EARLY MARINE CEMENTATION PROCESSES AND VELOCITY EVOLUTION

Mara R. Diaz, Ralf J. Weger, Peter K. Swart, Qian Ding[1], and Gregor P. Eberli
[1)] *Petroleum Exploration & Product Research Institute of SINOPEC*

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 inorganically precipitated cements on acoustic velocity and rock strength of carbonates.

PREFACE

This project was planned for 2021 but travel restrictions and new policies and research permits in the Bahamas have delayed the execution of the project. We expect policy changes that would allow us to retrieve samples this year.

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.

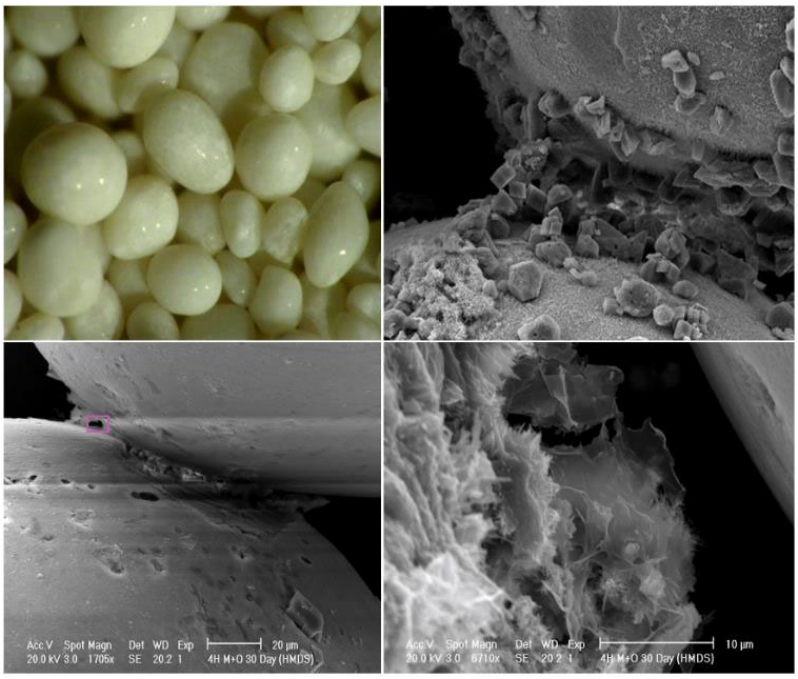

Figure 1: Results of inorganic and microbially mediated precipitation study. Top right, clean ooids before experiment. Top right, calcium carbonate crystals precipitated during the experiment. Precipitation occurs preferentially at the ooid-to-ooid grain contacts. Bottom right, illustration of microbially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

There is increasing evidence 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 bridges, meniscus cements and fringing cements. This implies that microbes are important in the initial cementation and stabilization of sediments. This notion is supported by our observations on interclasts from the Bahamas and Hamelin Pool, Australia (Diaz and Eberli, 2021) 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).

This study addresses the role of microbes in cementation and their impact on the elastic properties following 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.

APPROACH

Experiments will be tailored to determine the extent to which microbial precipitation affects rock-physics. To this end, the experiments will quantify both the chemical changes in the fluids and the diagenetic and petrophysical changes within the sediments (i.e. acoustic velocity and permeability).

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 to identify grain binding, porosity and microbial colonization. SEM-EDS analyses will be used to document the involvement of extracellular polymeric substances (EPS) and the presence of ACC as a precursor to cementation processes.

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 precipitation and their location within the rock framework.

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