

The Maness Shale: A Comparison of the Geomechanical and Mineralogic Properties within the Lower Eagle Ford Near the San Marcos Arch*

Samantha Patterson¹ and Richard Denne¹

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Abstract

The Lower Cenomanian Maness Shale is a clay-rich mudrock originally identified in the East Texas Field lying between the Woodbine and Buda Limestone that has been correlated to the basal Lower Eagle Ford in the vicinity of the San Marcos Arch. Where present, the Maness has been known to pose instability problems for horizontal wells that have encountered it. However, presence of the Maness may prove beneficial if it acts as a fracture barrier between hydraulically fractured Eagle Ford wellbores and underlying aquifers. Petrographic, x-ray diffraction (XRD), and geomechanical (point load penetrometer and micro-rebound hammer) analyses were performed on two industry cores taken in the vicinity of the San Marcos Arch that sampled the section from the lower Austin Chalk, Eagle Ford, Maness, and the uppermost Buda. The geomechanical studies demonstrated that the Maness is significantly weaker than the other formations; after converting the geomechanical raw data to unconfined compressive strength (UCS), average UCS values derived from the penetrometer for the Maness were 32% less than those for the Eagle Ford and 75% less than the Buda. Similarly, average micro-rebound hammer UCS values for the Maness were 36% less than the Eagle Ford and 77% less than the Buda. XRD analyses found that the shale samples from the Maness contained an average of 50% clay, whereas the overlying Eagle Ford marls contained an average of 40% clay.

Four horizons (top of overlying phosphate lag, Maness top, intra-Maness limestone, Buda top) were correlated in 345 wells within a six-county region (Karnes to Fayette counties) near the arch. Thicknesses of the Maness were found to trend northeast-southwest, in alignment with the Karnes-Gonzales troughs and the Sligo-Stuart City reef trends. The thickest intervals (>25 ft) occurred within the Gonzales trough, whereas the Maness was found to pinch-out south of southern Karnes County. Regression analysis found a 91.7% correlation between Maness thickness and oil/water ratios, which were based on cumulative first year oil and water production data from over 2000 horizontal wells in the study area, indicating that the Maness may be acting as a fracture barrier in the region. This analysis also found a 50% decrease in oil/water ratios between Maness thicknesses of 5 to 10 ft, suggesting that a minimum of 10 ft is needed for the Maness to effectively act as a fracture barrier.

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THE MANESS SHALE: A COMPARISON OF THE GEOMECHANICAL AND MINERALOGIC PROPERTIES WITHIN THE LOWER EAGLE FORD NEAR THE SAN MARCOS ARCH



Samantha Patterson
Dr. Richard Denne



COLLEGE OF
SCIENCE & ENGINEERING



Fault in the Eagle Ford Shale outcrop – Del Rio, Texas

Executive Summary

- The Maness Shale is the basal member of the Eagle Ford Group and lies directly above the Buda Limestone in South Texas
- Maness has a higher clay content than the Eagle Ford
- Unconfined Compressive Strength (UCS) estimates for the Maness averaged 34% less than the overlying Eagle Ford
- The thickness of the Maness ranges from 0-25 ft with the thickest interval confined to the Gonzales Trough
- Regression analysis found a 91.7% correlation between Maness thickness and oil/water ratios in 2,000 wells, suggesting that the Maness acts as a fracture barrier in the region.

Outline

Introduction

- Regional Geology
- Stratigraphy

Methods

- Materials
- Mapping Units

Results

- Core and thin sections
- Mineralogy
- Geomechanical Analysis
- Well Logs and Maps

Discussion

Summary and Conclusions



Fish fossil found in the Sante North Unit A 1H within the Maness Shale.

Introduction

- Regional Geology
- Stratigraphy

Methods

- Materials
- Mapping Units

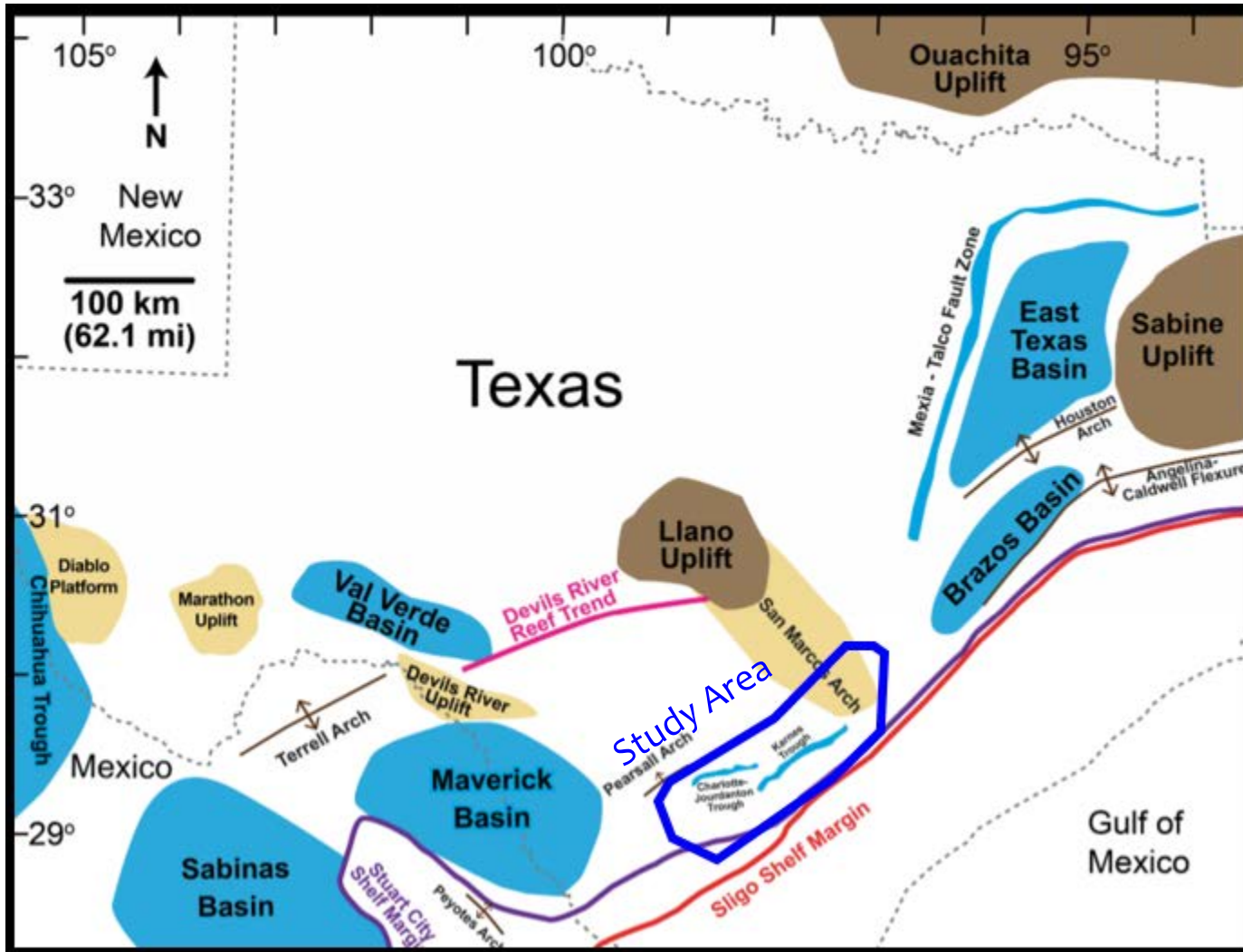
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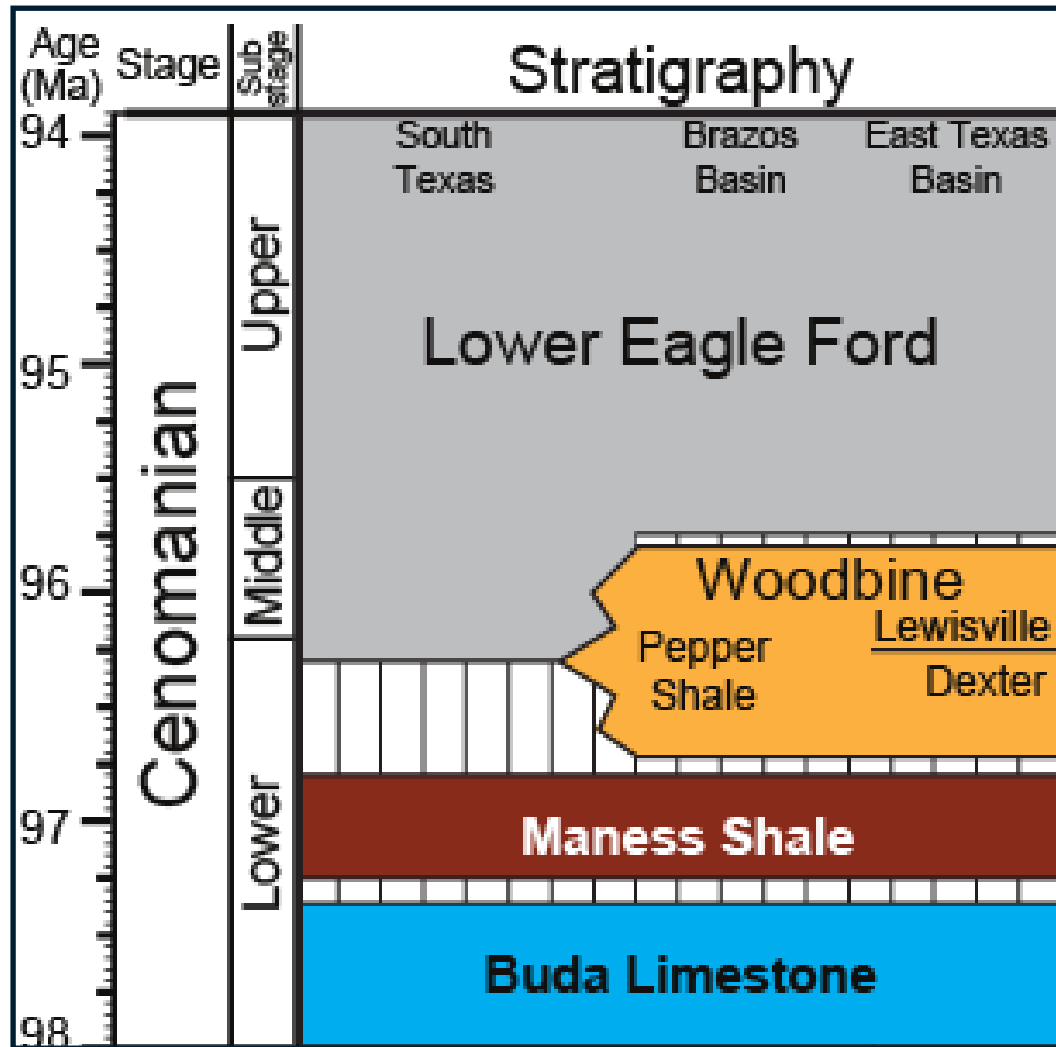
Introduction – Regional Geology



- Map of structural features that affect Eagle Ford deposition:
 - Uplifts – Sabine Uplift
 - Flexures – San Marcos Arch
 - Grabens – Karnes and Gonzales Troughs
 - Lower Cretaceous reef shelf margins

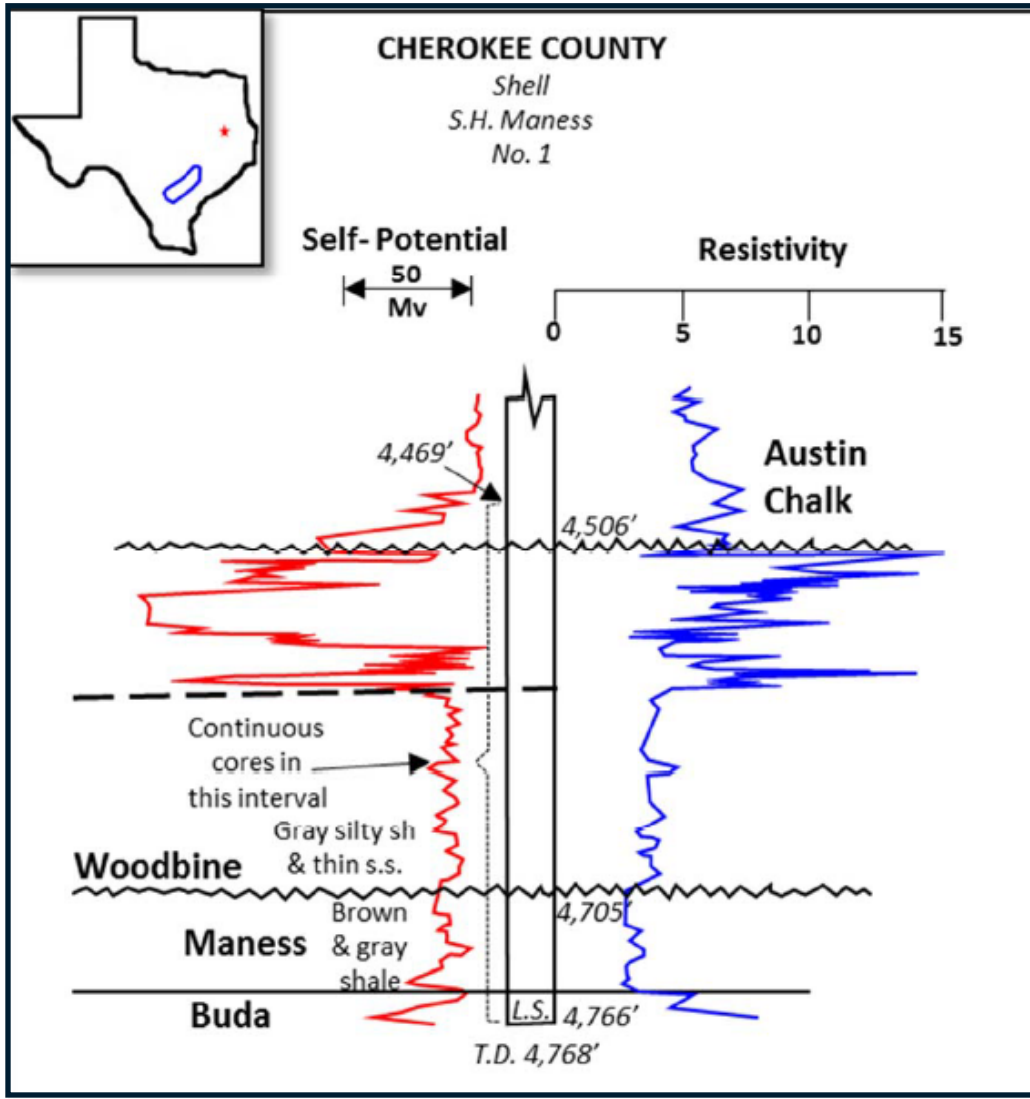
(Revised from Denne and Breyer, 2016)

Introduction - Stratigraphy



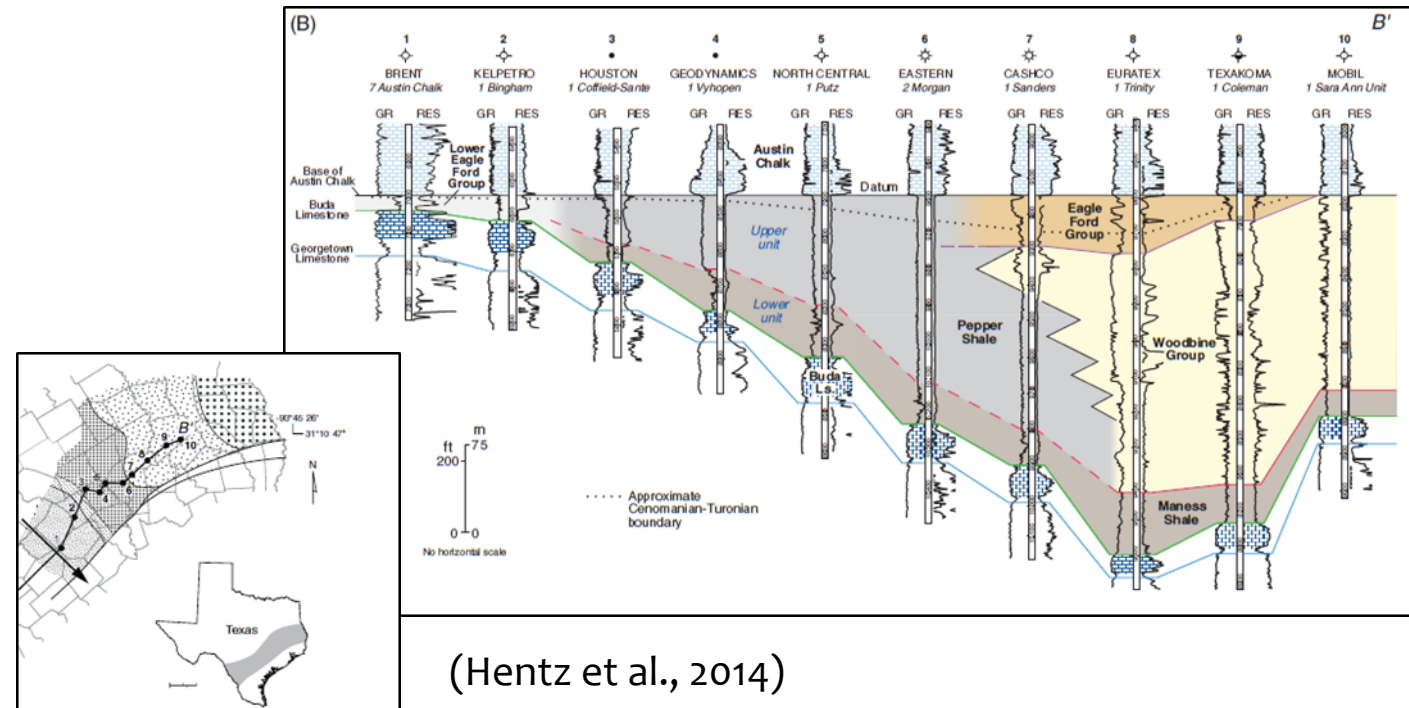
- East Texas
 - Maness occurs between Buda and Woodbine
- South Texas
 - Maness occurs between Buda and Lower Eagle Ford

Introduction



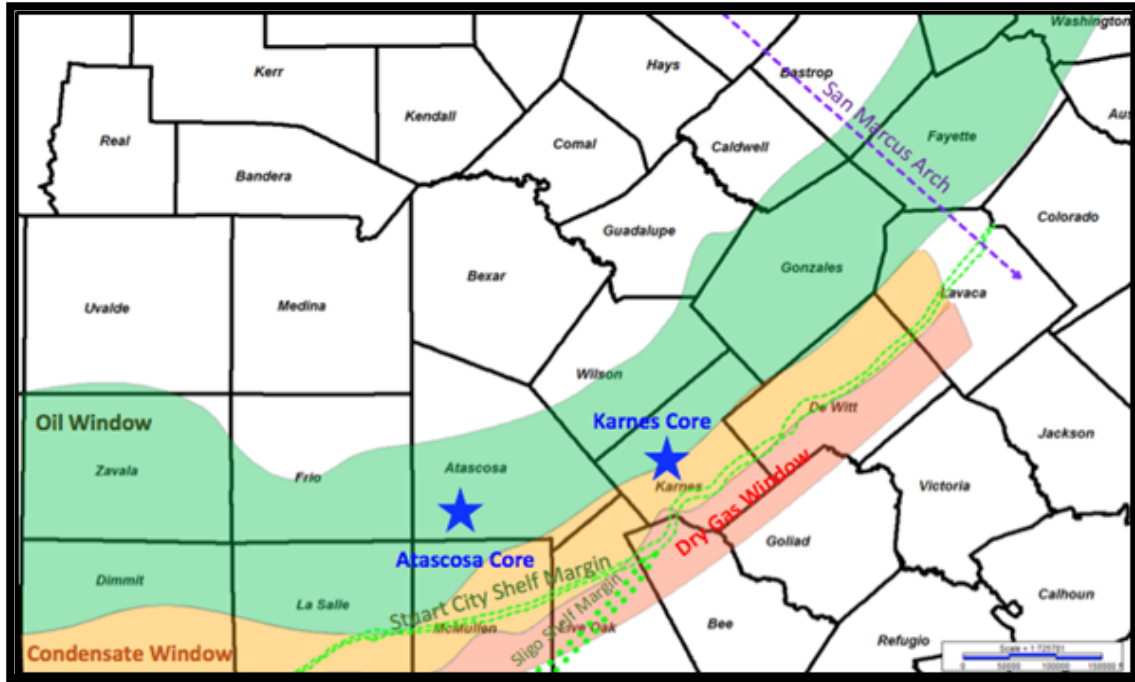
(Revised from Bailey et al., 1945)

- Maness initially described in Shell Oil Company's Maness Well No.1 in Cherokee County in 1943.
- Maness was described as a bronze or copper-colored to dark gray, partially calcareous, clay shale and claystone with a change in fauna at the top of the Maness that is not seen in the Woodbine indicating an unconformity



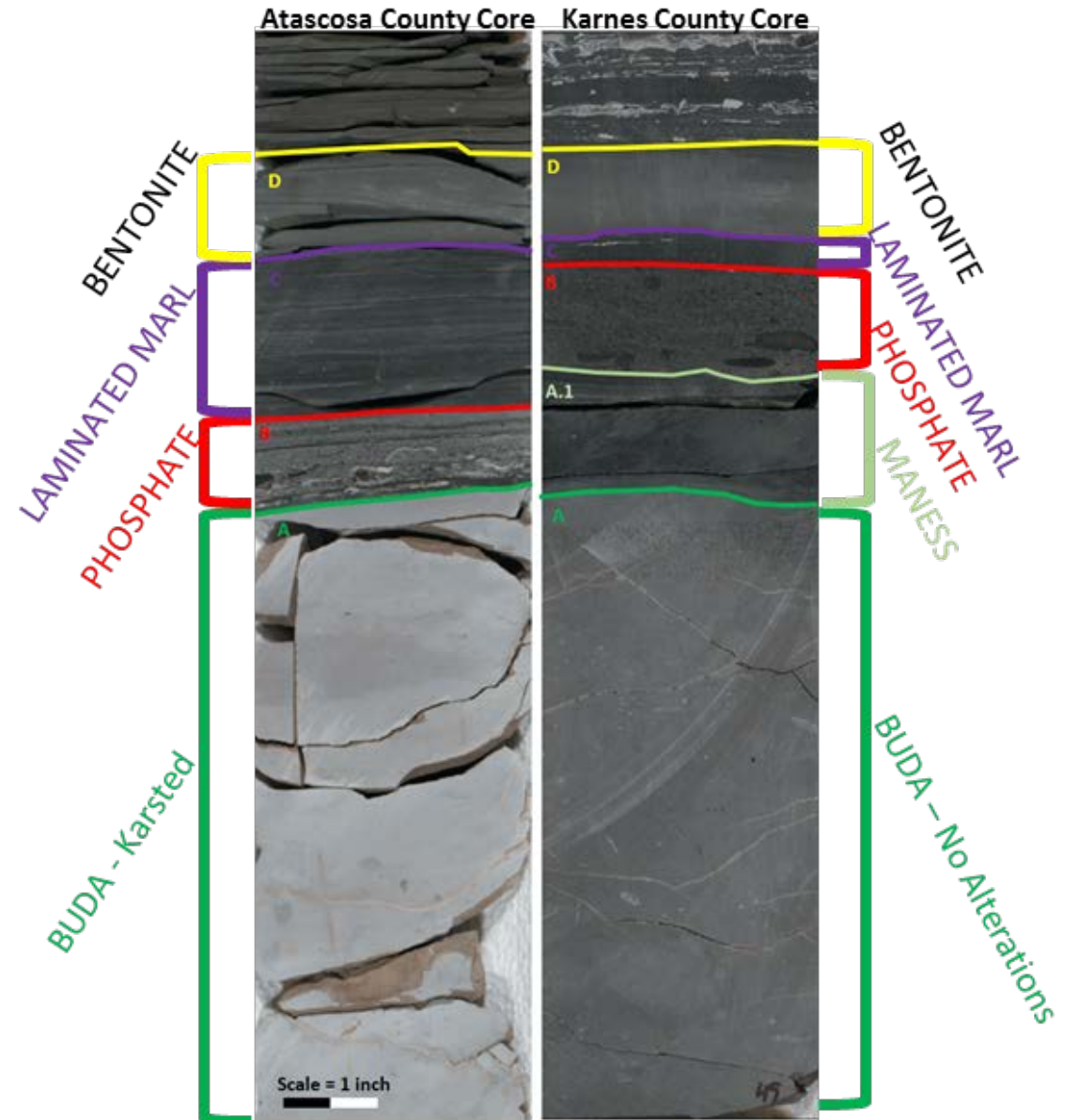
(Hentz et al., 2014)

Introduction – Previous Studies



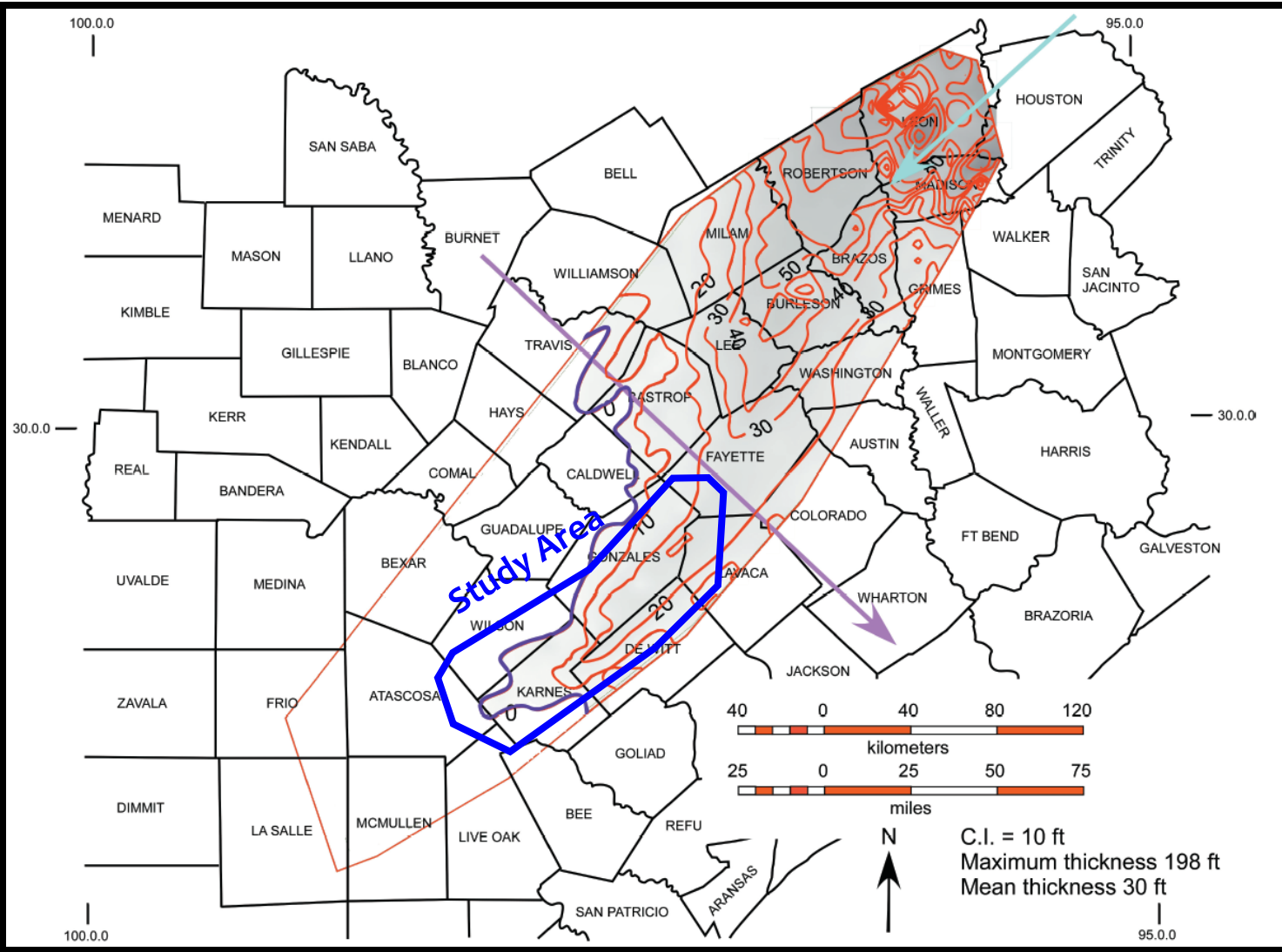
Published studies of South Texas Maness were by Denne et al., 2016 and Denne and Breyer, 2016

- Atascosa core does not contain the Maness
 - Buda Limestone is karsted
- The Karnes core contains very thin Maness
 - Buda Limestone is unaltered



(Denne et al., 2016).

Introduction – Previous Studies



- Isopach map across the San Marcos Arch indicates that the sediment source is to the northeast
- Maness pinches out in Karnes County

(Denne and Breyer, 2016).

Introduction

- Regional Geology
- Stratigraphy

Methods

- Materials
- Mapping Units

Results

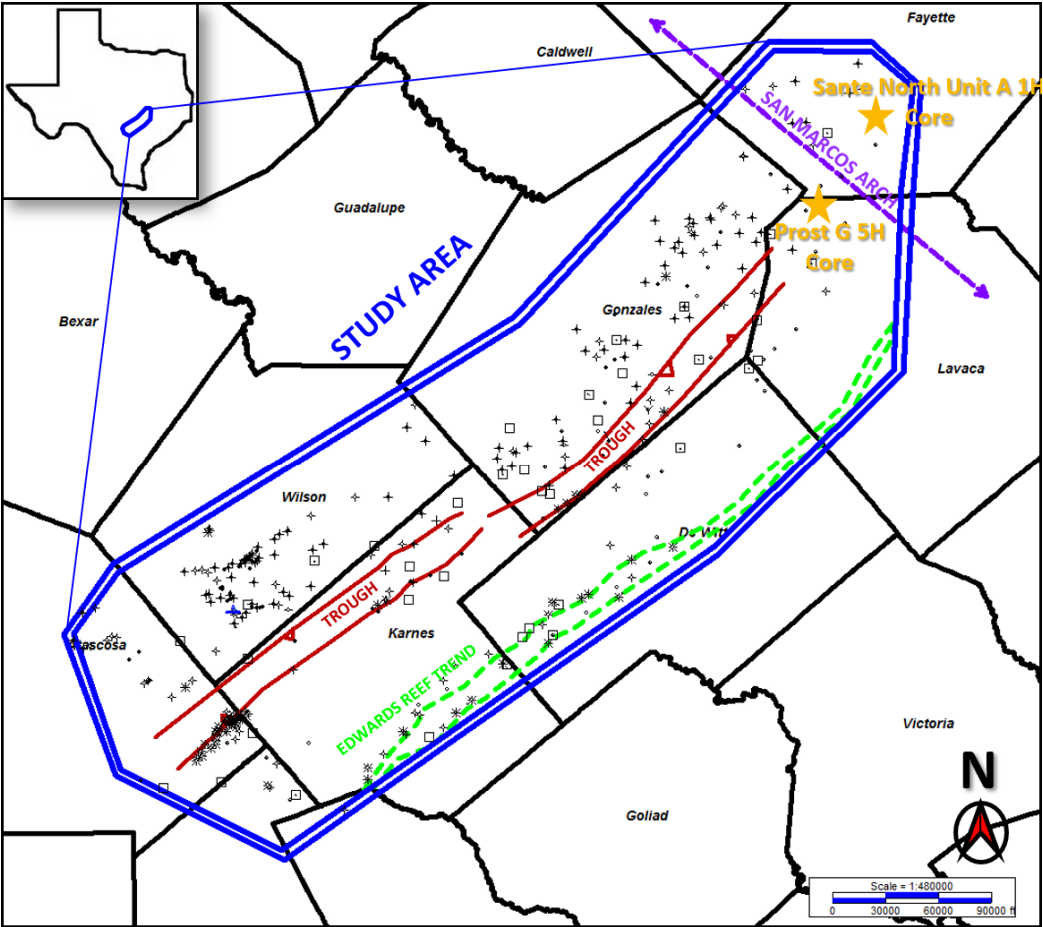
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Methods and Materials

Well Name and Number	County, State	Depth (ft)	Total Cored Footage	Total Feet of Eagle Ford (Including Maness)	Feet of Maness
Prost Unit G 5H	Lavaca, TX	10,906' -11,089'	183'	115'	30'
Sante North Unit A 1H	Fayette, TX	11,175' -11,357'	182'	96'	33'



Two cores – Provided by Lonestar Resources: CORES

- Data points for strength and hardness tests using a point-load penetrometer (dimpler) and micro-rebound hammer (bambino):
 - 247 from Prost G 5H
 - 236 from Sante North Unit A 1H
- X-ray Diffraction (XRD) analyses conducted at UTA
- Over-sized thin sections cut at the same depth as XRD
 - 14 from Prost G 5H
 - 13 from Sante North Unit A 1H

Well data collected and analyzed from 7 counties: WELL LOGS

- 345 wells with at a minimum a GR curve were correlated

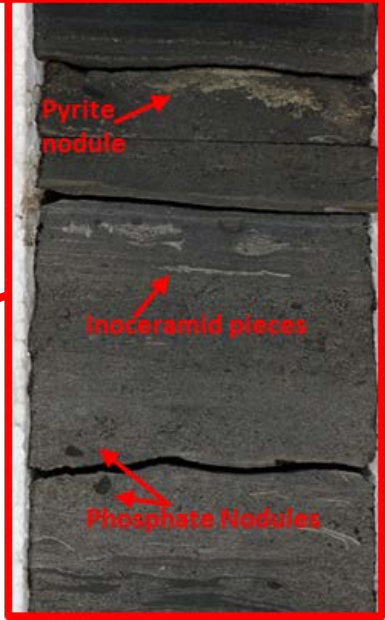
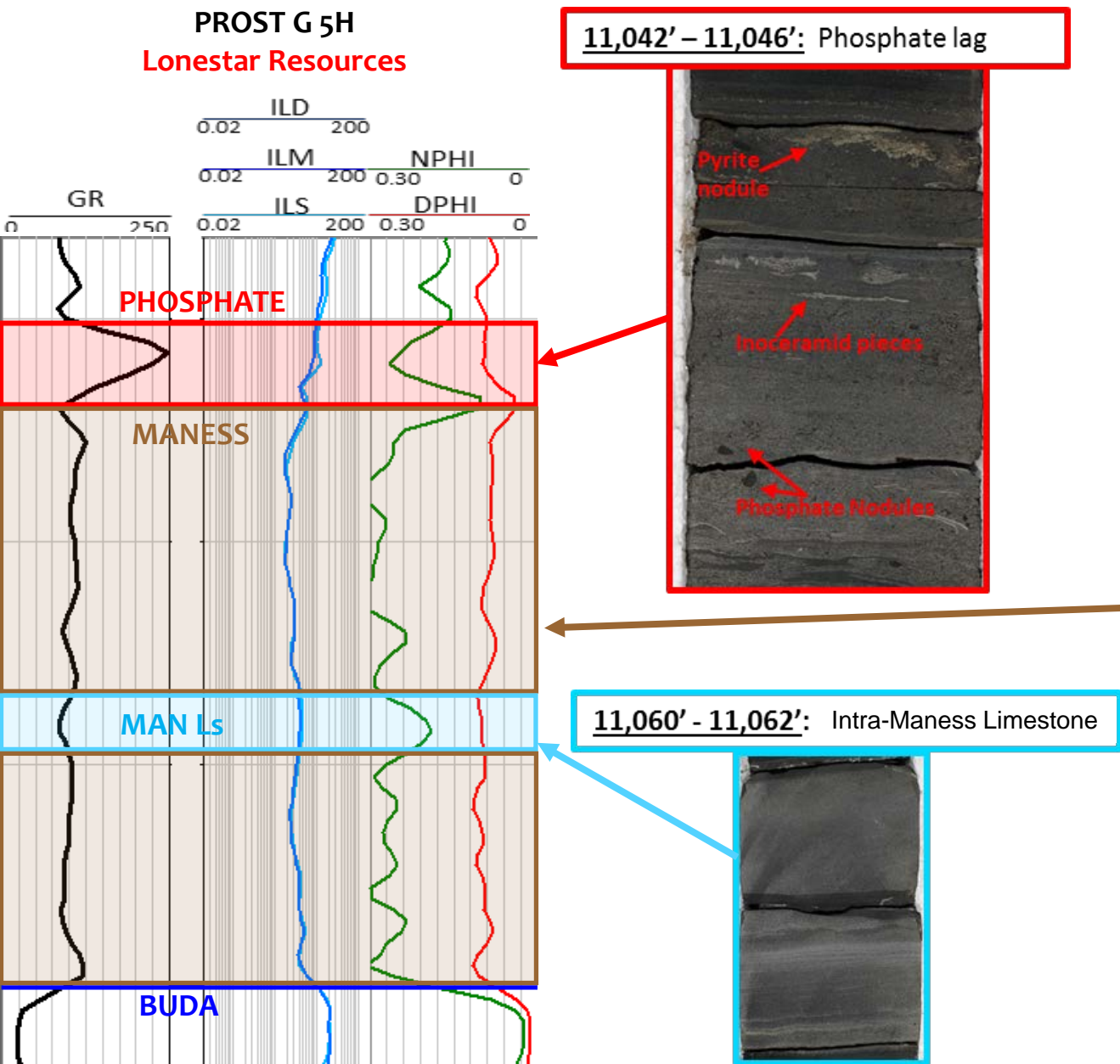
PRODUCTION DATA

- Monthly data provided by Lonestar Resources
- ~2,000 wells production Drilling Info

Presenter's notes:

- 2/3 section of the core
- Place pieces of tape ever 6 inches in the Maness and every 1 ft in adjacent formations
- Remove the core from the box and place into a container full of sand
- Place carbide tip on ink pad and then on the tape on top of the core
- Slightly press down on the top to compress the Dimpler and apply a pressure to the tape creating a 'dimple'
- 3 dimples diameters were averaged

Methods and Materials – Mapping Units



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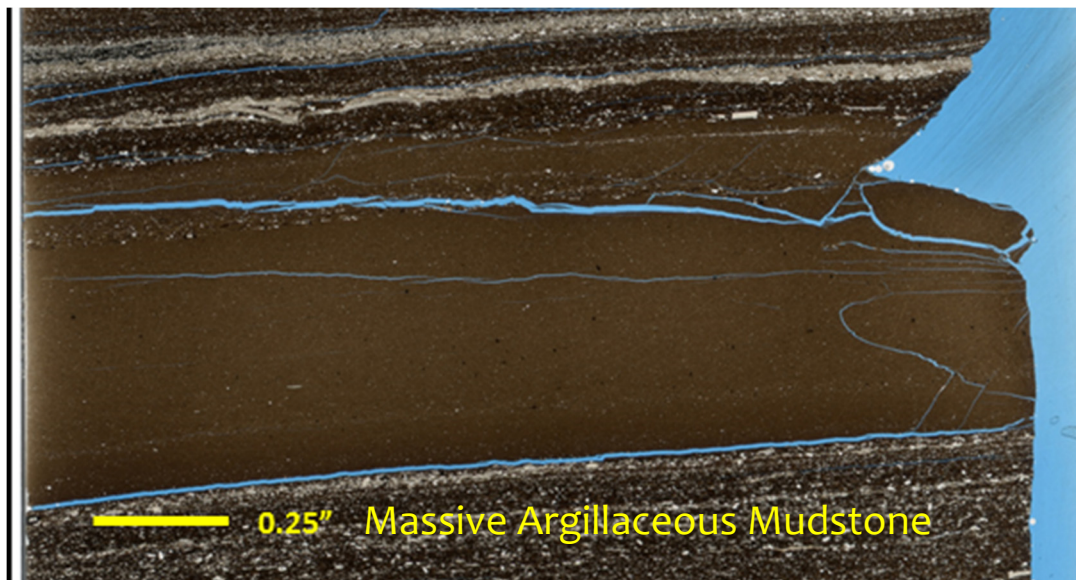
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Results –Microfacies / Lithofacies

Two microfacies / lithofacies were found only in the Maness:

Massive Argillaceous Mudstone



- Black to dark gray, massive to indistinctly laminated mudstone
- Foraminiferal laminae are sparse to non-existent



- Internally structureless
- largely homogeneous mudstone

Presenter's notes: **Microfacies from Thin Sections**

Microfacies

Name

Description

a

Massive Argillaceous Mudstone

Internally structureless, largely homogeneous mudstone layer, dark brown in color, with frequent pyrite framboids (Ichaso and Dalrymple, 2009).

b

Indistinctly Laminated Mudstone

Displays parallel, discontinuous laminations of planktonic foraminifera, pyrite framboids, fish debris, inoceramid pieces, and dark brown clasts.

c

Partially Recrystallized Limestone

Made up of primarily recrystallized limestone, with calcite-filled foraminifera and pyrite framboids; original bedding mostly preserved.

d

Fibrous Calcite

Calcite “beef” crystals (Cobbold et al., 2013) ranging up to 0.72 inch (2 cm) in length usually encasing ash beds.

e

Calcsphere Packstone

Found only in the Buda Limestone, the fossils are cemented in sparry calcite and is mottled to massive, bioturbated, with abundant calcspheres, agglutinated and planktonic foraminifera, with rare ostracods and echinoid spines.

f

Ash beds

Clay rich beds that have no bedding features.

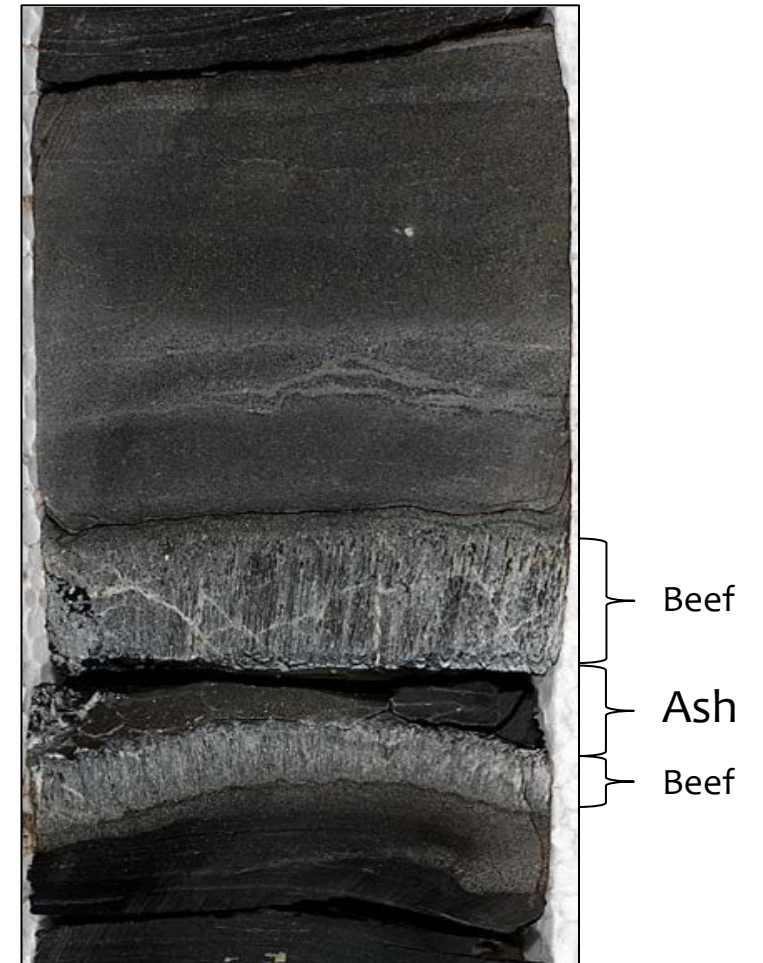
Results –Microfacies / Lithofacies

Two microfacies / lithofacies were found only in the Maness:

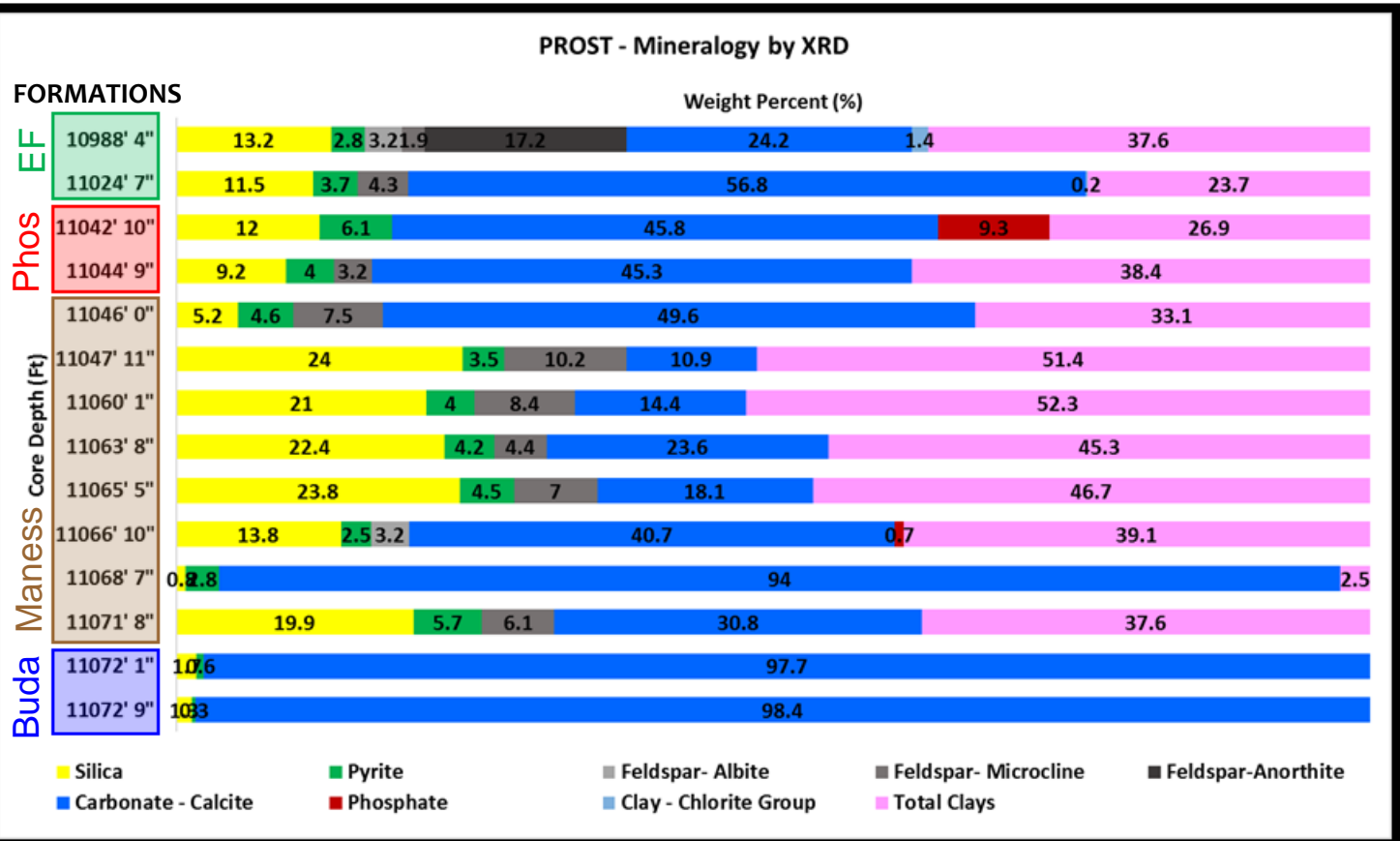
Limestone nodule with fibrous calcite



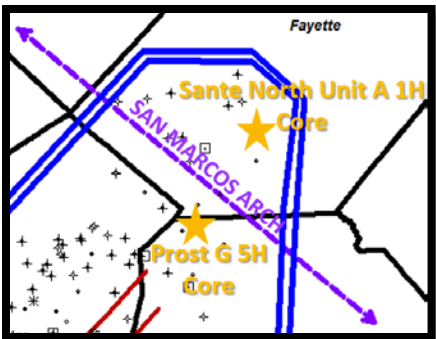
- Fibrous calcite crystals range up to 0.72 inch (2 cm) in length
- Usually encase ash beds



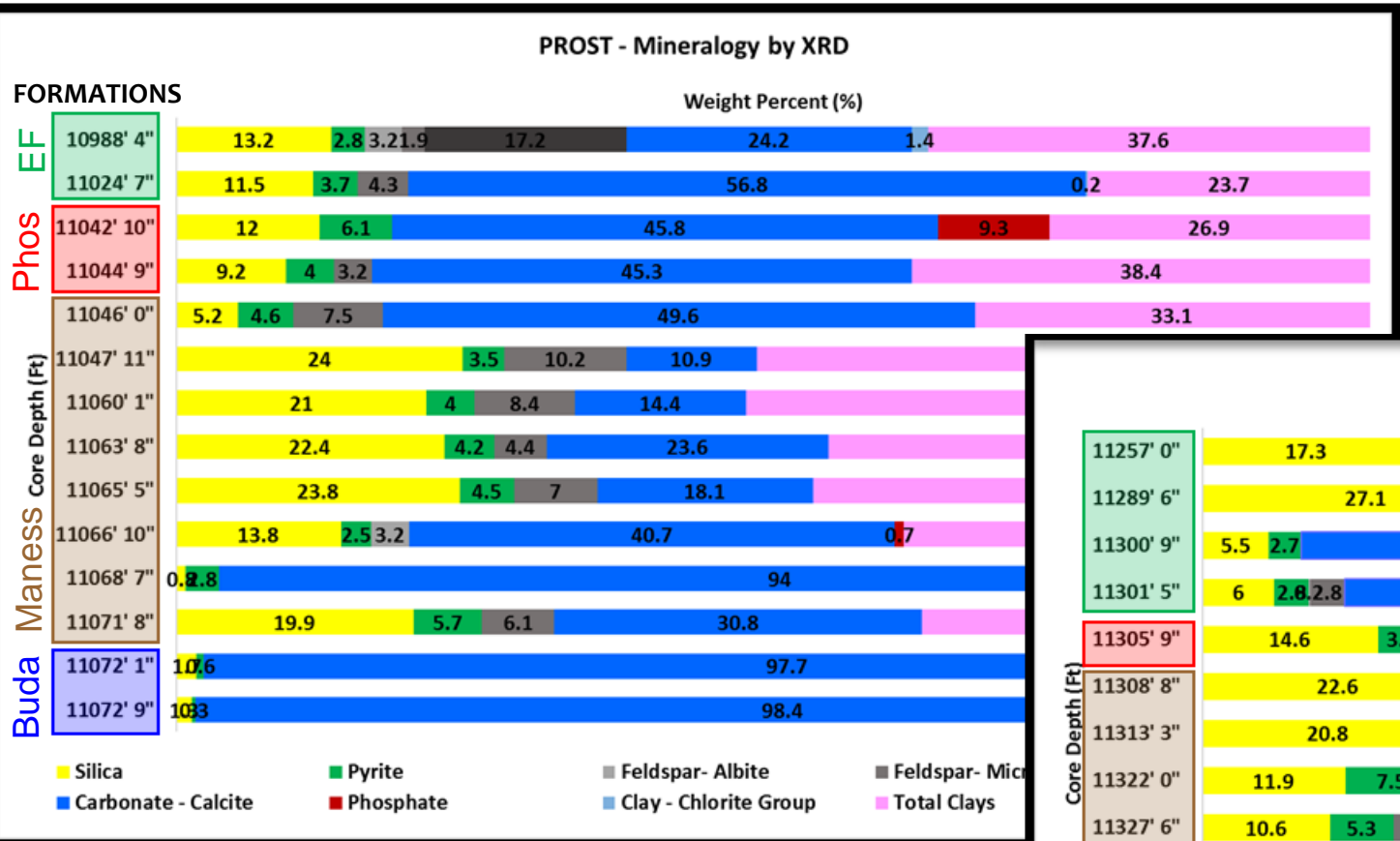
Results – XRD Mineralogy



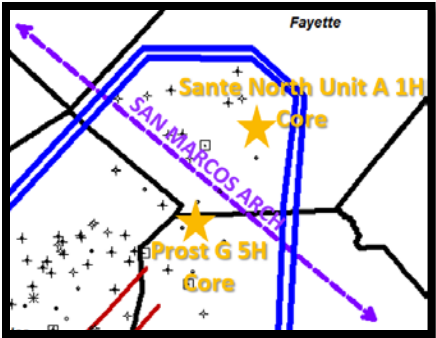
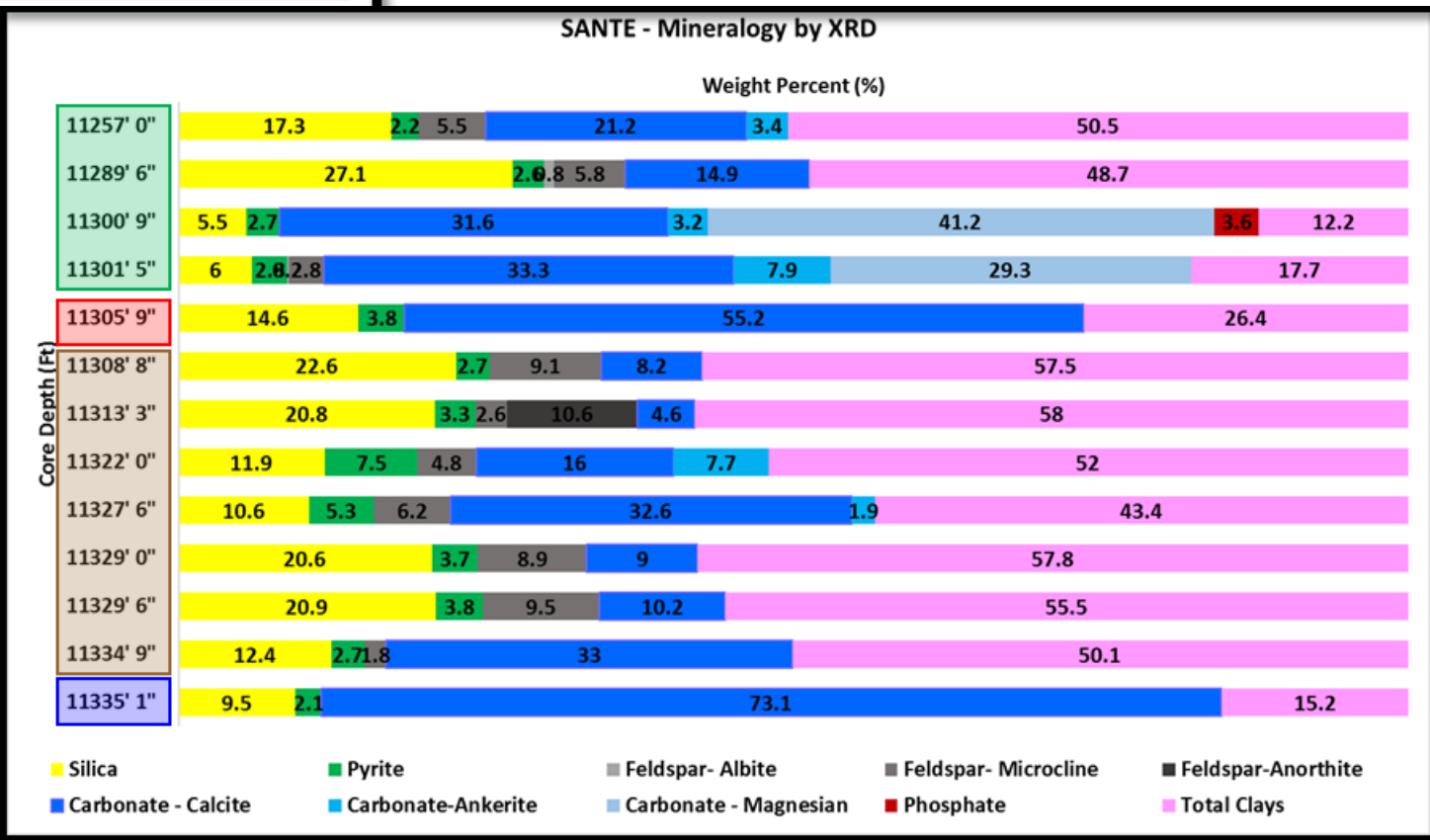
- Maness has higher clay content than overlying Eagle Ford



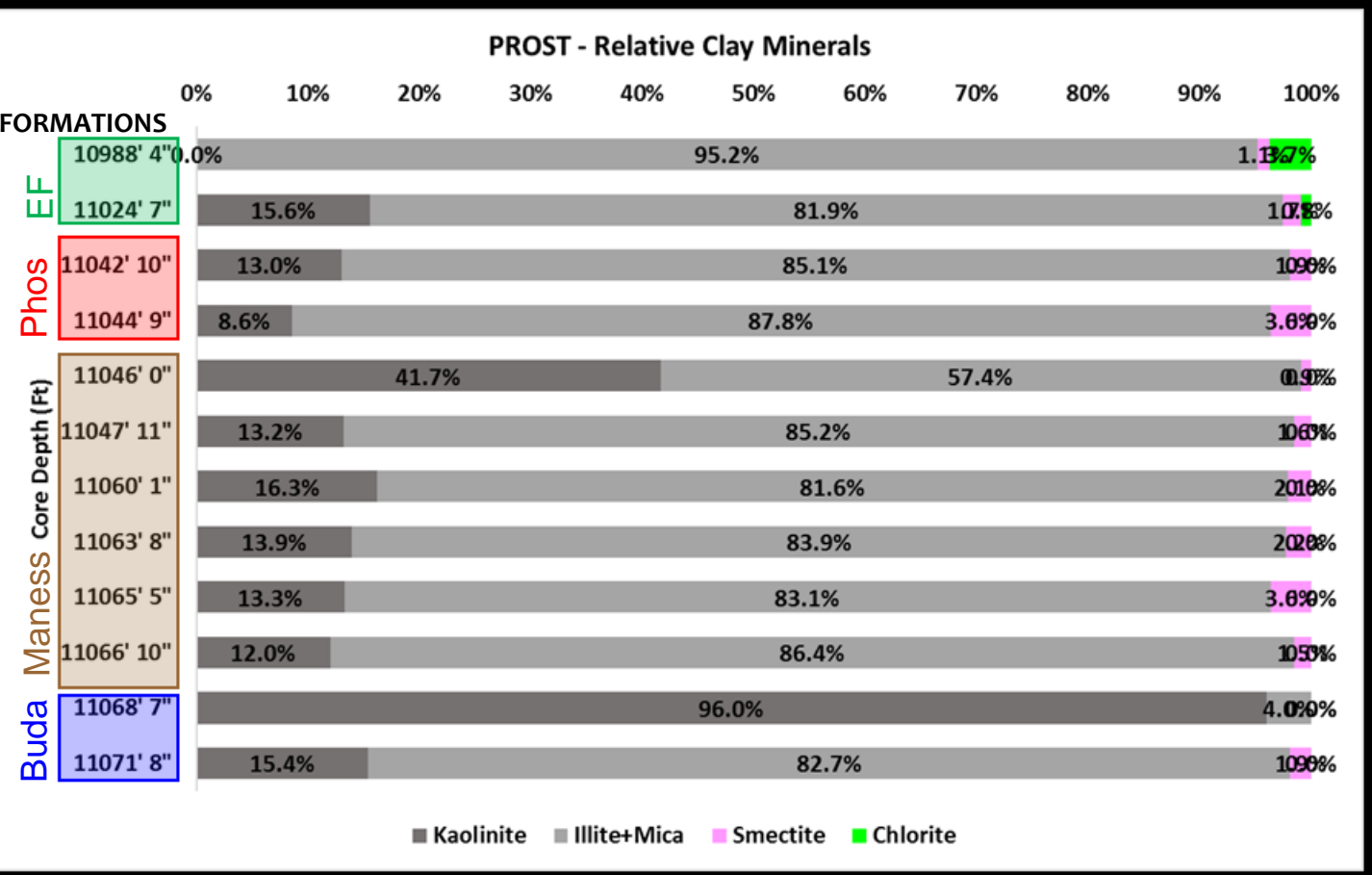
Results – XRD Mineralogy



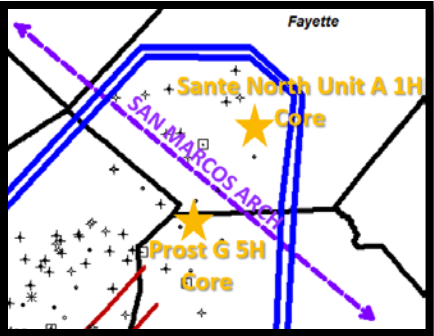
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Results – Clay Mineralogy

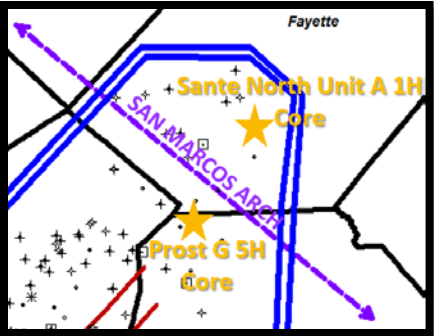
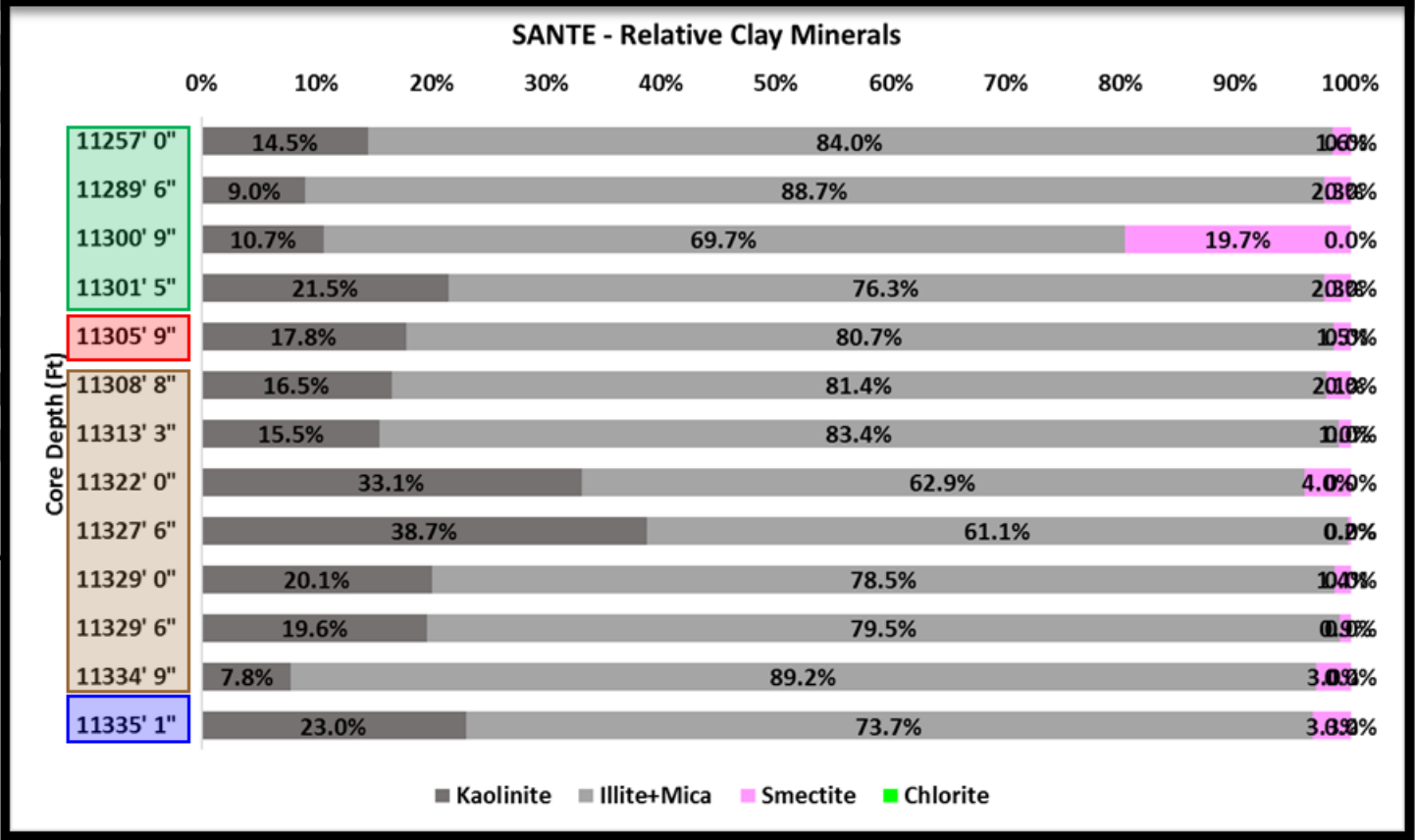
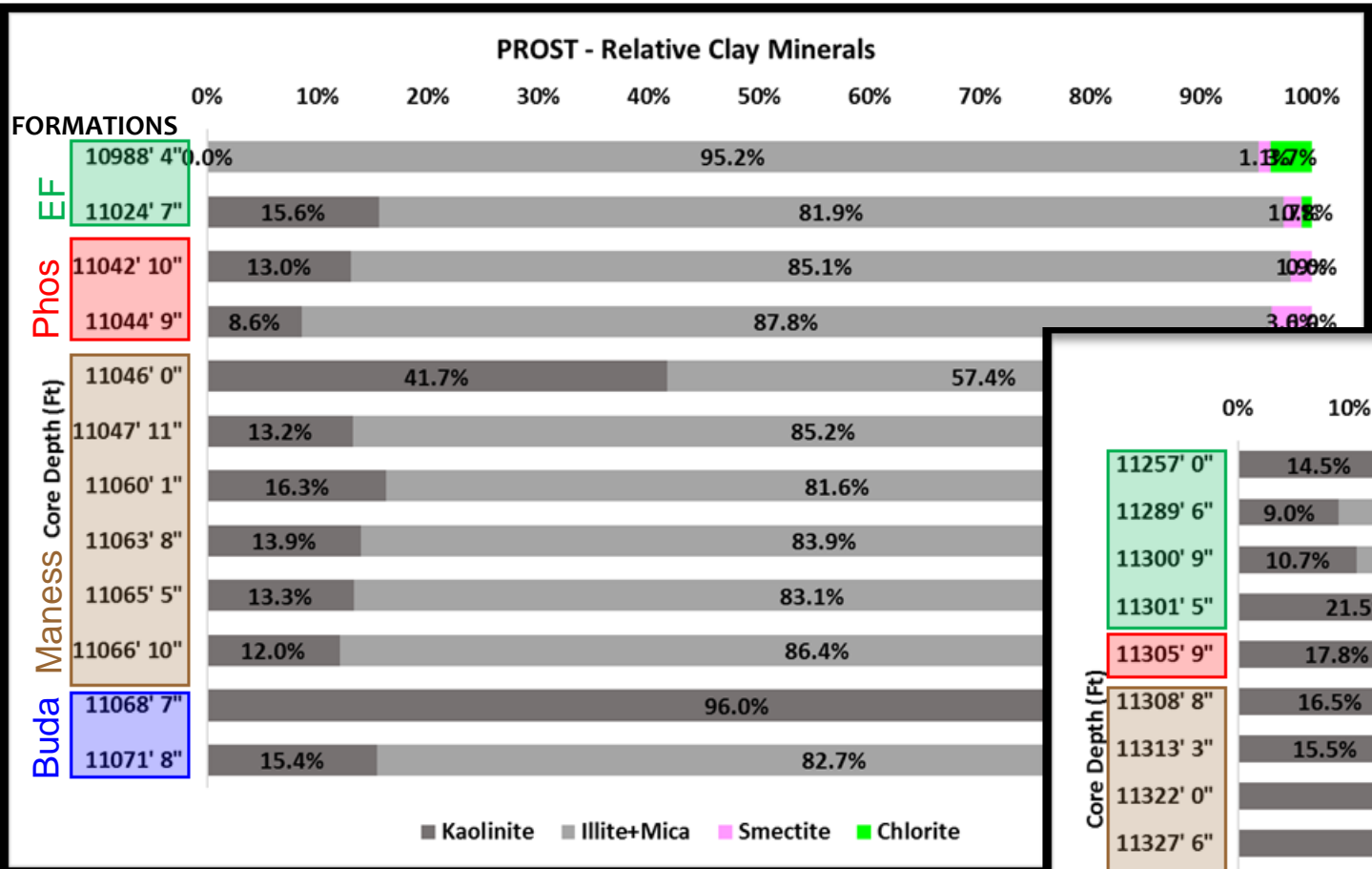


- Predominant clay type is illite+mica
- Kaolinite averages 15-20% and higher are directly from ash beds

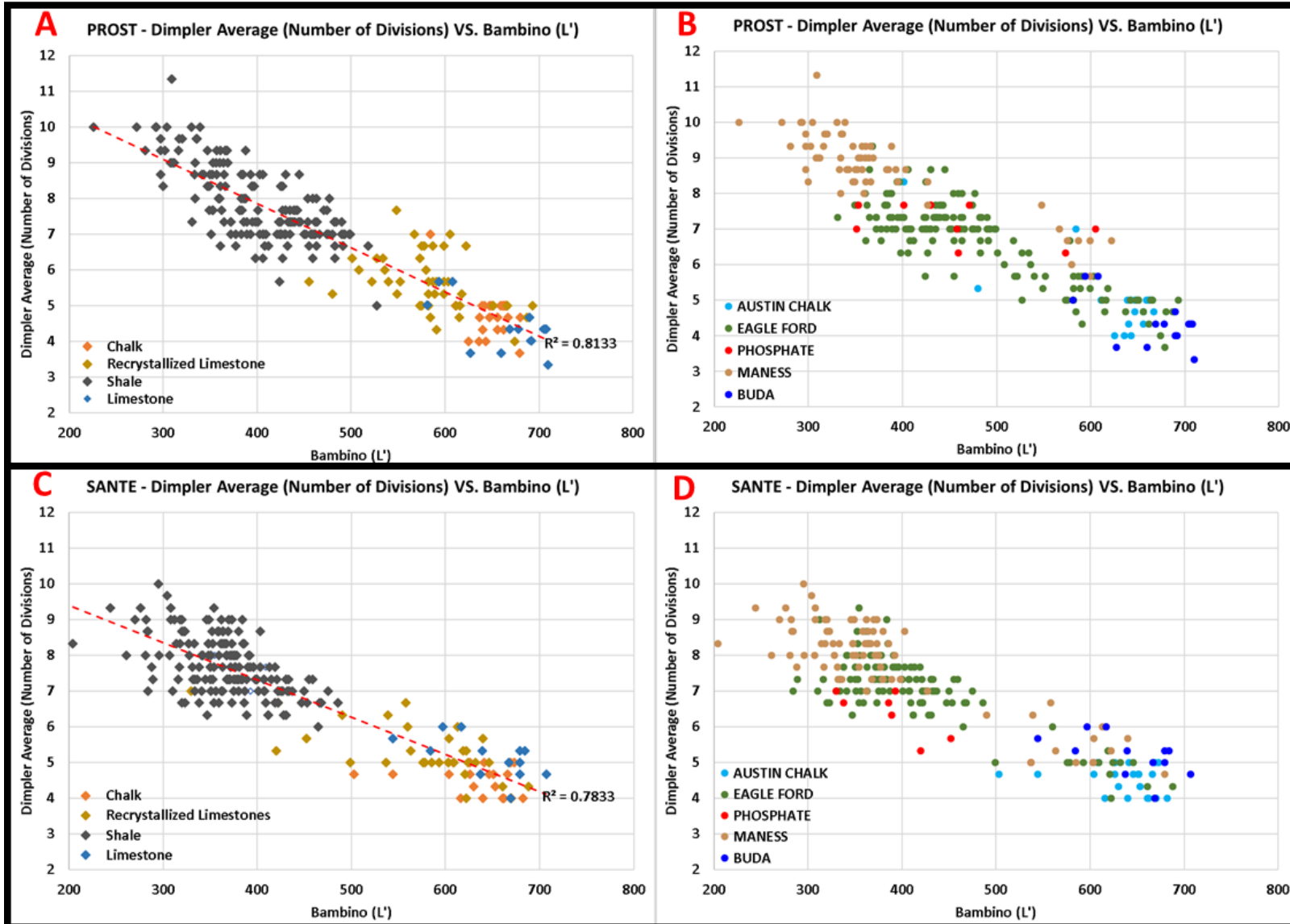


Results – Clay Mineralogy

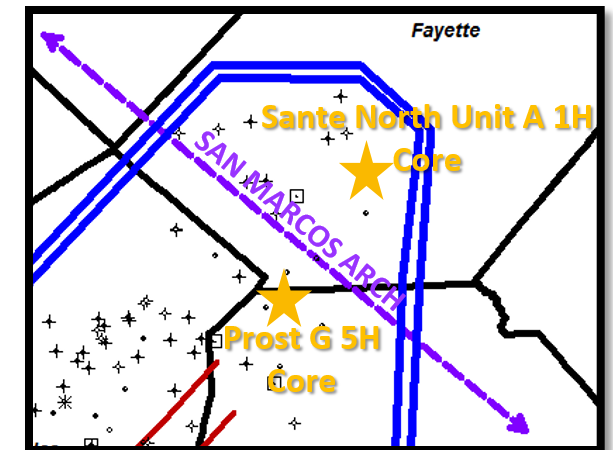
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Results - Geomechanics

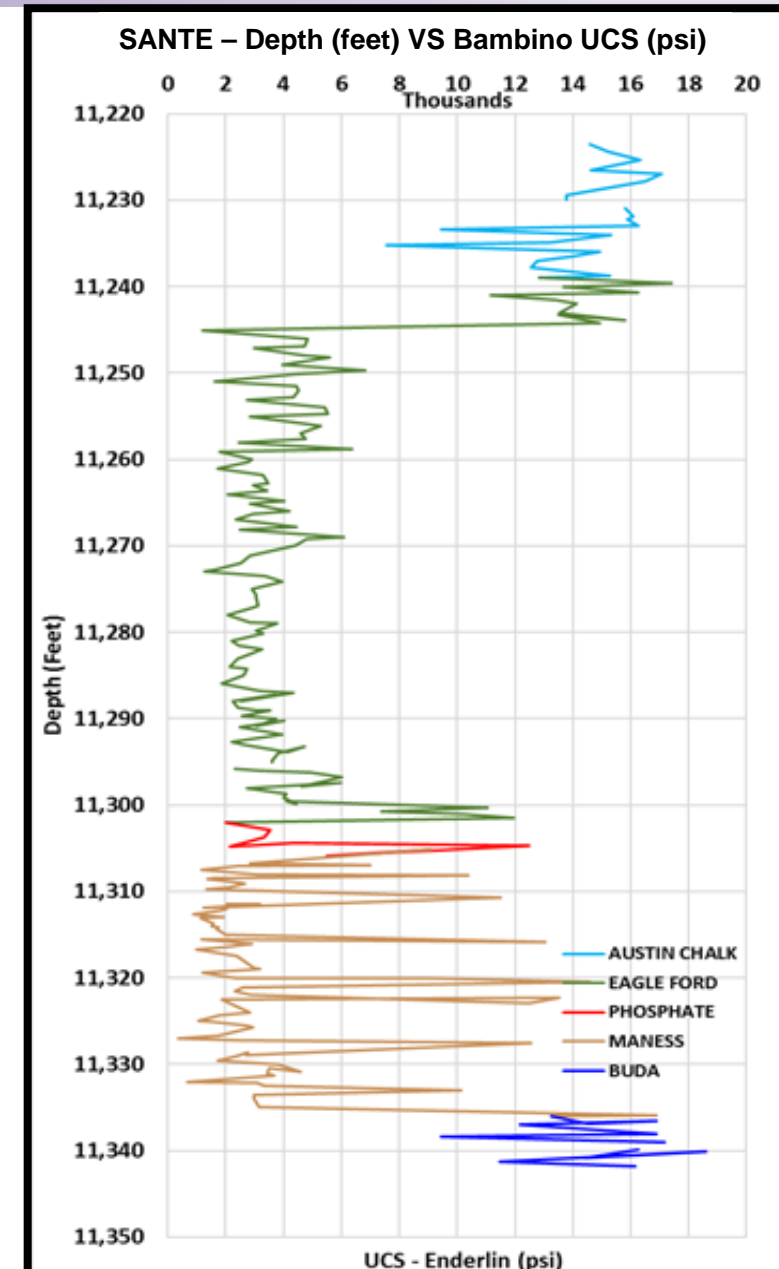
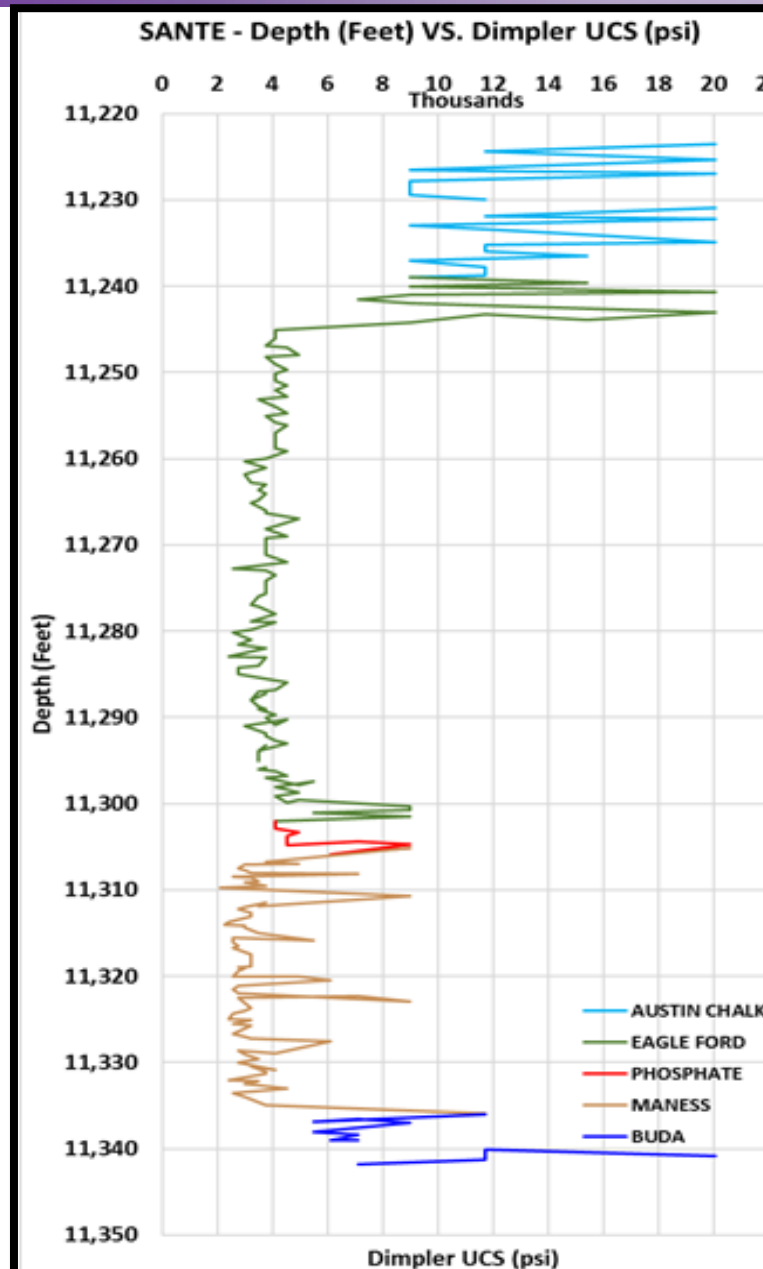
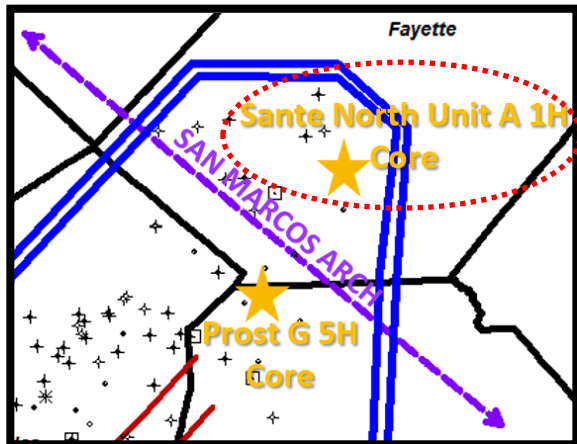


- Cross plot of the Dimpler VS Bambino raw data
- For both cores and data types they have similar trends.
- Dimpler and Bambino have inverse relationships
 - Generic lithologies – picked while collecting data
 - Note the recrystallized limestones in yellow
- Formations



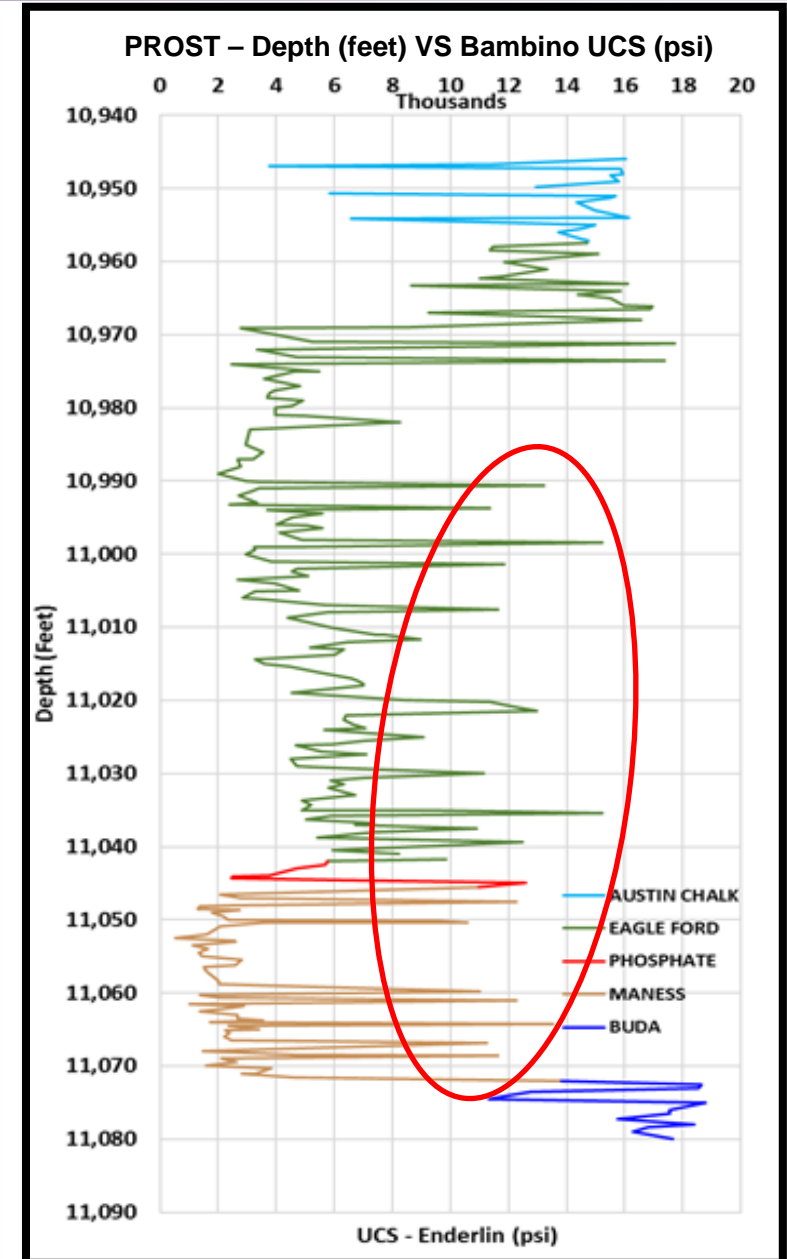
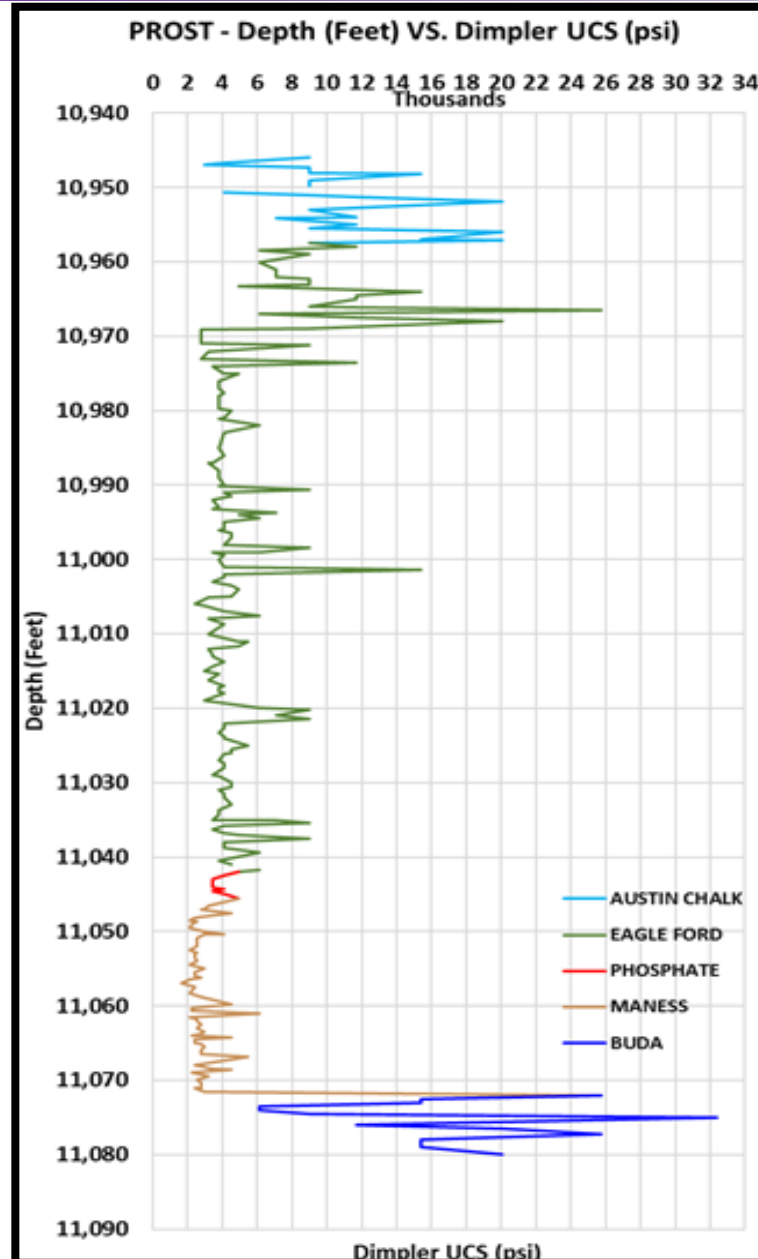
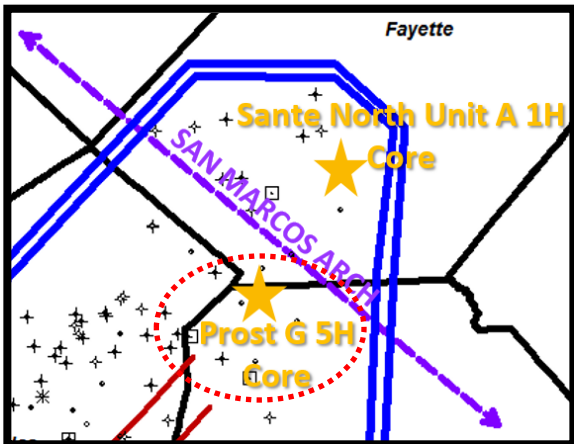
Results – Geomechanics for the Sante North Unit A 1H

- The Sante North Unit A 1H lies North of the arch
- When converting to UCS, the Maness averages to be **27.4%** weaker than Eagle Ford
- The lower the UCS value the weaker the material tested

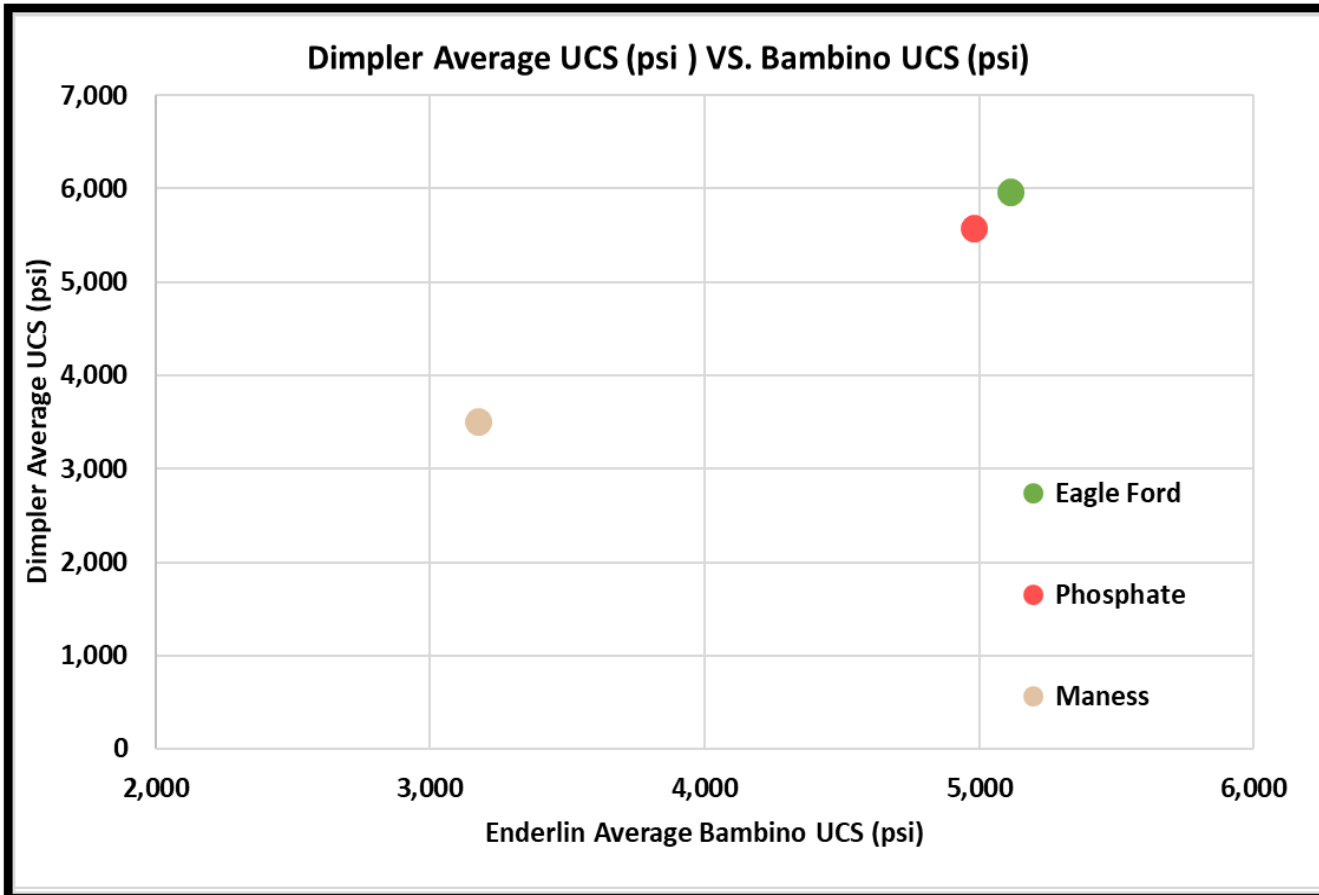


Results – Geomechanics for the Prost G 5H

- The Prost G 5H lies South of the arch
- The UCS of the Maness averages **49.1%** weaker than Eagle Ford
- Note the abundant amount of high UCS values indicate a recrystallized limestone data point within the Eagle Ford and Maness
- The lower the UCS value the weaker the material tested



Results – Geomechanical Data with Limestones Removed

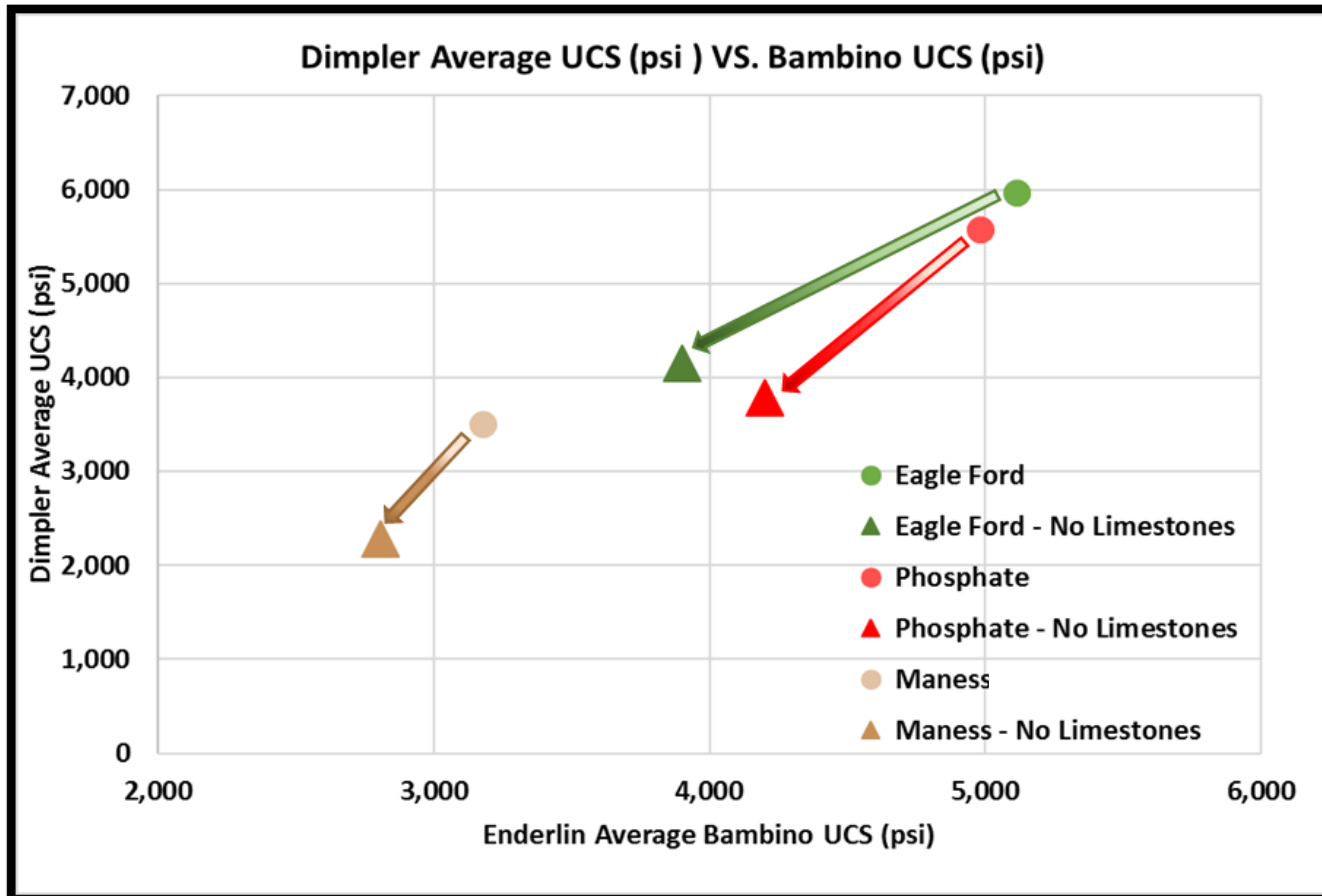


- Comparison of UCS values per formation
- The limestones within each formation were removed to have a shale to shale comparison.
 - On average the Maness is **36.6%** weaker than Eagle Ford with the limestones removed

Point Load Penetrometer - Dimpler				
Formation	Number Of Samples	Enderlin Average UCS (psi)	Enderlin Minimum UCS (psi)	Enderlin Maximum UCS (psi)
Eagle Ford	181	3,899	2,411	7,239
Phosphate	11	4,202	3,800	4,966
Maness	116	2,806	1,900	3,800

Equotip Bambino				
Formation	Number Of Samples	Enderlin Average UCS (psi)	Enderlin Minimum UCS (psi)	Enderlin Maximum UCS (psi)
Eagle Ford	181	4,153	1,596	7,730
Phosphate	11	3,779	2,300	4,878
Maness	116	2,275	438	4,604

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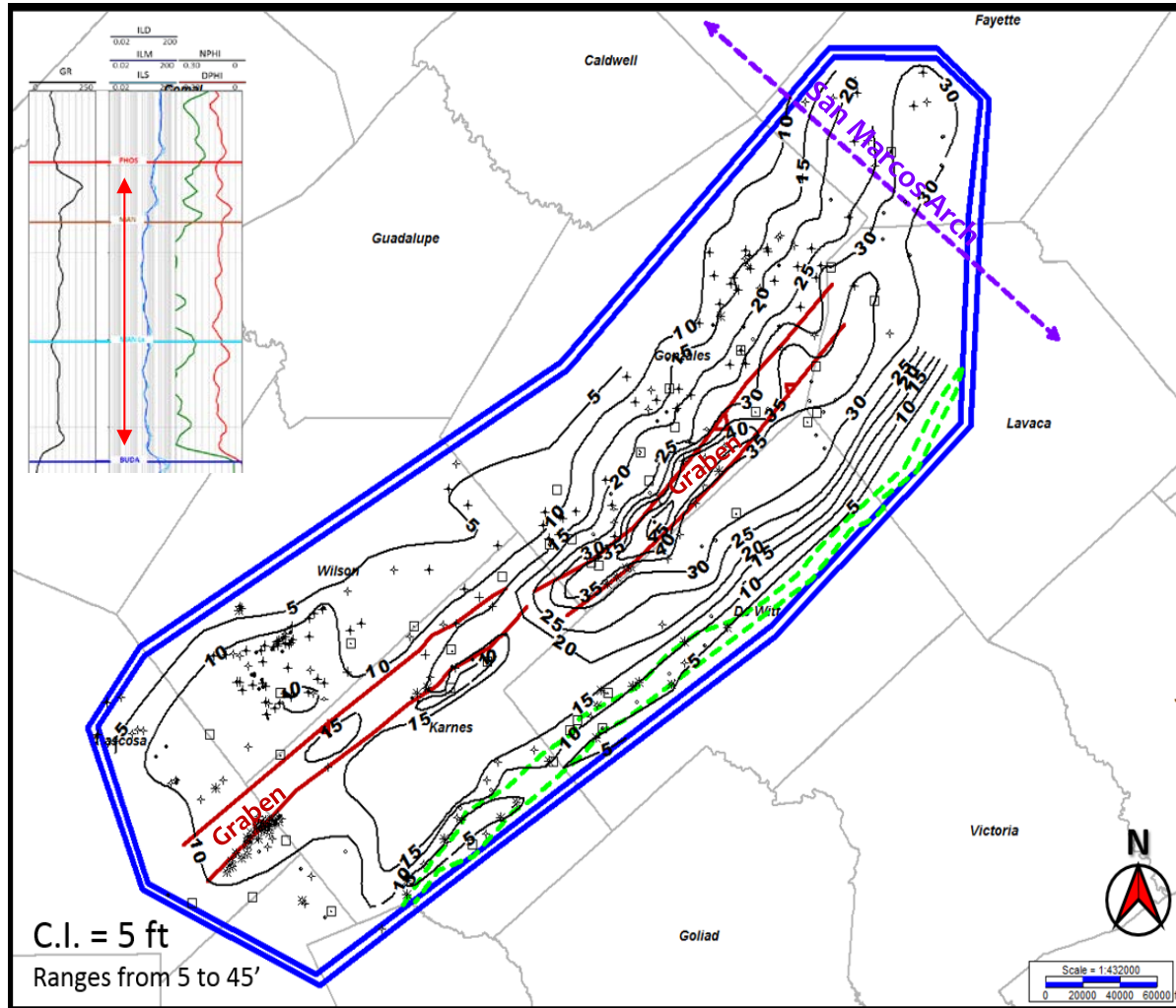
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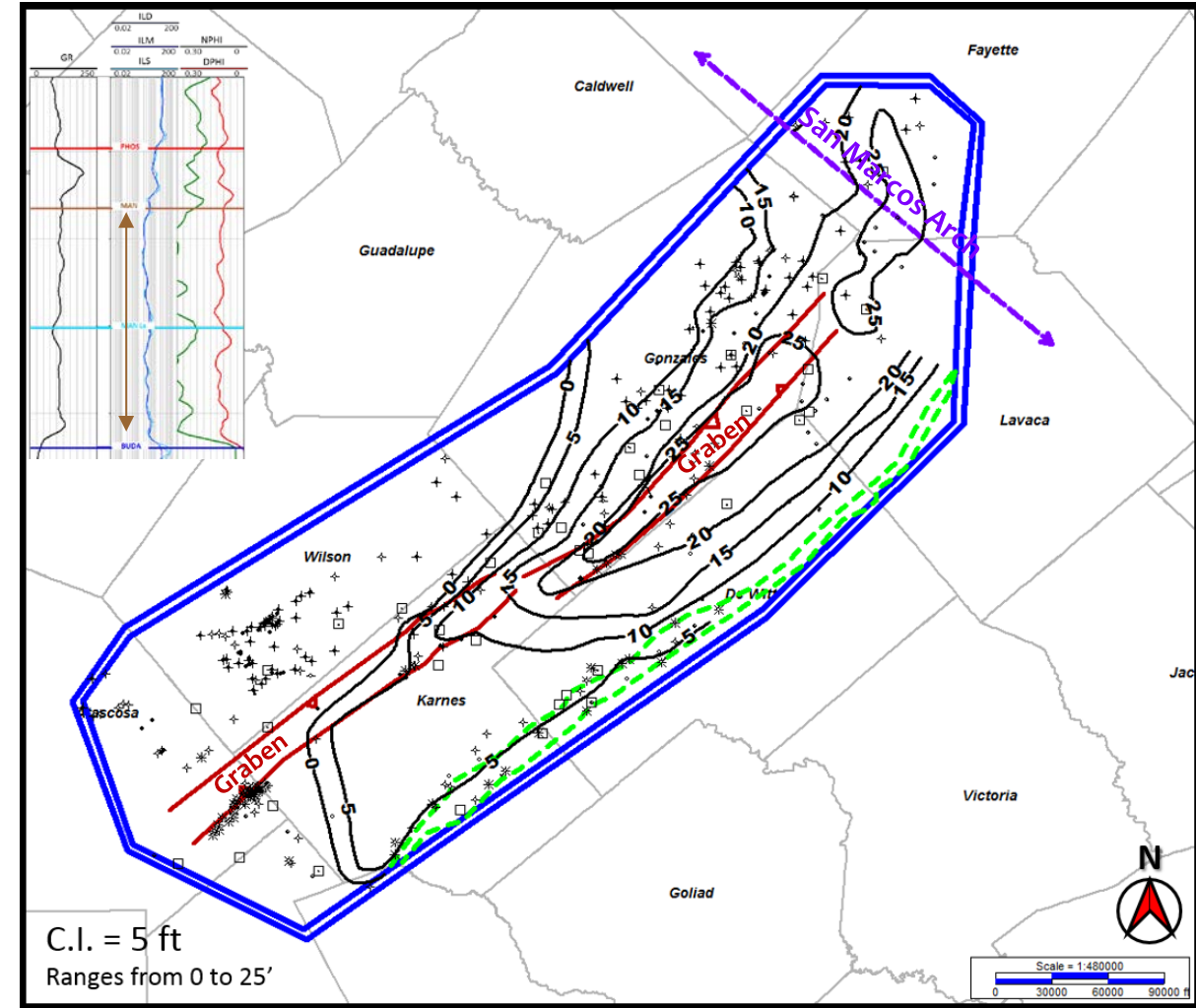
Results – Isopach Maps

Phosphate + Maness



- The phosphate does not pinch out
- The phosphate + Maness is thickest to the NE and thins to the SW
- Thickest interval confined within the Gonzales Trough

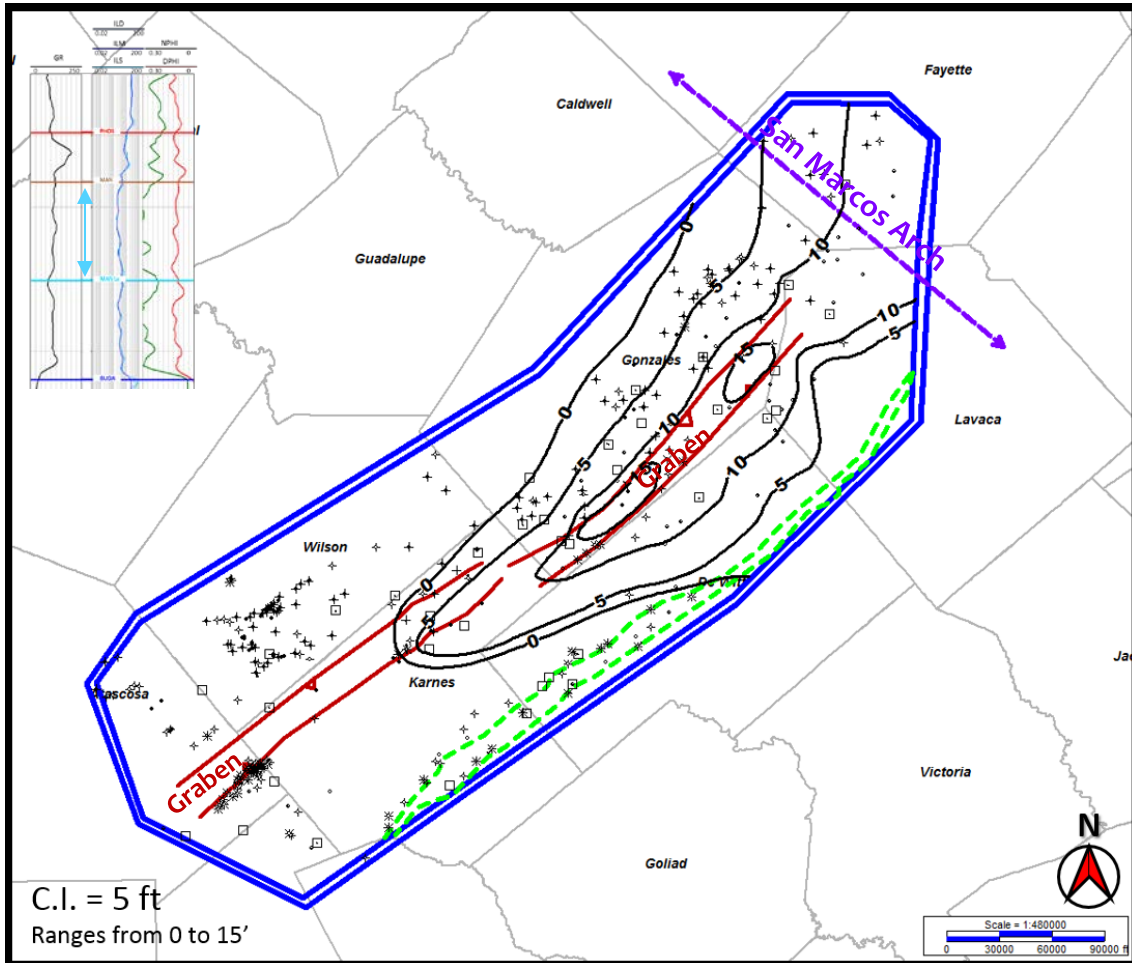
Maness



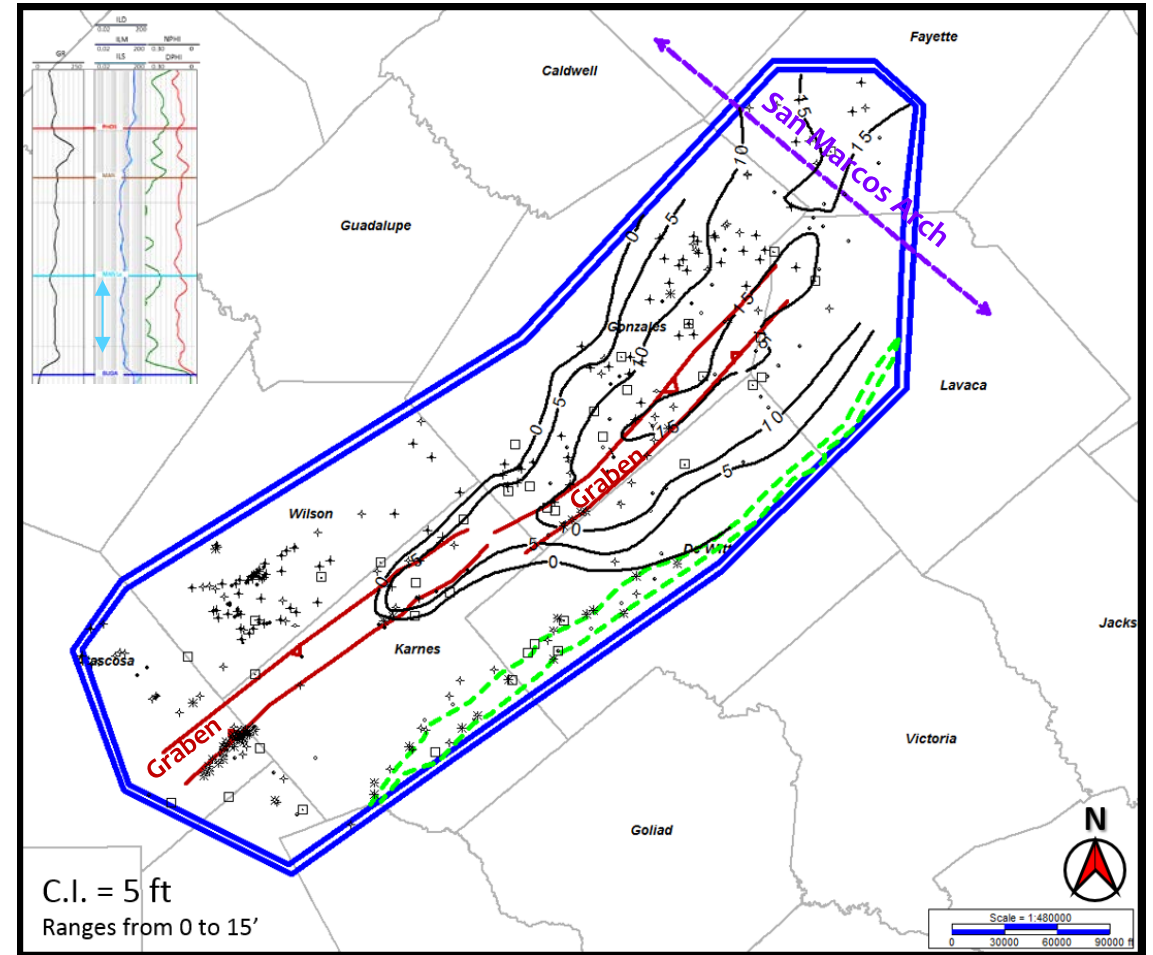
- The Maness shale pinches out to the West of the study area
- Thickest interval confined within the Gonzales Trough

Results – Isopach Maps

Upper Maness



Lower Maness



- Both the upper and lower Maness separated by the intra-Maness limestone pinches out to the West of the study
- The two mapped intervals have a maximum thickness of 15'

Results – Stratigraphic Cross Section Along Strike

A

- The phosphate does not pinch out
- The phosphate + Maness is pinched out to the SW and thickens to the NE

A'

Sante North
Unit A 1H

NE

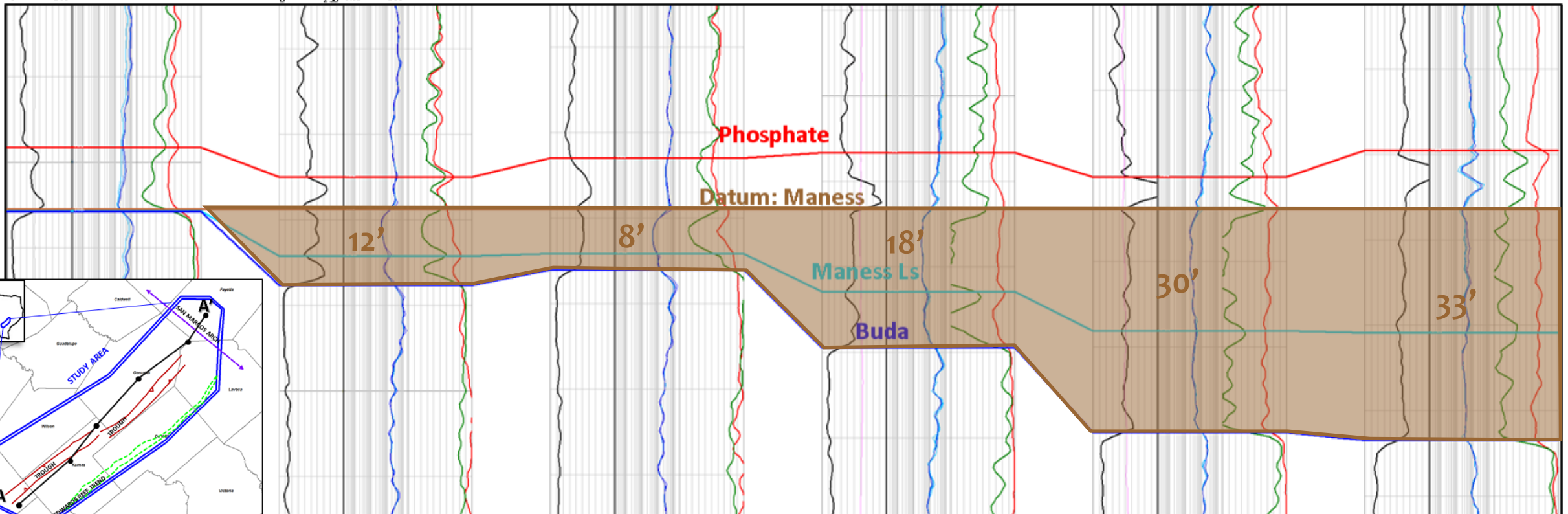
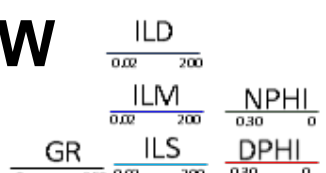
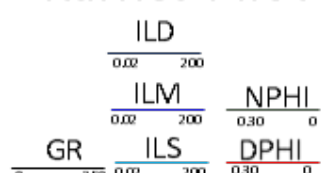
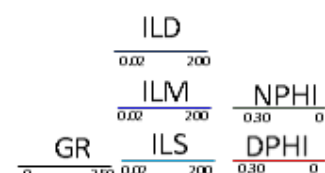
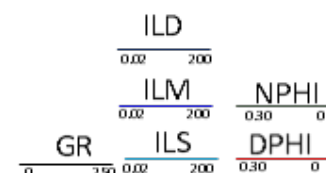
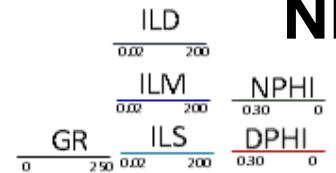
Atascosa Pilot

Central
Karnes Pilot

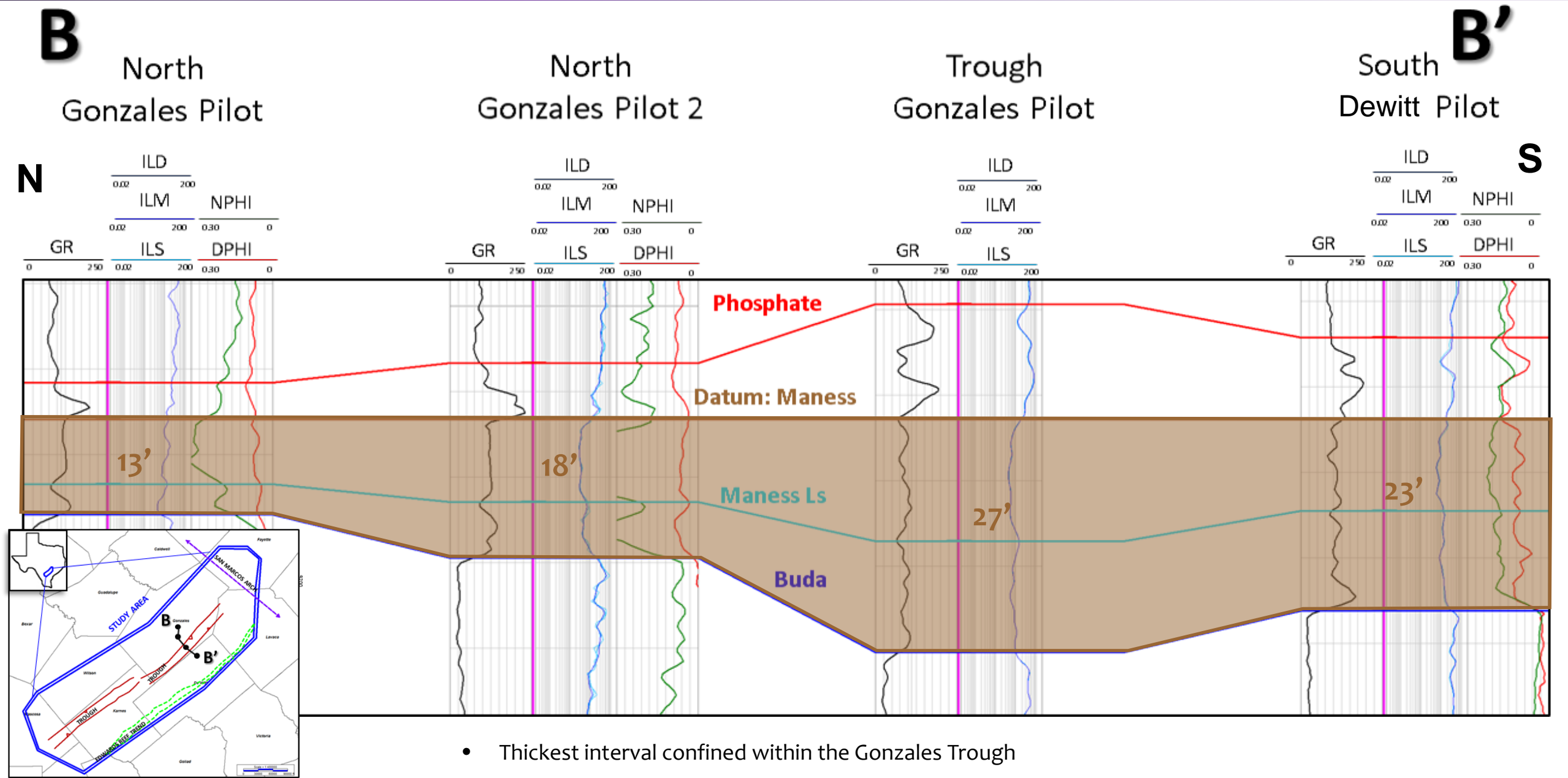
Eastern
Karnes Pilot

Gonzales Pilot

Prost G 5H



Results – Stratigraphic Cross Section Along Dip



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Unconventional Hydrocarbon Production

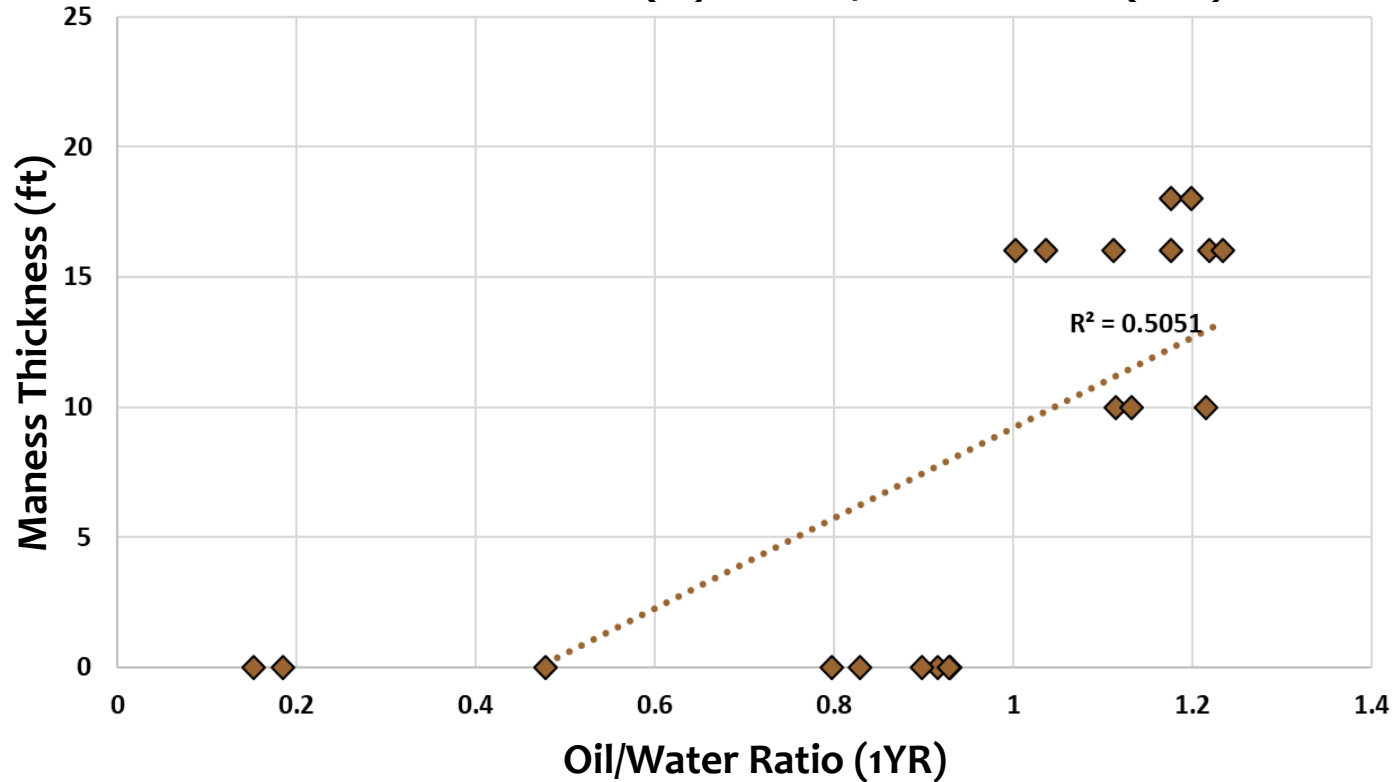
- During the first six months of production an unconventional oil or gas well produces 20% to 50% of the total production over its lifetime.
- When a decline in water production does not occur after the first six months of production, there is reason to believe that as the well is producing water from an adjacent water wet formation.

Two water data sources:

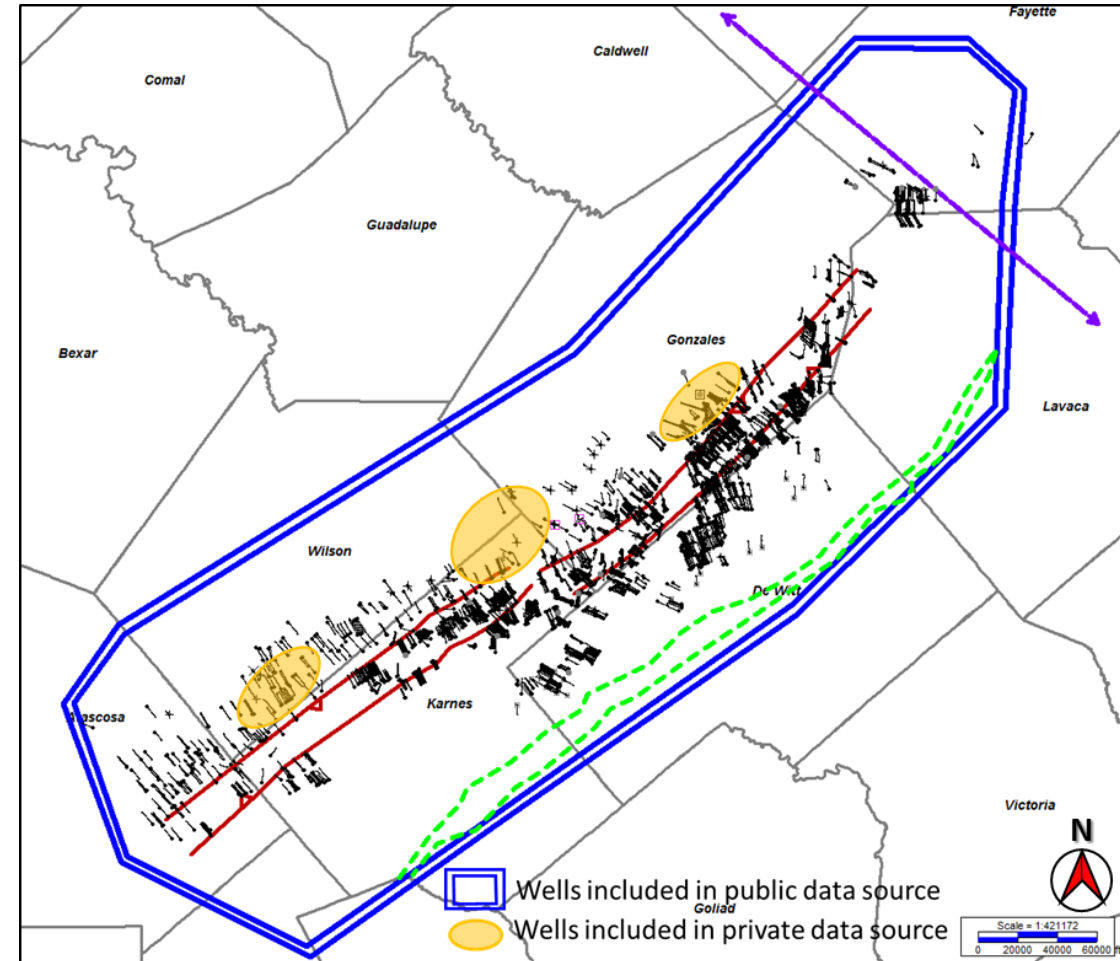
- Private data set - provided by an operator who drilled, completed, and produced the wells. This dataset has precise production measurements with pilot holes adjacent to the productive wells, enabling a more precise measurement of Maness thicknesses
- Public data set – provided by Drilling Info has water and oil production data that was reported to the state at a lease level and the Maness thicknesses were based on average thicknesses within nearby wells.
 - Six operators production data to reduce variability associated with completion and production techniques

Discussion

Maness Thickness (ft) VS. Oil/Water Ratio (1YR)

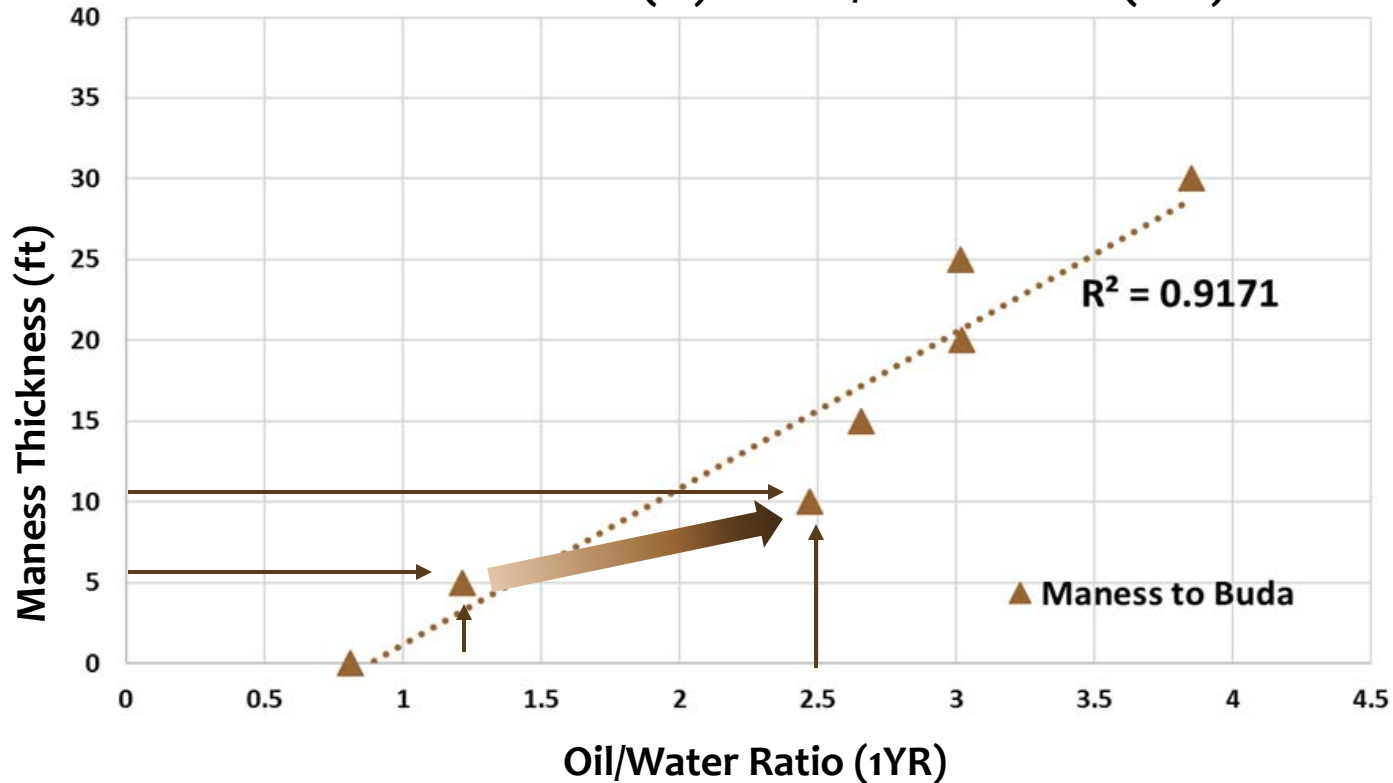


- Private dataset included individual well data and showed significantly less water production (higher oil/water ratio) when Maness >10 ft thick.
- An increase in oil/water ratio indicates a reduction in over all water production

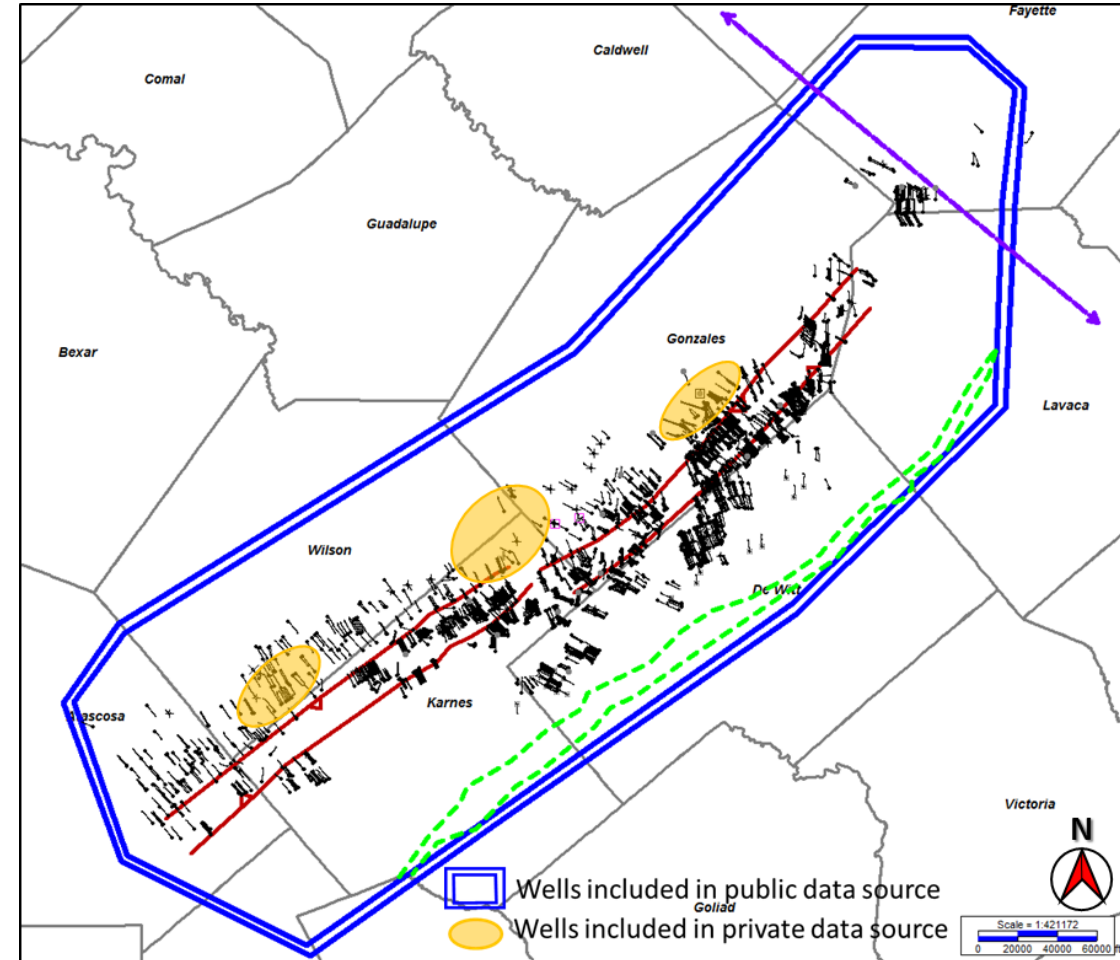


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- Public data source included 2,002 wells and each well was assigned Maness thicknesses based on the isopach map in 5 ft intervals
- The wells with the same isopach thickness had the Oil/Water ratios averaged so each isopach value has one data point
- High correlation between Maness thickness and oil/water ratio
 - Jump in oil/water ratio between 5 and 10 ft



Summary and Conclusions

- Identified 6 microfacies and 7 lithofacies
 - Massive argillaceous mudstone and fibrous calcite occur only in the Maness
- The geomechanical studies measuring rock strength were performed utilizing the point load penetrometer (Dimpler) and the micro-rebound hammer (Bambino)
 - The Maness was found to be significantly weaker than the other formations.
- XRD analyses found that an average Maness sample was composed of 45.5 % clay, whereas the average Eagle Ford sample was 31.7 % clay, 13.8 % less than the Maness.
- The isopach map trends suggest a clay-rich deltaic source to the northeast was active during Maness time but was not a significant source of clay during Eagle Ford time.
- A comparison of oil to water ratios to Maness thicknesses showed a strong correlation between the two variables:
 - As Maness thicknesses decreased, oil to water ratios also decreased

Conclusions



1. Maness Shale is geomechanically weaker than the Eagle Ford Shale.
2. Maness Shale has a higher clay and lower calcite content than the Eagle Ford Shale.
3. The Maness acts as a fracture barrier between the Eagle Ford and the underlying water-bearing limestones.

Fish fossil found in the Sante North Unit A 1H within the Maness Shale.

References

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