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HOLOCENE DEPOSITIONAL HISTORY OF CONCEPTION ISLAND, BAHAMAS

Steven W. Mitchell
Department of Geology
California State University
Bakersfield, CA 93311

Nancy Buening
Department of Geology
Sonoma State University
Rohnert Park, CA 94928

John N. Baldwin, Jr.
Earth Sciences Board of Studies
University of California
Santa Cruz, CA 95064

Betsey Westell
Department of Geology
California State University
Los Angeles, CA 90032

ABSTRACT

The surficial rocks of Conception Island can be assigned to four different lithofacies: 1-Holocene multiple beach-dune ridges, 2-late Pleistocene poorly cemented eolianites, 3-late Pleistocene well cemented eolianites, and 4-late Pleistocene subtidal calcarenites. The Holocene depositional history of Conception Island began with an atoll-like island having many inlets to the interior lagoon. Late Holocene accretion of beach-dune ridges enclosed the lagoon to form a tidal creek with a single inlet. Soil erosion, associated with prehistoric and Loyalist plantation clearing, has contributed to the rapid infilling of the tidal creek system over the past 500 years.

INTRODUCTION

Conception Island is the surface expression (about four square kilometers in area) of an isolated platform in the central Bahamas. The platform has an aerial extent of about 65 square kilometers and is generally submerged to a depth of 20 to 30 meters. The island is located 50 kilometers west-southwest of San Salvador island and 20 kilometers northwest of Rum Cay. Conception Island is a Bahamas National Trust Park; it is unoccupied and has no roads or airstrip. The general geography of the island is presented in Figure 1. For reference purposes, the apparently unnamed points have been given the names of the compass directions toward which they point. The coast lines will be referred to in the same way: the coast between North and West Points would be the northwest coast, the coast between West Point and Wedge Point would be the southwest coast, the coast between Wedge Point and East Point would be the southeast coast, and the coast between East Point and North Point would be the northeast coast. Also, the small island northwest of East Point is here referred to as East Point Cay.

Although Conception Island is presently unoccupied, there is evidence that this island was inhabited in prehistoric times (Hoffman, 1988) and a Loyalist plantation, including the remains of buildings, stone fences, and a well still containing fresh water, is located in the area of West Point (Fig. 1).

PURPOSE

This paper summarizes the results of the first geological reconnaissance of Conception Island. There are no previous publications covering any aspect of the geology of the island. A thorough understanding of the Holocene sedimentary development of Conception Island will be extremely useful in interpreting the events associated with the internal flooding of much larger islands in the Bahamas during a very high sea level stand 120,000 - 125,000 years ago (Mitchell, 1987). On a much smaller scale, Conception Island presently probably appears very similar to larger islands (such as Great Inagua Island and Rum Cay) at the peak of this high sea level stand. Also, the small size of the Conception Island Platform should provide a relatively uncomplicated record of the effects of the successive transgressions and regressions affecting the Bahama Archipelago during the late Quaternary. Thus, Conception Island should provide a useful modern analog for interpreting the Quaternary geological history of the Bahamas.

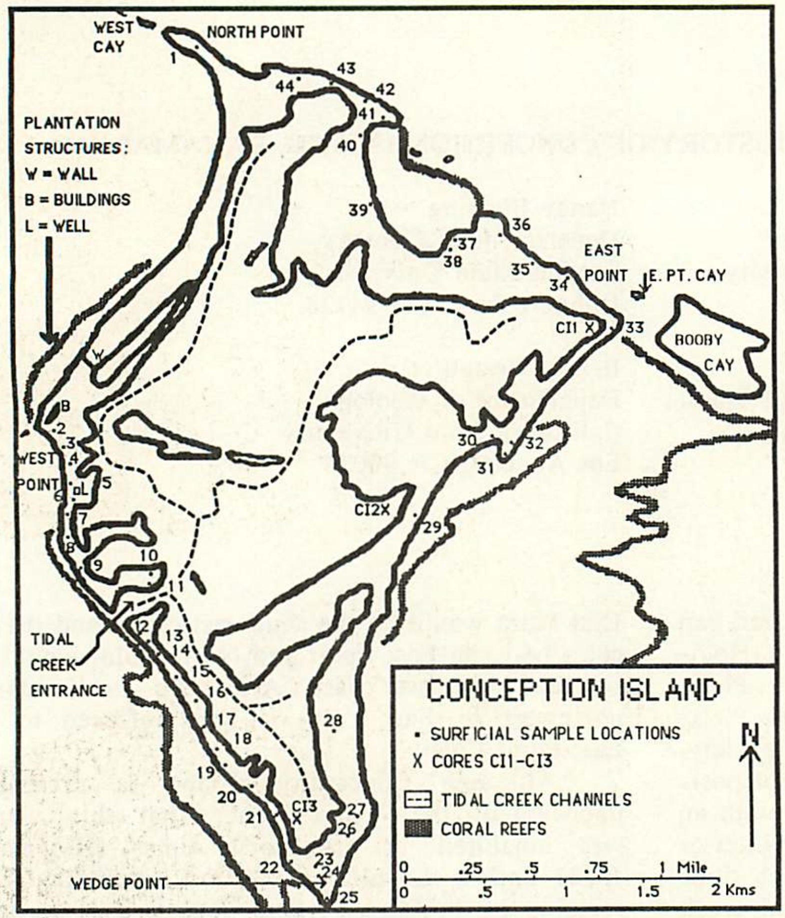

Fig. 1. Map of the geography of Conception Island showing the locations of surficial field samples and shallow cores.

METHODS

A geological reconnaissance of Conception Island was carried out during the summer of 1987 as a part of a Center for Field Research Earthwatch Expedition to the central Bahama Islands. Three days of field work by the authors and 12 volunteer assistants were undertaken in June; the senior author returned to the island in August and conducted one additional day of field survey work with 10 volunteer assistants. Further information on the first geological survey of Conception Island is given by Dumene (1988).

The areas sampled in summer 1987 are shown in Figure 1 and include all coastlines of the island. Samples were collected from all major Holocene and Pleistocene lithofacies encountered. Coastal, lake, and tidal creek sediments were collected. Also, three shallow cores (60-68cms in depth) were obtained from the interior tidal creek system. The locations of lithologic and sediment samples and cores CI1-CI3 are also shown in Figure 1.

Laboratory analyses included thin section petrology, mechanical sediment analysis, and micropaleontologic and grain morphotype analysis.

A Phillips Norelco XRG-3000 X-ray diffractometer was used for the investigation of the bulk mineralogy of sediments and lithologic samples. The silt-clay and sand fractions of the units of cores CI1-CI3, surficial sediments and crusts, and samples of Holocene and Pleistocene lithofacies were analyzed to determine the relative abundances of low and high Mg-calcite, aragonite, and protodolomite. Approximate mineral abundances were determined using a set of mixed standards as described by Blackmon (1962).

MAJOR SURFICIAL LITHOFACIES

Five major surficial lithofacies were mapped and sampled during the field survey of Conception Island. Mineralogic, sedimentologic, and paleontologic analyses of the samples provide evidence for the age and depositional environments of the lithofacies. The approximate distribution of each lithofacies, and the locations of major exposures which were sampled, are presented in Figures 1, 3, and 7. The lithofacies are described below in order of increasing geologic age.

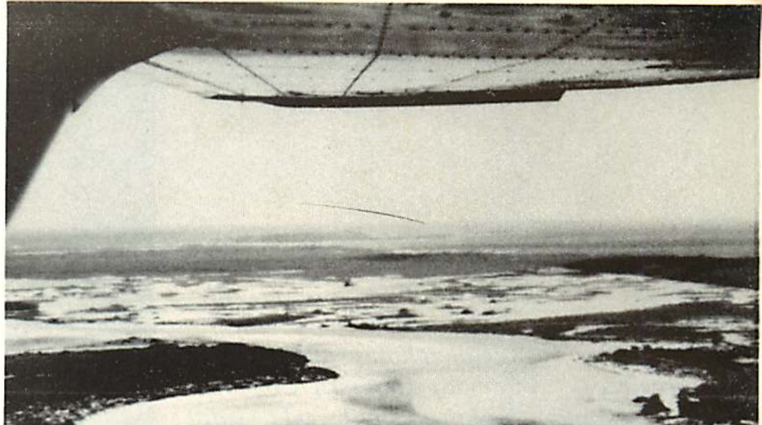

Fig. 2. Aerial photograph of the inlet to the tidal creek system, looking northwest (Booby Cay is in the background).

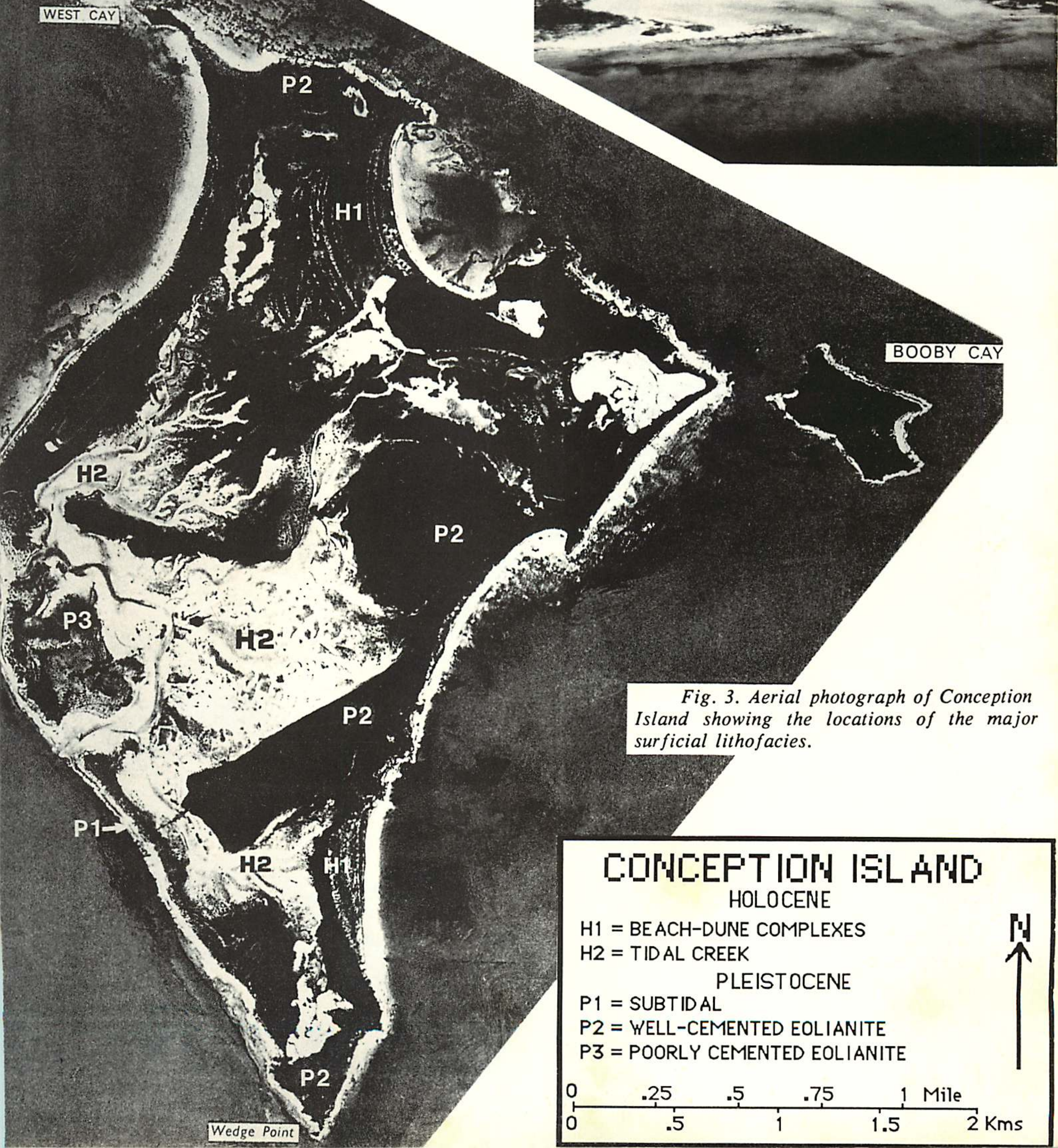

Fig. 3. Aerial photograph of Conception Island showing the locations of the major surficial lithofacies.

Fig. 4. Aerial photograph of the tidal creek system of southern Conception Island, looking southwest (tidal creek inlet is in the left background).

Fig. 5. Ground view of Pleistocene eolianite lithofacies, eastern Conception Island (Loc. 34), looking southeast.

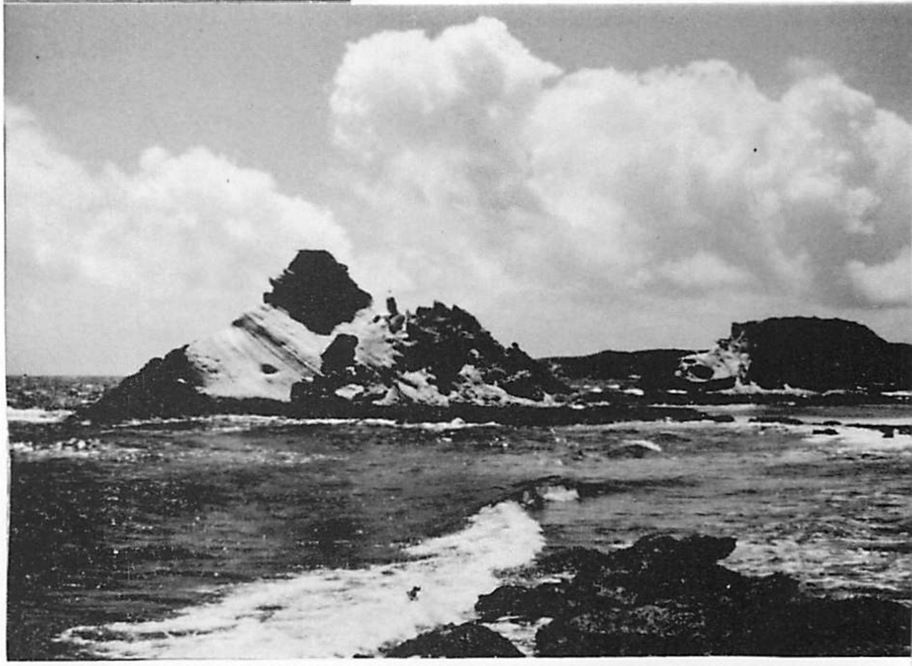

Fig. 6. Ground view of Pleistocene eolianite lithofacies with rhizocretions, eastern Conception Island (Loc. 31), looking northeast.

Holocene Multiple Beach-Dune Complex Lithofacies

Since the last lowest sea level stand about 17,000 years ago, rising sea level has inundated the Conception Island Platform. The island has grown by the accretion of Holocene beach-dune complexes, especially during the past 3,000 years when sea level reached levels near those at present. The sediments of the beach-dune complexes are predominantly skeletal. However, some peloids and ooids do occur in Holocene sediments from the southern coasts of Conception Island (Locs. 19 and 33). The unconsolidated Holocene beach-dune sediments usually contain 65-90% aragonite, 5-30% Mg-calcite, and 3-5% low Mg-calcite. The accretion of Holocene beach-dune ridges has closed off the interior of Conception Island, forming a large, shallow tidal creek system (Figs. 2-4, 7). The creek system would be classified as a single inlet, peloid lithofacies tidal creek using the classification of Mitchell (1987).

Well cemented Holocene beachrock is developed at many locations along the coasts of Conception Island; samples were collected from five of these occurrences: Localities 2, 34, 36, 38, and 42. Aragonite ranged from 50 to 85% in the samples, while Mg-calcite varied between 15 and 35%. Low Mg-calcite was more common (5-15%) than in Holocene beach-dune sediments.

Late Pleistocene Poorly Cemented Eolianite Lithofacies

Following the late Pleistocene highest sea level stand about 120,000 - 125,000 years before present, a series of fairly high sea level stands occurred. Some of these high stands inundated the Conception Island Platform, generating sediments ultimately incorporated into poorly cemented late Pleistocene eolianites composed of fine oopelsparites. This lithofacies seems to be restricted to areas of the northeast and northwest coasts of the island, where it overlies the Well Cemented Eolianite Lithofacies (Fig. 7). A sample from Locality 44 consisted of 60% aragonite, 35% Mg-calcite, and 5% low Mg-calcite -- a composition similar to that of modern coastal dunes. Since the

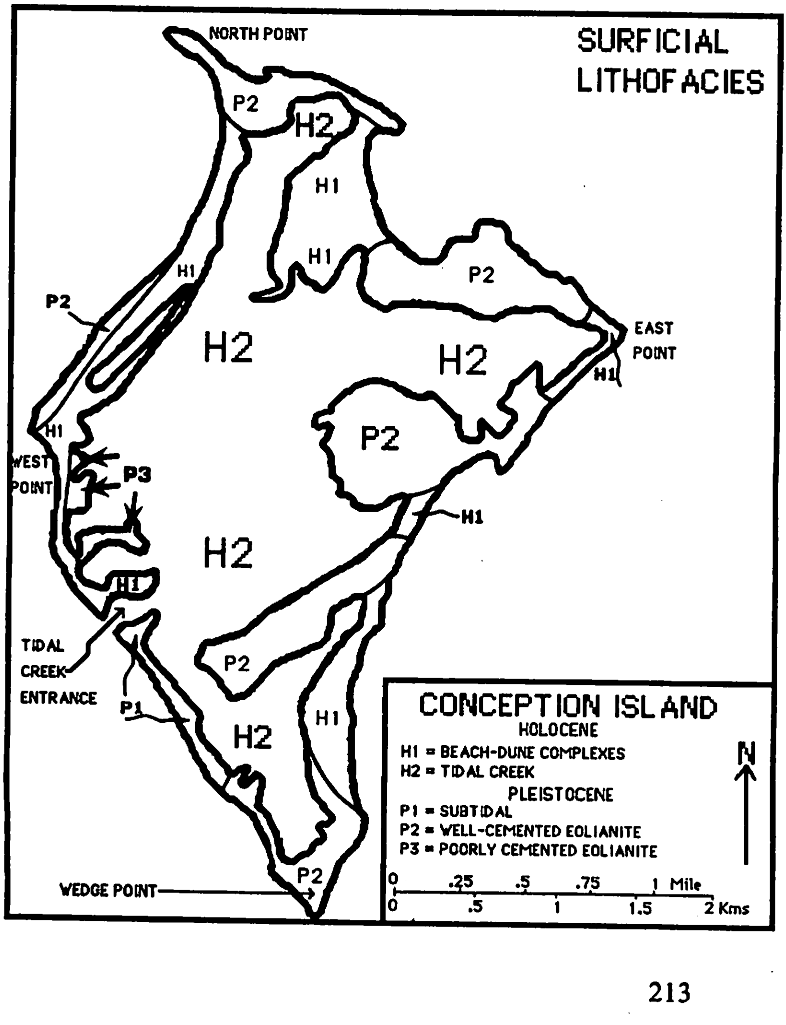

Fig. 7. Preliminary map of the surficial lithofacies of Conception Island.

areal extent of this lithofacies at Locality 44 is not known, its distribution along the northeast coast is not shown in Figure 7. A sample from Loc. 3 (where a thin layer of Holocene dune sand overlies this lithofacies) consisted of 80% aragonite, 5% Mg-calcite, and 15% low Mg-calcite.

Late Pleistocene Well Cemented Eolianite Lithofacies

This lithofacies overlies the Pleistocene Subtidal Lithofacies, which was deposited during a very high sea level stand 120,000 - 125,000 years before present. In areas where the Subtidal Lithofacies is exposed, it grades vertically into the Well Cemented Eolianite Lithofacies, forming a regressive sequence. The Well Cemented Eolianite Lithofacies is composed of coarse oosparites, oopelsparites, and rounded biosparites. Large, individual paleodunes are exposed along the eastern coast of Conception Island; rhizocretions are locally well-developed (Figs. 5-6). The land gastropod *Cerion* is a common fossil in this Lithofacies at Loc. 41. The mineralogy of samples of the Well-Cemented Eolianite Lithofacies from ten localities (Locs. 4, 16, 24, 27, 29, 30 31, 41, 42, and 43) was analyzed. Most of the samples contained 75-80% aragonite and 20-25% low Mg-calcite. Two samples (Locs. 41 and 42) were from calcrete zones associated with rhizocretions. These samples had a much lower level of aragonite (25-40%), with low Mg-calcite increasing to 60-75%.

Pleistocene Shallow Subtidal Lithofacies

The oldest surficial lithofacies mapped on Conception Island occurs sporadically along all coasts, where it underlies the younger eolianite units (Figs. 3 and 7). The Pleistocene Shallow Subtidal Lithofacies is best exposed along the coast south of the inlet to the interior tidal creek system (Locs. 12-17). In this area, the Lithofacies consists of a very well cemented zone of coral reef rubble extending for a distance of about 1 kilometer along the coast. The Lithofacies is also exposed below the Pleistocene Well Cemented Lithofacies at locations (for example Locs. 30 and 42) along the eastern coast of the island. Isolated heads of *Diploria strigosa* (Dana) are present at Loc. 30.

QUATERNARY DEPOSITIONAL HISTORY

The late Quaternary surficial lithofacies of Conception Island are suggestive of the following sequence of events:

1. The formation of reef rubble (calcirudites) and other shallow subtidal sediments on bathymetic highs of the platform during a very high sea level stand 120,000 - 125,000 years before present.
2. The deposition of (well cemented) eolianites as a regressive sequence directly overlying the subtidal lithofacies.
3. The later deposition of a series of (poorly cemented) eolianites during high sea level stands in the latest Pleistocene.
4. The flooding of the Conception Island Platform in the mid-Holocene, forming an atoll-like feature (similar to the present Hogsty Reef of the southern Bahamas) with large inlets to the central lagoon occurring on all sides of the island.
5. A rapid late Holocene inflling of the lagoon and closing off of the inlets by the longshore, eolian, and tidal transport of sediments.

LATE HOLOCENE DEPOSITIONAL HISTORY

Interpretation of the Cores

Three shallow cores (60-68cms in depth) were obtained from the edges of the tidal creek system at East and Wedge Points and at about the middle of the southeast coast of the island (Fig. 1). The analysis of cores CI1-CI3 provides detailed information on the last 500 years of the development of the central tidal creek system. The cores were divided into units 3cms or less in thickness. The silt-clay percent, bulk mineralogy, grain morphotypes, and foraminiferal, ostracod, and molluscan biofacies of each unit were analyzed. A summary of the biofacies and silt-clay abundances is given in Figure 8; the levels of low Mg-calcite and protodolomite are plotted in Figure 9.

Biofacies

Mitchell (1984, 1985), Mitchell and Keegan (1987), Mitchell and Sealey (in press), and Mitchell and Sigler (this volume) have developed a classification of foraminiferal, ostracod, and molluscan biofacies for use in evaluating the paleoenvironments of Bahamian tidal creeks and lakes. The Conception Island cores preserve many of these biofacies.

Foraminiferal Biofacies. Three foraminiferal

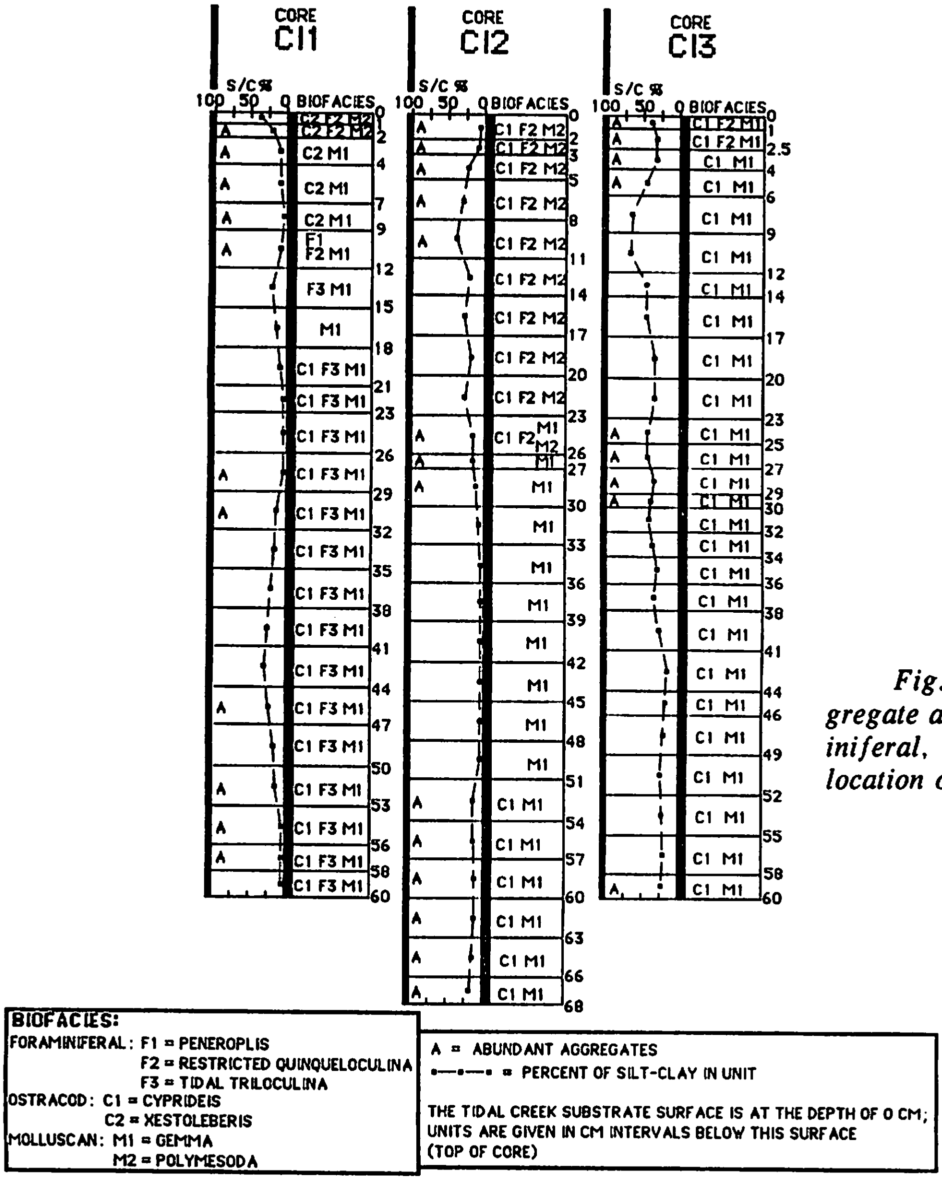

Fig. 8. Summary of silt-clay percent, aggregate abundance, and biofacies (ostracod, foraminiferal, and molluscan) of cores CI1-CI3; the location of the cores is given in Figure 1.

biofacies were encountered in the cores: (F1) *Peneroplis* Biofacies, (F2) Restricted *Quinqueloculina* Biofacies, and (F3) Tidal *Triloculina* Biofacies. The *Peneroplis* Biofacies is dominated by the species *Peneroplis proteus* Orbigny, which is most common in the high salinity portions of the upper reaches of tidal creeks. *Quinqueloculina bosciana* Orbigny and *Q. costata* Orbigny are the characteristic species of the Restricted *Quinqueloculina* Biofacies. This foraminiferal biofacies occurs in hypersaline to brackish lakes and in the most restricted upper reaches of tidal creeks. The Tidal *Triloculina* Biofacies is present in tidal creek channels where salinities and dissolved oxygen levels are intermediate between those of the open coast and the upper reaches of the creek system. *Triloculina bassensis* Parr and *T. bermudezi* Acosta are common species in this biofacies.

Ostracod Biofacies. Two ostracod biofacies were present in the cores: (C1) *Cyprideis* Biofacies, and (C2) *Xestoleberis* Biofacies. The *Cyprideis* Biofacies contains *Cyprideis americana* and *Hemicyprideis setipunctata* (Brady); *Actinocytheris subquadrata* Puri is occasionally present. This biofacies is found in hypersaline lakes and in the restricted upper reaches of tidal creeks. The *Xestoleberis* Biofacies includes the species *Xestoleberis curassavica* Klie and *Dolerocypria inopinata* Klie. These species are most common in slightly hypersaline lacustrine and tidal creek environments with salinities typically ranging between 38 and 42 o/oo.

Molluscan Biofacies. Two molluscan biofacies occur in the cores: (M1) *Gemma* Biofacies, and (M2) *Polymesoda* Biofacies. *Gemma* (Totten) is an abundant bivalve in the mid to upper reaches of

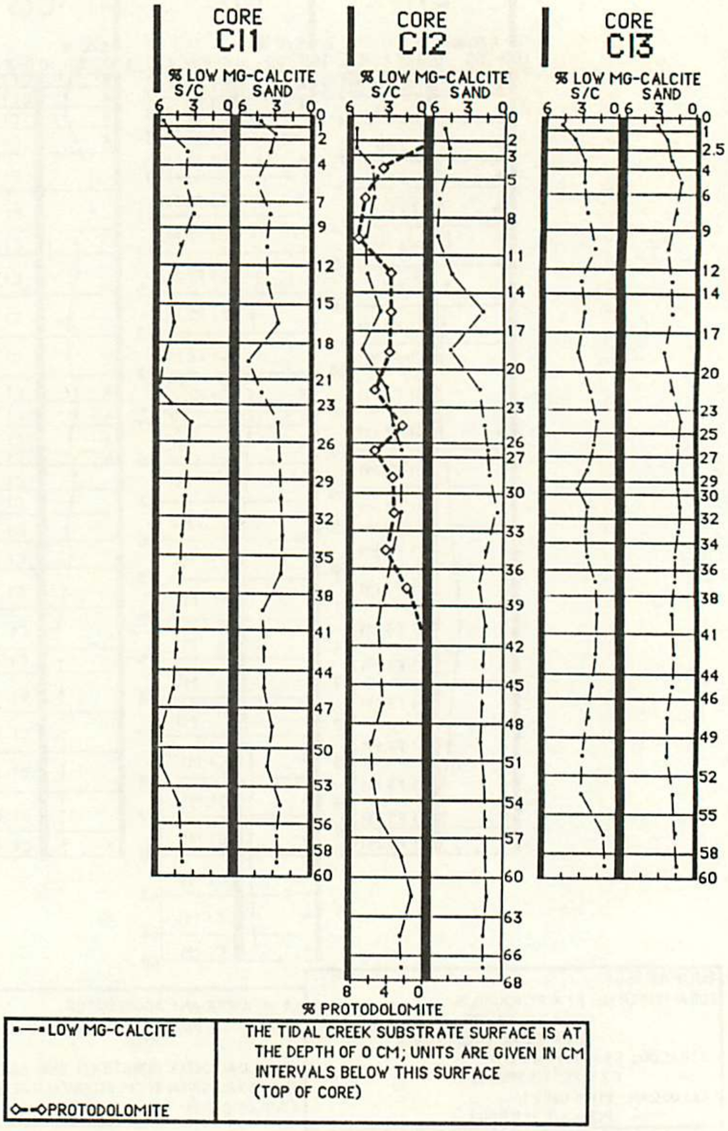

Fig. 9. Mineralogy of the silt-clay and sand fractions of cores CI1-CI3 given in percent of low Mg-calcite and protodolomite; the remainder of each fraction is composed of aragonite and high Mg-calcite.

tidal creeks in the central Bahamas. In the Conception Island cores this species is often found associated with the gastropods *Acteocina canaliculata* (Say), *Cerithidea costata* (da Costa), *Cerithium eburneum* Bruguiere, *Diastoma varium* (Pfeiffer), *Marginella carnea* (Storer), *Olivella* floralia (Duclos), and *Zebina browniana* (Orbigny) and the bivalve *Tellina iris* Say. Bahamian lacustrine environments typically contain the *Polymesoda* Biofacies, which is dominated by bivalves such as *Polymesoda maritima* (Orbigny) and *Anomalocardia brasiliana* (Gmelin). The gastropods *Batillaria minima* (Gmelin) and *Cerithidea costata* (da Costa) are common. The biofacies also occurs in the restricted, uppermost reaches of tidal creeks.

Core CI1

This core was obtained from a small hypersaline lake recently cut off from the tidal creek system at the end of East Point (Fig. 1). The molluscan and foraminiferal biofacies indicate a transition from a tidal creek to a lacustrine environment at a depth of 2cm (Fig. 8). Between 2 and 12cm, the biofacies suggest an environment typical of the upper reaches of the tidal creek system, but only slightly hypersaline. The sand fraction of the sediments from 0 to 9cm is largely composed of the rounded skeletal sand of the nearby beach and low dunes, while fine peloids dominate in the interval from 38 to 60cm. Between 9 and 38cm, the sediment is a variable mix of these two sediment sources. The sediments of core CI1 reflect the infilling of a deep, extensive central tidal creek system to form the present localized lake environment. As the interior creek system shallowed rapidly, changes in the coastline of East Point also seem to have occurred, allowing beach sand to be blown and washed directly into the tidal creek behind East Point. This points to a thinning of the extensive sand flats off the coast of eastern Conception Island and a reduction in the size of the coastal beach-dune ridge making up East Point (Fig. 1).

Core CI2

This core was obtained from a fairly large coastal lake present at about the middle of the southeast coast of the island (Fig. 1). A tidal creek-lake transition at a depth of 23cm is indicated by the biofacies (Fig. 8). Again, the sand fraction of the upper part of the core (0 to 14cm) is dominated by rounded skeletal sand derived from the nearby beach. Fine peloid sand dominates in the depth interval of 51 to 68cm. Between 30 and 51cm the sediment is a mix of fine peloid and coarse rounded beach and contains very little silt-clay. Core CI2 is similar to the East Point core in reflecting a transition from a deeper, better developed interior tidal creek system (depth of 51 to 68cm) to a present lacustrine environment (0 - 23cm). Also, there is similar evidence for coastline modification that increased the likelihood of the transport of beach sand into the interior of the island. The overall sequence of sediments and biofacies in core CI2 suggests that the low coastal beach and dune sediments were breached, forming a local temporary entrance to the tidal creek system. The sediments in the depth interval between 30 and 51cm were deposited during the time this inlet was open. By the time the inlet had begun to close off (23 to 30cm) the infilling of the interior tidal creek had already isolated this eastern arm of the creek system. The final sealing off of the temporary inlet then produced the present lake. The sediments of core CI2 are unusual in that they contain, in only the silt-clay fraction, low levels of protodolomite (Fig. 9). The protodolomite appears after the temporary inlet had breached the coastal beach-dune ridge. The precipitation of protodolomite continues upwards in the core until a maximum is reached in the 8-11cm interval. Its abundance then declines; protodolomite was not found in the upper 3cm of the core. The occurrence of this mineral supports the presence of a locally developed tidal inlet providing a source of marine pore water. The protodolomite appears to have grown around aragonite needles present in the silt-clay fraction of the sediment, similar to occurrences along west-central Andros Island and in Bonefish Pond of New Providence Island (Gebelein and Others, 1980; Mitchell and Sigler, this volume).

Core CI3

Core CI3 was collected from the upper reaches of the creek system about 0.5km north of Wedge Point. The entire length of the core contains the typical tidal creek biofacies. The sand fraction of the sediment includes a variable mix of fine peloids and rounded skeletal grains. The skeletal sand is presumably derived from the adjacent beach and is most common in the core below a depth of 27cm. The core provides evidence for additional coastline modifications along southern Conception Island. The diminution of rounded skeletal grains in the upper 27cm implies that the eastern side of Wedge Point has become more protected with less beach sand being blown and washed into the interior tidal creek system. A likely cause for this change would be an increase in the width and height of the coastal beach-dune ridge running northwest from Wedge Point (Fig. 1).

Tidal Creek Development

Mitchell (1984), Mitchell and Keegan (1987), and Mitchell and Sealey (in press) have proposed that some increases in the silt-clay content of shallow coastal lacustrine cores are the result of soil erosion due to Loyalist plantation clearing in the 1780s. Teeter and Others (1987) correlate the levels of insoluble residues and selected element distributions in a coastal lake core from San Salvador Island with the same event. There was apparently only a single, small Loyalist plantation constructed on Conception Island. Field mapping indicates that the main building structures were limited to the West Point area (Fig. 1). However, the usual farming procedure was to slash and burn large areas for cotton planting. The low coppice vegetation currently characterizing Conception Island is probably due to the fact that much of the northern and eastern sides of the island were cleared by the Loyalists. These are the areas of the best soil, and most likely, the locations of fresh water lenses. Conception Island, then, seems to be an ideal location to test the hypothesis that Loyalist plantation clearing produced significant soil erosion which was introduced into the sedimentologic record of lakes and tidal creeks.

Evidence for soil erosion might be most easily be determined if a clear relationship could be established between soil composition and the sediments occurring in adjacent lakes and tidal creeks. Analysis of the late Pleistocene well-cemented eolianites and subtidal calcarenites demonstrates that soils derived from these sources would have high levels of aragonite (75% or more); the remainder of the sediment would be low Mg-calcite. Soils derived from the later Pleistocene poorly cemented eolianites and unconsolidated Holocene beach-dune complexes would be expected to contain up to 35% Mg-calcite and 15% low Mg-calcite.

The sediments occurring in the tidal creek system, and local lakes, are restricted to peloids and skeletal grains. Aragonite is the dominant mineral present; it is derived from sources such as molluscs, calcareous algae, and scleractinian corals. High Mg-calcite is much less common; sand-sized grains of this mineralogy are derived from miliolinid foraminifera, ostracods, and echinoderms. The sand-sized fraction of the tidal creek and lacustrine sediments does not contain significant levels of any skeletal types known to have a low Mg-calcite mineralogy (for example, planktonic foraminifera, amphineurans, scaphopods, and Ostreid bivalves). Consequently, the predominant source of low Mg-calcite occurring in the sediment of the Conception Island tidal creek system would be the erosion of soils derived from the Pleistocene bedrock.

Figure 9 summarizes variations in the percentages of low Mg-calcite found in the silt-clay and sand fractions of cores CI1-CI3. High Mg-calcite levels were usually very close to those of low Mg-calcite, except in approximately the upper 12cm of all three cores. In this upper portion of the cores, high Mg-calcite increased to several times that of low Mg-calcite. An increase in the abundance of miliolinid foraminifera and ostracods seems to be the reason for the increase. The remainder of each sediment fraction was aragonite, with low levels of protodolomite also occurring in core CI2. The abundances of high and low Mg-calcite are generally quite similar in the complementary silt-clay and sand fractions of each unit (below 12cm) in each core. This indicates that the particles of low and high Mg-calcite are being derived from similar sources with a wide range of particle sizes.

Maximum percentages of low Mg-calcite occur at the depths of about 48-56cm, 18-23cm, and 0-4cm. The 18-23cm range corresponds well with an increase in silt-clay attributed to Loyalist plantation clearing (Mitchell, 1984; Mitchell and Keegan, 1987; Mitchell and Sealey, in press). A similar increase can be observed in cores CI1-CI2 (Fig. 8). If the 18-23cm level sediments are associated with a 1780's plantation clearing event, then the inferred depositional rate suggests that the increase in low Mg-calcite at a depth of 48-56cm would be the result of prehistoric clearing during the 1400s. A similar increase in soil erosion due to prehistoric activity has been reported from southern Samana Cay (Mitchell and Sealey, in press). Cores CI1 and CI2 are nearest to the area of presumed plantation clearing (northwest and southwest coasts) and prehistoric occupation (southwest coast). The increases in the abundance of low Mg-calcite are remarkably similar for the two cores. Core CI3 presents similar, but less pronounced, increases.

Overall, cores CI1-CI3 preserve a history of changes in sediment mineralogy which can be attributed only to different levels of soil erosion. While the erosion may be due in part to changes in precipitation levels, the underlying cause for erosion is believed to be vegetation modification in the form of slash and burn agriculture. Depositional rates for the three cores can be determined by matching the low Mg-calcite maxima with the inferred vegetation modification. Loyalist plantation clearing took place at a depth of about 20-22cm; the end of prehistoric activity (about 1500 AD) occurred at a depth of about 48-50cm. Using these approximate dates, a portion of the late Holocene history of Conception Island can be inferred.

The interior tidal creek system was much deeper and extensively developed prior to about 1600 AD. Accelerated infilling began at this time, caused by coastline modification which increased the influx of coastal beach-dune ridge sediment into the creek system. For example, the beach-dune ridge in the vicinity of core CI2 was breached from about 1500 to 1700 AD. In the 1780s, Loyalist plantation clearing significantly increased the soil erosion marginal to the creek system. The transport of beach-ridge sediments into the creek system reached a maximum along the southeastern side of the island during the past 100 years.

CONCLUSIONS

1. The surficial lithofacies of Conception Island are, in general, very similar to those of other islands in the central Bahamas.

2. The Holocene inundation of the Conception Island Platform produced an atoll-like island similar to the present Hogsty Reef.

3. Variation in the levels of late Holocene low and high Mg-calcite present in the island's central tidal creek sediments document a correlation between prehistoric and Loyalist plantation clearing and levels of soil erosion.

4. The interior tidal creek has undergone rapid infilling during the past 500 years. Coastline modification, allowing greater sediment influx from beach-dune environments, and soil erosion, have been major factors in this reduction in the creek system's extent.

5. The zone of protodolomite occurring in core CI2, along with the extensive distribution of protodolomite in Bonefish Pond on New Providence Island (Mitchell and Sigler, this volume) indicates that the contemporary formation of this mineral may be far more widespread in the Bahamas than previously recognized. New models for the late Holocene occurrence of Bahamian protodolomite may need to be developed.

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