#2792 Herbert River Catchment.

JON BRODIE

SEDIMENTATION BETWEEN THE HERBERT DELTA AND THE PALM ISLES, HALIFAX BAY, CENTRAL GREAT BARRIER REEF

by

D.P. Johnson

Department of Geology
James Cook University of North Queensland
Townsville 4811. Australia

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SUMMARY

Halifax Bay is a semi-protected embayment in the central Great Barrier Reef Province, shielded by the Palm Isles which lie 15 to 20km offshore. The carbonate content of sediments increases regularly eastwards across the Bay towards the islands where fringing reefs are developed. Seven sedimentary facies have been identified, based on total carbonate and mud contents. These facies can be grouped into three regimes of sedimentation :

1) Modern terrigenous regime (`30% carbonate) near the mainland coast, consisting of a prograding, sandy sublittoral platform with a muddy outer slope.

2) Modern-palimpsest regime (30-80% carbonate) covering most of the embayment floor, consisting of poorly sorted sediments, mainly palimpsest terrigenous material, with admixtures of modern terrigenous and modern and palimpsest carbonate.

3) Modern carbonate regime (¨80% carbonate) comprising fringing reefs and nearby off-reef deposits.

Cores through the fringing reefs contain three post-glacial stratigraphic units : 1) reef top unit of coral rudstone and framestone including Sinularia (soft coral) spiculite, 2) reef slope unit consisting of coral framestone and rudstone, and 3) basal unit of terrigenous sands or gravels with minor skeletal debris. Terrigenous content of sediments increases down the cores. Radiocarbon dating shows the reefs prograded seaward at almost stable sealevel. Vertical accumulation rates of the reefs are 2.5-6.7 mm/yr, and the rate of seaward progradation 1 m/10yr. Terrigenous content of the reef sediments is controlled by accumulation of fine terrigenous sediment on the reef slope, and does not appear to have changed markedly during Holocene reef growth.

Factors influencing development of these patterns include:

1) Rapid post-glacial sea-level rise forming a thin transgressive veneer,
2) Embayment configuration protecting the area and allowing fringing reef formation, and
3) Coastal processes retaining most terrigenous sediment near the coast.

INTRODUCTION

The Great Barrier Reef Province (Maxwell,1968) contains one of the largest rimmed shelves in the world, and is characterised by an extensive, offshore reef tract, and a wide, inner-middle shelf zone of terrigenous sediments, both modern and palimpsest. The relatively deep (up to 50m) lagoon between the coast and the reef tract has open marine circulation (Ginsburg and James,1974). Apart from the detailed studies of Frankel (1974) and Flood, Orme and Scoffin (1978), previous studies of shelf sediments in the Great Barrier Reef Province have generally been broad scale (e.g. Maxwell,1968; Maiklem, 1970; Maxwell and Swinchatt,1970; Orme and Flood,1980).

This report describes sedimentary facies in Halifax Bay (Fig.1), a small area of inner shelf in the Central Great Barrier Reef Province. The area is semi-protected, primarily by the Great Barrier Reef itself and secondarily by a group of nearshore continental islands, the Palm Isles (Fig.2). The main sedimentary facies are modern terrigenous sand and mud along the coast of the Herbert Delta, and mixed modern-palimpsest muddy sand and gravel in the central Bay. Carbonate content increases towards the islands where there are fringing reefs.

The main aims of this report are:

1) to detail the configuration of the embayment and the nature of sediments, both in the Bay and in the fringing reefs,

2) to investigate the nature of terrigenous sediments being deposited on the fringing reefs, and whether the amounts of sediment have changed during the Holocene, and

3) to outline a model of sedimentation for the area.

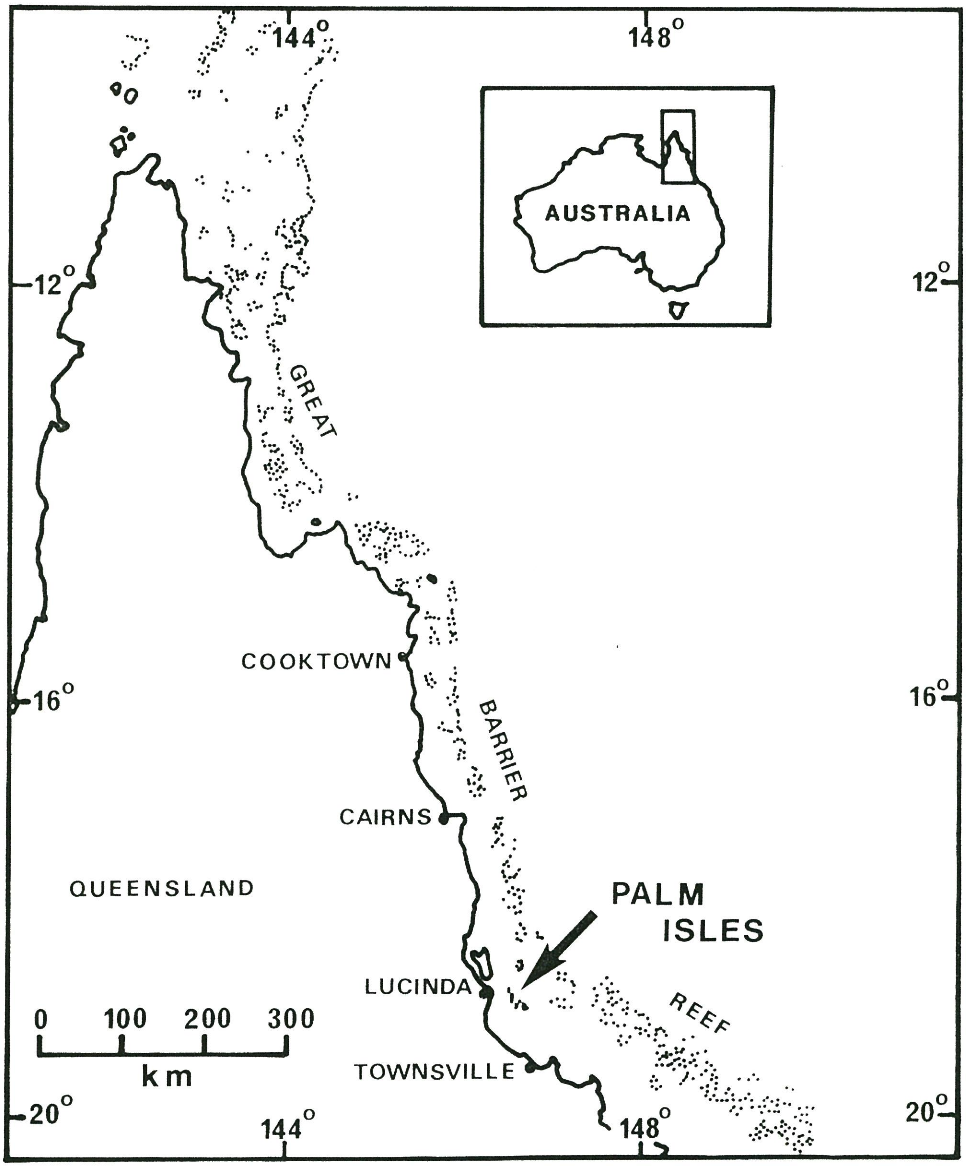


Figure 1 Location of study area.

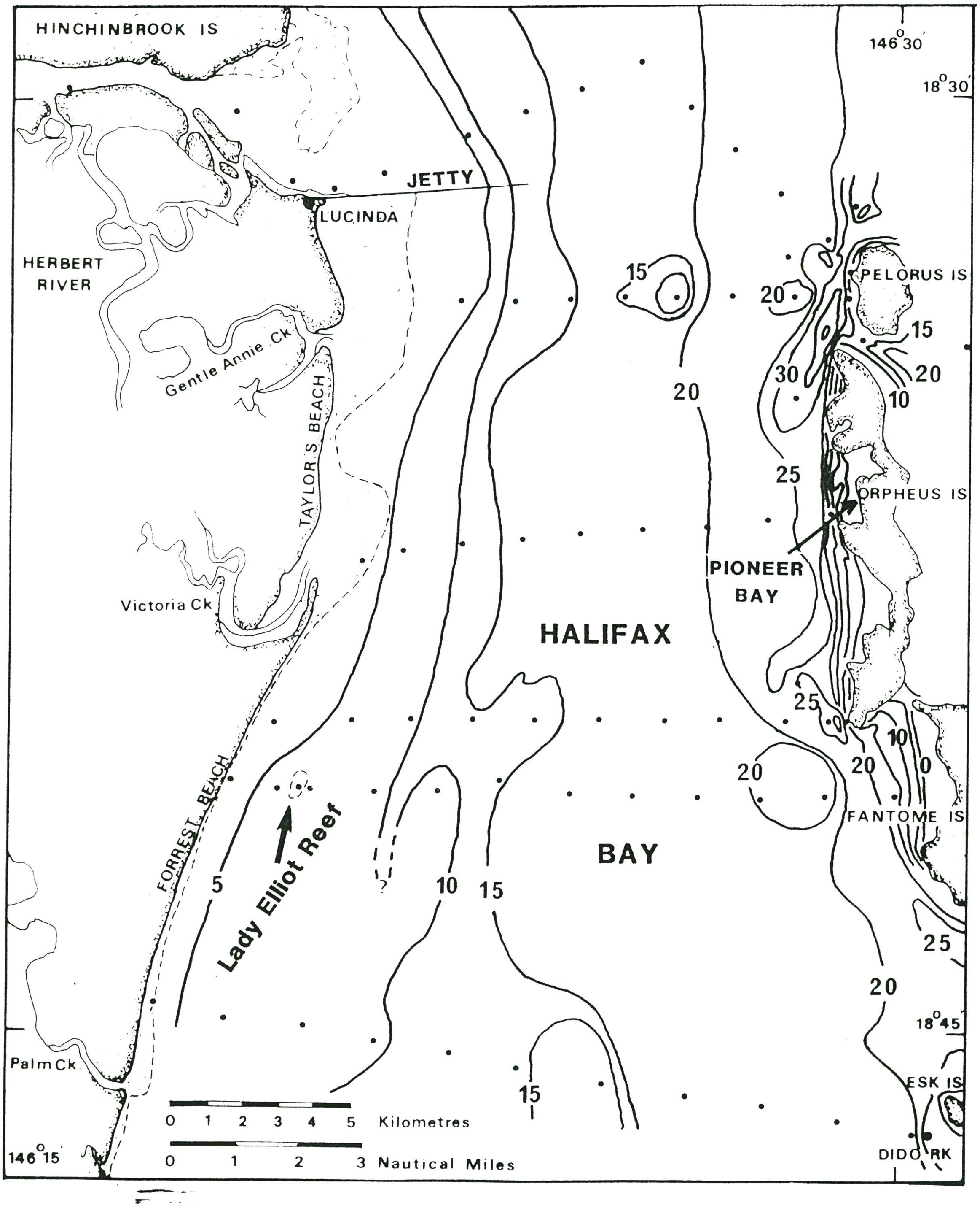


Figure 2 Bathymetry of northern Halifax Bay. Depths in metres. Sample locations and dive site are shown.

METHODS

Sixty-nine bottom sediment samples (Fig.2) were collected with a Van Veen grab with only small drainage holes so there was minimal disturbance of the sediment during sampling. Samples were wet-sieved to 1 phi intervals and dried at 105 C before weighing. Carbonate content was determined by weight difference after dissolution in 10% acetic acid. Component analyses of sands and gravels were done by visual estimation under binocular microscope using the charts of Terry and Chilingar (1955).

The nature of suspended sediment on the fringing reefs was investigated using sediment traps. Each trap consisted of triangular plastic slab with 30cm long, 50mm diameter plastic tubes at each corner, and was secured to the reef surface just below LWOST with metal tent pegs. Traps were sampled twice : once after the wet season and once after the dry season, when samples were recovered from each tube and stored individually in a refrigerator in seawater-rinsed, sealed plastic jars.

In the laboratory, sediment was washed free of seawater by placing the sample on filter paper in a conical funnel and repeatedly flushing with distilled water until the filtrate remained clear on addition of silver nitrate. Sediment was then dried at 105 degrees celsius, weighed and dissolved in 25% acetic acid with occasional agitation. Reaction mixtures were suction filtered through 4 micron ashless filter papers. The residue was dried and re-weighed to give acid soluble content, and the aliquots taken, digested by normal HF-Boric acid methods and analysed by atomic absorption spectrophotometry (AAS).

Cores of the Fantome Island leeward fringing reef were recovered using the JACRO drilling rig owned by the Australian Institute of

Marine Science, using techniques described by Rhodes (1981).

Matrix samples from the cores were also analysed for comparison with the contemporary suspended sediment recovered from the traps. Matrix was initially wet-sieved to remove material coarser than 0.5mm, since this grainsize was the maximum observed in the traps (apart from obvious whole skeletons), and since larger grains might bias compositional data for that sample. Aliquots of dried sample (1.0000gm) were dissolved in 20ml 20% acetic acid and the residues also analysed by AAS.

Filtrates after acid dissolution of trap and core matrix sediments were stored in rinsed volumetric flasks made up to 50ml (trap samples) and to 100ml (matrix samples) with distilled water, and sent for analysis by Inductively Coupled Plasma Spectrophotometry by AMDEL. Unfortunately several bottles leaked during transit, despite careful sealing, and analyses could not be determined for these samples.

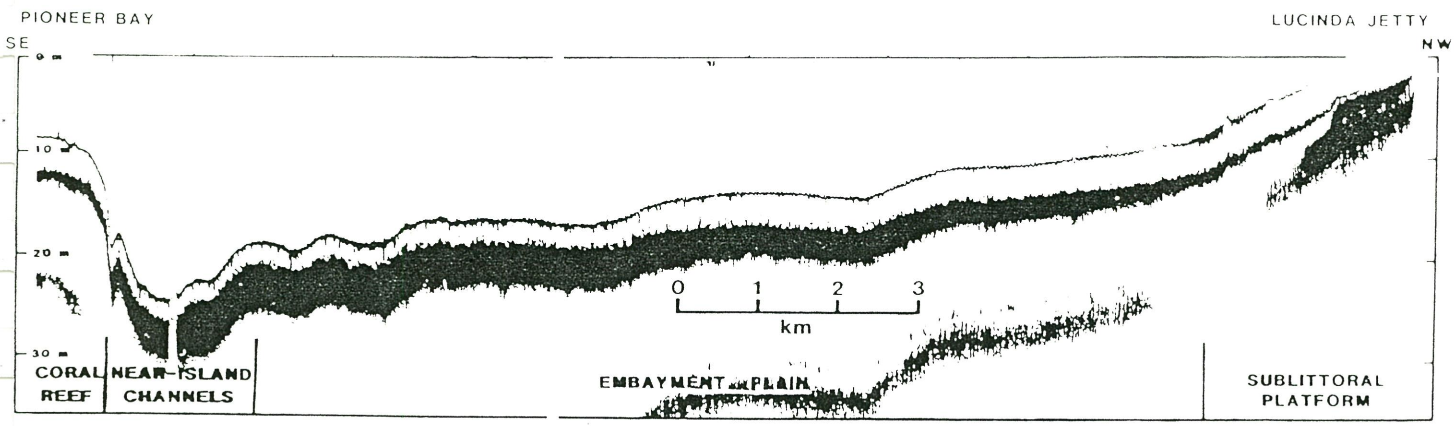
DESCRIPTION OF THE AREA

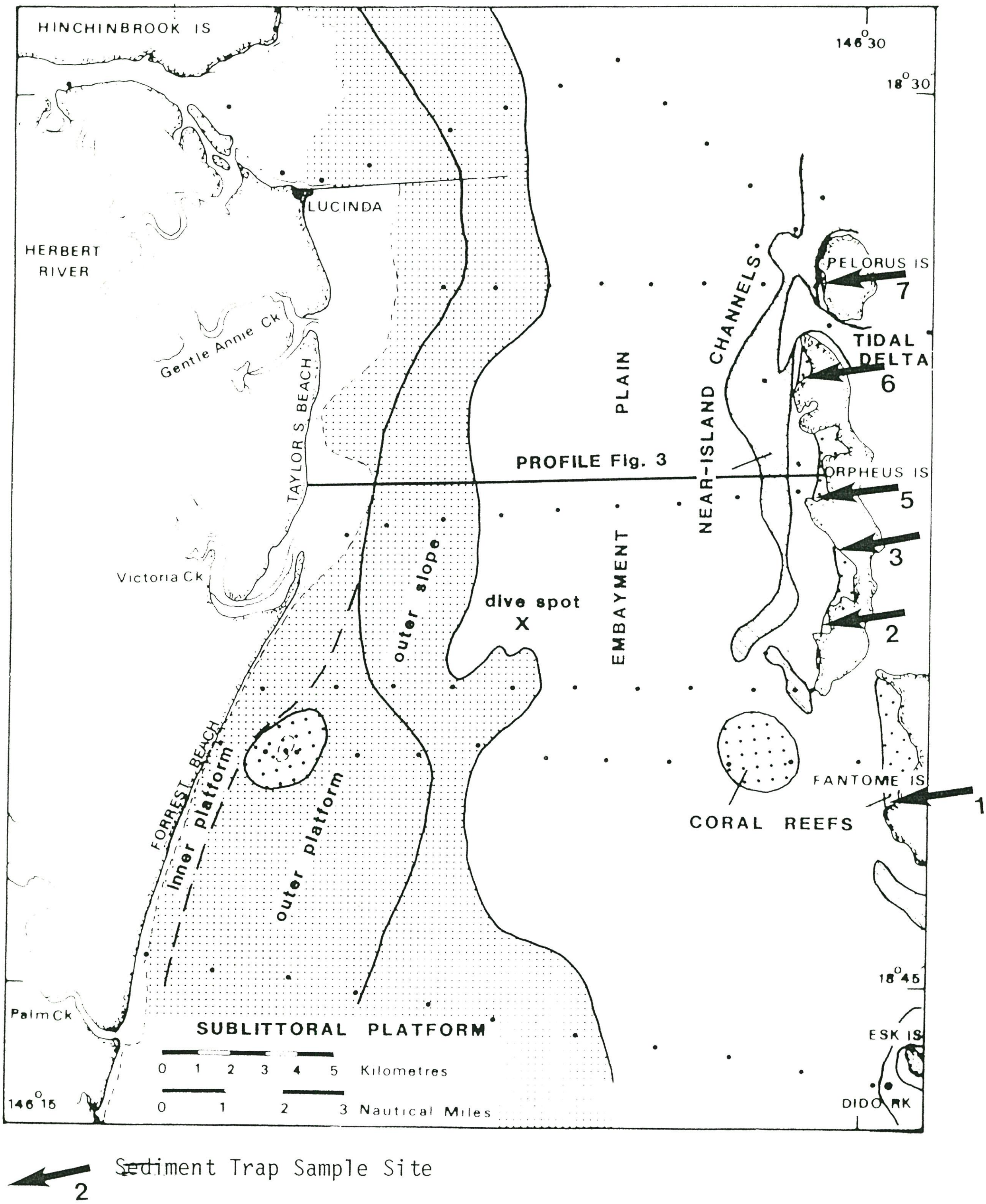
Location and Bathymetry

The area studied (Davidson,1981;Johnson and Risk,in press) is 70km NW of Townsville and covers approximately 600 sq km of northern Halifax Bay, between the Herbert Delta and the Palm Isles (Figs.1,2). It is situated within areas covered by previous regional studies (Maxwell,1968; Orme and Flood,1980;) and between detailed studies to the south (Belperio,1983) and to the north (Rhodes and Pye, in prep.).

Halifax Bay is a semi-protected embayment on the inner shelf. Most of the Bay is less than 20m deep, except along the western edge of the islands where channels up to 40m deep occur (Fig.2,3).

Figure 3 Bathymetric profile across Halifax Bay showing main subtidal physiographic units. Location shown in figure 4.





Sediment Trap Sample Site

Figure 4 Distribution of subtidal physiographic regions in Halifax Bay. Dots in this and subsequent figures mark sample locations.

Four subtidal physiographic units are recognised (Figs.2,3,4; Table 1): sublittoral platform, embayment plain, near-island channels and coral reefs.

TABLE 1

PHYSIOGRAPHIC REGIONS OF HALIFAX BAY

Region	Depth Range	Slope	Width
Sublittoral Platform			
upper surface	0 - 10 m	1 - 5 m/km	1 - 7 km
outer slope	5 - 15 m	3 - 6 m/km	2 - 7 km
Embayment Plain	15 - 20 m	0.7-0.9 m/km	3 - 8 km
Near-Island Channels	> 25 m	>3 m/km	0.7 - 2 km
Coral Reefs	0 - 10 m	very steep	<600 m

The sublittoral platform has a relatively flat top, sloping gently to 5 to 6m water depth, with a steeper outer margin which passes onto the embayment plain. To the north, the platform is 5 to 7km wide and passes shorewards onto intertidal sandflats. Though the modern Herbert River discharges at the northern end of the study area, much of the platform in the Lucinda Jetty area probably represents a tidal delta at the southern end of Hinchinbrook Channel, rather than a direct fluvio-deltaic deposit. To the south, there is a narrow inner platform (~1km wide) with sandy beaches along the inner edge, and an outer platform, which is broader, more uneven and with a steep outer slope.

The embayment plain slopes gently eastwards, steepening below 20m, where it passes into the near-island channels. There are small tidal deltas at the western ends of the passages between Orpheus and Fantome, and Orpheus and Pelorus Islands.

Three types of coral reef occur in the area: fringing reefs around the islands, a patch reef (Lady Elliot Reef, see figure 2) near the mainland, and an isolated submerged, patch reef on the embayment plain 5km west of Fantome Island.

The fringing reefs are extensive, up to 600m wide, and are best developed in protected bays along the western side of the islands. Fringing reefs have relatively flat intertidal upper surfaces and steeper seaward slopes. Landward the upper surface passes onto beaches, mangrove (*Rhizophora* sp) zones, or abuts rocky headlands. On broader reefs the upper surface commonly has an inner (sandflat) zone, and an outer (rubble) zone, while on narrow reefs, the sandflat is absent, and the rubble zone is backed by steep sand or boulder beaches. The outer slopes of the reefs descend from approximately low water level, either gradually onto the embayment plain or more steeply into the near-island channels.

The inner (sandflat) zone is mainly mobile sand, with a flat, rippled or burrowed surface, and rarely with patches of brownish algal mats. Sediment is medium to coarse, skeletal sand with scattered skeletal and lithoclastic gravel. Shallow pools contain small coral knobs, sponges and commonly algae and seagrasses (*Halimeda*, *Padina*, *Hydroclathrus*, *Halophila*). The outer zone is mainly hard substrate composed of coral heads and abundant coral rubble with scattered sandy pools. Both rubble and corals are heavily bored by sponges (*Cliona* spp), mytilids and sipunculids, and encrusted by *Chama* and *Spondylus*. There are no large, massive corals but small, live *Goniastrea favulus*, *Montipora ramosa* and *Porites* occur. However at the edge of the reef flat (approximately LWOST), there is up to 80% hard substrate with massive, dead colonies bored by *Tridacna*, and microatolls and other colonies up to 0.5m across. Common genera are *Goniastrea* and *Symphyllia*, with less common *Acropora millepora*, *Montipora ramosa*, *Leptastrea* sp and the soft coral *Sinularia*. The reef slopes commonly flatten at about 5-8m water depth. Towards the top of the slope are large coral colonies, commonly *Porites* sp, up to 2.5m high with intervening areas of rippled sand. Lower down the slope the substrate is muddy, *Porites* is absent and mounds of *Goniopora* and *Anacropora* occur.

Environment

Environmental data for the area are summarised by Pickard *et al.* (1977). The climate is tropical with marked dry winter (March-November) and wet summer seasons (December-February). Winds are dominantly the SE trade winds during winter, but during summer the monsoon introduces a NE component. From January to March the area is prone to cyclones with gale-force winds, heavy rain and storm-surges. Over 80% of the 2034mm annual rainfall occurs during summer.

Tides are semi-diurnal with a 2 to 3m range. Currents in the central Bay range up to 1 kt but are greater in constricted passages such as Hinchinbrook Channel and between the offshore islands. A wind-generated, northward-flowing current contributes to longshore drift in nearshore areas during most of the year (Pickard *et al.*,1977; Wolanski and Ruddick,1981).
Water characteristics have not been studied, but Cleveland Bay (70km south) shows the following features (Archibald and Kenny,1980). Water temperature ranges from 19 to 31 C, and salinity is normally 27 to 35‰, but extreme variations due to cyclonic rainfall occur, reducing salinity over reef-flats to less than 20 ‰.

NATURE OF BAY SEDIMENTS

Sediment Size Distribution

Sediment size distributions are summarised in figures 5,6 and 7. Detailed analyses are given in Davidson (1981). Gravel forms up to 30% of the sediment . High gravel contents occur on the southern end of the sublittoral platform, in the Hinchinbrook Channel and in isolated patches near the islands (Fig.5). Gravels are composed of bioclastic debris, terrigenous lithoclasts and carbonate nodules. Bioclastic gravel is composed dominantly of bivalves and gastropods, with minor bryozoans and foraminifera near the islands, and echinoids along the edge of the sublittoral platform. High proportions of bioclastic components generally occur where total gravel content is low. Terrigenous lithoclast gravel is most common on the southern end of the sublittoral platform, where it constitutes up to 95% of the gravel fraction. Lithoclasts are mainly granitoid and volcanic rock fragments. Carbonate nodules are restricted to the embayment plain where they form up to 30% of the gravel fraction. The nodules are rounded, brown clasts up to 5cm across,composed of muddy quartz sand with recrystallised molluscs and foraminifera, cemented by a coarse mosaic of low Mg calcite. X-ray diffraction analyses of crushed nodules show dominant low Mg calcite and quartz with minor clays and a trace of aragonite.

Sand forms 40 to 80 % of most Halifax Bay sediments (Fig.6). Areas of very high sand content (¨80%) occur along the inner edge of the sublittoral platform to a depth of approximately 4m, and on the flanks of the tidal delta between Pelorus and Orpheus Islands. Inshore near the Herbert Delta, the sand is characteristically well-sorted, fine to very fine, angular quartz sand with very minor coarser grained, terrigenous and biogenic

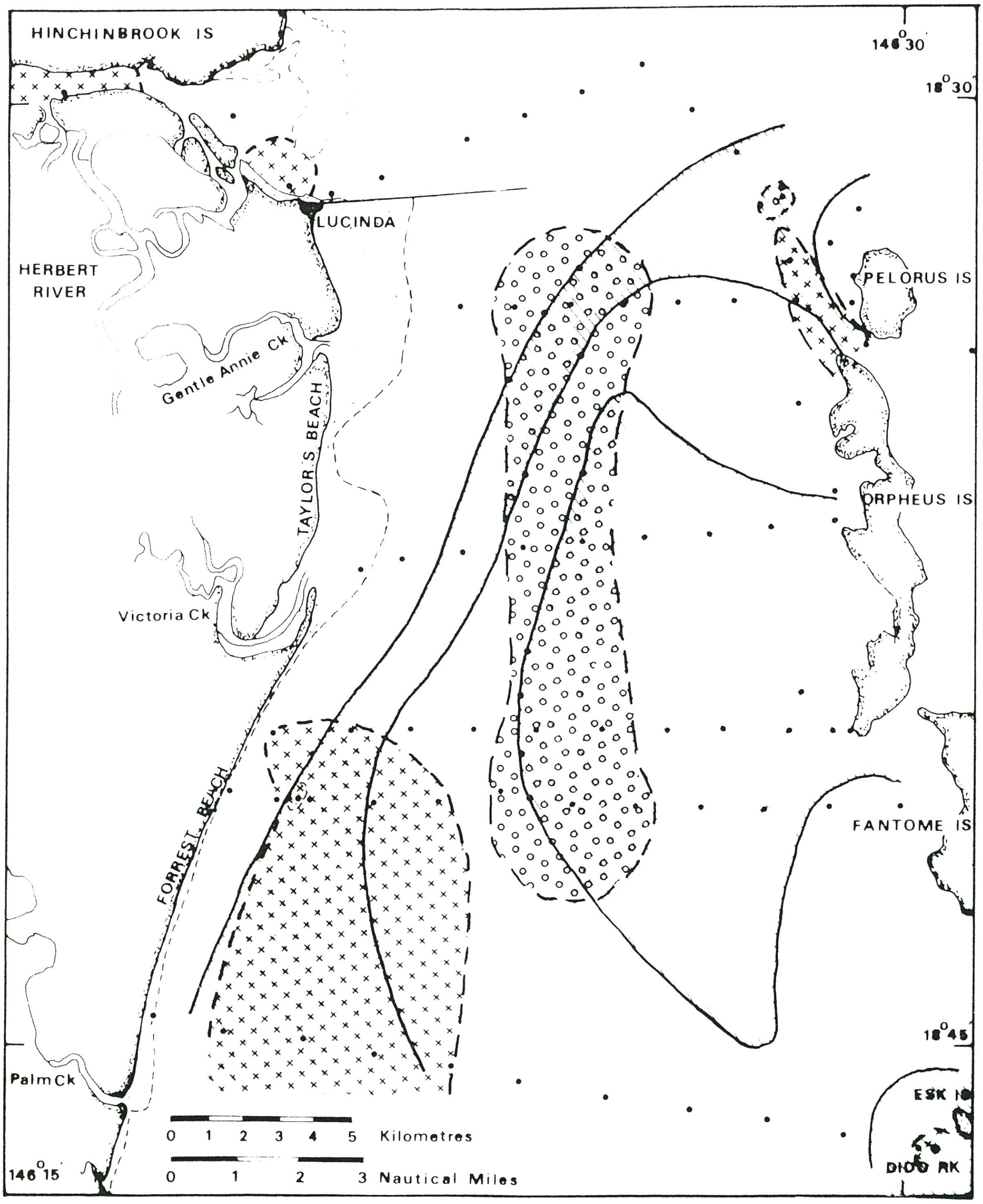


Figure 5 Distribution of gravel fraction (%) in surficial sediments. Cross-hatch pattern marks areas with ¨10% gravel. Composition is very variable : circle pattern shows main occurrences of carbonate nodules (¨15% of gravel fraction), cross pattern where terrigenous lithoclasts are dominant (¨60% of gravel fraction). Elsewhere biogenic gravel (80 to 100% of fraction) is dominant.

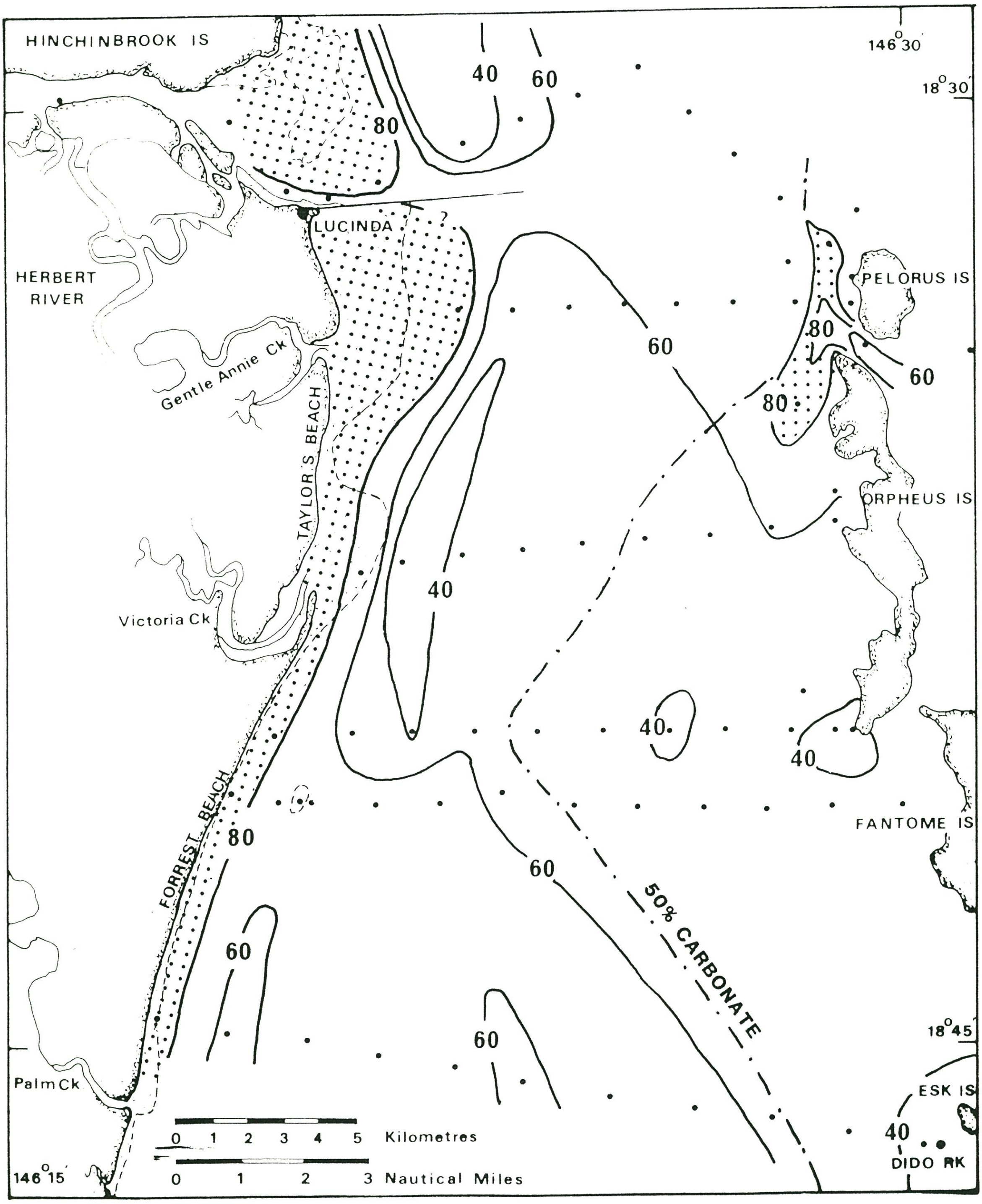


Figure 6 Distribution of sand (%) in surficial sediments. Stipple pattern indicates ¨80% sand in sample, and dot-dash line marks 50% carbonate content of sand, less to the west, more to the east.

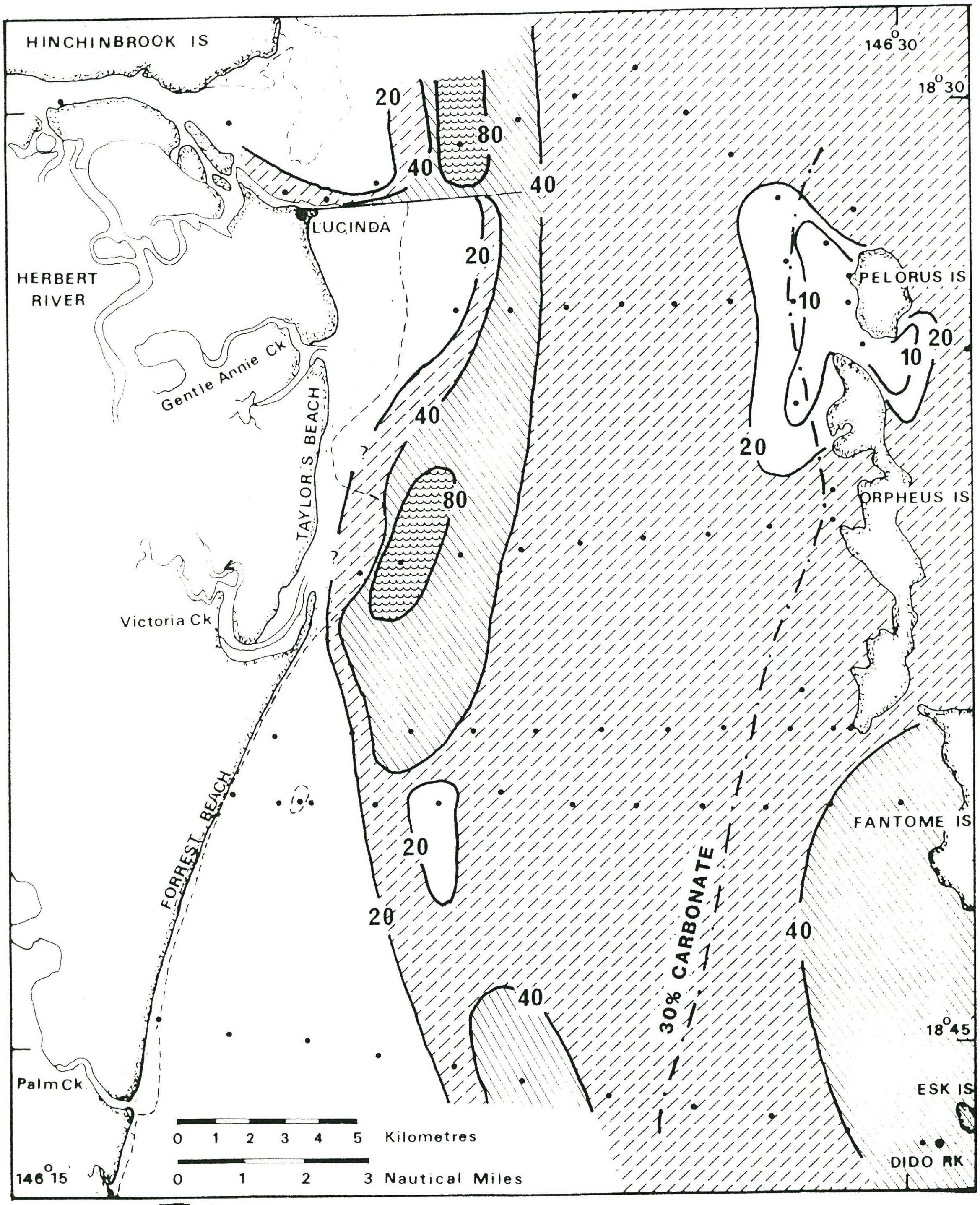


Figure 7 Distribution of mud fraction (%) in surficial sediments. Dot-dash line marks 30% carbonate content of the mud, higher values to the east.

detritus. Sand content of sediments decreases offshore. Areas of ~40% sand occur along the outer slope of the northern sublittoral platform (where mud accumulates), and offshore on the embayment plain (where there are high biogenic or lithoclast gravel contents). Although overall sand content tends to decrease offshore, modal sand size tends to increase. Offshore sands are normally poorly-sorted, of very coarse to fine grades, and are composed of two main types : 1) biogenic grains, particularly bivalves with minor gastropods, foraminifera and echinoderm debris, and 2) terrigenous grains, mainly quartz with rare lithoclasts. In general biogenic content of sands increases eastwards across the embayment plain.

Mud forms 20 to 40% of most sediments in the Bay (Fig.7). High mud contents (¨80%) occur only along the outer margin of the northern sublittoral platform, where the mud is ¨90% terrigenous, consisting of clays (kaolinite, illite and smectite), quartz and minor calcite and aragonite. Carbonate content of the mud increases eastwards across the embayment, and near the islands, the mud is 30 to 40 % aragonite and calcite. Examination by SEM indicates identifiable silt particles consist mainly of sponge-boring chips, tunicate sclerites, shell fragments and foraminifera. Many irregular silt grains seen under SEM were low magnesian calcite, and XRD analyses indicate 20 to 40% of the carbonate mud is low magnesian calcite. Areas of low mud content (~20%) occur on the inner, shallower parts of the sublittoral platform, particularly to the south, and on the tidal delta near Pelorus Island.

Carbonate Content

Total carbonate content of sediments increases eastwards across the Bay from ˜10% near the coast to ¨60% near the islands, with three samples ¨80% (Fig.8A). Carbonate contents of the gravel, sand and mud fractions are shown in figures 8B-D.

Gravel contains at least 60% carbonate in most samples (Fig.8B), and in many samples, particularly in the eastern Bay the content is ¨ 90%. Low carbonate contents (˜20%) are restricted to the coast and to a lobate area corresponding to the wide, southern sublittoral platform, and to two samples in the Hinchinbrook Channel. Off the platform, carbonate contents are generally ¨90%, although there is a meridional area of lower values (60 to 88%) on the central embayment plain. This area corresponds closely to the distribution of carbonate nodules (cf. Fig.5), and the lower values reflect the terrigenous content of the nodules. Sand ranges from 0 to 92% carbonate (Fig.8C), also showing an eastward, increasing trend. Low values (20%) are restricted to the coast and the southern sublittoral platform, and content increases steadily eastwards with high values (¨80%) restricted to the SE part of the area. Mud ranges from 4 to 43% carbonate, and the contours have meridional trends apart from some low values in the south of the area (Fig.8D).

Although total carbonate content of the sediments increases regularly eastwards (Fig.8A) corresponding to the sedimentary regimes, the carbonate contents of individual size fractions show different patterns (Figs.8B-D). Carbonate content of the gravel fraction is generally high in the eastern Bay (¨90%) due to the dominant biogenic content. Lower values in the central Bay are due to impure carbonate nodules. Very low values on the

Figure 8 Carbonate content of surficial sediments.
A. Total carbonate content of surficial sediments.
B. Carbonate content of gravel fraction of surficial sediments.
C. Carbonate content of sand fraction of surficial sediments.
D. Carbonate content of mud fraction of surficial sediments.

sublittoral platform are due to high terrigenous influx on the inner platform, and to accumulation of palimpsest lithoclast gravel on the southern outer platform. Thus at least four factors are contributing to the gravel distribution pattern. Sand carbonate is also lowest on the sublittoral platform, parallelling trends for the gravel carbonate. However the highest carbonate sand values occur to the west of the southern islands with an isolated sample off Pelorus Island, and probably represent lack of terrigenous input combined with material being swept off the fringing reefs. Mud carbonate content is the most regular pattern of all three fractions. Contours (Fig.8D) do not correspond to trends shown for the gravel and sand fractions, except for low values near the mainland coast. It seems most probable that the mud carbonate distribution is a function of decreasing eastward dispersal of terrigenous mud, and corresponding decreasing westward dispersal of lesser amounts of carbonate mud eroded from the fringing reefs. Both terrigenous and carbonate mud may be moving mainly in suspension, that is in quite a different way to the sand and gravel fractions.

SEDIMENTARY FACIES

Following previous studies of mixed terrigenous-carbonate sediments in the Great Barrier Reef province (Maxwell,1968; Maxwell and Swinchatt,1970; Frankel,1974; Flood *et al.*,1978), Halifax Bay sediments have been classified in terms of carbonate content and mud content. The scheme (Table 2) follows the broad-scale divisions of Flood *et al.*,(1978), but further subdivides the terrigenous type.

TABLE 2

CLASSIFICATION OF SEDIMENTARY FACIES

TYPE	CARBONATE %	FACIES	MUD %
1. CARBONATE		Carbonate sand facies	< 10 %
	80		
2A. IMPURE		Impure carbonate moderate-high mud facies	10 - 40 %
2B. CARBONATE		Impure carbonate very high mud facies	> 40 %
	60		
3B. TRANSITIONAL		Transitional moderate-high mud facies	10 - 40 %
	30		
4A. TERRIGENOUS		Terrigenous sand facies	< 10 %
4B.		Terrigenous moderate-high mud facies	10 - 40 %
4C.		Terrigenous very high mud facies	> 40 %

Distribution of sedimentary facies is shown in figure 9. The transition from terrigenous sediments at the coast to carbonate-rich sediments near the islands is clear.

The terrigenous sand facies is restricted to the inner part of the sublittoral platform and the Hinchinbrook Channel, extending landwards onto the intertidal sandflats and beaches. The sediments are more muddy offshore, where the terrigenous moderate-high mud facies covers most of the upper surface of the sublittoral platform. On the inner platform sediments are well-sorted, quartzose sands with minor lithoclasts and molluscs. Sand size is coarsest along the beaches (1 to 3 phi)

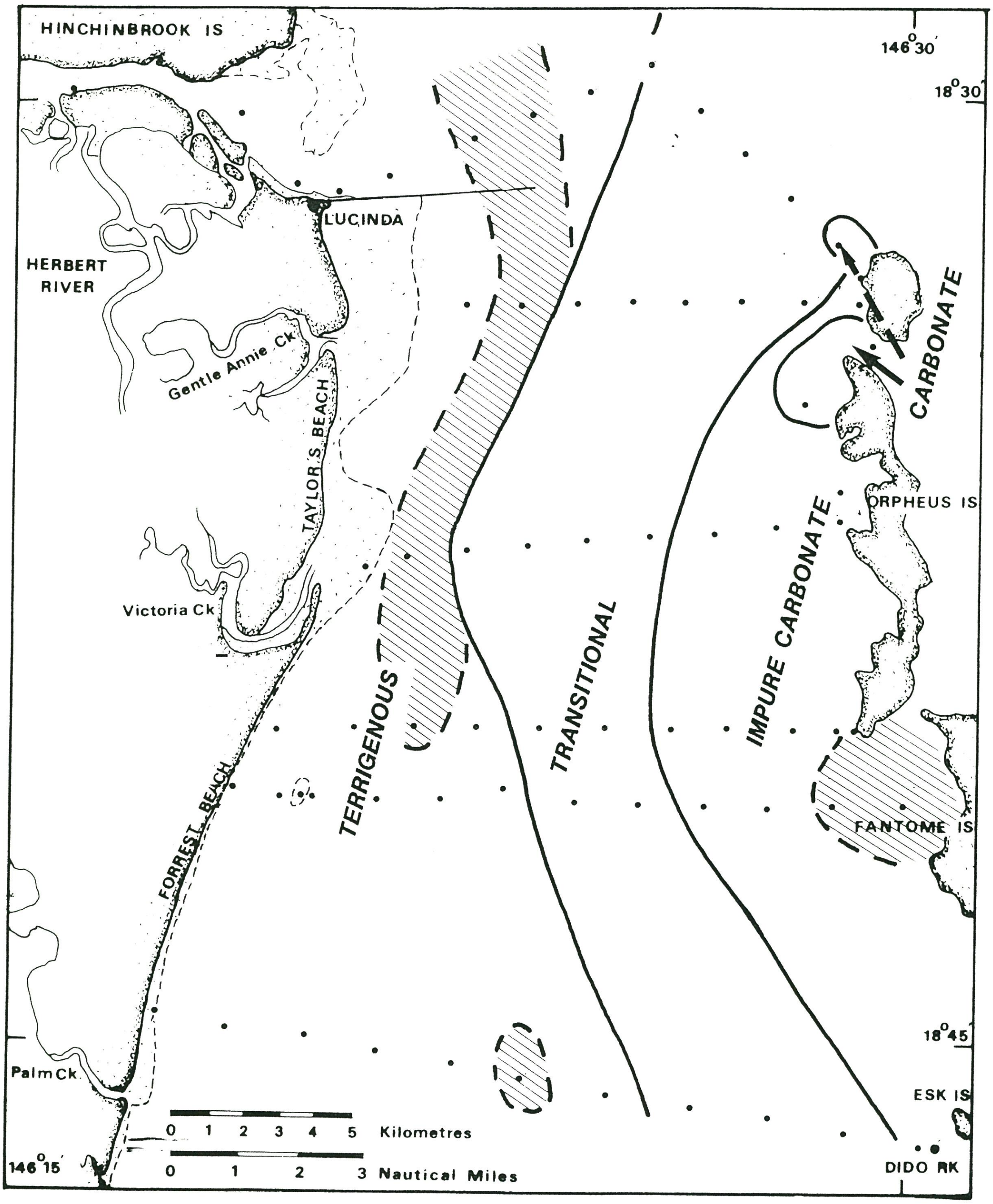


Figure 9 Distribution of sedimentary facies, showing extents of sediment types defined in Table 2. Hachured areas represent very high muddy (¨40% mud) facies.

and finest on the outer platform margin (2 to 4 phi). Muddy sands with 20 to 30% mud occur in protected sites such as in the lee of Lady Elliot Reef and on some sandflats on the inner platform. The terrigenous moderate-high mud facies on the southern, outer sublittoral platform is reddish-brown, poorly sorted gravelly sediment, characterised by ¨20% lithoclast gravel, and sand composed of quartz, lithoclasts and minor shells. Mud forms ˜20% of the sediment.

The terrigenous very high mud facies is developed as a continuous belt on the outer slope of the sublittoral platform north of Lady Elliot Reef, with an isolated patch to the south of Orpheus Island. Sediments are mud and sandy mud with minor (˜5%) gravel. Sand is mainly fine to very fine, angular quartz. Mud is terrigenous with ˜10% carbonate content.

The transitional moderate-high mud facies blankets the western and central areas of the embayment plain, generally in water depths of 15 to 20m, and is composed of muddy sand. Sediments are poorly sorted and contain 47 to 71% sand which is dominantly quartz, with minor biogenic material, mainly molluscs. Sands are fine to very coarse grained, that is much of the sand is coarser than sand on the sublittoral platform to landward. Gravel (3 to 21%) is composed of molluscs, carbonate nodules and other biogenic debris. Mud forms 12 to 40%, and increases in carbonate content from 8 to 30% eastwards.

The impure carbonate moderate-high mud facies occurs on the eastern embayment plain and in the near-island channels, in water depths from 20 to 40m, and extends slightly shallower and more westward in the central part of the area. The sediments are very poorly sorted. Sand ranges from very coarse to very fine grades and generally contains ~20% terrigenous material. Most of the carbonate sand is molluscan (both debris and micromolluscs), with lunulitiform bryozoans, foraminifera, solitary corals (Heteropsammia sp. and Flabellum sp.), polychaete tubes and ostracods. The lustrous condition of shells and the occurrence of live specimens indicate most of the carbonate sand is produced in situ. Very gravelly sediments occur near reefs and adjacent to island points. The mud fraction is mainly terrigenous with 20 to 40% carbonate content.

The impure carbonate very high mud facies is restricted to the protected area of shelf behind Orpheus and Fantome Islands, and is grey sandy mud. Sand composition is similar to the impure carbonate sandy facies, but mud is 35 to 41%, and is 35 to 40% carbonate.

The carbonate sand facies is restricted to near-island channels, tidal deltas and fringing reef flats in the north of the area. Sediments are sands and gravelly sand with very low mud (~10%). Sand is mainly biogenic and of similar composition to the impure carbonate sands, but with up to 40% terrigenous grains, mainly quartz. Modern carbonate sediments in the embayment are composed mainly of molluscs, minor bryozoans and foraminifera, with corals and calcareous algae near the reefs. Sediments on the reef flats consist mainly of medium to very coarse sand-size Halimeda, mollusc and coral debris, foraminifera and quartz, feldspar, granitic and volcanic rock fragments. Gravel-size lithoclasts and skeletal debris are common near the seaward edge of the flat. Testing with Feigl's solution or X-ray diffraction analyses confirms original aragonite or magnesian calcite mineralogy.

Sediments of the reef slopes are generally dark grey sandy muds with less than 40% carbonate content. Because of their small areal extent they have not been plotted on the facies maps. The sand fraction is fine to medium grade and composed of micromolluscs, molluscs, foraminifera and corals, with up to 20% terrigenous grains. The mud fraction is mainly terrigenous clays and quartz with a carbonate content of 20-40%.

GEOCHEMICAL NATURE OF FRINGING REEF FINE SEDIMENTS

The geochemical nature of fine sediments suspended in waters over the fringing reefs was investigated using sediment traps placed at several localities along the leeward side of the Palm Isles (Table 3, Fig.4). Representative samples of matrix from the Fantome Island fringing reef cores were also analysed to investigate changes during the postglacial reef growth. Major element geochemistry of the acid soluble fraction of the trap and core sediments is listed in Table 4, and of the insoluble residue in Table 5.

Acid Insoluble Residue

Acid insoluble content of trap sediments is generally in the range 20-35%, and shows no regular change from north to south along the island group. There is little seasonal difference, with dry season samples having the same (5A,7A) or slightly lower (1A,6A) values than dry season samples (1,5,6,7). One site (2) had an unusually low amount of insoluble residue, but this may have been due to human interference since the trap had been moved before the next sampling. Alternatively, the fringing reef at this site is particularly wide and with a wide mangrove fringe, both factors which would diminish terrigenous influx to the reef flat.

TABLE 3
SEDIMENT TRAP FIELD DATA

SAMPLE	LOCATION	DATE SET	DATE SAMPLED	COMMENTS
POST WET SEASON RECOVERY				
1A	Southern	23DEC80	7APR81	Black, anoxic clay
1B	end of	23DEC80	7APR81	Black, anoxic mud
1C	Juno Bay	23DEC80	7APR81	Black, anoxic mud
2A	Southern	23DEC80	6APR81	No sediment, only fish
2B	end of	23DEC80	6APR81	Black, anoxic sediment
2C	Hazard Bay	23DEC80	6APR81	No sediment, only fish
3A	Northern	23DEC80	6APR81	Trap lost
3B	end of	23DEC80	6APR81	Trap lost
3C	Hazard Bay	23DEC80	6APR81	Trap lost
5A	Southern	23DEC80	6APR81	Anoxic, colloidal mud
5B	end of	23DEC80	6APR81	Anoxic, colloidal mud
5C	Pioneer Bay	23DEC80	6APR81	Anoxic, colloidal mud
6A	South of	23DEC80	6APR81	Black anoxic mud with small fish
6B	Iris Point	23DEC80	6APR81	Black, anoxic mud
6C		23DEC80	6APR81	Insufficient sample
7A	Pelorus	23DEC80	6APR81	Anoxic mud
7B	Island	23DEC80	6APR81	Anoxic mud
7C		23DEC80	6APR81	Anoxic mud
POST DRY SEASON RECOVERY				
1AA	Southern	7APR81	22SEP81	Black, anoxic mud
1BA	end of Juno	7APR81	22SEP81	Black, anoxic mud with live gastropod
1CA	Bay	7APR81	22SEP81	Black, anoxic mud
2AA	Southern	6APR81	23SEP81	Trap moved 50m, and
2BA	end of	6APR81	23SEP81	turned upside down,
2CA	Hazard Bay	6APR81	23SEP81	no sample.
3AA	Northern	-	-	Trap lost
3BA	end of	-	-	
3CA	Hazard Bay	-	-	
5AA	Southern	6APR81	22SEP81	Anoxic sediment
5BA	end of	6APR81	22SEP81	Anoxic sediment
5CA	Pioneer Bay	6APR81	22SEP81	Anoxic sediment
6AA	South of	6APR81	24SEP81	Black, anoxic mud
6BA	Iris	6APR81	24SEP81	Black, anoxic mud
6CA	Point	6APR81	24SEP81	Black, anoxic mud
7AA	Pelorus	6APR81	24SEP81	Anoxic mud
7BA	Island	6APR81	24SEP81	Anoxic mud
7CA		6APR81	24SEP81	Anoxic mud

TABLE 4

COMPOSITION OF ACID SOLUBLE FRACTIONS (%)

SAMPLE	ACID SOL %	SiO_2	TiO_2	Al_2O_3	Fe	MnO	MgO	CaO	NaO	K_2O	SrO
TRAP SAMPLES											
1	69	0.23	Tr	0.13	0.33	0.02	2.26	54	0.93	0.13	0.60
1A	79	0.16	Tr	0.10	0.21	0.01	1.94	57	0.59	0.07	0.65
2	92										
2A	-	No samples									
5	69	0.24	Tr	0.12	0.38	0.03	2.35	54	1.53	0.13	0.59
5A	67	0.24	Tr	0.13	0.39	0.02	2.41	53	0.68	0.13	0.57
6	69	0.23	Tr	0.11	0.27	0.02	2.09	51	0.58	0.10	0.57
6A	77	0.21	Tr	0.10	0.19	0.02	2.12	55	0.62	0.07	0.60
7	69	0.23	Tr	0.11	0.24	0.02	2.22	55	0.67	0.10	0.60
7A	66	0.26	Tr	0.13	0.16	0.03	2.36	54	0.65	0.11	0.61
CORE MATRIX SAMPLES											
FANTOME 1											
1.80	89	0.15	Tr	Tr	0.07	Tr	1.74	58	0.57	0.13	0.66
4.00	67	0.27	Tr	Tr	0.13	Tr	1.92	58	0.56	0.12	0.64
5.25	67	0.25	Tr	Tr	0.13	Tr	1.78	59	0.53	0.12	0.64
6.90	51	0.35	Tr	Tr	0.16	Tr	2.16	56	0.61	0.24	0.53
10.00	42	0.43	Tr	Tr	0.48	Tr	2.40	55	0.53	0.33	0.43
10.90	31	0.52	Tr	Tr	0.46	Tr	3.09	54	1.08	0.26	0.39
10.93	20	0.54	Tr	Tr	0.69	Tr	2.45	56	0.54	Tr	0.34
11.50	2	Insufficient sample for analysis									
13.00	4	Insufficient sample for analysis									
FANTOME 2											
2.50	75	0.23	Tr	Tr	0.11	Tr	1.53	56	0.56	0.15	0.69
3.95	68	0.25	Tr	Tr	0.15	Tr	2.42	56	0.56	0.19	0.63
FANTOME 3											
1.00	94	0.12	Tr	Tr	0.05	Tr	1.60	58	0.49	0.09	0.69
2.00	82	0.19	Tr	Tr	0.10	Tr	2.13	57	0.52	0.13	0.62
3.80	68	0.13	Tr	Tr	0.15	Tr	2.19	57	0.57	0.15	0.63
4.90	58	0.36	Tr	Tr	0.19	Tr	2.34	57	0.59	0.23	0.55
5.65	43	0.46	Tr	Tr	0.28	Tr	2.76	56	0.64	0.39	0.51
7.00	53	0.36	Tr	Tr	0.19	Tr	2.09	57	0.57	0.21	0.63
8.70	64	0.27	Tr	Tr	0.16	Tr	1.49	58	0.61	0.16	0.68
10.00	39	0.46	Tr	Tr	0.36	Tr	2.31	57	0.69	0.33	0.51
10.30	7	Solution too dilute for analysis									

Note: Fe is total iron expressed as Fe_2O_3 .
Core sample numbers correspond to depth (m) below surface

O

TABLE 5

COMPOSITION OF ACID INSOLUBLE RESIDUE (%)

SAMPLE	ACID INSOL%	SiO_2	TiO	Al_2O_3	Fe	MnO	MgO	CaO	Na_2O	K_2O
TRAP SAMPLES										
1	31	58	0.71	17	5	0.03	1.5	1.7	1.0	2.4
1A	21	63	0.58	16	4	0.02	1.3	1.5	1.1	4.1
2	8	Insufficient residue for analysis								
2A	-	No samples								
5	31	59	0.74	17	5	0.03	1.6	1.8	0.9	2.0
5A	33	58	0.75	17	6	0.03	1.8	1.6	0.8	1.9
6	31	58	0.80	16	5	0.03	1.6	2.3	1.4	1.8
6A	23	58	0.73	16	5	0.03	1.6	2.4	0.9	1.8
7	31	58	0.72	16	6	0.03	1.5	2.2	0.9	1.8
7A	34	60	0.68	16	5	0.03	1.6	2.0	1.0	1.8
CORE MATRIX SEDIMENTS										
FANTOME 1										
1.80	11	59	0.90	16	7	0.03	1.8	1.4	1.1	1.8
4.00	33	60	0.95	17	5	0.03	1.9	1.3	1.1	1.8
5.25	33	59	0.92	16	5	0.04	1.8	1.4	1.2	1.8
6.90	49	60	0.89	17	5	0.04	1.8	1.4	1.2	1.9
10.00	58	61	0.88	16	5	0.03	1.6	1.3	1.2	1.8
10.90	69	64	0.82	15	4	0.03	1.3	1.4	1.3	2.0
10.93	80	74	0.42	12	2	0.02	0.5	1.1	2.0	3.0
11.50	98	70	0.47	15	3	0.02	0.4	0.7	1.7	2.9
13.00	96	70	0.48	13	4	0.02	0.6	0.8	1.3	2.4
FANTOME 2										
2.50	25	55	0.93	18	5	0.03	1.6	1.4	1.0	1.8
3.95	32	58	0.95	18	5	0.03	1.6	1.3	1.0	1.9
FANTOME 3										
1.00	6	Insufficient residue for analysis								
2.00	18	64	0.90	15	4	0.03	1.8	1.4	1.1	1.8
3.80	32	59	0.88	16	5	0.03	1.8	1.4	1.1	1.8
4.90	42	60	0.89	17	5	0.03	1.8	1.3	1.1	1.8
5.65	57	61	0.90	16	5	0.03	1.6	1.3	1.1	1.8
7.00	47	61	0.90	16	5	0.03	1.5	1.3	1.1	1.8
8.70	36	61	0.79	15	4	0.03	1.2	1.3	1.3	2.1
10.00	61	64	0.75	15	4	0.03	1.2	1.1	1.3	2.1
10.30	93	60	0.65	18	5	0.02	0.8	0.8	1.1	1.8

Note : Fe is total iron expressed as Fe_2O_3
Core sample numbers refer to depths (m) below surface

Acid insoluble content of core matrix decreases regularly upwards, reflecting progreessive decrease in terrigenous sediment being deposited on the reef in shallow water (Fig. 10). Contours are essentially horizontal and subparallel to stratigraphic units.

Corals from deeper levels in the cores tended to have both lower growth rates and higher insoluble residues after dissolution (Fig.11a,b;Johnson and Risk, inpress) indicating coral skeletons do preserve evidence of growth in a more muddy environment. Elsewhere Barnard and others (1974) have observed that Porites can trap suspended siliciclastic sediment inside the colony, and Cortes and Risk (inpress) demonstrated that growth rates on a siltation-stressed reef were inversely proportional to the amounts of suspended sediment in the water column, and that coral colonies trapped sediment in amounts proportional to the suspended sediment.

Composition of the insoluble residues of both trap and core sediments is dominated by silica and alumina, and the elemental compositions are consistent with a clay-quartz-feldspar mineralogy. The iron contents are rpobably due to colloidal or very fine grained oxide/hydroxides. Within the reefal section of Fantome 1, the acid insoluble residues show significant downward increases in silica, sodium and potassium, with decreases in most other elements, notably aluminium, titanium, iron, manganese, magnesium and calcium. These trends are consistent with greater contents of silica-rich minerals, quartz and feldspar, towards the base and more phyllosilicates (clays) towards the top. In Fantome 3 these trends are not developed apart from magnesium, titanium and calcium which display similar downward decreases.

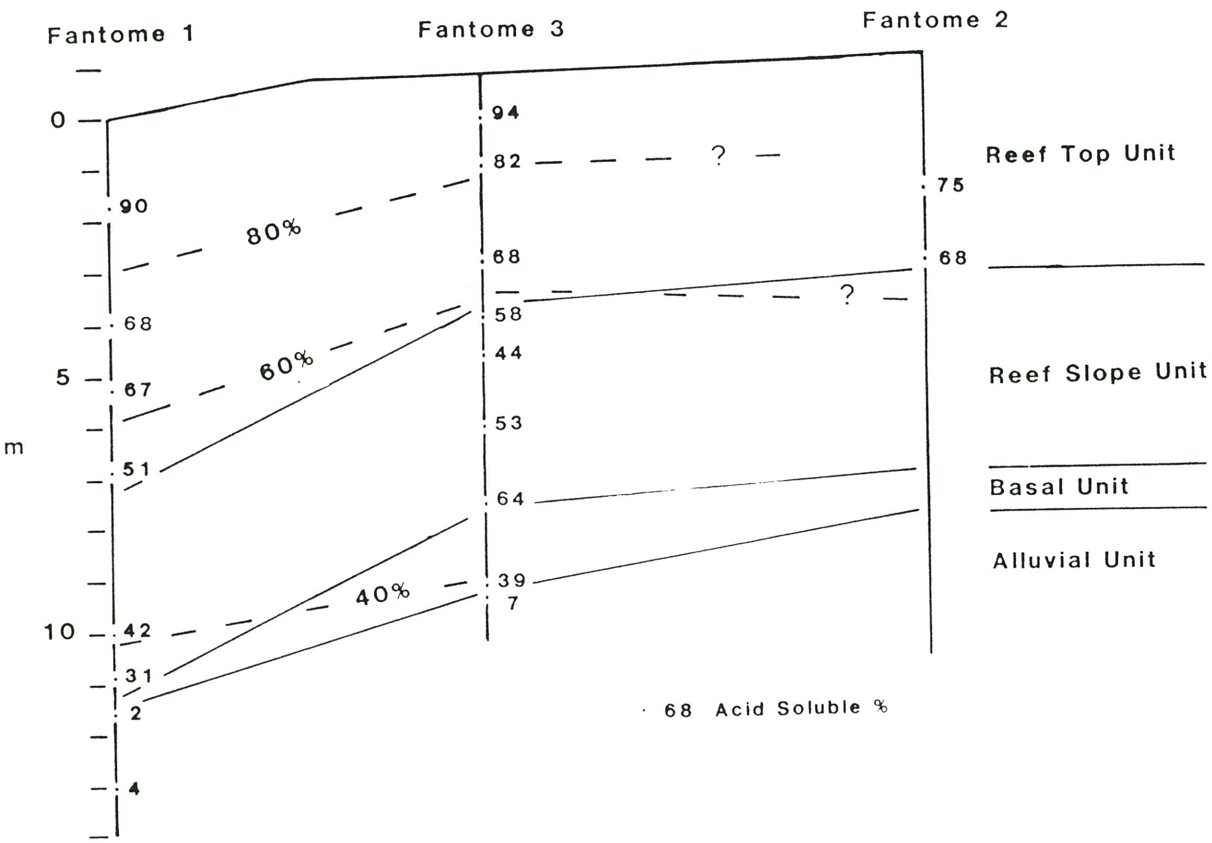


Figure 10 Acid soluble content of <0.5mm fraction of core matrix sediments.

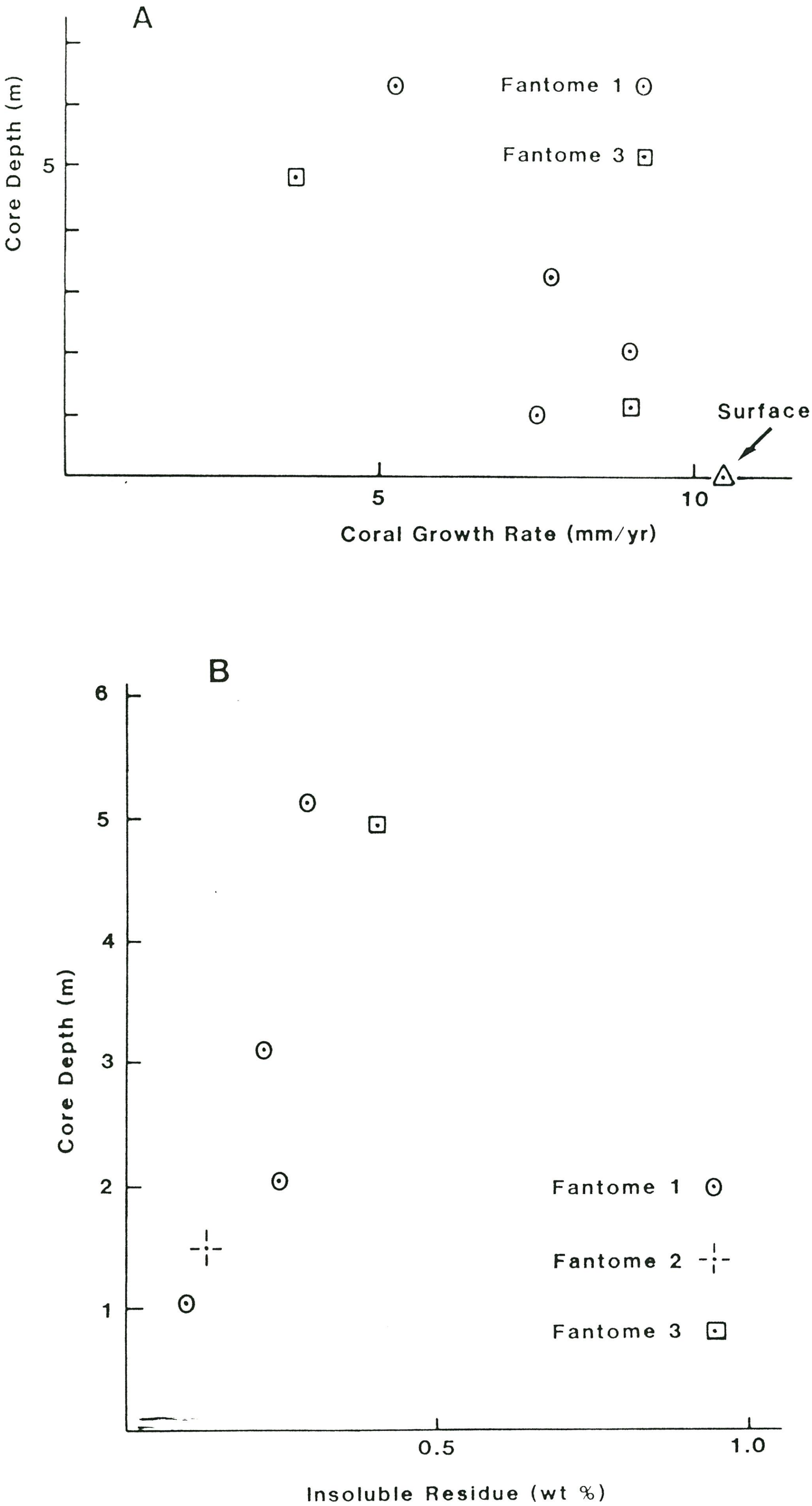
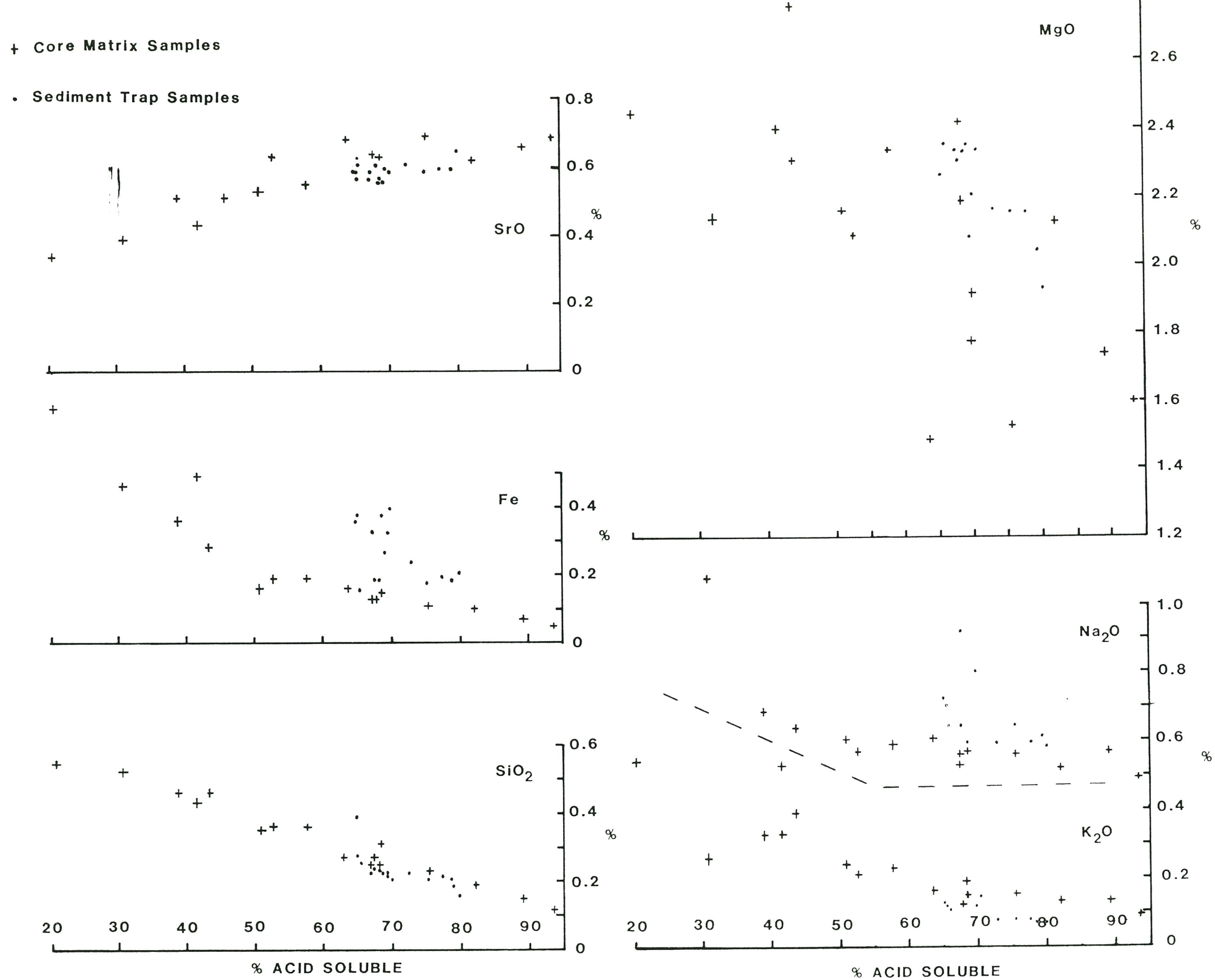


Figure 11 Growth rates (A) and acid insoluble contents (B) of corals from the Fantome Reef leeward fringing reef cores (from Johnson and Risk, in press).



+ Core Matrix Samples
• Sediment Trap Samples
SrO
Fe
SiO2
MgO
Na2O
K2O
%
% ACID SOLUBLE
% ACID SOLUBLE

Acid Soluble Composition

As expected the acid soluble fraction of trap and core matrix samples is composed mainly of calcium carbonate. Comparison of values for samples recovered after the wet season (1,5,6,7) with samples recovered after the dry season (1A,5A,6A,7A) shows there is no significant seasonal difference in composition. Calcium oxide is generally in the range 53-55% with spurious values up to 59% still within the 5% allowable error of the stoichiometric limit for pure calcium carbonate of 56%. The magnesium content is due to magnesian calcite from skeletons of coralline algae, miliolid formaninifera and some echinoids, and the strontium due to aragonite derived from corals, some molluscs and codiacean algae. Other oxides listed in Table 5 are higher than would be expected for skeletal materials. Both these and the excess calcium could be derived from three sources :

1) Cations adsorbed on clays which were stripped off during acid dissolution.

2) Partial dissolution of feldspar or other mineral grains.

3) Cations incorporated as impurities within skeletons as a result of living in an area of high terrigenous influx.

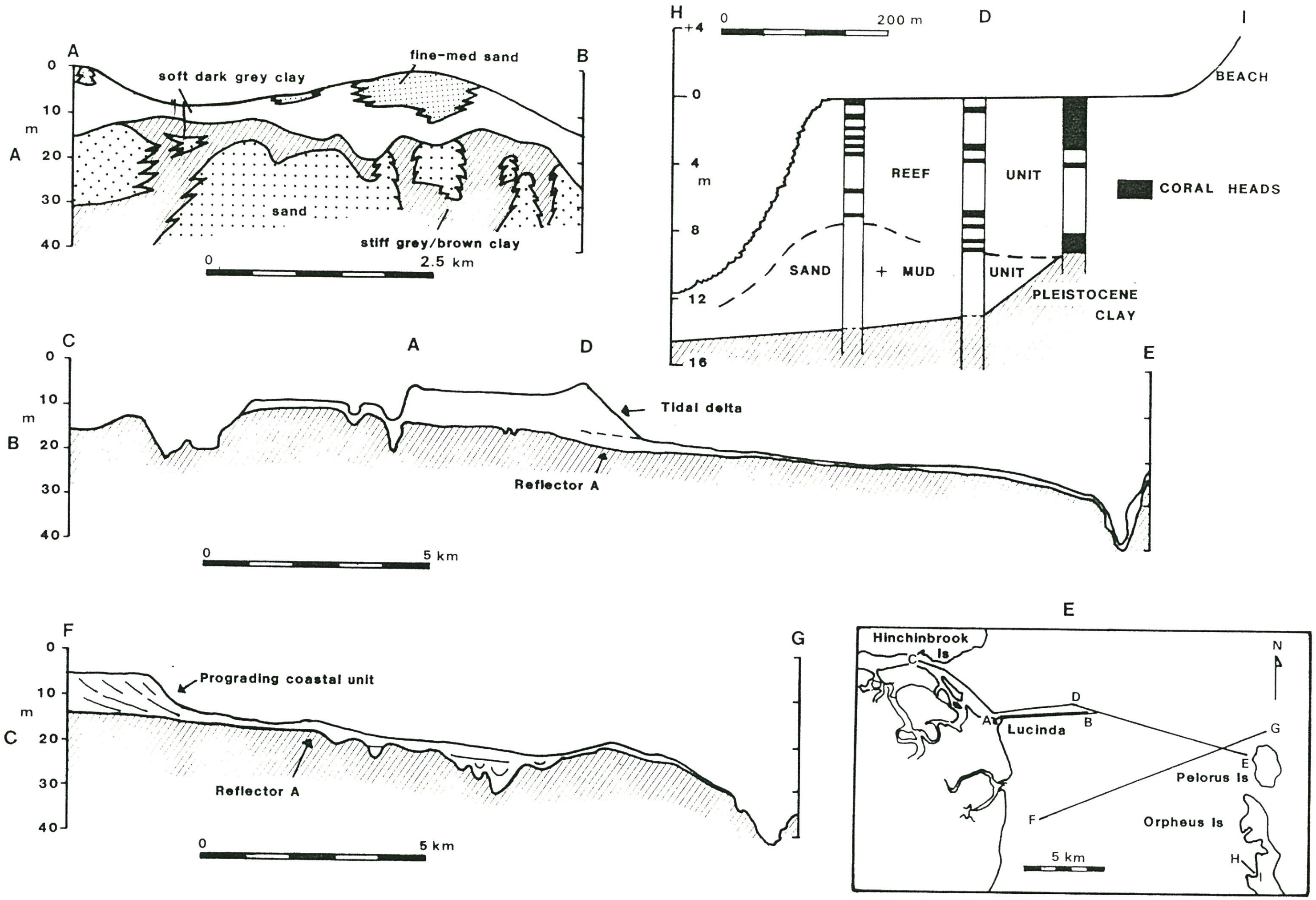
Cation contents show systematic relationships to the acid soluble contents (Fig.12). With increasing acid soluble content, strontium increases due to greater quantities of dissolved aragonite, while silica, iron, potassium and sodium decrease, due to leser amounts of terrigenous grains. The relationships are reasonably tight for the core matrix samples with increased scatter for samples of high terrigenous content (~50% acid soluble). Trap samples tend to show more scatter than matrix samples. Magnesium appears to vary inversely with acid soluble content, but the scattergram shows broad spread since the magnesium could be derived from either the acid soluble fraction (e.g. skeletal magnesian calcite) or from the insoluble residue (e.g. clay stripping).

STRATIGRAPHY

A stratigraphic cross-section across the northern part of the area can be assembled using data from three sources: Lucinda Jetty borings (McDonald, Wagner and Priddle, pers.comm.), continuous seismic profiling (CSP) (Johnson, Searle and Hopley,1982; Johnson and Searle, 1984) and fringing reef drilling (Hopley,1982; Johnson and Risk, 1982). Relevant data is given in figure 13A-D and section locations in figure 13E.

Figure 13A shows a lithologic profile based on borings for geotechnical studies for the Lucinda Jetty. The tidal delta is composed of fine to medium sand at the crest grading downwards and laterally into very soft, dark grey clay. Together these deposits form an upper unit of unconsolidated sediments, 2 to 20m thick, which overlies a lower unit of mottled, grey-brown, stiff silty clay with lenses of sand. The boundary between the upper and lower units corresponds to a marked increase in consolidation as measured by standard penetrometer tests (MacDonald, Wagner and Priddle, pers. comm.). Examination of a limited number of wash samples indicates the upper unit contains well preserved foraminifera, while the lower unit has no biogenic debris. It seems the boundary between the upper and lower units is the pre-Holocene unconformity for three reasons: 1) increased consolidation, 2) lack of biogenic debris in the lower unit and 3) mottled brown (?weathered) nature of the lower unit.

Figures 13B and 13C show seismic stratigraphic units interpreted from CSP profiles. Comparison of figures 13A and 13B shows reflector A in figure 13B closely parallels the boundary between the upper and lower units in figure 13A. Reflector A has been interpreted as the pre-Holocene unconformity by Johnson, Searle



A
B
fine-med sand
soft dark grey clay
sand
stiff grey/brown clay
0
10
20
30
40
m
0
2.5 km
H
I
D
0
200 m
+4
4
8
12
16
BEACH
REEF
UNIT
CORAL HEADS
SAND
+ MUD
PLEISTOCENE
CLAY
C
E
Tidal delta
Reflector A
5 km
F
G
Prograding coastal unit
Hinchinbrook
Is
Lucinda
Pelorus Is
Orpheus Is
N

Figure 13 Stratigraphic data from northern Halifax Bay.

A. Lithologic section along the Lucinda jetty showing soft dark grey clay and fine to medium sand interpreted as post-glacial sediment, overlie stiff grey/brown clay and sand, interpreted as pre-Holocene deposits.

B. A CSP profile from Hinchinbrook Channel, beside the Lucinda jetty to Pelorus Island, showing postglacial sediments overlying pre-Holocene units.

C. Another CSP profile from the sublittoral platform south of Lucinda to Pelorus Island.

D. Cross-section through the Pioneer Bay fringing reef (Orpheus Island) after Hopley (1982).

E. Locations for sections in A-D.

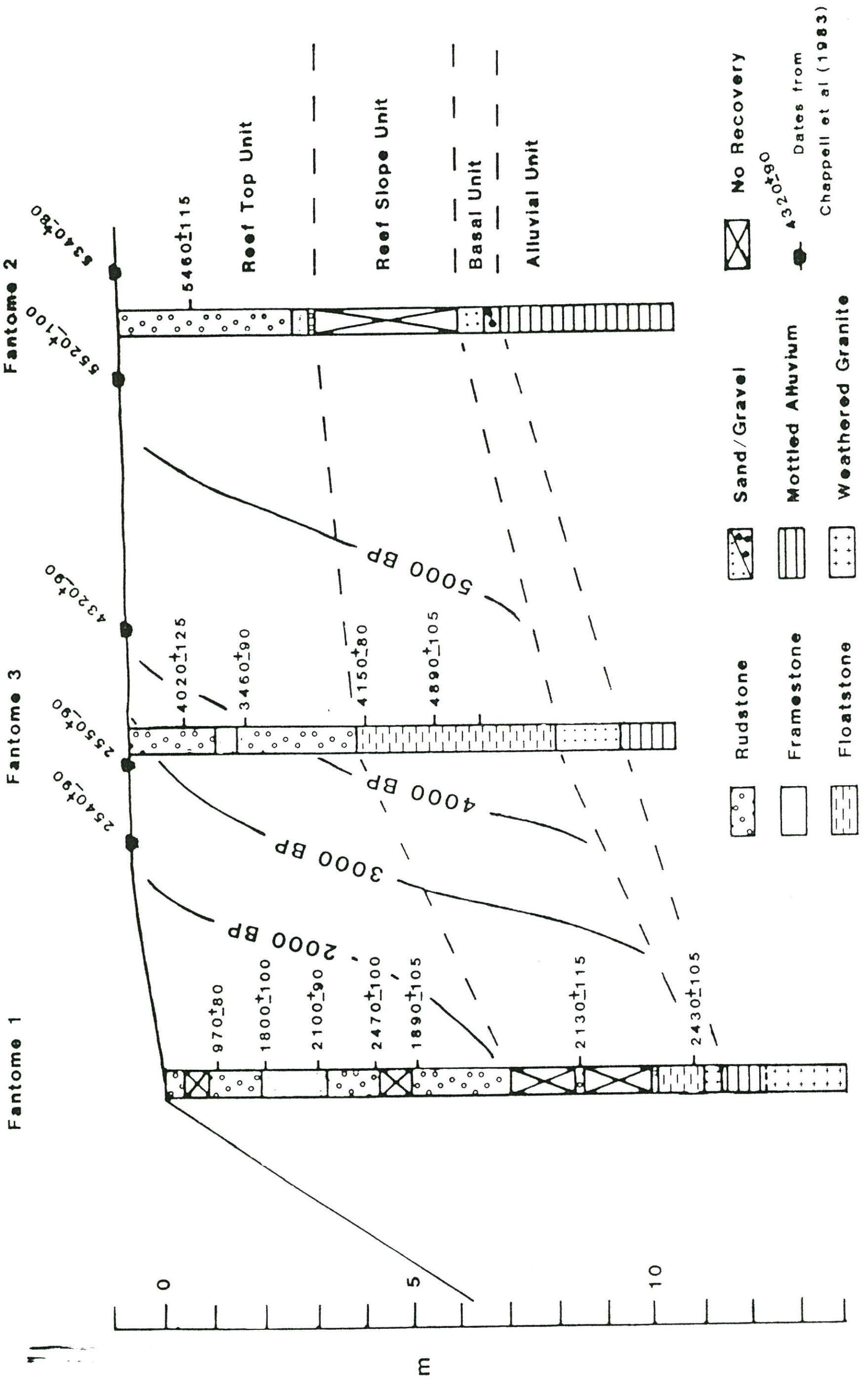


Figure 14 Stratigraphic cross-section showing reef top, reef slope, basal and alluvial units (from Johnson and Risk,inpress).

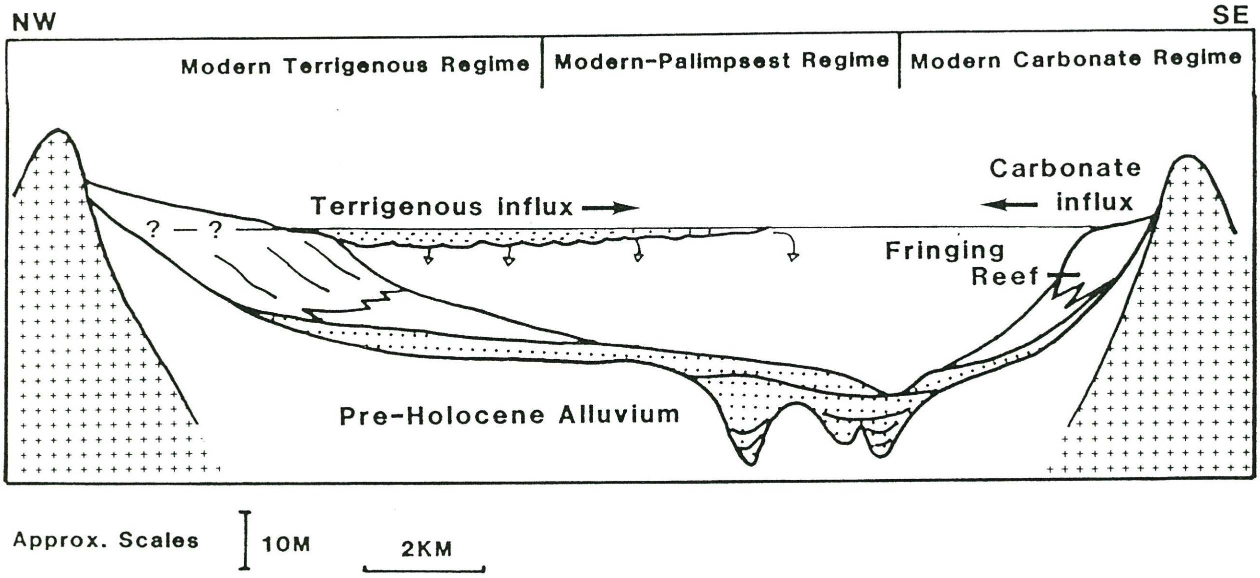


Figure 15 Model for sedimentation in Halifax Bay, showing back-filled fluvial channels and transgressive units (stippled) overlain by prograding wedge of modern terrigenous sediments along mainland coast, with fringing reefs around offshore islands which are contributing carbonate detritus to the embayment.

and Hopley (1982), based partly on the Lucinda Jetty data and partly on other drilling data. Offshore the CSP profiles show the post-glacial sediments thin away from the coast and are ~2.5m thick over most of the embayment plain. The thin nature of the post-glacial cover was confirmed by augering at the dive site (Fig.4). The auger penetrated 0.15m of unconsolidated muddy sands and then 0.6m of stiff, mottled green/brown sandy mud with low magnesian calcite nodules. We interpret this contact as the pre-Holocene unconformity and correlate it with reflector A.

Drilling of fringing reefs (Hopley,1982; Hopley and others,1983; Johnson and Risk, 1982,in press) shows modern reef units are prograding over weathered Pleistocene alluvial sediments (Figs. 13D,14). Three reef units are generally present: (in the terminology of Johnson and Risk,1982) reef top unit, reef slope unit and basal unit.

The reef top unit is composed of coral rudstone and framestone with massive colonies of Porites and Symphyllia up to 0.35m thick. Intervals of Sinularia spiculite in which the sclerites are cemented by botryoidal aragonite also occur. The rudstone comprises abraded and bored, gravel-size clasts of molluscs and corals in a matrix of muddy sand. The reef slope unit is rarely recovered in cores and consists of very muddy sediment, mainly coral and mollusc debris (less abraded and bored than in the reef top unit) in a matrix of mud or sandy mud with abundant urchin spines, alcyonarian and sponge spicules, ostracods and fine plant debris. The basal unit is gravelly, quartzose sand with minor skeltal debris. The top of the unit is finer and muddy, probably due to burrowing of sediments from the overlying reef slope unit.

Radiocarbon dating shows the fringing reefs started to grow prior to 5,500 yr BP, and probably before 6,000 yr BP (Fig.14, Hopley and others,1983). A Holocene sea-level curve from the region also indicates sea level reached present levels prior to 6,000 yr BP (Grindrod and Rhodes,1984). Considering the dead coral microatolls at elevated positions on the inner reef flats, initial growth probably started at a slightly higher sea level, as proposed by Chappell and others (1982) and Chappell (1983). A coarse, terrigenous basal unit developed over the weathered Pleistocene alluvium followed by regressive deposition of the reefs. The reef top units have prograded over muddy reef slope units. The average rate of progradation at the leeward Fantome reef has been 1m/10 yr. Average vertical accretion rates have been in the range 2.5mm/yr at Pioneer Bay (Hopley and others,1983) to 6.7mm/yr (Johnson, 1984; Johnson and Risk, in press).

REGIMES OF SEDIMENTATION

The stratigraphic data show there is a wedge of sediments along the coast and a thin veneer on the embayment plain and near-island channels, which correspond to the areas of deposition of the terrigenous and of the transitional and impure carbonate sediment types respectively. Figure 15 is a schematic model proposed for sedimentation in northern Halifax Bay, based on CSP, reef drilling and surface sediment data. The Bay is situated between isolated outcrops of Carboniferous granitic/volcanic bedrock (de Keyser, Fardon and Cuttler, 1965), and has a floor of weathered pre-Holocene alluvium. This alluvium has been sampled under fringing reefs on the islands, in an auger hole on the embayment plain and in borings near the coast. CSP profiles indicate this alluvium is continuous beneath the Bay.

Post-glacial marine deposition in Halifax Bay commenced when rising sea-level reached the 25m isobath, approximately 10,000 years B.P. judging by the sea-level curve of Bloom *et al.*, (1974). As sea level rose, fluvial channels were backfilled, and in some cases overfilled, forming the gently undulating seabed of the embayment plain. Sea-level rise was relatively rapid (Thom and Chappell,1974) and transgressive deposits are represented by only a thin, widespread veneer. In central parts of the embayment plain, the veneer forms the seabed. However CSP data indicates the veneer extends under prograding coastal deposits (Johnson and Searle, 1984).

Post-glacial sedimentation has occurred in three regimes : 1) modern terrigenous, 2) modern-palimpsest and 3) modern carbonate.

Modern Terrigenous Regime

The modern terrigenous regime comprises the terrigenous sand, moderate-high mud and very high mud facies (Fig.9).

The Herbert River is the main terrigenous source although minor amounts may be reworked from alluvium or coastal deposits. Victoria and Gentle Annie Creeks may also be important terrigenous sources, particularly during flood events. Fluvial sediment consists of granitic and volcanic lithoclastic gravel, quartzose/arkosic sand, and mud. Orientation of coastal spits (Fig.2) indicates net longshore drift is northward, though near Lucinda Jetty the situation is probably more complex. Here, tidal currents, northeasterly weather and waves refracted around the northern end of Pelorus Island could cause significant southward longshore sediment movement. Terrigenous mud has been dispersed over the whole area judging by the dominant amounts of non-carbonate mud in sediments near the islands. Processes of mud dispersal have not been studied but must include river plume movements, tidal currents and storm wave effects.

To the south we have no seismic data near the coast. The poorly sorted sediments of the outer sublittoral platform are characterised by abundant lithoclast gravel, indicating a major local source of terrigenous gravel. Minor creeks (e.g. Palm Creek) are unlikely to produce such deposits, especially 5km offshore. CSP evidence (Johnson and Searle, 1984) indicates the Herbert River flowed towards the southern edge of the Herbert delta as sea-level approached present level. Thus the southern outer platform is probably an abandoned lobe of the Herbert delta. The gravelly sands represent a transgressive veneer developed in the late Holocene, after the Herbert River shifted to its present position, depriving the coast of the southern delta of sediment input. Without this input, coastal processes eroded the shoreline to its present position.

Modern-Palimpsest Regime

The modern-palimpsest regime comprises sediments covering most of the embayment plain and near-island channels, which CSP evidence indicates are only a thin veneer over pre-Holocene substrates (except where there are channel fills). The surface sediments are transitional and impure carbonate types (Fig.9). Sediments are poorly sorted and mainly palimpsest, with admixtures of modern terrigenous to the west and of modern carbonate sediments to the east. The high carbonate content of the sediments of the impure carbonate regime is due partly to both minimal contemporary terrigenous input, diluting *in situ* biogenic production, and also to fine carbonate derived from nearby fringing reefs.

Palimpsest terrigenous sediment (in the sense of Swift et al., 1971) is identified as coarse sand and gravel seaward of the main areas of finer, modern terrigenous sediment. Such coarse sediment is unlikely to have been transported across the finer sediments within such a protected embayment. We interpret this coarse sediment as having been deposited during the last post-glacial sea-level rise as coastal deposits, which were reworked by the surf zone during the transgression leaving a surficial layer of coarse, gravelly sediment. There is probably very little redistribution of this coarse sediment now occurring.

Palimpsest carbonate is a relatively minor though important component, and is of two types. Firstly large, abraded and bored molluscs present in water depths ¨15m are probably remnants from lower sea levels. Finer skeletal material, for example foraminifera, may be of the same origin but are impossible to identify. Secondly, there is reworked Pleistocene carbonate. For example, the low magnesian calcite mineralogy and mosaic cements of the carbonate nodules indicates they suffered subaerial diagenesis (cf. Harrison,1977). Irregular nodules and veins of fine-grained low magnesian calcite were found in the green and red clays which underlie the fringing reef deposits of Fantome Island (Johnson and Risk, 1982). Thus it is probable that much of the finer (low magnesian calcite) carbonate has been reworked from the underlying Pleistocene and is now palimpsest.

Modern Carbonate Regime

The modern carbonate regime comprises deposition of the carbonate sediment type in fringing reefs beside the islands, and in nearby channels and tidal deltas (Fig.9). All sediments contain terrigenous components which are probably derived from erosion of colluvium on the islands.

The fringing reefs developed after post-glacial reworking of the regolith produced terrigenous sand and gravel on the unconformity. Rising sealevel allowed deposition of muds which were partly reworked by burrowers into the sands, and finally establishment of coral zones around the present shoreline. After deposition of muddy sediments in the bays, coral framestone and rudstone were deposited forming the reef top unit, which then prograded seawards over the muddy reef slope unit.

Although the reef becomes progressively muddy downwards, and the amount of intraskeletally-trapped terrigenous sediment increases downward, the overall rate of input of fine terrigenous sediment to this reef did not change during most of postglacial time. The terrigenous content of the reef top unit in all three cores is low, for a time span in excess of 3,000 years. Since the reef youngs westward and not upward, the decreasing insoluble content up the cores does not indicate decrease in terrigenous input with time, but is a function of deposition of fine terrigenous sediment in the reef slope unit. Although this study indicates no change of terrigenous input during the Holocene, more detailed study is required to analyse whether changes have occured since European settlement.

Overall the model is of a semi-protected embayment which is being filled from one side by terrigenous sediments and from the other by carbonates. The major factors that have governed distribution of sediments since about 10,000 years B.P.are firstly the rapid post-glacial, sea-level rise which produced a thin veneer of coarse sediment which is now being buried by sediments forming at a stable sea-level. Secondly, the configuration of the islands which protects the Bay from prevailing SE weather allowing modern accumulation of muddy sediments in the Bay and the development of fringing reefs. Passages between the islands control the development of sandy, carbonate-rich tidal deltas. Thirdly, terrigenous input is limited mainly to the western side of the Bay where waves and tidal currents are the dominant processes fashioning the sublittoral platform.

CONCLUSIONS

1) Three major sedimentary regimes occur in Halifax Bay : modern terrigenous, modern-palimpsest, and carbonate, forming an offshore terrigenous to carbonate facies transition.
2) The modern terrigenous regime (`30% total carbonate) occurs along the coast of the Herbert Delta and comprises a prograding sublittoral platform with a sandy or moderate-high muddy upper surface, and a very muddy outer slope. A wider platform to the south, surfaced by gravelly sediments is interpreted as a transgressed, abandoned delta lobe.
3) The modern-palimpsest regime (30 to 80% total carbonate) covers most of the embayment and is mainly coarse, palimpsest terrigenous sediment deposited during the last phases of the post-glacial transgression, with admixtures of fine modern terrigenous sediment and palimpsest and modern carbonate sediment.
4) The modern carbonate regime (¨80% total carbonate) occurs close to the islands and comprises fringing reefs with off-reef deposits. Fringing reefs have developed as coral-dominated reef top units have prograded over muddy reef slope units.

5) Although total carbonate content of sediments increases eastwards across the Bay, patterns for carbonate content of gravel, sand and mud fractions differ, indicating different processes have influenced the dispersal of each fraction.

6) Terrigenous input to the fringing reefs has not changed significantly during the Holocene, but this study did not determine whether changes could have occurred in the shorter time-span since European settlement.

7) The major factors influencing facies patterns have been :

(i) Rapid post-glacial sea-level rise forming a thin transgressive veneer.

(ii) Embayment configuration which (a) allowed establishment of fringing reefs particularly in the lee of the islands, and (b) partially protects the embayment from regional weather systems.

(iii) Waves and tidal currents which fashion a sandy coastal sublittoral platform, retaining most terrigenous sediment near the coast, separate from the offshore carbonate sediment sources.

ACKNOWLEDGEMENTS

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