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Trace Fossils in Pleistocene Carbonate Rocks of San Salvador, Bahamas

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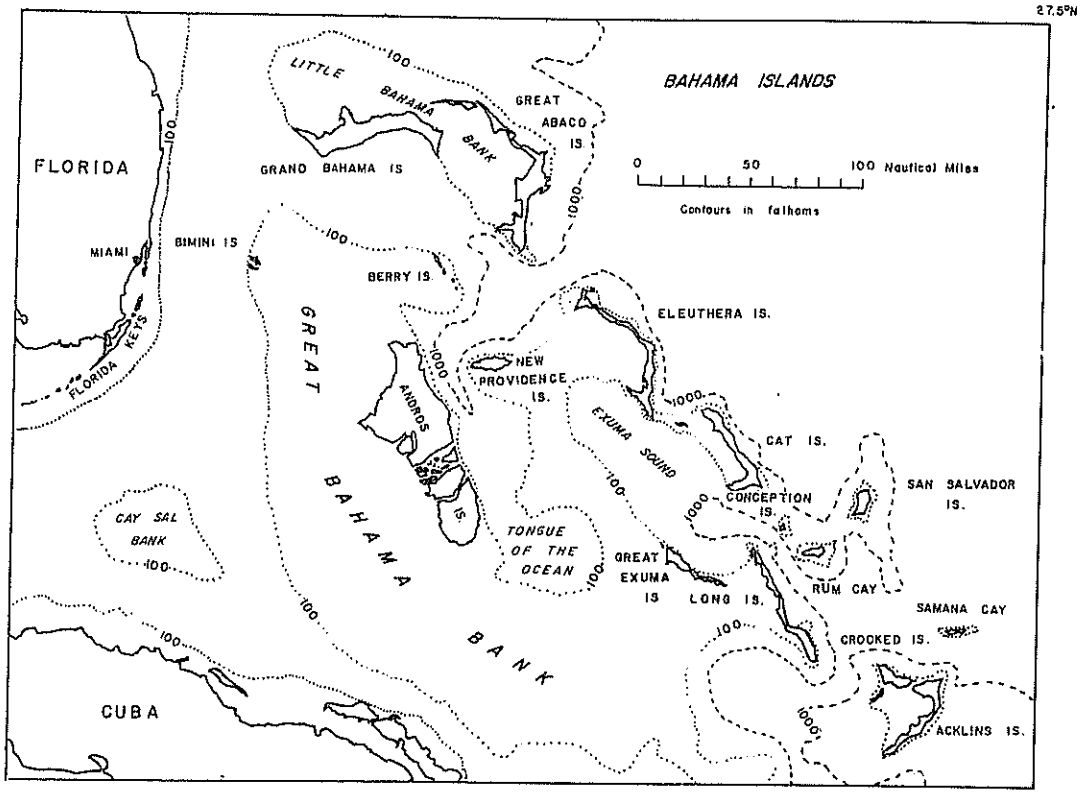

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TRACE FOSSILS IN PLEISTOCENE CARBONATE ROCKS OF SAN SALVADOR, BAHAMAS

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Trace fossils are tracks, trails, burrows, borings, coprolites, and other similar structures (e.g. rhizocretions[1]) made by organisms in or on a substrate (Frey, 1973; Basan, 1978). Since trace fossils reflect various aspects of behavioral activity of the organisms producing them and because trace fossils normally are preserved in situ, information gained from the study of these fossils can contribute much to paleoenvironmental reconstructions and to the recognition of sedimentary facies changes.

To date, most studies of trace fossils have been restricted to siliciclastic sedimentary rocks, primarily due to the mistaken notion that trace fossils are difficult to recognize in carbonate rocks because of modification by diagenetic processes after formation of the traces (Basan, 1978). Trace fossils in the Pleistocene age carbonate rocks of San Salvador can be used as an example to dispel this notion. Not only are trace fossils often common to abundant in these rocks, they also can be quite well preserved (see Fig. 1).

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[1]Rhizocretions are concretionlike masses, often branching, that formed around the roots of once living plants. Although not all workers agree, rhizocretions are considered as valid trace fossils by Sarjeant (1975), and the author concurs with this view. In the rocks of San Salvador, rhizocretions are composed of calcrete and can be variably hollow or solid tubules.

Occurrence of the Trace Fossils Ophiomorpha and Skolithos

Well preserved specimens assignable to the ichogenera Ophiomorpha and Skolithos occur in full relief in calcarenites exposed at the Cockburn Town fossil reef locality and at Quarry "E" (see index map). Ophiomorpha is a clay-lined burrow formed by fossorial callianassid shrimp. The burrow tubes (generic diameter range 0.5-3 cm) are smooth on the interior surface and pelleted to somewhat rugose on the exterior surface. Burrow systems consist of shafts with connecting tunnels in uniform to highly irregular arrays (see Frey et al ., 1978, Fig.2).

Skolithos is a straight, unbranched tube (generic diameter range 1-15 mm) generally perpendicular to bedding and found most commonly in marine arenaceous sediments. Tubes of this sort, which may be readily fossilized, are formed by a variety of polychaets, but other worms and worm-like organisms also may produce Skolithos. Characteristic Ophiomopha and Skolithos specimens from San Salvador are illustrated in Figure 1 and described further below.

Cockburn Town Reef Locality

Specimens of Ophiomorpha sp. and Skolithos are found in beds of the current-bedded, medium to coarse skeletal calcarenite facies generally overlying the various coral-algal facies of the reef complex. Ophiomorpha sp. occurs in an irregular boxwork configuration of inter-connecting shafts and tunnels similar to that described by Frey et al. (1978, Fig.2E) in a calcarenite matrix. Burrow tubes have thick walls (2-3 mm) formed of micritic material with smooth interior surfaces and distinctly

Fig. 1: a-d from Cockburn Town fossil reef locality;
e-f from "E" quarry locality.

a) Close-up of Ophiomorpha sp. showing smooth interior wall surface of tube.

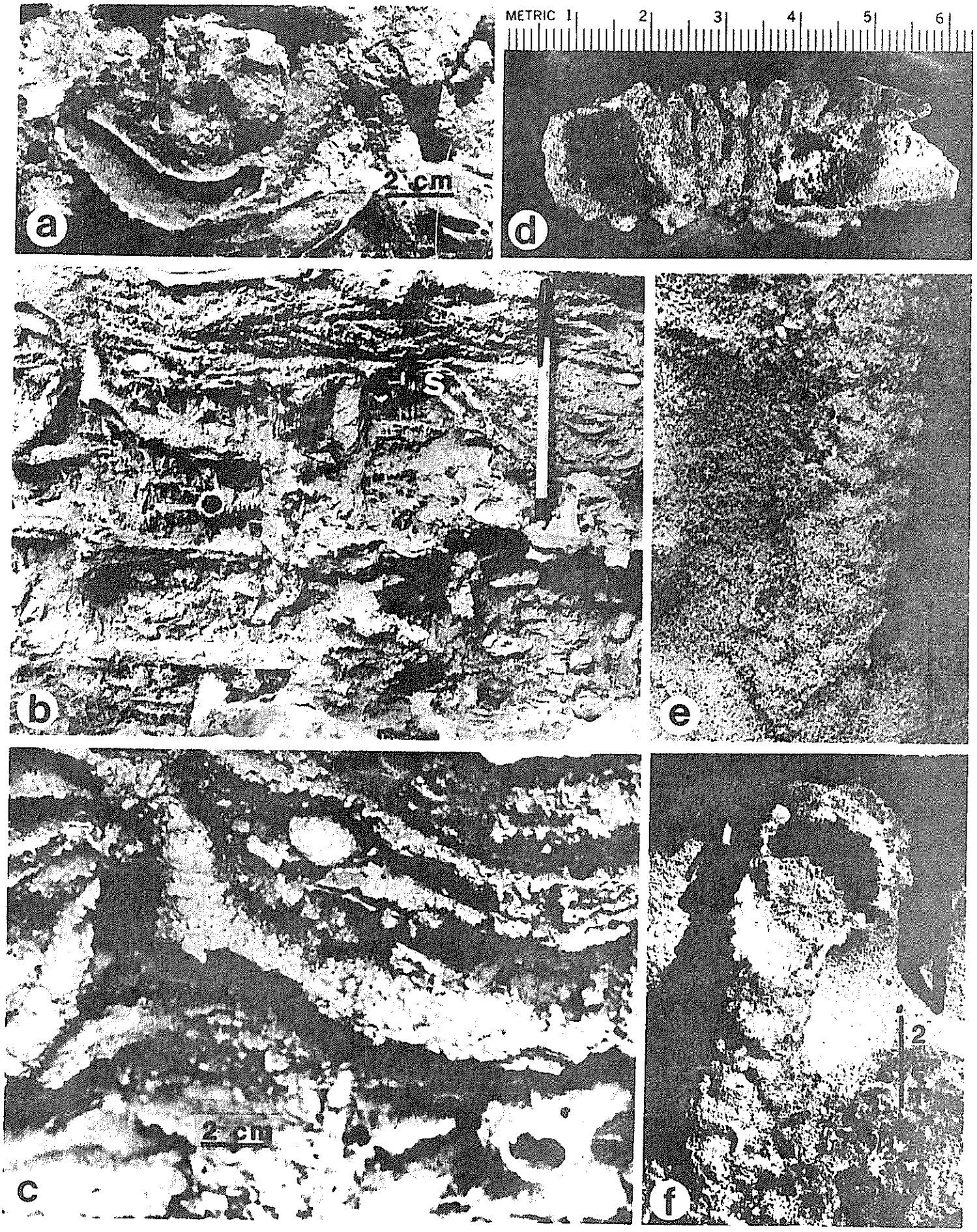
b) Vertical exposure reveals numerious Ophiomorpha sp. shafts and tunnels and small tubes of Skolithos (=S); pen is 16 cm.

c) Close-up of branching Ophiomorpha sp.

d) Close-up of Ophiomorpha sp. tube showing mammilated to rugose exterior surface.

e) Ophiomorpha sp. shaft in poorly cemented calcarenites.

f) Cross section close-up of Ophiomorpha sp. showing wall structure and fill characteristics.


2 cm
a
METRIC 1 2 3 4 5 6
d
S
M
b
e
2 cm
c
2
f

mammilated to rugose exterior surfaces. Tubes have outside diameters of 1-2.5 cm, and individual shaft or tunnel segments can be measured for lengths of up to 25 cm. Although these Ophiomopha sp. burrows exhibit an obviously pelleted exterior wall surface, the pattern of pellet arrangement is not nearly so regular or distinct as that normally found in O. nodosa specimens preserved in siliciclastic sediments (see Frey et al., 1978, Fig.1), and these specimens should not be assigned to the ichnospecies O. nodosa.

Occurring with Ophiomorpha sp., often in abundance, are vertical burrow tubes less than 1 cm in outside diameter and with lengths of up to 15 cm. These tubes are assigned to Skolithos, and two or more types are present, based on different diameter classes. These tubes probably were formed by polychaets which made a lined dwelling burrow with sand grains adhered to the outer surface.

Rhizocretions formed of calcrete and presumably initiated by the action of plant roots occur commonly in most rock facies on San Salvador, including facies exposed at the Cockburn Town locality. Rhizocretions easily can be mistaken for trace fossils of invertebrate origin, particularly Ophiomorpha sp. Criteria for distinguishing Ophiomorpha sp. from rhizocretions include: 1) Ophiomorpha sp. has a distinct lining of regular thickness, and individual segments of the burrow system have consistent diameter; rhizocretions do not have a distinct lining and are irregular in diameter. 2) The interior surface of Ophiomorpha sp. is smooth and the exterior surface distinctly mammilated;

rhizocretions have highly variable interior and exterior surfaces, with many rhizocretions being solid or with small diameter tubular interiors. 3) Ophiomorpha sp. complexes have more consistent patterns of shaft/tunnel arrangement than exhibited by rhizocretion systems.

At the Cockburn Town reef locality fossilized branches of the coral Acropora cervicornis also easily can be confused with Ophiomorpha sp. because the diameter of the coral branches is similar, the exterior surface of the coral becomes bumpy as the individual cups of the polyps wear, and the Y-shaped branching of the coral resembles superficially the branching of Ophiomorpha sp. However, comparison of A. cervicornis and Ophiomorpha sp. cross section will reveal that A. cervicornis specimens are composed of solid calcium carbonate with crystals radiating from the center; if weathering has occurred, a small diameter tubule may be present. Ophiomorpha sp. tubes normally are filled with calcarenite matrix, and the presence of the micritic wall is obvious in cross section. Furthermore, close examination will show that the pelleted exterior surface of Ophiomorpha sp. is quite different from the polyp-bearing surface of A. cervicornis.

"E" Quarry Locality

Specimens of Ophiomorpha sp. and Skolithos also are present in the cross-stratified Halimeda rich, coarse calcarenites exposed in the principal wall of the "E" quarry. These beds are interpreted as having been deposited in a Pleistocene tidal delta setting similar to the modern Pigeon

Creek tidal delta on San Salvador. Here the Ophiomorpha sp. specimens occur as well developed but more isolated shafts (Figure 1), with connecting tunnels less common and conspicuous than at the Cockburn Town reef exposures. Skolithos specimens, often gently curved, and with diameters of 2-8 mm, also are more isolated in occurrence than at the Cockburn Town reef. Rhizocretions also are present in these beds, so care must be taken in identification.

Modern Analogs for Ophiomorpha and Skolithos

Ophiomorpha sp. systems preserved in calcarenites on San Salvador undoubtedly were formed by fossorial callianassid shrimp living in shallow subtidal environments with relatively strong bottom currents and good water circulation. The author has observed presumed Callianassa sp. burrow openings while snorkeling over shallow subtidal, rippled carbonate sand surfaces at numerous locations surrounding the Island. Such openings normally do not have sediment mounds at their apices. Walls of the burrows sometimes can be seen projecting up from ripple troughs where they have been exposed by shallow erosion. Plastic casts of these burrows have not been made (excavation of such casts in subtidal settings is difficult), but, based on similar sediment characteristics, the modern burrow systems probably are like the Ophiomorpha sp. systems preserved at the Cockburn Town reef and "E" quarry localities.

Shinn (1968) described modern Callianassa sp. burrow systems from intertidal carbonate mud flats and Thalassia grass beds of the Florida Keys and western Bahamas. This Callianassa

(species unidentified by Shinn) forms a large sediment "volcano" at the surface and has a highly distinctive burrow system of radiating tunnels connected to incurrent and excurrent shafts (see Shinn, Text-fig. 10). The author has seen similar sediment "volcanoes" in Thalassia beds of the San Salvador area, and an extensive shallow subtidal to intertidal surface of such "volcanoes" is located along the western side of the mid-reach of the north arm of Pigeon Creek. Presumably burrow complexes formed by the Callianassa sp. of Shinn lie beneath the sediment surface, but plastic casts will need to be taken to confirm this. To date, Ophiomorpha sp. systems with a radiating tunnel system as illustrated by Shinn have not been found in the rock record on San Salvador or elsewhere.

There are many modern species of Callianassa, and it may be that the species occupying subtidal, current-rippled sand areas around San Salvador (and which presumably formed the Ophiomorpha sp. systems at Cockburn Town reef) is a different species of Callianassa than that which occupies the grass beds and the Pigeon Creek flats. To the author's knowledge, no collections of Callianassa specimens and species identifications have been made from San Salvador to confirm this speculation.

Undoubtedly close modern analogs for Skolithos also occur today in the shallow subtidal, current-rippled sand areas of the San Salvador shelf and in the Pigeon Creek delta complex. A survey of the infaunal polychaets of San Salvador is needed to identify these analogs.

Further Trace Fossil Studies

Calcarenites of beach facies are widespread along the coastline of San Salvador. The beach facies apparently do not contain Ophiomorpha sp., but infrequently present in this facies are trails and unlined vertical burrows, diameter 3-4.5 cm, often with a Y-shaped branch at the top, and with lengths of up to 100 cm. These trace fossils now are under further study by the author and can be best attributed to the activity of crabs, most likely Ocypode quadrata (the ghost crab) common today on San Salvador beaches.

The ubiquitous rhizocretions in the rocks on the Island properly can be considered trace fossils (Sarjeant, 1975). Their mode of formation and distribution merits further attention, along with establishing analogs for the various rhizocretion forms by study of the root structure of modern plants of the Island likely to form rhizocretions.

Finally, a comprehensive inventory of the infaunal invertebrates of the marine environments surrounding San Salvador is needed to enable better understanding of the significance of body and trace fossils in the Pleistocene rocks of the Island. The author has made some initial investigations of potential Ophiomorpha- and Skolithos- producing modern organisms and plans to continue with these studies in the future.

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