

The Geological Reservoir Characterization and Assessment of Reservoir Deliverability for Unconventional Niobrara and Codell Reservoir Targets In the Hereford Field Area, Weld County, Colorado

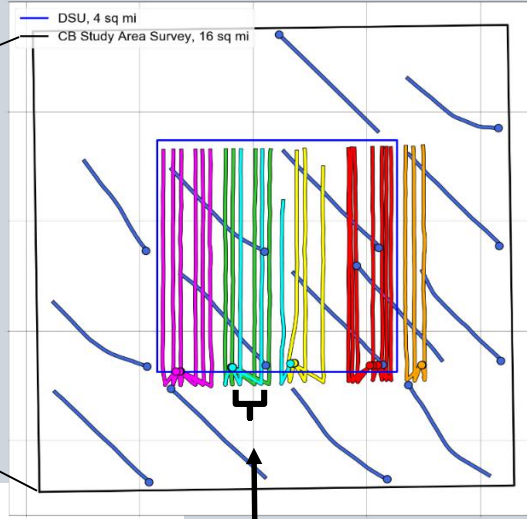
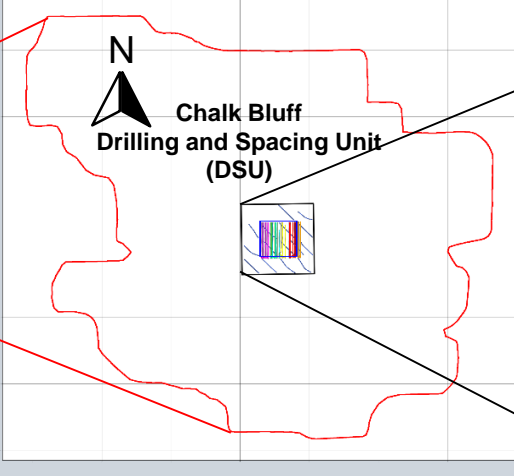
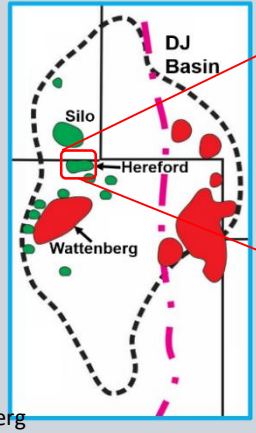
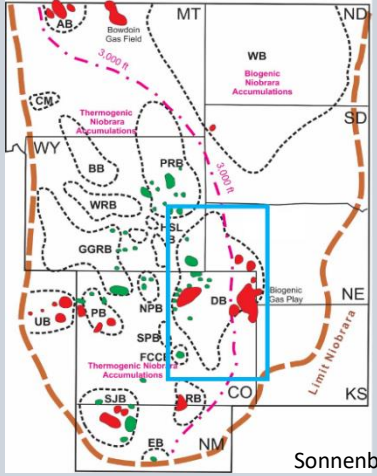


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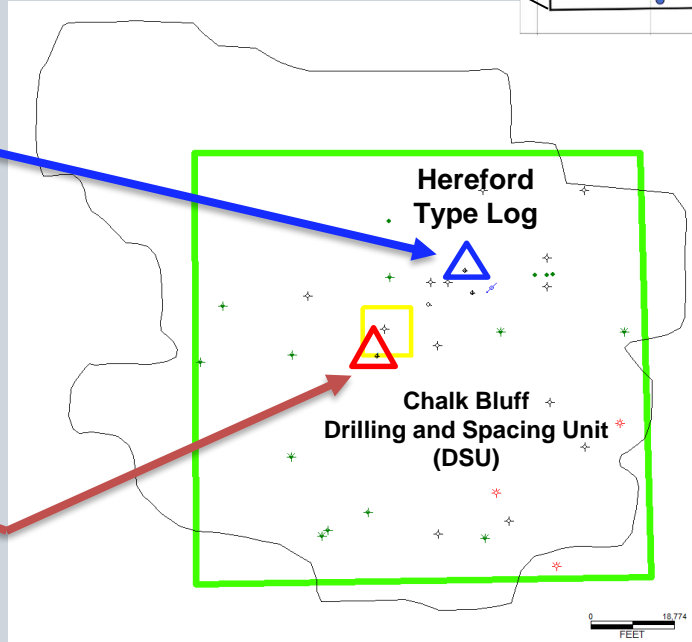
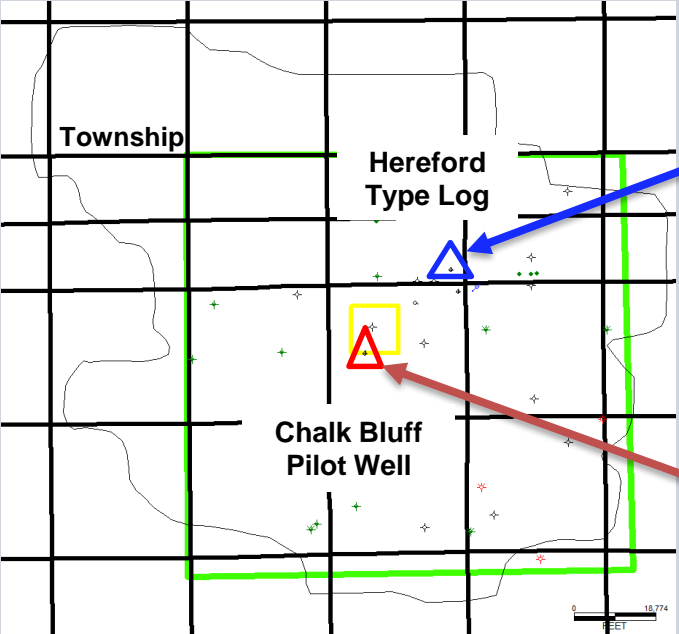
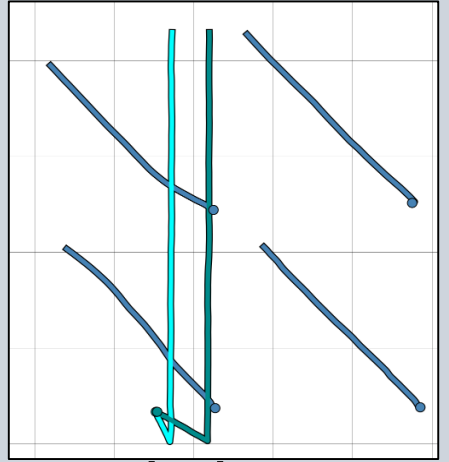
Chad Taylor

MSc Geology
Student
Fall 2022

Hereford Study - Data Overview

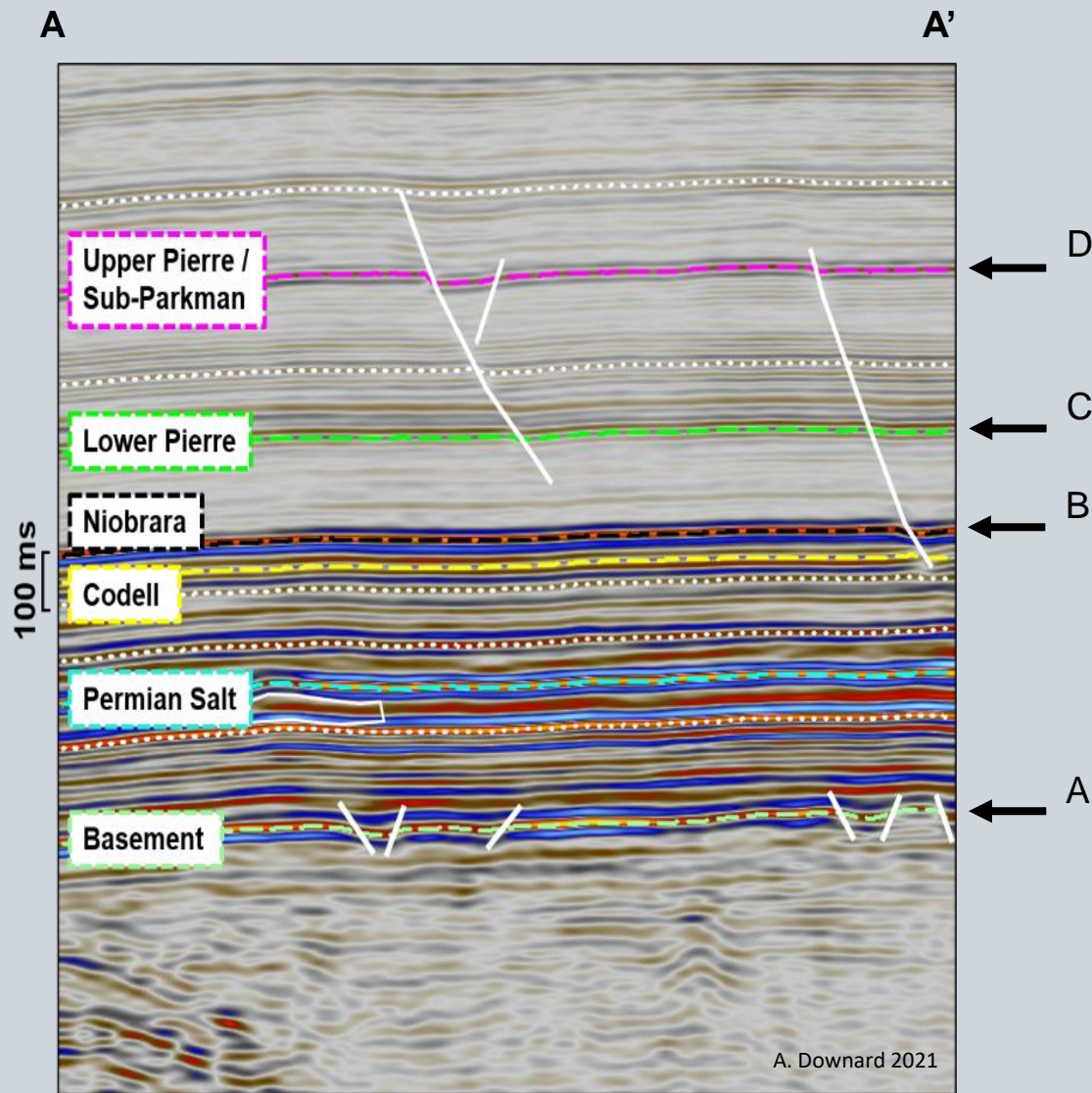
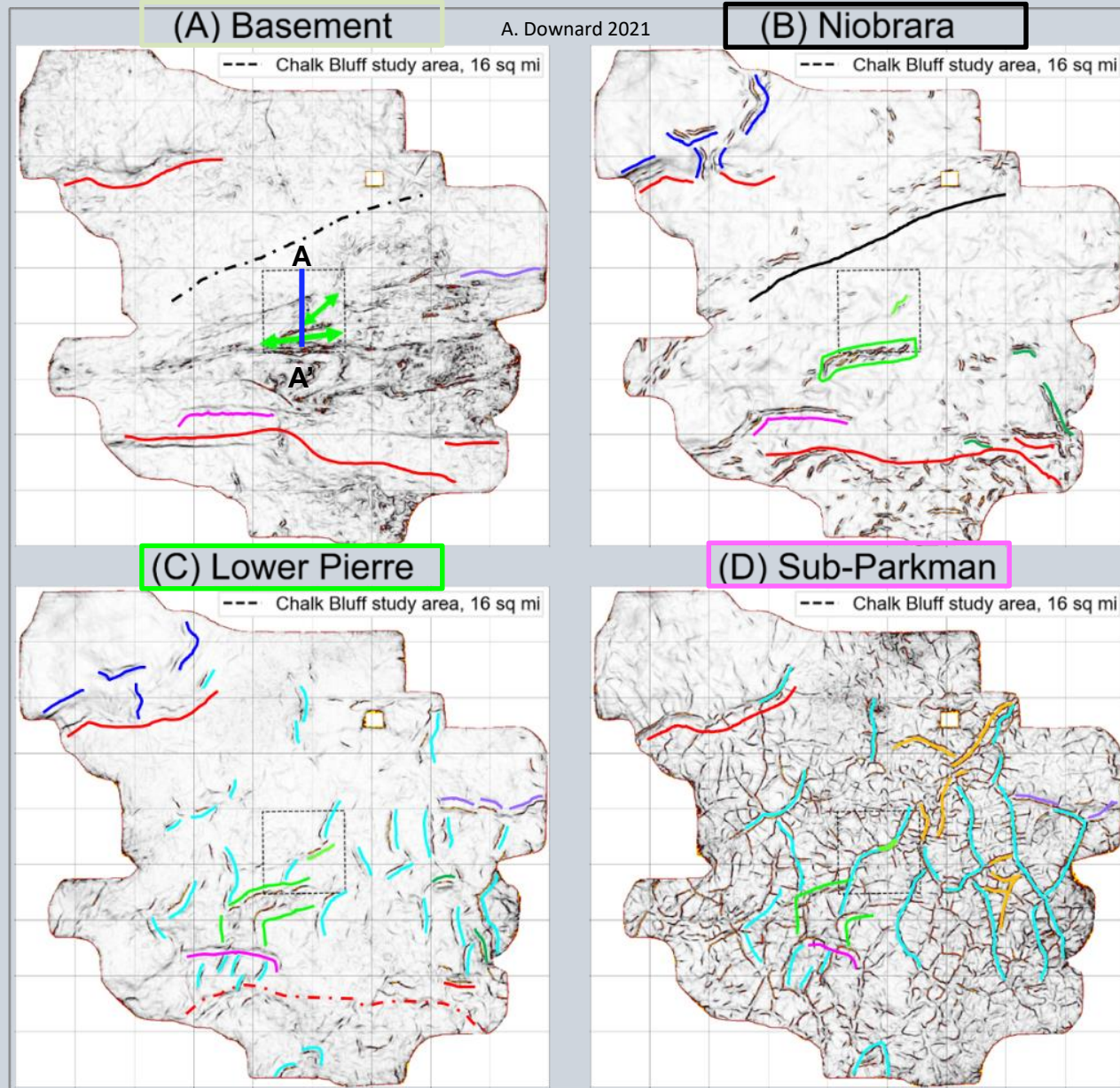


- Study Area Survey, 16 sq mi
- Regional Survey, Hereford Field
- Legacy Well
- Niobrara B Chalk
- Codell Sandstone

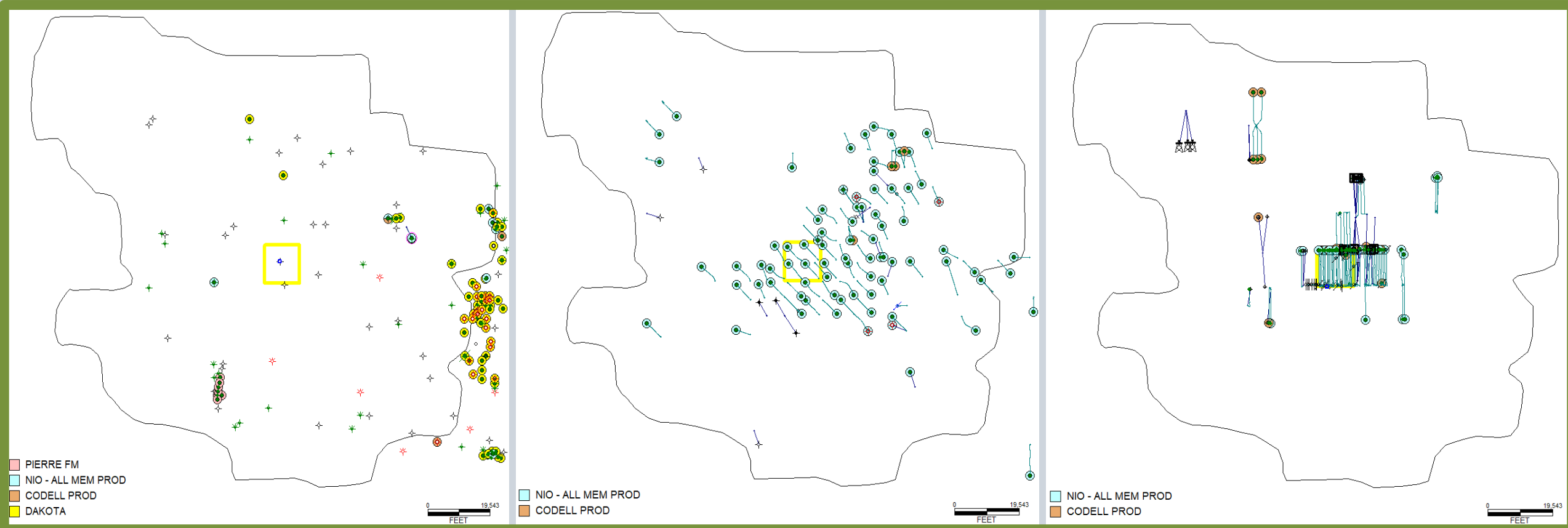


Hereford / Chalk Bluff Study Vertical Well Data Distribution

Structural Context



Hereford Field - Production Evolution



Existing Conventional Wells

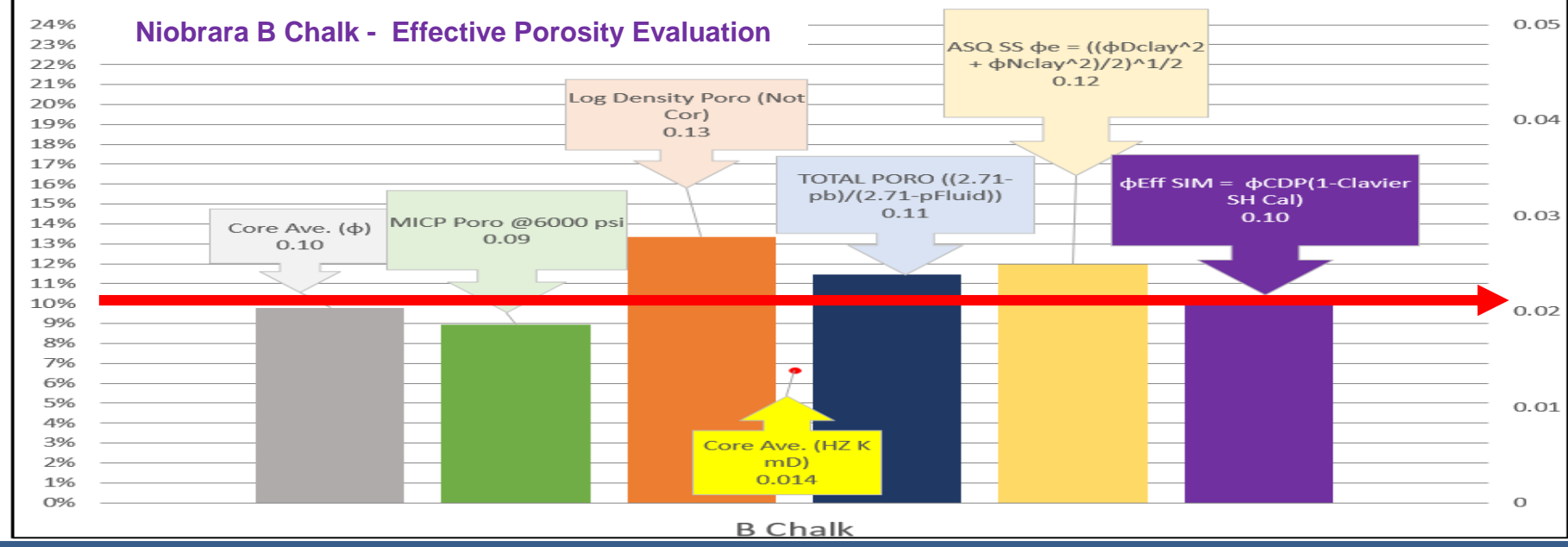
(Pre 2009)

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

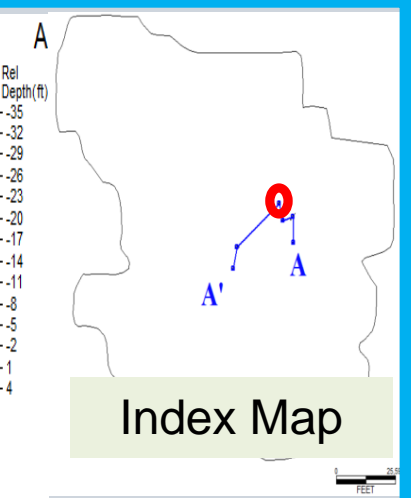
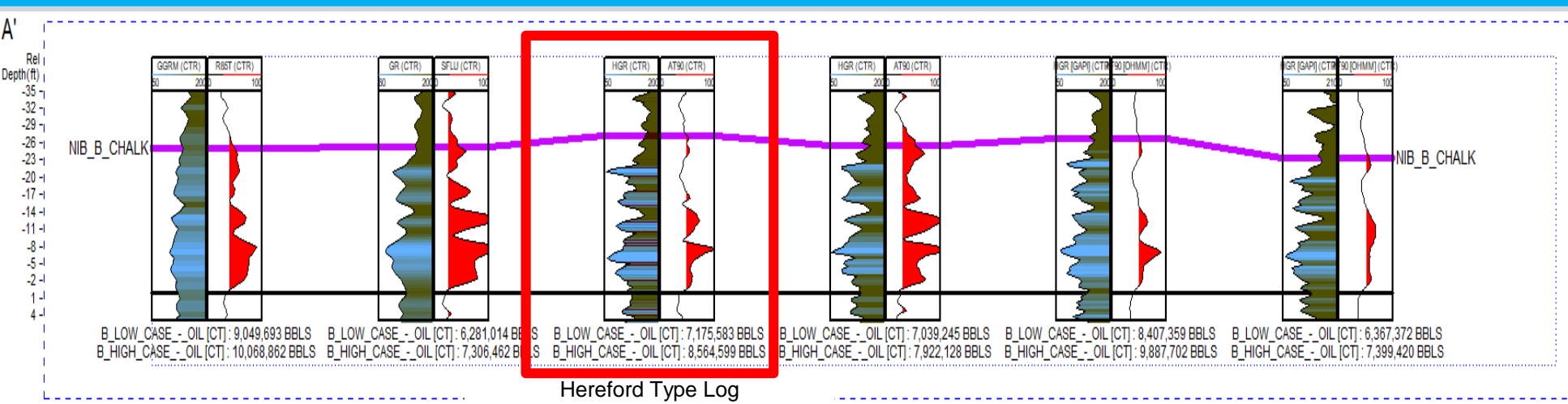
Petrophysical Reservoir Quality



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

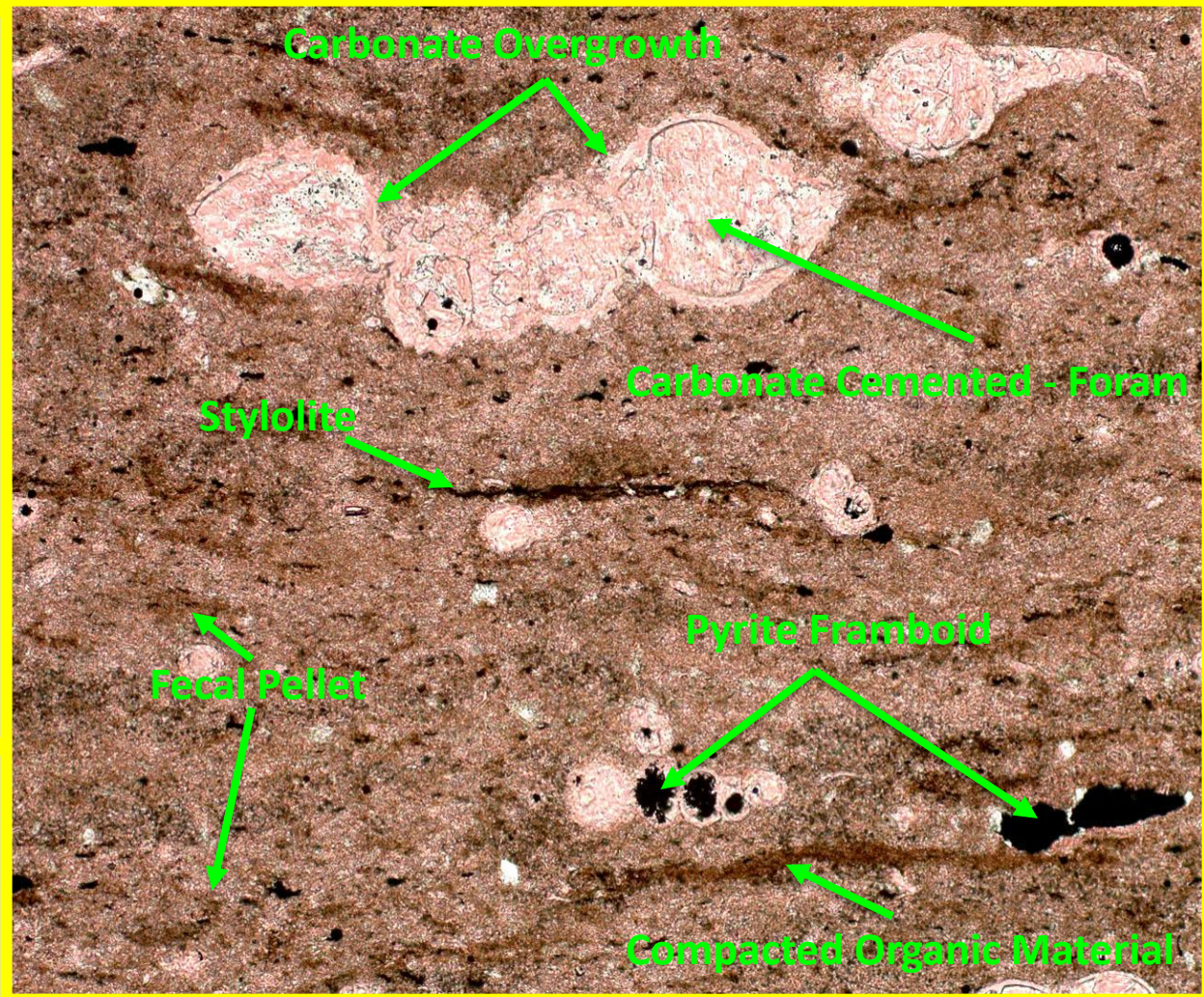
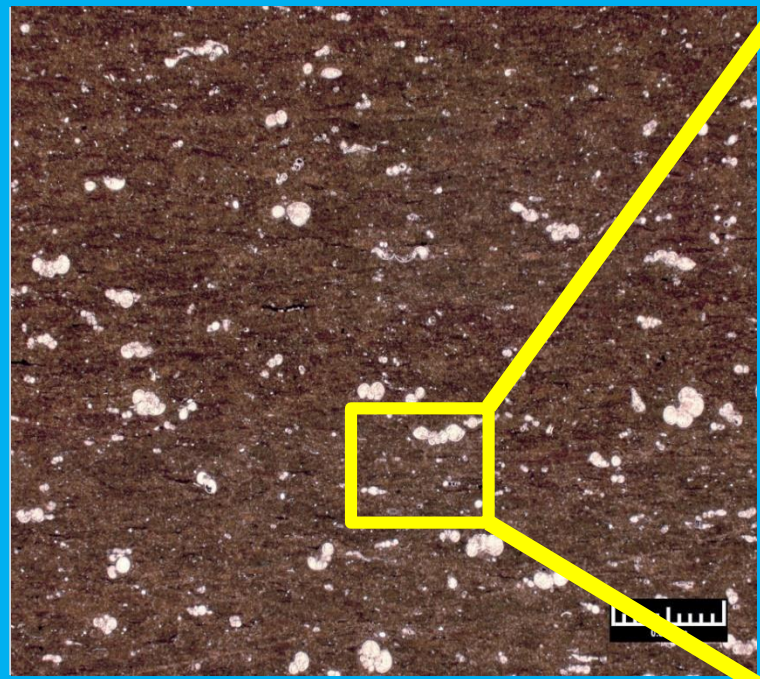


Hereford - Niobrara B Chalk

Reservoir Quality - Pore Scale

XRD (wt.%)

Calcite:	96.12%
Dolomite:	.07%
Siderite:	.02%
Fluorapatite:	.17%
Quartz:	2.29%
K-Spar:	0%
Pyrite:	.08%
Total Clays:	1.24%
Marcasite:	.03%
Illite:	.06%
Kaolinite:	1.07%
Chlorite:	.11%



MICP @ 6000 psi

Porosity:	10.5%
Pore Throat Radius (µm):	.026
Perm (mD):	.00856

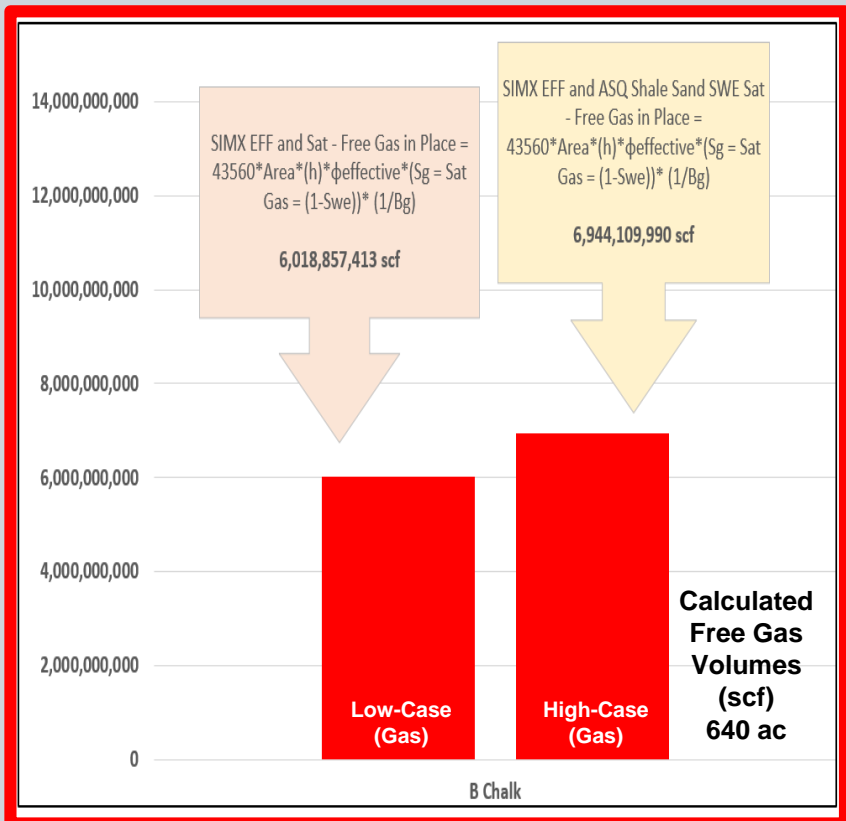
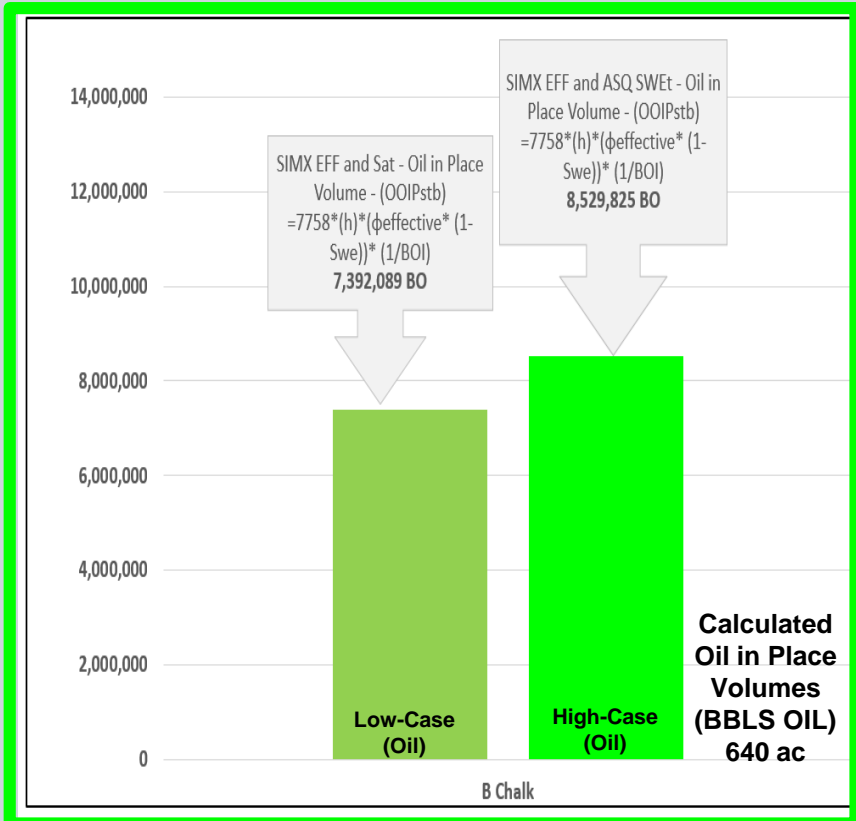
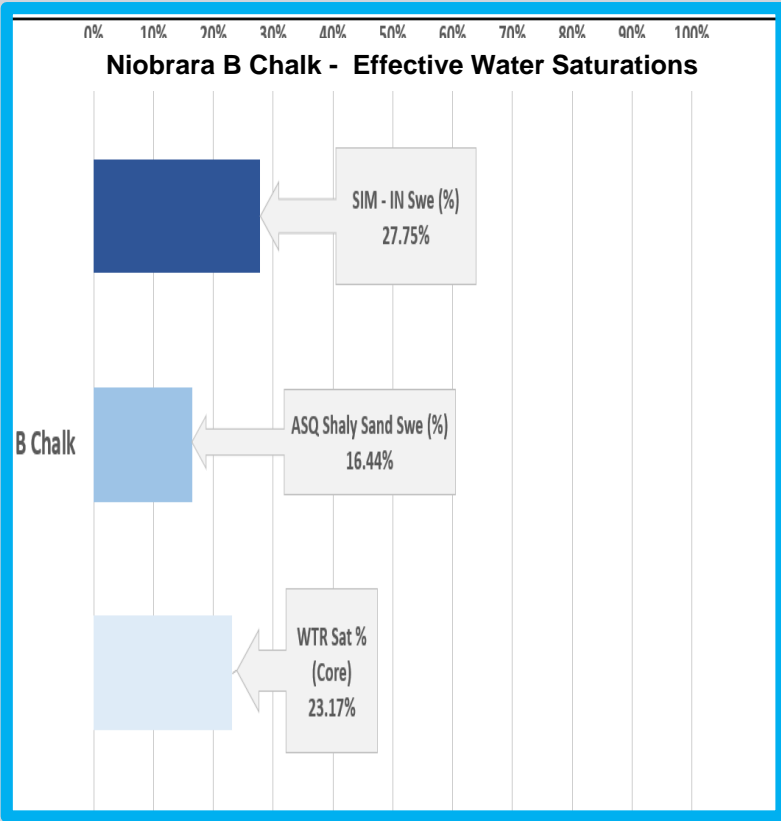
Core (Crush)

Porosity:	9.66 %
Perm (mD):	.0025
Sat:	43% Oil, 47% Gas, 10% WTR

7413

Hereford - Niobrara B Chalk

In-Place Reserves

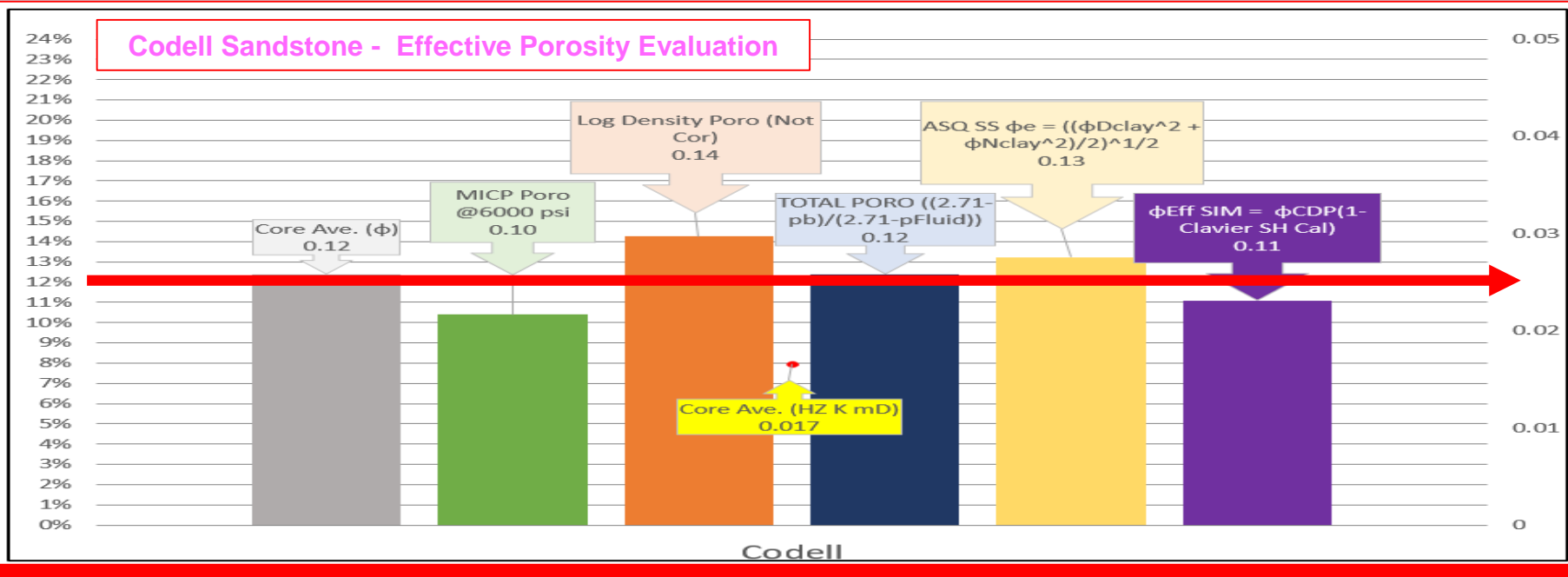


B Chalk – Average In-Place Reservoir Volumes (Est 640ac) :

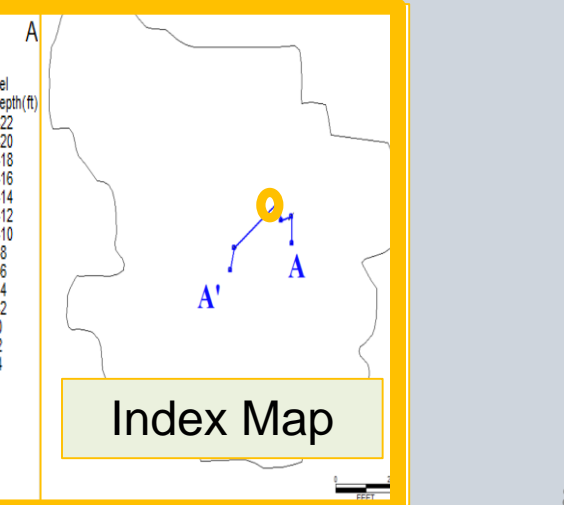
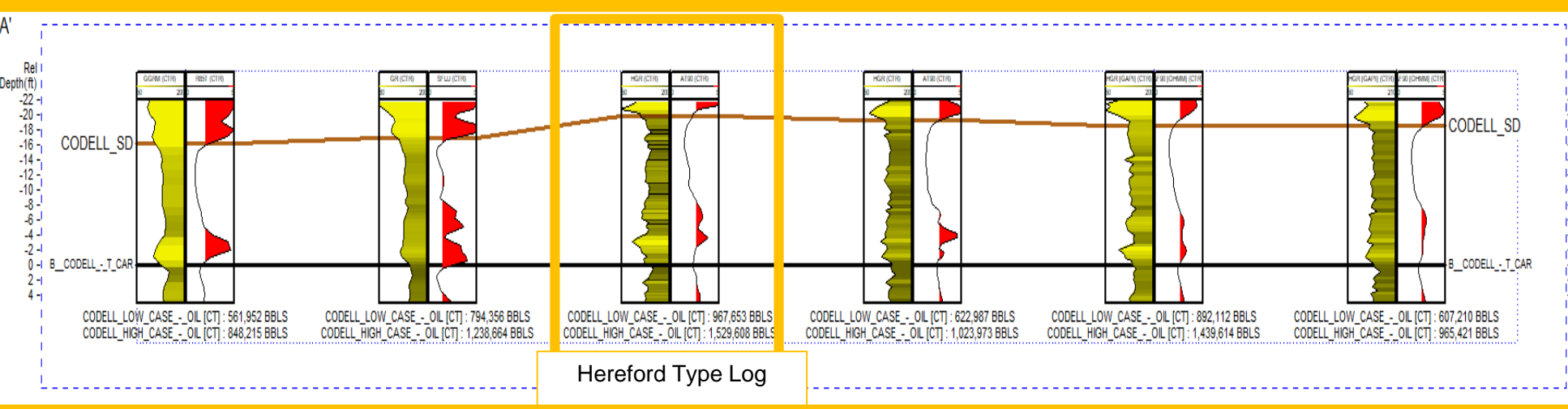
Gas (High Case): **6.9 BCF**
 Case): **6 BCF**

(Low

Hereford - Codell Sandstone Petrophysical Reservoir Quality



- 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
 - Migrated Hydrocarbons charge - Carrier Bed Reservoir (Sonnenberg 2021)
 - XRD show increasing quartz and decreasing clay with corresponding reservoir quality in Codell lithofacies



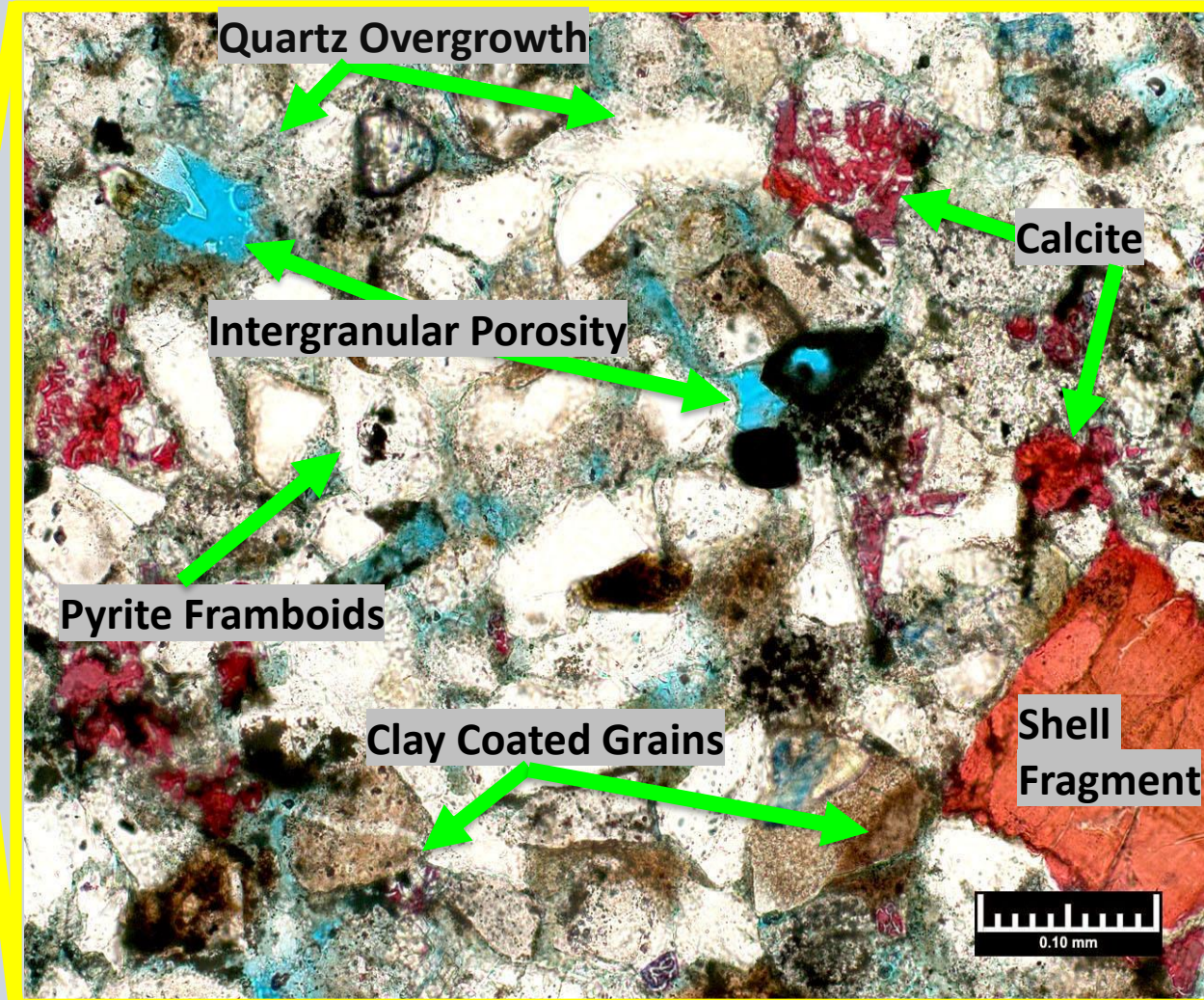
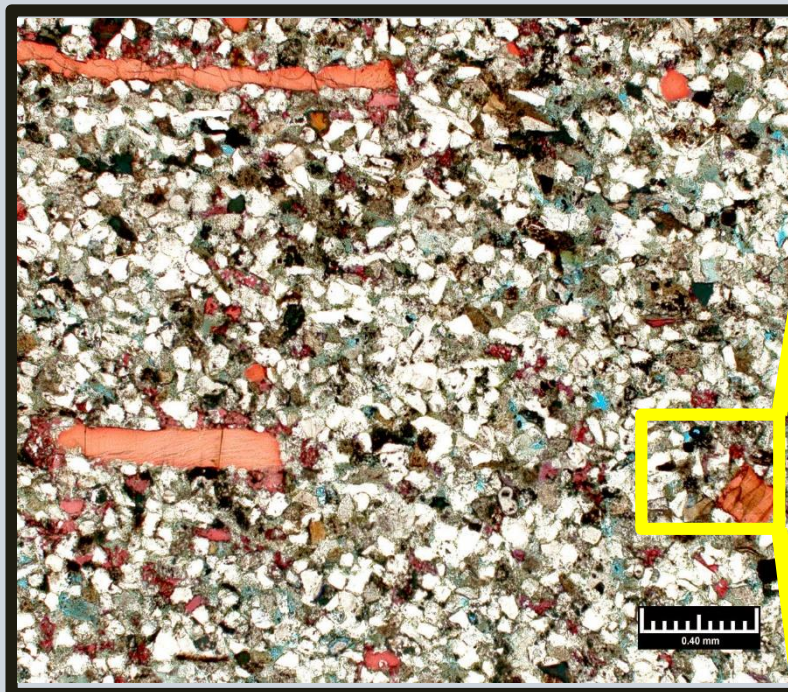
Hereford - Codell Sandstone

Pore Scale Reservoir Quality - (Upper Bioturbated Facies)

XRD (wt.%)

Calcite: **3.98%**
Dolomite: **.43%**
Siderite: **.04%**
Fluorapatite: **.13%**
Quartz: **61.46%**
K-Spar: **7.04%**
Pyrite: **.69%**

Total Clays: **26.22%**
Marcasite: **.01%**
Illite: **16.70%**
Kaolinite: **6.16%**
Chlorite: **3.35%**



MICP @ 6000 psi

Porosity: **10.7%**

Pore Throat Radius (μm): **.0017**

Perm (mD): **.144**

Core (Crush)

Porosity: **11.2 %**

Perm (mD): **.0048**

Sat: 25% Oil, 35% Gas, 40% WTR

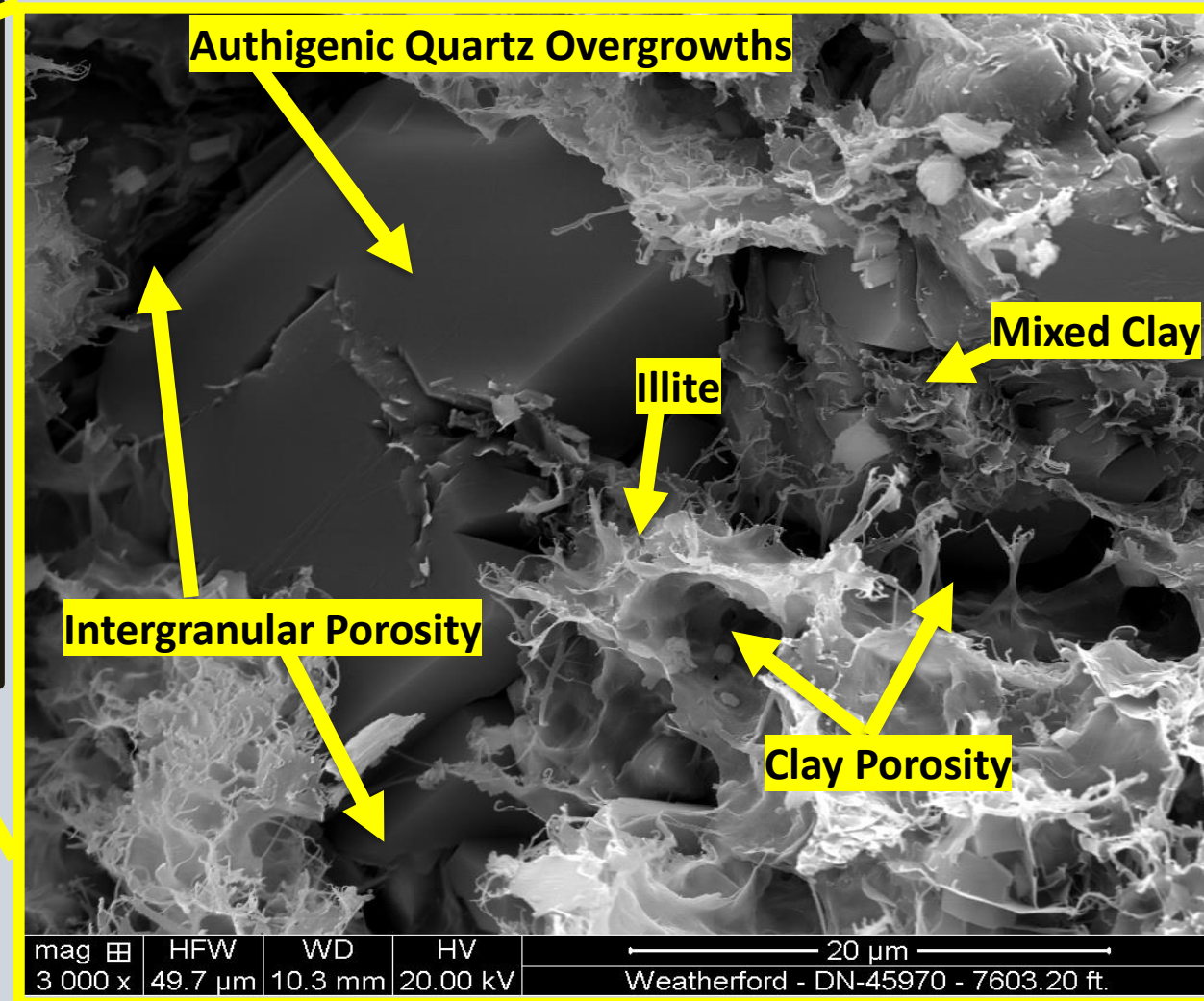
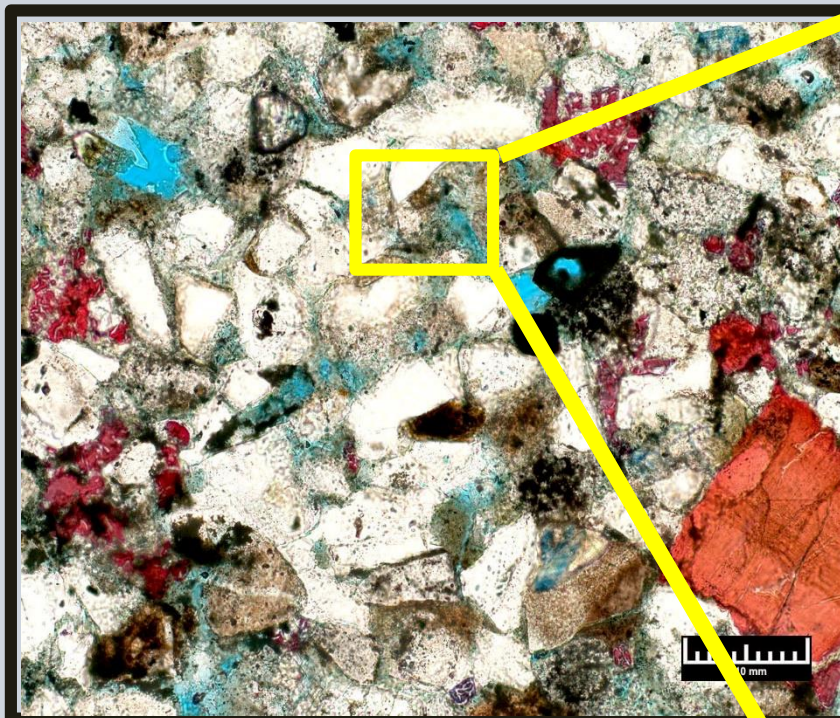
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Hereford - Codell Sandstone

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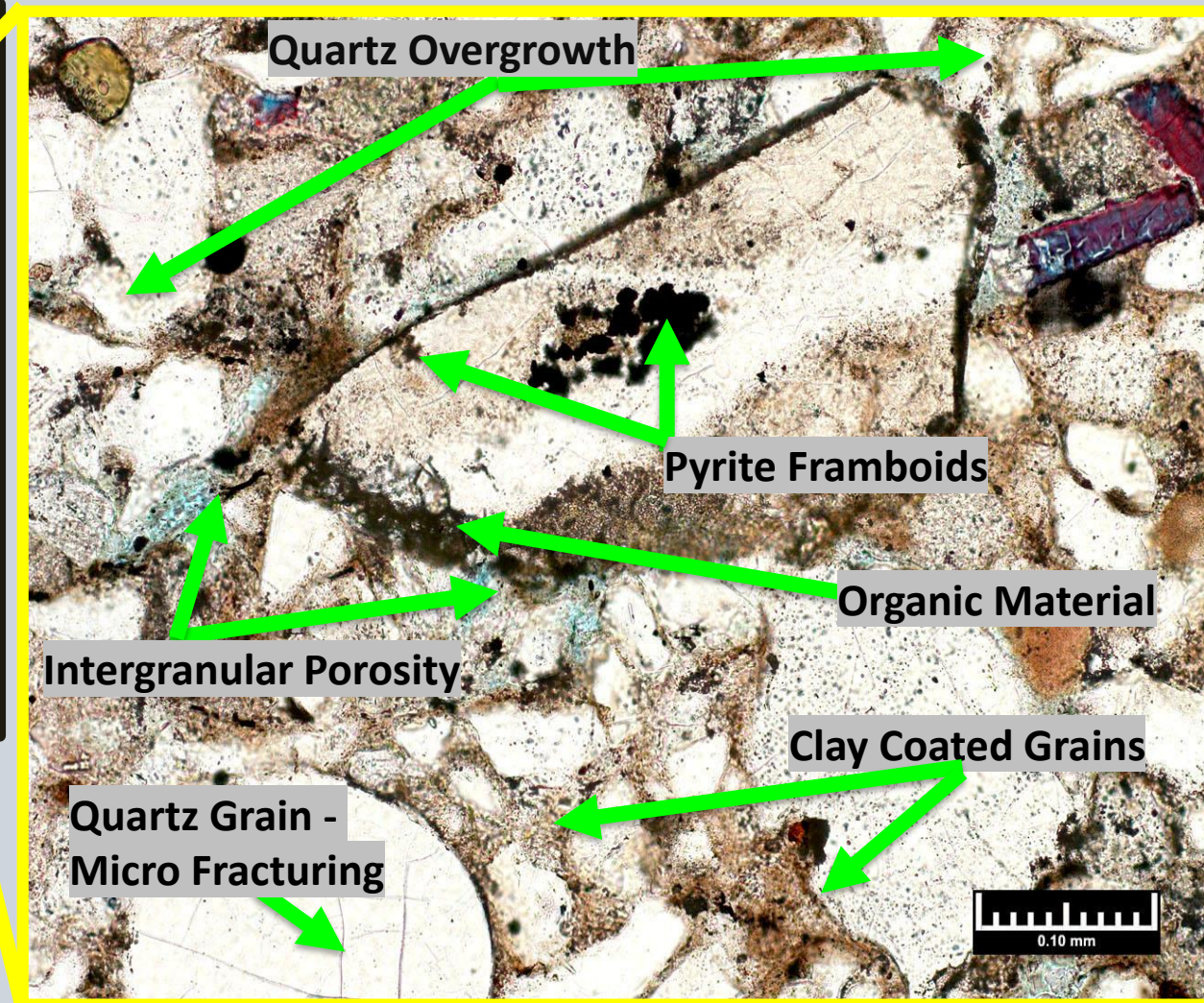
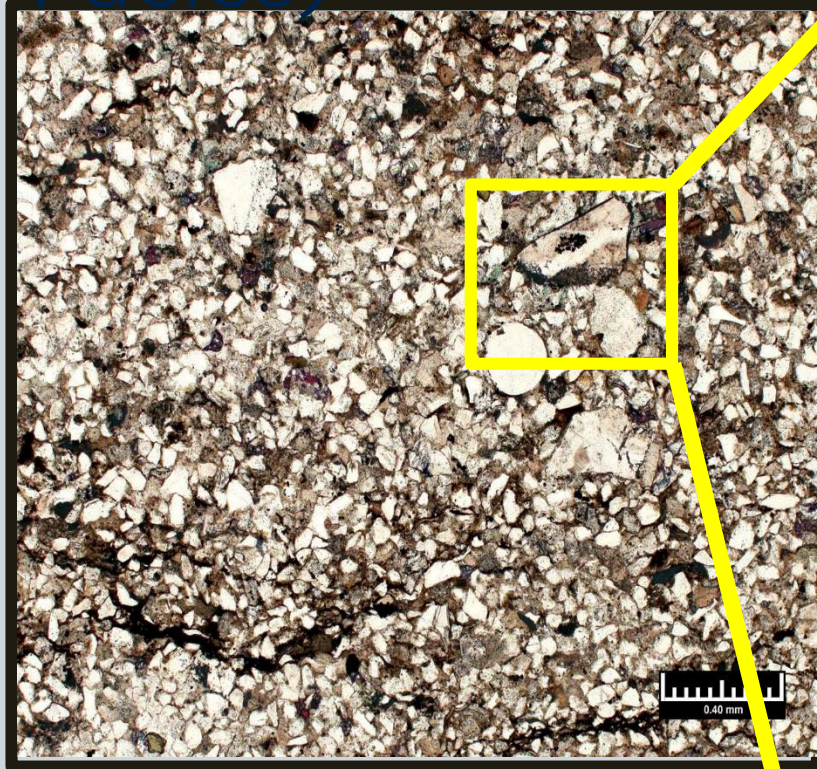
Hereford - Codell Sandstone

Pore Scale Reservoir Quality - (Lower X-Laminated Facies)

XRD (wt.%)

Calcite: 1.53%
 Dolomite: .23%
 Siderite: .51%
 Fluorapatite: .08%
 Quartz: 57.82%
 K-Spar: 8.02%
 Pyrite: .26%

Total Clays: 31.29%
 Marcasite: .26%
 Illite: 21.48%
 Kaolinite: 6.82%
 Chlorite: 2.99%



MICP @ 6000 psi

Porosity: 10.8%
 Pore Throat Radius (μm): .026
 Perm (mD): .0185

Core (Crush)

Porosity: 10.64 %
 Perm (mD): .0014
 Sat: 7% Oil, 27% Gas, 62% WTR

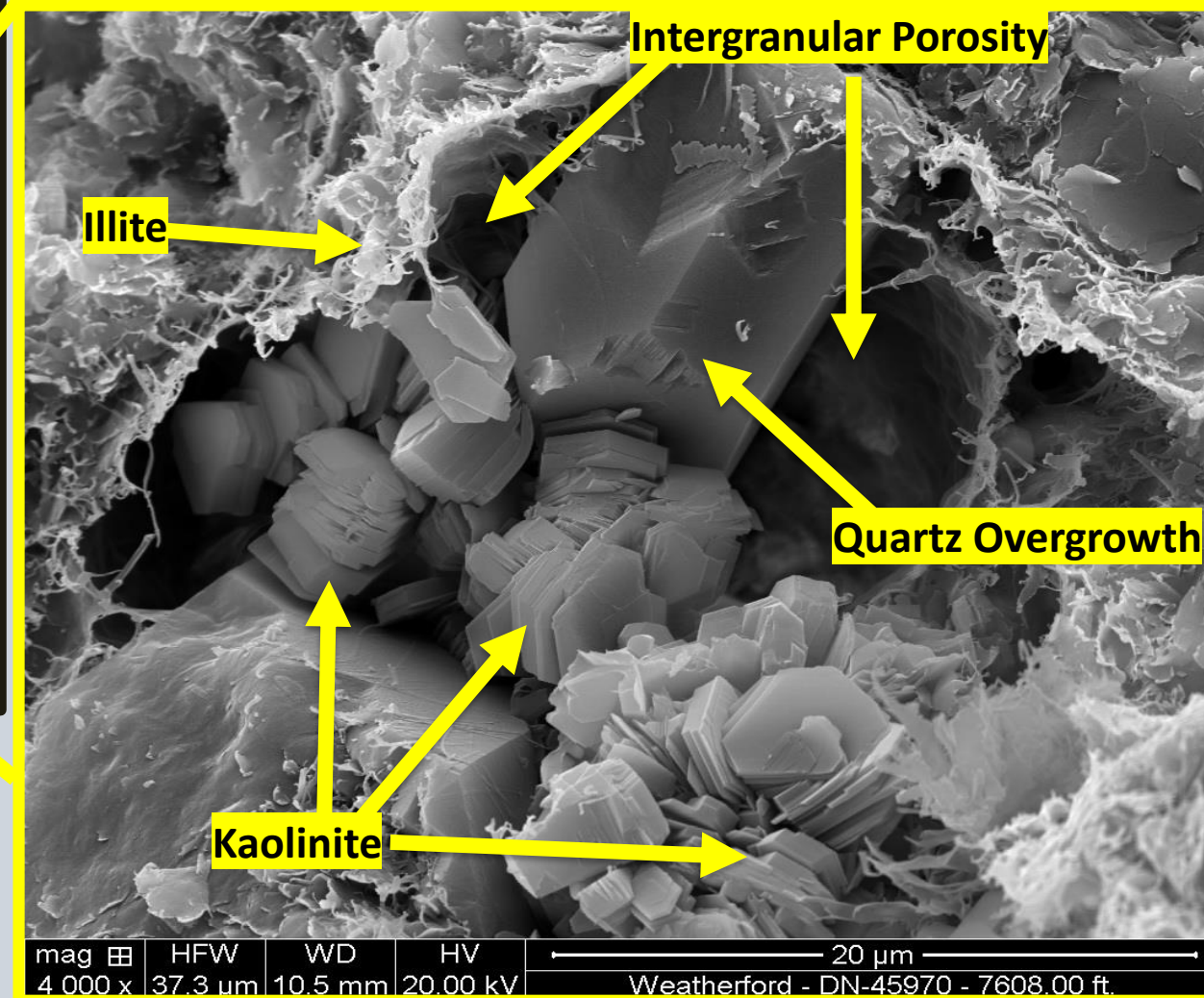
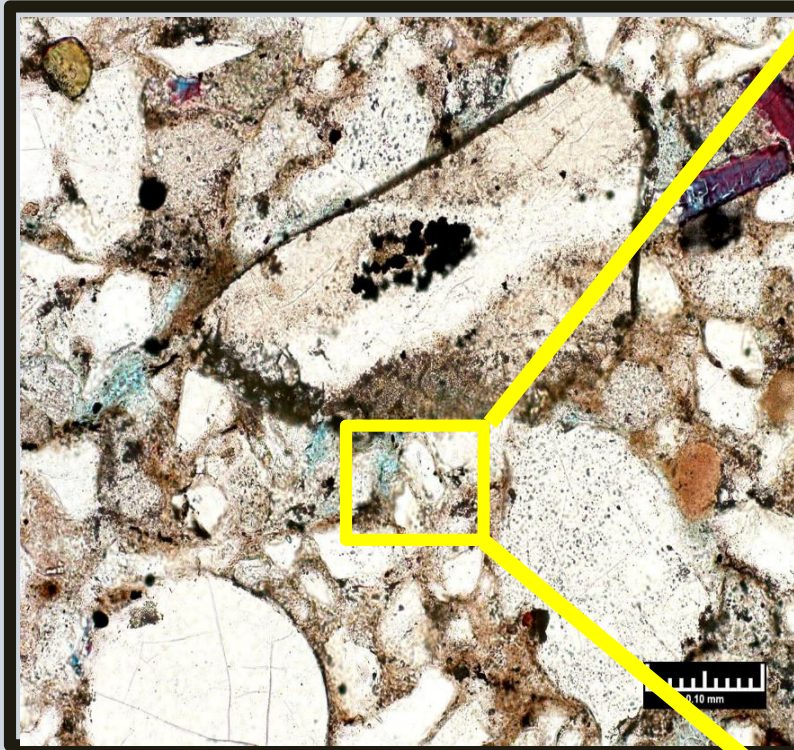
Weatherford - Codell Sandstone

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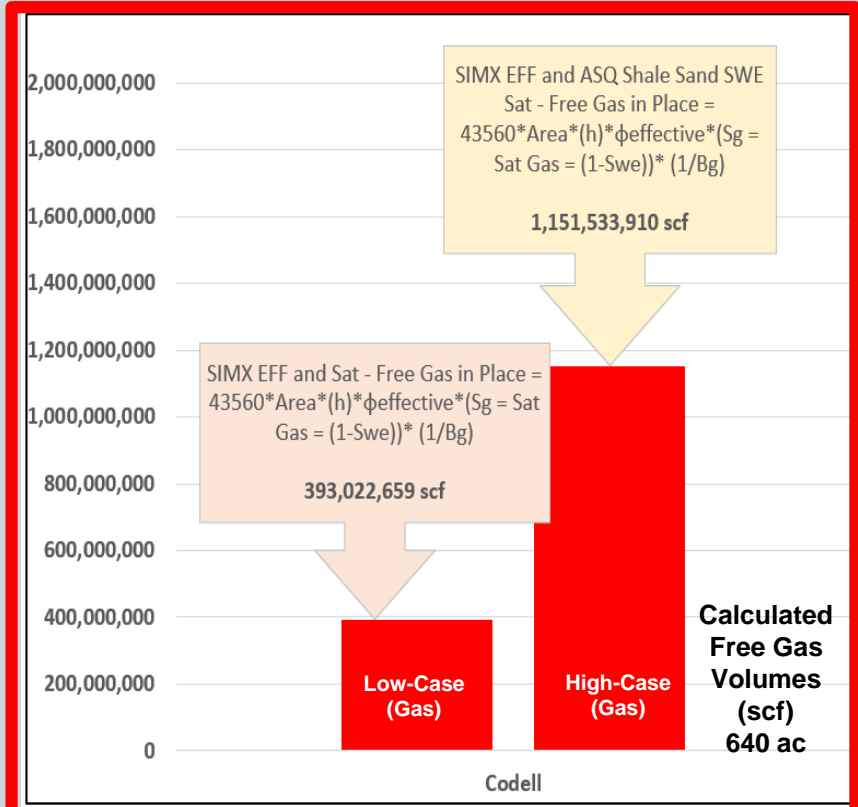
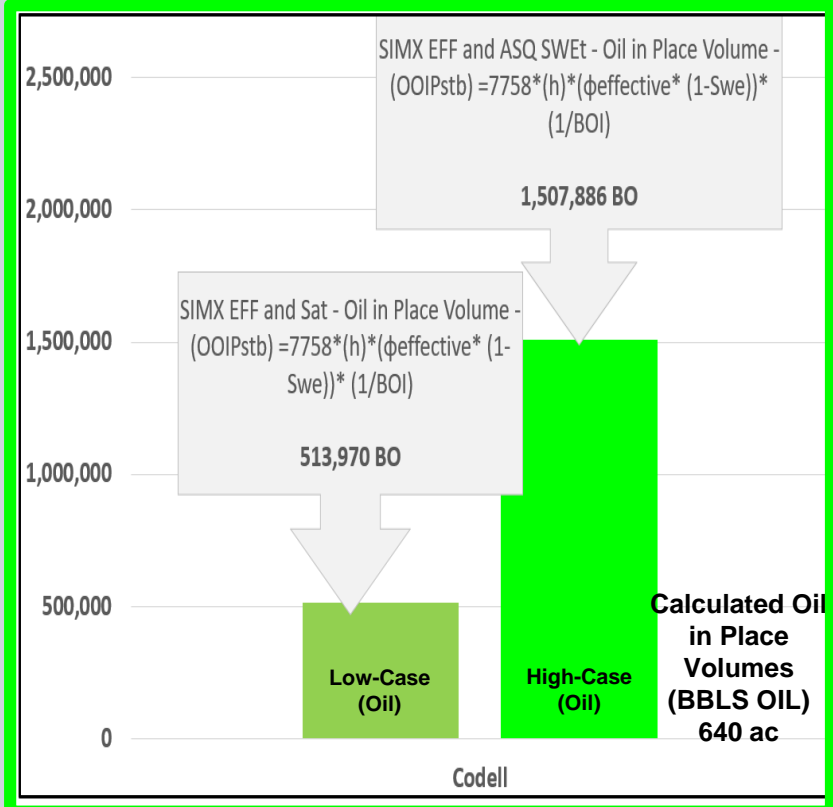
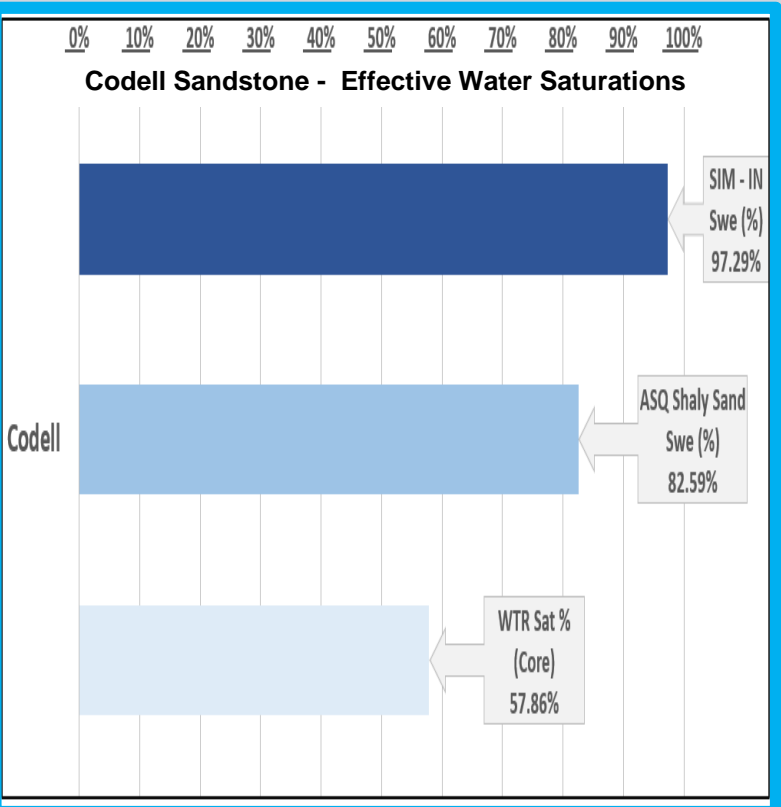
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Hereford - Codell Sandstone

Average In-Place Reserves



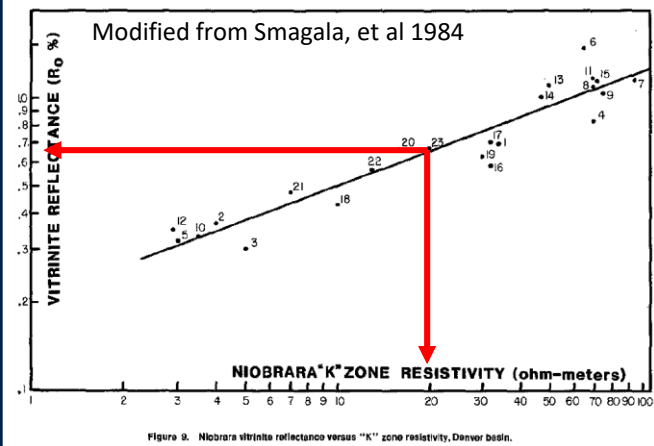
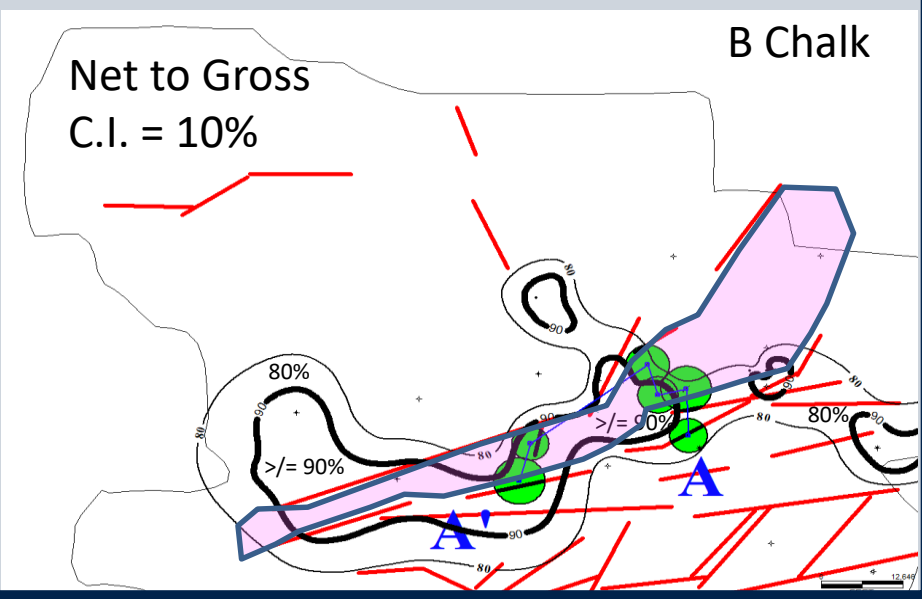
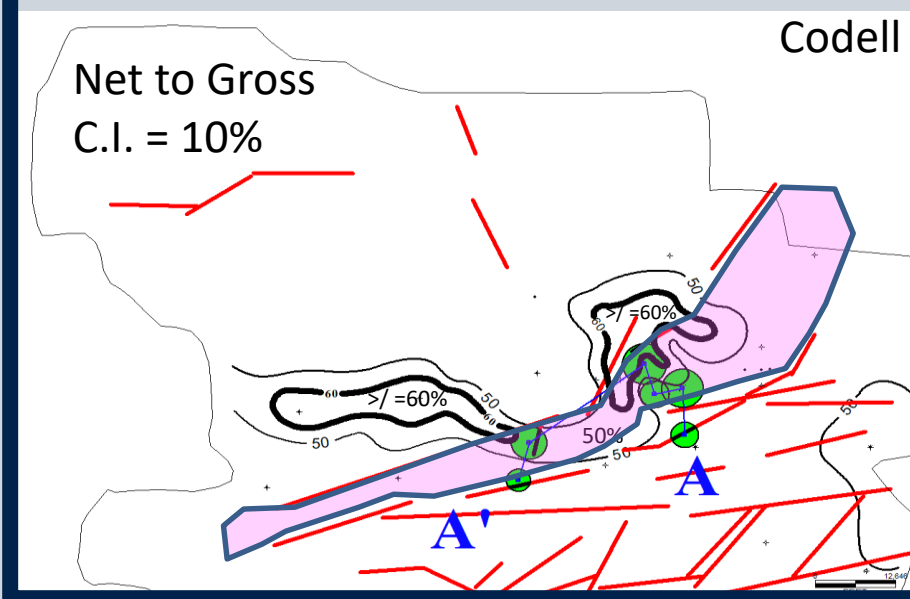
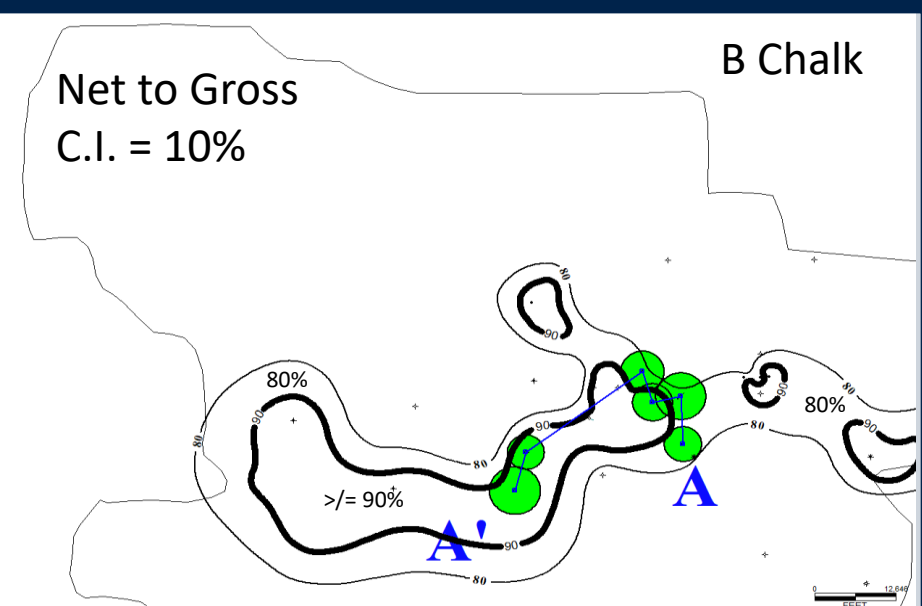
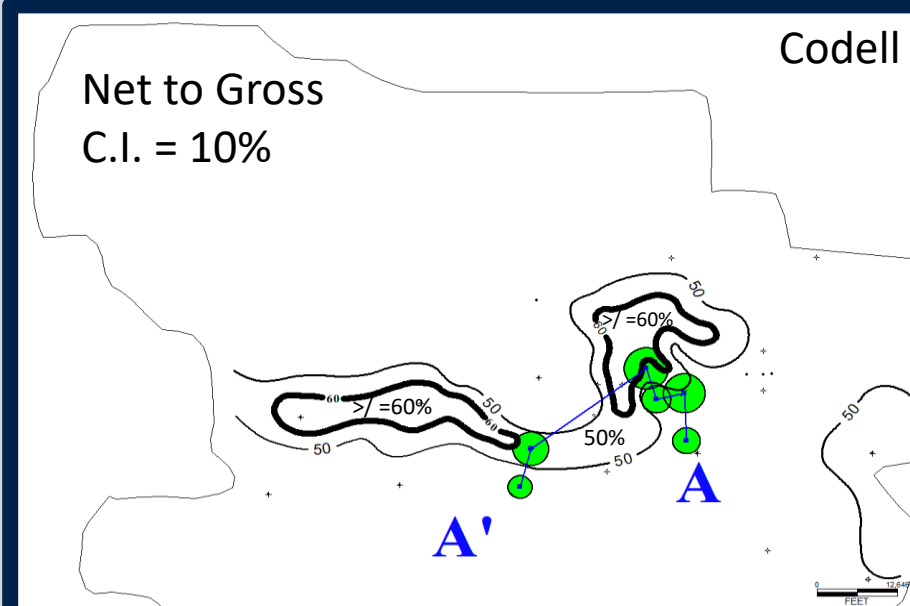
Codell - Average In-Place Reservoir Volumes (Est 640ac) :

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

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

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)

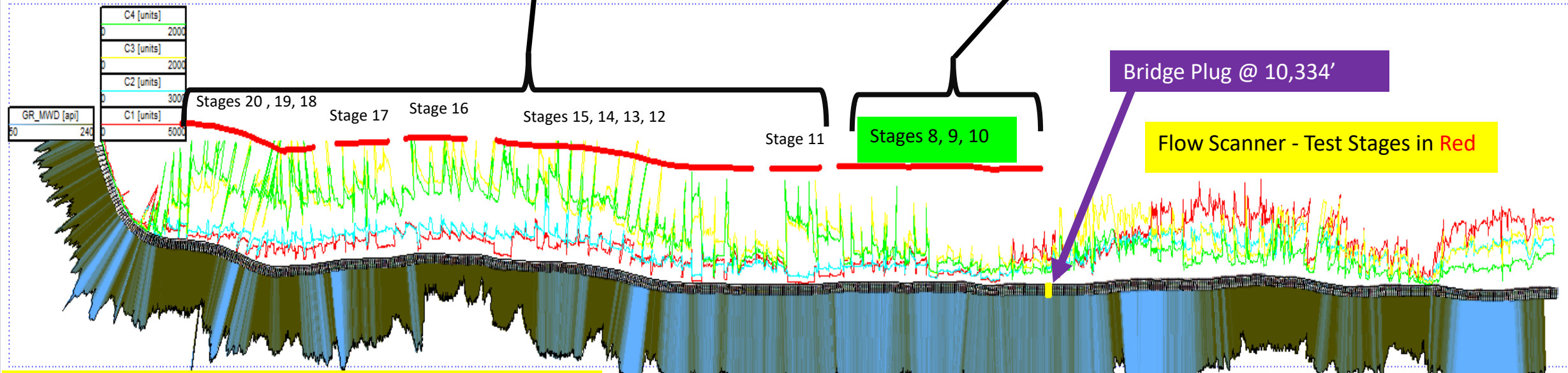
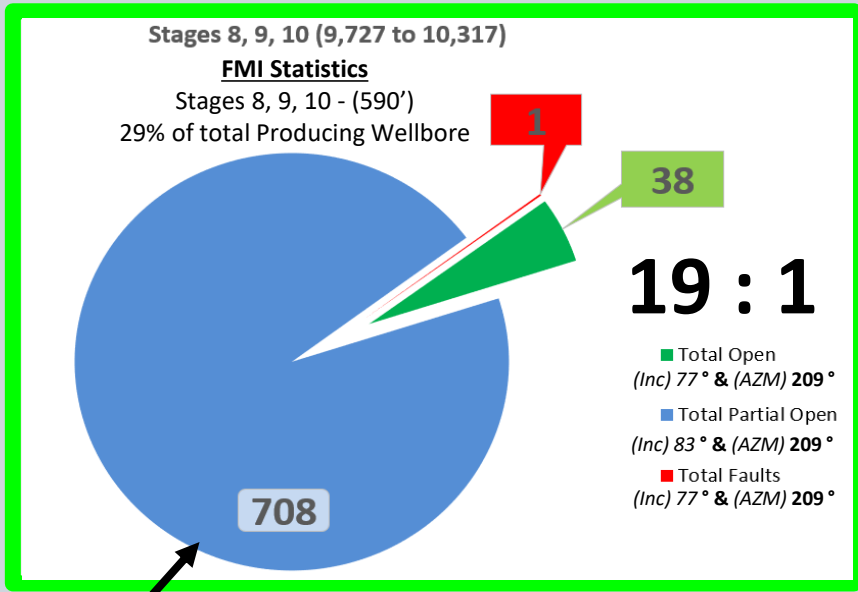
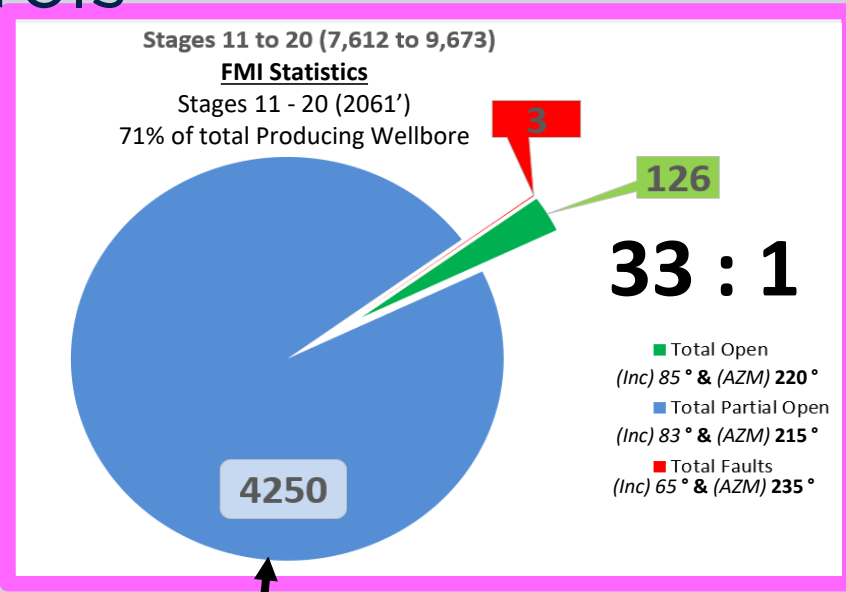
Red lines = Potential Faults (Visually Interpreted from Basement Seismic Amplitudes)

Hereford - Legacy Niobrara B Chalk Reservoir Controls



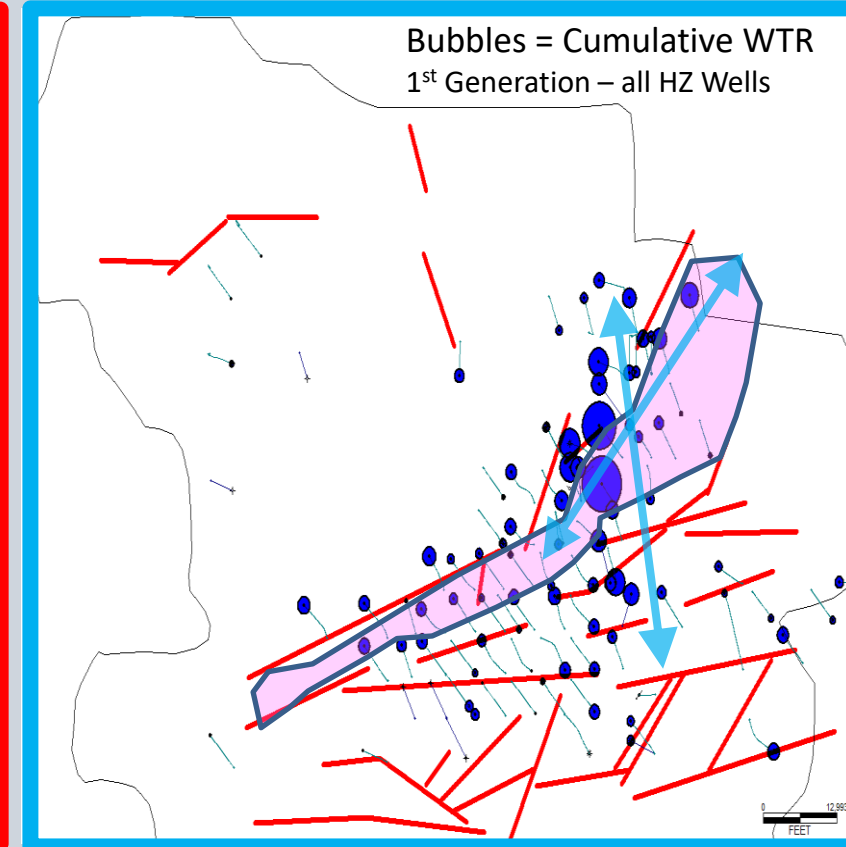
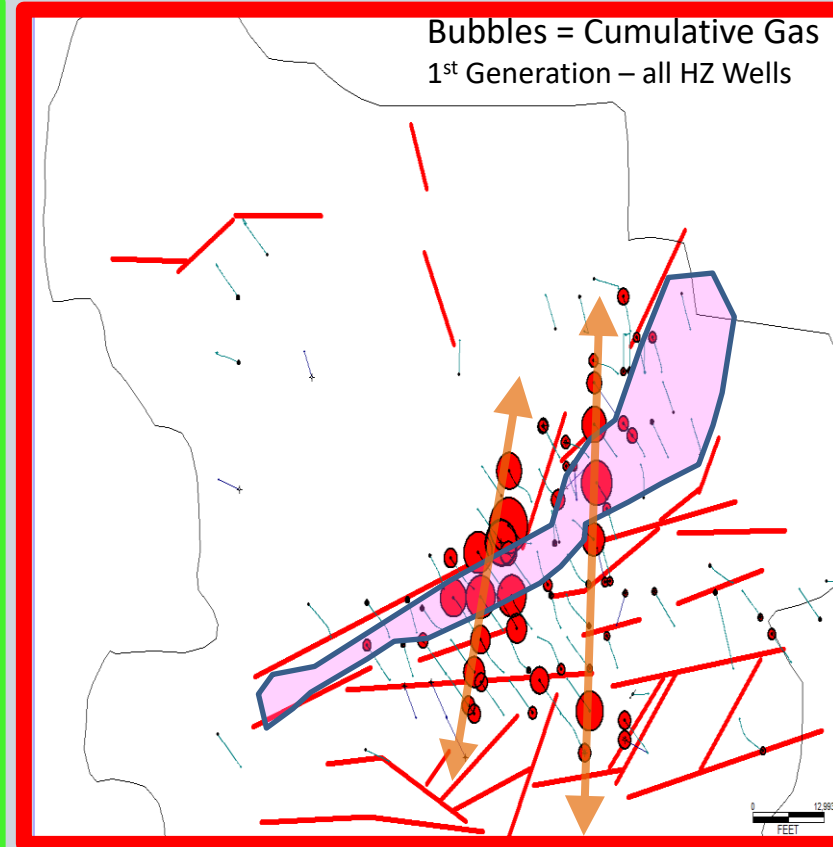
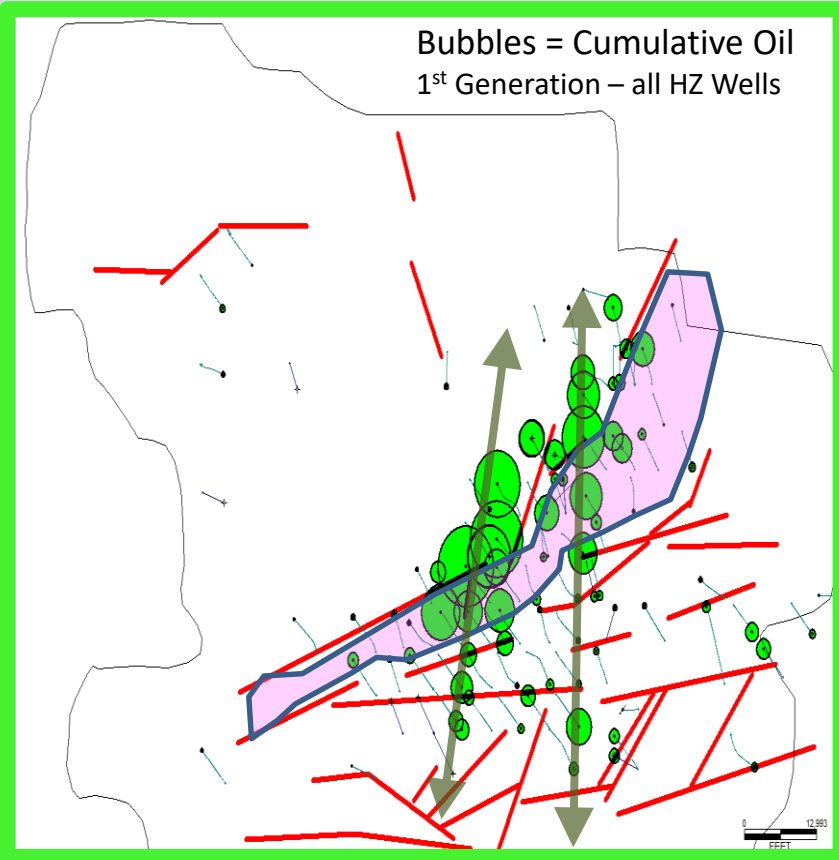
EOG 1st Generation Niobrara Completion
 Comp Date: 7/3/2010
 IPF: 622 BO + 407 MCF & 110 BW
 Oil Gravity: 35.3
 Cum: 334 MMBO + 525 MMCF

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



7482 FMI Fractures Interpreted – Total Wellbore

Hereford- Production Summary



- Structurally-controlled
 - definable fracture fairways – Largely hosted in most brittle (clean) chalk

- Fluid and **pressure** depletion of fractures will play a likely role in future wells recovery factor

- Future HZ Well steering is key
 - Not all Fractures contain equal value

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