). The apparent widespread occurrence of these deposits indicates the regional significance of aeolian reworking of the exposed shelf at lower sea levels.

The preceding discussion has identified broad similarities in the nature of shoreface and inner shelf deposits throughout the CYPLUS area. While these similarities emphasise regional patterns of terrigenous and marine sedimentation in response to late Pleistocene-Holocene sea level changes, they overlook the different process regimes operating in the shallow coastal waters of the Cape York Peninsula. Using the coastal subdivision proposed by Burne and Graham (1995), it is possible to develop a series of conceptual models outlining patterns of inner shelf sedimentation within the study area. Four models are described in the following paragraphs covering the low energy Gulf of Carpentaria inner shelf, the high energy Endeavour and southern Torres Strait shelf, the low energy protected embayments of the Great Barrier Reef Lagoon, and the high energy exposed coast of the Great Barrier Reef Lagoon. It must be emphasised that the models are speculative and intended to identify salient components of the various inner shelf settings described in Section 4.

The eastern Gulf of Carpentaria coast is characterised by extensive prograded barrier systems of both Holocene and Pleistocene age, tidal inlets infilled with terrigenous sediment, and coastal rivers with highly seasonal discharges and rates of sediment supply. Wave energy is low throughout much of the year except in the summer months when episodic tropical cyclones produce strong onshore winds, storm surges and high energy waves. Sea floor slopes are low and sediments grade from shoreface sands to inner shelf sandy muds and gravels (Fig. 5.1).

The model shown in Figure 5.1 identifies the main surficial sediment units and likely dispersal patterns for terrigenous sediment delivered into shoreface and inner shelf environments. Coarse grained terrigenous sediment is trapped on the shoreface an redistributed alongshore by the prevailing wave climate. Waves eventually move the sediment back onshore where it is incorporated into the prograding barrier systems. The finer terrigenous sediment is deposited within the prograding coastal plain and further offshore, possibly into water depths of up to 20m some 15km from the coast. A thin layer of shelly inner shelf sediments superficially overlies the pre-Holocene land surface. Reworked fluvial gravels occur where the pre-Holocene surface either crops out or shallowly underlies the sea bed. Relict river channels incised into the pre-Holocene surface are infilled with shallow marine and estuarine deposits formed when the shelf was inundated during the postglacial marine transgression.

Under conditions of a stable sea level and continued terrigenous sedimentation, the coast will continue to prograde seaward as the advancing wedge of shoreface sediments blankets inner shelf deposits and areas of exposed pre-Holocene substrate. The deposition of fine and coarse grained terrigenous sediments on the inner shelf is facilitated by the relatively rapid rates of coastal progradation and low wave energy environment.

Endeavour Strait and southern Torres Strait are located west of Cape York at the northeastern entrance to the Gulf of Carpentaria. The shelf is influenced by strong tidal currents flowing between the Australian mainland and a series of offshore islands and reefs. The coast consists of small bedrock embayments in the east and a prograded barrier coast in the west, particularly west of the Jardine River entrance. Bedrock outcrops are common on the sea bed in the east, while sandwaves associated with extensive submarine tidal shoals occur in the west. The model shown in Figure 5.2 focuses on the coast and shelf in the vicinity of the Jardine River near the western entrance of Endeavour Strait.

Sediment delivered to the coast by the Jardine River is swept alongshore and to the west by the prevailing tidal currents. The tidal regime creates a clear separation of the shoreface and inner shelf environments wherein terrigenous sediments (coarse and fine) are held close to the coast and prevented from being dispersed further seawards onto the inner shelf. As a consequence, inner shelf sediments are relatively thin and consist of a lag of reworked coarse grained carbonate sands and gravels. The shoreface and inner shelf are characterised by a suite of features indicating pronounced alongshore sediment dispersal to the west (eg. shore-connected sand spits, asymmetric bedforms up 4m high, megaripples) with bedforms best developed in water depths of around 5m on the shoreface. Tidal currents are effective in preventing any significant longshore dispersal of sediments to the east. The long term effect of the prevailing tidal regime has been to redistribute large volumes of terrigenous sediment to the west, providing material for the formation of extensive tidal shoals, sand islands, and prograded barrier systems (Fig. 5.2). Contemporary patterns of terrigenous sedimentation and tidal reworking on the shelf in the vicinity of the Jardine River entrance will produce further coastal progradation to the west and, ultimately, connection with the mainland of sand islands formed around submerged sand spits (eg. Crab Island).

Vibrocore and surface sediment data from the shelf to the west of Endeavour Strait suggest the presence of a source of quartzose rather than carbonate sediments for many of the tidal shoals. This pattern presumably reflects the influence of the Jardine River which must have delivered significant volumes of terrigenous sediment to the inner shelf at lower sea levels. A complex scenario of sediment delivery, dispersal and reworking is likely to have characterised marine and terrigenous sedimentation in the Strait in response to sea level changes throughout the late Quaternary.

Two types of clastic dominated depositional environments are recognised in the Great Barrier Reef

Lagoon, primarily on the basis of exposure to the prevailing southeast wind and wave climate. The first of these is the protected embayment setting (Fig. 5.3), examples of which include Newcastle, Lloyd and Princess Charlotte Bays. These north-facing embayments typically occupy structural depressions at the entrance to major coastal rivers and are characterised by low wave energy and high rates of terrigenous sediment supply. The embayments contain prograded coastal plains comprised of cheniers and beach ridges and broad, mangrove-fringed tidal inlets. Sea bed slopes are low with muddy shoreface sediments (muddy sands and sandy muds) grading offshore to shelly bay floor sandy muds. Seaward of the embayment, the more exposed sections of the inner shelf are mantled by reworked fluvial and aeolian deposits (Fig. 5.3). A wedge of late Holocene terrigenous sediments extends offshore from the coast, blanketing early Holocene channel-fill sequences containing transgressive estuarine (mangrove peats) and shallow marine deposits. Coastal progradation is facilitated by the accumulation of large volumes of fine grained terrigenous sediment on the bay floor within the protected waters of the embayments.

Sections of coast exposed to the persistent southeast wave and wind climate differ from the protected embayments in terms of their onshore geomorphology, inner shelf sediments, and shallow seismic stratigraphy (Fig. 5.4). These coasts consist of extensive transgressive dune fields produced by the persistent southeast wind climate, sandy shorefaces with strong northward littoral drift in response to the prevailing southeast wave climate, and an inner shelf characterised by a thin sequence of shelly muddy sands overlying the pre-Holocene land surface (Fig. 5.4).

The dunefields consist of white quartz sands derived from local lithologies (eg. granites and sandstones). Multiple phases of dune instability are preserved within the dunefields and dating of relict land surfaces indicates that the older dunes are likely to have formed during periods of lower sea level in the late Pleistocene and early Holocene (Lees, 1992; Lees et al., 1995). Remnants of the relict dunefield extend offshore where they are preserved beneath shoreface and inner shelf deposits at a number of locations between Cape Grenville and Cape Flattery.

Terrigenous sediment delivered to the coast is reworked northward by the prevailing wave climate and redeposited in a series of nearshore terraces and submerged sand spits. There is very little evidence for the accumulation of significant volumes of fine or coarse grained terrigenous sediment on the inner shelf seaward of the nearshore terraces. Seismic data suggest that the terraces have been produced by the alongshore and offshore dispersal of littoral sediment at present sea level although some terraces contain a complex internal structure which may indicate a core of older transgressive deposits (?dune) underlies the recent littoral sediments. The terraces occur in 5m water depth and are characterised by numerous bedforms on their upper surface. Submerged sand spits frequently occur offshore of bedrock headlands at the downdrift ends (north) of the terraces. The association of nearshore terraces and submerged spits highlights the efficacy of the southeast wave climate in transporting shoreface sediments alongshore and (possibly) between embayments.

It should be emphasised that the terraces are not a continuous feature of shorefaces along exposed sections of the Great Barrier Reef lagoon coast. Rather, there appears to be sections of the coast where the terraces and submerged spits are well developed and other areas where they are less obvious or even absent. This raises the possibility that there may be a series of discrete littoral compartments wherein sediment supplied to the coast is redistributed to the north to accumulate in shallow nearshore environments and submerged spits at the downdrift end of each system. In view of the uncertainty as to what proportion of the shoreface sediments are derived from contemporary river sources (eg. rivers) or coastal erosion (reworked dune), it is possible that the updrift sections of each littoral system will be characterised by long-term coastal erosion while the down drift ends have stable or prograding coastlines.

The preceding discussion has highlighted similarities and dissimilarities of the various inner shelf settings recognisable within the CYPLUS area. An attempt has been made to relate the marine and onshore data so as to form a generalised overview of how the coastal systems are operating today and are likely to have evolved during the Holocene. Clearly many of the points raised in this discussion are speculative and require confirmation by further field work. Despite these reservations, the conceptual models presented here do provide a starting point for more detailed examinations of specific coastal-inner shelf environments of the Cape York Peninsula.

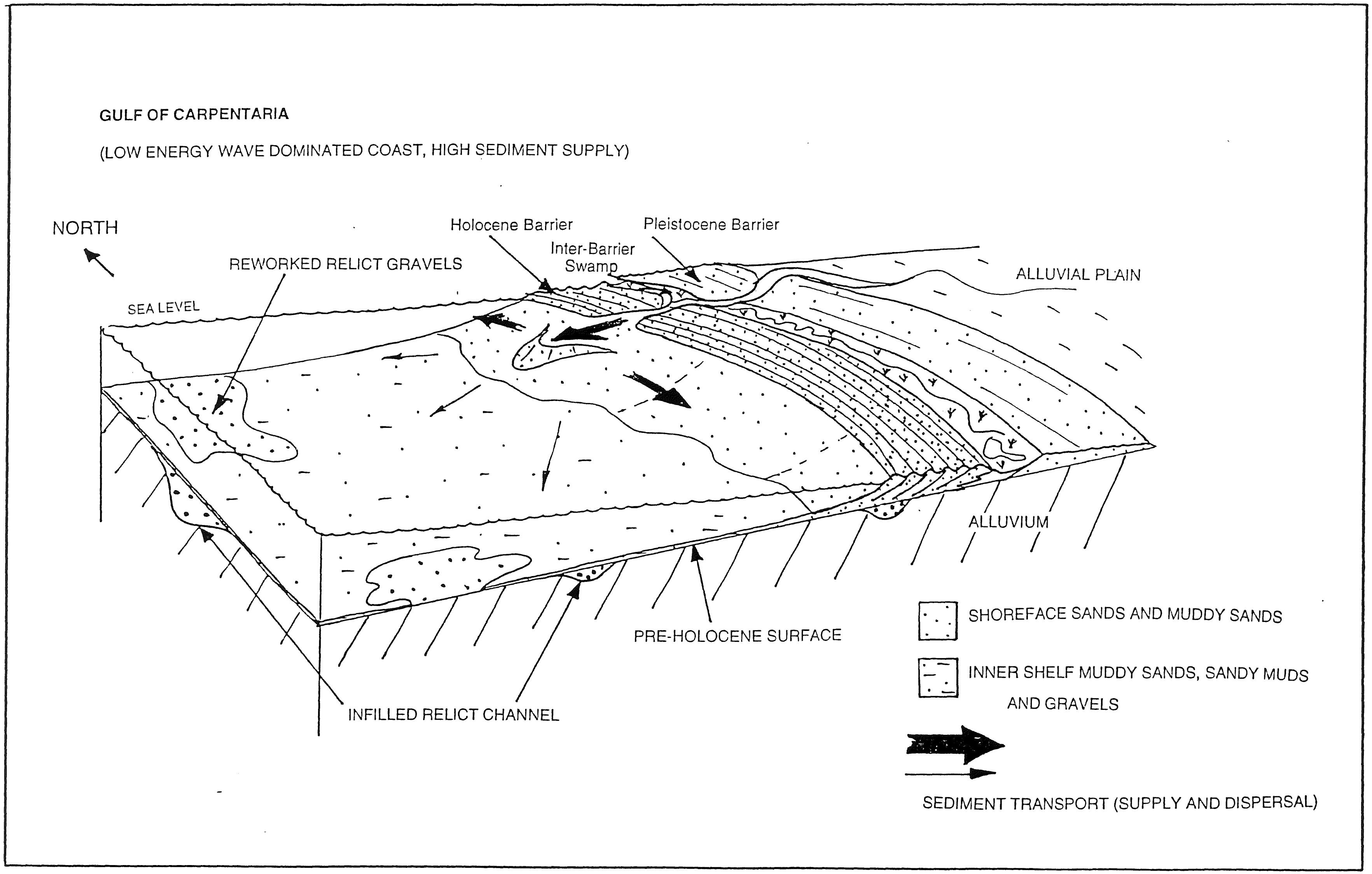


Figure 5.1 Conceptual model of shallow stratigraphy and patterns of contemporary sedimentation on the Gulf of Carpentaria shelf north of Weipa. See text for discussion.

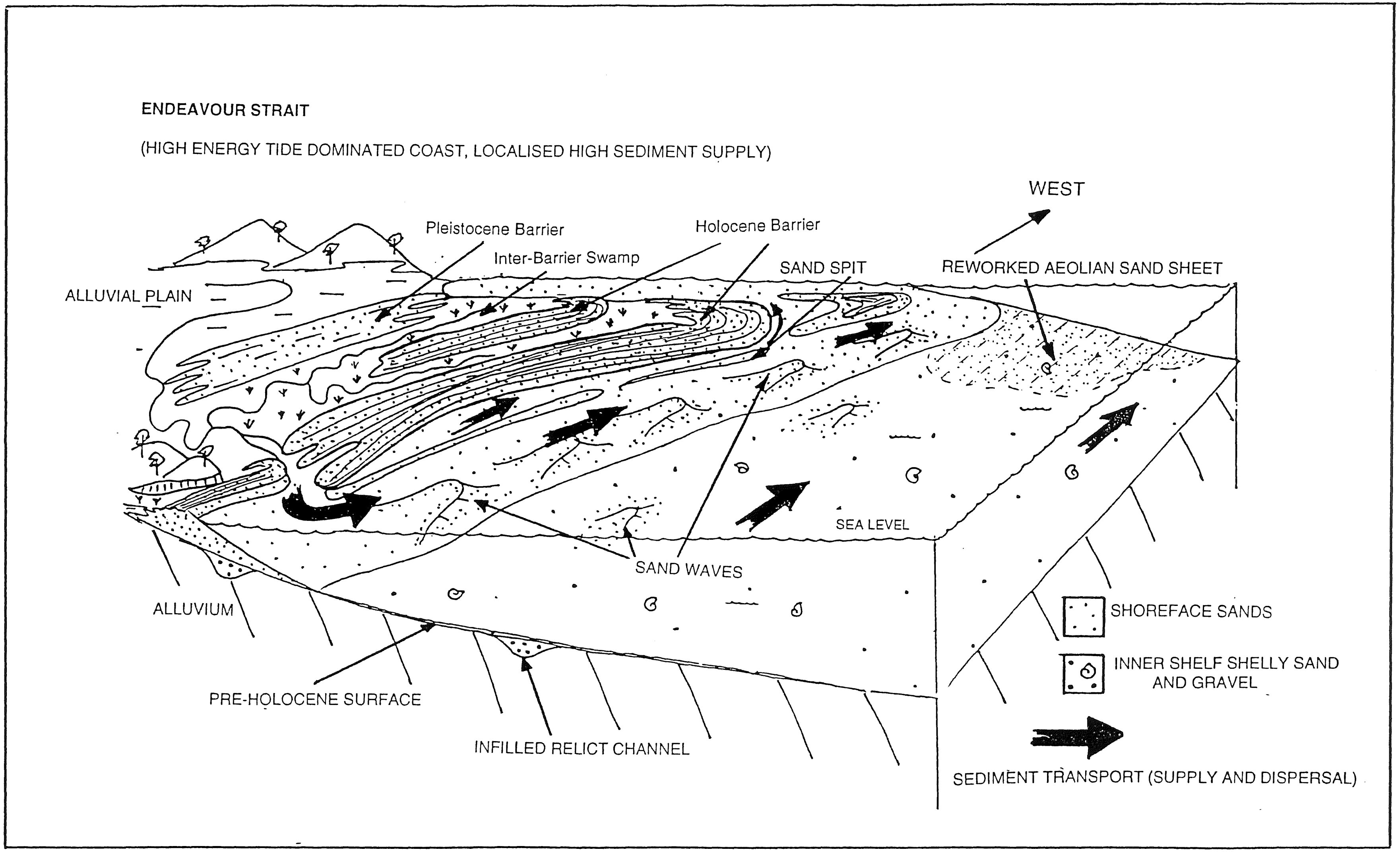


Figure 5.2 Conceptual model of shallow stratigraphy and patterns of contemporary sedimentation on the Endeavour Strait shelf in the vicinity of the Jardine River entrance.See text for discussion.

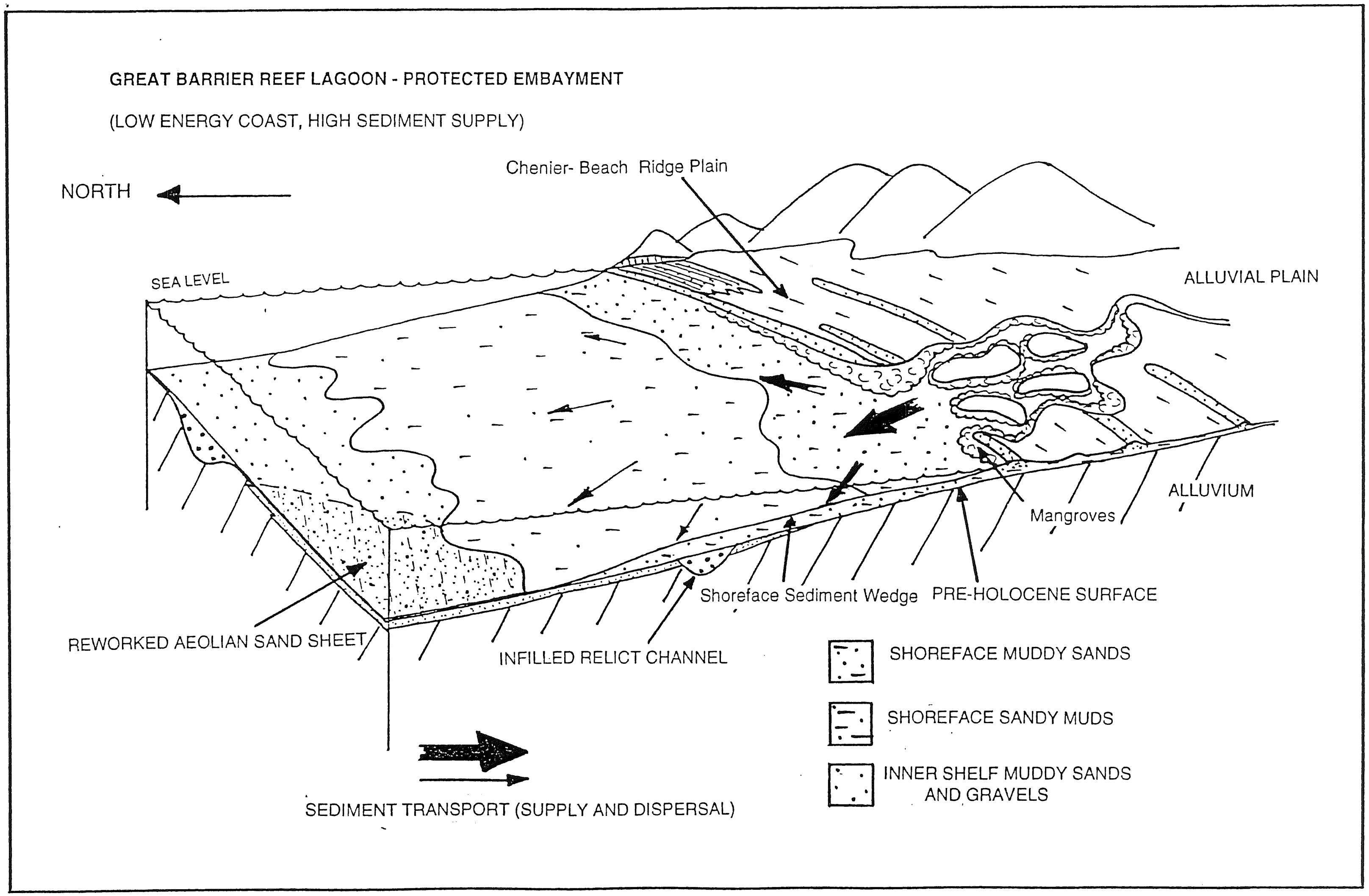


Figure 5.3 Conceptual model of shallow stratigraphy and patterns of contemporary sedimentation in protected embayments on the Great Barrier Lagoon coast. See text for discussion.

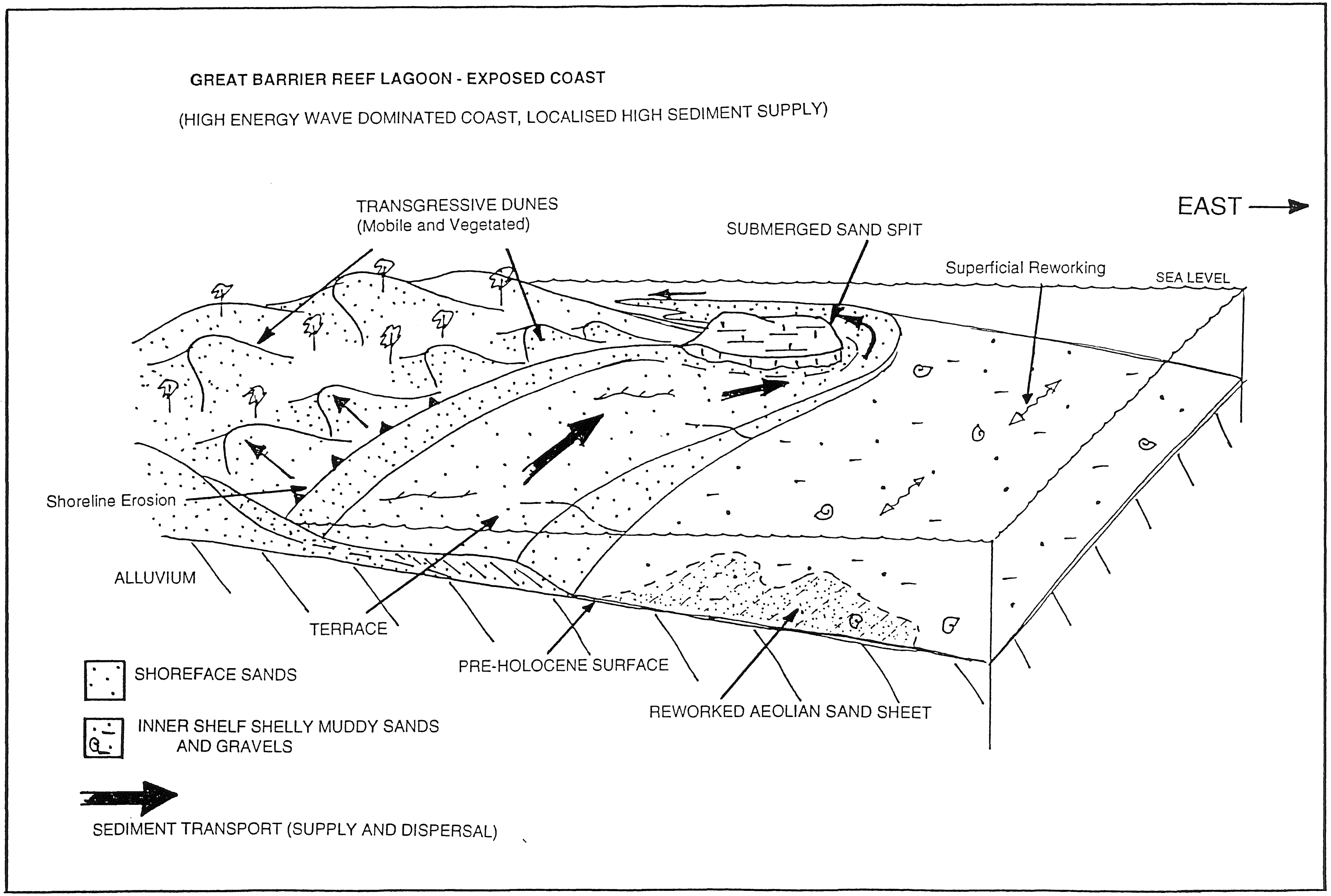


Figure 5.4 Conceptual model of shallow stratigraphy and patterns of contemporary sedimentation on the exposed coast and inner shelf of the Great Barrier Lagoon. See text for discussion.

6. Conclusions

A review of data collected by the Australian Geological Survey Organisation in the shallow coastal waters of the Cape York Peninsula has identified the regional impact late Pleistocene sea level changes have had on the long term evolution of inner shelf environments plus the influence coastal setting and associated process regimes have on contemporary patterns of shoreface and inner shelf sedimentation. The main findings of this study include:

1) A regionally significant flat-lying seismic reflector can be recognised shallowly underlying much of the inner shelf in the Gulf of Carpentaria, Endeavour and southern Torres Straits, and the Great Barrier Reef Lagoon. This reflector is interpreted as the pre-Holocene shelf surface which was exposed during periods of lower sea level in the late Pleistocene and inundated during the early to mid Holocene postglacial marine transgression. Vibrocores which intersected this surface show it typically to be composed of an orange-brown, stiff, ferruginous, sandy clay. Whilst the seismic data indicated that the surface is frequently within 5m of the sea bed, vibrocores clearly demonstrate that the surface is commonly less than 2m below the present day sea bed (ie. beyond the resolution of the Uniboom seismic system). The pre-Holocene surface occurs at a greater depth in the vicinity of relict river valleys which traverse the Gulf of Carpentaria and Great Barrier Reef Lagoon inner shelf. Valley incision appears to have been greatest on the Great Barrier Reef Lagoon shelf.

2) The Holocene sediment sequence is comprised of contemporary inner shelf and shoreface sediments which either directly overlie the pre-Holocene surface or early to mid Holocene transgressive estuarine and relict dune deposits. The age relationships of these units has been confirmed by a series of radiocarbon dates on shell and organic material enclosed within the Holocene sequence. In general, the Holocene sequence forms a seaward thinning wedge of sediment which rarely exceeds 10m thickness and is commonly less than 5m thick in shoreface deposits at the coast. Further seaward, the sediment wedge thins to less than 1m over large areas of the inner shelf. The exception to this trend occurs where relict river valleys are incised into the pre-Holocene surface. In these locations the inferred thickness of the Holocene sequence is of the order of tens of metres, perhaps as thick as 30m. In the absence of any deep drill hole data some caution should be exercised in inferring that the valleys fills are only Holocene in age. Stacking of channel sequences observed in some seismic sections suggests that much older deposits may occur at depth within the valley fills.

3) Regional trends in the thickness and composition of contemporary shoreface and inner shelf deposits suggest that there is limited dispersal of clastic sediments (terrigenous sand and mud) across the inner shelf. A seaward decrease in the terrigenous component of shoreface and inner shelf sediments is observed in the Gulf of Carpentaria and Great Barrier Reef Lagoon. Furthermore, the influence of relict deposits (eg. quartzose dune deposits) beneath the sea bed on the composition of inner shelf sediments has been noted in the Gulf of Carpentaria and Great Barrier Reef Lagoon, emphasising the apparently low rates of contemporary inner shelf sedimentation.

4) Coastal waters of the Cape York Peninsula can be subdivided into at least four distinct zones based on the balance between marine wave/tidal energies and terrigenous sediment supply. These zones include:

- -Eastern Gulf of Carpentaria north of Weipa (low wave energy, high terrigenous sediment supply).
- -Endeavour and southern Torres Strait (high tidal energy, localised high terrigenous sediment supply).
- -Great Barrier Reef Lagoon protected embayment (low wave energy, high terrigenous sediment supply).
- -Great Barrier Reef Lagoon exposed coast (high wave energy, localised high terrigenous sediment input).

Models of contemporary sedimentation proposed for each of these zones (Section 5) reflect the efficacy of the marine environment in dispersing river sediments delivered to the coast and inner shelf. In high energy settings such as the Endeavour Strait and exposed Great Barrier Reef Lagoon coast there appears to be limited dispersal of terrigenous sediment across the shoreface and onto the adjacent inner shelf. In these locations much of the sediment is transported alongshore by the prevailing wave/tidal currents and redeposited within the prograding coastal plain. Lower energy settings such as occur in the eastern Gulf of Carpentaria and protected embayments of the Great Barrier Reef Lagoon allow for greater offshore dispersal of river sediments. Inner shelf and bayfloor deposits in these locations are characterised by relatively high proportions of terrigenous muds.

The conclusions listed above are based on reconnaissance surveys of a remote section of the northern Australian shelf which prior to the AGSO surveys in 1992 and 1993 remained largely uncharted and bereft of detailed sea bed information. While the results reported here go some way to improving our understanding of the Cape York Peninsula inner shelf they must be viewed as preliminary and requiring confirmation. Confirmation can only come through further surveys.

Additional surveys of representative sections of the Cape York Peninsula shelf are recommended. The surveys should incorporate a similar suite of procedures to those used previously but with an emphasis on establishing the relationships between shoreface and inner shelf environments. Offshore surveys should be linked to work onshore (eg. drilling and dating of coastal sequences, coastal mapping etc.) in an attempt to determine modes and rates of coastal evolution and how these in turn influence nearshore environments. Sensible management options for the coast and shallow coastal waters of the Cape York Peninsula must await the collection of this fundamental data.

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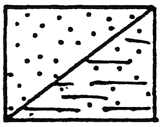
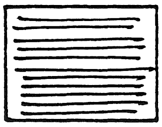
8. APPENDIX

APPENDIX A: GRAPHIC CORE LOGS

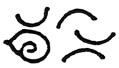
GRAPHIC LOGS KEY


SAND / MUDDY SAND to SANDY MUD


MUD


SUBAERIALLY WEATHERED SURFACE


LITHIC FRAGMENTS (GRAVEL SIZED)


SHELL AND SHELL FRAGMENTS
(Dom. mollusc and gastropods - GRAVEL SIZED)


MUD CLAST

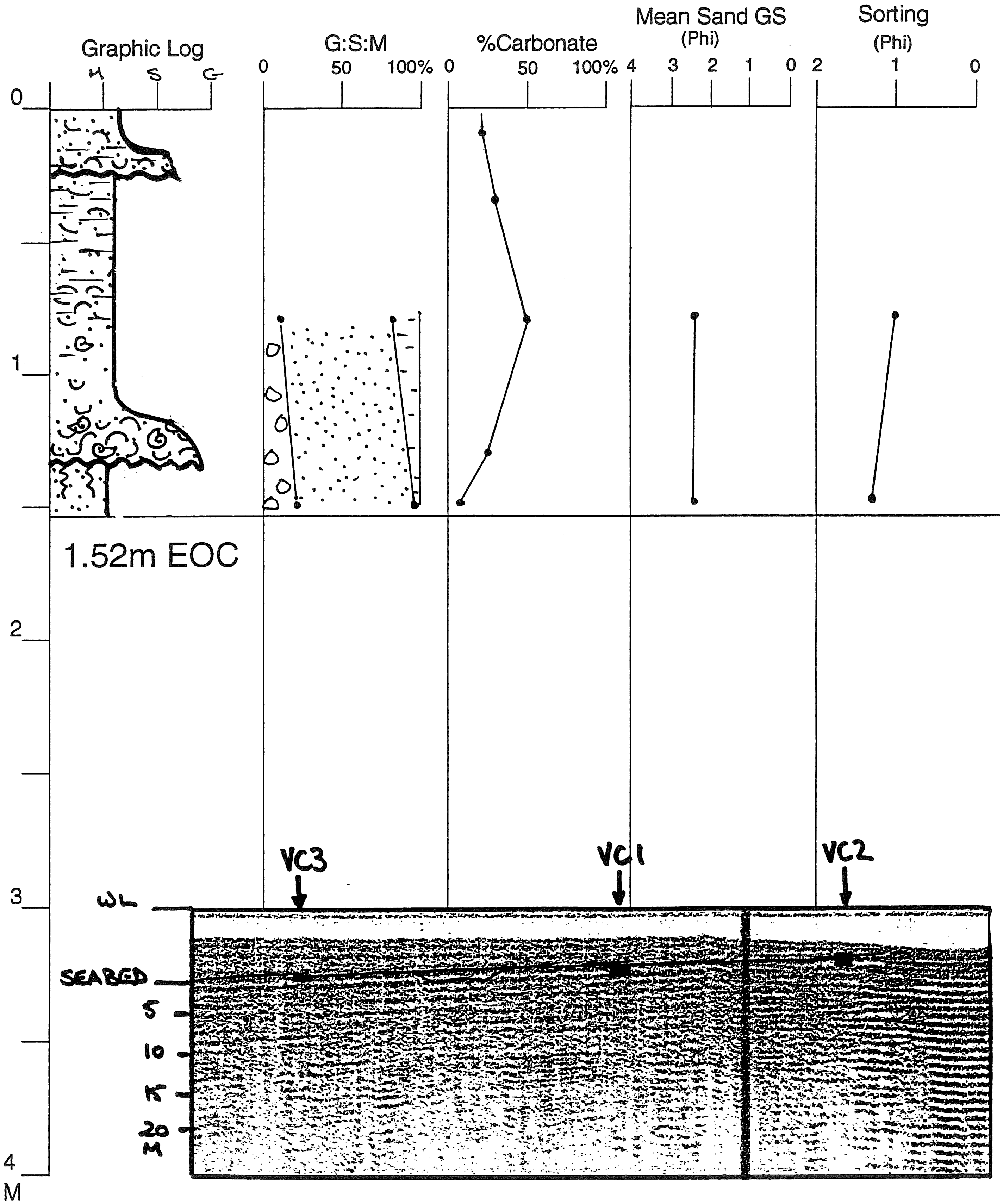

ORGANICS (Plant material)


BURROWS (Bioturbation)


Wk 3878
RADIOCARBON DATE AND LAB. ID.

Zone: Duyfken Point to Crab Island

Core ID.: VC1 Water Depth (m): 5.5



Zone: Duyfken Point to Crab Island

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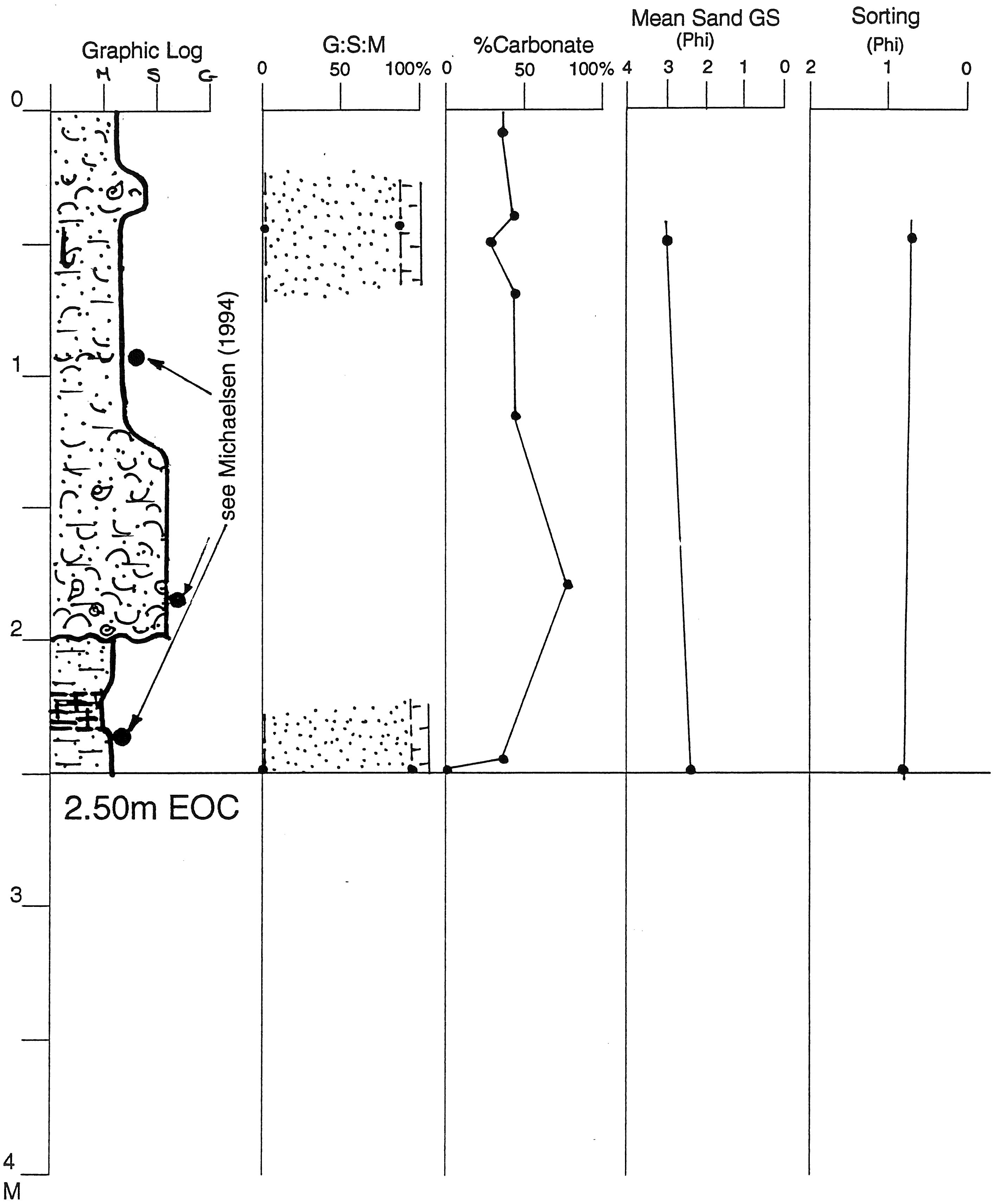

Zone: Duyfken Point to Crab Island

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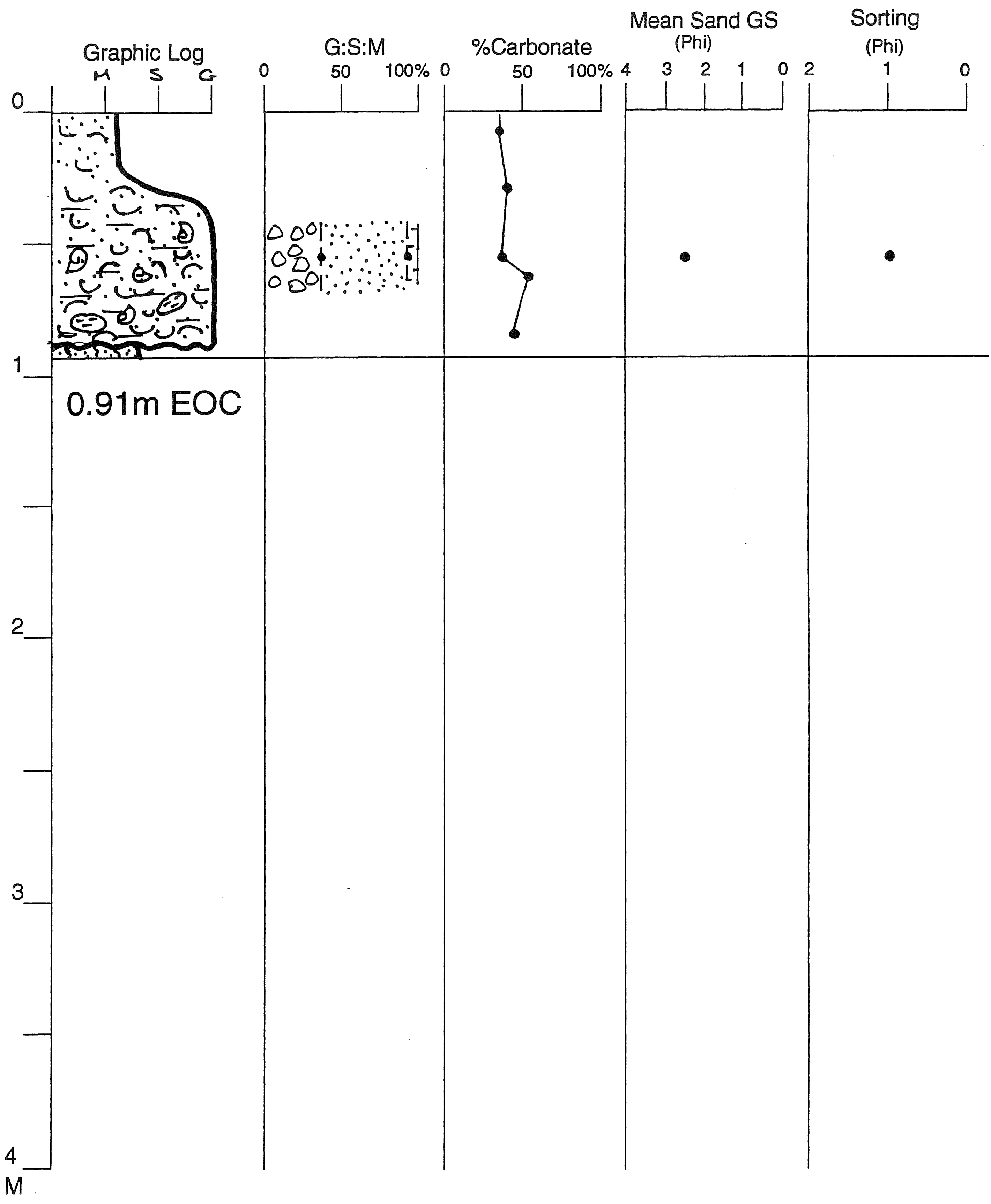

Zone: Duyfken Point to Crab Island

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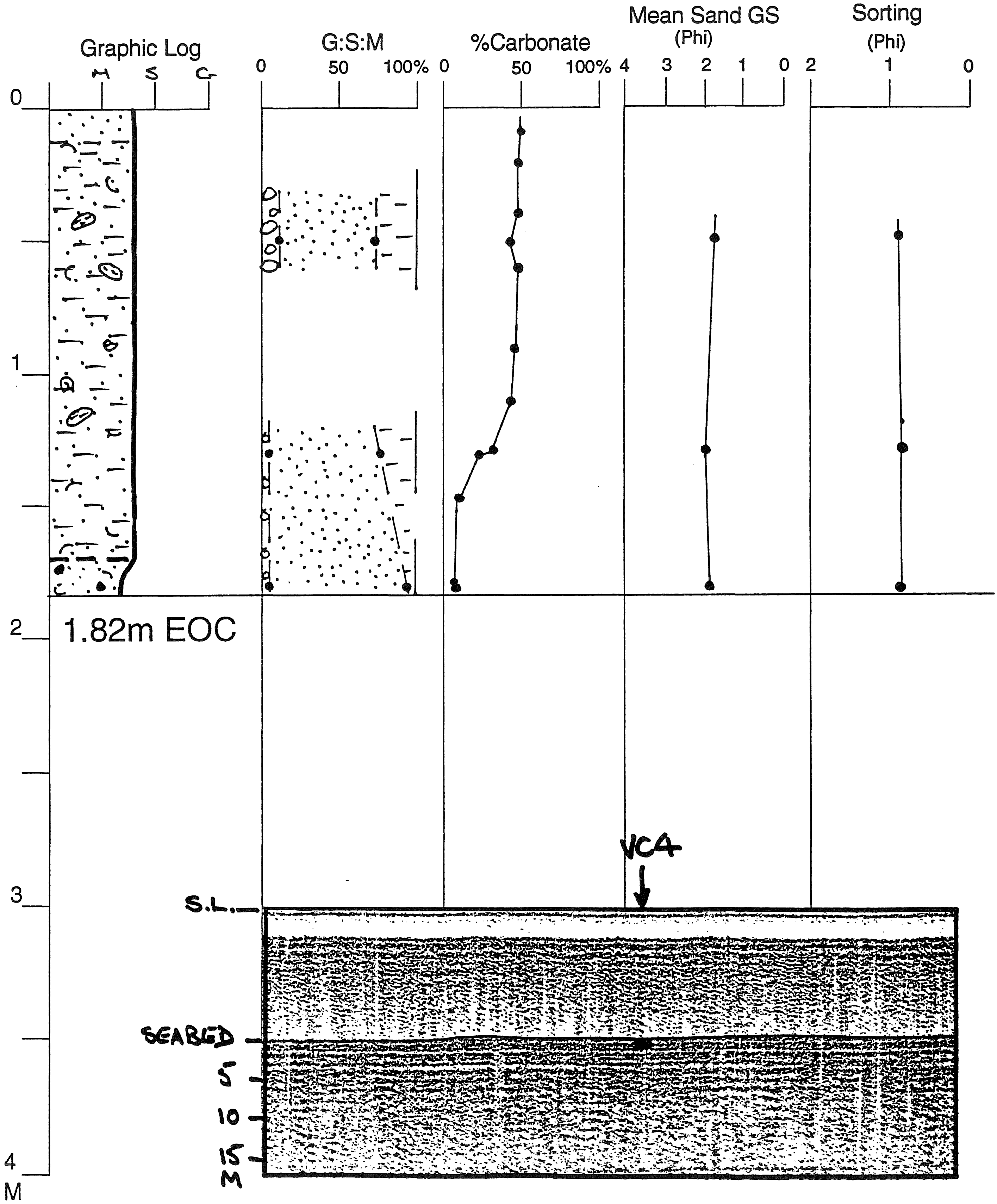

Zone: Duyfken Point to Crab Island

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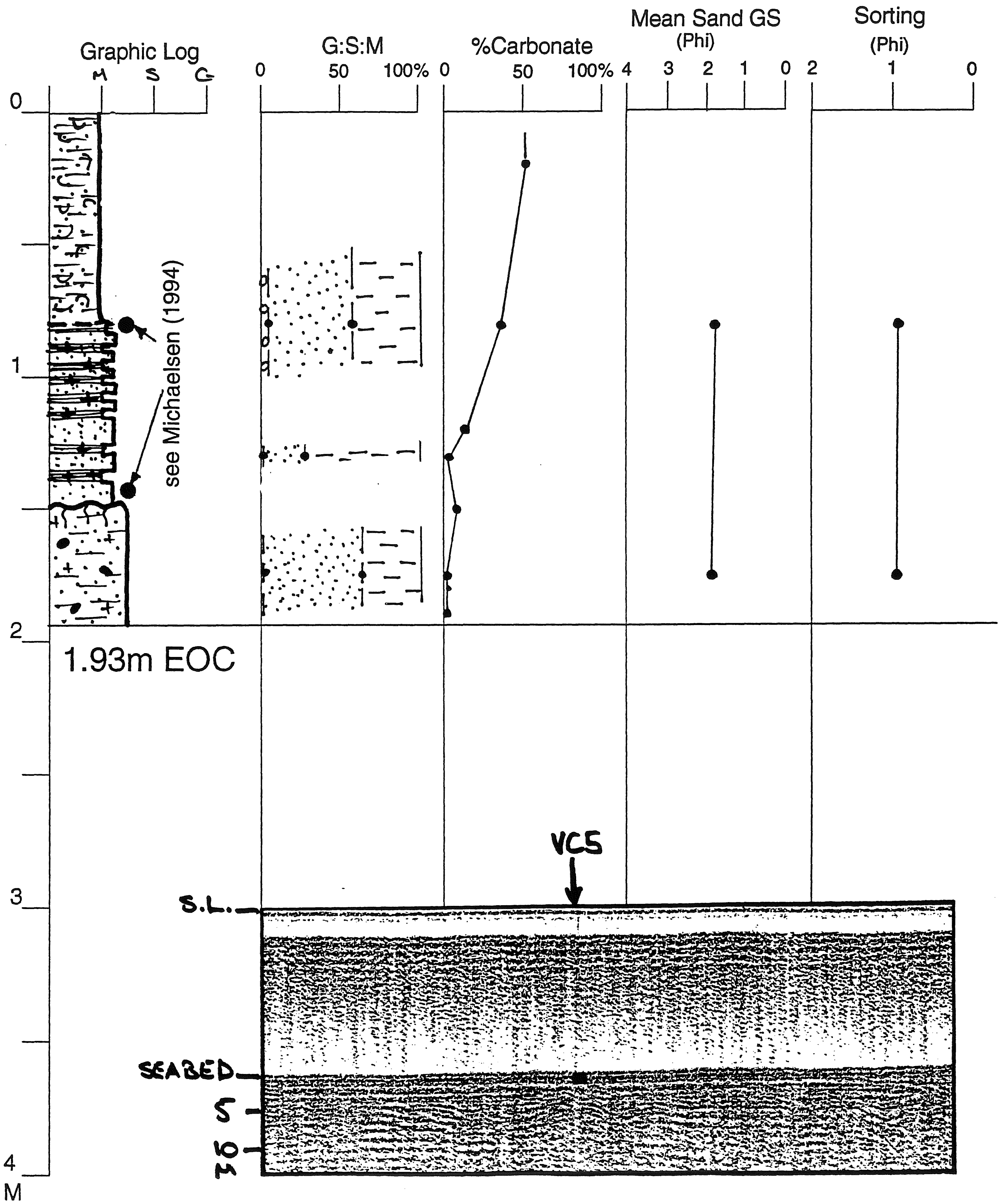

Zone: Duyfken Point to Crab Island

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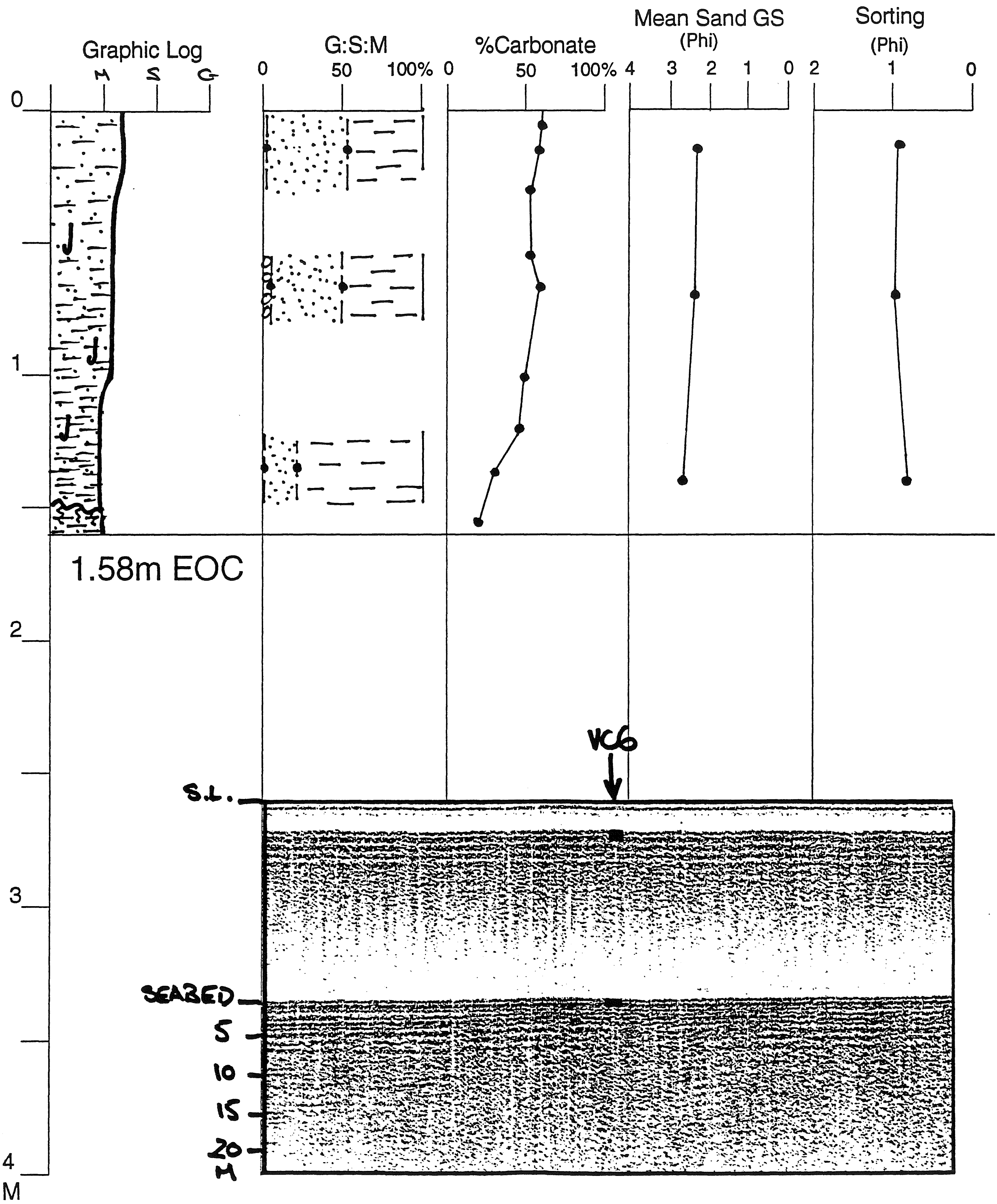

Zone: Duyfken Point to Crab Island

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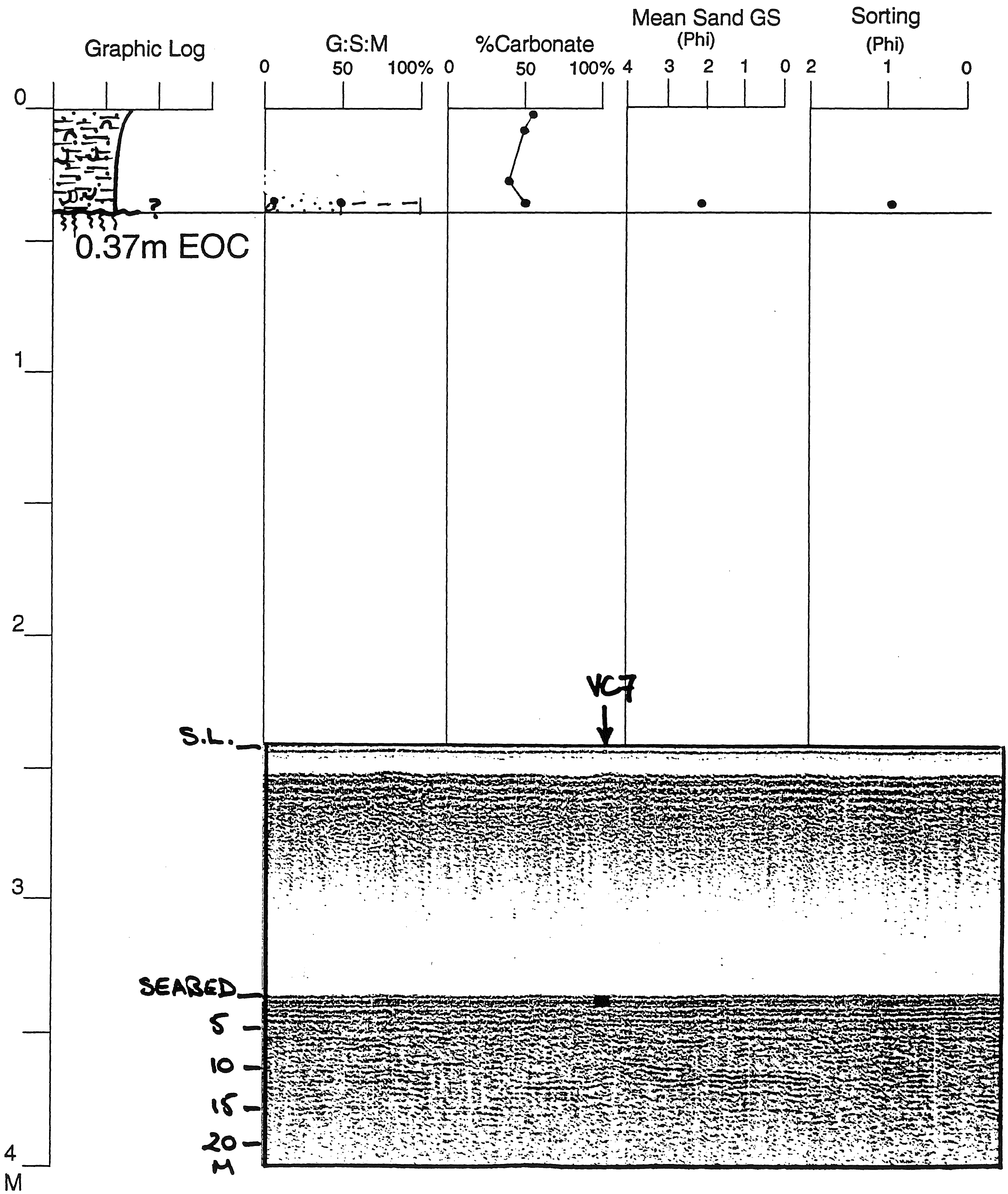
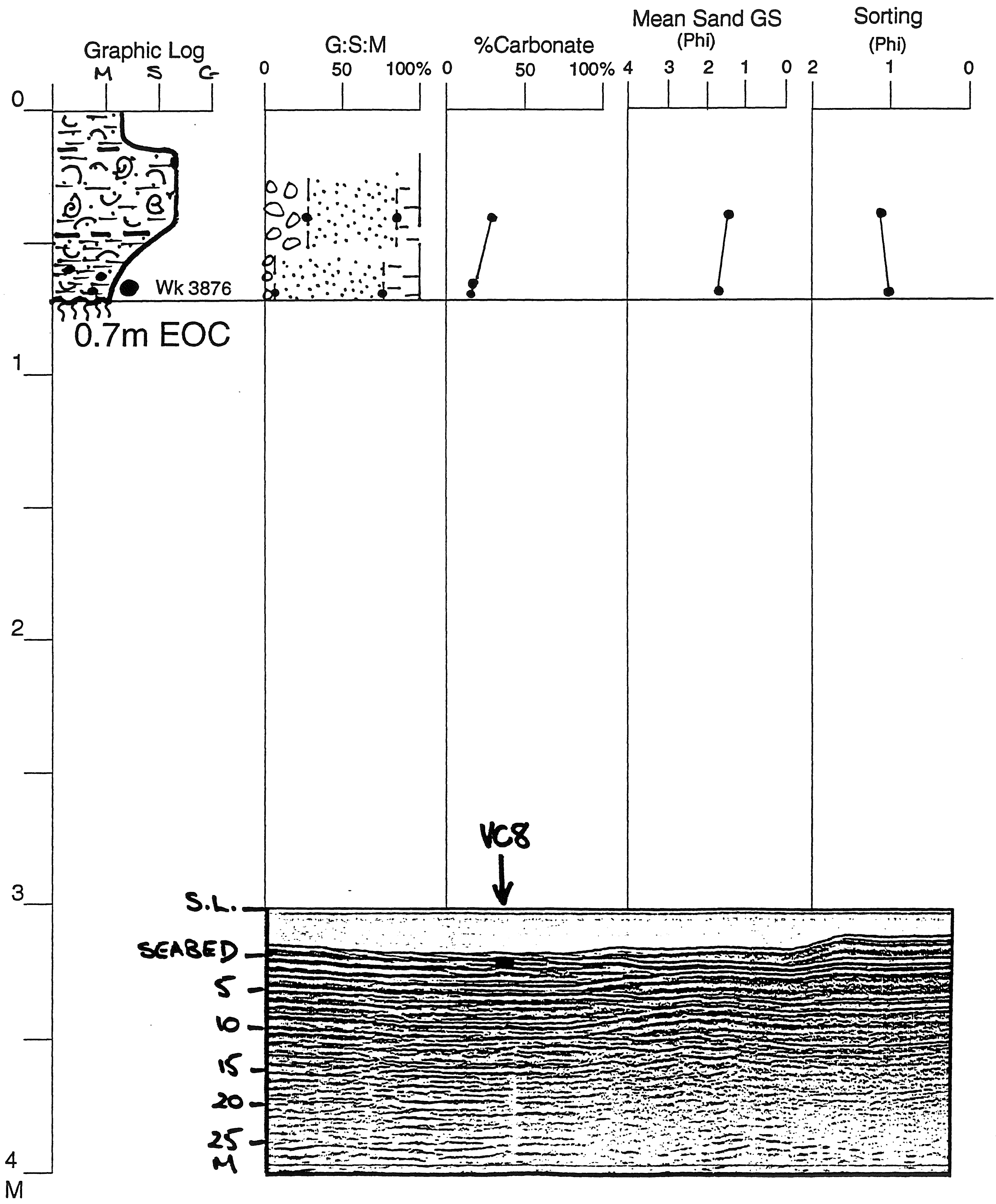


Zone: Duyfken Point to Crab Island

Core ID.: VC8 Water Depth (m): 8.0



Zone: Duyfken Point to Crab Island

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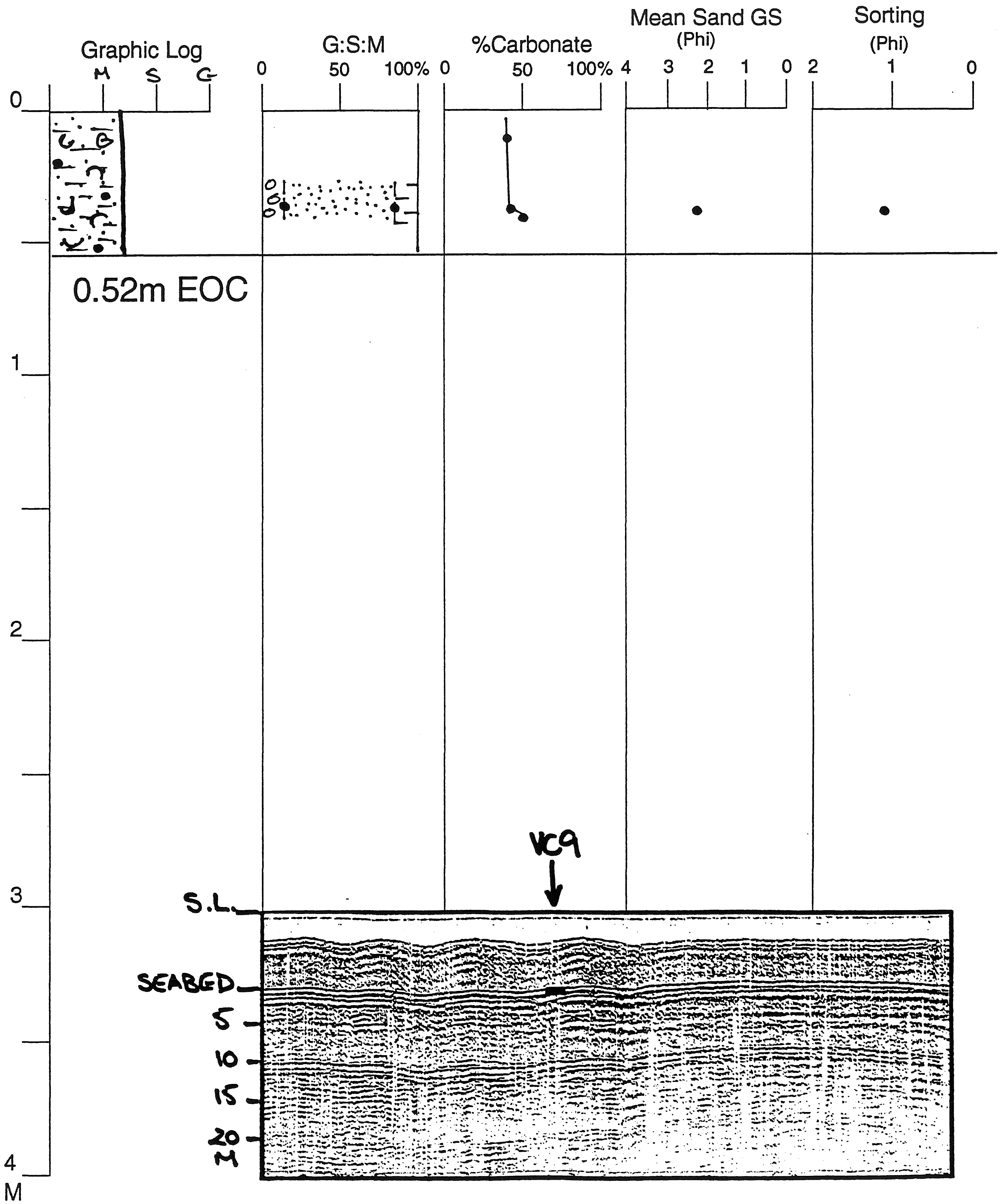

Zone: Duyfken Point to Crab Island

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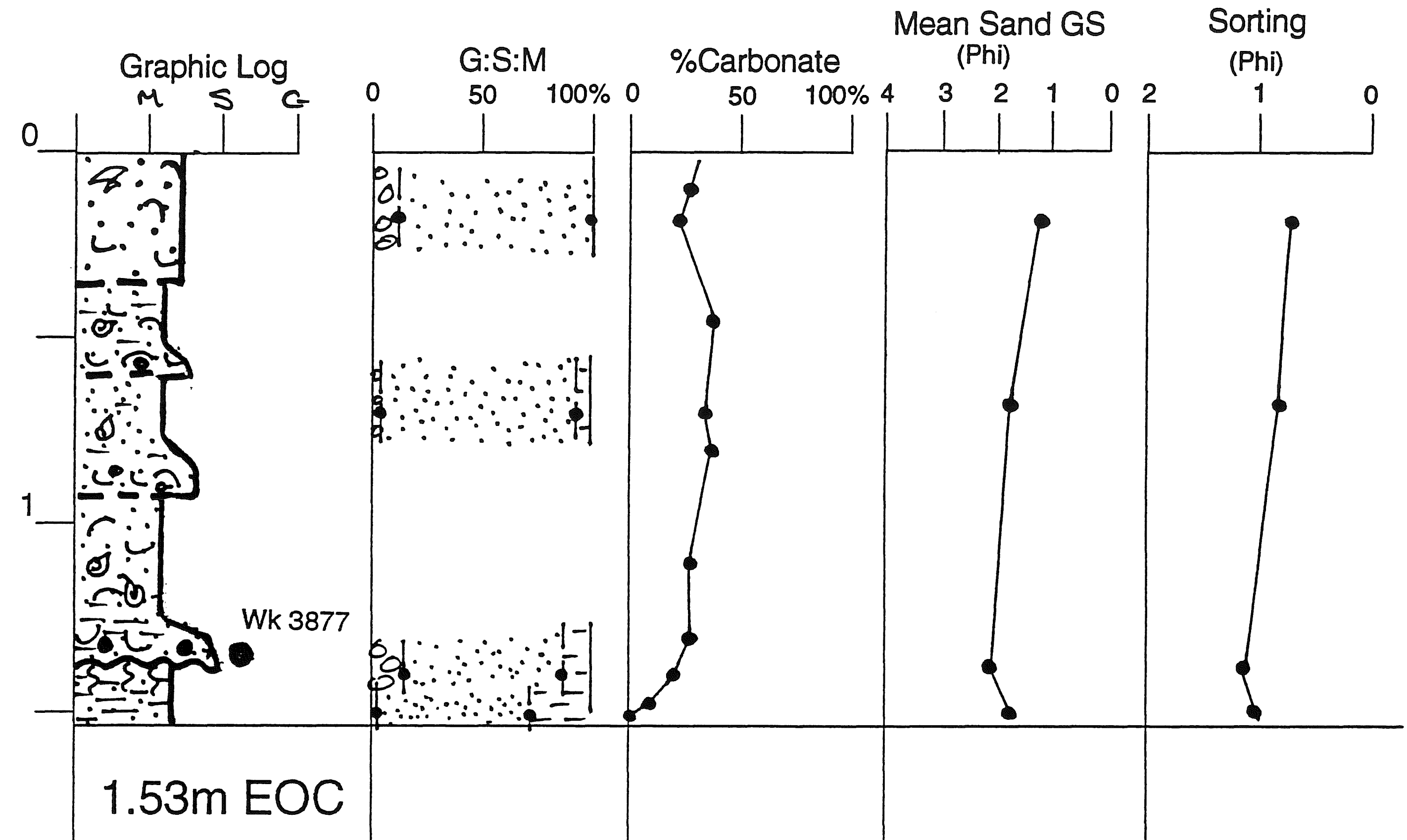

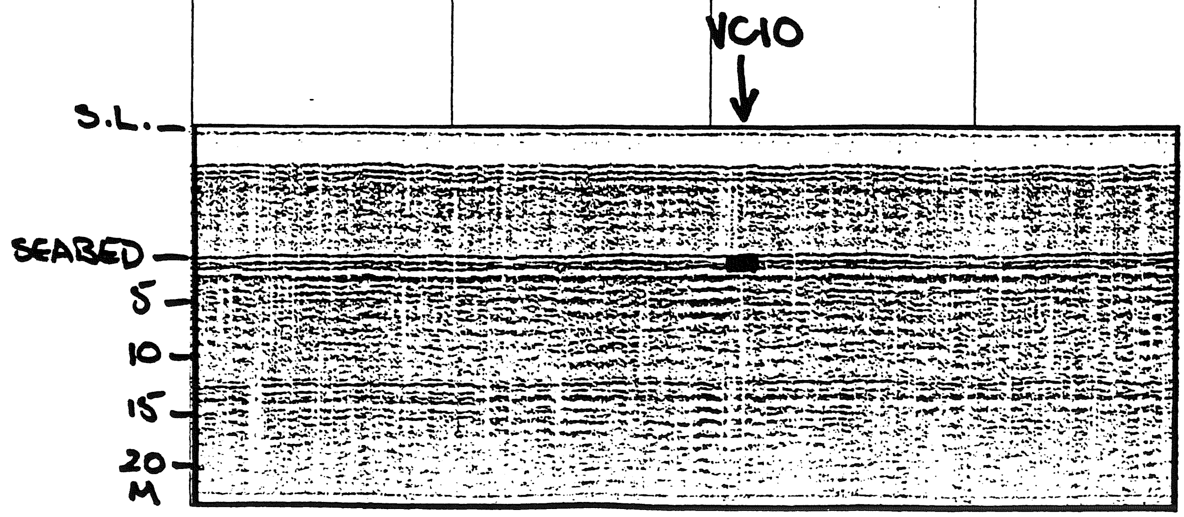

Zone: Duyfken Point to Crab Island

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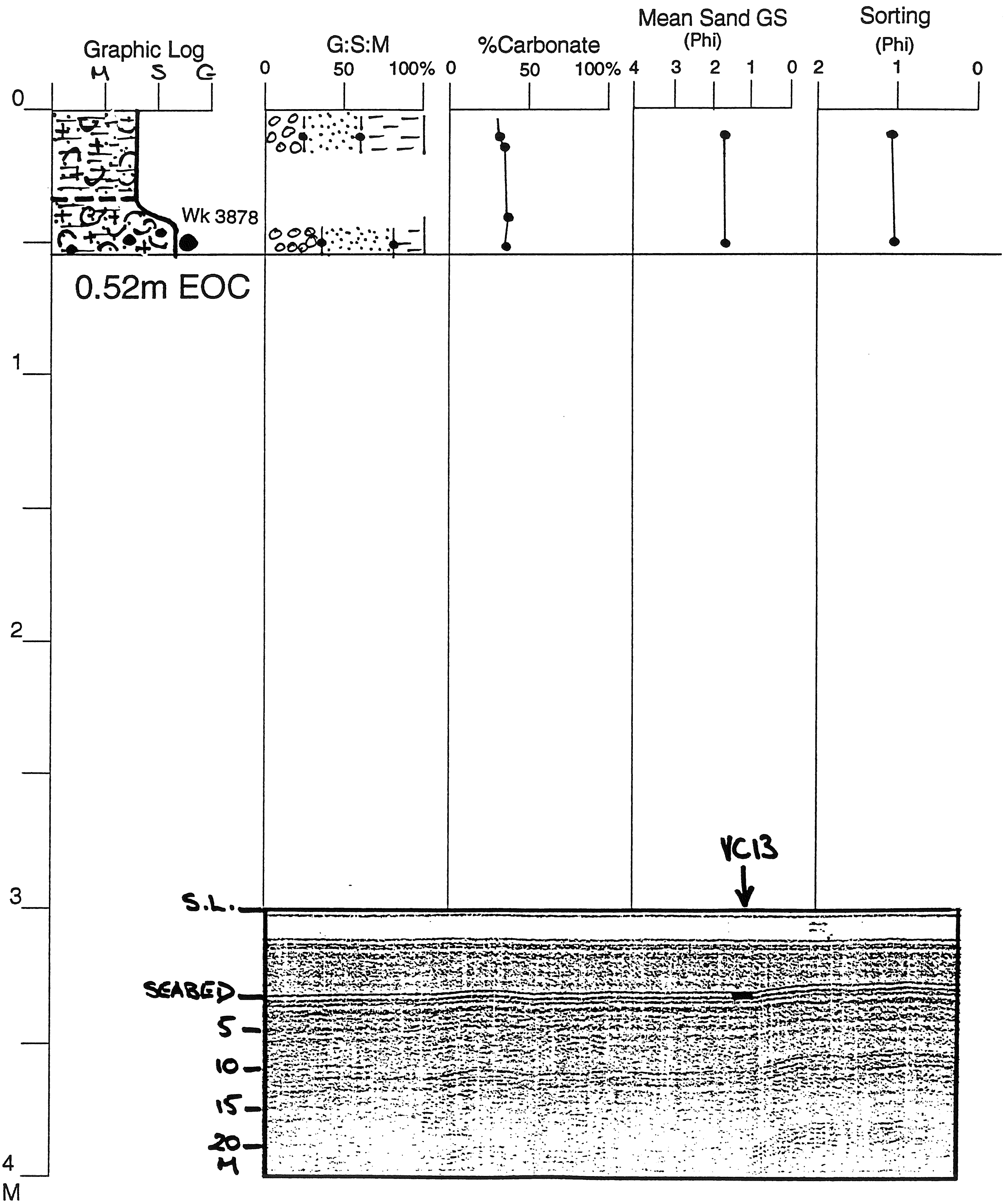

Zone: Duyfken Point to Crab Island

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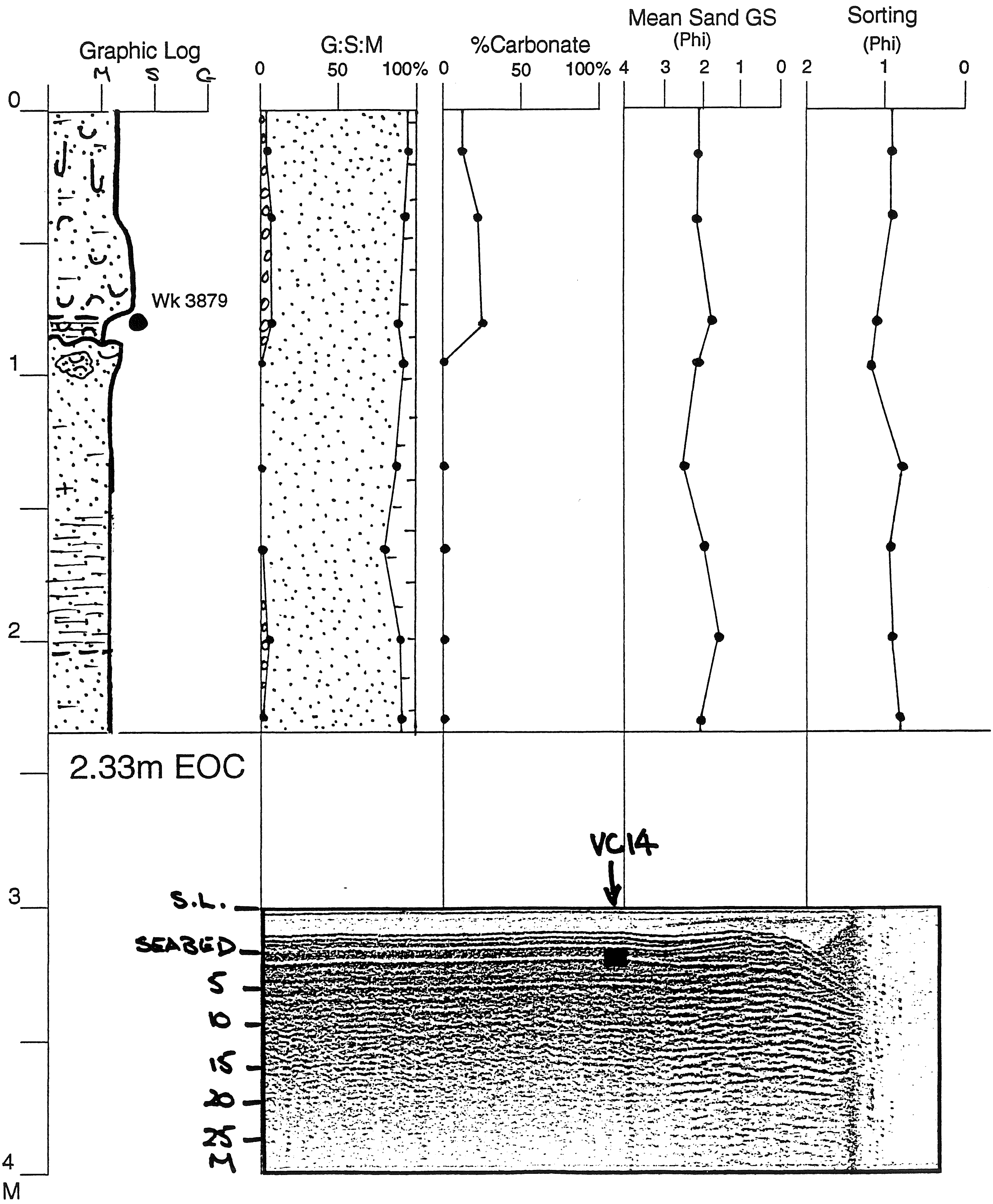

Zone: Duyfken Point to Crab Island

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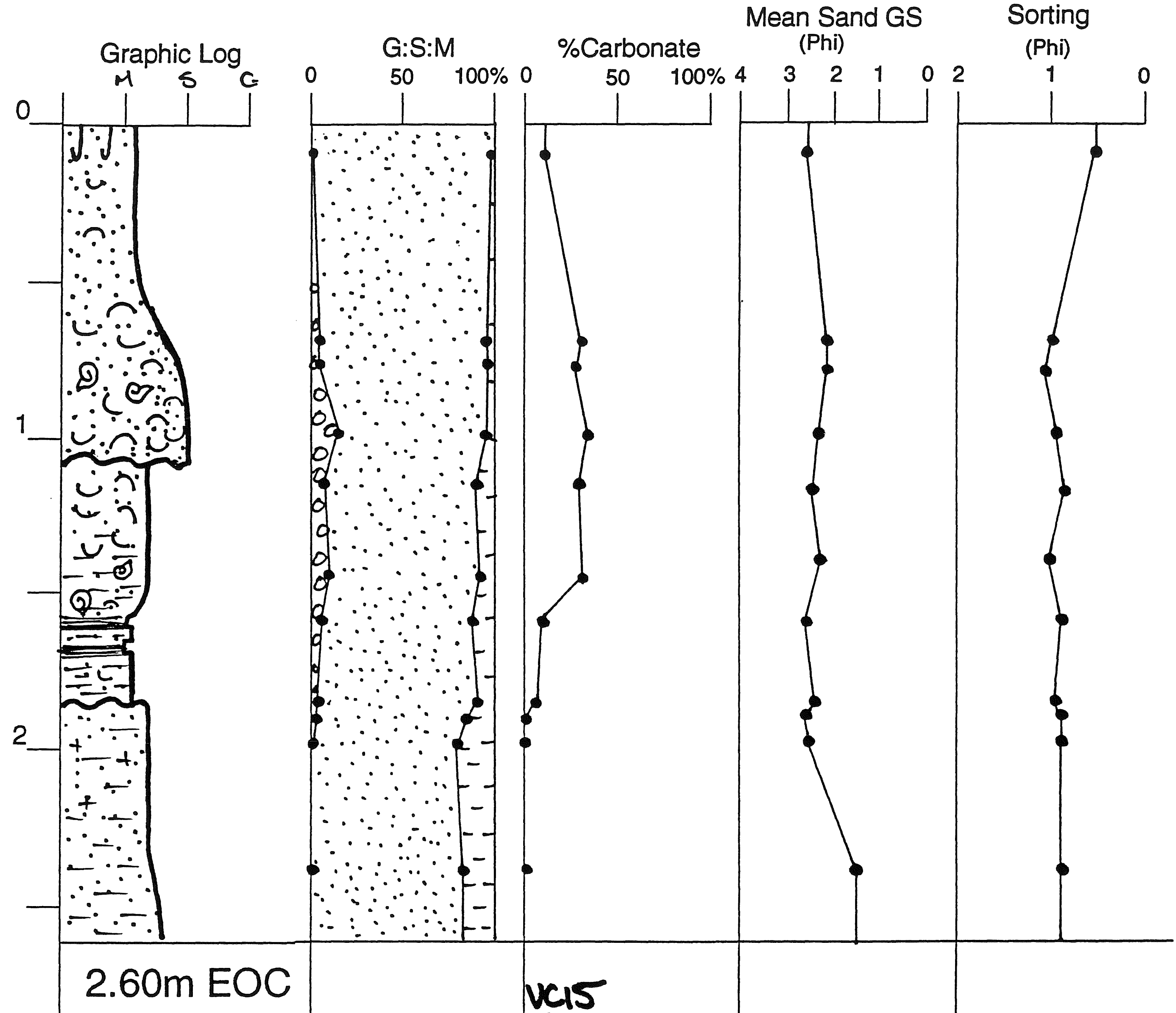

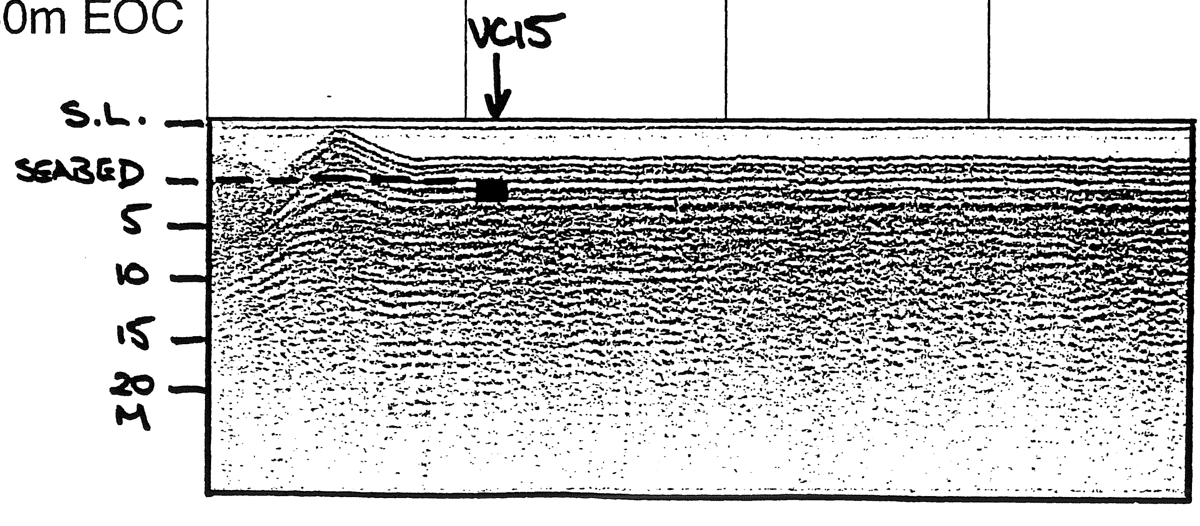

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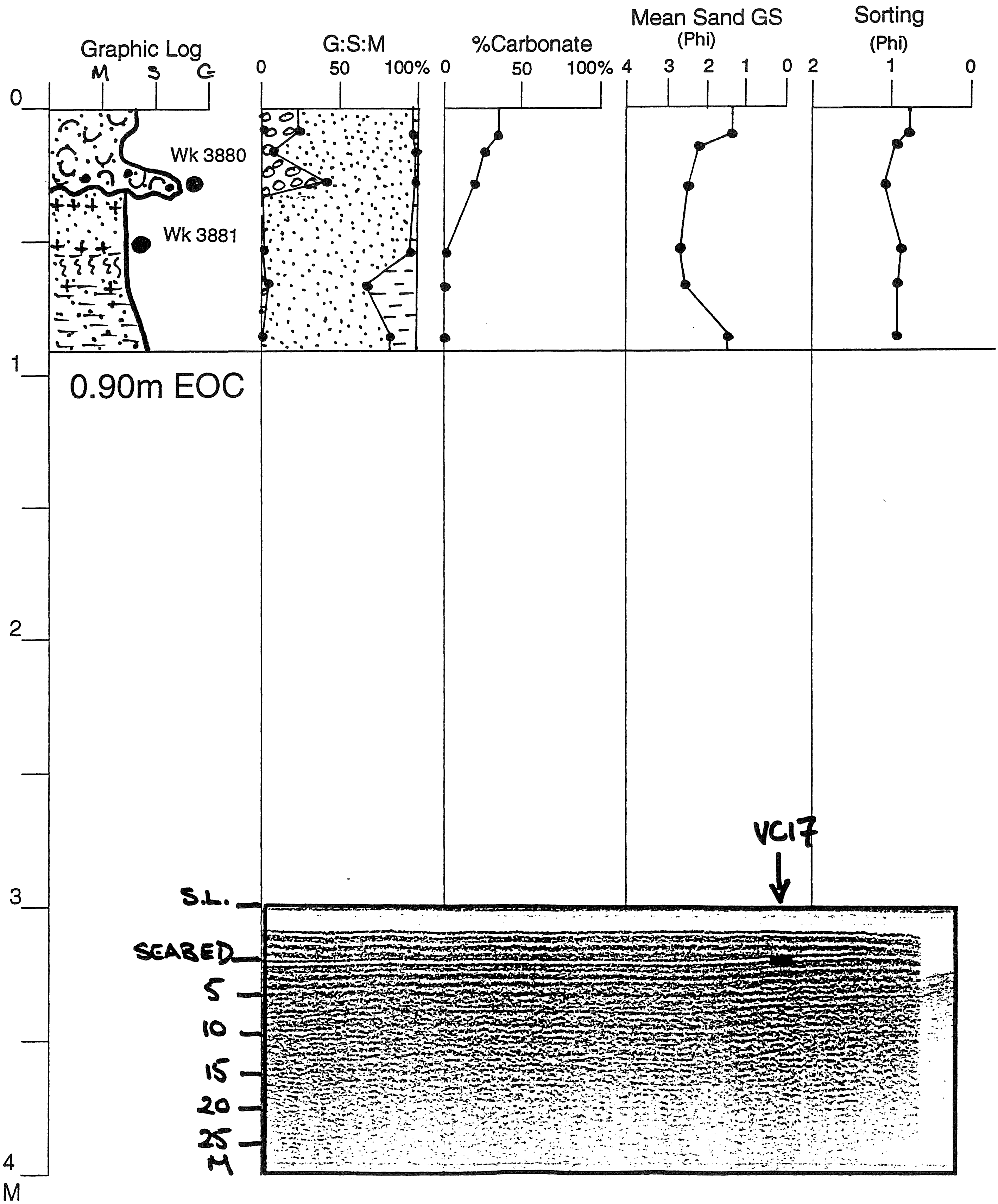

Zone: Duyfken Point to Crab Island

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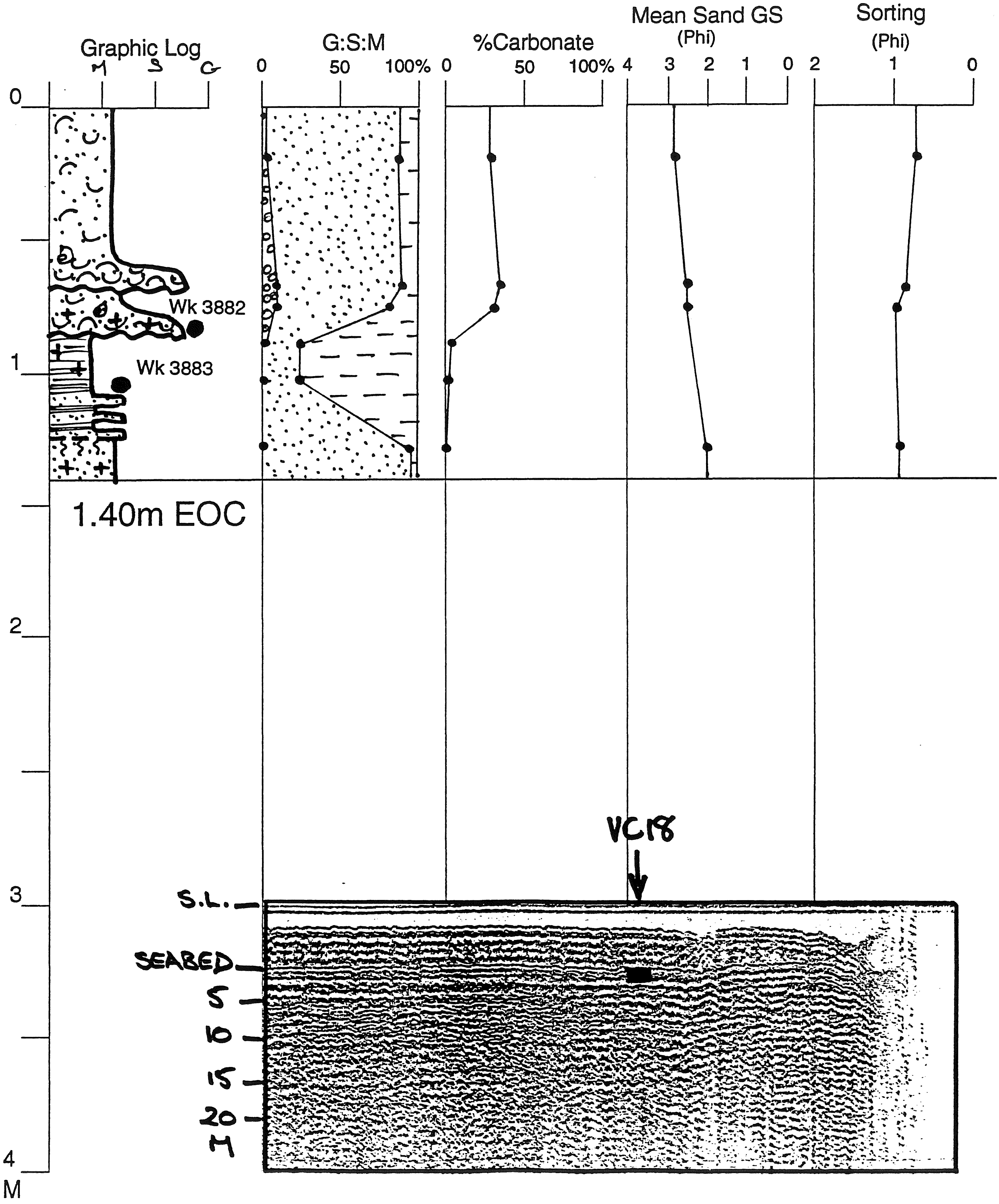

Zone: Crab Island to Cape York

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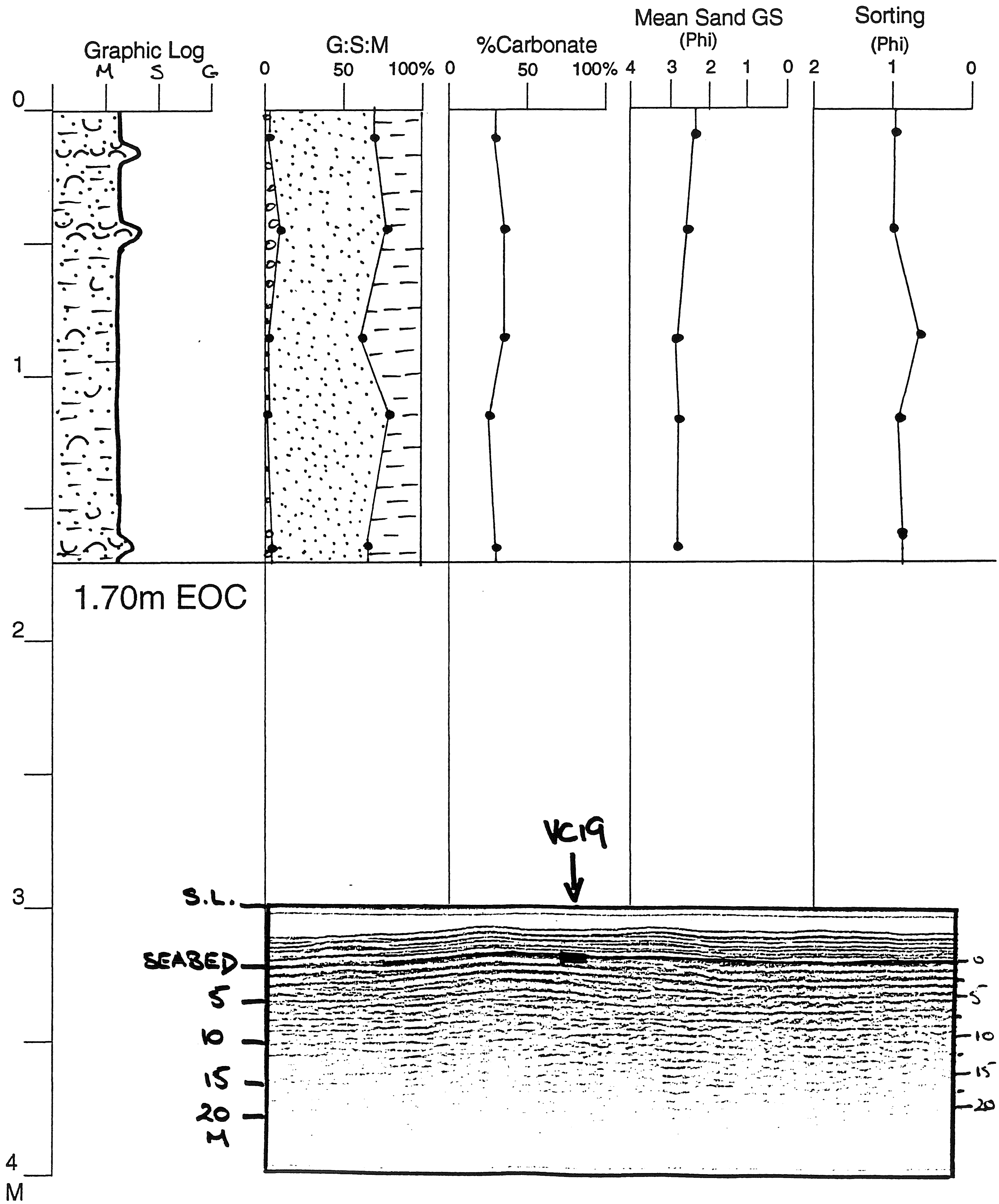

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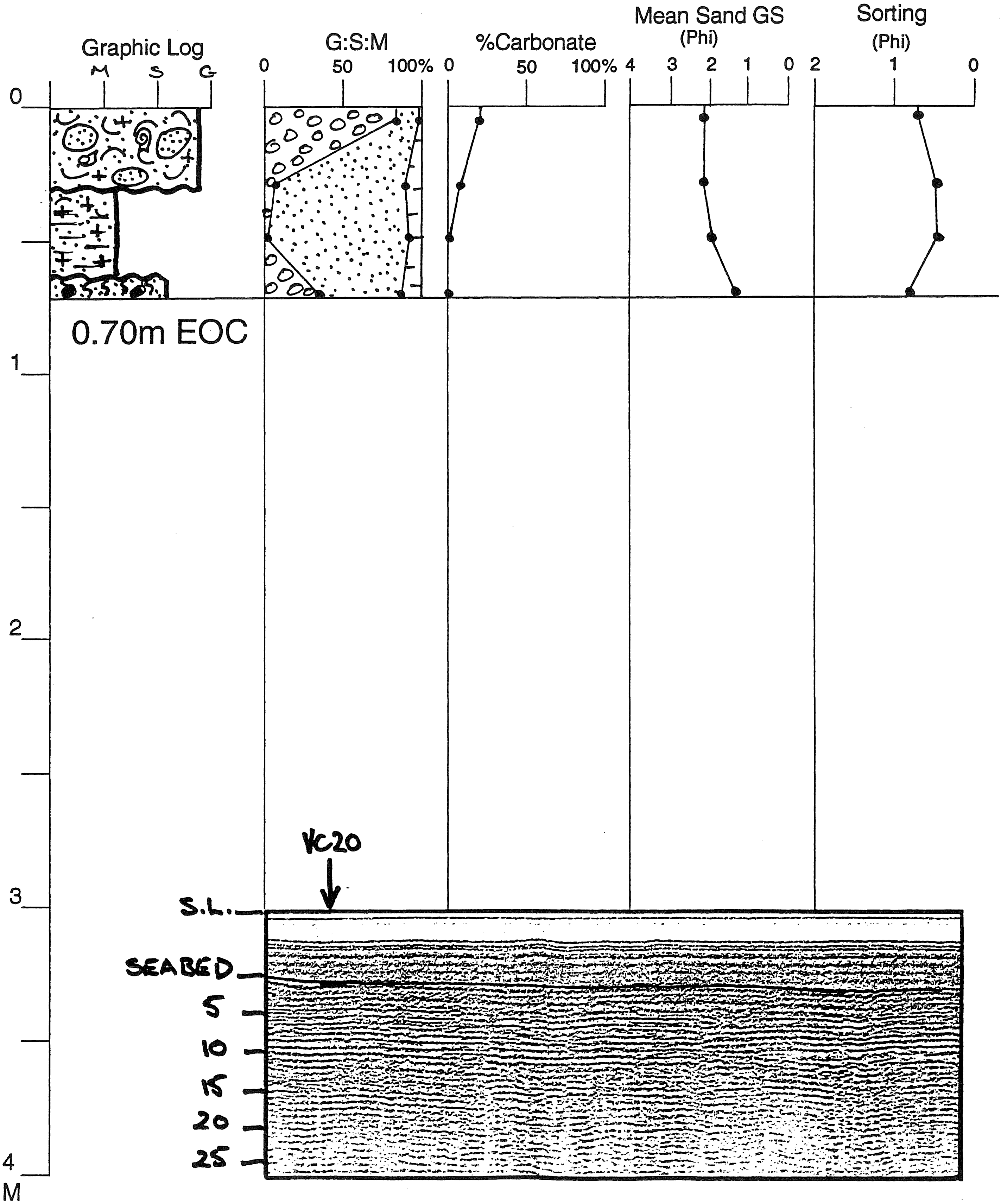

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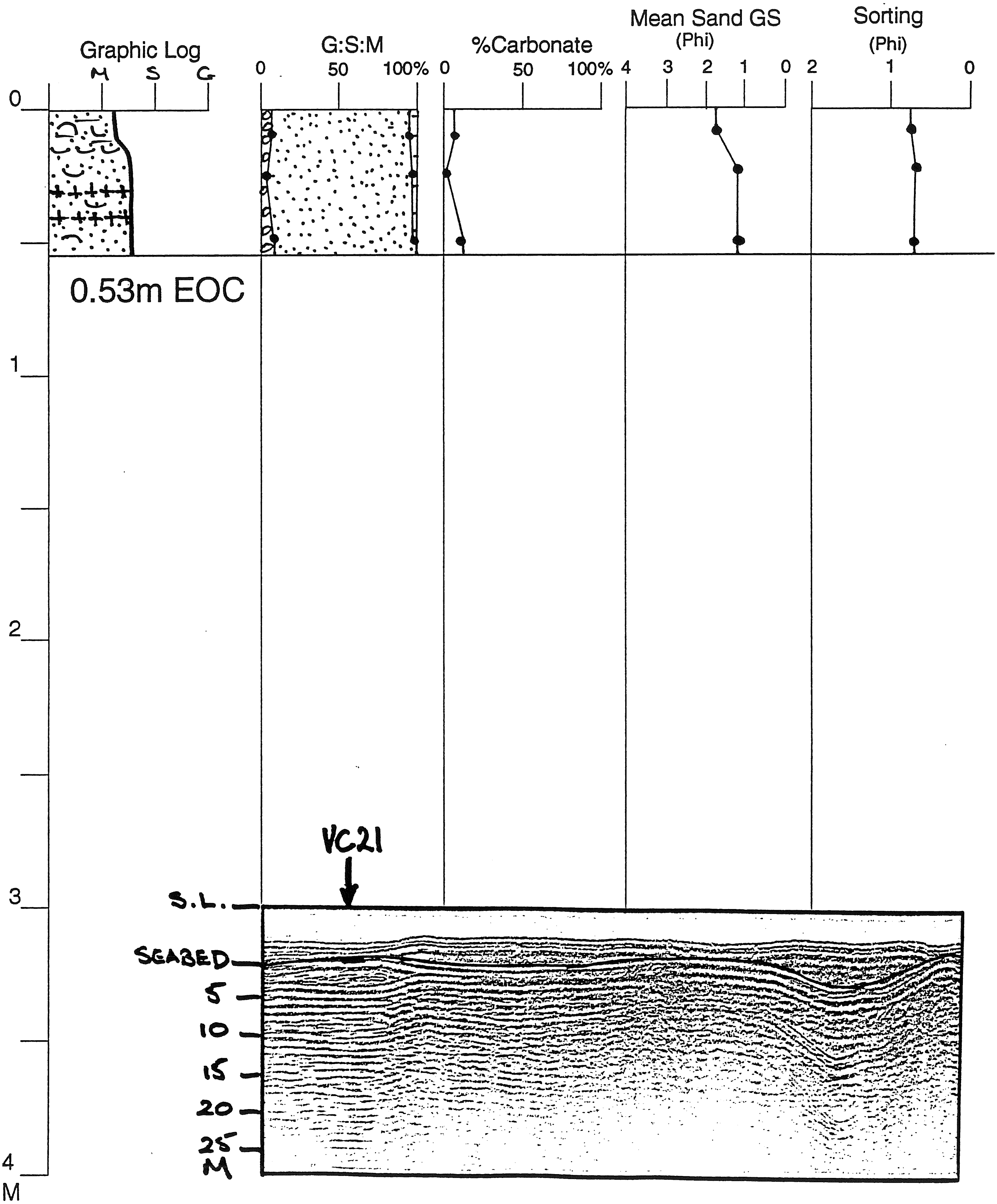

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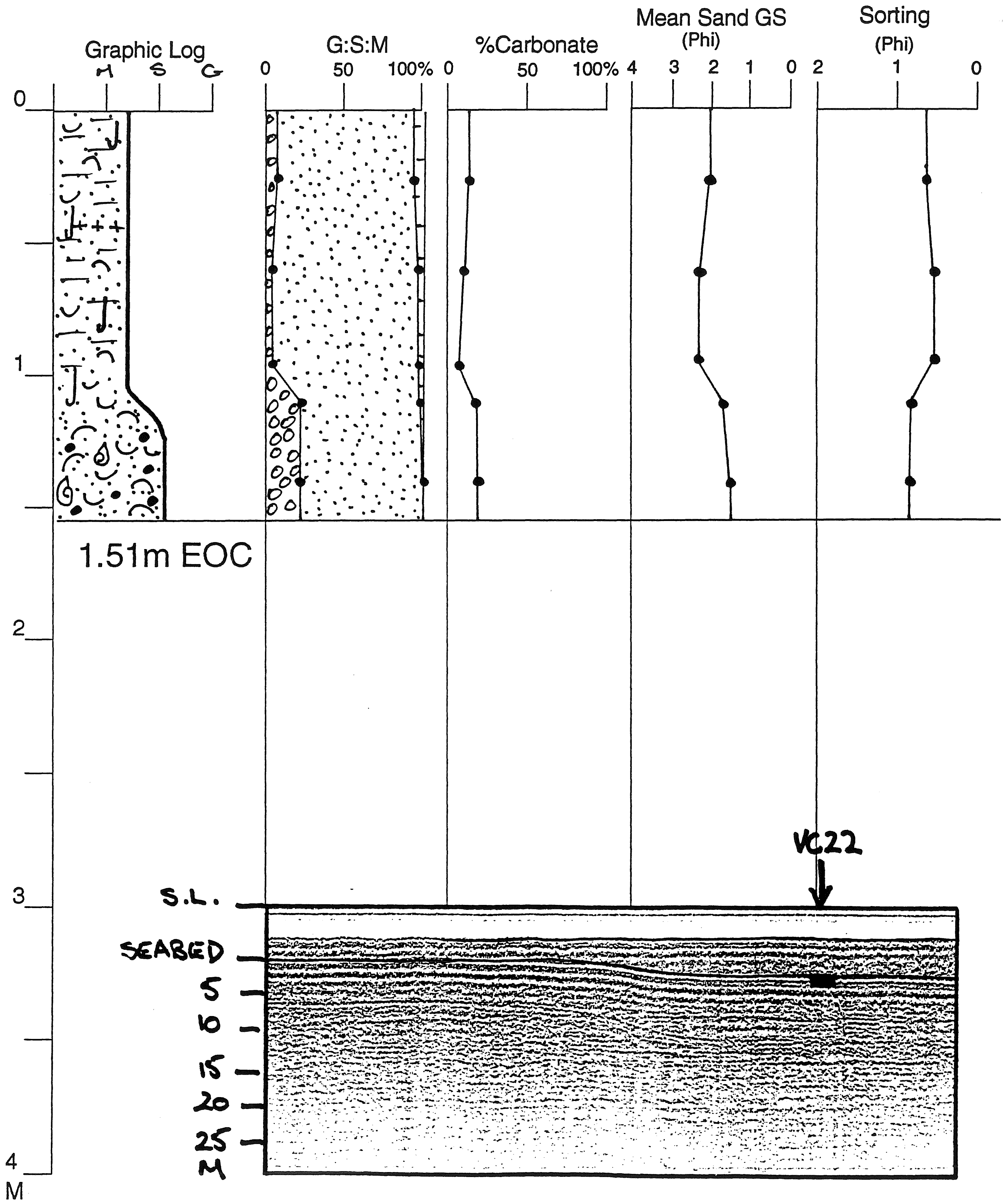

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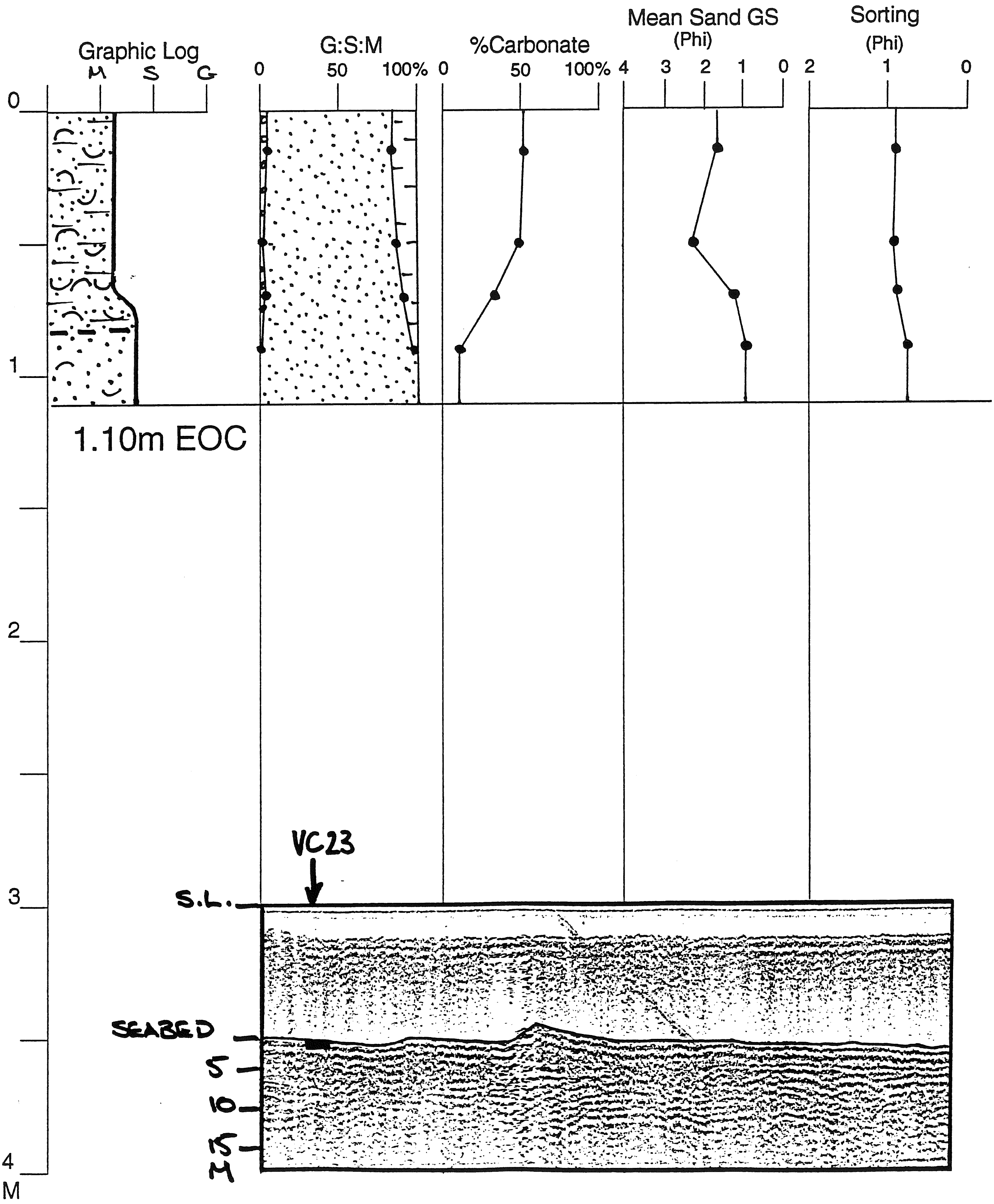

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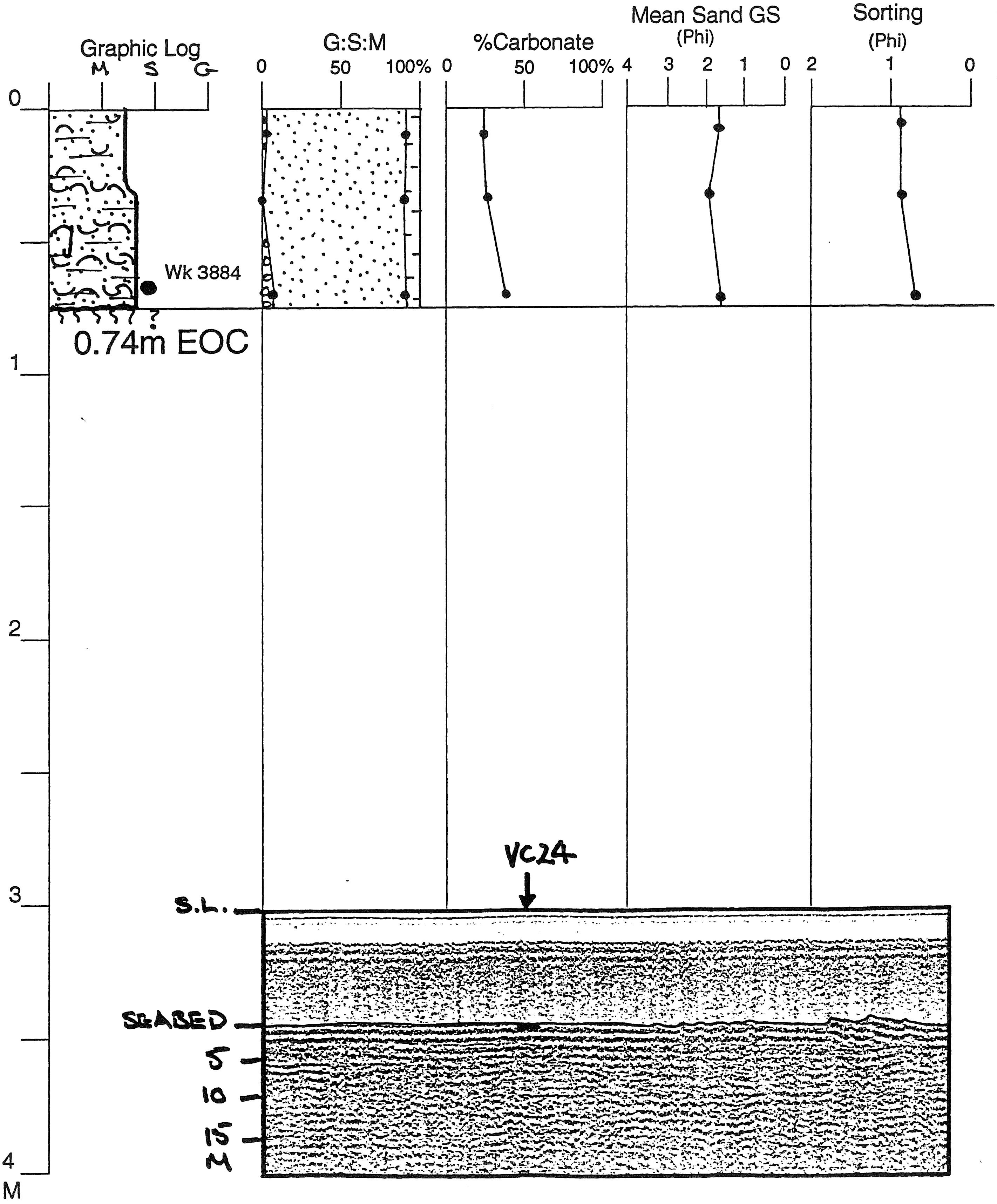

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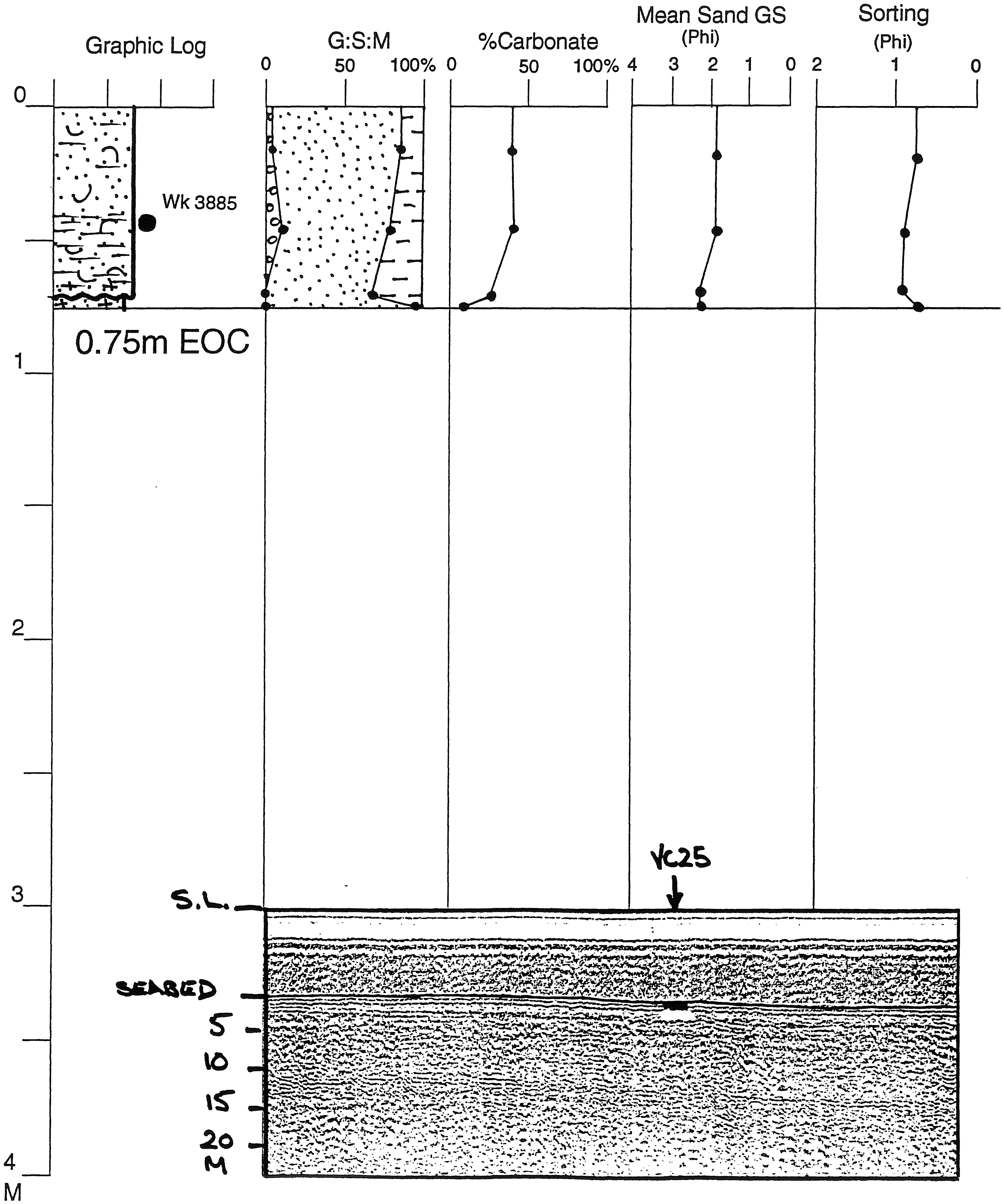

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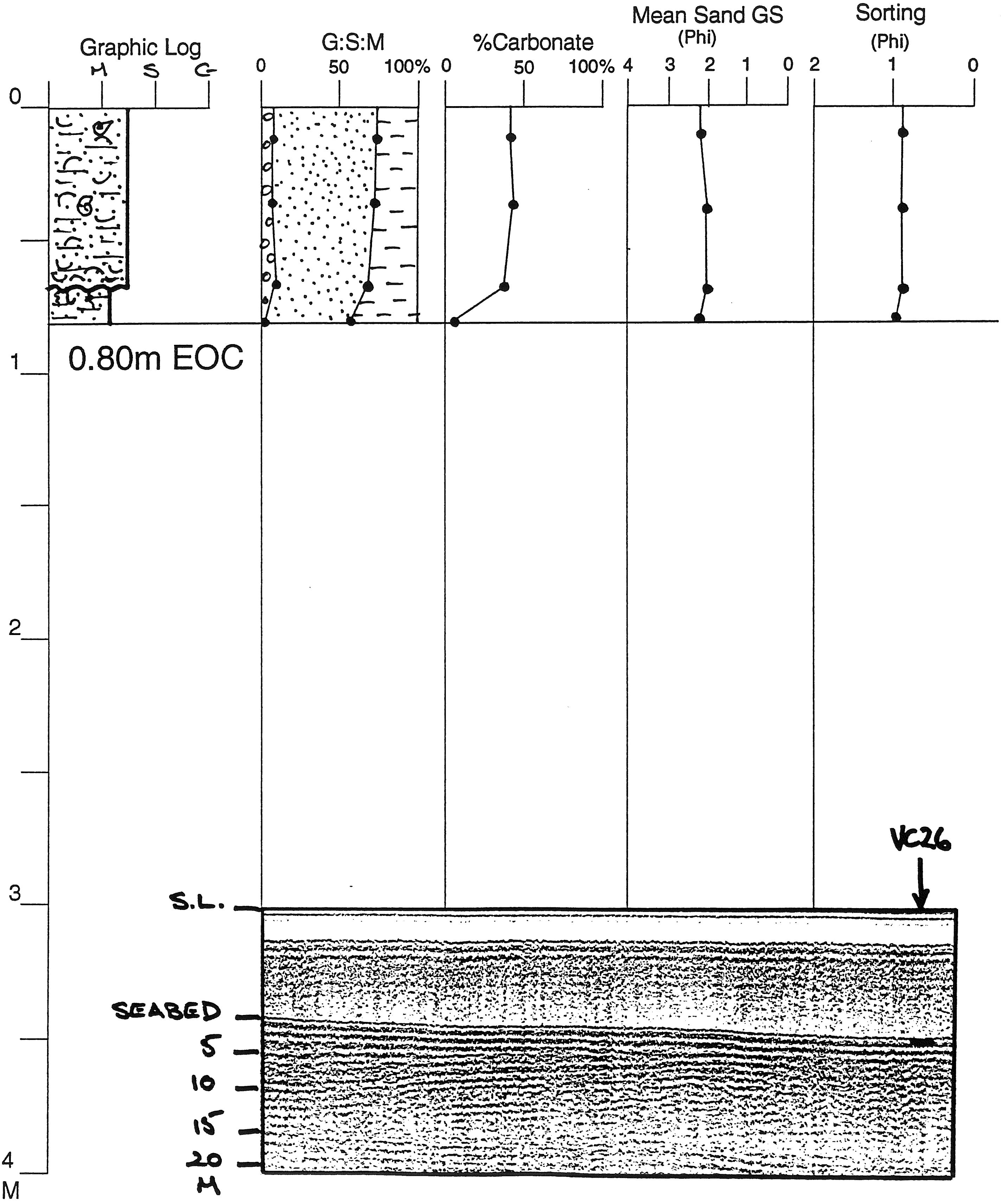

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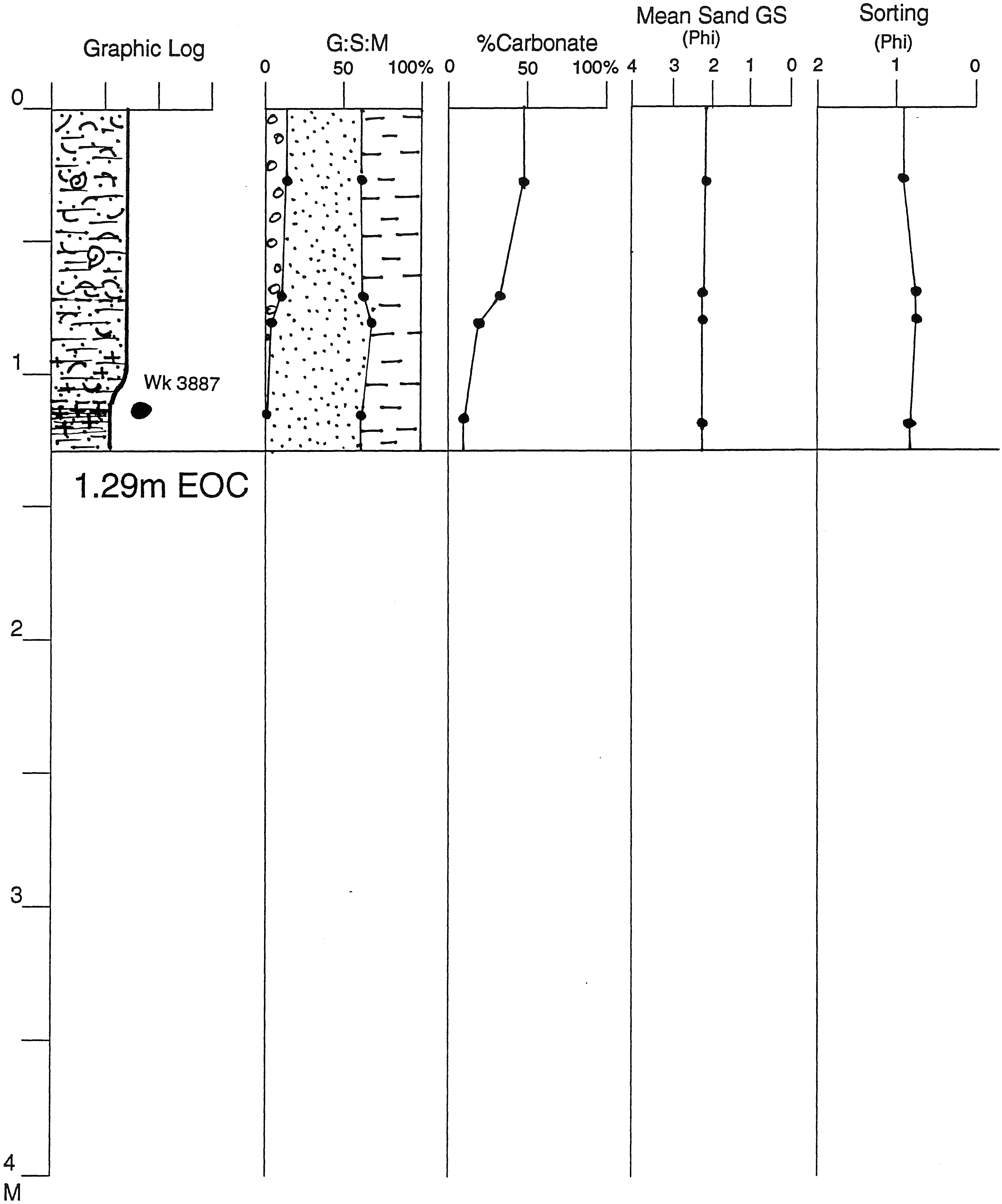

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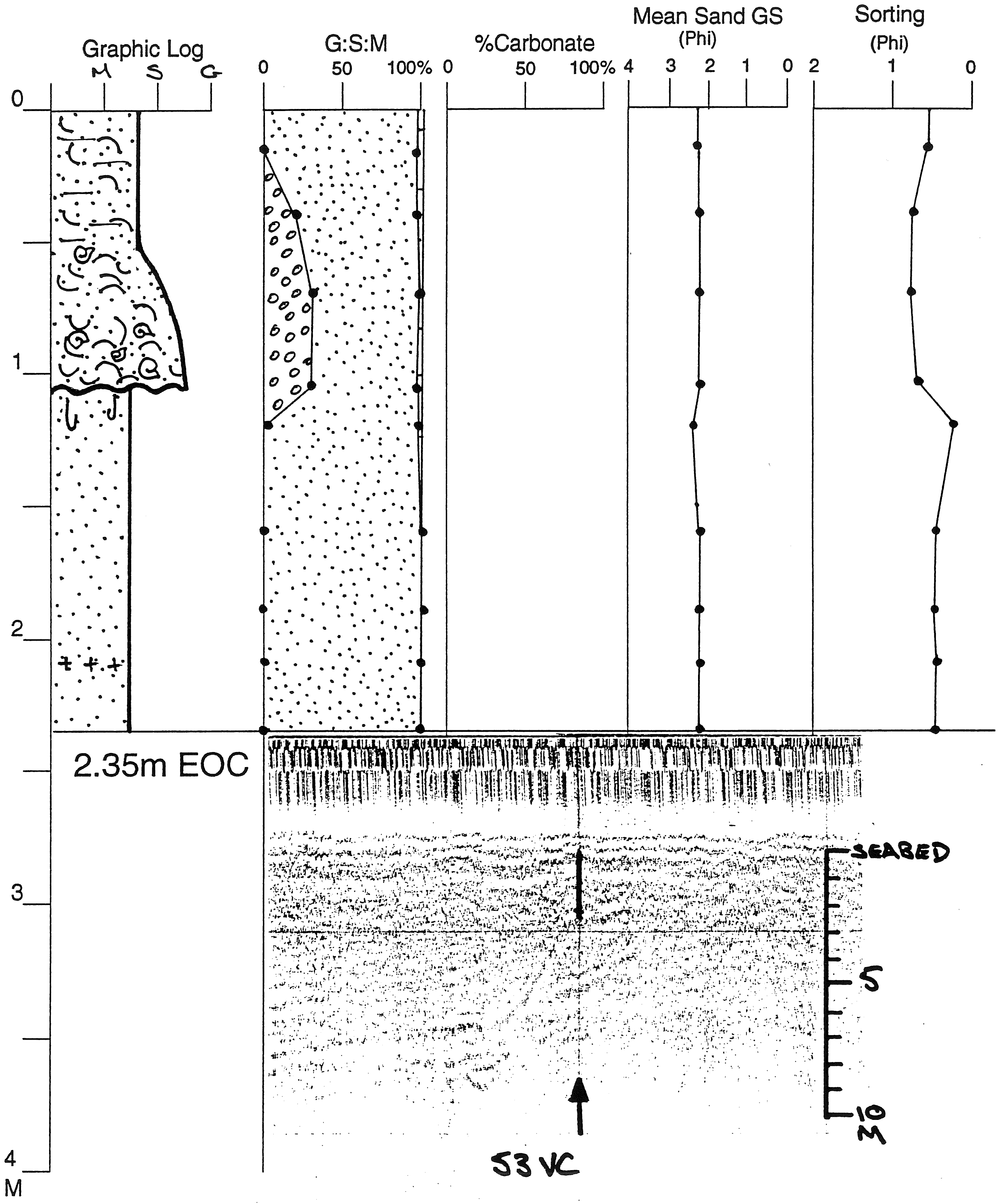

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CYPLUS - MARINE GEOLOGY REPORT

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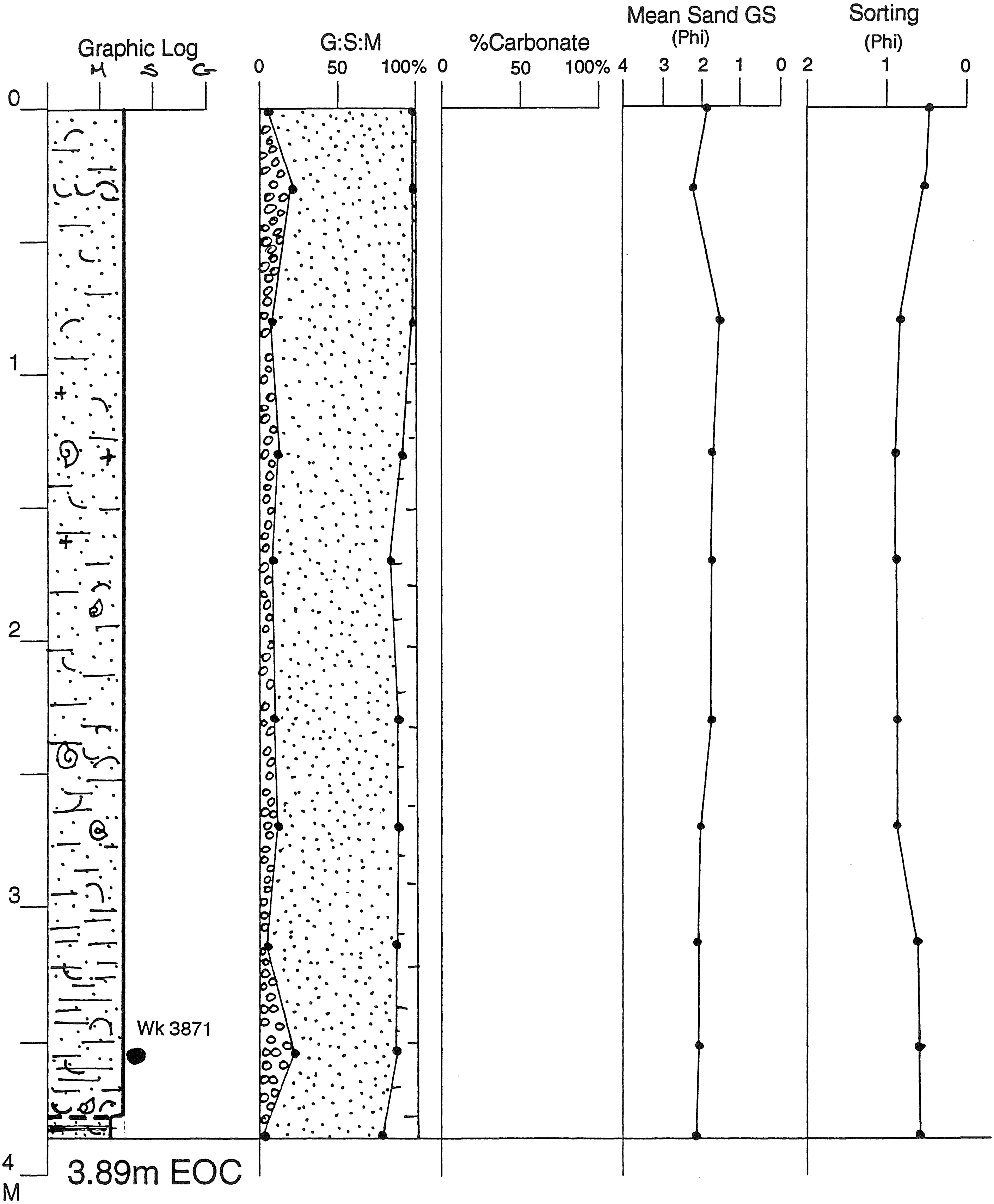

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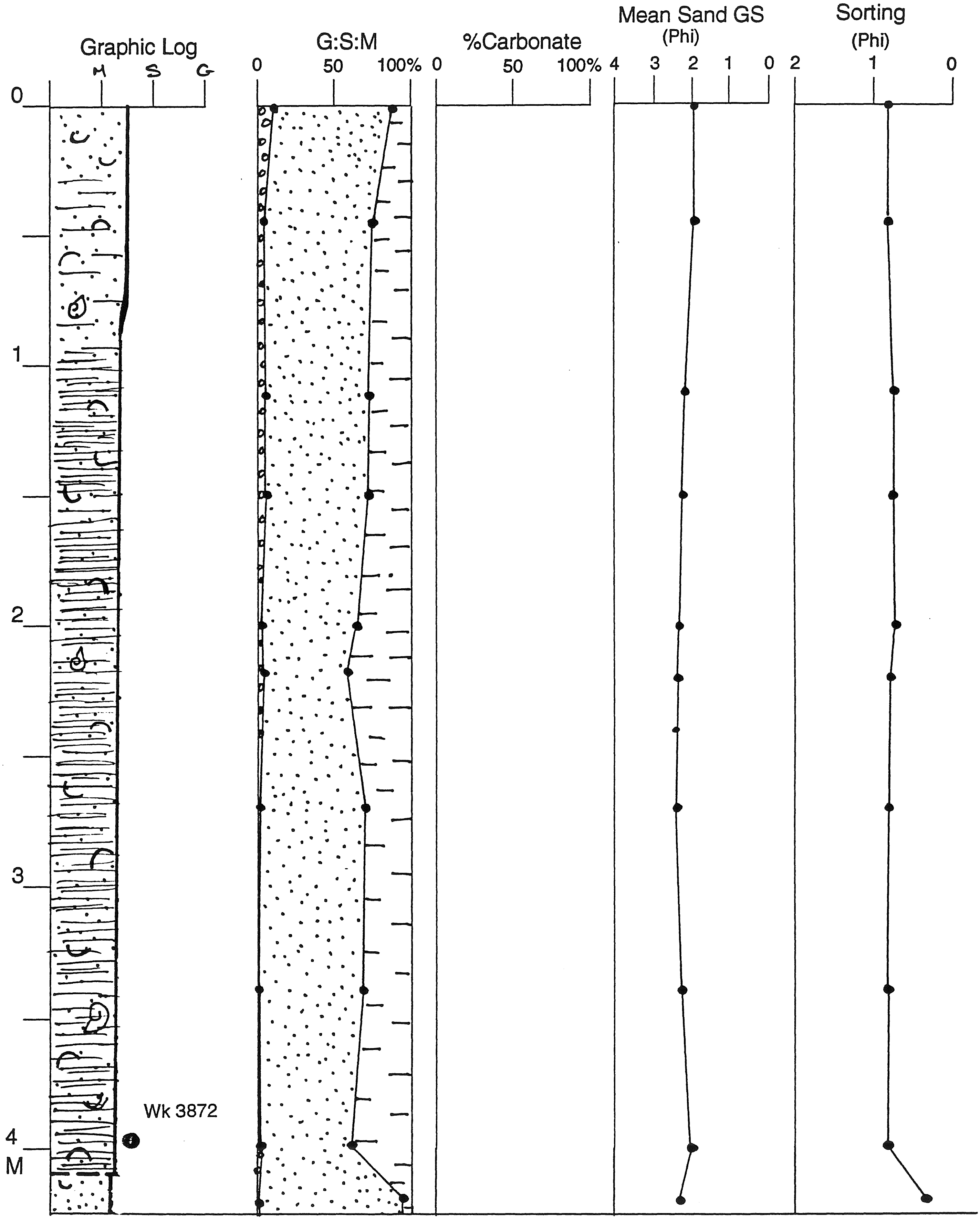

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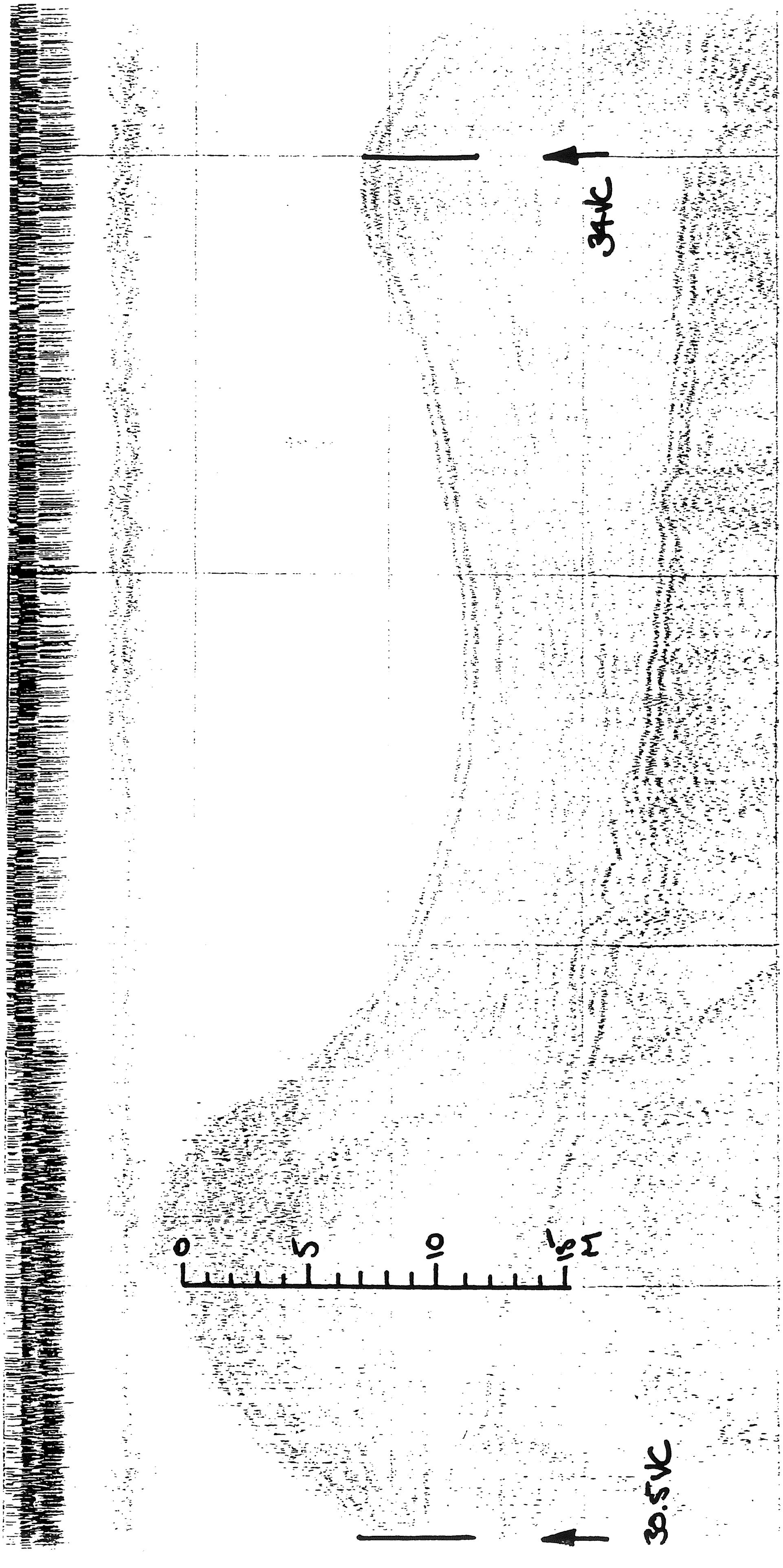
34VC
0
5
10
15
30.5VC

Zone: Cape York to Cape Direction

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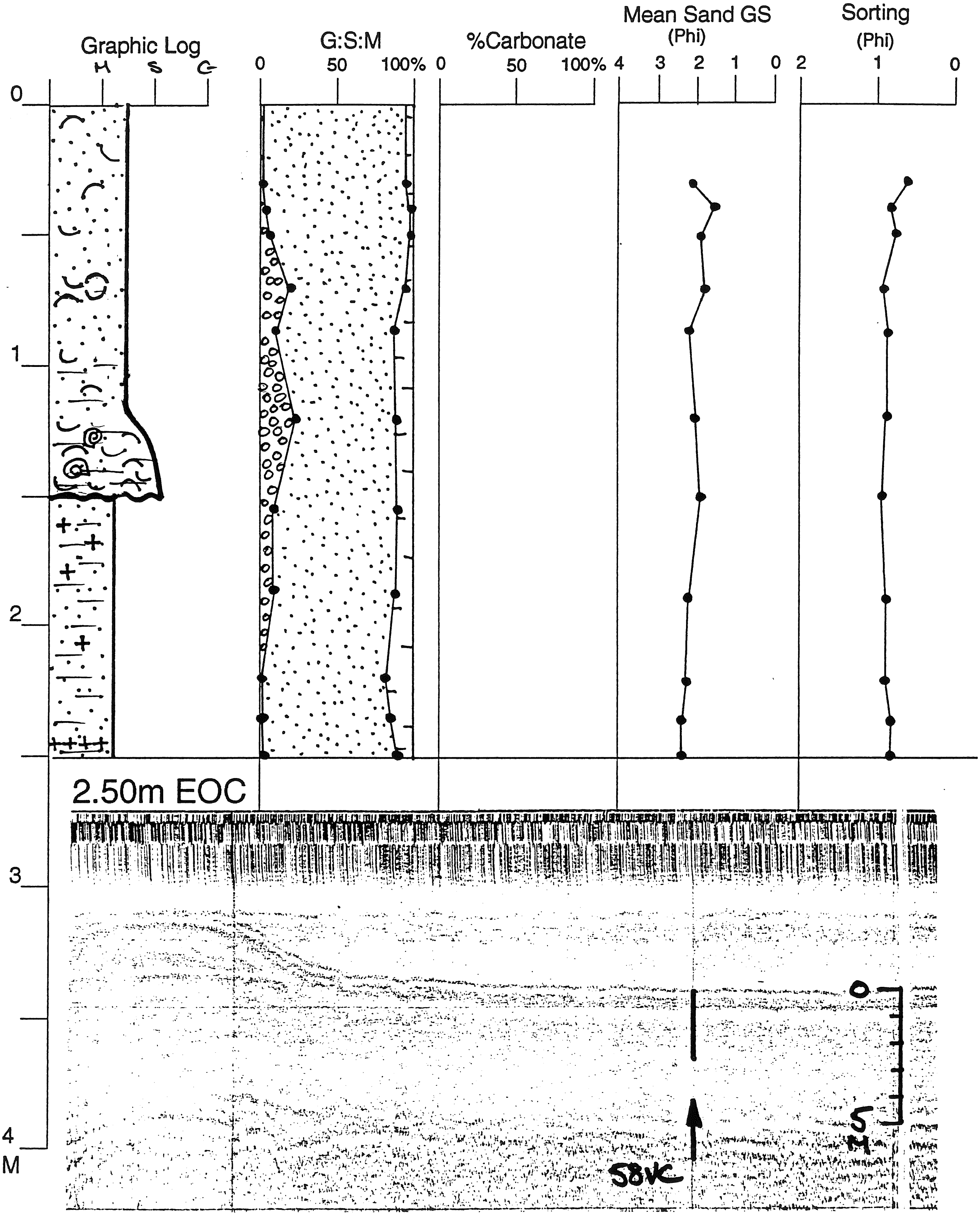

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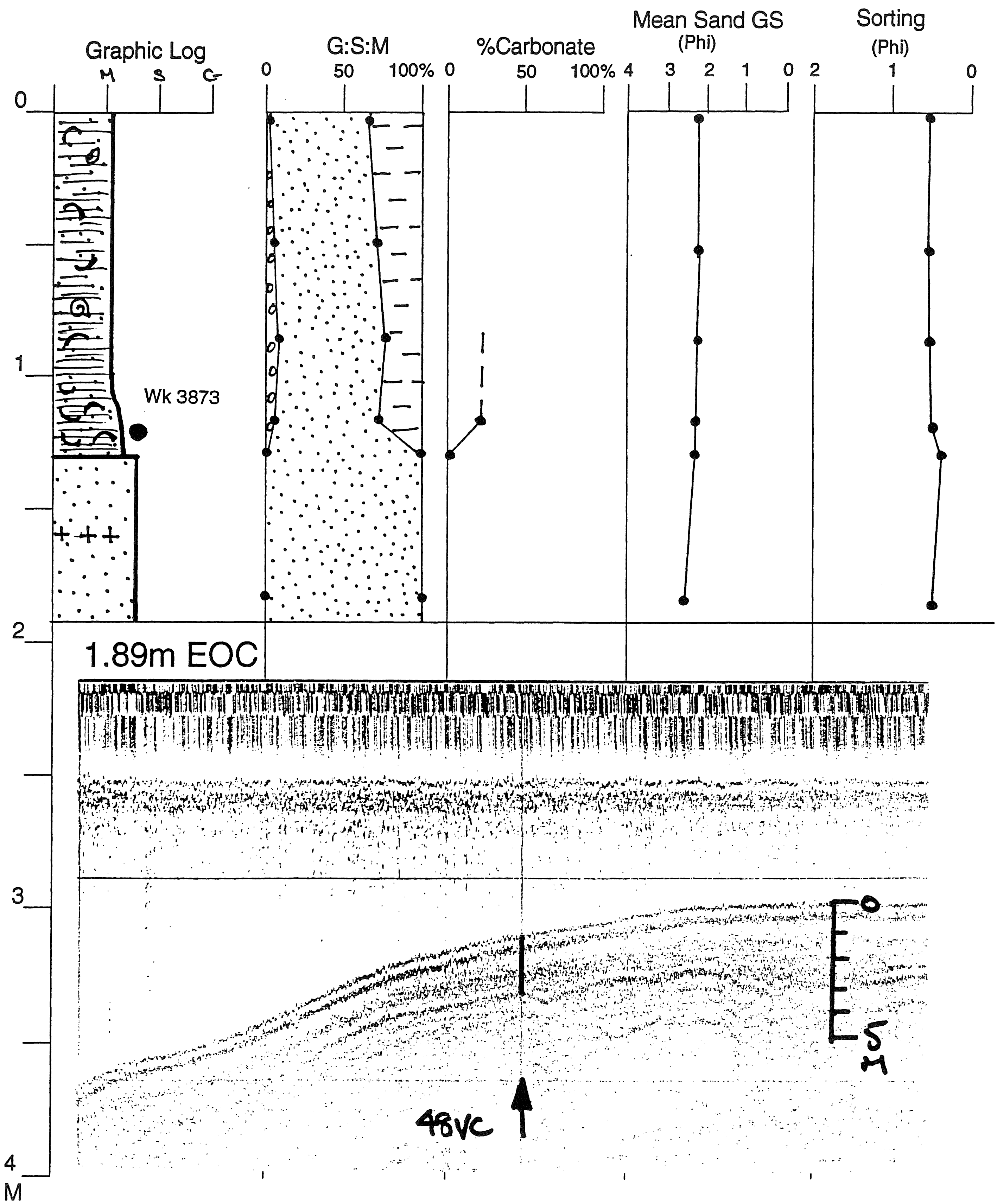

Zone: Cape Melville to Cape Flattery

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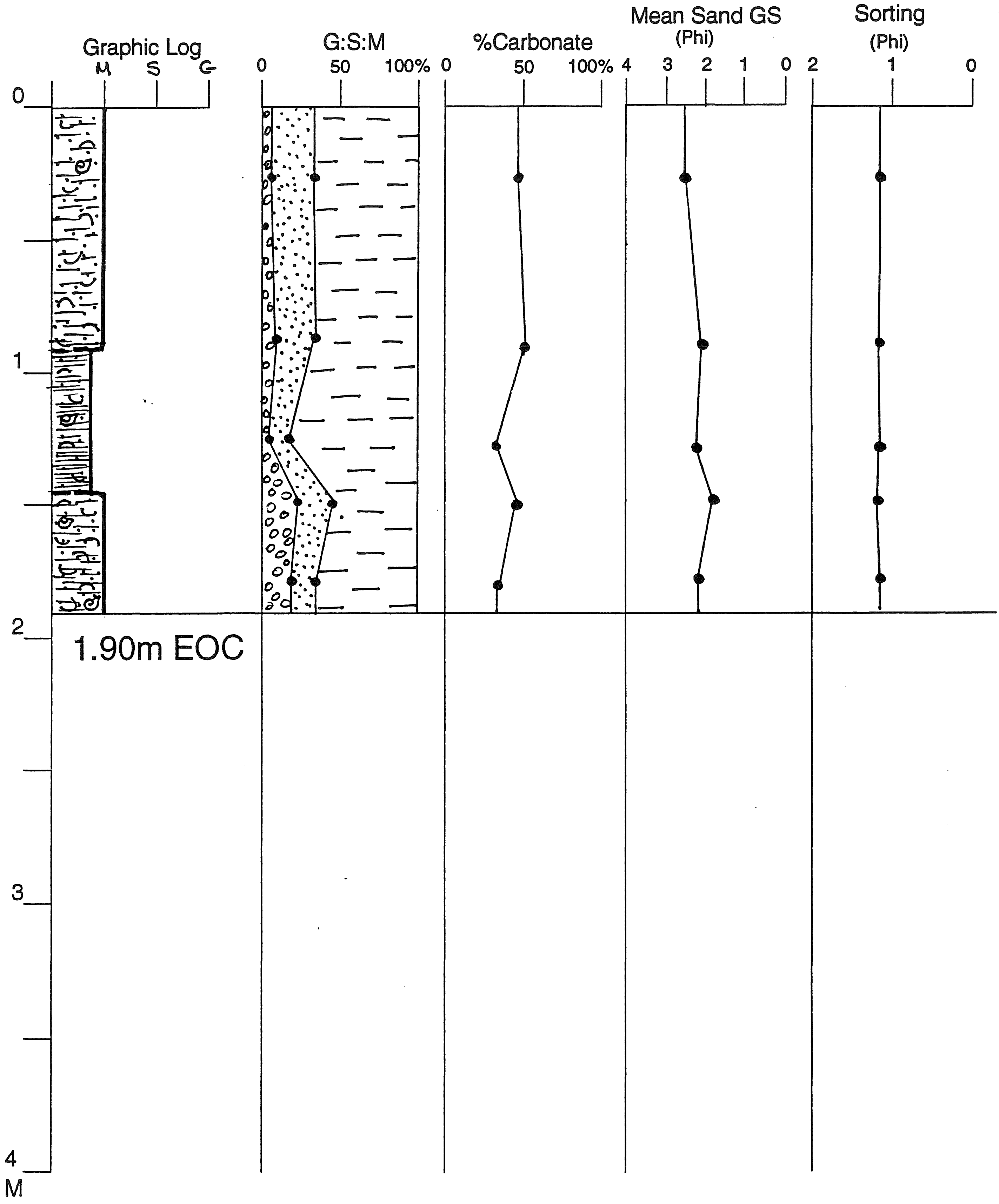

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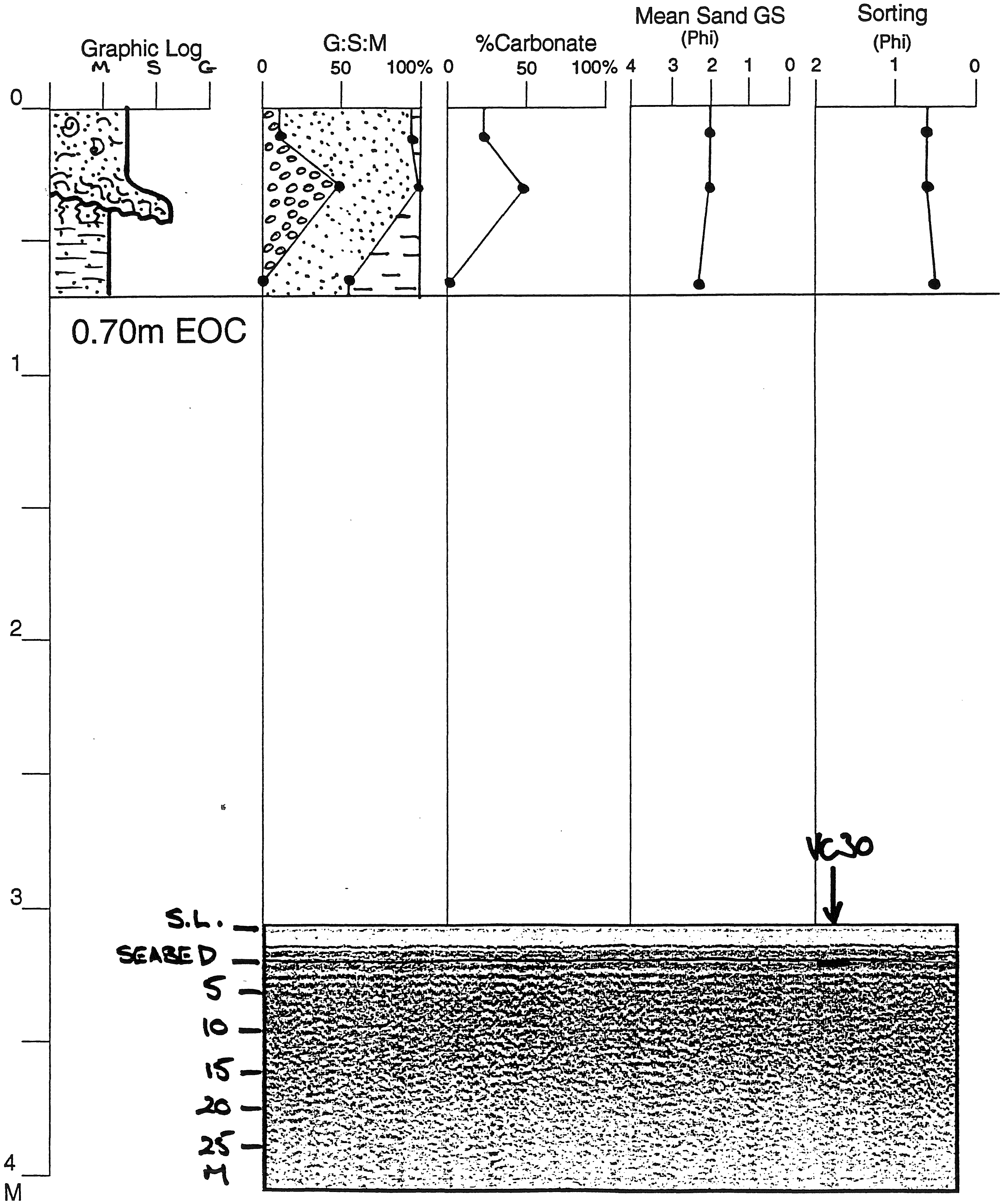

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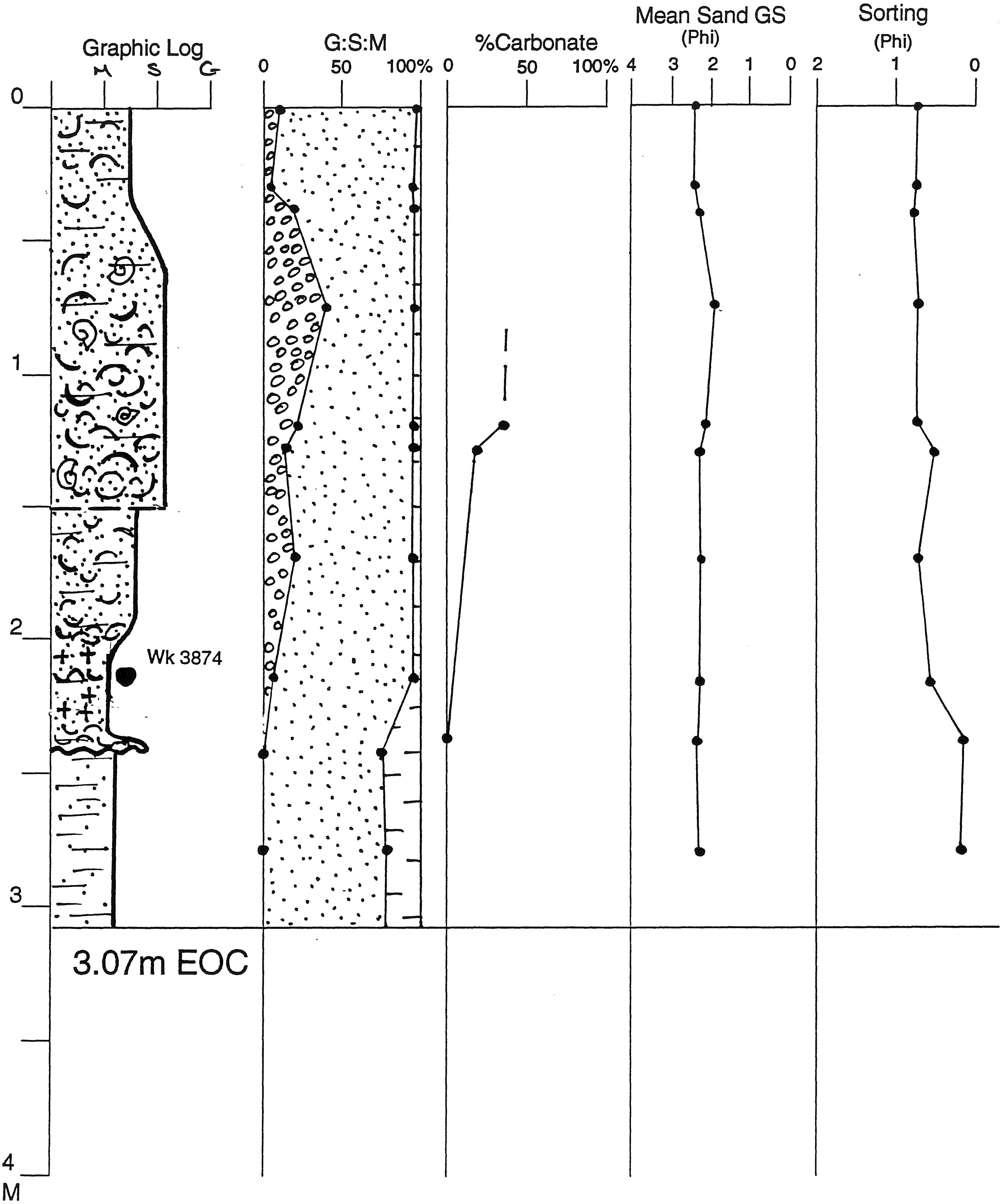
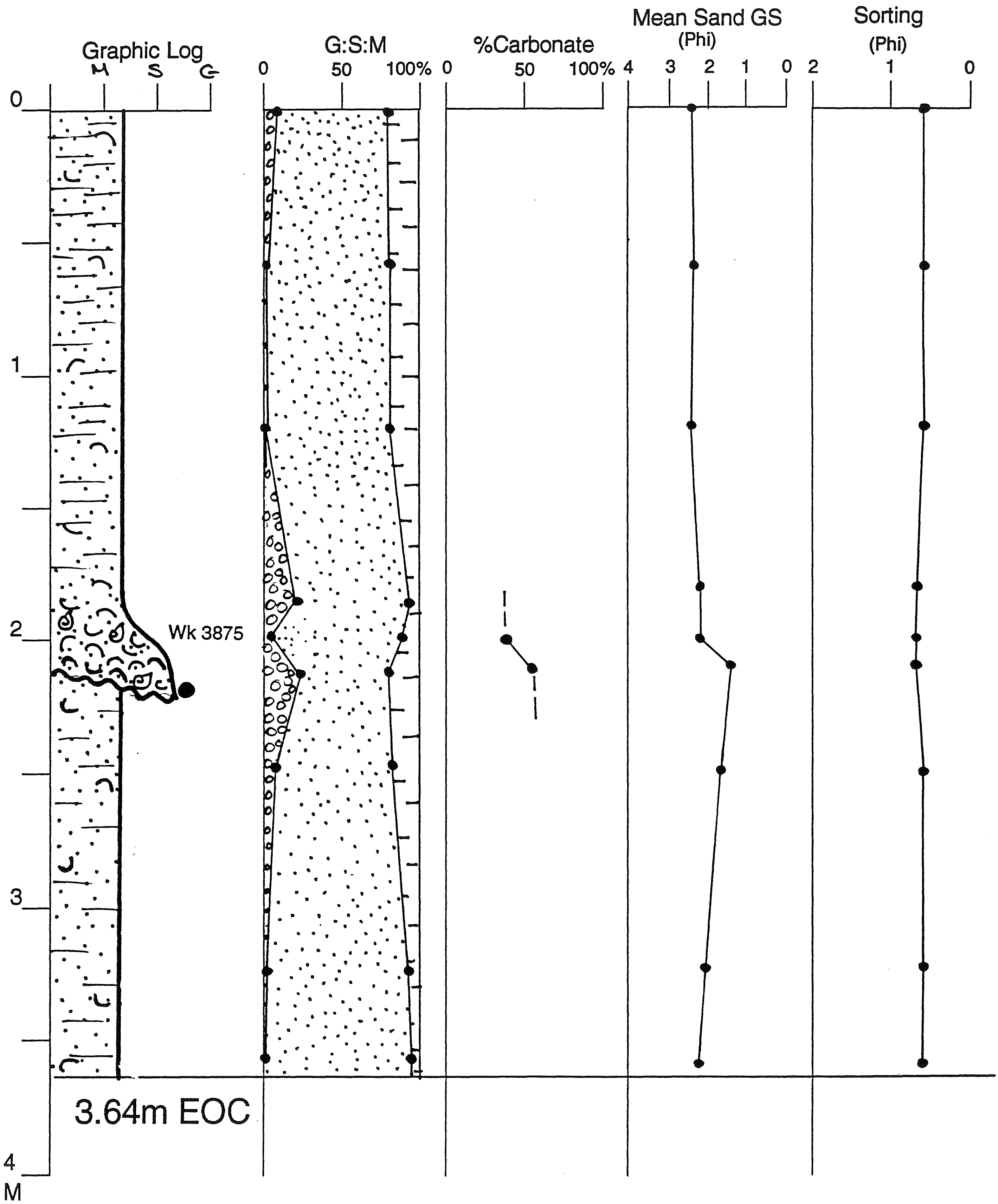
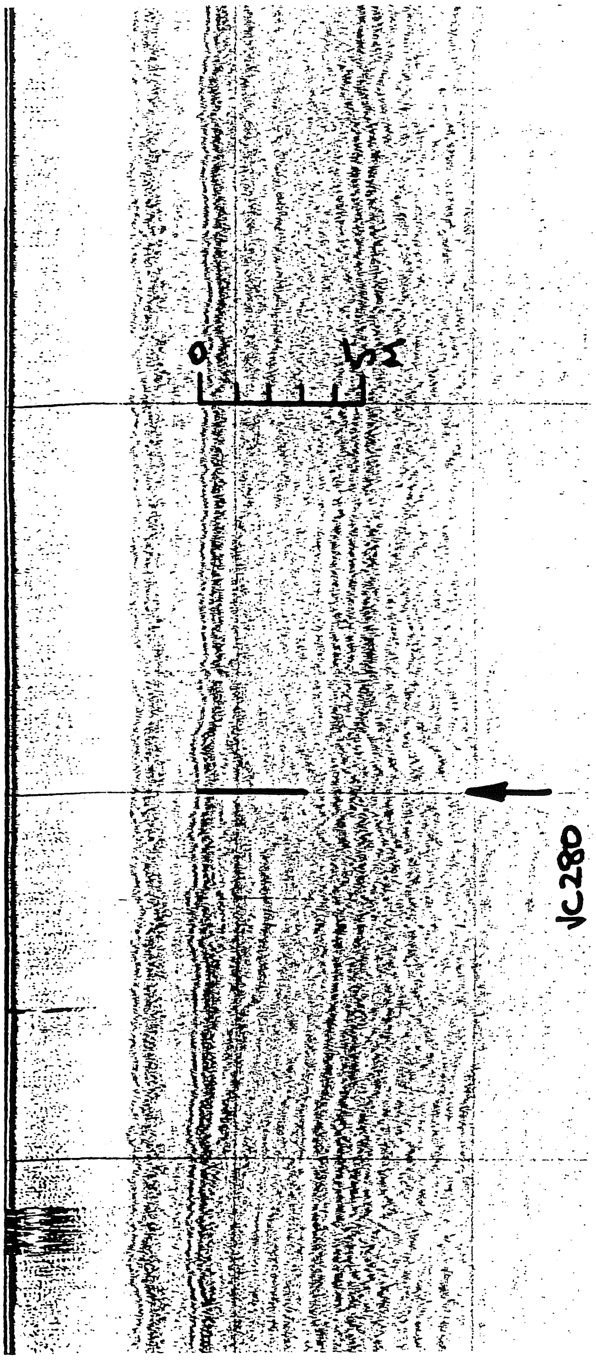
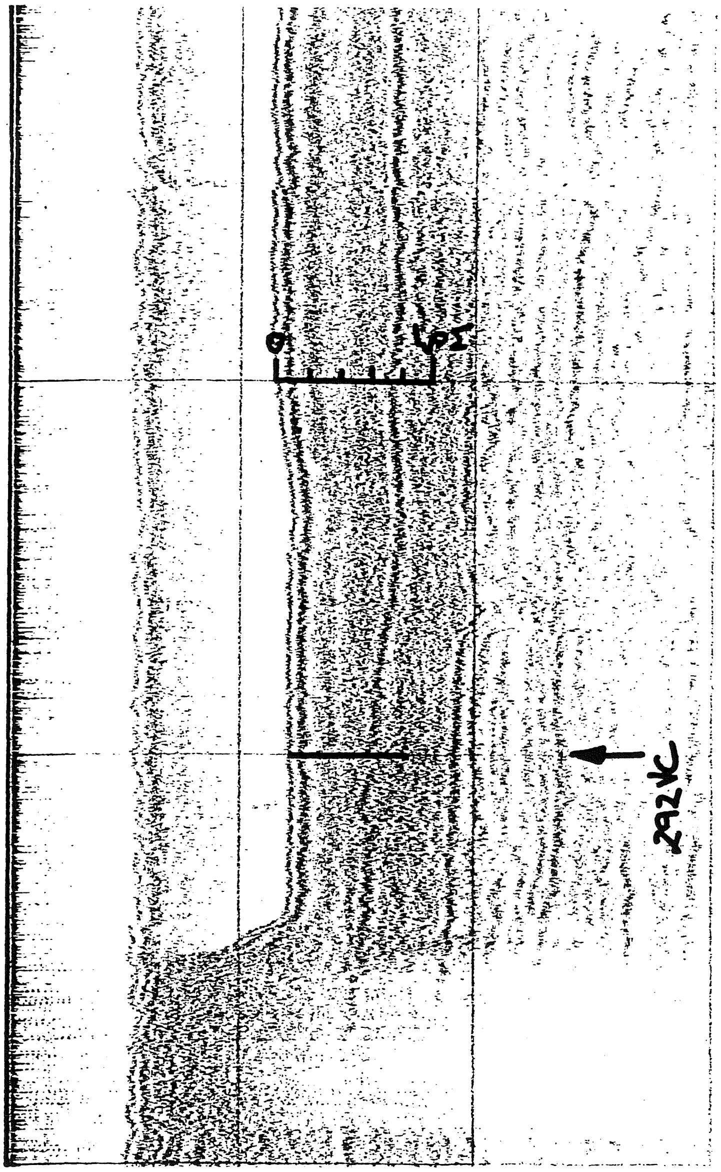


Zone: Cape Melville to Cape Flattery

Core ID.: 292VC Water Depth (m): NR




VC280


292VC

Zone: Cape Melville to Cape Flattery

Core ID.: VC29 Water Depth (m): 6