PROCEEDINGS OF THE EIGHTH SYMPOSIUM ON THE GEOLOGY OF THE BAHAMAS AND OTHER CARBONATE REGIONS

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Bahamian Field Station, Ltd.
San Salvador, Bahamas
1997

Front Cover: View to the SSE on White Cay in Grahams Harbour off the north coast of San Salvador, Bahamas. At this spectacularly scenic site one can see that marine erosion has removed the entire windward portion of these early Holocene eolianites (North Point Member, with an alochem age of ~5000 radiocarbon years B.P.) that were deposited when sea level was at least 2 meters below its present position.

Back Cover: Stephen Jay Gould, keynote speaker for this symposium, holds a *Cerion rodregoi* at the Chicago Herald Tribune's 1891 monument to the landfall of Christopher Colombus, which is located on the windward coast of Crab Cay on the eastern side of San Salvador Island, Bahamas. The monument consists of an obelisk constructed from local limestone which houses a carved rock sphere depicting the globe with the continents. The inscription carved in a marble slab, reads: "On this spot, Christopher Columbus first set foot upon the soil of the New World."

Printed in USA by Don Heuer

ISBN 0-935909-63-X

SEDIMENTOLOGIC AND MORPHOLOGIC CHANGES ON THE LEEWARD MARGIN OF THE GREAT BAHAMA BANK DURING THE PLIOCENE AND PLEISTOCENE

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ABSTRACT

Two deep continuous core-borings, Clino (662 m) and Unda (442 m), drilled on the leeward margin of the Great Bahama Bank, indicate several major sedimentologic and morphologic changes from Pliocene to Pleistocene. The study interval, which includes the upper 200 m of the cores, consists of a tripartite offlapping succession, from a skeletal, non-reefal- to reefal- to shallow-water bank top. Earlier core studies suggested that the evolution of Great Bahama Bank was akin to an upside-down bucket building upward with reef rims and a shallow lagoon. However, Clino and Unda illustrate that the bank's morphology changed from sloping in the Pliocene to slightly-steepened to flat-topped and steep-sided during the late Pleistocene (as a result of several progradational pulses). Corals and reefs play a significant role in the leeward margin's progradational (and aggradational) evolution until the latest Pleistocene. The sedimentologic and morphologic changes reported were in response to changing sea level.

INTRODUCTION

Two closely-spaced (8.3 km apart), continuous core borings (Clino and Unda), located 4.3 km from the modern leeward margin of northwest Great Bahama Bank (NWGBB) (Figure 1), provide a special opportunity to evaluate the Plio-Pleistocene evolution of that margin during a period of known frequent sea-level fluctuations. Previously, continuous cores penetrated only the upper 75 m of the banks (Beach and Ginsburg, 1980; Beach, 1982; Pierson, 1983; Williams, 1985; McNeill, 1989). Because they penetrate entirely through the shallow bank, the new cores allow us, for the first time, to document the complete sedimentological and morphological transformation of the bank's leeward margin during the Plio-Pleistocene. The cores are positioned on an excellent seismic profile which contains discrete packages of seismic sequences that were suggested to relate to sea-level fluctuations (Figure 2; Eberli and Ginsburg, 1989). Clino and Unda, therefore, provide new insight into the link between sea level and platform evolution (Kievman and Ginsburg, in press); a link that may serve as a model for other more ancient carbonate platforms (Kendall and Schlager, 1981; Goldhammer et al., 1990).

How carbonate platforms evolve has been the subject of numerous studies because they can encode important paleontologic, paleoceanographic, evolutionary, eustatic, and tectonic information (Beach and Ginsburg, 1980; Kendall and Schlager, 1981; Beach, 1982; Read, 1985; Ahr, 1989; Eberli and Ginsburg, 1989; Goldhammer et al., 1990; Mutti et al., 1996). Furthermore, as platform carbonates and reefs hold an appreciable share of the worlds oil and gas reserves, and significant amounts of metallic ores, understanding their anatomy and sedimentology can help guide exploration for, and development of, these essential resources. Platform margins are of particular interest because they are dynamic critical transition zones from shallow to deeper water. Here is the locus of the development of

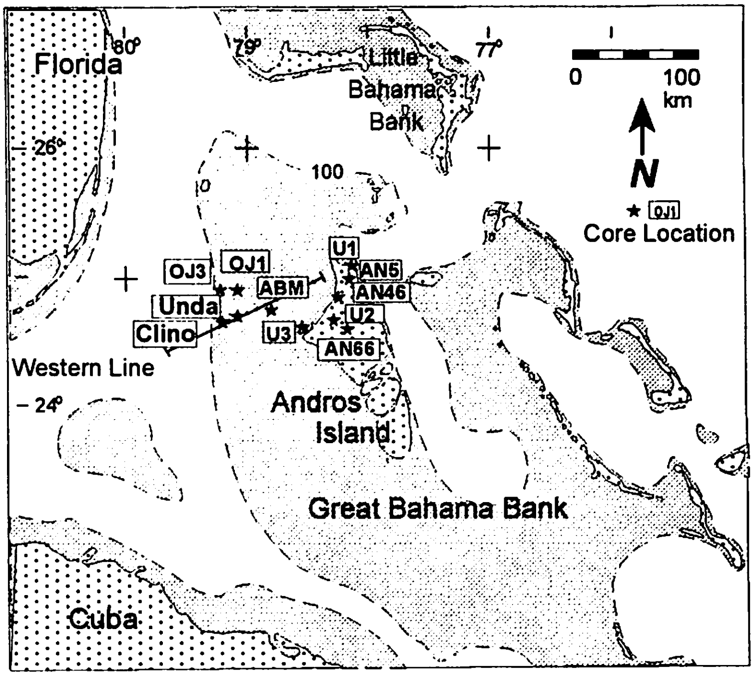


Figure 1: Location map of study area on North west Great Bahama Bank. Core Clino is located 8.5 km seaward of Unda. Both cores are positioned on a Western Geophysical seismic line. Other cores in the local area are also shown, although the deepest penetration of these was only 75.3 m at U-3.

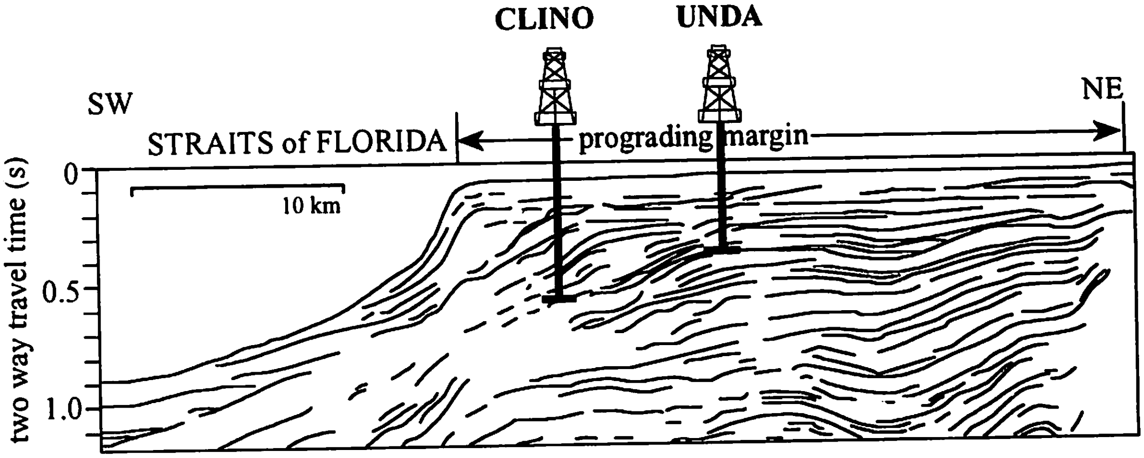


Figure 2: A tracing of the Western seismic line showing core Clino positioned to penetrate inclined reflectors, and Unda positioned to penetrate bankward equivalent reflectors. Packages of inclined reflectors have been suggested to be related to sea-level events (Eberli and Ginsburg, 1989).

reefs, shoals, and islands of calcareous sands that can influence the circulation of sea water, and in turn the environments and biotas of the adjacent platform.

Previous Studies of the Bahamas Archipelago

Past studies of the surface geology and shallow core borings from various parts of the Bahamas Archipelago provide a background on the stratigraphy, sedimentology, and general ages of late Cenozoic rocks in the region (Illing, 1954; Newell and Rigby, 1957; Purdy, 1963; Supko, 1970; Neumann and Moore, 1975; Beach and Ginsburg, 1980; Beach, 1982, Pierson, 1983; Garrett and Gould, 1984; Carew and Mylroie, 1985, 1995; Williams, 1985; McNeill, 1989; Chen et al., 1991). One advantage of working in the Bahamas is that modern sediments and environments can be used to guide paleoenvironmental interpretations. Five major sediment types based on predominant grain types are recognized from studies of the surface sediments on the shallow bank: peloidal, grapestone and aggregate, mud, coralgal, and oolitic (Illing, 1954; Purdy, 1963). For this research, the most significant of the five facies are the peloidal and the coralgal facies. Peloidal sediments are composed of various amounts of peloids and mud, with minor amounts of skeletal components. They occur over large areas of the semi-protected, bank interior at depths of less than 10 m, and they often extend across the leeward margins. The coralgal facies is composed of reefs and skeletal sands that are present on both margins of the GBB from the intertidal zone to depths of several tens of meters, but the facies is better developed and contains more coral on the eastern, windward margin (Purdy, 1963; Beach and Ginsburg, 1980). The constant northeasterly trade winds provide well-oxygenated, warm water that supports prolific coral growth on the windward margin of the bank.

Islands of the Bahamas are composed of mid- to early- late Pleistocene to Holocene carbonate rocks and unconsolidated sediment (Beach and Ginsburg, 1980; Garrett and Gould, 1981; Carew and Mylroie, 1985, 1995; Chen et al., 1991; Beach, 1995). Islands are extensive on windward margins, and far less abundant on leeward margins in the Bahamas. Reefs, eolian dunes, and beaches developed into islands (Supko, 1970; Beach and Ginsburg, 1980; Garrett and Gould, 1984; Pierson, 1983; Carew and Mylroie, 1985, 1995; Curran et al., 1989; Chen, et al., 1991; Beach, 1995). Several phases of island development were mapped on New Providence Island by Garrett and Gould (1984). They suggested that eolian dunes represent deposition during the Sangamon (120-132 ky) sea-level highstand. Fossil corals, exposed on islands, have been dated as Sangamon (Neumann and Moore, 1975; Curran et al., 1989; Chen et al., 1991).

From their study of cores, Beach and Ginsburg (1980) suggested that Andros Island did not become emergent until mid to late Pleistocene. A similar history is suggested for Long Island by Beach (1995). Additionally, cores from Cat, Exuma, and Eleuthera islands all show mid to early-late Pleistocene eolian dune development on the windward margin (Beach, 1995). Only one core on the leeward margin, OJ-3, consists of late Pleistocene to Holocene eolian dune and beach deposits (Figure 1).

Following their examination of subsurface Plio-Pleistocene rocks in 9 cores (OJ3, OJ1, ABM, U3, AN66, U2, AN46, AN5, and U1) (Figure 1) across NWGBB, Beach and Ginsburg (1980) described the stratigraphy of subsurface carbonates (across 120 km). From cores within the interior of the bank, they identified and named the Lucayan Formation, the uppermost pre-Holocene unit. Many counterparts of the Recent sedimentary facies were recognized in the Lucayan. They characterized it as a bioturbated, tan- to buff-colored, non-skeletal limestone facies with numerous earth-tone stained subaerial exposure horizons that would, in outcrop, give a layered appearance. The Lucayan Formation grades both laterally and vertically (down) to skeletal sediments and coral-bearing early Pleistocene lithofacies (Figure 3). By the latest Pleistocene, the skeletal margins become dominated by non-skeletal grain-types (Cant, 1977; Beach and Ginsburg, 1980; Beach, 1982; Beach, 1995). Pre-Lucayan rocks are characterized by skeletal-rich facies in the bank interior, and coral-bearing carbonates on the margin, interrupted by fewer exposure horizons (Beach and Ginsburg, 1980; Beach, 1982; Pierson, 1983; Williams, 1985; Beach, 1993). Because all cores on the leeward half of the bank were shallow, the pre-Lucayan was not penetrated, but a similar sedimentologic succession was inferred. Beach (1982) suggested that pre-Lucayan sediments represent slightly deeper water (10 m) than the Lucayan, and provide evidence for good cross-bank circulation. It was further inferred that an atoll-like (reef-rimmed, upside-down bucket shape) stage in the bank's history was masked by a thin veneer of late Pleistocene sands (Beach and Ginsburg, 1980).

The nature of the steep, often vertical margins of the bank has long been a subject of interest and speculation. Questions included:

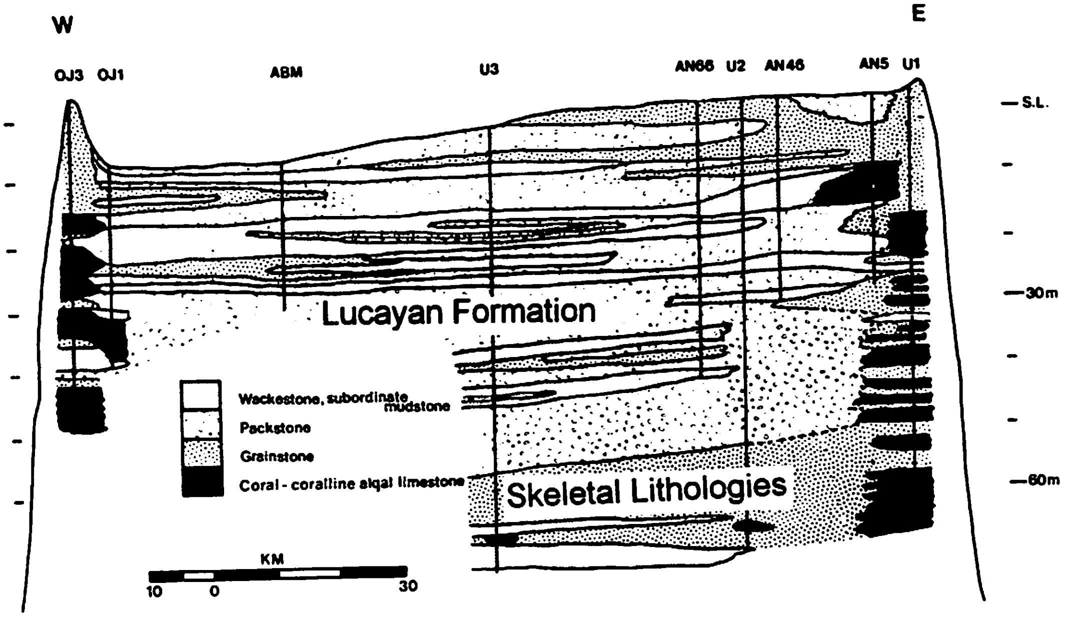


Figure 3: Cross-section of the Great Bahama Bank illustrating the Lucayan Formation (from Beach and Ginsburg, 1980).

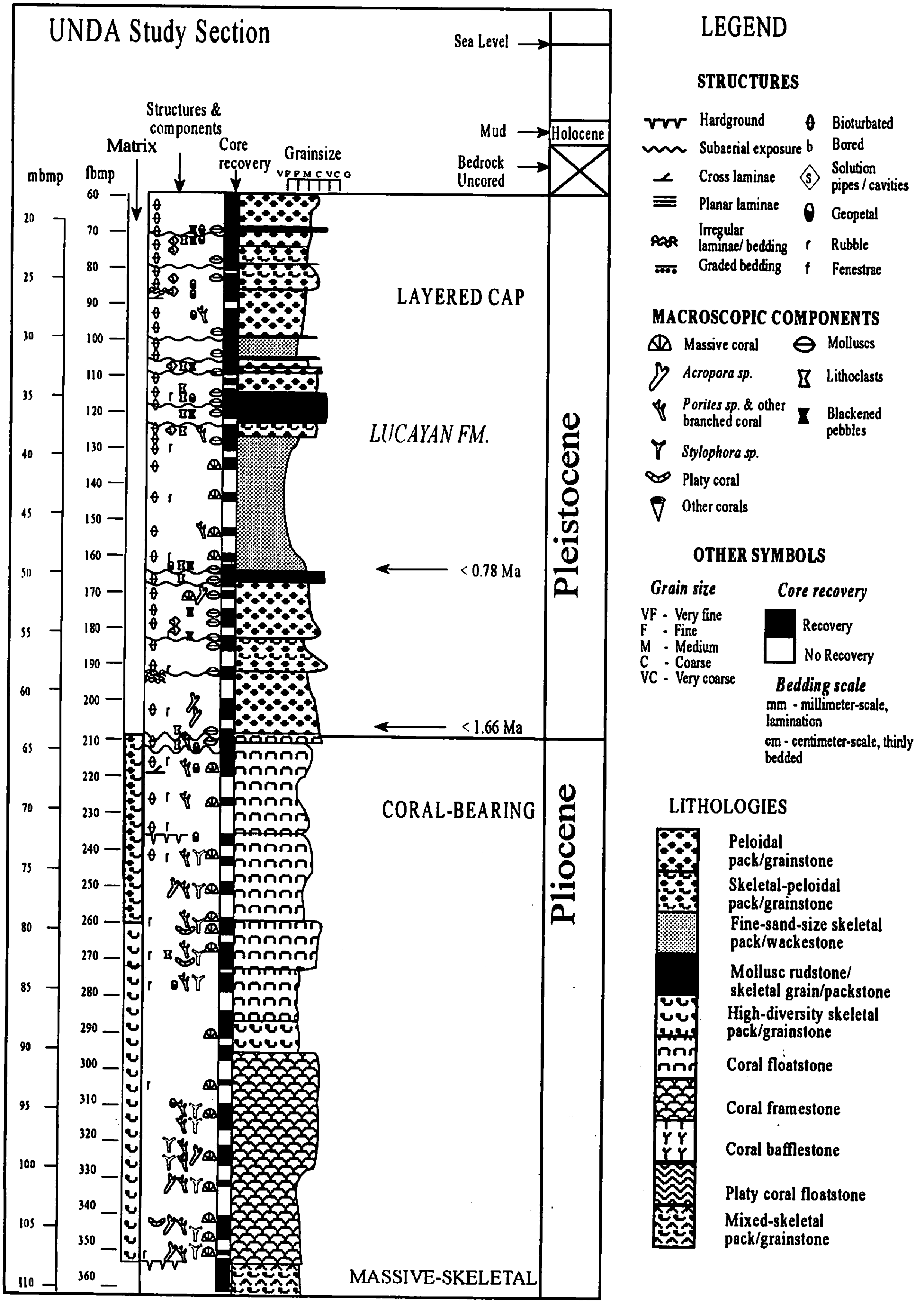
Are the margins an in-situ reefal deposit, or are they the result of submarine cementation of calcareous sands (Newell and Rigby, 1957; Neumann and Hine, 1974; Hine and Neumann, 1977; Mullins and Neumann, 1979; Beach and Ginsburg, 1980)? The first reports of the composition from core borings established that the margins had abundant reef-building corals (Cant, 1977). The abundance of corals on the margins and the steep sides led early researchers to propose an upside-down bucket model for the bank (Illing, 1954; Newell and Rigby, 1957). They suggested that the bank had an atoll-like morphology for most of its history. Beach and Ginsburg (1980) confirmed that corals were significant below both margins during early Pleistocene, and in the Pliocene along the windward margin. However, they could only infer Pliocene coralline rocks along the leeward margin.

METHODOLOGY

The upper 200 m of two continuous cores, Clino and Unda, from the leeward margin of the NWGBB were used for this study. They are located approximately 30 km due south of cores, OJ-1 and OJ-3, described by Beach (1982) and Beach and Ginsburg (1980) (Figure 1). Detailed descriptions of the corals, and coral occurrences in the cores, are found in Budd and Kievman (in press).

Cores were slabbed, and standard sedimentologic techniques were used in describing them. In addition, some 300 thin sections were used to identify predominant grain types, grain sizes, and porosity. Grain sizes were measured, but visual estimates were made of sorting and porosity. Embry and Klovan's (1972) modification of Dunham's (1962) classification scheme was used to describe carbonate fabrics. Burrowing and sedimentary structures were noted. Paleoenvironmental subdivisions are based on the major sedimentologic constituents and the overall appearance of the rock (e.g., massive or layered). Diagenetic features and coarsening and fining trends were logged. Core recovery was plotted next to the lithologic logs (Figures 4, 5). By convention, core recovered from

Figure 4 (facing page): Log of Core Unda showing the lithofacies, core recovery, structures, and a variety of components as described in the legend. The study section is composed of a tripartite succession from a layered cap, to a coral-bearing, to a mixed-skeletal packstone and grainstone. The base of the Lucayan Formation is marked by the change from skeletal to non-skeletal limestone and from few to numerous discontinuity horizons. Grain size is shown to the right of the lithology log, and the matrix found in the coral-bearing section is also indicated.


UNDA Study Section
Sea Level
Mud
Holocene
Bedrock Uncored
Structures & components
Matrix
Core recovery
Grainsize
VF F M C VC G
mbmp
fbmp
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
60
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170
180
190
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250
260
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290
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310
320
330
340
350
360
LAYERED CAP
LUCAYAN FM.
< 0.78 Ma
< 1.66 Ma
CORAL-BEARING
MASSIVE-SKELETAL
Pleistocene
Pliocene
LEGEND
STRUCTURES
Hardground
Subaerial exposure
Cross laminae
Planar laminae
Irregular laminae/ bedding
Graded bedding
Bioturbated
b Bored
Solution pipes / cavities
Geopetal
r Rubble
f Fenestrae
MACROSCOPIC COMPONENTS
Massive coral
Acropora sp.
Porites sp. & other branched coral
Stylophora sp.
Platy coral
Other corals
Molluscs
Lithoclasts
Blackened pebbles
OTHER SYMBOLS
Grain size
VF - Very fine
F - Fine
M - Medium
C - Coarse
VC - Very coarse
Core recovery
Recovery
No Recovery
Bedding scale
mm - millimeter-scale, lamination
cm - centimeter-scale, thinly bedded
LITHOLOGIES
Peloidal pack/grainstone
Skeletal-peloidal pack/grainstone
Fine-sand-size skeletal pack/wackestone
Mollusc rudstone/ skeletal grain/packstone
High-diversity skeletal pack/grainstone
Coral floatstone
Coral framestone
Coral bafflestone
Platy coral floatstone
Mixed-skeletal pack/grainstone

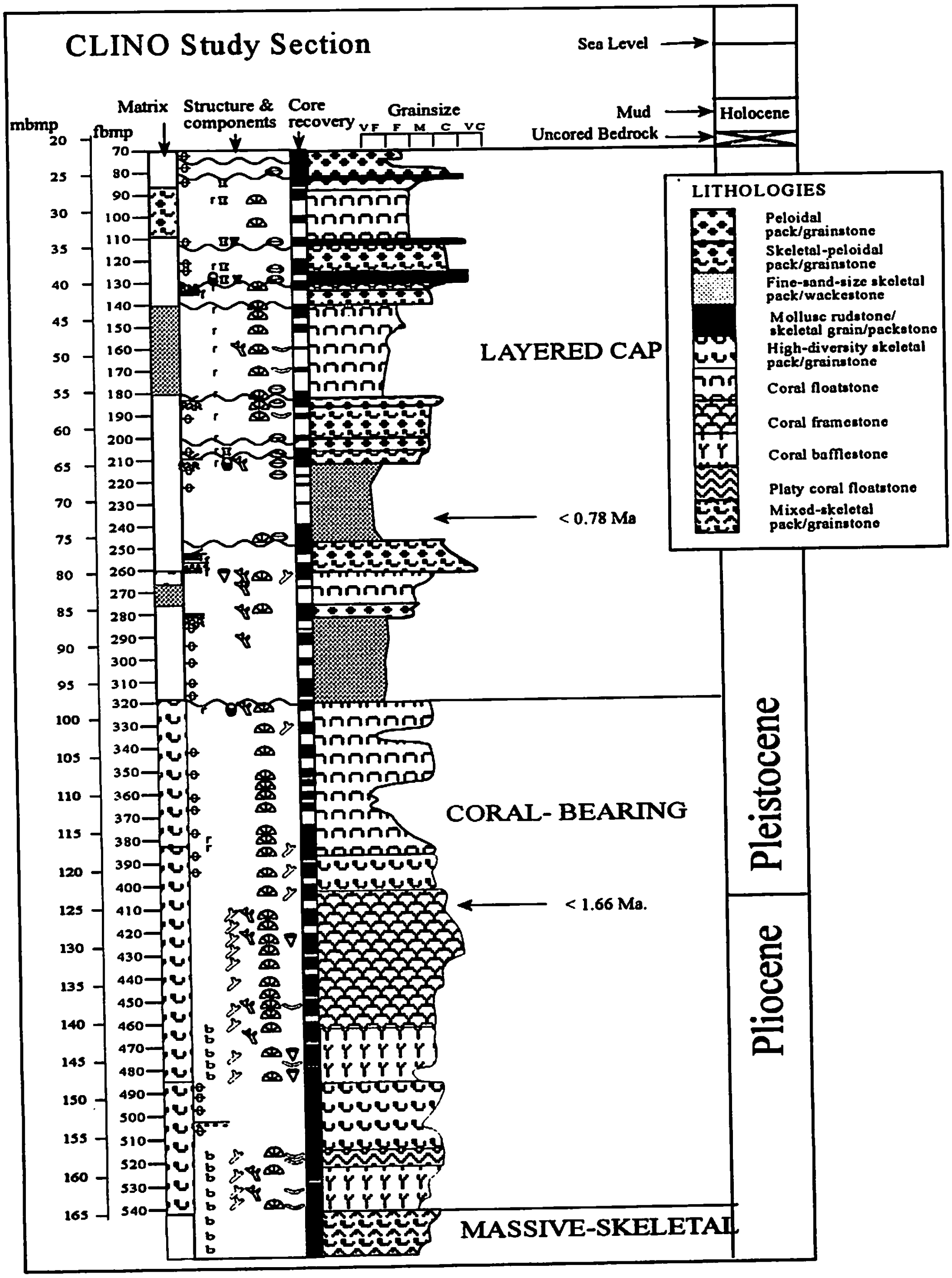

Figure 5: Log of Core Clino showing the lithofacies, core recovery, structures, and a variety of components. Note that despite the fact that Clino and Unda both consist of a similar tripartite succession, the lithologies are highly variable from Clino to Unda.

incomplete core barrels was always pushed up to the top of the cored interval.

Corals were described macroscopically and in thin section by A.F. Budd (Budd and Kievman, in press). Coral types, morphology, abundances, and matrix composition and fabric were used to subdivide the coral-bearing sections into lithofacies. Using the terminology of Embry and Klovan (1972), framestone is used for zones where predominant corals are massive, and their encrusted nature suggests an organically-bound reef structure; bafflestone is used where branched corals are predominant, and corals are inferred to be *in situ;* and floatstone is used for zones where corals are matrix-supported, and more than 10 % of corals are larger than 2 mm (Figures 4, 5).

In the remainder of the text, depths are expressed in meters below mud pit (mbmp); for Clino subtract 14.9 m for meters below sea floor (mbsf), for Unda subtract 11.9 m for mbsf.

SEDIMENTOLOGY

The major lithologic packages in the upper 200 m of the cores represent a tripartite offlapping succession. From the top down, this succession consists of the following intervals: (1) layered cap, (2) coral-bearing, and (3) mixed-skeletal packstone and grainstone (Figures 4, 5). The term layered cap is used to describe 1 to 10 m thick units separated by discontinuity horizons. Coral-bearing is used to describe the intervals with abundant corals. The term mixed-skeletal is used to describe intervals with predominantly skeletal, non-coralline components.

Sedimentology of the Layered Cap

Description

In Unda, the layered cap is 50 m thick (average core recovery is 62%), and in Clino it is 78.2 m thick (average core recovery is 44%). The layered cap consists of the Lucayan Formation in Unda, and its stratigraphic-equivalent coral-bearing interval in Clino (Beach and Ginsburg, 1980; Pierson, 1983; Williams, 1985) (see Figures 4, 5). Seven lithofacies identified in the layered cap are: peloidal, peloidal-skeletal, high-diversity skeletal packstone or grainstone, coral floatstone, fine sand-size skeletal packstone or wackestone, coarse skeletal grainstone or molluscan rudstone, and discontinuity horizons. Constituents include peloids, coated grains, benthic forams, and molluscs (for a more complete description of each lithofacies see Kievman and Ginsburg, in press). Deposits between the discontinuity horizons consist of alternations and mixtures of fine to coarse sand-sized grainstone to packstone, molluscan floatstone, and coralline floatstone with centimeter-sized vugs and moldic porosity.

In Clino, thick accumulations of corals and millimeter to centimeter-scale, planar- and cross-laminae occur. Whereas, in Unda, sedimentary structures consist of bioturbation, including circular areas of coarser grains and tubular structures inferred to be the results of burrowing by crustaceans (*Callianassa* spp.).

Boundaries

Coring in Clino and Unda began below the Pleistocene/Holocene boundary; however, the subaerial exposure horizon at the top of the Pleistocene is an unconformity that is post-Sangamon (Hoffmeister and Multer, 1964; Neumann and Moore, 1975; Beach 1982). In other cores from GBB, sediments from just below this unconformity are largely shallow-water bank carbonates (Beach, 1982). In Unda and Clino, the lower boundary, between the layered cap and coral-bearing sections, is a discontinuity horizon. In Unda, this boundary lies at 63.8 m, where there is a highly-altered, reddish-brown stained zone, and a sharp facies change from a branched coral floatstone below, to a skeletal-peloidal packstone above. In Clino, this boundary lies at 97.9 m, where there is a sharp facies change from massive-coral floatstone below, to very fine-grained skeletal packstone/wackestone above. In Clino, there is also a change in trace fossils at this boundary, from vertical *Thalassanoides* at 98 m and below, to a deeper-water, soft-bottom assemblage containing *Asterosoma* at 96.7 m and above (S. G. Pemberton, pers. comm., 1992).

Depositional Paleoenvironmental Interpretation.

The layered cap is interpreted as representing a shallow bank-top paleoenvironment because the predominance of peloid-rich facies in Unda is similar to the sediments found on the broad, protected, shallow-bank interior of GBB today. Likewise, the coralgal and skeletal facies in Clino are equated to the modern coralgal margin. The dominance of massive *Montastraea annularis* corals, the mound-shaped geometries of the strata, and the predominance of skeletal interstitial and interbedded sediments in Clino suggest that these were patch reefs. Discontinuity horizons consist of features that are indicative of subaerial exposure, and they are inferred to represent sea-level low stands, or more precisely, falling sea level. Each package of submarine limestone and subaerial exposure horizons is interpreted as a parasequence that is equivalent to a complete sea-level cycle.

Sedimentology of the Coral-Bearing Interval

Description

Below the layered cap, abundant and diverse corals extend for 44 m in Unda, and 67 m in Clino (Figures 4, 5). Average core recovery in this interval is 47 % in Unda, and 69 % in Clino. This interval consists of distinctive variations in abundance and frequency, types, and assemblages of corals. It includes: thick zones of coralline floatstones, bafflestones, and framestones interbedded with skeletal grainstones and packstones; variations in diversity, abundance, and types of corals (branching, platy, and massive-shaped coral); and centimeter-scale vugs, moldic, and intergranular porosity. Overall, coral diversity decreases upward in Unda; in Clino, however, diversity increases upward to 122 m, then decreases (Budd and Kievman, in press).

Boundaries

The boundary between the coral-bearing intervals and the overlying layered cap was previously discussed. In Unda, the lower boundary of the coral-bearing section is a sharp firmground surface on the mixed-skeletal sands (G. Pemberton, pers. comm., 1992). Also, molds of several pieces of flat-lying branching coral, *Stylophora* sp., occur at this boundary. In Clino, the lower boundary is placed at the base of the first zone of abundant coral (164.7 m) within a gradational zone of interbedded coral and skeletal sand (Figure 5).

DepositionalPaleoenvironmentalInterpretation

Coral-bearing intervals are interpreted as reefal by comparison with Pleistocene and modern reefs. Low- to high-energy, shallow bank-margin reefs, are inferred from the types of corals, the geometries and thickness of the strata, and the interstitial and interbedded sediments.

In Clino, the reef shoals upward. Near the base are platy corals interpreted as a deeper fore reef assemblage. This grades up to reef crest with a diverse assemblage of massive and branched corals, including *Acropora palmata*. Overlying this is a back reef composed of a low-diversity assemblage of predominantly massive corals. The back reef deposits are overlain by a fine-grained skeletal wackestone that marks the base of another shoaling-upward sequence.

In Unda, two reefal successions are inferred from the corals. At the base is a shallow diverse reef. The overlying interval is a shoaling-upward sequence from deeper fore-reef deposits composed of a low-diversity assemblage of small branched corals, to back reef deposits composed of a different low-diversity assemblage, mostly of branched corals, that are capped by a subaerial exposure horizon. Reefs as extensive as those found in Clino and Unda do not occur on the leeward margin of GBB today. Instead, the modern leeward margin is largely composed of skeletal and peloidal sands.

Sedimentology of the Mixed-Skeletal Packstone and Grainstone Interval

Description

Below the coral-bearing section, are bioturbated, fine- to coarse-grained, diverse skeletal packstones and grainstones without exposure horizons. In Unda, this interval continues from 108 m to 293 m, where an older coral-bearing interval begins. In Clino, this interval continues from 165 m to 197.5 m, where fine-grained deposits begin. Several features in these rocks provide important clues to the paleoenvironments represented by the mixed-skeletal interval: non-phototrophic organisms (e.g., ahermatypic corals), abundant bryozoans and planktic foraminifera, large (>2 mm) encrusting benthic foraminifera, burrow mottling and burrows filled with very coarse skeletal concentrations with abundant small molluscs (< 1 cm) in Unda, and large *Halimeda* plates in Clino. This interval includes zones of poorly indurated sediment interbedded with very well-indurated sediment, and hardground and firmground surfaces.

Boundaries

The upper boundary of this interval was discussed earlier. In Clino, the lower boundary, between the mixed skeletal section and the fine-grained deposits (at 197.5m) is a firmground surface (pers.comm., G. Pemberton, 1992). In Unda, the lower boundary is marked by the appearance of another coral-bearing deposit (at 293,m).

DepositionalPaleoenvironmentalInterpretation

The association with the overlying coralline rocks, the low abundance of peloids and other features diagnostic of the layered cap rocks, and the occurrence of a suite of skeletal components described above (including non-phototropic organisms), suggests a shallow-slope or deep fore-reef setting (water depths > 20 m). The lack of mud matrix suggests either low productivity of mud, wave winnowing, or possible bypassing.

GEOCHRONOLOGY

Two paleomagnetic reversals, the Brunhes/Matuyama (B/M at 0.78 Ma) and the top of Olduvai (1.66 Ma), provide control for high-resolution correlation previously unavailable in the Bahamas (McNeill et al., in press) (Figures 4, 5). Additionally, two of the cores (ABM and U3) that Beach (1982) described have been dated magnetostratigraphically by McNeill (pers. comm.), and were used to construct a new regional cross-section of the leeward bank (Figure 6). Unfortunately, these magnetostratigraphic dates are limited by the lack of biostratigraphic control, and the near complete recrystallization of aragonite (which precludes the use other potential dating methods).

EVOLUTION OF THE LEEWARD MARGIN

Despite dating limitations, cores Clino and Unda provide a new deeper view of the leeward margin of GBB, and they provide insight into the dynamics and timing of margin progradation. The correlation proposed is used to interpret the Pliocene to Recent history of the leeward margin of GBB. From the core descriptions and correlations, the changes identified include: a flattening of the platform slope (from Pliocene to Pleistocene), the development of meter-scale alternations of shallow-marine carbonates and subaerial exposure horizons, and major compositional changes in the sediment (Figure 6). Only during the latest Pleistocene did the entire leeward bank become similar in composition (non-skeletal) and morphology to the modern Great Bahama Bank.

The bank expanded, not as a simple continuous progradational event, but rather as several sedimentologic and morphologic steps in response to changing sea level (Figure 7). (1) During the Pliocene the margin backstepped (east). A thick interval of discrete packages of mostly medium- to coarse- grained skeletal, deep fore-reef packstone and grainstone grades down-slope to fine-grained slope sediments (from Unda to Clino). (2) Progradation occurred during the middle-late Pliocene, and resulted in the reef complex steepening the previous fore-reef grainstone deposits (Unda). (3) After an aggradational stage, sea level fell at least 60 m, and subaerially exposed the Pliocene reefal margin. (4) By late Pliocene to early Pleistocene, during a sea-level rise, a new reefal margin developed down-slope, some 100 m lower vertically (at Clino). (5) By early Pleistocene when rising sea level finally flooded the old Pliocene margin, a stage of renewed progradation occurred. It was at this time that sediment compositions changed from predominantly skeletal to non-skeletal (in Unda). Parasequences indicate that variations in sea level subaerially exposed the bank 12 times during the Pleistocene. Great Bahama Bank responded to these frequent late Pleistocene sea-level oscillations by shoaling to become a steep-sided, flat-topped bank.

The depositional history described highlights the important role corals and reefs have played in the development of Great Bahama Bank. Reef deposits can be used to track changing sea levels on the leeward margin. In response to changing sea level, reefal deposits prograde, downstep, and regress several times during the Pliocene and Pleistocene. It is only during the latest Pleistocene that reefs play a relatively minor

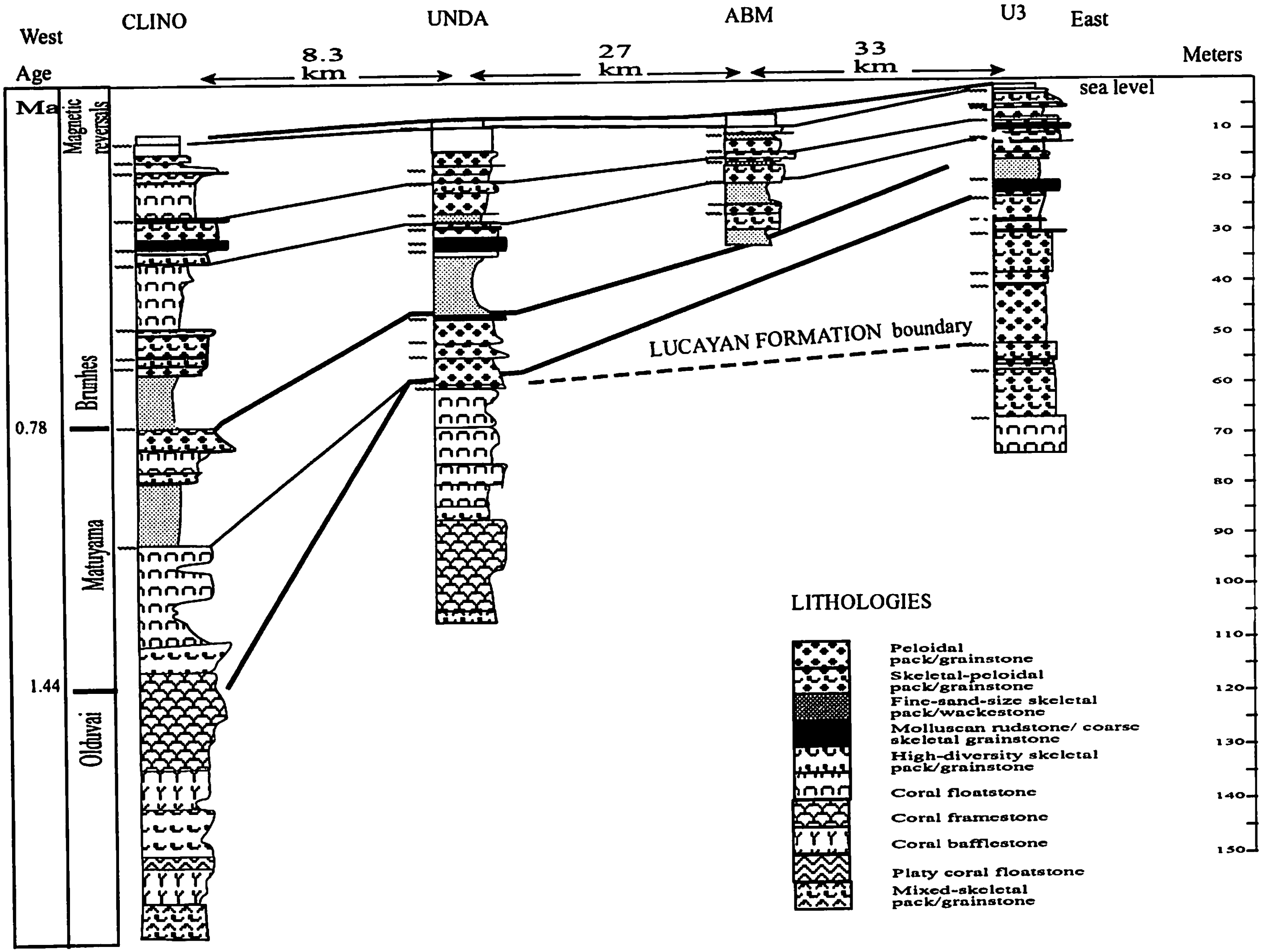

Figure 6: Correlation of cores that have been dated (Clino, Unda, ABM, U3). The major change from skeletal to non-skeletal facies can be seen in the interior of the bank. At Clino, however, Lucayan sediments are either coral-bearing, or are skeletal-peloidal packstone and grainstone, which makes it impossible to identify the formation on the margin.

role on the leeward margin.

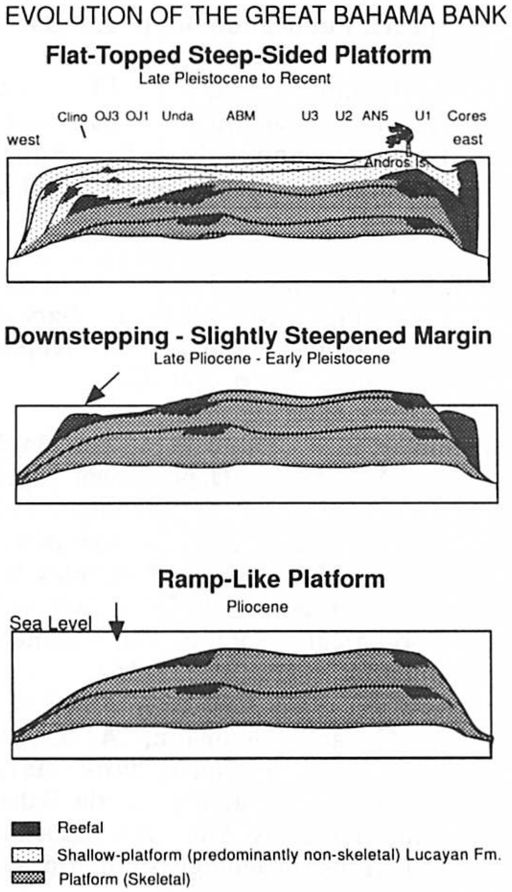

Figure 7: Diagrams illustrating the evolution of the Great Bahama Bank (see text).

ACKNOWLEDGMENTS

I thank Robert N. Ginsburg for his insight, and years of invaluable advice. Two anonymous reviewers are acknowldged for their helpful suggestions. Supported by funding from the Department of Defense National Science and Engineering Fellowship, and grants from the American Geological Institute and Exxon Corporation.

REFERENCES

Ahr, W. M., 1989, Sedimentary and tectonic controls on the development of an early Mississippian carbonate ramp, Sacramento Mountains area, New Mexico, *in* Crevello, P.D., Wilson, J.L., Sarg, J.F., Read, J.F., eds., Controls on Carbonate Platform and Basin Development: Society of Economic Paleontologists and Mineralogists, Special Publication 44, p. 203-212.

Beach, D. K., 1982, Depositional and diagenic history of Pliocene-Pleistocene carbonates of Northwestern Great Bahama Bank: Evolution of a carbonate platform: Ph.D. Dissertation, University of Miami, Florida, 600 p.

Beach, D. K., 1993, Submarine cementation of subsurface Pliocene carbonates from the interior of Great Bahama Bank: Journal of Sedimentary Petrology, v. 63, p. 1059-1069.

Beach, D. K., 1995, Controls and effects of subaerial exposure on cementation and development of porosity on the subsurface of Great Bahama Bank, *in* Budd, D. A., Saller, A. H., Harris, P.M., eds., Unconformities and Porosity in Carbonate Strata: American Association of Petroleum Geologists Memoir 63, p. 1-33.

Beach, D. K. and Ginsburg, R. N., 1980, Facies succession of Pliocene-Pleistocene carbonates, Northwestern Great Bahama Bank: American Association of Petroleum Geologists Bulletin, v. 64, p. 1634-1642.

Budd, A. F. and Kievman, C. M., in press, Environmental interpretations using corals: Results from the Bahamas Drilling Project: Society of Petroleum Geologists and Mineralogists, Concepts in Geology.

Cant, R. V., 1977, Role of coral deposits in building the margins of the Bahama Banks, *in* Taylor, D. L., ed., Proceedings of the Third International Coral Reef Symposium, v. 2, Geology, University of Miami, Florida, p. 9-13; Cenozoic carbonates of the Southeastern Bahamas: unpublished thesis, University of Miami, Florida, 312 p.

Carew, J. L. and Mylroie, J. E., 1985, Pleistocene and Holocene stratigraphy of San Salvador Island, Bahamas, with reference to marine and terrestrial lithofacies at French Bay, *in* Curran, H. A., ed., Guidebook for Geological Society of America, Orlando Annual Meeting Field Trip #2, Fort Lauderdale, Florida: San Salvador, CCFL Bahamian Field Station, p. 11-61.

Carew, J. L. and Mylroie, J. E., 1995, Depositional model and stratigraphy for the Quaternary geology of the Bahamas Islands, *in* Curran, H.A. and White, B., eds., Terrestrial and shallow marine geology of the Bahamas and Bermuda: Geological Society of America Special Paper 300, p. 5- 32.

Chen, J. H., Curran, H. A., White, B. and Wasserburg, G. J., 1991, Precise chronology of the last interglacial period:^{234}U-^{230}Th data from fossil coral reefs in the Bahamas: Geological Society of America Bulletin, v. 103, p. 82-97.

Curran, H. A., White, B.,Chen, J. H., and Wasserburg, G. J., 1989, Comparative morphologic analysis and geochronology for the development and decline of two Pleistocene coral reefs, San Salvador and Great Inagua Islands, Bahamas, *in* Mylroie, J.E., ed., Proceedings of the Fourth Symposium on the Geology of the Bahamas: San Salvador, Bahamian Field Station, p. 107-117.

Dunham, R. J., 1962, Classification of carbonate rocks according to depositional texture, *in* Ham, W. E., ed,. Classification of carbonate rocks: American Association Petroleum Geologists, Memoir 1, p. 108-122.

Eberli, G. P. and Ginsburg, R. N., 1989, Cenozoic progradation of Northwestern Great Bahama Bank: A record of lateral platform growth and sea-level fluctions, *in* Crevello, P. D., Wilson, J. L., Sarg, J. F., Read, J. F., eds., : Society of Economic Paleontologists and Mineralogists, Special Publication 44, p. 339-351.

Embry, A. F. and Klovan, J. E., 1972, A late Devonian reef tract on northeastern Banks island, N.W.T.: Bulletin Canadian Petroleum Geology, v. 19, p. 730-781.

Garrett, P. and Gould, S. J., 1984, Geology of New Providence Island, Bahamas: Geological Society of America Bulletin, v. 95, p. 209-220.

Goldhammer, R. K., Dunn, P. A., and Hardie, L. A., 1990, Depositional cycles, composite sea-level changes, cycle stacking patterns and the heirarchy of stratigraphic forcing: Examples from Alpine Triassic platform carbonates: Geological Society of America Bulletin, v. 102, p. 535-562.

Hine, A. C. and Neumann, A. C.,1977, Shallow carbonate-bank-margin growth and structure, Little Bahama Bank, Bahamas: American Association of Petroleum Geologists Bulletin, v. 61, p. 376-405.

Hoffmeister, J. E. and Multer, H. G., 1964, Growth rate estimates of a Pleistocene coral reef of Florida: Geological Society of America Bulletin, v.75, p. 353-358.

Illing, L. M., 1954, Bahaman calcareous sands: American Association of Petroleum Geologists Bulletin, v. 38, p. 1-95.

Kendall, C. G. St.C. and Schlager, W., 1981, Carbonates and relative changes in sea level: Marine Geology, v. 44, p. 181-212.

Kievman, C. M. and Ginsburg, R. N., in press, Depositional history of the leeward margin of the Great Bahama Bank, Pliocene to Pleistocene, SEPM Concepts in Geology.

McNeill, D. F., 1989, Magnetostratigraphic dating and magnetization of Cenozoic platform carbonates from the Bahamas: PhD Dissertation, University of Miami, Florida, 208p.

Mullins, H. T. and Neumann, A. C., 1979, Deep carbonate bank margin structure and sedimentation in Northern Bahamas: Society Economic Paleontologists Mineralogists, Special Publication 27, p. 165-192.

Mutti, M. , Bernoulli, D., Eberli, G. P. and Vecsei, A., 1996, Depositional geometries and facies associations in an upper Cretaceous prograding carbonate platform margin (Orfento supersequence), Maiella, Italy: Journal of Sedimentary Research, v. 66, p.749-765.

Neumann, A. C. and Hine, A. C., 1974, Shallow and deep bank margin structure and sedimentation: Little Bahamas Bank: Geological Society of America, Abstracts with Programs, v. 6, p. 888-889.

Neumann, A. C. and Moore, W. S., 1975, Sea level events and Pleistocene coral ages in the Northern Bahamas: Quaternary Research, v. 5, p. 215 - 224.

Newell, N. D. and Rigby, K., 1957, Geological studies on the Great Bahama Bank, *in* LeBland, R. J. and Breeding, J. G., eds., Regional Aspects of Carbonate Deposition: Society of Economic Paleontologists and Mineralogists, Special Publication, 5, p. 15-22.

Pierson, P. J., 1983, Cyclic sedimentation, limestone diagenesis and dolomization in upper Cenozoic carbonates of the Southeastern Bahamas: Ph.D. Dissertation, University of Miami, Florida, 312 p.

Purdy, E. G., 1963, Recent calcium carbonate facies of the Great Bahama Bank, pt. 2, Sedimentary facies: Journal of Geology, v. 71, p. 472-497.

Read, J. F., 1985, Carbonate platform facies model: American Association Petroleum Geologists Bulletin, v. 69, p. 1-21.

Supko, P. R., 1970, Depositional and diagenetic patterns in subsurface Bahamian rocks: Ph.D. Dissertation, University of Miami, Florida, 80 p.

Williams, S. C., 1985, Stratigraphy, facies evolution, and diagenesis of late Cenozoic limestones and dolomites, Little Bahama Bank, Bahamas: Ph.D. Dissertation, University of Miami, Florida, 217 p.