

# **Granite Wash Play Overview, Anadarko Basin Stratigraphic Framework and Controls on Pennsylvanian Granite Wash Production, Anadarko Basin, Texas and Oklahoma: Update\***

**Ed LoCricchio<sup>1</sup>**

Search and Discovery Article #80420 (2014)

Posted November 24, 2014

\*Adapted from oral presentation given at Granite Wash and Pennsylvanian Sand Forum, Oklahoma City, Oklahoma, September 25, 2014. **Presentation is update of [Search and Discovery Article #110163 \(2012\)](#).**

\*\*Datapages © 2014 Serial rights given by author. For all other rights contact author directly.

<sup>1</sup>Atlas Exploration, LLC ([elocricchio@comcast.net](mailto:elocricchio@comcast.net))

## **Introduction**

- Granite Wash play extends over 130 miles across 7 counties in the Anadarko Basin covering 2.5 million acres.
- Multi-stacked resource play concentrates value with potential of 40 Hz wells/section in Granite Wash.
- Almost no federal leases.
- Established infrastructure.
- Landowners and state governments are industry friendly.
- Completed wells cost range \$6-9MM.
- IP Range 50-3,500 BO and 3,000-30,000 MCFGPD.
- EUR Range 3-17 BCFE.
- Total Recoverable resources potential of 500 TCFE, (114 BBOE including NGL's).

## **Anadarko Basin**

### **Asymmetrical Basin**

- >35,000' Cambrian – Permian Sediments.
- Burial history suggests greatest subsidence in Lower Pennsylvanian.
- Thermal history indicates pre-GRWS source rocks entered oil generation window in Early Pennsylvanian, dry gas phase by Early Permian.

## **Stratigraphic Column**

### **Key Points**

- The Granite Wash and associated plays are among the most attractive domestic opportunities due to liquids-rich production, stacked pay zones, and high rates of return.
- Horizontal drilling technology, combined with advancements in multi-stage fracture stimulation, has caused a massive expansion of the resource potential with numerous attractively stacked development opportunities.
- Granite Wash is not one or two reservoirs, rather there are at least fifteen reservoirs, including at least eleven Desmoinesian reservoirs.

### **Challenges**

- Limited published studies
- Subsurface study only, no outcrops
- Over 30,000 wells to correlate; blessing and a curse.
- Eight years ago when we started this work there were few digital logs available
- Petrophysical challenges
  - Radioactive minerals
  - Variable clay content
  - Low porosity and permeability
  - Overbalanced drilling masked Granite Wash pay
  - No established stratigraphic framework
  - Nomenclature issues are a major hurdle to overcome

## **Mapping Strategy**

- Granite Wash divided into 11 zones (does not include Atoka Wash)
  - Correlate significant flooding surfaces across area of interest .
  - Create structure maps for each surface and project those surfaces into all wells.
  - Define zones based on projected surfaces to eliminate nomenclature issues and to be able to extract meaningful test, perf, and production data
- Net sand maps for each individual zone
  - Only wells penetrating that zone
  - Highlight wells with perfs in that zone
  - Highlight HZ wells in zone
- Eleven Stacked Horizons
  - All GRWS zones proven productive by 100's to 1000's of vertical wells, and over 1500 Hz wells
  - Most Hz wells target the upper zones
    - Shallower drilling
    - More liquid rich in central portion of the play

## **Opportunity Overview**

- One of the Most Attractive North American Resource Plays
- Basin activity supported by superior economics and longevity of the play
- Evolving resource play; several zones in early stages of technological development
- Returns competitive with the best basins in the U.S.

## **Conclusion**

- Desmoinesian Granite Wash Play in the Anadarko Basin is one of the most active plays in the Continental United States.
- Clastics shed from the Wichita Mountain-Amarillo Uplift were deposited in the Anadarko Basin by sediment gravity flows creating a massive submarine sand complex.
- Anomalously pressured hydrocarbon system, both under- and over pressured.

- Produces both oil and gas, ratios vary laterally and vertically.
- Minimum of fifteen separate reservoirs.
- Advent of horizontal drilling technology and isolated multi-stage fracture stimulation has revolutionized play.
- New technology has enabled development of a giant field within a mature basin. As mapped today this field will take decades to develop, with new isolated reservoirs still being discovered.



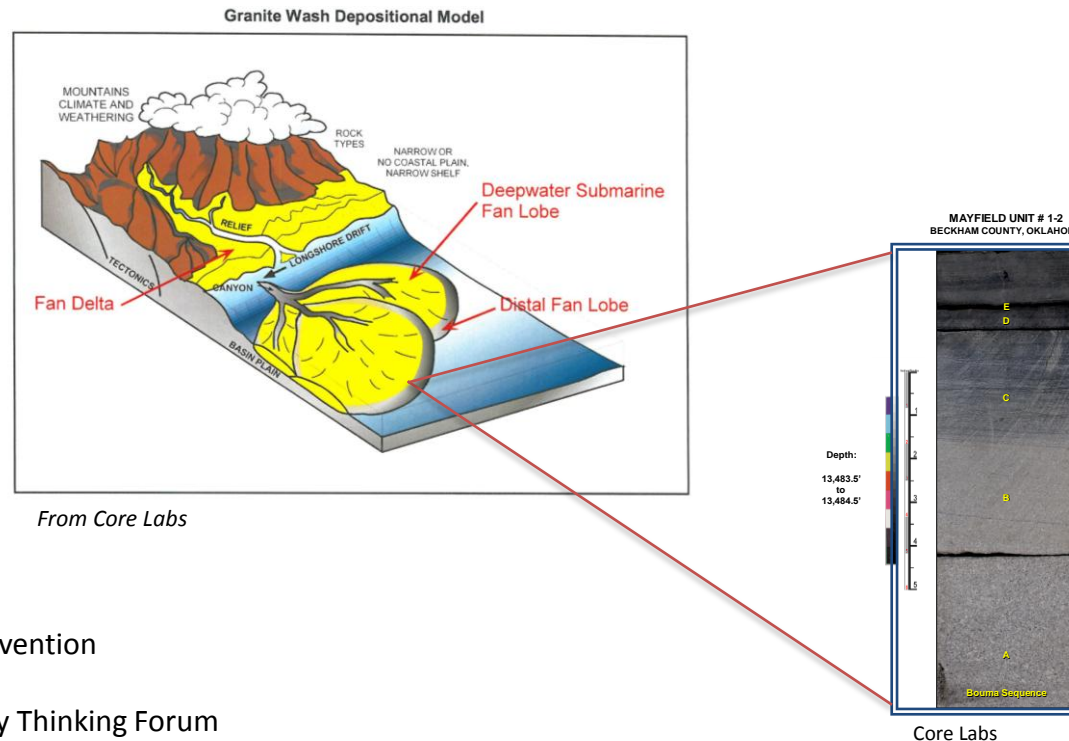
# ***Granite Wash Play Overview, Anadarko Basin***

## ***Stratigraphic Framework and Controls on Pennsylvanian Granite Wash Production, Anadarko Basin, Texas and Oklahoma***

Ed LoCricchio, Atlas Exploration, LLC

2014 AAPG Forum, Oklahoma City, Oklahoma

September 25, 2014



Original Presentation:

AAPG 2012 Annual Convention

Long Beach, California

April 23, 2012 Discovery Thinking Forum

# Acknowledgements

- **FourPoint Energy, LLC**  
**Thom Page**
- **Cordillera Energy Partners, LLC**  
**Barry C. McBride**  
**Andrew Heger**
- **Core Labs**
- **Grace Ford, Steve Cumella, Ed Dolly,  
Mike Gardner and the DBLS, Colorado  
School of Mines**



# Introduction

---

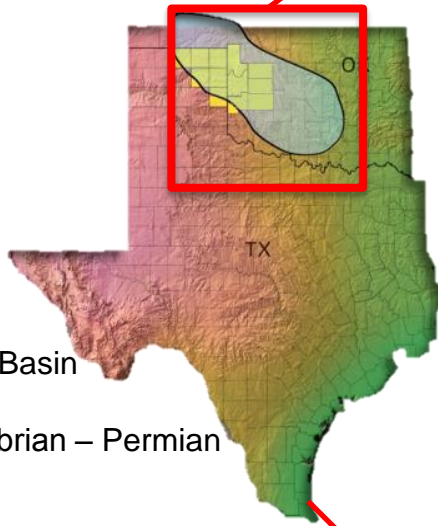
- Granite Wash play extends over 130 miles across 7 counties in the Anadarko Basin covering 2.5 million acres
- Multi-stacked resource play concentrates value with potential of 40 Hz wells/section in Granite Wash
- Almost no federal leases
- Established infrastructure
- Landowners and state governments are industry friendly
- Completed wells cost range \$6-9MM
- IP Range 50-3,500 BO and 3,000-30,000 MCFGPD
- EUR Range 3-17 BCFE
- Total Recoverable resources potential of 500 TCFE, (114 BBOE including NGL's)

# Discussion Outline

---

- **Location Map and Stratigraphic Column**
- **Play extents and expansion through time**
- **Depositional model and hydrocarbon system**
- **Challenges and hurdles to Granite Wash study**
- **Nomenclature issues and type log**
- **Regional cross-sections**
- **Net sand isopachs**
- **Conclusion**

# Anadarko Basin

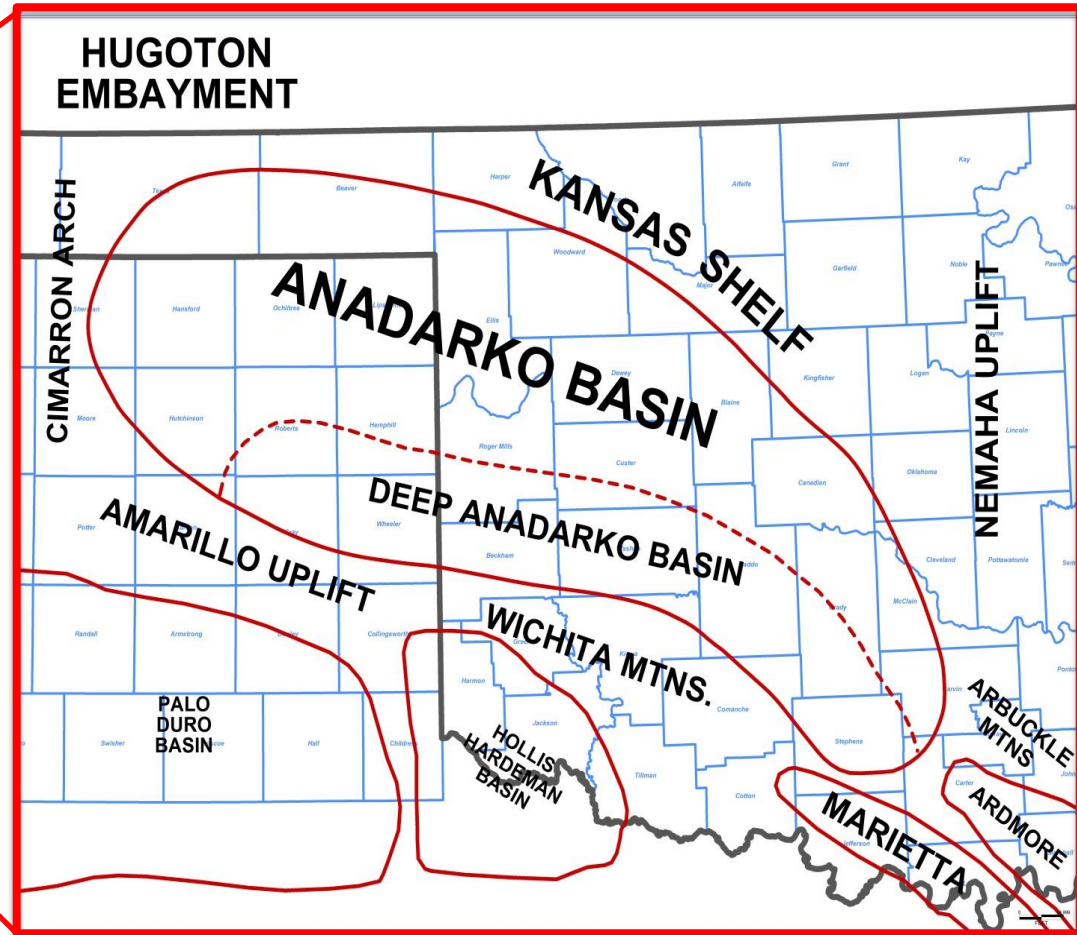


- Asymmetrical Basin

- >35,000' Cambrian – Permian Sediments

- Burial history suggests greatest subsidence in Lower Pennsylvanian

- Thermal history indicates pre-GRWS source rocks entered oil generation window in the Lower Pennsylvanian, dry gas phase by Lower Permian

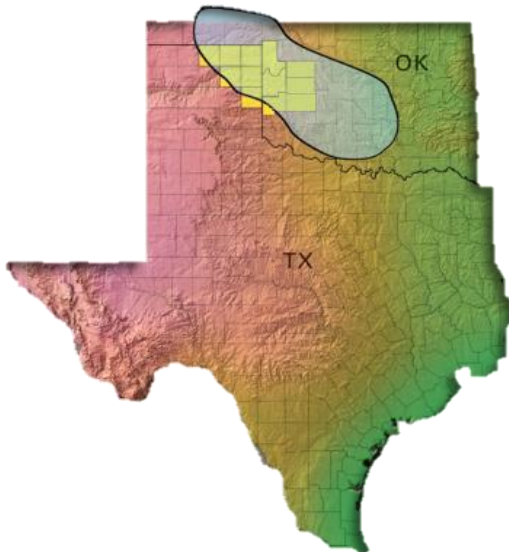


# Stratigraphic Column

## Key Points

- The Granite Wash and associated plays are among the most attractive domestic opportunities due to liquids-rich production, stacked pay zones and high rates of return
- Horizontal drilling technology, combined with advancements in multi-stage fracture stimulation, has caused a massive expansion of the resource potential with numerous attractive stacked development opportunities

## Map of Western Anadarko Basin



## Stacked Pay Zones

Anadarko Basin		
System	Series / Epoch	Generalized Stratigraphic Column
Lower Permian	Wolfcampian	Hugoton / Pontotoc (Brown Dolomite)
		Chase / Council Grove
		Admire
Pennsylvanian	Virgilian	Wabaunsee
		Shawnee
		Douglas
		Tonkawa
	Missourian	Cottage Grove
		Hoxbar / Hogshooter
		Checkerboard
		Cleveland
	Desmoinesian	Marmaton Group (Glover / Big Lime / Oswego)
		Cherokee (Skinner / Pink Lime / Red Fork)
	Atokan	Atoka Lime
	Morrowan	13 Finger Lime
		Morrow Shale / Dornick Hills Shale
Mississippian	Chesterian - Meramecian - Osagean - Kinderhookian	Springer
		Meramec Lime / St. Louis
		Osage Lime / Osage Chert
		Kinderhook / Sycamore Lime
Devonian	Upper Devonian	Woodford
		Hunton

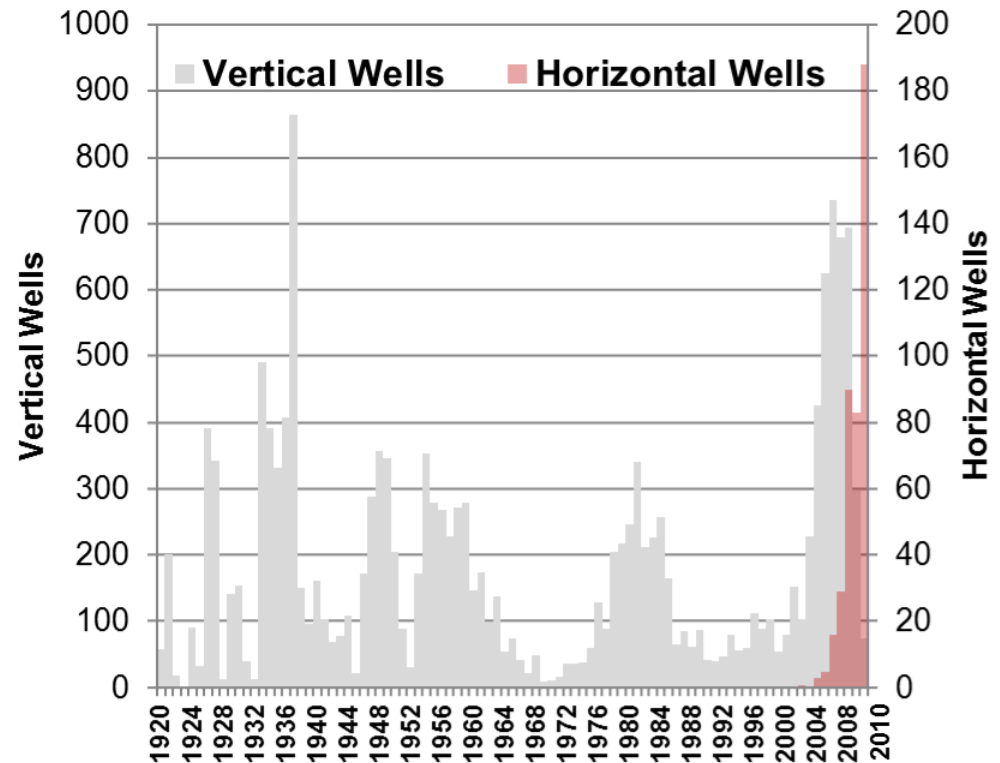
Note: Granite Wash spans from the Lower Permian to the Pennsylvanian in age. Areas marked with an oil, gas or liquids symbol represent zones present in the Western Anadarko Basin.

- Oil
- ⚡ Gas
- ⚡ Liquids

# Anadarko Basin Goes Horizontal

- First GRWS well 1920
- # Verticals 16,307
- First GRWS HZ 2002
- HZ Development Explodes in 2008
- # of HZ Completions 1586
- # Active GRWS HZ Rigs 33

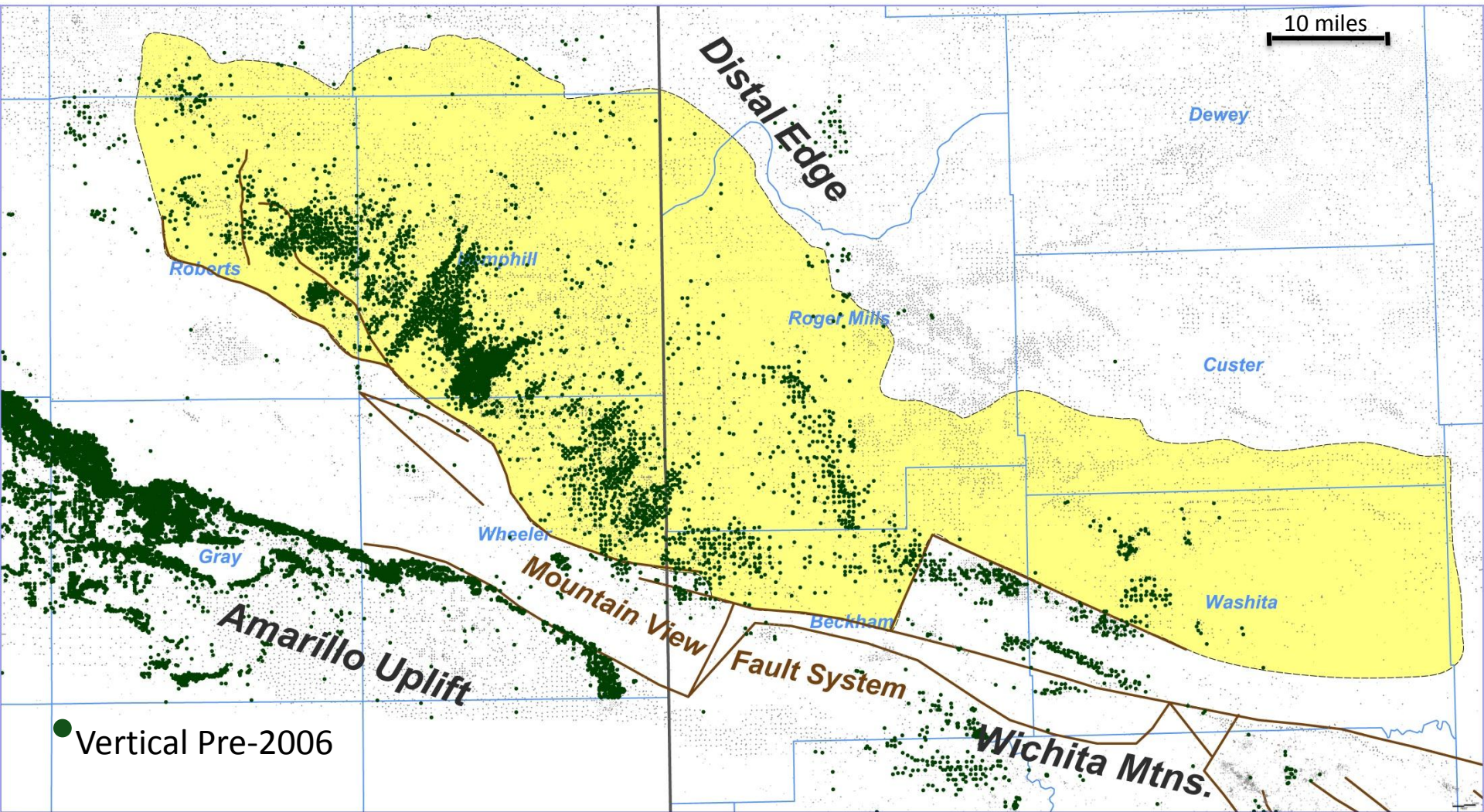
## Granite Wash Wells Completed



Source: IHS, Inc.

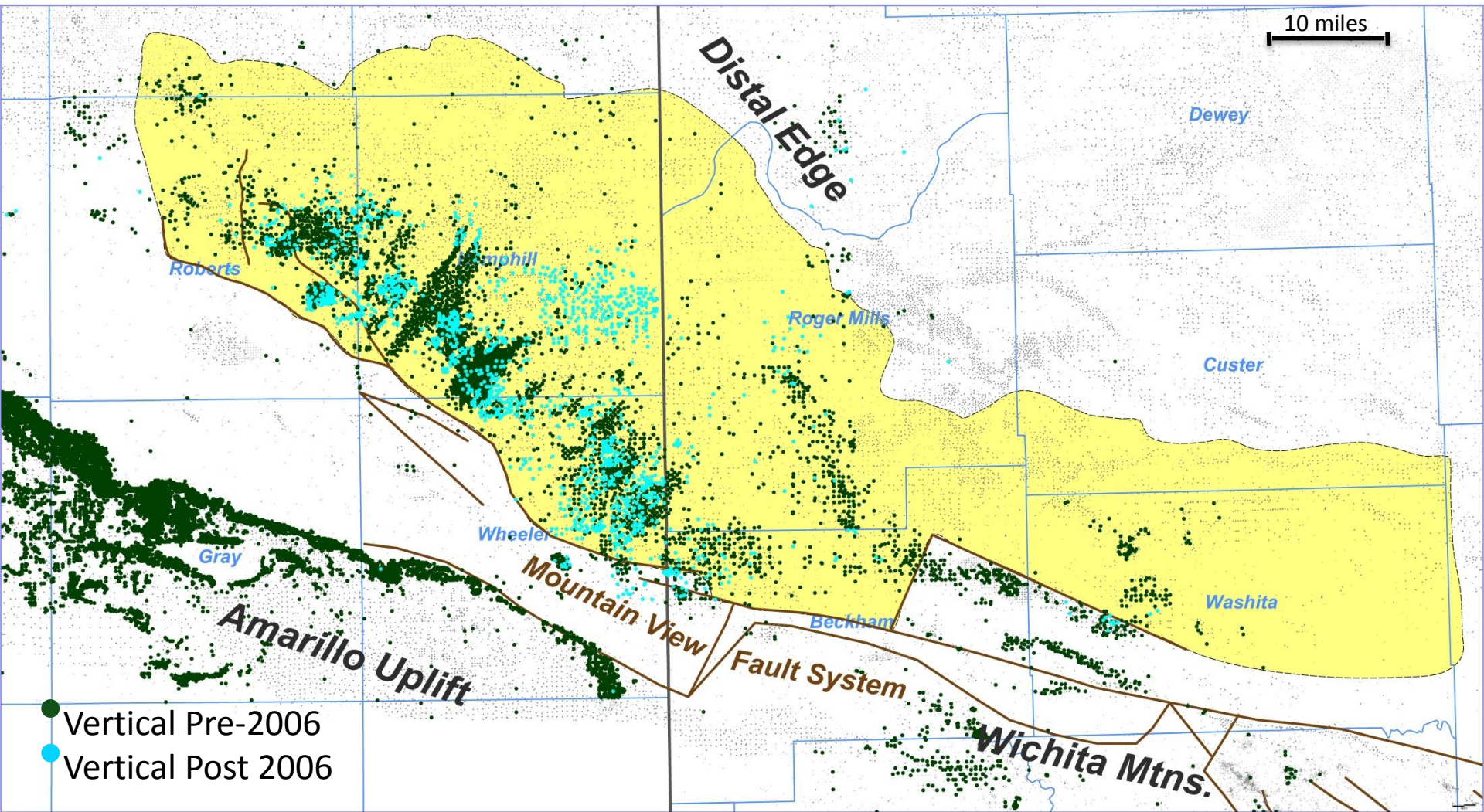


# Granite Wash Vertical Completions – Pre 1/1/2006



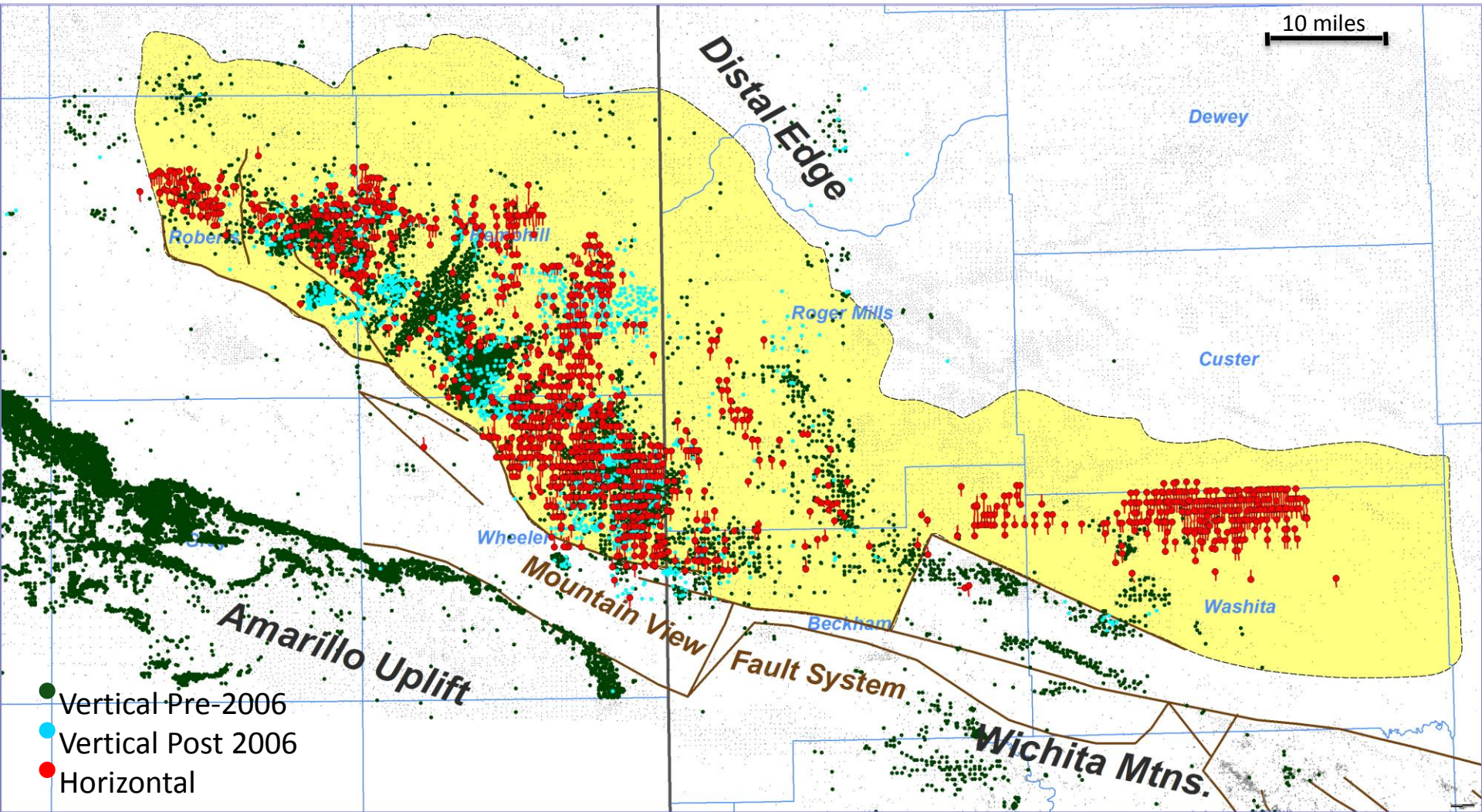


# Granite Wash Vertical Completions – Post 1/1/2006



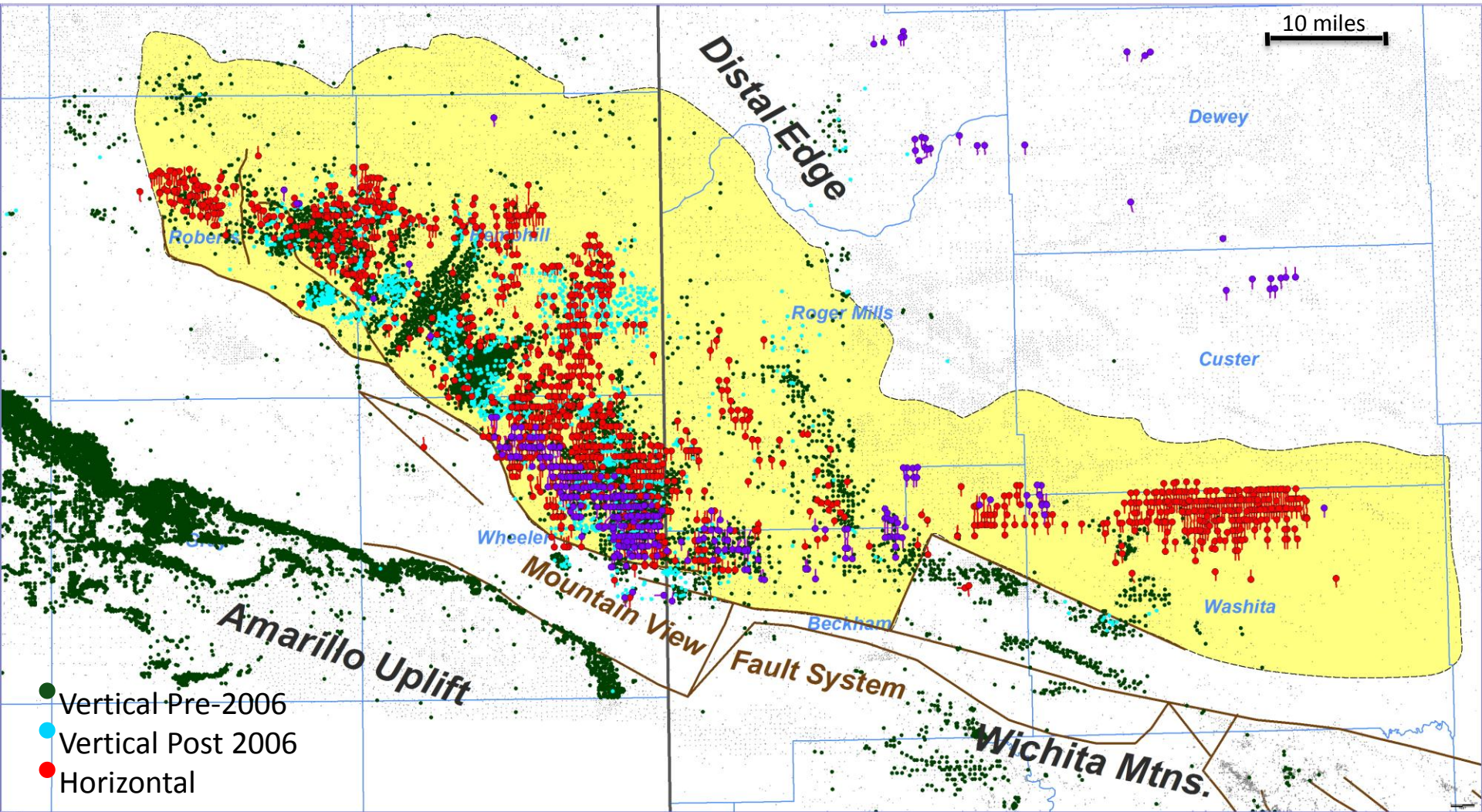


# Granite Wash Vertical & Horizontal Completions

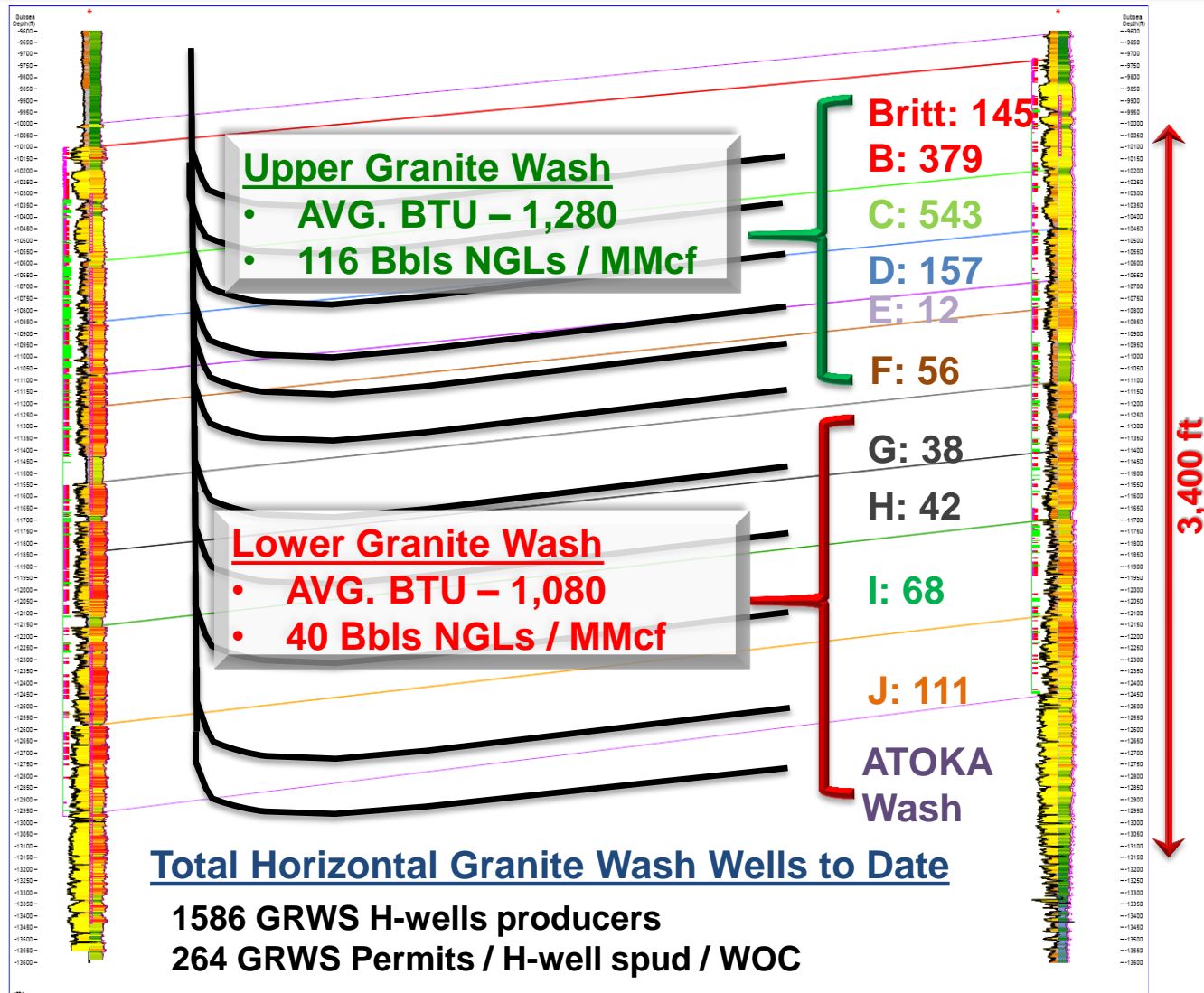




# Granite Wash Vertical & Horizontal Completions

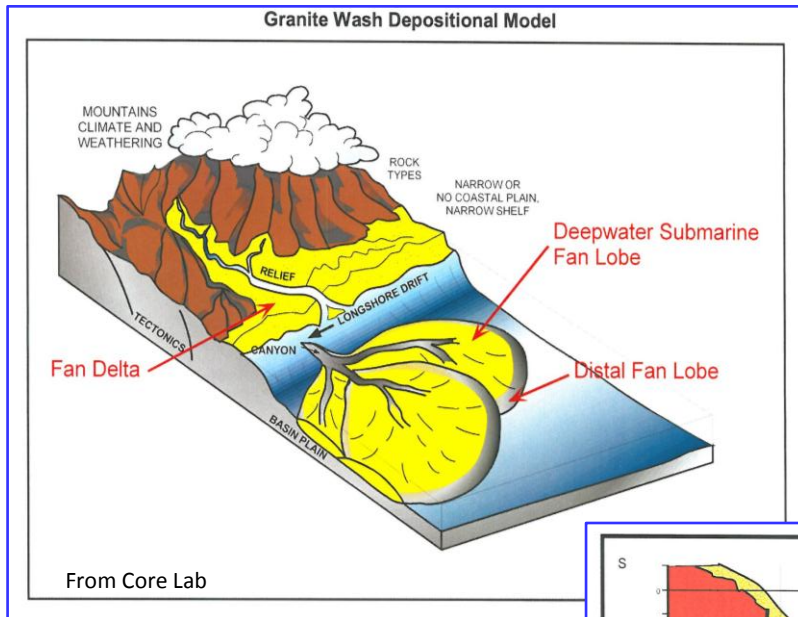


# Eleven Stacked Horizons



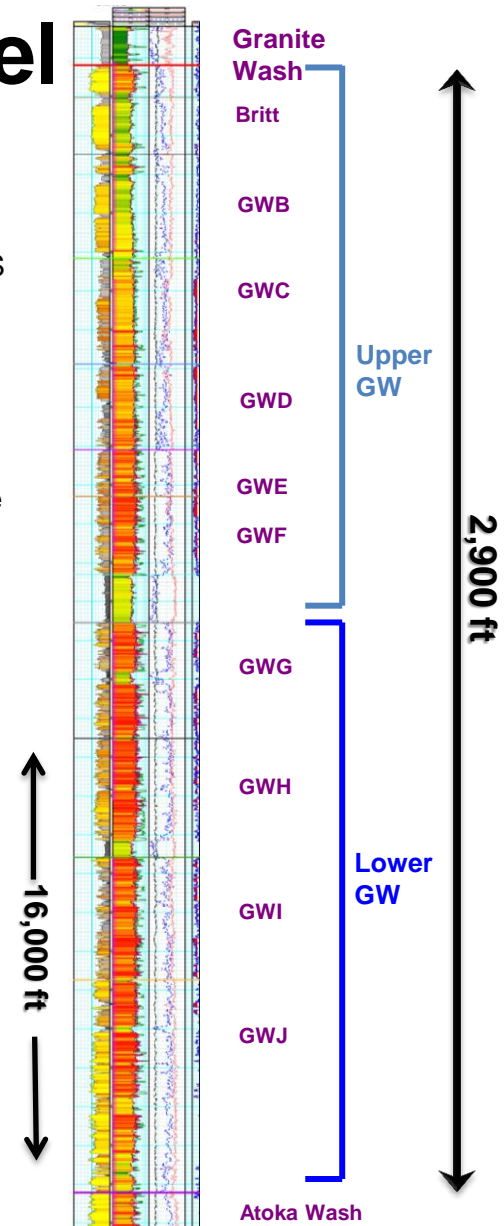
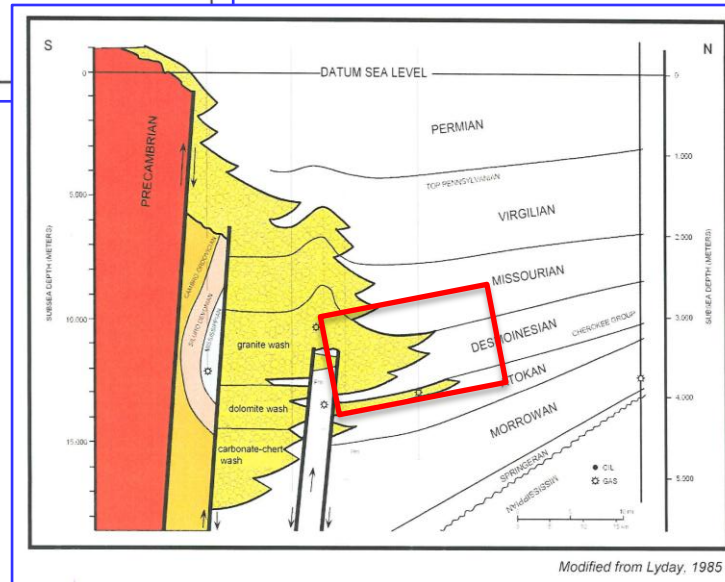


# Granite Wash Depositional Model

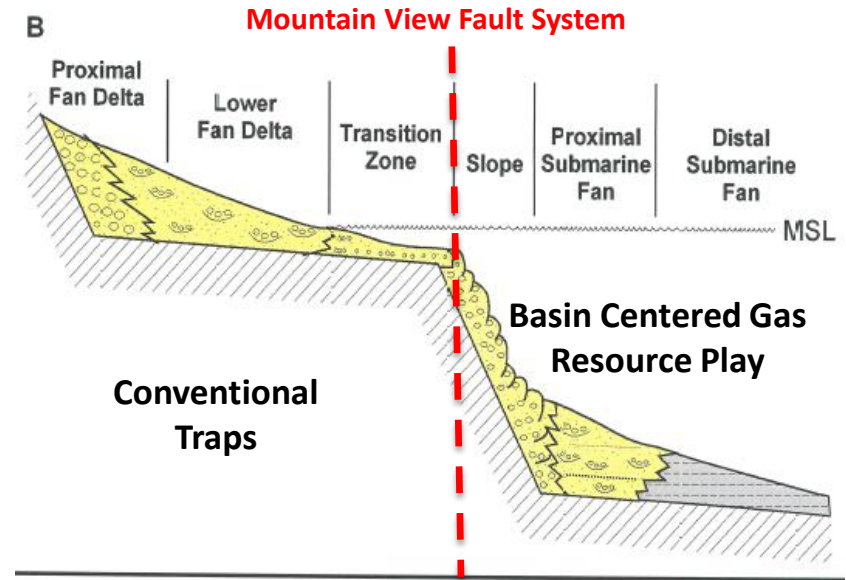
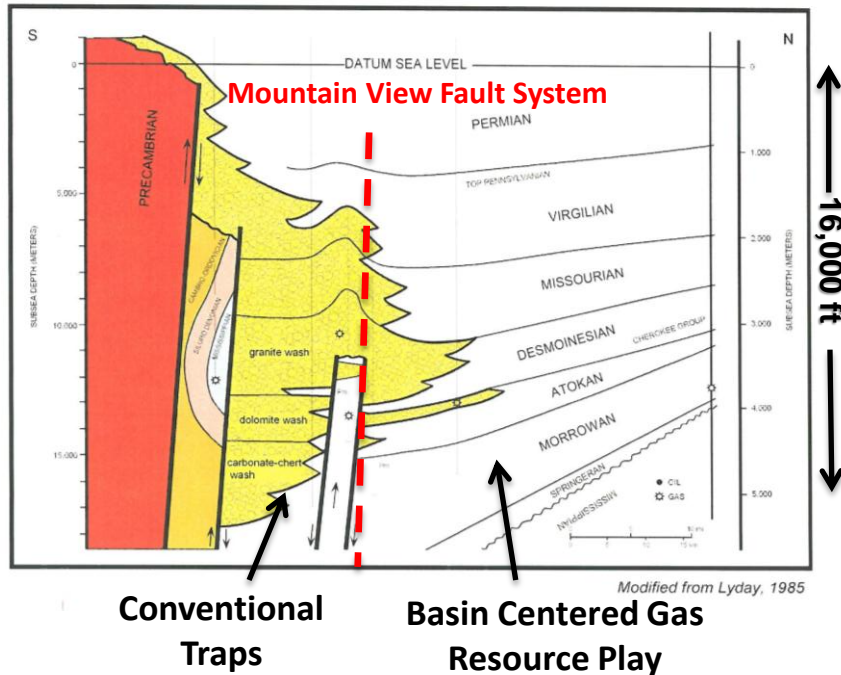


- Massive sand deposits shed off the Amarillo uplift and Wichita Mtn. to SW, >15,000 ft of GRWS deposits preserved in the rock record
- Sediments spread laterally and stacked vertically to create a submarine sand complex
- GRWS records cyclic sandstone and siltstone deposition that corresponds to submarine fan growth and abandonment
- Focus on DSMS GRWS

- Active petroleum systems charged by multiple source rocks
- Basin centered gas system combined with regional stratigraphic pinch-out
- Gross DSMS thickness as much as 3,400 ft
- Subdivided DSMS GRWS into 11 productive benches separated by regionally correlative shales



# Two Plays: Conventional and Unconventional



South of Mountain View Fault System: Conventional Traps

North of Mountain View Fault System: Basin Centered Gas Resource Play

# Challenges

---

## **Perception that the Granite Wash is only one or two reservoirs**

- When it is at least fifteen reservoirs
- At least eleven Desmoinesian age reservoirs

## **Limited published studies**

## **Subsurface study only, no outcrops**

- Over 30,000 wells to correlate; blessing and a curse.
- Eight years ago when we started this work there were few digital logs available

## **Petrophysical challenges**

- Radioactive minerals
- Variable clay content
- Low porosity and permeability
- Overbalanced drilling masked Granite Wash pay

## **No established stratigraphic framework**

## **Nomenclature issues are a major hurdle to overcome**

# What's in a name?

---

Numerous different styles for naming individual Granite Wash zones

## Lithology

### ***Granite Wash***

Conglomerate

Carbonate Wash

Dolomite Wash

## Age Connotation

Permian Wash

Pennsylvanian Wash

Missourian Wash

### ***Desmoinesian Wash***

Atokan Wash

Morrowan Wash

## Kansas Shelf Nomenclature

Cottage Grove Wash

Hogshooter Wash

Cleveland Wash

Marmaton Wash

### ***Cherokee Wash***

### ***Skinner Wash***

### ***Red Fork Wash***

Atoka Wash

Morrow Wash

## Other

Colors

Alpha-Numeric

Inverse Alphabetic

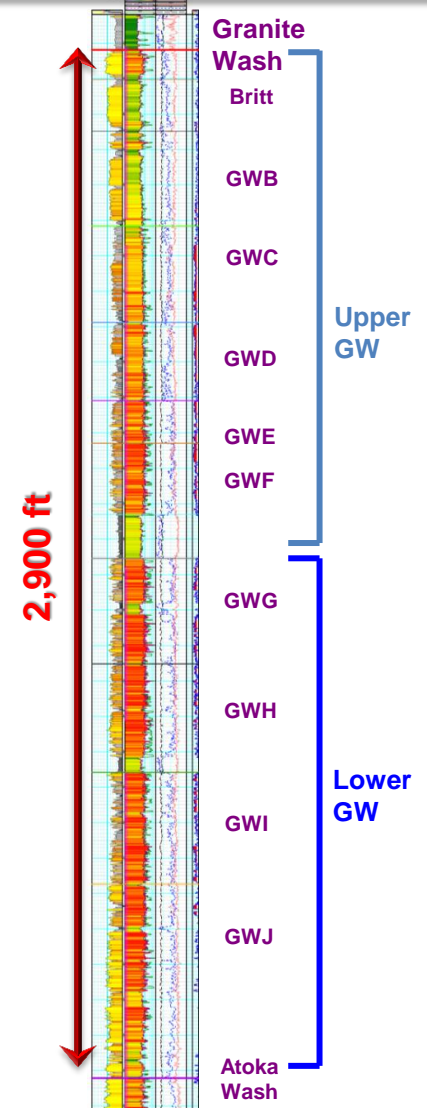


# Our Nomenclature

## ■ Divided the Desmoinesian age Granite Wash into eleven zones

- Separated by regionally correlative flooding surfaces
- Frac barriers
- At least eleven Desmoinesian age reservoirs

## ■ System is a hybrid of Core Lab study members



# Mapping Strategy

---

## **Granite Wash divided into 11 zones (does not include Atoka Wash)**

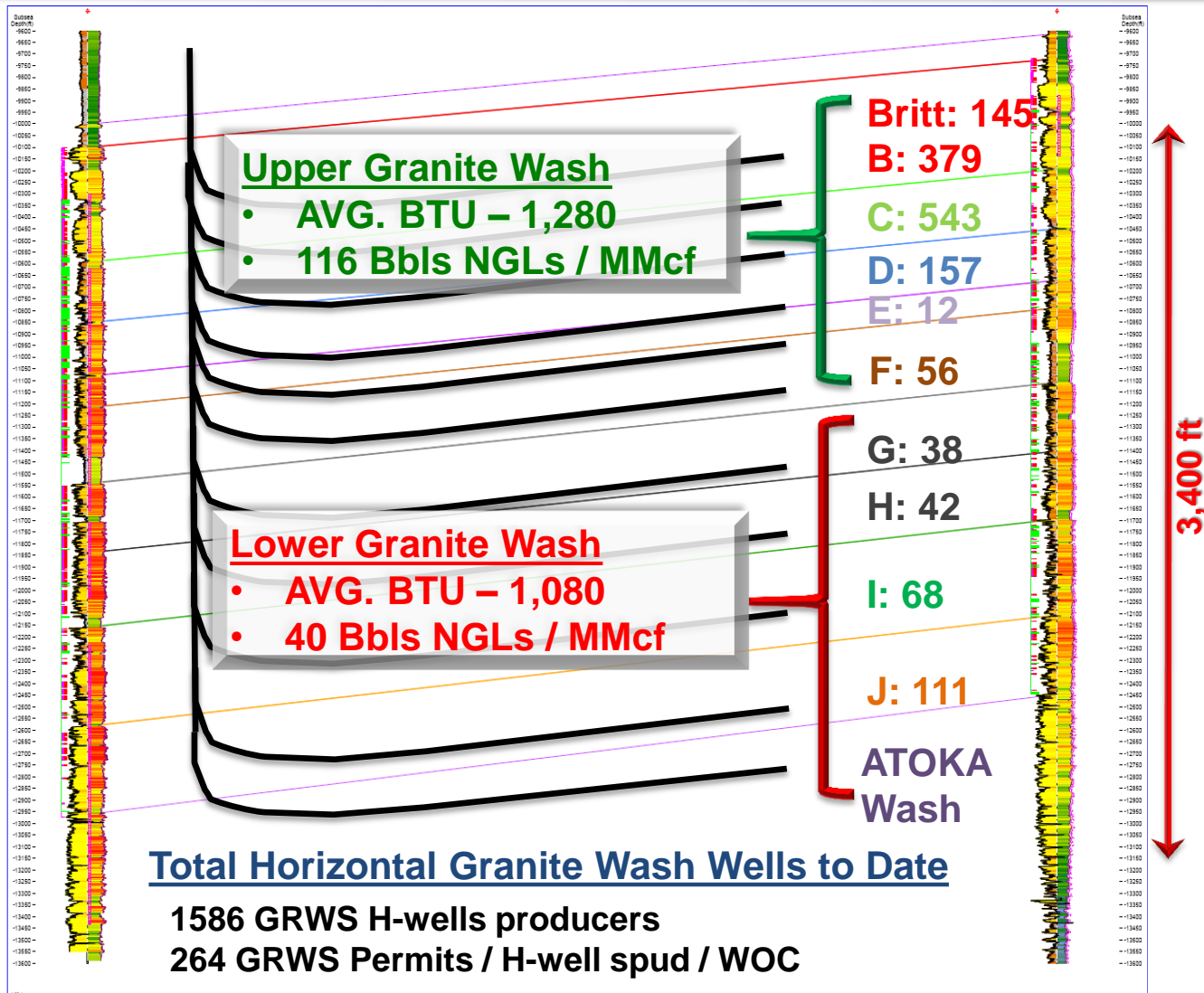
- Strategy was to correlate significant flooding surfaces across area of interest
- Create structure maps for each surface and project those surfaces into all wells
- Define zones based on projected surfaces to eliminate nomenclature issues and to be able to extract meaningful test, perf, and production data

## **Net sand maps for each individual zone**

- Only wells penetrating that zone
- Highlight wells with perfs in that zone
- Highlight HZ wells in zone

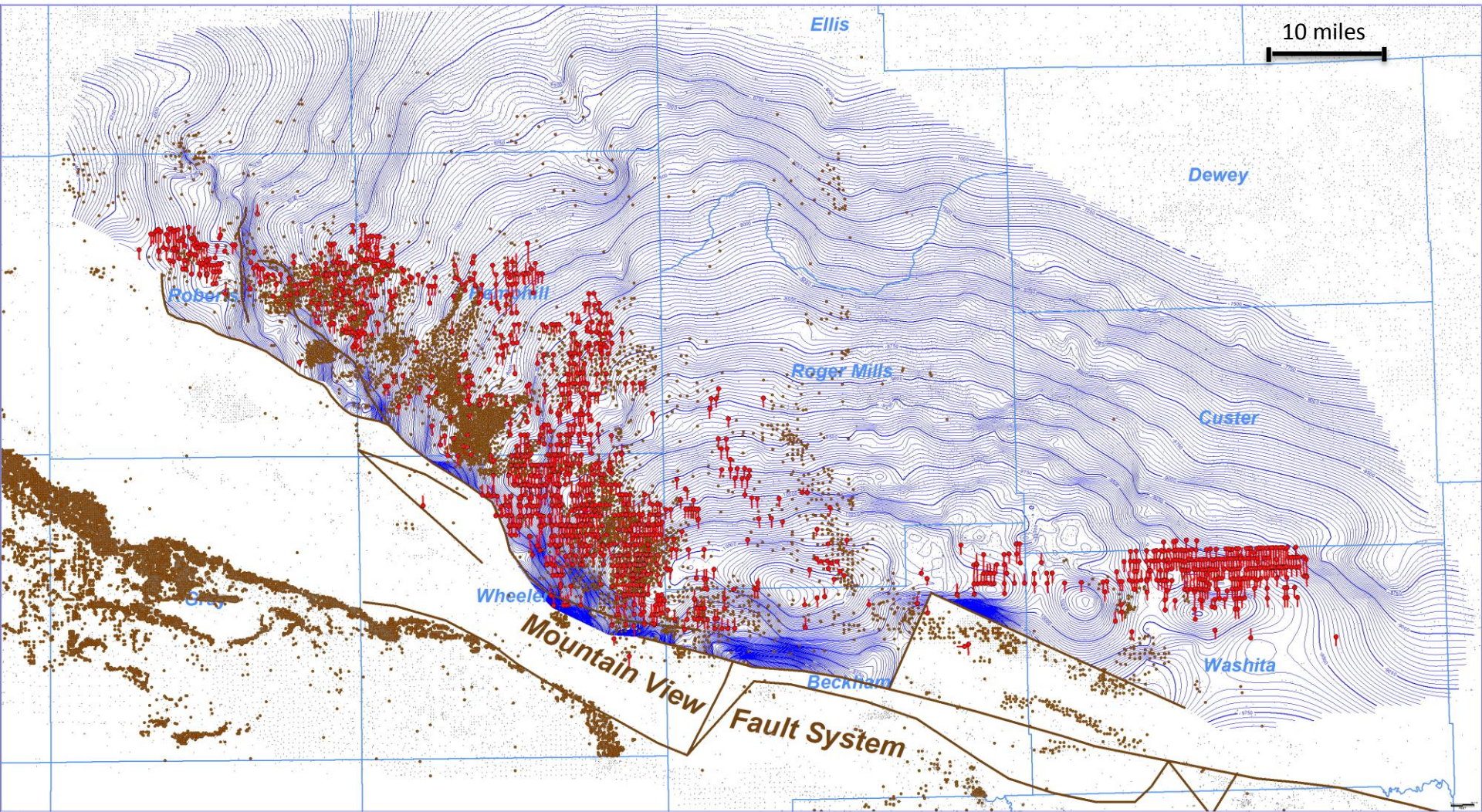
# Eleven Stacked Horizons

- All GRWS zones proven productive by 100's to 1000's of vertical wells, and over 1500 Hz wells
- Most Hz wells target the upper zones
  - Shallower drilling
  - More liquid rich in central portion of the play





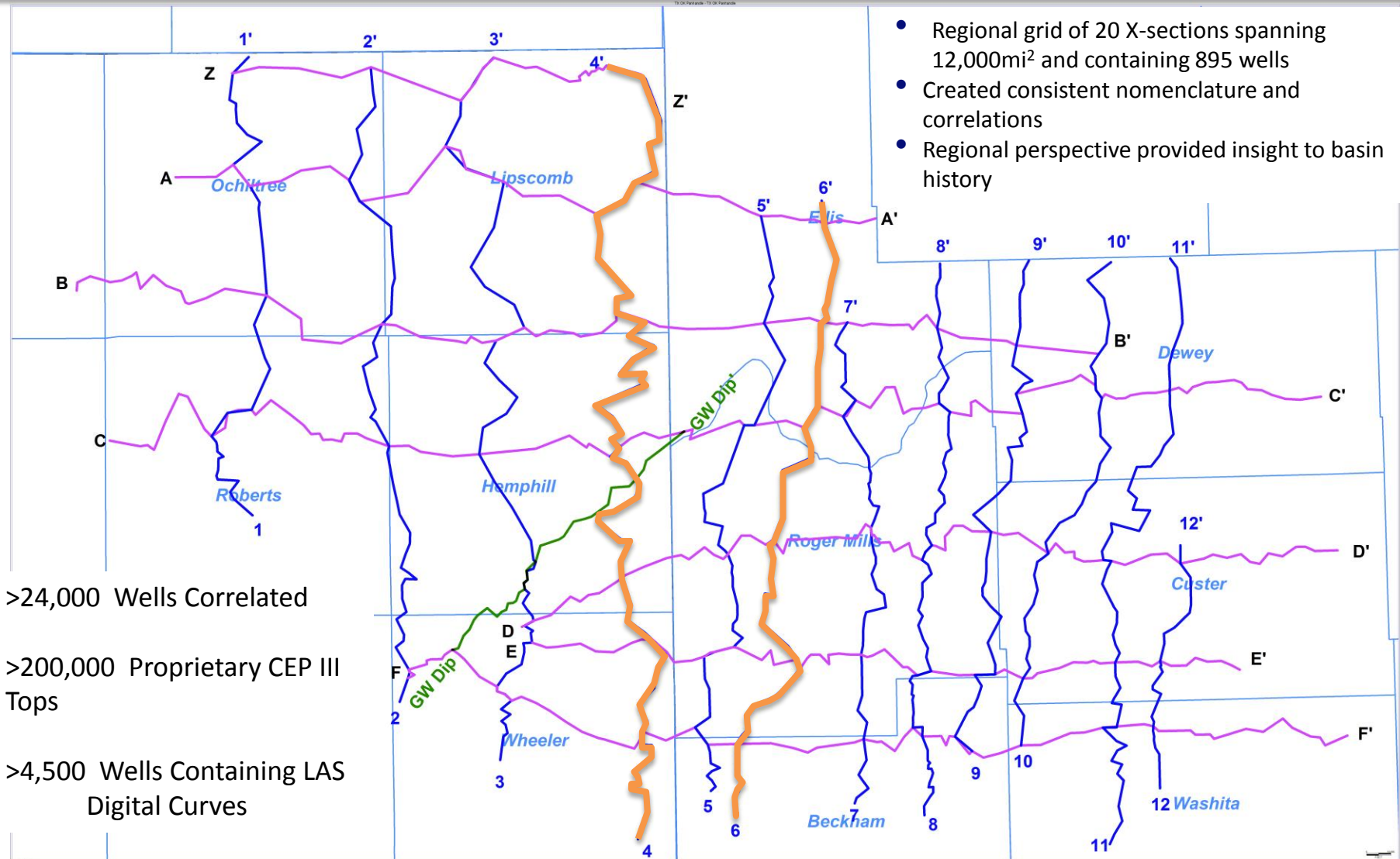
# Granite Wash Structure



C.I= 25'



# Regional Cross-Section Index Map

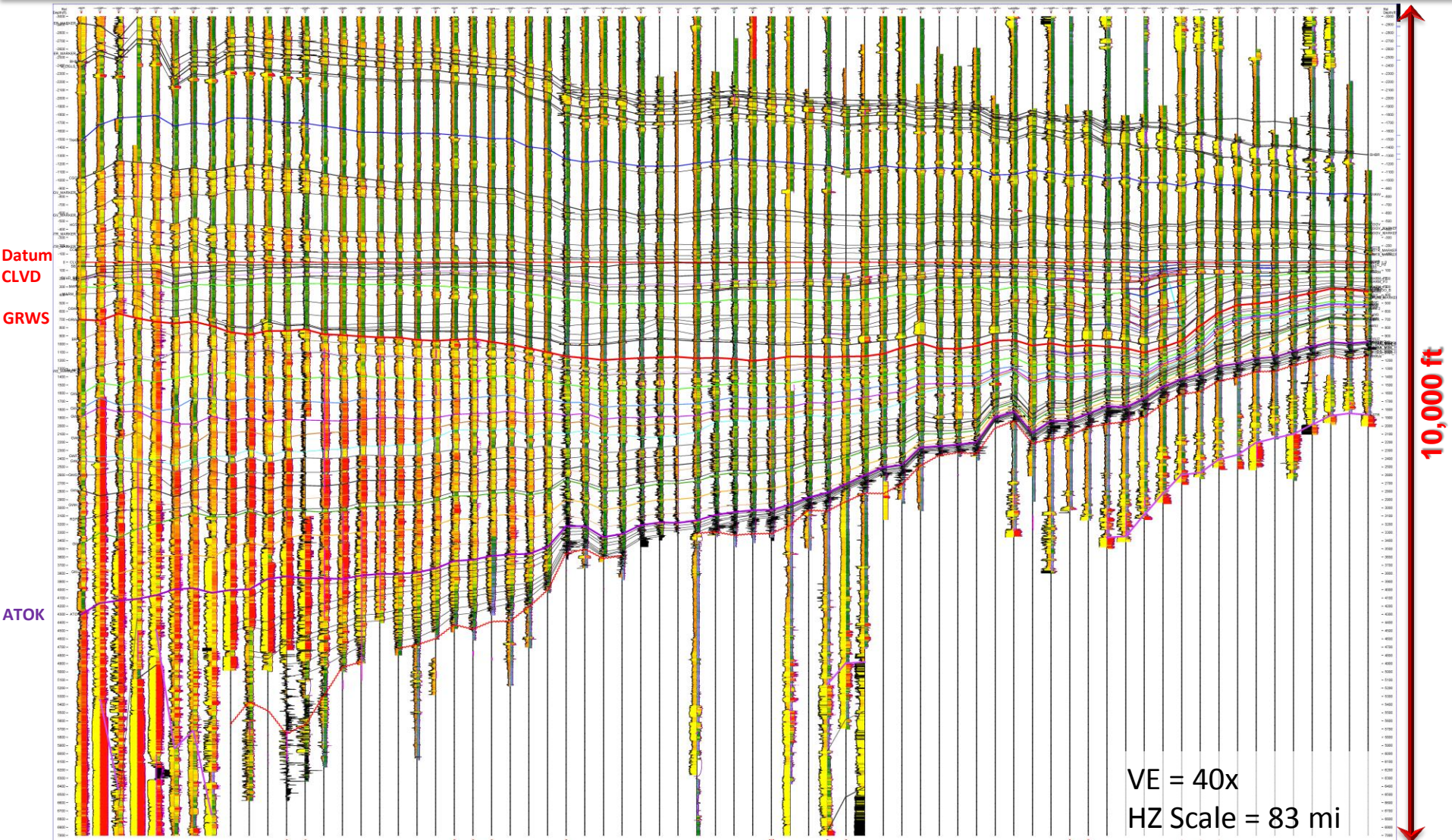




South

# Section 4

North

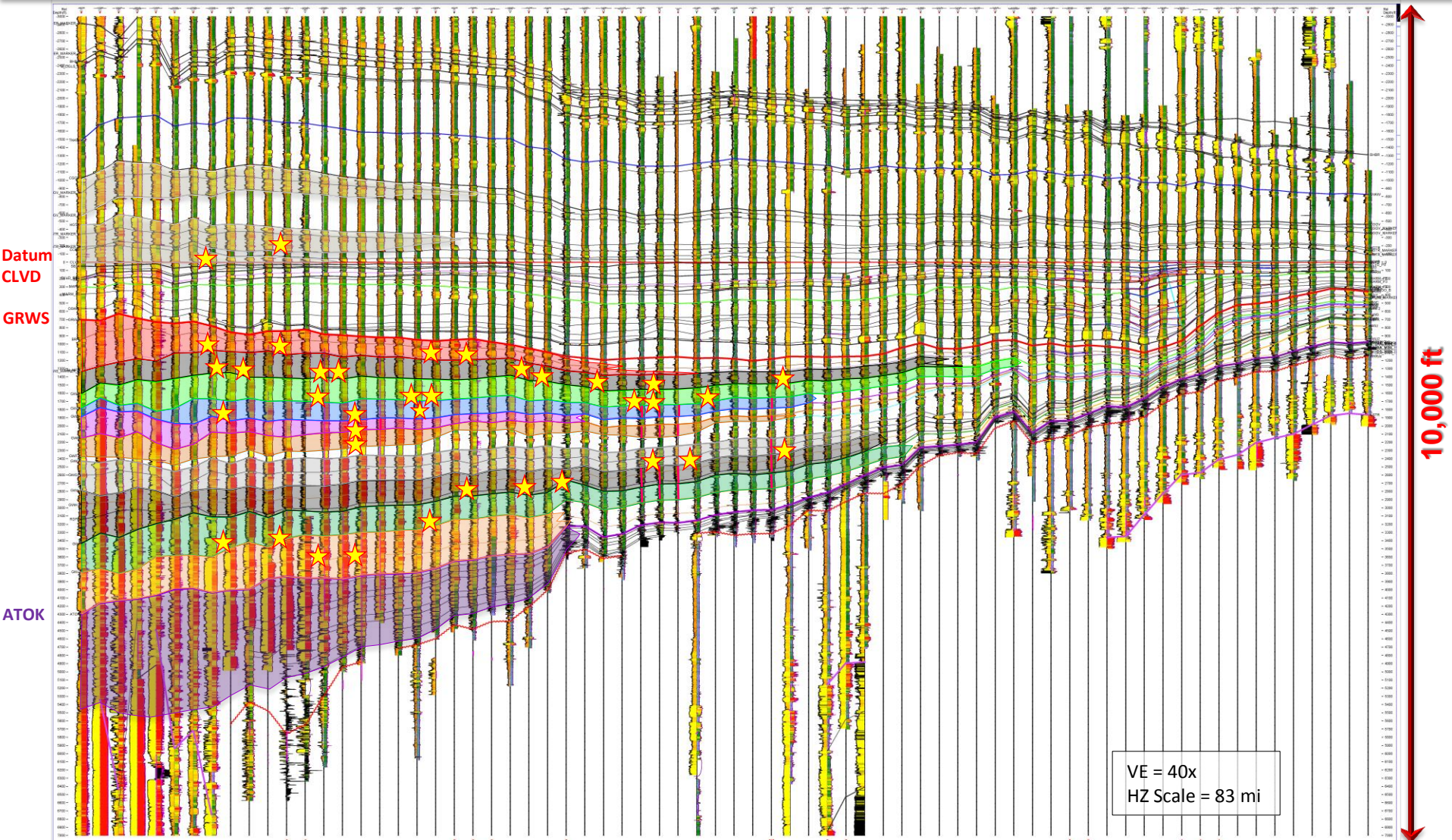




South

# Section 4

North

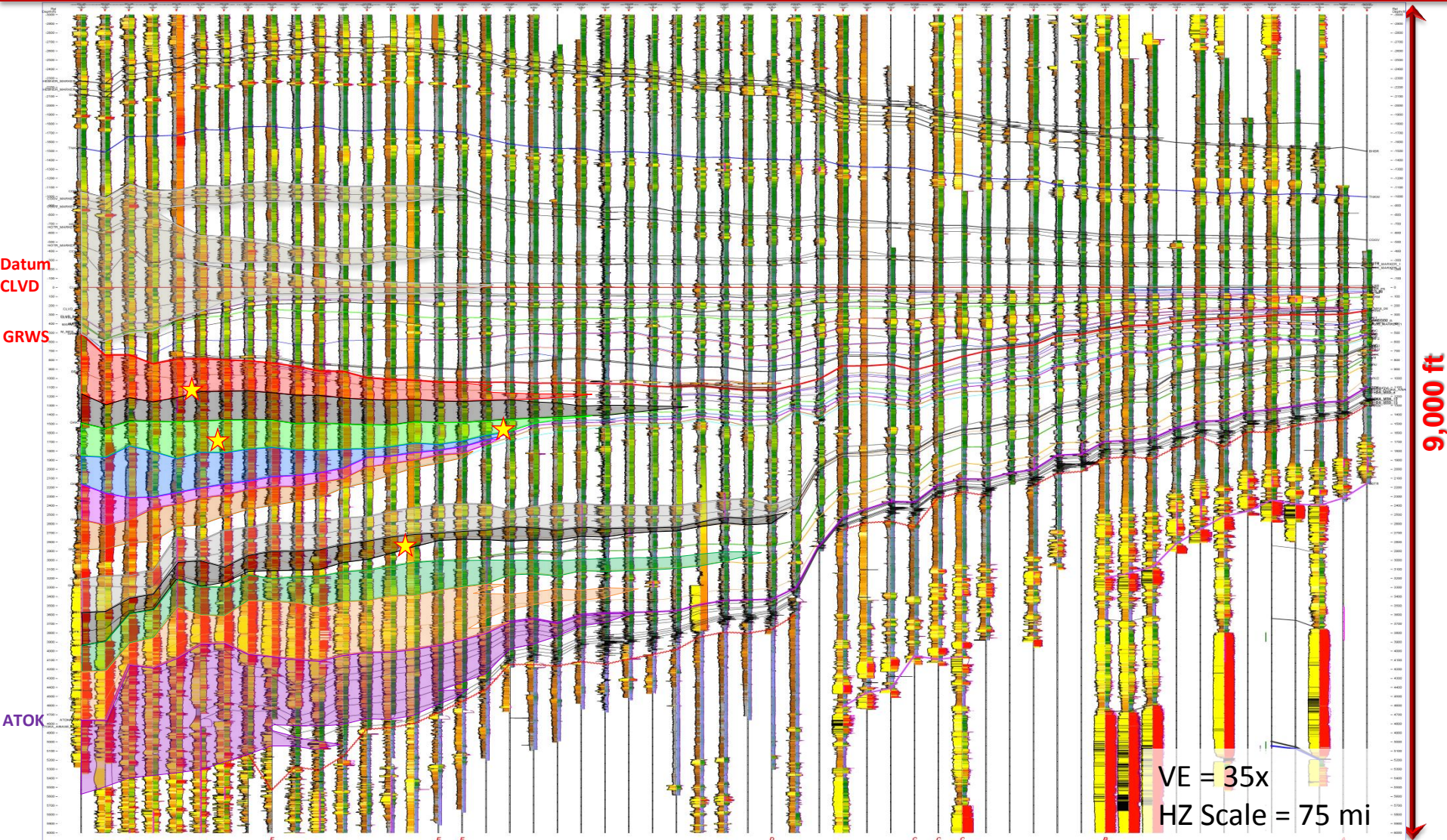




South

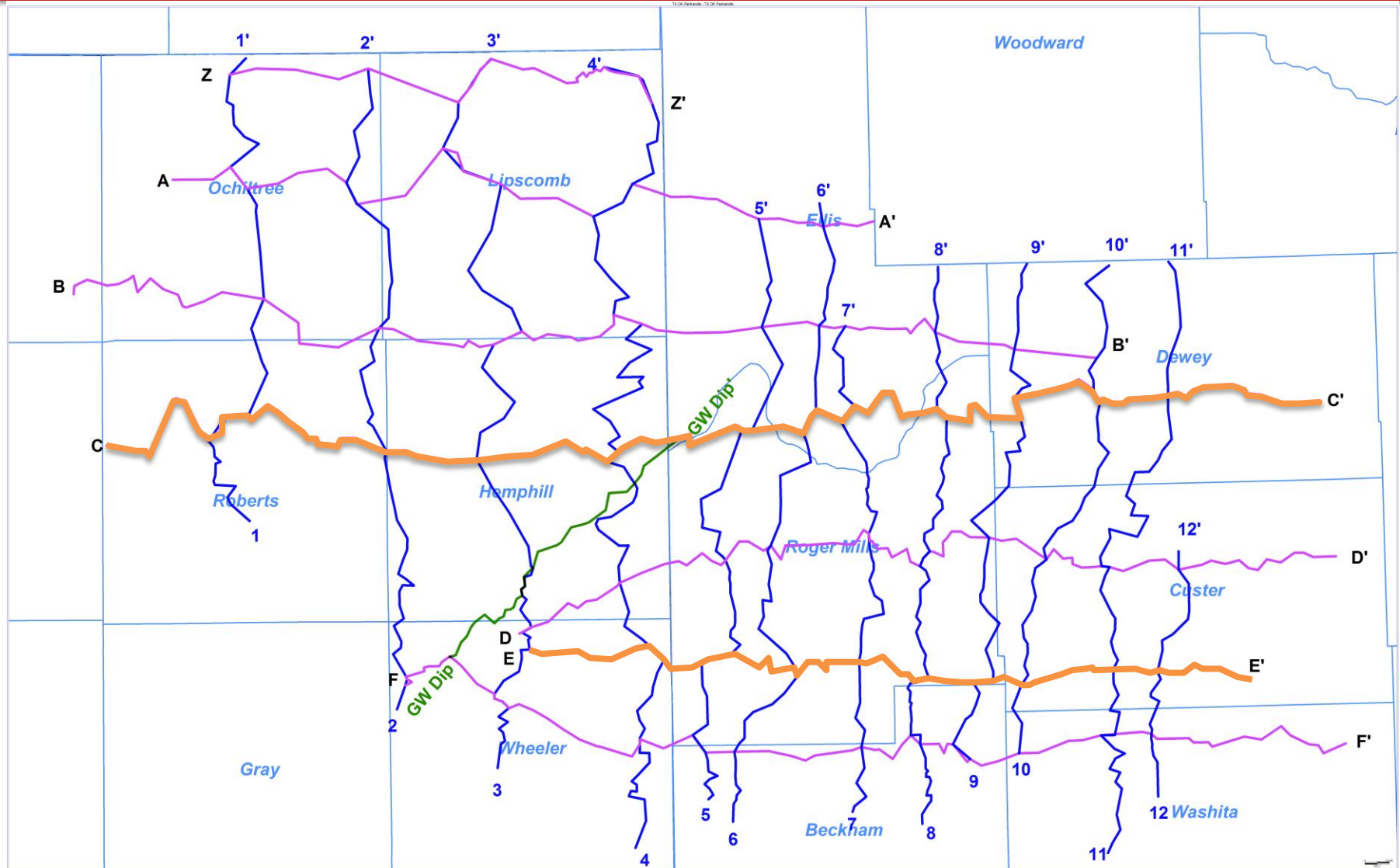
# Section 6

North





# Regional Cross-Section Index Map

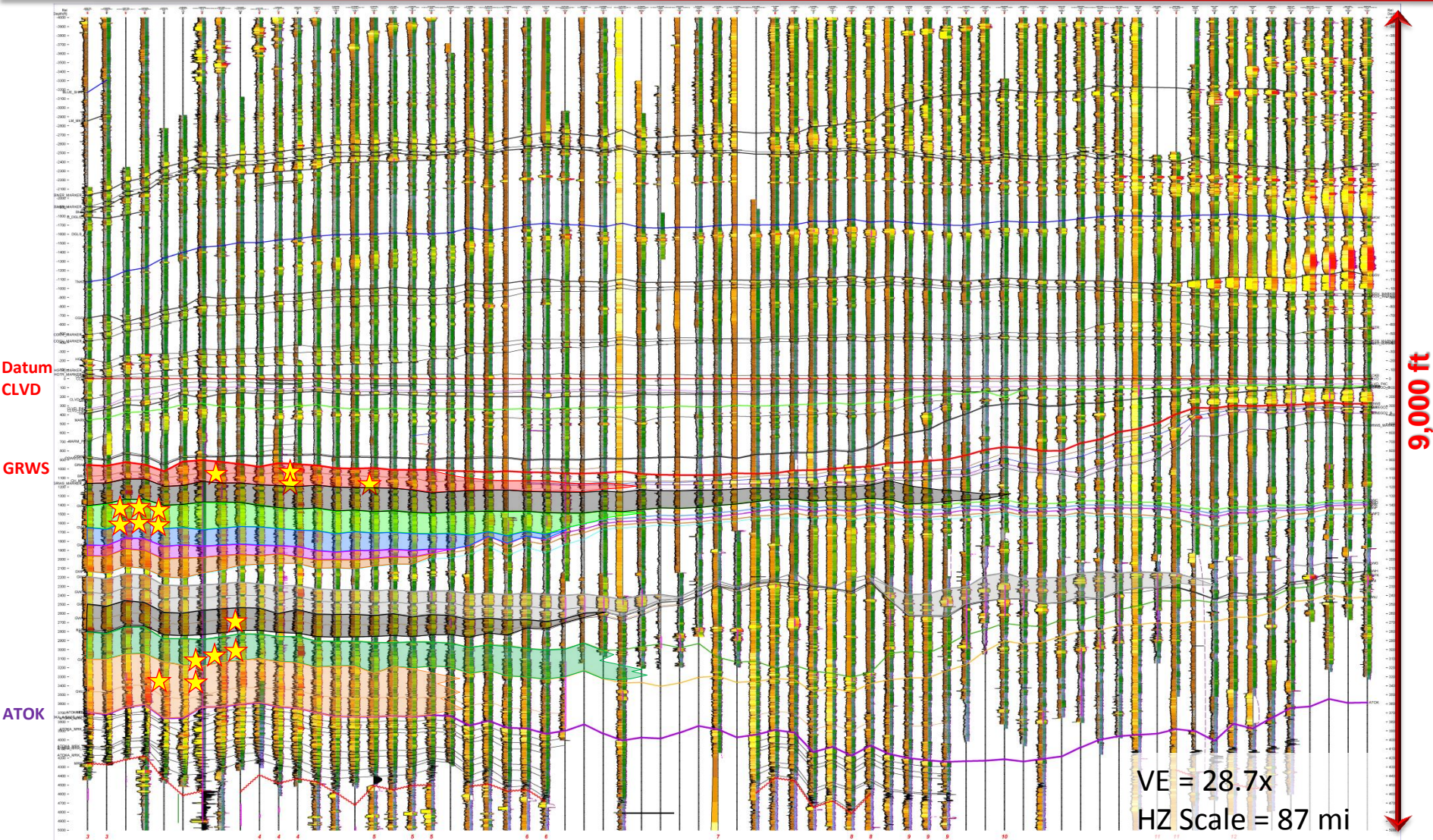




West

# Section E

East

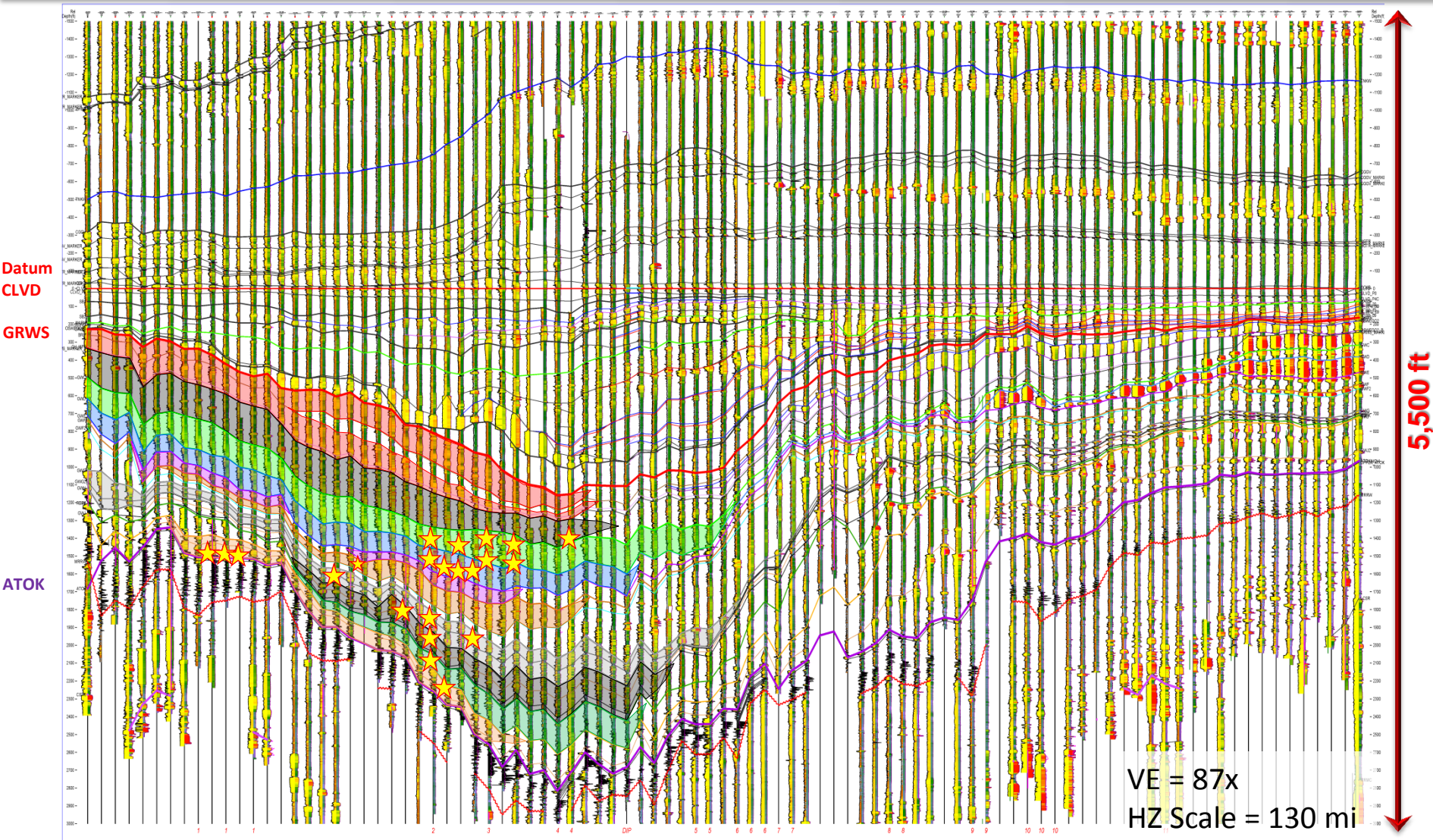


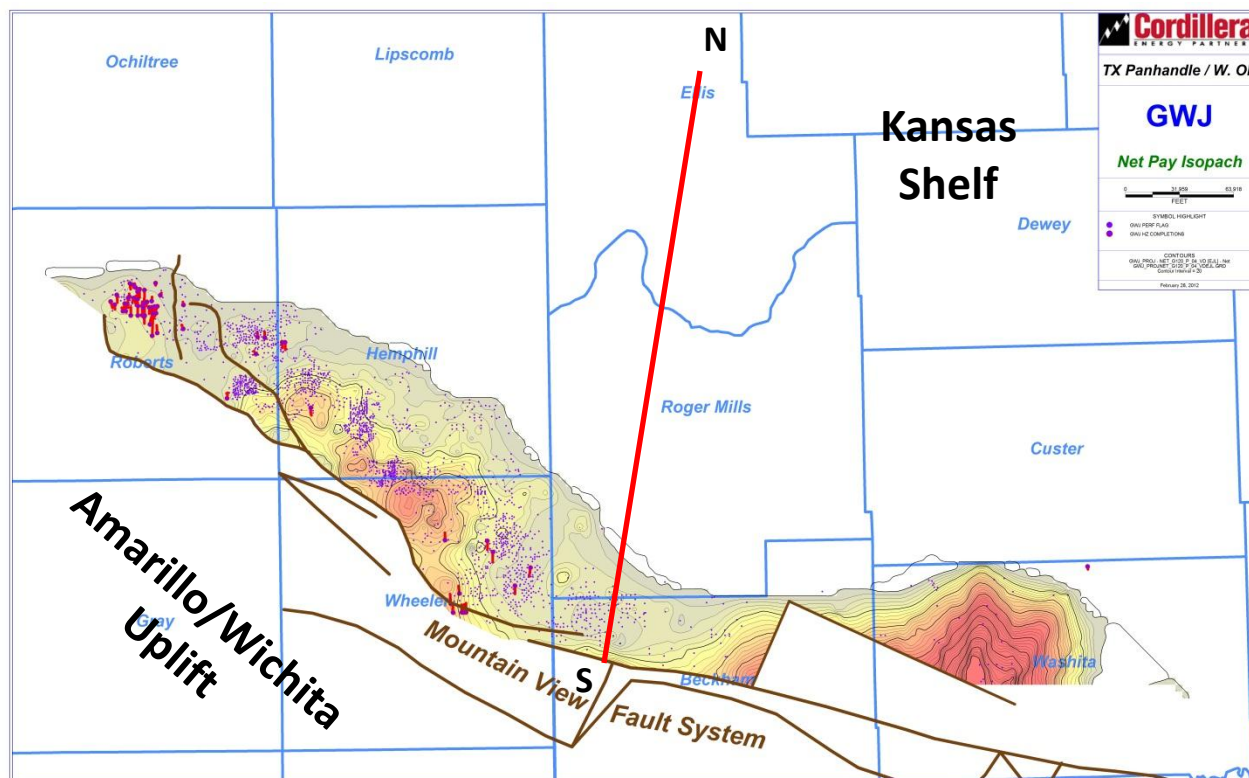


West

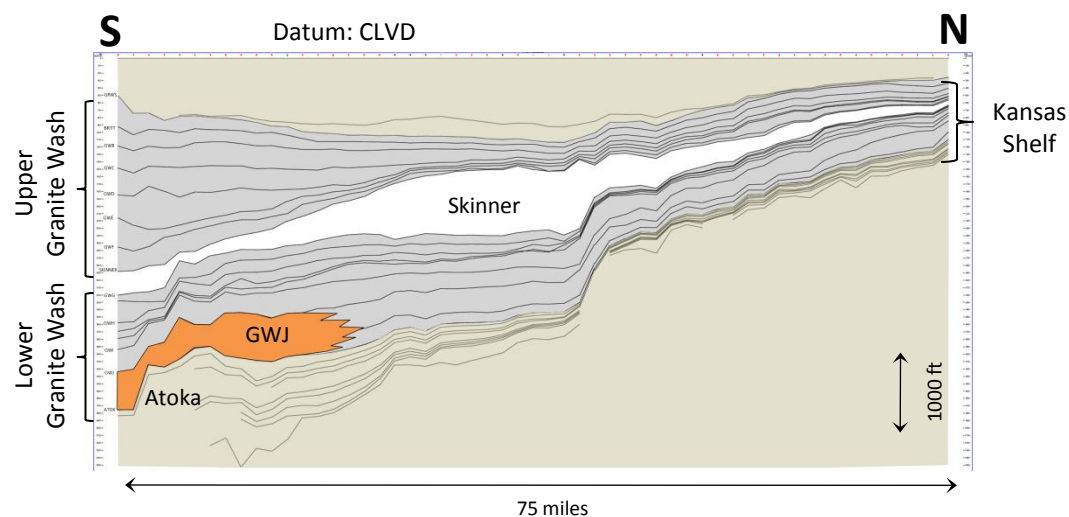
# Section C

East



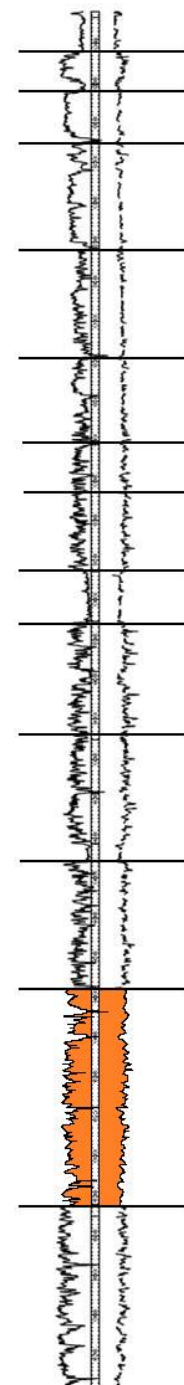


C.I= 20'

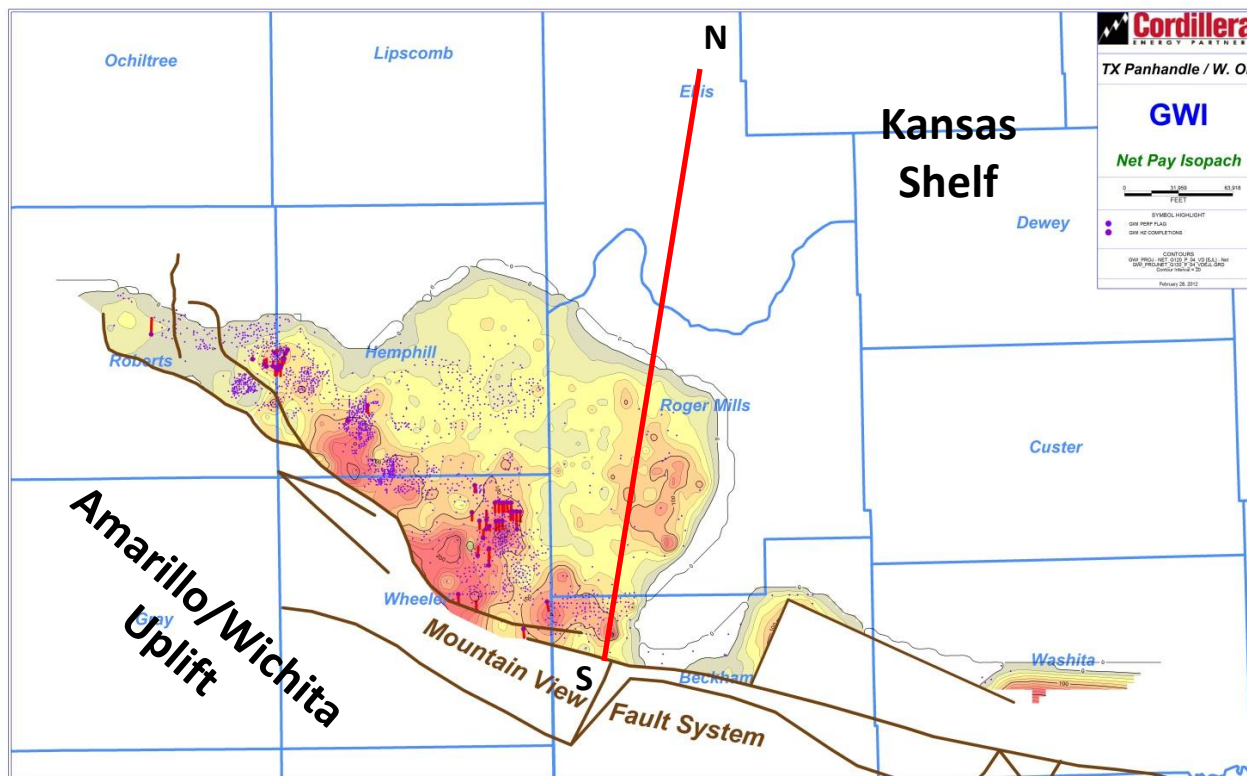


Granite Wash

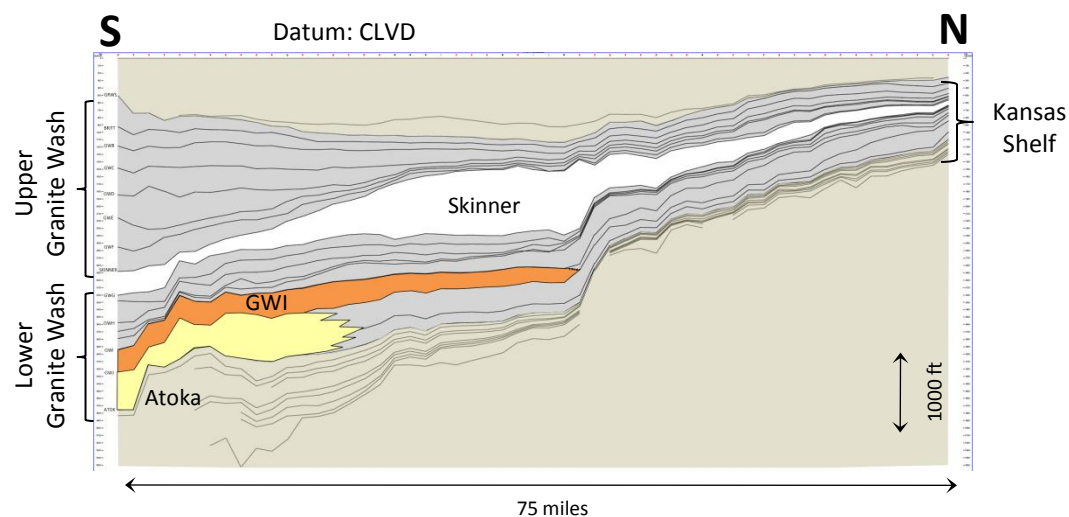
GRWS  
BRITT  
GWB  
GWC  
GWD  
GWE  
GWF  
SKINNER  
GWG  
GWH  
GWI  
GWJ  
ATOK





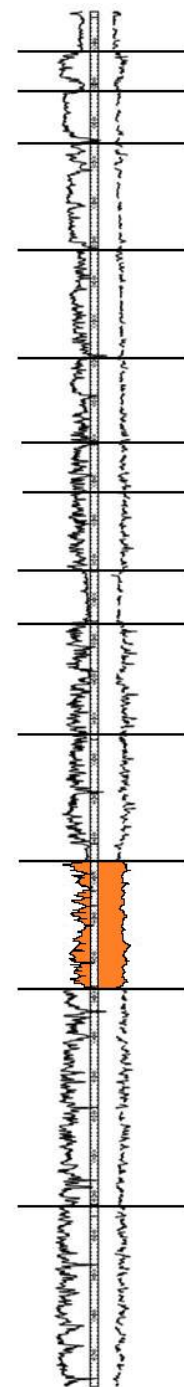


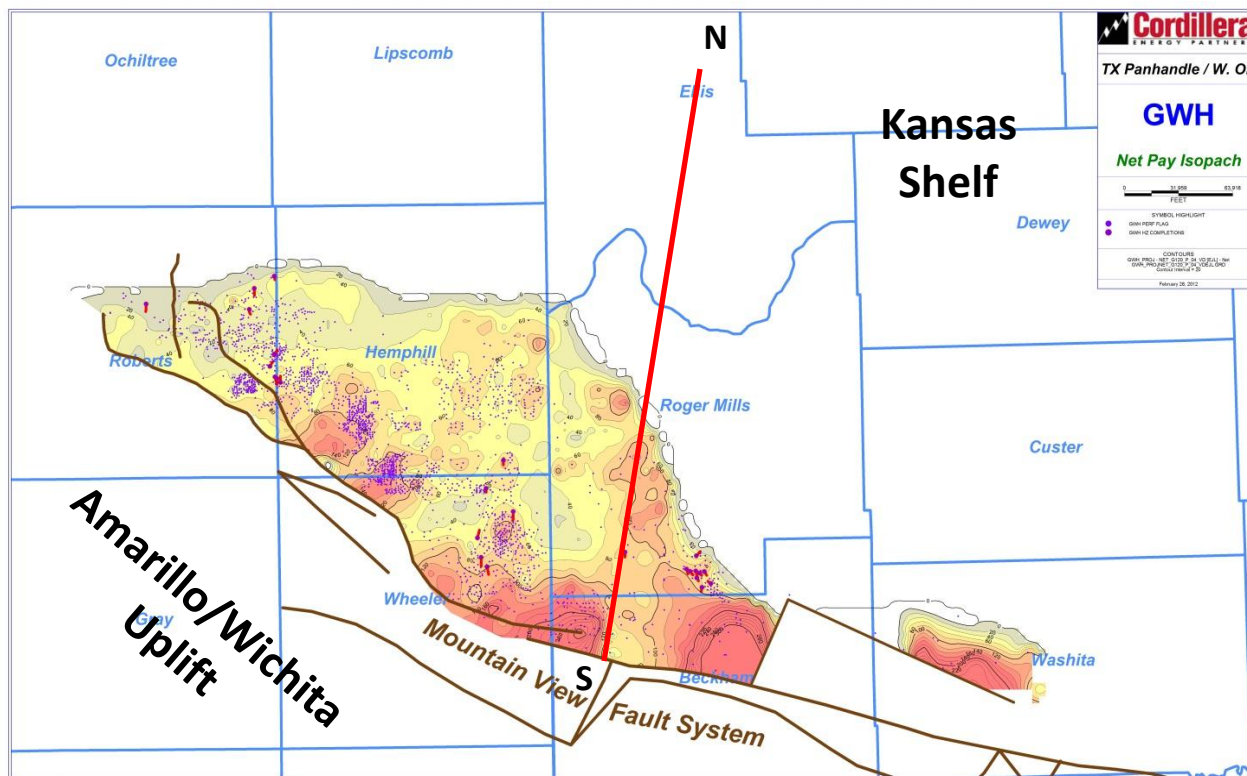
C.I= 20'



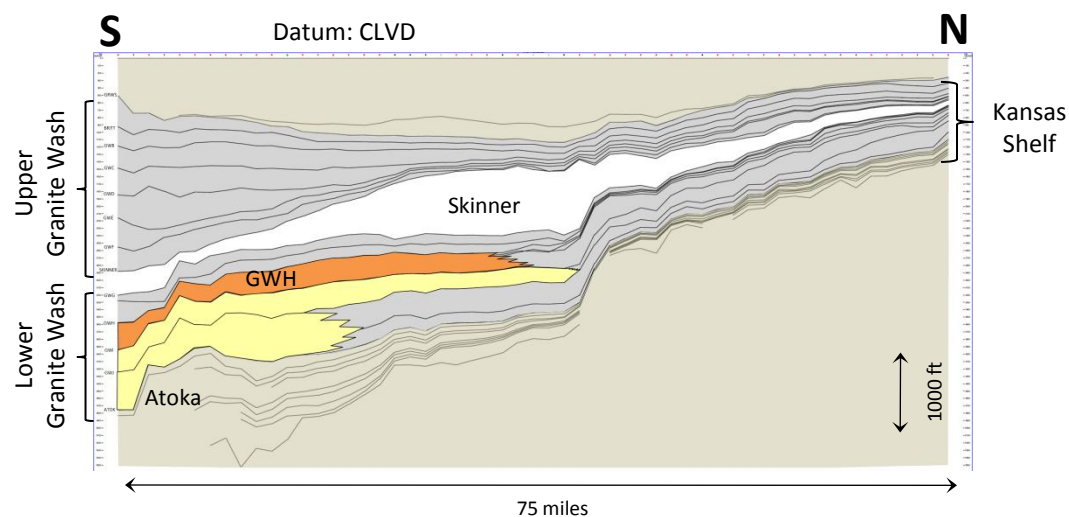
Granite Wash

GRWS  
BRITT  
GWB  
GWC  
GWD  
GWE  
GWF  
SKINNER  
GWG  
GWH  
GWI  
**GWI**  
GWJ  
ATOK



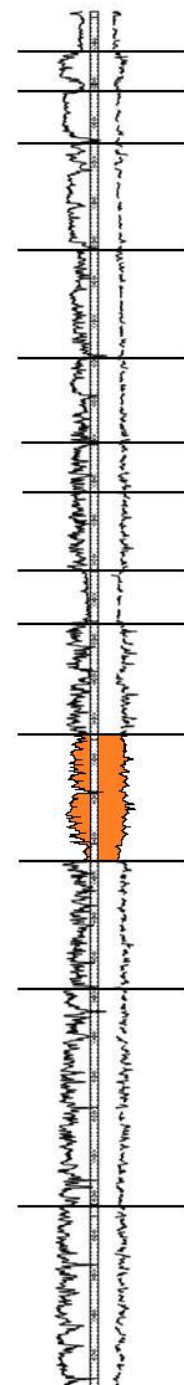


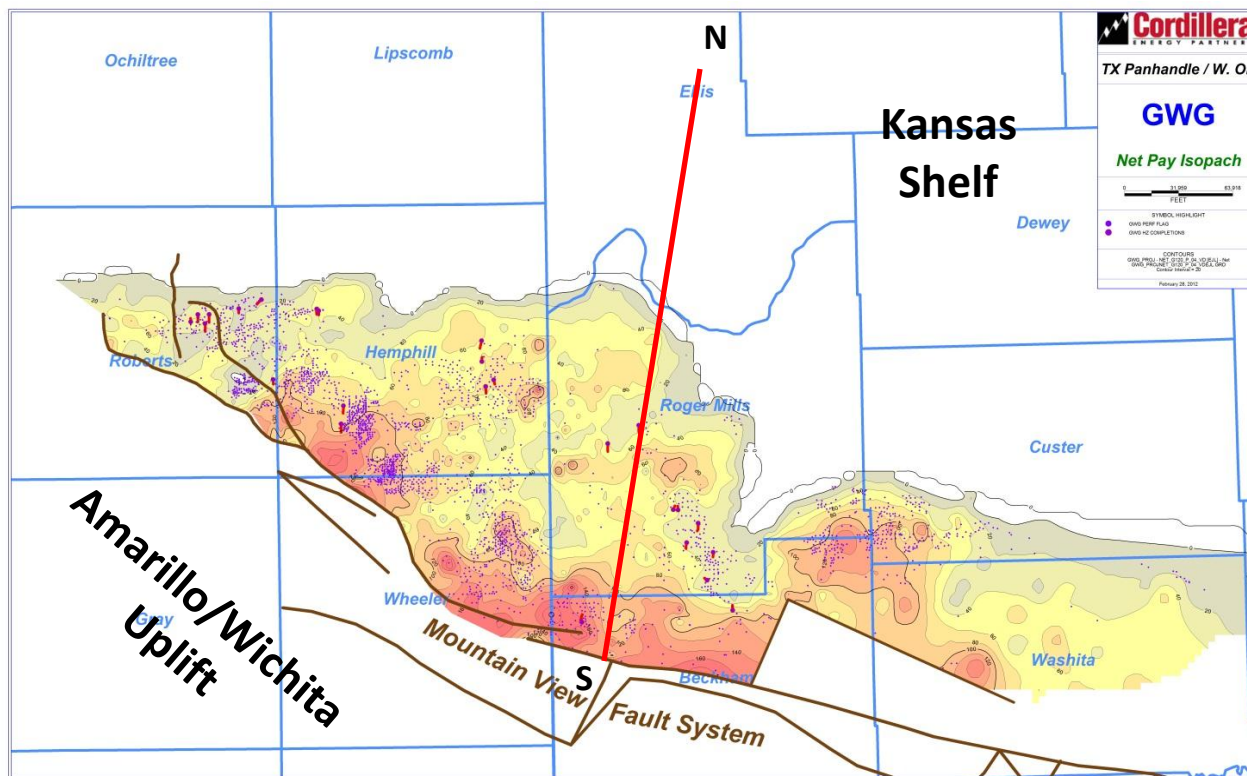
C.I= 20'



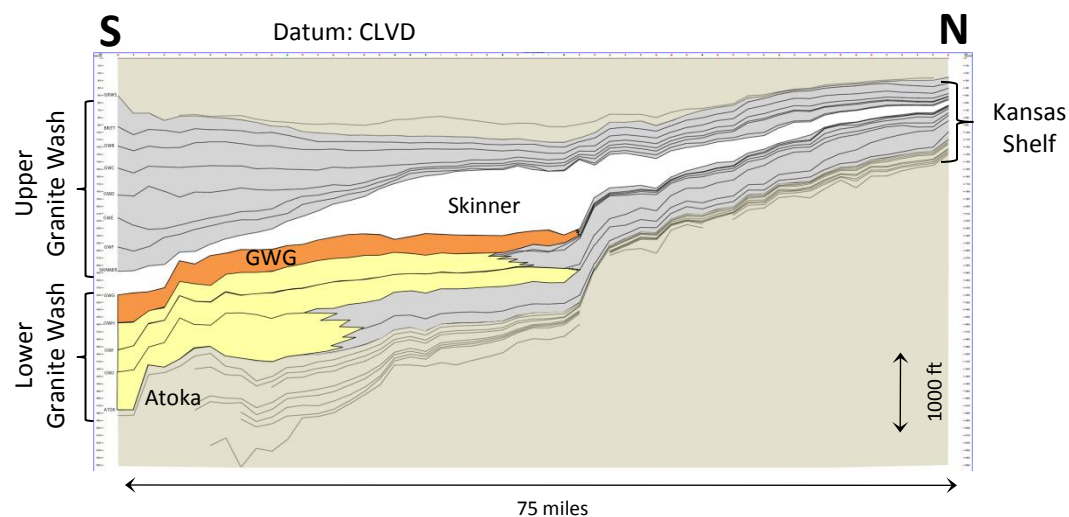
Granite Wash

GRWS  
BRITT  
GWB  
GWC  
GWD  
GWE  
GWF  
SKINNER  
GWG  
GWH  
**GWH**  
GWI  
GWJ  
ATOK



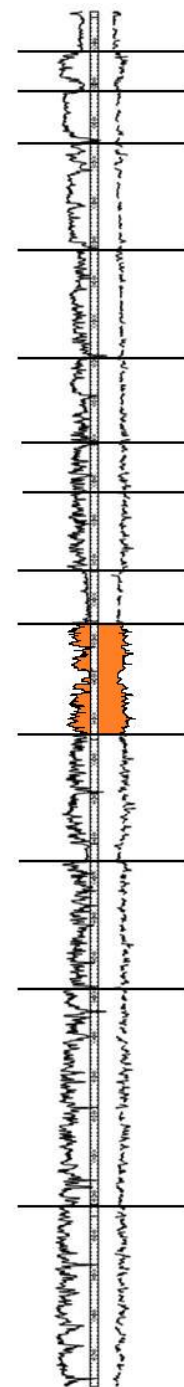


C.I= 20'



Granite Wash

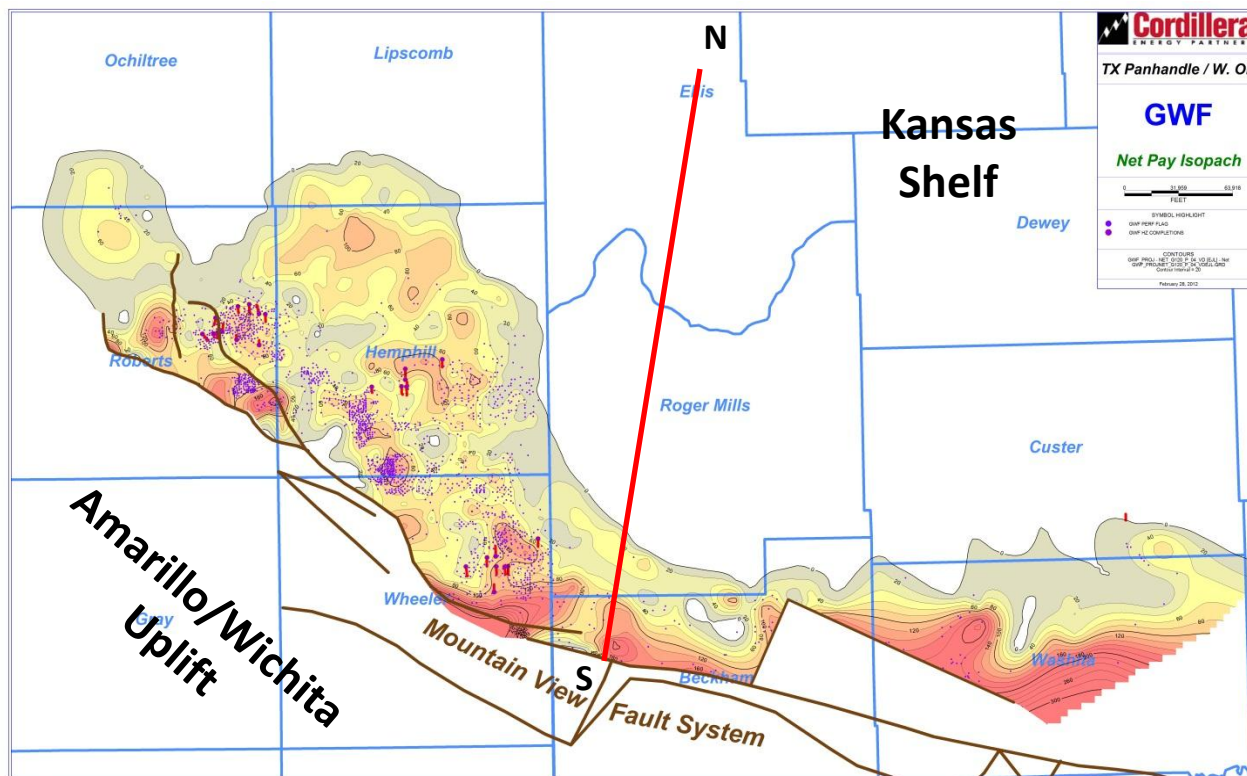
GRWS  
BRITT  
GWB  
GWC  
GWD  
GWE  
GWF  
SKINNER  
GWG  
GWH  
GWI  
GWJ  
ATOK



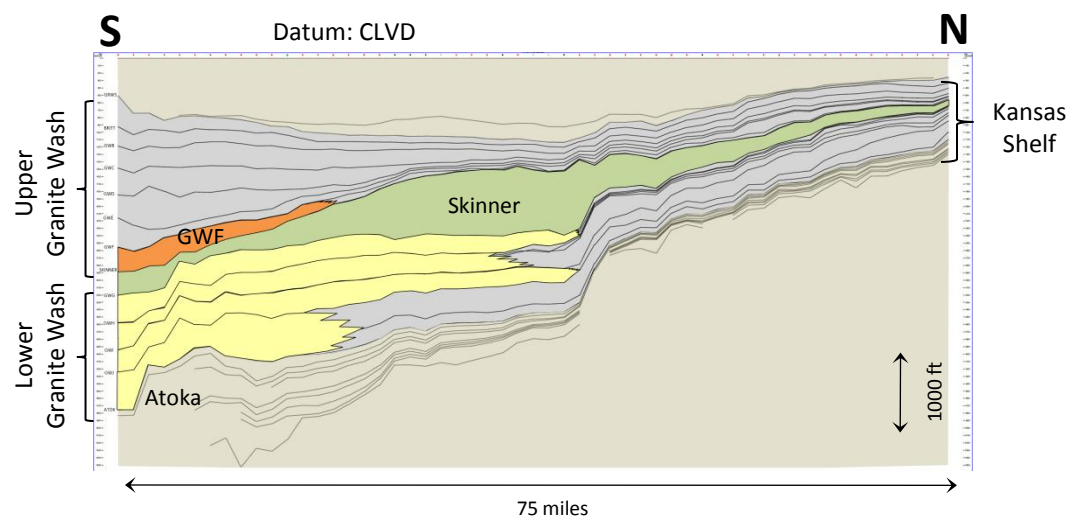






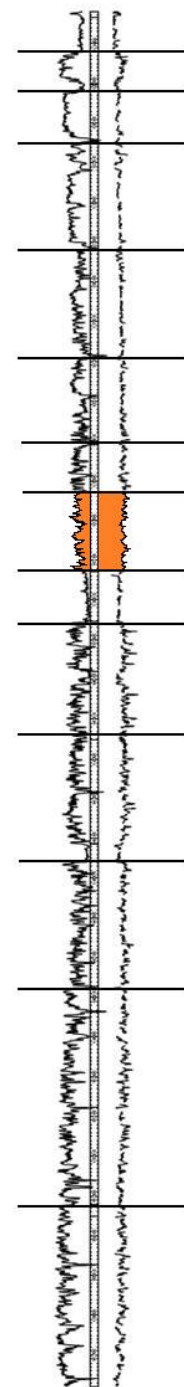


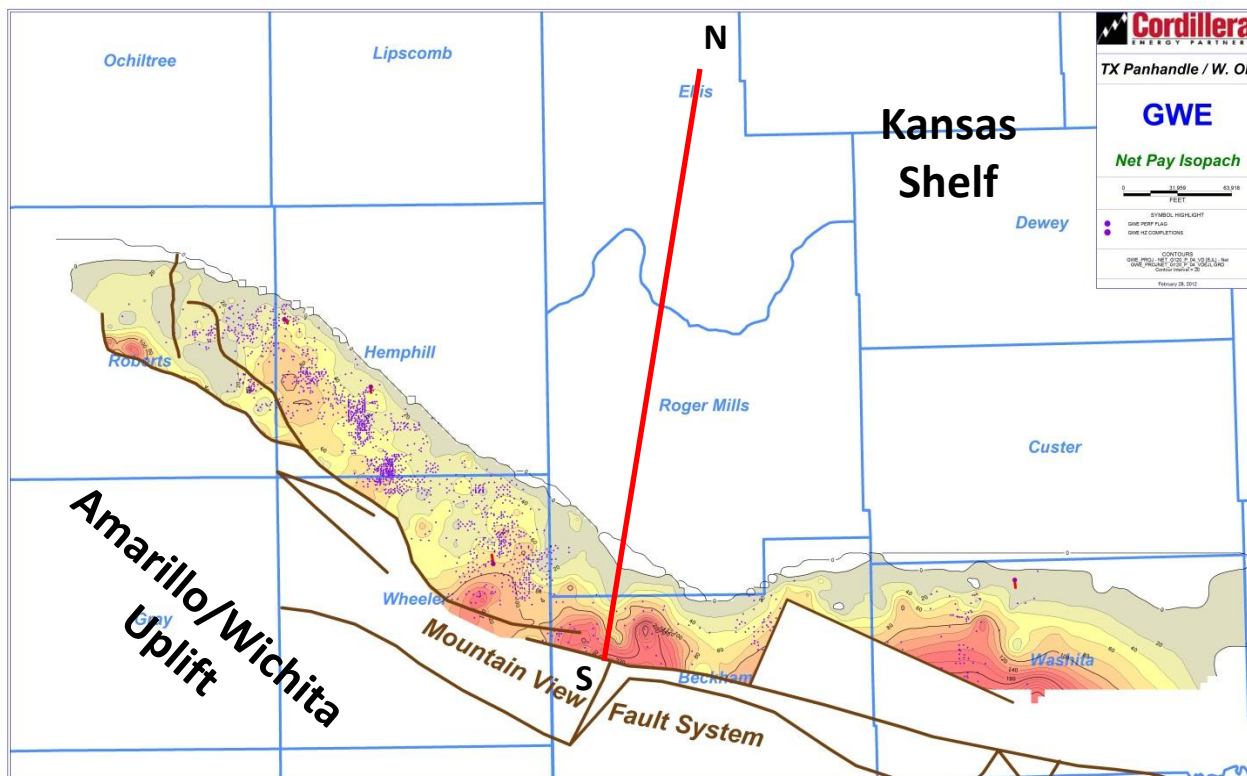
C.I= 20'



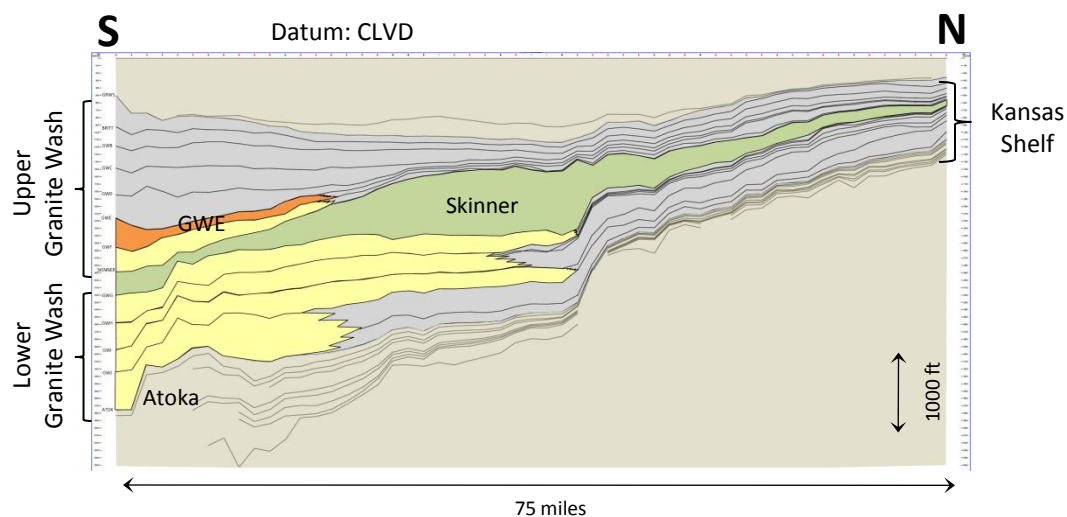
Granite Wash

GRWS  
BRITT  
GWB  
GWC  
GWD  
GWE  
GWF  
**GWF**  
SKINNER  
GWG  
GWH  
GWI  
GWJ  
ATOK



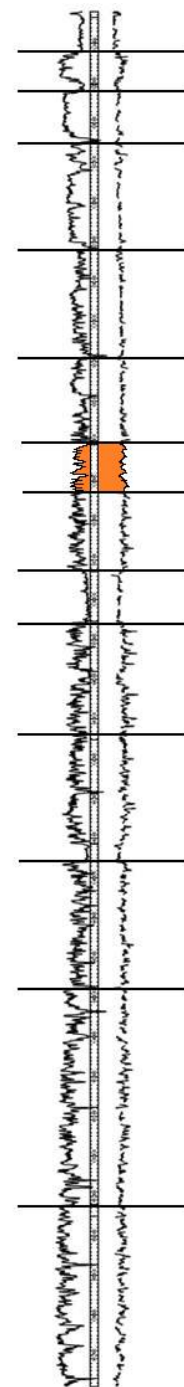


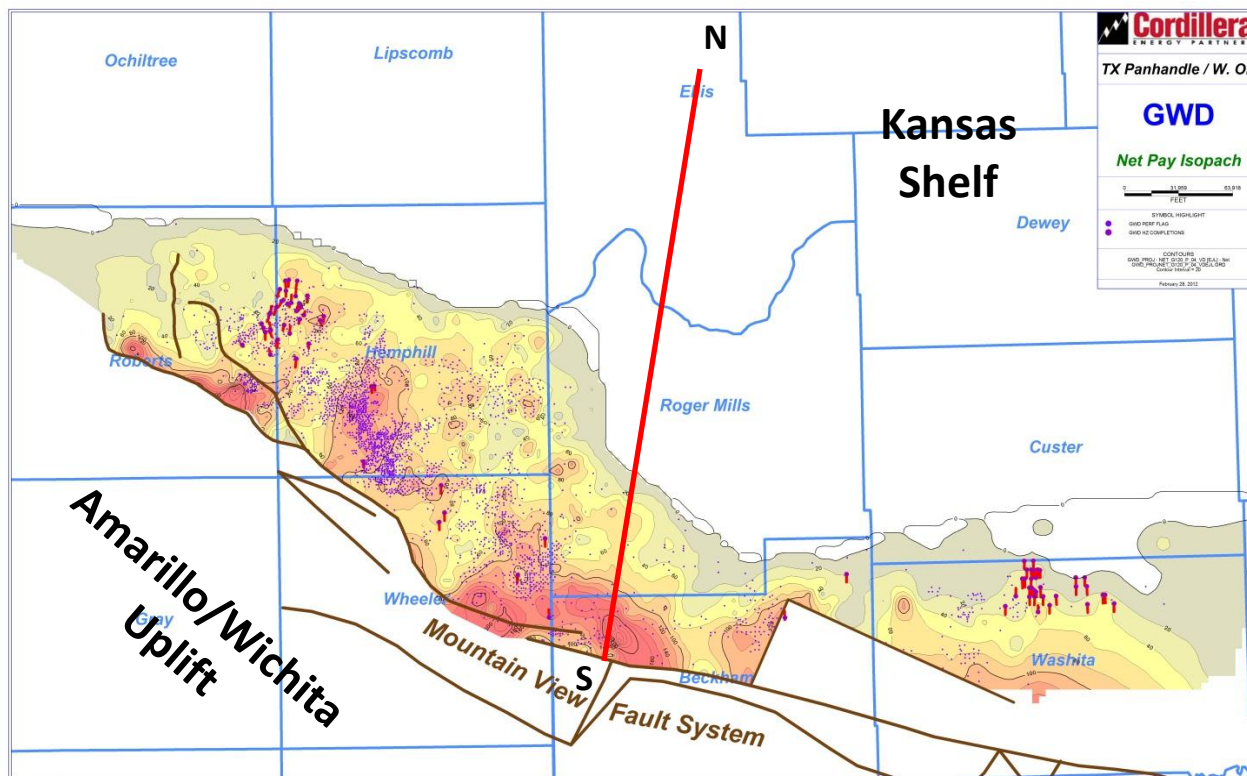
C.I= 20'



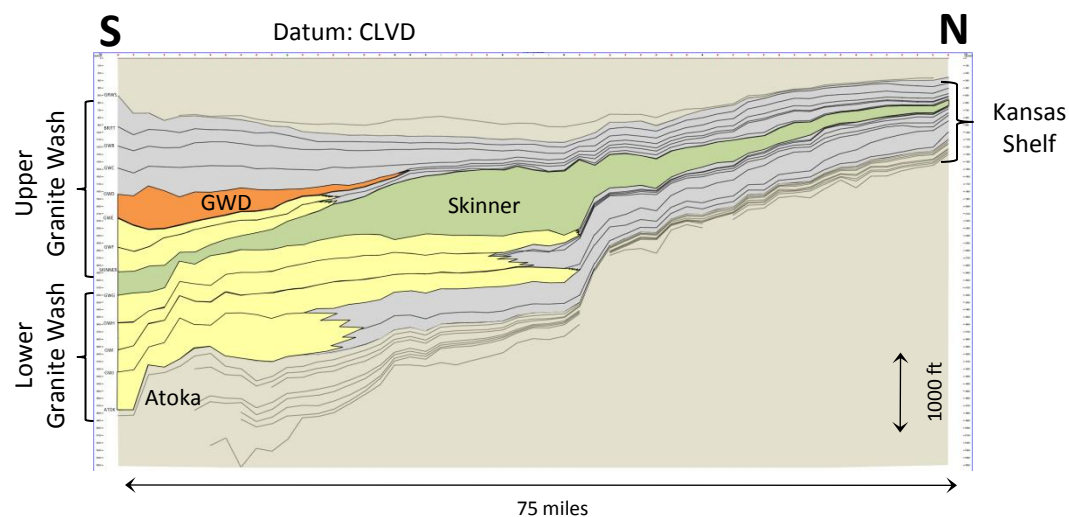
Granite Wash

GRWS  
BRITT  
GWB  
GWC  
GWD  
GWE  
**GWE**  
GWF  
SKINNER  
GWG  
GWH  
GWI  
GWJ  
ATOK



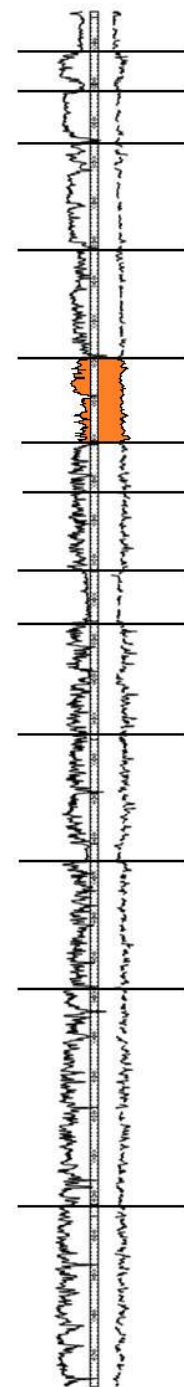


C.I= 20'

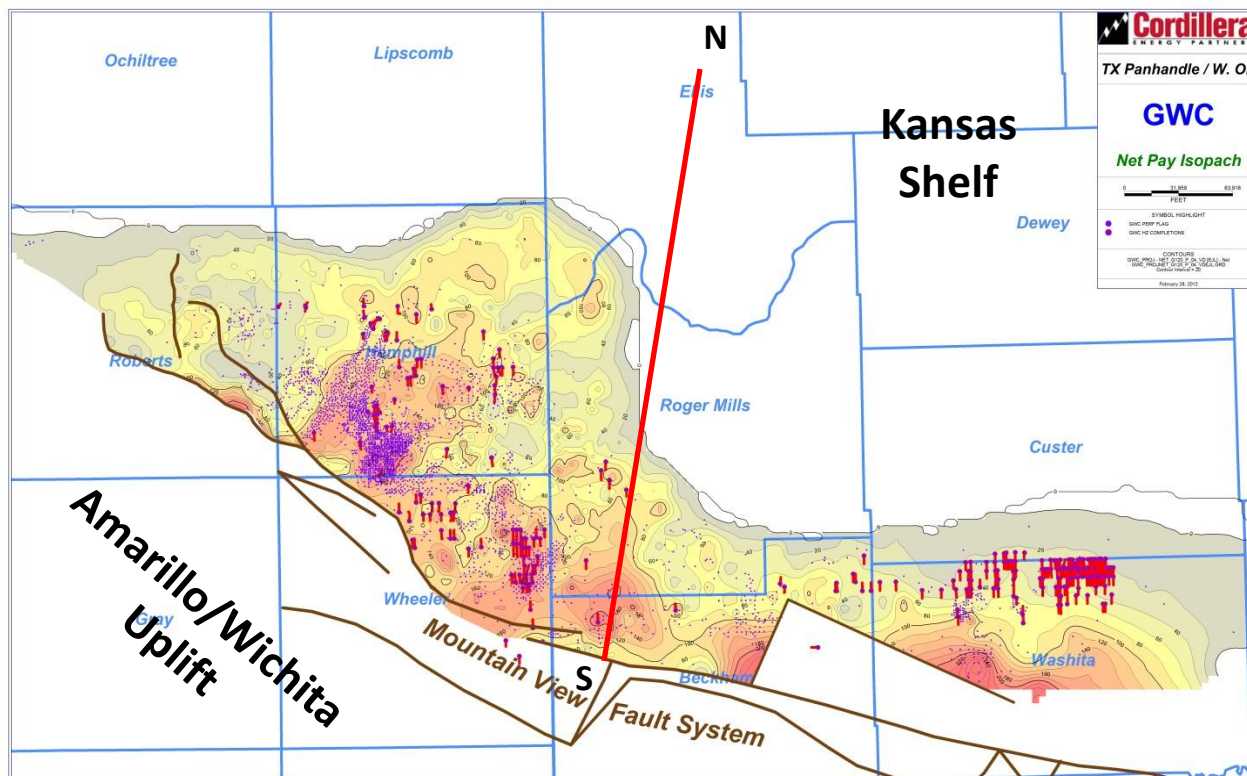


Granite Wash

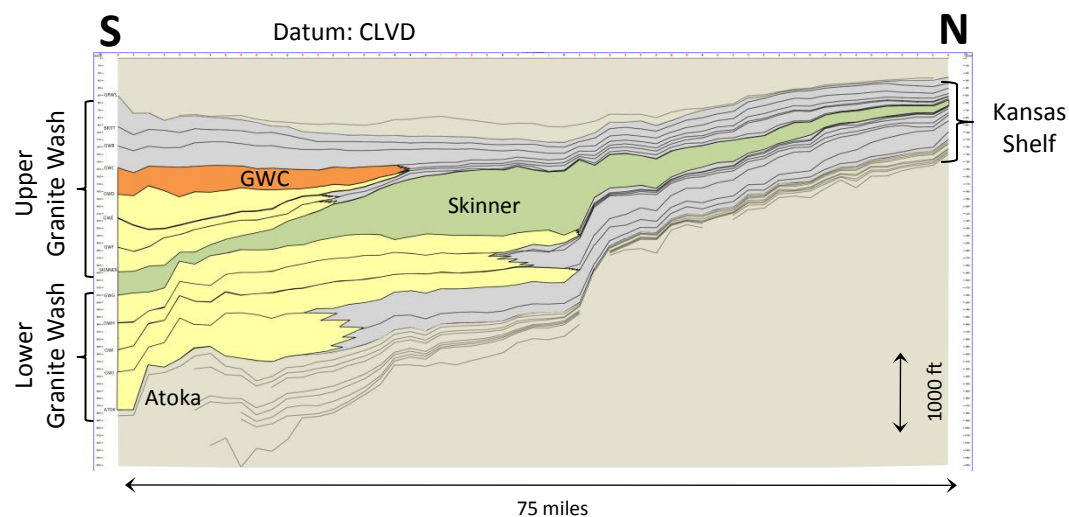
GRWS  
BRITT  
GWB  
GWC  
GWD  
**GWD**  
GWE  
GWF  
SKINNER  
GWG  
GWH  
GWI  
GWJ  
ATOK





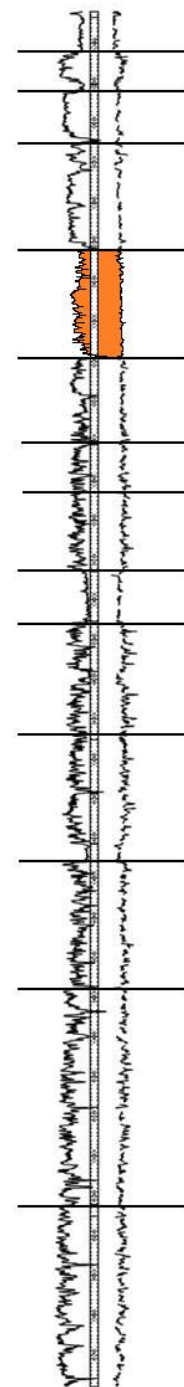


C.I= 20'

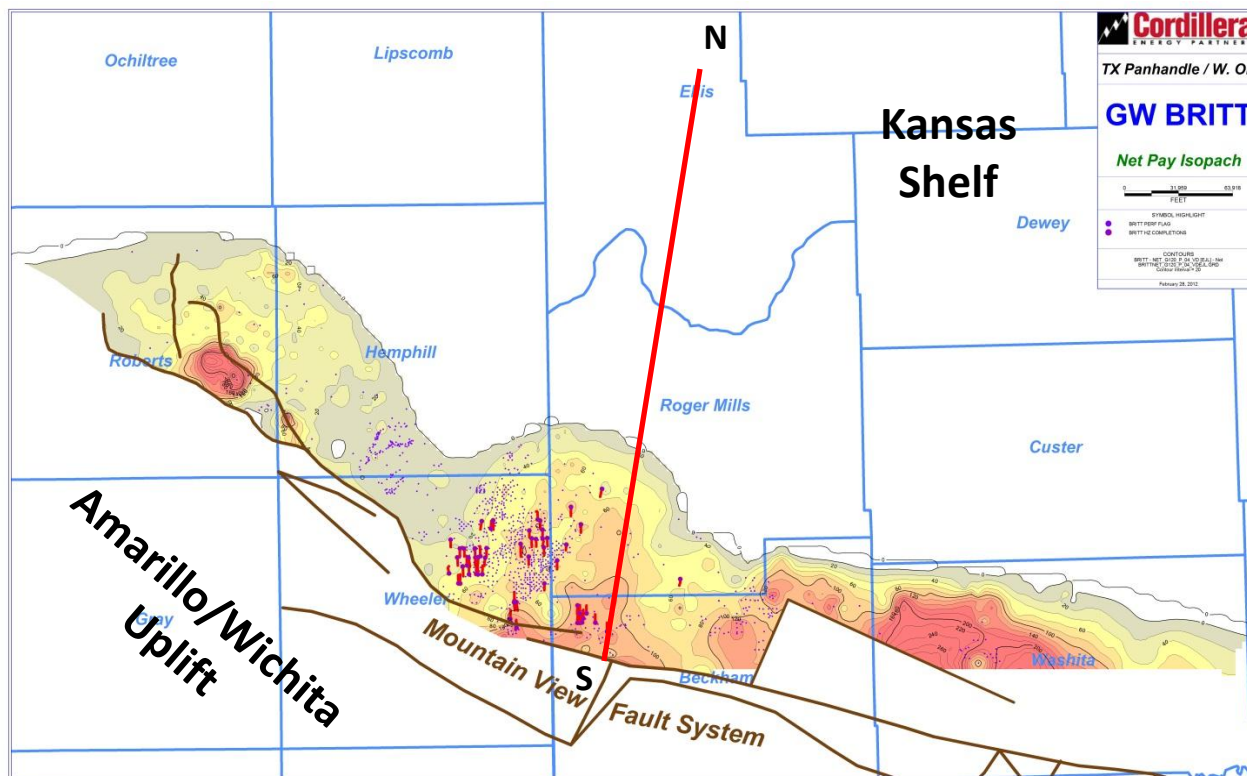


Granite Wash

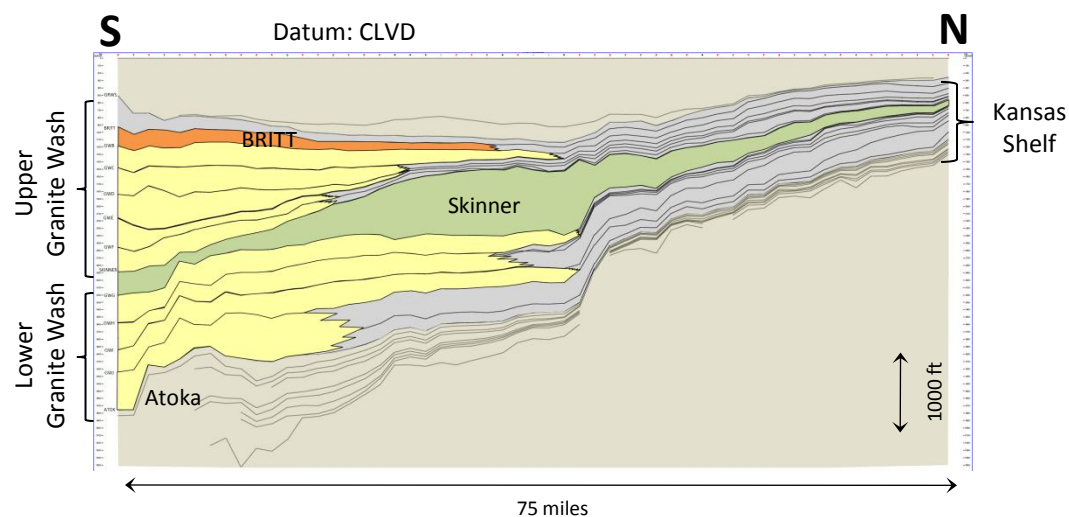
GRWS  
BRITT  
GWB  
GWC  
GWC  
GWD  
GWE  
GWF  
SKINNER  
GWG  
GWH  
GWI  
GWJ  
ATOK



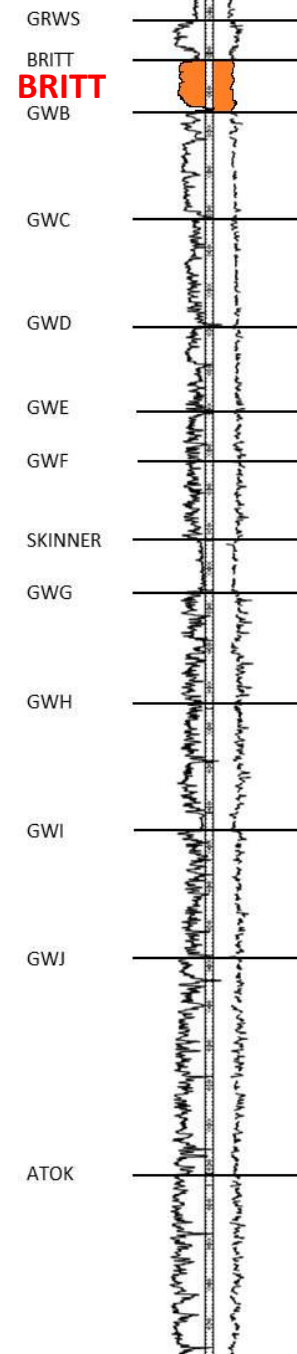




C.I= 20'



Granite Wash



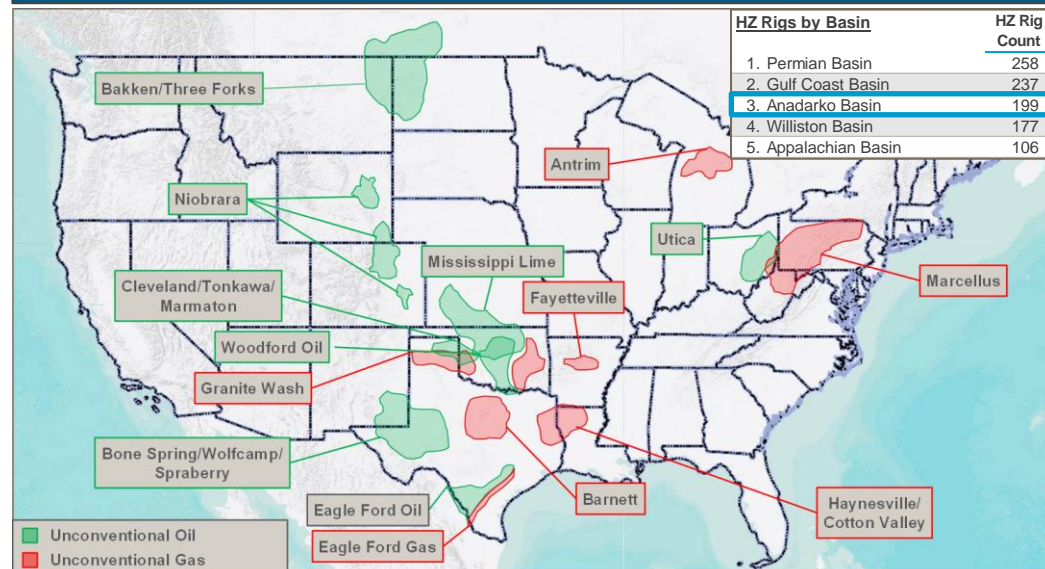


# Opportunity Overview

One of the Most Attractive North American Resource Plays

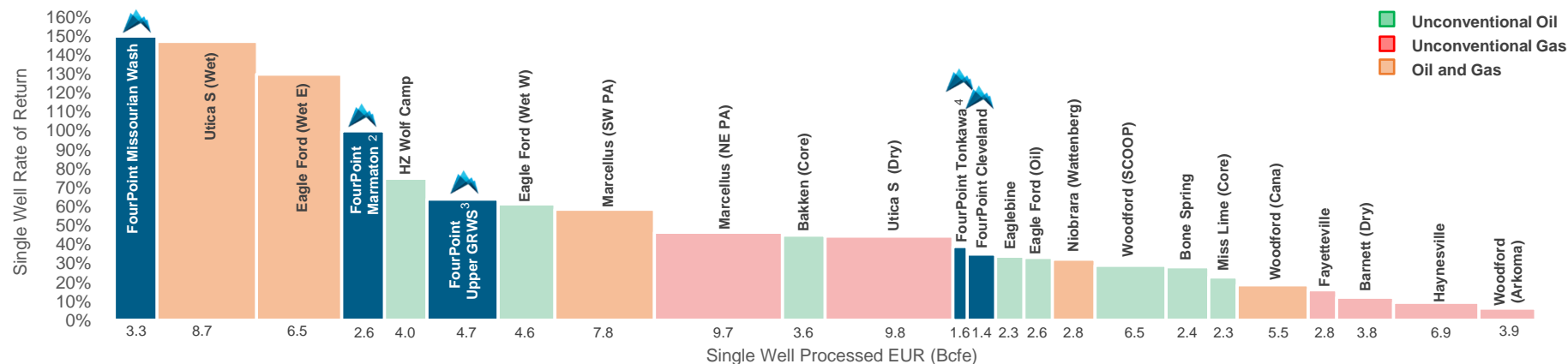
- Basin activity supported by superior economics and longevity of the play
- Evolving resource play; several zones in early stages of technological development
- Returns competitive with the best basins in the U.S.

## U.S. Shale Plays



Source: IHS Herold.

## Select Basin Type Curve Parameters<sup>1</sup>



<sup>1</sup> Source: Jefferies and Co.; May 29, 2014 NYMEX price strip.

<sup>2</sup> Includes upper and lower Marmaton Channel and Fan.

<sup>3</sup> Includes Britt and Granite Wash B, C, and D.

<sup>4</sup> Excludes TNKW Low GOR T2.

# Conclusion

---

- **Desmoinesian Granite Wash Play in the Anadarko Basin is one of the most active plays in the Continental United States.**
- **Clastics shed from the Wichita Mountain-Amarillo Uplift were deposited in the Anadarko Basin by sediment gravity flows creating a massive submarine sand complex.**
- **Anomalously pressured hydrocarbon system, both under- and overpressured.**
- **Produces both oil and gas, ratios vary laterally and vertically.**
- **Minimum of fifteen separate reservoirs.**
- **Advent of horizontal drilling technology and isolated multi-stage fracture stimulation has revolutionized play.**
- **New technology has enabled development of a giant field within a mature basin.**
- **As mapped today this field will take decades to develop, with new isolated reservoirs still being discovered.**