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Eagle Ford Shale and Austin Chalk Resevoir Properties From an Integrated Core Analysis Approach

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Abstract

The purpose of this Eagle Ford-Austin Chalk core was to characterize the physical properties and their variability among facies within a depositional system transitioning from TOC-rich carbonate-clastic mudrocks in a euxinic basin to TOC-poor, highly fossiliferous chalk in a relatively shallow water open shelf environment. The analysis utilizes thin sections, FIB-SEM, XRF, XRD, MICP, RCA, MRP, isotope, rock eval/TOC, Piccolo (UCS), and wireline log data in a rock-based approach combining geologic observations and core-based lab measurements into a petrophysical-based resource model. The model informs major field development decisions by identifying geochemically and geomechanically isolated pay zones within the section and thereby increasing the potential number of landing zones and overall well inventory.

Introduction

The primary objectives of this work was to 1) Quantify relationships between mineralogical composition, pore throats, pore volumes, wettability, and geomechanical properties. 2) Improve the time consuming and expensive methods for defining pore-fluid volumes, compositions, and fluid mobility/immobility. 3) The final objective was to develop a core to log-based petrophysical workflow that could be rapidly deployed and accurately represent resource in place for the formations of interest.

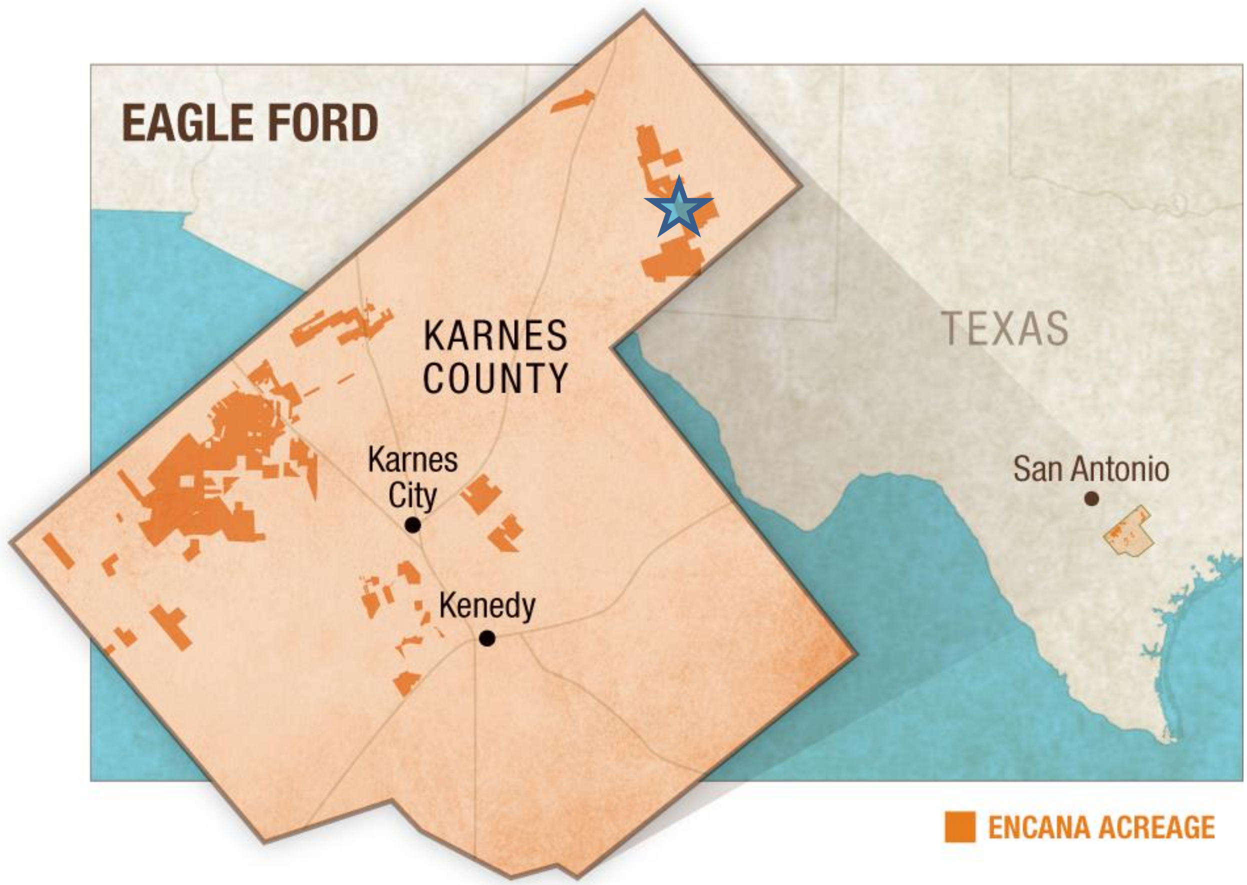

Figure 1. Location of Karnes County in the Gulf Coast Basin and location of displayed core (blue star).

Geologic Setting

The tectonic opening of the Gulf Coast region during the Upper Cretaceous resulted in the unconfomable deposition of the Eagle Ford Shale and Austin Chalk on top of Buda Limestone. The Eagle Ford Shale can be broken into a lower, organic and clay-rich, well-laminated transgressive sequence and an upper highstand tract of interstratified nearshore and distal sediments (calcareous shales, bentonites, limestones, and quartzose siltstones) that marks the start of a regressive sequence that carries into the Austin Chalk section. The Austin Chalk was deposited in a relatively shallow, open

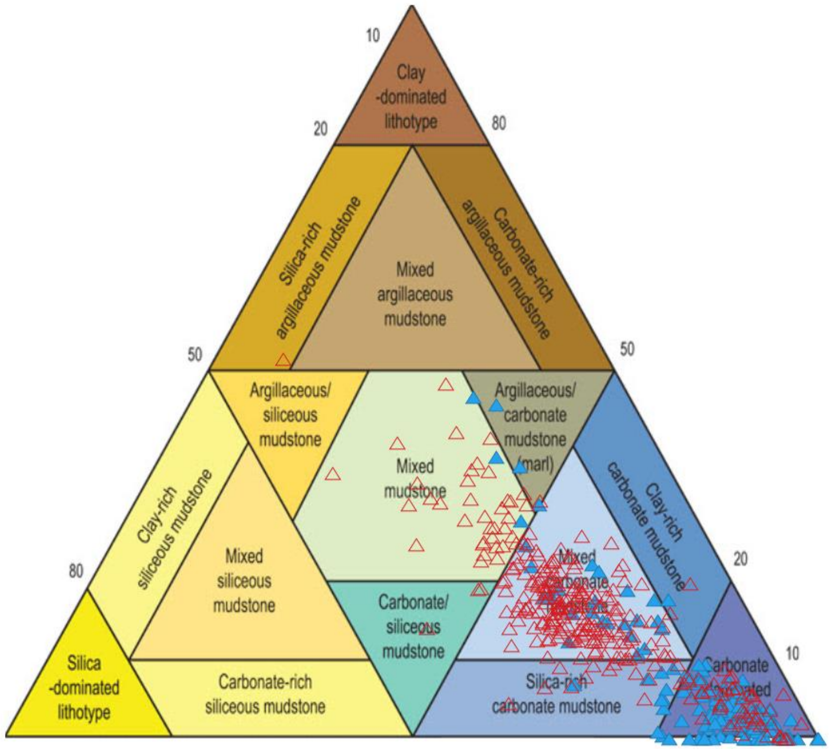

Figure 2. Ternary diagram from Schlumberger for mudrock lithofacies classification based on dry weight components of clay, carbonate, and quartz-feldspar-mica (QFM). Eagle Ford (red triangles) samples are characterized as mixed carbonate mudstones and the Austin Chalk (blue triangles) is classified as a carbonate dominated lithotype.

shelf, marine setting and contains bentonite and marl interbeds that impede or terminate fracture growth.

Method

Step 1: Define the core to log mineralogical and pore characterizations models

Normalized weight percentages of the dominant mineralogy, as defined by XRD data, are predicted using triple combo data for multiple wells across the play. Total organic content (TOC) from LECO-TOC measurements were predicted in a similar manner. A variable matrix density was then calculated through the assignment of mineral and TOC densities. Through the combination of bulk density logs, fluid density assumptions, and the variable matrix density a porosity model was generated that could be calibrated by comparison with core derived porosity values.

Step 2: Define the composition and mobility of the pore-fluid volumes

Accurate depiction of hydrocarbon saturation and geochemistry are fundamental to petroleum resevoir characterization, especially in shales and their potential couplet plays. The use of a simple classification scheme creates divsions of organic matter (OM) that can be divided into extractable OM (EOM) and non-extractable OM (NEOM). The EOM is then subdivided into gas and oil, which is subdivided again into the light and heavy components. NEOM, chemically equivalent to kerogen and pyrobitumen, is subdivided into dead and convertibel OM based on it’s ability to “crack” via pyrolysis.

This analysis is achieved through the integration of solvent extraction, multi-step programmed pyrolysis, Archimedes bulk density, and helium pycnometry. This is analysis is most critical when determing maturity based limitationson on a given source rocks ability to flow economic volumes of hydrocarbons.

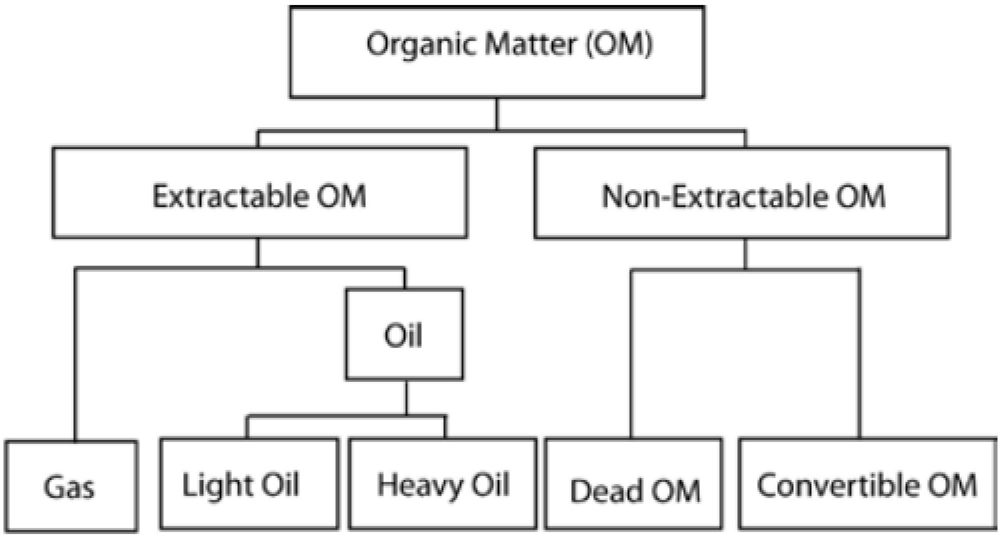

Figure 3. Organic matter classification scheme used for analysis of this core.

Conclusions

The predictive equations and subsequent conversions were all coded into a single program that interfaces with multiple mapping platforms and can read input logs and static constants that are defined by the user and dynamic constants that are defined by grids/zones (i.e. thickness, maturity) generated by the user. This creates a simple workflow that can be deployed in any asset and used by a wide range of individuals with varying experience, if inputs are verified by experienced individuals. The output logs represent a detailed accounting of mineralogy, porosity, fluid composition, mobility, maturity, and most importantly, volumes of mobile hydrocarbon.

References

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