2. DESCRIPTION OF THE AREA

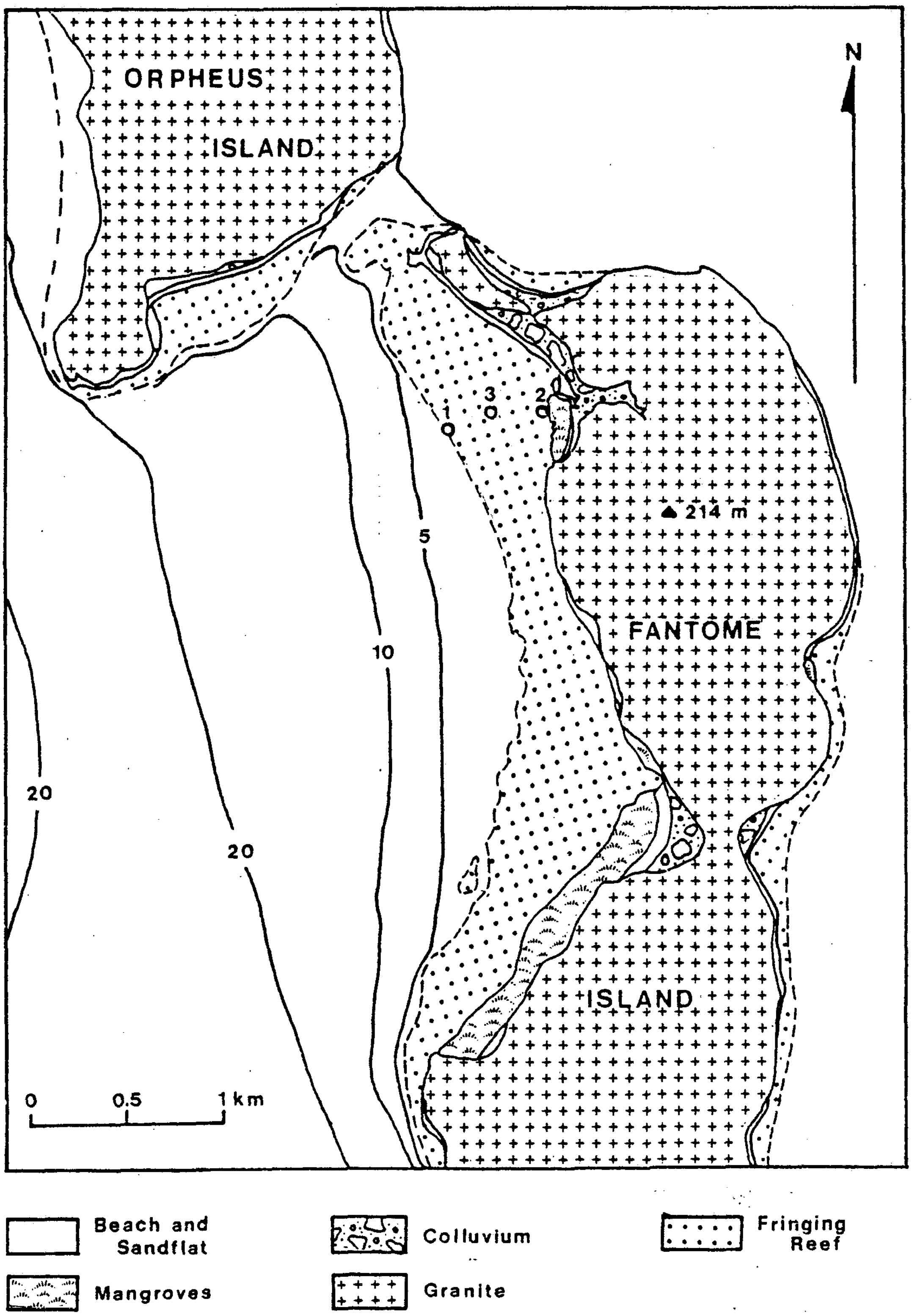
Small fringing reefs occur on the windward side of Fantome Island, and an extensive reef along the leeward side (Fig 2). The leeward reef is 600m wide and 5km long, with a relatively flat, intertidal, upper surface, and a steep seaward slope. Landward the reef passes onto beaches, mangroves (Rhizophora sp.) or abuts rocky headlands. Seaward the slope passes into Halifax Bay. Three zones are recognised across the modern reef: 1) inner (sandflat) zone, 2) outer (rubble) zone, 3) reef slope. The first two zones constitute the reef flat which occupies the lower half of the tidal range; the reef slope is subtidal.

The inner zone is up to 250m wide, and is 90% mobile sand, the surface of which may be flat, rippled or covered with conical mounds at the mouths of crustacean burrows. Patches of brownish algal mat occur along the inner edge. Sediment is medium to coarse skeletal sand with scattered skeletal and litoclastic gravel. Shallow pools contain rare knobs of Goniastrea, sponges, and commonly algae and seagrasses (Halimeda, Padina, Hydroclathrus, Halophila).

The outer zone comprises in situ coral heads and abundant rubble with scattered sandy pools. The seaward rim (approximately LWOST) has approximately 80% hard substrate, mainly dead, massive corals extensively bored by Tridacna. Many corals occur as microatolls with dead centres and living edges. Individual colonies may be up to 0.5m across, the most common genera are Goniastrea and Symphyllia, with less common Acropora millepora, Montipora ramosa and Leptastrea sp. Small colonies of Sinularia with spiculite bases occur. Apart from the rim, the rest of the outer zone contains only 50 to 80% hard substrate, with no large, massive corals, although small live Goniastrea favulus, Montipora ramosa and Porites sp. are present. Algae are abundant in shallow pools and rock crevices (Padina, Hydroclathrus, Halimeda). Dead coral colonies are extensively bored by Tridacna, mytilids, sponges and sipunculids, and encrusted with Chama and Spondylus.

FIGURE 2

Map of Study Area



The reef slope descends gradually seawards, flattening at approximately 8m water depth. The upper part of the slope has abundant Porites colonies 2 to 2.5m high with intervening rippled and burrowed sand. Porites extend to 5m water depth, where intervening sediment is muddy. Below this, Porites is absent and Goniopora mounds occur. Goniopora is replaced by Anacropora below 8m.

Environment

The climate is tropical with marked dry (winter) and wet (summer) seasons. Prevailing wind and weather systems are from the southeast, though during summer a NE component is introduced (Pickard, 1977). During summer (January-March) the area is prone to cyclones with gale-force winds, heavy rains and storm surges. Over 80% of the 2034mm annual rainfall occurs in summer.

Average seawater temperatures range from 19^{o}C (June-July) to 31^{o}C (December-March) (Pickard, 1977). Water remaining on the reef flat during low tide was hot to the touch. Elsewhere in the region cyclonic rain may lower normal surface seawater salinities (35^{o}/oo) to less than a 20^{o}/oo (Archibald & Kenny, 1980).

3. STRATIGRAPHY

All three cores penetrated through the reef to mottled brown clays and weathered granite which are interpreted as late Pleistocene colluvial units and bedrock respectively.

Four units are recognised in the cores (Fig 3) from top to bottom; reef top unit (4.0-7.2m thick), reef slope unit (3.0-4.1m), basal unit (0.9-1.5m), alluvial unit (greater than 2.0m). The reef top unit is composed of coral rudstone with massive colonies of Porites, Symphyllia and Sinularia spiculite. Gravel-sized coral and bivalve fragments are invariably abraded, bored by mytilids, sponges and sipunculids, and encrusted by coralline algae, milleporids, serpulids, bryozoans and rock oysters. Matrix is grey, muddy skeletal sand.

The reef slope unit is grey, carbonate/terrigenous mud with scattered coral gravel. Horizons of floatstone and rudstone occur. Coral and bivalve debris is less bored and encrusted, and matrix more muddy than in the reef top unit. The basal unit is coarse, often gravelly, quartz sand with minor skeletal and granitic lithoclast debris. It is generally finer and muddy towards the top, probably due to mixing of the overlying reef slope sediments by burrowers. The alluvial unit is brown/frey mottled sandy clay and weathered granite, with irregular nodules and veins of white (low Mg calcite) carbonate.

4. REEF HISTORY

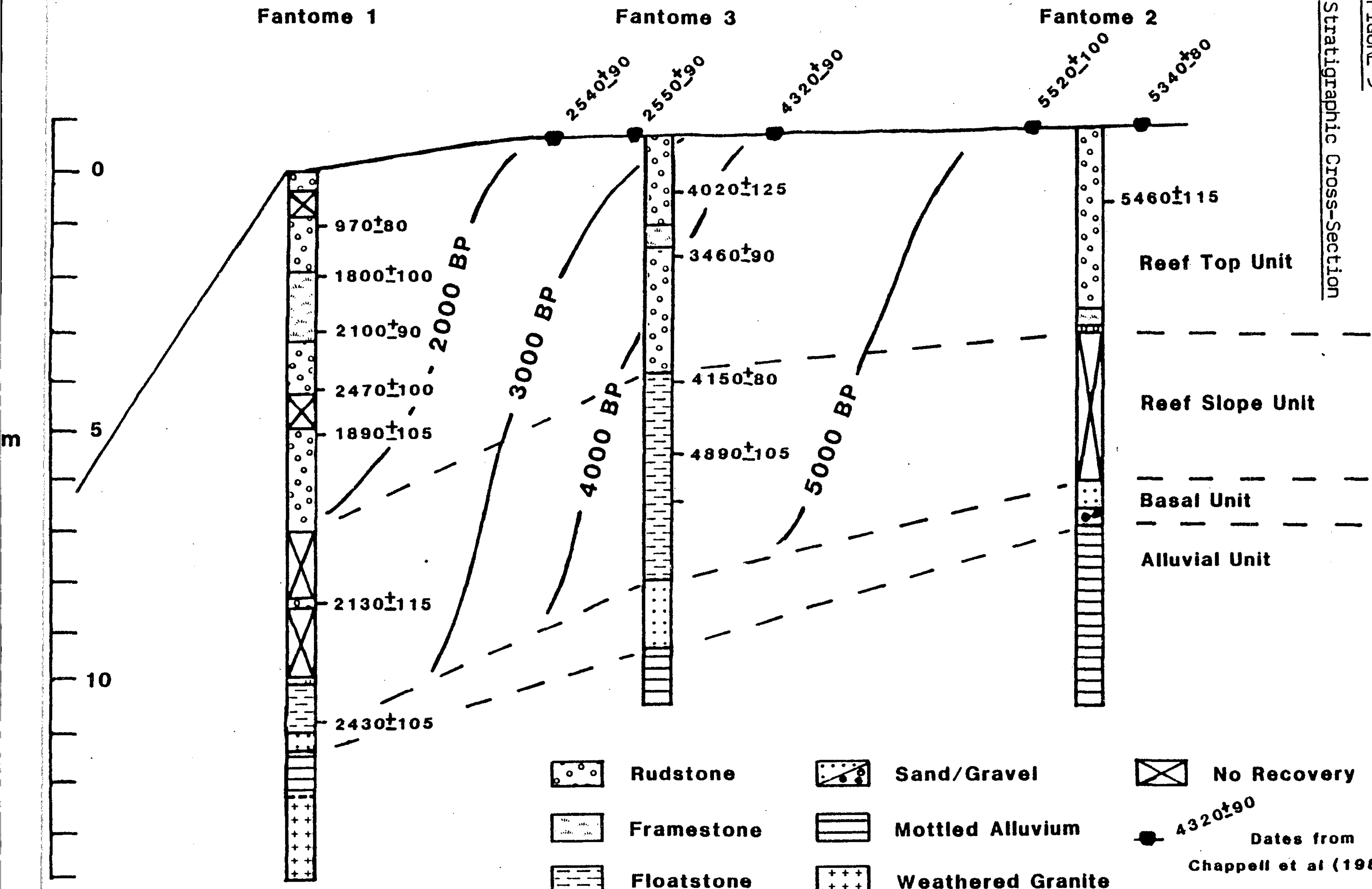
Radiocarbon results are plotted on a stratigraphic cross section (Fig. 3), together with relevant data from Chappel et al. (1983, Table 2). Chappel et al.'s dates were from microatolls collected along a levelled transect close to our drilling sites. Microatoll ages range from 5340 ± 80 years at the inner edge of the reef flat (0.8-1.2m above MLWS) to 2540 ± 90 years at the outer edge (0.35-0.55m above MLWS).

Fantome 1 is the most completely dated core, with seven dates, ranging from 970 ± 105 to 2430 ± 105 years B.P. There is reasonably consistent younging upwards, with a minor reversal in mid section. The second and third dates show that the colony is upright, with an indicated growth rate of 3.8 mm yr^{-1}. Dates in Fantome 1 are less than 2500 yrs B.P., and are all younger than in the other two cores.

Fantome 3 contains materials dated between 3460 ± 90 and 4890 ± 105 yrs B.P. The central three dates form an upward-younging sequence, but the top and bottom dates indicate age reversals. The top date and two of the three central dates have replicate age determinations which agree reasonably well, and further substantiate the upward-younging trend. The top date was determined on a discoloured *Porites* colony which contained approximately 1.5% calcite. The addition of younger matrix

FIGURE 3

Stratigraphic Cross-Section



carbonate would have produced a younger radiocarbon date, not an older one. Since the replicate dates are in agreement, we are confident the date, and hence the age reversal, are valid. The basal date was determined on a very muddy, heavily-bored coral, which had to be cut into small pieces to obtain relatively clean material. There was insufficient material for a replicate date. Although the coral analyzed as 100% aragonite, the discolouration indicated it may have contained younger matrix carbonate. We regard this as a bad date, and have omitted it from the cross-section.

Fantome 2 recovered only one fragment which met our requirements for datable material, and this date at 5460 $\pm$ 115 yrs B.P.

Seaward parts of the reef are younger than landward parts. (Fig 3). Microatoll dates in the vicinity of Fantome 3 are all greater than 5000 yrs B.P., and from Fantome 1, younger than 2500 yrs. B.P. (Chappell et al., 1983). Surface dates near Fantome 3 are slightly younger (approx. 2500 yrs B.P) than the range of dates from Fantome 3 (3,000 - 5,000 yrs B.P.). Clearly, the time lines cut across stratigraphic boundaries, and the reef has prograded, as opposed to having accreted vertically in a layer-cake fashion. Reef accumulation began nearshore prior to 5500 years B.P.

Hopley (1982) and Chappell et al. (1982) both proposed that sea level may have reached about 1m above modern datum in this area, before falling to the present level. Falling sea level, which has left microatolls stranded above their normal tidal levels across much of the reef flat, would tend to promote erosion, or interring of older reef flat by mobile sediments.

Age Reversals

The age reversals at the top of Fantome 3 and in the central part of Fantome 1 warrant further discussion. The reversal at the top of Fantome 3 involves a date approximately 600 years younger which is 1.25m higher in the core.

This higher, younger date could be due to moating. Such effects on modern reefs normally involve a height difference less than 0.8m (Scoffin and Stoddart, 1978; McLean et al., 1978), and hence a 1.25m difference may be too large to explain this effect. A more reasonable explanation is transport, which is supported by observations of large amounts of mobile rubble on the modern reef flat. Furthermore, erosion and redistribution could have occurred during the postulated late Holocene drop in sea level.

The reversals in Fantome 1 occur in the lower part of the reef top unit and in the reef slope unit. Assuming the second top date and the basal dates in Fantome 1 are correct, the reversals involve six dates in a total time interval of some 670 years, over an accumulated thickness of 8.85 m. The average difference between successive dates is 354 years, which is not large (less than two combined standard deviations of the relevant dates). There are, therefore, several dates over a relatively short time interval, during which there was rapid reef accumulation. The age reversals are interpreted as representing transported material. Although Easton and Olsen (1976) pointed out that such reversals should be common in fringing reefs, they normally have not been reported. Part of the reason may be the generally longer average time interval sampled in published studies (e.g. 2,240 years, in Macintyre and Glynn, 1976). The tight sampling interval in Fantome 1 has demonstrated the highly dynamic nature of such reefs, where erosion and storm transport are capable of admixing debris of widely varying ages. A similarly tight sampling interval in one of the Pioneer Bay fringing reef cores (R/1 in Hopley et al., 1983, Fig (1)) showed an age reversal near the top.

Data from ancient rocks supports the transported nature of much of reef material. Middleton (1954) found that one-quarter of large (greater than 0.3 m) stromatoporoids were over-turned in Devonian reefs of south Devon, while Kobluck et al. (1977) found half the coral and stromatoporoid heads in Silurian and Devonian reefs were overturned or disoriented, in a size-independent fashion.

These results imply that most of the heads in these fossil reefs were displaced, and that those in "growth position" had simply been overturned an even number of times. The effect of storms on modern reefs has been well documented (Stoddart, 1962; Ball et al., 1967; Woodley et al., 1981; Hopley, 1982). Modern reef deposits are dominantly transported material judging from maps of surface facies distributions (Longman, 1981).

Growth Rates

Average accumulation rates for the Fantome fringing reef can only be estimated reliably from Fantome 1 data, where the average rate, between 1.08-10.90 m, is 6.7 mm yr^{-1}. Radiography showed the individual colony near the top had a growth rate of 3.8 mm yr^{-1} (vertically; location of the growth axis was not determined). All of Fantome 1 was deposited within the last 2,500 years; that is, at virtually stable sea level. Hopley et al., 1982, reported a growth rate during the last 3,000 years of 2.5 mm yr^{-1} at Pioneer Bay, Orpheus Island, based on two dates in one hole. The Fantome rate is compatible with the normal range for fringing reefs, 3.3-10.0 mm yr^{-1} (Hopley, 1982).

The age contours (Fig. 3) indicate the major pattern of reef growth has been progradation. The oldest reef is at the inner margin, and all the material in the Fantome 1 is younger than the rest of the reef. Initial growth at the innermost part is a similar pattern to that described by Hopley (1982) for the Pioneer Bay fringing reef. Initial growth probably occurred at a slightly higher sea-level, considering the 1m isobase at 5500 years B.P. proposed by Chappell et al. (1982). The stratigraphy of the Fantome Island fringing reef records development of a coarse transgressive basal unit over alluvium and weathered bedrock towards the end of the last post-glacial transgression. The reef top and slope units are interpreted as regressive deposition, such that the hard reef top unit progrades over the soft, reef slope unit. The average rate of progradation over the past 5,000 years has been 1 m/10 years.