EARLY MARINE CEMENTATION PROCESSES AND VELOCITY EVOLUTION

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PROJECT OBJECTIVES

- To investigate the role of microbes in ooid lithification processes that leads to the formation of grapestones and rocks.
- Compare the influence of biologically mediated versus inorganic precipitated cements on acoustic velocity and rock strength of carbonates.

PROJECT RATIONALE

Diagenetic alterations can trigger drastic changes in the petrophysical properties of carbonate grains. Newly formed cements can occlude or partially line pores which results in changes in the strength of granular rocks. When the new precipitates form at grain-to-grain contacts, an increase in stiffness and shear stress behavior is often foreseeable, affecting compaction, bulk and shear modulus (Bernabe et al. 1992; Dvorkin and Nur, 1996). The induction period for inorganic carbonate crystal precipitation at grain contact and non-contact areas – based on *in vitro* experiments with supersaturated solutions of $CaCO_3$ – can occur in as little as a few weeks (Fig. 1), while in the marine-realm, cementation processes can take place on a scale of a few months or years.

There is increasing evidence to suggest that cementation is not a purely abiotic process as organomineralization processes – mediated by microbes and EPS biofilms – can induce many forms of early cements, including micrite envelopes, micritic

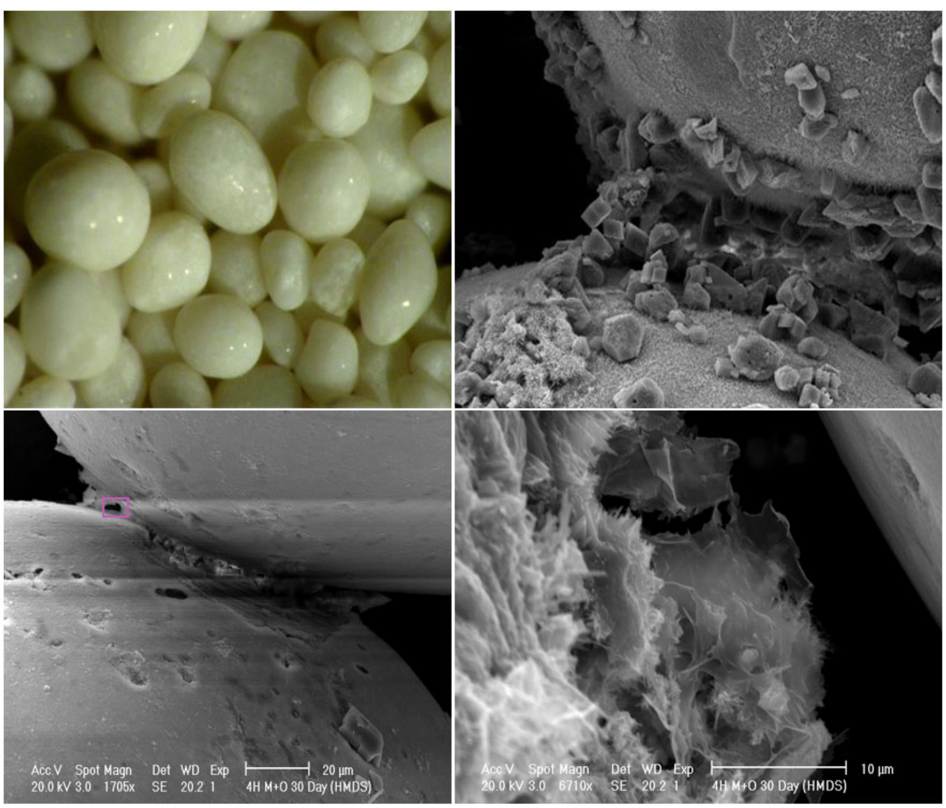

Figure 1: Results of inorganic and microbially mediated precipitation study. Top right, clean ooids before experiment. Top right, calcium carbonate crystals precipitated during the experiment. Precipitation occurs preferentially at the ooid-to-ooid grain contacts. Bottom right, illustration of of microbially induced cementation after 30 days. Note the EPS at grain contact area.

bridges, meniscus cements and fringing cements. This evidence strengthens the notion that microbes are important in the initial cementation and stabilization of sediments. The latter is further supported by our previous observations on a myriad of interclast marine samples from the Bahamas and Hamelin Pool, Australia and in-house experiments with in-vitro incubations of loose ooid sands in the presence and absence of native microbial populations. Under the presence of microbial flora, our experiments show that the initial stages of grain consolidation can occur at 30 days with more advanced stages at 60 days. In contrast, sterilized ooids remain unconsolidated after 60 days (Fig. 1).

Based on the growing evidence supporting the influence of microbes in cementation, this study addresses their role and their impact on the elastic properties following grain cementation and rock formation. Of special interest is determining whether microbial cementation enhances the stiffness of loose sands and how it influences velocity and compaction. To this end, experiments that quantify both the chemical changes in the fluids and the diagenetic and petrophysical changes within the sediments (i.e. acoustic velocity and permeability) will be undertaken in parallel with SEM observations.

APPROACH

To determine the extent to which microbial precipitation affects rock-physics, experiments will be tailored to:

Quantify the geochemical alterations in the fluids and petrophysical changes as unconsolidated ooid sands undergo compaction through time. To assess differences in petrophysical properties and the effect of microbial colonization on lithification, two sets of incubations - representing abiotic and biologically mediated precipitation - will be undertaken in chambers containing ooids that have undergone physical and chemical sterilization (to ensure axenic or microbial free conditions), whereas microbially mediated precipitation will use freshly collected ooids with their native microbial flora. Visual inspection of grain contact areas will use petrographic thin sections and SEM-EDS analyses to identify mineral structure composition, grain binding, porosity and microbial colonization. The involvement of extracellular polymeric substances (EPS) and the presence of ACC as a precursor to cementation processes will use SEM analysis.

KEY DELIVERABLES

A data set will be created capturing changes in acoustic velocity and fluid flow permeability generated by microbially and non-microbially induced precipitation. High-resolution images using SEM will provide insights on the role of microbes and associated EPS in precipitated material and their preferential location within the rock framework.

BIBLIOGRAPHY

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