# Characterization of the Graneros Shale: A Key Source Rock of the Denver Basin

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MUDTOC Spring 2021 Meeting

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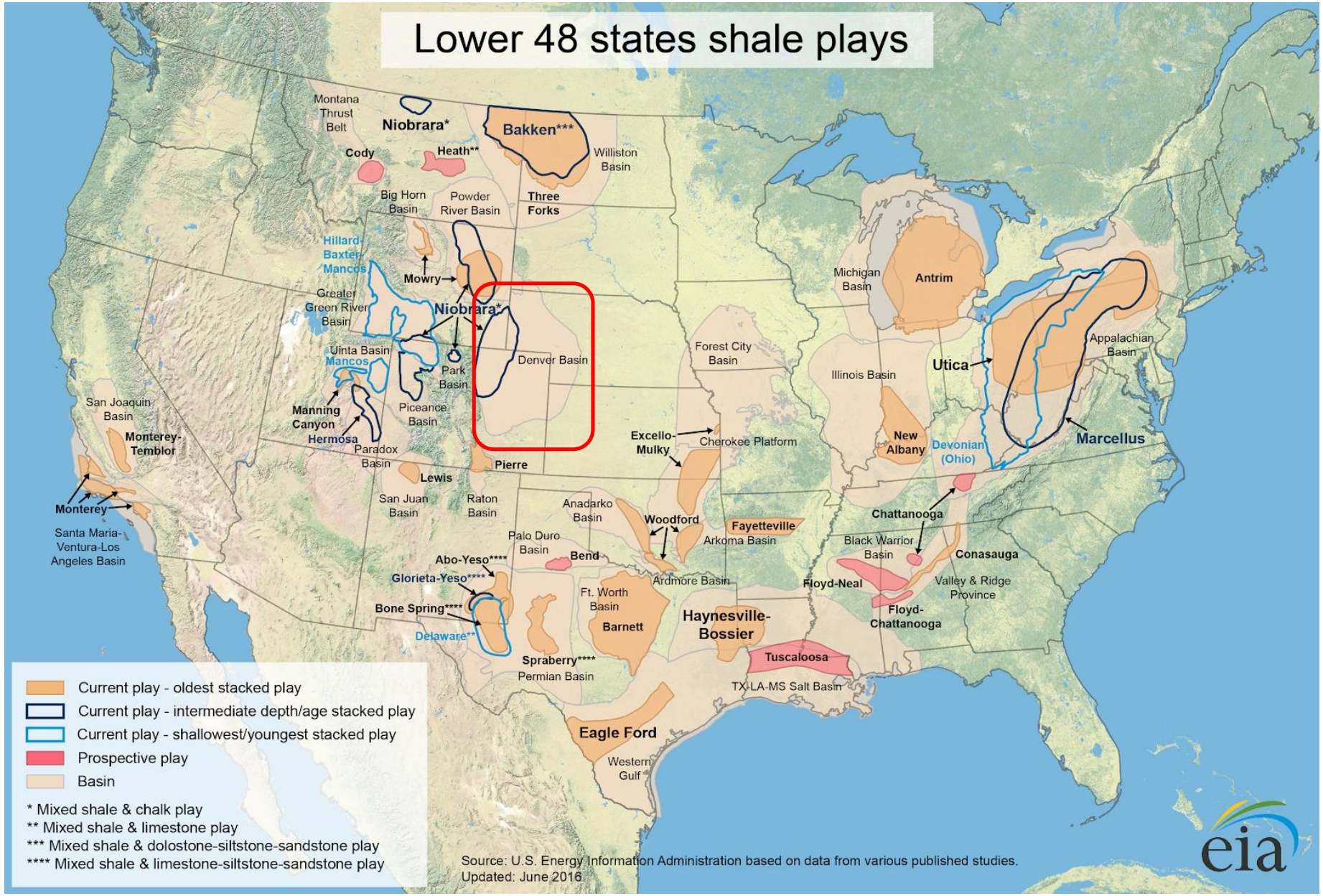
# Project Summary

**The primary goal of this study is to characterize the source potential of the Graneros Shale in the Denver Basin.**

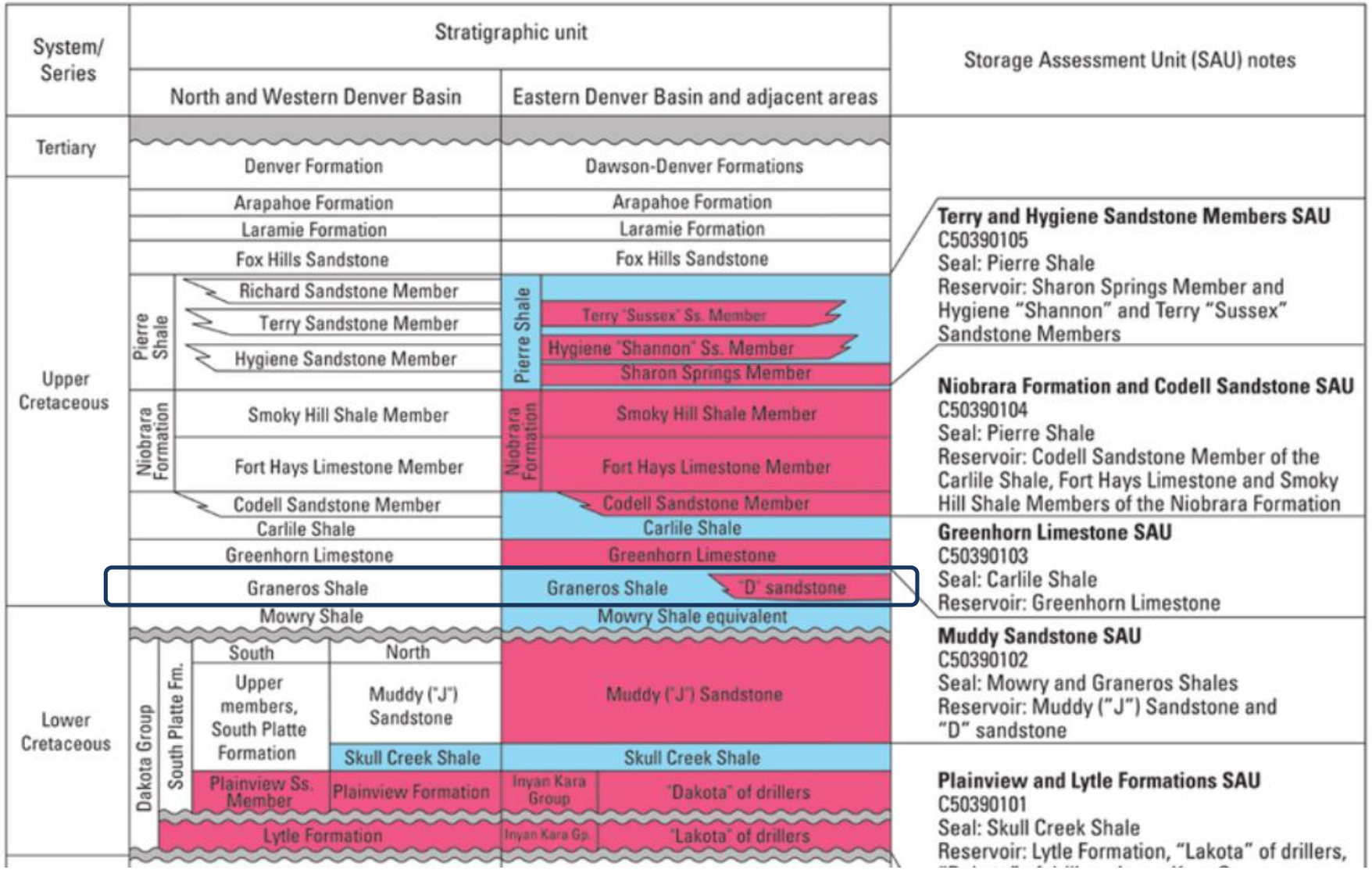
# Outline

- Geologic Overview
  - Location
  - Stratigraphic setting
  - Geologic Setting
- Petroleum System
- 6-32 Box Elder Farms Core
  - Core Description Overview
  - Thin Sections: Initial Findings
  - XRF Data
  - Mineral Model
- Future work

# Location


Lower 48 states shale plays
Montana Thrust Belt
Niobrara*
Bakken***
Cody
Heath**
Williston Basin
Big Horn Basin
Powder River Basin
Three Forks
Hillard-Baxter-Mancos
Mowry
Greater Green River Basin
Niobrara*
Uinta Basin
Mancos
Park Basin
Denver Basin
Piceance Basin
Manning Canyon
Hermosa
Paradox Basin
Pierre
Lewis
San Joaquin Basin
Monterey-Temblor
Monterey
Santa Maria-Ventura-Los Angeles Basin
San Juan Basin
Raton Basin
Anadarko Basin
Palo Duro Basin
Bend
Abo-Yeso****
Glorieta-Yeso****
Bone Spring****
Delaware**
Spraberry****
Permian Basin
Ft. Worth Basin
Barnett
Ardmore Basin
Woodford
Fayetteville
Arkoma Basin
Haynesville-Bossier
Tuscaloosa
TX-LA-MS Salt Basin
Eagle Ford
Western Gulf
Excello-Mulky
Cherokee Platform
Forest City Basin
Illinois Basin
Michigan Basin
Antrim
Utica
Appalachian Basin
Marcellus
New Albany
Devonian (Ohio)
Chattanooga
Black Warrior Basin
Conasauga
Floyd-Neal
Floyd-Chattanooga
Valley & Ridge Province
Current play - oldest stacked play
Current play - intermediate depth/age stacked play
Current play - shallowest/youngest stacked play
Prospective play
Basin
* Mixed shale & chalk play
** Mixed shale & limestone play
*** Mixed shale & dolostone-siltstone-sandstone play
**** Mixed shale & limestone-siltstone-sandstone play
Source: U.S. Energy Information Administration based on data from various published studies.
Updated: June 2016
eia

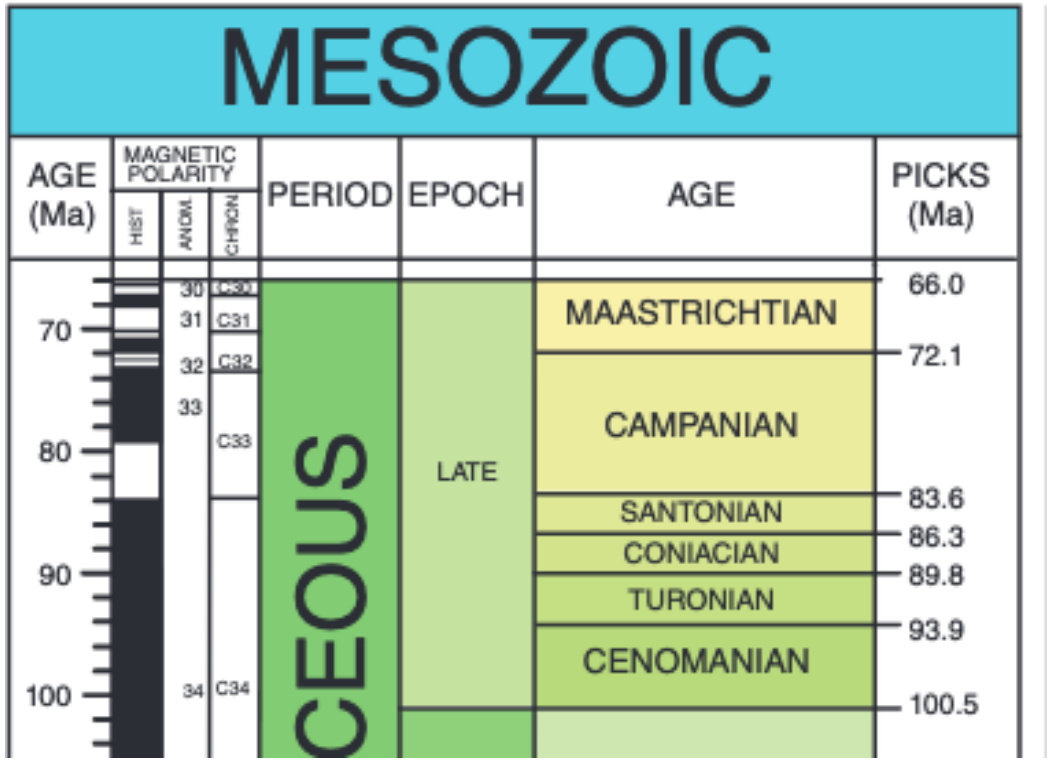
# Stratigraphic Setting




Drake et al, 2014; modified from Higley and Cox, 2007

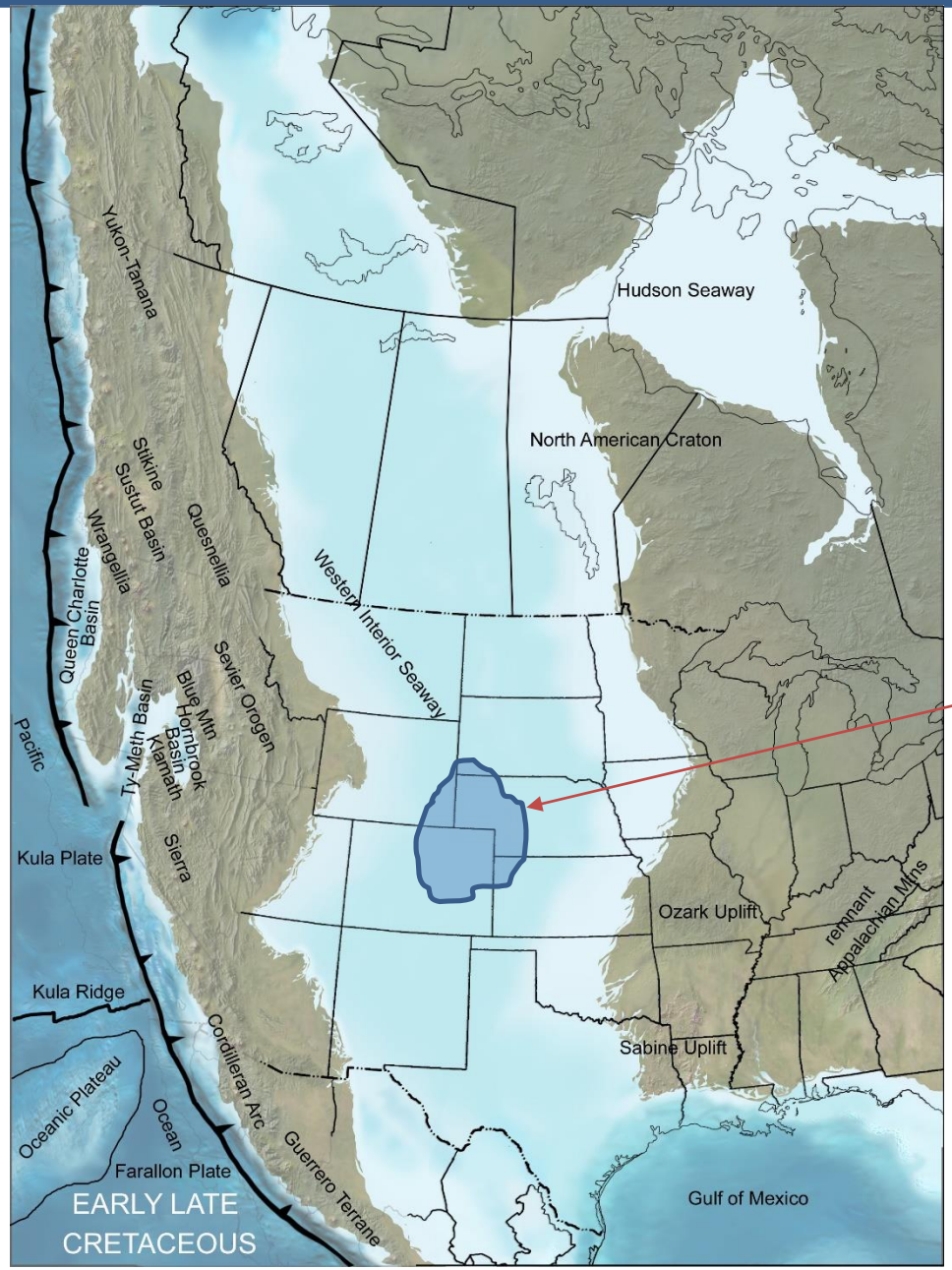
# Geologic Setting

- The Late Cretaceous spans from 100.5 Ma to 66 Ma.
- The Graneros was deposited during the Cenomanian, closer to 100.5 Ma.
- The Western Interior Seaway divided North America.



GSA Geologic Time Scale v 5.0

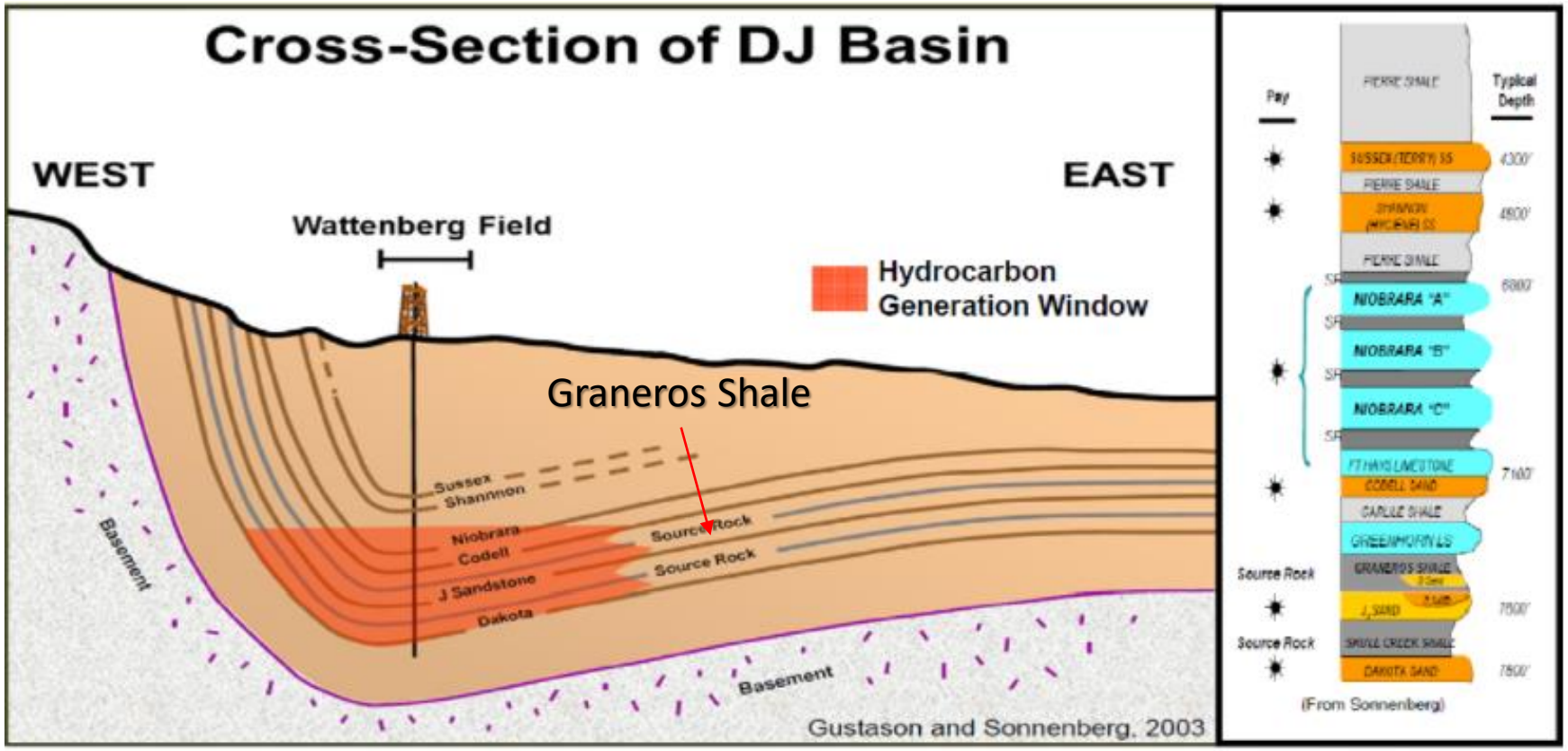
# Geologic Setting




Approximate location of the Denver Basin

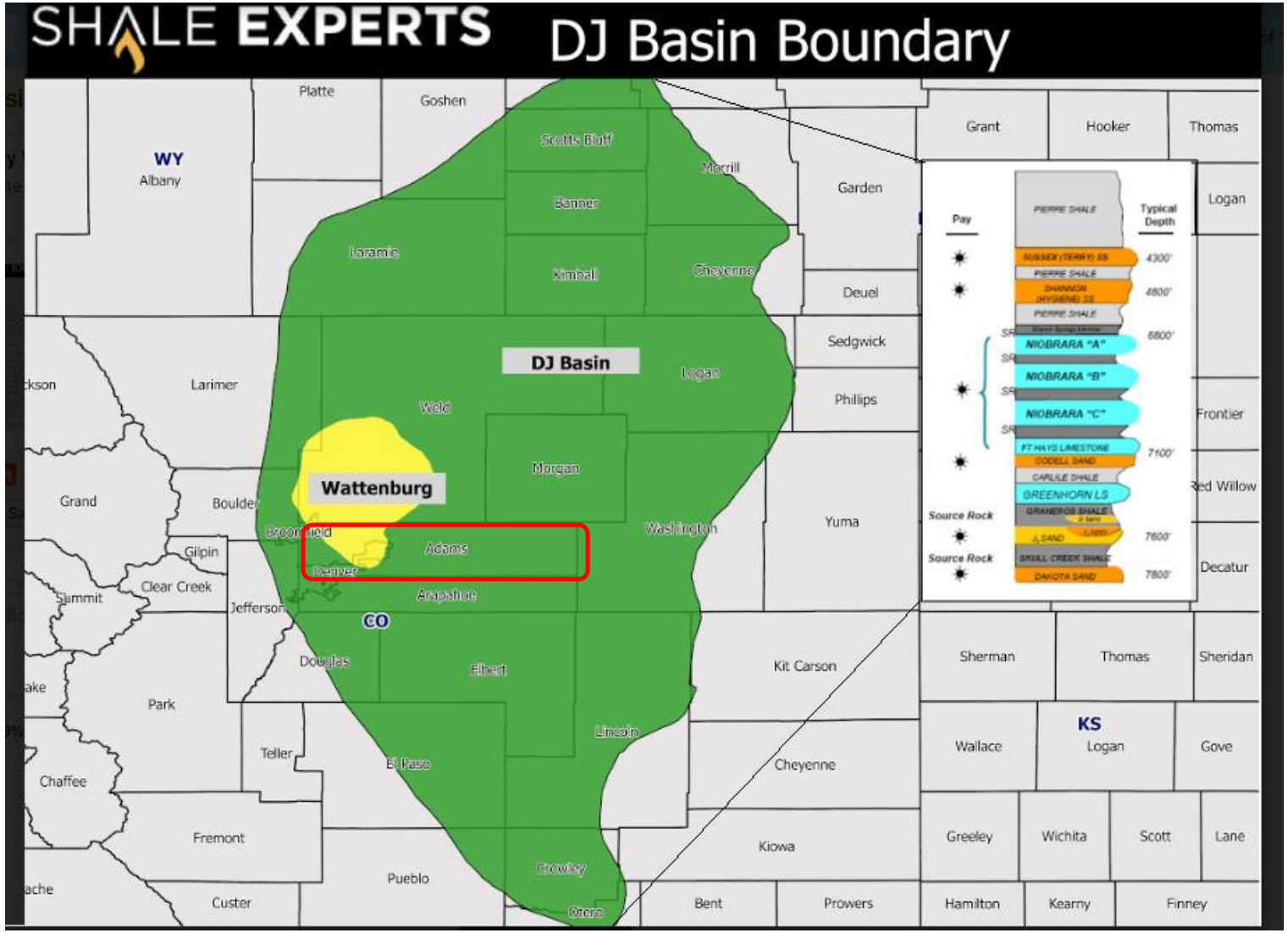
Modified from Blakey (Early Late Cretaceous)

# Petroleum System Cross Section




(Modified from Gustason and Sonnenberg, 2003)

# 6-32 Box Elder Core

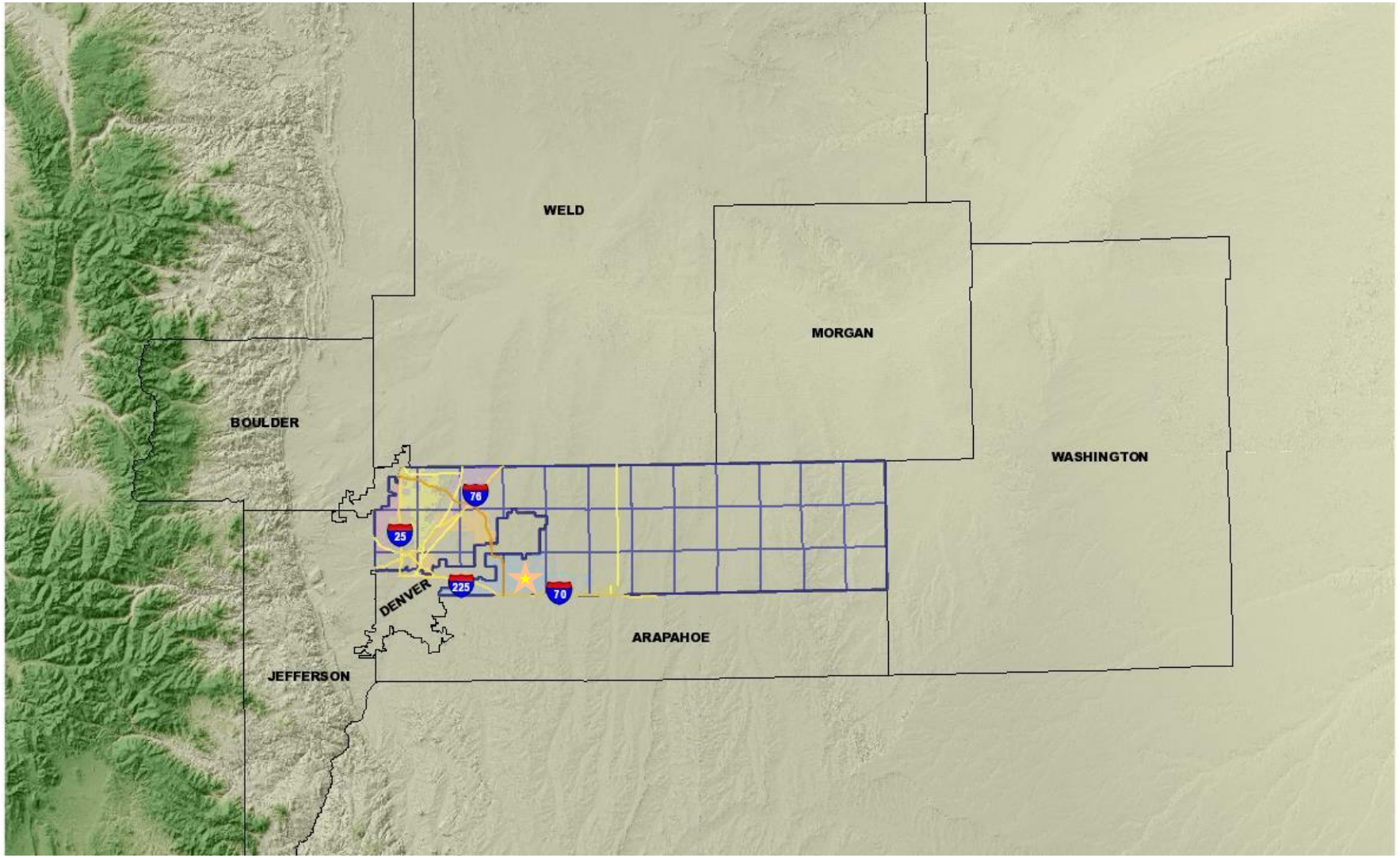



Location:

- Adams County, CO
- S 6, T 3s, R 65 W

Modified from Shale Experts

# 6-32 Box Elder Farms Core



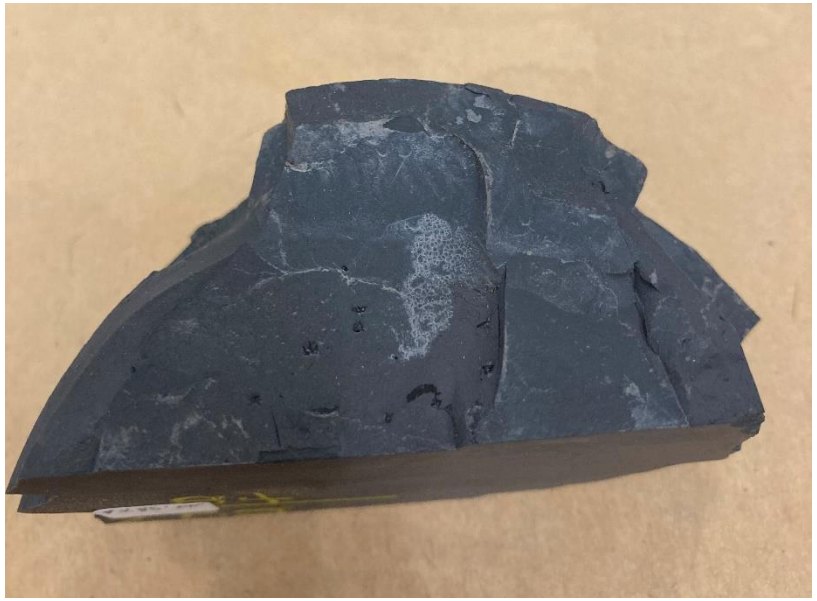

Modified from Adams County, CO Government

# Core Description

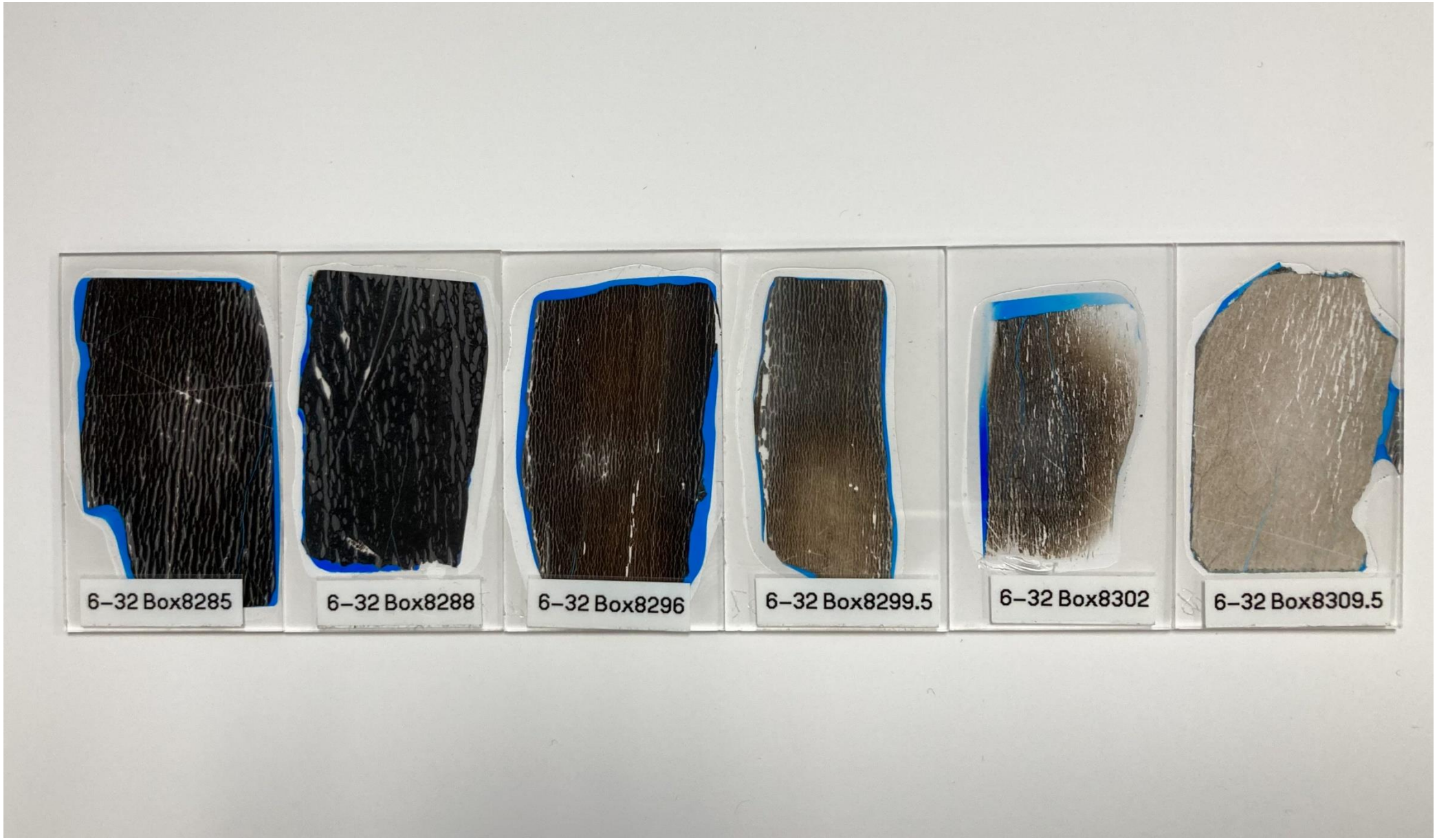
- Grain size: clay
- Bioturbation Index: 0
- Structures: subtle planar laminations
- Flecks of pyrite throughout.
- Two volcanic ash layers at 8303’ 01” and 8306’ 06”
- Fragments of black, reflective matter on bedding plane surfaces.
  - OM or phosphatic fragments.

Challenges:

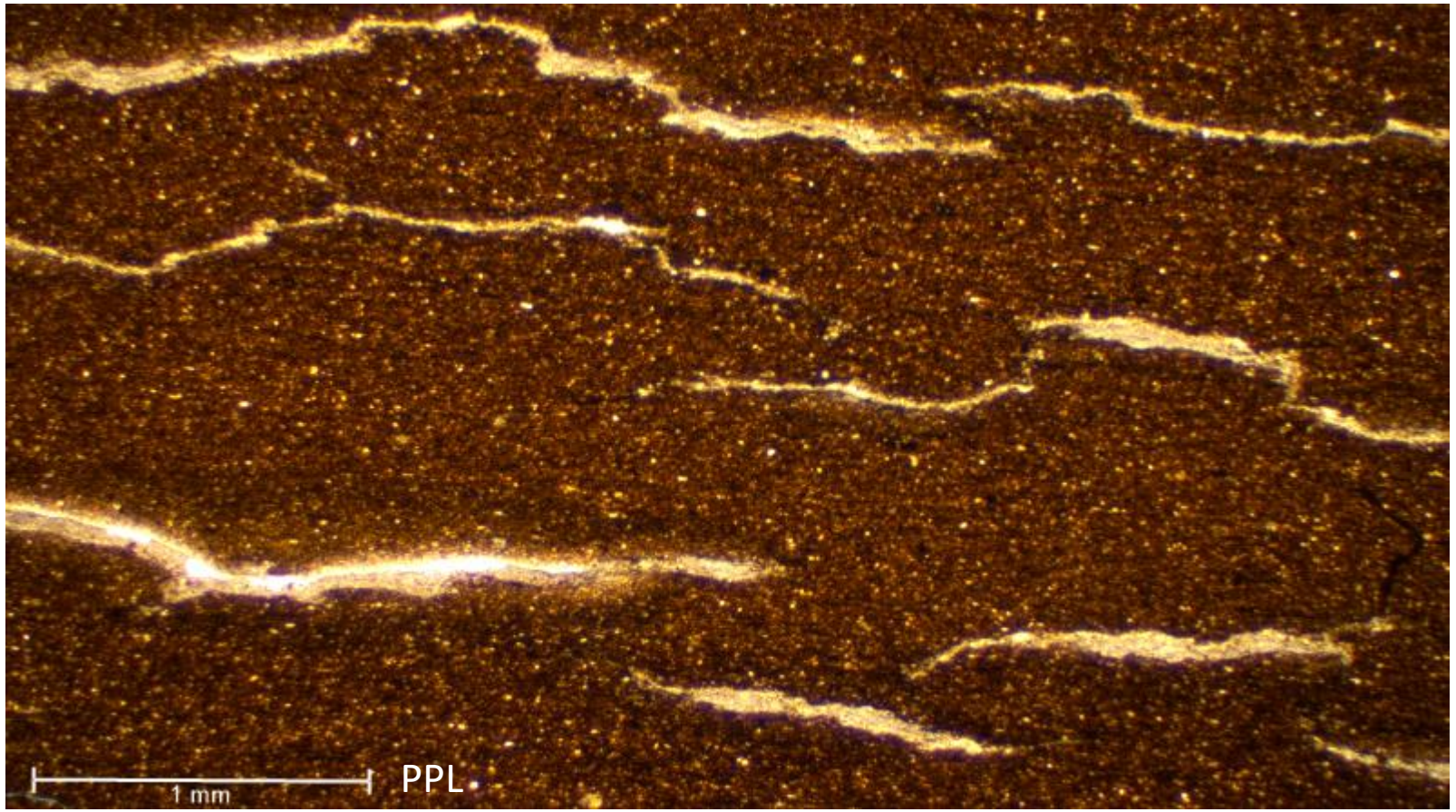
- So fine grained that it is challenging to glean much information.
- The core does not go through the top of the Graneros.



# Thin Sections: Initial Findings

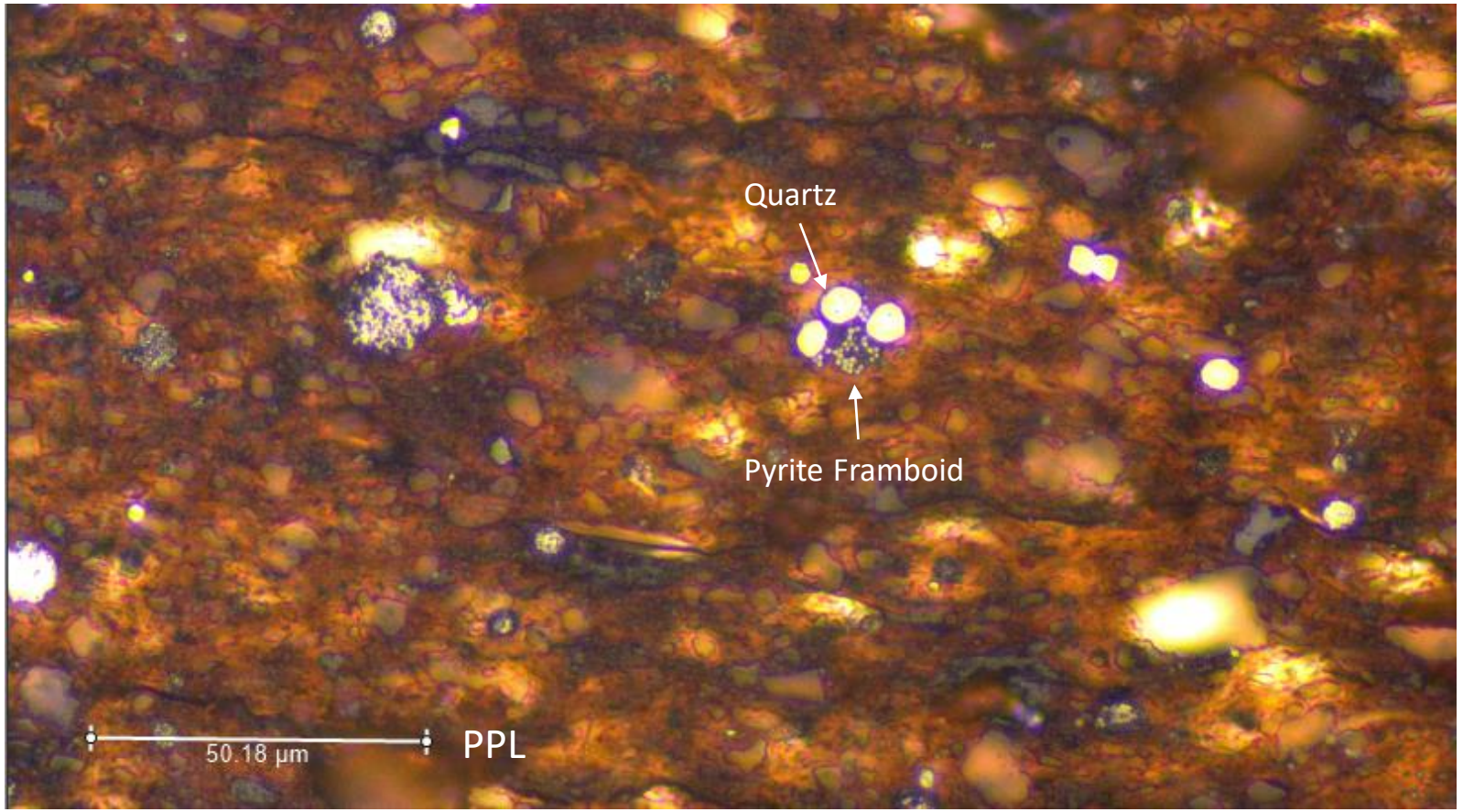


# Thin Sections: 8285 ft



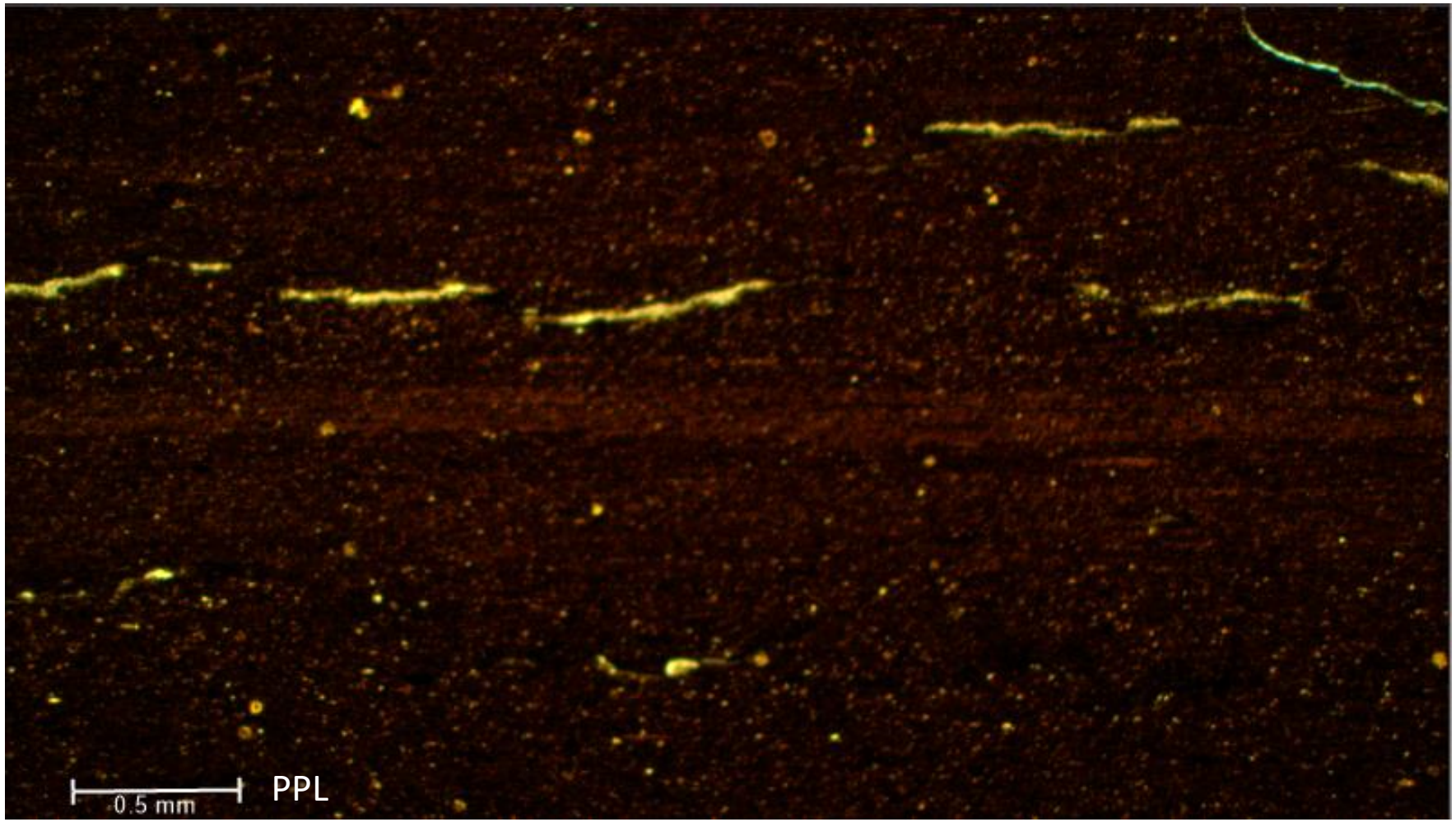

- Reticulated texture
- Darker, more clay-rich layers and lighter, more quartz-rich layers

# Thin Section: 8285 ft



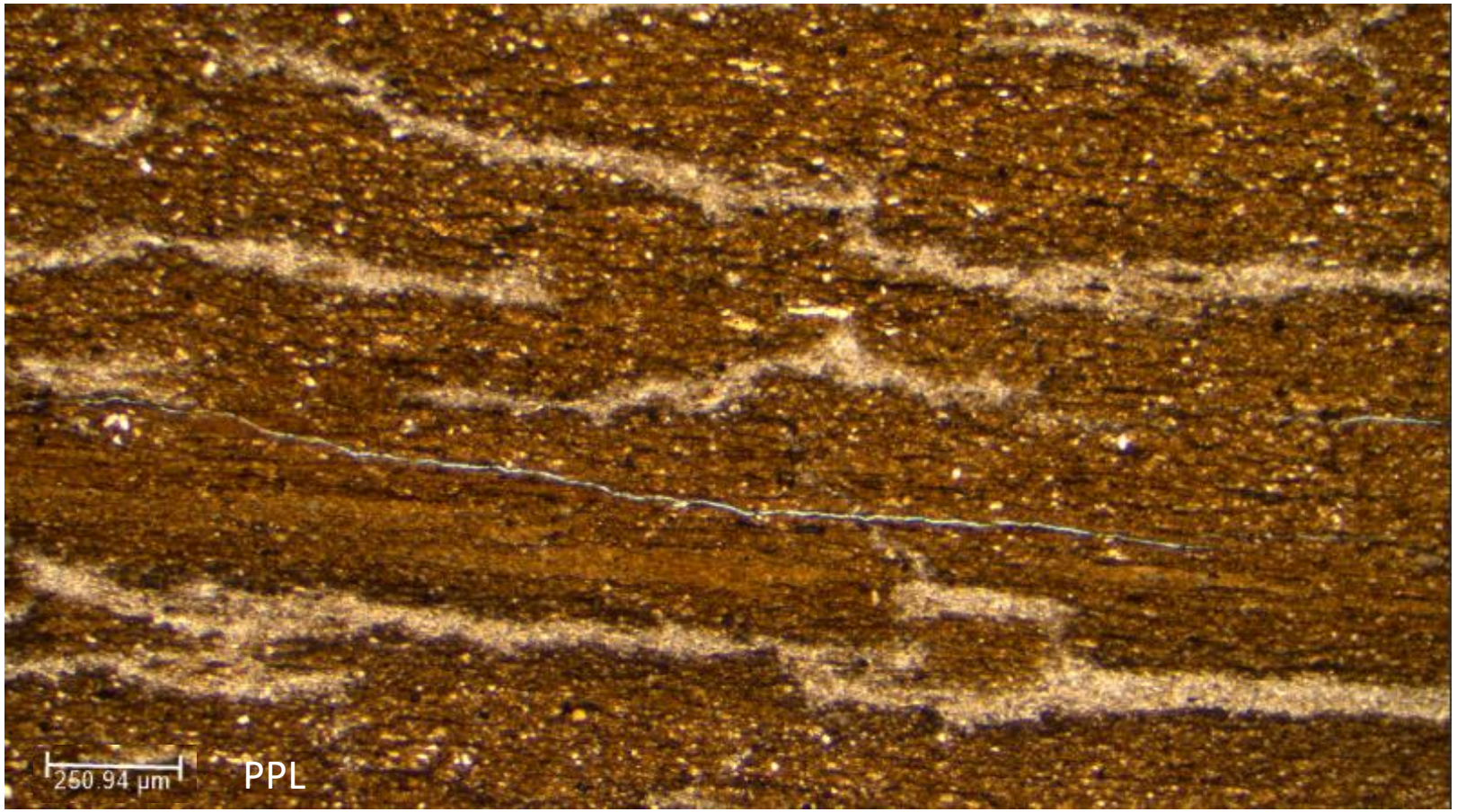

- At 50x
- Pyrite visible
- Clay still challenging to see

# Thin Section: 8288 ft



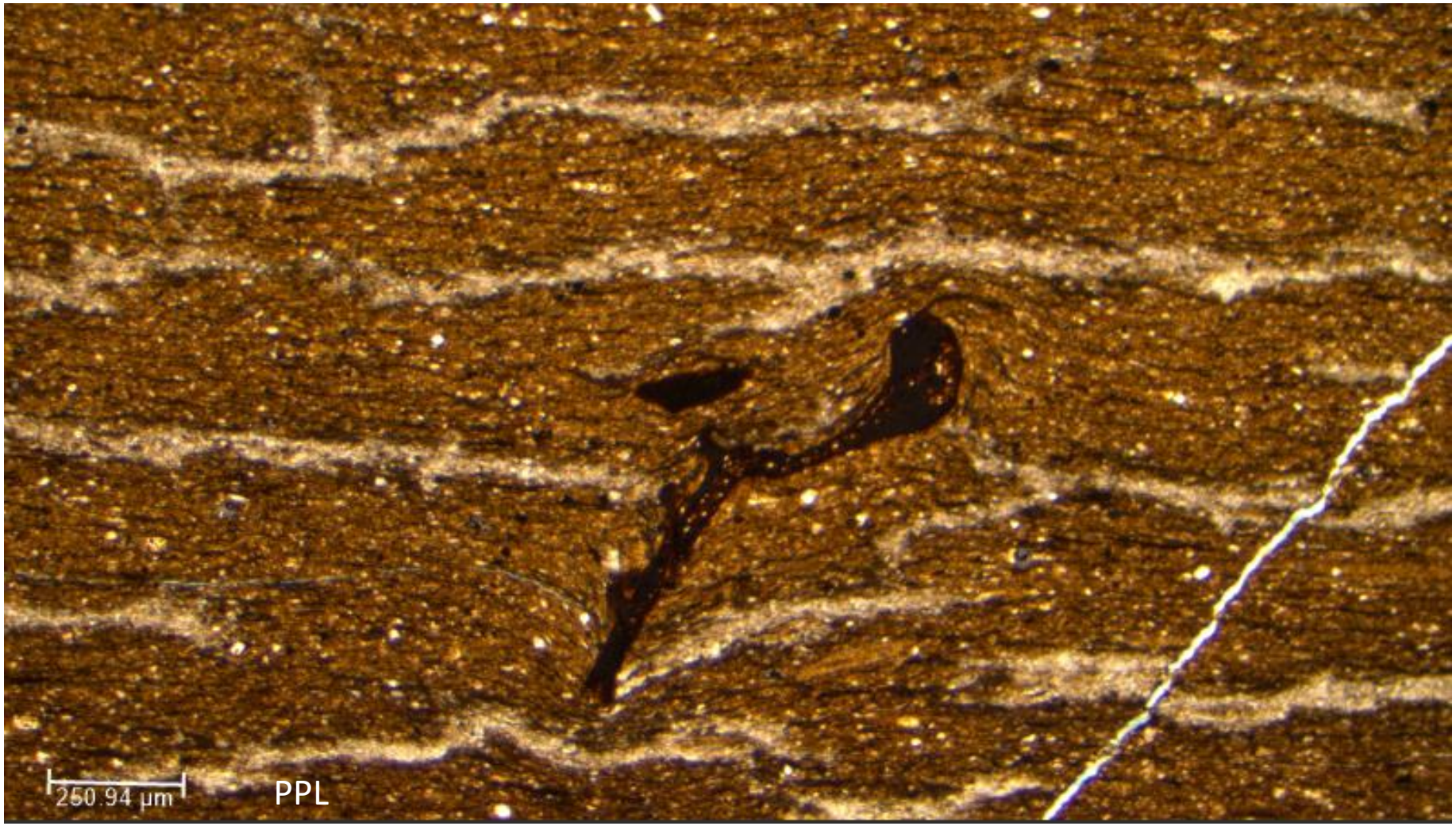

- Planar laminations are visible here.
- This section is much darker than the others.

# Thin Section: 8296 ft



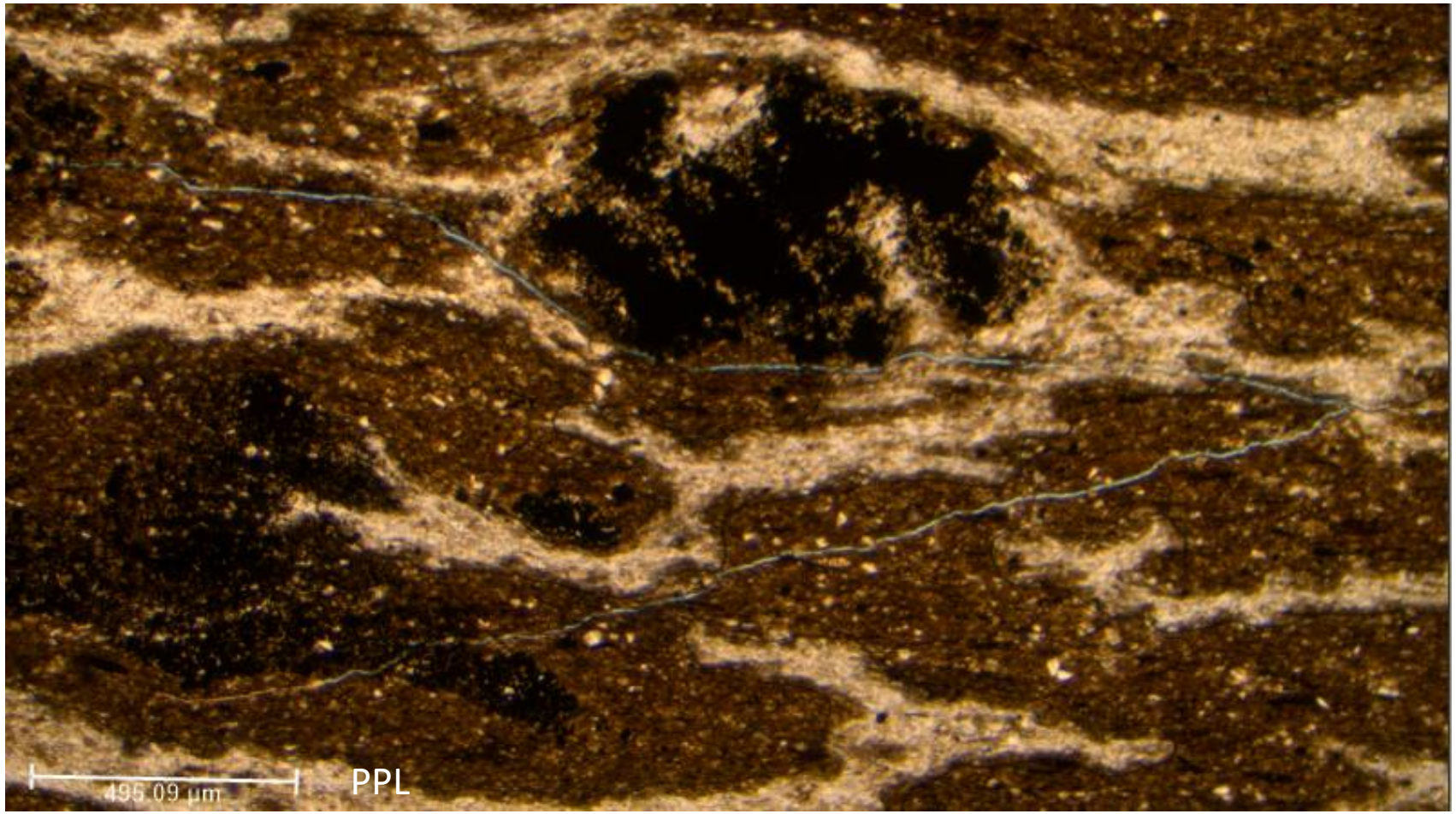

- Reticulated texture still present
- Epoxy filled cracks
- Darker material around the quartz-rich layers

# Thin Section: 8296 ft



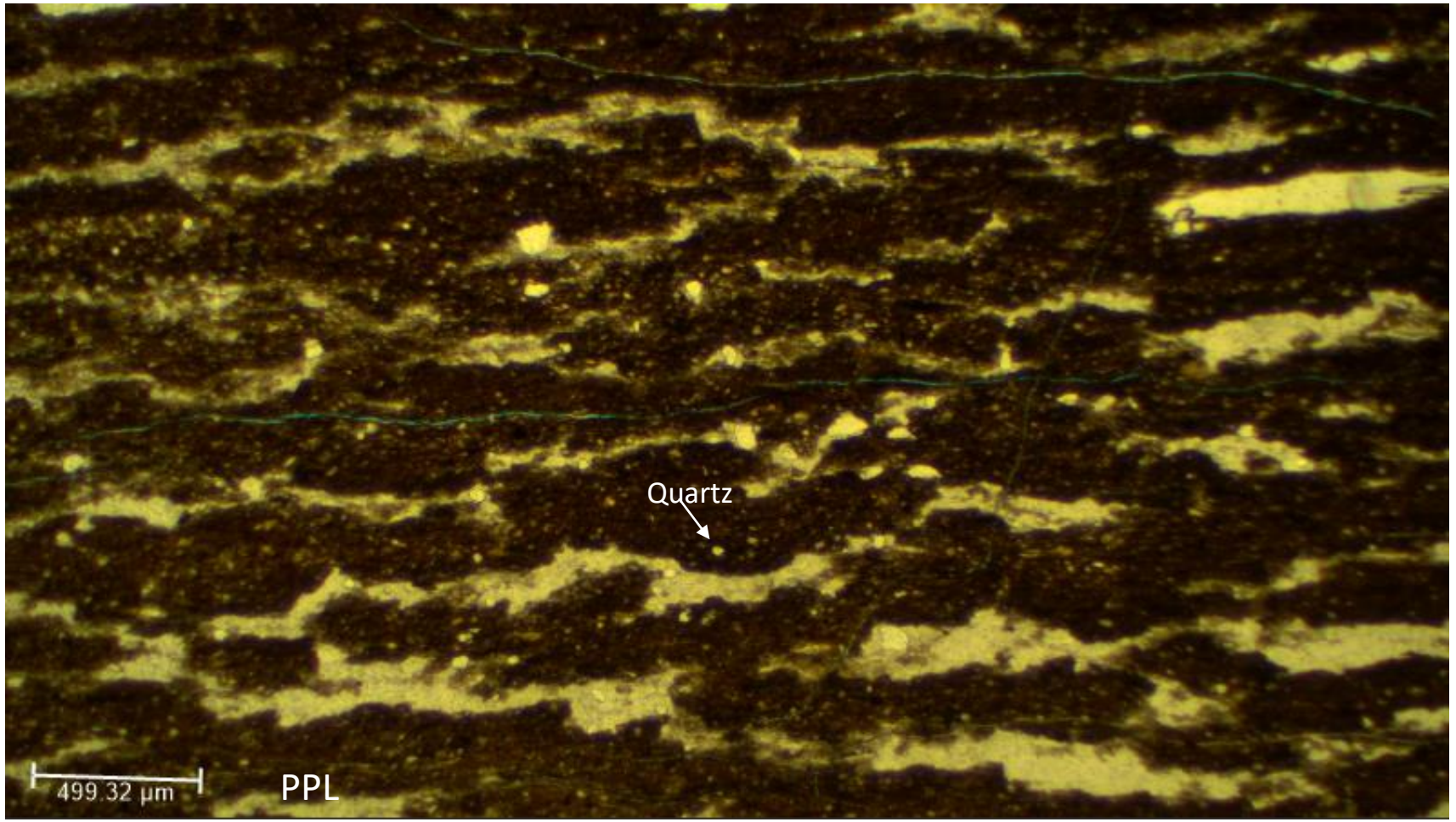

- Fish bone fragment

# Thin Section: 8299.5 ft



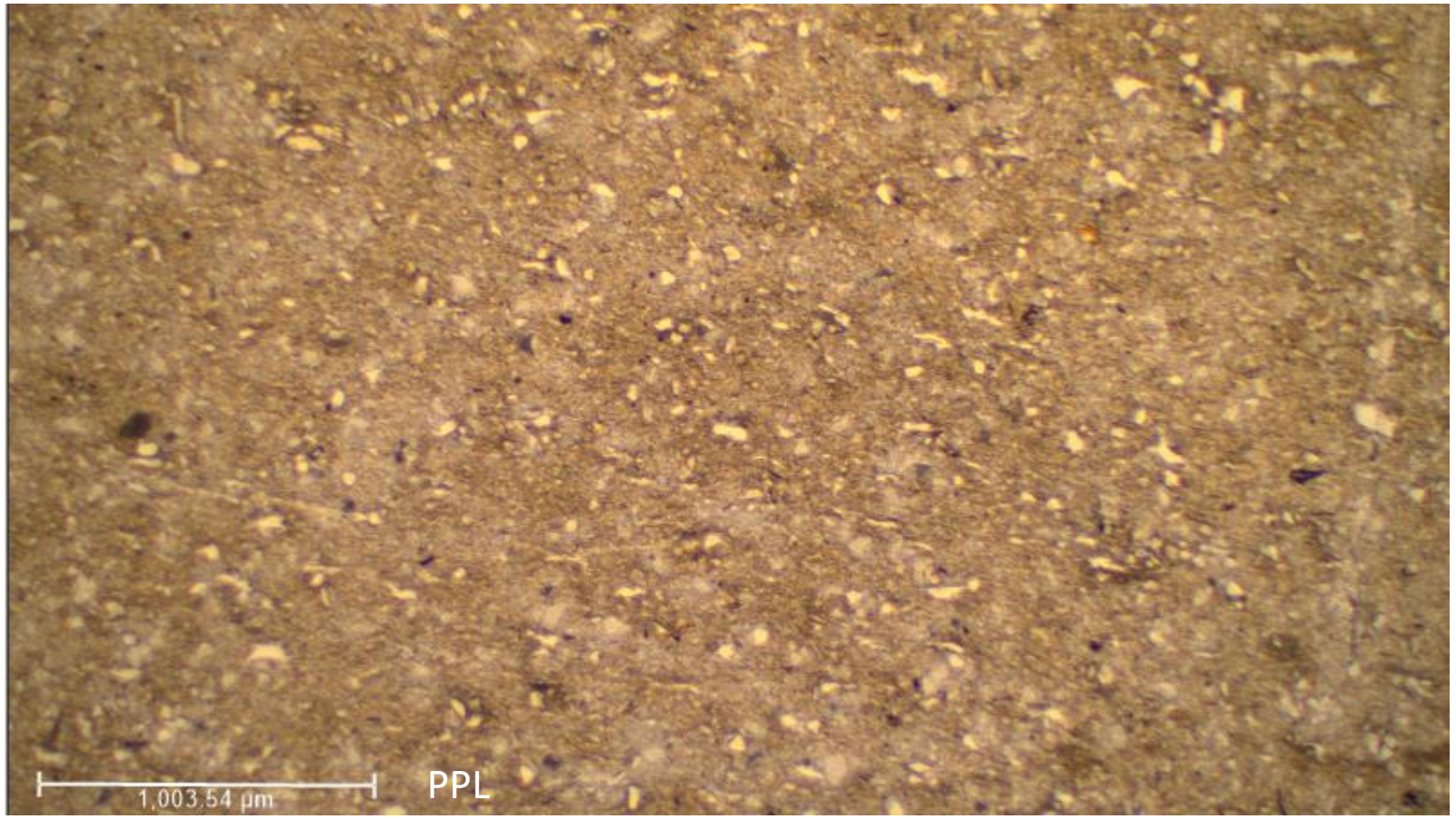

- Large opaque areas.
- More organic matter in this section.
- Reticulated texture still present.

# Thin Section: 8302 ft




- Reticulate texture continues.
- Much darker thin section again.
  - Hard to see, even in PPL

# Thin Section 8309.5 ft




- Volcanic ash layer
- FE-SEM will likely provide more insight

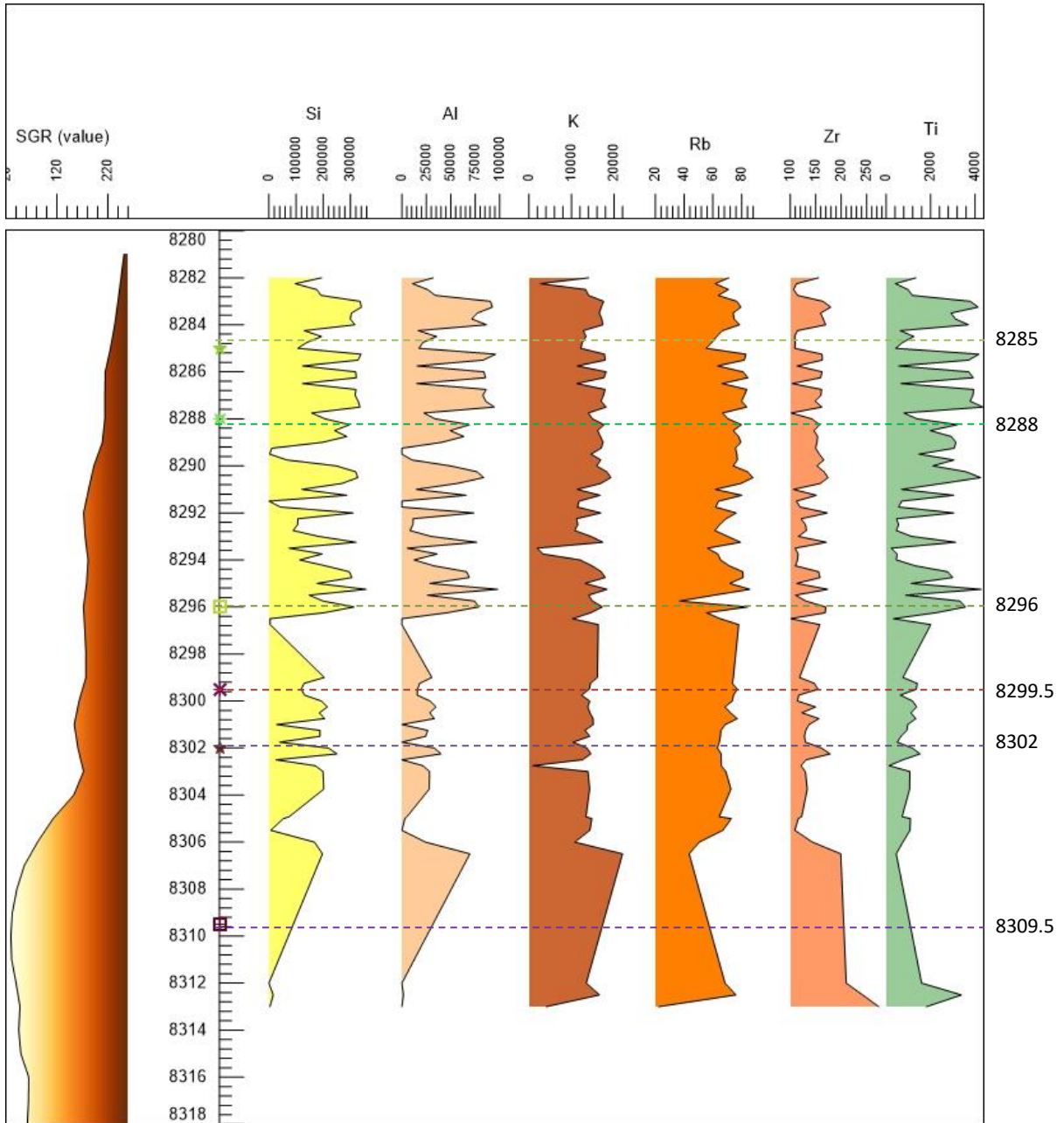
# XRF

- Took measurements every 3 inches.
- There were some areas where the depth was questionable.
  - Representative measurements taken for these intervals.


Thermo Fisher Scientific

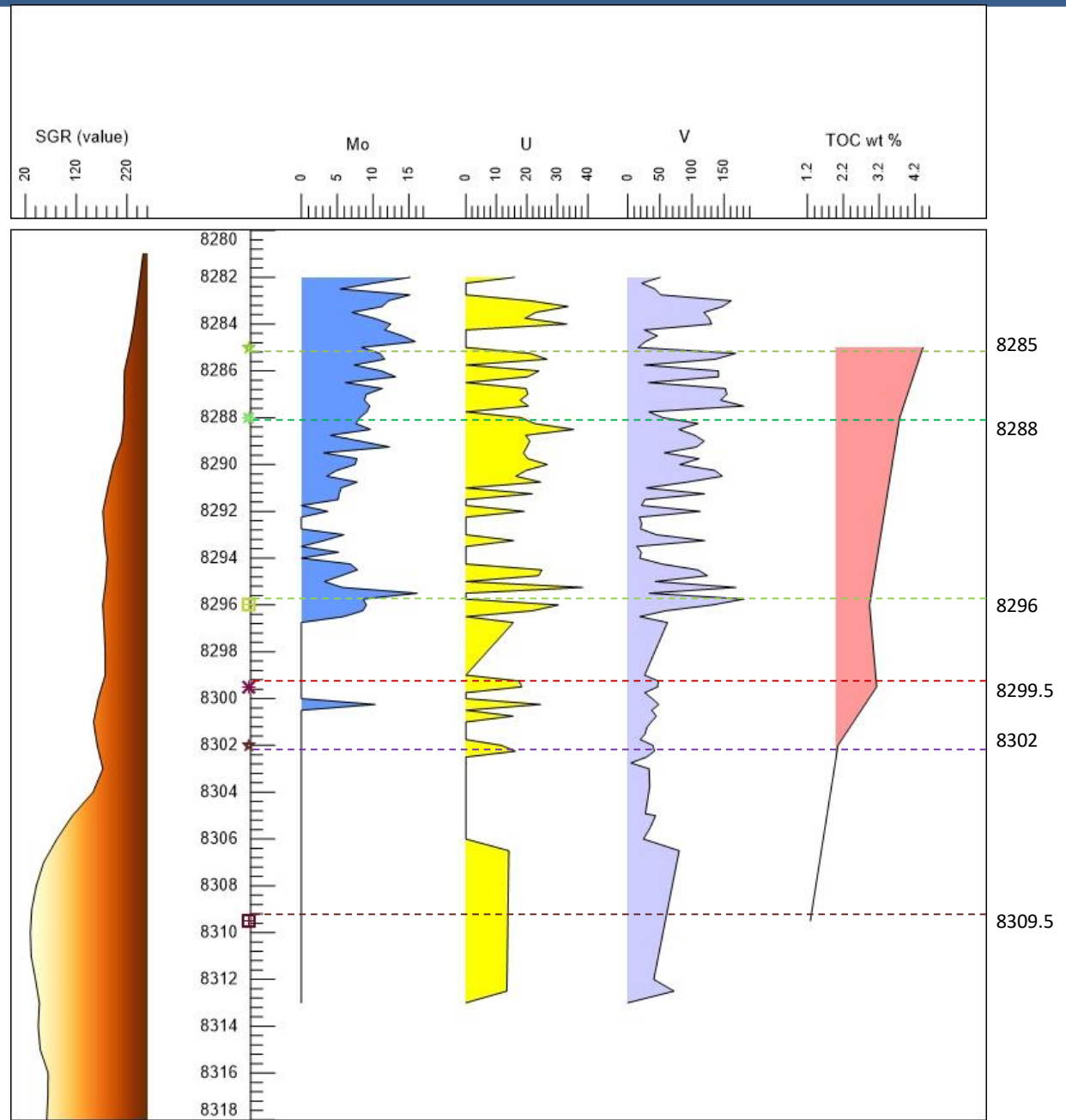
# XRF Major Elements

- Major Elements present
  - Silica
  - Aluminum
  - Potassium
  - Rubidium
  - Zirconium
  - Titanium
- Indicative of terrestrially-derived sediments.



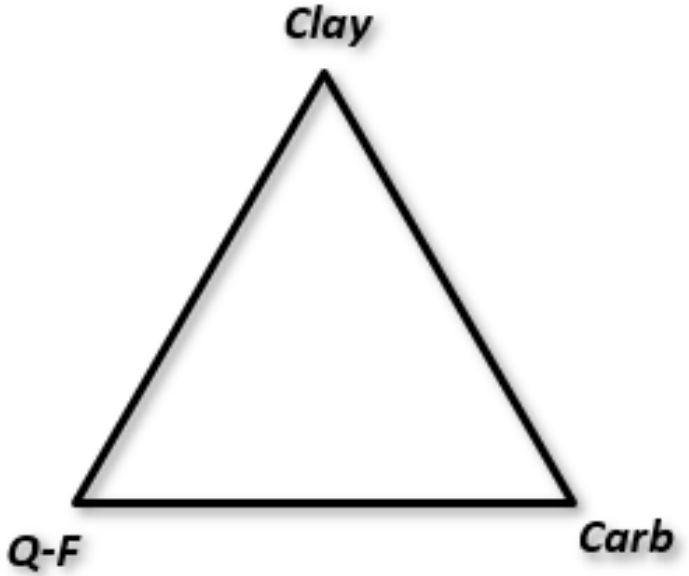
# XRF: Trace Elements

- Trace elements present
  - Molybdenum
  - Uranium
  - Vanadium
- The U and V peaks line up



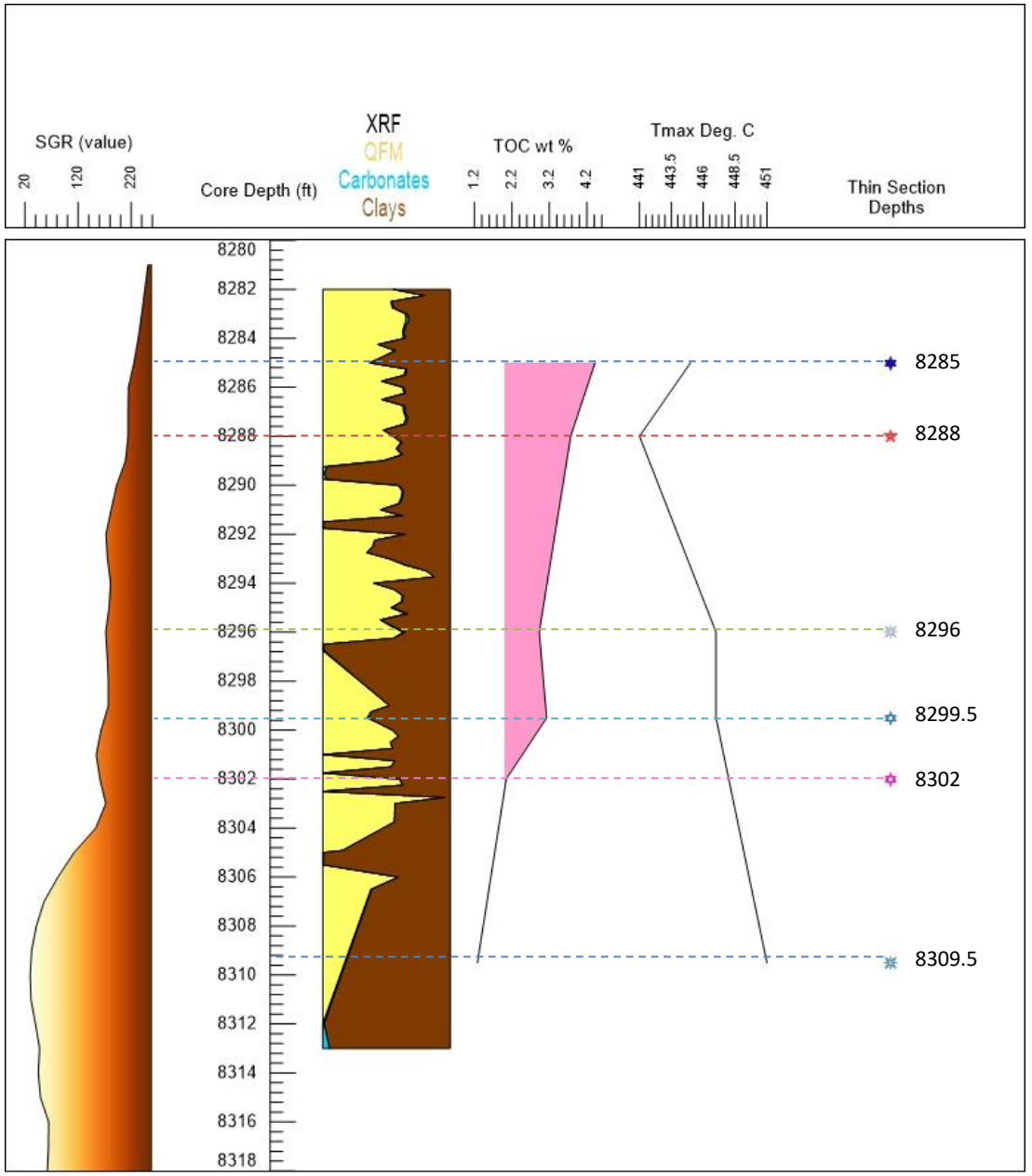
# Mineral Modeling

- Three main components: carbonate, clay, and quartz.
- Plotting the Graneros on a ternary diagram allow it to be easily compared to other shales.
- Three assumptions:
  - Calcium is assigned to calcite
  - All the potassium is assigned to illite
  - Specific portion of silica goes to illite, the remainder is assigned to quartz



# Mineral Model – XRF Comparison

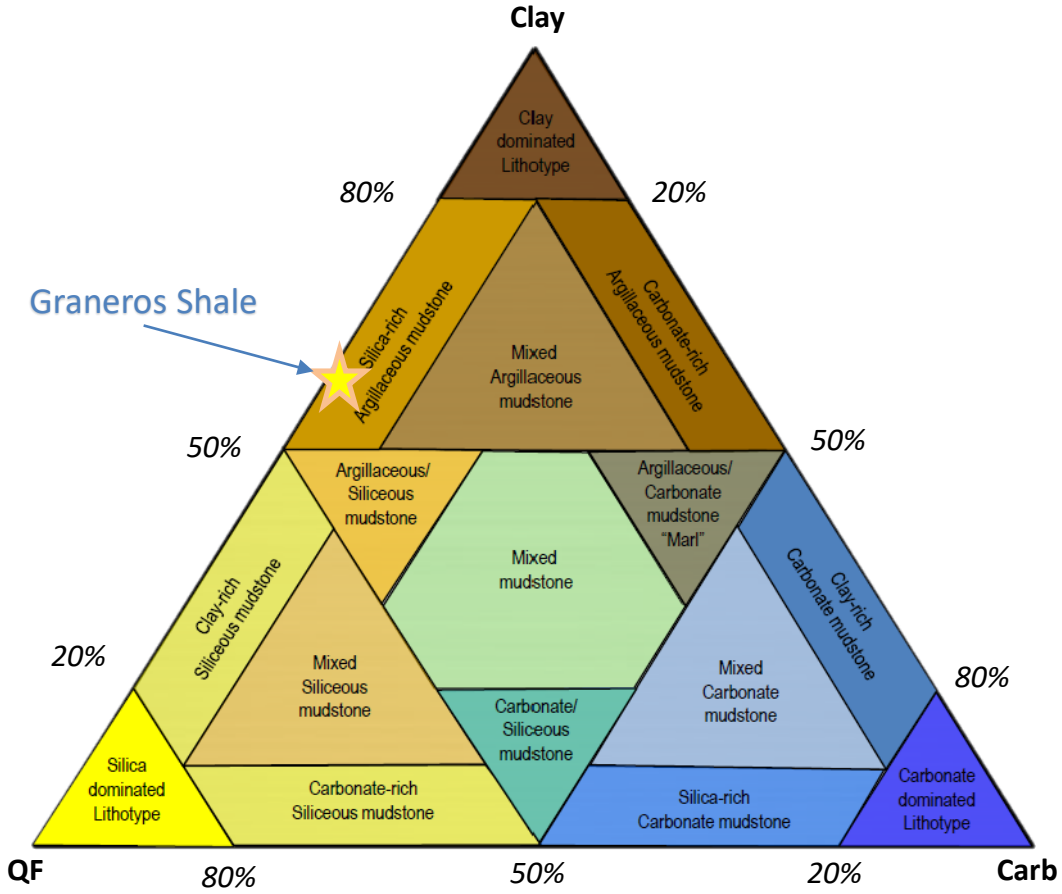
- The Graneros at this core is dominantly clay and quartz.
- TOC and Tmax data is from Pietraszek-Mattner, 1995



# Mineral Model

6-32 Box Elder Farms Averages:

- Illite – 63%
- Quartz – 36%
- Calcite – 1%




*Modified from Gamero-Diaz et al (2012)*

# Mineral Model Comparison

6-32 Box Elder Farms

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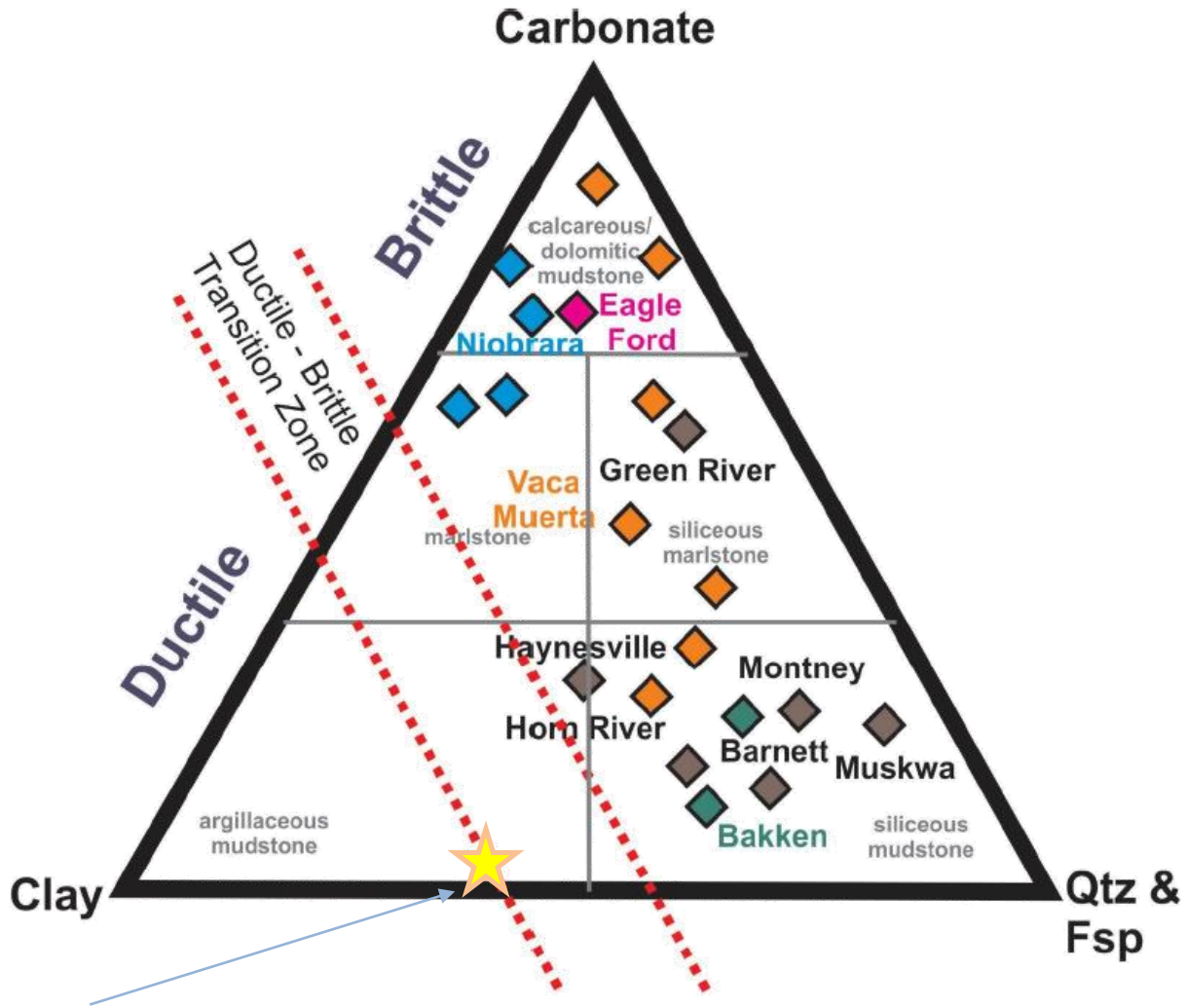


Graneros Shale at Box Elder Farms

*Modified from Sonnenberg (2017)*

# Future Work

- Box Elder Core
  - XRD to compare to XRF and see where mineral model over/under estimates for calcite, illite, and quartz
  - FE-SEM to go to a smaller scale better understand what is going on in thin section (since so fine grained)
- Weld County, CO cores and butt boxes courtesy of Anadarko/Oxy
  - Describe the core, take XRF data, make thin sections, FE-SEM
  - Compare the cores from various wells.

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