Lithostratigraphy of the Woodford Shale, Anadarko Basin, West-Central Oklahoma*

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Search and Discovery Article #50518 (2011)
Posted November 30, 2011

*Adapted from oral presentation at AAPG Mid-Continent Section meeting, Oklahoma City, Oklahoma, October 1-4, 2011

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Abstract

Since early 2008 over three-hundred horizontal Woodford Shale wells have been completed in the Anadarko basin, west-central Oklahoma, along a northwest-southeast trend approximately 100 miles (161 km) in length and 20 miles (32 km) wide. Shallowest production to date occurs at 10,500 ft (3,200 m), and deepest production occurs at 16,100 ft (4,900 m).

Seven mudrock lithofacies, defined mainly on the basis of percent TOC and variations in mineral content (primarily quartz, clay, and dolomite), make-up the fifteen stratigraphic units that comprise the Lower, Middle, and Upper Woodford in the geographic center of the play where the Woodford is 175 to 330 ft (53 to 100 m) thick. The basal-most units of the Woodford in this area are TOC-poor clayey mudrock (<2% TOC), recording the first transgression of the Woodford seas. The overlying Lower Woodford and the Middle Woodford are composed of 10 to 30 ft (3 to 9 m) intervals dominated by one of three lithologies: clayey mudrock (CM) (38% clay and 41% quartz), clayey siliceous mudrock (CSM) (27% clay and 55% quartz), and less common dolomitic clayey mudrock (DCM) (33% clay, 32% quartz, and 15% dolomite). These mudrock lithologies are organic-rich with TOC values averaging 5 to 6.5%. Clay is predominantly illite, and dolomite is commonly ferroan. Quartz is biogenic and detrital. The Upper Woodford in this area is predominately CSM and siliceous mudrock (SM) (14.5% clay and 75% quartz). CSM and SM units are characterized by density-neutron cross-over and are readily distinguishable on wireline logs. The more silica-rich mudrocks (CSM and SM) are likely dominated by biogenic silica, recording distal deposition in areas less affected by detrital influx.

References

Johnson, K.S., R.A. Northcutt, and G.C. Hinshaw, 2000, Petroleum production from marine clastics in Oklahoma, *in* K.S. Johnson, ed., Marine clastics in southern Midcontinent, 1997 symposium: Oklahoma Geological Survey Circular 103, p. 1-17.

Sondergeld, C.H., R.J. Ambrose, C.S. Rai, and J. Moncrieff, 2010, Micro-Structural Studies of Gas Shales: SPE Paper 131771, SPE Unconventional Gas Conference, Pittsburg, Pennsylvania, 17 p. Web accessed 10 November 2011, http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-131771-MS&soc=SPE

LITHOSTRATIGRAPHY OF THE WOODFORD SHALE, ANADARKO BASIN, WEST-CENTRAL OKLAHOMA

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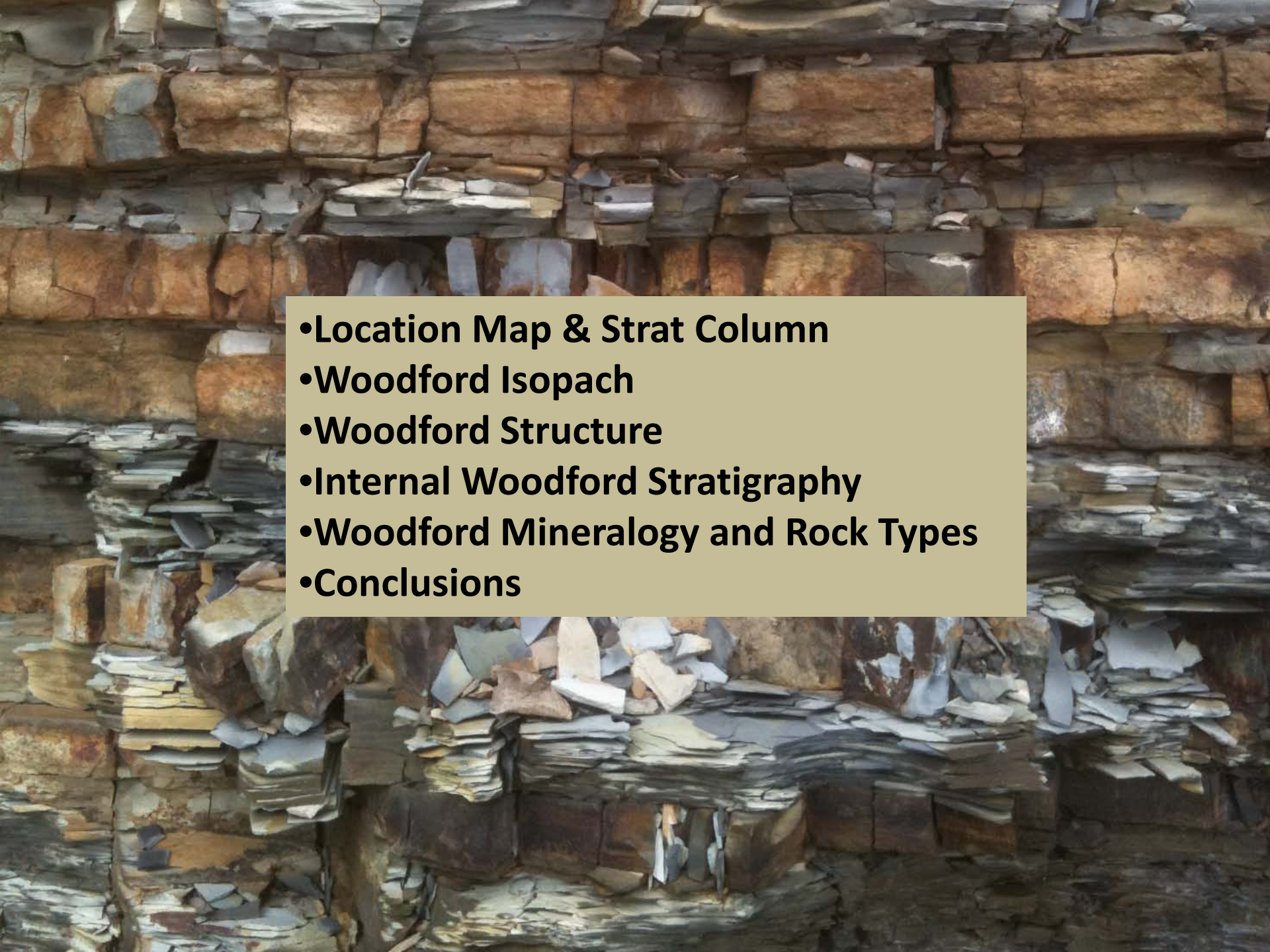
ACKNOWLEDGEMENTS

Cimarex Energy Co.

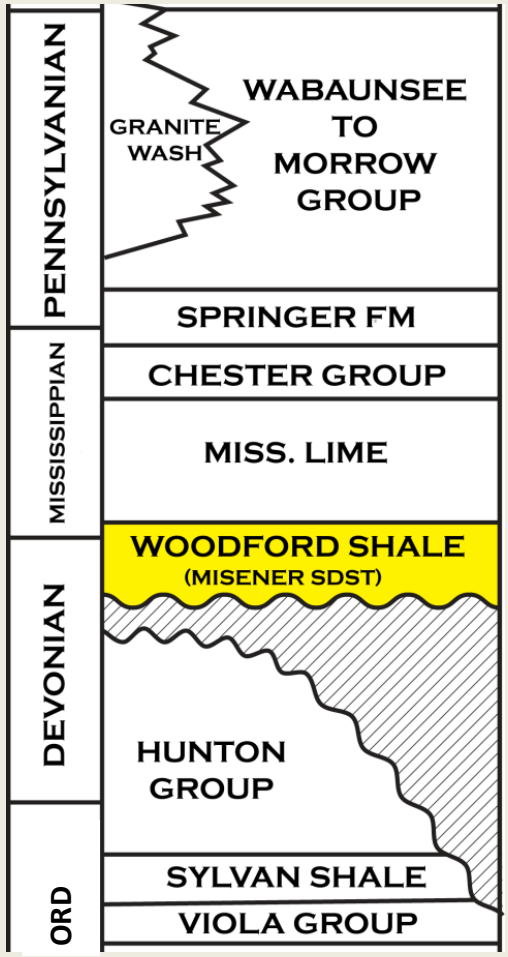
Devon Energy Corp.

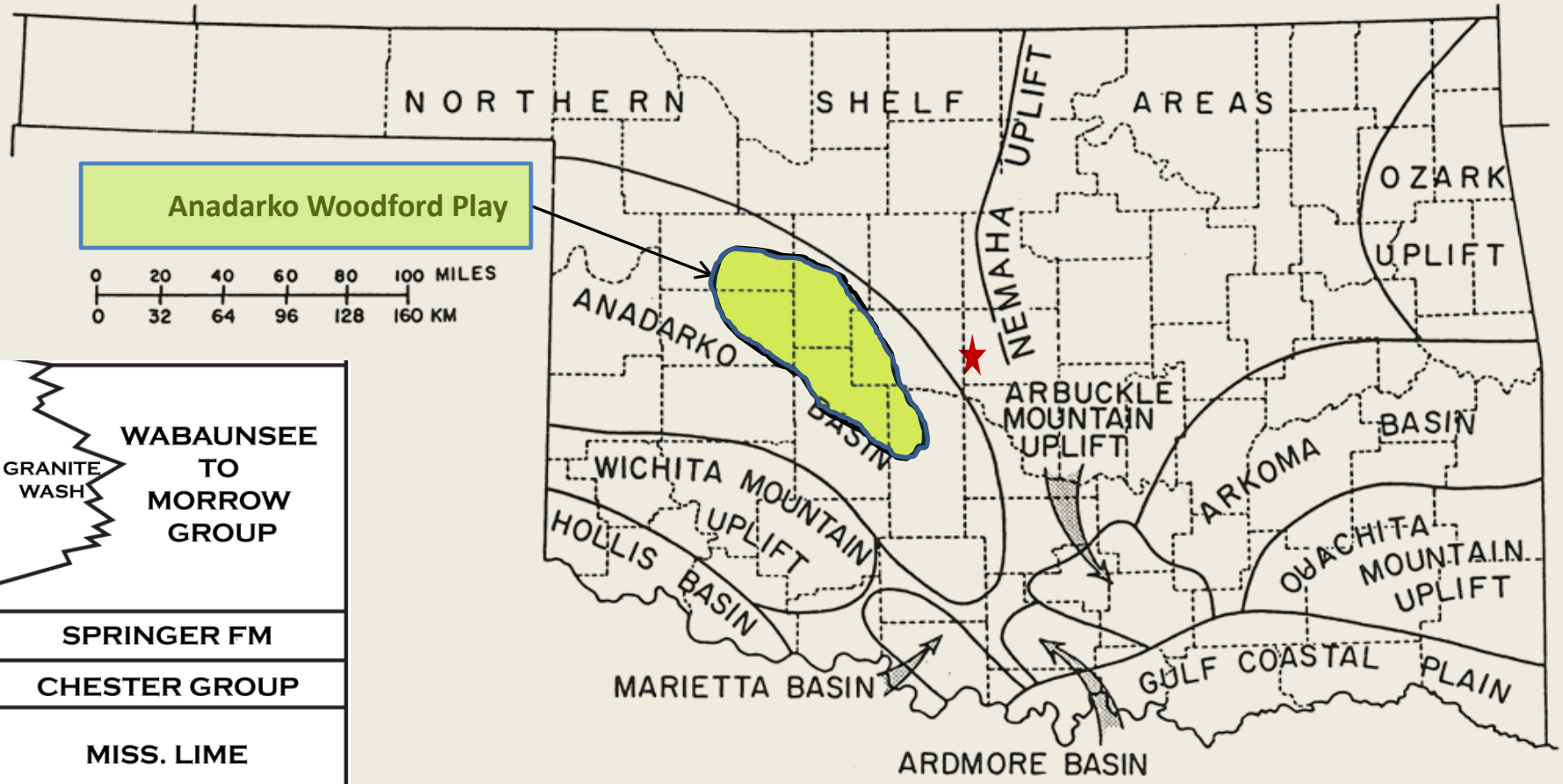
Weatherford (TOC)

Terra Tek Inc. (XRD & Photomicrographs)



- Location Map & Strat Column
- Woodford Isopach
- Woodford Structure
- Internal Woodford Stratigraphy
- Woodford Mineralogy and Rock Types
- Conclusions



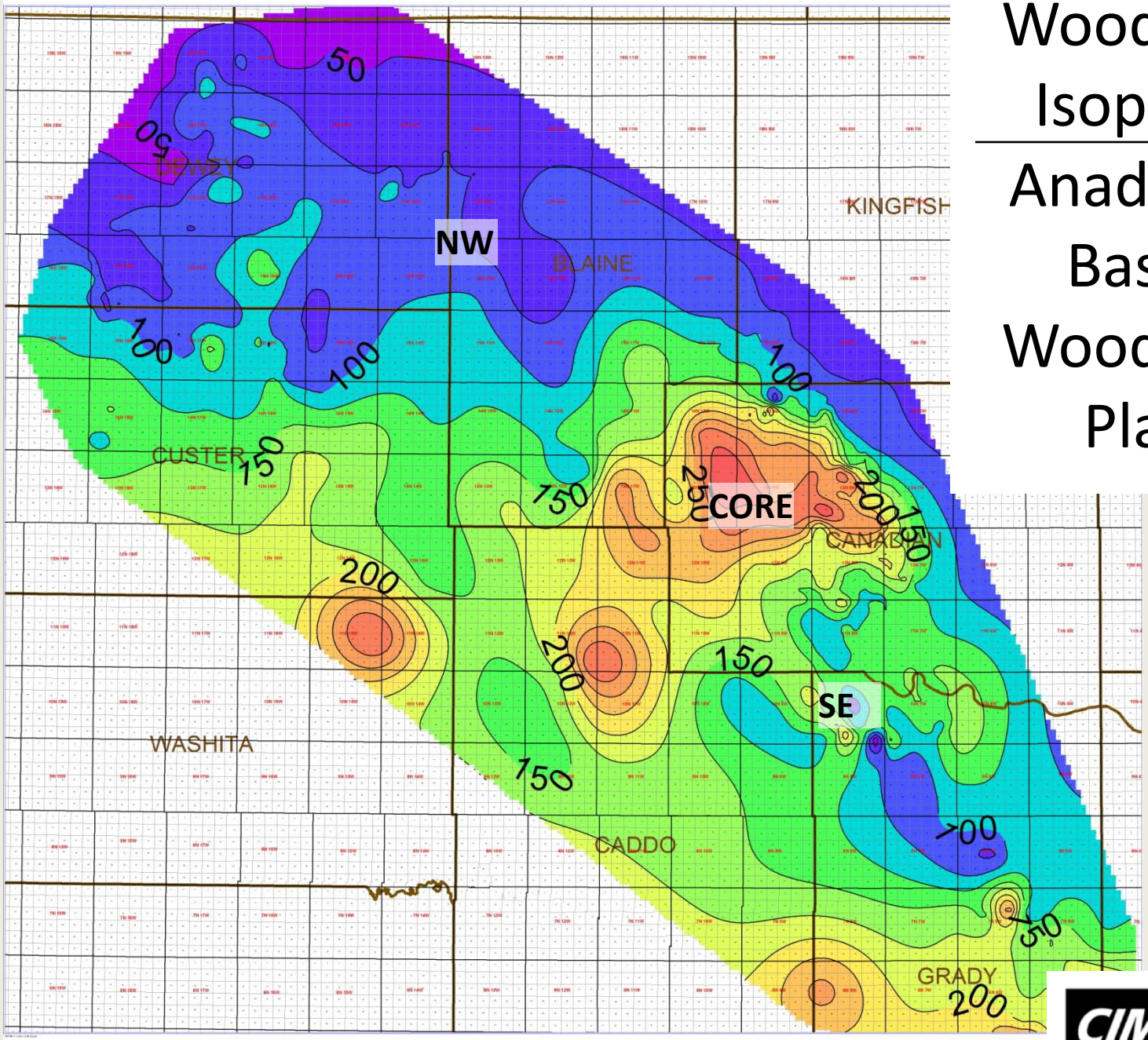


STRAT COLUMN AND MAJOR GEOLOGIC PROVINCES OF OKLAHOMA

*After Johnson et al (2000)

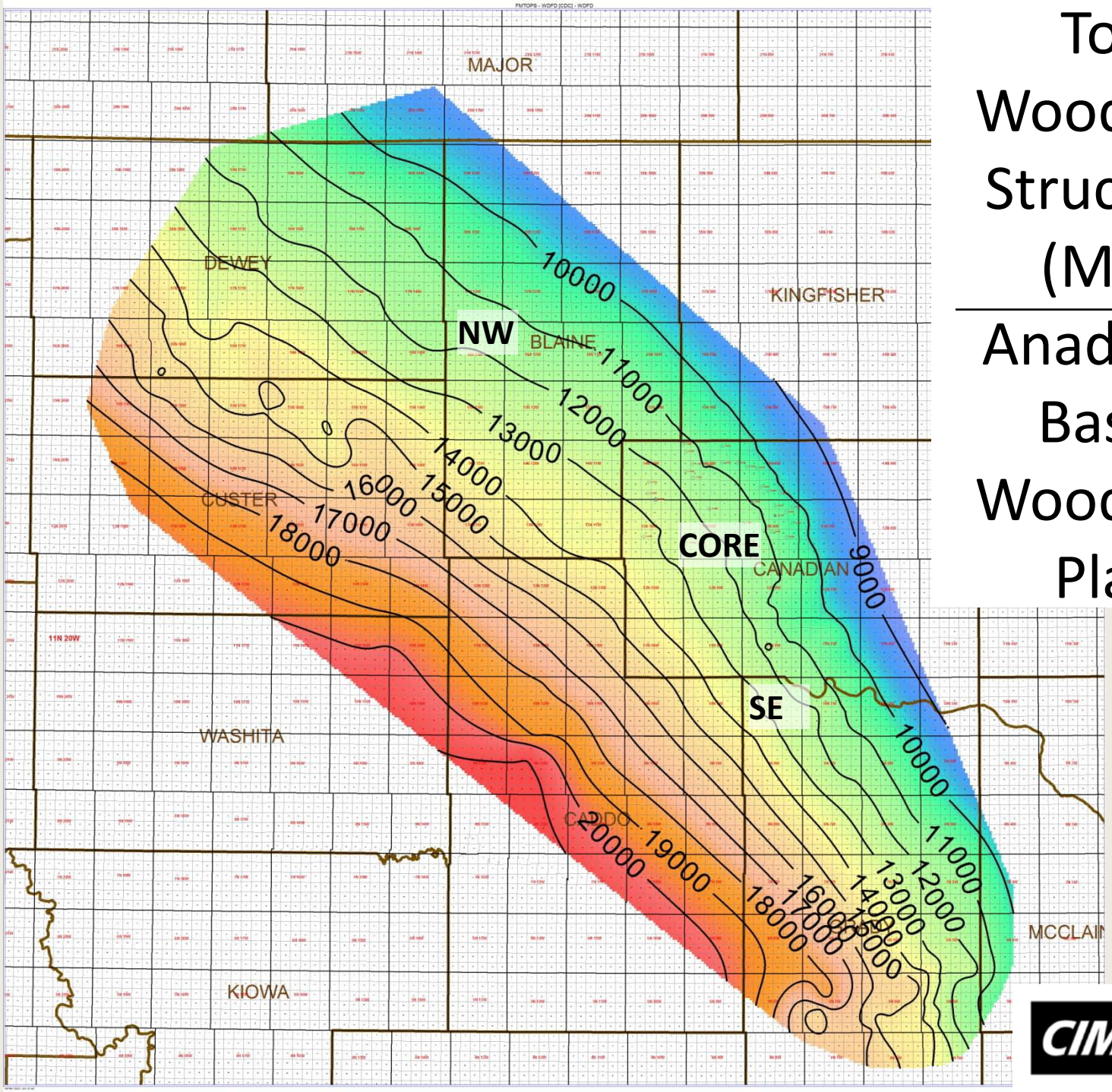
Woodford Isopach

Anadarko Basin Woodford Play



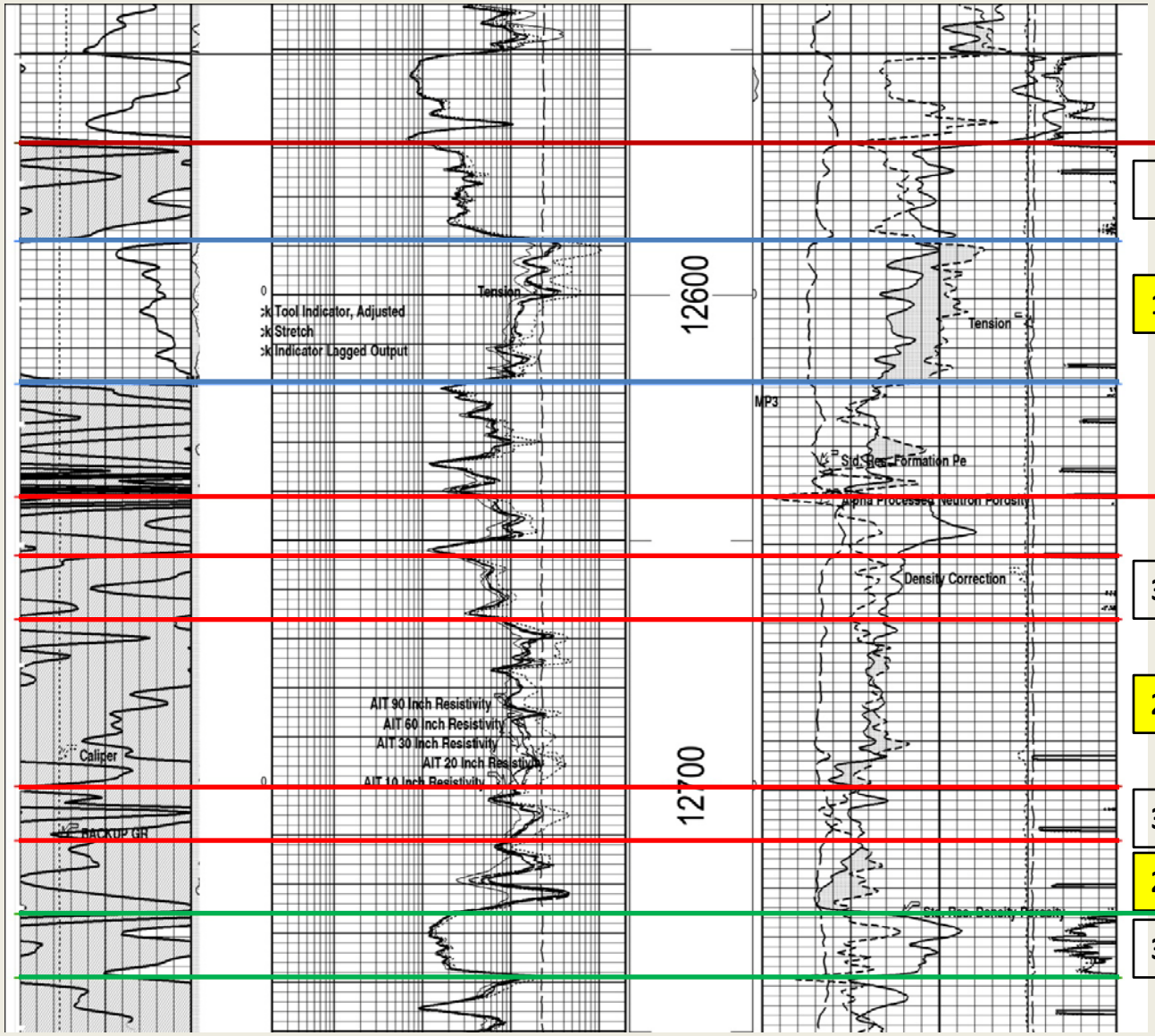
Top Woodford Structure (MD)

Anadarko Basin Woodford Play

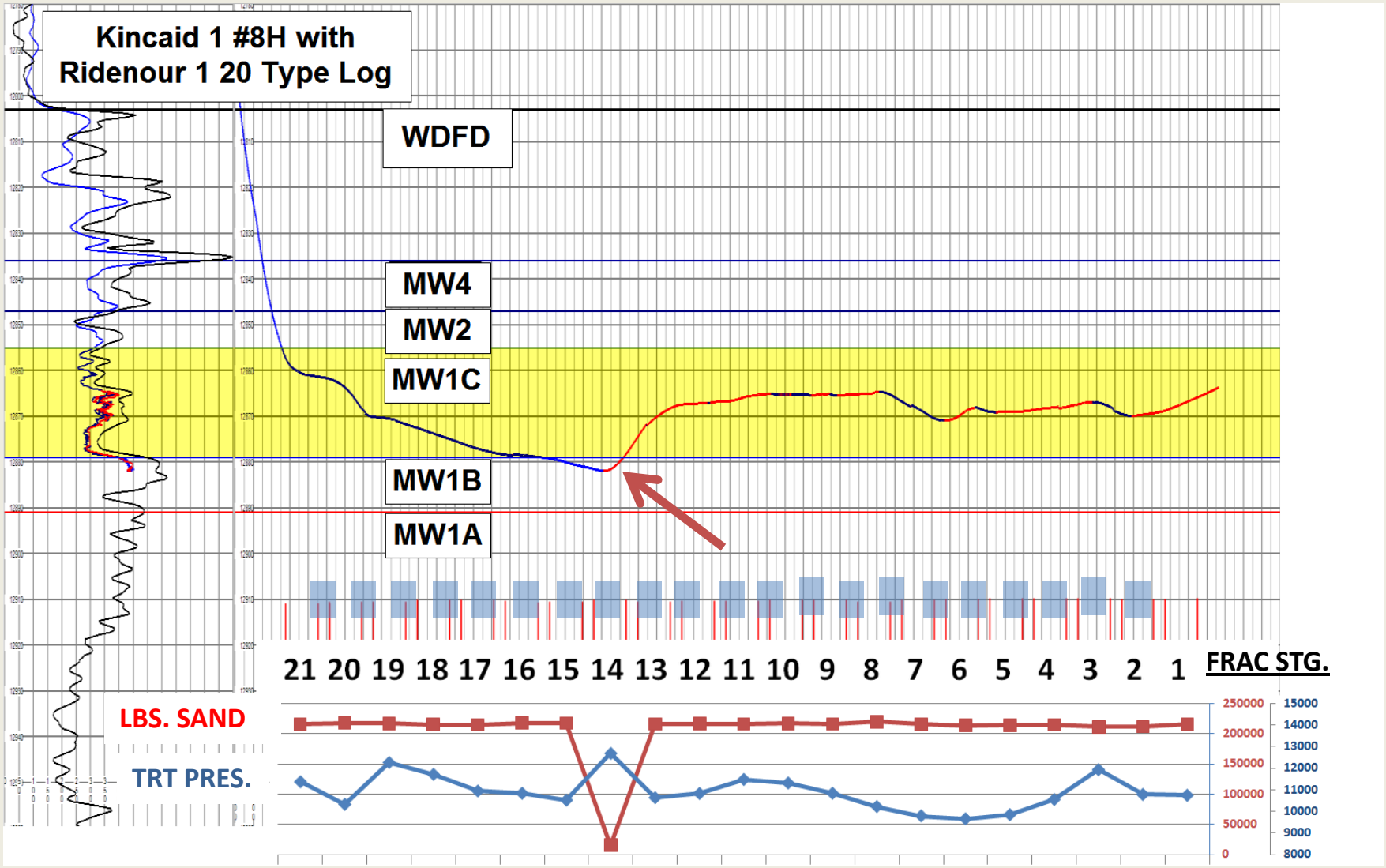


CIMAREX

Type Log from Core Area Showing Lithostratigraphy and % Clay for Middle & Upper Woodford



Well Path Showing Woodford Lithostratigraphy and Lateral Placement



Woodford Lithofacies
Anadarko Basin Woodford Play

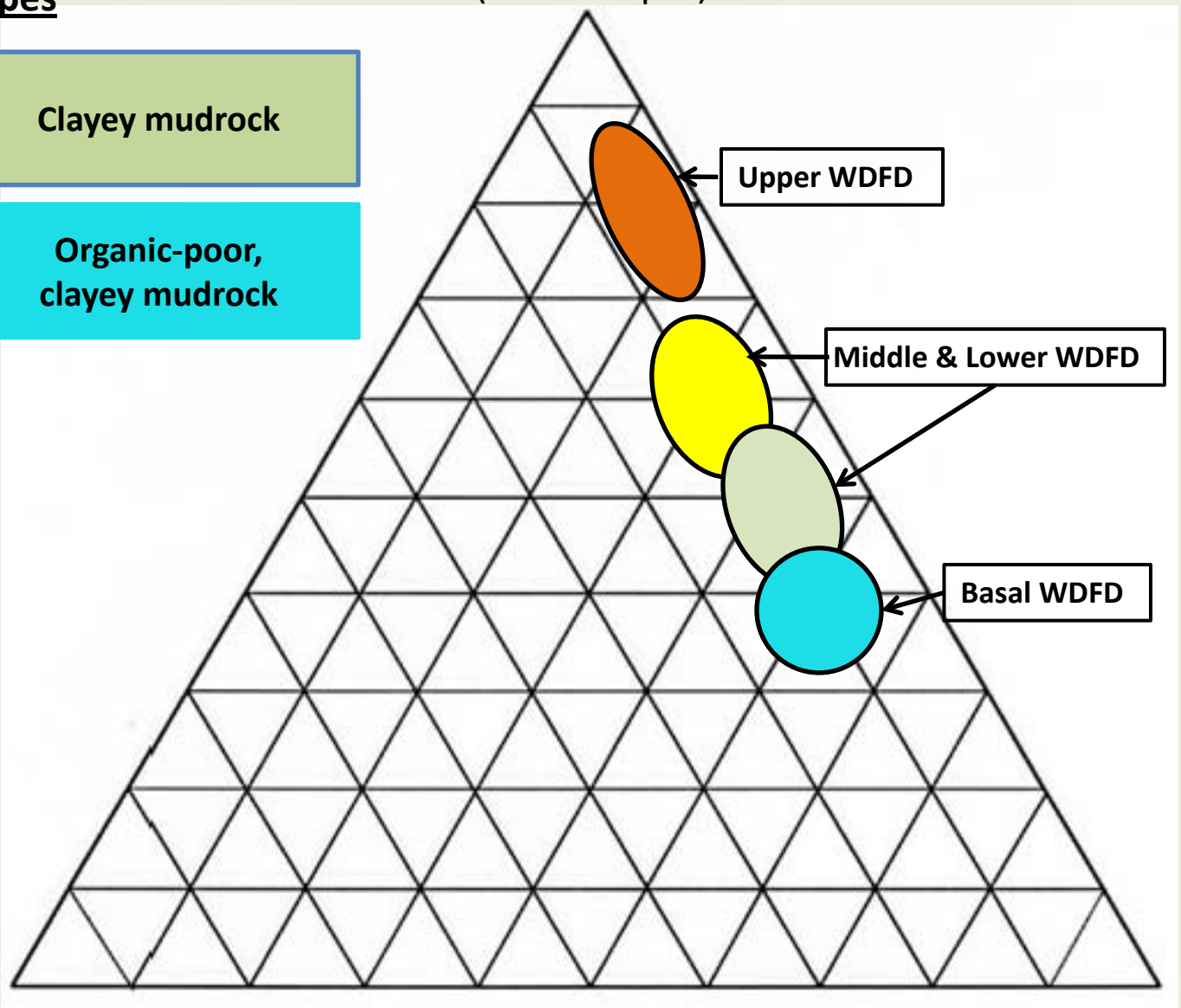
LITHOFACIES	% QUARTZ	% CLAY	% TOC	% GAS-FILLED POROSITY	PRv	Brittleness Index*
Siliceous mudrock	75.2	14.5	4.86	5.4	0.155	0.75
Clayey, siliceous mudrock	54.8	27.4	6.43	6.8	0.164	0.55
Clayey mudrock	40.6	38	5.97	5.6	0.192	0.41
Organic-poor, clayey mudrock	27.3	52.4	0.6	1.8	0.25	0.27

*B.I.=Quartz/Qtz+Carbonates+Clay

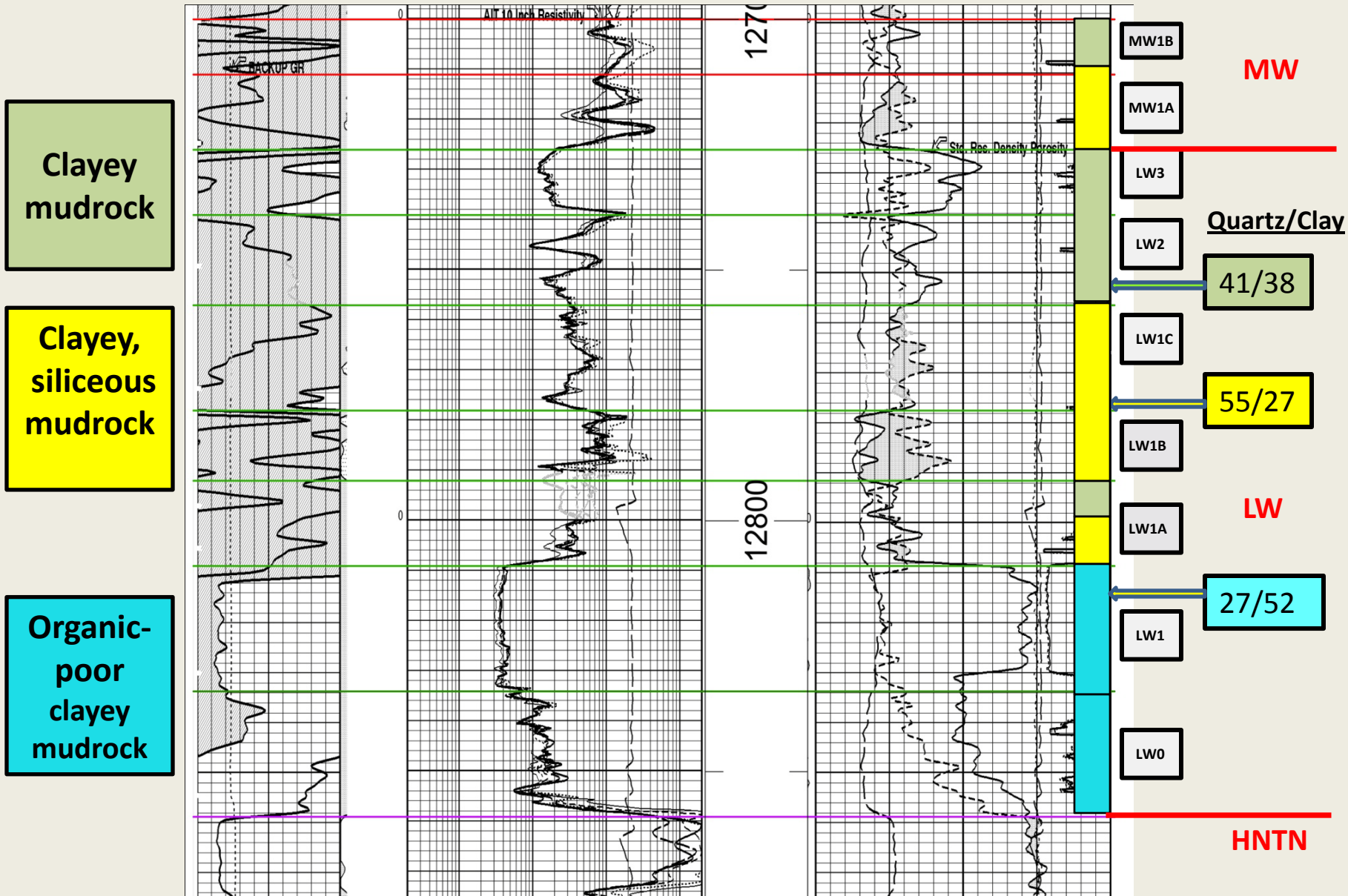
(Sondergeld et. al., 2010)

Anadarko Woodford Mineralogy (XRD) and Rock Types

Siliceous mudrock	**Clayey mudrock**
Clayey, siliceous mudrock	**Organic-poor, clayey mudrock**



Lower & Middle Woodford Lithostratigraphy, Anadarko Woodford Play – Core Area

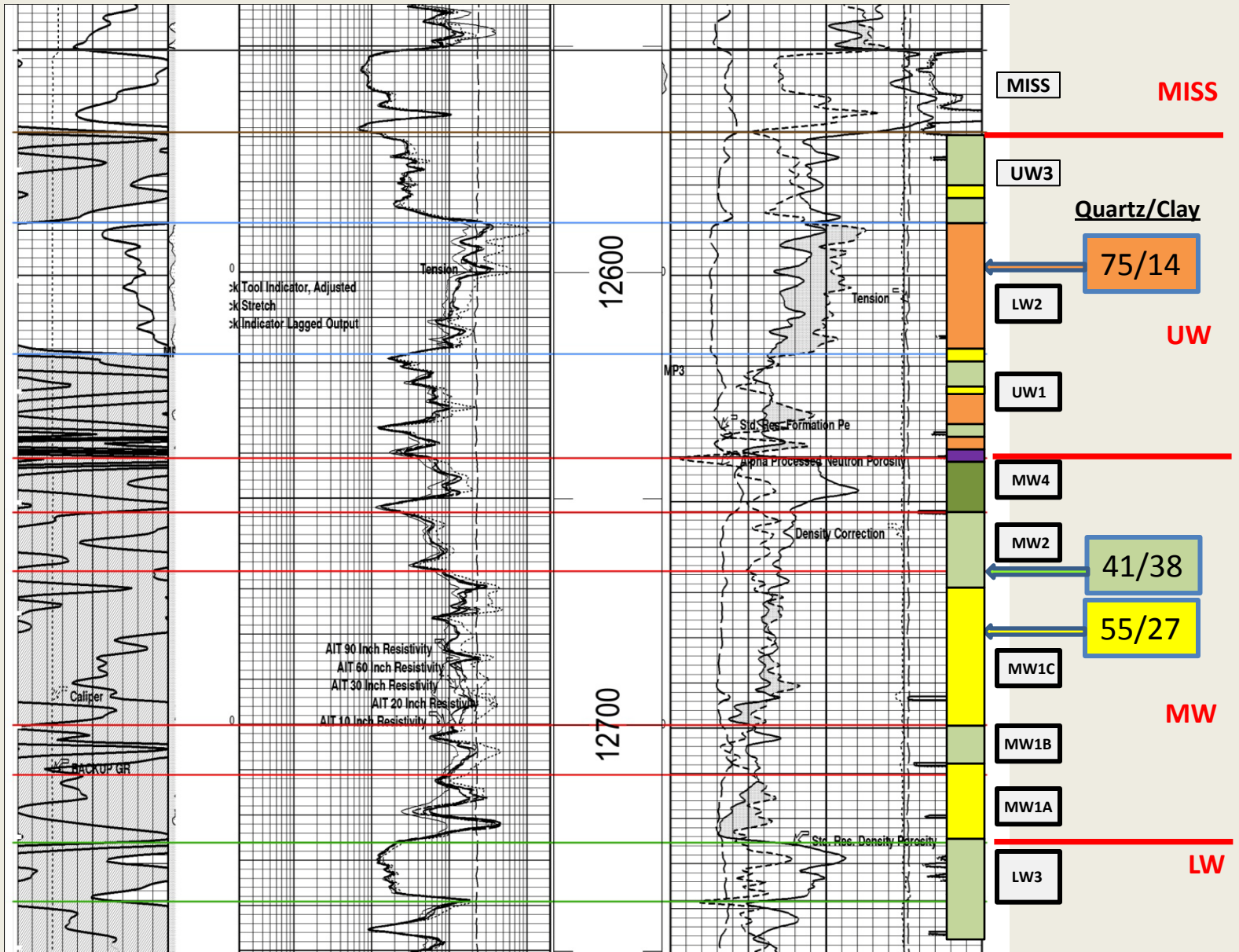


Middle and Upper Woodford Lithostratigraphy, Anadarko Woodford Play – Core Area

Siliceous mudrock

Clayey mudrock

Clayey, siliceous mudrock



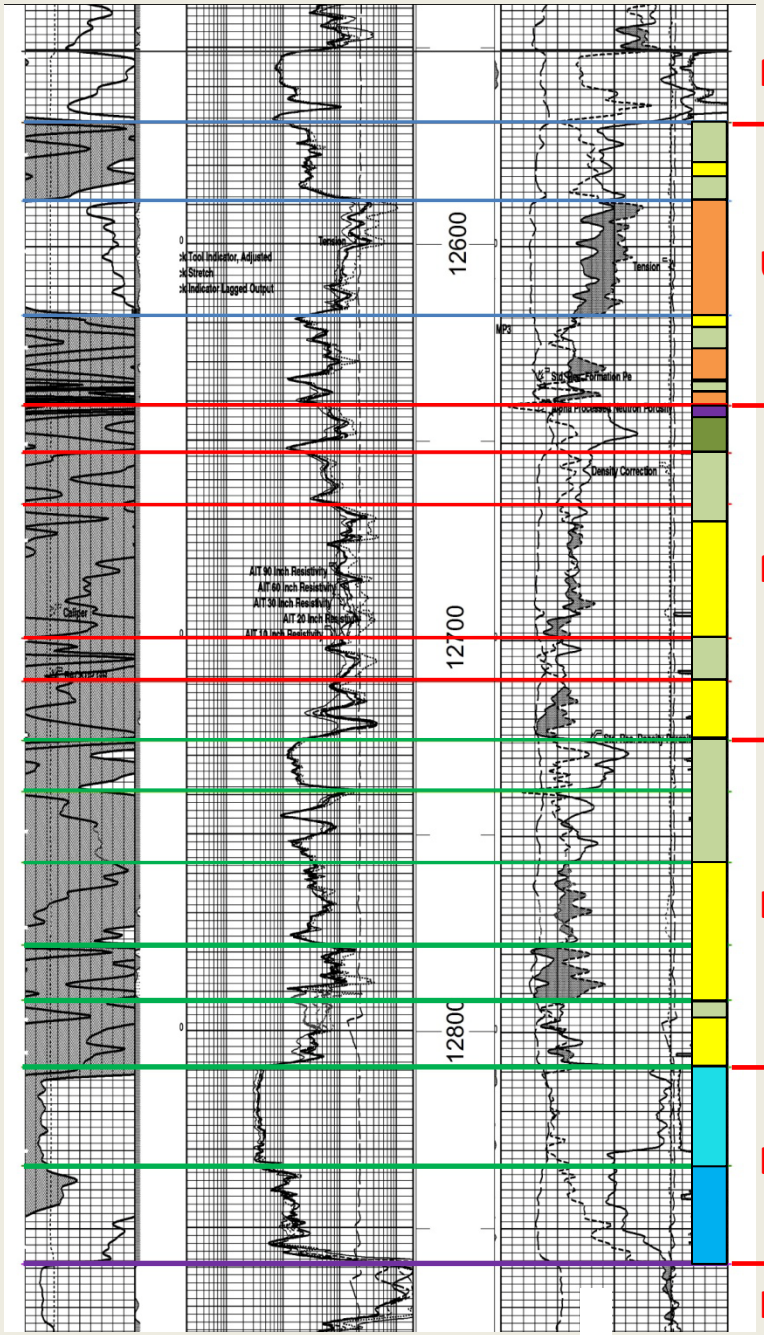
Woodford Lithostratigraphy Anadarko Basin Woodford Play Core Area

Siliceous mudrock

Clayey, siliceous mudrock

Clayey mudrock

Organic-poor clayey mudrock



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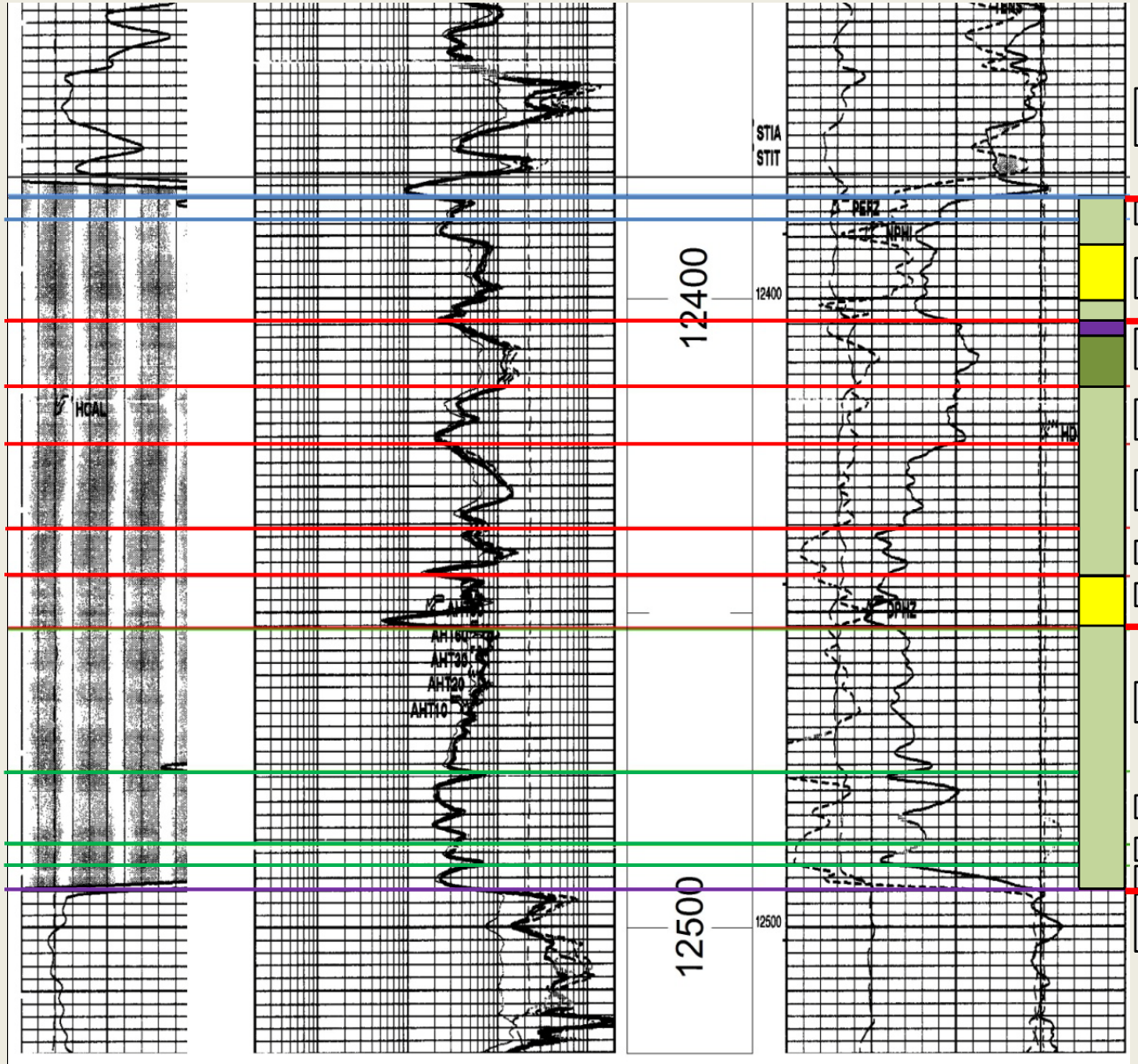
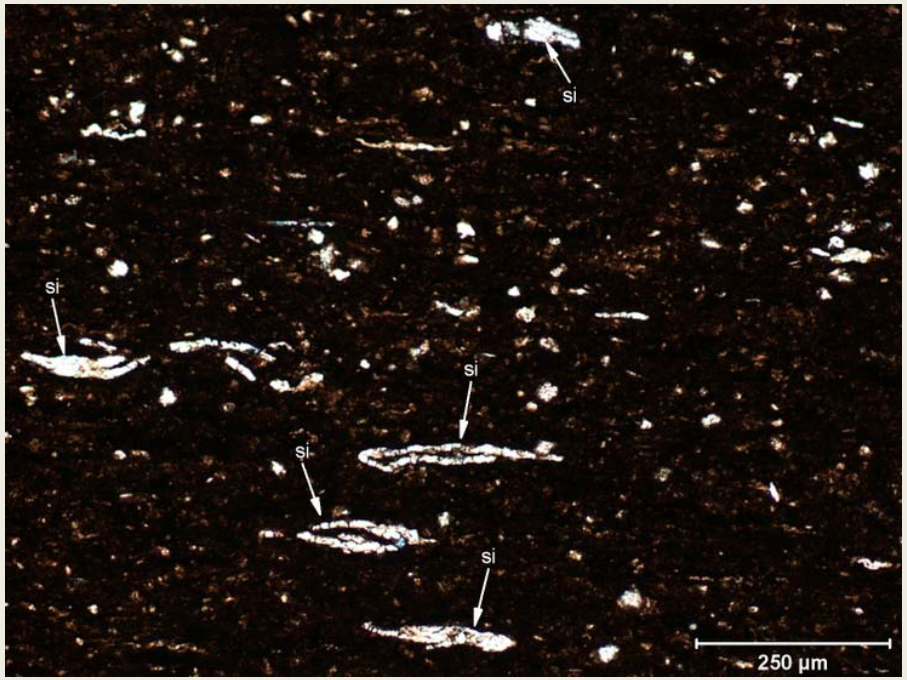
Woodford Lithostratigraphy Anadarko Basin
Woodford Play - SE Area

Clayey mudrock

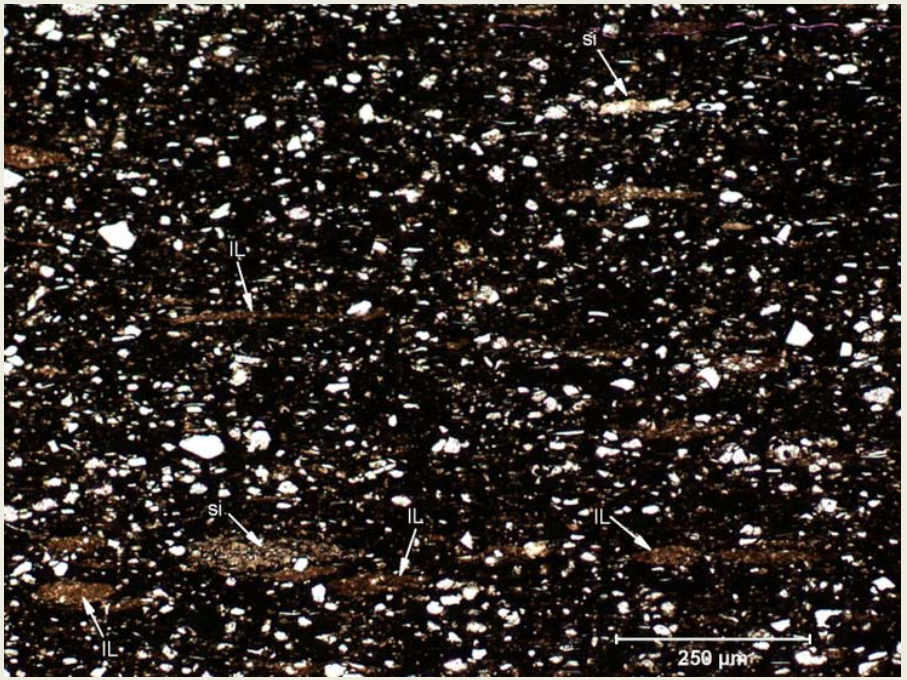
Clayey, siliceous mudrock



Thin Section Photomicrographs of Woodford Rock Types



UW1 sample showing silicified Tasmanites; sample is 64% quartz and 21% clay. Siliceous mudrock lithofacies.



MW1B sample showing detrital silt; sample is 34% quartz and 38% clay. Clayey mudrock lithofacies.

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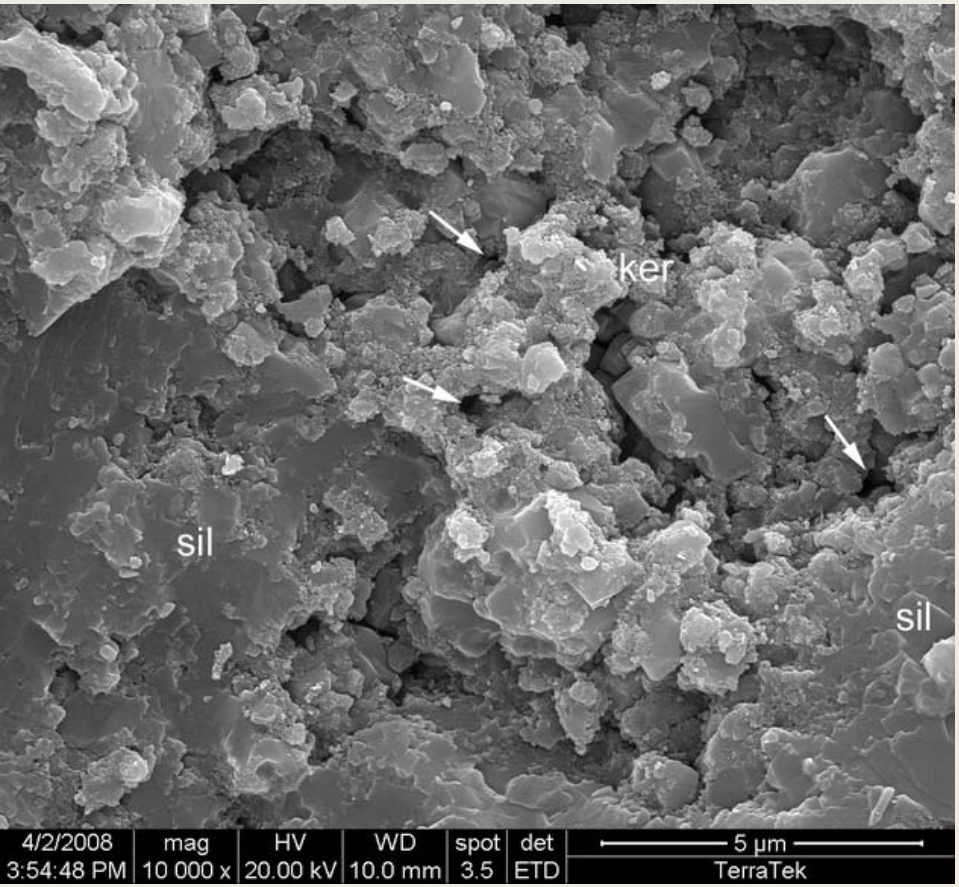
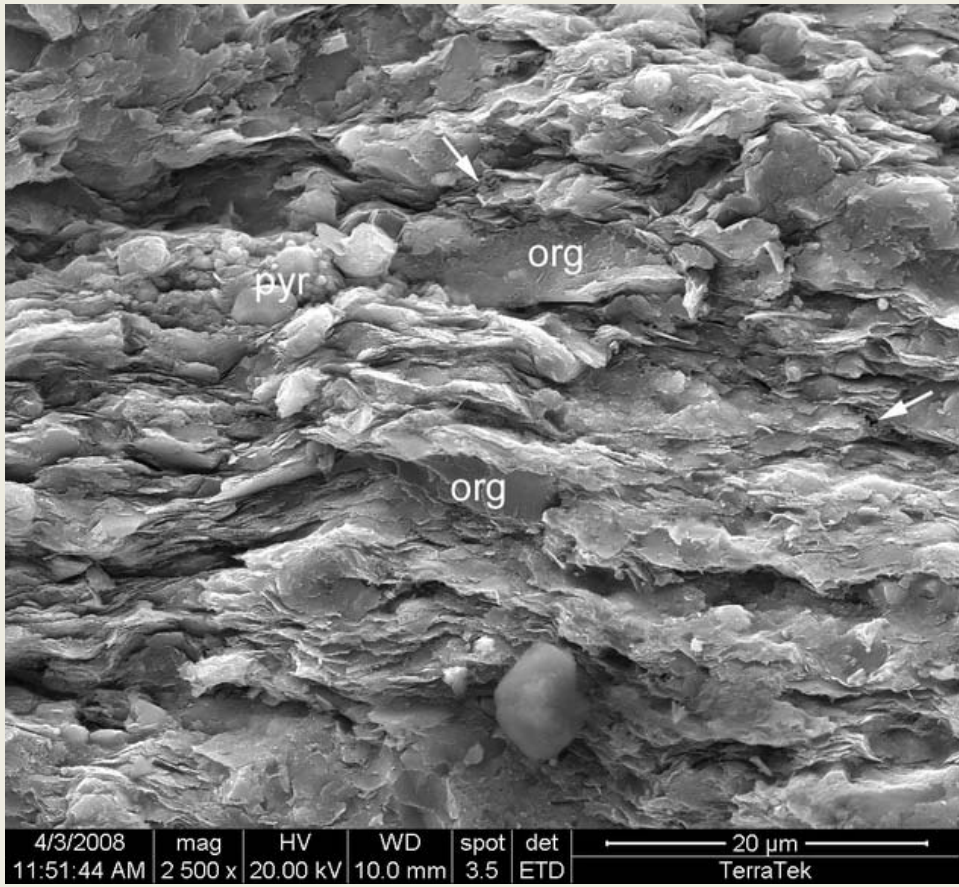
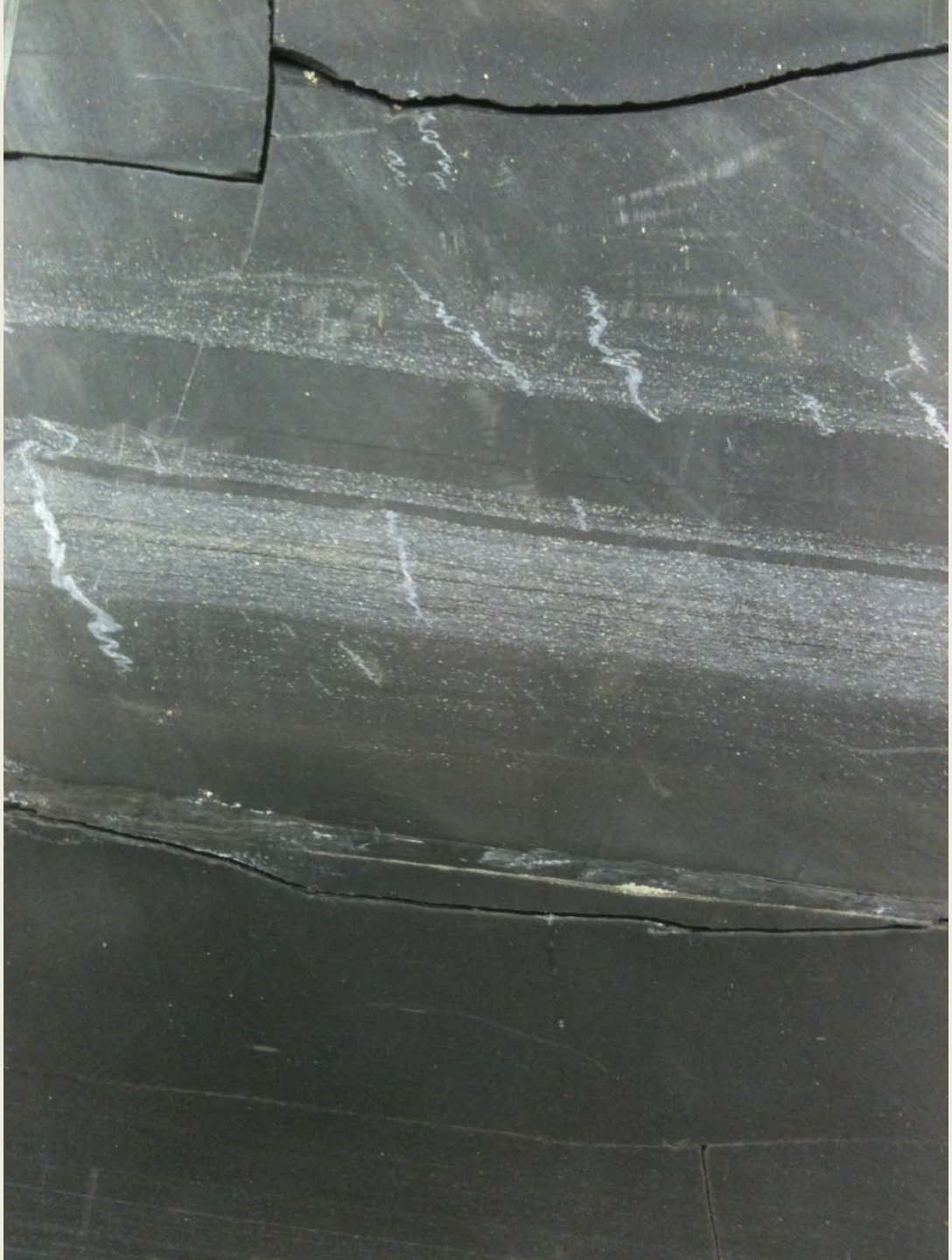
SEM Photomicrographs of Woodford Microfabrics



UW2 sample showing microcrystalline silica with intercrystalline porosity; sample is 76% quartz and 18% clay. Siliceous mudrock lithofacies.



MW4 sample showing parallel alignment of illite clay; sample is 26% quartz and 44% clay. Clayey mudrock lithofacies.

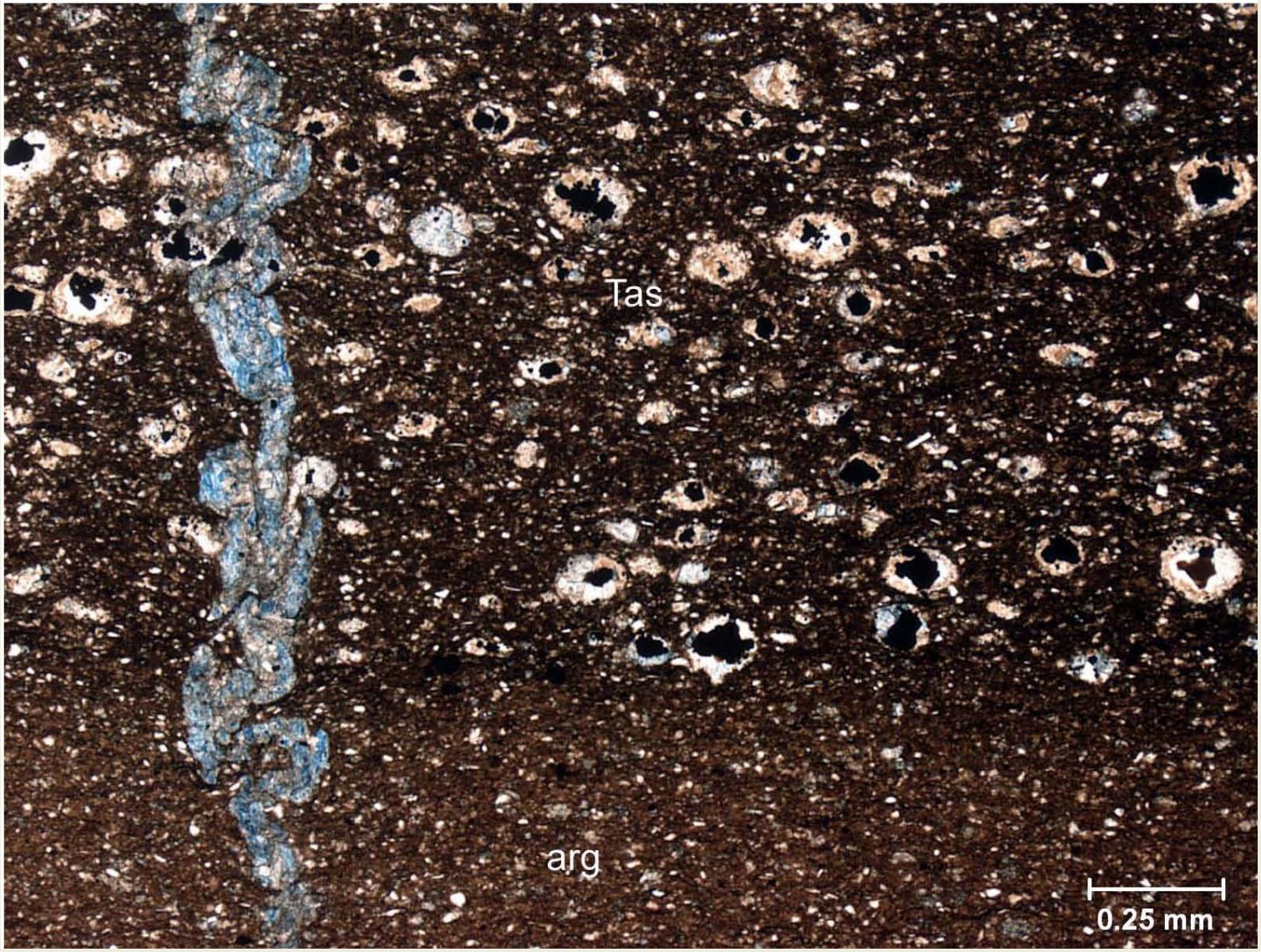


Bed-limited dolomite-cemented fractures in thin silicic layers

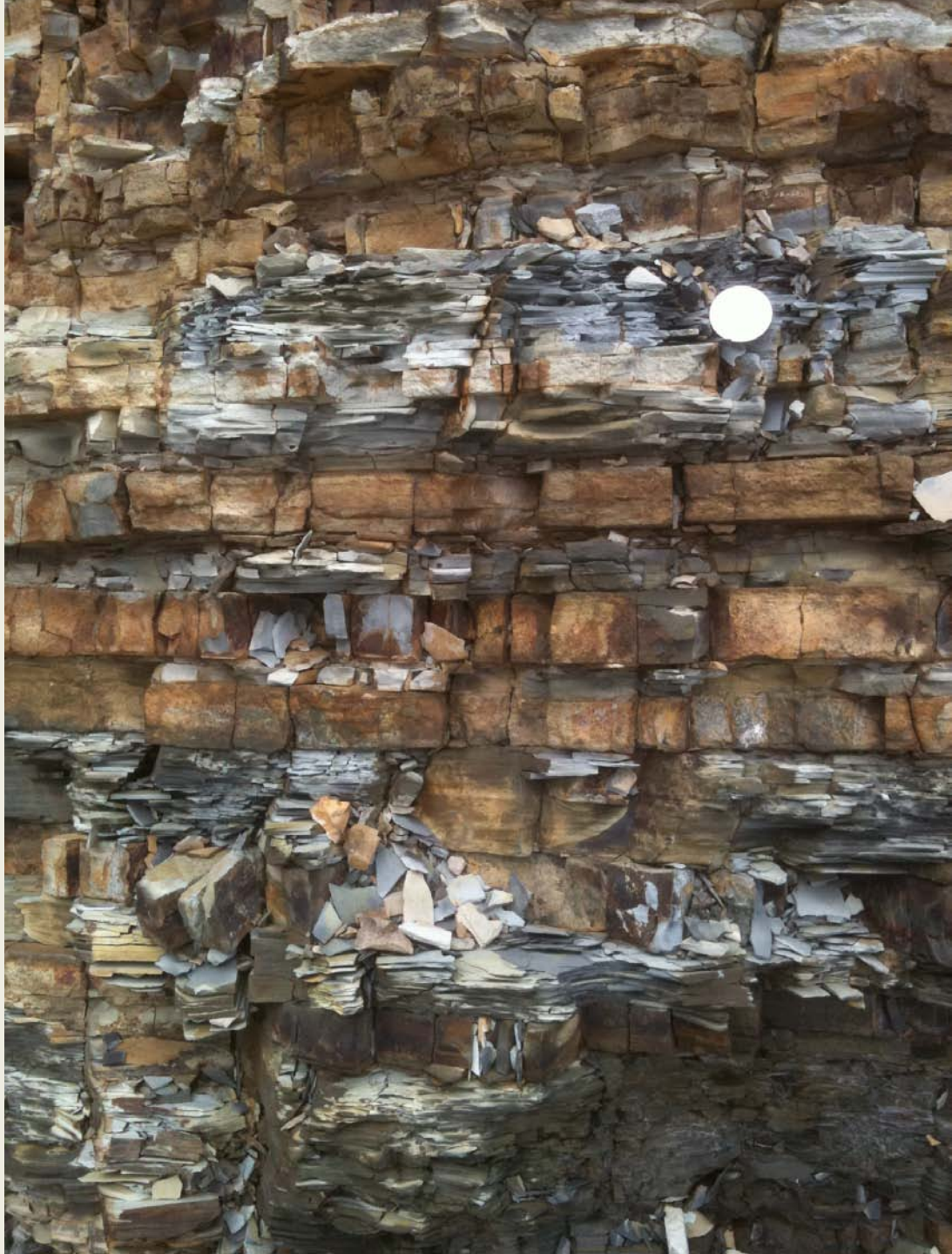
Siliceous mudrock lithofacies

CIMAREX

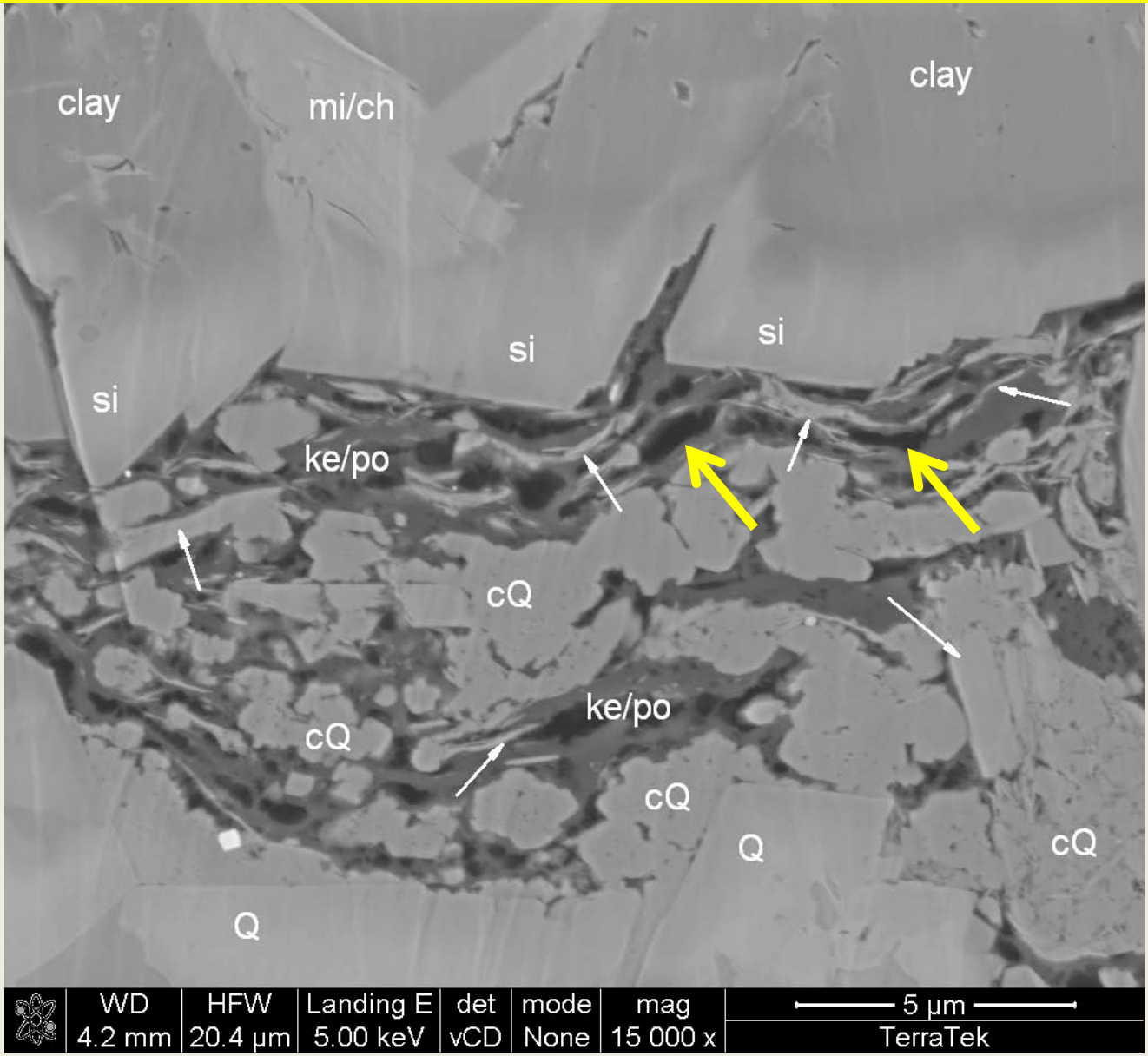
Silicic laminae with dolomite-cemented fracture
Siliceous mudrock lithofacies



Upper Woodford
Arbuckle Mountains

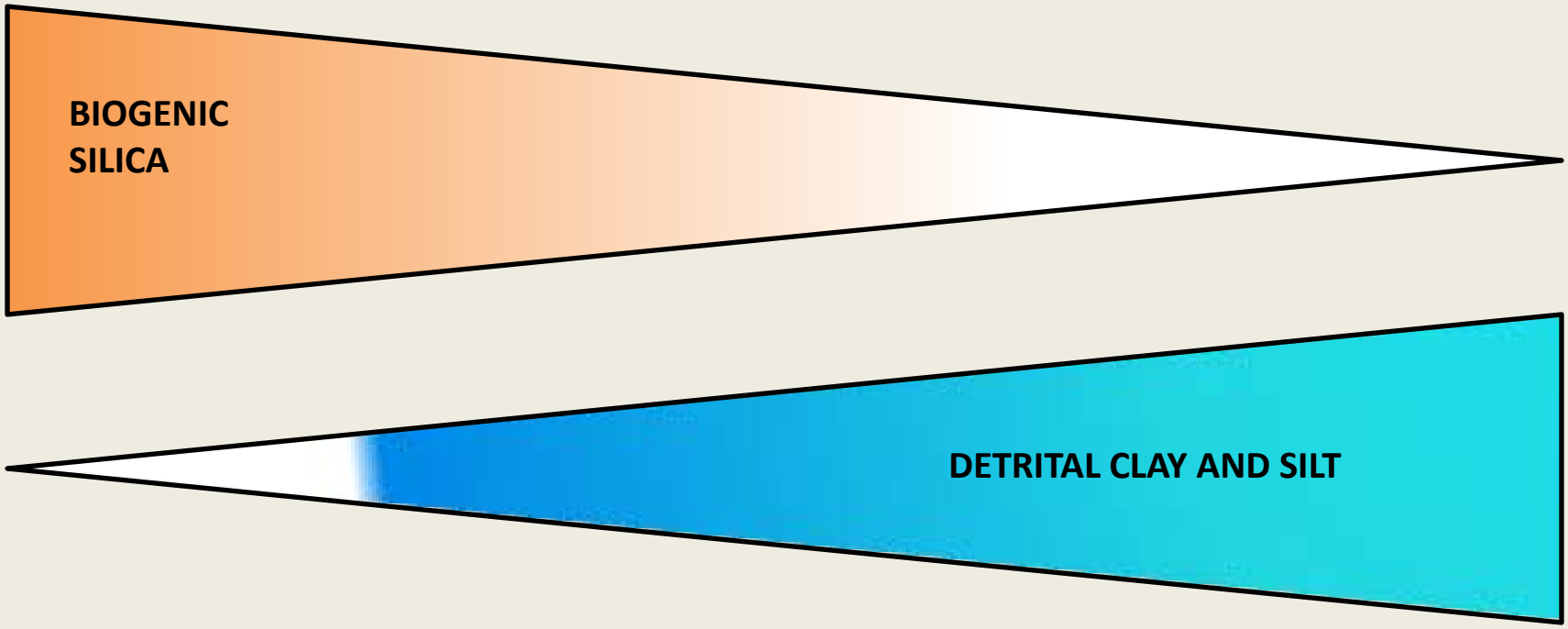


Porosity in organic laminae
Clayey siliceous mudrock



Bioturbated bed
Clayey mudrock lithofacies

Woodford Lithofacies

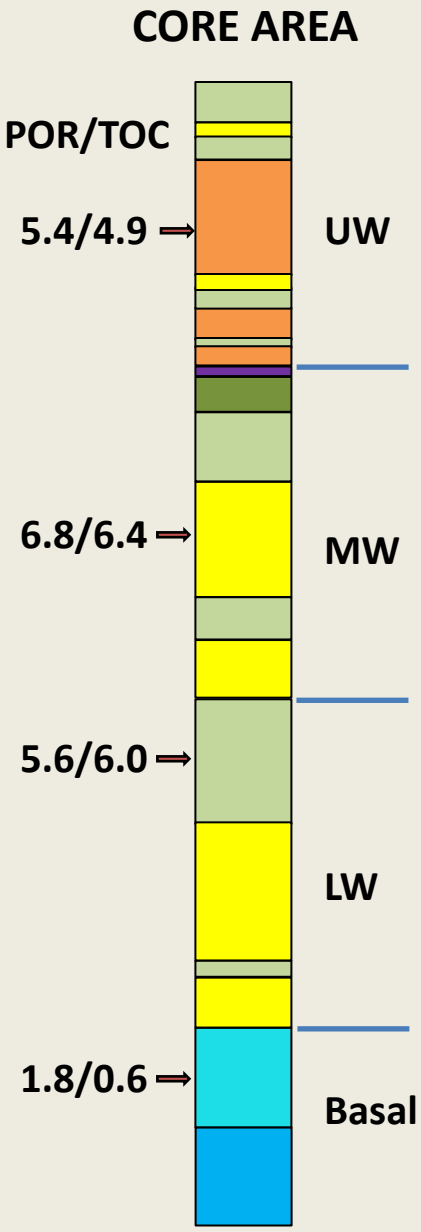


Distal (?)

Proximal (?)

“GOOD” MECHANICAL PROPERTIES

“POOR” MECHANICAL PROPERTIES



CONCLUSIONS:

- A lithostratigraphy/mechanical stratigraphy was developed for the Anadarko Woodford
- Seven mudrock lithofacies were defined in the Core Area on the basis of mineral content and percent TOC.
- The Woodford thins and siliceous rock types are less common to the SE and NW of the Core Area.
- Excluding the basal Woodford, the percent TOC (4.9-6.4%) and gas-filled porosity (5.4-6.8%) display relatively minor variations with Woodford rock types.
- Mechanical properties (including “fracability”) and the occurrence of natural fractures are lithofacies dependent.