

Are Geologic/Reservoir/Completion Models Properly Constrained (are they working) in the Permian Basin?*

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Abstract

Multiple resource horizons are being targeted in the Permian Basin. These include the Spraberry, Bone Spring (Spraberry time equivalent in the Delaware Basin) and Cline (Upper Pennsylvanian). It also includes re-exploration and development of Upper Permian targets on the Central Basin Platform, northern shelf, deeper basins, Woodford and others. The Wolfberry in the Midland Basin and WolfBone in the Delaware Basin have been the main focus over the last several years, with growing interest and attention focused on the other reservoirs as knowledge, implementation and execution have enhanced economic results and applied to other reservoirs. As an example, the WolfBone development in the southern Delaware Basin is a sample of combining geologic, reservoir and completion results to guide economic development of the play and are reviewed. The Wolfcamp is an ideal heterogenetic resource consisting of quartz, carbonate and kerogen.

Exploration and field development will be successful over a large area. However, the geologic and economic sweet spot is generally found in the deeper basin floors. In this setting quartz and kerogen accumulated in the quiet deep-basin interrupted by episodic deposition of shelf-to-basin-floor carbonate debris flows that settled basin ward of the de-acceleration boundary between the slope and basin floor. These depositional processes resulted in compositional and grainsize heterogeneities and accumulation of the thick organic-rich, technically and economically exploitable targets. During maturation, large volumes of oil were sealed in place (108 MMBOIP per section). Upslope, up dip or in more shaly facies, these conditions do not exist and are outside the economic sweet spot. Units thin, become more shaly retarding geochemical maturation, some units become more gas-prone and the mixture of coarser-grained shelf carbonates and sandstones provided migration pathways breaching the closed system, limiting productivity and ultimate economic recoveries. In those environments, generally deeper stratigraphic units are targeted. This play has been developed initially and continuing today with vertical wells co-mingling the oil-resource with conventional reservoirs. Interpretation of imaging logs has identified the primary fracture orientation and zones with conjugate fractures systems. Integration with production logs, chemical tracers, and micro-seismic has optimized horizontal target identification and horizontal drilling has overtaken vertical well development. Have we maximized and fully integrated drilling, geology, reservoir description, stimulation, production

information and economic results? Are we working on the same scales and communicating observations providing feedback among disciplines? Some observations are provided.

Reference Cited

Creaney, S., and Q.R. Passey, 1993, Recurring patterns of total organic carbon and source rock quality within a sequence stratigraphic framework: AAPG Bulletin, v. 77/3, p. 386-401.

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Revitalizing Reservoirs – Texas, Gulf Coast
and Latin America,
San Antonio, Texas
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OUTLINE:

1. Exploration, Synthesis of Early Development Geologic Information and Reservoir Performance to Enhance Economic Performance: Example from the Southern Delaware Basin, West Texas.
2. Are we Integrating our Input with other Disciplines, communicating with Management and other Interest Holders to Maximize Economic Outcomes?

Production from the Permian System

■ Permian system comprised of multiple basins:

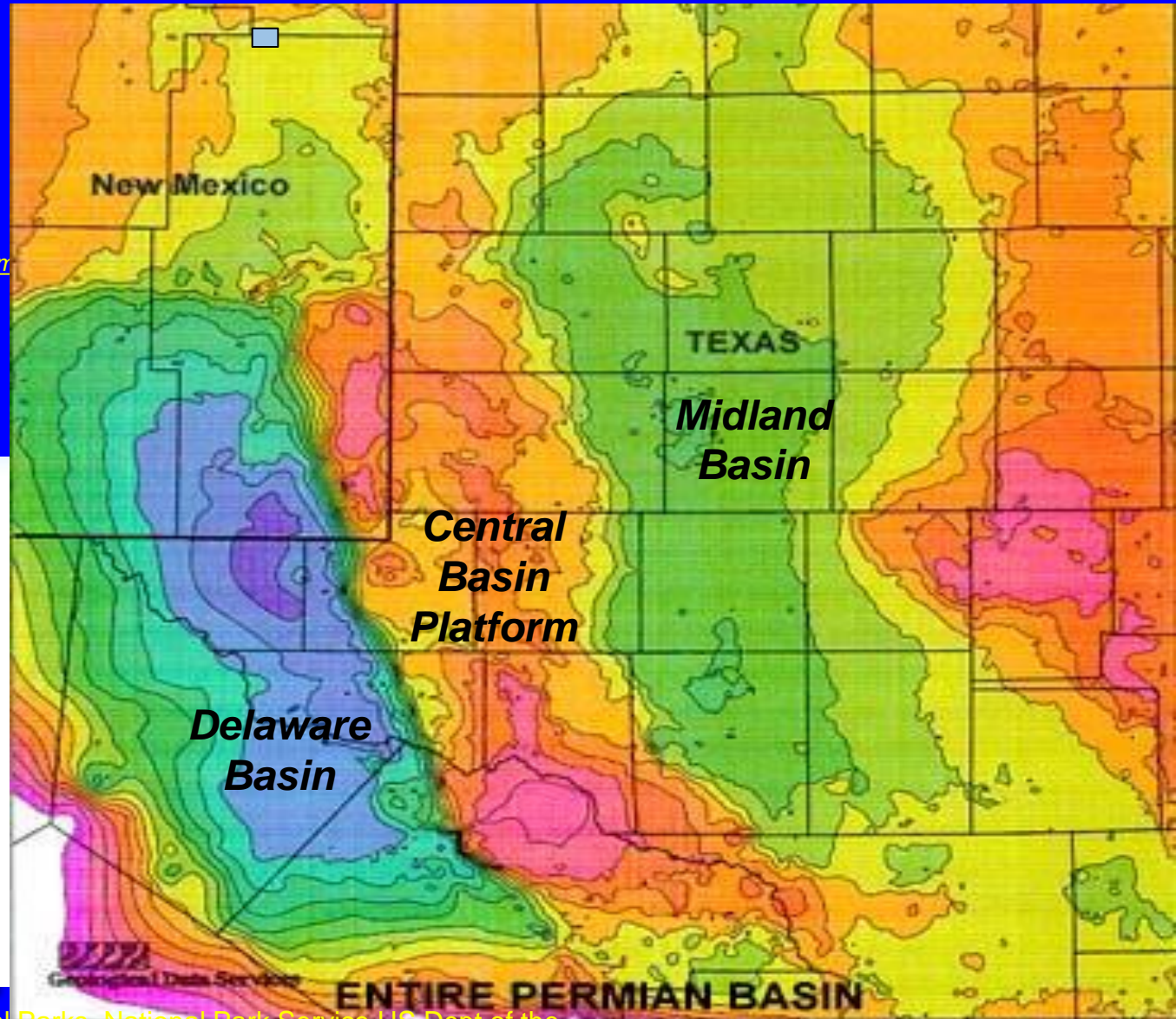
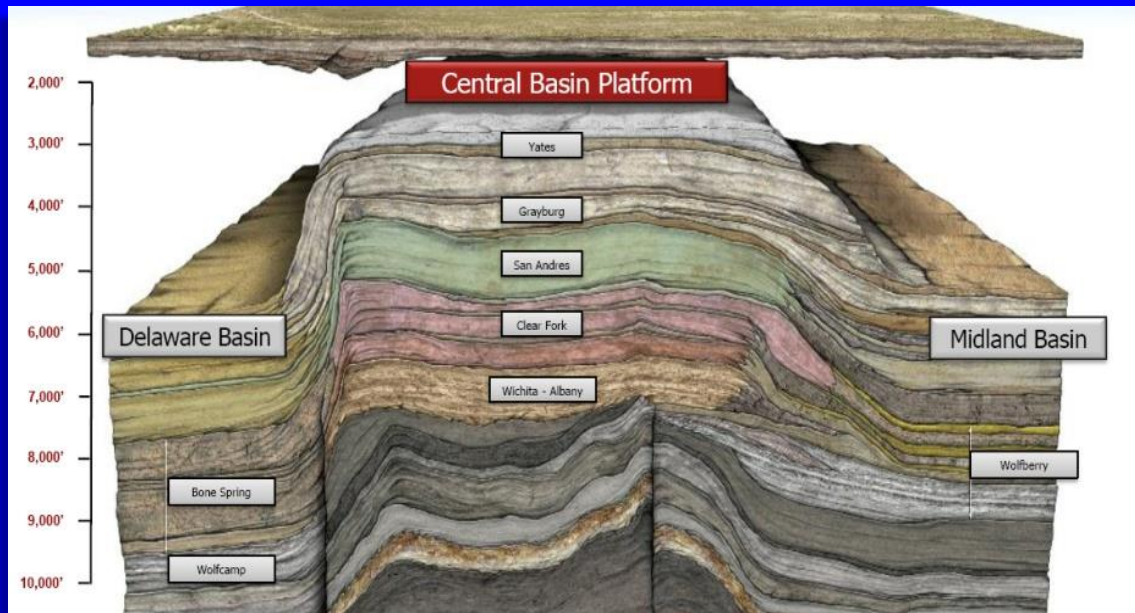
- Delaware Basin
- Central Basin Platform
- Midland Basin

■ Development progression:

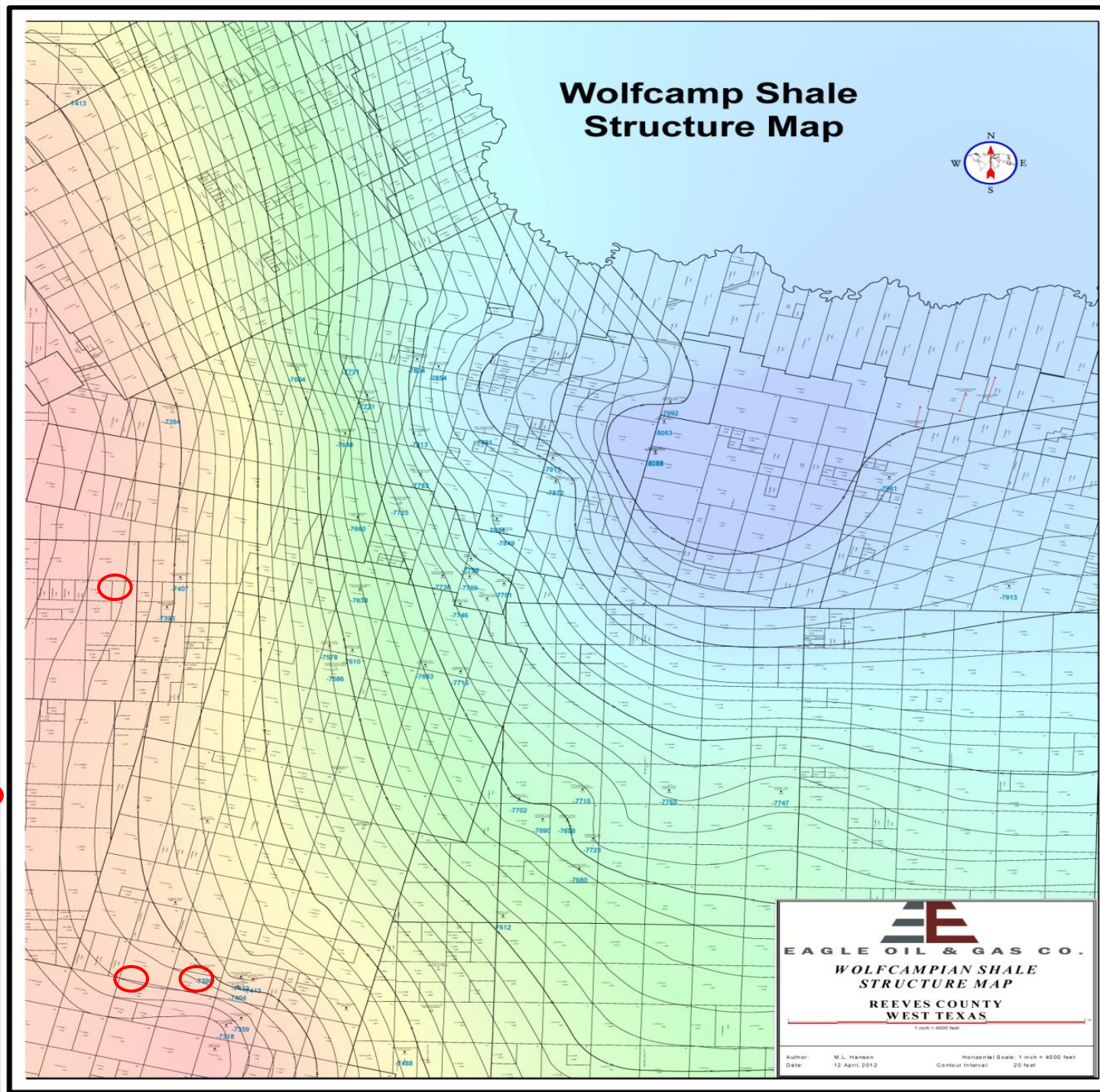
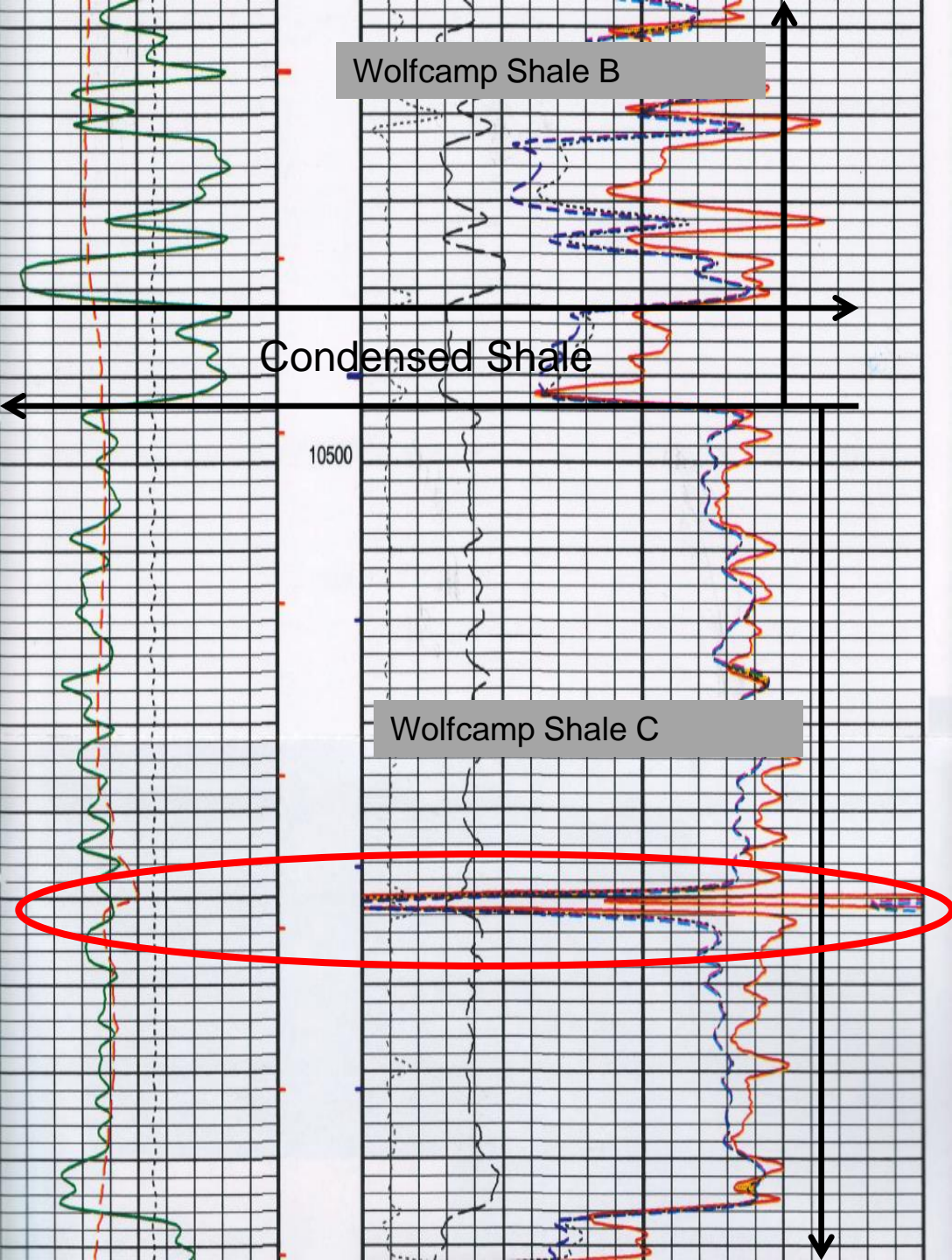
- Early production from shallow formations on the basin edges
- Transition to deeper deposits in the central Delaware (Avalon, Bone Spring, & Wolfcamp)

■ Recent basin revitalization:

- Comingled vertical completions
- Modern horizontal drilling and completion technologies



Source: Center for Energy & Economic Diversification UTPB, Geology of National Parks, National Park Service US Dept of the Interior, Society for Sedimentary Geology, Sandridge IR presentation.



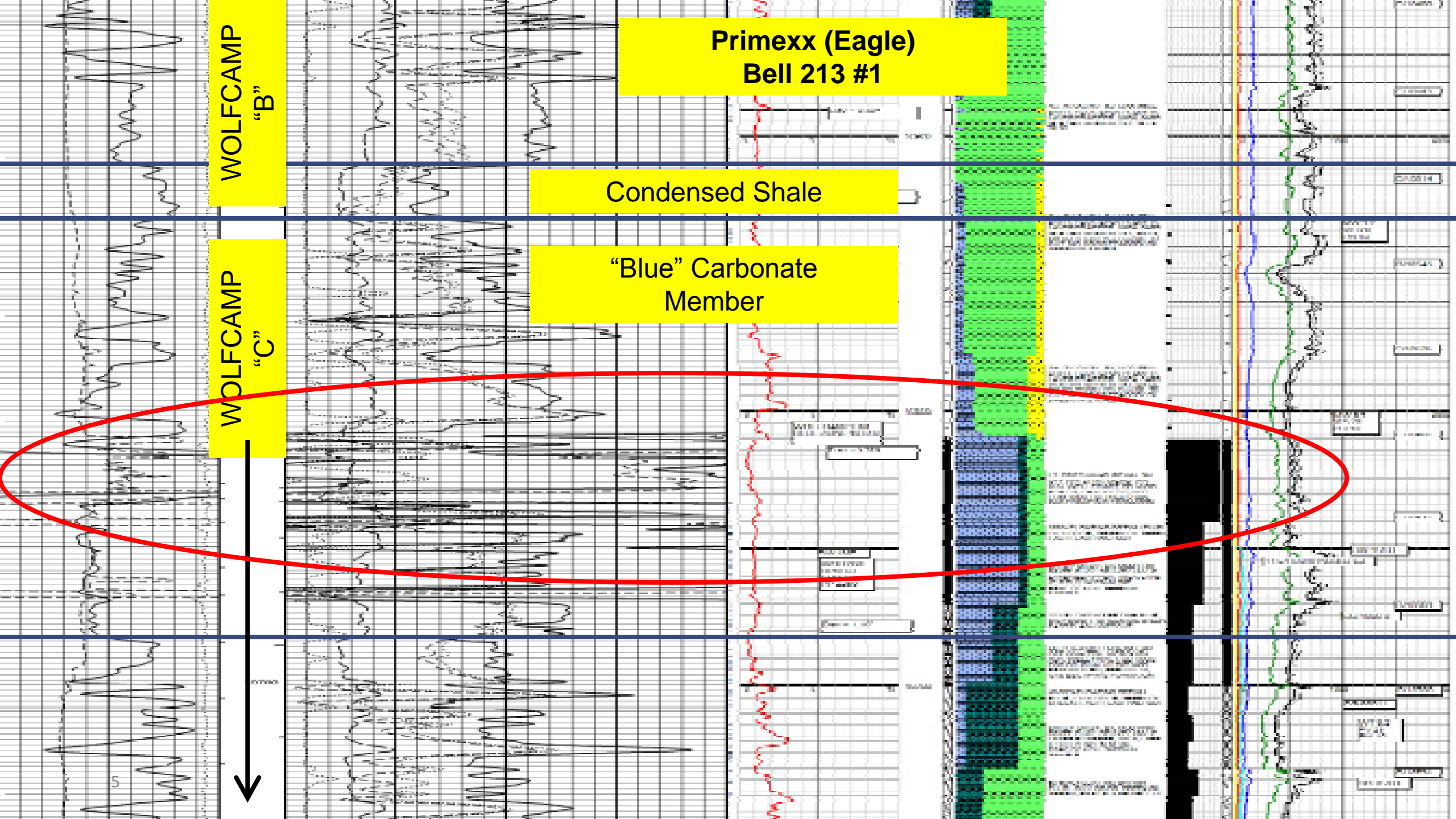
**Primexx (Eagle)
Bell 213 #1**

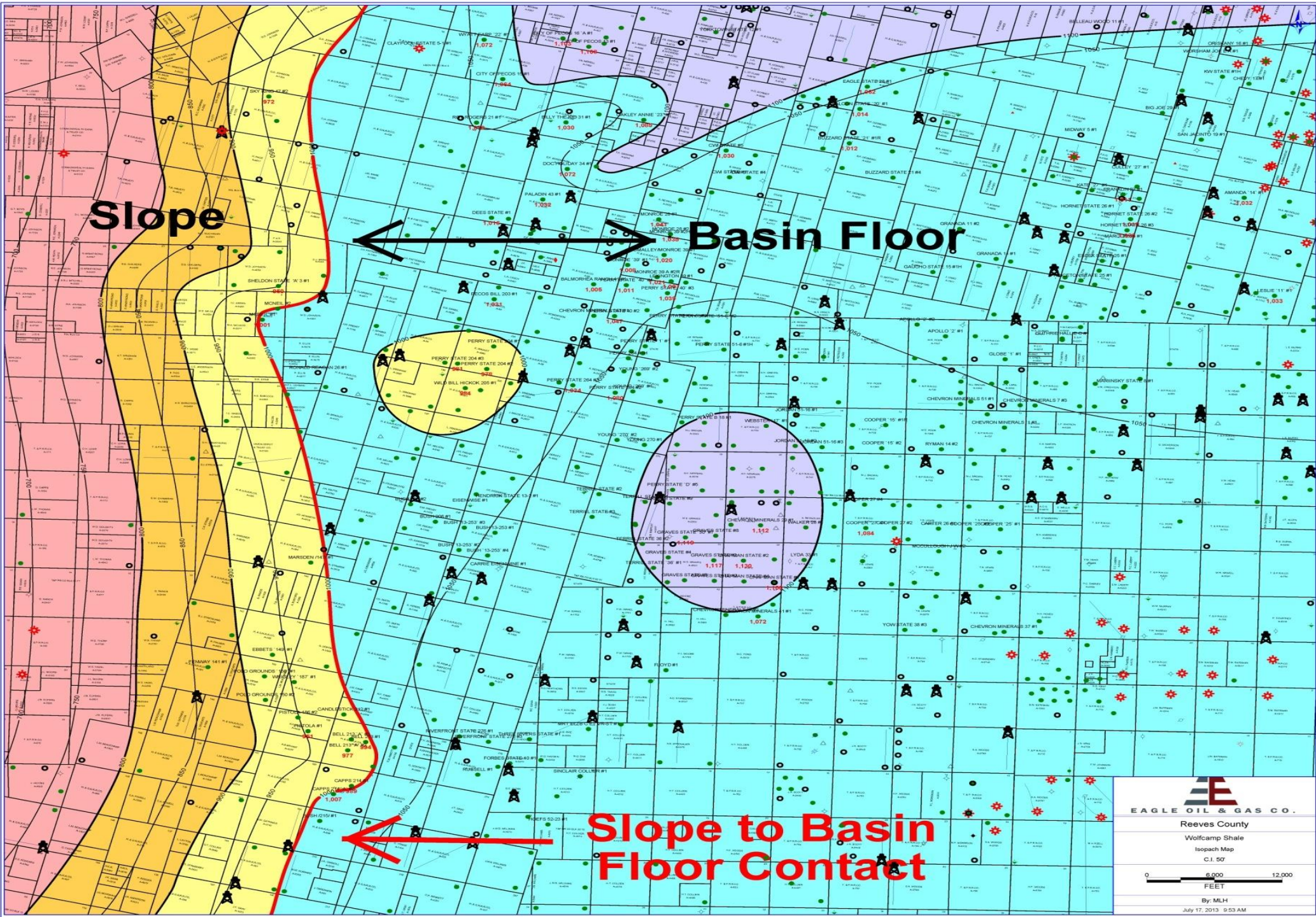
Condensed Shale

"Blue" Carbonate
Member

WOLFCAMP
"B"

WOLFCAMP
"C"

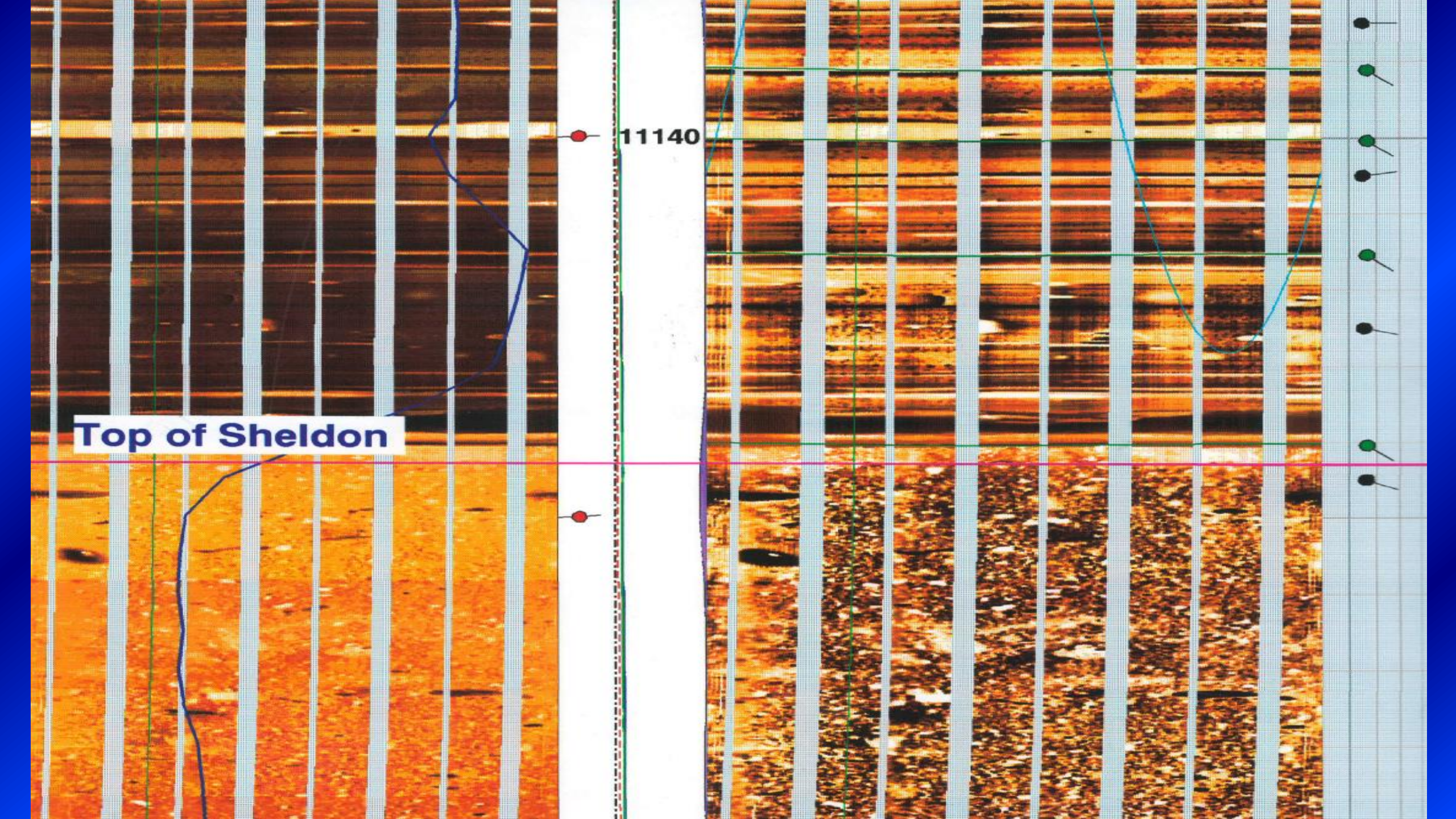




EAGLE OIL & GAS CO.
Reeves County
Wolfcamp Shale
Isopach Map
C.I. 50'
0 6,000 12,000
FEET
By: MLH
July 17, 2013 9:53 AM

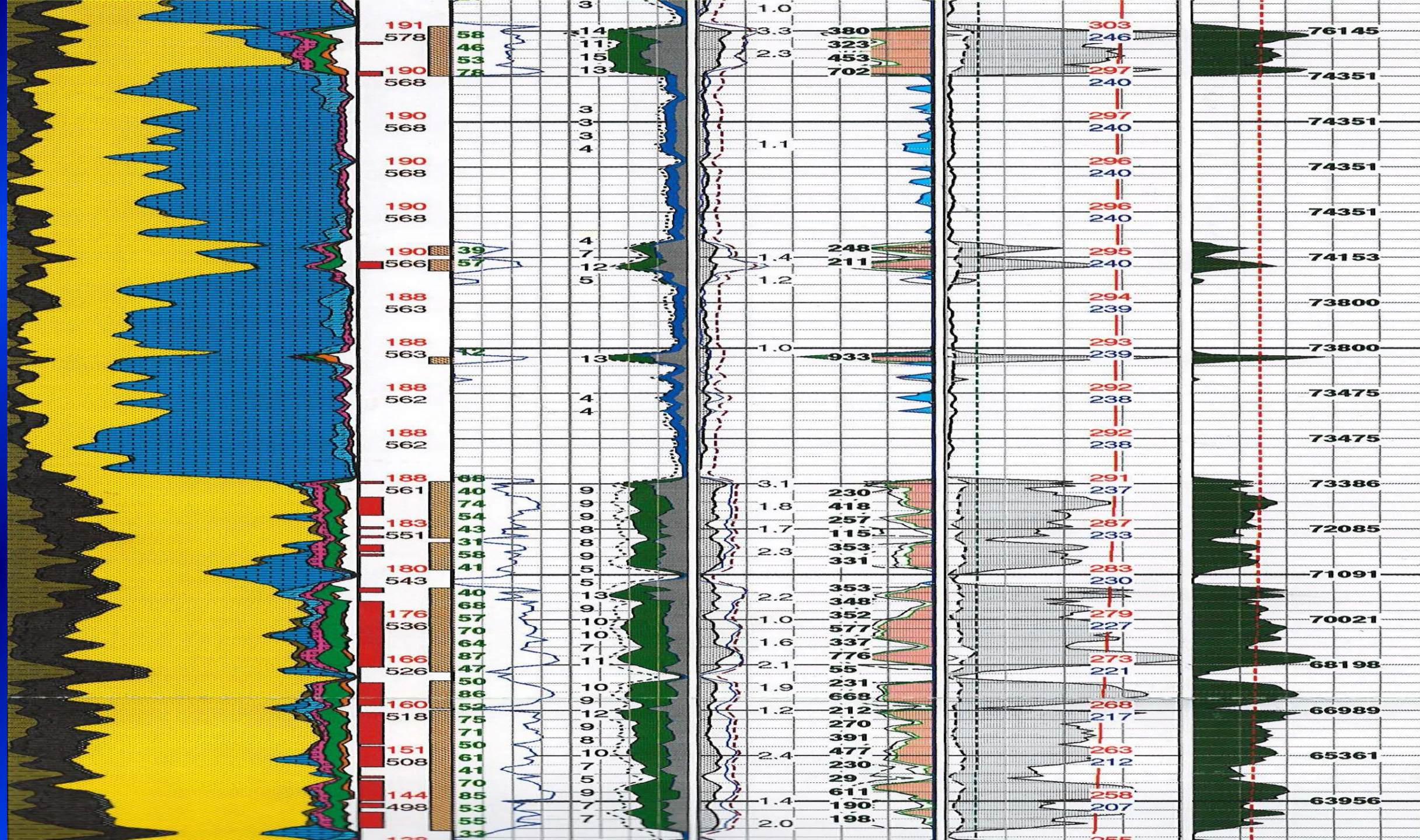
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Top of Sheldon



Blessing of Heterogeneities:

- It is the Heterogeneities in mineralogy, grain size, texture, organic material, stage of maturation that define high potential source rock (resource plays) from low potential systems.
- It is the Heterogeneities within each source rock (resource play) that define the economic “Sweet Spots” within each of those systems from lower-potential, generally more basin-wide distribution of lower quality economic objective acreage.
- It is the responsibility of the Geoscientist working within their teams to define these as early as possible, to be the first to the right play, to be first to the “Sweet Spot” and assist in the optimum development of the resource.



**Primexx (Eagle)
Bell 213 #1**

Condensed Shale

**"Blue" Carbonate
Member**

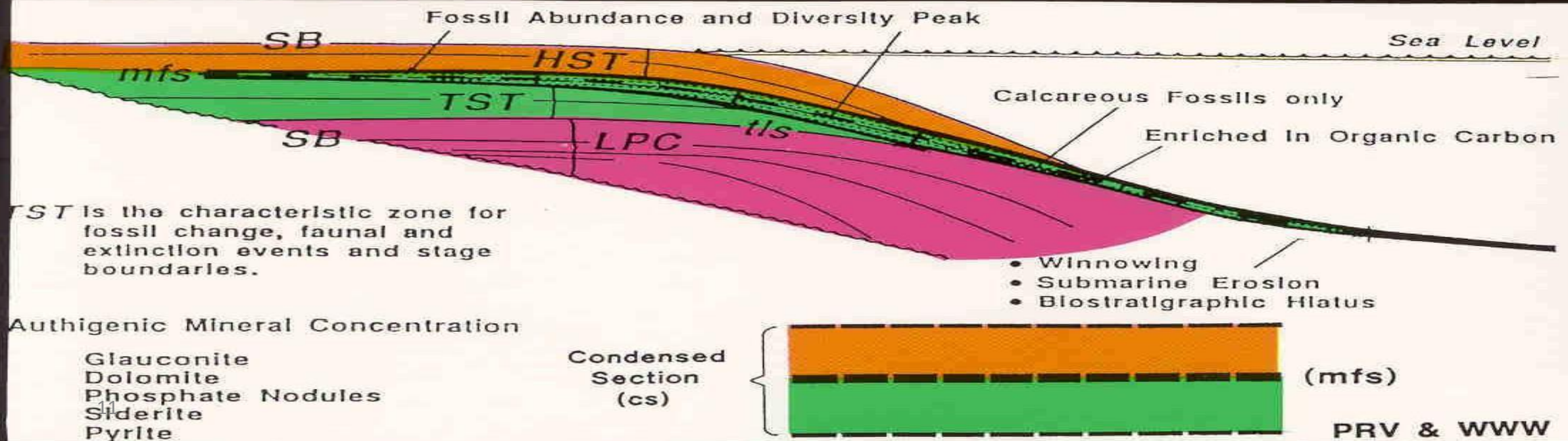
**WOLFCAMP
"B"**

**WOLFCAMP
"C"**

Condensed Section

A thin chronostratigraphic interval of **time correlative** sediments deposited at extremely slow rates during sediment starvation, **in each of the marine environments** through a period of maximum relative sea-level rise and maximum transgression of the shoreline. It is characterized by **autothonomous sedimentation** and maximum abundance and diversity peaks of planktonic fossils. The maximum flooding surface within this maximum flooding surface condensed section, provides a chronostratigraphic (time) correlation between shelf and slope sediments.

and is typically “Enriched in Organic Carbon”.



DECREASING SEDIMENTATION RATE →

ORGANIC-RICH
SHALE

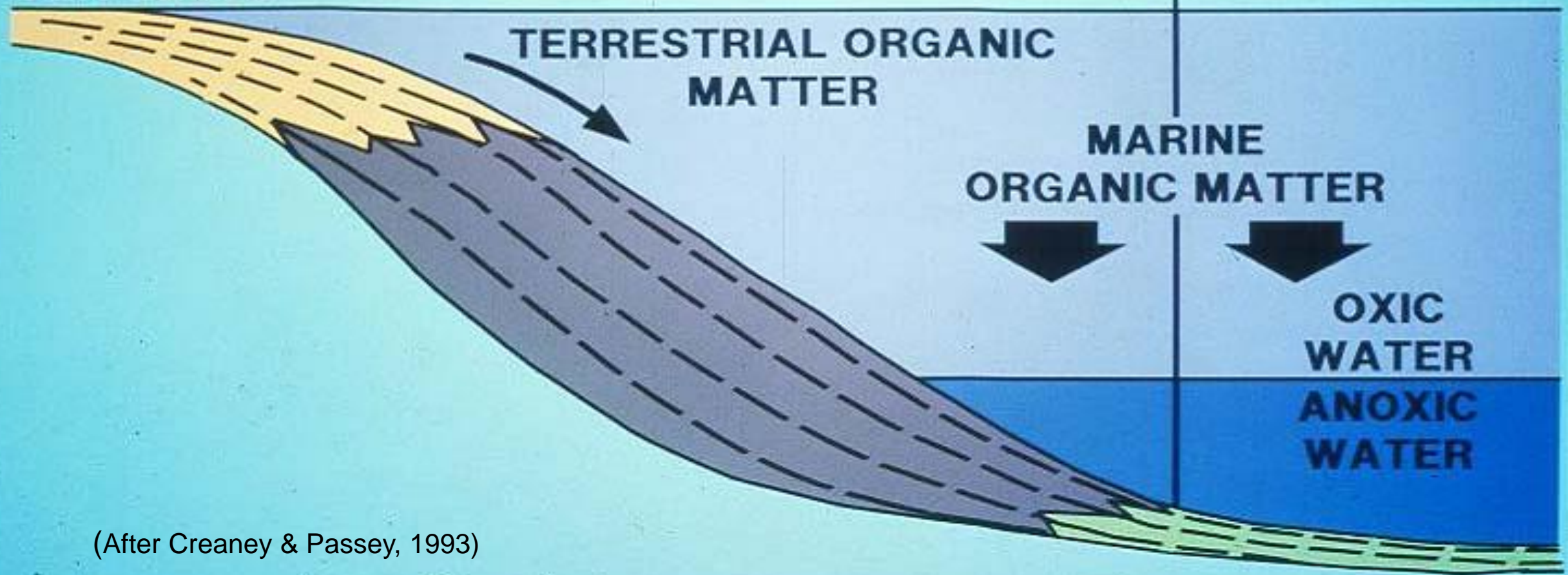
SEA LEVEL

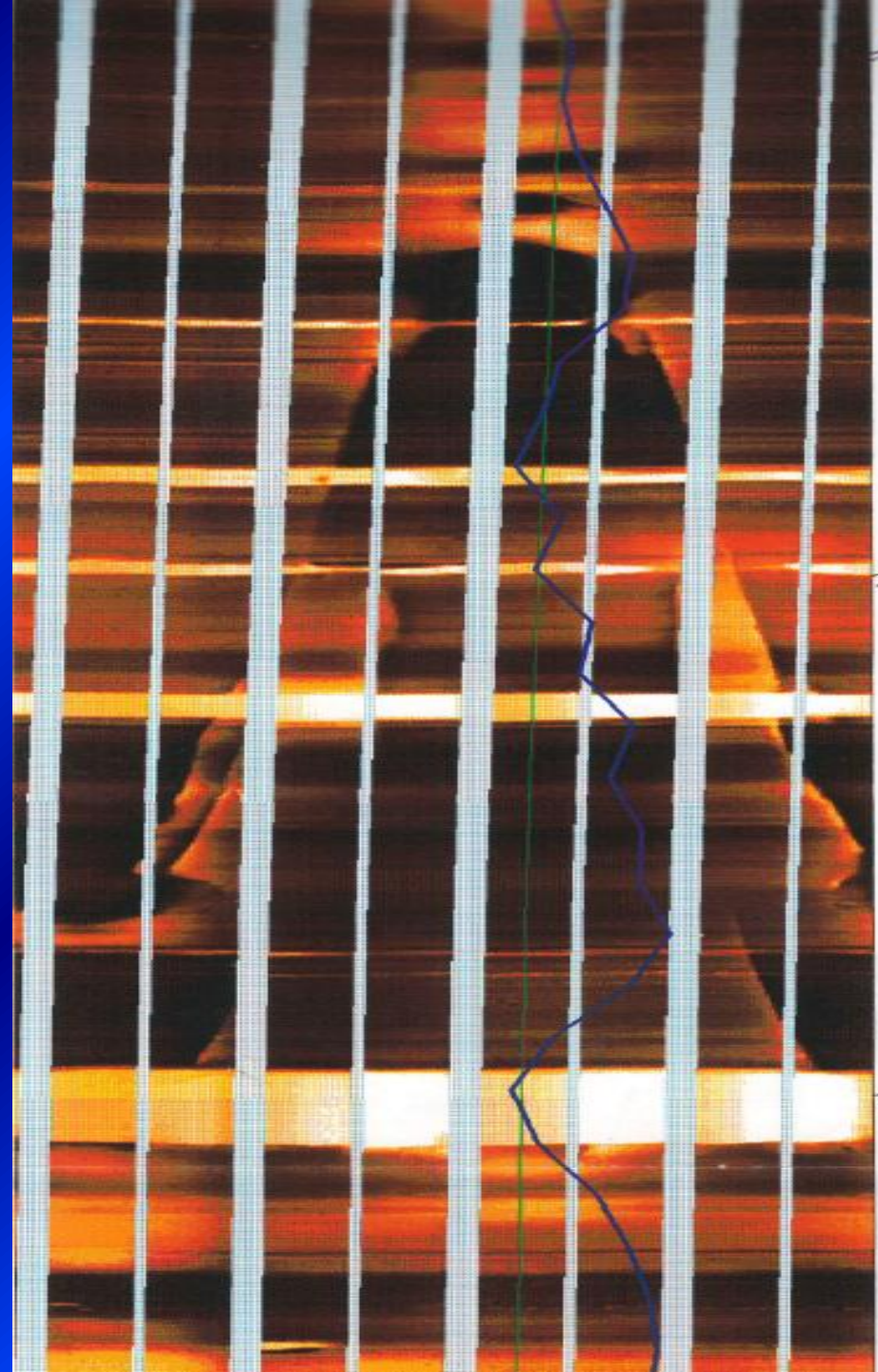
TERRESTRIAL ORGANIC
MATTER

MARINE
ORGANIC MATTER

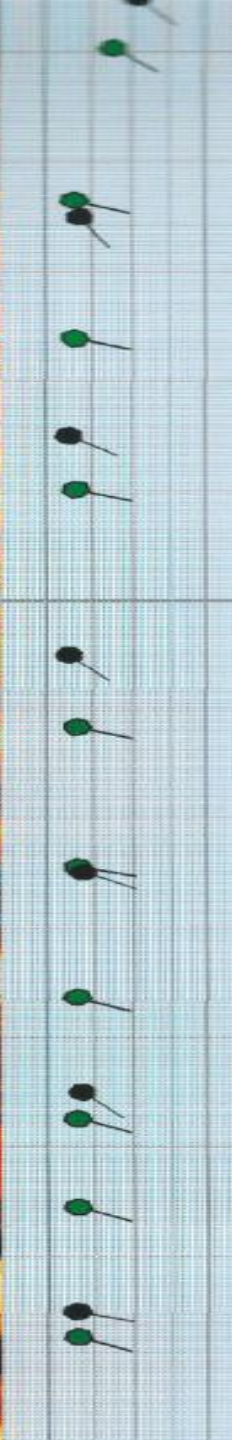
OXIC
WATER
ANOXIC
WATER

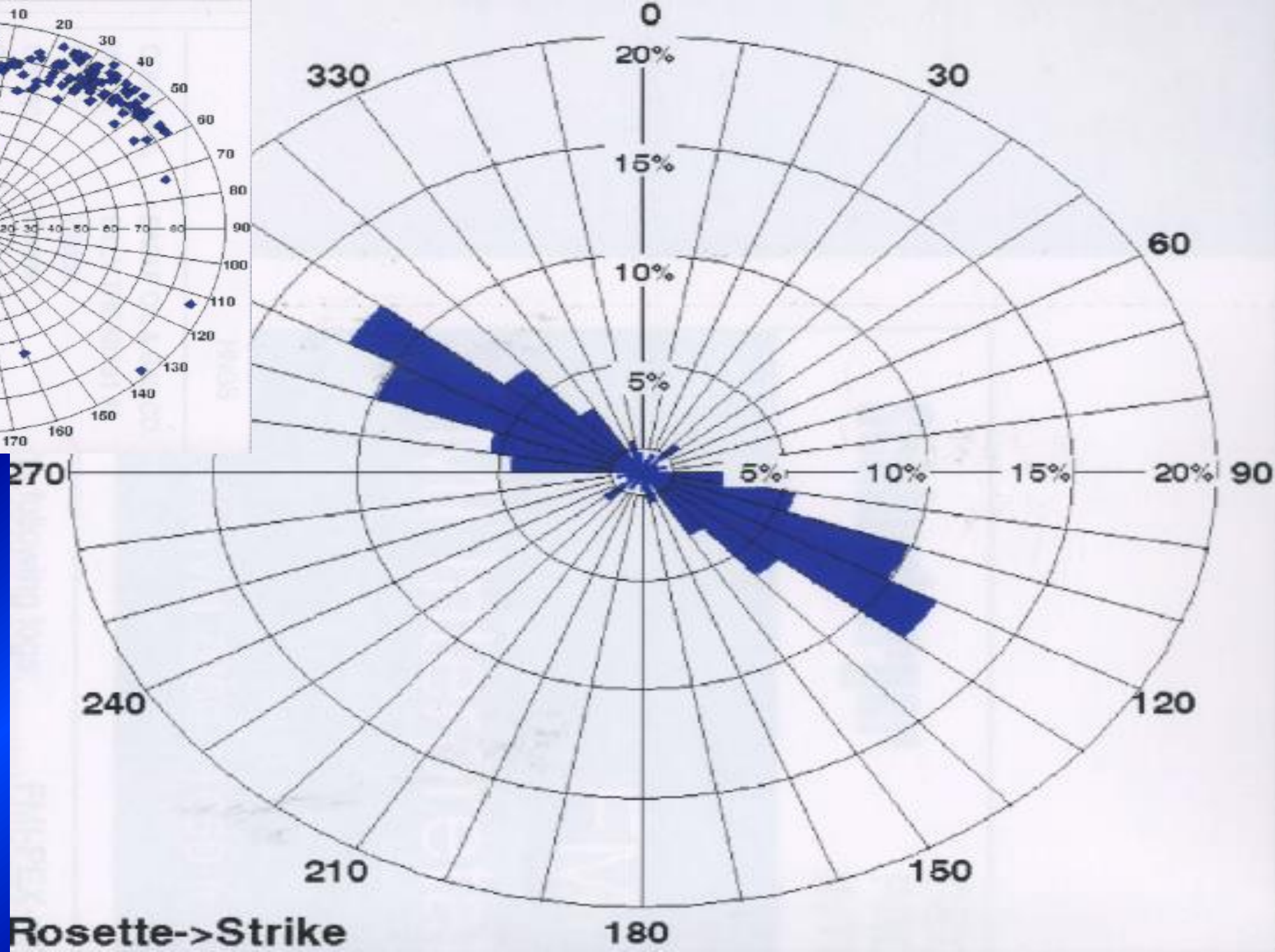
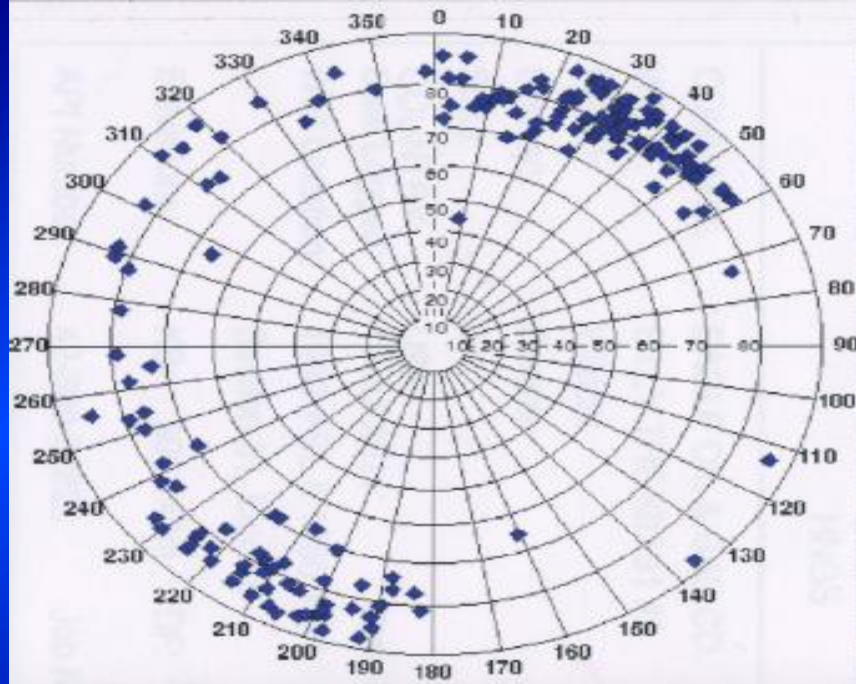
(After Creaney & Passey, 1993)





10990







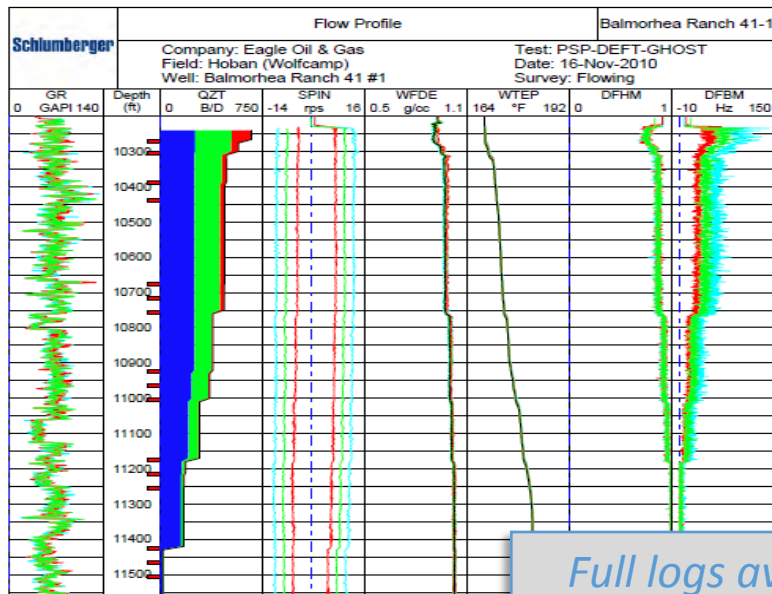
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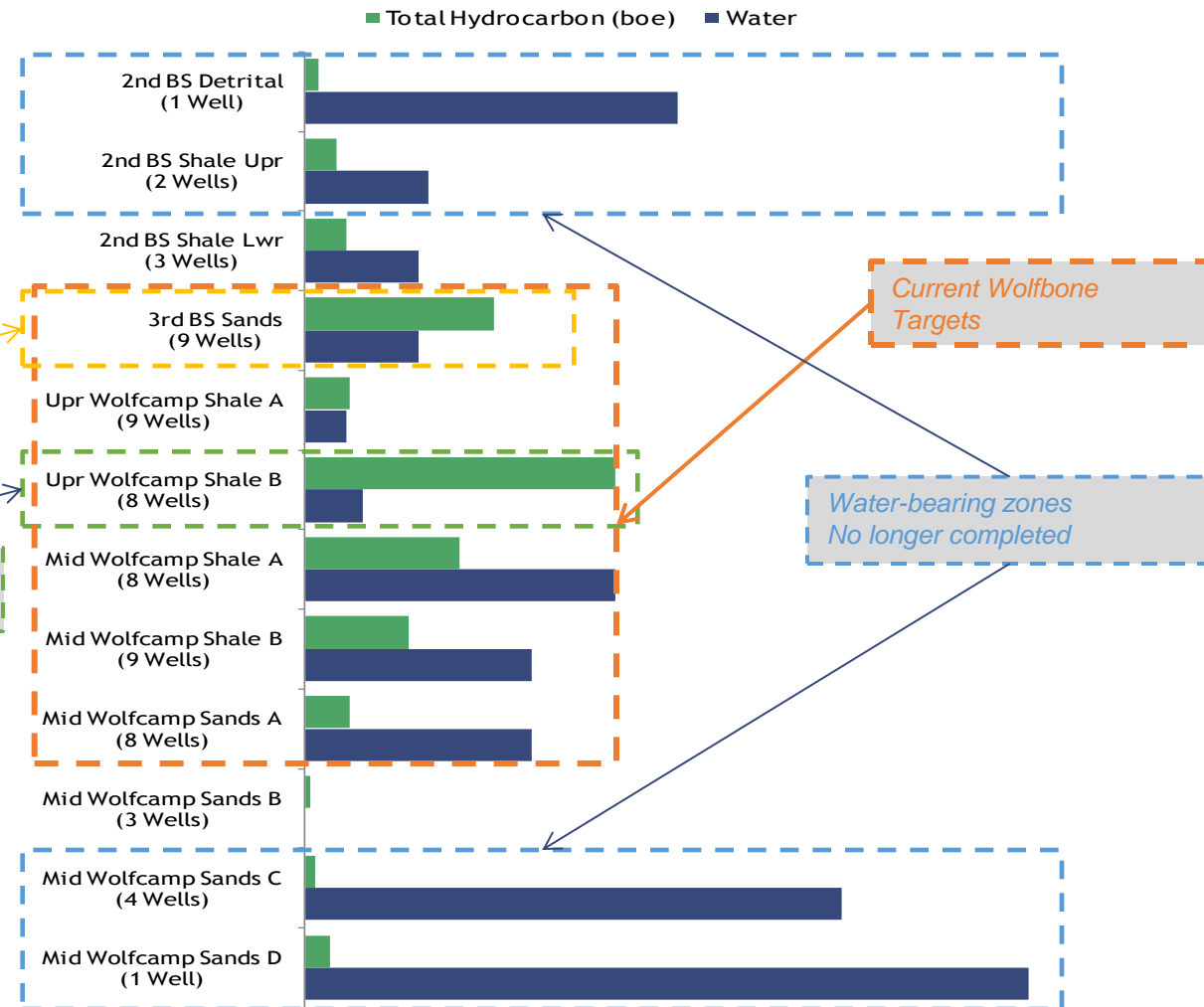
Production Logs = Precision Completions

Production Logs Used to Identify Target Intervals

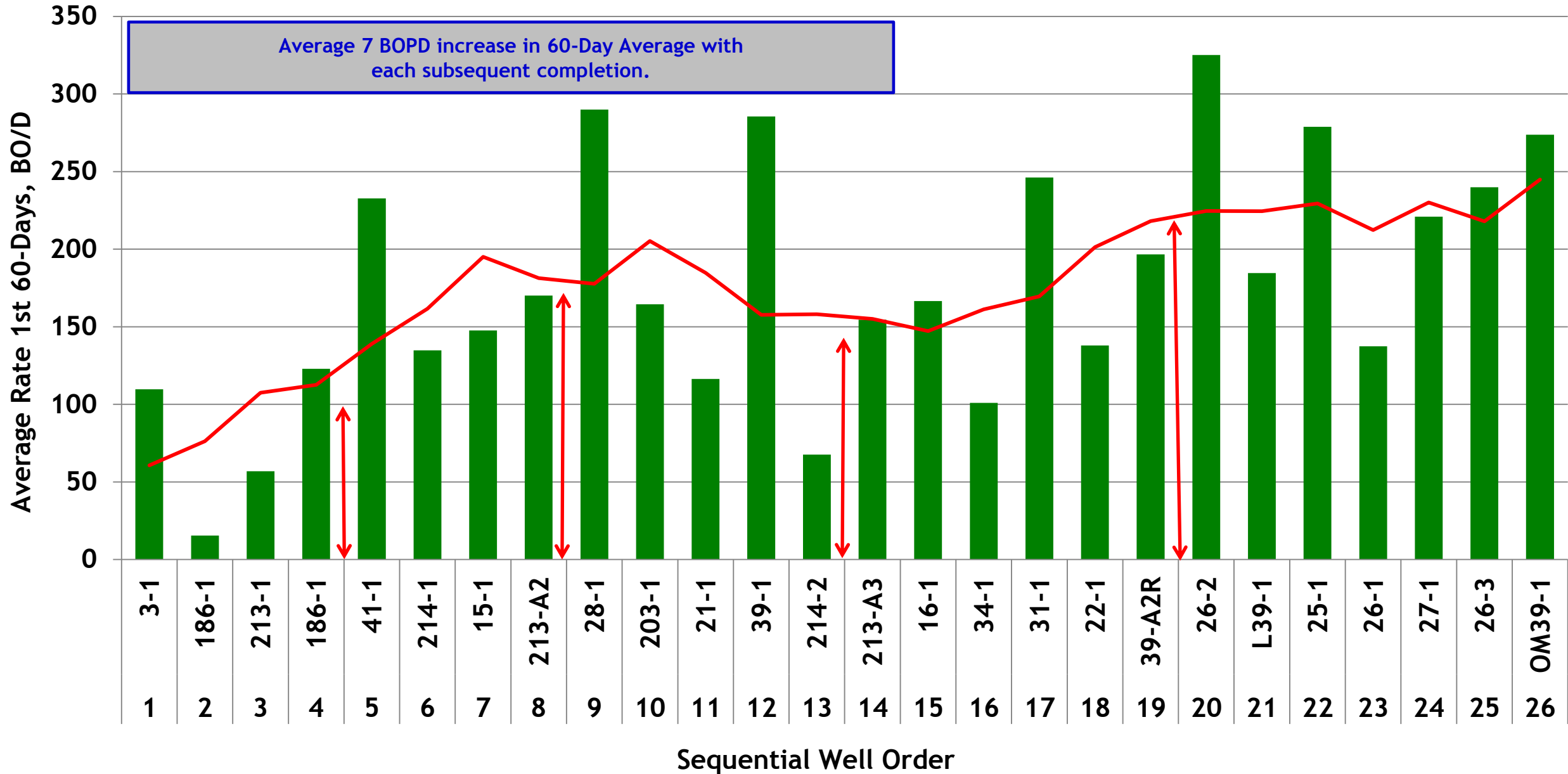
- Eagle has run production logs in 9 Wolfbone wells
- Tool has multiple sensors to identify contributing intervals:
 - Spinner with dual-axis caliper
 - Pressure and temperature sensors
 - Digital Entry Flowview Imaging Tool (DEFT)
 - Water measurement
 - Gas Holdup Optical Sensing Tool (GHOST)
 - Gas measurement



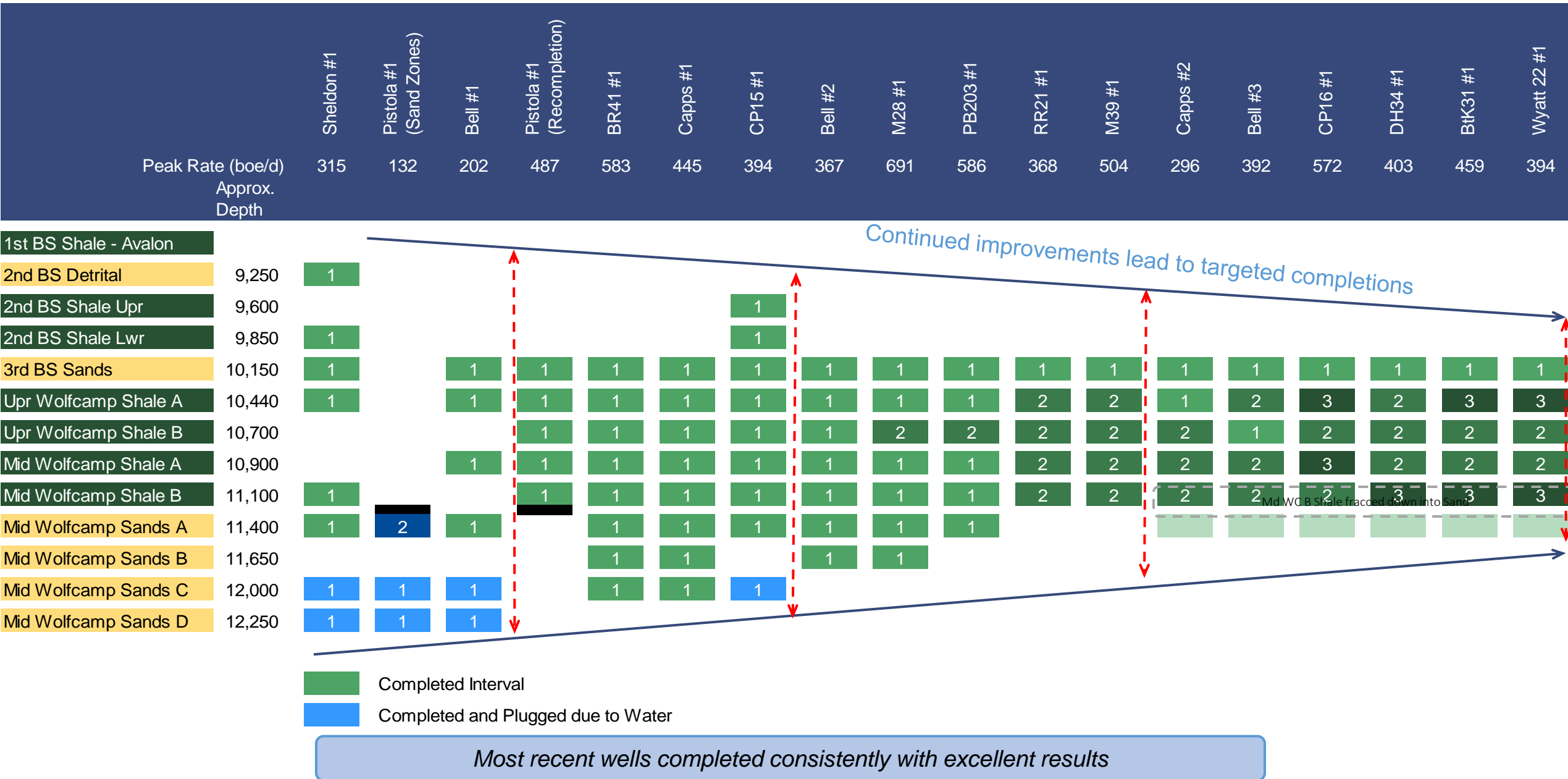
Relative Flow Contribution by Member(1)



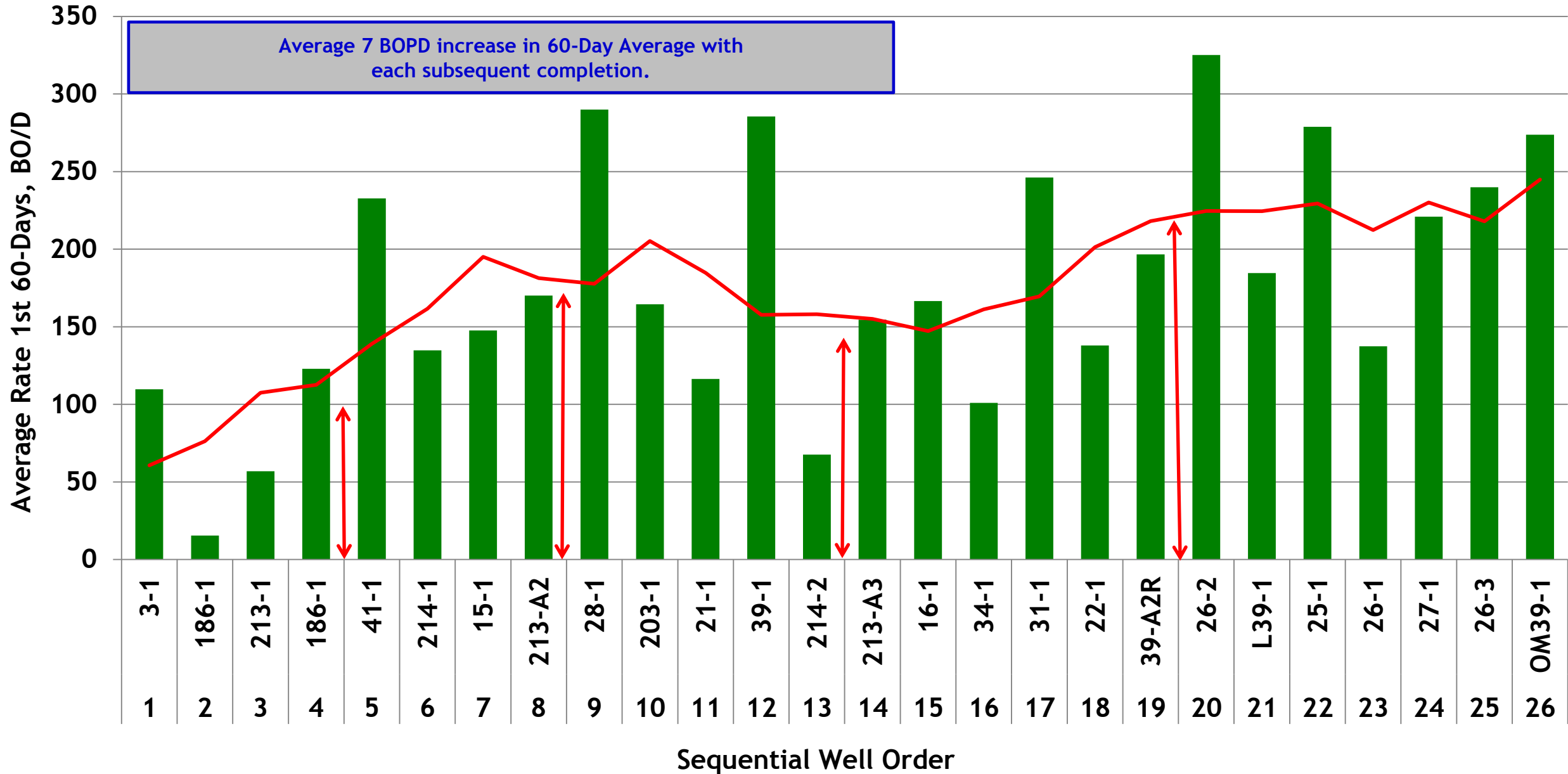
First 60-Day Average Production in Sequential Order Completed With 5-Well Moving Average



Focusing the Effort



First 60-Day Average Production in Sequential Order Completed With 5-Well Moving Average



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Drilling:

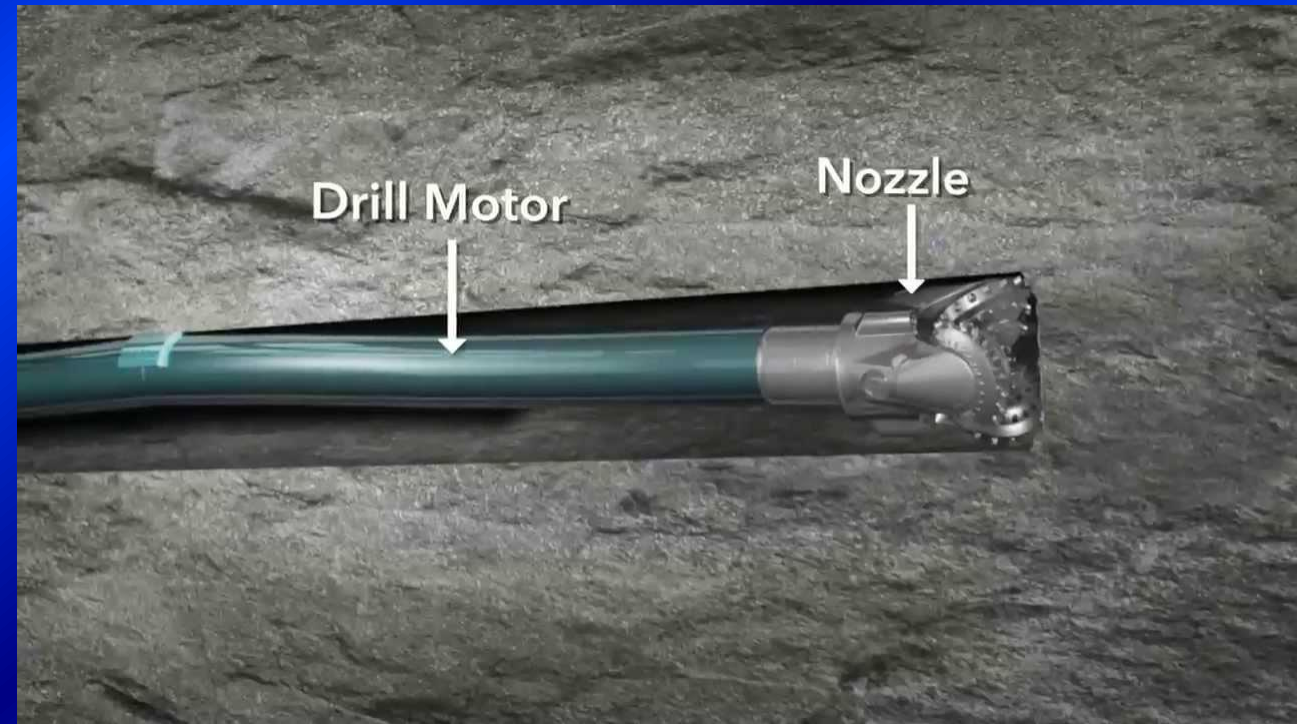
- Drilling limitations of approximately 20,000' have been overcome.
- Drilling time has been reduced in some cases by as much as 85%.
- Walking rigs, vertical / horizontal manufacturing processes have increased efficiencies and reduced costs.

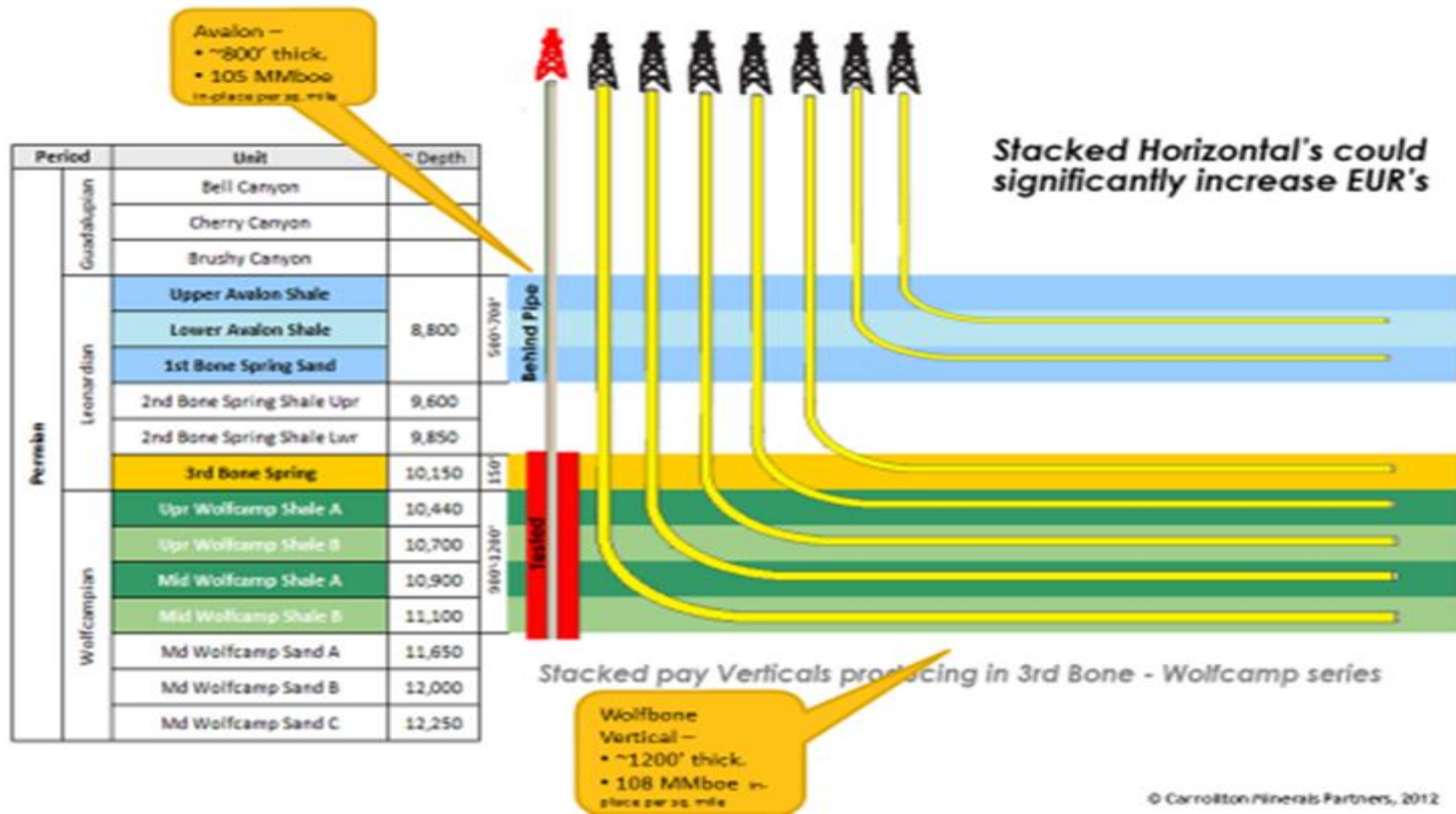




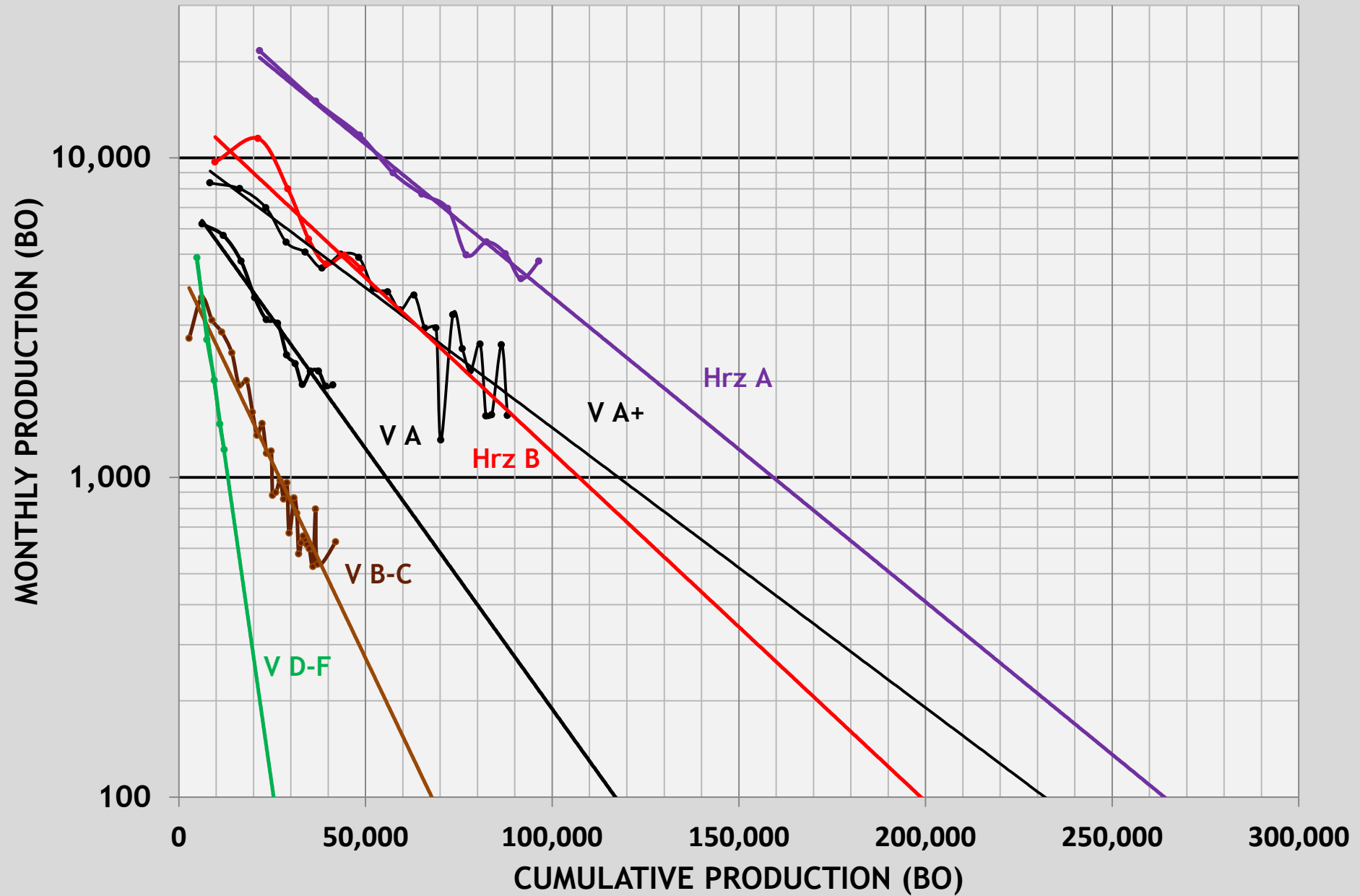
Drilling:

Horizontal technology and interactive, synthesis of Geologic input has reduced horizontal drilling times, increased geologic data collection and maximized horizontal length in the target zone.





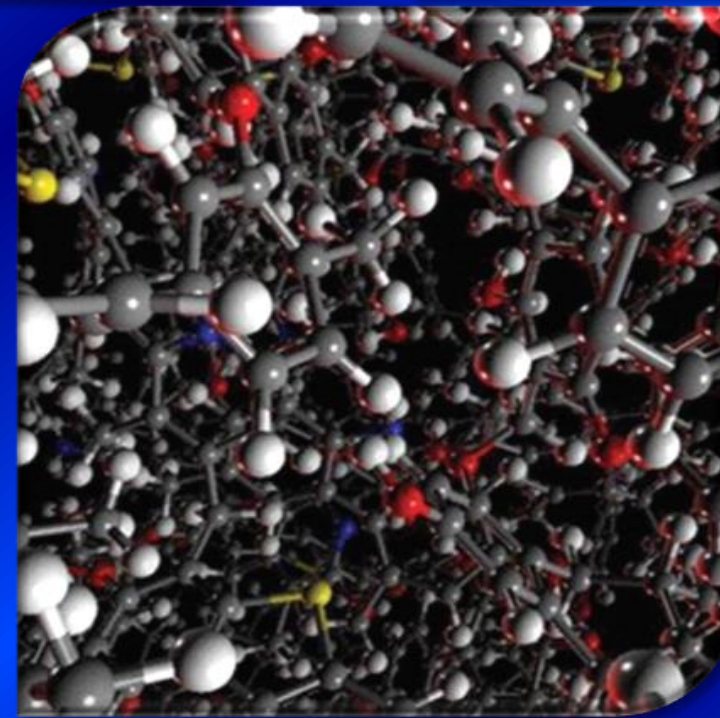
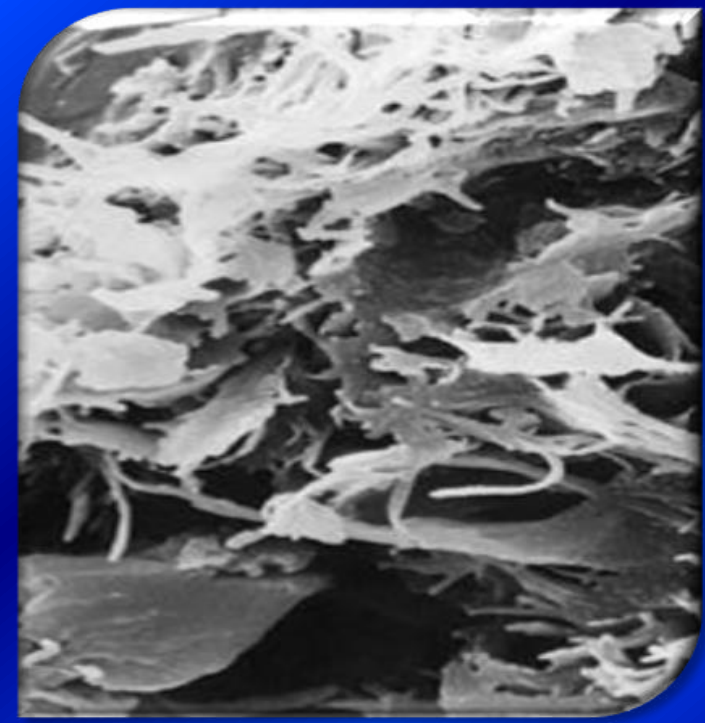
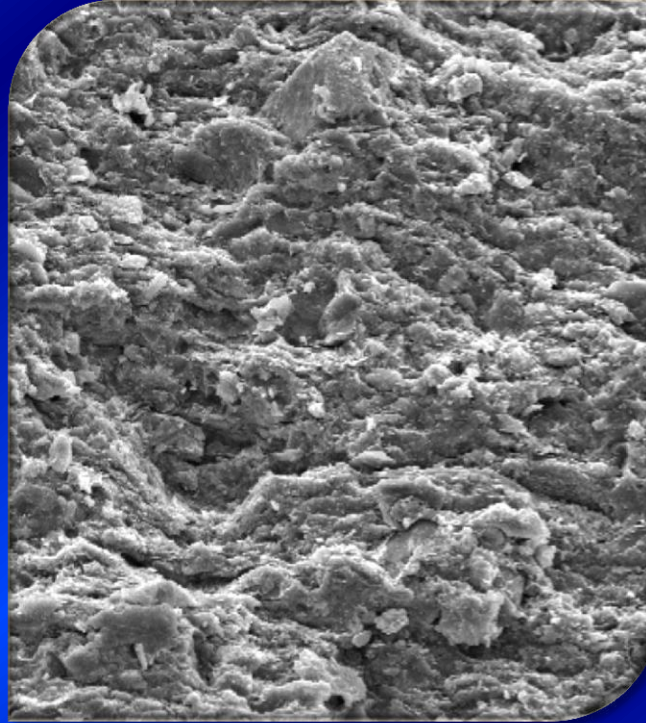
AVERAGES OF ALL GRADES OF VERTICAL AND HORIZONTAL WELLS, REEVES COUNTY



Type	Well \$	1 st Mo	EUR	NPV9	D(ROI)	ROI	I(ROR)	Payout
Well	(\$MM)	Prod (BO)	(MBO)	(\$MM)	I(EFF)	:\$:\$		
Target					2.0	3.0		
V D-F	\$3.5	5,000	25	N/A	N/A	N/A	N/A	N/A
V B-C	\$3.5	4,000	73	-0.07	0.98	1.16	4.88	6.20
V A	\$3.5	6,500	236	5.27	2.50	4.76	37.45	1.86
Hrz B	\$7.5	10,000	434	11.08	2.47	4.34	37.32	1.91
Hrz A	\$7.5	20,000	722	22.07	3.97	7.97	57.87	1.75
Hrz A “Best To Date”	\$7.5	20,000	268	7.5	2.00	2.31	49.72	1.75

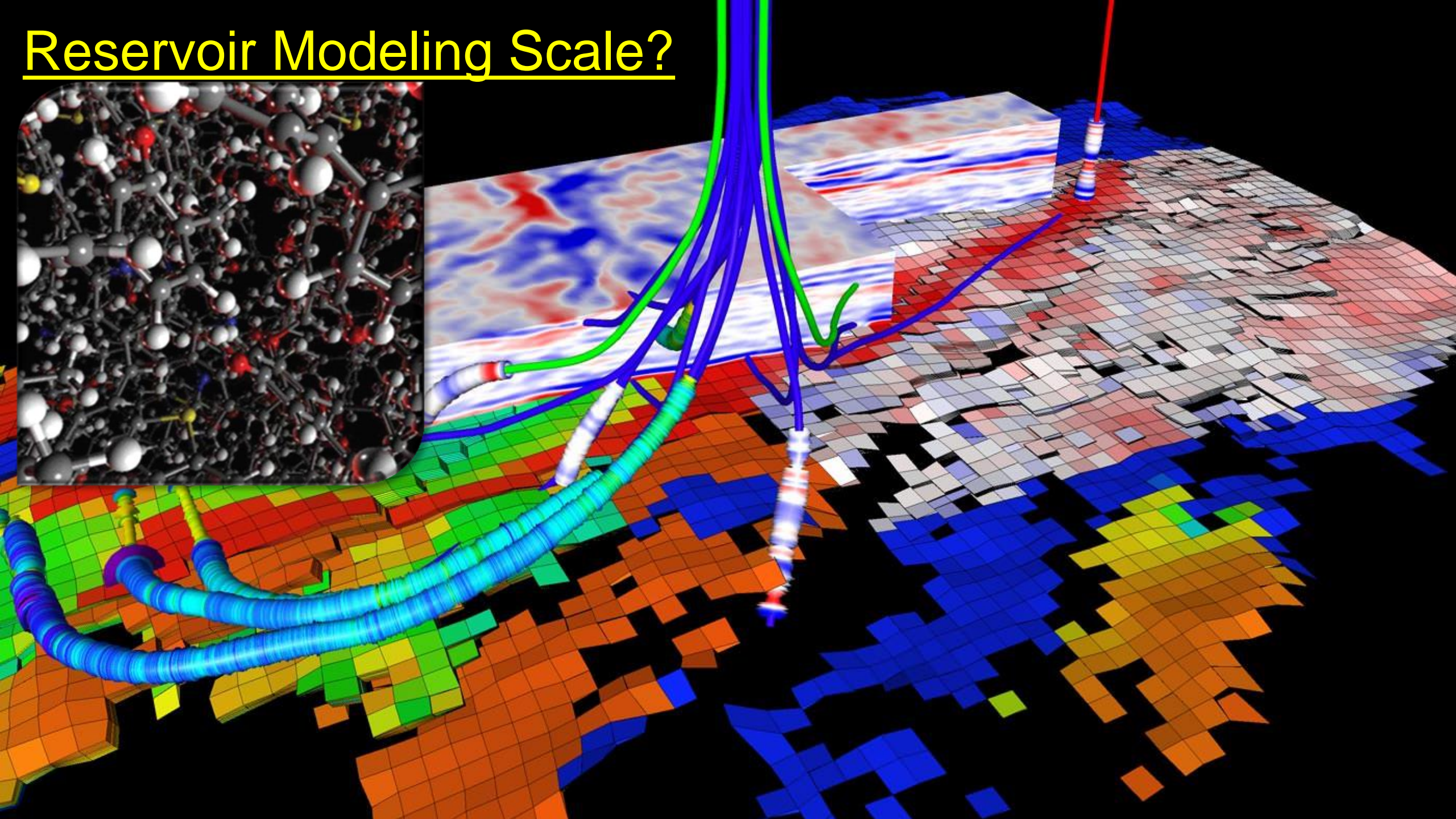
Geologic / Reservoir Modeling:

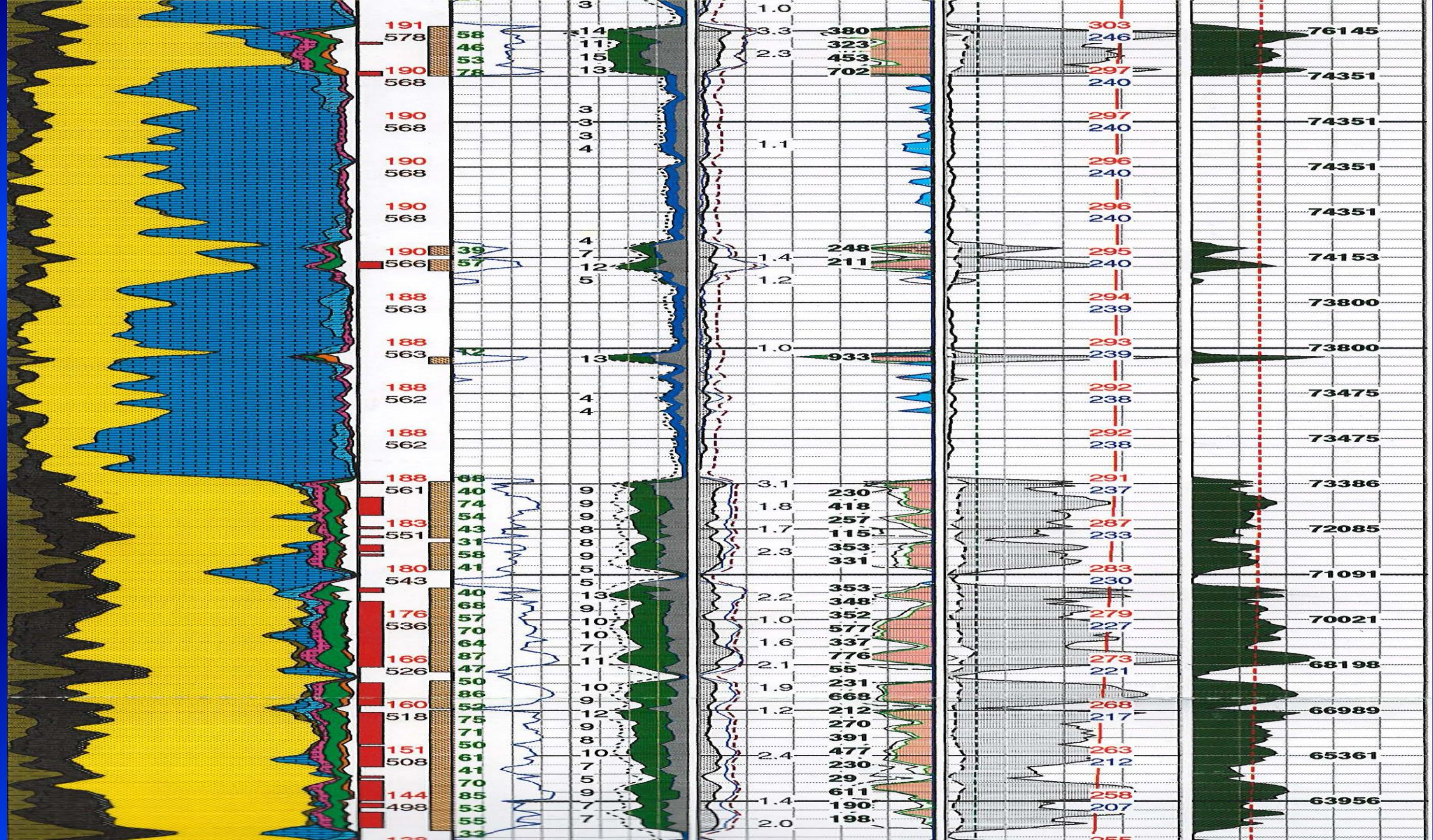
- 10 years ago we could not adequately explain how gas moved through reservoir rocks but knew that oil would never be economically producible from such reservoirs.
- Obviously our explanations have changed.
- What about our measurement tools, techniques, methods output and analyses.



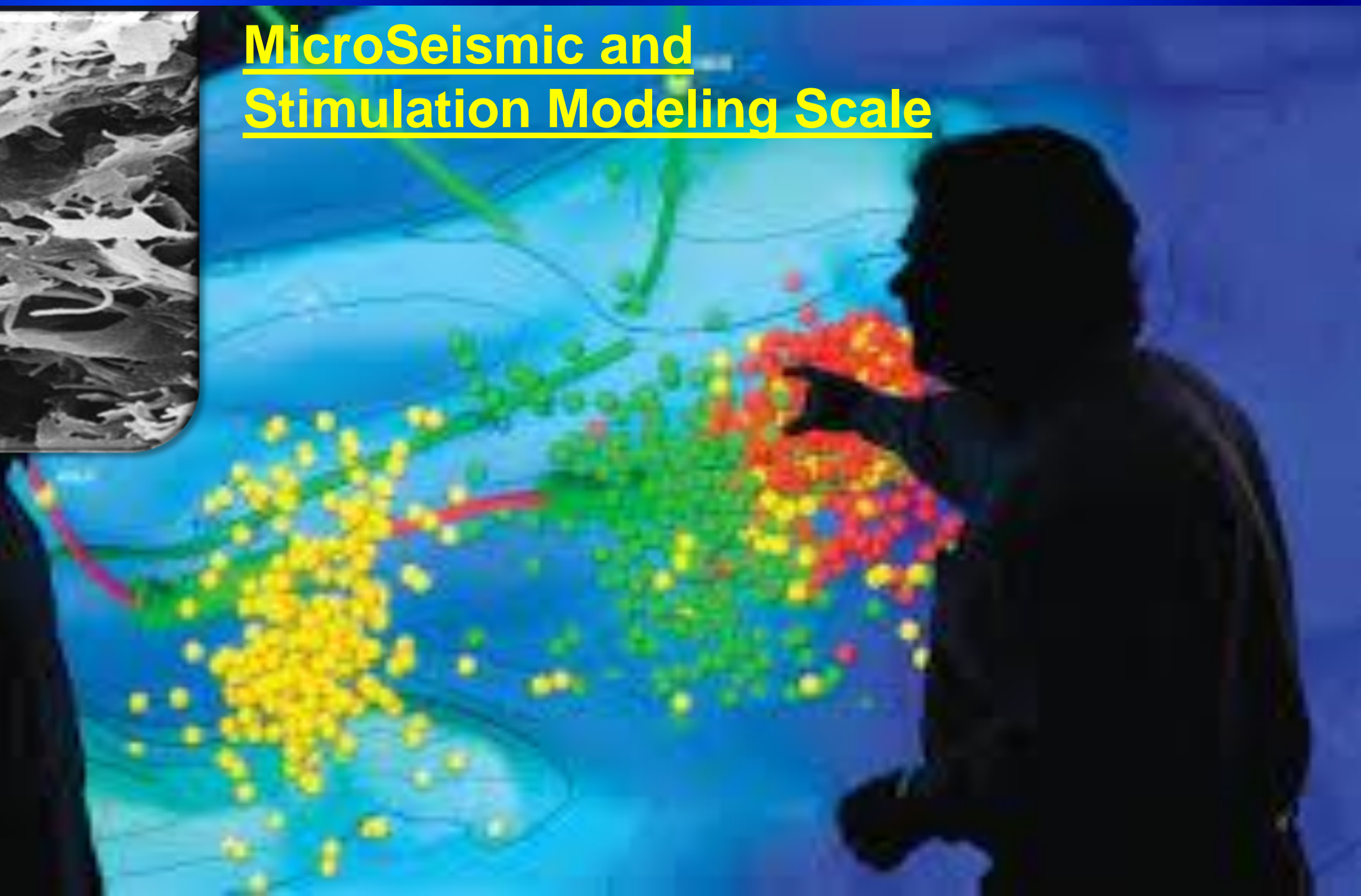
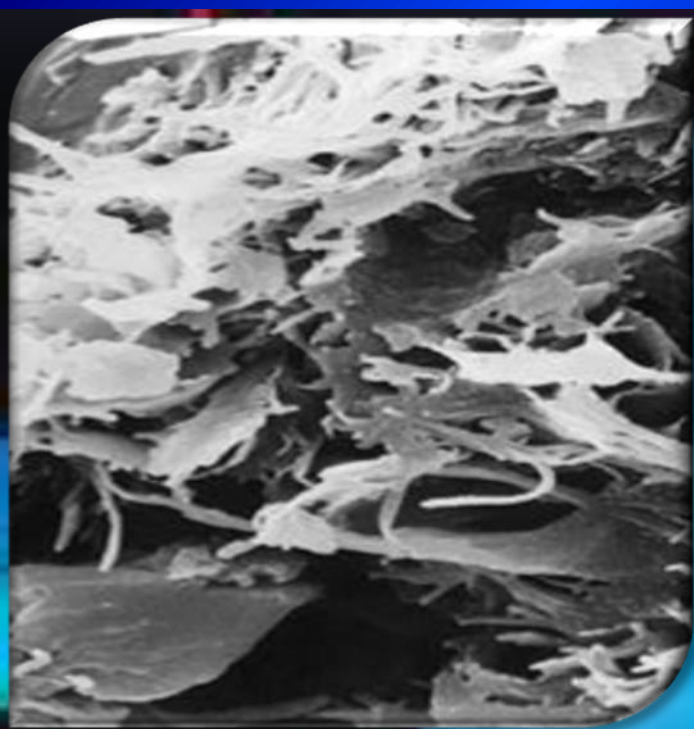
Pictures from
Halliburton's
website.

Reservoir Modeling Scale?





MicroSeismic and Stimulation Modeling Scale



MicroSeismic and Stimulation Modeling Scale

Kx WWW.SANTECPE.COM

