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Field Guide to the Cockburn Town Fossil Coral Reef, San Salvador, Bahamas

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PROCEEDINGS

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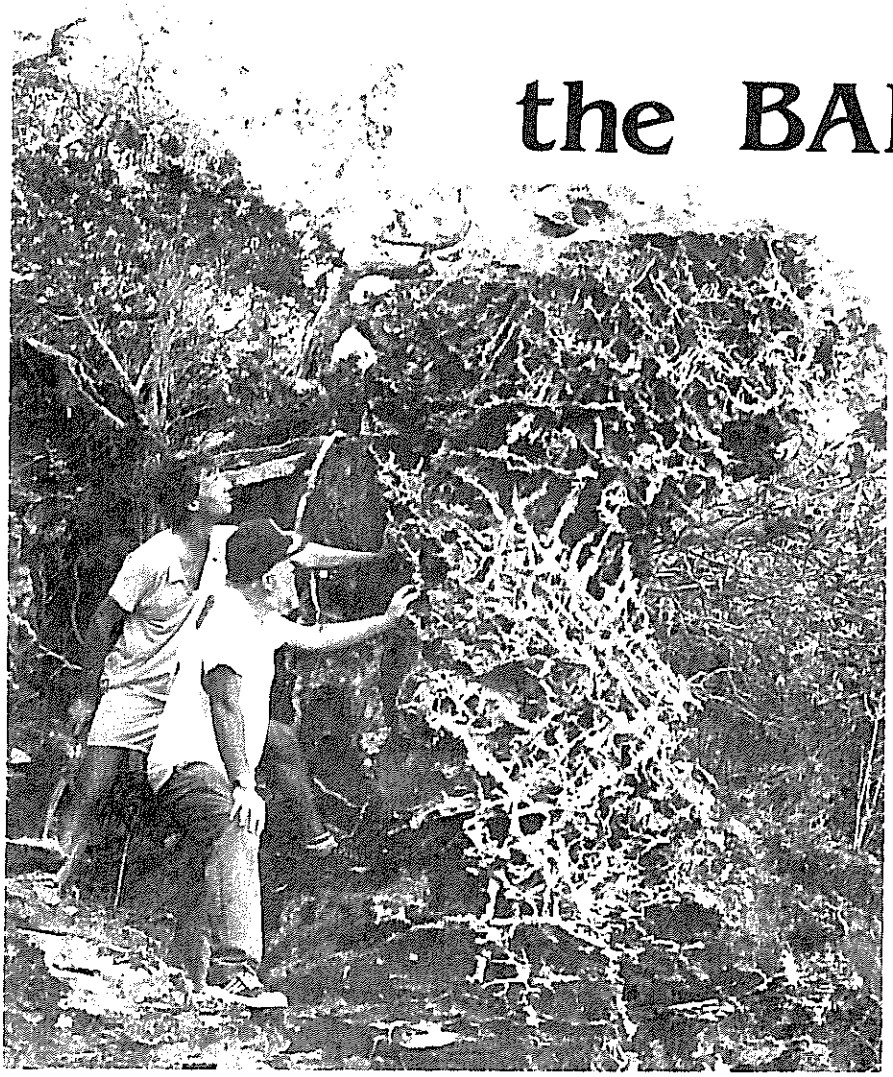
2nd Symposium on the GEOLOGY of the BAHAMAS



June 1984

CCFL Bahamian Field Station

FIELD GUIDE TO THE COCKBURN TOWN FOSSIL CORAL REEF, SAN SALVADOR, BAHAMAS

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Introduction

Background - A Pleistocene coral reef located along the western coast of San Salvador northwest of the center of Cockburn Town is the largest and best exposed ancient reef presently known and described from the Bahamas. The Cockburn Town reef is an excellent fossil example of a bank/barrier reef as defined by Kaplan (1982, p. 99-100); such reefs are common today on the narrow, wave-cut shelves of islands in tropical Atlantic and Caribbean waters. Modern bank/barrier reefs normally are only hundreds of meters from a land mass, not thousands of meters offshore as is common for true barrier reefs, more typically found in the Pacific Ocean.

There is no evidence that the Cockburn Town fossil reef ever was contiguous with a land mass during its development in Late Pleistocene time. Consequently, using Kaplan's definition (1982, p. 96-97), the Cockburn Town reef does not qualify as a fringing reef as was suggested by Moshier et al. (1979).

The main part of the Cockburn Town reef, the fossil reef crest zone, consists of coralstone composed of near *in situ* *Acropora palmata* and subordinate *A. cervicornis*. This part of the fossil reef bears close resemblance to the modern Gaulins Reef located along the northern shelf edge of San Salvador.

Because the fossil reef is easily accessible, well exposed, and excellently preserved, this is a particularly good field locality for visiting geologists and biologists. This guide provides a general overview of the reef and more detailed information for ten field stops. The locations of these stops and all stratigraphic profiles are shown on the geologic map found at the end of the guide. This map was prepared with the help of Smith College geology students during the summers of 1983 and 1984. Topography was mapped using plane table and alidade. Reference starter points for the topographic survey were bench marks 1 and 2, (see Adams, 1980, p. 61 for further informaion); these bench marks have been tied directly to accurately measured mean sea level.

Amino acid racemization dating of specimens of the bivalve Chione cancellata and the coral Acropora cervicornis from the reef site yielded ages of 120,000 to 140,000 years b.p. and 75,000 to 130,000 years b.p. respectively (Carew, 1983). These dates indicate that the reef formed and flourished during the Sangamon interglacial interval of the Pleistocene Epoch.

Previous Work - The geologic setting of the reef was described by Adams (1980), and a preliminary analysis of the corals and facies of the reef was presented in an abstract by Moshier et al. (1979). Kissling (1980, p. 57) compiled a list of fossil corals most commonly found in the reef facies, and a key to the common coral species of the Cockburn Town reef was constructed by Besom and Curran (1984). Trace fossils from the

calcarenite facies associated with the reef have been described by Curran (1983, 1984). Two studies recently completed by Smith College students have provided further information about the petrology (Kurkjy, 1984) and molluscan biofacies (Blette, 1984) of the reef complex. The shallowing-upward sequence and diagenetic history of the reef complex and their significance with respect to reef development and sea level change is discussed by White et al. (this volume).

Location - The Cockburn Town fossil coral reef is exposed by coastal outcrops and in a small quarry located a short distance northwest of the center of Cockburn Town. Reefal rocks extend in a northwesterly direction from the old town dock for a distance of about 650 m, terminating near a cable trench cut into the Pleistocene shallow subtidal and beach calcarenites that flank and overtop the reef at its northern end.

A field trip to the reef should start from the parking area adjacent to the new town dock. The shallowing-upward sequence of calcarenites overlying reefal rocks is well exposed in the roadcut on the east side of the road leading to the dock and launch area (Stop 1, this guide). The main part of the reef can best be reached by walking WNW from the parking area (or NW along the coast from Stop 1) through the woods to the coast in the vicinity of "Ophiomorpha Bay" (Stop 2, see map). The reefal facies are particularly well exposed in the quarry area a short distance beyond Stop 2.

Some Do's and Don'ts for Visiting the Reef

Sturdy shoes with thick rubber soles are recommended for hiking over the reefal rocks; some exposures have rough surfaces with many sharp edges, particularly in the heavily bioeroded zone near the water's edge. Wet, algae-covered surfaces in the intertidal zone are very slippery, so caution is advised. The quarry area of the reef can be hot and glary on sunny days, so hats and sun glasses are helpful. Do bring cameras to photograph the well exposed facies and fossil corals of the reef complex.

Because this fossil reef is an attraction of considerable geologic and biologic importance, every reasonable effort should be made to preserve it for future visitation and study. Accordingly, we ask that no rock hammers be used to collect samples from the reef exposures and no spray-paint markers be made for reef surveys. Some rock drilling has been done on the reef to collect unaltered samples for thin-sectioning, but every effort has been made to place these holes in inconspicuous locations. Fossil corals and mollusks can be collected from rubble in the quarry area, but specimens should not be removed from outcrop. Your cooperation in preserving the reef will be appreciated by those who follow you.

Descriptions of the Field Stops

Locations for the stops described herein and for the stratigraphic profiles are given on the geologic map found at the end of this guide.

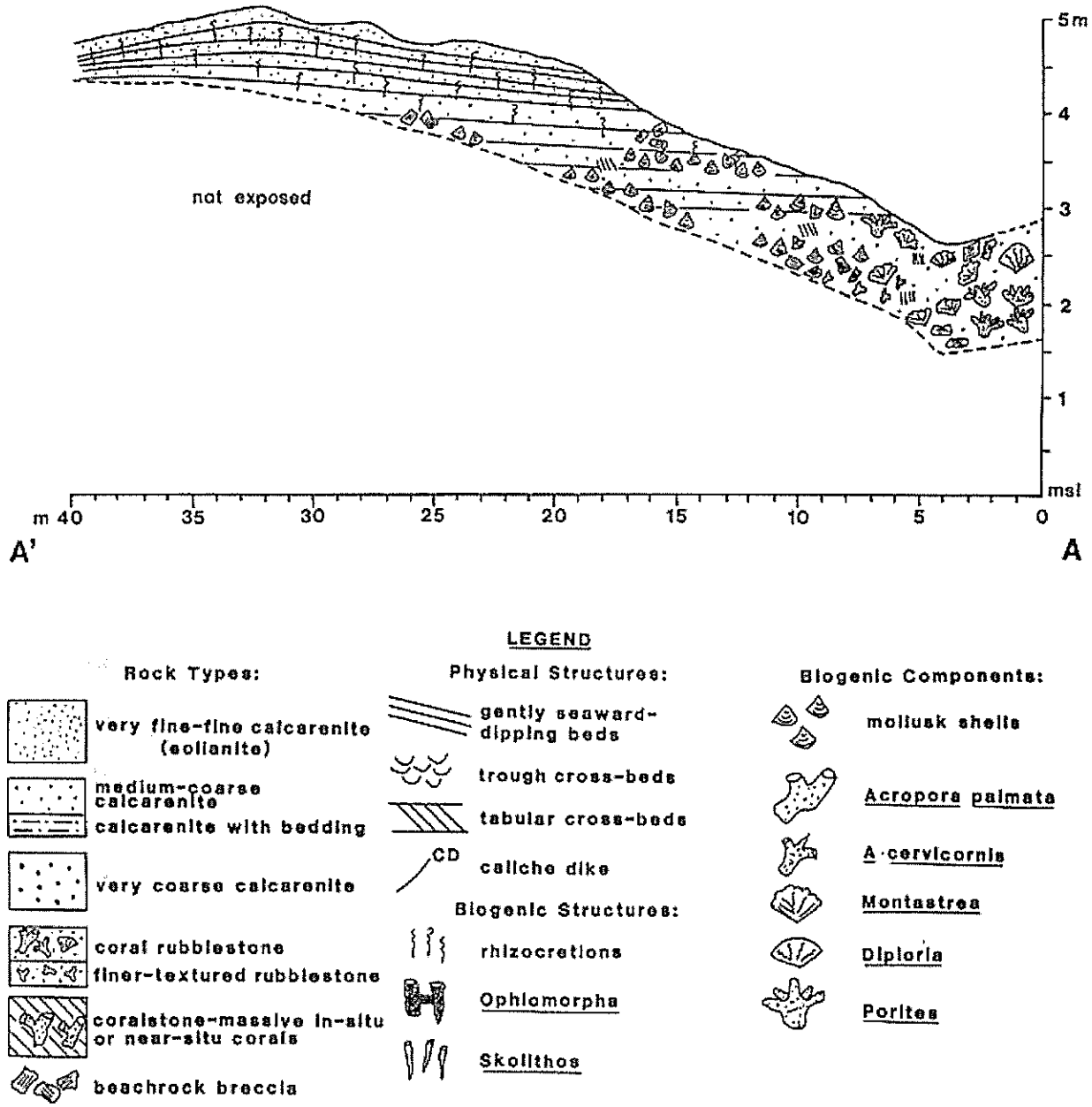

Fig. 1: Stratigraphic profile A-A'; exposure along road leading to Cockburn Town dock and launch area (precise locations for all profiles are drawn on the map found at the end of this guide). Lower part of the figure presents the legend of symbols used in the stratigraphic profiles that follow.

Stop 1 - Road-cut exposure on the east side of road leading to the new town dock and launch area (Fig. 1, Profile A-A'). This exposure demonstrates clearly the shallowing-upward nature of the reef complex and associated facies. Near the water's edge, several large coral heads (Diploria strigosa, Montastrea annularis, and Porites asteroides) are preserved in near in situ position in a matrix of shelly, coarse to very coarse calcarenite (Profile A-A', 0-8 m).

Moving along the outcrop, coral rubblestone gives way to shelly, medium to coarse calcarenite. The most prominent shells are single valves and valve fragements of the bivalve Chione cancellata. Gently seaward-dipping bedding begins to become apparent here, and there is some weakly developed trough cross-bedding. A few clasts of beachrock breccia also are present.

Farther north along the outcrop, the calcarenite becomes progressively finer-grained and less shelly. The last shell fragments occur at about the 23 meter mark on Profile A-A'. The uppermost part of the outcrop is composed of fine to very fine calcarenites (= eolianite), which contain some rhizocretions.

The facies present here represent three distinct environments of a regressive sequence: a shallow subtidal environment with corals such as Diploria, Montastrea, and Porites characteristic of patch reefs; a very nearshore to beach environment with gently seaward-dipping beds and beachrock breccia clasts; and a coastal dune environment with fine to very fine calcarenites containing rhizocretions.

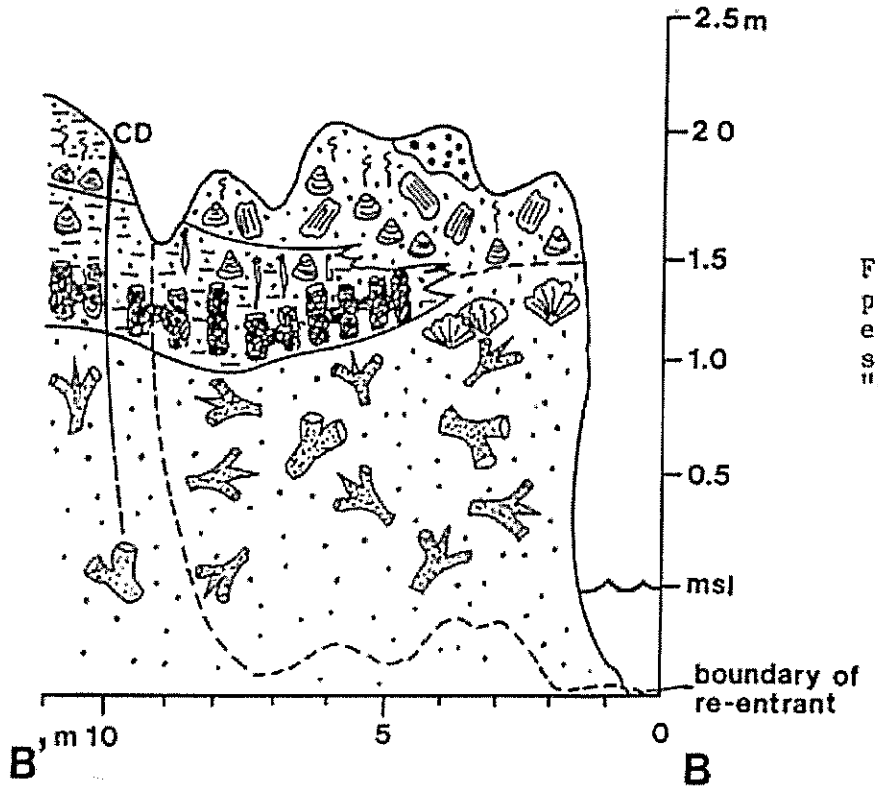

Fig. 2: Stratigraphic profile B-B'; exposure along southeast wall of "Ophiomorpha Bay".

The area of coastal exposure to the east of the new town dock is rugged and not easily traversed by groups, but it does display good outcrops of coral rubblestone with many prominent heads of Montastrea annularis and Diploria strigosa. Less common are heads of M. cavernosa, D. labryinthiformis, and Porites asteroides. In the vicinity of the old town dock, the coral rubblestone is overlain by bedded calcarenite (ancient beachrock) that terminates the reefal exposure.

Stop 2 - "Ophiomorpha Bay", a small wave-cut re-entrant about 100 m northwest along the coast from new town dock (Fig. 2, Profile B-B'). One of the best trace fossil localities found to

date on San Salvador occurs in this re-entrant exposure. The outcrop area immediately southwest of the re-entrant contains many well-preserved, in situ coral heads of Diploria strigosa (Fig. 3a), Montastrea annularis (Fig. 3b), and Porites porites (Fig. 3c) in coral rubblestone. A prominent caliche dike can be traced from immediately behind the re-entrant for a distance of about 60 m southeast to the water's edge.

Coral rubblestone dominated by fragments of Acropora cervicornis forms the lower and middle part of the re-entrant exposure. These beds are overlain by and interfinger with shelly, coarse calcarenites containing the trace fossils Ophiomorpha sp. and Skolithos linearis. These trace fossils have been described and their paleoenvironmental significance discussed by Curran (1983, 1984). Tunnels and shafts of Ophiomorpha sp. are particularly abundant and well developed here (Fig. 3d). The interfingering of the coral rubblestone and Ophiomorpha-bearing calcarenites indicates the contemporaneous subtidal nature of the coral reef and the surrounding environment of current-bedded carbonate sands. Burrowing of the subtidal sands by callianassid shrimp produced Ophiomorpha sp., dwelling tubes of the shrimp.

The Ophiomorpha-bearing calcarenites are overlain by a shelly, coarse to very coarse calcarenite that contains clasts of beachrock breccia and some rhizocretions. Patches of a rather well sorted, coarse to very coarse calcarenite overlie the beachrock-bearing calcarenite. Both units suggest a near beach to beach environment; thus, the shallowing-upward sequence again

is demonstrated.

Walk-By Stop - The shallowing-upward sequence again is well exposed on an unvegetated slope upwards from the water's edge about 35 m northwest of Stop 2. Here an amphitheater-like, wave-cut re-entrant, with boulders in and just above the intertidal zone, exposes coral rubblestone containing several large Diploria and Montastrea heads. On the northwestern side of the exposure, Acropora palmata appears for the first time as an important constituent of the rubblestone, a trend that continues into the quarry area. Shelly, medium to coarse calcarenite overlies the coral rubblestone. As seen earlier at Stop 1, the calcarenites fine upward to eolianites toward the top of the hill slope.

Stop 3 - In the quarry, on interior face of the oceanside quarry wall, about 13 m beyond the southwest end (entrance) to the quarry. A pocket of shelly, coarse to very coarse calcarenite with coral clasts and several Ophiomorpha sp. shafts and tunnels occurs here. The calcarenite is surrounded by Acropora cervicornis and A. palmata-dominated rubblestone. Some of the calcarenite may have been deposited as void fill in the rubblestone, but at least the upper part of the calcarenite appears to interfinger with the rubblestone, indicating the contemporaneous deposition of the two facies.

Stop 4 - Exposures on the oceanside quarry wall at the

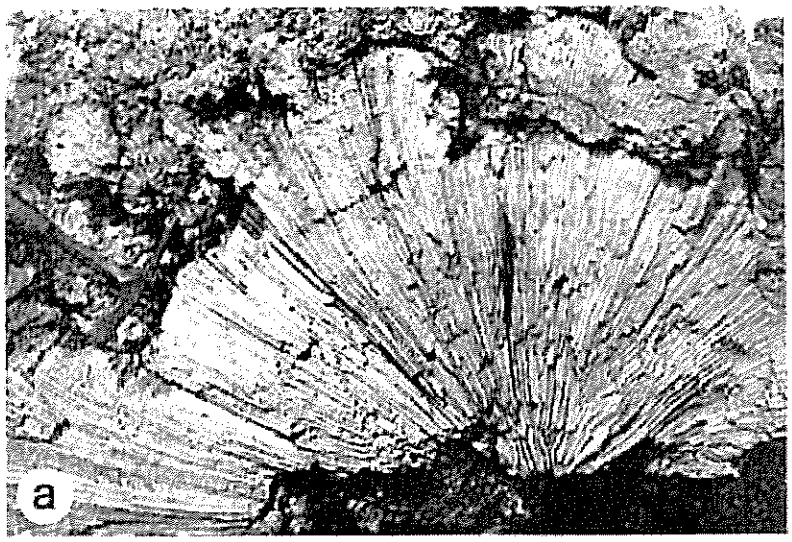

Fig. 3a: Large head of Diploria strigosa (common brain coral) exposed in cross section. Such heads are common throughout the coral-bearing facies of the reef complex.

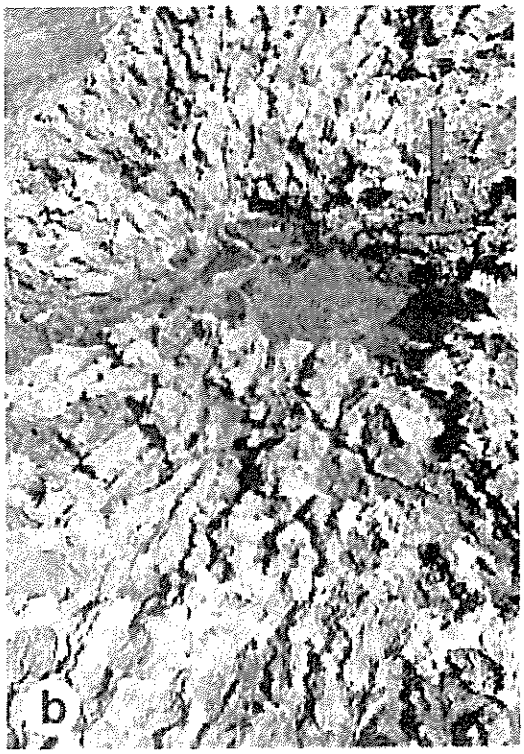

Fig. 3b: Exceptionally large head of Montastrea annularis (common star coral) preserved in growth position. This specimen is located at water's edge about 45 m southeast of "Ophiomorpha Bay".

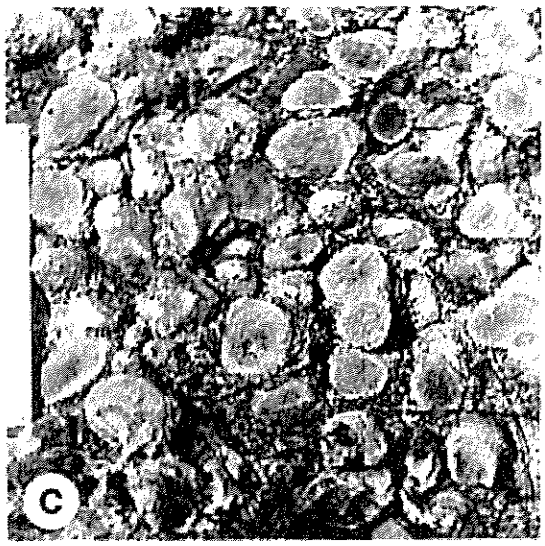

Fig. 3c: Typical clump of Porites porites (clubbed finger coral) preserved in growth position. Scale = 15 cm.

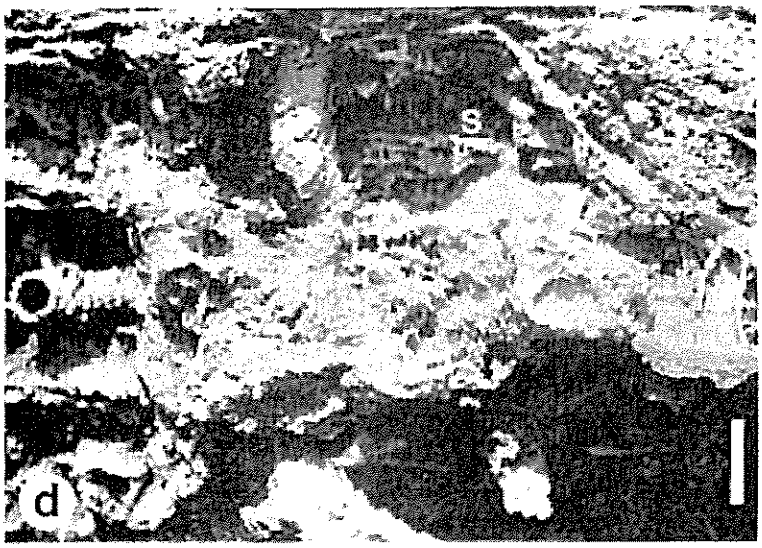

Fig. 3d: Ophiomorpha sp. shafts and tunnels and small tubes of Skolithos linearis (= S) at "Ophiomorpha Bay", Profile B-B'. Bar scale = 4 cm.

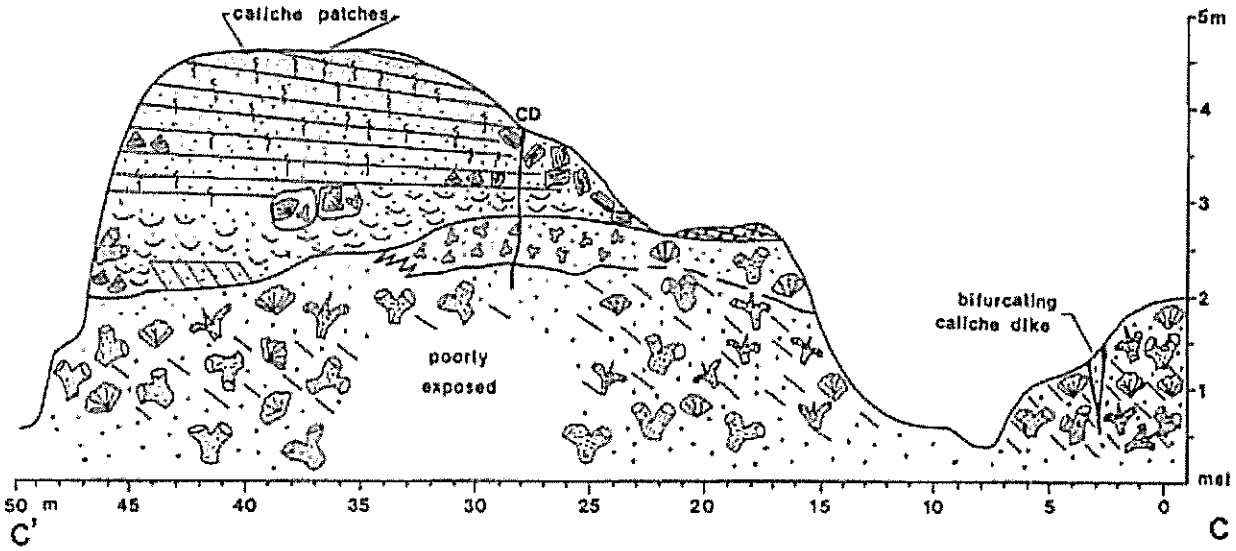

Fig. 4: Stratigraphic profile C-C' in the quarry area; exposure from the water's edge along the northwest face of the knoll.

beginning of Profile C-C' (Fig. 4), extending for a distance of about 20 m along the profile. Particularly good exposures of coralstone dominated by large, near in situ chunks of Acropora palmata are located here. Coralstone makes up the major part of the rock forming the oceanside quarry wall and parallels the N 50 degrees W strike of the wall, a trend that may well reflect the life orientation of the long axis of the main part (A. palmata crest) of the Cockburn Town reef. A large, bifurcating caliche dike is prominently exposed on the top of the wall, and several large heads of Diploria also occur here.

Move across the quarry floor to the front (oceanward) face of the prominent knoll located within the quarry area. This knoll largely has been created by quarrying operations on all

sides. The front face (15-20 m on Profile C-C') reveals well a zone of Acropora palmata-dominated coralstone overlain by coarse, A. cervicornis-dominated rubblestone (Fig. 6a). Beds of shelly, coarse to very coarse calcarenite overlie the rubblestone on this front face of the knoll.

Stop 5 - Northwest side of the knoll along Profile C-C' (20-50 m). The full range of facies occurring in the Cockburn Town fossil reef complex can be seen in this exposure. Acropora palmata-dominated coralstone forms the lower part of the exposure, and the overlying rubblestone can be traced along the side of the knoll to about the 30 m point on Profile C-C'; in this area, the rubblestone has a distinctly finer texture.

Shelly, medium to coarse, tabular and trough cross-bedded calcarenites overlie the coralstone and coral rubblestone and are well exposed on the sides of the knoll, particularly between 25-50 m along Profile C-C' and on the rear (northeast) side. The most prominent set of tabular cross-beds (Fig. 6b) dips in a westerly direction, essentially perpendicular to the flow direction of currents that produced the surrounding trough cross-beds. Our interpretation is that the tabular cross-beds were deposited by a storm event, possibly a hurricane. The trough cross-beds were deposited by northerly flowing currents, possibly longshore currents created by wave refraction around the south end of ancient San Salvador Island (see further discussion in White et al., this volume). Two blocks of coral rubblestone, probably deposited by storm waves, are prominent in the exposure

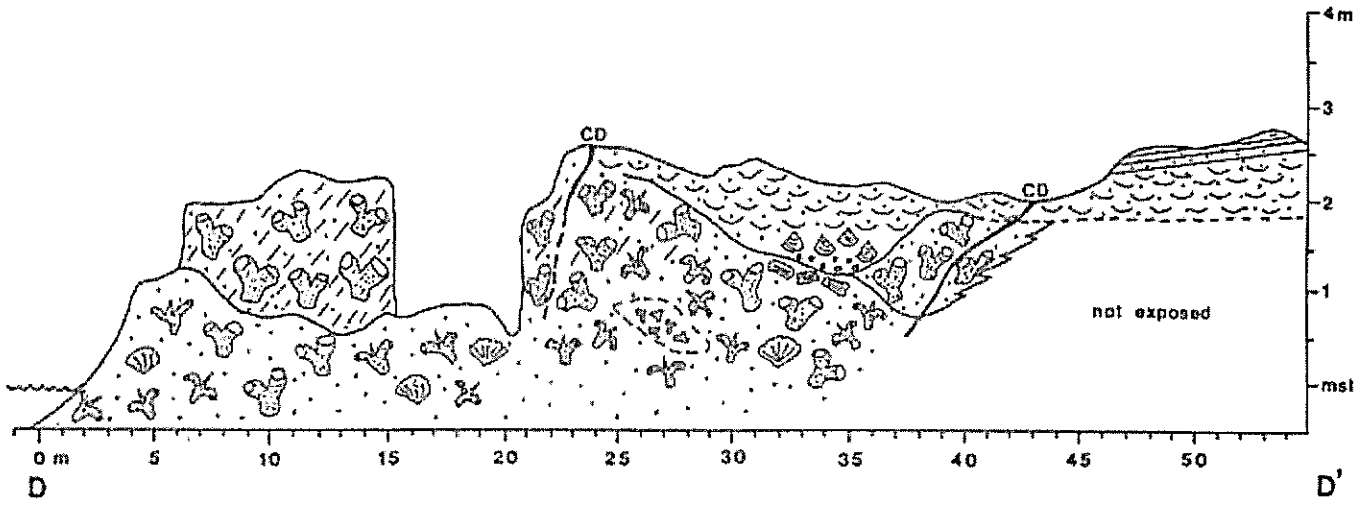

Fig. 5: Stratigraphic profile D-D', northwest end of quarry area; exposure includes the main part of the zone of Acropora palmata in near growth position.

and are completely surrounded by the trough cross-bedded calcarenites.

The upper part of the section consists of gently westerly dipping, shelly, medium calcarenites with beachrock breccia clasts. These beds grade upward into eolianites. Facies contacts, patterns of bedding, and other physical sedimentary structures are particularly well displayed on the steep rear (northeast) face of the knoll.

Stop 6 - Exposure toward northwest end of the quarry, at water's edge along Profile D-D' (Fig. 5, 0-17 m). This exposure consists of a large mass of coralstone on a base of Acropora

Fig. 6a: Coral rubblestone dominated by fragments of Acropora cervicornis (staghorn coral); this is a major rock type of the reef complex. Bar scale = 4 cm.

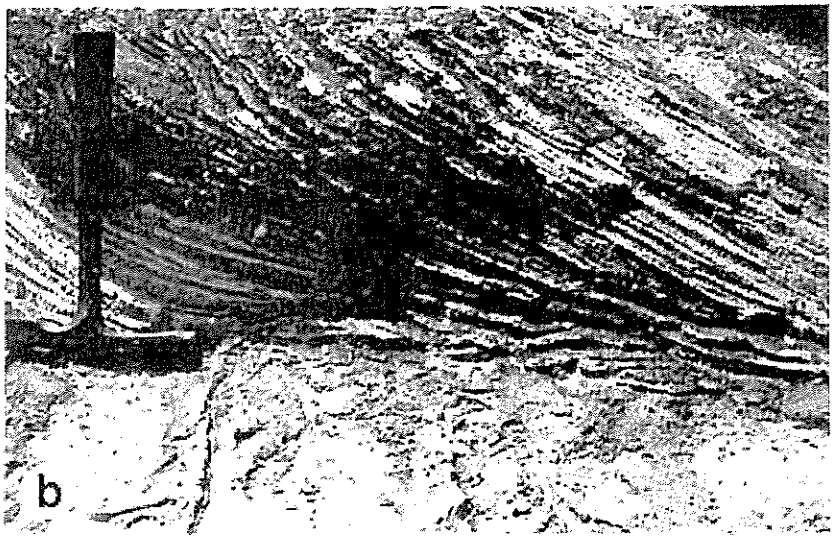

Fig. 6b: Tabular crossbedded calcarenites overlaying ripplebedded surface; northwest side of knoll, Profile C-C'.

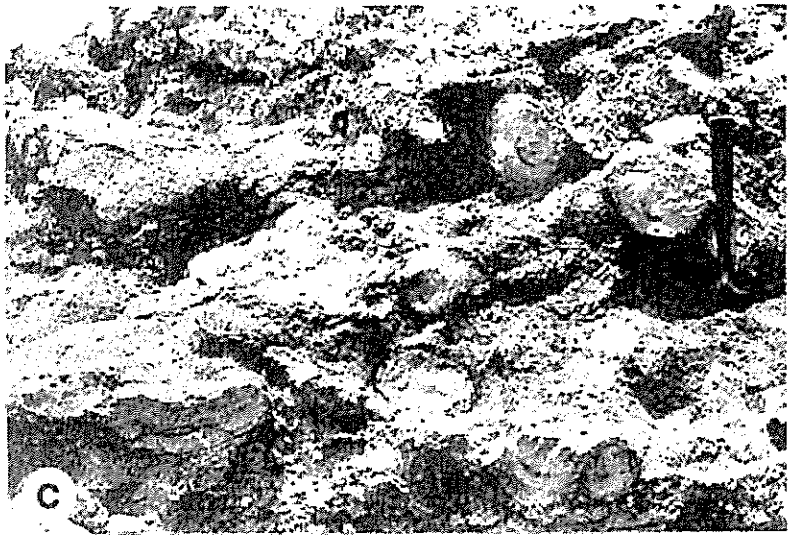

Fig. 6c: Main zone of Acropora palmata (elkhorn coral) in near growth position; northwest end of quarry, Profile D-D'.

palmata-dominated coral rubblestone similar to that found elsewhere in the quarry. The exceptional aspect here is the coralstone which is formed of large lithified chunks of A. palmata (Fig. 6c). Although the coral heads are collapsed, they are essentially in situ and represent the palisades of A. palmata typical of a reef crest zone. This reef crest zone appears to extend at least for the full length of the oceanside quarry exposure (about 200 m).

The top of the Acropora palmata-dominated coralstone mass is at an elevation just over +2 m. Assuming a growth height of 3 to 4 m for living A. palmata heads of this fully mature size and assuming that the tips of the fronds rose to mean low sea level, this suggests a minimum sea level of +5 to 6 m above present at the time of coral growth (see also White et al., this volume).

The interstices of the Acropora palmata coralstone mass are filled with poorly lithified, shelly, coarse to very coarse calcarenite. The molluscan fossils often are well preserved; the fauna here is dominated by ark shells of the species Arca imbricata, Barbatia cancellaris, and B. domingensis. These bivalves today are common inhabitants in and around coral heads.

Stop 7 - Exposure along the north end of Profile D-D' (Fig. 5, 20-55 m). Acropora palmata-dominated coralstone continues to overlie coral rubblestone. The new feature of interest here is a well developed channel cut into the rubblestone and filled with calcarenite (Fig. 8a). Fill at the base of the channel consists of shelly, coarse to very coarse

calcarenite. Upwards in the channel, trough cross-bedding is obvious and the calcarenite texture becomes finer.

The north side of the channel is bounded by Acropora palmata-dominated coralstone which has a different character from that seen previously. Here the coralstone consists primarily of tightly lithified fronds of A. palmata (Fig. 8b); coral trunk pieces are much less abundant than elsewhere. Again, we interpret the rock as representing coral heads that are collaped, compacted, and then lithified essentially in situ. Several large boulders of this type of A. palmata-dominated coralstone can be seen at this end of the quarry.

Stop 8 - Exposures along Profile E-E' (Fig. 7), about 50 m beyond the northwest end of the quarry. The oceanward half of the profile consists of coral rubblestone exposures dominated by Acropora cervicornis. Fragments of Diploria and Montastrea are common, and the importance of A. palmata has decreased markedly from its dominant levels in rubblestone exposures of the quarry area.

The principal features of interest along this profile are the overlying calcarenite beds and their sedimentary structures (Profile E-E', 25-45 m). Particularly prominent is a set of steeply dipping tabular cross-beds up to 1 m thick in places (Fig. 8c). These tabular cross-beds dip in a westerly direction as do the similar beds described earlier at Stop 5 (Profile C-C'), and we interpret them as representing deposition by the

calcarenite is packed in and around exposures of coralstone and coral rubblestone; the calcarenites clearly overlie the coralstone on the landward side of the outcrop area.

The main point of interest here is the nature of the coralstone. It is dominated by Acropora cervicornis in what we think is essentially growth position; also present are several large heads of Montastrea annularis, smaller heads of Diploria, and clumps of the finger coral Porites furcata (Fig. 8d), all in situ. This marks the first common occurrence of P. furcata in growth position seen in the reef complex.

Although Acropora cervicornis is widespread in the coral-bearing rocks of the reef complex, it usually occurs fragmented and in rubblestone. We interpret the coralstone of this area of the reef as representing an in situ A. cervicornis thicket with its associated coral species. Thus we see here another aspect of the Cockburn Town reef complex and another fine example of preservation.

Stop 10 - Exposures in the northwestern-most area of the reef, across a small stone brige about 20-70 m beyond Stop 9. This also is an exposure area of coralstone and coral rubblestone and once again the coralstone is composed of in situ or near in situ Acropora cervicornis. Several large heads of Montastrea annularis and Diploria are prominently exposed. Calcarenite is packed in and around the coral heads, and calcarenite beds overlying the reefal rocks are well exposed on the landward side of the outcrop area.

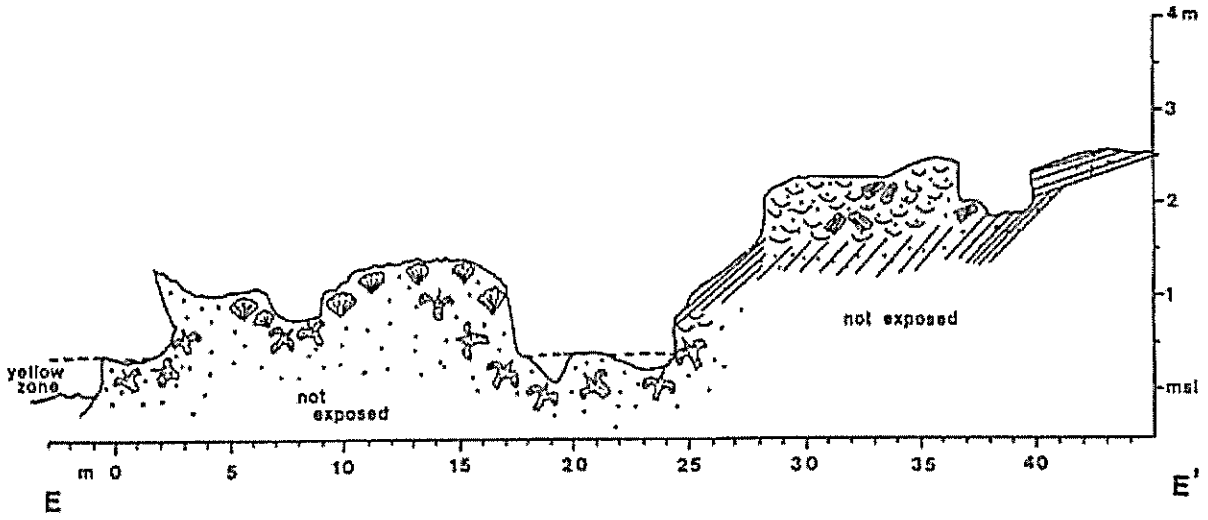

Fig. 7: Stratigraphic profile E-E', northwest of the quarry area.

same large-scale storm event (see also White et al., this volume).

The overlying trough cross-bedded calcarenites were deposited by northerly flowing, perhaps longshore, currents (White et al., this volume). Overlying the trough cross-bedded calcarenites are westerly dipping calcarenites with low angle cross-beds and beachrock clasts. These beds progressively overstep the trough cross-bedded, subtidal calcarenites and represent the deposits of a westerly facing and westward migrating beach formed during sea regression (White et al., this volume).

Stop 9 - Area of coralstone and coral rubblestone about 40 m northwest of Stop 8 (Profile E-E'). Here medium to coarse

Fig. 8a: A channel cut in coral rubblestone filled with shelly, coarse calcarenite; north end of Profile D-D'.

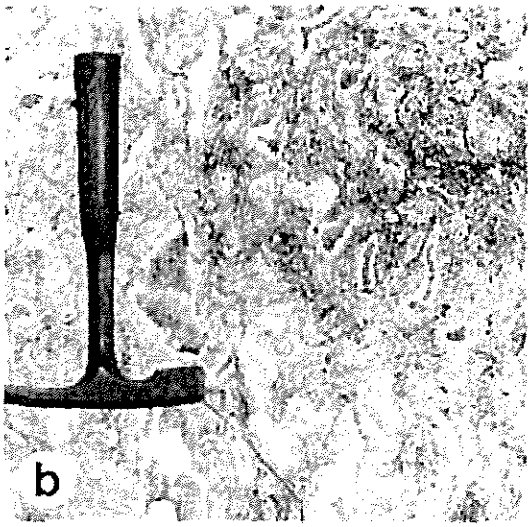

Fig. 8b: Lithified fronds of Acropora palmata form coralstone found along part of Profile D-D'.

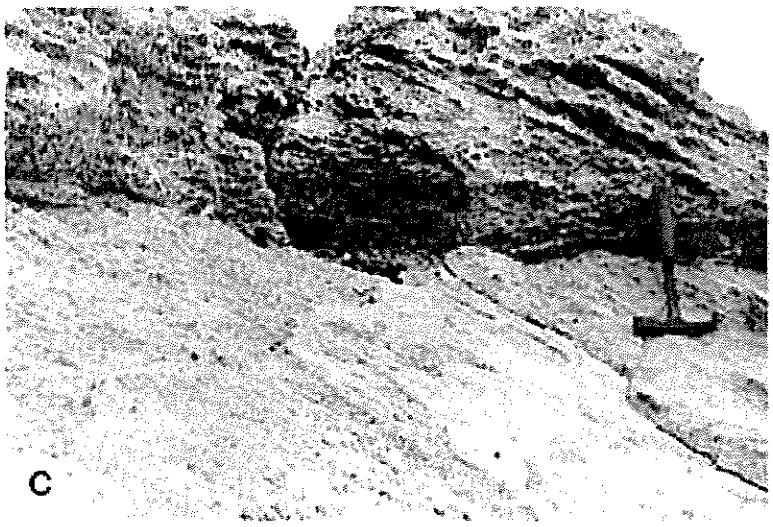

Fig. 8c: Trough crossbedded calcarenies overlie a large set of tabular cross-bedded calcarenites; area just south of Profile E-E'.

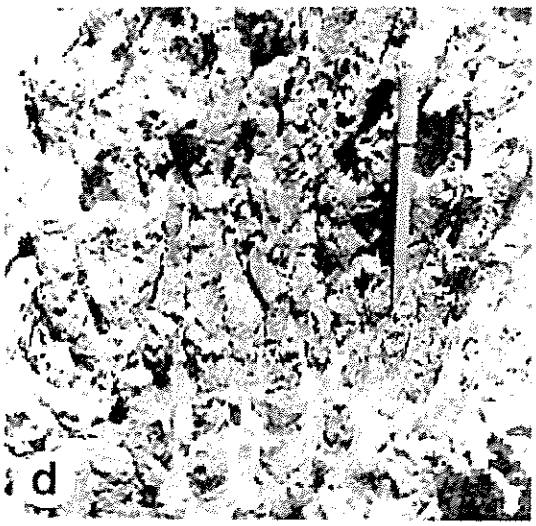

Fig. 8d: Porites furcata (finger coral) preserved in growth position; large clumps of this coral are found in the northwestern-most areas of the reef exposure.

The reef proper ends very abruptly. The final visible exposures of coral rubblestone are virtually surrounded by calcarenites. Looking northwestward along the coast from the last coral rubblestone exposures, one sees only gently seaward dipping calcarenites. The texture and bedding of these calcarenites is well exposed in vertical section in the cable trench immediately beyond the last rubblestone outcrop. This trench marks the northwestern boundary of our geologic map and of our study area.

Acknowledgments

We are grateful to the College Center of the Finger Lakes, Bahamian Field Station, and its staff on San Salvador Island for full logistical support during our field study of the fossil reef. Smith College geology majors, including Kim Besom, Veronica Blette, Elizabeth Dole, Kate Japy, Karen Kurkjy, Laine Landau, Jean Lawlor, Patricia Pierce, and Kim Pirie, have made significant contributions to this study through field mapping conducted in June 1983 and 1984. Follow-up studies by Karen Kurkjy (petrology and diagenesis), Kim Besom (coral identifications), and Veronica Blette (mollusk identifications) have added much useful information to our interpretations and understanding of the reef. Barbara Kiteley drafted final copies of the geologic map and stratigraphic profiles.

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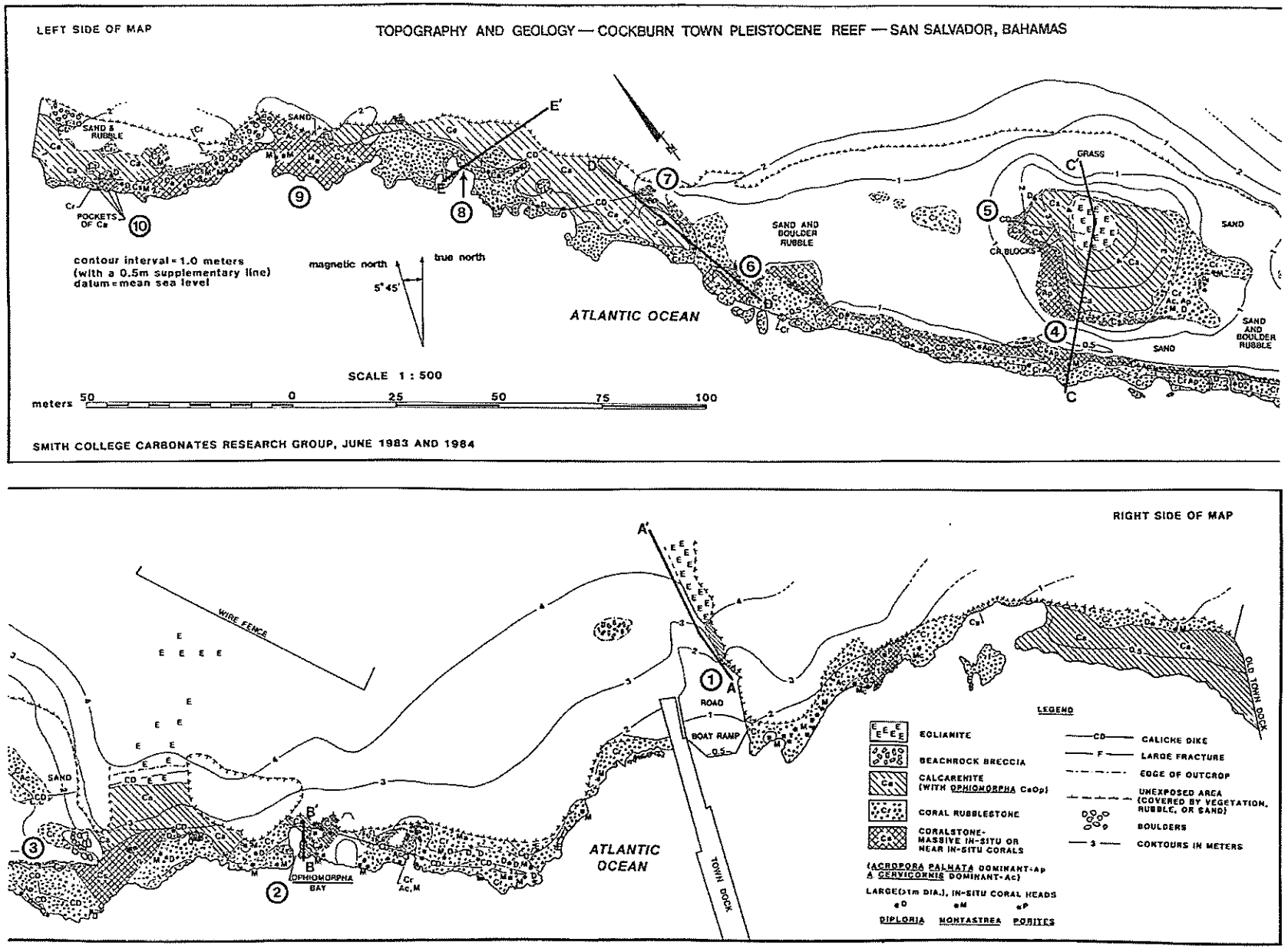
LEFT SIDE OF MAP
TOPOGRAPHY AND GEOLOGY — COCKBURN TOWN PLEISTOCENE REEF — SAN SALVADOR, BAHAMAS
SAND & RUBBLE
POCKETS OF Cs
SAND
SAND AND BOULDER RUBBLE
GRASS
CR. BLOCKS
ATLANTIC OCEAN
contour interval = 1.0 meters
(with a 0.5m supplementary line)
datum = mean sea level
magnetic north
true north
5° 45'
SCALE 1 : 500
meters 50 0 25 50 75 100
SMITH COLLEGE CARBONATES RESEARCH GROUP, JUNE 1983 AND 1984
RIGHT SIDE OF MAP
WIRE FENCE
ROAD
BOAT RAMP
OPHIOMORPHA BAY
TOWN DOCK
OLD TOWN DOCK
ATLANTIC OCEAN
LEGEND
EOLIANITE
BEACHROCK BRECCIA
CALCARENITE (WITH OPHIOMORPHA CsOp)
CORAL RUBBLESTONE
CORALSTONE- MASSIVE IN-SITU OR NEAR IN-SITU CORALS
(ACROPORA PALMATA DOMINANT-Ap & CERVICORNIS DOMINANT-Ac)
LARGE (>1m DIA.), IN-SITU CORAL HEADS
DIPLORIA MONTASTREA PORITES
CALICHE DIKE
LARGE FRACTURE
EDGE OF OUTCROP
UNEXPOSED AREA (COVERED BY VEGETATION, RUBBLE, OR SAND)
BOULDERS
CONTOURS IN METERS

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