Northwest Shelf Horizontal San Andres Play

Russell K. Hall

CO2 ROZ 2017 Conference

CO_2 Recovery Conference

- Permian Basin Trends
- NW Shelf San Andres Play
- Fluid Properties

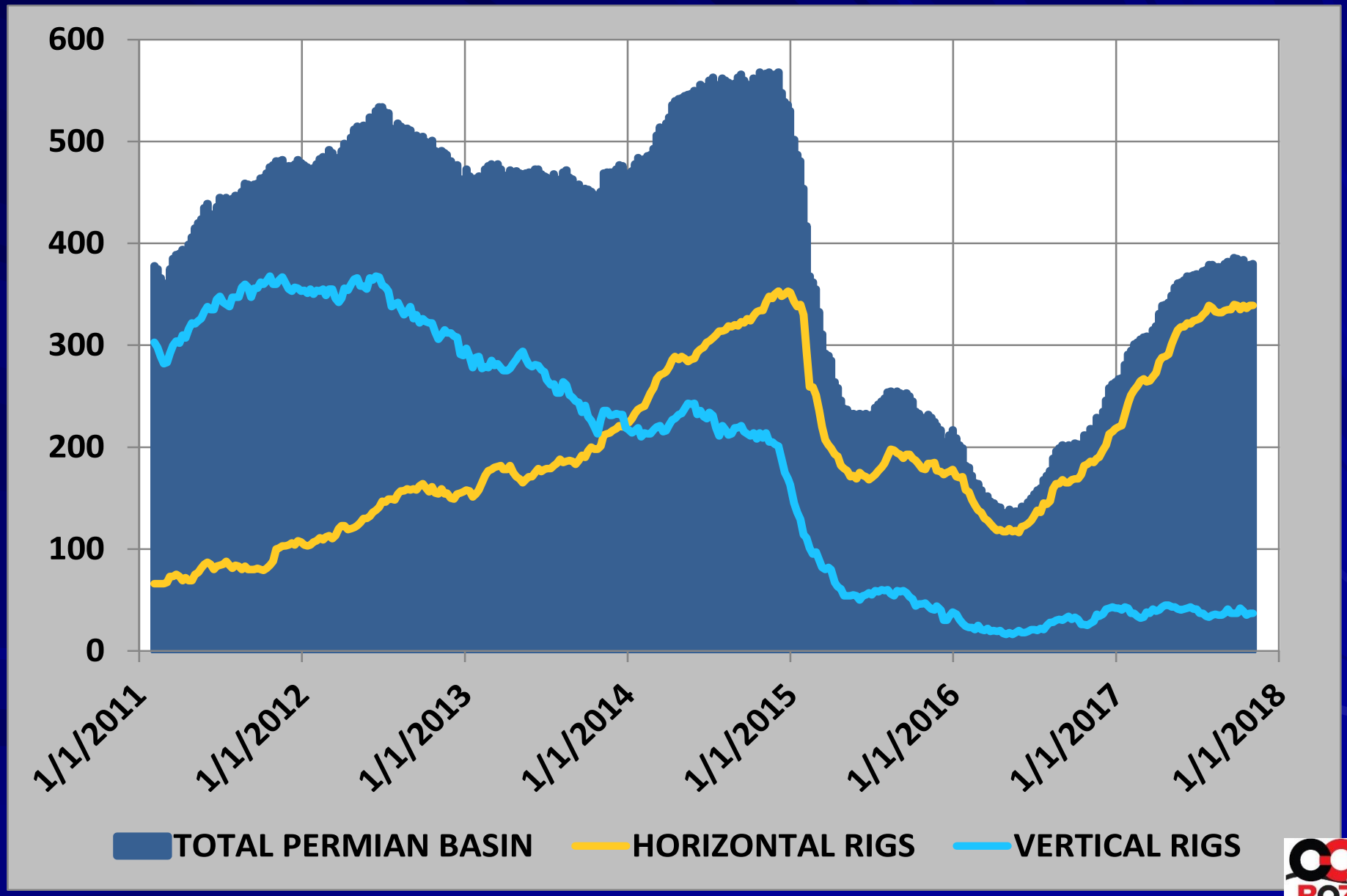
PERMIAN BASIN TRENDS

- Economic Return is Key Driver of Drilling

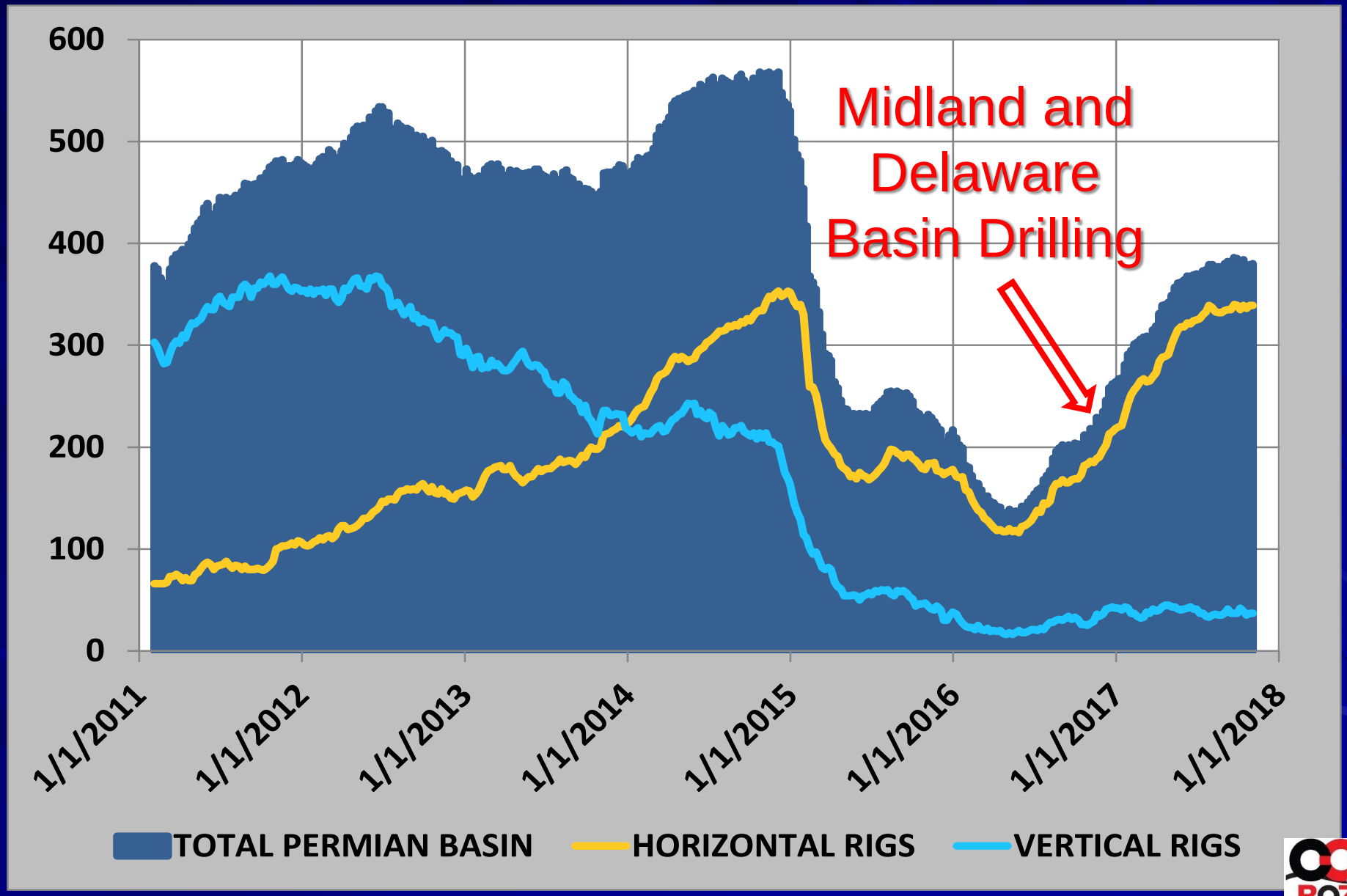
POSTED OIL PRICE

POSTED OIL PRICE

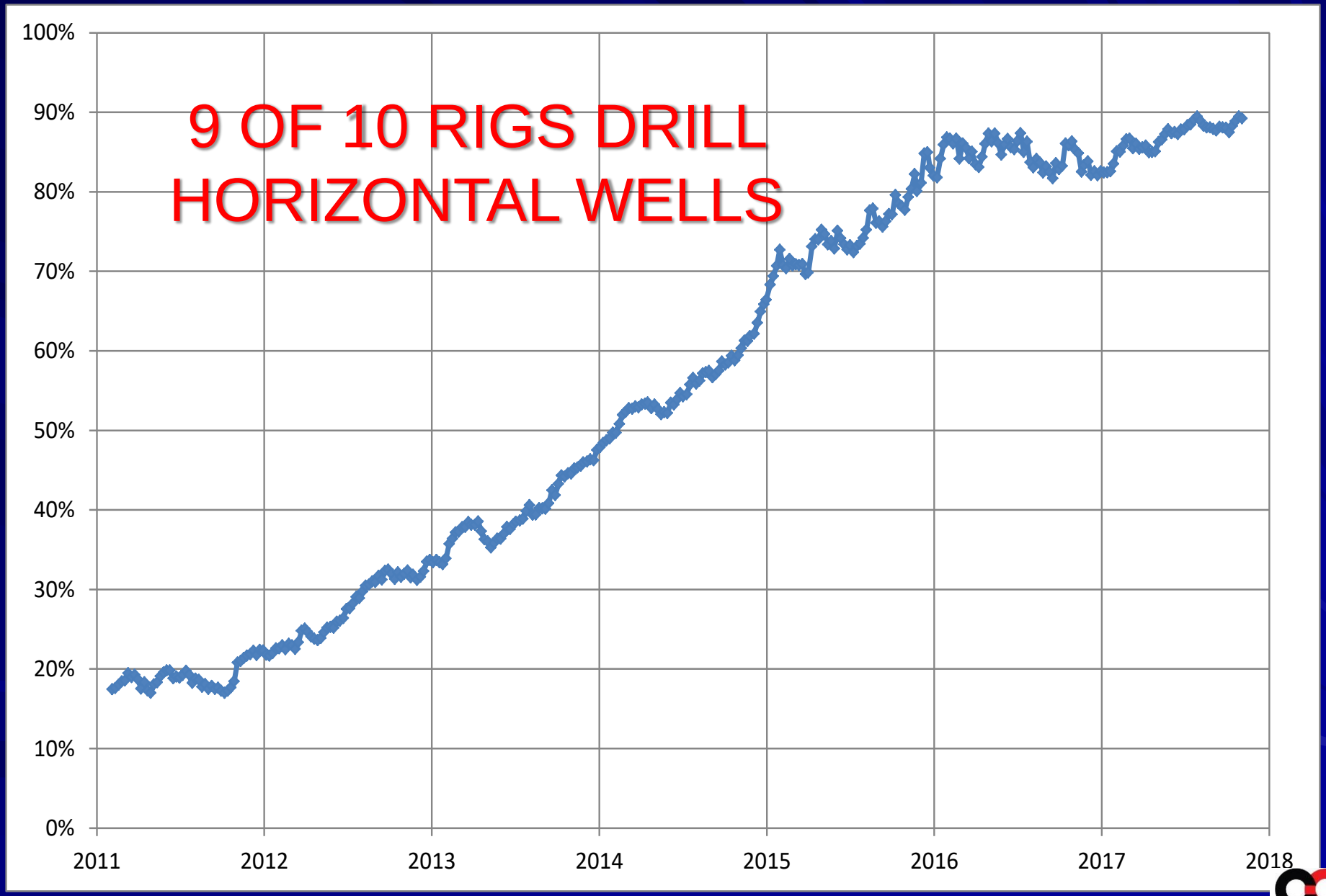
PERMIAN BASIN RIG COUNT



PERMIAN BASIN RIG COUNT



PERMIAN BASIN HZ RIGS



PERMIAN BASIN TRENDS

- Economic Returns Are Driving Drilling
- Oil Field Workers Have Left Industry

OIL&GAS JOURNAL

WASHINGTON PULSE MAGAZINE PAST ISSUES

Rystad: Global oil field services layoffs at 300,000, but tide is turning

HOUSTON, Apr. 6
04/06/2017
By OGJ editors

About 35% of the total workforce of the world's top 50 oil field services companies was laid off during 2014-16, research from oil and gas consulting service Rystad Energy shows. That amounts to around 300,000 employees.

The firm notes the North American shale industry in particular took a hard hit with the lower activity levels. Two of the largest land drillers, Nabors Industries Ltd. and Helmerich & Payne Inc., have announced several staff cuts resulting in an overall reduction of more than 50%. The Big Four, all exposed to the US land market, were forced to lay off between 30-40% of their workforce. Companies exposed to more of the international market have cut more modestly in the range of 20-30%.

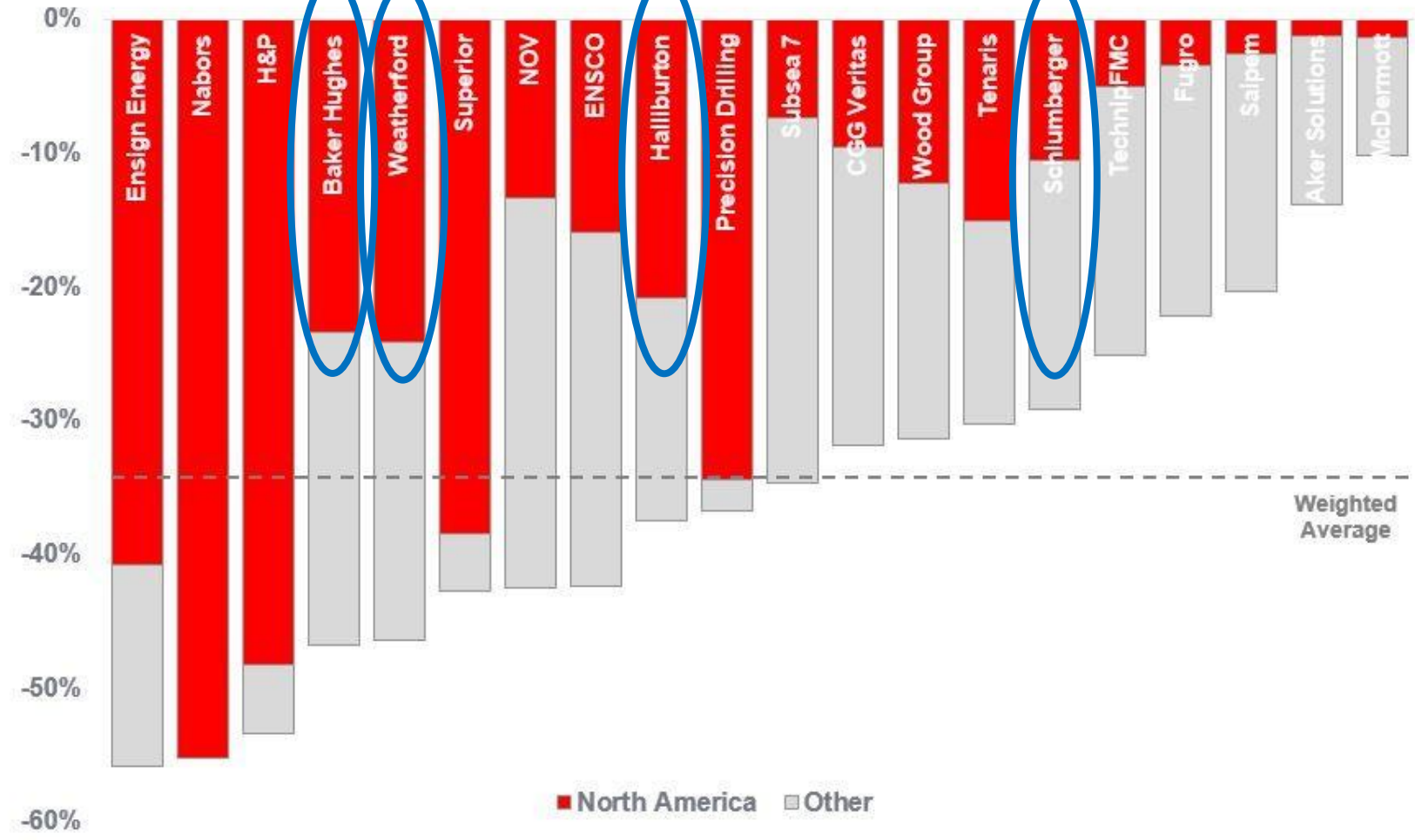
"However, the negative trend is about to turn and over the last few months we have seen more job-postings in North America from companies such as Weatherford, Nabors, and Precision Drilling, among others," said Audun Martinsen, Rystad vice-president of oil field service research. "Last week, Halliburton announced its plan to add 2,000 jobs to the pressure pumping and cementing business."

OIL&GAS JOURNAL

WASHINGTON PULSE MAGAZINE PAST ISSUES

Workforce reduction in 2014-2016, %

Split by revenue source in 2014



Source: Rystad Energy SCube, Rystad Energy Research

PERMIAN BASIN TRENDS

- Economic Return is Key Driver of Drilling
- Oil Field Workers Have Left Industry
- Number of Frac Crews, Although Growing, is Insufficient

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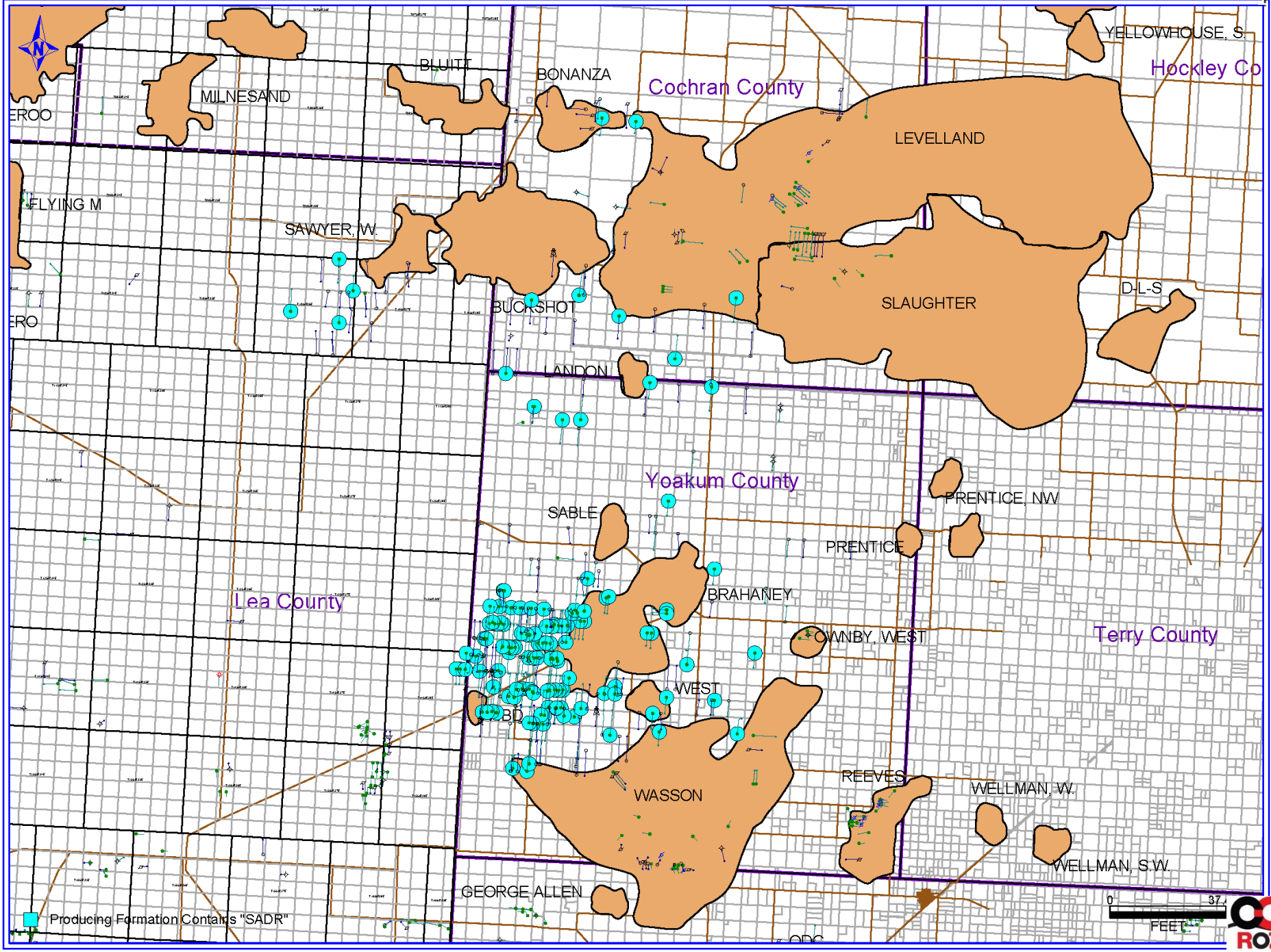
- Number of Frac Crews, Although Growing, is Insufficient
- Stimulation Costs Have Risen Substantially

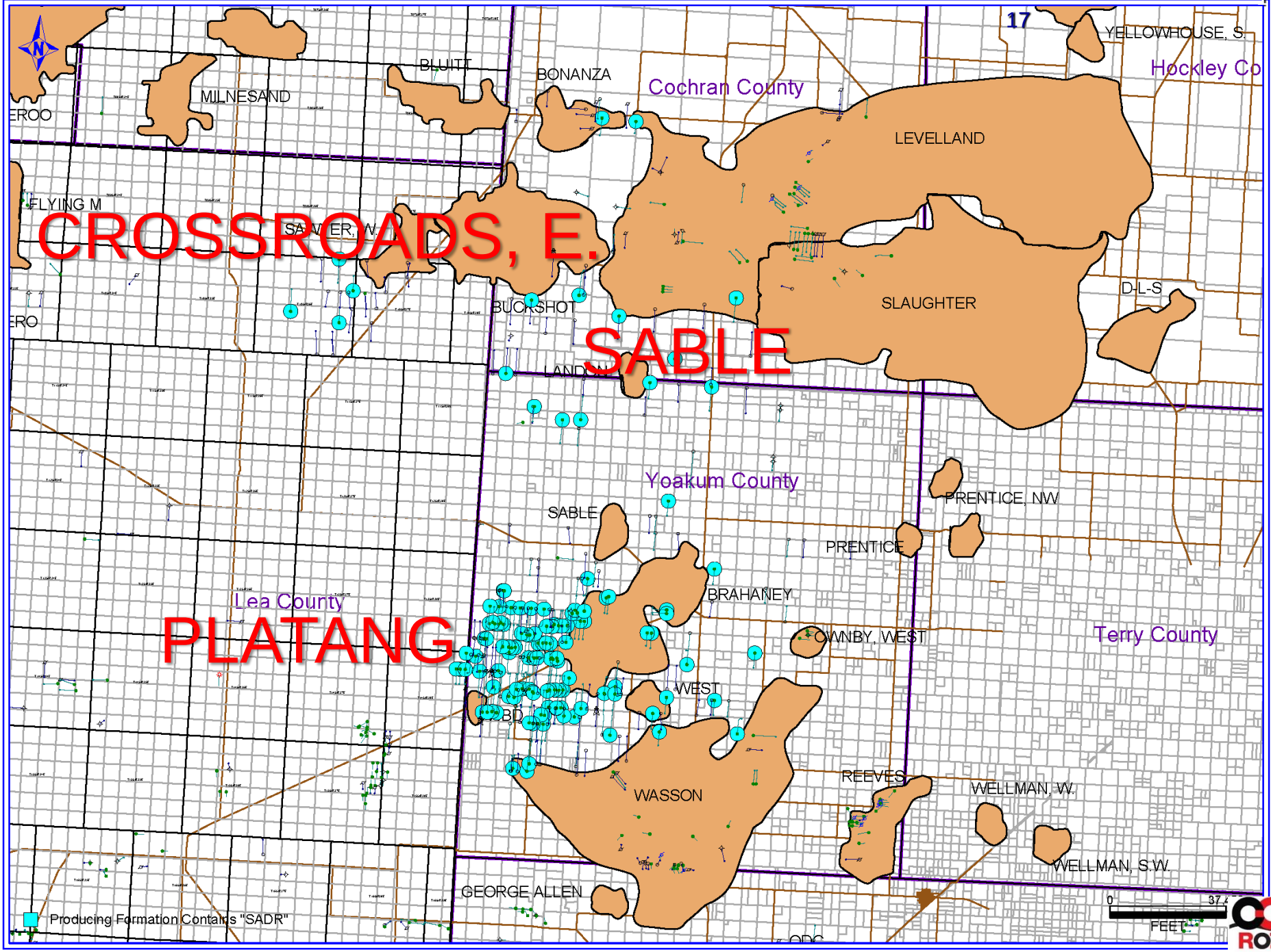
ENERGY HUNTER RESOURCES ANNOUNCES … SAN ANDRES OIL PLAY ACQUISITION IN THE PERMIAN BASIN

Dallas, TX – December 4, 2017

- Approximately 9,413 net acres located in Cochran County, Texas
- More than 45 identified horizontal drilling locations and approximately 20 recompletion opportunities
- Exclusive Right to Purchase An Additional 9,600 Net Acres in Cochran County, Texas

Northwest Shelf Horizontal San Andres Play


YELLOWHOUSE, S.
Hockley Co
BLUITT
BONANZA
Cochran County
MILNESAND
LEVELLAND
FLYING M
SAWYER, W.
SLAUGHTER
D-L-S
BUCKSHOT
LANDON
Yoakum County
PRENTICE, NW
SABLE
PRENTICE
BRAHANEY
Lea County
OWNBY, WEST
Terry County
WEST
BD
REEVES
WELLMAN, W.
WASSON
WELLMAN, S.W.
GEORGE ALLEN
Producing Formation Contains "SADR"
0
FEET


17
YELLOWHOUSE, S.
Hockley Co
BLUITT
BONANZA
Cochran County
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LEVELLAND
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CROSSROADS, E.
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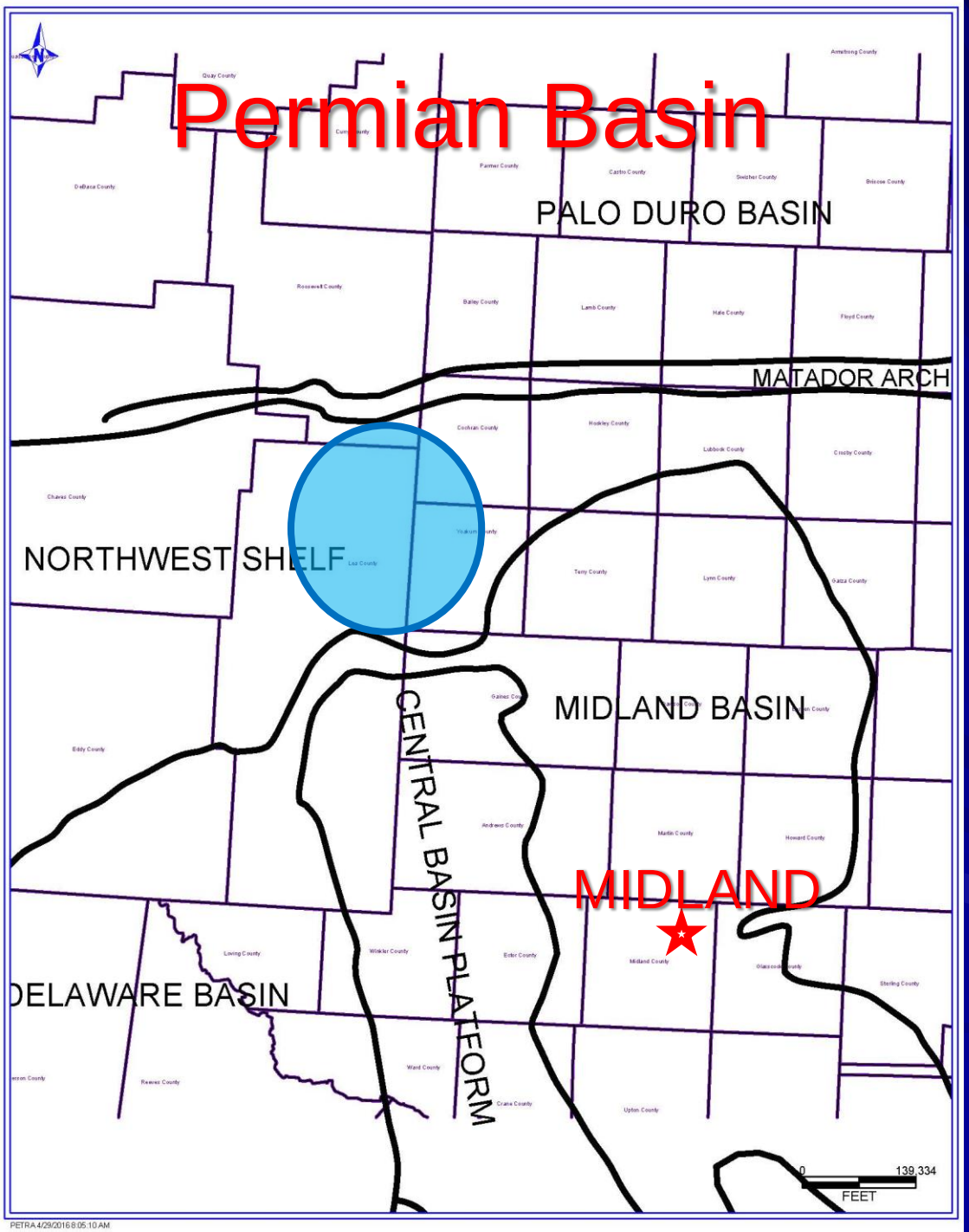
HZ San Andres Performance

- Restricted Marine Carbonate Platform Depositional Environment


Permian Basin
PALO DURO BASIN
MATADOR ARCH
NORTHWEST SHELF
MIDLAND BASIN
CENTRAL BASIN PLATFORM
MIDLAND
DELAWARE BASIN
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139,334
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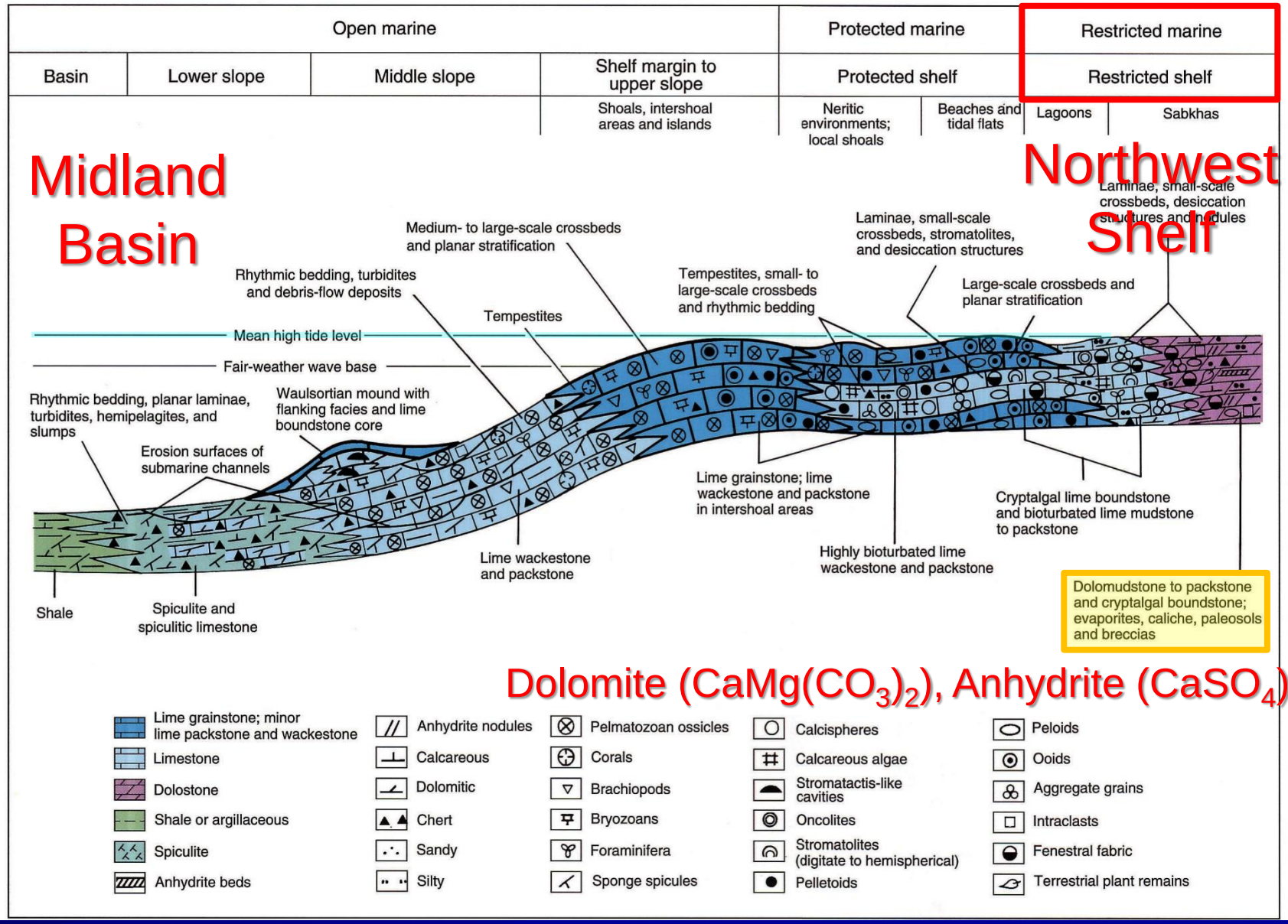
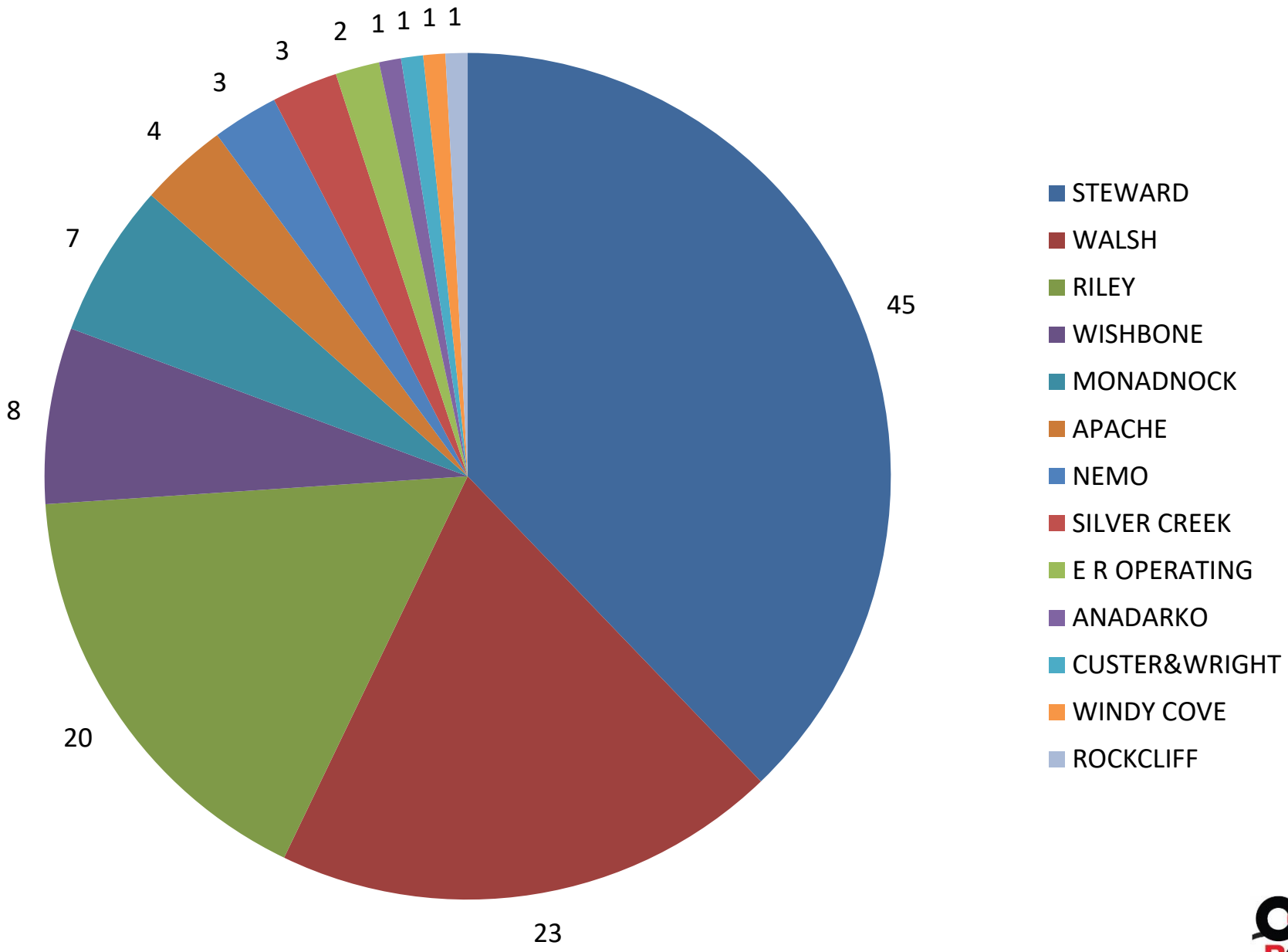
Carbonate Platform Environment



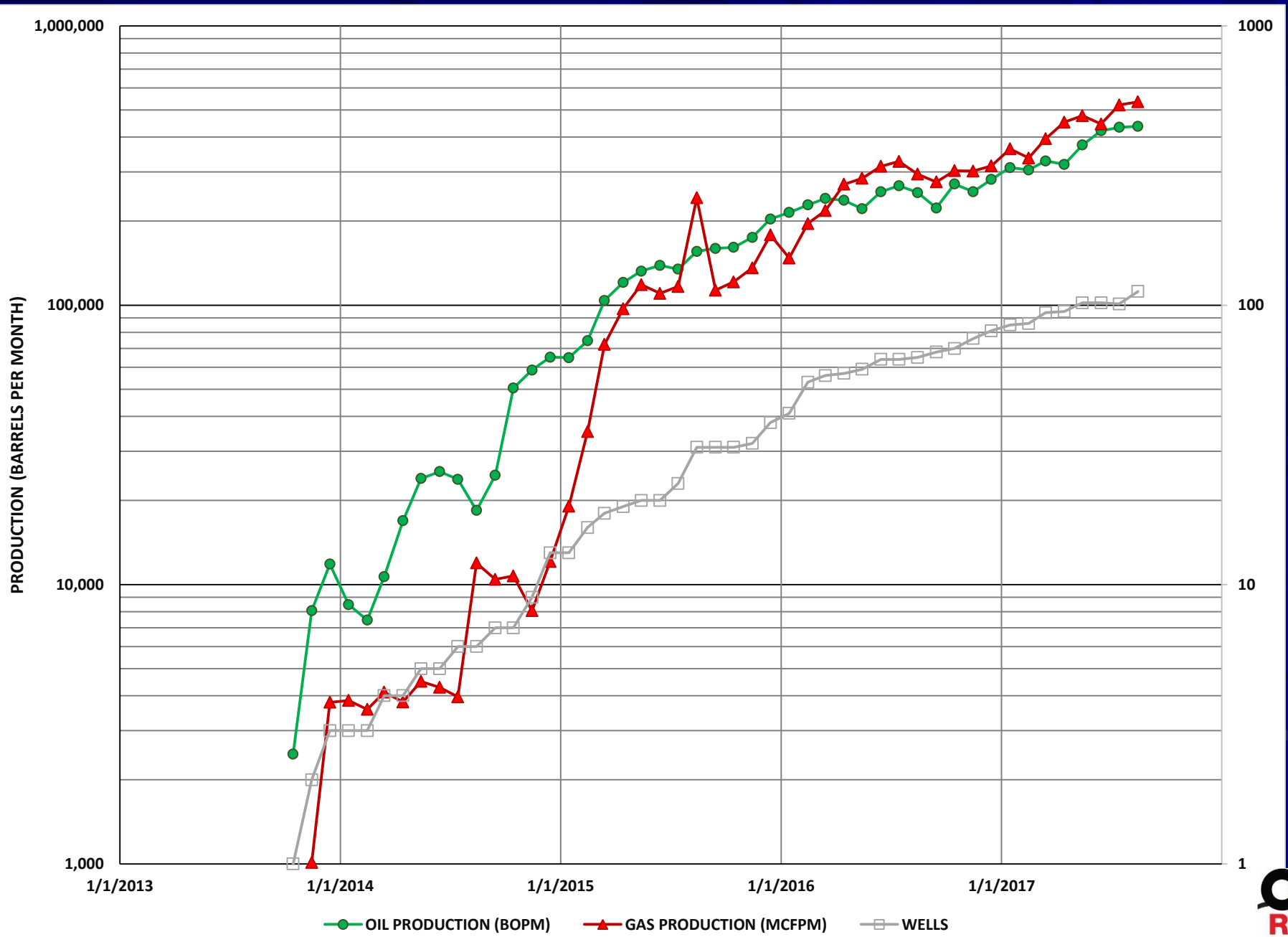
HZ San Andres Performance

- Restricted Marine Carbonate Platform Depositional Environment
- Development History and Performance

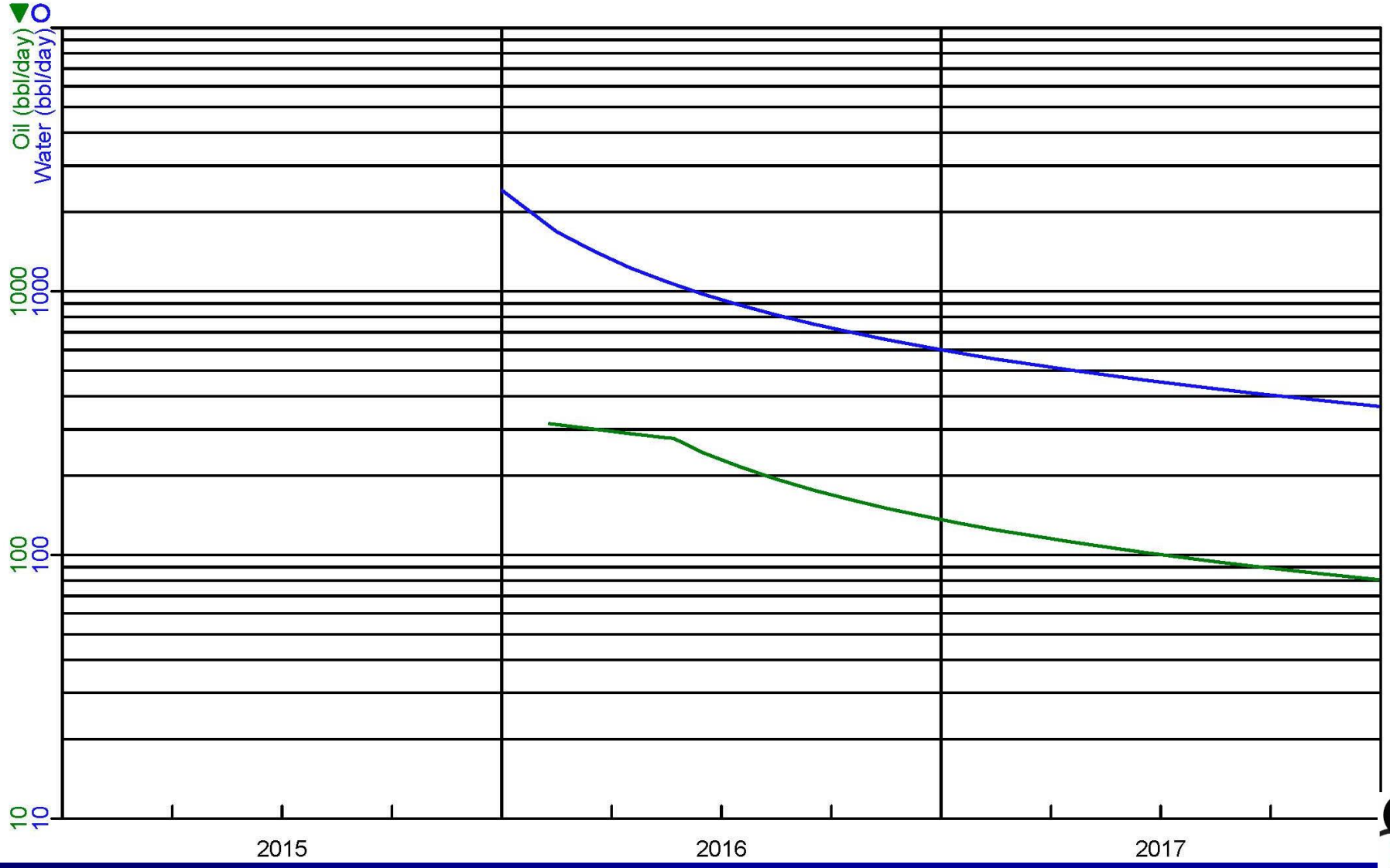
HZ Completions By Operator



HZ Well Performance



Typical Well Performance



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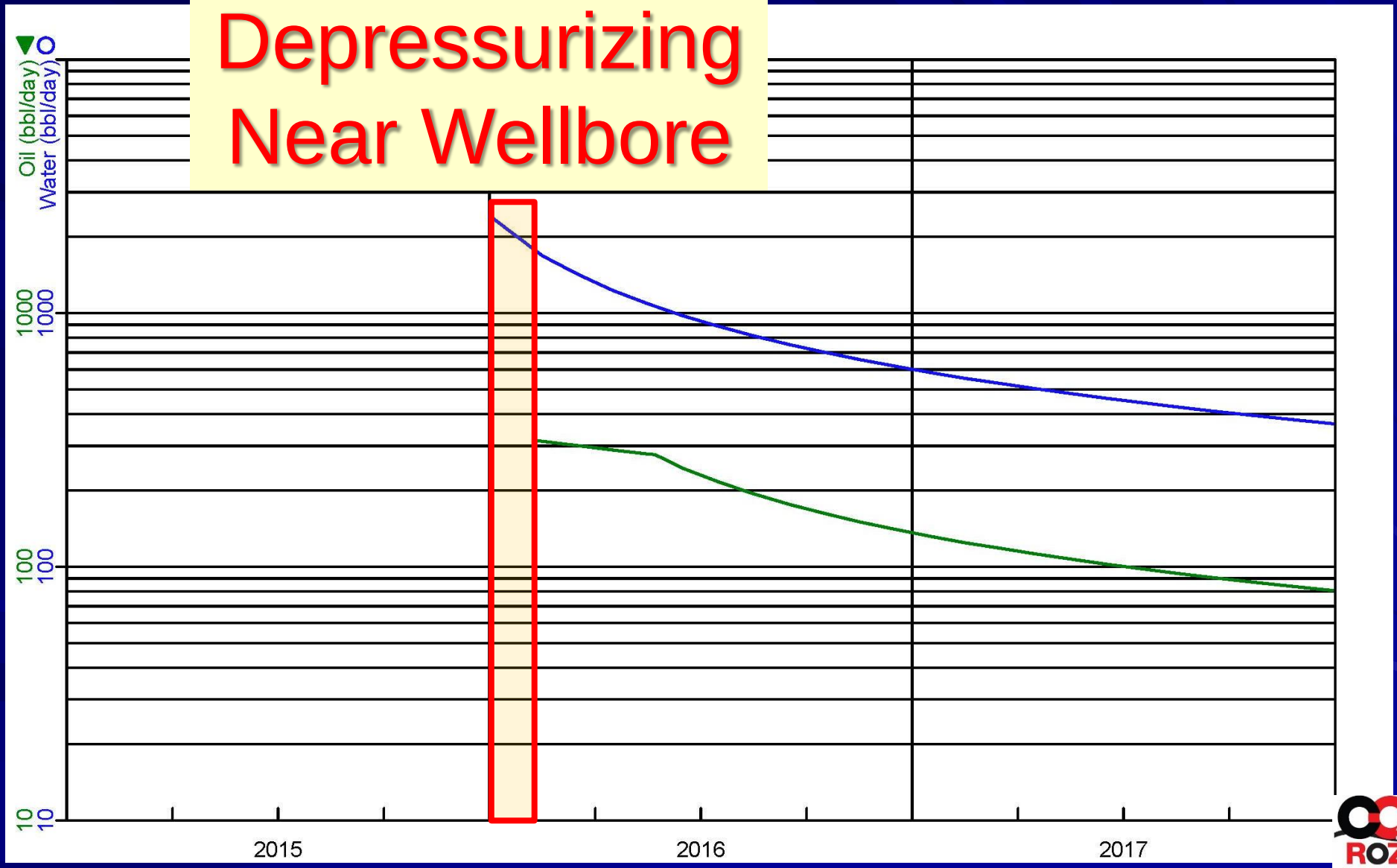

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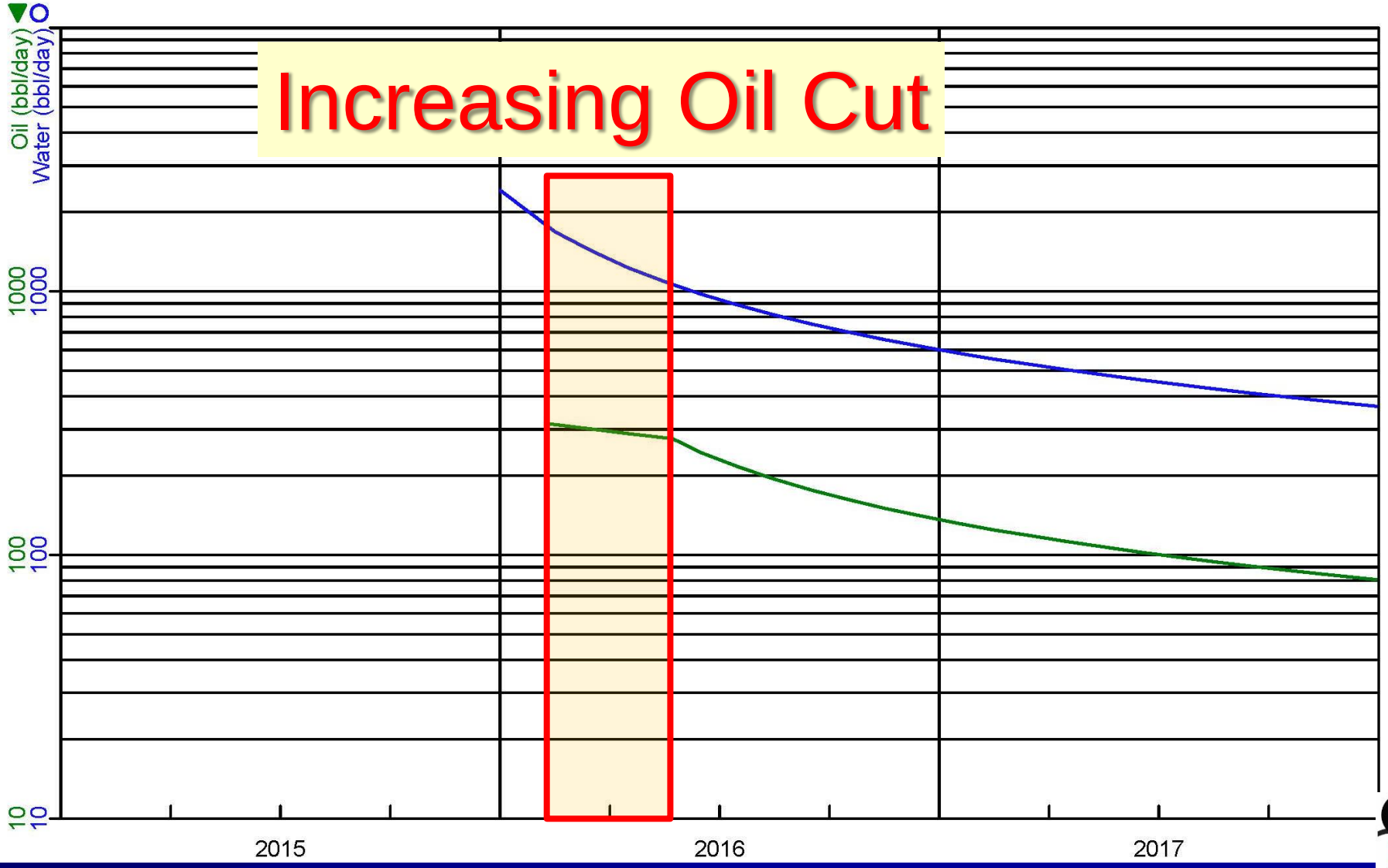

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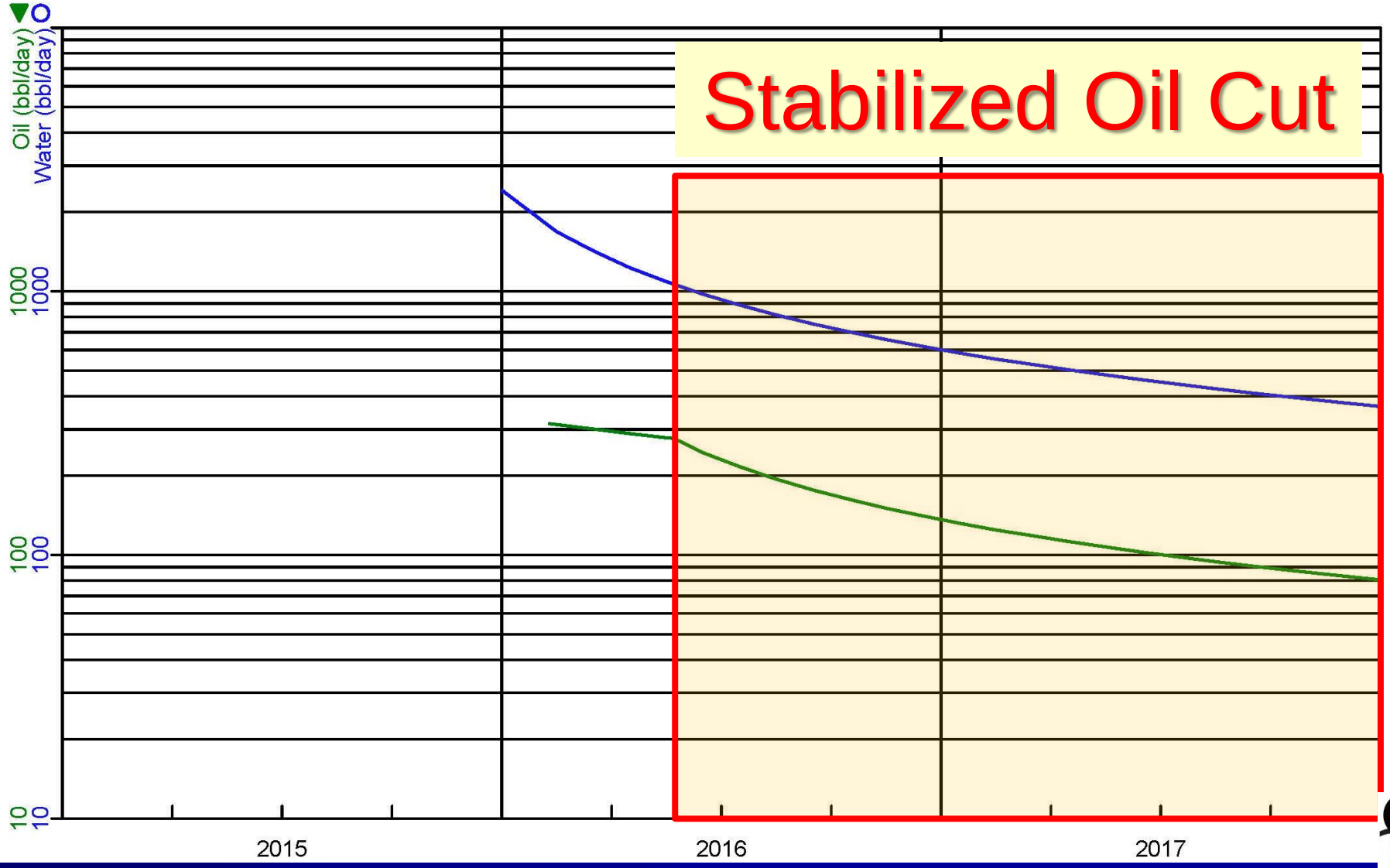
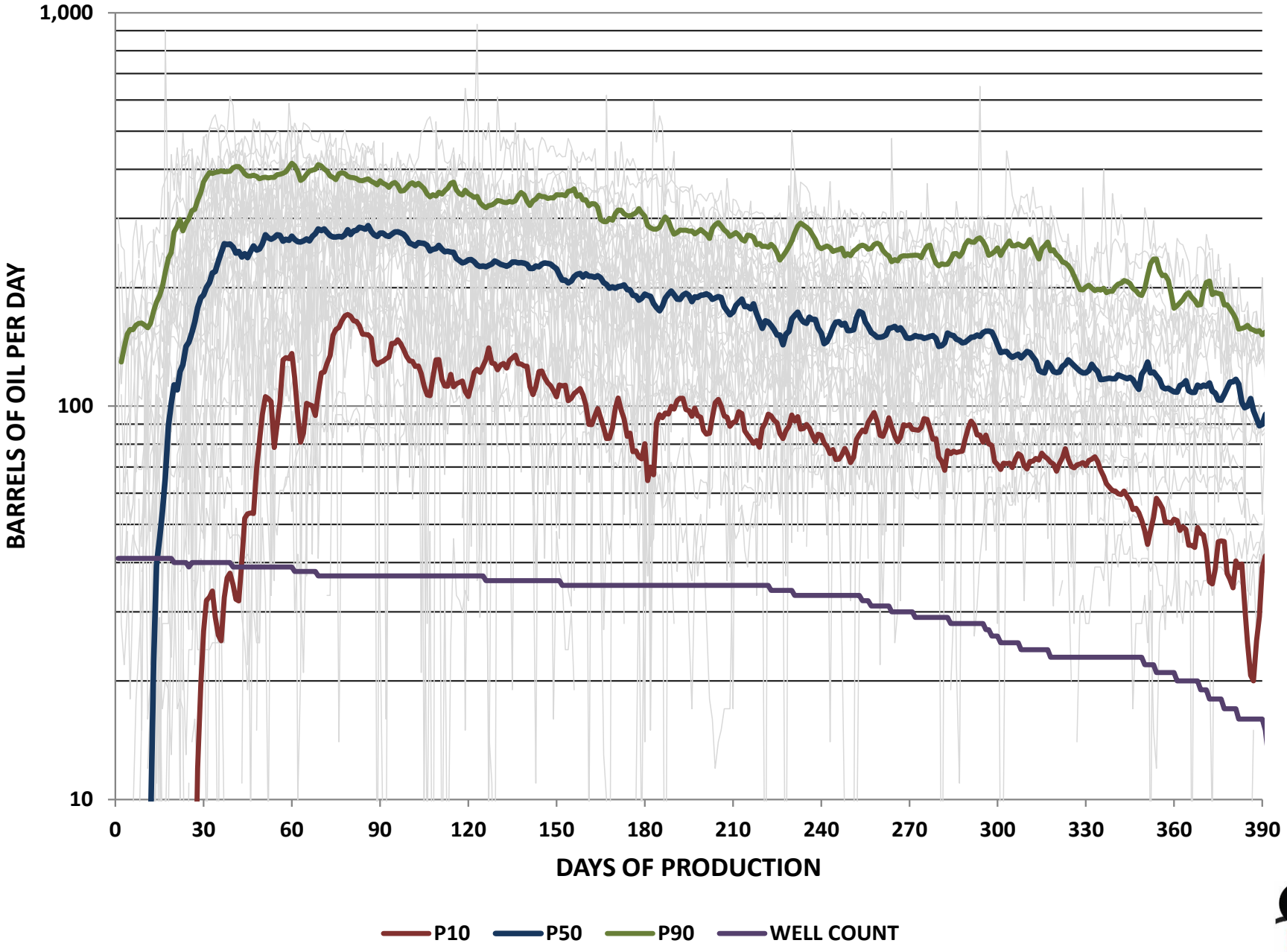


Oil Performance



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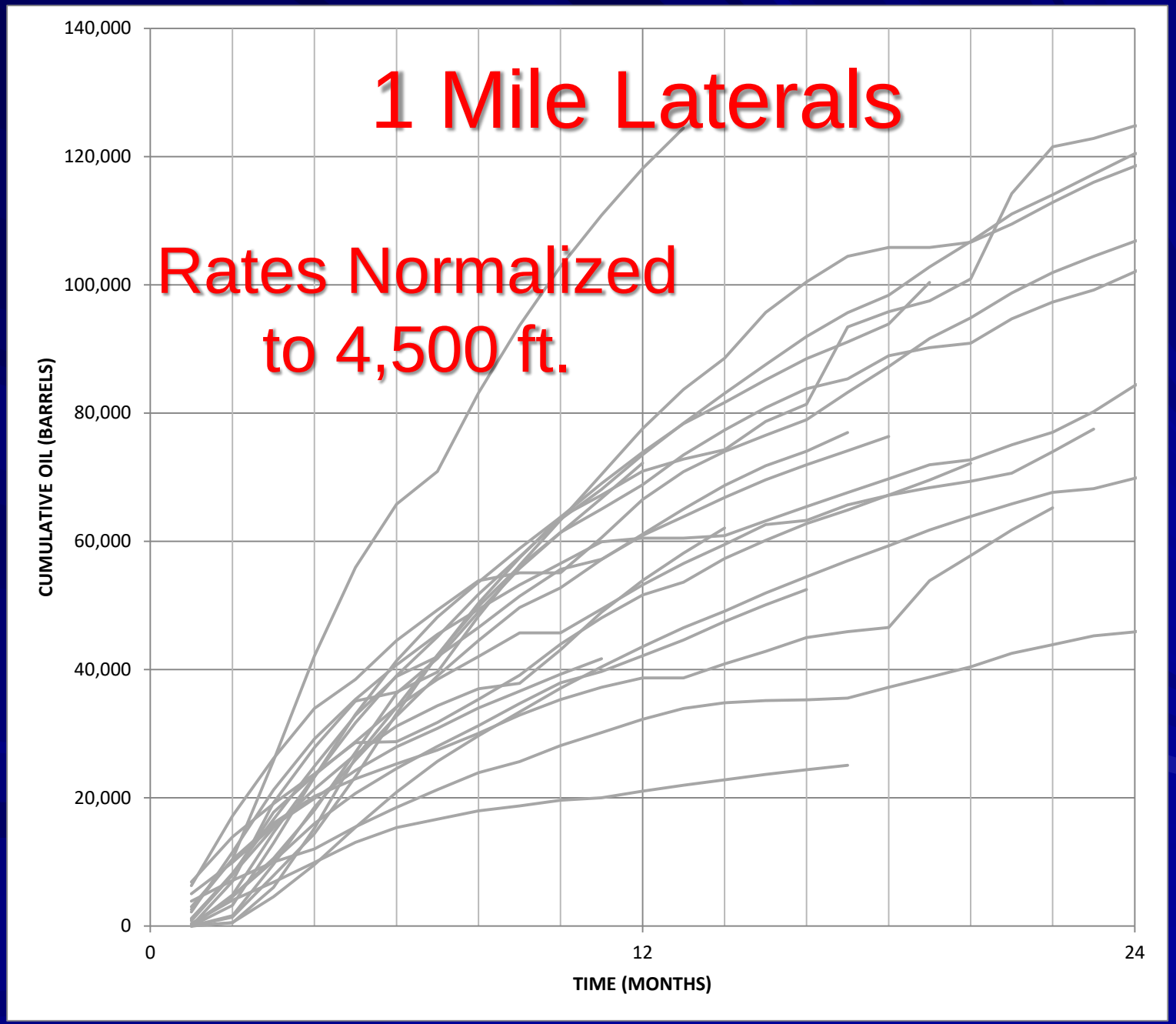

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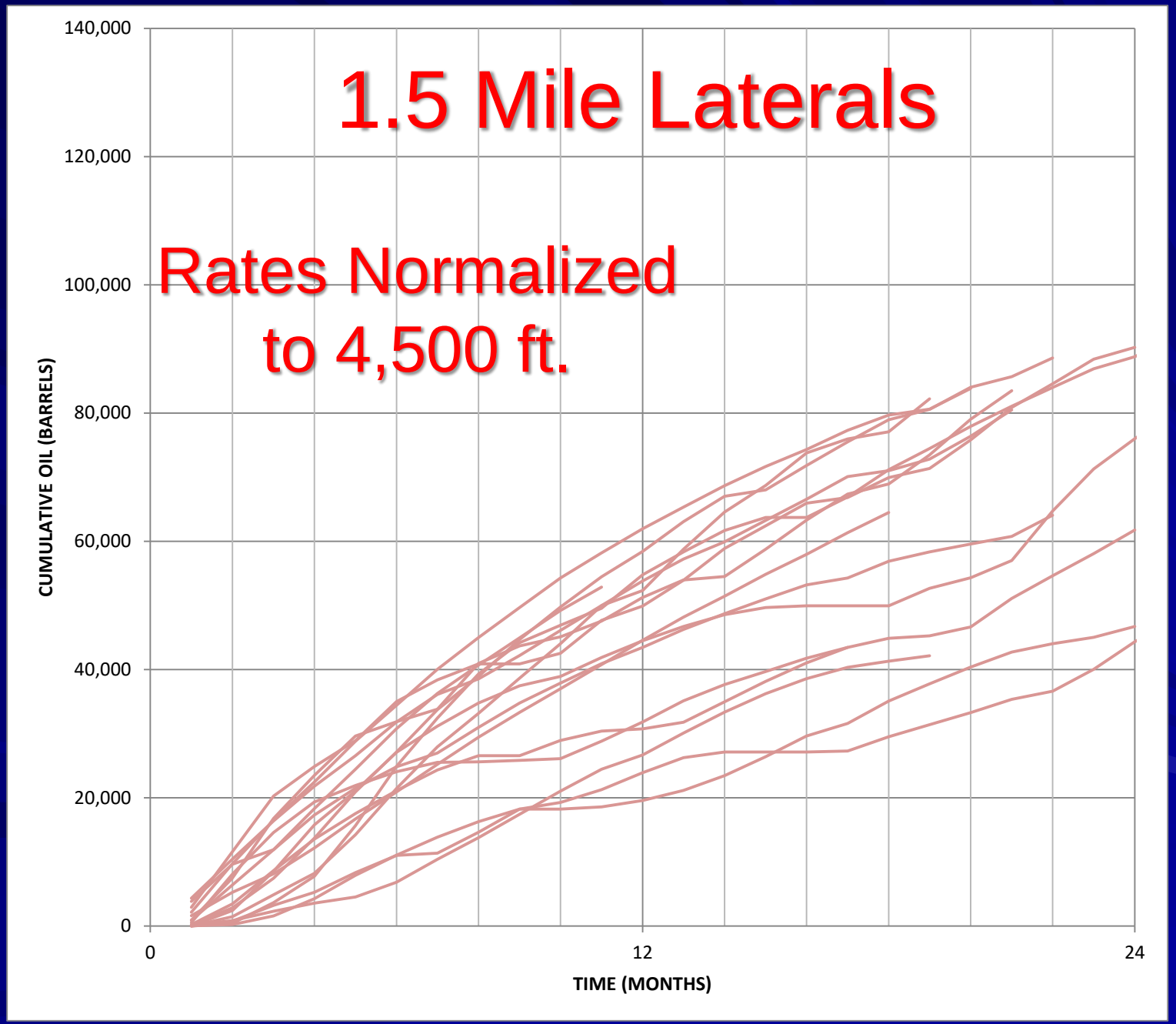

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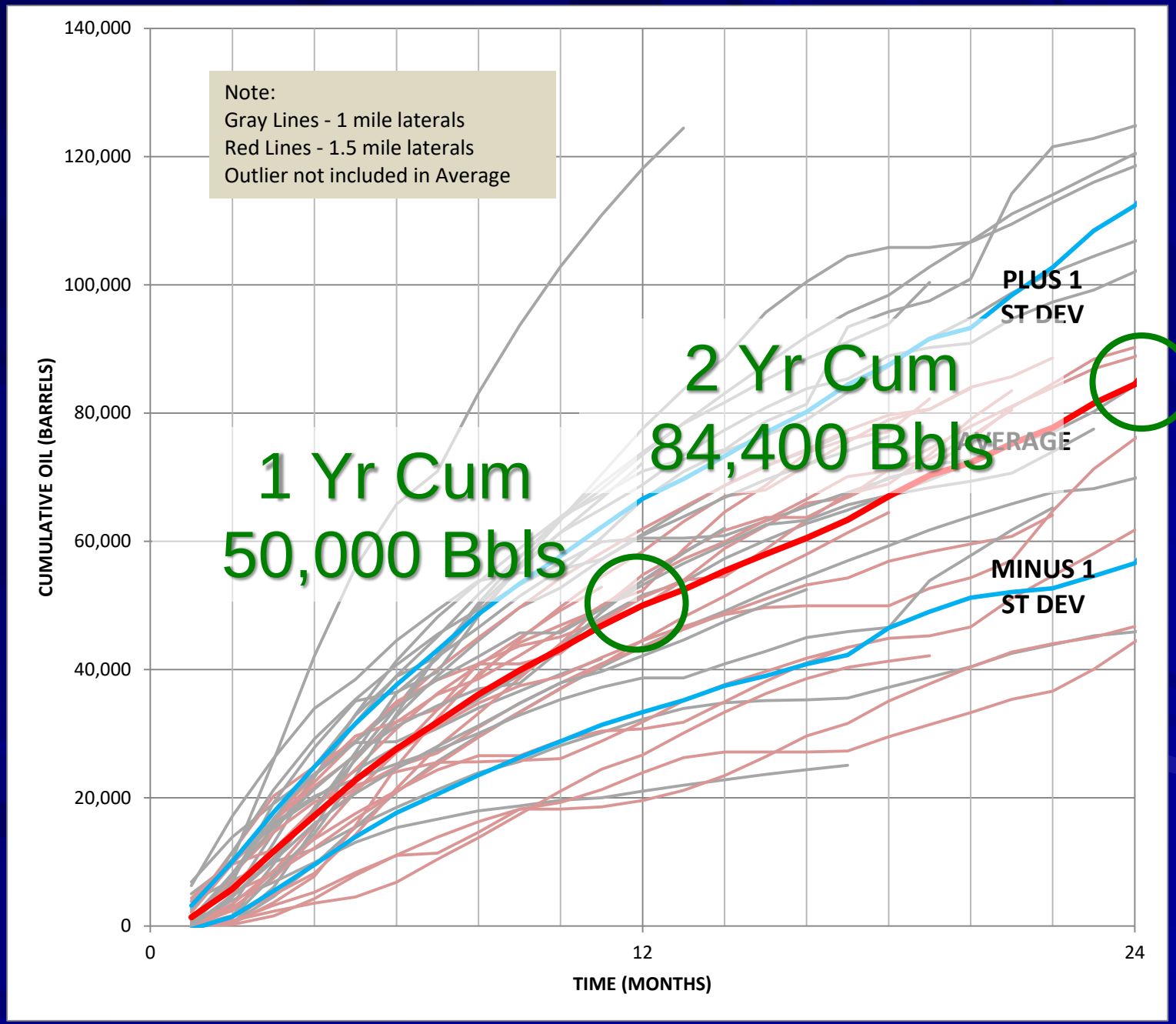

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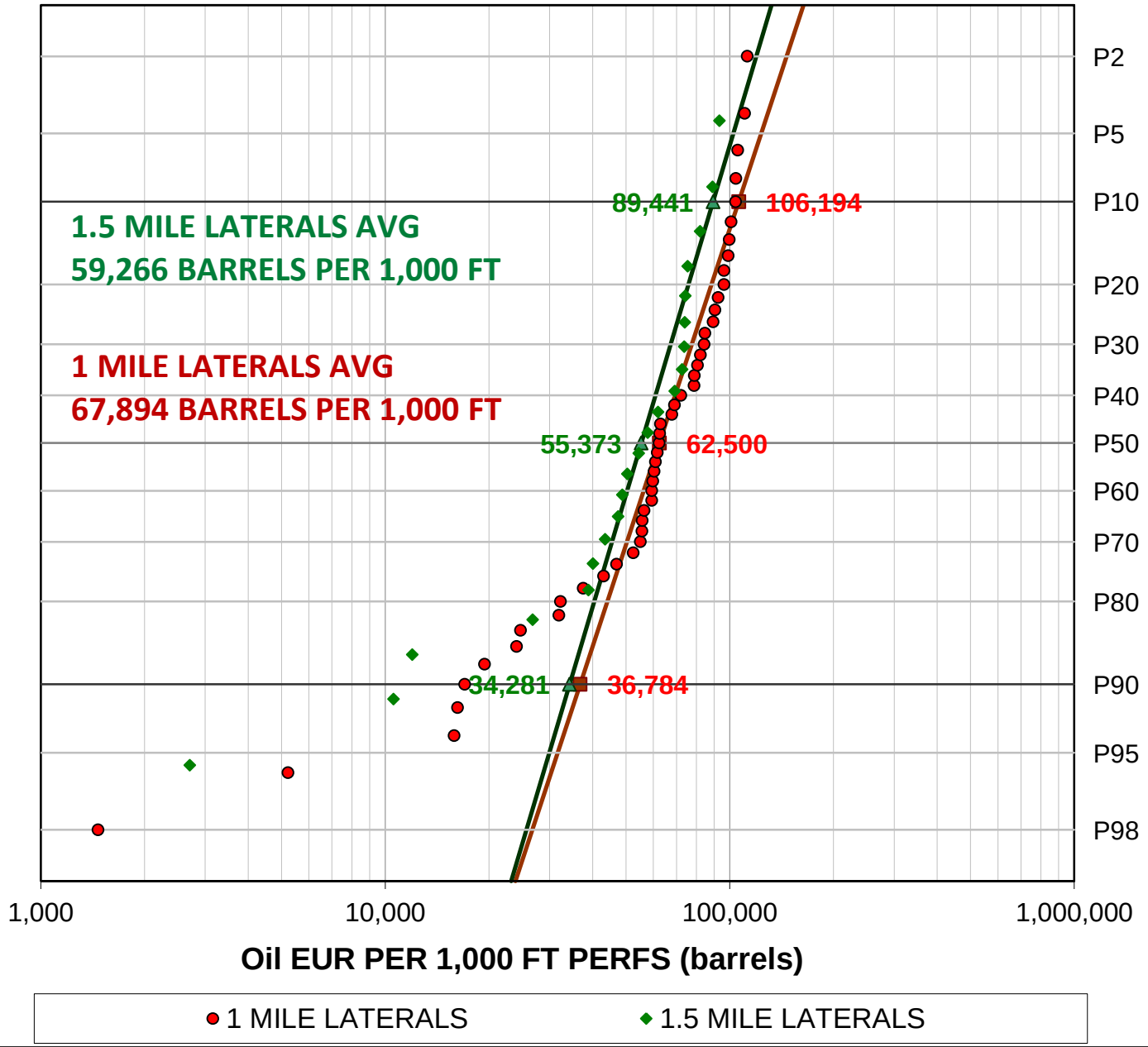

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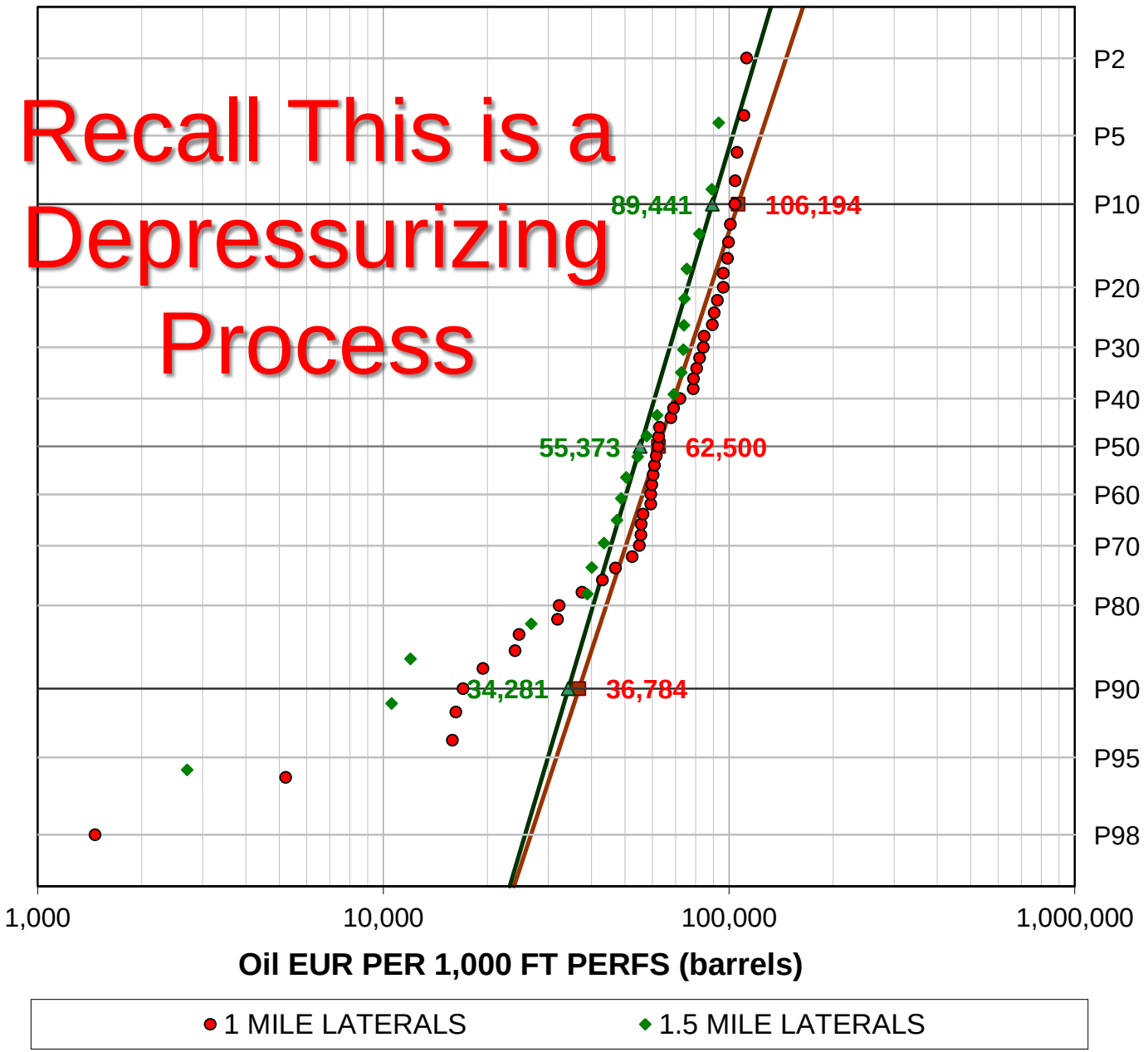

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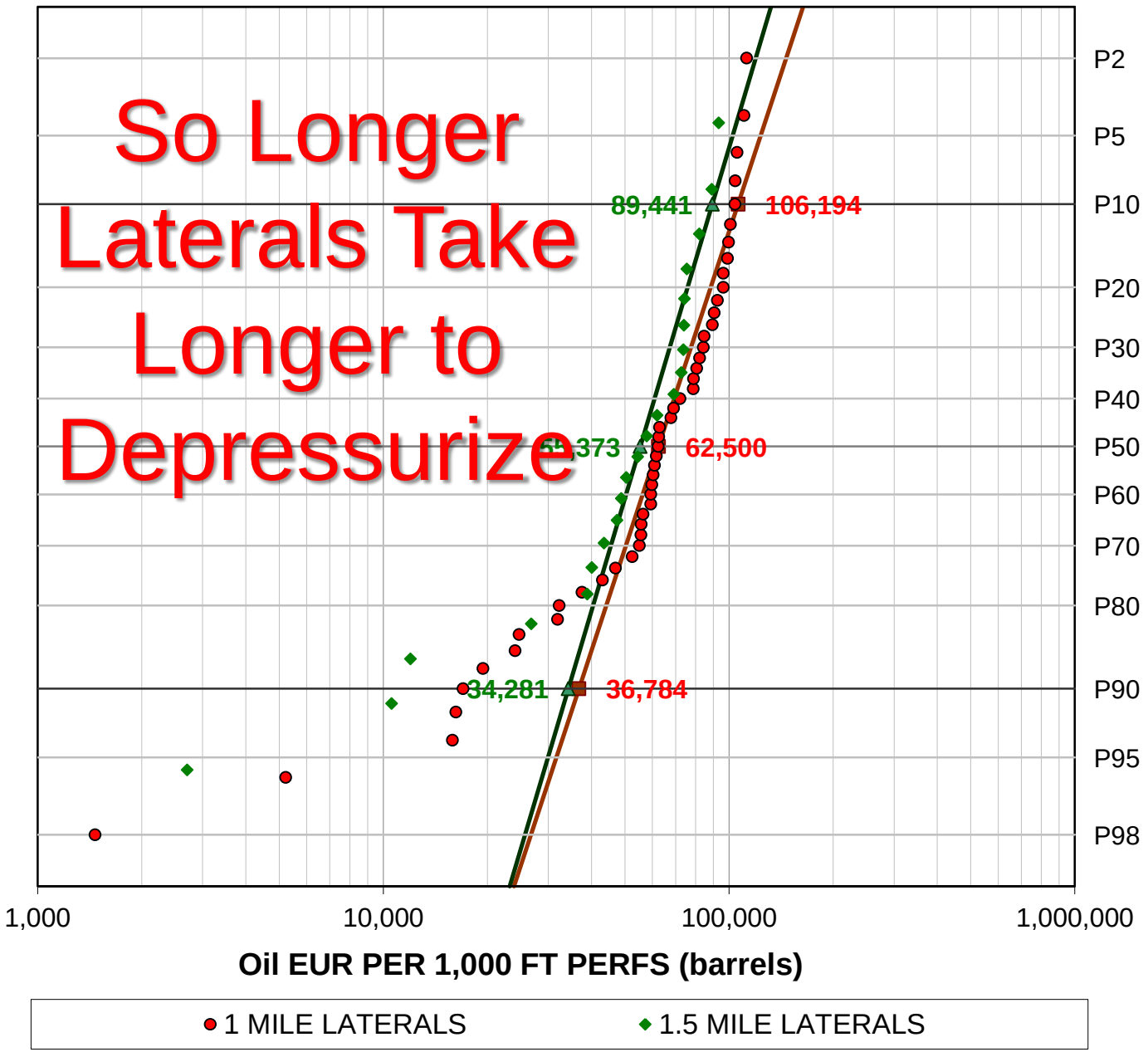

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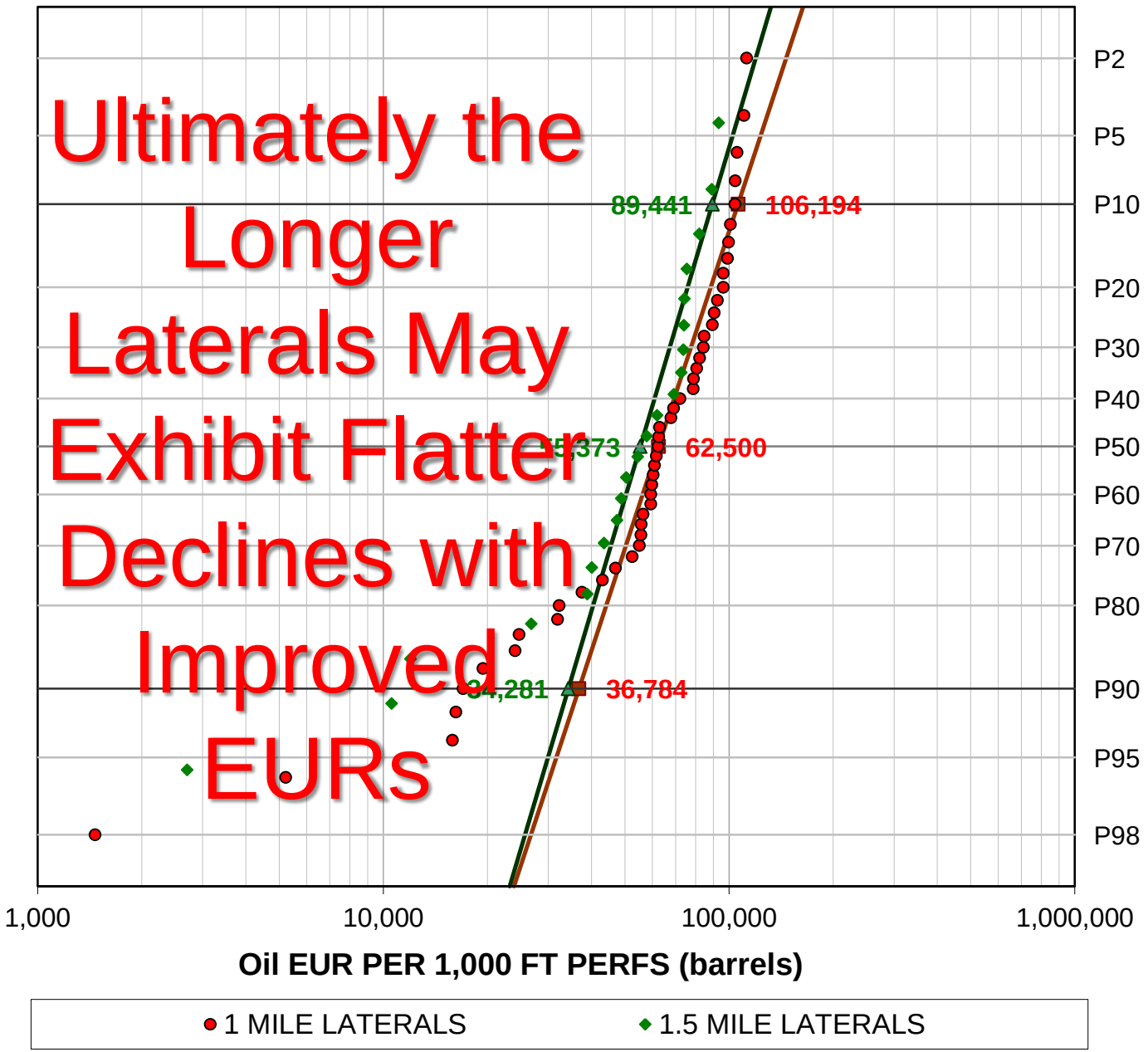
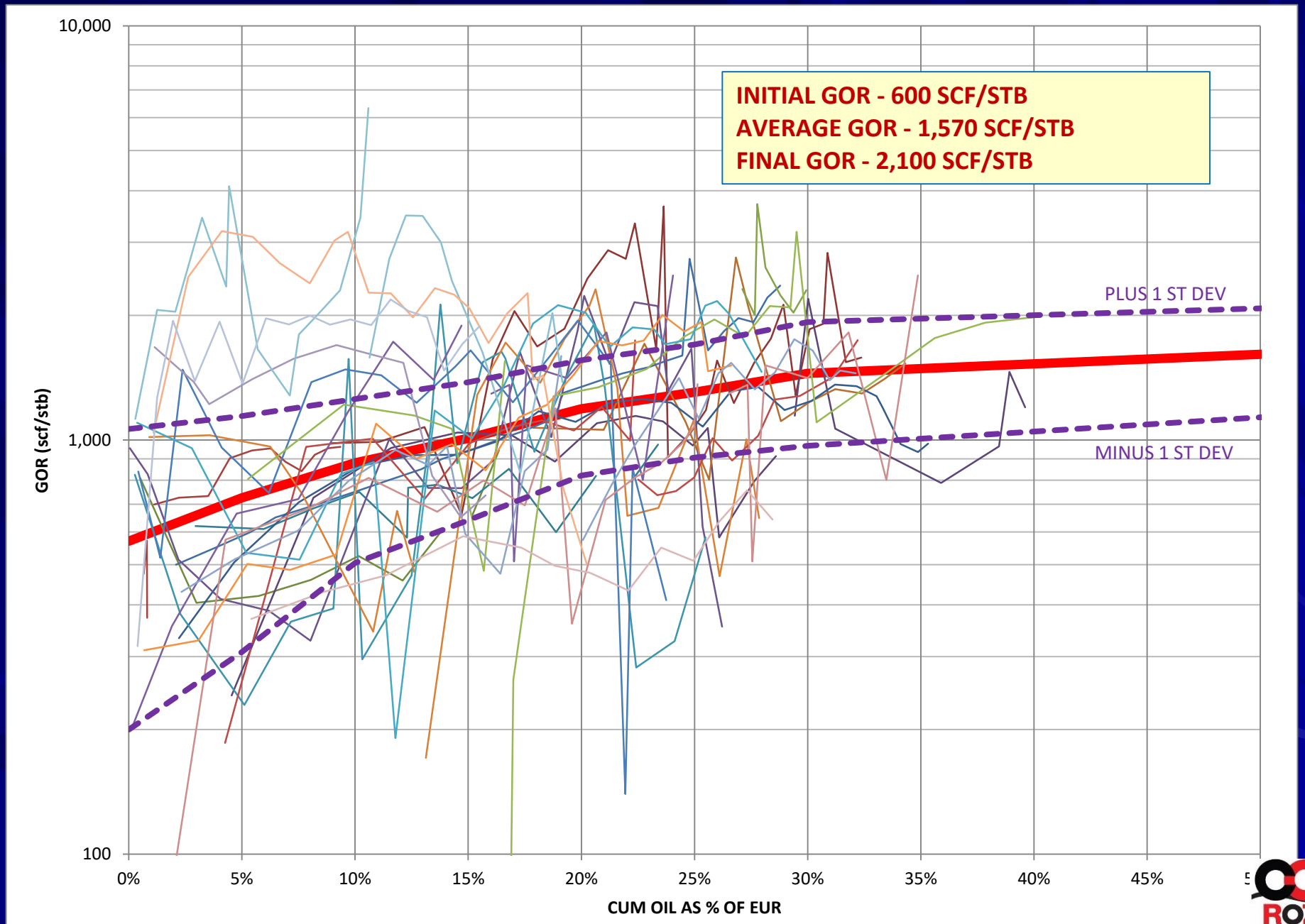


GOR Performance



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- Development History and Performance
- Average Porosity Ranges from 8.5% to 12%

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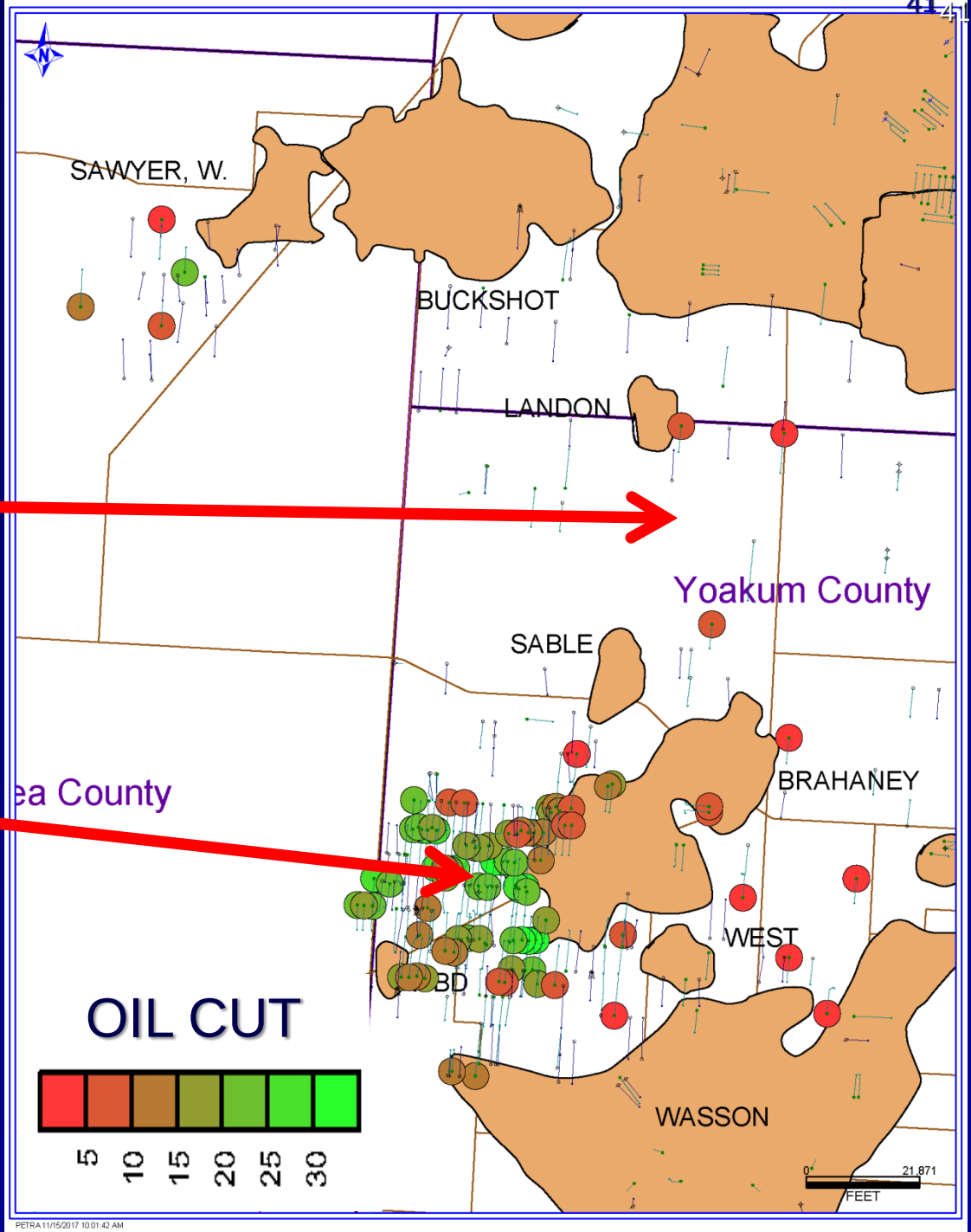
- Average Porosity Ranges from 8.5% to 12%
- Thickness Ranges from 60 ft to 90 ft
- Water Saturation Ranges from 45% to 55%
- Water Cut Varies More Than Log Measured Rock Properties Would Suggest

HZ San Andres Performance

5% to 10% Oil Cut

10% to 30% Oil Cut



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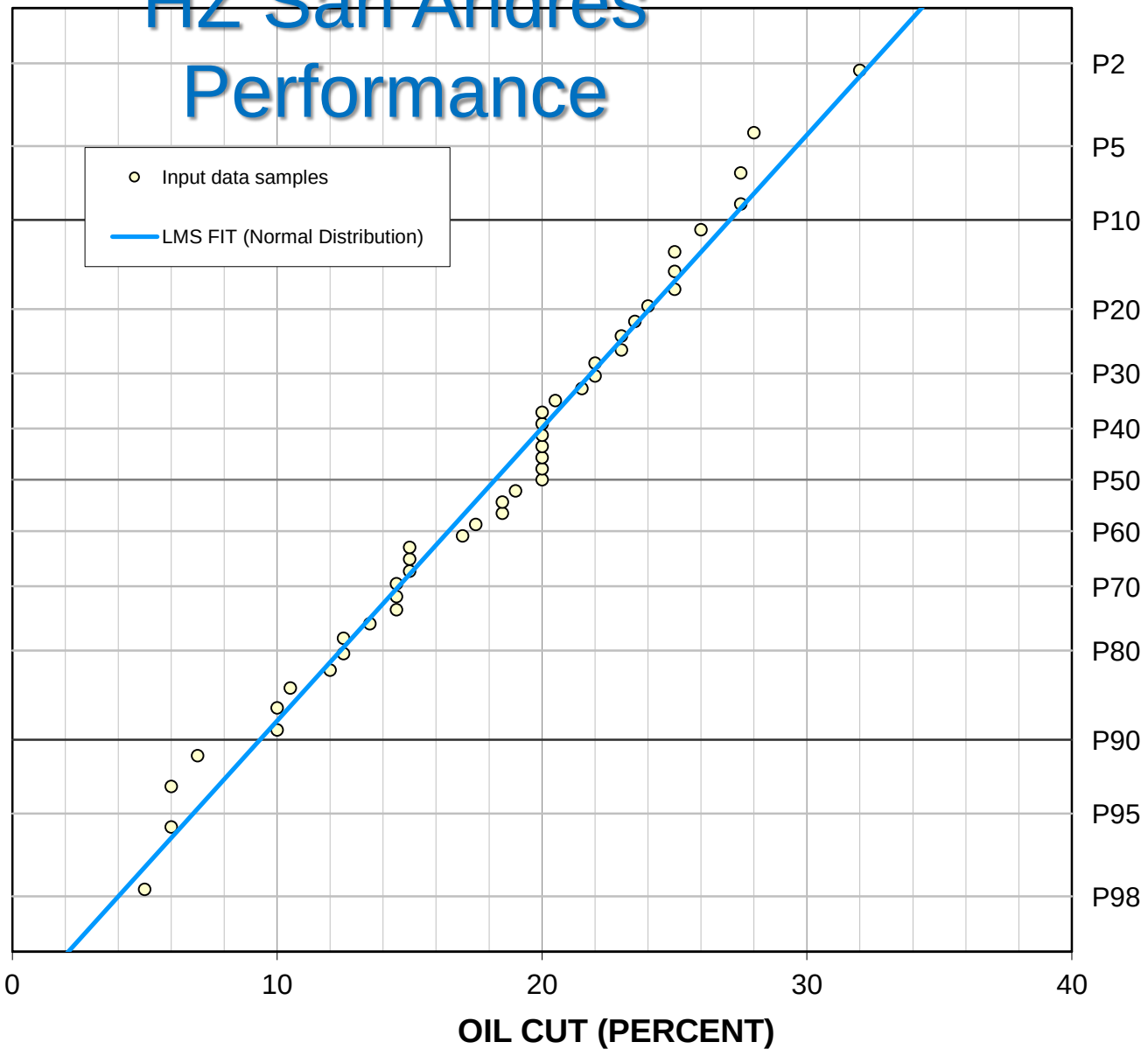

HZ San Andres Completions

- Operators Continue to Experiment With Completion Design

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- 100 Mesh Sand Is Used Less or Not At All

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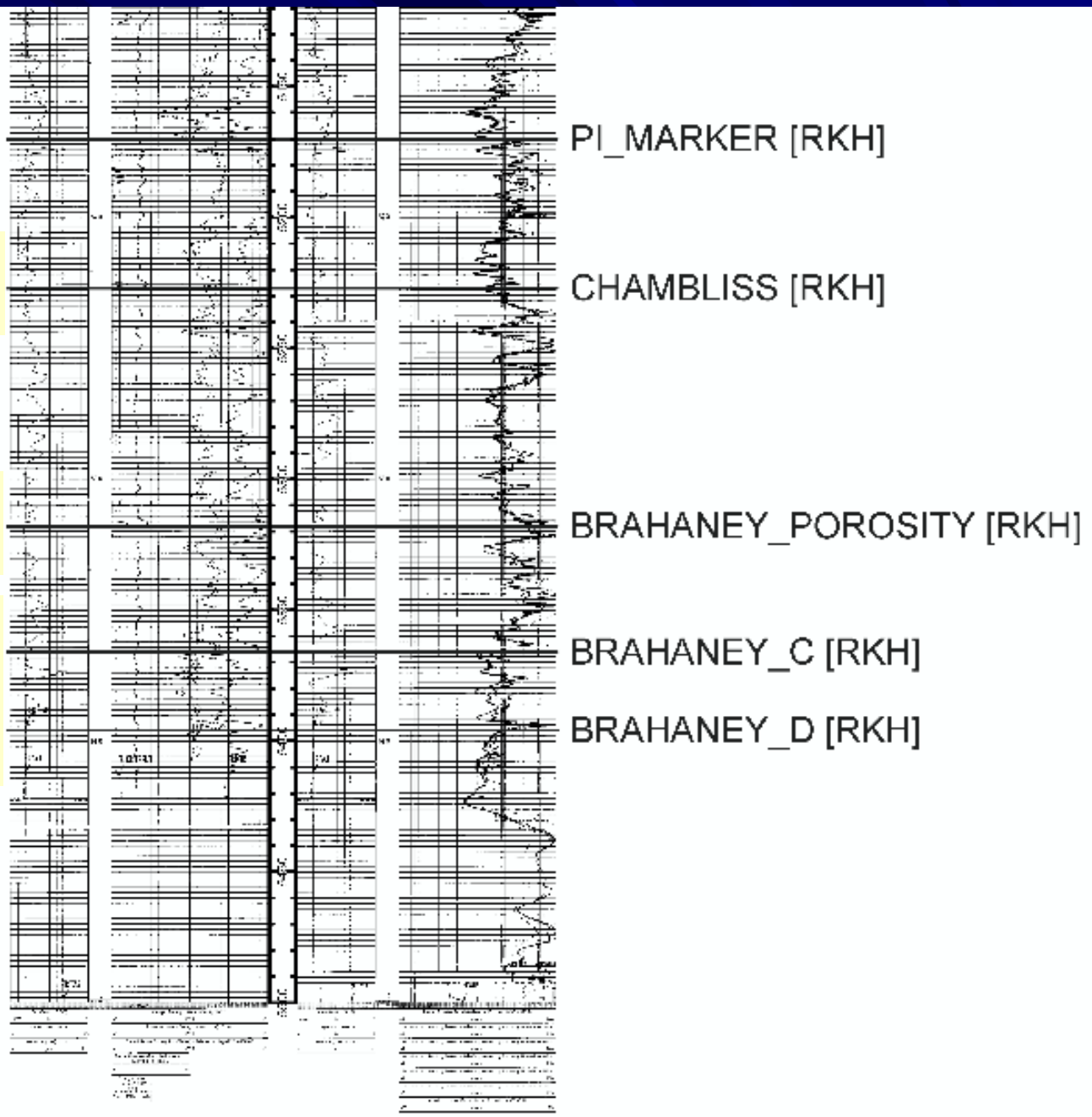
- High Rate Fracs Tend To Propagate Downward Into Underlying Wetter Intervals

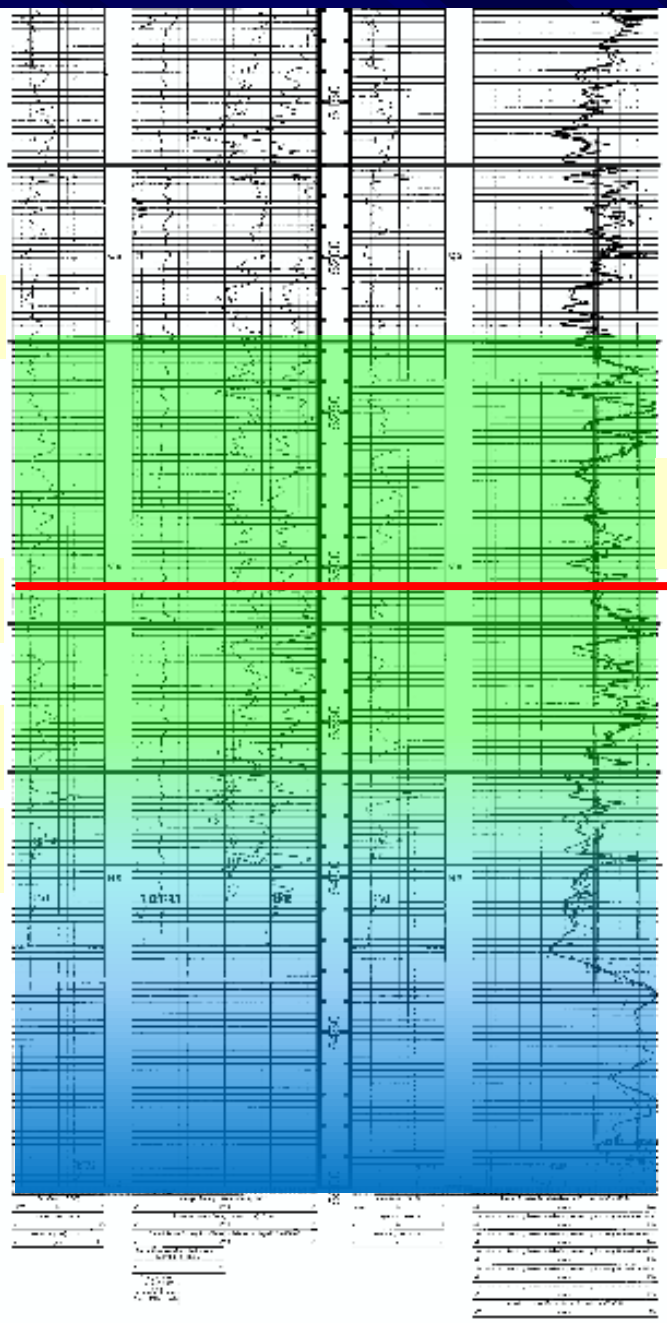


5,227

5,318

5,366

5,396



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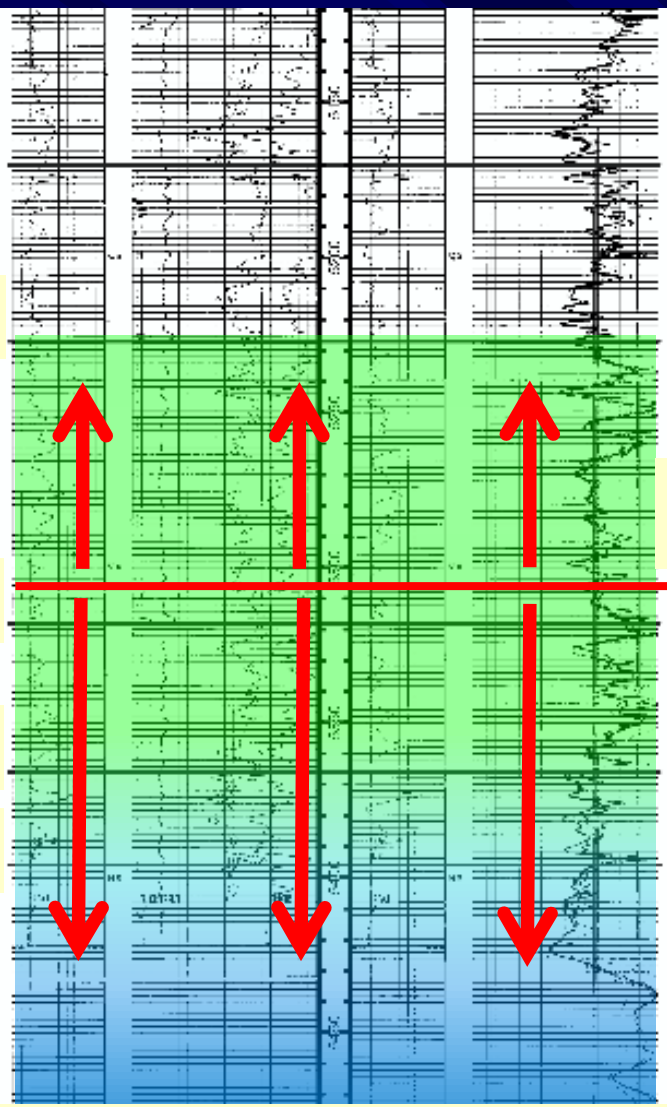
HZ LANDING DEPTH



5,227

5,318

5,366

5,396

HZ LANDING DEPTH

FRAC CAN PROPOGATE DOWNWARD INTO HIGHER PERM AND WETTER ROCK

HZ San Andres Completions

- Fracs Tend Towards Downward Growth (Path of Least Resistance)
- Permeability Increases with Depth
- Deeper Formations have Higher Water Saturation
- Stimulations Out of Zone Make LOTS of Water

Reservoir Fluid Properties

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- Evaluators Usually Consider Rock Properties (Porosity, Permeability, and Saturations)

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BUT OFTEN OVERLOOK

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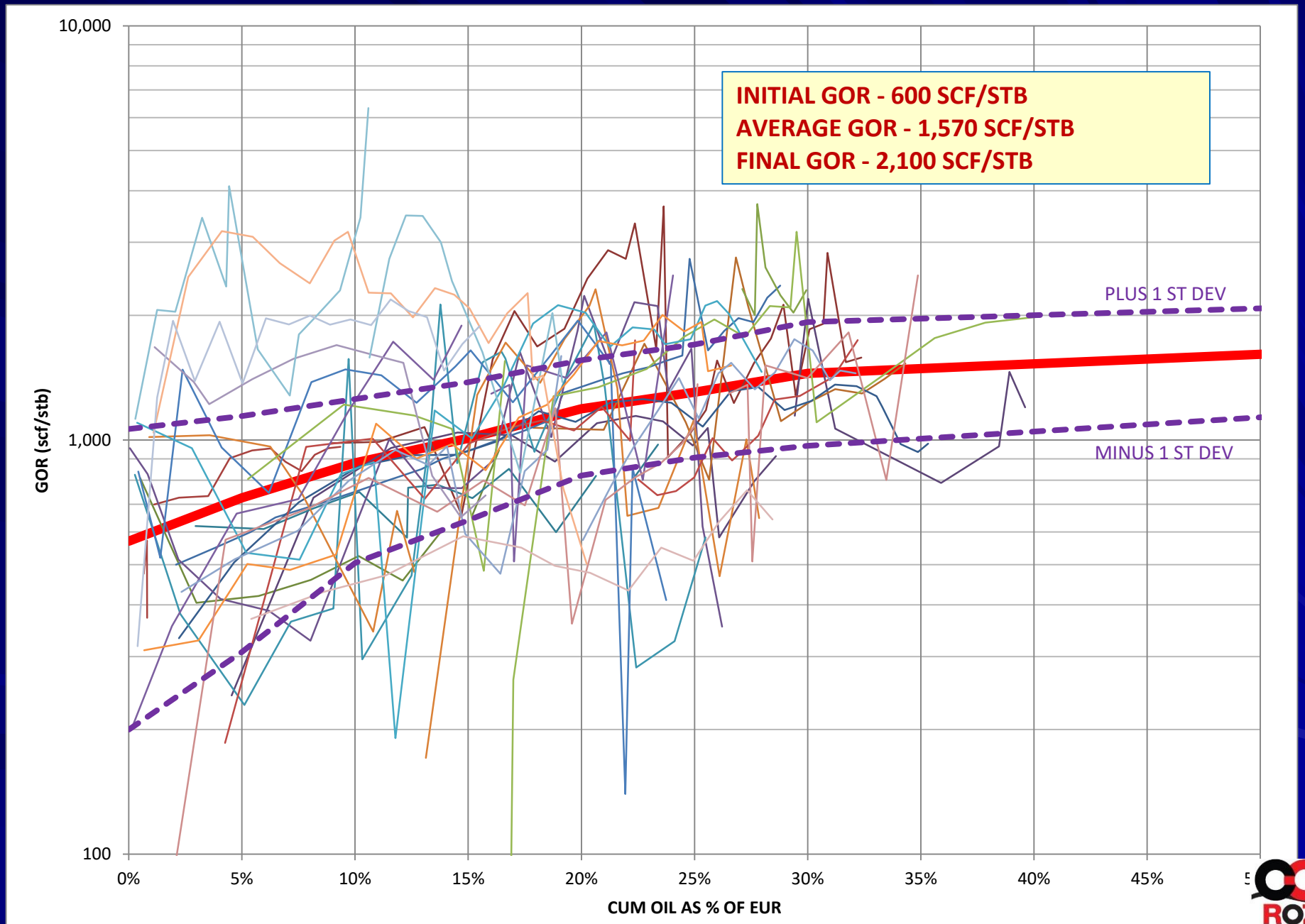
BUT OFTEN OVERLOOK

- Reservoir Fluid Properties (Viscosity, Solution GOR)

Reservoir Fluid Properties

- Solution Gas-to-Oil Ratio (GOR)

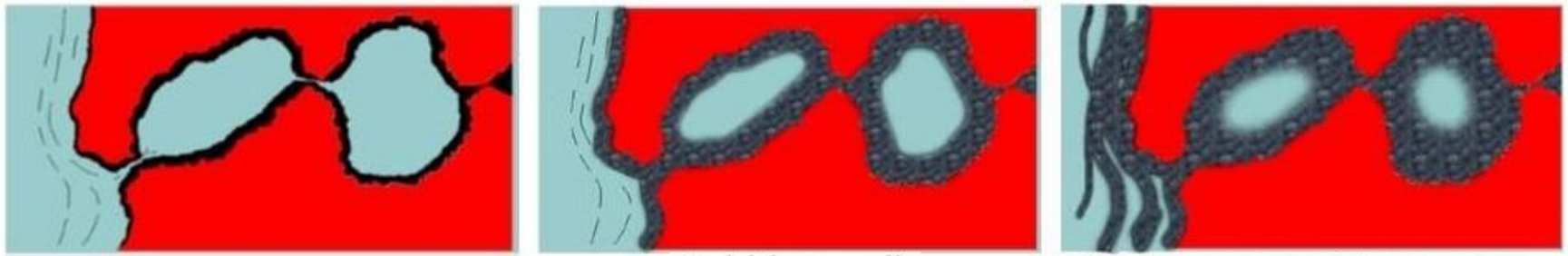
GOR Performance



ROZ Depressuring

How Does ROZ Depressuring Work?

The ROZs have Oil Affixed to the Rock Surfaces and, if that Oil Has Gas in it, Depressuring Releases Some of the Oil and Entrained Gas



Bubbles swell

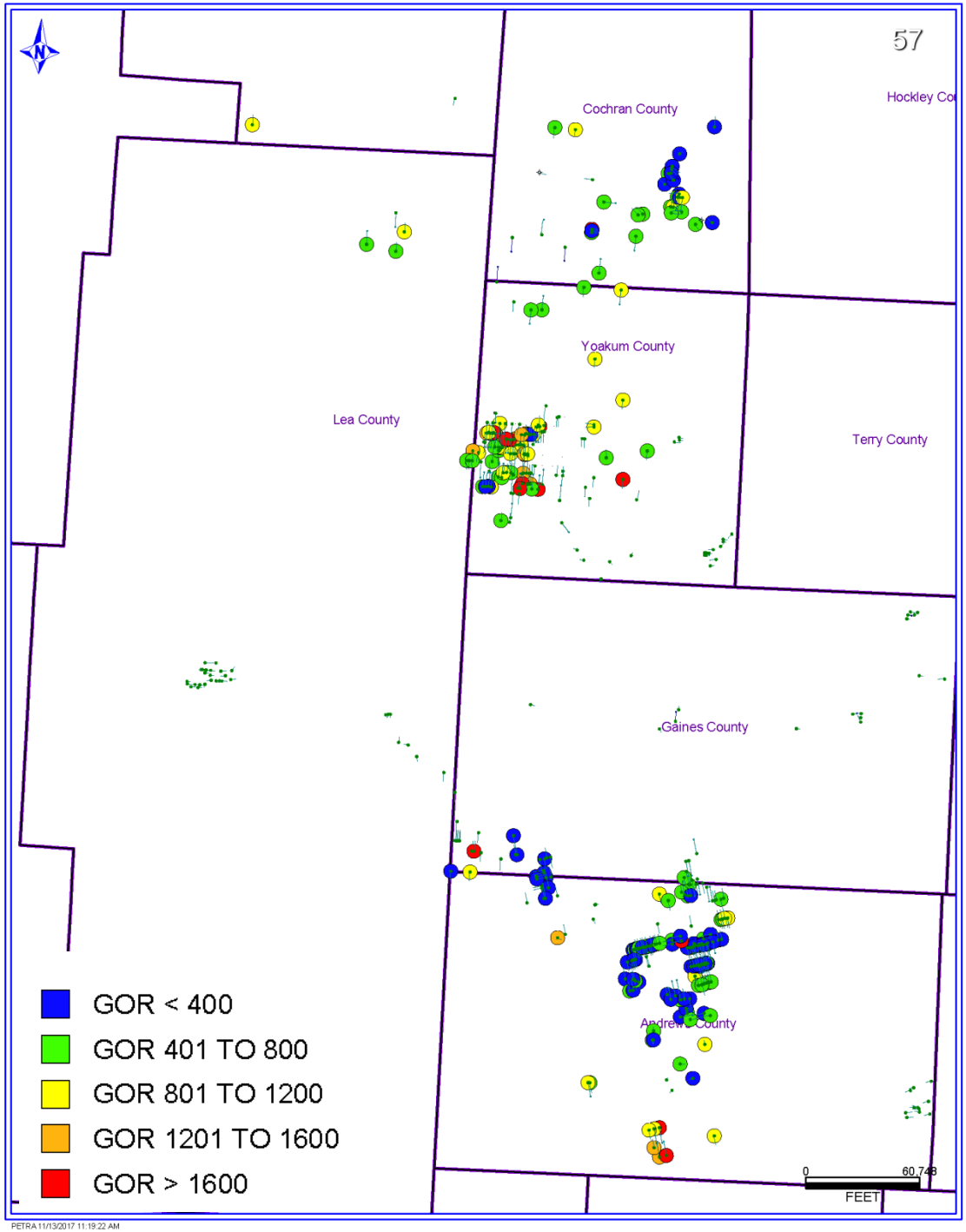
Oil Seeps out of the poors. …

…and into the flowstream to flow to the well. Lots of water is produced to accomplish the depressuring

Melzer Consulting

Gas to Oil Ratio (GOR)

After Producing 1 Year



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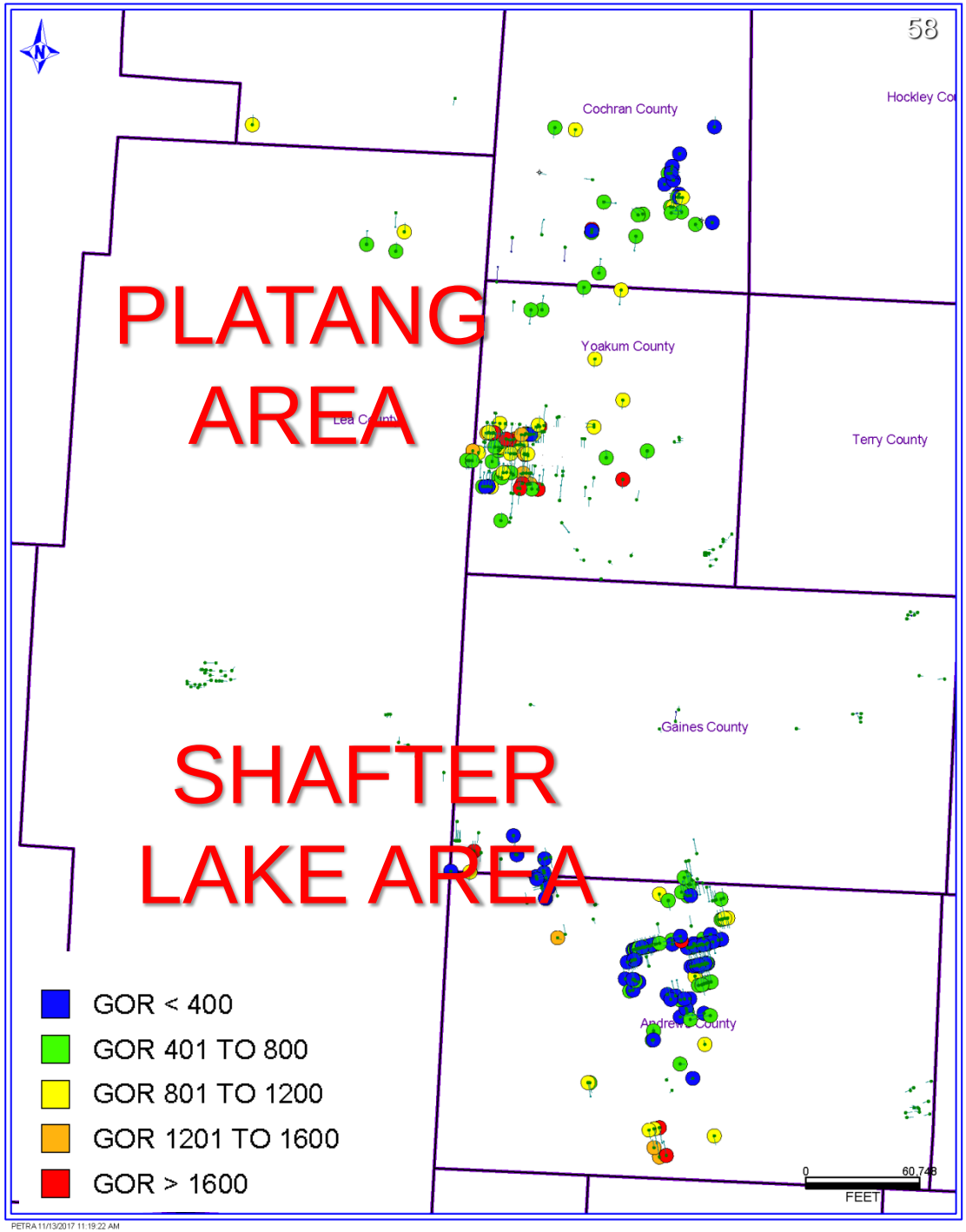

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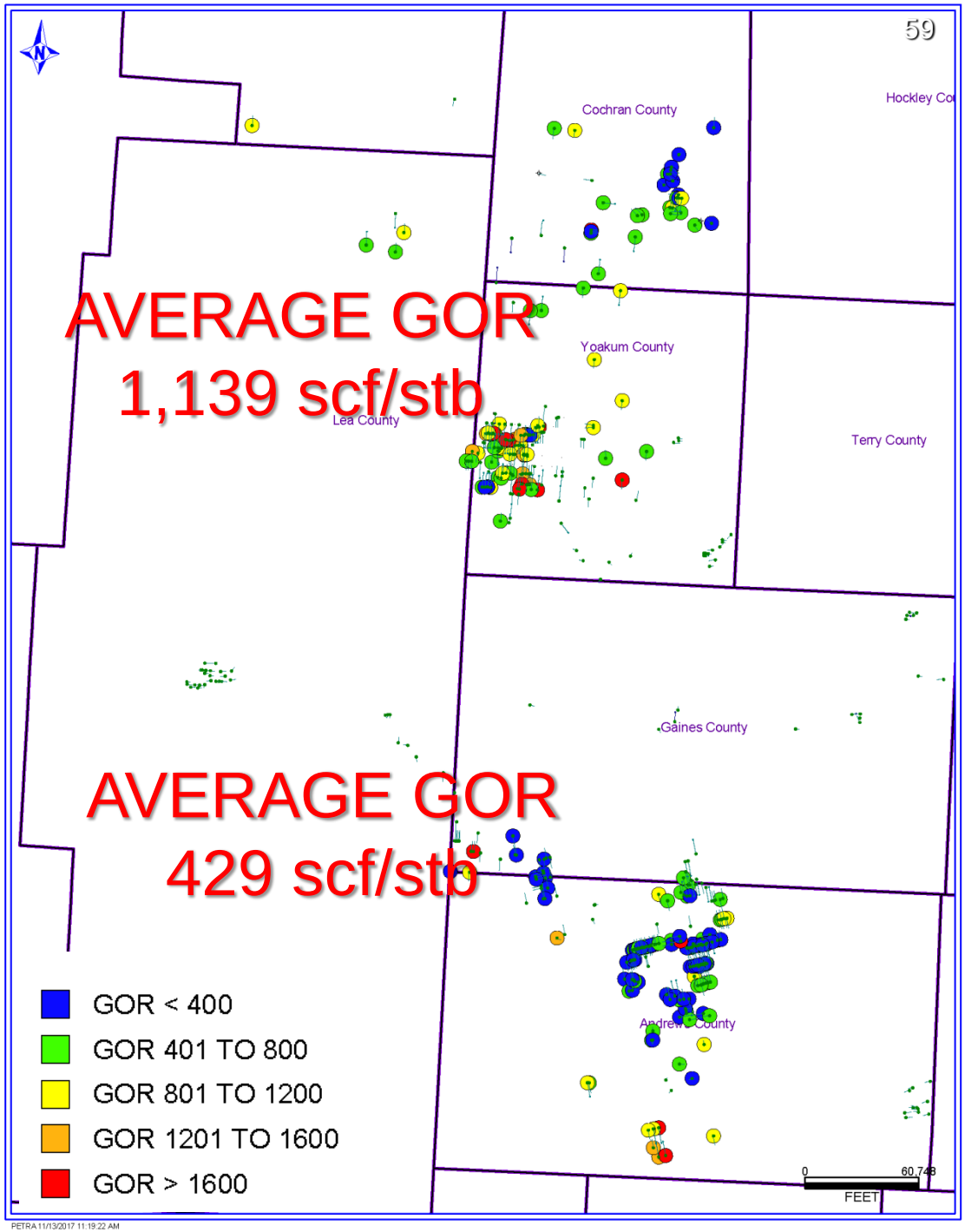
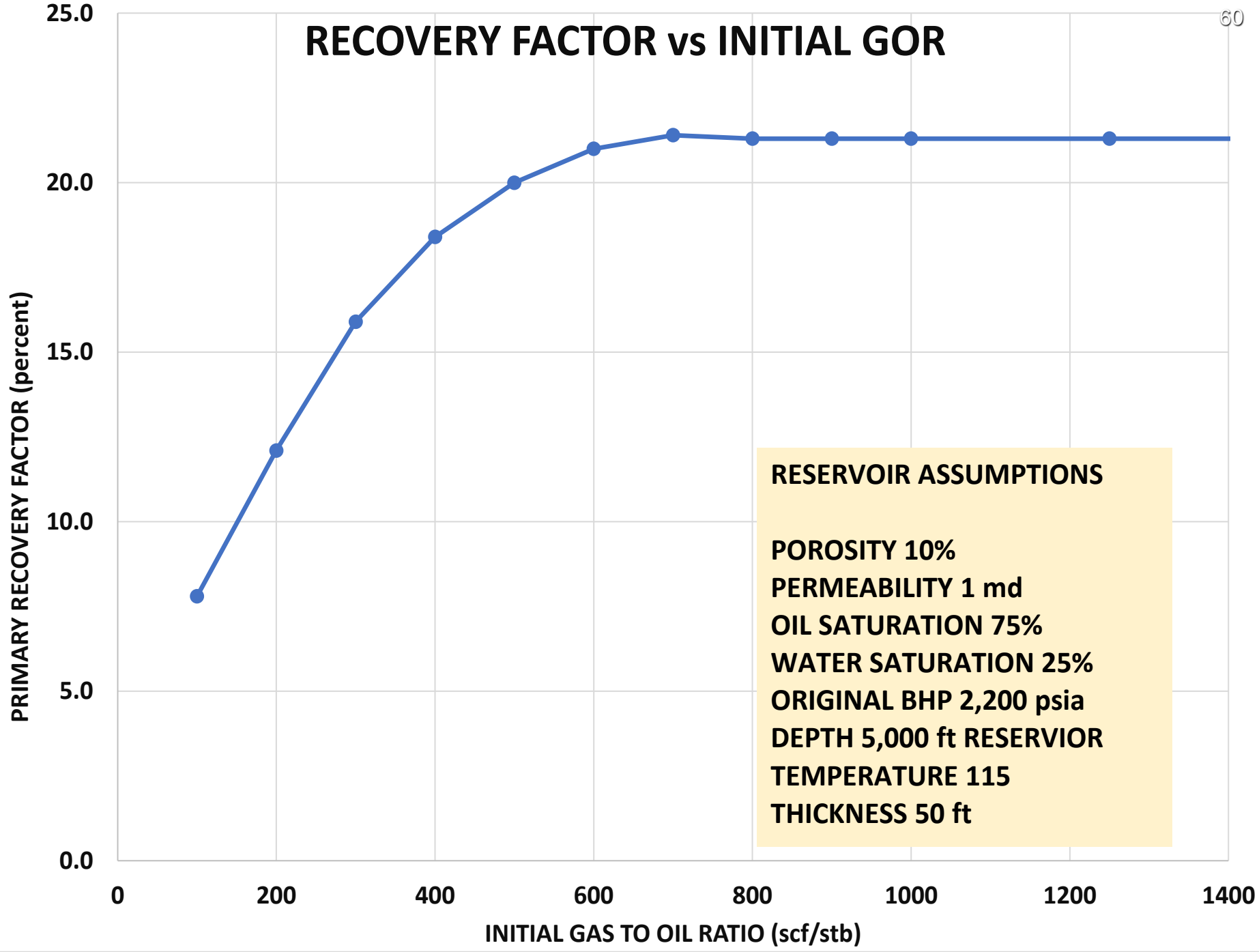
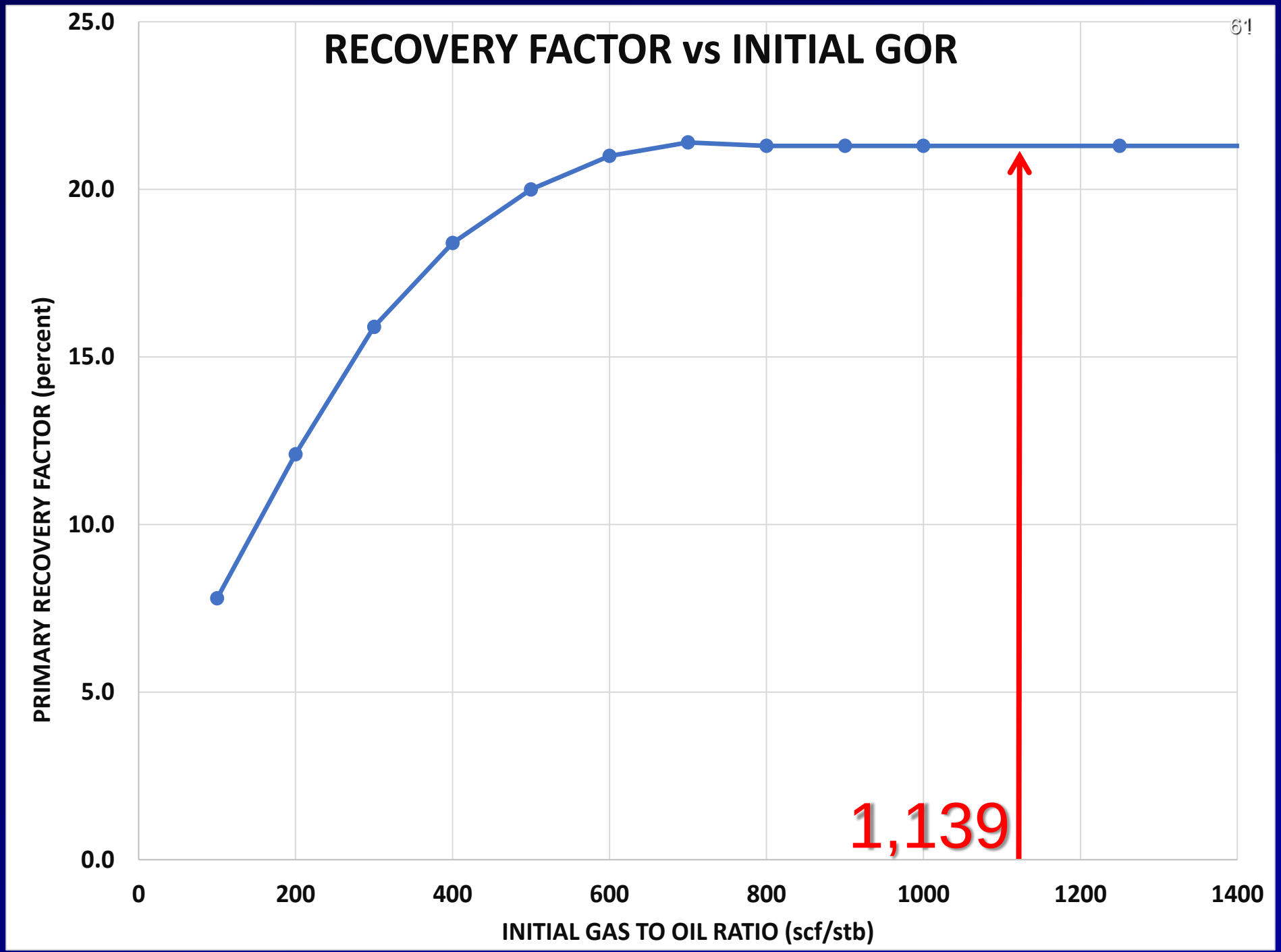
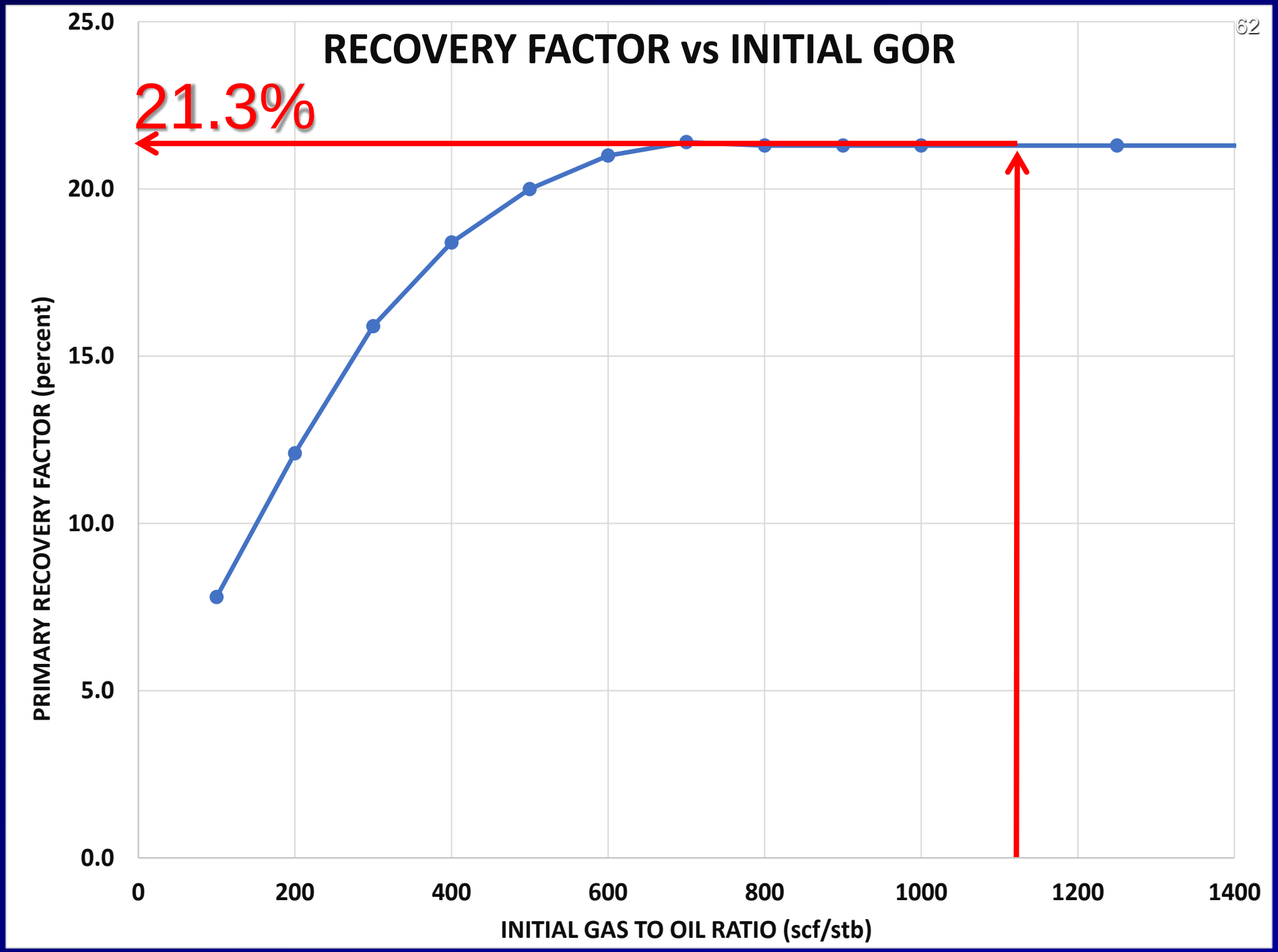
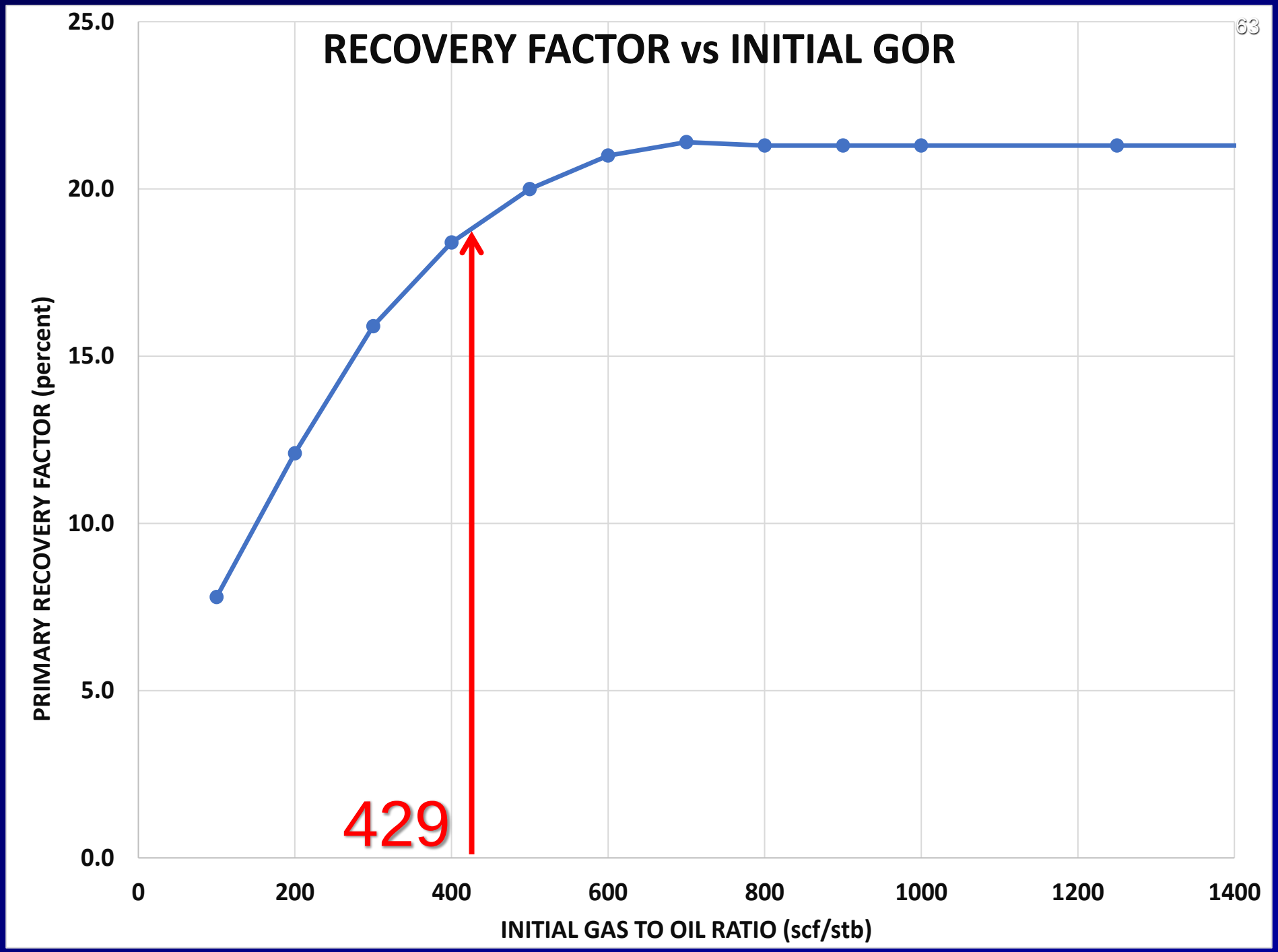


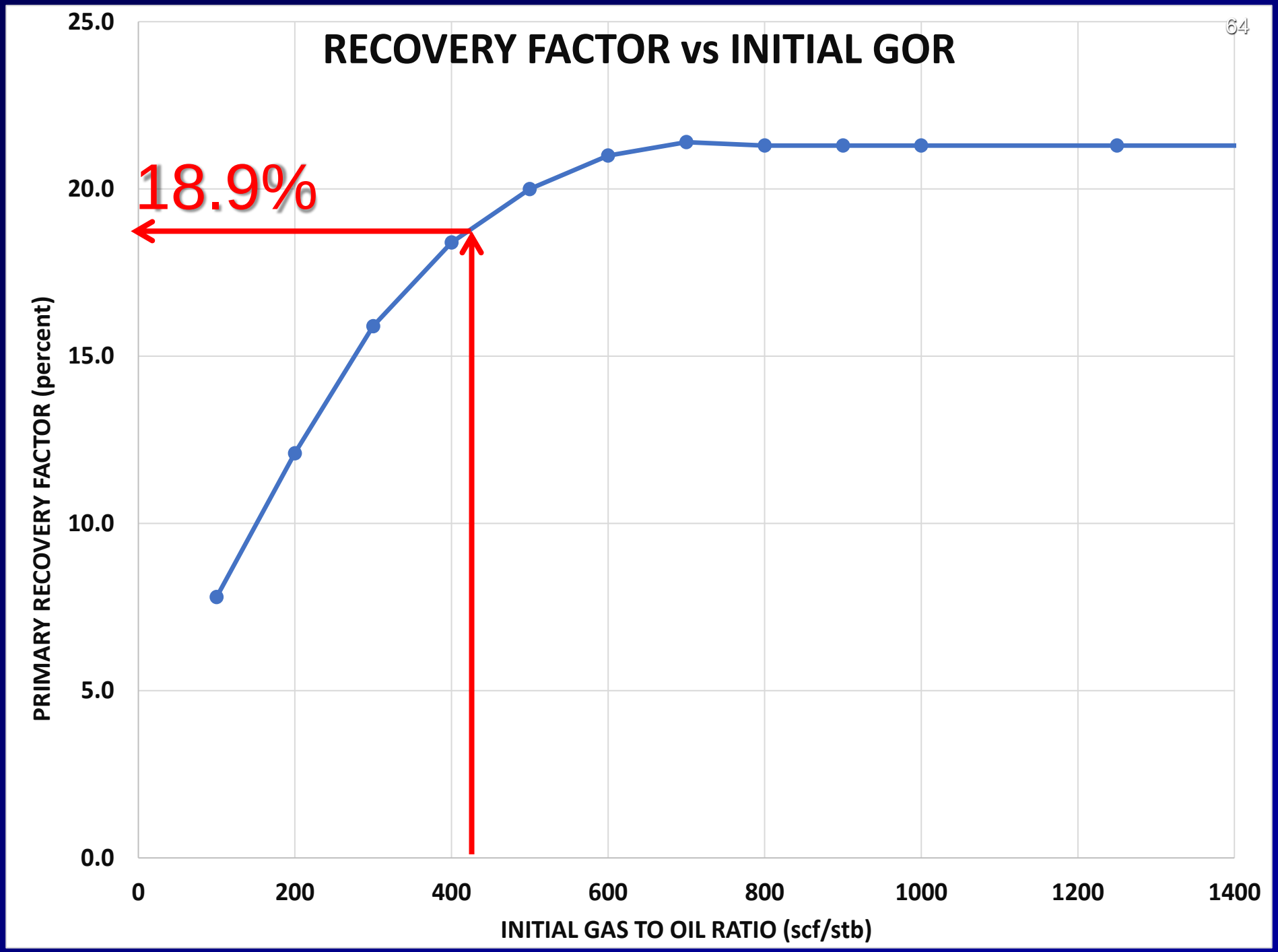
RECOVERY FACTOR vs INITIAL GOR




RECOVERY FACTOR vs INITIAL GOR
PRIMARY RECOVERY FACTOR (percent)
25.0
20.0
15.0
10.0
5.0
0.0
0
200
400
600
800
1000
1200
1400
INITIAL GAS TO OIL RATIO (scf/stb)
1,139


RECOVERY FACTOR vs INITIAL GOR
21.3%
PRIMARY RECOVERY FACTOR (percent)
25.0
20.0
15.0
10.0
5.0
0.0
0
200
400
600
800
1000
1200
1400
INITIAL GAS TO OIL RATIO (scf/stb)


RECOVERY FACTOR vs INITIAL GOR
25.0
20.0
15.0
10.0
5.0
0.0
PRIMARY RECOVERY FACTOR (percent)
0
200
400
600
800
1000
1200
1400
INITIAL GAS TO OIL RATIO (scf/stb)
429

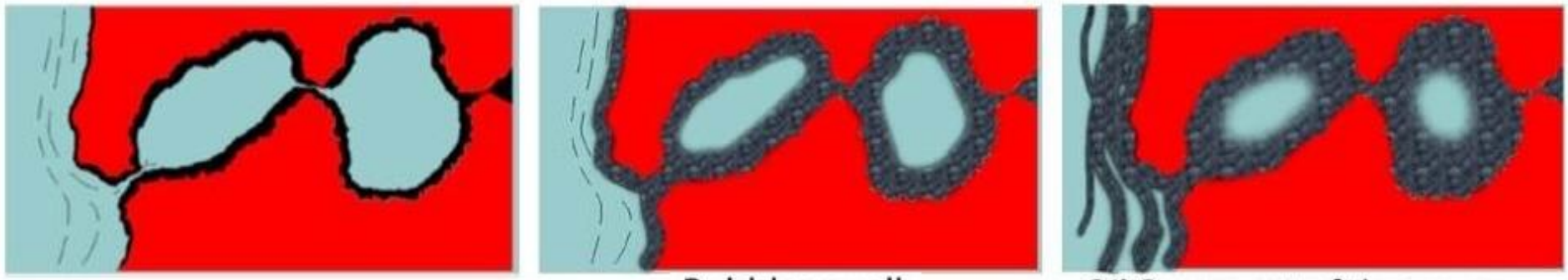

RECOVERY FACTOR vs INITIAL GOR
18.9%
PRIMARY RECOVERY FACTOR (percent)
25.0
20.0
15.0
10.0
5.0
0.0
0
200
400
600
800
1000
1200
1400
INITIAL GAS TO OIL RATIO (scf/stb)

Reservoir Fluid Properties

- Change in GOR (1,139 to 429) Results in 11% Drop in Recovery Factor

Reservoir Fluid Properties

- Change in GOR (1,139 to 429) Results in 11% Drop in Recovery Factor
- However GOR Change May Have a MORE PRONOUNCED Effect Due to ROZ Depressurization



Source Melzer

Reservoir Fluid Properties

- Solution Gas-to-Oil Ratio (GOR)
- Oil Gravity

DARCY'S LAW

$$q \propto \frac{\Delta p k h}{\mu}$$

where:

q – Flow Rate

Δp – Pressure

k – Permeability

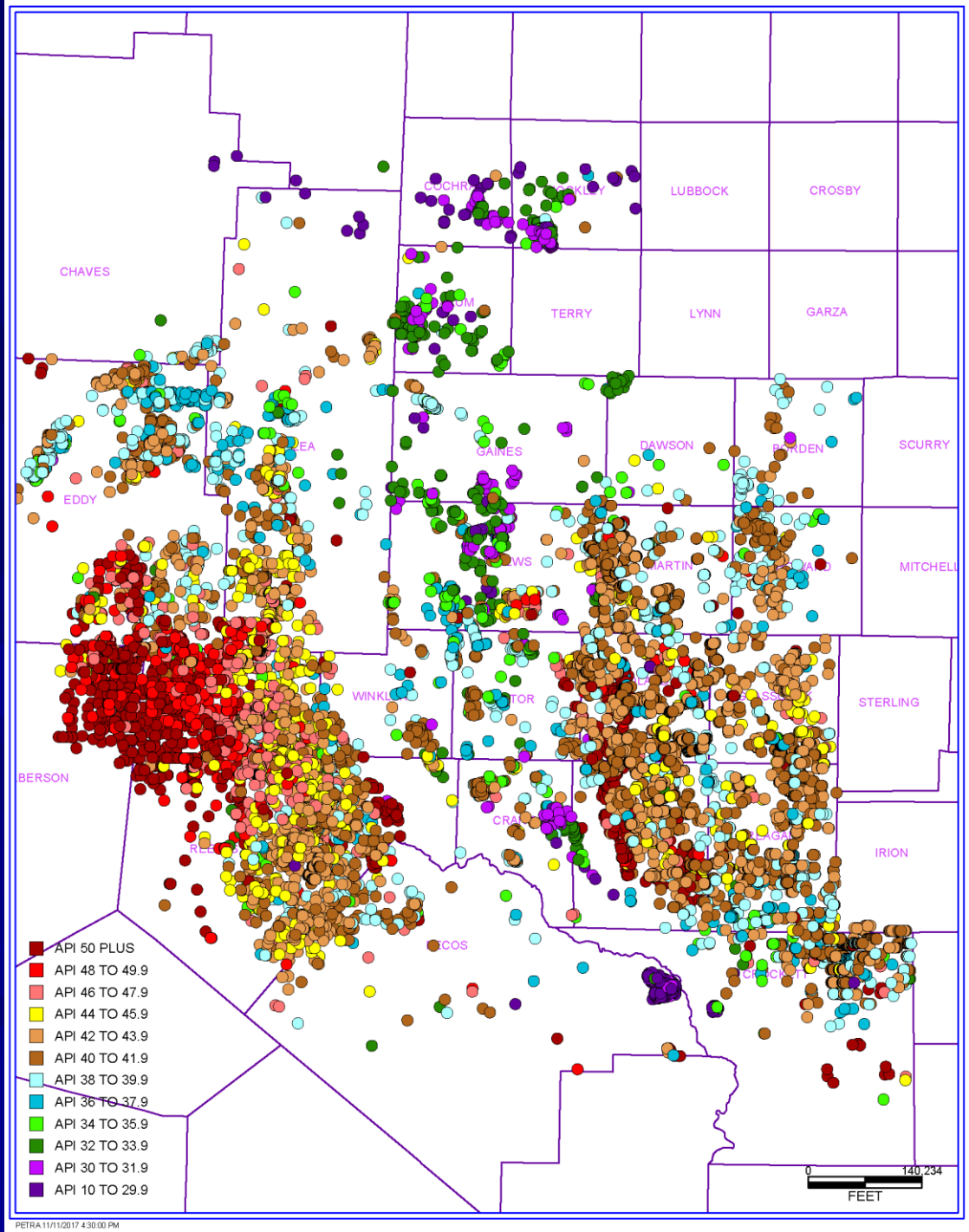
h – Height

μ - Viscosity

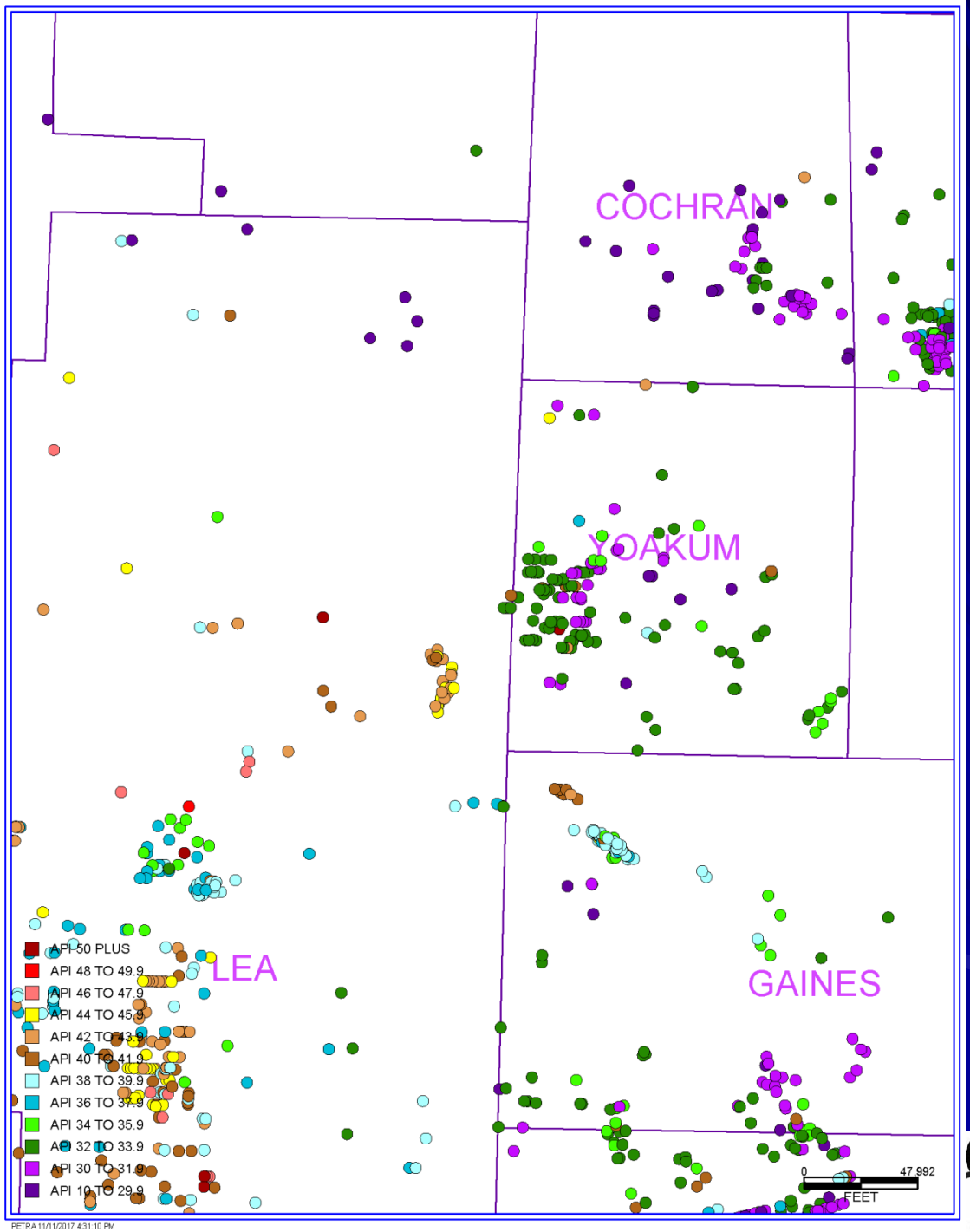
CO_2 ROZ 2017 Conference

API Gravity

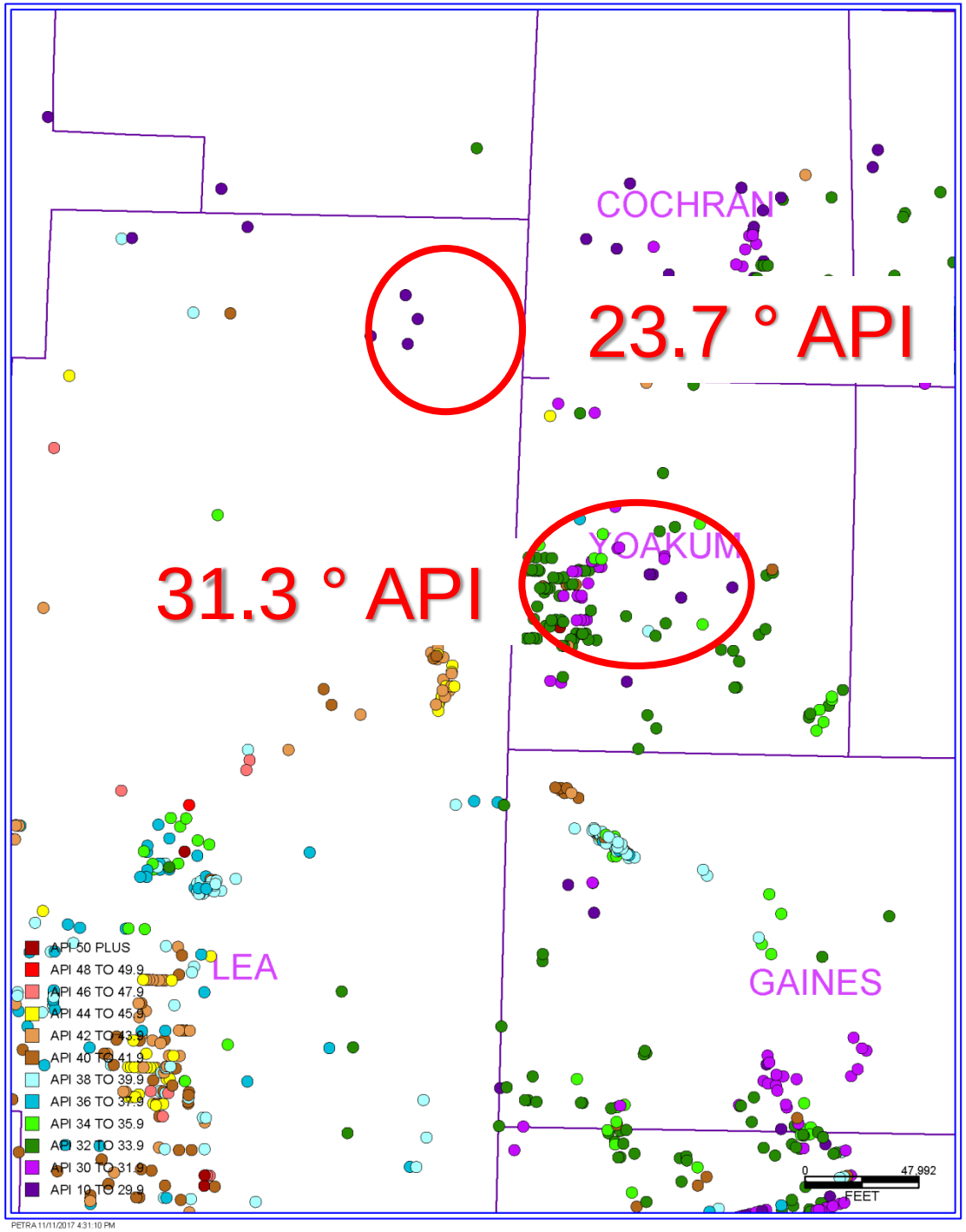
Permian Basin Horizontal Wells



API Gravity


COCHRAN
YOAKUM
LEA
GAINES
API 50 PLUS
API 48 TO 49.9
API 46 TO 47.9
API 44 TO 45.9
API 42 TO 43.9
API 40 TO 41.9
API 38 TO 39.9
API 36 TO 37.9
API 34 TO 35.9
API 32 TO 33.9
API 30 TO 31.9
API 10 TO 29.9
0
47,992
FEET
PETRA 11/11/2017 4:31:10 PM

API Gravity


COCHRAN
23.7 ° API
31.3 ° API
YOAKUM
LEA
GAINES
API 50 PLUS
API 48 TO 49.9
API 46 TO 47.9
API 44 TO 45.9
API 42 TO 43.9
API 40 TO 41.9
API 38 TO 39.9
API 36 TO 37.9
API 34 TO 35.9
API 32 TO 33.9
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API 10 TO 29.9
0
47,992
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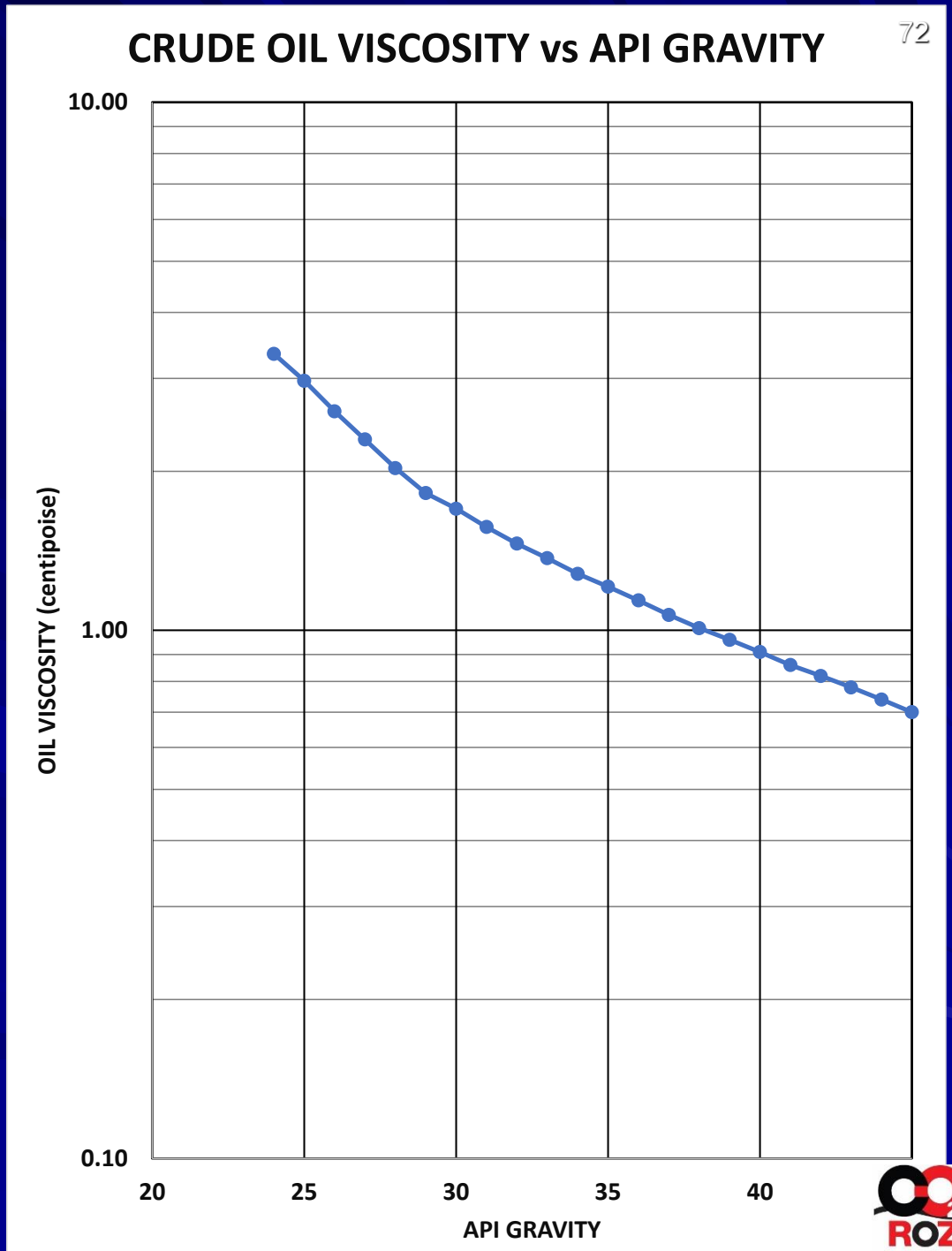
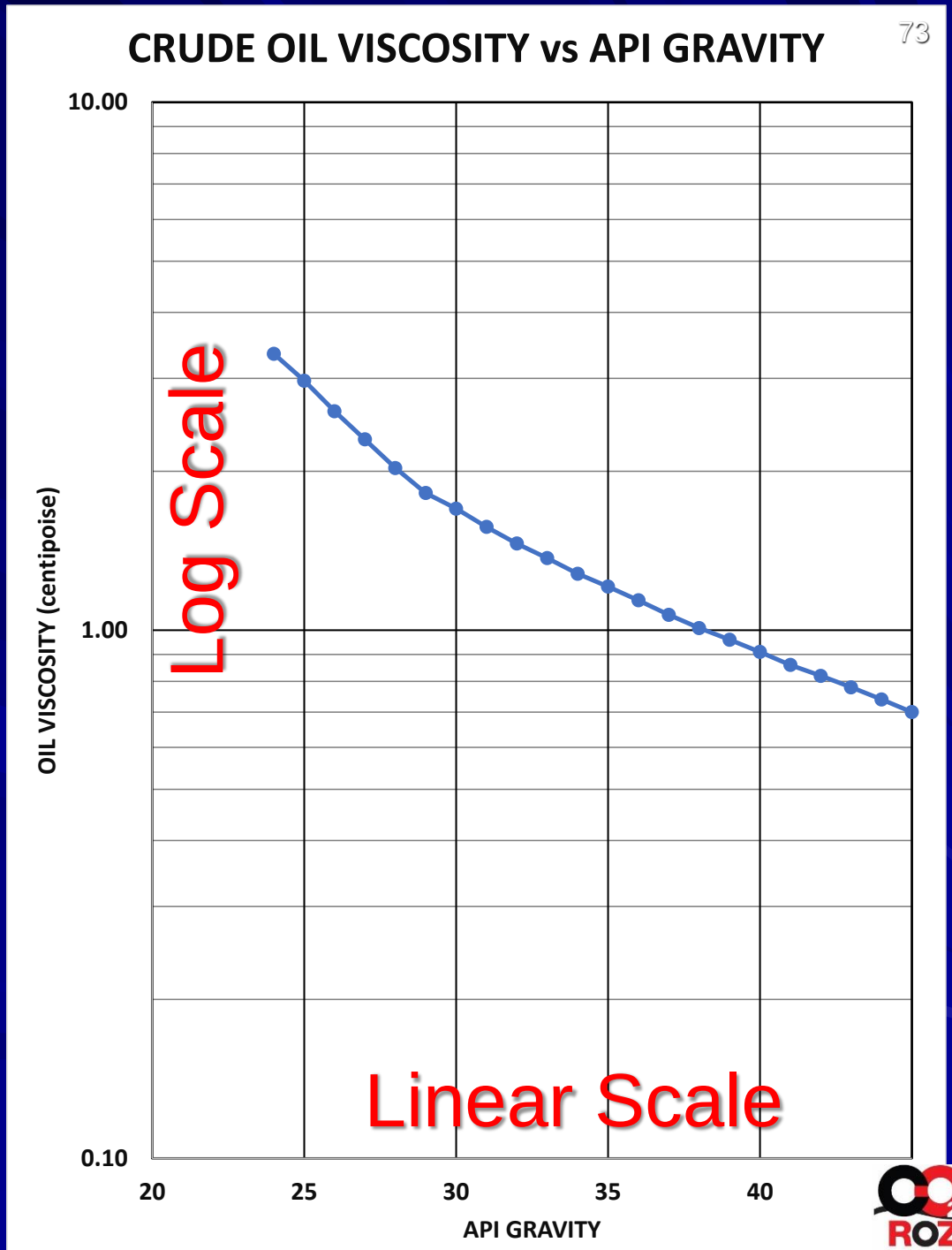
PETRA 11/11/2017 4:31:10 PM

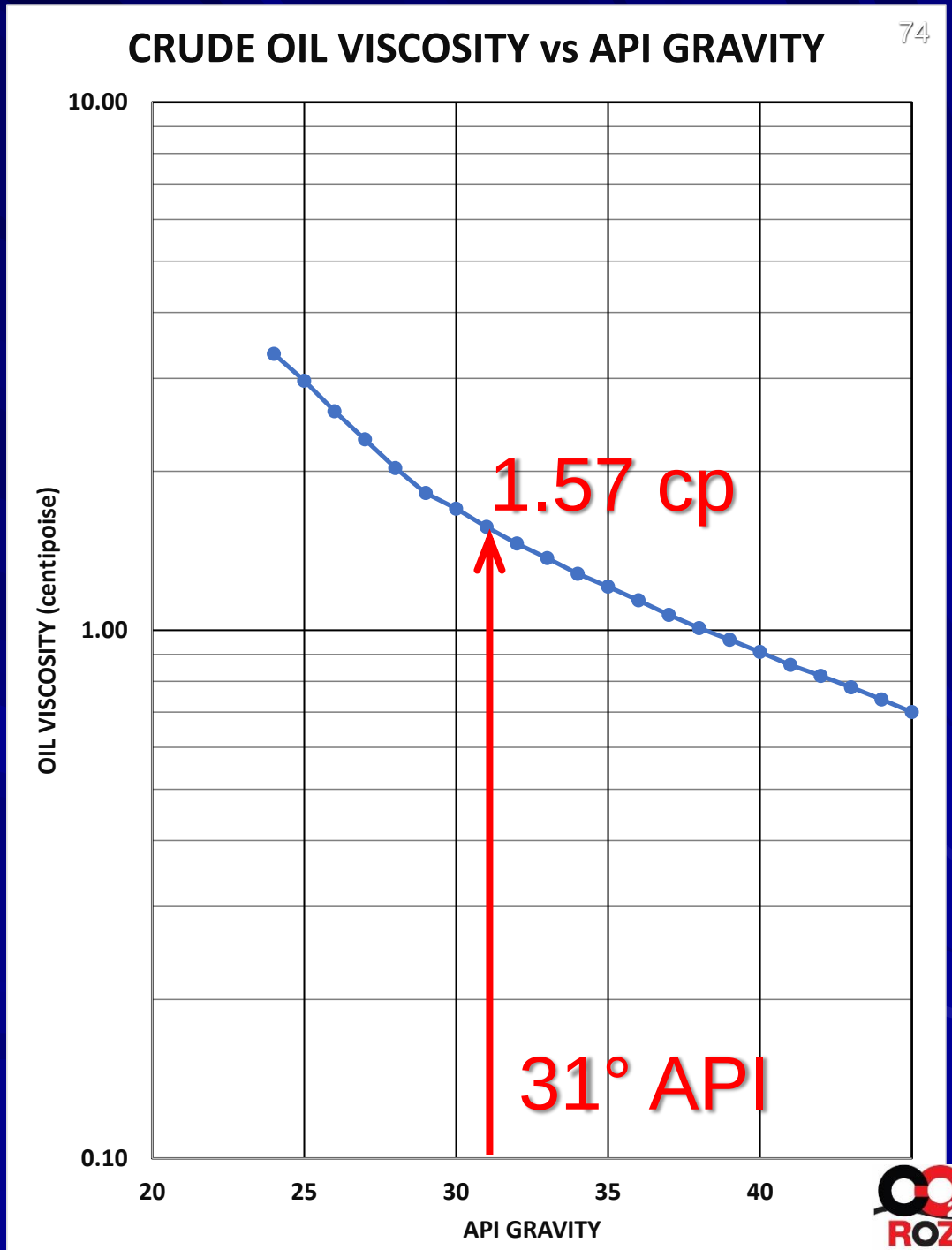
Crude Oil Viscosity Changes Dramatically With API Gravity



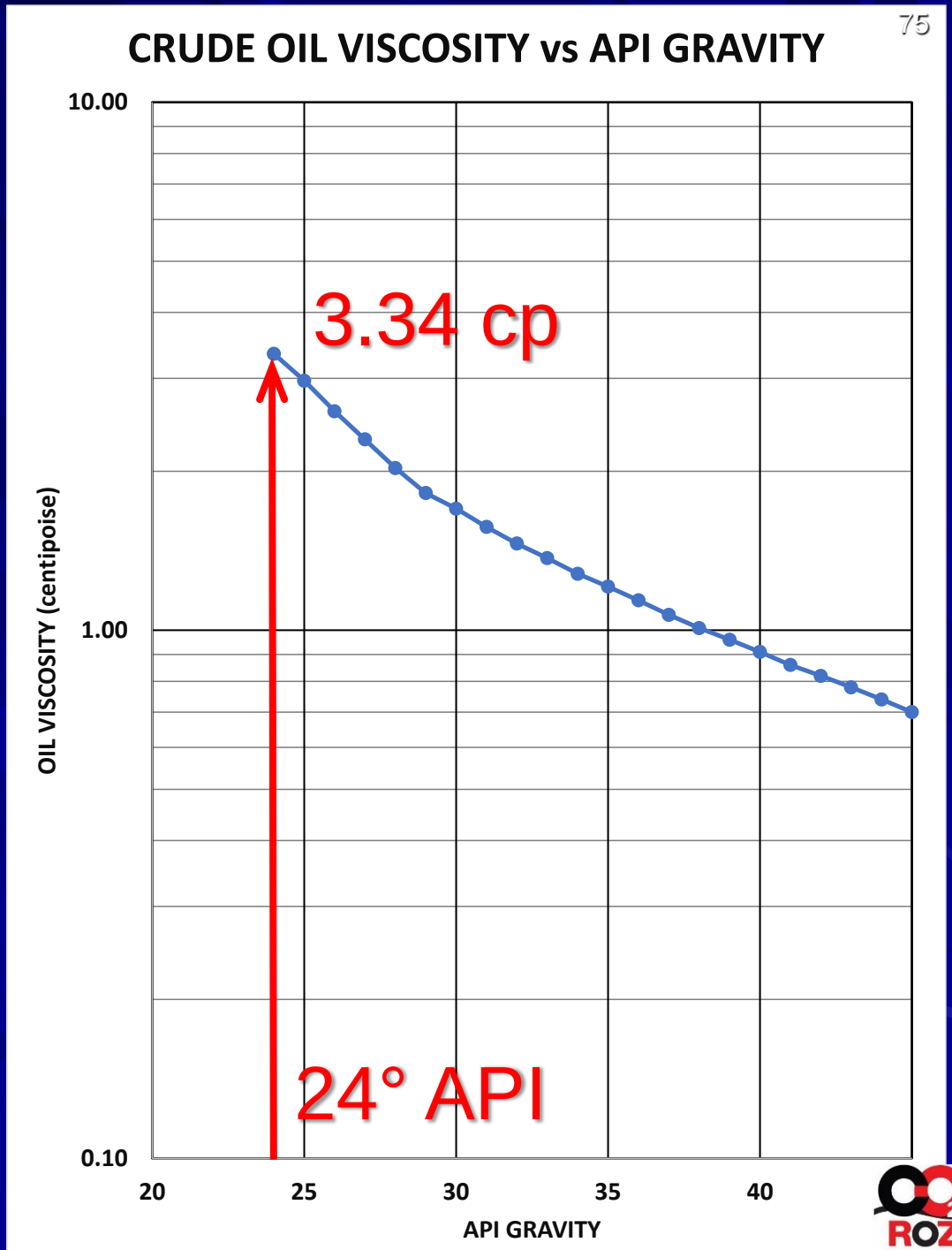
Crude Oil Viscosity Changes Dramatically With API Gravity



Crude Oil Viscosity Changes Dramatically With API Gravity



Crude Oil Viscosity Changes Dramatically With API Gravity

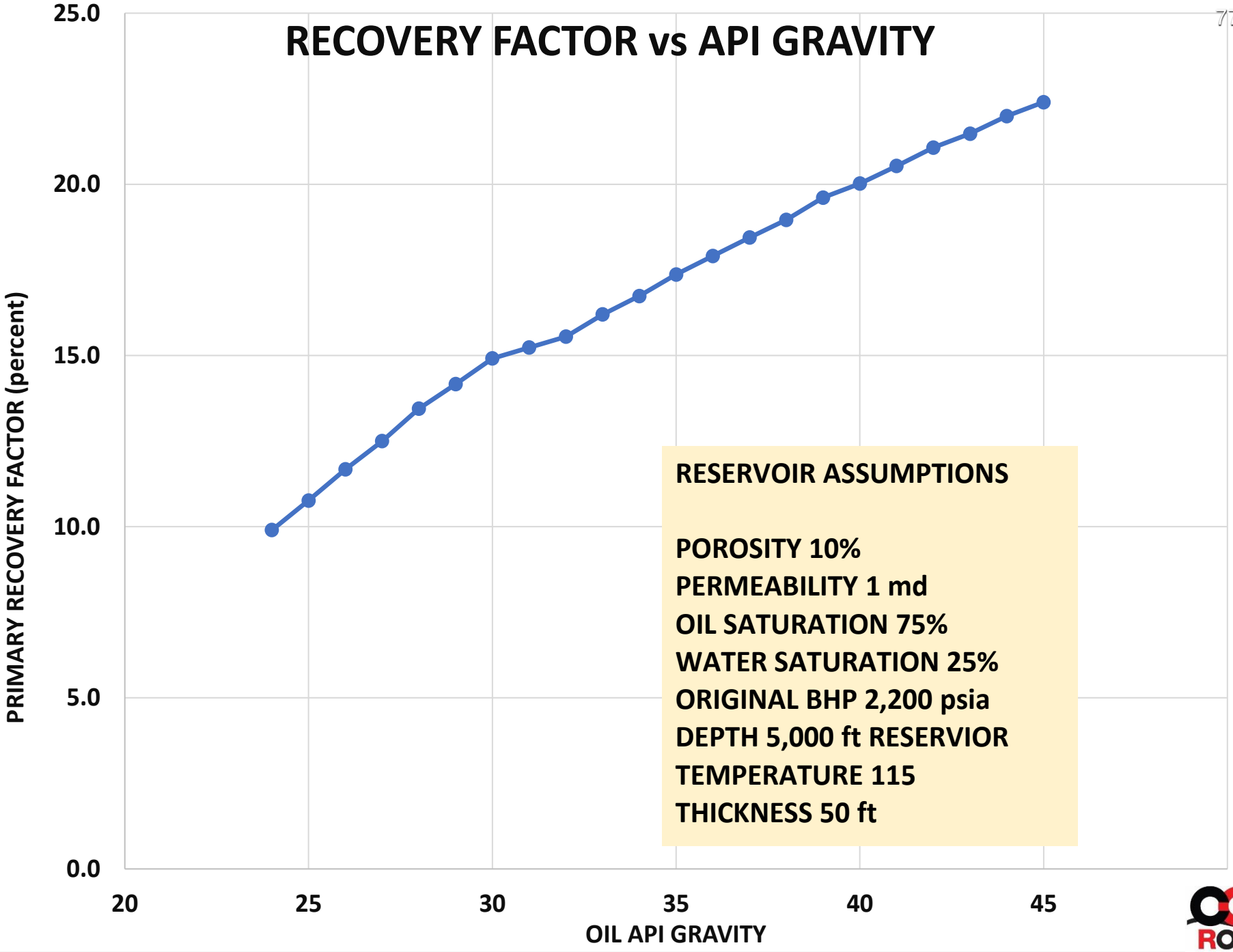


DARCY'S LAW

$$q \propto \frac{\Delta p k h}{\mu}$$

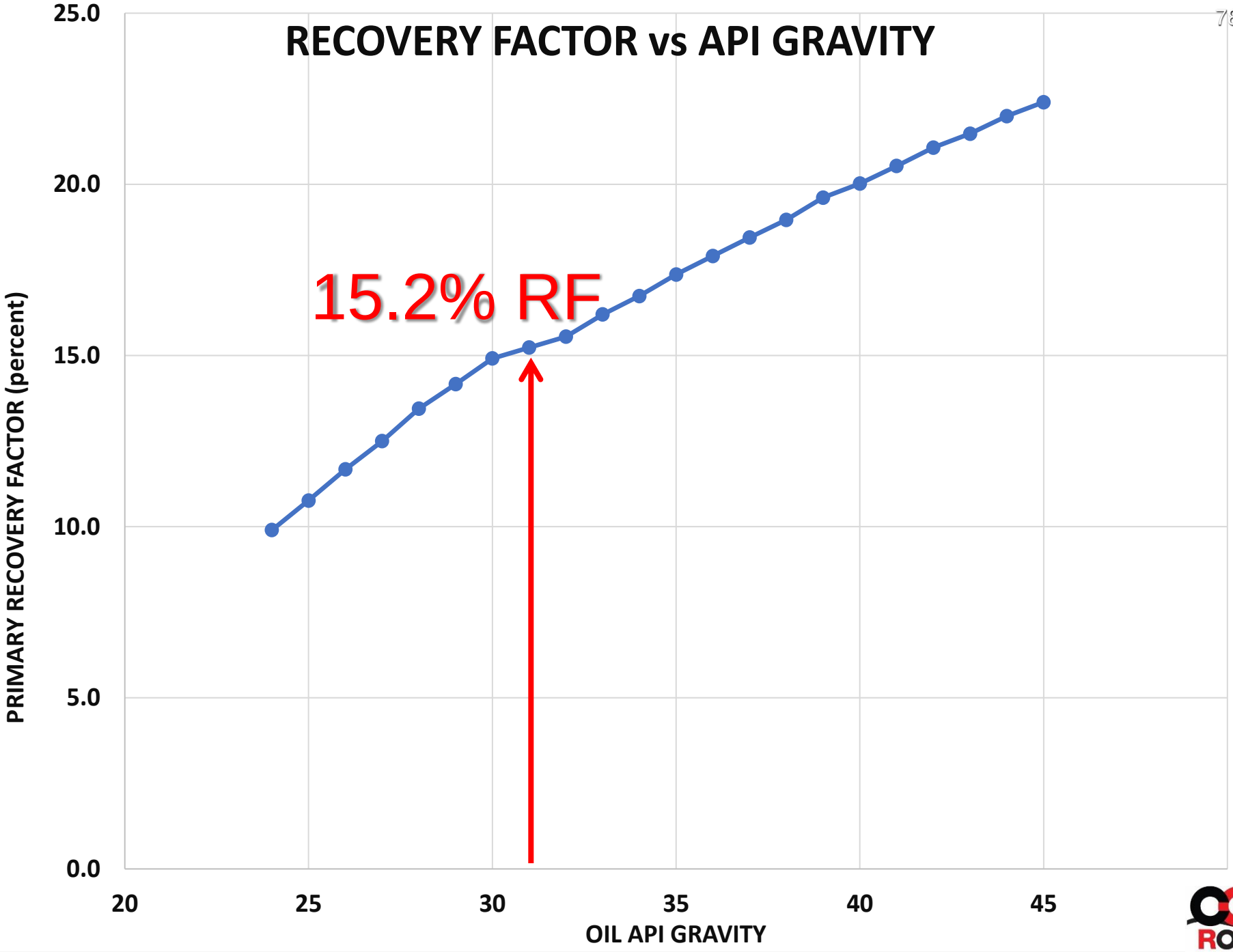
- Viscosity of 24° Crude Oil is 2.1 Times That of 31° Crude Oil (3.34 cp vs 1.57 cp).
- Flow Rate of Lower Gravity Crude Oil is Only 1/2 of the Higher Gravity Crude Oil.

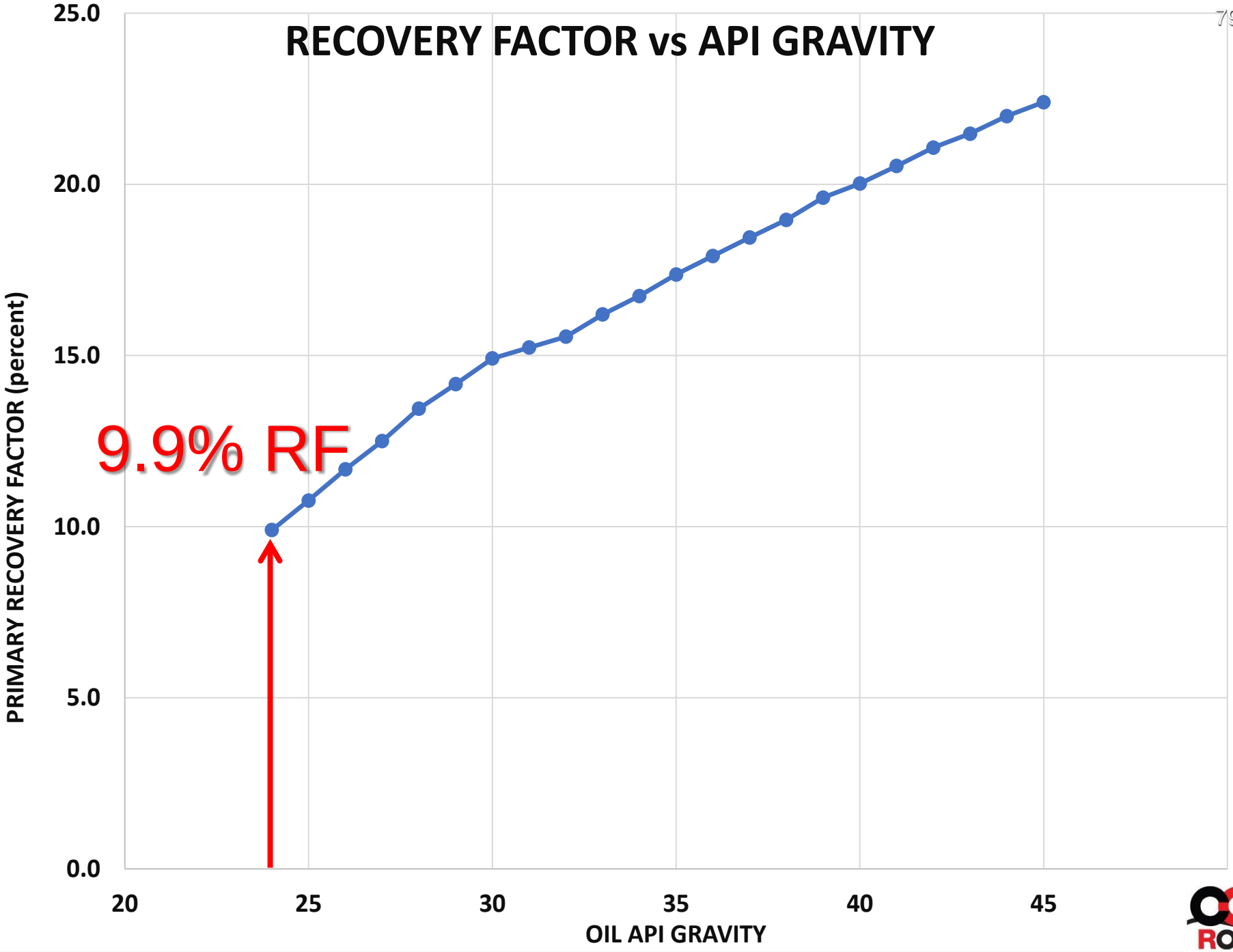
RECOVERY FACTOR vs API GRAVITY



RESERVOIR ASSUMPTIONS

POROSITY 10%
PERMEABILITY 1 md
OIL SATURATION 75%
WATER SATURATION 25%
ORIGINAL BHP 2,200 psia
DEPTH 5,000 ft RESERVIOR
TEMPERATURE 115
THICKNESS 50 ft


RECOVERY FACTOR vs API GRAVITY
15.2% RF
PRIMARY RECOVERY FACTOR (percent)
25.0
20.0
15.0
10.0
5.0
0.0
20
25
30
35
40
45
OIL API GRAVITY


RECOVERY FACTOR vs API GRAVITY
PRIMARY RECOVERY FACTOR (percent)
25.0
20.0
15.0
10.0
5.0
0.0
9.9% RF
20
25
30
35
40
45
OIL API GRAVITY

Reservoir Fluid Properties

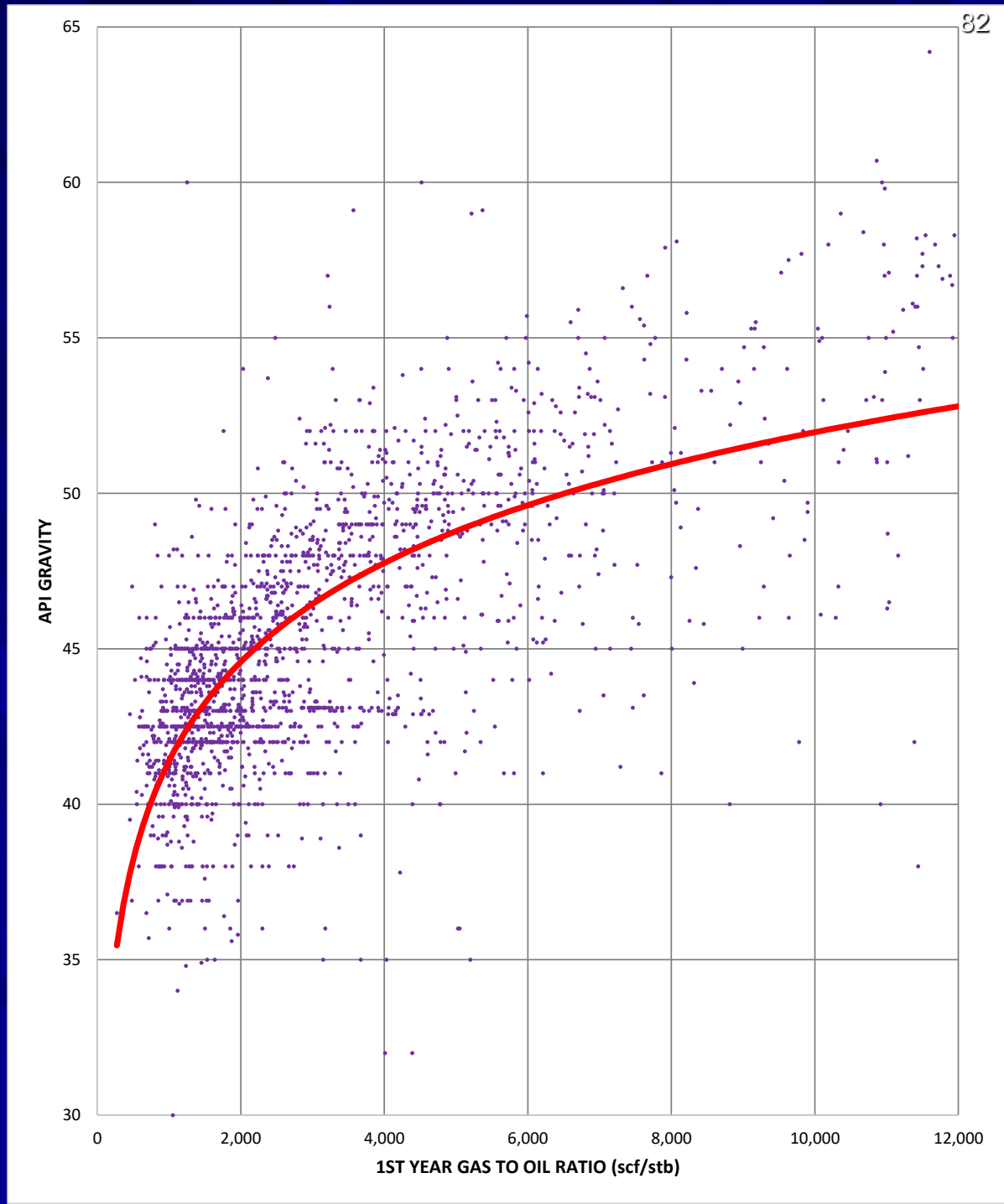
- Change in API Gravity From 31° to 24° Decreased Recovery Factor From 15.2% to 9.9% or a Reduction of 35%.

Reservoir Fluid Properties

- Change in API Gravity From 31° to 24° Decreased Recovery Factor From 15.2% to 9.9% or a Reduction of 35%.
- API Gravity and GOR Often Move Together (Thermal Maturity), Further Exacerbating Changes in Recovery Factor

Delaware Basin HZ Wolfcamp

API Gravity vs GOR



Reservoir Fluid Properties

- Evaluators Usually Consider Rock Properties (Porosity, Permeability, and Saturations)

DON'T FORGET

- Reservoir Fluid Properties (Viscosity, Solution GOR)

Thank You

Russell K. Hall, P.E.

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Midland, Texas

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