2 PREVIOUS INVESTIGATIONS

Studies of the Cape Tribulation Area

Ewart (1985) briefly described the geology of a small portion of the Cape Tribulation area. His research centred on the Thornton batholith, a Permian igneous intrusion that outcrops 3 km east of Cape Tribulation, and the Hodgkinson Formation, a Devonian metasedimentary complex that outcrops along the coast in the study area.

Cribb (1985) listed many species of marine algae that live in the backreef area of Rykers Reef. He also studied algae from along the rocky shore near Cape Tribulation and in the mangrove swamp south of Cape Tribulation.

Ayling and Ayling (1985) described some of the coral and fish species of the subtidal areas of several Cape Tribulation reefs. They concluded that living coral colonies on the Cape Tribulation fringing reefs constitute one of the most taxonomically diverse coral communities in the Great Barrier Reef system.

Veron (1987) listed 141 scleractinian coral species belonging to more than 50 genera found in the Cape Tribulation reefs, including three species not previously recorded on the Great Barrier Reef.

Hoyal (1986) discussed recent sedimentation trends in the Cape Tribulation area. He used sediment traps to measure suspended sediments in the water column of the intertidal and subtidal zone. Although rates of sediment settlement and levels of suspended sediment in the water column were high, Hoyal concluded that much of the sediment in the waters surrounding the reefs is continuously resuspended by normal wave action as well as by occasional storms. He also concluded that sediments from stream runoff were not the major cause of sea water turbidity.

Previous Investigations of the Age and Structure of Great Barrier Reef Fringing Reefs

Other investigators have studied fringing reefs located along and near the northeastern Australian coast. Closest to the study area, Bird (1971) described a continental fringing reef at Yule Point, located adjacent to the coastline approximately 60 km south of Cape Tribulation. He did not core this reef or determine C^{14} dates for the coral colonies in the reef, but he did obtain a C^{14} date of 4130 ± 130 years BP (Before Present) for surface coralline algae. However, Bird acknowledged that coralline algae may yield questionable C^{14} dates.

Comparatively little work has been carried out on the age and structure of fringing reefs in the Great Barrier Reef province. Hopley *et al* (1978) examined cores obtained for engineering purposes on Hayman Island fringing reef which was shown to consist of a Holocene biohermal cover overlying a Pleistocene reefal base, the diagenetic features of which suggested prolonged subaerial exposure. The reef commenced to grow prior to 8300 yrs BP and, growing upwards at a rate of 4 to 5 mm/yr , reached modern sea level around 4500 yrs BP. The unconformity occurs approximately 20 m below MLWS beneath the present reef crest and appears to rise towards Hayman Island to about 15 m below MLWS (see also Hopley, 1982, Ch 12; and Hopley *et al*, 1983).

Slocombe (1981) as published in Hopley *et al* (1983) drilled the fringing reef adjacent to the Orpheus Island Research Station, Pioneer Bay, Palm Islands. This reef became established on the rocky shores of the island about 7000 yrs BP. It prograded over its own sand and shingle forereef talus as a relatively thin 3 to 4 m framework veneer. These reefal units have been established over an early?? Holocene transgressive unit, which in turn overlies a weathered Pleistocene clay base. Mean vertical accretion rates decline from 6.78 mm/yr for the inner reef flat to 2.2 mm/yr for the outer reef.

Hopley *et al* (1983) also reported on the drilling of a single hole on Rattlesnake Island. Again, beneath the reef at 11.5 m depth was a heavy oxidised presumably Pleistocene basement. Reef framework was very limited, forming only a thin <1.0 m veneer over a rubble base in which corals were rare but which had a mean accretion rate of 6.7 mm/yr. Information on other fringing reef structures came from engineering reports. Interpretation by Hopley *et al* (1983) suggested that reefs on Great Palm, Dunk and Magnetic Islands were all relatively thin with limited framework forming thin veneers over sand, mud or gravel lower sections.

A more exposed windward fringing reef was examined by Barnes (1984, published in Hopley and Barnes, 1985) at Iris Point on Orpheus Island. The Holocene reef was established over a Pleistocene boulder beach which currently outcrops behind the reef. Reef growth commenced prior to 7300 yrs BP and the reef was at or close to modern sea level by 6250 yrs BP. Mean vertical growth rates varied from 1.3 mm/yr to 4.7 mm/yr.

Another reef in the Palm Group, that on Fantome Island, was investigated by Johnson and Risk (1987). The reef is almost identical to the similarly situated Pioneer Bay reef on Orpheus Island, with reef flat established prior to 5500 yrs BP and a mean vertical accretion rate of 6.7 mm/yr. Terrigenous sediments also form a major part of the basal unit of the reef.

A further research programme is currently underway in the Cumberland and Northumberland Islands on the structure and growth of fringing reefs close to their southern growth limits under the supervision of one of the authors (David Hopley). To date, cores have been recovered from reefs on Cockermouth, Penrith and Scawfell Islands. Although analysis is only just commencing it is notable that extensive and shallow Pleistocene reef has been established on Cockermouth Island. Coring has also taken place on Lindquist Island in the Barnard Group though no results are yet available (T Graham, *pers comm*).

Contemporaneous with the commencement of this study was a parallel investigation on the Cape Tribulation area (Johnson and Carter, 1987) which included some auger drilling of the reef just north of Myall Creek. Radiocarbon dating of samples from the inner part of the fringing reef showed that the reef top unit commenced accumulating at least 6000 yrs BP. Encasement of the reef framework by a subsequent sediment matrix was also suggested.

3 METHODS

Field Survey

Fieldwork was conducted between February and July 1986. Initial work involved mapping the Cape Tribulation fringing reefs and associated lithofacies. Surveys were made using a transit level and a 3 m staff to:

- Outline shore and reef profiles
- Accurately locate drilling sites on the reefs
- Precisely determine the heights of the reefs relative to mean sea level and to the extremes of tidal fluctuations.

Twenty-one transects of at least four stations each were surveyed along the foreshore and across the reefs in the study area. Cross-sections of the reefs were constructed using this survey data and borehole information. All references to sea level or sea level variation were made relative to Cairns Port Datum. This predicted tidal datum, or zero point, has been calculated (Hampson, 1985) for tides at Cairns, that is 100 km south of the study area. The Cairns Port tidal charts were compared with those of Cooktown, located 72 km to the north of the study area, to determine values for Mean High Water Springs and other tidal planes in the study area.

Aerial Photography and Mapping

Aerial photography flown by both the Queensland Beach Protection Agency (QP3706: nos 87, 89, 91; QP4238: nos 22, 23, 24, 25, 26) and specially for this project in both colour and near infra-red was used in association with the surface surveys to accurately locate specific sample collecting sites. The aerial photographs were also used to construct planimetric outline base maps of the Cape Tribulation coastal area. The base maps were corrected to scale by use of a binocular plan variograph. Surface lithofacies maps (Fig 3) were made by plotting on the base maps field observations, sediment sample locations, and other measurements.

Coring

A portable rotary drilling rig (Fig 6) was used to obtain cores from nine boreholes in three of the Cape Tribulation fringing reefs. Four boreholes were cored in Rykers Reef, three in South Myall Reef, and two in Emmagen Reef. Drilling was halted when basal non-reef deposits were reached. Borehole depths ranged from 4.5 to 8.3 m. A coring bit and core catcher in the drill pipe allowed solid 45 mm diameter samples to be recovered. Sea water was continuously circulated through the drill pipe during drilling to remove cuttings and to prevent the drill string from binding in the hole. Because of the circulating water, unconsolidated sediments could not be collected in core samples. Only massive corals, cemented reef rubble and large detrital pieces were collected in the cores. Branching corals, such as acroporids, were usually obtained as broken pieces. Because of their size and shape, the pieces often jammed the core barrel.

Drilling logs were made during coring operations and amended after laboratory examination of the cores. Detailed microscopic examinations of the cores were carried out to determine lithologies and to identify fossils.

Corals were identified to genus and species if possible in the field or during subsequent laboratory study. The taxonomic names assigned to all coral specimens conform to those of Veron and Pichon (1976, 1979, 1982) and Veron and others (1977) for northeastern Australia. Coral identifications were verified by Dr Michel Pichon (*pers comm*, September 23 and 24, 1986). Identification to the species level often required an undamaged surface corallite, that was seldom obtained in core samples. Many of the borehole samples are therefore identified only as acroporids or *Porites* sp. Lithologic descriptions follow Dunham (1962) and Embry and Klovan (1971).

Core Analysis

More than one hundred individual rock samples, varying in length from less than 1 cm to 59 cm, were recovered from the cores. The core barrel was designed to collect samples up to 150 cm long. In practice, continuous cores over 60 cm long always broke during drilling.

Twenty-two 100-300 g surface samples, consisting of loose and cemented sediment, were collected along transects across each of the reefs and associated beach areas. Splits of these samples were sieved and the various grain-size fractions were determined according to methods of Folk and Ward (1957). A computer program for standard sedimentology computations, including grain-size distributions, was used to expedite data analysis. The program was written by the members of the Geology Department of the University of Waikato, New Zealand (Dr David Johnson, *pers comm*, August 12, 1986). Splits of sediment samples from each reef were placed in 10 percent HCl to determine the weight percentage of acid-soluble material in each sample. These sample splits were first dried and weighed, then placed in the acid. The residues were dried and weighed. All samples were also examined with a microscope at 10 to 100 diameters of magnification to help identify mineralogic and biologic components. Seven samples of unconsolidated sediment were also collected

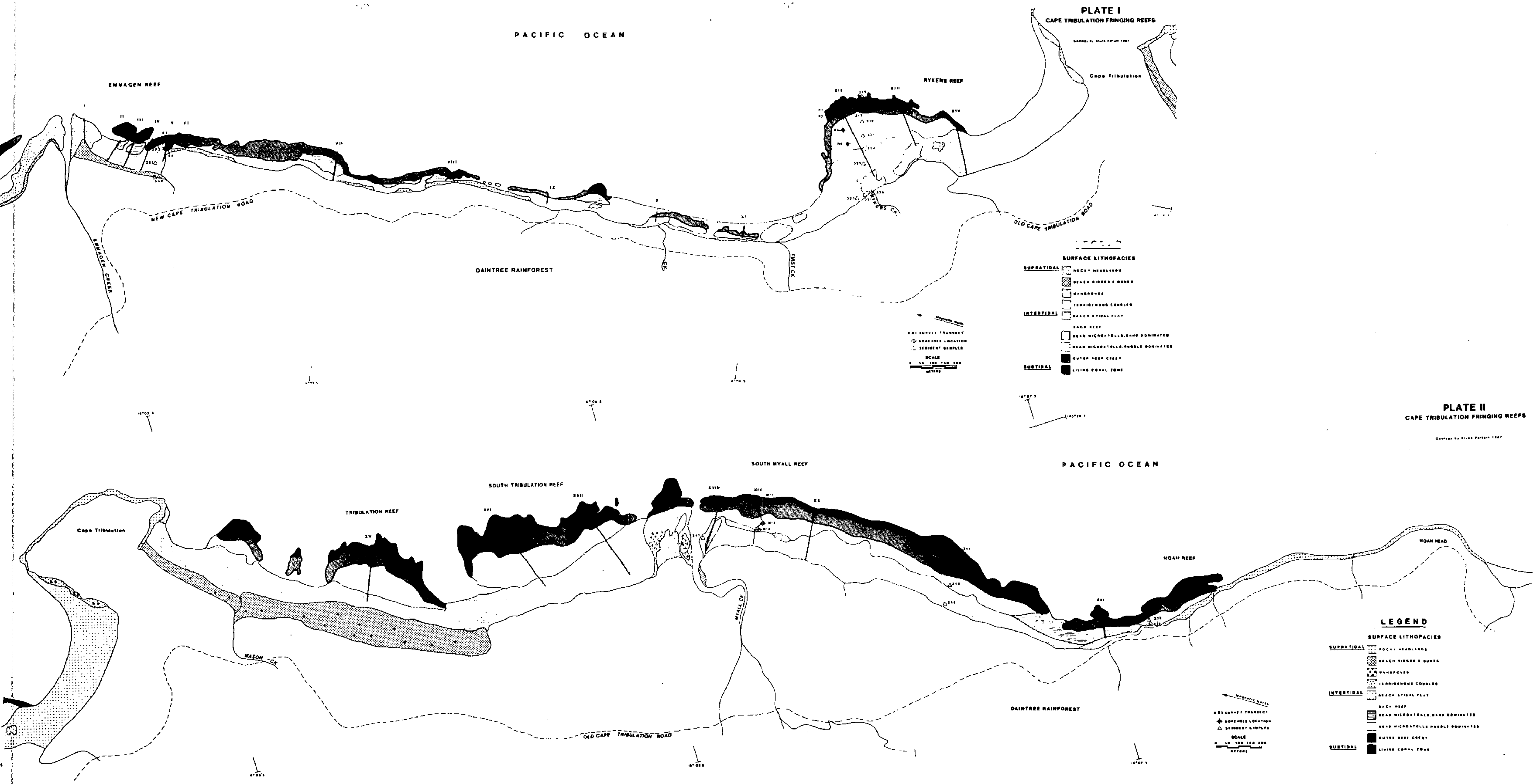

Figure 3. Surface lithofacies, Cape Tribulation reefs.

during drilling as the sediment circulated to the top of the borehole. These samples, three from Rykers Reef, three from South Myall Reef, and one from Emmagen Reef, were also analysed by sieving, acid digestion, and microscope study.

All core sections solid enough and long enough to be sawed were cut lengthwise. A 7 mm wide centre slice was taken from those core segments containing *Porites* sp. These slices were x-rayed to reveal coral growth-band patterns. Radiographs were made under the supervision of Keith Barry of Waterhouse Radiology, Townsville, Australia, using a Circlex condenser-discharge unit. Exposures ranged from 47-50 kilovolts at 15-20 milliamp-seconds with a tube-to-film distance of 90 cm. Fuji orthochromatic, green-sensitive radiographic film was used. Seventy-five thin sections were made from solid core and indurated surface sediment-samples. Because of the friable and porous nature of the samples, each thin-section sample block was vacuum-impregnated with "815" brand epoxy before being cut. The sample blocks were then mounted on frosted glass slides and cut and lapped to a thickness of 30 microns. To determine mineralogy and the extent of diagenesis in each sample, thin sections were studied at various magnifications with petrographic, scanning electron, or transmission electron microscopy. Solid sample chips were also studied with the electron microscope.

Selected thin sections were stained with Feigl's solution, Clayton Yellow, potassium ferrocyanate, and a mixture of Alizarin Red-S and NaOH (Feigl, 1958; Friedman, 1959).

High-magnesian calcite stains red while low-magnesian calcite remains colourless when stained with Clayton Yellow stain. High-magnesian calcite also stains with Alizarin Red-S in solution with 30 percent HaOH. Low-magnesian calcite remains colourless while magnesian calcite becomes purple. Feigl's solution (Feigl, 1958) is used to differentiate aragonite from calcite. Aragonite stains black while calcite and dolomite remain unstained. Control tests, using an echinoid spicule (high-magnesian calcite), a coral fragment (aragonite), and a pure (low-magnesian) calcite crystal, were performed to verify the staining procedures.

Thin sections were placed in a small beaker filled to a level where one-third of the section was stained. After one stain had dried, the section could be stained on the opposite end with a second stain. A small area in the centre of each slide was left unstained. Staining time was ten minutes for Feigl's solution, seven minutes for Clayton Yellow, and ten minutes for the Alizarin Red-NaOH solution.

The bulk of the laboratory work was done in Townsville, at James Cook University of North Queensland.

Radiocarbon Dating

Fourteen borehole samples and one surface sample, ranging from 21-103 g, were selected for C14 radiometric age dating. One surface sample and seven core samples were used from Rykers Reef, four core samples from South Myall Reef, and three core samples from Emmagen reef. Samples were selected on the basis of being relatively "clean", that is, free of bioturbation and visible precipitated cement. Generally, samples containing *Porites* sp and coalesced acroporid corals were chosen. All traces of boring or cementing organisms were removed with a Dremel Mototool hand drill. Samples were then dipped in 5 percent HCl, washed in distilled water and dried at 70°C. C14 dating was done by Sydney University's MacIntosh Centre for Quaternary Dating. Absolute ages were obtained for each sample by determining the C^{14} to C^{12} ratio and comparing this ratio to a known radioactivity-time scale (Urey, 1947; Gillespie, 1982).