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<u>Front Cover</u>: 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.

<u>Back Cover</u>: 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."

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LICHEN-LIKE PITTING ON *CERION* FROM SAN SALVADOR ISLAND, BAHAMAS

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ABSTRACT

Lichen-like pits are found in modern and fossil *Cerion* shells from San Salvador Island, Bahamas. These pits indicate that the shells have undergone, or have started to undergo, biodiagenesis. Because of the potential for biodiagenesis to alter shell material, potential anomalies in geochronologic analyses may result if these shells are used to document the stratigraphy of Bahamian Islands. A microscopic analysis of *Cerion*, or other terrestrial shells from subtropical and tropical environments, must be conducted prior to age-dating analysis. Such an examination will quickly elucidate whether the shells have been altered by algae, fungi, lichen, or lichen-like organisms.

INTRODUCTION

Lichen, fungi, and other microbionts associated with carbonate shell material may alter the substrate and accelerate diagenesis (e.g., Lukas, 1979; Jones and Pemberton, 1986). These microbionts can pit and corrode the surface of shells which leads to biotic dissolution and corrosion features, a form of biodiagenesis (after Jones and Kahle, 1985), and may introduce organic and inorganic contaminants. In addition to the affects on potential age determinations resulting from dissolution via subaerial exposure and meteoric waters, microbionts can also affect the age-dating of such shells (Walker, 1979). *Cerion*, an ubiquitous terrestrial snail of the Bahamas with an excellent modern and fossil record (Gould, 1988; Gould and Woodruff, 1986, 1990; Garrett and Gould, 1984), is not immune to microbiont infestation. *Cerion* is a potentially important biostratigraphic indicator (Garrett and Gould, 1984) for the Quaternary geology of the Bahamas, and it has had a limited, albeit, controversial use in developing a chronology for surficial rocks of the Bahamas (Carew and Mylroie, 1995; Mirecki et al., 1993). Its limited geochronologic usefulness is primarily because a large standard error is reported for AAR analyses using *Cerion* shells from various localities (Mirecki et al., 1993, and this volume). Could this be from vital effects of the snail, or from contamination by lichen or other microbionts either before or after burial? Microbiont occurrence was examined on modern and fossil *Cerion* from San Salvador Island, Bahamas to determine whether lichen-like associations were present, and to determine how widespread infestation by these organisms is. Additionally, we wanted to determine if these lichen-like organisms produce a taphonomic signature on the shell that can be recognized in fossil shells of *Cerion*.

METHODS

Modern and fossil shells of *Cerion* were collected from 13 localities on San Salvador Island, Bahamas. Shell height was measured with calipers, and all shells were examined for the presence of microbionts using a dissecting microscope (at 400x). Among the microbionts observed, the ones reported here are chiefly lichen-like forms; black-colored organisms that occur on both the calcareous substrate (rock or soil) and modern and fossil shells. Use of the term "lichen-like" for these organisms was suggested by Thomas Taylor (pers. comm., 1996, University of Kansas). Lichen-like organisms make pits in the shells, very much like those reported from bioerosion in intertidal areas. Similar black coatings have been attributed to lichen on brecciated limestone clasts (Jones and Kahle, 1985), and black lichen is also reported to form caliche in tropical and subtropical environments (Klappa, 1979). Thus, the term "lichen-like" is chosen here to describe this biotic feature seen on empty shells of modern and fossil *Cerion*. Also, cyanobacteria and algae are also present in shells that have a greenish coloration.

RESULTS

Examination of 748 modern and fossil *Cerion* shells indicates that lichen-like pits are primarily associated with float shells found at fossil localities (Table 1). "Float" shells are not *in situ*, but consist chiefly of fossil shells that have eroded out of an adjacent deposit, and come to rest on the modern substrate, where they are more prone to infestation with the lichen-like organisms that are found in these carbonate sands and soils (similar to algae and fungi described by Kahle, 1977). *In situ* fossil shells may also be infested by lichen-like organisms, if the shell is exposed above the surrounding matrix (Walker, pers. observ.). This is not a purely modern phenomenon, however, as shells currently imbedded in matrix may have been reworked in similar fashion in the past.

The lichen-like pits on the float and modern shells commonly contain this black-colored microbiont, but it is not present within similar pits on fossil shells that were enclosed by a surrounding matrix (i. e., *in situ*). The occurrence of lichen-like pits on examined fossil shells varied from none (at Watling's Quarry West) up to 75% (at the upper Gulf site) (Table 1). The mean percent of occurrence of pitting on shells from fossil sites was 23%. The mean percent of occurrence of lichen-like pitting on float shells was 47%.

Lichen-like pitting commonly occurs on portions of shells that are in contact with the substrate, which sometimes produces a "ring-like" feature on the shells (Figure 1A, B). The lichen-like organism produces roughened, irregular to perfectly rounded pits on the exterior and the interior of the aperture of *Cerion* shells (Figure 2).

DISCUSSION

Microbionts (e.g., fungi, lichen, algae) use acids to bore into carbonate substrates (Golubic, 1969; Silverman and Munoz, 1970). These organisms may also be responsible for forming calcareous crusts by a process involving both acidic dissolution and re-precipitation of micrite ("sparmicritisation"), but this process is not well understood (Kahle, 1977). Similar "crust-like" features occur within calcareous "paleosol" deposits that contain fossil *Cerion*. Some fossil-bearing deposits have also been seen to be covered by black, lichen-like crusts. Shells in contact with these crusts will be invaded by lichen-like organisms, and will develop and retain a taphonomic signature of irregular to rounded pits found on many areas of the shell.

The occurrence of lichen-like pits indicate that a shell has undergone, or has started to undergo, biodiagenesis. Because of the potential for biodiagenesis to alter shell material (e. g., Jones and Pemberton, 1986) and produce potential age-dating anomalies (Walker, 1979), it is imperative that a microscopic analysis of *Cerion*, or other terrestrial shells from subtropical and tropical environments, be conducted prior to age-determination analysis. Such an examination will quickly elucidate whether the shells have been altered by algae, fungi, lichen, or lichen-like organisms.

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TABLE 1. Lichen-like pitting on modern and fossil *Cerion*, San Salvador Island, Bahamas

Locality	Sample Size	Shell Height mean in mm (range)	Pitting from Lichen No. (%)	Presence of Algae/Cyano-bacteria
Almgreen Cay Fossil	51	21.23 (6.85-24.57)	2 (0.04)	0 (0.0)
Altar Cave Fossil	43	19.38 (15.54-20.98)	2 (0.05)	1 (0.02)
Altar Cave Float	44	19.14 (15.68-21.60)	23 (0.52)	0 (0.0)
Catto Cay, Fossil	50	19.05 (17.86-22.22)	13 (0.26)	0 (0.0)
Crab Cay, Fossil	16	20.84 (18.70-26.75)	1 (0.06)	0 (0.0)
French Bay, Fossil	42	21.96 (19.61-25.59)	23 (0.55)	0 (0.0)
Man Head Cay Fossil	101	14.70 (13.04-17.18)	9 (0.21)	0 (0.0)
North Point Holocene	55	23.68 21.24-27.61)	8 (0.15)	2 (0.04)
North Point Float	101	23.88 (19.97-25.84)	19 (0.19)	30 (0.30)
Snow Bay, Fossil	14	23.94 (22.86-29.10)	3 (0.21)	0 (0.0)
The Bluff Upper Paleosol Fossil	32	24.49 (21.35-28.43)	7 (0.22)	0 (0.0)
The Bluff, Lower Protosol	16	23.48 (18.96-27.72)	1 (0.06)	0 (0.0)
The Upper Gulf Paleosol (fossil)	32	22.59 (18.43-27.24)	24 (0.75)	0 (0.0)
Watling's Quarry West, fossil	44	19.56 (16.92-21.76)	0 (0.0)	0 (0.0)
Watling's Quarry East Side, Fossil	35	17.78 (13.77-22.75)	10 (0.29)	9 (0.0)
Watling Quarry Float	72	18.86 (10.03-23.02)	50 (0.69)	0 (0.0)

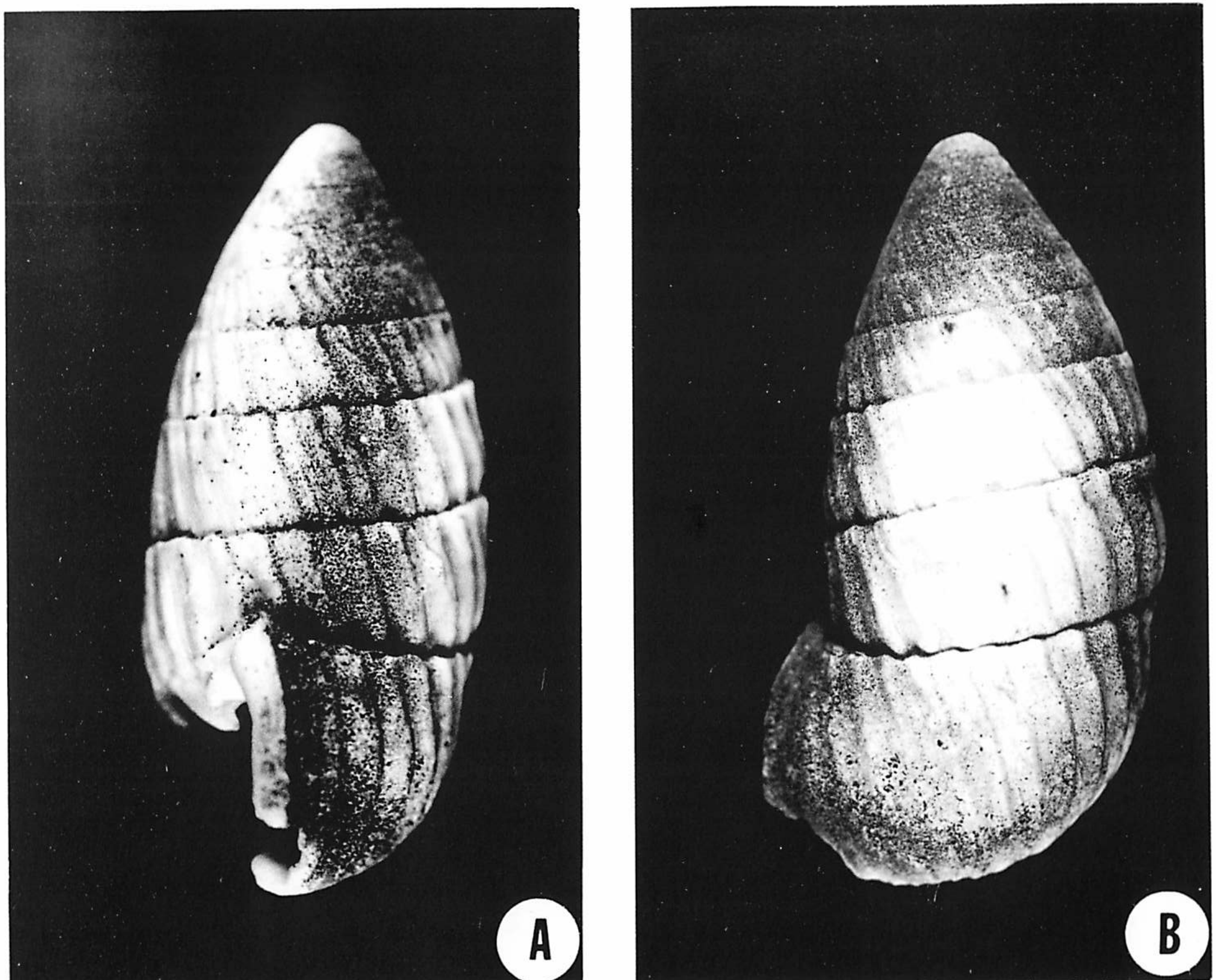

Figure 1. Recent Cerion from Crab Cay, San Salvador Island, Bahamas, with lichen-like organisms covering most of the shell. ***A**, side view, and **B**, top view,* *showing a ring-like appearance of lichen-like organisms on the shell.*

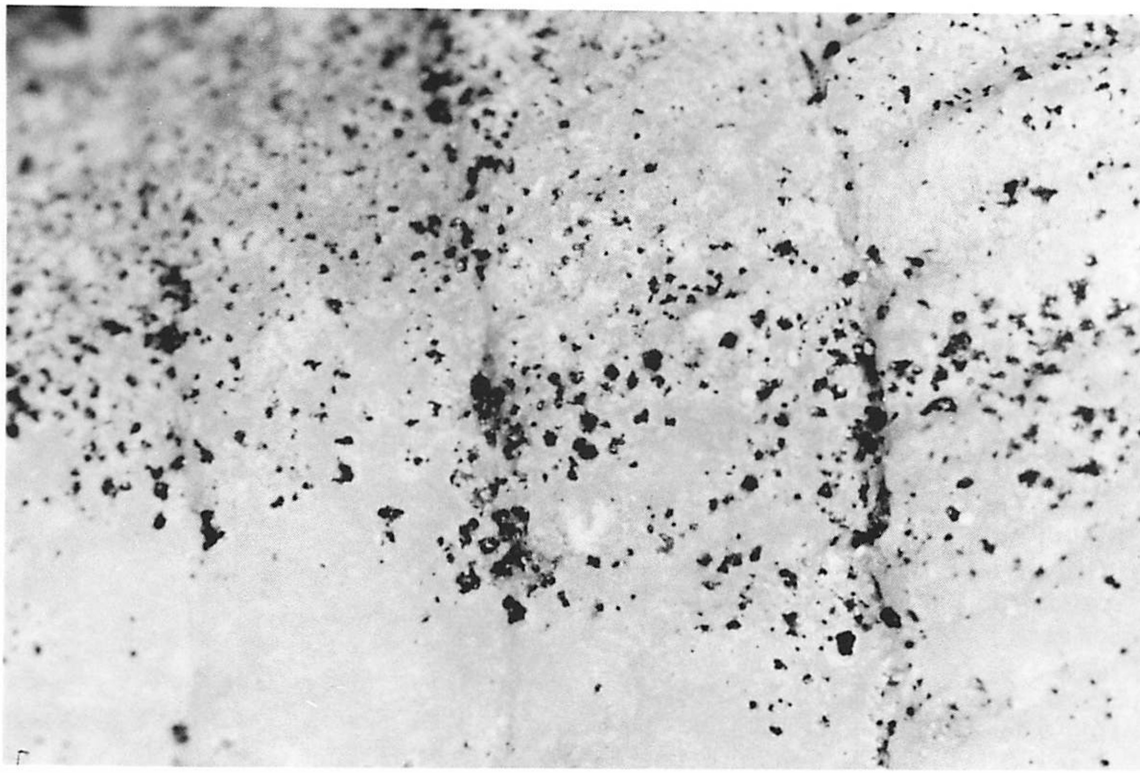

Figure 2. Lichen-like organisms and their pits on a Recent Cerion. (750x).

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