

The Search for New Exploration Plays: When Only the Best Will Do*

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Search and Discovery Article #10810 (2015)**

Posted December 14, 2015

*Adapted from oral presentation at Tulsa Geological Society, November 10, 2015.

Editor's note: Presentation was made also to Dallas Chapter, SIPES and Oklahoma City Geological Society and is also available on the website of Roxanna Oil Company (http://roxannaoil.com/wp-content/uploads/2015/11/The-Search-for-New-Exploration-Plays_When-Only-the-Best-Will-Do.pdf).

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Abstract

Over the past decade, there has been a rapid evolution of plays that have benefited from efficiencies in horizontal drilling, beginning with shale gas, later to shale oil and tight oil plays, and today, even conventional reservoirs. As explorationists, we have used our understanding of these technology advancements by developing new plays that were either overlooked or underdeveloped, but can be economic with improved recoveries.

With oil prices hovering at \$40, our understanding of both the geology and the economic drivers to commercial projects are critical in finding the very best areas to invest. Early entry into the “sweet spots” of these plays is an important economic driver; thus, the ability to quickly screen and execute leasing in the best areas of the plays is a key element of our strategy. We examine some of our company's criteria and analytical approaches for exploring new plays, with examples from our New Albany and Woodford shale plays, our Paradox Basin and Las Animas Arch tight carbonate play, and a horizontal development of a conventional carbonate oil field.

Selected References

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Downey, M.W., J. Garvin, R.C. Lagomarsino, and D.F. Nicklin, 2011, Quick look determination of oil-in-place in oil shale resource plays: Search and Discovery Article #40764 (2011). Website accessed November 21, 2015, (http://www.searchanddiscovery.com/documents/2011/40764downey/ndx_downey.pdf).

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The Search for New Exploration Plays

When Only the Best Will Do



Julie Garvin
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*Presented at the Tulsa Geological Society Luncheon
November 10, 2015*

Roxanna

Track Record

***Generating, Participating, and
Operating in early-entry resource plays
for over a decade***

Meade Peak Shale

2006



Chainman Shale

2006



Las Animas Arch

2013



New Albany Shale

2010



Marcellus Shale

2008



Paradox Basin

2013



Woodford Shale / Miss Lime

2009



Forest City Basin

2014



Black Warrior Basin

2004 - 2005



Caney Shale



Barnett Shale

2005



Conventional Wells



Lower Saxony Basin

2013



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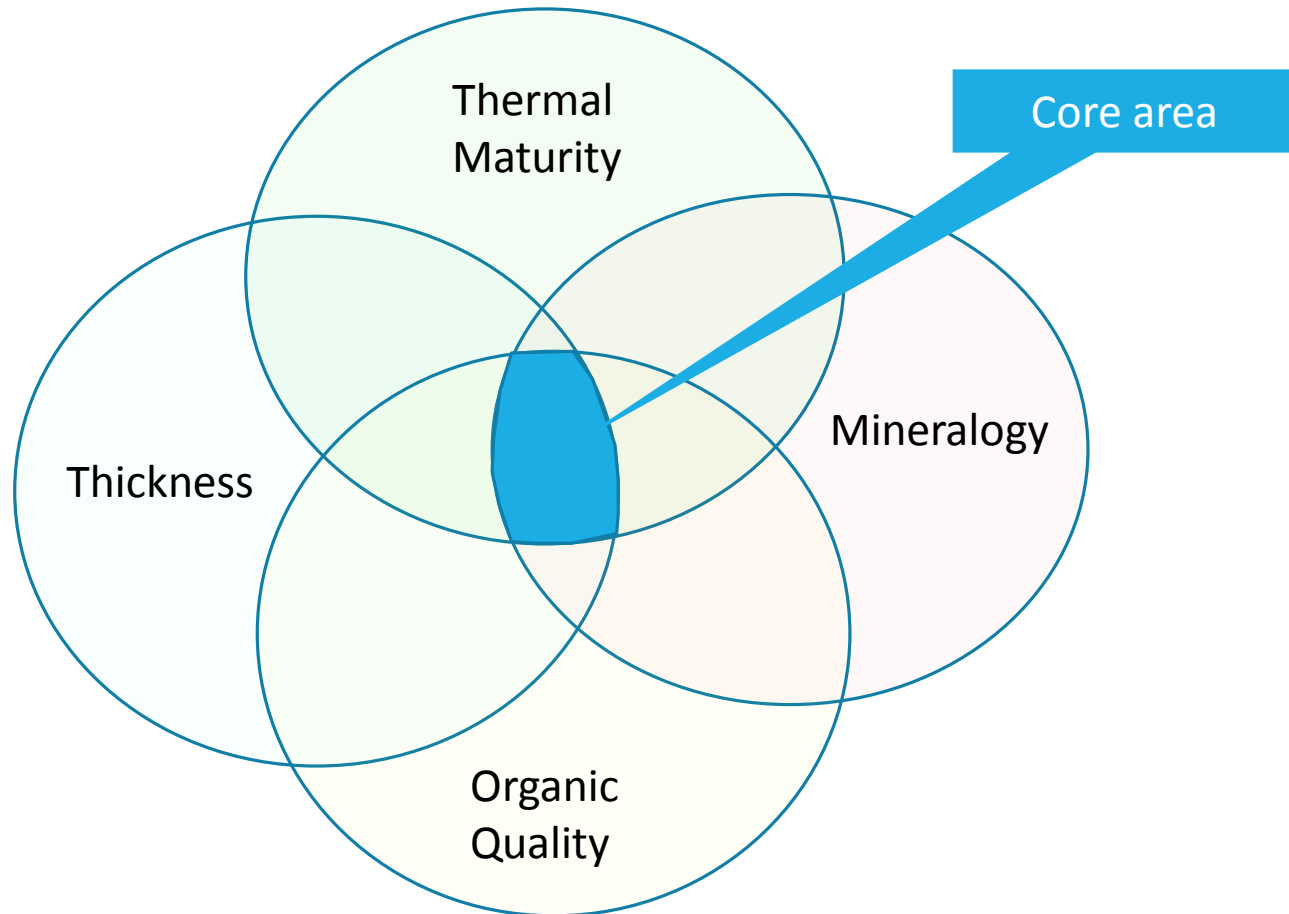
What do we do at Roxanna to find the best new exploration plays?

- Focus on Fundamentals of Petroleum System
 - Where is the oil??
 - Screening Criteria
- Technological Advances
 - What can we do today, that couldn't be done yesterday?
- Creativity
 - Ask "How come?, Why not?, Who says...?"
- Economics
 - "Geology is Science, Exploration is a Business" -Marlan Downey

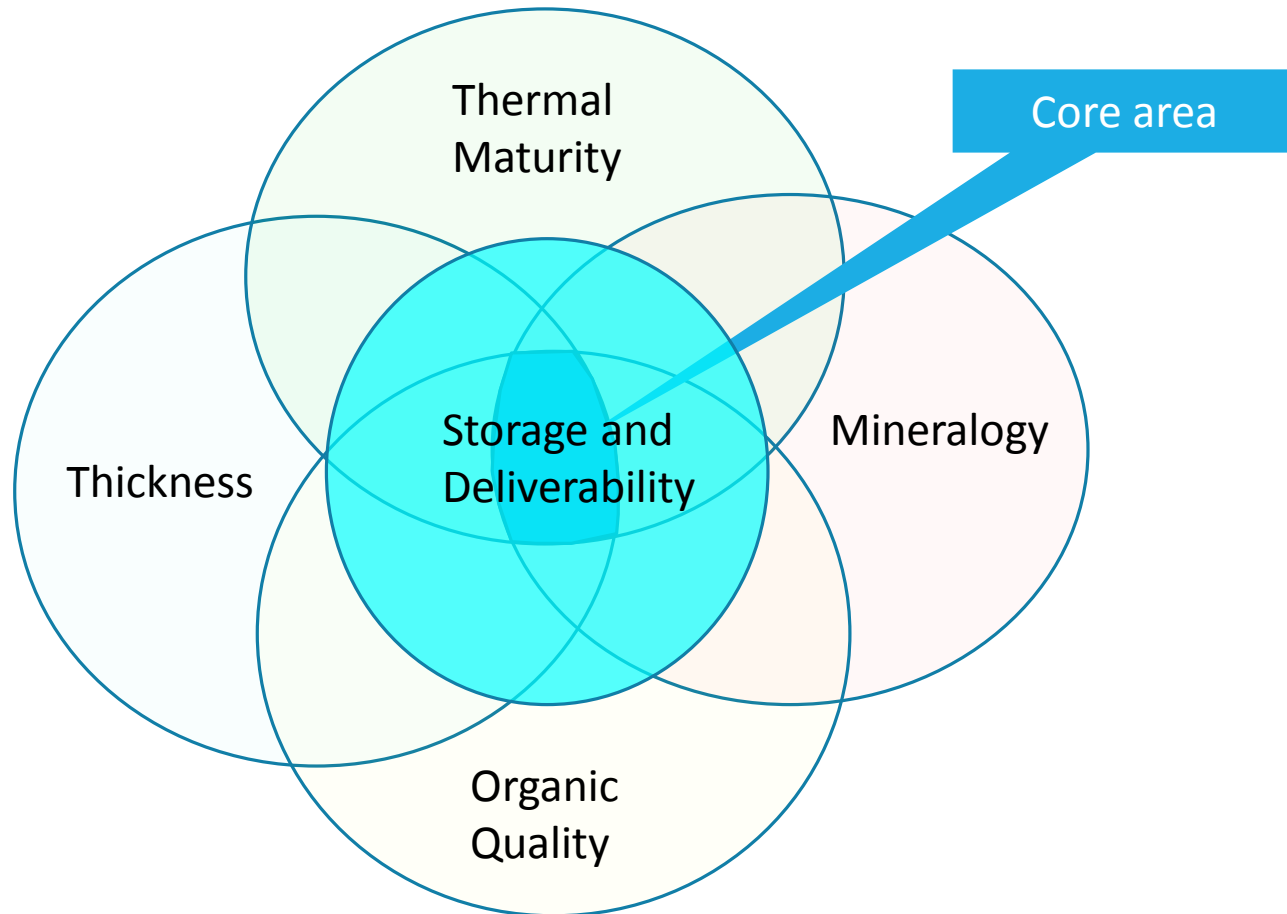
Economic Screening Criteria

- Accessing the best areas of the plays “sweet spots”
- Early entry=Low Lease Costs
- Understanding of corporate economic metrics
 - Payout time
 - IRR
 - Risked NPV
- Marketability of the play and Execution Risks
 - Alaska vs Oklahoma
 - BLM acreage, New York
 - Large acreage position vs small

Geologic Screening Criteria



Geologic Screening Criteria



Examples of our thinking and techniques from four different plays

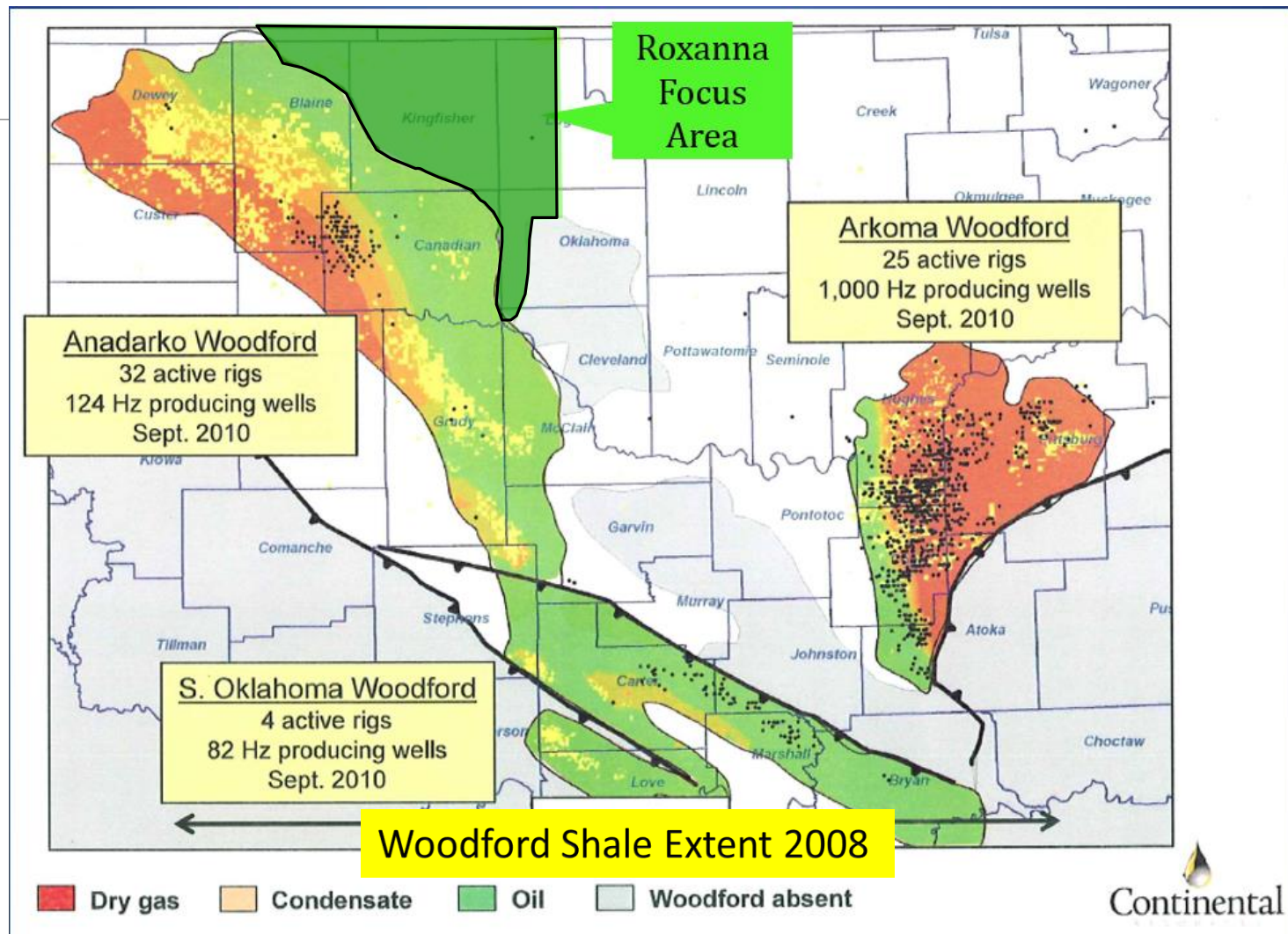
Woodford Shale Oil Play - Early mapping and observations from shows that led to identification of new play area

New Albany Shale Oil Play - Application of thermal maturity data to identify core of play

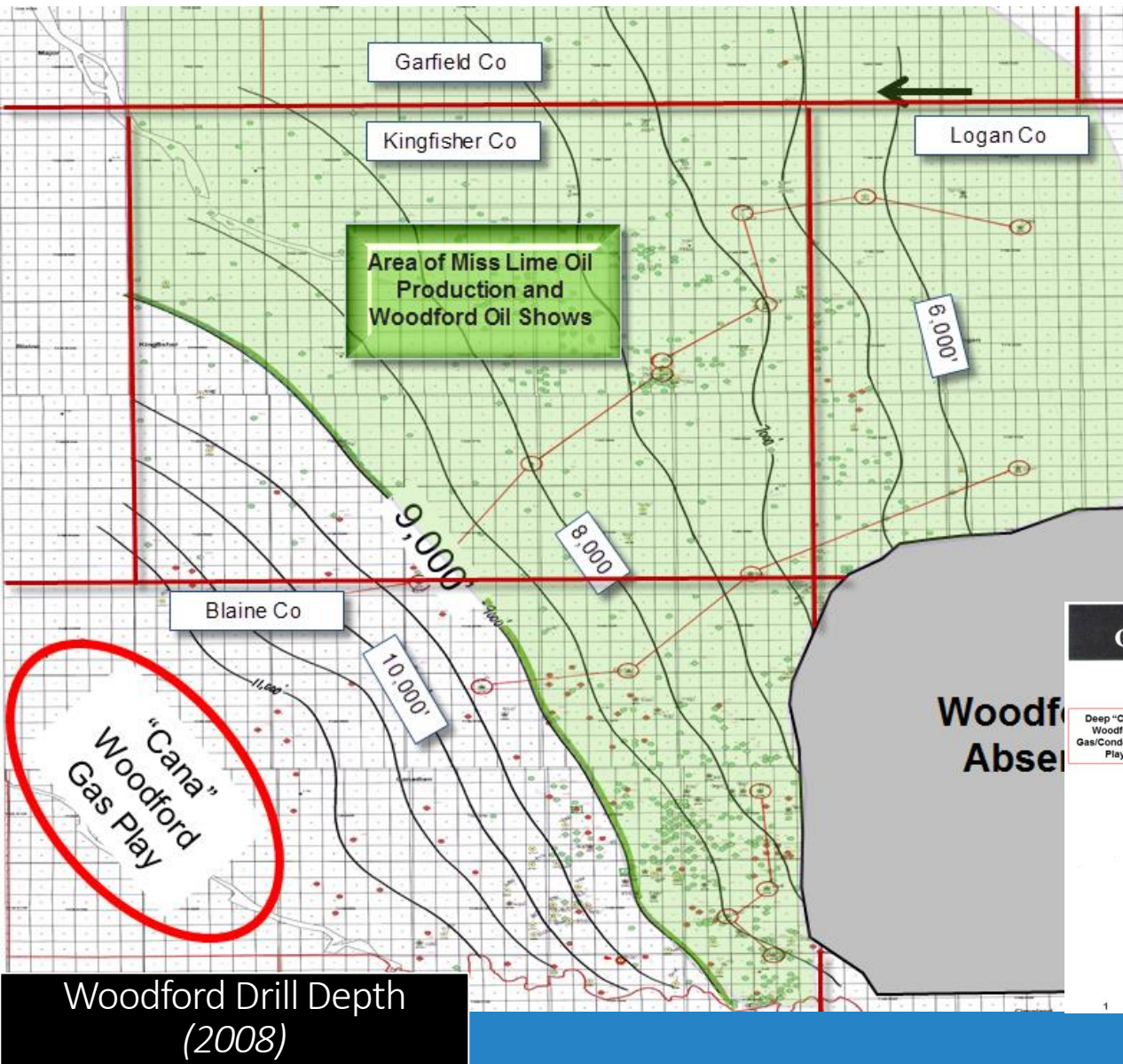
Paradox Basin - Example of a “coupled system” of source rock, reservoir and seal

Las Animas Arch - Tight carbonate play with local petroleum system. Use of capillary pressure data to understand reservoir

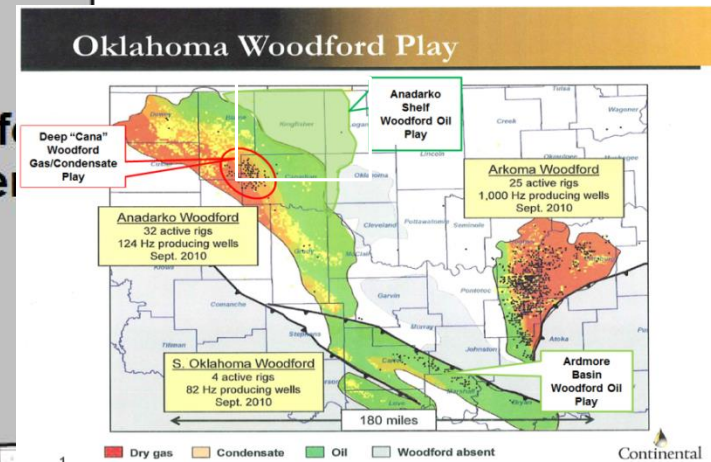
Woodford Shale/Miss Lime Stack Nemaha Area



Why is there so much oil in the Miss Lime in the Sooner Trend? Is the Woodford oil mature below??

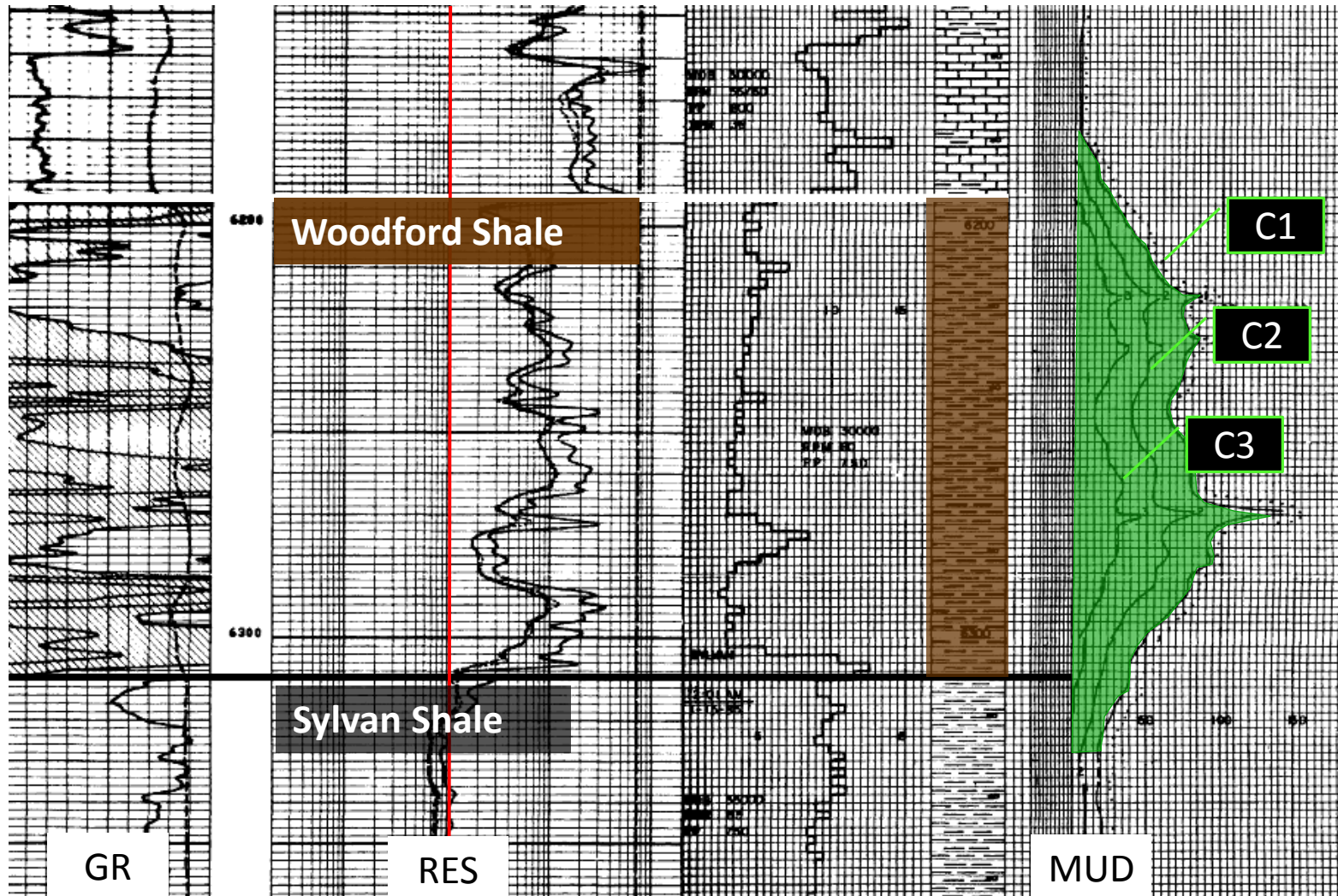


- Miss Lime Production as proxy for Woodford Maturity (vertically fractured=limited horizontal migration)
- Historical Woodford completions that flowed oil, mud log oil shows



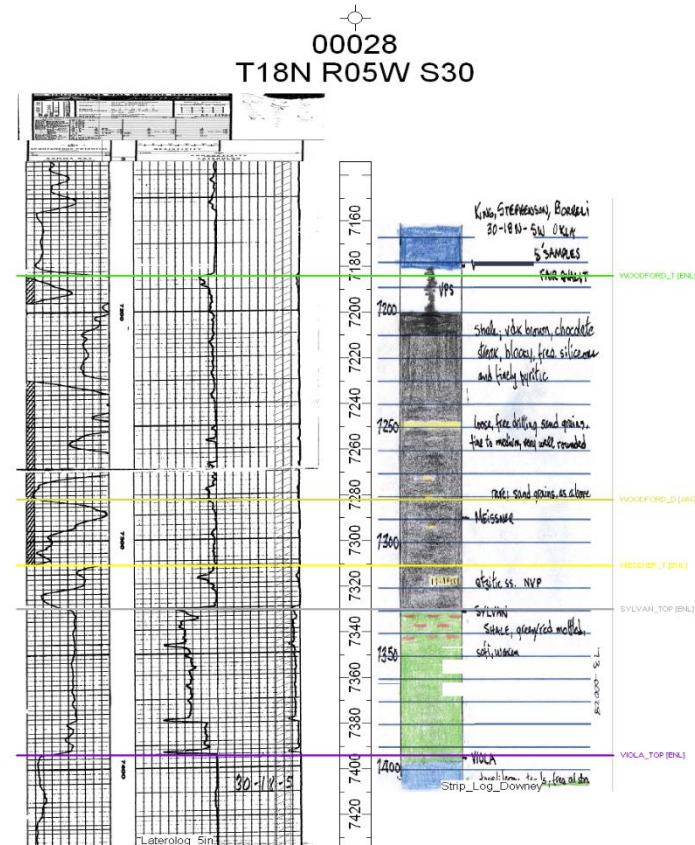
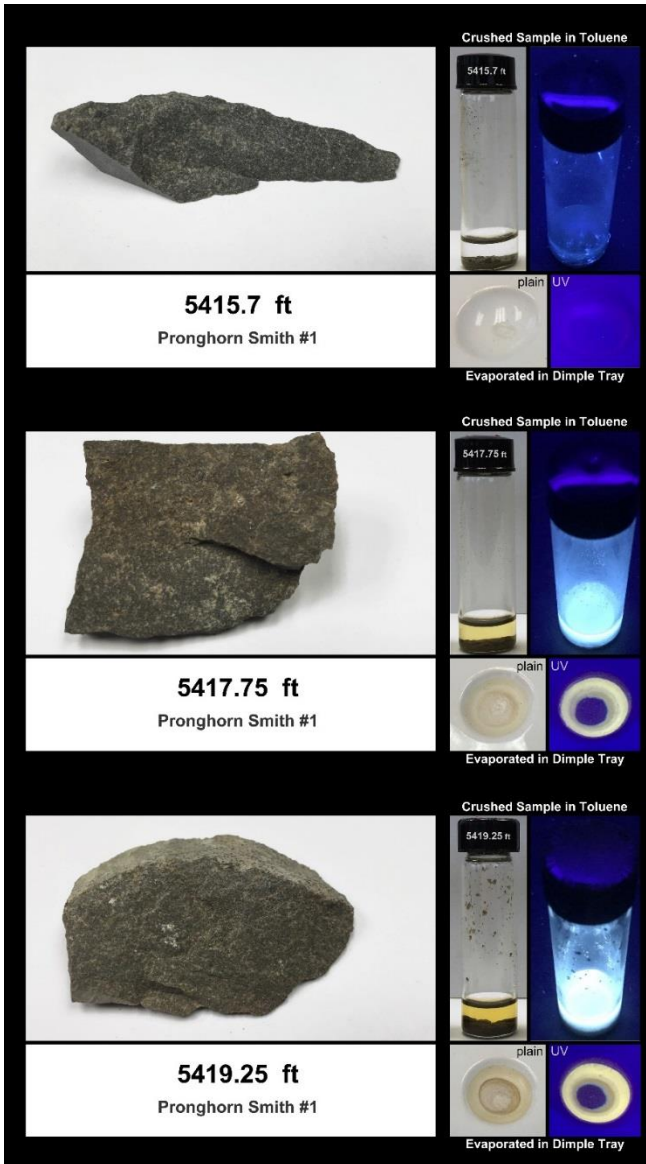
How do we confirm a mature, oil charged source rock?

Mud log oil shows indicate that the formation is capable of flowing live oil



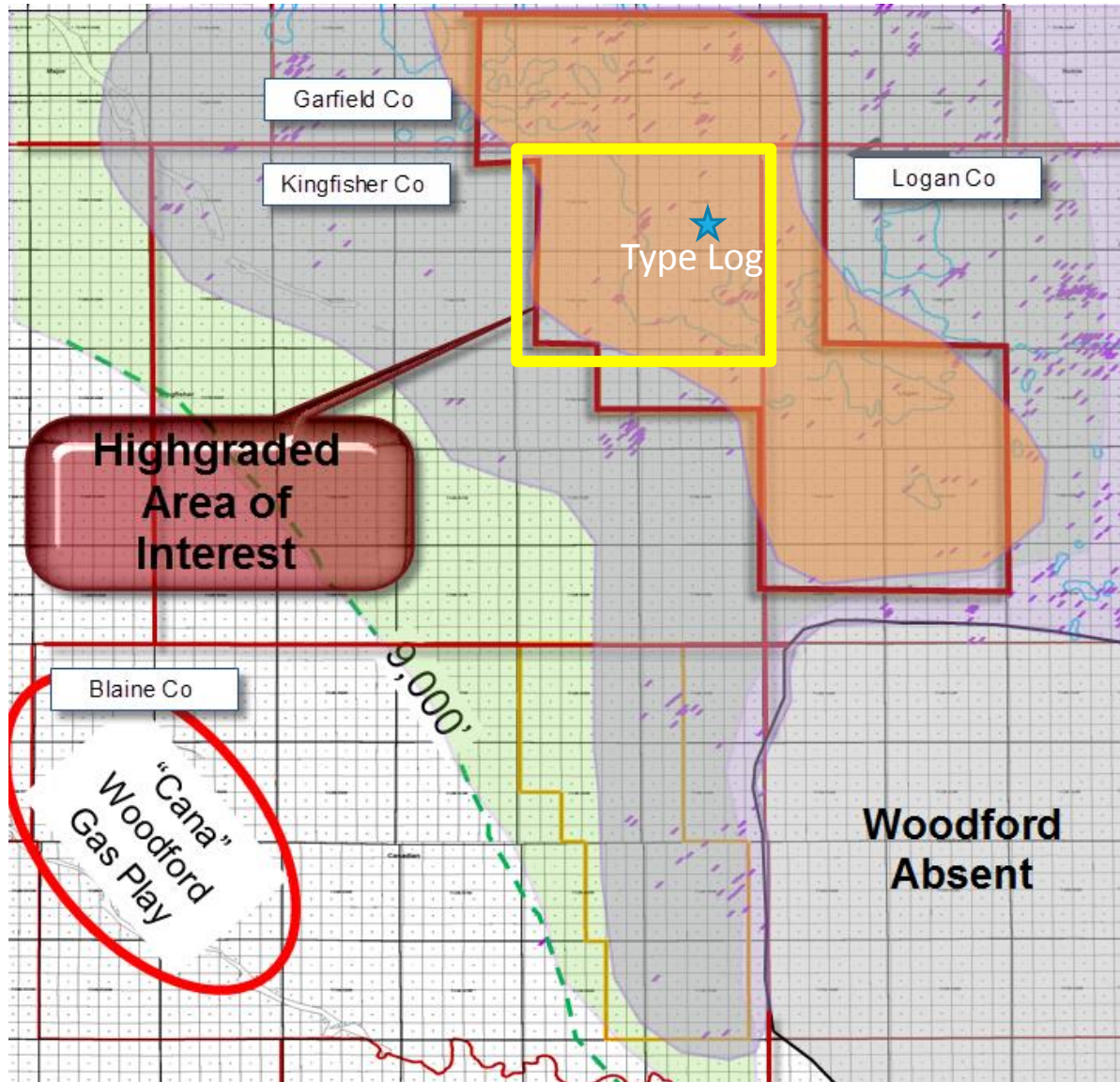
In-house sample descriptions and show analysis

- * Qualitative show analysis can confirm presence of oil



SLOAN OIL CORPORATION
L.N.U.(BORELLI 1)

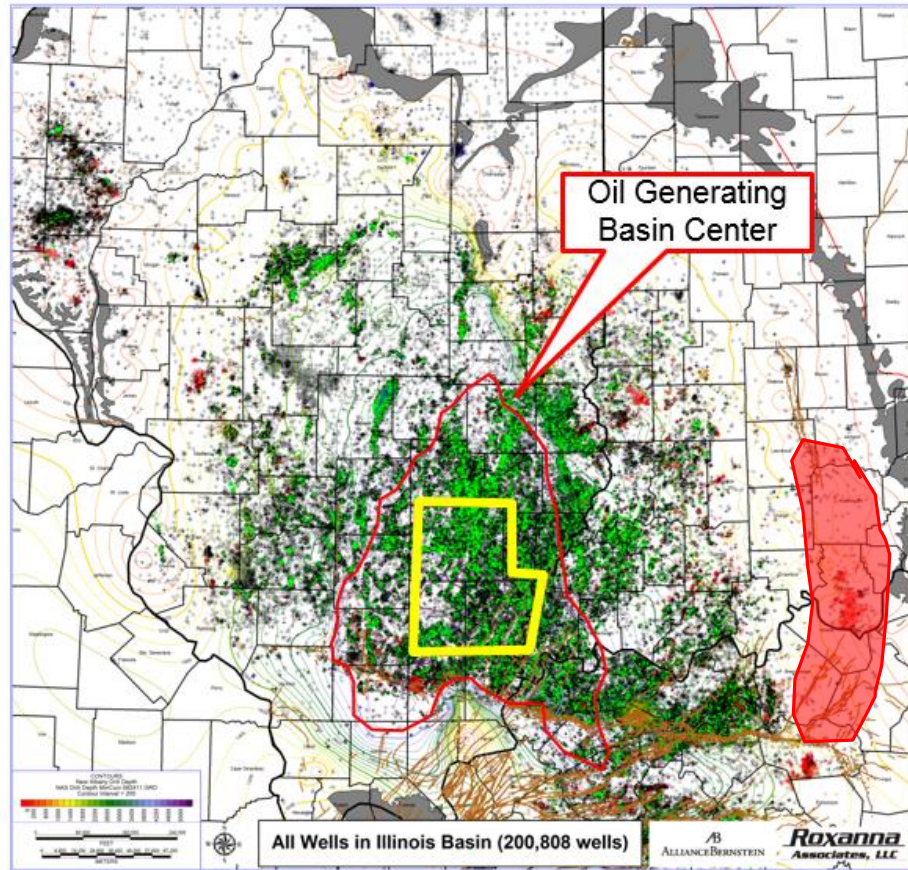
Where is the best area to begin leasing??



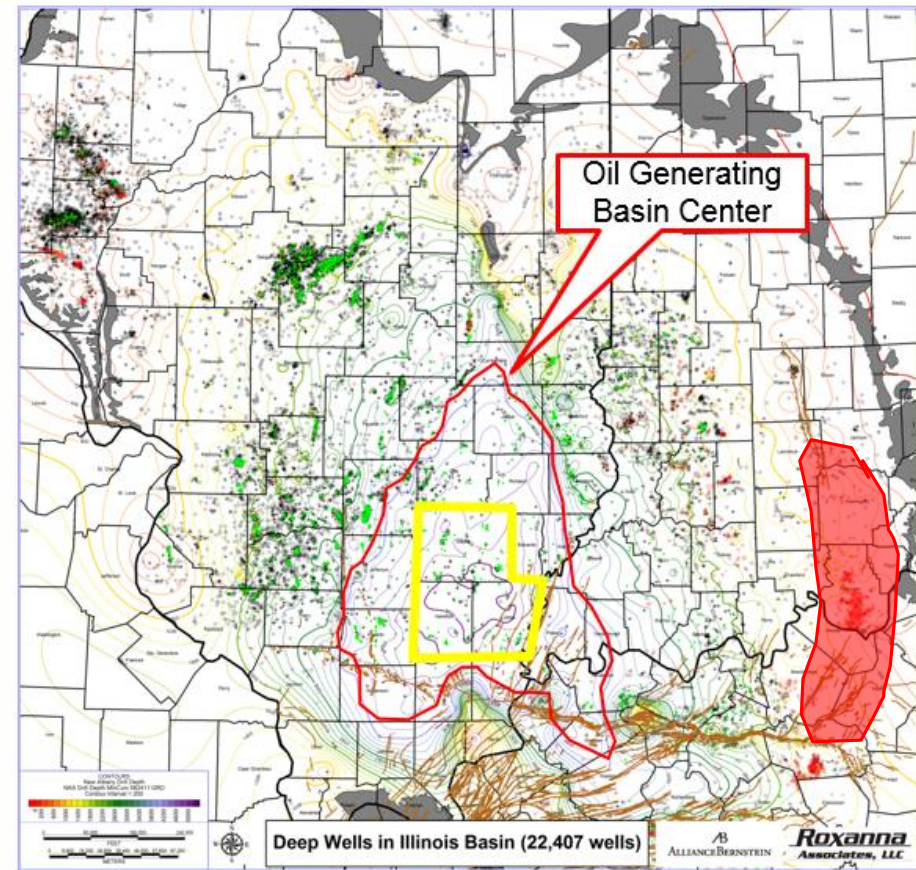
- Initial focus in 4 townships in Kingfisher County
- Overlap of implied maturity, >75’ Woodford shale, Misener sand deposition at base

New Albany Shale, Illinois Basin

Over 5 BBO produced in Illinois Basin, yet all shale maps showed the New Albany as a biogenic gas play !!??

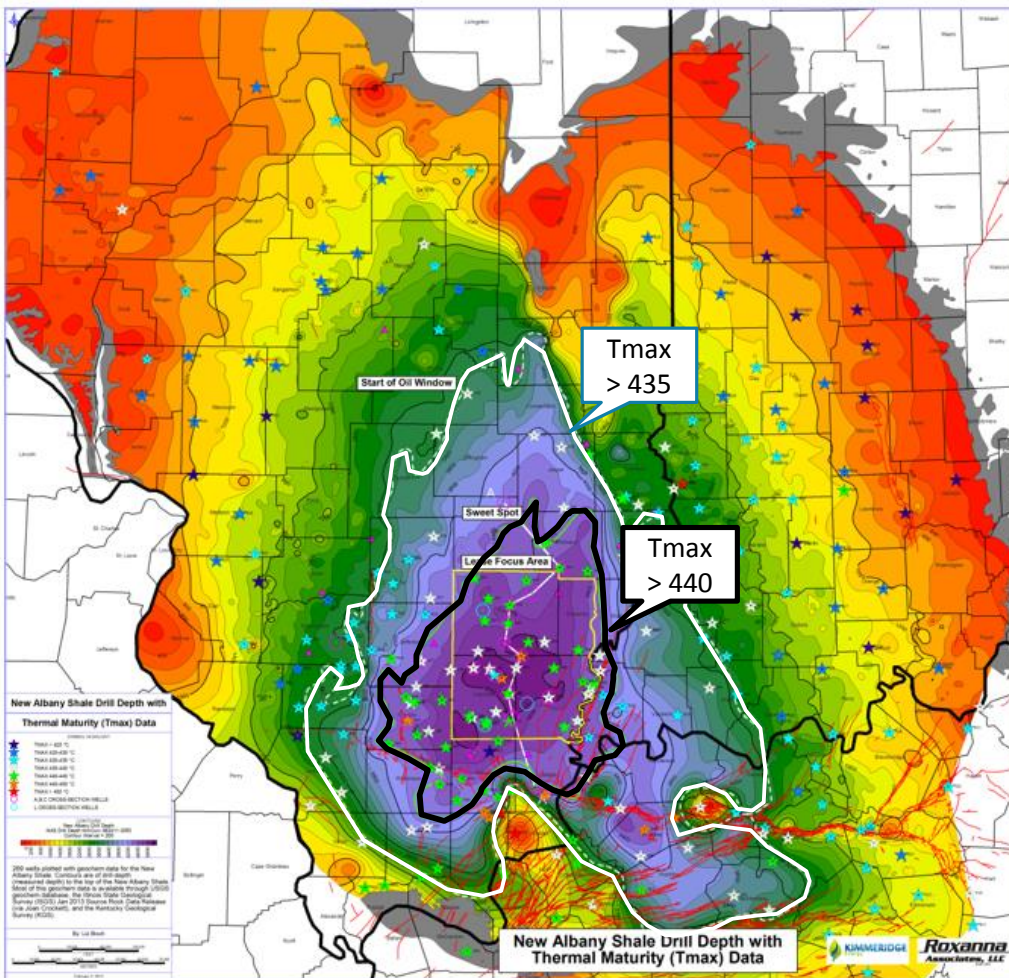


All Wells
(+_200,000)

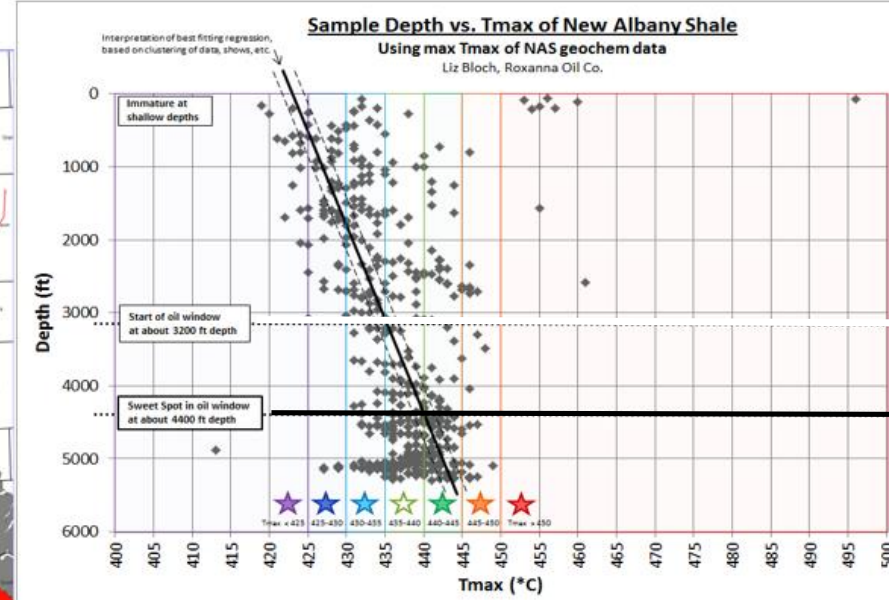


New Albany and Older Penetrations
(+_20,000)

New Albany Shale Thermal Maturity

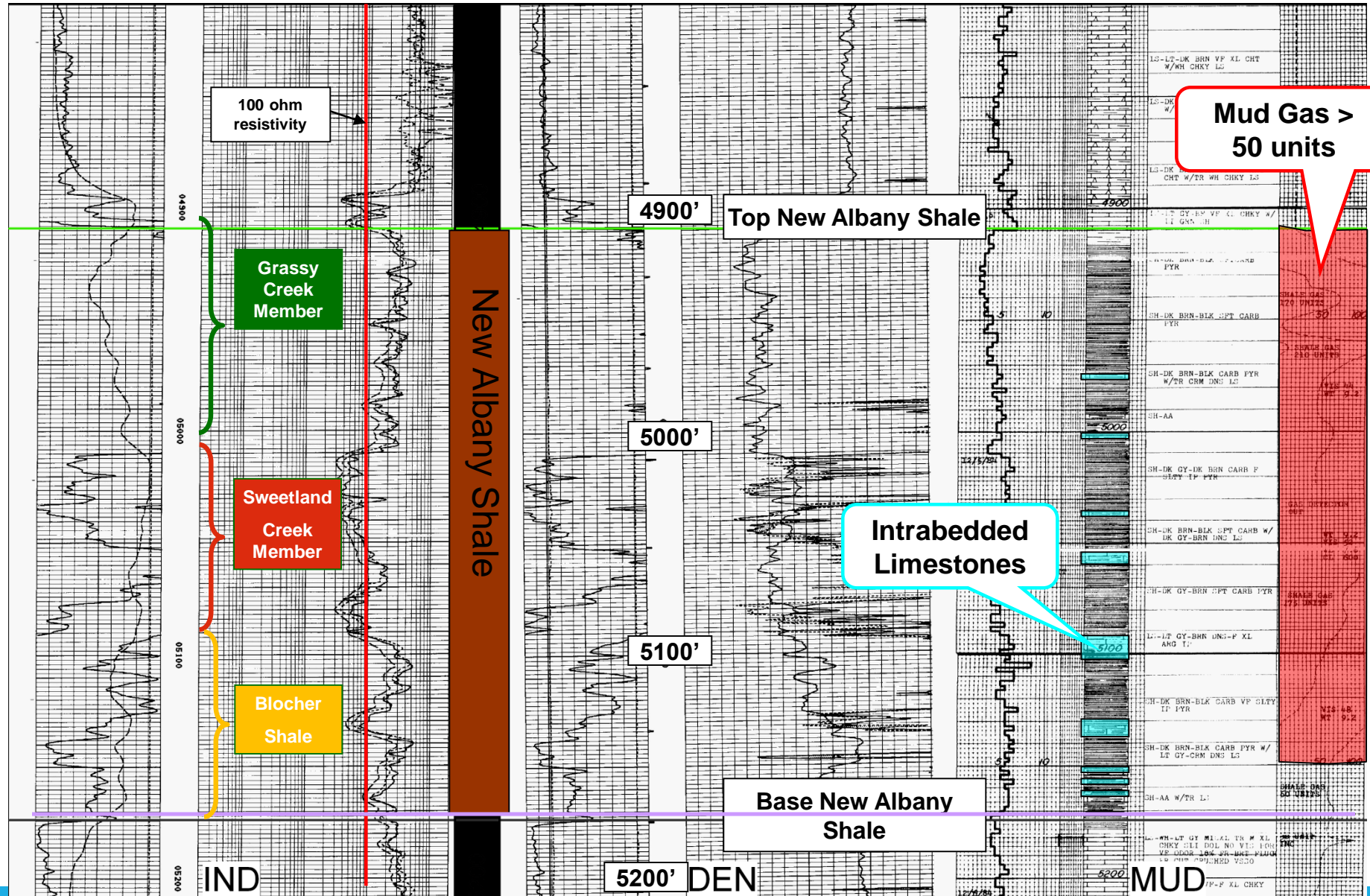


Stars color-coded by Thermal Maturity

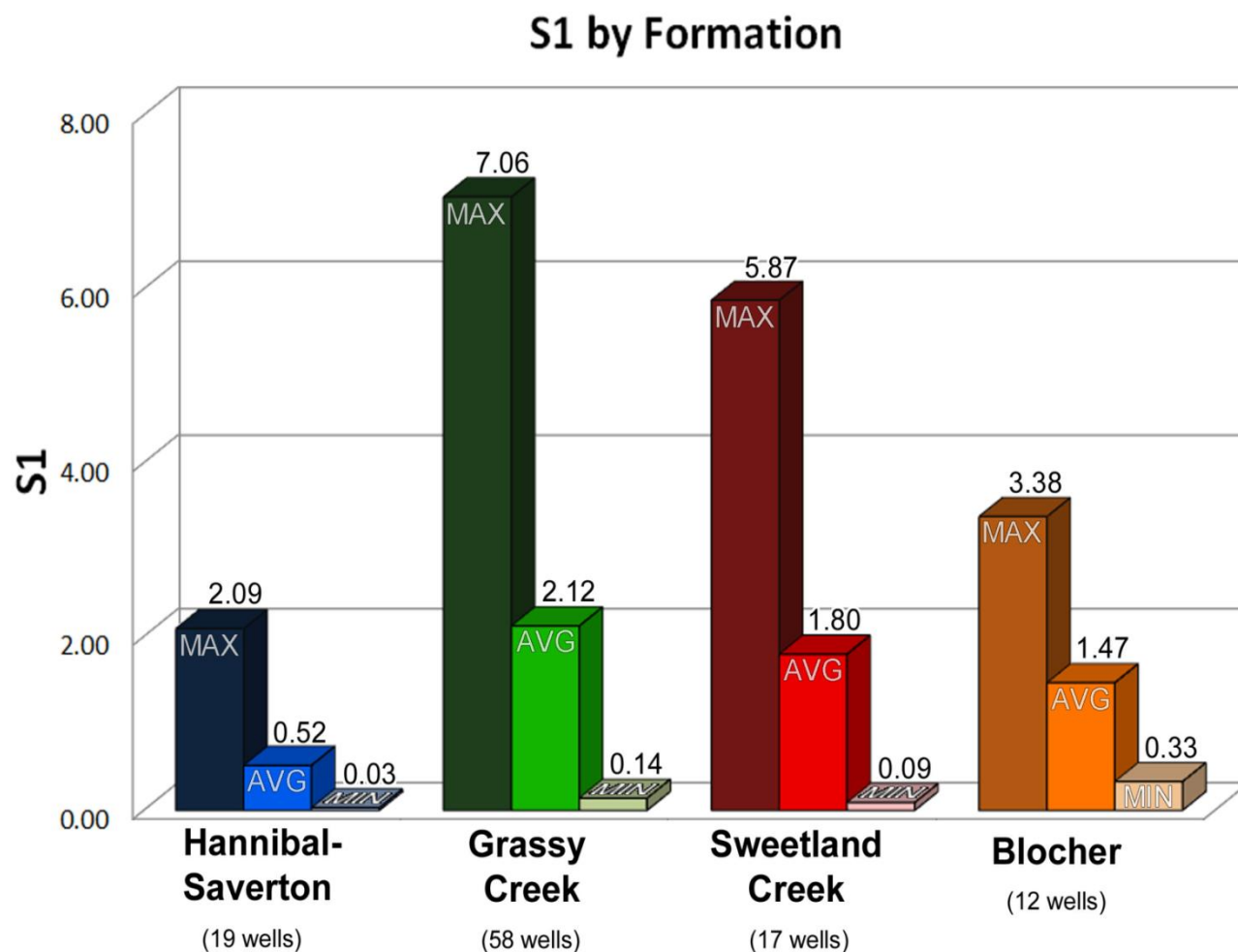


- Thermal maturity data (Tmax) indicates the depth to the top of the oil window is at about 3200'.
- Higher values are reported near major thermal anomalies associated with Cottage Grove fault system to the south.
- Leasing efforts have focused in the three counties where the shale is well within the oil window (Tmax > 440 °C).

New Albany Type Log



New Albany Shale – Oil in Place from S1

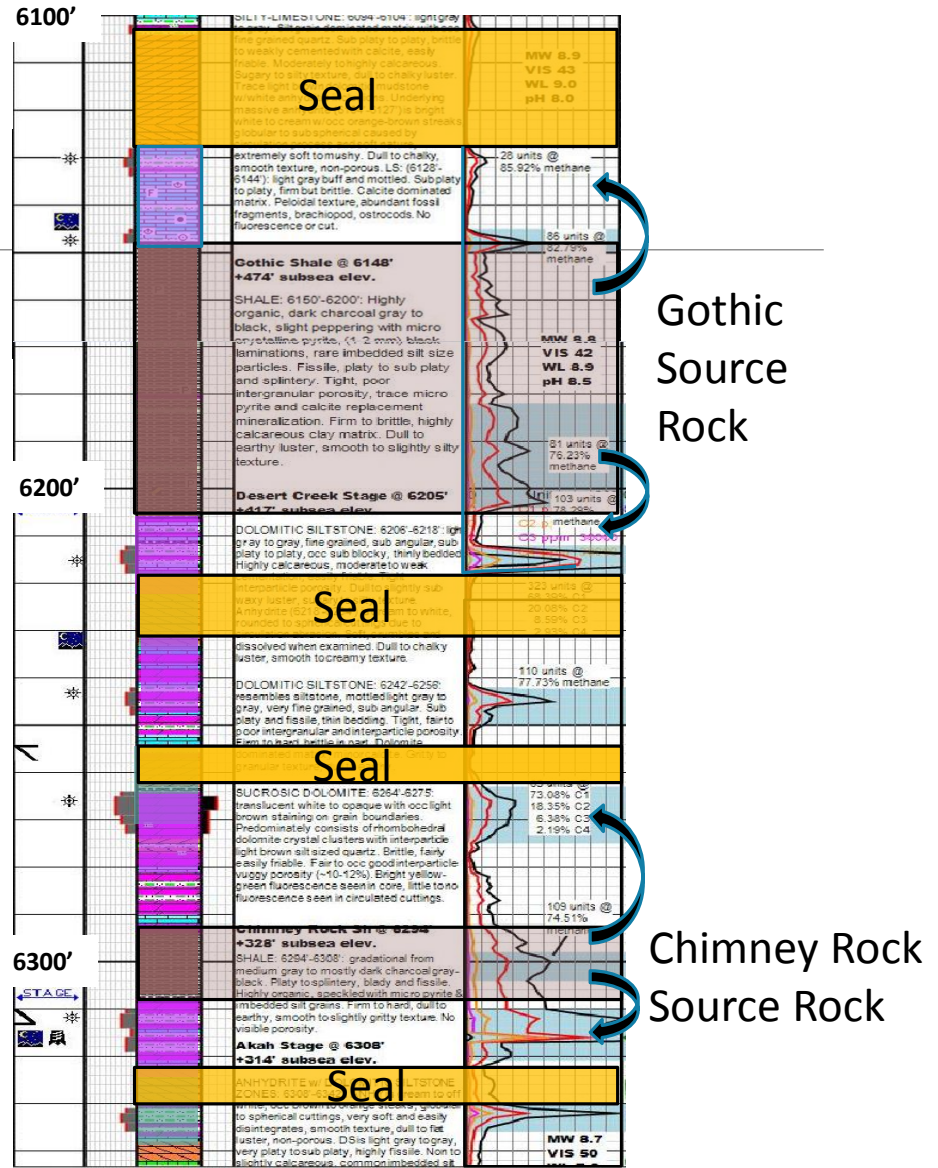
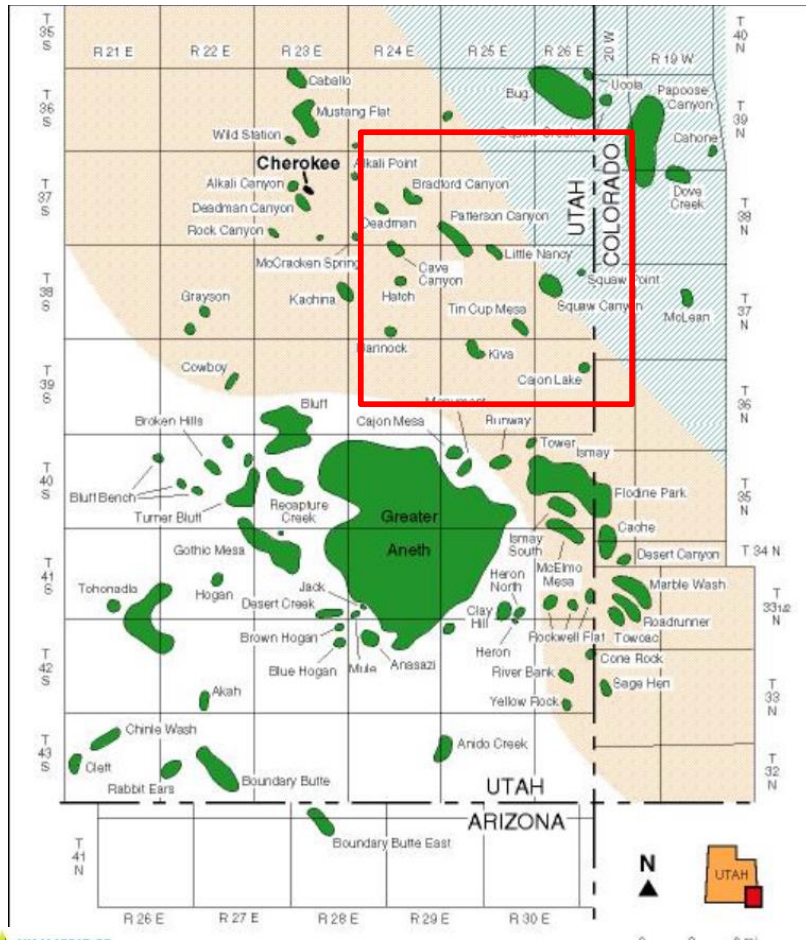


Note: Wells selected met the following criteria: 1) geochem data available, 2) located within interpreted start of oil window (where New Albany Shale top is at a measured depth of ~3000 ft and deeper), and 3) log control (for confidence and consistency in formation tops).

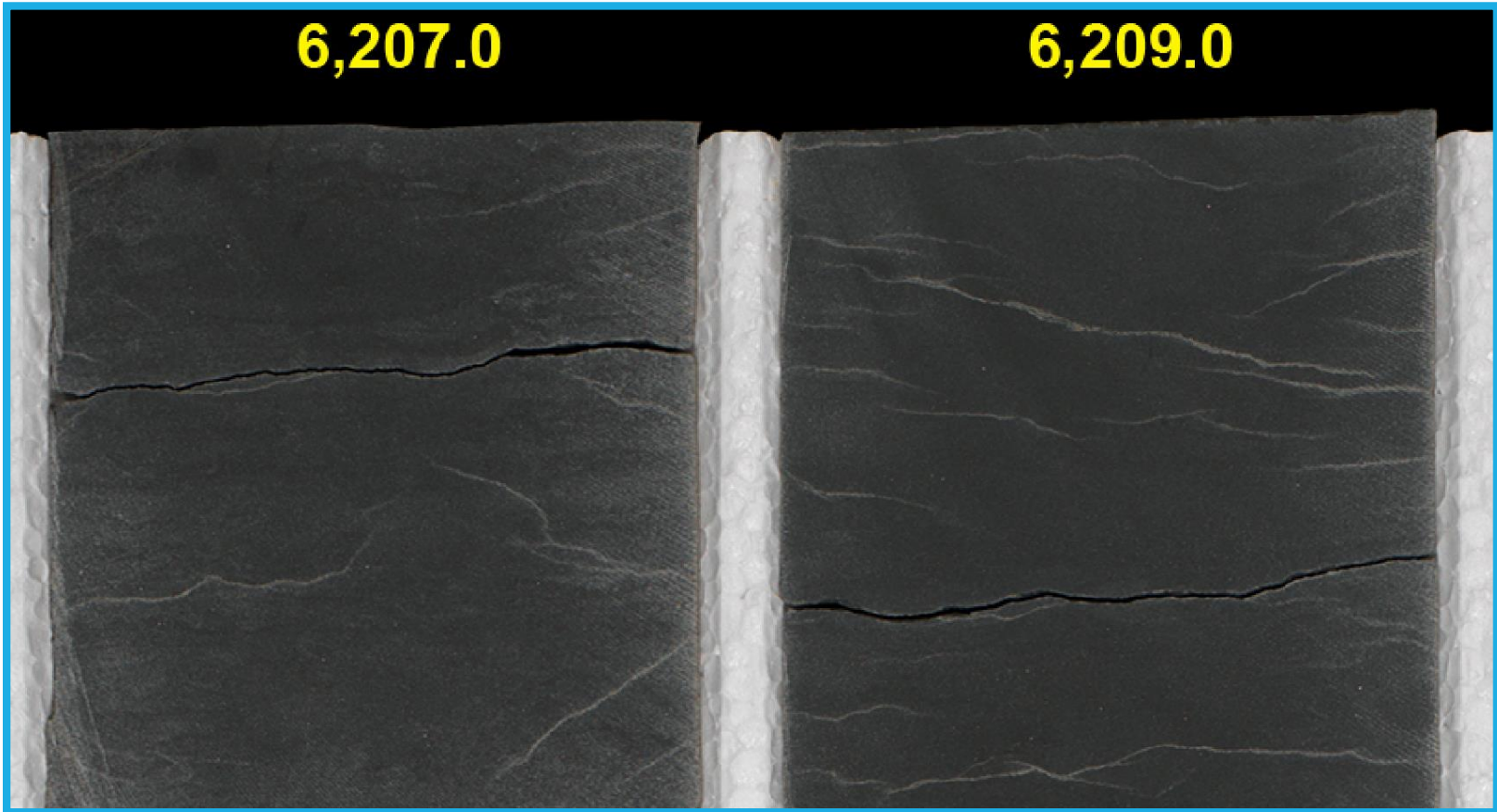
- S1 from RockEval pyrolysis is a direct measurement of live oil in the matrix.
- Measurements are greatly suppressed in cuttings due to loss of volatiles in small grain sizes.
- Useful in comparing oil concentrations laterally within a play and vertically within formations.
- Rule of thumb is S1 value of 1.0 equals approx. 1.6 MMBOIP/section/100' using **Downey/Lagomariso** method*

Paradox Basin

Pennsylvanian “coupled system”

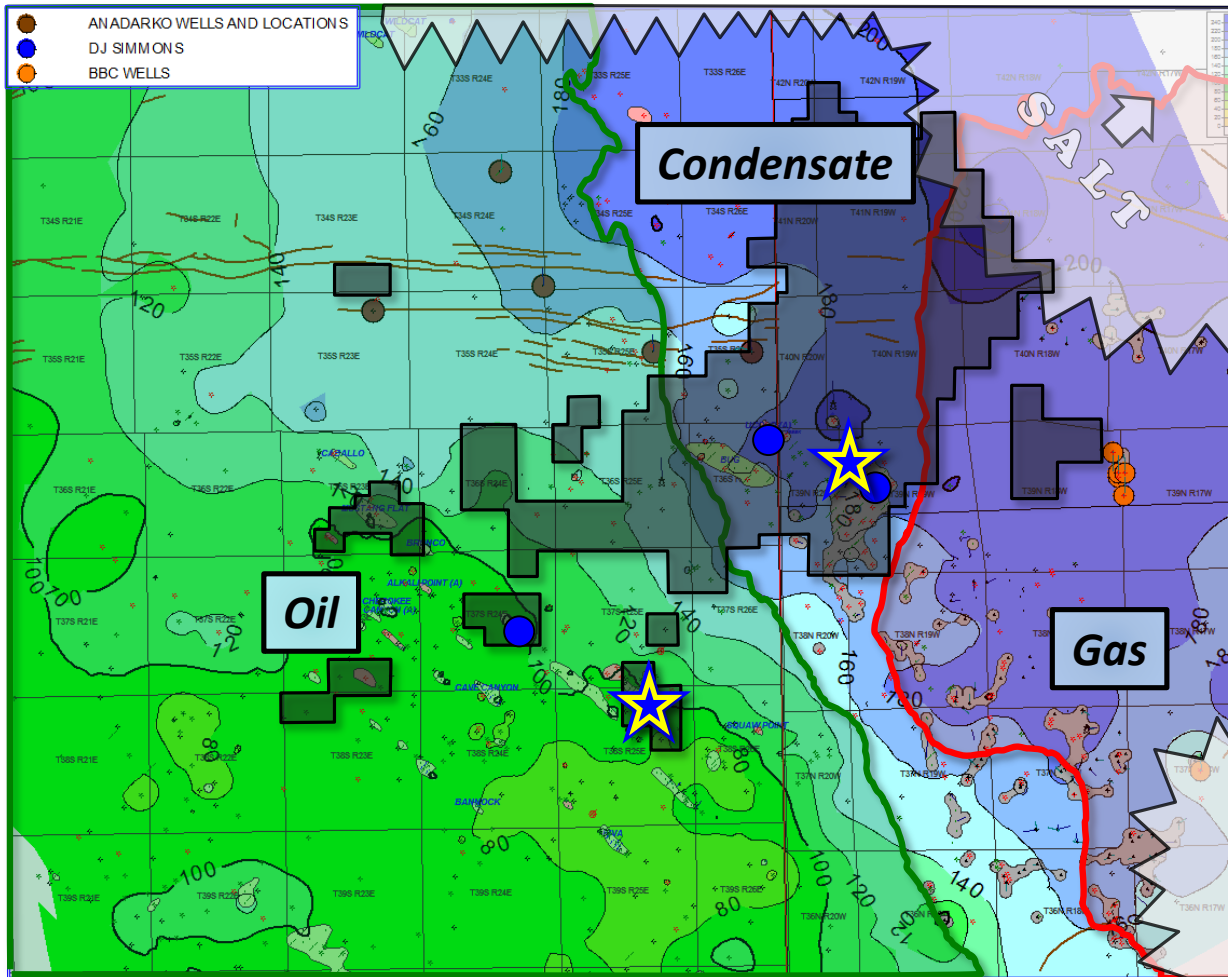


Observations of expulsion fractures give indications of above normal pressures due to thermal generation of hydrocarbons within a sealed system



Pinto 1-7

Paradox Basin Highgraded Areas



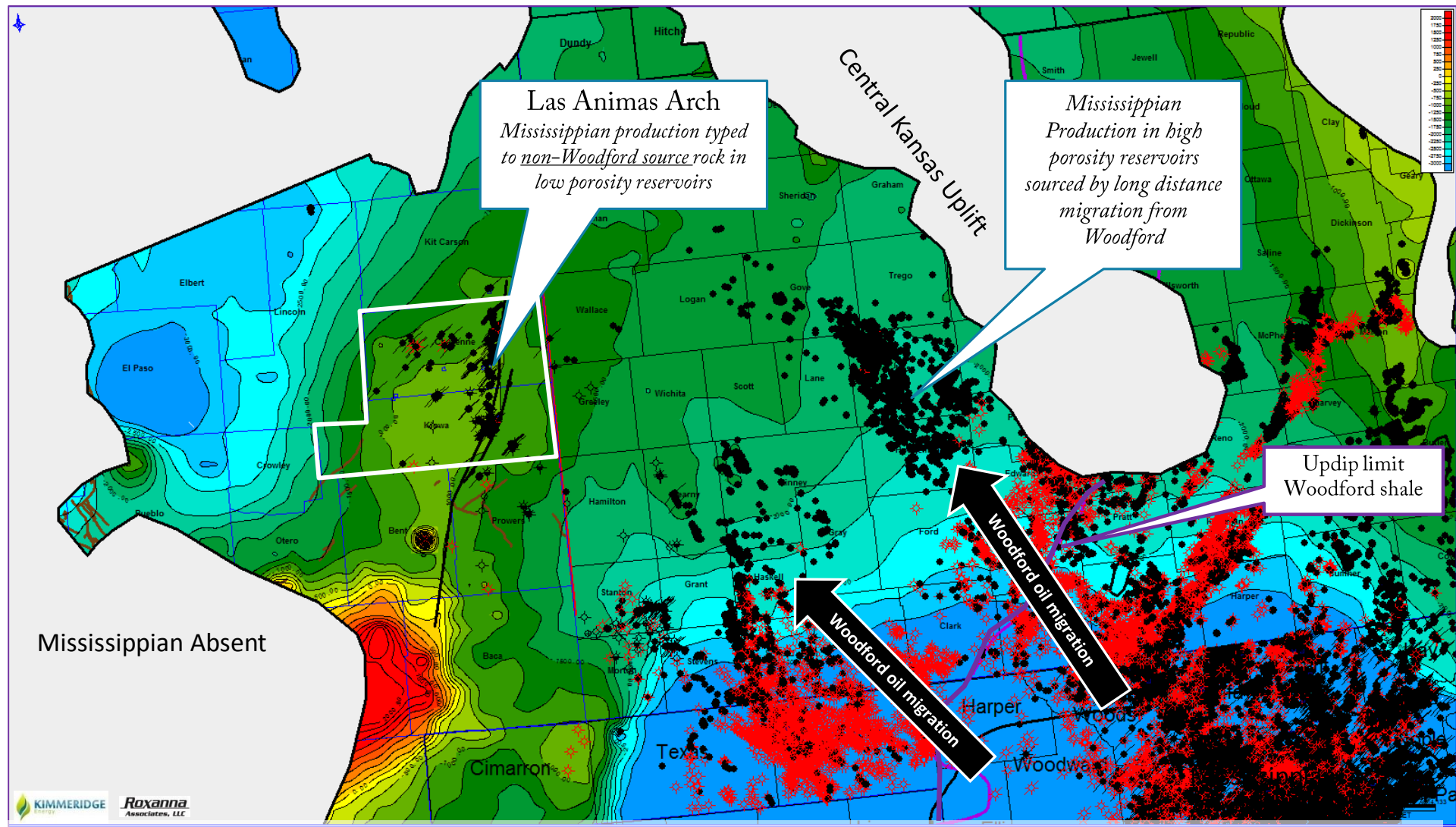
Net Source Rock Isopach & Maturity

- Net source rock thickness over acreage position ranges from 120 – 200+ ft thick.
- Acreage is dominantly in the condensate and oil windows.
- Salt begins to step up section to the NE, but is always below the Gothic in the Kimmeridge AOI.

Net SR Includes:

P1 = Hatch
P2 = Hovenweep
P3 = Gothic
P5 = Chimney Rk

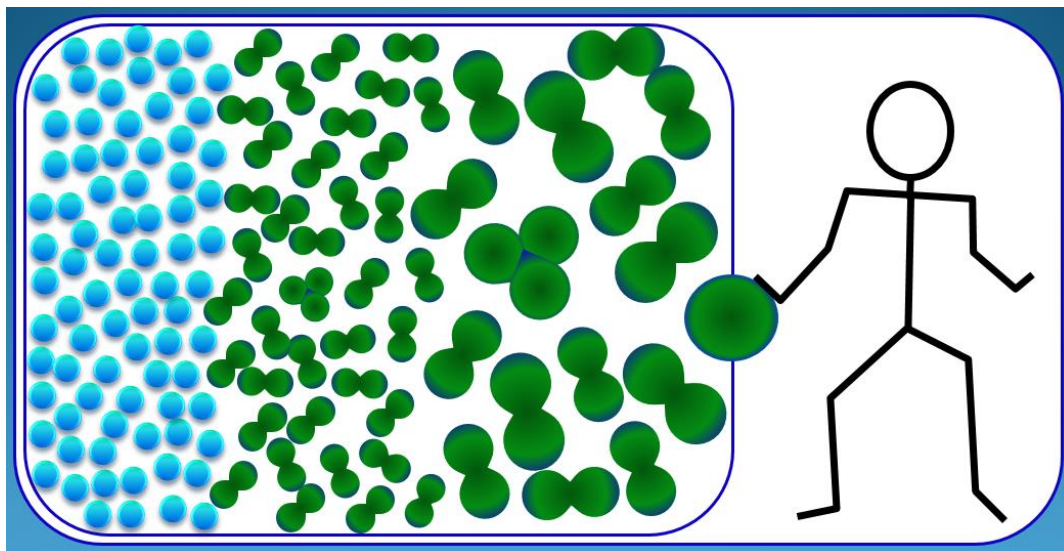
Las Animas Arch-Mississippian Tight Oil Play



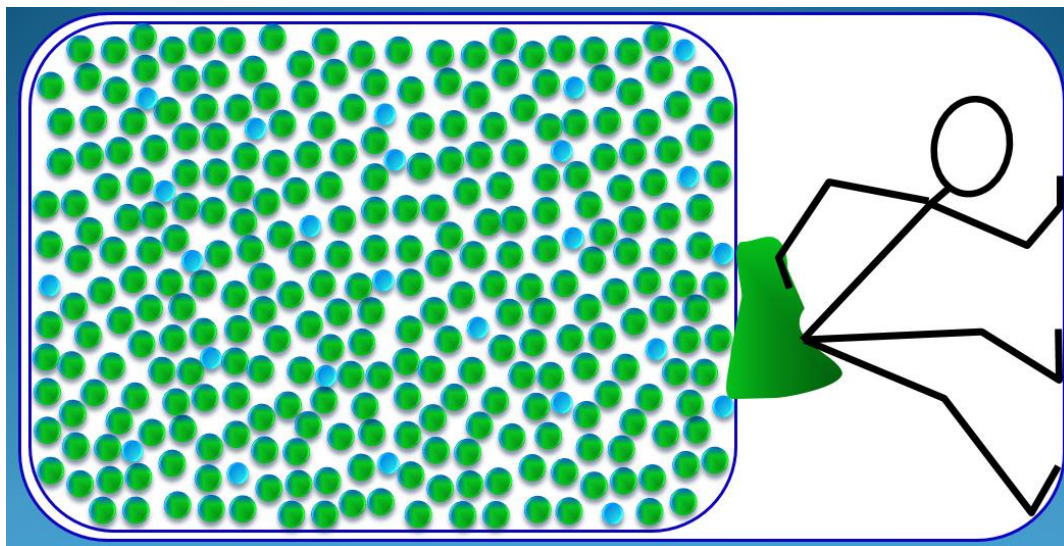
Regional Mississippian Structure and Production

“Oil only enters the pore sizes permitted by its buoyancy pressure.”

M. W. Downey
“Thinking Like Oil”
AAPG Midcontinent Section
Wichita, Ks. 10/13



LOW PRESSURE; OIL ONLY
IN LARGE PORES



OIL IN SMALL PORES; HIGH
IMPREGNATING PRESSURE

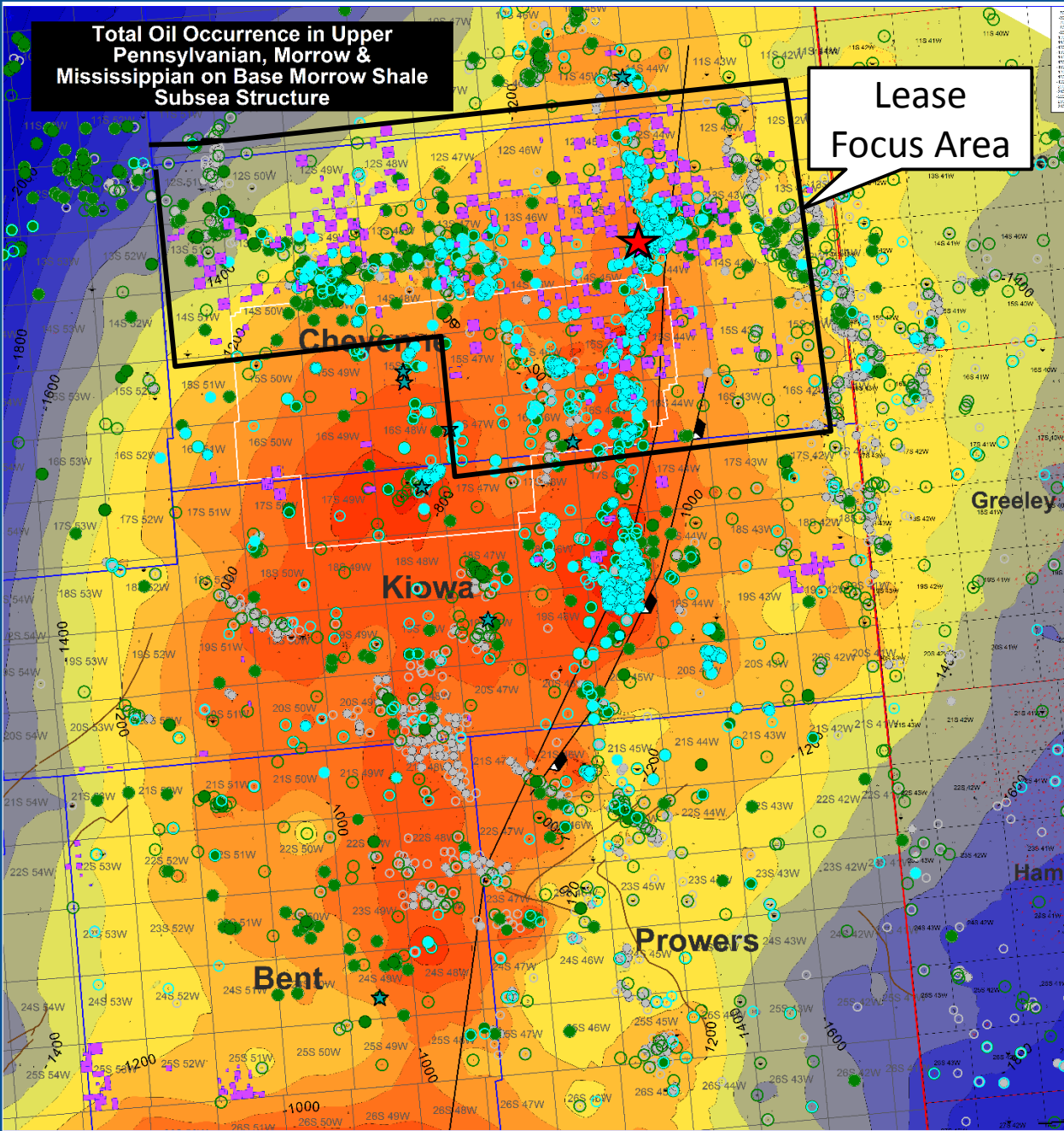
Total Oil Occurrence in Upper
Pennsylvanian, Morrow &
Mississippian on Base Morrow Shale
Subsea Structure

Lease
Focus Area

Las Animas Arch

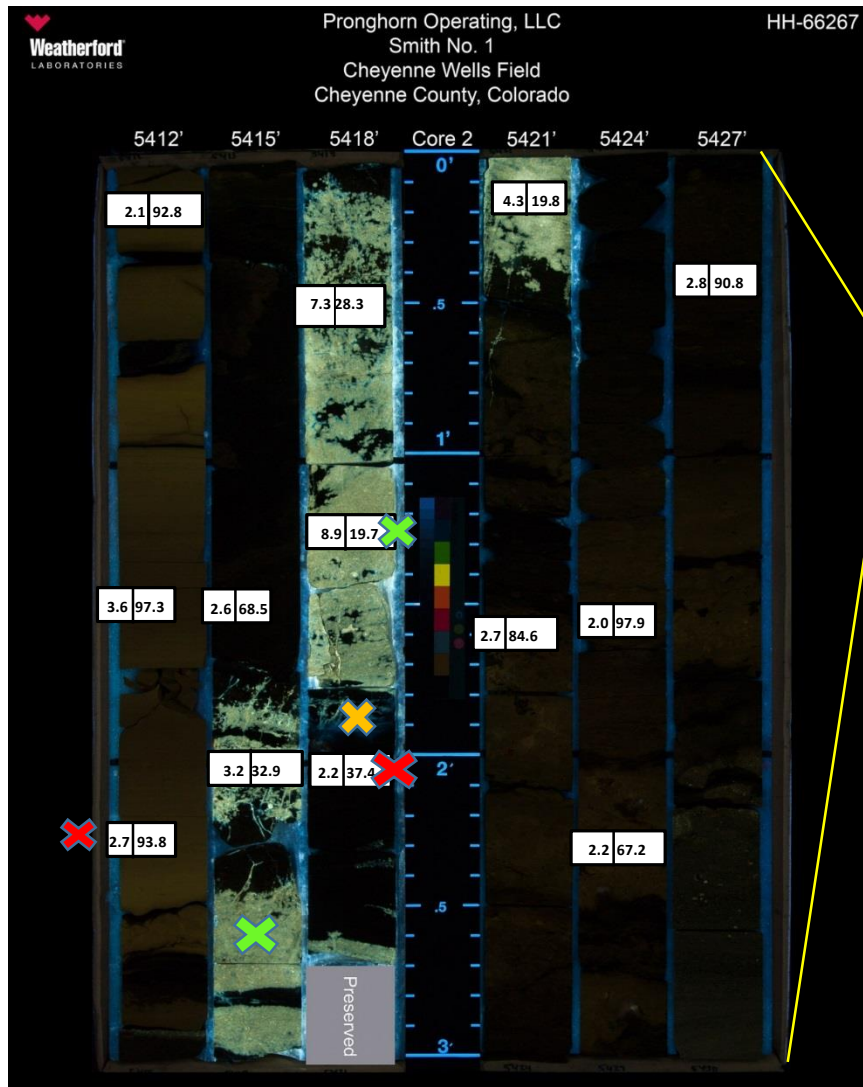
Pennsylvanian and
Mississippian Production, Tests
and Mud Log shows

Ubiquitous nature of oil
shows implied local
petroleum system

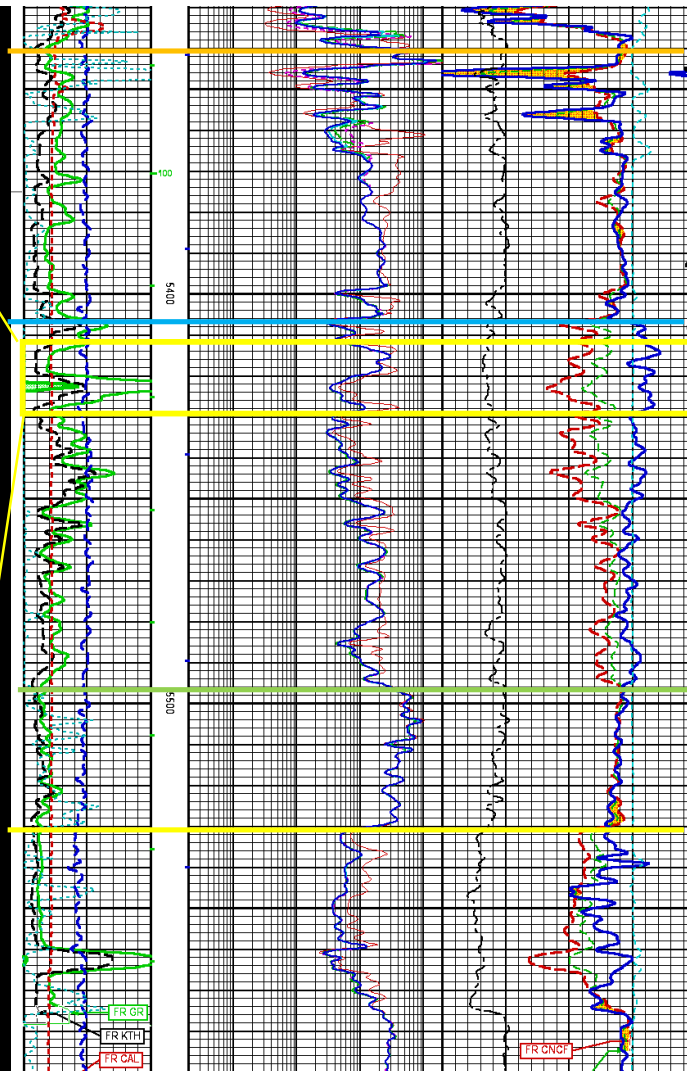


- Pennsylvanian
- Morrow
- Mississippian
- ★ Kimmeridge Core

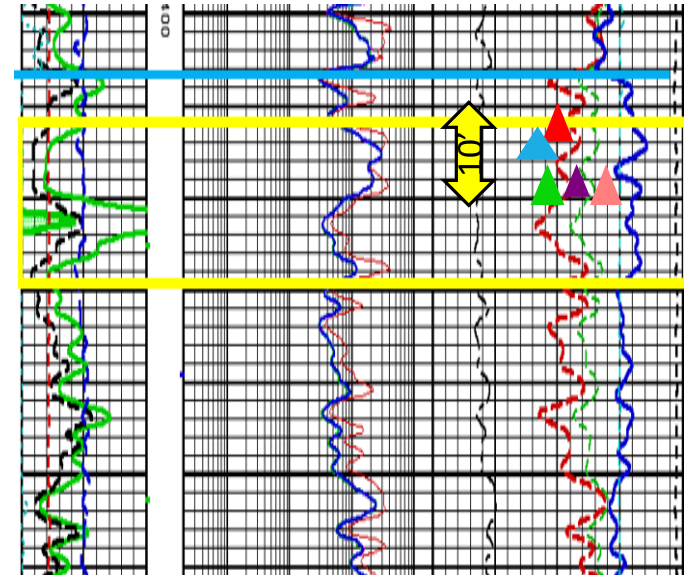
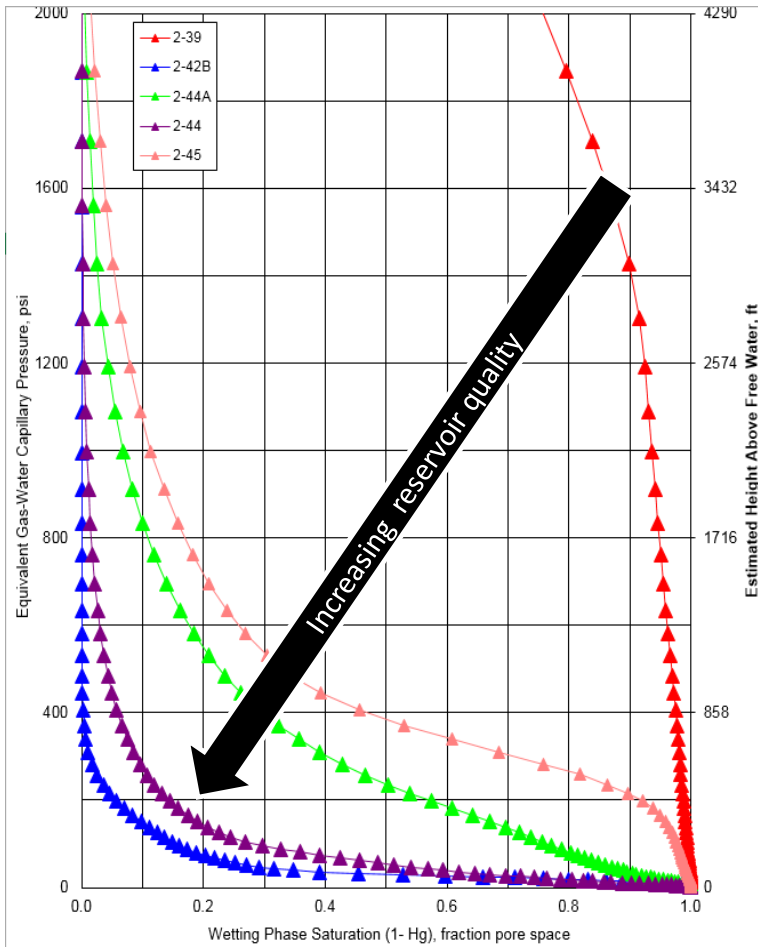
Pronghorn Smith #1 Cored Interval



Φ Sw



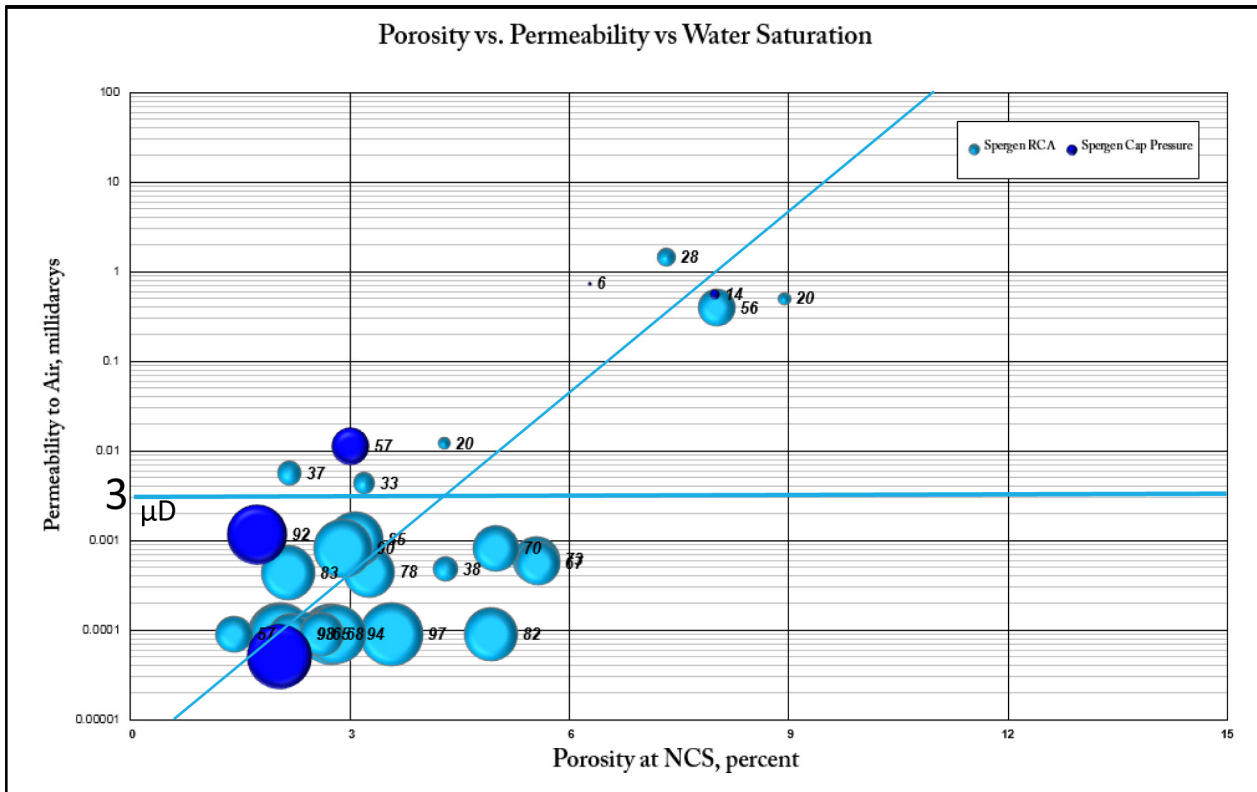
Capillary pressure measurements allow us to see which rocks the oil can enter.



| Sample Number | Sample Depth, feet | Permeability to Air, millidarcys | Porosity, fraction | Grain Density, grams/cc | Fluid Saturation at 200 psi Equivalent |
|---------------|--------------------|----------------------------------|--------------------|-------------------------|---|
| | | | | | Gas-Water Capillary Pressure, fraction pore space |
| 2-39 | 5414.30 | 0.0001 | 0.020 | 2.80 | 0.988 |
| 2-42B | 5417.65 | 0.7321 | 0.063 | 2.83 | 0.056 |
| 2-44A | 5419.90 | 0.0111 | 0.030 | 2.83 | 0.569 |
| 2-44 | 5419.25 | 0.5534 | 0.080 | 2.84 | 0.143 |
| 2-45 | 5420.15 | 0.0012 | 0.017 | 2.84 | 0.918 |

Core Analysis allows us to quantify the minimum cutoffs for our petrophysical analysis

Pronghorn Smith #1 Core Analysis Conclusions



- RCA data combined with cap pressure data, core florescence, and log analysis indicates the presence of oil in 4% and greater porosity Spergen reservoirs.
- Oil saturations > 65% are seen in Spergen reservoirs with >3 microdarcy perm
- Core florescence and S1 measurement confirms oil saturation in low porosity, low perm reservoirs
- Tight oil play is continuous across the arch as seen in numerous oil shows and tests that were never developed due to historical economic porosity cutoffs

The Search for New Exploration Plays

- New play concepts evolve over time as a response to changes in commodity price, technology, and learnings
- Where is the oil and how do we get it out!!
- Fundamentals of the petroleum system-source, migration and storage
- Early identification of the core areas of these plays leads to superior economics

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