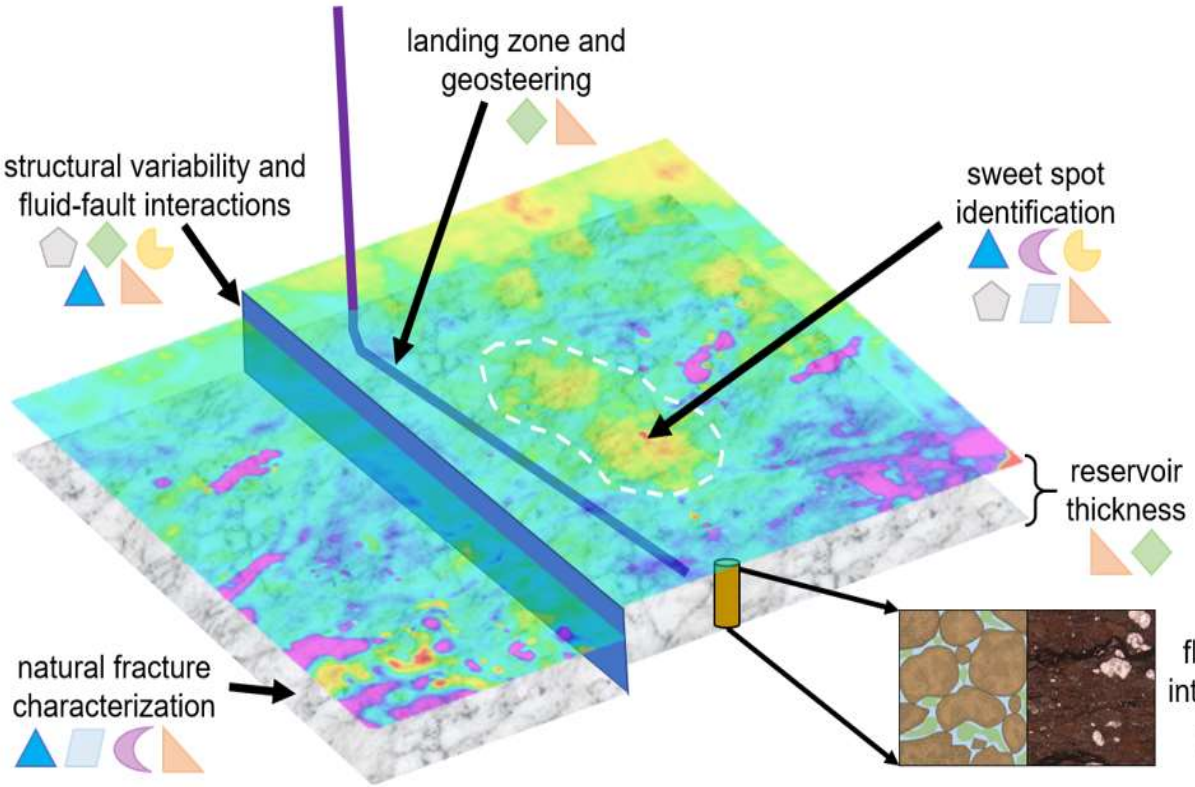
Chad Taylor, MSc Geology, 2022

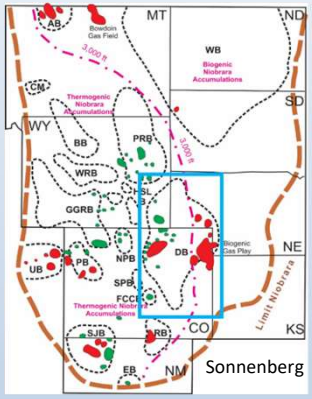
THE GEOLOGICAL RESERVOIR CHARACTERIZATION AND ASSESSMENT OF RESERVOIR DELIVERABILITY FOR UNCONVENTIONAL NIOBRARA AND CODELL RESERVOIR TARGETS IN THE HEREFORD FIELD AREA, WELD COUNTY, COLORADO

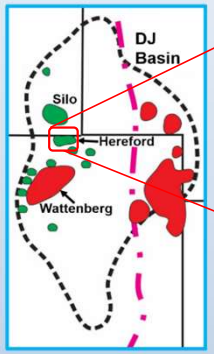
RCP Phase XVII – Characterizing Geologic Heterogeneity

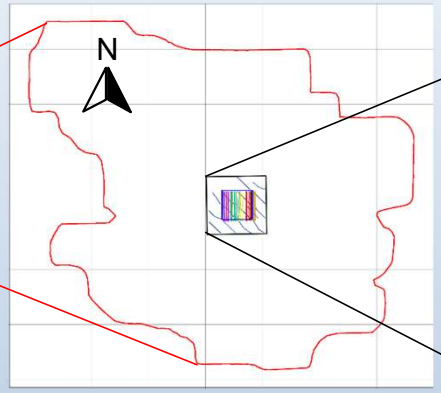


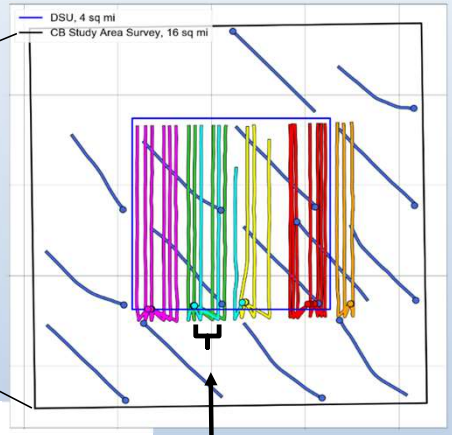
Method	Symbol
Seismic attribute analysis	
Image log analysis	
Structural modeling	
Seismic inversion	
Production evaluation	
Petrophysical characterization	
Petroleum systems analysis	

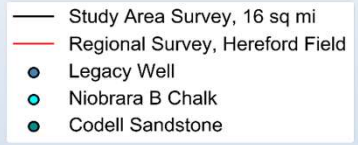
Hereford Study - Data Overview

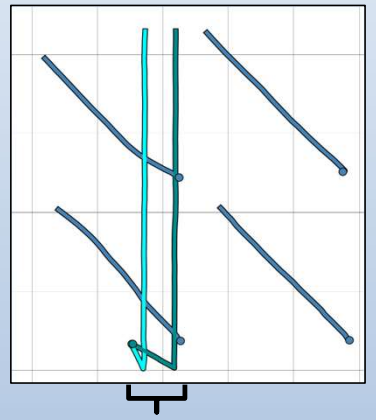


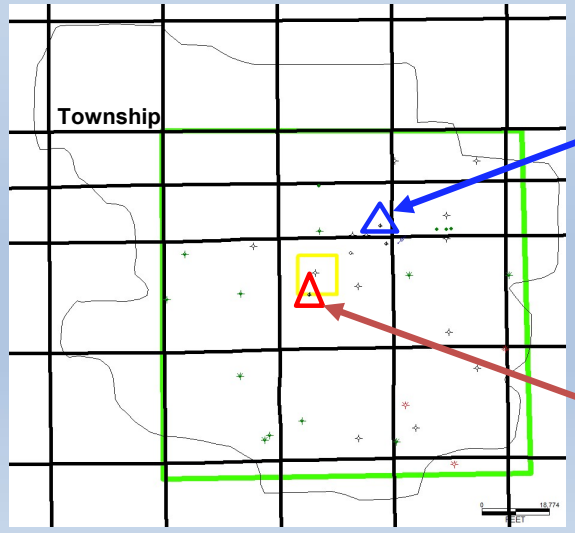




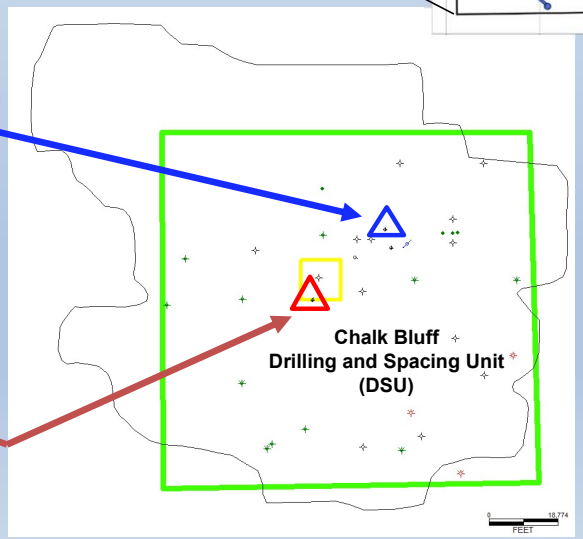






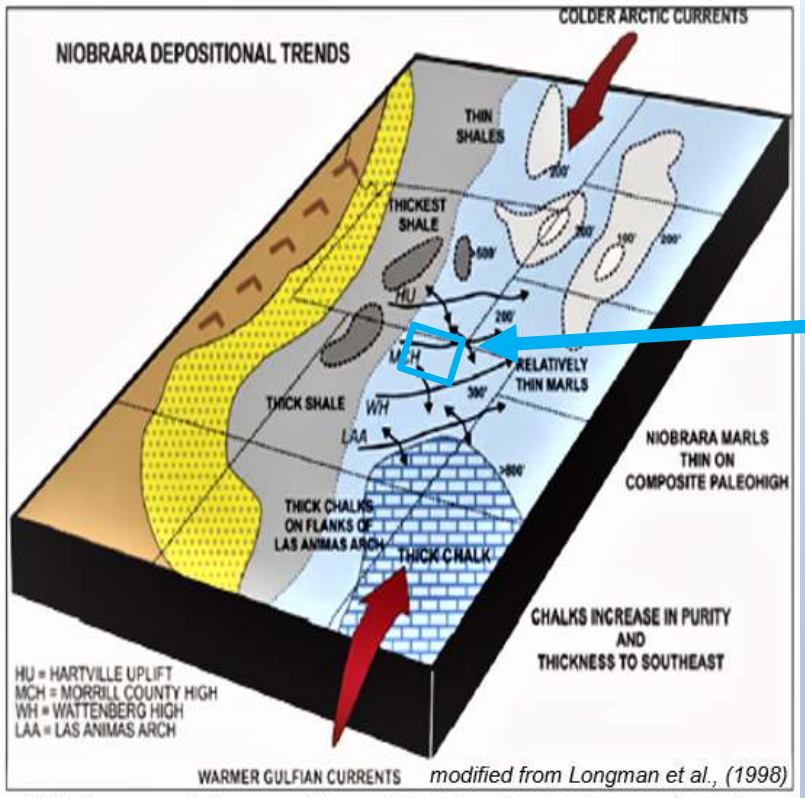


Hereford Type Log

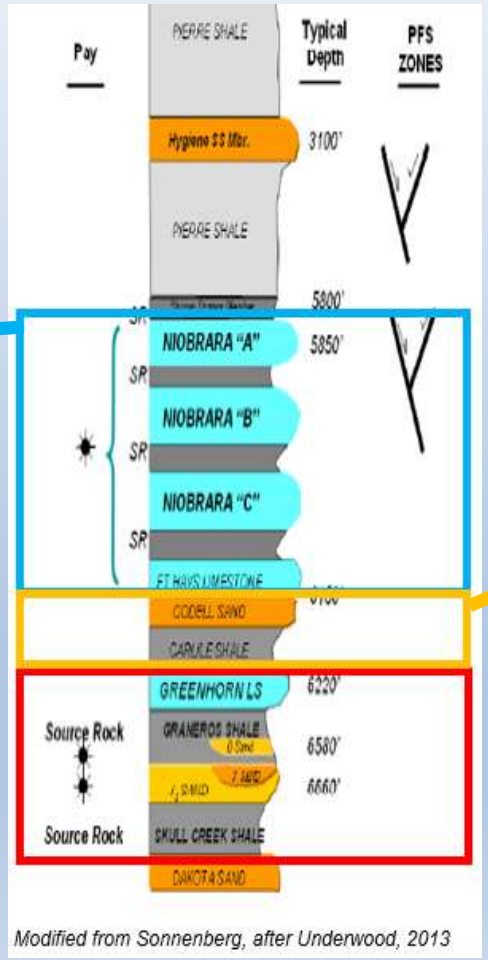


Hereford / Chalk Bluff Study
Vertical Well Data Distribution

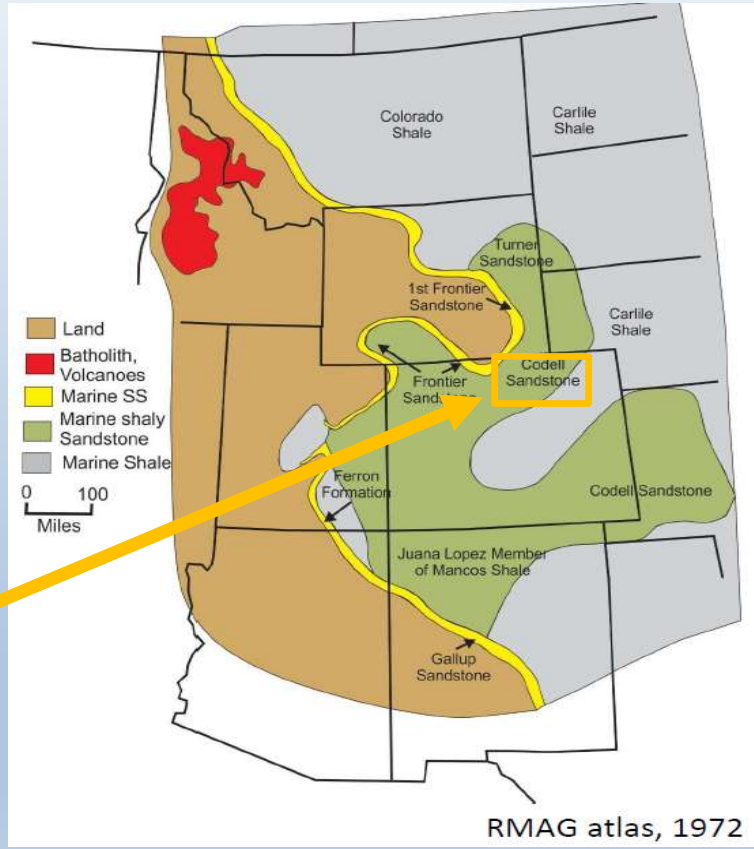
Hereford - Depositional Context



Niobrara Formation *(Santonian - Turonian Age)*

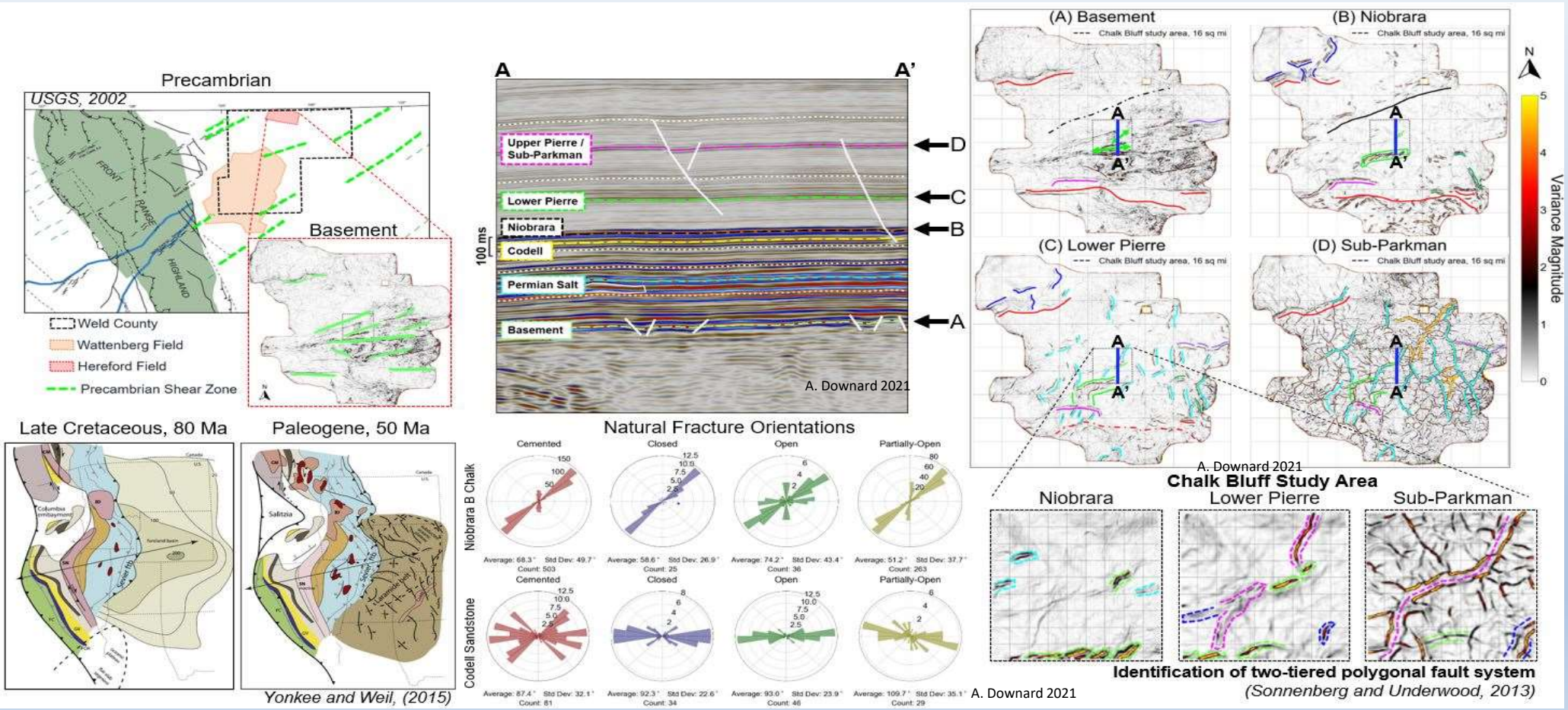


Modified from Sonnenberg, after Underwood, 2013

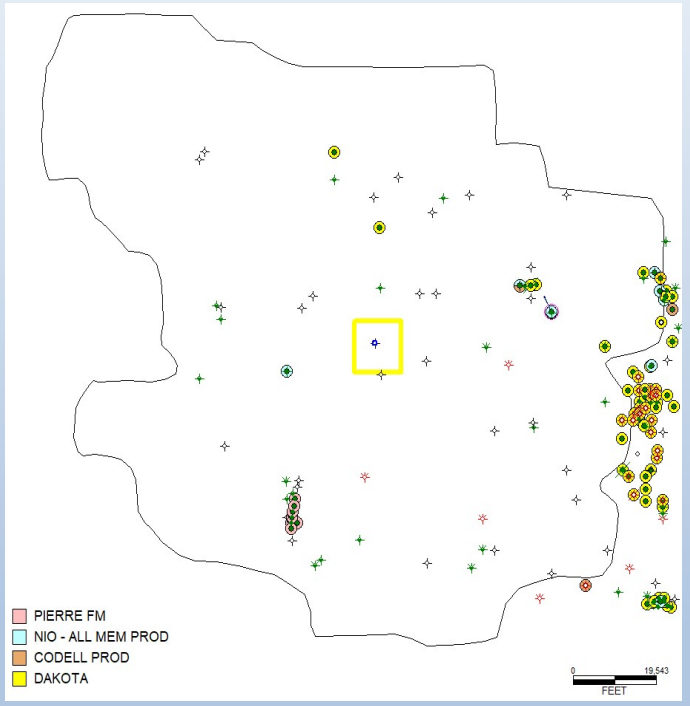


RMAG atlas, 1972

Hereford - Structural Context

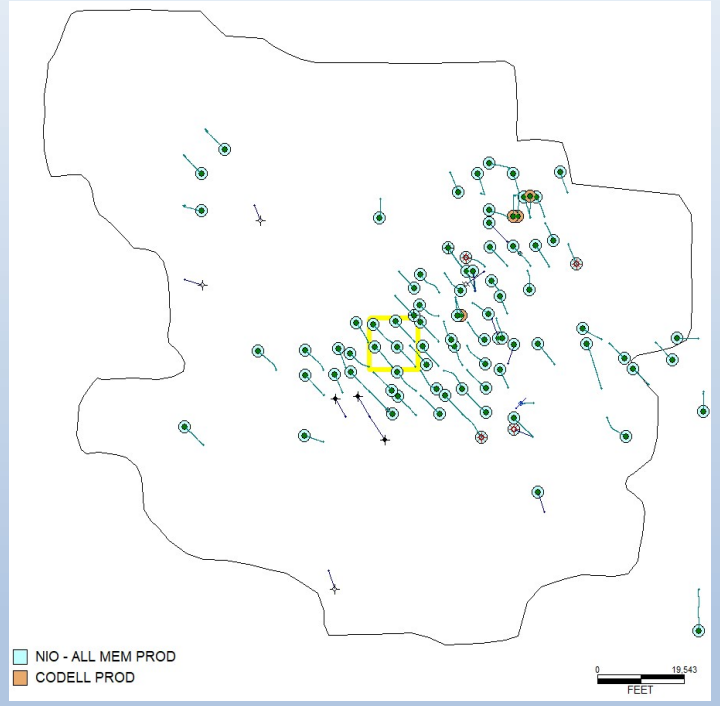


Hereford Field - Production Evolution

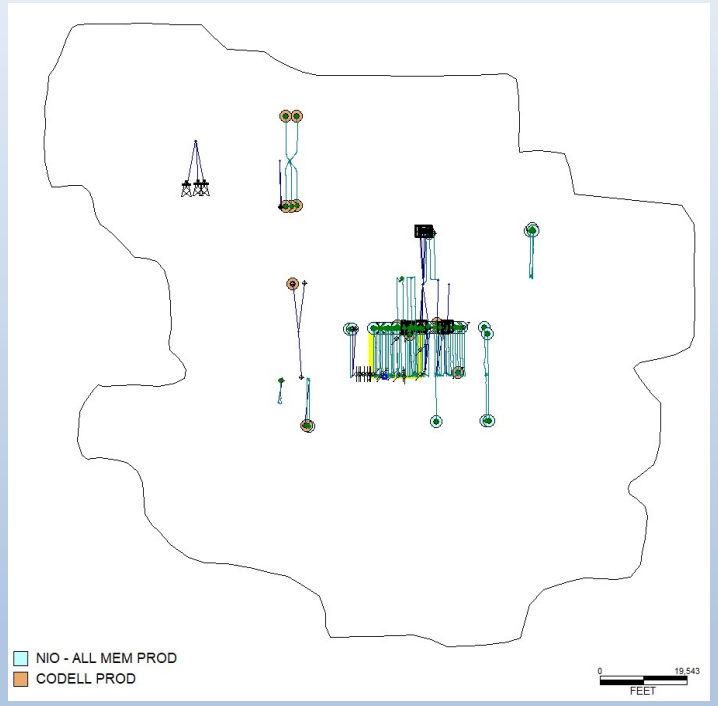


1st Generation Conventional Wells

(Pre 2009)



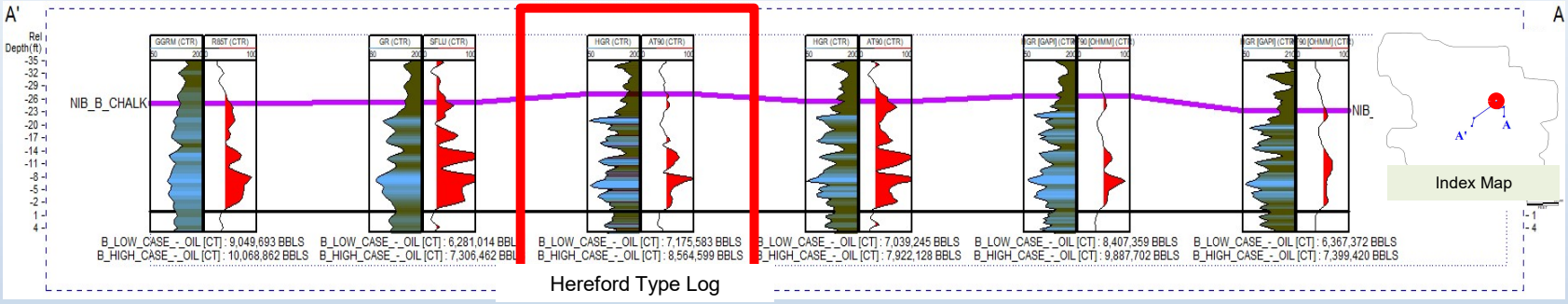
1st Generation Unconventional Wells, EOG
Uncemented Liner – Sliding Sleeve Completions (SRL)
(2009 - 2015)



2nd & 3rd Generation Unconventional Wells
Fifth Creek & HighPoint Resources
Cemented CSG with Plug & Perf Completion (SRL and XRL)
(2015 - 2021)

Hereford - Niobrara B Chalk

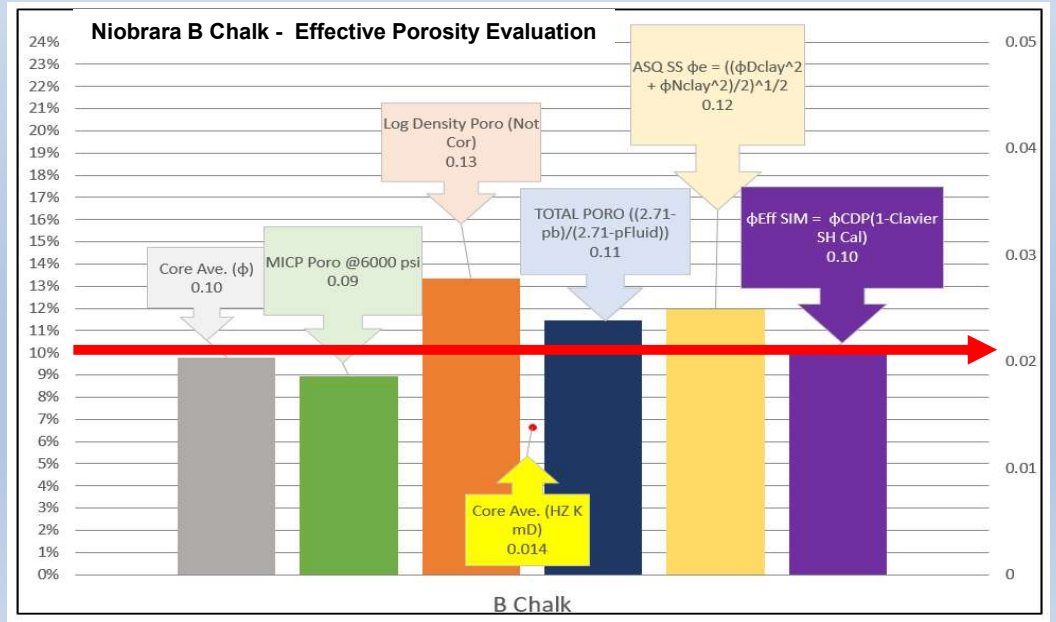
Petrophysics & Geochemistry

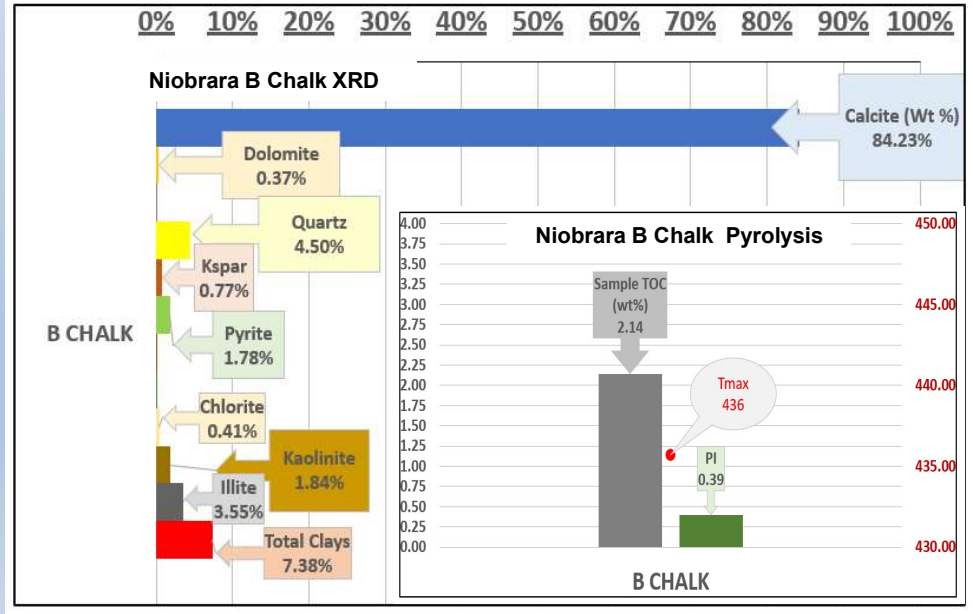


B Chalk (Herford Study Area)

- Avg Thickness: 36'
- Range (20 to 56')
- > / = 20 ohm/m (DIL): 0 to 43' (25' Ave)

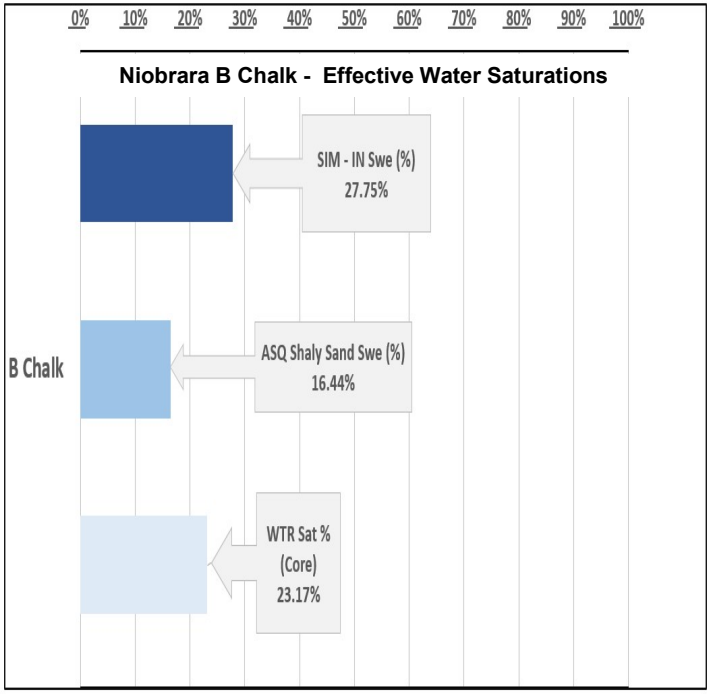
- Highest calcite % of all Hereford Niobrara Chalks
- < 10% Clay Content
- Lower organic content but efficient generation potential
- Lean anoxic mineralogy

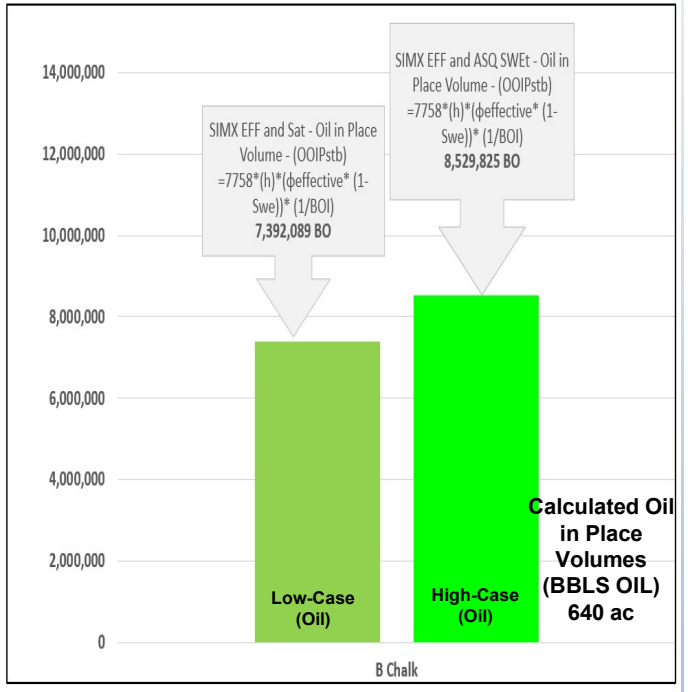


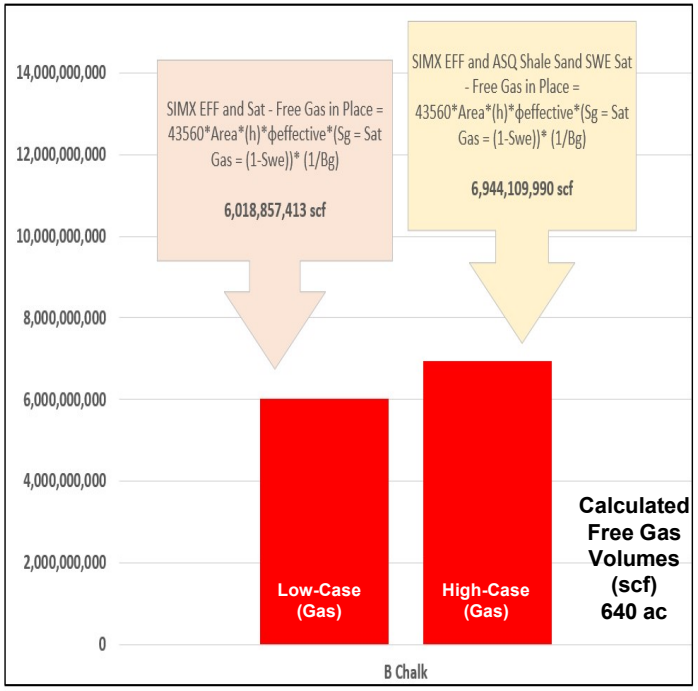


Hereford - Niobrara B Chalk

In-Place Reserves







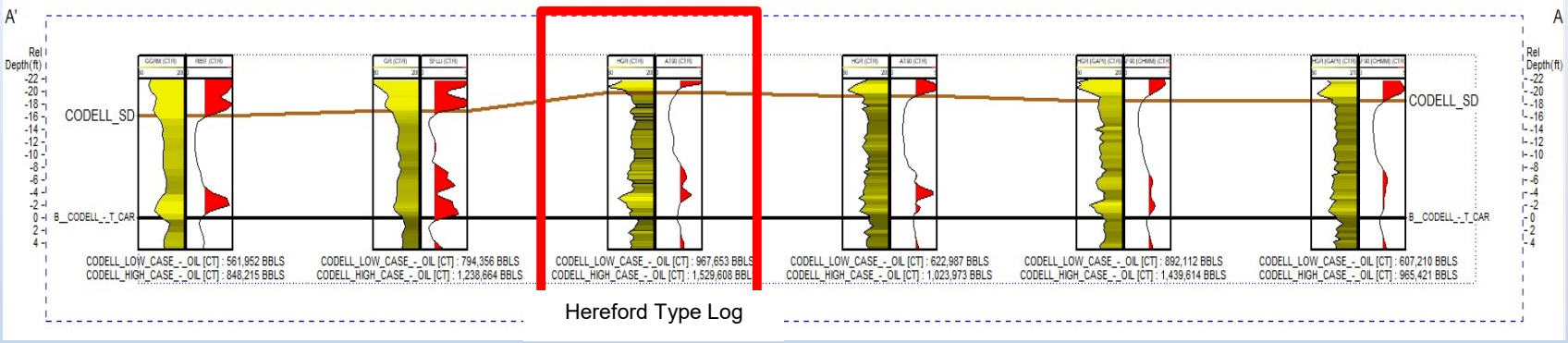
B Chalk – Average In-Place Reservoir Volumes (Est 640ac) :

Gas (High Case): **6.9 BCF** (Low Case): **6 BC**

Oil (High Case): **8.5 MMBO** (Low Case): **7.4 MMBO**

Hereford – Codell Sandstone

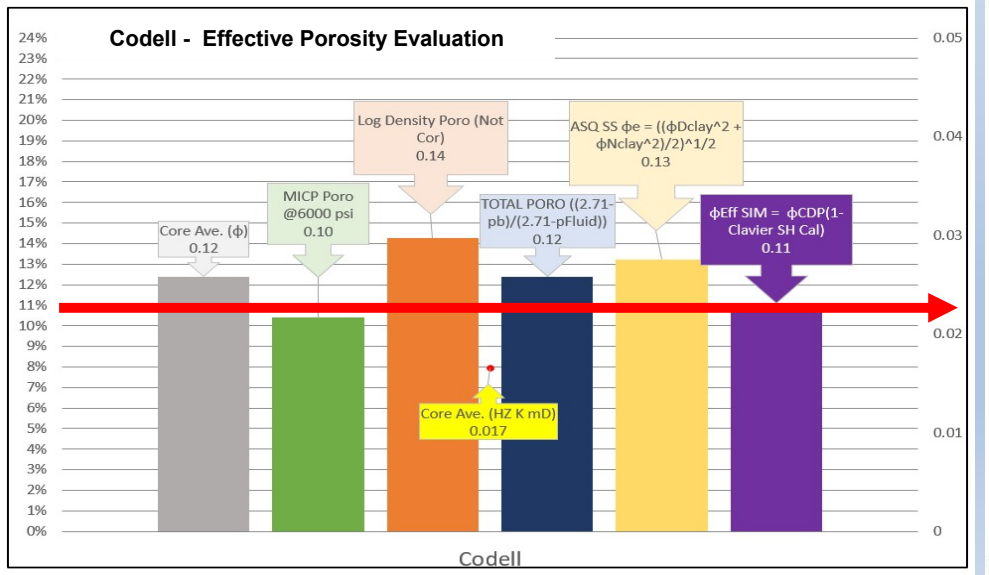
Petrophysics & Geochemistry

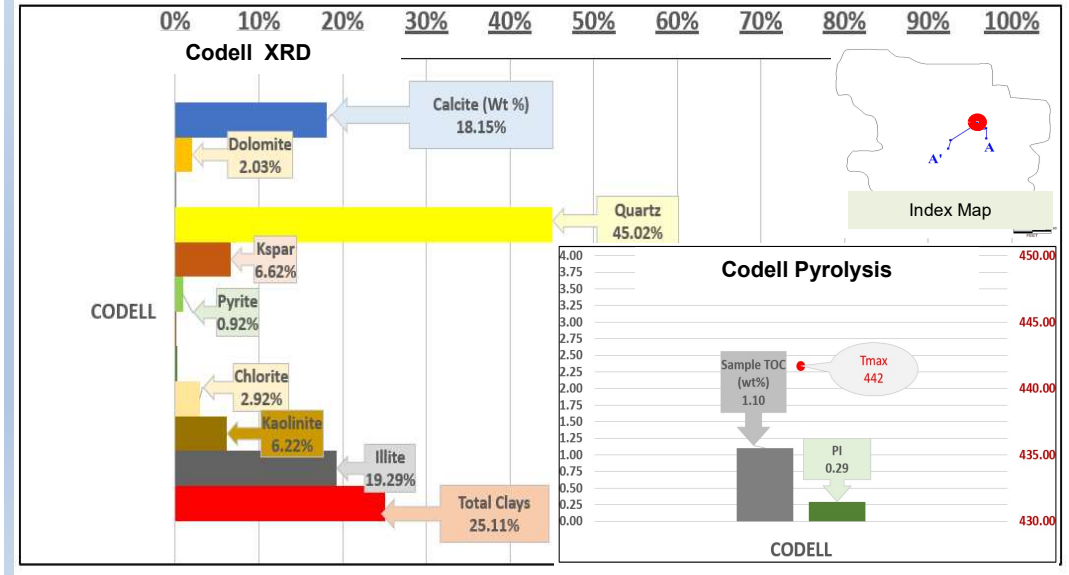


Codell (Hereford Study Area)

- Avg Thickness: 16.5'
- Range (<1 to 25")
- > / = 4 ohm/m (DIL): <2 to >19 (7.4' Ave)

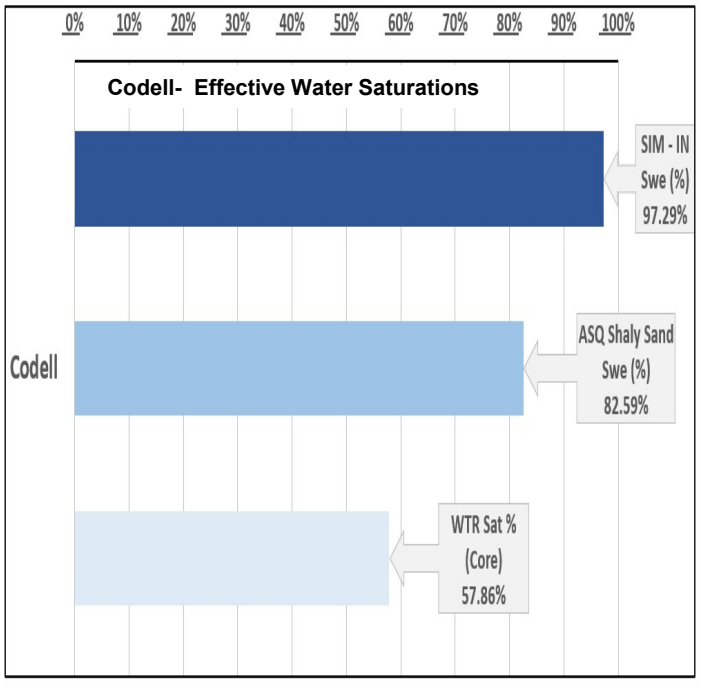
- >25 % Clay Content – major impact on reservoir quality
- Illite dominated
- Mostly Migrated Hydrocarbons
- XRD show increasing quartz and decreasing clay with corresponding reservoir quality in the lower half of the Codell - Upper shore face deposition

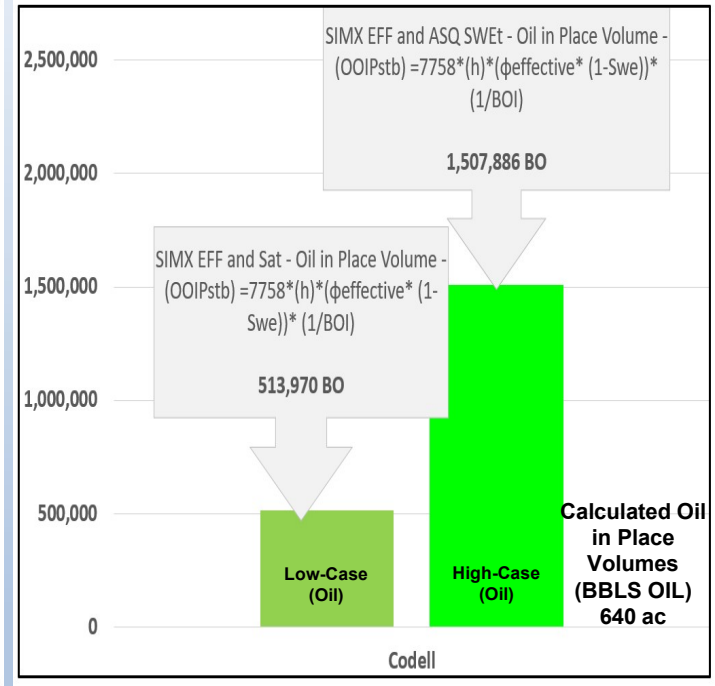


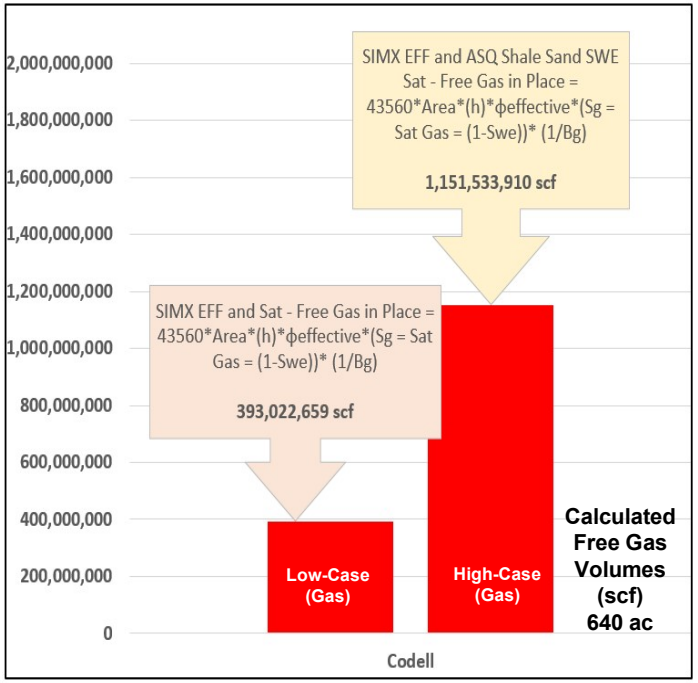


Hereford – Codell Sandstone

Average In-Place Reserves







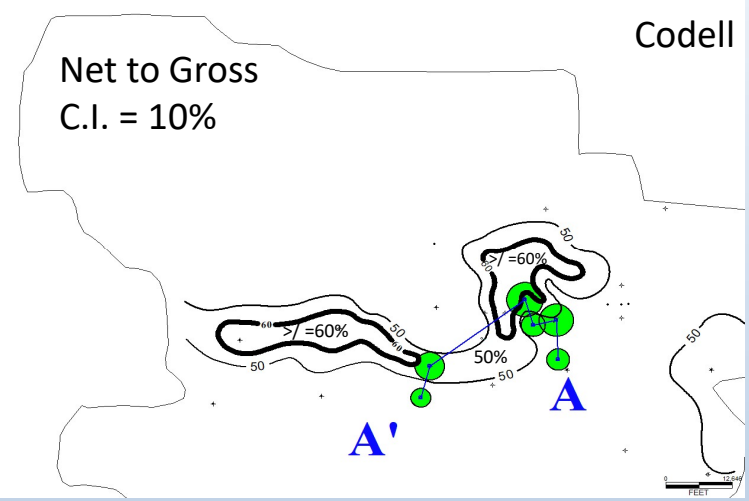
Codell – Average In-Place Reservoir Volumes (Est 640ac) :

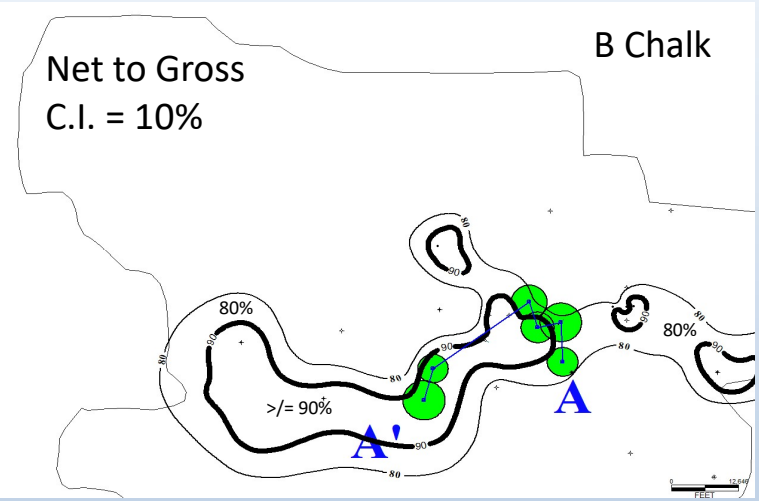
Gas (High Case): **1.2 BCF** (Low Case): **393 MMCF**

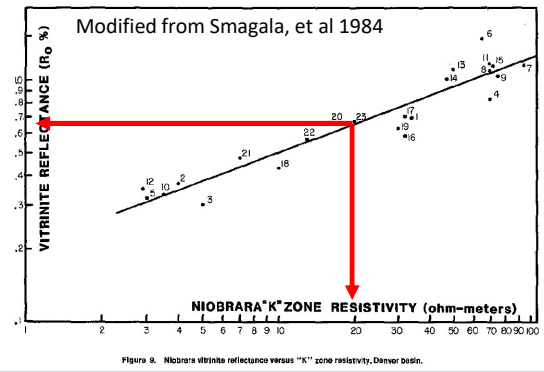
Oil (High Case): **1.5 MMBO** (Low Case): **514 MBO**

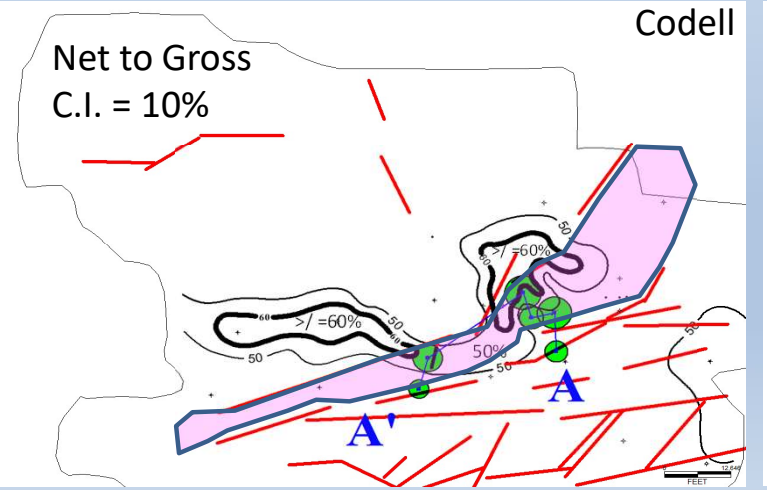
Unconventional Reservoir Quality

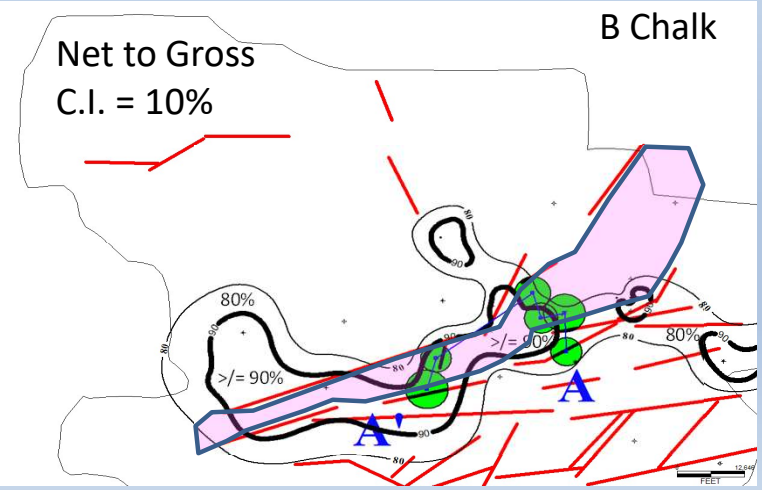
Reservoir Matrix and Tectonic Controlling Elements











Mapped % Formation Net to Gross

Niobrara Net = (>/=) 20 Ohm RT 80
Codell Net = (>/=) 4 Ohm RT 80

Bubbles = Calculated OOIP from High Case Oil (per formation)

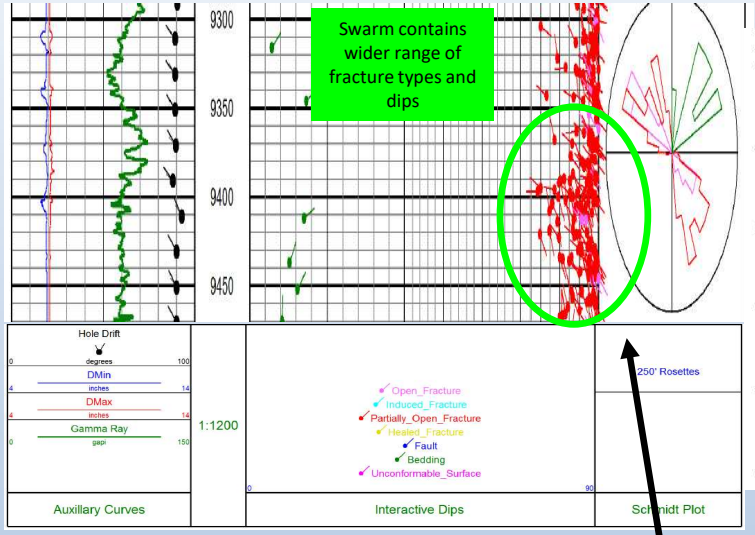
Red lines = Potential Faults (Visually Interpreted from Basement Seismic Amplitudes)

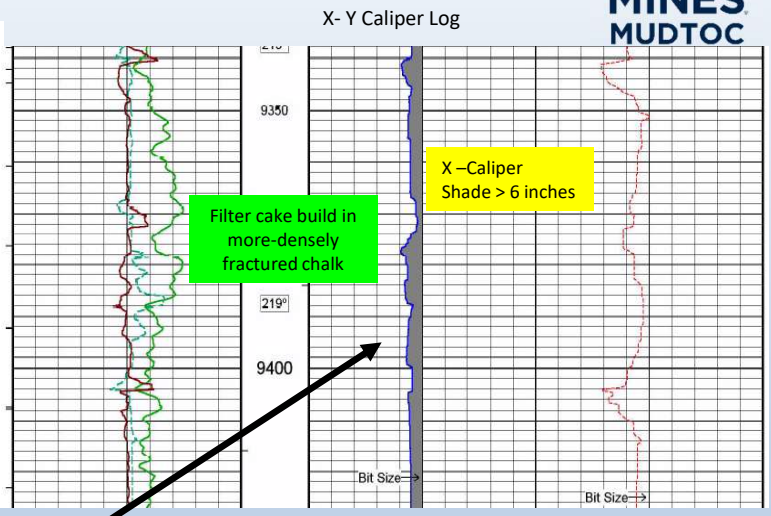
Hereford - Legacy Niobrara Production

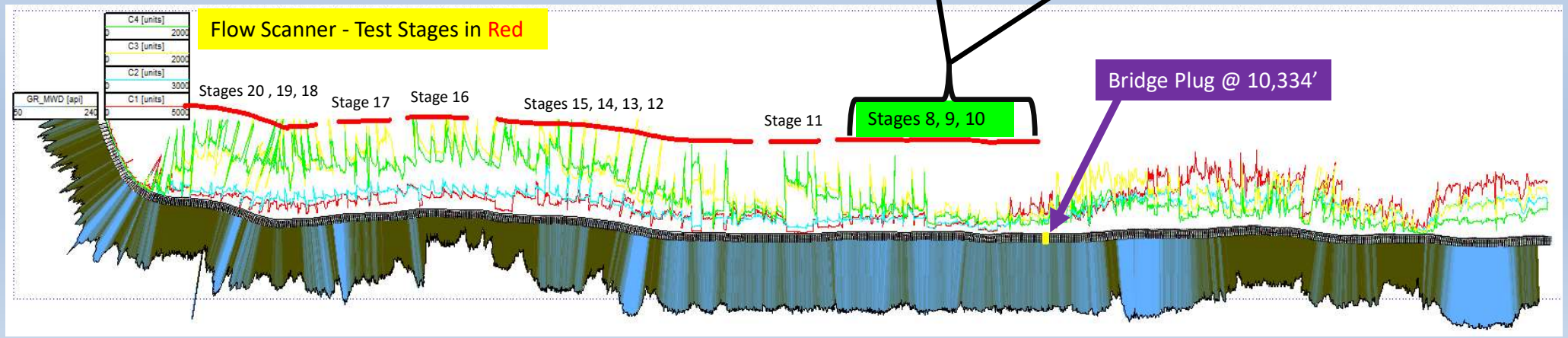
EOG 1st Generation Niobrara Completion
Comp Date: 7/3/2010
IPF: 622 BO + 407 MCF & 110 BW
Oil Gravity: 35.3
Cum: 334 MMBO + 525 MMCF

Schlumberger Flow Scanner Test

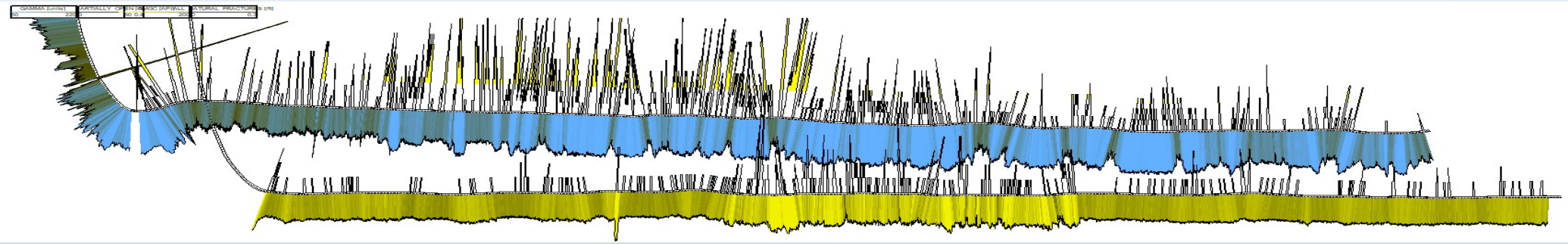
Stages: **8, 9,10** (9,727 – 10,317MD)
335 BOPD – Pre-IP well test
~80% of the lateral production



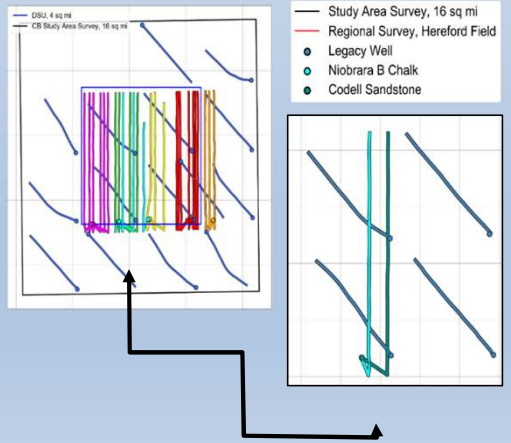


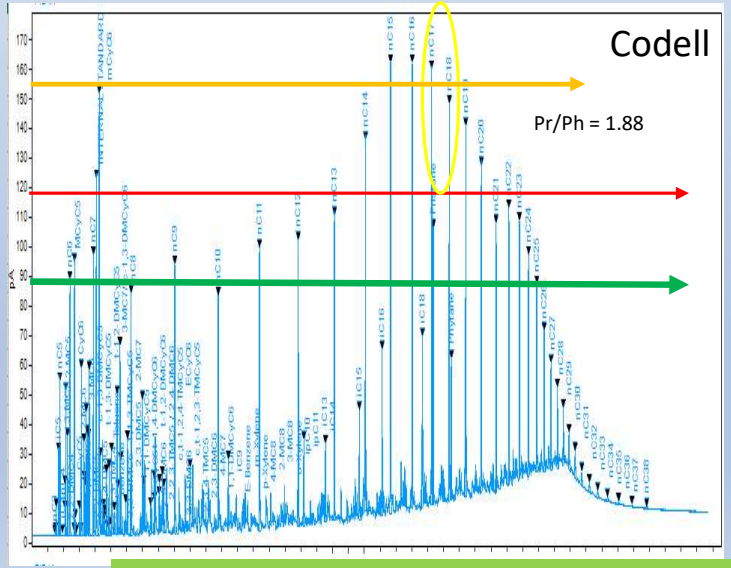


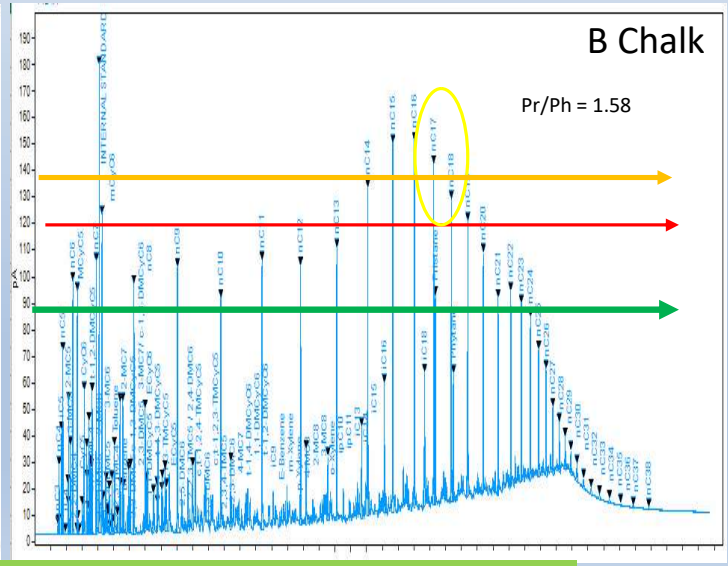
Hereford – Modern Horizontal Production



FIBER WELL INDEX

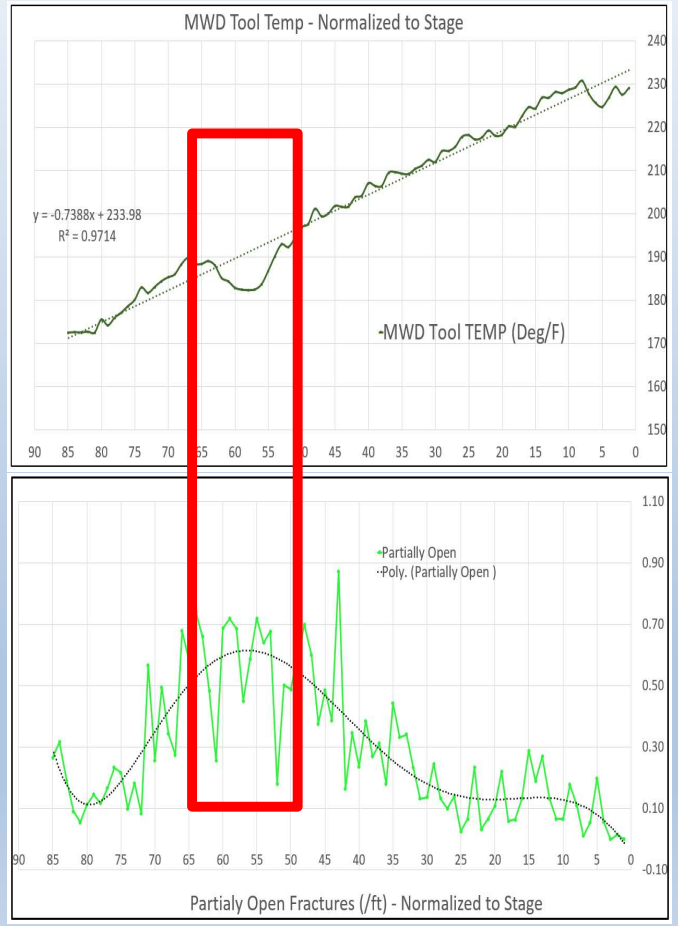


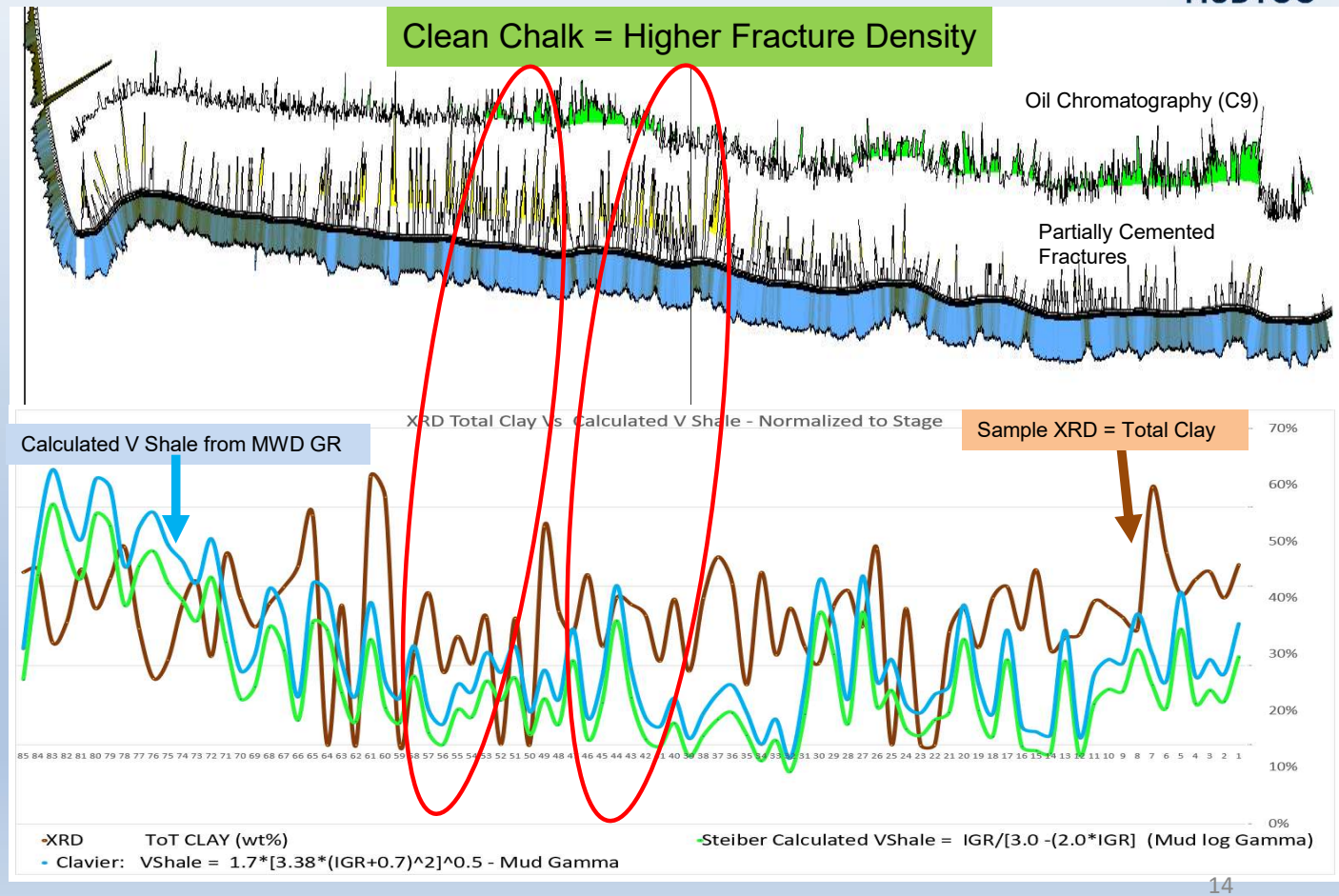




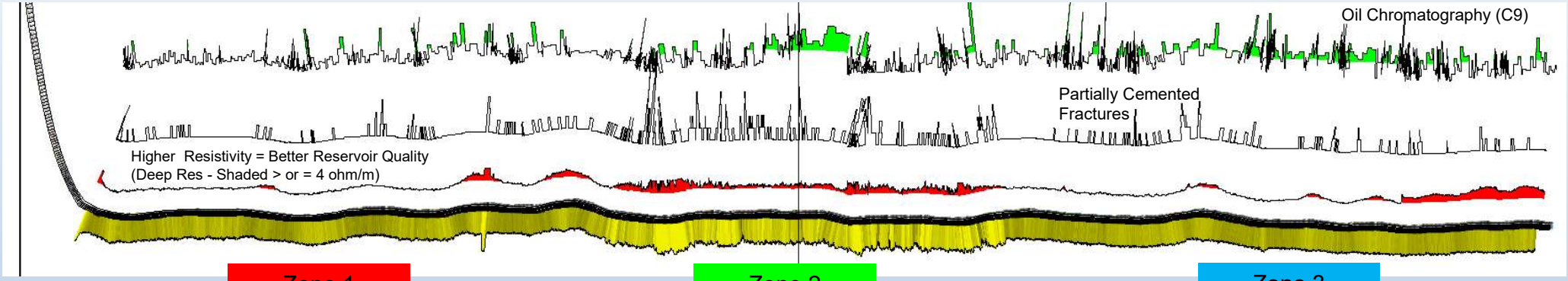
Reservoir Fluid Suggests Complicated Oil Charge and Kerogen Mixing History

Niobrara B Chalk – XRL





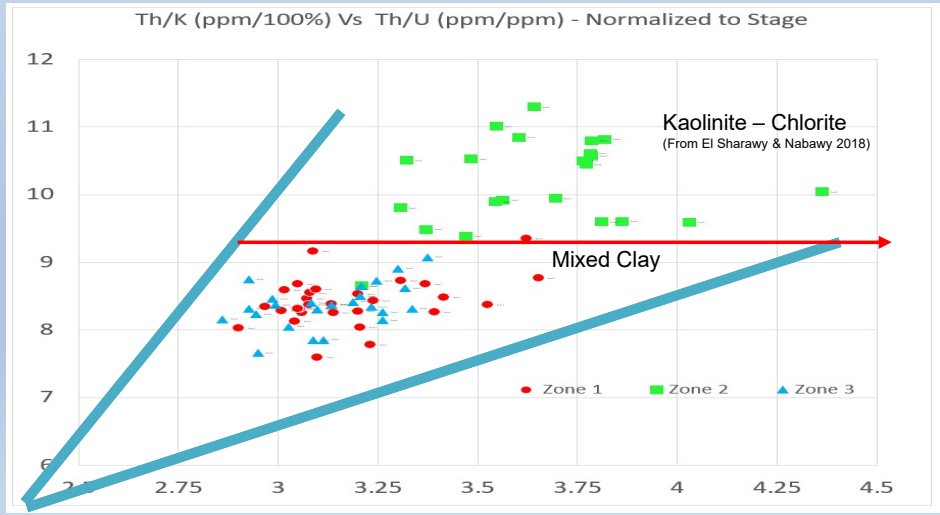
Codell – XRL

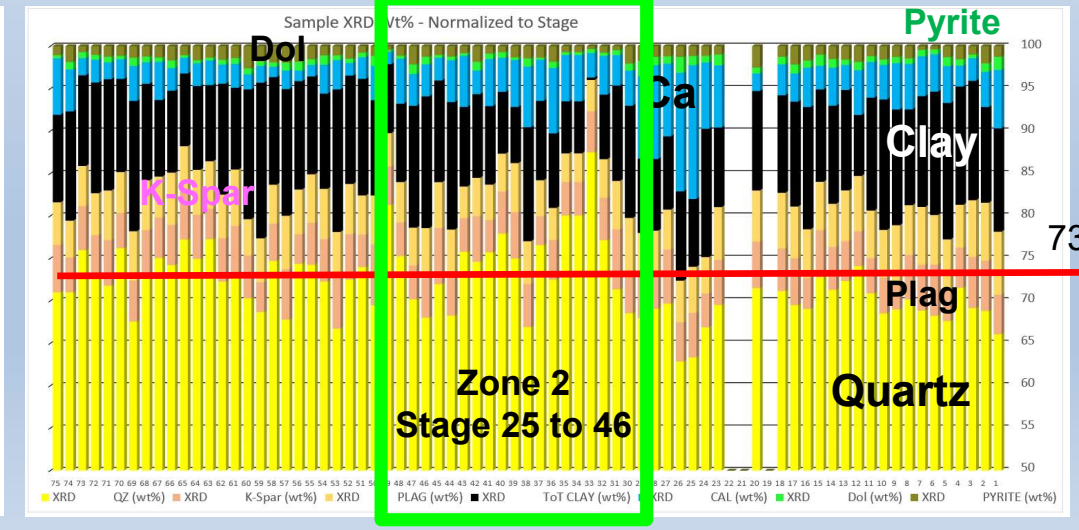


Zone 1
Stage 47 to 75

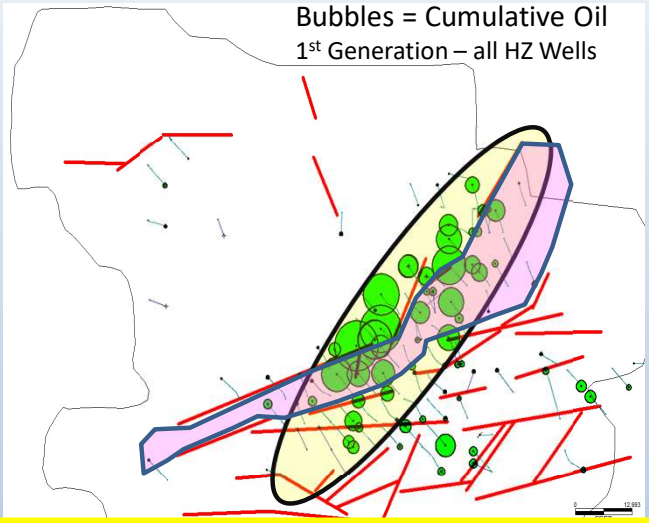
Zone 2
Stage 25 to 46

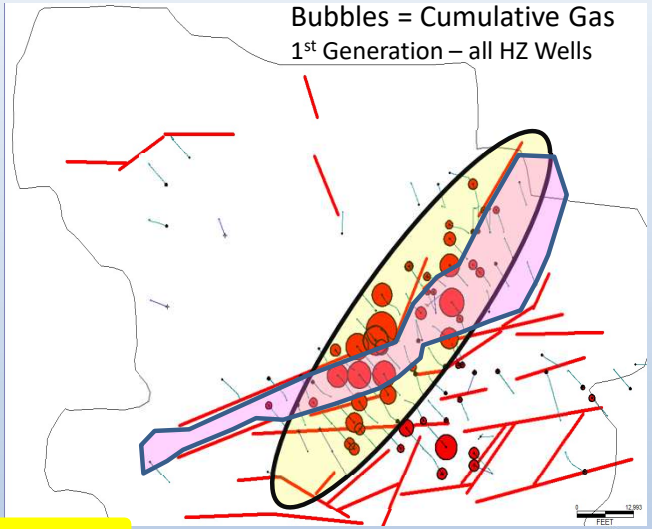
Zone 3
Stage 1 to 24

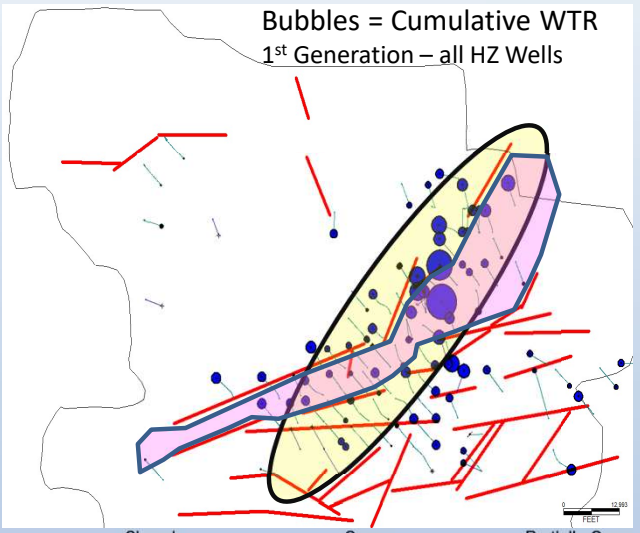


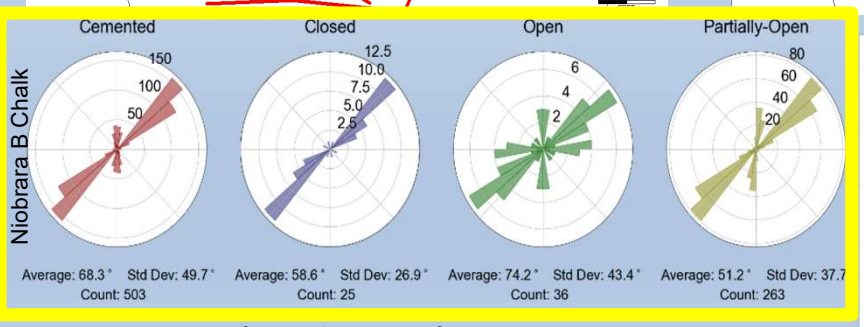


Hereford- Reservoir Deliverability





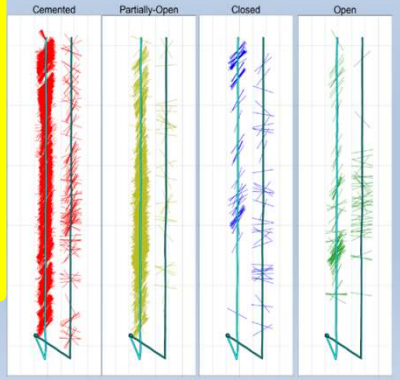




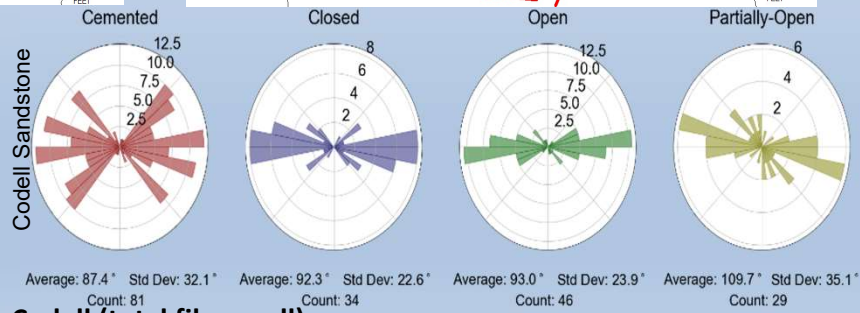
Niobrara B Chalk (total fiber well):

Cumulative fracture count: 827

Average Orientation Angle : 45 deg (= / -)



Natural Fracture Orientations



Codell (total fiber well):

Cumulative fracture count: 190

Average Orientation Angle : 91 deg (+ or -)

Hereford Summary

Niobrara

- Structurally-controlled
  - definable fracture fairways – Largely hosted in most brittle (clean) chalk
  - HZ Well steering is key
- Fluid and **pressure** depletion of fractures
  - Relatively lower GOR → in-tact bubble point, larger volumes of legacy fluid produced
  - Relatively higher GOR → more bubble-point breakout, lower volumes of legacy fluid produced
  - Redefine reservoir quality for new phases of production
- Upside potential in the Niobrara
  - additional targets in the B1 Chalk and C Marl

Codell

- Stratigraphically-controlled
  - lower-Codell brittle (less clay, more quartz and calcite) pay zone
  - Contains >80% of oil saturation
- Non-Niobrara sourcing
  - Observable kerogen mixing → potential to develop deeper source intervals
- Upside potential
  - predictable pay across the region, mappable with well and seismic
  - Definable top and bottom-seal, good candidate for EOR
  - HZ Well steering is key

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MJ Logs

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