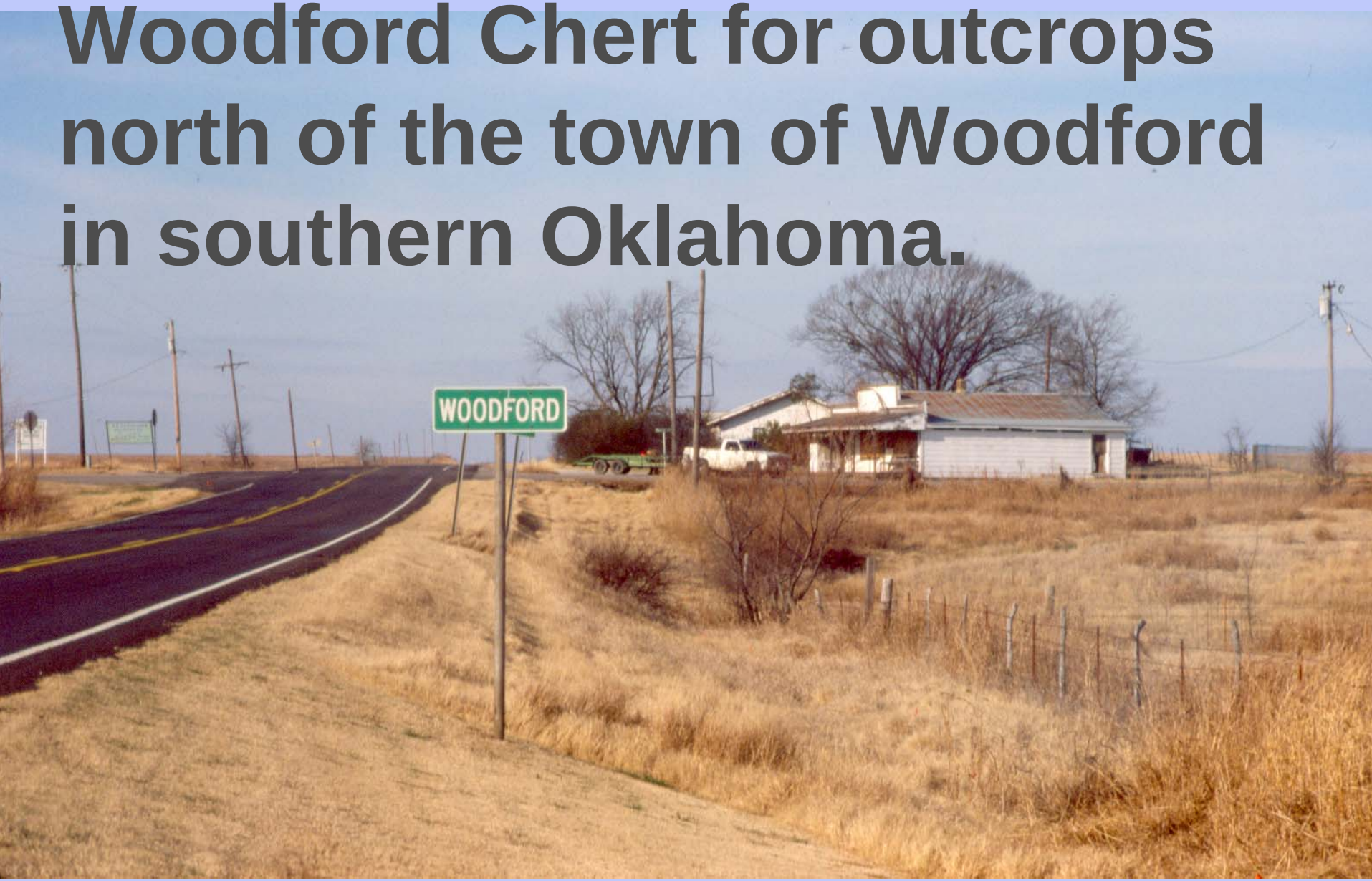
Overview of Woodford Gas-Shale Play in Oklahoma

Brian J. Cardott

Oklahoma Geological Survey

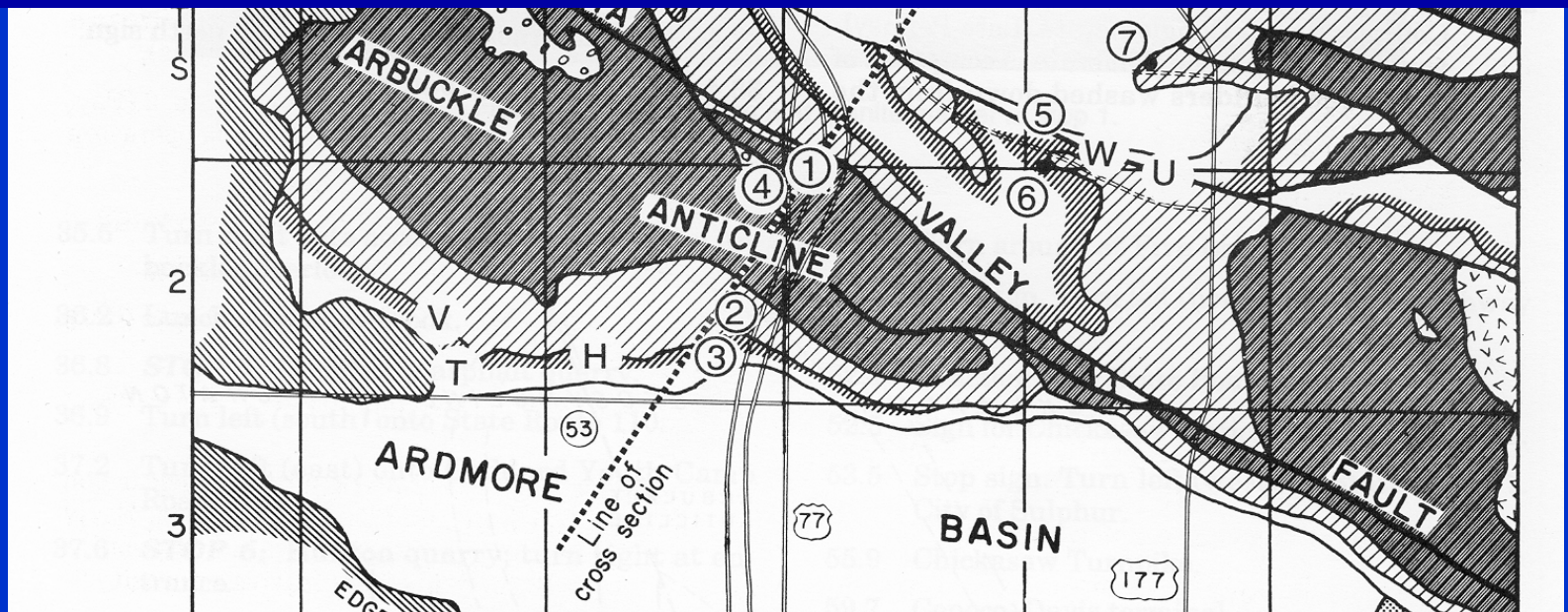
Taff (1902) introduced the name Woodford Chert for outcrops north of the town of Woodford in southern Oklahoma.



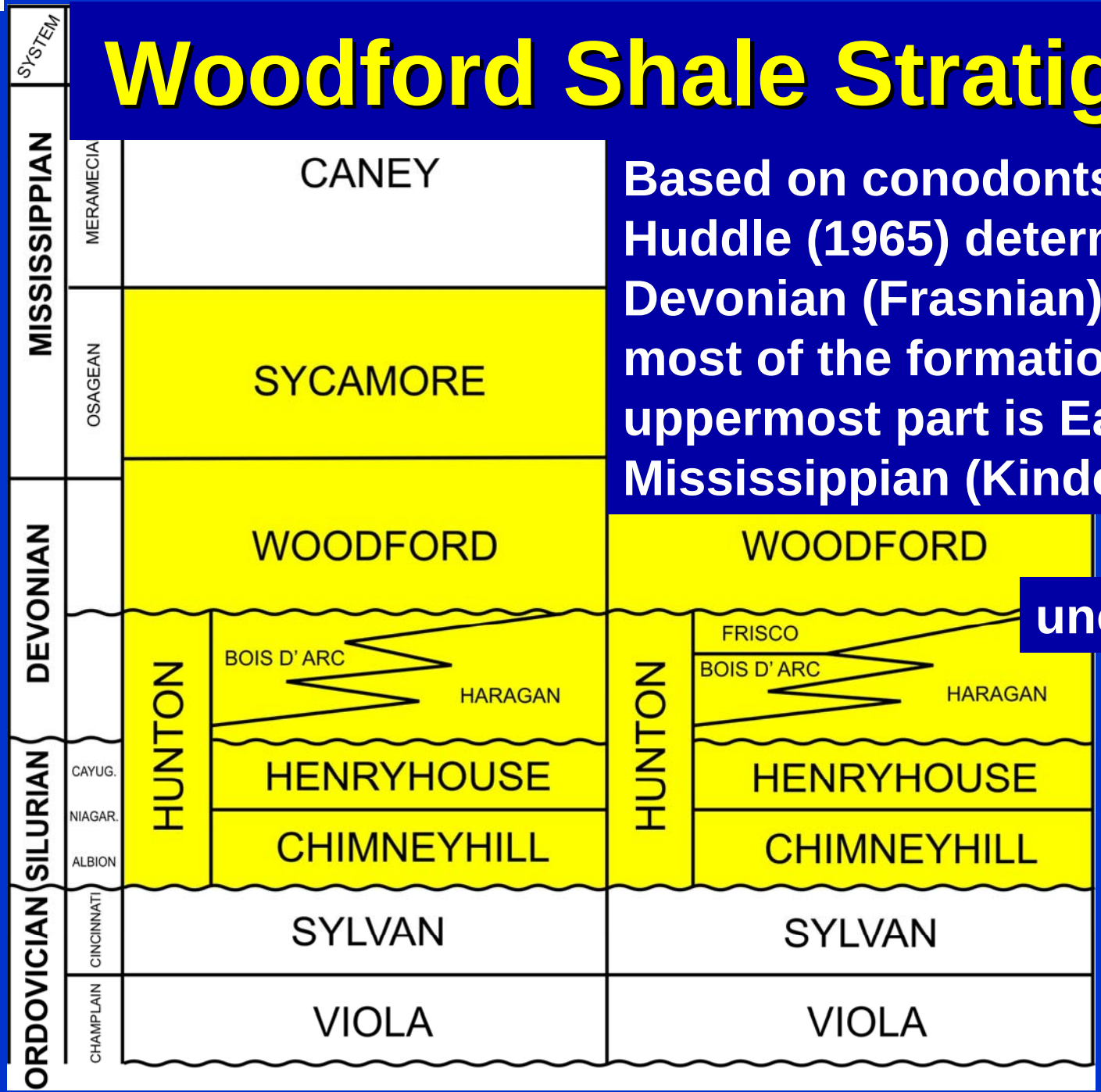
WOODFORD CHERT: Taff (1902), Gould (1925), Wilmarth (1938), Dott (1952)

WOODFORD FORMATION: Morgan (1924), Amsden (1957-1963), Wilson (1958), O'Brien and Slatt (1990)

WOODFORD SHALE: Tarr (1955), Jordan (1957, 1959, 1962), Urban (1960), Hass & Huddle (1965), Amsden (1975, 1980)

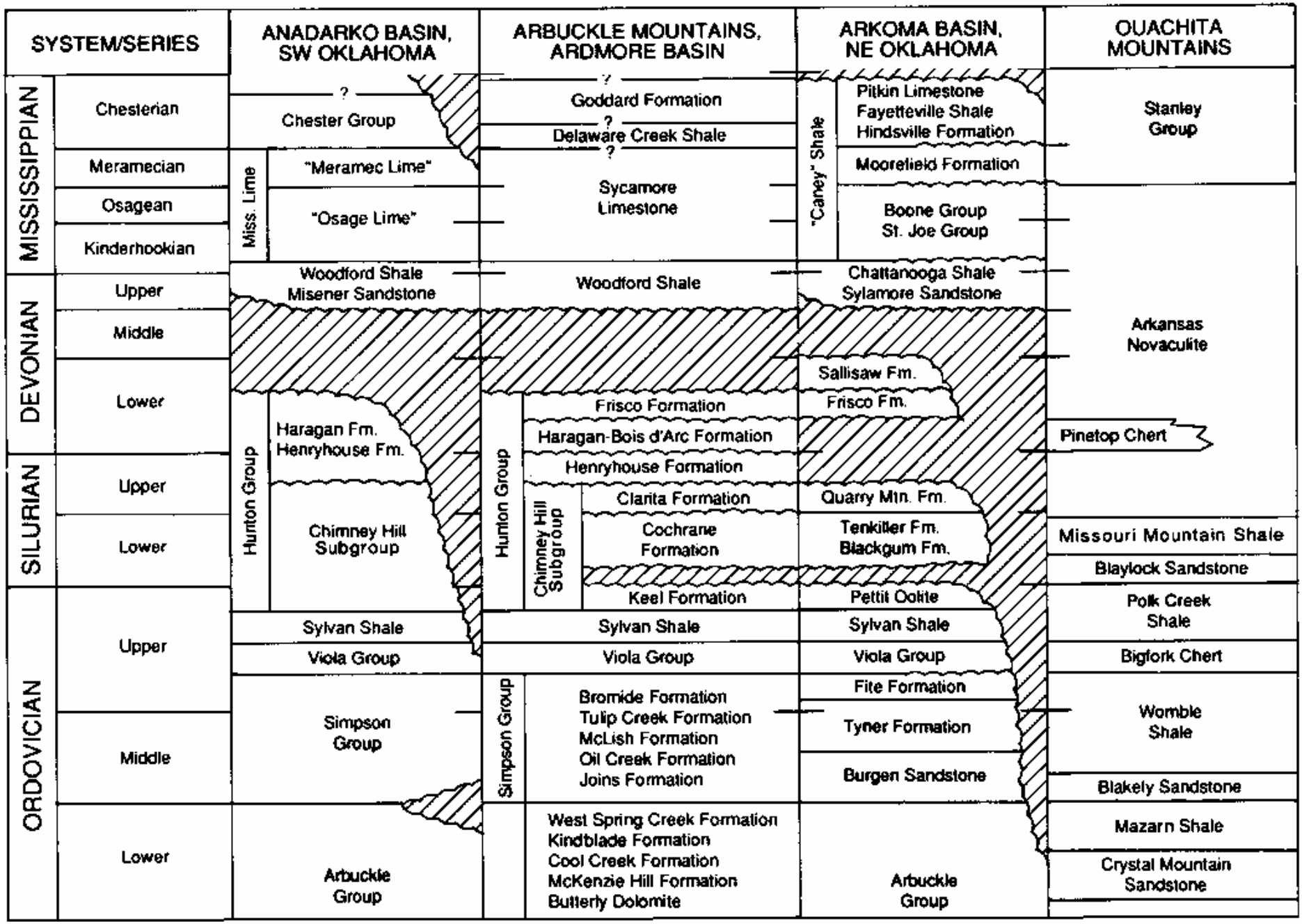


Woodford Shale Stratigraphy



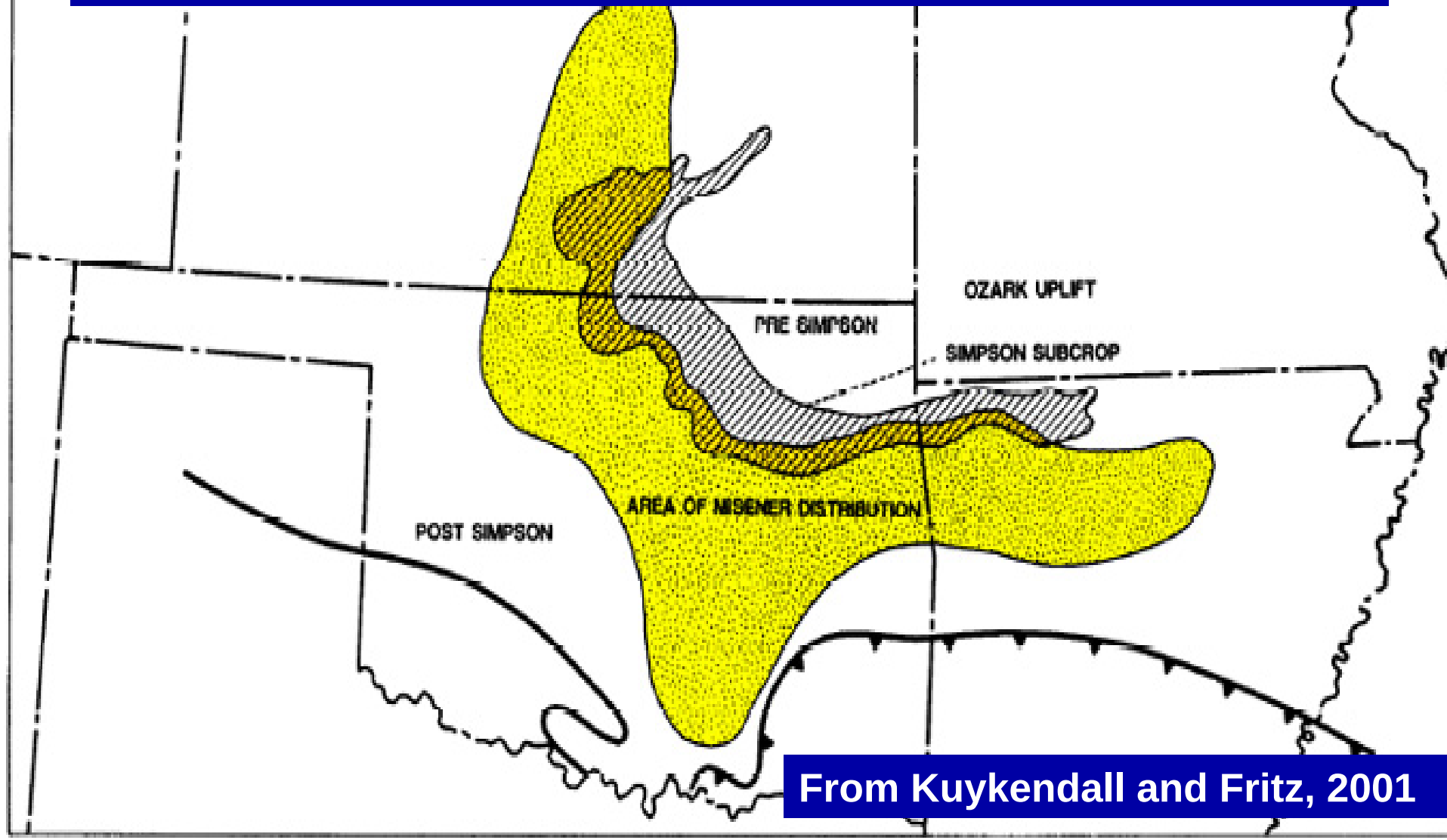
Based on conodonts, Hass and Huddle (1965) determined a Late Devonian (Frasnian) age for most of the formation; uppermost part is Early Mississippian (Kinderhookian)

unconformity



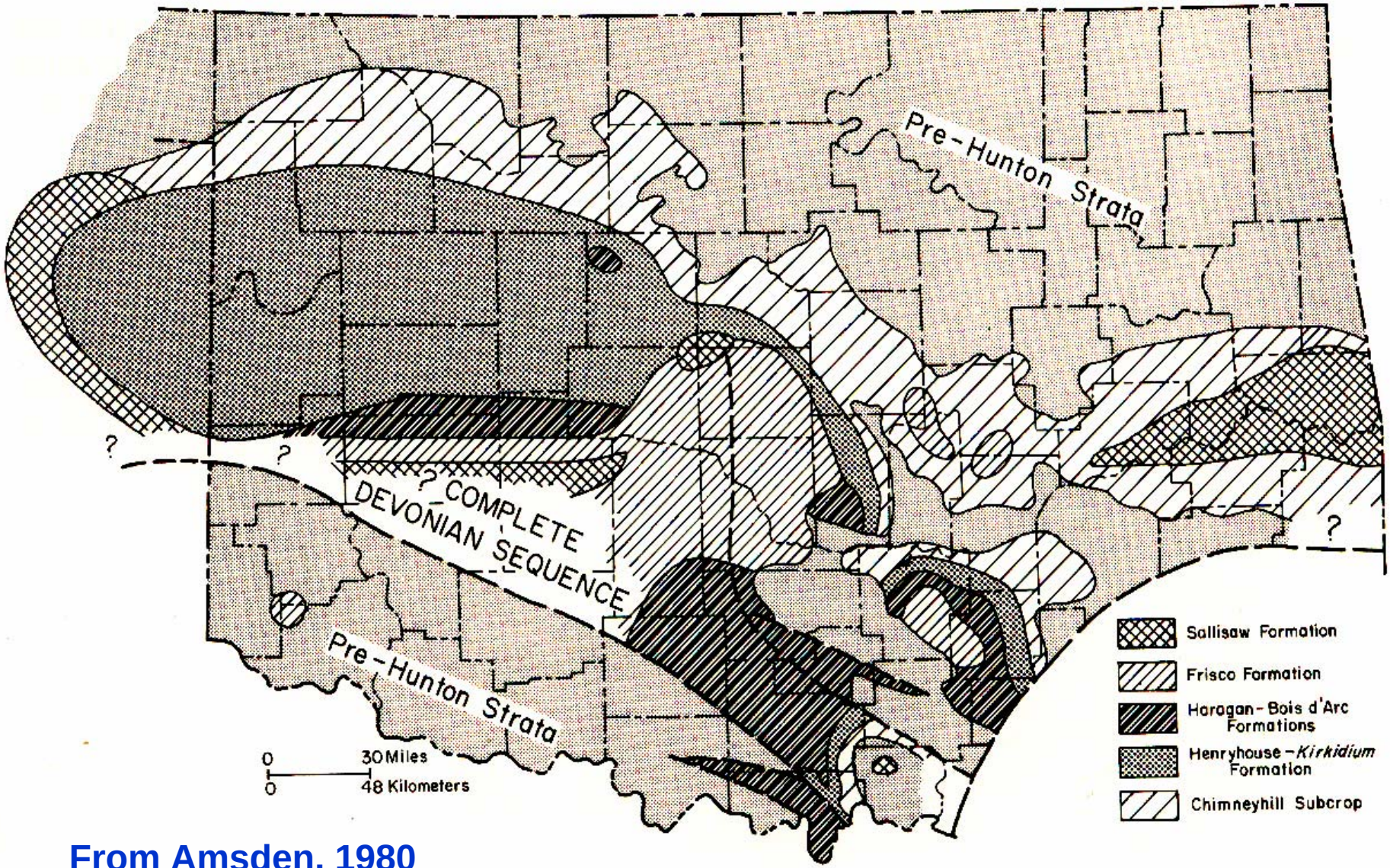
Modified from Johnson and Cardott, 1992

Approximate distribution of Misener Sandstone

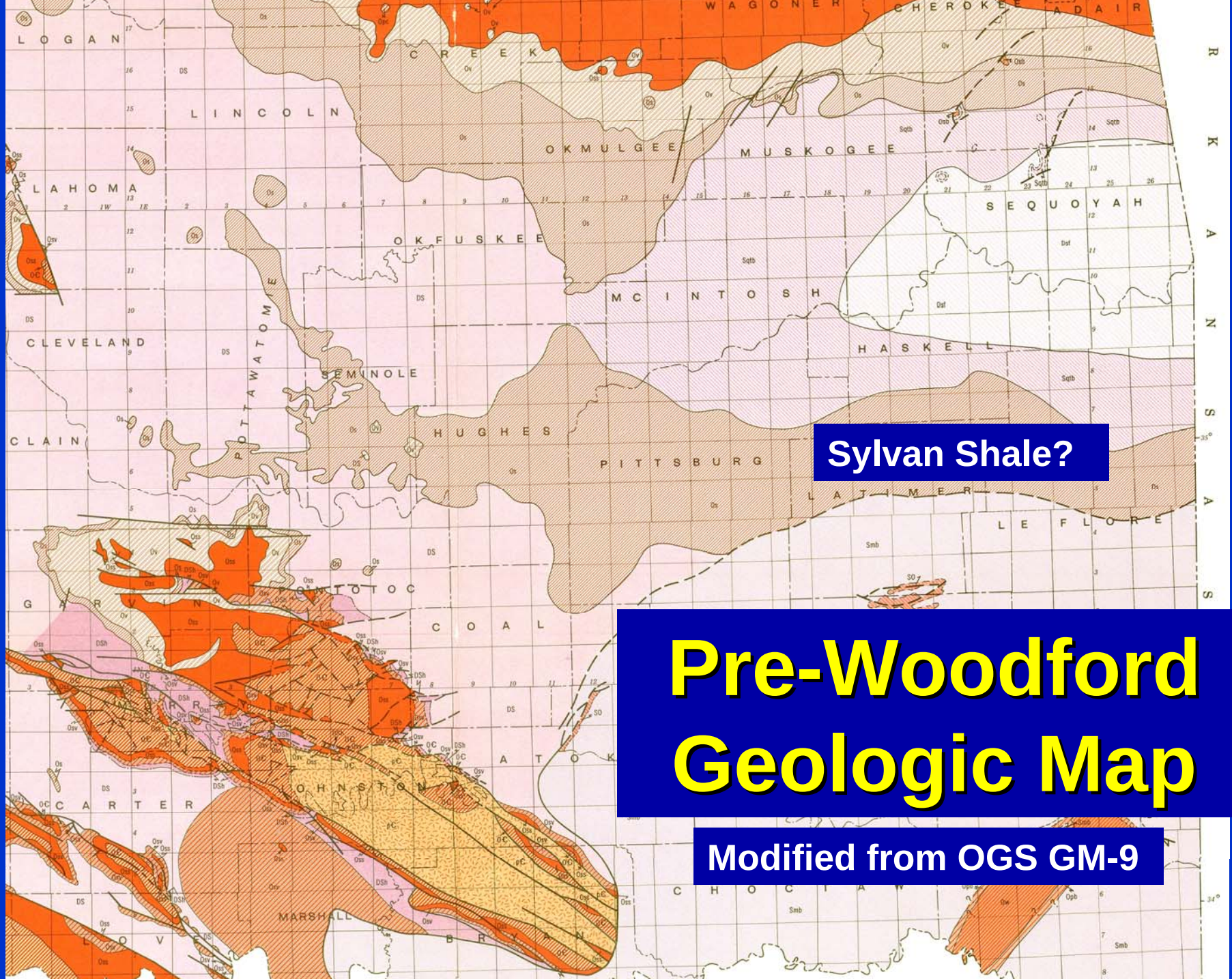


From Kuykendall and Fritz, 2001

Pre-Woodford Geologic Map

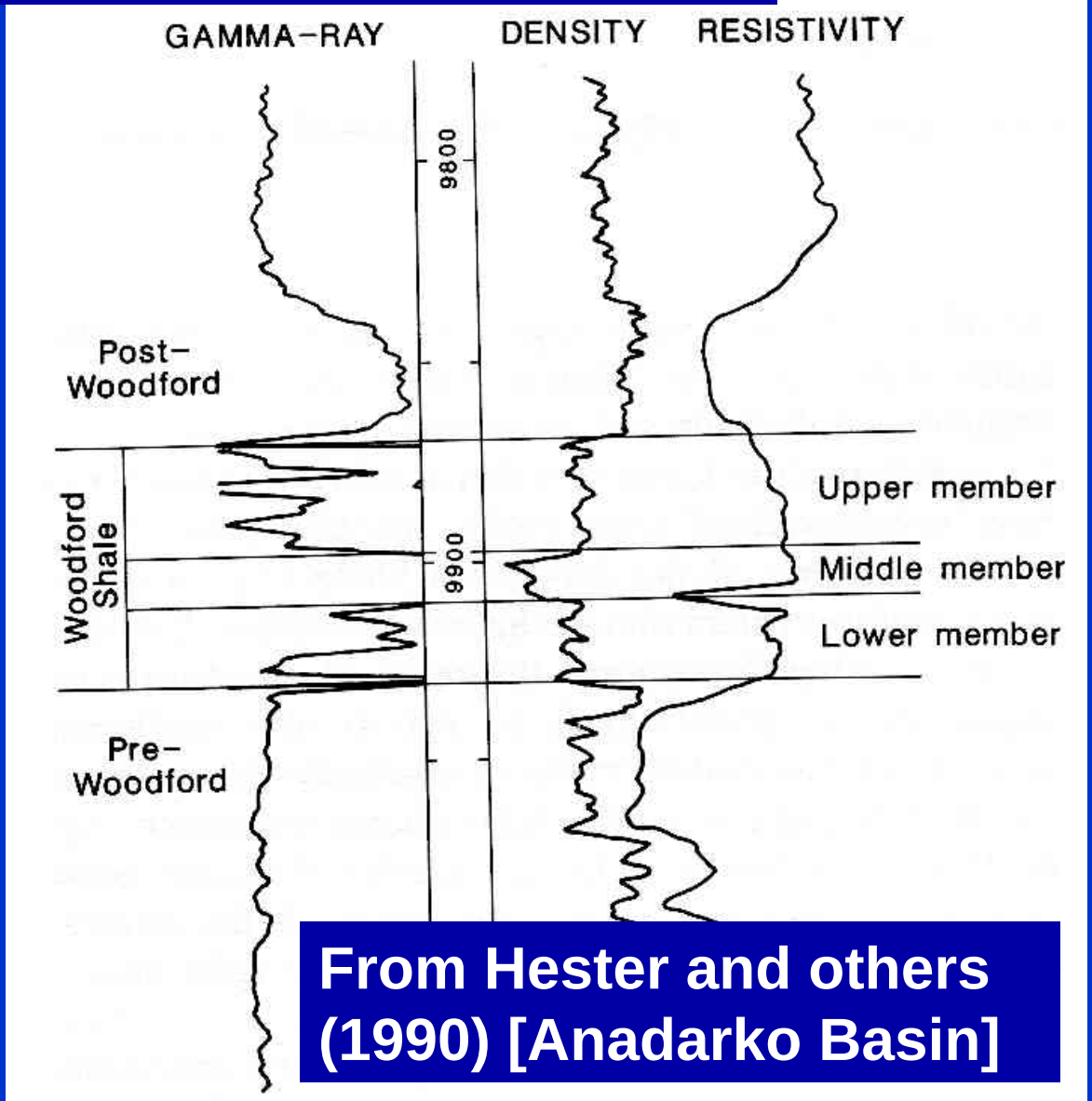


From Amsden, 1980


Sylvan Shale?
Pre-Woodford Geologic Map
Modified from OGS GM-9

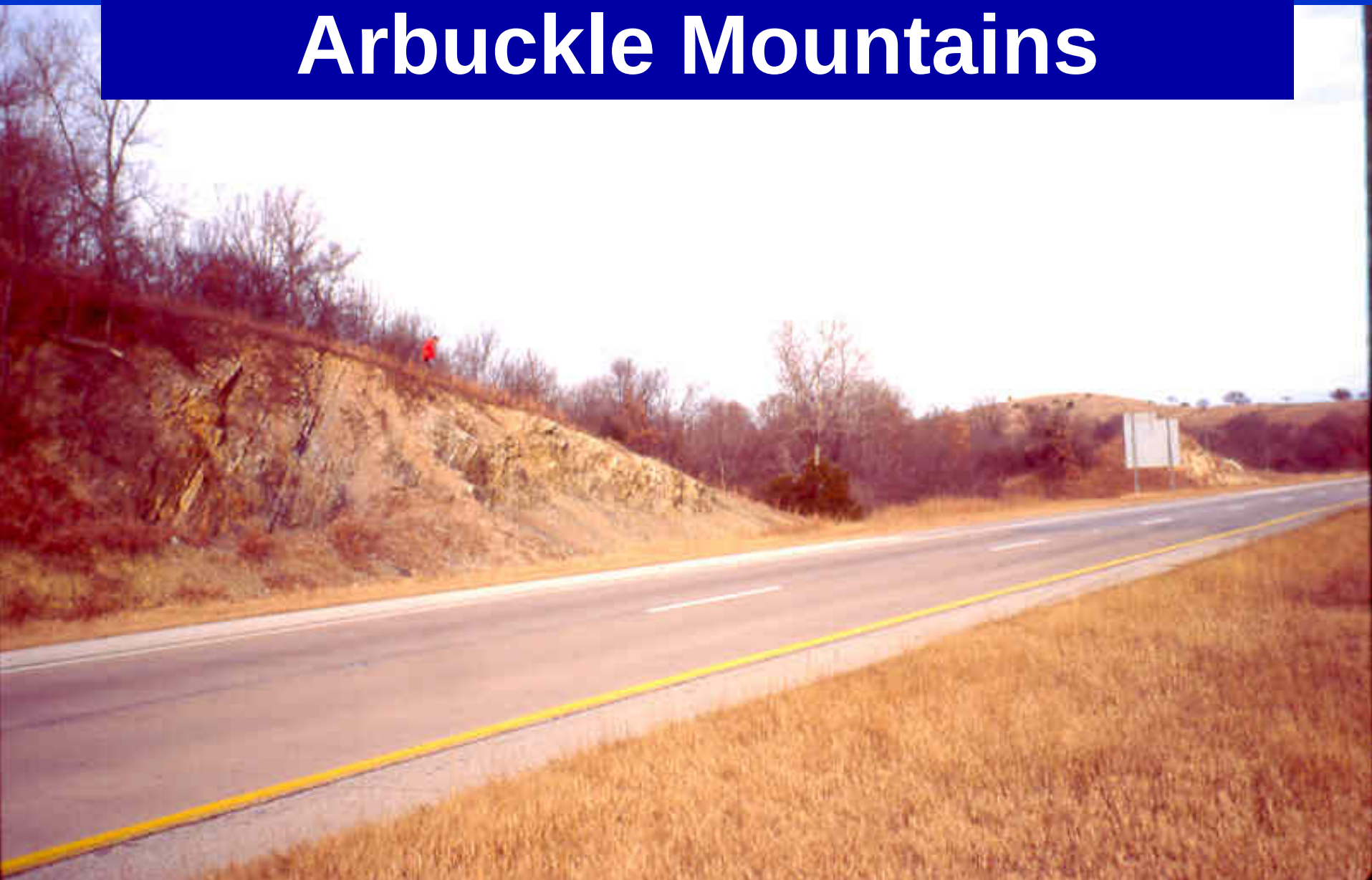
Woodford Shale Members

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

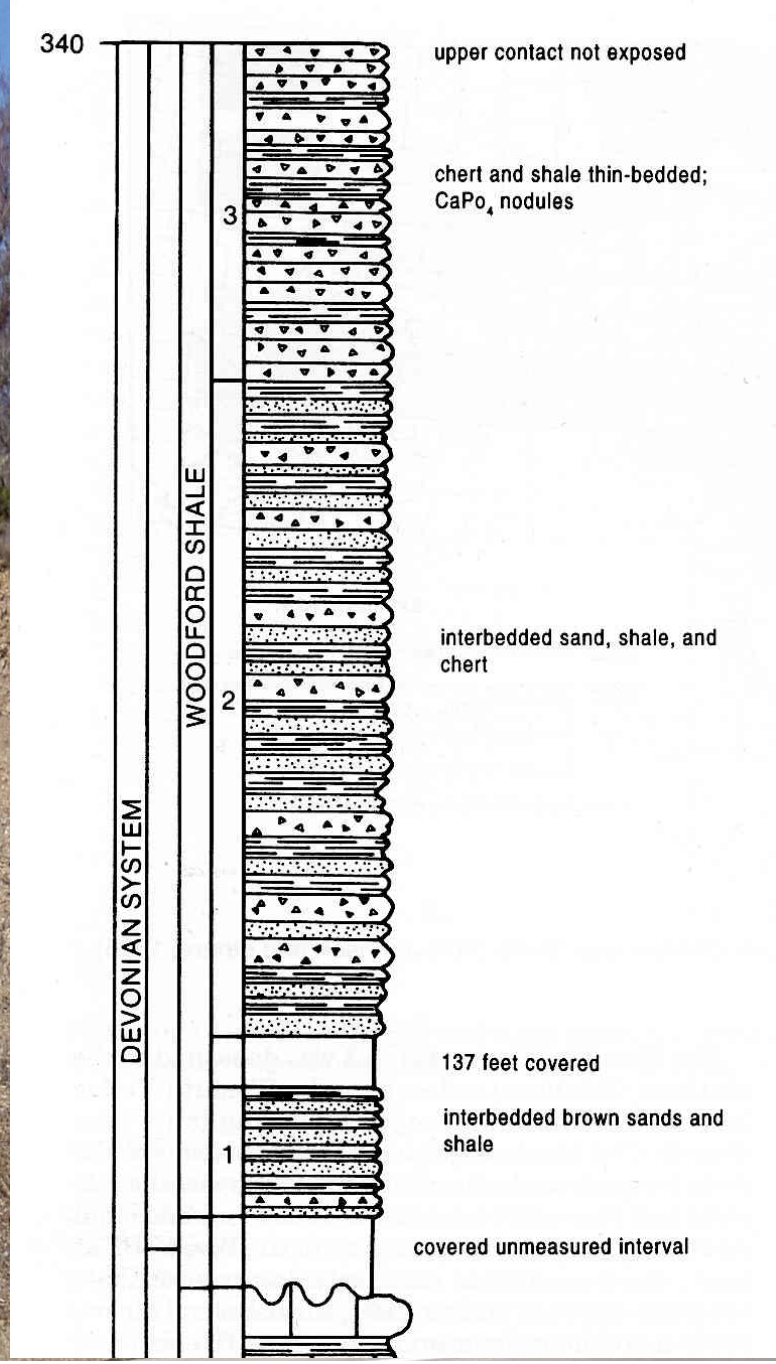


From Hester and others (1990) [Anadarko Basin]

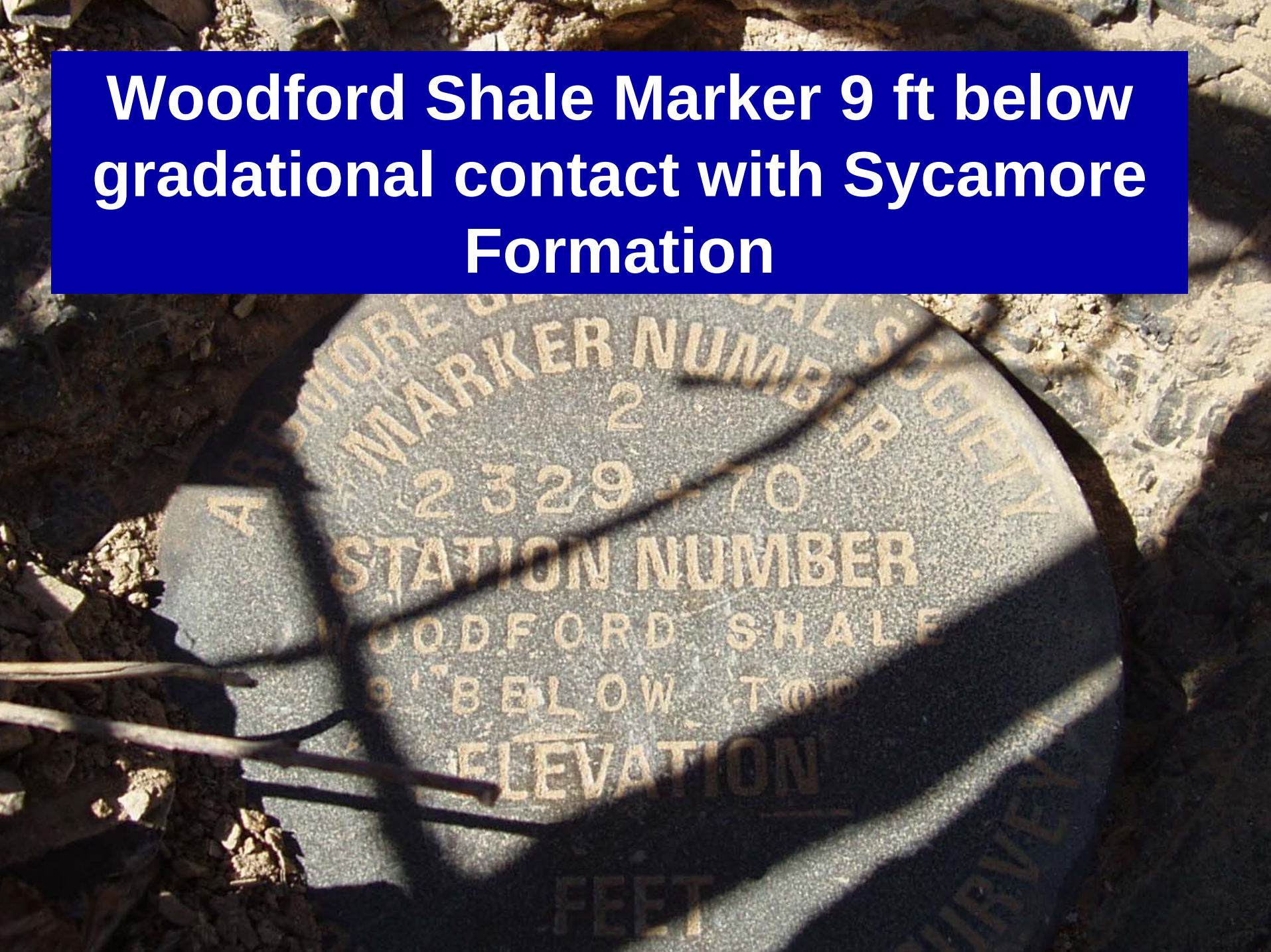
Woodford Shale in southern Arbuckle Mountains



Woodford Shale in southern Arbuckle Mountains

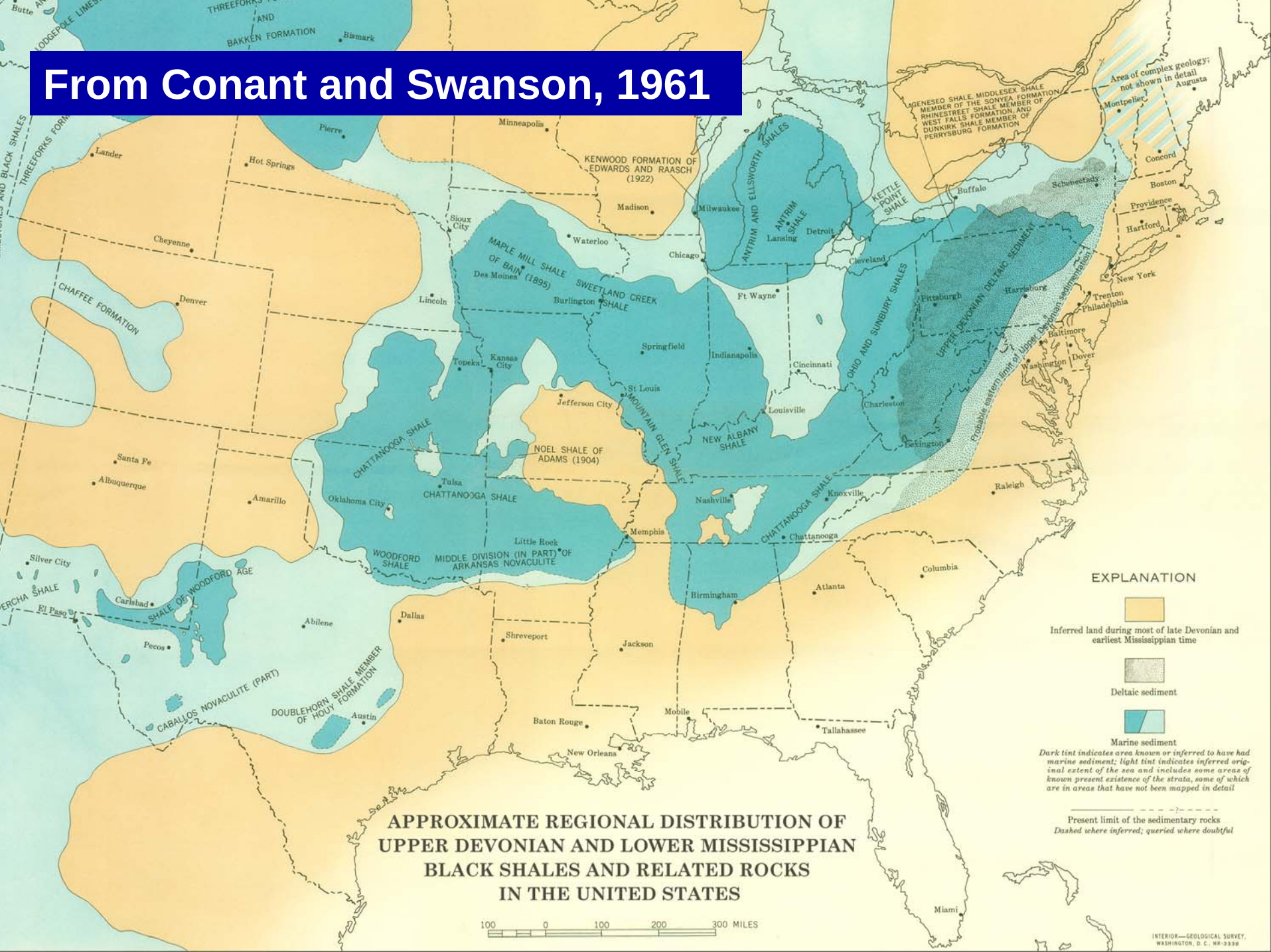


Modified from Ellis and Westergaard, 1985

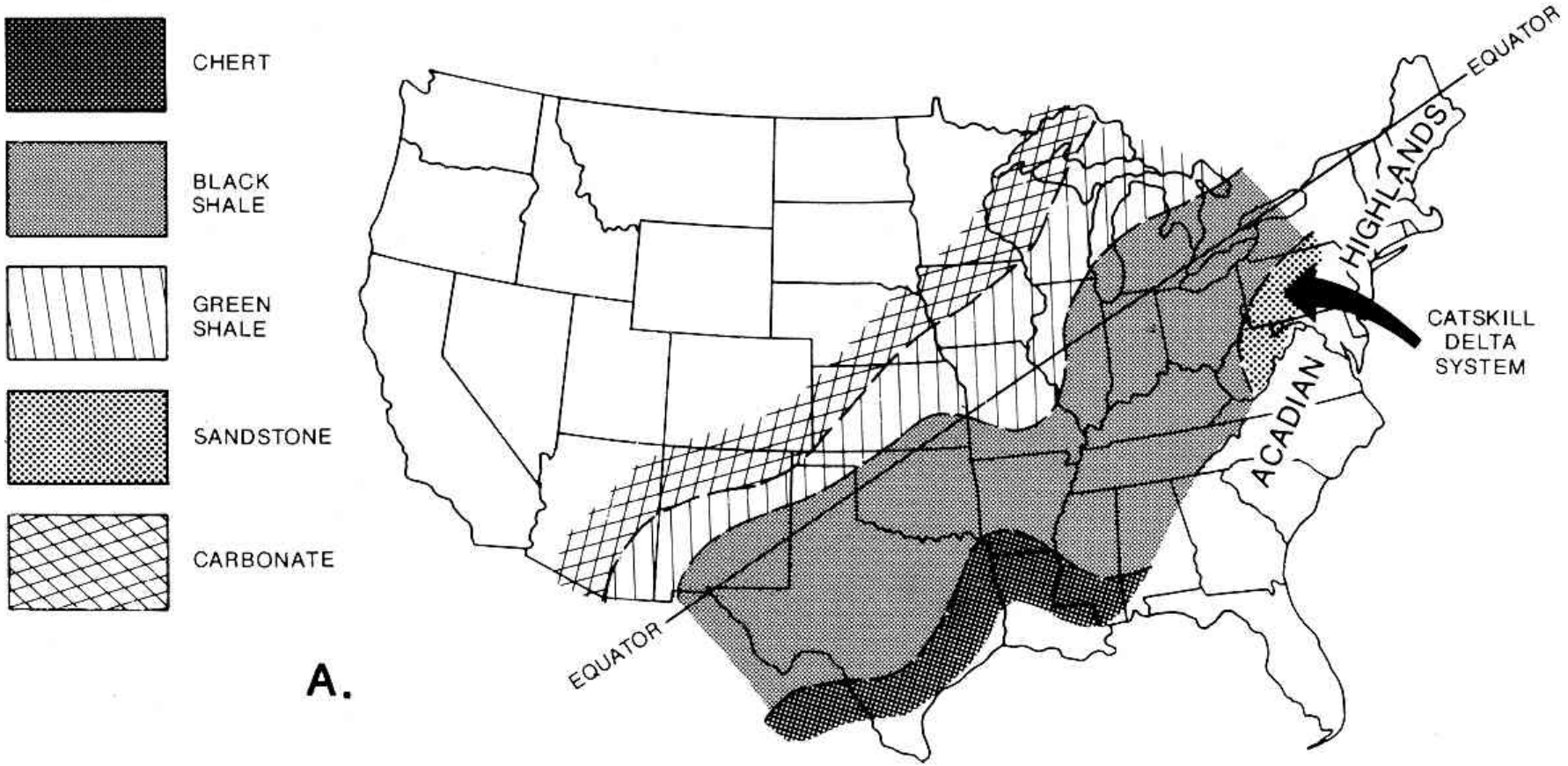


Woodford Shale Marker 9 ft below gradational contact with Sycamore Formation

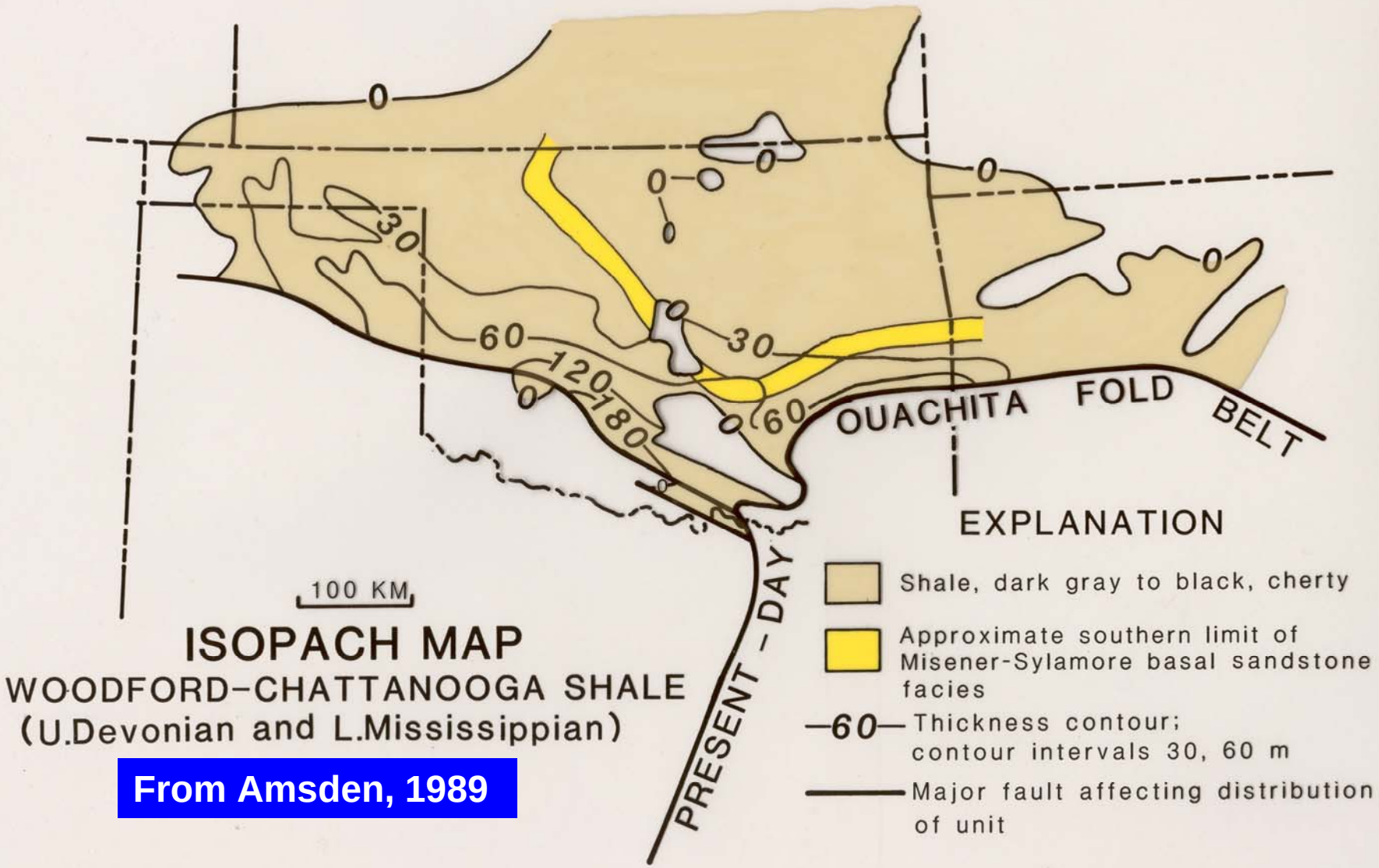
From Conant and Swanson, 1961



Paleogeography and Facies Distribution in the Late Devonian



From Kirkland and others, 1992



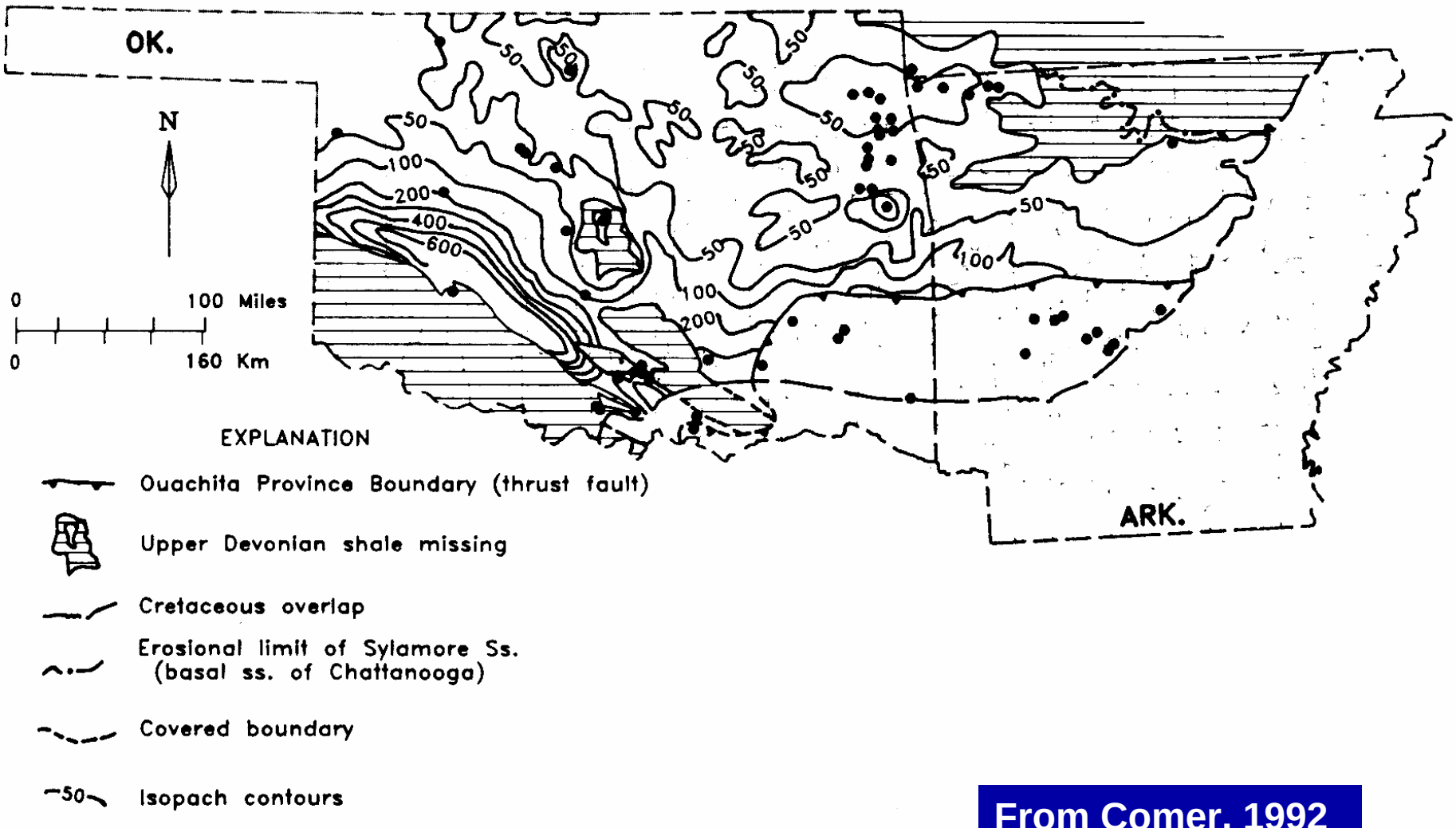
ISOPACH MAP

WOODFORD–CHATTANOOGA SHALE

(U.Devonian and L.Mississippian)

From Amsden, 1989

Isopach Map of Woodford Shale



From Comer, 1992

Woodford Shale Mineralogy

O'Brien and Slatt (1990; Carter County): 63% quartz, 3% plagioclase feldspar, 10% calcite, 6% dolomite, 5% pyrite, 14% total layer silicates.

Kirkland and others (1992; Arbuckle Mountains): 55-87% quartz, 0-7% K-feldspar, 0-3% dolomite, 0-1% apatite, 0-1% pyrite, 8-34% illite, 3-7% kaolin

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

Gas Shales

Gas shales are varieties of hydrocarbon source rocks (an important part of a petroleum system).

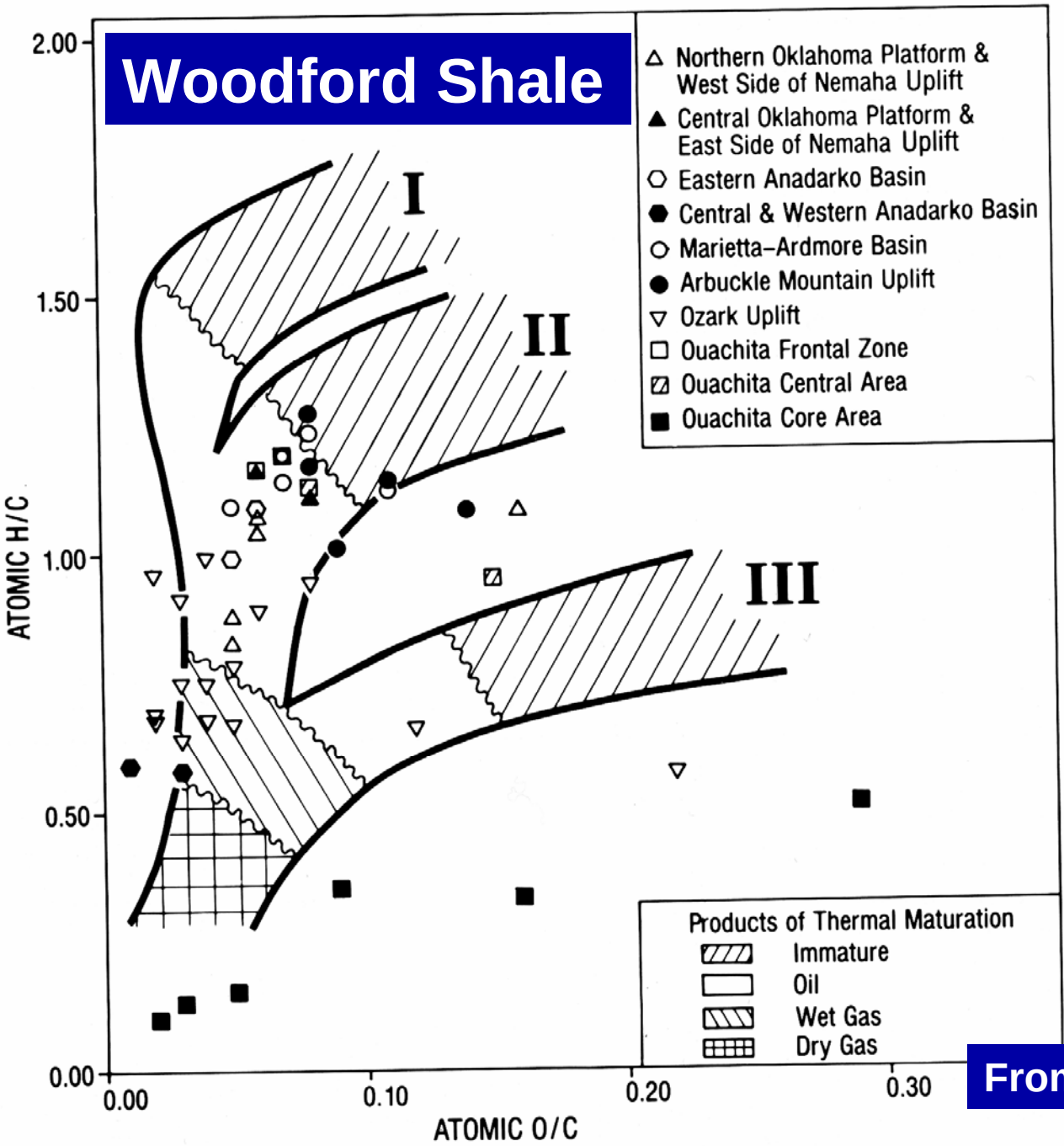
HYDROCARBON SOURCE ROCK CLASSIFICATION

Organic matter type refers to the kerogen or maceral type and can be lumped into gas generative (Type III), oil generative (Types I and II), or inert (Type IV).

Organic matter quantity is determined by the total organic carbon (TOC) content (weight percent, whole-rock basis).

Vitrinite reflectance (%Ro, oil immersion) is the most common **thermal maturity** indicator. Vitrinite is a maceral derived from the woody tissues of vascular plants. The oil window is considered to be from 0.5–1.35% Ro.

Woodford Shale



From Comer, 1992

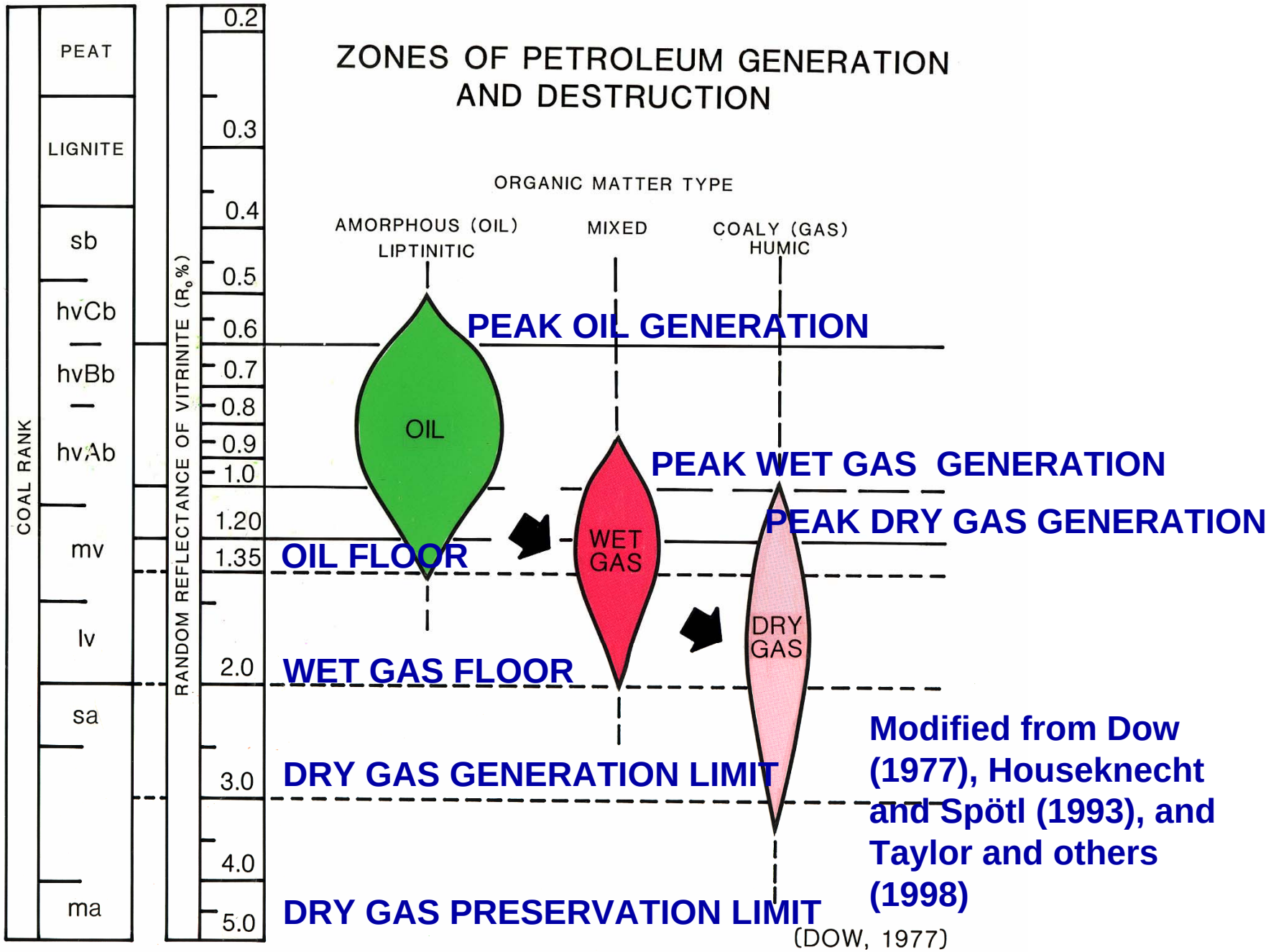
Gas Shales

Definition: Gas shales are organic-rich, fine-grained sedimentary rocks (shale to siltstone) containing a minimum of 0.5 wt % TOC.

Gas shales may be thermally marginally-mature (0.4–0.6% Ro) to **mature/post-mature** (0.6–>2.0% Ro) and contain biogenic to **thermogenic** methane. Gas is generated and stored in situ in gas shales as both adsorbed (on organic matter) and free gas (in fractures and pores). As such, gas shales are self-sourced reservoirs. Low-permeable shales require extensive fractures (natural or induced) to produce commercial quantities of gas.

Questions to Resolve

- What is the minimum thermal maturity needed for shales containing oil-generative organic matter (Types I and II Kerogen) to be economic gas shales? **[>1.10-1.3%VRo]**
- What is the importance of:
  - natural vs. induced fractures?
  - free gas vs. sorbed gas?
  - mineralogy?


ZONES OF PETROLEUM GENERATION AND DESTRUCTION
ORGANIC MATTER TYPE
AMORPHOUS (OIL) LIPTINITIC
MIXED
COALY (GAS) HUMIC
COAL RANK
PEAT
LIGNITE
sb
hvCb
hvBb
hvAb
mv
lv
sa
ma
RANDOM REFLECTANCE OF VITRINITE (R_o%)
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.20
1.35
2.0
3.0
4.0
5.0
OIL
WET GAS
DRY GAS
PEAK OIL GENERATION
PEAK WET GAS GENERATION
PEAK DRY GAS GENERATION
OIL FLOOR
WET GAS FLOOR
DRY GAS GENERATION LIMIT
DRY GAS PRESERVATION LIMIT
Modified from Dow (1977), Houseknecht and Spötl (1993), and Taylor and others (1998)
(DOW, 1977)

Guidelines for the Barnett Shale

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)

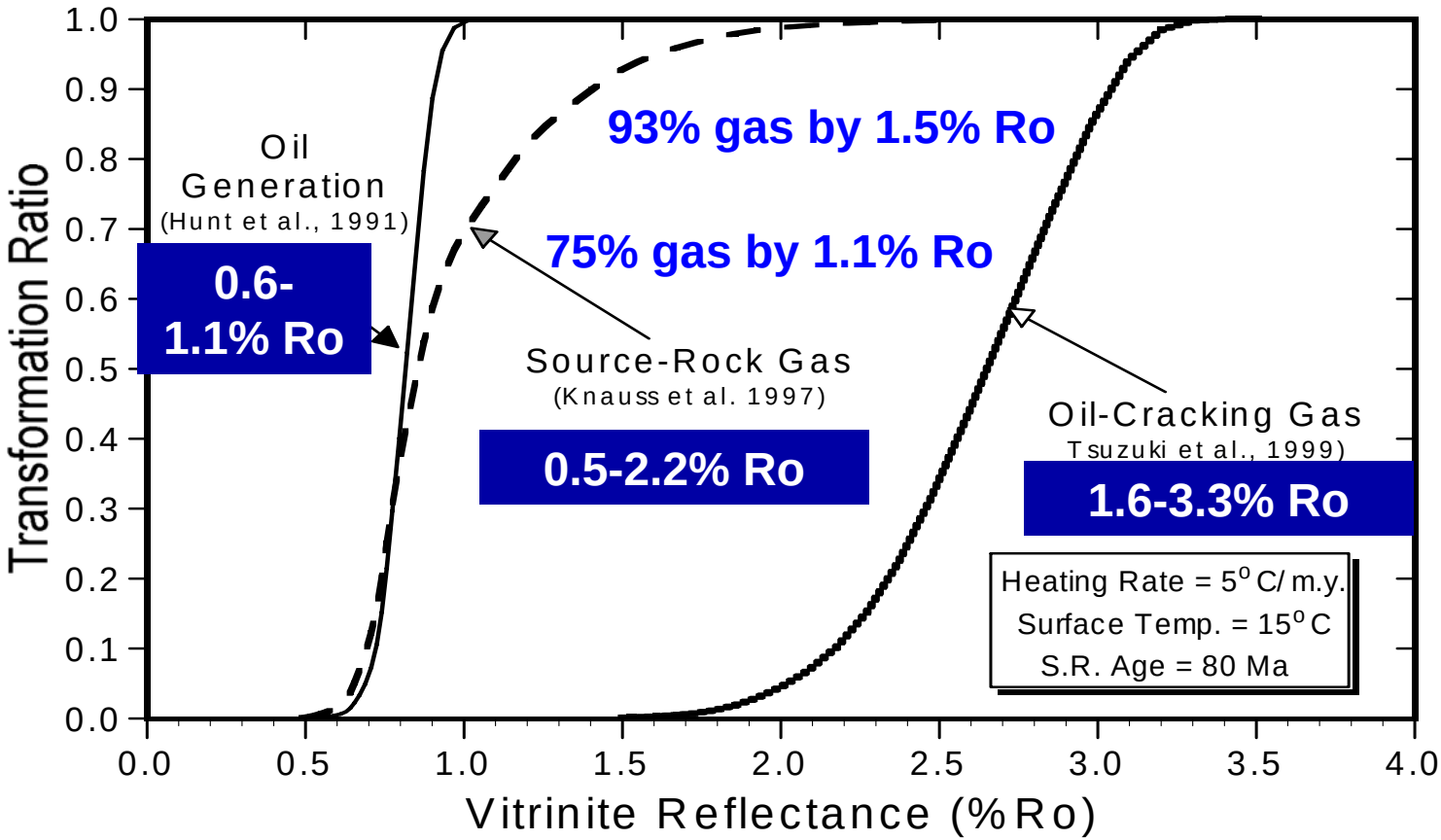


Figure 1: Generation of oil and gas from an 80-Ma source rock with Type-II kerogen and associated crude oil. Curves are based on kinetic parameters determined by hydrous and hydrothermal pyrolysis and EASY%Ro (Swweeney and Burnham, 1990).

From Lewan, 2002

Gas Generation by Kerogen Type

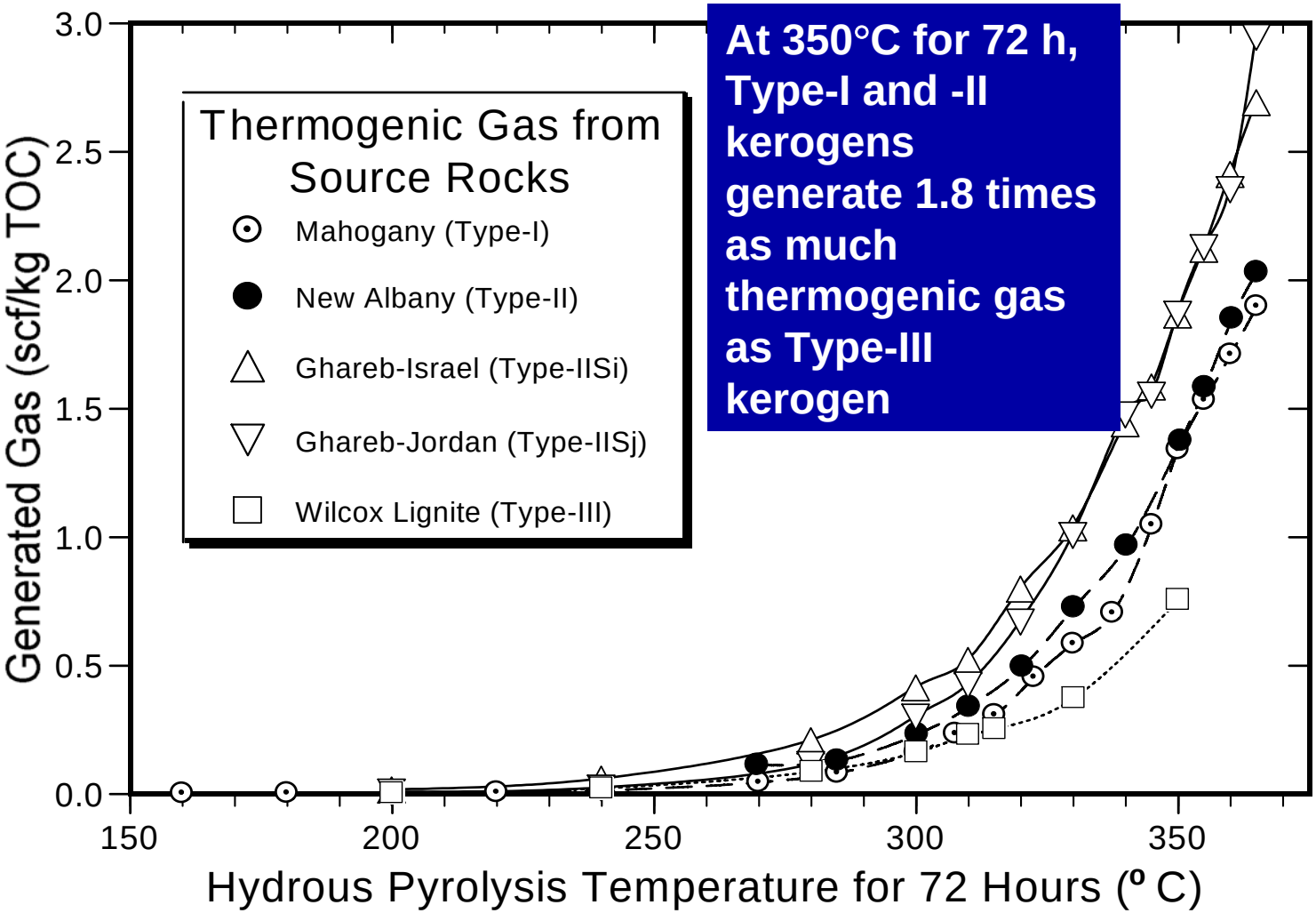
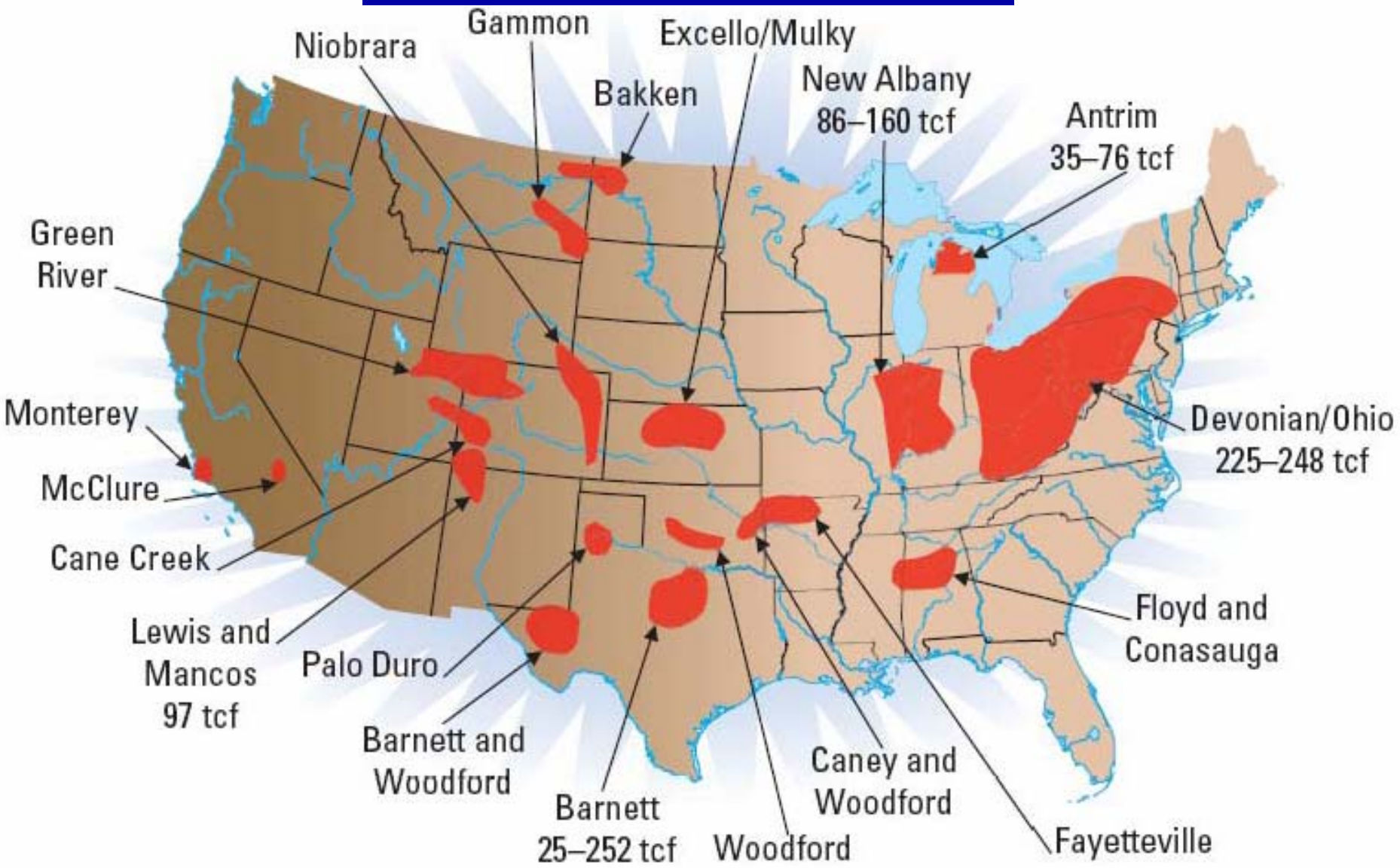


Figure 2: Volume of hydrocarbon gas (C_1-C_5) generated by hydrous pyrolysis from thermally immature source rocks bearing different kerogen types (Lewan and Henry, 2001).

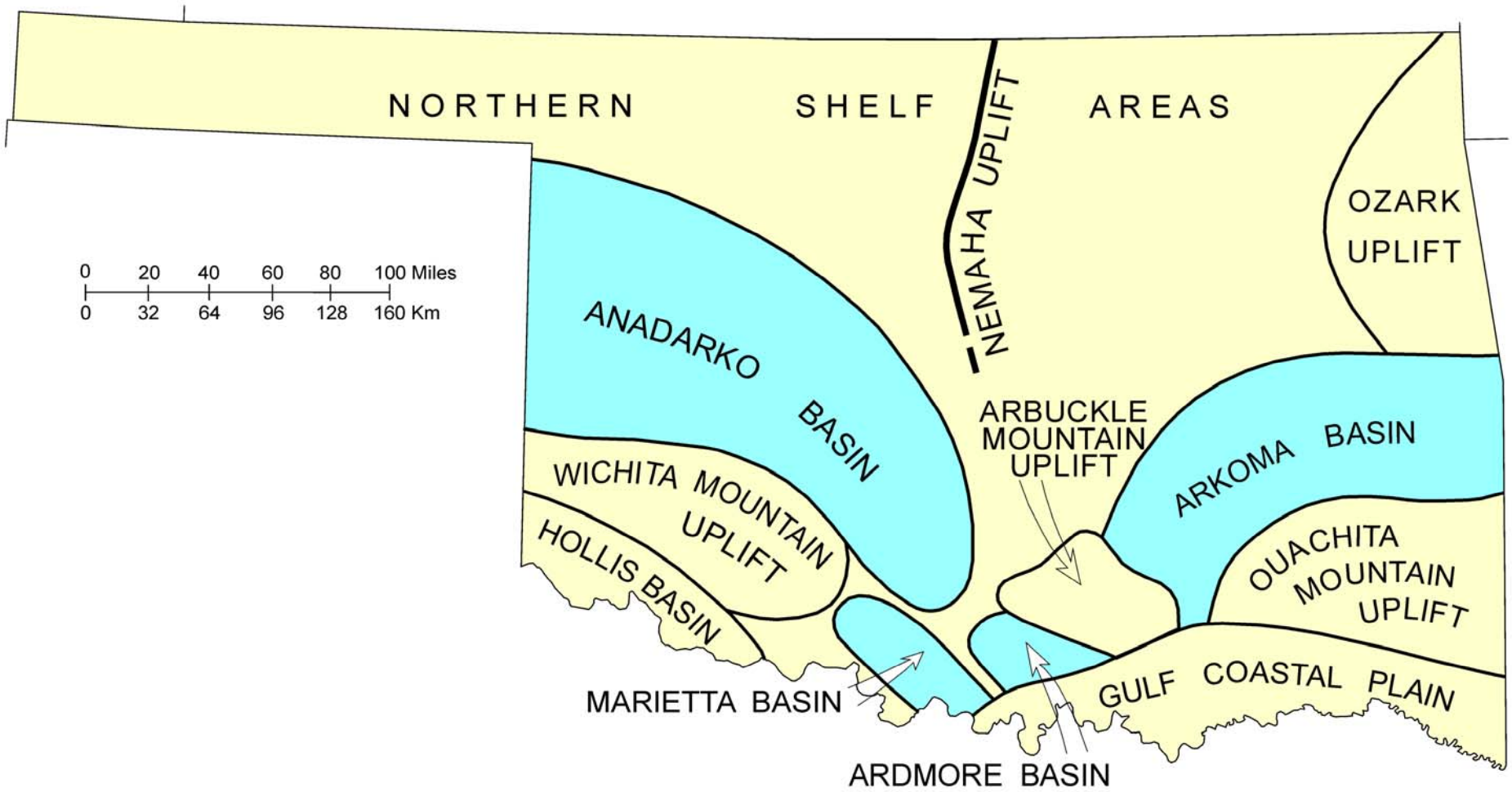
From Lewan, 2002

U.S. Shale Gas Basins

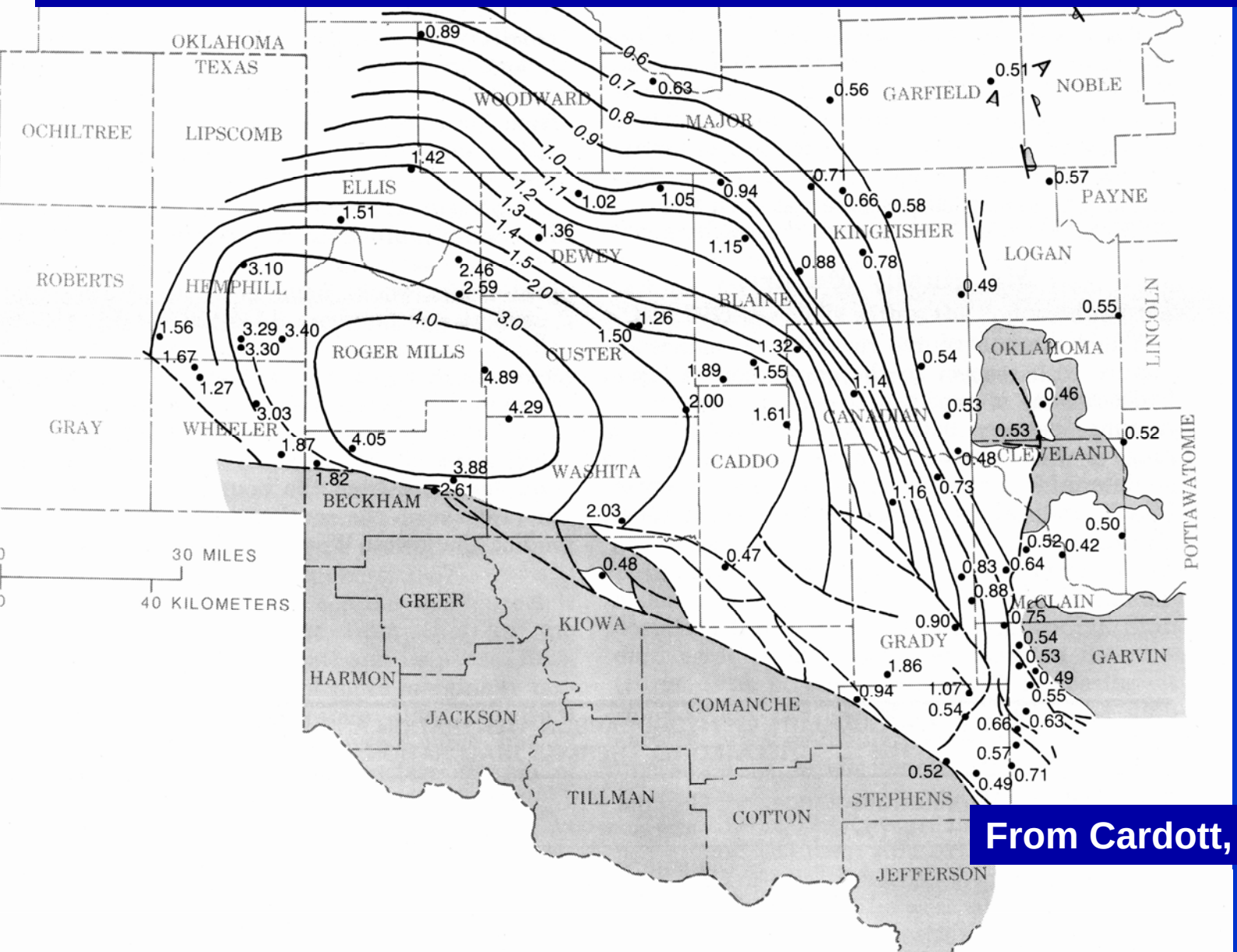


Source: Schlumberger shale gas white paper, 2005

Geologic Provinces of Oklahoma

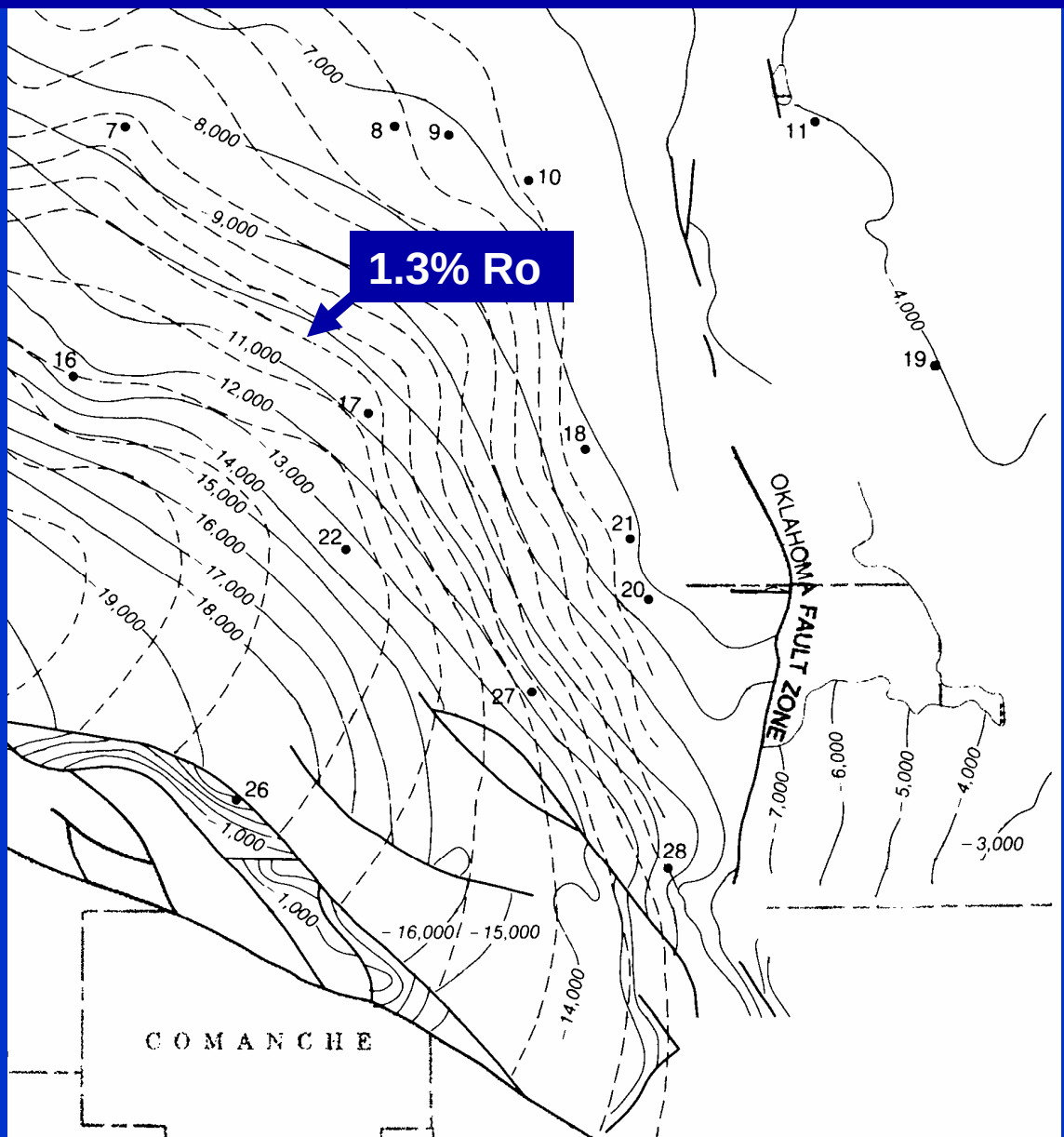


Vitrinite Reflectance of Woodford Shale, Anadarko Basin



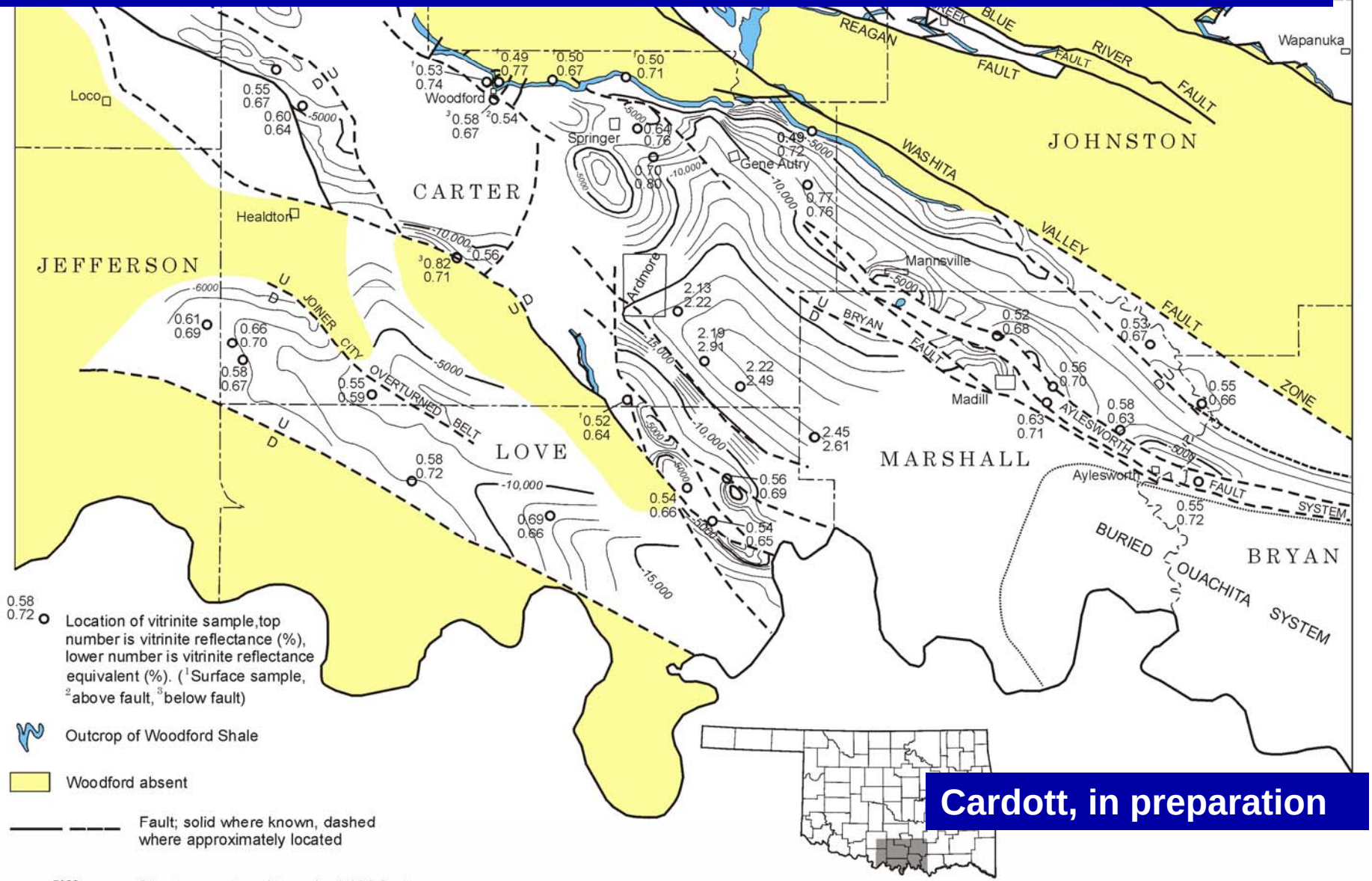
From Cardott, 1989

Structure and Vitrinite Reflectance of Woodford Shale, Anadarko Basin

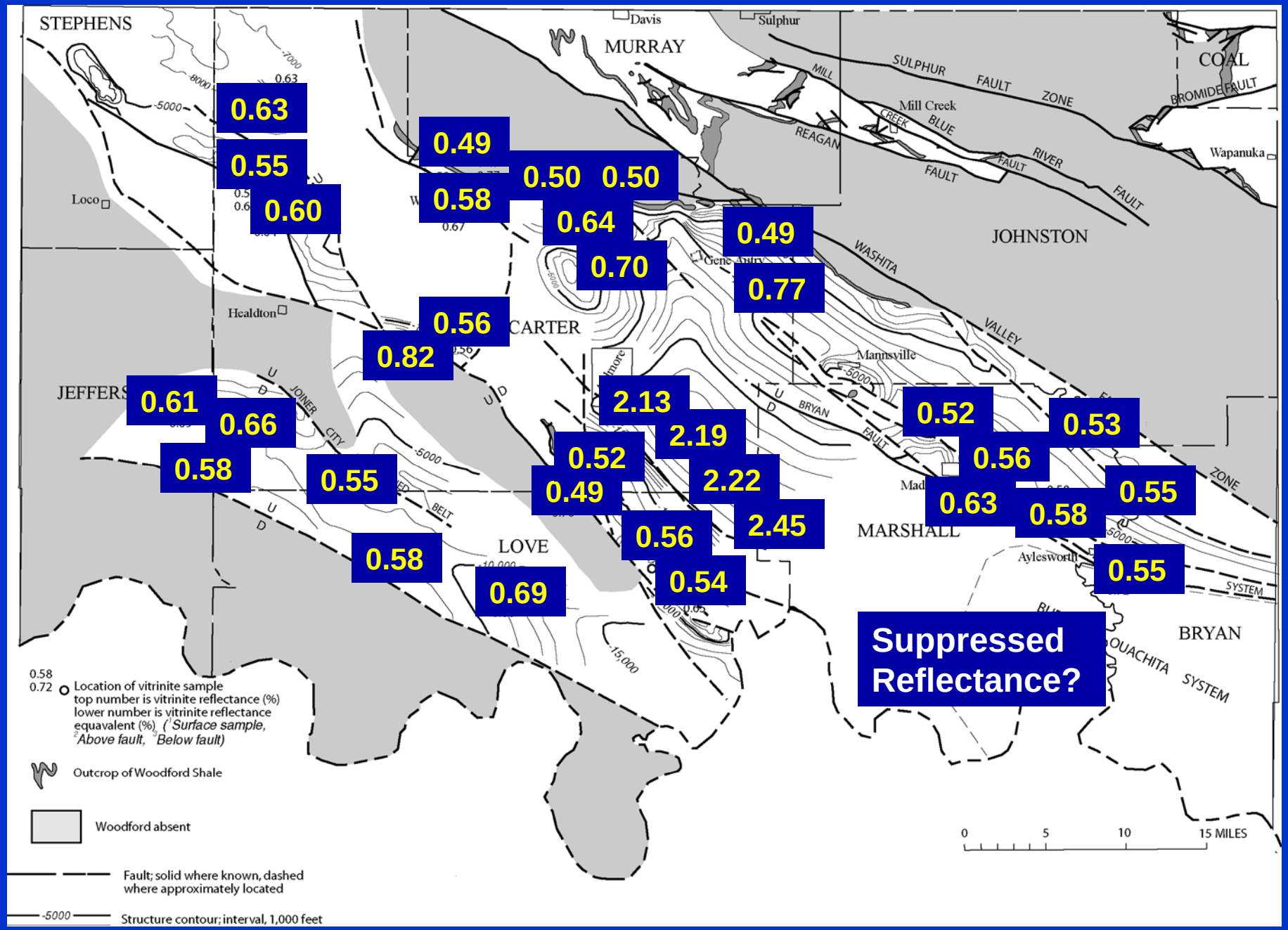


From Cardott and Lambert, 1985

Structure and Vitrinite Reflectance of Woodford Shale, Southern Oklahoma



Cardott, in preparation

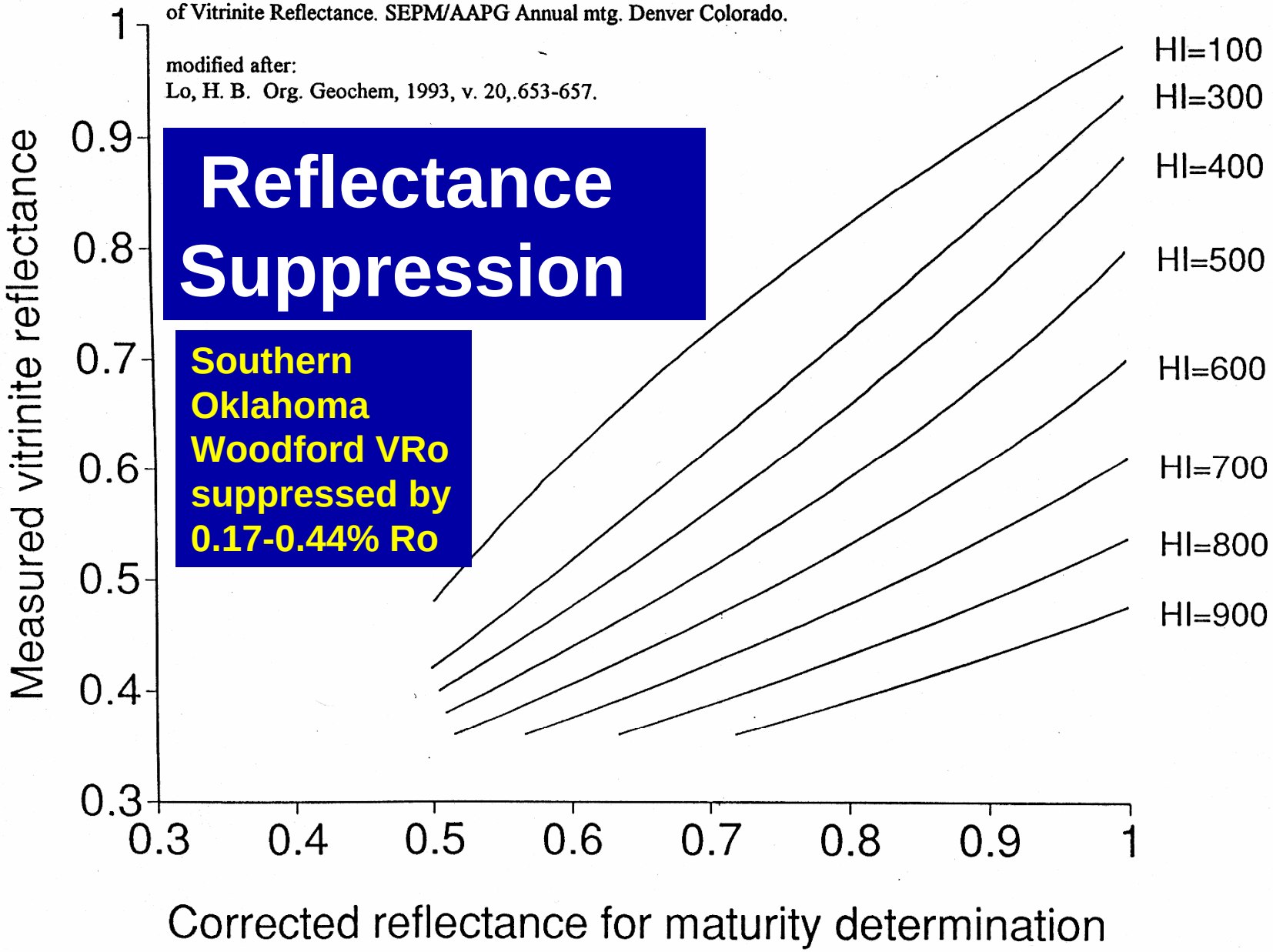

0.63
0.55
0.60
0.49
0.58
0.50
0.50
0.64
0.70
0.49
0.77
0.56
0.82
0.61
0.66
0.58
0.55
2.13
2.19
0.52
0.49
2.22
2.45
0.56
0.54
0.58
0.69
0.52
0.53
0.56
0.63
0.58
0.55
0.55
Suppressed Reflectance?
STEPHENS
MURRAY
Davis
Sulphur
COAL
JOHNSTON
CARTER
LOVE
MARSHALL
BRYAN
JEFFERS
Loco
Healdton
Mannsville
Aylesworth
Wapanuka
Mill Creek
SULPHUR FAULT ZONE
REAGAN
BLUE RIVER FAULT
WASHITA VALLEY FAULT
BROMIDE FAULT
JOINER CITY
BRYAN FAULT
ARBUCKLE MOUNTAIN SYSTEM
OUACHITA SYSTEM
0.58
0.72 Location of vitrinite sample
top number is vitrinite reflectance (%)
lower number is vitrinite reflectance equavalent (%) (1Surface sample, 2Above fault, 3Below fault)
Outcrop of Woodford Shale
Woodford absent
Fault; solid where known, dashed where approximately located
-5000 Structure contour; interval, 1,000 feet
0 5 10 15 MILES

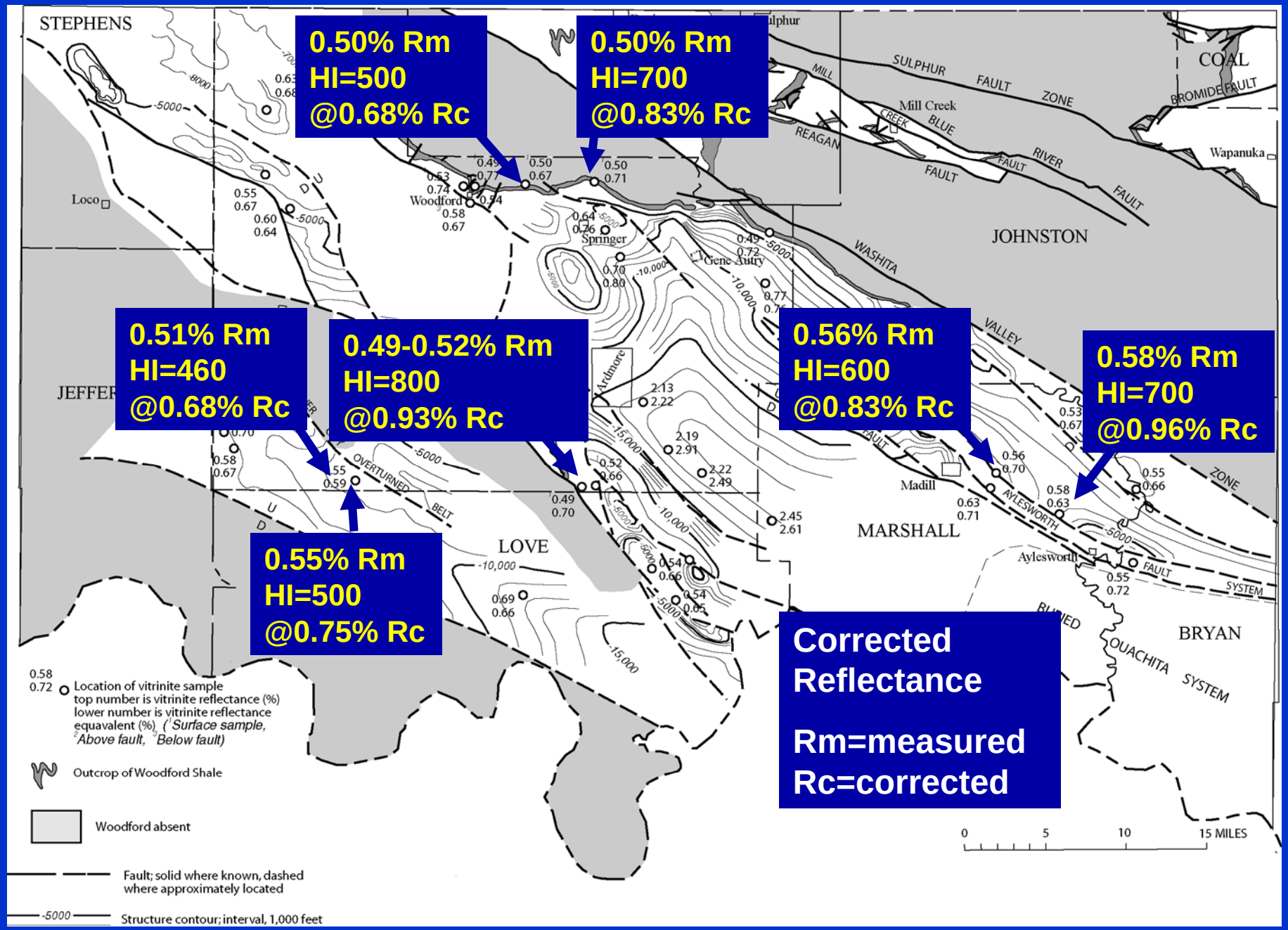
from:
Quick, J. C., Wavrek D. A., 1994, Suppressed reflectance vitrinite:Recognition and correction. , Poster Session on: Thermal Maturity in Sedimentary Bains: Uses and Abuses of Vitrinite Reflectance. SEPM/AAPG Annual mtg. Denver Colorado.

modified after:
Lo, H. B. Org. Geochem, 1993, v. 20,.653-657.

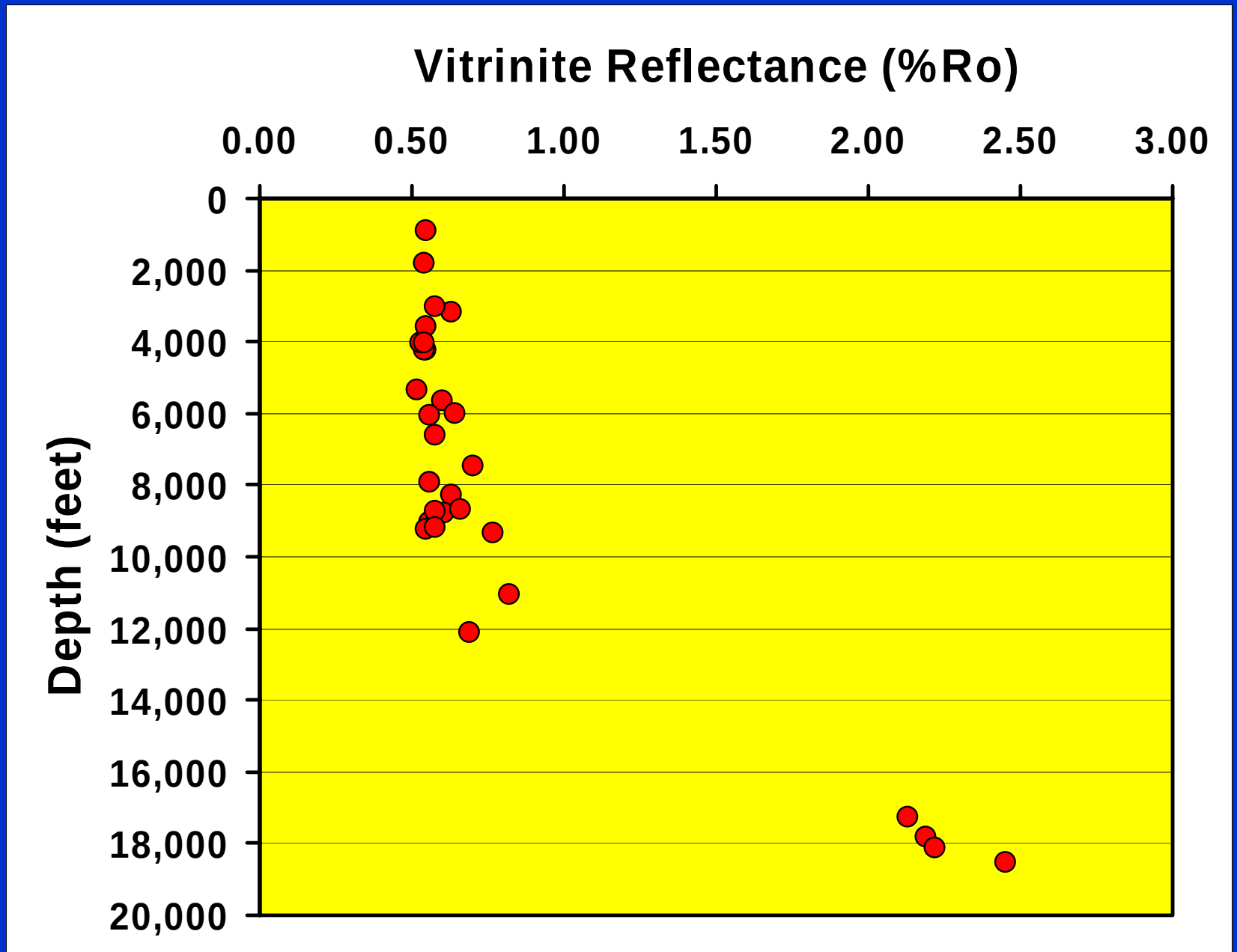
Reflectance Suppression

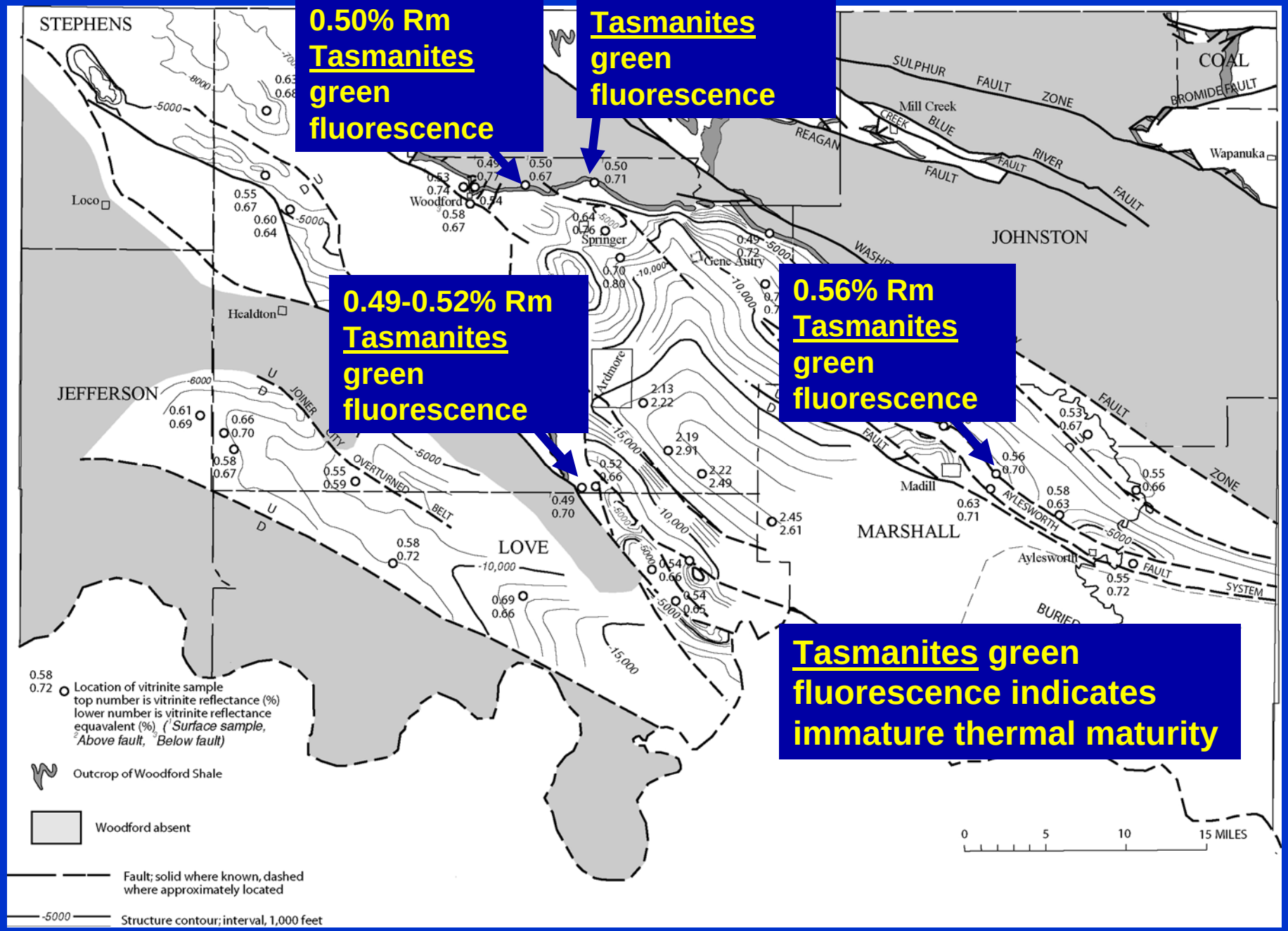
Southern Oklahoma Woodford VRo suppressed by 0.17-0.44% Ro

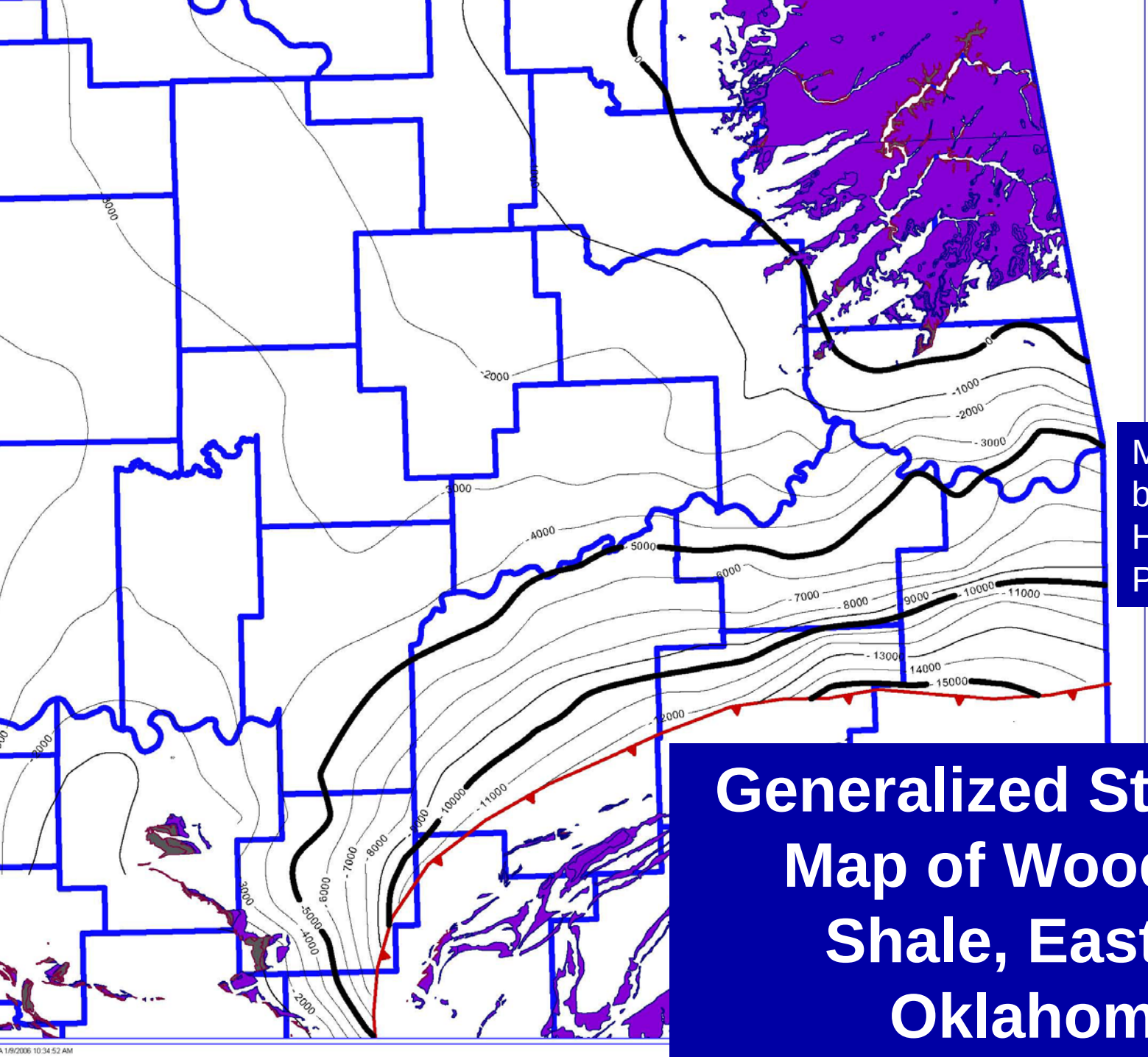



0.50% Rm
HI=500
@0.68% Rc
0.50% Rm
HI=700
@0.83% Rc
0.51% Rm
HI=460
@0.68% Rc
0.49-0.52% Rm
HI=800
@0.93% Rc
0.56% Rm
HI=600
@0.83% Rc
0.58% Rm
HI=700
@0.96% Rc
0.55% Rm
HI=500
@0.75% Rc
Corrected Reflectance
Rm=measured
Rc=corrected
STEPHENS
JOHNSTON
MARSHALL
LOVE
BRYAN
JEFFER
Loco
Woodford
Springer
Gene Autry
Ardmore
Madill
Aylesworth
Wapanuka
COAL
SULPHUR FAULT ZONE
MILL CREEK BLUE REAGAN FAULT
BROMIDE FAULT
WASHITA VALLEY FAULT ZONE
OVERTURNED BELT
OUACHITA SYSTEM
0.58
0.72
Location of vitrinite sample
top number is vitrinite reflectance (%)
lower number is vitrinite reflectance equavalent (%) (1Surface sample, 2Above fault, 3Below fault)
Outcrop of Woodford Shale
Woodford absent
Fault; solid where known, dashed where approximately located
-5000
Structure contour; interval, 1,000 feet
0
5
10
15 MILES

Southern Oklahoma VRo vs Depth



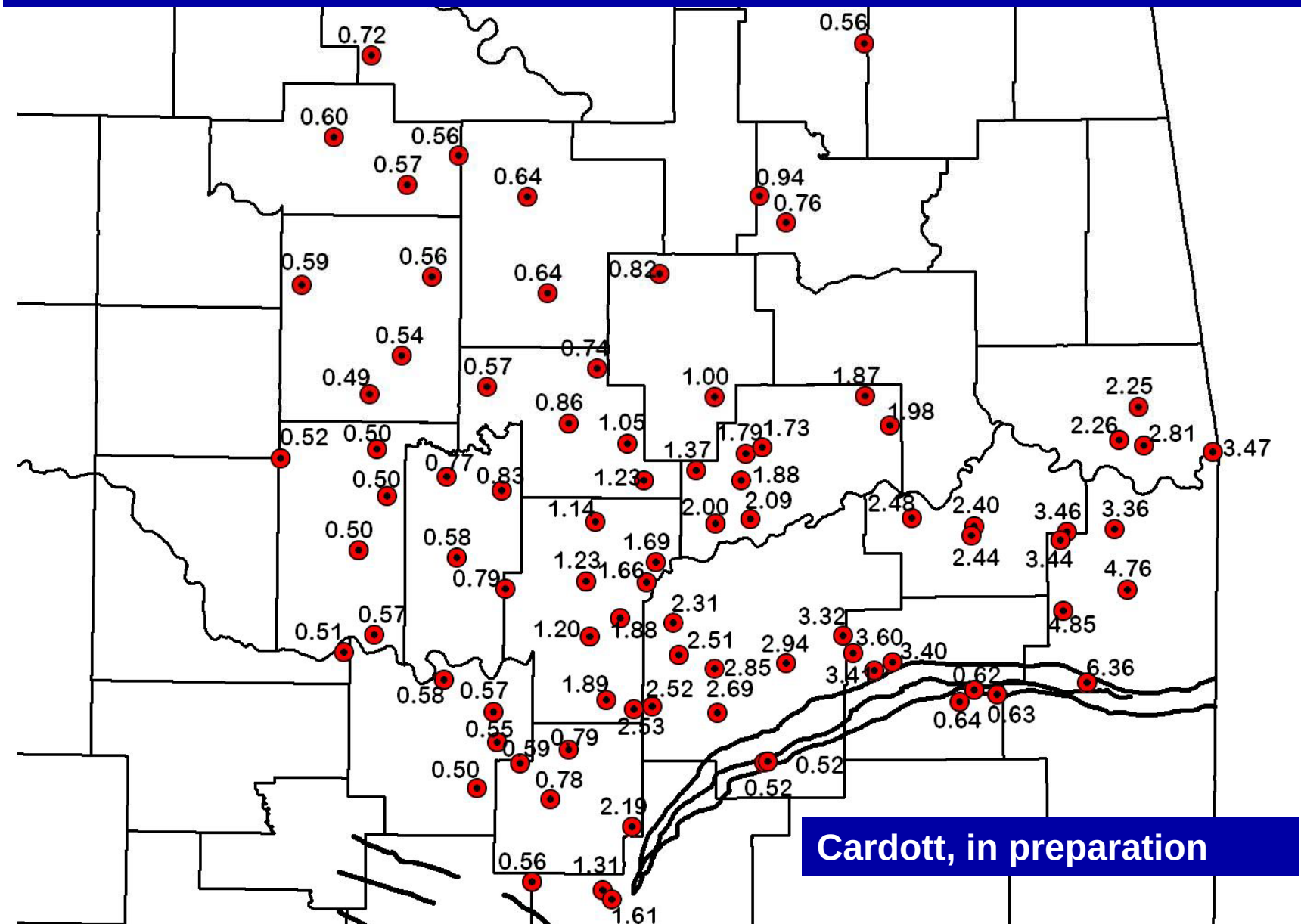

0.50% Rm Tasmanites green fluorescence
0.50% Rm Tasmanites green fluorescence
0.49-0.52% Rm Tasmanites green fluorescence
0.56% Rm Tasmanites green fluorescence
Tasmanites green fluorescence indicates immature thermal maturity
STEPHENS
JEFFERSON
LOVE
MARSHALL
JOHNSTON
COAL
Loco
Healdton
Woodford
Springer
Gene Autry
Ardmore
Madill
Aylesworth
Wapanuka
SULPHUR FAULT ZONE
Mill Creek BLUE CREEK FAULT
REAGAN FAULT
BROMIDE FAULT
RIVER FAULT
JOINER CITY OVERTURNED BELT
AYLESWORTH FAULT ZONE
FAULT SYSTEM
0.58 0.72 Location of vitrinite sample top number is vitrinite reflectance (%) lower number is vitrinite reflectance equavalent (%) (1Surface sample, 2Above fault, 3Below fault)
Outcrop of Woodford Shale
Woodford absent
Fault; solid where known, dashed where approximately located
-5000 Structure contour; interval, 1,000 feet
0 5 10 15 MILES



Map prepared by R. Vance Hall using Petra

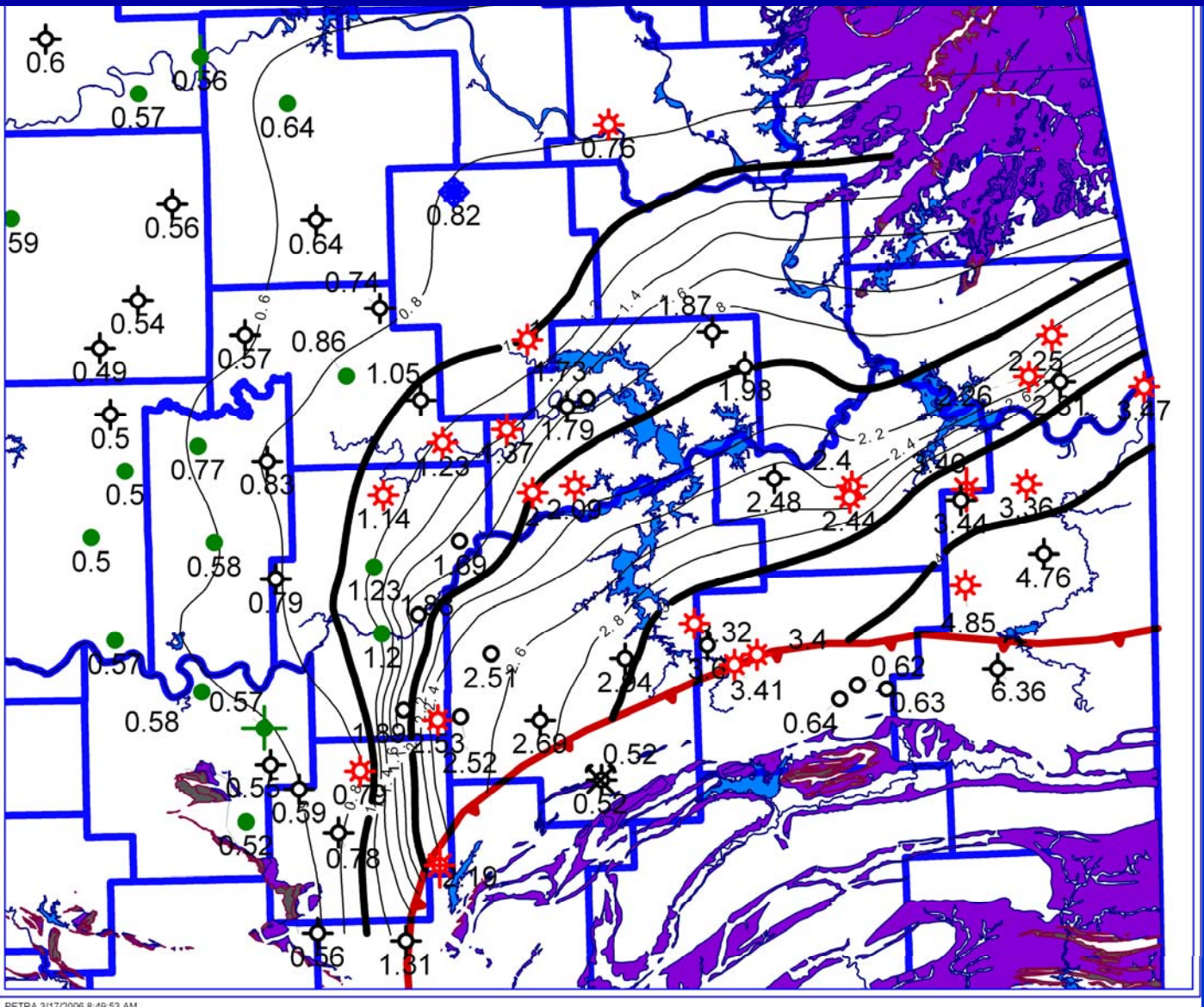
Generalized Structure Map of Woodford Shale, Eastern Oklahoma

Vitrinite Reflectance of Woodford Shale, Eastern Oklahoma



Cardott, in preparation

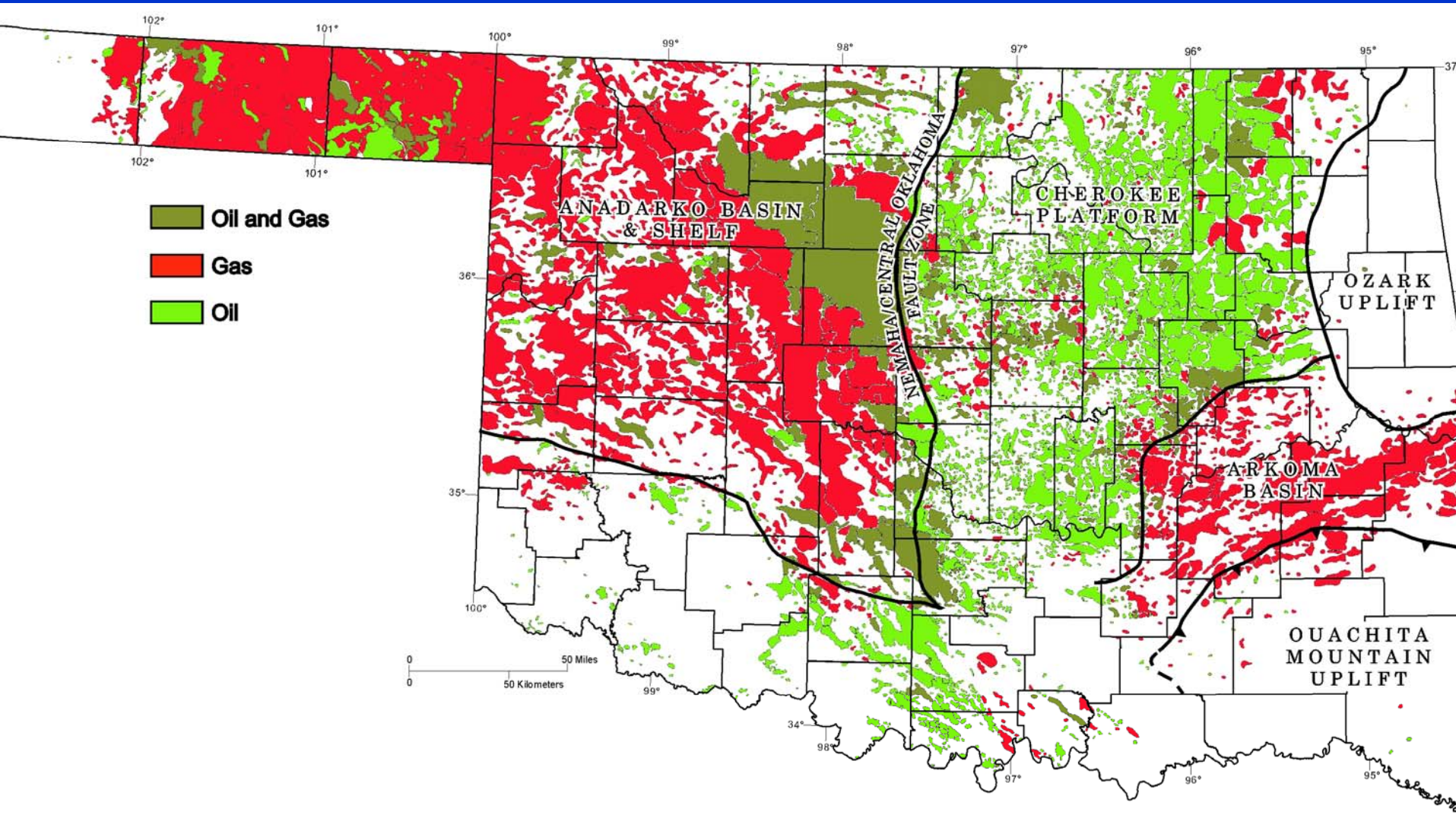
Isoreflectance Map of the Woodford Shale in Eastern Oklahoma



Map prepared by R. Vance Hall using Petra

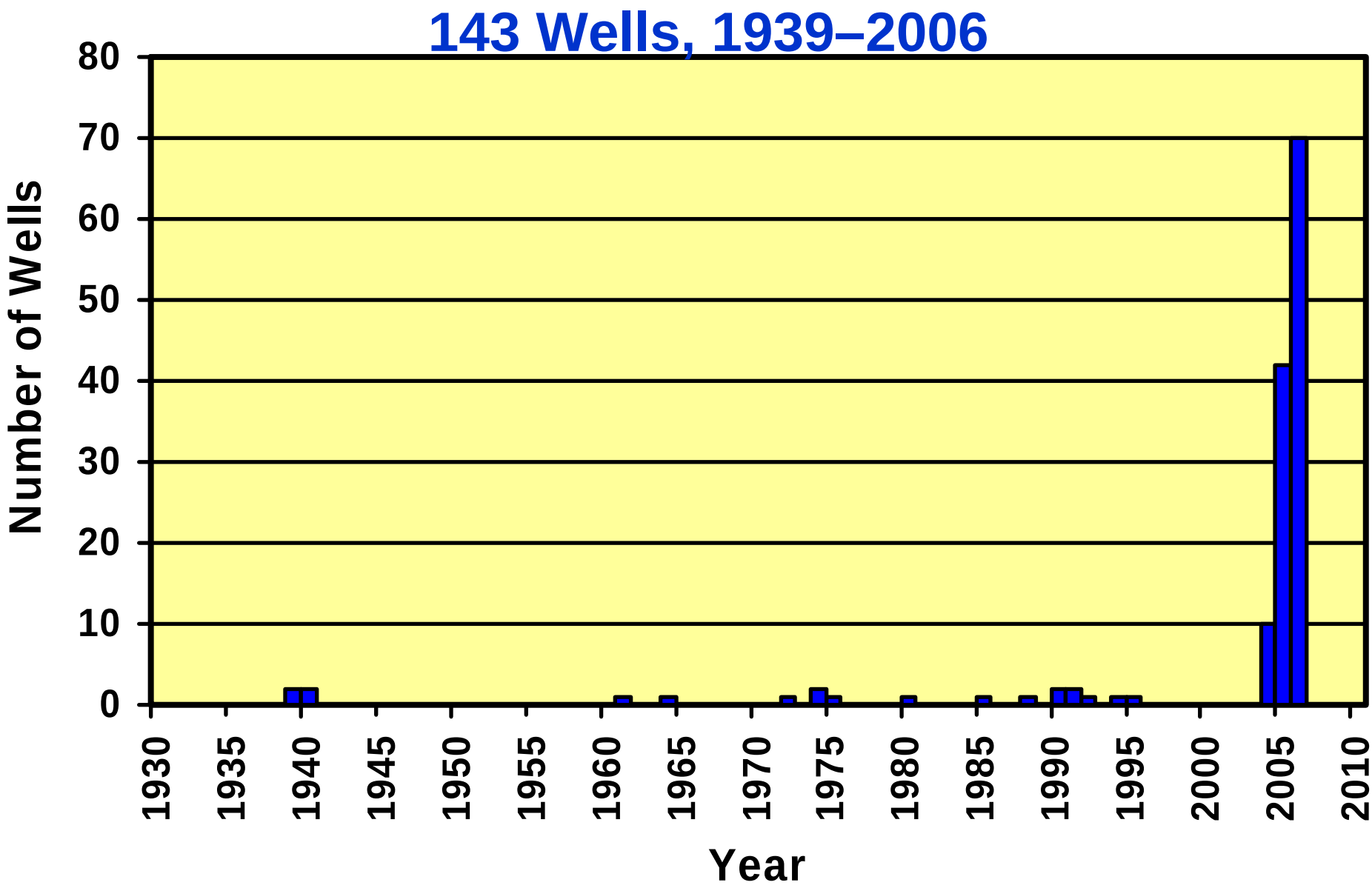
Cardott, in preparation

Oil and Gas Fields Map of Oklahoma



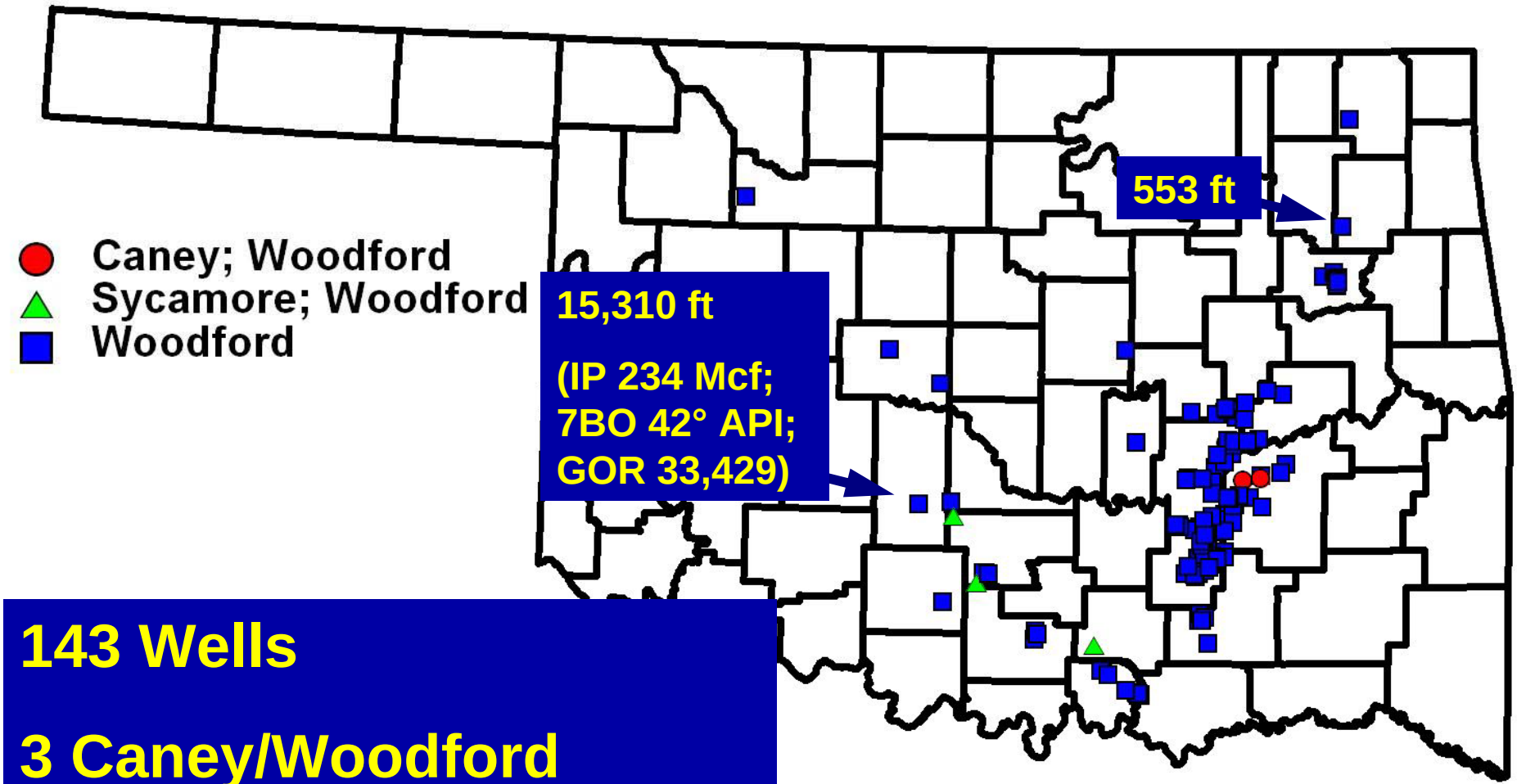
From Boyd, 2006

Woodford Shale GAS Wells



Woodford Gas Shales

1939–2006



143 Wells

3 Caney/Woodford

3 Sycamore/Woodford

Woodford Gas Shales

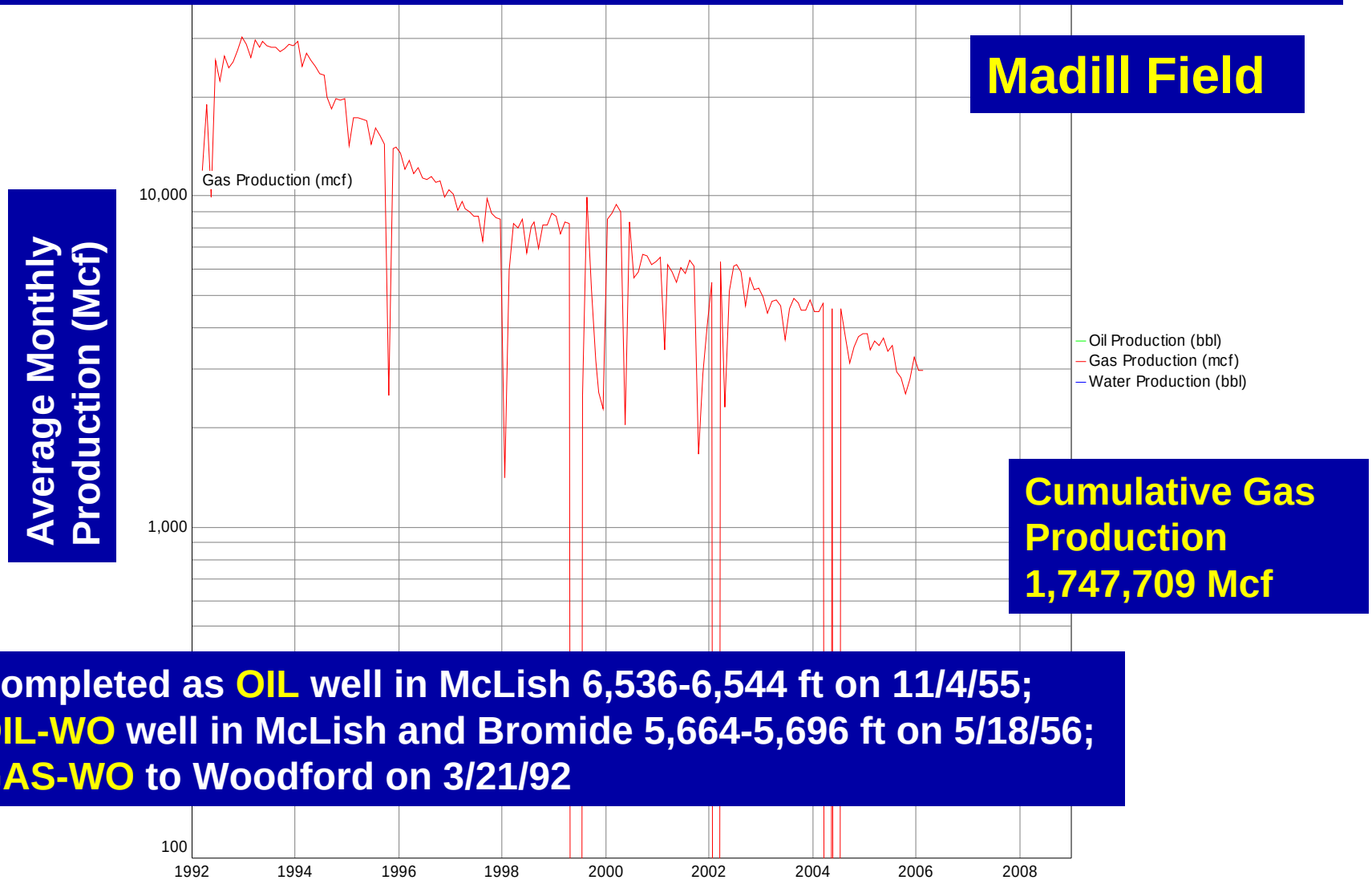
1939-1996

21 Wells

1 Sycamore/Woodford

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

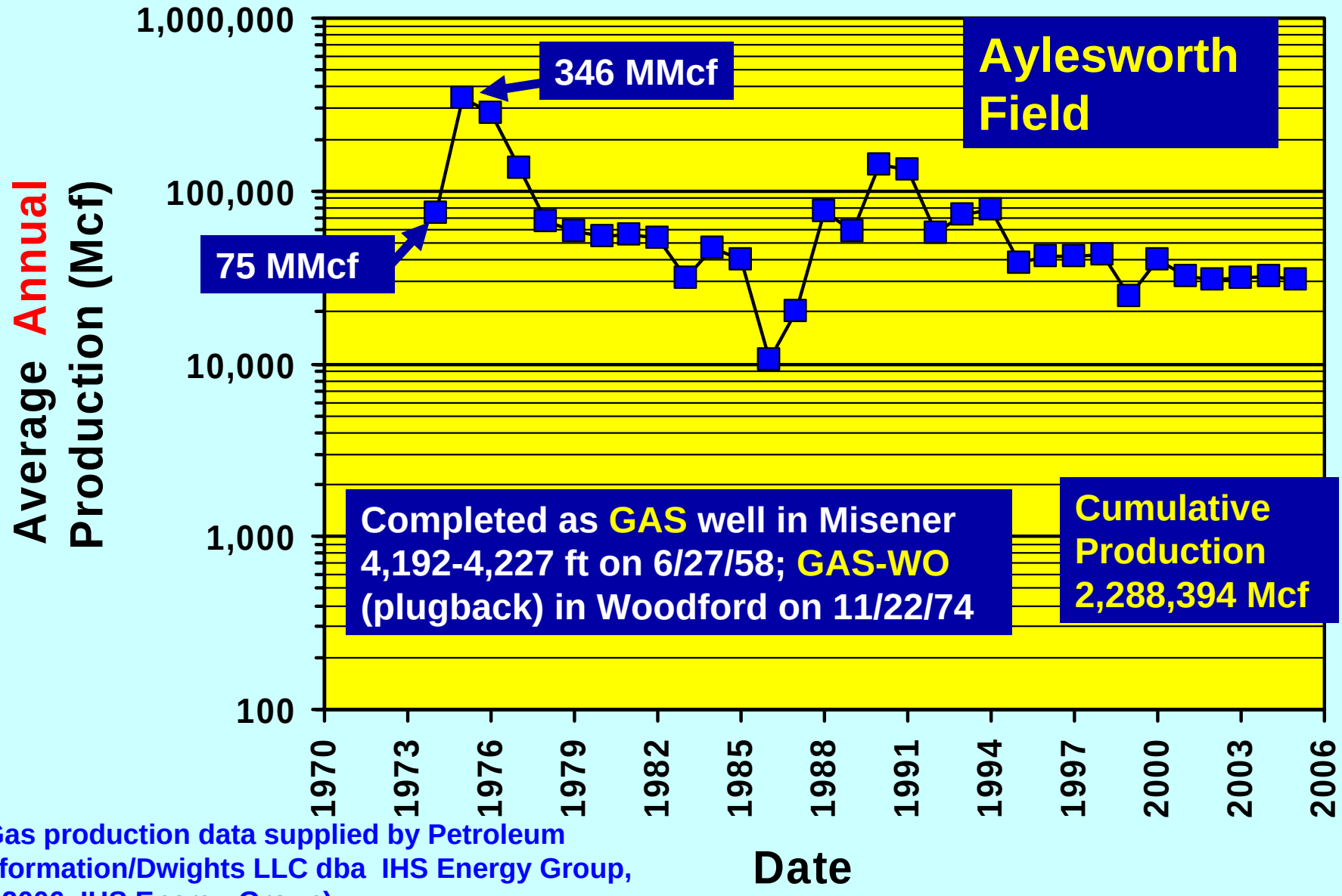
Madill Field



Cumulative Gas Production 1,747,709 Mcf

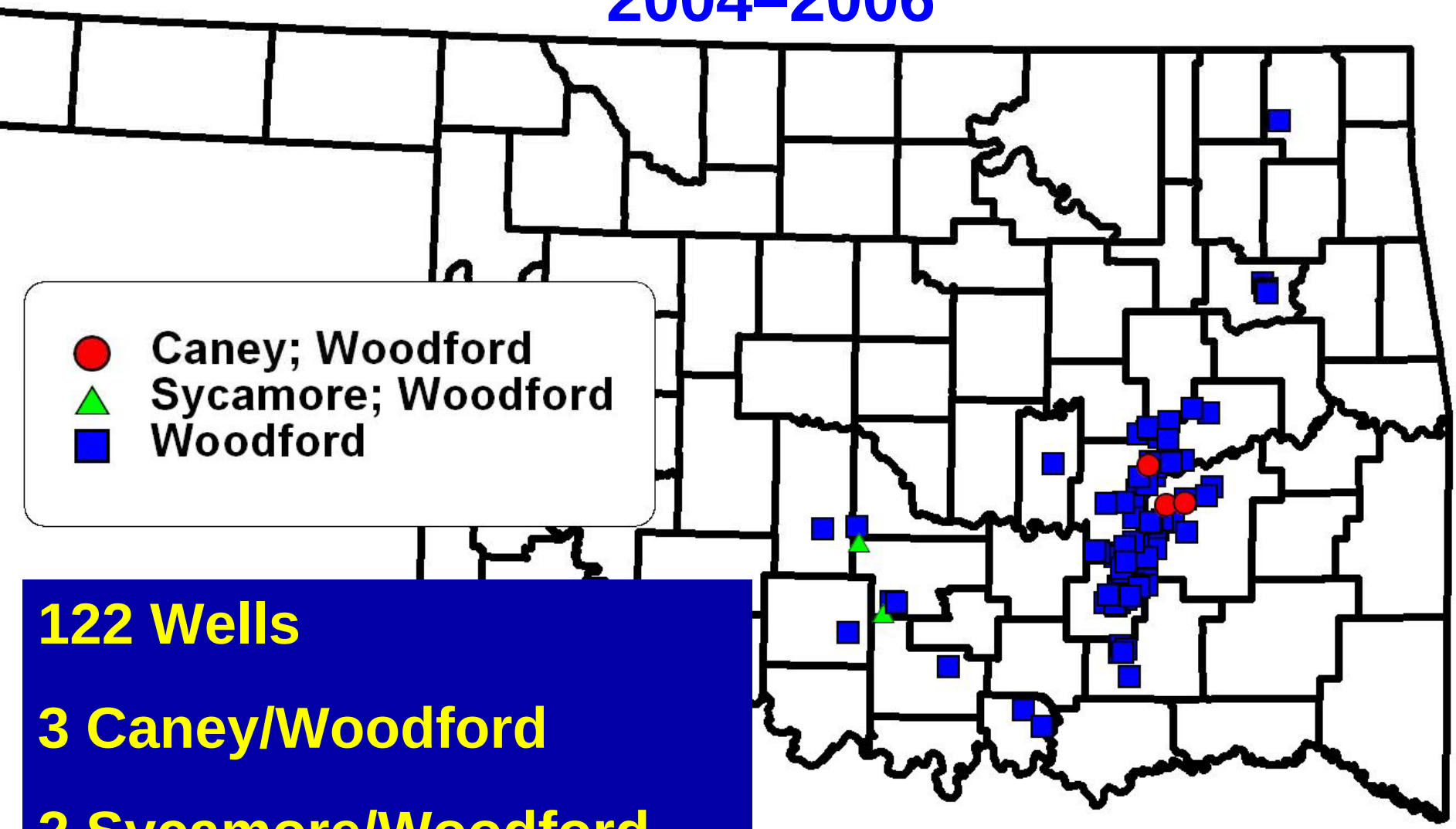
**Completed as OIL well in McLish 6,536-6,544 ft on 11/4/55;
OIL-WO well in McLish and Bromide 5,664-5,696 ft on 5/18/56;
GAS-WO to Woodford on 3/21/92**

Verdad Oil & Gas 1 Mary Haynie
(Bryan CO, 22-6S-7E; IP 962 Mcfd; 3,710-4,054 ft)



Woodford Gas Shales

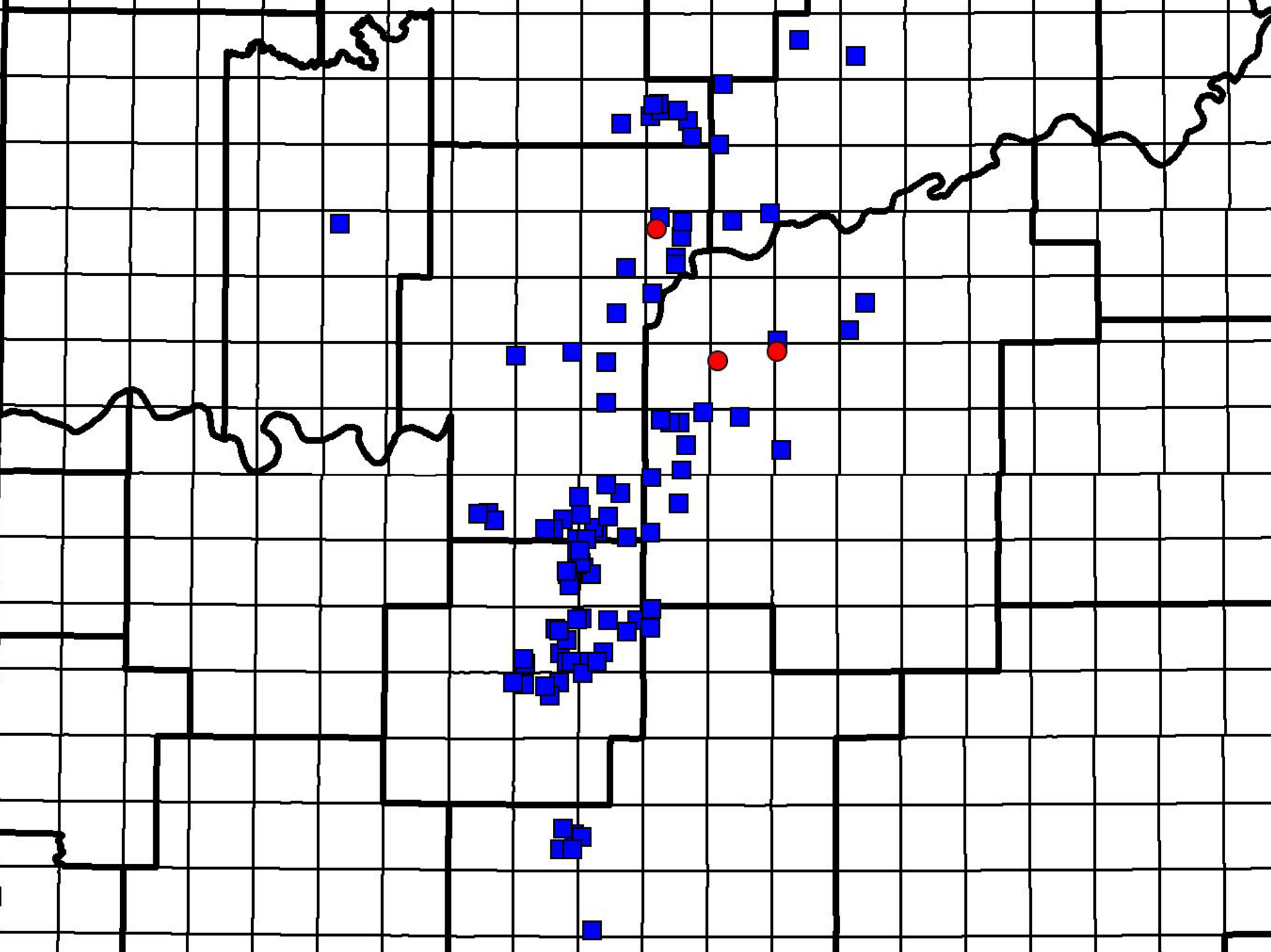
2004–2006

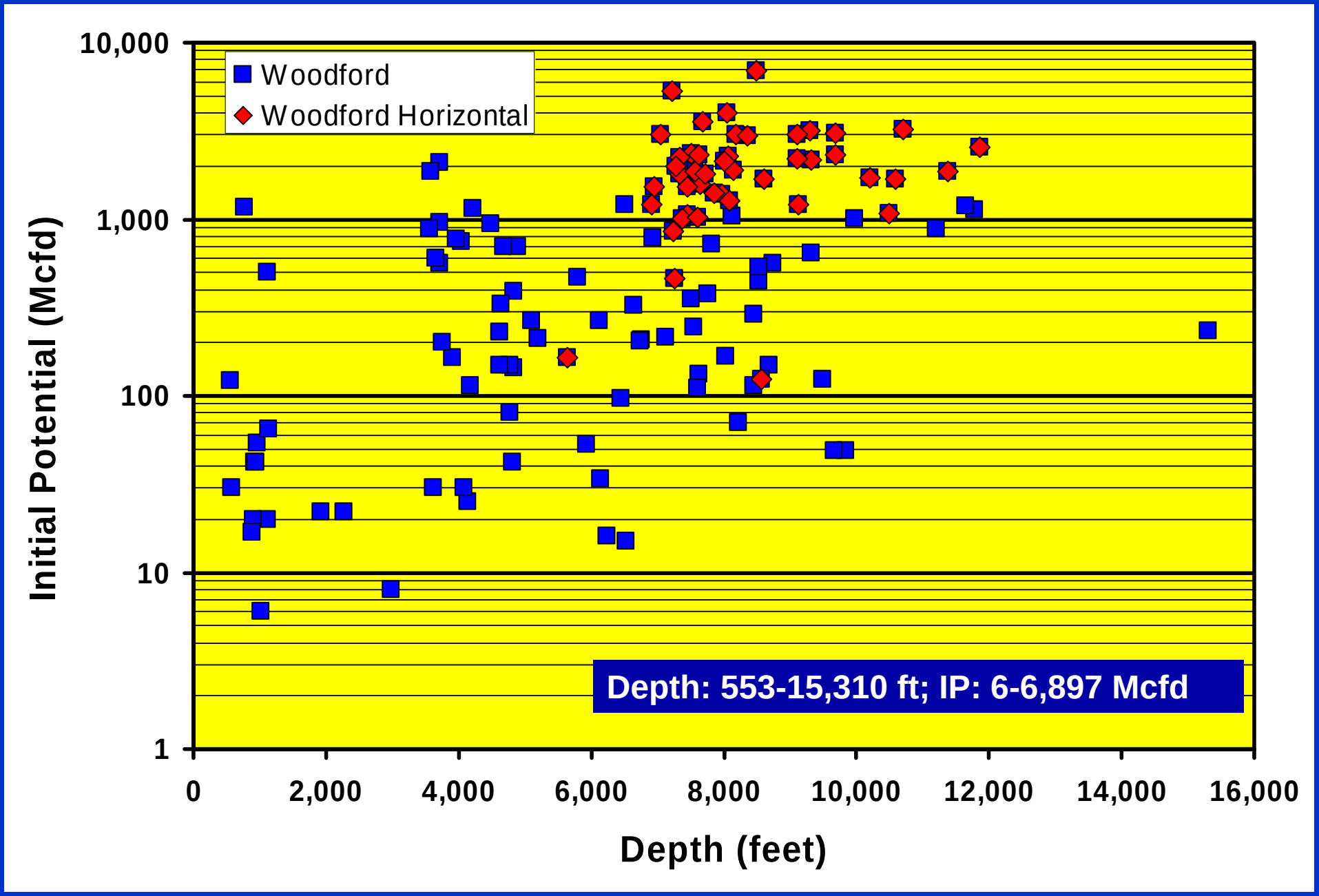


122 Wells

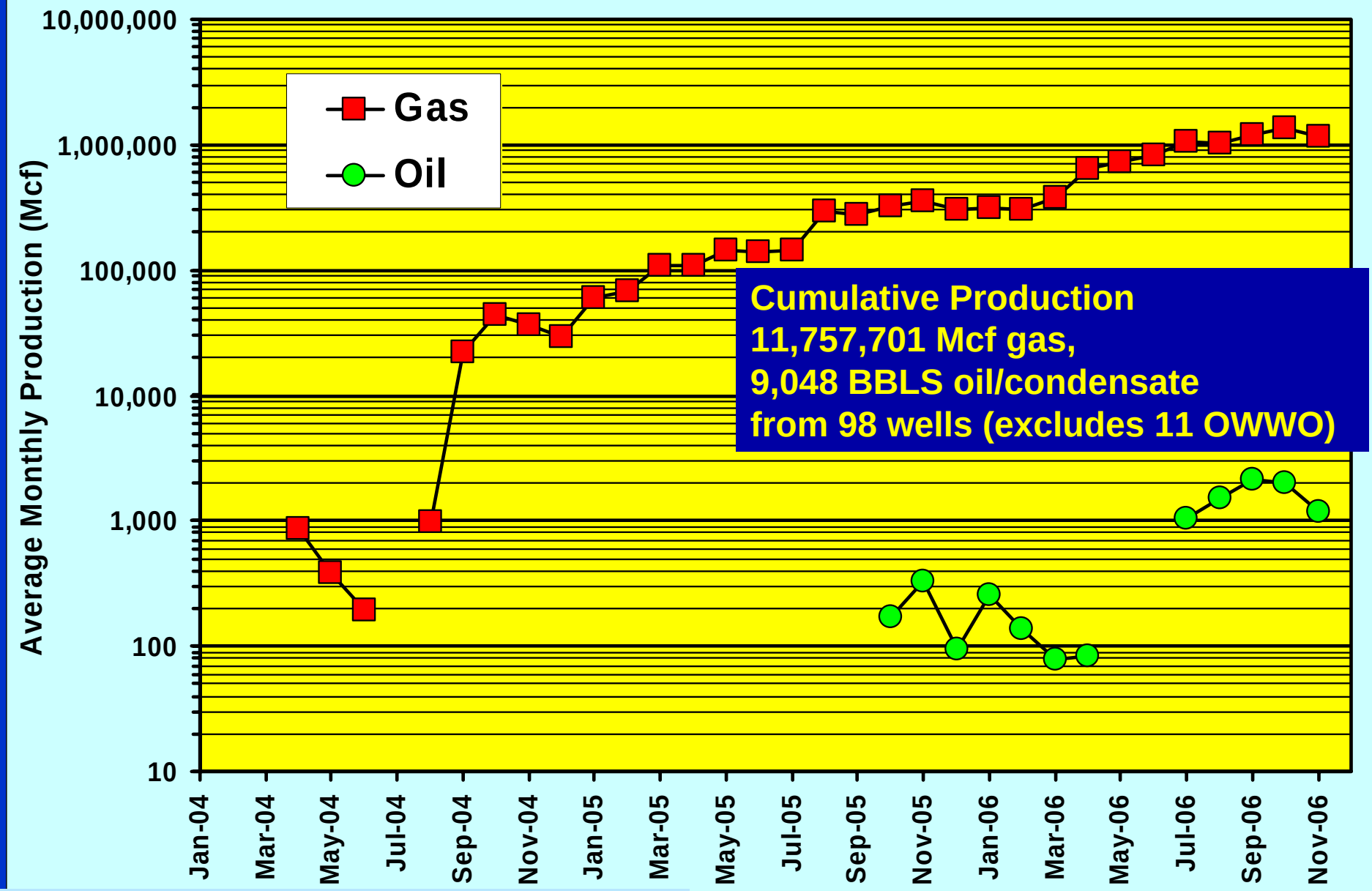
3 Caney/Woodford

2 Sycamore/Woodford

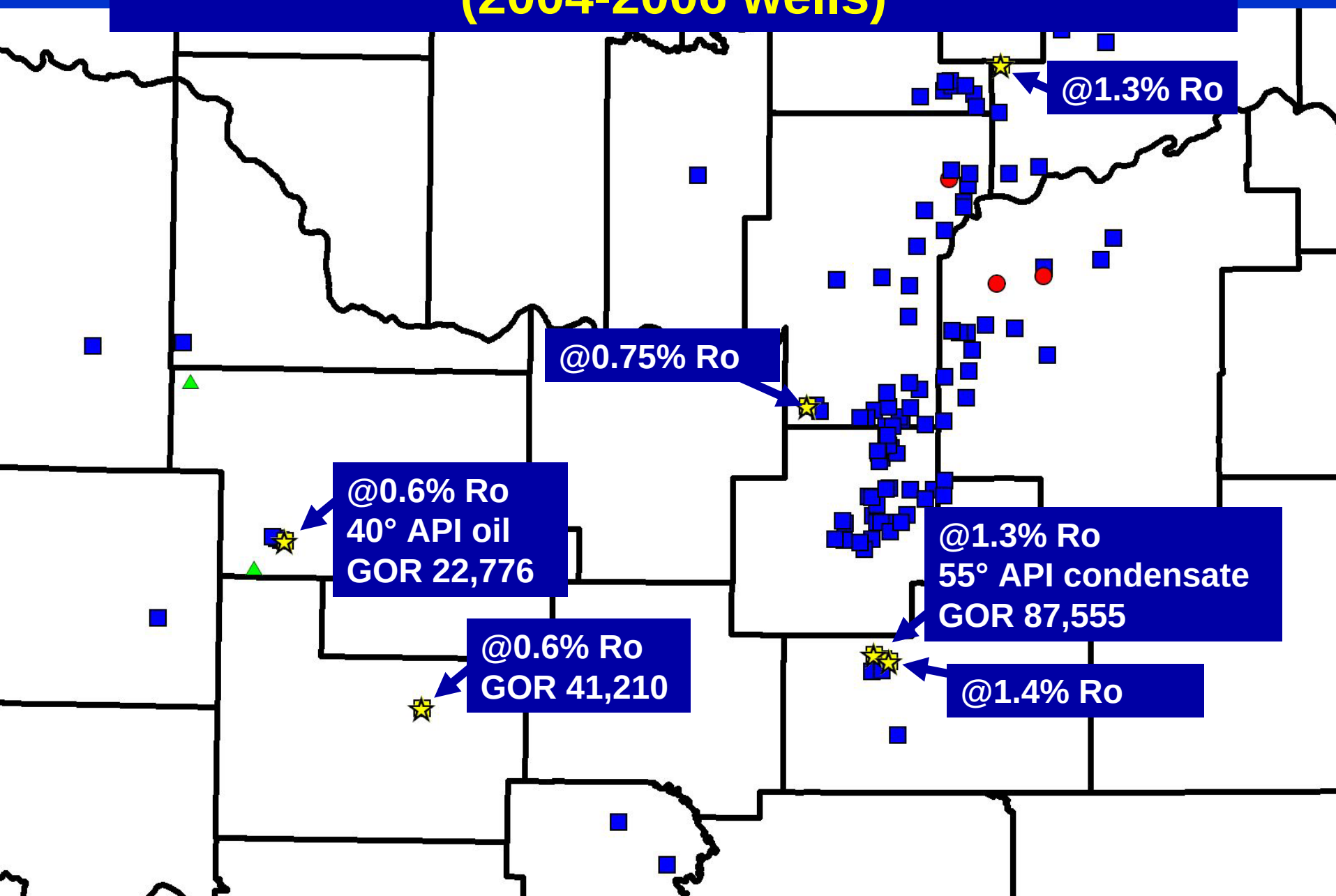



Woodford
Woodford Horizontal
10,000
1,000
100
10
1
Initial Potential (Mcfd)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
Depth (feet)
Depth: 553-15,310 ft; IP: 6-6,897 Mcfd

Woodford Shale Production (2004-2006 wells)



Woodford Shale Oil/Condensate Production (2004-2006 wells)



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- Oklahoma Stratigraphic Columns
- Links
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Oklahoma Hydrocarbon Source Rocks and Gas Shales

- References
- Presentations & Reports
- Oklahoma Gas-Shale Completions Map, 1939-2006
- Oklahoma Gas-Shale Completions Map, 2002-2006
- Gas Shales Database

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

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

ment: Done (0.359 secs)

References

Brian J. Cardott
Oklahoma Geological Survey

Bibliography of Caney Shale

Bibliography of Excello Shale

Bibliography of Woodford Shale

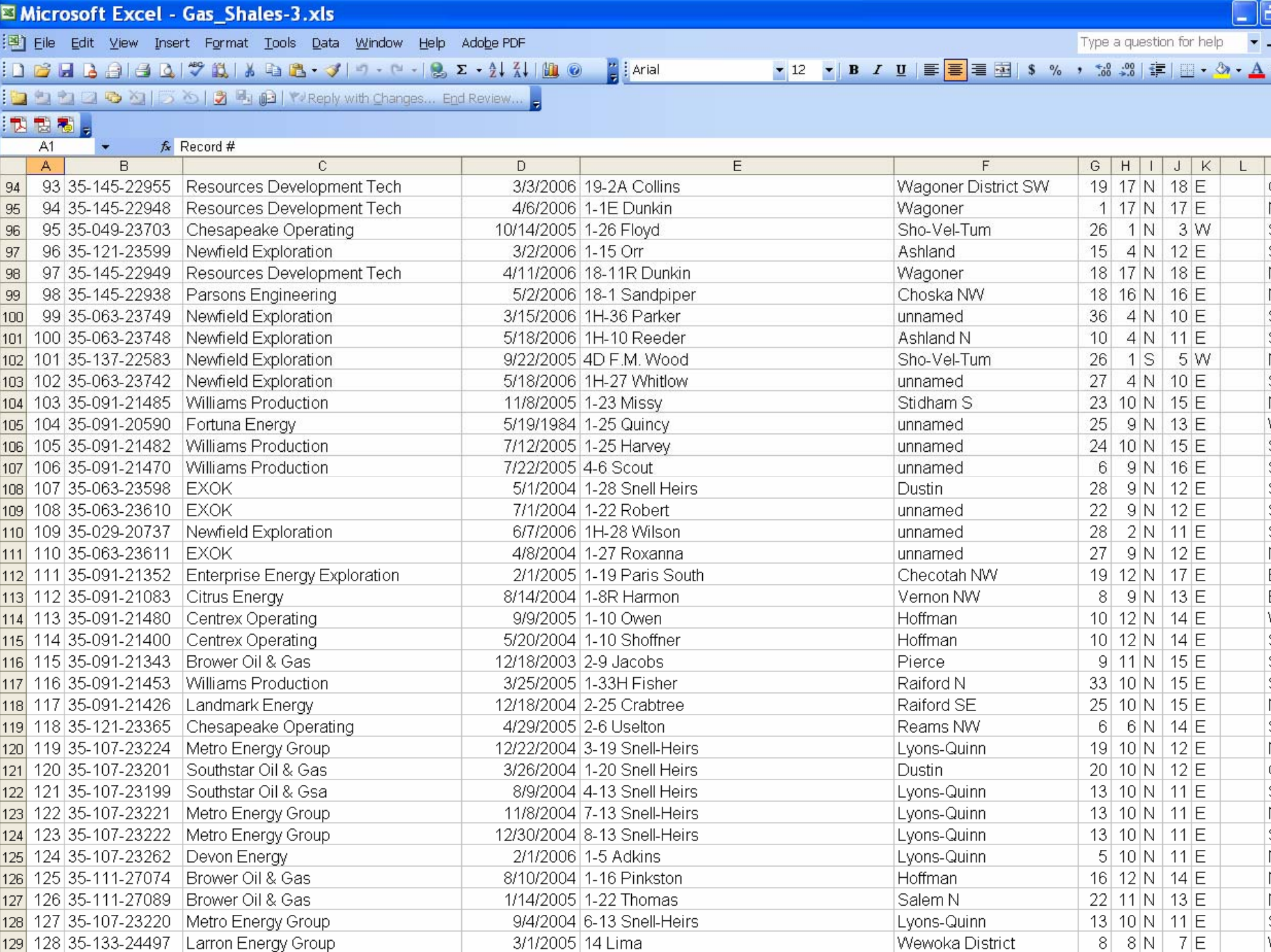
Bibliography of Oklahoma Asphalt

Bibliography of Oklahoma Rock-Eval

Bibliography of Oklahoma Solid Hydrocarbons

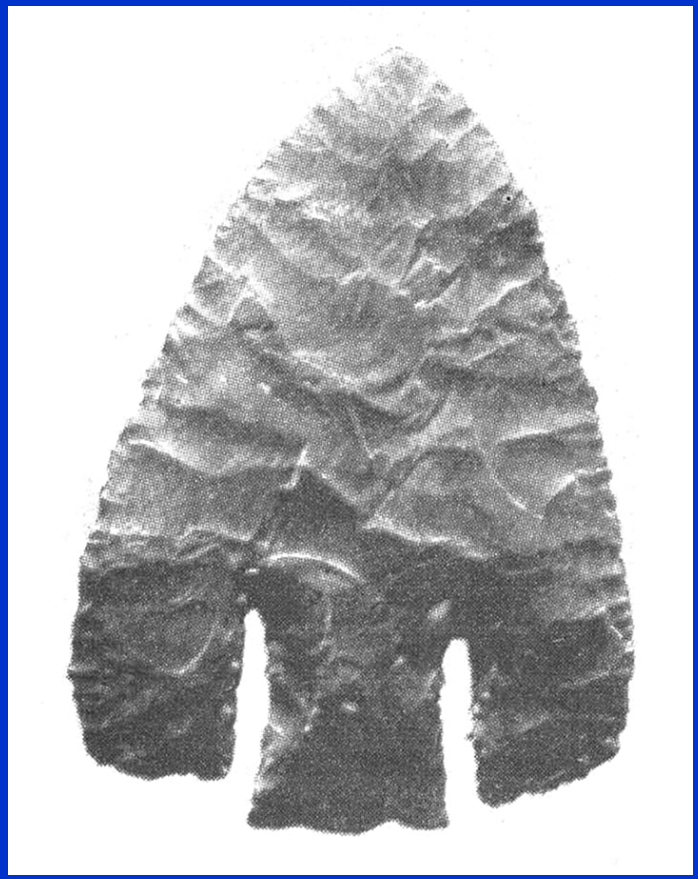
Bibliography of Oklahoma Gas Shales

Bibliography of Oklahoma Hydrocarbon Source Rocks



	A	B	C	D	E	F	G	H	I	J	K	L
94	93	35-145-22955	Resources Development Tech	3/3/2006	19-2A Collins	Wagoner District SW	19	17	N	18	E	
95	94	35-145-22948	Resources Development Tech	4/6/2006	1-1E Dunkin	Wagoner	1	17	N	17	E	
96	95	35-049-23703	Chesapeake Operating	10/14/2005	1-26 Floyd	Sho-Vel-Tum	26	1	N	3	W	
97	96	35-121-23599	Newfield Exploration	3/2/2006	1-15 Orr	Ashland	15	4	N	12	E	
98	97	35-145-22949	Resources Development Tech	4/11/2006	18-11R Dunkin	Wagoner	18	17	N	18	E	
99	98	35-145-22938	Parsons Engineering	5/2/2006	18-1 Sandpiper	Choska NW	18	16	N	16	E	
100	99	35-063-23749	Newfield Exploration	3/15/2006	1H-36 Parker	unnamed	36	4	N	10	E	
101	100	35-063-23748	Newfield Exploration	5/18/2006	1H-10 Reeder	Ashland N	10	4	N	11	E	
102	101	35-137-22583	Newfield Exploration	9/22/2005	4D F.M. Wood	Sho-Vel-Tum	26	1	S	5	W	
103	102	35-063-23742	Newfield Exploration	5/18/2006	1H-27 Whitlow	unnamed	27	4	N	10	E	
104	103	35-091-21485	Williams Production	11/8/2005	1-23 Missy	Stidham S	23	10	N	15	E	
105	104	35-091-20590	Fortuna Energy	5/19/1984	1-25 Quincy	unnamed	25	9	N	13	E	
106	105	35-091-21482	Williams Production	7/12/2005	1-25 Harvey	unnamed	24	10	N	15	E	
107	106	35-091-21470	Williams Production	7/22/2005	4-6 Scout	unnamed	6	9	N	16	E	
108	107	35-063-23598	EXOK	5/1/2004	1-28 Snell Heirs	Dustin	28	9	N	12	E	
109	108	35-063-23610	EXOK	7/1/2004	1-22 Robert	unnamed	22	9	N	12	E	
110	109	35-029-20737	Newfield Exploration	6/7/2006	1H-28 Wilson	unnamed	28	2	N	11	E	
111	110	35-063-23611	EXOK	4/8/2004	1-27 Roxanna	unnamed	27	9	N	12	E	
112	111	35-091-21352	Enterprise Energy Exploration	2/1/2005	1-19 Paris South	Checotah NW	19	12	N	17	E	
113	112	35-091-21083	Citrus Energy	8/14/2004	1-8R Harmon	Vernon NW	8	9	N	13	E	
114	113	35-091-21480	Centrex Operating	9/9/2005	1-10 Owen	Hoffman	10	12	N	14	E	
115	114	35-091-21400	Centrex Operating	5/20/2004	1-10 Shoffner	Hoffman	10	12	N	14	E	
116	115	35-091-21343	Brower Oil & Gas	12/18/2003	2-9 Jacobs	Pierce	9	11	N	15	E	
117	116	35-091-21453	Williams Production	3/25/2005	1-33H Fisher	Raiford N	33	10	N	15	E	
118	117	35-091-21426	Landmark Energy	12/18/2004	2-25 Crabtree	Raiford SE	25	10	N	15	E	
119	118	35-121-23365	Chesapeake Operating	4/29/2005	2-6 Uselton	Reams NW	6	6	N	14	E	
120	119	35-107-23224	Metro Energy Group	12/22/2004	3-19 Snell-Heirs	Lyons-Quinn	19	10	N	12	E	
121	120	35-107-23201	Southstar Oil & Gas	3/26/2004	1-20 Snell Heirs	Dustin	20	10	N	12	E	
122	121	35-107-23199	Southstar Oil & Gsa	8/9/2004	4-13 Snell Heirs	Lyons-Quinn	13	10	N	11	E	
123	122	35-107-23221	Metro Energy Group	11/8/2004	7-13 Snell-Heirs	Lyons-Quinn	13	10	N	11	E	
124	123	35-107-23222	Metro Energy Group	12/30/2004	8-13 Snell-Heirs	Lyons-Quinn	13	10	N	11	E	
125	124	35-107-23262	Devon Energy	2/1/2006	1-5 Adkins	Lyons-Quinn	5	10	N	11	E	
126	125	35-111-27074	Brower Oil & Gas	8/10/2004	1-16 Pinkston	Hoffman	16	12	N	14	E	
127	126	35-111-27089	Brower Oil & Gas	1/14/2005	1-22 Thomas	Salem N	22	11	N	13	E	
128	127	35-107-23220	Metro Energy Group	9/4/2004	6-13 Snell-Heirs	Lyons-Quinn	13	10	N	11	E	
129	128	35-133-24497	Larron Energy Group	3/1/2005	14 Lima	Wewoka District	8	8	N	7	E	

THANK YOU



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