#### Midland Basin Wolfcamp Horizontal Development\*

#### Greg Wilson<sup>1</sup>

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#### **Abstract**

Energen has begun the first phase of a development drilling program in the Wolfcamp Shale in Glasscock County, Texas. This is a discussion of what we have done so far, and where we are going.

#### References

Fu, Q., 2011 A synthesis of the Wolfcampian platform carbonate system in the Permian Basin Region: West Texas Geological Society, Presentation 03/08/2011. Website accessed August 4, 2015, <a href="http://www.wtgs.org/media/files/None/Synthesis-of-the-Wolfcampian-Platform.pdf">http://www.wtgs.org/media/files/None/Synthesis-of-the-Wolfcampian-Platform.pdf</a>.

Galloway, W.E., T.E. Ewing, C.M. Garrett, N. Tyler, and D.G. Bebout, 1983, Atlas of Major Texas Oil Reservoirs: Bureau of Economic Geology, The University of Texas at Austin, 139 p.

#### Website

Spindletop, April 23, 1904, priweb.org, courtesy of American Petroleum Insitute. Website accessed August 4, 2015, http://www.priweb.org/ed/pgws/history/spindletop/spindletop.html.

<sup>\*</sup>Adapted from presentation at the AAPG DPA Forum Midland Playmaker, Midland Texas January 14, 2015.

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**Greg Wilson** 

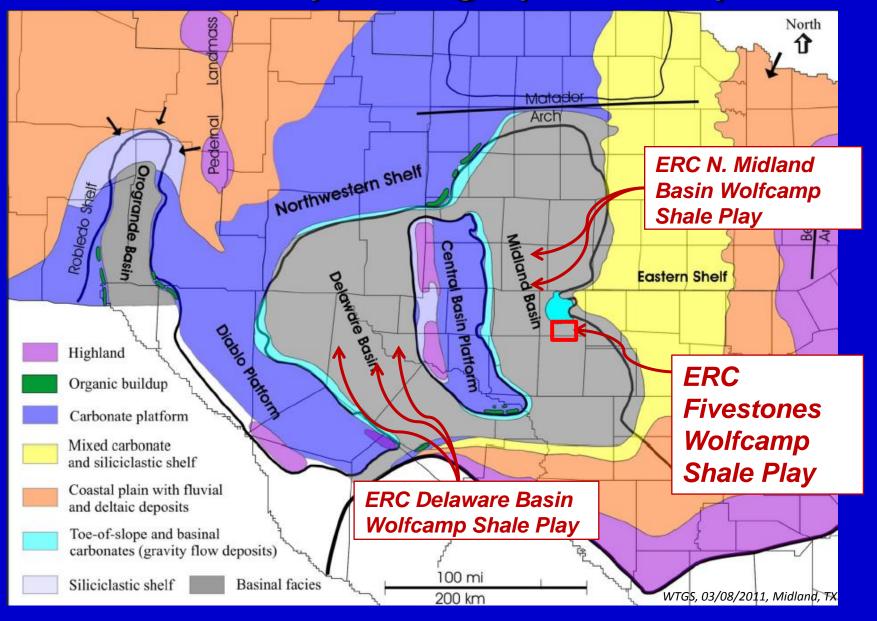
#### What Makes RESOURCE PLAYS Work?

- Organic Mudstones (basinal source rocks)
- Mappable (significant thickness & areal extent)
- Richness (generated oil in place)
- Repeatable (predictable results)

## What Makes RESOURCE PLAYS Work? Cont'd

- Thermal Maturity
  - Hydrocarbon Generation (Oil / Wet Gas / Dry Gas)
  - Reservoir Quality (porosity & permeability)
- Petrophysical Properties (identify, measure, analyze & map)
- Clay Volume (low to moderate volume, minimal swelling clays)
- Rock Mechanical Properties
  - Drillable
  - Fracable

### Wolfcamp Paleographical Map



Permian Basin Stratigraphic Column &

AGE	Relative Oil Production	SYSTEM	SERIES	ı	AWARE	NW SHELF			CENTRAL BASIN		MIDLAND BASIN	
Mya 251	Production			BASIN Dewey Lake		Dewey Lake			PLATFORM Dewey Lake		Dewey Lake	
251			Ochoan	Rustler Salado		Rustler		Rustler		Rustler		
						Salado			Salado		Salado	
				Castile								
255					Lamar	Whitehorse		Tansill Yates Seven Rivers Oueen		Tansill Yates Seven Rivers Queen	şe.	Tansill
				į	Bell Canyon				Capitan		Yates	
				₹ ₽						Seven Rivers	- ji  -	Seven Rivers
			Guadalupe	aware Min. Group	Cherry Canyon	W	Graybu		ľ	Queen Grayburg	W	Queen Grayburg
		Permian	7	Dela .	Brushy Canyon	Word	San And	<u> </u>	Word		p.	San Andres
				_			Glorie	eta Č Š			Word	San Angelo
270							1	addock	- 14	U. Clearfork	- 14	
	•		Leonard	5	Avalon	Yes	io 1	Blinebry Tubb	Clearfork	Tubb	Clearfork	U. Leonard
				Spring	Shale		1	rinkard	L. Clearfork	S S		
					Bn Sp Sand		'					U Spraberry
					on Con Consid			Wichita		Wichita	L Spraberry	
				2 <sup>nd</sup> Bn Sp Sand 0 0 3 <sup>rd</sup> Bn Sp Sand		Abo			Albany		Vict	Lopiaberry
											-	Dean
				Wolfcamp		Wolfcamp Hueco Bursum		Hueco			Wolfcamp	
	•		Wolfcamp					Wolfcamp		•		
302	•	Pennsylvanian	Cisco	Cline		Cisco		Cisco		Cline		
			Canyon	Canyon		Canyon			Canyon		Canyon	
			Strawn	Strawn		Strawn			Strawn		Strawn	
			Atoka	Atoka		Atoka		Atoka		Atoka		
			Morrow	Morrow		Morrow			Morrow			
323	•	Mississippian	Chester	Barnett Upr Miss Shale Lm		Barnett Shale			Barnett Shale		Barnett Shale Upr Miss	
			Meramec- Osage	Mississippian Lm		Mississippian Lm			Mississippian Lm		L. Mississippian Lm	
			Kinderhook	Kinderhook		Kinderhook			Kinderhook		Kinderhook	
262			Upper	Woodford		Woodford		Woodford		Woodford		
363	•	Devonian	Middle									
			Lower	Thirtyone		Thirtyone			Thirtyone		Thirtyone	
417	•	Silurian	U. Niagaran	Wristen		Wristen			Wristen		Wristen	
			L. Niagaran	Fusselman		Fusselman			Fusselman		Fusselman	
			Alexandrian Cincinnatian	Montoya			Montoya				75.0	Iontoya Sylvan
443	•	Ordovician	Mohawkian	IVI	Bromide	] šdu		mide		Montoya Bromide	IV.	Bromide
			Chazyan	g -	ulip Creek		Tulip Creek	McKee Sand	Ę.		<b>=</b>	Tulip Creek McKee Sand
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				is	Oil Creek		Oil Creek	Connell Sand	. ii	Oil Creek Connell Sand	] iii	Oil Creek Connell Sand
					Joins	Ш	Jo	ins		Joins		Joins
			Canadian Ozarkian	Ellenburger		Ellenburger			Ellenburger		Ellenburger	
495		Cambrian Upper								Wilberns		
												Hickory
		Granite Wash										
		pre-Cam	ıbrian									
Modified from Galloway et al.												

**Focus Plays** 

- Bulk of production comes from the Permian sequence
- Major source rocks in the Ordovician, Woodford, Barnett, Cline, Wolfcamp and Leonard
- Historical activity and production has been dominated by shelf carbonate plays
- Shelf carbonates are still being drilled, but activity today is dominated by basinal plays
- Industry activity today is focused on the Leonardian, Wolfcampian and Upper Pennsylvanian basinal lithology in the Delaware and Midland Basins

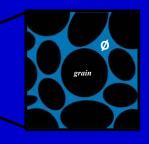
Source Rocks

## Reservoir Quality in a Resource Rock Intergranular and Intra-Kerogen Ø





Rock related



Intra-Kerogen Ø



Maturity related



Reservoir space is a network of Intergranular and Intra-Kerogen pores molded into a complex geometry

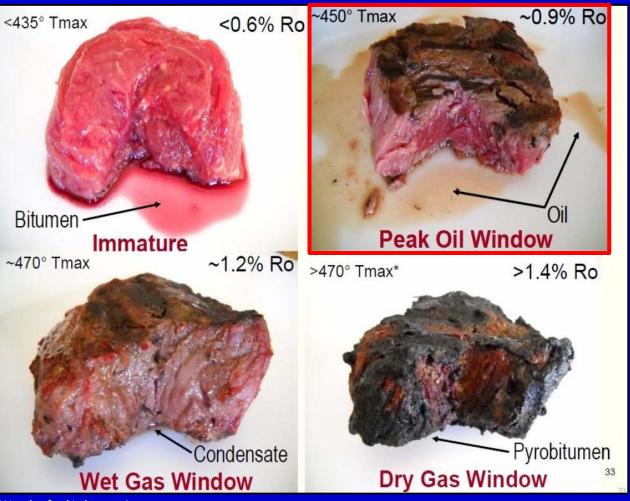
Porosity determination from Petrophysics requires careful calibration of wireline logs to core measurements, rock mineralogy and clay content

Permeability is dependent upon the pore sizes and their inter-connectivity

Reservoir space is filled with a combination of Oil, Gas & Water

Flow varies with fluid phase, permeability and reservoir pressure

## Thermal Maturity Hydrocarbon Generation and Reservoir Quality



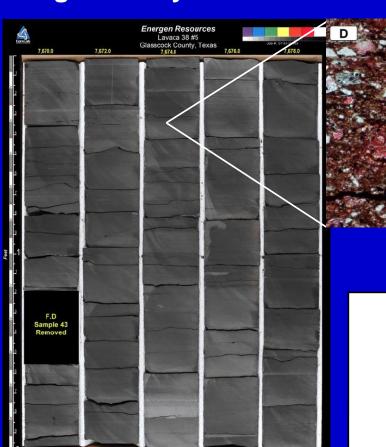
- % Ro (vitrinite reflectance) industry standard for maturity assessment
  - Microscopic examination from cuttings/core samples
  - Calculated to equivalent %
     Ro from laboratory data
- Tmax (Temp of max hydrocarbon released in analysis)
  - Measured from laboratory analysis

Weatherford Laboratories

#### **Wolfcamp "A" Core Data**

#### **Lavaca 38 #5**

#### **Organic Silty Mudstone**

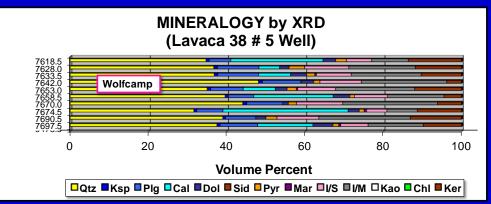


TOC = 2.0 - 4.6% (wt%)

Ro (calc) = 0.85 - 0.9%

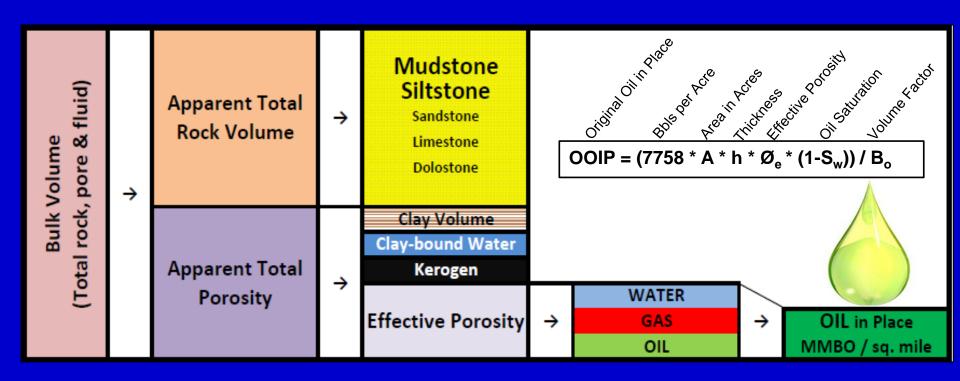
Tmax = 445-449 (deg C)

Total Clay = Avg 35% (vol%)

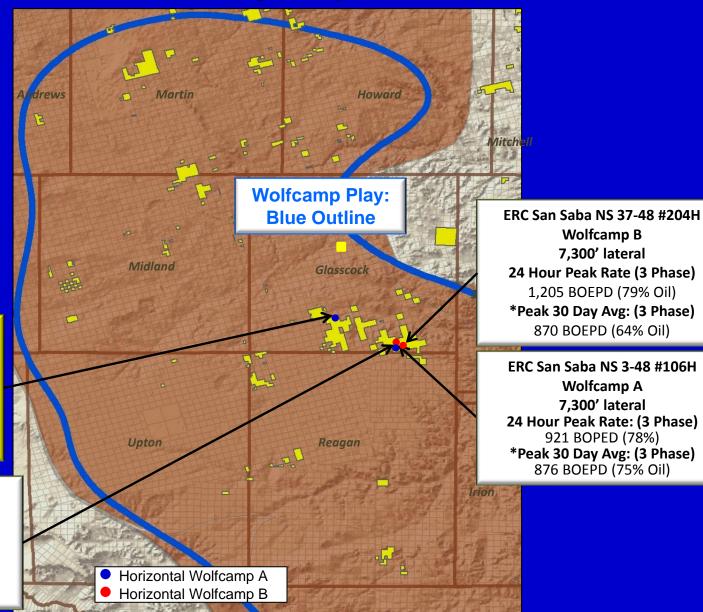


#### The Petrophysical Model

The Petrophysical Model must be rooted in the rock, fit within the geologic framework, and be vetted against the production



## Midland Basin Exploratory Drilling Program South Glasscock Wolfcamp A & B Results



ERC Daniel SN 10-3 #101H
Wolfcamp A
8,150' lateral
24 Hour Peak Rate: (3 Phase)
707 BOEPD (89% Oil)
20 Day Peak Rate: (3 Phase)

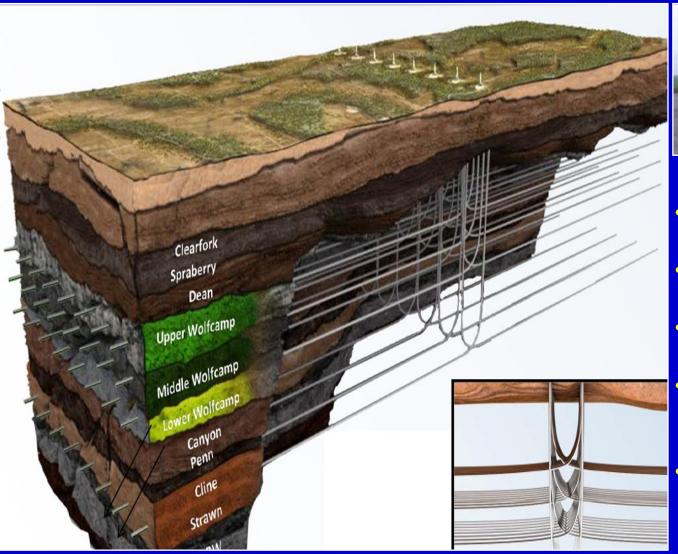
561 BOEPD (86% Oil)

ERC San Saba NS 37-48 #205H Wolfcamp B 7,300' lateral 24 Hour Peak Rate: (3 Phase) 1,387 BOEPD (80%) \*Peak 30 Day Avg: (3 Phase)

1,264 BOEPD (64% Oil)

## **ERC Development Plan**

### **Pad Drilling**



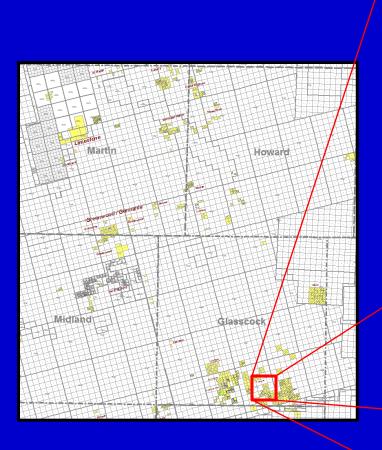


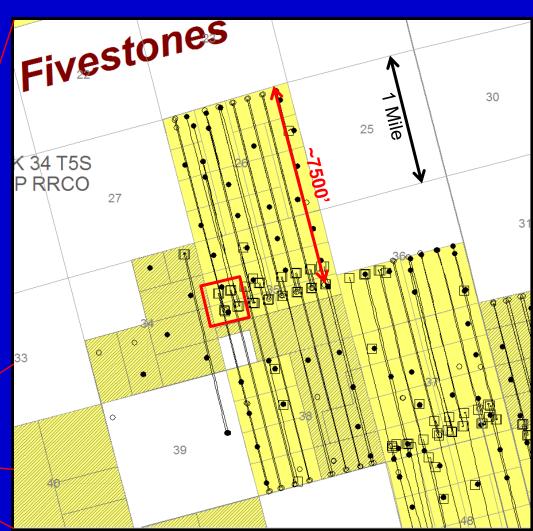
- Minimizes land impacts
- Allows quicker rig moves
- Permits "Zipper" fracing
- More efficient facilities hookup
- Facilitates water recycling

Image source: Laredo Petroleum

#### **Development Pattern**

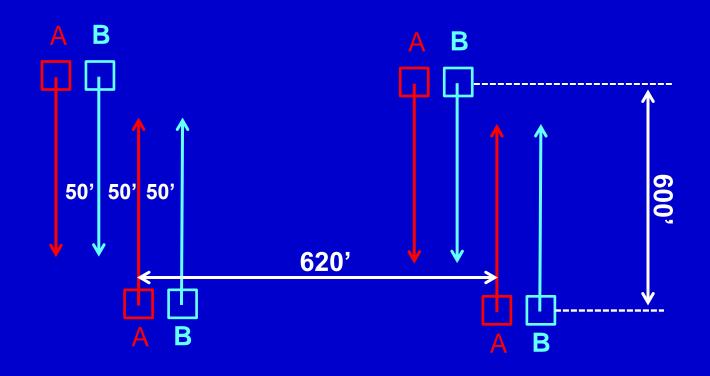
**Maximizing the Resource** 





#### **Development Pattern**

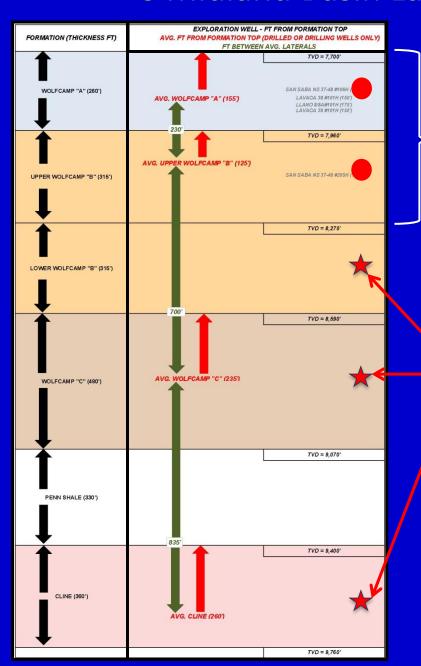
Current inter-well spacing N to S and S to N crossing wells



## **Lateral Targets**

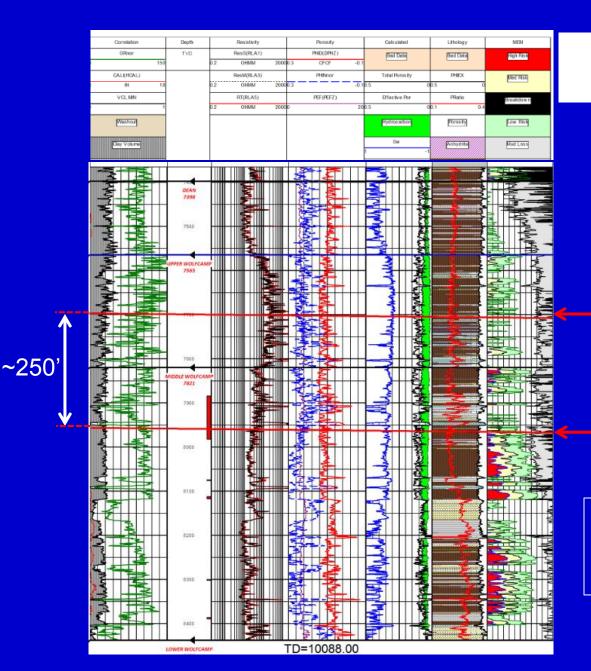


#### S Midland Basin Lateral Schematic



Current ERC Development Program

Additional Potential Hz Targets



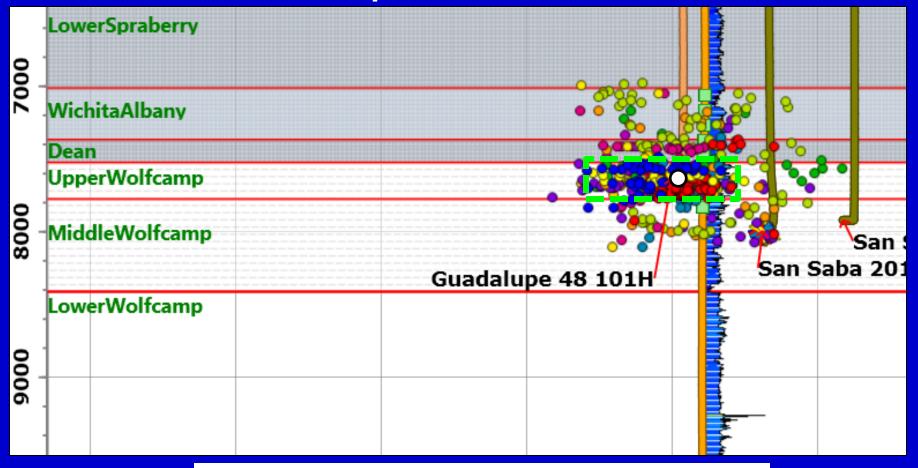
ERC LAVACA 38A 2 County=GLASSCOCK KB = 2733.00

WC A Target

WC B Target

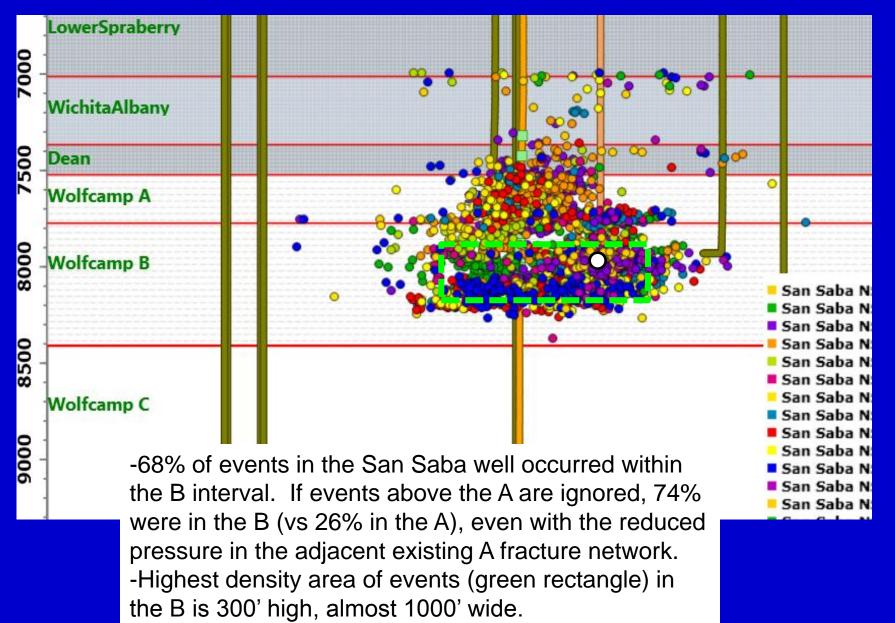
Is 250' vertical separation too close for stacked laterals?

#### WC A - Guadalupe 48 #101H Gun-barrel view



-67% of events in the Guadalupe well occurred within the A interval. If events above the A are ignored, 87% were in the A (vs 13% in the B). -High-density area of events in the A is 250' high, almost 1000' wide.

#### WC B - San Saba NS 204H Gun-barrel view



## So do the stacked wells communicate?

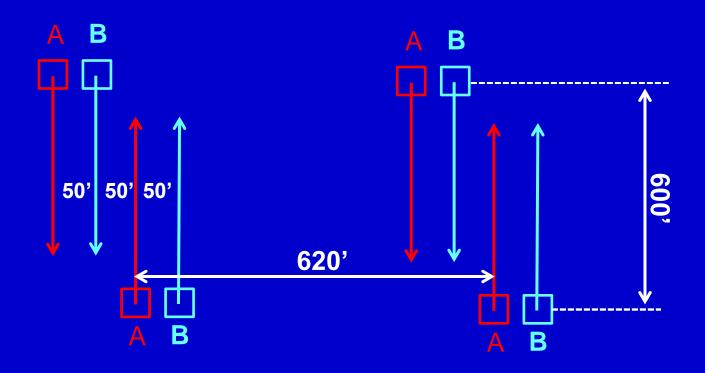
**During the fracture stimulation: Yes.** 

But, flowback and production characteristics suggest....not much.

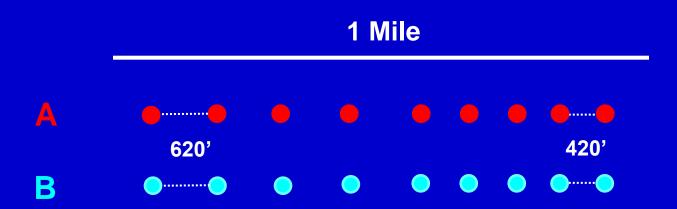
### **Spacing: How close is close enough?**



### **Currently about 620'**



## One way to find out: Spacing test



Two sets side by side, all parameters (length, stimulation, landing) the same except spacing

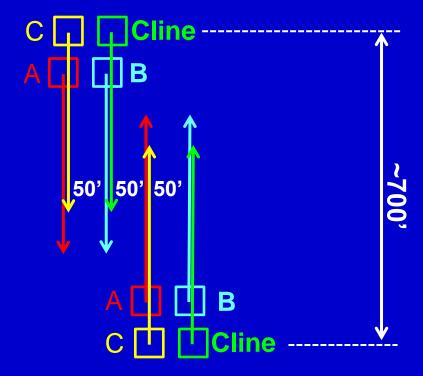
### Development Pattern: The Next Step

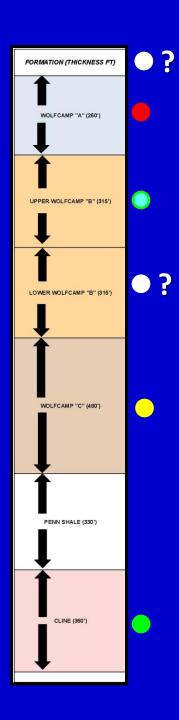


# FORMATION (THICKNESS FT) WOLFCAMP "A" (260') UPPER WOLFCAMP "B" (315') LOWER WOLFCAMP "B" (315') WOLFCAMP "C" (480') PENN SHALE (330')

#### **More Pad Drilling**

What's the best arrangement?





### How many total horizons?

More to be tested.

Potentially 6+ horizons per pad, 8 pads across a section, 48+ wells per section

### It's going to get crowded out there

(but only on the drilling pads)

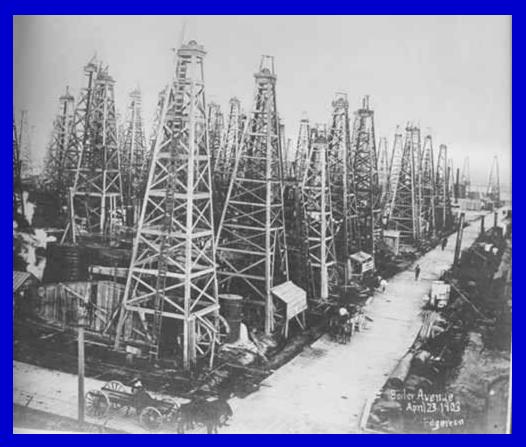


Photo from the American Petroleum Institute, via priweb.com

## Questions?

