

# **AV Characterizing and Exploiting the “Clear Fork Shale” near the Midland Basin Margin in Eastern Andrews County, Texas\***

**Paul S. Molnar<sup>1</sup>**

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## **Abstract**

We utilized onsite cuttings geochemistry and wireline logs to select rotary sidewall core points in a vertical well to identify possible horizontal targets on an approximately 8000- gross/net-acre block in eastern Andrews County, near the western margin of the Midland Basin. The “Clearfork Shale” was determined to have the best potential for horizontal exploitation in this area. The “Clearfork Shale” is Leonardian age, equivalent to the “Avalon Shale” in the Delaware Basin and the basal San Andres Formation (*not* the Clearfork Formation) on the Central Basin Platform. Two different intervals, approximately 250 feet apart stratigraphically, have been tested within the Clearfork Shale. The results are encouraging, and more development is planned when crude price recovers.

## **Selected References**

Blakey, R., 2013, North American Paleogeographic Maps, Late Permian (260 Ma): Colorado Plateau Geosystems. Website accessed August 2, 2015, <http://cpgeosystems.com/namP260.jpg>.

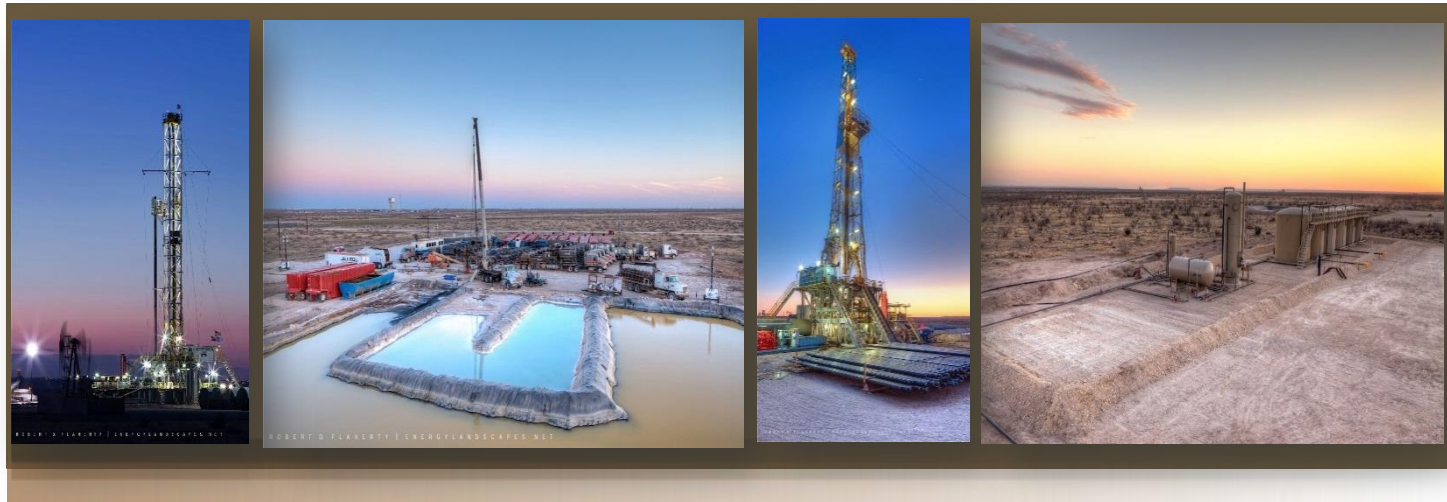
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Ruppel, S. C., 1992, Styles of deposition and diagenesis in Leonardian carbonate reservoirs in west Texas: Implications for improved reservoir characterization: Society of Petroleum Engineers Annual Exhibition and Technical Conference, Washington, D. C., October 4–7, 1992, SPE Paper 24691, p. 313–320.

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Ruppel, S.C., and R.R. Harrington, 2012, Facies and sequence stratigraphy: Critical tools for reservoir framework definition, Fullerton Clear Fork Reservoir, Texas, *in* S.C. Ruppel, editor, *Anatomy of a Giant Carbonate Reservoir: Fullerton Clear Fork (Lower Permian) field, Permian Basin, Texas*: AAPG Studies in Geology 63, p. 5–48.

# **DIAMONDBACK** Energy

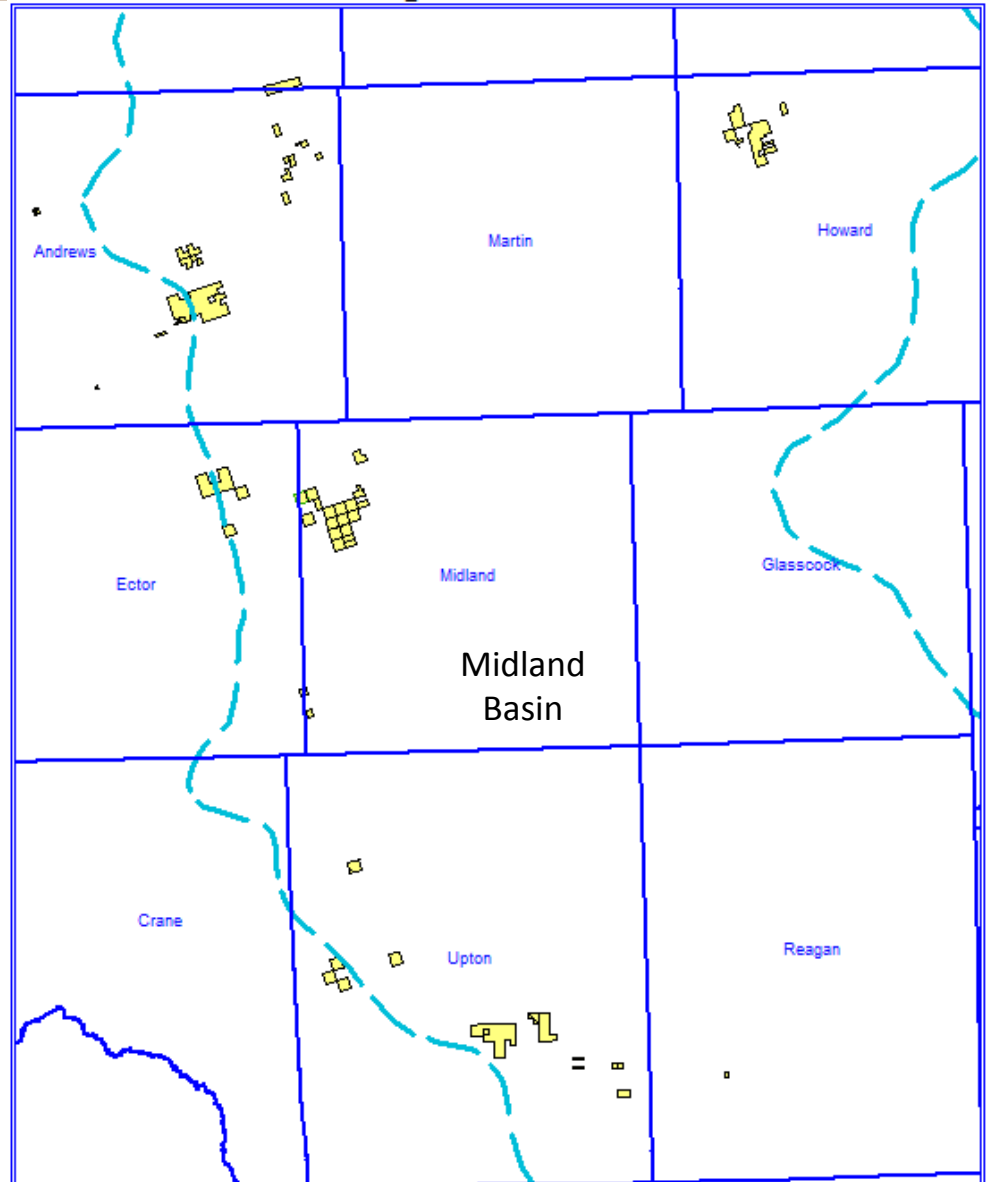


## **Horizontal Development of the “Clearfork Shale” near the Midland Basin Margin in Eastern Andrews County, Texas**

Paul Molnar  
January 14, 2015

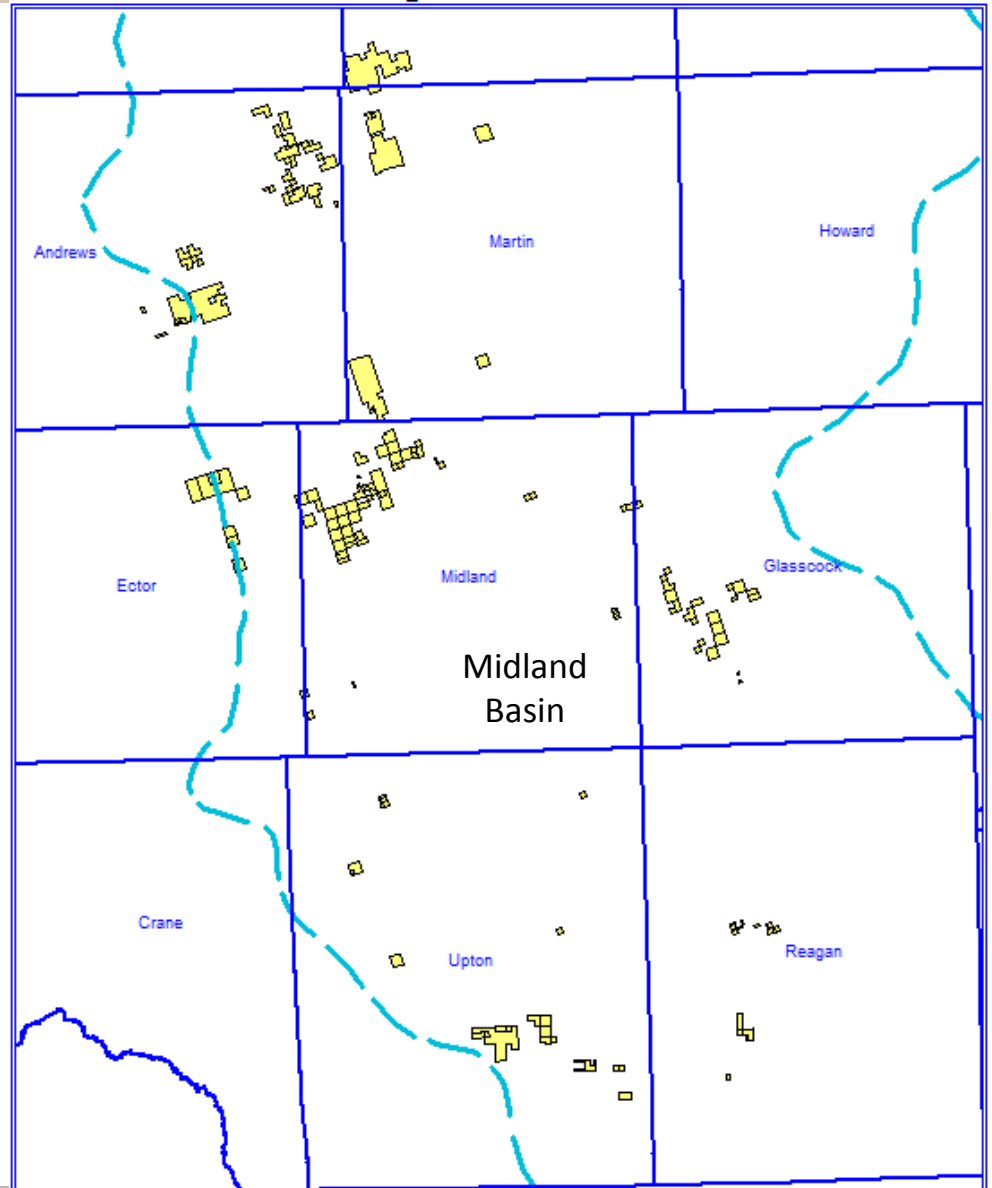
# A Brief History of Diamondback Energy

- First asset acquisition was made in 2006
- In 12/2011, the Company had 54M gross/31M net acres in the Midland Basin, 18 employees and 2,000 BOEPD net production



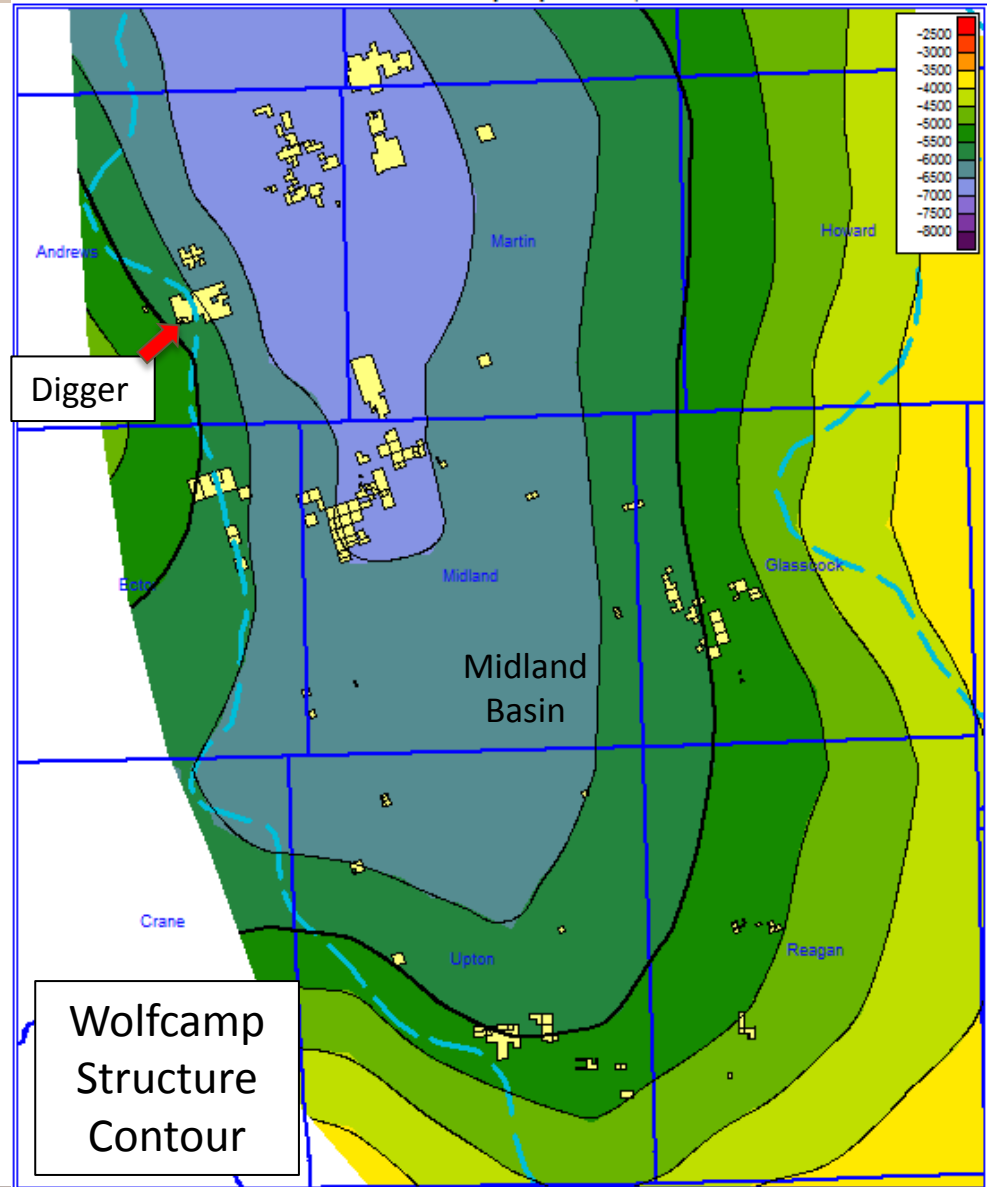
# A Brief History of Diamondback Energy

- First asset acquisition was made in 2006
- In 12/2011, the Company had 54M gross/31M net acres in the Midland Basin, 18 employees and 2,000 BOEPD net production
- Diamondback IPO'd in 10/2012 at \$17.50/share (NASDAQ: FANG)
- Diamondback currently has 105M gross/85M net acres under lease, >100 employees and, as of 4Q14, almost 26 MBOEPD net production
- In 2013, had the largest stock growth within the energy sector; the recent pullback follows the decline in crude price

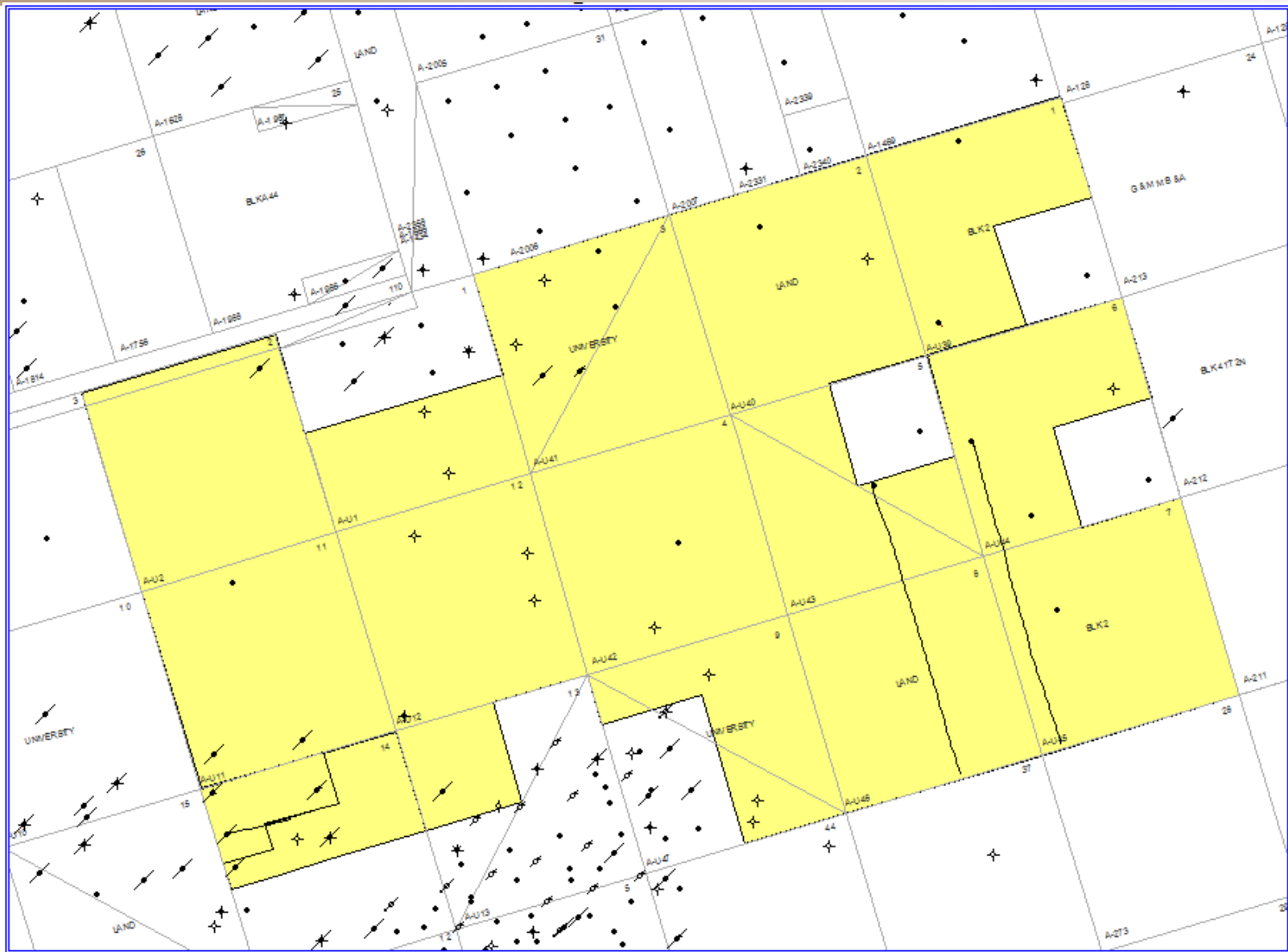


# Asset Assessment and Development

- The majority of existing acreage, and all of the acreage acquired after IPO, is within the “Wolfberry” horizontal play fairway
- Some of the existing acreage is situated near the basin margin, on the flank of the play’s fairway, where Wolfberry Shale pays are not well developed
- Other targets needed to be identified
- The UL “Digger” unit is one such area, and is the subject of this presentation



# University Lands Beekeeper Unit "Digger" Area



# Digger Area Play Assessment

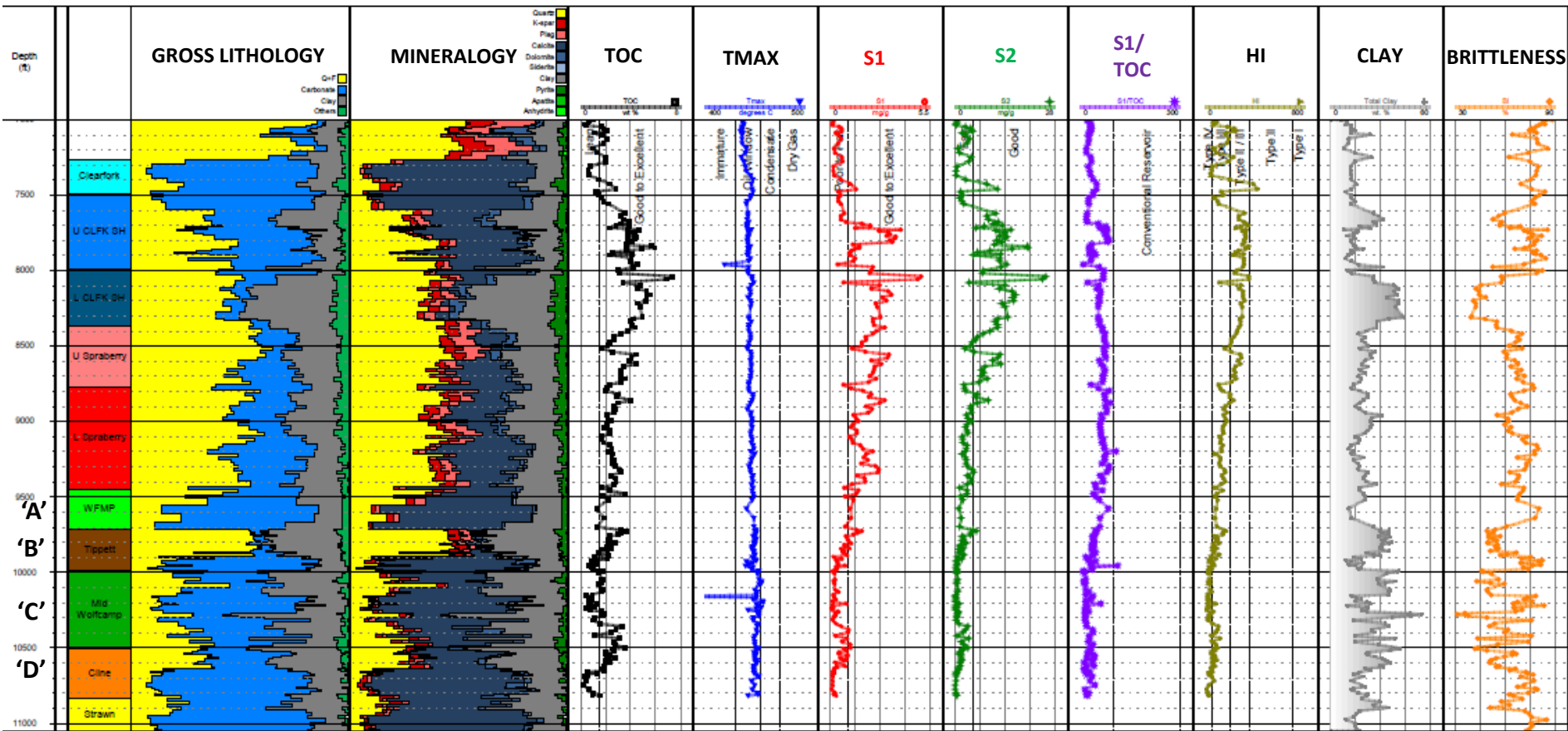
## ***Objective: Determine best target zone for horizontal exploitation in Digger***

- Large acreage position (~8,000 gross/net acres) with overall disappointing results from vertical program, especially on west side of block (moving onto platform).
- Acreage is laid out ideally for horizontal (N – S laterals, perpendicular to regional P1).
- A vertical test, the UL I 113 was being planned; a data collection program was developed to help identify potential horizontal targets:
  - Weatherford Labs onsite geochem lab
  - Full suite of openhole logs
  - 25 rotary sidewall cores
- Monitor industry activity in the area – other horizontal plays being made?
- Test potential horizontal target intervals in vertical wells, if feasible.



# Weatherford Sample Cuttings Geochem Analyses

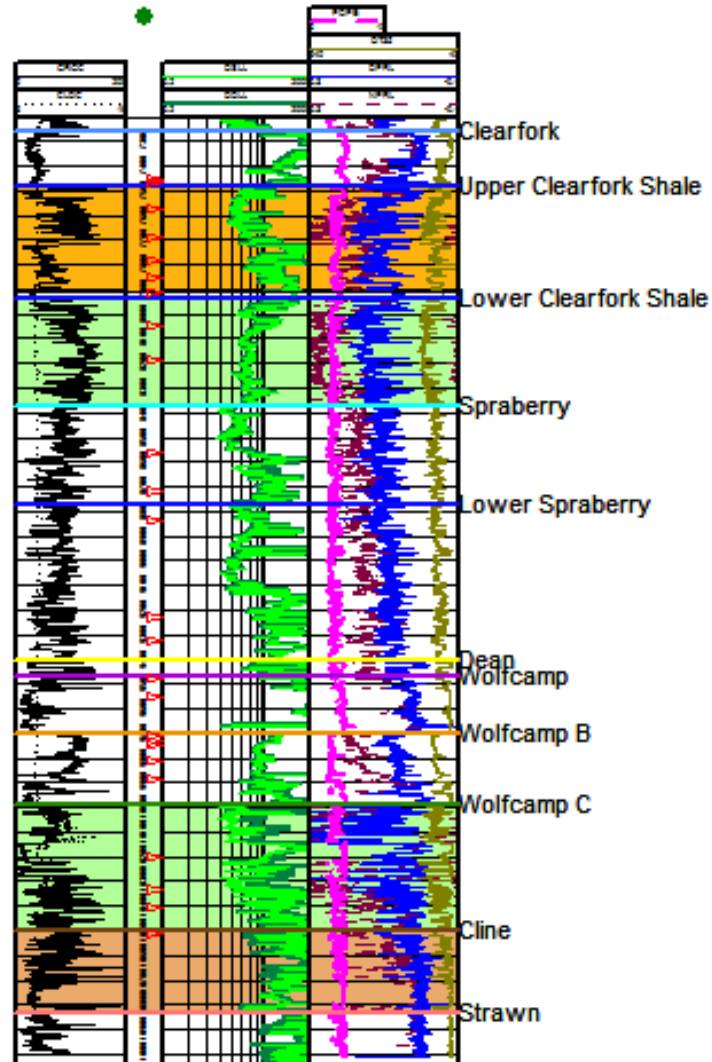
UL 1-13



*Entire Sampled Interval*

# Rotary Sidewall Core Points

DIAMONDBACK E&P LLC  
UL  
113



*RSWC points indicated by red arrows in depth track*

# Digger Area Play Assessment

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- Acreage is laid out ideally for horizontal (N – S laterals, perpendicular to regional P1).
- A vertical test, the UL I 113 was being planned; a data collection program was developed to help identify potential horizontal targets:
  - Weatherford Labs onsite geochem lab
  - Full suite of openhole logs
  - 25 rotary sidewall cores
  - **Results - The Clearfork Shale has good source quality, is mature, relatively brittle; best horizontal candidate observed in this wellbore.**  
Other candidates include Spraberry, Wolfcamp “A”, “B” and “D” (“Cline”).
- Monitor industry activity – other horizontal plays being made?
  - SM Energy – positive results documented in 2 wells targeting upper Clearfork Shale ~6 miles to the SW (EUR’s ~270 mboe). Digger area ~700’ deeper; more mature, higher pressure, thicker.
- Test potential horizontal target intervals in vertical wells, if feasible.
  - Isolated Clearfork Shale tests in two vertical wells confirmed oil production.

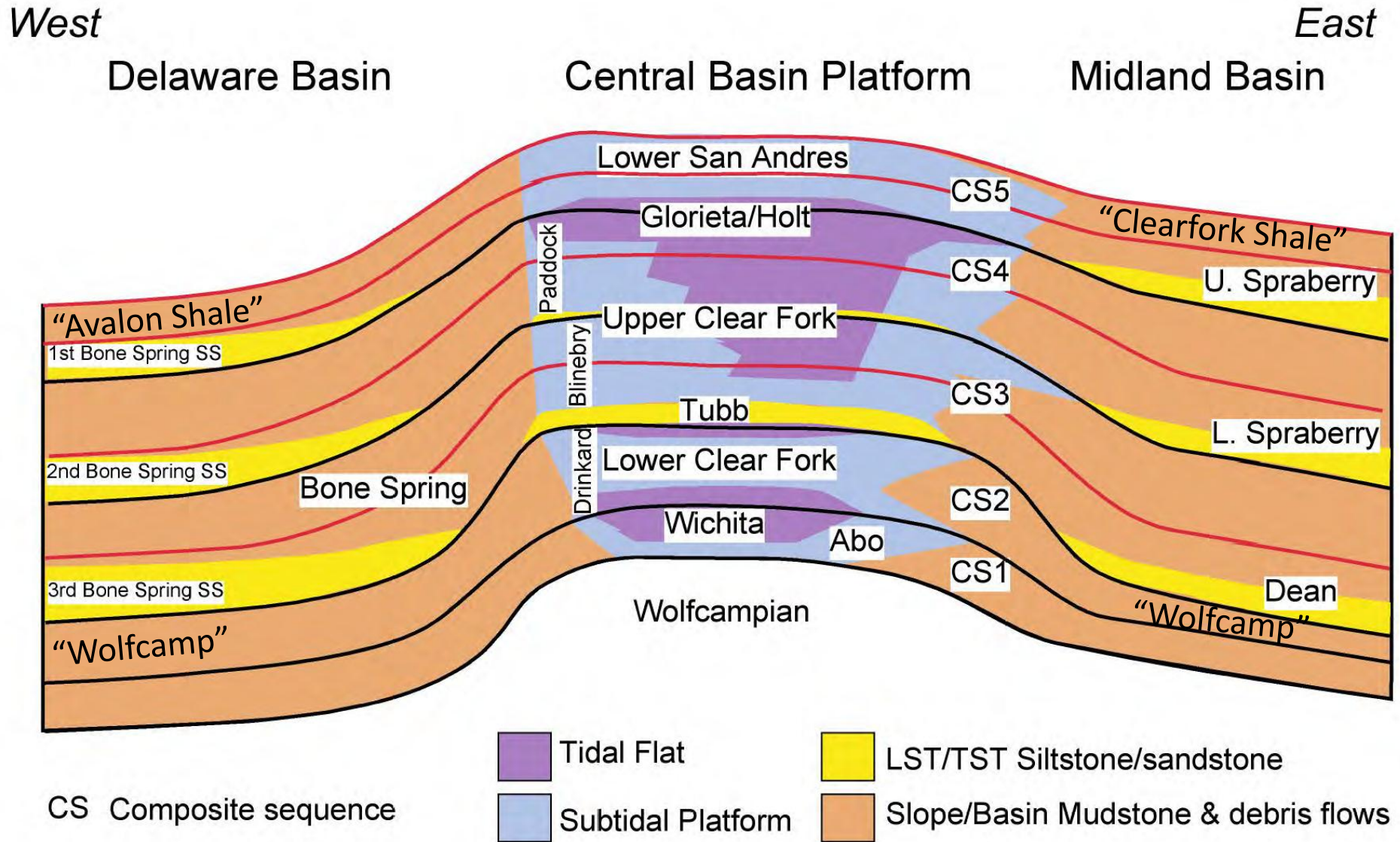
# Late Permian (260 Mya) Paleogeography



Source: *Blakey, Colorado Plateau Geosystems*

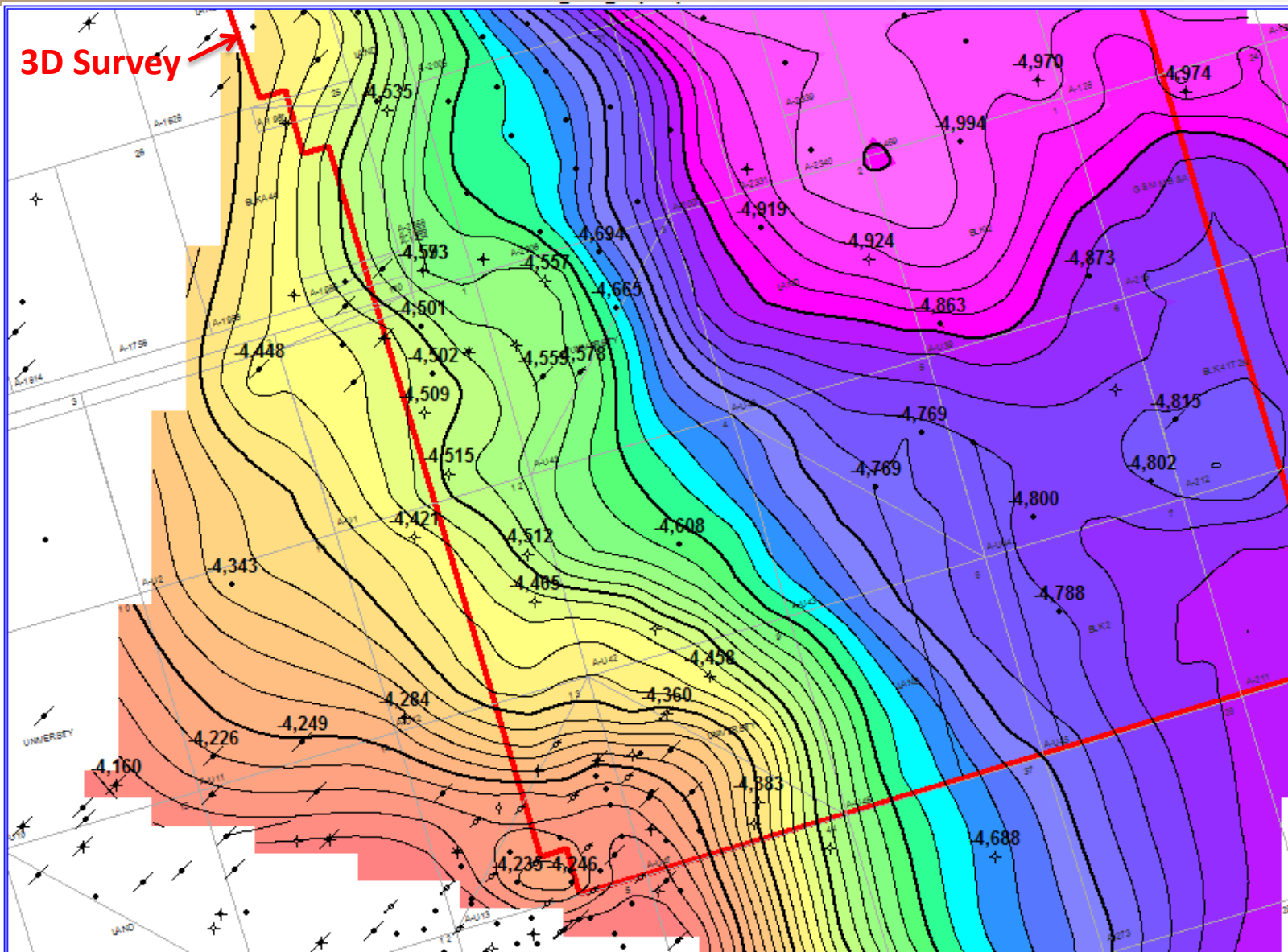


# Regional Permian Basin Leonardian Stratigraphy

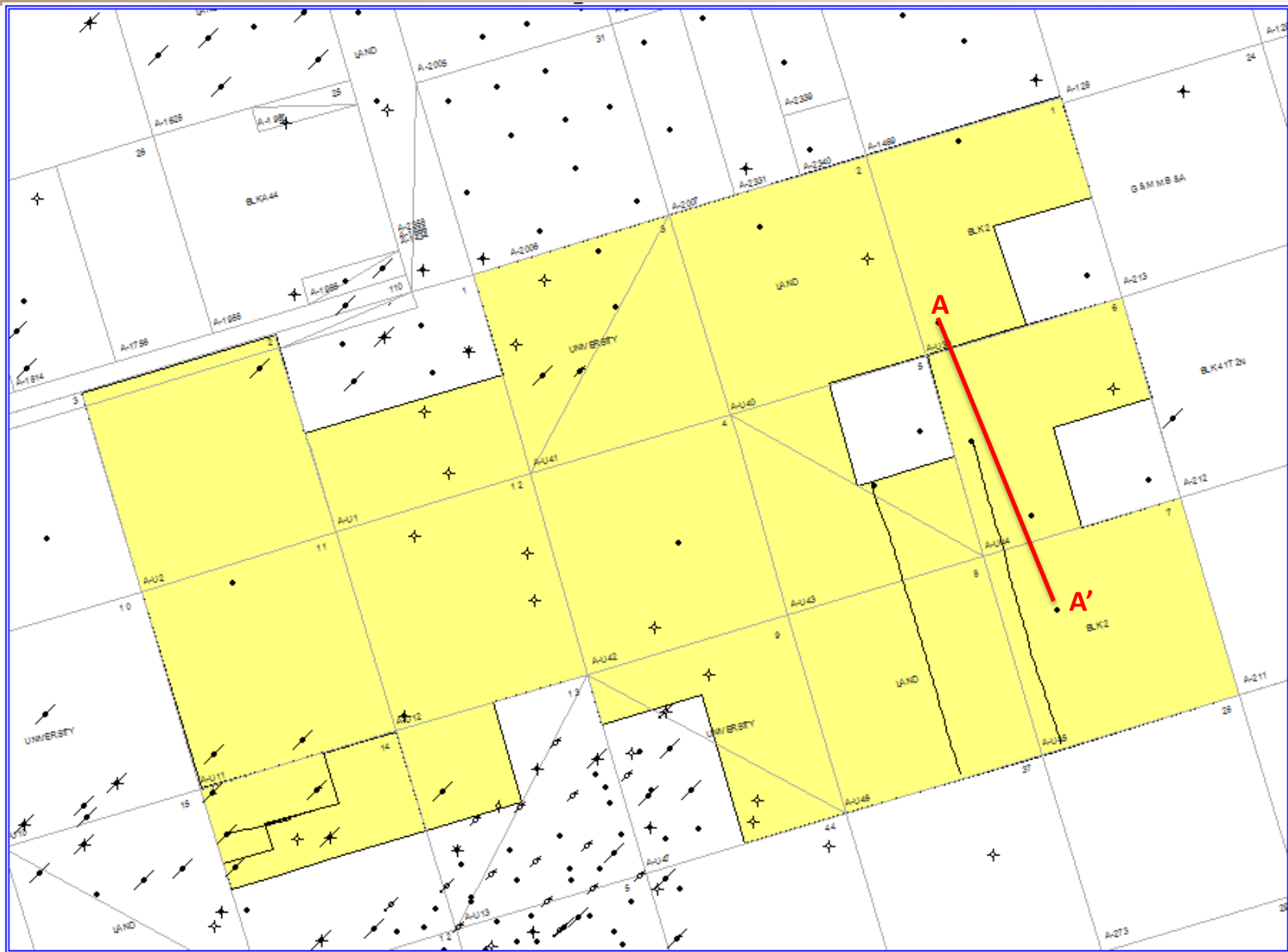


Source: Pollock, 2012 AAPG SW Section, Modified from Ruppel, 2010 BEG

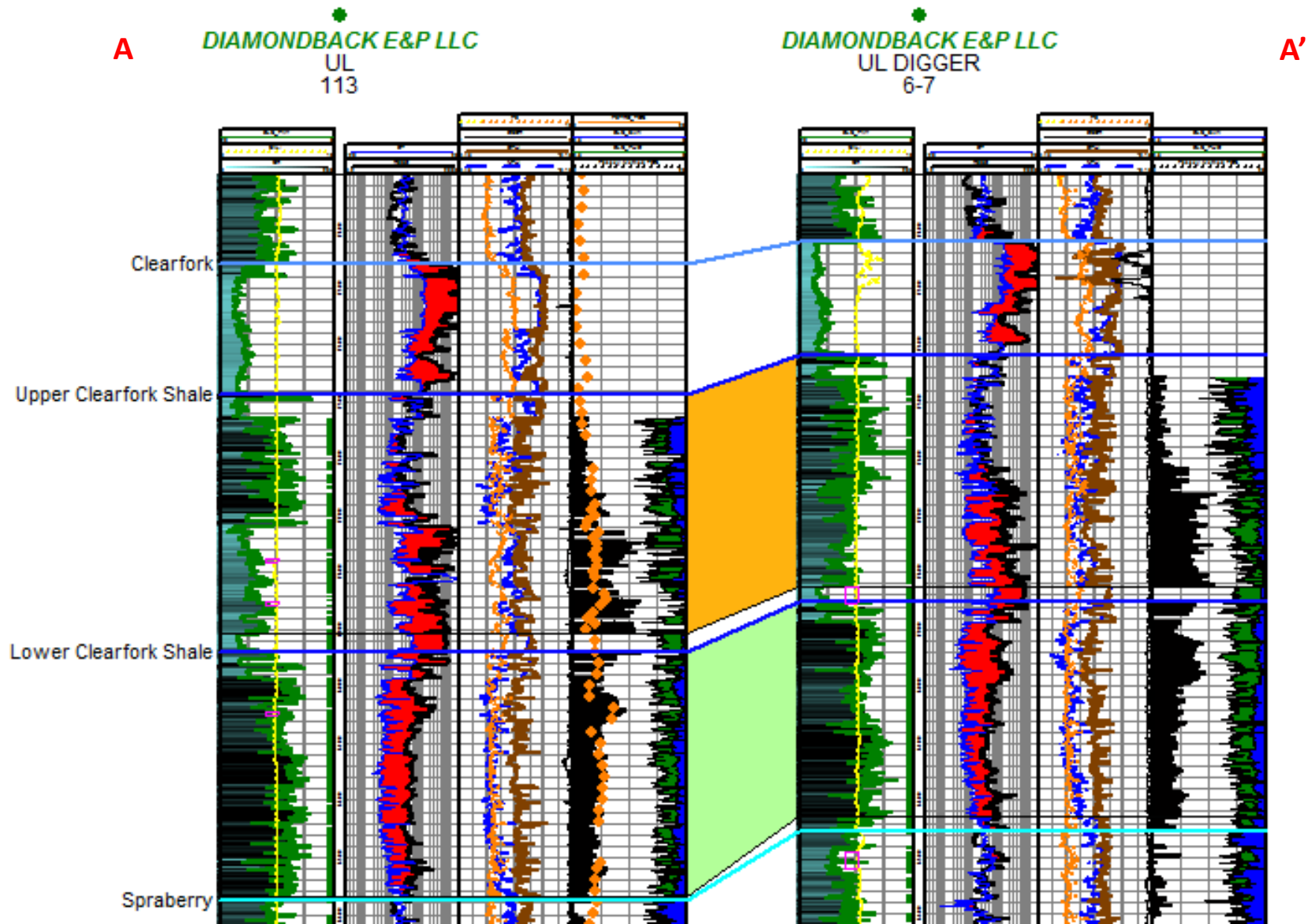
# Structure Contour – Top of Lower Clearfork Shale



# University Lands Beekeeper Unit "Digger" Area



# Clearfork Structural Cross-Section with Petrophysical Analysis

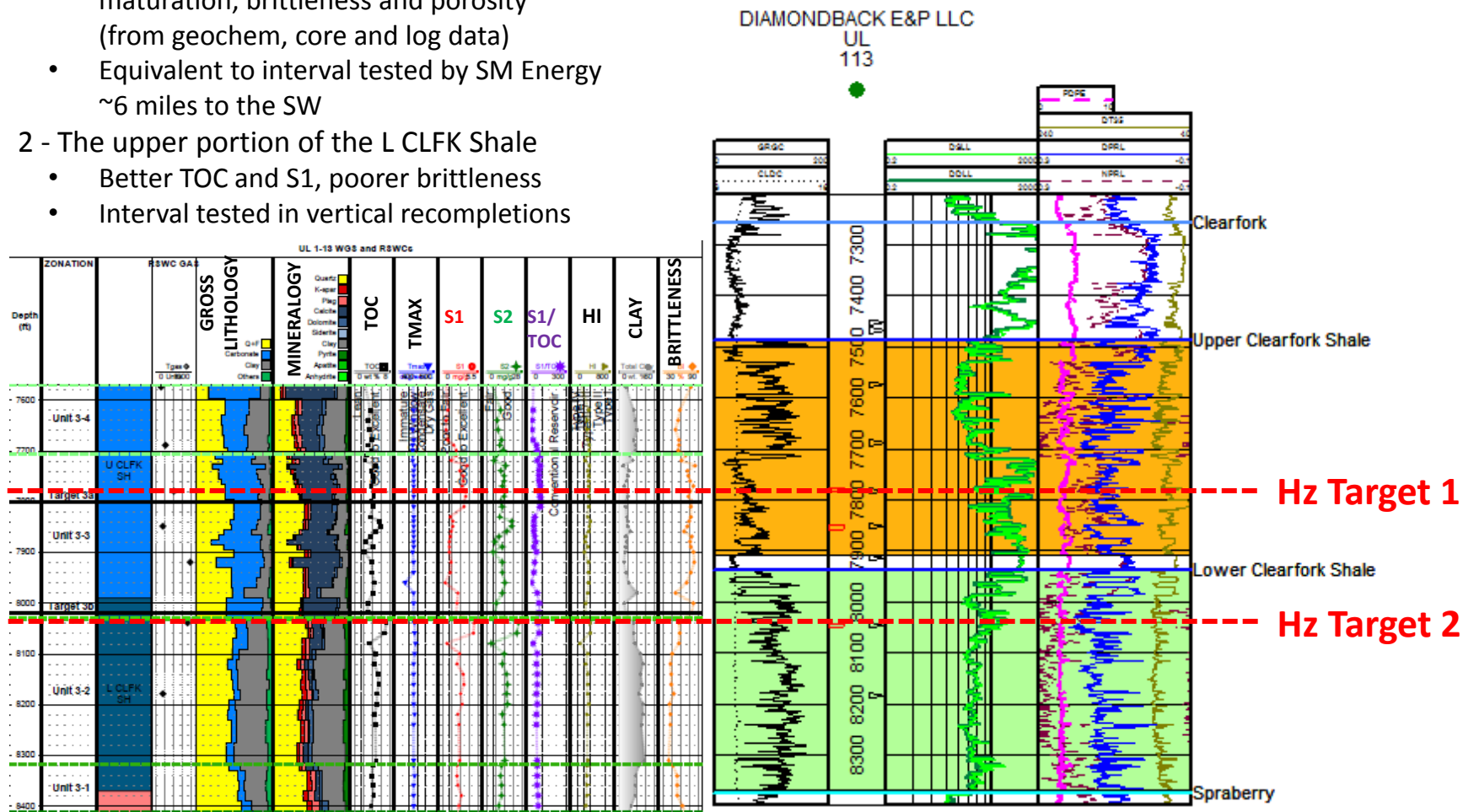




# Geochemical Data Confirms Clearfork Hz Potential at UL Digger Unit

## Two horizontal CLFK targets were delineated:

- 1 - The lower portion of the U CLFK Shale
  - This interval exhibits excellent source quality, maturation, brittleness and porosity (from geochem, core and log data)
  - Equivalent to interval tested by SM Energy ~6 miles to the SW
- 2 - The upper portion of the L CLFK Shale
  - Better TOC and S1, poorer brittleness
  - Interval tested in vertical recompletions



# Triaxial Compressive Tests and Acoustic Velocities for UL 113

Diamondback E&P LLC  
UL No. 113

Andrews County, TX

Sample 6 is lower portion of U CLFK shale; sample 8 is upper portion of L CLFK shale; sample 18 is upper WC B

Sample No.	Depth (ft)	Confining Pressure (psi)	Bulk Density (g/cc)	Ultrasonic Wave Velocity				Dynamic Elastic Parameter			
				Compressional		Shear		Young's Modulus (x10 <sup>6</sup> psi)	Poisson's Ratio	Bulk Modulus (x10 <sup>6</sup> psi)	Shear Modulus (x10 <sup>6</sup> psi)
				ft/sec	μsec/ft	ft/sec	μsec/ft				
6	7853.00	2500	2.42	16163	61.87	9531	104.92	7.31	0.23	4.57	2.96
8	8047.00	2500	2.33	14428	69.31	8879	112.63	5.92	0.20	3.24	2.48
18	9734.00	3100	2.53	16624	60.15	10754	92.99	8.97	0.14	4.16	3.93

Diamondback E&P LLC  
UL No. 113

Andrews County, TX

Sample No.	Depth (ft)	Confining Pressure (psi)	Compressive Strength (psi)	Static Young's Modulus (x10 <sup>6</sup> psi)	Static Poisson's Ratio
6	7853.00	2500	41558	4.48	0.19
8	8047.00	2500	24812	3.04	0.18
18	9734.00	3100	36920	5.07	0.19

*Although the sample from the lower CLFK Shale target interval (#8) is less brittle than the upper CLFK Shale target interval (#6), it still appears to have sufficient brittleness to be a good candidate for frac stimulation*

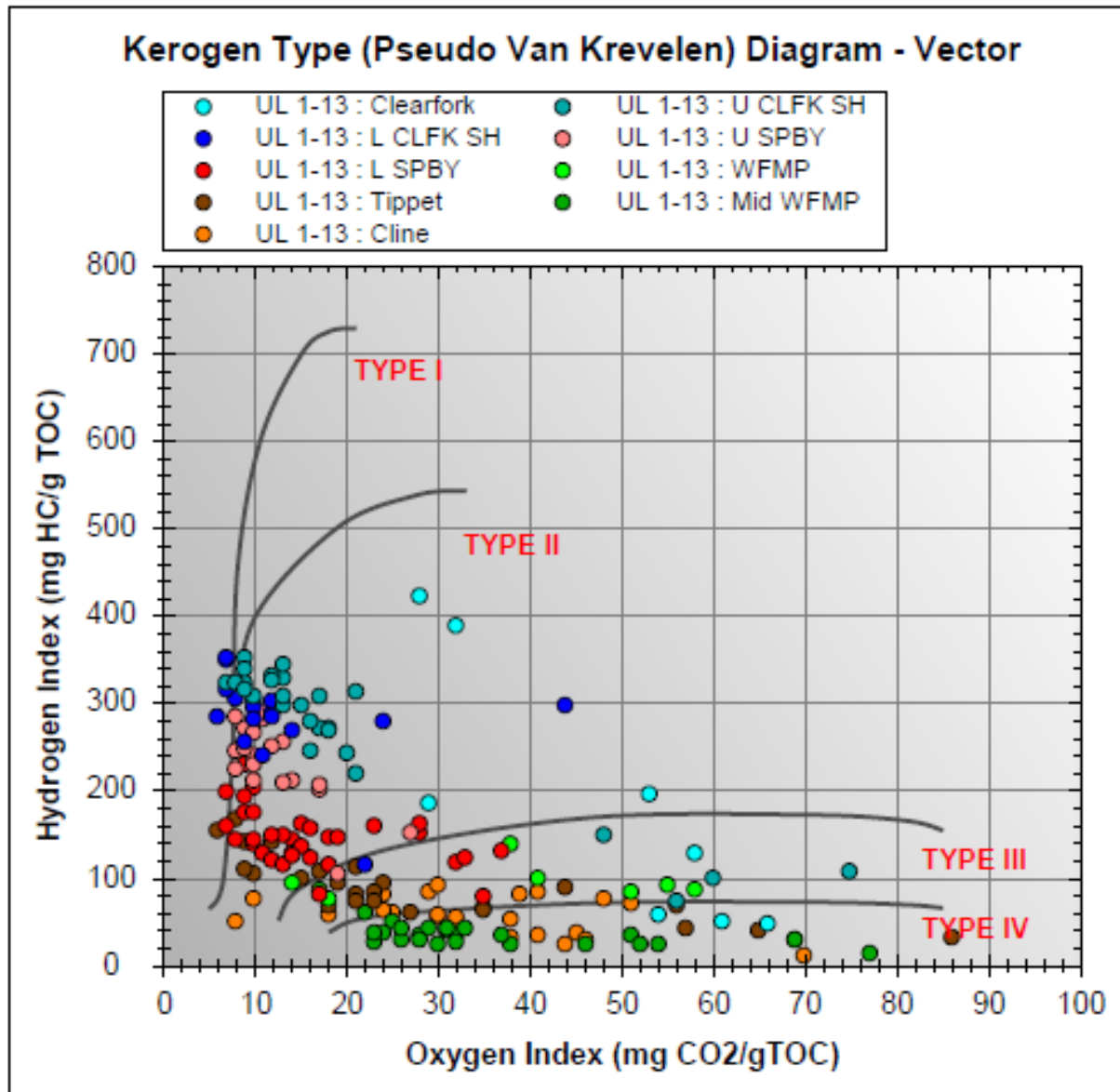
# Rock Eval and TOC for Two Clearfork Target Intervals

Depth (m) Top	Formation	Sample Type	Sample Prep	*	Leco TOC	RE			Tmax (°C)	**	Ro, %	HI	OI	S2/S3	S1/TOC *100	PI
						S1	S2	S3								
7853	U CLFK	Plug	NOPR		4.01	4.93	20.15	1.73	441			503	43	11.6	123	0.20
8047	L CLFK	Plug	NOPR		6.12	7.87	30.33	1.63	440			495	27	18.6	129	0.21

*Upper Clearfork target has good TOC and S1;  
Lower Clearfork target is even better.*

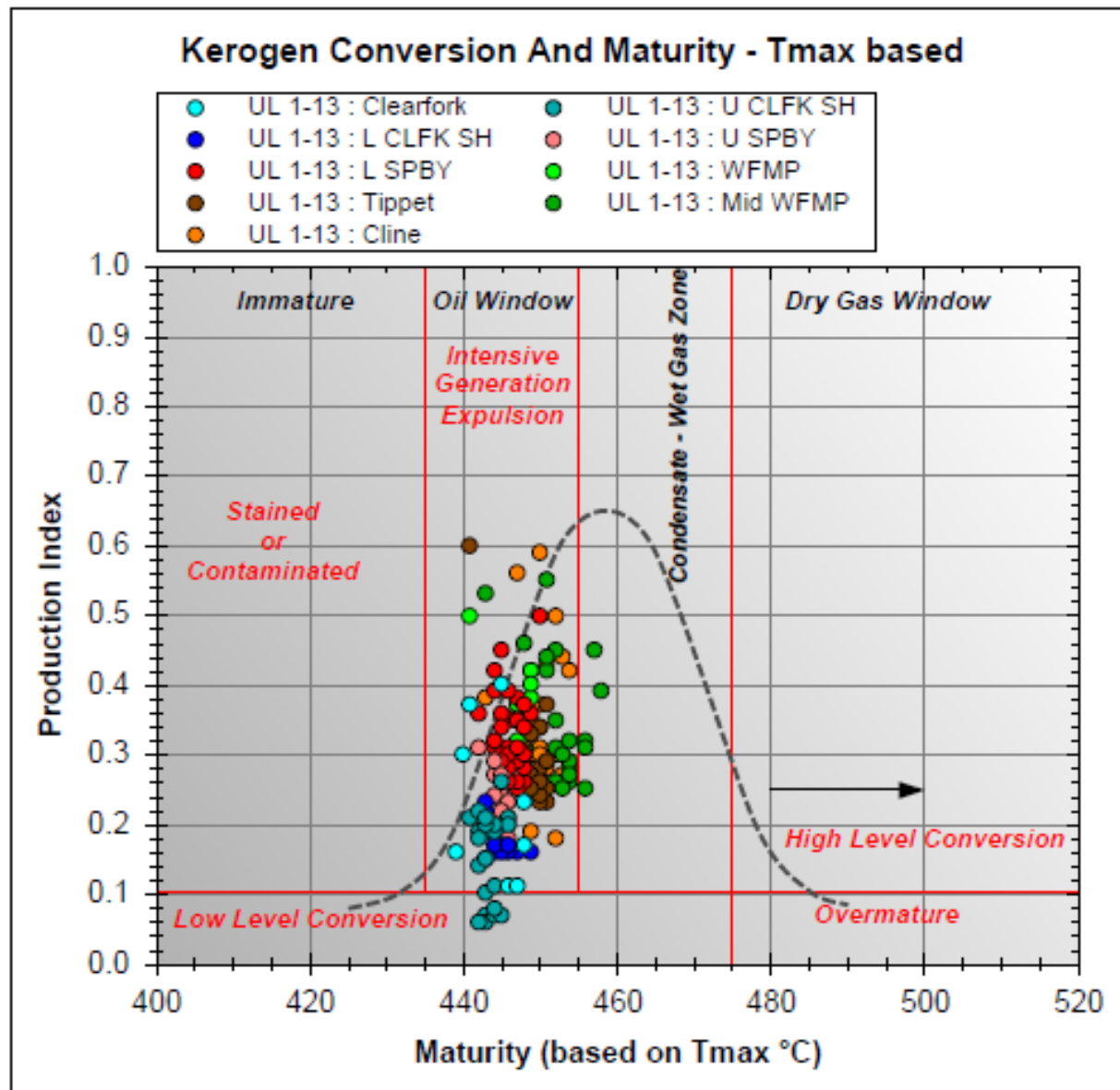
*Brittleness is the only characteristic that is poorer in  
Lower Clearfork target than Upper Clearfork target.*

# Cuttings Geochem Diagrams



Weatherford Laboratories

# Cuttings Geochem Diagrams (continued)



# SM Energy Had Been Testing Correlative Interval Nearby

SM UL '3' Callaway 2H Location

SM UL 7 Berkley 4H (aka 10H):  
IP 46 bopd, 106 mcfgd, 1,001 bwpd

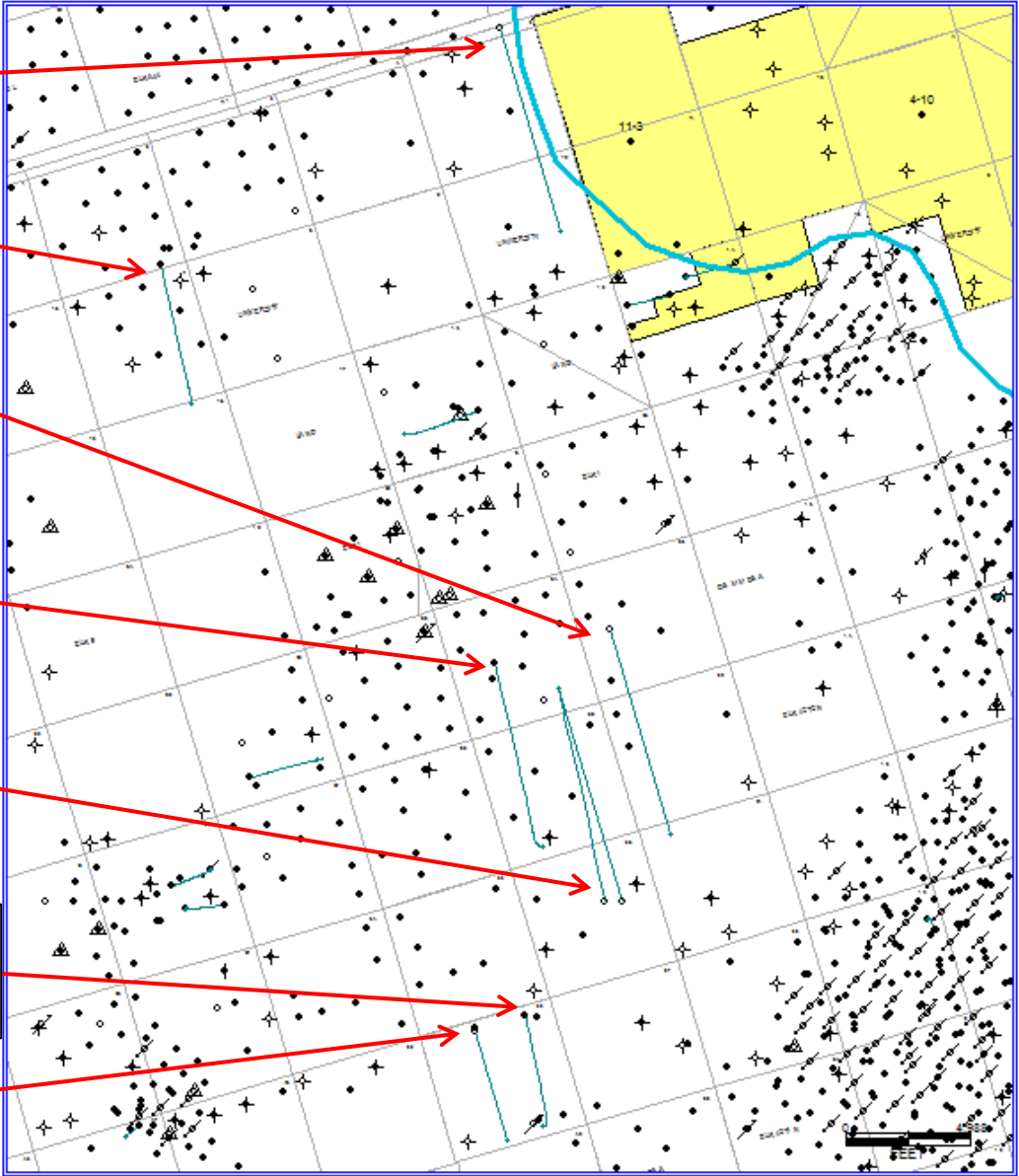
SM UL 30 Cobra 5H: Frac'd 4/11/13

SM UL '29' Sawgrass 5H: IP 136  
bopd, 238 mcfgd, 702 bwpd; 1st mo  
avg. 345 boepd

SM UL '29' Sawgrass 2H: 1st prod 2/13

SM UL '36' Pinnacle 2H: IP 192 bopd, 330  
mcfgd, 340 bwpd; 1st mo avg. 288 boepd

SM UL '36' Pinnacle 4H Location

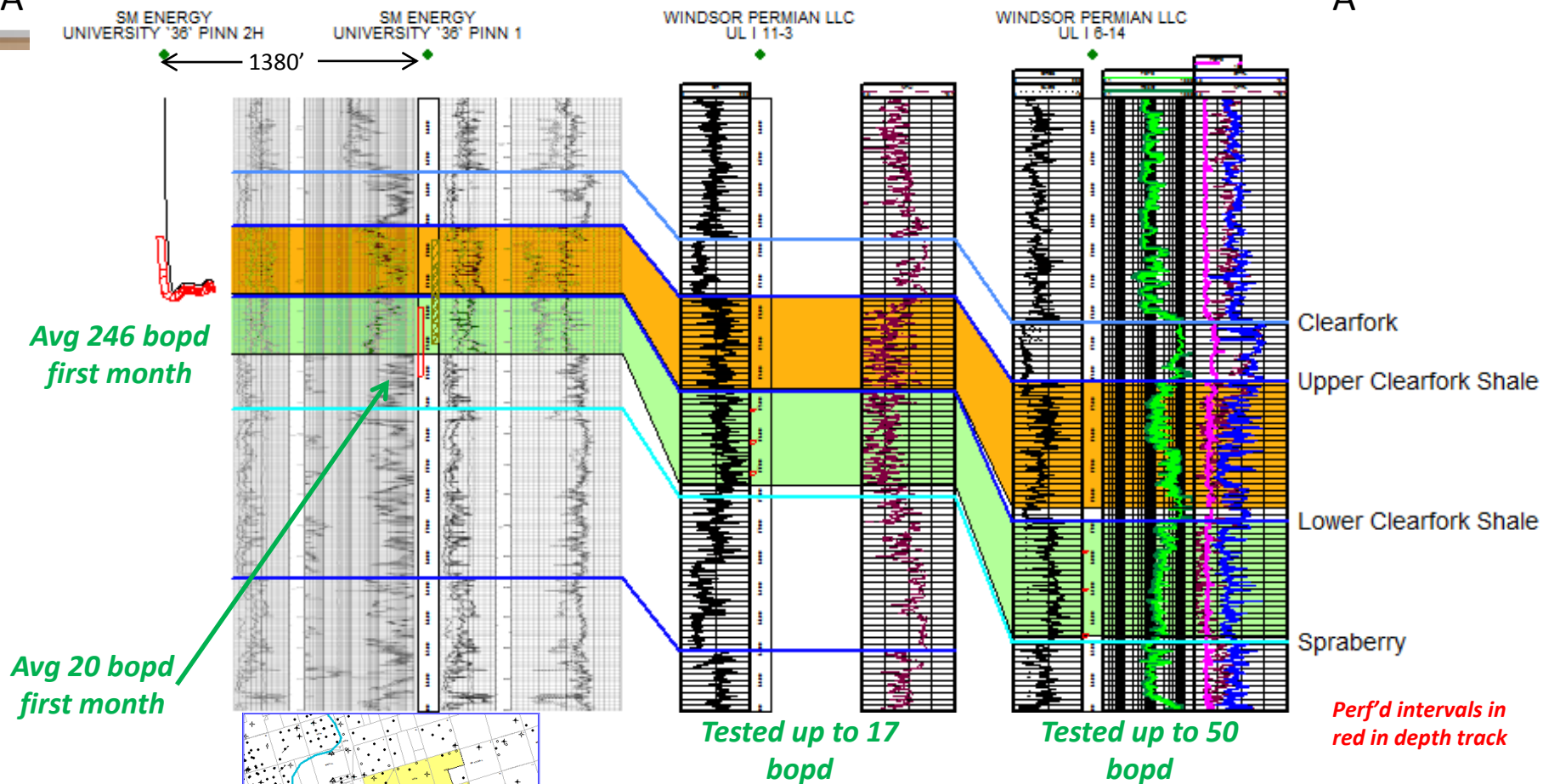




# Clearfork Tests/Activity Near Digger Unit

A

A'



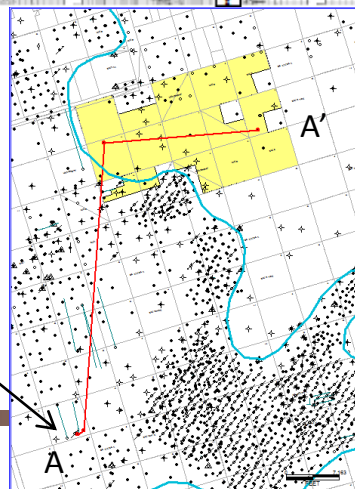
*Avg 20 bopd first month*

*Tested up to 17 bopd*

*Tested up to 50 bopd*

*Perf'd intervals in red in depth track*

SM Hz Clearfork

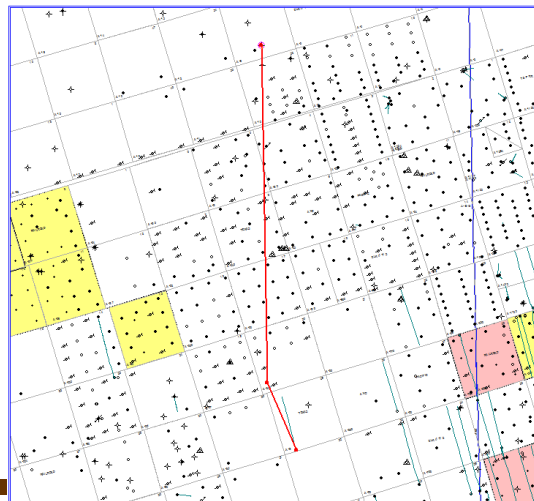
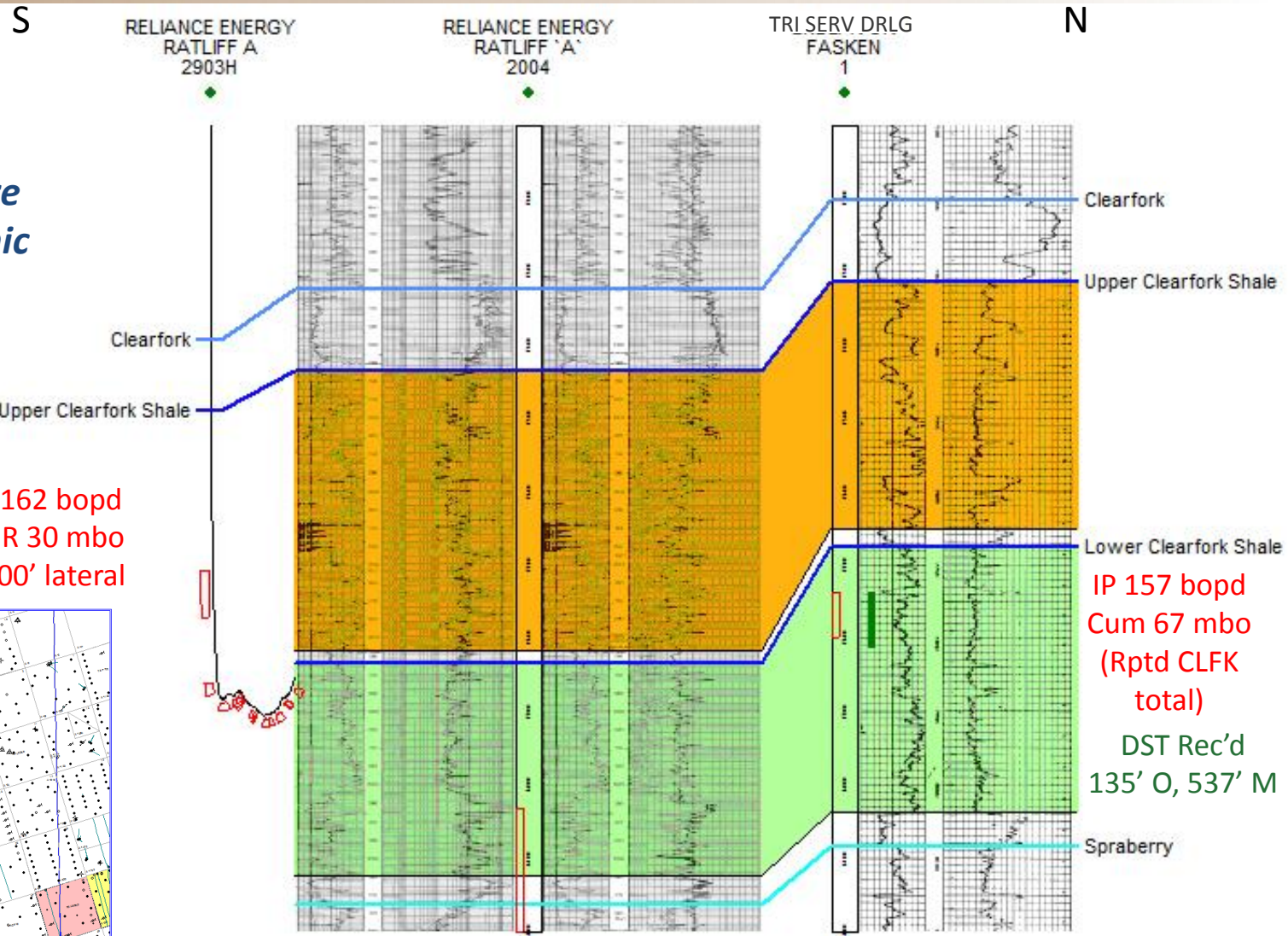


SM Energy cored and tested the Clearfork Shale in a vertical well. In April 2012, they drilled a hz Clearfork well (4,160' lateral length) that produced 7,629 bo and 7,730 mcfg the first month (avg rate 288 boepd).

# Lower Clearfork Zone Had Been Tested 19 Miles to the South

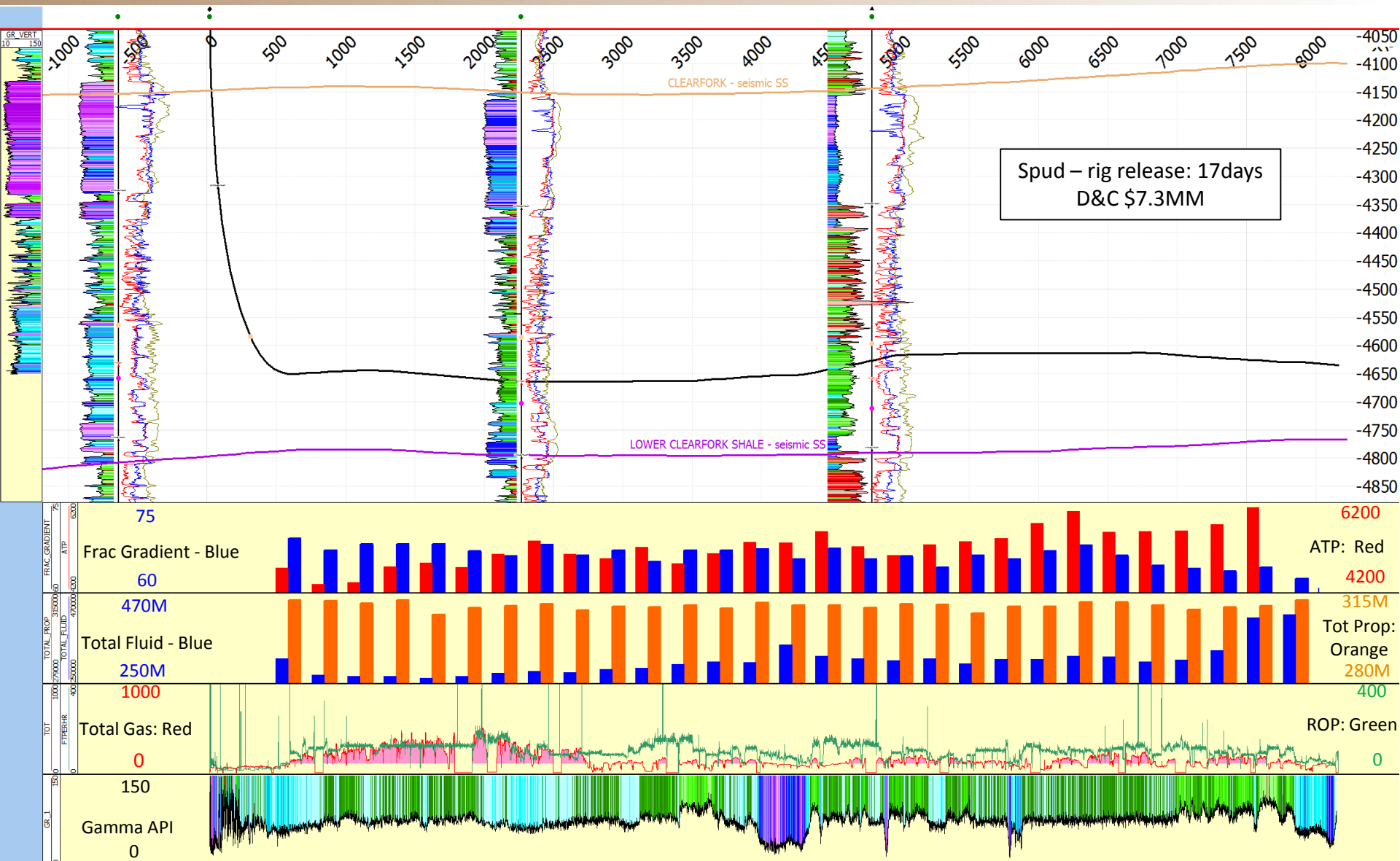
*Results were sub-economic*

IP 162 bopd  
EUR 30 mbo  
4400' lateral

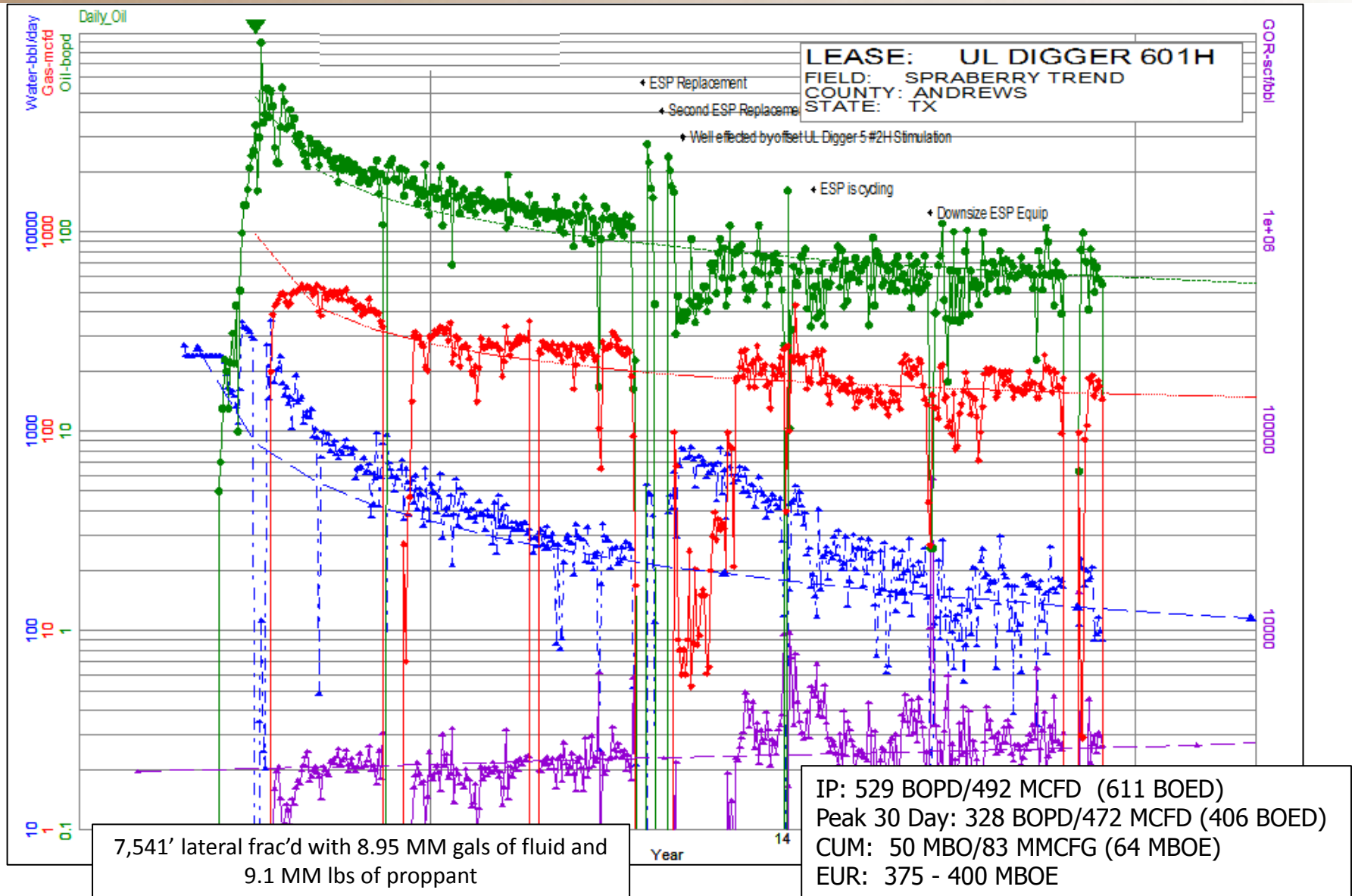




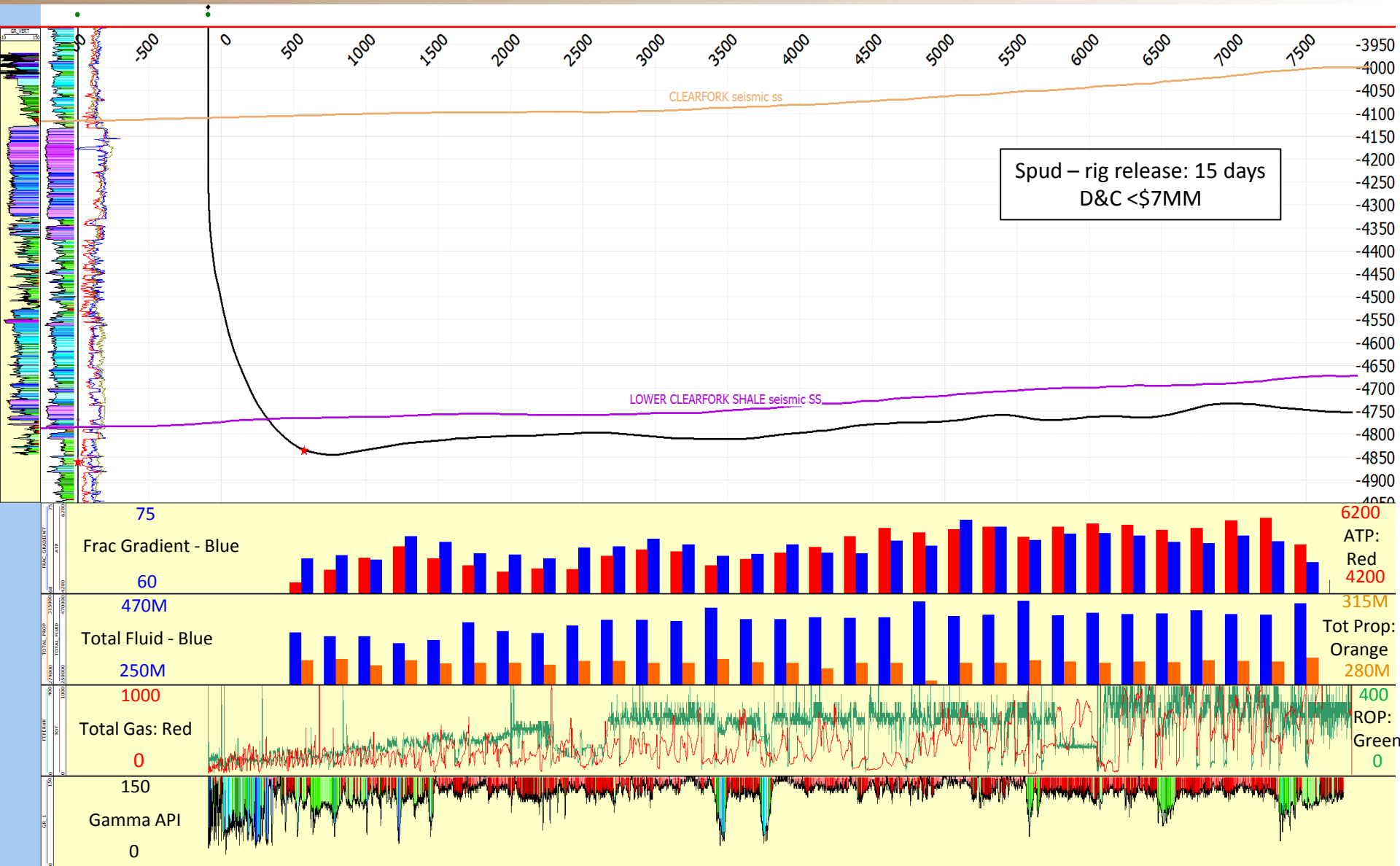
# UL Digger 601H: Initial Clearfork Shale Test (Upper Shale)



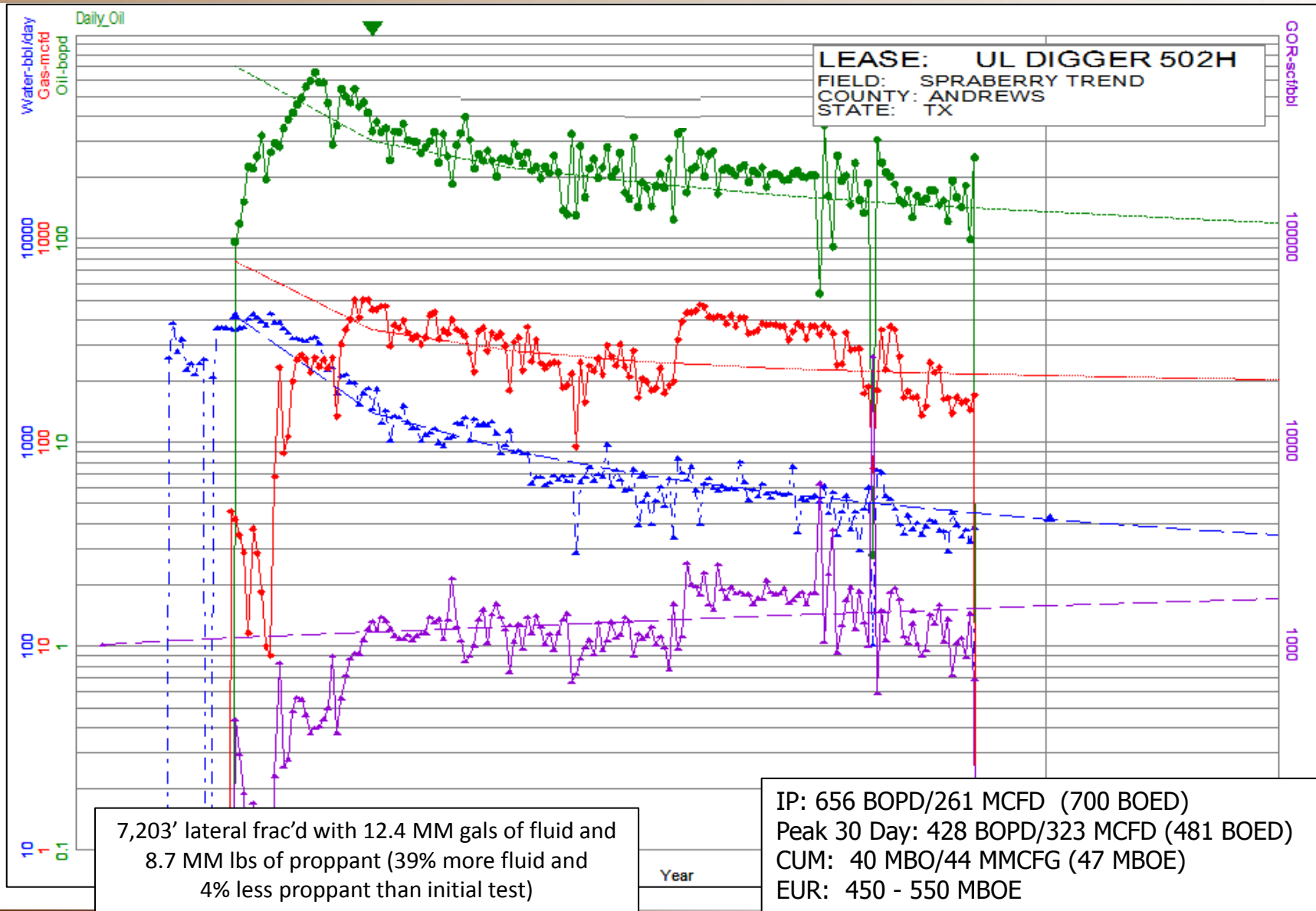
# Initial Clearfork Shale Horizontal Test (Upper Shale)



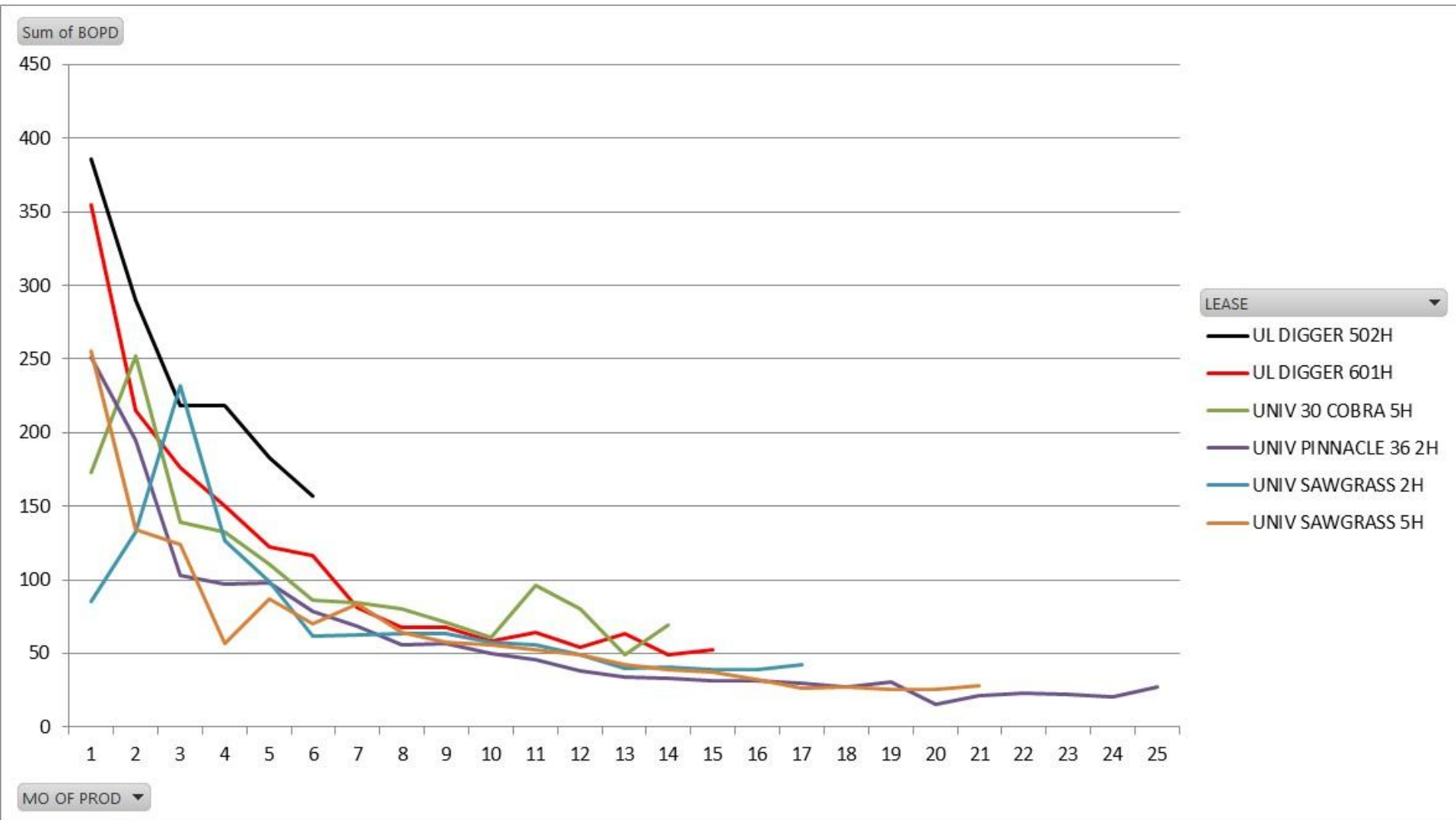
# UL Digger 502H: Second Clearfork Shale Test (Lower Shale)



# Second Clearfork Shale Horizontal Test (Lower Shale)



# Digger and Nearby Clearfork Horizontal Well Production



# Conclusions

- There are multiple prospective horizontal shale targets in the Permian Basin, even beyond the traditional “Wolfberry” zones (some may be crude price-sensitive inventory).
- Identify potential candidates:
  - Seek combination of good TOC, maturation, porosity/permeability, brittleness and adequate thickness
  - Look for productive analogs
  - If possible, test in vertical wellbore(s)
- Cuttings geochem is a fast, cost-effective supplement to whole core analysis; onsite analysis can be used in real time in conjunction with openhole wireline logs to select rotary sidewall core points.
- The Permian Basin is a world-class basin with numerous unconventional shale targets within the mature oil window. There’s no better place to hold acreage...

# Acknowledgements

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Dave Cannon, Scott Cross, Tom Daneker,  
Russell Pantermuehl, Greg Fitzgerald, Kyle Lutkewitte,  
Weatherford Laboratories