Echo from the Past: The Finney-Scott Basin, 320 Million Years Ago and Today, Finney and Scott Counties, Kansas*

John R. Mitchell[1]

Search and Discovery Article #30360 (2014)**
Posted September 8, 2014

*Adapted from presentation at Tulsa Geological Society dinner meeting, October, 2013, and presented at Kansas Next Step Oil and Gas Conference, Hays, KS, August, 2013
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Abstract

In the Hugoton Embayment in Scott and Finney Counties, Kansas a small depositional sub-basin formed approximately 320 million years ago during Early Pennsylvanian Morrowan time. The sub-basin extends along an elongate north-south axis from Township 18 South, Ranges 32 and 33 West southwards to Township 22 South Ranges 32 and 33 West. Covering approximately 250 square miles, the sub-basin was primarily the site of shale deposition with minor amounts of limestone and sandstone also being deposited. The Morrowan sediments have an aggregate thickness of as much as 265 feet, but more commonly they are 80 to 150 feet thick and thin rapidly to the east and west. A range of buried hills formed by the underlying Mississippian age limestones of the St. Genevieve Formation formed the western edge of the sub-basin. These buried hills are along an anticlinal belt extending northward through Finney County into Scott County. St. Louis Formation (Mississippian) oolitic limestone reservoirs are oil productive along this trend at depths of 4700 to 4800 feet. Lenticular Morrowan sandstones are also oil productive at depths of approximately 4600 feet in structural-stratigraphic traps in fields such as Hugoton North and Damme.

In 1940's the Kansas Geological Survey published two reports on the geology and groundwater resources of Finney and Scott counties (Latta, 1944; Waite, 1947). In the reports the names "Finney Basin" and "Scott Basin" were applied to a topographic basin present today at the surface in the two counties. The "Finney-Scott Basin" is an unusual closed topographic basin at the eastern terminus of Whitewoman Creek and several smaller ephemeral streams. It formed quite recently due to dissolution of the Blaine Salt (Permian) at a depth of 1600 feet. Interestingly it closely overlies the Morrowan sub-basin at a depth of 4600 feet. This overlay is believed to be the result of recurrent structural and fluid movement along a deep seated fault zone.

References Cited

Adler, F.J., W.M. Caplan, M.P. Carlson, E.D. Goebel, et al., 1971, Future petroleum provinces of the Mid-Continent, Region 7, *in* I.H. Cram, ed., Future petroleum provinces of the United States their geology and potential: AAPG Memoir 15, p. 985-1120.

Latta, B.F., 1944, Geology and ground-water resources of Finney and Gray counties, Kansas (with analyses by E.O. Holmes): Kansas Geological Survey Bulletin 55 (http://www.kgs.ku.edu/General/Geology/Franklin/index.html) (website accessed August 16, 2014).

Waite, H.A., 1947, Geology and ground-water resources of Scott County, Kansas: Kansas Geological Survey Bulletin 66 (http://www.kgs.ku.edu/General/Geology/Scott/07_levels.html) (website accessed August 16, 2014).

Echo From The Past: The Finney-Scott Basin, 320 Million Years Ago and Today, Finney & Scott Counties, Kansas

January 2014

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Tulsa, Oklahoma

Key Points

- The Finney-Scott Basin is a surface drainage depression encompassing ~750 square miles in Finney and Scott Counties, Kansas
- It was formed in the recent past from dissolution of the Blaine Evaporite (Permian) at an average depth of 1500 feet.
- The dissolution edge overlies a forty-mile-long, north-south-trending structural feature (Finney-Scott structure) that formed significant structural and/or paleotopgraphic relief during Late Mississippian (Meramecian) to Early Pennsylvanian (Atokan) time
- The structural and/or paleotopographic relief was mostly filled in the early Pennsylvanian (320 MYBP) by deposition of as much as 250 feet of shale, limestone and sandstone of the Morrowan/Atokan stages
- Sandstone deposition in the Morrowan/Atokan was strongly influenced by the depositional topography with little or no sandstone present on the Mississippian topographic highs
- Isopach and structural maps of various post-Morrowan stratigraphic intervals suggest the Finney-Scott structure had recurring movement
- This movement probably localized groundwater circulation that resulted in dissolution of the Blaine evaporite unit along the north-south structural zone
- In effect, the current-day Finney-Scott Basin reflects the earlier development of the Late Mississippian to Atokan sub-basin from 340 million years B.P.

Shaded Relief Map Showing Location of Focus Area

Stratigraphic Column for Area

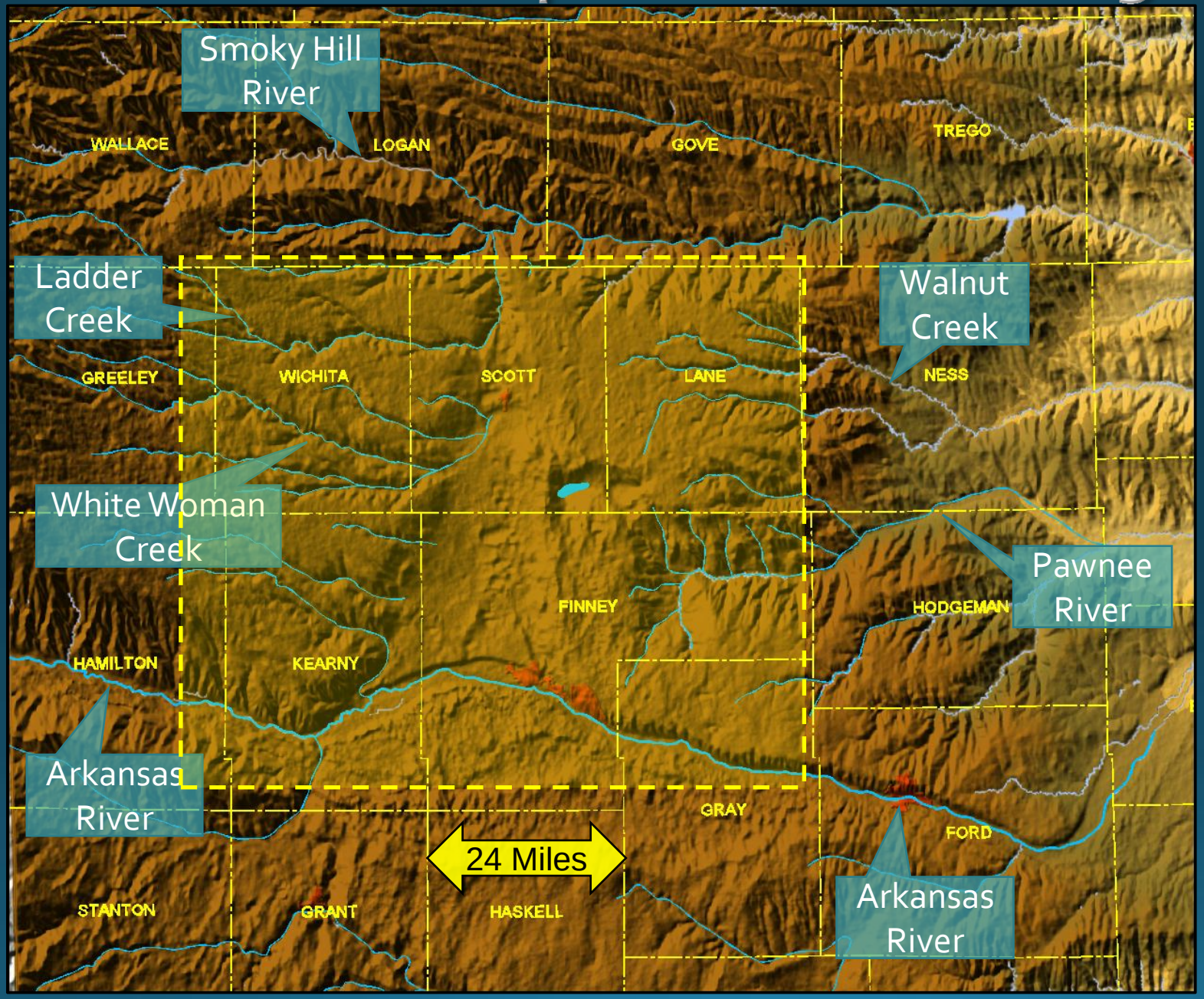
1500' Mapping Horizons/Depth

● Oil Producing Horizon

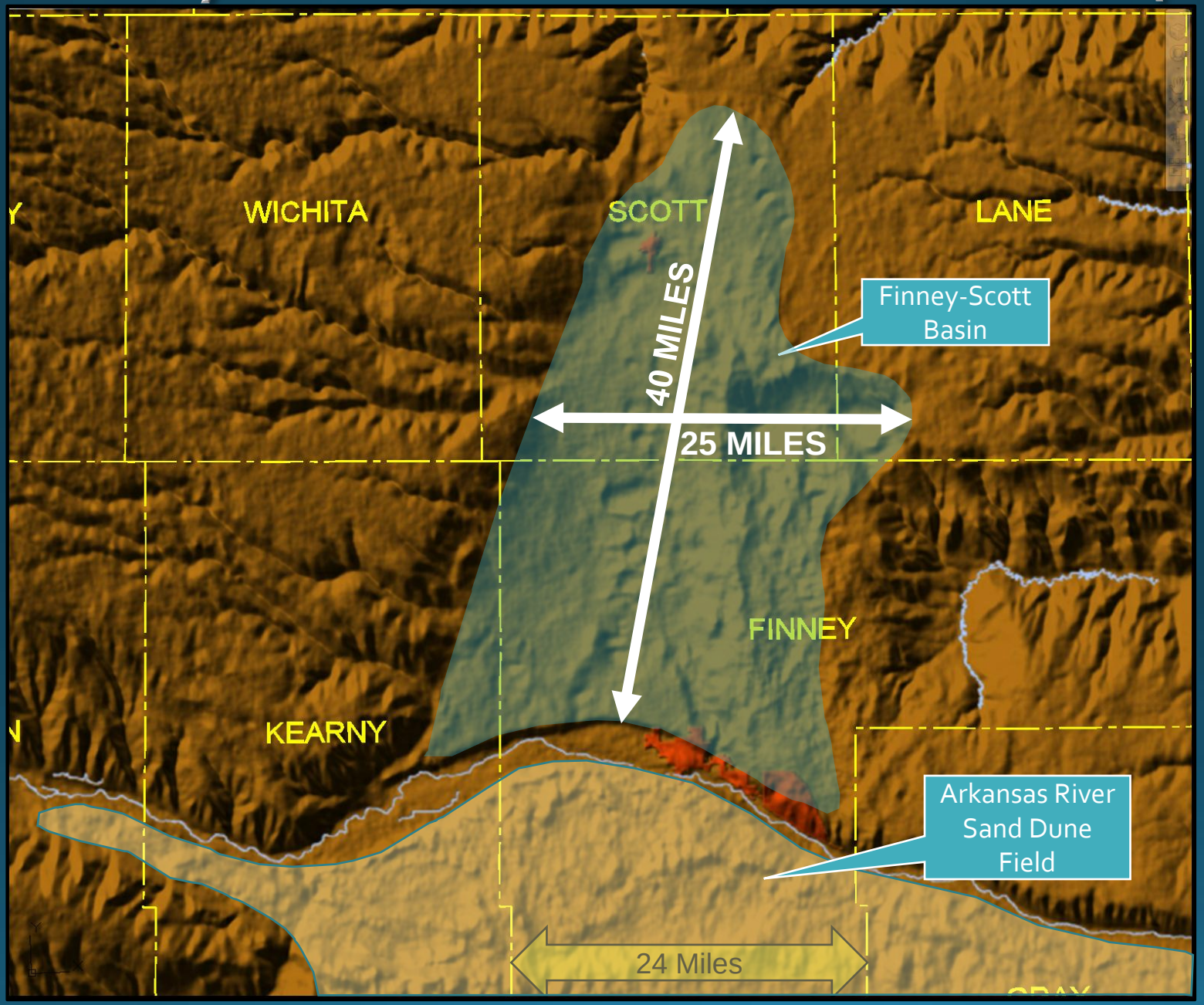
SYS.	STAGE/SERIES	GROUP	FORMATION
QUATERNARY	PLEISTOCENE	Loess, Sand Dunes, Fluvial Deposits	
NEOGENE	PLIOCENE MIOCENE	Ogallala Formation	
CRETACEOUS	UPPER	Colorado Group	Niobrara Chalk Smoky Hill Member Fort Hays Member Carlile Shale Greenhorn Limestone
	LOWER	Dakota Formation Kiowa Formation Cheyenne Sandstone	
PERMIAN	GUADALUPIAN	Whitehorse Formation	
	LEONARDIAN	Nippewalla Group	Dog Creek Formation Blaine Formation Flowerpot Shale 1500'
		Sumner Group	Stone Corral Formation Ninnescah Shale Wellington Formation
	WOLFCAMPIAN	Chase Group	Winfield Limestone Krider Limestone
		Council Grove Group	Beattie Limestone
		Admire Group	Foraker Limestone

		Council Grove Group	Beattie Limestone
PENNSYLVANIAN	VIRGILIAN	Admire Group	Foraker Limestone
		Wabaunsee Group	Emporia Limestone
		Shawnee Group	Topeka Limestone
		Douglas Group	Heebner Shale 3600'
	MISSOURIAN	Lansing Group ●	Stanton Limestone
		Kansas City Group ●	Dennis Limestone Swope Limestone
		Pleasanton Group	
	DESMOINESIAN	Marmaton Group ●	Pawnee Limestone Fort Scott Limestone
		Cherokee Group	Excello Shale 4400'
	ATOKAN	●	
	MORROWAN	Kearny Formation ●	4800'
MISSISSIPPIAN	MERAMECIAN	St. Genevieve Limestone ● St. Louis Limestone Salem Limestone Warsaw Limestone	4900'
	OSAGIAN	Keokuk Limestone Burlington Limestone	

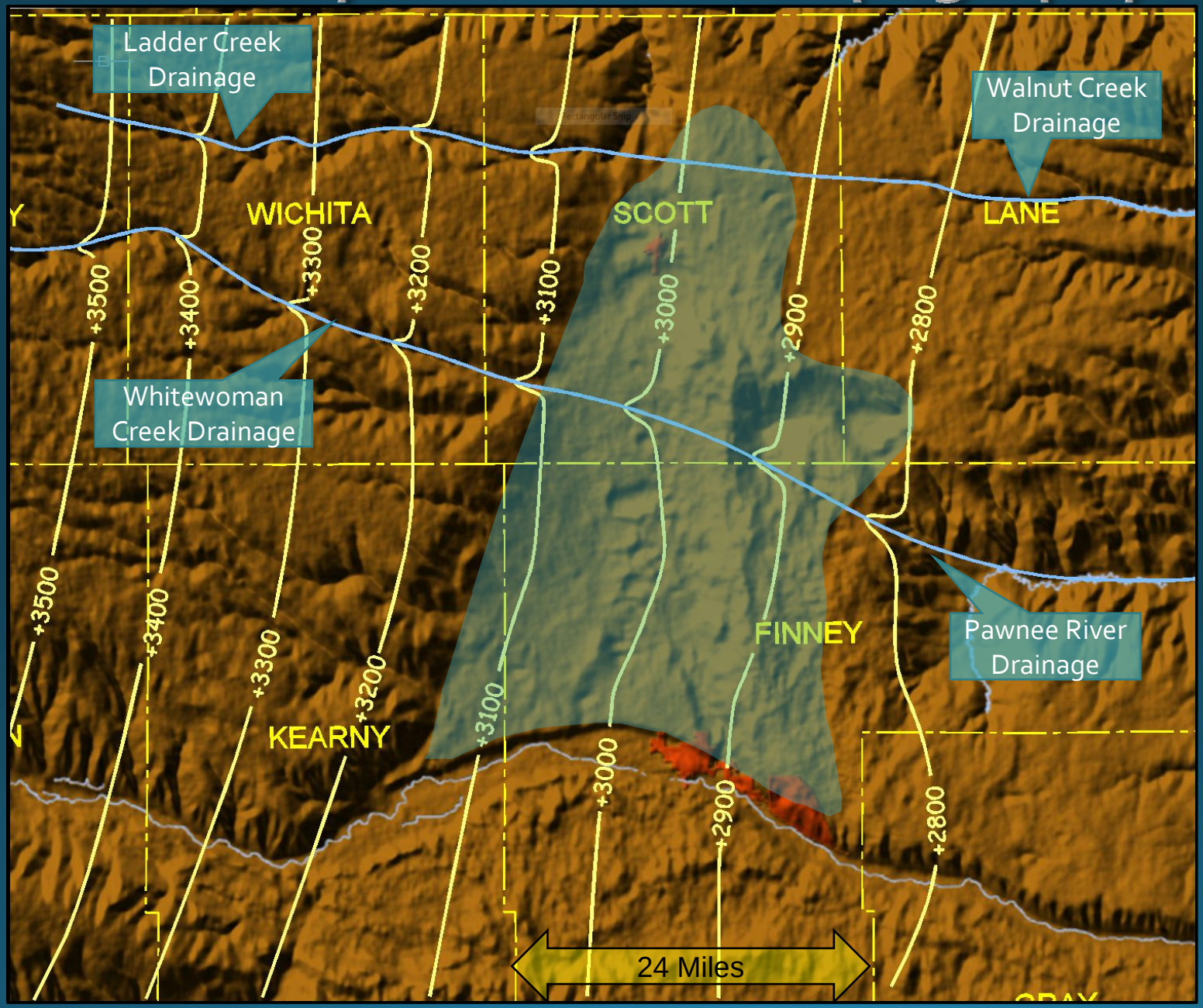
Shaded Relief Map & Stream Drainages



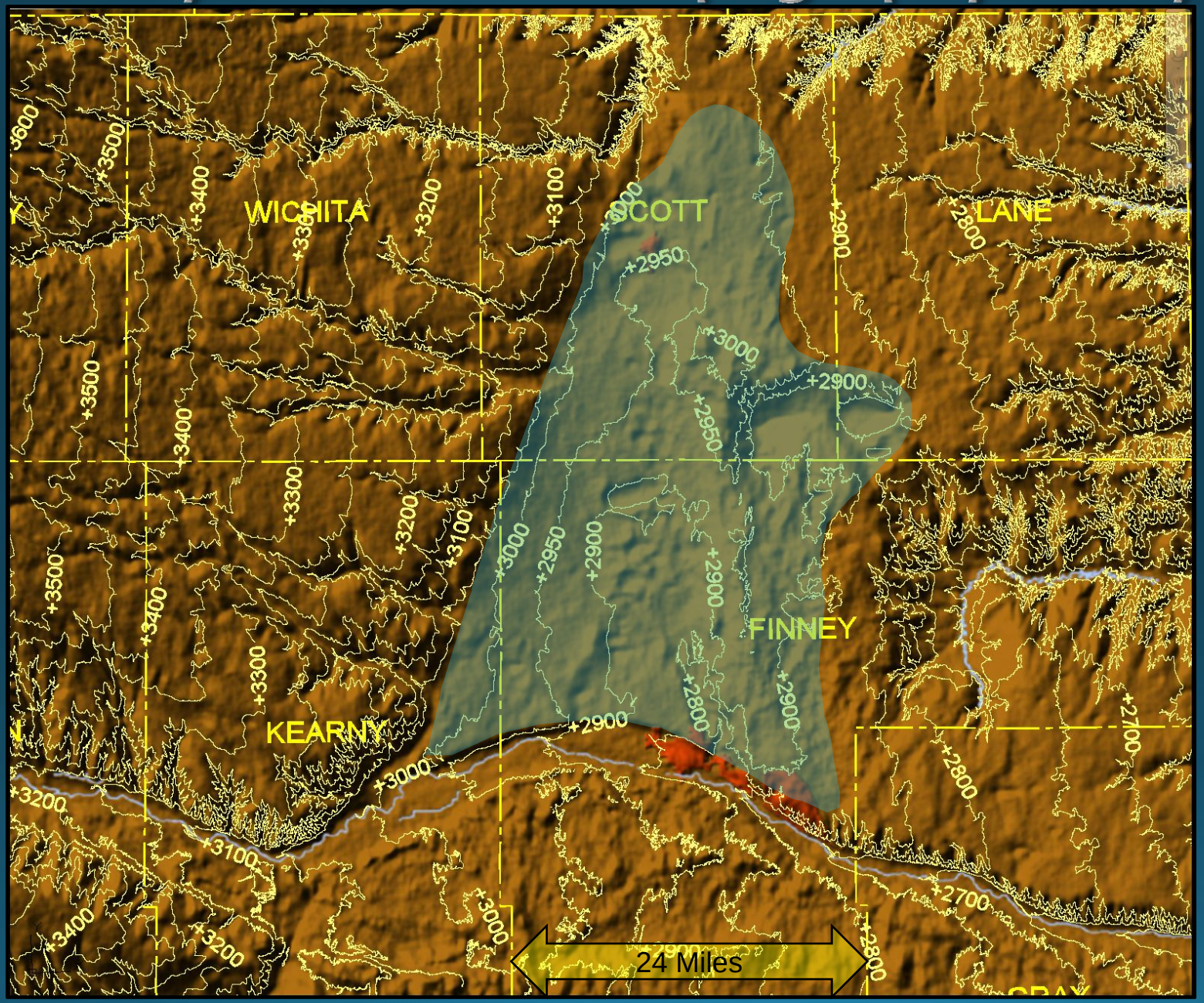
Finney-Scott Basin: Shaded Relief Map



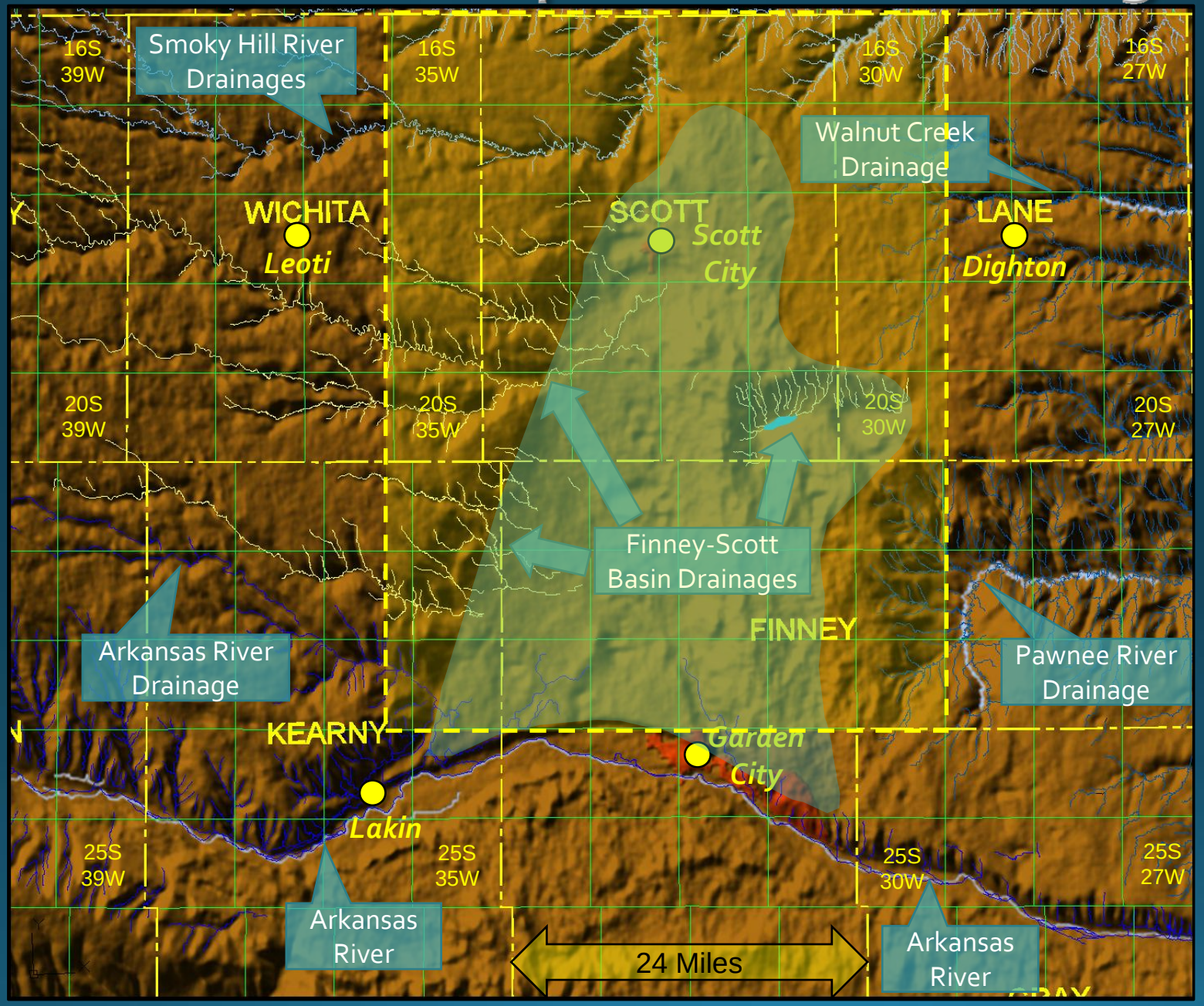
Pre-Finney-Scott Basin Topography?



Finney-Scott Basin Topography Today



Shaded Relief Map & Stream Drainages



Evolution of the Scott-Finney Basin

Stratigraphic Column-Top of the Mississippian

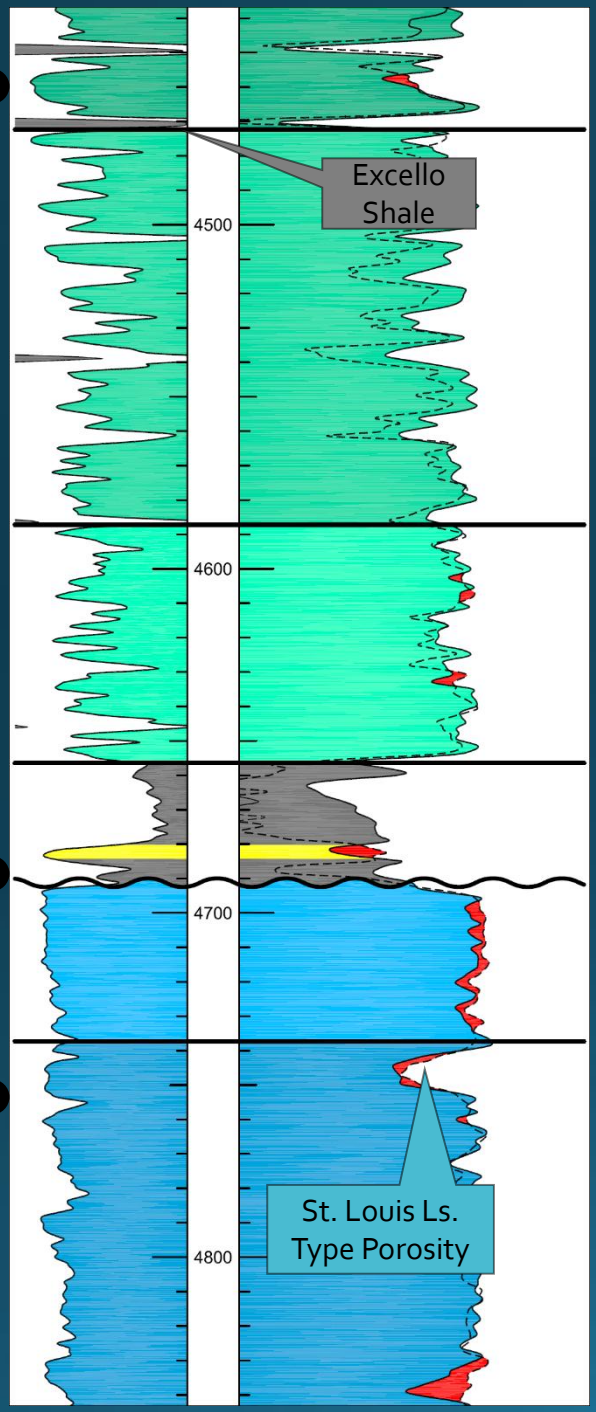
SYS.	STAGE/SERIES	GROUP	FORMATION
QUATERNARY	PLEISTOCENE	Loess, Sand Dunes, Fluvial Deposits	
NEOGENE	PLIOCENE MIOCENE	Ogallala Formation	
CRETACEOUS	UPPER	Colorado Group	Niobrara Chalk Smoky Hill Member Fort Hays Member Carlile Shale Greenhorn Limestone
	LOWER	Dakota Formation Kiowa Formation Cheyenne Sandstone	
PERMIAN	GUADALUPIAN	Whitehorse Formation	
	LEONARDIAN	Nippewalla Group	Dog Creek Formation Blaine Formation Flowerpot Shale
		Sumner Group	Stone Corral Formation Ninnescah Shale Wellington Formation
	WOLFCAMPIAN	Chase Group	Winfield Limestone Krider Limestone
		Council Grove Group	Beattie Limestone
		Admire Group	Foraker Limestone

		Council Grove Group	Beattie Limestone
PENNSYLVANIAN	VIRGILIAN	Admire Group	Foraker Limestone
		Wabaunsee Group	Emporia Limestone
		Shawnee Group	Topeka Limestone
		Douglas Group	Heebner Shale
	MISSOURIAN	Lansing Group ●	Stanton Limestone
		Kansas City Group ●	Dennis Limestone Swope Limestone
		Pleasanton Group	
	DESMOINESIAN	Marmaton Group ●	Pawnee Limestone Fort Scott Limestone
		Cherokee Group	Excello Shale
	ATOKAN		
	MORROWAN	Kearny Formation ●	
MISSISSIPPIAN	MERAMECIAN	St. Genevieve Limestone ● St. Louis Limestone Salem Limestone Warsaw Limestone	
	OSAGIAN	Keokuk Limestone Burlington Limestone	

← Map Horizon

● Oil Producing Horizon

Finney-Scott Basin Type Log-St. Louis Ls. To Marmaton Group:



Marmaton Gp. Desmoinesian

Cherokee Group Desmoinesian Stage (Pennsylvanian)

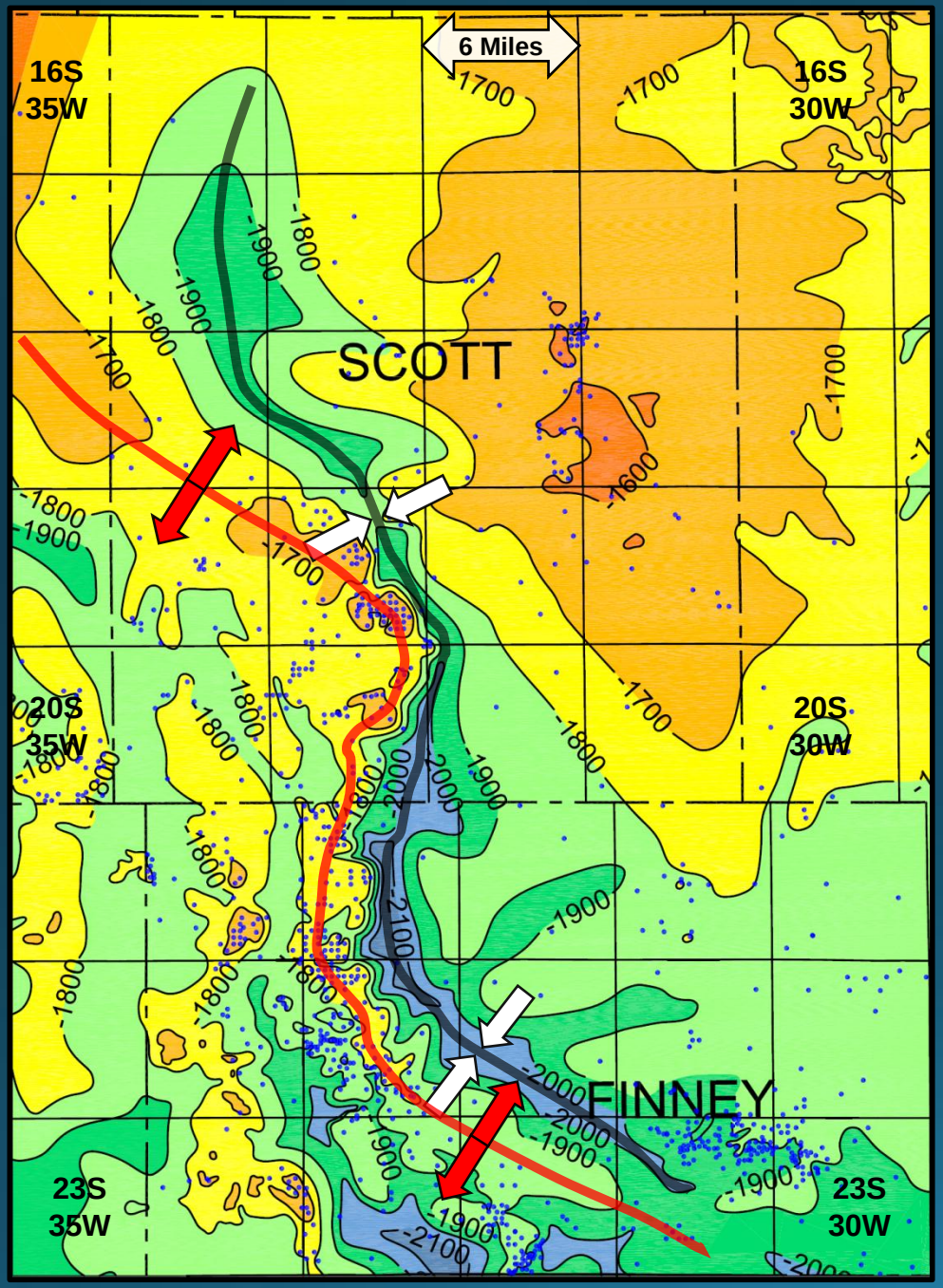
Atokan Stage (Pennsylvanian)

Morrowan-Atokan Clastics (Pennsylvanian)

St. Genevieve Ls. (Mississippian)

St. Louis Ls. (Mississippian)

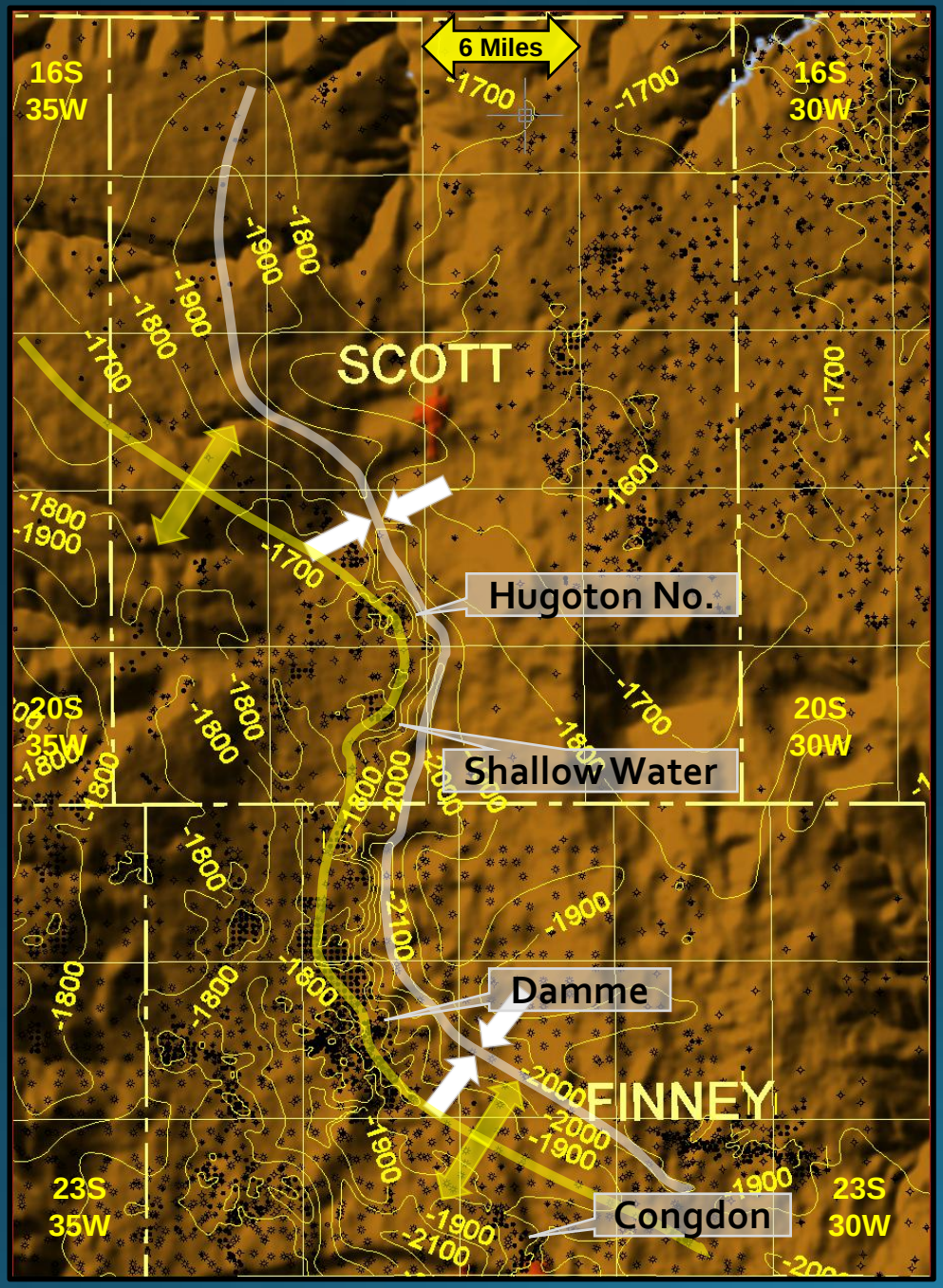
Hartman #39 Damme
Sec. 28, T22S R33W
Finney County, Kansas
Damme Field



Structure Map: Top of the Mississippian Lime

Contour Interval: 100 Feet

This structure map on the top of the Mississippian Limestone shows a 50-mile-long syncline (grey line) . The thick red line marks the persistent structural high west of the syncline. The structural trend likely reflects movement of crustal lineaments and/or faults.



Structure Map: Top of the Mississippian Lime

Contour Interval: 100 Feet

Note the locations of key oil fields located along the structural high associated with the Finney-Scott structural feature.

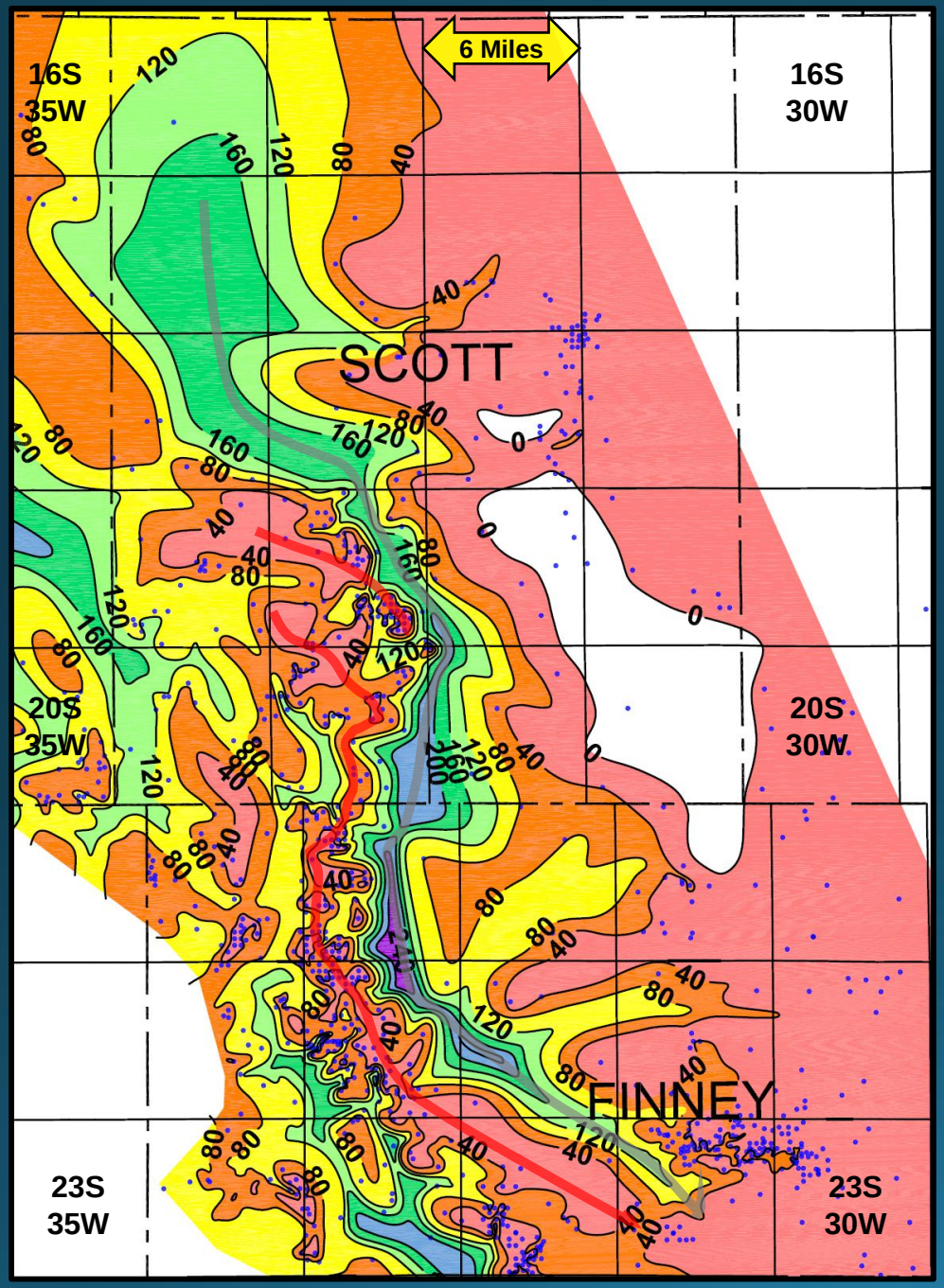
Stratigraphic Column: Morrowan-Atokan

SYS.	STAGE/SERIES	GROUP	FORMATION
QUATERNARY	PLEISTOCENE	Loess, Sand Dunes, Fluvial Deposits	
NEOGENE	PLIOCENE MIOCENE	Ogallala Formation	
CRETACEOUS	UPPER	Colorado Group	Niobrara Chalk Smoky Hill Member Fort Hays Member Carlile Shale Greenhorn Limestone
	LOWER	Dakota Formation Kiowa Formation Cheyenne Sandstone	
PERMIAN	GUADALUPIAN	Whitehorse Formation	
	LEONARDIAN	Nippewalla Group	Dog Creek Formation Blaine Formation Flowerpot Shale
		Sumner Group	Stone Corral Formation Ninnescah Shale Wellington Formation
	WOLFCAMPIAN	Chase Group	Winfield Limestone Krider Limestone
		Council Grove Group	Beattie Limestone
		Admire Group	Foraker Limestone

		Council Grove Group	Beattie Limestone
PENNSYLVANIAN	VIRGILIAN	Admire Group	Foraker Limestone
		Wabaunsee Group	Emporia Limestone
		Shawnee Group	Topeka Limestone
		Douglas Group	Heebner Shale
	MISSOURIAN	Lansing Group ●	Stanton Limestone
		Kansas City Group ●	Dennis Limestone Swope Limestone
		Pleasanton Group	
	DESMOINESIAN	Marmaton Group ●	Pawnee Limestone Fort Scott Limestone
		Cherokee Group	Excello Shale
	ATOKAN	●	
	MORROWAN	Kearny Formation ●	
MISSISSIPPIAN	MERAMECIAN	St. Genevieve Limestone ● St. Louis Limestone Salem Limestone Warsaw Limestone	
	OSAGIAN	Keokuk Limestone Burlington Limestone	

← Map Horizon

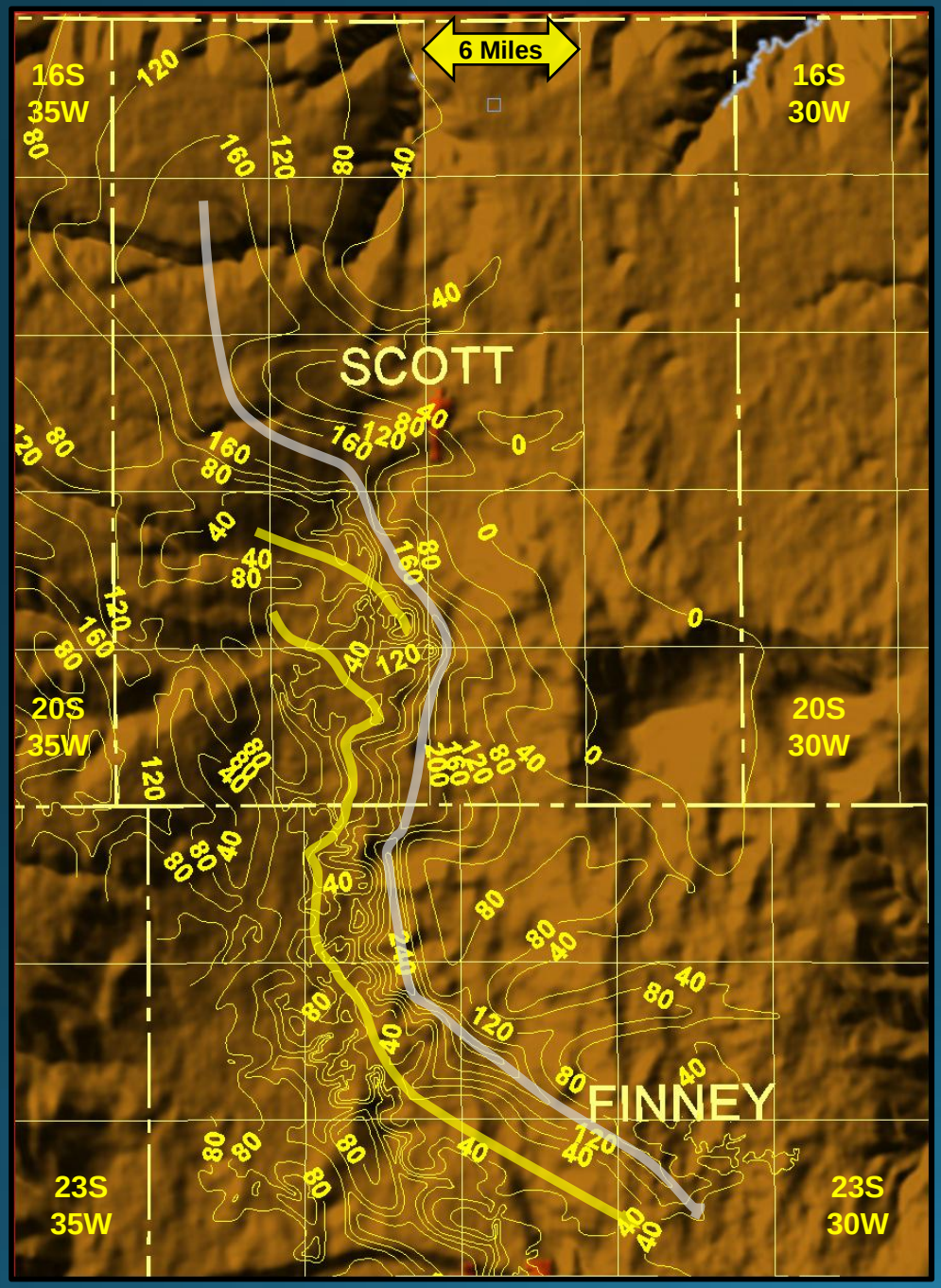
● Oil Producing Horizon



Isopach Map: Morrowan-Atokan Clastics

Contour Interval: 40 Feet

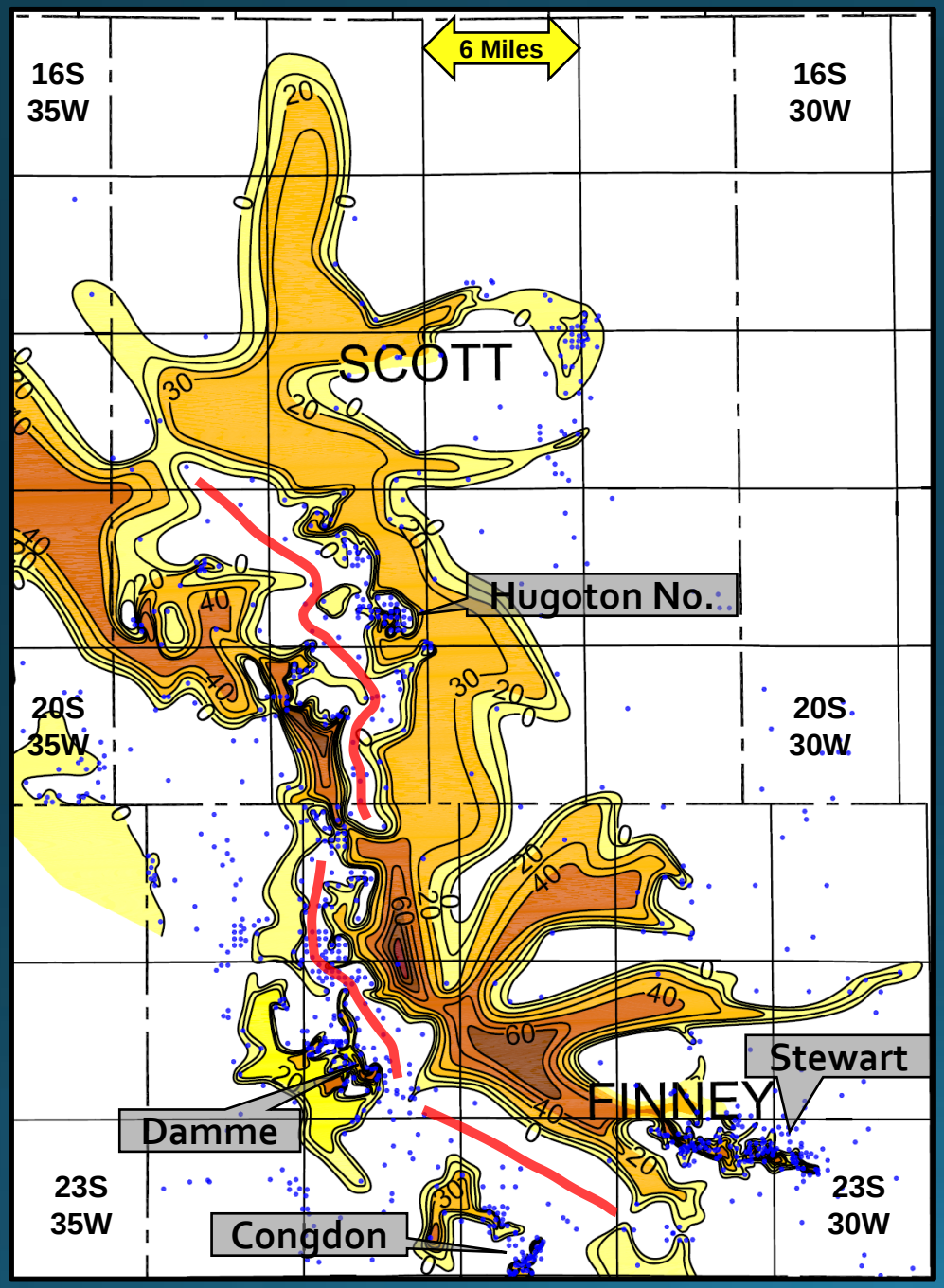
The Scott-Finney structure had the greatest depositional impact on the Morrowan-Atokan clastic strata (Early Pennsylvanian). The Morrowan-Atokan ranges in thickness from 240+ feet in the synclinal area (grey line) to less than 10 feet on the structural / topographic high areas to the west (red line). The map interval is at an average depth of 4700 feet in southern Scott County.



Isopach Map: Morrowan-Atokan Clastics

Contour Interval: 40 Feet

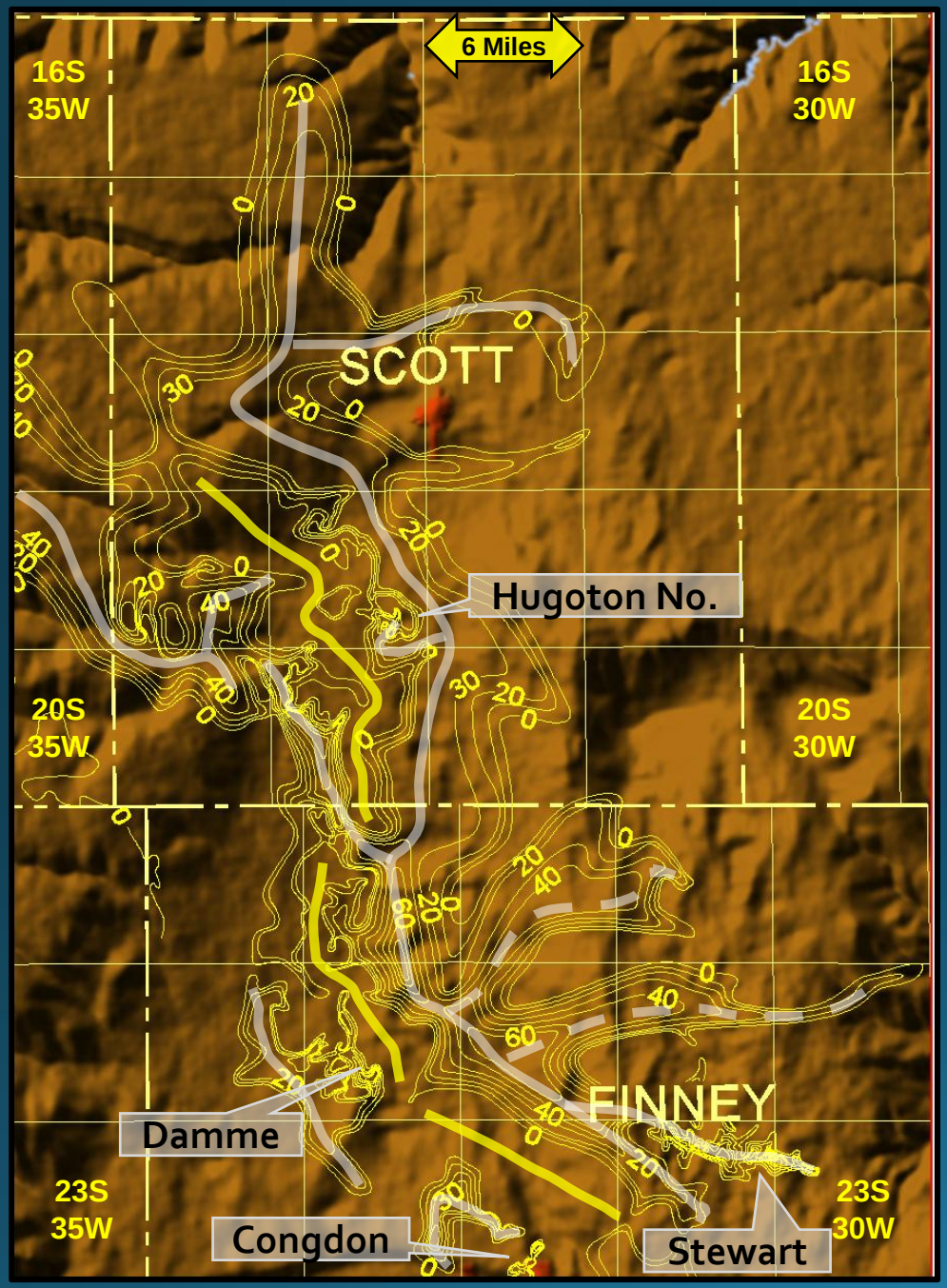
The maximum thickness of the map interval lies in a north-south trend that corresponds closely to the axis of the present day topographic basin.



Isolith Map: Feet of Sandstone in the Morrowan-Atokan Clastics

Contour Interval: 10 Feet

The sandstone in the Morrowan-Atokan was deposited primarily in the synclinal areas and generally thins onto the topographic / structural high areas (red lines). Oil traps were formed on the structural highest positions of the sandstone bodies in fields such as Hugoton North, Damme, and Congdon. Additionally, a significant stratigaphic oil trap is present at Stewart field in a valley-fill sandstone reservoir in the Morrowan/ Atokan interval.



Isolith Map: Feet of Sandstone in the Morrow-Atoka Clastics

Contour Interval: 10 Feet

The source of the sandstone in the Morrowan-Atokan in the map area was likely from the Central Kansas uplift to the east. Westward -flowing streams entered the Scott-Finney Basin area from the east. The incised valley-fill sandstone reservoir at Stewart field is a good example of such a system. It is possible that additional stream systems are present in Finney and Scott Counties north of Stewart field.

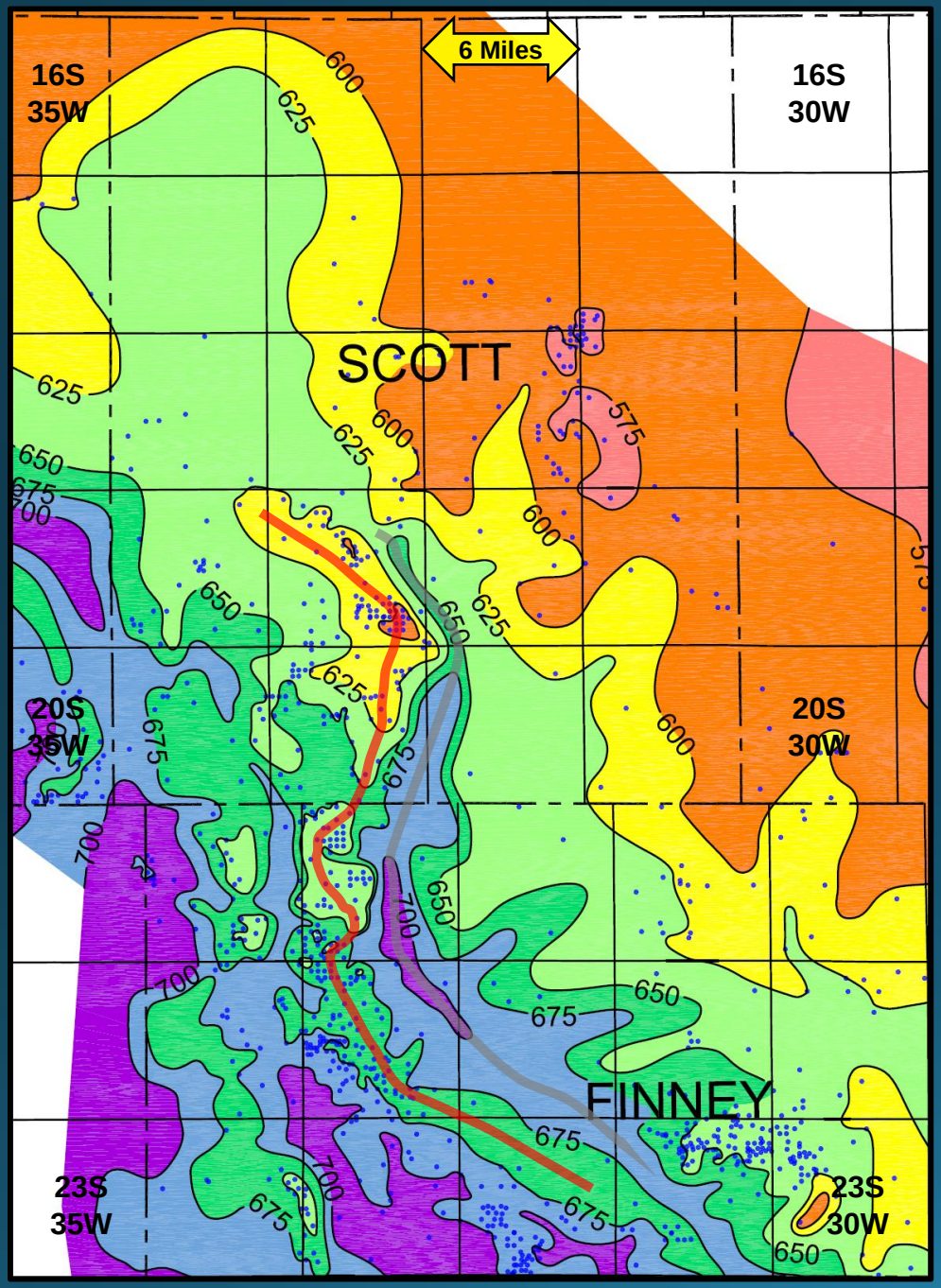
Stratigraphic Column: Missourian thru Desmoinesian Stages

SYS.	STAGE/SERIES	GROUP	FORMATION
QUATERNARY	PLEISTOCENE	Loess, Sand Dunes, Fluvial Deposits	
NEOGENE	PLIOCENE MIOCENE	Ogallala Formation	
CRETACEOUS	UPPER	Colorado Group	Niobrara Chalk Smoky Hill Member Fort Hays Member Carlile Shale Greenhorn Limestone
	LOWER	Dakota Formation Kiowa Formation Cheyenne Sandstone	
PERMIAN	GUADALUPIAN	Whitehorse Formation	
	LEONARDIAN	Nippewalla Group	Dog Creek Formation Blaine Formation Flowerpot Shale
		Sumner Group	Stone Corral Formation Ninnescah Shale Wellington Formation
	WOLFCAMPIAN	Chase Group	Winfield Limestone Krider Limestone
		Council Grove Group	Beattie Limestone
		Admire Group	Foraker Limestone

		Council Grove Group	Beattie Limestone
PENNSYLVANIAN	VIRGILIAN	Admire Group	Foraker Limestone
		Wabaunsee Group	Emporia Limestone
		Shawnee Group	Topeka Limestone
		Douglas Group	Heebner Shale
	MISSOURIAN	Lansing Group ●	Stanton Limestone
		Kansas City Group ●	Dennis Limestone Swope Limestone
		Pleasanton Group	
	DESMOINESIAN	Marmaton Group ●	Pawnee Limestone Fort Scott Limestone
		Cherokee Group	Excello Shale
	ATOKAN		
	MORROWAN	Kearny Formation ●	
MISSISSIPPIAN	MERAMECIAN	St. Genevieve Limestone ● St. Louis Limestone Salem Limestone Warsaw Limestone	
	OSAGIAN	Keokuk Limestone Burlington Limestone	

Map Interval

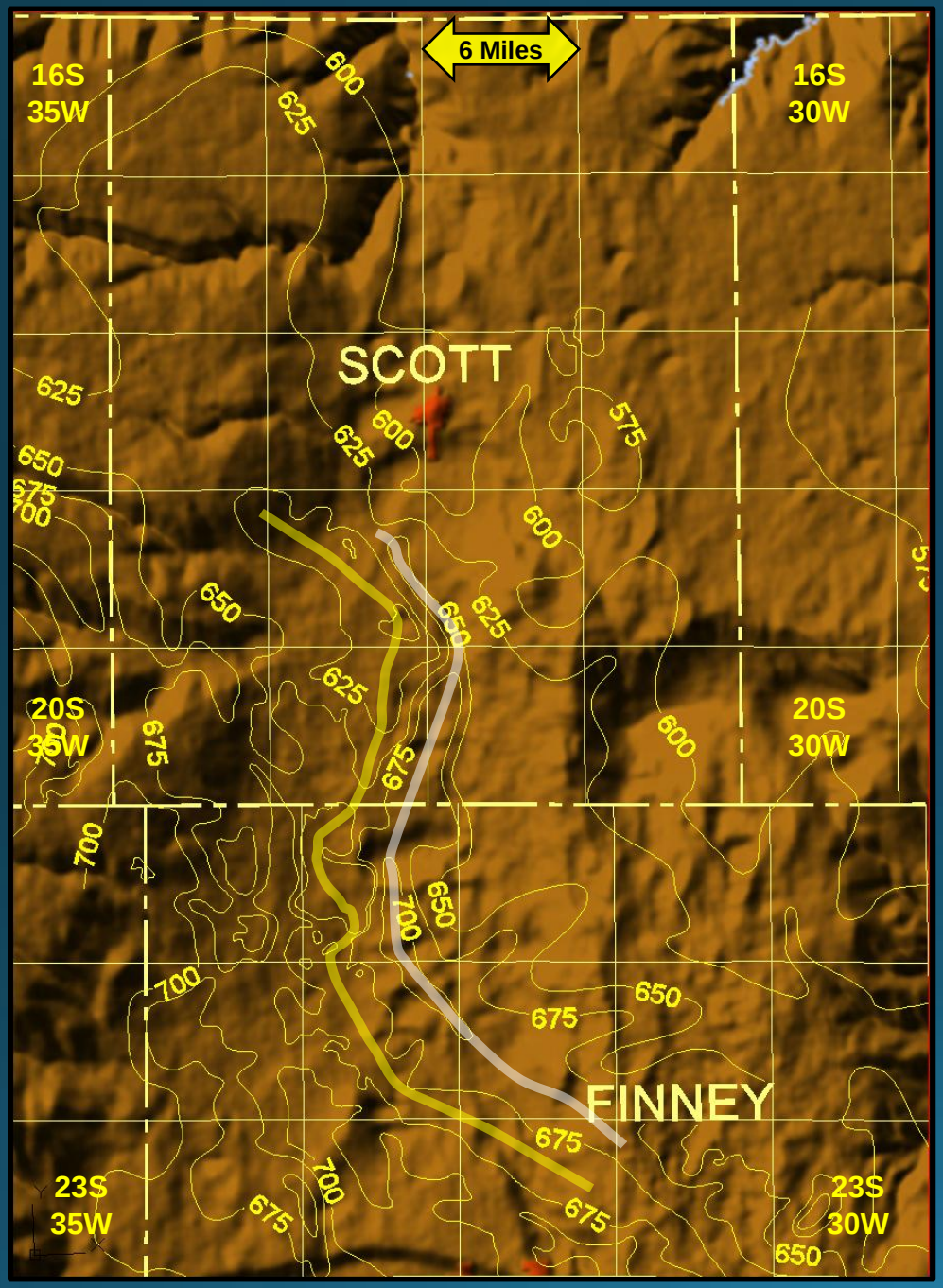
● Oil Producing Horizon



Isopach Map: Top of the Heebner Shale to the Excello Shale

Contour Interval: 25 Feet

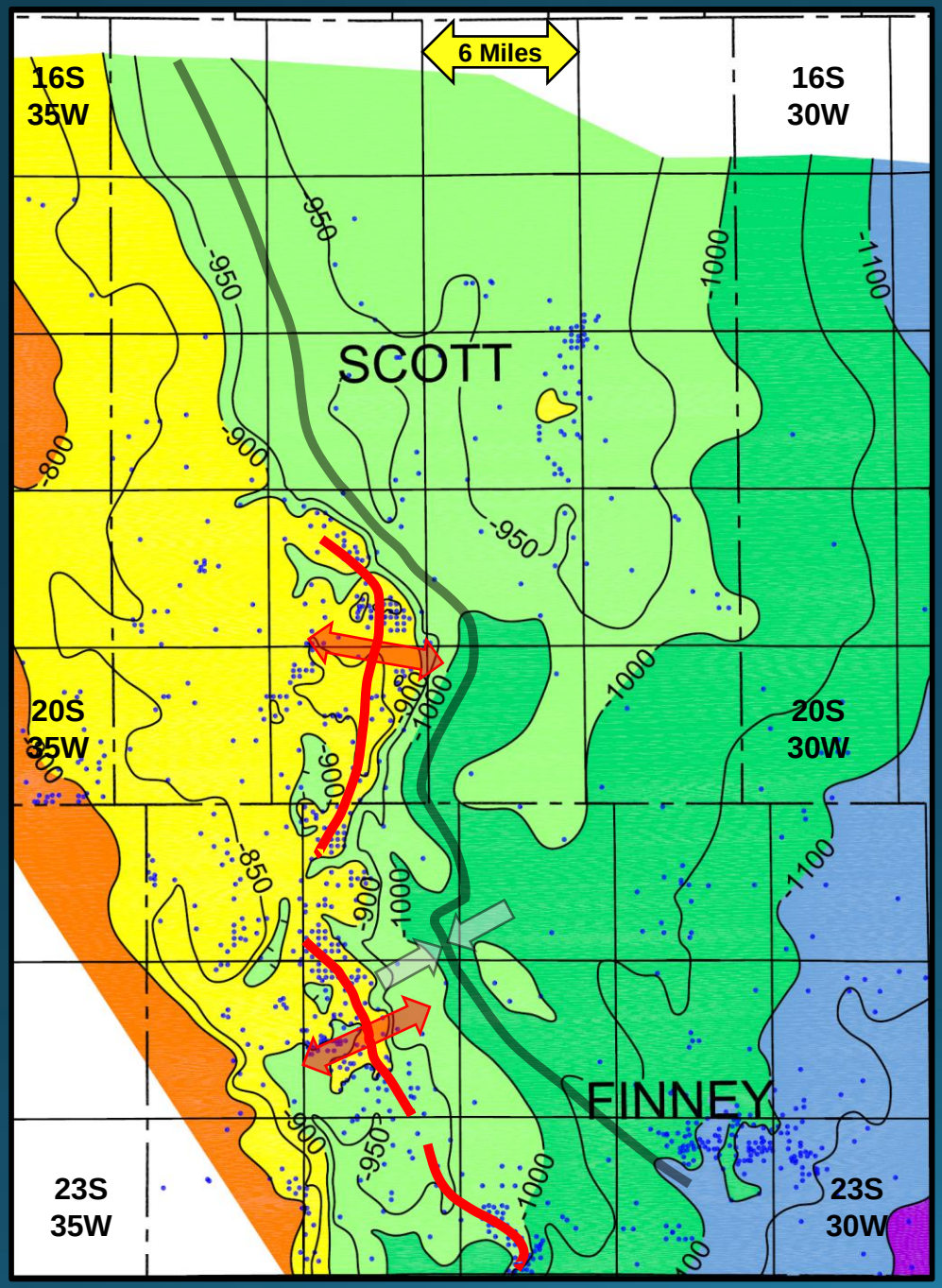
Thickening of the Middle Pennsylvanian sedimentary layers demonstrates structural movement during deposition. The synclinal area has up to 80′ of additional sediments (grey line) compared to the structural high immediately to the west (red line). The Excello Shale is at an average depth of 4550 feet in southern Scott County.



Isopach Map: Top of the Heebner Shale to the Excello Shale

Contour Interval: 25 Feet

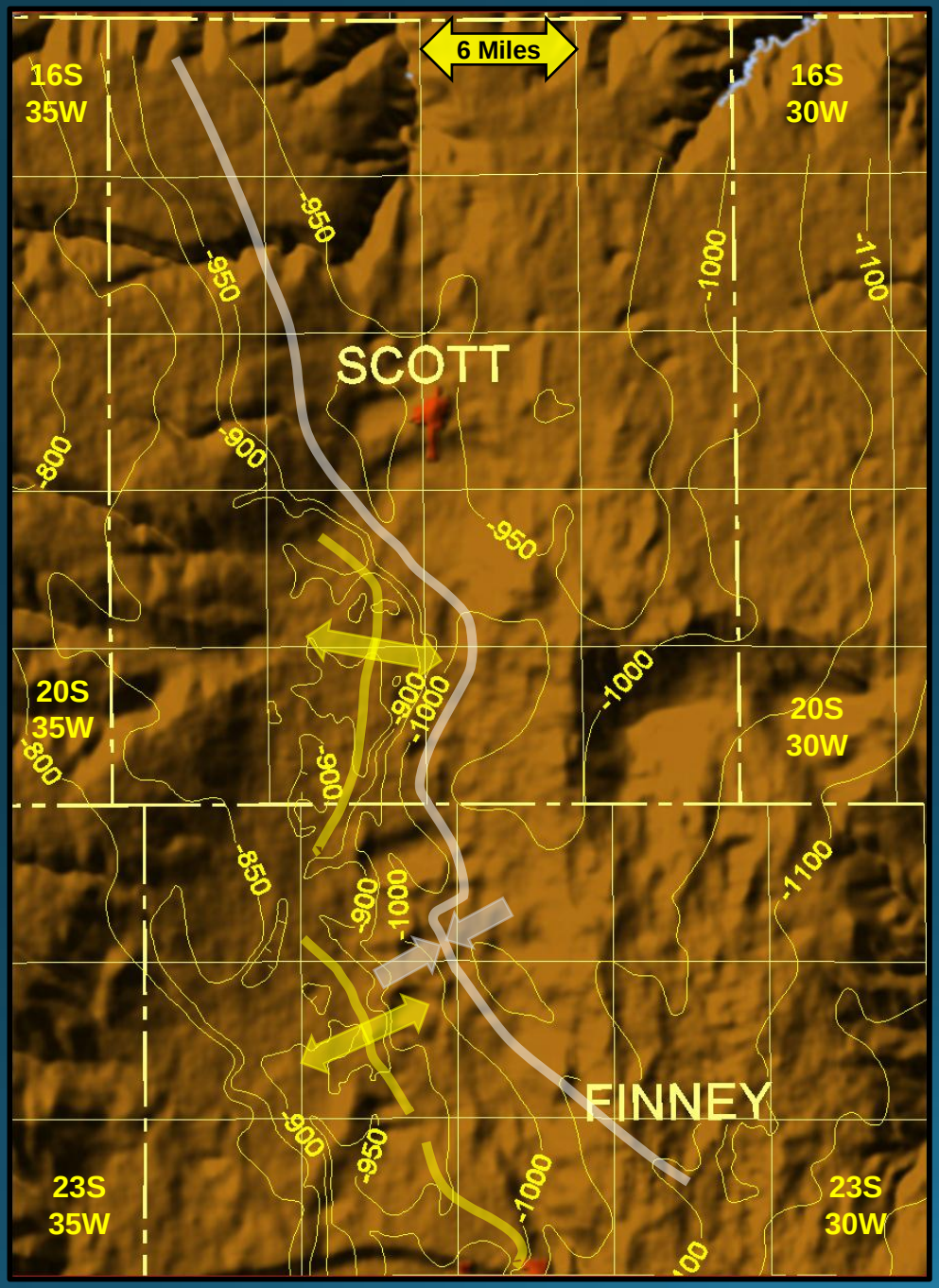
Thickening of the Middle Pennsylvanian sedimentary layers demonstrates structural movement during deposition. The synclinal area has up to 80' of additional sediments (grey line) compared to the structural high immediately to the west (yellow line).



Structure Map: Top of the Heebner Shale

Contour Interval: 50 Feet

This structure map on the Upper Pennsylvanian Heebner Shale shows a marked syncline (grey line) . The thick red lines mark the persistent structural high west of the syncline. The Heebner is at an average depth of 3900 feet in southern Scott County.



Structure Map: Top of the Heebner Shale

Contour Interval: 50 Feet

This structure map on the Upper Pennsylvanian Heebner Shale shows the Finney-Scott structural feature as a broad anticlinal feature (thick yellow lines) flanked by a marked syncline (grey line) .

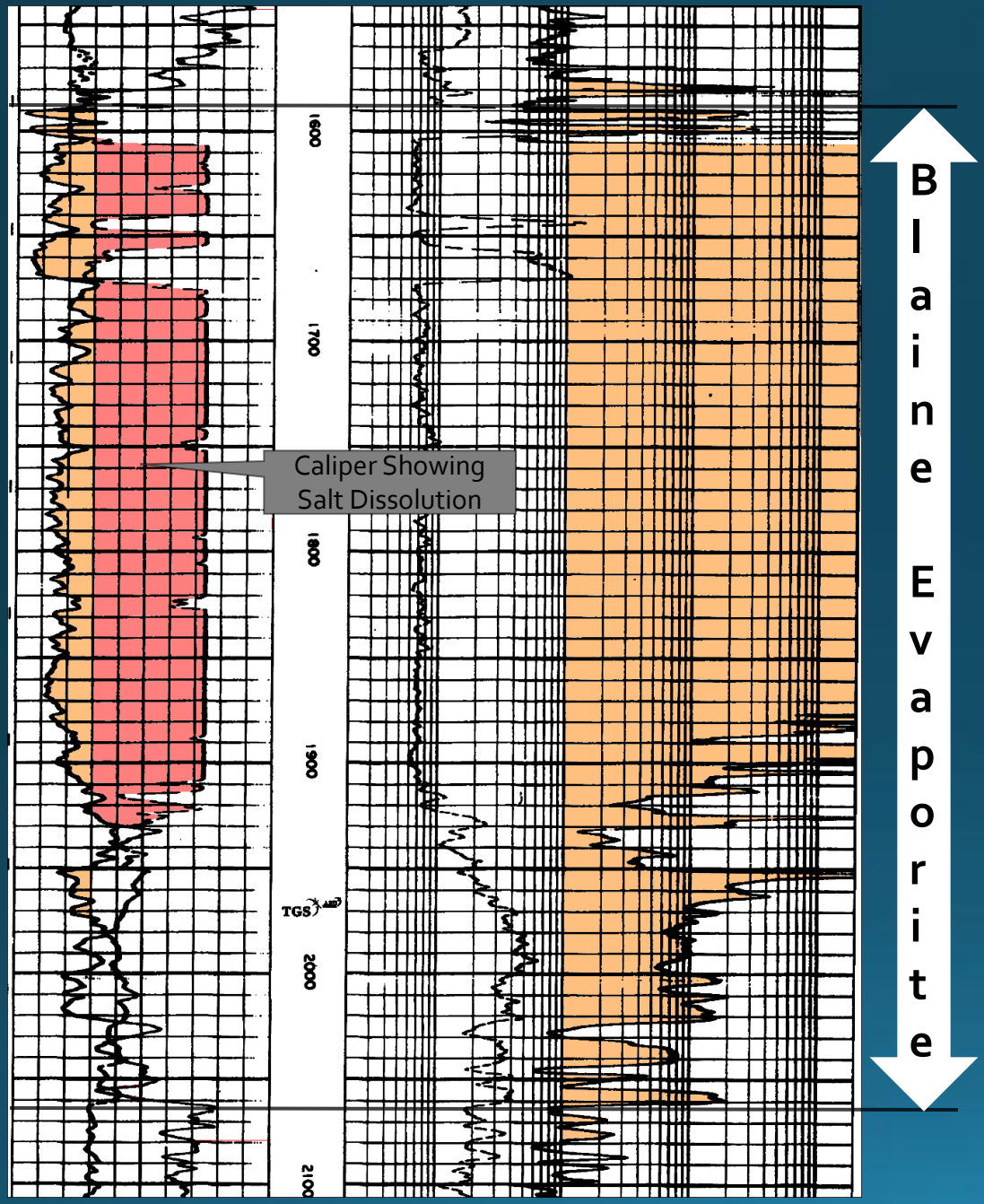
Stratigraphic Column: Blaine Evaporite Leonardian Stage (Permian)

SYS.	STAGE/SERIES	GROUP	FORMATION
QUATERNARY	PLEISTOCENE	Loess, Sand Dunes, Fluvial Deposits	
NEOGENE	PLIOCENE MIOCENE	Ogallala Formation	
CRETACEOUS	UPPER	Colorado Group	Niobrara Chalk Smoky Hill Member Fort Hays Member Carlile Shale Greenhorn Limestone
	LOWER	Dakota Formation Kiowa Formation Cheyenne Sandstone	
PERMIAN	GUADALUPIAN	Whitehorse Formation	
	LEONARDIAN	Nippewalla Group	Dog Creek Formation Blaine Formation Flowerpot Shale
		Sumner Group	Stone Corral Formation Ninnescah Shale Wellington Formation
	WOLFCAMPIAN	Chase Group	Winfield Limestone Krider Limestone
		Council Grove Group	Beattie Limestone
		Admire Group	Foraker Limestone

		Council Grove Group	Beattie Limestone
PENNSYLVANIAN	VIRGILIAN	Admire Group	Foraker Limestone
		Wabaunsee Group	Emporia Limestone
		Shawnee Group	Topeka Limestone
		Douglas Group	Heebner Shale
	MISSOURIAN	Lansing Group ●	Stanton Limestone
		Kansas City Group ●	Dennis Limestone Swope Limestone
		Pleasanton Group	
	DESMOINESIAN	Marmaton Group ●	Pawnee Limestone Fort Scott Limestone
		Cherokee Group	Excello Shale
	ATOKAN		
	MORROWAN	Kearny Formation ●	
MISSISSIPPIAN	MERAMECIAN	St. Genevieve Limestone ● St. Louis Limestone Salem Limestone Warsaw Limestone	
	OSAGIAN	Keokuk Limestone Burlington Limestone	

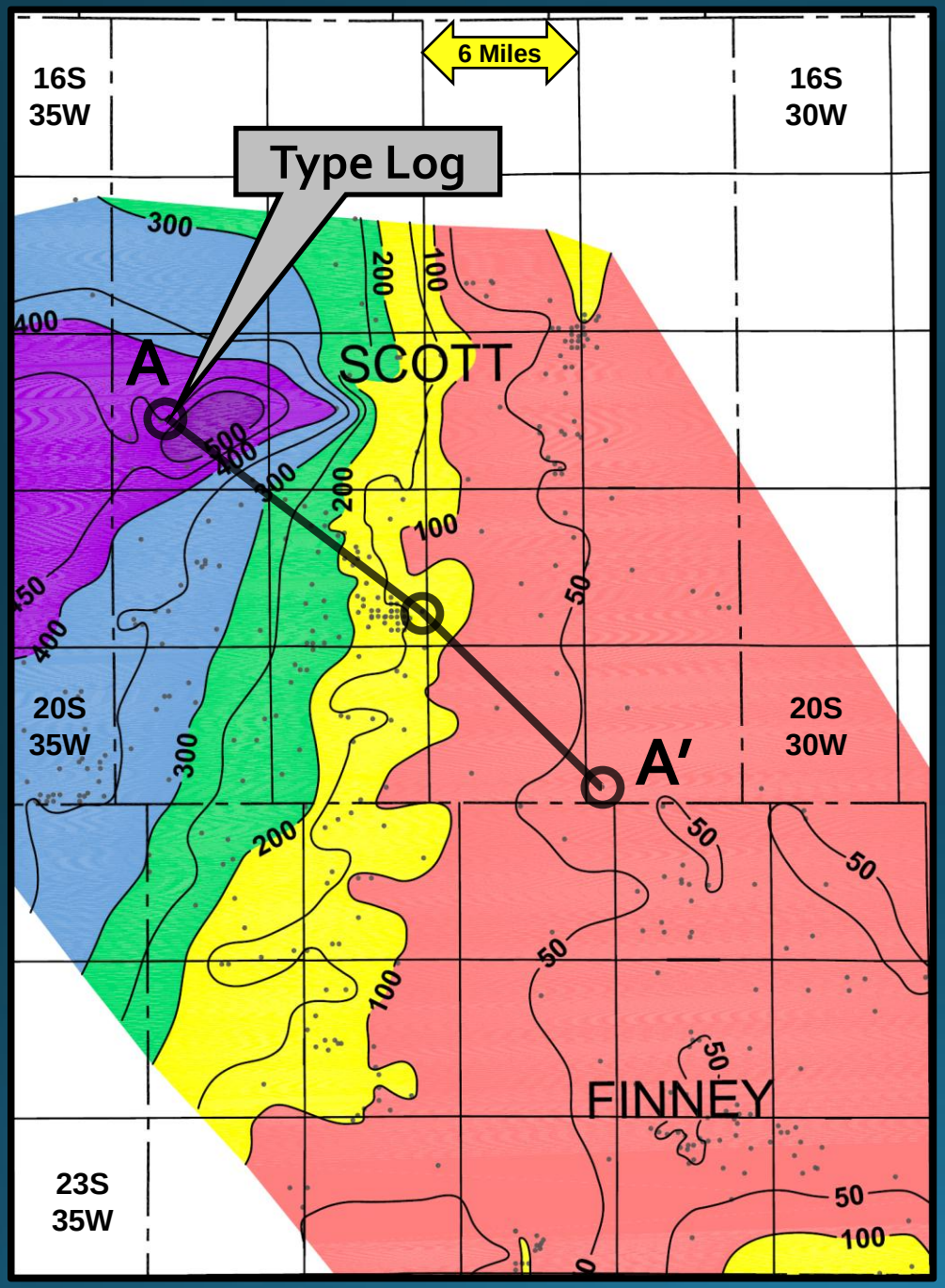
Map Horizon

● Oil Producing Horizon



Finney-Scott Blaine Evaporite (Permian) Type Log:

Allison #1 Krause
Sec. 20, T18S R34W
Scott County, Kansas

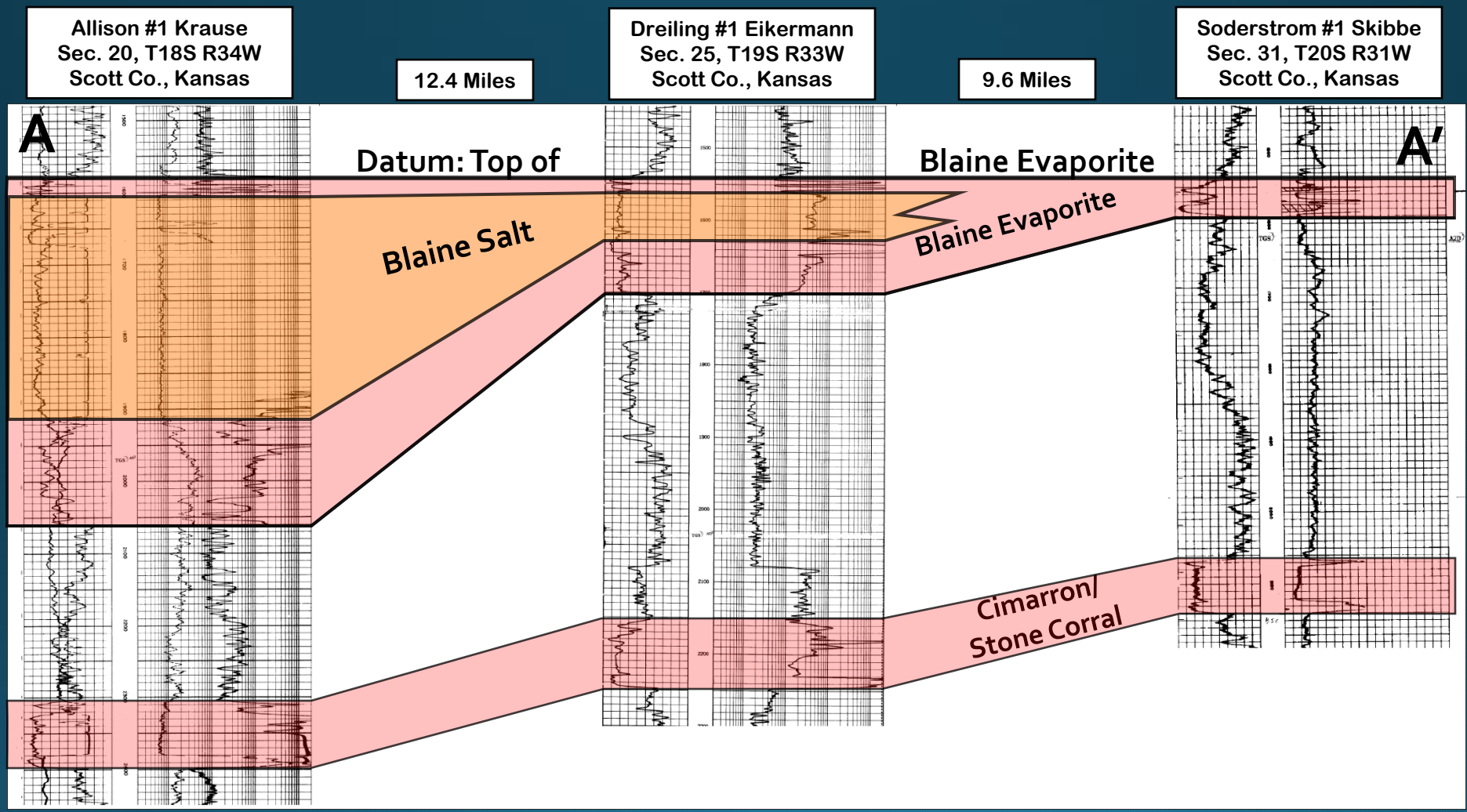


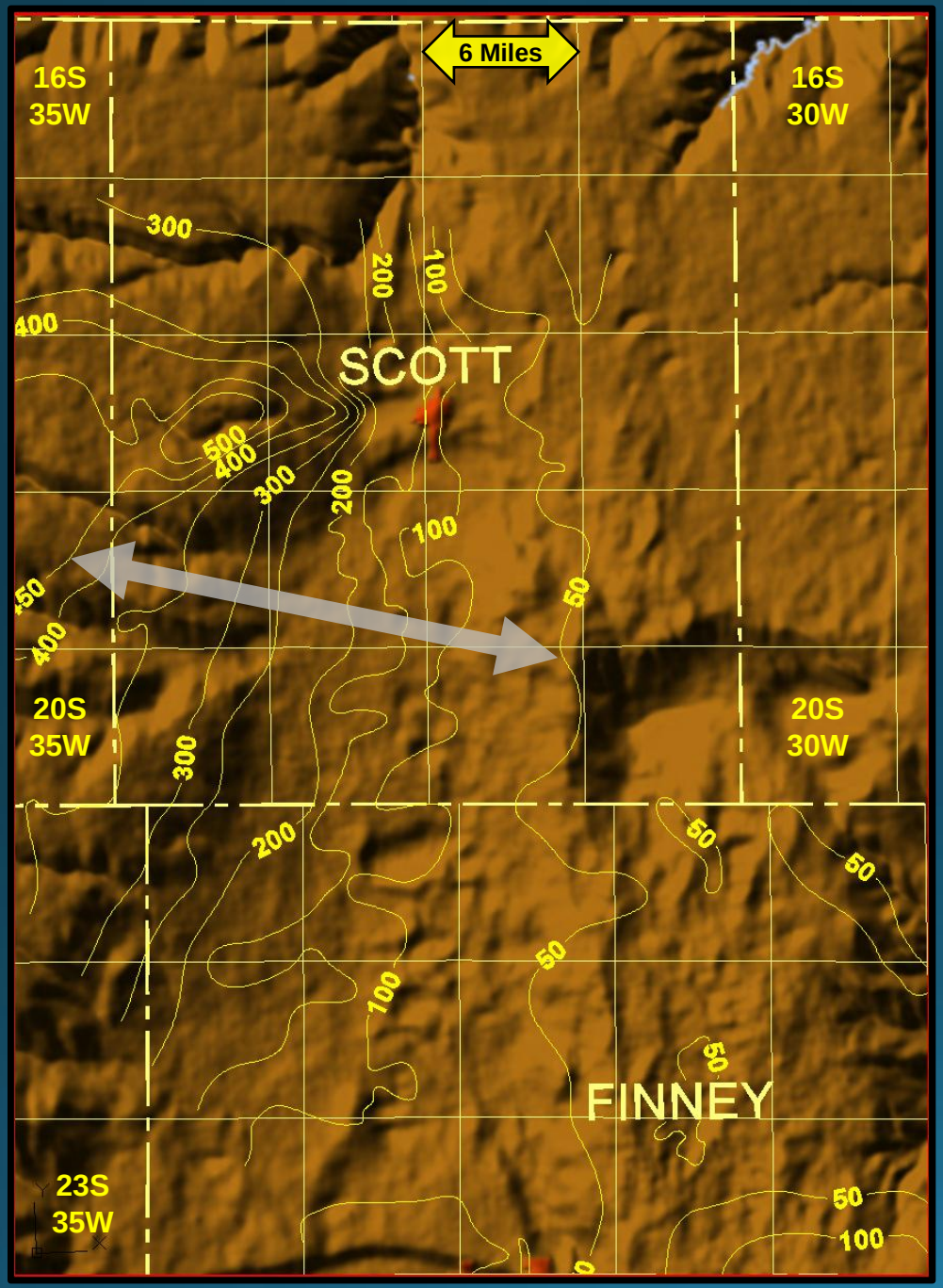
Isopach Map of the Blaine Evaporite

Contour Interval: 50 Feet

Dissolution of the Blaine Evaporite (Permian age) at an average depth of 1500 feet has occurred along the axis of the Finney-Scott Basin. The Blaine thins by 450 feet (arrow) from the west to east. This removal has lowered the surface elevation as much as 400 feet, creating the topographic basin. The area of closely spaced isopach contours in western Scott County directly underlies the topographic slope break.

Stratigraphic Cross Section: Permian Evaporites





Isopach Map of the Blaine Evaporite

Contour Interval: 50 Feet

The Blaine evaporate thins by 450 feet (arrow) from the west to east. This removal has lowered the surface elevation as much as 400 feet creating the topographic basin. The area of closely spaced isopach contours in western Scott County directly underlies the topographic slope break.

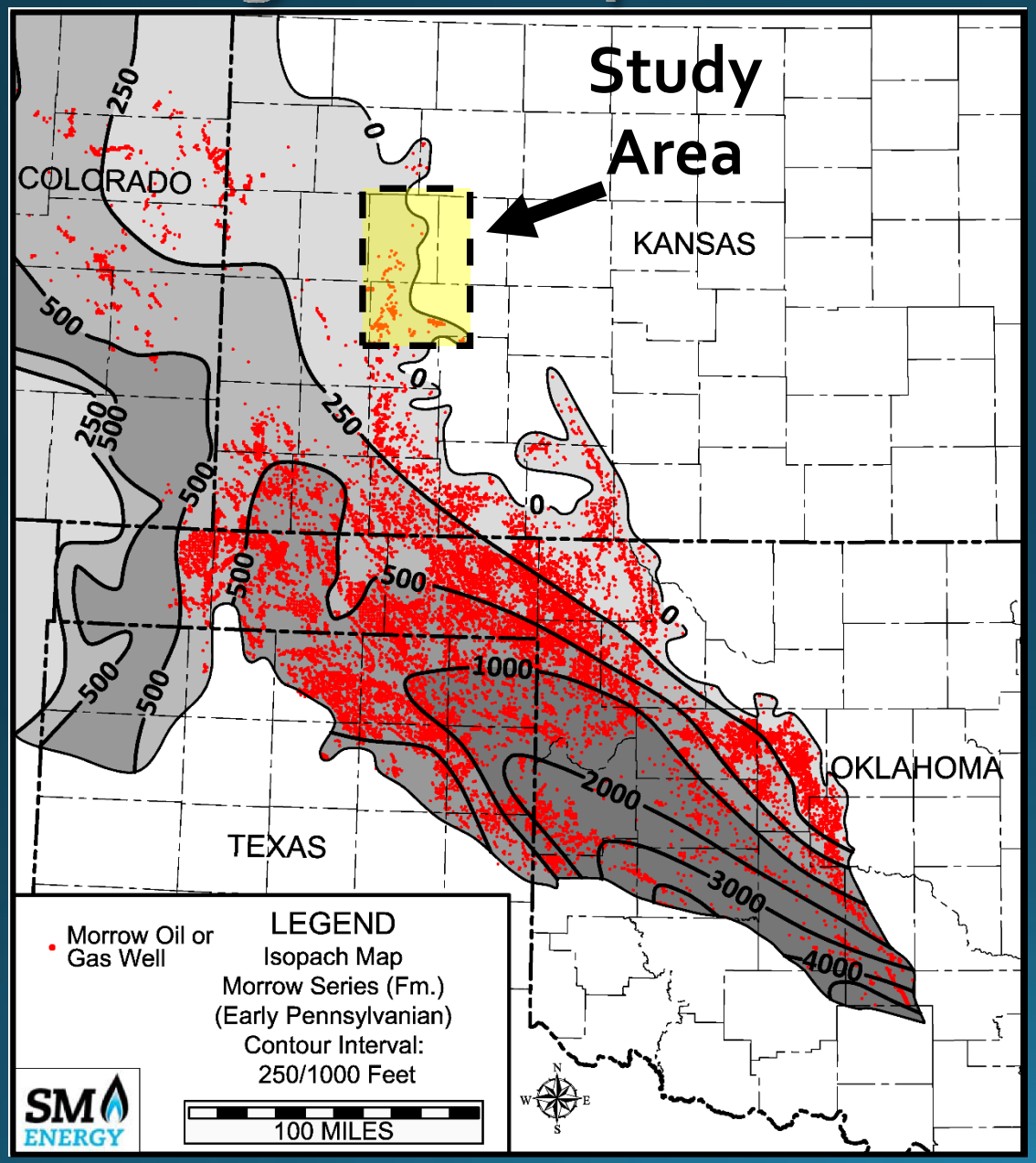
A Glance at Oil Production in the Scott-Finney Basin

Stratigraphic Column for Area Oil Pay

- Oil Producing Horizon

SYS.	STAGE/SERIES	GROUP	FORMATION
		Council Grove Group	Beattie Limestone
PENNSYLVANIAN	VIRGILIAN	Admire Group	Foraker Limestone
		Wabaunsee Group	Emporia Limestone
		Shawnee Group	Topeka Limestone
		Douglas Group	Heebner Shale
	MISSOURIAN	Lansing Group ●	Stanton Limestone
		Kansas City Group ●	Dennis Limestone Swope Limestone
		Pleasanton Group	
	DESMOINESIAN	Marmaton Group ●	Pawnee Limestone Fort Scott Limestone
		Cherokee Group	Excello Shale
	ATOKAN	●	
	MORROWAN	● Kearny Formation	
MISSISSIPPIAN	MERAMECIAN	● St. Genevieve Limestone ● St. Louis Limestone Salem Limestone Warsaw Limestone	
	OSAGIAN	Keokuk Limestone Burlington Limestone	

Regional Isopach – Morrowan Series

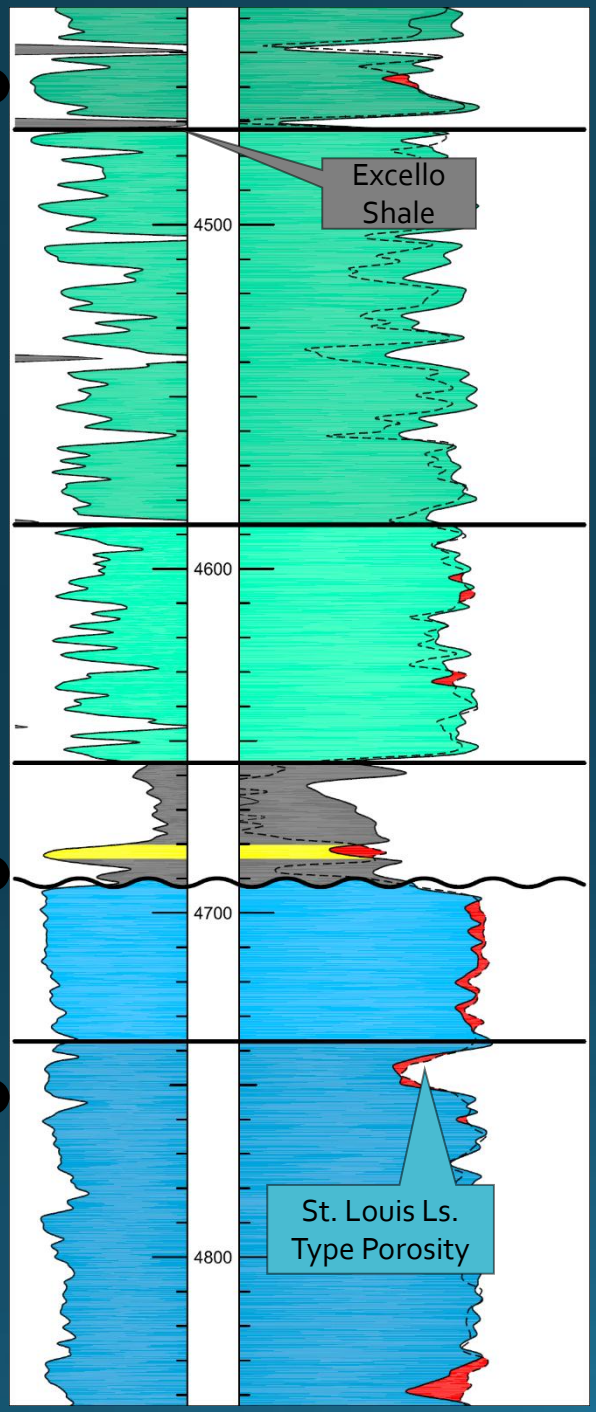


The sandstones of the Morrowan series form some of the best oil and gas reservoirs in the Anadarko Basin. Morrowan rocks have produced 25 TCF (21%) of the natural gas and 908 MMBO (17%) of the oil in the basin. The great majority of production has come from stratigraphic traps. An estimated 200 million barrels of oil has been produced from Morrowan-age sandstone reservoirs in Kansas.

Map adapted from Adler & others, 1971

Finney-Scott Basin Type Log:

Hartman #39 Damme
Sec. 28, T22S R33W
Finney County, Kansas
Damme Field



Marmaton Gp. Desmoinesian

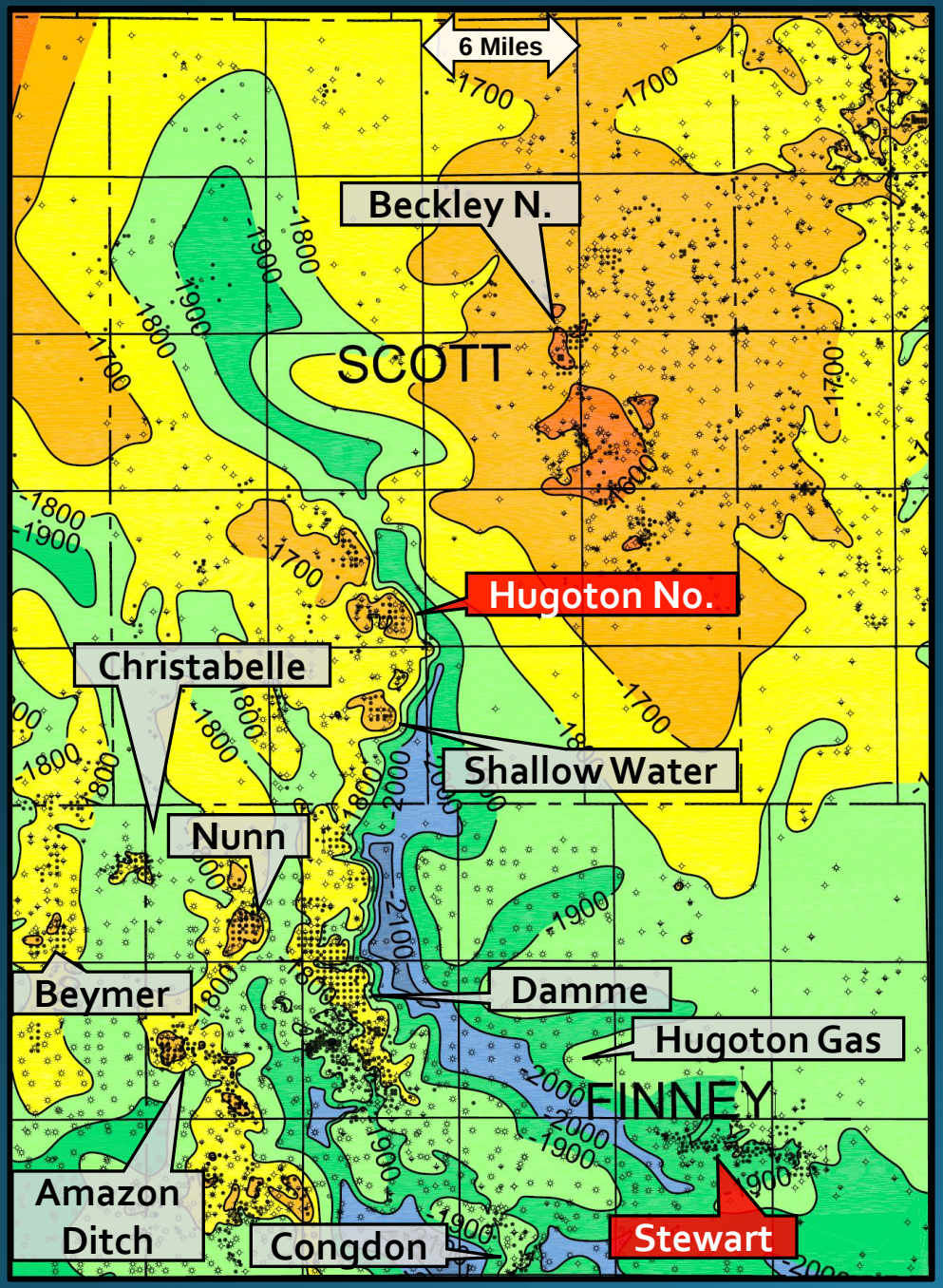
Cherokee Group Desmoinesian Stage (Pennsylvanian)

Atokan Stage (Pennsylvanian)

Morrowan-Atokan Clastics (Pennsylvanian)

St. Genevieve Ls. (Mississippian)

St. Louis Ls. (Mississippian)



Oil Fields and Structure Map:

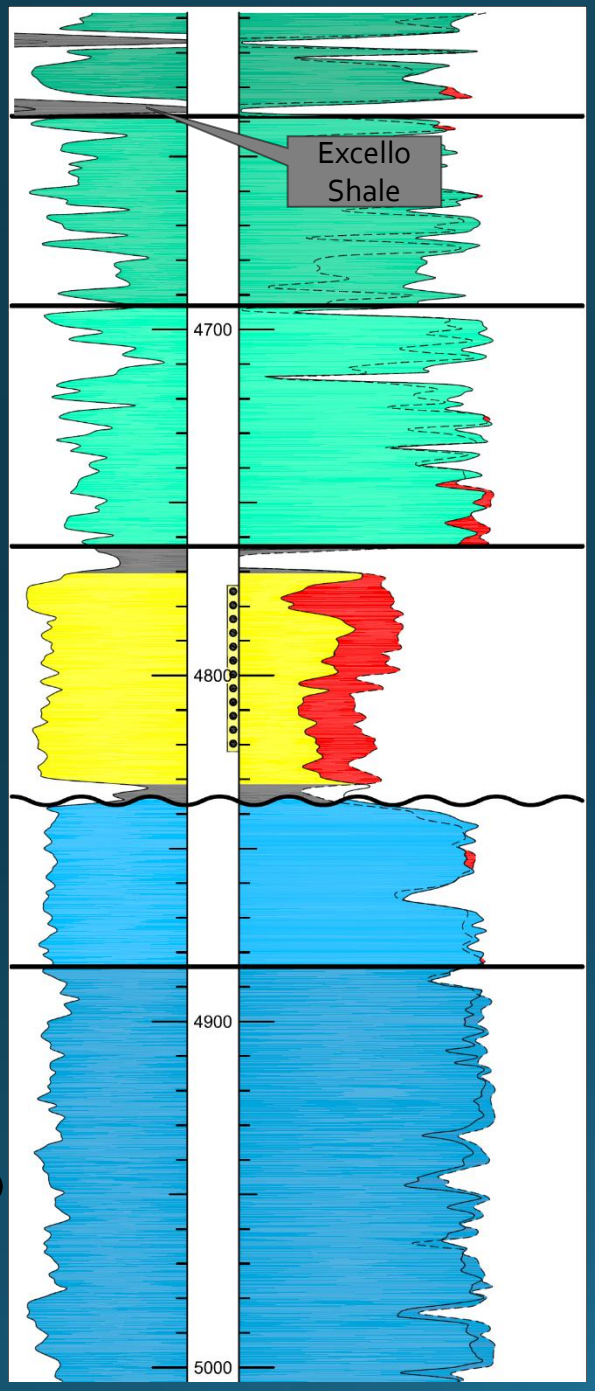
Top of the Mississippian

Contour Interval: 100 Feet

- Beckley North: 1.4 MMBO (1994)
- Hugoton No.: 1.3 MMBO (1962)
- Christabelle: 1.7 MMBO (1971)
- Shallow Water: 2.2 MMBO (1934)
- Nunn: 6.5 MMBO (1938)
- Beymer : 1.9 MMBO (1965, includes Beymer No. and Nw.)
- Damme: 23.9 MMBO (1951)
- Amazon Ditch: 8.4 MMBO (1961, includes Amazon Ditch East)
- Congdon: 3.8 MMBO (1977, includes Congdon North)
- Stewart: 10.8 MMBO (1952, field development in 1980's)
- 62 MMBO TOTAL

Stewart Field Type Log:

Beren #5 Haag Estate
Sec. 12, T23S R31W
Finney County, Kansas



Marmaton Gp.

Cherokee Group

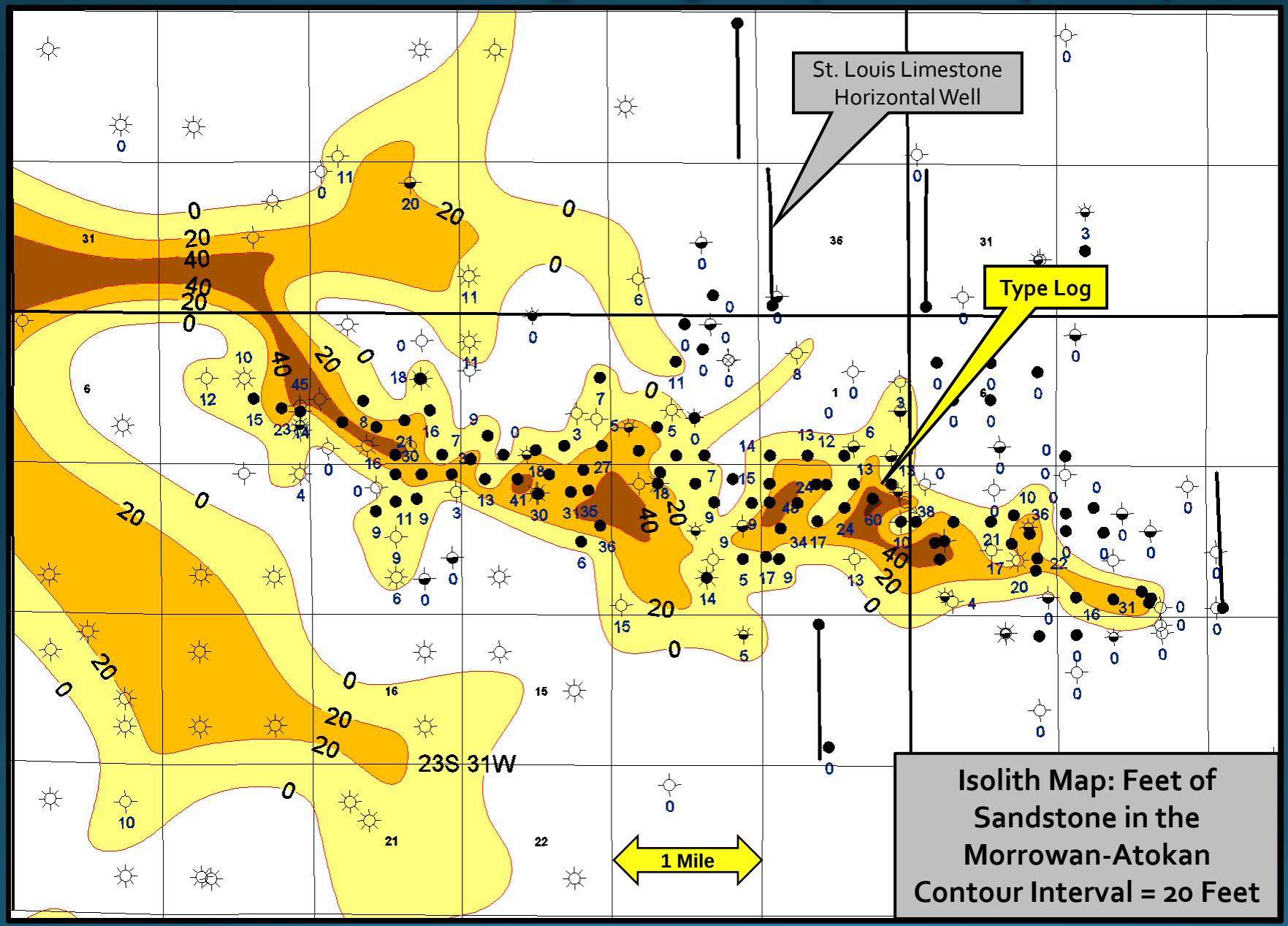
Atokan Stage

Morrowan-Atokan Clastics (Pennsylvanian)

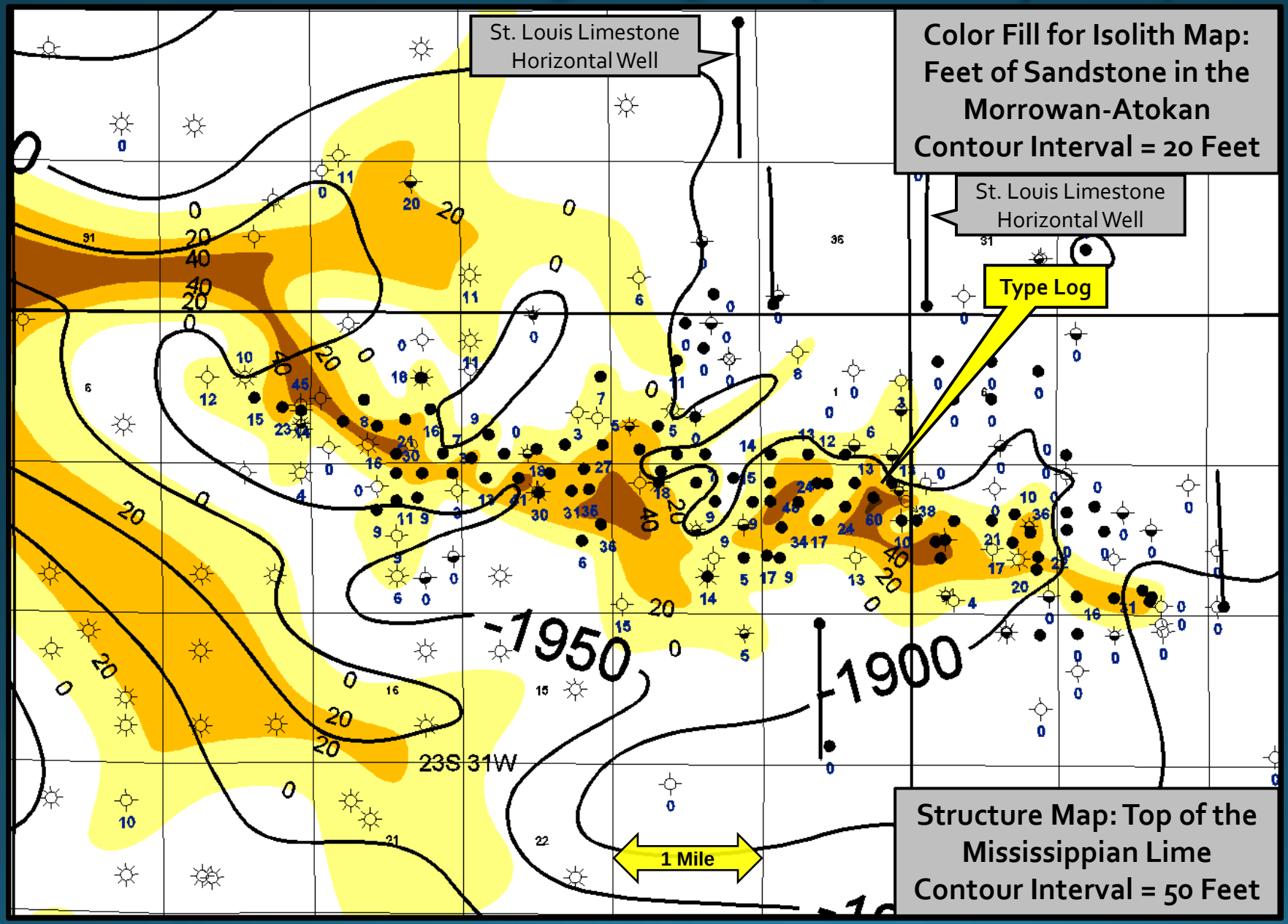
St. Genevieve Ls. (Mississippian)

St. Louis Ls. (Mississippian)

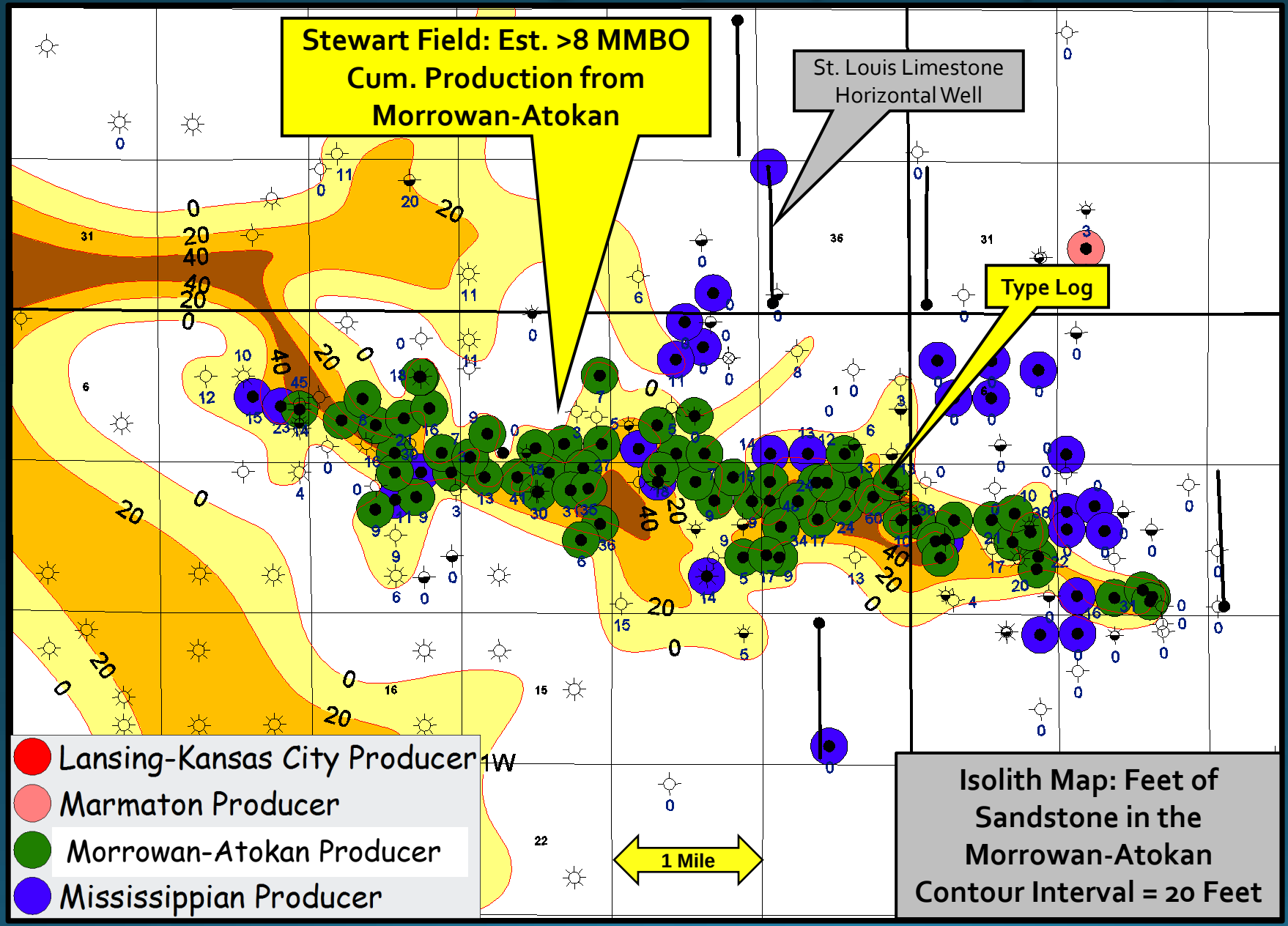
Stewart Field: T23S R31W, Finney Co., KS



Stewart Field: T23S R31W, Finney Co., KS

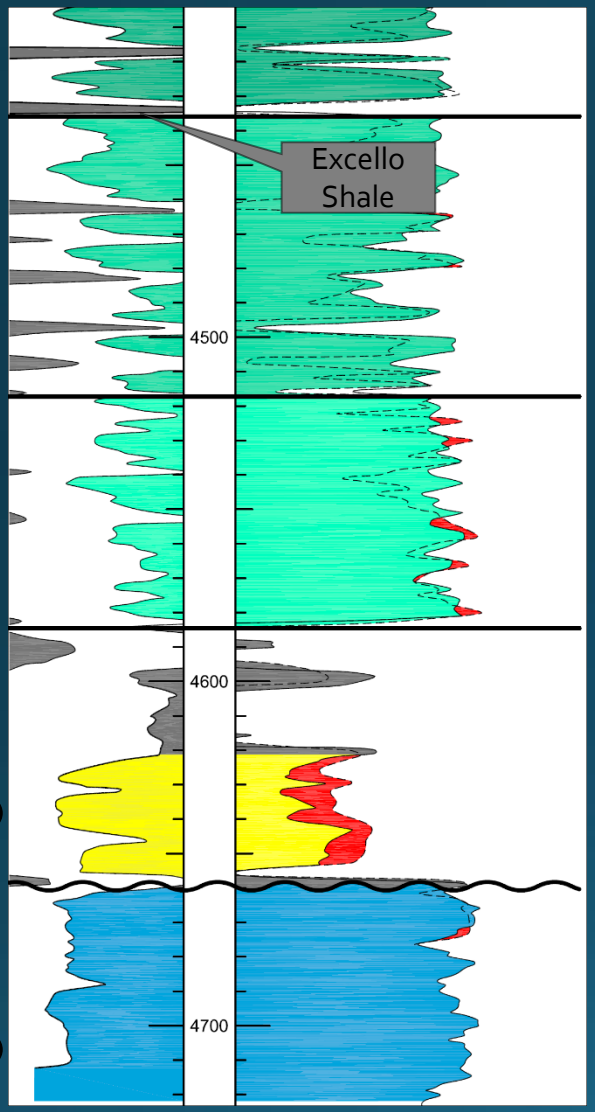


Stewart Field: T23S R31W, Finney Co., KS



Hugoton North Field Type Log:

M. L. Brown
#14 Smith
Sec. 26, T19S R33W
Scott County, Kansas



Marmaton Gp.

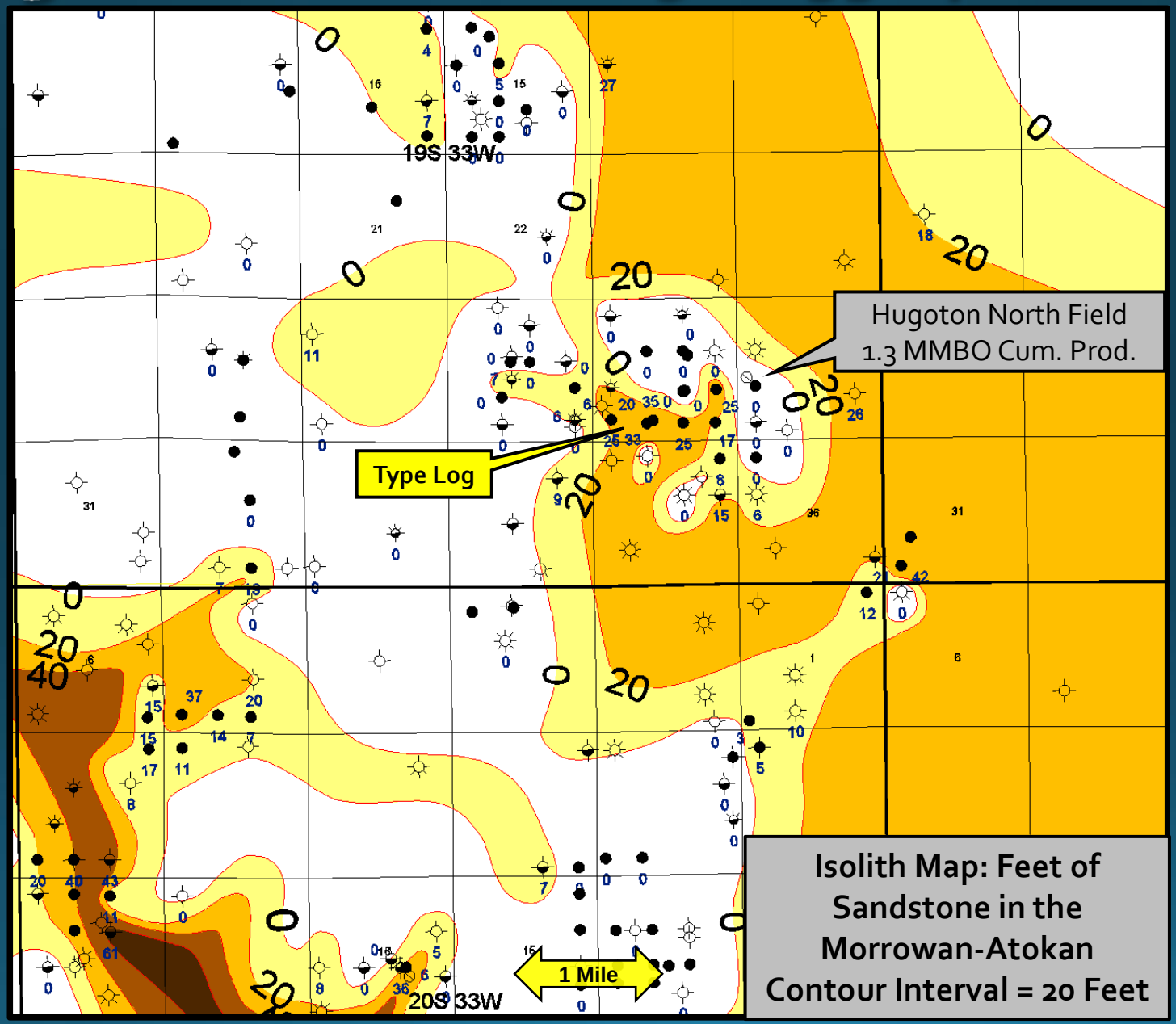
Cherokee Group

Atokan Stage

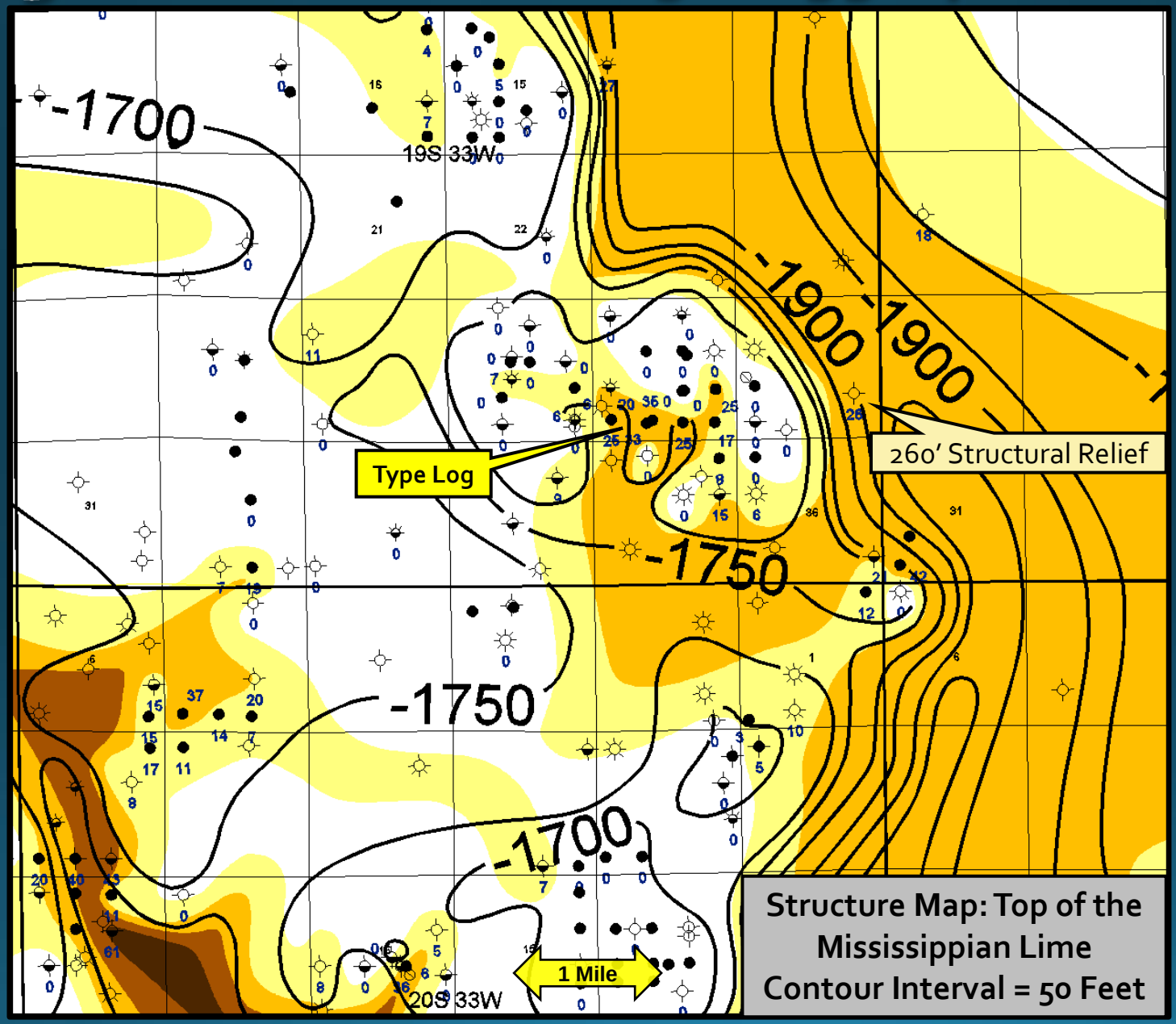
Morrowan-Atokan Clastics (Pennsylvanian)

St. Louis Ls. (Mississippian)

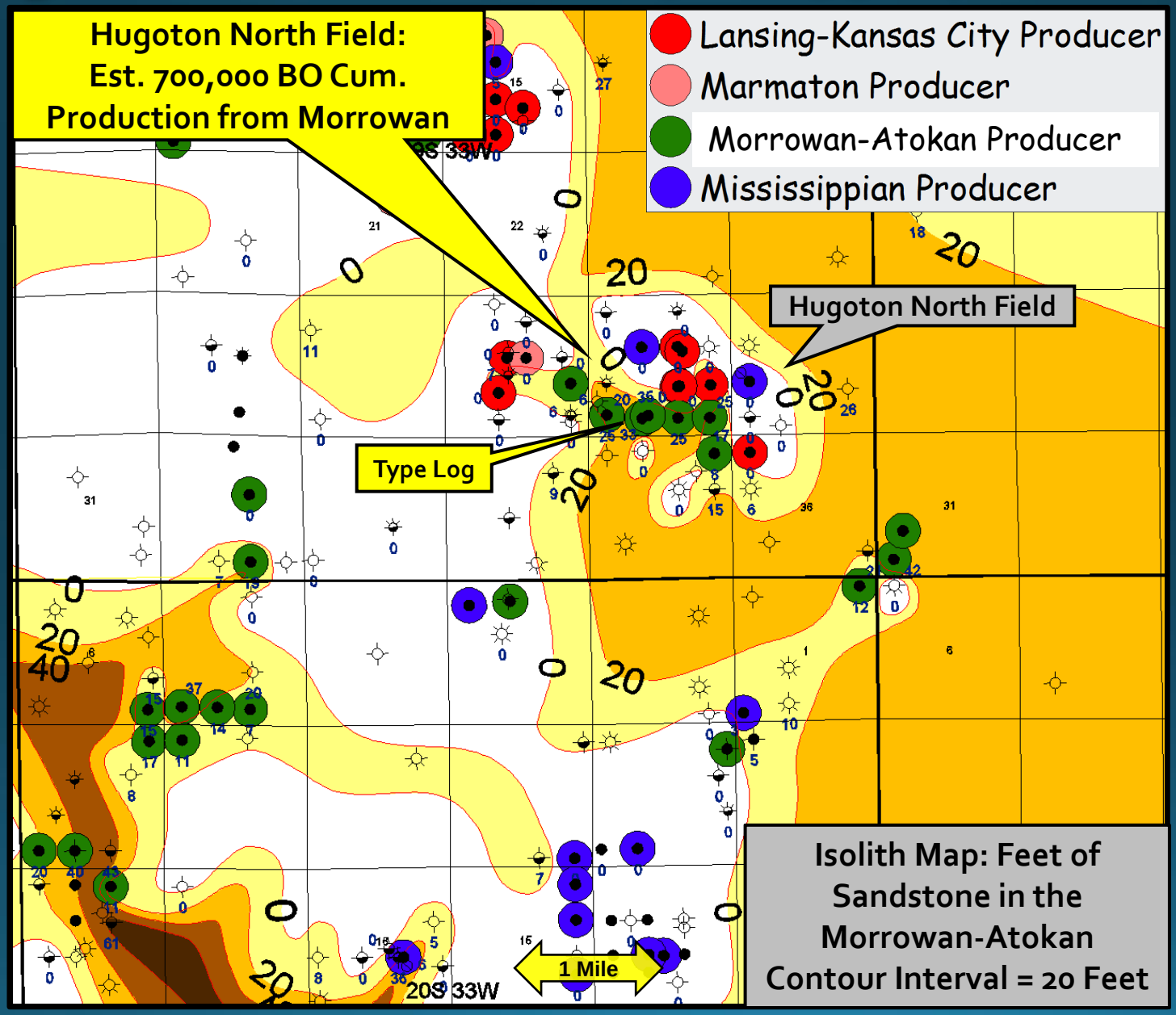
Hugoton No. Field: T19S R33W, Scott Co.



Hugoton No. Field: T19S R33W, Scott Co.



Hugoton No. Field: T19S R33W, Scott Co.



Conclusions

- The Finney-Scott Basin is a surface drainage depression encompassing ~750 square miles in Finney and Scott Counties, Kansas
- It was formed in the recent past from dissolution of the Blaine Evaporite (Permian) at an average depth of 1500 feet.
- The dissolution edge overlies a forty-mile-long, north-south-trending structural feature (Finney-Scott Structure) that formed significant structural and/or paleotopgraphic relief during Late Mississippian (Meramecian) to Early Pennsylvanian (Atokan) time
- The structural and/or paleotopographic relief was mostly filled in the Early Pennsylvanian (320 MYBP) by deposition of as much as 250 feet of shale, limestone and sandstone of the Morrowan/Atokan stages
- Sandstone deposition in the Morrowan/Atokan was strongly influenced by the depositional topography with little or no sandstone present on the Mississippian topographic highs
- Isopach and structural maps of various post-Morrowan stratigraphic intervals suggest the Finney-Scott structure had recurring movement
- This movement probably localized groundwater circulation that resulted in dissolution of the Blaine evaporite unit along the north-south structural zone
- In effect, the current day Finney-Scott Basin reflects the earlier development of the Late Mississippian to Atokan sub-basin from 340 million years B.P.

Thanks!

Thanks to Ray Sorenson and Lynn Watney for sharing insights and data to improve my knowledge of the geology of western Kansas.