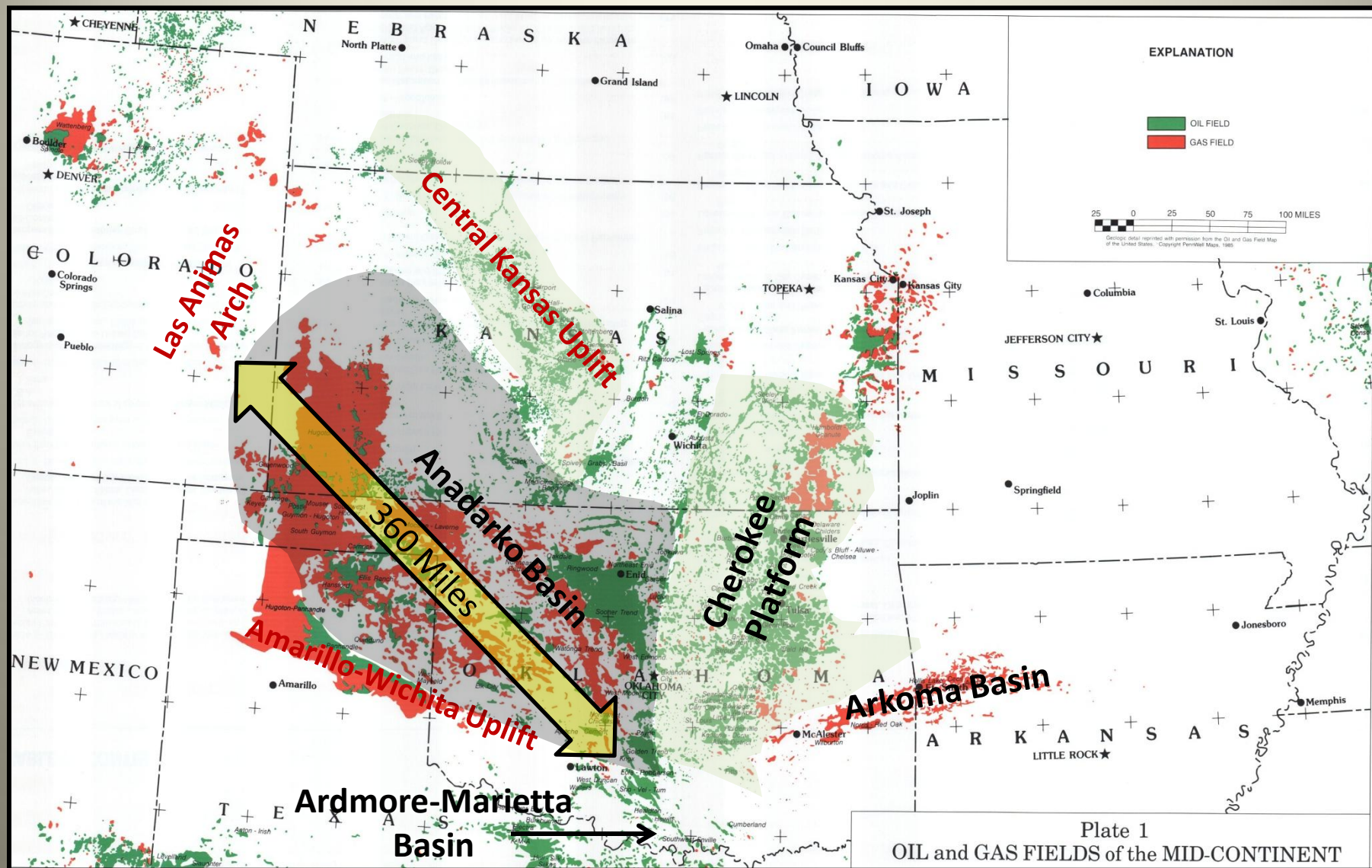


# **The Anadarko Basin: Oil and Gas Exploration – Past, Present and Future**



**John Mitchell, Senior Geologist  
SM Energy Co.  
Tulsa, Oklahoma  
March 2012  
Email: [jmitchell@sm-energy.com](mailto:jmitchell@sm-energy.com)**

# Regional Location Map



# **THE ANADARKO BASIN**

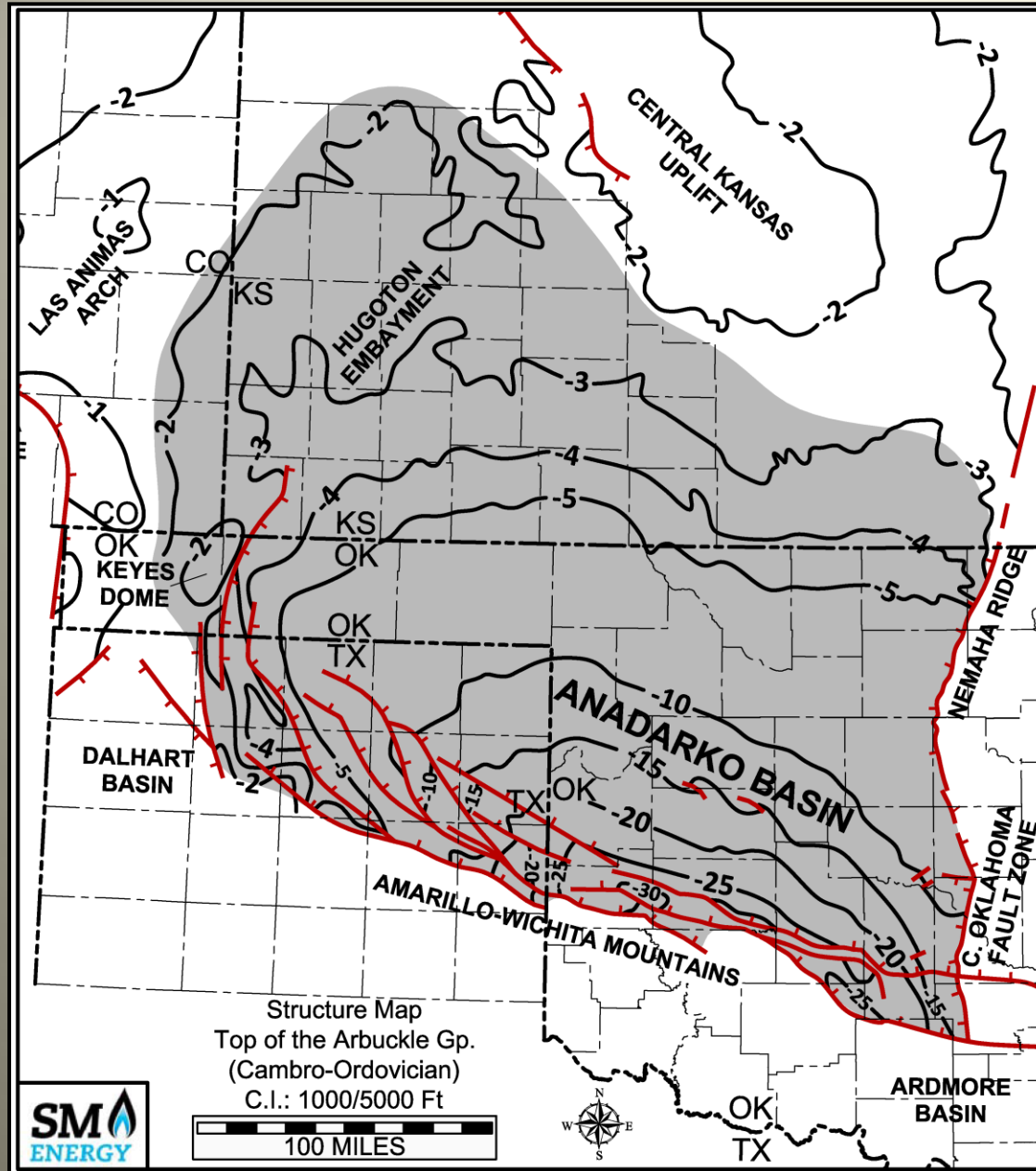
- **Located in western Oklahoma, southeastern Colorado, western Kansas and the northeastern portion of the Texas Panhandle**
- **Approximately 70,000 square miles in size**
- **Sedimentary column approaches 40,000 feet in thickness in deepest portion of basin**
- **Production comes from Cambro-Ordovician through Permian strata**
- **Estimated cumulative production of more than 125 trillion cubic feet of gas and 5.4 billion barrels of oil**

## **THE ANADARKO BASIN (CONTINUED)**

- **Bounded tectonically on the southern and eastern sides by major fault zones and/or uplifts**
- **Four major horizontal drilling plays in progress in oil and gas bearing horizons in (1) the Cleveland Ss., (2) the Granite Wash of Pennsylvanian age, (3) the Mississippian limestones, and (4) the Upper Devonian Woodford Shale**
- **Over four thousand horizontals completed in basin to date at vertical depths as great as 15,000 feet.**
- **Significant future horizontal development may await in Pennsylvanian sandstones and shales as well as in older carbonates in the Mississippian through Ordovician.**



# Regional Structure Map



**Structure Map:** Datum top of the Arbuckle Group (Cambro-Ordovician).

Contour Interval = 1000 feet or 5000 feet in deeper part of basin. Basin reaches maximum depths in Beckham, Washita and Caddo Cos., OK

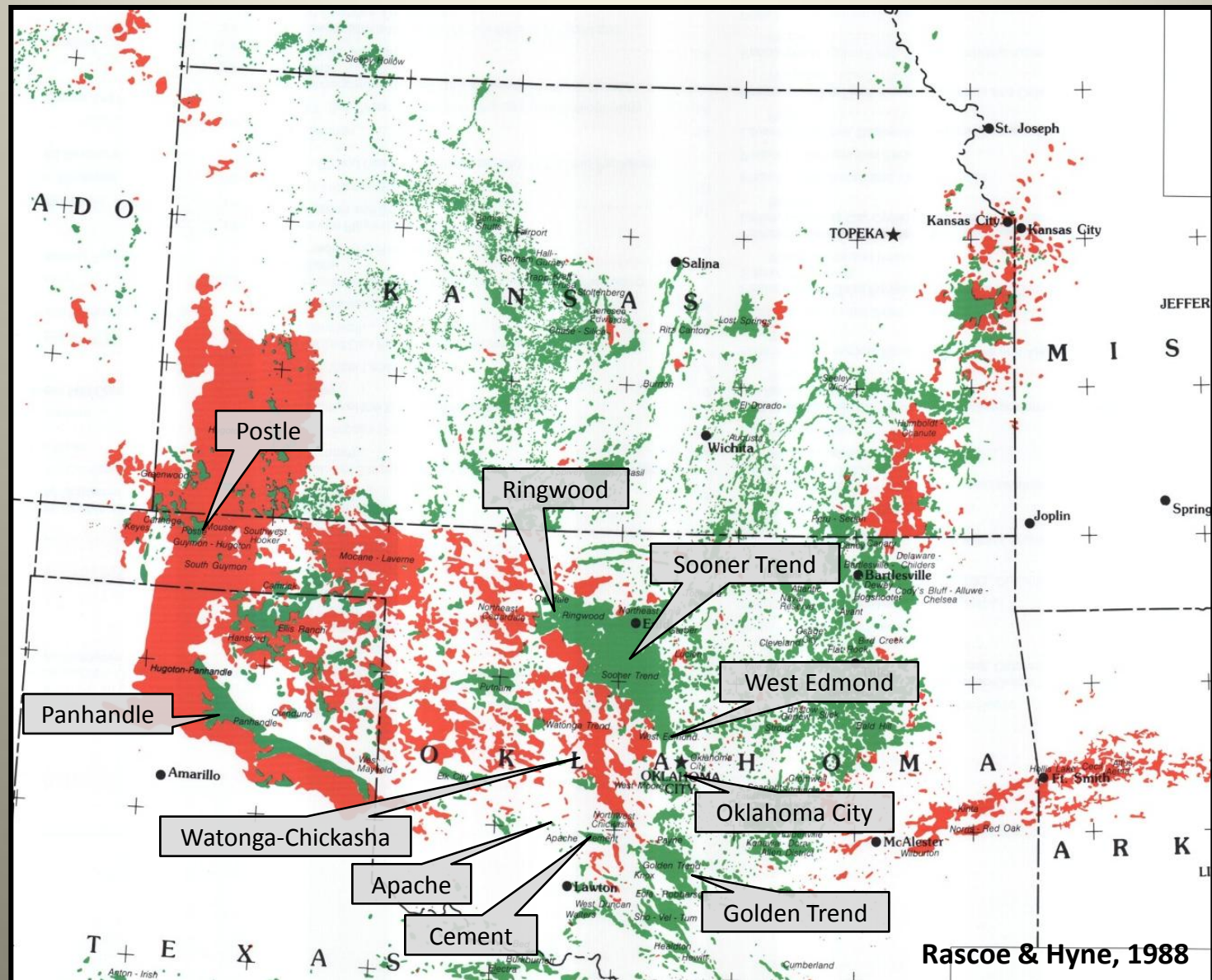
Grey shaded area is greater Anadarko Basin.

Red lines are faults, tic on downthrown side.

Structural relief on south side of basin in excess of 35,000 feet vertically and horizontally.

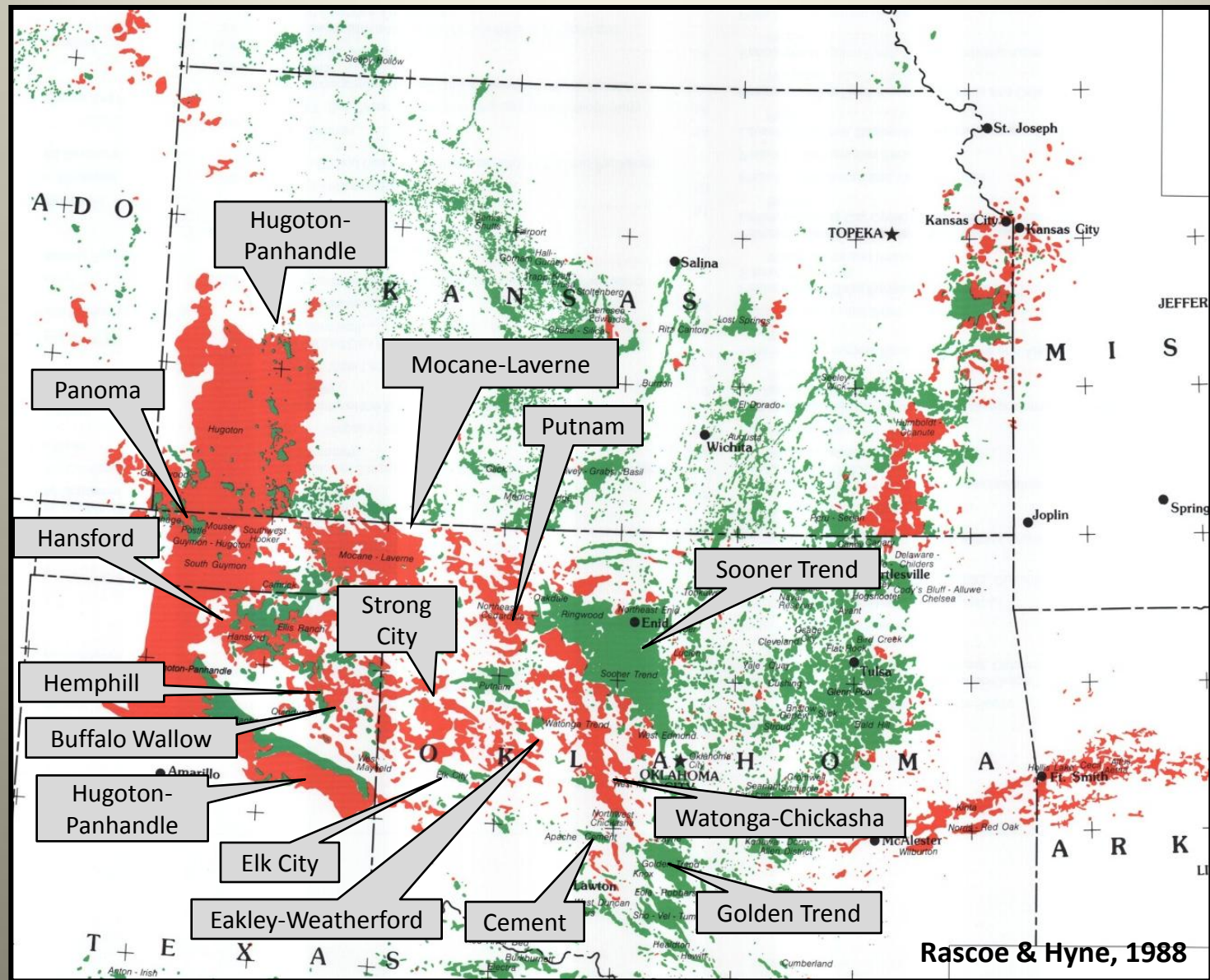
Map Adapted from H.G. Davis, 1988

# Giant (>100 MMBO) Oil Fields Map Anadarko Basin



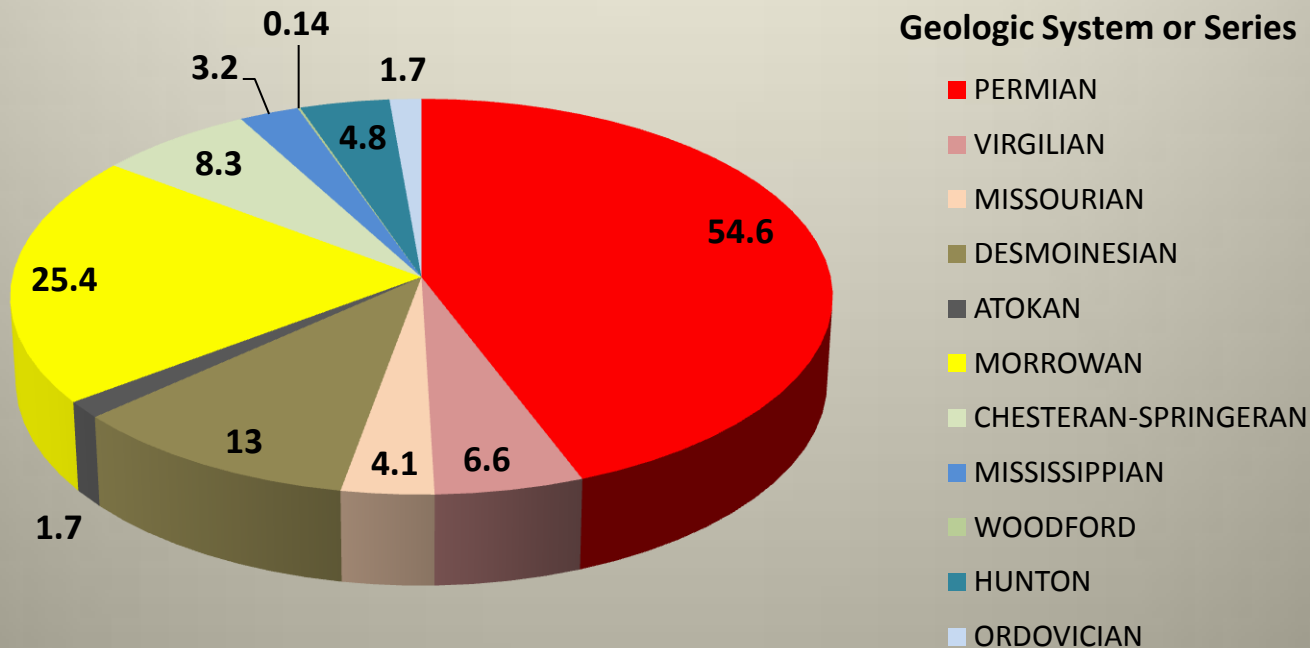


# Significant (>1,000 BCF) Gas Fields Map



# Distribution of Gas Production by Reservoir Age

**>123.5 TCF Total Gas in IHS Production Data Files for Anadarko Basin  
of Oklahoma, Texas Panhandle, Western Kansas and Southeastern  
Colorado**

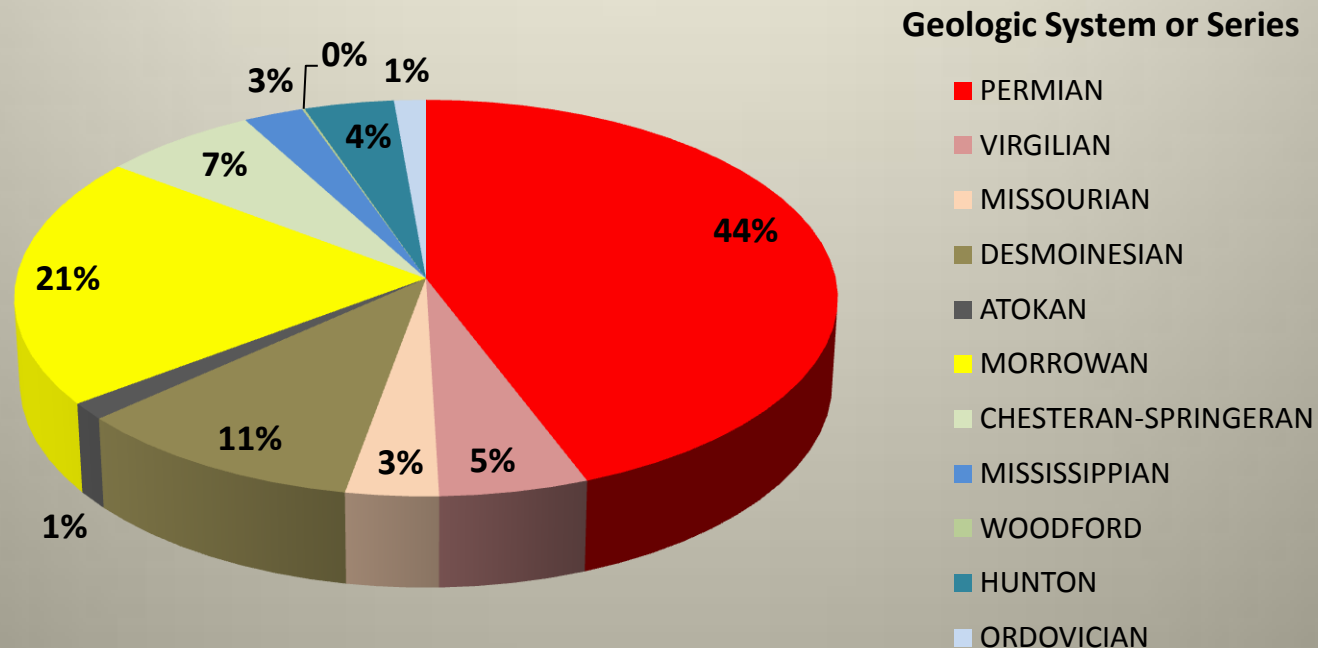


**Cumulative Gas Production in TCF by Geologic System or Series  
In the Anadarko Basin**



# Distribution of Gas Production by Reservoir Age

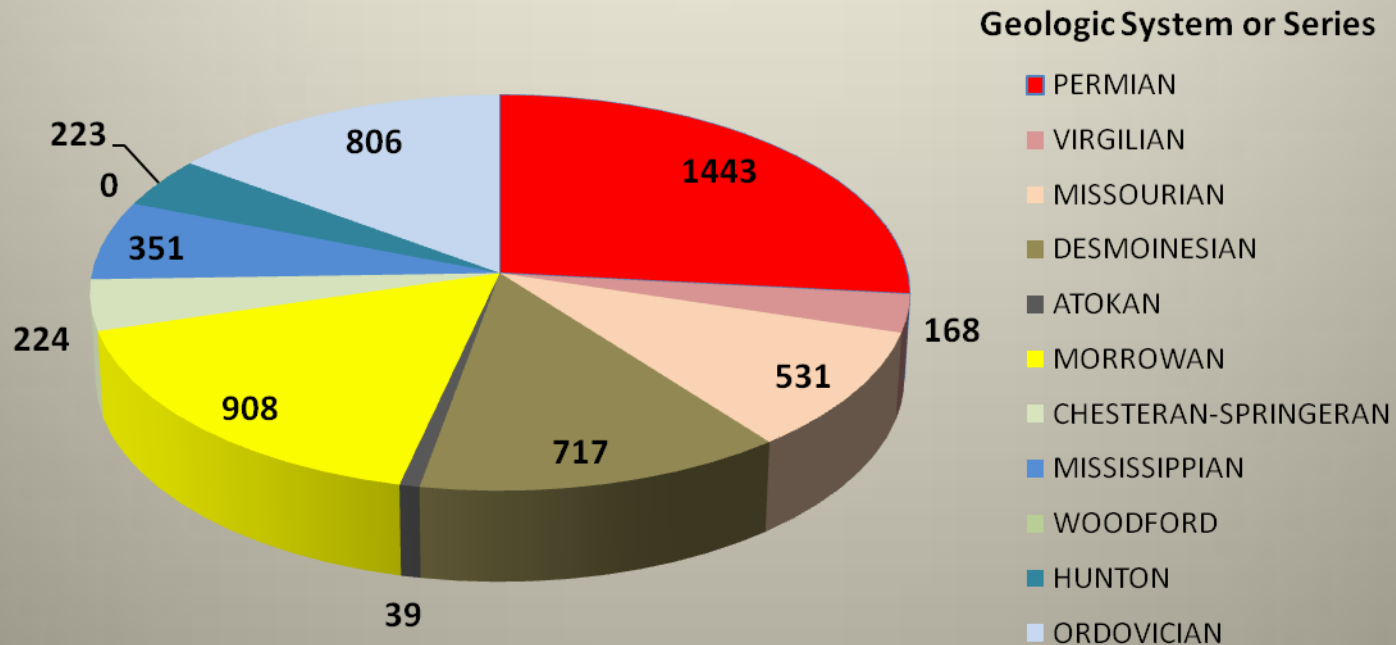
**>123.5 TCF Total Gas in IHS Production Data Files for Anadarko Basin  
of Oklahoma, Texas Panhandle, Western Kansas and Southeastern  
Colorado**



**Percentage of Cumulative Gas Production by Geologic System or  
Series In the Anadarko Basin**

# Distribution of Oil Production by Reservoir Age

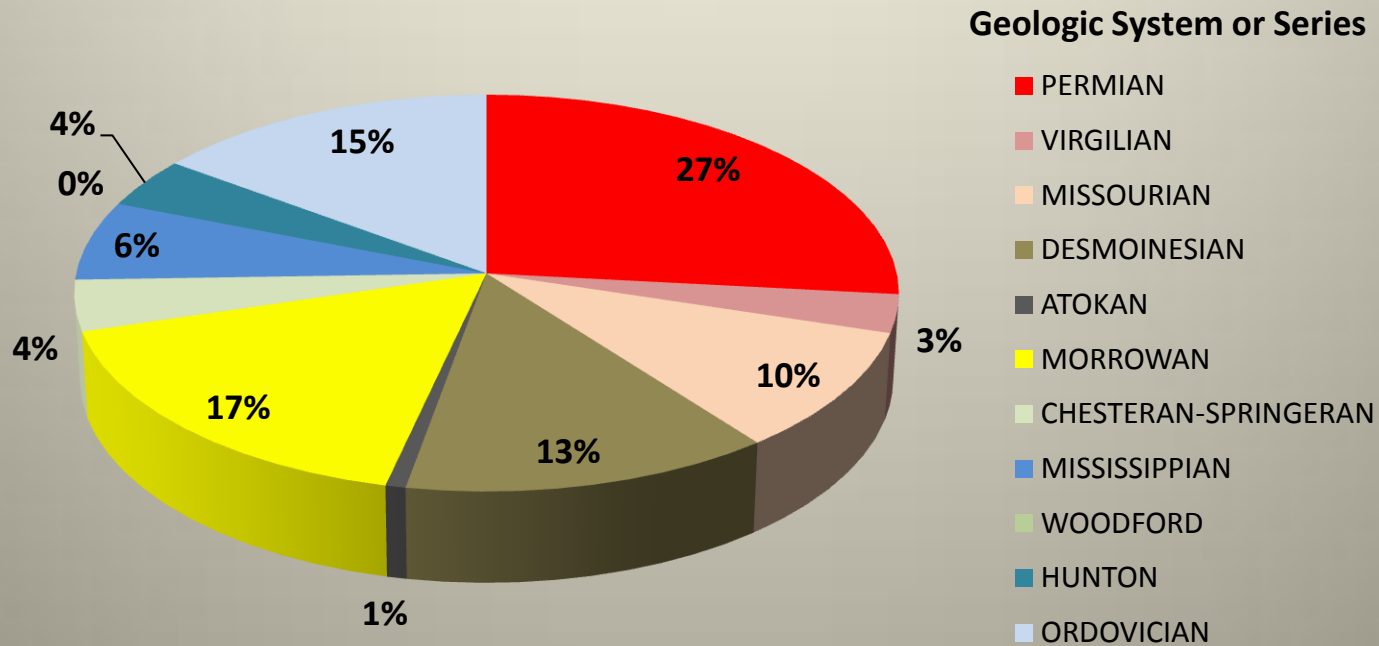
**>5,694 MMBO Total Oil in IHS Production Data Files for Anadarko Basin of Oklahoma, Texas Panhandle, Western Kansas and Southeastern Colorado**



**Cumulative Oil Production in MMBO by Geologic System or Series  
In the Anadarko Basin**

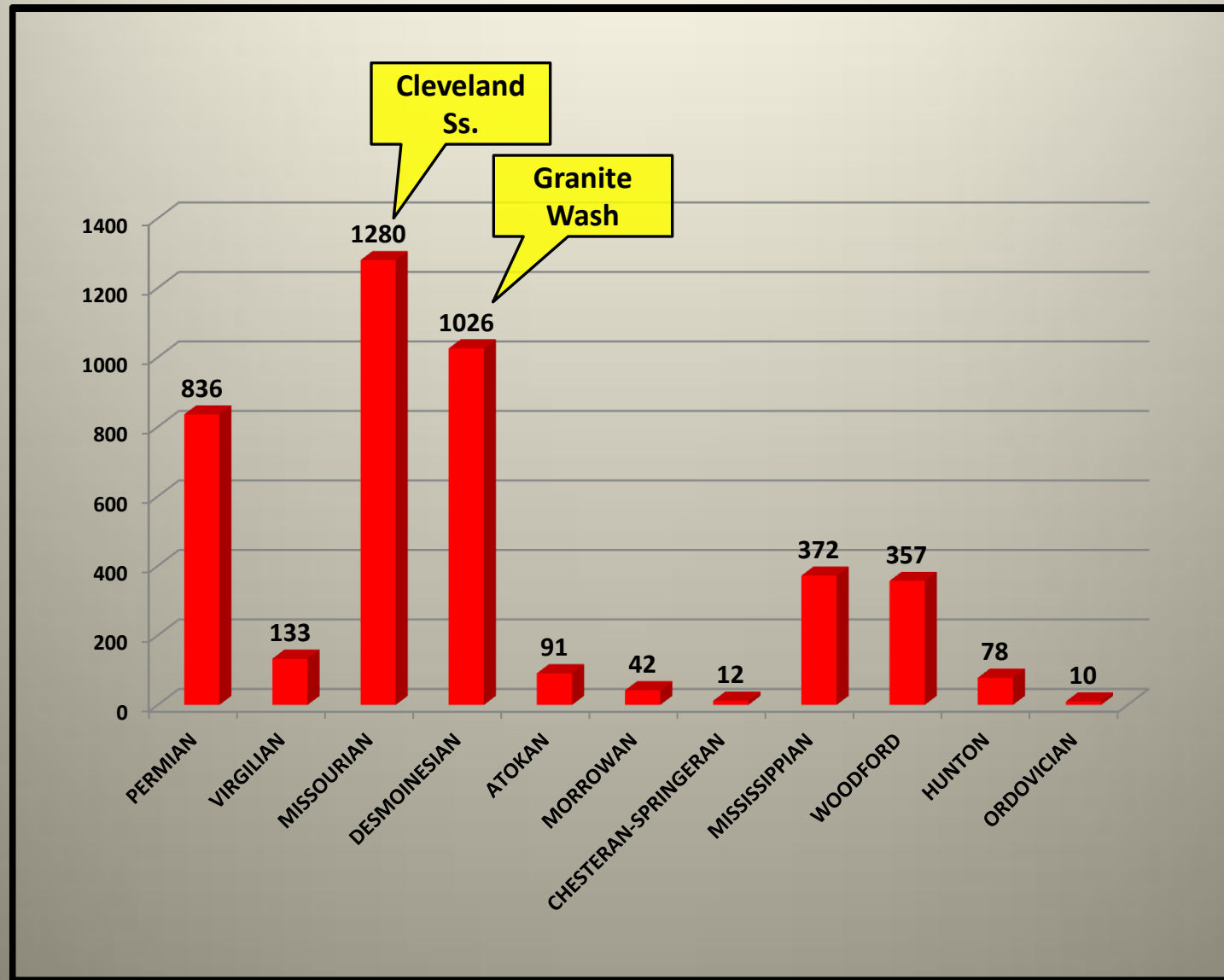
# Distribution of Oil Production by Reservoir Age

**>5,694 MMBO Total Oil in IHS Production Data Files for Anadarko Basin of Oklahoma, Texas Panhandle, Western Kansas and Southeastern Colorado**



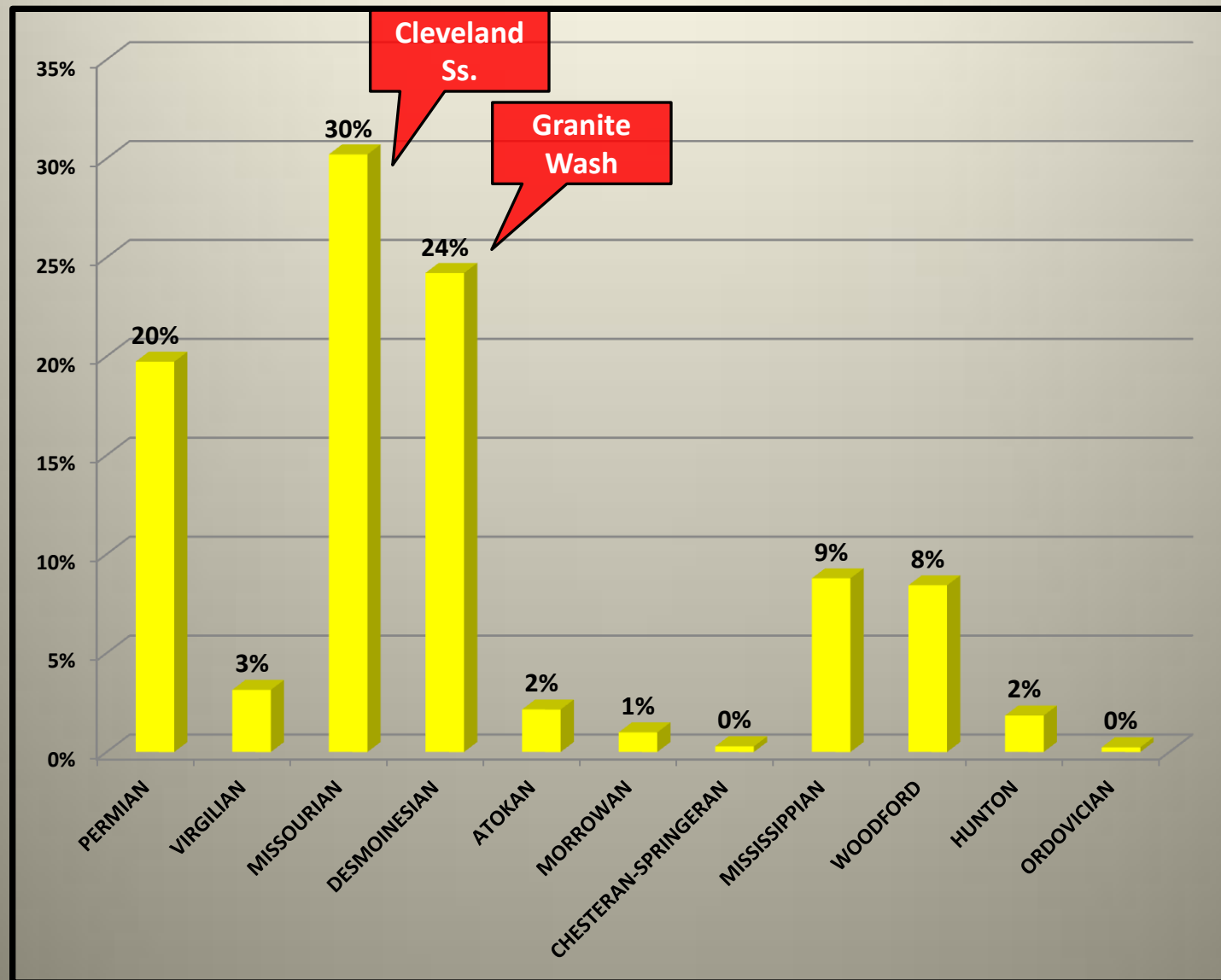
**Percentage of Cumulative Oil Production by Geologic System or Series in the Anadarko Basin**

# Distribution of Horizontal Well Completions by Reservoir Age

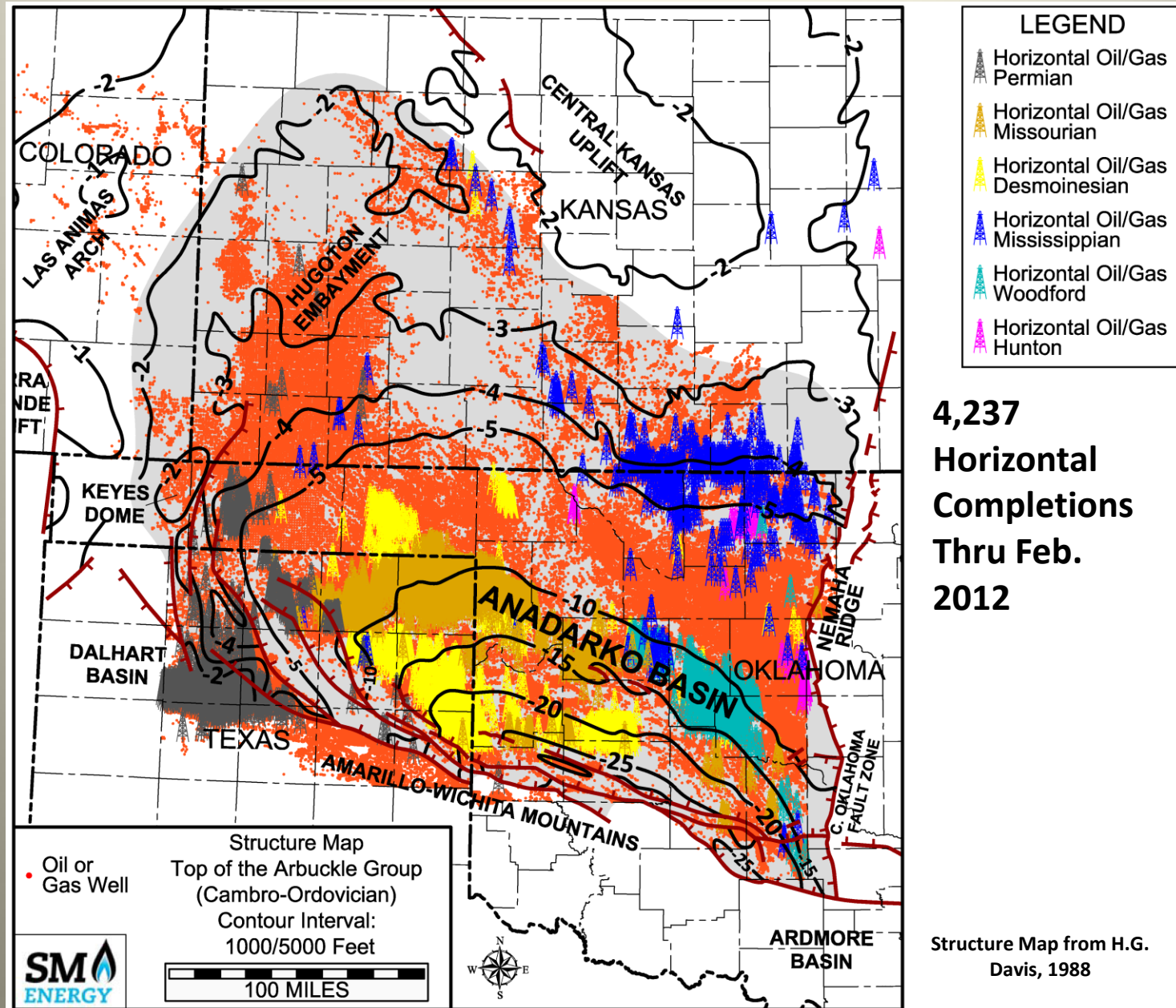




# Distribution of Horizontal Well Completions by Reservoir Age



# Regional Structural Features-Horizontal Wells



# **SIX MID-CONTINENT OIL AND GAS PETROLEUM SYSTEMS**

- **Permian Carbonates and Granite Wash**
- **Pennsylvanian Fluvio-deltaic Sandstone, Marine Sandstone and Limestone**
- **Mississippian Carbonate and Upper Devonian Shale and Chert**
- **Siluro-Devonian Carbonate (Hunton Group)**
- **Middle/Upper Ordovician Sandstone & Limestone (Simpson & Viola Groups)**
- **Cambro-Ordovician Carbonate (Arbuckle Group)**

# **MID-CONTINENT OIL AND GAS SOURCE ROCK UNITS**

- **Woodford formation (Upper Devonian) in Anadarko, Arkoma and Ardmore-Marietta Basins**
- **Pennsylvanian marine shales (Virgilian, Missourian, Desmoinesian, Atokan, Morrow-Springer)**
- **Mississippian Caney/Goddard Shale**
- **Ordovician Carbonates (Viola Group)**
- **Ordovician Shales (Simpson Group)**



# MID-CONTINENT OIL AND GAS SOURCE ROCK UNITS

| SYSTEM         | PRODUCING INTERVAL                           | HYDROCARBON-SOURCE ROCK        | KEROGEN TYPE | TOC %   |
|----------------|--|--------------------------------|--------------|---------|
| PERMIAN        | PERMIAN (UNDIFFERENTIATED)                   |                                |              |         |
| PENNSYLVANIAN  | VIRGILIAN                                    | UPPER AND MIDDLE PENNSYLVANIAN | II III       | <1-25   |
|                | DESMOINESIAN                                 |                                |              |         |
|                | ATOKAN                                       | MORROWAN                       | III          | 0.5-3.4 |
|                | MORROWAN                                     |                                |              |         |
| MISSISSIPPIAN  | SPRINGER FORMATION                           | SPRINGER FORMATION             | III          |         |
|                | PRE-CHESTER MISSISSIPPIAN (UNDIFFERENTIATED) |                                |              |         |
| DEVONIAN       | HUNTON GROUP                                 | WOODFORD SHALE                 | II III       | <1-14   |
| SILURIAN       |  |                                |              |         |
| ORDOVICIAN     | SIMPSON GROUP                                | SYLVAN SIMPSON GROUP           | I II         | <1-9    |
| UPPER CAMBRIAN | ARBUCKLE GROUP                               |                                |              |         |

Figure 6. Paleozoic producing intervals, hydrocarbon source rocks, kerogen type, and total organic carbon content (TOC %) of Oklahoma basin (after Wenger and Baker, 1986; Rice and others, 1989; Burruss and Hatch, 1989).

# MID-CONTINENT OIL TYPES

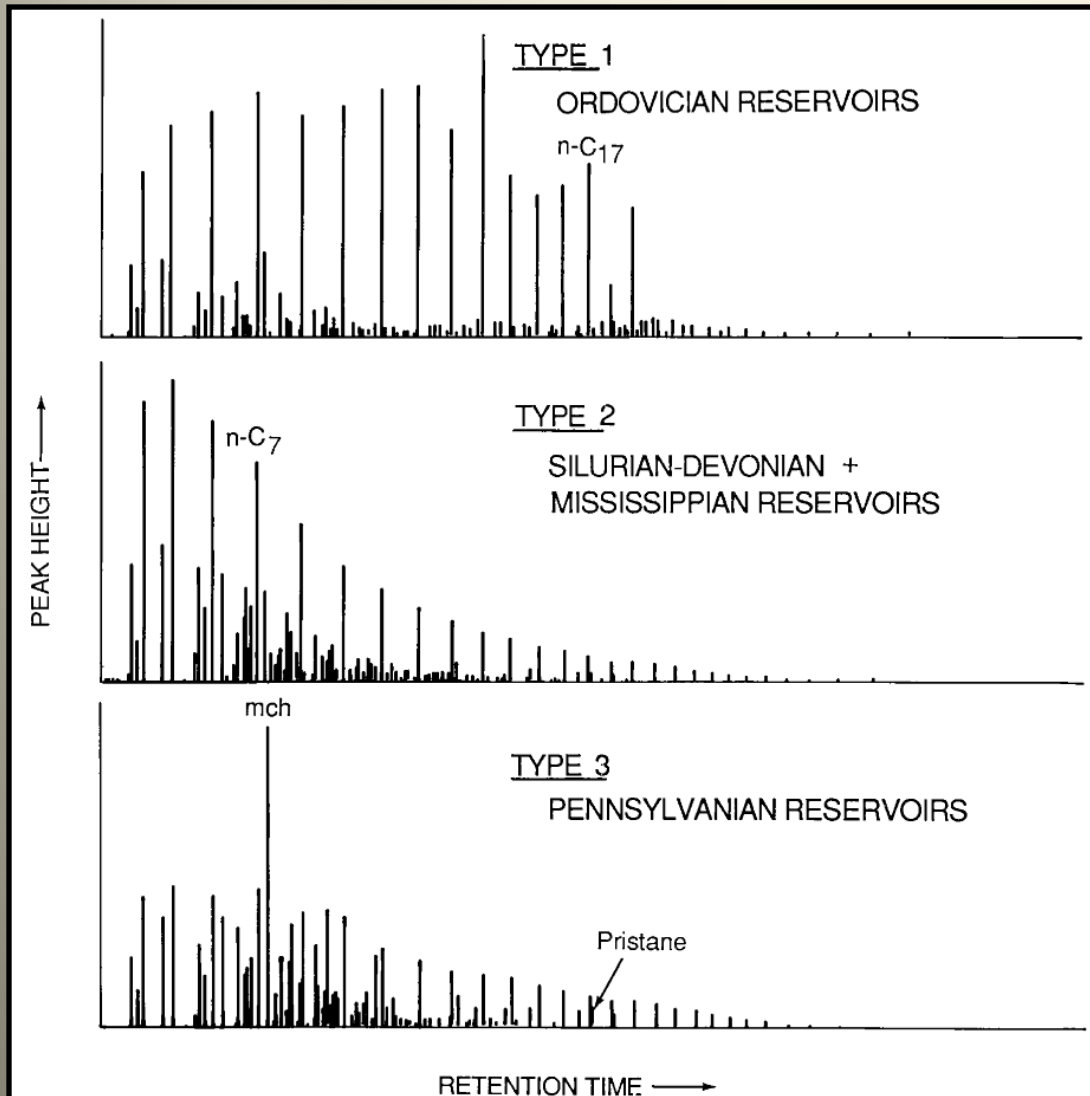


Figure 6. Whole-oil gas chromatograms of representative oil samples from Anadarko basin reservoirs in different stratigraphic intervals, illustrating major differences in hydrocarbon compound distributions.

Gas chromatogram plots of representative oil samples, Anadarko Basin, showing three distinctive crude oil types. A definitive source unit for the Type 1 oil produced from Ordovician reservoirs has not been well identified. Type 2 oil from Siluro-Devonian and Mississippian reservoirs is sourced from the Woodford Shale. Type 3 oils produced from Pennsylvanian units comes from associated marine shales in the Pennsylvanian section. (Burrus and Hatch, 1989).

# SOURCE ROCK UNITS – WOODFORD FM.

**T9N R6W SEC 31  
BATTIEST #1-31  
GRADY CO., OK**

**Sycamore Ls.  
(Mississippian)**

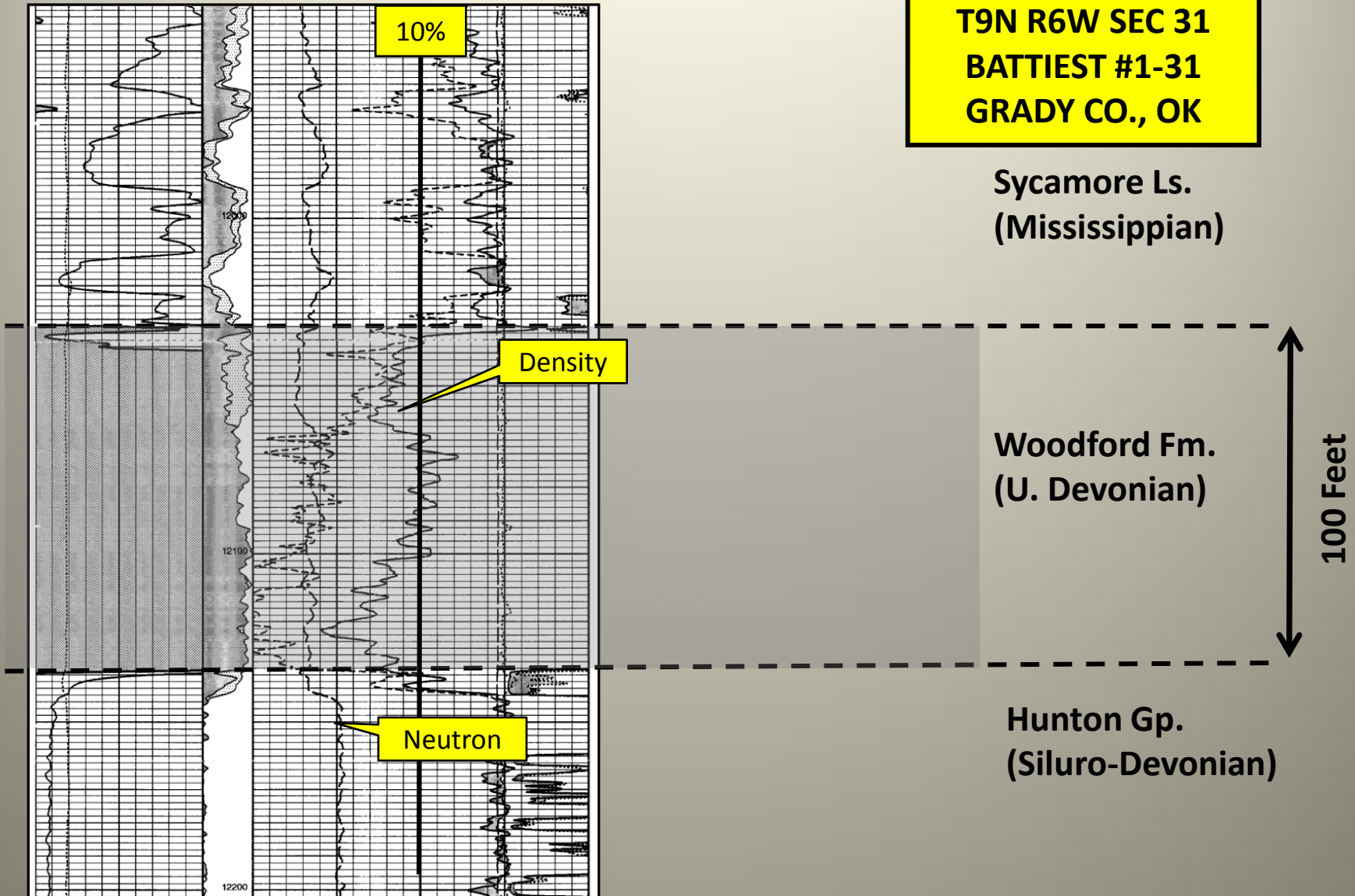
**Density**

**Neutron**

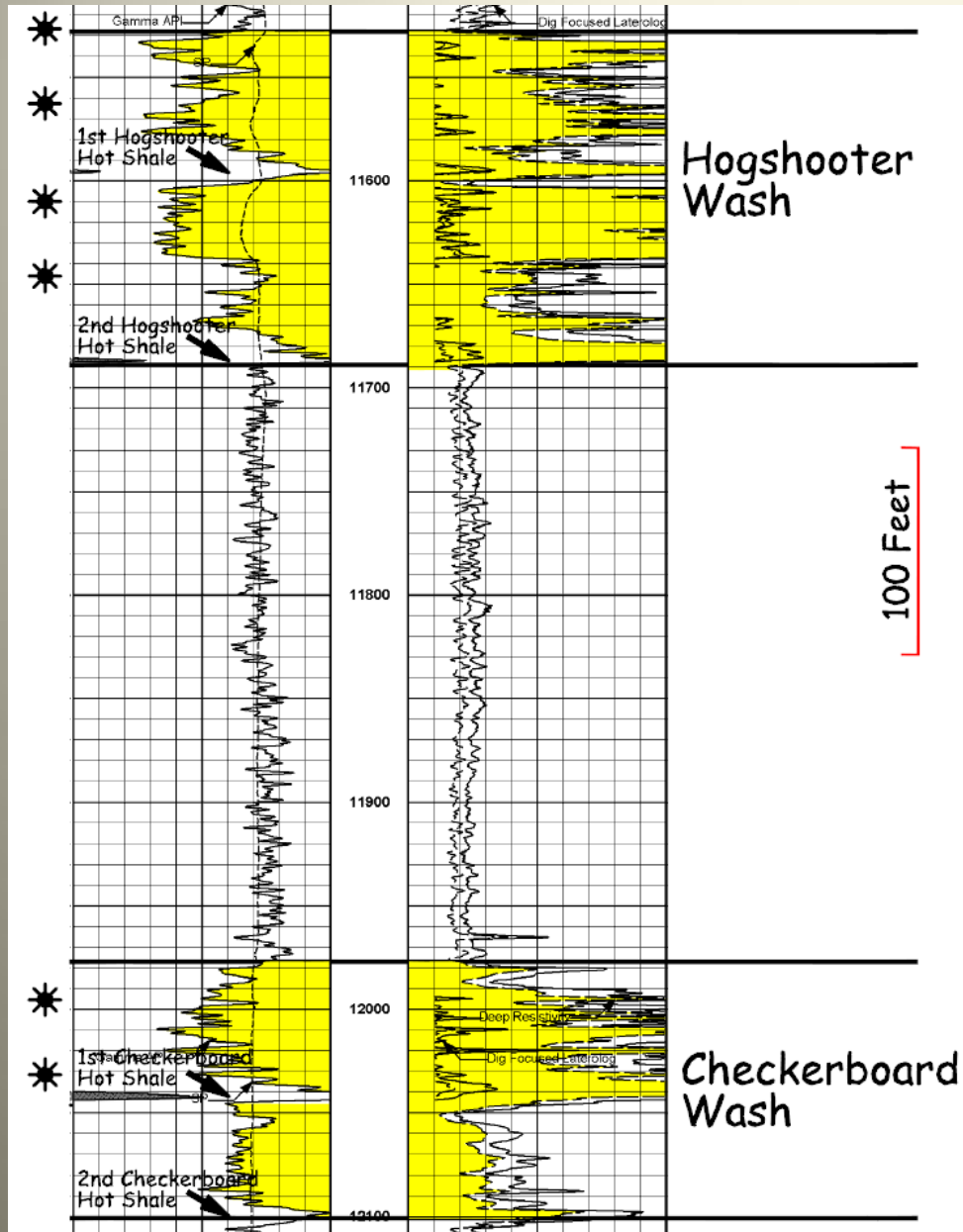
**Woodford Fm.  
(U. Devonian)**

**Hunton Gp.  
(Siluro-Devonian)**

**100 Feet**



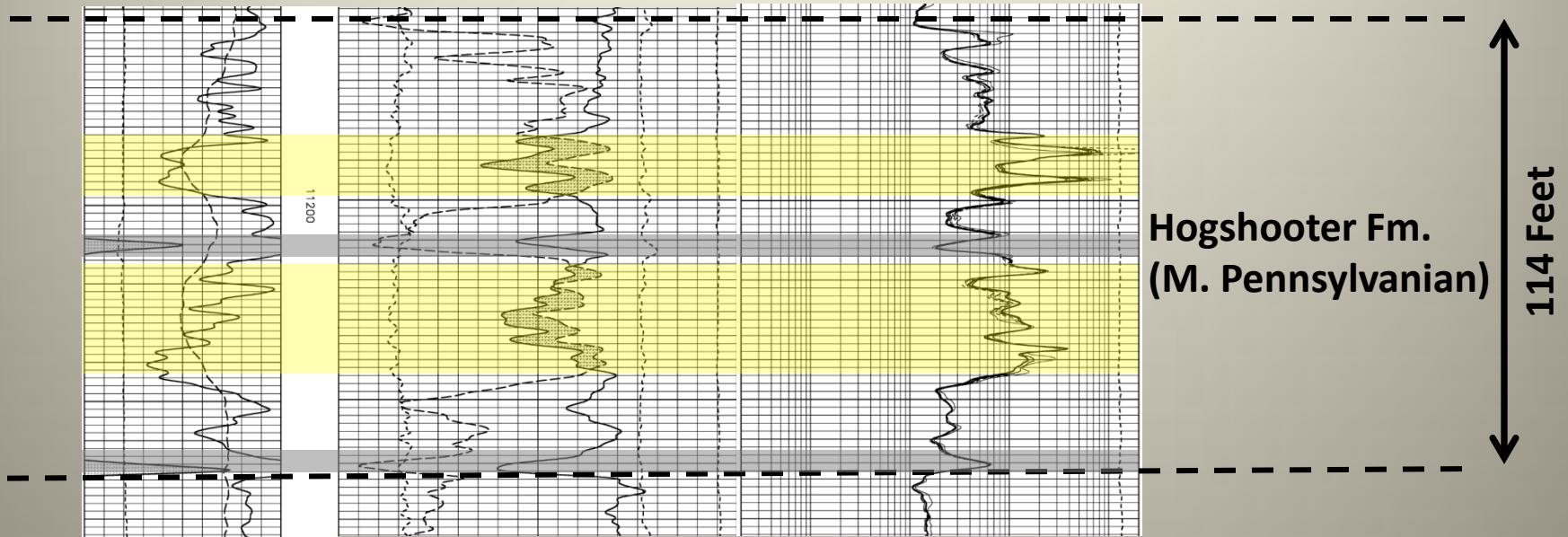
# SOURCE ROCK UNITS – MISSOURIAN SHALES



The thin radioactive shales in the Missourian section have 2-6% TOC (SM Energy data) in Beckham Co., Oklahoma and are well into the oil window.



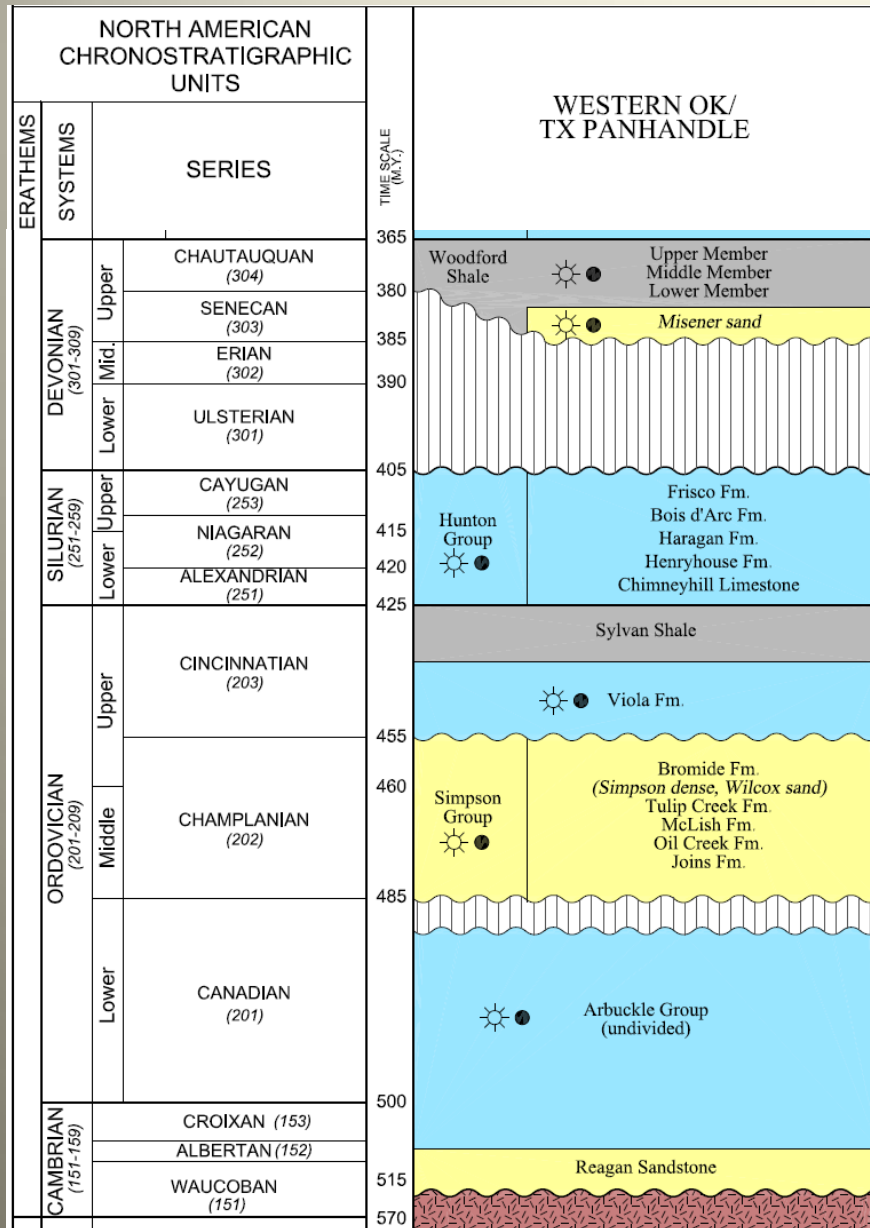
**SOURCE ROCK UNITS – HOGSHOOTER FM.  
SM ENERGY #1-26H BECK  
SEC. 26, T11N R23W, BECKHAM COUNTY, OK**



**The thin radioactive shales in the Missourian section have 2-6% TOC (SM Energy data) and are well into the oil window. This log shows the Upper and Lower Hogshooter Wash sandstones that have been completed in recent horizontal wells for as much as 2000 BOPD + 4 MMCFGPD.**

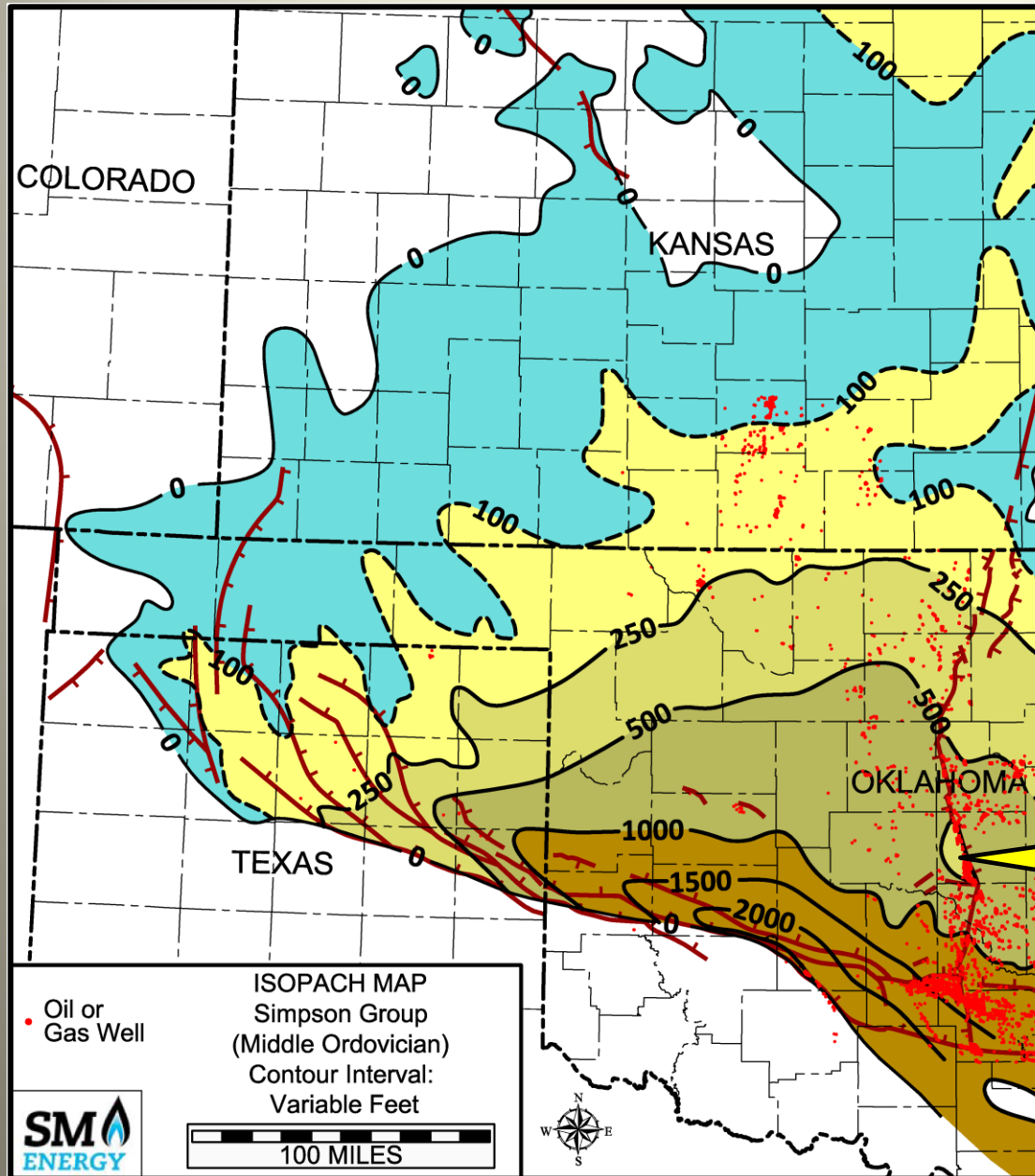
# **Regional Isopach, Production and Horizontal Activity Maps by Geologic System or Series**

# Regional Stratigraphic Column: Lower Paleozoic



A total of 6.5 TCF of gas (5% of Mid-Continent total) has been produced from the Siluro-Devonian and Cambro-Ordovician reservoirs. Total oil production of 1,029 MMBO (19%) has come from these reservoirs. The Hunton carbonate interval has made the majority of the gas while the sandstones in the Ordovician Simpson Group have made most of the oil, primarily from Oklahoma City field. Only eighty-eight horizontal wells (3% of basin total) have been completed these reservoirs in the Anadarko Basin.

# Regional Isopach-Simpson Gp. (M. Ordovician)

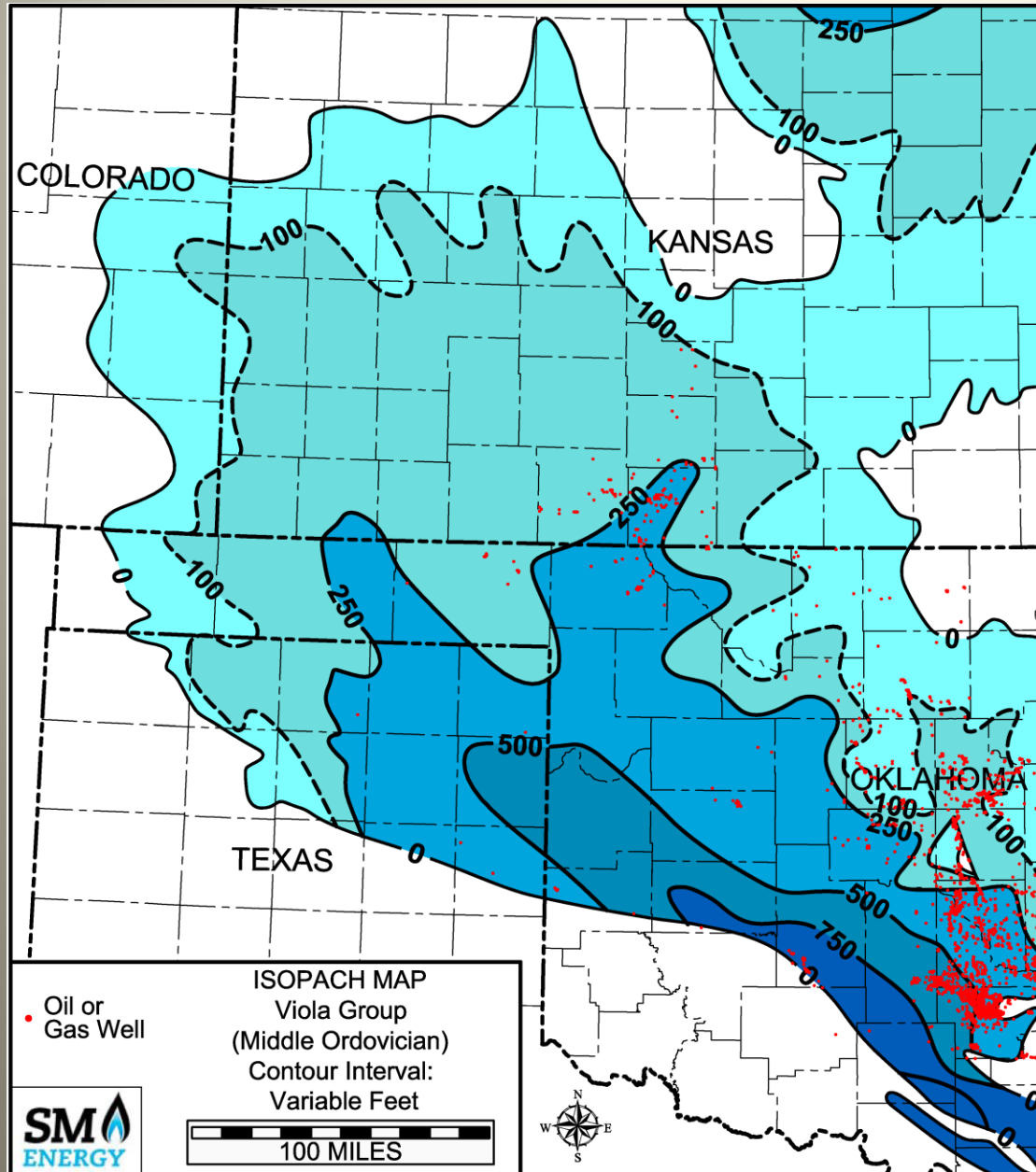


Although the Simpson Group sandstones (Bromide, McLish and Oil Creek are prolific oil producers in central Oklahoma, the high porosity and conventional nature of the reservoirs have precluded the use of horizontal wells. Very few wells have penetrated the Simpson in the deep Anadarko Basin.

Oklahoma City Field:  
>500 MMBO from  
Simpson Group  
sandstones

Map adapted from Adler & others, 1971

# Regional Isopach-Viola Group

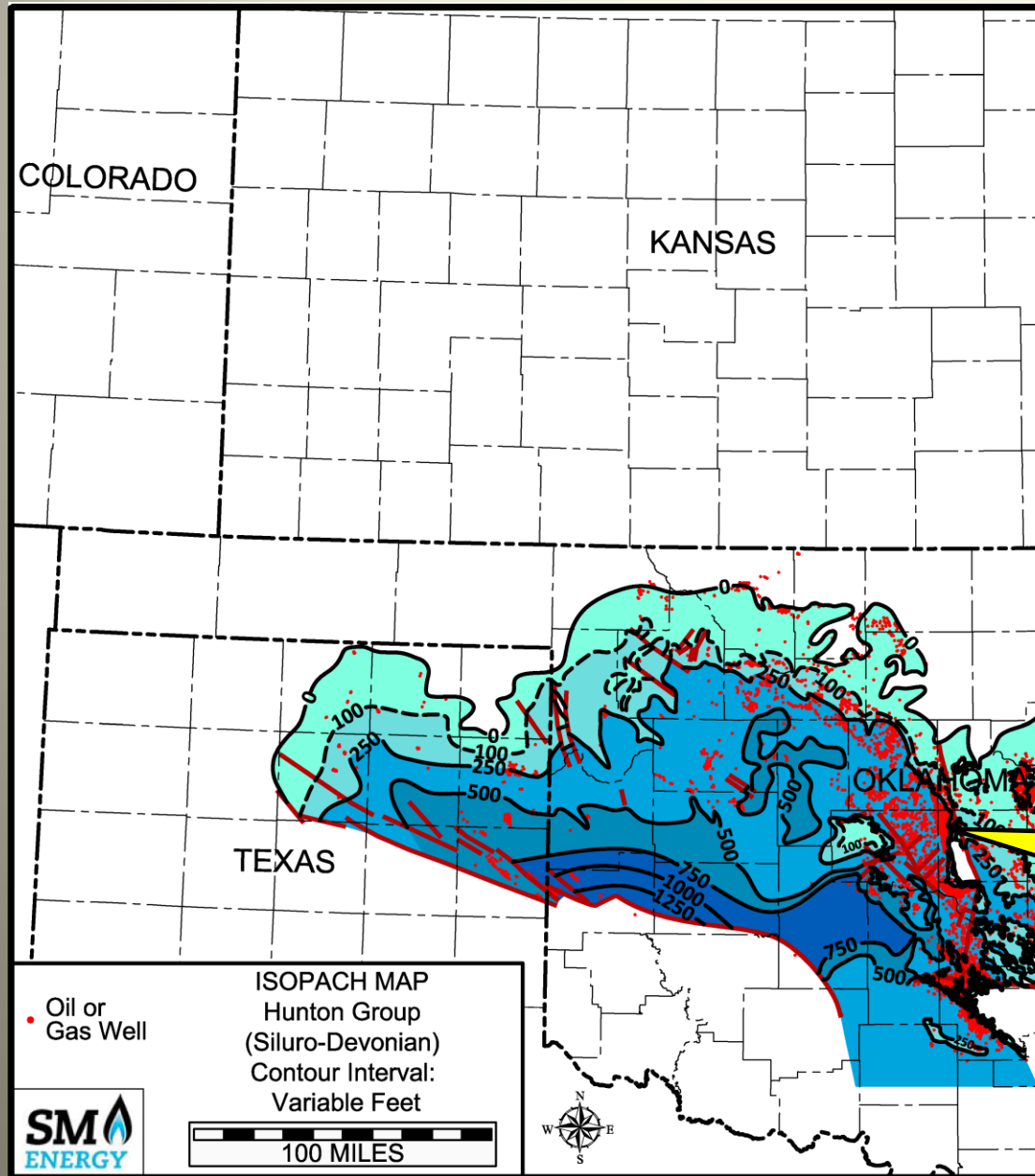


Widespread oil production has been obtained from thick (>100 ft) low porosity limestone in the Viola Group in the southeastern portion of the basin. Production is from mainly fractured reservoirs and is highly variable. Only a few horizontals have been placed in the Viola in Oklahoma. Very few vertical wells have penetrated the Viola in the deep Anadarko Basin.

Map adapted from Adler & others, 1971



# Regional Isopach-Hunton Gp. (Siluro-Devonian)



The Hunton Group is truncated by pre-Woodford and pre-Pennsylvanian erosion surfaces on the north, west and east sides of the basin. Porous dolomite reservoirs in the Frisco, Bois d'Arc and Chimneyhill members of the Hunton are present along the northern and eastern portions of the play.

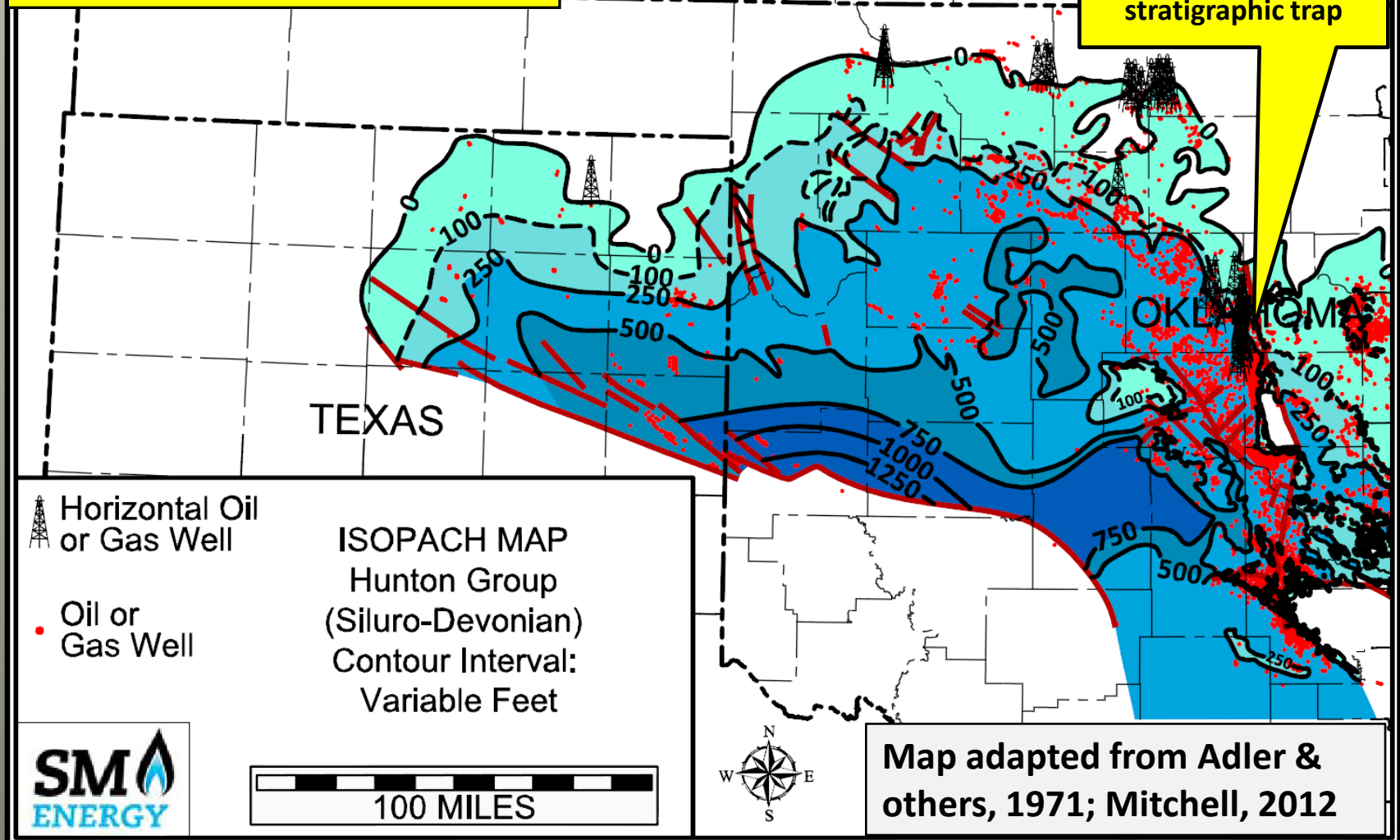
West Edmond Field:  
>150 MMBO from  
Hunton in major  
stratigraphic trap

Map adapted from Adler & others, 1971; Mitchell, 2012






# Regional Isopach-Hunton Gp. & Horizontal Wells

Only seventy-eight horizontals have tested the Hunton in the Anadarko Basin.

West Edmond Field:  
>150 MMBO from  
Hunton in major  
stratigraphic trap

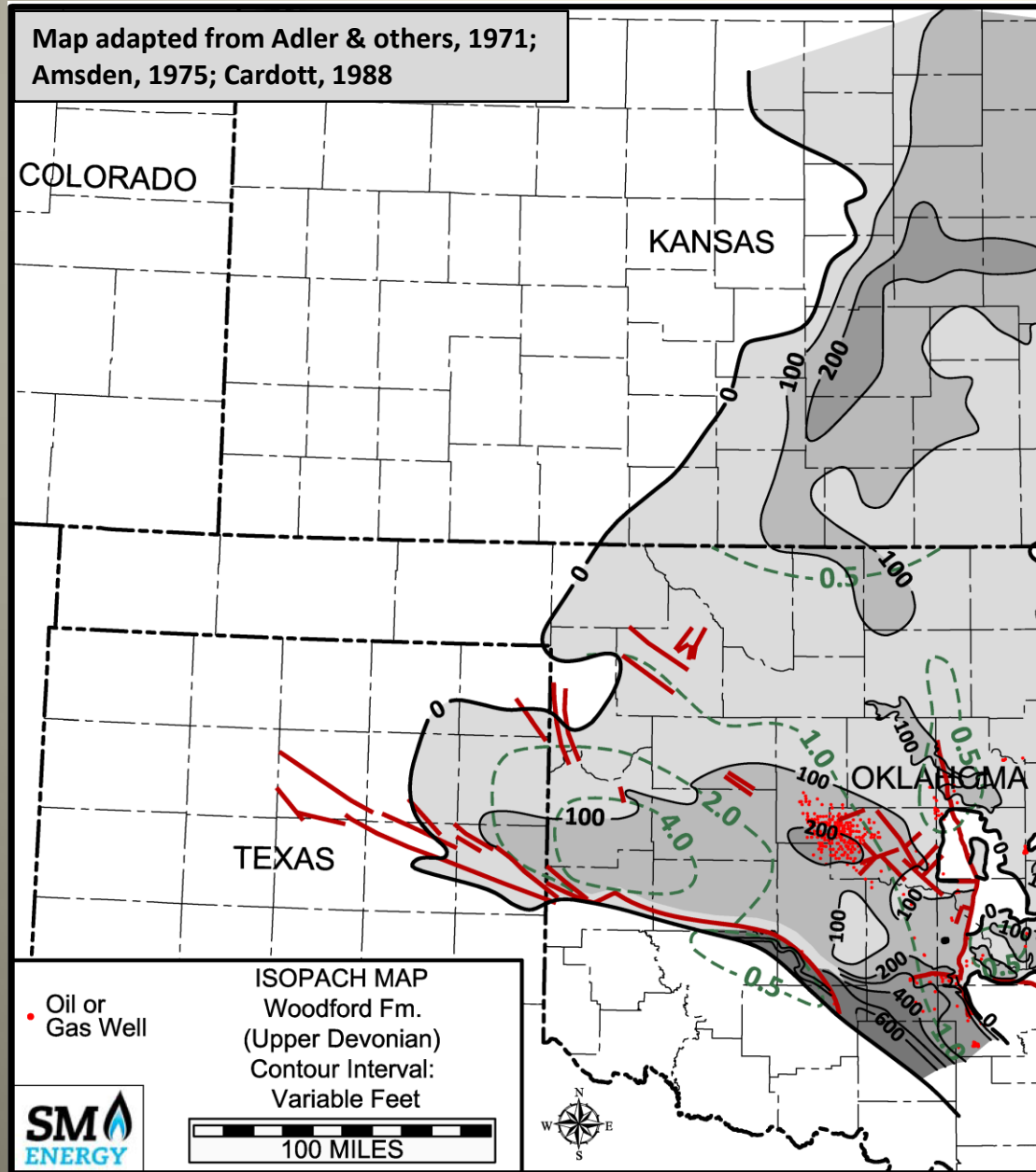


# Regional Stratigraphic Column: Upper Devonian & Lower/Middle Mississippian

| NORTH AMERICAN CHRONOSTRATIGRAPHIC UNITS |                            |                        | TIME SCALE (Ma) | WESTERN OK/ TX PANHANDLE |  |
|--|----------------------------|------------------------|-----------------|--------------------------|--|
| ERATHEMS                                 | SYSTEMS                    | SERIES                 |                 |                          |  |
| DEVONIAN<br>(307-369)                    | MISSISSIPPIAN<br>(357-369) |                        | 340             | Chester Group            |  Manning Zone   |
|  |                            | MERAMECIAN<br>(353)    |                 | Meramec Lime             |  St. Genevieve Limestone<br>St. Louis Limestone<br>Spergen-Warsaw Ls.<br>Mississippian lime |
|  |                            | OSAGEAN<br>(352)       | 355             | Osage Lime               |  Mississippi chat<br>Cowley Fm.<br>Mississippi solid<br>Mississippian lime                  |
|  |                            | KINDERHOOKIAN<br>(351) |                 |                          | Kinderhook Shale   |
|  | Upper                      | CHAUTAUQUAN<br>(304)   | 365             | Woodford Shale           |  Upper Member<br>Middle Member<br>Lower Member  |
|  |                            | SENECAN<br>(303)       | 380             |                          |  |
|  |                            | ERIAN<br>(302)         | 385             |                          |  Misener sand   |
|  |                            | ULSTERIAN<br>(301)     | 390             |                          |  |
|  | Lower                      |                        | 405             |                          |  |
|  |                            |                        |                 |                          |  |

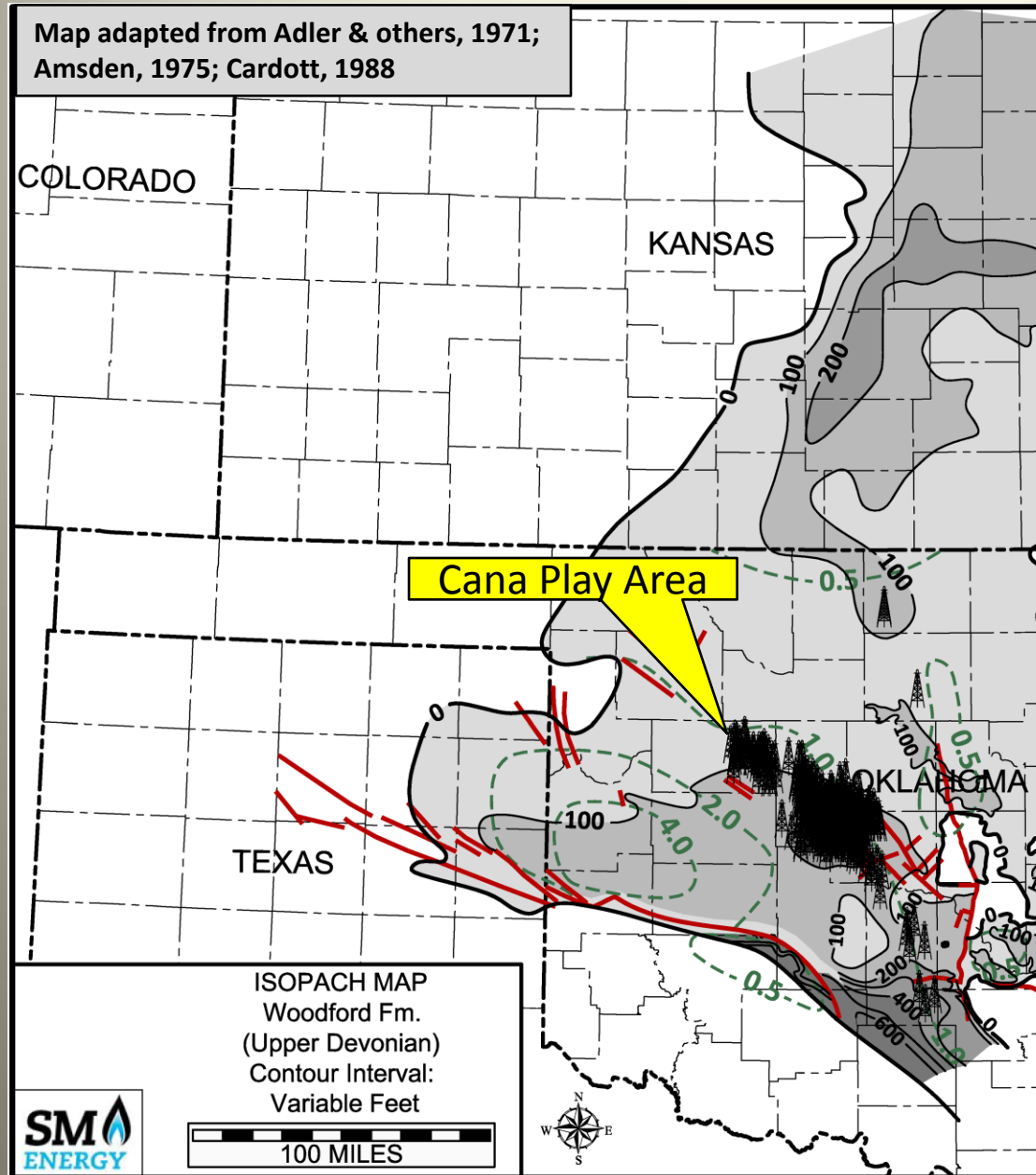
Only 3.3 TCF of gas (3% of Mid-Continent total) has been produced from the Middle Mississippian through Upper Devonian reservoirs. Total oil production of 351 MMBO (6%) has come from these reservoirs. The Mississippian carbonate interval has made most of this oil and gas. Seven hundred and twenty-nine horizontal wells (17% of basin total) have been completed in the Mississippian Limestone and Woodford Fm. reservoirs in the Anadarko Basin.

# Regional Isopach-Woodford Fm. (U. Devonian)



The organic rich siliceous shales in the Woodford Fm. are well developed in the southeastern portion of the basin. The Woodford thickens rapidly to the southeast and exceeds 600 feet in thickness in southern Oklahoma. Note the vitrinite reflectance contours in green on the map. They show a wide range of maturities with portions of the deep basin being thermally overmature and through the gas window. Large areas of Oklahoma are underlain by significant thicknesses of Woodford shale that is well into the oil window. It is the primary source for oil and gas in Mississippian, Siluro-Devonian and Ordovician units.

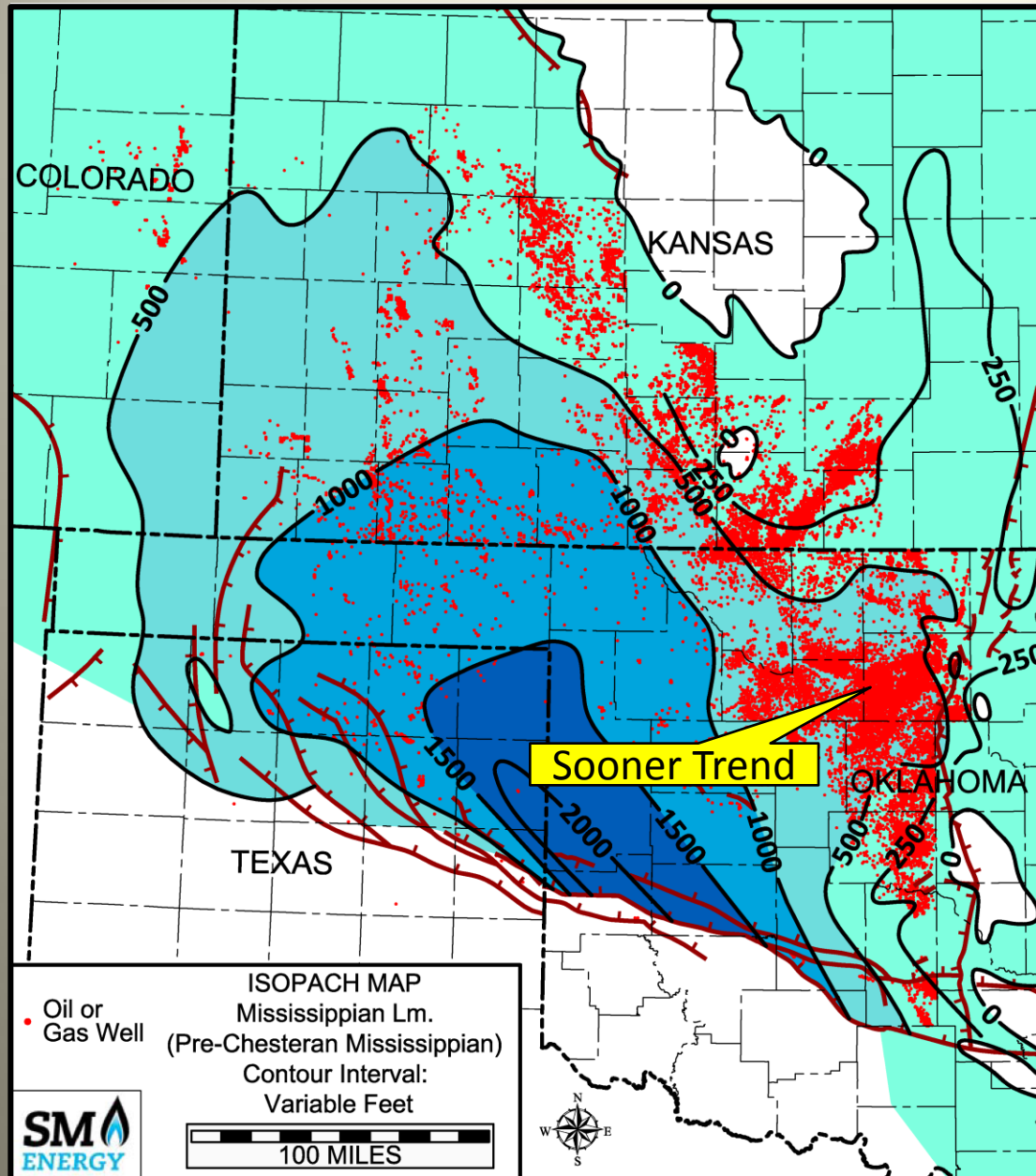
# Regional Isopach-Woodford Fm. & Producing Wells



In Canadian and Dewey Counties, Oklahoma over three hundred and fifty horizontal completions have been made in the Woodford. This area is known as the Cana (Canadian County!) play and the production is primarily gas with significant amounts of condensate and natural gas liquids. Depths range from 10,000 to 15,000 feet to the Woodford.



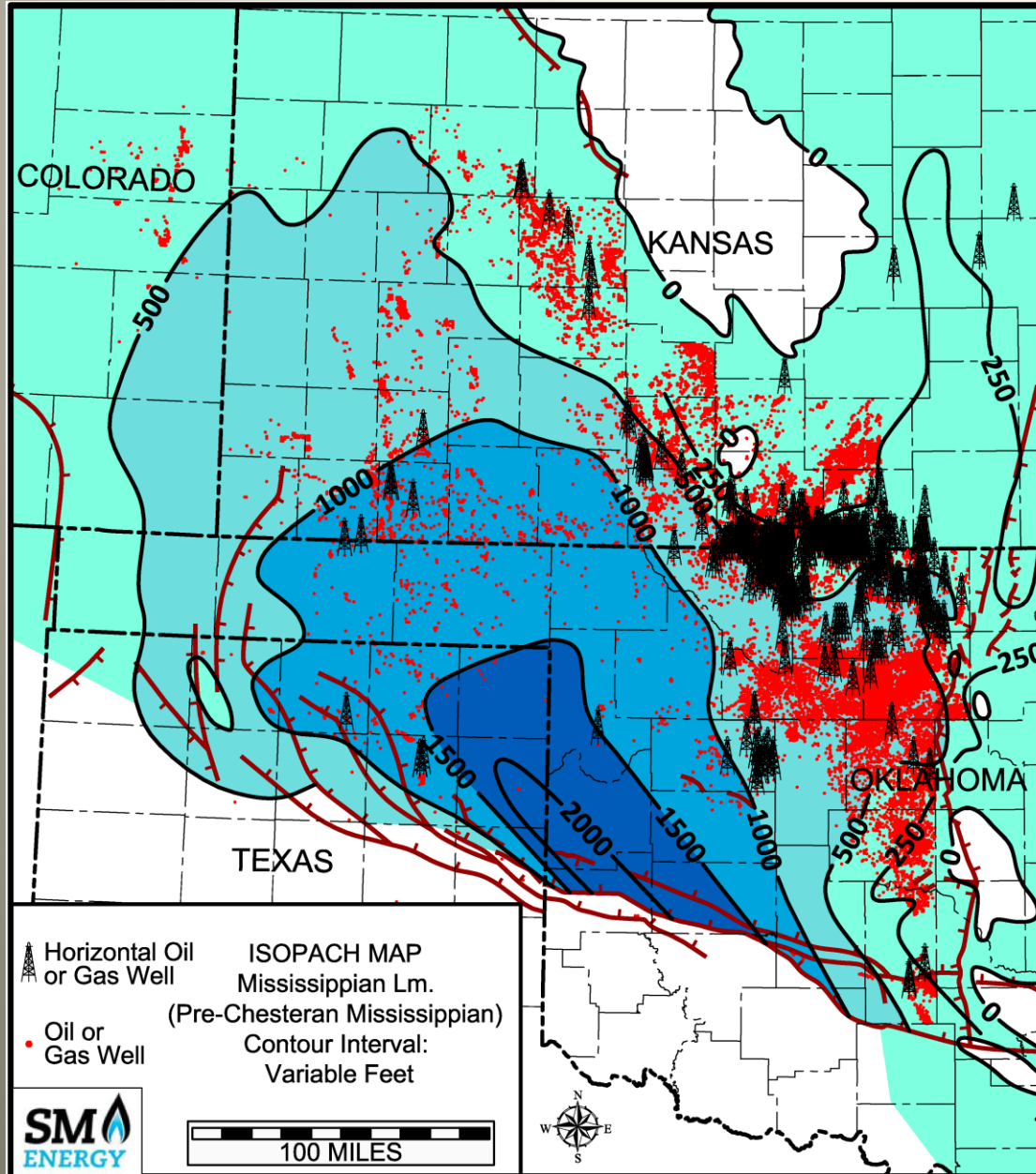
# Regional Isopach-Mississippian(Pre-Chesteran)



Widespread oil accumulations are present in low porosity limestones across multiple counties in Oklahoma and Kansas. This is north of and updip to the Mississippian oil and gas production in the enormous Sooner Trend in Kingfisher, Major and Garfield Counties, OK. Large areas of the deeper portions of the basin in Oklahoma are lightly tested in the Mississippian section.

Map adapted from Adler & others, 1971;  
H. G. Davis, 1989

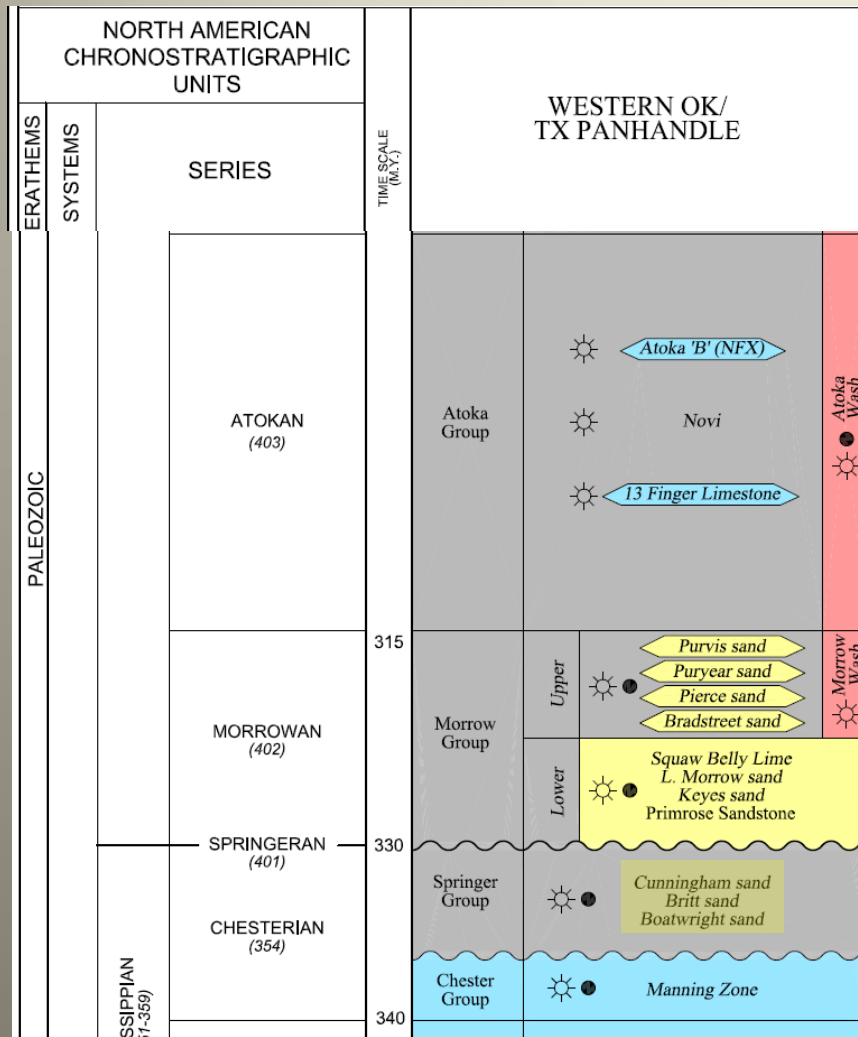
# Regional Isopach-Mississippian & Producing Wells



In the northeastern portion of the basin there is an active oil horizontal drilling play targeting siliceous limestones in the lower and middle Mississippian strata. Operators are pushing northward into Kansas in 2012.

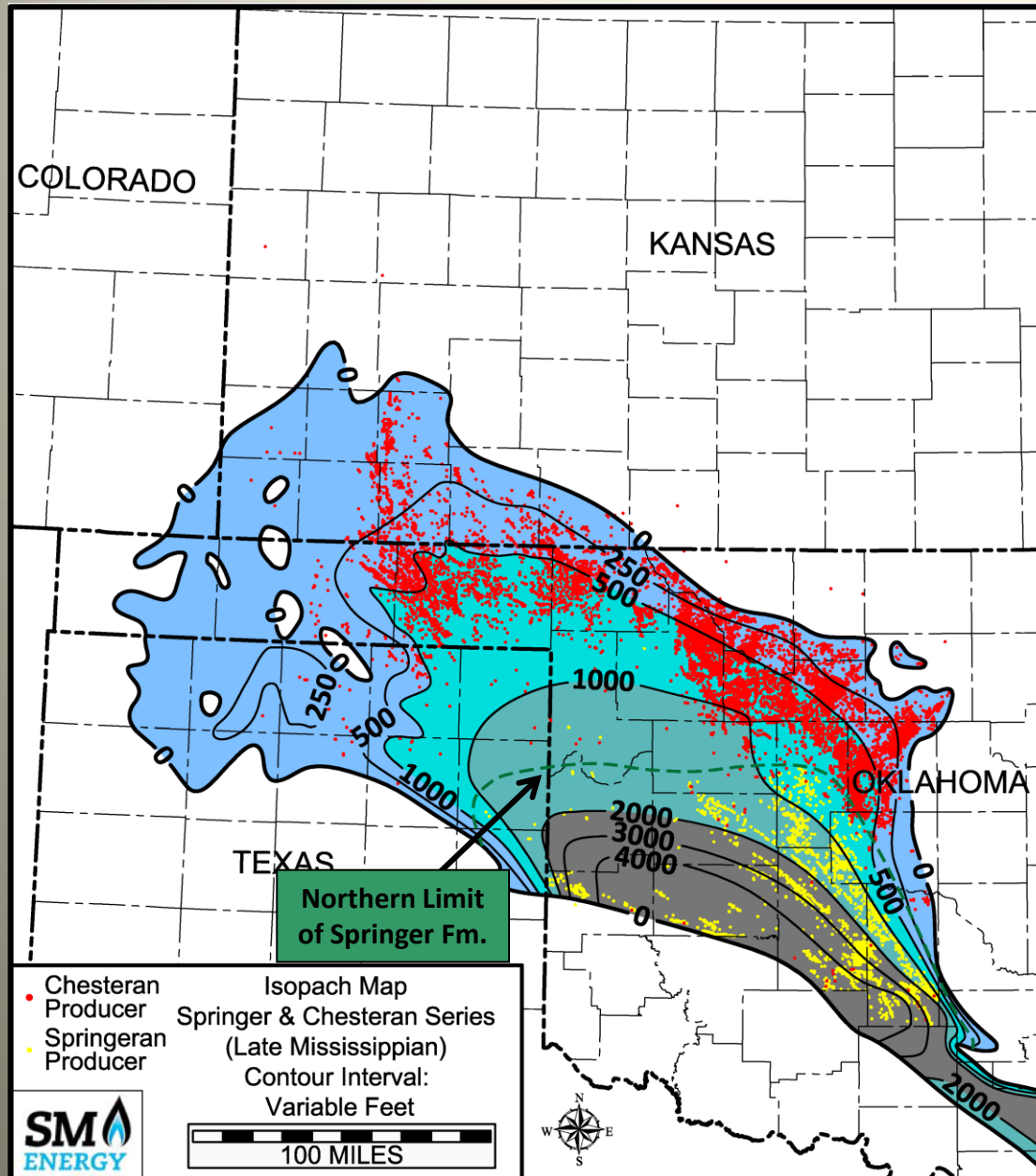
Map adapted from Adler & others, 1971;  
H. G. Davis, 1989

# Regional Stratigraphic Column: Upper Mississippian & Lower Pennsylvanian



**35.4 TCF of gas (29% of Mid-Continent total) has been produced from the Atokan through Chesteran series of the Upper Mississippian and Lower Pennsylvanian. Total oil production of 1,171 MMBO (22%) has come from these reservoirs. The Morrowan series has made the majority of this oil and gas. Only one hundred and forty-five horizontal wells (3% of basin total) have been completed in these reservoirs in the greater Anadarko Basin. The Morrow and Springer sandstones have had outstanding individual well performances in overpressured conventional deep gas reservoirs in the basin.**

# Regional Isopach-Chesteran & Springer Series

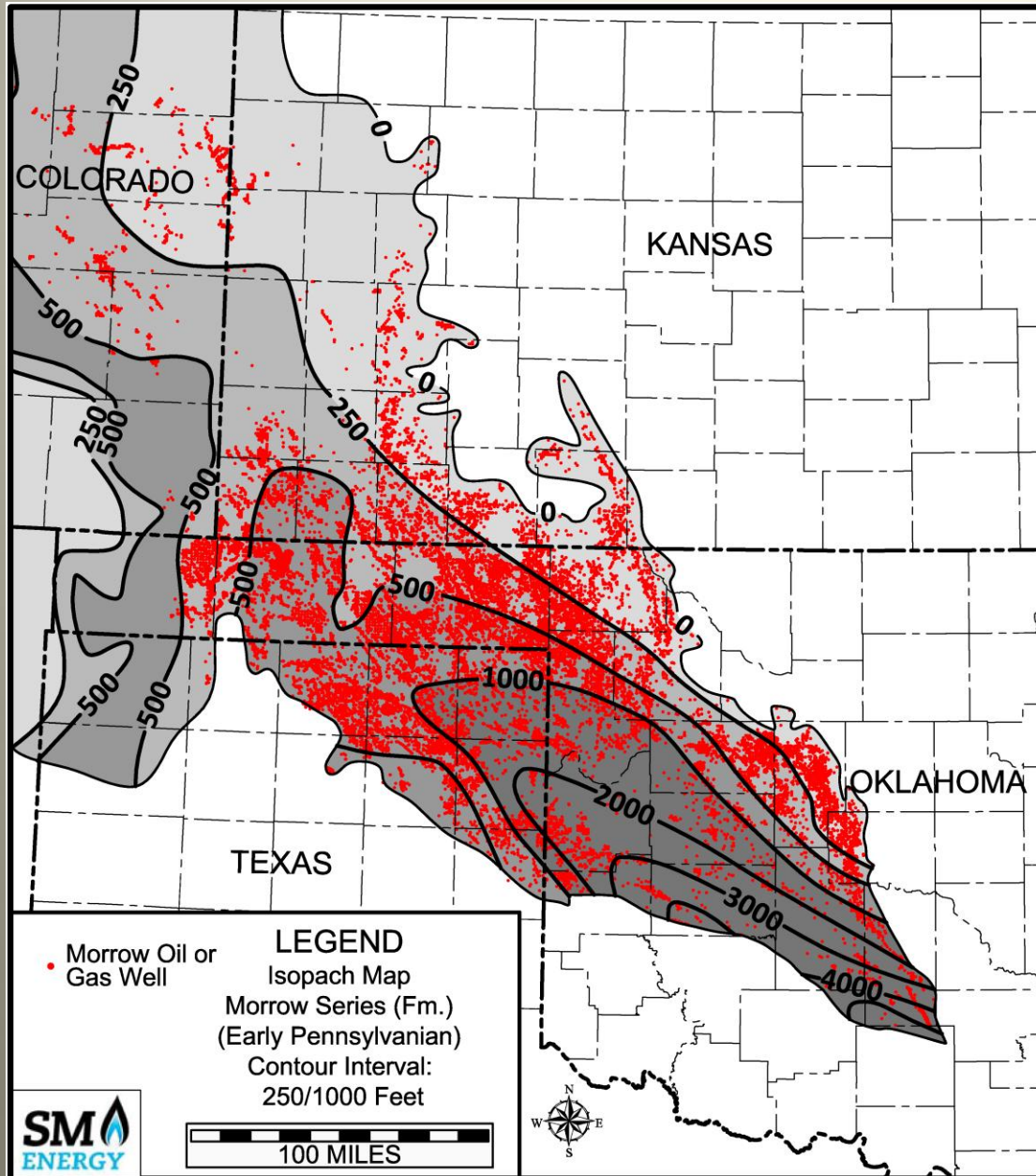


The late Mississippian Chesteran and Springeran series sandstones and limestones were deposited along the eastern portion of the basin prior to the initiation of profound structural movement in the Morrowan series. The Springer Ss. is a prolific gas producer in Caddo and Grady Counties, Oklahoma. Here the overpressured Springer sands were deposited in northwest trending marine sand bars capping coarsening upward cycles. The Chesteran reservoirs are primarily limestones forming traps beneath the pre-Penn unconformity.

Map adapted from Adler & others, 1971



# Regional Isopach-Morrowan Series

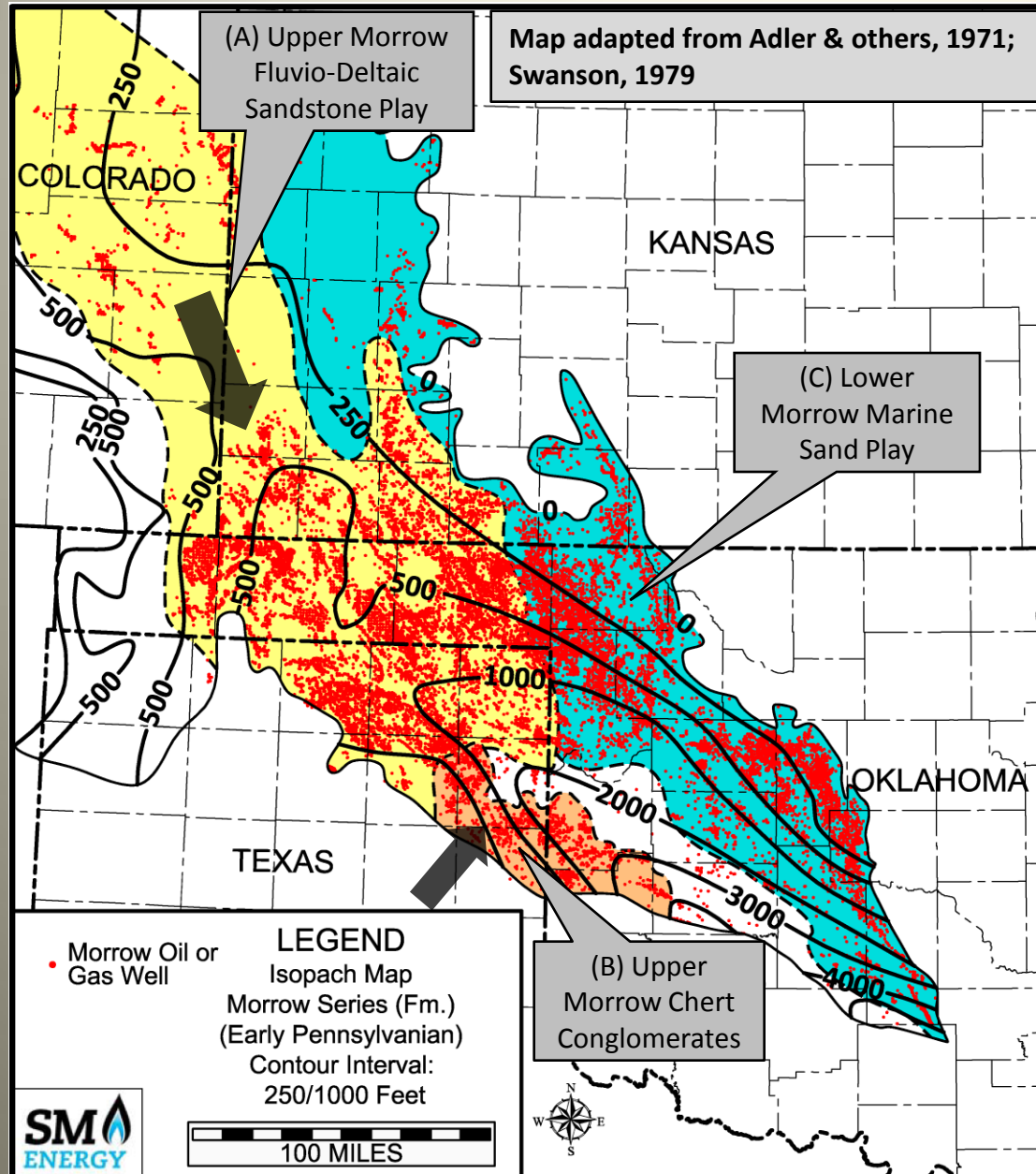


The sandstones of the Morrowan series form some of the best oil and gas reservoirs in the basin. Morrowan rocks have produced 25 TCF (21%) of the natural gas and 908 MMBO (17%) of the oil in the basin. The great majority of production has come from stratigraphic traps. As of 2012 the Morrowan rocks have not really been tested horizontally along the 300 mile long fairway from southeastern Colorado to western Oklahoma.

Map adapted from Adler & others, 1971



# Morrowan Series-Deposition



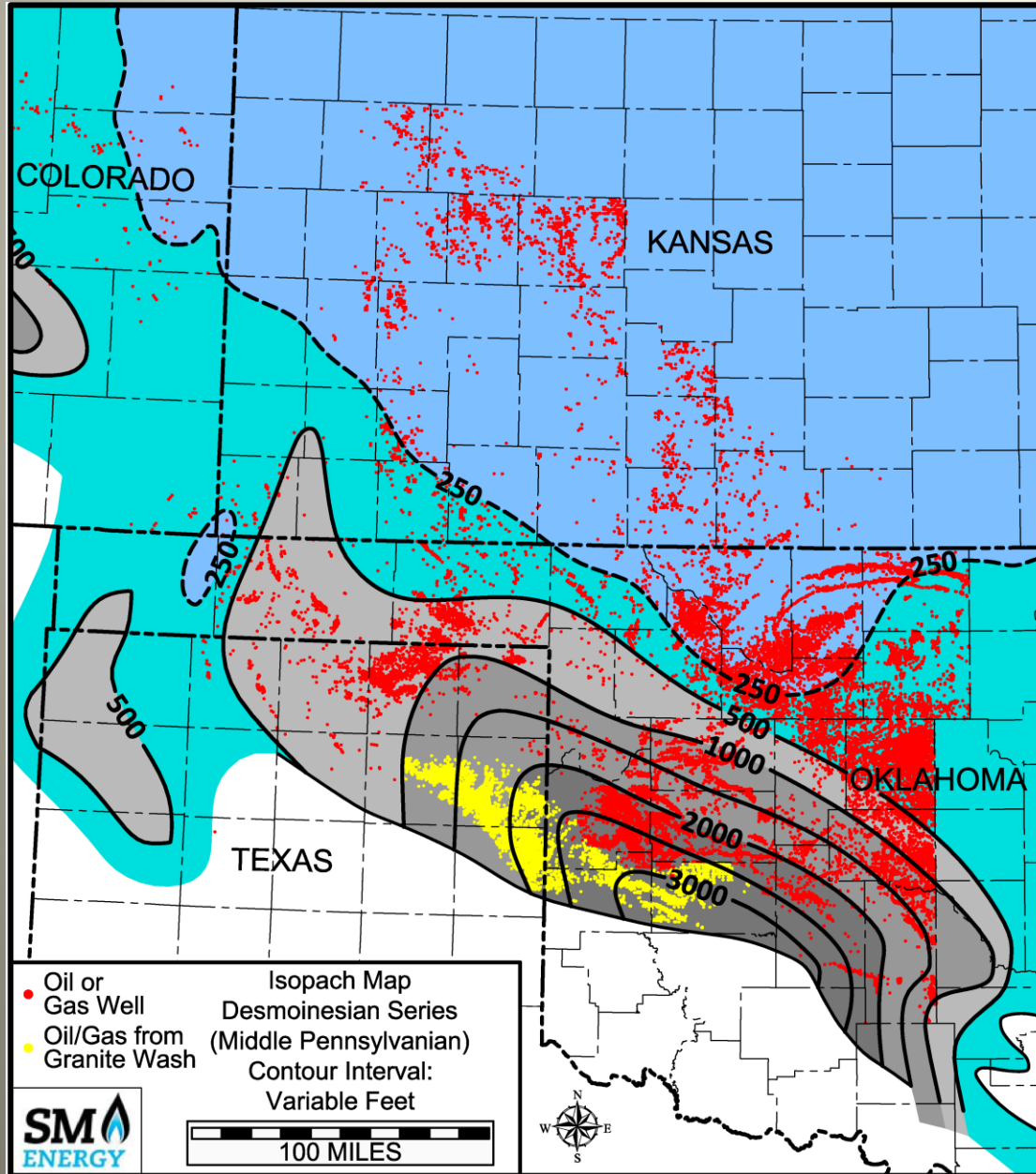
Three distinctive play types are present along the length of the Morrow fairway. They are (A) the Upper Morrow fluvio-deltaic play in SE Colorado, SW Kansas and the Panhandles of Oklahoma and Texas. At depths of 4,500 to 10,000 feet this is where the bulk of the Morrowan oil is produced. Play area (B) is along the basin axis in front of the Amarillo-Wichita Uplift. Here the Upper Morrowan sandstones are productive at depths from 14,000 to 18,000 feet and are overpressured at a gradient as high as 1.0 PSI/foot. The Lower Morrowan marine sandstones (C) are widespread producers along to the northeast.

# Regional Stratigraphic Column: Middle/Upper Pennsylvanian

| NORTH AMERICAN CHRONOSTRATIGRAPHIC UNITS |                         |                    | TIME SCALE (Ma) | WESTERN OK/ TX PANHANDLE |  |                                 |
|--|-------------------------|--------------------|-----------------|--------------------------|--|---------------------------------|
| ERATHEMS                                 | SYSTEMS                 | SERIES             |                 |                          |  |                                 |
| CARBONIFEROUS                            | PENNSYLVANIAN (401-409) | VIRGILIAN (406)    | 290             | Admire Group             | Foraker Limestone<br>Fall Limestone<br>City Limestone  |                                 |
|  |                         |                    |                 | Wabaunsee Group          | Brownville Limestone<br>Bird Creek Limestone   |                                 |
|  |                         |                    |                 | Shawnee Group            | Topeka Limestone<br>Hoover sand<br>Carmichael sand<br>Oread lime<br>Heebner Shale<br>Endicott sand<br>Toronto Limestone<br>Lovell lime   | Undifferentiated Wash Intervals |
|  |                         |                    |                 | Douglas Group            | Ireland Sandstone<br>Douglas sand<br>Tonkawa/Stalnaker sand<br>Tonganoxie Sandstone  |                                 |
|  |                         | MISSOURIAN (405)   | 310             | Lansing Group            | Avant Limestone<br>Cottage Grove Sandstone   |                                 |
|  |                         |                    |                 | Kansas City Group        | Dewey Limestone<br>Hogshooter Limestone<br>Dodds Creek Sandstone<br>(Layton sand)<br>Checkerboard Limestone<br>(Cleveland sand)  |                                 |
|  |                         |                    |                 | Marmaton Group           | Oologah Limestone<br>(Big Lime)<br>Engelvale Sandstone<br>(Peru sand)<br>Fort Scott Limestone<br>(Oswego lime)   | Marmaton Wash                   |
|  |                         | DESMOINESIAN (404) |                 | Cherokee Group           | Lagonda Sandstone<br>(Pruc sand)<br>Verdigris Limestone<br>Chelsea Sandstone<br>(Skinner sand)<br>Tiawah Limestone<br>Pink Lime<br>Taft Sandstone<br>(Red Fork sand)<br>Inola Limestone<br>Bluejacket Sandstone<br>(Bartlesville sand)<br>Warner Sandstone<br>(Burgess sand) | U. Skinner Wash                 |
|  |                         |                    |                 |                          |  | L. Skinner Wash                 |
|  |                         |                    |                 |                          |  |                                 |
|  |                         |                    |                 |                          |  |                                 |

23.7 TCF of gas (19% of Mid-Continent total) has been produced from the Virgilian through Desmoinesian series of the Pennsylvanian. Total oil production of 1,416 MMBO (26%) has come from these reservoirs. The Desmoinesian and Missourian series have made most of this oil and gas. Two thousand four hundred and thirty-nine (2,439) horizontal wells (57% of basin total) have been completed in the Middle and Upper Pennsylvanian reservoirs in the greater Anadarko Basin.

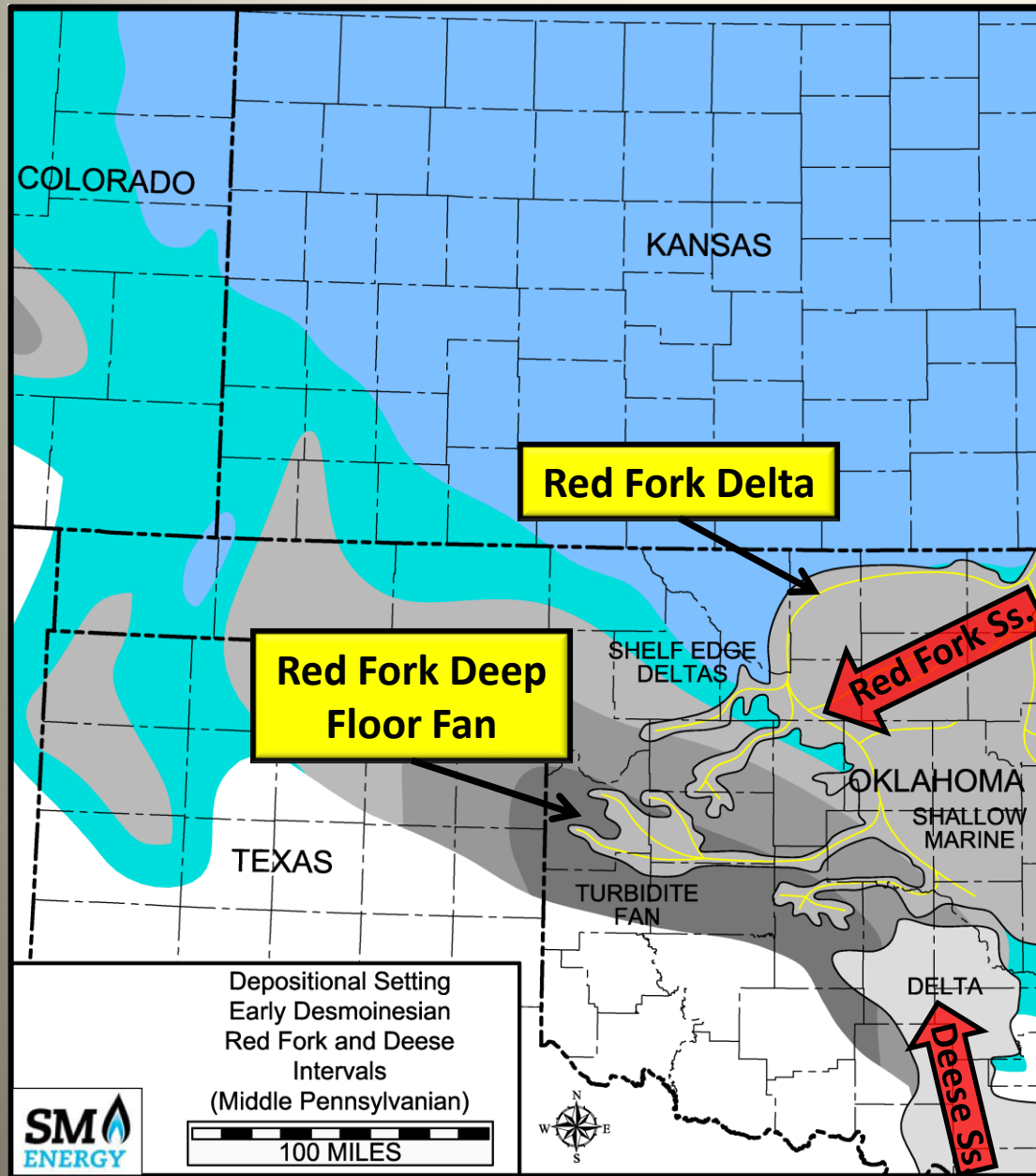
# Regional Isopach-Desmoinesian Series



Desmoinesian series reservoirs are the most widespread oil and gas producing horizons in the Mid-Continent. Prolific oil and gas production has been obtained from sandstones such as the Red Fork, Skinner, Marmaton and Granite Wash. The Oswego/Marmaton limestones are widespread oil and gas horizons in Kansas and northern Oklahoma. The Deese sandstones have produced hundreds of million barrels of oil in southern Oklahoma. Future production may come from horizontal wells in fine-grained sandstones, siltstones and shales in the Desmoinesian sediments.

Map adapted from Adler & others, 1971

# Desmoinesian Series-Red Fork and Deese Ss.

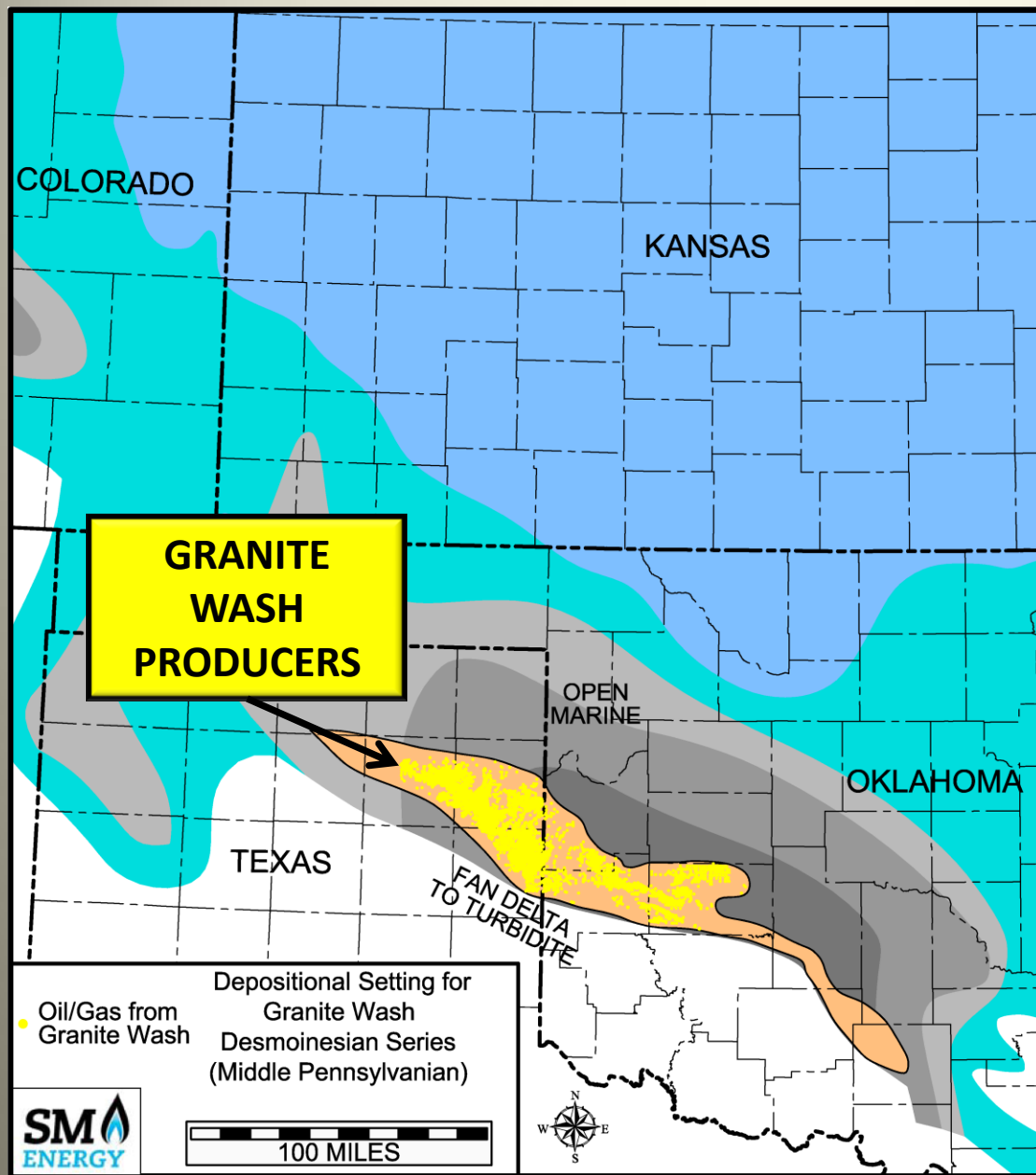


The Red Fork Ss. unit of the Middle Pennsylvanian has been a prolific oil and gas producing horizon across the state. Two notable depositional features are shown here: (A) is the northern Oklahoma deltaic complex that is productive of oil and gas from thousands of wells (previous slide) and (B) the deep floor fan and feeder channel that form a huge series of overpressured gas fields located across Custer and Roger Mills County. Additionally, in the southeastern corner of the basin the Deese Ss. has produced over 100 MMBO at the Golden Trend field.

Map adapted from Adler & others, 1971;  
Andrews, 1997



# Desmoinesian Series-Granite Wash

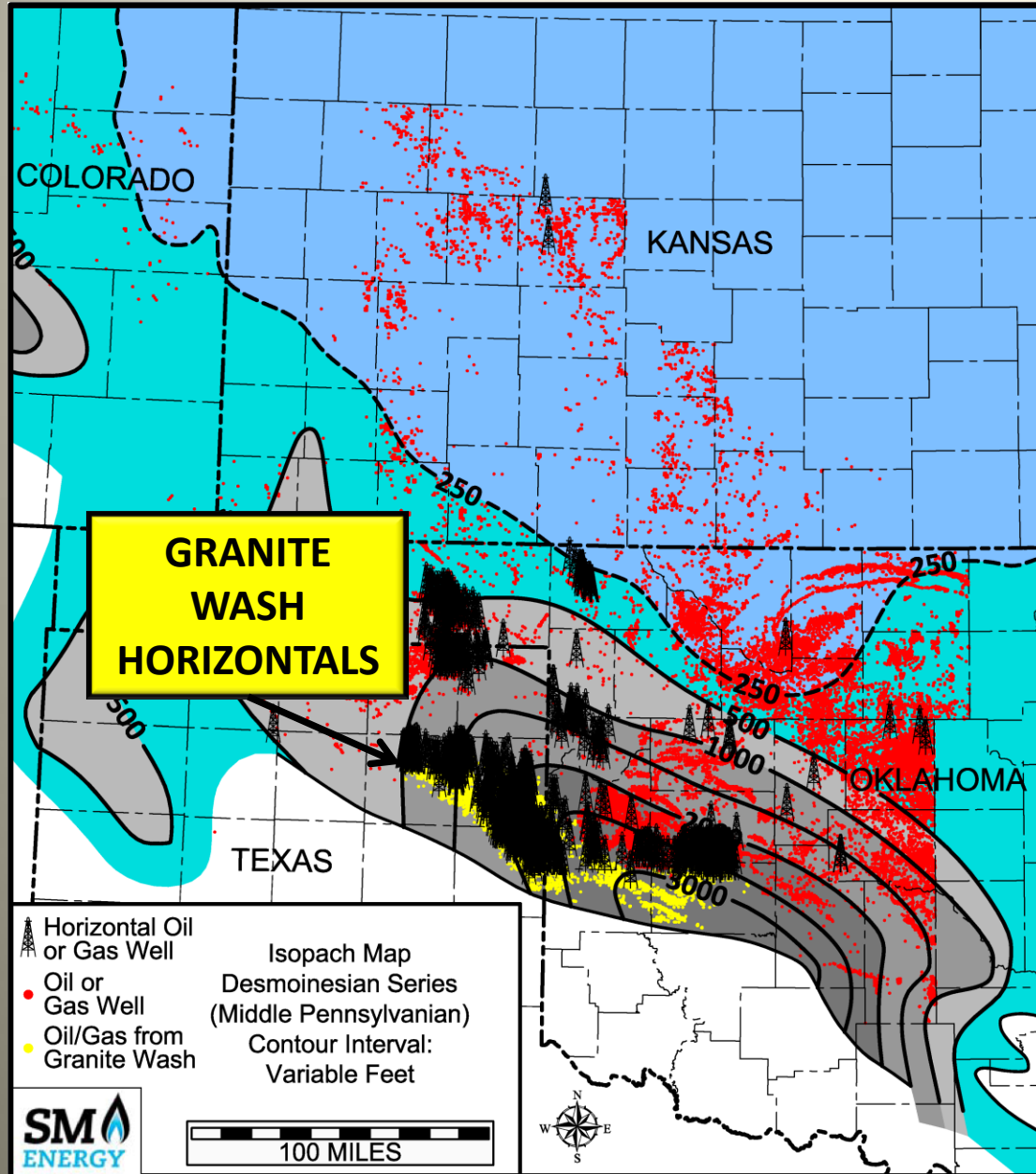


Over seven-hundred (700) horizontal Granite Wash wells have been completed along a one-hundred and twenty mile (120) long play area lying along the basin axis from Washita County, Oklahoma northwestward to Roberts County, Texas. The Granite Wash reservoirs are formed from sediments eroded from granitic, rhyolitic, and sedimentary rocks uplifted in the Amarillo-Wichita mountains primarily during Desmoinesian time.

Map adapted from Adler & others, 1971



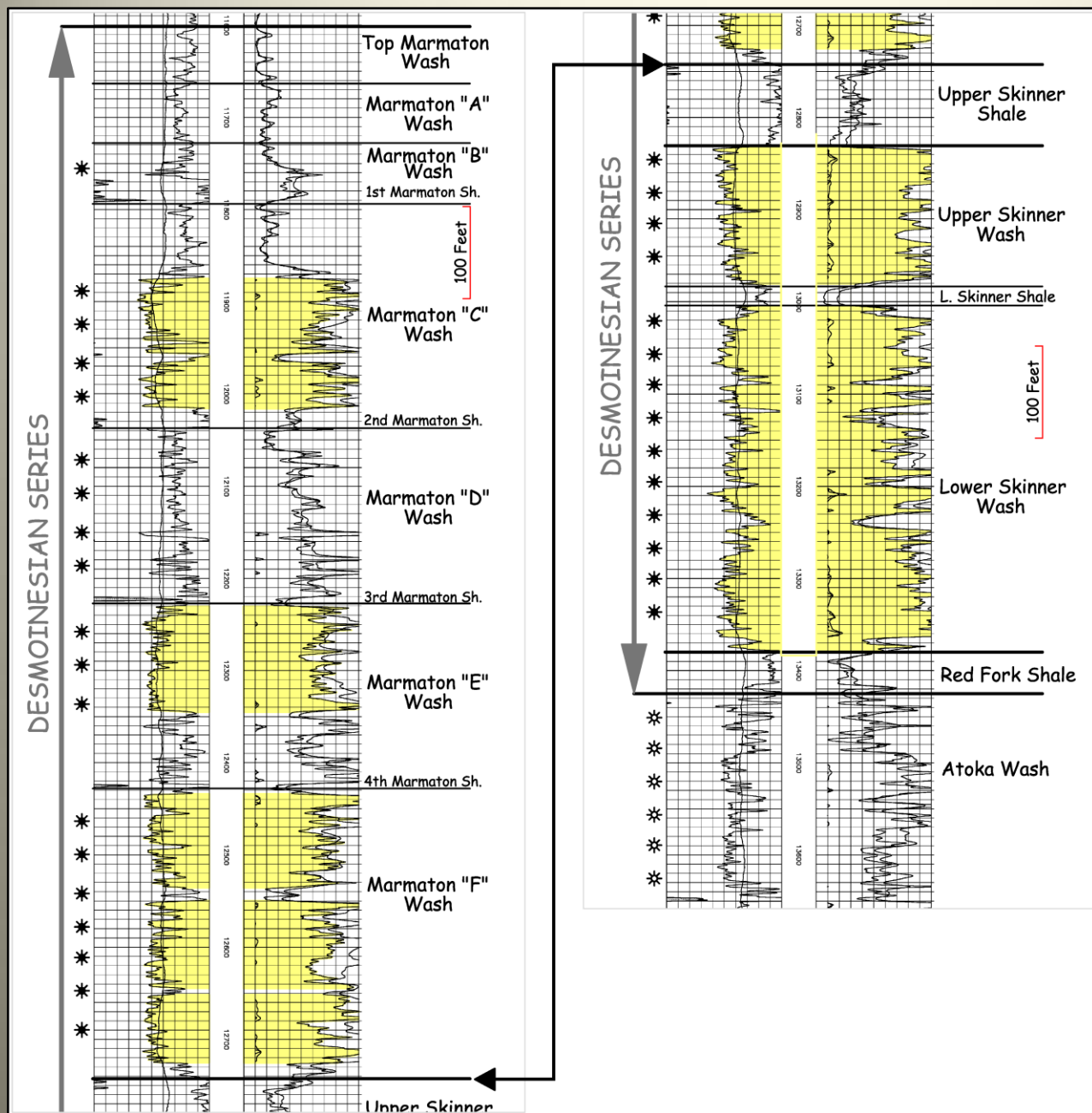
# Regional Isopach-Desmoinesian Series



Over seven-hundred horizontal Granite Wash wells have been completed along a one-hundred and twenty mile (120) long play area lying along the basin axis from Washita County, Oklahoma northwestward to Roberts County, Texas. Additional horizontals have been drilled in Desmoinesian sandstones in the Oklahoma Panhandle.

Map adapted from Adler & others, 1971

# HORIZONTAL GRANITE WASH PLAY

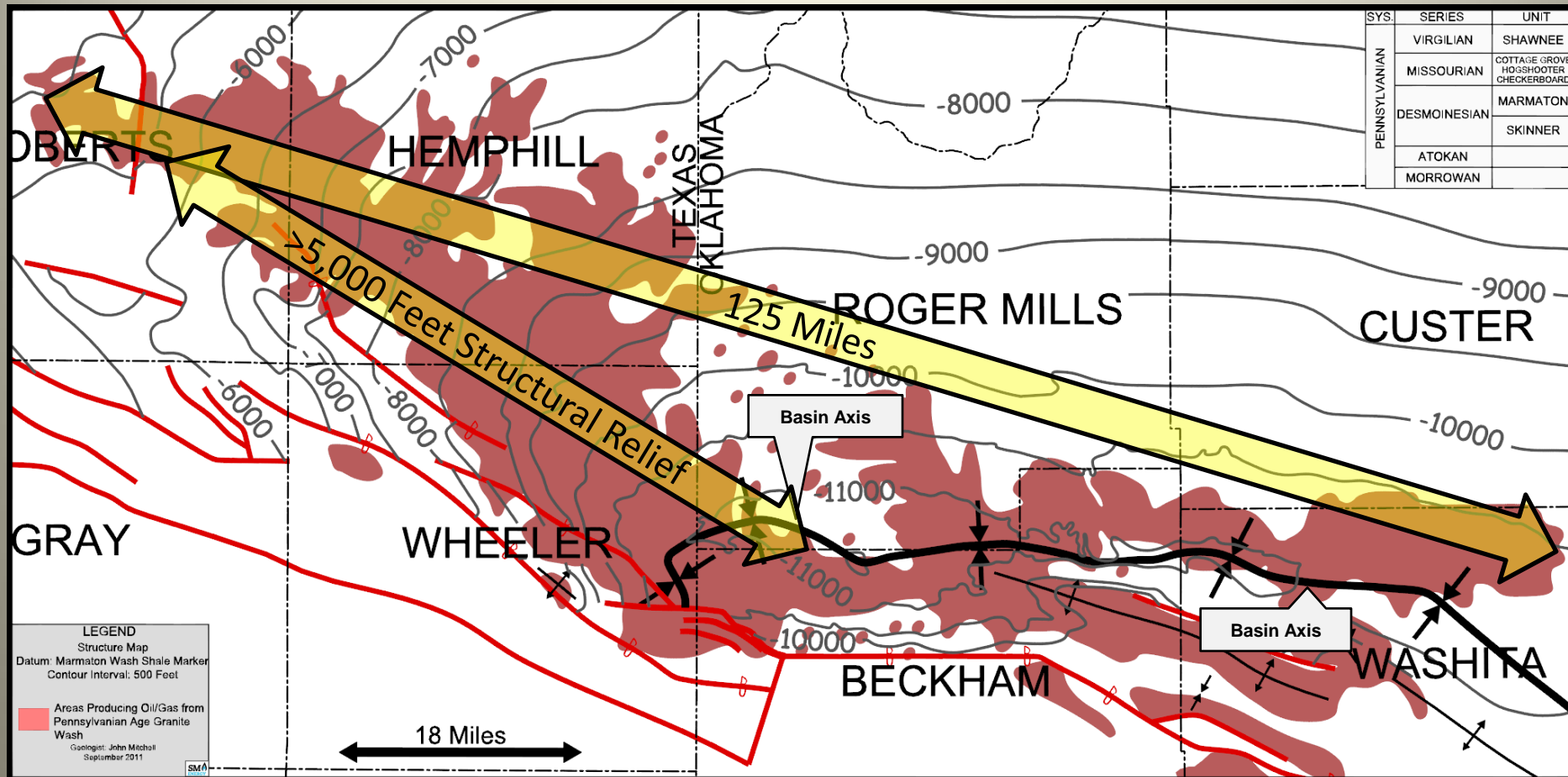


Type Log: 1,500 feet of Desmoinesian Wash, Deep Anadarko Basin, Texas & Oklahoma; Devon #16-4 Truman-Zybach, Sec. 16, Block R&E Survey, Wheeler Co., Texas

# HORIZONTAL GRANITE WASH PLAY

## Regional Structure Map – Marmaton Wash

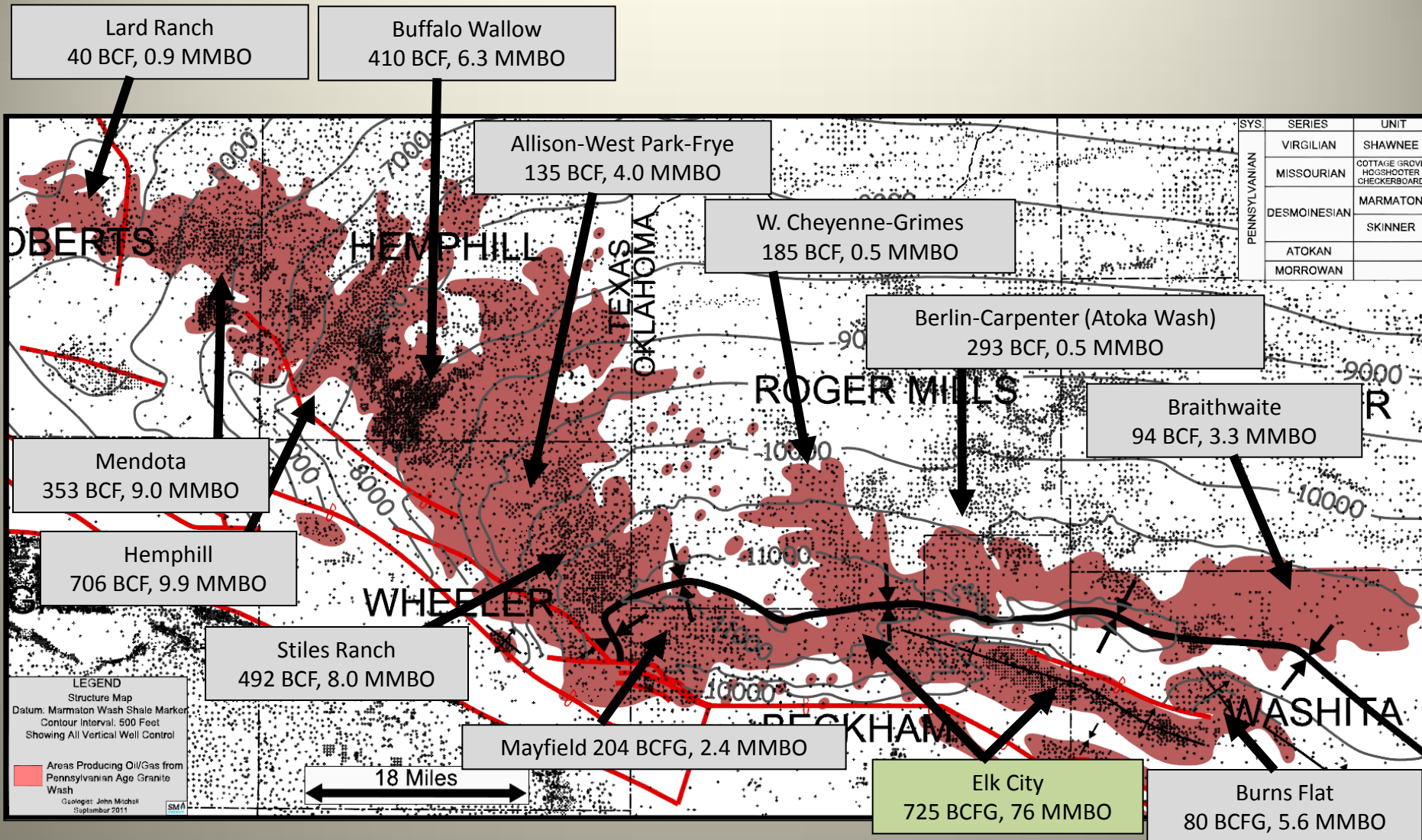
| SYS.          | SERIES       | UNIT          |
|---------------|--------------|---------------|
| PENNSYLVANIAN | VIRGILIAN    | SHAWNEE       |
|               | MISSOURIAN   | COTTAGE GROVE |
|               |              | HOSHOOTER     |
|               |              | CHECKERBOARD  |
|               | DESMOINESIAN | MARMATON      |
|               |              | SKINNER       |
|               | ATOKAN       |               |
|               | MORROWAN     |               |



Contour Interval = 500 Feet



# HORIZONTAL GRANITE WASH PLAY

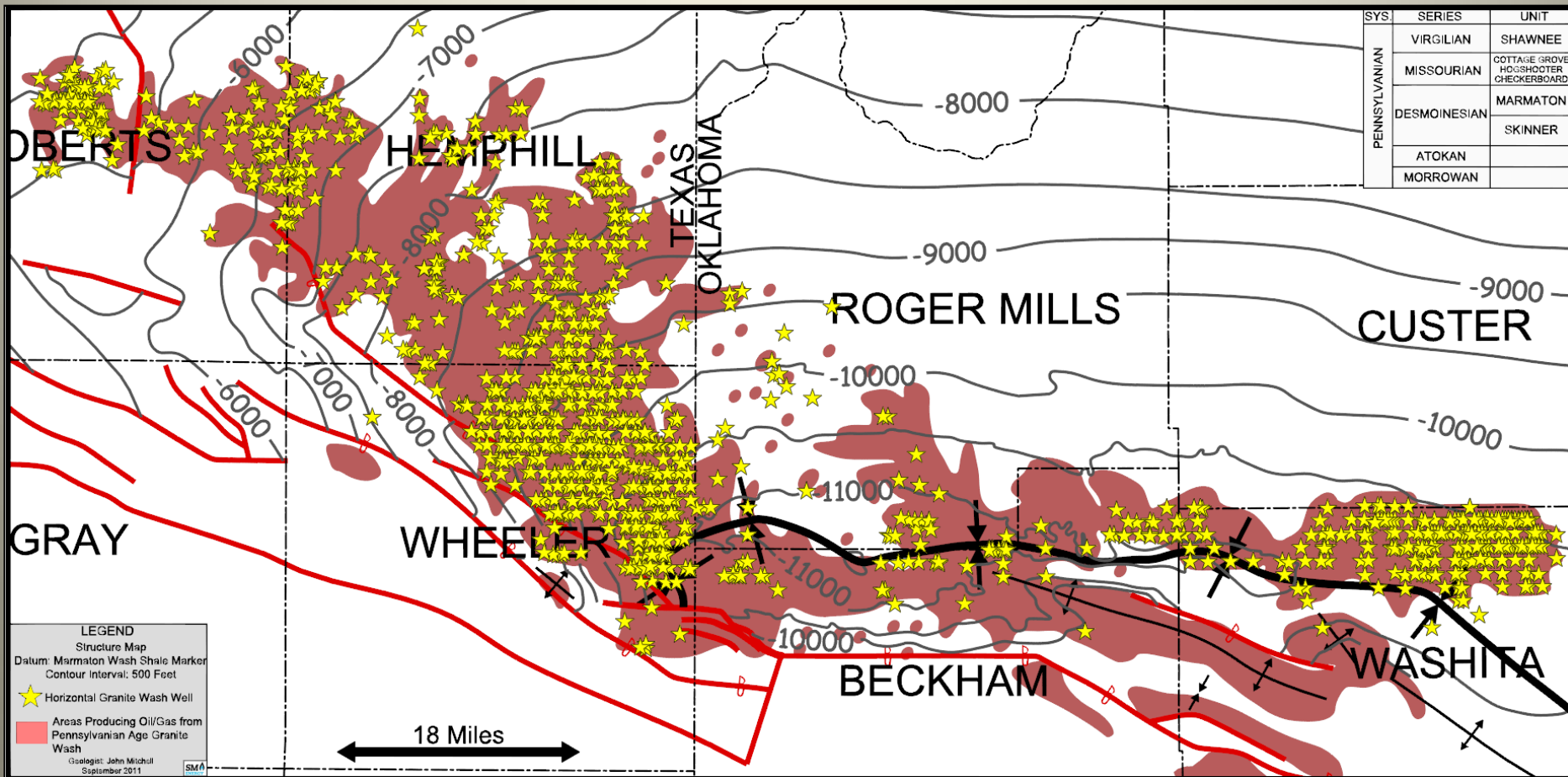


Principal Oil and Gas Field Production Information

>3.7 TCFG + 126 MMBO Cumulative Production from > 4,000 wells

# HORIZONTAL GRANITE WASH PLAY

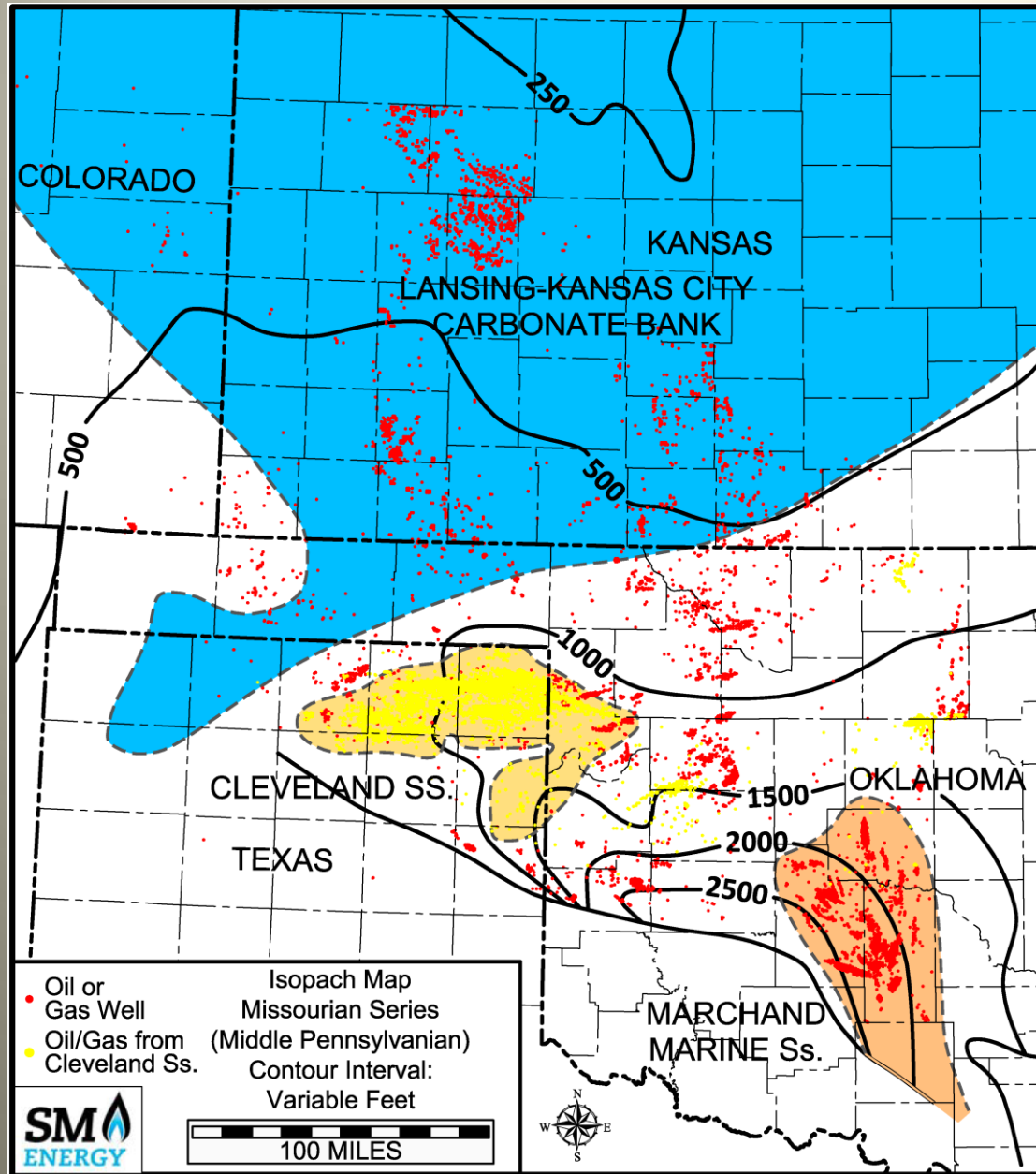
| SYS           | SERIES       | UNIT  |
|---------------|--------------|---|
| PENNSYLVANIAN | VIRGILIAN    | SHAWNEE                                     |
|               | MISSOURIAN   | COTTAGE GROVE<br>HOOSHOOTER<br>CHECKERBOARD |
|               | DESMOINESIAN | MARMATON                                    |
|               |              | SKINNER                                     |
|               | ATOKAN       |   |
|               | MORROWAN     |   |



1,206 Horizontal Granite Wash Wells  
 Spud Through September 2011



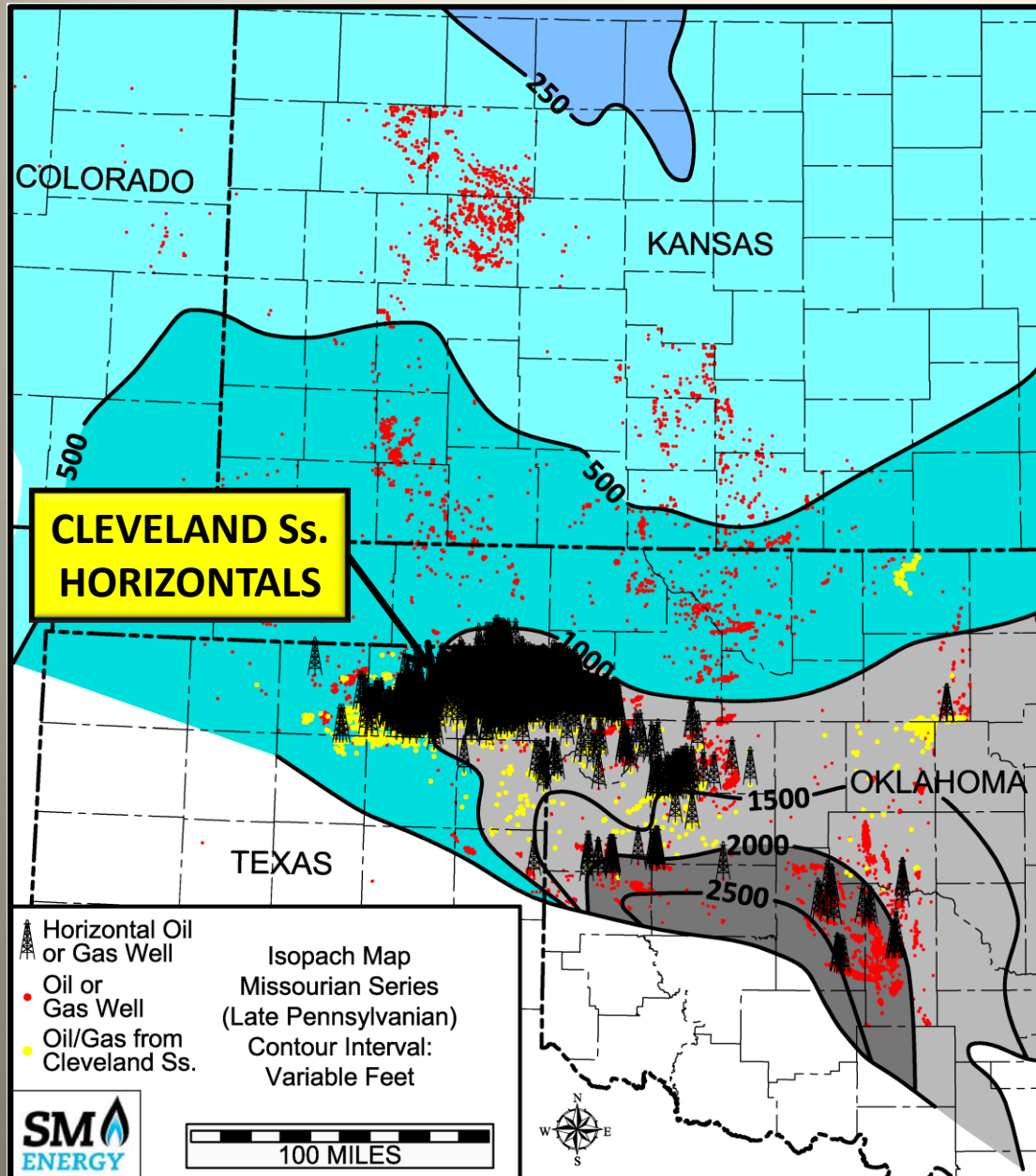
# Regional Deposition-Missourian Series



Thousands of oil and gas wells have been completed in the Cleveland sandstone along a ninety mile (90) long play area from Ochiltree County, Texas eastward to Ellis County, Oklahoma. The Cleveland is a shaley sandstone deposited in the basin by a low stand regressive system flowing west. In the southeastern corner of the basin the Marchand sandstone has been a prolific producer of oil. In the northern areas of the basin in western Kansas the Lansing-Kansas City limestone produces oil over a large area.

Map adapted from Adler & others, 1971

# Missourian Series-Horizontal Drilling

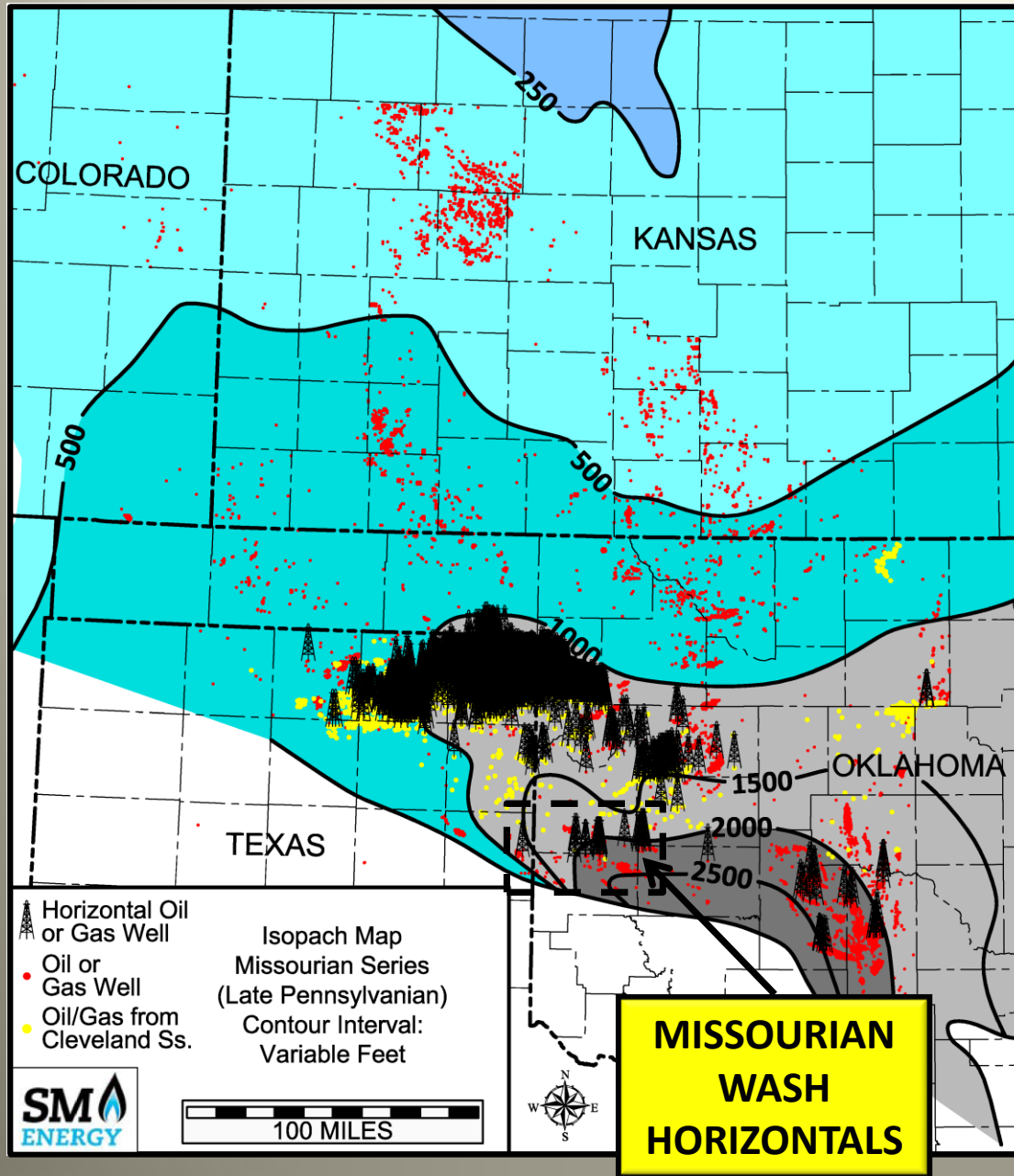


One thousand and sixty-five horizontal (1,065) oil and gas wells have been completed in Ochiltree and Lipscomb Counties, Texas eastward to Ellis County, Oklahoma. This area is the most active horizontal drilling area in the Anadarko Basin to date.

Map adapted from Adler & others, 1971

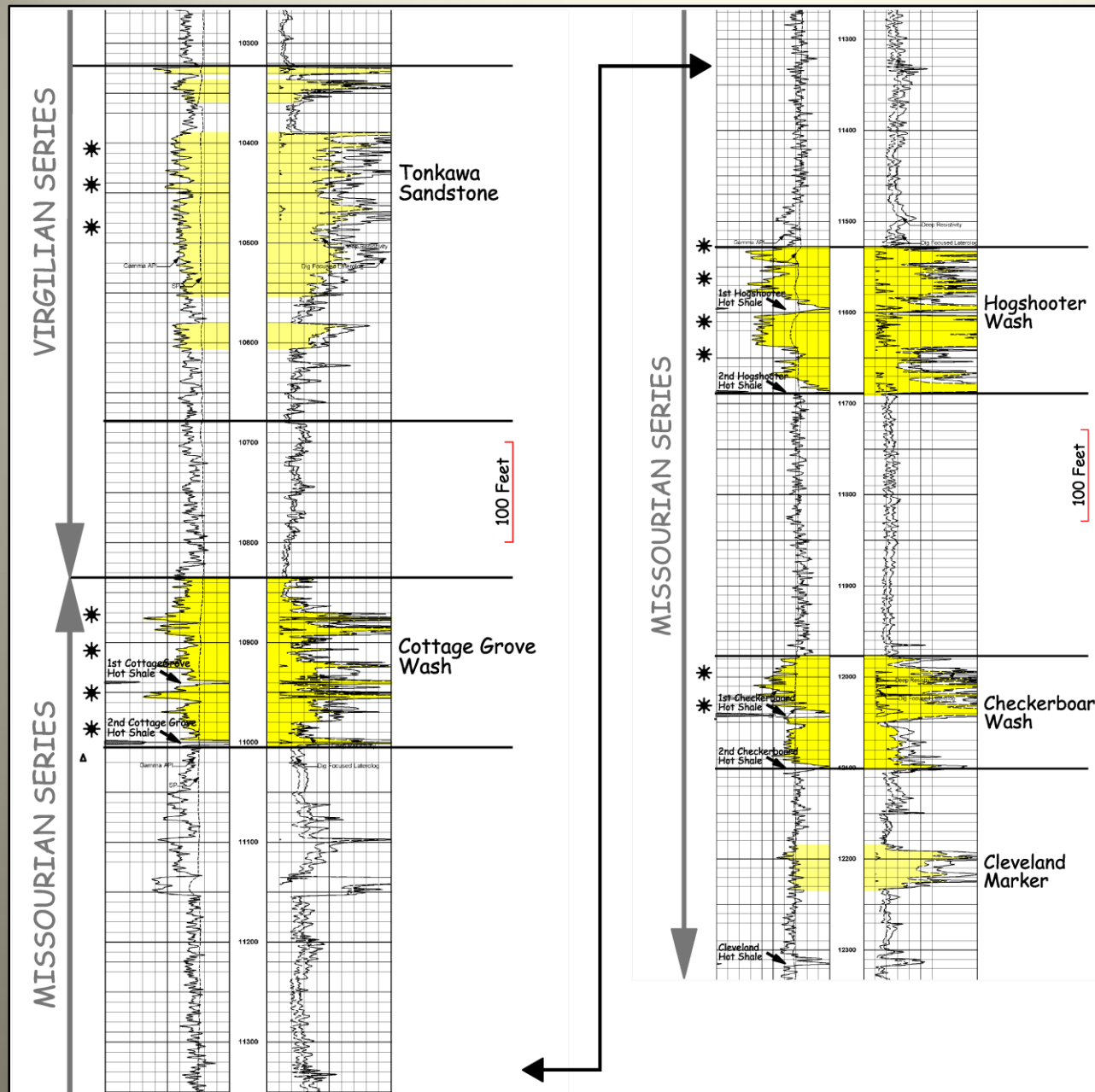
# Missourian Series-Horizontal Drilling

New high volume oil wells from Hogshooter and Cottage Grove Washes



Map adapted from Adler & others, 1971

# HORIZONTAL GRANITE WASH PLAY

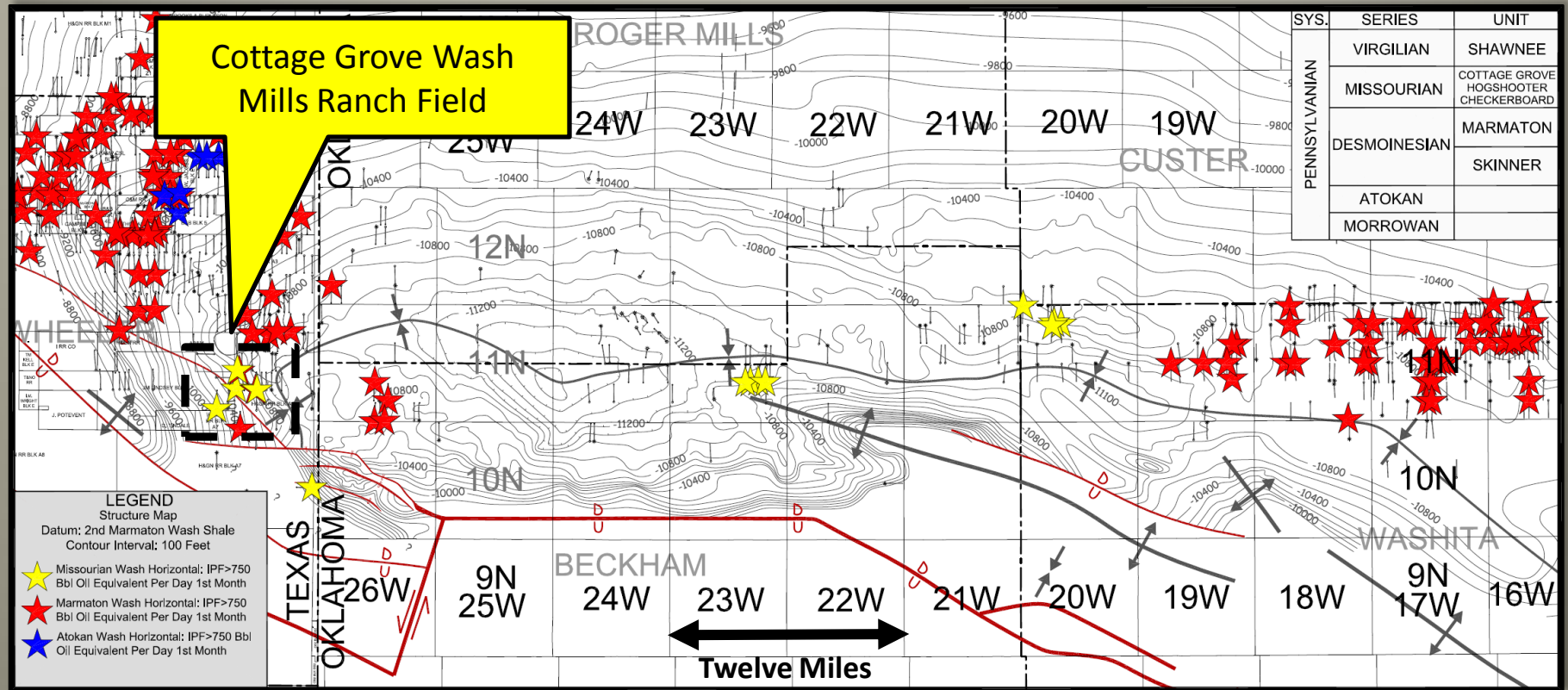


Type Log  
Missourian Wash, Deep  
Anadarko Basin, Texas &  
Oklahoma; Chesapeake  
#1-28 Mary K well,  
Sec. 28, T11N R23W,  
Beckham Co., Oklahoma

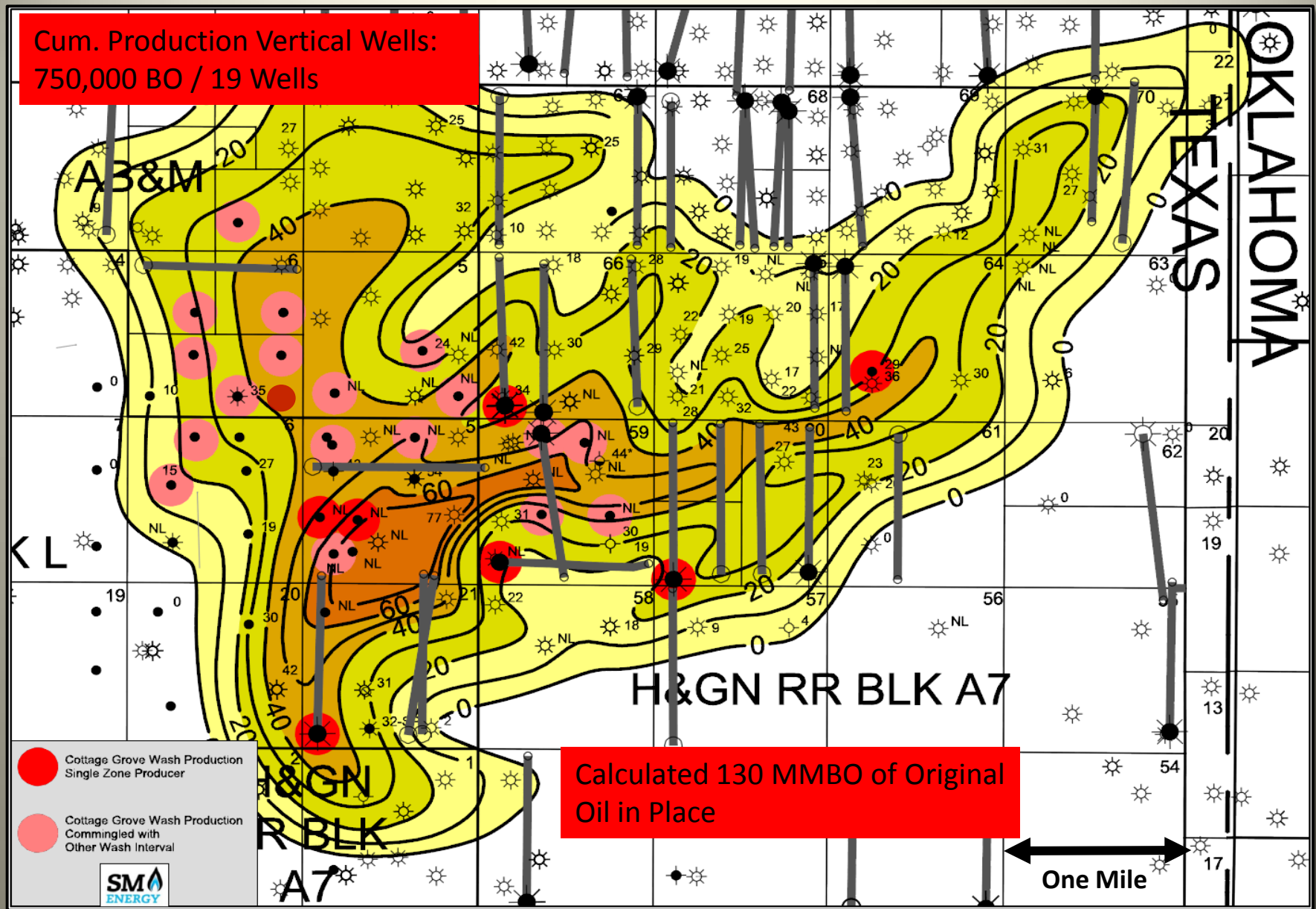


# Horizontal Granite Wash Play

## Missourian Wash Activity Areas

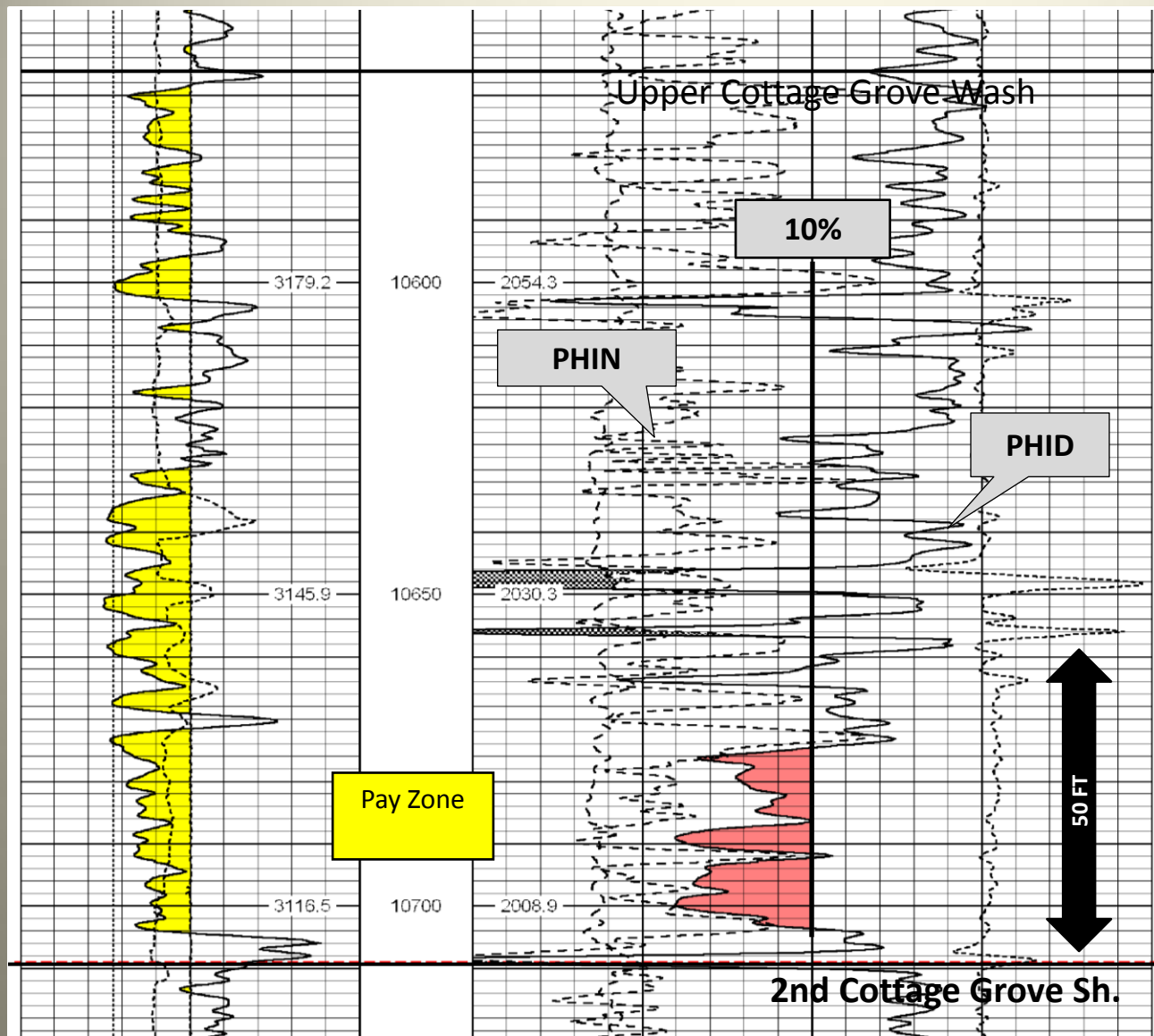






Porosity isolith map of the Upper Cottage Grove Wash with density porosity >10% on 2.71 gm/cc matrix; Contour interval = 10 feet ; Mills Ranch and Stiles Ranch fields, Wheeler Co., TX

# HORIZONTAL GRANITE WASH PLAY

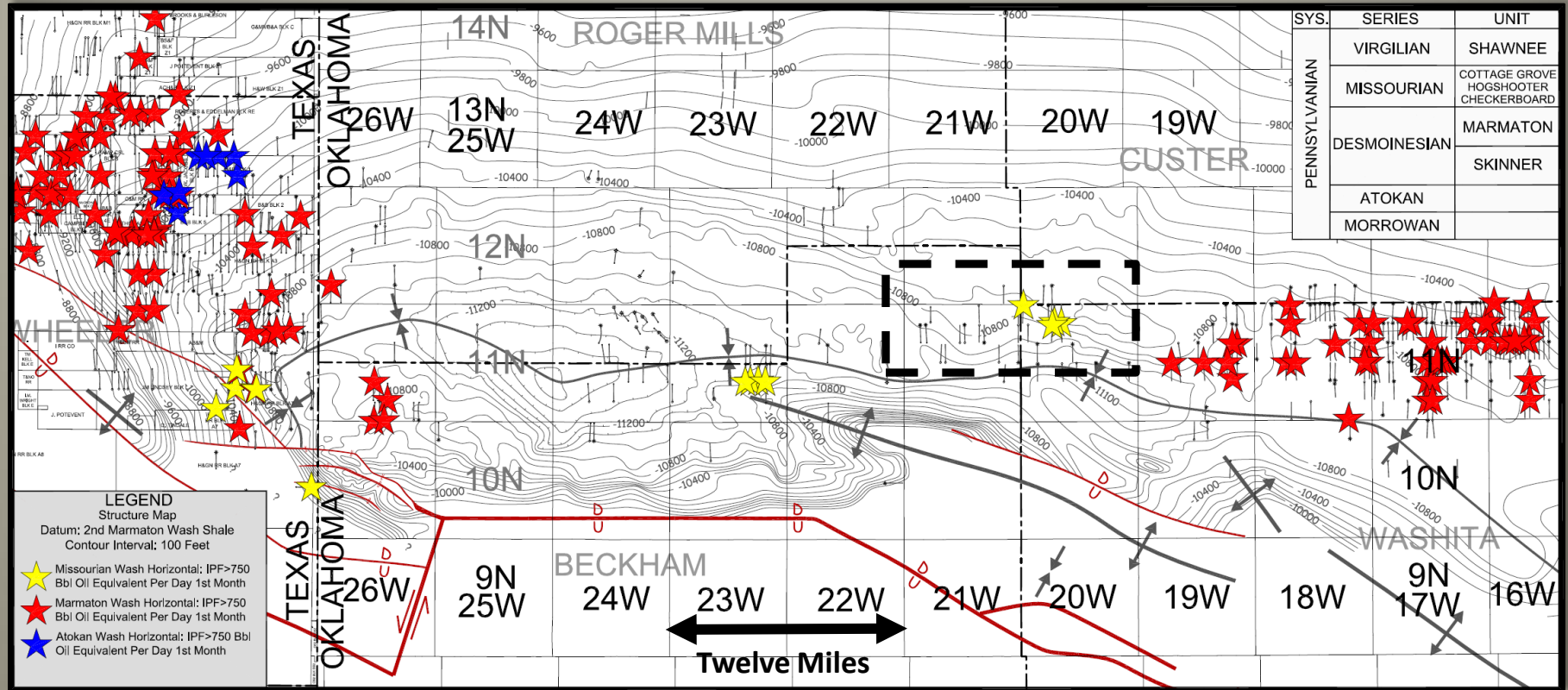


Type porosity log, Upper Cottage Grove Wash pay zone, SM Energy #2-60H Ruth pilot hole; NW NW NW Sec. 60, Block A-7, Stiles Ranch field, Wheeler Co., TX; porosity on lime matrix



# Horizontal Granite Wash

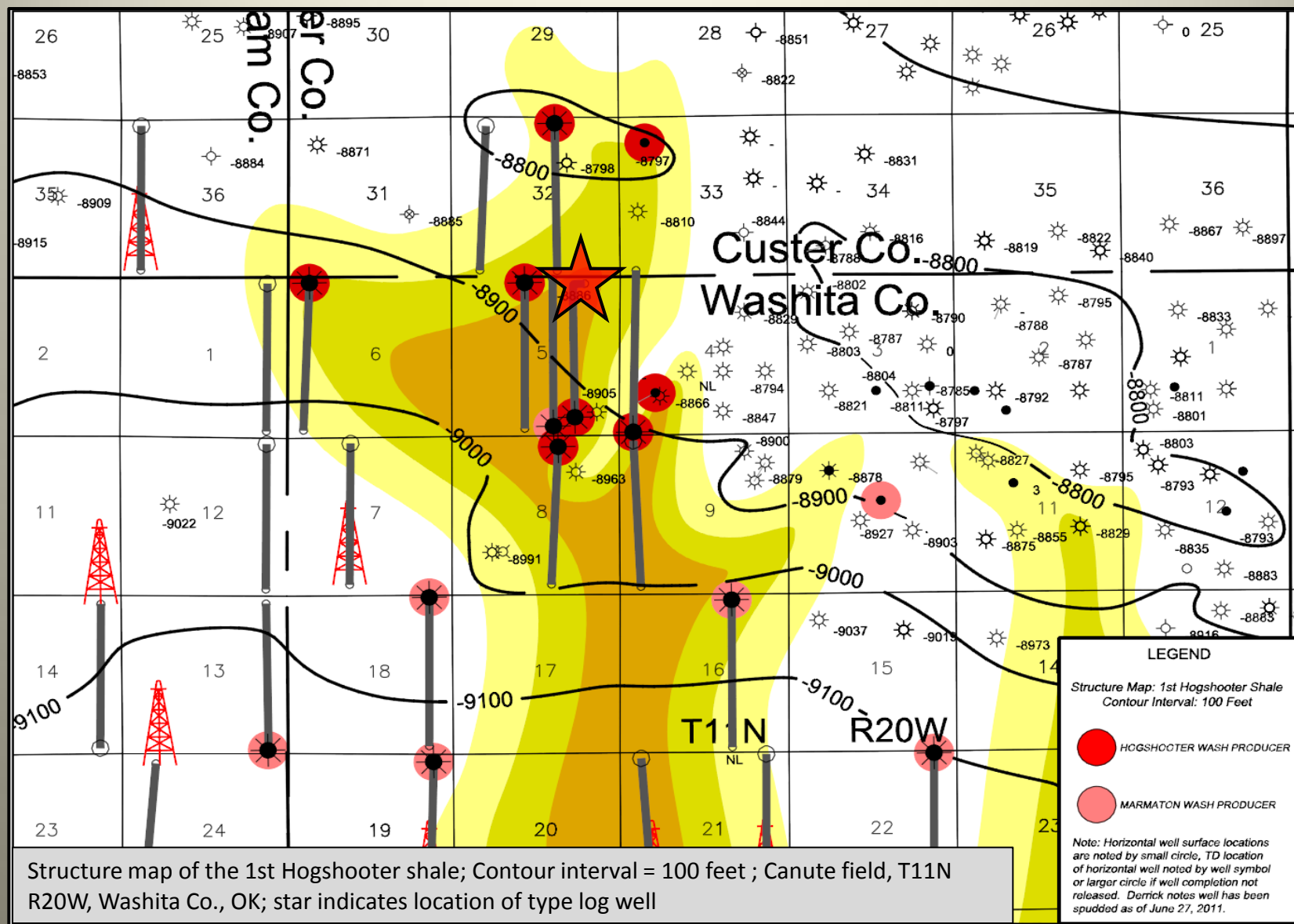
## North Canute to Elk City Area



Hogshooter Wash (Missourian)

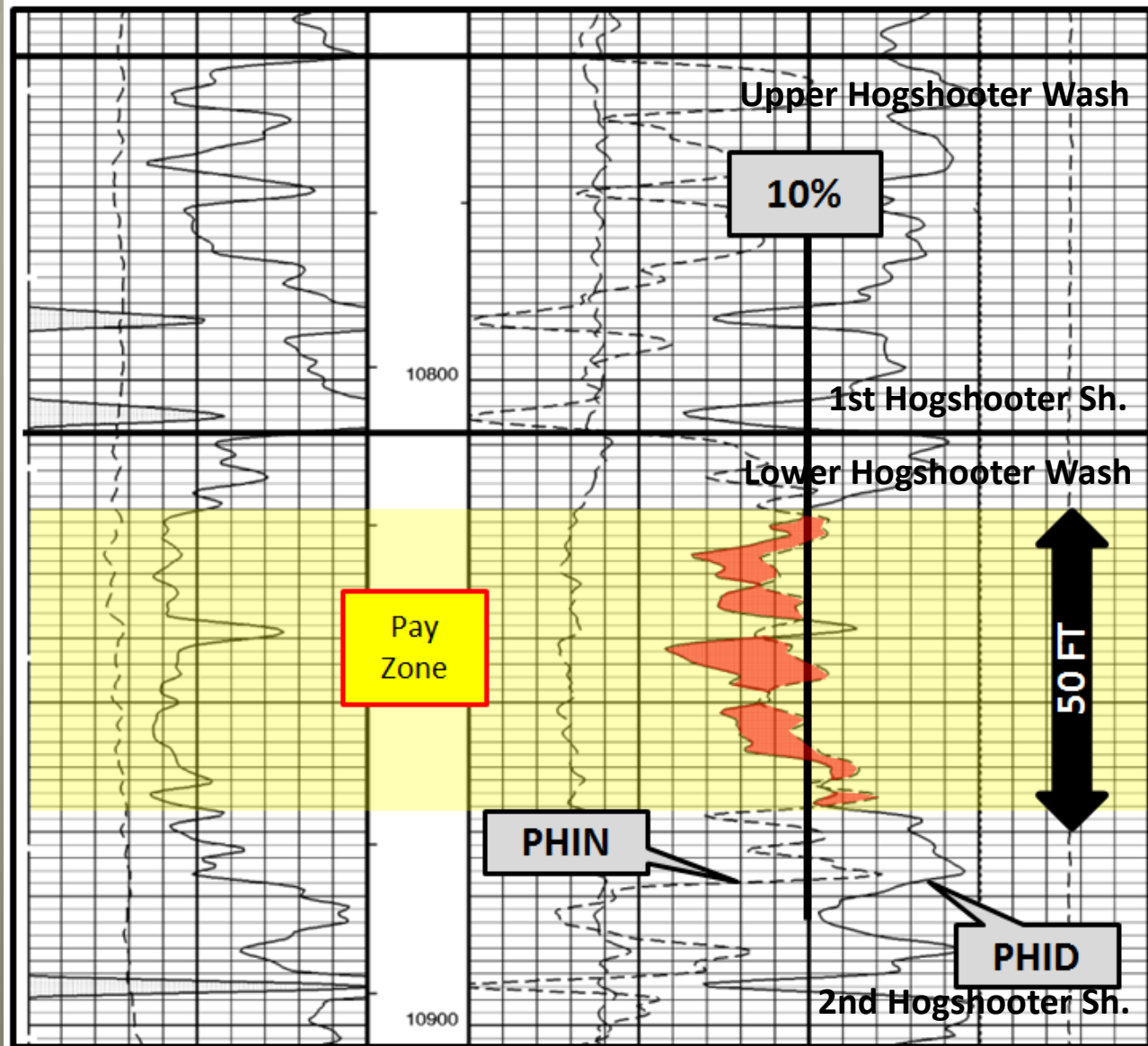


# Horizontal Granite Wash - North Canute Area



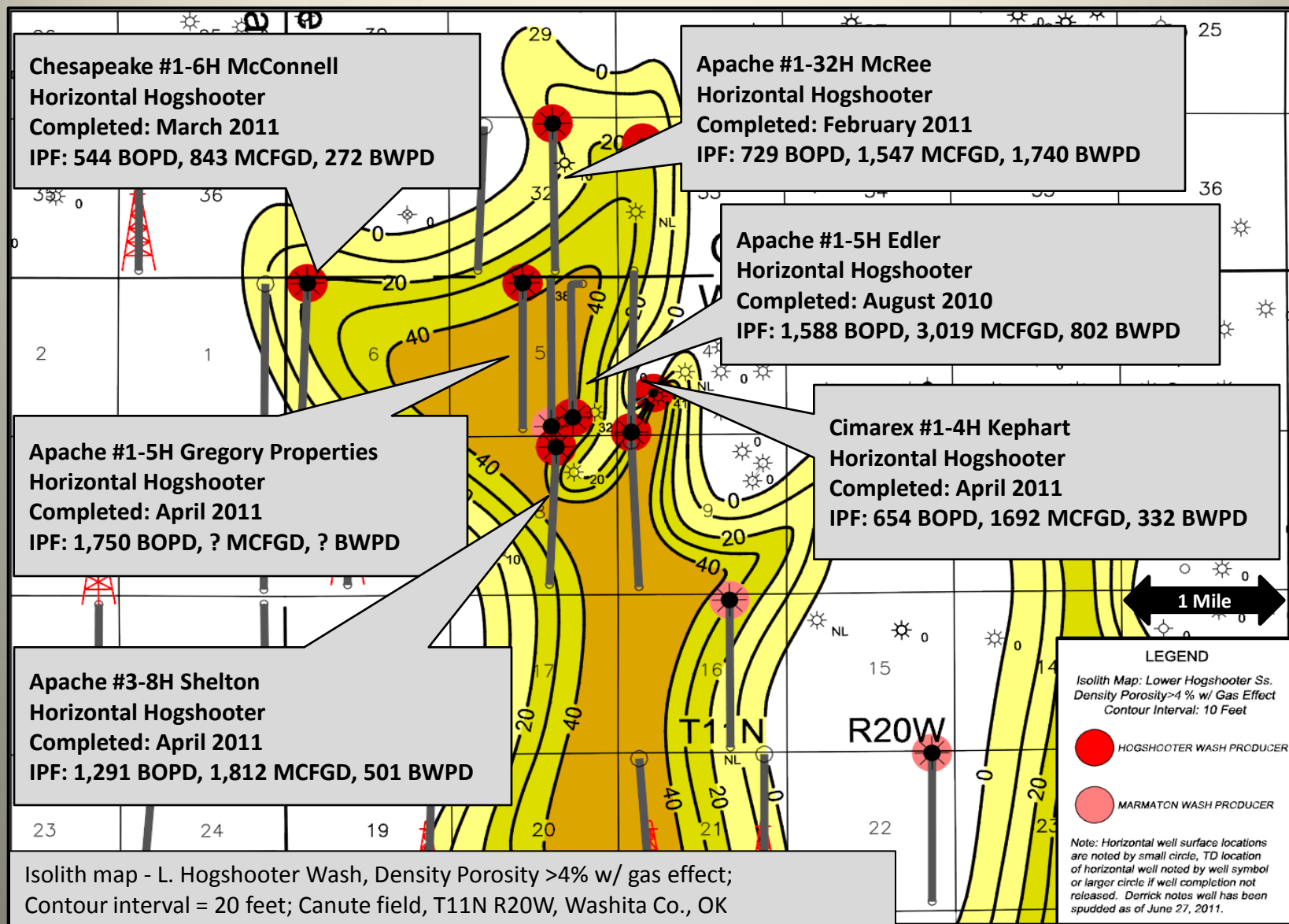


# HORIZONTAL GRANITE WASH PLAY







Type porosity log, Hogshooter Wash pay zone, Apache #1-5H McRee pilot hole; NW NW NE Sec. 5, T11N R20W, Canute field, Washita Co., OK; porosity on lime matrix; porosity exhibits gas effect (red shading) on log and is target zone for horizontals

# Horizontal Granite Wash - North Canute Area



# Regional Stratigraphic Column: Permian

| NORTH AMERICAN CHRONOSTRATIGRAPHIC UNITS |         |              |  | TIME SCALE (M.Y.)       | WESTERN OK/ TX PANHANDLE | SOUTHERN OKLAHOMA                               | ARKOMA BASIN OKLAHOMA   |  |  |
|--|---------|--------------|--|-------------------------|--------------------------|---|---|--|--|
| ERATHEMS                                 | SYSTEMS | SERIES       |  |                         |                          |   |   |  |  |
| PERMIAN (451-459)                        |         | UPPER        | OCHOAN (454)                                 | 250                     | Cloud Chief Fm.          |   |   |  |  |
|  |         |              | GUADALUPIAN (453)                            | 255                     |                          |   |   |  |  |
|  |         | LOWER        | LEONARDIAN (452)                             | 270                     | El Reno Group            | Dog Creek Sh. Blaine Fm.                        | Flowerpot Sh. Duncan Sandstone  |  |  |
|  |         |              | WOLFCAMPIAN (451)                            | 275                     | Enid Group               | Stone Corral Fm. Hennessey Shale Wellington Fm. |   |  |  |
|  |         |              |  |                         | 285                      | Chase Group                                     |    Krider Limestone Winfield Limestone Ft. Riley Limestone Wreford Limestone |  | Hennessey Gr. Garber Sandstone Wellington Fm. Nichols sand Ramsey/Fortuna sand |
|  |         |              |  |                         |                          | 290   | Council Grove Group   |  |  |
|  |         | Admire Group | Foraker Limestone FallimestoneCity Limestone | Arkose and conglomerate |                          |   |   |  |  |

At least 54.6 TCF of gas (44% of Anadarko Basin total) has been produced from the Wolfcampian (Lower Permian) carbonates and sandstones at shallow depths in the Hugoton-Panhandle field and adjunct fields. Additionally, the Hugoton-Panhandle field has produced 1,443 MMBO, mainly in the Texas Panhandle. This oil comprises 27% of the basin total. As of March 2012, 836 horizontal wells have been completed in the Permian reservoirs in the greater Anadarko Basin, all of them in the Panhandle-Hugoton field. The oil and gas in the shallow Permian reservoirs is believed to have migrated long distances from deeper portions of the basin into the Permian units (Rice et al, 1989).

# Conclusions

- **Four major horizontal drilling plays in progress in oil and gas bearing horizons in the Cleveland Ss. and Granite Wash of Pennsylvanian age, the Mississippian limestones, and the Upper Devonian Woodford Shale**
- **Over four thousand horizontals completed in basin to date at vertical depths as great as 15,000 feet.**
- **Significant future horizontal development may await in Pennsylvanian sandstones and shales as well as in older carbonates in the Mississippian through Ordovician.**

# SOURCES FOR ANADARKO BASIN OIL AND GAS RESEARCH

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- *Future Petroleum Provinces of the Mid-Continent*, AAPG Memoir 15, V. 2, 1971
- *Atlas of Major Midcontinent Gas Reservoirs*, Gas Research Institute, 1993
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- *Bibliography of Oklahoma Anadarko Basin*, Brian J. Cardott, Oklahoma Geological Survey
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- *Geochemistry of oils and hydrocarbon source rocks, greater Anadarko Basin: evidence for multiple sources of oils and long-distance oil migration*; Burruss, R.C., and J.R. Hatch, 1989 in K.S. Johnson, ed., Anadarko Basin symposium, 1988: OGS Circular 90, p. 53-64
- Oklahoma Geological Survey Circulars and Special Publications, available on the OGS website
- Oklahoma City Geological Society Shale Shaker Publications, also available on the Oklahoma Geological Survey website
- IHS Energy



# Thanks!

- **Many thanks to Carol Mitchell, my patient spouse and partner for thirty-six years.**
- **Also to Will Downs, Exploration Manager with SM Energy, Tulsa for permission and support in making this presentation.**