Reservoir Characteristics and Production Analyses for the Niobrara A Interval at Redtail Field, Weld County, Colorado

Scott K Manwaring, PG
smanwaring@mymail.mines.edu

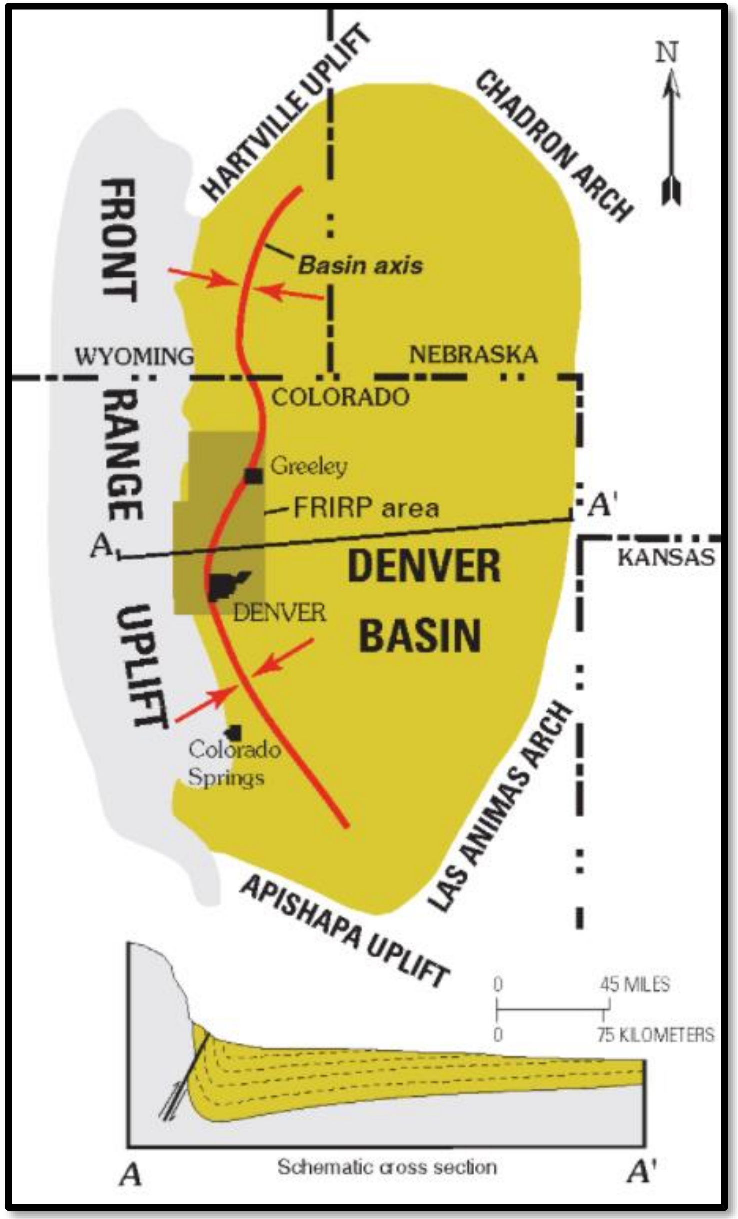
MS Geology

May 2021

Overview

- Introduction
- Purpose and Objectives
- Research and Methods
- Regional Geology
- Others Previous Work
- Completed Work

Location and Study Area



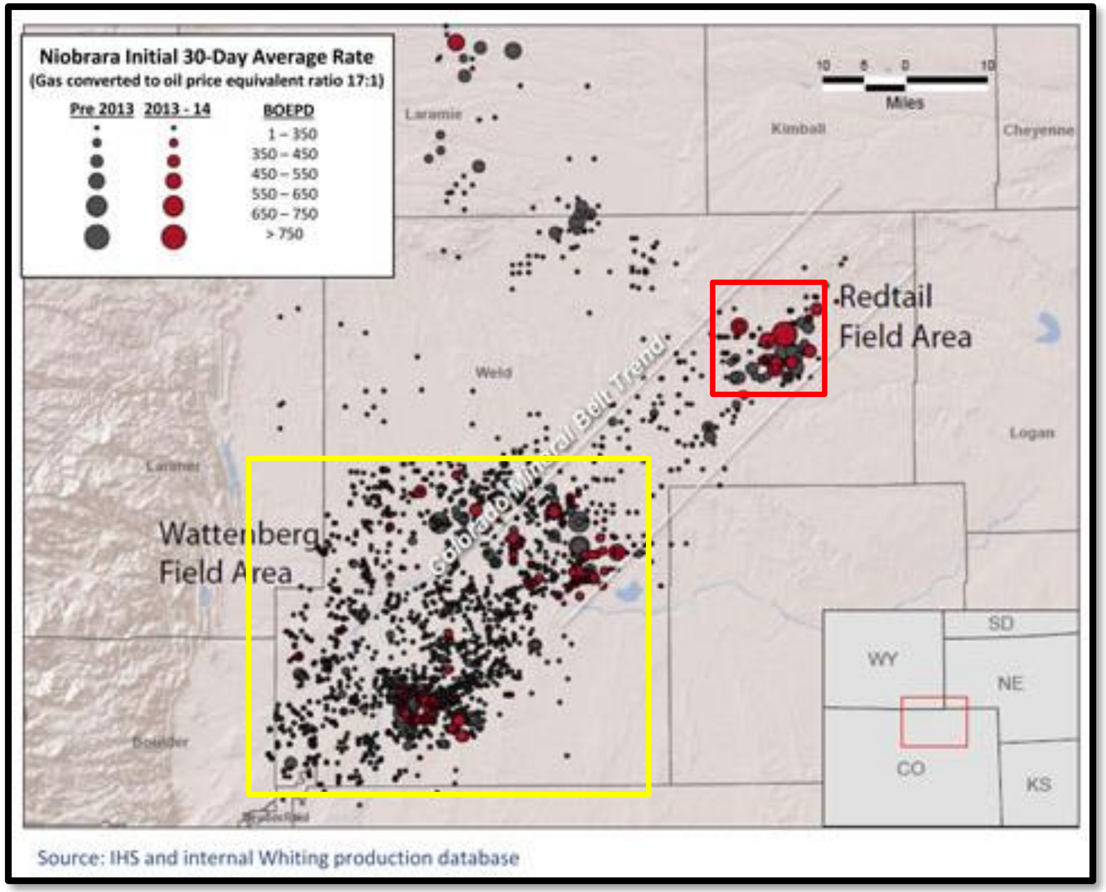
USGS, 2016

Denver Basin bound by:
Hartville Uplift and Chadron Arch to North
North American Craton to East
Apishapa Uplift and Las Animas Arch to South
Front Range Uplift to West

Redtail (and adjacent East Pony Field) are on trend with Wattenberg, but not necessarily continuous.

Why does Redtail Field exist where it is?

Townships: 9N, 10N, 11N
Ranges: 57W, 58W, 59W



Whiting Petroleum, 2014

Purpose and Objectives

Purpose:

- Broadly, to summarize the reservoir characteristics and production results of the Niobrara A interval at Redtail Field
  - Lack of understanding of the Niobrara A interval
  - Redtail Field contains nearly all Niobrara A wells in the Denver Basin

Objectives:

- Better understand the geologic controls on the limits of Redtail Field
- Extend the field model to other areas of the Denver Basin that may be prospective in the Niobrara A

Research and Methods

- Facies description of the Niobrara A interval in the Razor 25-2514 core
- Core-to-log model in the Razor 25-2514 (Φ, k, S_o and S_w, gamma correlations)
- Extension of core-to-log model to other 6 six cores in Redtail that contain the Niobrara A interval
- Extrapolation of core-to-log model outside Redtail

Research and Methods – cont'd

- Total organic carbon and pyrolysis analyses to evaluate thermal maturity, kerogen type, and calculate vitrinite reflectance of the Niobrara A interval
- Bottom-hole temperature (BHT) mapping to compare against thermal maturity
- BHT comparison to resistivity to ascertain viability in identifying edge of field

Research and Methods – cont'd

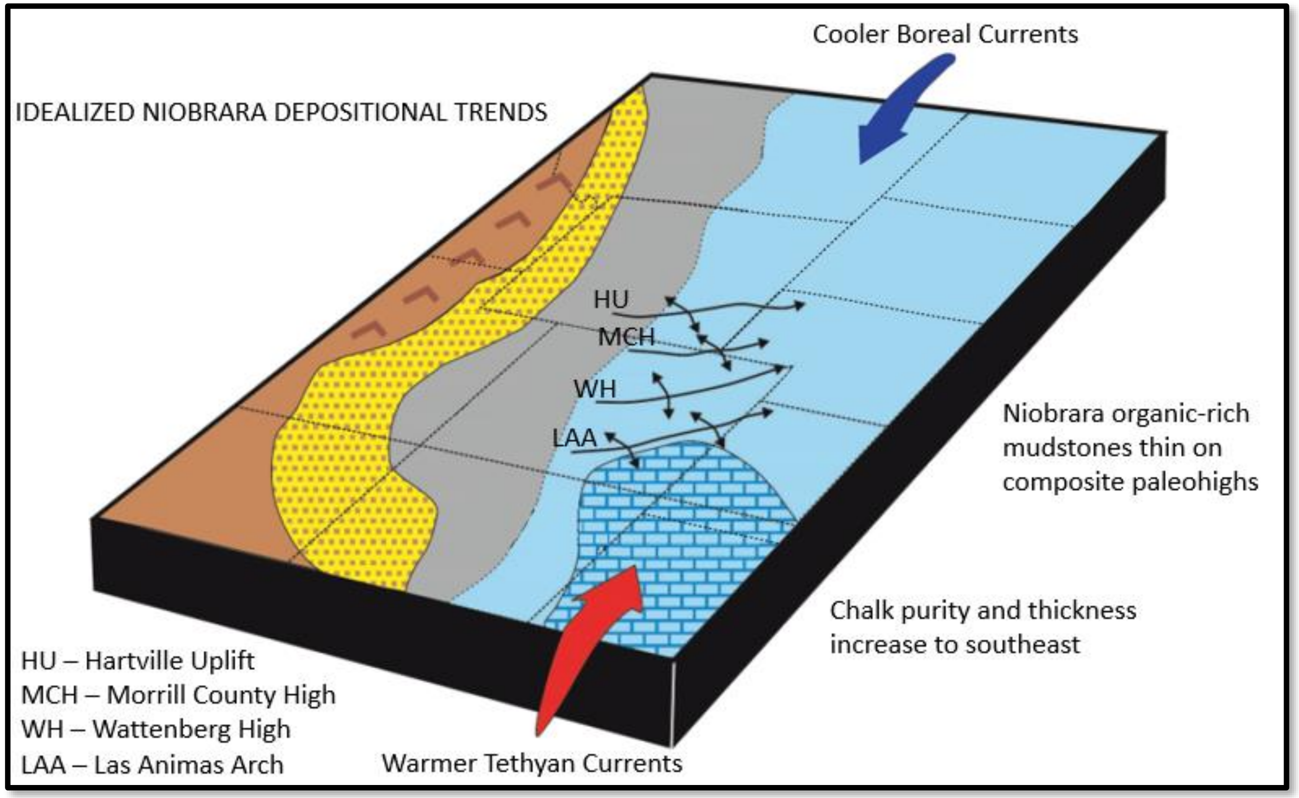
- Calculate OOIP and map values across Redtail
- Calculate average recovery factor from current production
- Calculate average decline curves
- Calculate EUR values for the Niobrara A interval
- Use EUR values to determine the viability of the Niobrara A interval as a development target

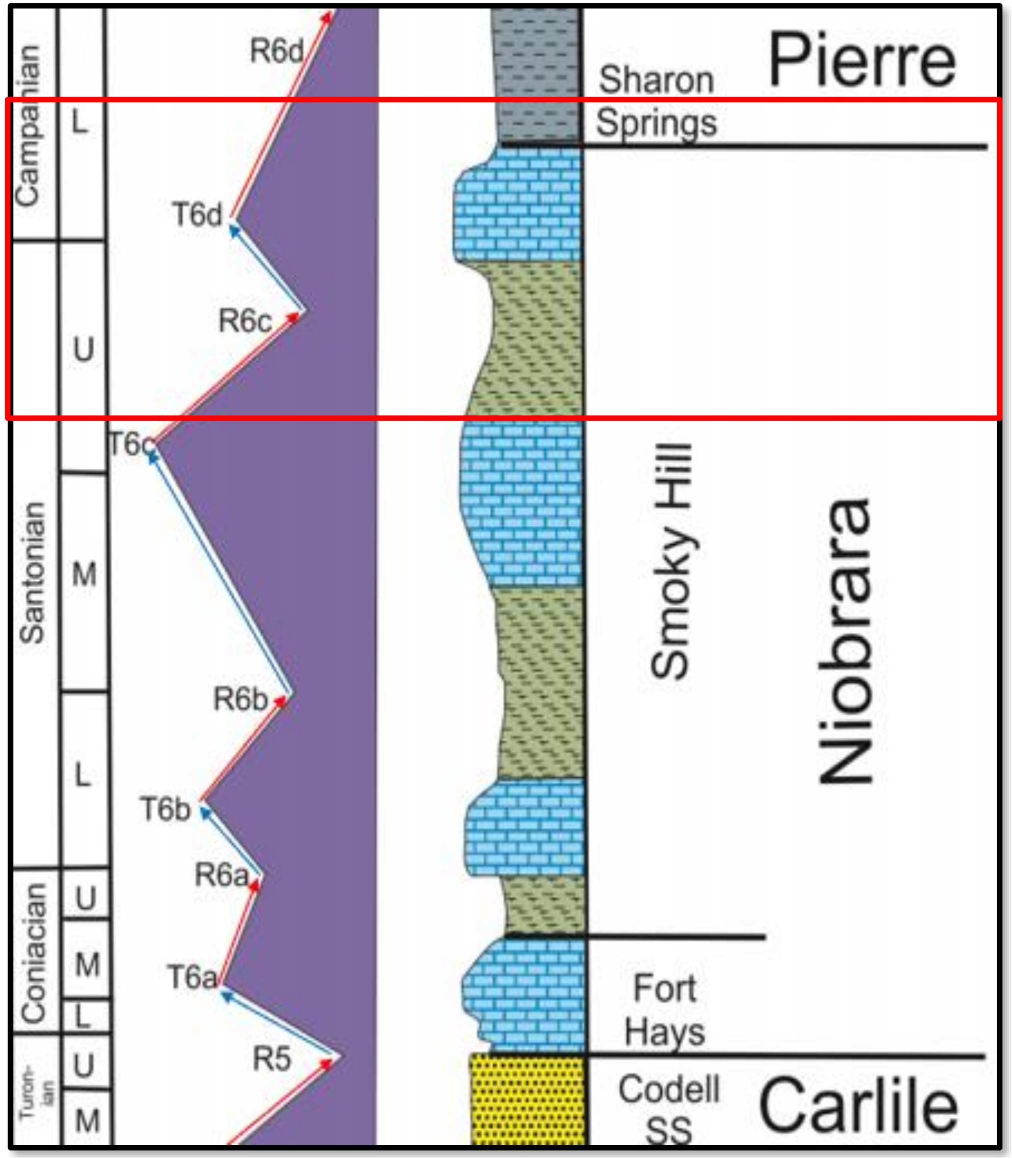
Regional Geology

- Cretaceous Western Interior Seaway connected Arctic Ocean and Tethys Ocean across the North American continent
- Resultant highstand(s) lasted millions of years
- Inundation allowed carbonate biota to flourish at different times
- Oscillations in water depth and water mixing led to different depositional geometries and environments

Blakey, 2008

Regional Geology – cont'd





Modified after Longman *et al.*, 1998

- Mixing of warmer and cooler waters, as well as distance from land, led to the deposition of shales and carbonates within the basin
- Relative sea level change caused fine-scale lithologic changes in the carbonates
- Alternating series of chalk and organic-rich mudstones characterize the Smoky Hill member of the Niobrara Formation

Regional Geology – cont'd

- As Cretaceous Western Interior Seaway withdrew, terrigenous deposition dominated
- Subduction angle transition led to Laramide Orogeny and fracturing of previous Western Interior Basin into smaller basins
- Denver Basin buried to sufficient depth to allow hydrocarbon generation
- Organic-rich mudstones acted as source rocks; chalks acted as reservoirs

Blakey, 2008

Others Previous Work

- Niobrara has been studied since the 1950s, publications continue to this day. However, most previous work did not treat the Niobrara A interval, usually due to the interval being non-existent or not having data available
- Pahnke (2014) investigated microporosity in the chalks of the Niobrara Formation, described the types of porosity therein, and explained how porosity changes in relation to burial depth and diagenesis
- ElGhonimy (2015) studied petrophysical, geochemical, mineralogical, and storage capacity of the entire Niobrara Formation and evaluated each bench individually
- Sonnenfeld *et al.* (2015) investigated bentonites within the Niobrara Formation and their impact on proppant placement and effective fracture continuity

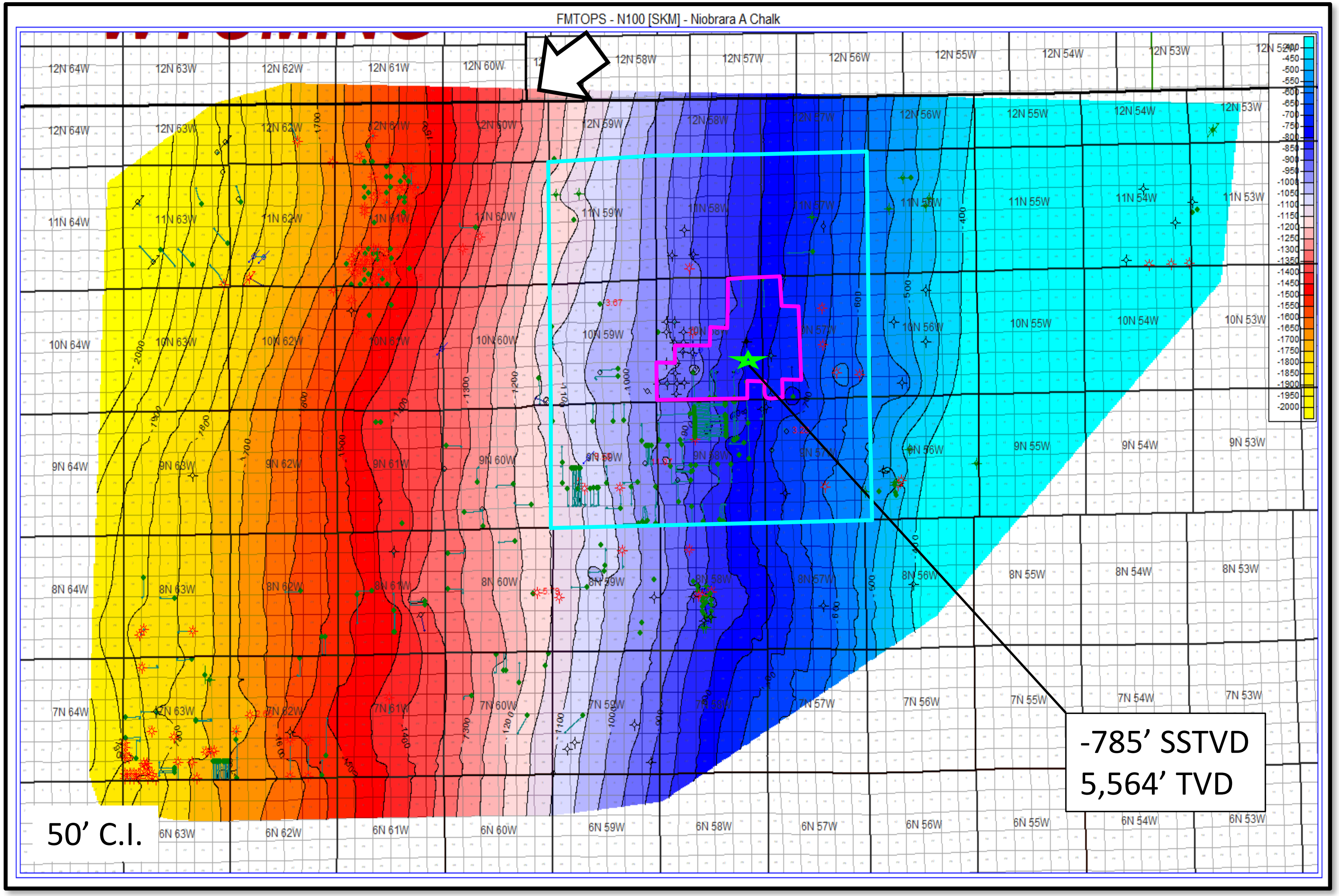
Previous Work – cont'd

- Zumberge *et al.* (2016) studied hydrocarbon sourcing and movements within the Niobrara Petroleum System
- Aydin (2017) researched the porosity and permeability of each bench of the Niobrara and concluded that the Niobrara A Chalk and A Marl contain the highest porosities and permeabilities of the Niobrara Formation
- Byrnes *et al.* (2017) investigated porosity and permeability in the Niobrara Formation by using digital rock physics to characterize chalk properties
- Deacon and McDonough (2018) studied how producibility of the Niobrara was impacted by depositional and stratigraphic complexities
- Lopez (2018) characterized peloids and diagenesis exclusively in the Niobrara A Chalk and noted loss of porosity with increased burial depth due to several factors

Important Observations

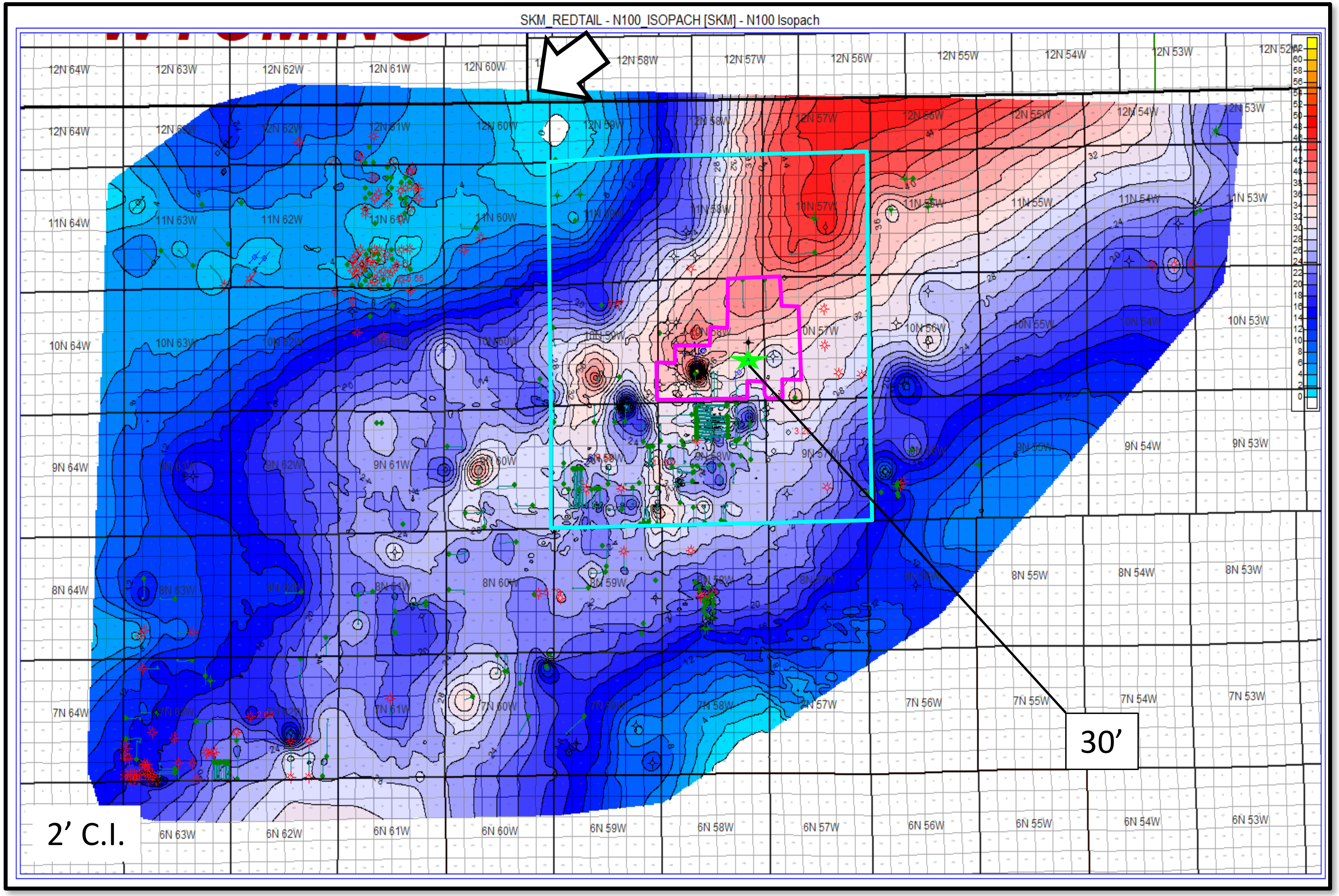
- Depth to Niobrara is as expected and unlikely to be a constraint on producibility
- Producing wells are not in the thickest A Chalk, nor the thickest Niobrara A interval
- BHTs were taken at various depths and will present false hot spots if depths are not accounted for
- Even with accounting for depth, some BHTs are still misleading due to being too shallow or too deep; this is not correctable and data points may need to be excluded

Niobrara A Chalk SSTVD



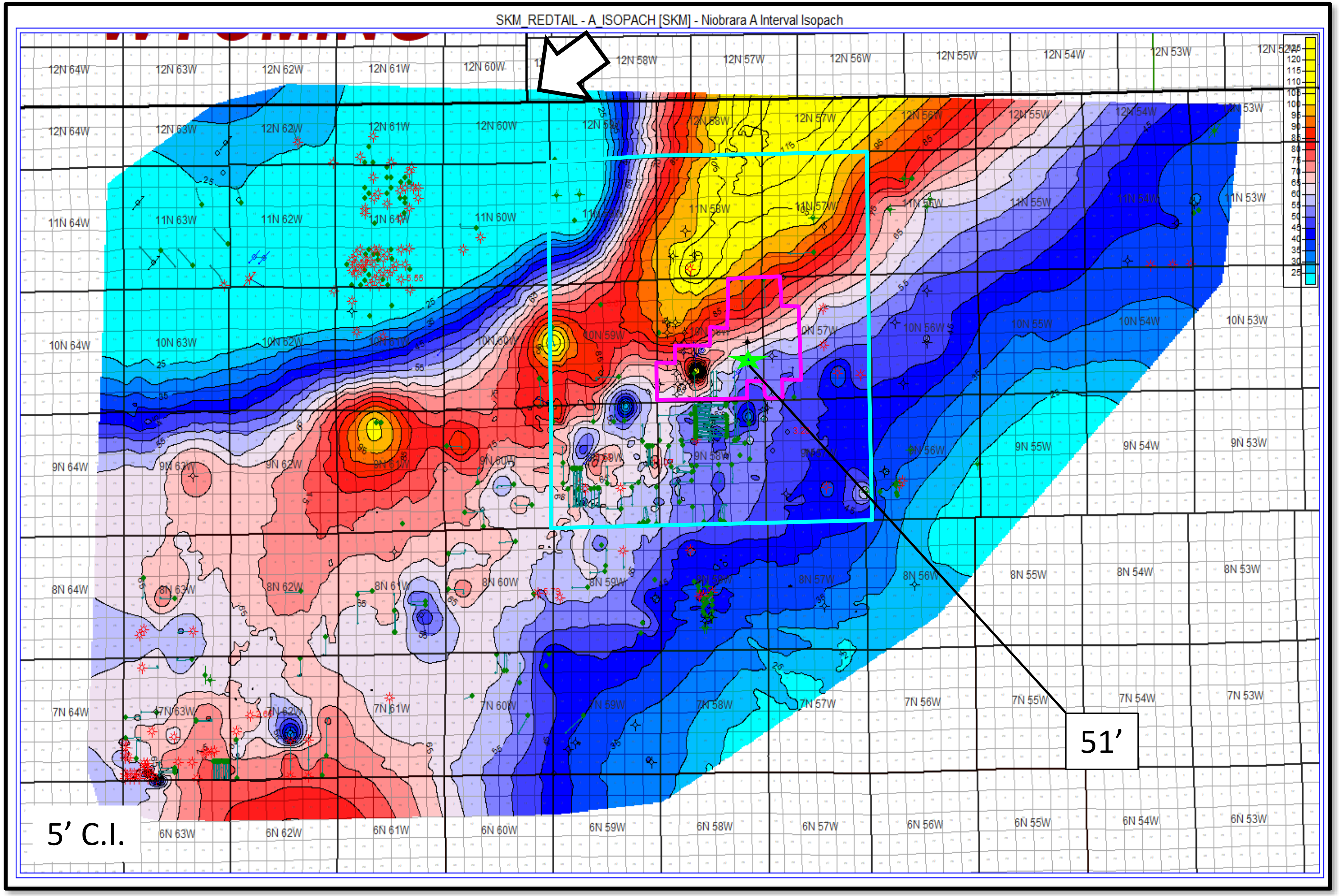
- Mapped from gamma picks in 482 wells
- Slope from east to west (to basin center)
- Overlying and underlying intervals are similar

Niobrara A Chalk Isopach



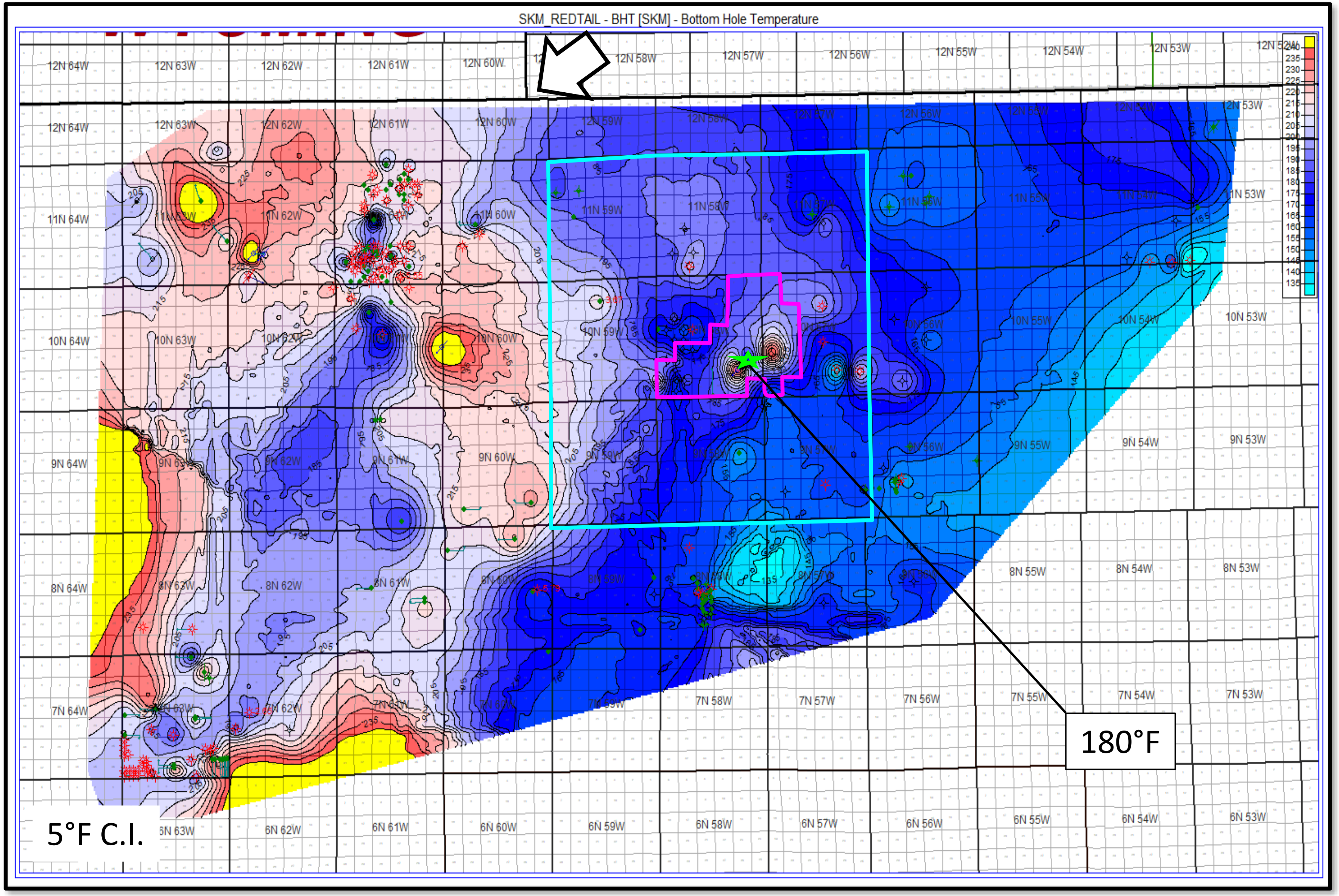
- Mapped from isopachs in 475 wells (-7)
- Thickening of A Chalk seen to NE into NE
- Redtail Production Fairway: 30'-38' thick

Niobrara A Isopach (Sharon Springs to top B Chalk)



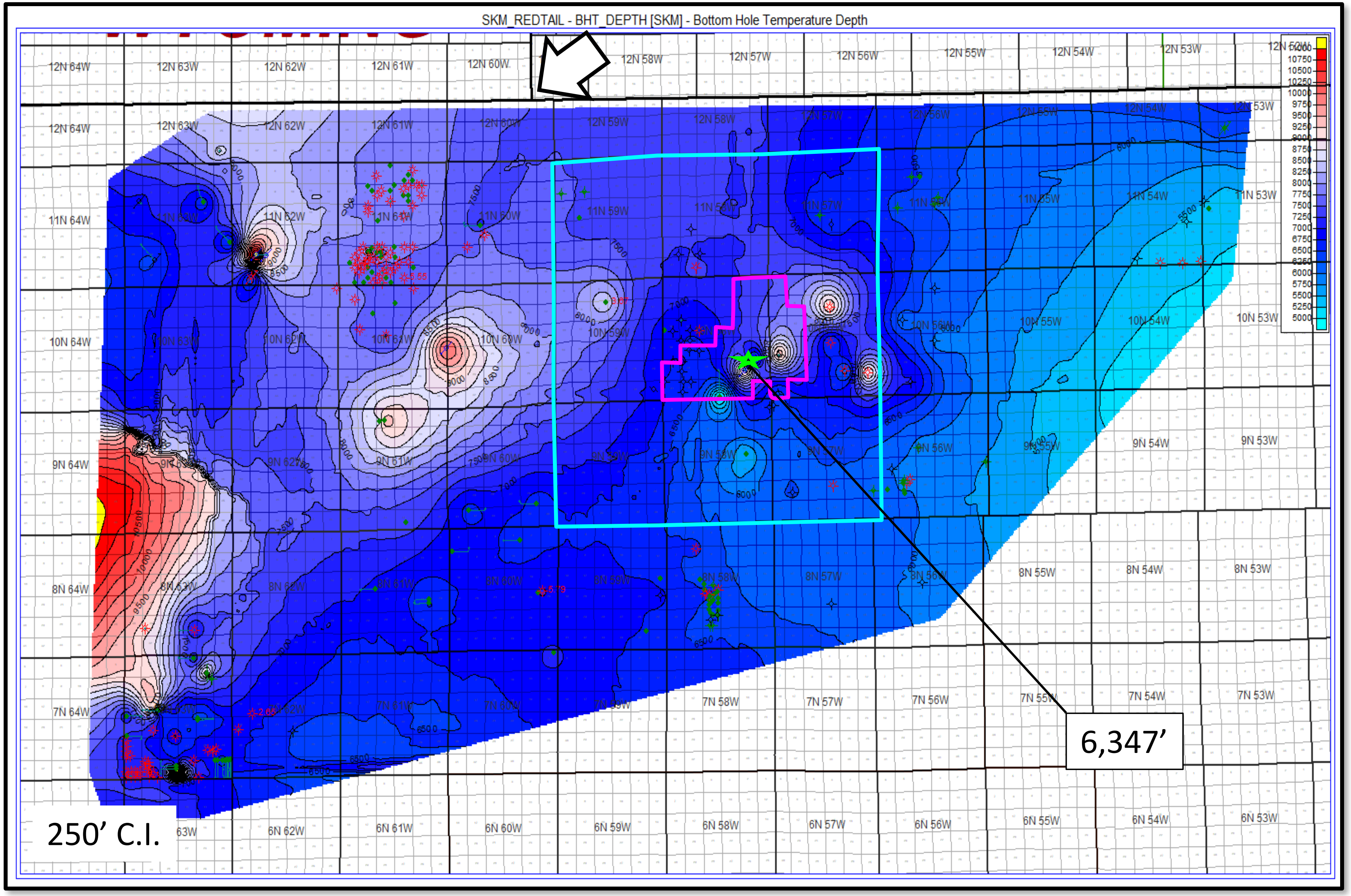
- Mapped from isopachs in 475 wells (-0)
- Thickening of A Interval seen to NE into NE
- Redtail Production Fairway: 50'-85' thick

Bottom Hole Temperatures



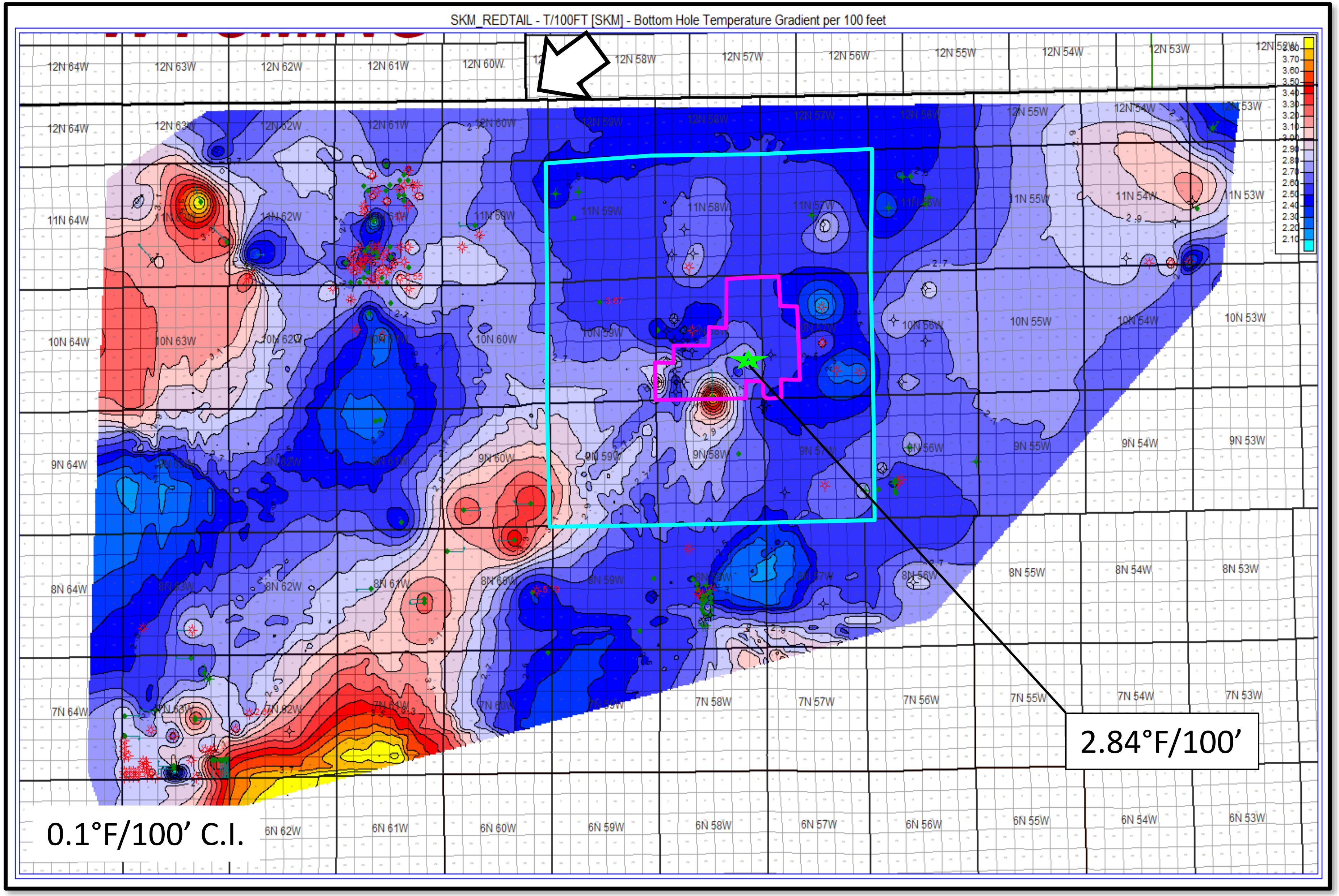
- Mapped from BHTs in 261 wells (-214)
- BHT generally decreases to E (or does it?)
- Redtail Production Fairway: 165°F-240°F

Bottom Hole Temperature Depths



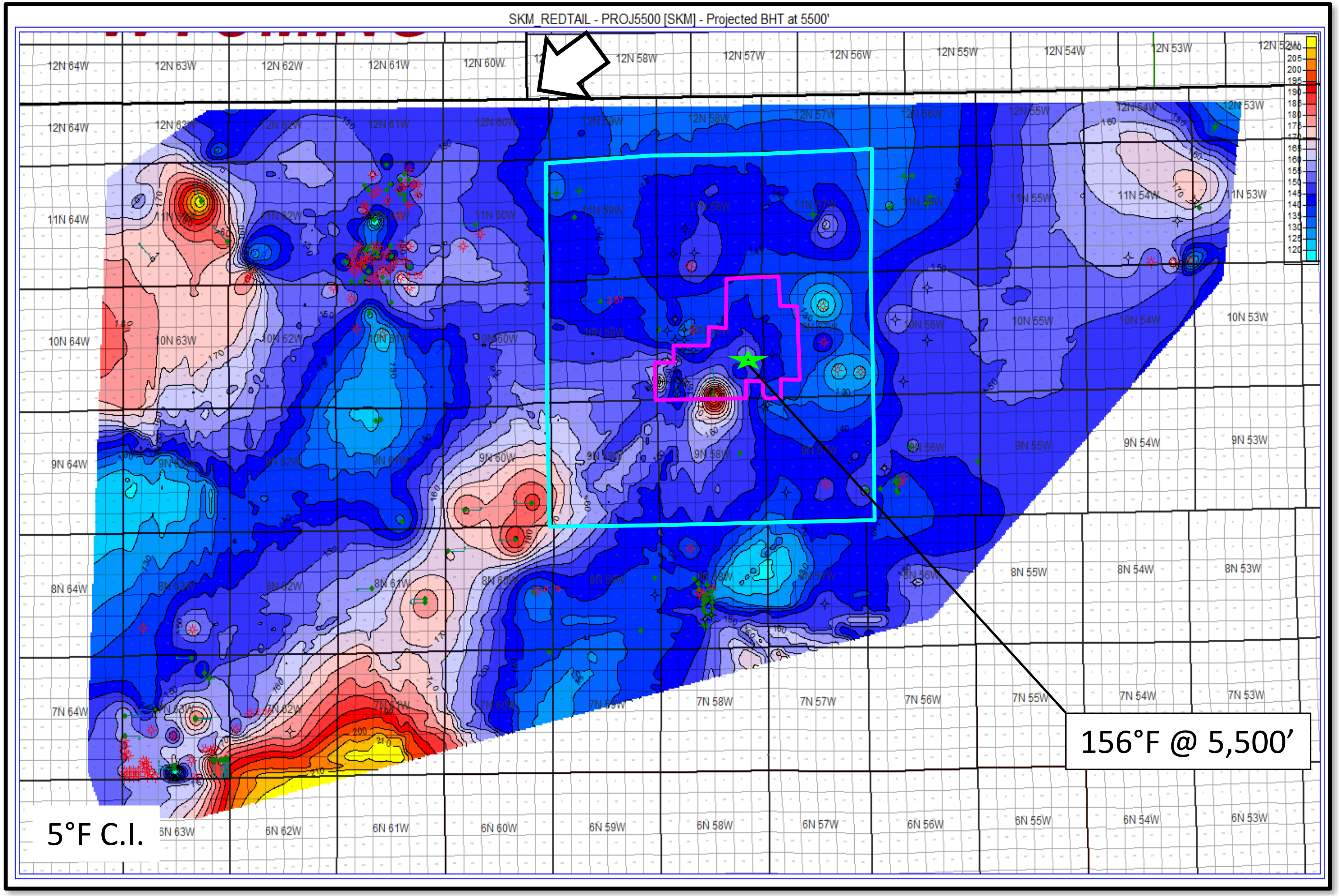
- Mapped from BHTs in 261 wells (-0)
- BHT depths generally decrease to E
- Redtail Production Fairway: 6,000’-8,000’

Bottom Hole Temperature Gradient per 100’



- Mapped from BHTs in 261 wells (-0)
- BHT gradient generally decreases to NE
- Redtail Production Fairway: 2.5°F-3.1°F per 100’

Projected Bottom Hole Temperature at 5,500’

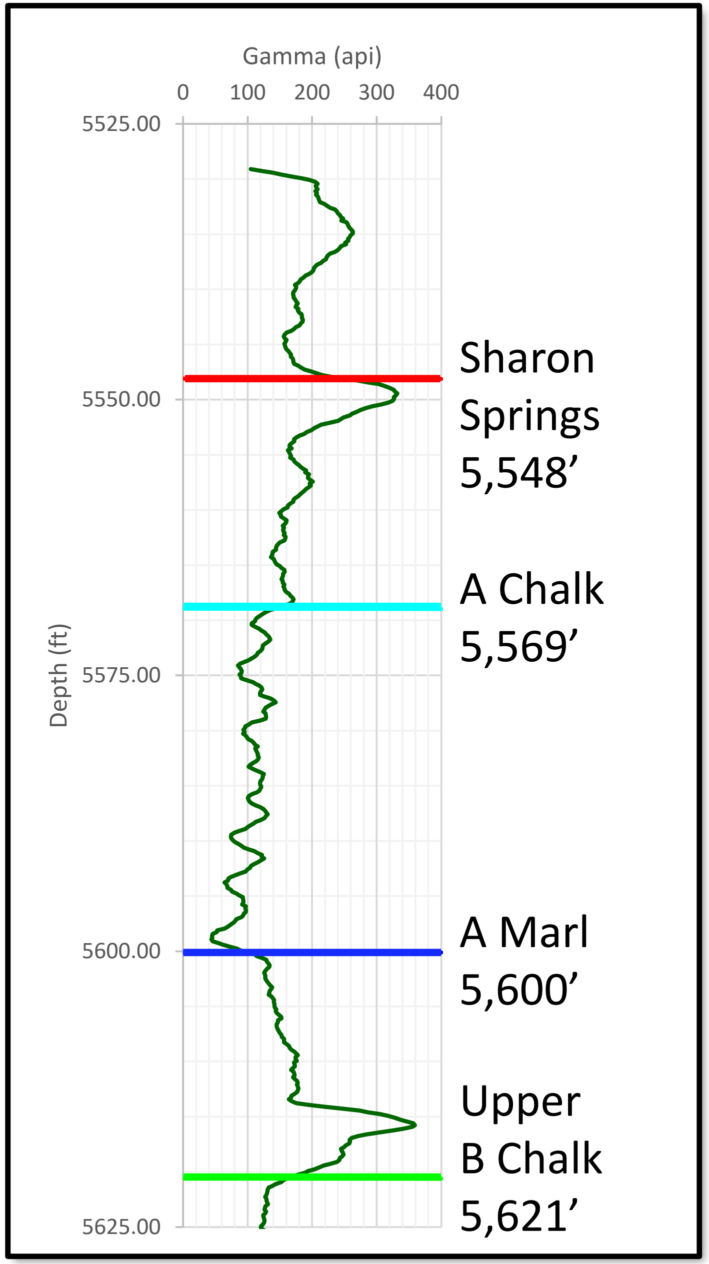


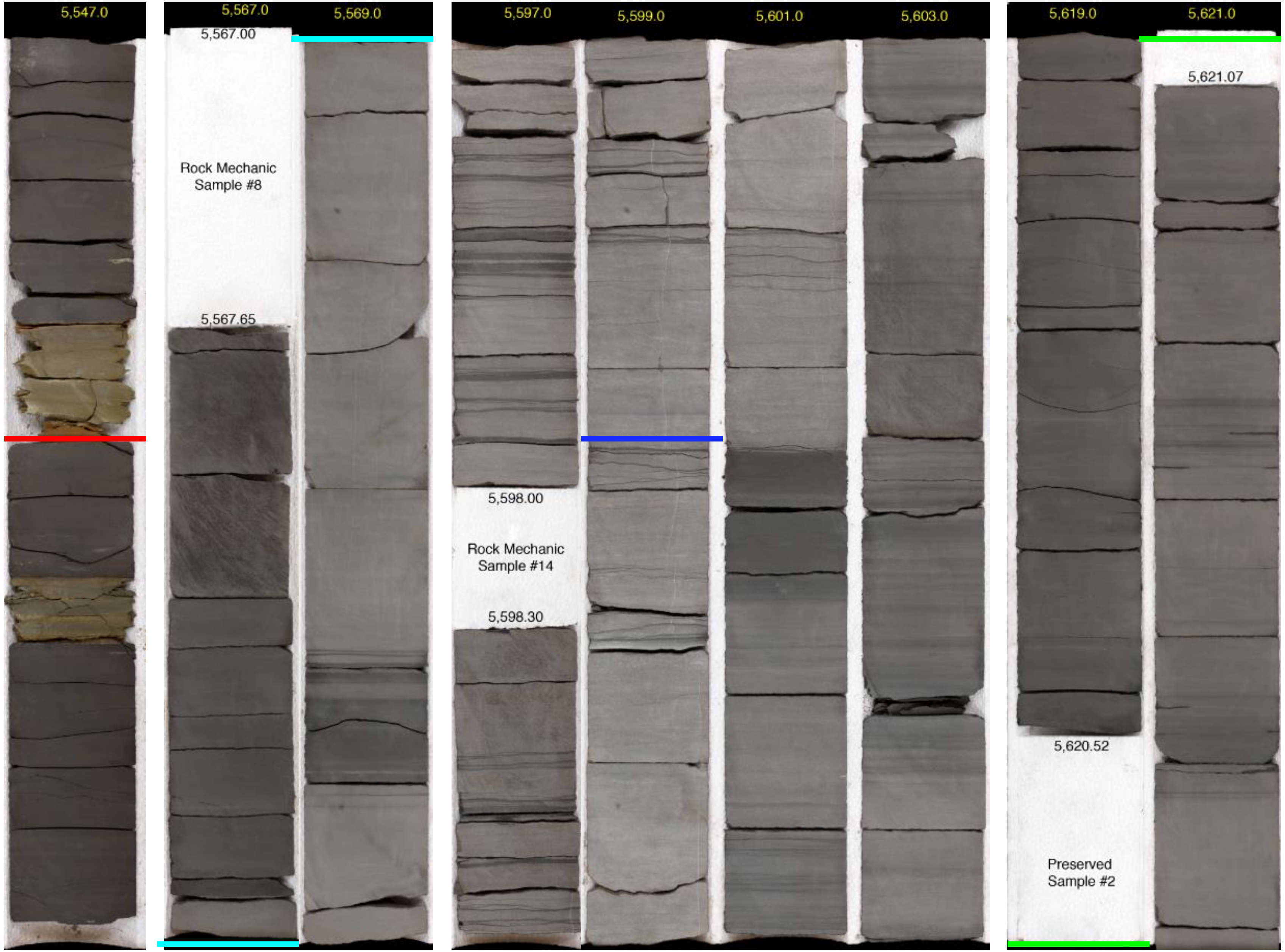
- Mapped from BHTs in 261 wells (-0)
- BHT gradient generally decreases to NE
- Redtail Production Fairway: 140°F-160°F @ 5,500’

Important Observations

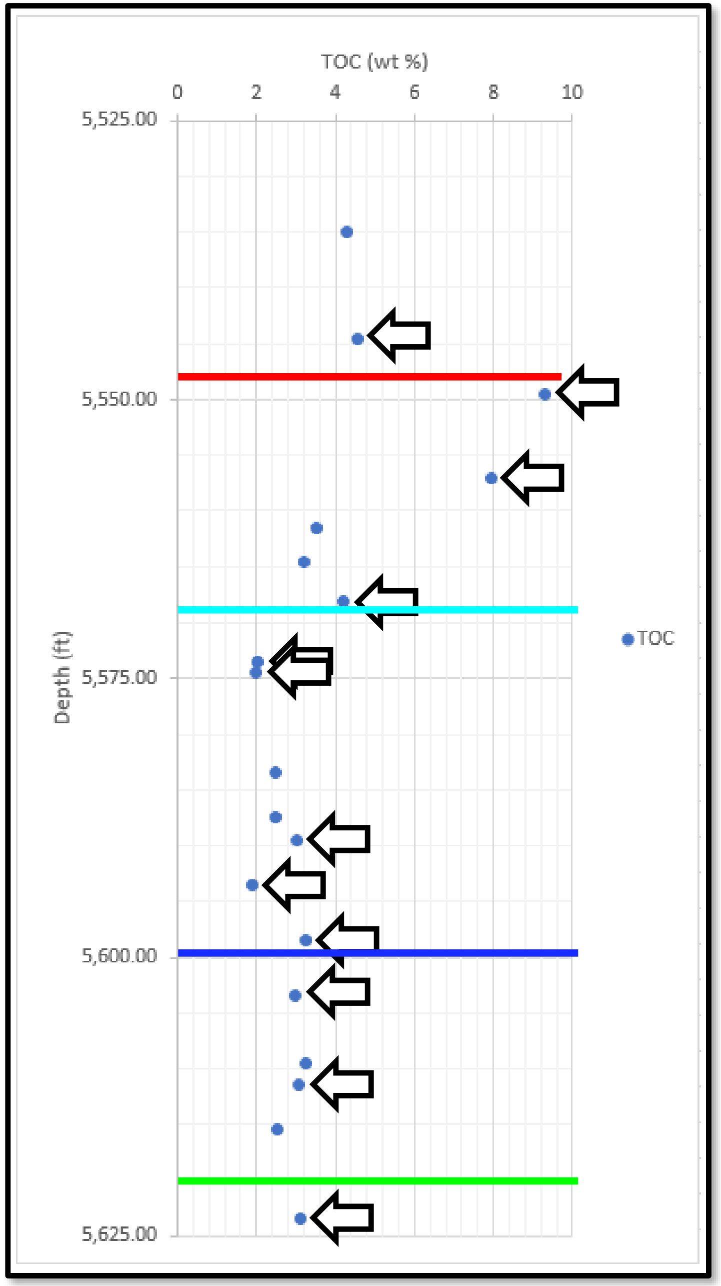
- Depth to Niobrara is as expected and unlikely to be a constraint on producibility
- Producing wells are not in the thickest A Chalk, nor the thickest Niobrara A interval
- BHTs were taken at various depths and will present false hot spots if depths are not accounted for
- Even with accounting for depth, some BHTs are still misleading due to being too shallow or too deep; this is not correctable and data points may need to be excluded

Type Log and Contacts

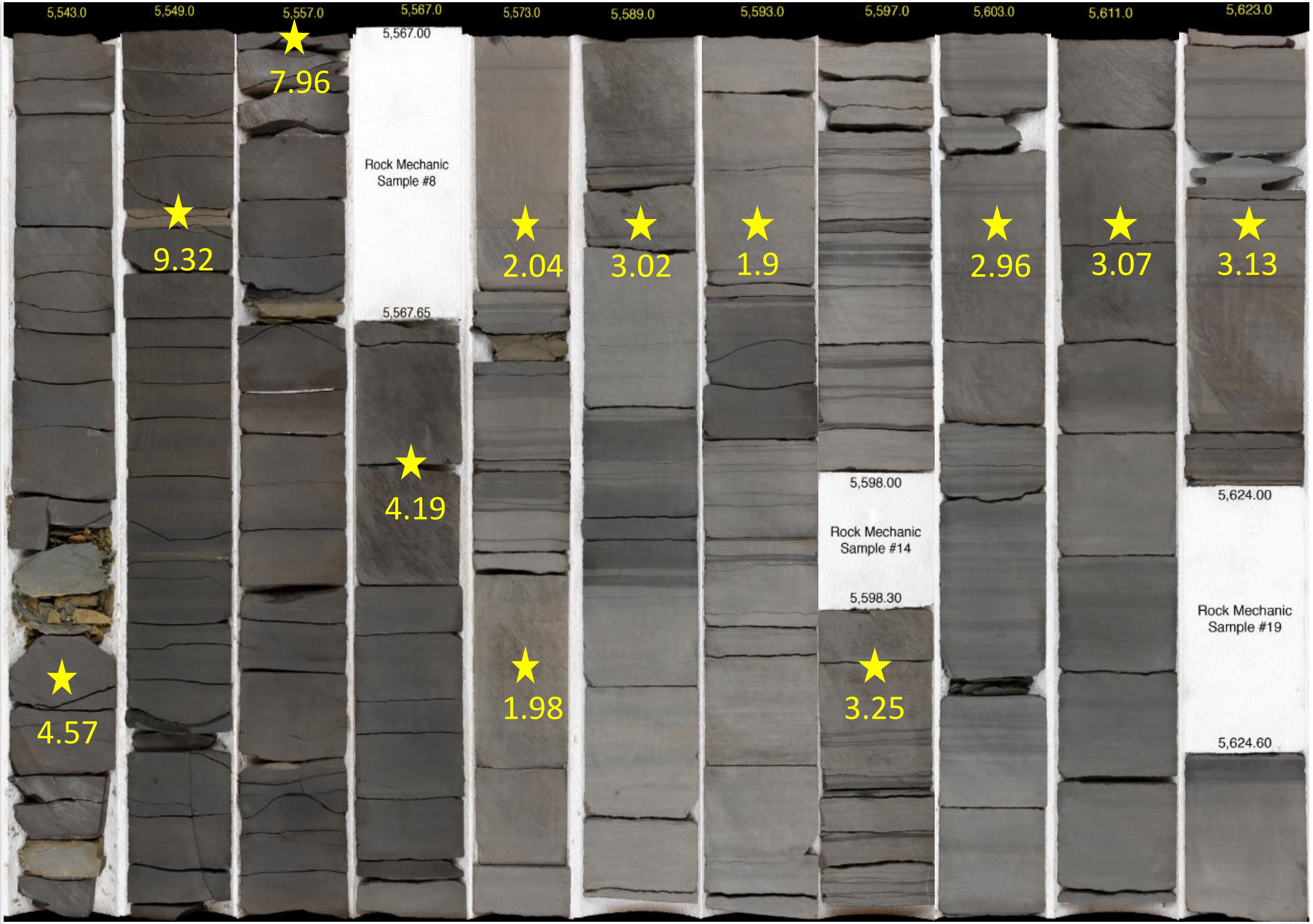




TOC Samples

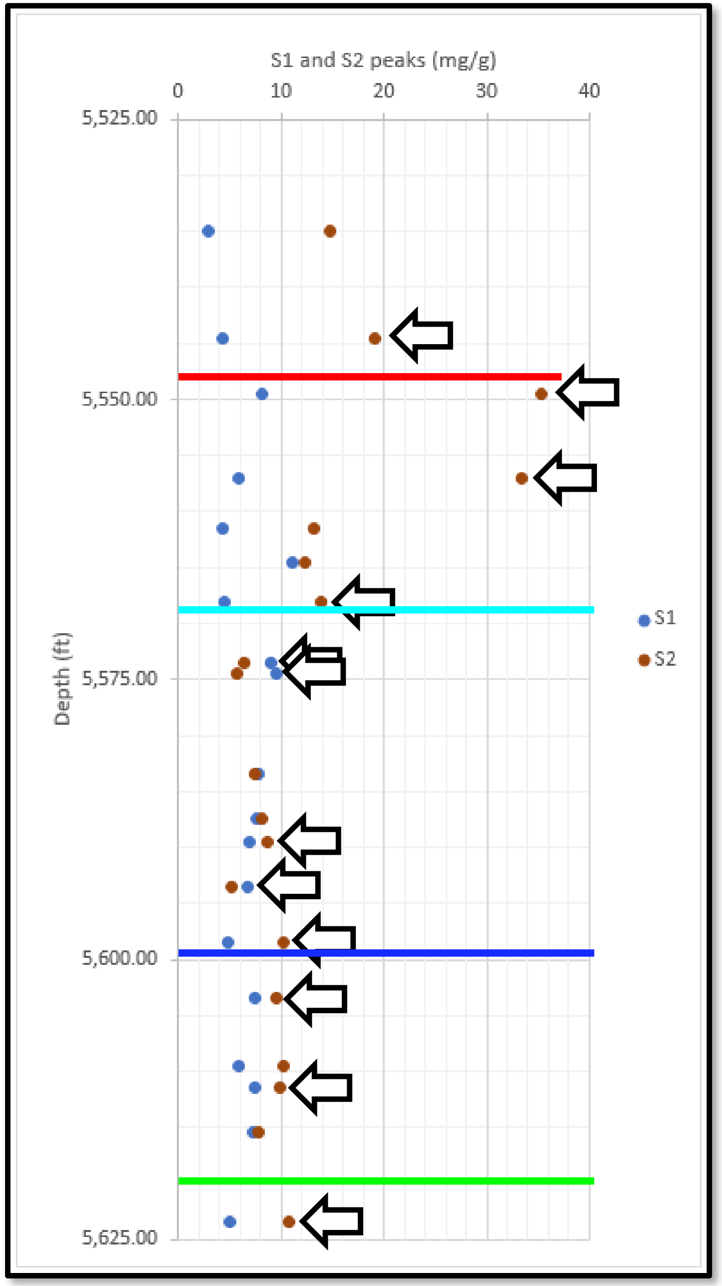


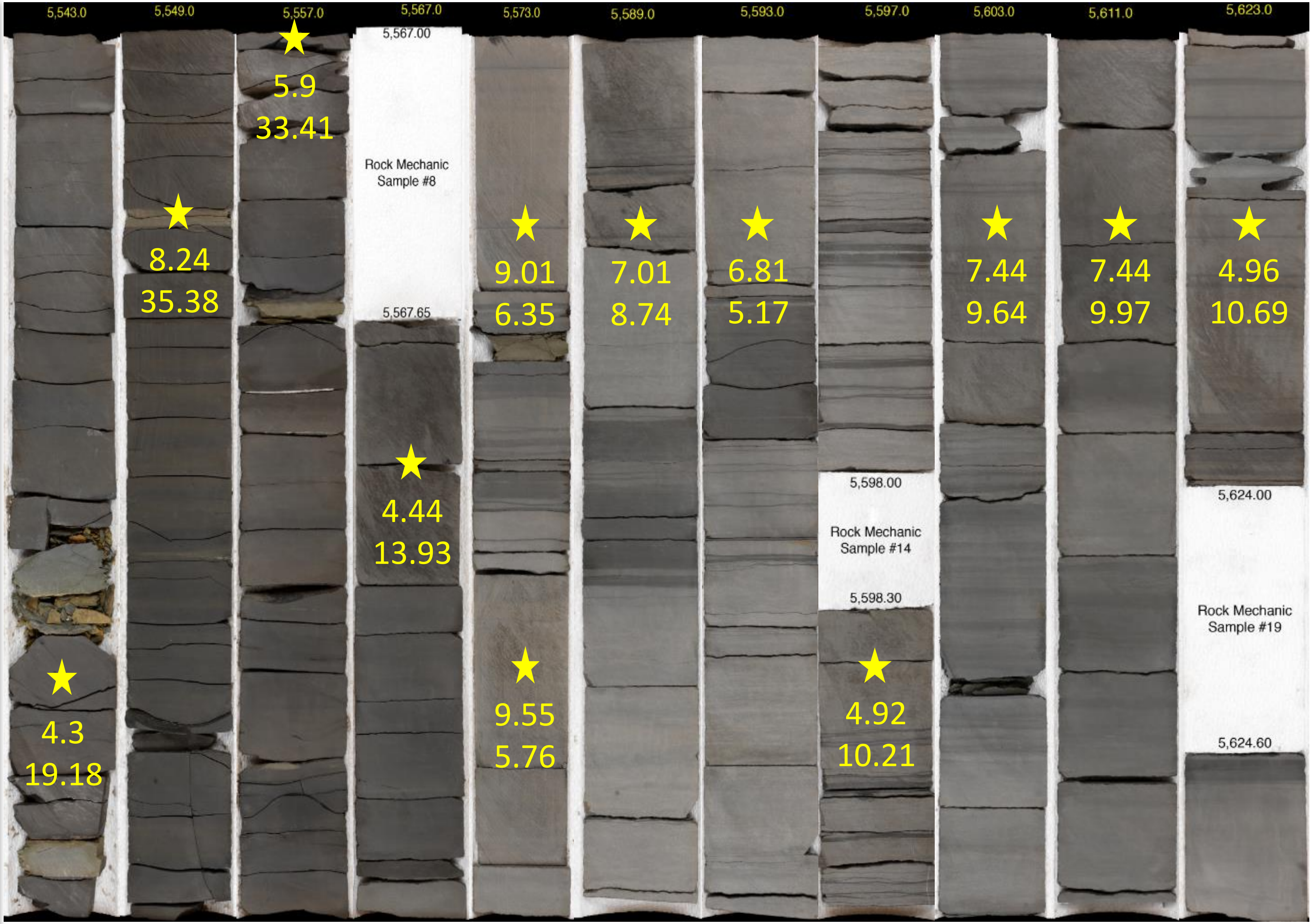
TOC (wt %)
0
2
4
6
8
10
5,525.00
5,550.00
5,575.00
5,600.00
5,625.00
Depth (ft)
TOC



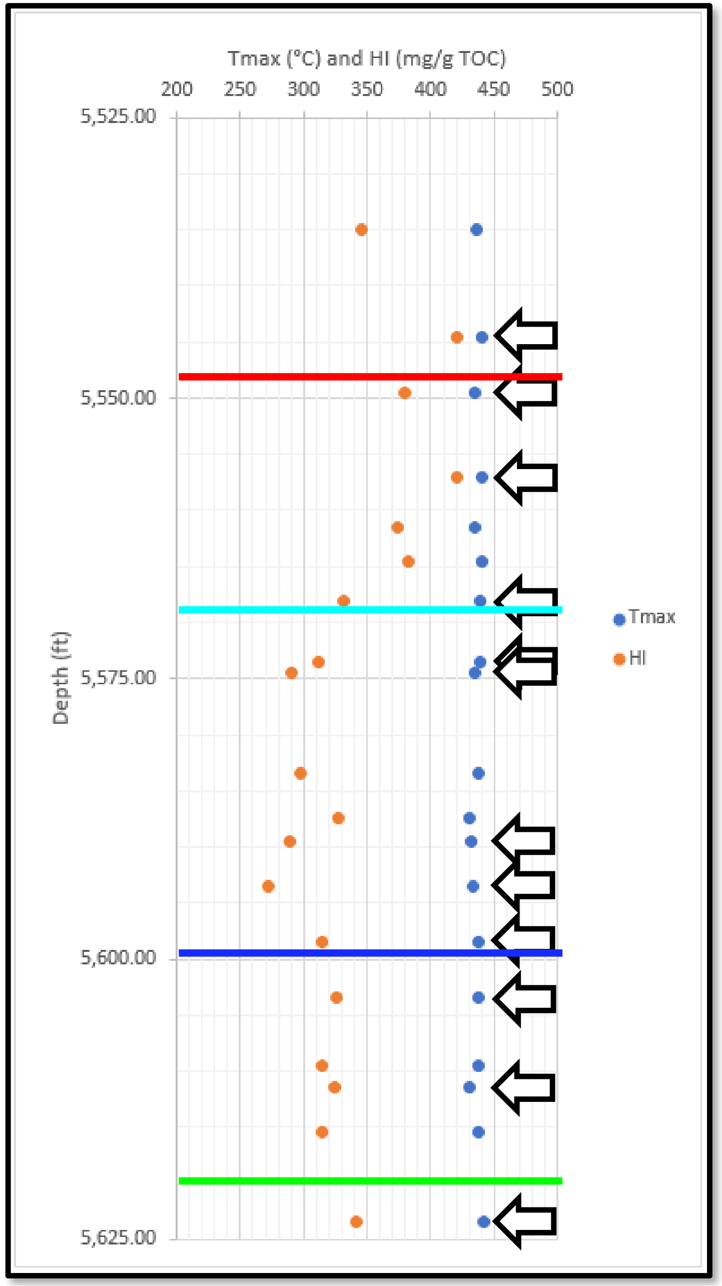
5,543.0
5,549.0
5,557.0
5,567.0
5,573.0
5,589.0
5,593.0
5,597.0
5,603.0
5,611.0
5,623.0
5,567.00
Rock Mechanic Sample #8
5,567.65
7.96
9.32
2.04
3.02
1.9
2.96
3.07
3.13
4.19
4.57
1.98
3.25
5,598.00
Rock Mechanic Sample #14
5,598.30
5,624.00
Rock Mechanic Sample #19
5,624.60

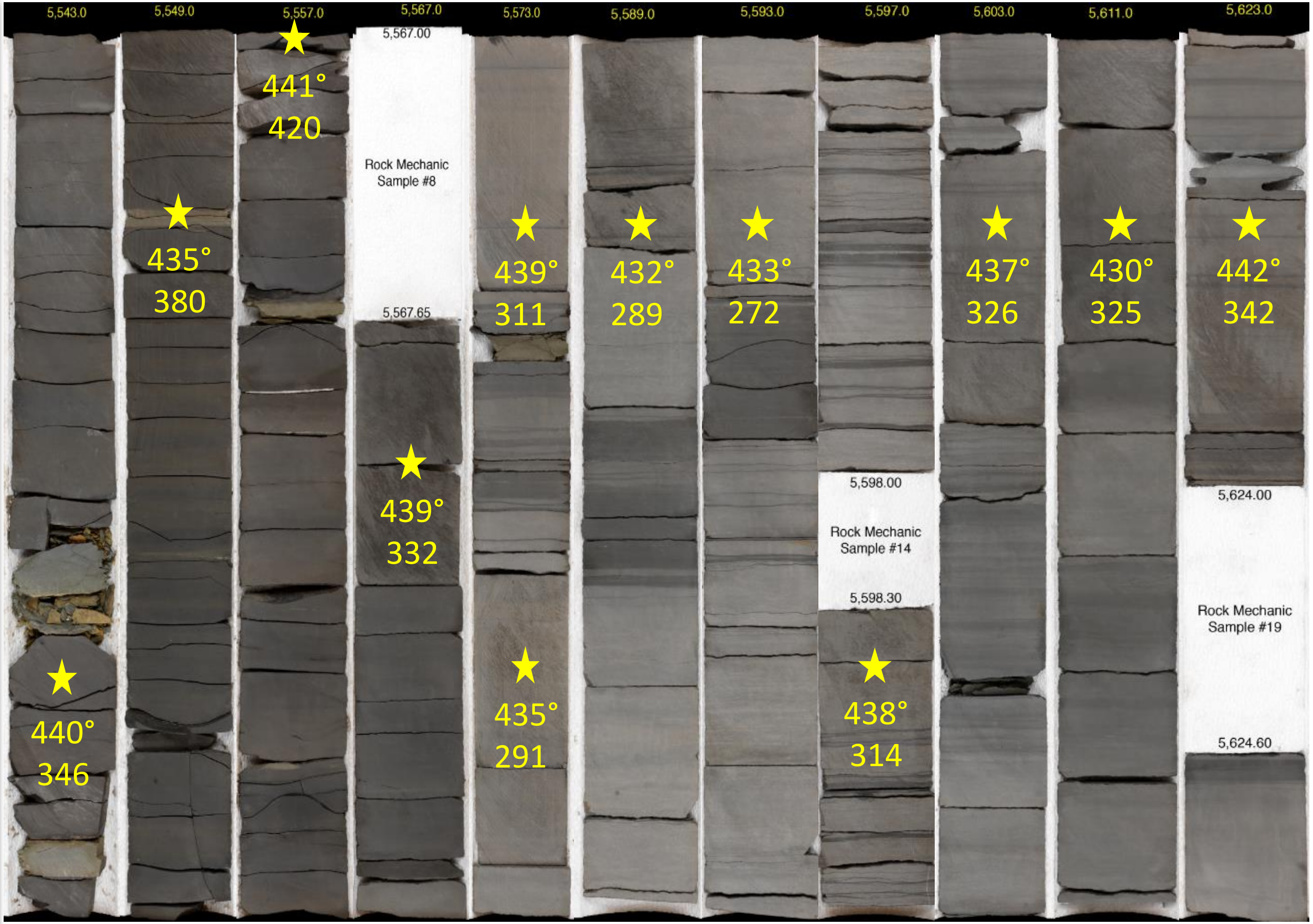
S1 and S2 Peaks



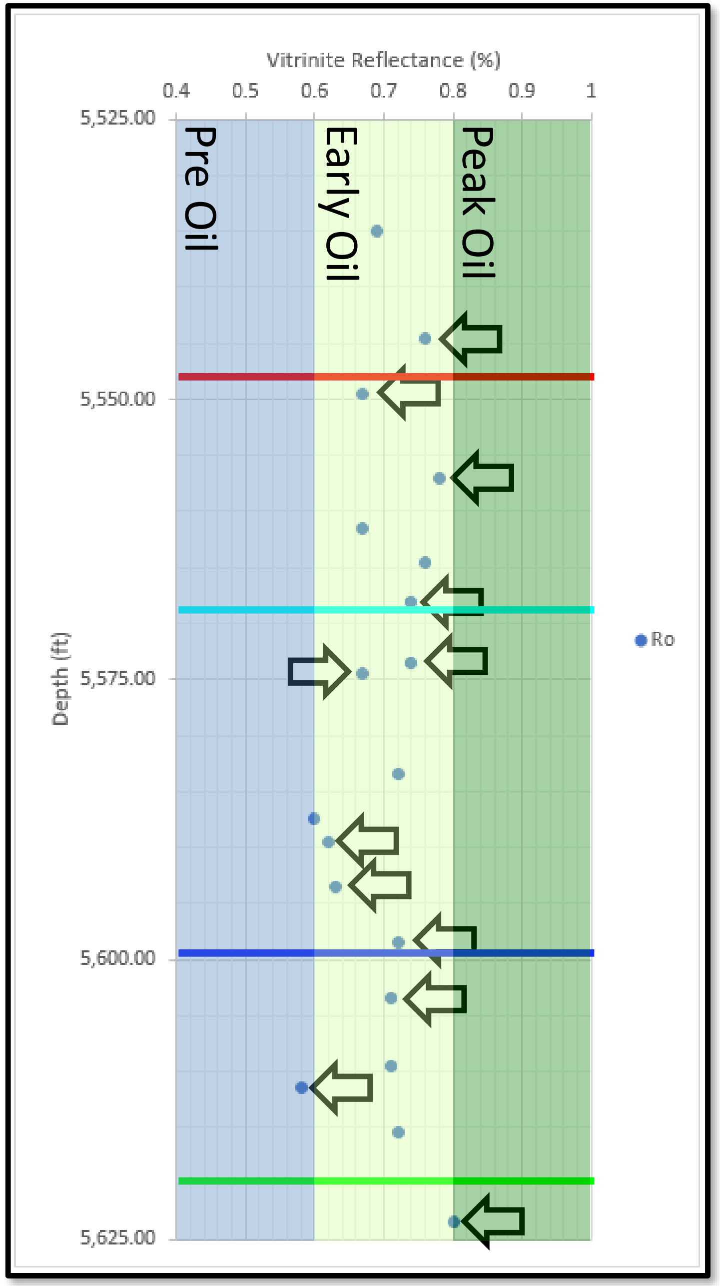


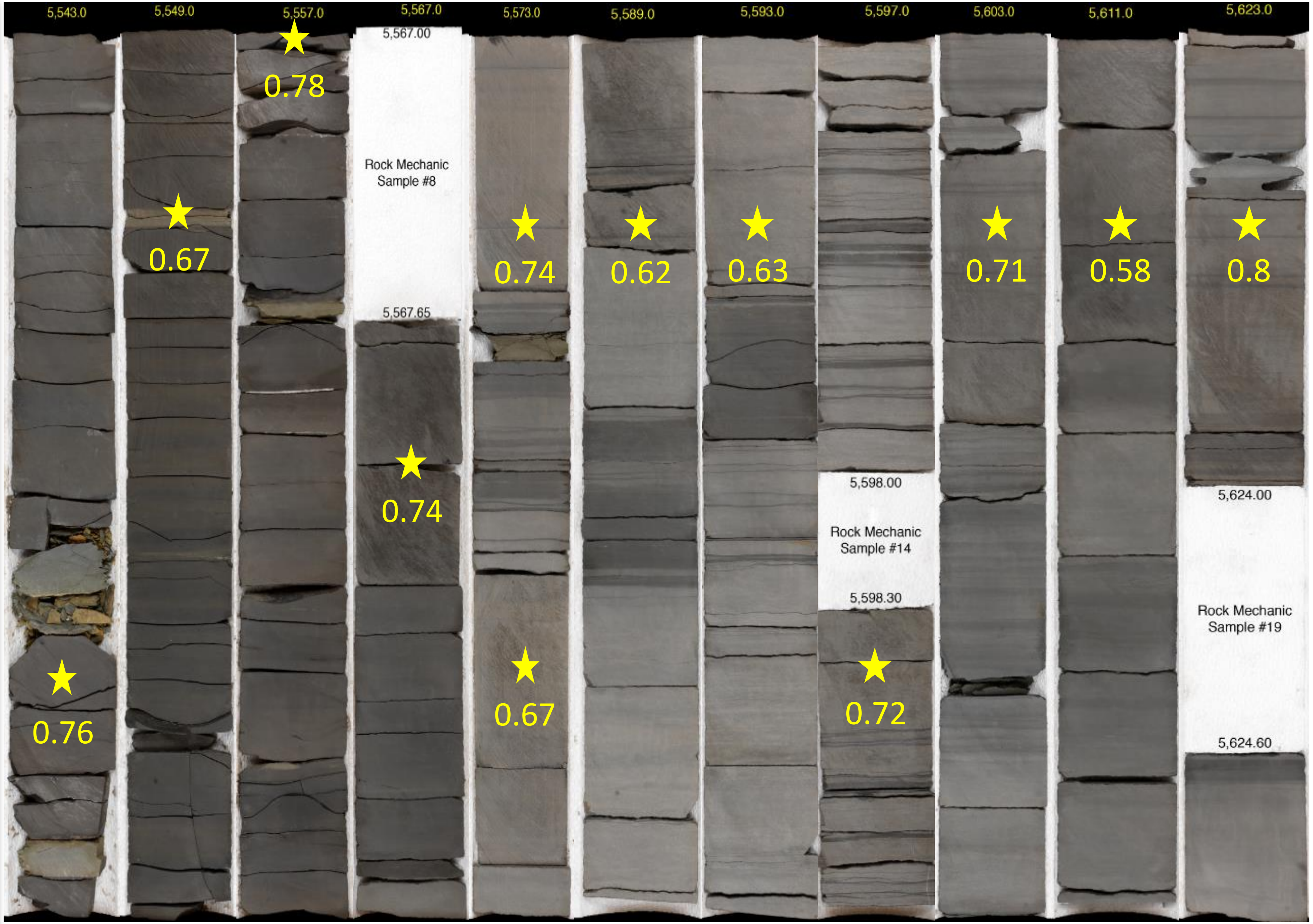
Tmax and Hydrogen Index





Calculated Vitrinite Reflectance





MUDTOC Consortium Sponsors Fall 2020

Sponsoring Member Companies

Anschutz Exploration Corporation

Red Willow Production Company

Antero Resources

Shell

Crestone Peak Resources

TGS

EOG Resources

Chevron

White Eagle Exploration

2M

HighPoint Resources

Stratum Reservoir

Cimarex

devon

Enverus

GMT Exploration Company LLC

Whiting

Supporting Companies

GeoMark

Mike Johnson & Associates

IHS

Schlumberger

MJ Systems

The Energy of Enerplus

PlatteRiver Associates Inc.