

The Importance of Early Cements in Maintaining Porosity and Permeability during Burial

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Project Purpose

Understanding the factors that sustain good porosity and permeability values in the subsurface is still a problem. Rock mechanics experiments show that even applying pressures in simulation to real burial depth, carbonate rocks can maintain good reservoir quality, and some permeability was maintained even after increasing the compaction until the pores collapsed. Our working hypothesis is that cementation during the early diagenesis is the main factor for sustaining the reservoir quality porosity and permeability at great depth. To test this hypothesis, we plan compaction experiments of modern sediments and Pleistocene samples with different amounts of cementation to assess the decrease of this initial porosity and permeability at different burial depths. The results will provide much needed information on the factors that maintain porosity and permeability in the deep burial realm.

Project Description

This project will examine the influence of the amount of early cementation as a factor in sustaining porosity and permeability at deep burial depths. Compaction experiments will simulate the evolution of permeability from the surface to the equivalent of 3,000 meters of burial depth. We selected Pleistocene oolitic peloidal grainstones and packstones from six cores on Great Bahama Bank (Ocean Cay, Andros Island, New Providence, Cat Island, Long Island, and Eleuthera Island). The analyzed facies consist of oolitic, peloidal, and skeletal grainstones, partially cemented with 5 - 20% of marine and meteoric cementation. The meteoric cements are equant spar crystals forming a fringe around the grains or filling the pore throats as meniscus. Marine diagenesis occurred as an isopachous fringe and micrite cement filling the pore throat forming a meniscus texture. Compaction experiments are simulating the evolution of permeability from the surface to the equivalent of 3,000 meters (approximately of 69 MPa) and 5,000 meters of burial depth (approximately of 127 MPa). We are simulating different burial depths in these samples starting with their initial porosity and permeability values, and then monitor their decreasing values as compaction increases, which we equate to the increase of burial depth. After the experiments, thin sections will be cut from each sample and we will measure the capillary pressure using Hg injection (P_{Hg}) and perform microtomography. Combined, these post experiment investigations will help to evaluate the main changes of the distribution and shape of the pores. The geomechanical experiments will be done at Rock Mechanics Laboratory at Petrobras Research Center with a MTS 315.02, an axial compression of 270 Tf power, and 12000 psi of confining pressure.

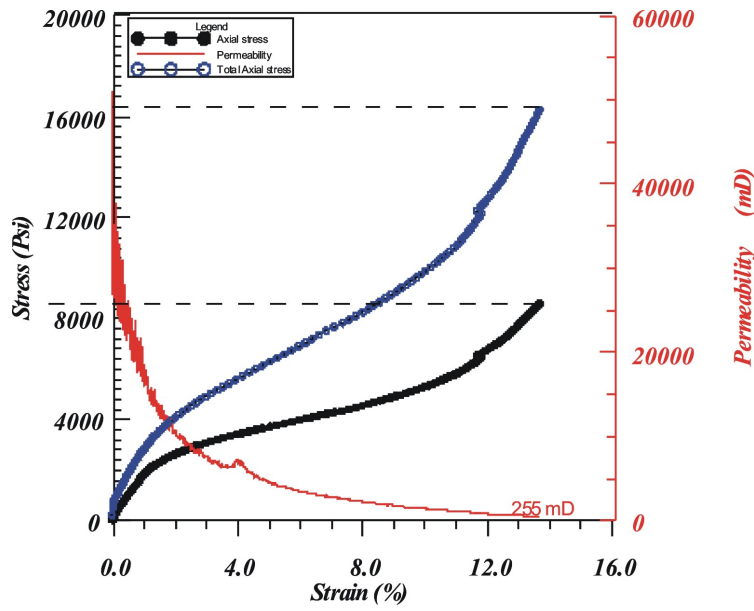


Figure 1. Stress versus strain and permeability of an ooid sample. Permeability (thin red line) abruptly increases at 4% of strain, which is probably caused by micro-fractures that start to develop. The decreasing permeability with increasing stress indicates that these micro-fractures close with increasing burial.

The petrophysical values of the Pleistocene rocks after the compaction experiment will be compared to the Albian rocks from to Brazilian basins at different burial depths. In addition we will compare the similarity of the early diagenesis and facies at the Albian cores with the early diagenesis and facies at the Pleistocene cores. The samples for this comparison are from the Campos Basin at 2,700 meters of burial depth and Santos basin at 5,000 meters of burial depth, respectively. We will describe and quantify the amount of cement, type of pores, and compare the petrophysical values of the Pleistocene rocks after the compaction experiment with Albian rocks from the Brazilian Basins.

Key Deliverables

This project will provide diagenetic characterization and integrated petrophysical dataset on Holocene and Pleistocene carbonate rocks with a thorough determination of the vertical heterogeneities of these deposits. The integrated dataset will provide a comprehensive diagenetic model of these rocks with porosity, permeability, and acoustic characteristics. This diagenetic model will be used in comparison with other oolitic reservoirs at different depths.

The dataset will be available to the Industrial Associates and can be used to evaluate variations in petrophysical parameters that feed geologic or simulation models for carbonate reservoirs.