# Reservoir Characterization of the Niobrara B Interval at Redtail Field: Weld County, Denver Basin, Northeast Colorado

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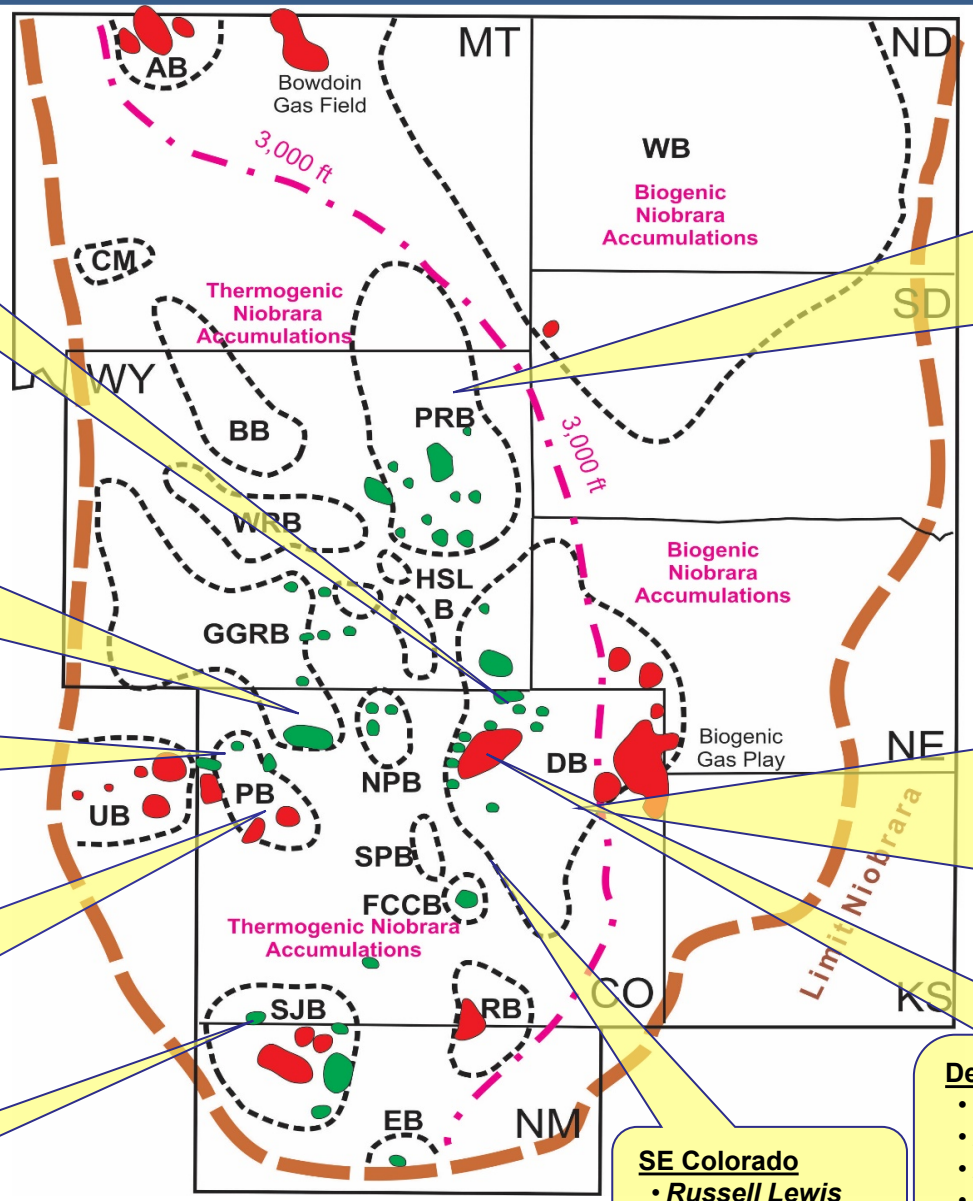
# MUDTOC Regional Research 2010-2020



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- *Steve Crouch*
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- *David Underwood*
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- ❖ Cankut Kondacki (PhD)

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- *Kira Timm (PhD)*
- *Nick Matthies*

Research 2010 – 2020
- *Completed Theses*
- ❖ In Progress

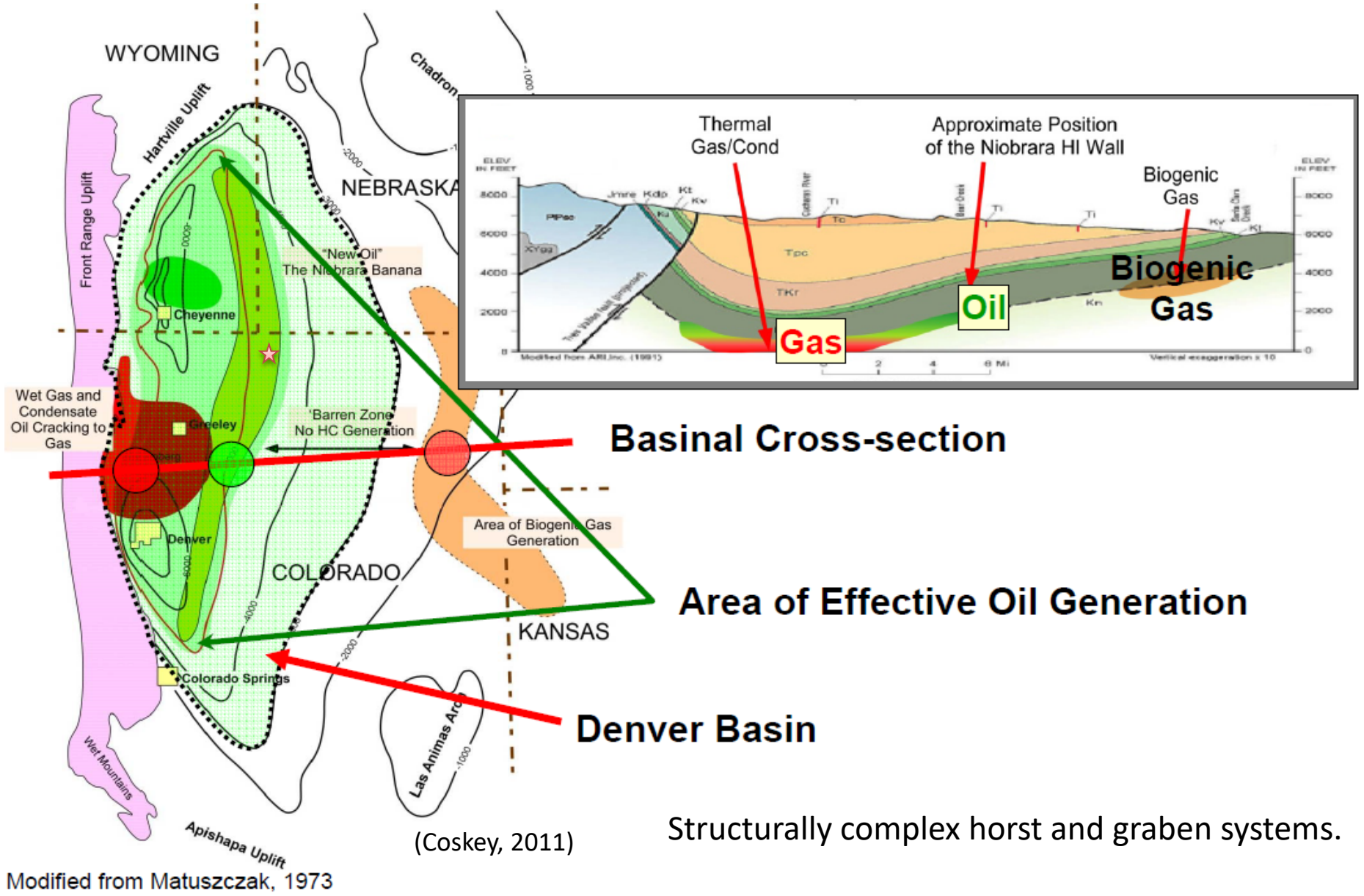
# Outline



- Introduction
- Geologic Maps and Study Area
- Type Well
- Well Core Photos
- Pyrolysis Data
- X-ray Fluorescence (XRF) Analysis
- Future Work

# DJ Basin Cross Section





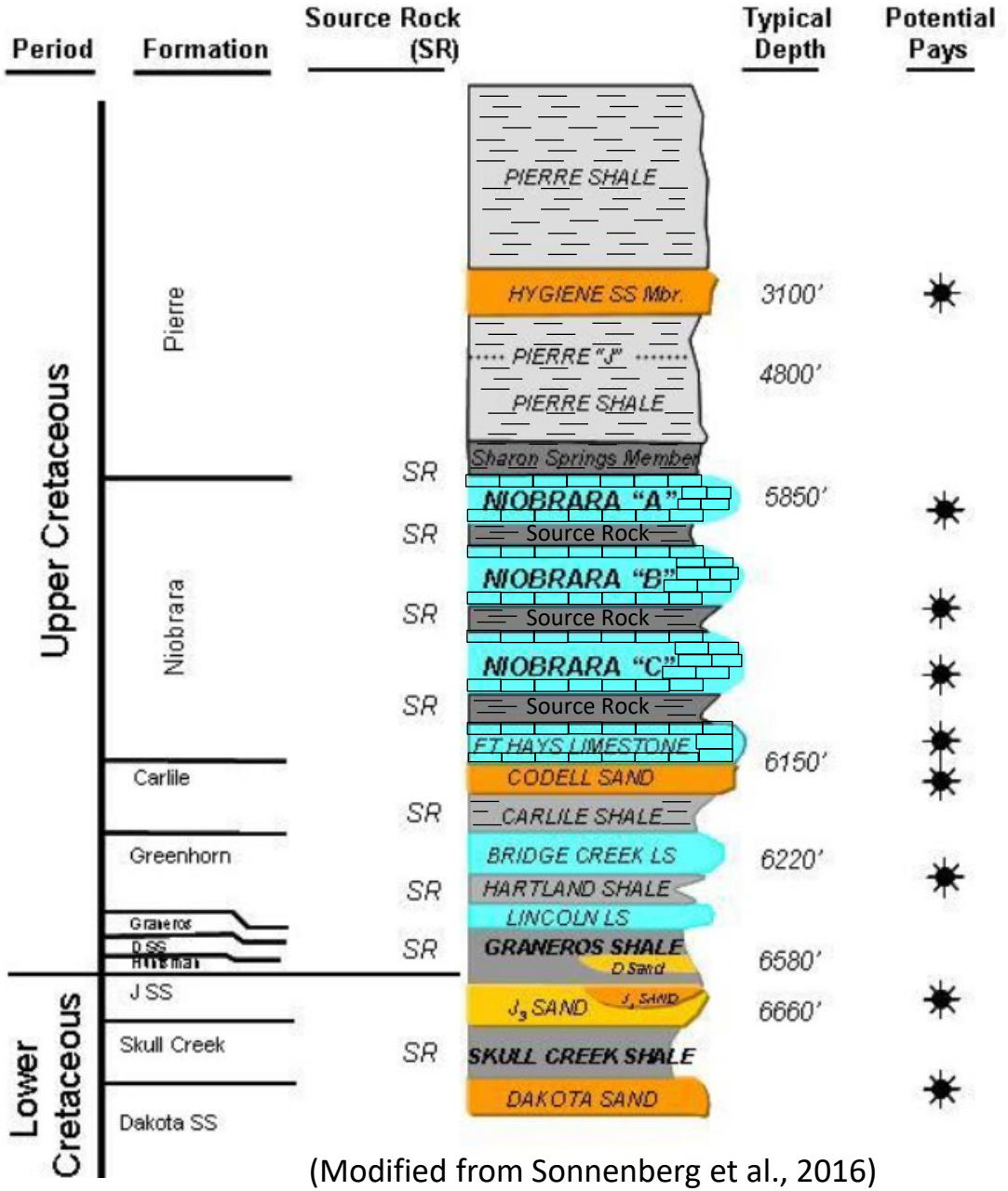

(Coskey, 2011)

Modified from Matuszczak, 1973

Structurally complex horst and graben systems.

# DJ Basin Stratigraphic Column

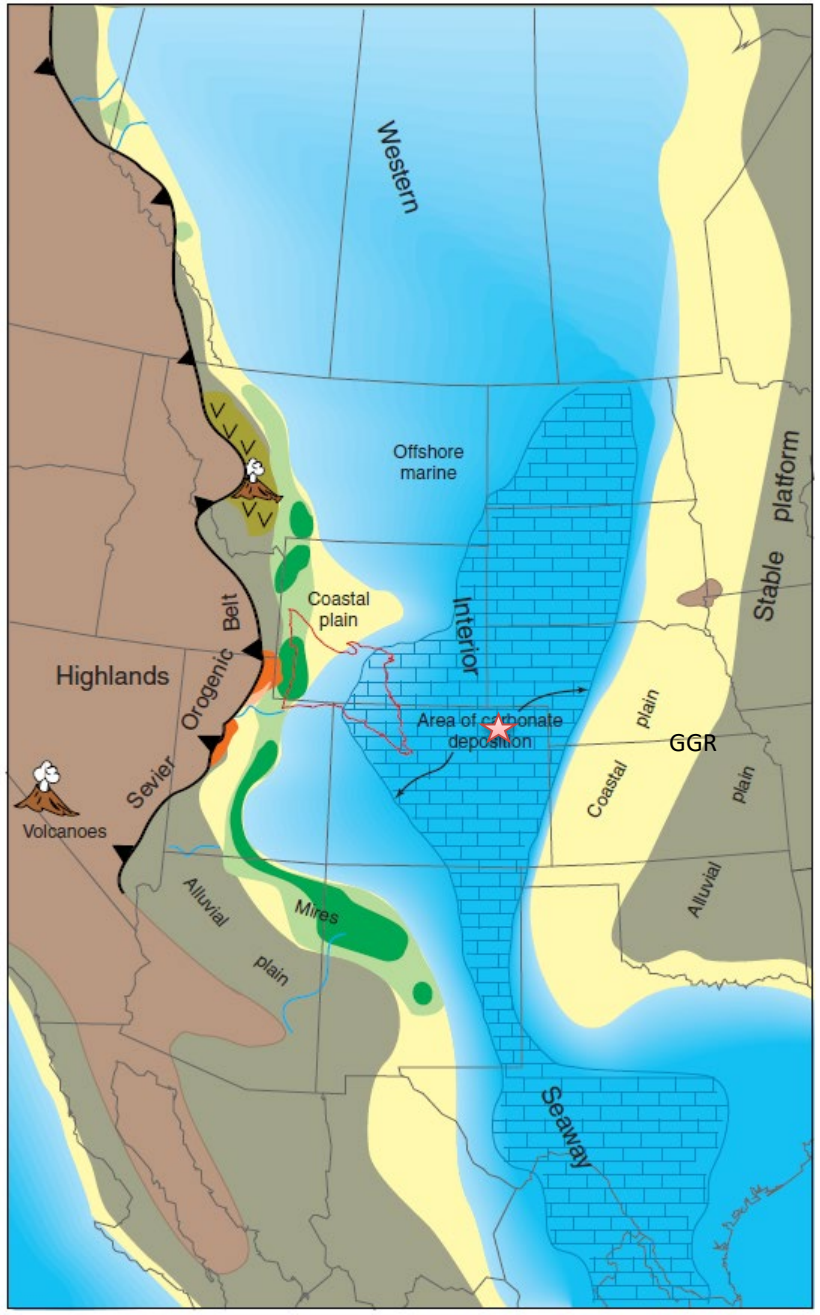





(Modified from Sonnenberg et al., 2016)

The age of the Niobrara Formation is Coniacian, Santonian, and Campanian of the Late Cretaceous (81-89 mya)

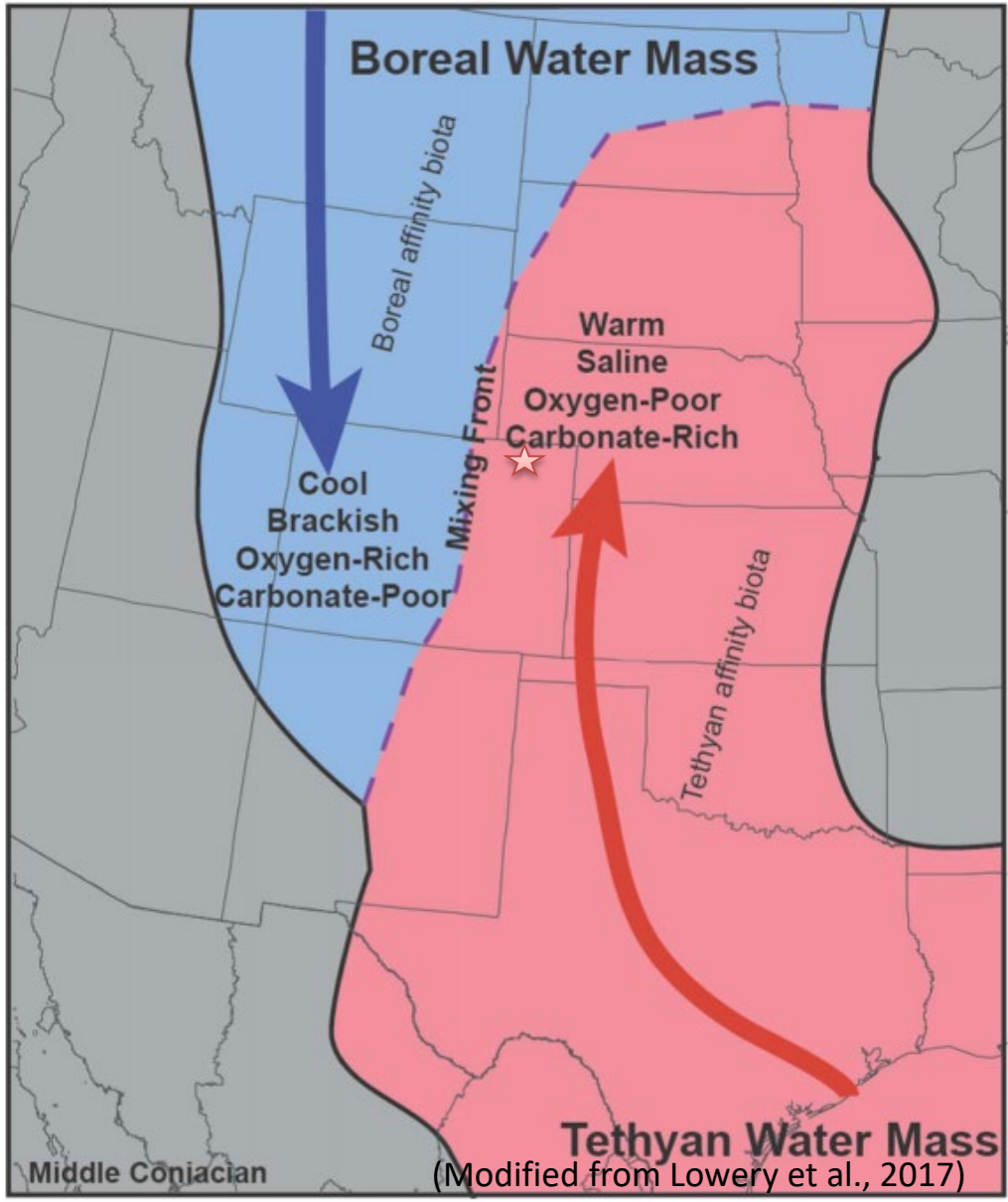
# Western Interior Seaway




(Modified from Finn and Johnson, 2005)

Western Interior Seaway during the Coniacian-Santonian time of the Late Cretaceous.

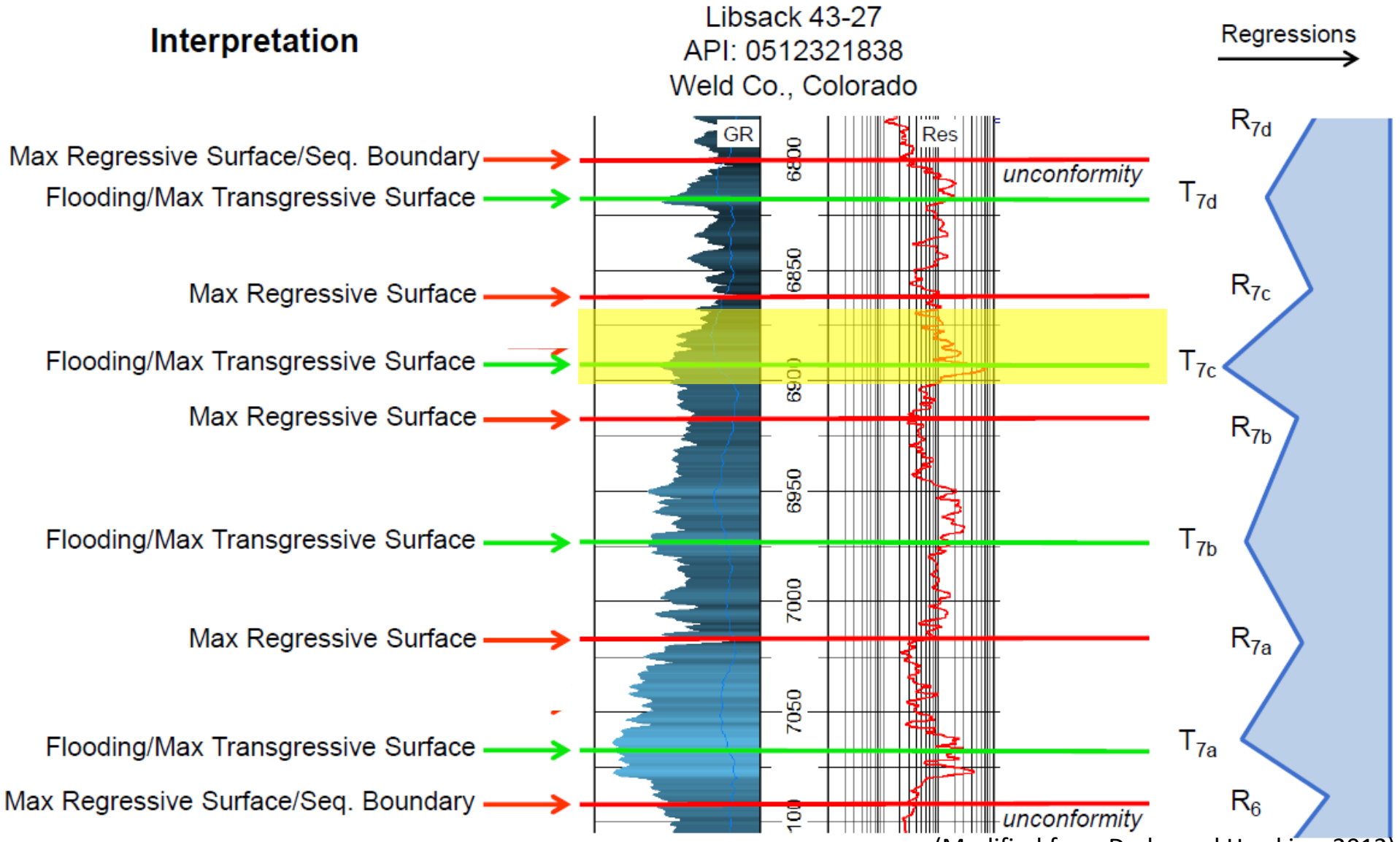
During this time nutrient rich cold-water from the north and warm-water from the south mixed together and created a pristine environment for algae to grow.




(Modified from Lowery et al., 2017)

# Western Interior Seaway Cycles






(Modified from Drake and Hawkins, 2012)

Deposition during a marine transgressive cycle (Niobrara Cyclothem)

Boxed in yellow is the Niobrara B interval and was deposited during a marine transgressive cycle

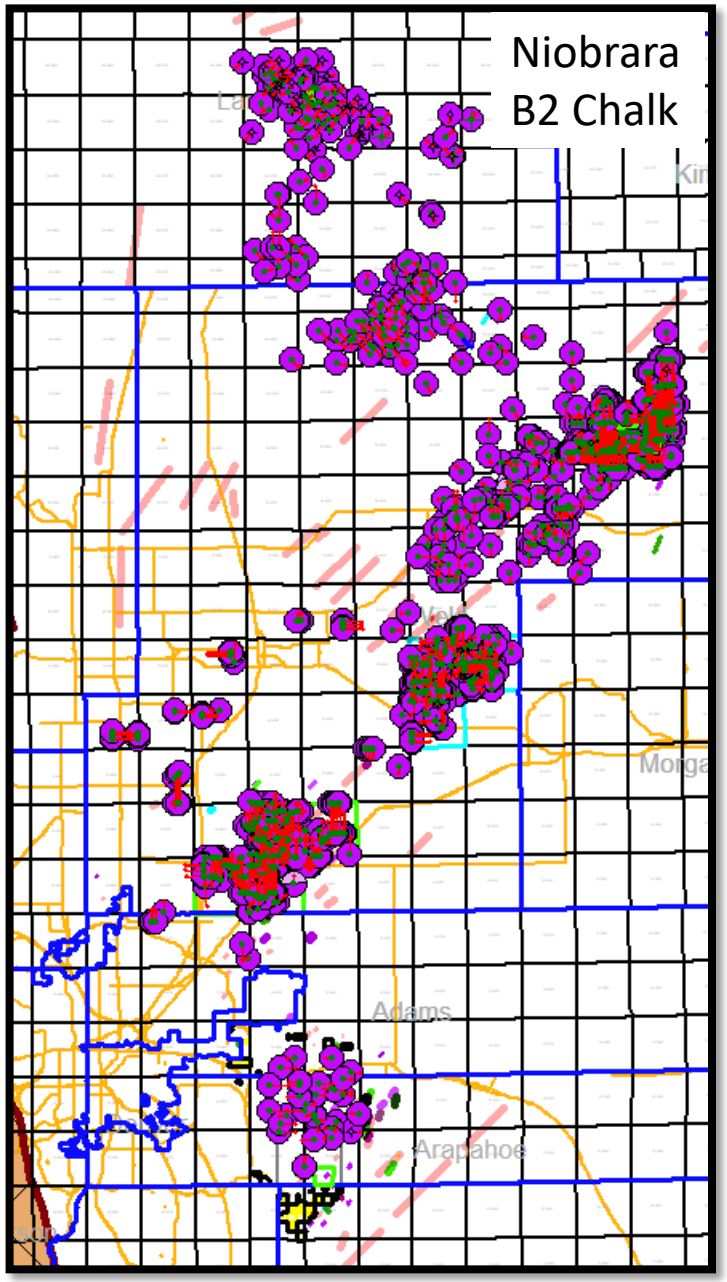
# Niobrara Production

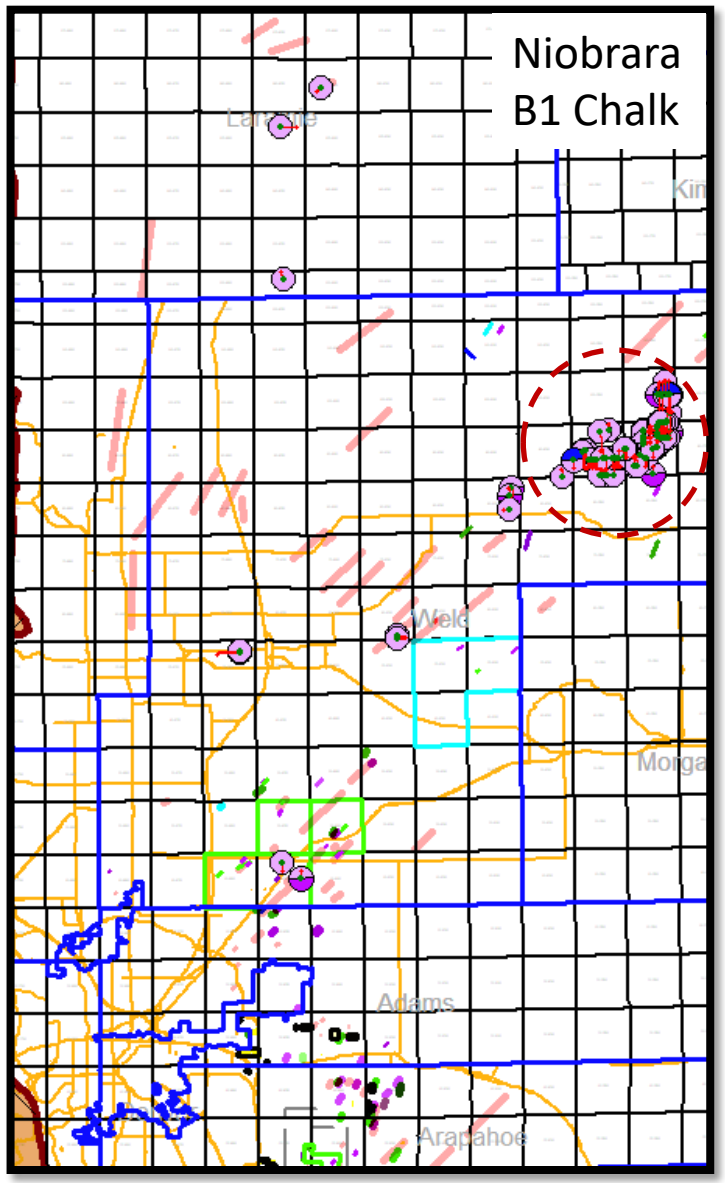


2,617 total production zones pick for horizontal wells including: Niobrara A, B1, B2, C, D intervals, the Fort Hays Limestone and the Codell Sandstone.

Out of all these horizontal wells, 44.4% are producing out of the Niobrara B2 chalk and 3.6% out of the Niobrara B1 chalk.

These zones were picked and maps were made while interning at GMT Exploration.



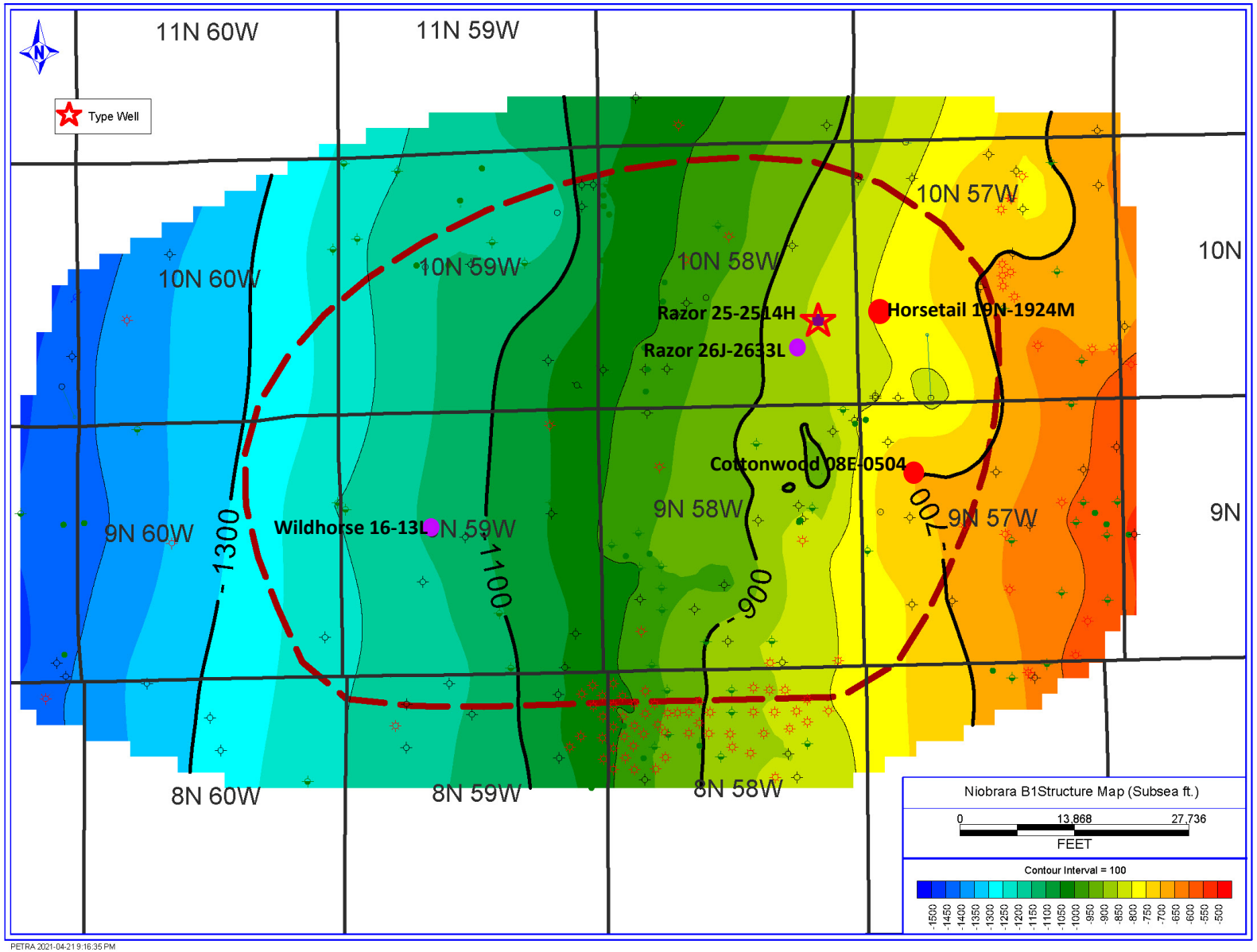




Wells with Niobrara B1 Chalk as Production Zone

Wells with Niobrara B2 Chalk as Production Zone

# Niobrara B1 Structure Map






In Redtail Field the Niobrara Formation is at a depth of -700-1,250ft subsea.

266 wells used

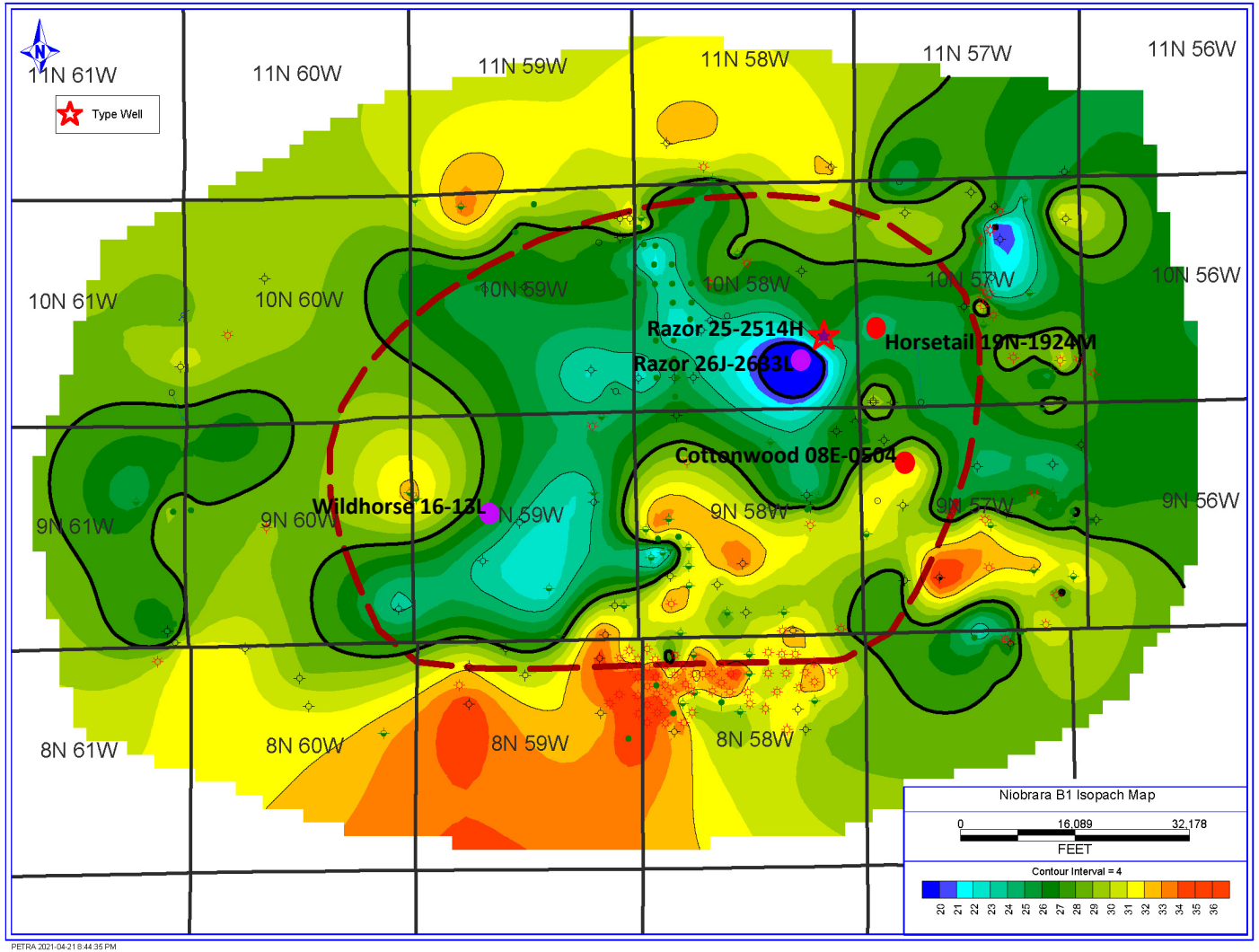
Three wells shown in red have core that fully includes the B1 and B2 intervals and are: Razor 25-2514H, Horsetail 19N-1924M, and Cottonwood 08E-0504.

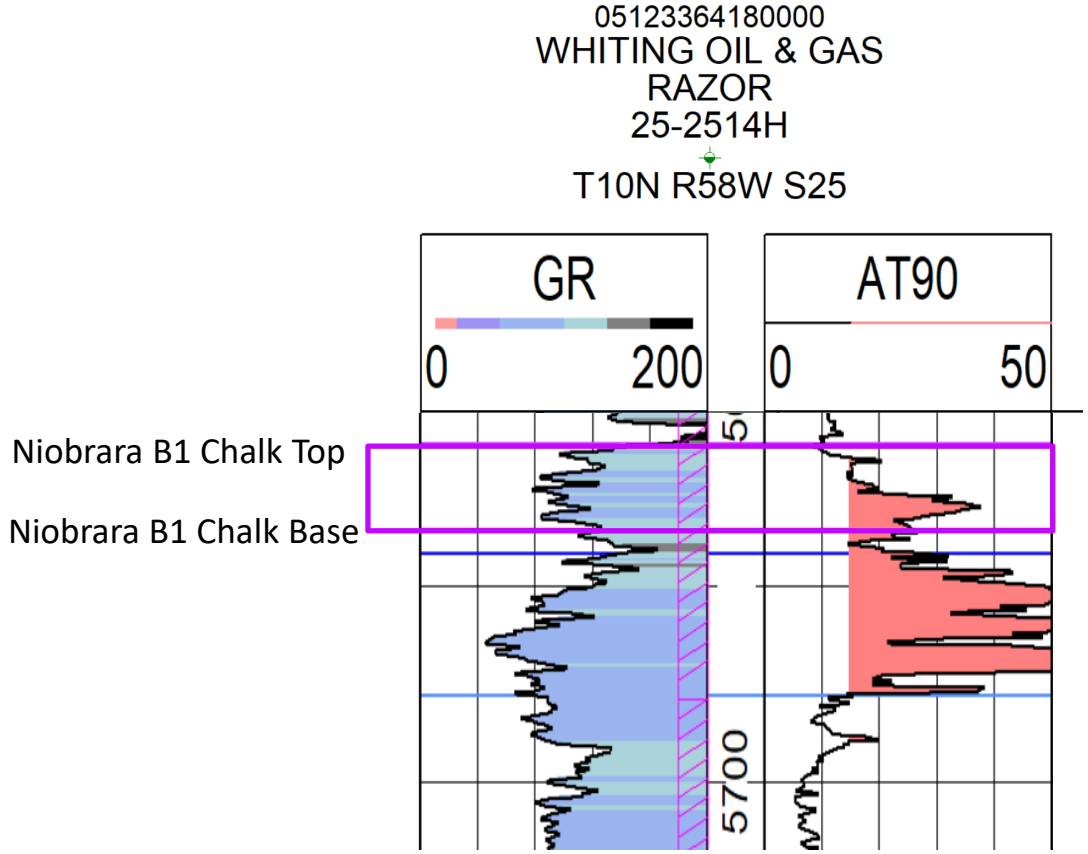
Two wells shown in purple have core that partially includes the study interval and they are: Razor 26J-2633L and Wildhorse 16-13L.

These well cores were provided by Whiting Petroleum.

# Niobrara B1 Chalk Isopach Map



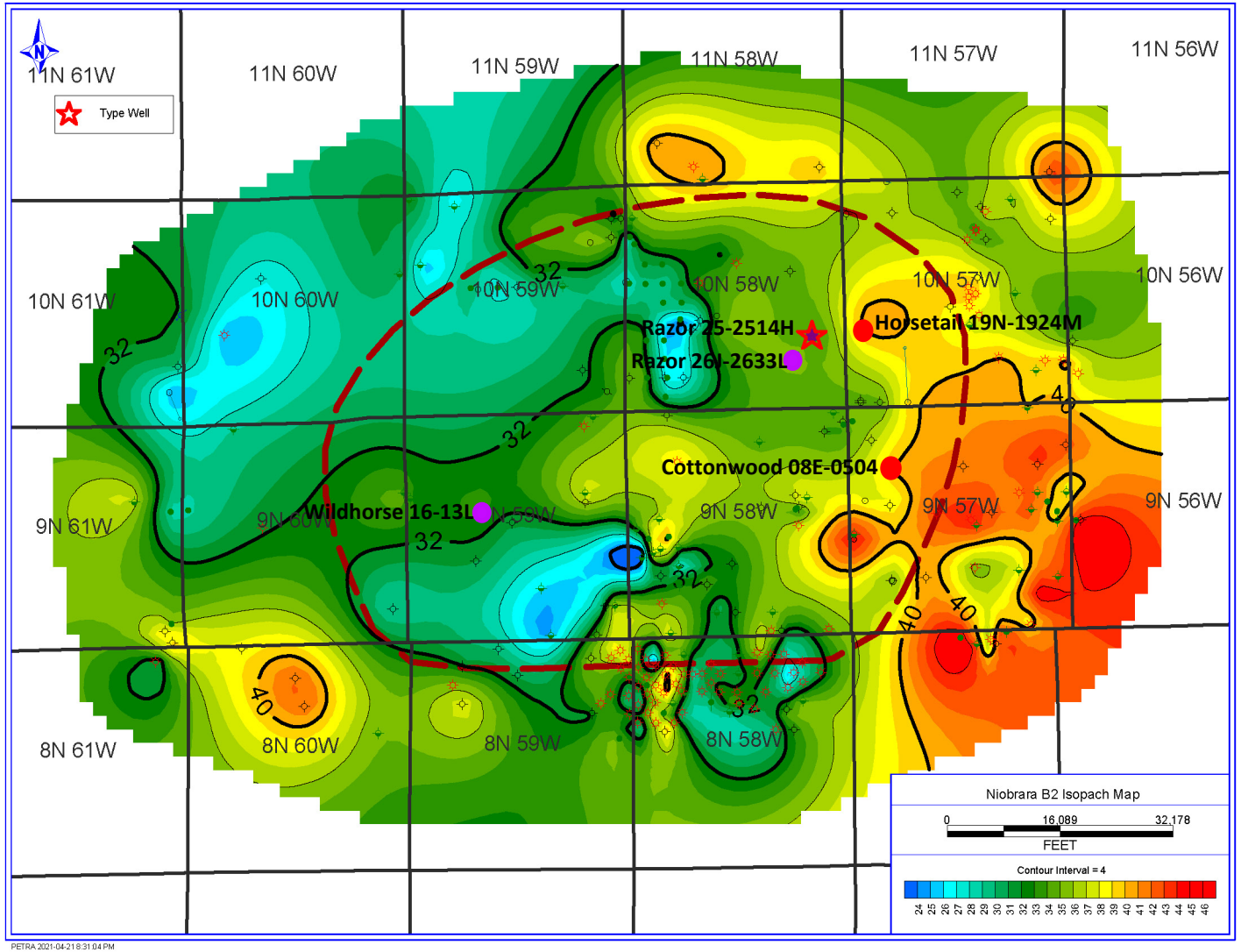


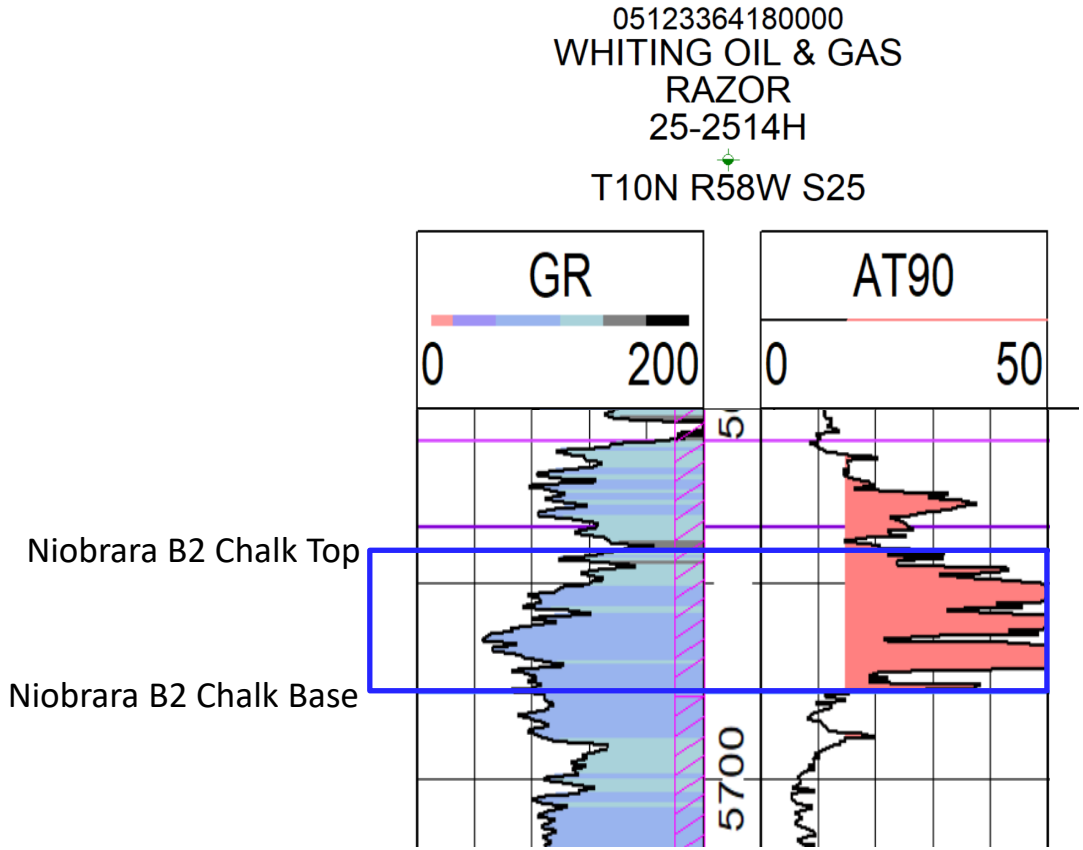




B1 Chalk has a variable thickness in the field ranging from 20-35 ft.
The dark blue spot is the location of the Razor 26J-2633L well. The thickness of the other interval seem appropriate and my current theory is that there is a fault that thinned the Nio B1.

# Niobrara B2 Chalk Isopach Map






Niobrara B2 has a variable thickness in the field ranging from 24-43 ft. B1 thin is compensated by thicker B2.

# Niobrara Type Well

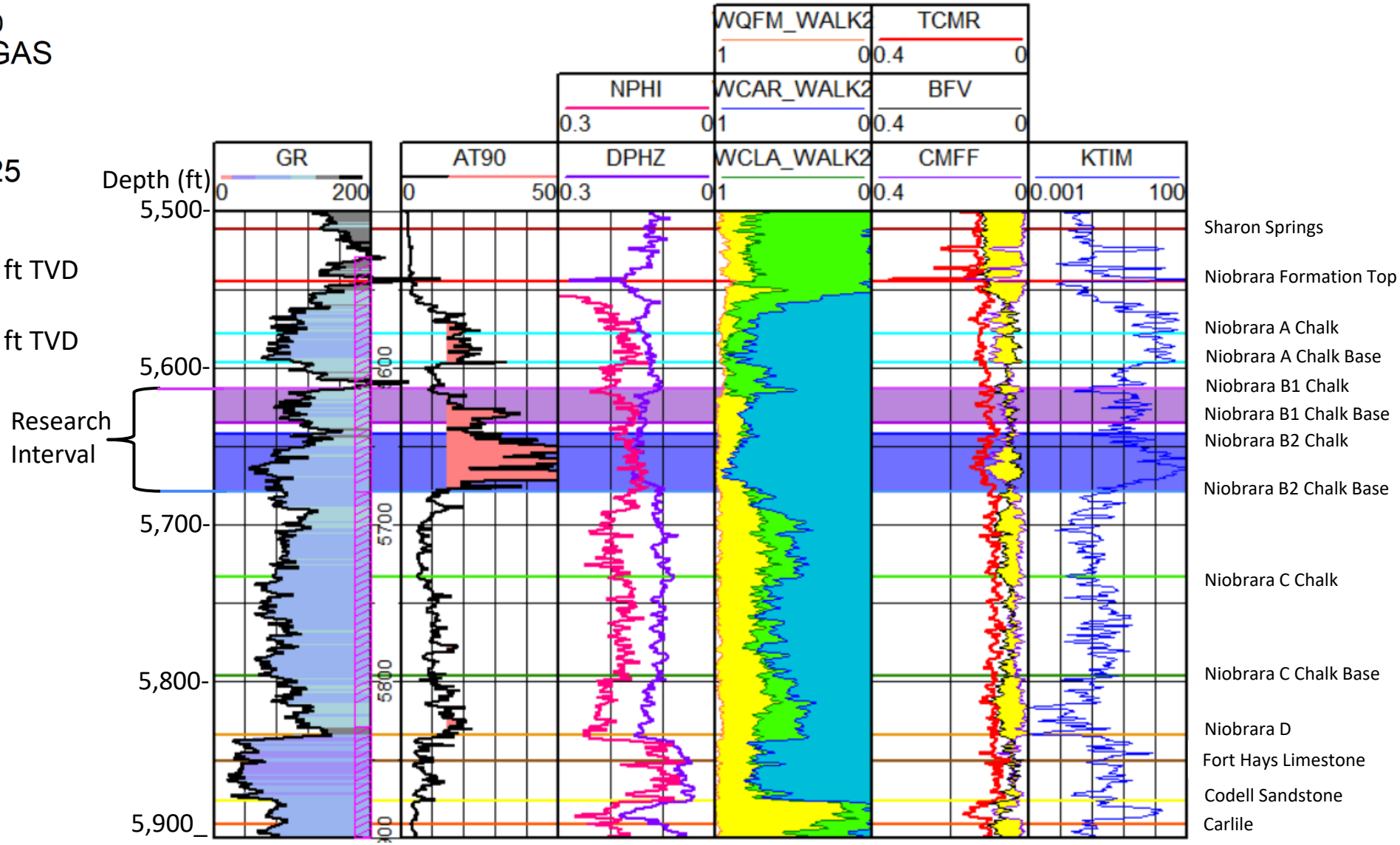


05123364180000
WHITING OIL & GAS
RAZOR
25-2514H

T10N R58W S25

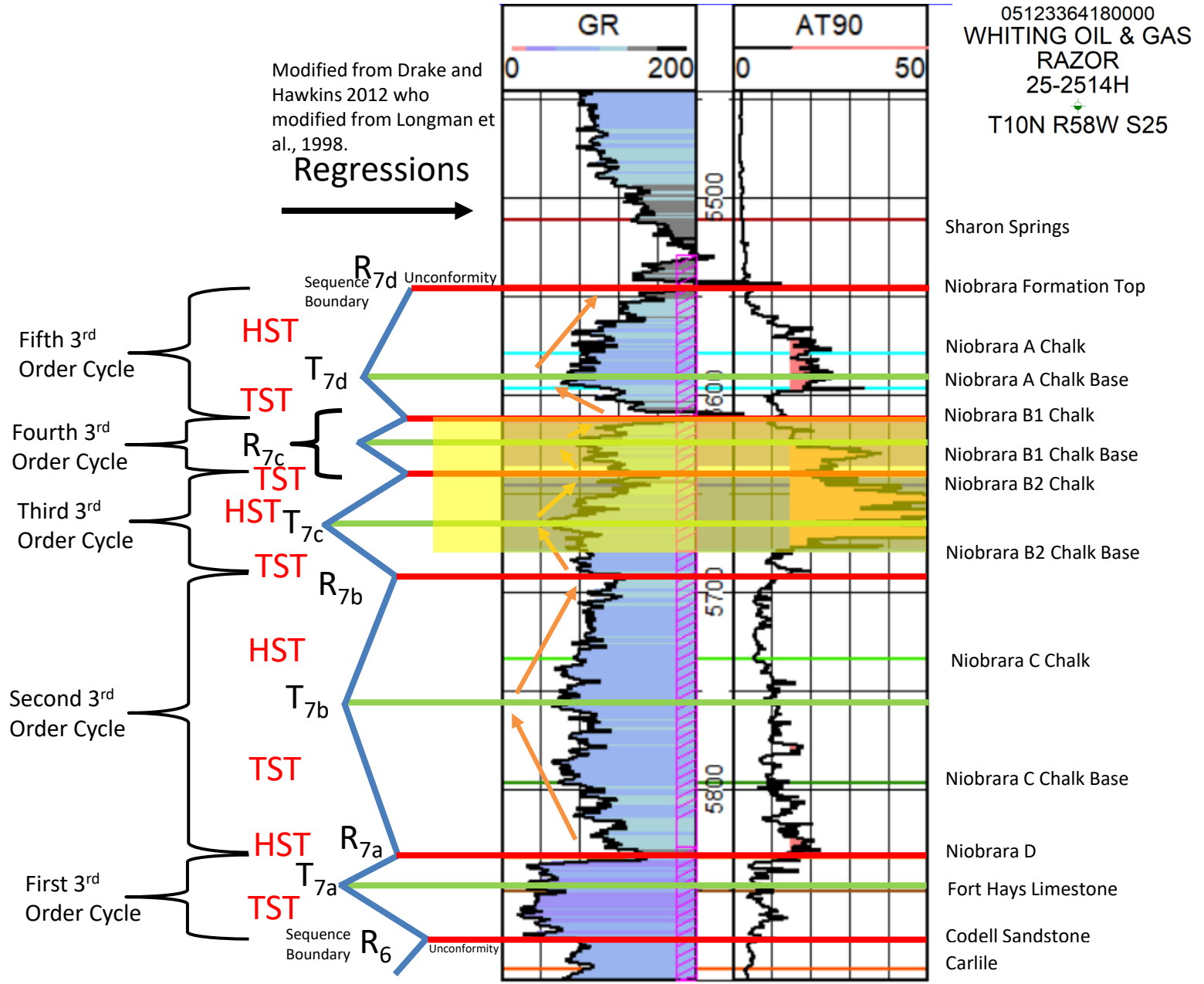
B1 Chalk: 5,613-5,639 ft TVD

B2 Chalk: 5,645-5,678 ft TVD



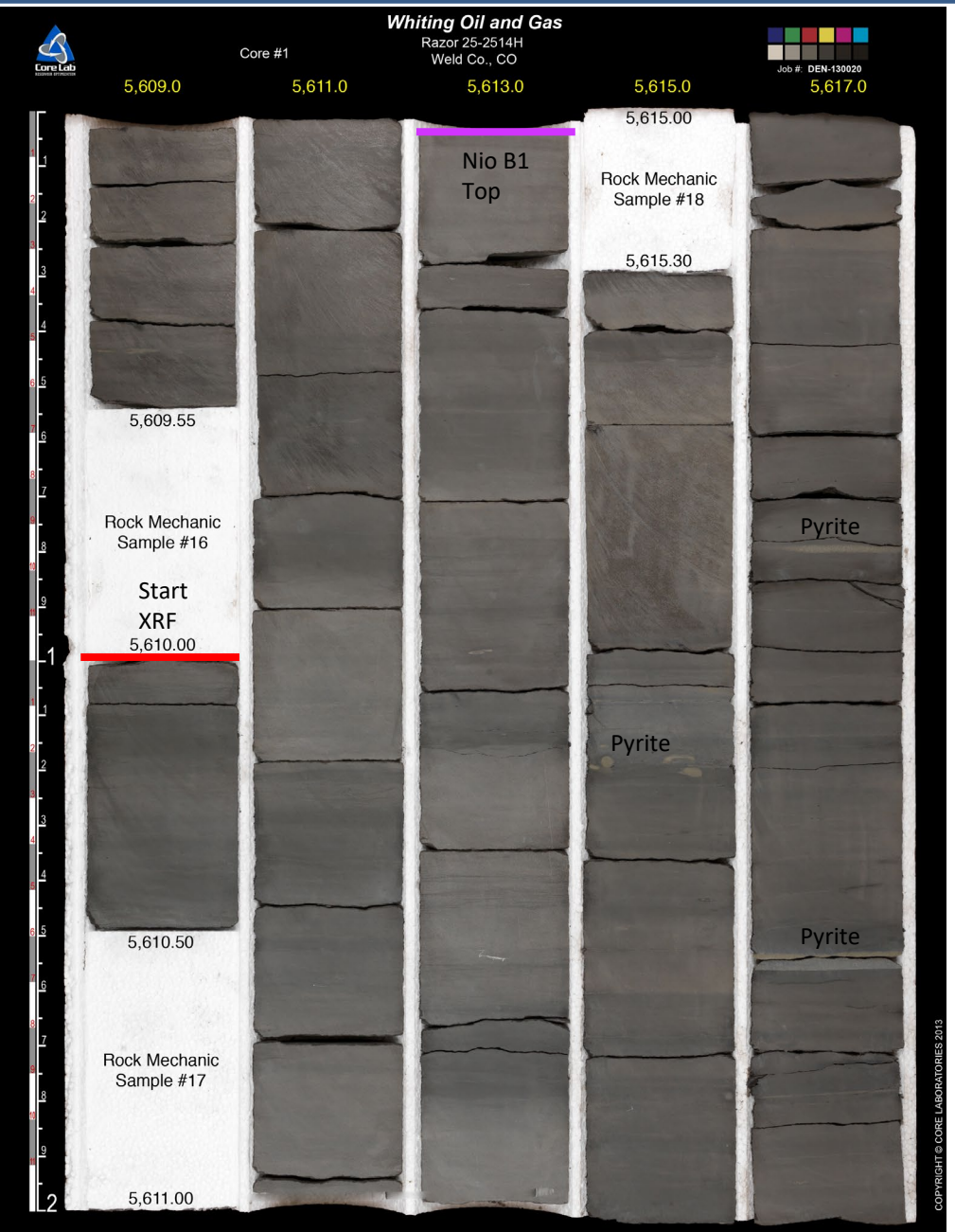
# Adjusted Model for Type Well

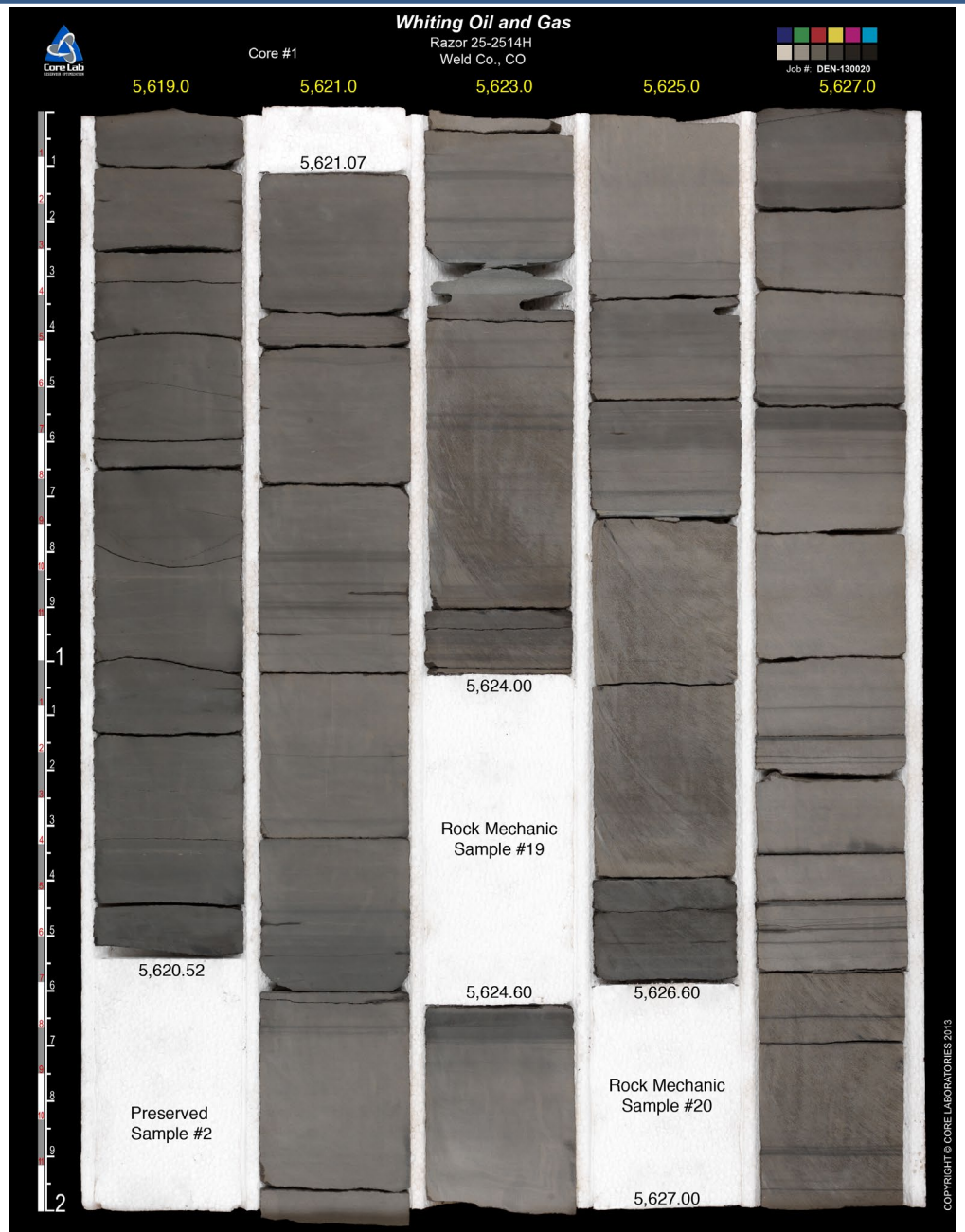
In this region of study the B interval is split into the B1 and B2 Chalks. I adjusted the model because there seemed to be a sea level rise and fall in the $R_{7c}$ period defined by Longman et al., 1998.



# Razor 25-2514H Core Photos

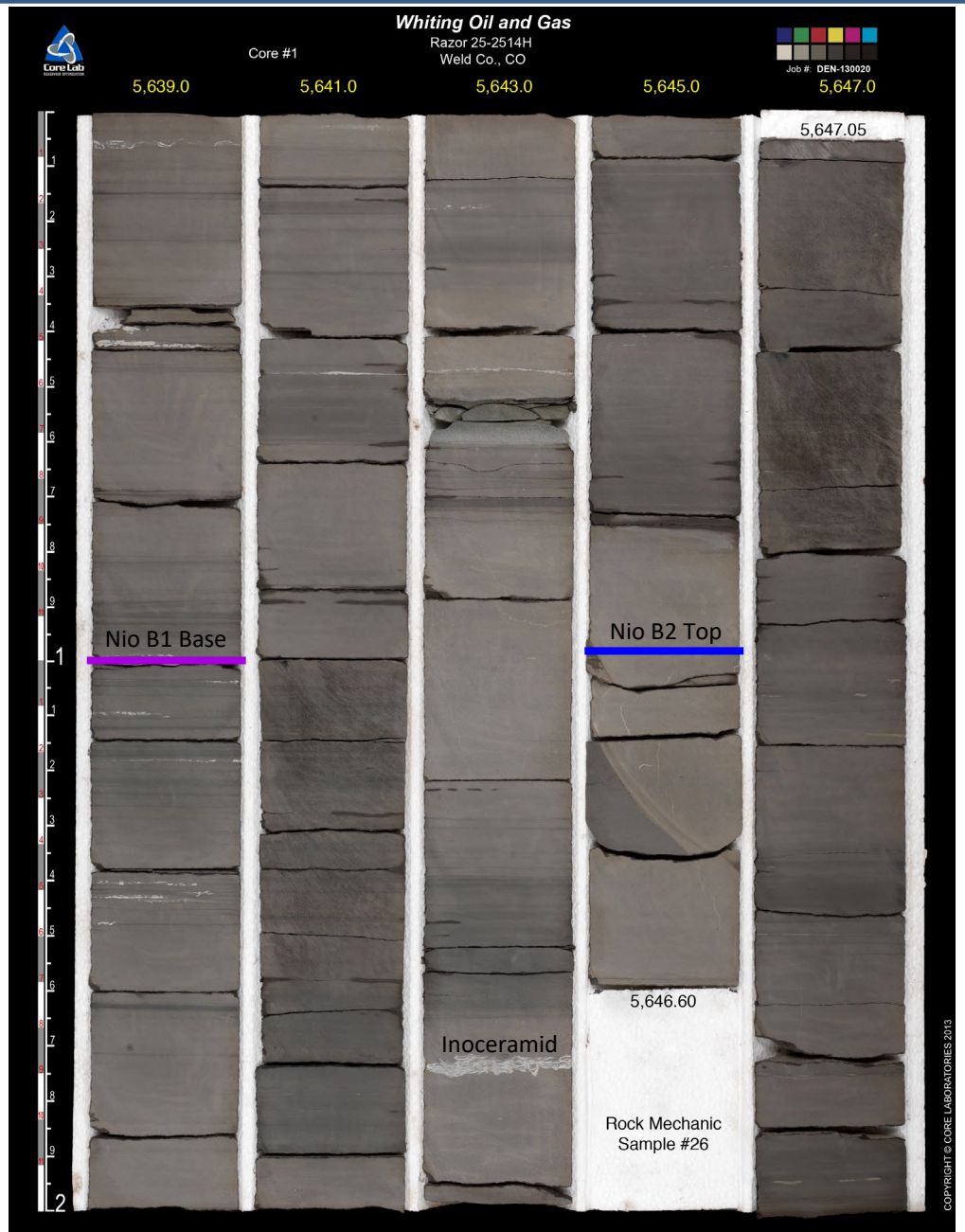




# Razor 25-2514H Core Photos



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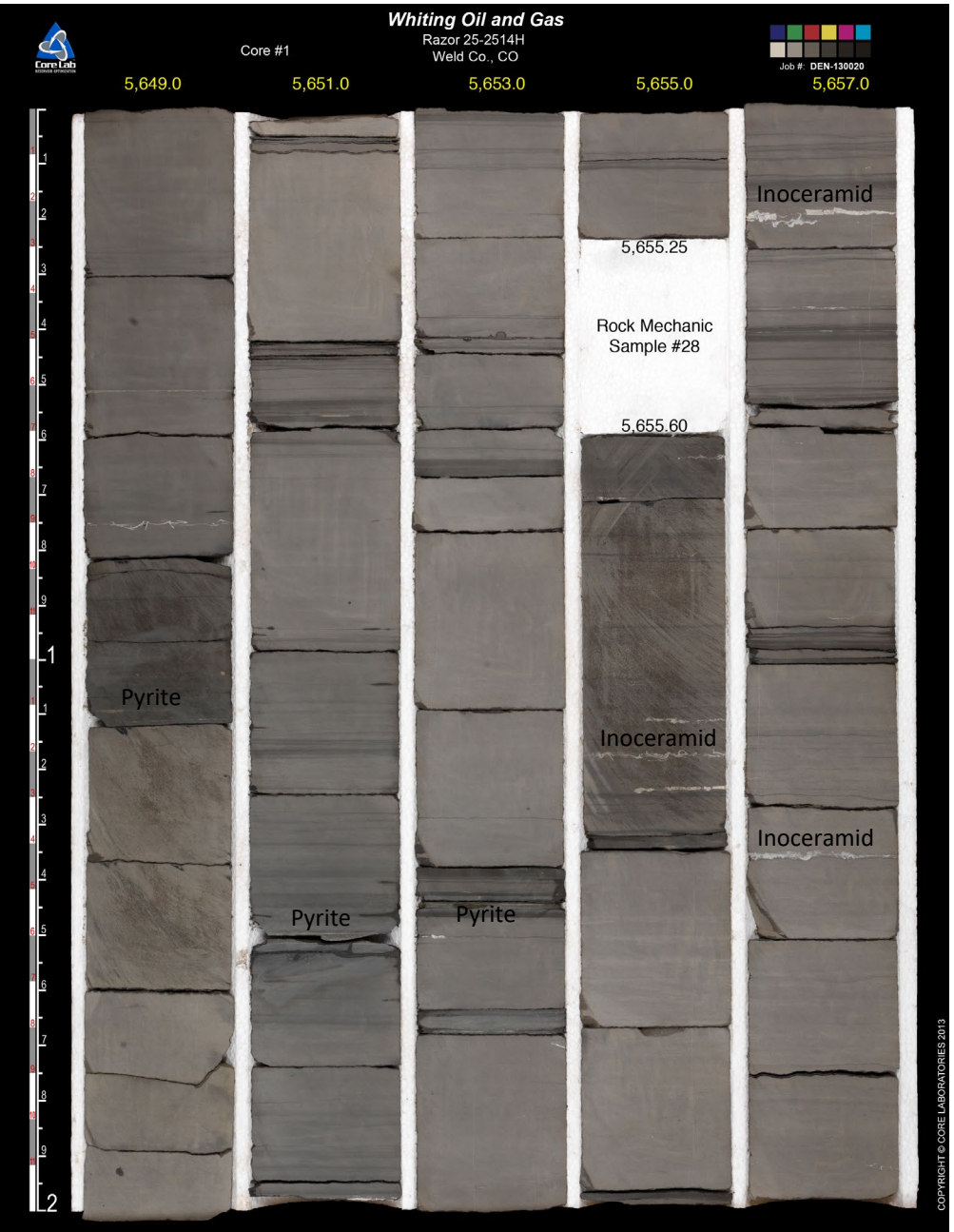


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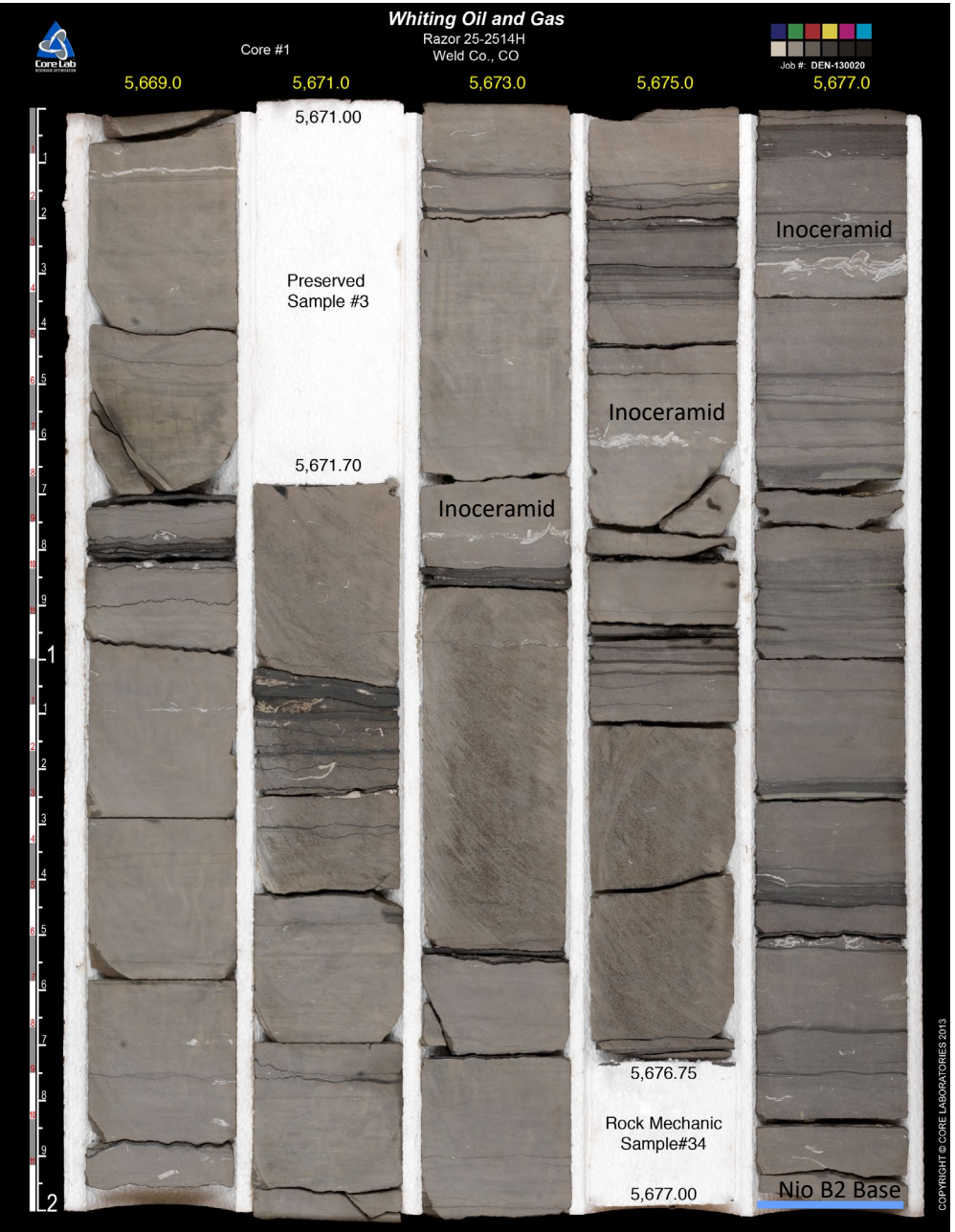
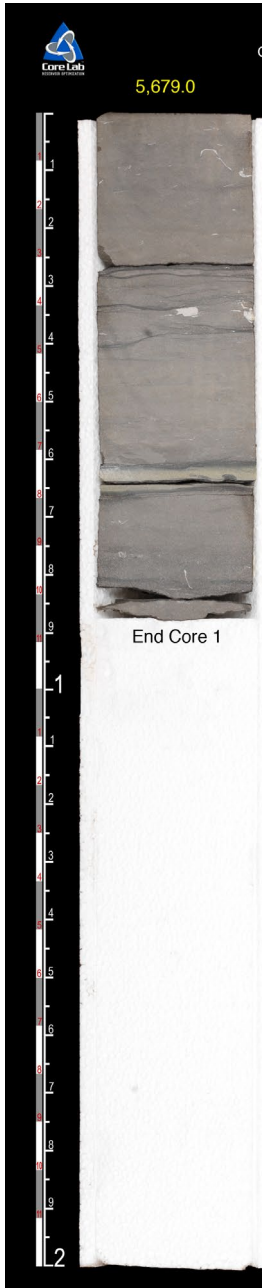


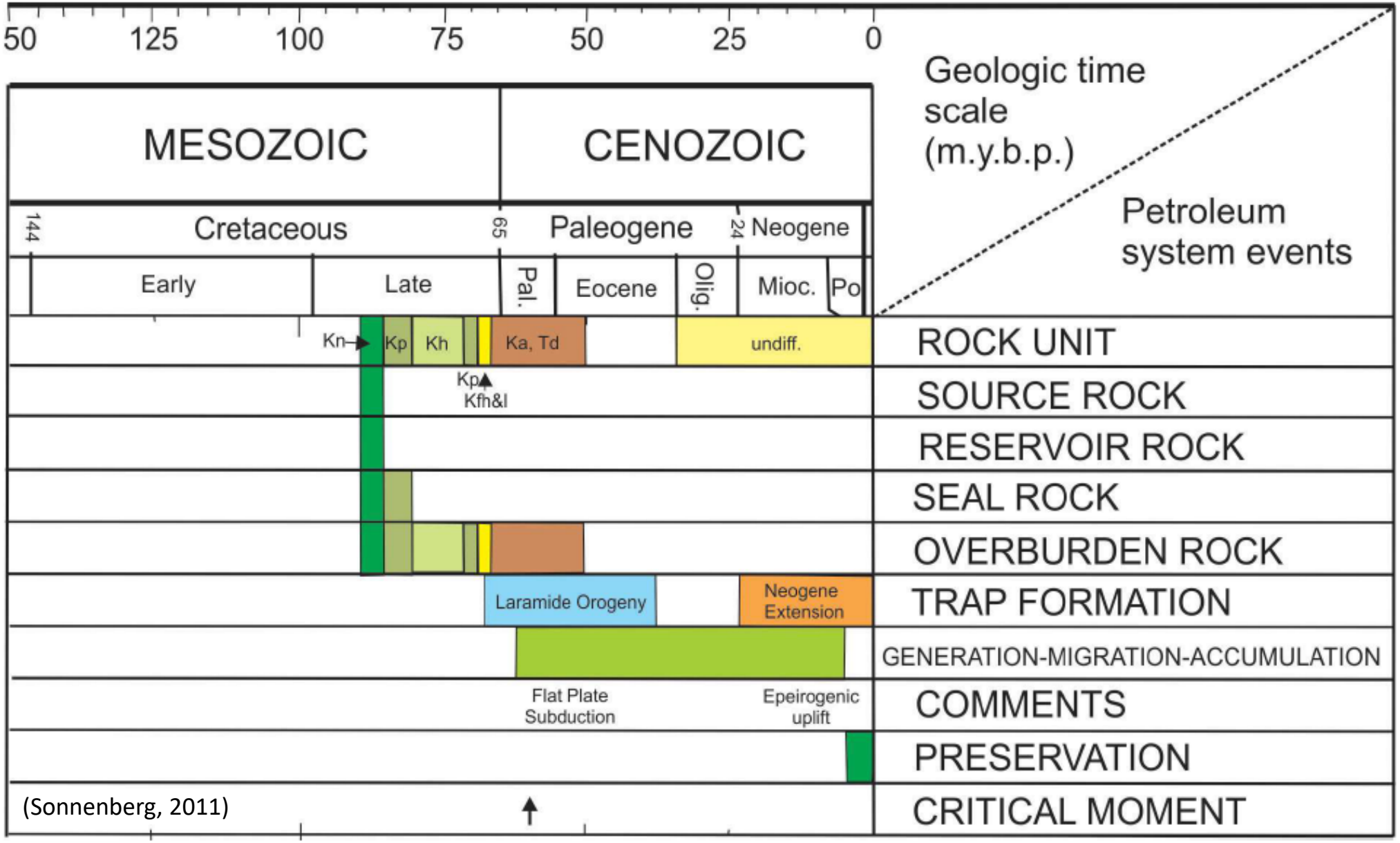

Inoceramids are found in nearshore sandstones to deep sea shales. Most dominant to exclusive macro fossil found in facies associated with oxygen deficient benthic conditions.
Since they had a large gill area, they could survive in oxygen deficient waters.

Have been used to suggest nonanalog bathyal conditions during the Late Cretaceous greenhouse climate.

(Berrocoso, et al., 2008)

# Niobrara Petroleum System Events Chart

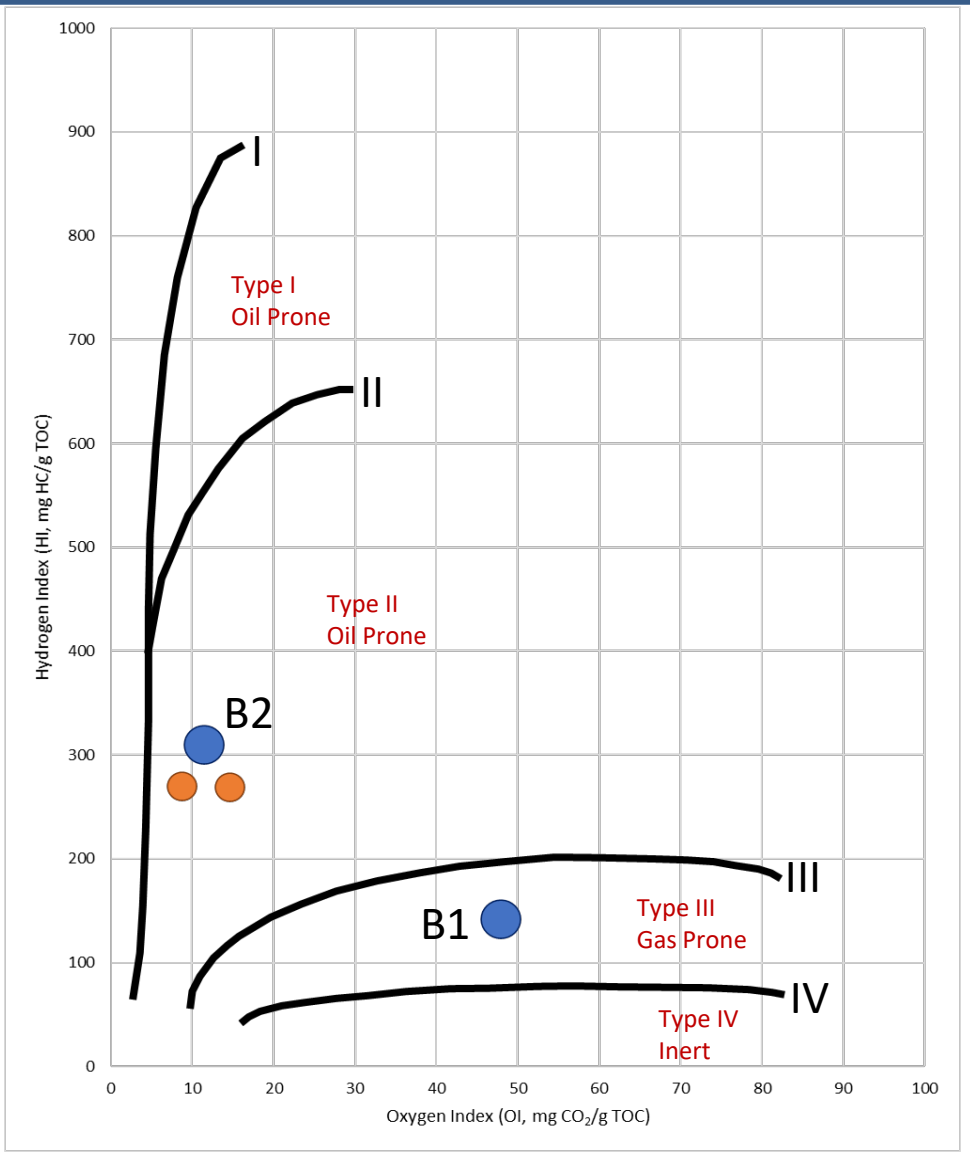





(Sonnenberg, 2011)

# Modified Van Krevelen Diagram



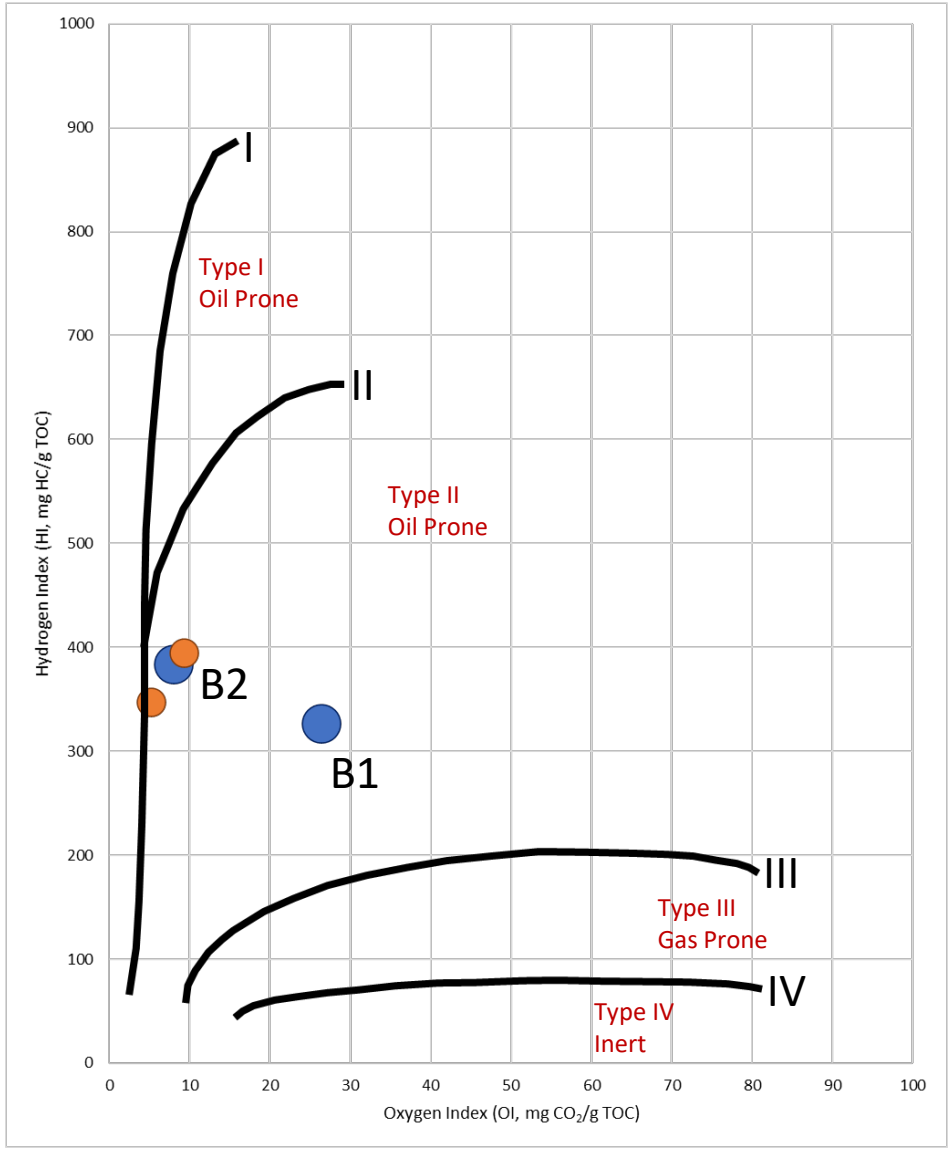



Solvent Extraction

Niobrara B Interval

Niobrara C Interval

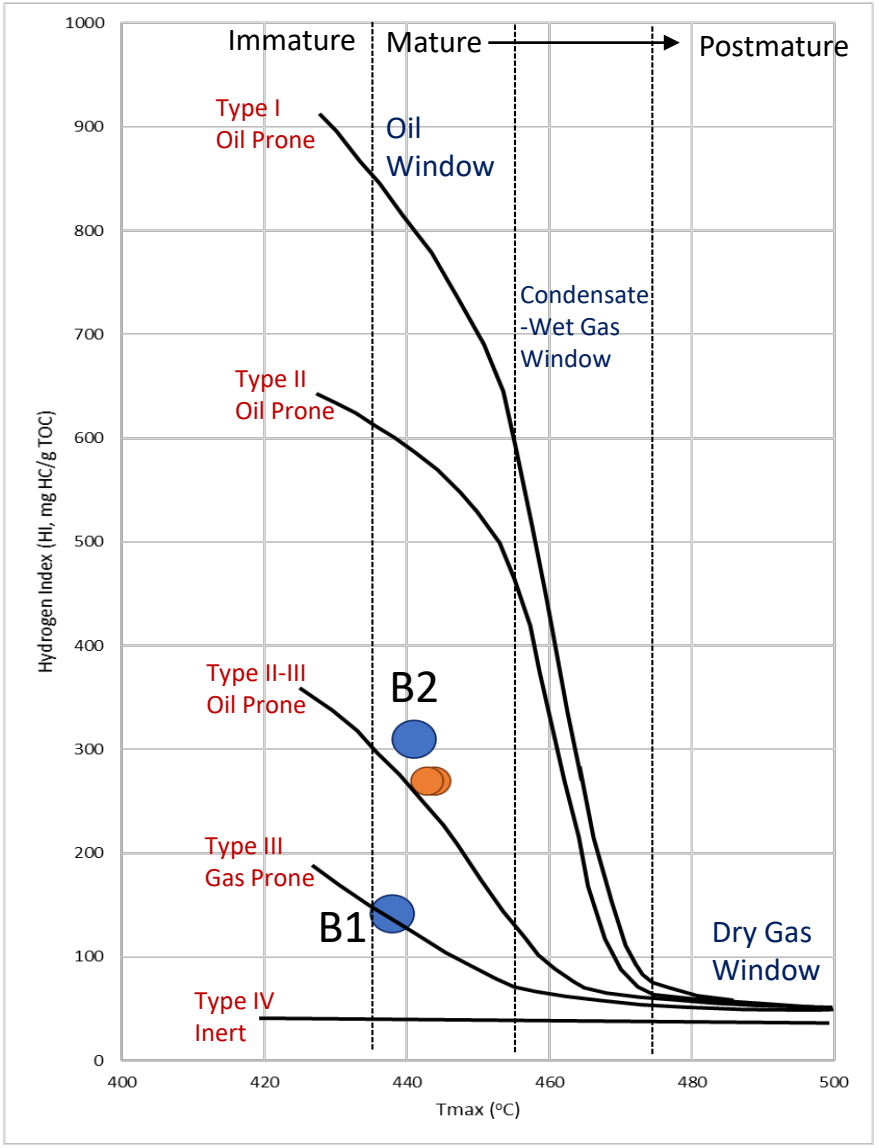
Razor 25-2514H




No Extraction

# Maturity Plot



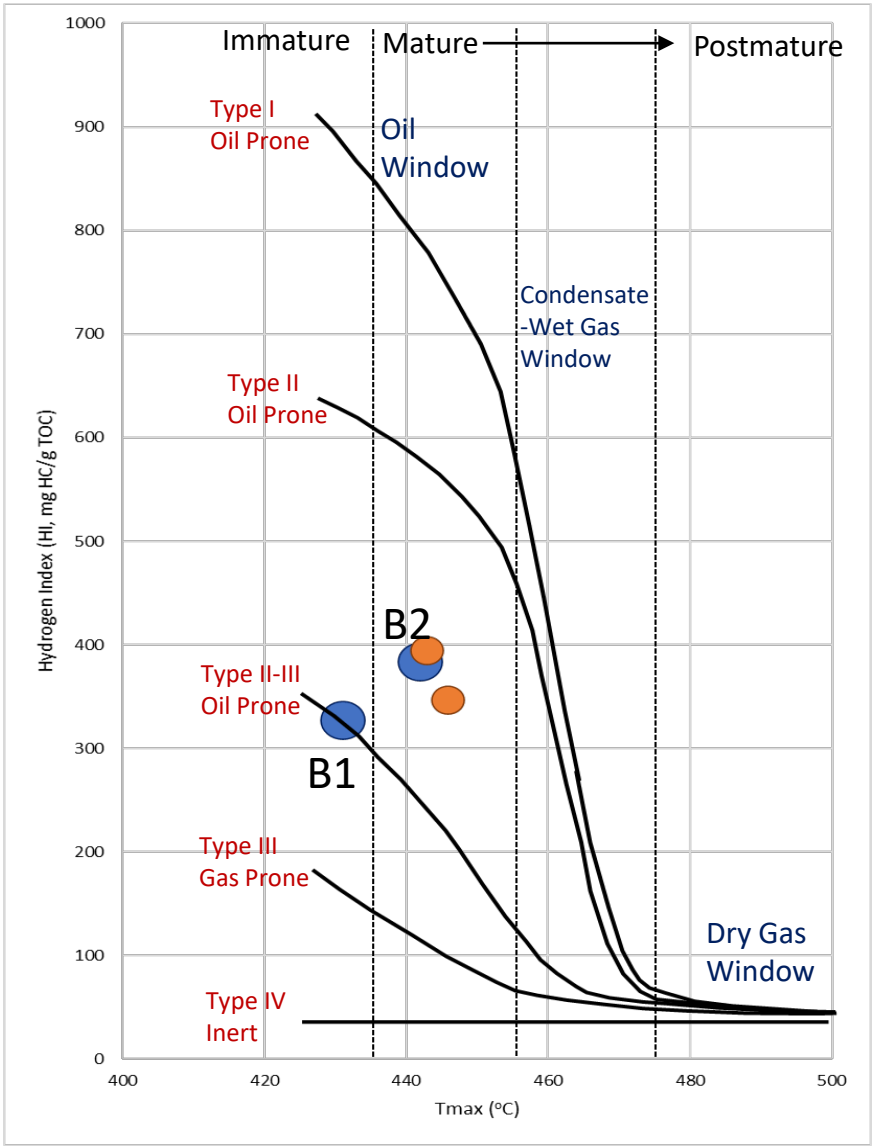



Solvent Extraction

Niobrara B Interval

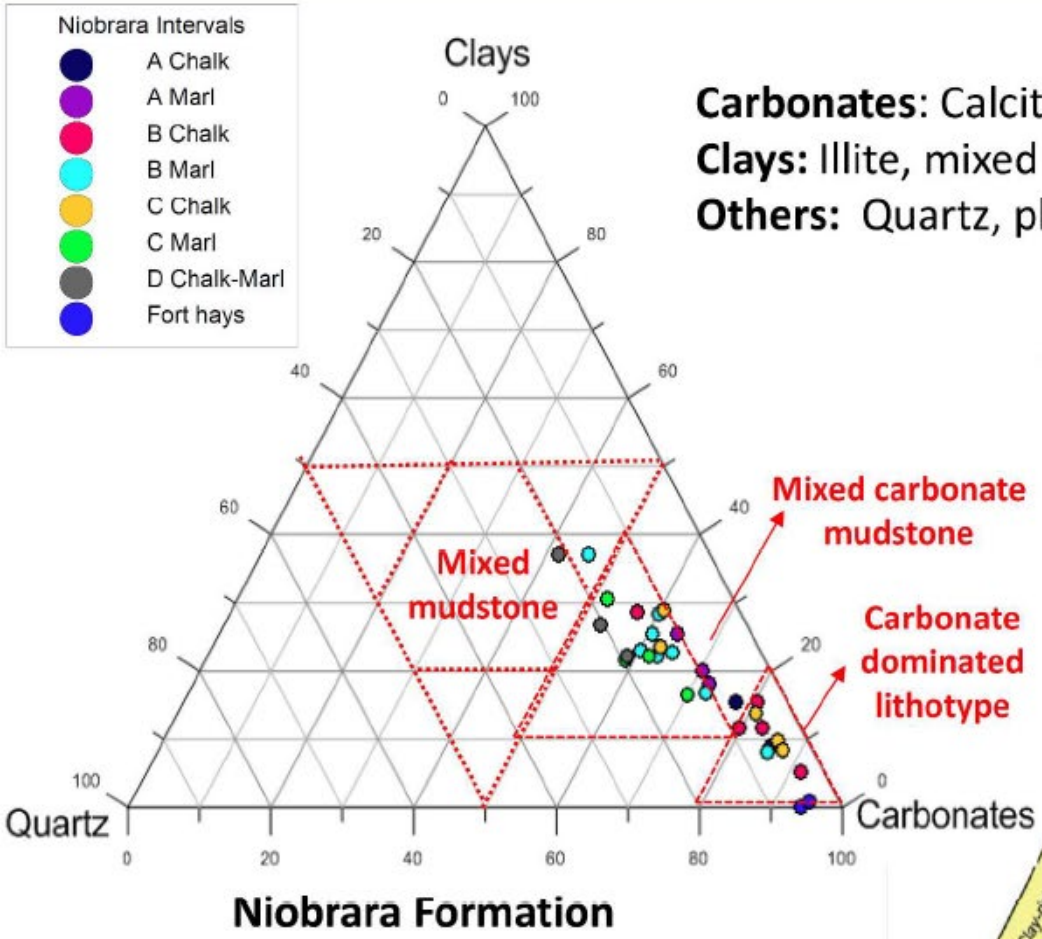
Niobrara C Interval

Razor 25-2514H

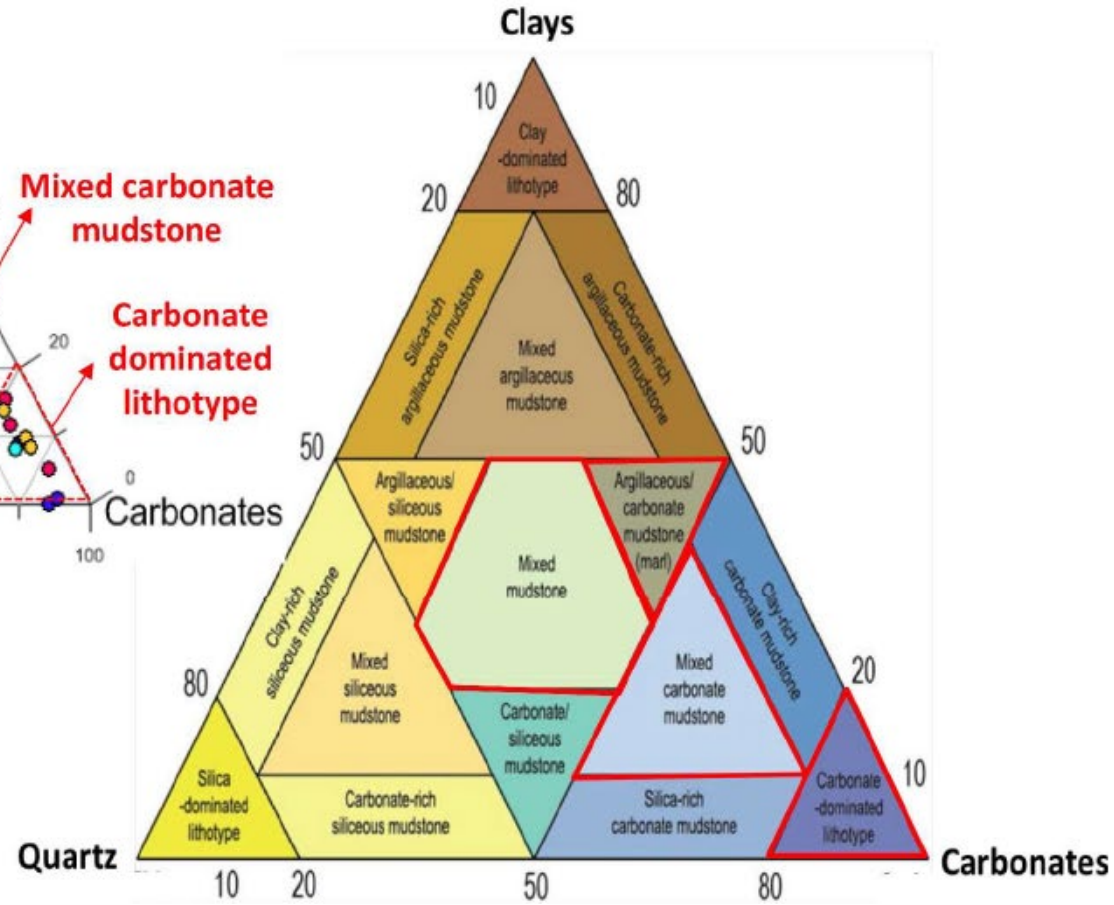



No Extraction

# Niobrara Mineralogy



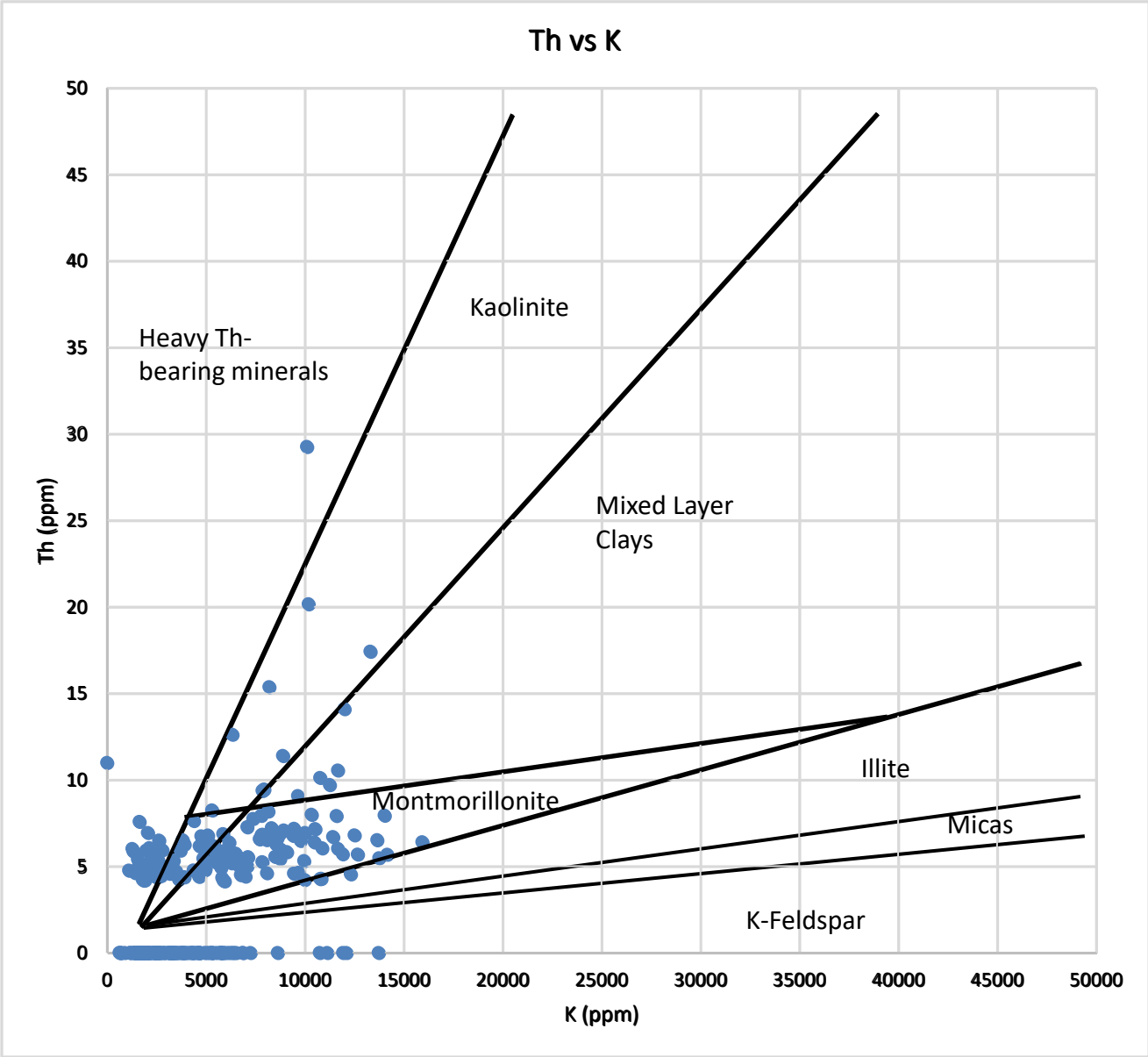

**Carbonates**: Calcite, Dolomite
**Clays:** Illite, mixed layer illite-smectite (20-30% smectite)
**Others:** Quartz, plagioclase and pyrite




(ElGhonimy and Sonnenberg, 2015: Modified from Gamero et al., 2012)

# Razor 25-2514H Potassium-Thorium Cross Plot



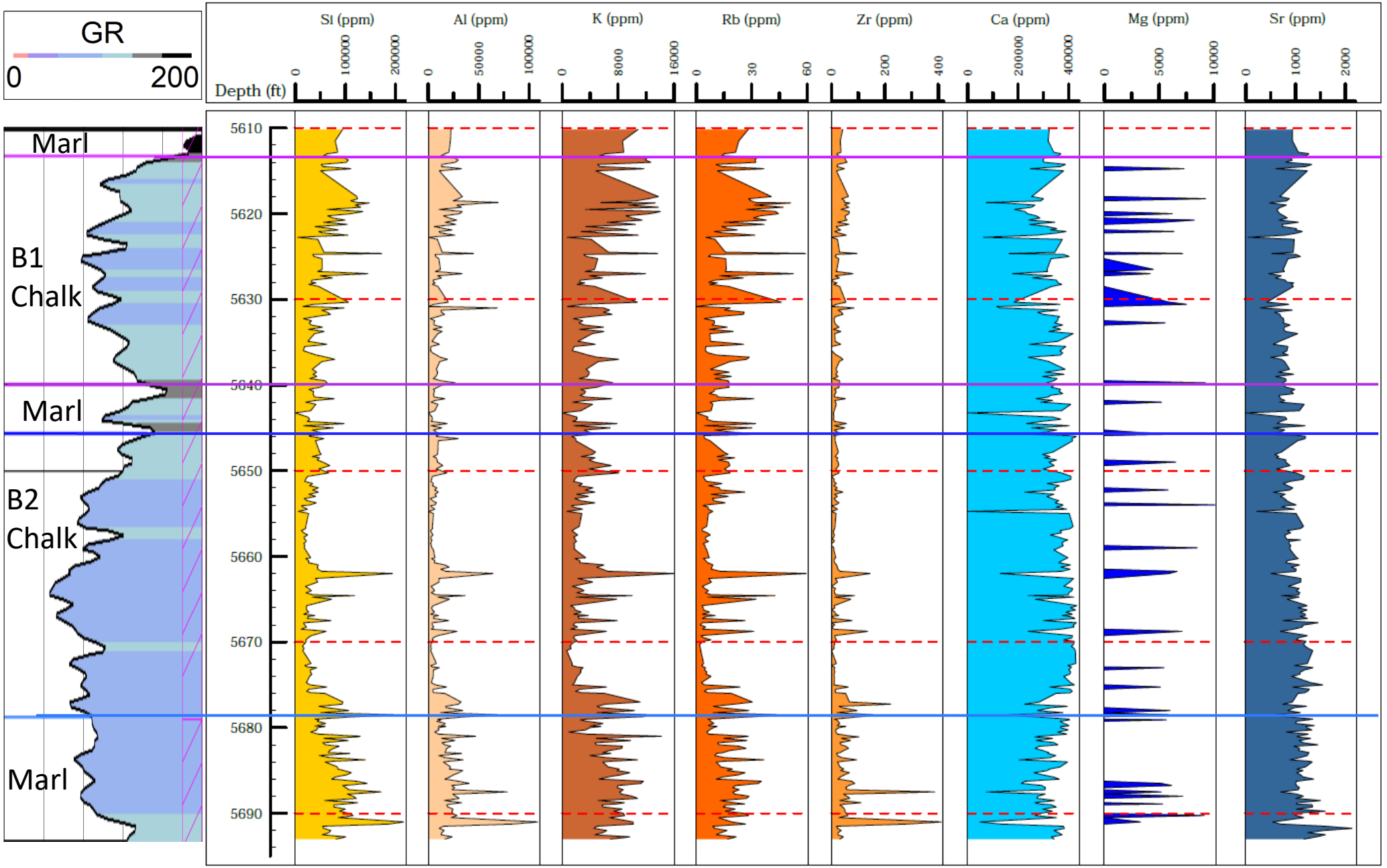



XRF analysis of the B Interval shows the clay mineralogy.
Majority of the measurements indicate a montmorillonite with some kaolinite.
(Template from Schlumberger, 1985)

Further analysis using XRD will aid in supporting this conclusion.

# Razor 25-2514H Detrital and Carbonate Indicators





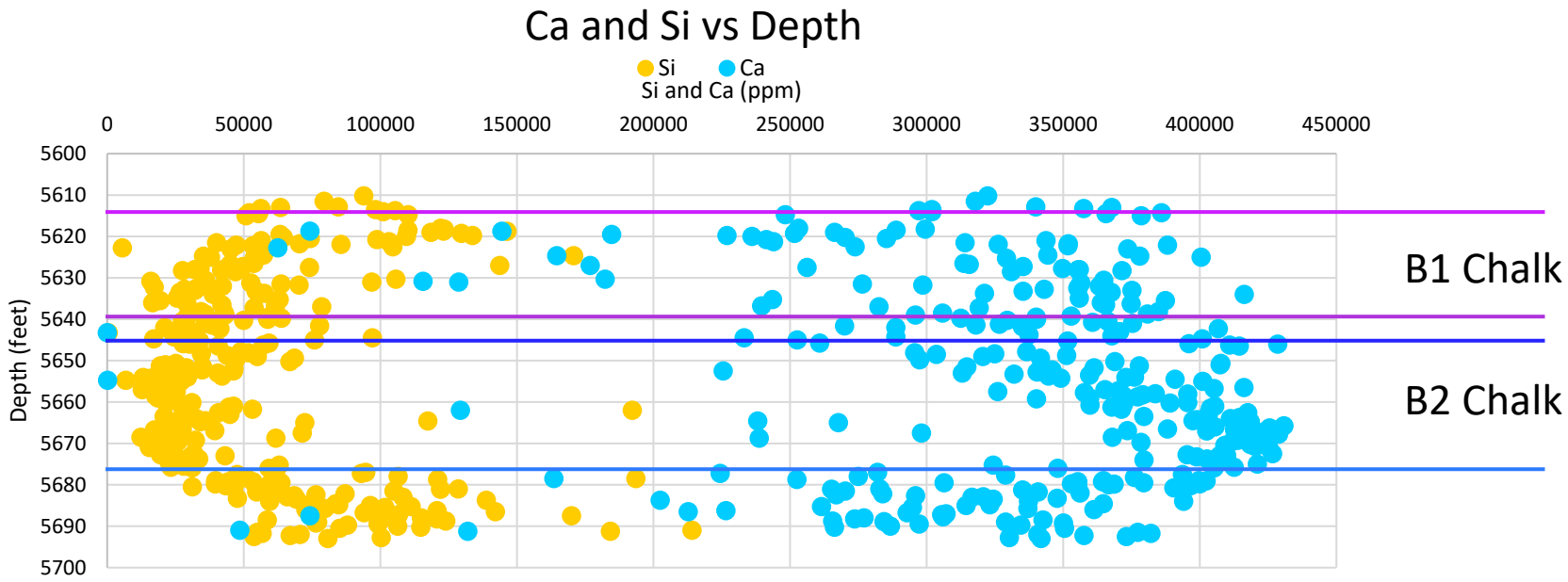
# Elements vs Depth

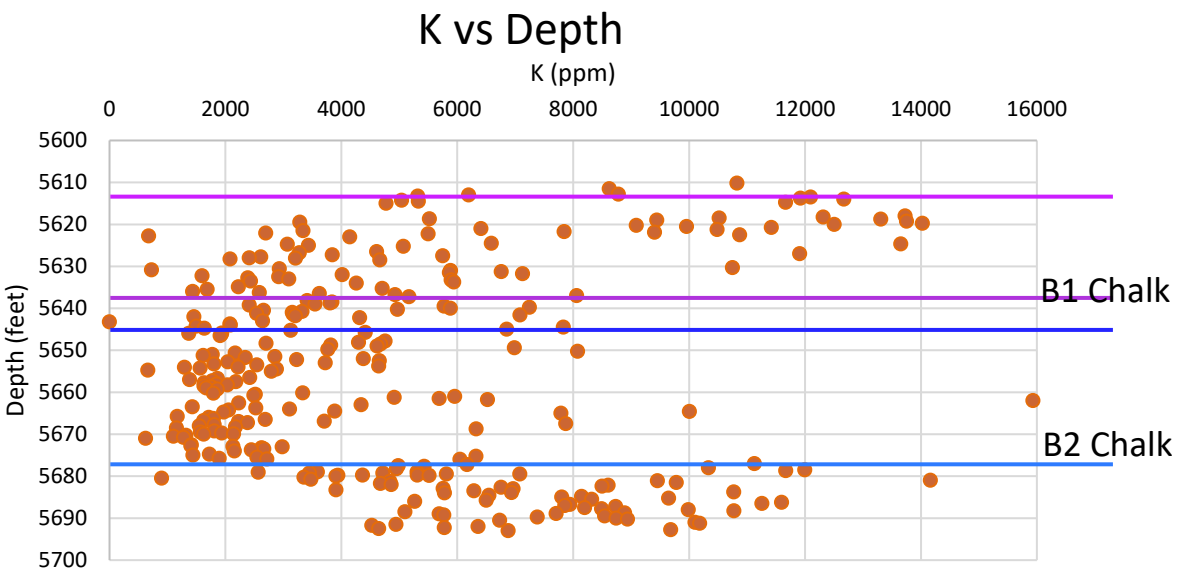


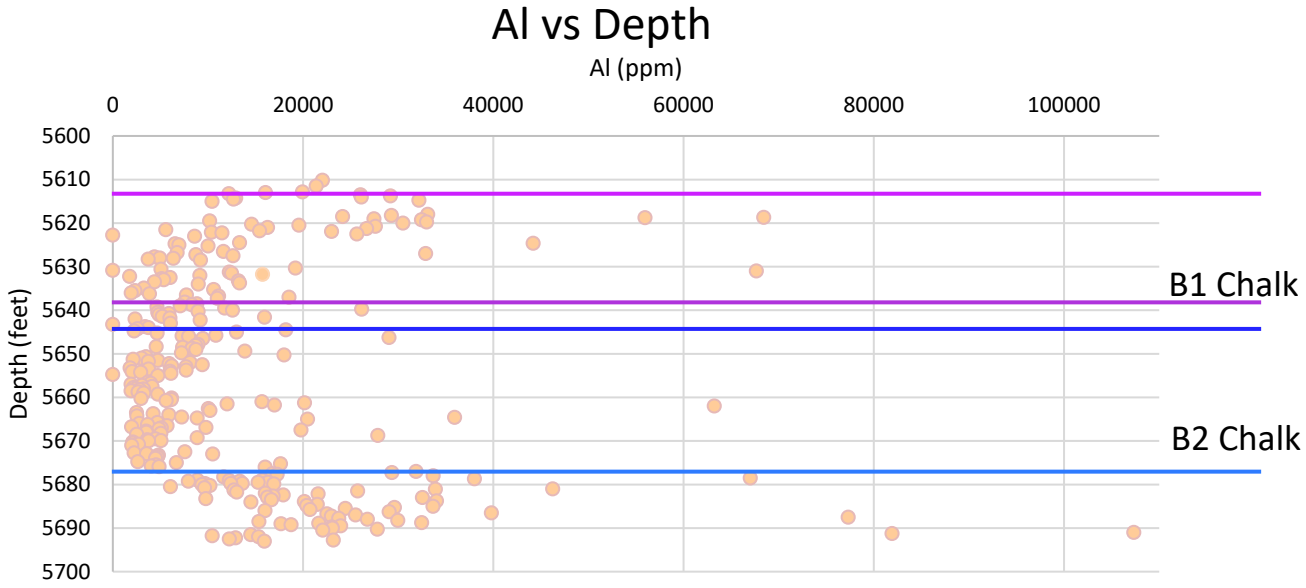
Razor 25-2514H

B1 Chalk: 5,613-5,639 ft TVD

B2 Chalk: 5,645-5,678 ft TVD



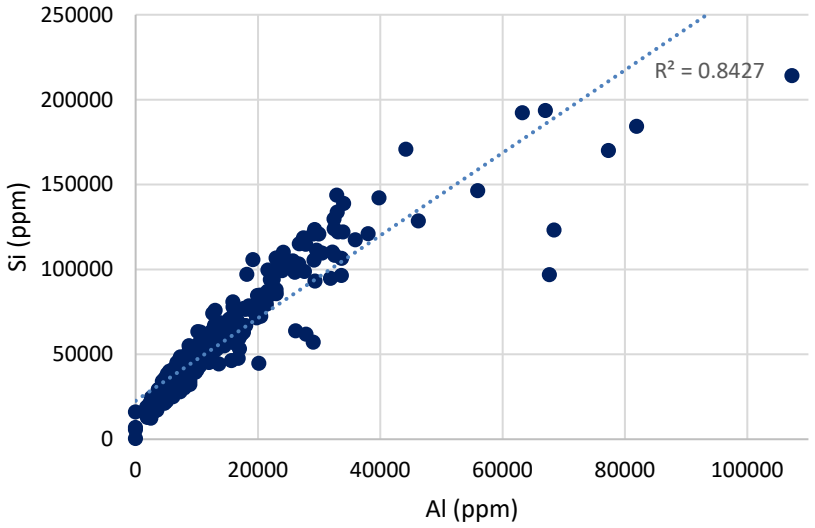



# Razor 25-2514H Elemental Cross Plots

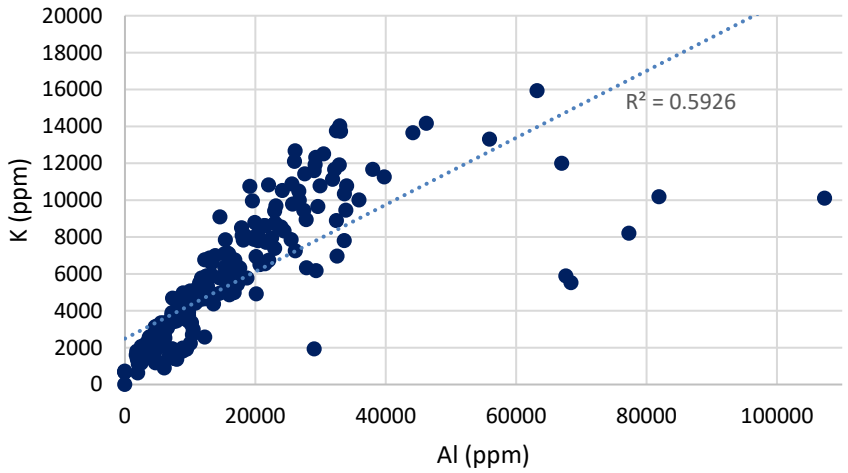


## Si vs Al



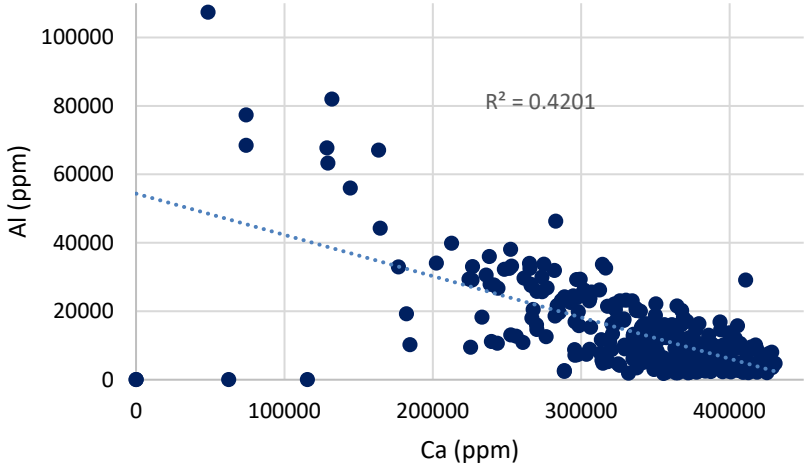

Si vs. Al cross plot shows a great correlation and indicates that the silicon content is detrital sourced.

## K vs Al



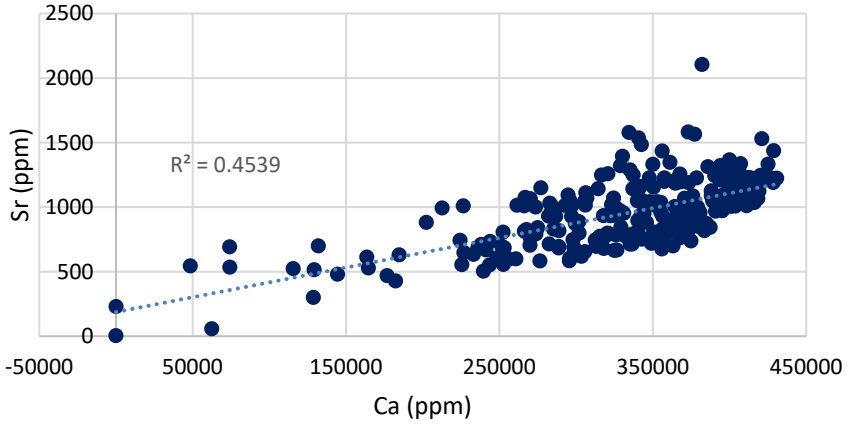

K vs. Al cross plot shows a good correlation and is due to the large amount of both elements in clay.

## Al vs Ca




Al vs. Ca cross plot has a negative correlation which indicates that the Al is detrital. Ca can be authigenic and biogenic, since my trend is a little scattered part of the calcium was formed in an authigenic process.

## Sr vs Ca

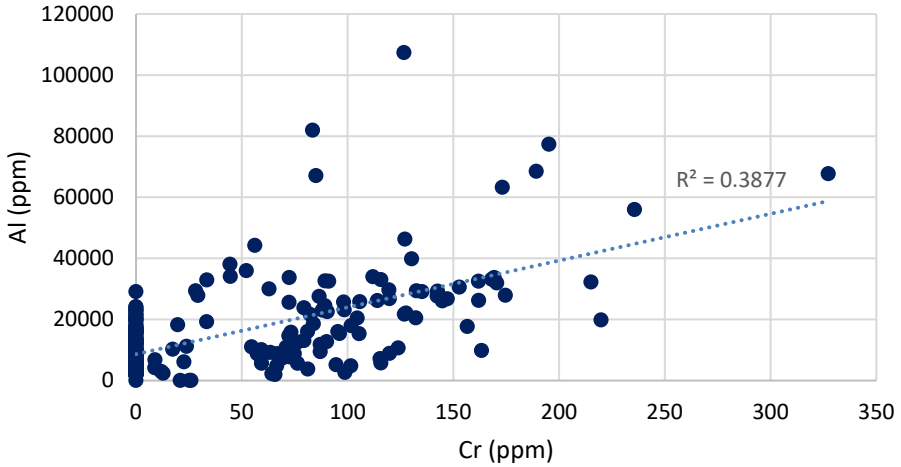



Sr vs. Ca cross plot has a good correlation and indicates that there is no aragonite enrichment present.

# Razor 25-2514H Redox Trace Elements

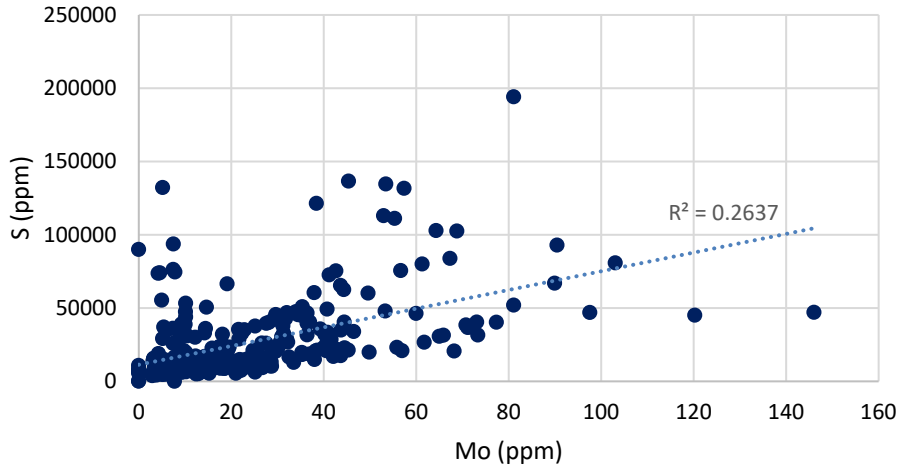


Al vs Cr




Al vs. Cr show a moderate correlation indicating Cr enrichment that can be attributed to the detrital component in addition to authigenic enrichment through redox processes.

S vs Mo

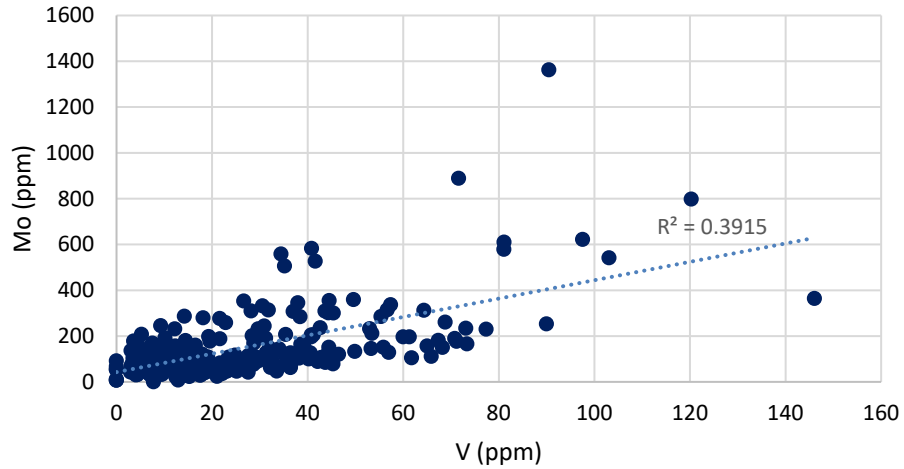



Presence of Mo indicates authigenic enrichment in euxinic waters.

S vs. Mo shows a weak positive covariance which indicates the relationship to pyrite through Mo-Fe-S compounds during authigenic enrichment.

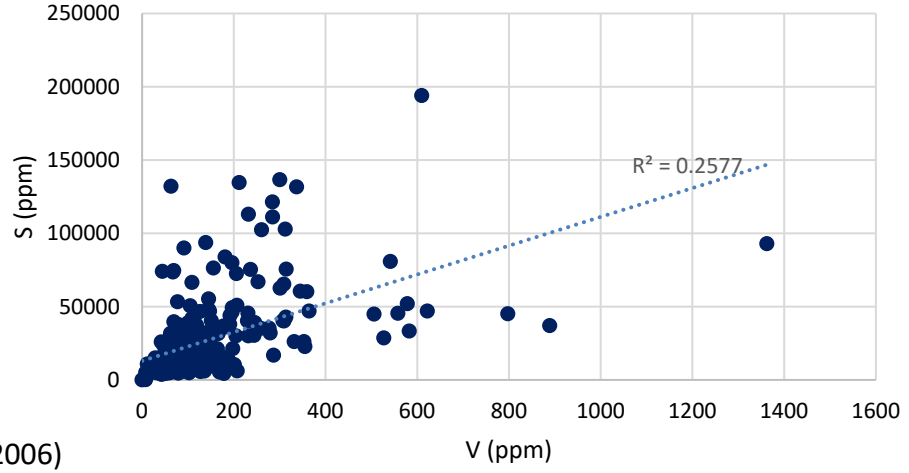
Could be anoxic than euxinic. A lot of iit is not auxinic. A lot is anoxic to dyoxic. I might be over using it euxinic

Mo vs V




Mo vs. V show a moderate covariance indicating similar authigenic enrichment pathways and further supports deposition in anoxic waters.

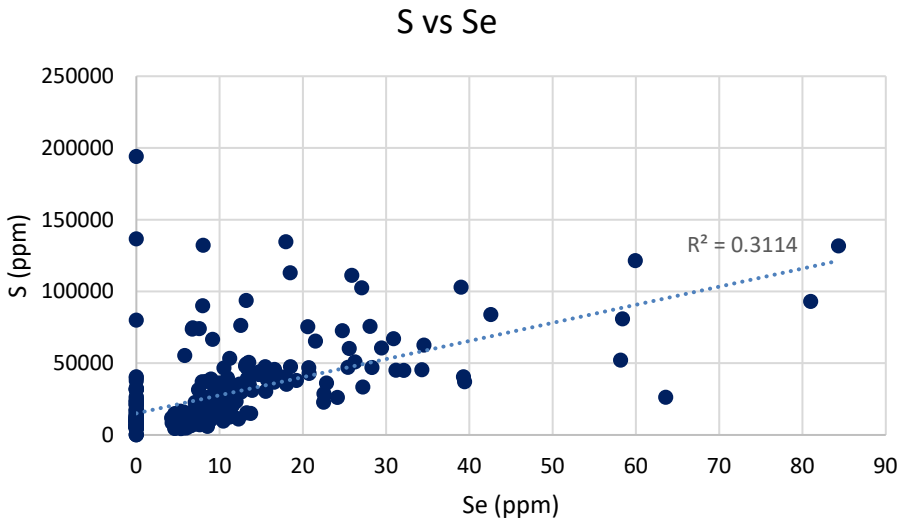
S vs V



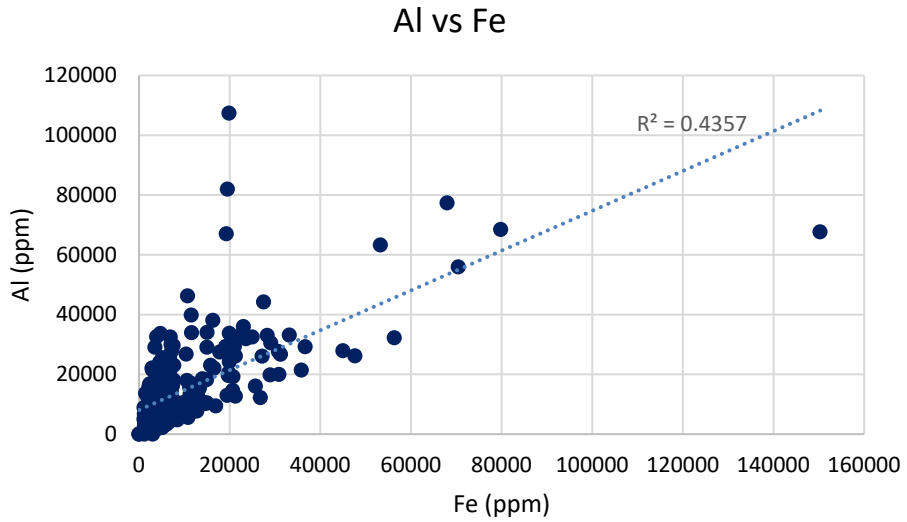

S vs. V has a weak correlation which indicates that the V enrichment can possible follow pyrite precipitation.

(Tribovillard et al., 2006)

# Trace Elements



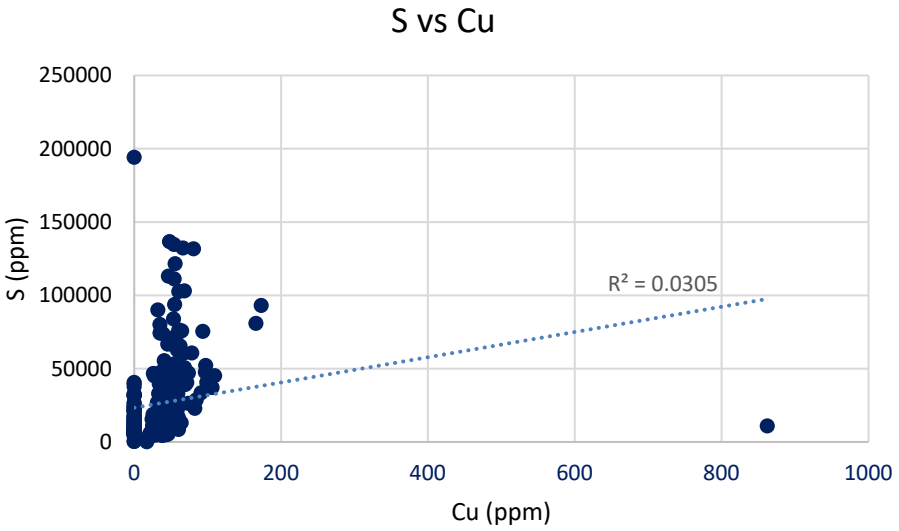

In euxinic conditions, Se can be a substitute for S in pyrite as it precipitates out of the water column. So it can indicate euxinic conditions with excess S.

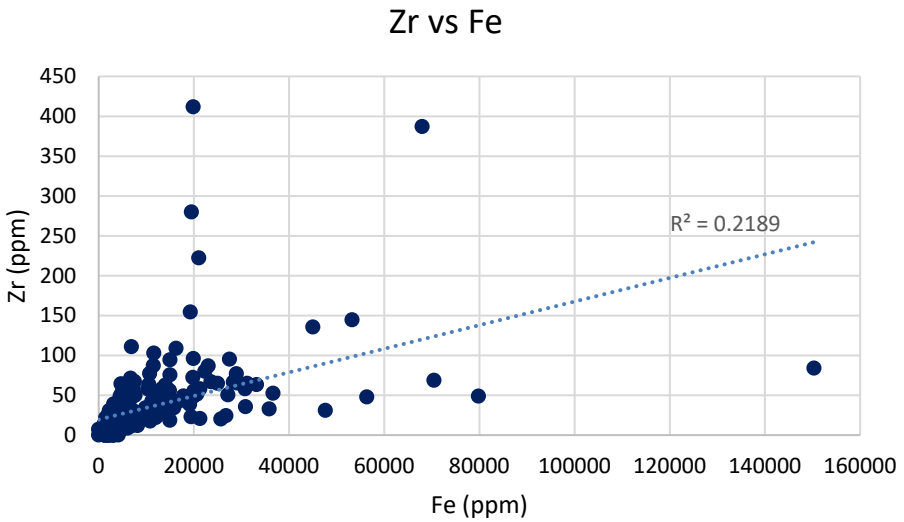


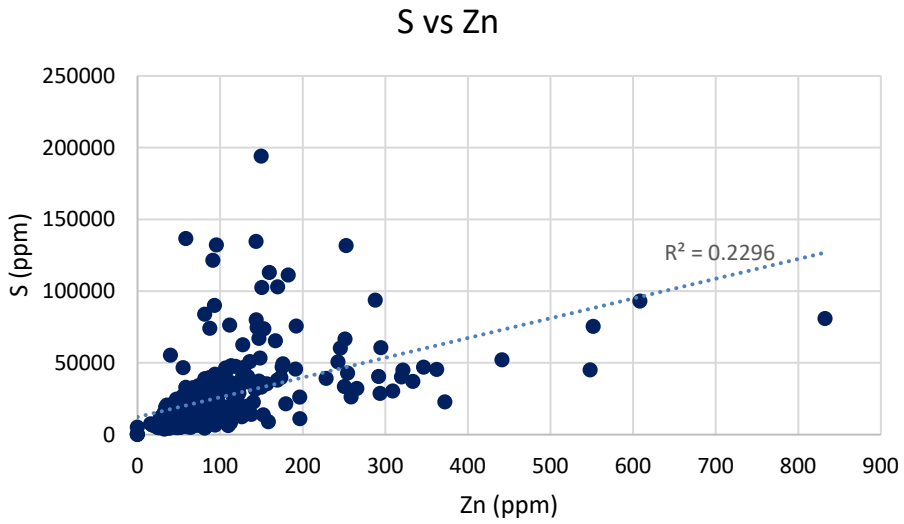

Fe enters system through detrital mechanisms and should follow other detrital indicators.
This is shown by the moderate correlation between Al vs. Fe.

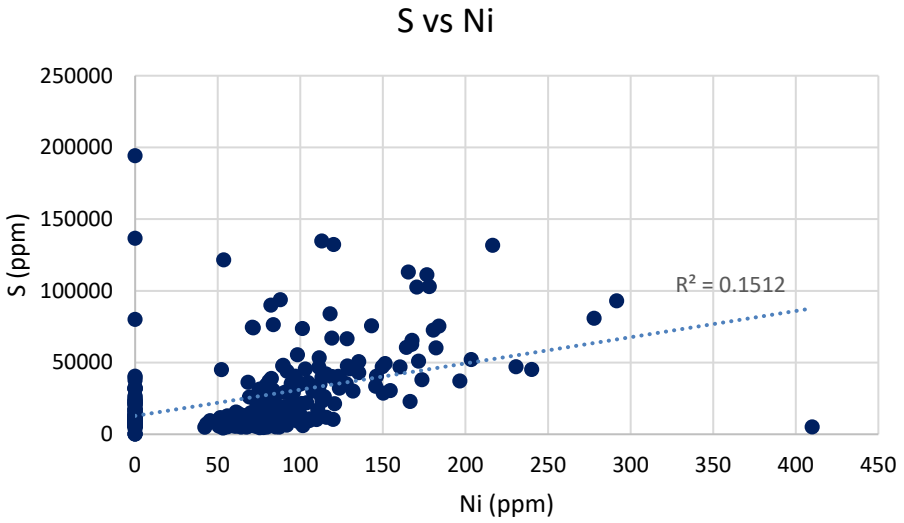
(Tribovillard et al., 2006)

# Trace Elements




Positive correlation between Cu, Ni, and Zn with S indicate authigenic enrichment. Cross plots of these elements vs. TOC need to be created to interpret if the authigenic enrichment took place via organic productivity and preservation via anoxic processes. I Need more pyrolysis data for the study interval.

(Tribovillard et al., 2006)

# Future Work



- Split up the Niobrara B1 and Niobrara B2 in Razor 25-25 XRF data. Really need to have this, need to know the elemental data, don’t want to drill the top B1 zone, want to drill were is more carbonate.
- Why does the B1 have a larger detrital component?
- XRF on other cores
- Core descriptions, facies distribution, mineralogy, X-ray Diffraction (XRD), Field Emission Scanning Electron Microscope (FE-SEM), source rock analysis, and petrophysical analysis.

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