

A Structural Re-Evaluation of the Ardmore Basin*

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Abstract

We are attempting to interpret the original style of rifting of the Precambrian Southern Oklahoma Aulacogen and its influence on Pennsylvanian tectonics and structural styles. In contrast to the historical interpretation of a single symmetric or asymmetric graben, we propose that the SOA consisted of two asymmetric half-grabens linked by a transfer zone. Detailed studies of the Sho-Vel-Tum and Eola-Robberson Fields were conducted to better understand the structural and tectonic evolution of the basin. Evidence from the Sho-Vel-Tum area suggests flexural-slip folding, into-the-hinge thrust faulting during transpression, and a decrease in accommodation space to the northwest along anticlinal hinges. Evidence from the Eola-Robberson area suggests transpressional deformation with significant vertical uplift. Key differences between the field studies suggest that the orientation of maximum compression varies, with Sho-Vel-Tum showing a stronger compressional component than Eola-Robberson. In a related study, gravity and magnetic data along with basement well penetrations were used to construct a basement structure map. These results suggest that the deformation styles are heavily influenced by the orientation of pre-existing faults where east-west faults are dominated by strike-slip movement, and northwest-southeast faults are dominated by transpression. This study supports the hypothesis that the initial rift geometry was composed of two asymmetric half-grabens.

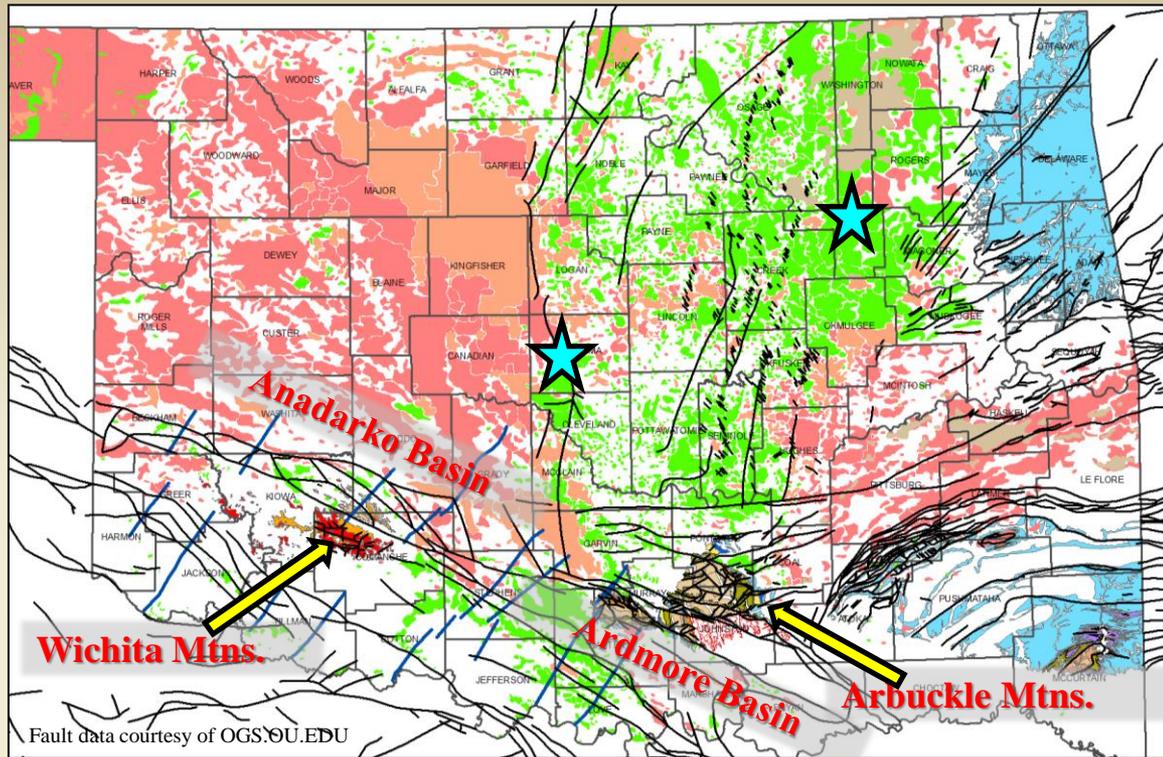
Selected References

Brewer, J.A., R. Good, J.E. Oliver, L.D. Brown, and S. Kaufman, 1983, COCORP profiling across the southern Oklahoma Aulacogen: Overthrusting of the Wichita Mountains and compression within the Anadarko Basin: *Geology*, v. 11, p. 109-114.

Granath, J.W., 1989, Structural evolution of the Ardmore basin, Oklahoma, U.S.A.: Progressive deformation in the foreland of the Ouachita collision: *Tectonics*, v. 8/5, p. 1015-1036.

Huisman, R.S., and C. Beaumont, 2003, Symmetric and asymmetric lithospheric extension: Relative effects of frictional-plastic and viscous strain softening: *Journal of Geophysical Research*, v. 108/B10, doi:10.1029/2002JB002026.

Kilic, D., 2013, Structural analysis of the Eola-Robberson Field using balanced cross sections, Garvin County, Oklahoma: M.S. Thesis, University of Tulsa, 143 p.



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University of Oklahoma

October 2015 AAPG MCS

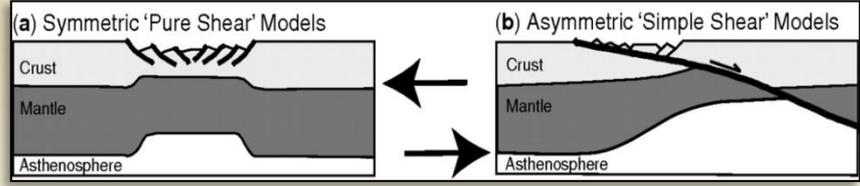
Outline

- Research Goals
- Geologic Background
 - Precambrian Rifting
 - Pennsylvanian Deformation
- Previous Work
- Current Project
 - Cross-Section Results
- Conclusions & Future work

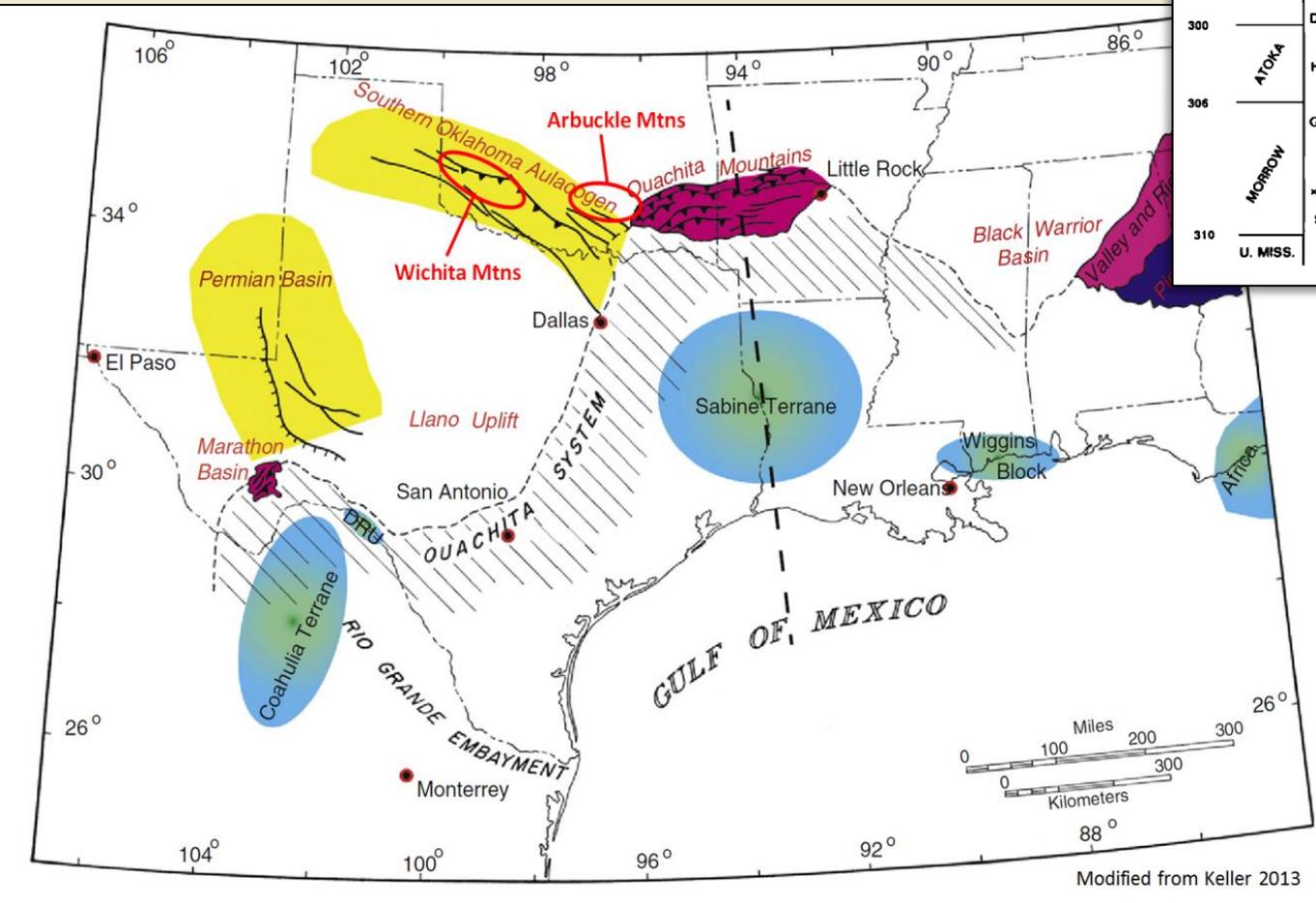
Geologic Background

Pre-Cambrian Aulacogen
 Pennsylvanian Orogeny

- Multiple pulses



AGE MYBP	SERIES	GROUP	FORMATION	MEMBERS	TECTONIC ACTIVITY
280	L. PERMIAN	PONTOTOC GROUP	Vanoss Fm.		ARBUCKLE
286	VIRGIL		Collings Ranch CGL.		
288	MISSOURI		Hoxbar Fm.	Zuckerman Ls.	msc. lms pebble classic conglomerate
				Daube Ls.	
				Anadarche Ls.	
				Crinerville Ls.	
DES MOINES			Deese Fm.	West Arm	msc. "Warren Ranch CGLS"
				Campground	
				Rocky Pt. Cgl.	
300	DORNICK HILLS GROUP	UPPER	Big Branch Fm.	Pumpkin Creek Ls.	2nd WICHITAN
				Frenley Ls.	
306	MORROW GROUP	LOWER	Golf Course Fm.	Jolliff Cgl.	
				Primrose Ss.	
310	U. MISS.	SPRINGER GROUP	Lake Ardmore SS.	Overbrook Rod Club Goddard-Caney	



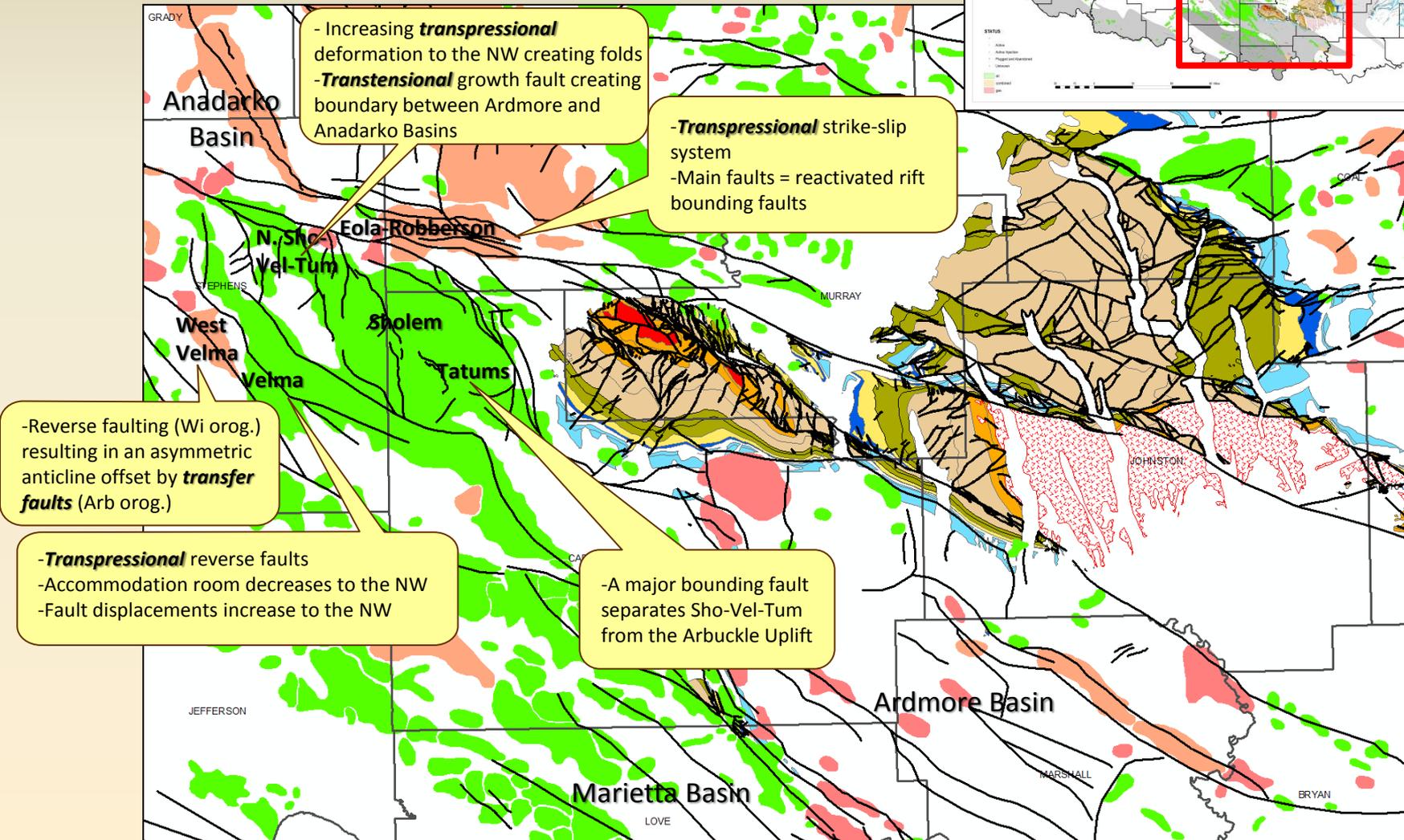
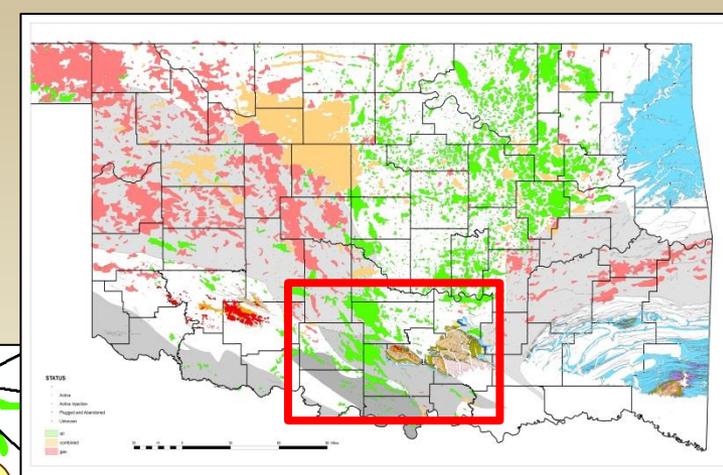
Modified from Keller 2013

Granath 1989

Previous Work: Field Studies

University of Tulsa

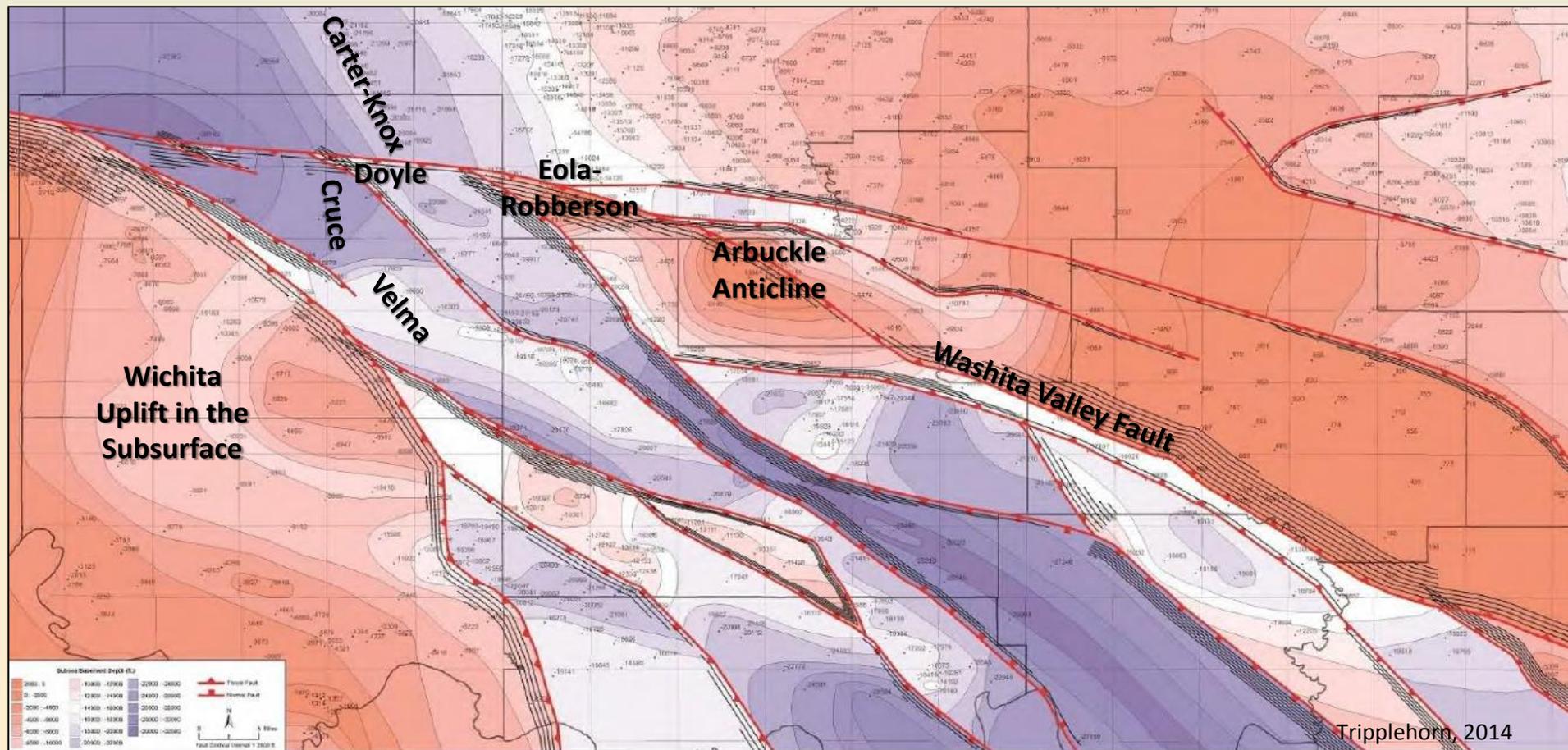
1. Eola-Robberson: Kilic 2013
2. Sho-Vel-Tum (Velma, Shoalem, Tatums, SW Arbuckle Anticline): Simpson 2011
3. West Velma: Akintomide 2014
4. N. Sho-Vel-Tum: Kocyigit 2014
5. Ardmore Basin basement faults: Tripplehorn 2014



Previous Work: Basement Faults

Pennsylvanian deformation styles due to orientation of pre-existing faults:

- E-W faults dominated by strike-slip movement
- NW-SE faults dominated by transpression



Current Project

Interpret Regional Cross-Sections

-Timing of deformation

- Onlapping
- Unconformities

-Levels of detachment

- Basement
- Deeper Paleozoic (Arbuckle detachment)
- Shallower Paleozoic (Springer detachment)
- Others?

-Amount of shortening

-Stress Directions

-Strain Path

Data

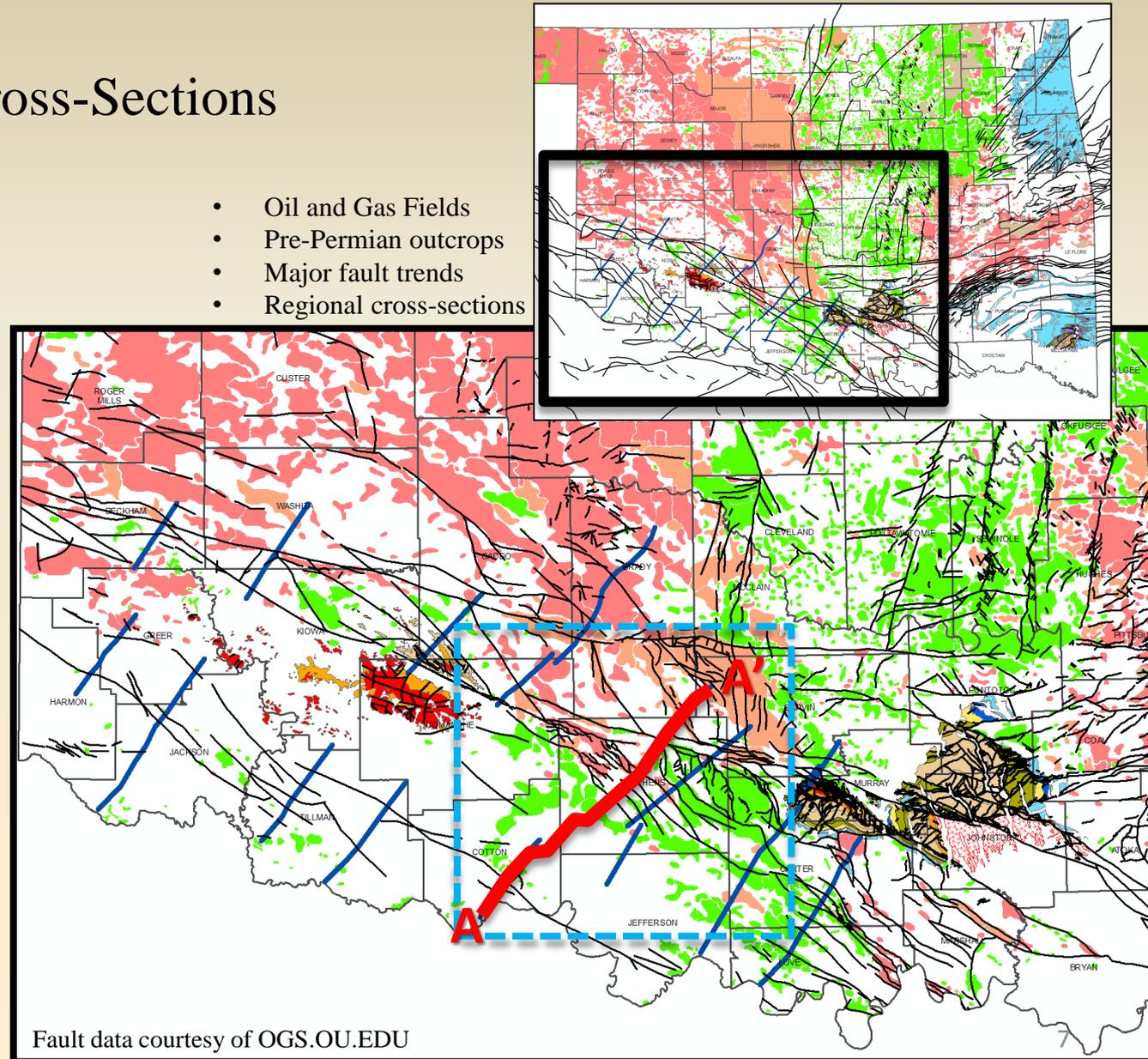
-2D/3D Data

-High resolution gravity & magnetic data

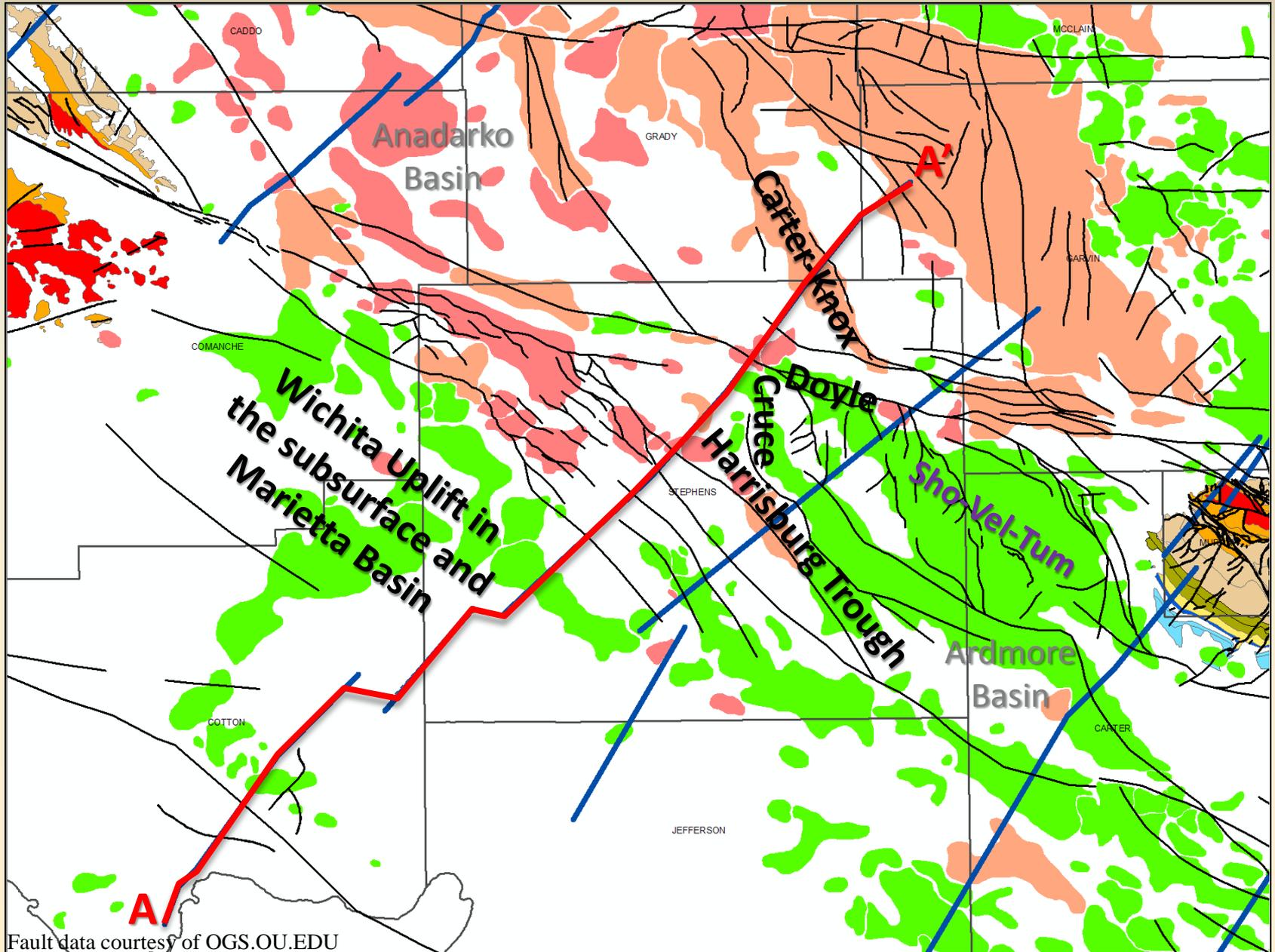
-Well data

-Surface geology

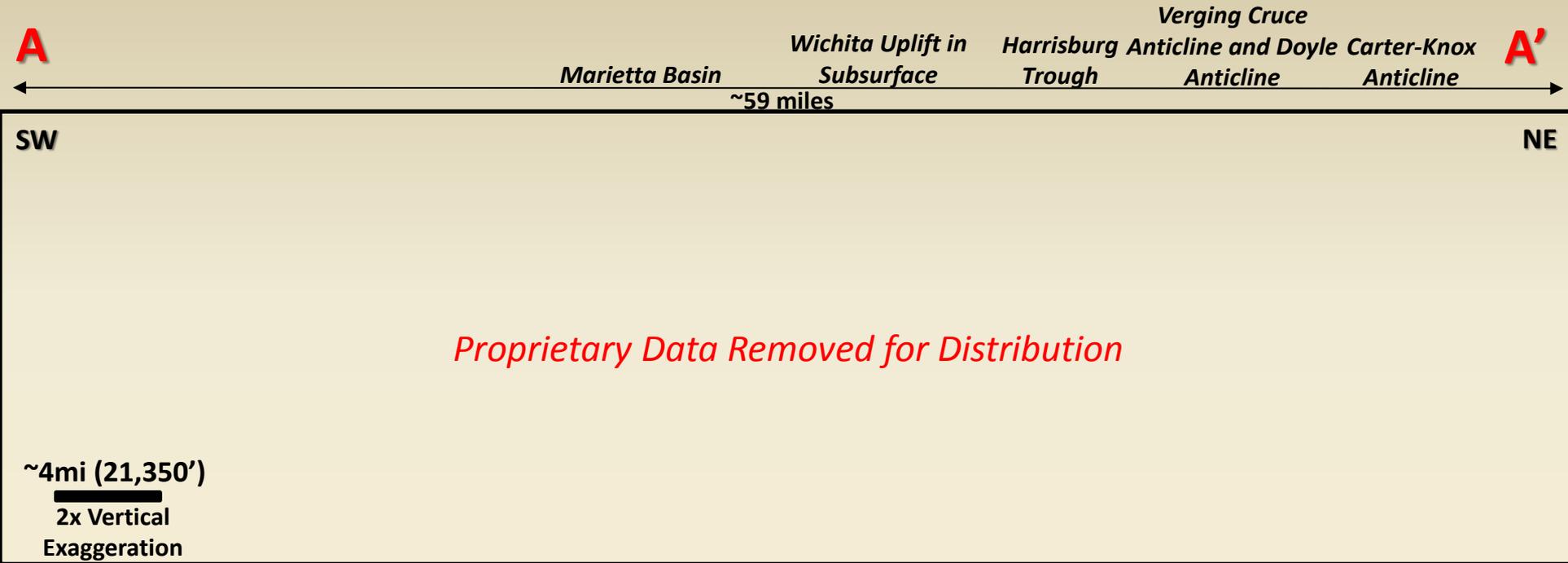
- Oil and Gas Fields
- Pre-Permian outcrops
- Major fault trends
- Regional cross-sections



Base Map



Uninterpreted Seismic Section



Seismic Data Courtesy of **MIDCON** Data Services, LLC and Seismic Exchange, Inc.; Interpretation is that of Molly Simpson

Interpreted Seismic Section w/ Wells

Verging Cruce

Marietta Basin Wichita Uplift in Subsurface Harrisburg Anticline and Doyle Trough Carter-Knox Anticline

A

A'

~59 miles

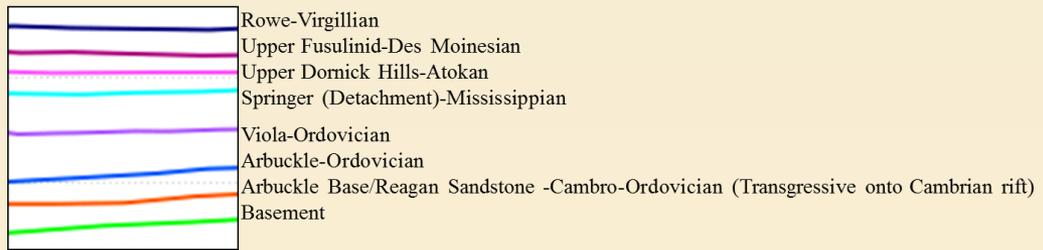
SW

NE

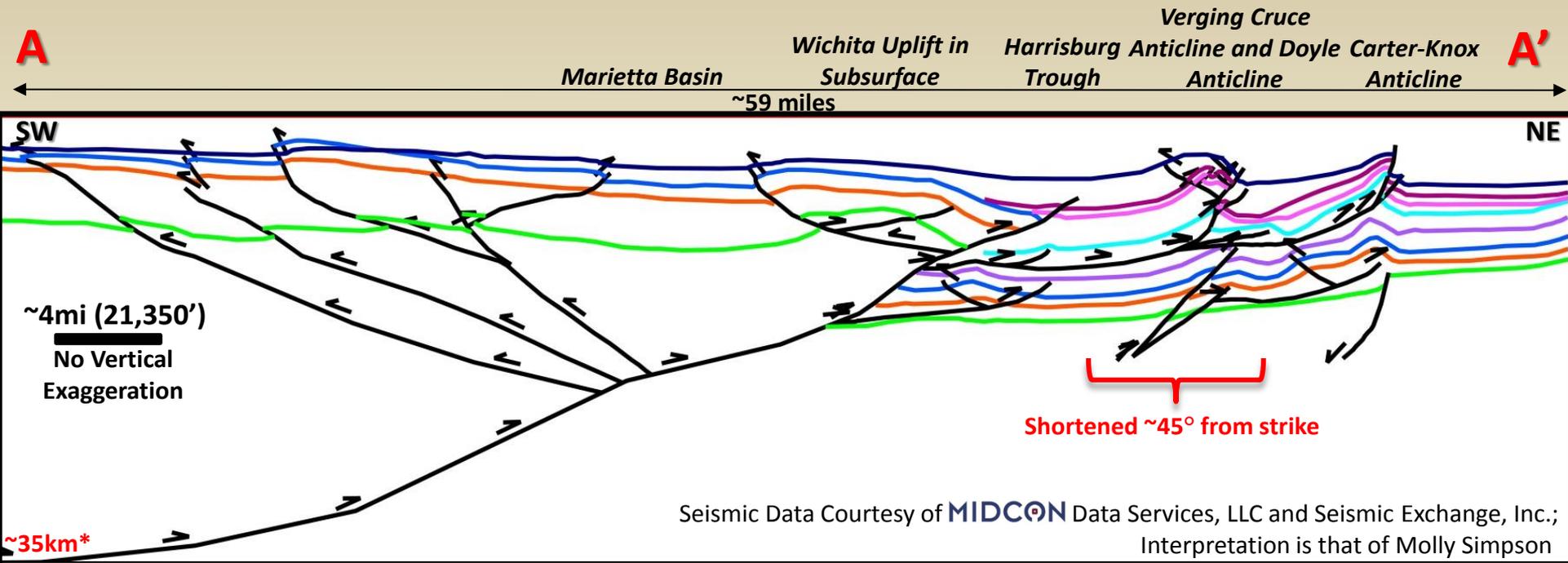
Proprietary Data Removed for Distribution

AGE MYBP	SERIES	GROUP	FORMATION	MEMBERS	TECTONIC ACTIVITY
280	L. PERMIAN	PONTOTOC GROUP	Vanos Fm.		
286	MISSOURI		Hoxbar Fm.	Zuckerman Ls. Daube Ls. Anadarche Ls. Crinerville Ls. Confederate Ls.	ARBUCKLE
288	DES MOINES		Deese Fm.	West Arm Campground Rocky Pt. Cgl. Devils Kitchen	ARBUCKLE
300	ATOKA	DORNICK HILLS GROUP	Big Branch Fm.	Pumpkin Creek Ls.	
306	MORROW		Golf Course Fm.	Jolliff Cgl. Primrose Ss.	1st WICHITAN
310	U. MISS.	SPRINGER GROUP	Lake Ardmore SS.	Overbrook Flod Club Goddard-Caney	

and Seismic Exchange, Inc.; Interpretation is that of Molly Simpson

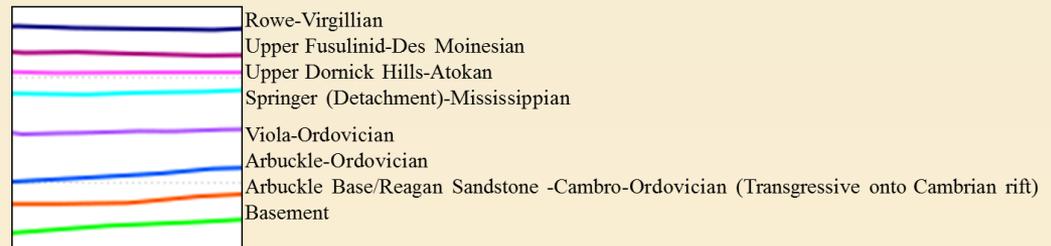


Interpreted Cross-Section



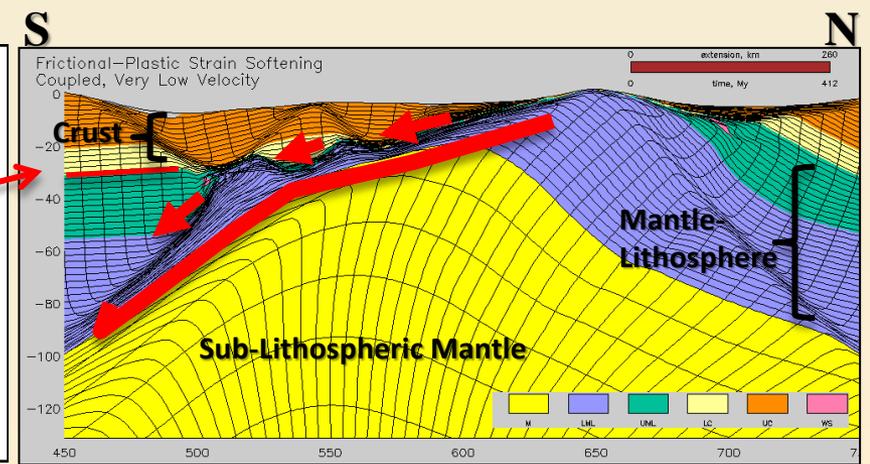
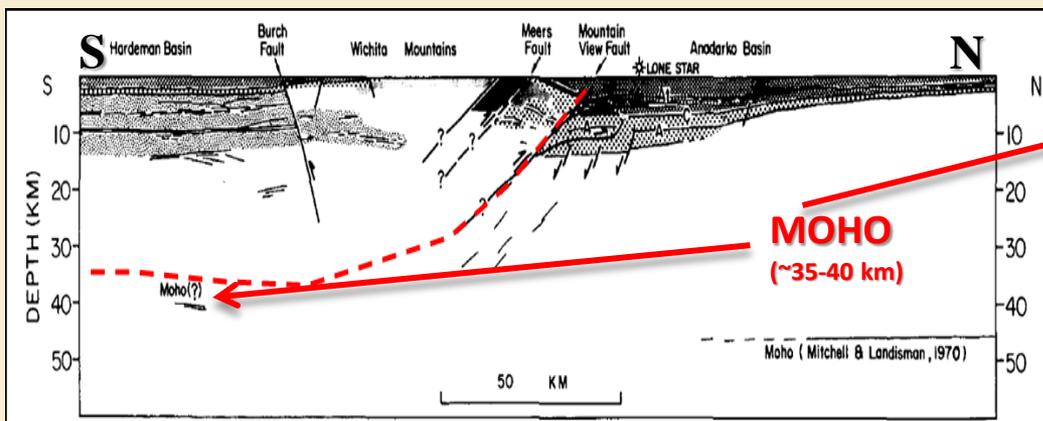
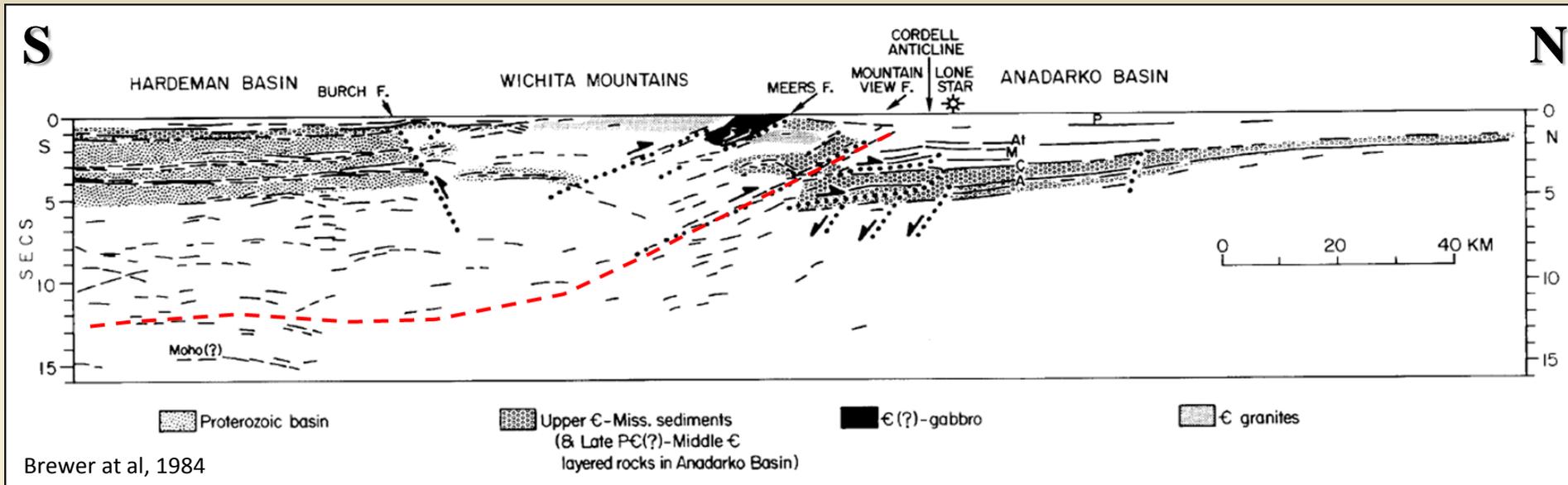
***Based on COCORP Data from Brewer et al., 1983/1984**

- Model for deep detachment
 - COCORP Data
 - Numeric rift models
- Balancing results
 - ~4.9 mi slip on deep detachment
 - Cruce anticline is at ~45° to shortening (3D time slice)

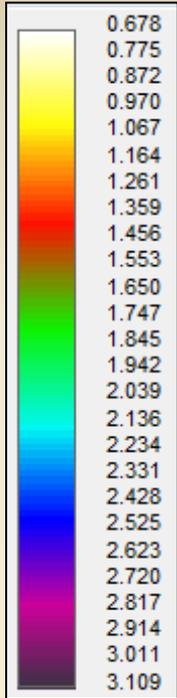


Model for Deep Detachment

COCORP Study: Consortium for Continental Reflection Profiling “Deep Seismic Data”



Time Structure Map



Proprietary Data Removed for Distribution

**Hoxbar Time
Structure
C.I. 0.05ms**

3D Cross-Section w/ “Light Interpretation”

*Wichita
Uplift*

Harrisburg Trough

*Cruce
Anticline*

*Doyle
Anticline*

*Carter-Knox
Anticline*

B

B'

Proprietary Data Removed for Distribution

*Igneous/
Rhyolite*

Springer???

*Viola-
Arbuckle???*

10,000'
10,000'

~2x V.E.

Retrodeformation

Simple Line Length Restoration

Shortening***

- ROWE 2mi (10,520')
- FSLD 3.7 mi (19,425')
- DKHL 3.4 mi (17,805')
- SPRG 2.9 mi (15,375')
- ABCK 10 mi (53,415'); NE of WT 1.2 mi (6,475')
- BSMT 13mi (68,795'); NE of WT 0.9mi (4,855')

Fault Slip

WT ABCK Displacement

- Slip 4.9 mi (25,875')
- Uplift 1.7 mi (8,975')
- Throw 4.7 mi (24,815')

Cruce/Doyle FSLD***

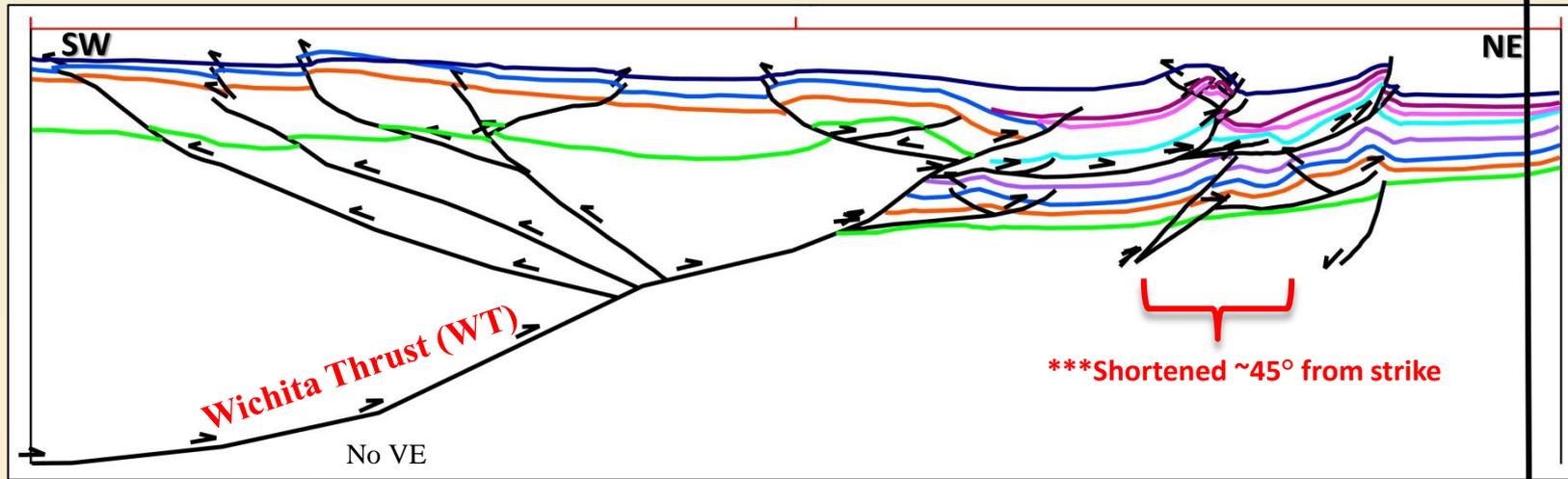
- Slip 1.2 mi (6,150')
- Uplift 0.9 (4,730')
- Throw 0.7 mi (3,785')

Carter-Knox FSLD

- Slip 1 mi (5,675')
- Uplift 0.9 (4,730')
- Throw 0.3 mi (1,420')

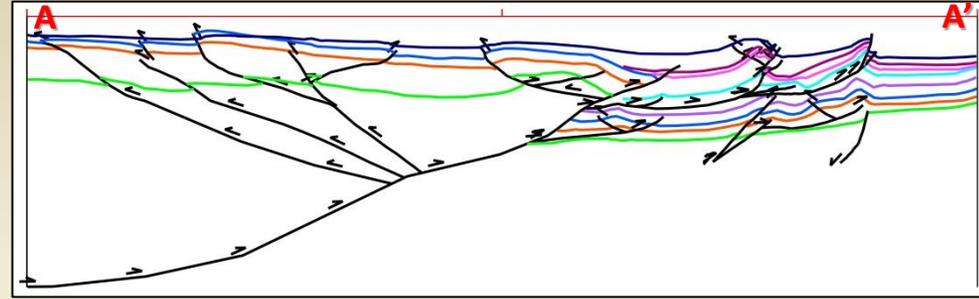
1.5 VE

Pin Line



Conclusions & Future Work

- Part of an *ongoing* research project to unravel the aulacogen
- Regional cross sections
- Strain paths
- Stress directions
- Timing of deformations



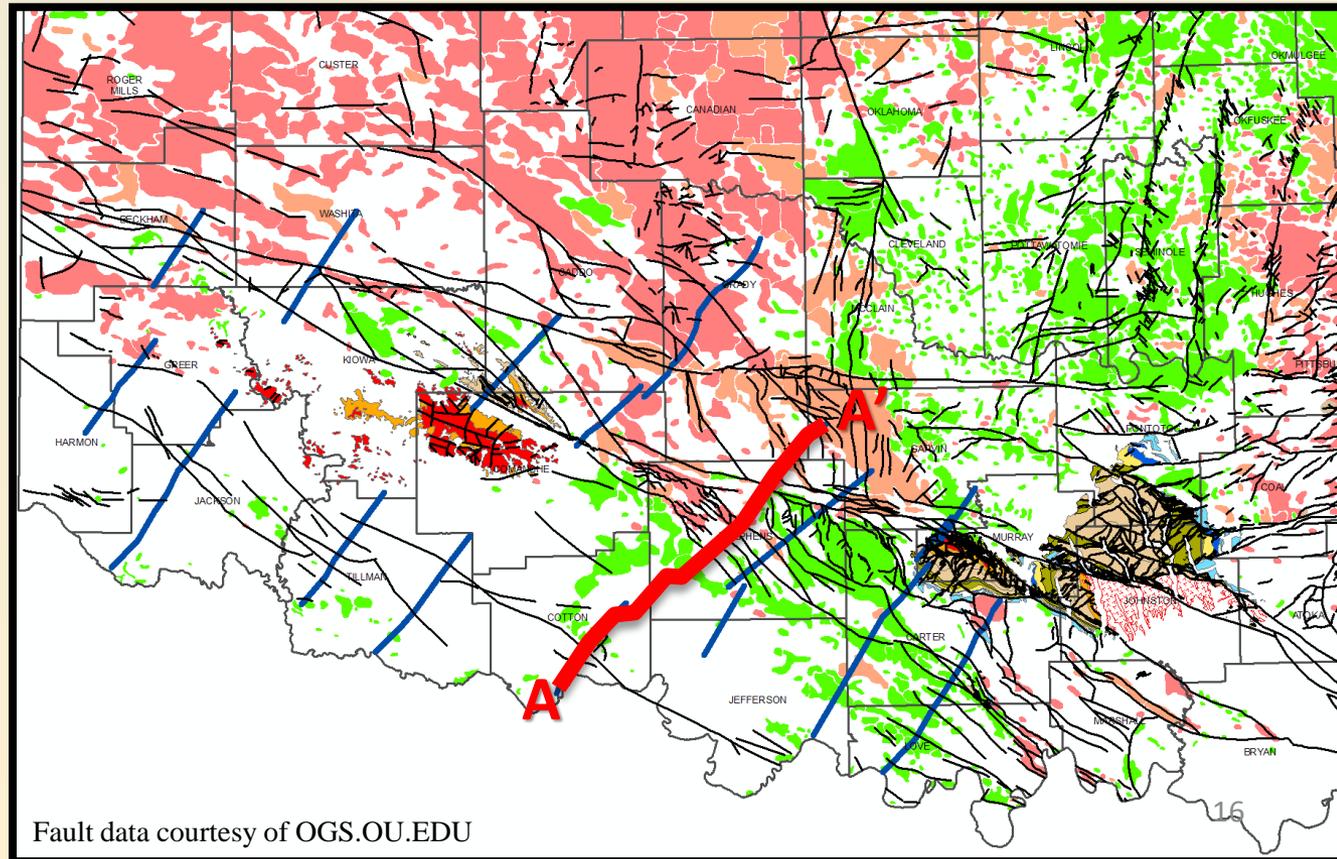
A-A' Results

- Could have up to 10 mi of shortening-Based on ABCK horizon
- WT had ~4.9 mi of slip
- Springer detachment
- Basement detachment

Future Work

- Continue interpreting regional cross-sections and tie them together
- Map faults above and below different detachment levels, how do they line up?
- Understand strain paths and stress directions-How did the 'whole' system move?

Can the original rift geometry be determined?





The End

Special Thank You to:

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