

# The Permian Basin – Evolution of a Perfect Petroleum System

February 2018



Please see the end of this presentation for important disclosures

# Agenda

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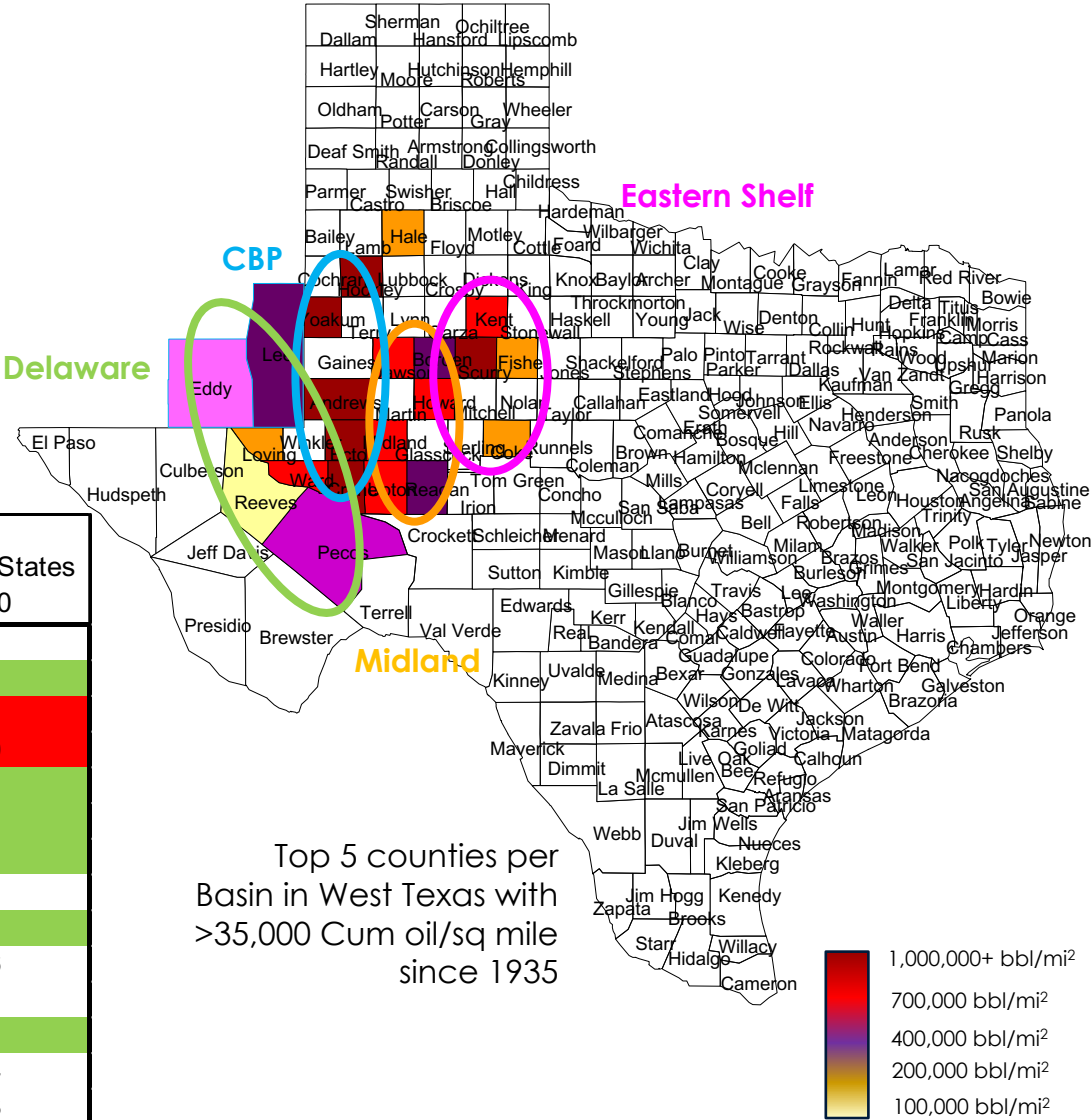
- Texas and West Texas history and Petroleum System
- The Three Phases of Permian Horizontal Drilling
  - › Midland Basin
  - › Delaware Basin
  - › CBP?
- Summary



# History of the Permian Basin of West Texas

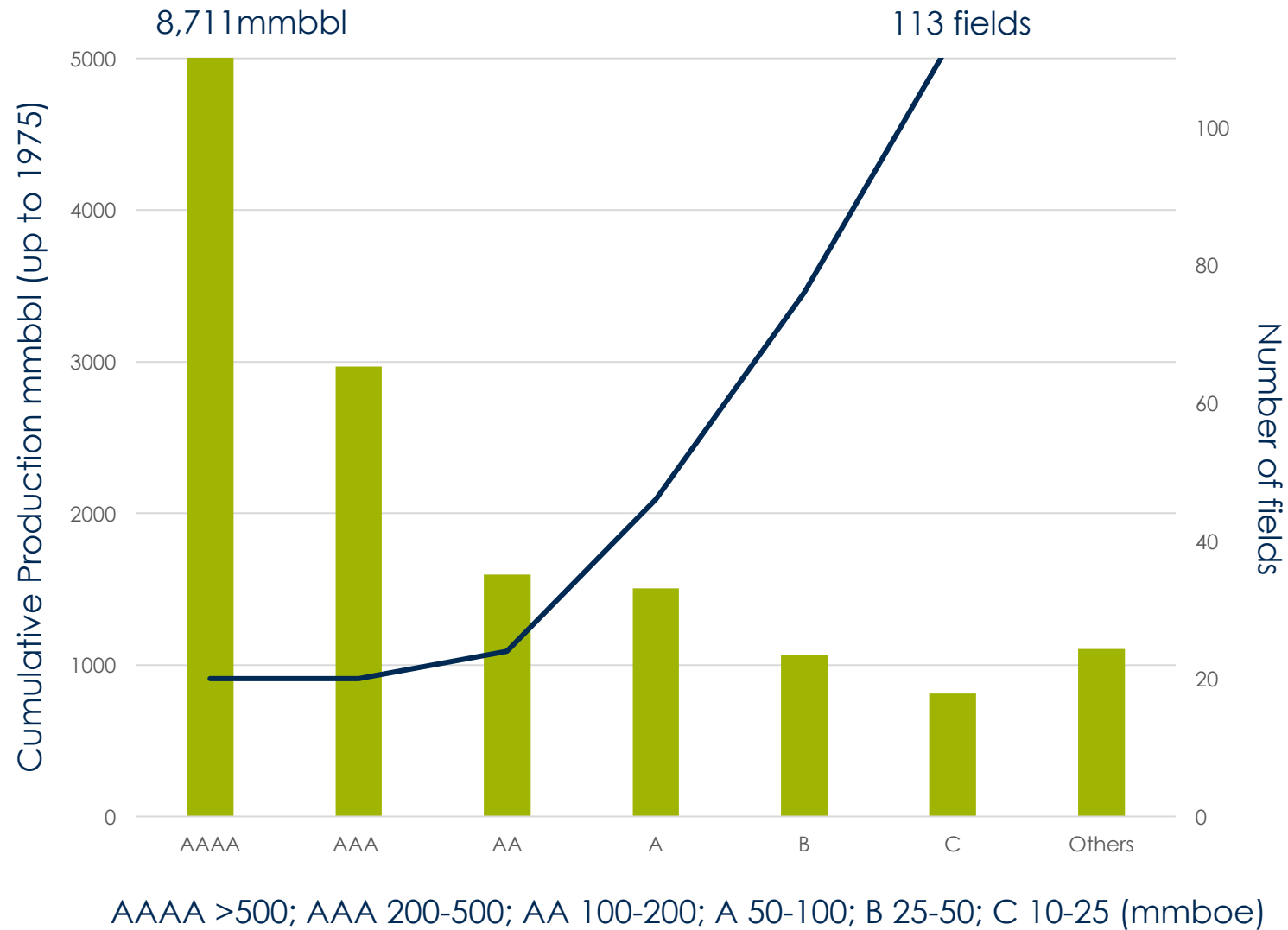
- High quality unconventional plays typically occur beneath prolific historic conventional fields
- Texas has produced a third of the US conventional oil reserves and the Permian Basin of West Texas has produced about 40% of Texas's oil

State	Onshore production 1862-2016 BnBbl	Top Onshore States % 1862-2016	Onshore States 1862-2016	Onshore production pre 1961 BnBbl	Top Onshore States % 1862-1960	Rank of Onshore States 1862-1960
U.S. Onshore Total	196.2			65.1		
Texas	68.4	34.4%	1	23.4	36.0%	1
California	28.8	14.5%	2	12.0	18.5%	2
Alaska	18.3	9.2%	3	0.0	0.0%	20
Louisiana	16.3	8.3%	4	5.3	8.1%	3
Oklahoma	8.5	4.3%	5	3.1	4.8%	4
Wyoming	7.6	3.8%	6	1.9	2.9%	7
Kansas	6.5	3.3%	7	3.1	4.8%	4
New Mexico	5.9	3.0%	8	1.3	1.9%	8
North Dakota	4.2	2.1%	9	0.3	0.4%	16
Illinois	3.5	1.8%	10	2.1	3.2%	6
Colorado	2.7	1.3%	11	0.5	0.8%	11
Utah	2.0	1.0%	12	0.4	0.7%	14
Montana	1.5	0.8%	13	0.2	0.3%	18



# Permian Basin: The Perfect Petroleum System

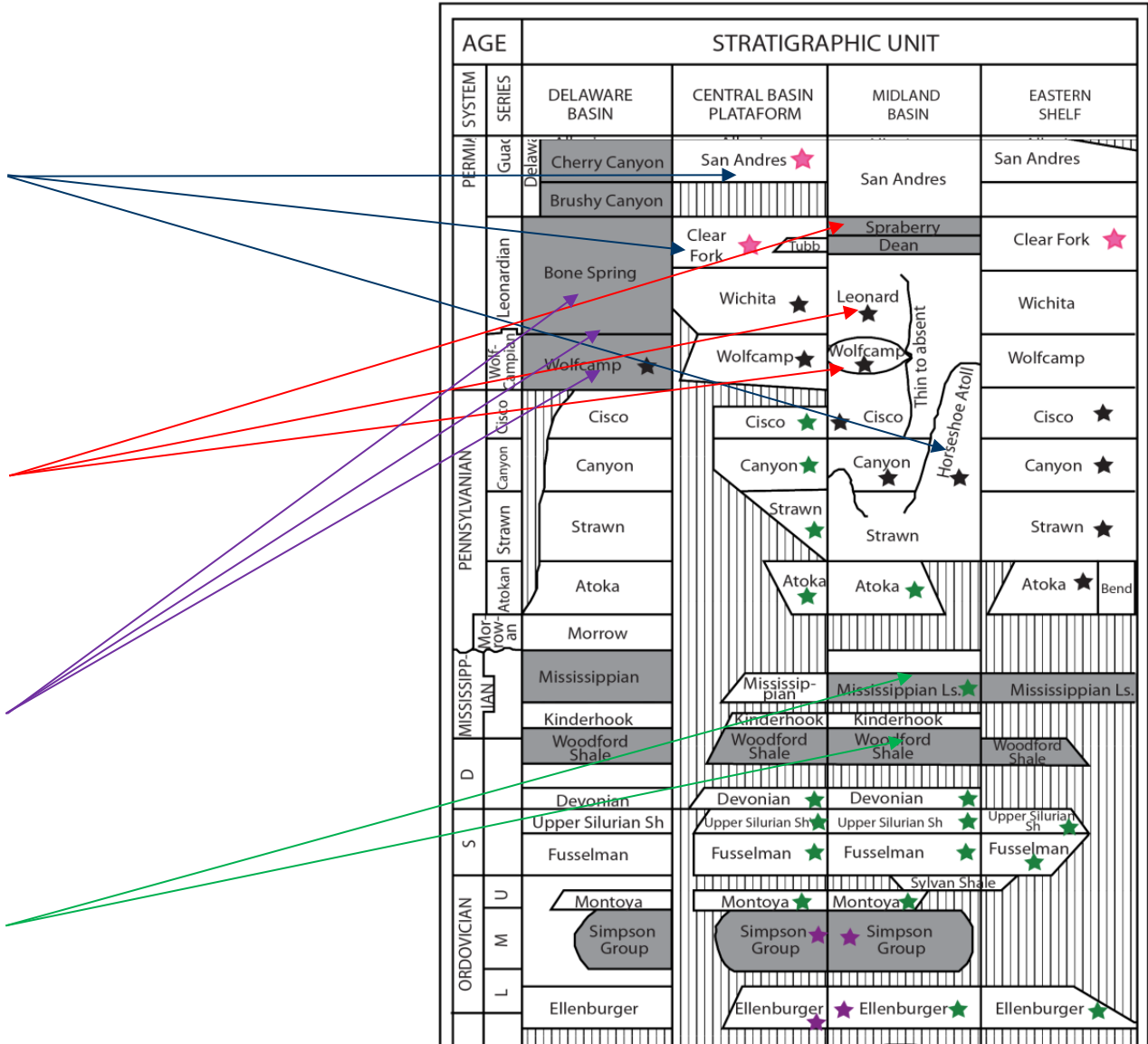
- Around 29 Bnbbl oil and 75 Tcf gas have been produced from the Permian (mainly conventional production)
- Unconventional exploration and development has now started in the basin with the Midland then the Delaware and now the CBP attracting attention
- The Permian is a Perfect Petroleum System as it has generated significant amounts of hydrocarbons concentrated in a few giant conventional fields



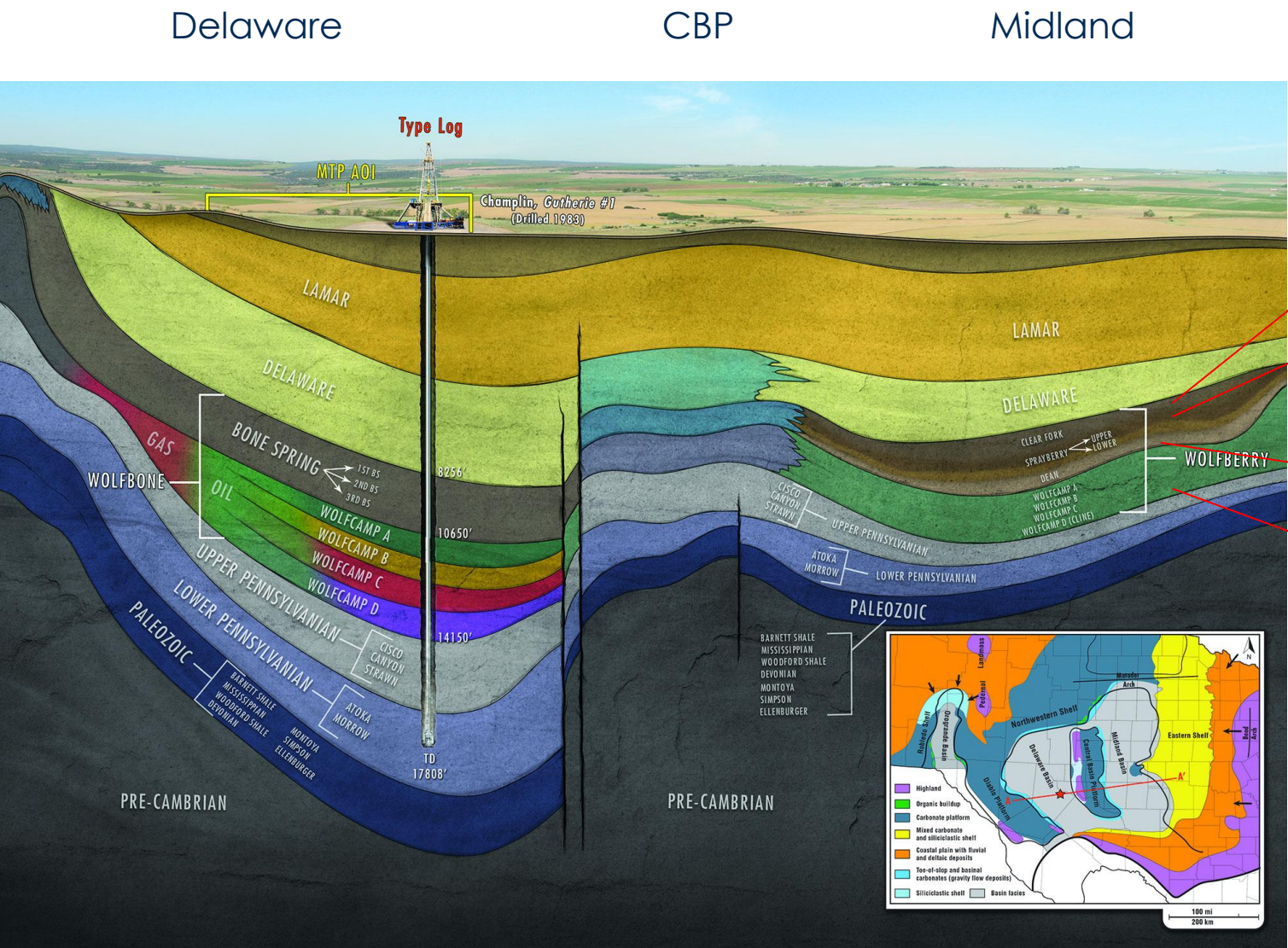


# Permian Basin: Overview and Key Unconventional Reservoir Intervals

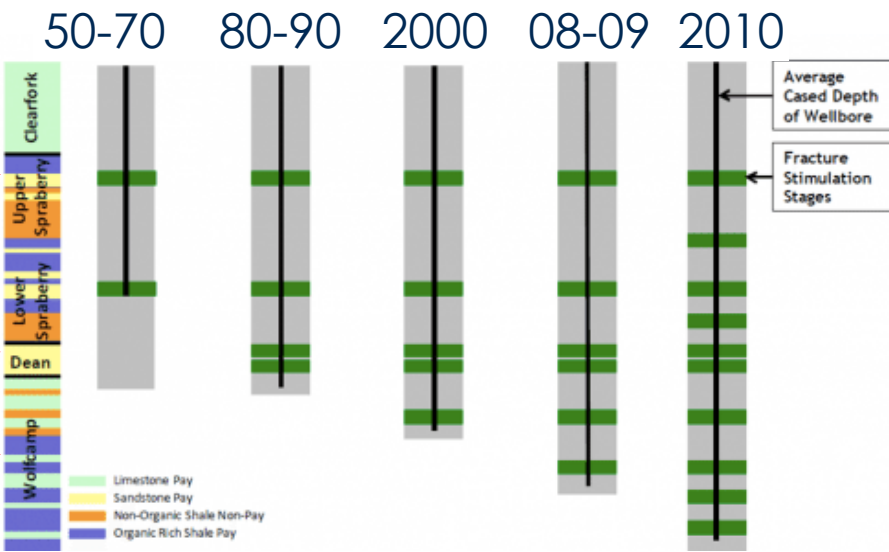
- Main Conventional Reservoirs (CBP)
  - › San Andres
  - › Clear fork
  - › Strawn/ Horse Shoe Atholl
- First Horizontal Unconventional Reservoirs (Midland)
  - › Bone Springs Sst & Leonard
  - › Spraberry/Wolfberry
- Second Phase Unconventional Reservoirs (Delaware)
  - › Wolfcamp A, B, C/D Benches
  - › Bone Springs Shale & X/Y Sands
- Third Phase Unconventional Reservoirs (CBP)
  - › Woodford Shale & Barnett Shale



# Permian Basin: Midland Basin – The First Phase of Horizontal Drilling



Midland Vertical Unconventional wells started as early as 2000 with Horizontal activity taking off after 2008

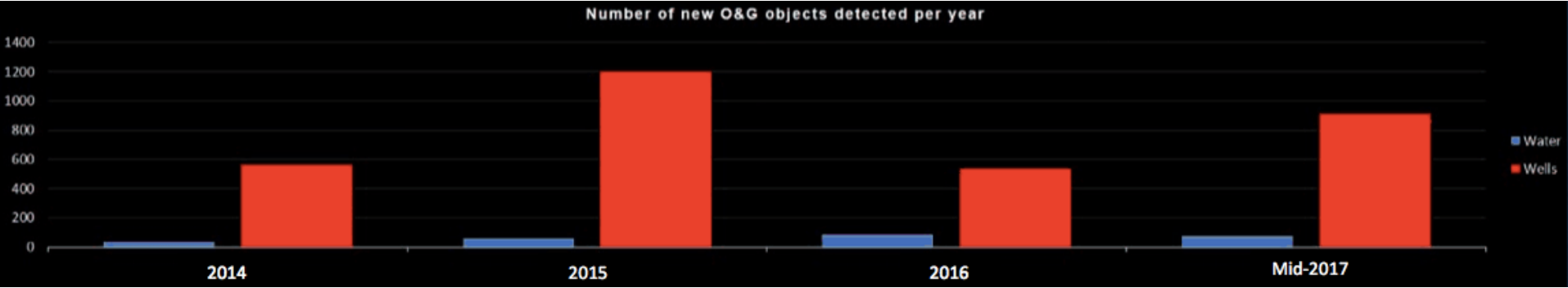
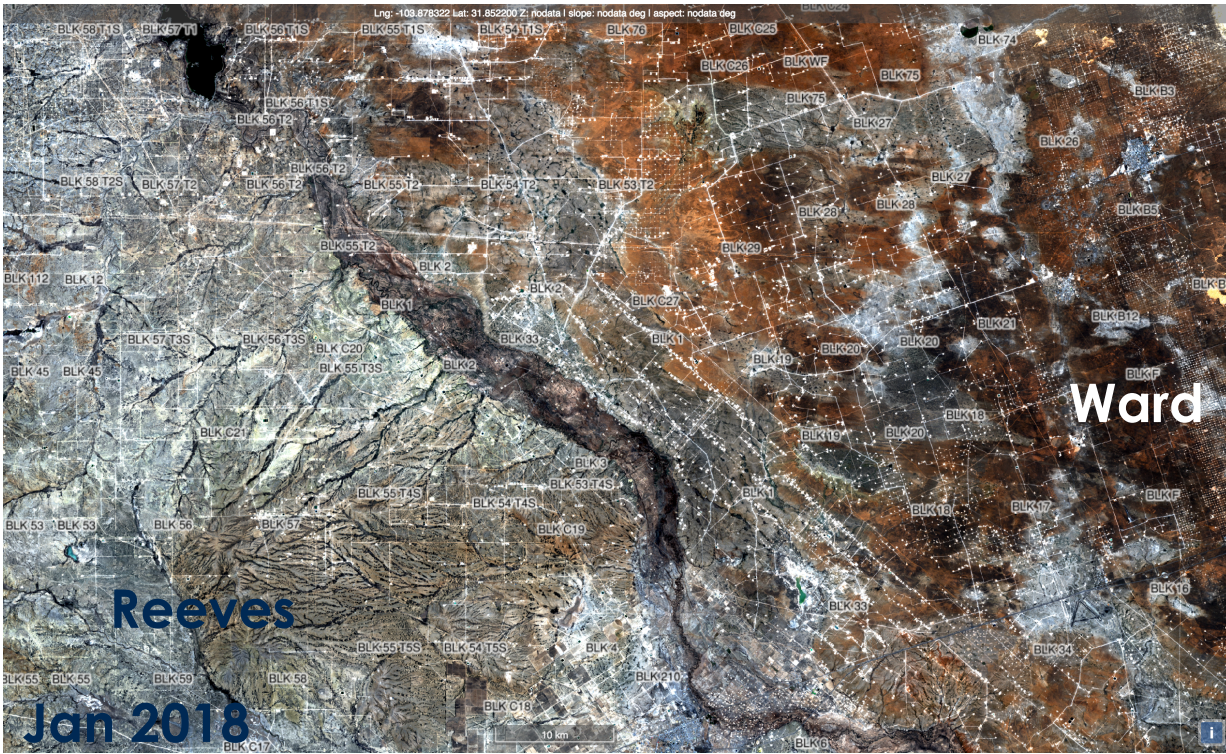
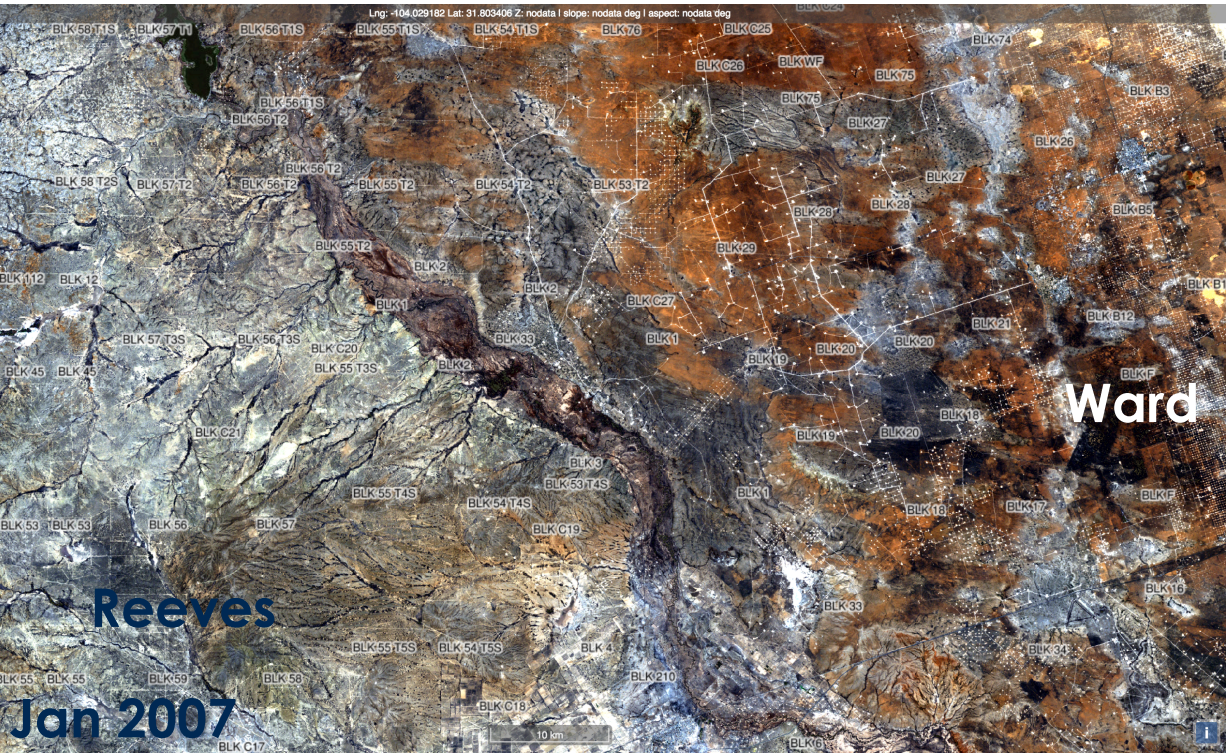


Many companies targeted the first Midland Horizontal Wells on the:

- Clear Fork
- Upper Spraberry
- Lower Spraberry
- Wolfcamp



# Permian Basin: Delaware Basin – The Second Phase of Horizontal Drilling



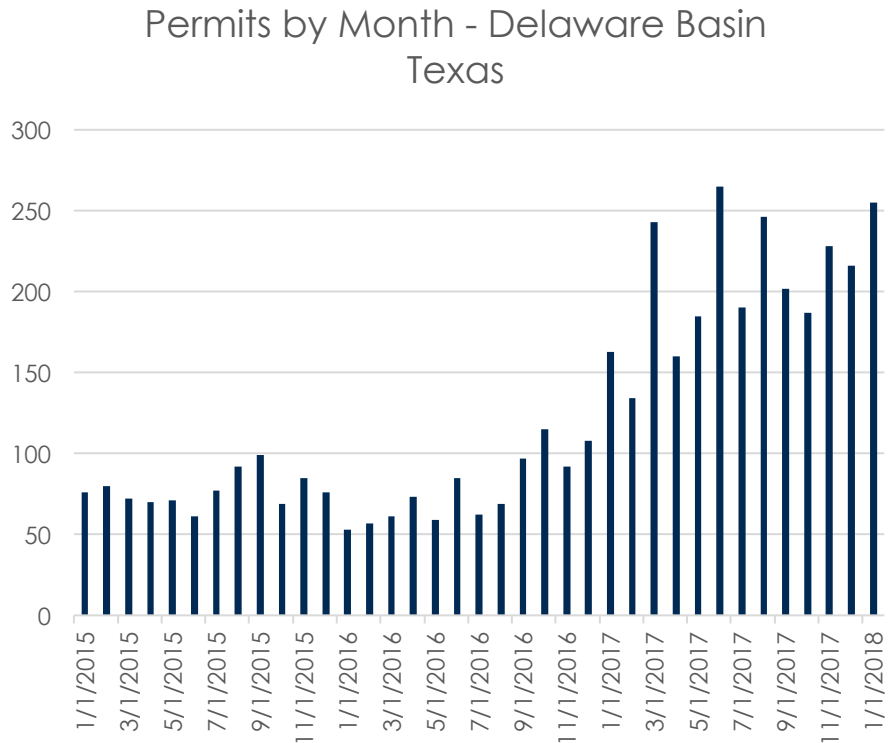
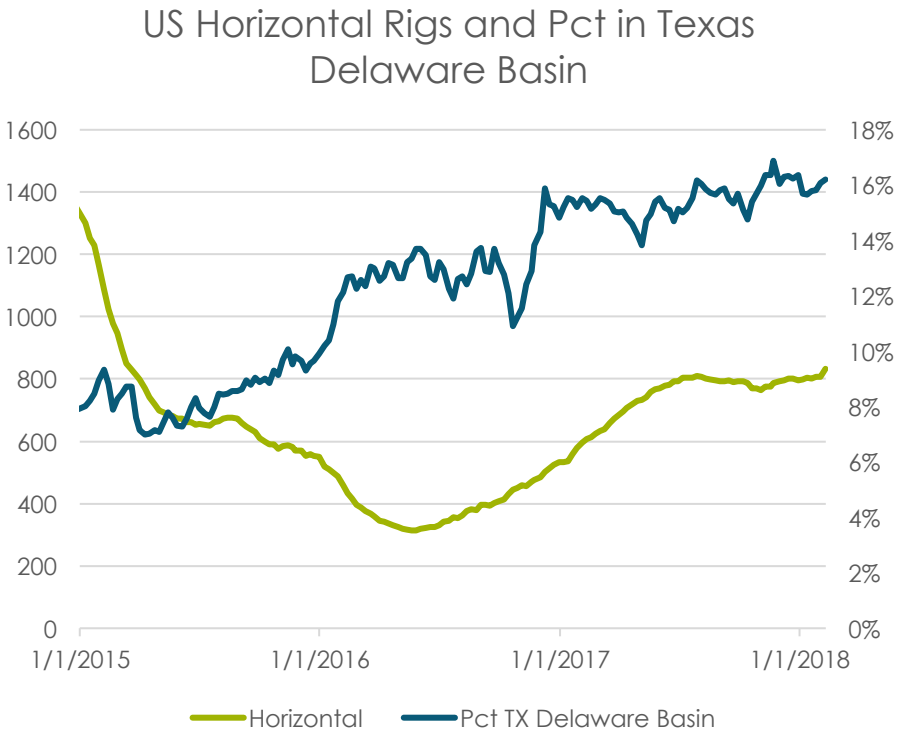
Source: Terrabotics Kimmeridge Study





# Permian Basin: Delaware Basin - Rig and Permit Activity

- The core Delaware Basin horizontal rig count is 1 19 rigs, which represents 32% of all rigs in the Permian
- In 2016 68 horizontal permits were approved per month. In the past six months, the average is over 200.

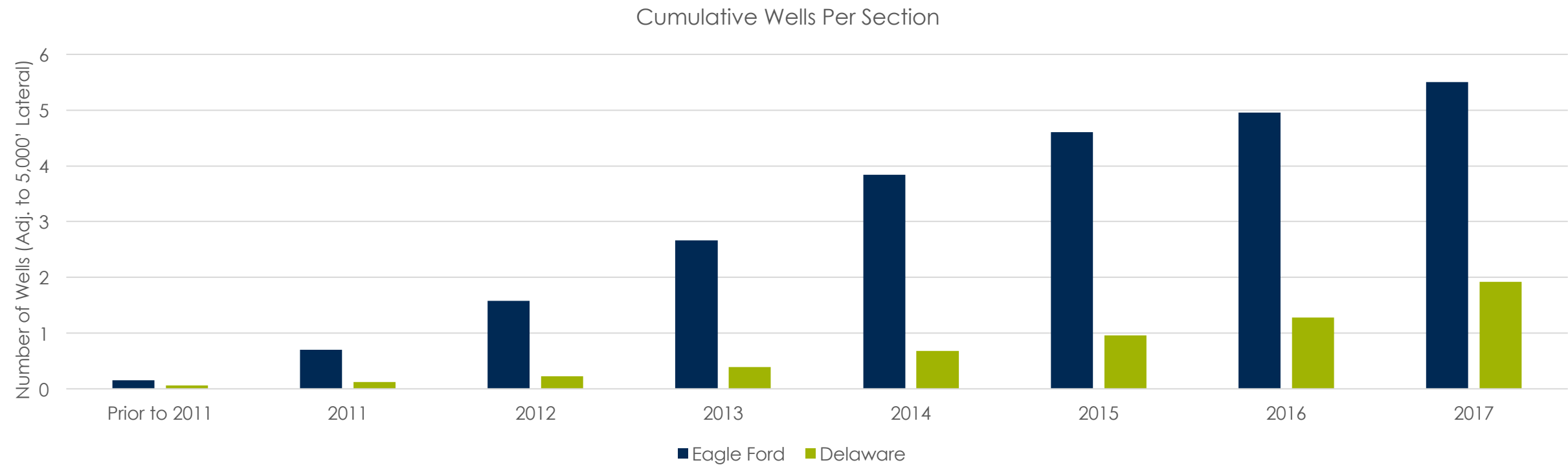


\*Core Delaware: Reeves/Culberson/Ward/Loving Counties

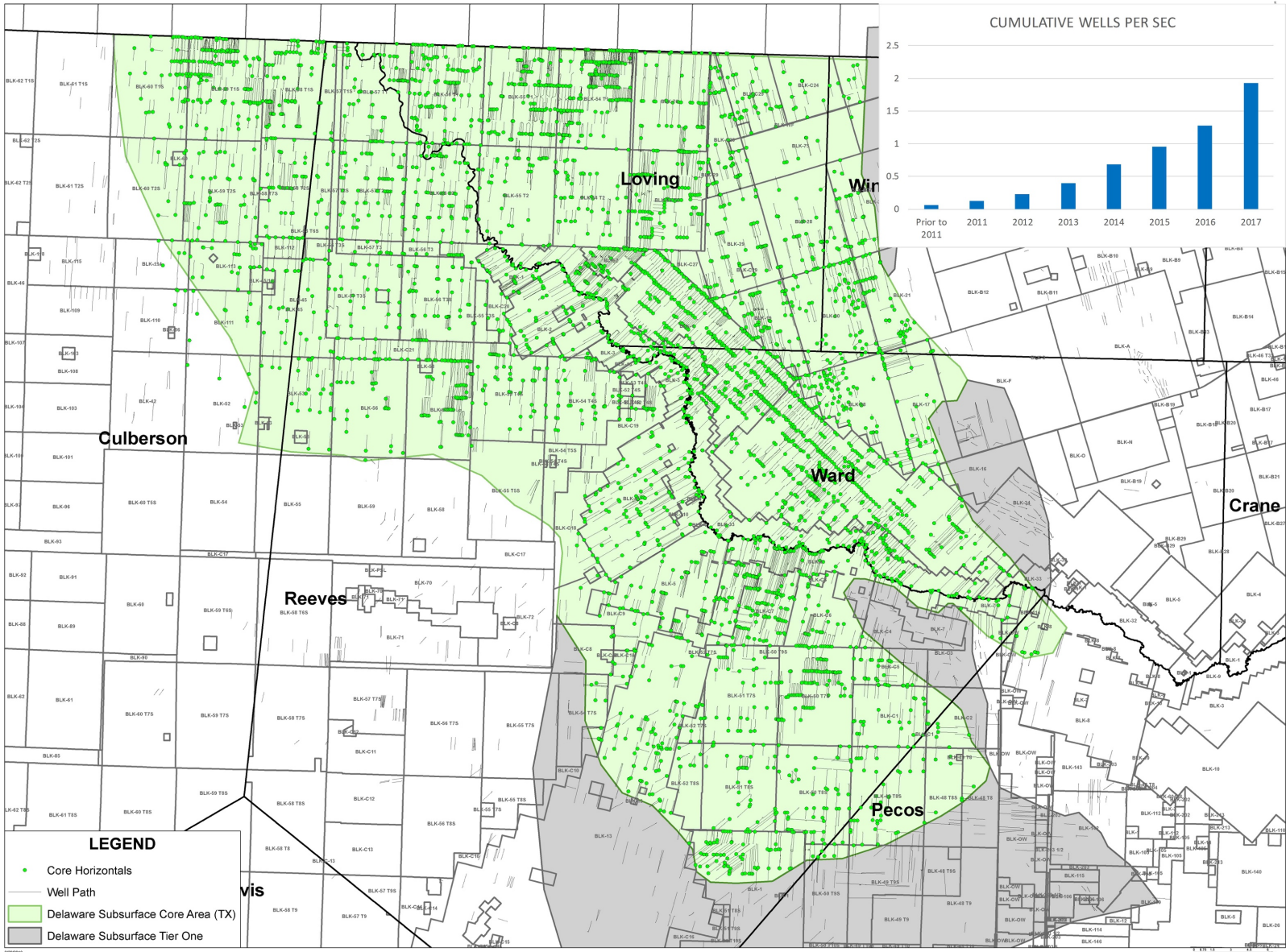


# Permian Basin: Delaware Basin - Basin Drilling Density

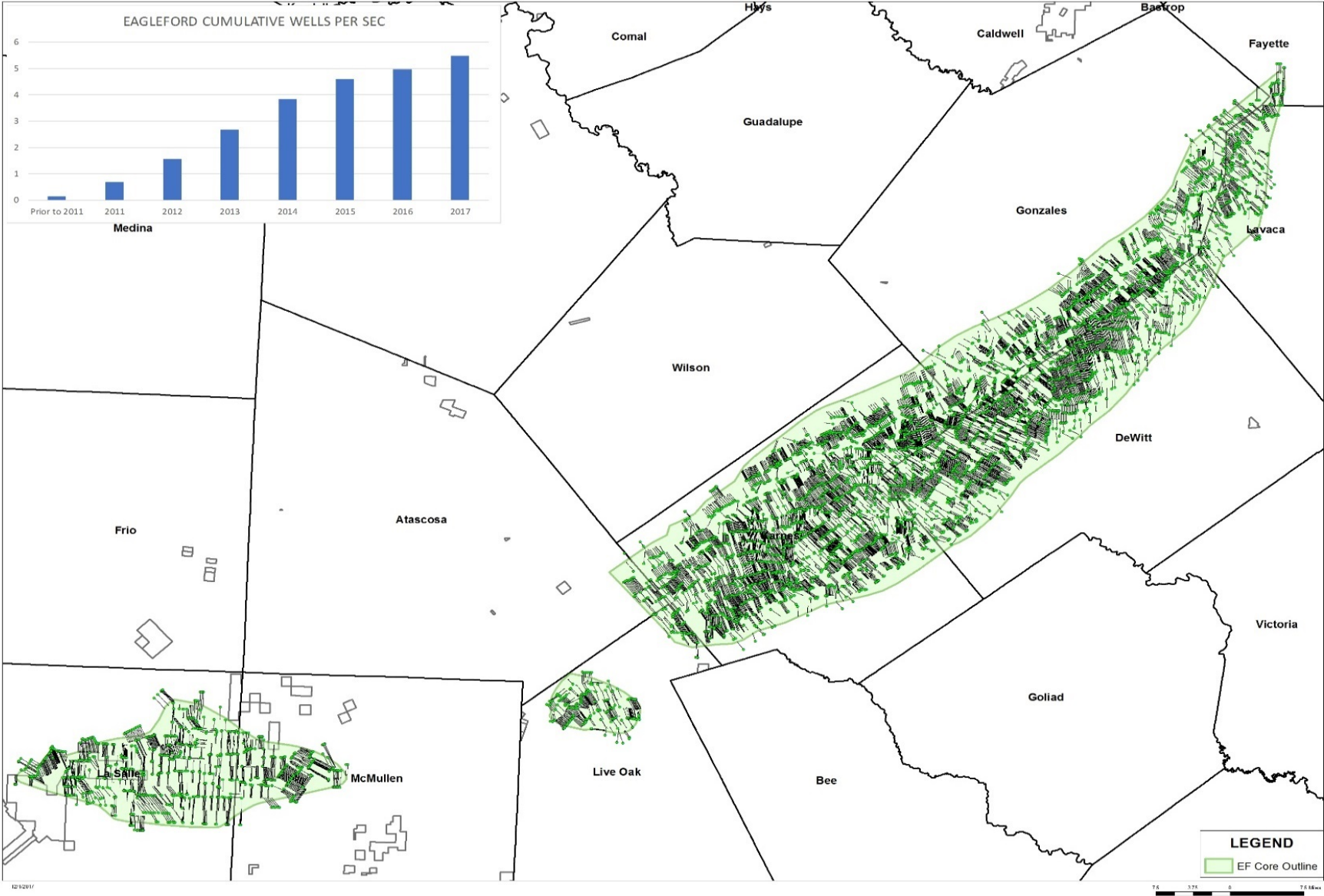
- The multi-play stacked Delaware Basin is not yet downspaced - in 2017, just under two horizontal wells per section on average were drilled across the Basin's core area.
- By comparison, the single-play stacked Eagle Ford is characterized by more than five horizontals per section on average.



# Permian Basin: Delaware Basin – Core Area with Drilling Density



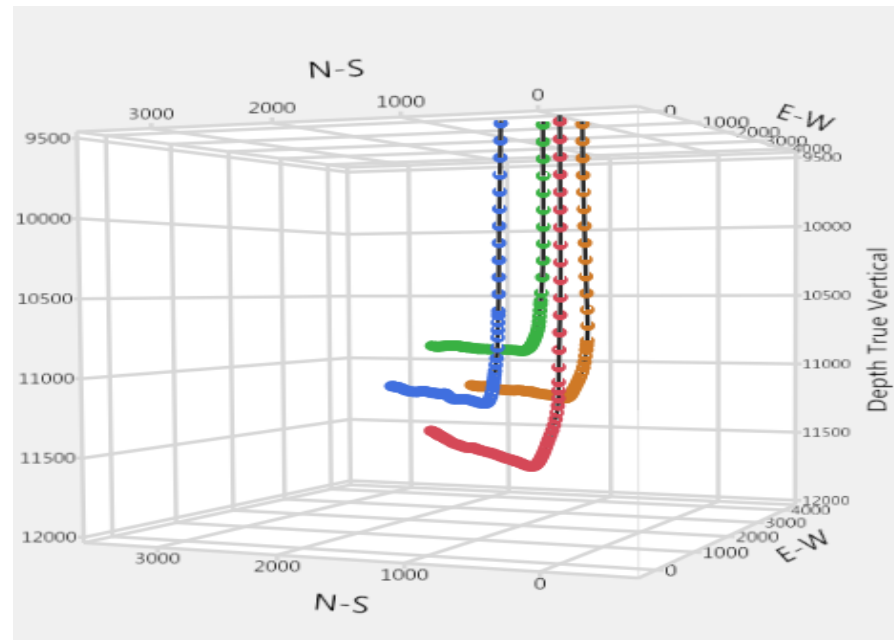
# Permian Basin: Comparison to Eagle Ford – Core Area with Drilling Density





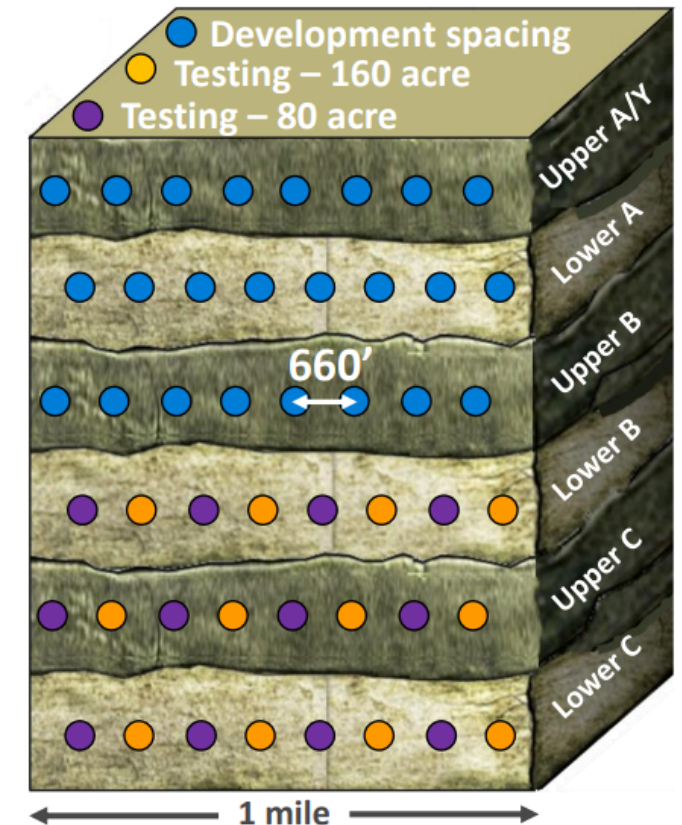
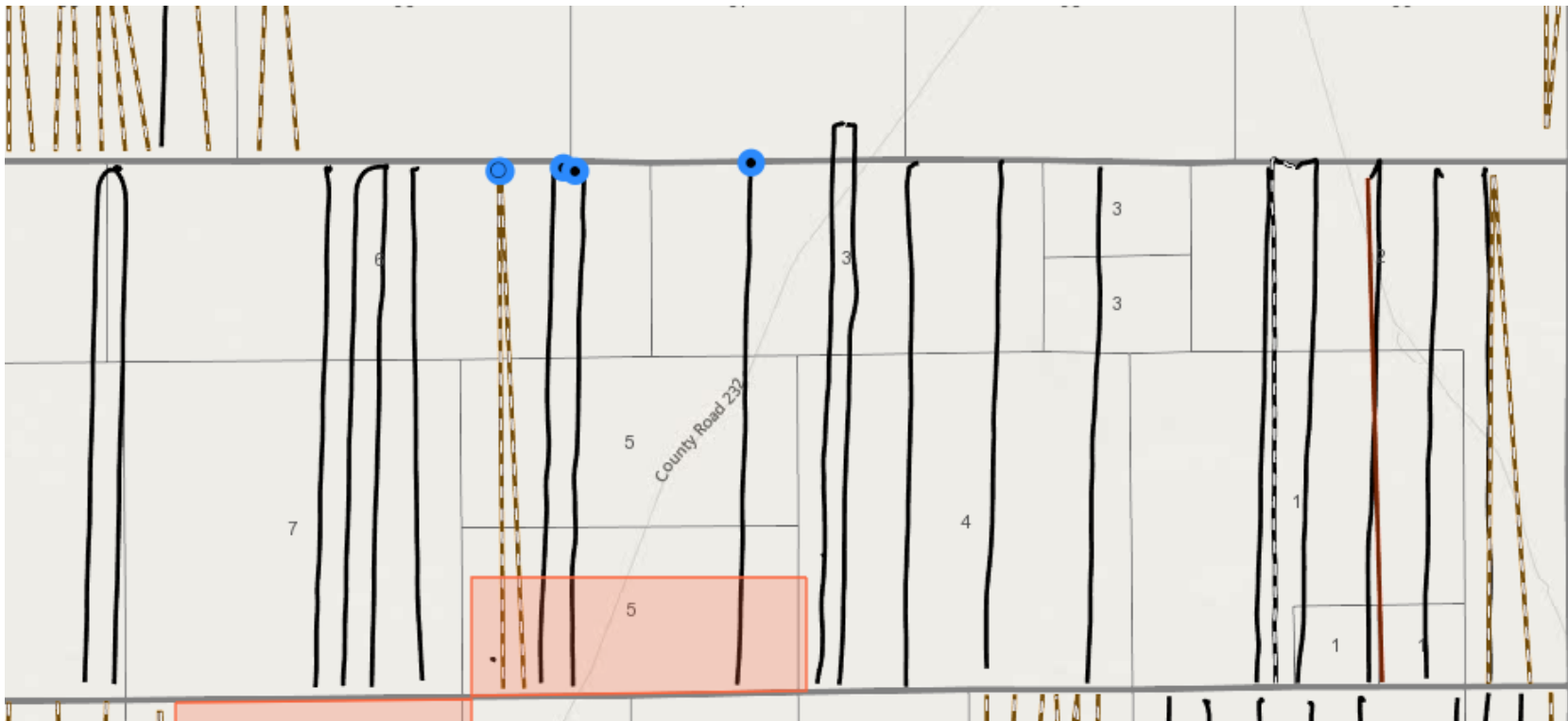
## Permian Basin: Delaware Basin - Downspacing Example #1

- Downspacing on certain sections has begun
- The Energen Quarterback well pad consists of four wells, three in the Wolfcamp A (in an upper A/lower A stagger) and one in the Wolfcamp B.
- The section is irregularly shaped, but the spacing is indicative of eight wells per section (one mile by one mile), per horizon:
  - › 16 wells in the Wolfcamp A due to the stagger pattern (eight upper A and eight lower A)
  - › Eight wells in the Wolfcamp B



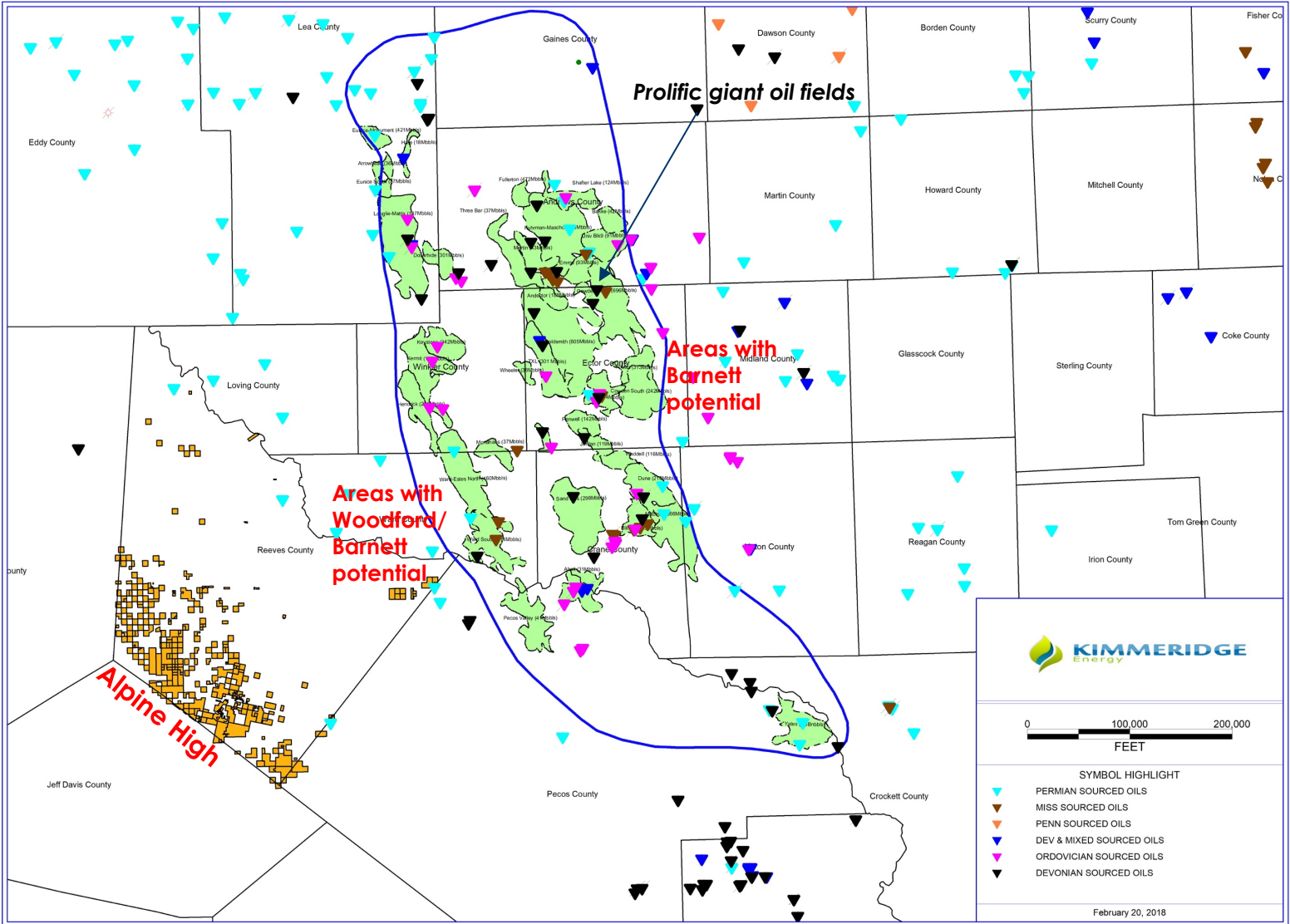
## Permian Basin: Delaware Basin - Downspacing Example #2

- Resolute is drilling eight wells/section/horizon in Block C21
- Resolute plans to drill 16 Wolfcamp A wells per section and eight Wolfcamp B wells per section. In total, they plan to drill 36-48 wells per section



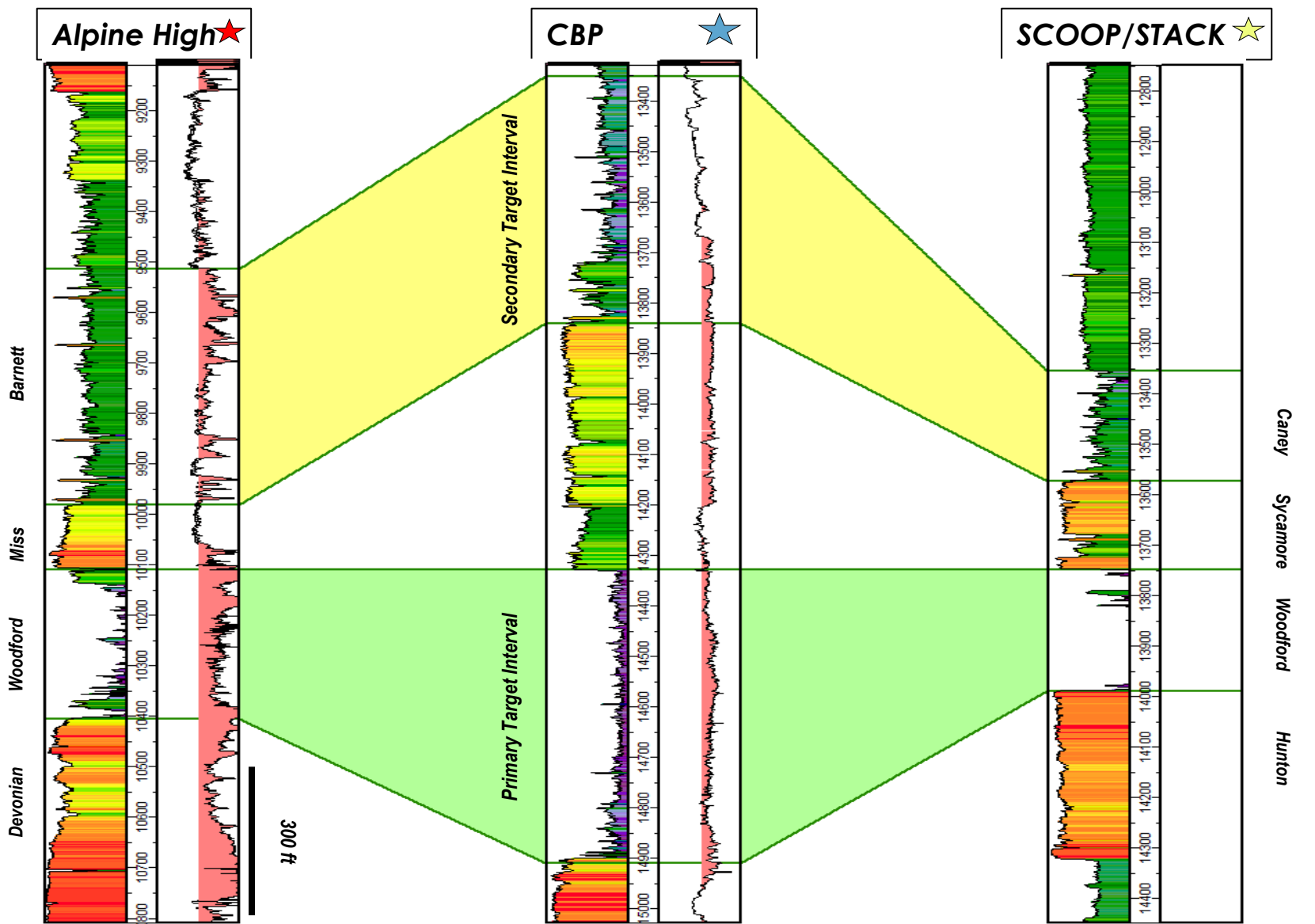
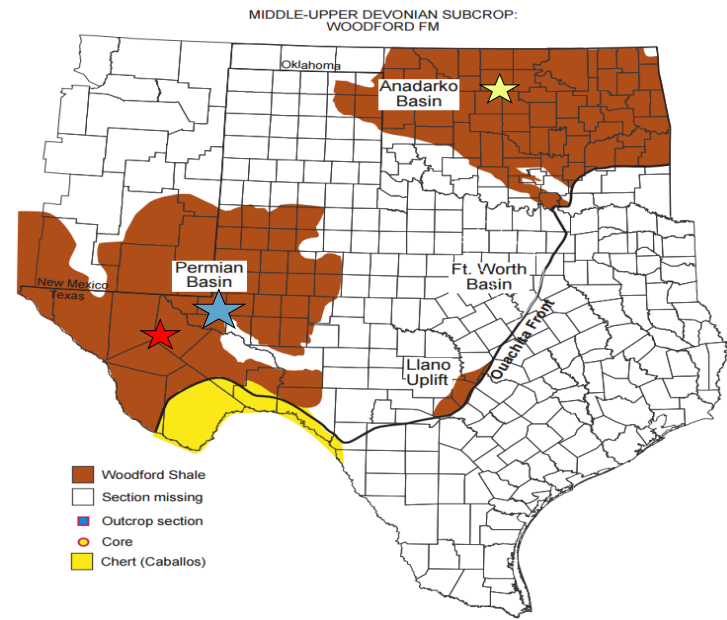
# Permian Basin: Woodford/STACK – The Third Phase of Horizontal Drilling?

- Woodford and Barnett are both older than the Permian aged Wolfcamp
- Sparse data and analysis on source rock oil typing has lead to uncertainty over the origin of oils in CBP fields
- However, geochemical analysis definitively indicates mainly in-situ sourcing from the prolific, oil-mature source rocks of the Woodford, Barnett and Simpson.
- The thickness of the Woodford/STACK play is around 2,000-3,000ft



# Permian Basin: Woodford/STACK Analogue – Southern Delaware Basin and CBP

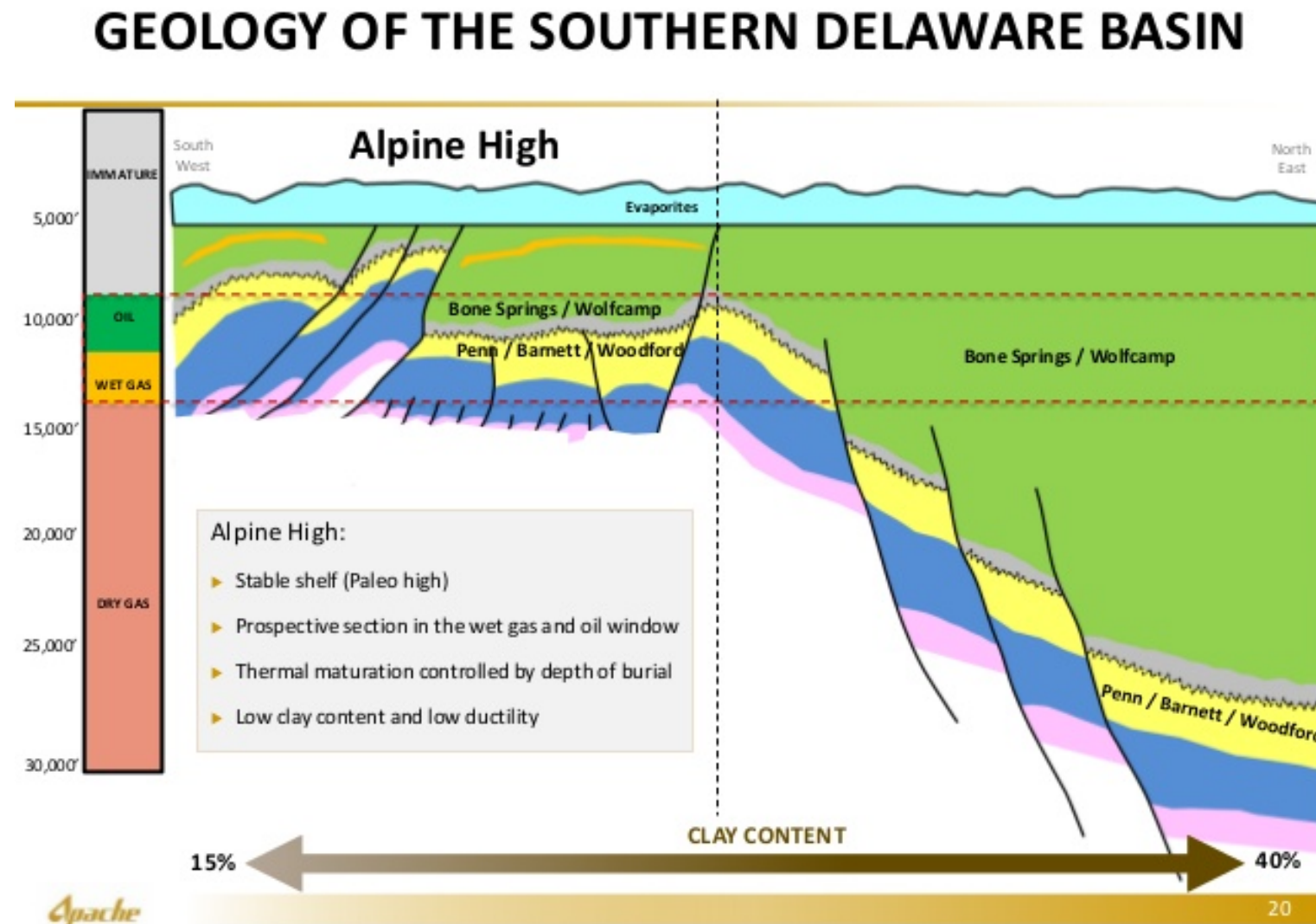
- The Alpine High play in the Delaware and the Woodford Barnett play in the CBP exhibits comparable depositional environments to the proven Woodford play in Oklahoma





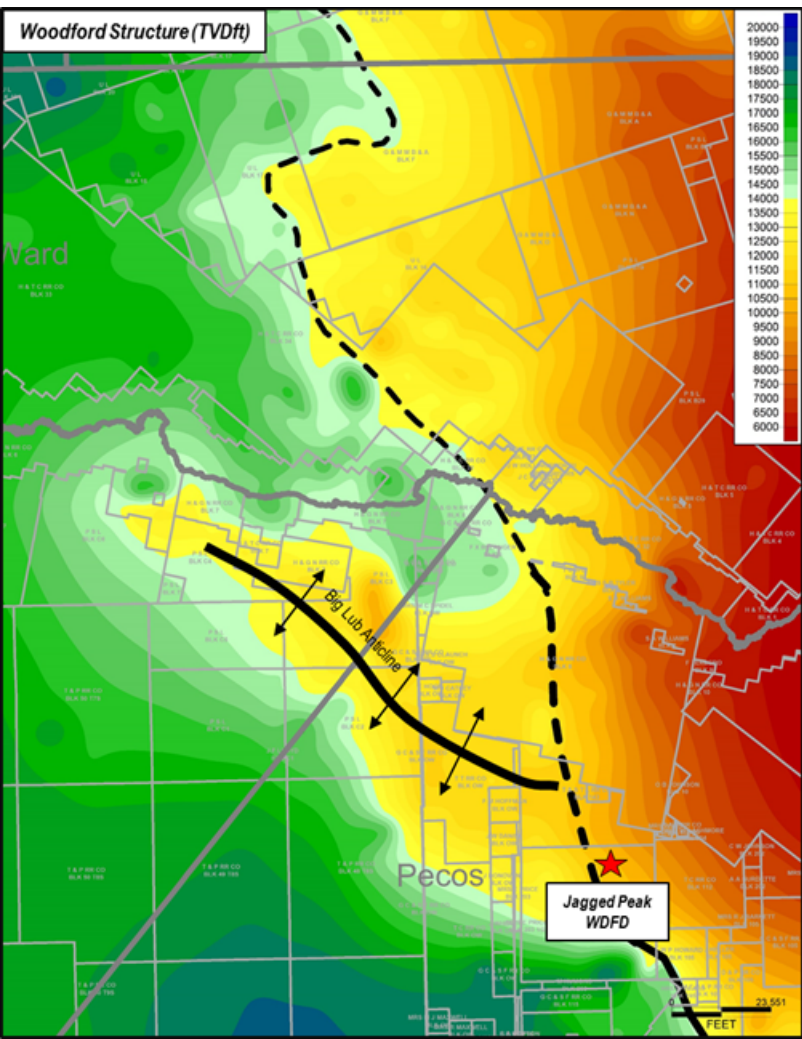
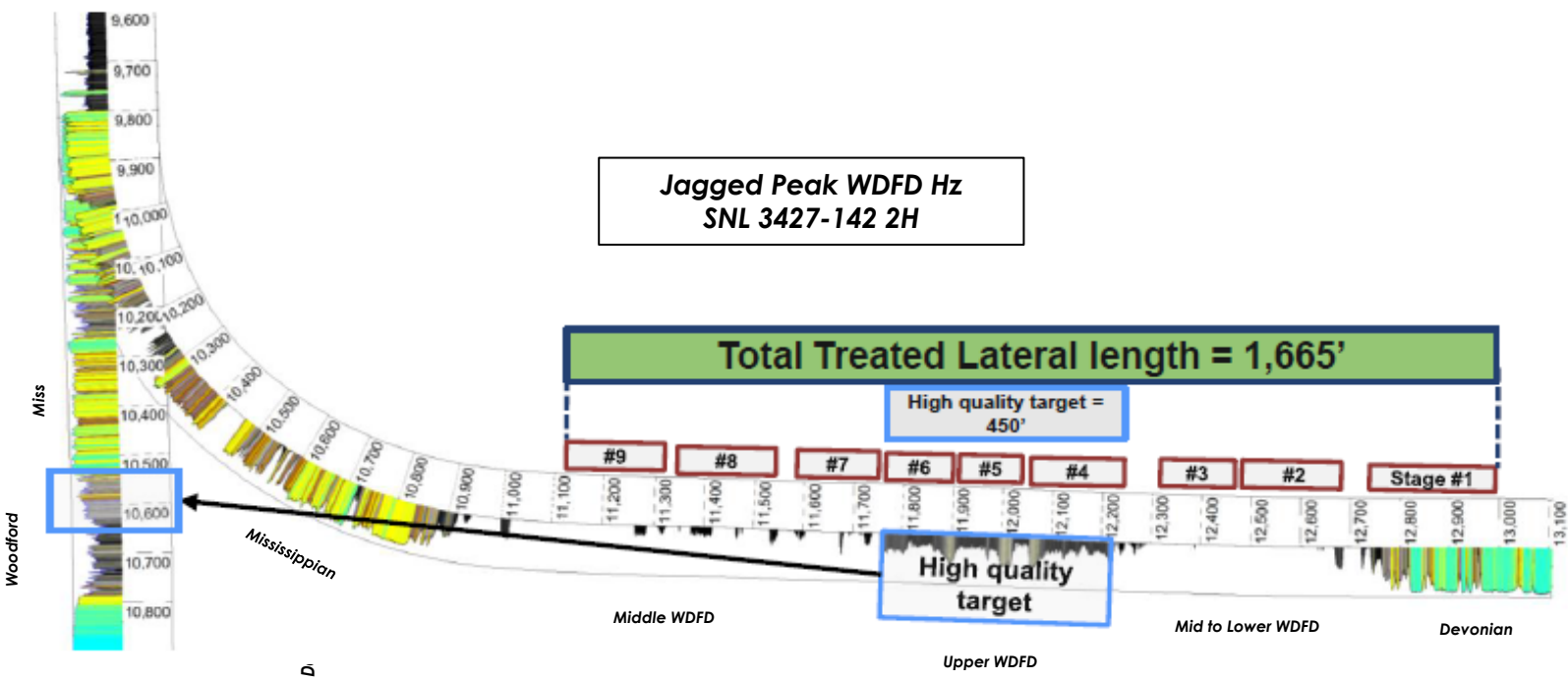
## Permian Basin: Woodford/STACK – Southern Delaware Basin Alpine High

- In the Alpine High, Apache claims multiple targets throughout different hydrocarbon phases
- Apache has broken out the Alpine High into three different maturity regimes
  - › Northern Flank – More prospective for liquids in the 3<sup>rd</sup> Bone and WFCP
  - › Central – Mostly wet gas production in Barnett and Woodford
  - › Southern Flank – Less mature but mostly wet gas to this point



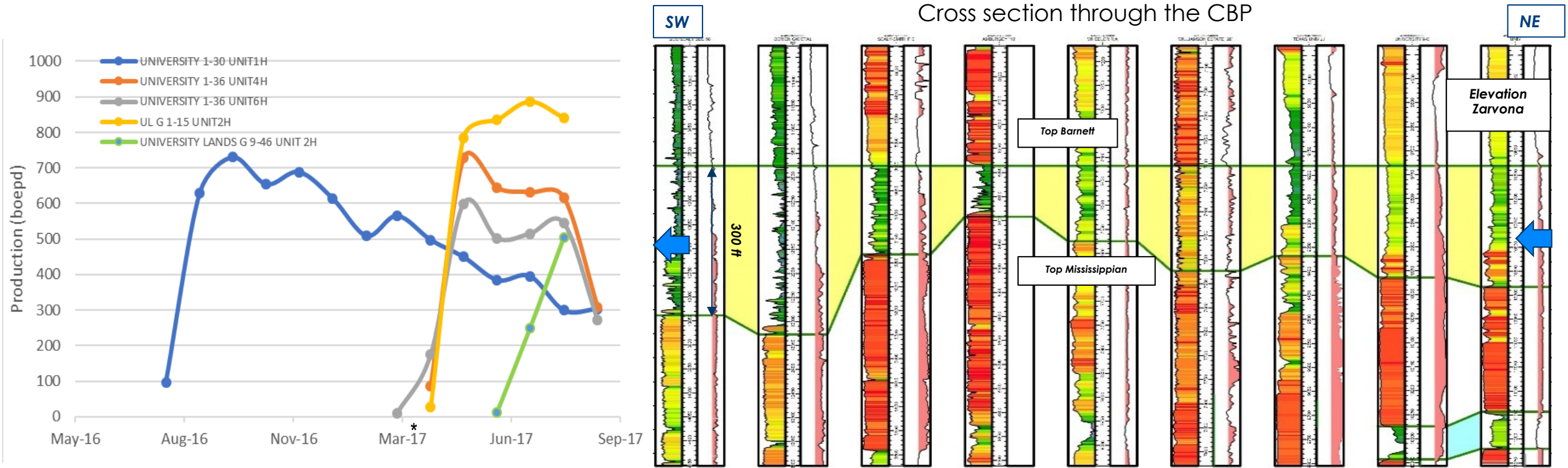
Permian Basin: Woodford/STACK – CBP Jagged Peak Well

- Jagged Peak (“JAG”) drilled a deep pilot hole for a Wolfcamp horizontal (SNL 3405-142 2H) that was cored in October 2016
- The lateral was only ~2,300’ (1,665’ stimulated), but the well had a reported IP30 of 227 boepd/1,000’ (normalized to the 1,665 stimulated feet)



Permian Basin: Woodford/STACK – CBP Barnett Horizontals

- Zarvona and Elevation Resources have drilled five horizontal Barnett wells on the eastern CBP with good results
- Their oldest well is a single section lateral that had an IP90 ~124 boepd/1000'





## Permian: Summary

- The Permian has had a long history of conventional production and represents a world-scale hydrocarbon basin made up of four sub-basins
- The Permian is a Perfect Petroleum System in that it has significant oil reserves focused in a small number of giant fields sourced from a number of world class organic rich formations throughout the geologic record
- There have been two phases of rejuvenation in the basin from unconventional activity
  - › Initial the Midland Basin tested out the horizontal technology and is now mature
  - › the Delaware basin is the focus today and is in the development phase
- There may be a third phase emerging in the form of the Woodford/STACK concept in the Southern Delaware and the CBP
- There will likely be many more phases in the future



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