STRUCTURAL DIAGENESIS OF A SUB-SALT RESERVOIR, CARBONATE ROCKS, NE BRAZIL

Lizzy McKinnon

ABSTRACT

The Crato Formation of NE Brazil is an Aptian fractured limestone that has been considered an analog to low-permeability laminated facies of pre-salt carbonate reservoirs of Brazil. The structural diagenesis of fractures is necessary to understand the evolution and migration of fluids in the reservoir. This study presents outcrop and microstructural analyses of the Crato Fm. in the Três Irmãos complex of strip mines (TIC). The Crato Fm. within the TIC includes fifteen meters of lacustrine limestones that are horizontally laminated on a millimeter scale and are gray or yellow in color. Overlying the laminated limestones are ten meters of intercalated mudstones and marls that are capped by non-stratified massive gypsum deposits at least fifteen meters thick.

I pay special attention to the evolution of horizontal gypsum veins (gypsum beef) and approximately vertical gypsum veins, both with minimum lengths that exceed ten meters. Cross-cutting relationships between all structures observed in the TIC reveal that gypsum beef and veins were among the earliest fractures to form. Gypsum veins were mapped throughout the TIC. Aperture and spacing data related to gypsum beef were recorded in vertical scanlines on quarry walls of the TIC. Cements from vein walls and beef were sampled for petrographic analysis.

Gypsum beef are restricted to the upper five meters of the planar laminates. With the exception of one, two-centimeter aperture beef, macroscopic gypsum beef and veins are absent in the marls and mudstones that make up the top of the Crato Fm. Gypsum beef and veins occur in yellow limestones of the TIC. Gray limestones are devoid of gypsum beef and rarely contain gypsum veins. When present in gray limestones, gypsum veins are stained yellow along their margins into the host rock. Petrographic analysis reveals that both vein sets were subject to multiple events of fracture opening and cementation. Anhedral and fibrous gypsum crystals are both present in gypsum beef and veins. There is evidence for post-cementation fracturing and stylolitization within beef cements. Regions of fibrous cement contain organic material, especially along grain boundaries and filling intra-crystal fractures.

According to their similarities in cement type and texture, their cross-cutting relationships with other structures and their spatial proximity, gypsum beef and vertical veins were likely coeval. It is concluded that the opening of gypsum beef was driven by super-lithostatic fluid pressure beneath the overlying low-permeability mudstones, marls and gypsum deposits. Progressive compaction cannot drive fluid pressure above lithostatic, so at least some fluid must have been allochthonous, either from up-section or down-section of the Crato Fm. Because beef are filled with gypsum, a candidate source of fluid is dehydration of the gypsum deposits above the Crato Fm. Yellow limestones are associated with the gypsum bearing fluids and are stacked above gray limestones. Stacking implies that the allochthonous waters were less dense than autochthonous formation water, implying that added water was warmer and may have been sourced from below the Crato Fm. The first possibility for allochthonous fluids could be tested by stable isotope measurements of gypsum vein cements and the overlying gypsum deposit. The second possibility could be tested by fluid inclusion microthermometry of gypsum vein cements, where fluids sourced down-section would reveal a temperature above the geotherm for the burial history of Crato Fm.

Randall Marrett

Advisor: Randall Marrett