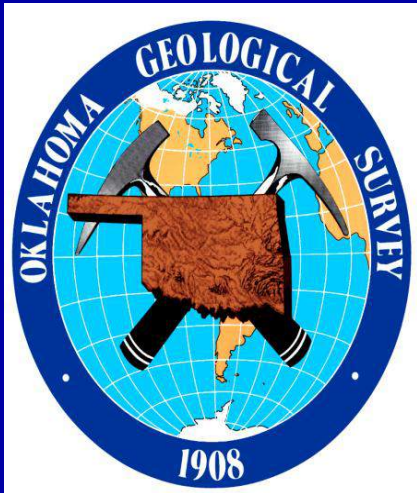


AAPG Mid-Continent
Section Meeting

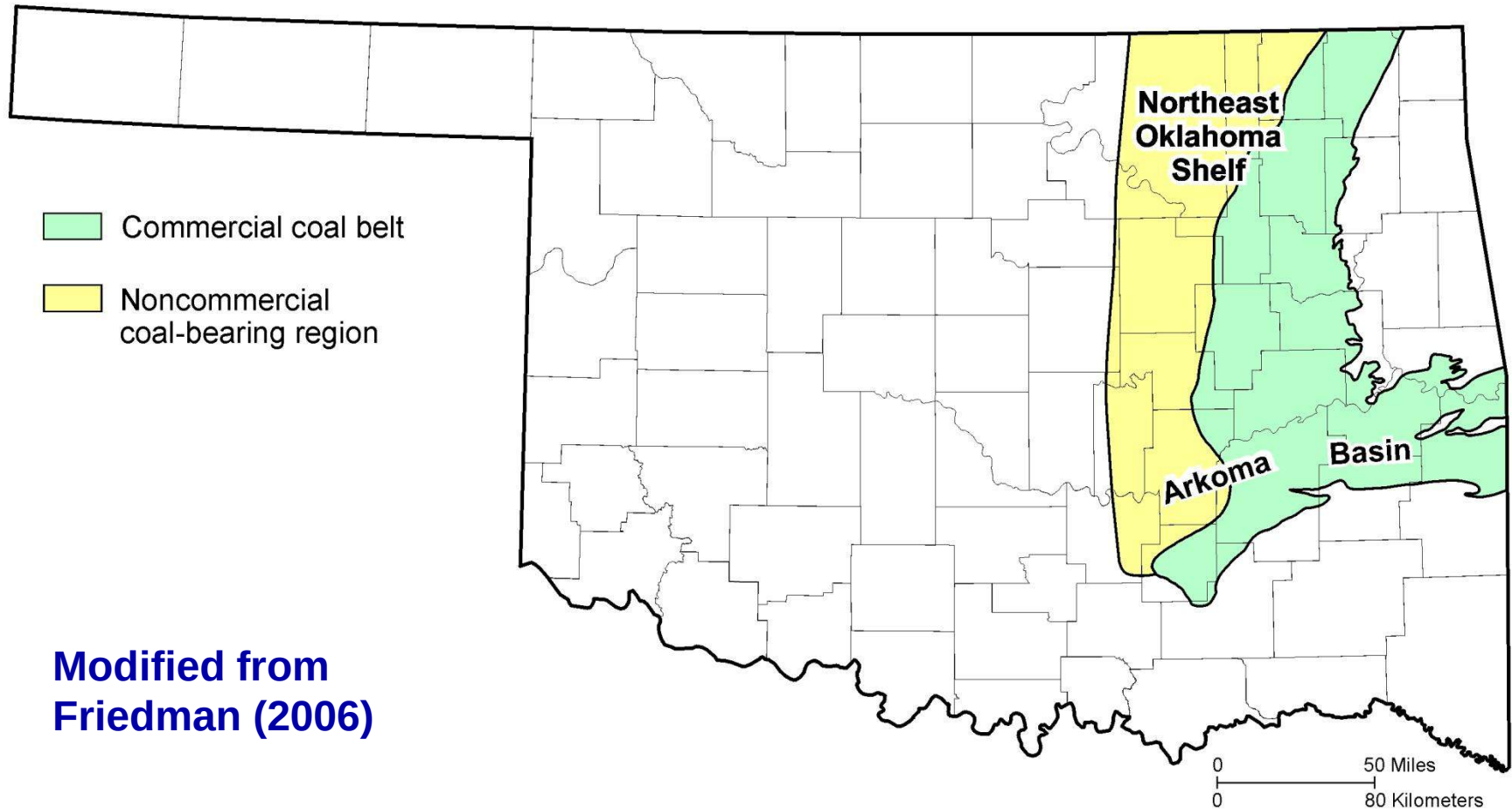
October 12, 2009

Two Decades of Oklahoma Coalbed-Methane Activity, 1988-2008

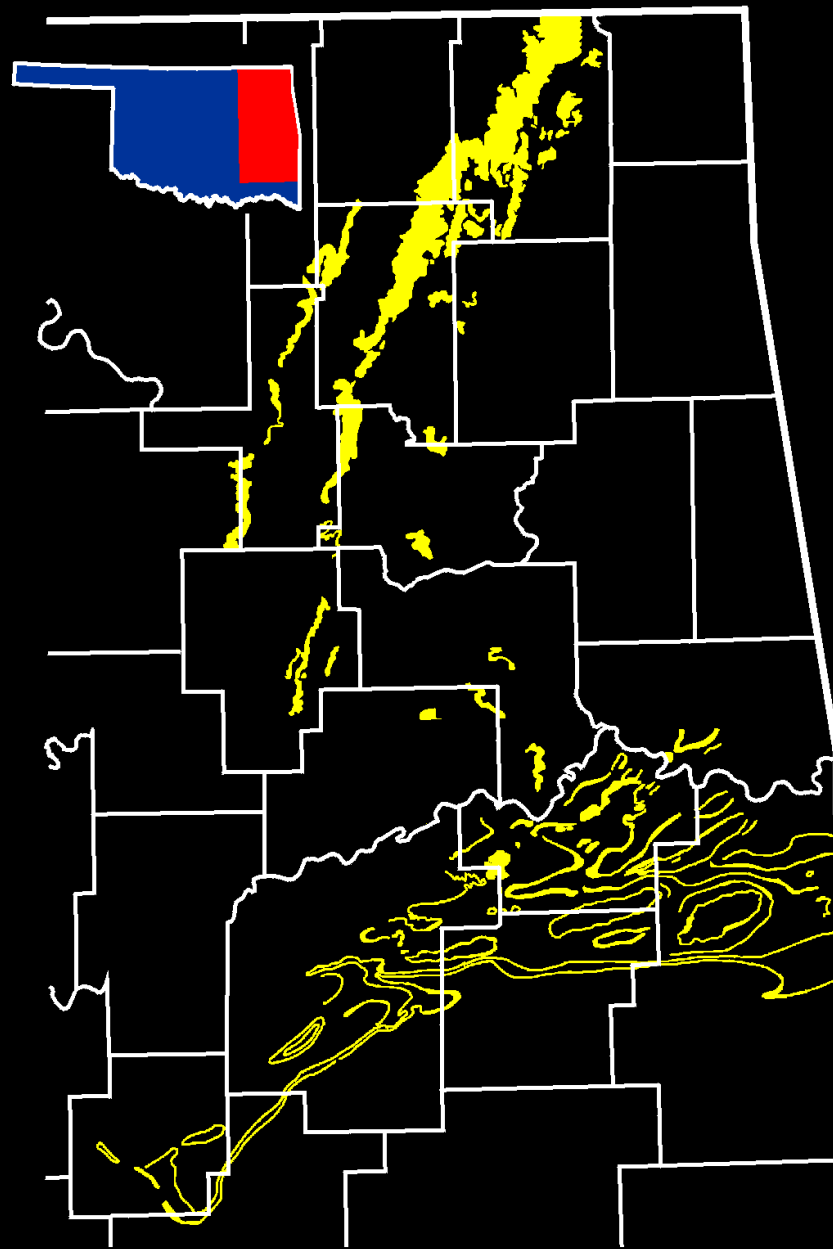


Brian J. Cardott
Oklahoma Geological Survey

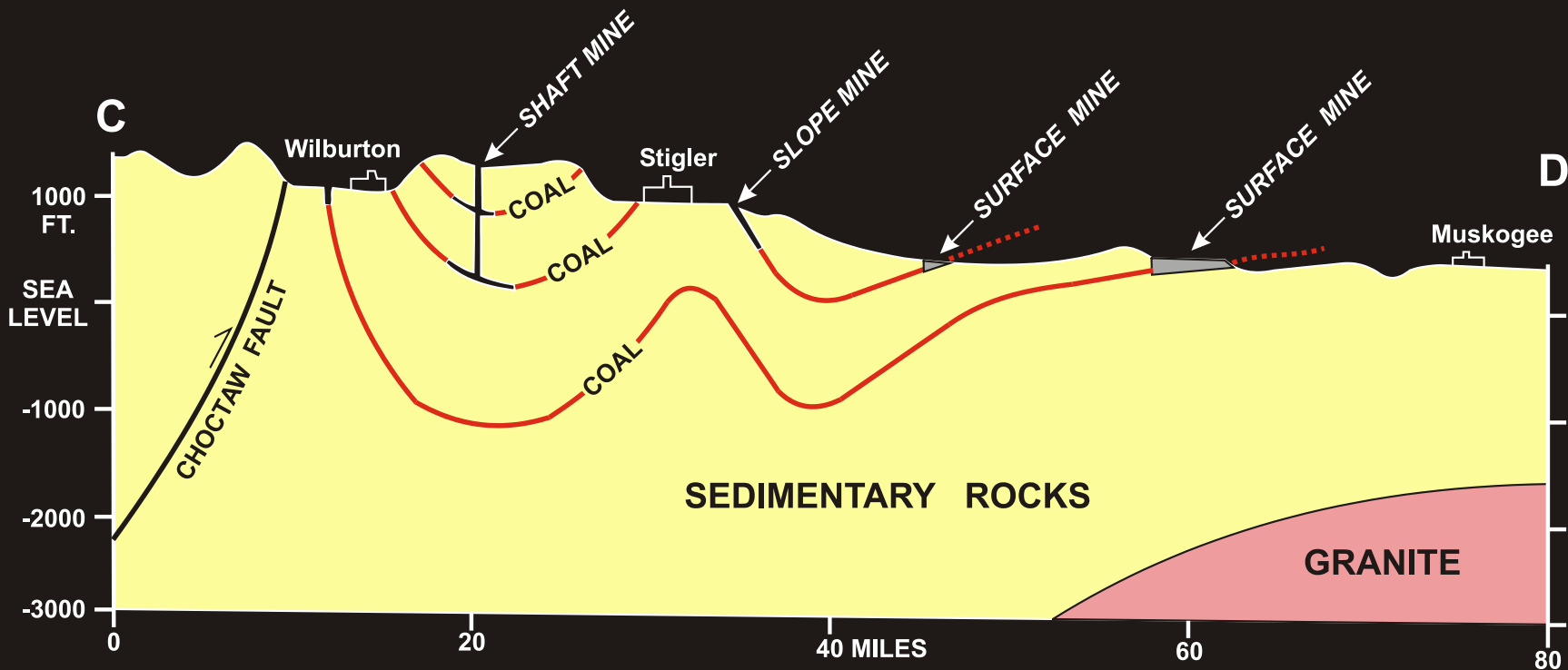
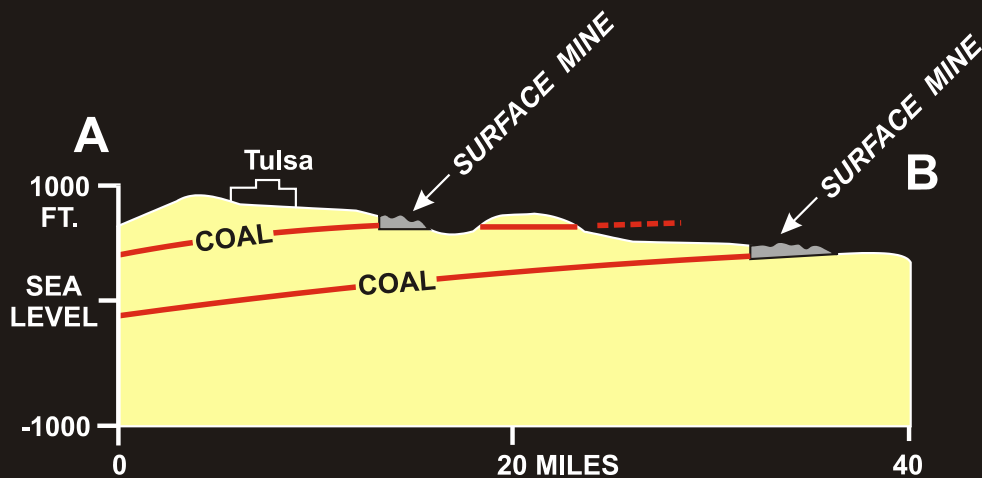
Oklahoma Coalfield



Modified from
Friedman (2006)



**COAL OUTCROP AND SUBCROP MAP
OF OKLAHOMA COALFIELD (Friedman, 1982)**



Modified from Johnson (1974)

OKLAHOMA COAL RANK Generalized for all coals, at or near the surface

High-volatile
bituminous



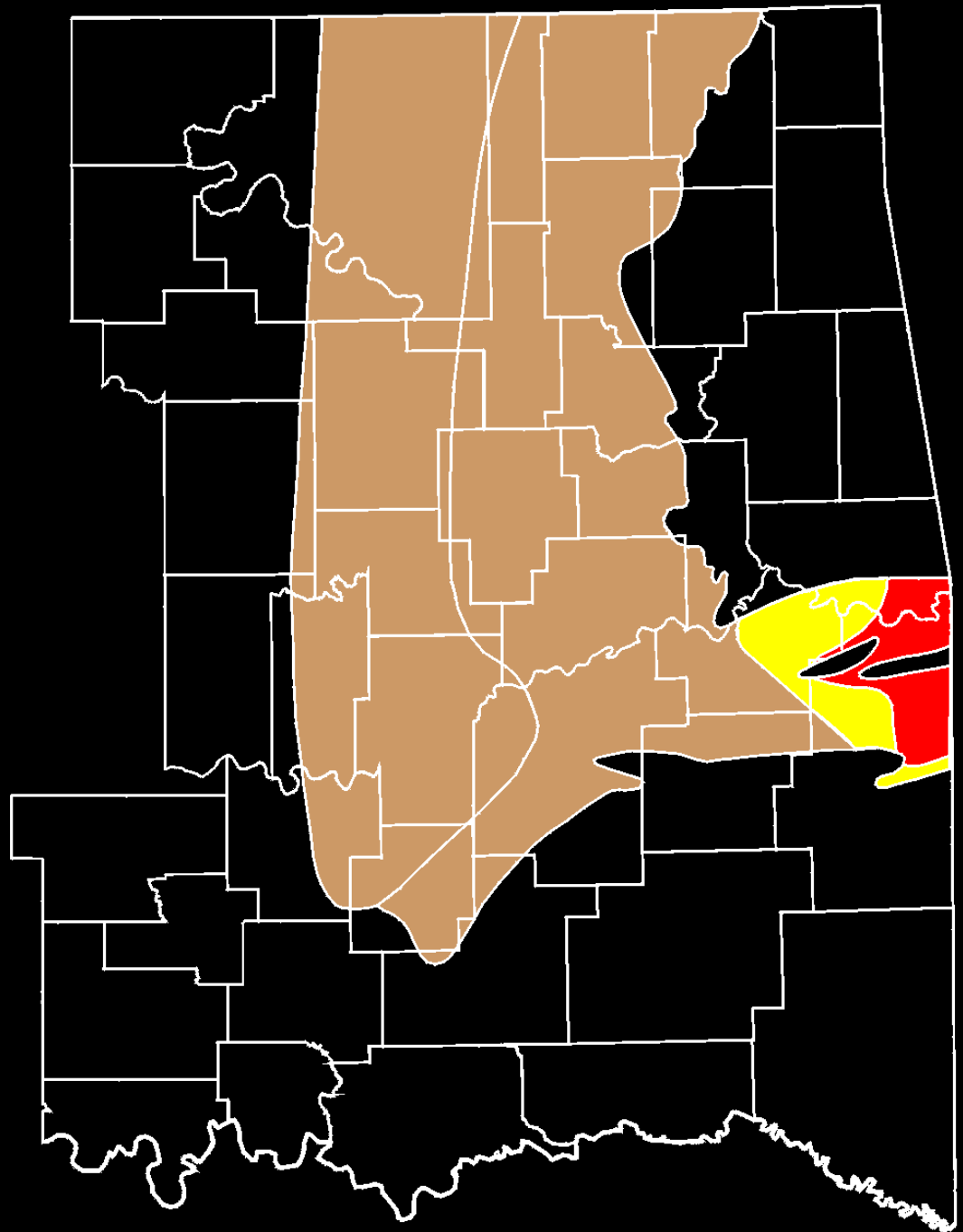
Medium-volatile
bituminous



Low-volatile
bituminous



0 50 Miles
0 80 Kilometers



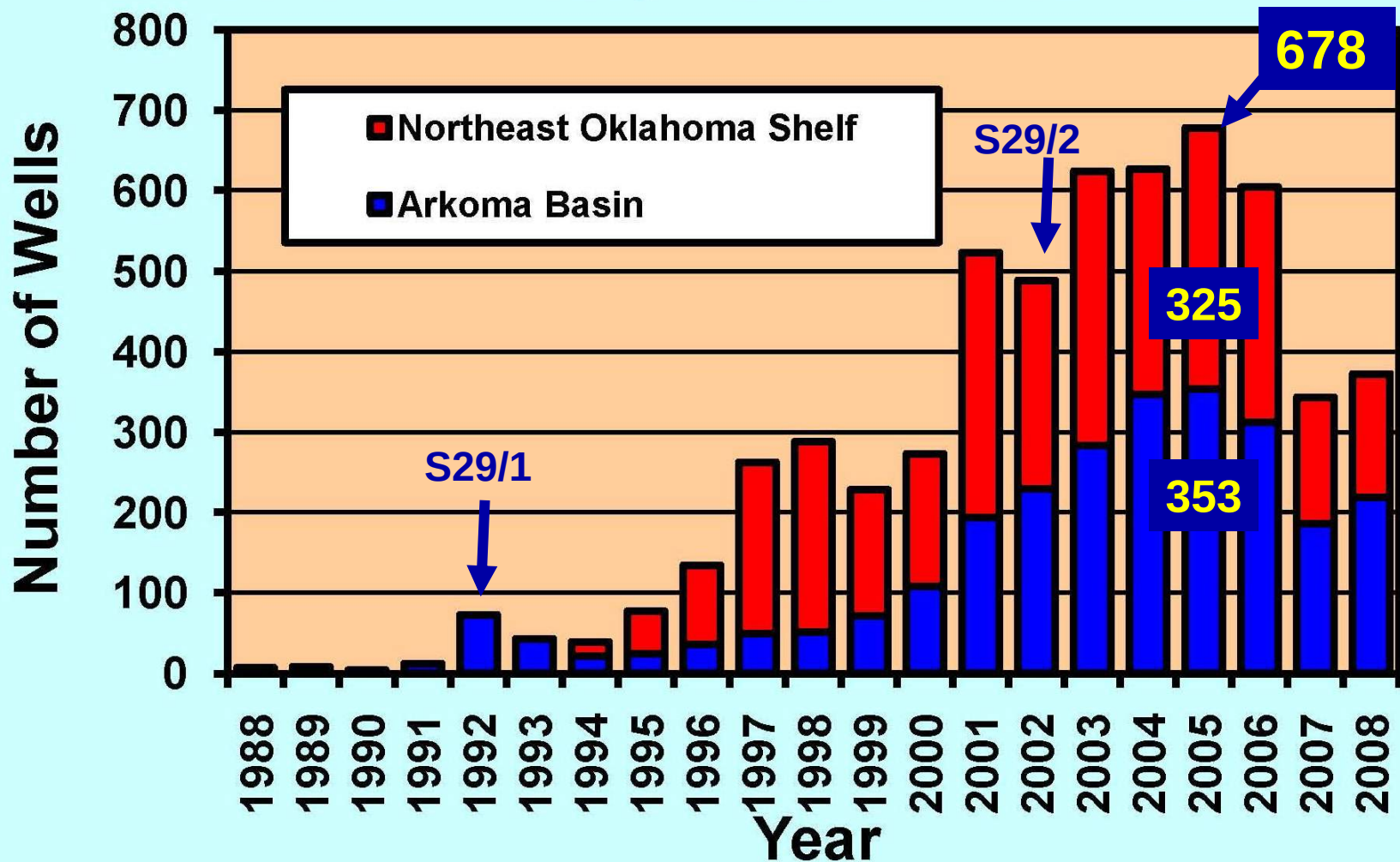
Phase One of IRS Section 29 Tax Credit (Non-Conventional Fuels):

Tax credit on gas produced from new coal gas wells drilled from January 1, 1980 to December 31, 1992.

Phase Two of IRS Section 29 Tax Credit:

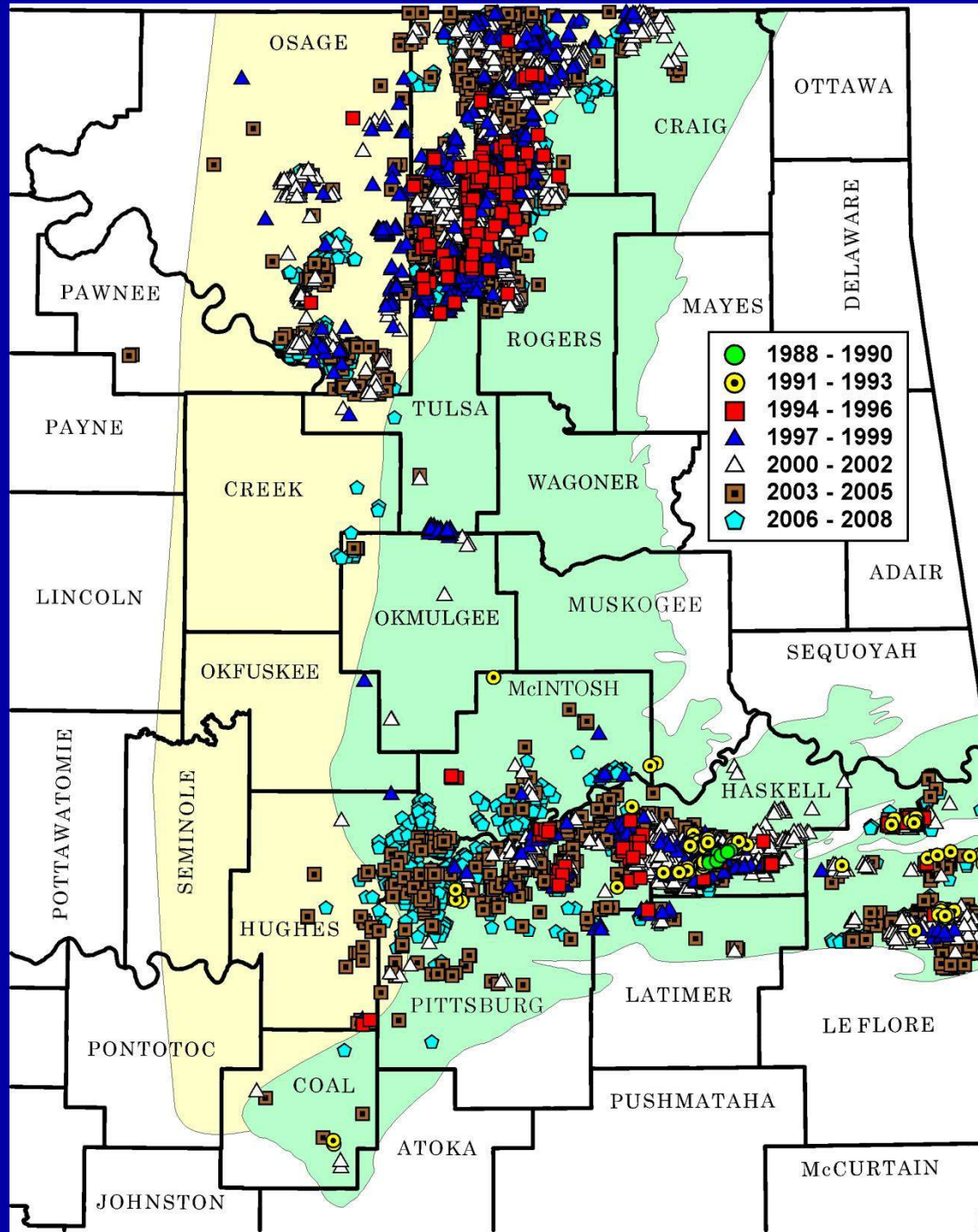
Tax credit on gas produced from recompleted wells drilled from January 1, 1993 to December 31, 2002.

CBM Well Completions in Oklahoma

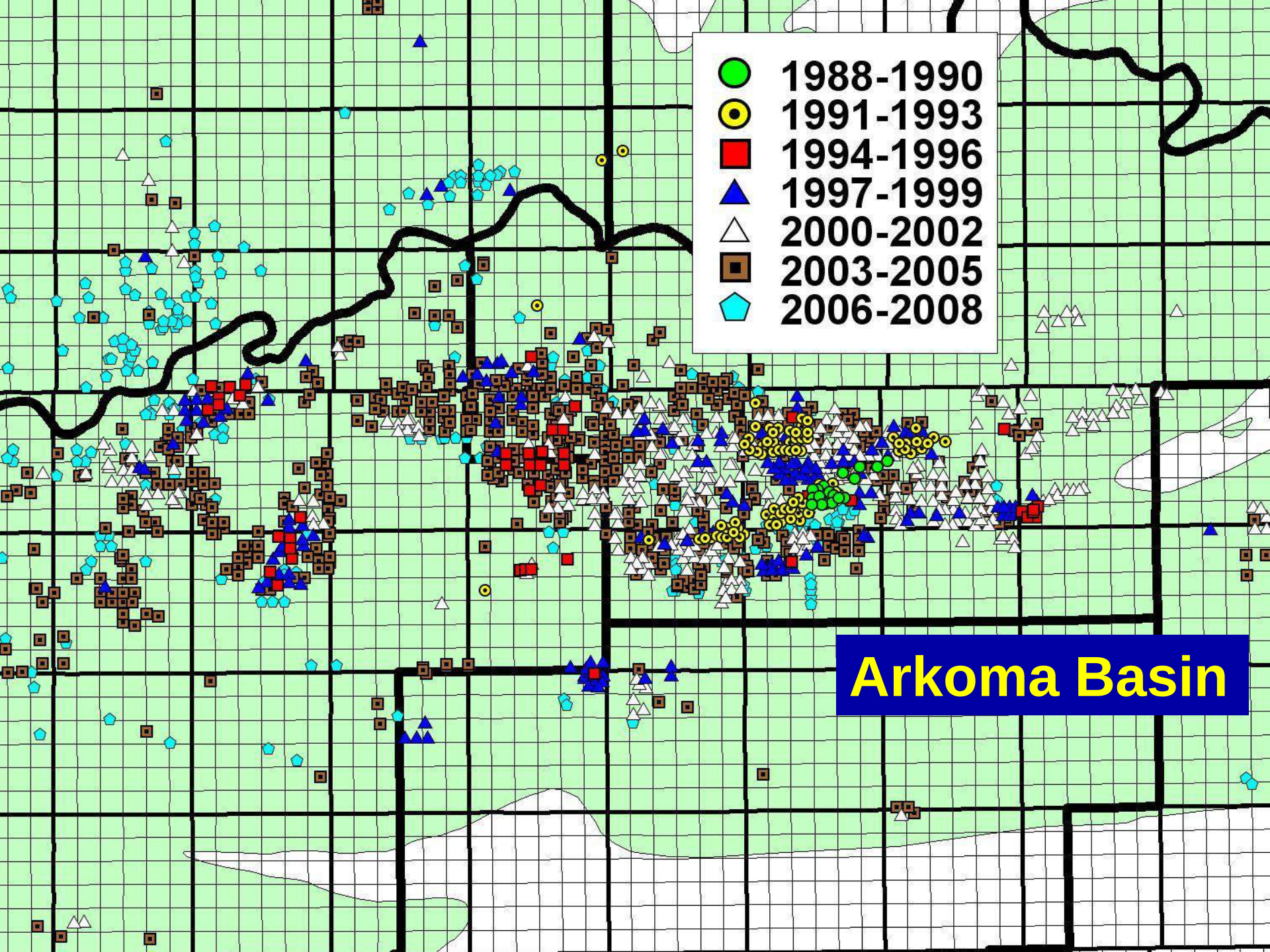


5,707 CBM Completions 1988-2008

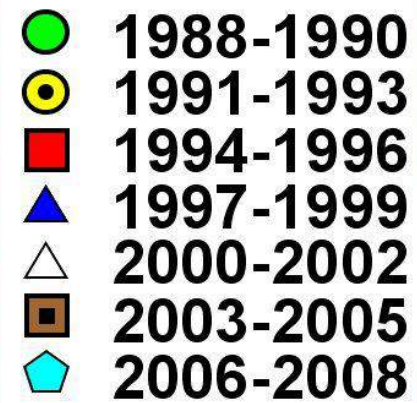
372 wells in 2008



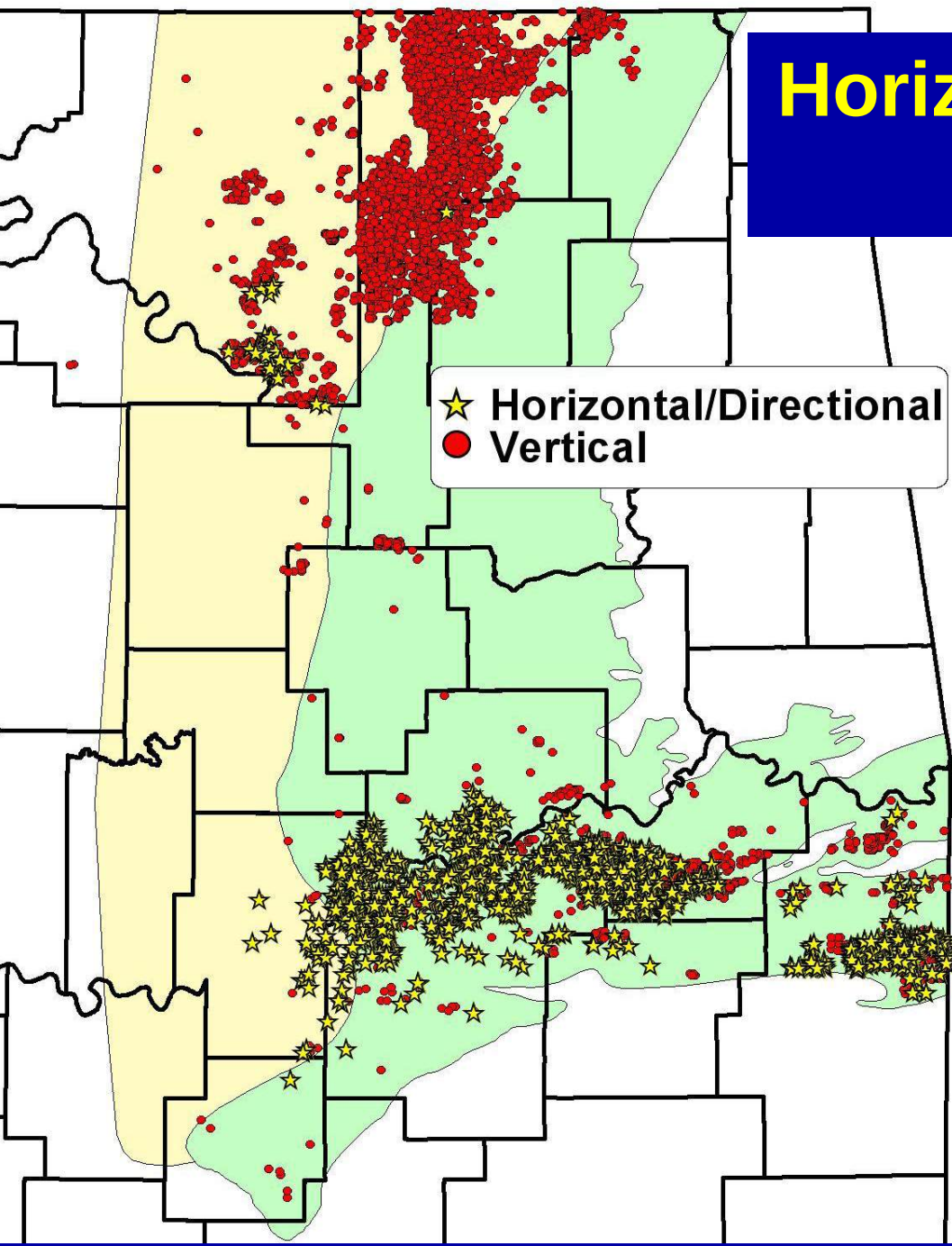
Oklahoma CBM Completions by Year (5,707 wells)



Shelf



Horizontal CBM Wells (1998-2008)

A map of Oklahoma with county boundaries. The state is divided into three colored regions: a yellow region in the northwest, a green region in the center and south, and a white region in the east. Red dots representing vertical wells are densely clustered in the yellow region and scattered in the green region. Yellow stars representing horizontal/directional wells are clustered in the green region. A legend box is located in the center of the map.

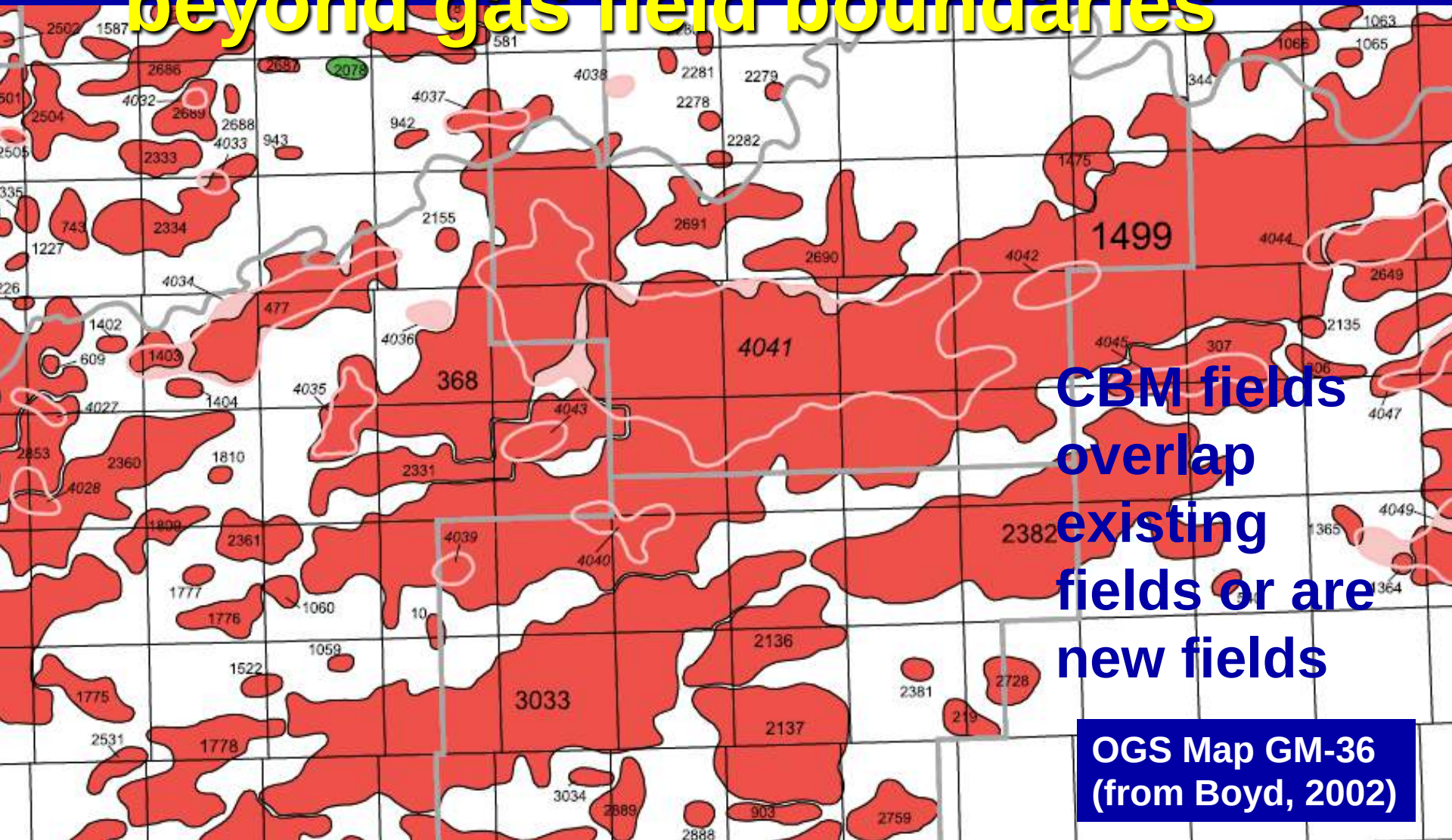
★ Horizontal/Directional
● Vertical

Coalfield: 4,104 vertical wells;

Shelf: 28 horizontal/8 directional wells by Amvest Osage & CEP Mid-Continent (2004-2008);

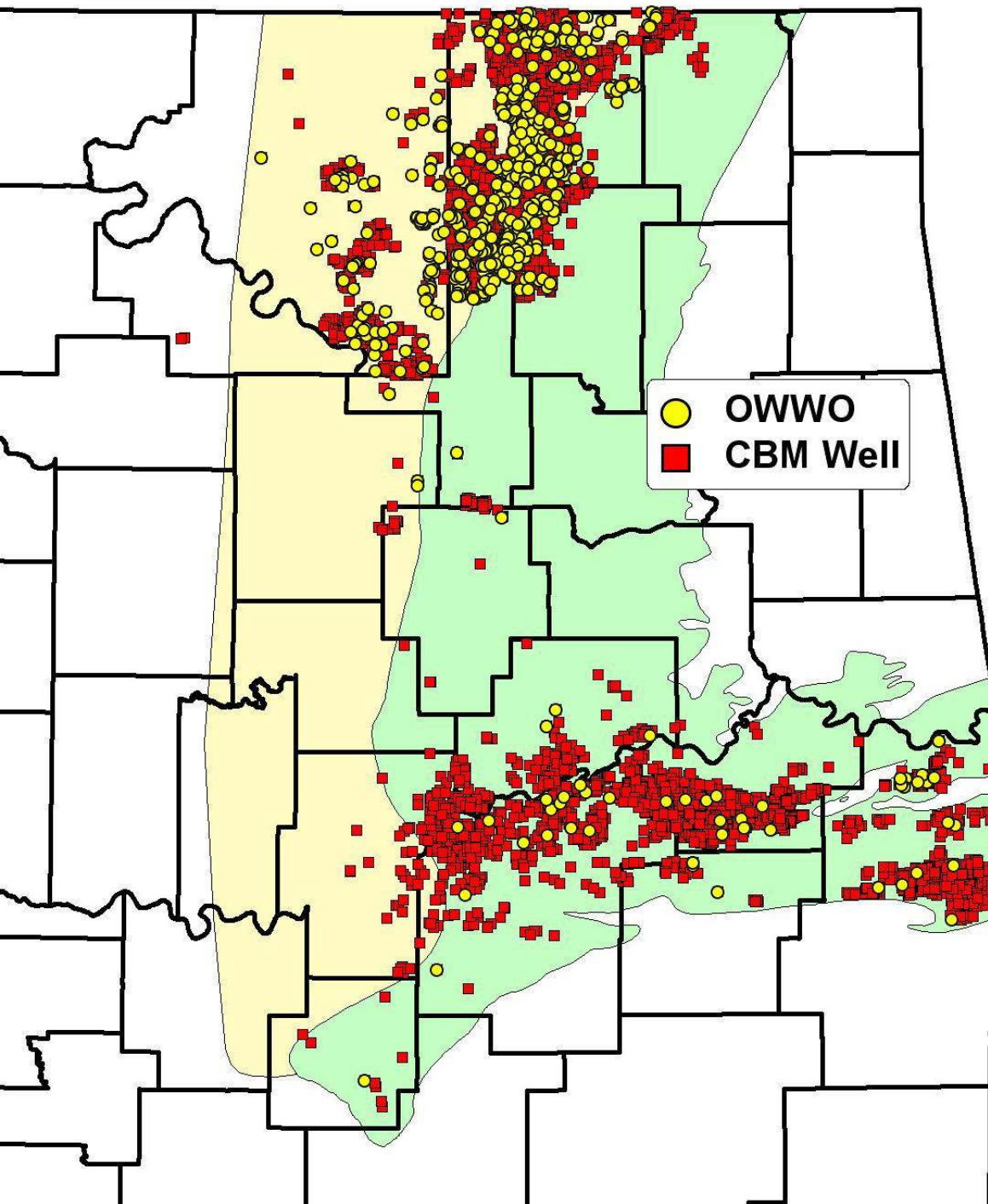
Arkoma: 1,567 horizontal wells

CBM Field Boundaries: coals are continuous reservoirs extending beyond gas field boundaries



Oklahoma Corporation Commission added “County CBM Gas Area” field names in 2001

me	Field_Name	S	Toi	I	4t	3r	2r	1st	County	Coal_Bed	Depth	Se		
	Ramona	29	24	N	13	E		SH	SE	NW	Washington	Rowe	1488-14	14
	Brooken	7	8	N	18	E		NE	SE	NW	Haskell	Hartshorne	1807	
	Le Flore County CBM Gas Area	6	5	N	27	E		NE	SW	SW	Le Flore	Hartshorne	3643-36	37
Gas	Delaware-Childers	12	27	N	14	E		SW	SW	SW	Nowata	Mulky; Iron P	0902-09	09
	Coffeyville S	15	29	N	15	E		SE	SE	SE	Nowata	Riverton	1103-11	
	Brooken	12	8	N	17	E		NE	NW	SW	Pittsburg	Hartshorne	1924	
	Brooken	12	8	N	17	E		NW	SW	SW	Pittsburg	Hartshorne	1912	
ch	Woody	10	24	N	14	E		C	SE	SW	Rogers	Rowe	1248-12	
ch	Woody	11	24	N	14	E		C	SE	SW	Rogers	Rowe	1334-13	
	Tulsa County CBM Gas Area	3	22	N	14	E		NE	SE	NE	Tulsa	Rowe	1061-10	10
	Tulsa County CBM Gas Area	3	22	N	14	E		NW	SE	SE	Tulsa	Mulky	0406-04	
	Tulsa County CBM Gas Area	3	22	N	14	E		EH	NW	SW	Tulsa	Rowe	1066-10	10
	Ramona	11	24	N	12	E		C	SE	SE	Washington	Mulky	1088-10	
	Ramona	8	24	N	13	E		SW	NW	SE	Washington	Riverton	1481-14	
	Washington County CBM Gas Are	27	24	N	13	E		NW	NE	NE	Washington	Rowe	1341-13	13
	Vera	33	24	N	14	E		EH	SW	NE	Washington	Rowe	1272-12	
Gas	Washington County CBM Gas Are	16	27	N	14	E		SW	SW	NE	Washington	Mulky; Iron P	0917-09	09
	Kinta	35	8	N	21	E		C	NE	SW	Haskell	Hartshorne	0853-08	
	Rogers County CBM Gas Area	9	24	N	15	E		C	SE	NW	Rogers	Rowe	1058-10	10
	Washington County CBM Gas Are	25	25	N	12	E		EH	EH	SE	Washington	Riverton	1462-14	
	Kinta	35	8	N	21	E		NH	SW	NW	Haskell	Hartshorne	0947-09	
	Le Flore County CBM Gas Area	11	6	N	24	E		SW	NE	SE	Le Flore	McAlester; Ha	2316-23	23
	Le Flore County CBM Gas Area	17	6	N	25	E		SE	NW	NW	Le Flore	McAlester; Ha	1358-13	14
	D&A	9	26	N	12	E		SE	SE	NW	Osage	Iron Post		
inch	Woody	15	24	N	14	E		C	SE	NE	Rogers	Rowe	1223-12	
	Collinsville	10	22	N	14	E		SW	SE	NW	Tulsa	Mulky	0422-04	04

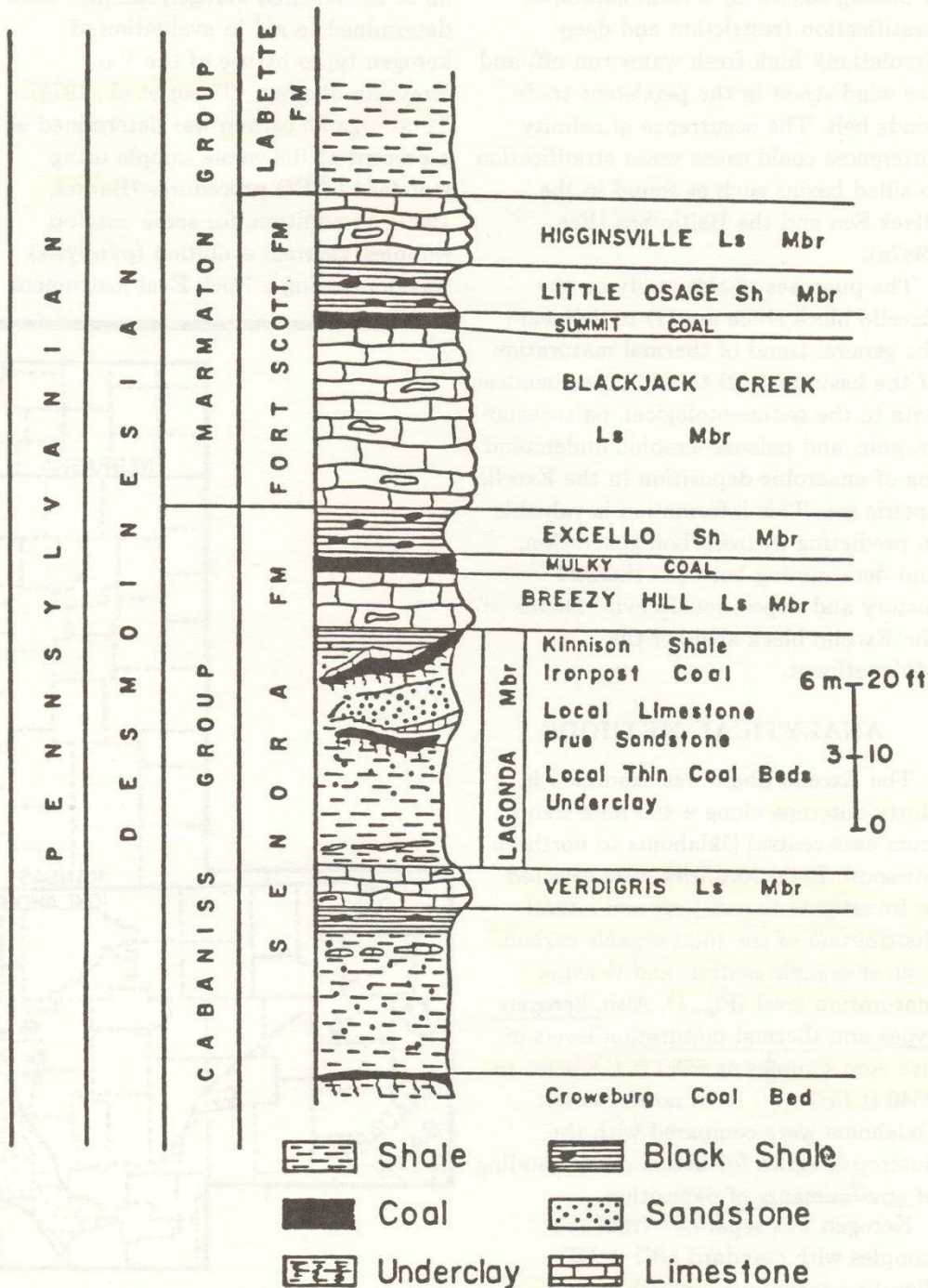


Old Well
Workover
(OWWO)
completed as
CBM wells
beginning in
1991
(Hartshorne) &
1994 (NE OK
shelf)

727 (13%) of
5,707 wells

Mulky “Coal” Problem

Mulky-only coalbed-methane production is primarily Excello Shale gas production.



Excello Shale Stratigraphy

(<16 ft thick)

Ece (1989)

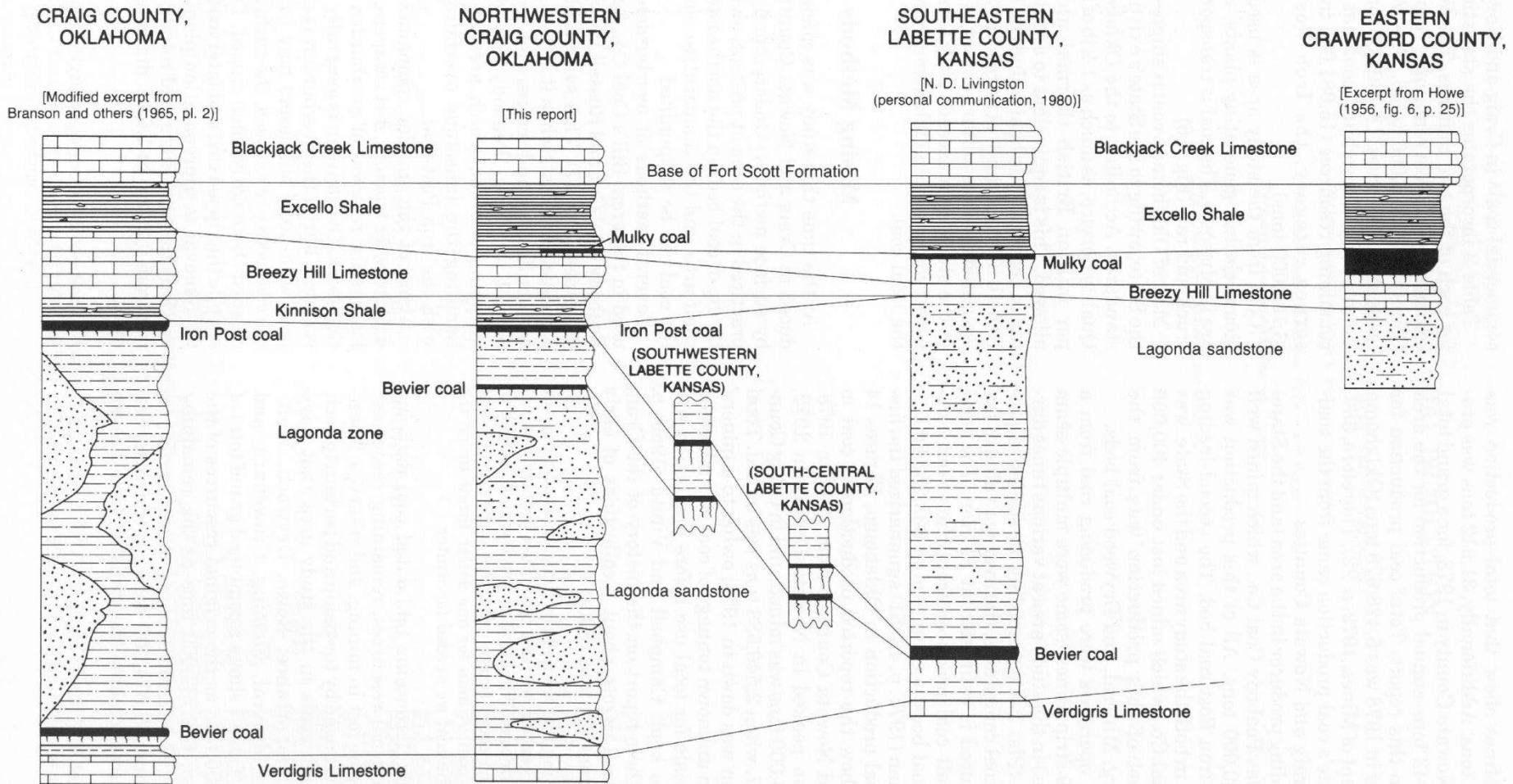
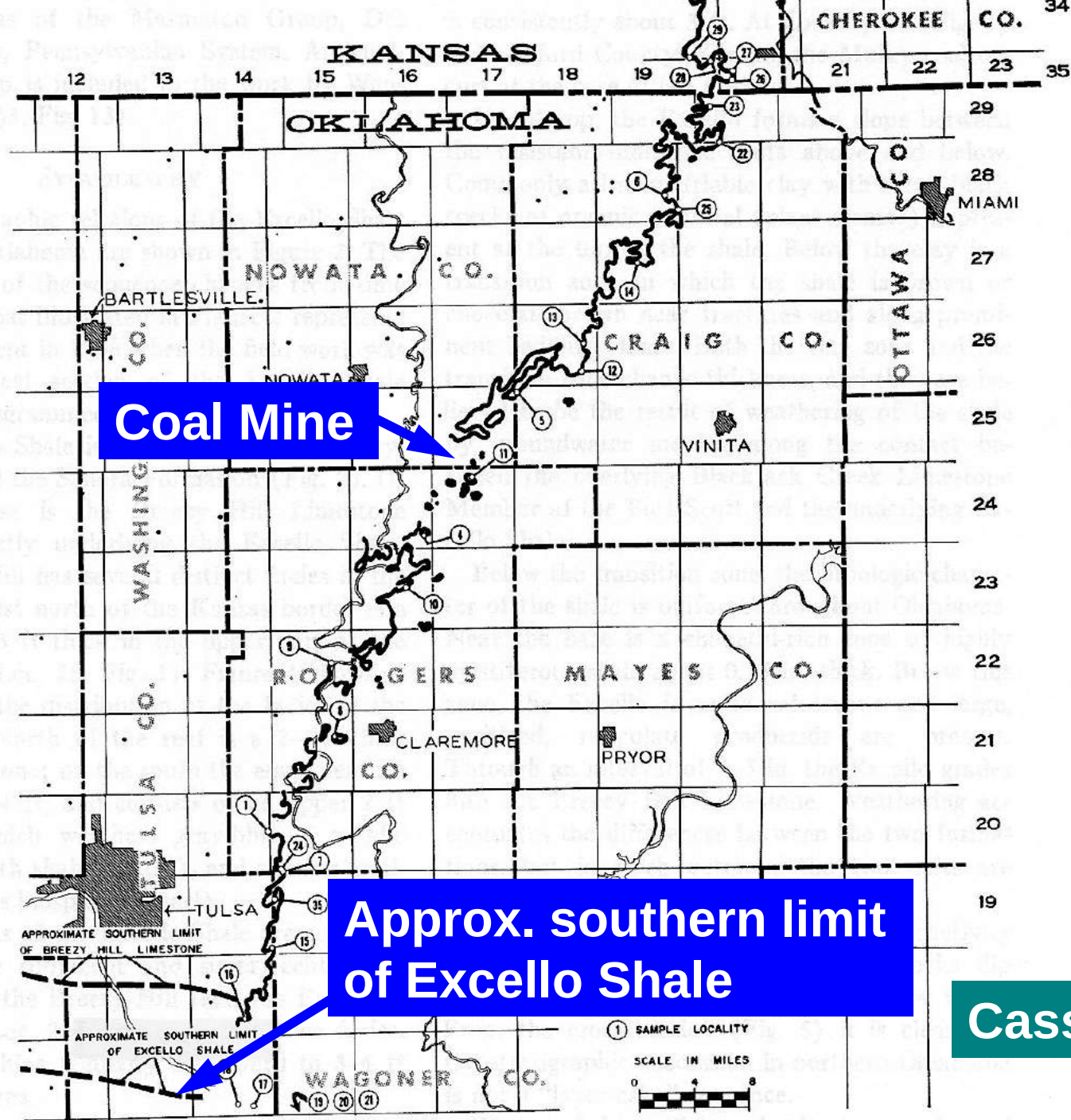


Figure 13. Stratigraphic positions of the Bevier coal, the Iron Post coal, and the Mulky coal, and correlation of beds in northwestern Craig County, Oklahoma, southern Labette County, Kansas, and eastern Crawford County, Kansas. The stratigraphic interpretation of Branson and others (1965) contrasts with the interpretation of this report. Thickness of units approximate.



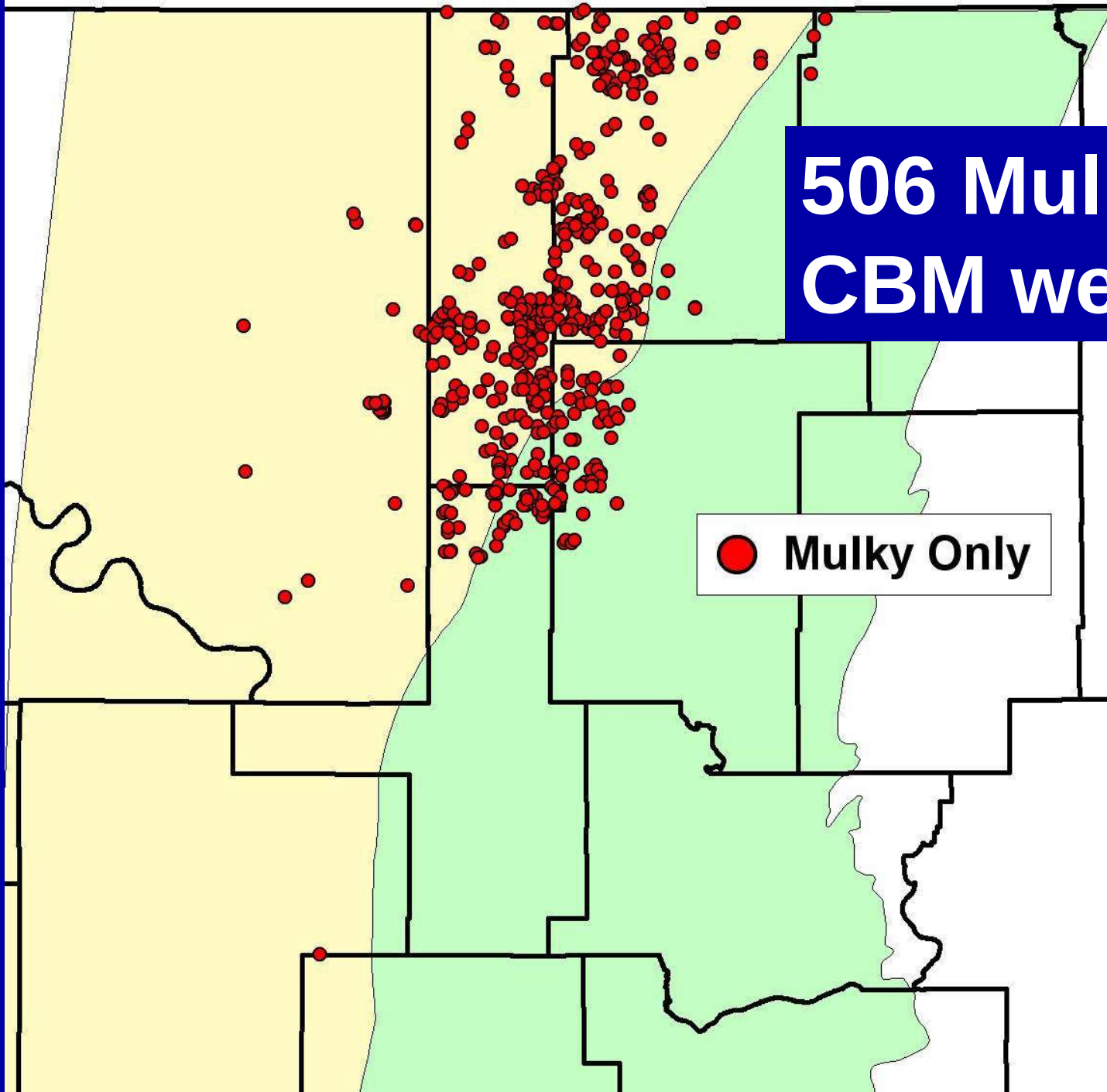
Cassidy (1968)

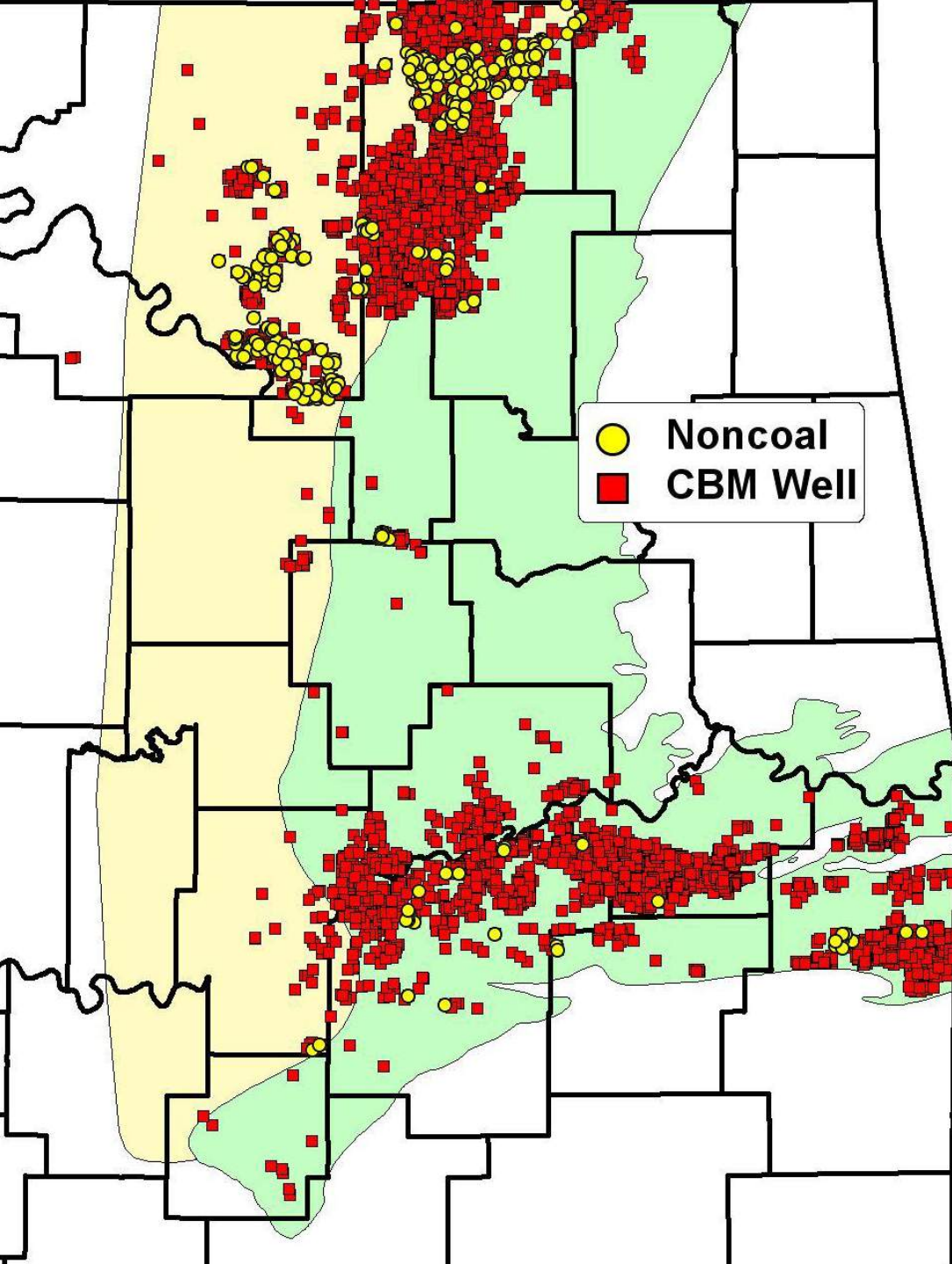
**Excello Shale and Breezy Hill
Limestone contact with no Mulky
coal in Nowata County coal mine**



506 Mulky-Only CBM wells

● Mulky Only





Coal
commingled
with thin
noncoal
(shale or
sandstone)
beginning in
1992

341 (6%) of
5,707 wells

Examples of Noncoal

Sandstone

Bartlesville

Burgess

Cleveland

Peru

Red Fork

Skinner

Tucker/Cushing

Limestone

Big Lime

Oswego

Pink Lime

Verdigris

Shale

Little Osage

Nuyaka

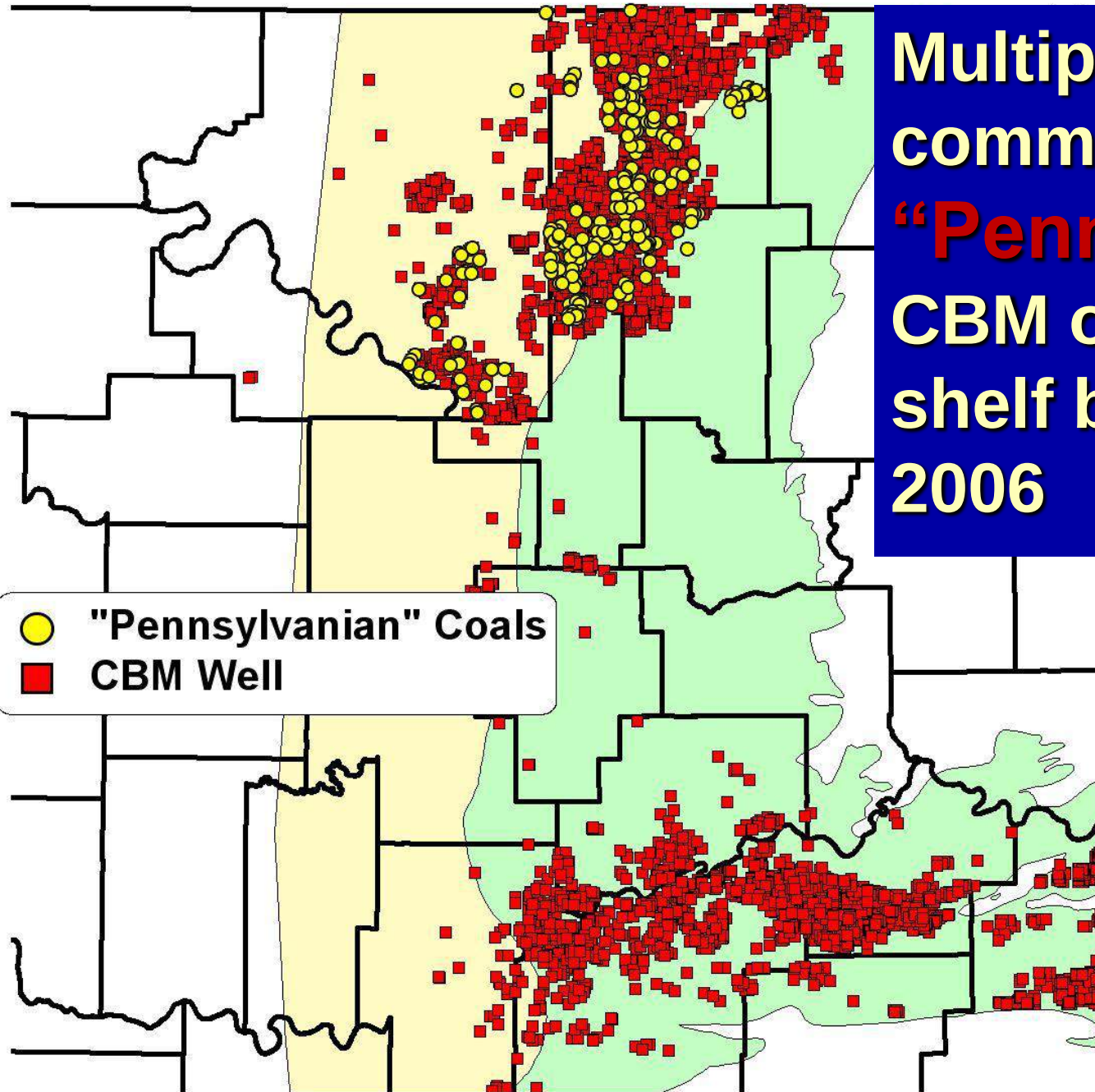
Oakley

Summit

Multiple coals
commingled as
"Pennsylvanian"
CBM on NE OK
shelf beginning in
2006

● "Pennsylvanian" Coals
■ CBM Well

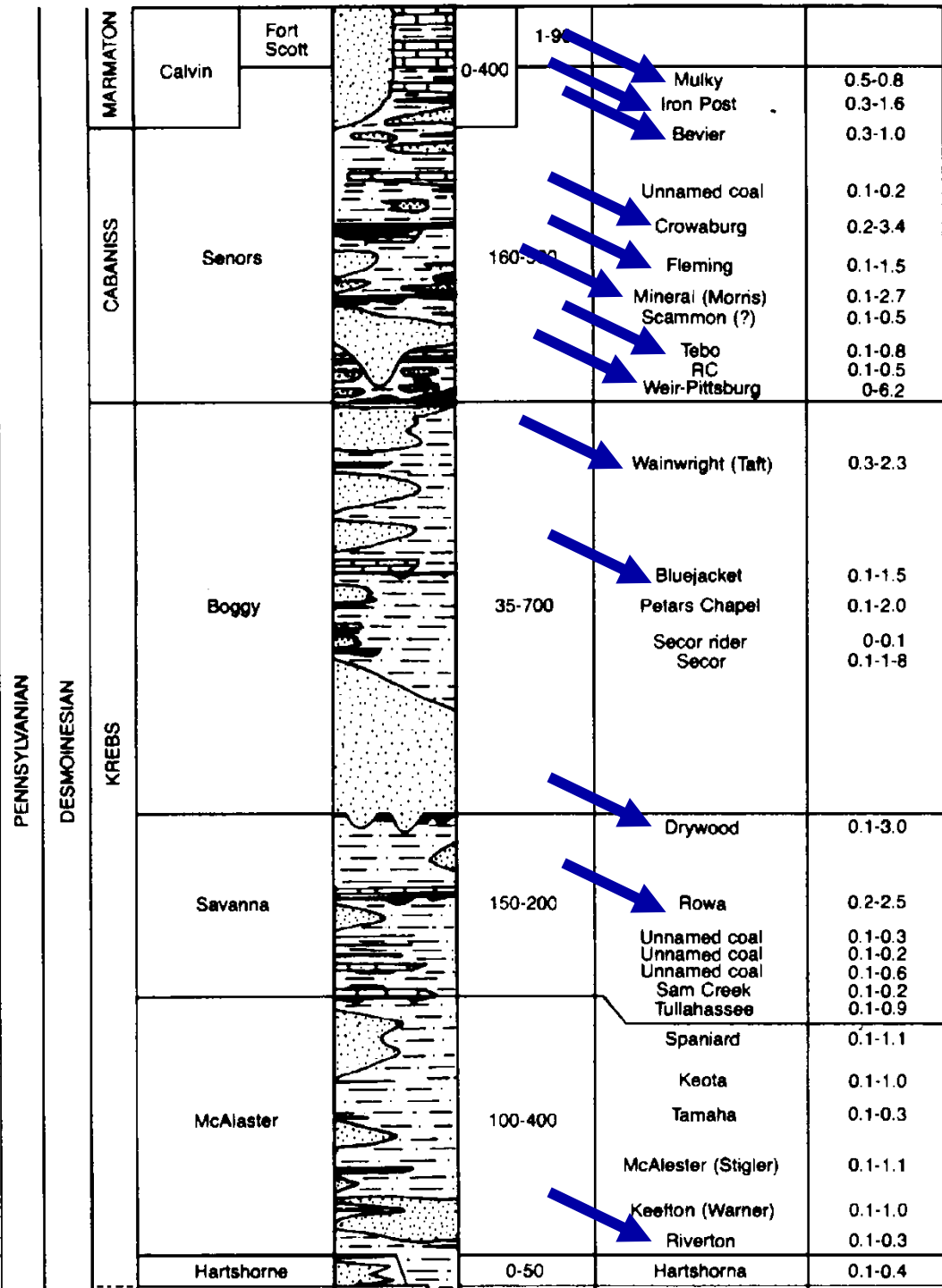
248 (4%) of
5,707 wells



COMMINGLED: There are more than 40 named and unnamed coals in NE OK. Numerous CBM wells have commingled more than 3 coals on the NE OK shelf beginning in 1999 (only shallowest coal symbol is plotted on map)

Generalized Stratigraphic Column for Northeast Oklahoma Shelf (13 common coals in NE OK CBM wells)

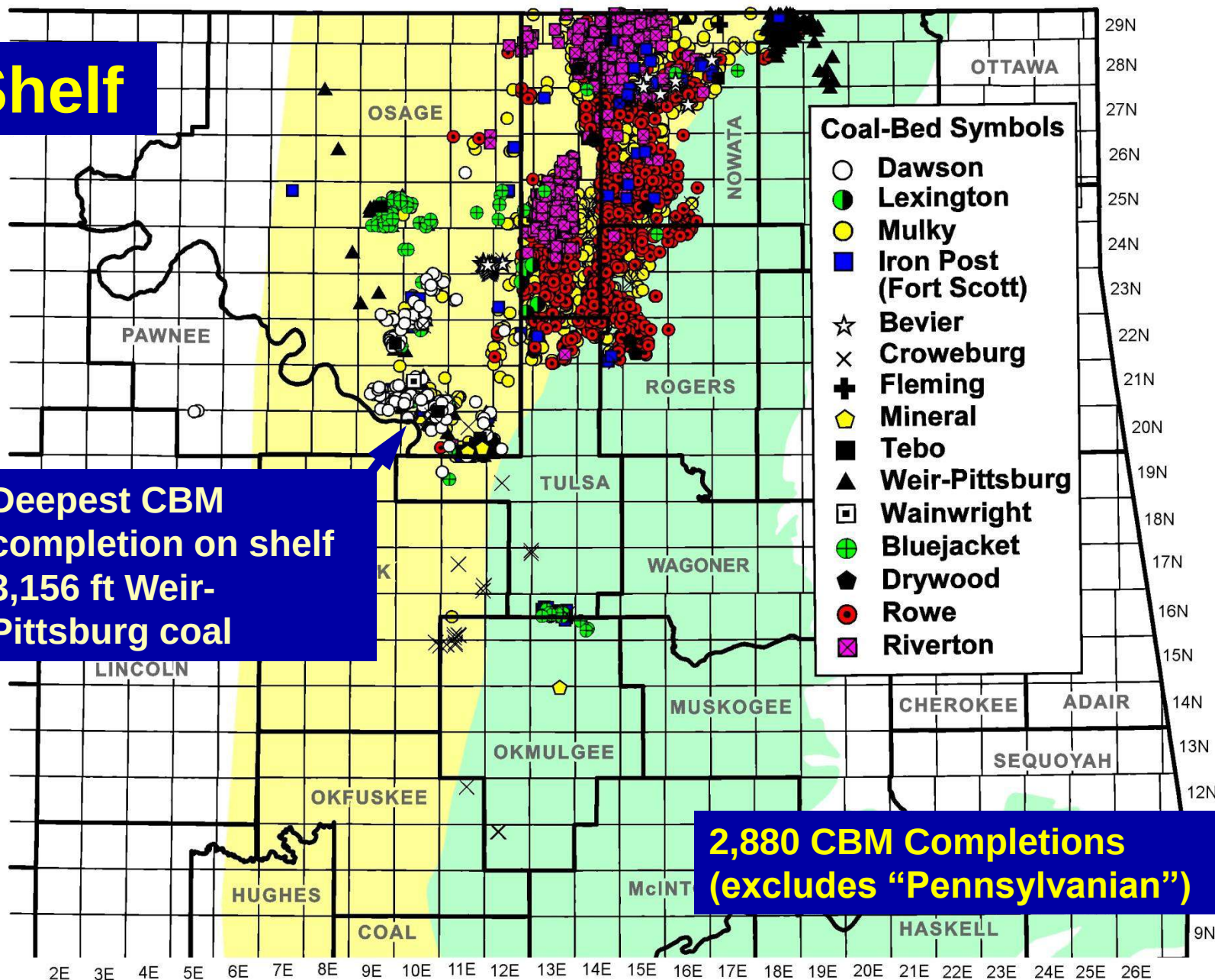
Modified from Hemish (1988)



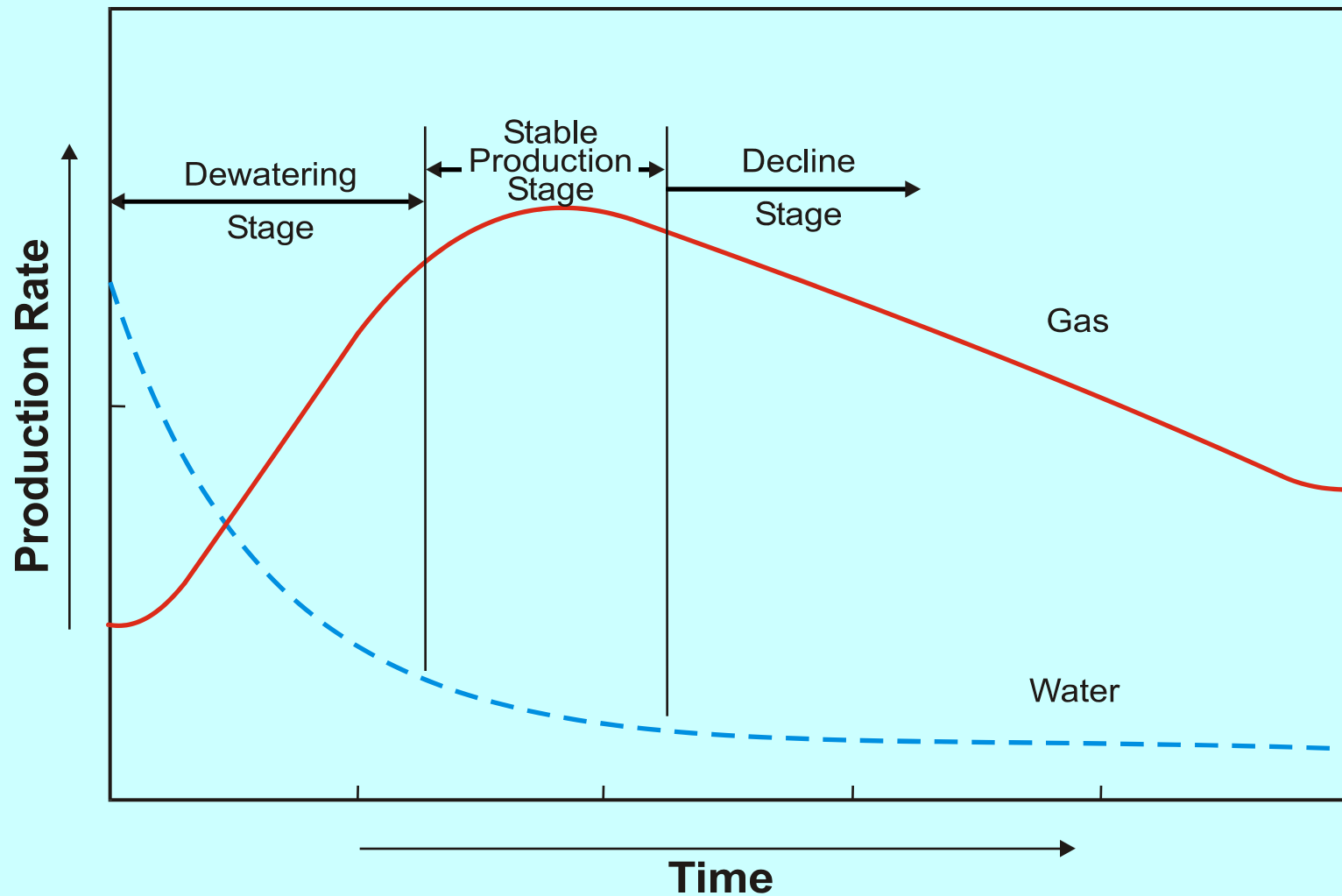
Shelf

Deepest CBM completion on shelf
3,156 ft Weir-Pittsburg coal

2,880 CBM Completions
(excludes "Pennsylvanian")



Theoretical decline curve for CBM well



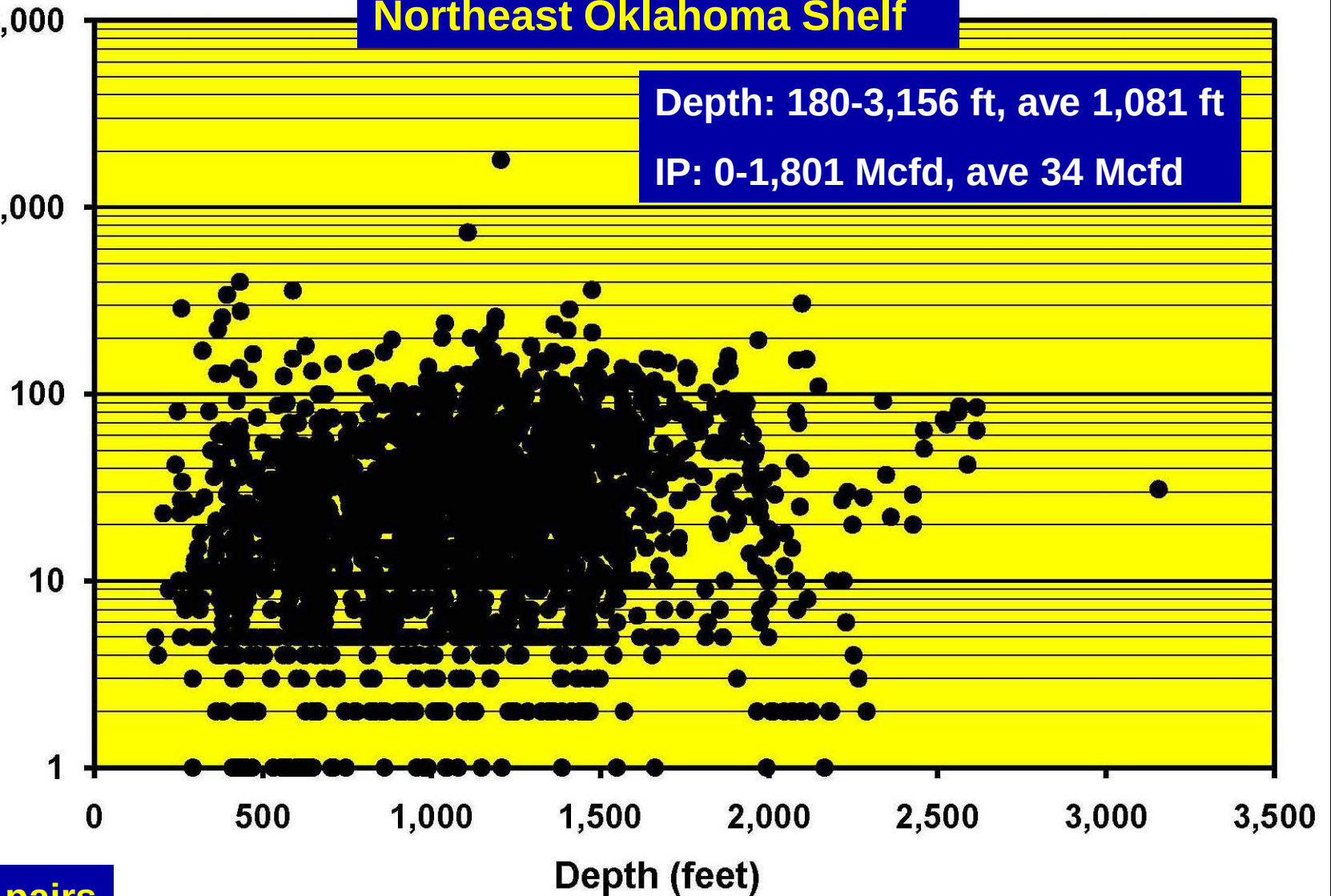
From Schraufnagel (1993)

Northeast Oklahoma Shelf

Depth: 180-3,156 ft, ave 1,081 ft

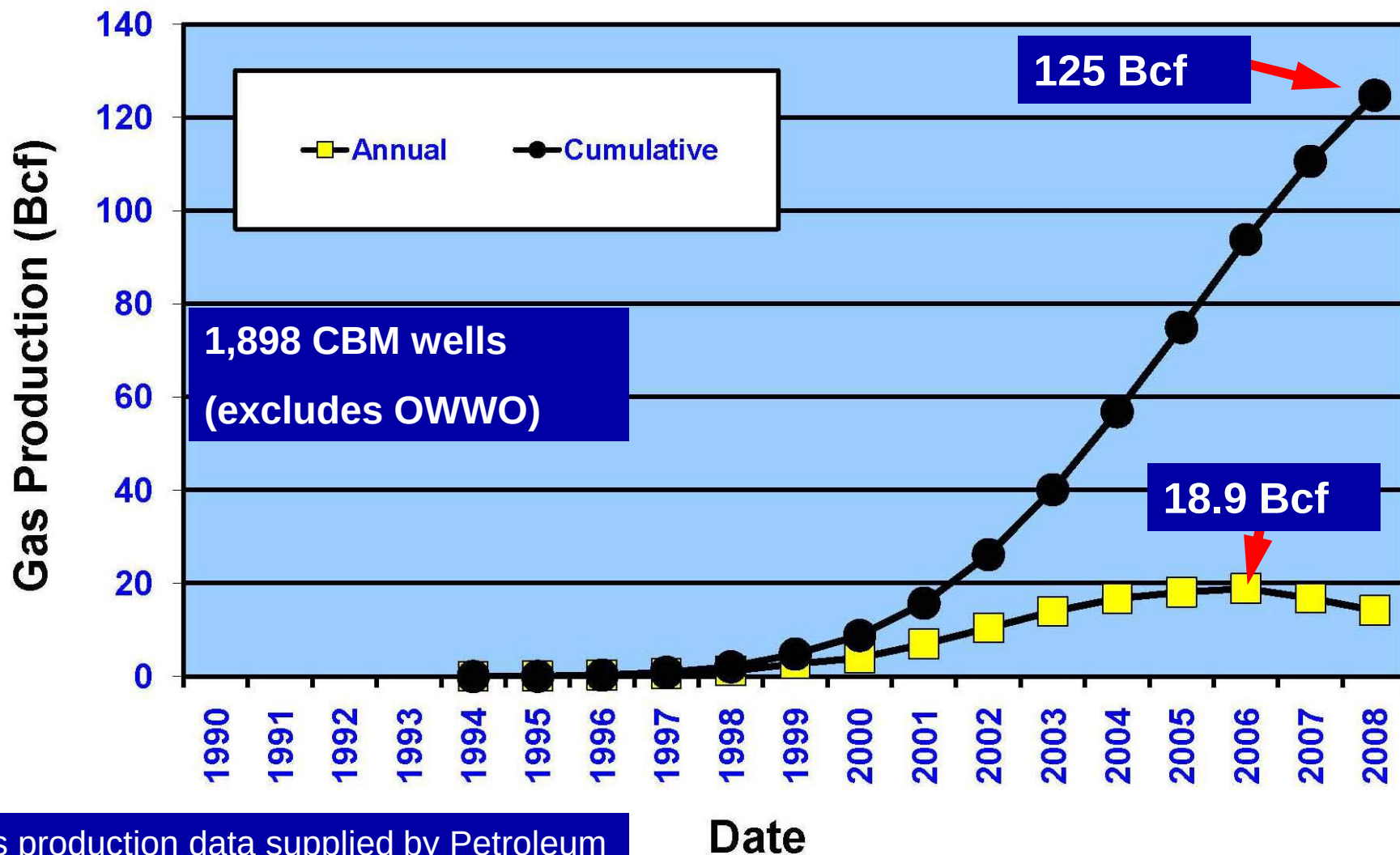
IP: 0-1,801 Mcfd, ave 34 Mcfd

Initial Production (Mcfd)



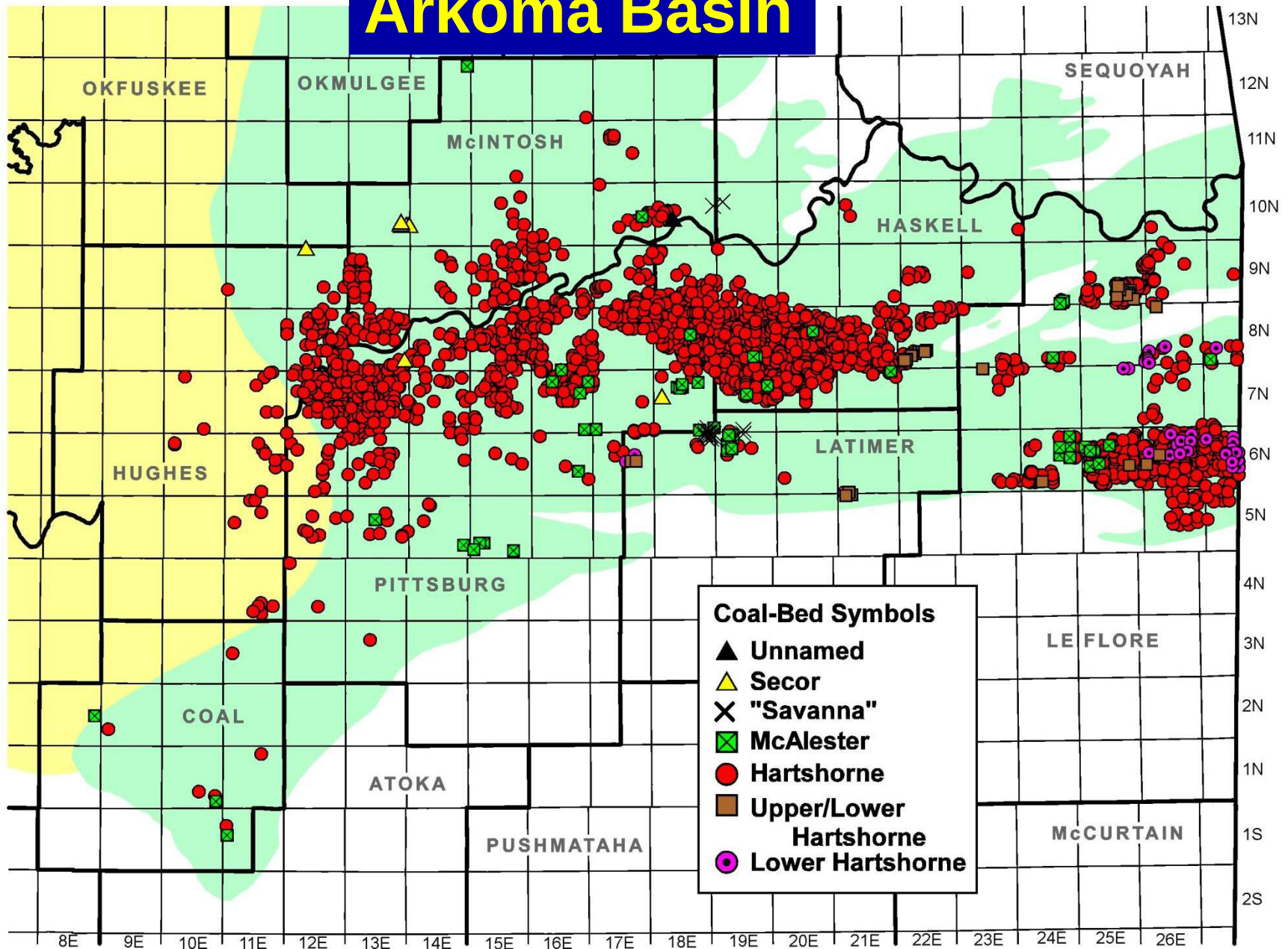
2,628 pairs

Northeast Oklahoma Shelf CBM Production



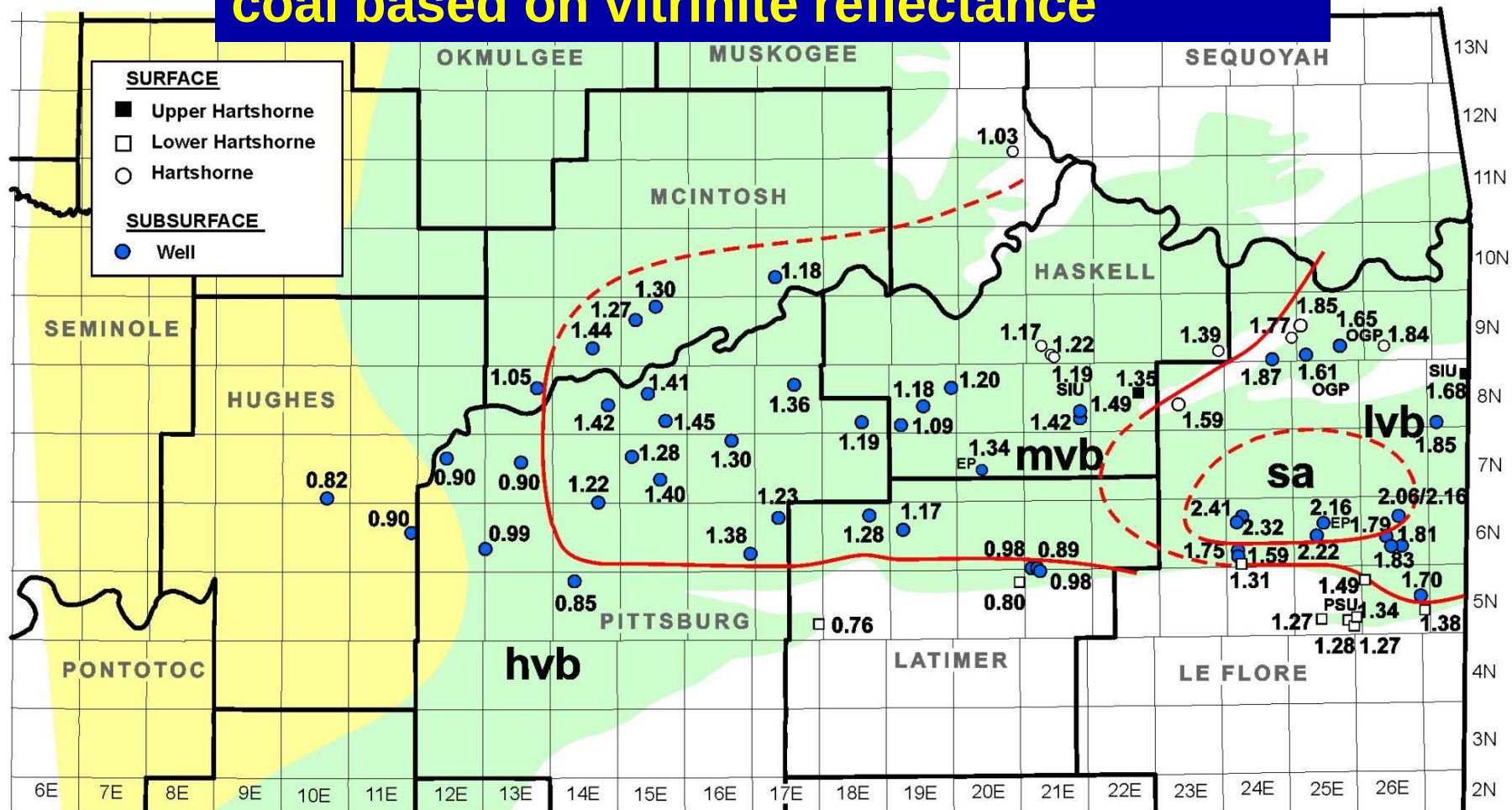
Gas production data supplied by Petroleum Information/Dwights LLC dba IHS Energy Group © 2009

Arkoma Basin



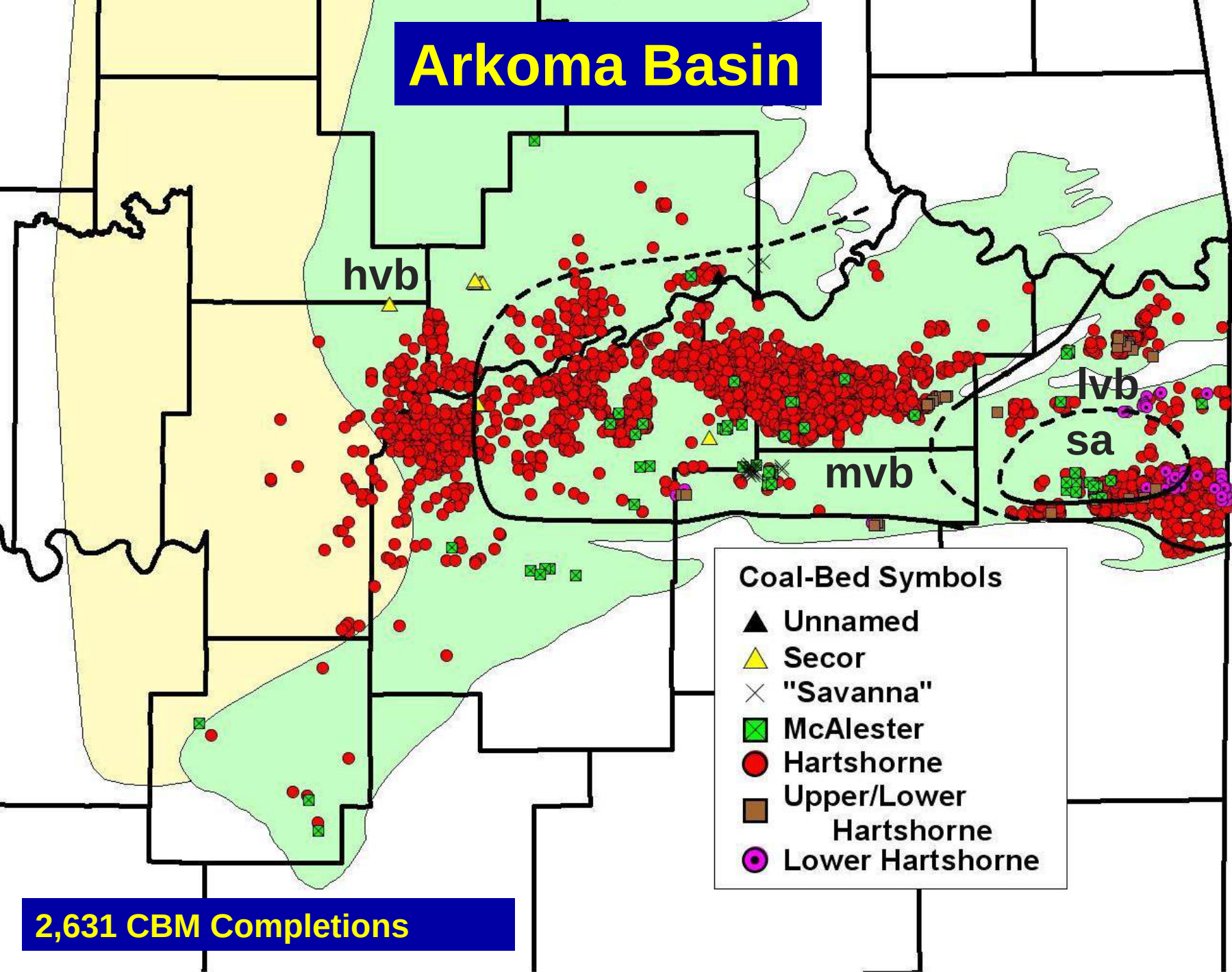
2,631 CBM Completions

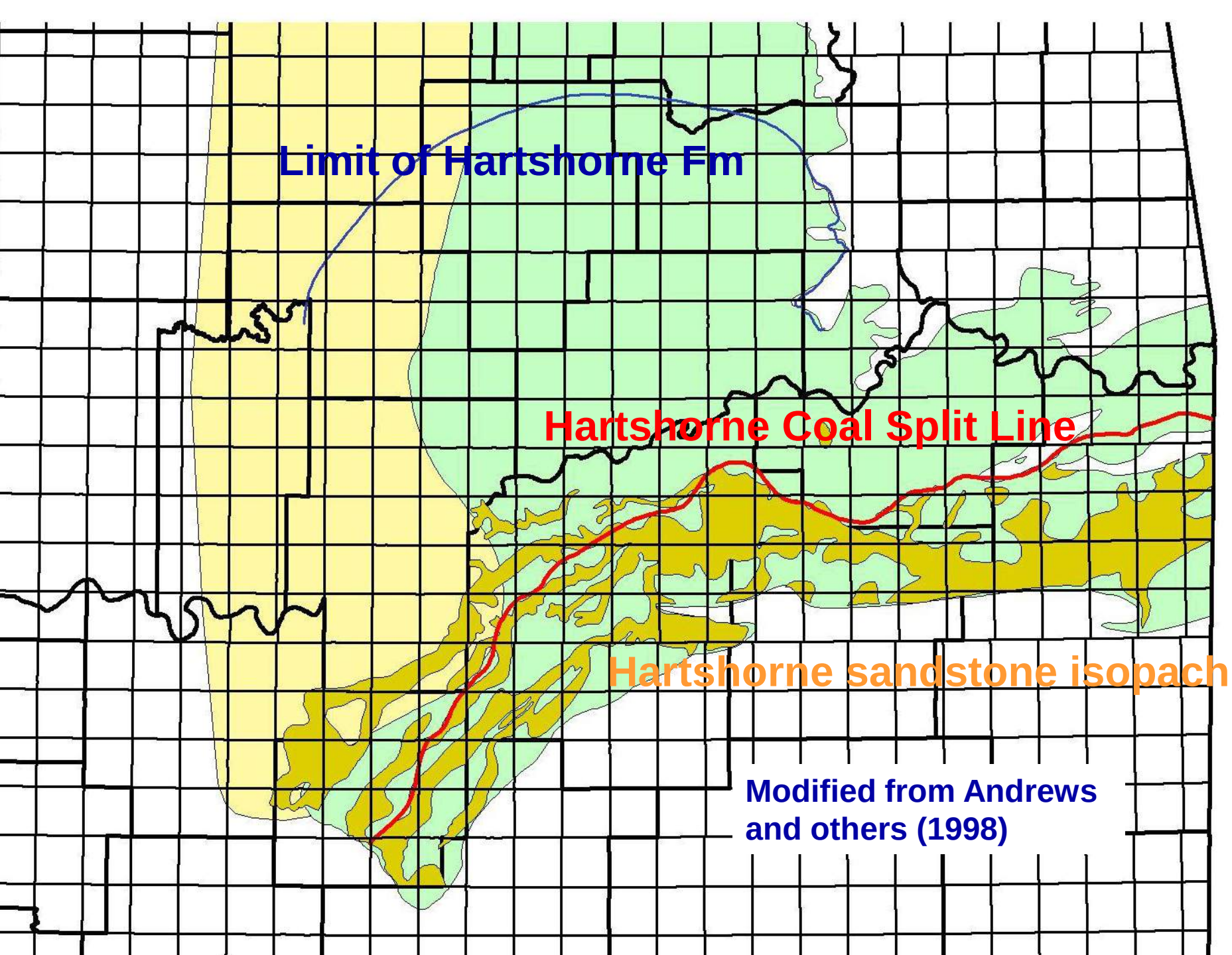
Preliminary coal rank map of Hartshorne coal based on vitrinite reflectance

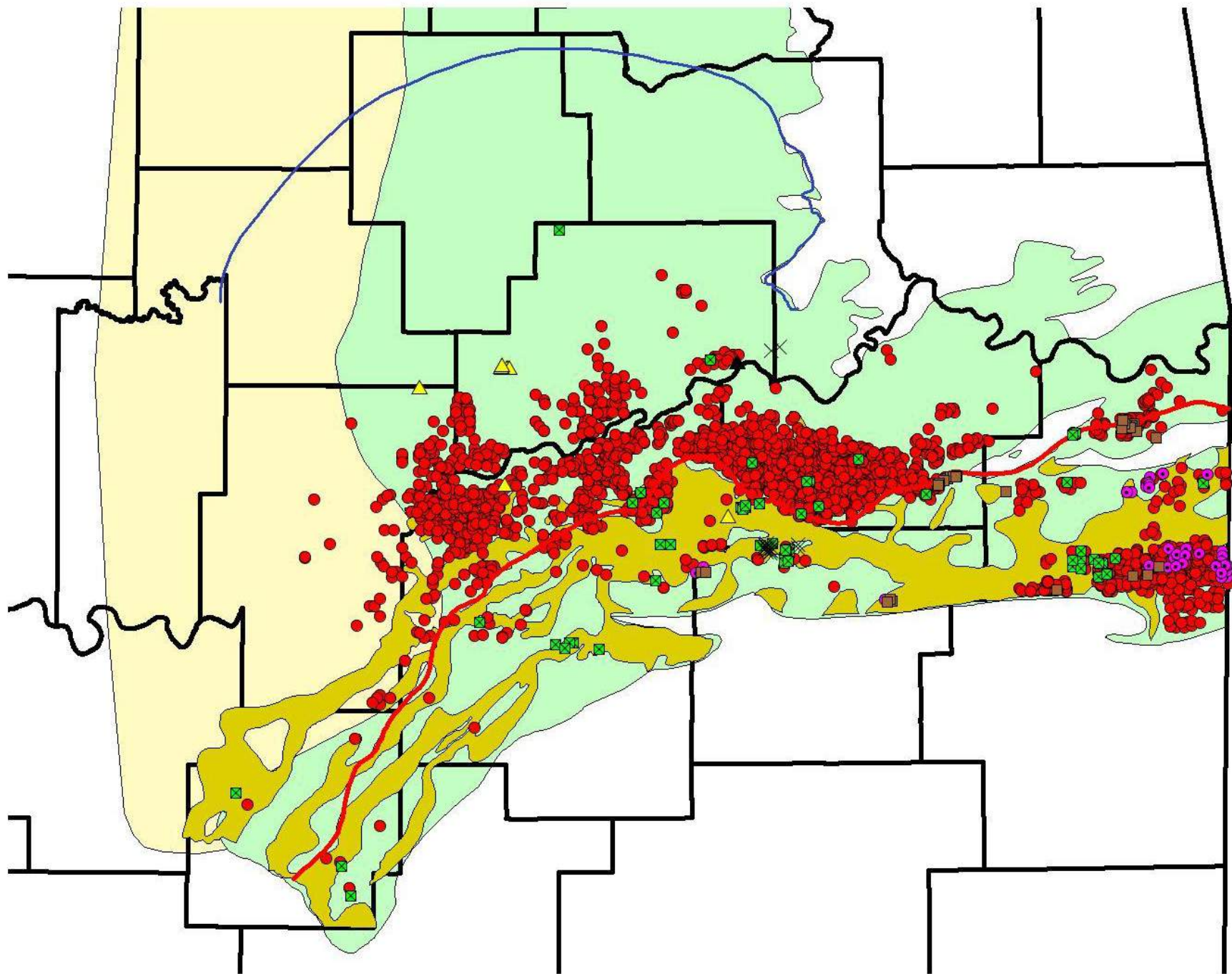


Preliminary coal rank map of Arkoma Basin based on mean maximum vitrinite reflectance of Hartshorne coal samples (hvb = high volatile bituminous; mvb = medium volatile bituminous; lvb = low volatile bituminous; sa = semianthracite). Data by Brian Cardott, Oklahoma Geological Survey, unless specified otherwise. Additional data from OGP Operating (OGP), The Pennsylvania State University (PSU), Southern Illinois University at Carbondale (SIU), and Pratt and others (2004; El Paso cores, EP). Revised 5/2009.

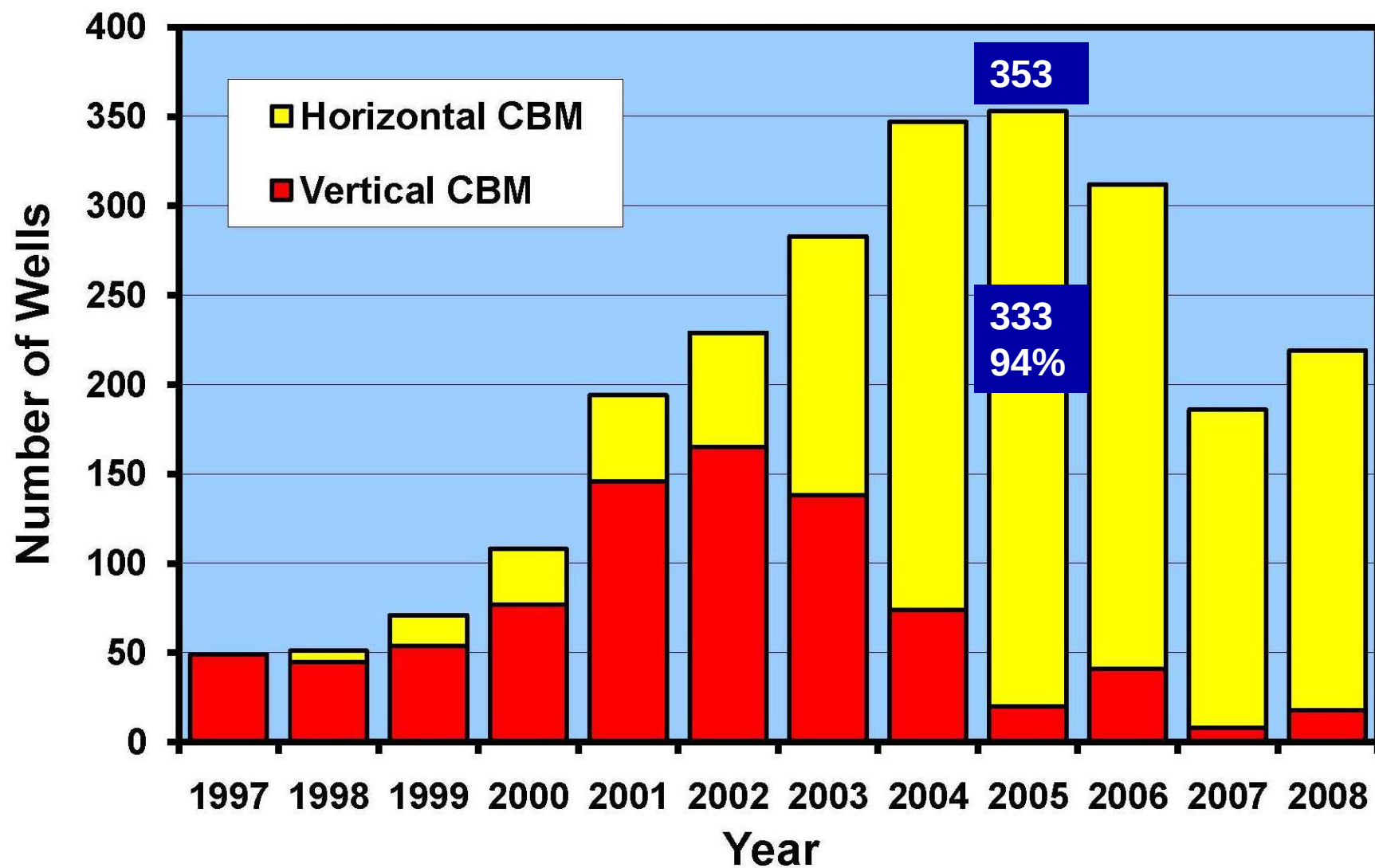
Arkoma Basin







Arkoma Basin

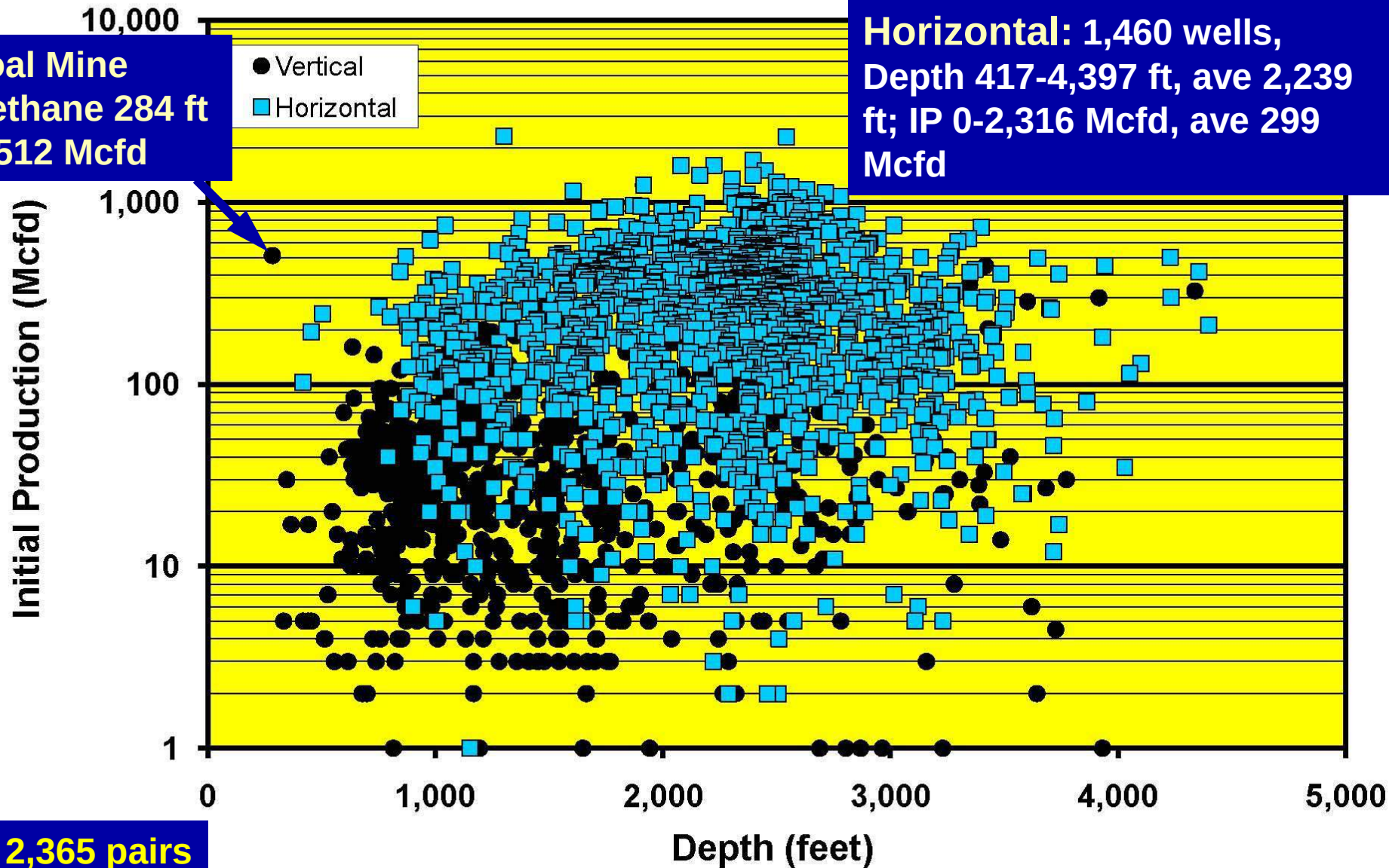


Arkoma Basin

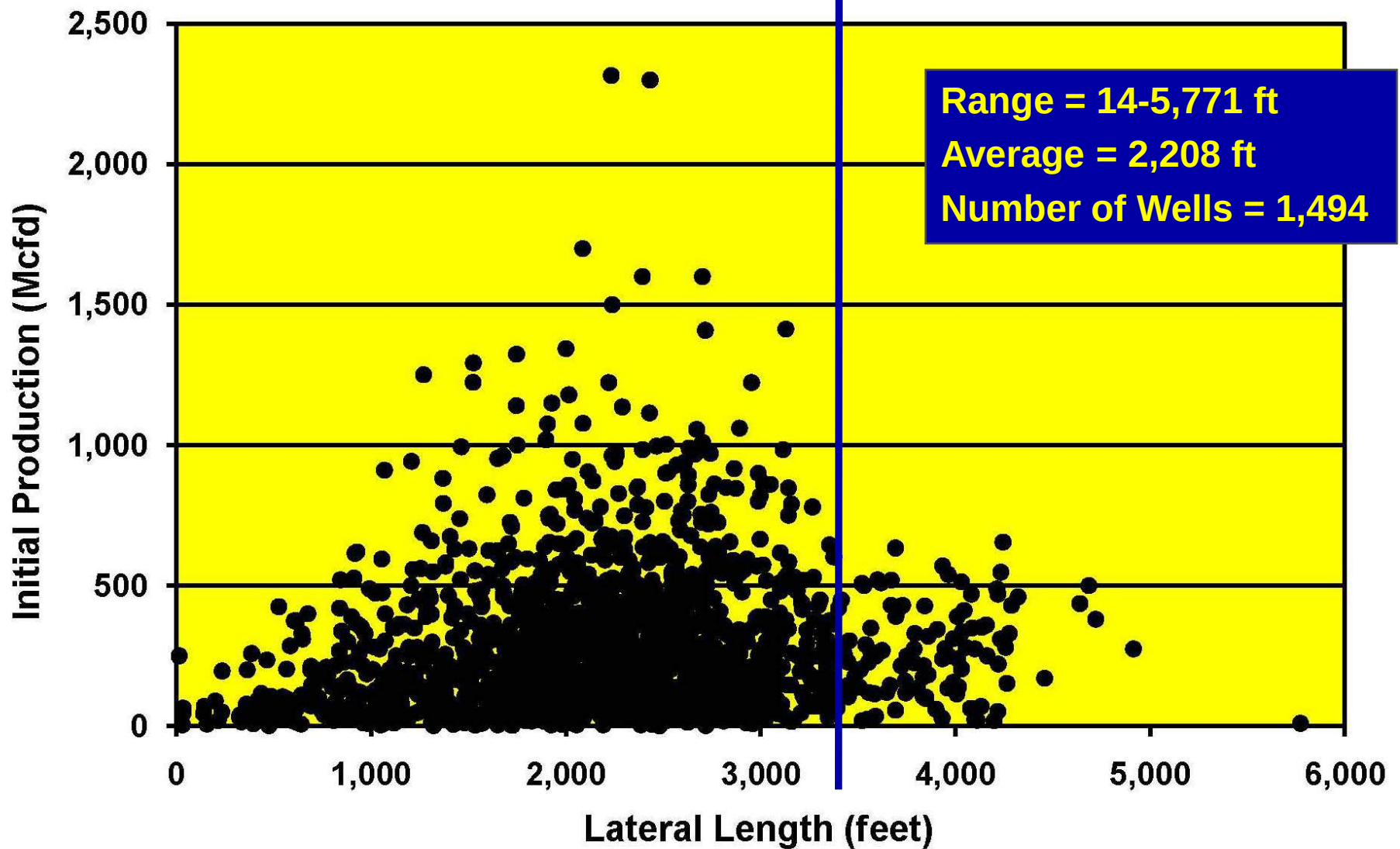
Vertical: 905 wells, Depth 284-4,337 ft, ave 1,449 ft; IP 0-512 Mcfd, ave 49 Mcfd

Horizontal: 1,460 wells, Depth 417-4,397 ft, ave 2,239 ft; IP 0-2,316 Mcfd, ave 299 Mcfd

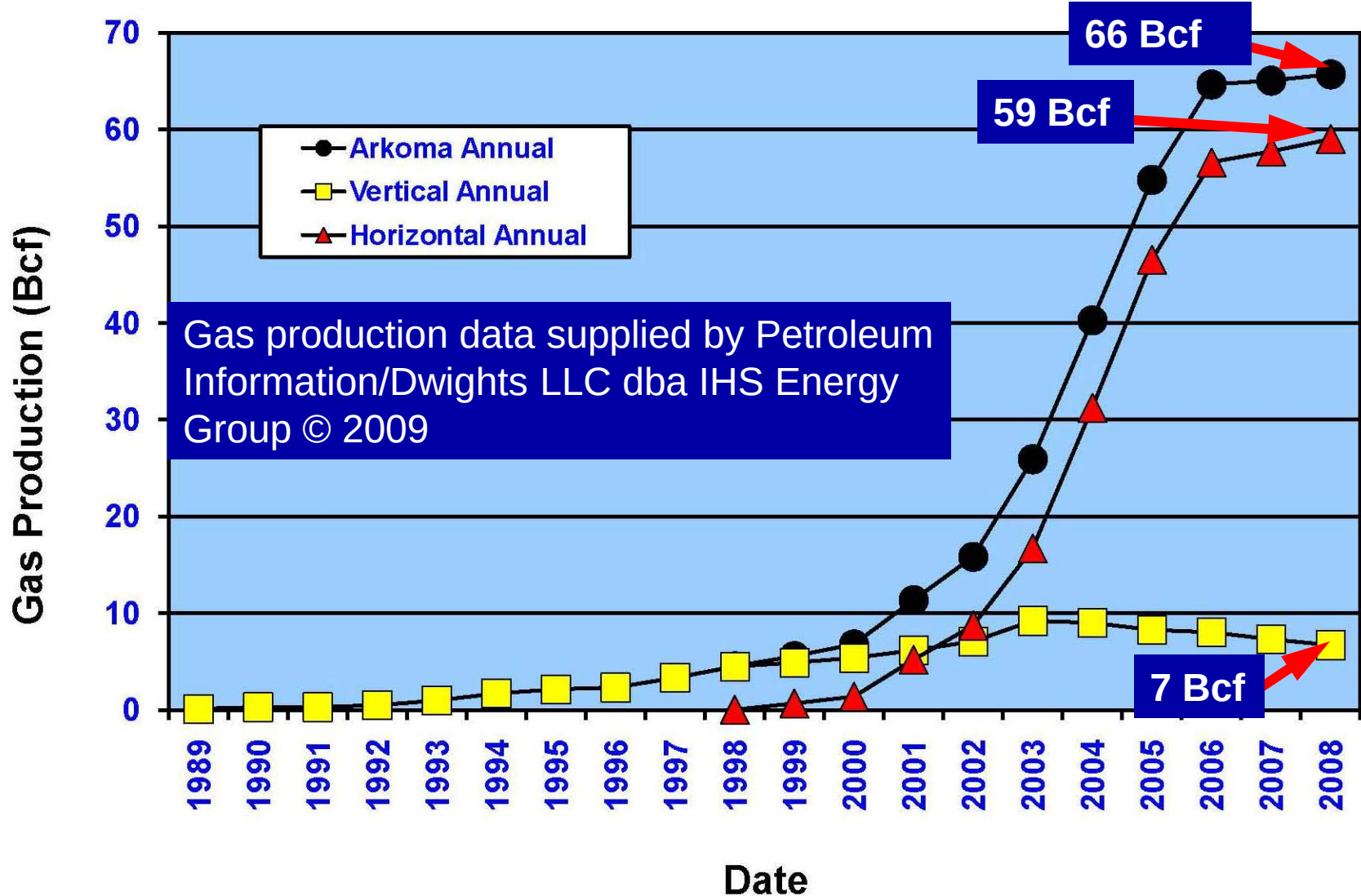
Coal Mine Methane 284 ft & 512 Mcfd



Horizontal CBM Wells

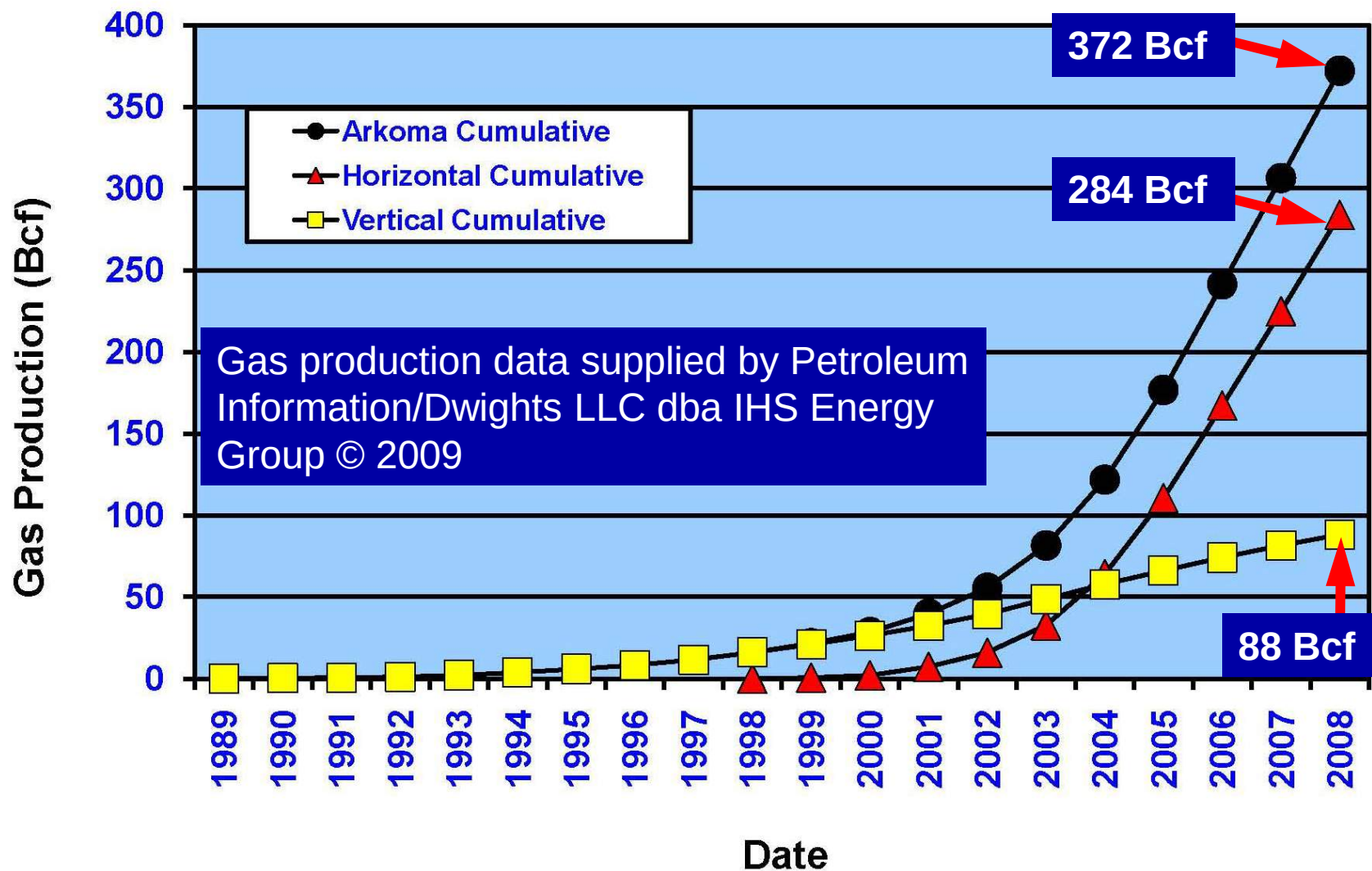


Arkoma Basin Annual CBM Production



923 vertical; 1,495 horizontal wells

Arkoma Basin Cumulative CBM Production





OKLAHOMA
GEOLOGICAL
SURVEY

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COAL AND COALBED METHANE

OKLAHOMA GEOLOGICAL SURVEY

Coal is an organic-rich rock derived from plant material deposited in a swamp, marsh, or bog. Coal varies by grade (percentage of mineral impurities), type (organic composition), and rank (level of coalification). Rank describes the transformation from peat (unconsolidated plant remains) through lignite, subbituminous, bituminous, semianthracite, and anthracite coal (rock) from increasing burial pressure, temperature, and time.

The [coalfield](#) in eastern Oklahoma is divided into the northeast Oklahoma shelf and the Arkoma Basin based on physiographic and structural differences. The commercial coal belt contains coal beds ≥ 10 in. thick that are mineable by surface methods at depths < 100 ft and coal beds ≥ 14 in. thick that are mineable by underground methods. The noncommercial coal-bearing region has limited information on coal thickness and quality or contains coals that are too thin, of low quality, or too deep for surface mining.

The age of commercial coal-bearing strata in the Oklahoma coalfield is Desmoinesian (Middle Pennsylvanian). Generalized [stratigraphic columns](#) of the northeast Oklahoma shelf and Arkoma Basin show about 40 named and several unnamed coal beds and their range in thickness measured from outcrops, mines, and shallow core samples.

[Coal rank](#), generalized for all coals at or near the surface, ranges from high-volatile bituminous in the northeast Oklahoma shelf and western Arkoma Basin to medium-volatile bituminous and low-volatile bituminous in the eastern Arkoma Basin in Oklahoma. Rank increases from west to east and with depth in the Arkoma Basin, attaining semianthracite in Arkansas.

Remaining identified bituminous coal resources in beds ≥ 10 in. thick total 8.09 billion short tons (1 short ton equals 2,000 pounds) in 19 counties in eastern Oklahoma, an area of approximately 8,000 square miles. About 1.5 billion short tons of bituminous coal reserves (the economically recoverable part of coal resources) remain in Oklahoma. Oklahoma ranks 19th of 32 coal-bearing states in the U.S. based on coal reserves. From 1873-2008, 292 million short tons of bituminous coal were produced from underground and surface mines in the Indian Territory and Oklahoma. Peak annual [coal production](#) was 5.73 million short tons in 1981, with smaller production peaks during and immediately following World War I and World War II.

There are many uses for coal, primarily in combustion (generation of electricity, used to make steel), conversion (gasification and liquefaction), and it is used in Oklahoma in electric power plants and lime and cement kilns.

Coal generates and stores large quantities of natural gas (methane). Oklahoma is in the [northeast Oklahoma shelf](#) and [Arkoma Basin](#).

[Presentations, Reports and Maps](#)

[Coal Bibliographies](#)

[Links](#)

[Coal Database](#)

[Coal Maps and Illustrations](#)

Related interest: [Oil and Gas in Oklahoma](#)

LINKS

Example of coal and coalbed-methane information available on the OGS Web site
(<http://www.ogs.ou.edu/coaldb.php>)

CBM Completions Table on OGS Web Site

Security Warning Certain content in the database has been disabled Options...

Coalbed-Methane Completions

Rec	API Number	Operator	Completion Date	Well Name	Field Name	S	Top	1	1	4t	3r	2r	1st
2571	35-061-21844	Williams Production	5/31/2003	2-32 Penny	Kinta	32	8	N	19	E	NE	SE	SW
1502	35-121-22664	Mannix Oil	11/20/2001	3-9 Snowball	Pittsburg County CBM Gas A	9	8	N	17	E	SW	SW	NE
2219	35-121-22644	Mannix Oil	11/20/2001	1-9 Snowball	Pittsburg County CBM Gas A	9	8	N	17	E	NW	SW	NE
4301	35-105-20715	Endeavor Energy Resources	2/21/2002	18-2 Delaware Gas	Delaware-Childers	18	27	N	15	E	SE	NE	NW
1504	35-121-22684	Mannix Oil	11/20/2001	2-9A Snowball	Pittsburg County CBM Gas A	10	8	N	17	E	SW	SW	NW
4755	35-091-21619	Williams Production	10/11/2006	3-8 Campbell	Vernon NW	8	9	N	13	E	C	C	SW
4757	35-091-21618	Williams Production	10/24/2006	3-24 Saltsman	McIntosh County CBM Gas A	24	9	N	15	E	SE	NW	NW
5201	35-121-23979	Ardmore Production & Exploration	11/21/2007	1H-15 Dustin	Scipio NW	15	7	N	13	E	SE	NW	SE
4198	35-091-21552	Orion Exploration	5/18/2006	1-19 Gates HHC	McIntosh County CBM Gas A	19	9	N	13	E	SE	SW	SW
5075	35-091-21654	Williams Production	4/27/2007	5-23H Mary Dover	McIntosh County CBM Gas A	23	9	N	15	E	SE	NW	NE
2187	35-121-28847	Davis Operating Company	1/28/2003	1 Belt	Kinta	24	8	N	18	E	SE	NE	NW
3762	35-121-23394	Petroquest Energy	4/8/2005	2-10 Hodges	Pittsburg County CBM Gas A	10	7	N	15	E	NE	NE	SW
1577	35-061-21592	Mannix Oil	8/20/2001	3-13 Verdell	Kinta	13	8	N	18	E	WH	WH	SE
4163	35-121-23590	Questar Exploration & Production	2/22/2006	3-14H Monks	Brooken	14	8	N	17	E	NE	NE	NE
2184	35-121-22850	Davis Operating Company	2/18/2003	1 Higgins	Kinta	24	8	N	18	E	SW	SW	SE
4087	35-121-23522	Jay Petroleum	1/5/2006	3 Medley	Scipio NW	29	7	N	13	E	SW	SE	SW
5310	35-121-23861	Canaan Resources	2/14/2008	1H-22 Gareth	Scipio NW	22	7	N	13	E	NW	NW	SW
1503	35-121-22645	Mannix Oil	11/20/2001	4-9 Snowball	Pittsburg County CBM Gas A	9	8	N	17	E	NW	SW	NE
1242	35-061-21448	Mannix Oil	10/1/2000	3-31 Molly	Kinta	31	8	N	19	E	SW	NW	SE
1494	35-121-22624	Mannix Oil	12/1/2001	1-10 Hook	Pittsburg County CBM Gas A	10	8	N	17	E	WH	WH	NE
4573	35-121-23714	Tag Team Resources	8/9/2006	1H-31 Sissy Cat	Pittsburg County CBM Gas A	31	7	N	13	E	SW	SW	SE
4001	35-121-23515	Tag Team Resources	10/6/2005	1H-13 Luanne	Scipio NW	13	7	N	12	E	NE	NE	NE
5043	35-091-21648	Williams Production	6/1/2007	2-21H Young	McIntosh County CBM Gas A	21	9	N	15	E	NW	SW	SE
1495	35-121-22620	Mannix Oil	11/22/2001	2-10 Hook	Pittsburg County CBM Gas A	10	8	N	17	E	WH	WH	SE
3484	35-121-23315	Tag Team Resources	12/13/2004	1H-32 Charless III	Reams NW	32	7	N	13	E	SW	SW	SE
4244	35-121-23621	Tag Team Resources	3/22/2006	1H-30 Janet	Scipio NW	30	7	N	13	E	SW	SW	SE
4483	35-121-23639	Chesapeake Operating	8/12/2006	1-24H Jana	Scipio NW	24	7	N	12	E	SW	SW	NE
4003	35-121-23484	Tag Team Resources	10/6/2005	1H-20 Zachary	Scipio NW	20	7	N	13	E	NW	NW	SE
5308	35-121-23966	Canaan Resources	2/7/2008	1H-16 Dian	Scipio NW	16	7	N	13	E	SW	SW	SW
1511	35-121-22625	Mannix Oil	12/1/2001	4-10 Hook	Pittsburg County CBM Gas A	10	8	N	17	E	EH	EH	NW
5017	35-121-23787	Penn Virginia MC Operating	4/6/2007	1-3A Edmonds	Unnamed 80	3	7	N	12	E	SW	SW	SE
4228	35-121-23457	Petroquest Energy	7/20/2005	1-31 PSO	Canadian	31	9	N	16	E	SW	SE	SW
4002	35-121-23477	Tag Team Resources	9/30/2005	1H-17 Scipio	Scipio NW	17	7	N	13	E	NE	NE	SW
3918	35-121-23411	Tag Team Resources	4/24/2005	1H-13D L	Scipio NW	13	7	N	12	E	SW	SW	SE
3920	35-121-23436	Tag Team Resources	7/8/2005	1H-32 Norma	Scipio NW	32	7	N	13	E	SW	SW	NW
5162	35-121-23838	Penn Virginia MC Operating	8/4/2007	1-26 Lott	Pittsburg County CBM Gas A	26	8	N	12	E	SW	SW	SE
5125	35-121-23852	Penn Virginia MC Operating	8/6/2007	4-36 Butler	Pittsburg County CBM Gas A	36	8	N	12	E	NW	NW	SW
4102	35-121-23475	Tag Team Resources	9/24/2005	1H-18 Ruth	Scipio NW	18	7	N	13	E	NW	NW	NE

Record: 1 of 5774

5,774