Fine-Scale Spatial Distribution of Organofacies in the Mowry Shale, Wind River Basin, Lander, WY*

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Abstract

The Cretaceous Mowry Shale is an organic rich, siliceous marine shale, and as such is a major source rock in the Western United States. Because the amount of organic material in a rock is linked to its oil and gas generative capability, several studies have outlined the lateral variability of total organic carbon (TOC) on a basin scale, covering large areas with limited sample sets. Little is known about fine-scale lateral variations of TOC on a scale of several miles, however. Over 300 samples from the same 10-cm stratigraphic interval of the Mowry Shale have been collected at regular 10 meter intervals over three outcrops near Lander, Wyoming. Pyrolysis analysis and clay mineralogical characterization of samples shows meaningful fine-scale variations and spatial trends. Average TOC of all samples is 1.65% with a standard deviation of 0.229 and a range of 1.57%, and samples are characterized as either Type III or mixed Type II/III source facies. Based on a 3D spatial model built in Petrel, TOC decreases basinward (southeast) in the study area despite a documented larger regional increasing basinward trend. Additionally, kerogen types become slightly more gas prone in a basinward direction. This suggests important localized trends, often important on a production scale, in both the Mowry Shale and other fine-grained systems can be quite different than larger, generalized basinward trends.

References Cited

Blakey, R., 2014, Western Interior Seaway Paleogeographic Maps and Cross Sections.

Finn, T.M., 2007, Source Rock Potential of Upper Cretaceous Marine Shales in the Wind River Basin, Wyoming: USGS Digital Data, v. DDS-69-J.

Kirschbaum, M.A. and T.J. Mercier, 2013, Controls on the Deposition and Preservation of the Cretaceous Mowry Shale and Frontier Formation and Equivalents, Rocky Mountain Region, Colorado, Utah and Wyoming: American Association of Petroleum Geologists Bulletin, v. 97/6, p. 899-921.

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Outline

Problem, Significance

Geologic History

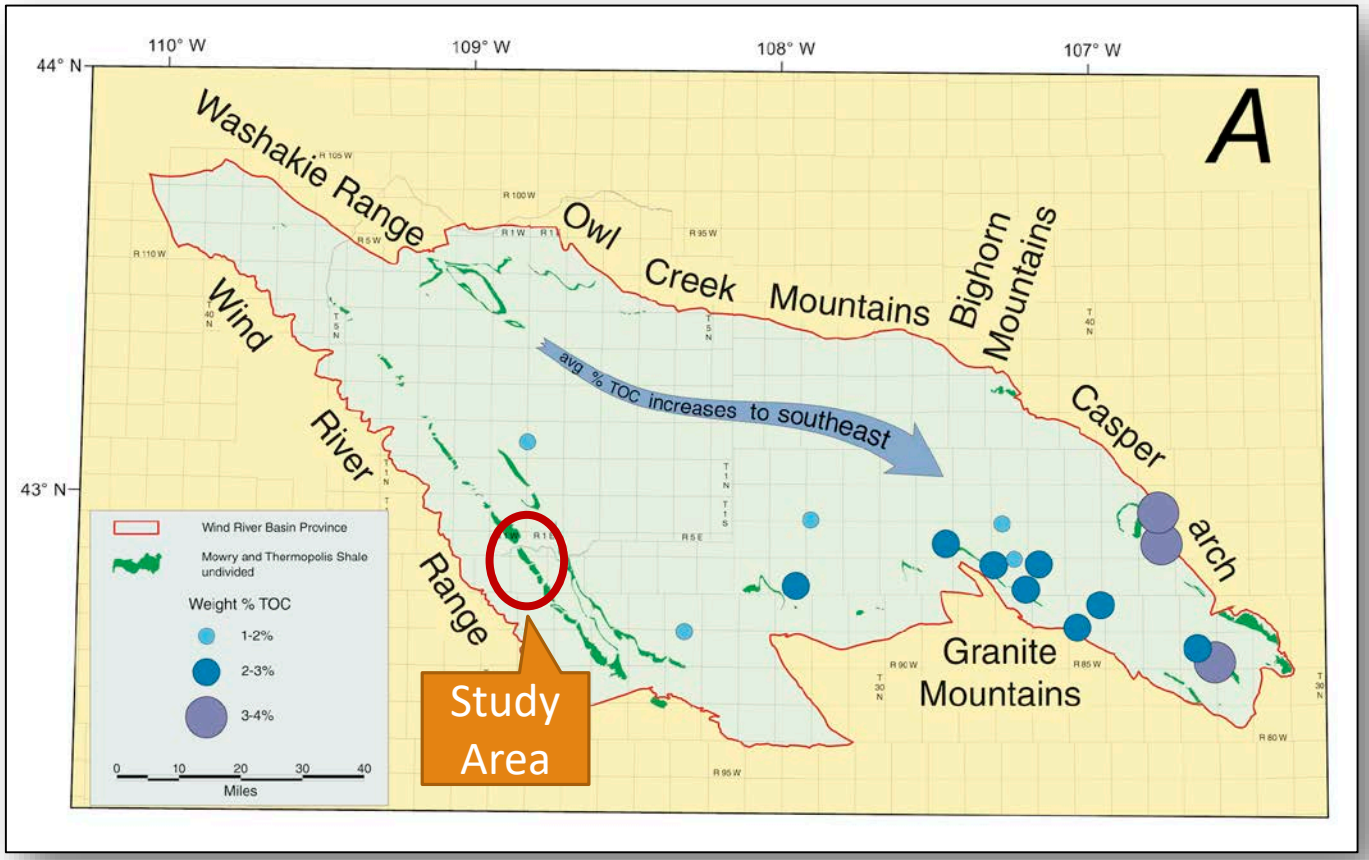
- Mowry Deposition
- Stratigraphy
- Facies

Methods

Results

Conclusions

Problem



From Finn, 2007

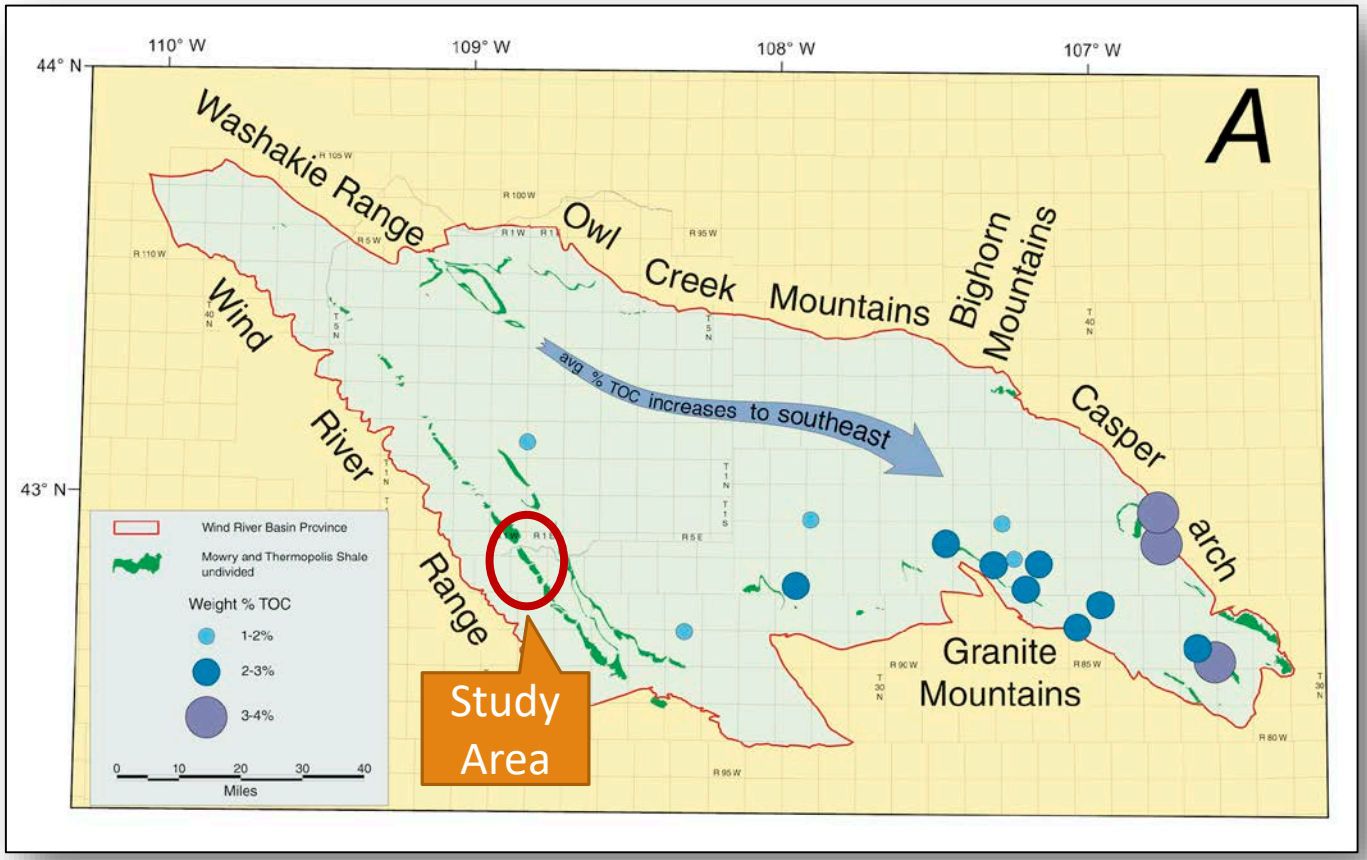
Focus on Regional variations in TOC

USGS Study

- 17 samples basin wide
- From cuttings
- TOC Increases to Southeast

Are there localized trends that differ from regional ones?

Significance



From Finn, 2007

Long-reach laterals = spatial heterogeneity matters!

In order to build a better paleogeographic understanding, detailed spatial information is key (process sedimentology, predictive power).

Geologic History

Mowry Deposition

From Blakey, 2014

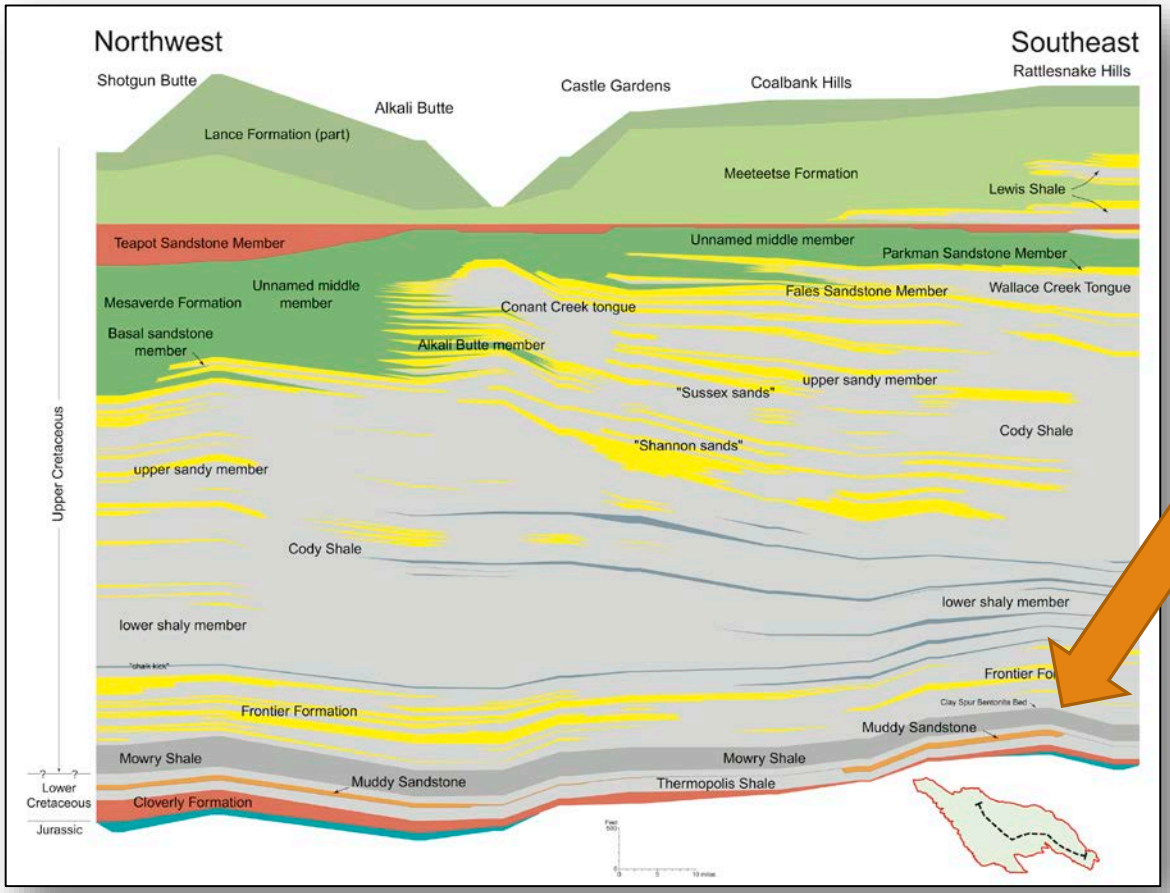
Cordilleran Orogeny and associated foreland basin

Mowry Sea: 100 Ma

- No connection to present day gulf
- Earliest phase of Western Cretaceous Interior Seaway

Mowry Shale in Montana, Wyoming, and Northern Utah and Colorado

Stratigraphy



From Finn, 2007

Jurrasic: Redbeds

Lower Cretaceous:

- Cloverly Formation
- Thermopolis Shale
- Muddy Sandstone

Mid-Upper Cretaceous

- Mowry Shale (250-475 ft thick)
  - Lower: Shell Creek Shale
  - Upper: Hard brittle siliceous shale
- Frontier Formation
- Cody Shale
- Mesaverde Formation

Methods

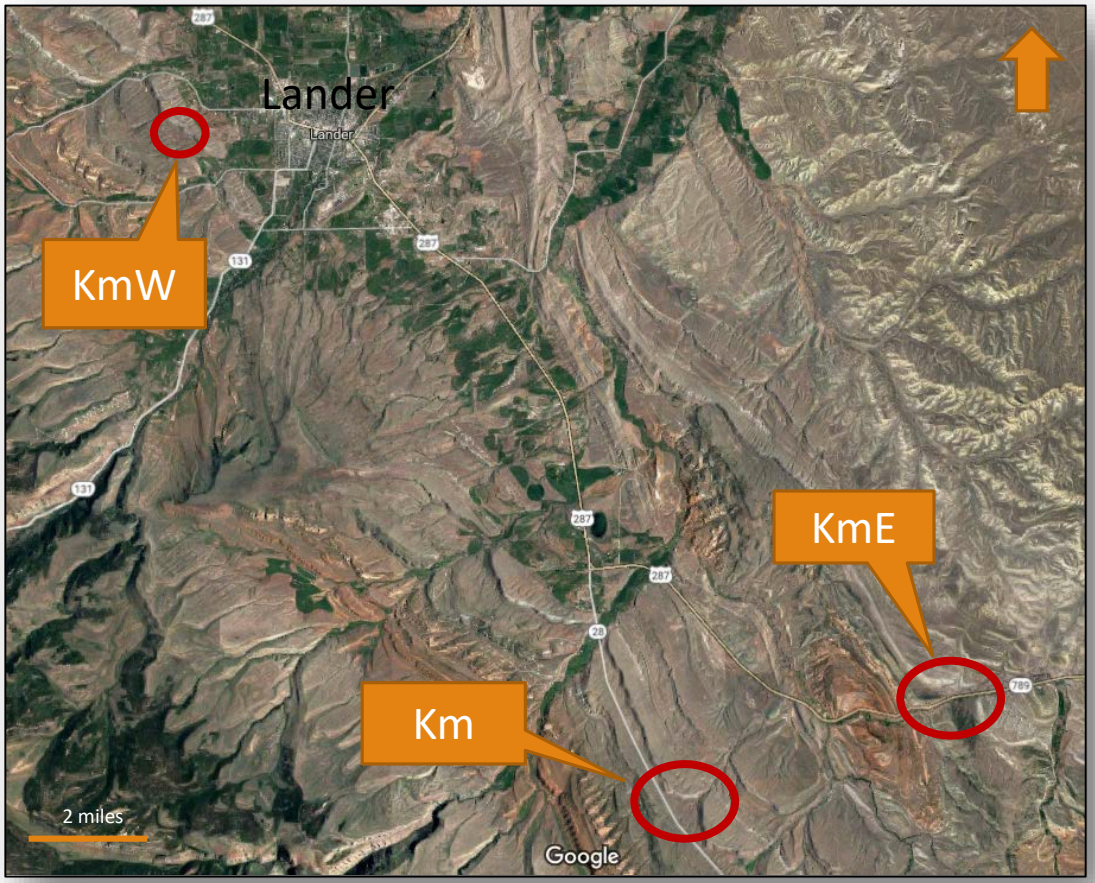
Methodology

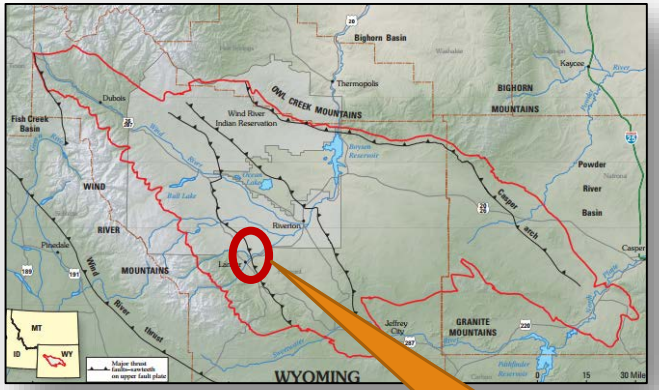
Measure, describe, and sample several vertical sections within a small sub-region of the Wind River Basin for organofacies variability.

Pick a horizon that we feel is traceable across the area, based upon field observations, geochemical characterization, and sample laterally at a very fine spacing (~5 meters).

- ~350 samples across three outcrop localities.

Study Area

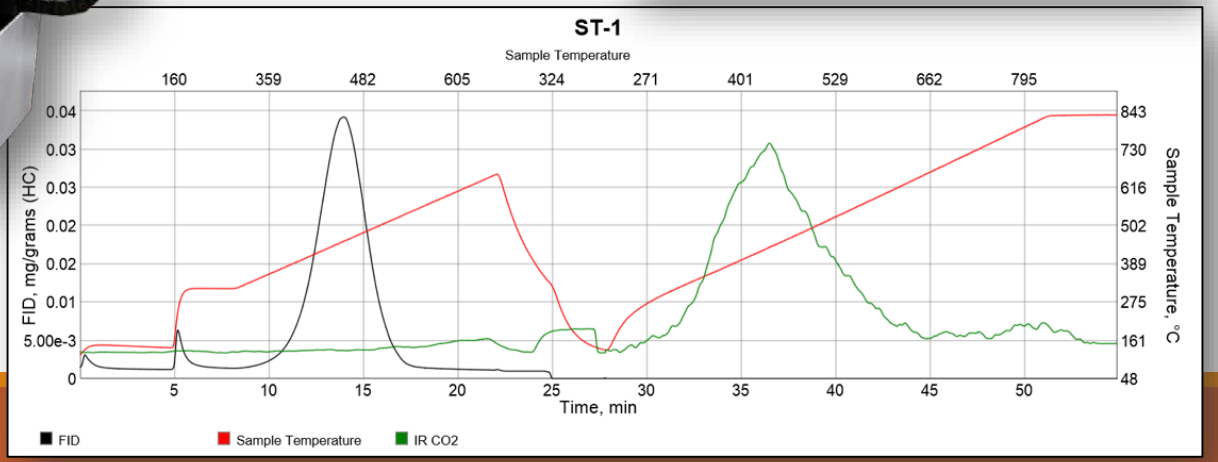




From Kirschbaum et al, 2005

Lab Techniques

HAWK Pyrolysis



Results

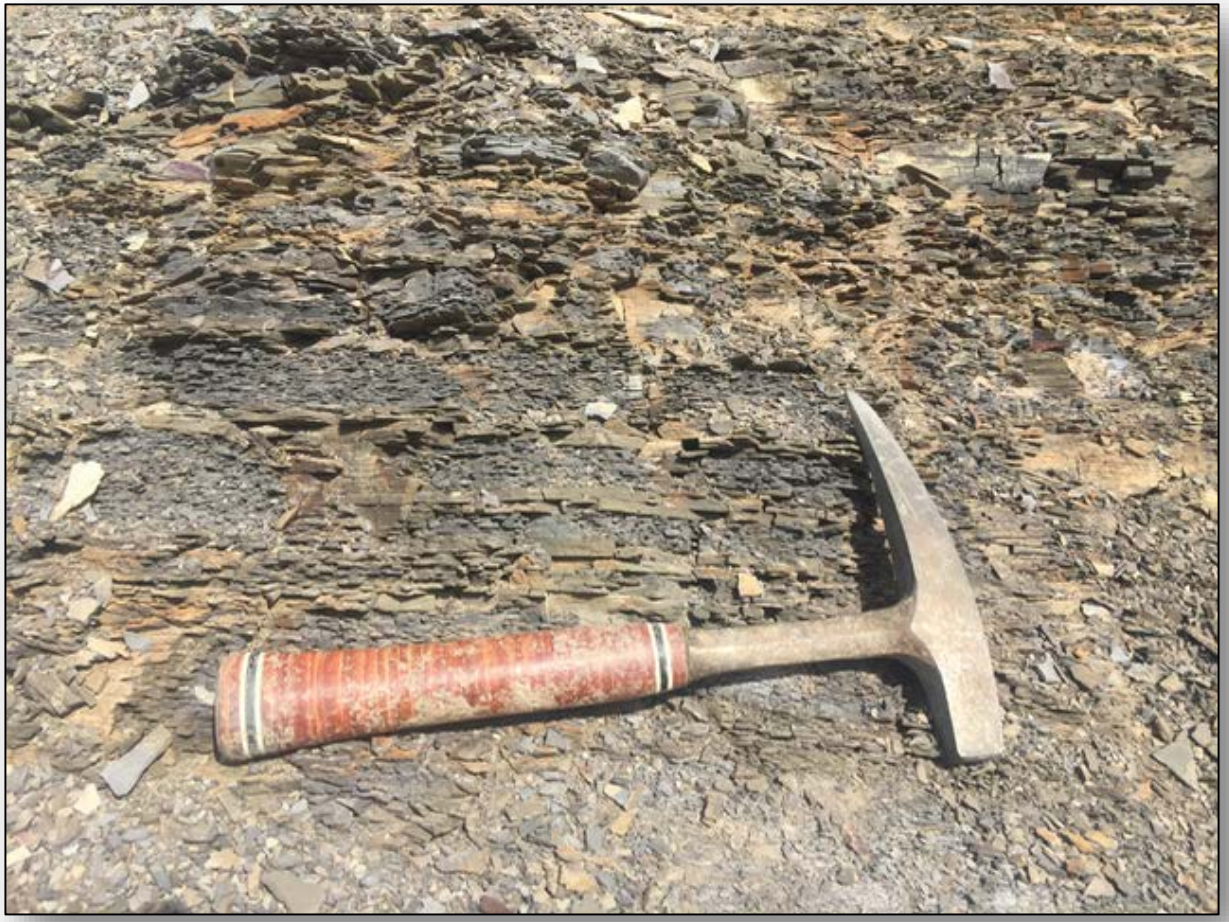
Facies

Facies A

2-10 cm often discontinuous beds of poorly laminated resistant grey-brown silty shale

Often interbedded with 1-5 cm grey-black laminated mudstone beds (Facies B)

Facies



Facies B

Well laminated silty black-grey shale beds

Millimeter laminations

Often associated with 2-5 cm lenses of discontinuous resistive grey-brown shale (Facies A)

Facies

Facies C

Well laminated silty grey shale beds

Millimeter laminations

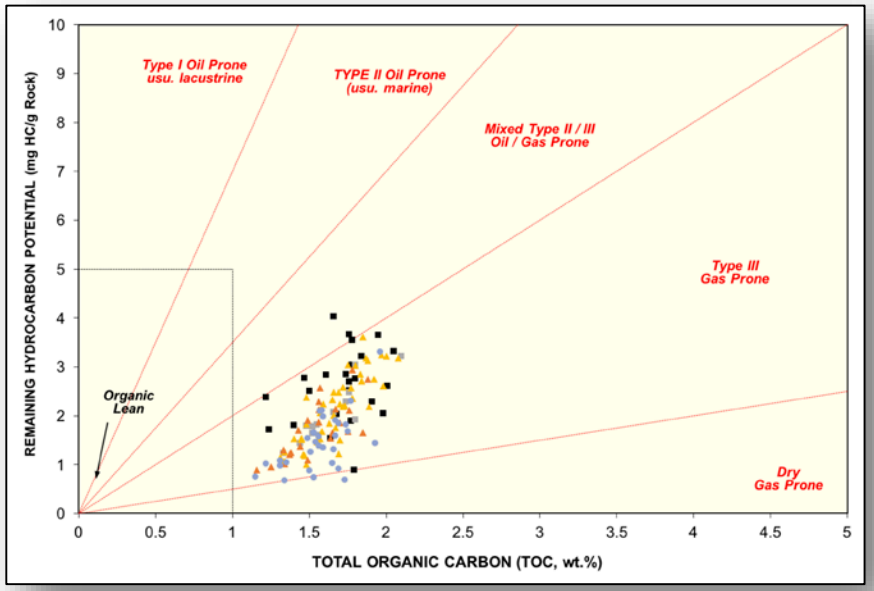
Often associated with 1-2 cm continuous orange-brown bentonite beds

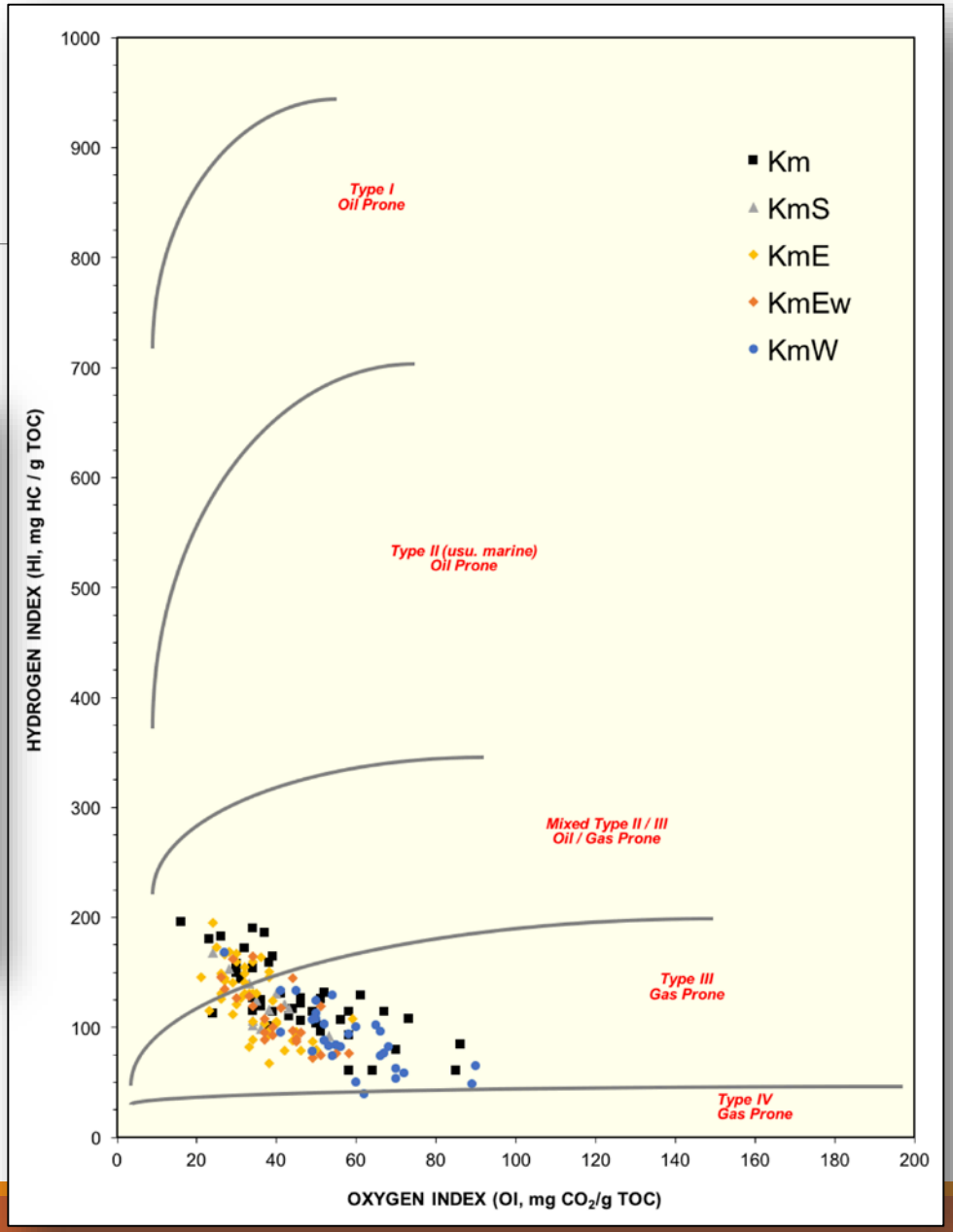
Facies

Other facies include:

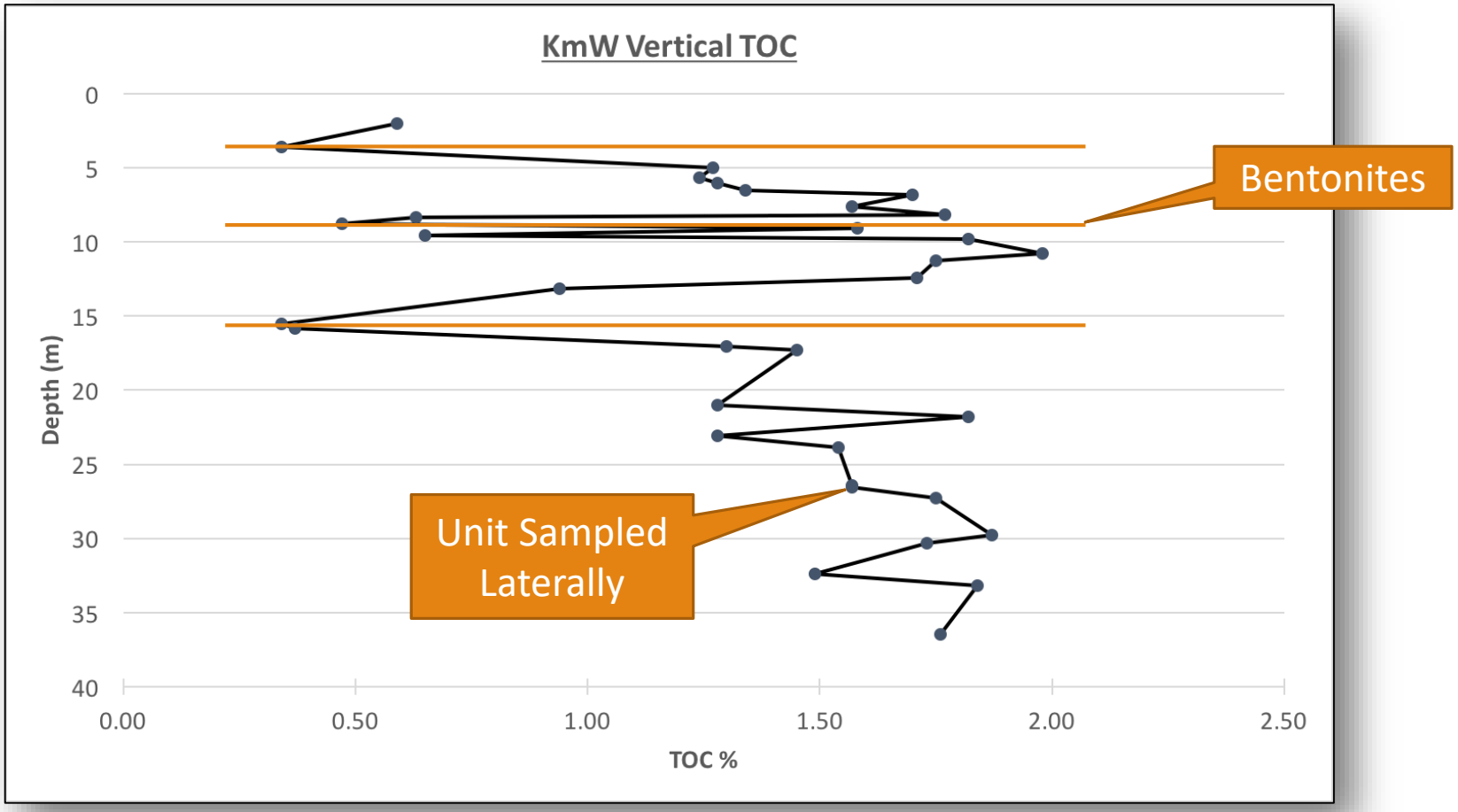
- - Bentonites (3 major horizons)
- Silty Sandstones
  - 2 major ones (major being a relative term), both capped by a bentonite.

Kerogen Type

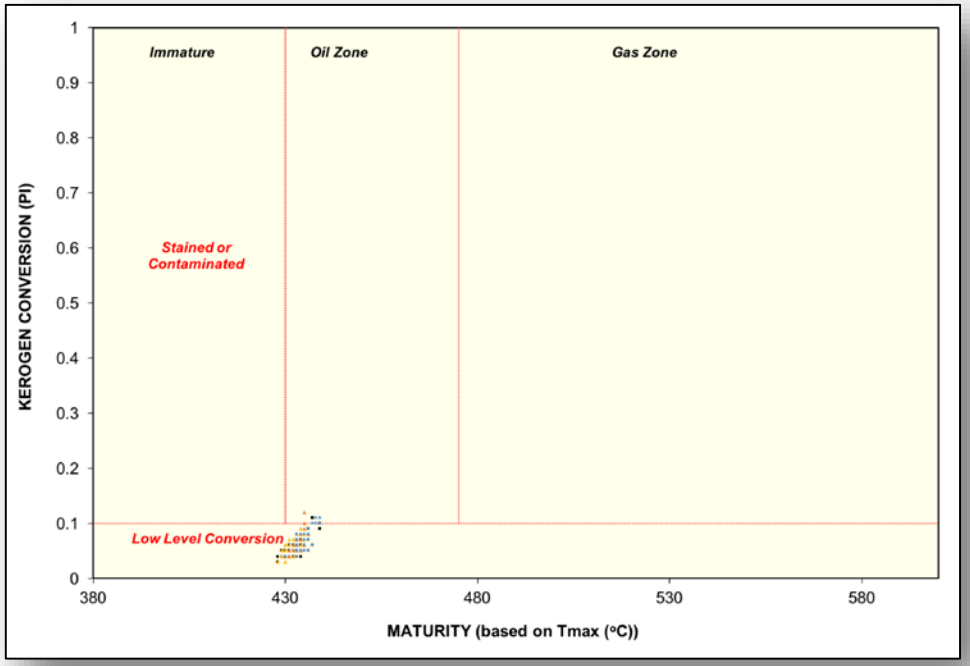


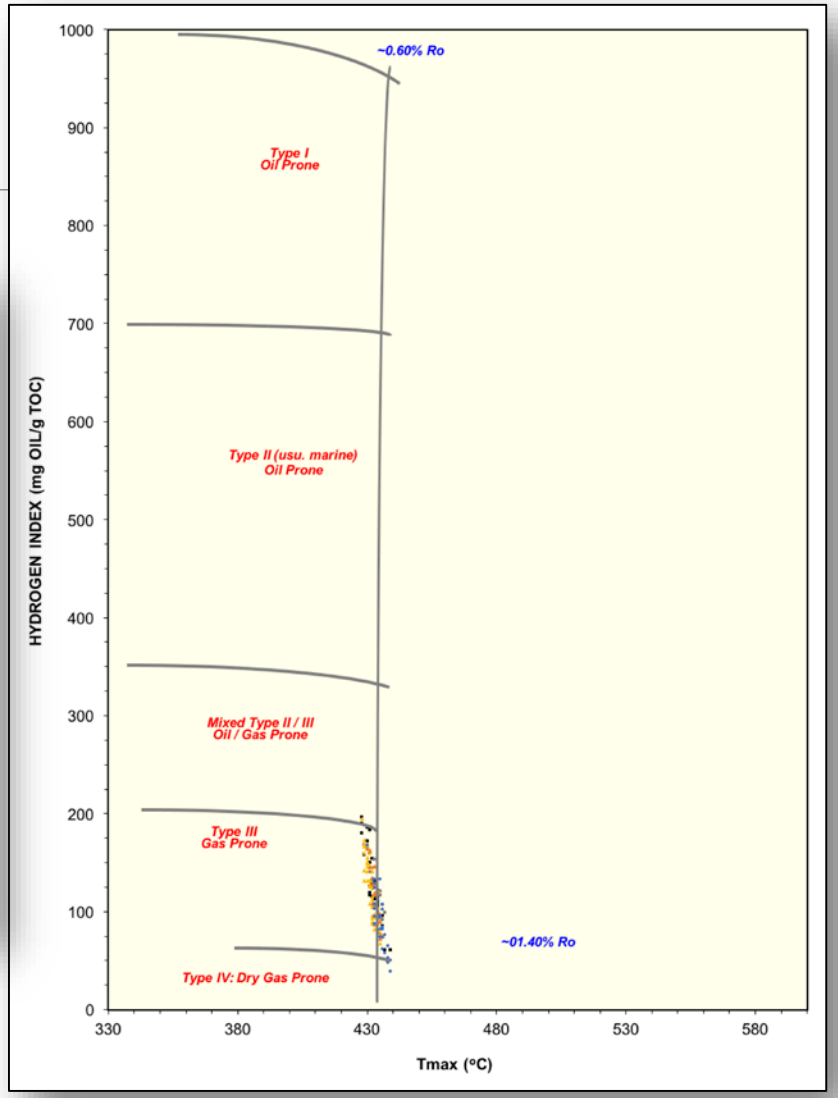


Vertical Samples

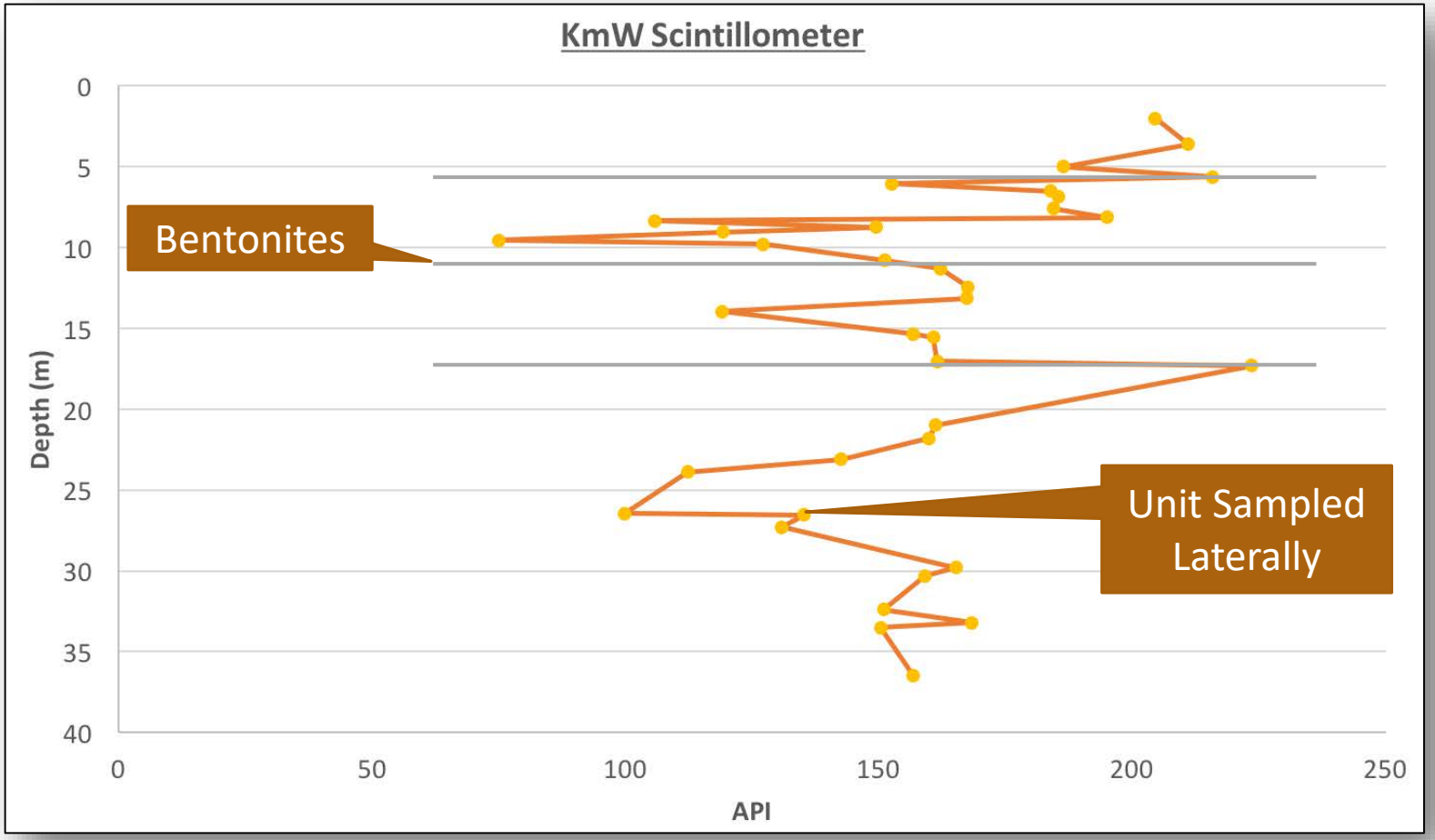


Maturity

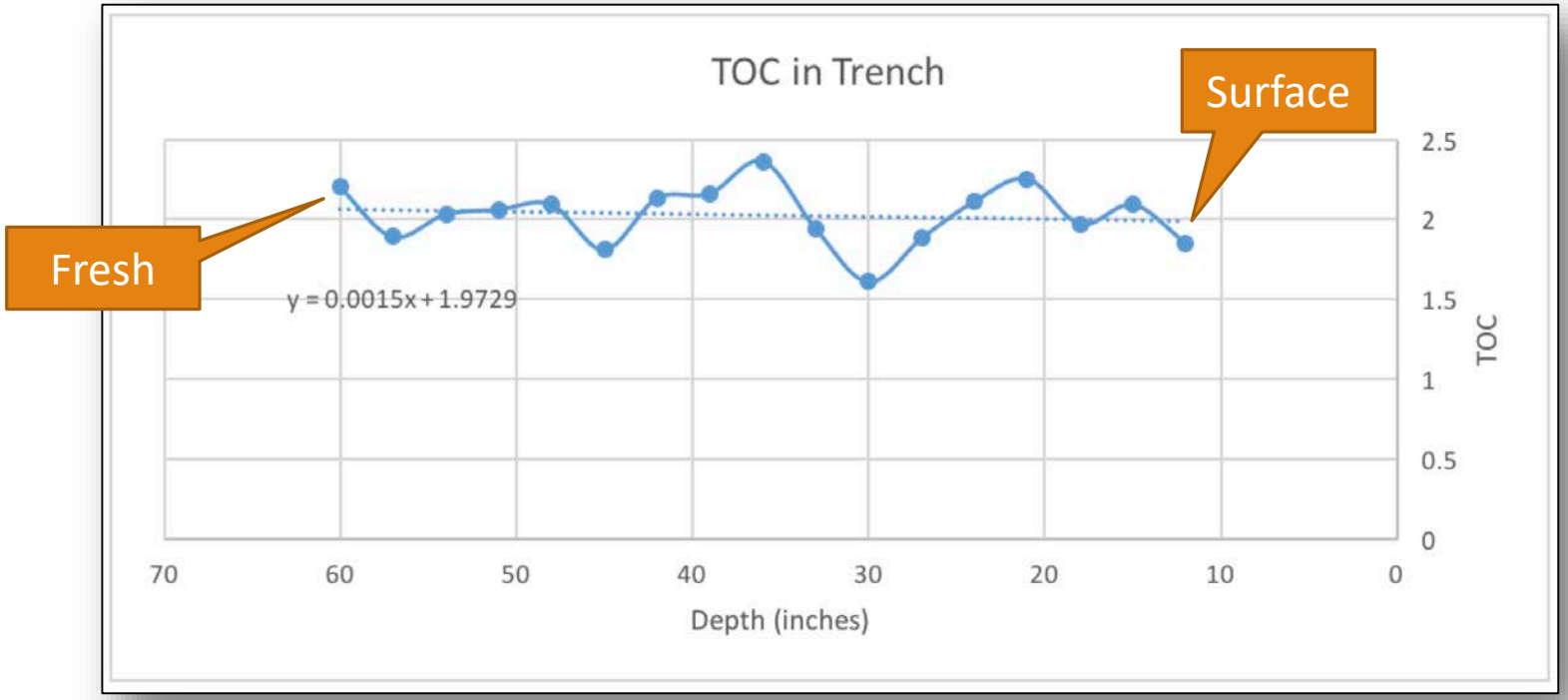

Immature
Oil Zone
Gas Zone
Stained or Contaminated
Low Level Conversion
KEROGEN CONVERSION (PI)
MATURITY (based on Tmax (°C))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
380
430
480
530
580


~0.60% Ro
Type I
Oil Prone
Type II (usu. marine)
Oil Prone
Mixed Type II / III
Oil / Gas Prone
Type III
Gas Prone
~01.40% Ro
Type IV: Dry Gas Prone
HYDROGEN INDEX (mg OIL/g TOC)
Tmax (°C)
0
100
200
300
400
500
600
700
800
900
1000
330
380
430
480
530
580

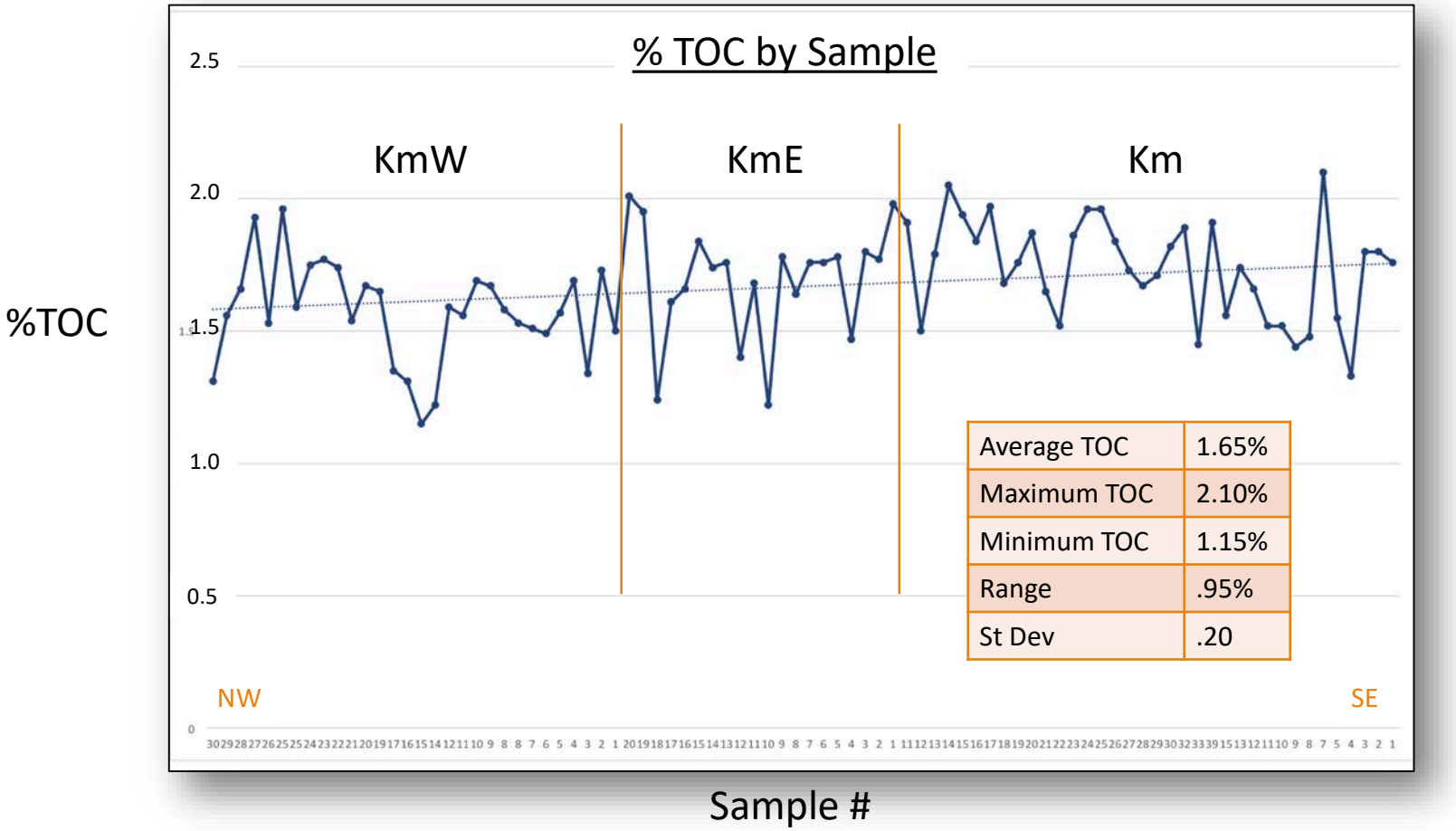
Scintillometer



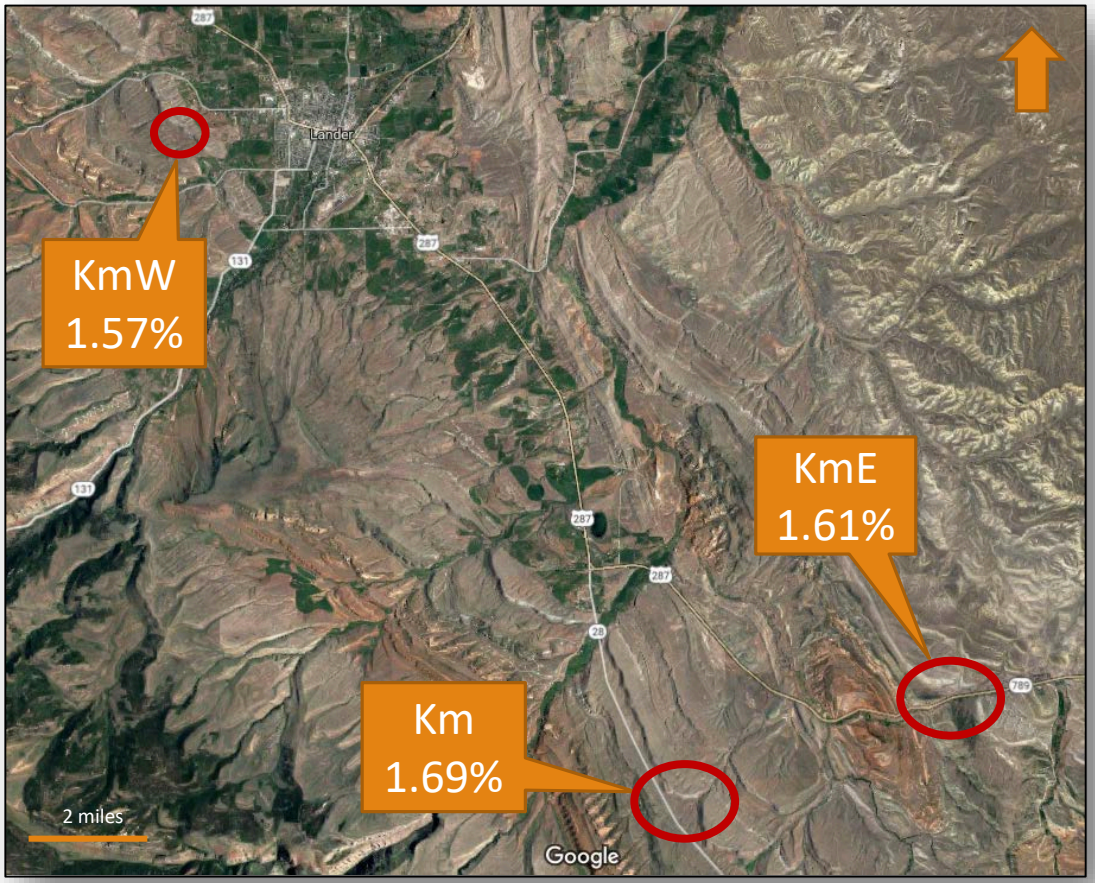
Weathering Profile



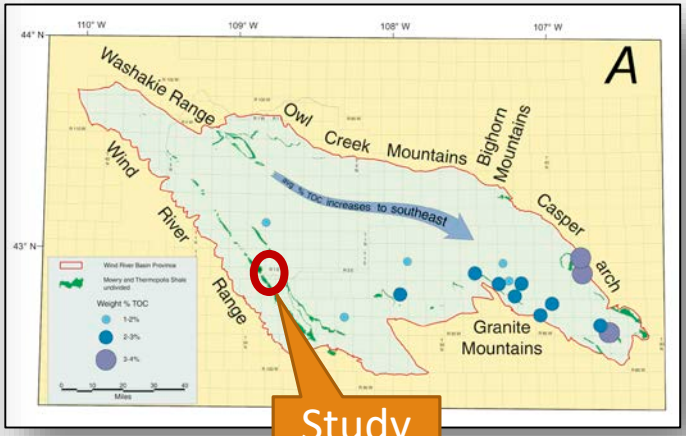
Lateral Samples



Lateral Samples



Average TOC increases to the southeast



From Finn, 2007

Conclusions

Significant vertical heterogeneity in organic content, temporal variability.

In contrast, very little spatial heterogeneity. Drilling implications…

Lateral homogeneity suggests constant spatial deposition, local basin was not segmented, no structural impediments, consistent oxic conditions, and correlations can be made based on geochemical signature in this area.

TOC at surface is not significantly affected by weathering.

Samples are dominantly Type III with some mixed Type II/III suggesting close proximity to shoreline and/or terrestrial input, consistent with other studies and outcrop location near basin margin.

5 m lateral sample interval is probably overkill.

References

Blakey, R., 2014, Western Interior Seaway Paleogeographic Maps and Cross Sections: (http://cpgeosystems.com/images/wiscretalb_cen.jpg, March 24, 2016).

Finn, T.M., 2007, Source Rock Potential of Upper Cretaceous Marine Shales in the Wind River Basin, Wyoming: USGS Digital Data, v. DDS-69-J.

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Thank you!