EARLY MARINE CEMENTATION IN SKELETAL SANDS

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PROJECT OBJECTIVES

- To elucidate the effect of microbial communities in diagenetic processes that lead to the cementation of skeletal grains.
- Toward this end, *in vitro* incubation experiments will be conducted with skeletal grains in the presence and absence of microbial marine communities.
- To determine whether microbial exudates of exopolysaccharide substances (EPS) influence agglutination and early cementation of skeletal grains.
- To document the development of inter/intragranular cements and identify textural forms and mineral microstructure composition of early marine cementation areas using petrographic thin-sections and SEM/EDS.

PROJECT RATIONALE

Many micritic early marine cements display microbial fabrics consistent with microbial mediation (Dravis, 1979; Hillgärtner et al.,2001; Diaz and Eberli 2022). Based on recent studies with a cohort of field collected samples from the Bahamas and Hamelin pool, we hypothesize that initial cementation and stabilization of carbonate sediments result from the interplay of metabolic activities and passive processes influenced by extracellular polymeric substances (EPS) and entombment of cells. Results from *in vitro* experiments undertaken with ooids in the presence and absence of native microbial communities support this hypothesis (Diaz and Eberli, 2022). We have shown, for instance, that early cements and grapestone formation is a fast process (30 to 60 days), primarily assisted by exudates of microbial EPS, microbial filaments and metabolic activities within the sedimentary grains. We also speculated that the mircrobial community responsible for the early cements are indegenous to the ooids that carry a highly diverse microbial community (Diaz et al. 2023). The scarcity of grapestone and intraclasts in skeletal carbonate sands might be the direct result of the limited micorbial community in skeletal sand.

In this new experiment, we plan to test this hypothesis and establish whether early cementation in skeletal grains follow a similar trend and rate of cementation. Given that ooids harbor an astonishing rich diversity of micro-organisms we expect cementation of skeletal grains to occur at a reduced rate.

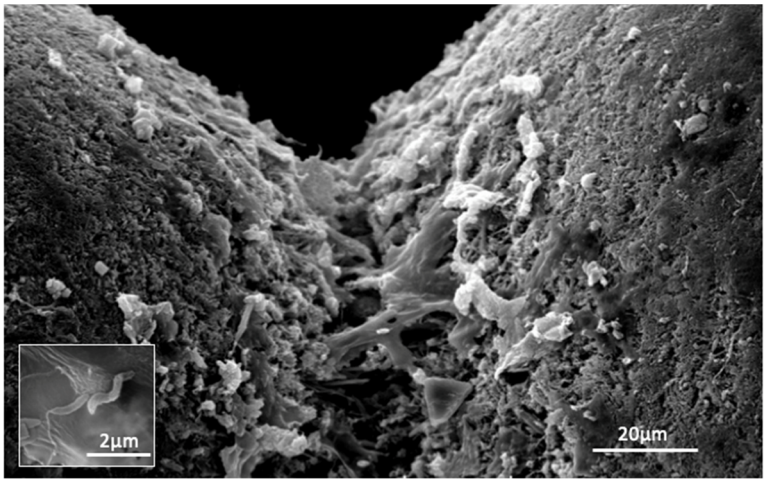


Figure 1. Example of agglutination of ooid grains assisted by EPS and biofilm bacteria after 30 days incubation (from Diaz and Eberli, 2023).

SAMPLE SITE

We will collect samples from the White Sands in the Florida Reef Tract and repeat the experiment following the protocol of the ooid study (Diaz et al., 2023).

Figure 2: The Florida Reef Tract is a patchwork of coral reefs and high-energy skeletal sands (White Sands). Well-sorted skeletal sands will be collected using a protocol that preserves the indigenous microbial communities (Diaz et al., 2023)

APPROACH AND METHODOLOGY

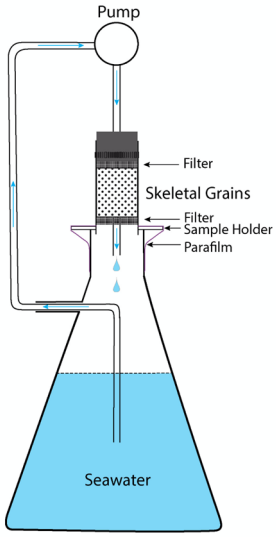
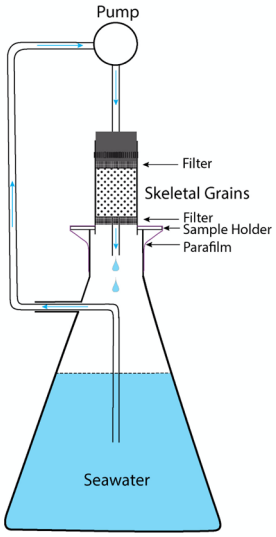
The experimental approach: We will use two sets of incubations - representing abiotic and biologically mediated precipitation (see inset). In vitro experiments will be undertaken in chambers containing skeletal grains that have undergone sterilization (to ensure axenic or microbial free conditions), whereas microbially mediated precipitation will use freshly collected skeletal grains with their native flora. The packed grains are sealed with two porous disks, permitting the inflow/outflow of seawater through the sleeve. A continuous inflow of sterilized seawater (seawater not enriched with nutrients) will be applied. The samples will be subject to alternating cycles of daylight and dark conditions to allow 12 hours photosynthetic processes and 12 hours darkness to stimulate heterotrophic activity under low oxygen conditions.

Visual inspection of contact areas to identify grain binding and microbial colonization will be conducted at different time intervals (0 to 4 months) using petrographic thin sections and SEM analysis. SEM-EDS analysis will also be used to document and characterize the mineralogy of early cements as well as the potential involvement of extracellular polymeric substances (EPS) and presence of ACC as a precursor to cementation processes.

Characterization of microbes associated with the evolution of cements will be carried out using SEM analysis. Characterization of the skeletal grains and cements will be done on epoxy-impregnated thin sections.

SIGNIFICANCE

This study will provide insights on the role of microbes and associated EPS in cementation processes in carbonate skeletal sands. In addition, the results will reveal how much the rate of cementation in skeletal sands differ from those in ooid sands that contain a high-diversity microbial community. There are indications from other studies and in the geologic record that the rate of cementation might be lower in skeletal sands. Grammer et al. (1999) conducted a cementation experiment with ooid samples that were suspended above the sea floor at various depth across the margin of Great Bahama Bank. Partial lithification by fibrous aragonite cement was observed within 8 months in water depths of up to 60 m and complete lithification in 20 months (Grammer et al. 1999). The experiment also included skeletal sand but the cementation was minimal over the same time intervals and was not reported (Grammer pers. comm.), indicating a reduced rate of cementation compared to the ooid samples.

abiotic	biologically mediated
	
Sterile skeletal sand	*Skeletal sand with indigenous microbial communities*

In the geological record, neritic skeletal sands especially in cool-subtropical and cool-water settings can be loosely cemented even when they are many million years old. It has been speculated that early removal of aragonite prevents the early cementation so that lithification is delayed until substantial burial and chemical compaction (James et al., 2005). Another characteristic of (temperate) skeletal sands is the near absence of micritic envelopes that are formed by endolithic borers (Betzler et al., 1997). The absence of micritic envelopes might also indicate a smaller role of microbial organisms in the cementation process compared to the one in ooid sands. Together, decreased microbial activity and delayed cementation produce highly porous and permeable rocks with excellent reservoir quality (Ehrenberg et al. 2006).

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