Depositional Environment and Diagenesis of the Medrano Sandstone, Southern Oklahoma Hoxbar Oil Trend (SOHOT), Anadarko Basin, Oklahoma

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- Previous Investigations
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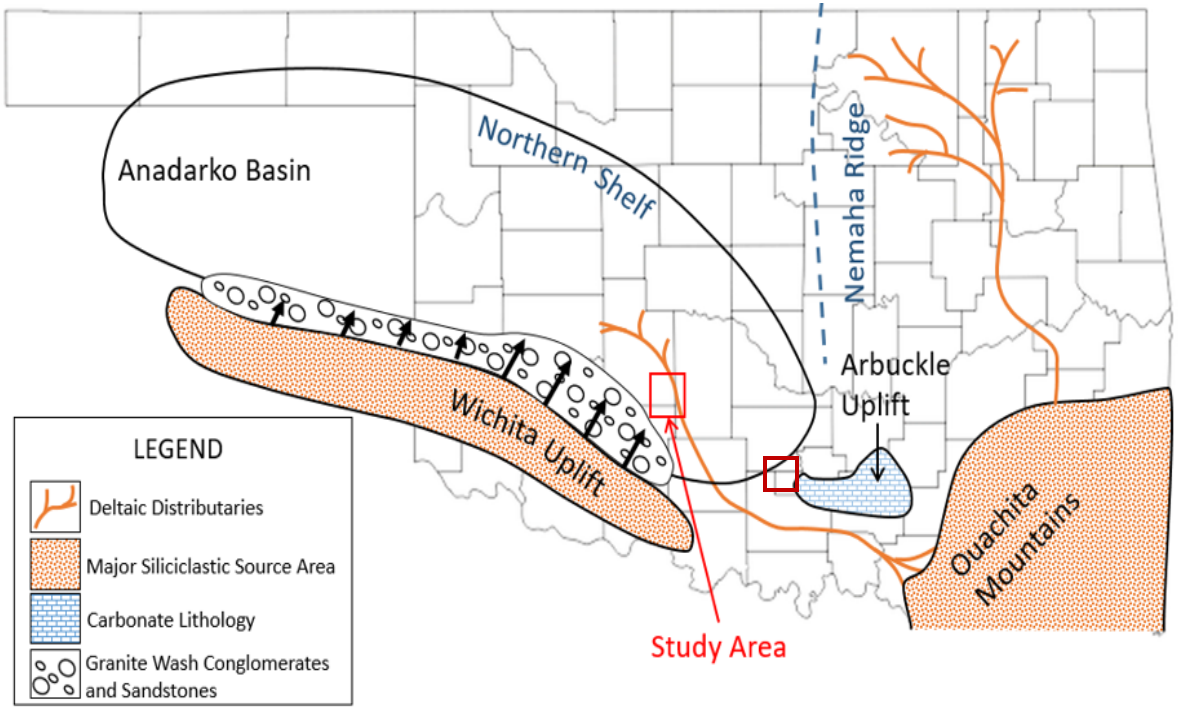
Geological Setting

- Located in the southeastern part of Anadarko Basin.
- Upper Pennsylvanian, Kasimovian (Missourian) Hoxbar Group/Hoxbar Formation (USGS)
- Divided into upper and lower members with operational names tied to principal sandstones
- Hoxbar represents up to >3000 feet of sedimentary section
- Medrano Sandstone is focus of study



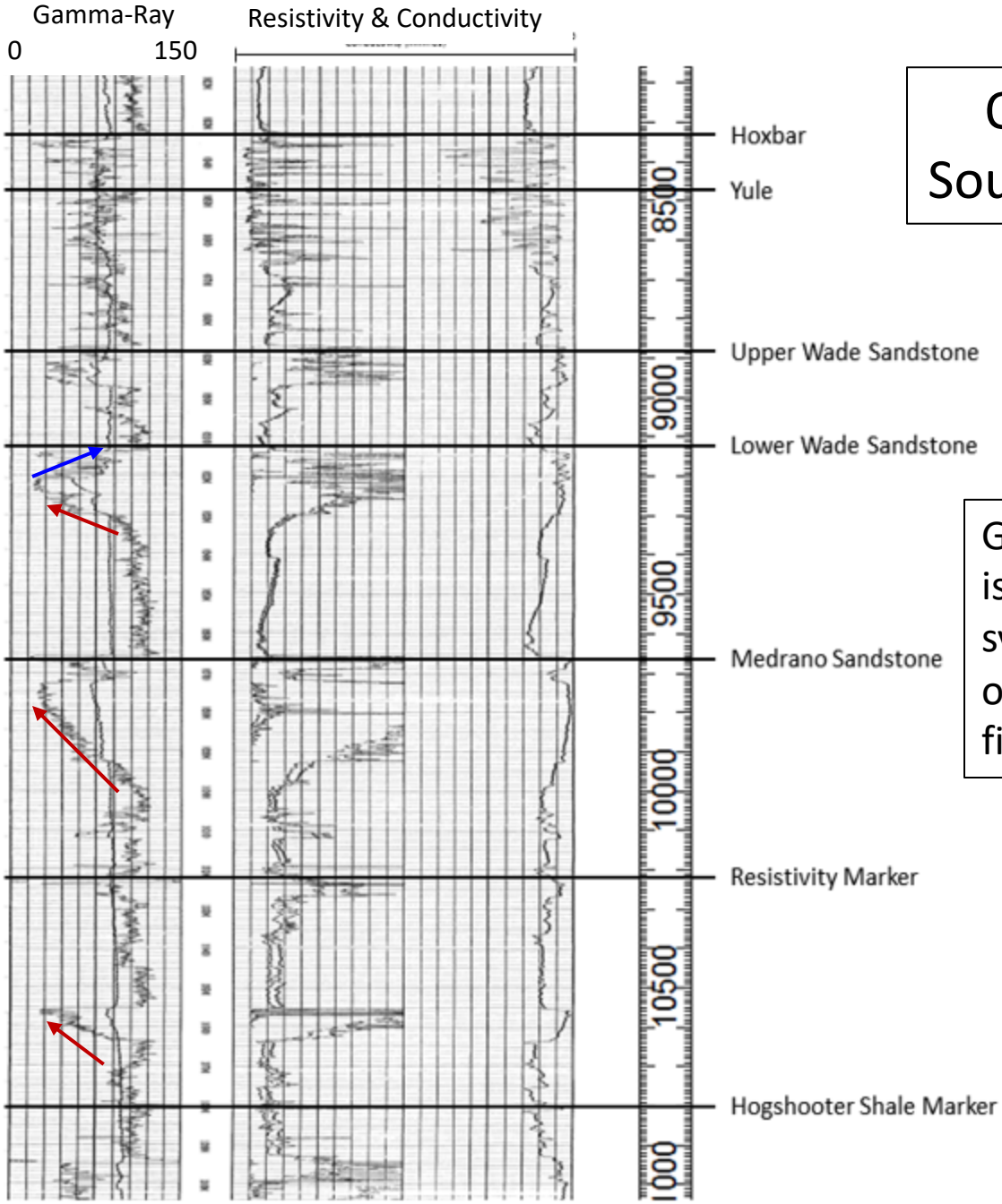
(Modified from Rascoe & Adler, 1983)

Cement-Chickasha Area

System	Sub-system	Series	Group	Subsurface Nomenclature
CARBONIFEROUS	Pennsylvanian	Virgilian	Cisco/Douglas	Gray LS
				Griffin LS
				Rowe SS
				Niles SS
		Missourian	Hoxbar	Oolitic LS
				Yule/Funk SS
				Ostracod LS
				Main Oolitic LS
				Wade SS
				Medrano SS
				Hedlund SS
				Hogshooter Mkr
				Marchand SS
				Culp SS
				Melton SS
		Des Moines	Deese	First Deese
				Second Deese

(Modified from Lange, 1984)

Operational Stratigraphy Southeastern Anadarko Basin



Gamma-ray character of sandstones is typical of progradational sand systems: cleaning upward (red arrow) overlain by thinner blocky or fining-upward pattern (blue arrow)

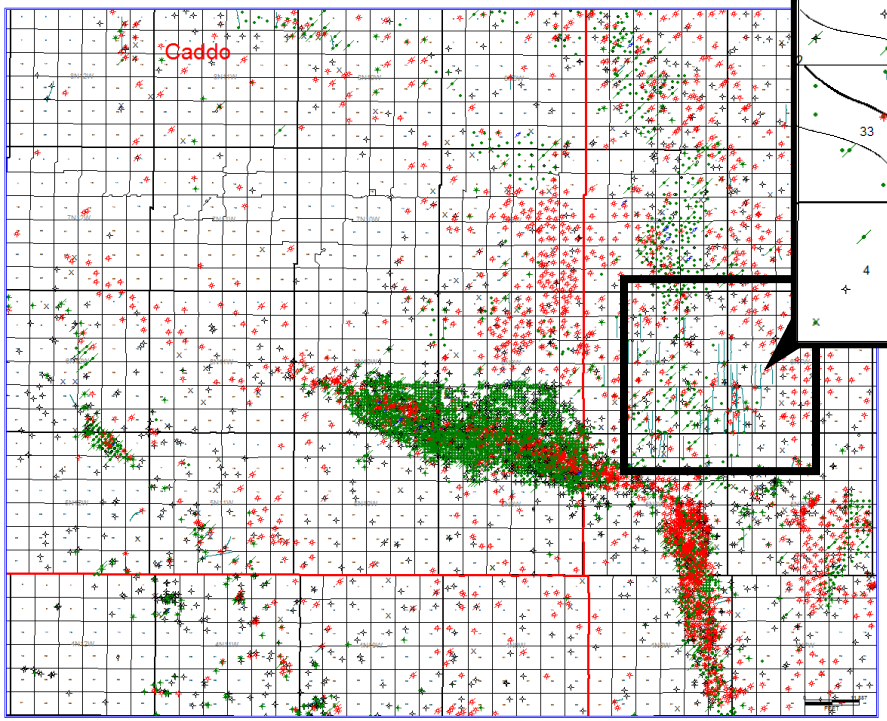
Section of wireline log
From T.6N., R.8W., Grady Co.

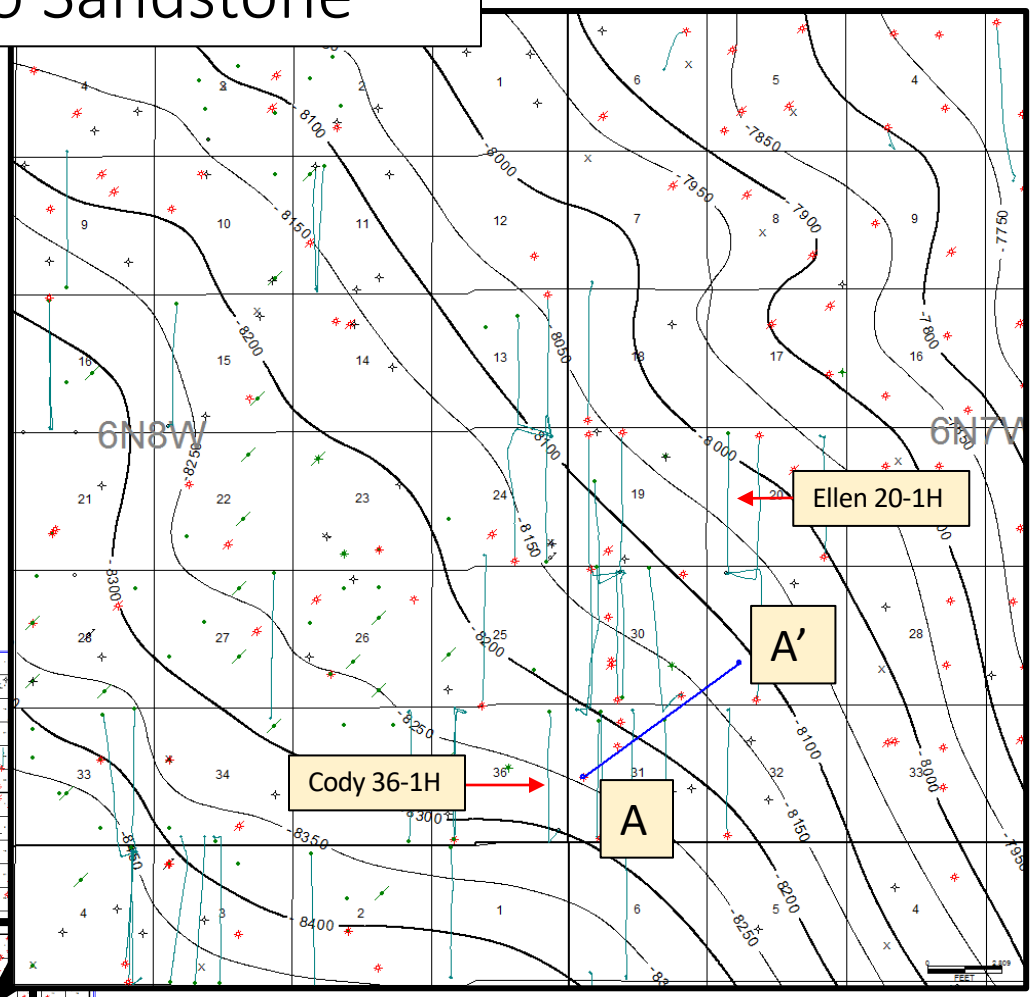
Previous Studies: Hoxbar sandstones

- Medrano interpreted as transgressive prograding deltaic system (Lange, 1984)
- Marchand interpreted as a tide-dominated deltaic depositional environment or fluvial channel to fluvial dominated deltaic environment (Sawyer, 1973)(Seale, 1982).
- Study and surrounding areas includes faulted anticlines (Cement & Chickasha anticlines).
- Principal structures influenced depositional patterns and sediment dispersal (Boeckman, 1958) (Lange, 1984).
- Multiple sources suggested for Hoxbar sands include Wichita Mountains, Cement Anticline, and Ouachita Mountains (Rascoe & Adler, 1983) (Krumme, 1975) (Padgett, 1988) (Seale, 1992)

Project Motivation: Medrano Sandstone

- Horizontal wells targeting the Medrano Sandstone have noticeable differences in initial production rates.
- Sandstones correlated with confidence using log data, but rock data is scarce and geologic models tentative.
- Rock controls on production rate and recovery needed to improve exploration and development strategies.
- Provenance of Medrano sediments is debated. This study examines detrital grains to establish sediment source and impact of porosity.

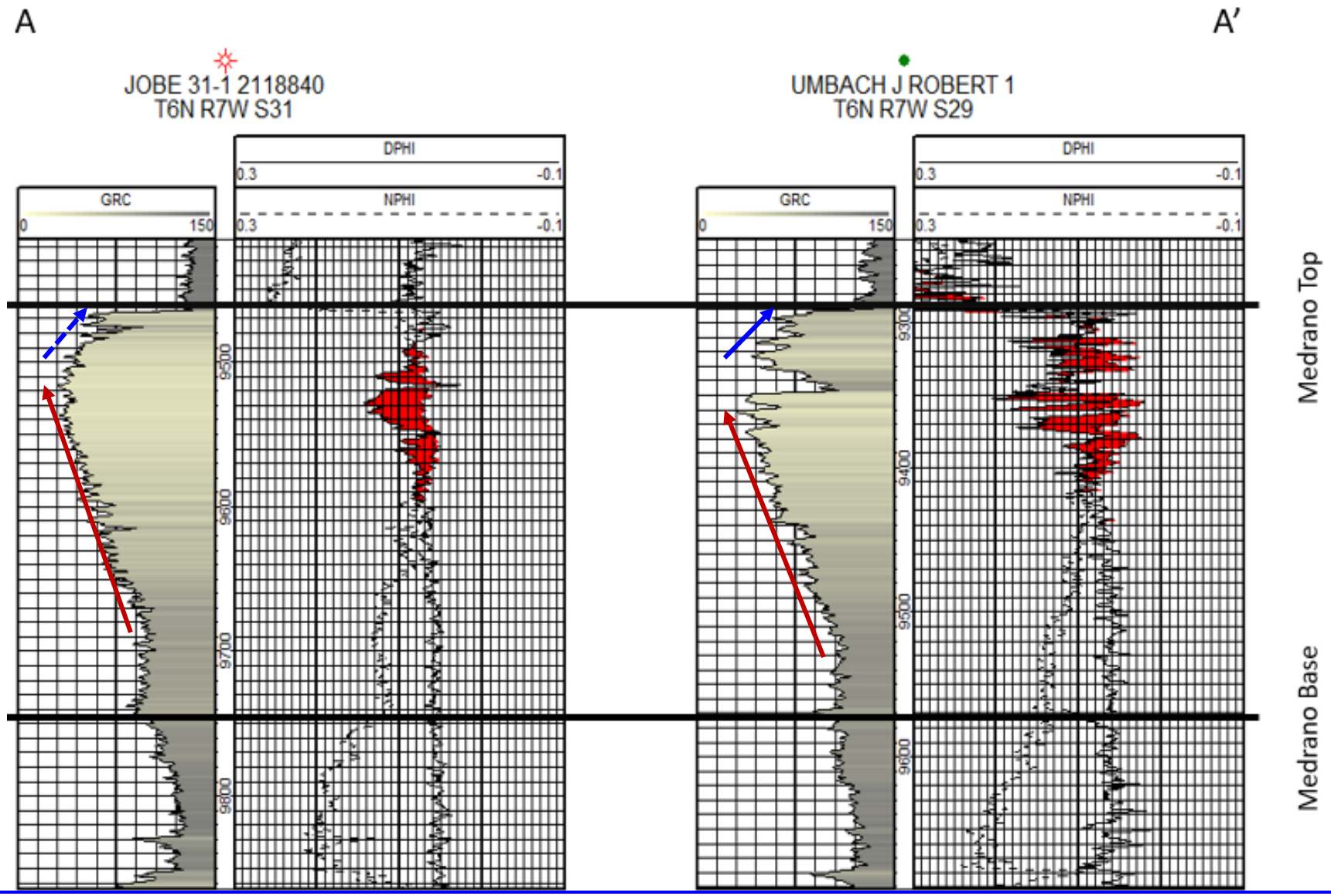




Medrano Sandstone Structure Map
C.I. = 50 feet

Teal lines indicate horizontal well paths
Blue line indicates cross section (A-A')

Cross section A-A’ with Conventional Logs



Red shading indicates neutron-density crossover (hydrocarbon effect). Coarsening-upward and fining-upward indicated by red and blue arrows, respectively.

A

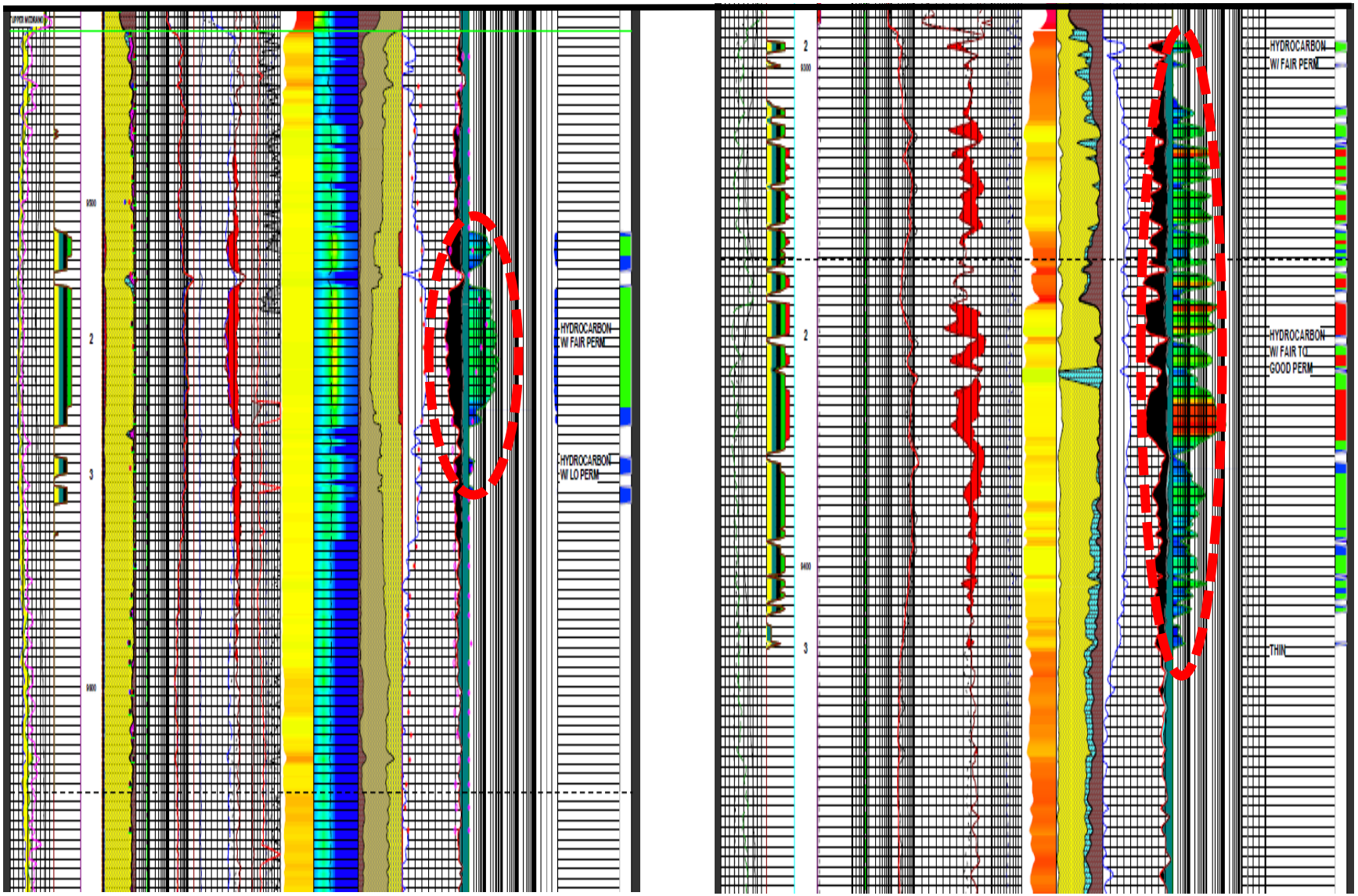
Cross section A-A’ with Interpreted NUTECH Logs

A’

Jobe 31-1

Umbach 1

Top of Medrano Sandstone



Jobe 31-1: pay ≈37 feet

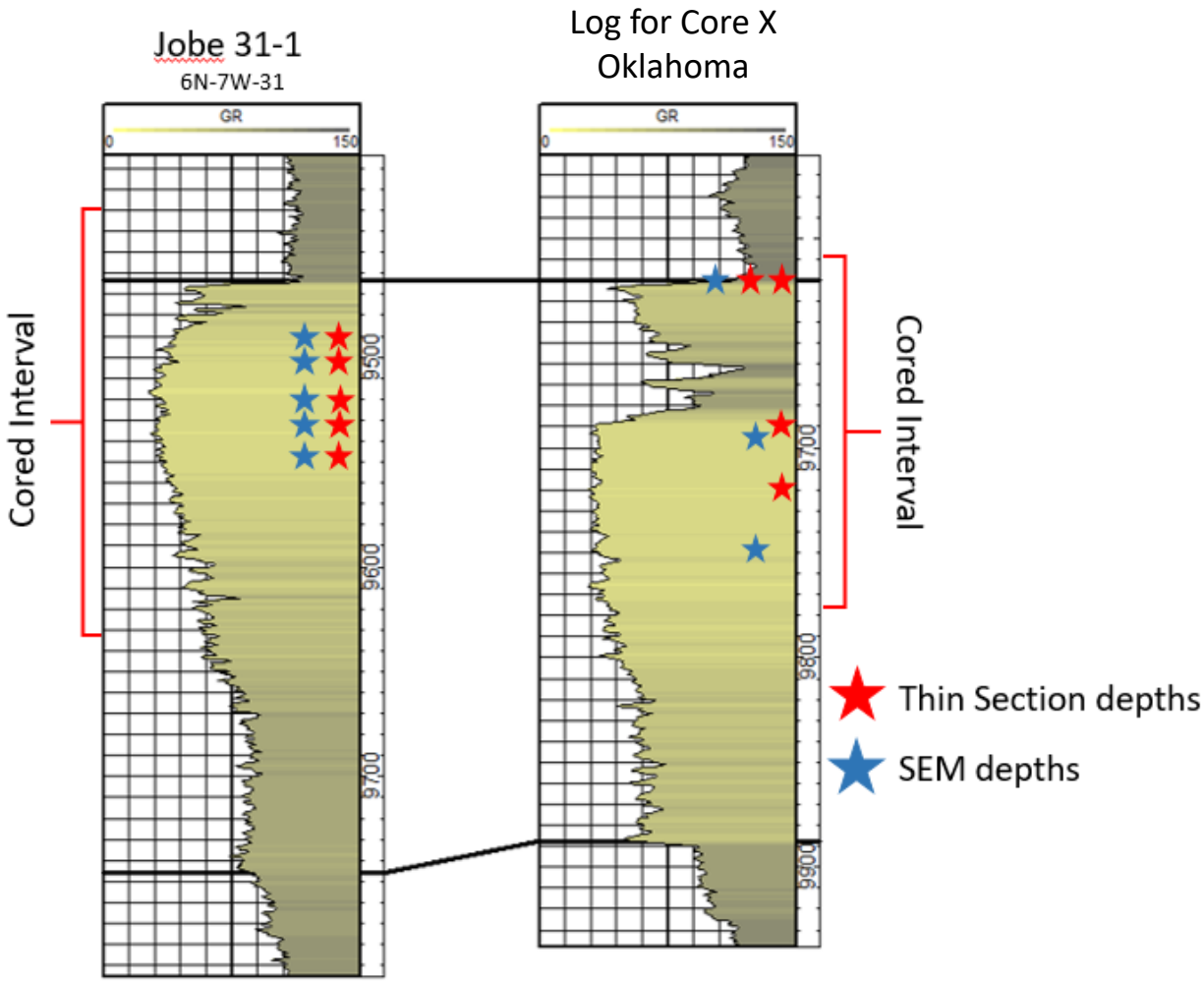
Umbach 1: pay ≈108 feet

Project Objectives

- Determine the factors that are influencing the reservoir quality within the Medrano Sandstone.
- Investigate the depositional environment of the Medrano Sandstone
- Investigate impact of depositional environment and diagenetic history on reservoir quality in Medrano Sandstone
- Determine detrital composition of Medrano Sandstone and make inferences concerning source area

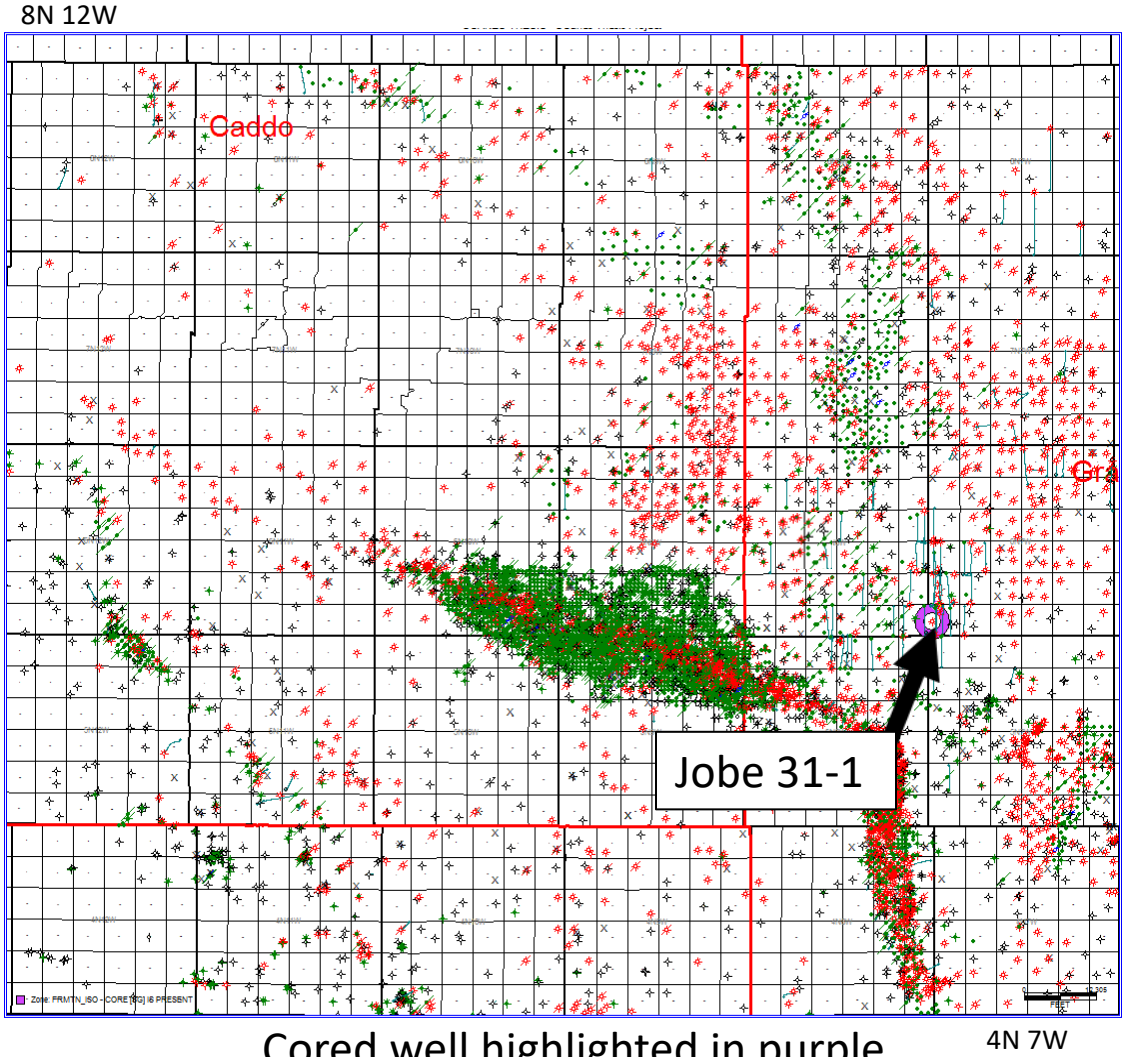
Data Acquisition & Methods

- Two cores (Jobe 31-1 & Core X) were examined described and correlated to associated wireline well logs
- Petrographic analysis – thin sections & SEM images (Jobe 31-1 & Core X).
- Well to well facies correlation and mapping using public logs (8,000+) and NUTECH logs(40+).



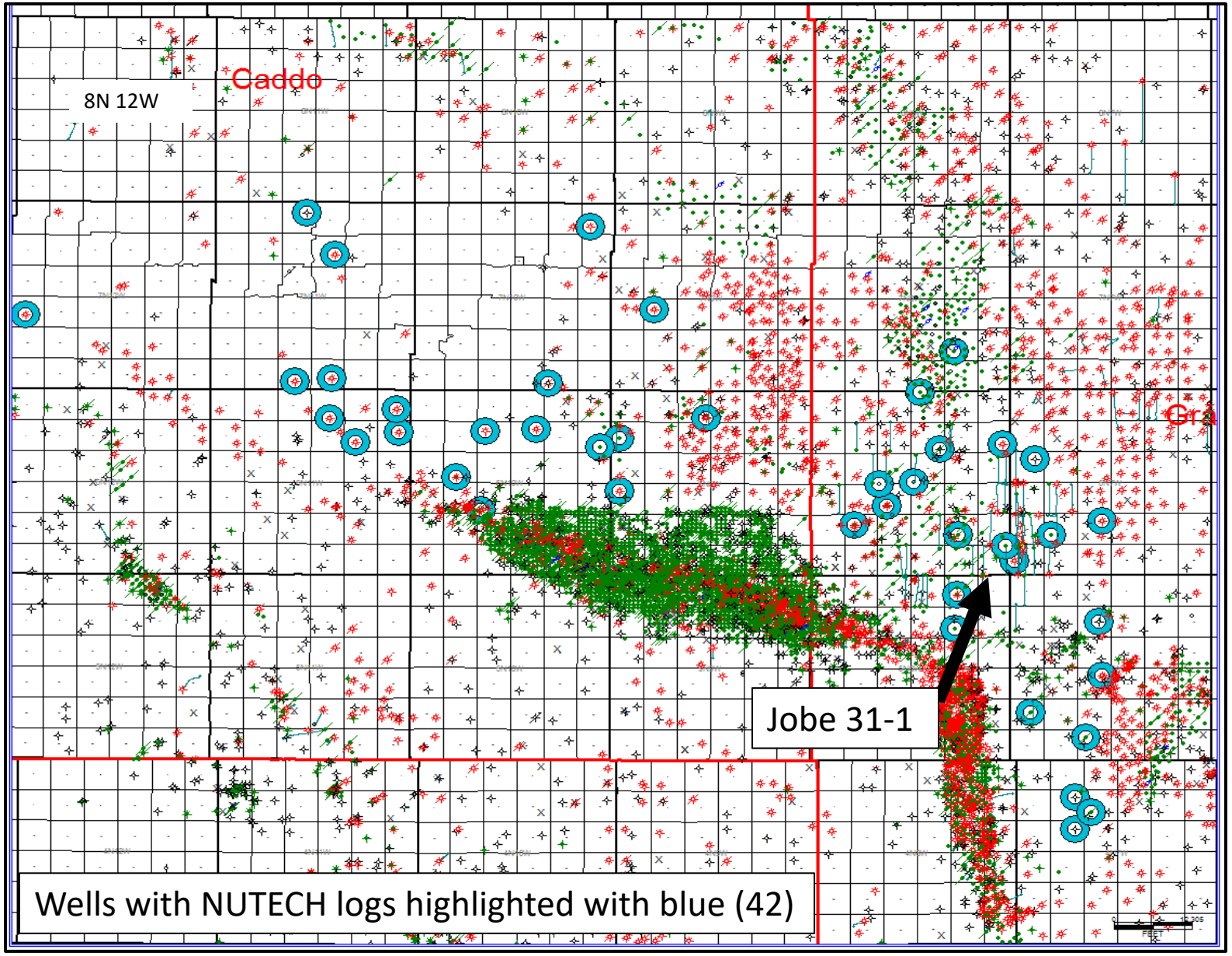
Core analysis and Core Calibration

- Jobe 31-1 cored interval 9430’-9634’ (204’)
- Core X cored interval XX08’- XX74 (166’)



Cored well highlighted in purple

Facies mapping

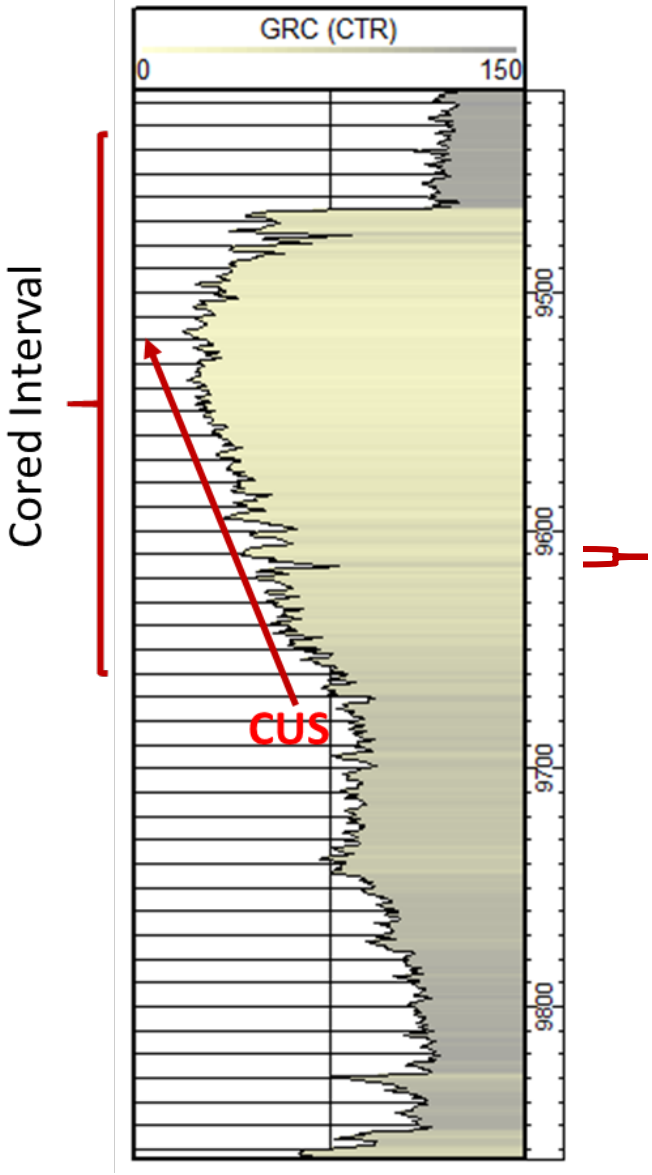


Expected Results

- Confirm the interpretation of depositional environment from previous studies in the area or establish a new interpretation of the depositional environment.
- Establish a model for predicting areas of better reservoir characteristics for commercial development.
- Insight into the discrepancy in reservoir characteristics between wells that is evident in the NUTECH interpretations and possibly use this area as an analog for sandstones formed in similar environments.
- Establish or confirm provenance of Medrano sands.

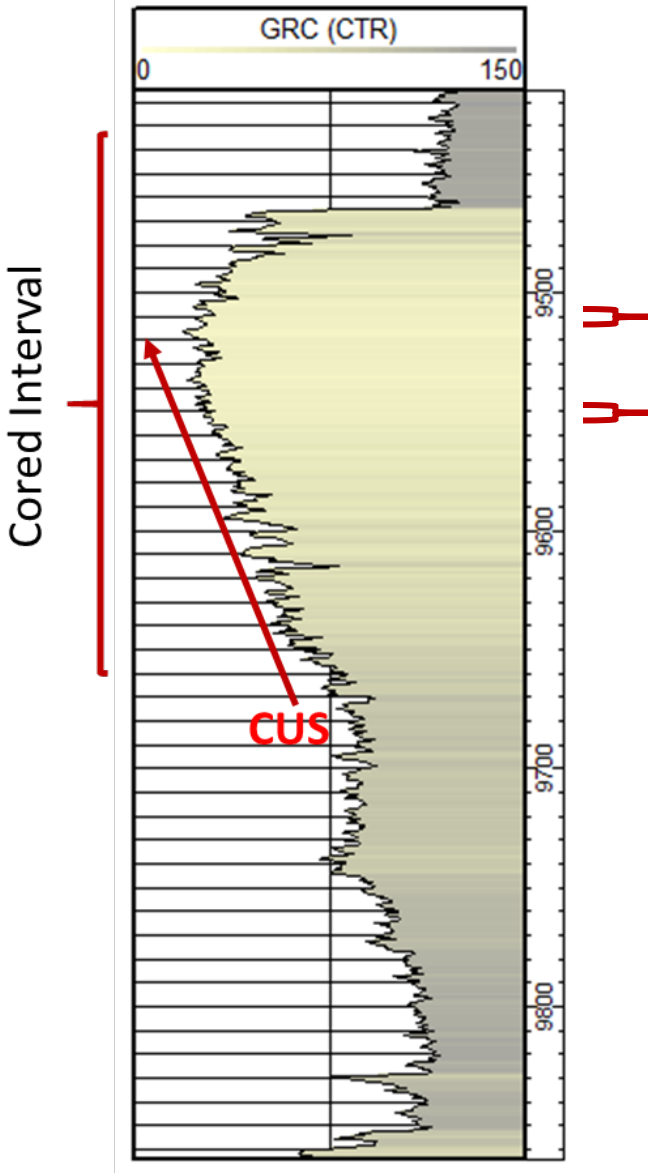
Results: Depositional and biotic features in lower Medrano Sandstone section

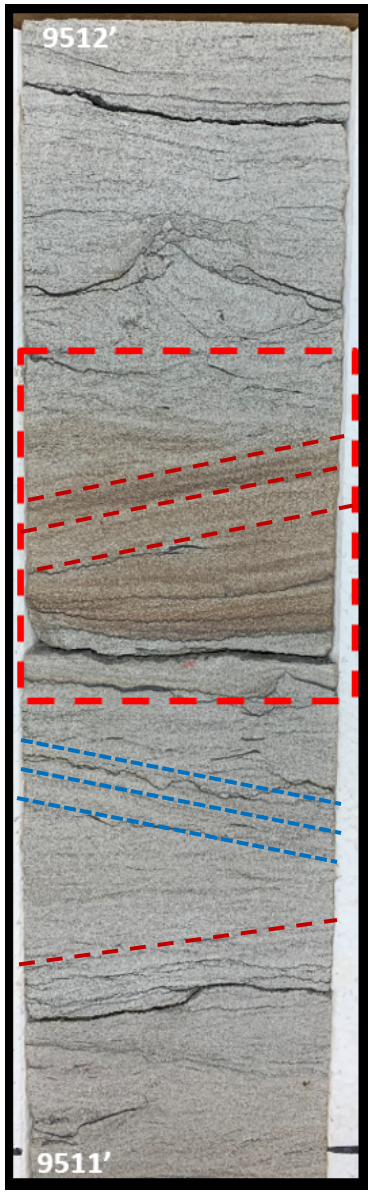
- Interbedded to interlaminated shale and sandstone
- Intensely burrowed in sections; bedding disrupted



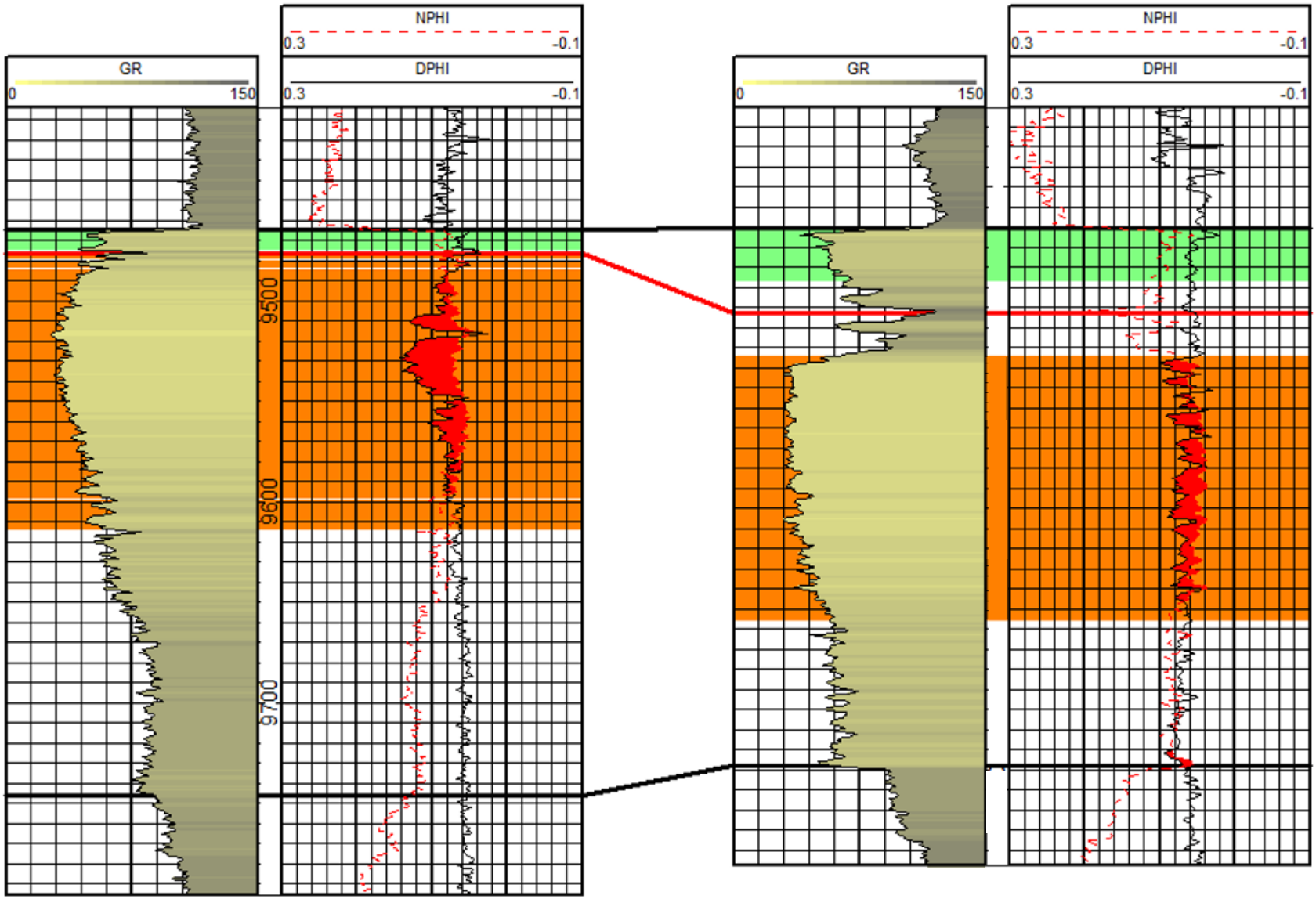
Results: Depositional and biotic features in Medrano Sandstone

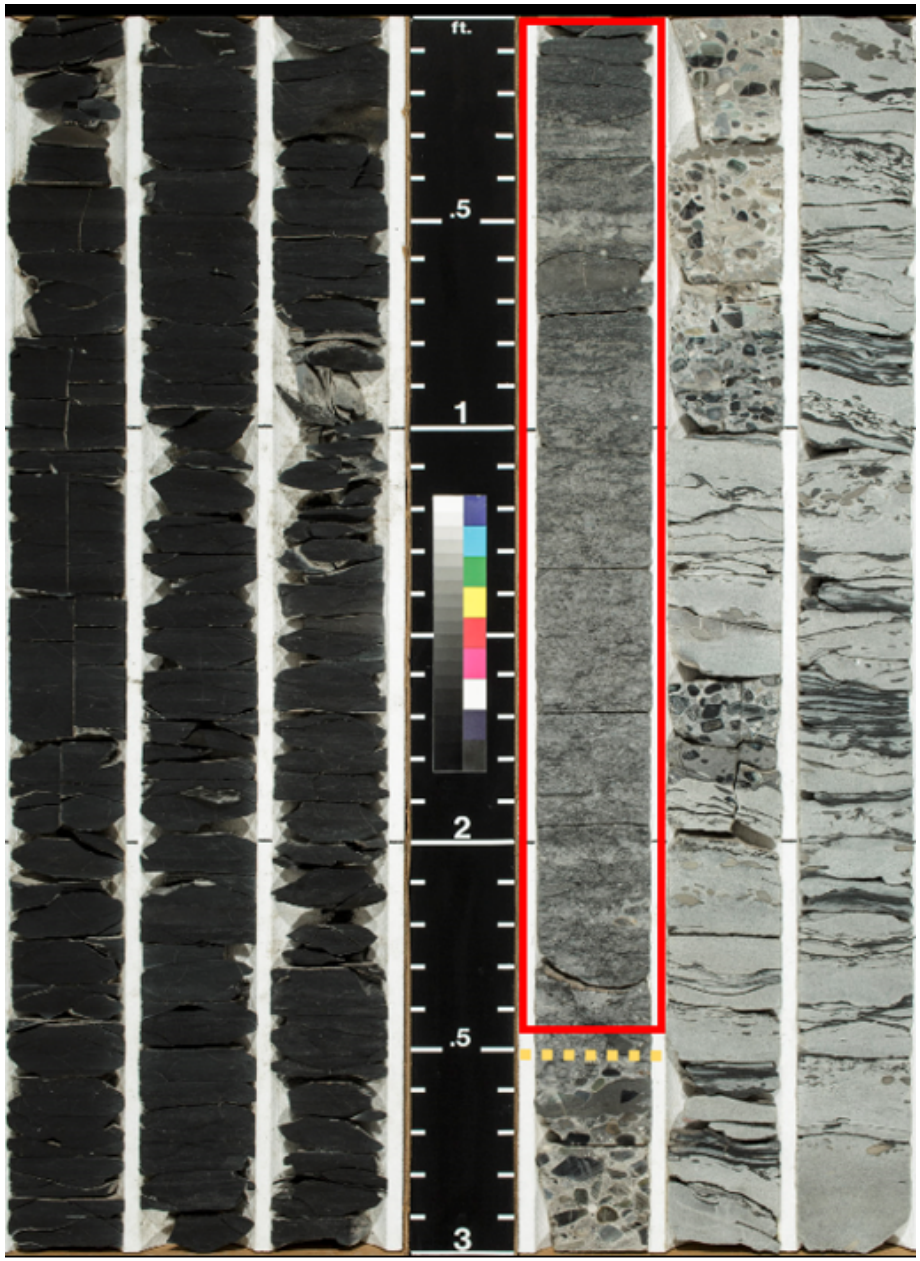
- Right - Clay clasts (sideritized) in sandstone w/ clay drapes and stylolitic bed boundaries (9548-9549 feet)
- Left – Siderite clay along cross stratification (red box) with opposite dip below (blue lines) (9512-9513 feet)





Preliminary Results: two separate sandstone bodies

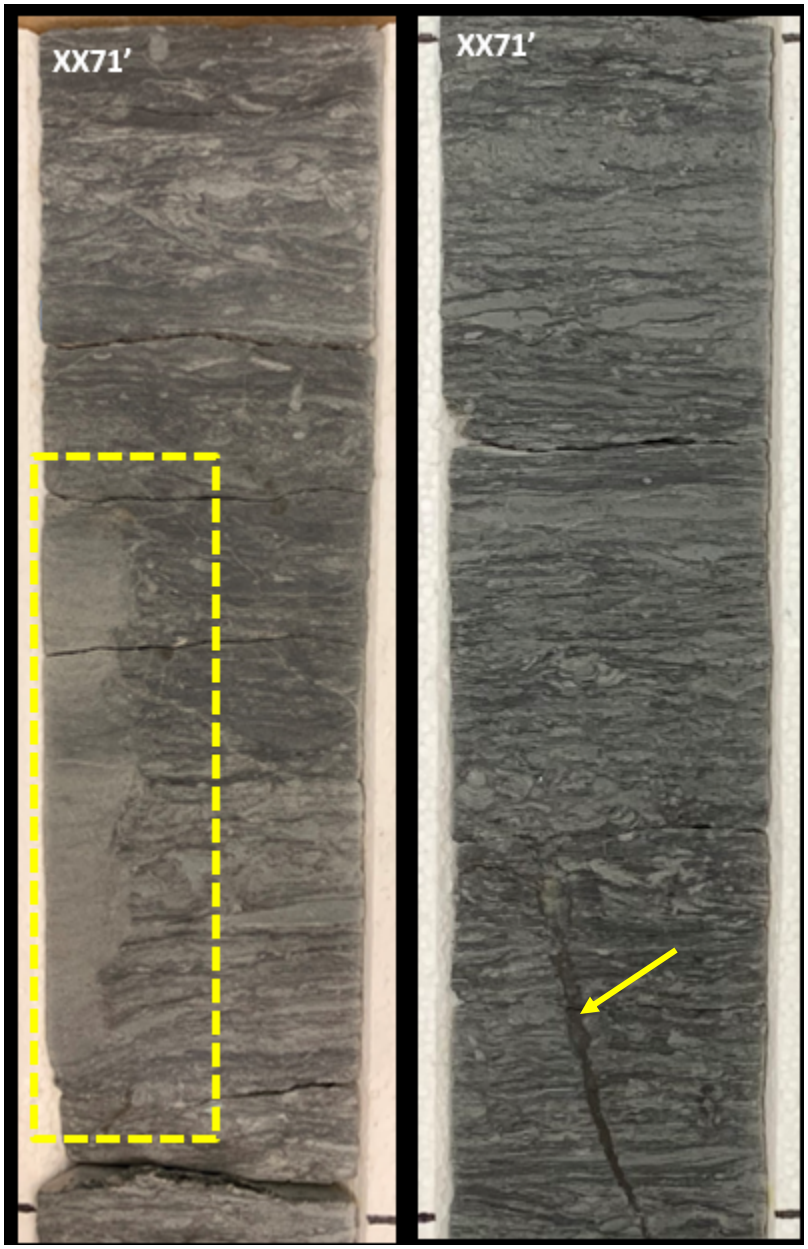




RESULTS: Depositional patterns in core

Top of Medrano Sandstone interval is burrowed, soft-sediment deformed sandstone and conglomeratic sandstone.

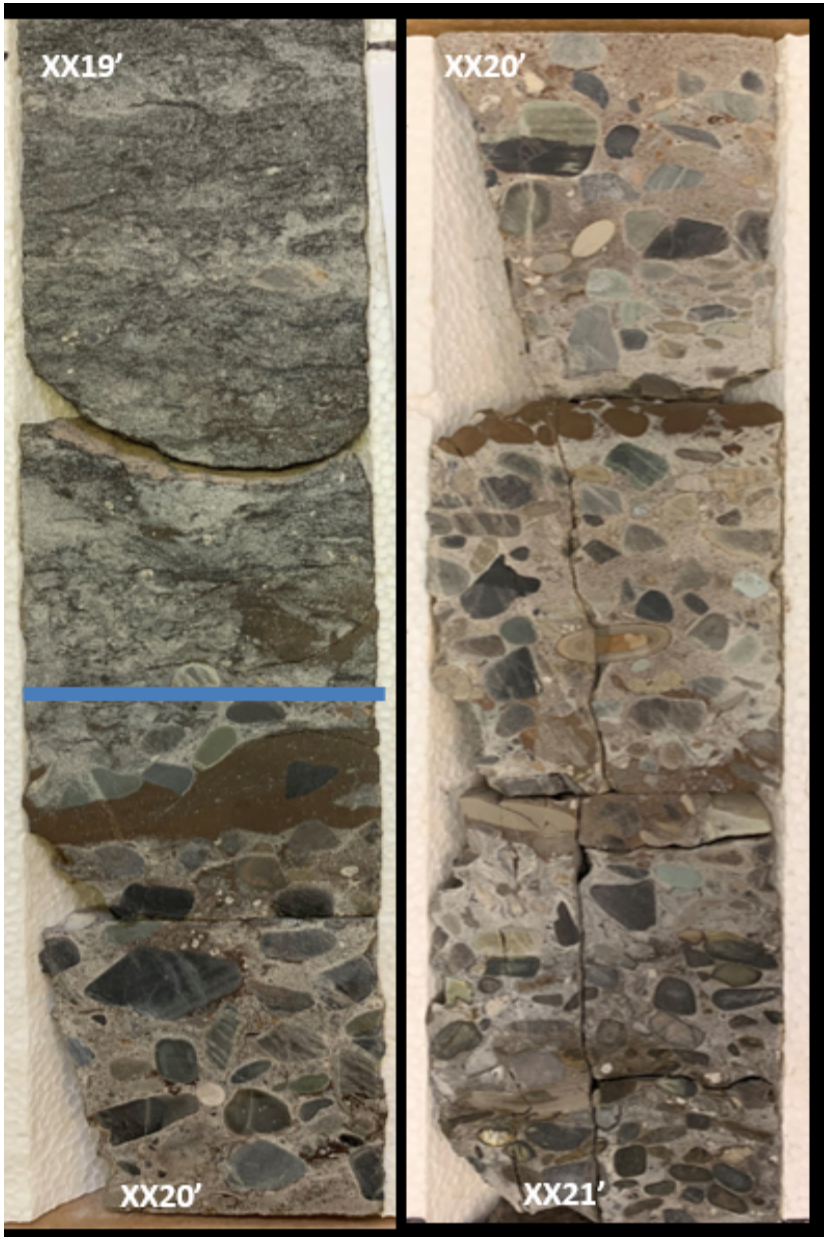
This interval is overlain by highly bioturbated sandstone (red box) that is in turn, succeeded by dark shale with marine invertebrate fossils



RESULTS: Depositional and biotic patterns in core

Highly burrowed interlaminated sandstone-shale interval with abundant smaller horizontal burrows and large vertical burrows (yellow box and arrow).

Core is approximately 3.5 inches in width.



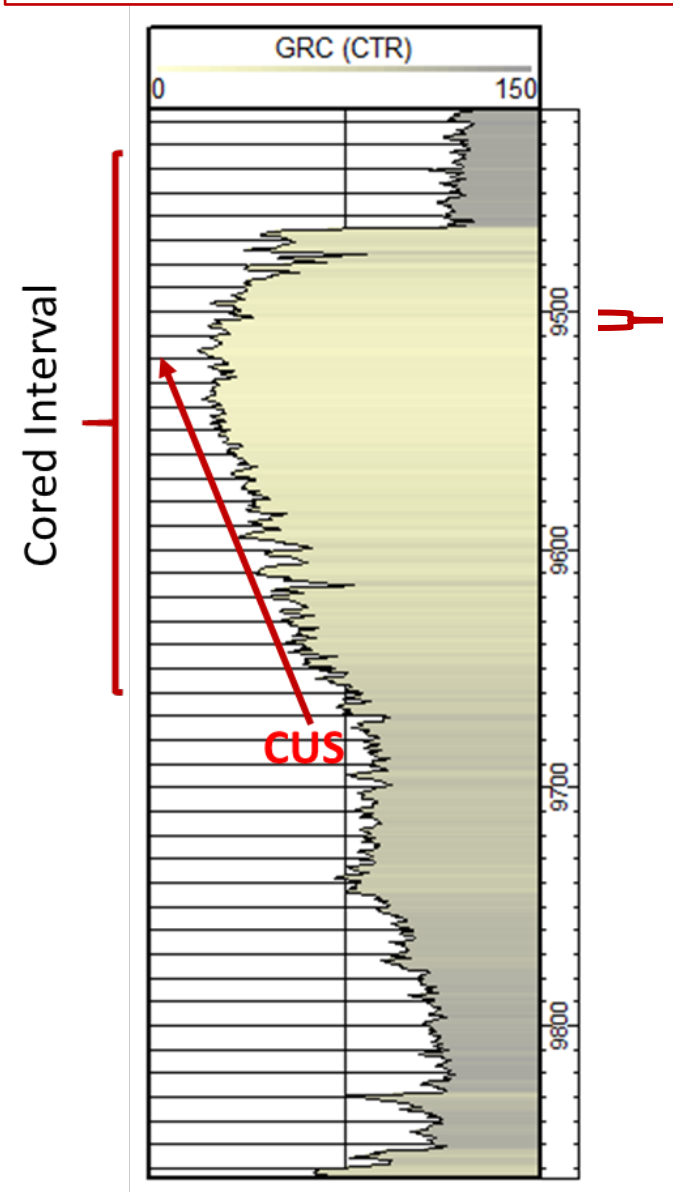
RESULTS: Depositional and biotic patterns in core

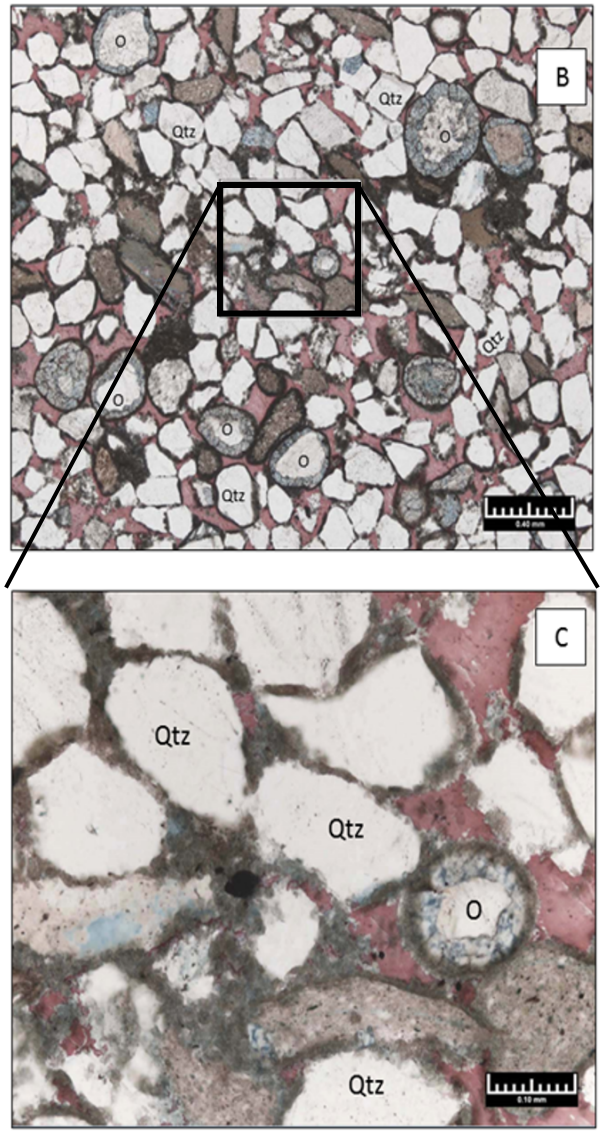
Conglomeratic (chert pebble) sandstone overlain by highly burrowed interlaminated sandstone-shale interval. Blue line marks stratigraphic surface. Conglomerate occurs at top of the Medrano Sandstone and marks a distinct increase in energy.

Core is approximately 3.5 inches in width.

Results: Sedimentary features in the Medrano Sandstone

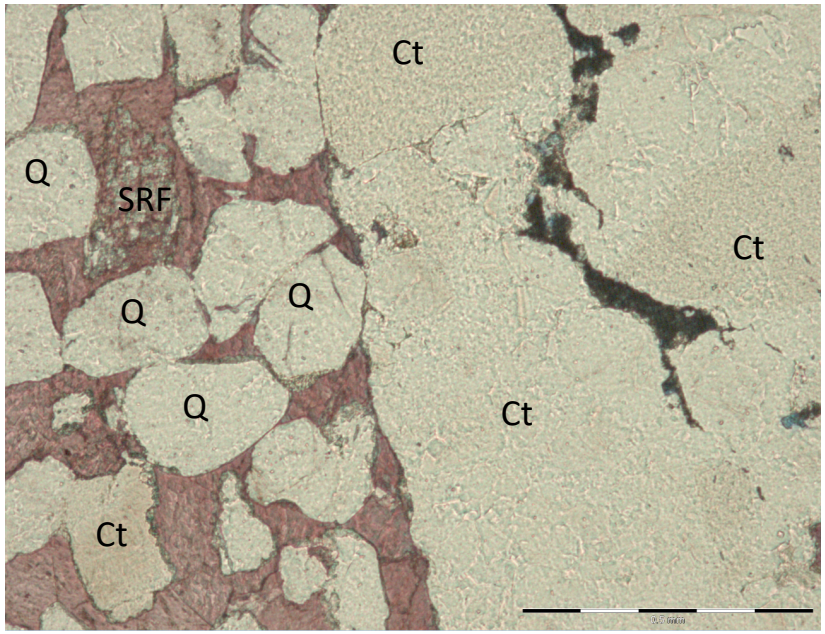
- Left - Cross bedded sandstone with ripples (orange)
- Right – Photomicrographs showing micrite coated quartz (Qtz) and ooids nucleated on quartz (O) cemented by calcite (pink). C is close up of B.



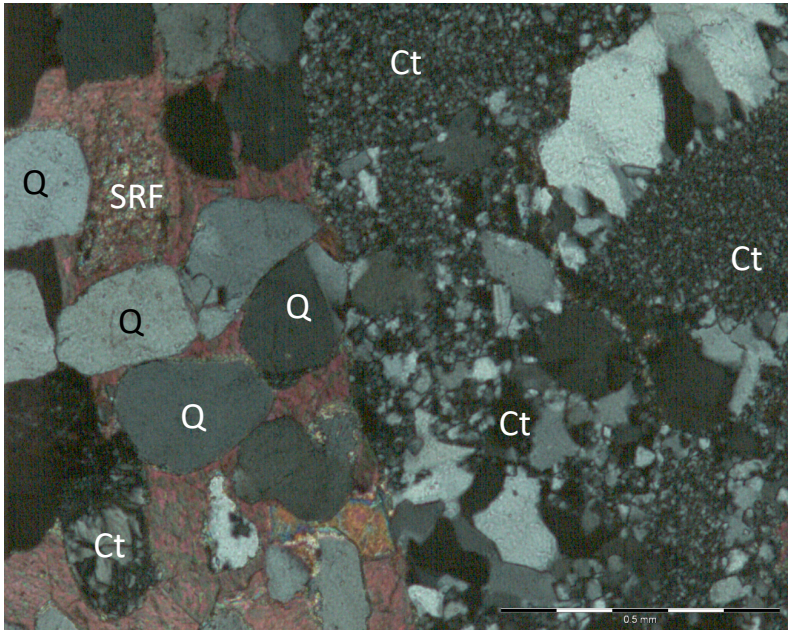


Results: Thin Section Petrography

- Samples dominated by detrital quartz, chert and sedimentary rocks, with lesser amounts of plagioclase feldspar and microcline.
- Chert in conglomeratic sandstone are indication of likely Ouachita Mountain source.
- Calcite cement is early in some sections and prevented quartz overgrowth.
- Plutonic rock fragments distinct to the Wichita Mountains are not observed.
- Sandstones plot as sublitharenite on Folk (1962) ternary diagram.



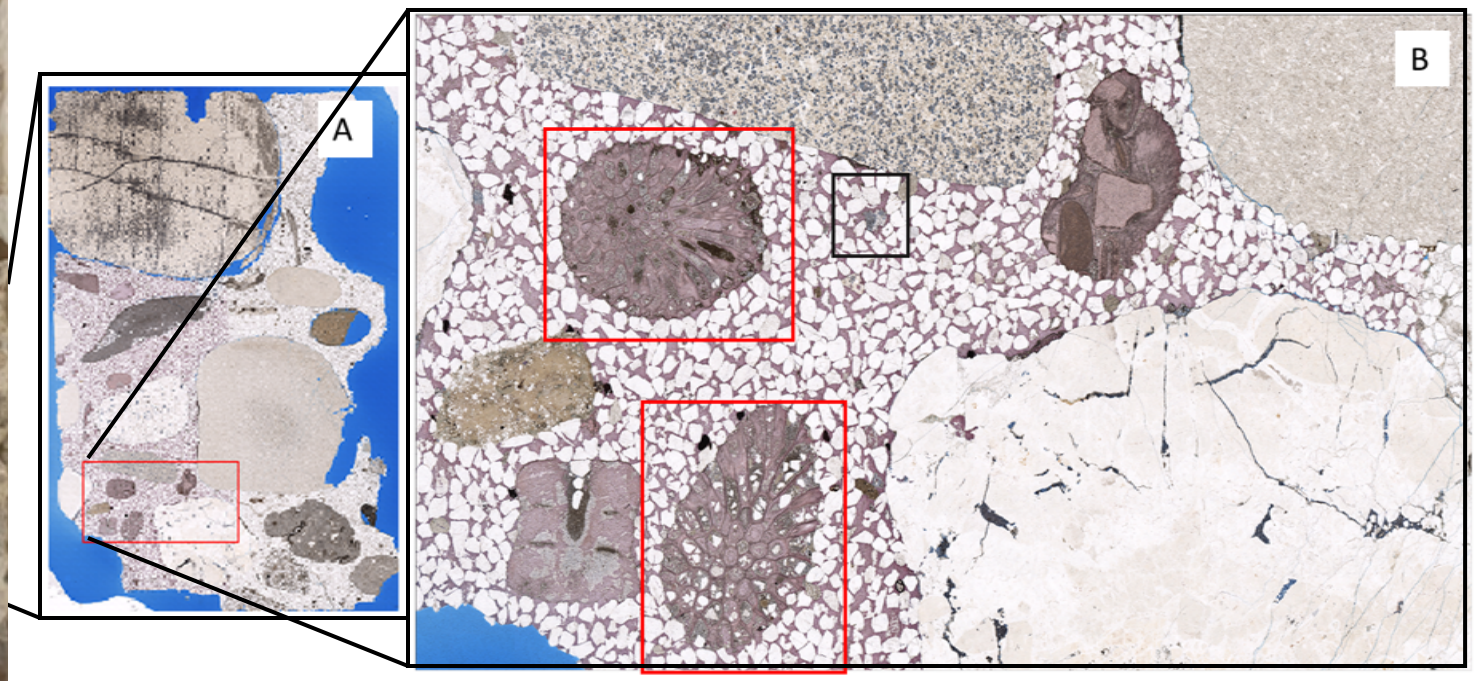
Plane-polarized light **(.05 mm scale)**



Cross-polarized light **(.05 mm scale)**

Quartz (Q), chert (Ct) and sedimentary rock fragment (SRF) cemented by calcite (pink)

RESULTS: Marine Indicators in Conglomeratic Sandstone

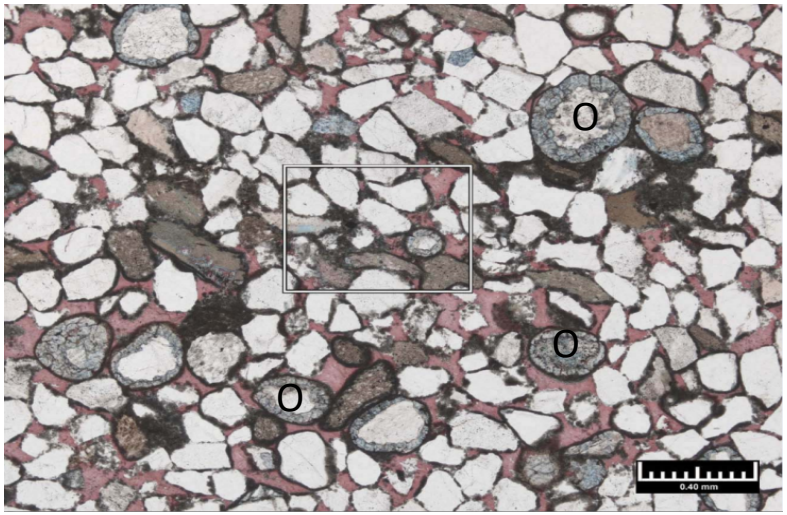


Medrano conglomeratic sandstone with alternating Beds of sideritized clay clasts (arrow) and chert pebbles.

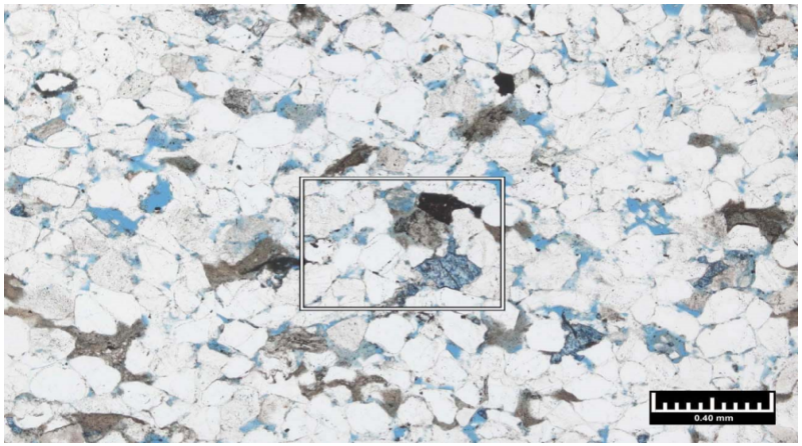
Thin section photomicrograph showing bryozoan fragments (red boxes) and pebbles in sand matrix

RESULTS: SEM Microscopy

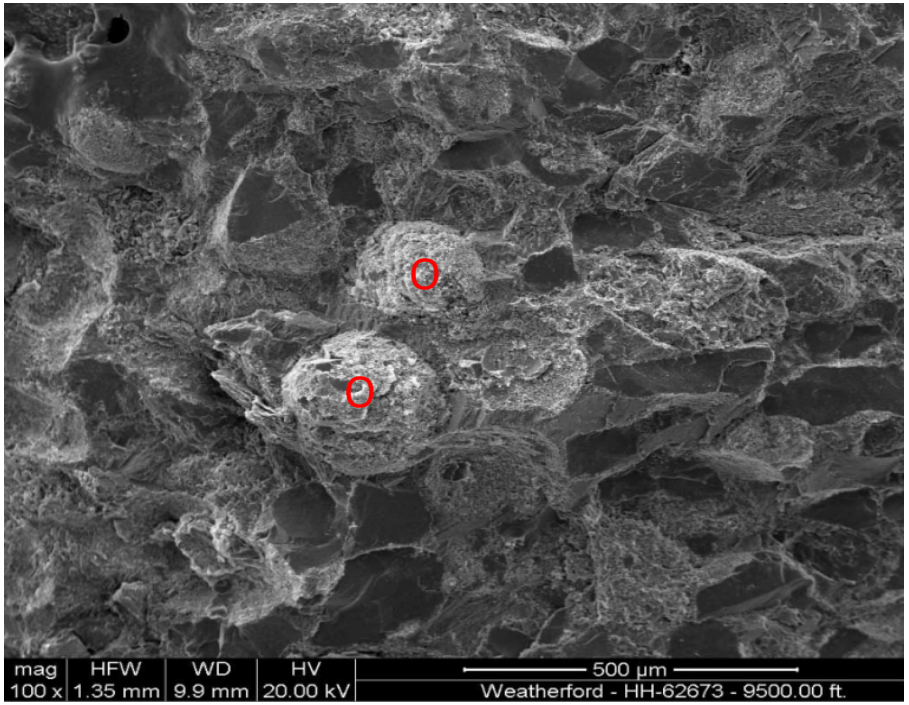
Ooids in upper photomicrograph (O) and clay coated grains in lower image



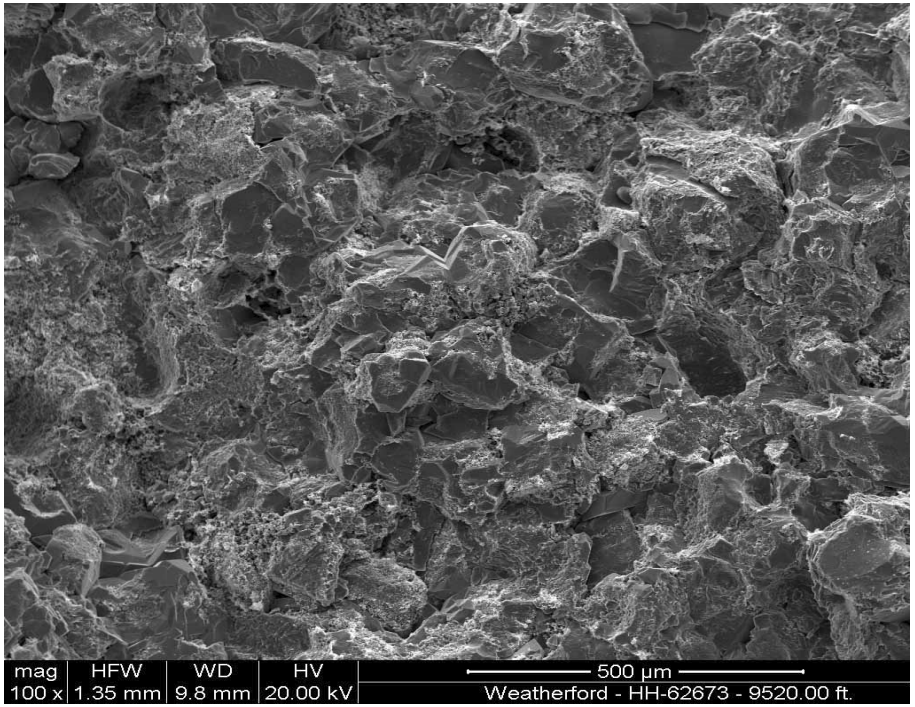
Secondary porosity (blue) mostly dissolution of sedimentary rock fragments and feldspar



(0.4 mm scale)

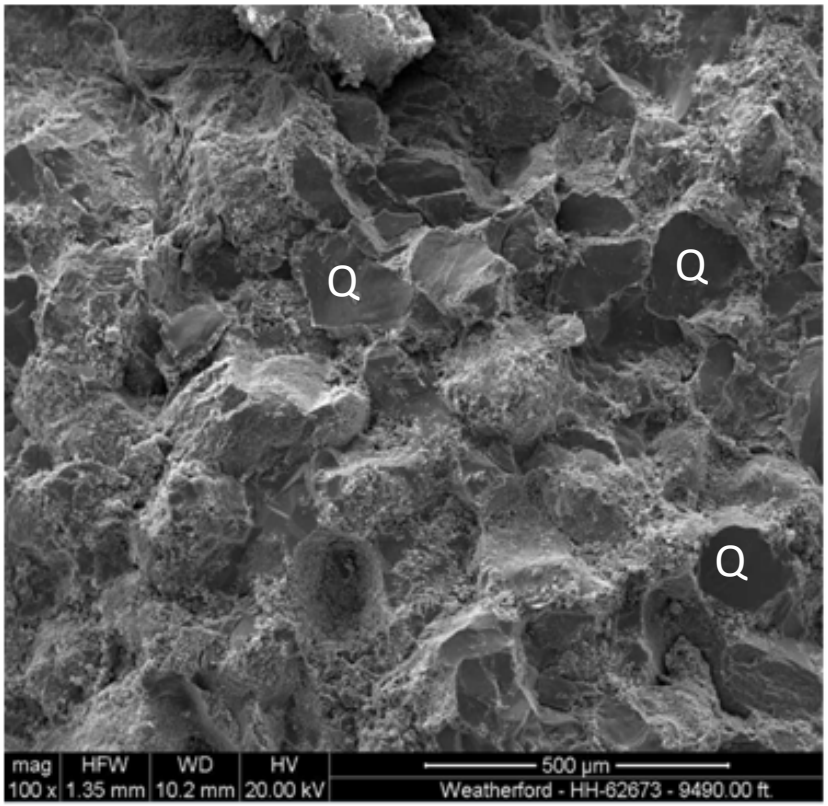


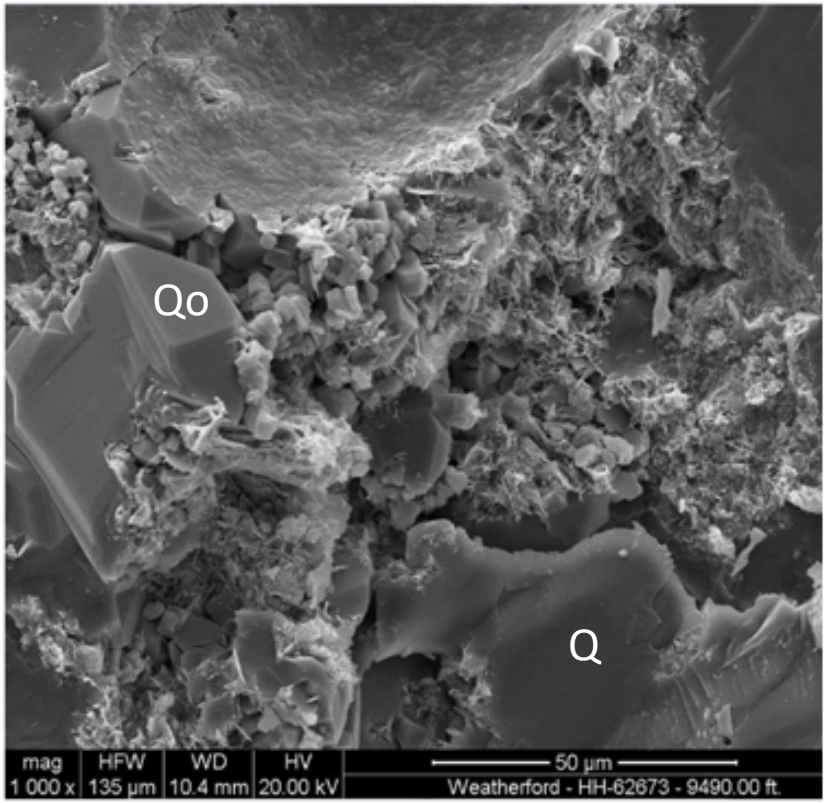
SEM Image Jobe-31 @ 9500' (500 µm scale)



SEM Image Jobe-31 @ 9520' (500 µm scale)

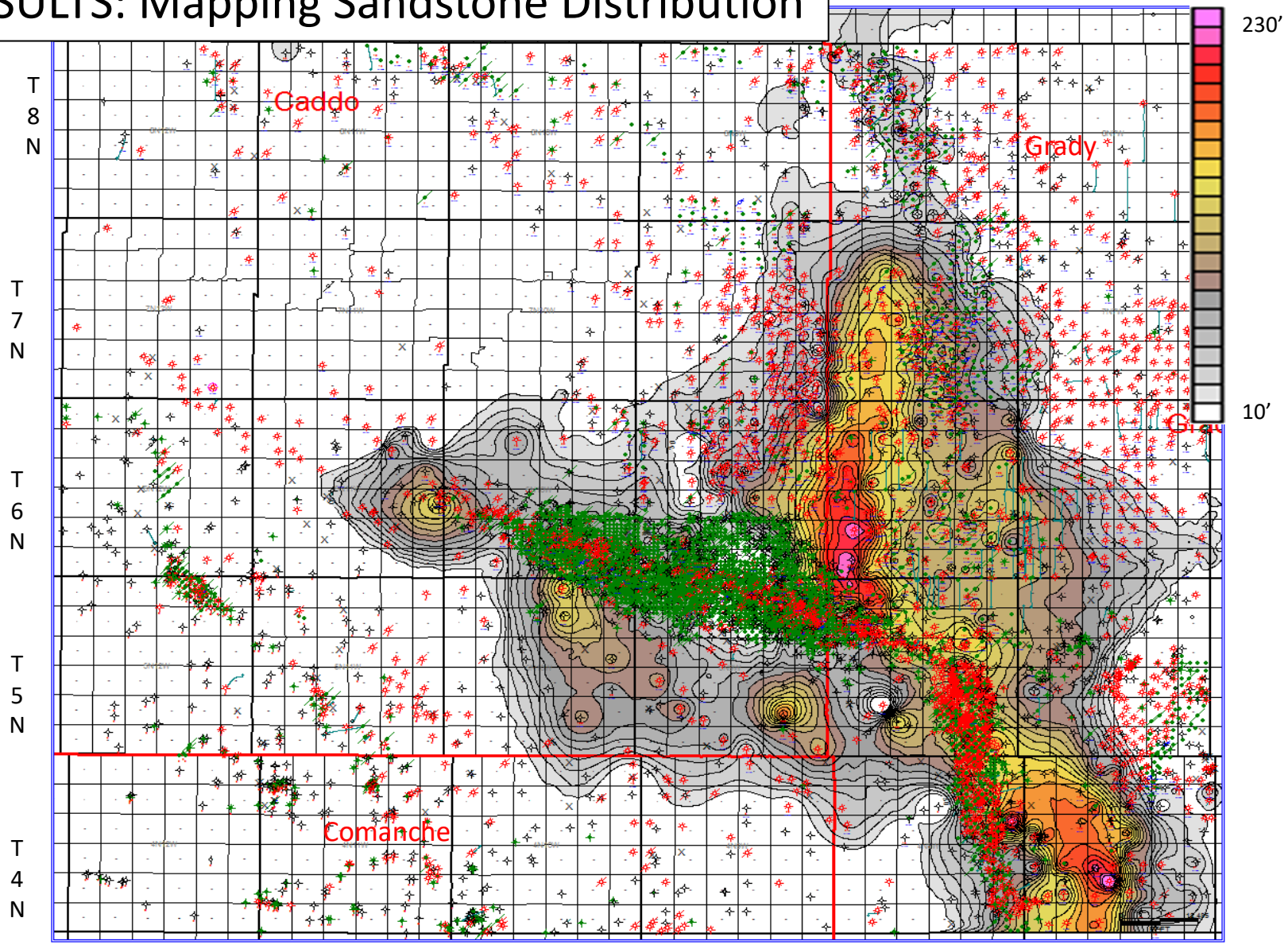
RESULTS: SEM Microscopy





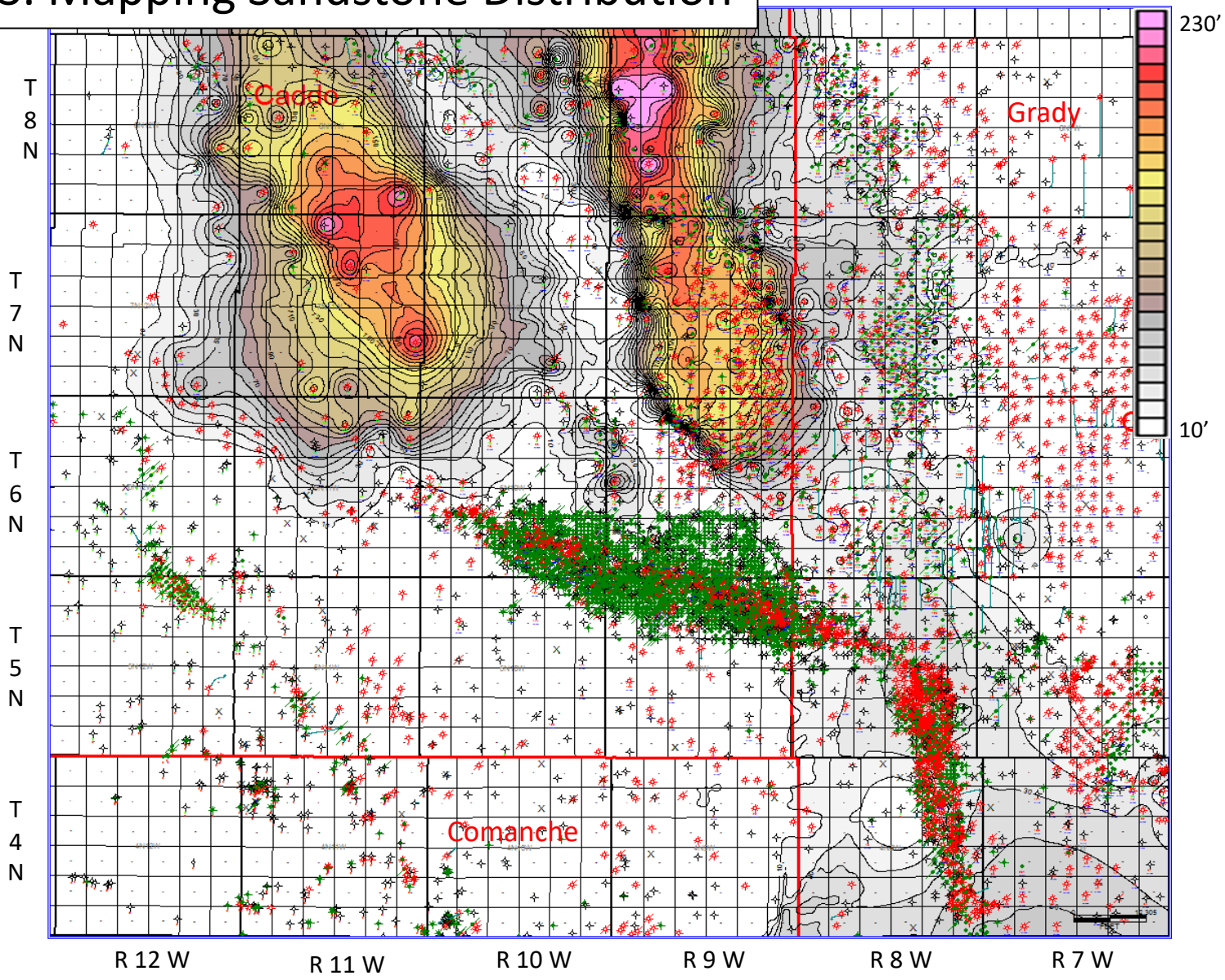
Detrital quartz (Q) with overgrowth (Qo) and authigenic clay partially occluding porosity in Medrano Sandstone. Illite is dominant clay, but morphology indicative of mixed layer Illite/smectite was observed. Microporosity between clay plates contributes to total porosity, but permeability is reduced.

RESULTS: Mapping Sandstone Distribution



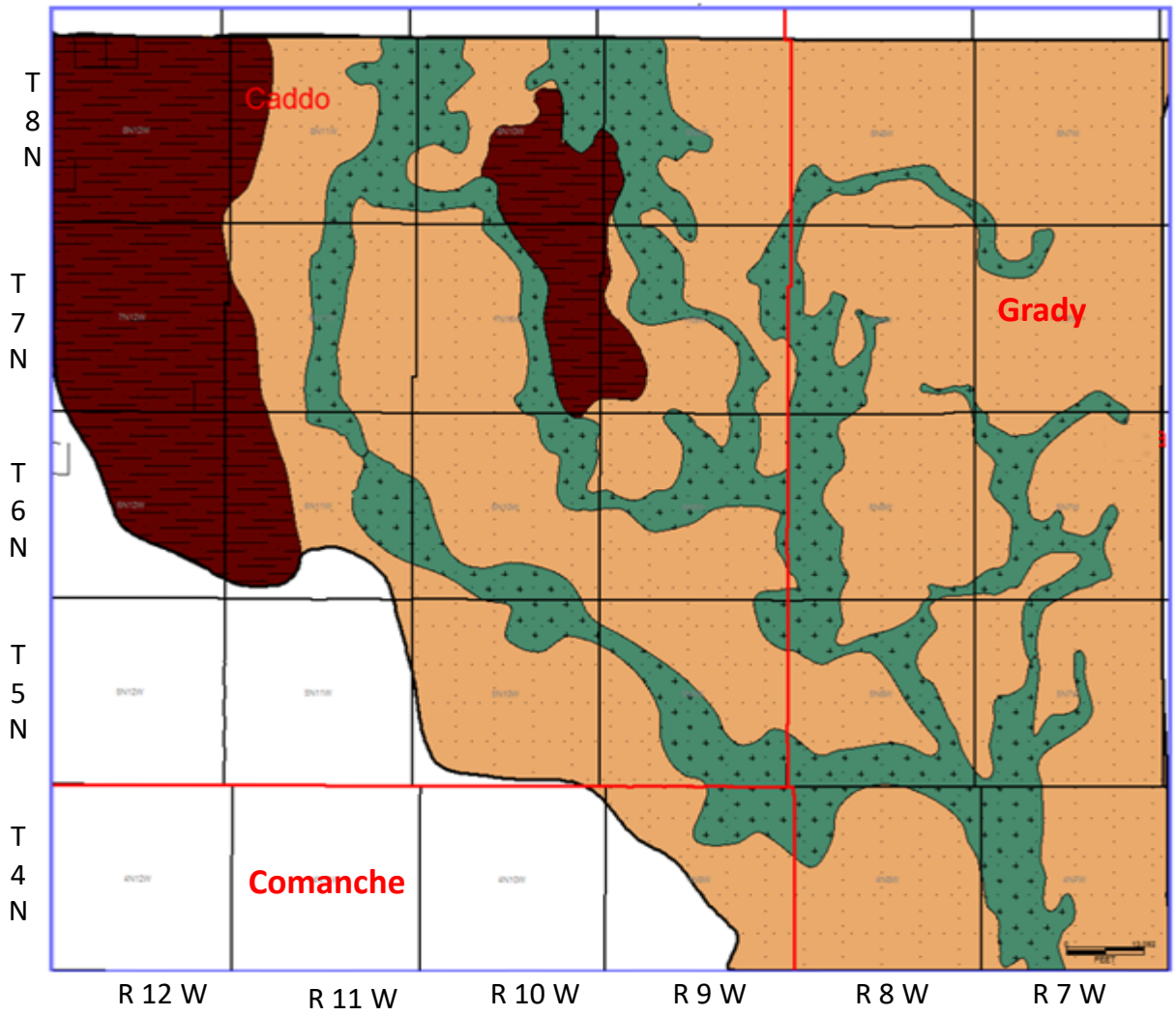
Distribution of the Lower Medrano Sandstone (<37% V-shale)

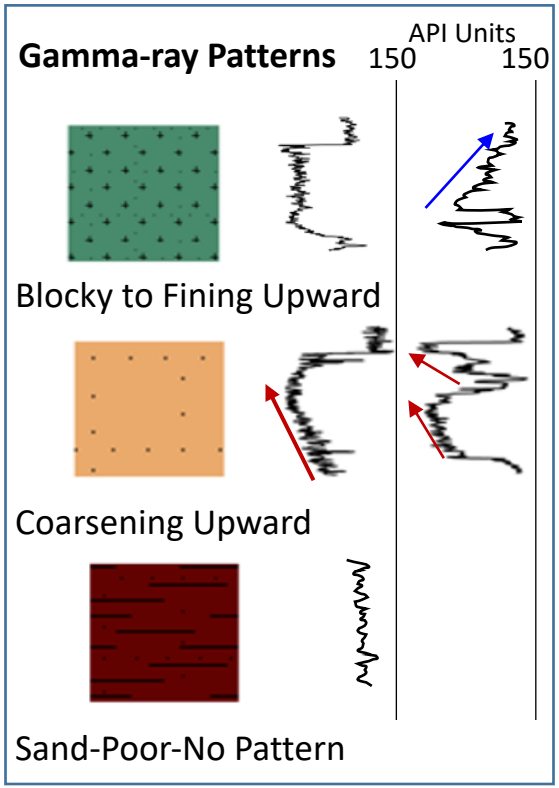
RESULTS: Mapping Sandstone Distribution



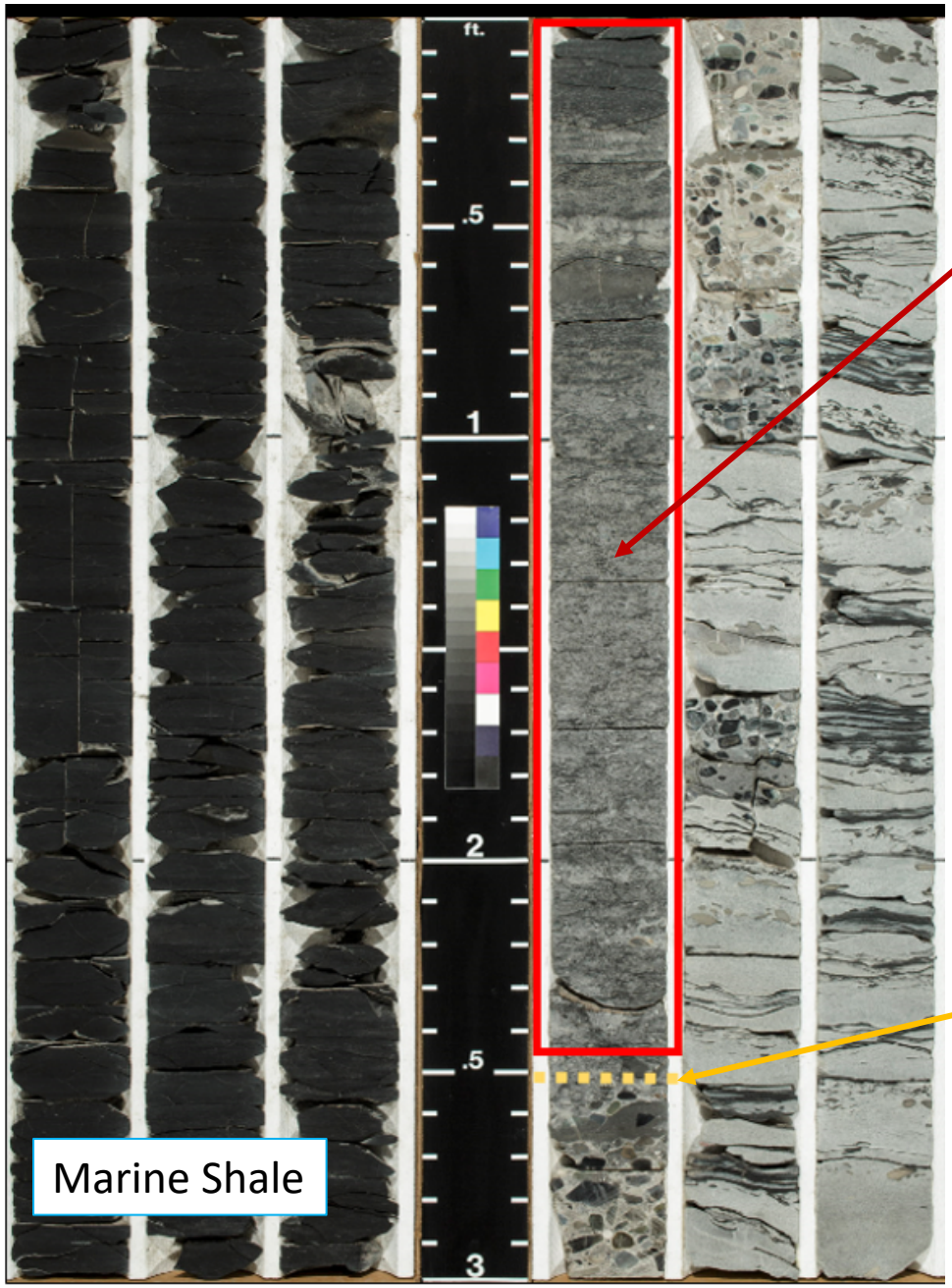
Distribution of the Upper Medrano Sandstone (<37% V-shale)

INTERPRETATION: Weakly defined distributary channels that succeeded the northerly prograding sediment dispersal system





Distribution of Electrofacies from Wireline Gamma-ray Patterns



INTERPRETATION: Marine flooding initiates deposition of overlying Wade interval

Highly Bioturbated Zone

Flooding of Medrano Sandstone

Following storm-generated (?) chert-rich conglomerate, Medrano sand was flooded by shallow marine water w/ abundant burrowing organisms. With increasing rise in sea level, shallow water deposit was overlain by dark-colored deeper marine mud.

Flooding Surface

CONCLUSIONS

1. The Medrano Sandstone represents deposition as part of a northerly prograding sediment dispersal system that was followed by a weakly defined distributary channel network likely associated with a tide-dominated delta.

2. The Medrano Sandstone interval was inundated by a transgression associated with initial deposition of the overlying Wade Sandstone interval.

3. Thin section petrography supports marine-influenced deposition, whereas sedimentary structures and biotic features indicate tidal influence in a well-oxygenated environment.

4. Porosity is mostly secondary and resulted from dissolution of feldspar and SRF.

5. The Medrano Sandstone is rich in authigenic clay that contributes to porosity, but reduces permeability critical to economic production of oil and gas.

6. Preliminary results indicate better production is associated with the distributary system, but this observation is based on limited data and is part of future work.

7. The lack of Wichita Mtn. plutonic rock fragments and abundant chert support hypothesis that the Ouachita Mountains were a significant source for Medrano sediments.

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