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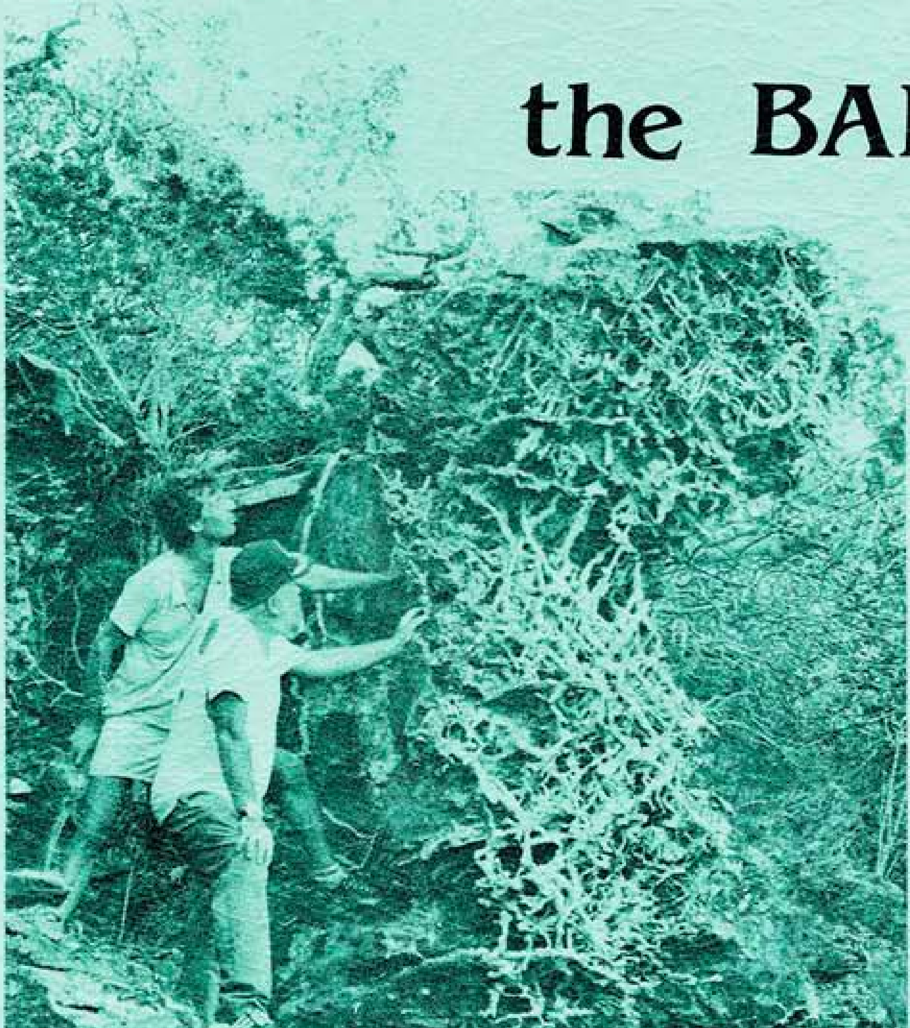

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CCFL Bahamian Field Station

HOLOCENE DEPOSITION OF A MULTILAYERED CARBONATE SEQUENCE IN RECKLEY HILL SETTLEMENT POND, SAN SALVADOR ISLAND, BAHAMAS

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Abstract

The geologic history of Reckley Hill Settlement Pond is recorded within the pond's underlying meter-thick accumulation of interbedded unconsolidated sediments and lithified intervals or crusts. Ten sedimentologically distinct units are recognized within this Holocene sediment suite, including (ascending) lithified carbonate sand, unconsolidated carbonate sand, muddy sand, algal mats and stromatolites, dolomitic mud and crust, grey muck, pelecypod-ostracod sediments and crust, peneroplid foraminiferal sediments and crust, red muck, and modern sediments and crust. Stratigraphically, the succession of units reflects four major changes of environment. The bottommost lithified sand was deposited as eolian dunes. Subsequent flooding of interdunal lowland effectively originated Reckley Hill Settlement Pond. The unconsolidated and muddy sands were deposited in this restricted marine and/or hypersaline pond environment. The overlying algal mats and stromatolites and dolomitic mud and crust are interpreted as deposits of intertidal flat and marsh environments, respectively. The remaining sediments; shell conquinas, mucks, and modern sediments; were deposited in a hypersaline pond in which depth increases gradually with time. The lithified intervals contained in several of these units reflect periodic supersaturation of pond waters that promoted the cementation of grains by high-Mg calcite or dolomite. Deposition of red muck and modern sediments continues today.

Indroduction

Reckley Hill Settlement Pond presently occupies one hundred thousand square meters of interdunal lowland situated 0.7 km southeast of the CCFL Bahamian Field Station. A sequence of interbedded unconsolidated sediments and lithified intervals, averaging one meter in thickness, mantles the Pleistocene bedrock floor of the pond. A stratigraphic and sedimentologic study of these Holocene carbonate deposits was initiated in June 1983 and field work was completed in June 1984. Collected samples include forty-two hand-driven cores, up to 91 cm in length, and numerous grab samples. Continuing lab work includes X-ray diffraction, thin-section, and S.E.M.-elemental analyses. This preliminary report presents brief descriptions of the ten sedimentologically distinct units that are recognized in the sedimentary section (Table 1). Based on the character and succession of these units, a depositional history of Reckley Hill Settlement Pond is proposed.

Depositional History

The geologic history of Reckley Hill Settlement Pond began in Pleistocene time as recorded by eolian dune ridges that constitute the bedrock floor of the pond and which crop out as topographic highs along its southern and eastern shores (Titus, 1984). During low sea-level stand, probably during the Late Pleistocene or Early Holocene, erosive forces acting on these strata carved out the irregular topographic surface upon which the Holocene sequence would be laid. A thin, poorly developed and noncontinuous caliche profile apparently marks the unconformity between deposits of the two series.

As sea level rose eustatically from its glacial low, water and sediments eventually began to encroach upon and bury the weathered Pleistocene bedrock beneath a NE-SW trending series of carbonate sand dunes of Holocene age (Table 1, Unit 1). The initial dune ridge, lying athwart the present pond, with its back swale situated to the southeast, effectively created an enclosed depression for the future Reckley Hill Settlement Pond (Fig. 2a).

The presence of low-Mg calcite meniscus cement suggests that these deposits, now extensively micritized, were lithified within the meteoric-vadose zone. Today, a complex of eolian dunes exists in the area, and is still actively prograding seaward at the shoreline, 0.5 km northwest of the pond.

As sea level continued to rise, Reckley Hill Settlement Pond eventually filled with water. It is unclear whether the original influx came from meteoric sources, from the sea via a karstic passage in the bedrock, or from surficial marine flooding of interdune lowlands. Despite this uncertainty, inundation of the earliest low lying dunes opened an ecologic niche in which a mangrove community flourished, with roots anchored in shifting eroded sands (Table 1, Unit 2 and Fig. 2b).

A gradual drop in water level in Reckley Hill Settlement Pond led eventually to demise of the mangroves and subsequent deposition of muddy sand (Table 1, Unit 3), algal mats and stromatolites (Table 1, Unit 4), and dolomitic mud (Table 1, Unit 5). The muddy sand occurs only in the southeastern depression (the original back swale) where it overlies unconsolidated sand or bedrock. In view of its sedimentologic character and sparse fauna, which is dominated by thin shells of the bivalve *Anomalocardia* sp., Unit 3 is interpreted as the deposit of a hypersaline pond or restricted marine environment, such as a lagoon (Fig. 2c). Transition to an intertidal flat environment is recorded by upward gradational to algal mats that overlie the muddy sand. This algal unit extends northward as well developed, oncolite-based stromatolites that grew directly atop the

Table 1: Description of Units from Reckley Hill Settlement Pond

Unit 1-Lithified Sand

Well-sorted, well-rounded, medium-grained calcarenite with planar bedding; light tan in color; constituent skeletal grains slightly polished, dominated by foraminifera, mollusk, and coral fragments; pellets rare; loosely cemented by a low-Mg calcite meniscus cement.

Unit 2-Carbonate Sand

Maximum thickness 68 cm. Moderately well-sorted, medium- to fine-grained sand, with -10% aragonitic mud fraction; tan in color; constituent skeletal grains dominated by foraminifera, mollusk, and coral fragments; pellets common; Cerion shells and other abraded mollusk debris sparse; vertical mangrove roots abundant 10 cm to 40 cm below unit top; pebbles and cobbles of lithified sand locally common at unit bottom.

Unit 3-Muddy Sand

Maximum thickness 24.5 cm. Poorly sorted mixture of aragonitic mud (-30%), pelleted fine-grained sand and mud, and medium grained skeletal sand dominated by mollusk and foraminifera fragments; light gray in color; primary sedimentary structures absent; slight H_2S odor; mangrove rootlets and other organic detritus rare; sparse unabraded shells primarily of the pelecypod Anomalocardia sp.

Unit 4-Algal Mats and Stromatolites

Maximum thickness 4 cm and 15 cm, respectively. Thin algal mats -2mm thick, yellowish white in color, interlaminated with gray to tan, muddy bioclastic to pelletal carbonate sand and mud; laminae generally crinkled and broken; whole mollusk shells of Anomalocardia sp. and the gastropod Cerithidea costata common: Stromatolites exteriorly dark gray in color, internally white; up to 6 cm in diameter; laminae moderately well developed; specimens dominated by smooth and pustular mat structures; basal oncolites abundant and well developed, up to 14 mm in diameter; X-rays show only high-Mg calcite composition. See Figure 1e.

Unit 5-Dolomitic Mud and Crust

Maximum thickness, 26 cm and 6 cm, respectively. Bottom-most sediment gray, muddy, bioclastic to pelletal sand with -20% aragonitic mud; mangrove root hairs sparse; Cerithidea costata and Anomalocardia sp. common; unit grades upward into tan to gray laminae of pelleted mud (-60%), interbedded with laminae containing dark brown organic matter; birdseye vugs common between laminae; skeletal fragments and pellets increasingly obscured upward because of increasing dolomitization of sediment; complete obliteration of constituents in top dolomitic crust (26% dolomite); desiccation cracks penetrate top 6 cm with well rounded polygons up to 15 cm in diameter. See Figure 1d.

Unit 6-Grey Muck
Maximum thickness 30 cm. An accumulation of finely particulate organic detritus of colloidal nature; extremely well compacted; slick and plastic in texture; dark gray in color; slight H_2S odor; distinct organic-rich laminae common; whole leaves and stems sparse; abraded shell debris rare.

Unit 7-Pelecypod-Ostracod Sediments and Crust
Maximum thickness 32 cm and 5.5 cm, respectively. Homogeneous mixture of bivalve shells and ostracod tests, dominantly Anomalocardia sp. and Hemicyrideis setipunctata, respectively; pellets abundant; bivalves are notably concave down. Lithified zone extremely well indurated, laterally continuous, and generally present in lower 10 cm of unit; meniscus and rim cements composed of high-Mg calcite; complete filling of tests common. See Figure 1c.

Unit 8-Peneroplid Foraminifera Sediments and Crust
Maximum thickness 9 cm and 4 cm, respectively. Accumulation of unabraded Peneroplis sp. tests with varying amounts of other skeletal remains, dominantly gastropods and pelecypods. Lithified zone thin, laterally discontinuous, and vertically gradational; very friable; under petrographic scope cement appears as a micritic coating, S.E.M. resolves the equant crystals of a high-Mg calcite; X-rays indicate -5% dolomite. See Figure 1b.

Unit 9-Red Muck
Maximum thickness 59 cm. Accumulation of finely particulate organic detritus of colloidal nature, in deposits -30 cm thick; flocculent texture; deposits -30 cm typically thicken downward into a custard-like material; dark reddish brown to dusky red color; strong H2S odor at bottom of thicker accumulations; recognizeable detritus 15%, primarily including leaves, stems, and roots of the red mangrove Rhizophora mangle dried sample dark brown in color and extremely well indurated; elemental analysis indicates 0-15% silica and 0-20% aluminum by wgt. %.

Unit 10-Modern Sediments and Thin Crust
Maximum thickness 12 cm. Homogeneous mixture of several gastropod species, dominantly Batillaria minima the bivalve Anomalocardia sp. and possibly Geloina sp., and the ostracod Cyprideis ovata; pellets abundant. Thin crust o.3-0.8 mm thick developed atop 2-4 cm of modern sediments that are underlain by a widespread 2-8 cm thick layer of red muck; smooth surface coating composed of white high-Mg calcite cement typically encrusting algal tubules; calcareous tubes of Spirorbis common. See Figure 1a.

unconsolidated sands of Unit 2 (Fig. 2d). The algal mats were buried by dolomitic mud that was deposited in a marsh environment. These light tan, pelleted sediments have primary laminations and birdseye structures that are similar to marsh deposits of Andros Island, Bahamas (Shinn et al., 1969). The increasingly laminated nature of the uppermost part of the mud unit, upward increase in dolomite content, and capping desiccation features record the climax of drying conditions in the marsh (Fig. 2e). Excessive evaporation occurring at this time almost certainly led to development of supersaturated brines. Consequently, high concentrations of calcium and magnesium ions, owing to 'evaporitic pumping' (Hsu and Siegenthaler, 1969), promoted the formation of a dolomitic crust that constitutes the first known example of surficial dolomite on San Salvador Island. The reduction of water depth necessary for the development of environments that produced Units 3, 4, and 5 was in part a result of shoaling due to sedimentation. In addition, the increasingly restricted passage of marine waters around prograding and eroding eolian deposits that blocked the pond from direct oceanic influence, and/or a eustatic drop in sea level, may also have been influential.

The grey muck of Unit 6 (Table 1) may also have originated during the aforementioned drying period, provided such an extreme had at least local, if not widespread, detrimental effect on vegetation. Any large-scale destruction would have created substantial amounts of organic detritus which, if transported by later runoff of available rainwater or wind, would

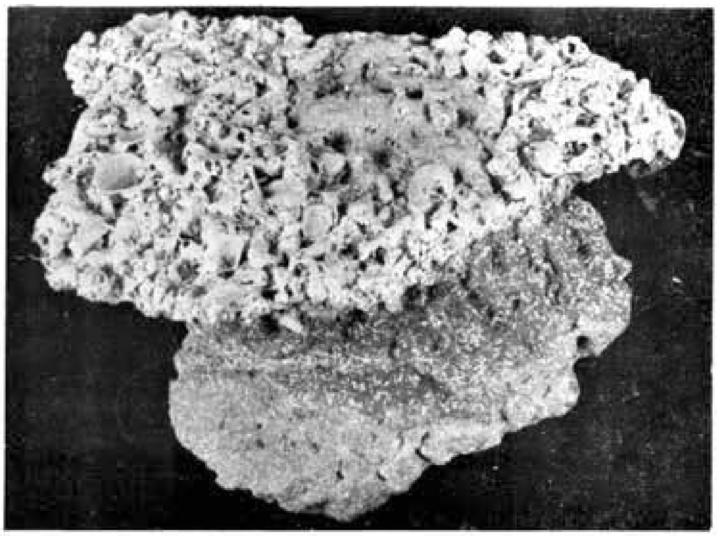

Figure 1a: Thin crust from modern sediment unit cemented atop a carbonate sand clast.

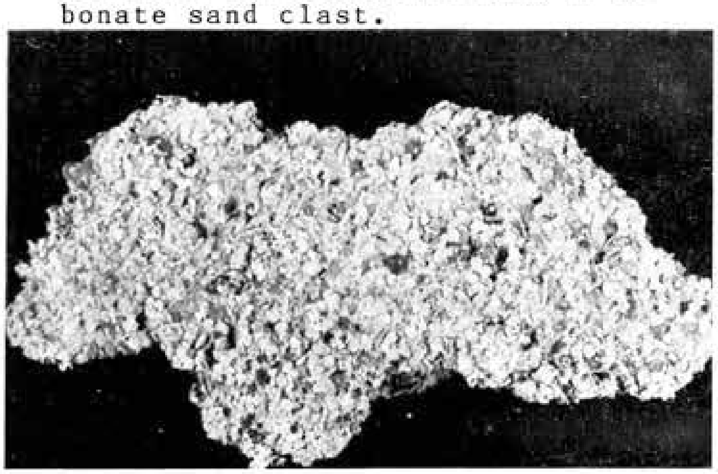

Figure 1b: Side view of a peneroplid-foraminifera crust.

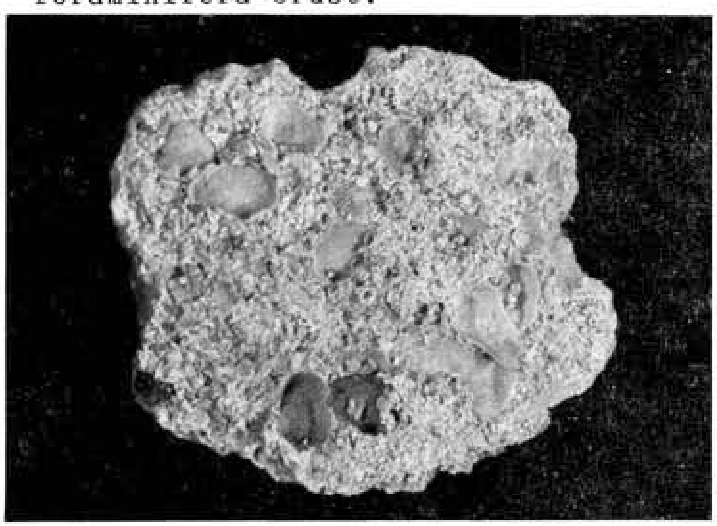

Figure 1c: Bottom view of a pelecypod-stracod crust.

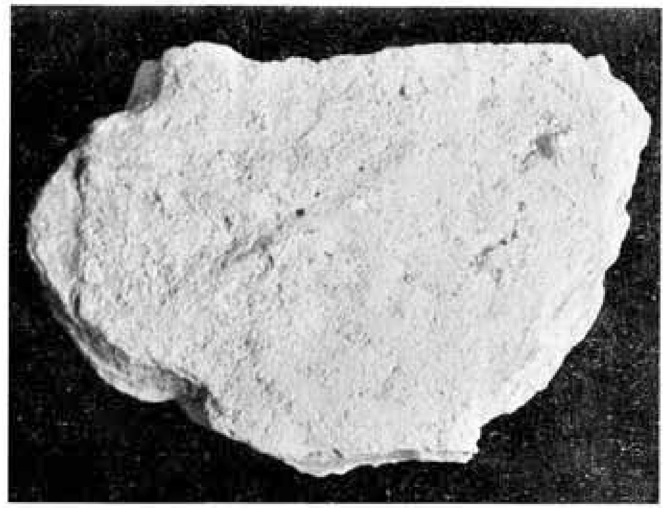

Figure 1d: Rounded desiccation poly gon of a dolomitic crust.

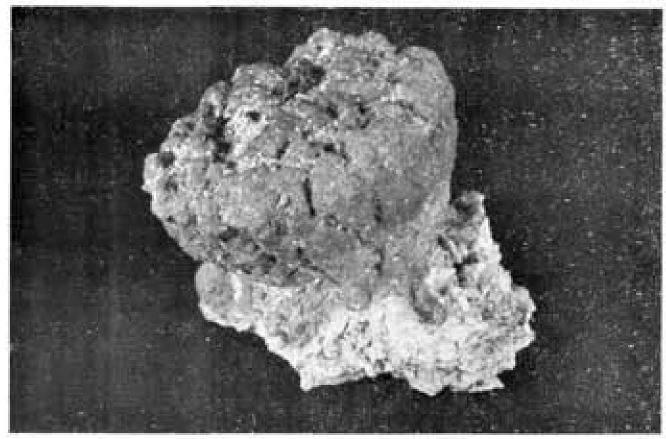

Figure 1e: A solitary stromatolite column.

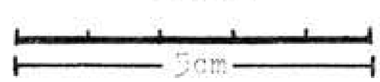

Figure 2: ILLUSTRATED DEPOSITIONAL HISTORY OF THE RECKLEY HILL SETTLEMENT POND SEDIMENTS

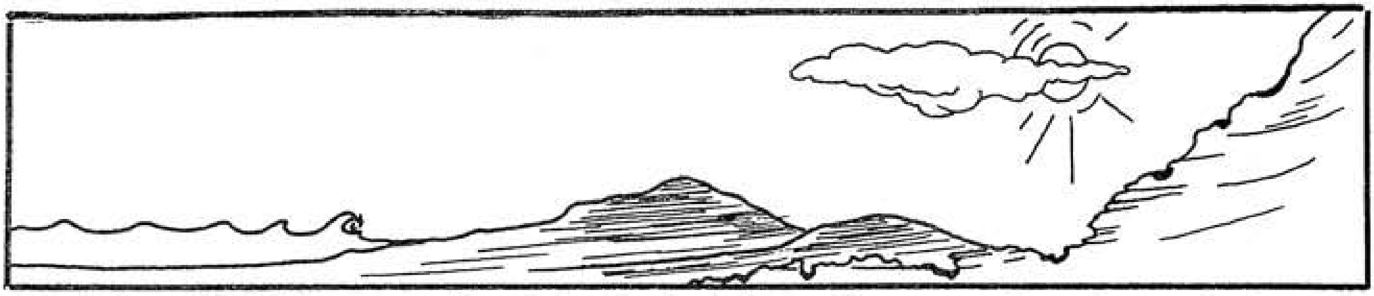

Fig. 2a: Pleistocene bedrock is buried beneath prograding dunes during the early Holocene.

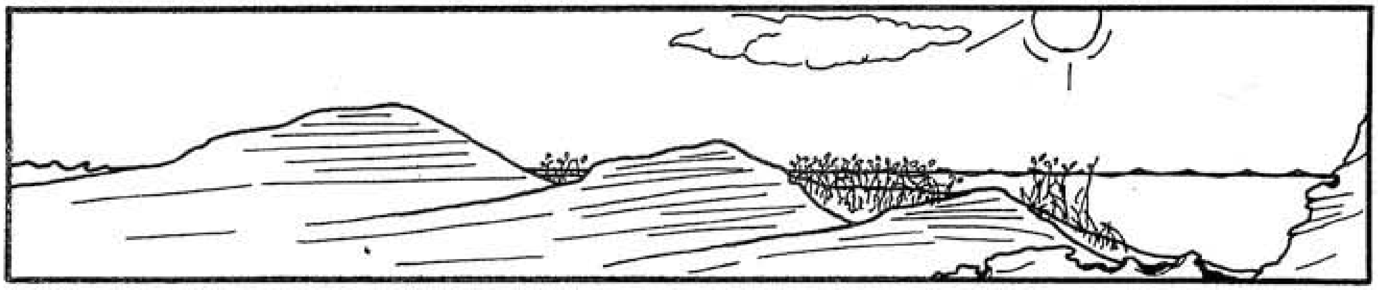

Fig. 2b: Lowlands flooded, creating Reckley Hill Settlement Pond; mangroves flourish in the shallow waters, anchored in eroded sands

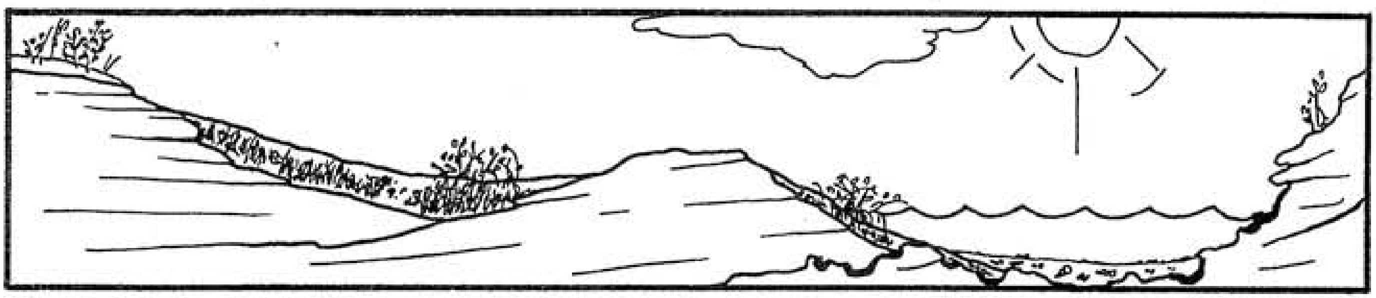

Fig. 2c: A restricted marine/hypersaline pond environment becomes dominant, muddy sand with a sparse biota deposited.

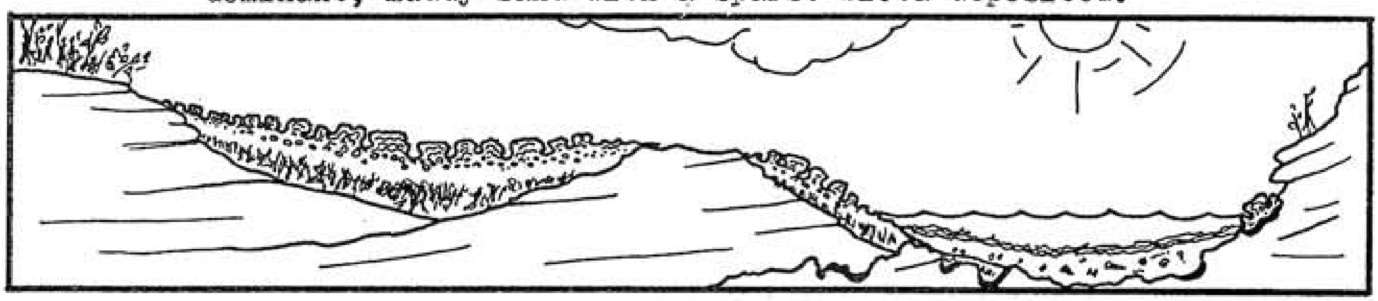

Fig. 2d: An intertidal flat environment is initiated, promoting the growth of stromatolites and algal mats.

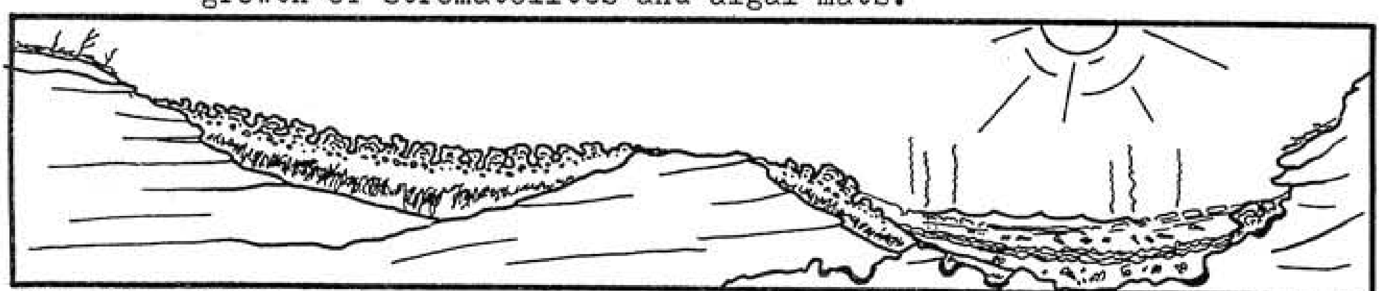

Fig. 2e: Continued emergence promotes the development of a marsh environment with laminated pelleted muds and a dolomitic crust.

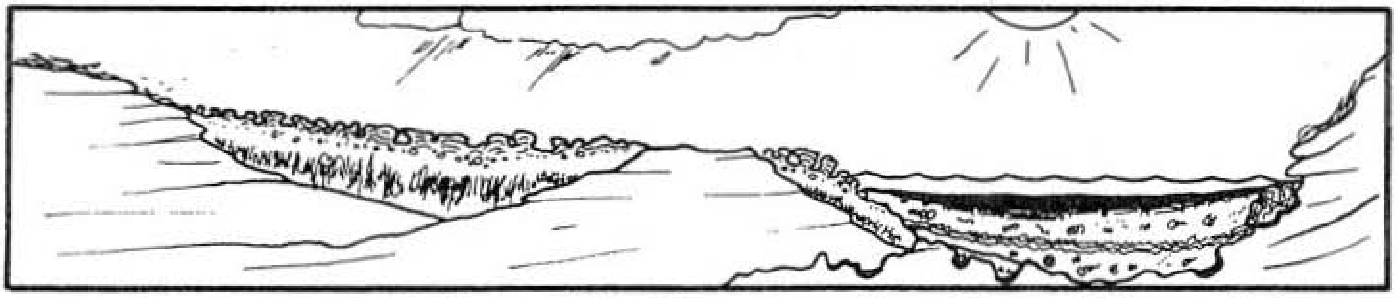

Fig. 2f: Local vegetation killed by extremely arid conditions; this organic detritus accumulates in the lowland as grey muck.

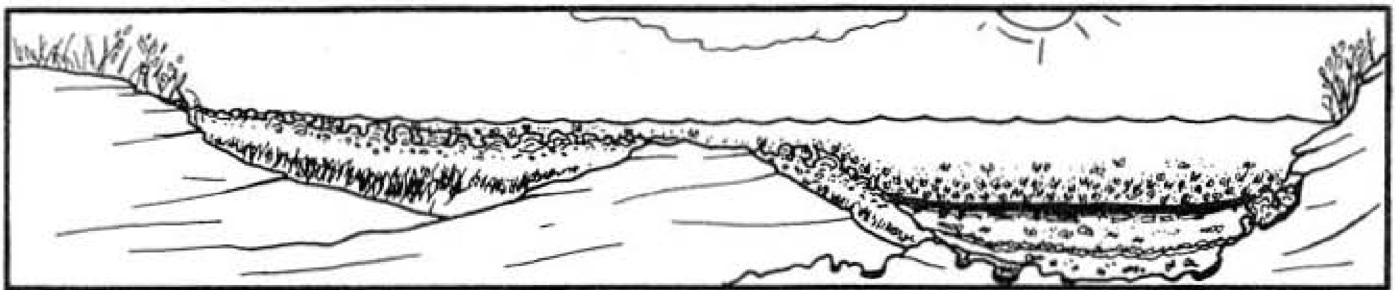

Fig. 2g: Return to brackish waters promotes the blossoming of a faunal assemblage of pelecypods and ostracods.

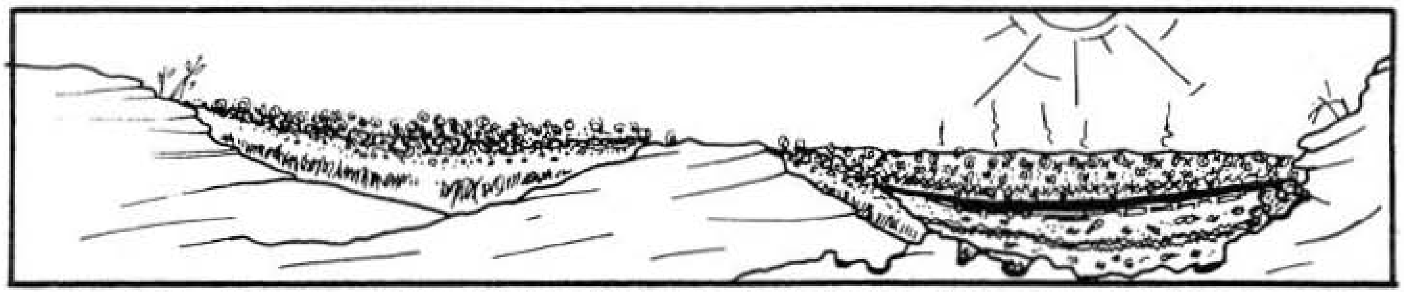

Fig. 2h: Extreme hypersalinity wipes out Peneroplid-foraminifera community; lithification of shells occurs in supersaturated brines.

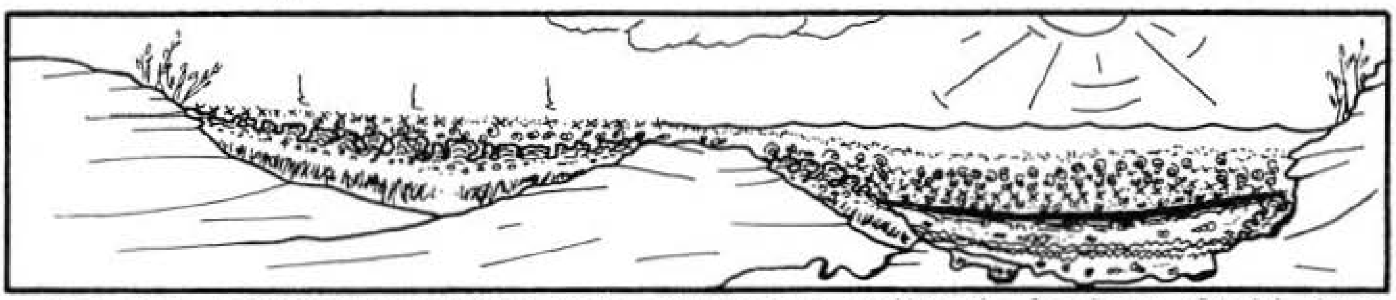

Fig. 2i: Deposition of red muck and modern sediments begins; slight drop in water level promotes cementation of a thin crust.

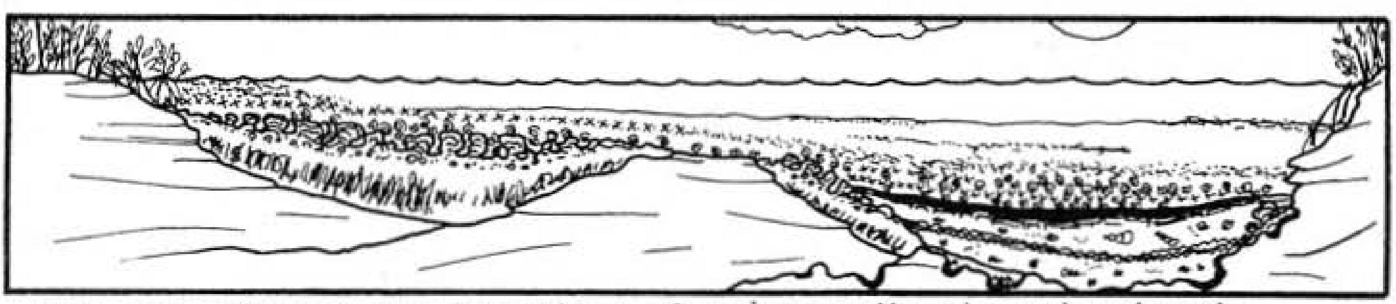

Fig. 2j: Present day deposition of modern sediments and red muck .

have accumulated in lowlands such as Reckley Hill Settlement Pond. Early investigation of the production of mucks in South Florida (Davis, 1940) and study by Hatcher (1978) of eighteen meters of similar accumulations in Mangrove Lake, Bermuda, support this idea (Fig. 2f).

The lateral extent of the two succeeding sediment units, which are essentially coquinas, indicates that as the depression again filled as a result of eustatic sea-level rise, the modern dimensions of Reckley Hill Settlement Pond were attained. Deposition of these faunal assemblages (pelecypod-ostracod of Unit 7; peneroplid foraminifera of Unit 8) directly on top of the grey muck suggests a change from possibly anaerobic conditions (slight H_2S odor and gray color) to well-circulated waters. The climax and demise of each of these euryhaline assemblages records a significant increase in the salinity of the pond water. Under conditions of extremely high salinities the faunas perished and the increased concentrations of calcium and magnesium ions facilitated cementation of newly deposited tests by high-Mg calcite rim cements (Fig.2g, 2h).

The red muck of Unit 9 (Table 1) and other modern sediments (Table 1, Unit 10) have a complexly interbedded relationship that is a result of contemporaneous deposition. Development of both units most likely began soon after lithification of the peneroplid foraminiferal crust and subsequent rise of water level to the present elevation. Throughout time conditions apparently remained relatively constant and are exemplified by the present environment (hypersaline waters having salinity of 41.5 to 47 ppm, water depth that averages one meter, low diversity of species, and growth of the red mangrove Rhizophora mangle around the perimeter of the pond). A notable exception to this sort of environment is recorded by local occurrence of a thin surficial crust. Slightly arid conditions, resulting in a drop in water level and an increase in salinity, may have facilitated the precipitation of high-Mg calcite around the grain-binding algal tubes that occur within this crust (Fig. 2i).

The red muck, also called liver gel because of its appearance (Davis, 1940), is an accumulation of finely particulate organic detritus consisting mostly of decomposing mangrove leaves, stems, and roots. A significant quantity of this detritus may also have eroded from the hills surrounding Reckley Hill Settlement Pond, particularly two to three centuries ago when the San Salvador mahogony forests were being cut for timber. The presence of cut limbs believed to be mahogany and high amounts of aluminum and silica (elemental analysis) in the muck supports this hypothesis. At present, the light and flocculent nature of muck that is partially suspended in water has facilitated its transport across much of the pond and its accumulation in depressions. The distribution of the other modern sediments, shells in particular, is similarly widespread: however, thickest accumulations tend to be found along the shallow southern and western shores. Modern sediments also occur in thin blankets less than two centimeters thick, that are interbedded with red muck; however, these deposits are too discontinuous to document as distinct units. Both the red muck and other modern sediments continue to be deposited at the present time (Fig. 2j).

Conclusion

The study of landforms on San Salvador, in particular the various trends of cross-cutting arcuate hills deposited by successive stages of eolian ridge formation, has facilitated most current thought on the island's accretionary growth. However, little consideration has been given to the numerous occurrences of interdune sedimentary sequences that lie in marshes and lakes between the dune ridges. The study of the Reckley Hill Settlement Pond sediment suite, including composition and stratigraphic succession, has clearly demonstrated the detail, continuity, and utility of sedimentary record preserved in such lowland deposits. Future attempts to refine the Holocene sedimentary record of San Salvador Island, should not overlook these lowland suites of sediments.

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