EFFECTS OF SEA LEVEL RISE ON THE DIAGENESIS OF QUATERNARY CARBONATE EOLIANITES OF SAN SALVADOR ISLAND, BAHAMAS

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INTRODUCTION

The study described in this paper began with field work done during the month of June 1988 on San Salvador Island in the eastern Bahamas and was completed as part of a year long senior thesis. The work involved careful mapping, profiling, and sampling of the Holocene and Pleistocene eolianites in the northeast corner of San Salvador. A detailed and extensive petrographic analysis of the eolianites was conducted to supplement the field work and create a comprehensive study of the diagenetic effects of the encroaching sea on the eolianites.

San Salvador Island is a small island approximately 11 km wide and 19 km long. It is surrounded by a narrow shelf which drops off quickly leading to a very steep continental slope (Curran, 1985). As with the other exposed Bahamian islands, the geology of San Salvador has been largely controlled by transgressions and regressions of the sea associated with the Pleistocene glacial advances and retreats. The oscillations of sea level first allowed for the formation and then lithification of the Pleistocene eolianites such as those found on Man Head Cay and then later the Holocene eolianites which line the coast at North Point (Carew and Mylroie, 1985) (See Figure 1).

The Pleistocene eolianites that are part of this study are found on Man Head Cay and belong to the Cockburn Town Member of the Grotto Beach Formation. These rocks were deposited during the Sangamon high stands and the following regression. The top of the section is marked by a paleosol/calcrete. This paleosol combined with rhizomorphs can be seen clearly on Man Head Cay (Carew and Mylroie, 1985).

The Holocene eolianites examined in this study are found at North Point and make up part of the coast along Rice Bay. They belong to the North Point Member of the Rice Bay Formation. These rocks were deposited in the post-glacial period before sea level rose to its present position, evidenced by the bedding of these eolianites that dips steeply below present sea level (Carew and Mylroie, 1985).

FIELDWORK

The eolianites of San Salvador have a color zonation similar to that first described in the Florida Keys by Stephenson and Stephenson (1950). In San Salvador there are four zones, White, Grey, Yellow, and Green. These color zones are associated with their position above sea level and some algal growth. The White and Grey zones are in the supratidal area while the Yellow is in the intertidal and the Green is in the intertidal to subtidal area. In this study a map was made of the field area at North Point demarking the zone contacts and topographic contours. From this map it can be seen that the zonation is not correlated exactly to elevation above sea level. Instead it varies somewhat depending on the details of the coastal morphology and exposure to seawater. Profiles were measured from the top of the eolianites, the White zone, down to the sea through the Grey and Yellow zones into the Green zone, and carefully sampled. (See Figure 2)

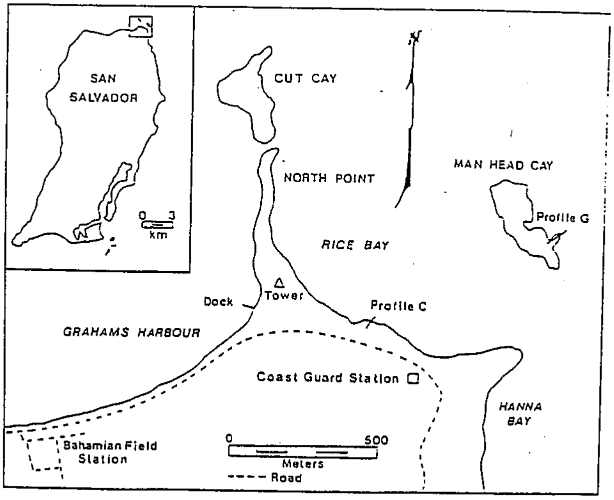

Figure 1

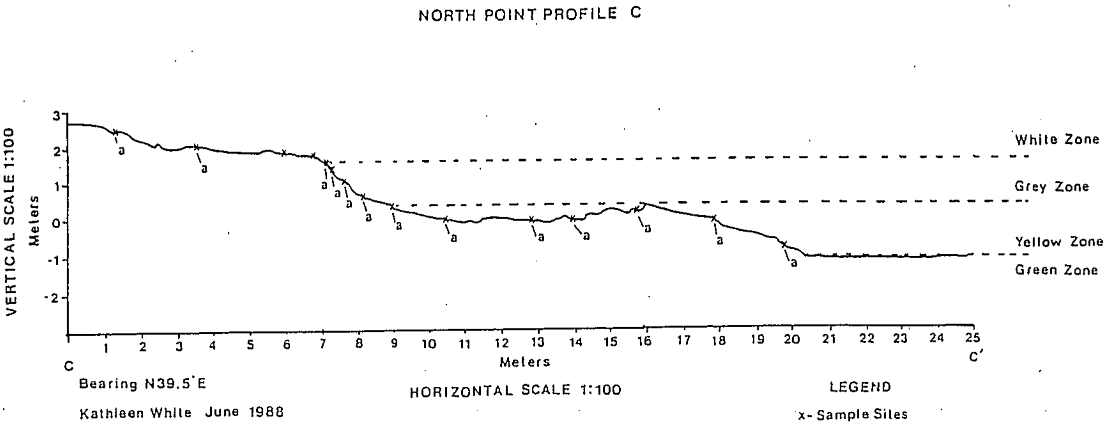

Figure 2a- Holocene Profile

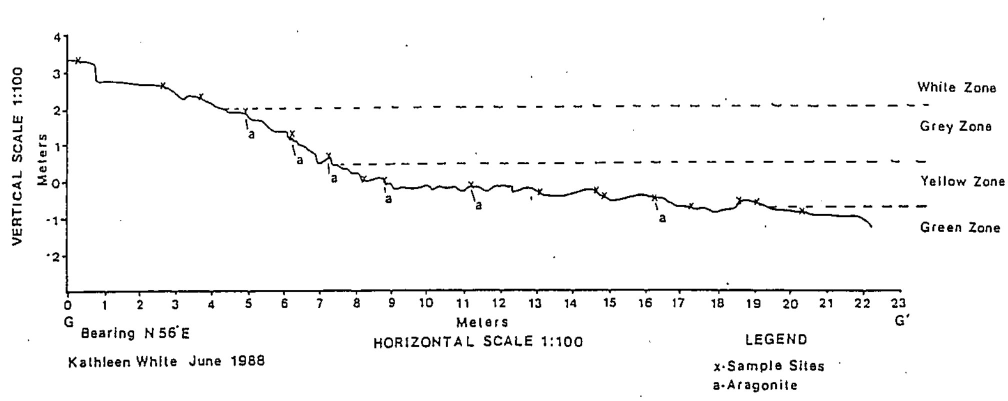

Figure 2b - Pleistocene Profile

Description of the Color Zones

The White zone has well-laminated sediments that clearly show the alternation between fine and coarse-grained layers characteristic of carbonate eolianites. In places the rocks are very smooth and in others the rock is riddled with holes which creates a pointy, sharp surface. The smoother surfaces show a very white color while the rougher areas are sometimes slightly greyer. Vegetation is scattered throughout this zone. The Grey zone also has smooth and rough areas. The lamination is still visible in this zone, but is not as distinct as in the White zone. The alternation of fine and coarse-grained layers is still determinable, but is not as evident as in the White zone. In the rough areas the rocks are very sharp and sometimes crumble underfoot. The Yellow zone is very similar to the rougher areas of the Grey zone except for the color. The fine and coarse-grained layers are still visible. Areas of this zone are very flat as if they are a bedding plane while other areas are much more eroded and small intertidal pools are present. The Green zone is almost always flat and smooth. It is encrusted with algae, worms, barnacles, chitons, and many other life forms. Because of the massive encrustation of the Green zone this study only involves the White, Grey, and Yellow zone in the sampling and petrographic analysis parts of this project.

PETROGRAPHIC ANALYSIS

The majority of the laboratry work done in this project was extensive petrographic analysis of the eolianite samples taken in San Salvador. Over 150 thin sections were examined for the grain composition of the samples and to determine the types of carbonate cements that are present in these rocks. The eolianites in general are dominated by freshwater cements, both phreatic and vadose. The cement is an equant-grained sparite that occurs intergranularly, intragranularly, and as a rim cement. Its dominant form is as an intergranular cement holding the grains together. Many of the samples have only this sparite cement in one form or another. However there is a significant number of samples which have an aragonite cement as well as the sparite cement, and even some which are dominantly aragonitic with only a small amount of the sparite cement. The presence of the aragonite cement is evidence that the eolianites are already undergoing marine diagenesis.

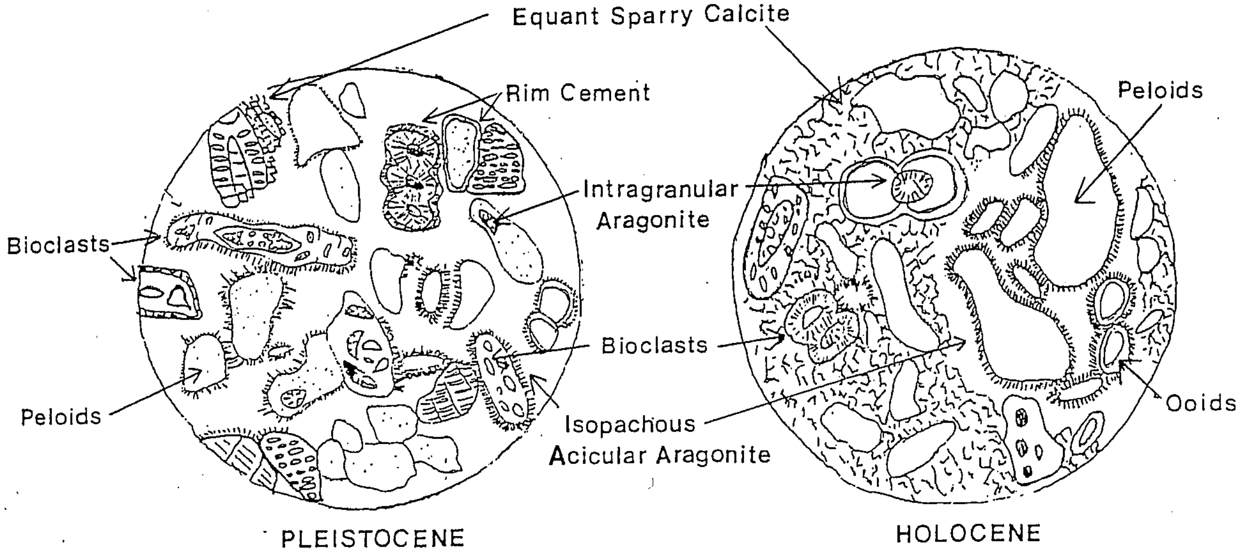

Figure 3

The aragonite cement is acicular in form and is both intergranular and intragranular. It often has an isopachous nature to it when it grows on grain edges or lines holes in grains, especially peloids. The aragonite forms most commonly where there is a lesser amount of sparite present, but it does grow directly on both the intergranular and intragranular sparite cement in places. Much of the intragranular aragonite fills chambers of foraminifera and gastropods, as well as other bioclasts, but it can also be found filling in dissolution holes in peloids and ooids. One especially good example of the intragranular aragonite is found in a sample where two ooids are joined and a dissolution hole cuts through both the ooids and is lined with acicular aragonite.(See Figure 3)

The intergranular acicular aragonite can be found as an abundant isopachous cement on every grain in a thin section. Sometimes the cement is so well-developed that acicular aragonite on one grain becomes interwoven with the acicular aragonite on another grain to form a network which holds these grains together. This occurs when the sparite cement is no longer present in an area of the thin section. The intergranular acicular aragonite cement is also found scattered throughout a thin section appearing on a grain edge, but not having an isopachous texture.

Both Pleistocene and Holocene samples have intergranular and intragranular aragonite cements. The major difference between the Pleistocene samples with aragonite and the Holocene samples with aragonite is the amount of sparite also present in the sample. The Pleistocene rocks in general are fairly devoid of the sparite cement, but especially so in the samples which contain aragonite. When aragonite is present in the Pleistocene samples it is abundant and forms on almost all the grains. When aragonite is not present in these samples there is either a sparite rim cement which holds the grains together, or a tiny amount of sparite scattered throughout the grain. This sparsity of cement contributes to their very friable nature.

The Holocene rocks still contain a fair amount of sparite cement, although the amount varies from sample to sample. It is this sparite cement that fundamentally holds the rocks together, but it is slowly being replaced by the marine aragonite cement. The presence of aragonite in the samples is controlled by the environment that the rock is in and its elevation above sea level. This also appears to be true in the Pleistocene, but is more clearly evident in the Holocene samples because there are six Holocene profiles available for comparison in this study and only one Pleistocene profile. The Holocene profiles are of three distinct morphologies, promontory, bay , and cliff. The abundance of aragonite found in the profiles of a promontory nature far exceeds the amount of aragonite found in either a bay area or a cliff section both in the amount in each sample and in the forms that the aragonite develops. The one Pleistocene profile was also of a promontory nature and contains an abundance of aragonite.

The other factor which determines the presence of aragonite is the position above sea level of the sample. The dominant zone for the presence of aragonite is between -1m and 2m above sea level. There are cases where either limit is exceeded, especially the higher boundary in a promontory section. This is probably because the ocean crashes up onto the promontory during high tide, and so forces the seawater up higher than the actual sea level. This does not occur in the bay sections, and only strong storm action can force the seawater up the cliff face.

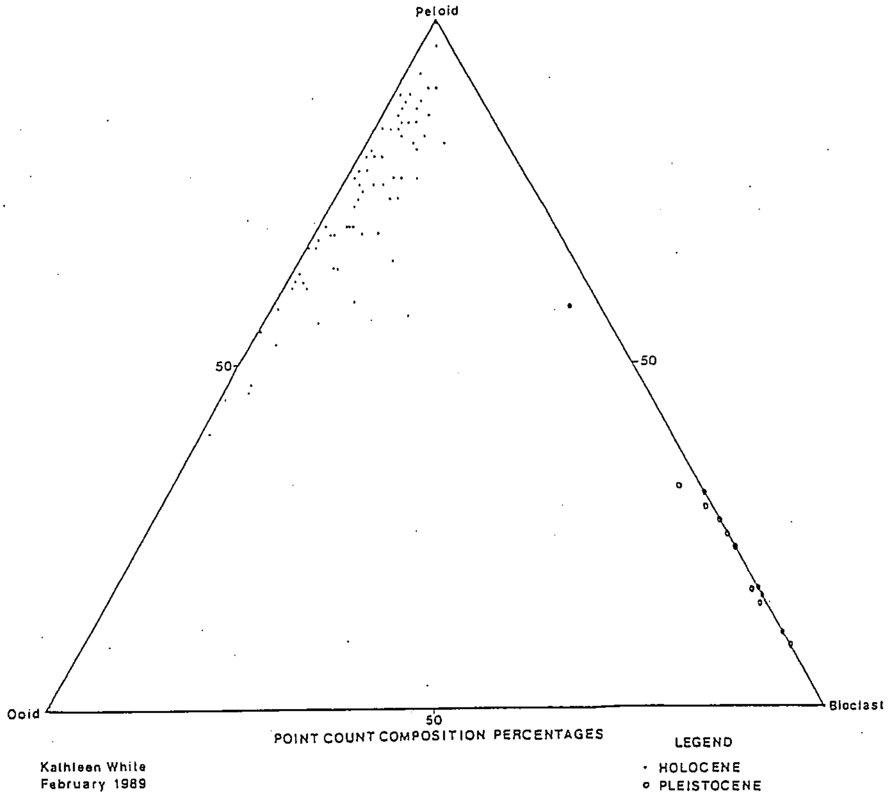

Figure 4

Further evidence that the presence of aragonite is dependent on elevation above sea level comes from point count data of the composition of all of the samples. There is very little difference between the compositions of any of the Holocene rocks. They are all dominated by peloids with some ooids and a small amount of bioclasts. Even though there is little difference between the compositions of these rocks there is a difference in the presence and abundance of aragonite. Furthermore the compositions of the Pleistocene rocks are very different from the Holocene rocks although very similar to each other (See Figure 4). These rocks are dominated by bioclasts with a small amount of peloids, and a few to no ooids present. The nature of the aragonite in the Pleistocene rocks is no different from the aragonite in the Holocene rocks. Therefore the chemical content and general nature of the grains is not contributing to the type of the cements found in these rocks.

In this project it was possible to conduct a well-controlled natural experiment because the eolianites' history of formation in a nonmarine environment and subsequent marine diagenesis during the Holocene transgression is simple and well known. The work done in the field and laboratory shows that the influence of sea level on the eolianites of San Salvador is a very strong one. Changes in sea level have not only allowed for their creation and lithification, but also for their later marine diagenesis.

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