The Maness Shale:

A Comparison of the Geomechancial and Geochemical Properties within the Lower Eagle Ford

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ABSTRACT

America's energy independence has been fueled by the advent of horizonal drilling technologies in unconventional Shales. The Eagle Ford Shale in south Texas has been a prolific unconventional play since its discovery in 2008. It was deposited in the Gulf Coast Basin along the southern rim of Texas. This play covers a vast area that stretches approximately 7 million acres (2.8 hectares) and extends from the College Station area to the USA-Mexico Border near Del Rio. The majority of the Eagle Ford has been thoroughly studied and analyzed, however, there is much to learn about the basal member, the Maness Shale.

The Maness Shale was deposited 97 million years ago and is the clay rich lower member of the Eagle Ford that sits upon the Buda Limestone. The Maness has been mapped across the San Marcos Arch however, the complete up dip and down dip extents remains unknown. The Maness obtains a maximum thickness of 40 feet (12.2 meters) in the Karnes Trough and thins to 10 feet (3.048 meters to the northern extent of the study area. To E&P companies actively drilling in the Eagle Ford Shale, the Maness is a geohazard that must be avoided due to the borehole instability because the interval's high clay content. Complete accurate mapping of the interval of the Maness structure and isopach is paramount to a successful drilling program.

To further understand the geomechanical properties of the Maness Shale, two hand-held devices will be used on cores taken near the San Marcos Arch to determine rock strength variations between the Maness Shale and the overlying Eagle Ford Group. The Equotip Bambino is a micro-rebound hammer that provides hardness data values that can be used to estimate unconfined compressive strength. The Dimpler is a micro-indentation device that infers rock strength by measuring the depth and diameter of a dimple created by the tool. Cross plots comparing the unconfined compressive strength, hardness and XRD derived mineral and clay compositions will be used in an effort to understand the variations in Maness Shale across the study area.

REGIONAL GEOLOGY

- The Early Cenomanian (96.0 Ma), the flooding of the North American continent established a connection between the Texas Shelf and the Western Interior Seaway (Fig. 1).
- The Maness was deposited at the initial on set of the marine transgression that culminated at Oceanic Anoxic Event 2 (OAE2) located from the east Texas basin down to the San Marcos Arch.
- Stratigraphic column specific to study area, showing the Eagle Ford Formation and deposition versus hiatus of the Maness Shale (Fig 2.).

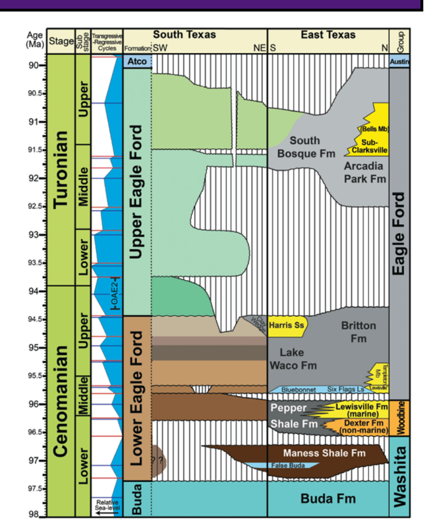


Figure 2. Stratigraphic column for this semi-regional study with Wheeler diagrams for south and east Texas using age models developed by Denne et al 2016. (Revised from Denne and Breyer, 2016).

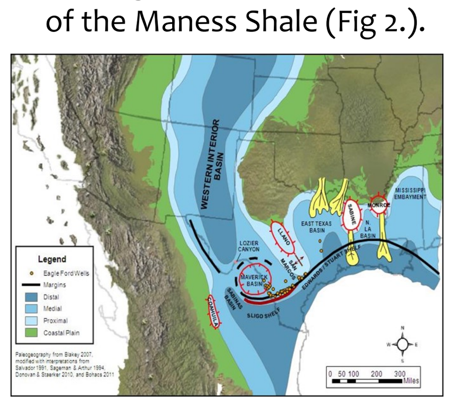


Figure 1. Paleogeographic map of the Gulf Coast region during the Late Cenomanian showing the major topographic features and relative distance from sediment sources (Image modified from Donovan and Staerker ,2010).

DATA & LOCATOR MAP

- Three cores will be used for this study that go across the San Marcos Arch. These are represented as G-1, L-1 and F-1 (Fig 3.).
- Over 250 wells have been correlated using a gamma ray log curve across the entire Eagle Ford Shale Trend. (Fig 4.).

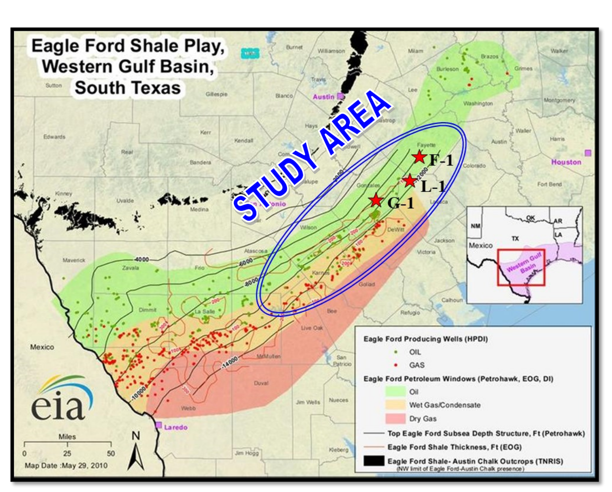


Figure 3. Eagle Ford Shale Play map indicating core locations and study area (US Energy Information Administration, 2014).

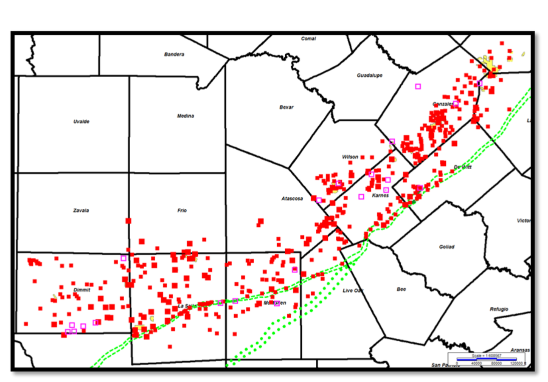


Figure 4. Working map displaying pilot hole control points.

METHODS

LOGS

- A spike in the gamma ray log marks the transition from the Lower Eagle Ford to the Maness Shale. This is a reflection of a phosphatic lag that contains a high amount of uranium.
- The entire Maness unit has a higher gamma ray reading due to the increase in uranium and due to the Shale with a high clay content of over 50% (Adams and Carr, 2010; Jennings and Anita, 2013; Denne and Breyer, 2016).
- The gamma ray spike is used to correlate in logs across multiple counties (Fig. 5). South of the San Marcos Arch, specifically in Karnes County, the Maness Shale is thinned to only the phosphatic lag that can be used in log correlation (Denne and Breyer, 2016).

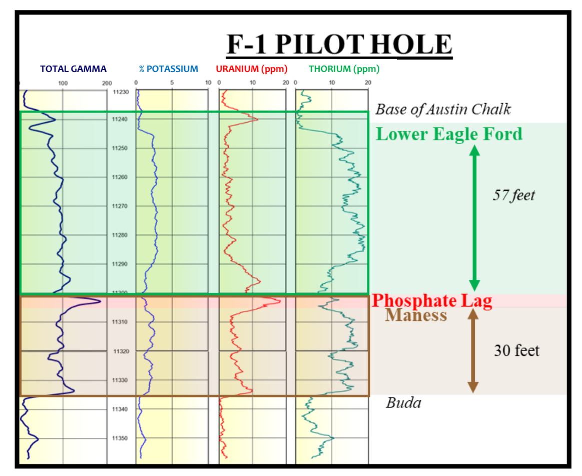


Figure 5. Type log using core depth and formation tops.

CORE

Testing cores (Fig. 6) for:

- Hardness & strength - devices that measure hardness by data values that can be used to estimate unconfined compressive strength and hardness.
  - Equotip Bambino 
  - Point load penetrometer - Dimpler 
- Composition 
  - X-Ray Diffraction XRD – bulk and clay analysis

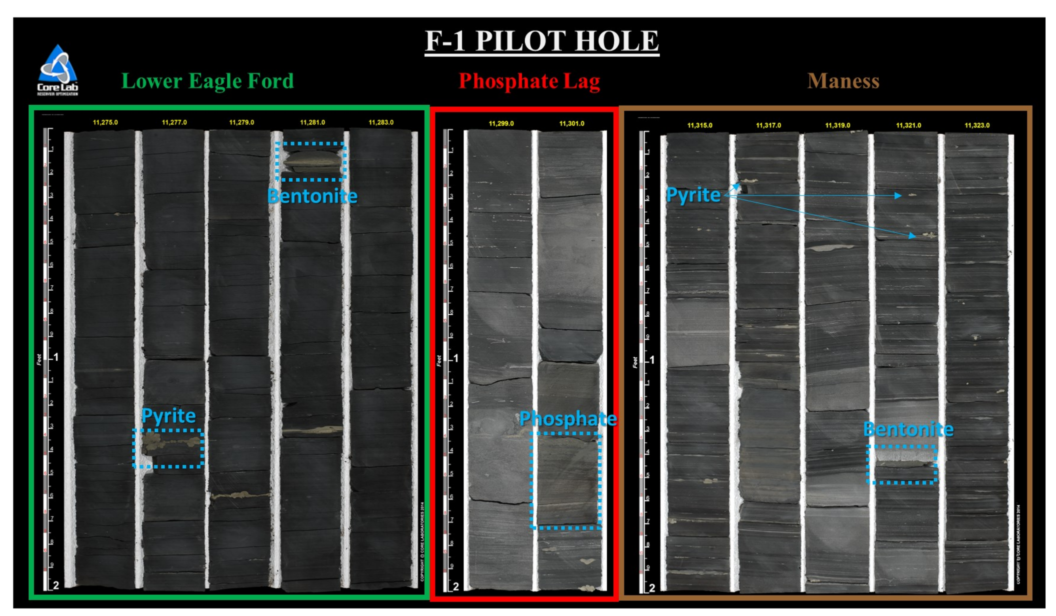


Figure 6. Photographs of F-1 core separated into three segments; lower Eagle Ford, phosphate lag and Maness. These three separations are noted in the same color scheme in the above type log (Fig 6). The hardness and strength have been recorded approximately every 6 inches (15.24 cm).

INITIAL GEOMECHANICAL DATA

The raw data (Fig. 7a and 7b) from the Bambino that measures rock strength in Leebs (HLD) will later be converted to unconfined compressive strength units in psi.

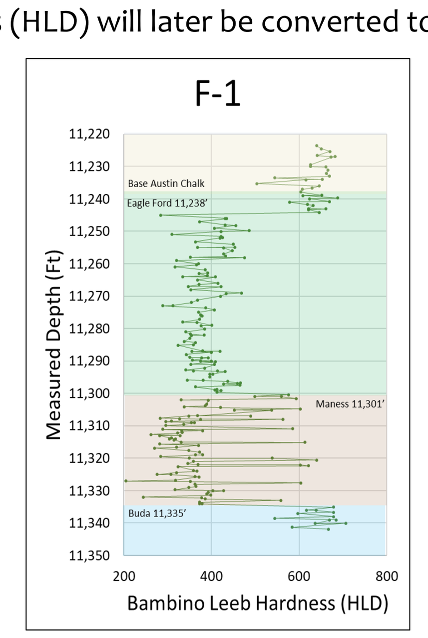


Figure 7a. Unfiltered Bambino hardness data for well F-1.

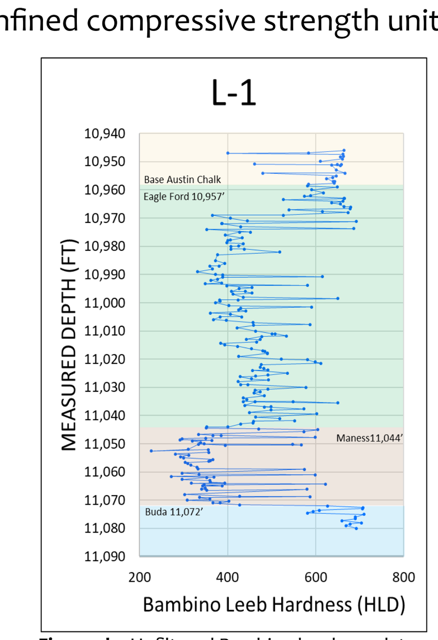


Figure 7b. Unfiltered Bambino hardness data for well L-1.

INITIAL CORREALTIONS AND MAPPING

STRATIGRAPHIC CROSS SECTION

- First, I correlated Buda, Maness, Lower and Upper Eagle ford tops in 50 wells that had a robust data set that included gamma ray, resistivity and neutron density. (Fig. 8)
- Then correlated about 250 additional wells that had fewer logs, e.g., gamma ray and resistivity only.
- This process then established a working Maness Shale isopach map (Fig. 9).

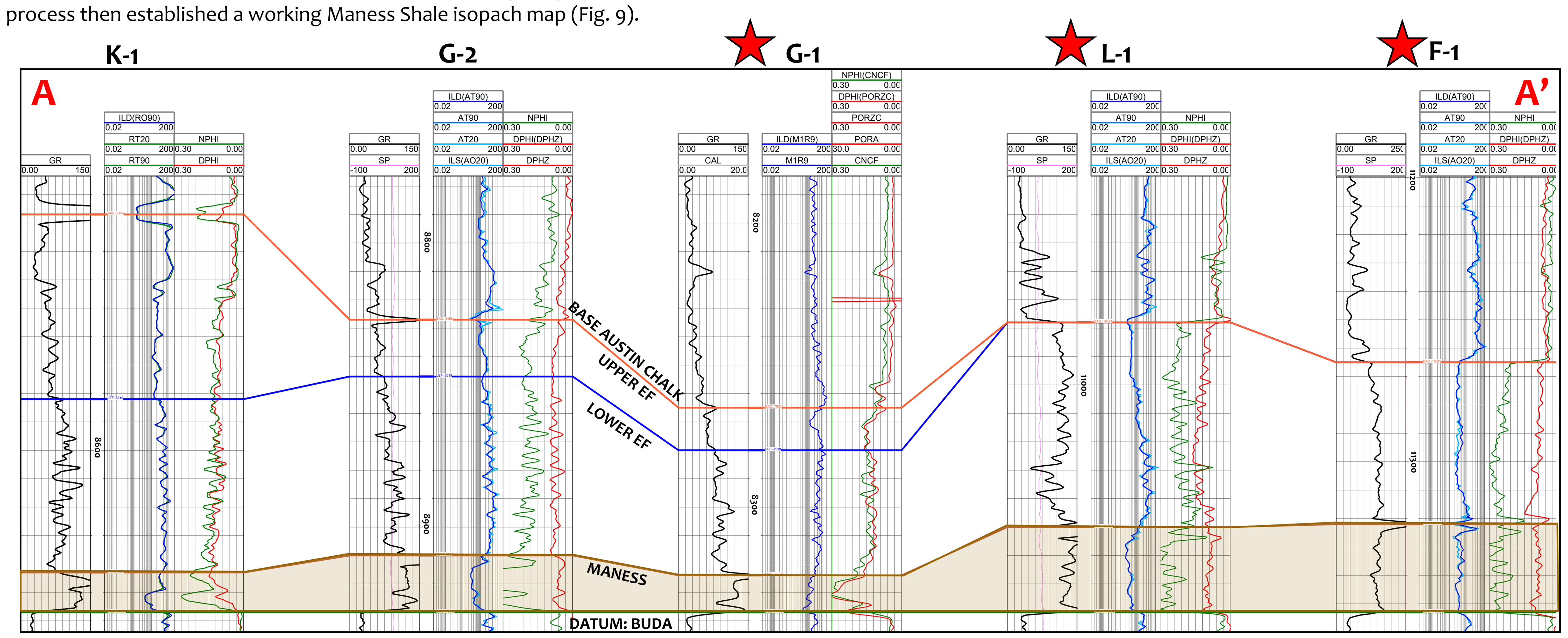
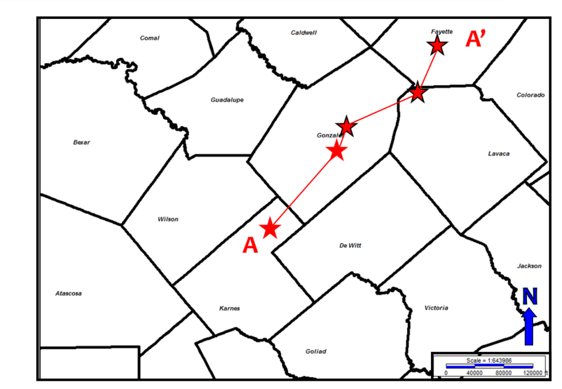


Figure 8. Stratigraphic cross section going from A to A' across the San Marcos Arch. Note the neutron density ranges between 20-30% indicating a high clay content.



MANESS ISOPACH MAP

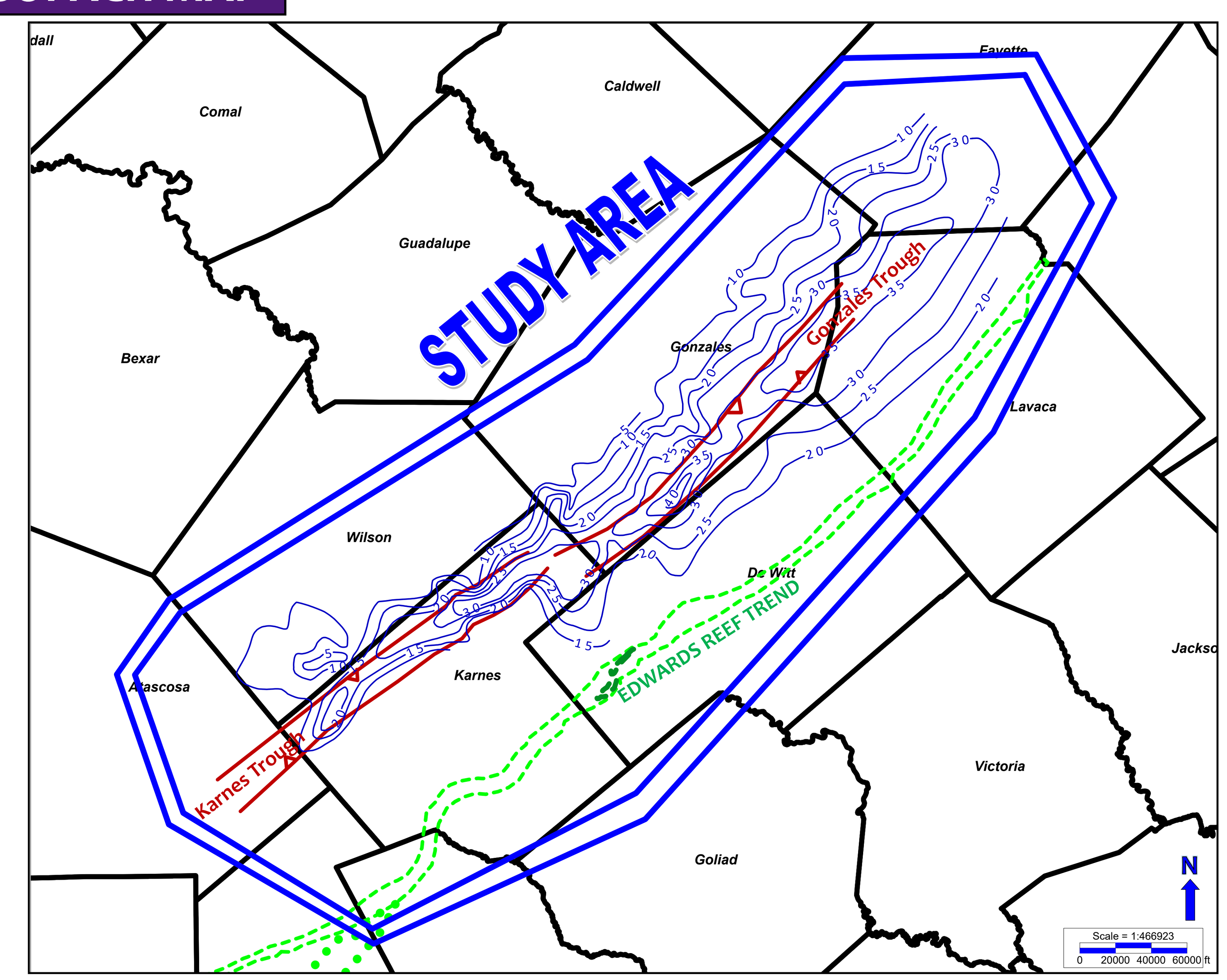


Figure 9. The Maness Isopach map resulted in having a maximum thickness of approximately 40 feet (12.2 meters) in the Karnes trough. The Maness Shale thickness thins out the further away from the trough and disappears to the southwest around the McMullen county line. To the northeast, more mapping will have to be done to find the extents of the Maness.

RESULTS

- Mapping
  - Initial mapping identified a maximum thickness of approximately 40 feet (12.2 meters) in the Karnes and Gonzales troughs. The Maness Shale horizon thins out away from the trough and disappears to the southwest around the Atascosa county line.
- Geomechanics
  - As predicted, the Eagle Ford has higher Leeb Hardness (HLD) values than the Maness, indicating that the Eagle Ford is mechanically stronger than the underlying Maness Shale.
  - The Buda Limestone and Austin Chalk have HLD values that are 50 percent higher than the Eagle Ford average due to carbonate.
  - Carbonate nodules in the Maness provide intermittent hard grounds that have typical hardness of a limestone.

REFERENCES: Bailey, Thomas L., Frank G. Evans, and Walter Scott Adkins. "Revision of stratigraphy of part of Cretaceous in Tyler Basin, northeast Texas." *AAPG Bulletin* 29.2 (1945): 170-186.;Fairbanks, Michael D., Stephen C. Ruppel, and Harry Rowe. "High-resolution stratigraphy and facies Architecture of the Upper Cretaceous (Cenomanian–Turonian) Eagle Ford Group, Central Texas." *AAPG Bulletin* 100.3 (2016): 379-403.; Denne, Richard A., and John A. Breyer. "Regional Depositional Episodes of the Cenomanian-Turonian Eagle Ford and Woodbine Groups of Texas and their Relationship to Oceanic Anoxic Event 2 (OAE2)." (2016): 145-158.; Denne, Richard, et al. "Part 1: Biostratigraphic and Geochemical Constraints on the Stratigraphy and Depositional Environments of the Eagle Ford and Woodbine Groups of Texas." (2016): 1-86.; Jennings, Debra S., and Jonathan Antia. "Petrographic characterization of the Eagle Ford Shale, South Texas: Mineralogy, common constituents, and distribution of nanometer-scale pore types." *Electron microscopy of Shale hydrocarbon reservoirs: AAPG Memoir* 102 (2013): 101-113.; Lozo, Frank E. "Stratigraphic Notes on the Maness (Comanche Cretaceous Shale)." (1951): 65-92.; Railroad Commission of Texas Production Data Query System, 2017 (http://www.rrc.state.tx.us); Sageman, Bradley B., and Michael A. Arthur. "Early Turonian paleogeographic/ paleobathymetric map, western interior, US." Rocky Mountain Section (SEPM), 1994.; U.S. Energy Information Administration (EIA) http://www.eia.gov/oil_gas/rpd/Shaleusa9.pdf