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Round up the Usual Suspects: Building the Case to Define Overpressure-Generation Mechanisms in Upper Cretaceous to Tertiary Shales Overlying the Eagle Ford Play

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EXTENDED ABSTRACT

Wireline logs, cuttings, and other datasets were analyzed to determine the origin of overpressure in Upper Cretaceous to Eocene shales overlying the Eagle Ford play of South Texas (Fig. 1). In this area, soft overpressures begin near the base of the Wilcox Group and increase downward through the Midway and Navarro shale section to the top of the overpressured Austin Chalk and Eagle Ford (Fig. 2).

Compaction disequilibrium is a commonly cited mechanism for generating overpressures in Tertiary shales of the greater Gulf of Mexico. In this scenario, muddy sediments are deposited faster than they can dewater. The pore-pressure prediction in Figure 2 is calculated based on this assumption. Our scanning electron microscope (SEM) images, and those of a parallel SEM-based study (Landry et al., 2020) clearly demonstrate the effects of mechanical compaction, primarily through the increased alignment of clay minerals and reduction of inter-particle porosity in clay-dominated rocks.

However, density and sonic logs show trends in the Lower Wilcox and Midway Shale intervals that are best interpreted as indicating that overpressures are related to "unloading" (Fig. 3) in that part of the section. Unloading refers to the onset of a pore-pressure generation mechanism once the strata has already compacted to some degree. We rule out hydrocarbon maturation as a possible mechanism because of the organically lean, thermally immature nature of this part of the section.

The conversion of smectite to illite releases water that can generate overpressures in shales—another type of unloading mechanism. Our bore-

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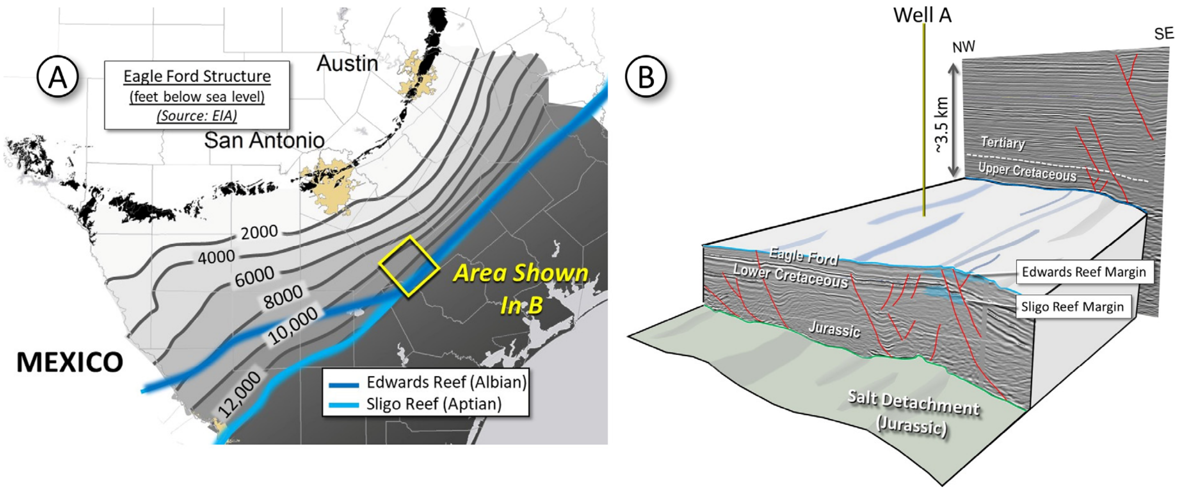

Figure 1. (A) Location map showing simplified structural contours on top of the Eagle Ford. Yellow box shows approximate location of dataset used in this study. (B) Annotated seismic imagery showing broad-scale structural configuration, ages of main stratigraphic units, and approximate location of the well used in this paper. This paper focuses on the Upper Cretaceous and Tertiary section above the Eagle Ford.

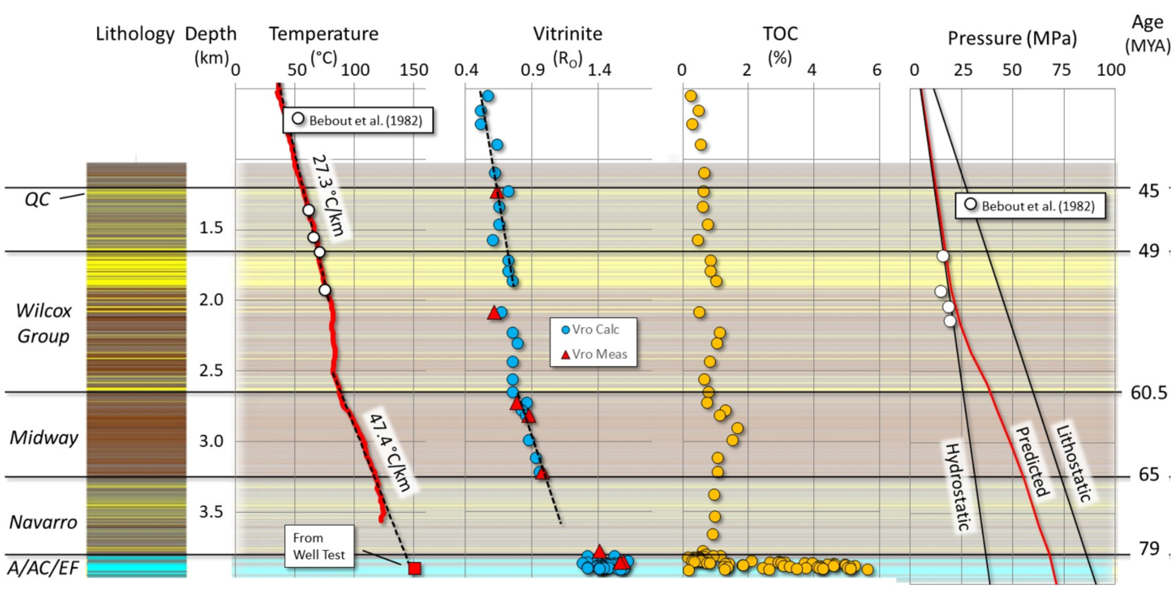

Figure 2. Left to right: Lithology profile derived from the gamma-ray log (yellow, sand; brown, shale; and blue, carbonates). Temperature profile (from measurement-while-drilling), vitrinite reflectance (measured and calculated from T_{max}), predicted pore pressure, and calculated sedimentation rates. Stratigraphic names include the Queen City (QC) and Anacacho/Austin Chalk/Eagle Ford (A/AC/EF) interval at the base.

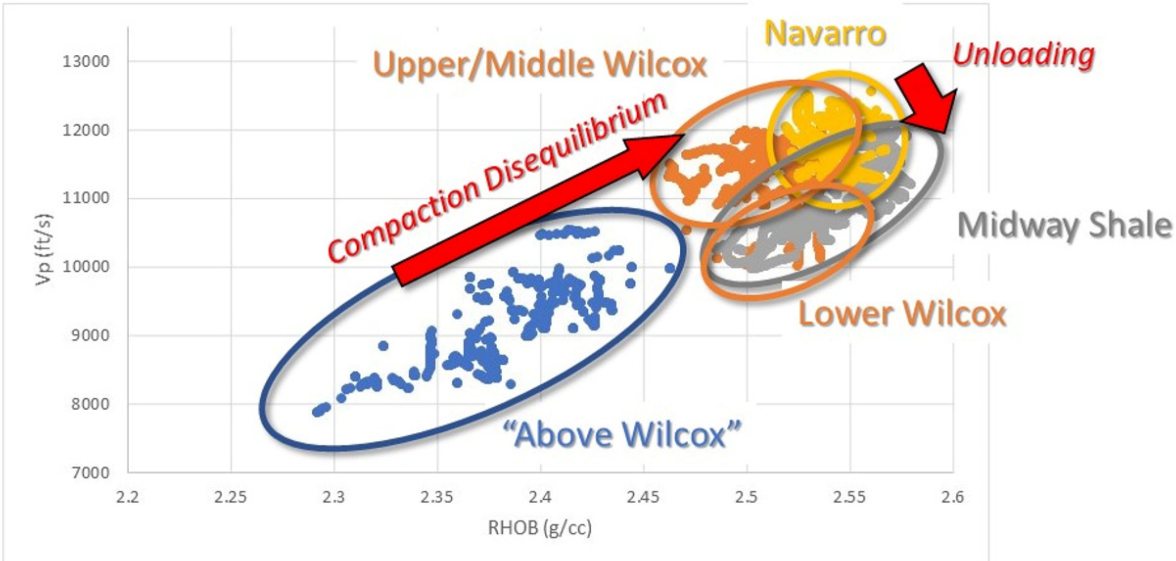

Figure 3. P–wave velocity (Vp) versus density (RHOB) for Upper Cretaceous and Tertiary shales overlying the Eagle Ford/Austin Chalk reservoirs. Trends as defined by Swarbrick (2012). Trends from lower left to upper right correspond to normal or disequilibrium compaction trends with depth. The section above the Wilcox, the Upper Wilcox, and the Navarro Group fall along this trend. Data from the Lower Wilcox Group and Midway Shale fall to the lower right of that trend, suggesting that some type of unloading mechanism (e.g., fluid expulsion associated with smectite-to-illite transition) has been operative in these intervals.

hole temperature and organic maturity data suggest that the smectite-illite transition should begin in the Wilcox interval. This prediction is supported by x–ray diffraction (XRD) analyses of clay minerals (decrease in the amount of smectite in mixed-layer clays) and SEM imagery showing the precipitation of quartz overgrowths in the shales. The silica is probably released through the smectite-illite conversion. Together, the weight of the evidence suggests that clay-mineral transition is the primary cause of overpressures in shales overlying the Eagle Ford trend. Hard overpressures present locally in the Eagle Ford have formed in response to thermal cracking of oil to gas (e.g., Kalinec and Hart, 2021).

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