Horizontal San Andres Well Performance & Future Potential Offsetting Wasson Field,

Yoakum, Co., TX - Riley Exploration Permian LLC

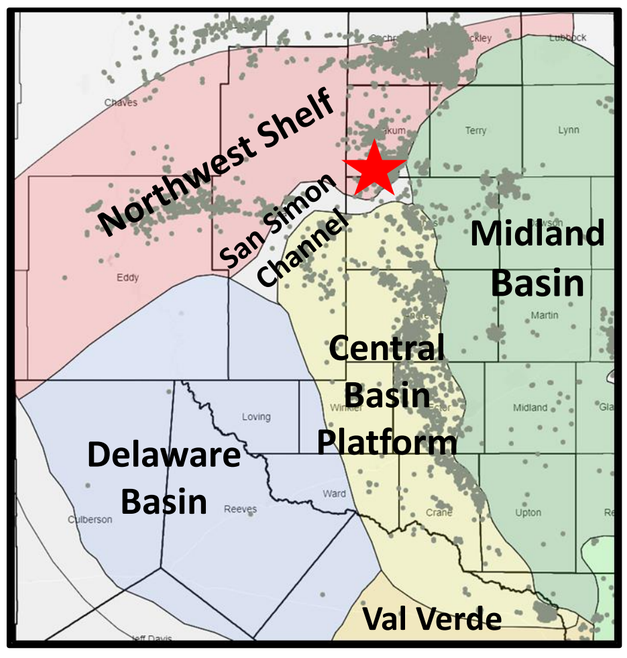
Presented at the 25th Annual CO_2 Conference

Thursday Dec 12th, 2019

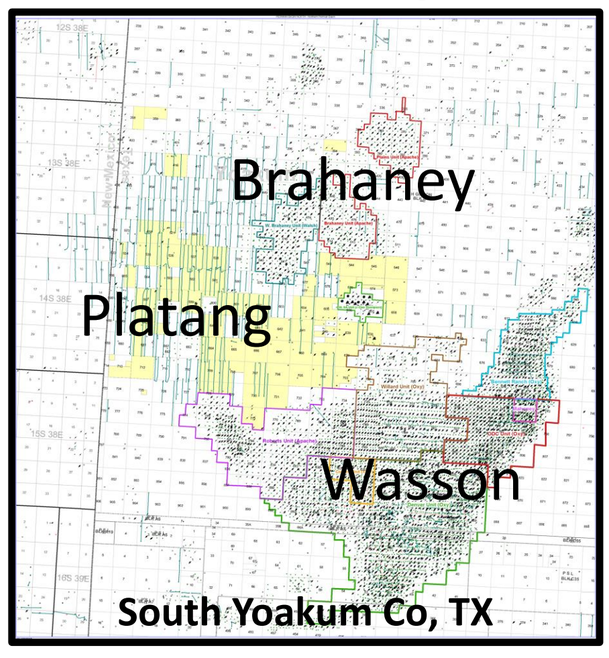
Bush Convention Center

Midland, Texas

Permian Basin



Wasson etal System



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Riley Exploration Permian (REXP) History

- 2009 - Riley management team formed
  - Wolfcamp etal Midland Basin Assets in Howard, Glasscock & Sterling Cos., TX (27,000 net acres)
  - Eagle Ford Assets in Karnes Co. etal, TX (50,000 net acres)
  - CBM assets in Caldwell Parish, LA (30,000 net acres)

- 2012 - Partnered with Yorktown Energy Partners & formed Riley Exploration Group LLC (REX)

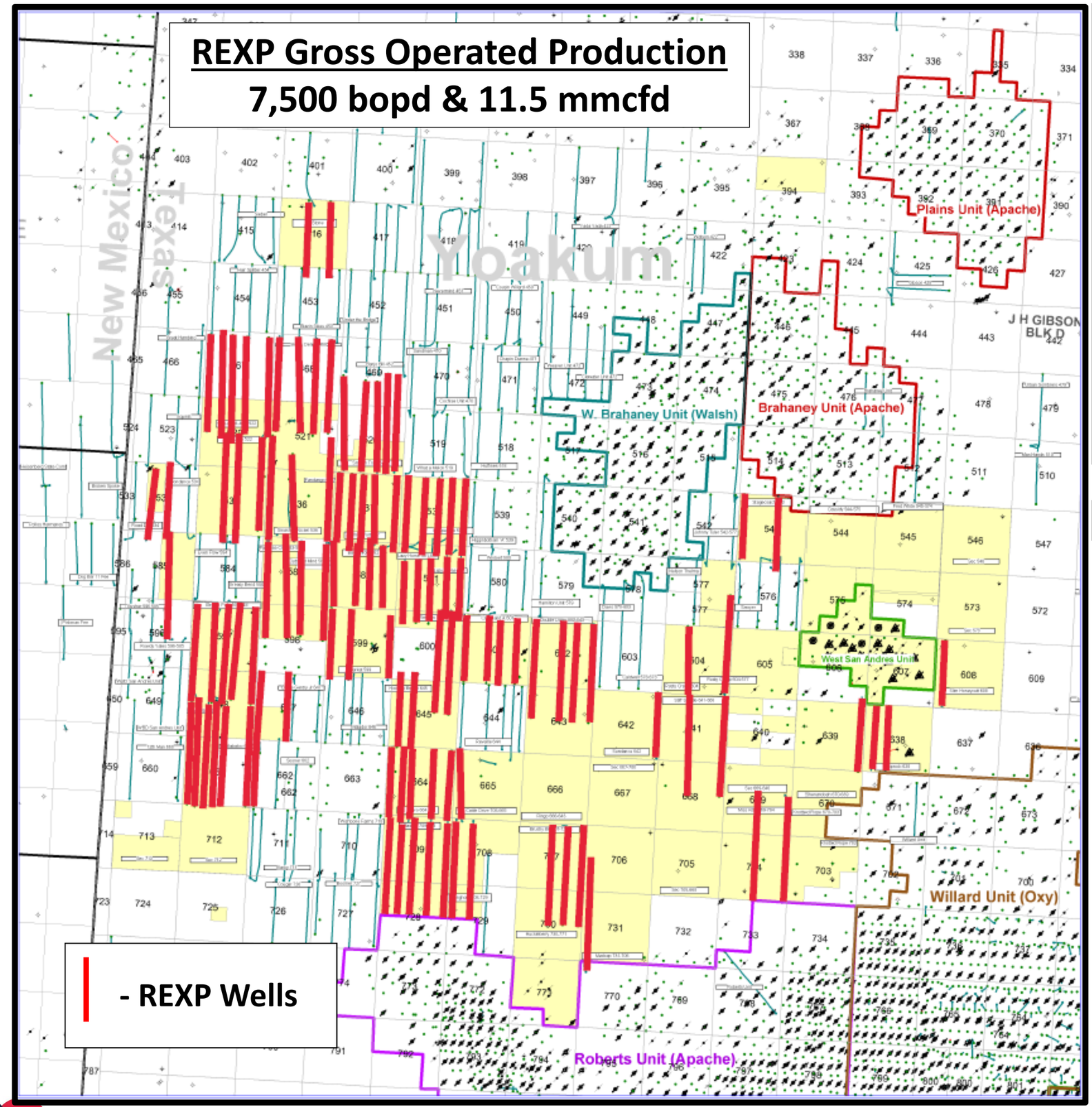
- 2013 - Acquired ~30,000 net acres in Lee, Bastrop & Fayette Cos., TX for Eagle Ford Shale, Chalk & Taylor Sand

- 2015-2016 - Acquired interests in Platang field in Yoakum Co., TX & formed Riley Exploration Permian LLC (REXP)

- 2018 – Acquired ~40,000 net acres with horizontal SA potential in Lea Co. etal, New Mexico

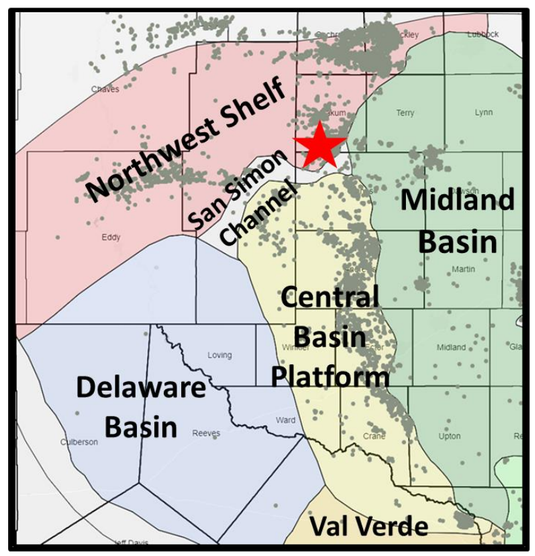
- 2015-2019 – Drilled & completed 50 operated wells plus participated in 56 non-operated wells in Platang

REXP – Horizontal SA Wells in Platang



Year	Operated Wells	Non-Operated Wells	Total Wells
2014	0	1	1
2015	4	17	21
2016	8	6	14
2017	11	11	22
2018	16	14	30
2019 ytd	9	7	16
2019 rem	2	0	2
Total Wells	50	56	106

Permian Basin

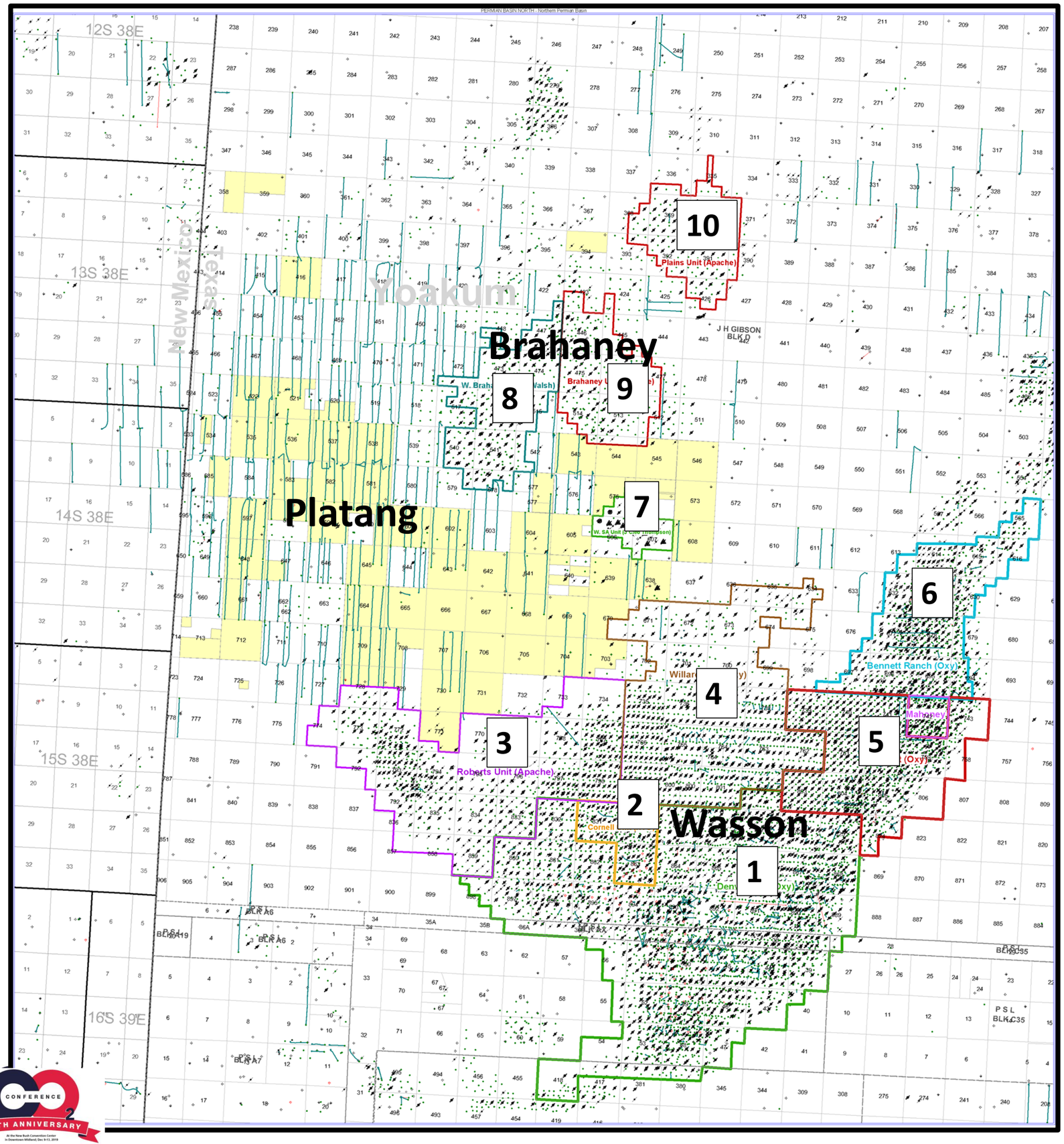


Geologic Overview

Wasson / Brahaney / Platang

One Large Oil Accumulation

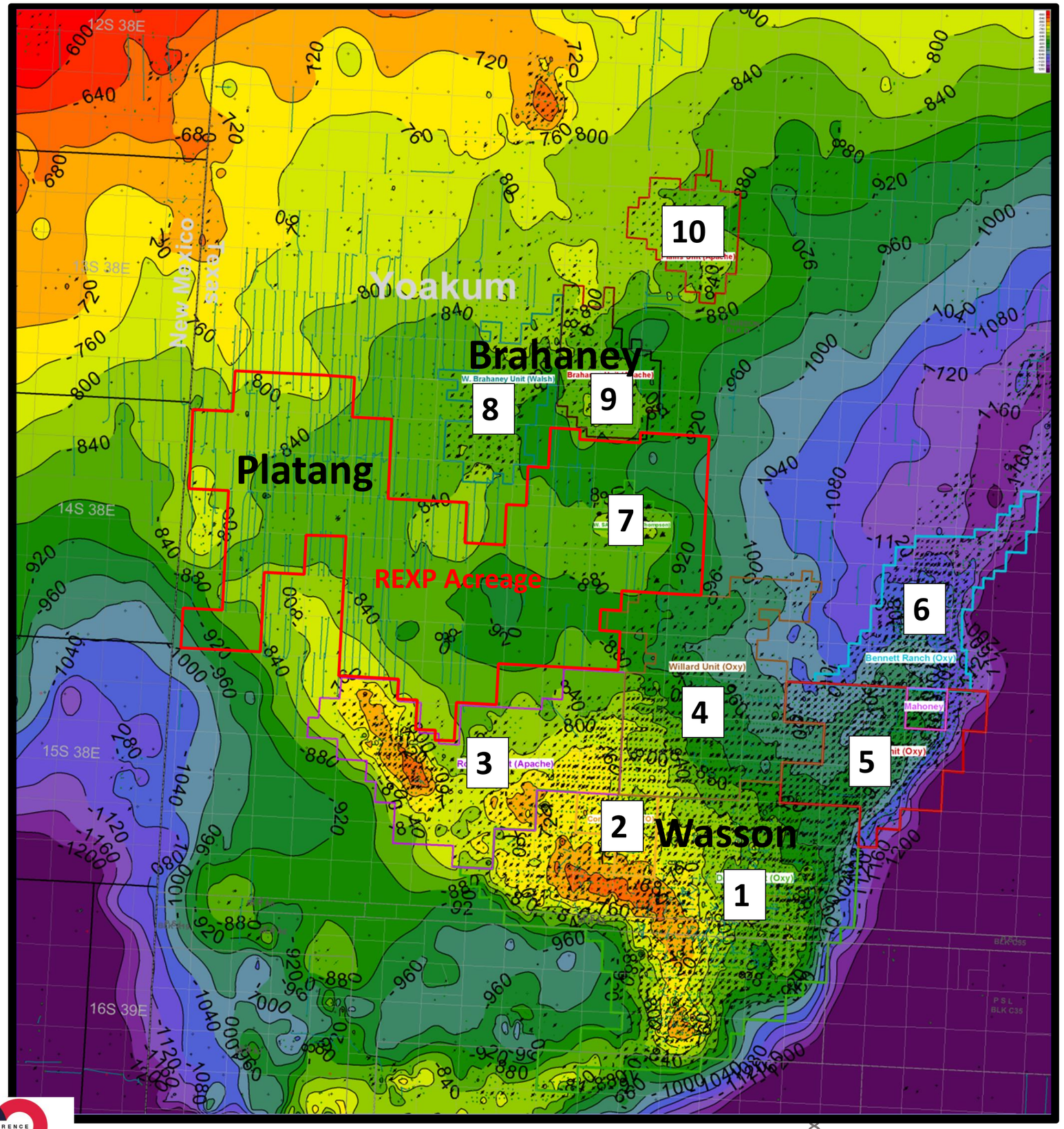
Wasson / Brahaney / Platang Complex – Base Map



Secondary/Tertiary Units

1. Denver Unit (Oxy)
2. Cornell Unit (XTO)
3. Roberts Unit (Apache)
4. Willard Unit (Oxy)
5. ODC Unit (Oxy)
6. Bennett Ranch Unit (Oxy)
7. West San Andres Unit (J Cleo Thompson / REXP)
8. West Brahaney Unit (Walsh)
9. Brahaney Unit (Apache)
10. Plains Unit (Apache)

Wasson / Brahaney / Platang Complex – Structure Map



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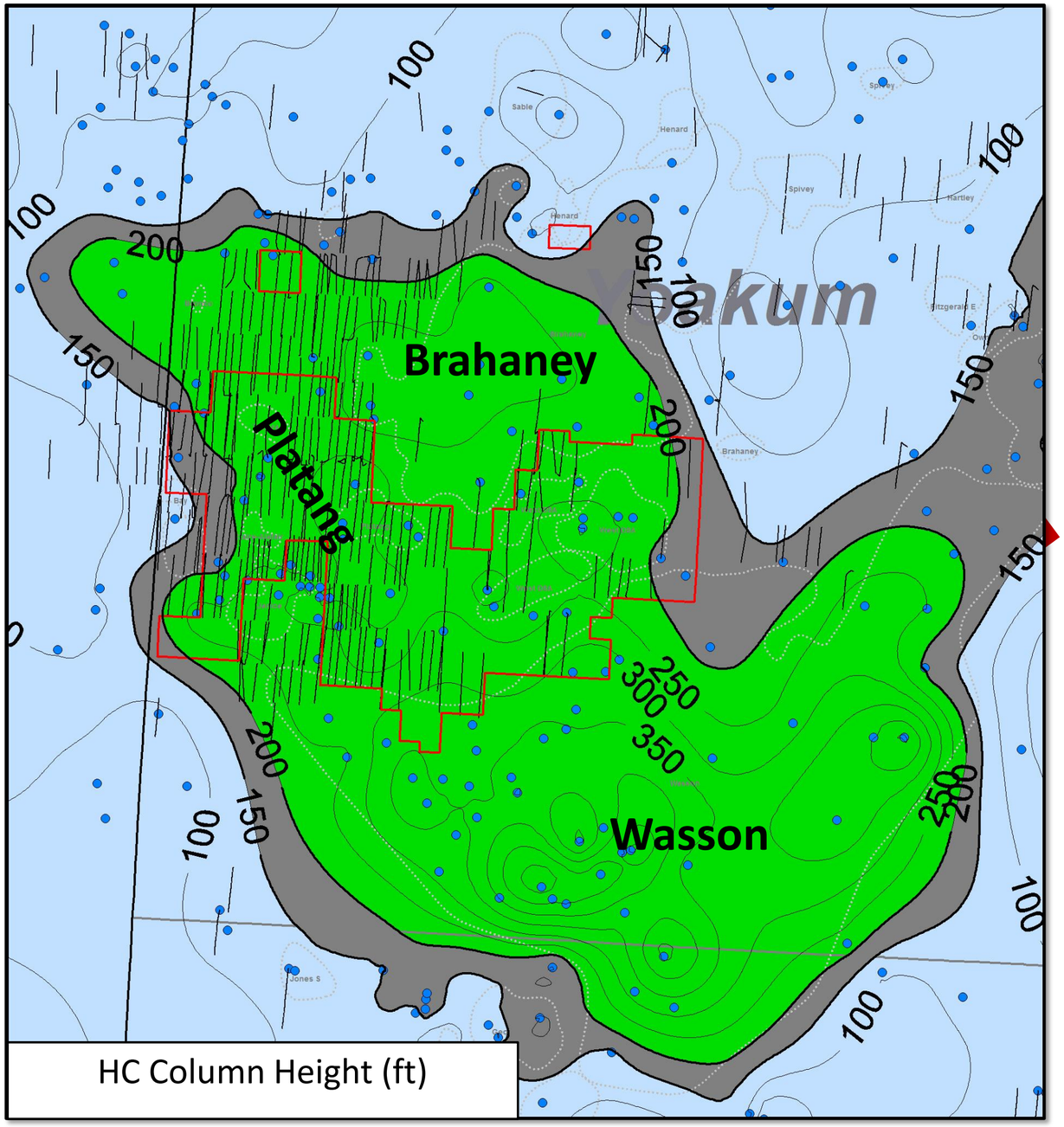
Platang - A Continuation of Wasson & Brahaney Fields



- Platang is a continuation of the Wasson & Brahaney accumulations
  - *Long (150 ft+) mobile oil columns are rare outside of existing fields*
  - *Platang has several billion barrels of oil in place*

- Platang has a single, unswept oil column with no ROZ
  - *Did not lose oil (and may have gained oil) during structural tilting*
  - *No evidence of fresh water sweep (high brine salinity, FWL is not steeply dipping)*
  - *Core data & high oil cuts from Horizontals near structural / stratigraphic trapping support that part of Platang contains "Conventional and Transition Zone Pay"*

Platang Producing Interval - ROZ or Transition Zones?

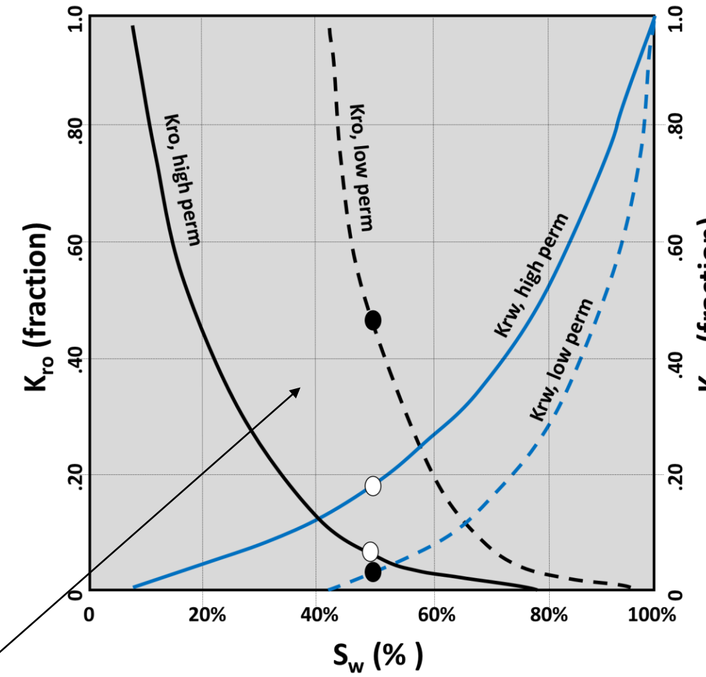
Water Distribution and Water Cut Curves for San Andres Dolomite

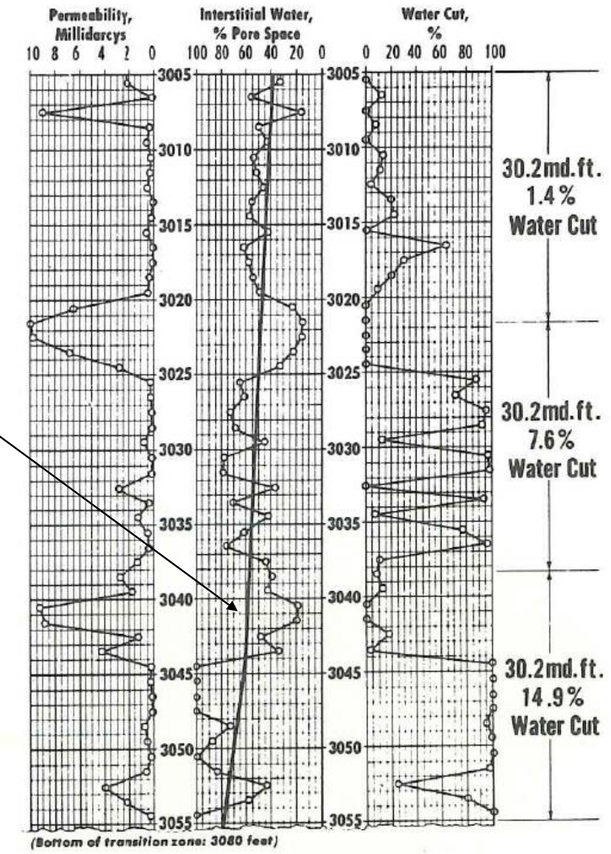
Reservoirs containing wide variations in porosity and permeability often flow water at great distances above the zero capillary pressure level, and the reservoir acts as if it were a large transition zone. At any selected elevation, rock of certain permeability and porosity flows only oil, other samples flow only water, and some samples flow both fluids.

The influence of permeability on initial water distribution and water cut is illustrated for a high and low permeability sample.

The special core graph indicates the gradual increase of interstitial water saturation with depth, and the corresponding increase in water cut for zones of equal flow capacity.

Source: "Fundamentals of Core Analysis", Core Lab , 1977



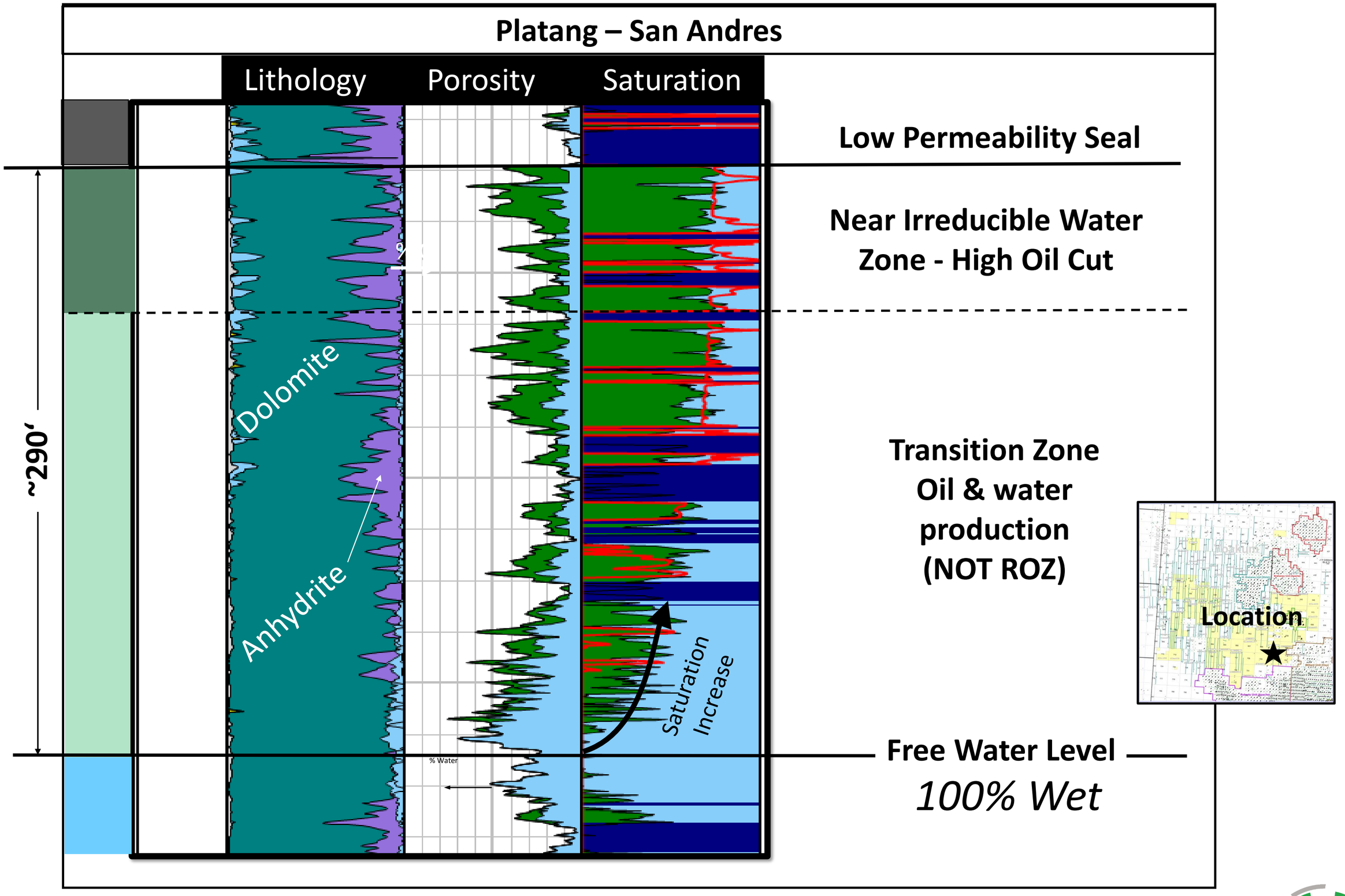


Special Coregraph of San Andres Dolomite Section

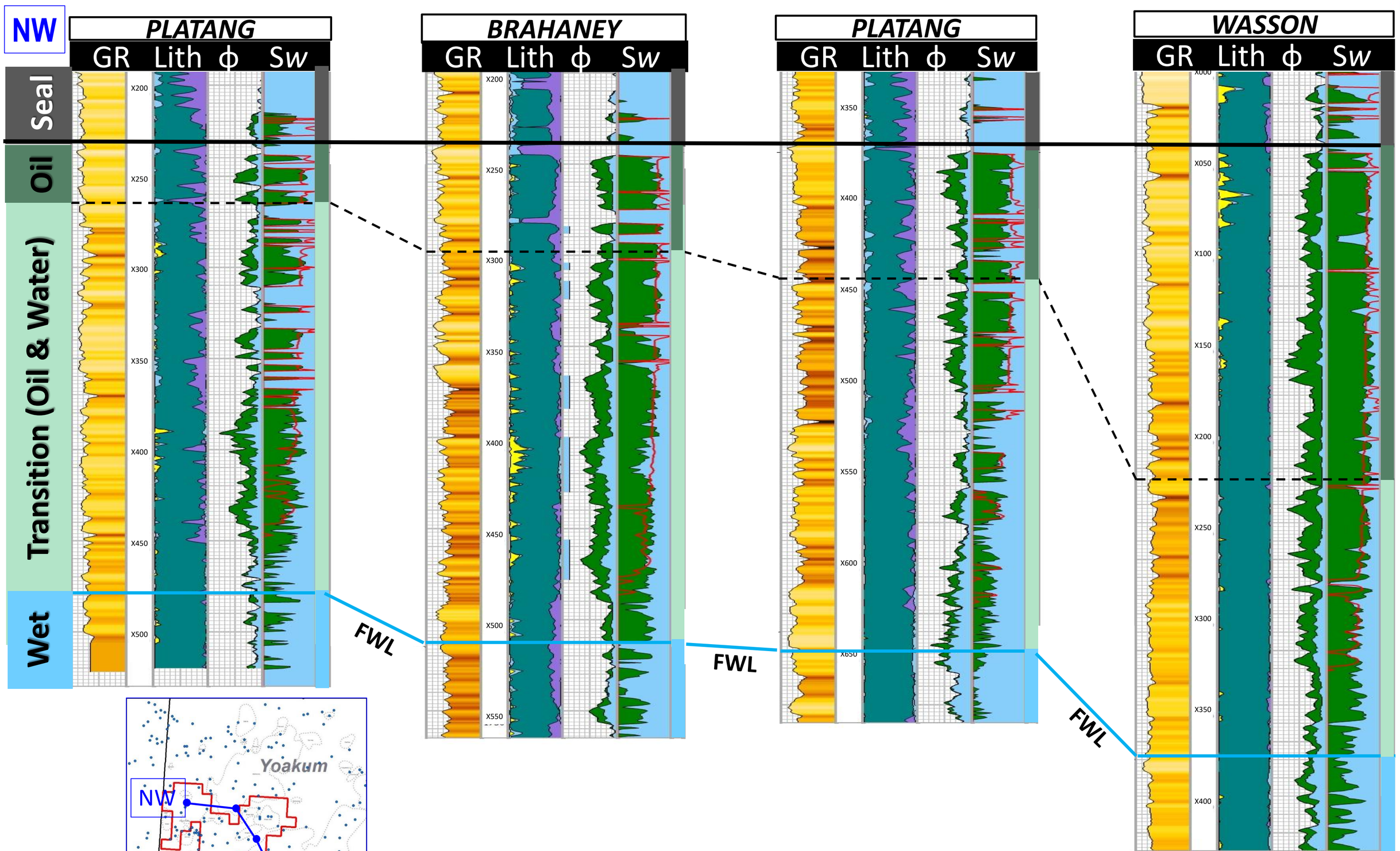
Example Calculation @ S_w = 50%

Low Permeability	High Permeability
• Kro = .45	• Kro = .07
• Krw = .04	• Krw = .18
• => Oil cut ~92%	• => Oil cut ~28%

Platang – Type Log

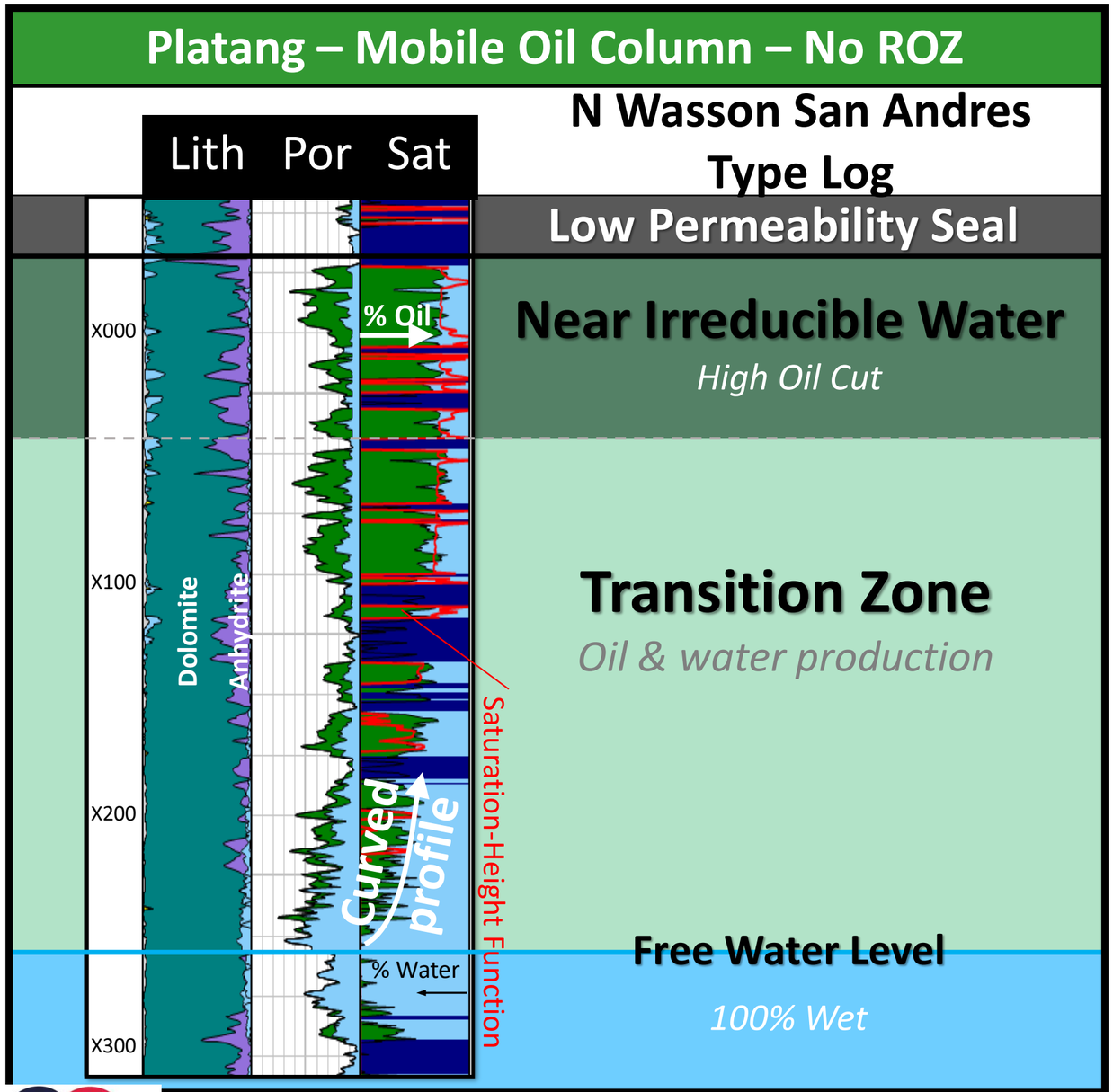


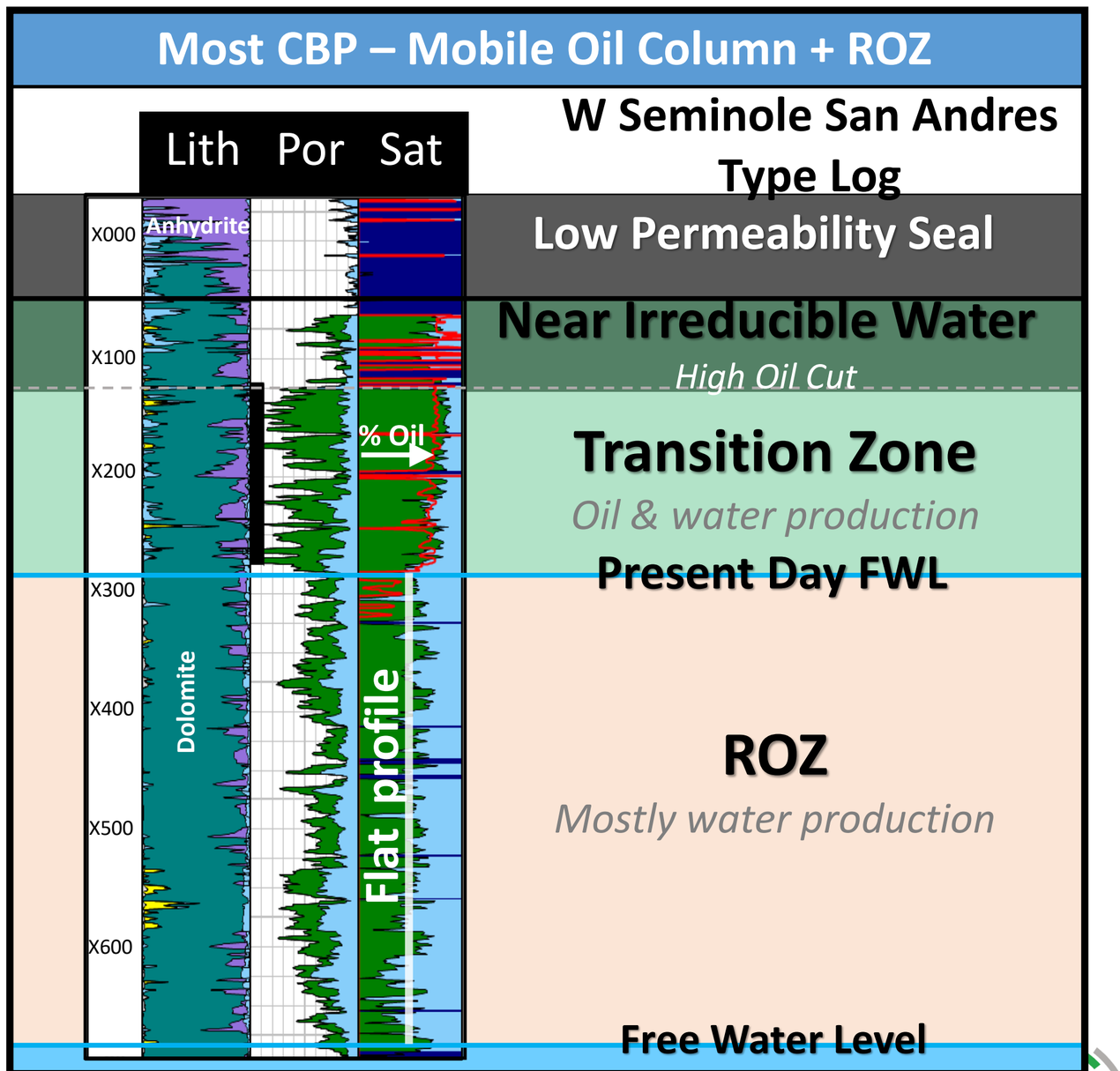
Wasson / Brahaney / Platang Complex – Cross-Section



ROZ – Created When Oil From Original Column Is Removed

- Caused by structural movement - oil spill point or post movement recharge
- Results in:
  - Reduced or absent moveable oil column
  - Column of swept oil at or near residual conditions
  - Different oil saturation profile (mostly flat) vs transition zone (decreasing with depth)



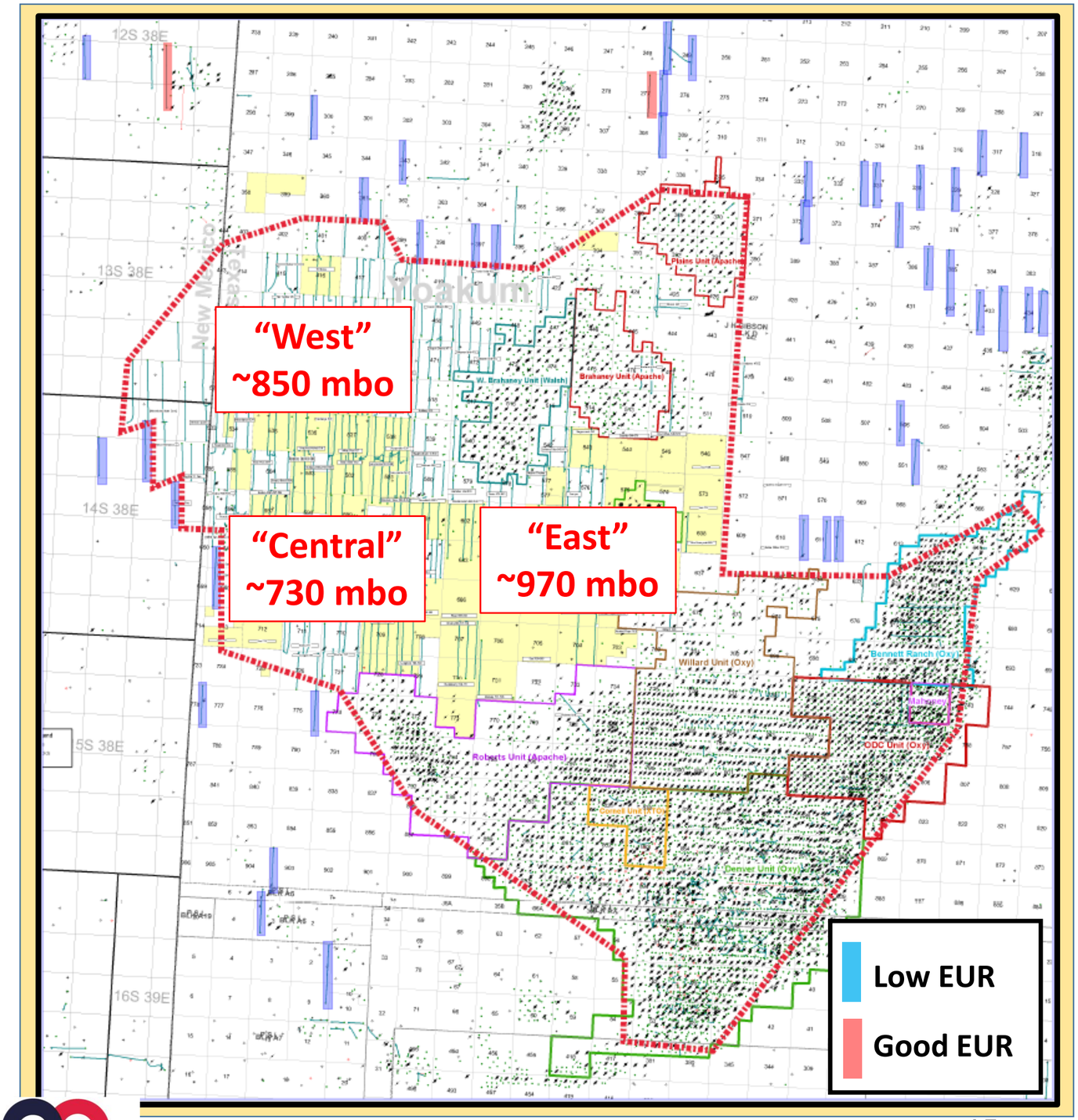


Platang - Horizontal San Andres Well Performance

…..Geology Dominates
All Else

Wasson-Brahaney Field – Platang Is An Extension of This Field Complex

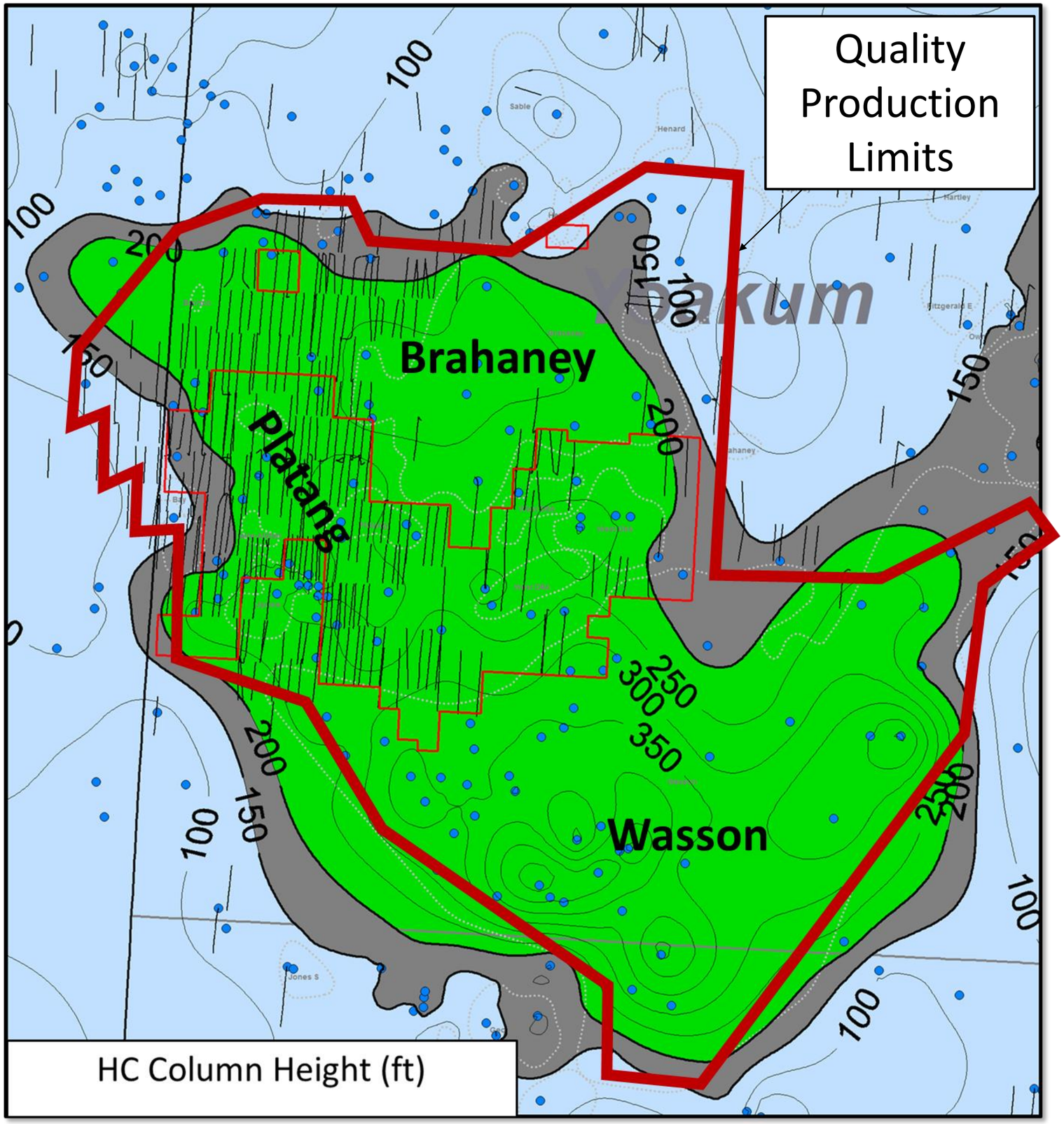
The San Andres is a proven ***Conventional Reservoir*** that has been producing since the 1920s. Wasson & Brahaney Field Complex have produced +2.3 billion barrels of oil



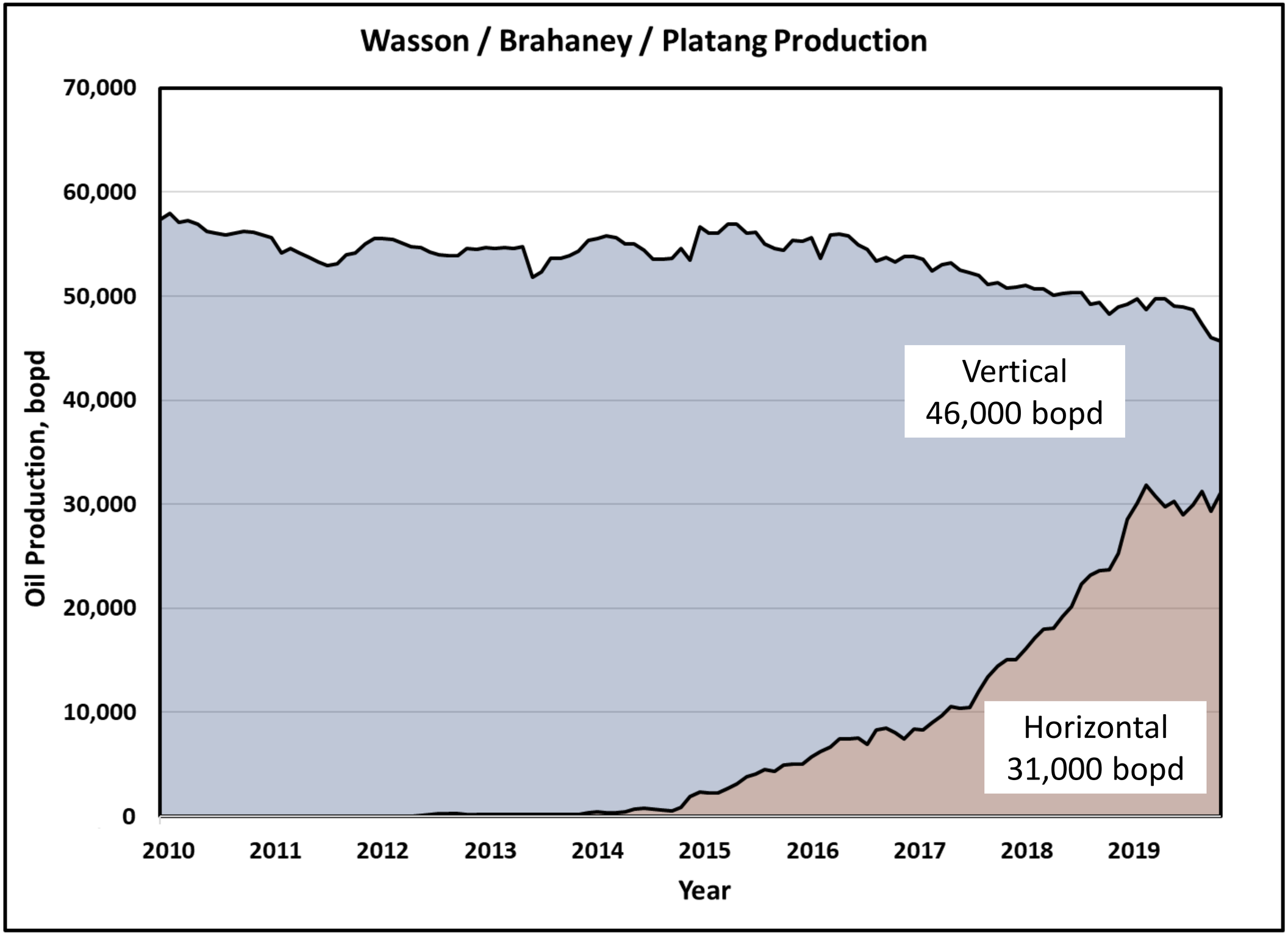
- ~200 horizontal wells have been drilled within the "Extended Field" boundary with excellent results
  - Avg ~590 mbo EUR
  - 4 wells < 250 mbo EUR

- ~42 horizontal wells drilled outside the "Extended Field" boundary
  - Low EUR's (20-100 mbo)
  - 2 wells > 350 mbo EUR

Platang – Quality Production Matches Oil Thickness….



Wasson / Brahaney / Platang Complex – San Andres Production



Source: IHS Info 2019-11

Platang San Andres Horizontal Development - Observations

- Horizontal well performance has <u>continued to improve over time</u>
  - Early $CaSO_4$ scale problems
  - Infrastructure limitations (water disposal, electric, gas….)
  - Completion practices (casing size, frac design….)

- High productivity wells

- Good average oil cut, but varies within field (average 18%)

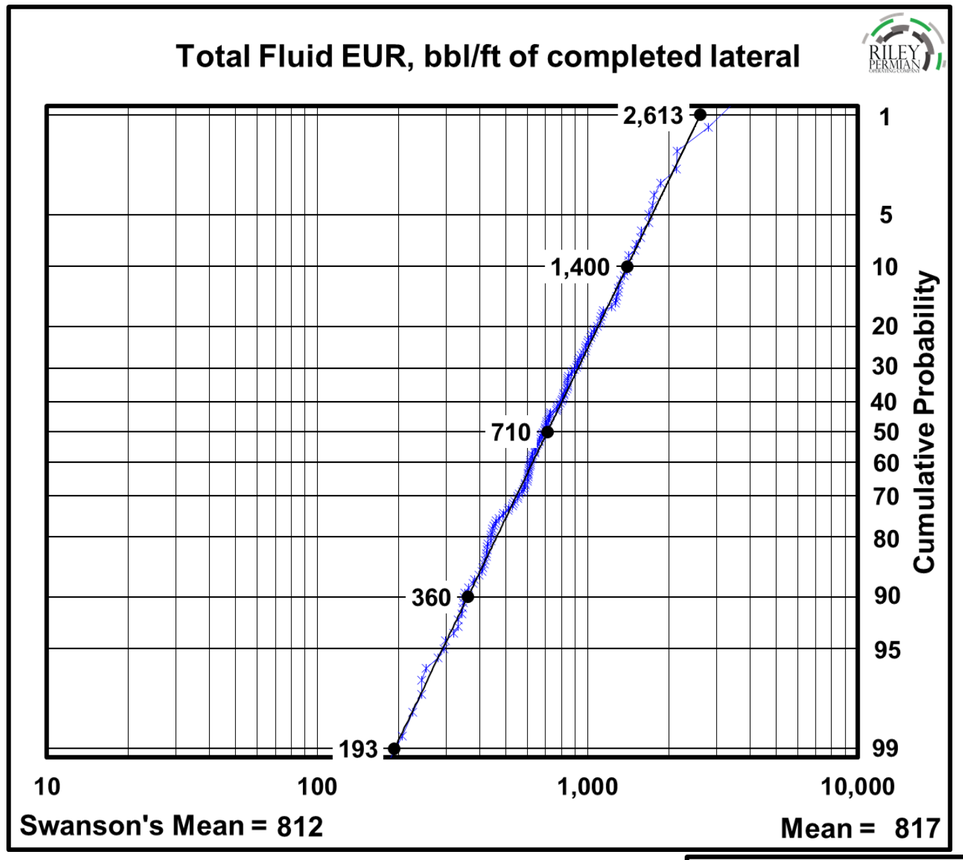
- Oil cut improves over several weeks to months and stabilizes

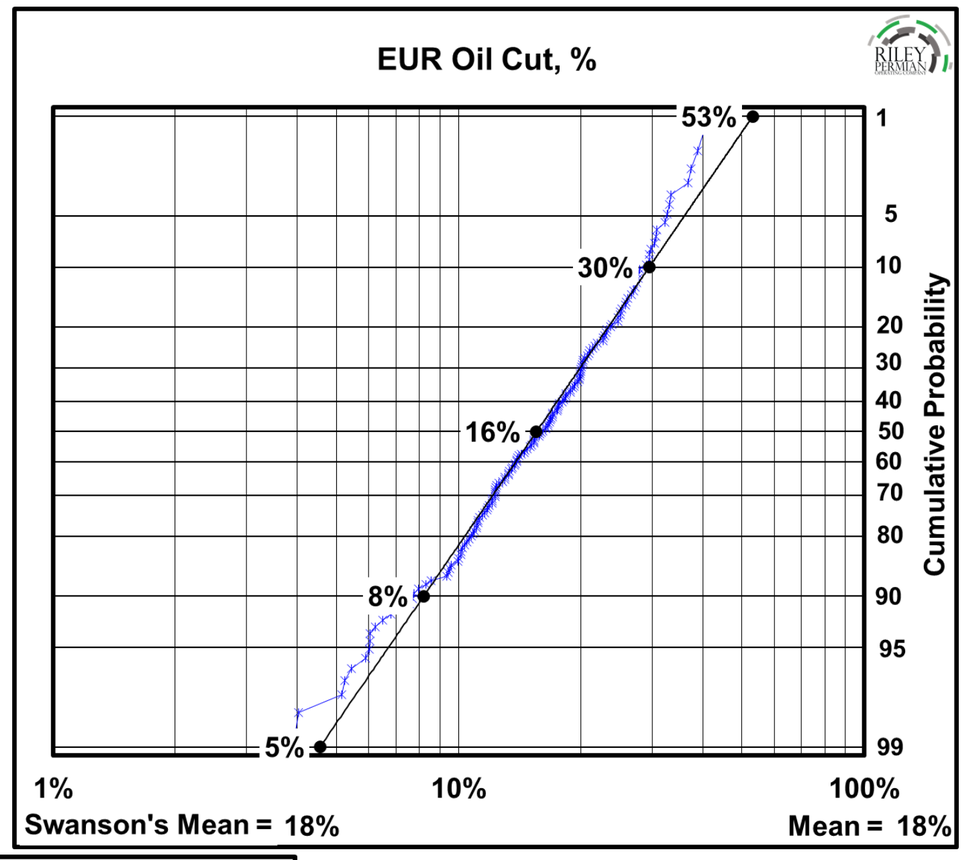
- Long life, shallow decline performance

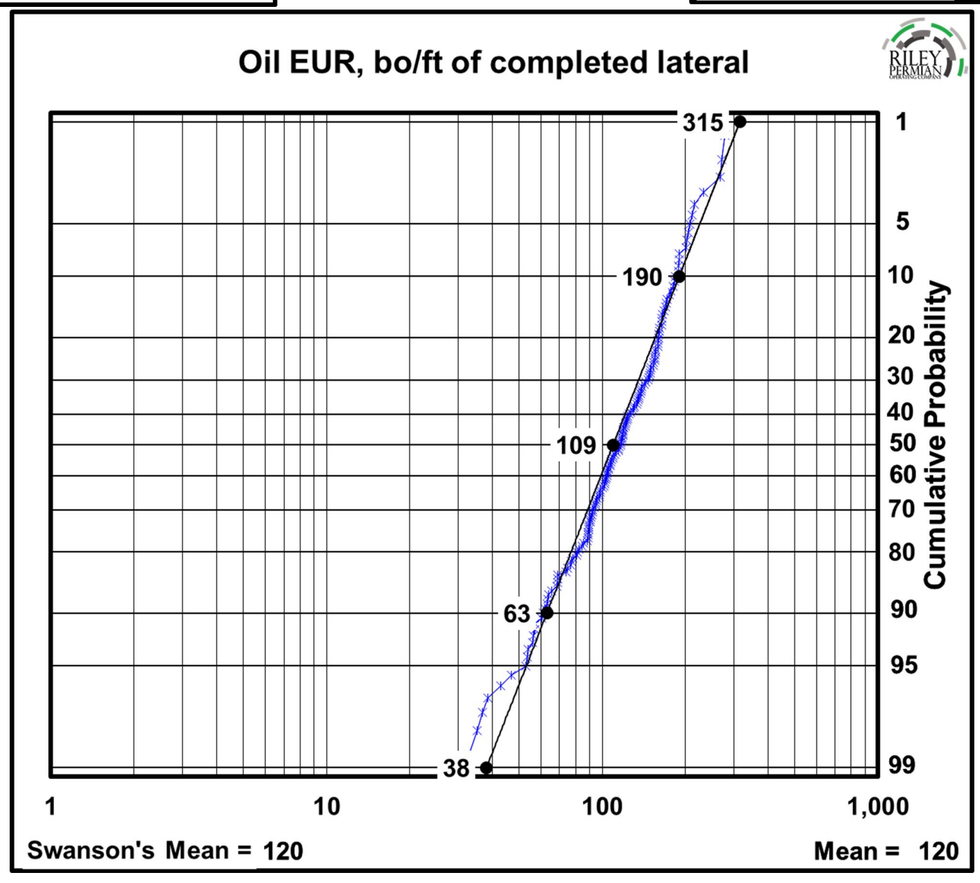
- Originally developed on 4 wells/section (1,320’ spacing – equiv to 40 acre vertical spacing east-west)

- Very encouraging infill development performance to date

Platang: EUR Is A Function Of Total Fluid EUR + Oil Cut







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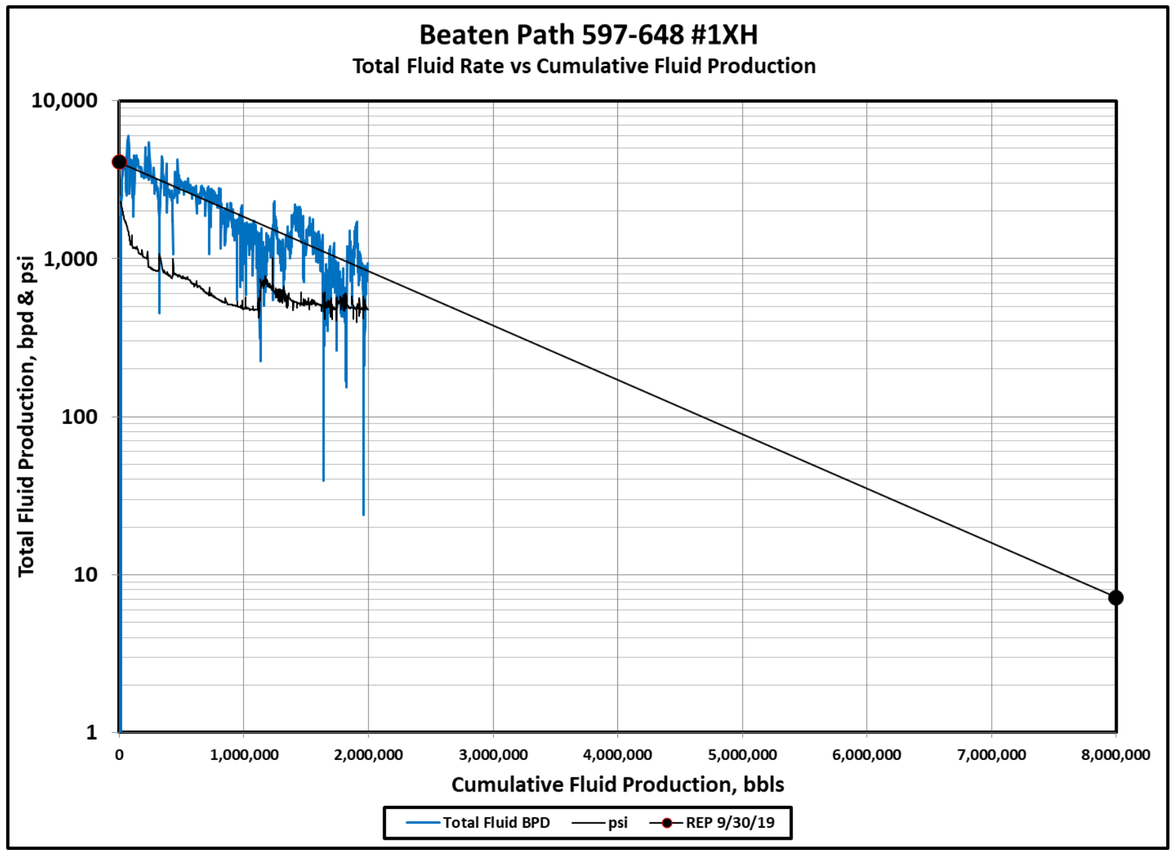
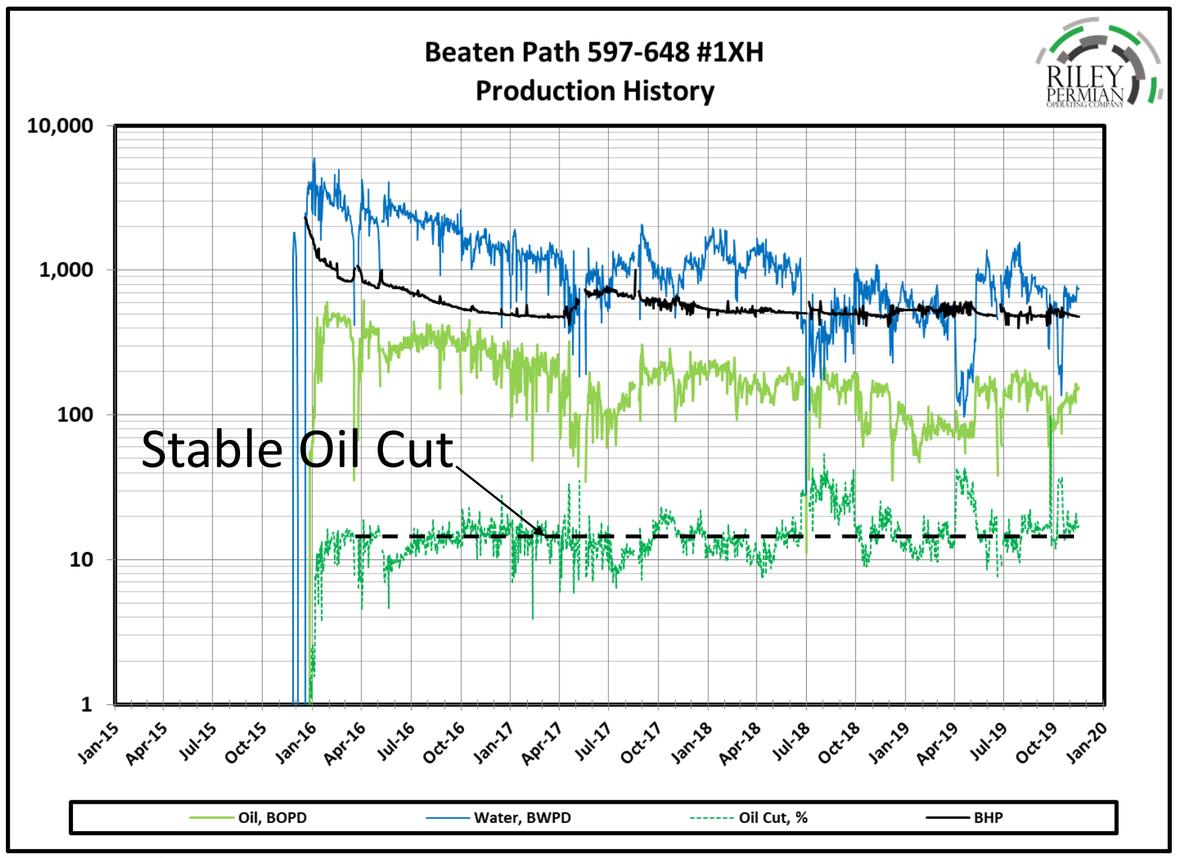
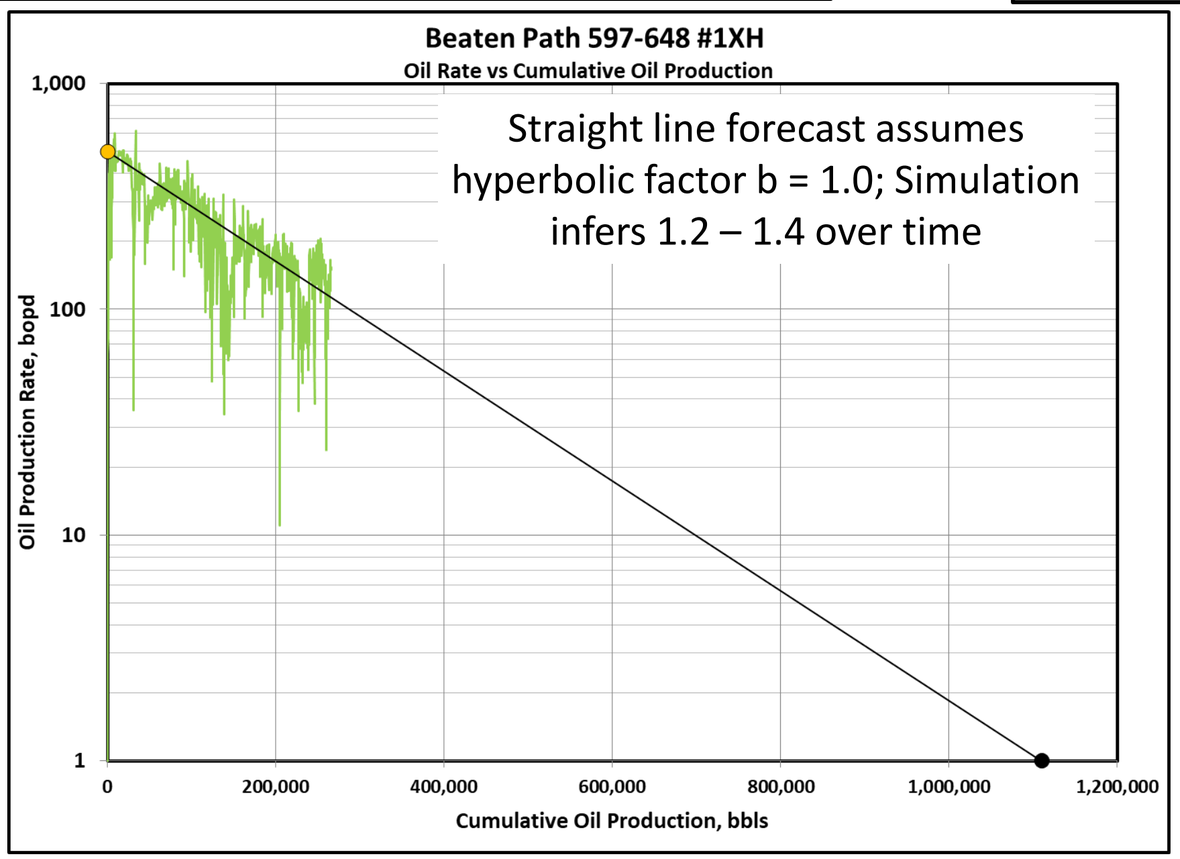






Uses Pseudo Material Balance Approach

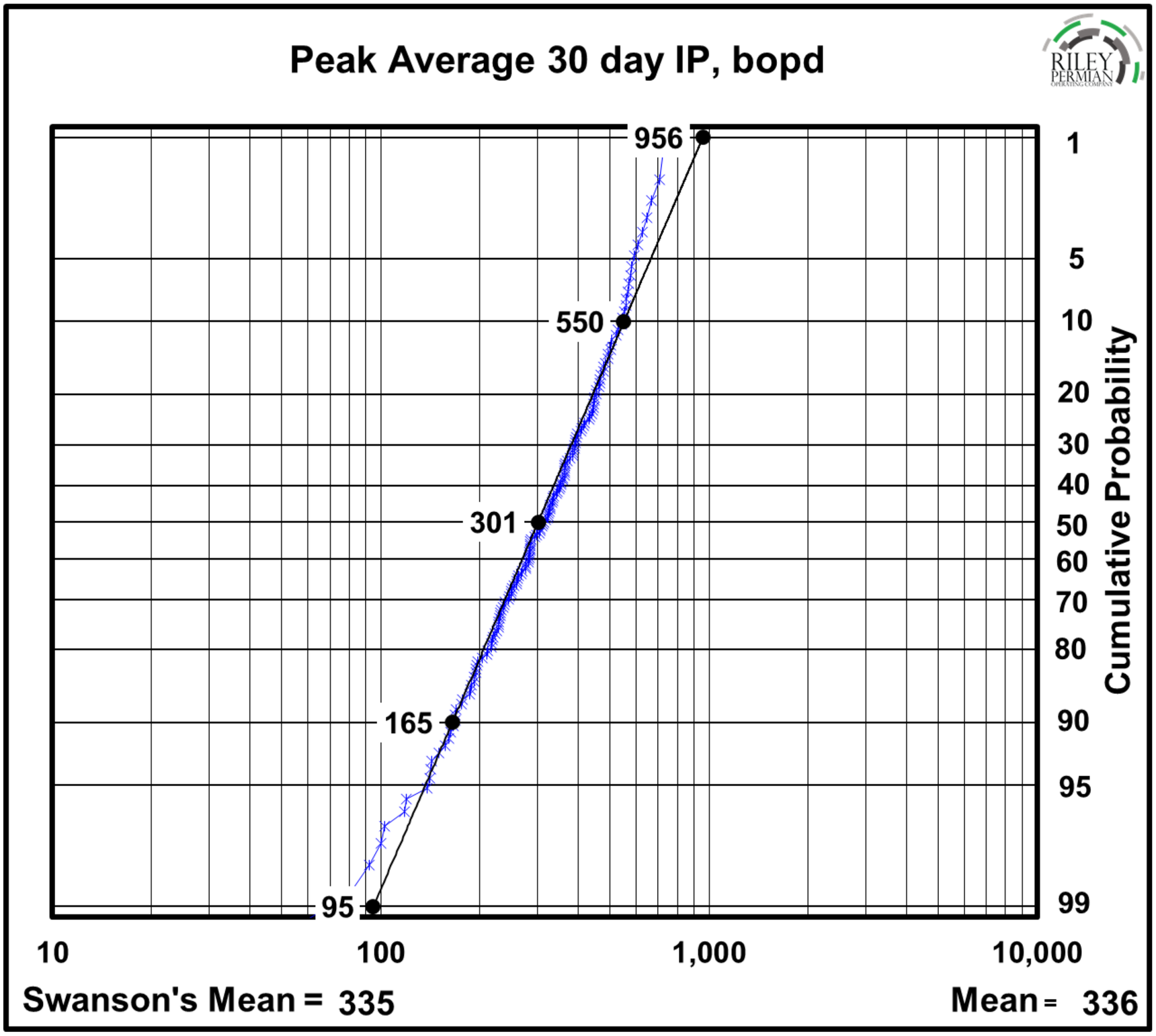
Volumetrics insufficient to quantify EUR:

- Lack of well log density across complex carbonate feature w / multi-stage diagenesis
- Log quantification of Sw & So combined with fractional flow / relative perm variability over various facies

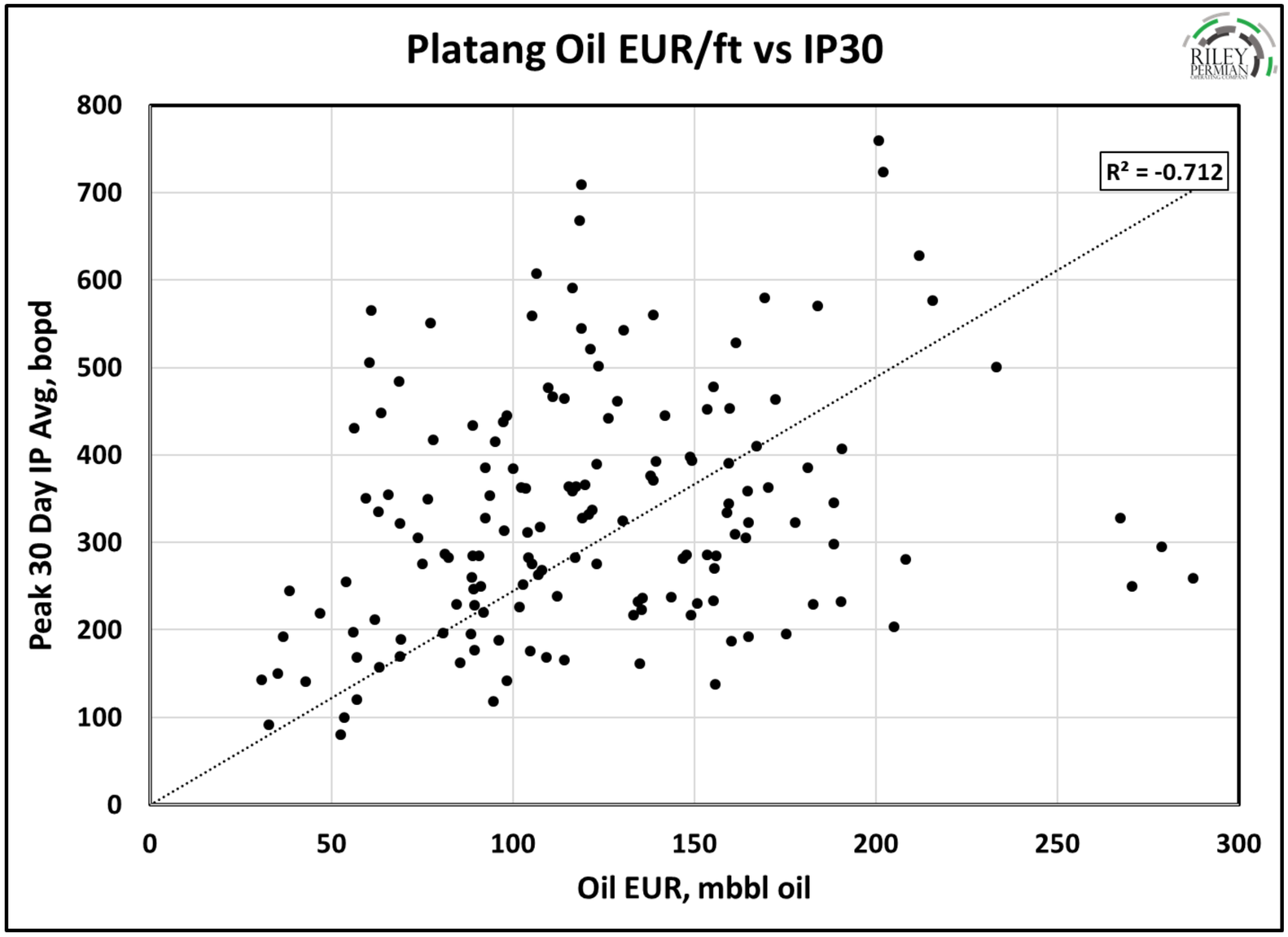
MB approach utilizes mass / total fluid forecast

Valid after oil cut stabilizes

Platang: Peak Oil IP30 Rate



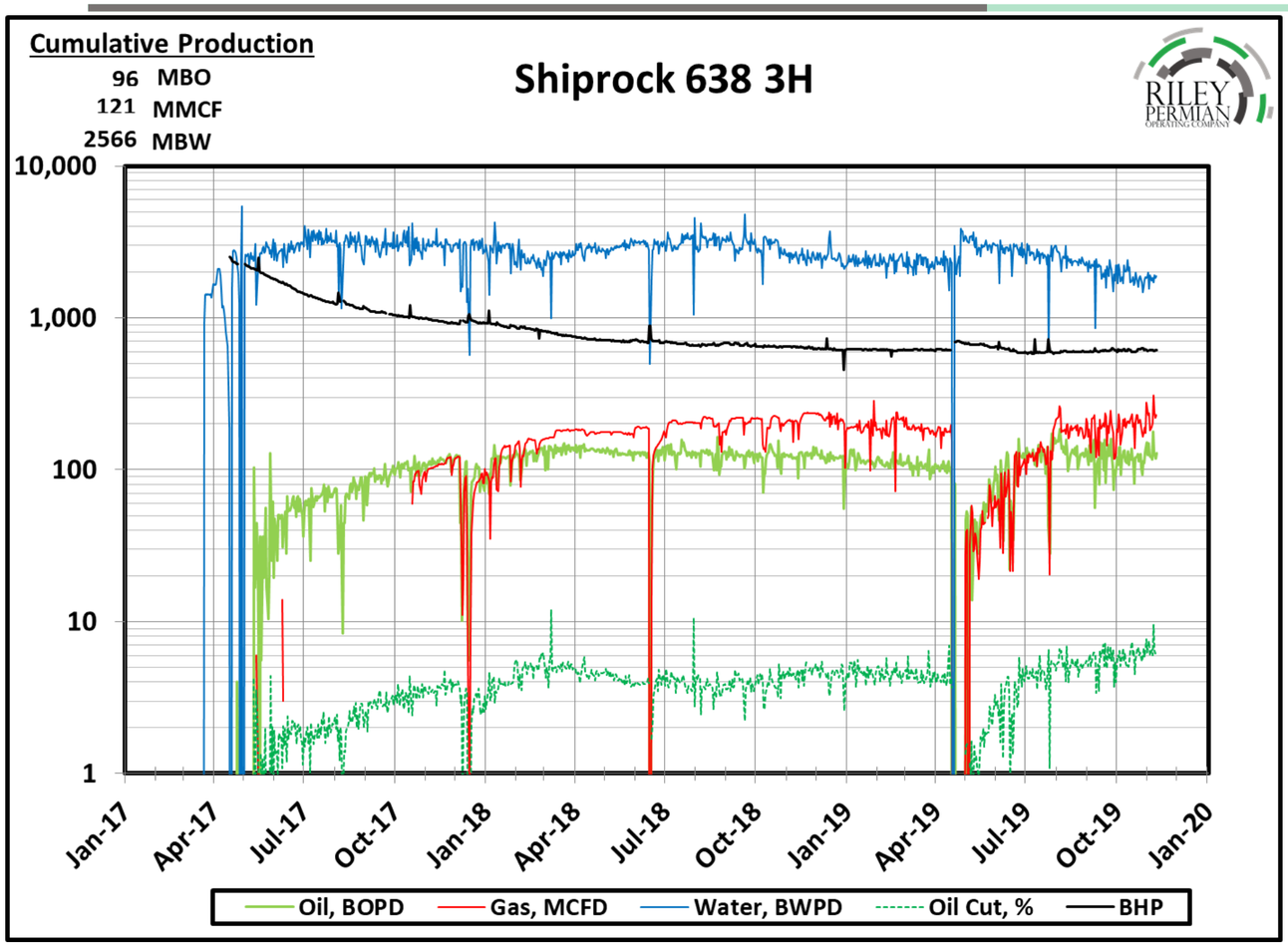
Platang: Relationship of Oil IP30 to Oil EUR/ft

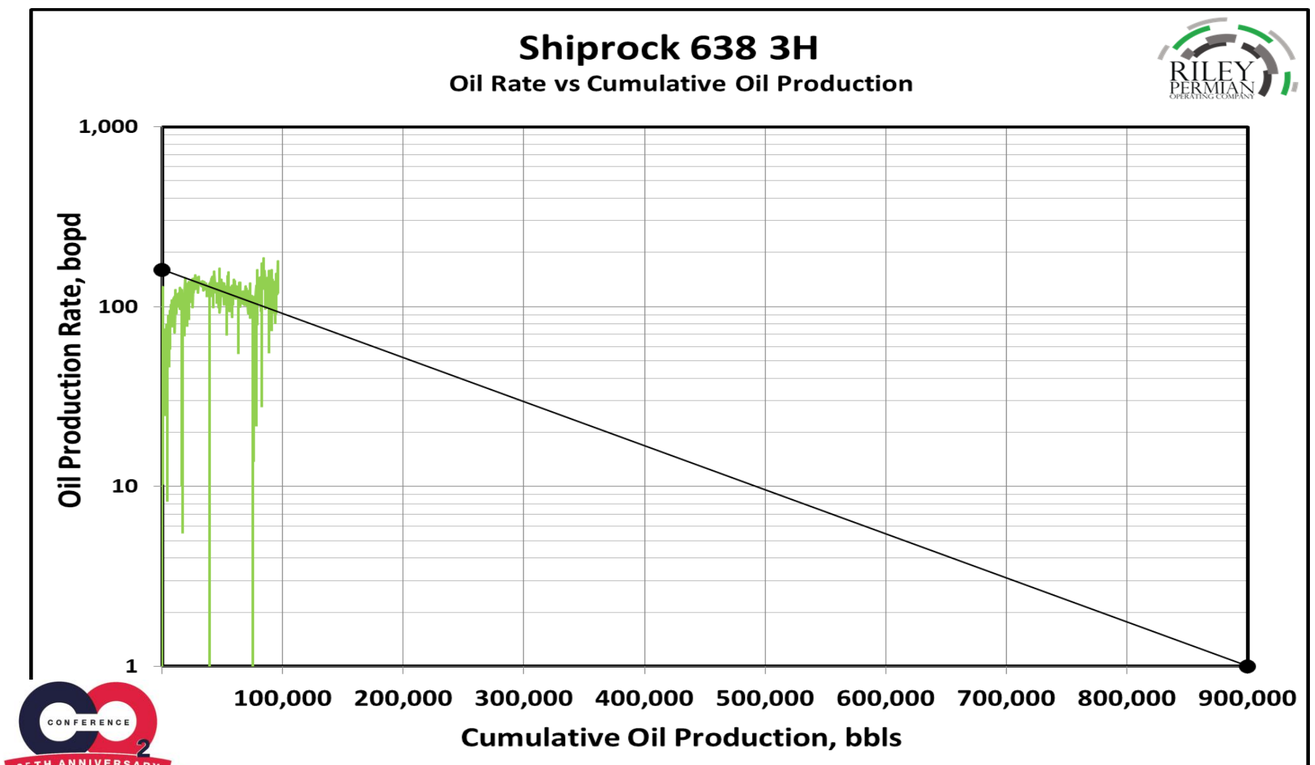


Poor correlation of rate to EUR…
WHY?

- Many high productivity wells
- Well productivity exceeds lift capacity for a few months to a couple of years
- Many wells have not been pulled down aggressively
- Synergy to offset wells help drawdown & increase both oil cut and rate
- Completions (frac size, lateral placement, clusters / stage, etc) affect early well productivity
- Early $CaSO_4$ scale issues impacted some wells prior to interventions & preventive treatments

Example of IP30 & EUR – Why The Disconnect?

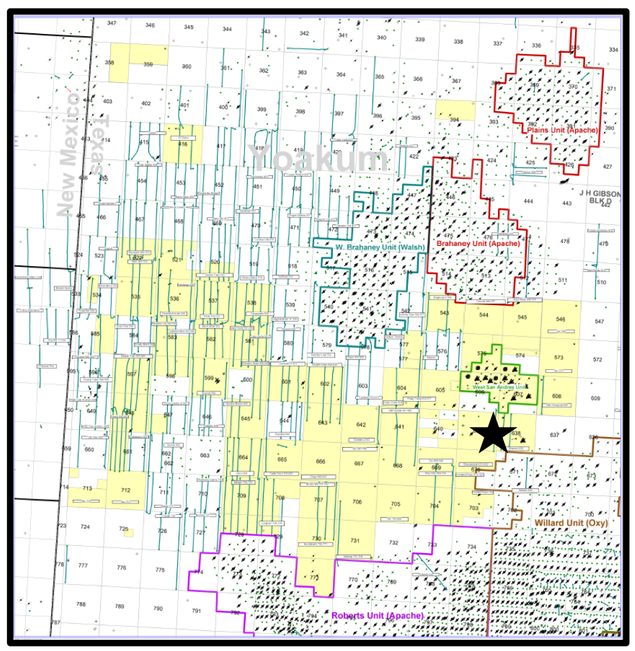




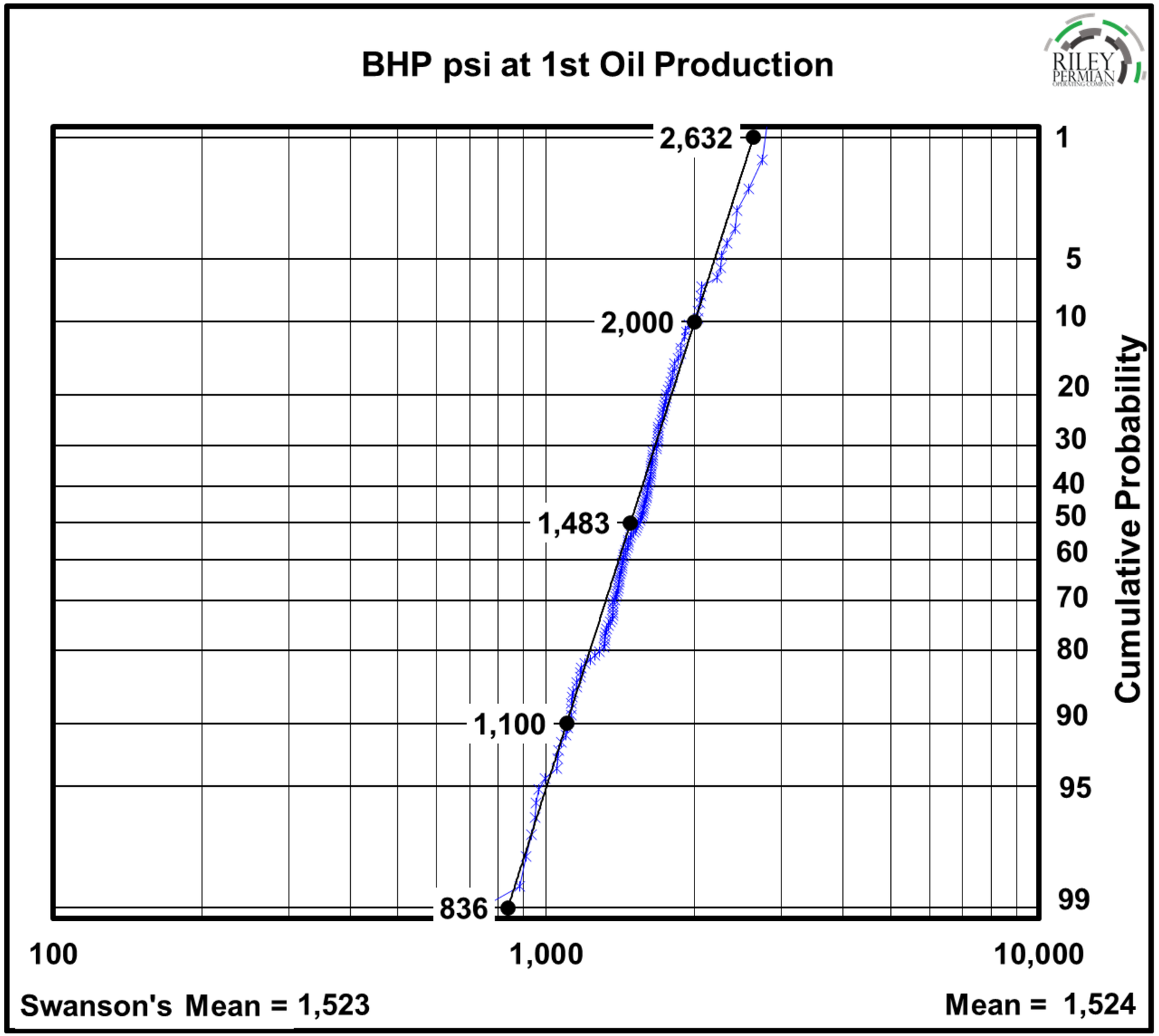
Example: Shiprock 638 3H

High productivity well in East end of Platang

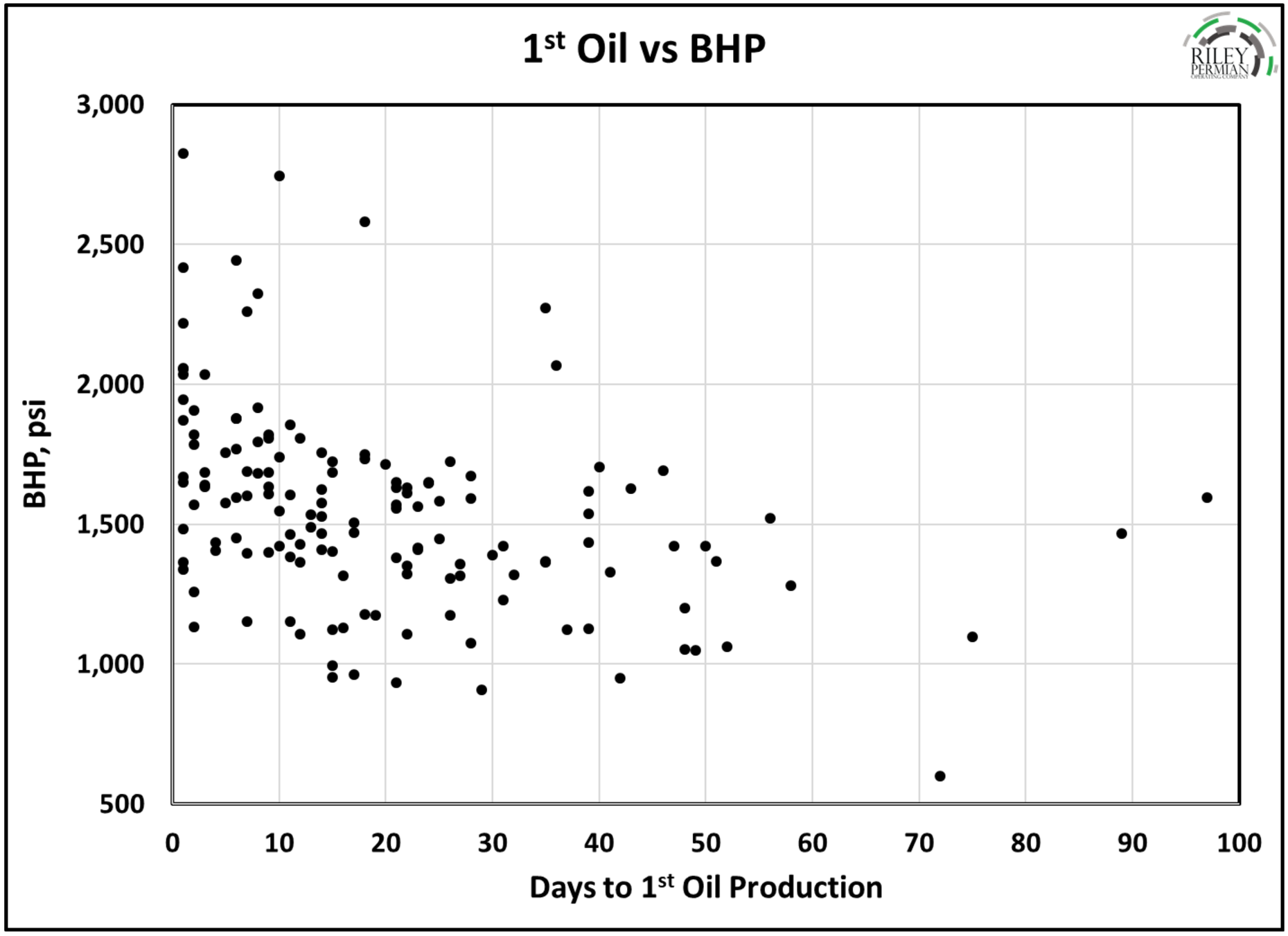
- Produced @3,000 bfpd (rate constrained)
- IPR showed well capable of >6,000 bfpd
- Result was low IP30 (~135 bopd), but slow increase for over 1 year
- Well is still not pumped off after 2 ½ years



Platang: Producing BHP at 1st Oil

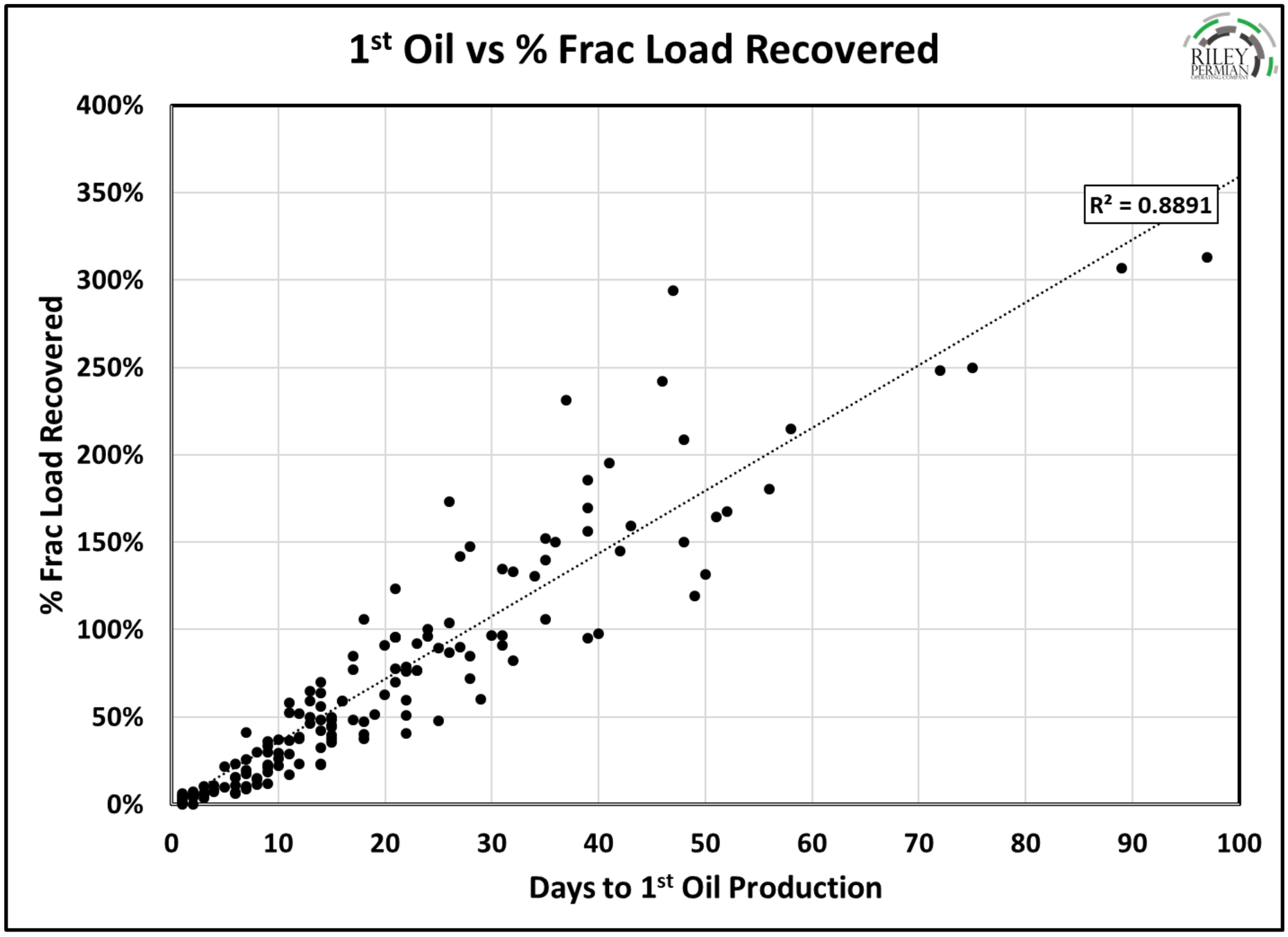


Platang: Relationship of 1st Oil to Producing BHP



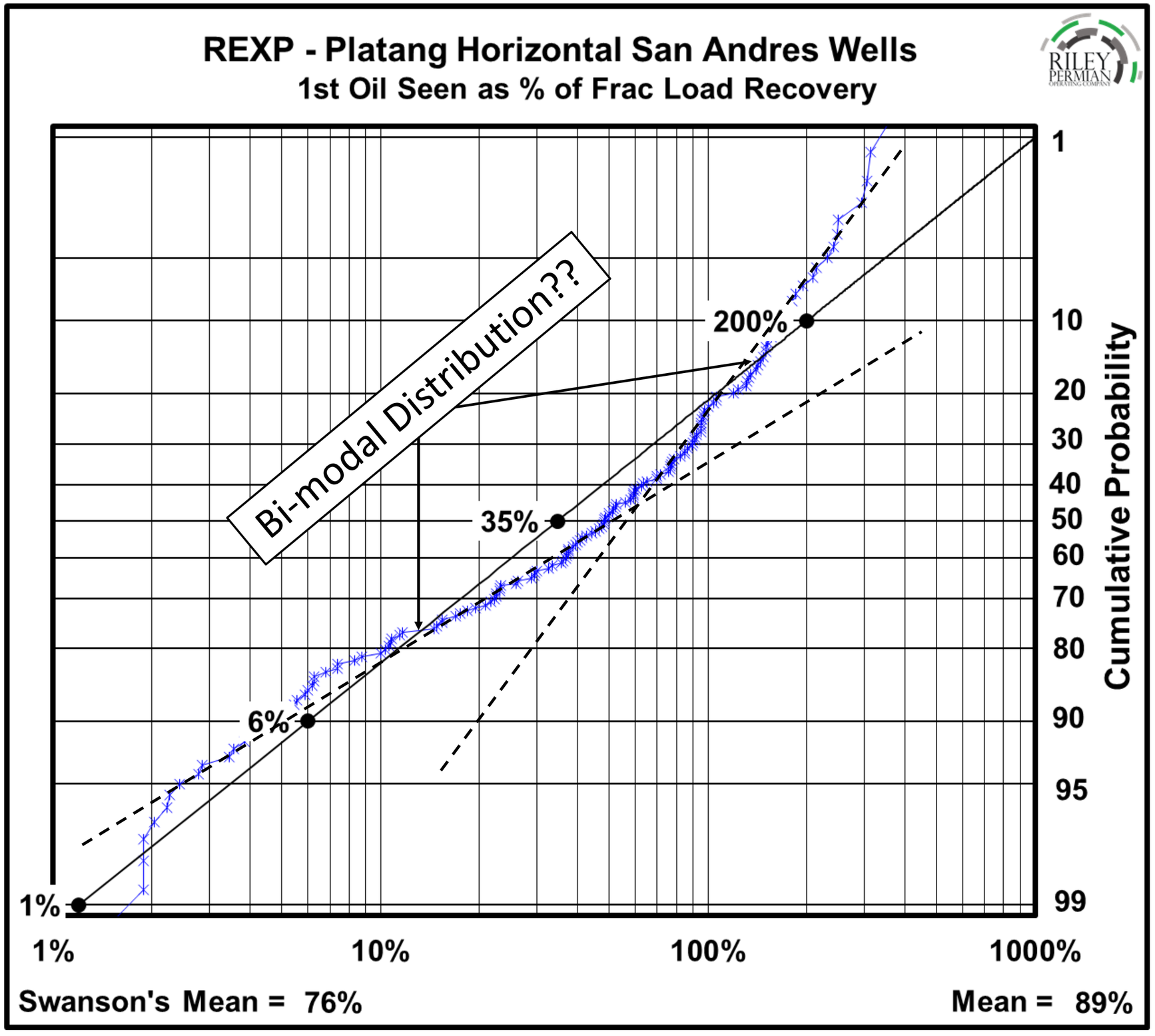
- No recognizable trend

Platang: Relationship of 1st Oil to % Frac Load Recovered

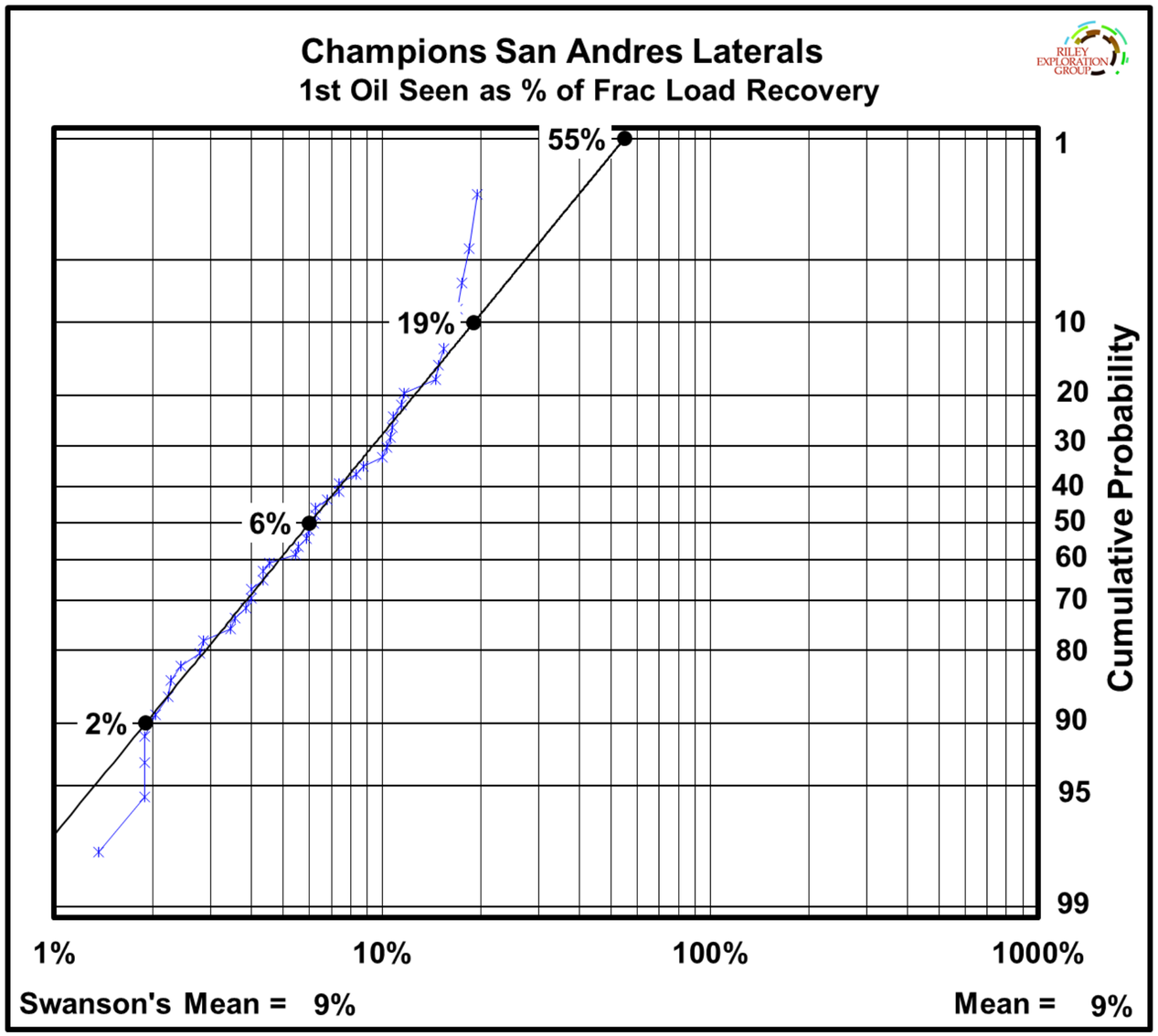


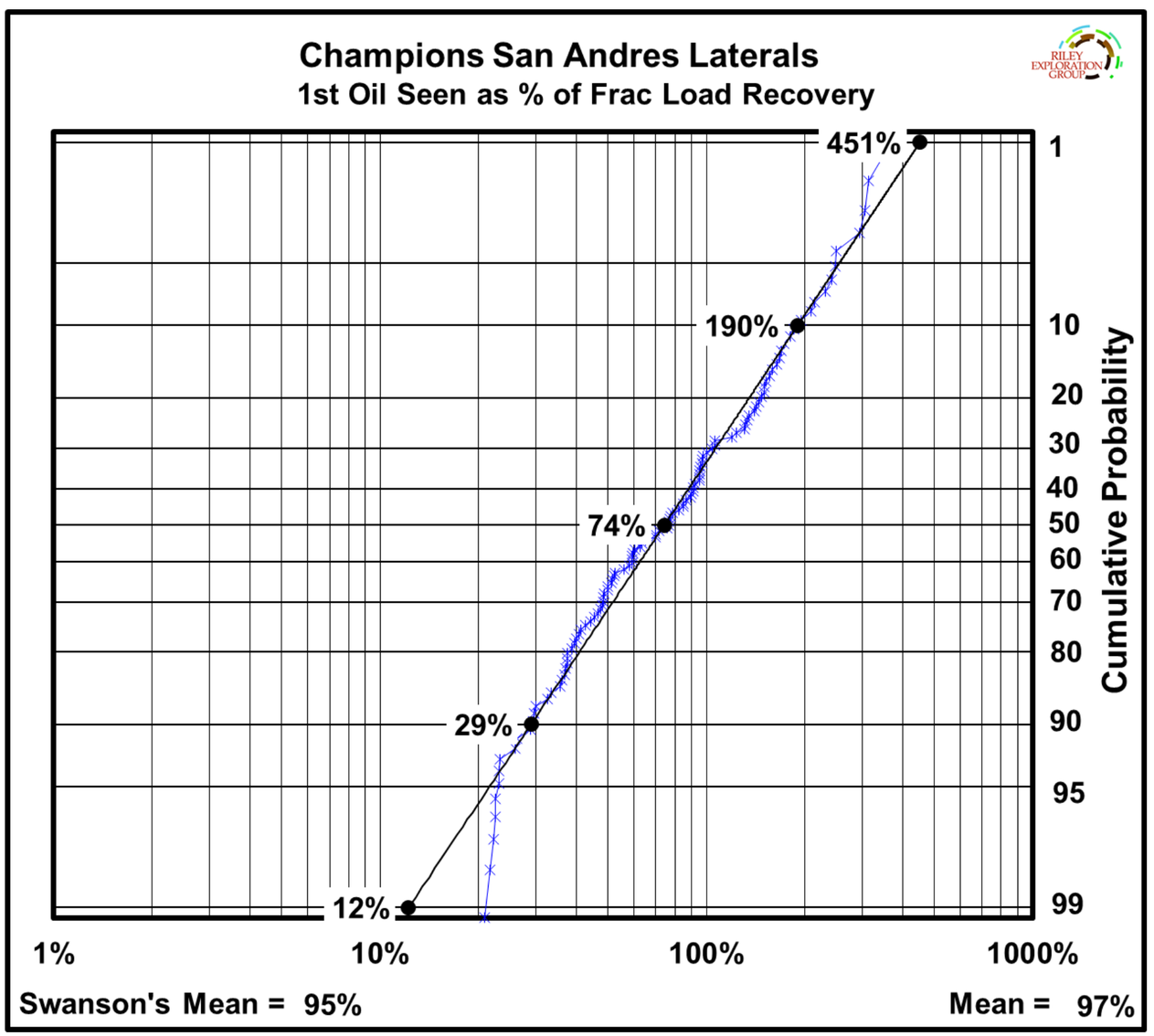
- Definite relationship to % Frac Load Recovery – does not require significant psi drawdown
  - Function of relative permeability
  - Remember – Platang is dominately a transition interval, not ROZ

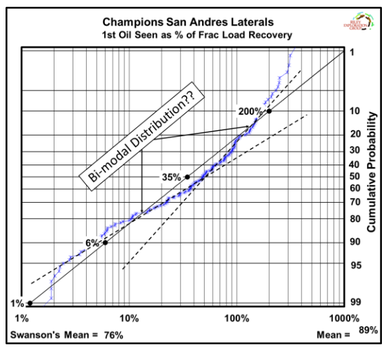
Platang: 1st Oil as % Frac Load Recovered



Platang: 1st Oil as % Frac Load Recovered – Bi-modal Distribution







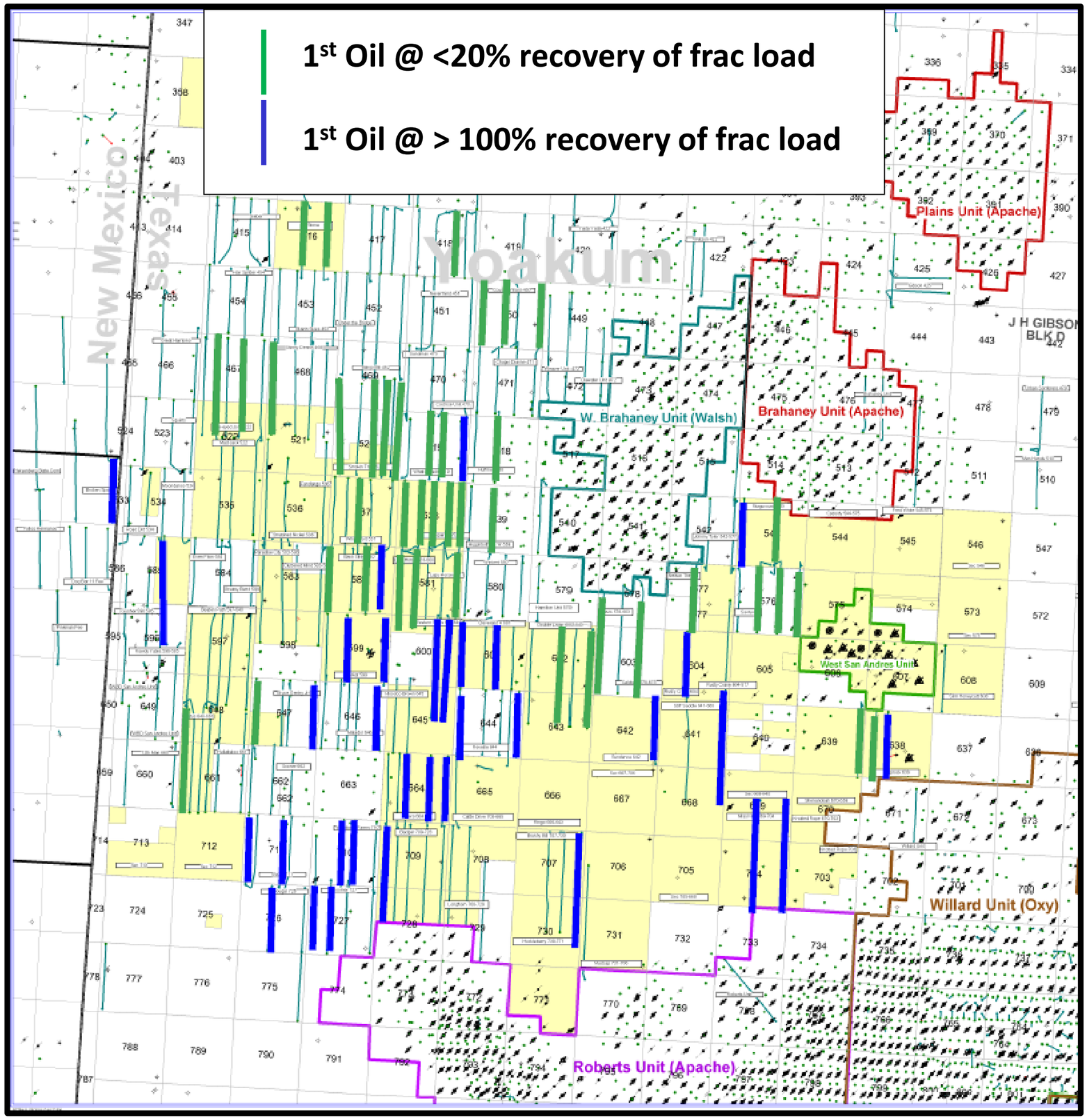
28% of wells make oil very early (<20% frac load recovery)…. Why?

- Structural / stratigraphic location in proximity to Brahaney field
- Includes infill (child) wells w/ sufficient initial (parent) well production

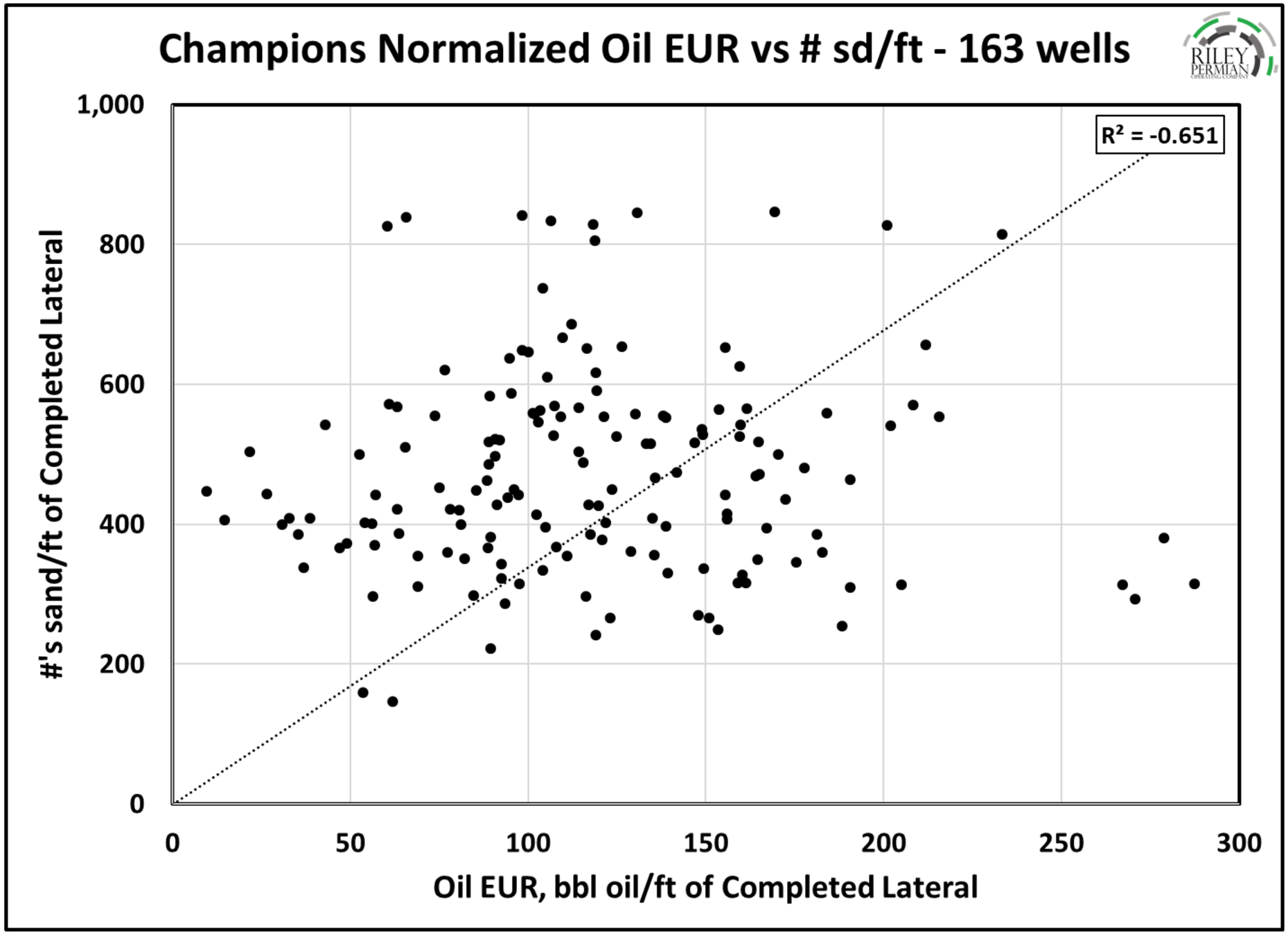
22% make oil after 100% load recovery

- High productivity / permeability wells
- Complex stratigraphy & relative permeability variations

Platang: 1st Oil as % Frac Load Recovered – Bi-modal Distribution



Platang: Relationship of #'s Frac Sd vs Oil EUR/ft



- Poor correlation of #'s frac sand to Oil EUR/ft
- Other factors impact efficiency (sand distribution, # clusters / stages, frac spacing, etc)

REXP Plans / Potential Going Forward (1)

Increased Density
Development Drilling

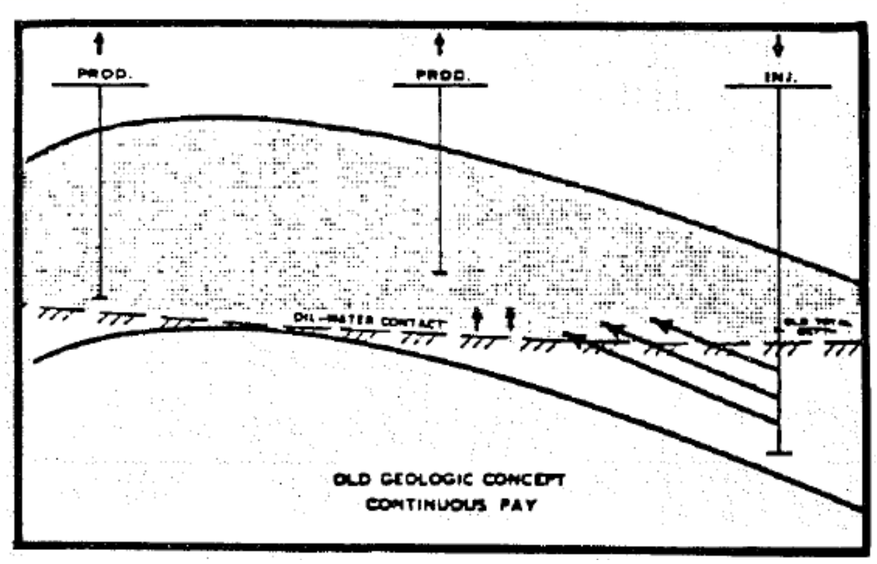
San Andres "Discontinuity" – Laterally and Vertically

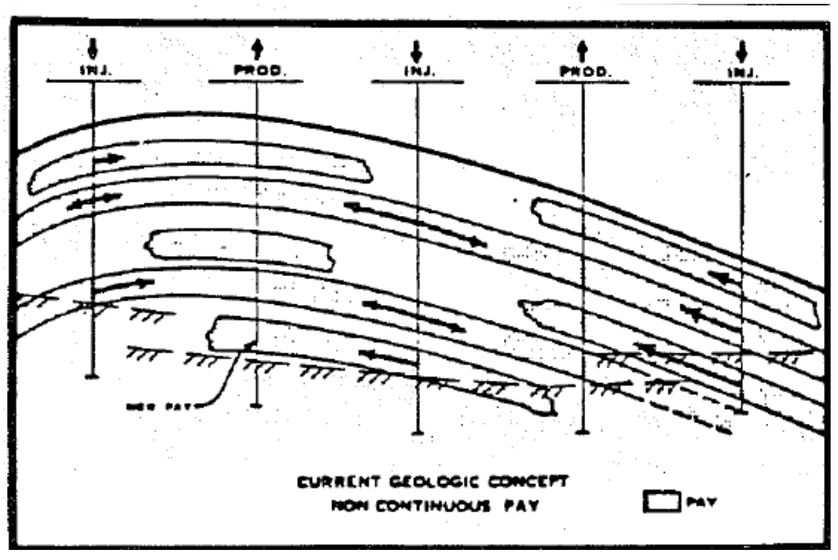
Most waterflood projects in west Texas carbonate reservoirs were originally implemented using peripheral patterns, which required good lateral and vertical pay continuity to be effective much beyond the outermost row of producing wells. Performance reviews of these projects, coupled with geologic studies[10], (Fig. 5) showed that west Texas carbonate reservoirs typically showed two types of heterogeneity:

(1) lateral discontinuity of porous (pay) intervals,

(2) barriers to vertical flow that prevented movement of fluids in other than a horizontal direction.

These "new" concepts led to widespread infill drilling and realignment of waterflooding patterns to line-drive and/or five- and nine-spot patterns. The various units of the Wasson field, including the Bennett Ranch unit, typically have this history.





Source: DOE/MC/08341-39 "Field Project to Obtain Pressure Core, Wireline Log, & Production Test Data for Evaluation of CO2 Flooding Potential" (Bennet Ranch Unit – Wasson Field), May 1982

The concept of discontinuous porosity zones

Denver Unit (Wasson Field) – San Andres Heterogeneity

Variability of Porosity & Permeability With SA Rock Type

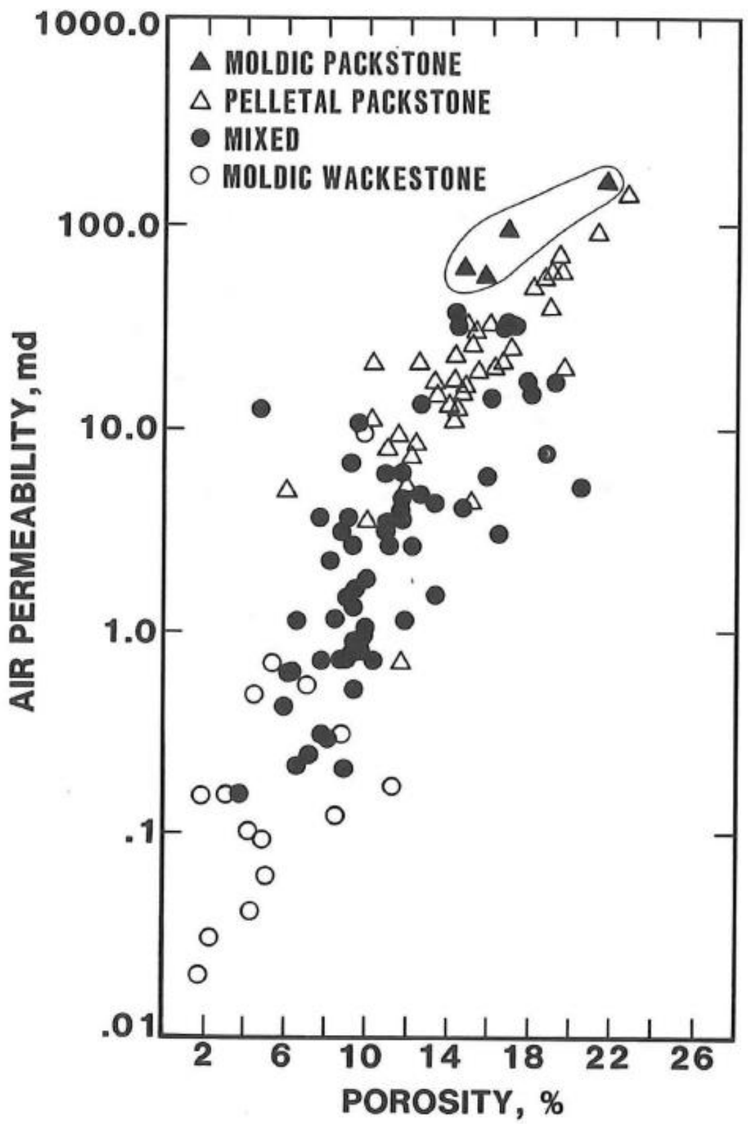


Fig. 7—Relationship between porosity, permeability and rock types.

Thin Section Photos of Varying Porosity Types in SA

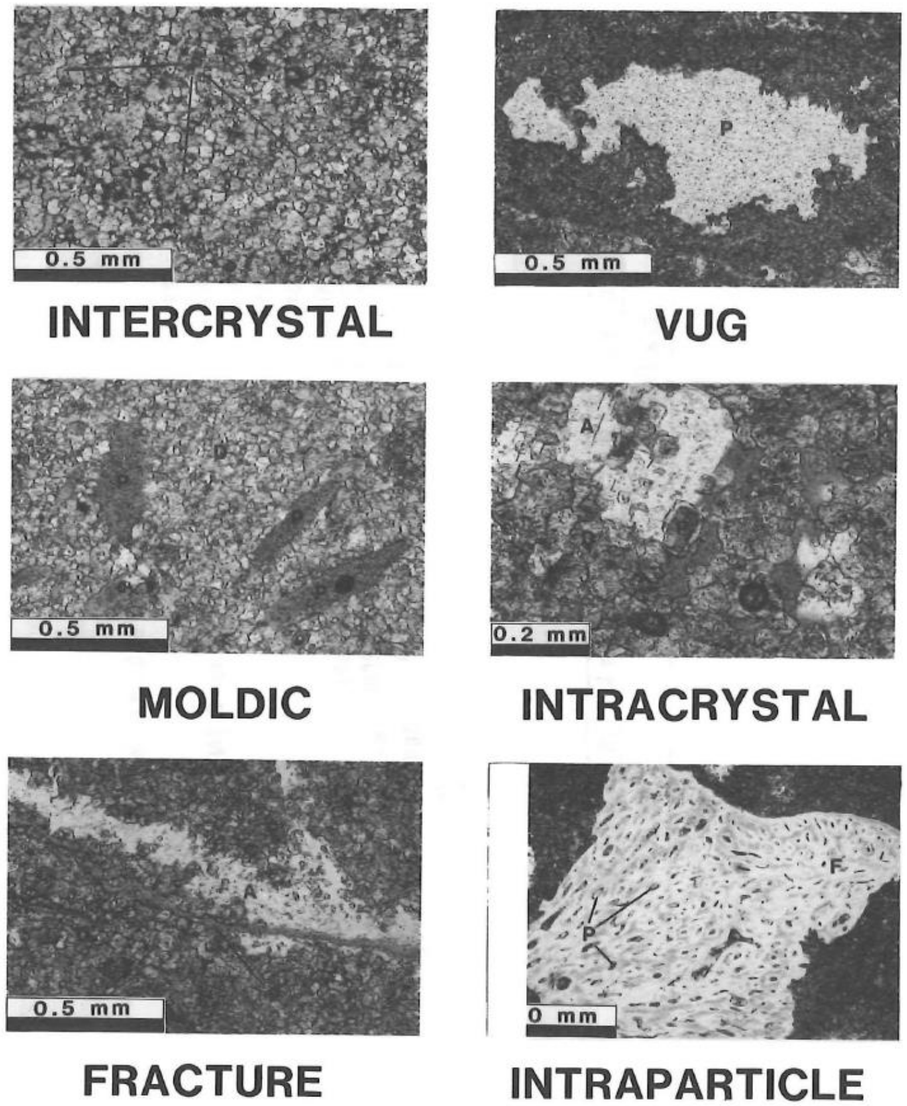
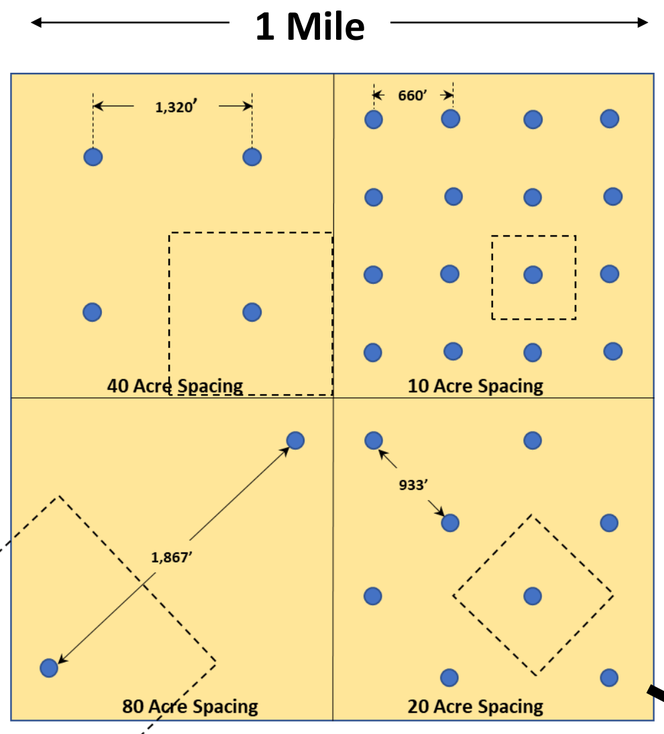


Fig. 6—Thin section photomicrographs of pore types from CO_2 pilot area: (A) anhydrite, (D) dolomite, (P) porosity, (F) fossil.

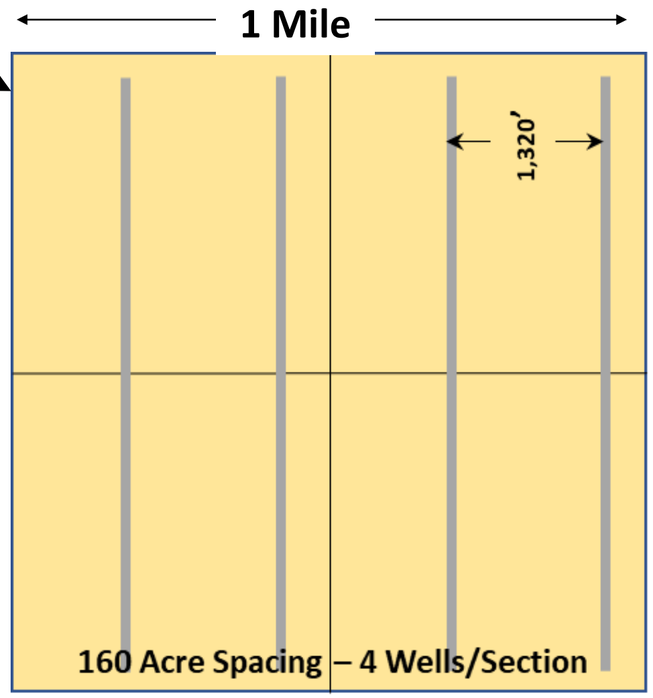
Source: SPE-13132 – "Effect of CO2 Flooding on Dolomite Reservoir Rock, Denver Unit, Wasson (San Andres) Field, TX"; Sept 1984

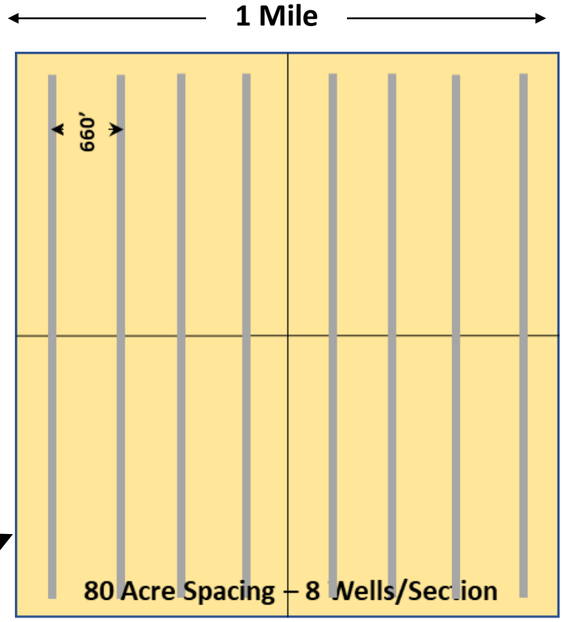
San Andres Historical Development in Wasson / Brahaney / Platang



Horizontal Development

- 2012-13 – Apache & Oxy drill 1st SA infield horizontals in Wasson & Brahaney waterfloods
- 2014 – Manzano (Steward) & Walsh drill 1st SA horizontal wells on west end of Brahaney
- 2015 – REXP drills its 1st horizontal SA wells
- Development was spaced at 4 wells / section
- 40 Acre E-W Spacing





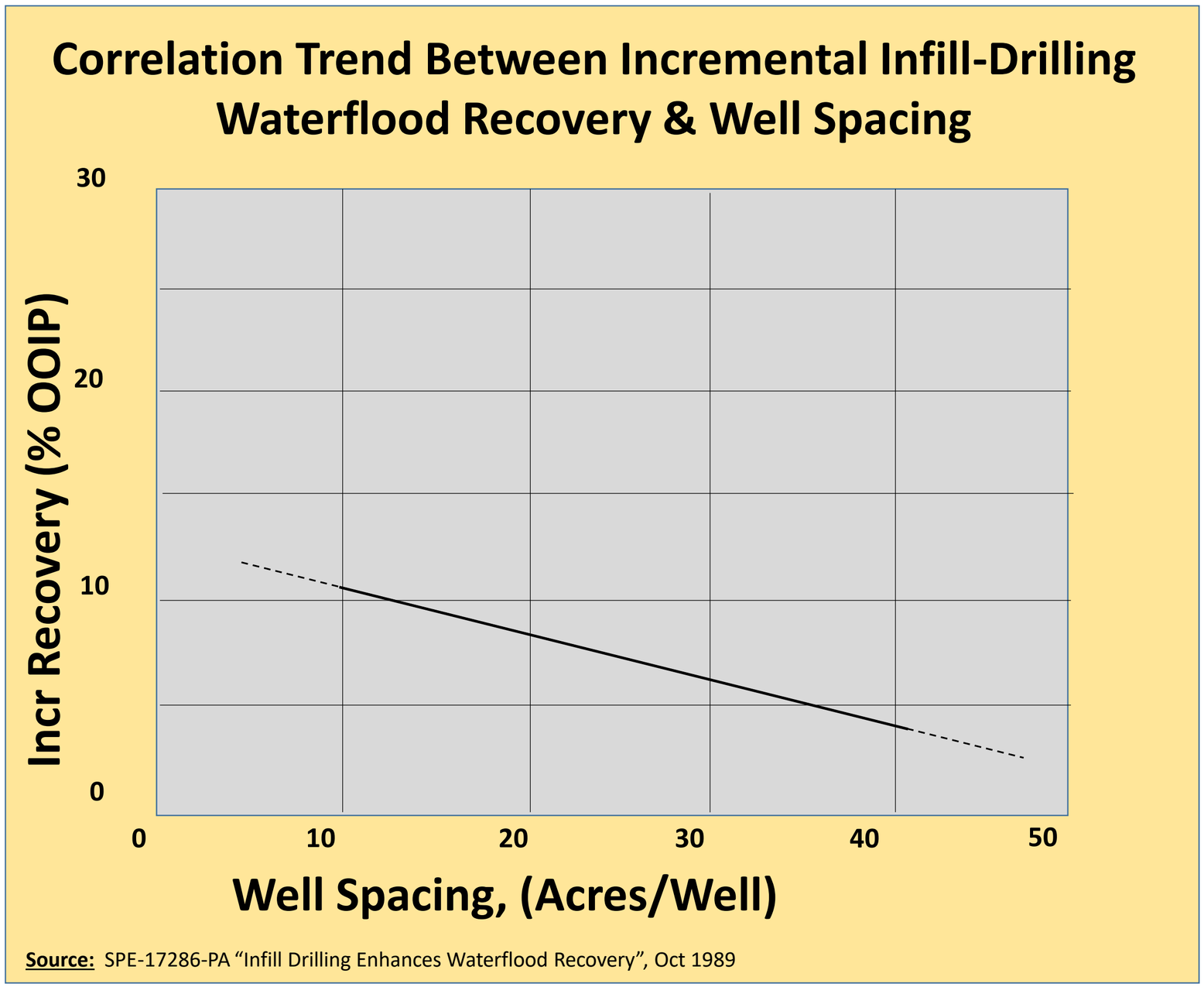
Vertical Well Development

- 1930's – 1963: Primary Development on 40-160 acre spacing
- 1964 – Unitization of Wasson (6 Units); waterflooding began
- 1970's began infill drilling to 20 & 10 acre spacing
- 1983 CO2 flooding began

Increased Density Horizontal Development

- 2018 – 9 increased density SA wells drilled with REXP WI
- 2019 – 5 increased density SA wells drilled with REXP WI
- Downspacing testing 5 to 8 wells / section
- Equiv to 10 Acre E-W Spacing

Incremental Recovery - Increased Density SA etal Projects



Source: SPE-17286-PA "Infill Drilling Enhances Waterflood Recovery", Oct 1989

Based on 15 Permian Basin SA / Grayburg / Clearfork Infill Drilling

- Adair/San Andres
- Block 31/Block 31
- Fuhrman-Mascho/Block9
- Fullerton/Clearfork
- Levelland/N.C.Levelland
- Means/San Andres
- Ownby/San Andres
- Robertson/Clearfork
- Russell/Clearfork
- Shafter Lake/Grayburg
- Triple-N/Grayburg
- Wasson/Cornell
- Wasson/Denver
- Wasson/Willard
- West Goldsmith/West Goldsmith
- West Seminole/San Andres

=> Downspacing from 40 to 10 acre vertical spacing yields <u>+6.5% incremental recovery</u>

Incr Rec from Incr Density SA Drlg - Dune Field, Crane Co. TX

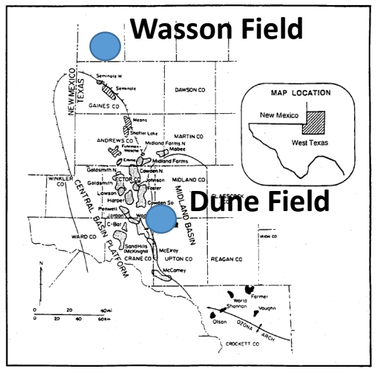


Table 5

Oil and Gas Recovery From Blanket Infill Development - Dune Field, Section 15

Development Strategy (acres/producer)	Incremental Contacted Oil (MB)	Incremental Recoverable Hydrocarbons Oil (MB)	OOIP (%)	Gas (MMcf)	OAGIP (%)
80 to 40	1,602	1,316	4.4	731	6.9
40 to 20	1,425	1,199	4.0	694	6.5
20 to 10	1,137	1,041	3.4	649	6.1
Total	4,164	3,556	11.8	2,074	19.5

=> Downspacing from 40 to 10 acre vertical spacing yields +7.4% incremental recovery

Source: SPE-18929 March 1989

Incr Rec from Incr Density SA Drlg - Dune Field, Crane Co. TX

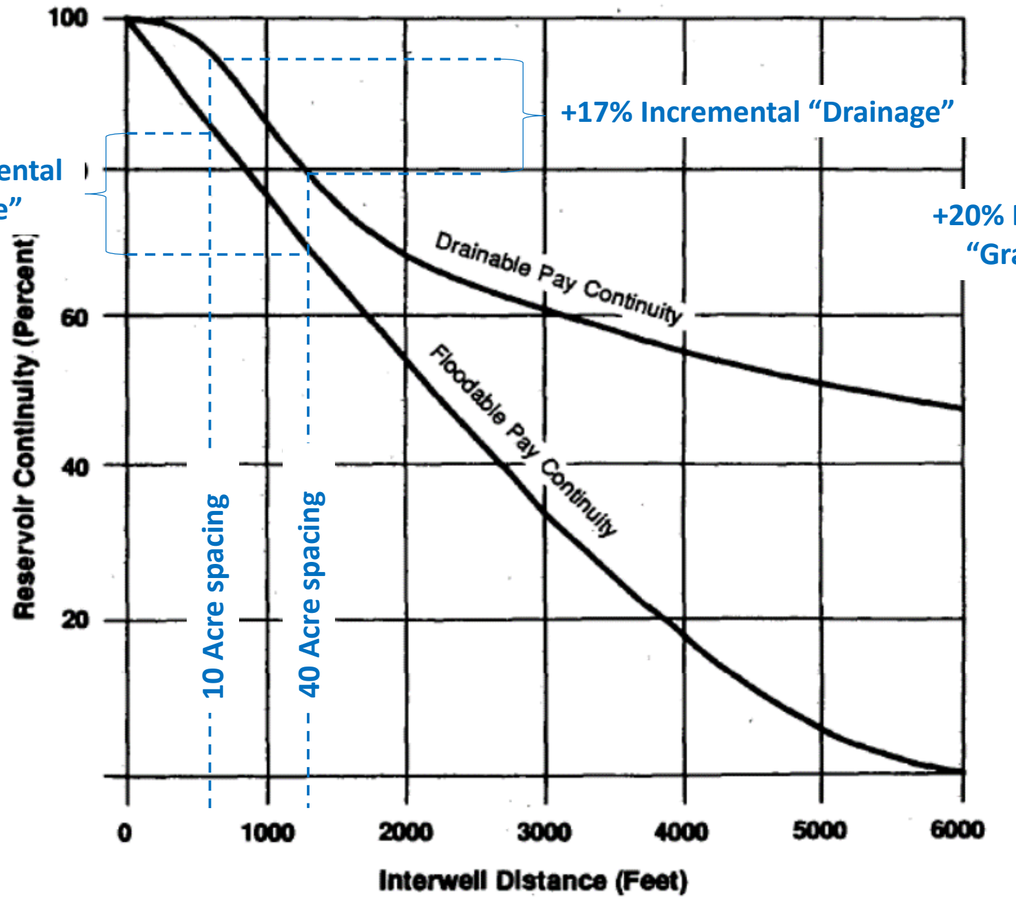


Figure 3. Reservoir continuity.versus interwell distance for blanket infill drilling, Dune Field, Section 15.

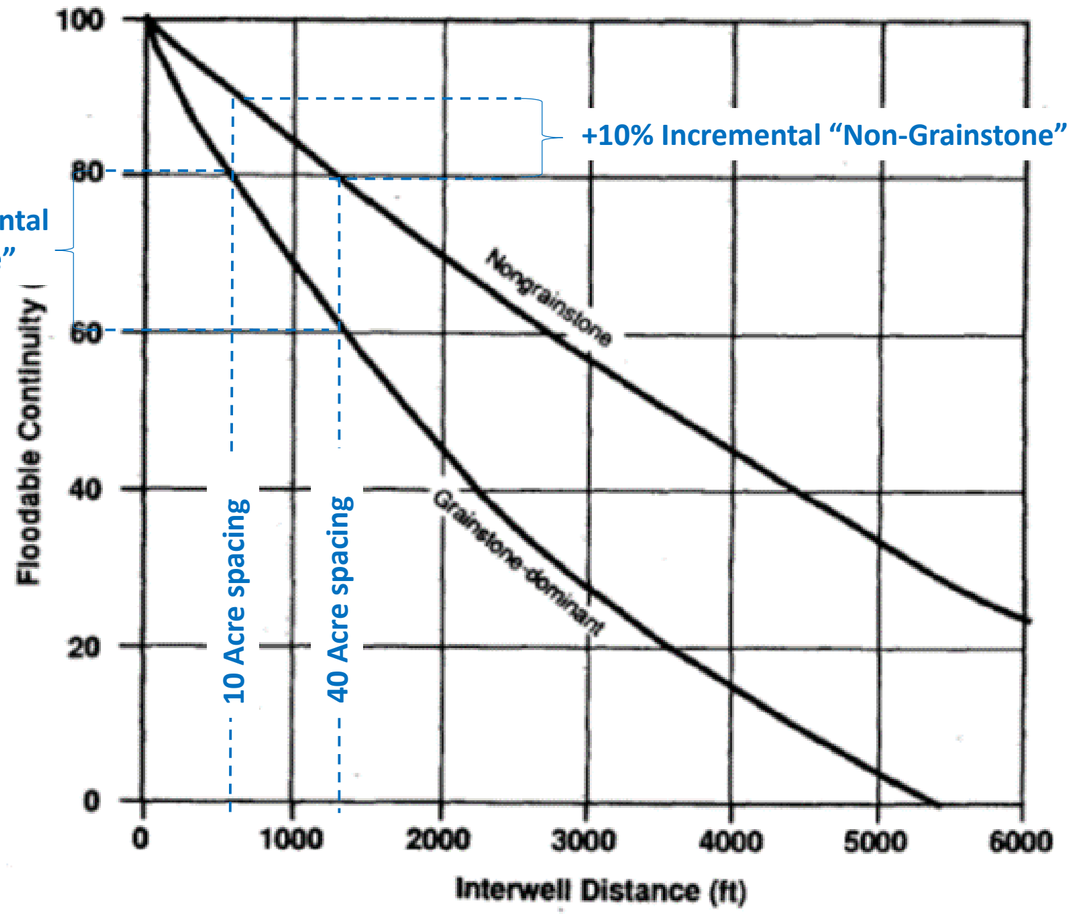


Figure 4. Grainstone-dominant and nongrainstone floodable continuity curves, Dune Field, Section 15.

=> Downspacing from 40 to 10 acre vertical spacing yields <u>+10-20% increased reservoir continuity</u>

Source: SPE-18929 March 1989

Platang – SA Incr Density Horizontal Wells – Results to Date

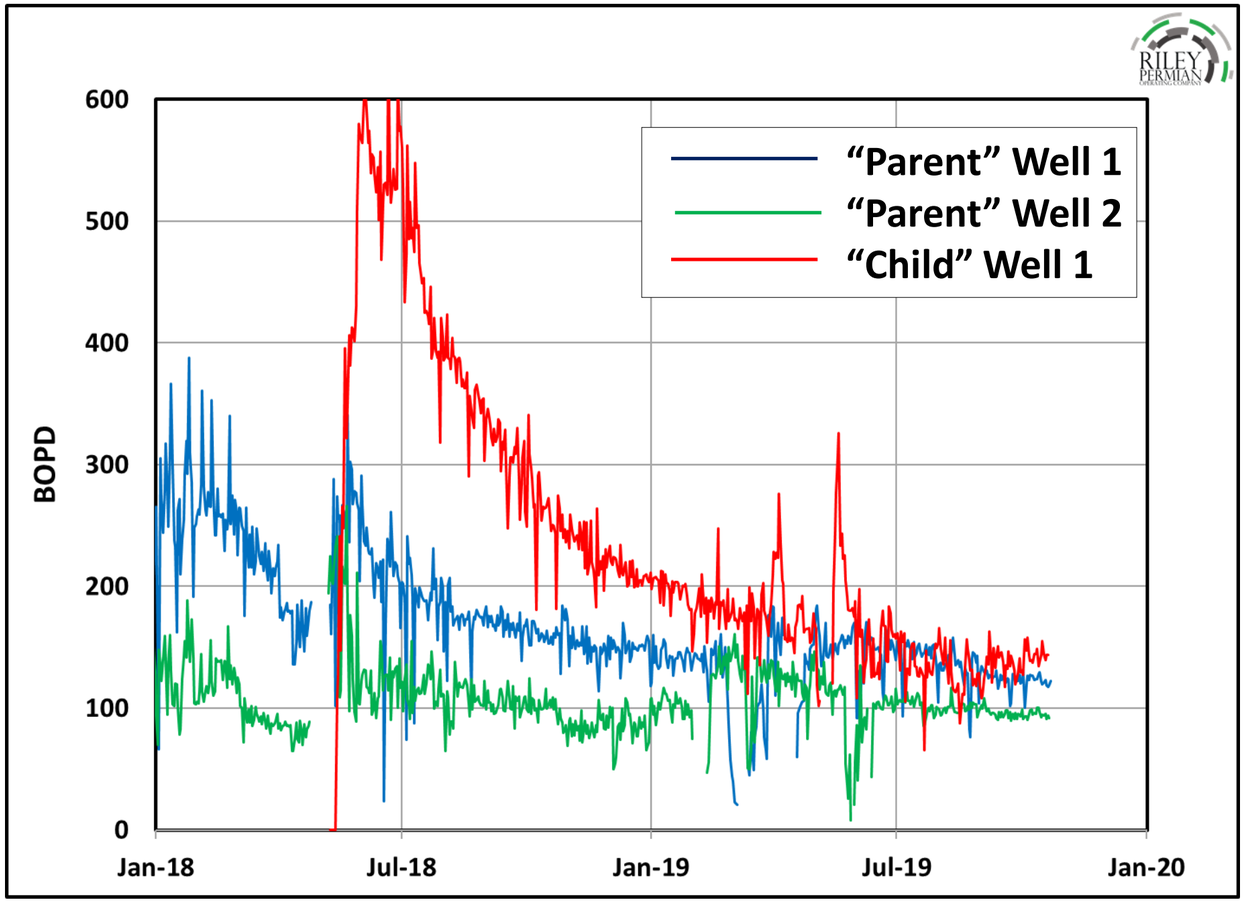
- 10 increased density horizontal tests (12 wells) to date with REXP WI wells
  - 7 more tests permitted / planned in near term
  - 5 to 8 wells / section spacing tests
  - 1 to 18 months historical data
  - 10 wells have sufficient data for forecasting EUR

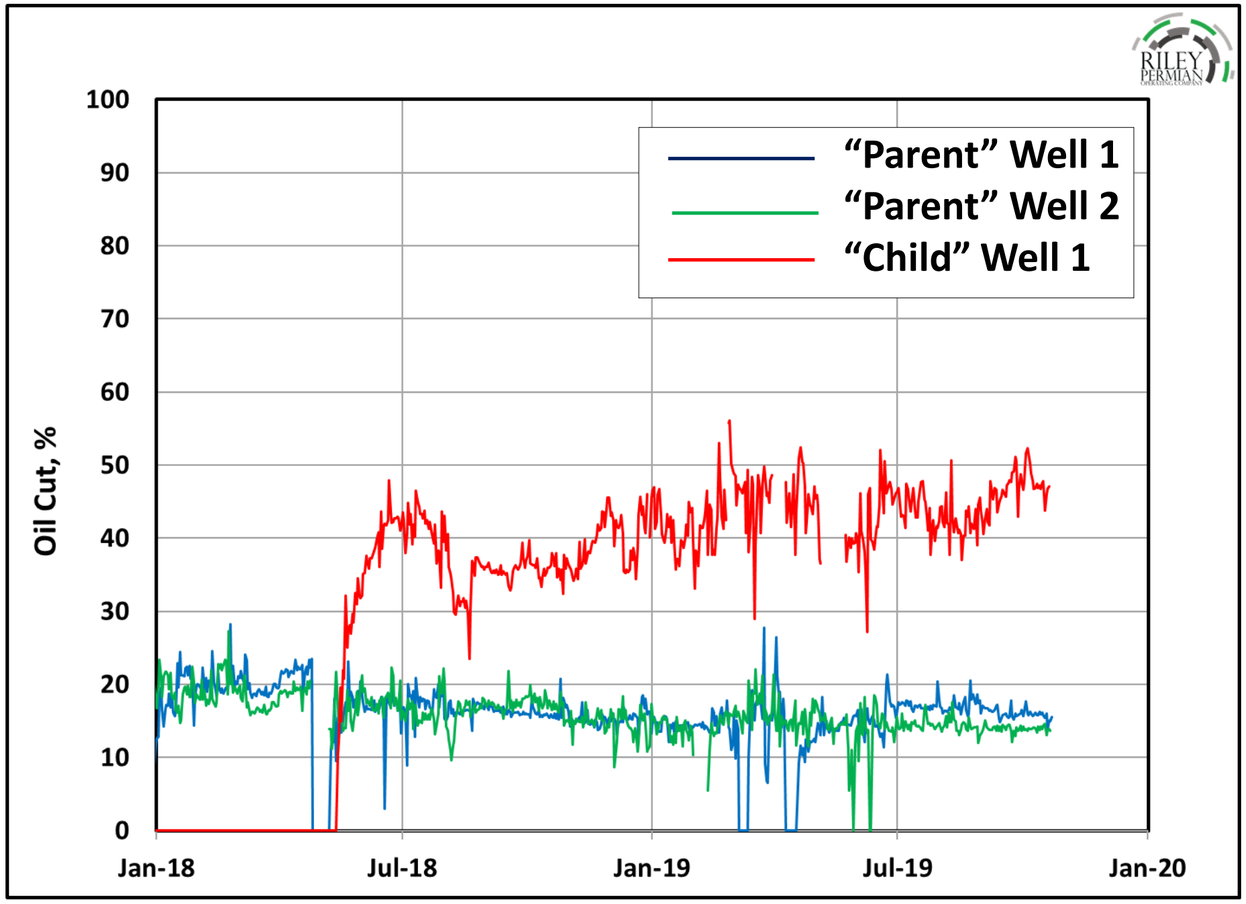
- *No negative impacts* to offset "parent" well rates or EUR seen to date

- Increased density "child" wells performance is very good – general observations:
  - Increased IP30 oil rates
  - Increased oil cut
  - Decreasing time to see 1st oil production
  - Decrease in water rates on several wells vs "parent"
  - Decrease in initial pressure on several wells vs "parent"
  - Occasional, minimal short term frac interference with "parent"; temporary

- ***VERY POSITIVE*** early; significant incremental oil is being recovered (consistent with historical San Andres vertical development on tighter spacing), but future acceleration from "parent" wells is also likely. *Consideration of acceleration must be incorporated into reserves analysis* to avoid double dipping reserves from "parent" and "child" wells

Platang - Increased Horizontal SA Density Drilling Example





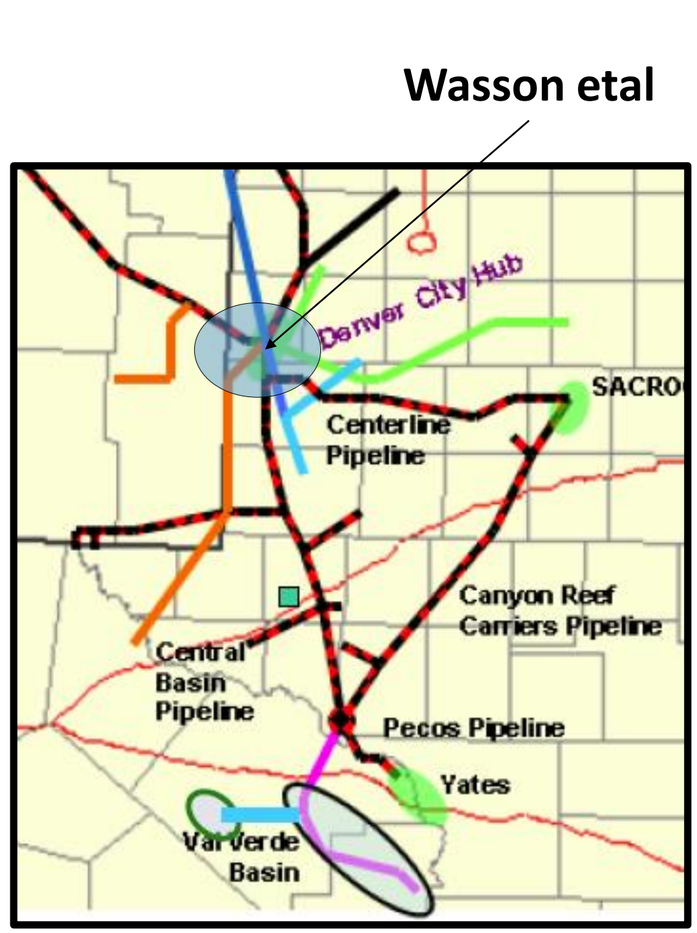
- E-W spacing equivalent to ~10 acre vertical well spacing (678' between wells)
- Cumulative production:
  - Combined 410 mbo from 2 "parent" wells (4½ years)
  - 125 mbo from "child" well (1½ years)
- Quicker oil, higher oil rate, better oil cut & no apparent interference between wells to date
- Similar results seen in other increased density tests

REXP Plans / Potential Going Forward (2)

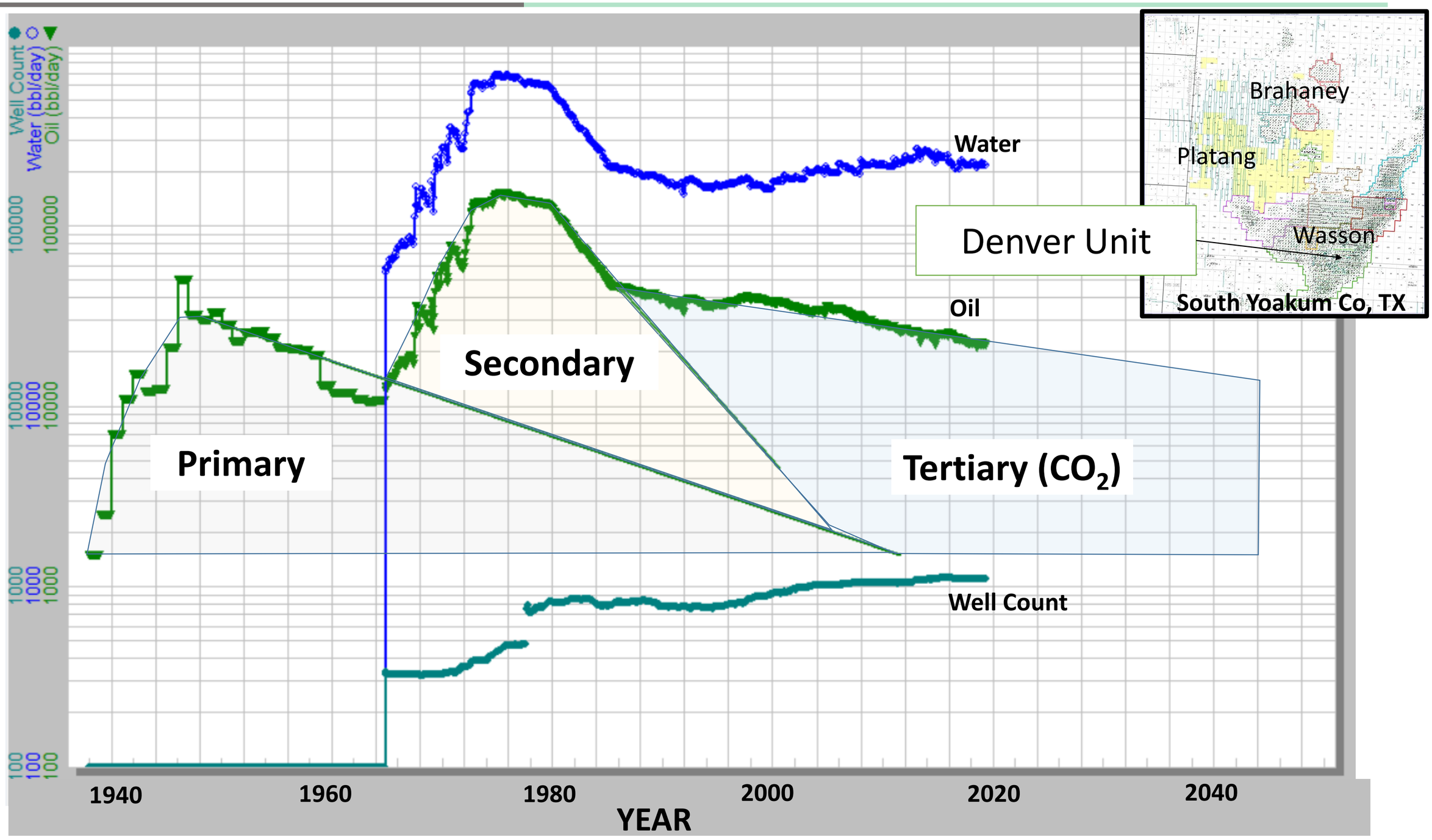
CO_2 Assessment & Test

Horizontal Producers & Vertical Injectors

Permian Basin CO_2 Pipeline Infrastructure



Denver Unit Historical Performance (2.8 billion bbls OOIP)



- Primary EUR 300 mm bbls oil; 11% OOIP
- Secondary EUR 550 mm bbls oil; 20% OOIP – combined waterflood & infill drilling
- Tertiary EUR 550 mm bbls oil; 20% OOIP – 300 mm bbls cum + 150 mm bbls remaining
- Total EUR – 1.4 billion bbls oil => <u>50% recovery of OOIP</u>

REXP CO_2 Initial Study

- Initial look began in 2016
  - Joint study with Baker Hughes
  - Detailed geology & reservoir characterization
  - Reservoir Simulation - history matching horizontal well performance & forecasting
- CO_2 efficiency evaluated with horizontal producers & vertical injectors
- Results indicated potential for +2X to +5X over primary

REXP CO_2 Pilot Feasibility Study – West San Andres Unit

- Study in progress
- WSAU unitized by Mobil in 1968
  - Vertical development
  - 40 acre spacing
  - Completed only upper SA
  - Minimal waterflooding
- Design for 2 CO_2 patterns
  - 3 horizontal producers (1-1¼ mile)
  - 8 – 12 vertical injectors
- Combining results of joint REXP/Baker study with Wasson historical results
- Incorporating costs, expected results & economic feasibility