Stratigraphy of the Ernst Member of the Upper Cretaceous Boquillas Formation, Black Gap Wildlife Management Area, Brewster County, Texas

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Abstract

The time-equivalent Boquillas Formation and Eagle Ford Shale (EFS) were deposited on the South Texas Shelf in the Late Cretaceous (Cenomanian-Turonian), during a time of widespread marine transgression. The two formations consist of organic-rich shales and marls interbedded with calcareous limestones that vary in thickness, laterally and vertically. The organic-rich shales and marls in the lower part of the EFS in the Maverick and East Texas Basin, have been major targets for unconventional production in south Texas since 2008. Until recently, the EFS was thought to be relatively homogenous throughout, but recent core and outcrop studies suggest the EFS contains complex lithological and geochemical heterogeneity (Donovan et al., 2012; Fry, 2015). An understanding of the heterogeneity of the formation at different scales is vital in characterizing the EFS play.

For the study, a section of the Ernst Member of the Boquillas Formation was measured and described in detail in Heath Canyon, Brewster County, Texas. Lithostratigraphy and biostratigraphy were determined via outcrop study. Chemical composition, chemostratigraphy, and mechanical stratigraphy were determined from sample collection and lab analysis. The was compiled and used to describe and characterize the depositional environment of the Ernst Member in the study area. Additionally, data from this project will be integrated with data from similar, proximal Boquillas outcrop studies for possible regional correlation to characterize the depositional environment of the Boquillas on the South Texas Shelf.

The Eagle Ford Shale in the Black Gap Wildlife Management Area shows similar characteristics to the Eagle Ford deposited in the Big Bend area just to the east. The lower portion of the Eagle Ford from the base to ~68 feet (20.7 m) is characterized by high concentrations of trace elements such as Mo, Ni, V, Th, and Zn. Additionally, more beds in the lower section plot further towards the aluminum and silica portions of the ternary diagram which is typical of the lower section of the Eagle Ford. Major elements like Ca show to be less abundant in the lower section and more abundant in the upper section. Overall, the Eagle Ford can be split into a lower and upper member based on chemical variations between the two. The lower section seems to be deposited in a more anoxic to euxinic environment, while the upper section seems to be deposited in a more toxic to suboxic environment.

Introduction

The EFS unconformably overlies the Upper Cretaceous Buda Limestone and is overlain by Upper Cretaceous Austin Chalk (Fig. 2). The Boquillas Formation, (EFS equivalent) in Trans-Pecos Texas, overlies the Buda Limestone and is separated into two formal units: the Ernst Member and the San Vicente Member (Maxwell and Dietrich, 1965). The Ernst Member represents deposition in an Eagle Ford type environment, whereas the San Vicente suggests deposition in an environment similar to the Austin Chalk. Additionally, the Ernst Member and EFS were deposited during Oceanic Anoxic Event (OAE) #2. This defines the Cenomanian-Turonian boundary and represents a time of maximum worldwide sea levels and ocean anoxia (Schlanger and Jenkyns, 1976.

With industry interest in the EFS, an understanding of the geology and depositional environment of these rocks is imperative to maximize well results. Boquillas Formation in southwest Texas is equivalent to the subsurface and exposed EFS. XRF and mechanical data are common tools to use to aid in characterizing the depositional environment of the similar sections. XRF gathers important elemental data that is used as proxies for common rock forming minerals including clay minerals, calcite, and quartz. Mechanical data can be used to determine strength of the rocks in the section and be used to find trends with elemental data to further describe and characteriz the section. These data will also be used to correlate with data from proximal Eagle Ford sections to aid in interpreting the depositional environment on the STS.

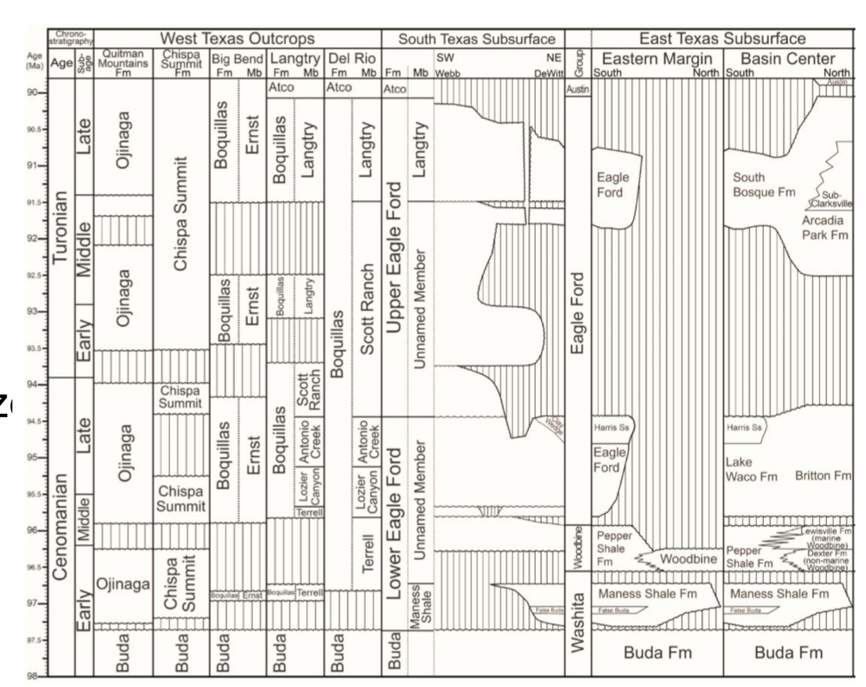

Figure 2. Wheeler diagram and stratigraphic nomenclature of the Eagle Ford in the west Texas outcrop area and east Texas subsurface. Modified from Denne et al., 2016.

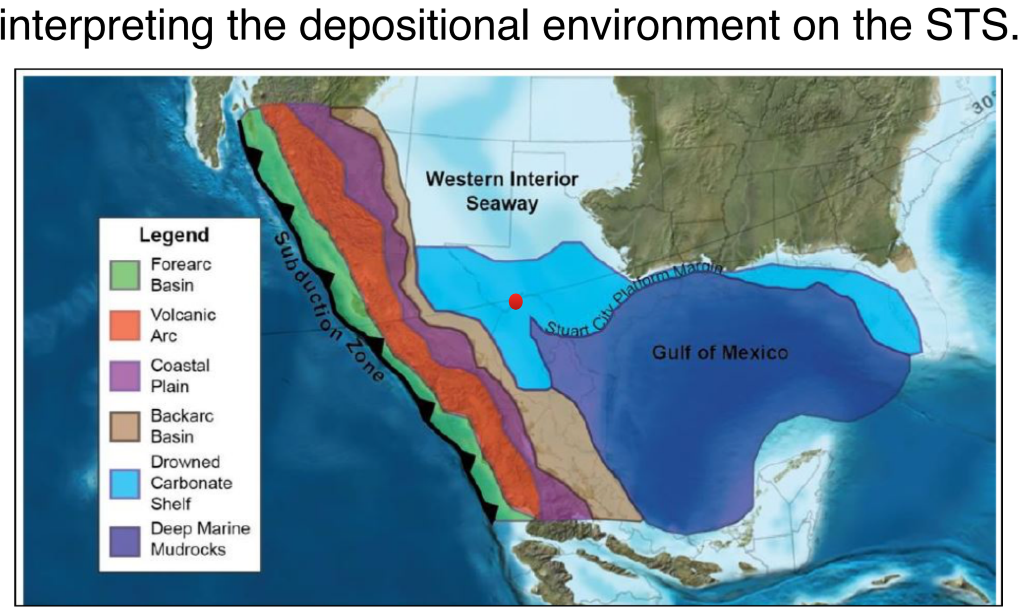

Figure 1. Late Cretaceous paleogeography of southern Laurentia showing Western Interior Seaway connection with the Gulf of Mexico. Light blue is drowned South Texas Shelf. Measured section location show by red dot. Modified after Fry, 2015.

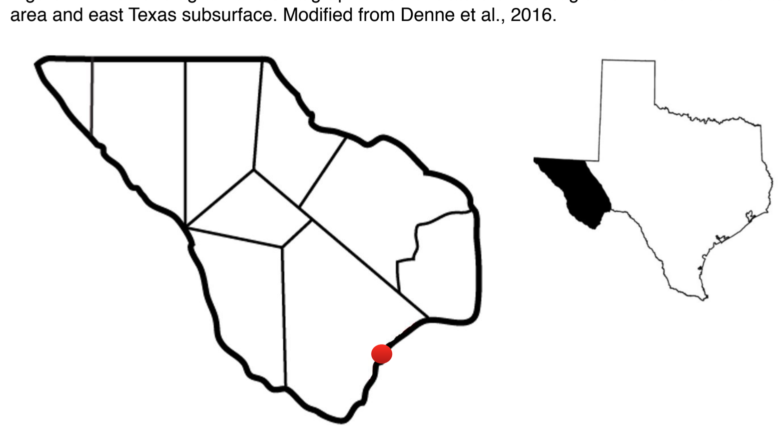

Figure 3. Texas outline with Trans-Pecos area shaded in black. Red dot shows approximate location of study area in the Black Gap Wildlife Management Area of Brewster County, Texas. Modified from Williams, 2017.

Methods

- A section of the Eagle Ford Formation was measured in the Black Gap Wildlife Management Area in Brewster County, Texas, totaling 223 feet (71m).
- Samples from outcrop were collected in 6 inch (15cm) intervals and used for chemical and mechanical analysis.
- A hand-held portable X-ray fluorescence (XRF) device was used to determine chemical composition of samples in the section which was used to indentify trends of major and minor elements within the section.
- A Radiation Solution Incorporated RS-230 BGO Super-SPEC portable gamma-spectrometer was used to collect percent potassium, uranium parts per million, and thorium parts per million of the section in 6 inch (15cm) interval. This was the converted into API units to give a well log signature of the section.
- The section was described in detail, individual bed thickness and continuity, color, clast size, grain size, composition, rounding, sorting, sedimentary structures, fossils, and trace fossils observed were noted. Thickness of section was determined using a metric tape measure.
- A point load penetrometer "dimpler" was used on the collected samples to determine unconfined compressive strength (UCS) in psi of the section.

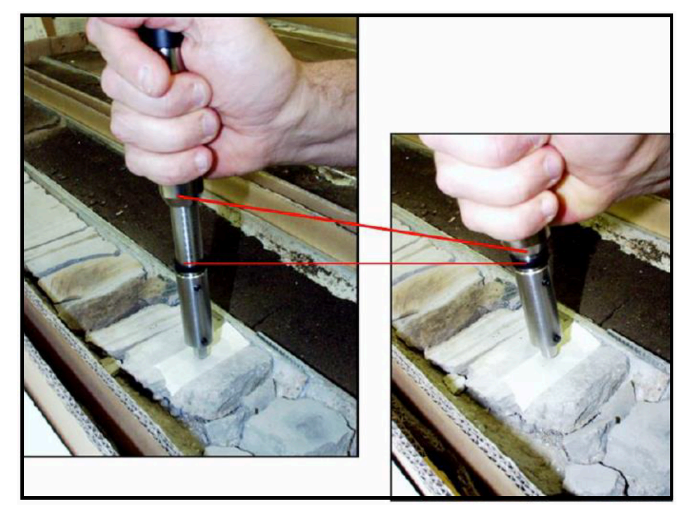

Figure 4. Image illustrating Dimpler use. Left image is before the dimple is made, right image is after dimple is made. From Enderlin, 2010.

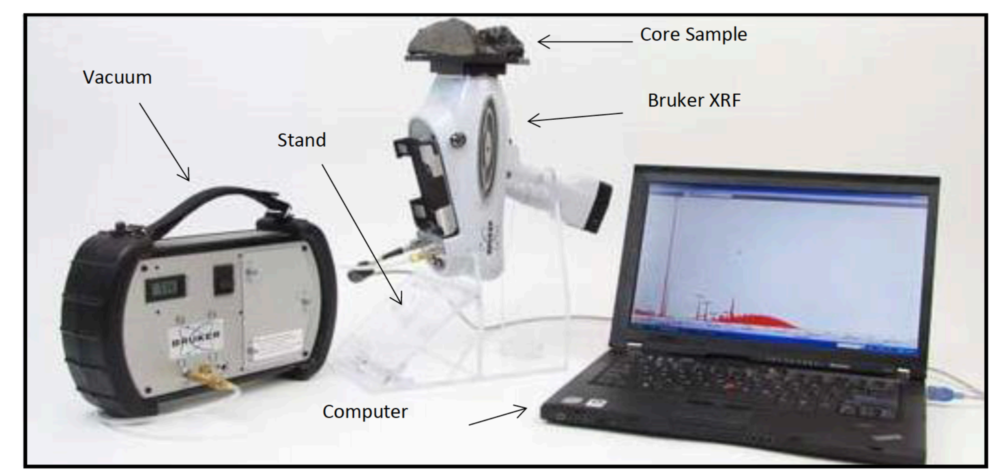

Figure 5. Image showing configuration of Bruker handheld XRF during data collection. Flat portion of sample was placed flush on platform to maximize accuracy. From Taylor, 2017.

Figure 6. Image showing Radiation Solution Incorporated RS-230 BGO Super-SPEC portable gamma-spectrometer used to collect percent potassium, uranium parts per million, and thorium parts per million of the section.

Figure 7. Image showing interbedded limestone and marl in the lower portion of the section. Metric tape measure was used to measure the thickness of the section and rock hammers were used to collect samples.

Results

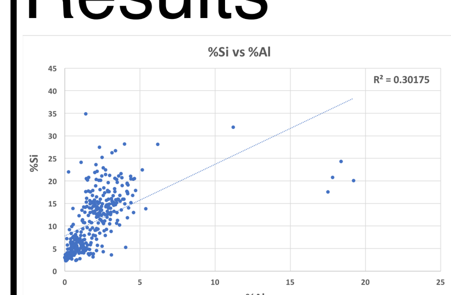

Figure 8. Cross plot of %Si vs. %Al for section.

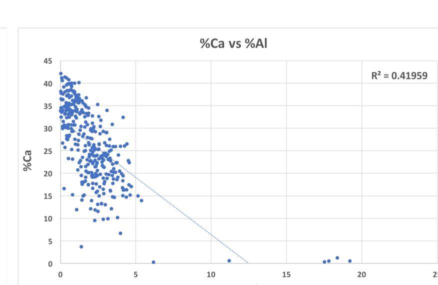

Figure 9. Cross plot of %Ca vs. %Al for section.

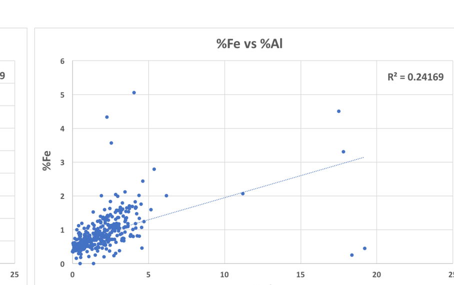

Figure 10. Cross plot of %Fe vs. %Al for section.

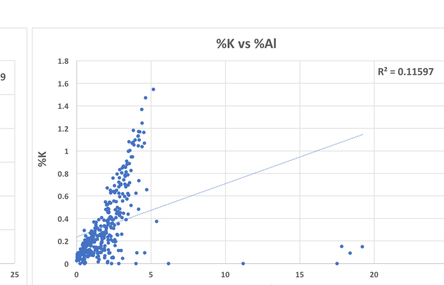

Figure 11. Cross plot of %K vs. %Al for section.

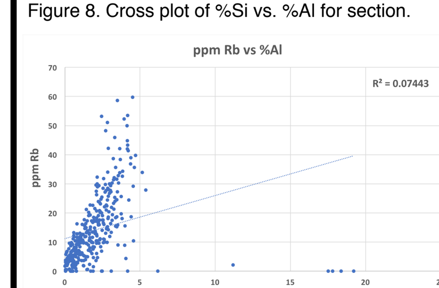

Figure 12. Cross plot of ppm Rb vs. %Al for section.

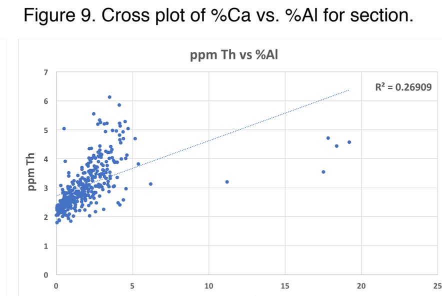

Figure 13. Cross plot of ppm Th vs. %Al for section.

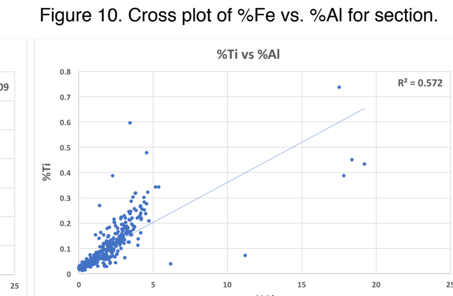

Figure 14. Cross plot of %Ti vs. %Al for section.

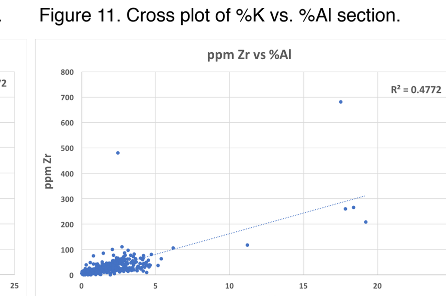

Figure 16. Cross plot of ppm Zr vs. %Al for section.

- Several major and minor elements are cross-plotted against Aluminum to determine if they are of detrital origin. Aluminum is used because it is typically of detrital origin and immovable during diagenesis.
- Most cross plots have similar trends, most are related linearly, while Ca and Al are inversely related.
- Si vs. Al, Ca vs. Al, Ti vs. Al, and Zr vs. Al have the highest R^2 values. R^2 values for the other cross plots are lower because of affect from outliers (possibly bentonites).

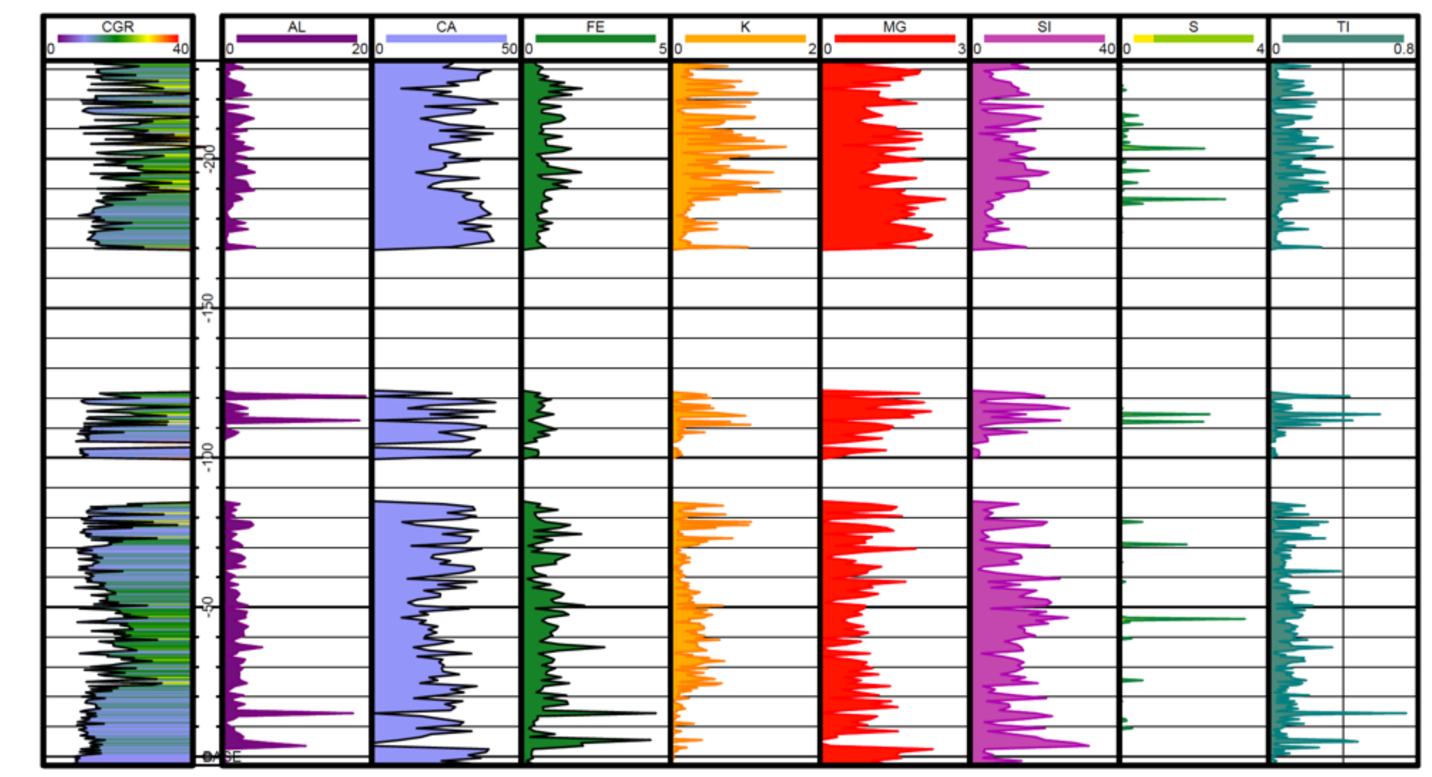

Figure 17. Major elements in weight percent and calculated gamma ray (API) versus thickness of measured section. Base represents top of Buda Formation and base of Eagle Ford Shale. Thicknesses appear to negative but are positive.

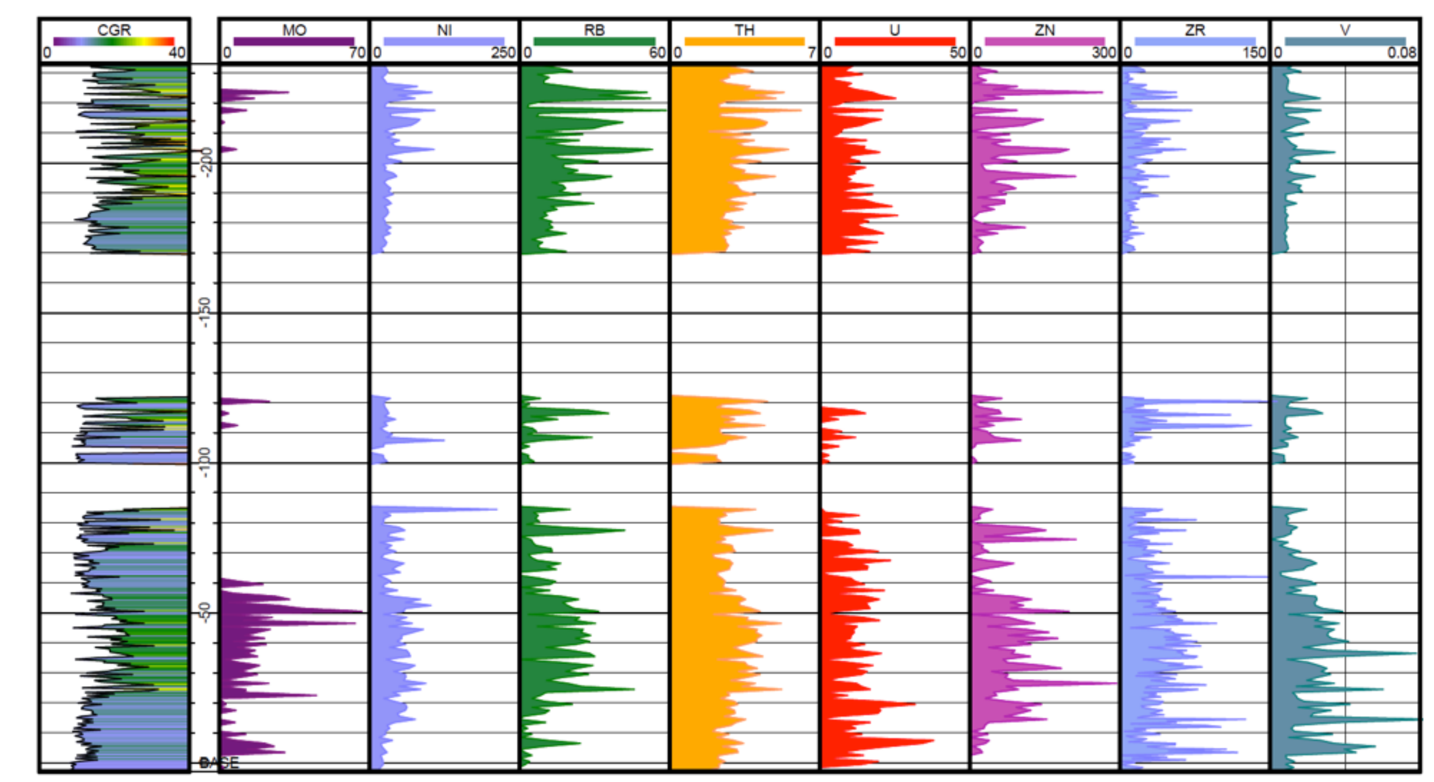

Figure 18. Trace elements in parts per million and calculated gamma ray (API) versus thickness of measured section. Vanadium was collected during major element scan and was left in weight percent. Base represents top of Buda Formation and base of Eagle Ford Shale. Thicknesses appear to negative but are positive.

Conclusions

The Eagle Ford Shale in the Black Gap Wildlife Management Area shows similar characteristics to the Eagle Ford deposited in the Big Bend area just to the east. The lower portion of the Eagle Ford from the base to ~68 feet (20.7 m) is characterized by high concentrations of trace elements such as Mo, Ni, V, Th, and Zn. Additionally, more beds in the lower section plot further towards the aluminum and silica portions of the ternary diagram which is typical of the lower section of the Eagle Ford. Major elements like Ca show to be less abundant in the lower section and more abundant in the upper section. Overall, the Eagle Ford can be split into a lower and upper member based on chemical variations between the two.

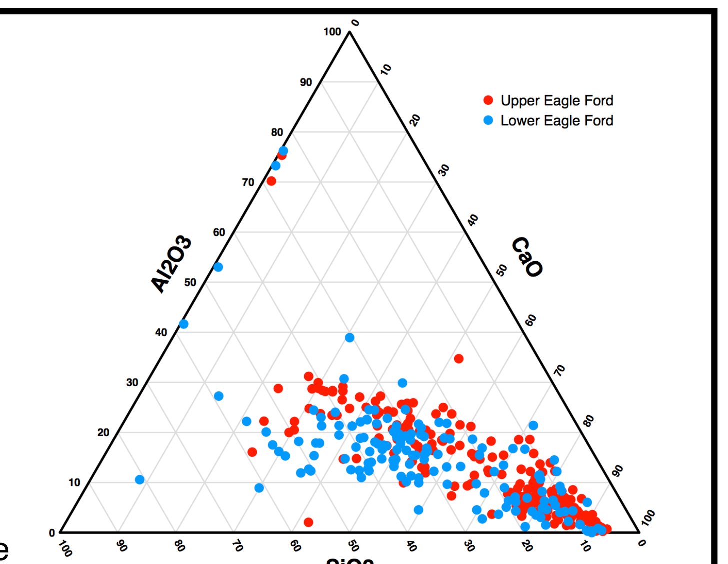

Figure 19. Calcium oxide (2 x CaO) - Alumina (5 x Al2O3) - Silica (SiO2) ternary diagram of the XRF data from the measured section. Lower Eagle Ford in blue, Upper Eagle Ford in red.

References

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