THE EFFECT OF MICROBIAL MEDIATED PRECIPITATION ON ROCK PHYSICS

Ralf J. Weger, Mara R. Diaz, Peter K. Swart, and Gregor P. Eberli

PROJECT OBJECTIVES

- To elucidate the involvement of microbes in ooid cementation processes and their potential effect on the acoustic properties of un-cemented ooid sandstone at low pressures.
- Compare the influence of microbial mediated versus inorganic precipitated cements on acoustic velocity and rock strengths of carbonates.

PROJECT RATIONALE

Carbonates can undergo diagenetic alterations, which often results in drastic changes in the petrophysical properties of the grain as newly formed cements may completely occlude or partially line the pores. This process can exert profound changes in the strength of granular rocks as it can increase the stiffness of a particulate aggregate, especially if the new cement precipitates at the grain-to-grain contacts (Bernabe et al. 1992; Dvorkin and Nur, 1996). These cements not only have a concomitant effect on the stiffness/shear stress behavior but can greatly affect compaction, bulk and shear modulus. Our previous in vitro precipitation studies have shown that inorganic carbonate crystal precipitation at grain contacts can occur in few weeks when ooids are incubated with supersaturated solutions of $CaCO_3$ (Fig. 1). Ongoing precipitation can also lead to overgrowth by needle structures that can embed the ooid surface. However, contrary to grain-to-grain contacts, which lead to an increase in rock stiffness and acoustic velocity, needle crystals reduce porosity but have a negligible effect on acoustic velocity.

Recent evidence, however, suggests that cementation is not a strictly inorganic process as microbial binding in micritic bridging and fringing cements has been documented, strengthening the notion that microbes are involved in

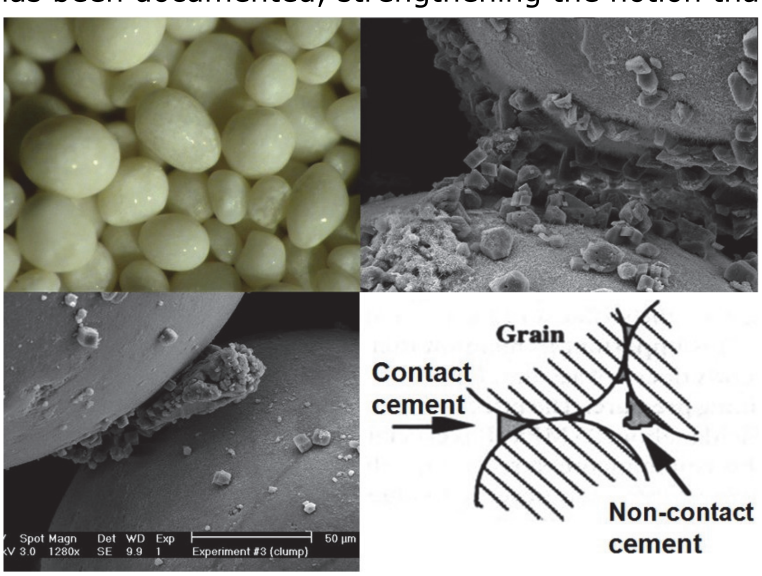

Figure 1: Results of inorganic precipitation study. Top right, clean ooids before experiment. Top right and bottom left, calcium carbonate crystals precipitated during the experiment. Precipitation occurs preferentially at the ooid-to-ooid grain contacts. Bottom right, illustration of contact vs. non-contact cement (from Dvorkin and Nur, 1996).

the initial cementation and stabilization of sediments. Our observations are further supported by preliminary experiments that use in-vitro incubations of ooids in the presence of indigenous microbial populations. Based on the growing evidence supporting the biological mediation theory, this study aims to address the involvement of microbes in early cementation processes and their impact on the elastic properties that leads to grain compaction and cementation. In particular, we will address whether microbial cementation can trigger increases in the stiffness of granular soils and how it affects velocity and compaction. Toward this end, experiments that quantify both the chemical changes in the fluids and the diagenetic and petrophysical changes (i.e. acoustic velocity and permeability) will be undertaken. Special attention will be given to the differences between microbial and inorganic precipitation. These measurements will be complemented with SEM observations.

APPROACH AND WORK FLOW

In order to improve our understanding of the impact of microbial precipitation on rock-physics experiments will be tailored to:

Quantify the chemical changes in the fluids and the diagenetic and petrophysical changes in the rocks during different types of precipitation, including inorganic and microbial mediated precipitation. While inorganic precipitation experiments will be undertaken in incubation chambers inoculated with sterilized ooids – to remove any potential microbial involvement in the calcification process – microbially mediated carbonate precipitation experiments will use an inoculum of freshly collected ooids.

Determine the presence and potential involvement of biofilm extracellular polymeric substances (EPS) in carbonate precipitation at grain-to-grain contact loci and non-contact areas of the grains. The presence of EPS will be determined with SEM image processing analysis and confocal laser scanning microscopy (CLSM). The CLSM analysis will allow visualization of EPS distribution in the grains via specific binding of lectins to EPS-carbohydrates.

Determine if ACC nanograins can act as precursors of cementation processes in ooids. Detection of ACC will use morphological attributes based on SEM image analysis.

KEY DELIVERABLES

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

BIBLIOGRAPHY

Bernabe, Y., Fryer, D.T. and Hayes, J.A., 1992, The effect of cement on the strength of granular rocks: Geophysical Research Letters 19, 1511-1514.

Dvorkin, J. and Nur, A., 1996, Elasticity of high porosity sandstones: theory for two North Sea data sets: Geophysics 61, 1363-1370.