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BUCK ISLAND BAR, ST. CROIX, USVI: A REEF THAT CANNOT CATCH UP WITH SEA LEVEL

BY

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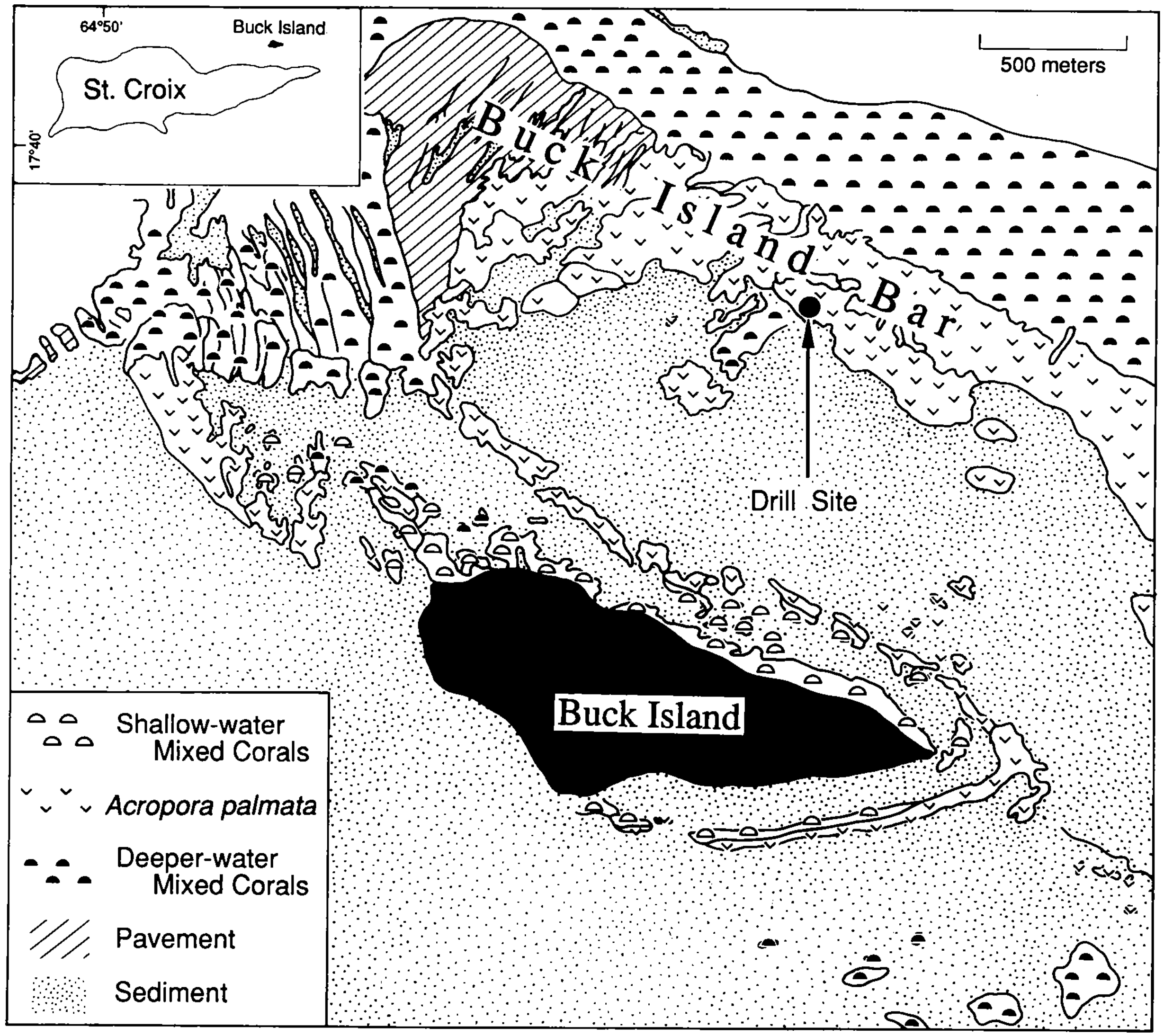

Fig. 1. Index map showing the general zonation of the sea floor around Buck Island and the location of the drill site on Buck Island Bar, near the outer edge of the shelf.

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ABSTRACT

Frequent storms have disrupted reef growth on Buck Island Bar at the shelf edge off the north coast of St. Croix, U.S. Virgin Islands and have prevented the reef from catching up with the rising seas of the Holocene Transgression. An 8-m-long core hole in this reef indicates that Acropora palmata has been established here for over 4,000 years. Although this branching coral is capable of growing at rates in excess of 10 m/1,000 years, extratropical swell and perhaps hurricane damage have limited framework accumulation, and the remaining geological record is dominated by massive coral heads and well-lithified bare pavements.

INTRODUCTION

Holocene coral reef frameworks up to 18 m thick have been documented from numerous localities in the eastern Caribbean (Adey and Burke, 1976). The shallow inshore reefs on the north side of St. Croix (where they are protected by Buck Island and associated reefs) and on the south side are capped by an extensive framework of Acropora palmata, a rapidly growing and robust coral. As a result, framework construction has exceeded the rate of late Holocene sea-level rise (Adey, 1975), and reef flats are common in these areas. A submerged coral reef also exists on a raised edge of the shelf along the north coast of Buck Island and extends around the entire east coast of St. Croix.

The purpose of our project was to obtain a deep core from the early Holocene framework and to establish a relationship between these shelf-edge reefs and the inshore bank-barrier reefs. In November 1977, we drilled a hole into the reef at Buck Island Bar, near the shelf edge north of Buck Island (Fig. 1). This proved to be a difficult undertaking as we had to work at a depth of 5.18 m among thickets of Acropora palmata (Fig. 2) during heavy swells. These conditions prevented us from drilling much deeper than 8 m. Despite these drawbacks, we obtained

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Fig. 2. Buck Island Bar drill site. Note the abundance of the branching coral Acropora palmata. Water depth 5.18 m.

valuable data that have shed additional light on the history of the Holocene reefs of St. Croix.

DESCRIPTION OF THE STUDY SITE

The map showing the location of the core hole (Fig. 1) was constructed from 1976 to 1979 by P. J. Curry and W. H. Adey from color positives of a 1971 aerial survey and was validated by numerous underwater observations. For a detailed description of the coral reefs and algal ridges off St. Croix, see Adey (1975).

We selected a drill site in an Acropora palmata community toward the outer edge of the shelf north of Buck Island. On naval charts this raised part of the shelf edge is identified as Buck Island Bar (U.S. Coast and Geodetic Survey Chart # 905). This shallower section of the shelf-edge reef system occurs at an average depth of about 4 m, but a few thickets of A. palmata extend to within 0.5 m of the water surface. The reef site is separated from the shallow bank-barrier and fringing reefs of Buck Island by a sandy shelf up to 14 m deep (Fig. 1).

SUBSURFACE DATA

A hydraulically powered drill designed for underwater operation (Macintyre, 1975; Fig. 2) was used to penetrate to a total depth of 8.21 m in five intervals (Fig. 3). The first core-hole interval (0-1.68 m) consists of mixed heads of Diploria sp., Porites astreoides, Montastrea annularis, and branching Acropora palmata, all of which exhibit patches of micrite cement crusts and infillings of submarine Mg-calcite.

This upper interval also contains two sections of well-lithified pavement limestone--one at a depth of 1 m, and the other at the base of the core interval--consisting of heavily cemented coral heads and Millepora sp. This limestone is similar to that found in other parts of the Caribbean, which is usually an agglomeration of high-energy reef components, including crustose coralline algae, Millepora sp., Porites astreoides, and Agaricia agaricites (Macintyre 1977), with a diagenetic matrix of micritic Mg-calcite that "completely infills most of the inter- and intraparticle pore space to form a marble-like limestone" (Macintyre and Marshall, in press). Much of the original skeletal material has been lost during multicyclic stages of boring, infilling, and lithification.

The next two intervals, to a depth of 4.19 m, are dominated by Montastrea annularis and Porites astreoides, with only one 10-cm core of Acropora palmata. Most of this material is encrusted and infilled with patches of submarine Mg-calcite cement. Half of the fourth core interval (4.19-5.72 m) consists of relatively fresh Porites astreoides and is followed by a section of lightly cemented Acropora palmata with crusts of coralline algae. Another section of pavement limestone is found at the base of this interval. In the final core interval (5.72-8.21 m), the coral barrel dropped almost a meter, probably because a sand section was

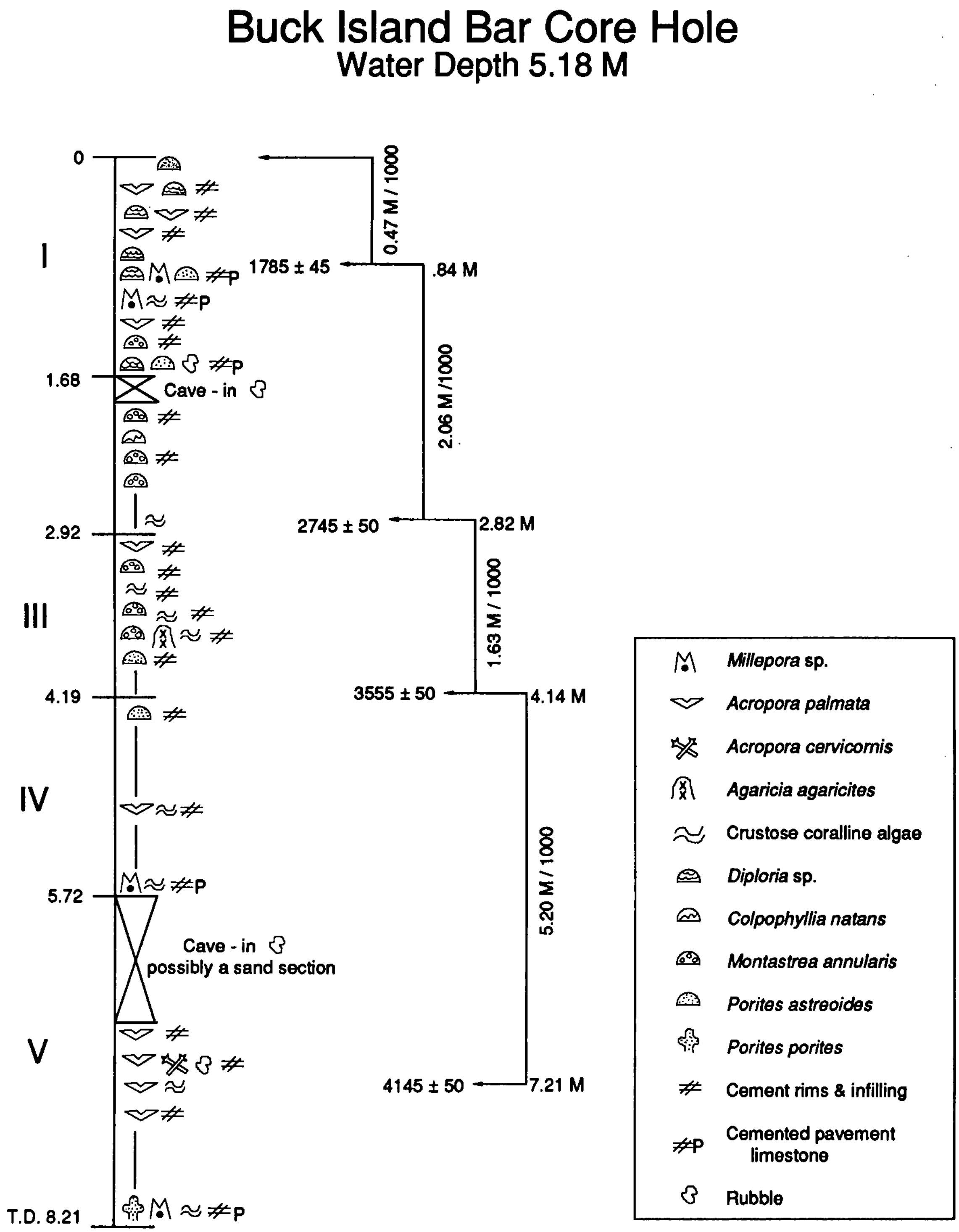

Fig. 3. Graphic summary of core data. Core intervals are indicated by roman numerals and are delineated by depths below the reef surface. Accumulation rates are recorded for intervals between radiocarbon-dated samples. Depths at right.

present. This was followed by about 1.5 m of lightly cemented A. palmata, which gives way to 8 cm of pavement limestone at the base of the core hole.

Four radiocarbon dates were obtained from four species of unaltered coral colonies--Acropora palmata, Porites astreoides, Montastrea annularis, and Diploria sp. (see Fig. 3). These dates were determined at the former Smithsonian Institution Radiation Biology Laboratory using a Libby half-life of 5,568 years and are uncorrected for $^{13}C/^{12}C$ ratios or for secular atmospheric variations.

DISCUSSION

A plot of four radiocarbon dates on a minimum sea-level curve for the western Atlantic (Lighty et al., 1982) (Fig. 4) indicates that the Holocene reef surface at the drill site has never been closer than 4.5 m to the water surface during the past 4,000 years.

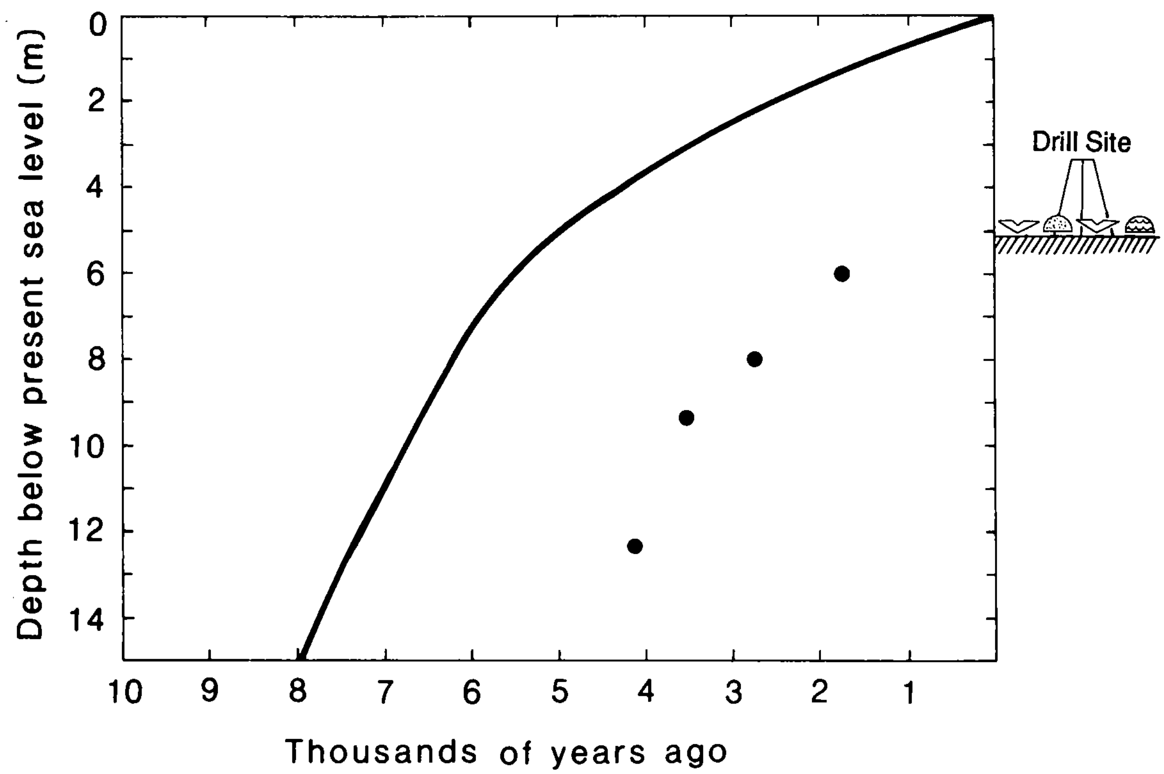

Fig. 4. Plots of four radiocarbon-dated samples on a minimum sea-level curve for the western Atlantic (Lighty et al., 1982). Present-day water depth of drill site illustrated on right side of plot.

The first three dated intervals show that the reef made some progress in catching up with the rising seas of the Holocene Transgression. The highest accumulated rate (5.2 m/1,000 years) is recorded at depths of 7.21 to 4.1 m, and probably reflects the fast growth rate of the Acropora palmata that dominates this interval (Fig. 3). The coral-head facies in the next two dated intervals only made limited progress in catching up with sea level, with accumulation rates of 1.63 and 2.06 m/1,000 years. Finally, the "race" to keep up with sea level in the last 1,785 years was lost, as is evident from the rate of 0.47 m/1,000 years estimated for the uppermost dated interval. Consequently, the present reef surface at the drill site is stranded at a depth of 5.18 m.

The sections of pavement limestone that occur throughout this core hole indicate periods in which most of the coral cover was removed--probably during storms--and the surface was left exposed for long periods of time (Macintyre and Marshall, in press). An interruption in reef growth is also reflected in the dominance of coral heads in the upper sections of the core hole. These corals (Montastrea annularis, Porites astreoides, and Diploria sp.) are all species that characteristically grow around and between stands of Acropora palmata and that are likely to remain on the substrate following the removal of this more fragile branching coral during severe storms.

The shelf edge of St. Croix frequently experiences the strong effects of extratropical winter swells--or "rollers," as they are called in this part of the Caribbean. These long-period waves can create havoc in coastal areas. Severe episodes of rollers have also been observed breaking along the entire shelf edge, even in areas where the water is 15 to 18 m deep. The devastating effects of hurricanes on reef structure, particularly the more fragile Acroporid corals has been well demonstrated in recent years (e.g., Woodley et al., 1981). Another factor contributing to the destruction of reef framework that should not be overlooked is mass mortality of corals caused by unusual temperature fluctuation or disease. In May 1989, for example, most of the thickets of Acropora palmata on Buck Island Bar were found to be dead and weakened by extensive boring by clionid sponges (M. M. Littler and D. S. Littler, pers. comm.), apparently as a result of the widespread "bleaching" that has recently attacked many corals in the Caribbean (Williams and Bunkley-Williams, 1990).

The overall pattern of reef growth on Buck Island Bar appears to be one in which Acropora palmata has thrived even at depths of 5 m--the maximum depth generally accepted for the development of A. palmata framework (Lighty et al., 1982). This coral is capable of accumulating at rates of 10 m/1,000 years or more (Adey, 1975; Macintyre and Glynn, 1976; Lighty et al., 1978). However, the deeper-water anastomosing thickets of A. palmata on Buck Island Bar are considerably more fragile than their robust shallow-water counterparts, and thus are highly susceptible to storm damage. It is not surprising that there have been frequent interruptions in the growth of this reef over the past 4,000 years--during which the branching A. palmata has been transported shoreward and the massive coral heads or bare pavements have been left behind. The facies in the Buck Island Bar core reflects a history of catch-up/keep-up coral growth in deeper water (Neumann and Macintyre, 1985) and show no indication of a catch-up sequence in shallow water.

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