Depositional and Stratigraphic Complexities of the Niobrara Formation and the Relationship to Producibility, DJ Basin, Colorado*

Marshall Deacon[1] and Katie Joe McDonough[2]

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[1]Edge Energy, Boulder, CO, United States (marshallwdeacon@gmail.com)
[2]Consultant, Pine, CO, United States

Abstract

A number of geologic variables assert some element of control on the producibility of the Niobrara Formation. Maturity, source, porosity, wettability, thickness, lithology, fracturing, depositional facies and stratigraphy are all critical to the Niobrara petroleum system. Understanding the distribution, variability, and role they play is critical to unraveling the economic viability across the basin. Depositional facies and stratigraphic framework are two of the most important as they form the basis and context for evaluating these controls. Over 50 cores have been taken in the Niobrara in the DJ and over 10,000 well logs tied to the cores allow the depositional and stratigraphic framework to be delineated.

The Niobrara is stratigraphically divided into chalk and marl sequences at multiple scales that occur across the entire basin. Depositional facies record this cyclicity with individual (cm scale) marl to chalk couplets stacking into chalkening upwards and marling upwards sequences (meter scale) as a result of climatic and sea level fluctuations. Marl beds are deposited during periods of increased terrigenous input with higher preservation of organic material. Chalk beds form during times of decreased terrigenous input and increased oceanic circulation with an associated increase in bioturbation resulting in higher porosity and permeability. Several basin-wide surfaces separate the Niobrara into genetically related sequences creating a unique depositional and stratigraphic framework for each zone. The surfaces are associated with regional chalk or marl beds and occur both at the base and within the C, B, and A intervals. They can be overlain by a thin lag deposit and show truncation of beds below and down lap above the surface. This can result in the erosion or non-deposition of entire intervals, both marl and chalk. Changes in sea floor currents and local sub-basin subsidence rates may explain their genesis. Conversely, locally expanded sequences are the result of increased relative subsidence rates with a corresponding change in rock properties.

Depositional facies is the dominant control on Niobrara source and reservoir rock properties and thus its producibility. The vertical and lateral variability of the facies and recognition of the sequence and bounding surfaces are thus critical in understanding the distribution of reservoir attributes.

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Marshall Deacon: Edge Energy

Katie Joe McDonough: KJM Consulting

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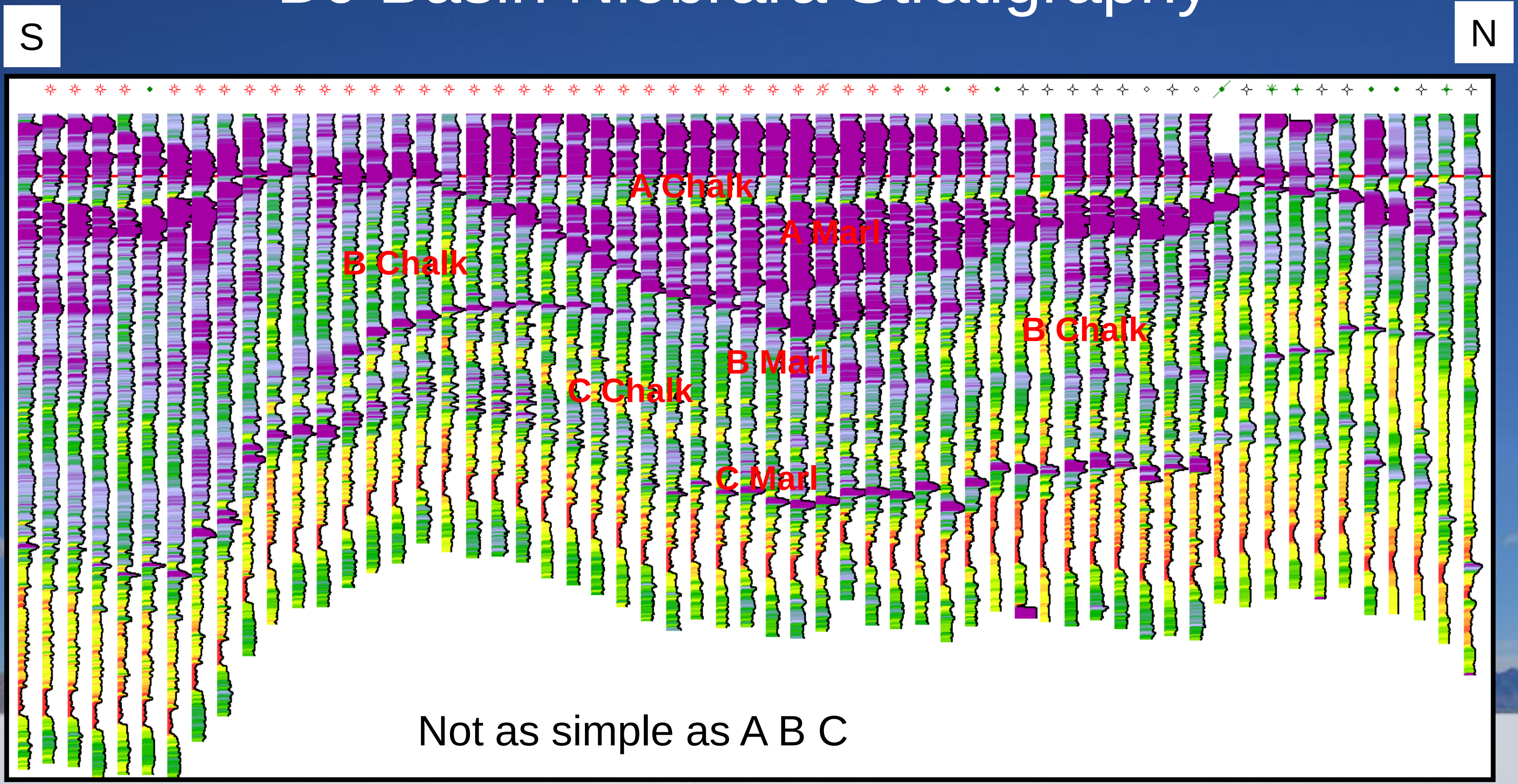
DJ Basin Niobrara Stratigraphy



Not as simple as A B C

For the talk-

What is the character of the surfaces & sequences?

What is the significance for the reservoir?

Possible Causes?

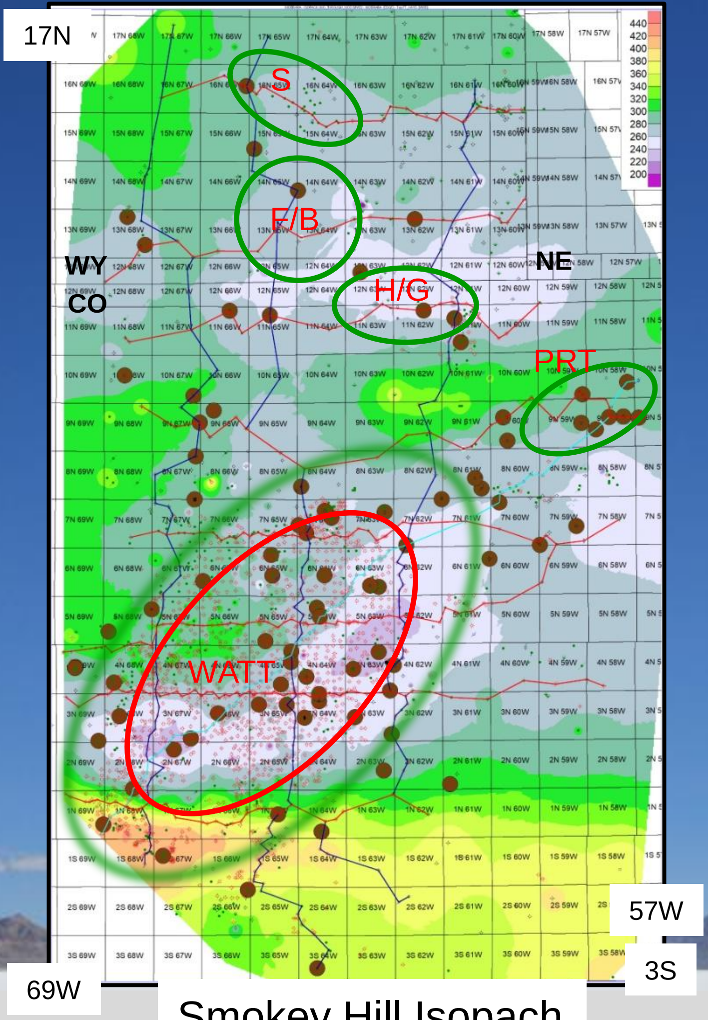
Dataset:

Mature HC basin

Thousands of vertical wells

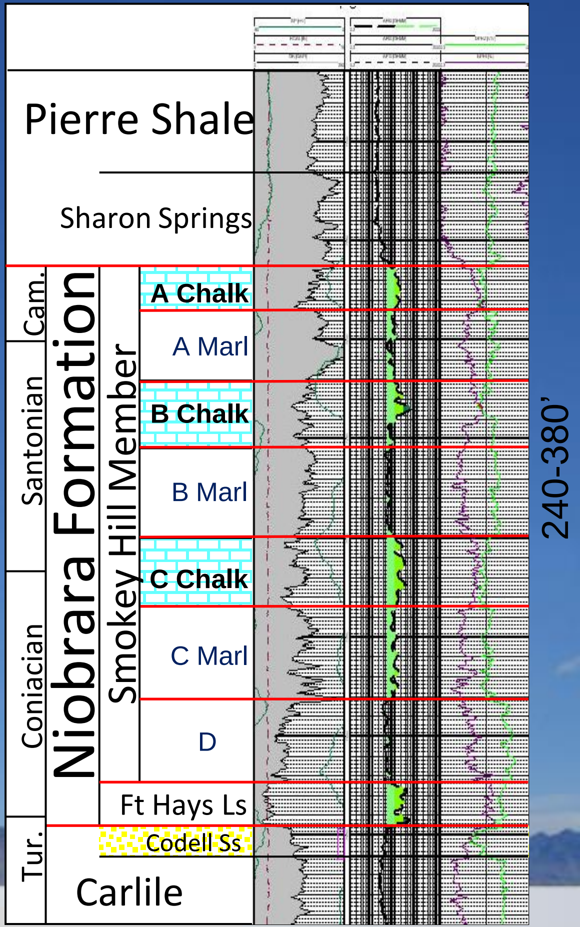
Tops picked in several wells/section

Over 50 Nio cores – mostly partial, some full



Smokey Hill Isopach

Niobrara Stratigraphy



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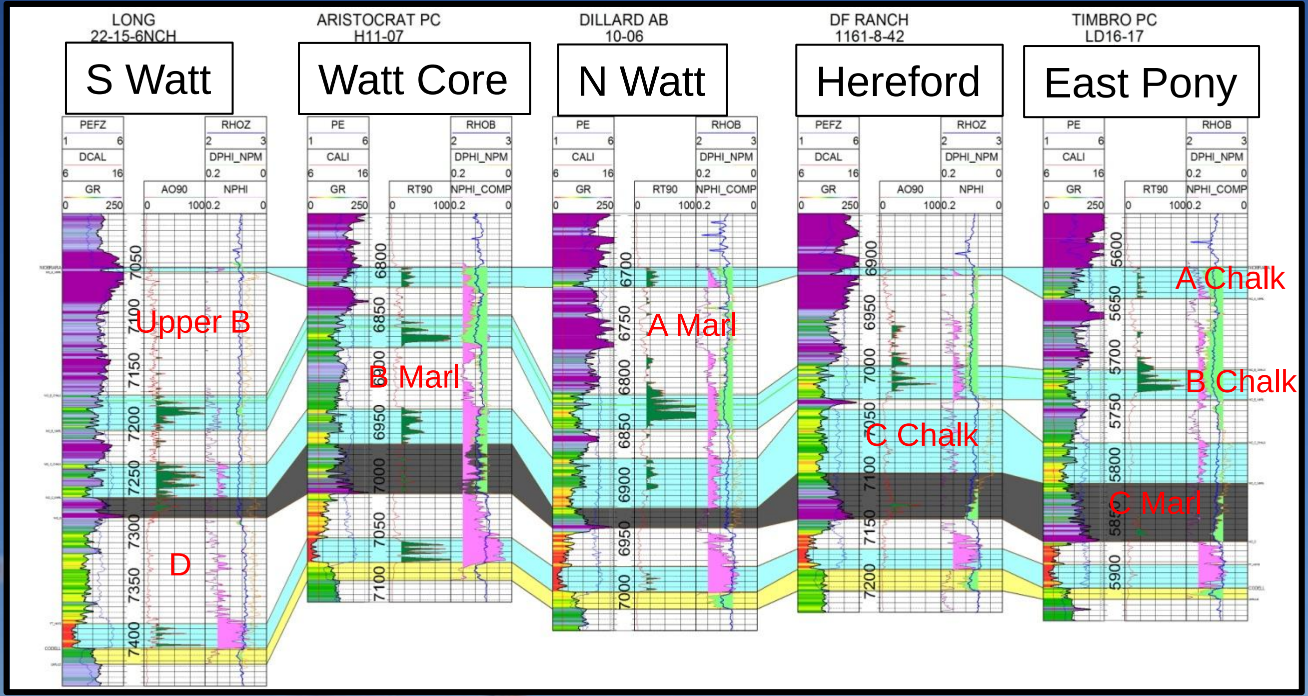
Niobrara Cores



Lithology: Foram Peloidal Wackestone – Packstone

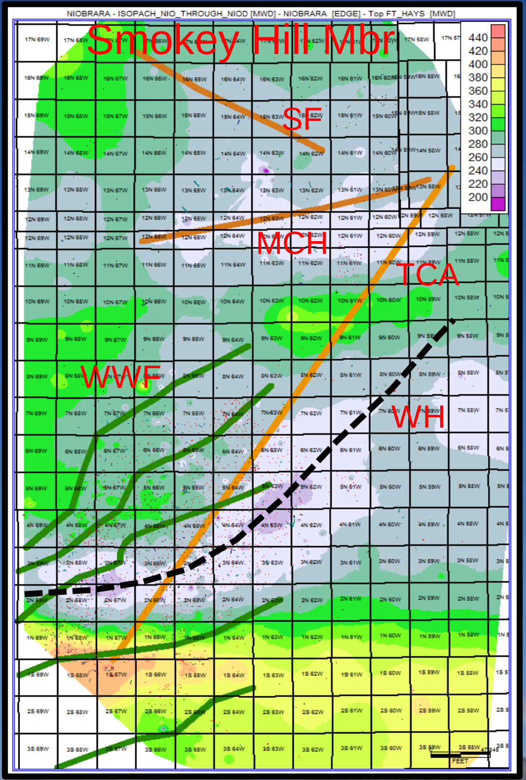
Facies within an interval/bed are consistent across the basin

Facies are different one interval to another
- bioturbation, micropore, clay
- C Chalk different than B Chalk

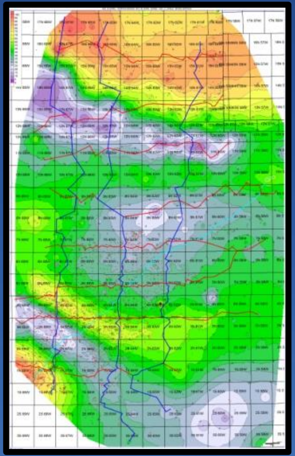
Current evidence – basal lags, shelly beds, starved ripples

Hyperpycnal deposits, graded/ inverse graded beds

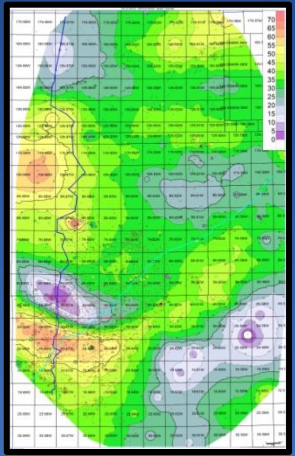
Interval thickness is not consistent …



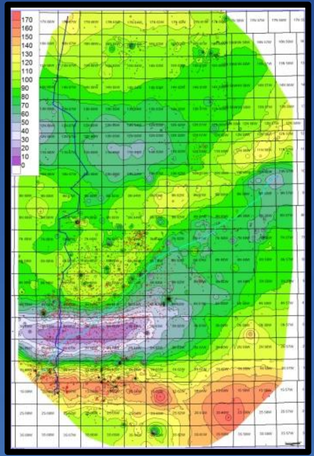
B Marl



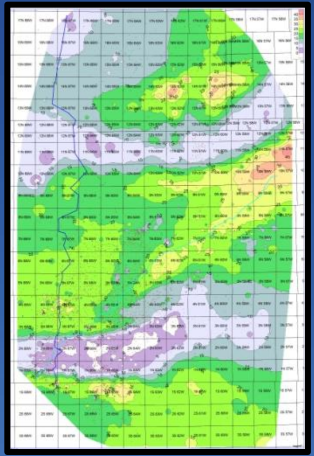
B Chalk



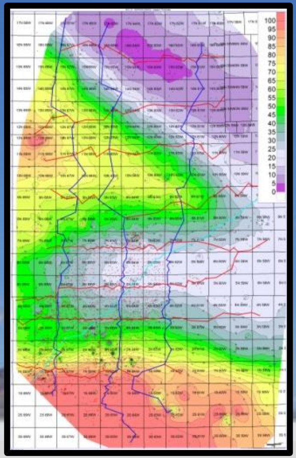
A Marl



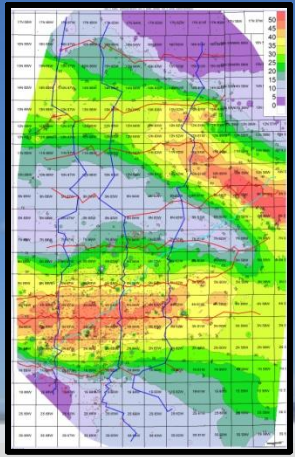
A Chalk



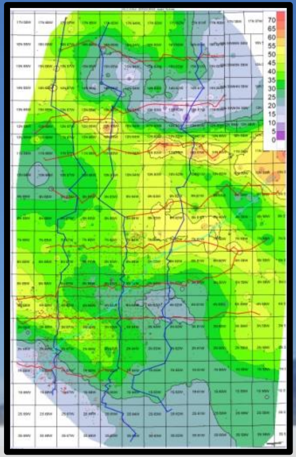
D Interval



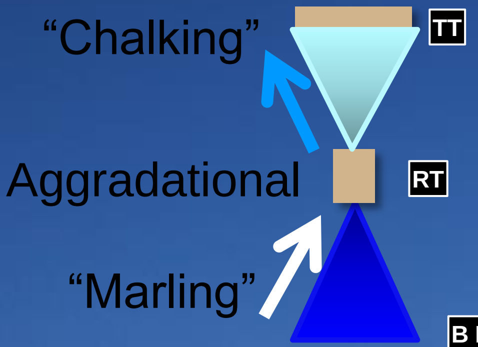
C Marl



C Chalk



Niobrara Depositional Sequence Summary

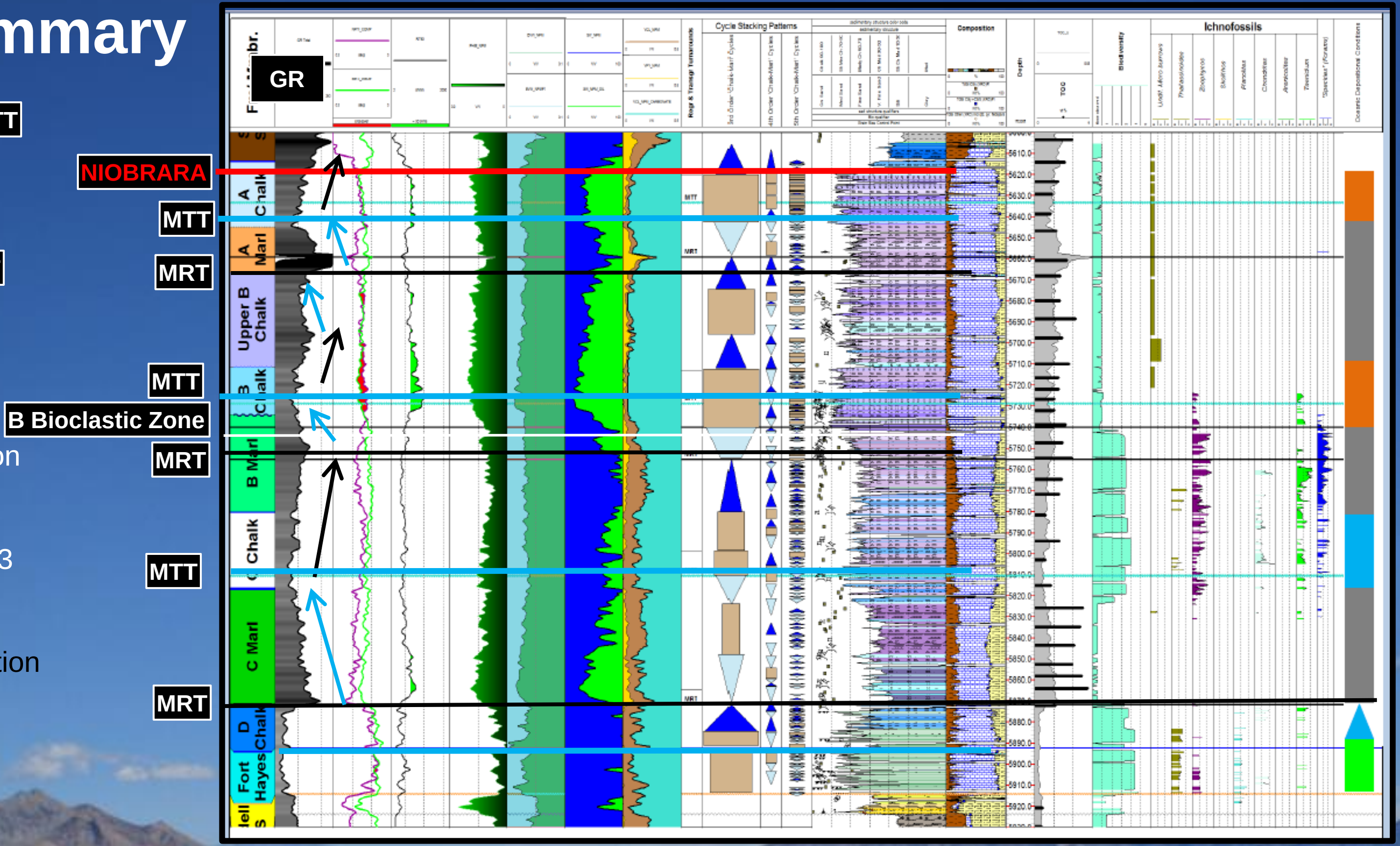


TT: Transgressive, open circulation

- Chalk-rich, dry cycle
- Low TOC
- Biotic processes dominate (CO3 productivity, microbial, burrowing)

RT: Regressive, restricted circulation

- Clay-rich
- Terrigenous influx, wet cycle
- High TOC



Deacon et al, 2013

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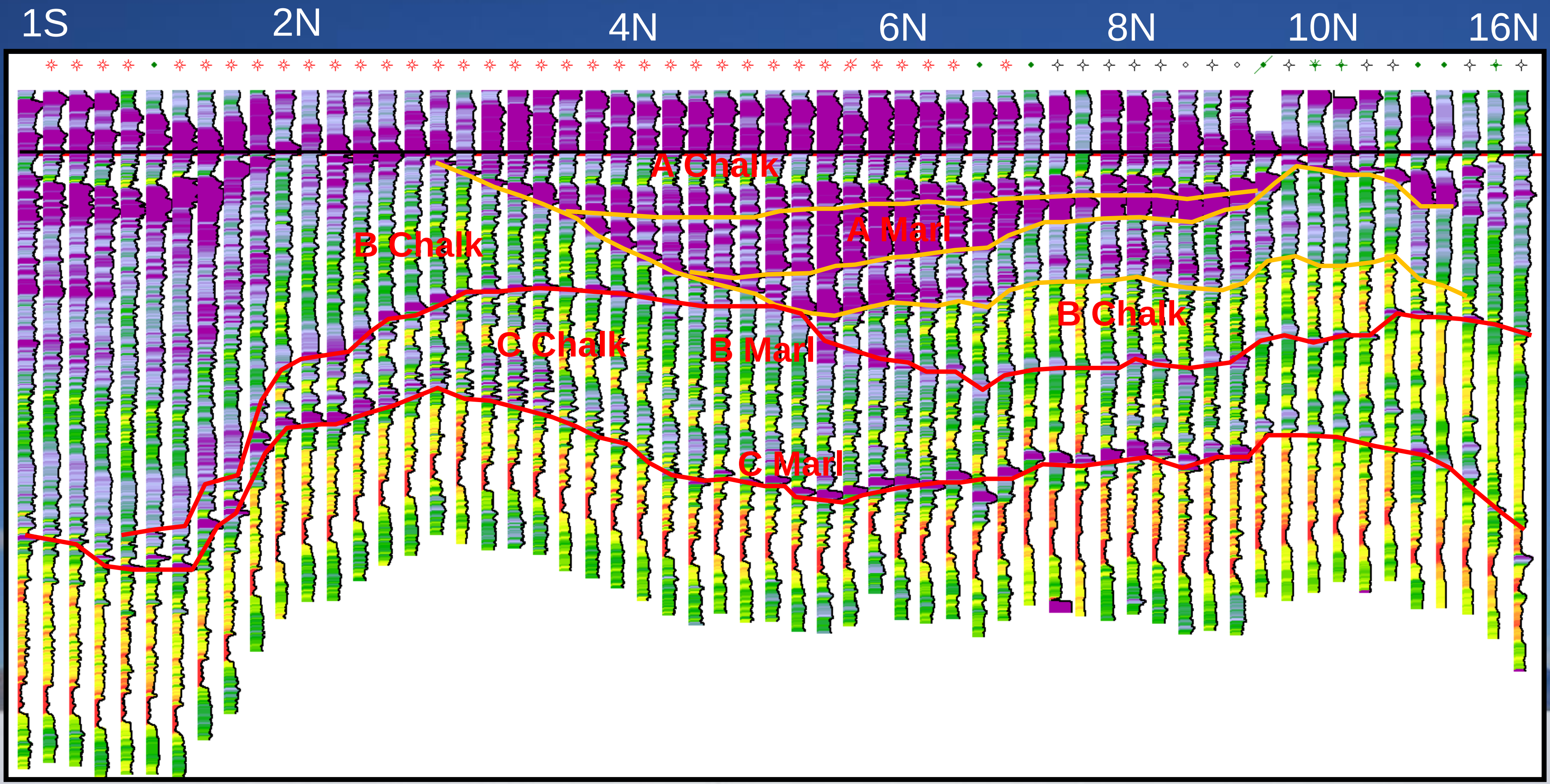
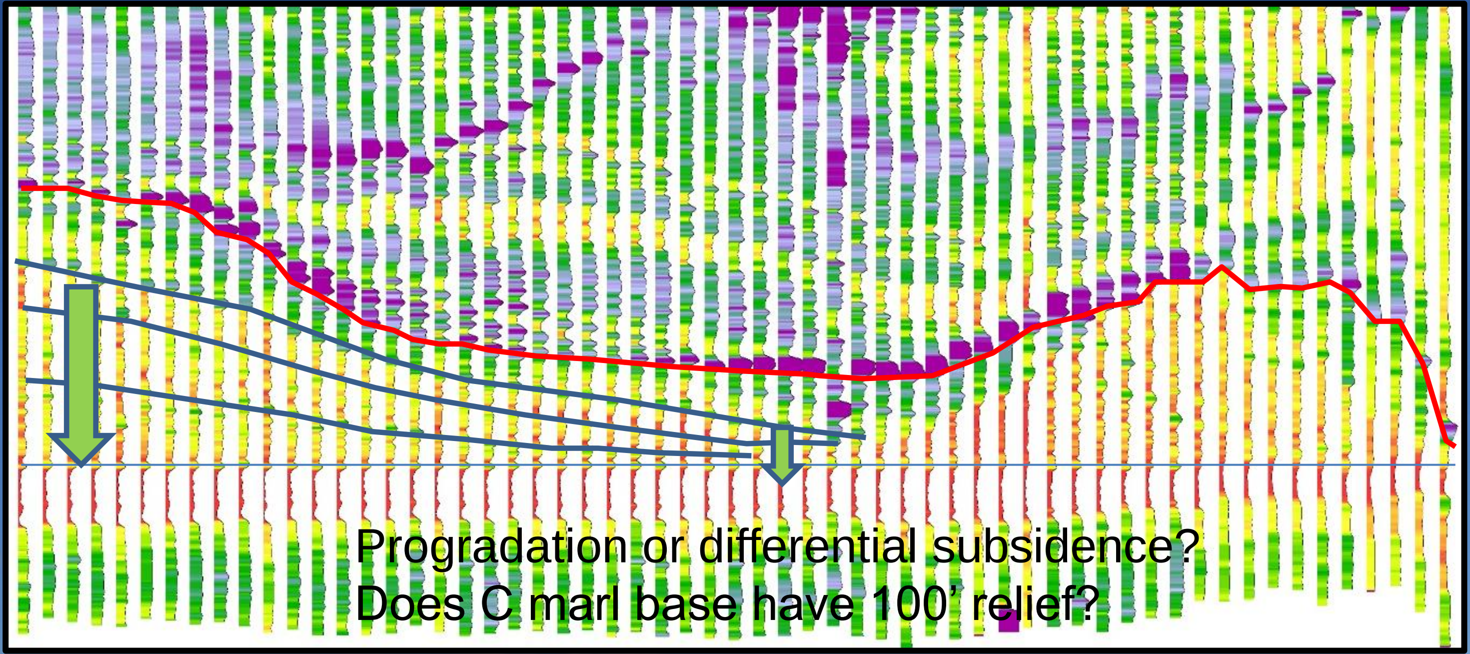
Key Surfaces & Sequences

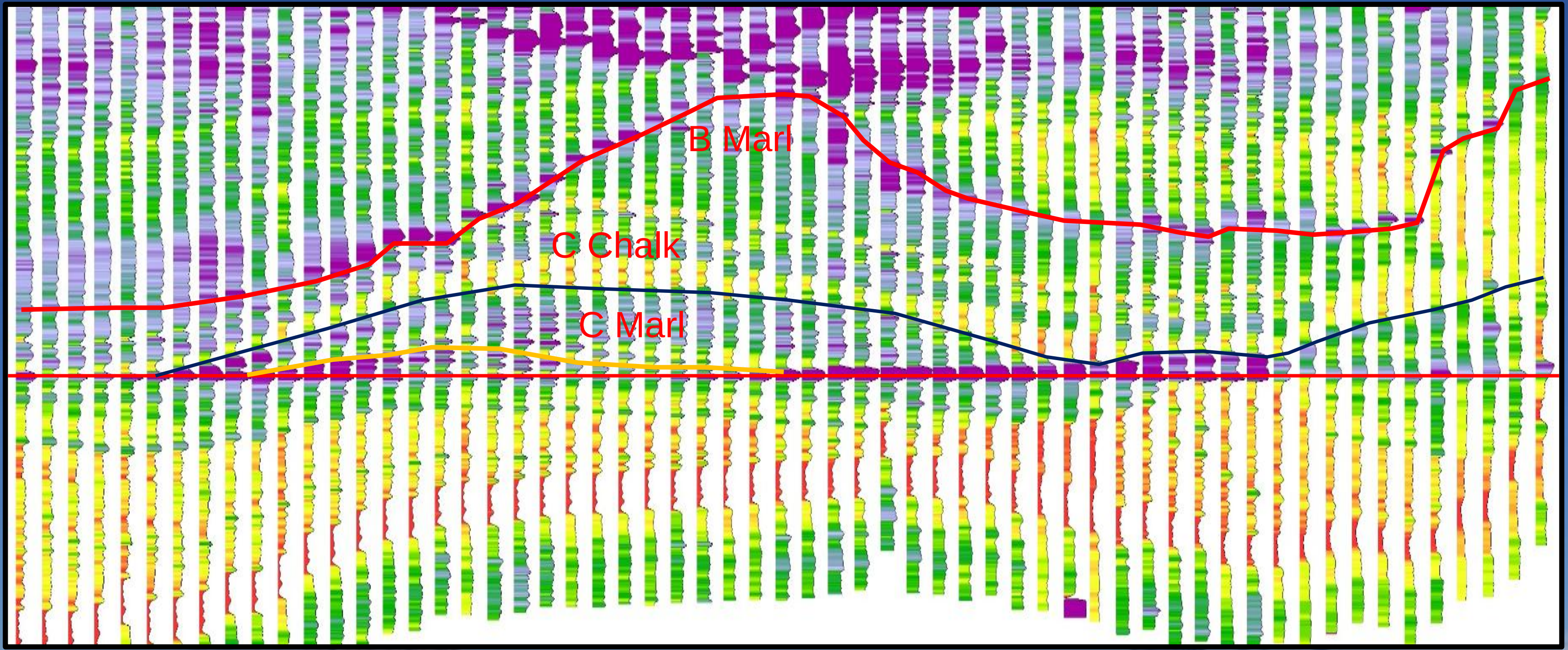


D Interval

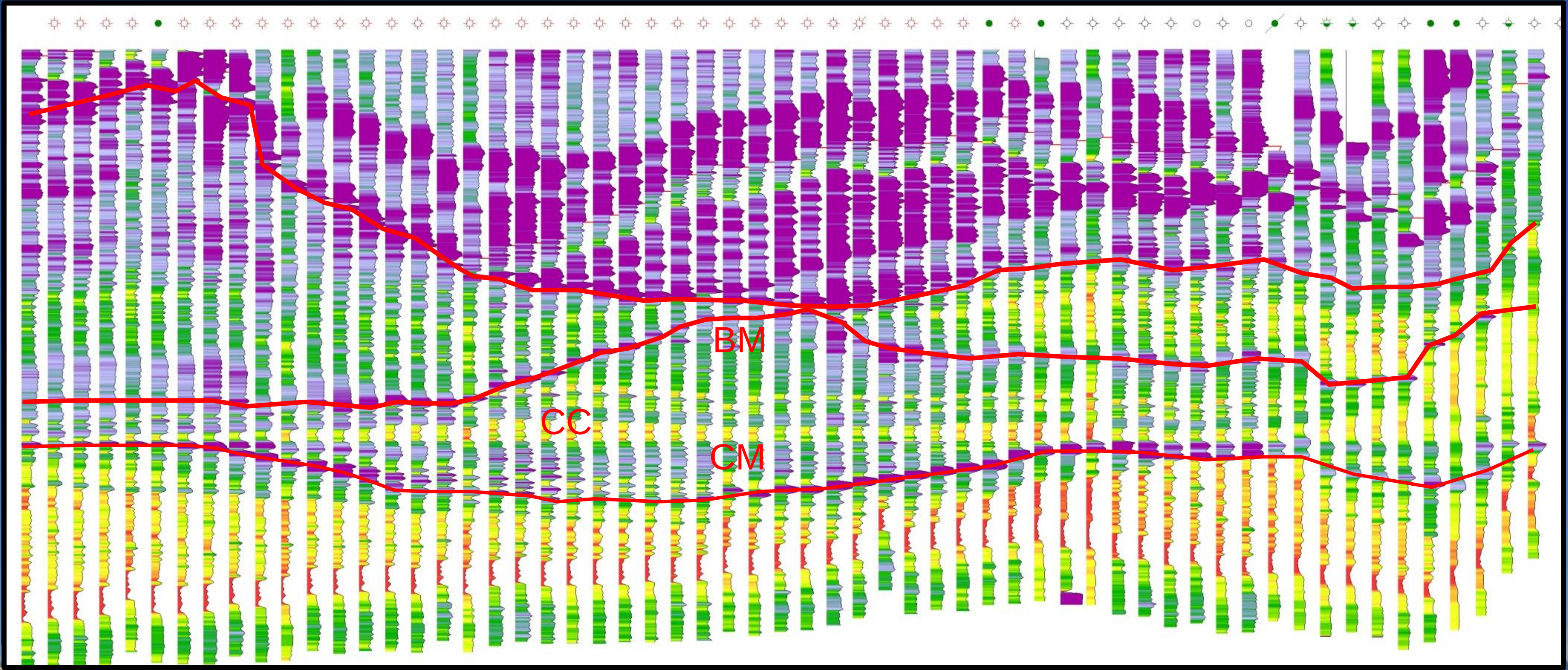
Little Source, No reservoir:
Barrier(?) between C Marl & Codell



C Marl – C Chalk

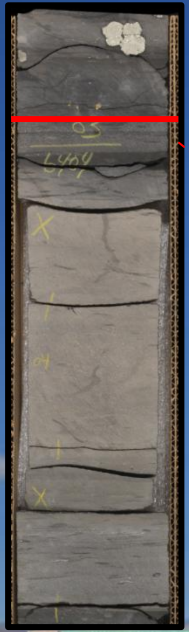


C Marl – C Chalk

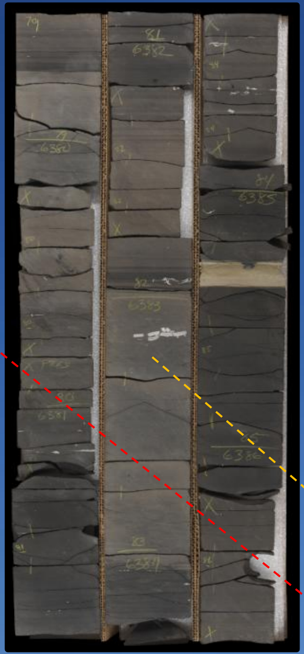


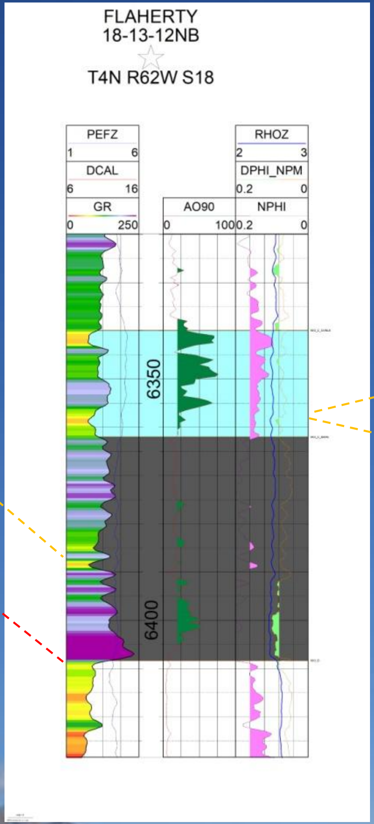
C Marl – C Chalk

Base Surface



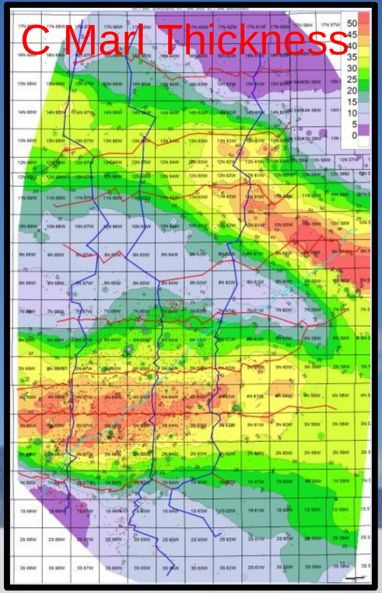
C Marl Facies



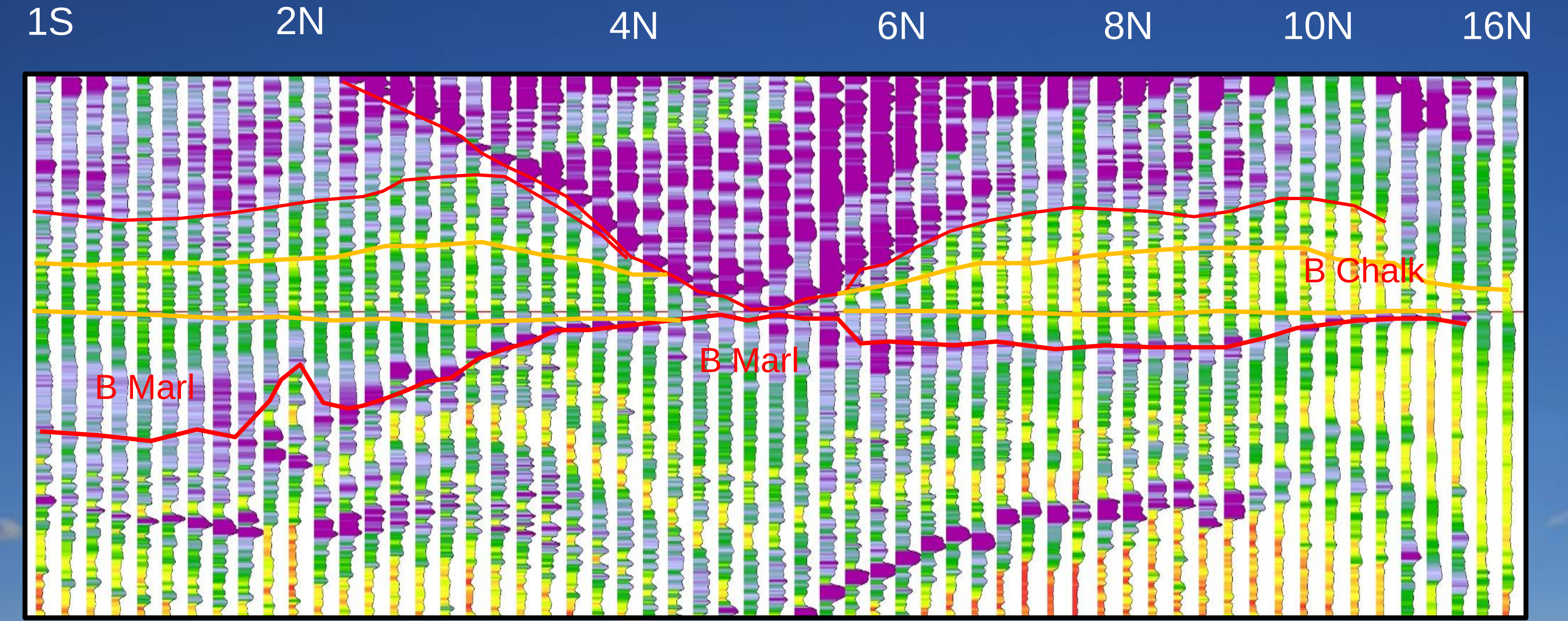


C Chalk Facies

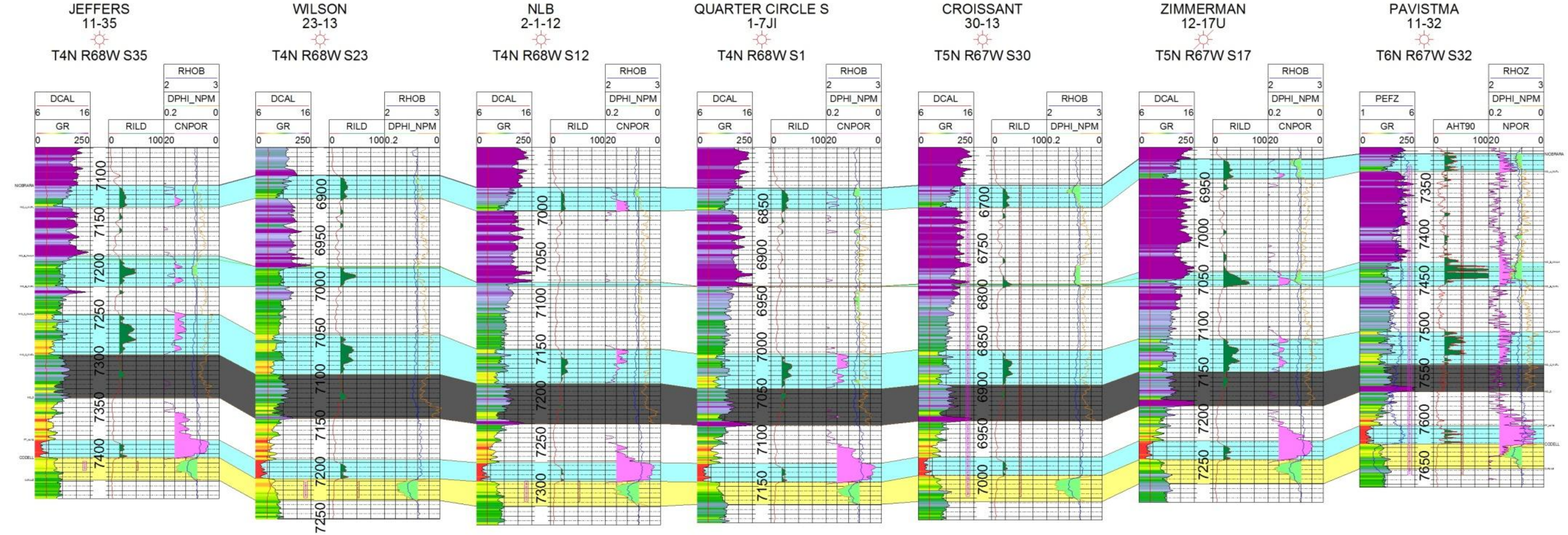
Non-depositional/Condensed base
Ash rich
C Marl downlaps onto surface
C Marl lens shaped geometry
C Chalk: Continuous facies across DJ
Macro bioturbated 1’ Chalk/Marl cycles



B Marl – B Chalk

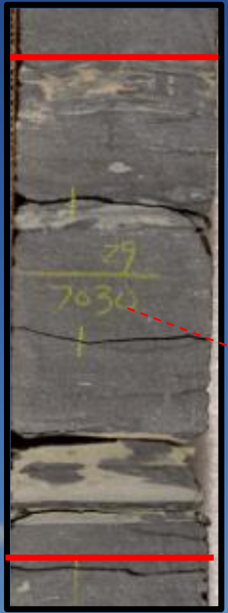


B Chalk Pinchout

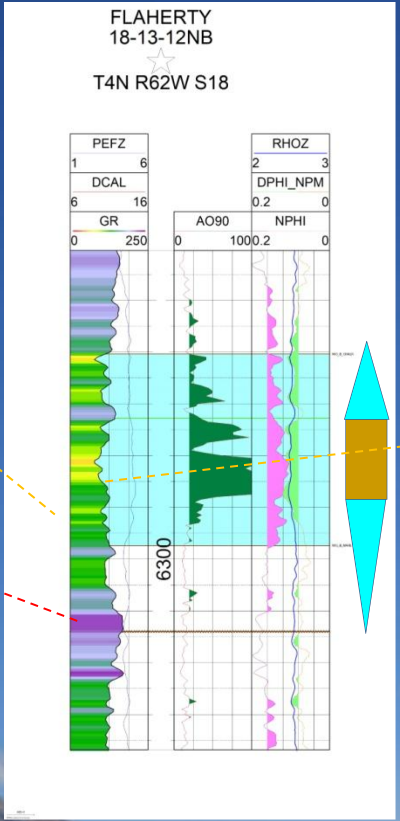


B Marl – B Chalk

Base Surface

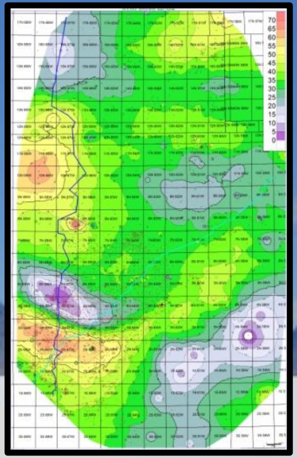


B Bioclastic



B Chalk Facies

Erosional/Non-depo (ash rich) base
Bioclastic facies at base downlaps,
Widespread across basin
B Chalk: Crinkly clean chalk facies,
sheet, widespread across DJ
Micro-bioturbated chalk
Pellets and matrix of coccolithic hash



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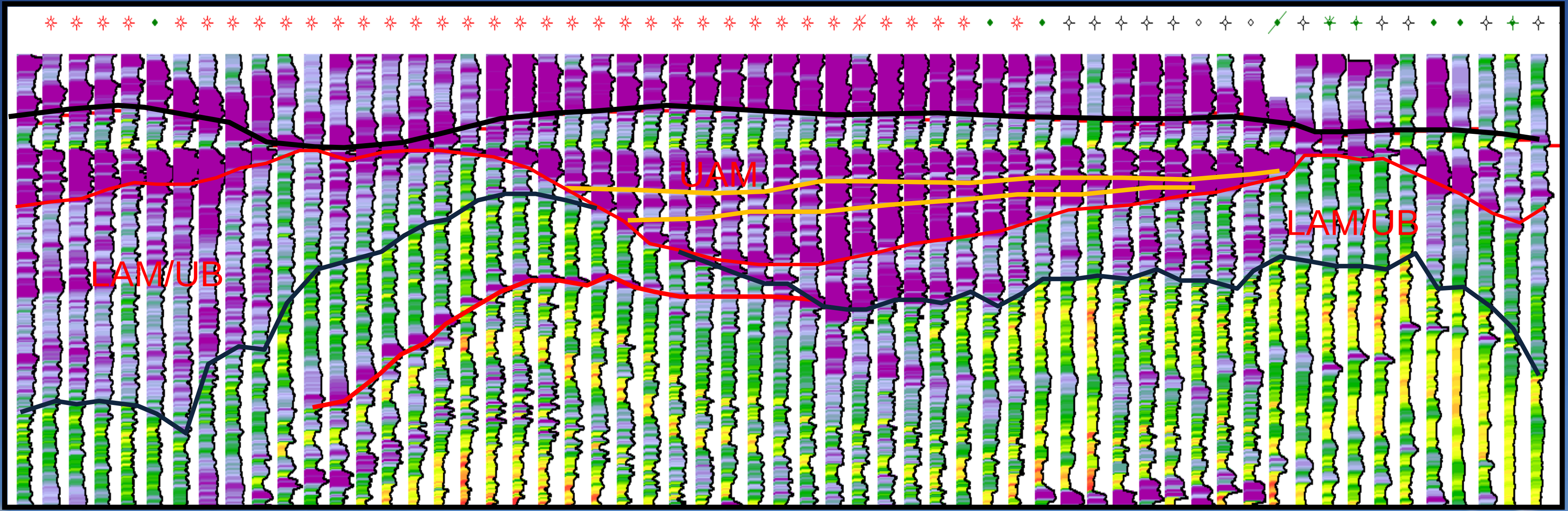
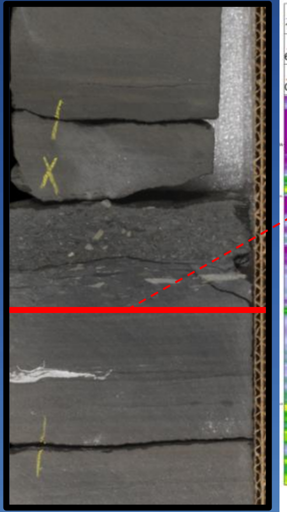
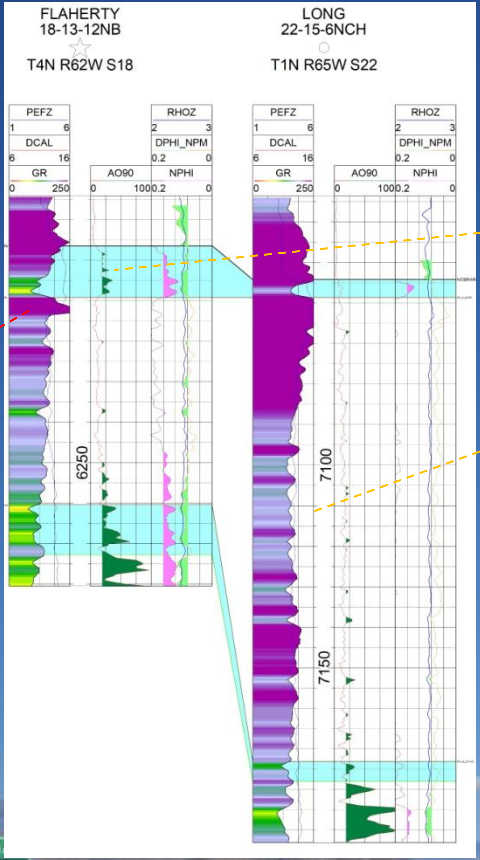
Niobrara A Marl – A Chalk



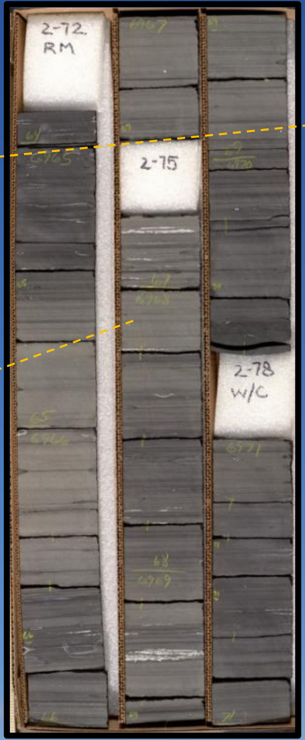
A Marl – A Chalk

Base Surface



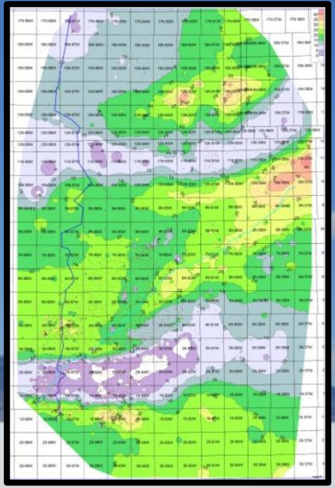


Upper B

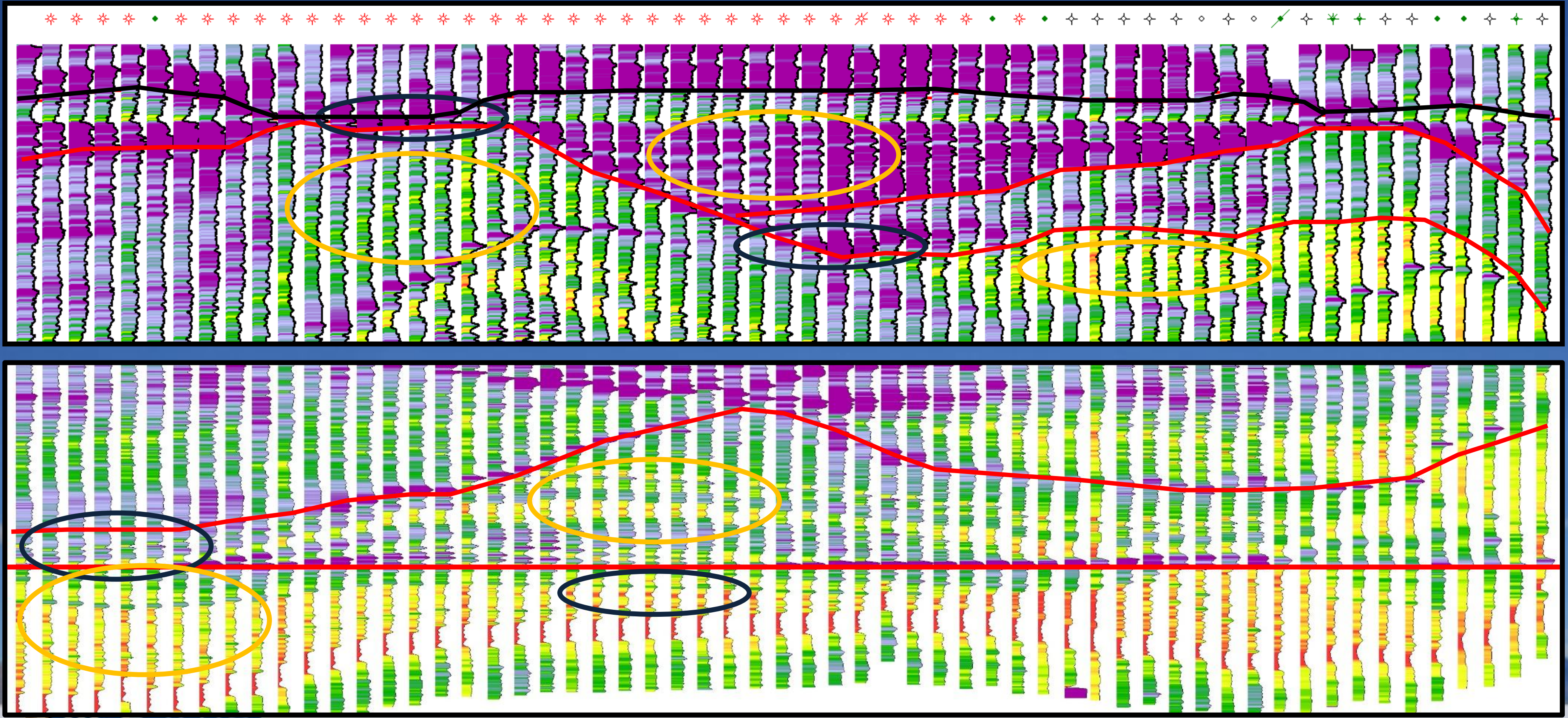


A Chalk Facies

Erosional base
A marl downlaps
Lens–shaped geometry
A Chalk – micro-biot clean chalk, continuous
Truncated by Top Nio Unconformity

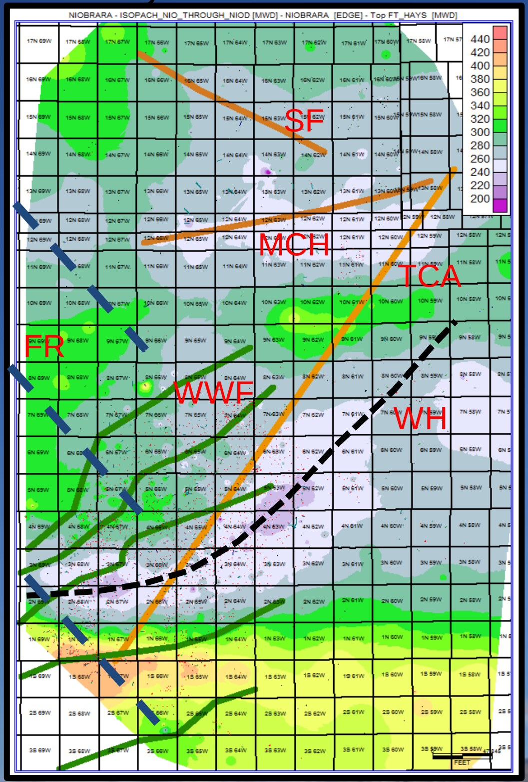


Summary



Conclusions:

Smokey Hill Mbr thickness



A, B, C Intervals bounded by non-depositional/condensed/erosional surfaces

Condensed intervals: higher TOC, increase in ash beds

Differential subsidence leads to condensed and expanded sections creating lens-shaped geometries

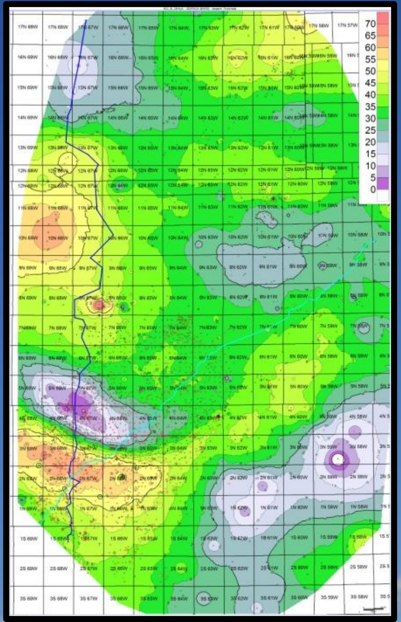
NW-SE (FR)\ SW-NE (WWF) orientation

Result of differential movement of WWF/Front Range type structures

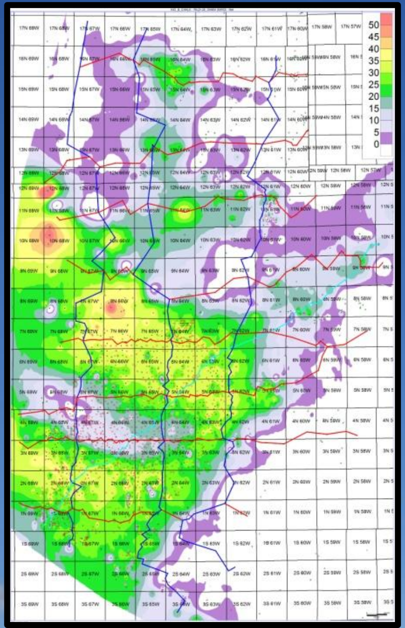
WIS regional surfaces or only specific to DJ?

Even in the DJ Niobara the stratigraphic architecture & facies are a critical control on OOIP and thus production

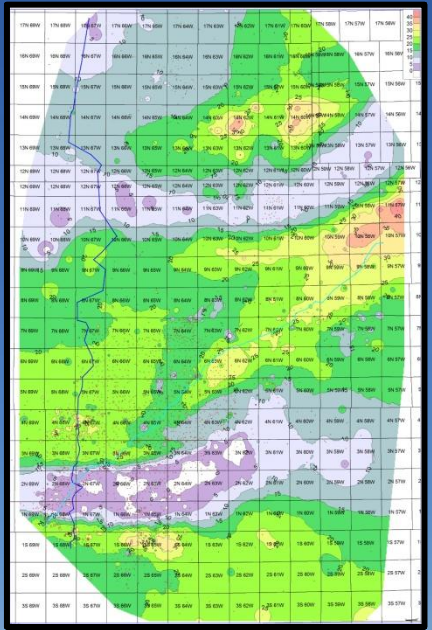
B Chalk
Thickness



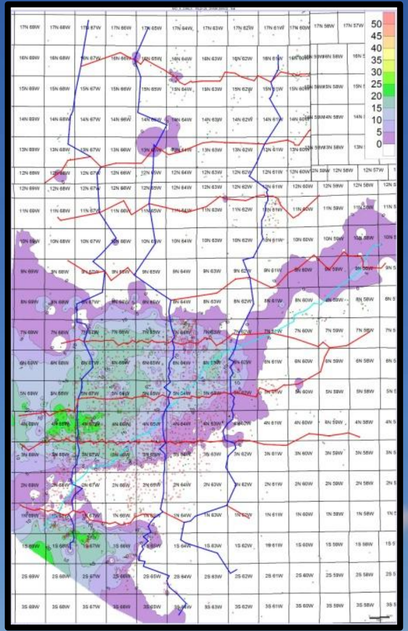
B Chalk
Res >25 ohmm



A Chalk
Thickness



A Chalk
Res >25 ohmm



Questions?

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Gus Gustason,
Bryan Richter,
Scott Friedman,
Lise Brinton,
Rick Geesamen,
Max Pommer,
Vanessa O’brien

Time for another Fieldtrip…..
Cheyenne RM AAPG 2019

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