ATOLL RESEARCH BULLETIN

NO. 196.

SUBMARINE CEMENTATION OF GRAINSTONE FABRIC, ST. CROIX, U.S. VIRGIN ISLANDS

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Issued by
THE SMITHSONIAN INSTITUTION
Washington, D.C., U.S.A.

February 1977

Atoll Research Bulletin No. 196. Gerhard, L.C. Feb. 1977

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ABSTRACT

Submarine cemented carbonate sand nodules occur off the northeast coast of St. Croix, U. S. Virgin Islands. Cementation occurs as a 50 micron thick rim of aragonite needles over a thin micrite envelope surrounding the cemented grains. The locality in which the nodules are found is characterized by large ripples with the sand in nearly constant motion. The sand is medium-grained with practically no very fine sand and no micrite; neither are pellets present. Cementation is the result of physicochemical processes, forming a basic grainstone fabric.

INTRODUCTION

Nodules of cemented carbonate skeletal sand occur several centimeters below and at the sediment-water interface in 35 feet of water off the northeast coast of St. Croix, U. S. Virgin Islands (Fig. 1), just west of Cottongarden Point. These nodules lie in loose sand in a channel between and parallel to the main barrier reef and a second, outer, reef which does not reach the surface. Actively moving large ripples in the sand bottom (Fig. 2) characterize the entire bottom of this area, including both areas of cemented nodules and areas where no cementation occurs.

Individual nodules range from a few cemented grains to masses 8 centimeters in maximum diameter (Fig. 3). Grains in cemented nodules, nodule-bearing sands, and non-nodule-bearing sands are medium-grained, well-sorted, skeletal sands (Fig. 4). Percentage of individual skeletal constituents are approximately the same in the cemented material, nodule-bearing sands, and non-nodule-bearing sands (Table 1), and no clastic rock grains are present in either nodules or sands. Practically no micrite or pellets are present in any sample.

The cement is exclusively aragonite, determined by SEM and electron microprobe (Fred T. Mackenzie personal communication). Aragonite needles rim individual grains or small clusters of several grains. These rims average about 50 microns in thickness, with individual crystals

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(Manuscript received August 1974--Eds.)

oriented normal or subnormal to grain boundaries (Fig. 5). Nearly every grain coated with the aragonite rim cement also has a thin micrite envelope below the aragonite. Cementation appears to be more complete in the centers of nodules than towards the exterior. Coarse particles are not cemented as well as those of near-mode size.

Sand ripples are symmetrical approximately 10 centimeters high from trough to crest, and the sand is in relatively constant motion during times of normal ocean swell (Fig. 2). Although the site of cementation has not been visited during storm swell times, logically the motion is even stronger then.

DISCUSSION

Many examples of modern carbonate cementation are known from a variety of geographic locations and environments. Nearly all of these examples are from "special" environments, that is, those with subaerial exposure, high salinity, or other non-normal marine characteristics. Most of these examples also involve either pellets in the sediment, micrite, or both. (A short note is not the place to give an extensive literature summary, but the papers and references of Macintyre et al, 1968; Bricker, 1971; and Sibley and Murray, 1972 are pertinent). Many of these previously described types of cementation occur on St. Croix in addition to the cement described here.

The major unique characteristics of the cementation described here are the occurrence of the cement in open, normal marine water, lack of pellets, lack of fine-grained sediment, and lack of a physical stabilizer. Cementation under these circumstances appears to be rare (Chilingar, et al, 1967, p. 186), although this cement is similar to that reported by Shinn (1969) in the Persian Gulf.

Granulometric analysis of nodule-bearing and non-nodule-bearing sands from the cement area provides little insight into the cause of cementation (Fig. 4). Both samples are well-sorted. Graphic standard deviation of the host sand is .40 phi, a well sorted sand (Folk, 1961) and the same parameter in the non-host sand is .50 phi, still a well-sorted sand. In both samples less than 5% of the total sample is less than 1.5 phi size, demonstrating that any fine sand or smaller particles either have been winowed out or have not been deposited. There is a sharp inflection in the cumulative curves of these samples between the most frequently occurring particle size and the next smaller 1/2 phi interval, although a much less marked inflection occurs to larger phi sizes. There is nearly no insoluble residue in these samples. The two samples are virtually identical in size and sorting except for the broader total size spread of the nodule-bearing area sample compared with the non-nodule-bearing area sample (-2.0 to 3 phi compared to -1.5 to 2.5 phi).

Constituent particle analysis of the two sand samples and the cemented sand itself sheds little additional information (Table 1). Coral content of each sample is about the same, no sample contains any pellets, and foraminifera, molluscs, and coralline algae form the remainder of the samples. The category "other" contains unidentified grains, Halimeda, echinoderms, and other miscellaneous skeletal materials. Individual grain skeletal fabrics are unaltered. No discoloration is present nor are any of the cemented grains previously micritized.

Radiometric dating has not been done, but the cementation is interpreted to be modern because the cemented sands are identical to the sands currently being generated and transported in that environment, no pre-existing cemented carbonates of this kind have been discovered in this general area (or anyplace else on the island), no terrigenous (clastic) grains exist in the cemented or uncemented sands, although such grains are ubiquitous in nearshore or beach deposits (if the cemented nodules were remnants of earlier Holocene beachrock, they would contain large numbers of clastic grains), and grains are not pervasively micritized as is common in most of the St. Croix examples of cemented carbonate sands.

Cementation cause is probably purely physicochemical. Cement morphology is that predicted for normal marine subtidal cement by Badiozamani, Mackenzie and Thorstenson (1973) from laboratory studies (Mackenzie, personal communication). Sands are not stabilized at the surface, but about 4 centimeters below the troughs of ripples the sand is not moved except during uncommonly high seas. Cementation apparently takes place in the temporarily stabilized sand forming nodules, which are periodically moved by storm waves. No cemented layer has been found, so the nodules do not lie at rest for really extended periods of time, but are moved several times each year. Nucleation of cement appears to be preferential to grains with micrite envelopes. The resulting fabric (Fig. 5) is the precursor of typical grainstone fabric such as that of the Lower Ordovician Manitou Limestone (Gerhard, 1972, p. 18).

CONCLUSIONS

Cementation in basically unstabilized carbonate sands which have no appreciable micrite component and which are deposited well below low tide occurs. There appears to be no granulometric or constituent skeletal particle basis for cementation control, as nodule-bearing and non-nodule-bearing sands are virtually identical in size, sorting, and constituent particles. Cementation appears to be the result of purely physicochemical processes in temporarily stabilized carbonate sands. This example of submarine cementation is significant because it occurs under normal marine conditions, forms a grainstone fabric, and can be the source of grainstone fabric intraclasts in other textural type carbonate rocks.

ACKNOWLEDGEMENTS

I wish to thank Fred T. Mackenzie for analysis of the cement composition and for his discussions of the problem, and John Milliman who read the manuscript and made suggestions for its improvement. This is West Indies Laboratory Contribution No. 20.

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Table 1. Constituent particle analysis of cemented nodules, nodule-bearing sand and non-nodule bearing sand.

	Cemented Nodule	Nodule-bearing Sand	Non-Nodule-Bearing Sand
Coral	50.6%	51.7%	51.1%
Foraminifera	20.6	16.5	26.5
Coralline Algae	14.5	18.9	12.9
Mollusc	11.6	8.2	5.7
Other	2.7	4.7	3.8
	100.0	100.0	100.0

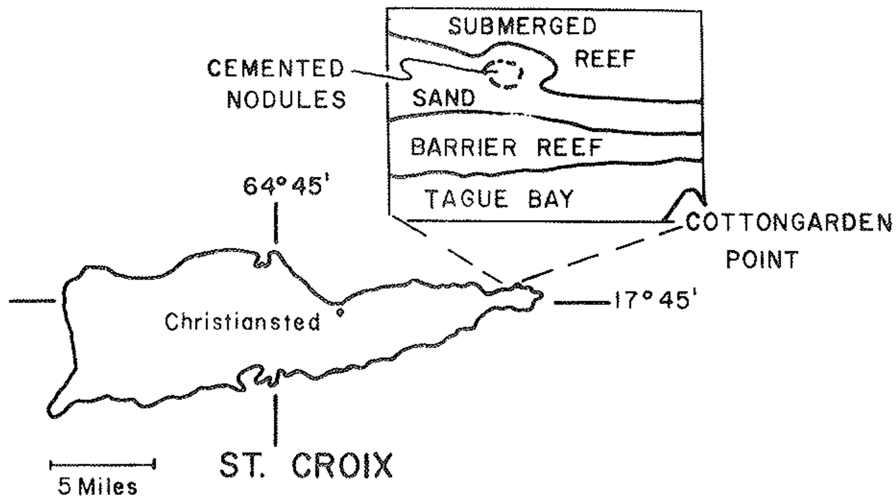

Fig. 1 Location map showing St. Croix and enlargement of area where cementation occurs.

Fig. 2 Sand ripples in cemented area, 35 feet deep, showing crestal sand in motion. Ripples are about 10 cm. high.

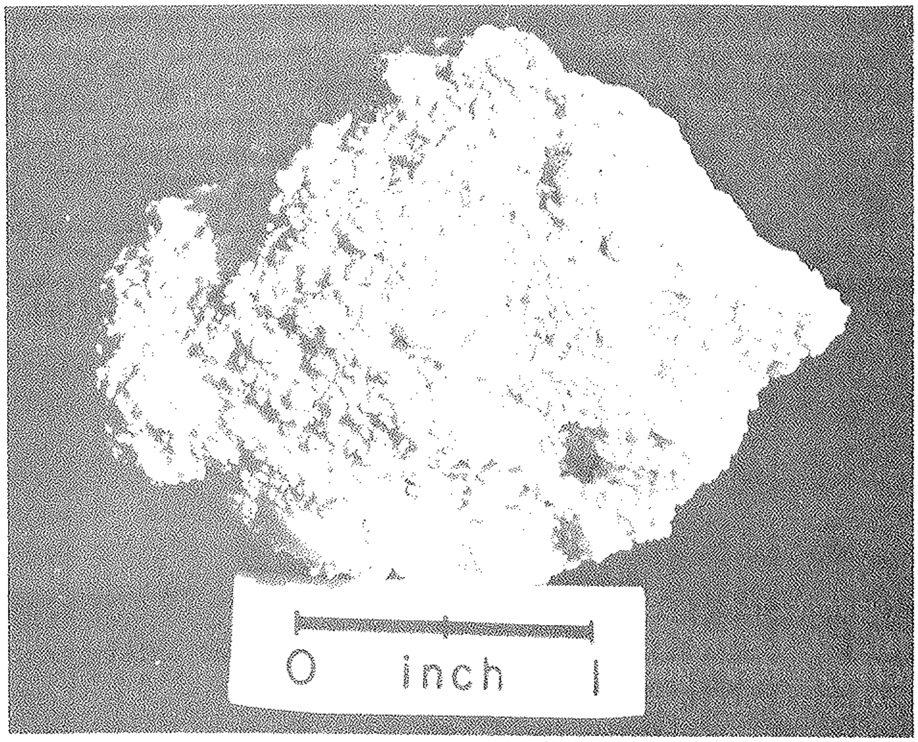

Fig. 3 Nodule of cemented sand from northwest of Cottongarden Point, St. Croix.

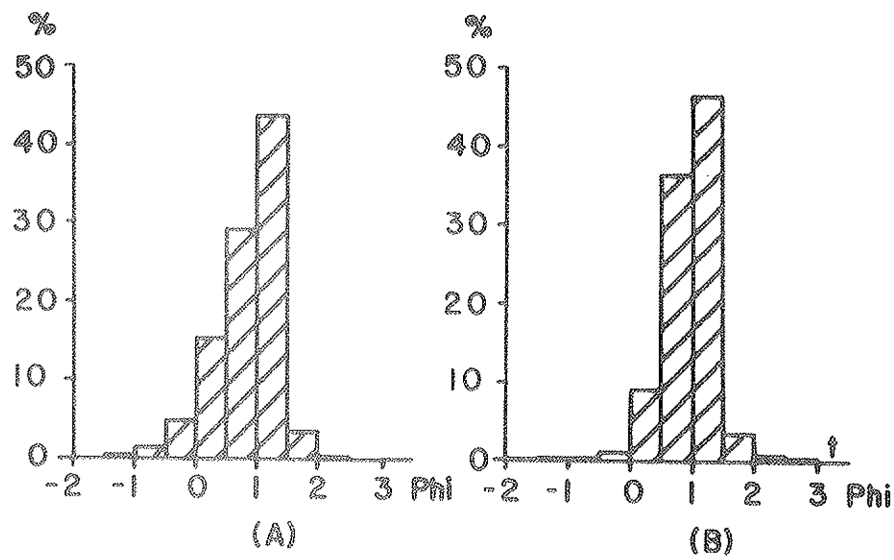

Fig. 4 Histograms of sand from non-cemented area (non-nodule bearing sand) (A) and cemented area (nodule-bearing sand) (B). Note the abrupt cutoff below 1.5 Phi size. Histogram drawn on 1/2 Phi intervals.

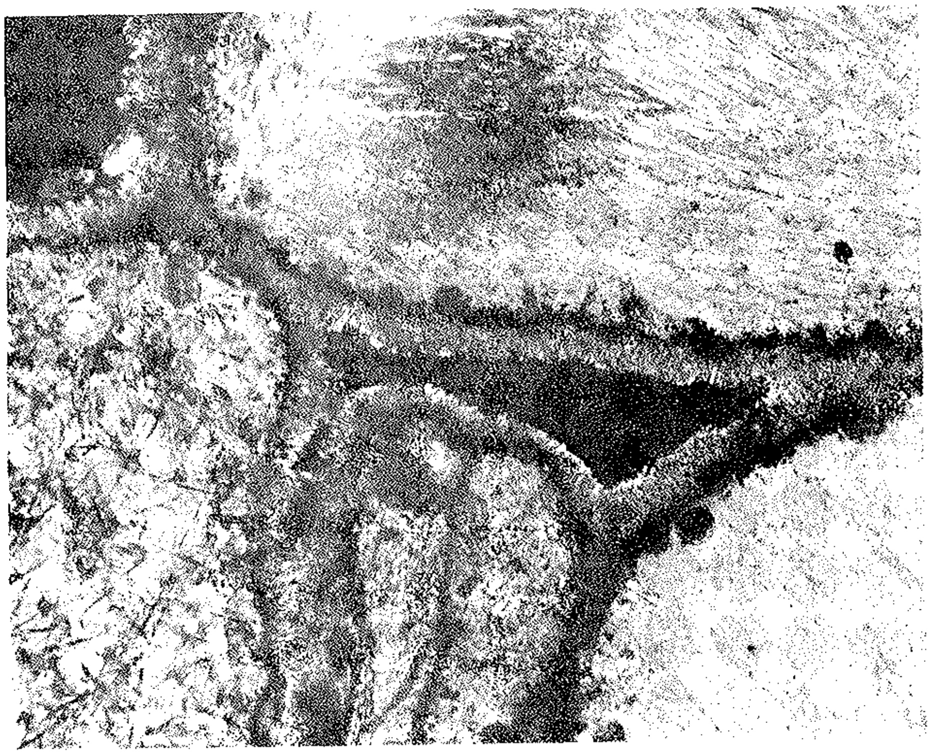

Fig. 5 Aragonite rims on micrite envelopes (dark grain coatings) cementing mollusc and bored coral sand grains. Field view is 1 mm. Crossed nichols.