Intra-Formational Flow and Fracture Barriers – Crystal Structure & Porosity of Stratigraphic Concretions, Vaca Muerta Formation

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Project Objectives

- Assemble data on concretion strength.
- Characterize nature of calcite cements and porosity in concretion beds.

Project Rationale

Concretionary beds are an integral part of mud-rich deposits, many of which form in unconventional reservoir systems. In both siliciclastic- and carbonate-rich mudstones, bedded "stratigraphic" concretions can form relatively low-permeability beds that form early in the burial sequence (Fig. 1). Pervasive cementation forms beds with low permeability that can act as a fluid baffle and a mechanically stiff layer. This study addresses the microstructure of the concretion beds and how cementation forms relatively strong units early in the burial history.

Approach

This study will employ two main analytical techniques. Concretion microstructure will be analyzed by SEM imaging of ion micromilled surfaces (Fig. 2). Concretion strength will rely on simple uniaxial compression testing (horizontal and vertical oriented plugs) to provide a measure of rock strength.

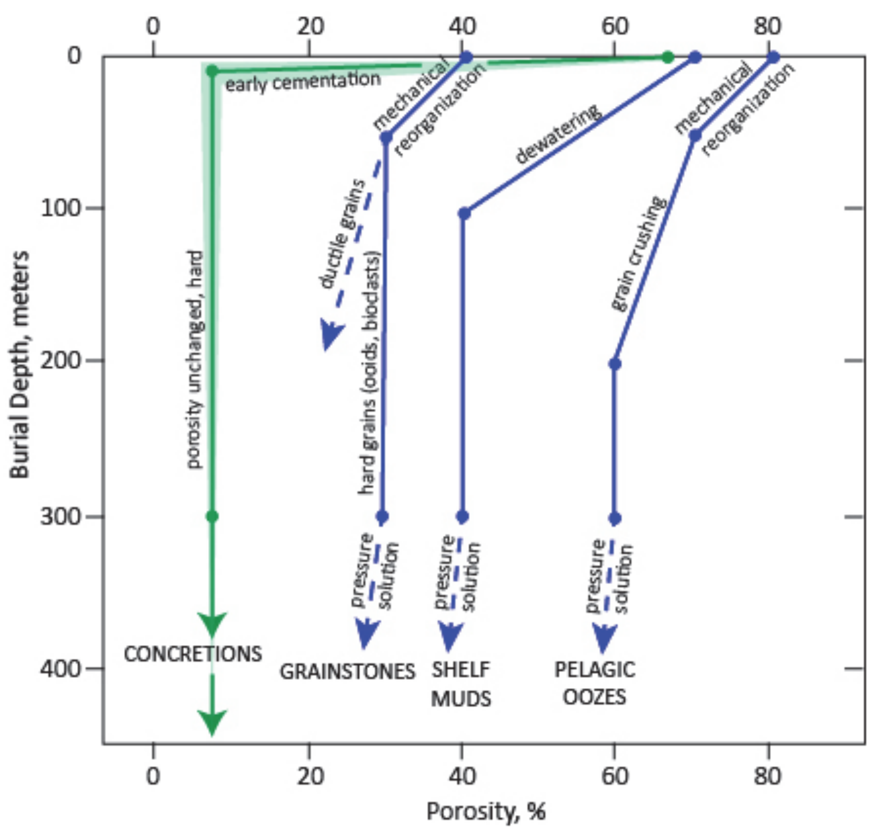

Figure 1. Porosity versus shallow burial depth for different types of carbonate lithologies (blue lines) based on fig. 9.5 of Moore (1989). Concretions show a distinct early cementation trend different from most carbonate and siliciclastic sediments.

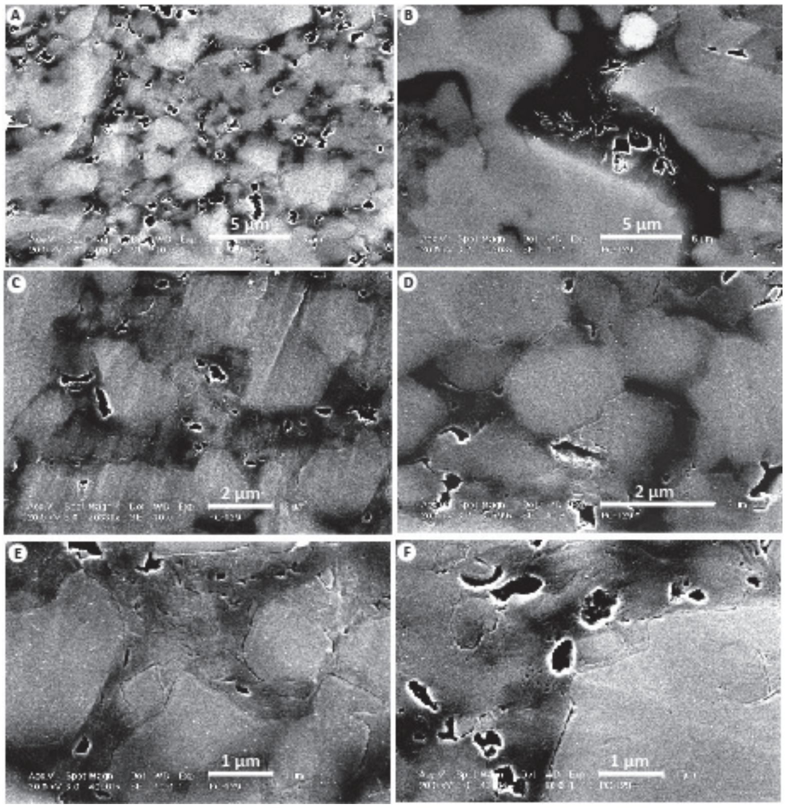

Figure 2: SEM photomicrographs of micromilled Vaca Muerta concretion surfaces showing calcite crystals (mostly light gray) and pore spaces (mostly black with white rims from electron charging at edge of pore).

Some inter-crystalline area is likely composed of organic matter and contains intraparticle organic pores. A) Overview image of calcite crystals and pores; B-D) typical oval to equidimensional pores that occur at the intersection of calcite crystals within the cement matrix. The dark matrix is likely organic matter and contains intraparticle pores; E-F) view of pores that also include elongate pores that occur at the boundary between calcite crystals or detrital grains. All images are from SC-PC03-129 at ~25 cm.

INITIAL RESULTS - CONCRETION CRYSTALLINITY & POROSITY

Scanning electron microscopy was used to examine ion-micromilled surfaces of Upper Jurassic concretions. Results indicate that the dominant crystal size is 1-3 μm (mean 2.08 μm microns; S.D. = 1.42 μm). Pores were formed at the intersections of calcite crystals by the constriction of the fluid-filled interstitial space, likely prior to dewatering and initial compaction. These (micro) pores are of the "Type III, fitted fused" variety. Two-dimensional pore shapes analyzed on micromilled surfaces are near equidimensional (length/width = ~1-1.5), oval (length/width = 1.5-5), and elongate (length/width = >5) forms. Equidimensional and oval pores occur at the intersections of calcite crystals (along with clay minerals and organic material). Elongate pores of uncertain origin are found at the boundaries between adjacent calcite crystals. Helium pycnometer porosity of the plugs associated with the Upper Jurassic micromilled sample is consistent with a relatively low total porosity, with values of 0.38, 0.58, and 0.82%. The size and shape of cement crystals and pores suggests that relatively early, rapid, and pervasive precipitation produced a homogeneous mass of calcite and small isolated pores.