ROCK FLUID INTERACTION: VELOCITY EVOLUTION DURING CONTROLLED PRECIPITATION AND/OR DISSOLUTION

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PROJECT OBJECTIVES (OR PURPOSE)

The processes of rock/fluid interaction and diagenetic alteration of carbonate rocks are well understood, but little data exist to quantify the resulting changes and their influence on petrophysical properties. In this project, experiments will be performed in order to:

- Quantify the chemical changes in the fluids and the diagenetic and petrophysical changes in the rocks
- Enhance our understanding of the effects of chemical rock-fluid interaction
- Capture changes of acoustic velocity and permeability during chemically controlled rock-fluid interaction

PROJECT RATIONALE

Carbonates are prone to diagenetic alterations that result in changes of the petrophysical properties. Small amounts of newly formed contact cement can stiffen the rock. Similarly, dissolution from slightly acidic formation waters or acid treatment during well completion can produce secondary porosity and increased permeability.

Laboratory experiments with controlled precipitation and dissolution are needed to better understand the acoustic behavior of carbonates during such processes. During these experiments the petrophysical properties of the sample need to be observed before, during, and after altering the rock. This experimental design will allow answering questions in regards to the stiffening of the rock frame by newly formed crystals at grain-grain contacts, and the evolution of fluid pathways, porosity and permeability as well as the softening of the rock framework during dissolution

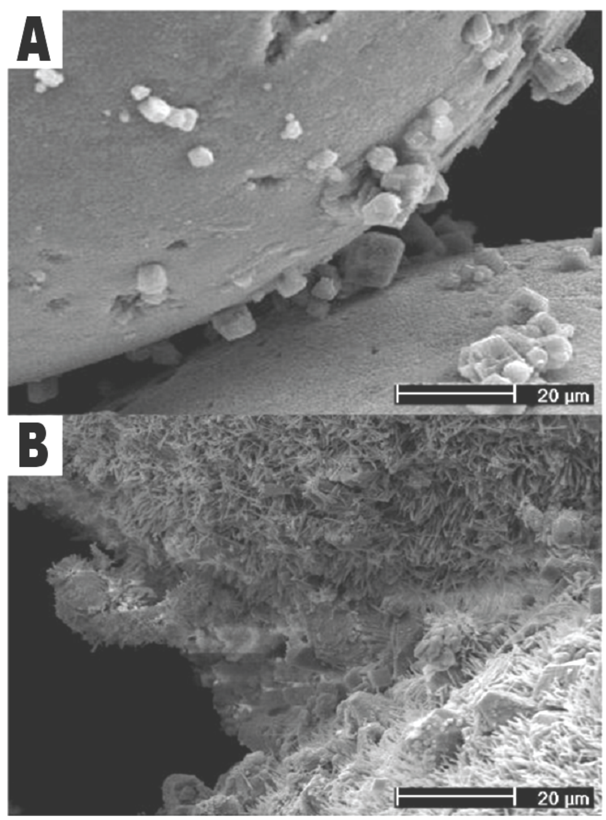

Figure 1: Precipitation occurs preferentially at the ooid-to-ooid grain contacts (top), but sometimes overgrows the entire ooid surface with needle structures (bottom).

PROJECT DESCRIPTION

Rock evolution and changes will be documented, particularly with respect to acoustic velocity. One aspect will be to evaluate the effects of observed crystallization at grain-to-grain contacts on measured acoustic velocity. Another aspect will concentrate on the effect of dissolution in ooid grainstones on both acoustic velocity and fluid flow permeability.

Results of phase 1 precipitation study have shown that clean ooids are cemented together by calcium carbonate crystal precipitation in only a few weeks (Figure 1). Precipitation occurs preferentially at the ooid-to-ooid grain contacts (Figure 1A), but sometimes overgrows the entire ooid surface with needle structures (Figure 1B). The contact cements are responsible for increasing rock stiffness and thus acoustic velocity. Needle structured crystals on the other hand reduce porosity with very little increase in velocity. The rock undergoes apparent weakening creating a rockframe of lower stiffnes for its lower porosity.

In the second phase of this project, the focus will be more on dissolution. Under-saturated solution will be circulated though the samples for several days. Fluid composition, acoustic velocity, and fluid flow permeability will be measured during the experiment. Changes in the rocks pore structure will be captured by high-resolution CT scans before and after the experiment. Changes in pore geometry will be analyzed in the context of changes in petrophysical parameters.

DISSOLUTION WORKFLOW

- Perform high-resolution CT scan of several samples of variable texture (grainstone, packstone, etc.) but similar porosity.
- Measure acoustic velocities and permeability.
- Expose these samples to long-term infiltration with an under-saturated solution.
- Measure velocity and permeability at set intervals during infiltration experiment.
- Sample and analyze downstream fluid line for chemical changes.
- Perform high-resolution CT scan and compare pore structure changes.

EXPECTED RESULTS

A data set will be generated that captures chemical changes of the pore fluid and the resulting changes in acoustic velocity and fluid flow permeability in the rock. High-resolution images using SEM and high-resolution CT scans will provide estimates of crystallization or dissolution during chemical rock-fluid interaction.

In particular, we will focus on determining the differences in acoustic velocity changes due to growth of different crystal structures. Preliminary results have shown that larger blocky crystals growing on grain-grain contacts create apparent stiffening while smaller needle like crystal growth creates apparent weakening. Additional experiments are design to confirm these findings.