

Oklahoma Gas Shales Conference      October 22, 2008

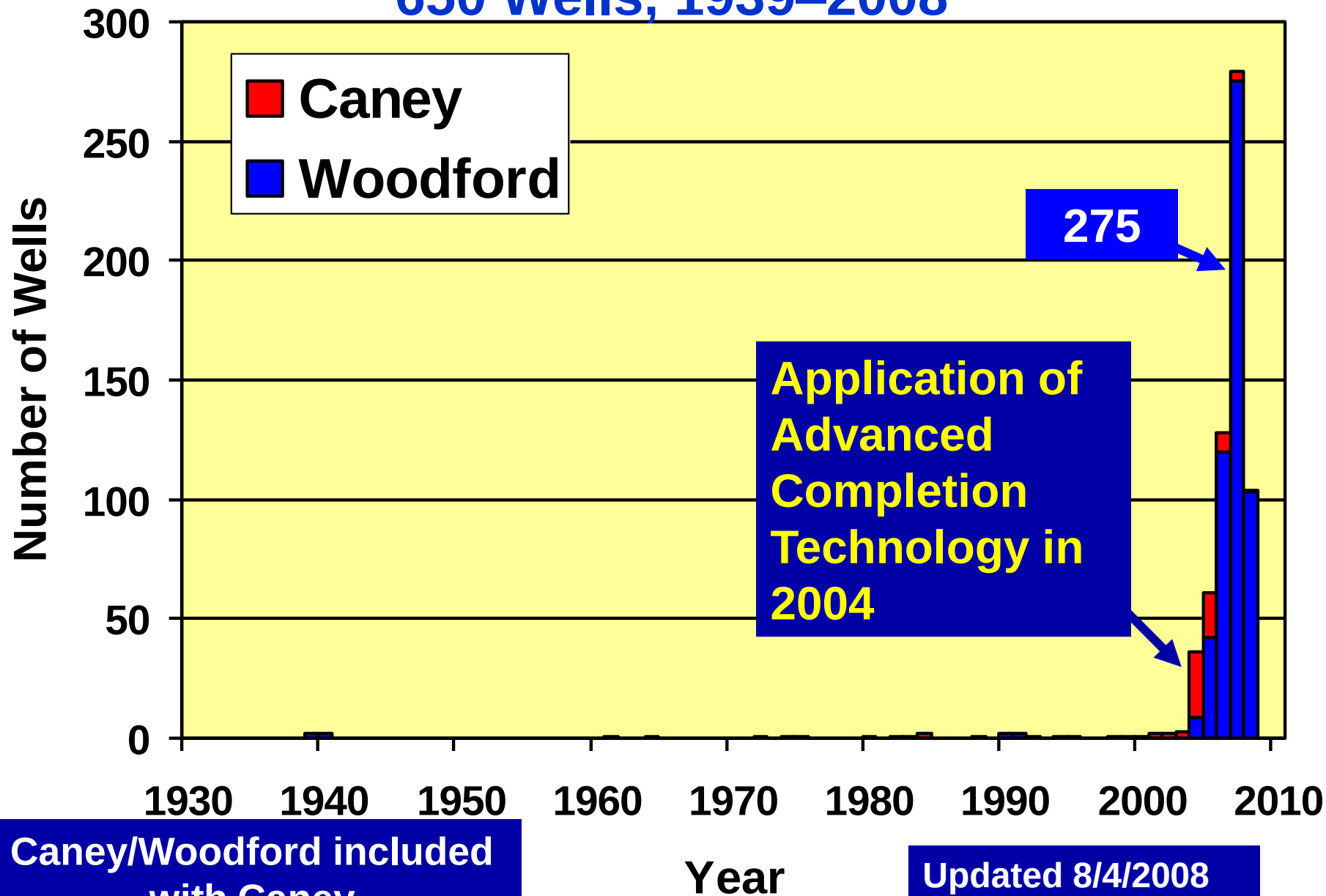
# Overview of Woodford Gas-Shale Play in Oklahoma, 2008 Update



Brian J. Cardott  
Oklahoma Geological  
Survey

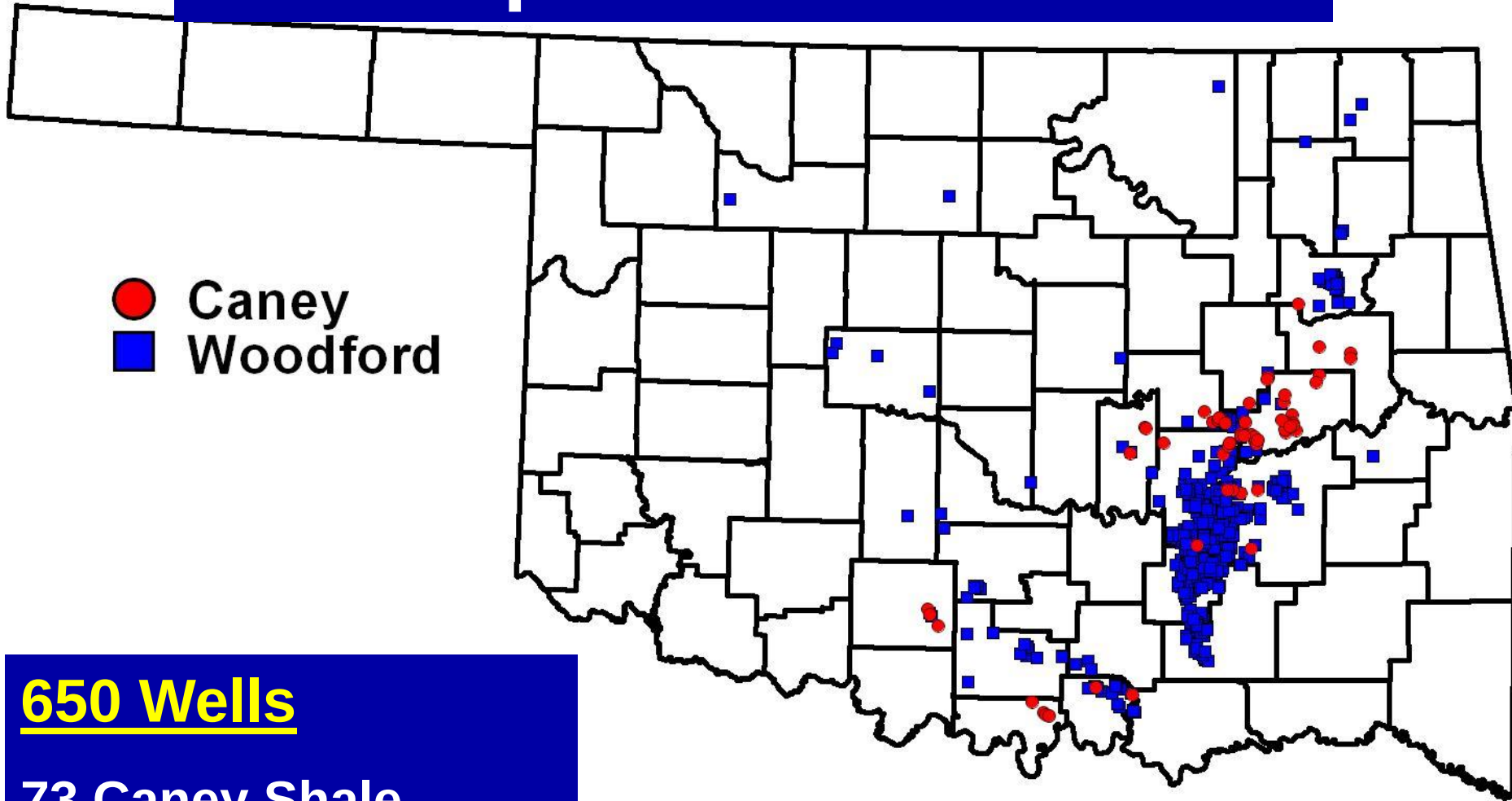
# Oklahoma Shale-Gas Well History

650 Wells, 1939–2008



# Oklahoma Gas-Shale Wells

## Completed 1939-2008



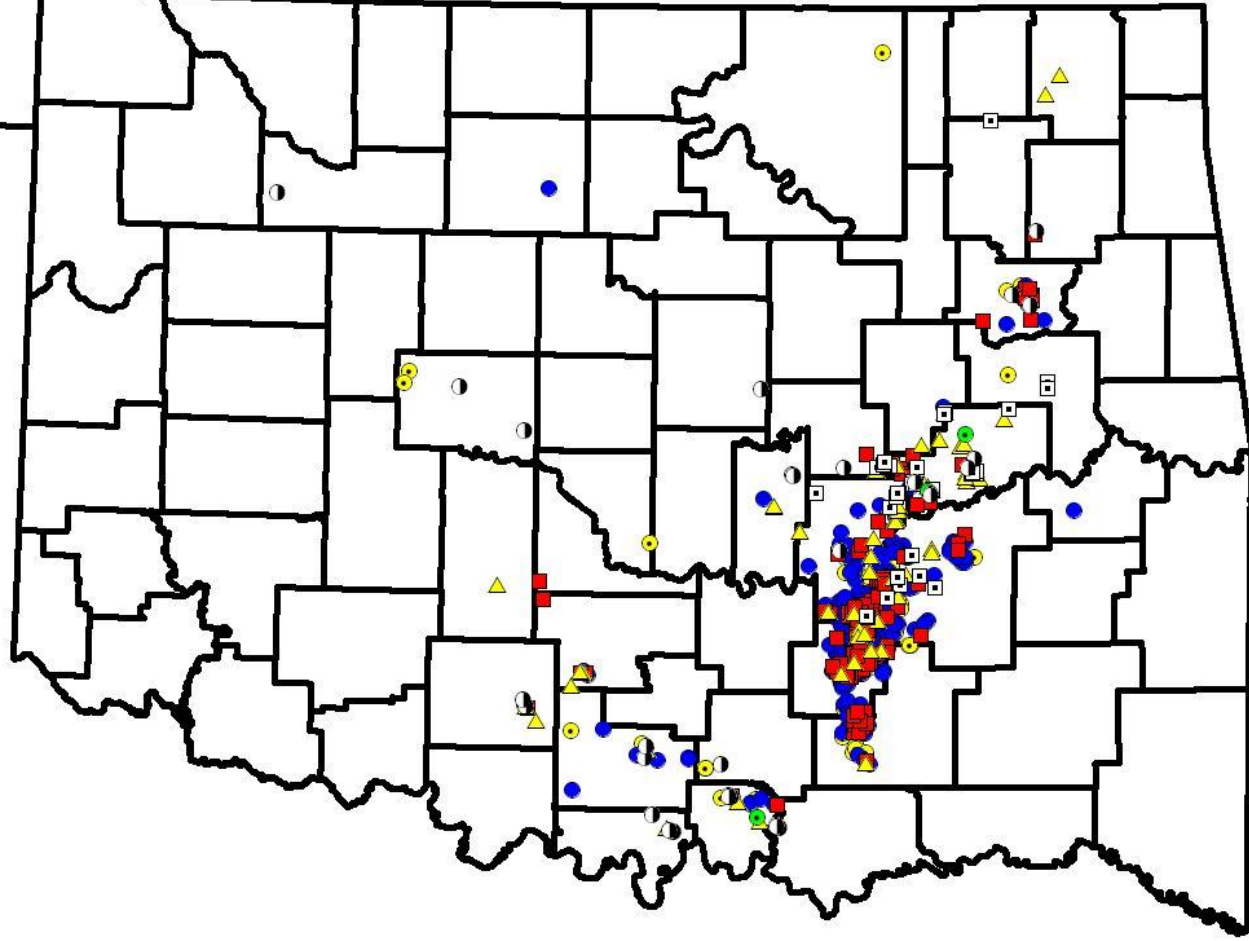
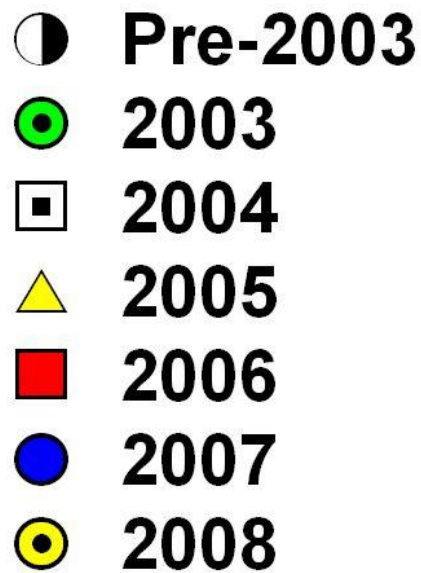
**650 Wells**

**73 Caney Shale**

**577 Woodford Shale**

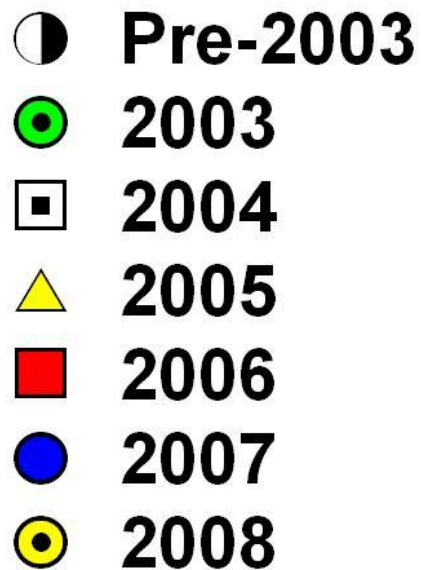
**Updated 8/4/2008**

# Oklahoma Gas-Shale Wells by Year (1939-2008)

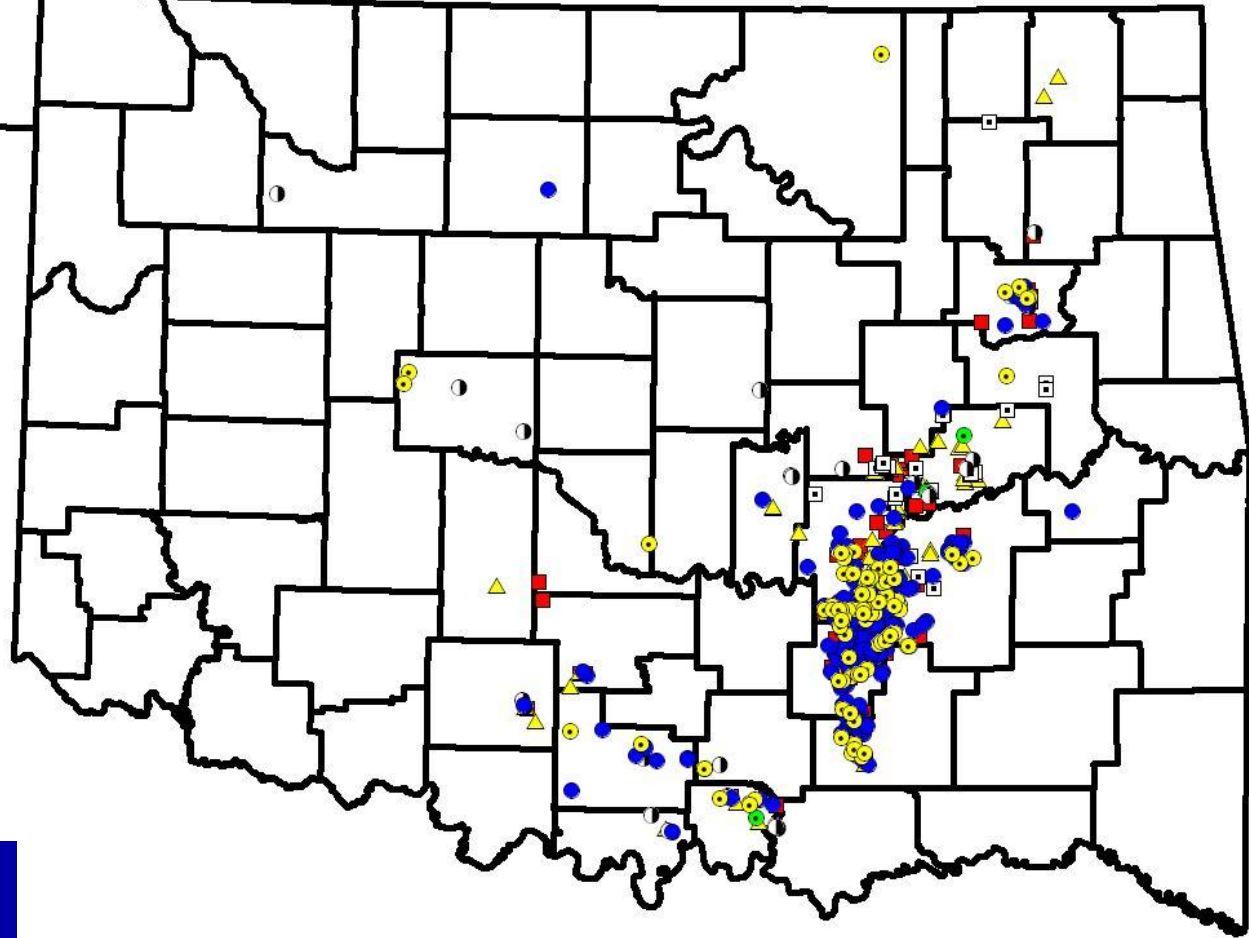


Updated 8/4/2008

# Oklahoma Gas-Shale Wells by Year (1939-2008)



Layered with 2008  
Prevalent



Updated 8/4/2008

# Woodford Shale Stratigraphy

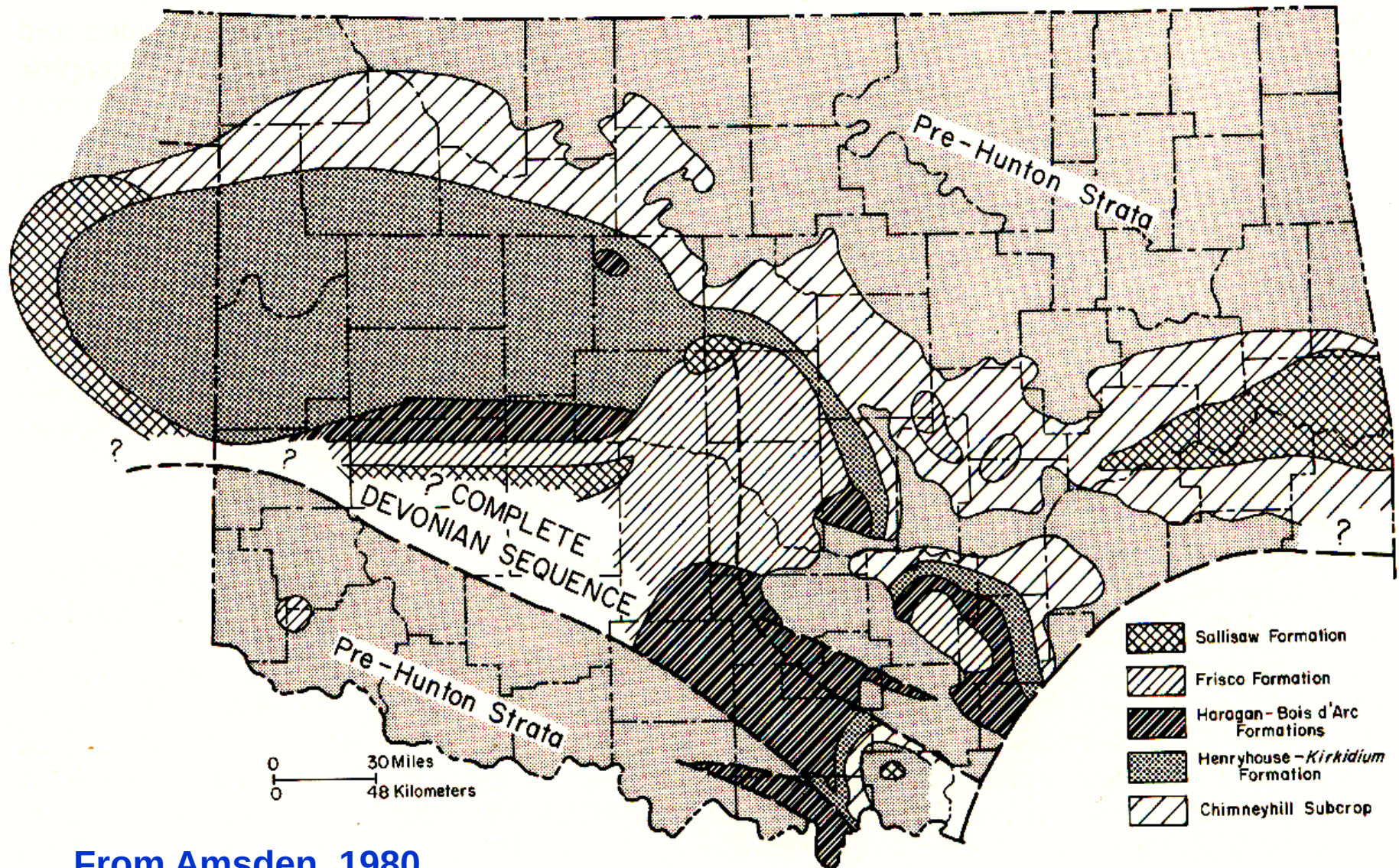
| SYSTEM | MISSISSIPPIAN |          | DEVONIAN | SILURIAN                                                                | ORDOVICIAN              |
|--------|---------------|----------|----------|-------------------------------------------------------------------------|-------------------------|
|        | MERAMECIA     | OSAGEAN  |          | CAYUG.<br>NIAGAR.<br>ALBION                                             | CINCINNATI<br>CHAMPLAIN |
|        | CANEY         | SYCAMORE | WOODFORD | HUNTON<br>BOIS D' ARC<br>HARAGAN<br>HENRYHOUSE<br>CHIMNEYHILL           | SYLVAN<br>VIOLA         |
|        |               |          | WOODFORD | HUNTON<br>FRISCO<br>BOIS D' ARC<br>HARAGAN<br>HENRYHOUSE<br>CHIMNEYHILL | SYLVAN<br>VIOLA         |

Based on conodonts, Hass and Huddle (1965) determined a Late Devonian (Frasnian) age for most of the formation; uppermost part is Early Mississippian (Kinderhookian)

unconformity



# Pre-Woodford Geologic Map

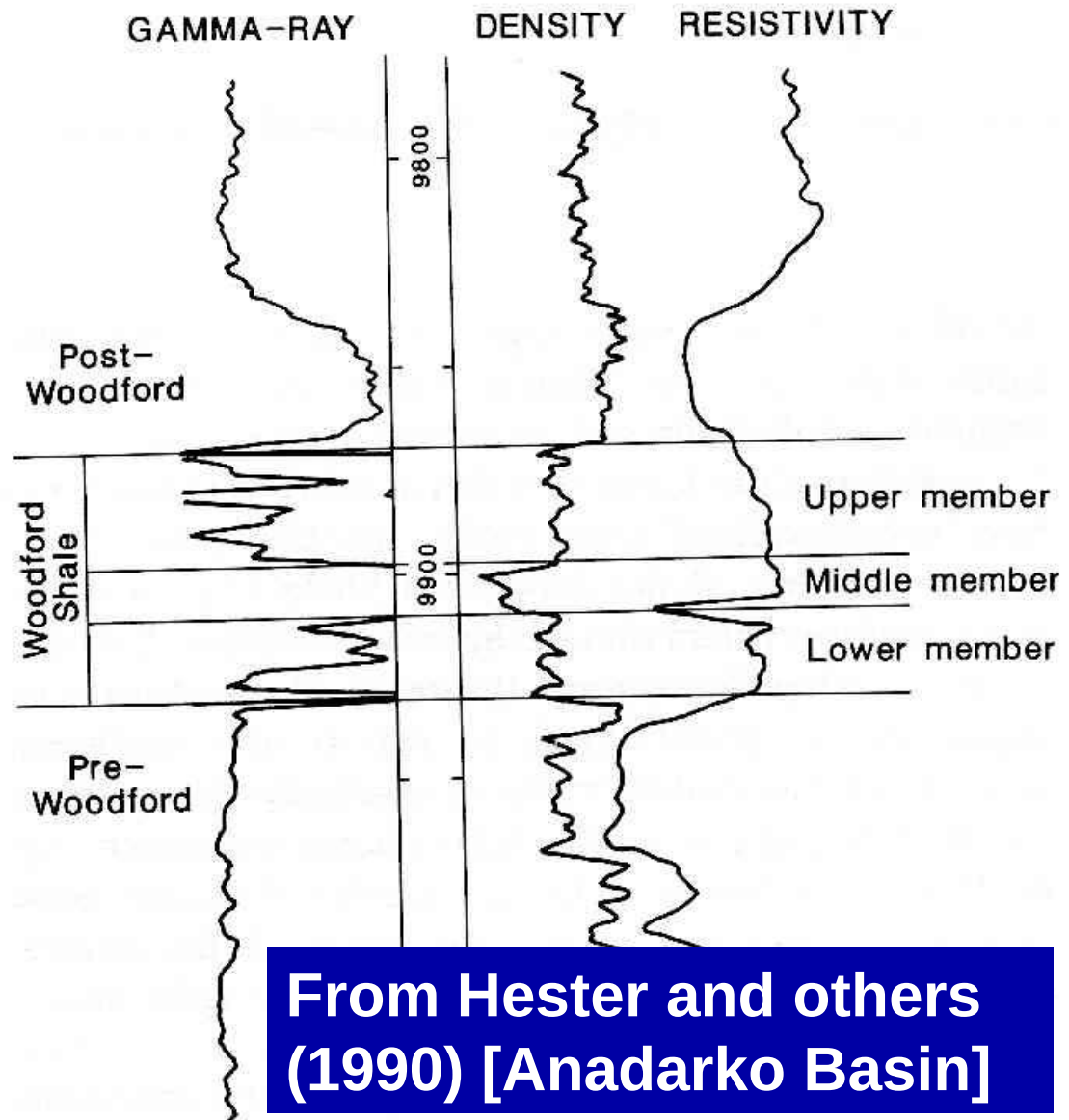


From Amsden, 1980



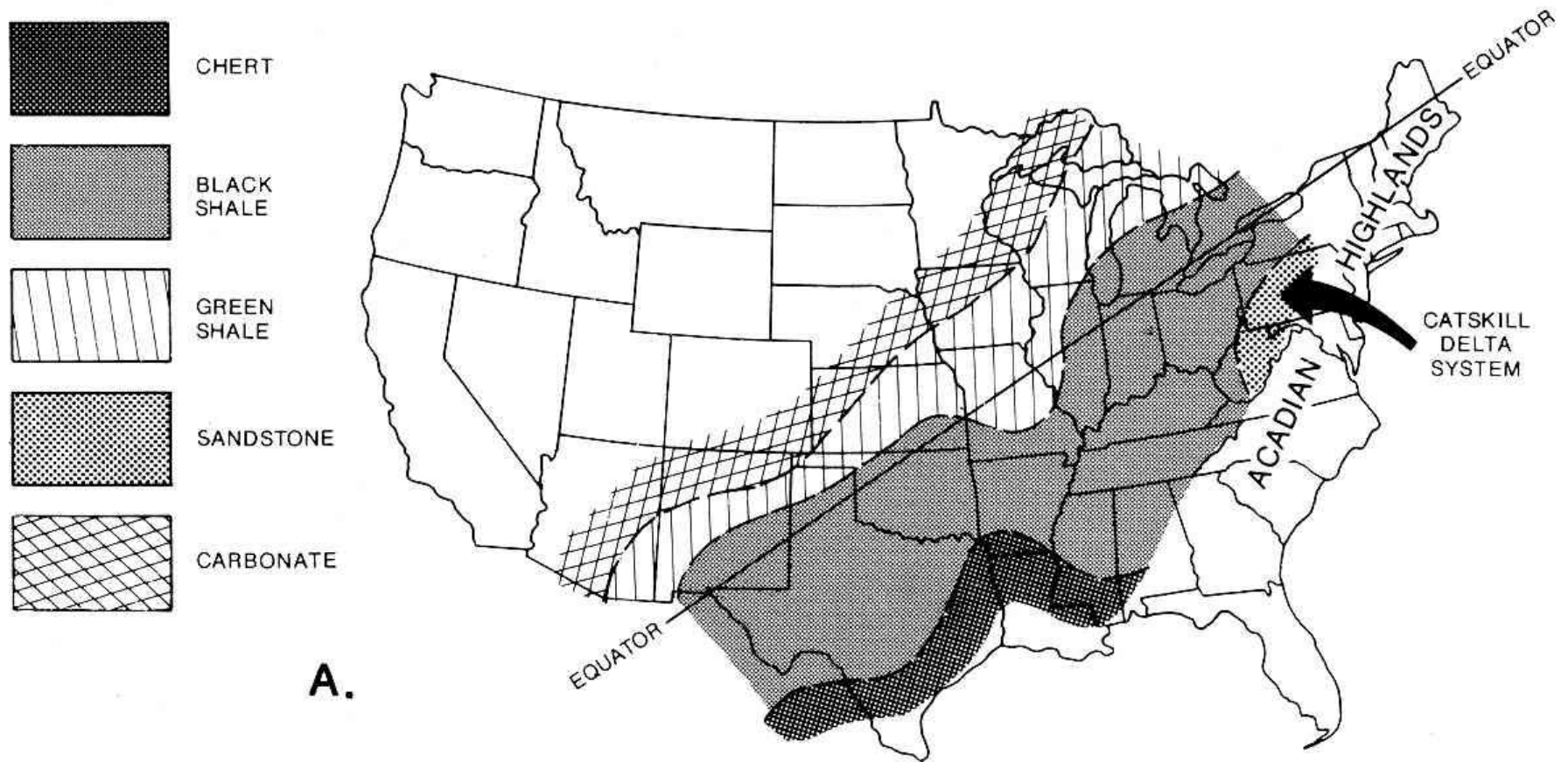
# Woodford Shale Members

Three informal members based on **palynomorphs** (Urban, 1960; Von Almen, 1970), **geochemistry** (Sullivan, 1985), **log signatures** (Hester and others, 1990; Lambert, 1993)



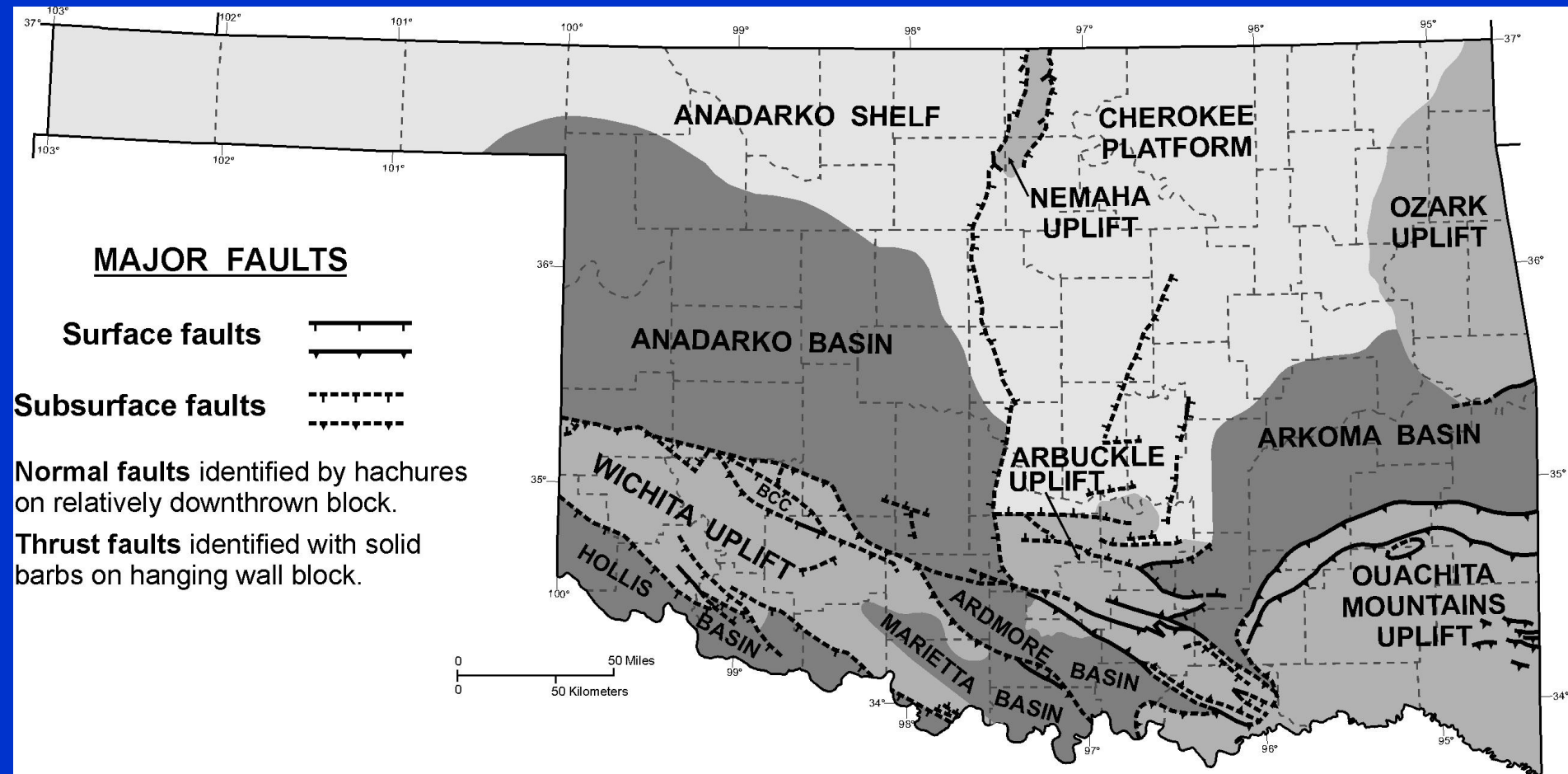


# Paleogeography and Facies Distribution in the Late Devonian



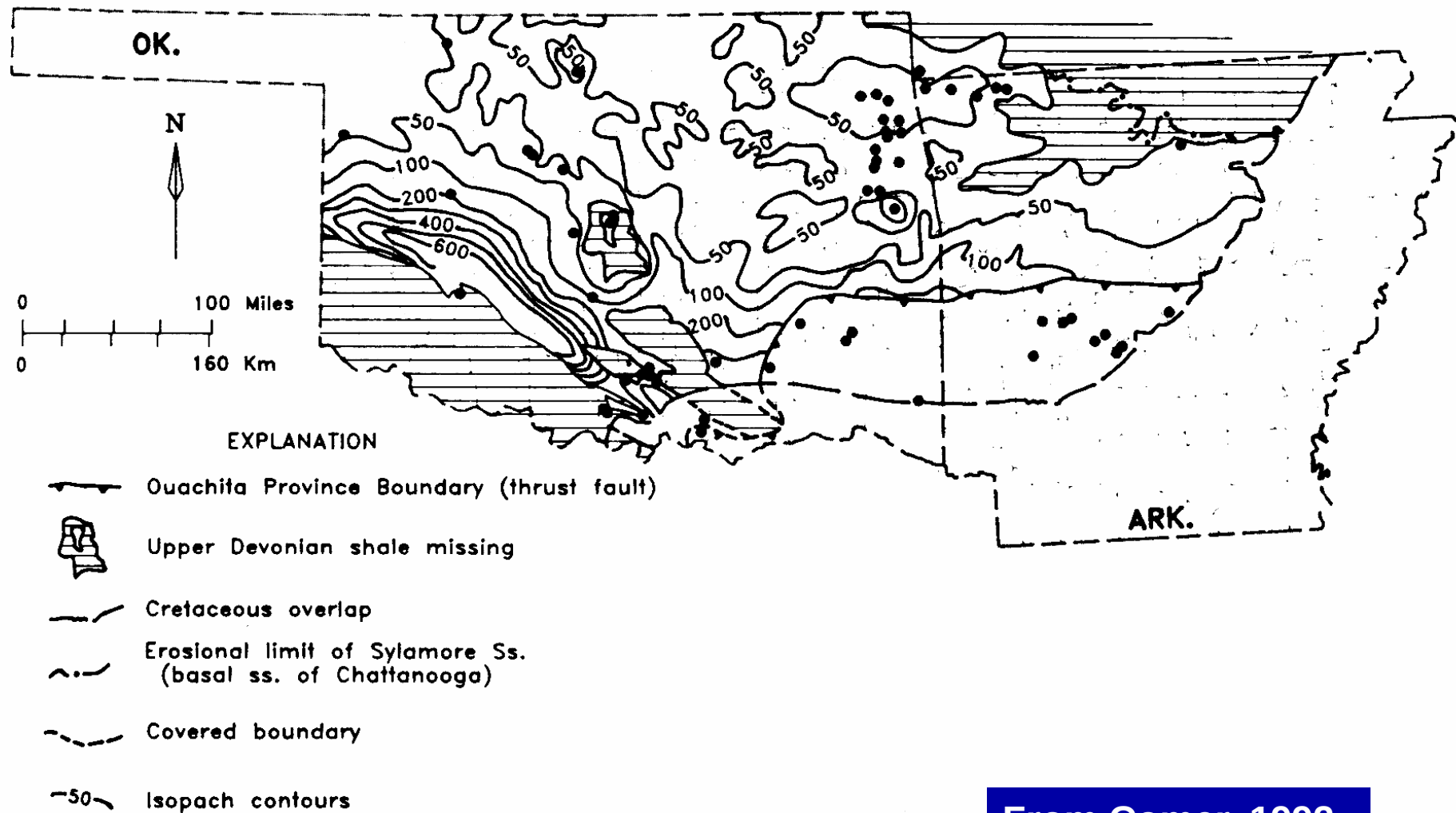
From Kirkland and others, 1992

# Geologic Provinces of Oklahoma



Northcutt and Campbell, 1995

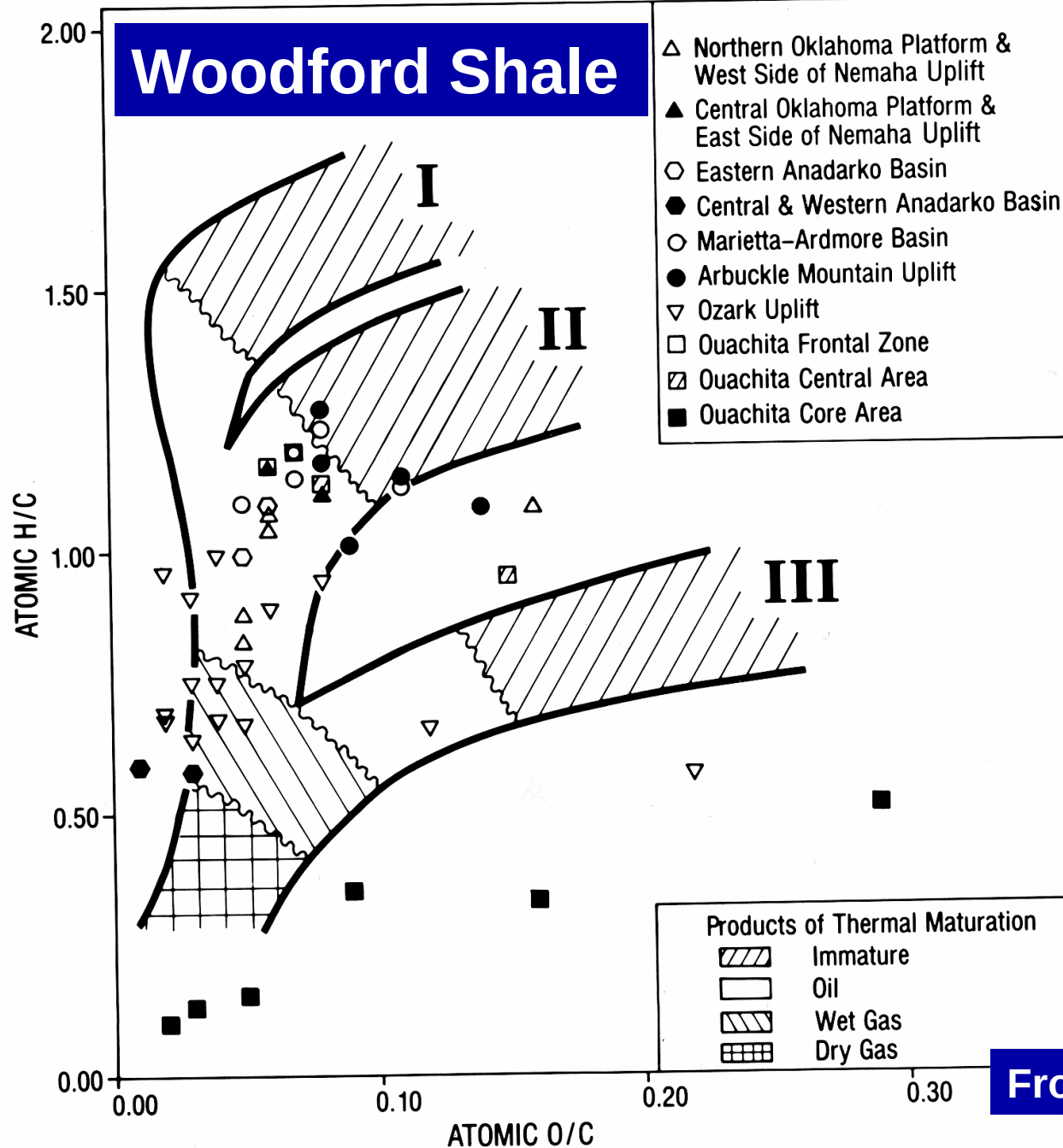
# Isopach Map of Woodford Shale



From Comer, 1992



# Woodford Shale



From Comer, 1992

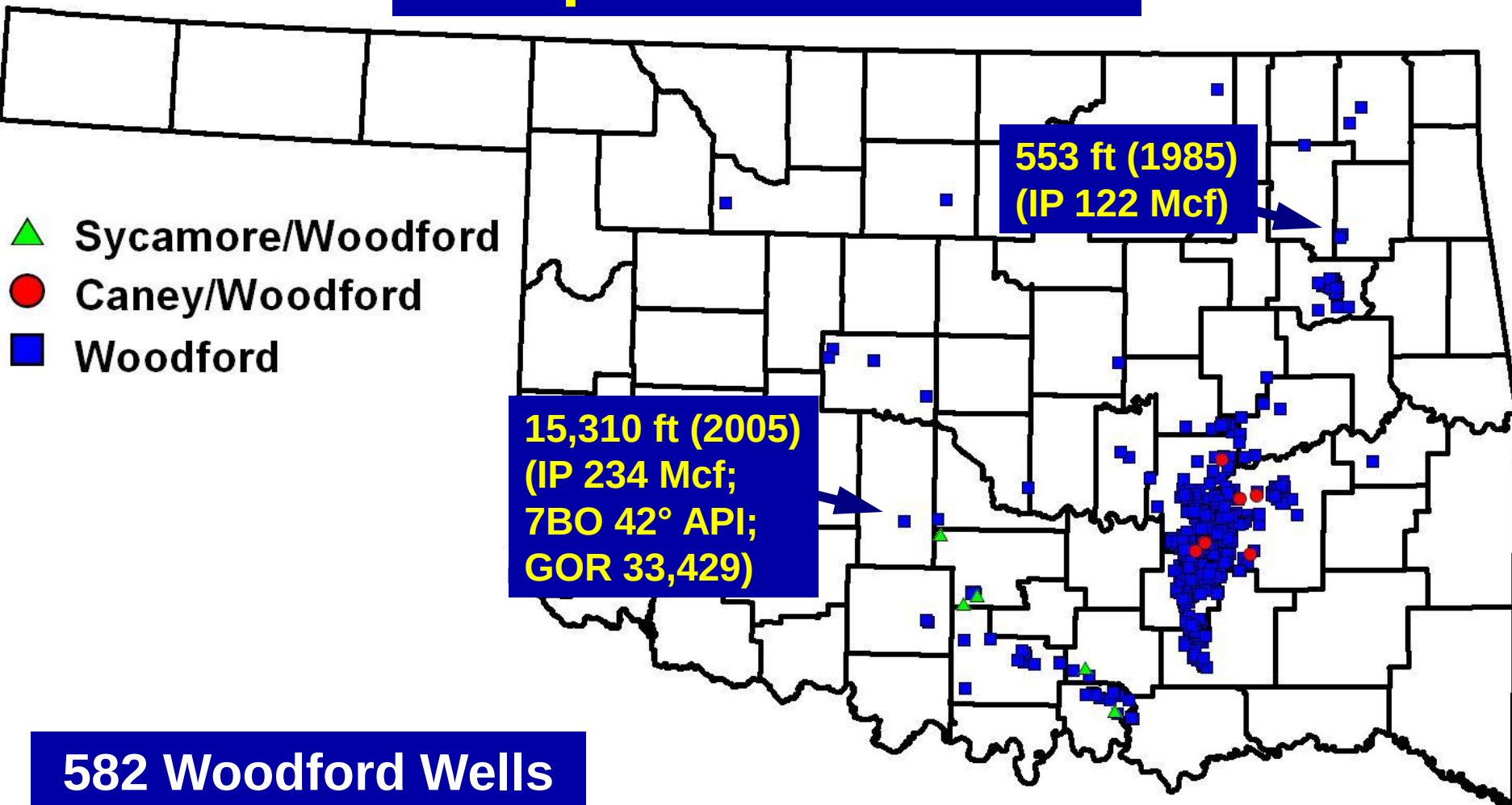
# Woodford Mineralogy

| <b>[grab samples]</b>  | <b>A</b>      | <b>B</b>      | <b>C</b>      | <b>D</b>     | <b>E</b>      |
|------------------------|---------------|---------------|---------------|--------------|---------------|
| <b>Quartz</b>          | <b>63-68%</b> | <b>29-87%</b> | <b>30-60%</b> | <b>9-61%</b> | <b>27-53%</b> |
| <b>K-Feldspar</b>      | <b>4%</b>     | <b>0-2%</b>   | <b>2-10%</b>  | <b>2-42%</b> | <b>0-2%</b>   |
| <b>Plagioclase</b>     | <b>3%</b>     |               |               |              | <b>1-4%</b>   |
| <b>Calcite</b>         | <b>10%</b>    |               | <b>5-25%</b>  | <b>0-7%</b>  | <b>0-11%</b>  |
| <b>Dolomite</b>        | <b>6-9%</b>   | <b>0-56%</b>  | <b>0-5%</b>   | <b>0-10%</b> | <b>0-6%</b>   |
| <b>Pyrite</b>          | <b>5-7%</b>   | <b>0-1%</b>   | <b>0-5%</b>   | <b>2-30%</b> | <b>1-13%</b>  |
| <b>Total Clays</b>     | <b>12-14%</b> |               |               |              |               |
| <b>Illite</b>          |               | <b>8-35%</b>  | <b>2-5%</b>   | <b>7-53%</b> | <b>13-40%</b> |
| <b>Illite/Smectite</b> |               |               | <b>2-20%</b>  |              |               |
| <b>Kaolinite</b>       |               | <b>1-7%</b>   | <b>2-5%</b>   | <b>0-2%</b>  | <b>0-5%</b>   |
| <b>Chlorite</b>        |               |               | <b>2-5%</b>   | <b>0-40%</b> | <b>0-5%</b>   |

A. O'Brien & Slatt, 1990; B. Kirkland et al., 1992; C. Greiser, 2006;  
D. Branch, 2007; E. Abousleiman et al., 2008

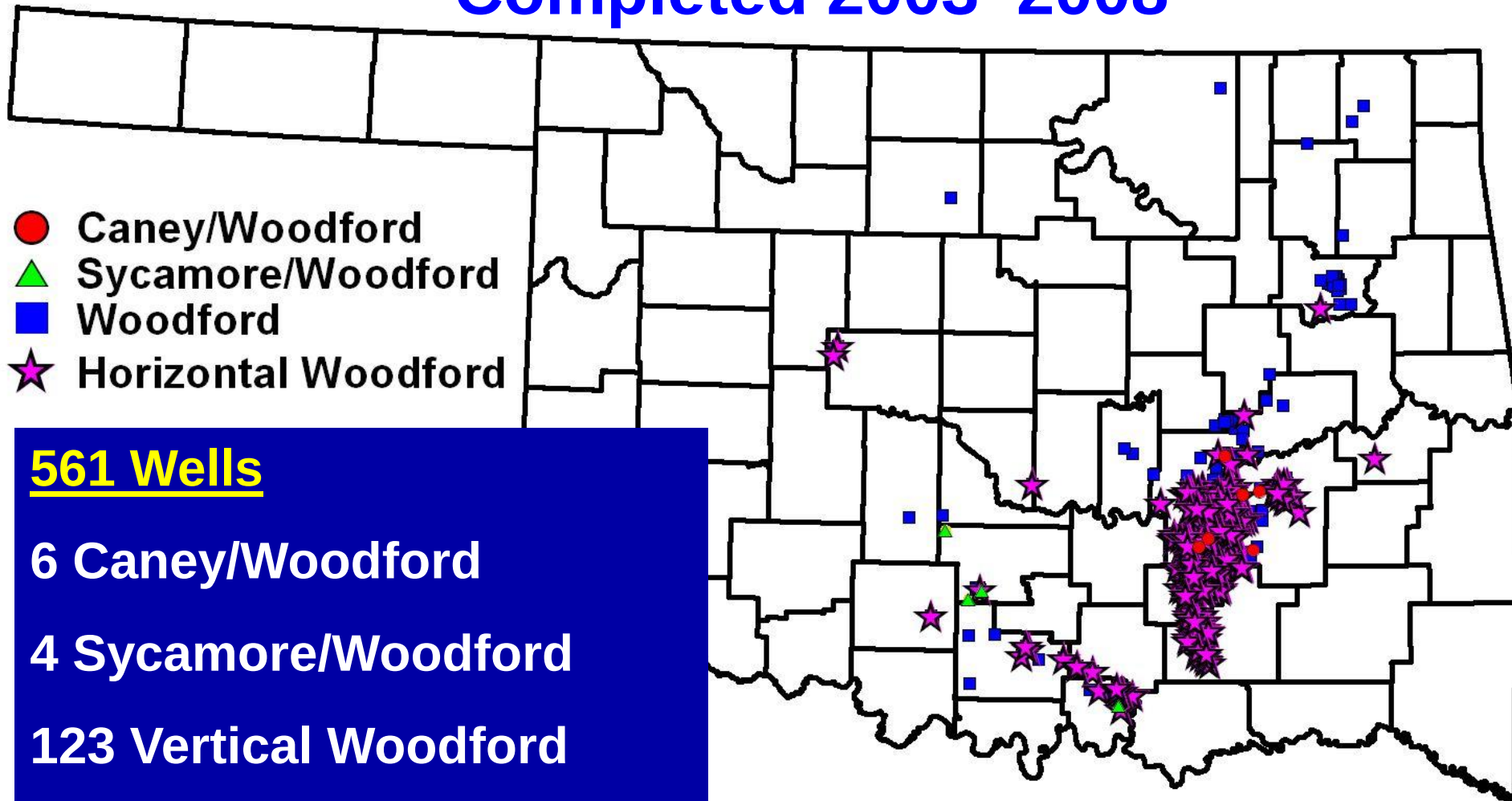
# Woodford Gas-Shale Wells

Completed 1939-2008



# Woodford Gas-Shale Wells

Completed 2003–2008



## 561 Wells

6 Caney/Woodford

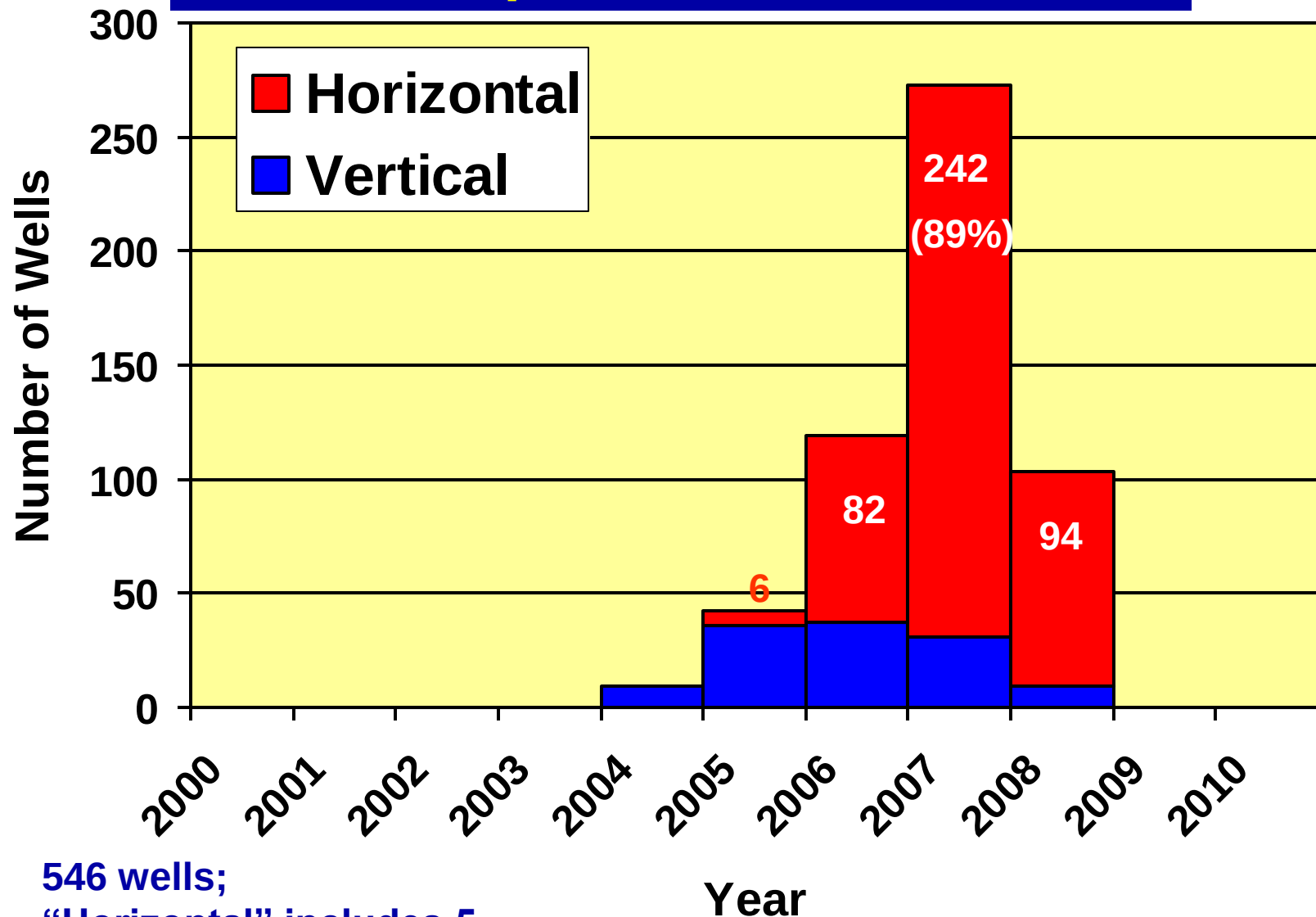
4 Sycamore/Woodford

123 Vertical Woodford

428 Horizontal/Directional  
Woodford (76%)

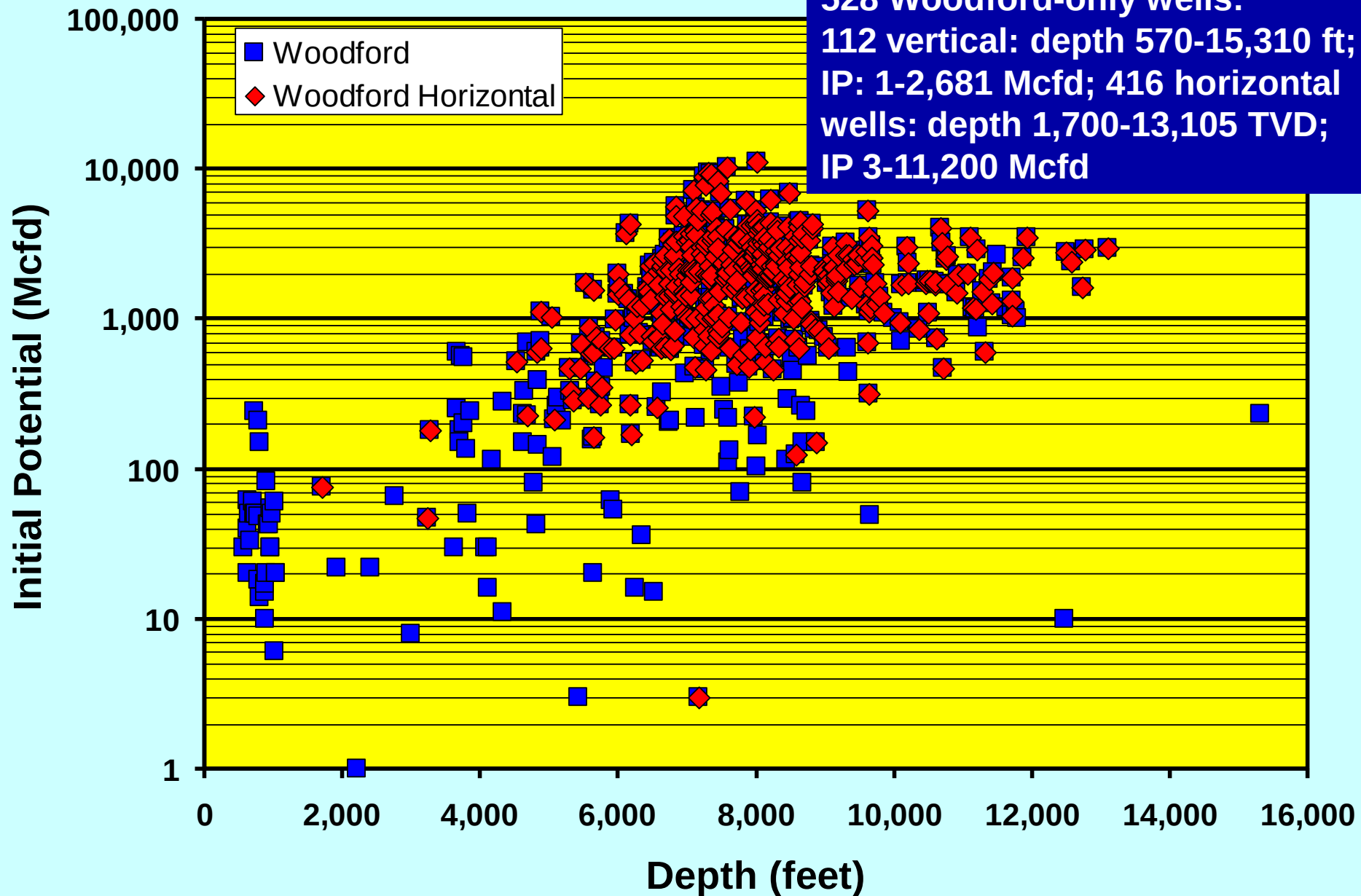


# Woodford Shale-Only Wells Completed 2004-2008

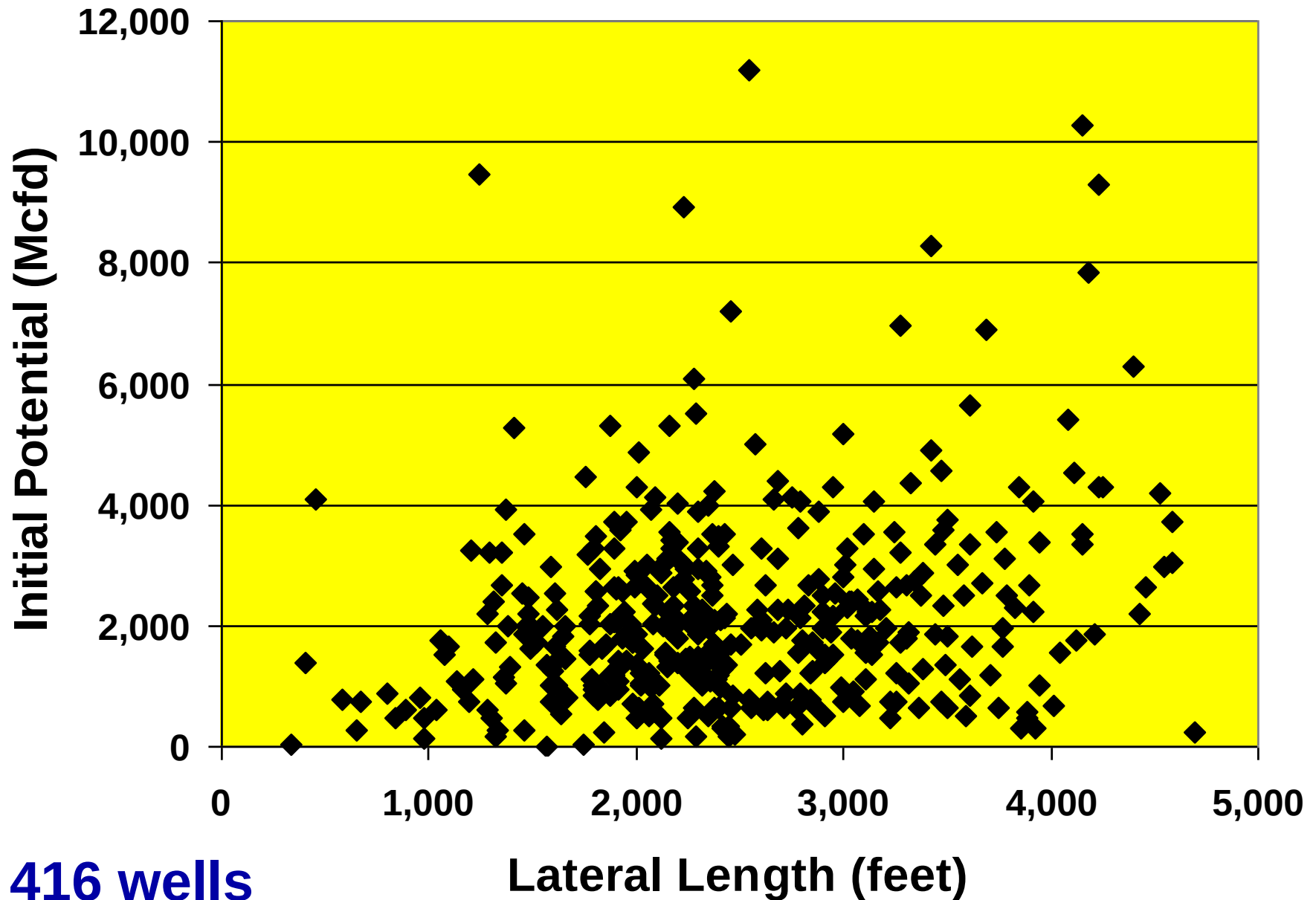


546 wells;  
"Horizontal" includes 5  
directional wells

# Woodford Shale Gas Wells, 2003-2007

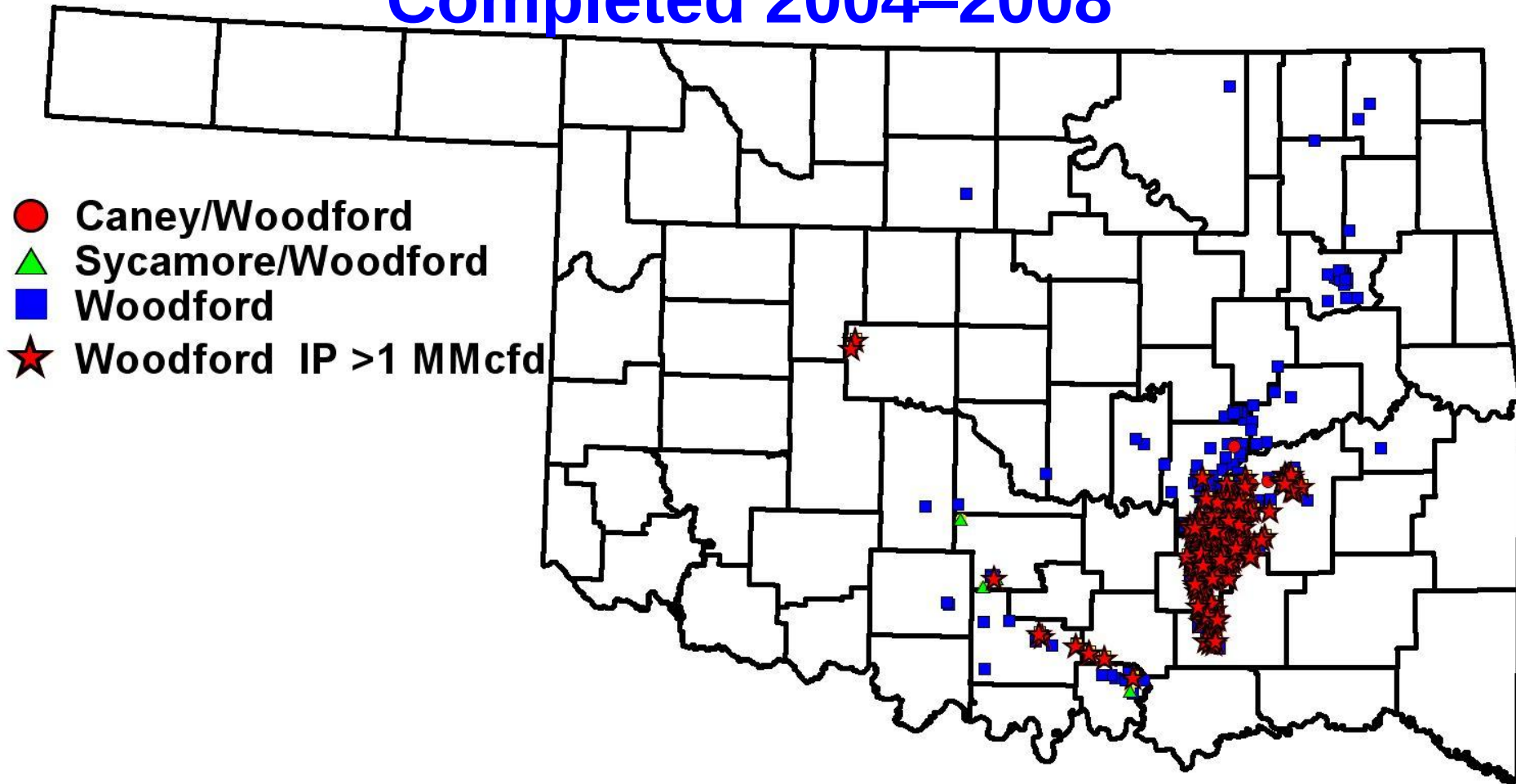


# Woodford Shale Horizontal Wells



# Woodford IP >1 MMcfd

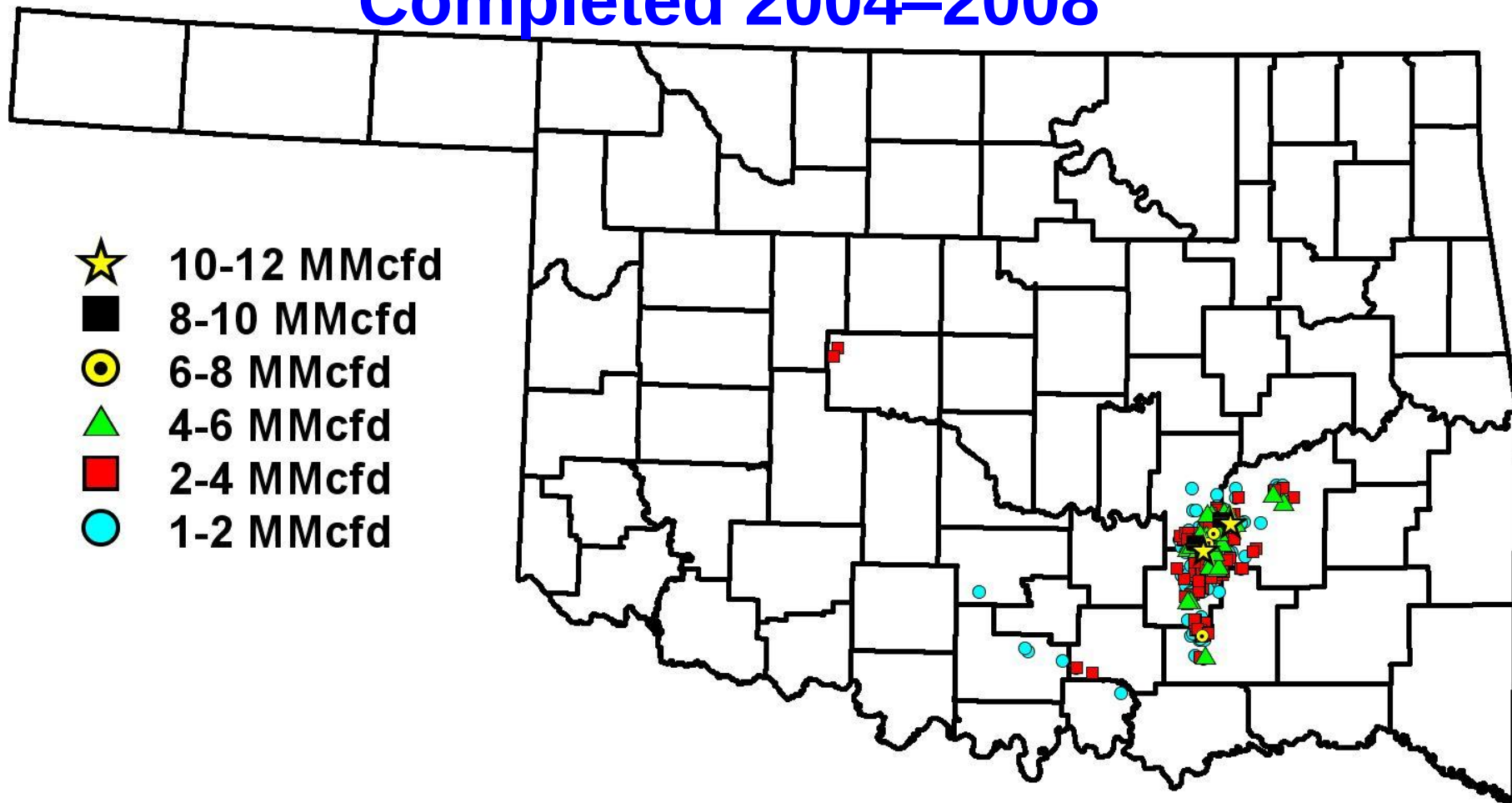
Completed 2004–2008



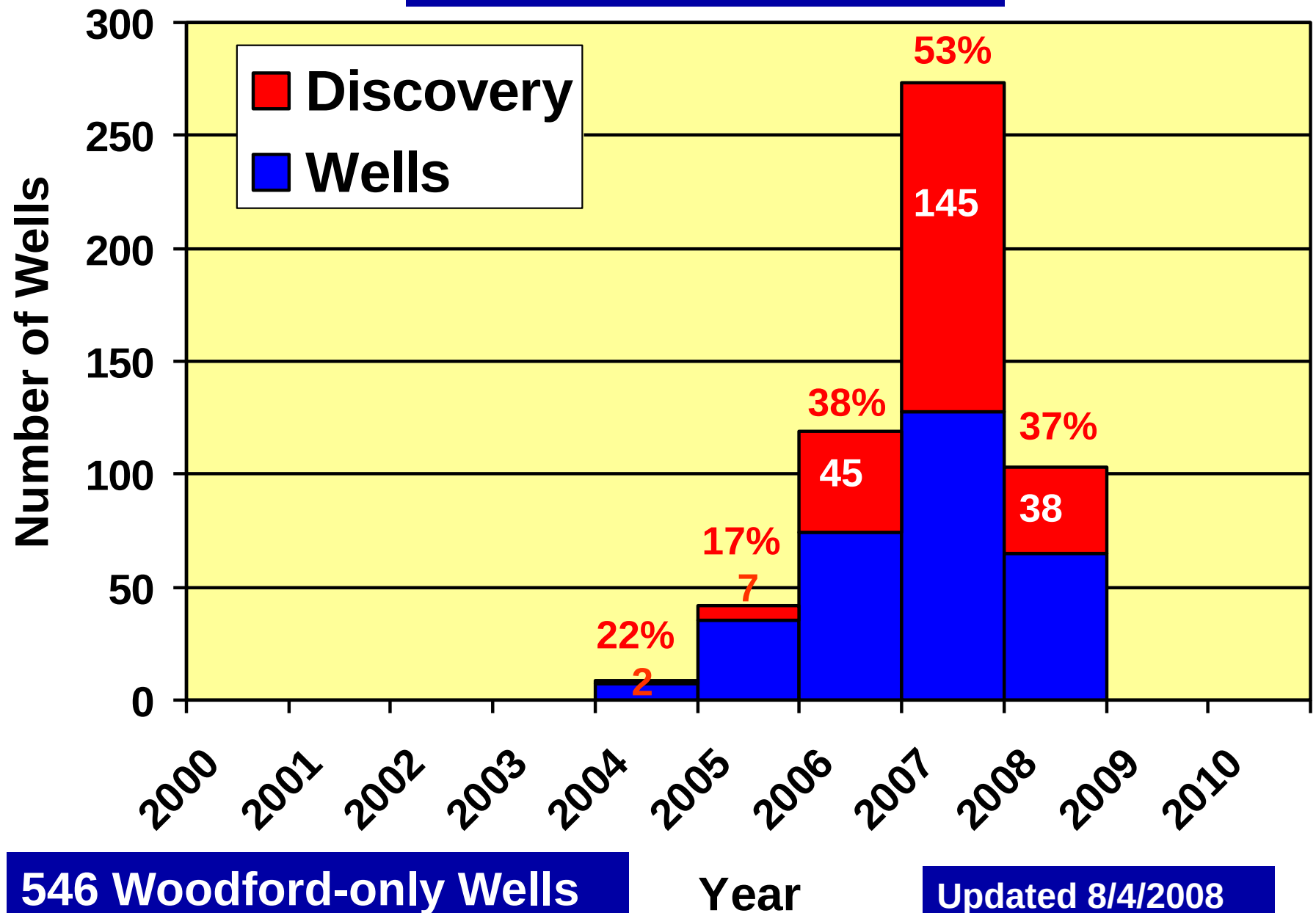


# Woodford IP >1 MMcfd

Completed 2004–2008

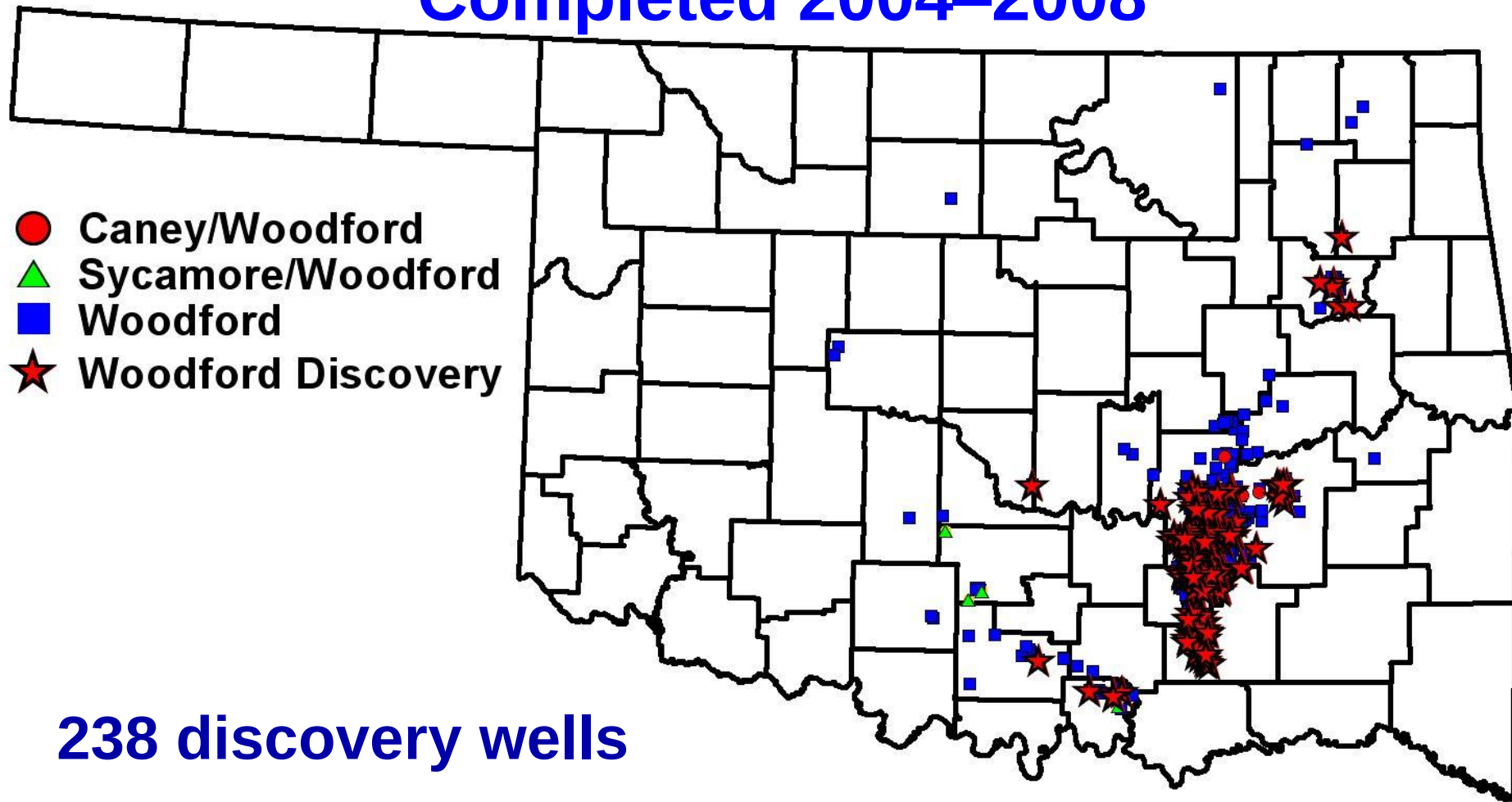


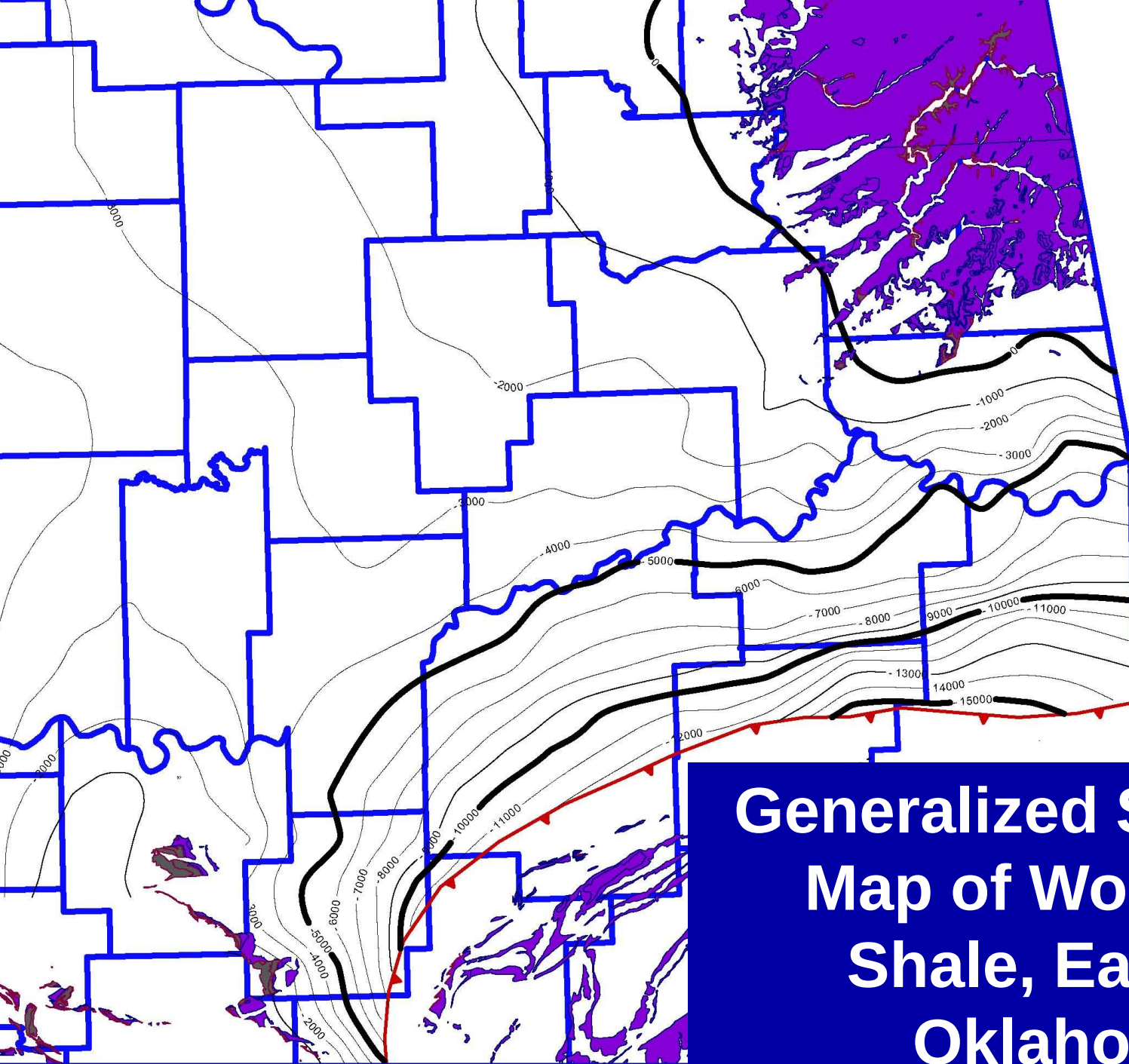
# Woodford Shale Discovery Wells (New Field or Extension)



# Woodford Shale Discovery Wells

Completed 2004–2008





Map prepared  
by R. Vance  
Hall using  
Petra

# Generalized Structure Map of Woodford Shale, Eastern Oklahoma

# Guidelines for the Barnett Shale (Based on Rock-Eval Pyrolysis)

## VRo Values

## Maturity

<0.55%

Immature

0.55-1.15%

Oil Window (peak  
oil at 0.90%VRo)

1.15-1.40%

Condensate–Wet-  
Gas Window

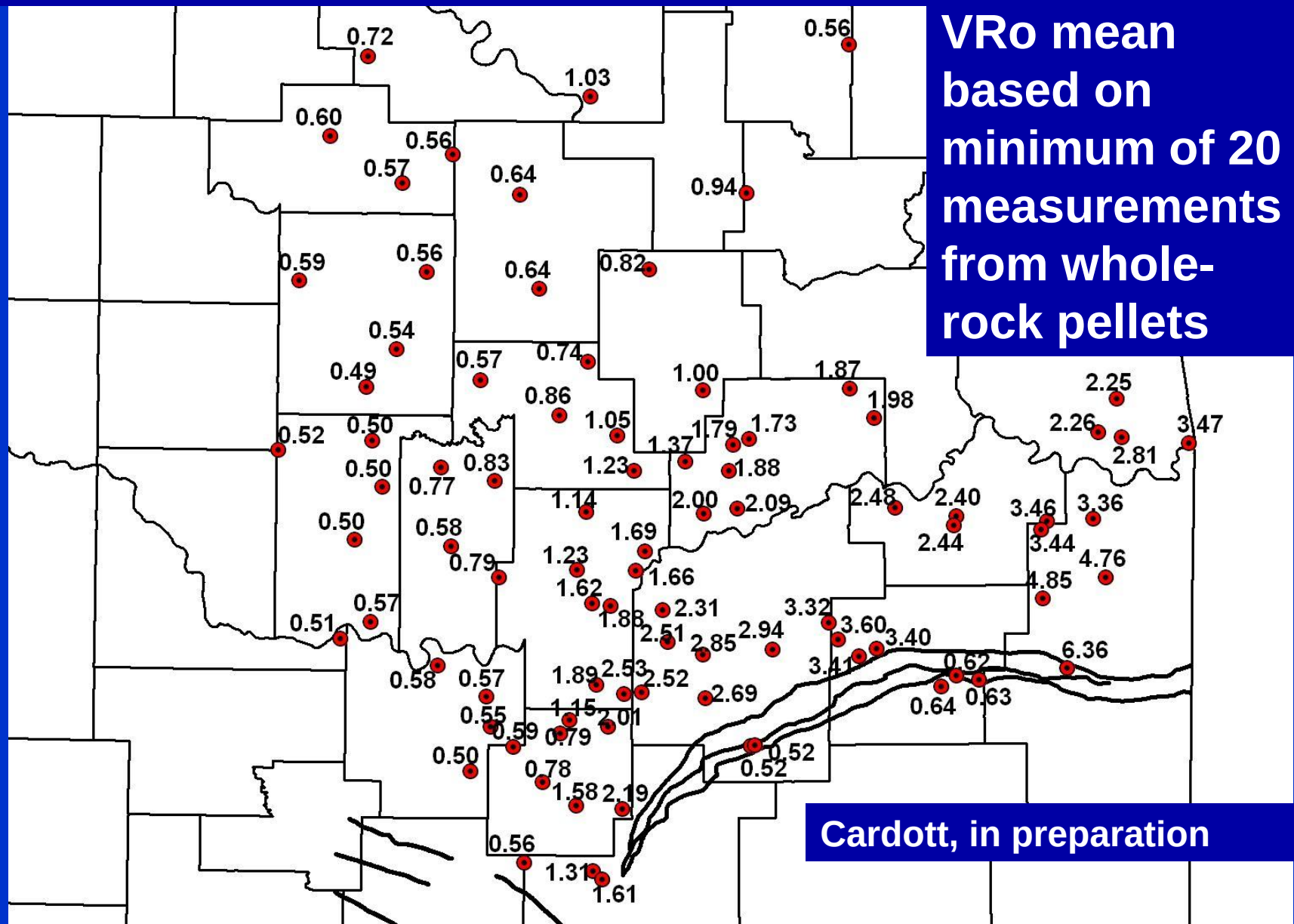
>1.40%

Dry-Gas Window

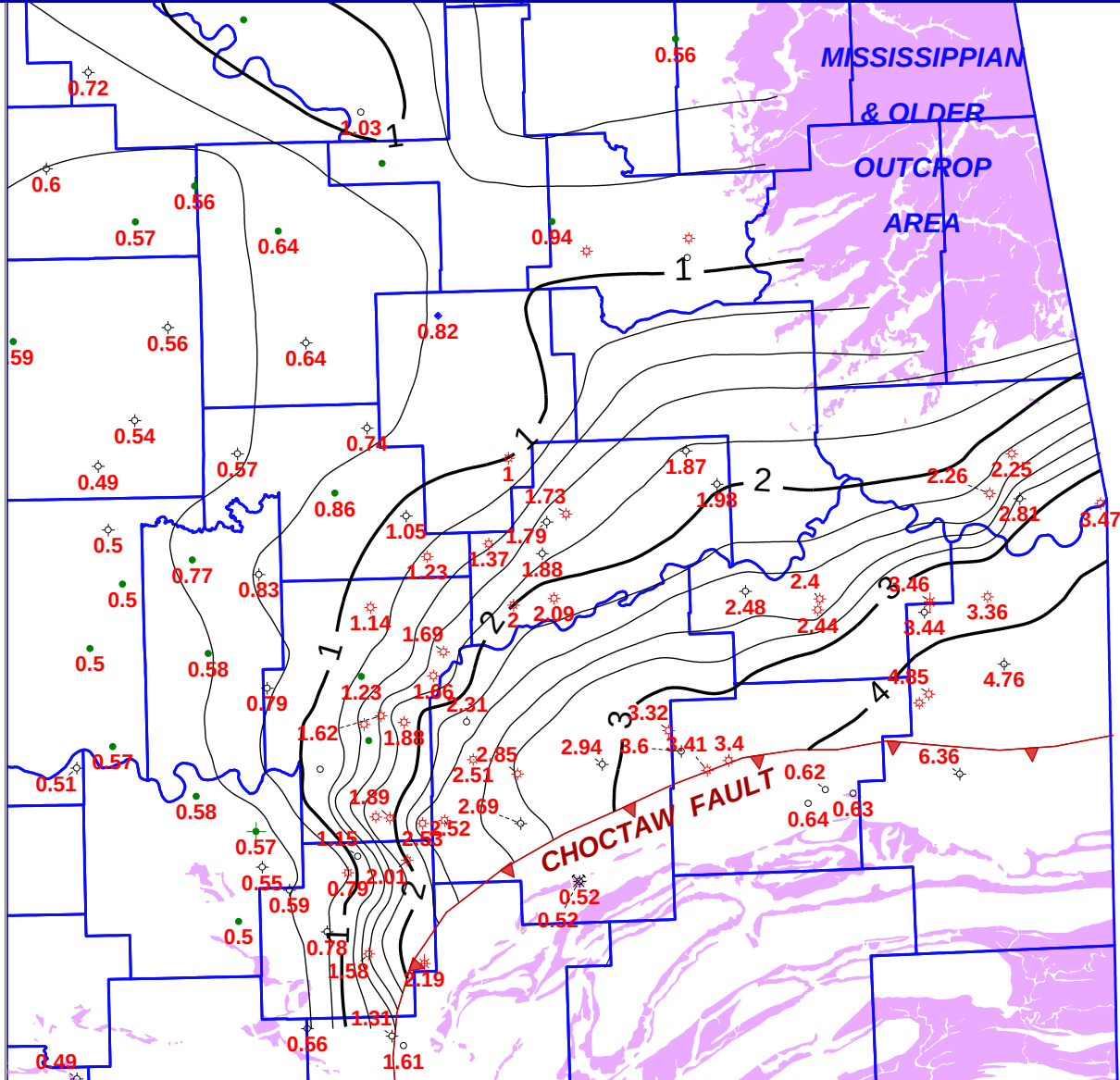
From Jarvie and others, 2005



# Vitrinite Reflectance of Woodford Shale, Eastern Oklahoma

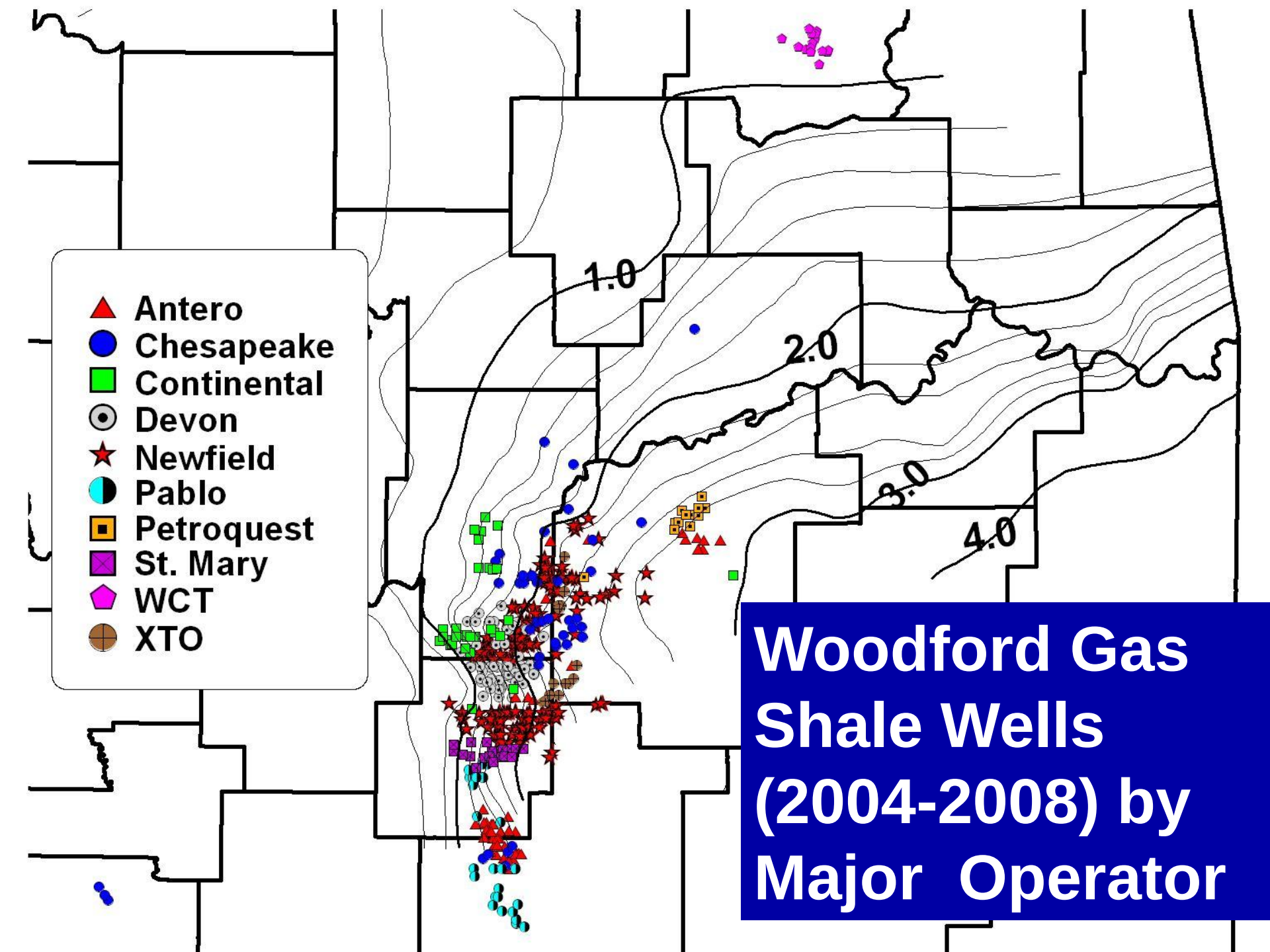


# Isoreflectance Map of the Woodford Shale in Eastern Oklahoma



Map prepared  
by R. Vance  
Hall using  
Petra

## Cardott, in preparation

- 
- A map of the Woodford Gas Shale region showing well locations from 2004 to 2008, categorized by major operator. The map includes county boundaries and contour lines labeled 1.0, 2.0, 3.0, and 4.0. A legend on the left identifies the operators by symbol: Antero (red triangle), Chesapeake (blue circle), Continental (green square), Devon (grey circle with a dot), Newfield (red star), Pablo (cyan circle), Petroquest (orange square), St. Mary (purple square), WCT (pink pentagon), and XTO (brown circle). The highest density of wells is in the southern and central parts of the map, particularly around the 1.0 and 2.0 contours. WCT wells are clustered in the north. Chesapeake wells are scattered in the central and southern areas. Antero, Newfield, and XTO wells are concentrated in the southern region. Continental and Petroquest wells are found in the central and southern areas. Devon wells are clustered in the southern region. Pablo wells are located in the southern region. A blue box in the bottom right corner contains the title text.
- ▲ Antero
  - Chesapeake
  - Continental
  - ⦿ Devon
  - ★ Newfield
  - Pablo
  - Petroquest
  - St. Mary
  - ◆ WCT
  - XTO

**Woodford Gas  
Shale Wells  
(2004-2008) by  
Major Operator**

# Woodford IP >1 MMcfd on Isoreflectance Map



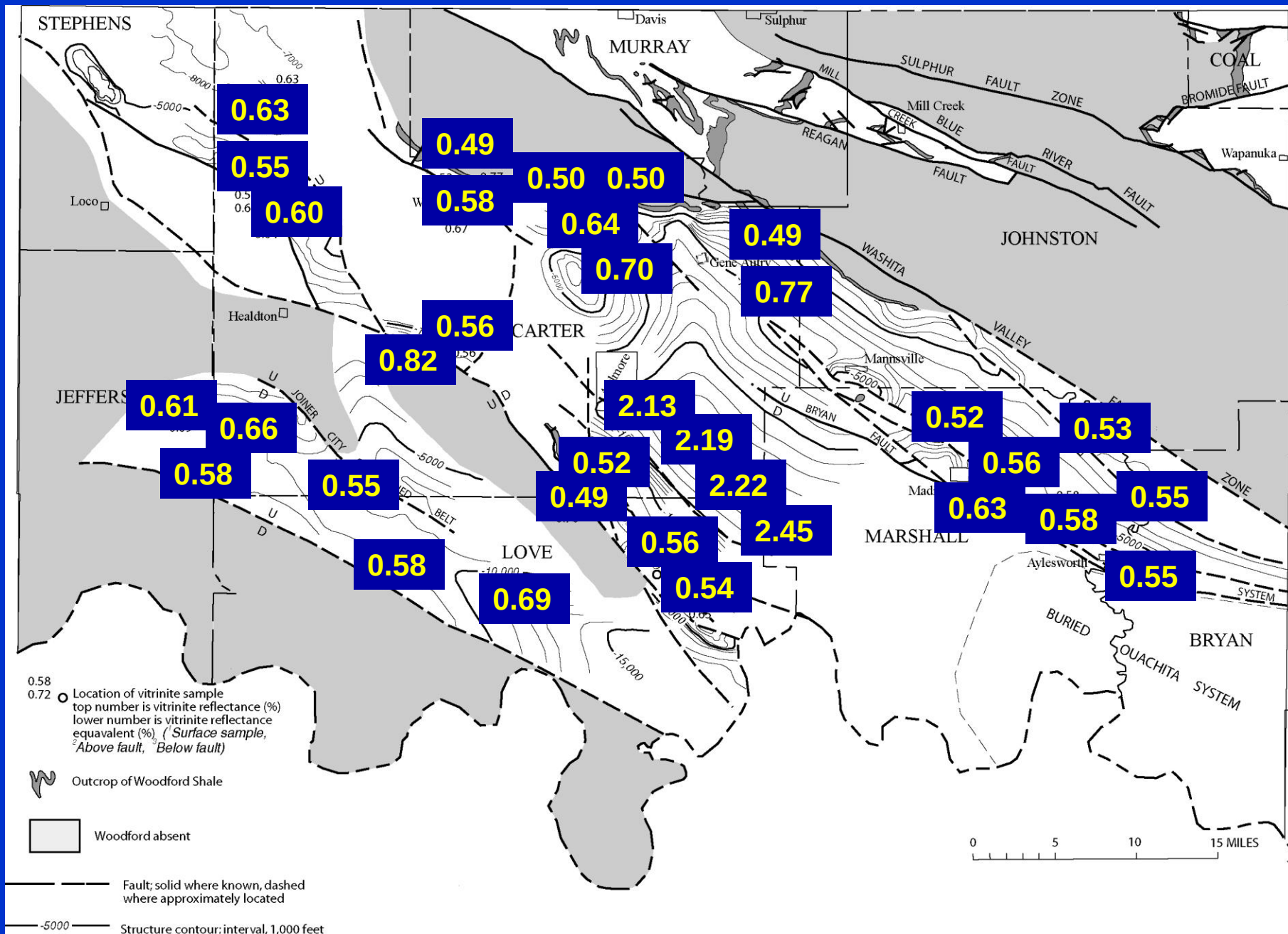
**Woodford Gas-Shale Play is  
primarily in eastern Oklahoma  
(western Arkoma Basin)  
where the shale is:**

- (1) in the gas window (pushing the  
lower limits to the west and  
upper limits to the east)**
- (2) greater than 100 ft thick**
- (3) relatively shallow (<12,000 ft)**

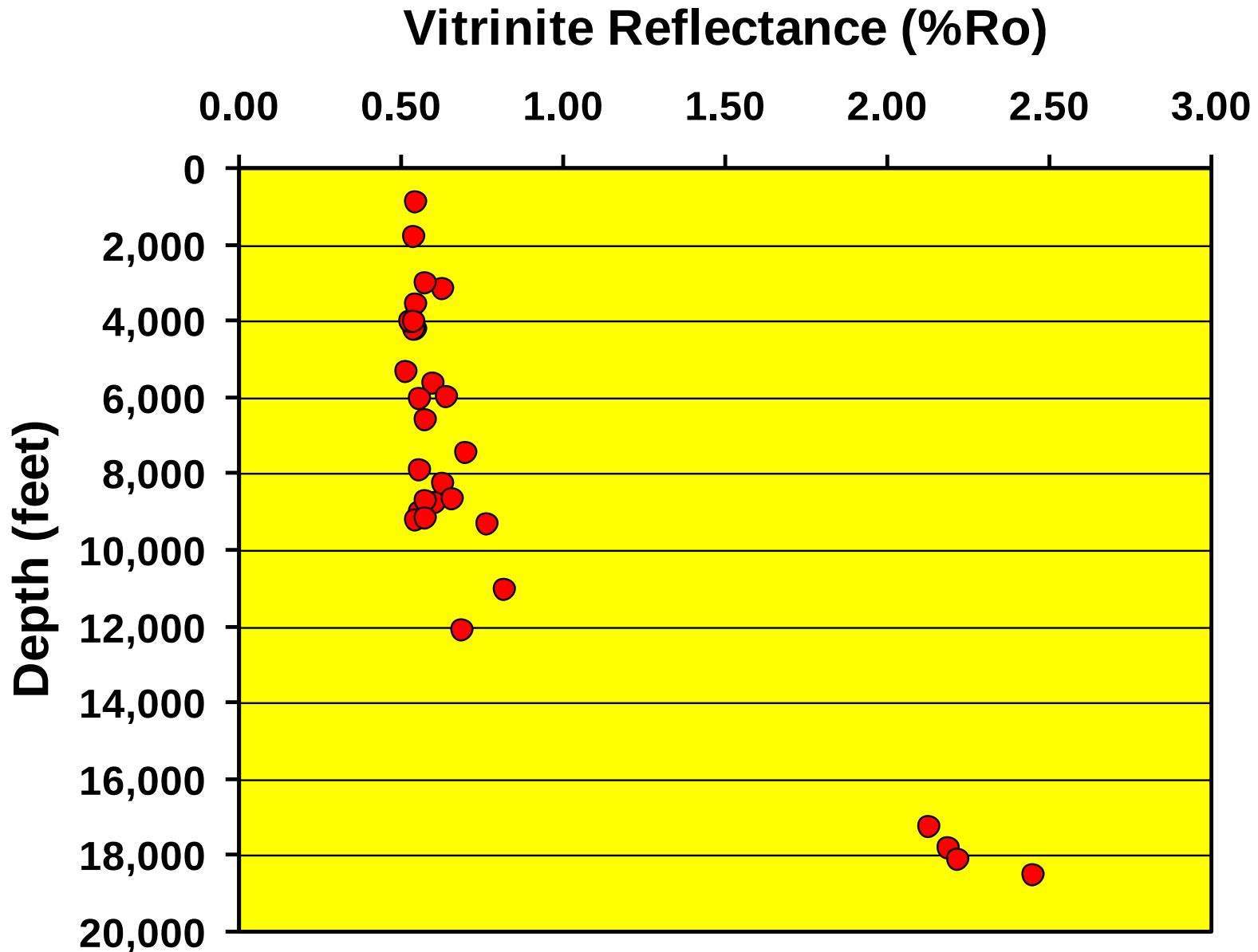


LT





# Southern Oklahoma VRo vs Depth



# Woodford Gas Shales

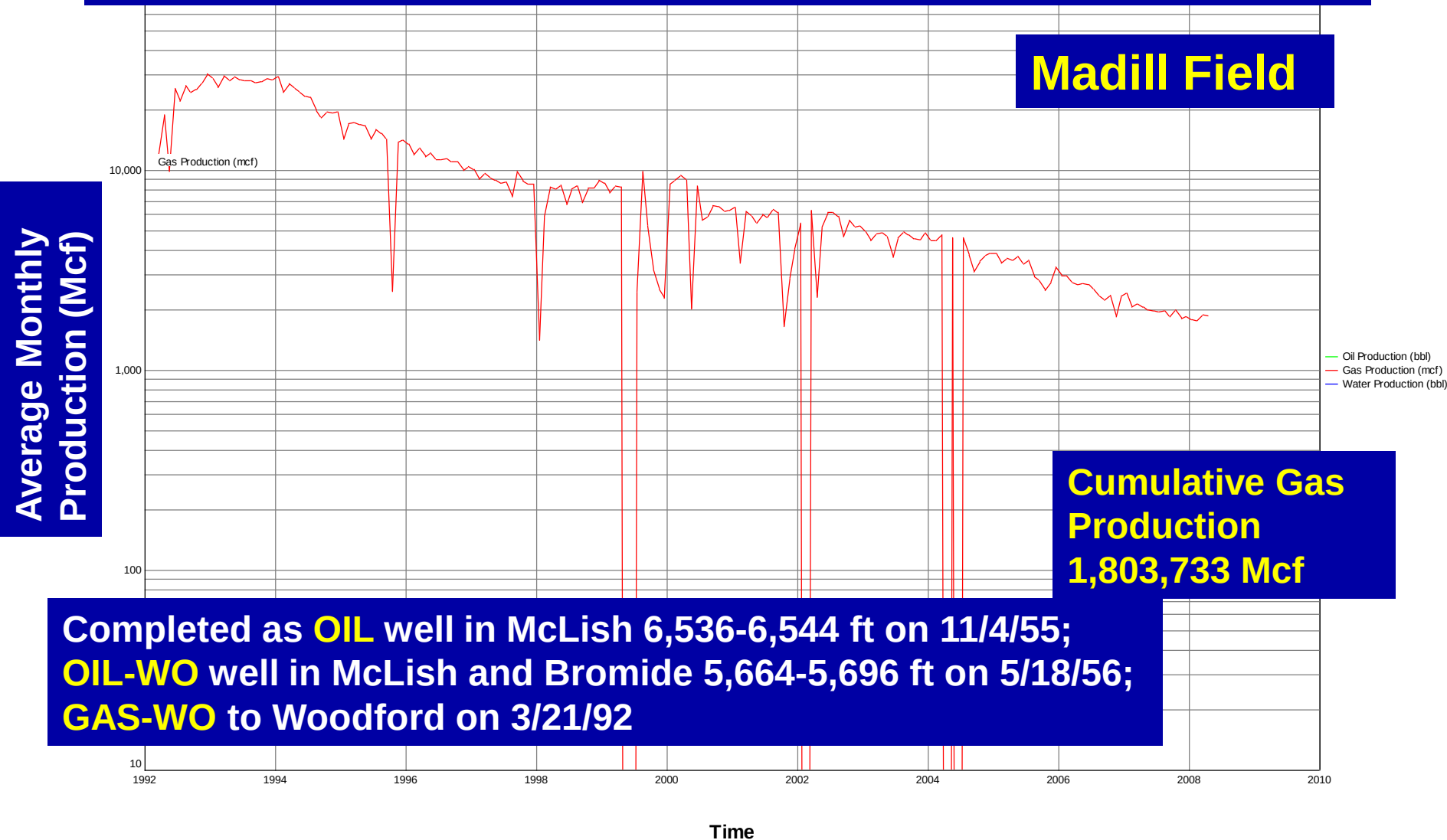
1939-1996



**21 Wells**

**1 Sycamore/Woodford**

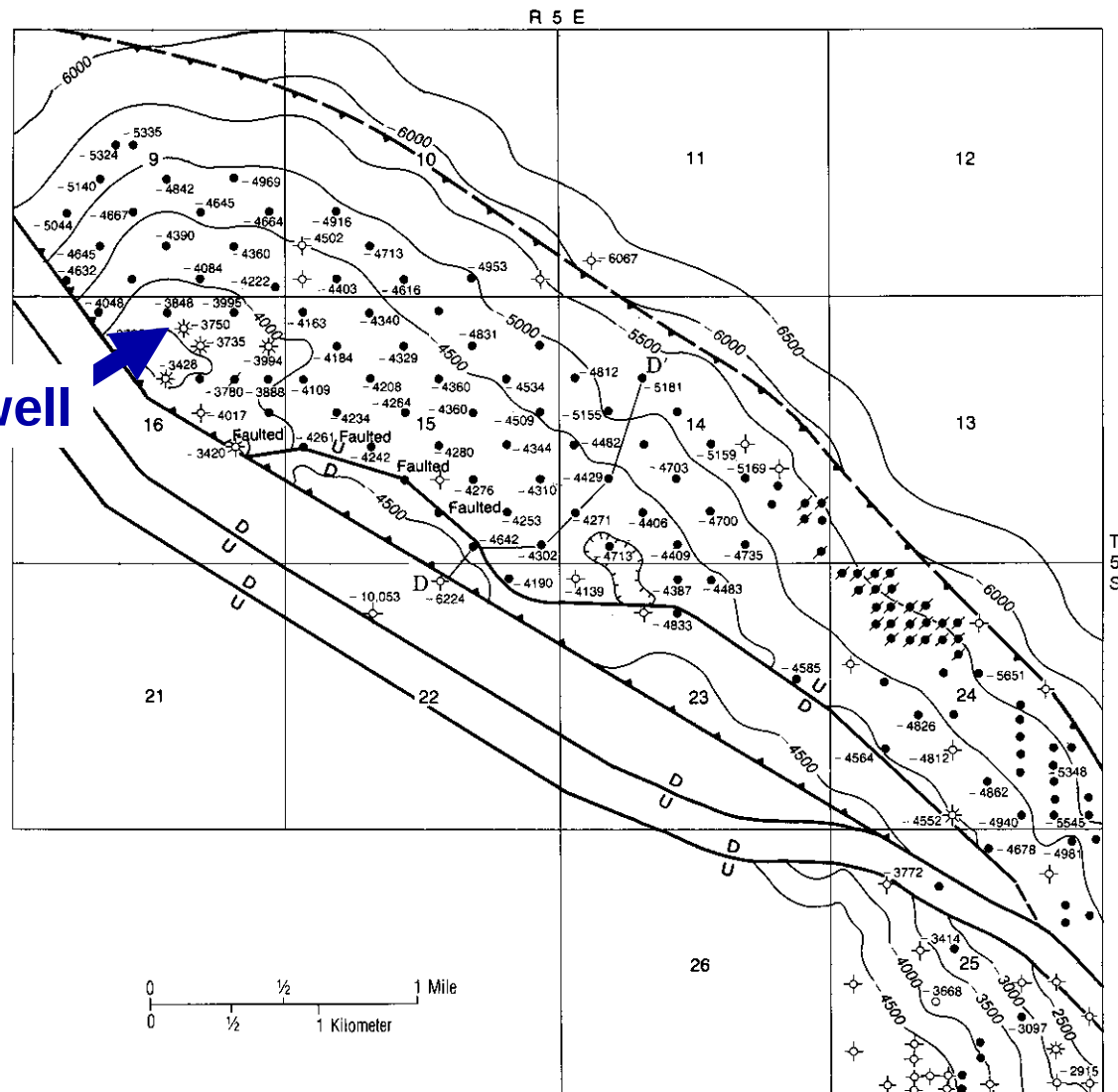
# Cimarex Energy 3 Griffin-Olmstead (Marshall CO, 16-5S-5E; IP 747 Mcfd; 4,052-4,135 ft)



(Gas production data supplied by Petroleum  
Information/Dwights LLC dba IHS Energy Group,  
© 2007, IHS Energy Group)



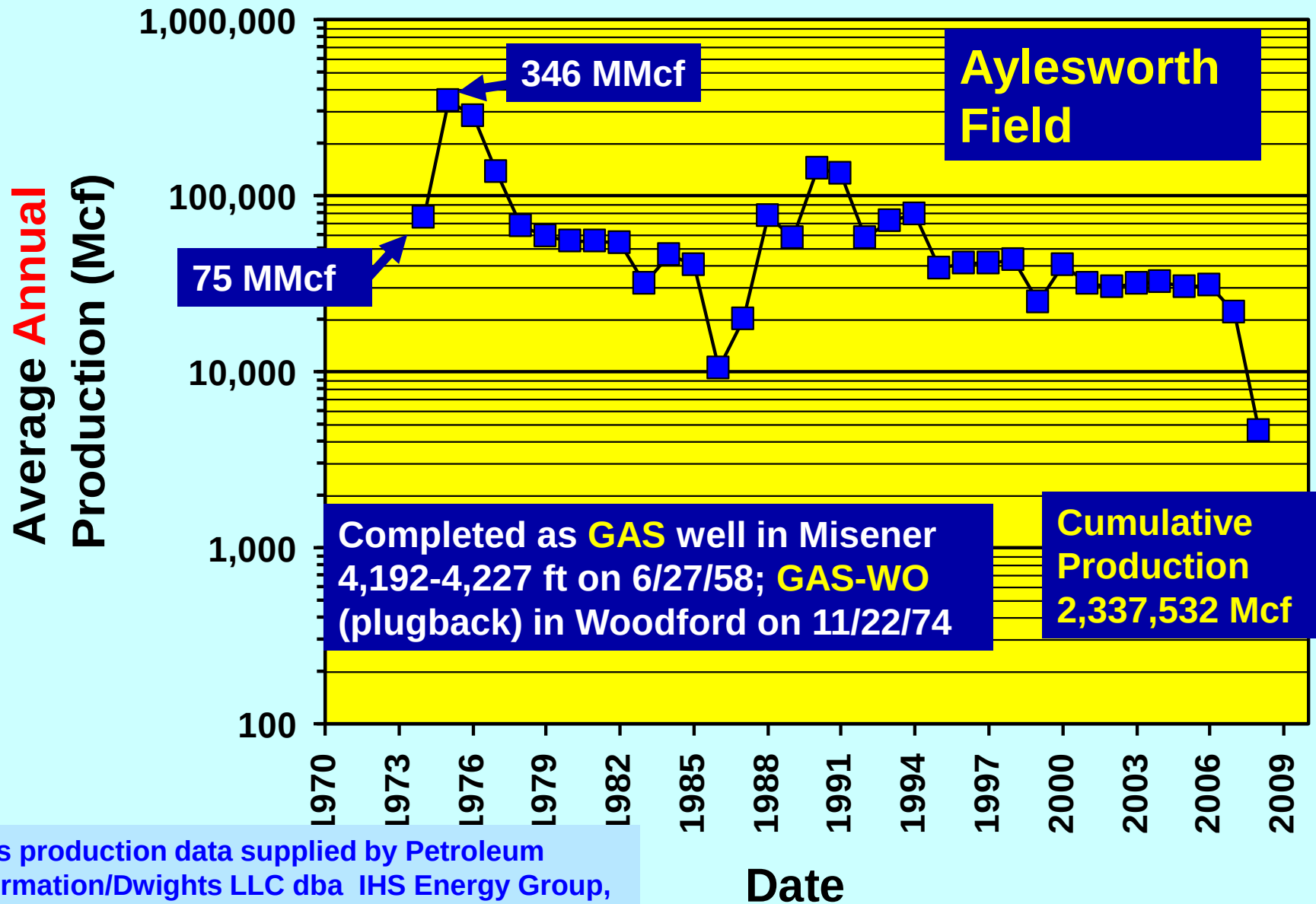
### 3 Griffin-Olmstead well



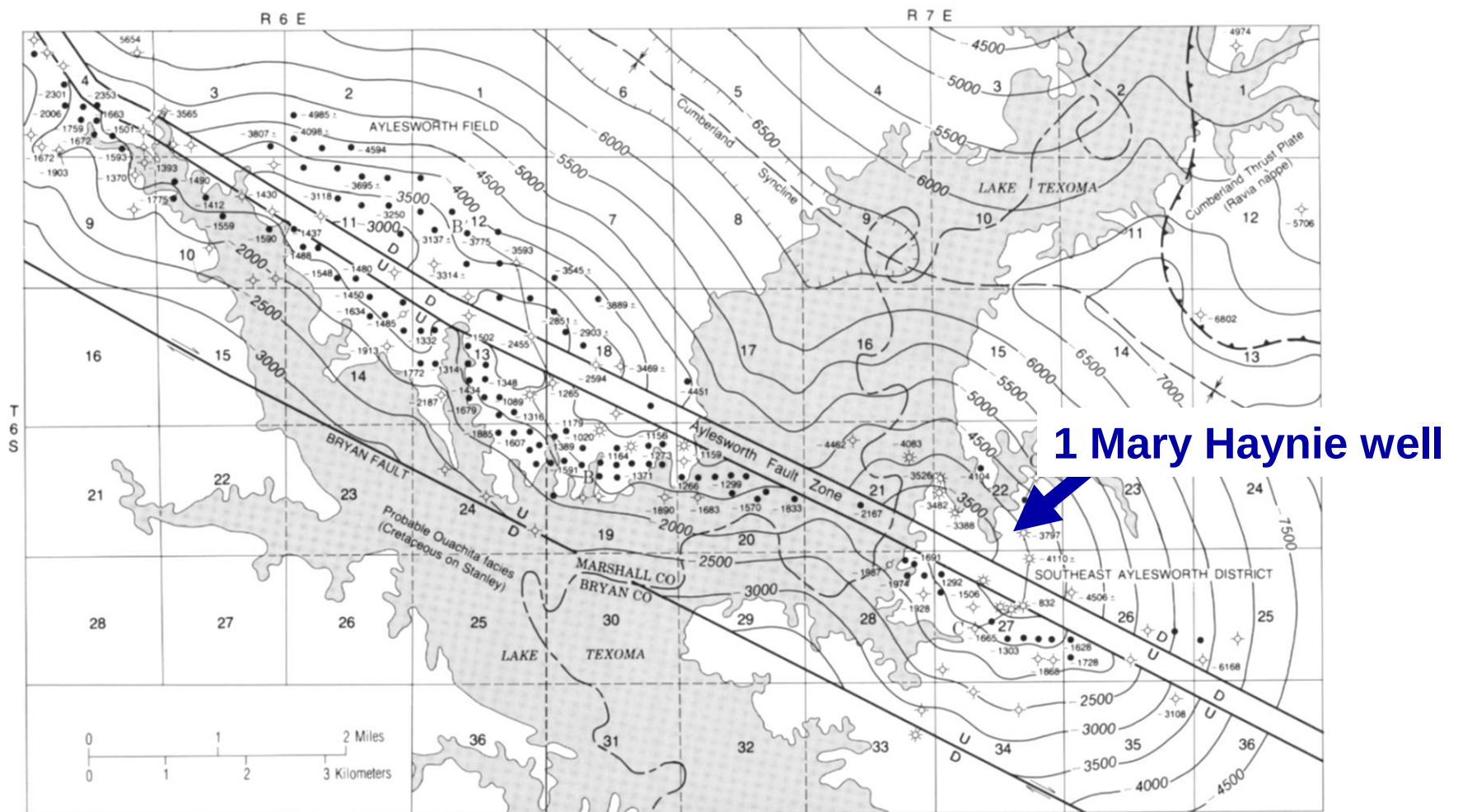
**Structure contour map of the top of the Viola Group (Ordovician) in the North Madill field (from Huffman and others, 1987)**

# Verdad Oil & Gas 1 Mary Haynie

(Bryan CO, 22-6S-7E; IP 962 Mcfd; 3,710-4,054 ft)

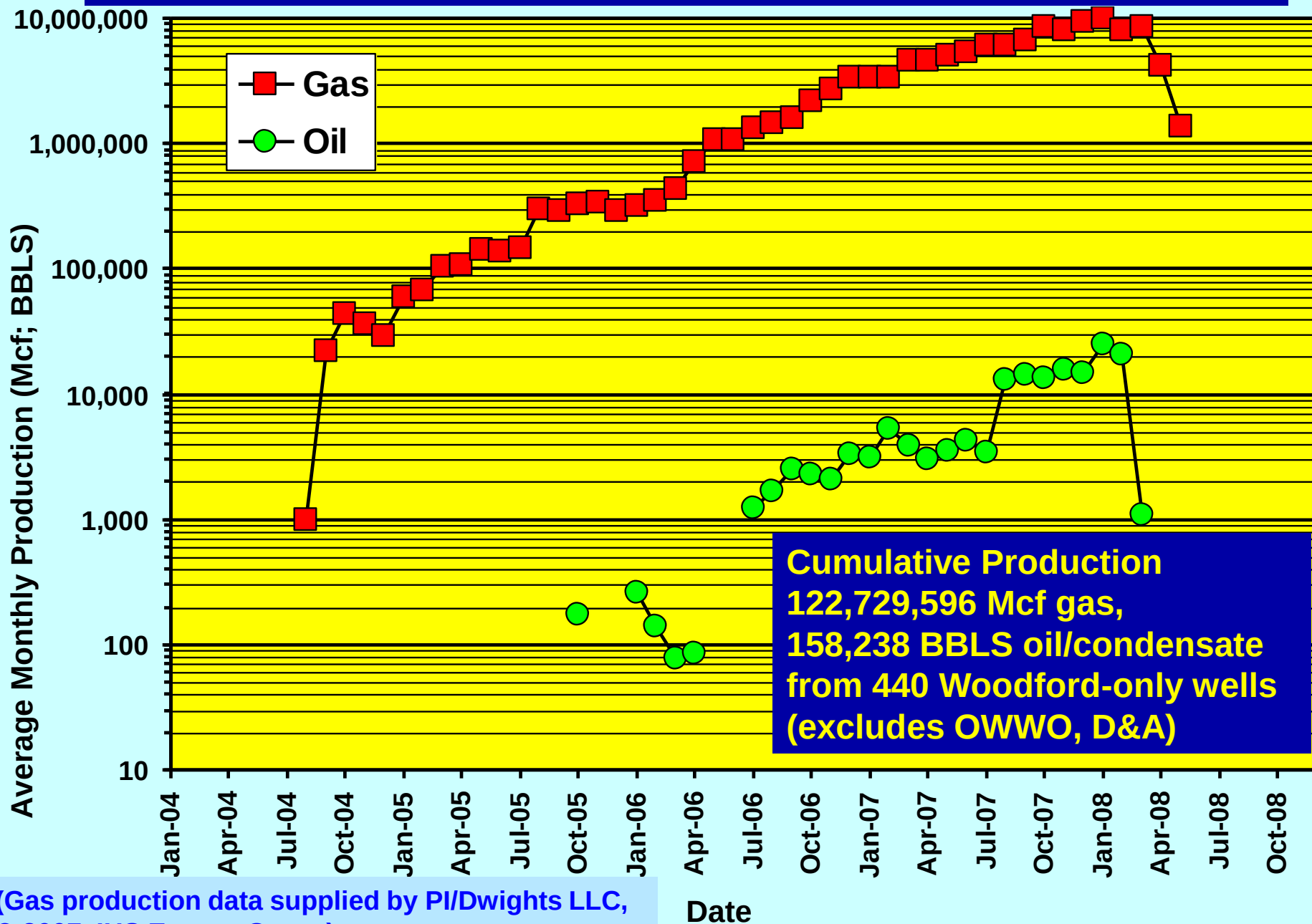


(Gas production data supplied by Petroleum Information/Dwights LLC dba IHS Energy Group, © 2007, IHS Energy Group)

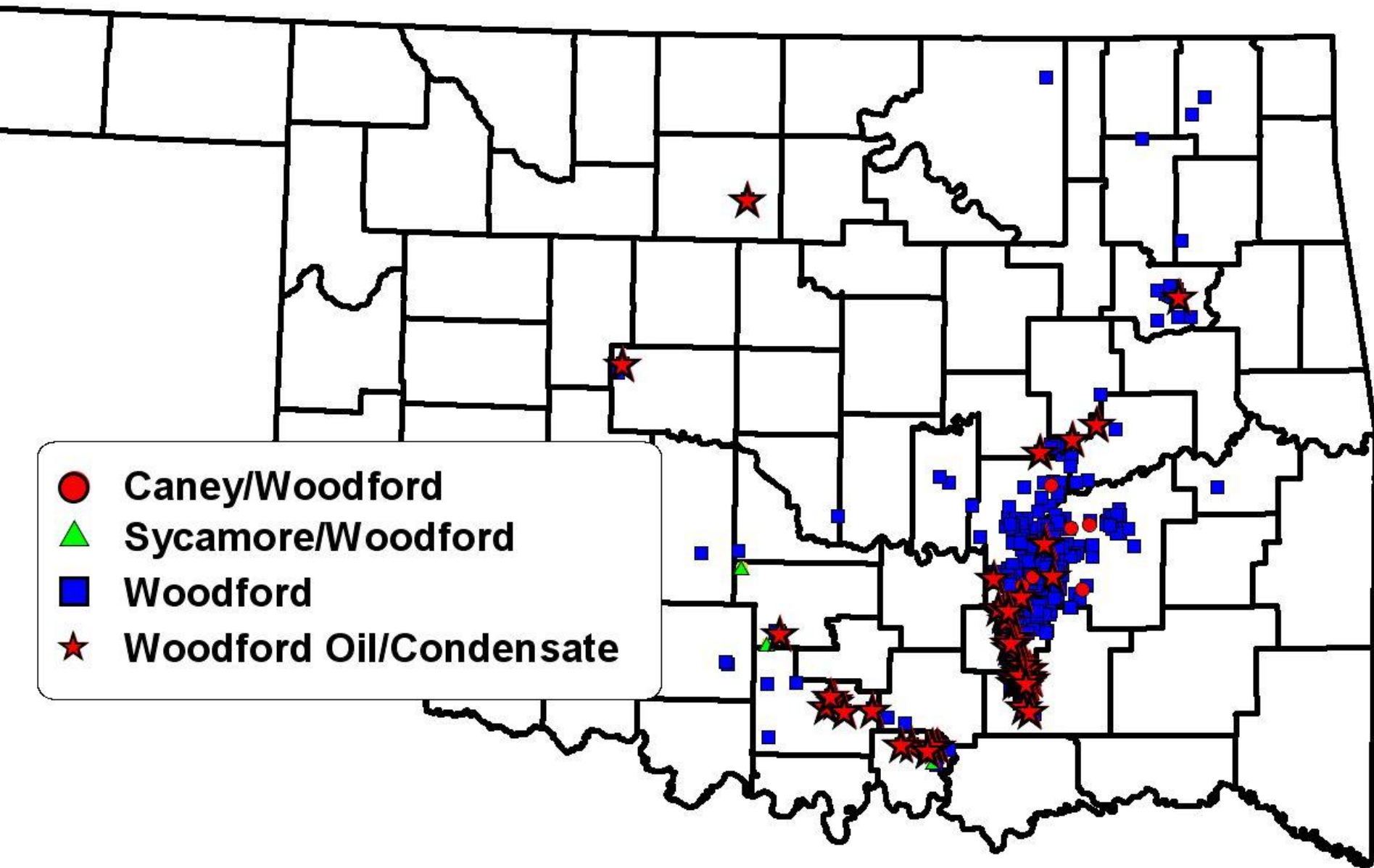


**Structure contour map of the top of the Viola Group (Ordovician) in the Aylesworth and SE Aylesworth District fields (from Huffman and others, 1987)**

# Woodford Shale Production (2004-2008 wells)

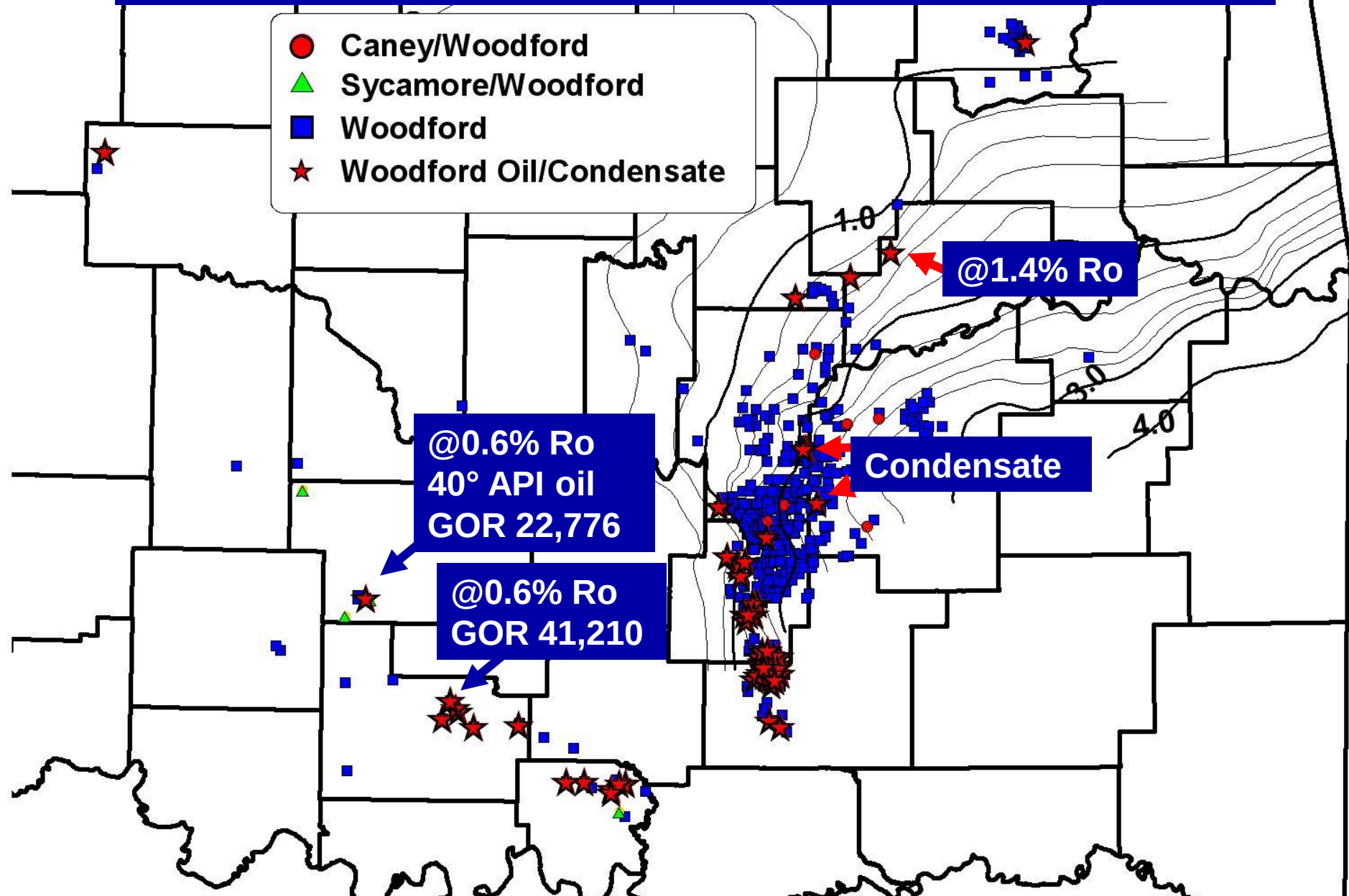


# Woodford Shale Only Oil/Condensate Production (67 of 440 wells; 2004-2008)





# Woodford Shale Only Oil/Condensate Production (67 of 440 wells; 2004-2008)

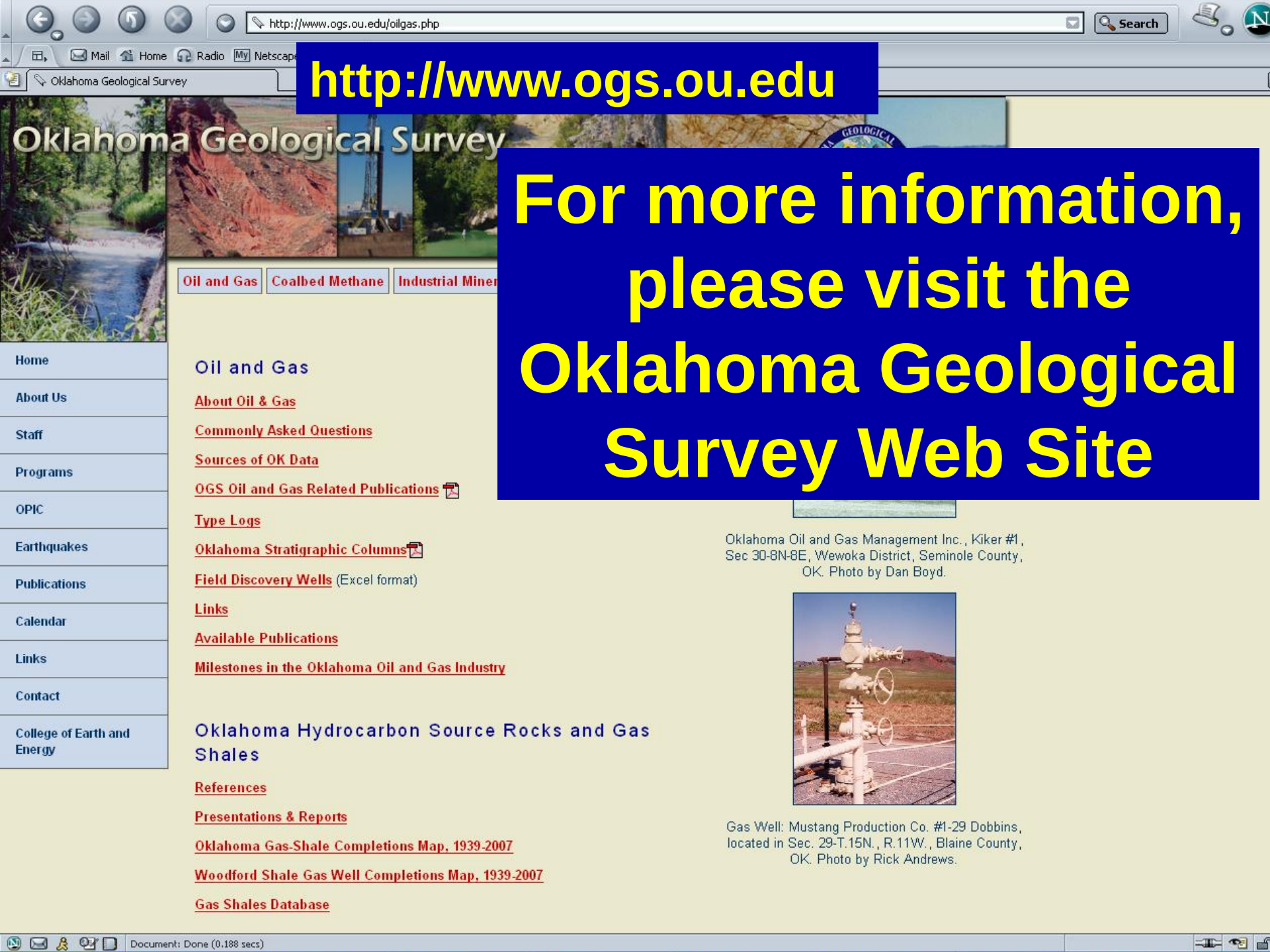


# SUMMARY OF WOODFORD GAS SHALE PLAY

- Woodford Shale contains Type II (oil generative) Kerogen with adequate TOC
- Woodford Shale is silica rich (e.g., fracture-able)
- Main Woodford Shale gas play is in eastern Oklahoma at  $>1.1\%$   $R_o$
- Some Woodford Shale gas potential is in southern Oklahoma at  $<1.1\%$   $R_o$

<http://www.ogs.ou.edu>

For more information,  
please visit the  
**Oklahoma Geological  
Survey Web Site**



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[Type Logs](#)

[Oklahoma Stratigraphic Columns](#)

[Field Discovery Wells](#) (Excel format)

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[Available Publications](#)

[Milestones in the Oklahoma Oil and Gas Industry](#)

## Oklahoma Hydrocarbon Source Rocks and Gas Shales

[References](#)

[Presentations & Reports](#)

[Oklahoma Gas-Shale Completions Map, 1939-2007](#)

[Woodford Shale Gas Well Completions Map, 1939-2007](#)

[Gas Shales Database](#)

Oklahoma Oil and Gas Management Inc., Kiker #1,  
Sec 30-8N-8E, Wewoka District, Seminole County,  
OK. Photo by Dan Boyd.



Gas Well: Mustang Production Co. #1-29 Dobbins,  
located in Sec. 29-T.15N., R.11W., Blaine County,  
OK. Photo by Rick Andrews.

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## References

**Brian J. Cardott**  
**Oklahoma Geological Survey**

[Bibliography of Caney Shale](#)

[Bibliography of Exello Shale](#)

[Bibliography of Woodford Shale](#)

[Bibliography of Oklahoma Asphalt](#)

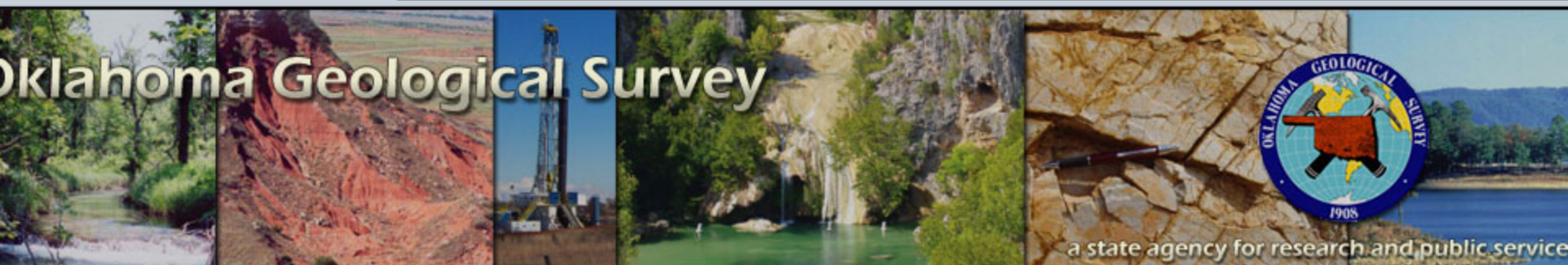
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[Bibliography of Oklahoma Solid Hydrocarbons](#)

[Bibliography of Oklahoma Gas Shales](#)

[Bibliography of Oklahoma Hydrocarbon Source Rocks](#)





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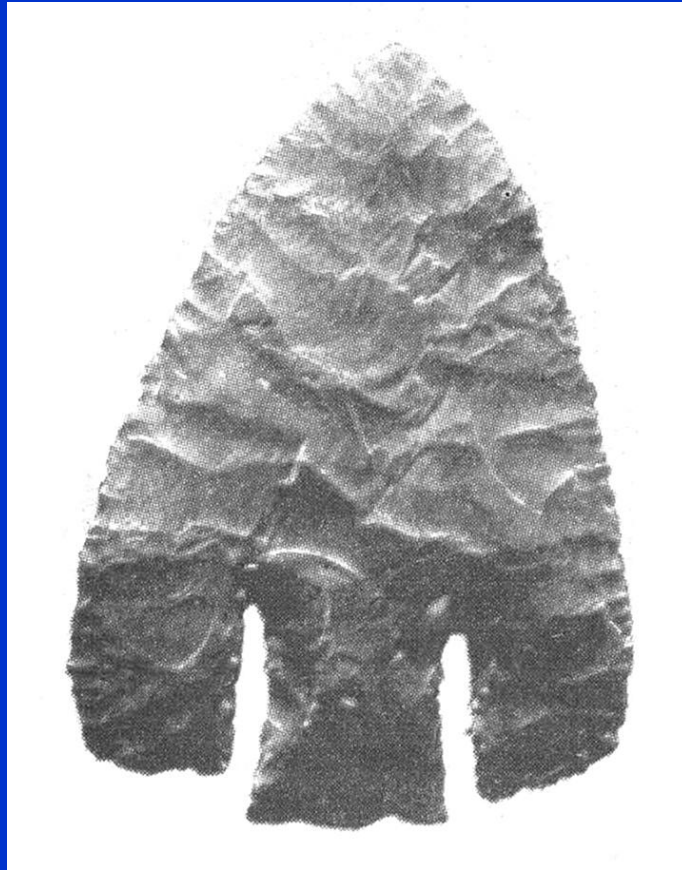
## Oil and Gas Presentations and Reports

- [Woodford Gas-Shale Play Update \(2008 AAPG Poster\)](#)
- [Conventional Wisdom Applied to Oklahoma Gas Shales](#) 
- [Overview of Woodford Gas Shale Play \(2007 Conference\)](#) 
- [Oklahoma Gas Shales \(2006 CBM Symposium\)](#) 
- [Woodford Shale and Caney Shale Reservoir Property Analysis Report](#) 



| V1 Initial_Potential_(MCFD) |        |              |                      |                 |                     |          |
|-----------------------------|--------|--------------|----------------------|-----------------|---------------------|----------|
|                             | A      | B            | C                    | D               | E                   |          |
| 1                           | Record | API Number   | Operator             | Completion Date | Well Name           |          |
| 2                           | 412    | 35-063-24000 | Newfield Exploration |                 | 3H-22 Tollett       |          |
| 3                           | 284    | 35-121-23817 | Newfield Exploration | 4/7/07          | 4H-22 Ellis Sherman | Pine H   |
| 4                           | 443    | 35-029-20907 | Newfield Exploration | 11/22/07        | 3H-31 Patterson     | unnam    |
| 5                           | 287    | 35-063-23816 | Newfield Exploration | 11/16/06        | 1H-13 Stuart        | unnam    |
| 6                           | 221    | 35-063-23801 | Newfield Exploration | 11/2/06         | 1H-22 Tollett       | unnam    |
| 7                           | 245    | 35-063-23826 | Newfield Exploration | 12/8/06         | 2H-31 Patterson     | unnam    |
| 8                           | 526    | 35-029-20908 | Newfield Exploration | 12/26/07        | 3H-36 Parker        | unnam    |
| 9                           | 442    | 35-063-23936 | Newfield Exploration | 10/5/07         | 2H-28 Sanford       | unnam    |
| 10                          | 222    | 35-063-23785 | Newfield Exploration | 11/4/06         | 1H-23 Tipton        | unnam    |
| 11                          | 184    | 35-005-20301 | Antero Resources     | 7/17/06         | 19-1H Pettigrew     | unnam    |
| 12                          | 362    | 35-063-23843 | Newfield Exploration | 2/23/07         | 1H-28 Smith         | unnam    |
| 13                          | 592    | 35-063-24040 | Chesapeake Operating | 3/1/08          | 1-3H Cypert         | Hill Top |
| 14                          | 427    | 35-063-23915 | Newfield Exploration | 9/19/07         | 2H-27 Whitlow       | unnam    |
| 15                          | 99     | 35-063-23749 | Newfield Exploration | 3/15/06         | 1H-36 Parker        | unnam    |
| 16                          | 305    | 35-121-23792 | Antero Resources     | 7/4/07          | 20-1H Silva         | unnam    |
| 17                          | 256    | 35-063-23825 | Newfield Exploration | 1/14/07         | 1H-20 Melvin        | unnam    |
| 18                          | 243    | 35-029-20805 | Pablo Energy II LLC  | 2/22/07         | 1H-28 Lemons        | Coalga   |
| 19                          | 229    | 35-121-23742 | Newfield Exploration | 11/20/06        | 1H-4 Elms           | Pine H   |
| 20                          | 246    | 35-121-23797 | Newfield Exploration | 1/28/07         | 1H-6 Grant          | Pine H   |
| 21                          | 251    | 35-063-23819 | Newfield Exploration | 2/18/07         | 1H-32 Gockel        | unnam    |
| 22                          | 270    | 35-063-23803 | Newfield Exploration | 11/14/06        | 1H-35 Turpin        | unnam    |
| 23                          | 495    | 35-029-20817 | Pablo Energy II LLC  | 8/13/07         | 1H-29 Ables         | Centra   |
| 24                          | 532    | 35-063-24006 | Newfield Exploration | 12/31/07        | 2H-17 Burton        | Ashlan   |
| 25                          | 273    | 35-029-20820 | Devon Energy         | 3/19/07         | 1-15H Sprague       | unnam    |
| 26                          | 444    | 35-029-20862 | Antero Resources     | 7/9/07          | 33-1H Brown         | Ashlan   |
| 27                          | 288    | 35-121-23749 | Newfield Exploration | 1/15/07         | 2H-23 McWilliams    | Pine H   |
| 28                          | 475    | 35-029-20921 | XTO Energy           | 3/9/08          | 12-25H Lemons       | Ashlan   |

# THANK YOU



**Typical Calf Creek point of Woodford chert found  
in Haskell County, Oklahoma (Norman  
Transcript, March 11, 2007, p. E1)**