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CARBONATE CEMENTS IN RECENT REEFS OF THE BERMUDAS AND BAHAMAS KEYS TO THE PAST?

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(2 planches)

RÉSUMÉ

Les divers types de cimentation que l'on peut rencontrer dans les milieux récifaux actuels sont rapidement illustrés. Une comparaison avec un récif Pléistocène des Bermudes montre qu'en l'absence de complications diagénétiques, ces divers ciments peuvent conserver, lors de la fossilisation, toutes leurs caractéristiques propres au milieu générateur.

ABSTRACT

Various types of cements met in Recent cup reefs are briefly illustrated. A comparison with a Pleistocene reef from Bermuda shows that, in the absence of significant diagenetic complications, these various cements can preserve all their features and environmental caracteristics during fossilization.

In detailed studies of the Recent Bermuda cup reefs a variety of seven high Mg calcite and aragonite cements were observed (table 1; Schroeder, 1972). That this variety is not unique is confirmed by preliminary results of investigations on Recent reef rocks from North Eleuthera Island (Bahamas) (table 1). The cements observed in both reefs studies occur without apparent pattern of distribution : different cements are found in adjacent pores of the same nature, and sequences of up to three cement generations within a given pore.

These cements present two problems : how are they formed? How are they preserved in the geologic record, and, conversely, have they any indicative potential in fossil reef rocks?

The second question will only be considered here. In search for an answer, the first step is to find a Pleistocene analogue to the Recent reef rocks studied as much similar in bio- and lithofacies as possible and to see if the cements of the Recent can be traced. Such an analogue to Recent cup reefs was found in the appr. 130.000 years old basal conglomerate of the Devonshire Formation at Grape Bay, Bermuda (Schroeder, in press). As shown in table 1, the four cements abundant or common in Recent cup reefs (fig. 1a — d) were found in the Pleistocene analogues, also sequences of up to three generations (fig. 2a, b). These were recognized on the basis of :

(a) analogies with Recent cements (for example with respect to fabrics and occurrence);

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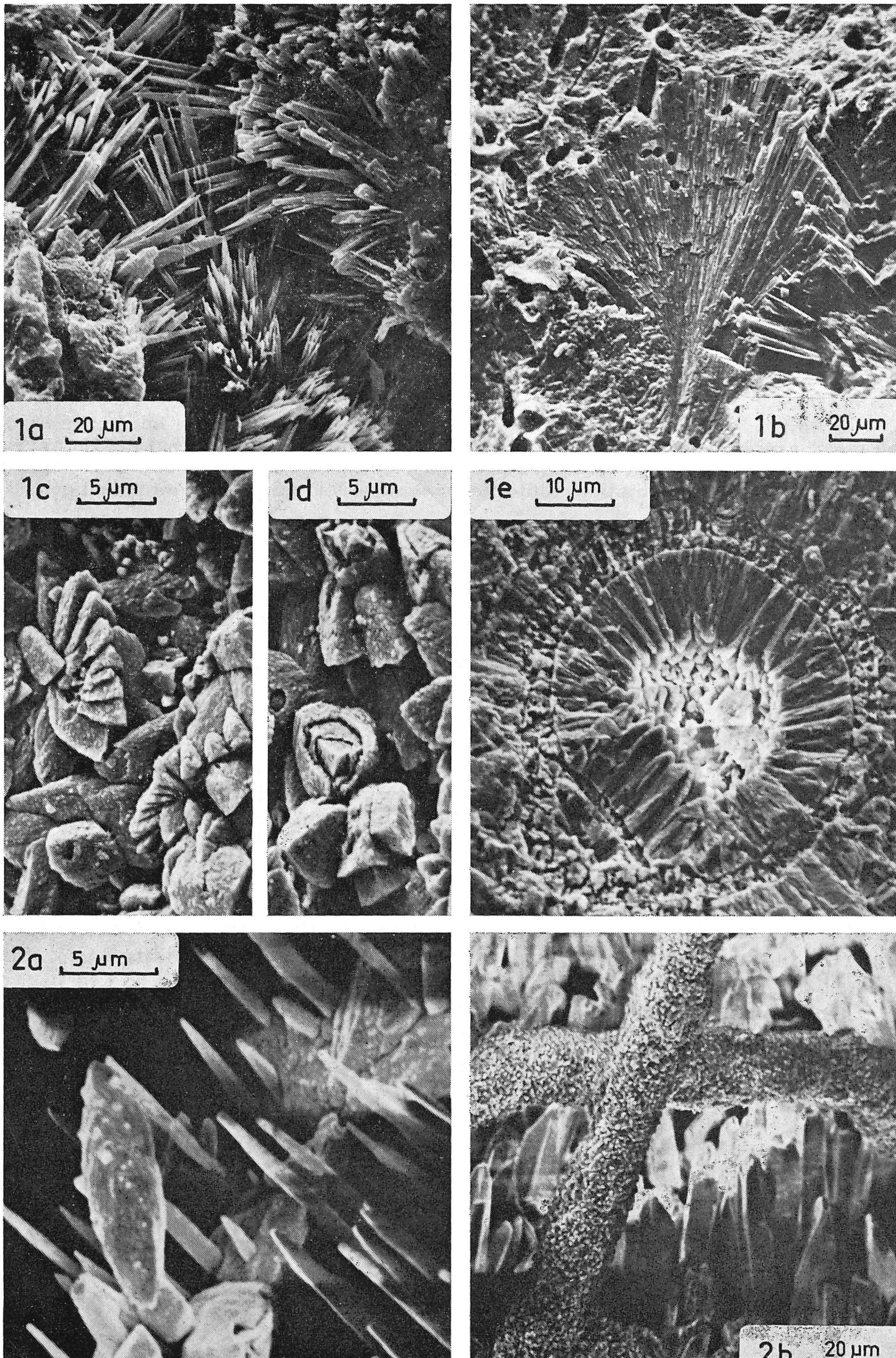

1a 20 µm
1b 20 µm
1c 5 µm
1d 5 µm
1e 10 µm
2a 5 µm
2b 20 µm

(b) composition (high Mg content of calcites, high Sr content of aragonites);

(c) circumstantial evidence (overgrowth by sessile reef organisms, boring by reef borers, overlying reef derived sediments);

(d) cement assemblage (taken together, the four cements encountered are more likely to indicate their origin than any one taken for itself).

These criteria were useful in this special case; whether they are generally applicable or not, remains to be tested.

In the Pleistocene occurrence, the submarine cements, individually or in sequence, may be followed by a vadose low Mg blocky calcite cement (fig. 3) whose environment of formation is evident in the meniscus outline (Dunham, 1971) frequently observed (fig. 4a — c). This outline assumes a variety of configurations dependant on permeability, solution supply, and morphology of the substrate, be it skeletal particle or cement (fig. 4d). Precipitation of this cement did not affect earlier cements, therefore the diagenetic history of these reef rocks is relatively clearly discernible.

This case study of Pleistocene reef rocks is encouraging with respect to the use of cements as indicators of diagenetic environments, but at the same time is misleading because this material has undergone very little diagenetic changes (Mg has been more or less retained by calcites; aragonite is not inverted). Diagenetic alteration, however, must be expected to obliterate some of the above criteria. In contrast to the well preserved Pleistocene reef rock, even in Recent material some of the cements listed in table 1 have been observed to be altered locally within 2000 — 3000 years, that is while the reef was still growing.

« Are cements known from the Recent useful as keys to the past? ». This question can be answered only after Recent submarine cements and cements added later, in other diagenetic environments, have been studied thoroughly with respect to their occurrences, fabrics, and other characteristics, their formation and alteration under various diagenetic conditions.

Fig. 1. — Submarine cements abundant and common in Recent and/or Pleistocene reefs.

a. Aragonite needle cement in intra-skeletal pore of *Millepora* crust within millimeters below the living surface; Recent Bermuda cup reefs (SEM).

b. Aragonite spherulitic cement in intra-skeletal pore of *Millepora* crust within millimeters below the growing surface; Recent Bermuda cup reefs (SEM).

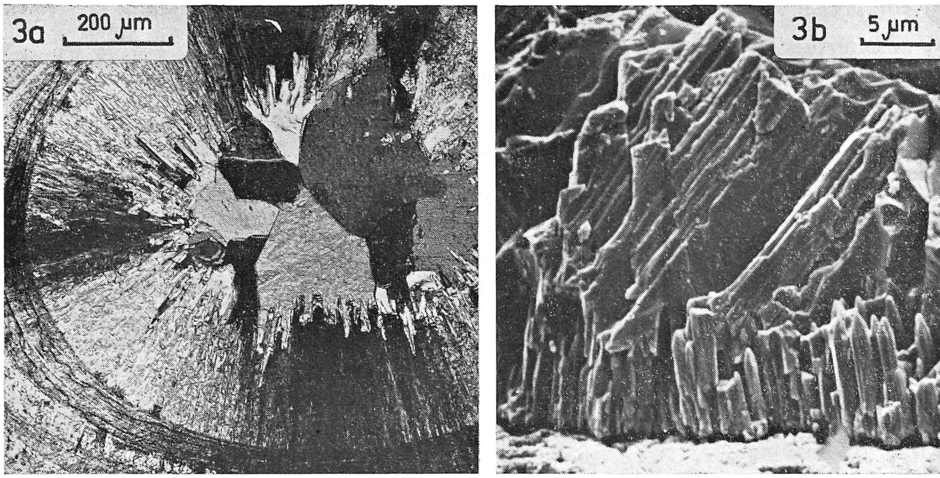
c. & d. High magnesium calcite micrite in gastropod chamber of Pleistocene reef rock from Grape Bay, Bermuda : *c.* intergrowth of several micrite crystals; *d.* micrite crystal consisting of three layers indicating zonation, thus discontinuous growth (both SEM).

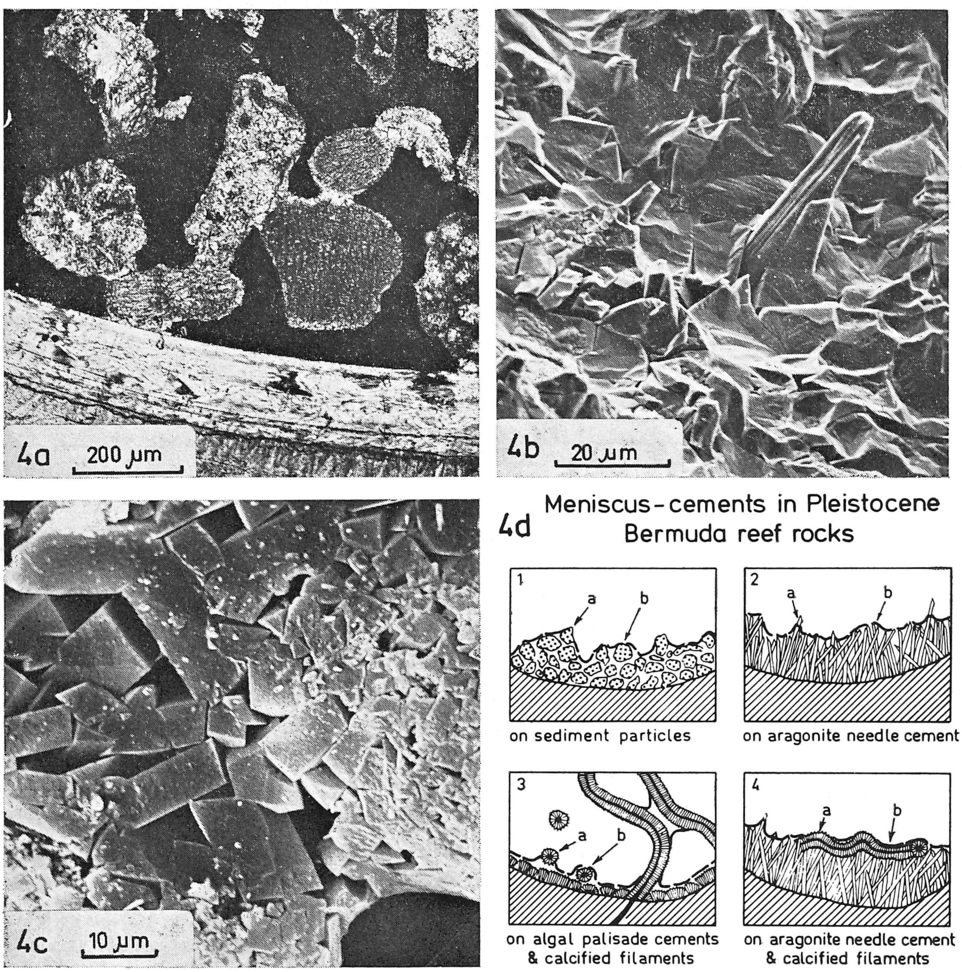
e. High magnesium calcite palisade cement in intraskeletal pore from Recent reefs W. of Bimini Island (Bahamas) (SEM).

Fig. 2. — Sequence of submarine cements in Pleistocene reef rock from Grape Bay, Bermuda.

a. Micrite crystals on aragonite needles (SEM).

b. Calcified algal (?) filaments in pore previously lined by aragonite needle cement.


3a 200 µm
3b 5 µm


4a 200 µm
4b 20 µm
4c 10 µm
4d Meniscus-cements in Pleistocene Bermuda reef rocks
1
a
b
on sediment particles
2
a
b
on aragonite needle cement
3
a
b
on algal palisade cements & calcified filaments
4
a
b
on aragonite needle cement & calcified filaments

REFERENCES

DUNHAM, R. J., 1971. — Meniscus cements. — In : Bricker, O. P., ed. : Carbonate cements. — John Hopkins University. *Studies in Geology*, **19**, 297-300.

SCHROEDER, J. H., 1972. — Fabrics and sequences of submarine carbonate cements in Holocene Bermuda cup reefs. *Geologische Rundschau*, **61**, 708-730.

SCHROEDER, J. H., 1974. — Submarine and vadose cement in Pleistocene Bermuda reef rock. In press, *Sedimentary Geology*.

Fig. 3. — Vadose low Mg blocky cement overlying earlier submarine aragonite needles cement in a gastropod chamber in Pleistocene reef rock from Grape Bay, Bermuda.

a. Thin section; Crossed nicols : Gastropod shell and aragonite needles are in optical continuity; the boundaries between aragonite needles and blocky calcite are sharp; intercrystalline boundaries between blocky calcite crystals are sharp and straight.

b. SEM of fractured surface : The argonite needles are clearly preserved as morphological entities. This and other submarine cements in these samples were not affected by subsequent precipitation of vadose cements.

Fig. 4. — Vadose low Mg blocky calcite cement exhibiting the meniscus outline diagnostic of the vadose diagenetic environment in Pleistocene reef rock from Grape Bay, Bermuda.

a. Sediment particles in a gastropod chamber are cemented to each other and the shell where the distance was short enough to permit formation of a solution meniscus (thin section; crossed nicols).

b. Aragonite needle cement covered by vadose blocky calcite meniscus. Two needles pierced the meniscus, which therefore forms a collar around them. Note irregular surface of concave curving crystal terminations (SEM).

c. Close-up of algal (?) filament (right) rising from the wall of a skeletal chamber (left) plastered by meniscus cement. Blocky crystals are randomly oriented as indicated by irregular interstices between them. Crystal terminations are not plane, but concave. Note smooth meniscus at lower right (SEM).

d. Schematic presentation of meniscus cements covering sediment particles (1), aragonite needles (2), algal (?) filaments (3), and argonite needles plus filaments (4); « a » indicates pointed or sharp protrusions which pierce or cut the meniscus, « b » indicates blunt protrusions which are covered by meniscus cement.

TABLE 1. — *Occurrence and characteristics of cements in Recent and Pleistocene Bermuda reef rocks and preliminary observations on their occurrence in N. Eleuthera (Bahama)* reefs. (Sr^{2+} *values give the order of magnitude, not exact values*).

Cement	Occurrence and characteristics	RECENT: Bermuda cup reefs (Schroeder, 1972): composition	RECENT: Bermuda cup reefs (Schroeder, 1972): max. long dimension (um)	RECENT: Bermuda cup reefs (Schroeder, 1972): relative abundance	RECENT: N. Eleuthera reefs: observed = o not observed 3 = n.o.	PLEISTOCENE: Bermuda reef rock (Grape Bay) (Schroeder, in preparation): composition	PLEISTOCENE: max. long dimension (um)	PLEISTOCENE: relative abundance
ARAGONITE	needle	10.000 ppm Sr^{2+}	400	abundant	o.	10.000 ppm Sr^{2+}	350	abundant
	spherulitic	10.000 ppm Sr^{2+}	400	common	o.	10.000 ppm Sr^{2+}	120	rare
	lath	no data	20	rare, locally abundant	o.	not observed		
CALCITE	micrite		15	very very abundant	o.	8.0 — 15.5 av. 12.5 mole % $MgCO_3$	15	very abundant
	scale	15 — 17 mole % $MgCO_3$	20	rare, locally abundant	n. o.	not observed		
	palisade incl.		80	common	o.	5.5 — 21.5 av. 14.0 mole % $MgCO_3$	35	common
	calc. filaments		200	abundant	o.		75	abundant
	blocky		60	rare	n. o.	< 1 mole % $MgCO_3$		abundant