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Coral Reefs

Halimeda bioherms along an open seaway: Miskito Channel, Nicaraguan Rise, SW Caribbean Sea

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Abstract. A recent research cruise to examine small, detached carbonate platforms situated on the Nicaraguan Rise in the SW Caribbean Sea has revealed the presence of numerous *Halimeda* bioherms. Based upon interpretations from seismic reflection data some exceed 140 m in relief. This is the first documented occurrence of these green-algal buildups in the Caribbean/Bahama Bank region. The *Halimeda* bioherms form a nearly continuous band that borders the margins of the Miskito Channel – a shallow, open, 125 km long seaway. This 220 m deep channel bisects the Miskito Bank which is a major carbonate shelf. In seismic profile the bioherms appear acoustically "soft" and reveal a local relief of 20–30 m. Tops of these features lie in about 40–50 m of water. Samples from dredge hauls are coarse, poorly cemented packstones/grainstones which are dominated by largely unbroken, disarticulated *Halimeda* segments set in a poorly sorted sandy matrix. Exposed surfaces were stained brown. Very little living material was brought up in the dredges. The significance of these bioherms and their full extent in the Caribbean are not understood. Undoubtedly, further study will provide important answers concerning their role in the geologic development of Caribbean carbonate platforms.

Introduction

A recent research cruise to examine the small, detached carbonate platforms situated on the Nicaraguan Rise in the SW Caribbean Sea revealed the presence of a 125 km long, nearly continuous band of *Halimeda* bioherms, some reaching as high as 140 m in relief, that has developed along the margins of the Miskito Channel – an open seaway that bisects the Miskito Bank (Figs. 1–4).

The Miskito Bank is a major carbonate shelf that is attached to the Nicaraguan/Honduran mainland and is situated upon the Nicaraguan Rise. The Nicaraguan Rise is a major tectonic/structural component of the Caribbean Plate and is an enormous topographic feature (4 km in relief) that extends from Central America east to Hispaniola (Arden 1975; Case and Holcombe 1980; Pindell and Dewey 1982).

The overall purpose of the research project was to determine the late Quaternary sedimentologic/stratigraphic development of several of the platforms situated upon the Nicaraguan Rise and to compare and contrast them to other well-known carbonate banks, such as the Bahama Banks to the northeast. Pedro, Serranilla, Rosalind, Miskito, and several unnamed banks located in the study area are relatively deep (30–40 m), small, are unaffected

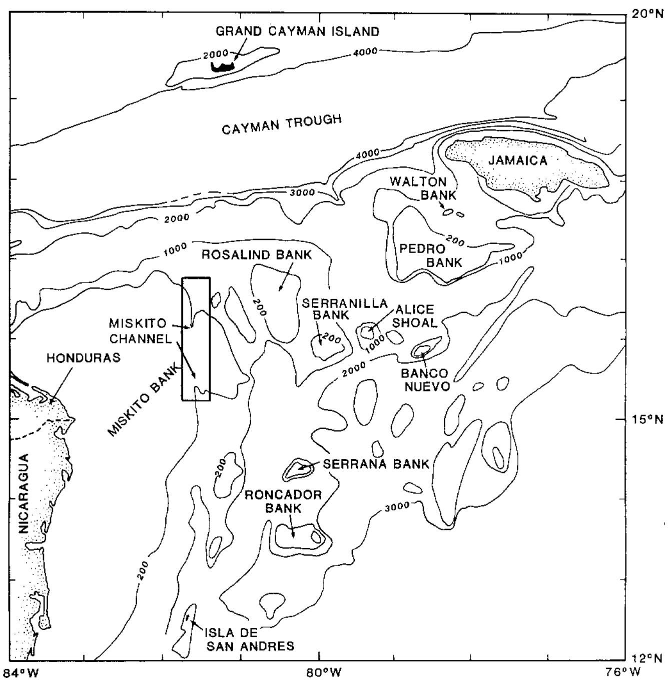

Fig. 1. Location map of study area. Miskito Channel is shown on most maps as a shallow, partially-infilled seaway that appears to be closed. The Nicaraguan Rise is the major structural/topographic feature that strikes NE-SW across the map, is bounded on the north by the Cayman Trough, and supports all the banks and islands including the eastern Nicaraguan/Honduran mainland. Note the presence of the numerous carbonate banks

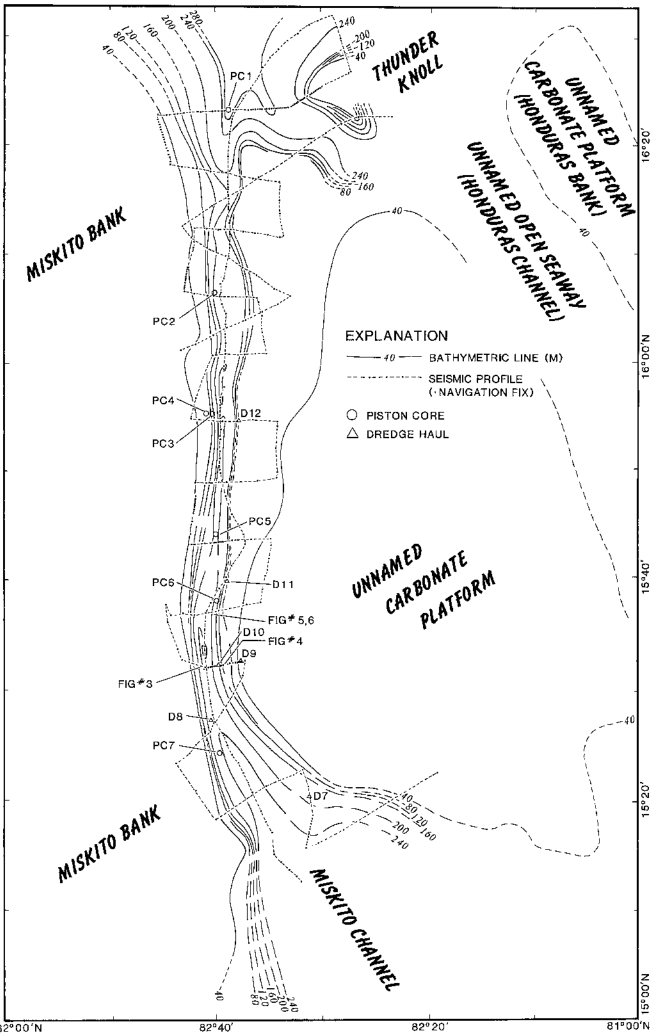

Fig. 2. Bathymetric map of the Miskito Channel based upon 3.5 kHz seismic profile data. This map indicates the along-slope, changing gradient of each margin of the channel from north to south. Note the location of the data panels from other figures

by cold weather frontal passages, are influenced by the NW flowing Caribbean current, respond to the steady E-NE Trade Winds, and lie in an active tectonic setting. All of these characteristics justified examining these non-Bahamian carbonate platforms in the modern ocean to provide additional sedimentological/stratigraphic models for those investigators studying ancient carbonate platform settings. Discovery of such large and heretofore unknown occurrence of *Halimeda* bioherms in the Caribbean/western Atlantic partially warranted our probe into this new and different carbonate regime.

The purpose of this short paper is to report the presence of the *Halimeda* bioherms and to describe the setting in which they formed.

Materials and methods

The primary data base within the Miskito Channel consists of a small chambered air gun (1″³) and 3.5 kHz high resolution seismic profiles coupled with 7 piston cores, 6 rock dredges, and 50 bottom grab samples (Fig. 2). The single channel air gun data were filtered between 100–500 Hz. A 60 element Teledyne streamer was used. Ship speed was approximately six knots. Positions were obtained using a combination of Satellite Navigation (SatNav) and the Global Positioning System (GPS). Due to the short period of time between the end of the cruise and the writing of this paper (8 weeks), no laboratory analyses are available.

Results

Miskito Channel

The Miskito Channel (our name) appears on most charts as an unnamed, partially closed or infilled 125 km long, 5–10 km wide, shallow seaway whose maximum depth is about 220 m (Figs. 2 and 3). It is the smallest and shallowest of three unnamed open seaways that define and separate at least four carbonate platforms in this area of the Nicaraguan Rise. Extensive faulting seen in our seismic data as well as the widely-recognized history of tectonic

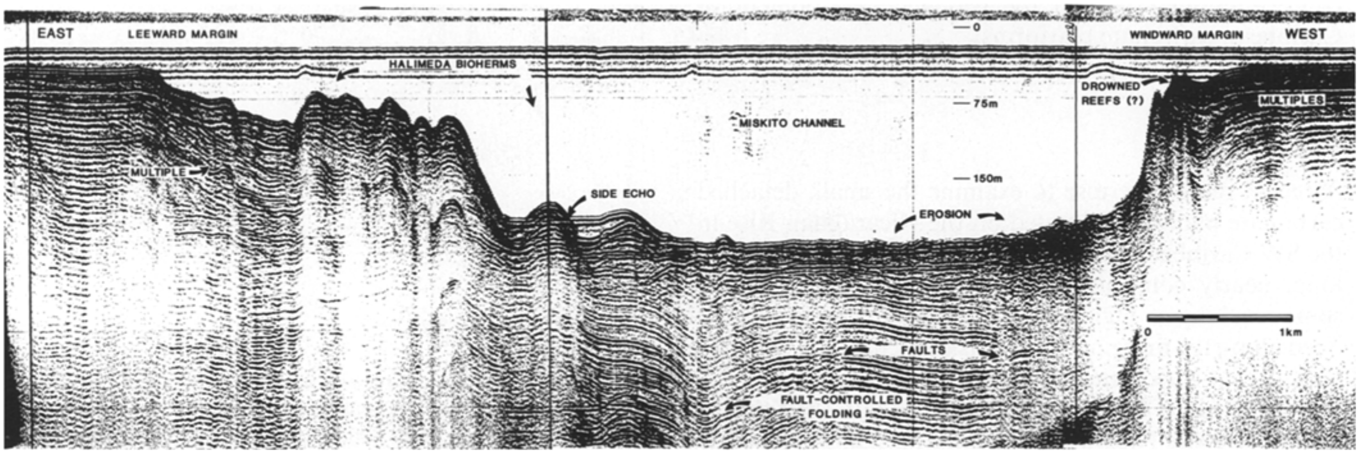

Fig. 3. Seismic profile line (1″³ air gun) run E-W across the southern portion of the Miskito Channel. This profile illustrates the low-gradient, eastern side with well-developed *Halimeda* bioherms and the steeper-gradient western side supporting reefal structures of unknown origin. The floor of the channel appears to be erosional along the western side. Note the faults and fault-controlled folding in the subsurface

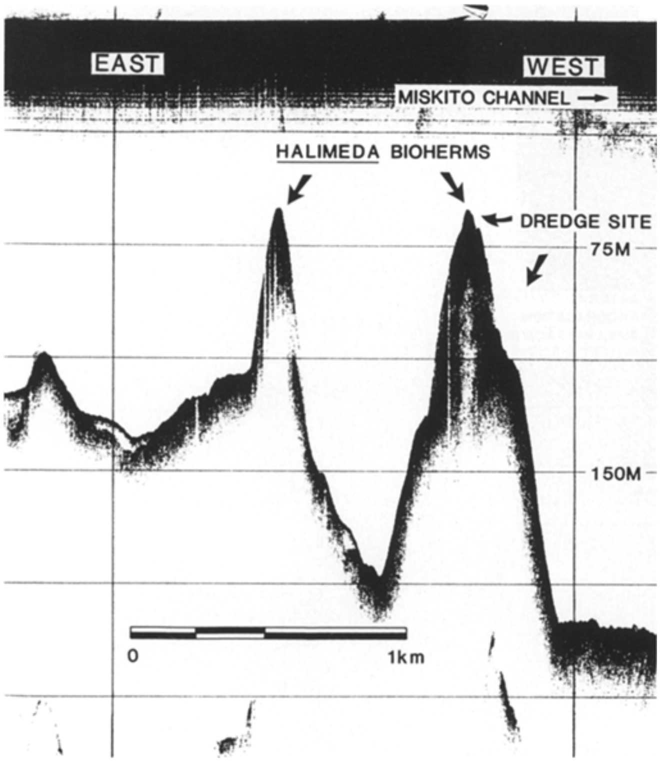

Fig. 4. A 3.5 kHz profile illustrating two very large *Halimeda* bioherms. The upper portion of the more western bioherm was dredged (D-10). Those rocks are illustrated in Fig. 7. The flat, basin floor of the Miskito Channel is seen on the far right of the profile. The maximum relief of the larger bioherm is approximately 140 m. This profile is located within a short distance (≈100 m) of the air gun seismic line illustrated in Fig. 3. The side echo noted in Fig. 3 represents the proximity of these large features

activity in this area suggest that the platforms and channels are structurally controlled.

Our seismic data clearly show that the Miskito Channel is an *open* seaway that has narrowed by lateral progradation along the margins of the channel. Westward dipping reflectors beneath the east margin (western margin of adjacent carbonate bank) indicate that such progradation has taken place (Figs. 5 and 6). The channel is only 5 km wide is several places indicating that eventual closure is possible in spite of the north-flowing Caribbean Current. The narrow dimensions and the low relief (180 m from platform top to basin center) of the Miskito Channel contrasts sharply with other well-known seaways either open or closed (see Mullins 1983 and references contained therein).

The west and east margins of this open seaway do not appear to directly conform to windward and leeward margins of carbonate platforms described by Hine and Neumann (1977) for the Bahama Banks. The bathymetry show that slope gradients along both margins change from relatively low and broad to narrow, steep-appearing escarpments. The *Halimeda* bioherms appear to be best developed on the mid-depth portions of the lower gradient margins. However, there are reef-like structures that appear on top of the margins that may be green-algal buildups as well (Fig. 3). More data are needed to determine detailed distribution of *Halimeda* bioherms and the presence of drowned (or even active) coral reefs in/along the Miskito Channel.

The lack of clear windward/leeward bank margins may be due to more effective oceanographic currents, (Caribbean Current) active now or in the past, passing

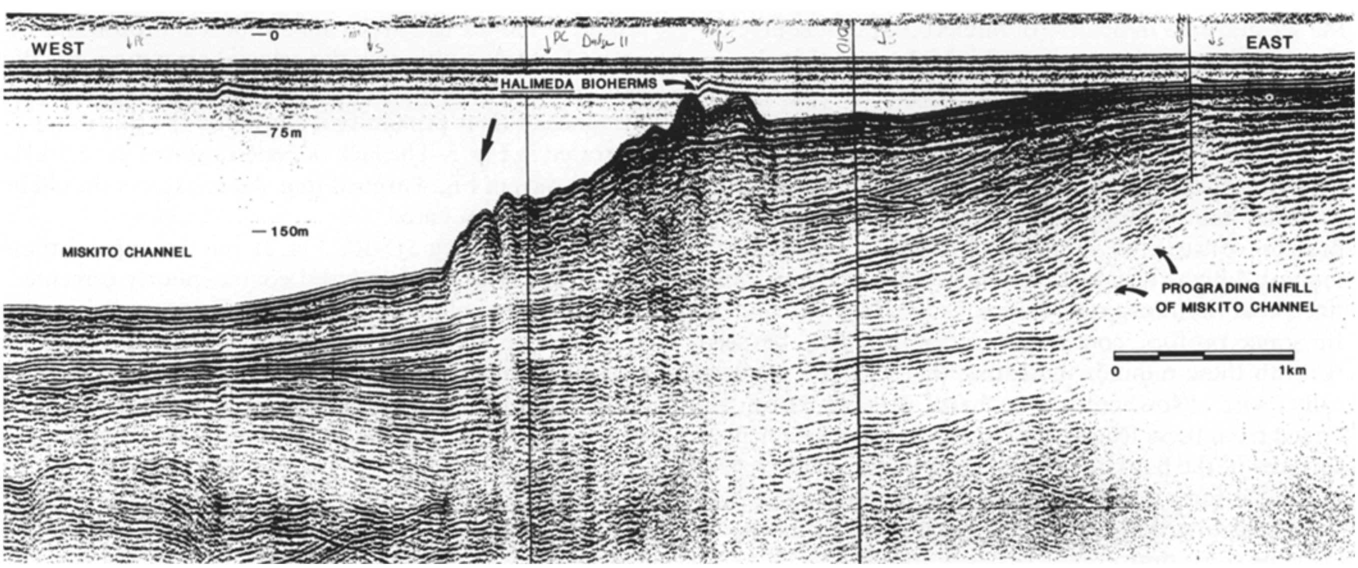

Fig. 5. Seismic profile line (1″^{3} air gun) run W-E across the eastern margin of the southern Miskito Channel. Profile illustrates the mid-slope location of this large area of *Halimeda* bioherms that have built vertically. West-dipping reflections indicate that this eastern margin has prograded toward the west partially infilling the Miskito Channel

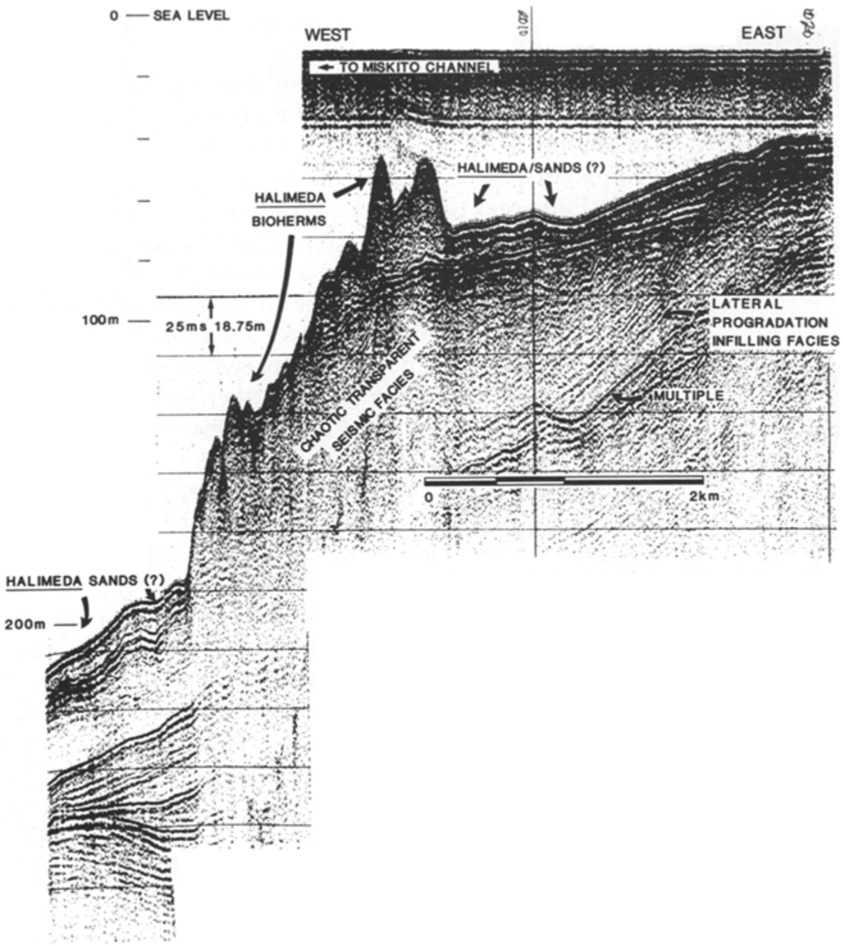

Fig. 6. Seismic profile line of the same area as shown in Fig. 5, but presented at an expanded scale to illustrate details. This seismic line was obtained using a smaller graphic recorder and hydrophone with a shorter active section. Most recent bioherms are situated upon a pronounced reflector. Note lateral-prograding infill

through the Miskito Channel. These currents may have dominated any windward/leeward effect generated by the easterly Trade Winds. The channel floor provides evidence of erosional scour as can be seen by distinctive, multiple, overlapping hyperbolic diffraction patterns in the seismic data indicative of numerous, point source reflections from rocky, topographic high areas (Fig. 3).

Features of the Halimeda bioherms

Preliminary interpretations of the seismic reflection data indicate that the middle slope of the lower gradient bank margin consists of numerous, rounded topographic, mounded highs which are supported below by an indistinct, chaotic-transparent seismic facies (Figs. 3, 5 and 6). In some profiles continuous reflections can be seen beneath these mounds indicating that they are acoustically "soft". Nowhere was a "hard" seismic return obtained from these features as compared to well-cemented surfaces of the bank top. These chaotic-transparent seismic facies form a lens or pod-like geometry in cross-section indicating that *Halimeda* bioherms have built vertically for some time.

The local relief of the green-algal buildups is generally 20–30 m. However, in one area, much larger, pinnacle-like topographic expressions were found in the 3.5 kHz data (Fig. 4). The profile data shown in Fig. 4 is located very close (≈ 100 m) to the air gun seismic line shown in Fig. 3. The 3.5 kHz profiler was used to locate potential sample sites (piston cores or rock dredges) originally picked from the air gun data. The navigation system would not allow us to relocate our previous positions exactly. Note that although the original air gun profile did not run right over the large bioherms illustrated in Fig. 4, evidence of their proximity is shown by the side echos illustrated in Fig. 3. The lack of penetration in the 3.5 kHz data shown in Fig. 4 argued that these features should be dredged and not cored.

Rock dredging (D-10, Fig. 2) on the top of these 140 m high features produced coarse, poorly cemented, buff-to-white colored *Halimeda* packstones/grainstones (Fig. 7). The dominant species represented is *Halimeda opuntia* [(Linné) Clinton Dawes, personal communication, 1987]. No other species of *Halimeda* appeared to be present. *Halimeda opuntia* (Linné) has a bathymetric distribution of 1 to 55 m with major development in depths <20 m. It is documented as a major carbonate sediment contributor in many western Atlantic locations (Ginsburg 1956; Goreau and Goreau 1973; Colin 1978).

Hardly any living material was attached to these rocks. The sparse fauna collected by dredge contained sponges, octocorals (seawhips and plumes), and echino-

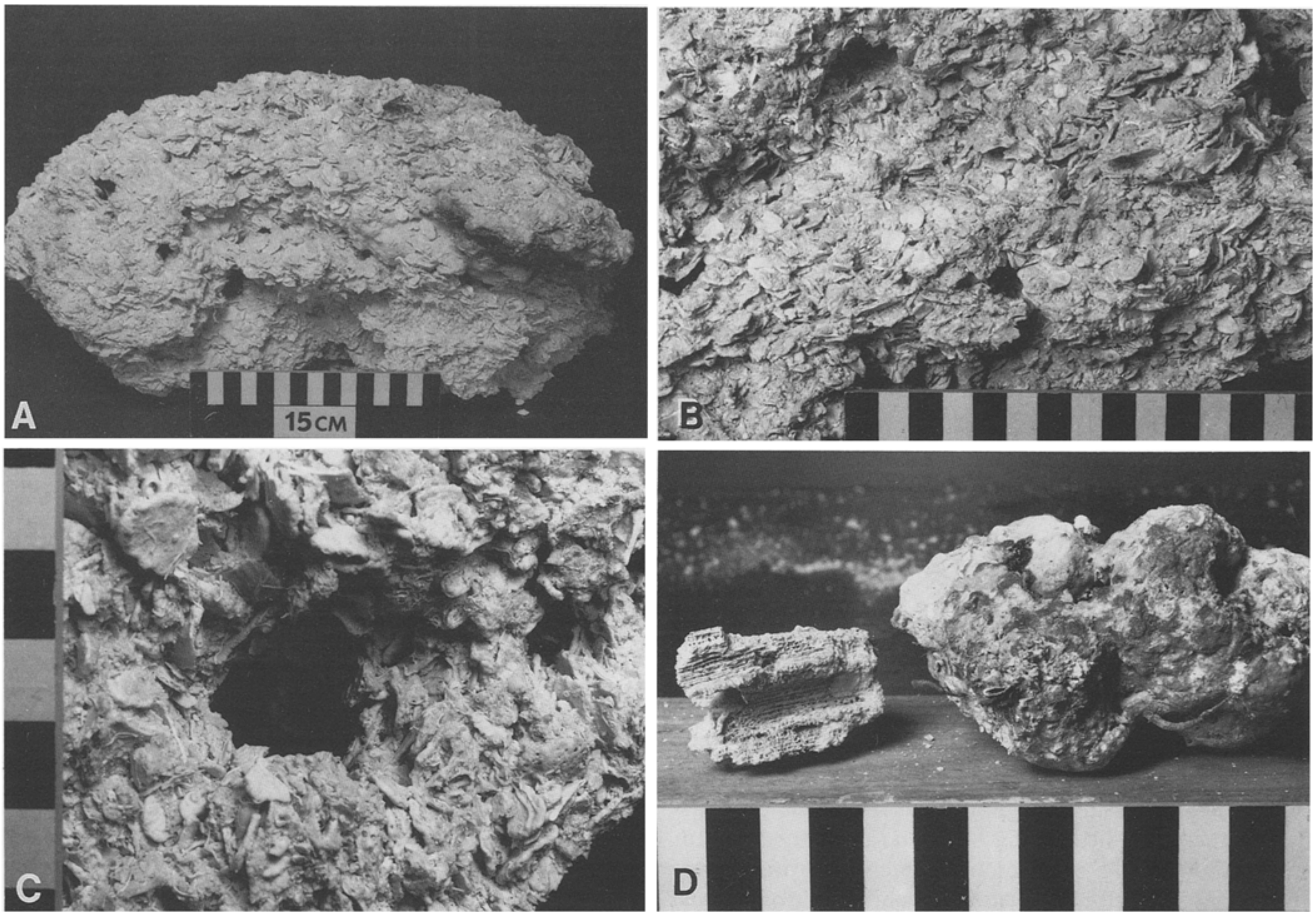

Fig. 7. A Photo of large *Halimeda opuntia* dominated packstone/grainstone rock obtained in D-10 dredge haul, **B** close-up photo of same rock shown in **A** illustrating coarse, unbroken nature of the *Halimeda* segments, **C** close-up photo of possible lithified burrow cavity. These features were common throughout the larger rock fragments, **D** photo of coral fragment and red-algal coated rock fragment (rhodolith) also brought up in the same dredge haul

derms (echinoids and ophiuroids); there were virtually no scleractinian corals, mollusks, or crustaceans. Since this assemblage is indicative of planktivory and detrivory, Miskito Bank appears to lack an epibenthic (reef) community typical of many Caribbean areas.

The exposed surfaces of the rocks were slightly bored and lightly stained brown in color. The large specimens were cavernous within the interior, reminiscent of preserved burrows (Fig. 7 B, C). The rocks contain a poorly sorted sandy matrix that separates the largely unbroken *Halimeda* grains (Fig. 7 B). Together, the matrix and grains form a crude bedding. We have not yet identified the matrix constituents nor the type of cement holding the rocks together. Gravel-sized particles, other than the coarse *Halimeda* grains, were fragments of corals, molluscs, and echinoderms (Fig. 7 D). A shark's tooth and possible whale bone were also imbedded into the matrix. Some of the rocks in the dredge haul were coated with red algae forming rhodoliths (Fig. 7 D).

In addition, a piston core (PC-3, Fig. 2) was obtained upslope and behind a zone of pronounced bioherms. That core consists of a continuous vertical sequence of uncemented, coarse *Halimeda* fragments that appear exactly like the cemented packstones/grainstones composing the surfaces of the pinnacles.

Discussion

These data and observations constitute the first description of *Halimeda* bioherms in the Caribbean Sea. Similar bioherms, albeit somewhat smaller in relief but located at the same depths, have been described in the western Pacific (Davies and Marshall 1985; Orme 1985; Phipps et al. 1985; Roberts et al. 1987 a, b). However, it is most likely that Roberts and Murray (1983, their Fig. 5), in their study of the Caribbean Shelf of Nicaragua, profiled over similar features situated along the deep, outer margin of this attached platform. They identified *Halimeda* coralline-algal mounds (Roberts 1987). However, since subbottom data and piston cores were not taken their existence could not be confirmed (H. H. Roberts, personal communication, 1987).

The presence of these green-algal buildups poses a number of questions that remain unanswered at the moment. Why do these features occur in the western Caribbean and have not been found elsewhere in well-studied areas such as the Bahama Banks? Is there a relationship between algal bioherms and the absence of coral reefs? Our work on the Nicaraguan Rise has indicated that coral reefs are nearly absent.

Diving observations on Serranilla Bank documented sparse reef development on this platform. Most diving site habitats consisted of a limestone sea floor with a thin veneer of sediments. Brown algae [*Turbinaria turbinata* (Linné), *Stypopodium zonale* (Lamouroux), and *Sargassum* spp.] dominated the epibenthos. Seven species of scleractinian corals were observed, none appeared to be constructing reef framework. A single reconnaissance dive was made on Pedro Bank located further to the northeast. In contrast, the reef development there appeared superior to that observed at Serranilla Bank. Fourteen species of scleractinian corals and a diverse reef fish community were observed; *Acropora palmata* (Lamarck) was abundant, in dense thickets, and appeared to be developing reef framework.

In addition, do these mounds illustrated in the seismic data really represent vertical accumulation of *Halimeda* or perhaps was the *Halimeda* a veneer that formed on earlier coral reefs? What is the detailed lithologic/paleobiologic composition of mounds' interior facies? What conditions are necessary for optimum *Halimeda* growth? Why is there very little living *Halimeda* along the Miskito channel? Were the algal bioherms active during lower stands of sea level? Were water currents faster or slower during low stands of sea level? How important is synsedimentary cementation in maintaining vertical growth? Have *Halimeda* bioherms played an important role in the lateral infilling of the seaway, or are they a relatively recent phenomenon?

We do not have the answers to this partial list of questions. However, we are confident that further study of these interesting features will provide important insights into the geologic and paleoceanographic history of this portion of the Caribbean Sea. In addition, analysis of modern *Halimeda* bioherms, wherever they are found, may provide important clues to understanding the paleosetting of ancient algal mounds and bioherms.

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