

Conventional Wisdom Applied to Oklahoma Gas Shales

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Oklahoma Geological
Survey



Outline

- **Conventional Wisdom of Gas Shales**
- **Oklahoma Woodford Shale**
- **Oklahoma Woodford Gas-Shale Play**

Conventional Wisdom
[Non-Negotiable Parameters]
Necessary for Gas Shales
(summarized from others
working on the Barnett Shale)

- **Fractures (permeability)**
- **Gas Source Rock (Gas Generation, Storage, and Preservation)**

Fractures

- **Lithology must be fracture-able (e.g., silica-rich shale)**
- **Fractures must stay in-zone (e.g., need fracture barriers; stay away from faults)**
- **Natural vs. induced fractures (gas-filled; not water-, oil-, or mineral-filled fractures)**

Example of Poor Gas Shale



**Weathered Clay-Rich Sylvan Shale
("Thud")**

Example of Good Gas Shale



**Fractured, Silica-Rich Woodford
Shale (“Ping”)**

Gas Generation: Organic-Rich Black Shale/Siltstone

- **Organic Matter Type:**
Type II (oil generative) Kerogen
- **Organic Matter Quantity:** minimum of 2% TOC (depends on thermal maturity)
- **Thermal Maturity** (highest gas rates in gas window, $>1.4\%$ VRo)

Gas Generation by Kerogen Type

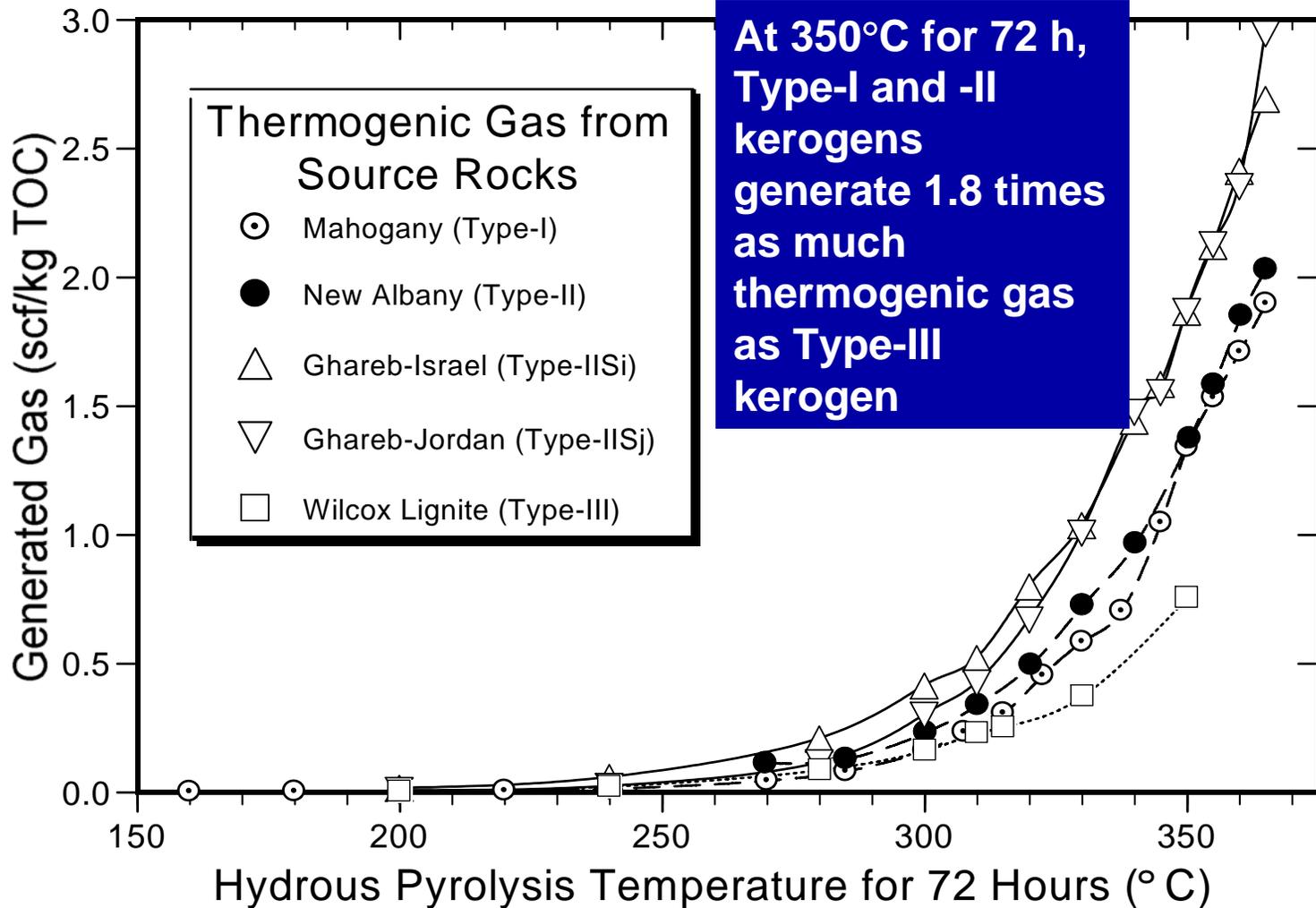


Figure 2: Volume of hydrocarbon gas (C₁-C₅) generated by hydrous pyrolysis from thermally immature source rocks bearing different kerogen types (Lewan and Henry, 2001).

From Lewan, 2002

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

Type II Kerogen Gas Generation (Hydrous Pyrolysis)

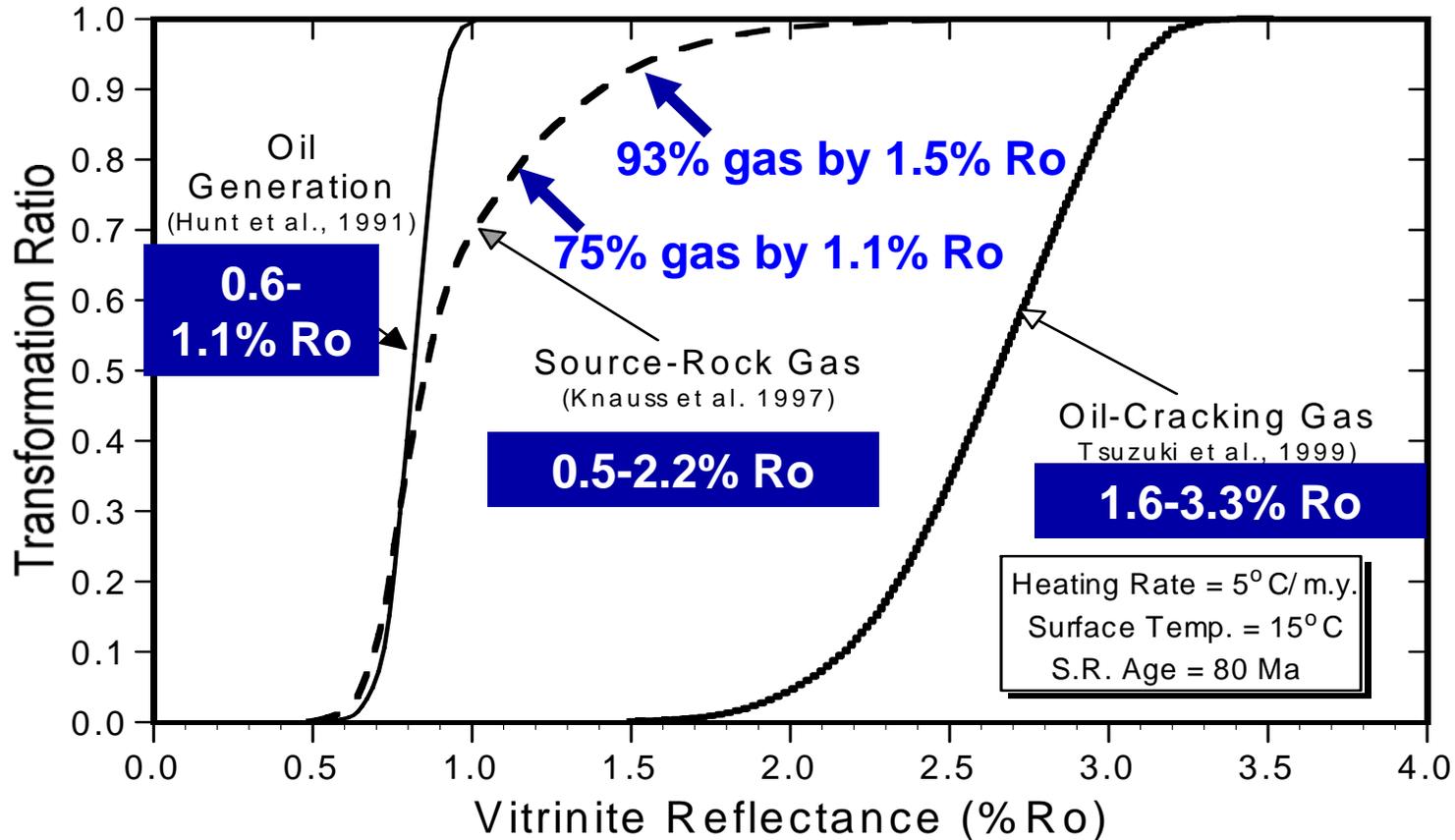
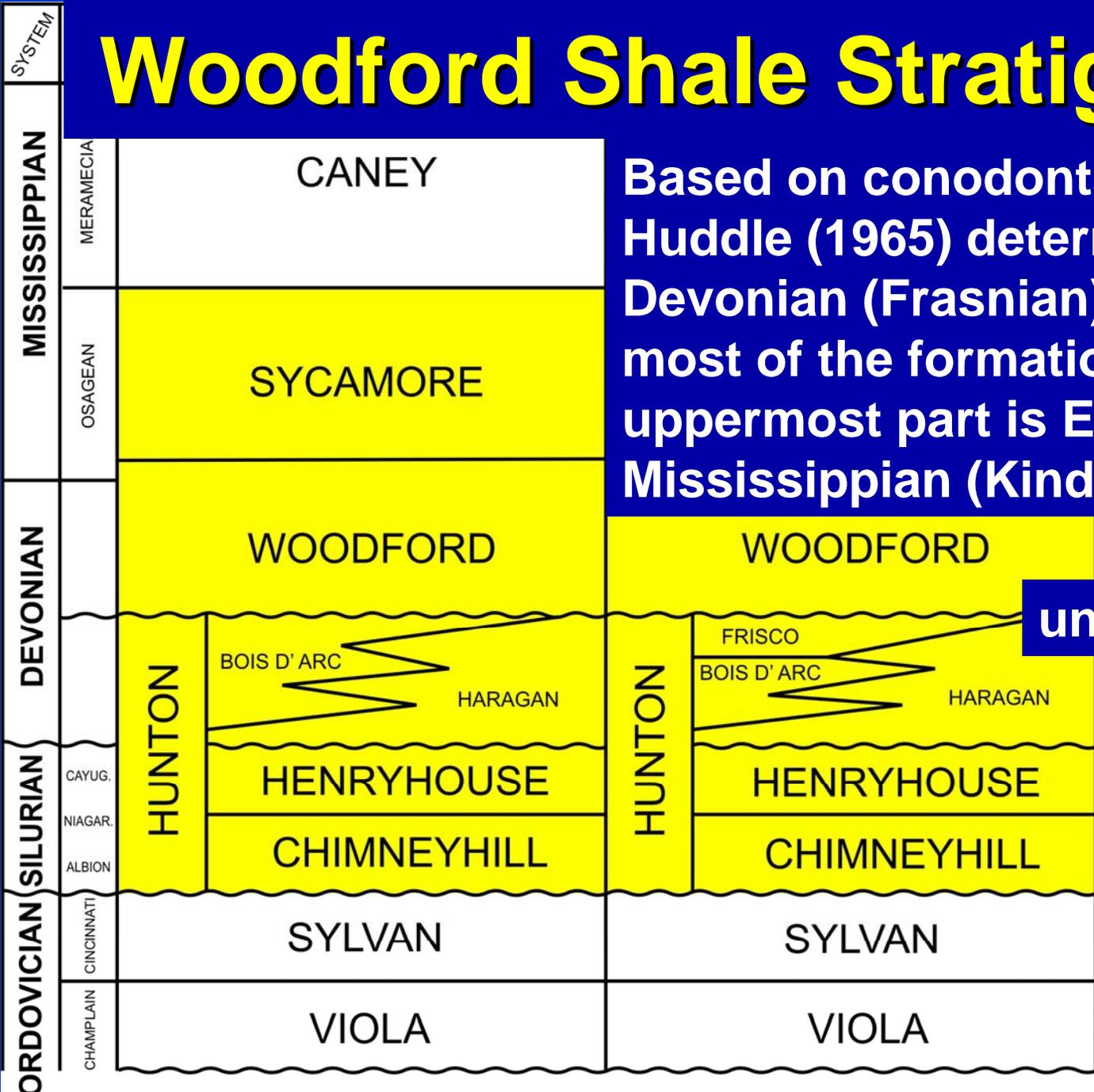


Figure 1: Generation of oil and gas from an 80-Ma source rock with Type-II kerogen and associated crude oil. Curves are based on kinetic parameters determined by hydrous and hydrothermal pyrolysis and EASY%Ro (Swweeney and Burnham, 1990).

From Lewan, 2002

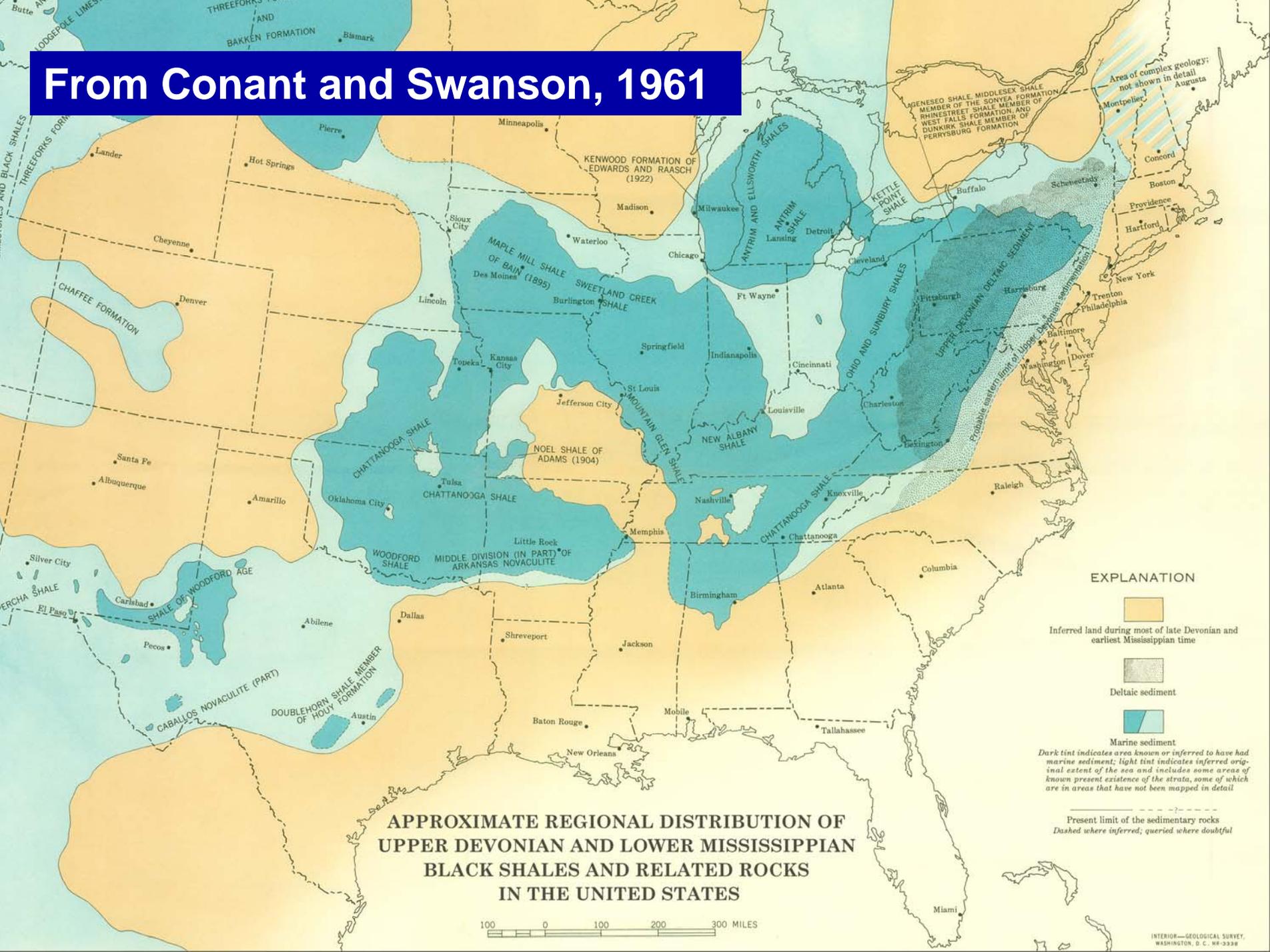
Woodford Shale Stratigraphy



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

From Conant and Swanson, 1961

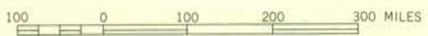


APPROXIMATE REGIONAL DISTRIBUTION OF UPPER DEVONIAN AND LOWER MISSISSIPPIAN BLACK SHALES AND RELATED ROCKS IN THE UNITED STATES

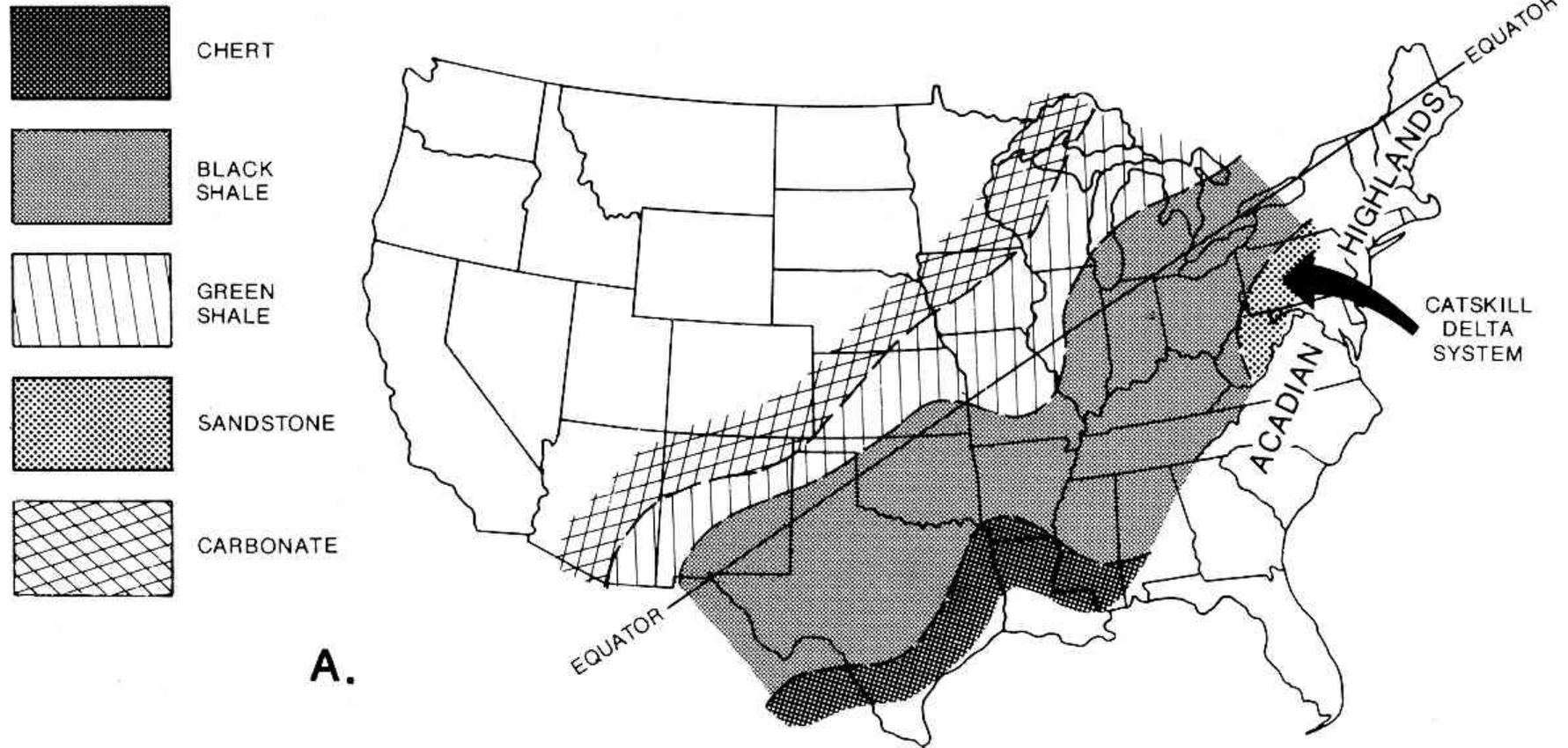
EXPLANATION

- Inferred land during most of late Devonian and earliest Mississippian time
- Deltatic sediment
- Marine sediment
- Dark tint indicates area known or inferred to have had marine sediment; light tint indicates inferred original extent of the sea and includes some areas of known present existence of the strata, some of which are in areas that have not been mapped in detail*

Present limit of the sedimentary rocks
Dashed where inferred; queried where doubtful

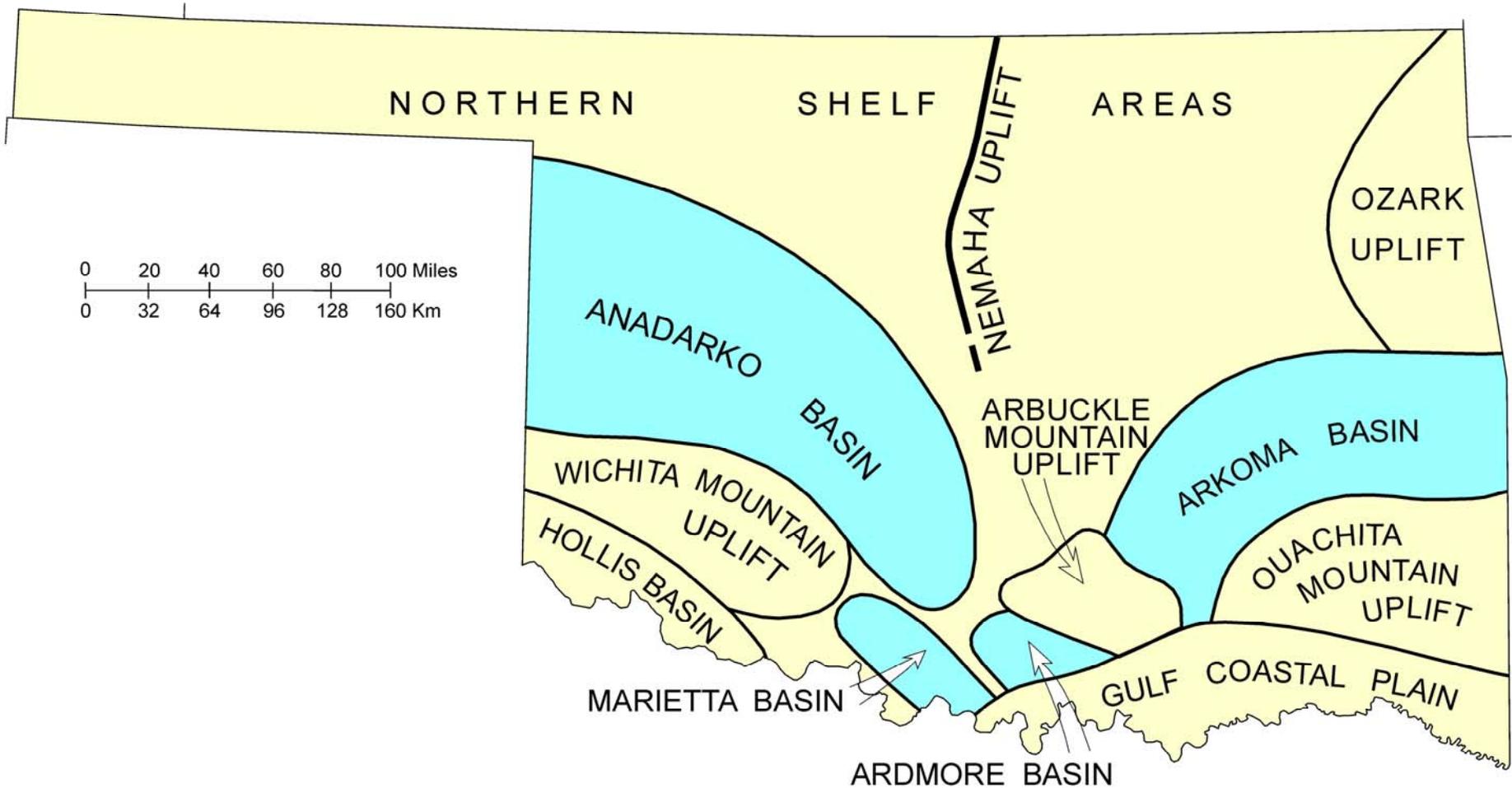


Paleogeography and Facies Distribution in the Late Devonian

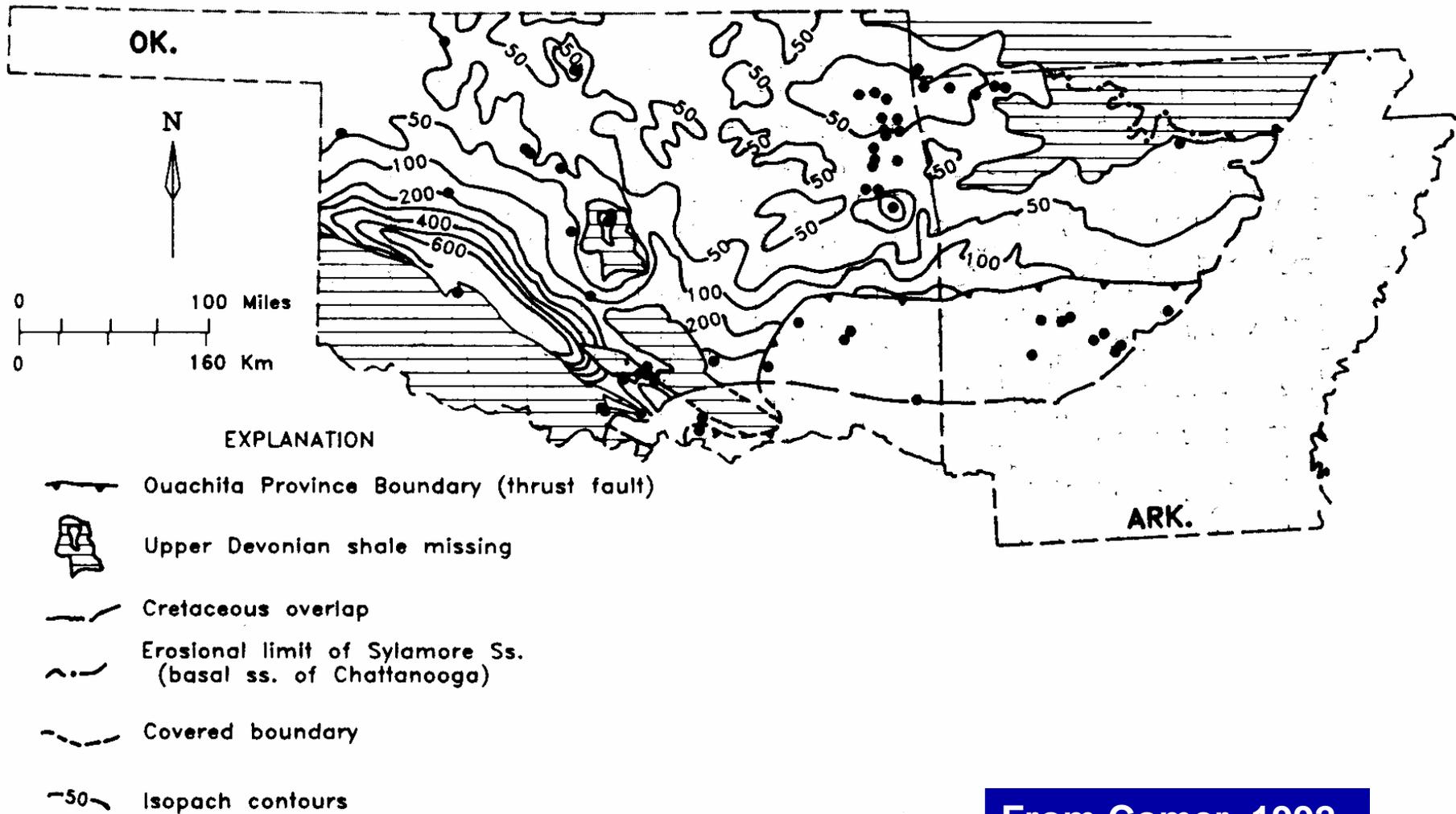


From Kirkland and others, 1992

Geologic Provinces of Oklahoma

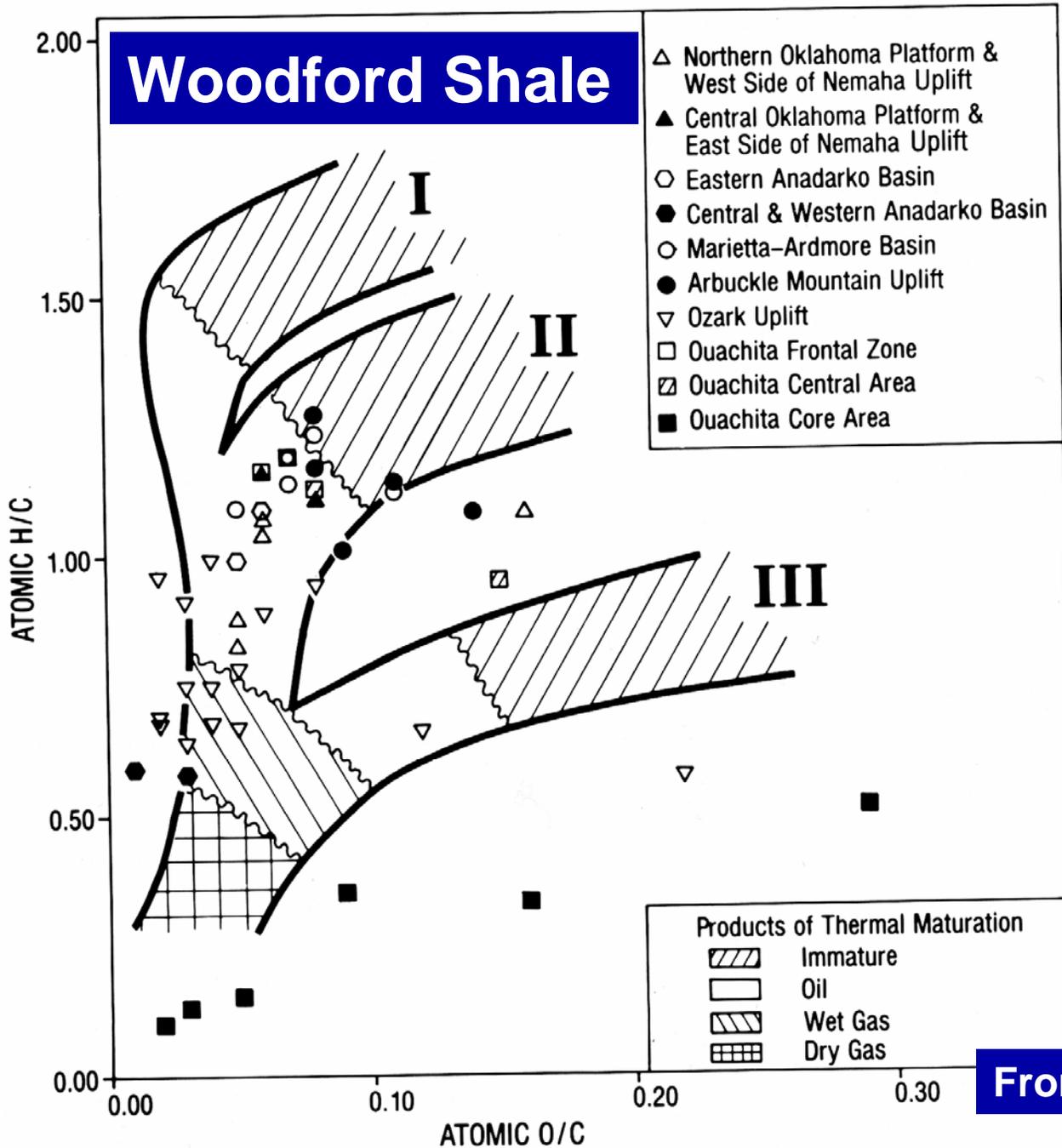


Isopach Map of Woodford Shale



From Comer, 1992

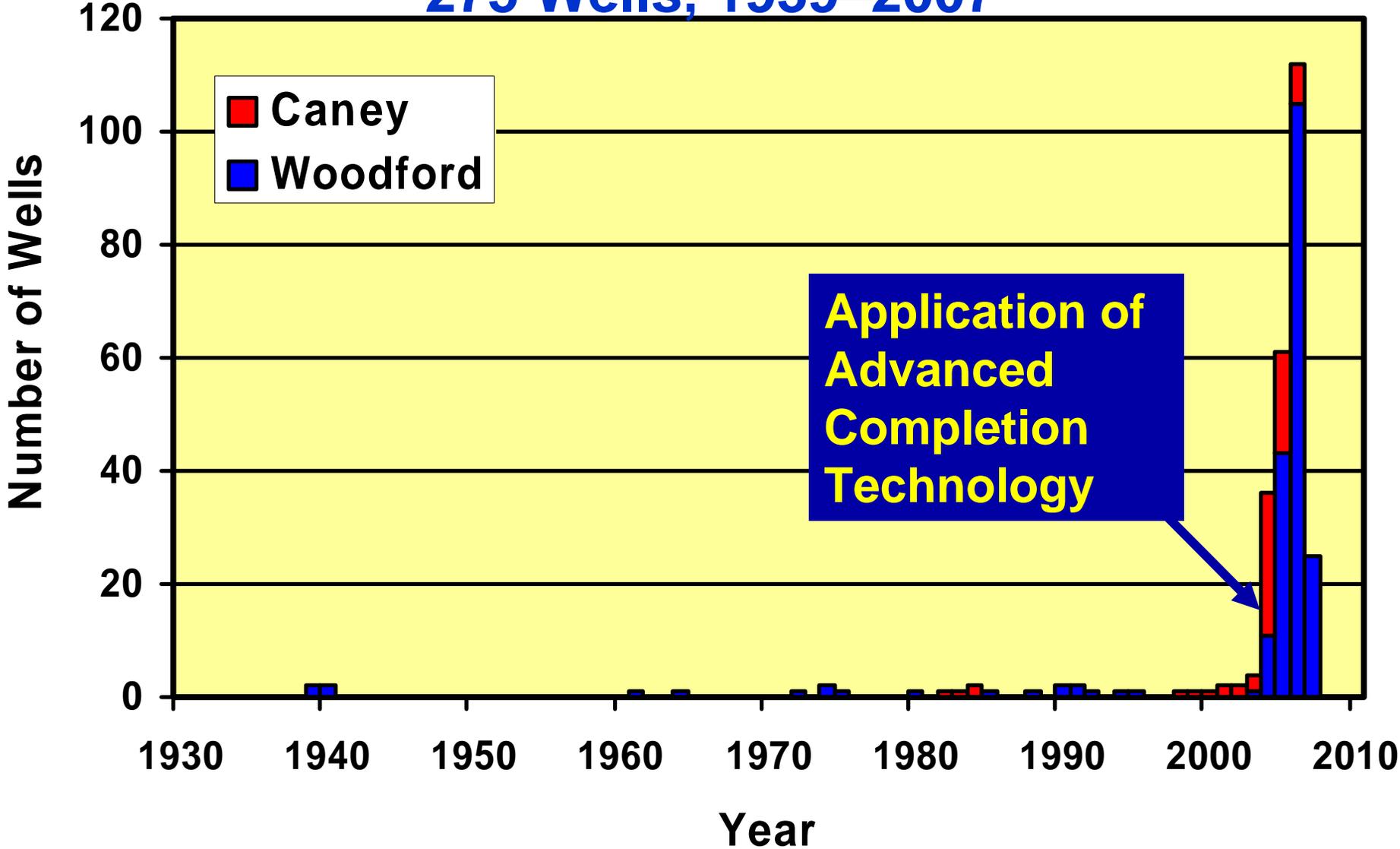
Woodford Shale



From Comer, 1992

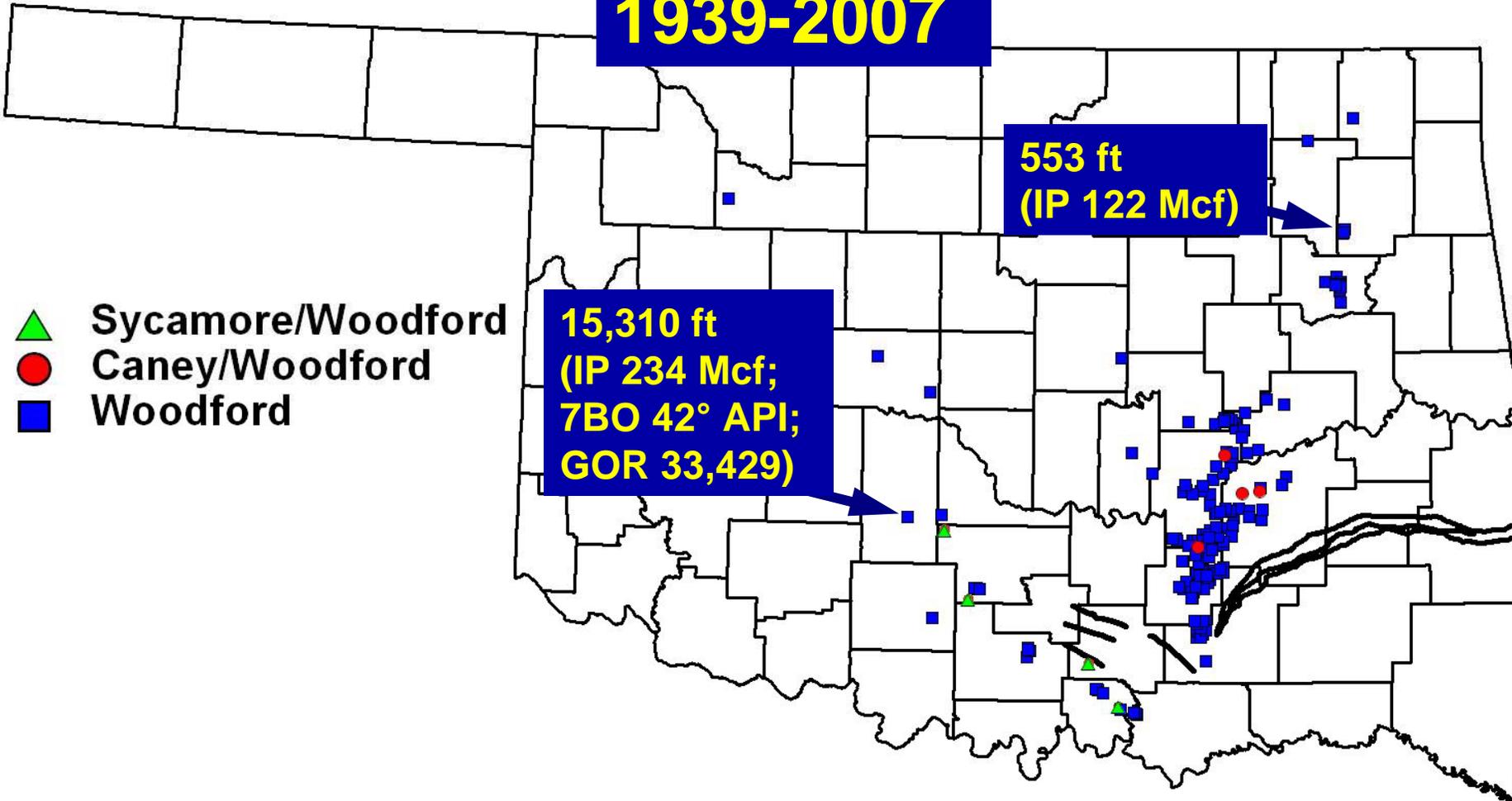
Oklahoma Shale-Gas Wells

275 Wells, 1939–2007



Woodford Gas Shales

1939-2007



Woodford Gas Shales

2003–2007

Why is the Woodford Shale Gas Play where it is?

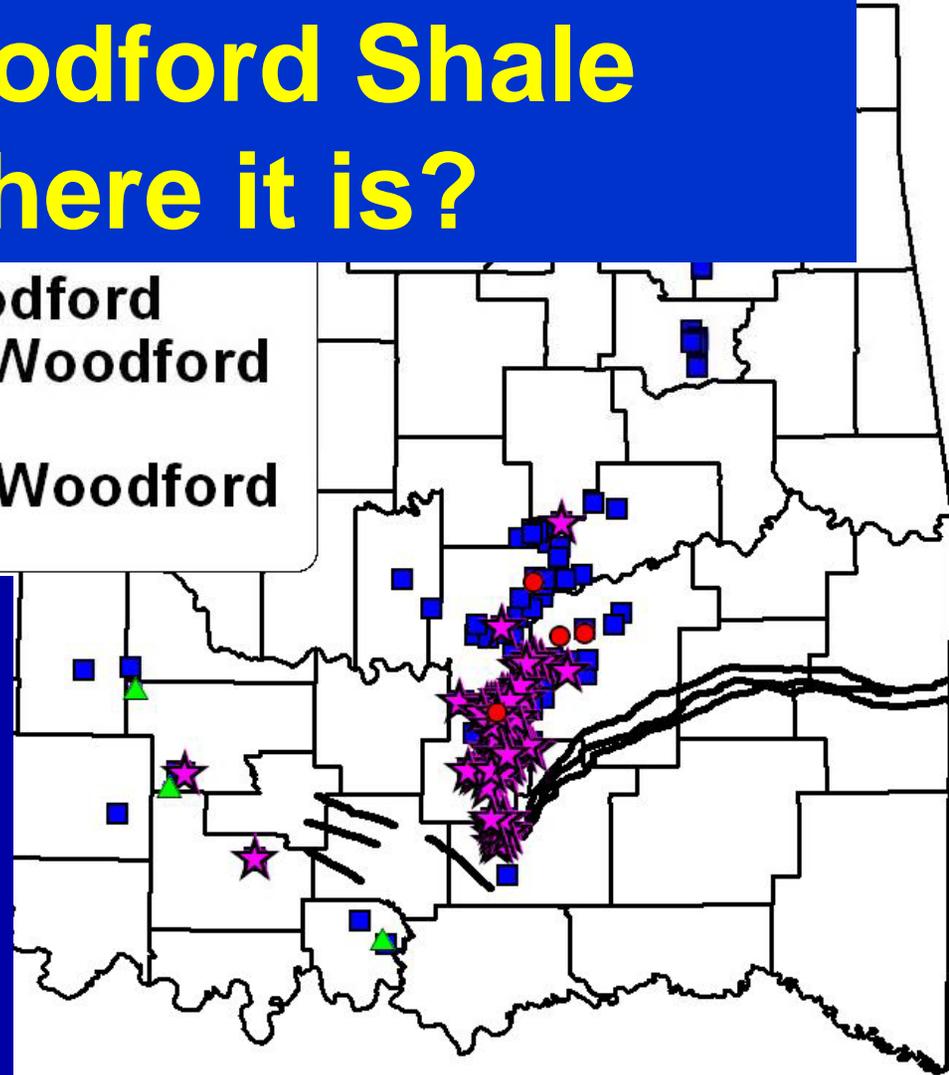
- Caney/Woodford
- ▲ Sycamore/Woodford
- Woodford
- ★ Horizontal Woodford

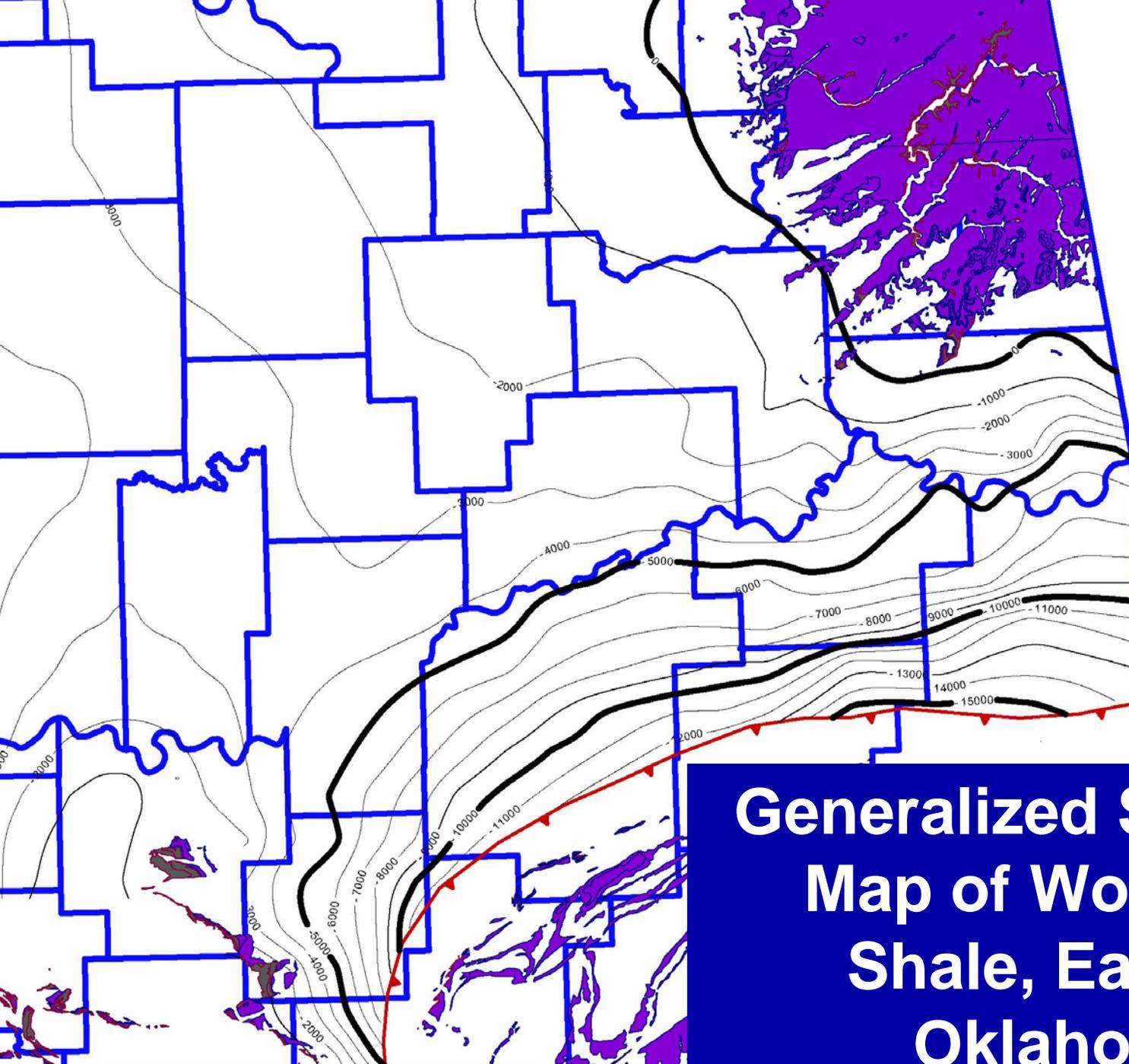
185 Wells

4 Caney/Woodford

3 Sycamore/Woodford

95 Horizontal Woodford





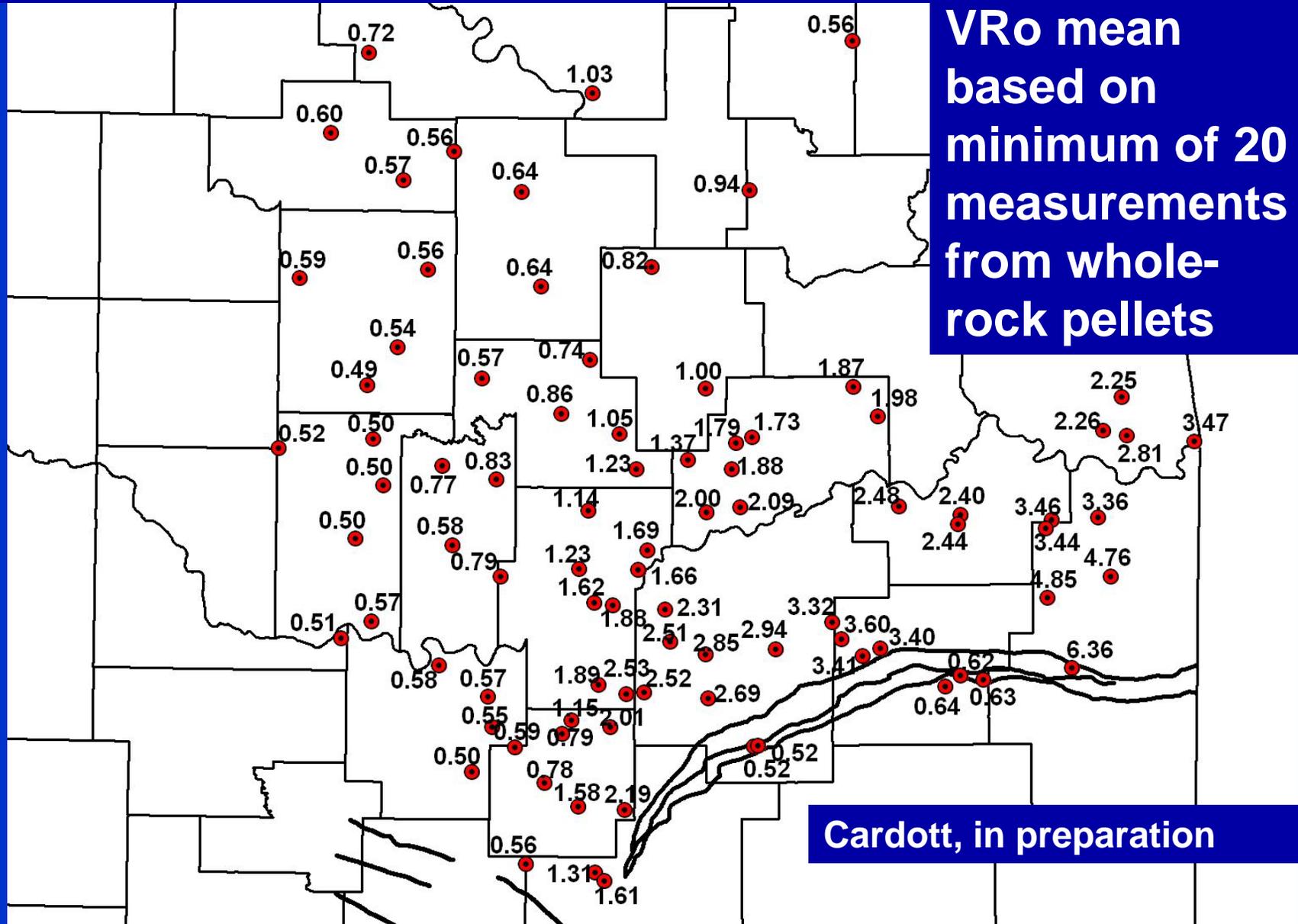
Map prepared
by R. Vance
Hall using
Petra

Generalized Structure Map of Woodford Shale, Eastern Oklahoma

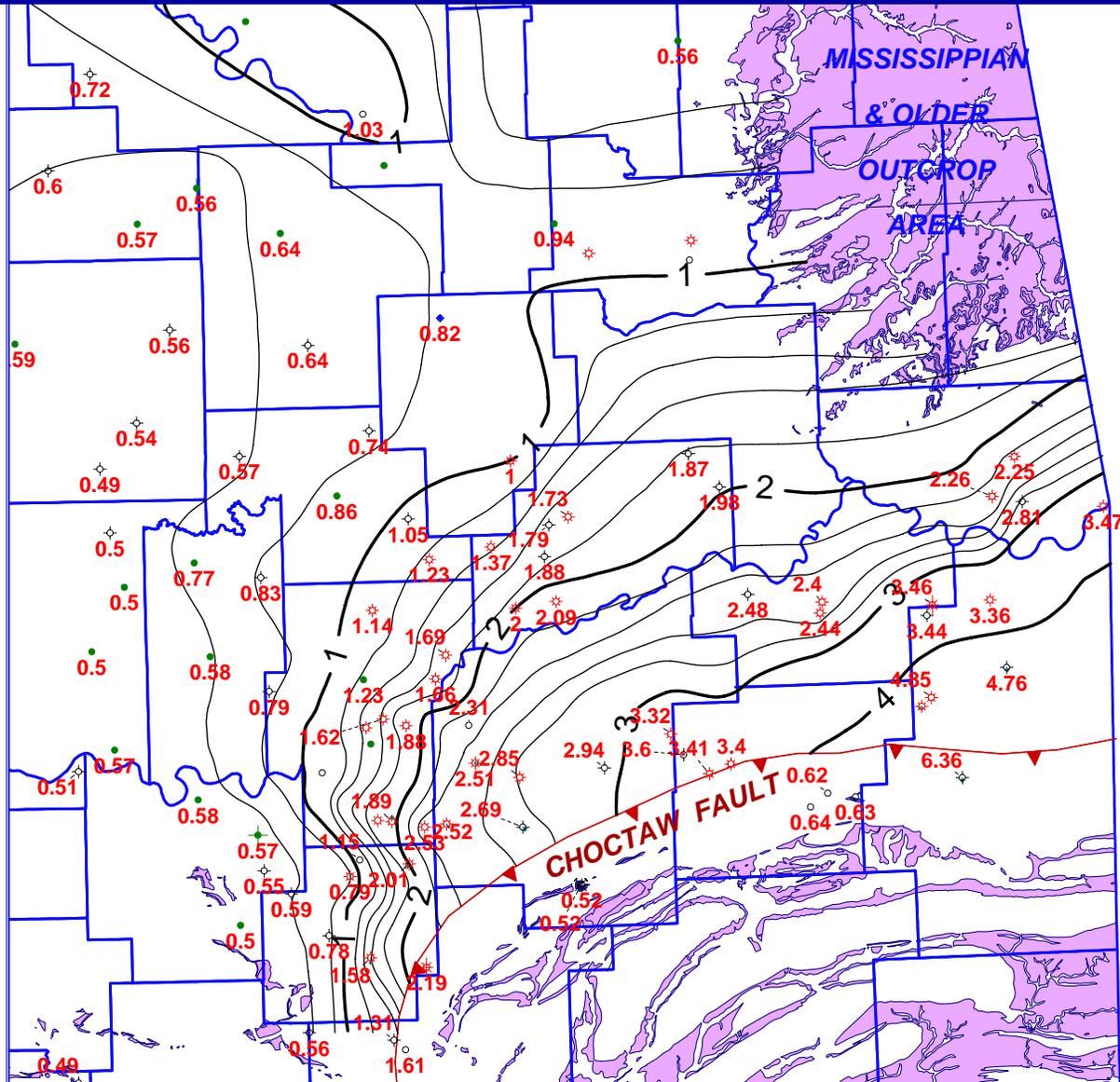


**Woodford Shale
is the oldest
rock in
Oklahoma that
contained wood
(vitrinite)
from the
progymnosperm
Archaeopteris
(organ genus
Callixylon)**

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

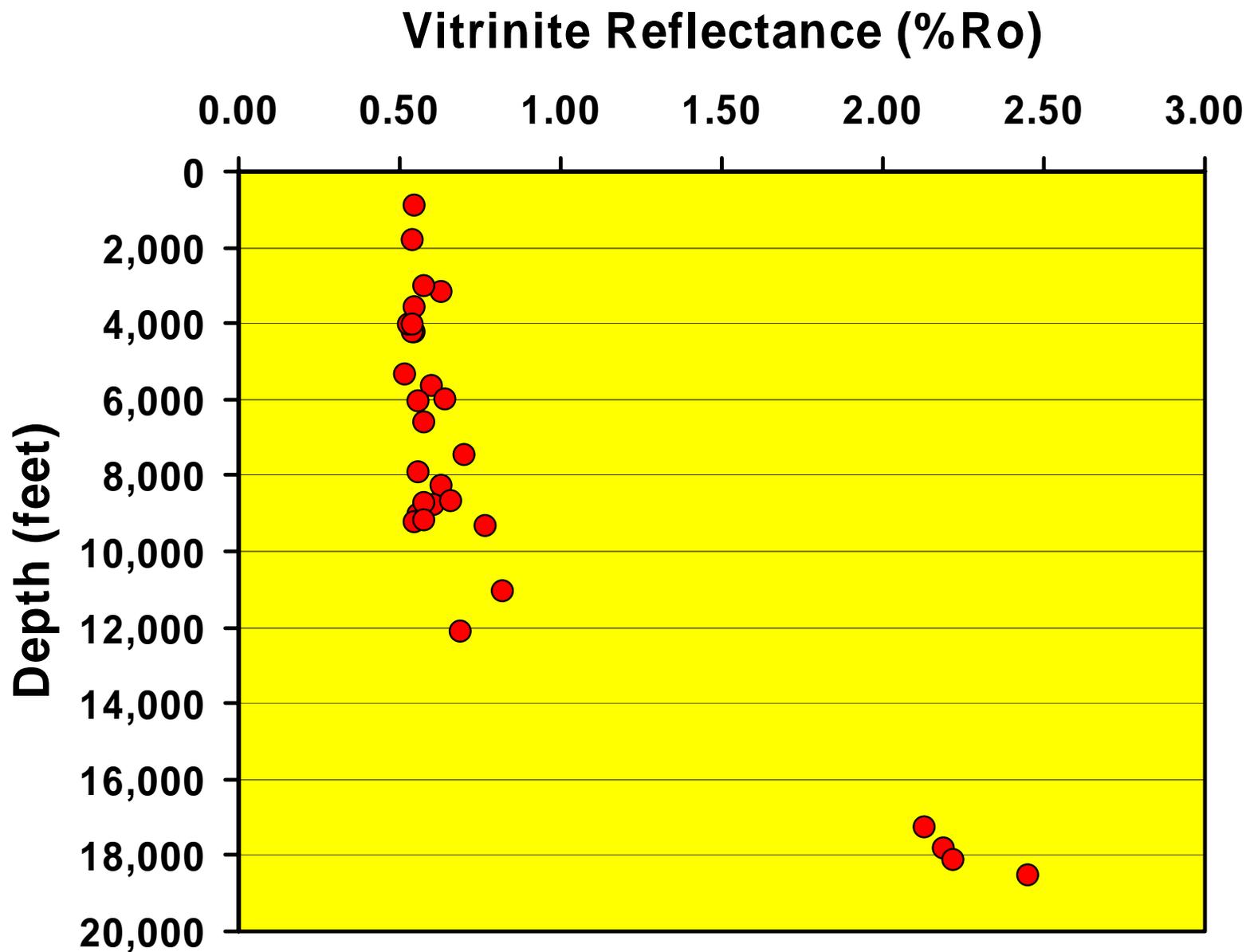
Woodford Gas-Shale Play is primarily in eastern Oklahoma (western Arkoma Basin) where the shale is:

(1) in the gas window (pushing the lower limits to the west)

(2) greater than 100 ft thick

(3) relatively shallow (<12,000 ft)

Southern Oklahoma VRo vs Depth



Woodford Gas Shales

1939-1996

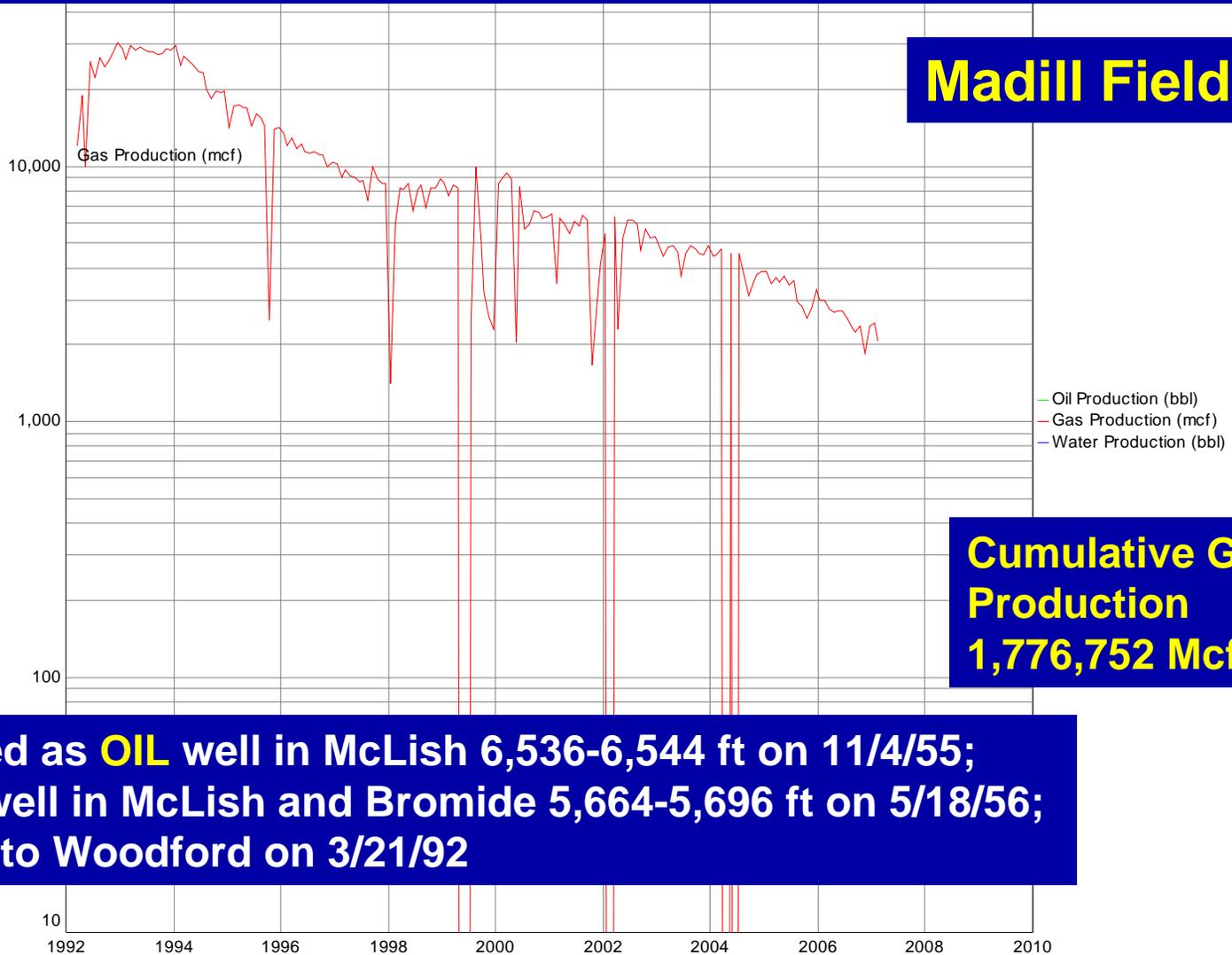


21 Wells
1 Sycamore/Woodford

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

Madill Field

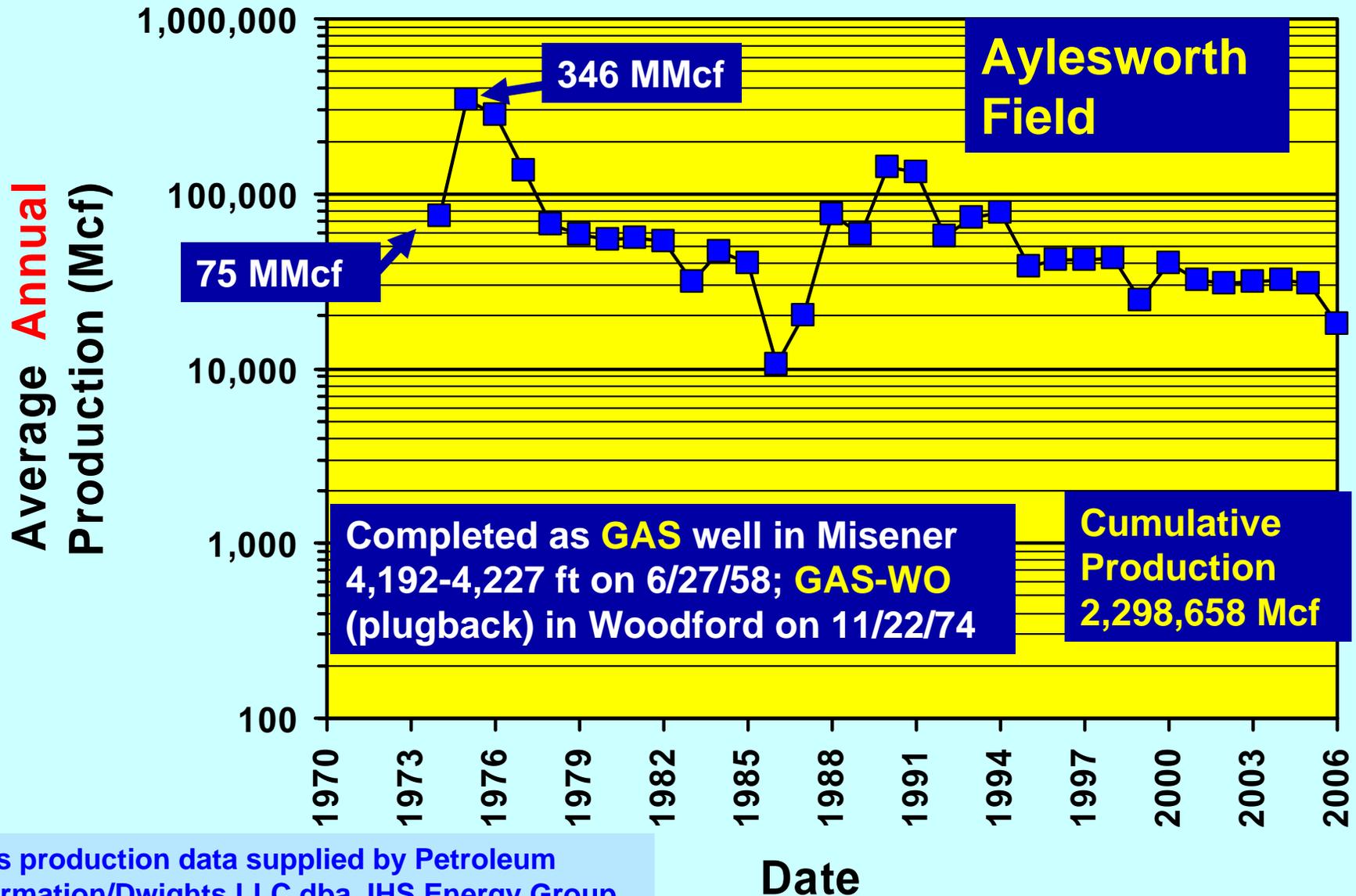
**Average Monthly
Production (Mcf)**



Completed as **OIL** well in McLish 6,536-6,544 ft on 11/4/55;
OIL-WO well in McLish and Bromide 5,664-5,696 ft on 5/18/56;
GAS-WO to Woodford on 3/21/92

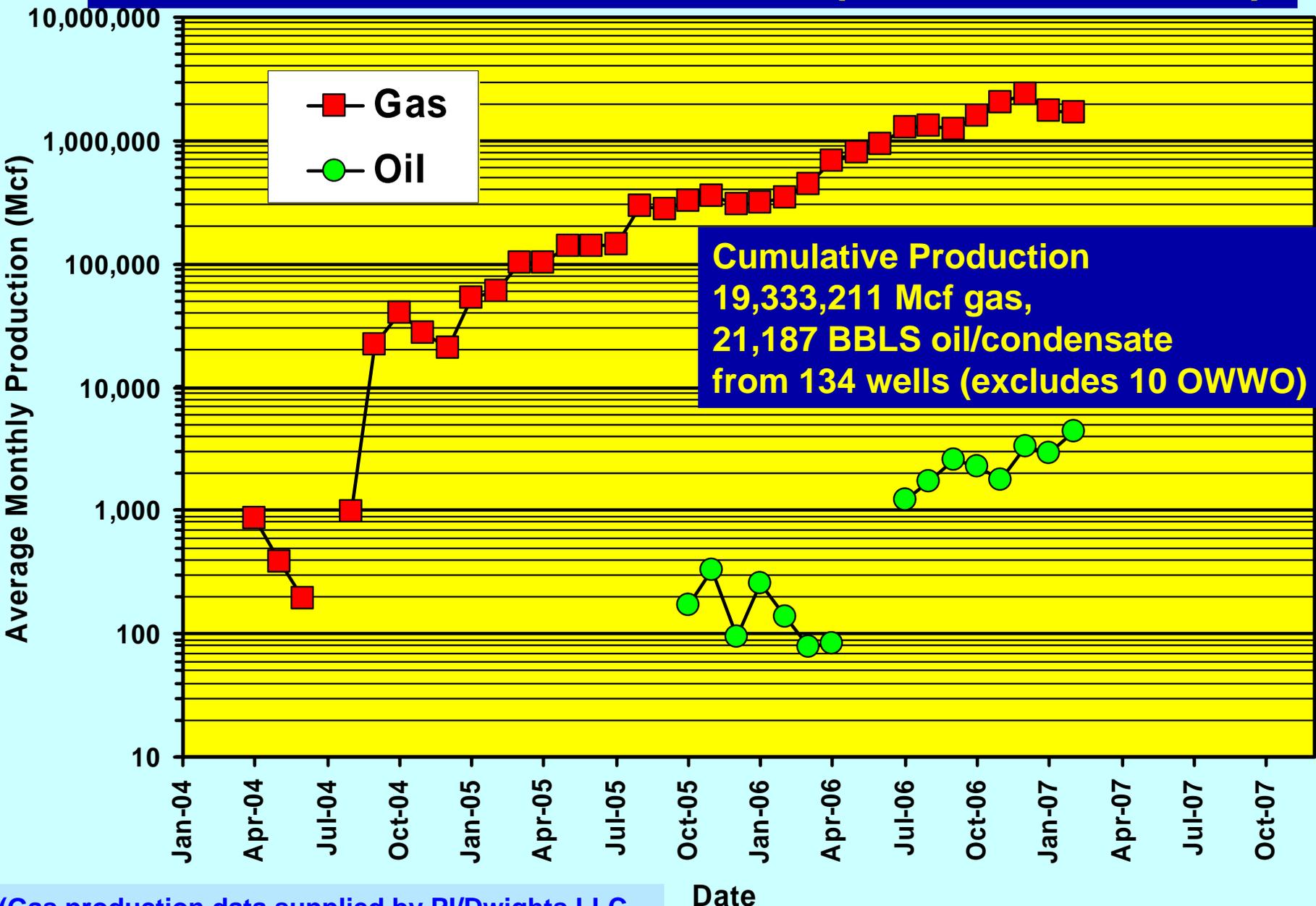
(Gas production data supplied by Petroleum
Information/Dwights LLC dba IHS Energy Group,
© 2007, IHS Energy Group)

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)

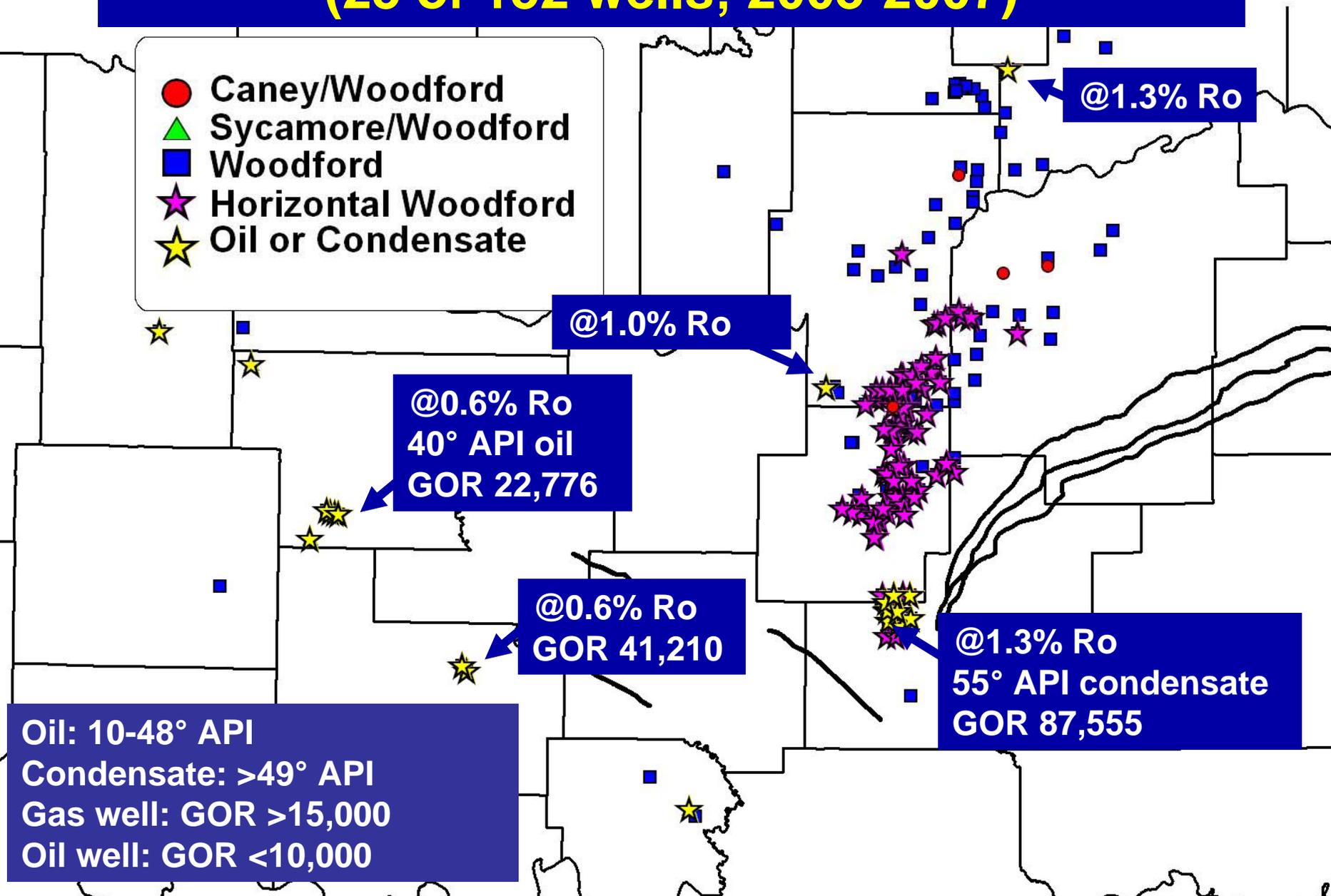
Woodford Shale Production (2003-2007 wells)



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

Woodford Shale Oil/Condensate Production (25 of 152 wells; 2003-2007)

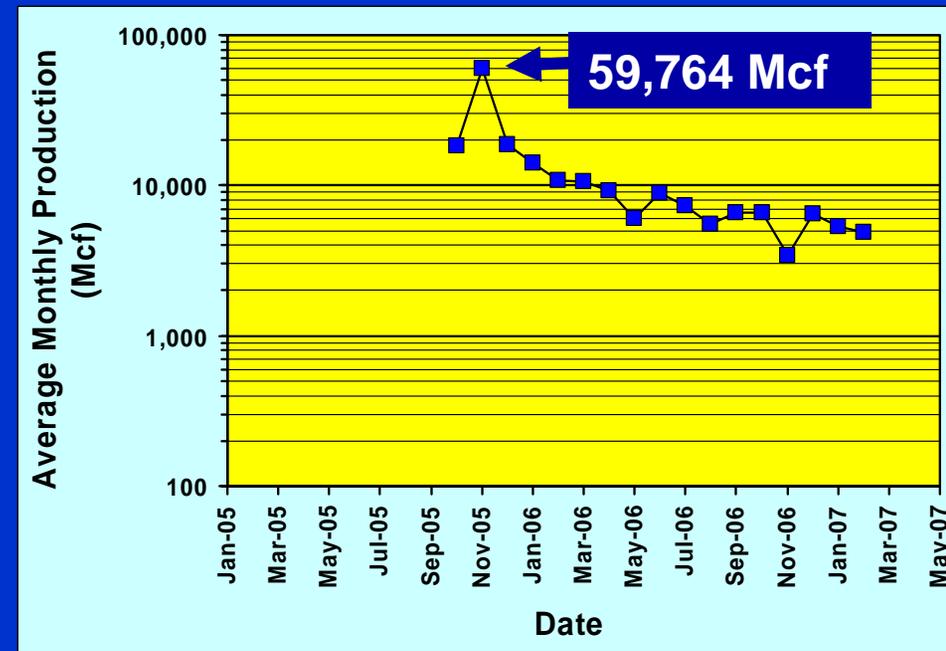
- Caney/Woodford
- ▲ Sycamore/Woodford
- Woodford
- ★ Horizontal Woodford
- ★ Oil or Condensate



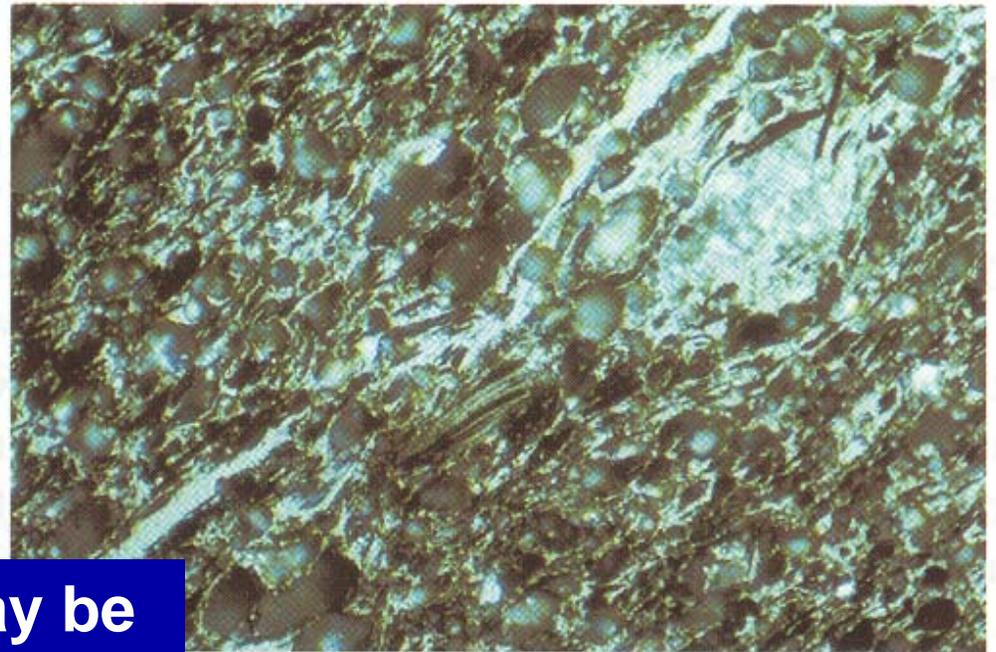
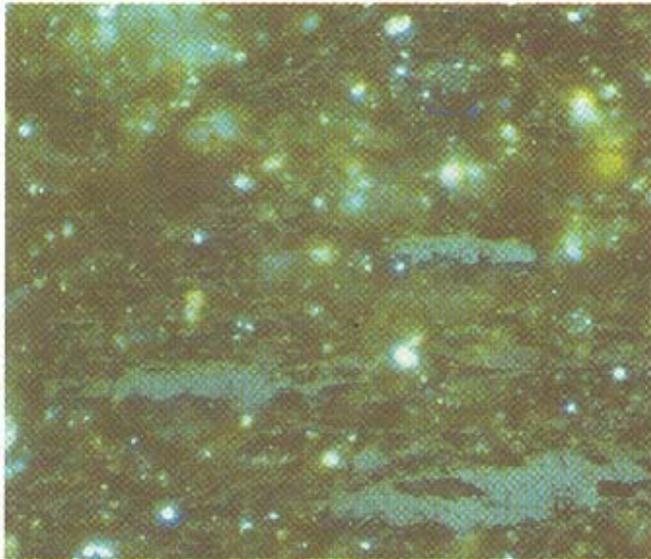
Gas Storage and Production

- Production decline curves suggest initial gas production is as **free gas** in fractures
- Gas Production ultimately depends on fracture connectivity with gas storage sites (**free and sorbed gas**)

Devon Energy 1-26
Edwards horizontal
Woodford well (2005)



KEROGEN NETWORK (SOLID BITUMEN; IMPSONITE)



Solid bitumen network may be important for gas storage and migration by diffusion

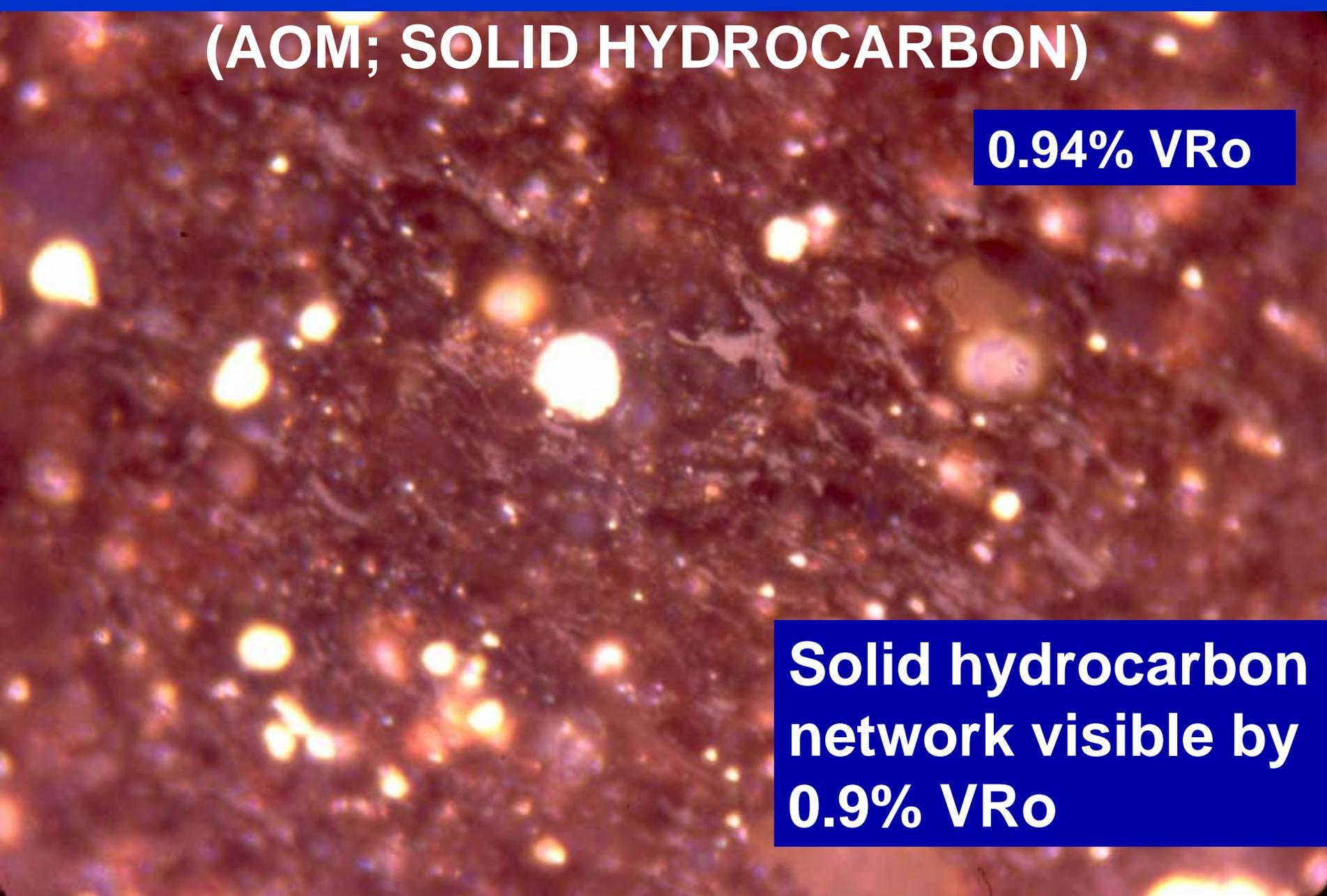
A

Taylor and others (1998)

ORGANIC NETWORK IN WOODFORD (AOM; SOLID HYDROCARBON)

0.94% VRo

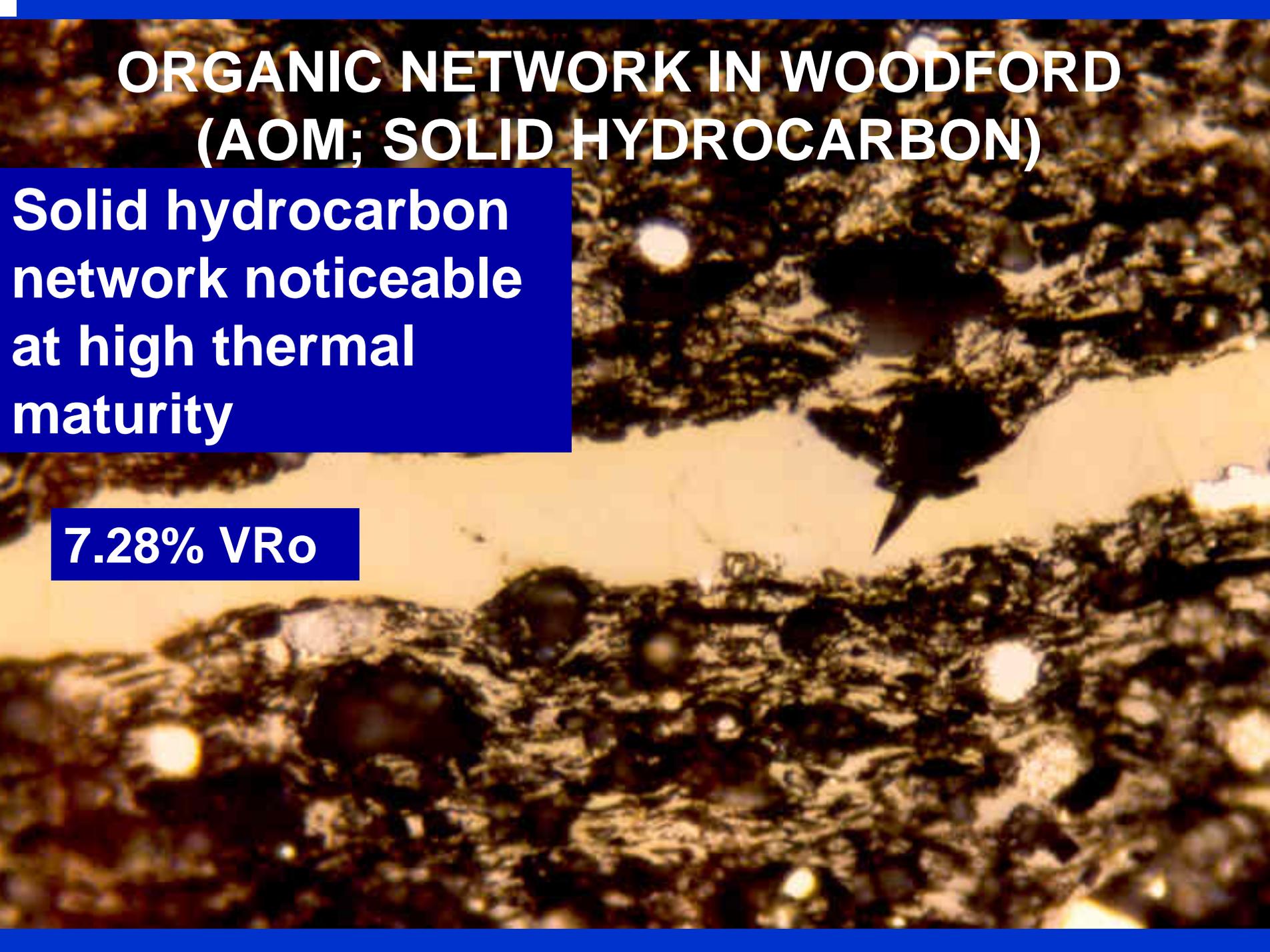
Solid hydrocarbon
network visible by
0.9% VRo



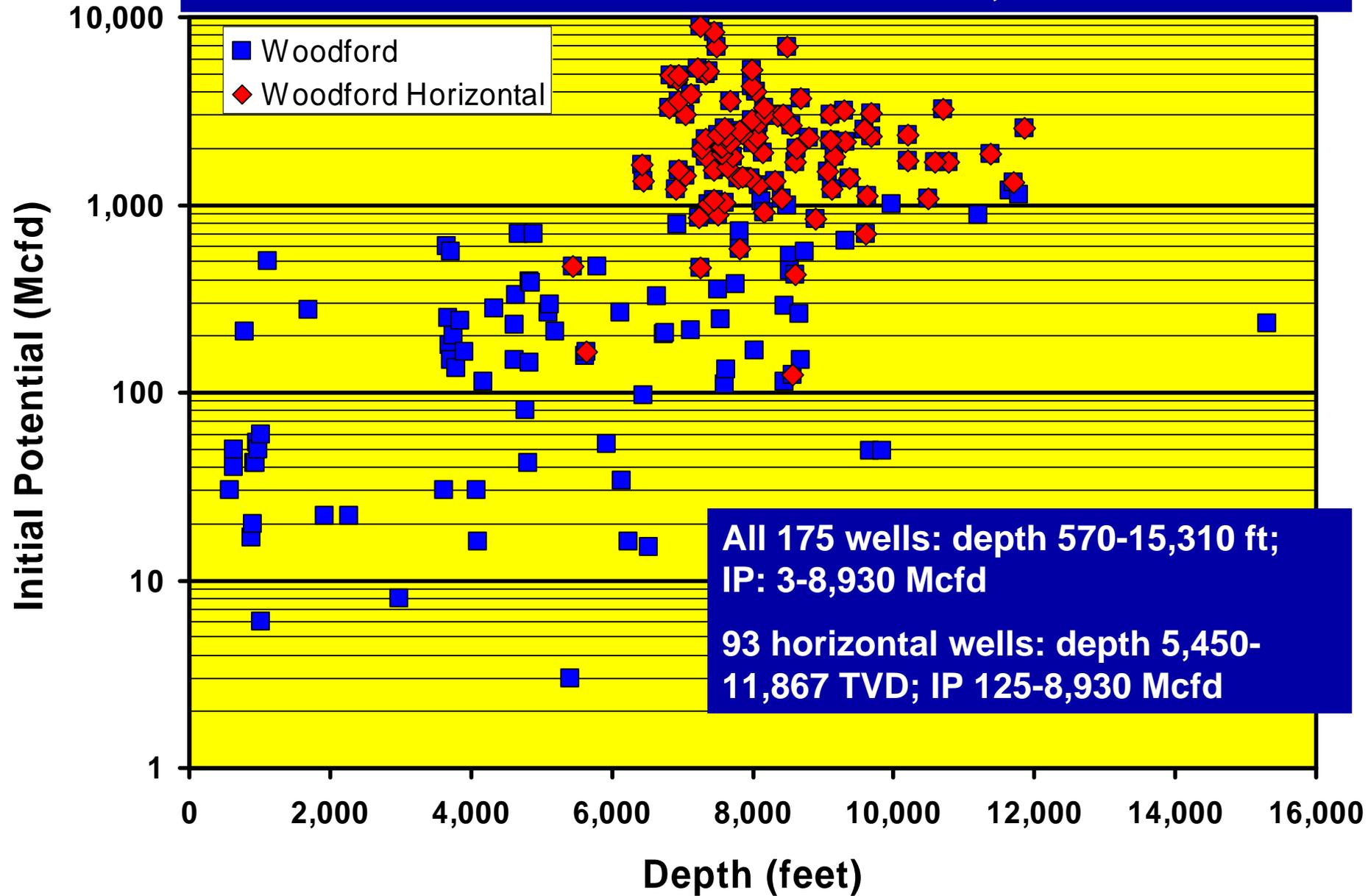
ORGANIC NETWORK IN WOODFORD (AOM; SOLID HYDROCARBON)

Solid hydrocarbon
network noticeable
at high thermal
maturity

7.28% VRo



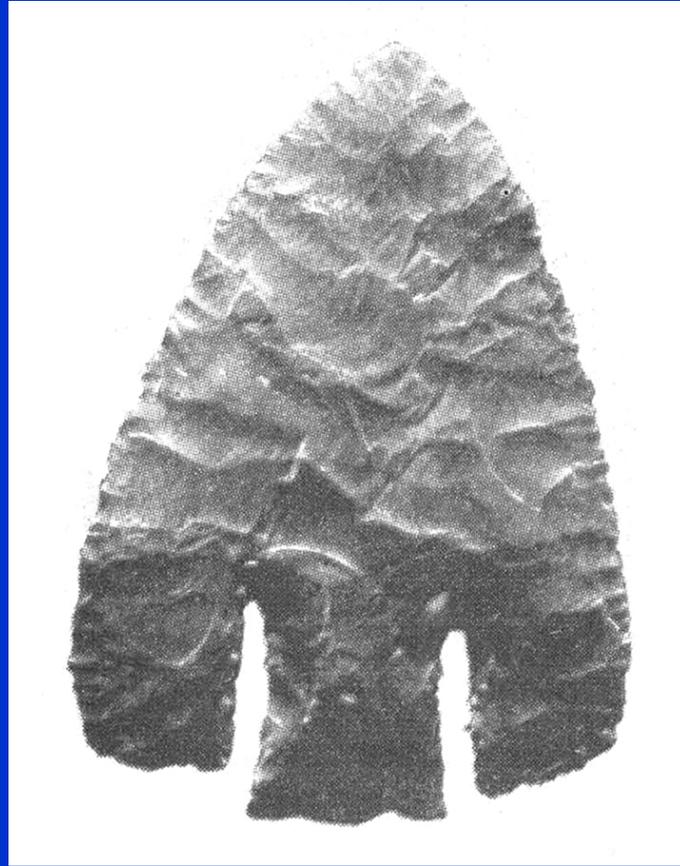
Woodford Shale Gas Wells, 2003-2007



SUMMARY OF WOODFORD GAS SHALE PLAY

- Woodford Shale contains Type II Kerogen with adequate TOC
- Woodford Shale is silica rich (e.g., fracture-able)
- Most 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
- Organic network may be important for gas diffusion in shales

THANK YOU



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