

FMI and Facies Analyses of the Codell Sandstone in the Redtail Field, North-Central Denver Basin



COLORADO SCHOOL OF
MINES
MUDTOC

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Overview

- Geologic Background
- Redtail Field Overview
- Data Inventory
- Facies Analysis
- Image Log Analysis
- Work to be completed
- Conclusion



Horsetail 19N-1924M

Geologic Background



Precambrian

- Faulting and shearing from tectonics

Cambrian

- Depositional dominance from Transcontinental Arch and Sierra Grande uplift

Middle - Late Paleozoic

- Uplift of the Ancestral Rocky Mountains

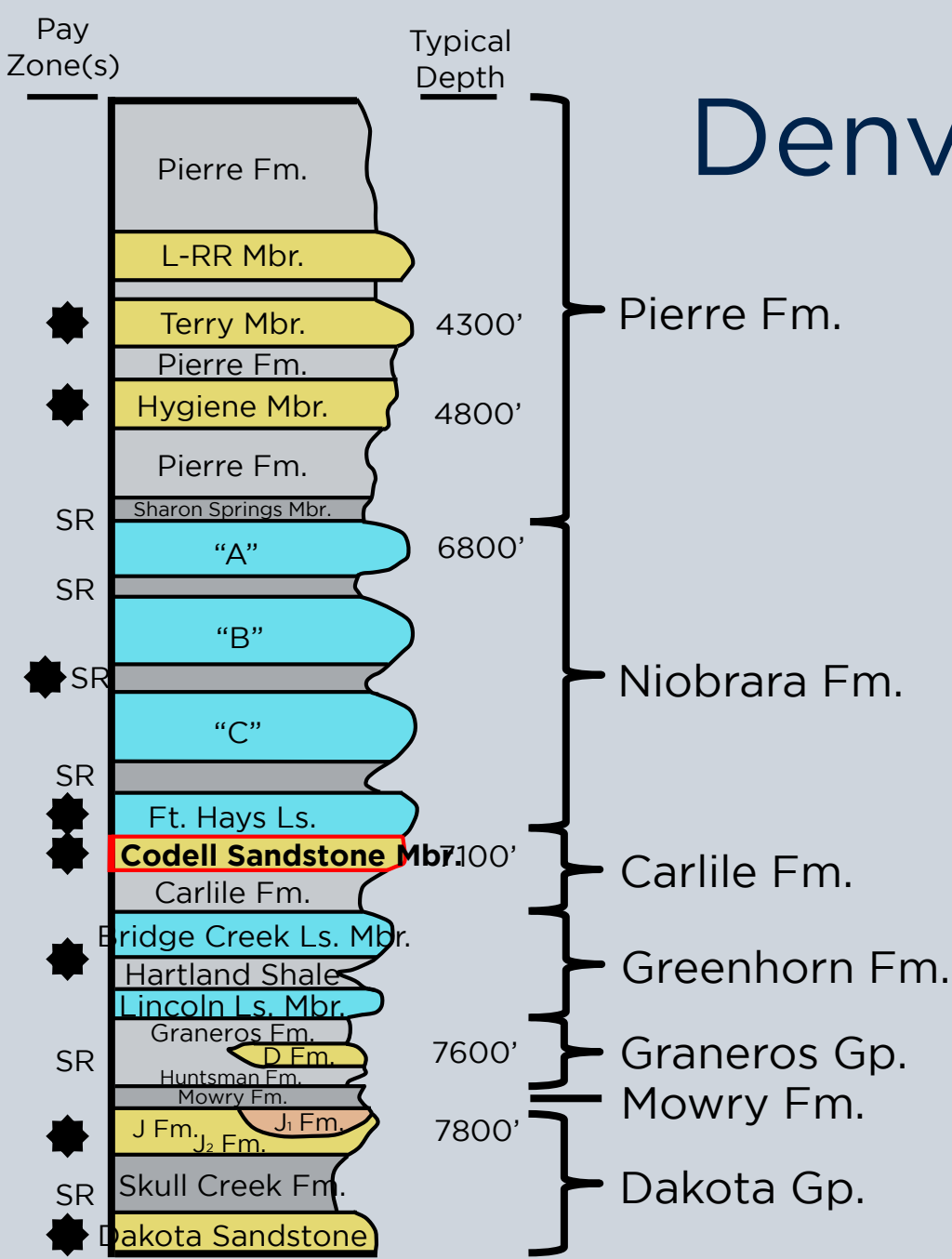
Mesozoic

- Formation of the Western Interior Seaway
- Start of the Laramide Orogenic event

Early Cenozoic

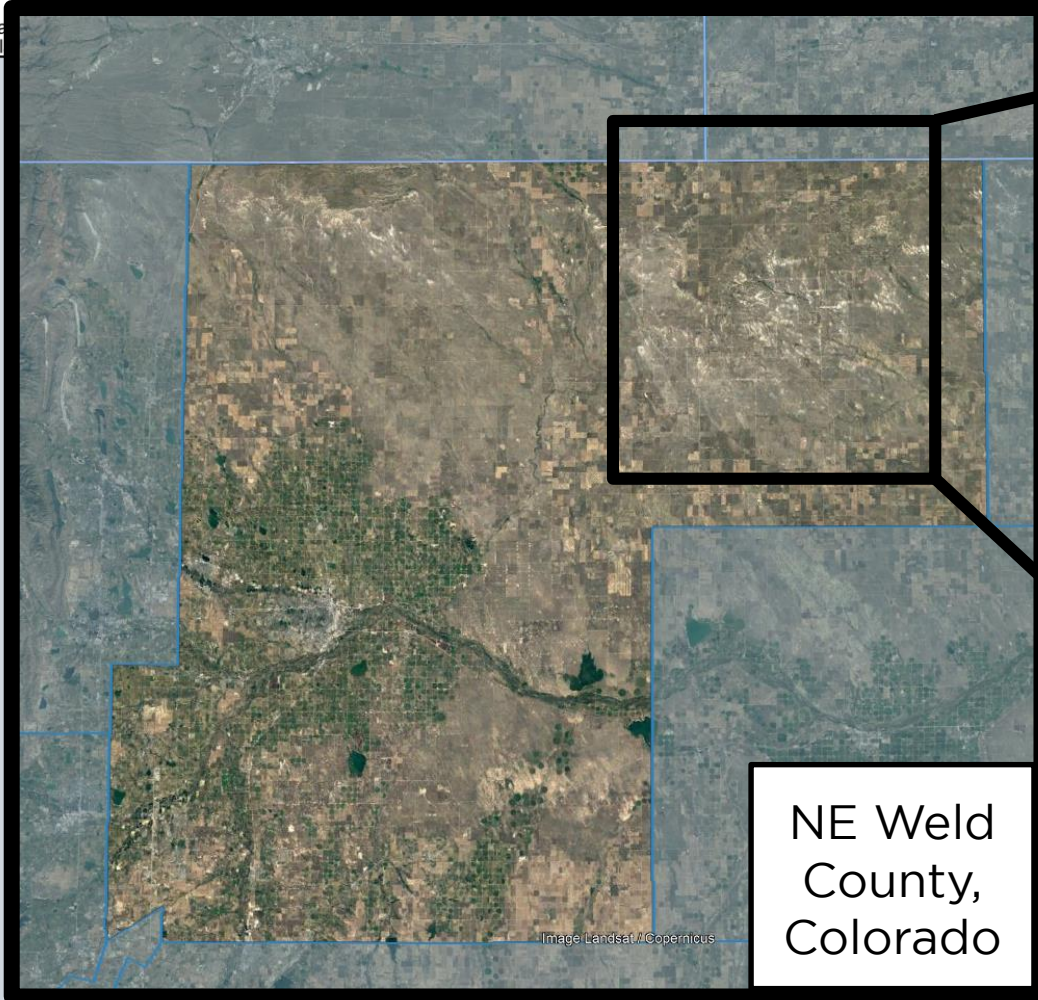
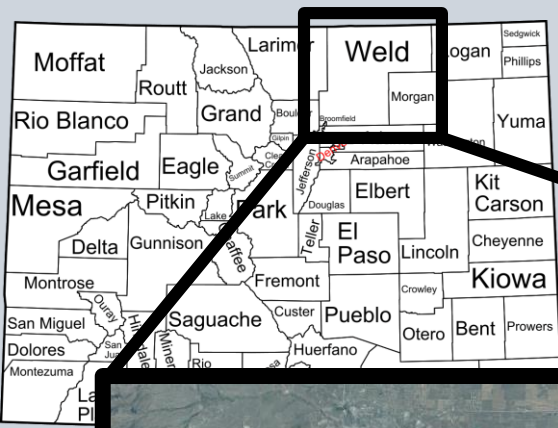
- Formation of the modern Rocky Mountains and Denver Basin

Denver Basin Strat Column

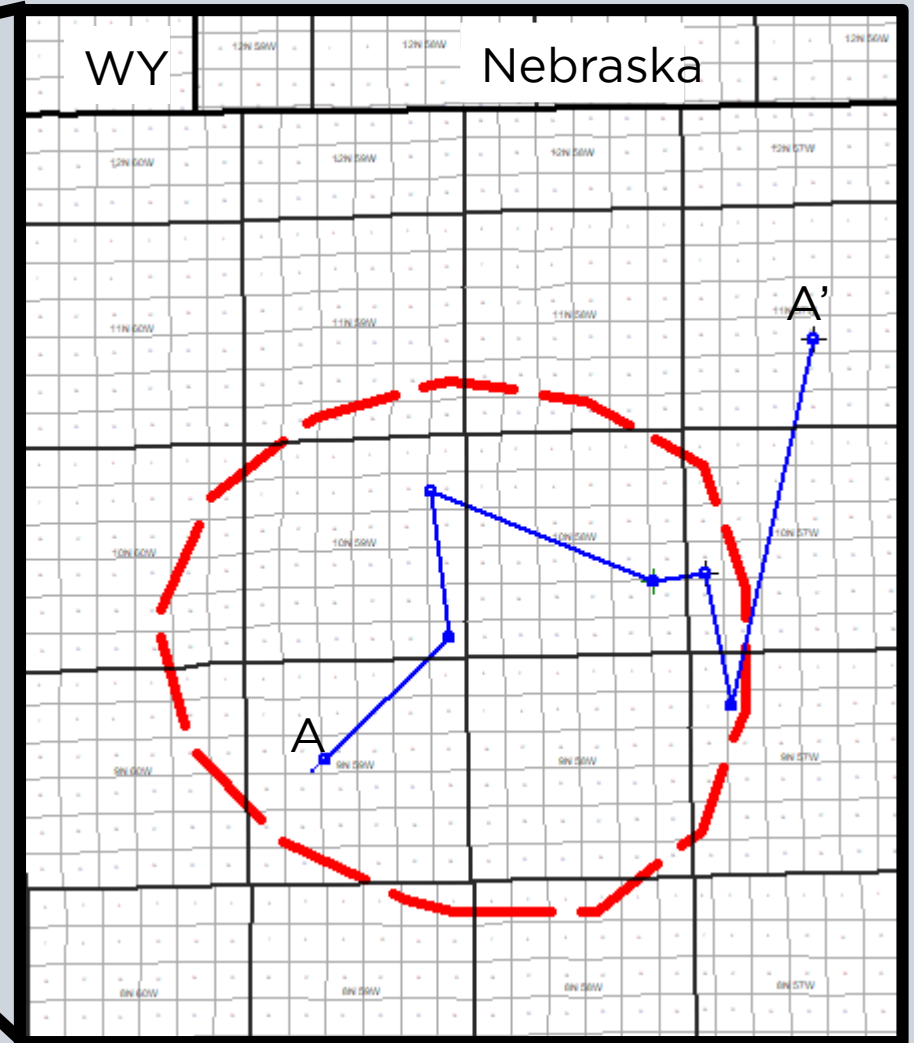


- The Codell Sandstone, labeled in red, is the uppermost member of the Carlile Formation.
- Above lies the Fort Hays Limestone of the Niobrara Formation.
- Below lies the Carlile Shale.
- The Codell Sandstone is a hydrocarbon reservoir.

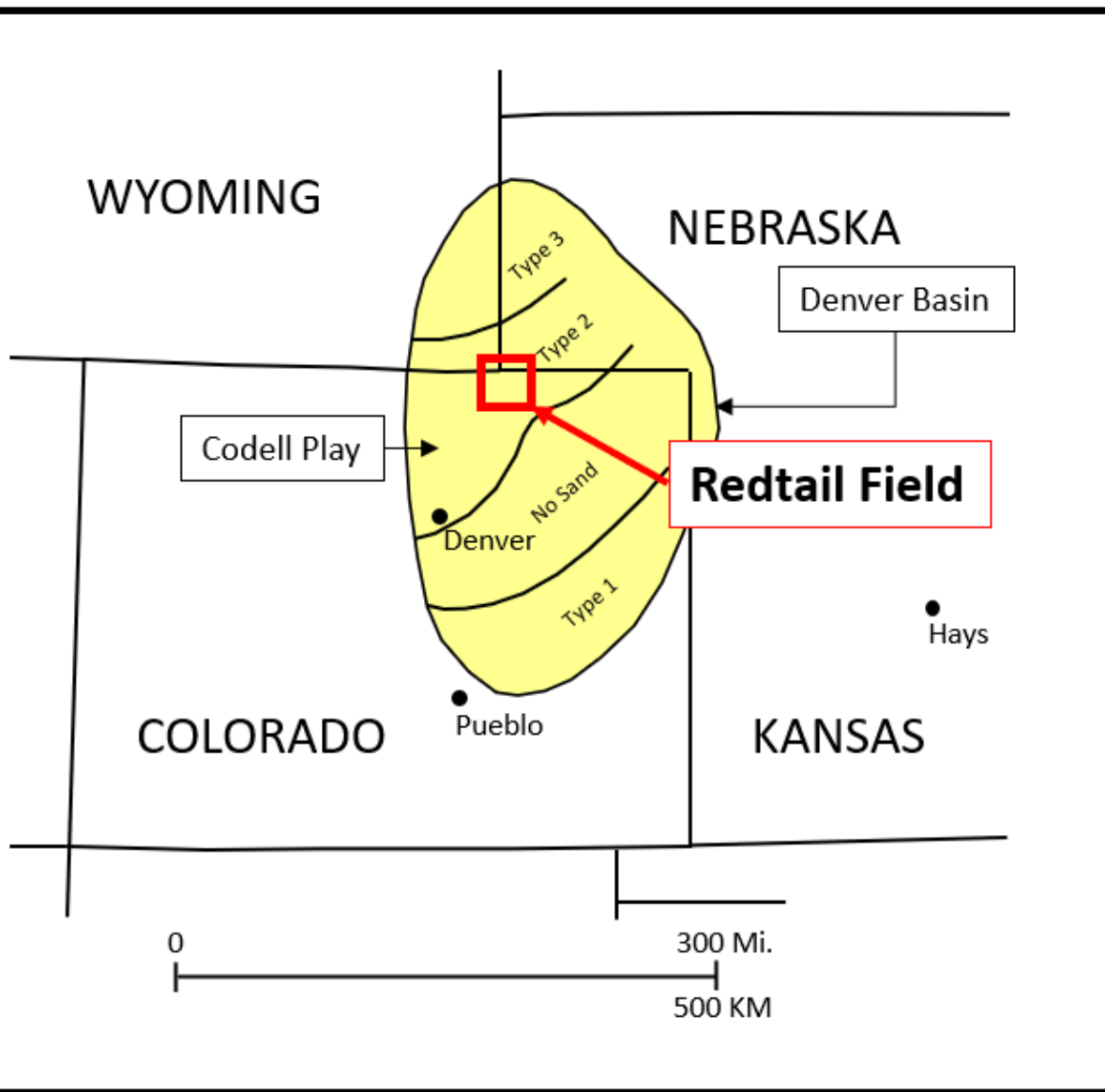
Redtail Field



Google Earth



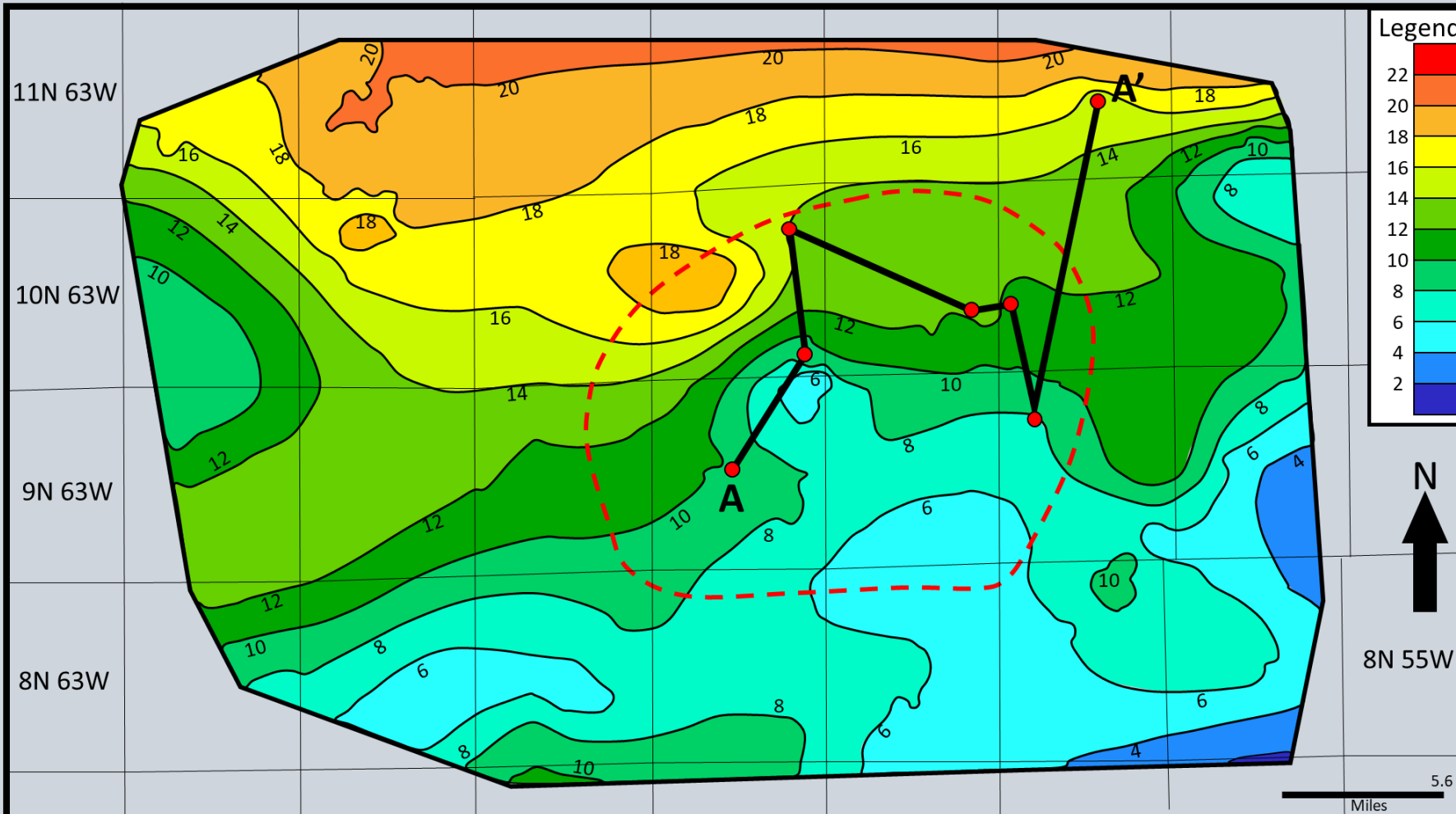
Redtail Field



- Codell has 3 subdivisions, Type 1, 2, and 3 based on distinct processes and environments of deposition
 - Type 1: Fine to medium sandstone deposited in a marine shelf or shoreline bar
 - Type 2: Lower permeability, higher bioturbated siltstone to very fine-grained sandstone deposited in a marine shelf
 - Type 3: Fine to medium grained with parallel to ripple laminae and sparse burrowing

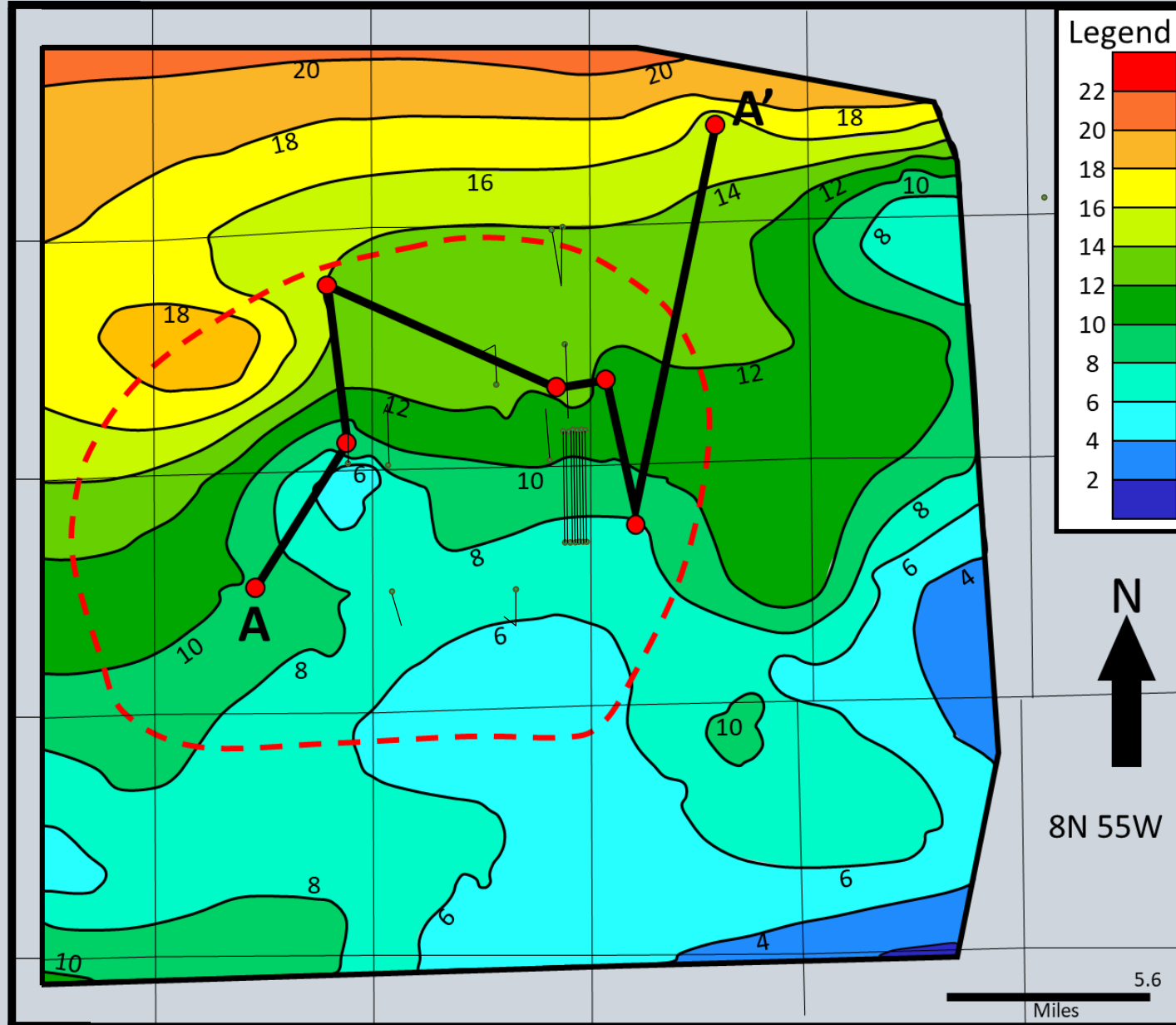
Based on the location of Redtail field and core description, Redtail Field is firmly a Type 2 Codell Sandstone. However, there seems to be some type 3 qualities seen in core.

Reservoir Characteristics



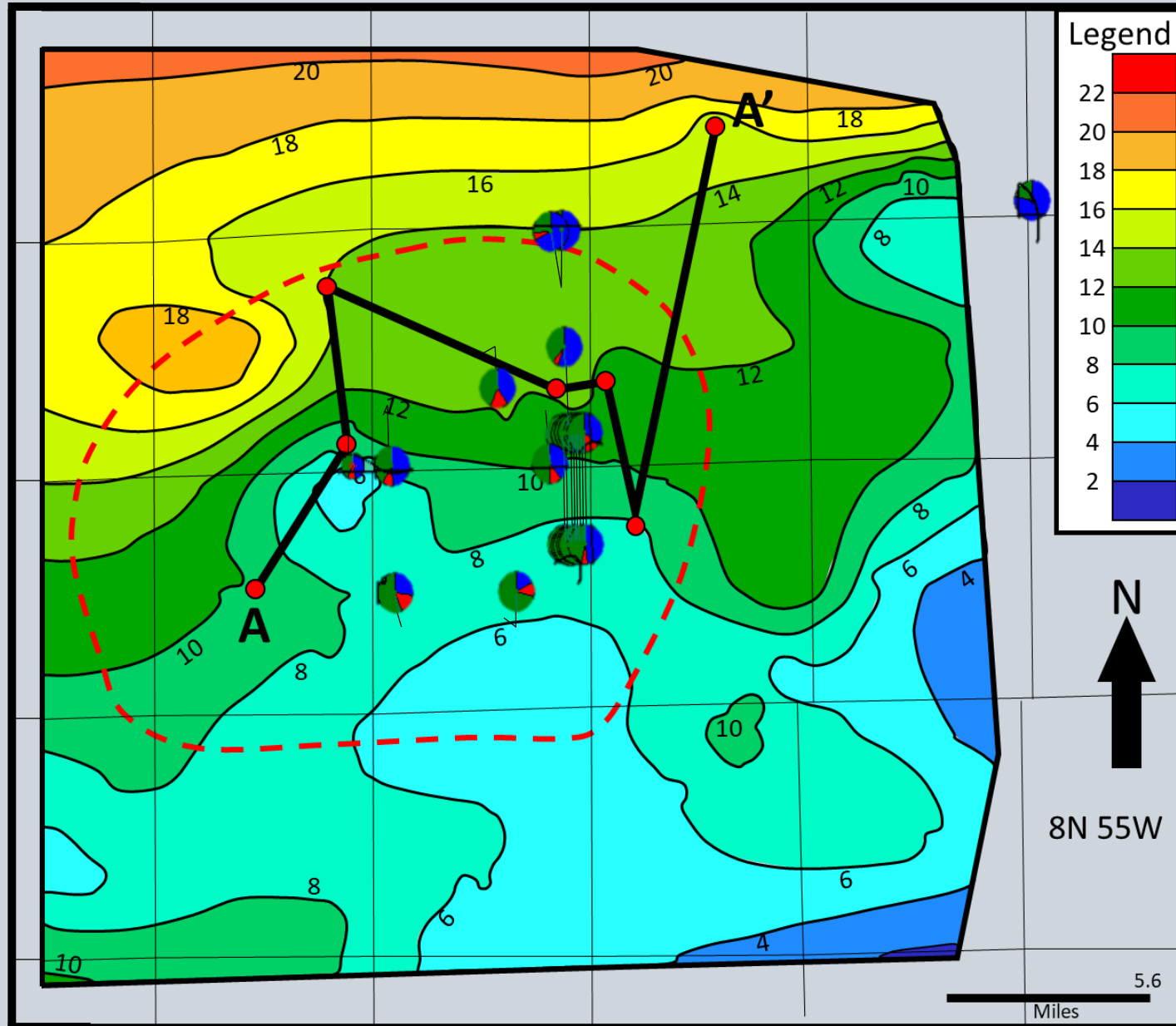
Average Porosity: 5-15%
Average Thickness: 10-20 ft
Permeability: 0.01 to .1 mD
TOC: Up to 4%

Production Data



- Producing Horizontal wells:
- Targets Moderately thick Codell Sandstones
 - Drilled along the S to N trend in thickness between 6' to 14'

Production Data



Production:

- Majority oil
- Various amount of water
- Gas (barrels equivalent)

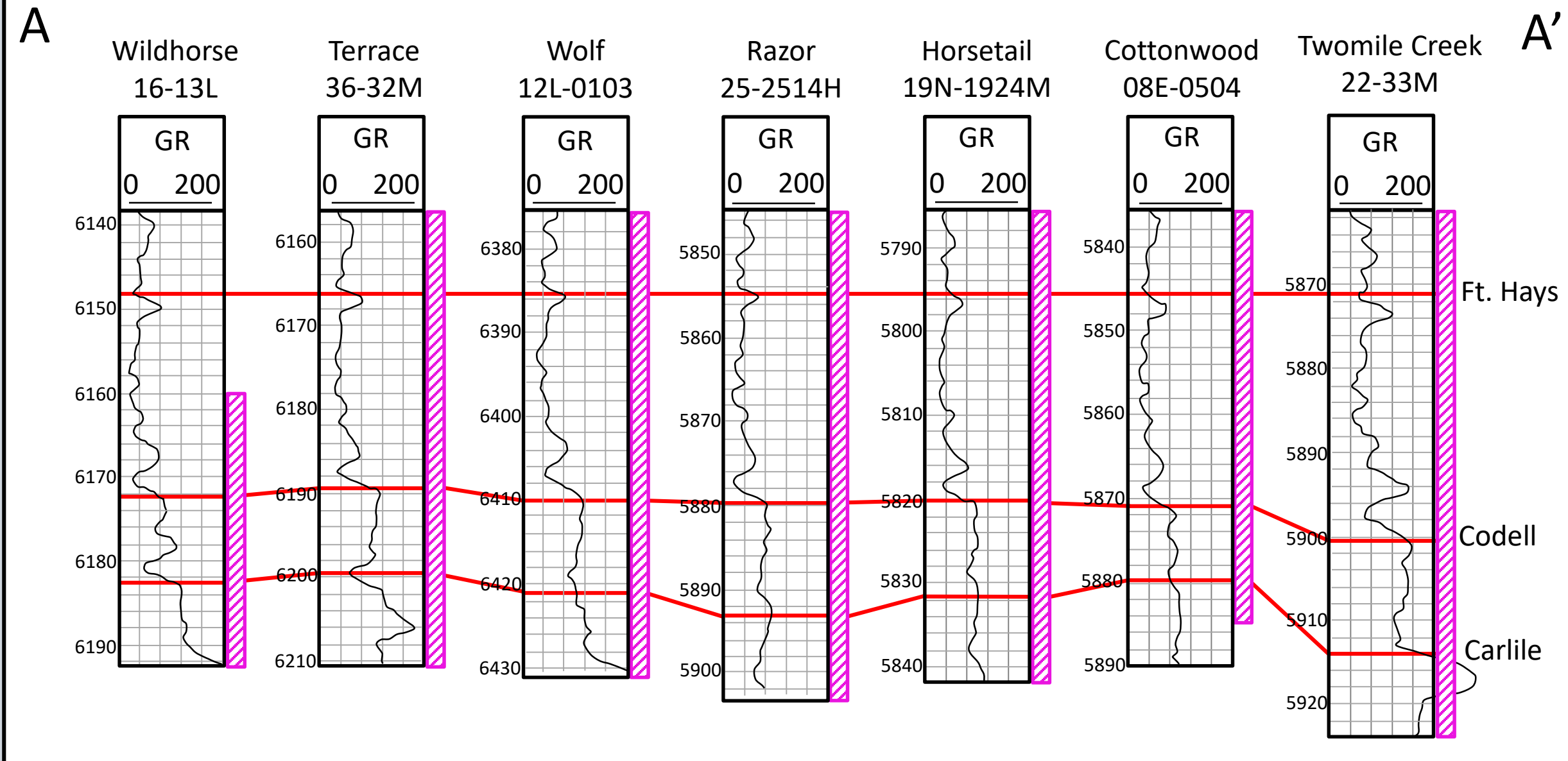
Trend:

- The more North, the less hydrocarbons and more water

Available Data

Well Name	Desired Cored Interval	FMI Image Logs	Log Data	Core Data	Thin Sections
Bories A-29D-D3	No	No	Yes	Yes	No
Bories C-24M-M2W	No	No	Yes	Yes	No
Cottonwood 08E-0504	Yes	No	Yes	Yes	Yes
Horsetail 19N-1924M	Yes	No	Yes	Yes	No
Horsetail 29G-2043	No	No	Yes	Yes	No
Lion Government #9	No	No	No	Yes	No
Razor 25-2514H	Yes	Yes	Yes	Yes	Yes
Razor 26J-2633L	No	Yes	Yes	Yes	No
Terrace 36-32M	Yes	Yes	Yes	Yes	Yes
Two Mile Creek #22-33M	Yes	Yes	Yes	Yes	No
Wildhorse 16-13L	No	Yes	Yes	Yes	No
Wolf 12L-0103	Yes	No	Yes	Yes	No
WRD 23-33	No	No	Yes	Yes	No

Cross Section A to A'



Facies Overview

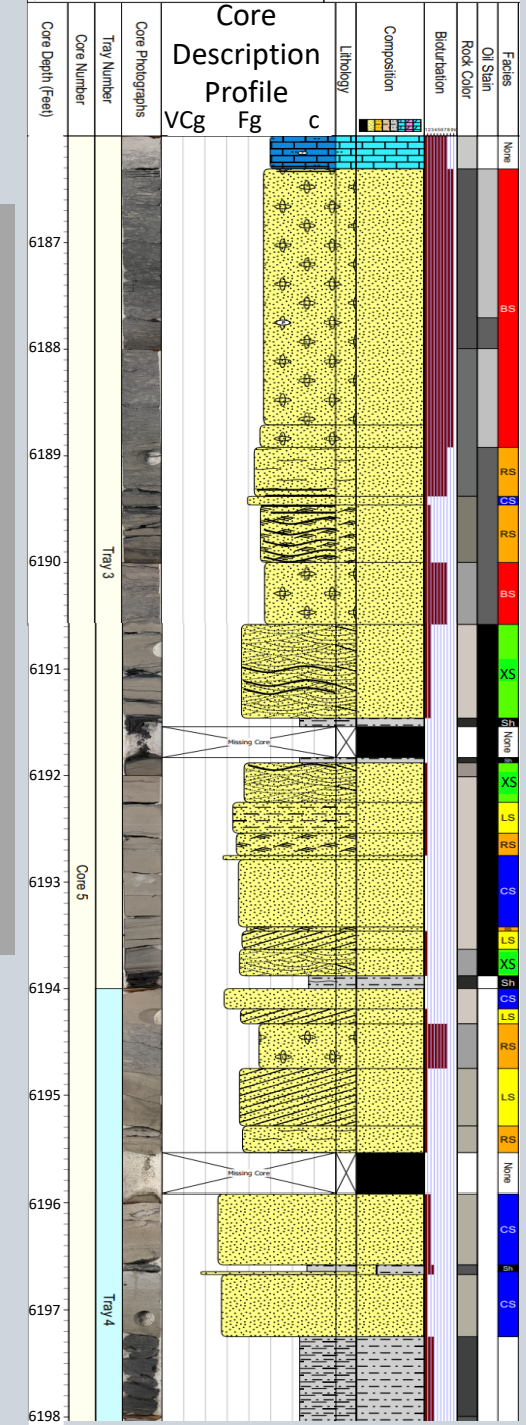


Fort Hays Limestone

- BS Bioturbated Sandstone
- RS Rippled Sandstone
- LS Low angle parallel laminated Sandstone
- XS Cross Stratified Sandstone
- CS Clean Sandstone
- Sh Shale

Carlile Shale

Codell Sandstone Facies



Facies BS: Bioturbated Sandstone

- Often very high degree of bioturbation, little of the original sedimentary structures remain
- Different burrows from various organisms
- Always at the top of the Codell Sandstone, seen in all available Redtail Field cores



Horsetail 19N-1924M

Facies RS: Rippled Sandstone



- Generally low angled, and symmetrical
- Often starved ripples
- Mudrock directly above
 - Can be up to millimeters thick
- Some ripples exhibit a sandier influence

Cottonwood 08E-0504

Facies LS: Low angle parallel laminated Sandstone



- Incorporates a wide range of angles
 - Sub horizontal to nearly 30 degrees
- May be sandy, or may have mudrock laminations

Terrace 36-32M

Facies XS: Cross Stratified Sandstone



- Most uncommon in core
- Thinner than other facies, but can be up to 6 inches thick
- Usually little to no bioturbation
- Little to no shale influence, but may have fine filaments of darker material along laminations
- These are interpreted as storm sediments deposited in a shallow marine environment

Facies CS: Clean Sandstone



Cottonwood 08E-0504

- No visually apparent sedimentary structures
 - Can have very faint low angle laminations
- Large range in grain size, upper very fine to coarse grained
- Along the base, coarse grained lag may be seen
 - Medium grain to pebble sized

Facies Sh: Shale

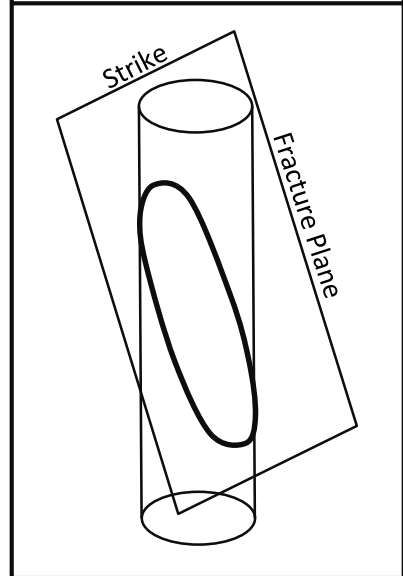


Cottonwood 08E-0504

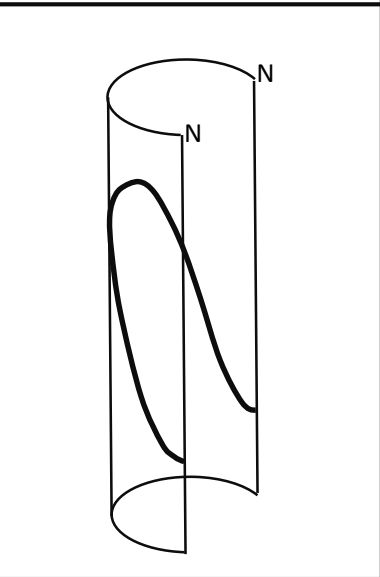
- Seen numerous times in every core
- Variable thickness but usually around 1 inch
- TOC up to 4 wt%

Image Logs General Information

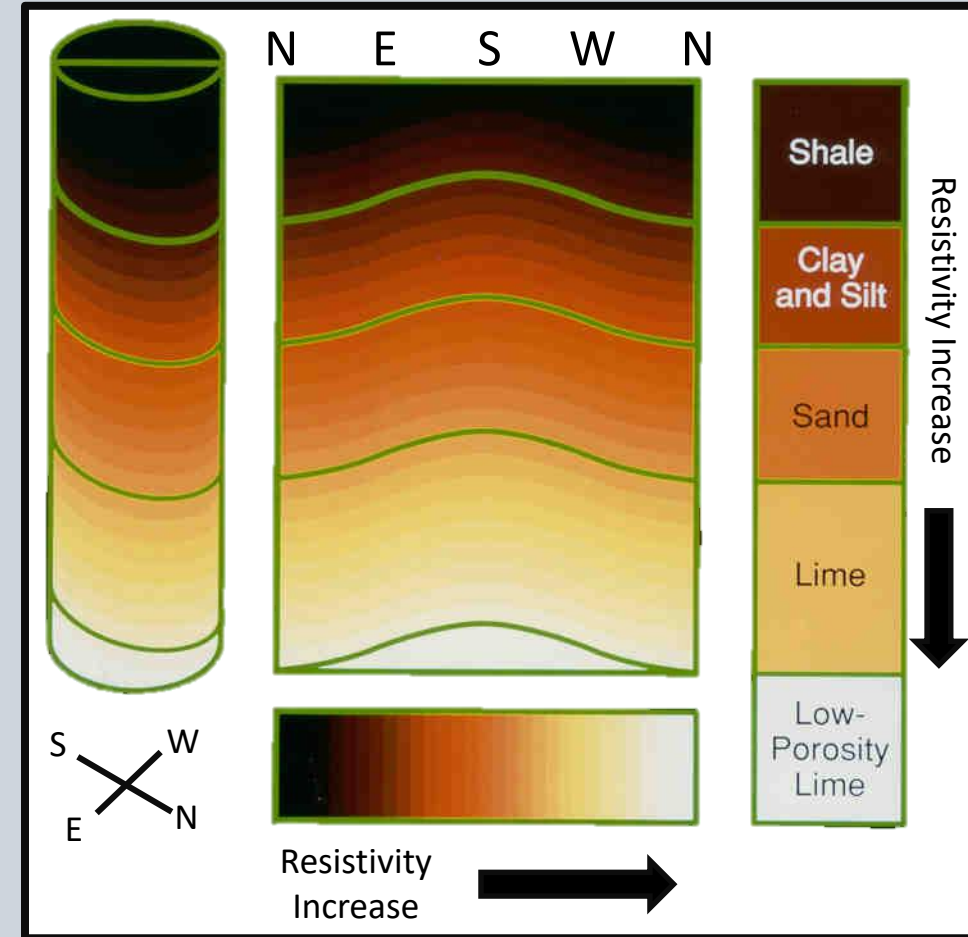
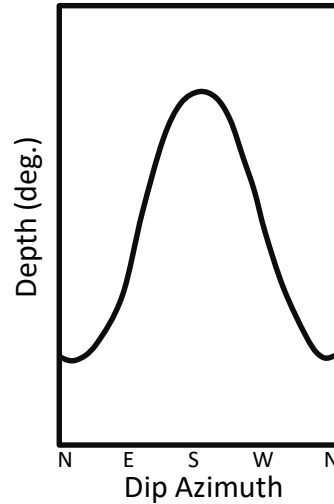
3-D View



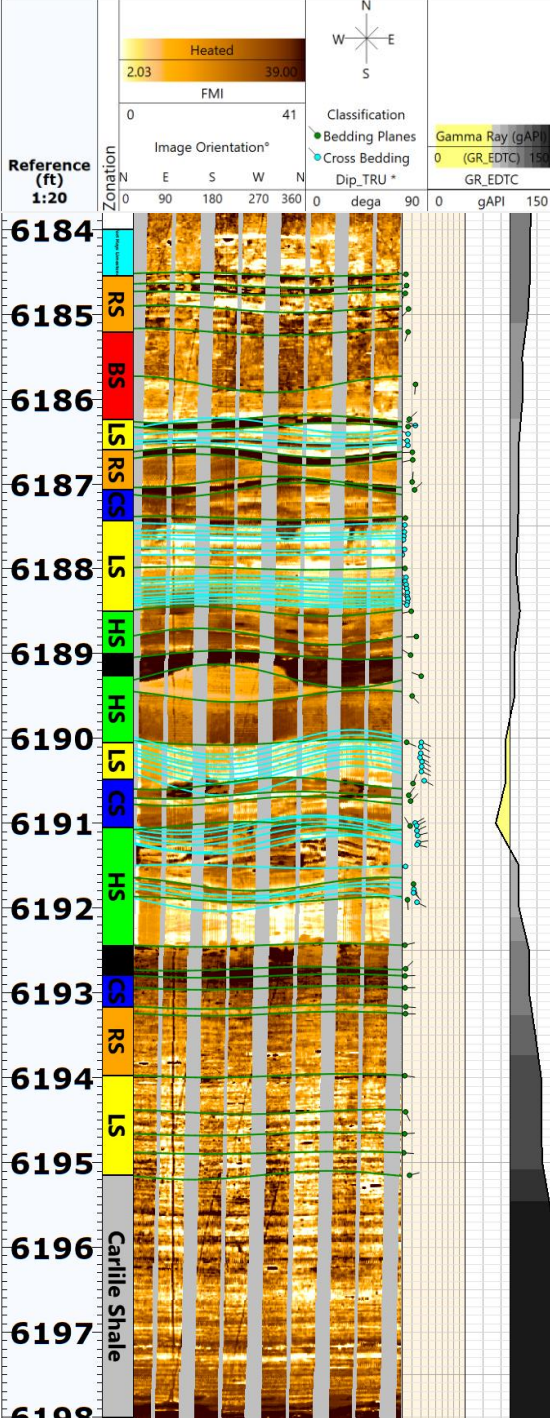
Unrolling the Cylinder



Resulting Image Log



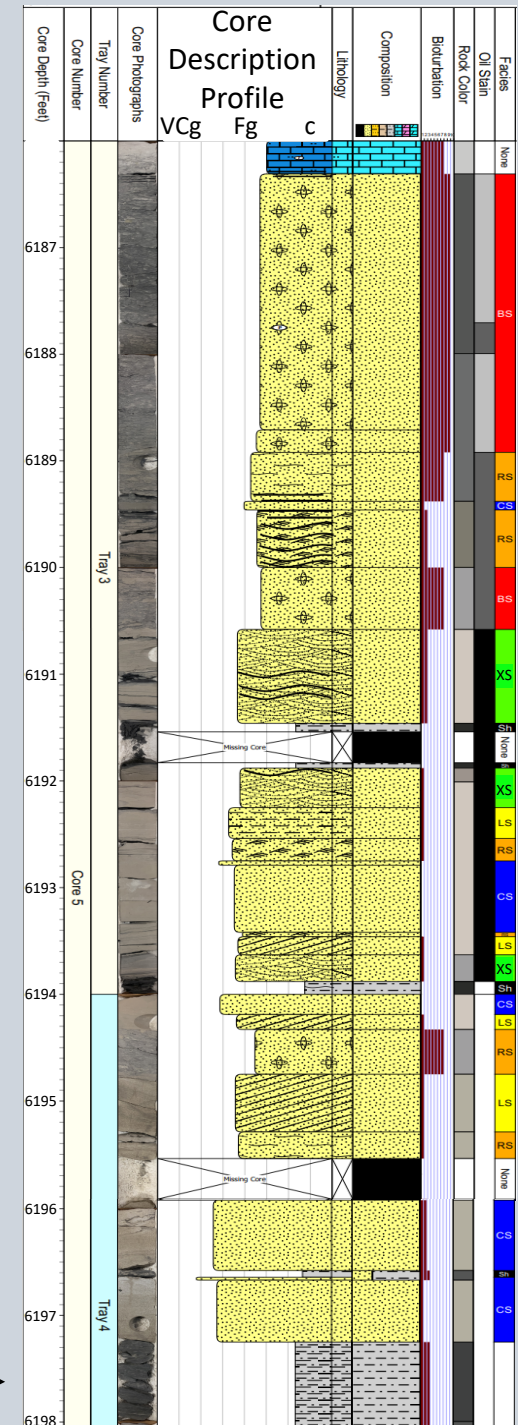
FMI Image Logs VS Core



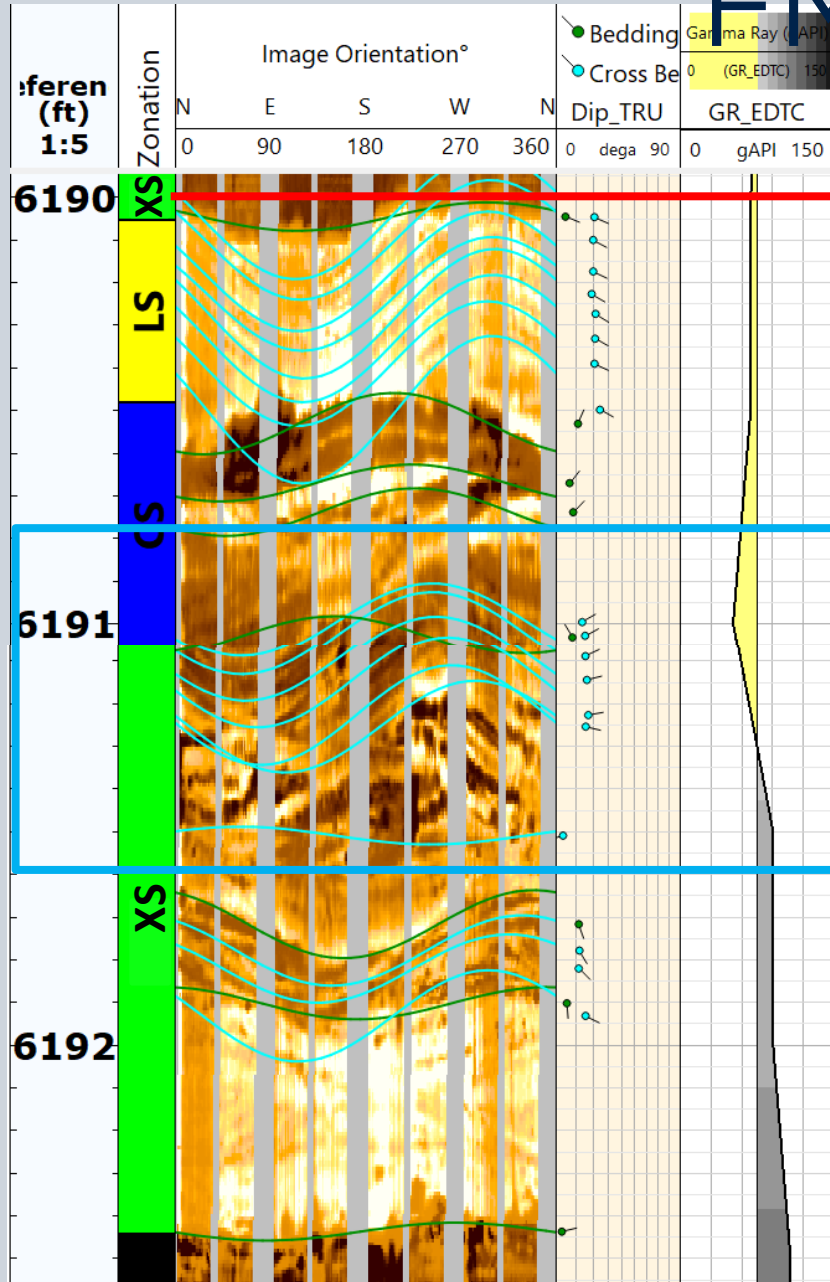
- FMI Image Logs:
- Sedimentary structures previously hidden in core may become apparent
 - Key reason why facies may be different than the core analysis
 - Easy Strike/Dip Analysis

- Core:
- Accuracy is dependent on rock quality
 - Deeper analysis will be conducted on CSM core

← Terrace 36-32M →



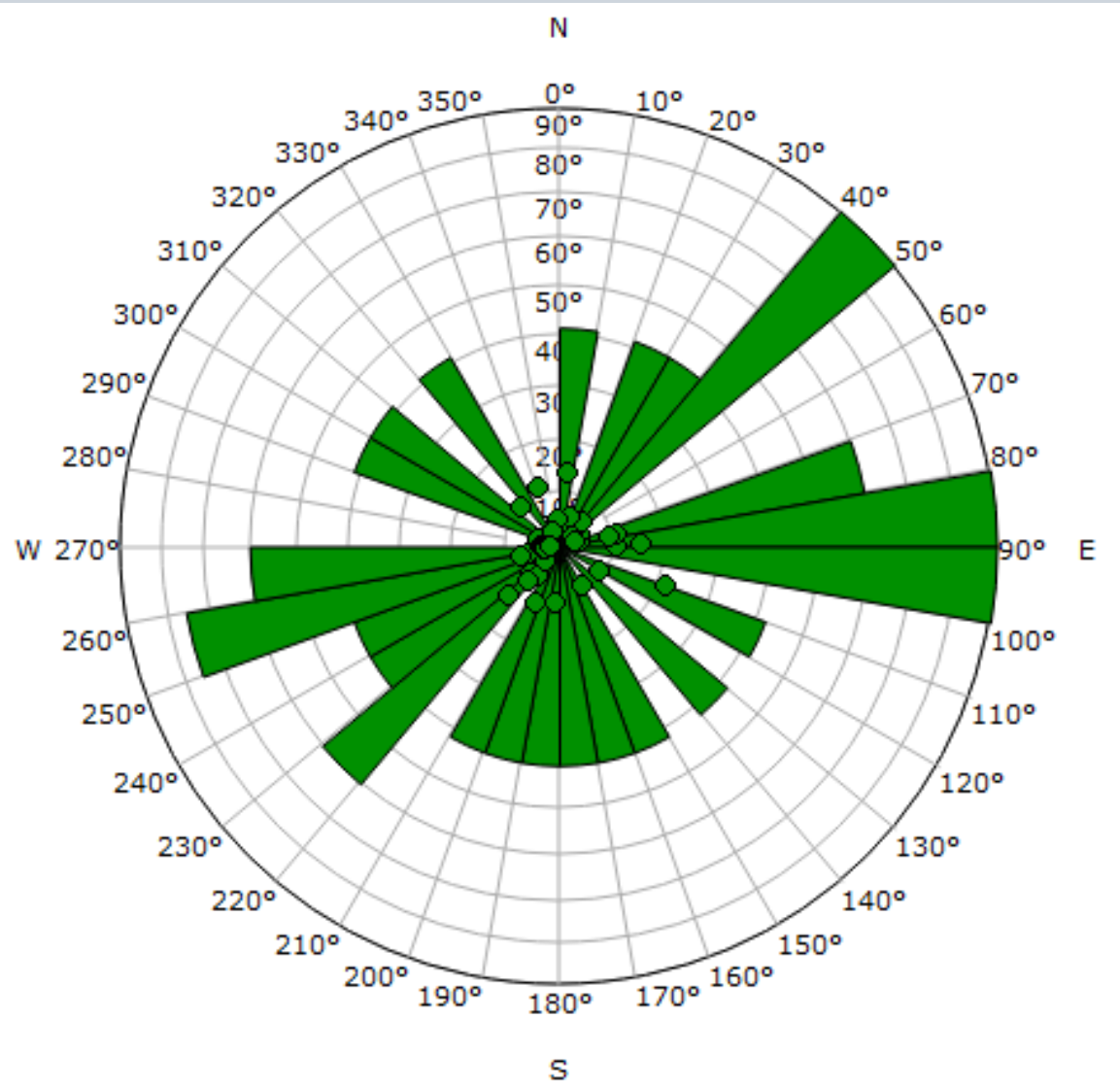
FMI Image Logs VS Core



Terrace 36-32M:
Core shows clean sand, but the FMI image log shows cross bedding in the same interval

So which facies is it actually?

Terrace 36-32M: Bedding Planes

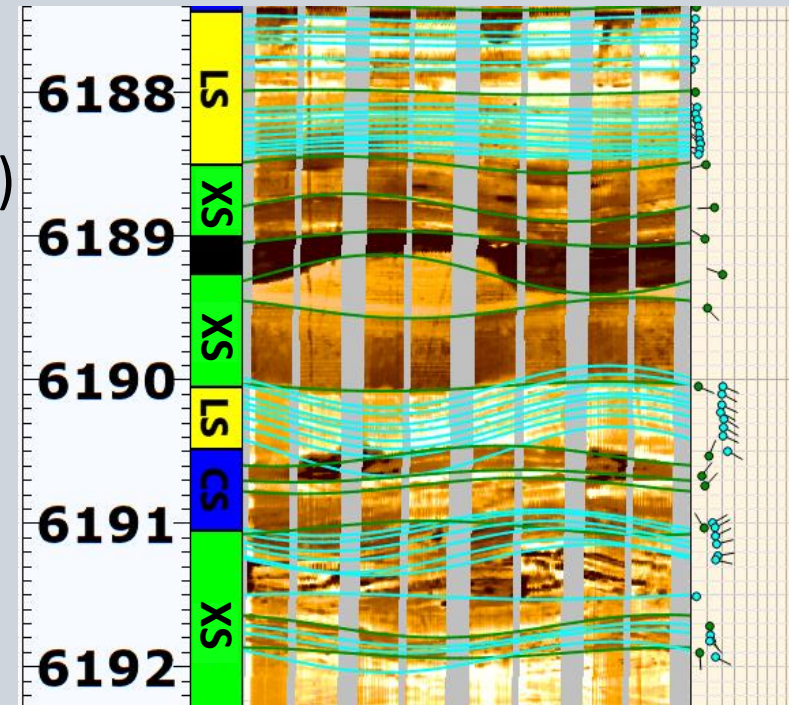
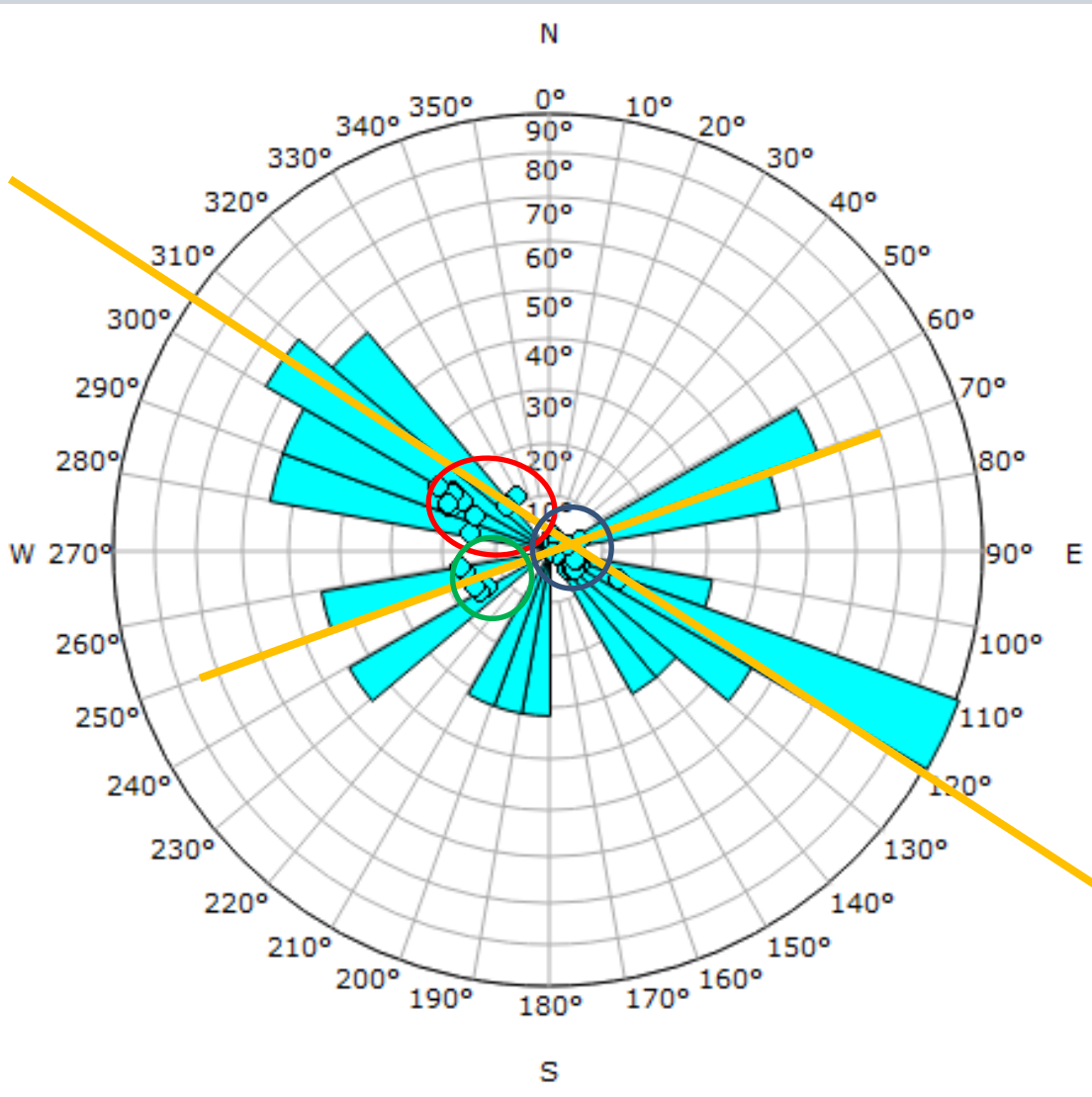


- Very wide range in strikes
 - Greater trend ENE-WSW
- Dips generally less than 20°
- Greatest dip 21°

Terrace 36-32M: Cross bedding

Cross bedding was found within the XS facies. Parallel laminations from LS facies included.

- Greatest trend: WNW-ESE (~305°)
- Secondary trend: WSW-ENE (~250°)
- Three dip clusters:
 - ~17° AVG (red)
 - ~15° AVG (green)
 - ~6° AVG (blue)



Future Work

- Log analysis in Petra to utilize the extensive log data given
- Petrography to narrow down the diagenetic history for the Codell Sandstone
- Thin section analysis of various facies
 - Geochemical analysis to determine the probable source for the hydrocarbons in the Codell Sandstone

Conclusion

- 1) The Codell Sandstone is complex given by different regions having different depositional characteristics and environments
- 2) At Redtail Field, the Codell Sandstone has 6 unique facies
- 3) FMI Image logs in Techlog can aid in geologic interpretation but can give different results than looking at core
- 4) Bedding and crossbedding of the Codell Sandstone follows specific trends in Redtail Field

References

Sonnenberg, S. A., 2017, Abstract: Keys to Niobrara and Codell production, East Pony/Redtail Area, Denver Basin, Colorado.

Weimer, R. J., and S. A. Sonnenberg, 1983, Codell Sandstone, new exploration play, Denver basin: The Rocky Mountain Section SEPM: p. 27-40

Damon, N., 2022, Reservoir Characterization of the Codell Sandstone at Redtail Field, Weld County, Colorado

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