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Coal Geology and Resources of the U.S. Gulf of Mexico Coastal Plain

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U.S. Department of the Interior
U.S. Geological Survey

Acknowledgements

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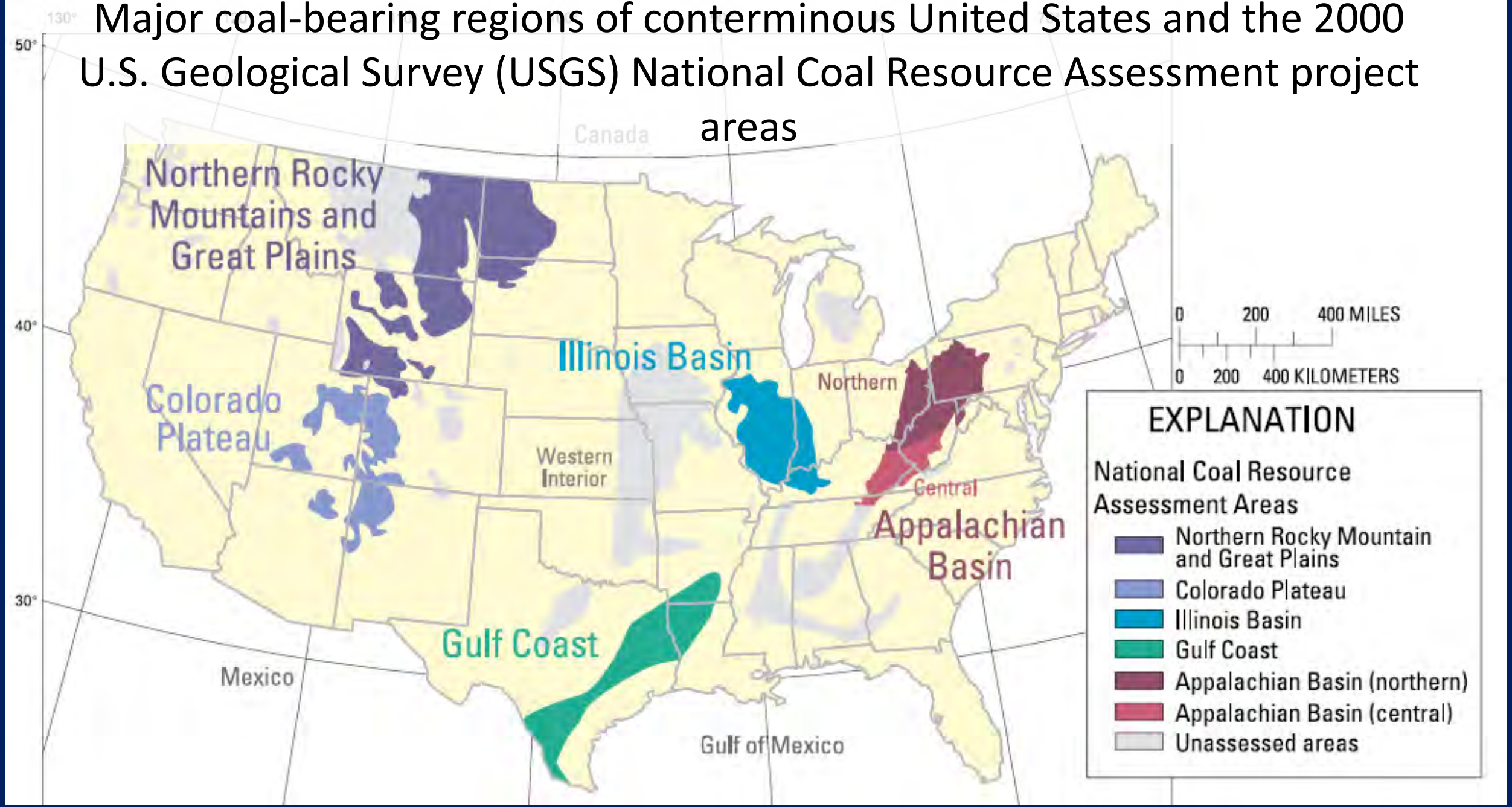
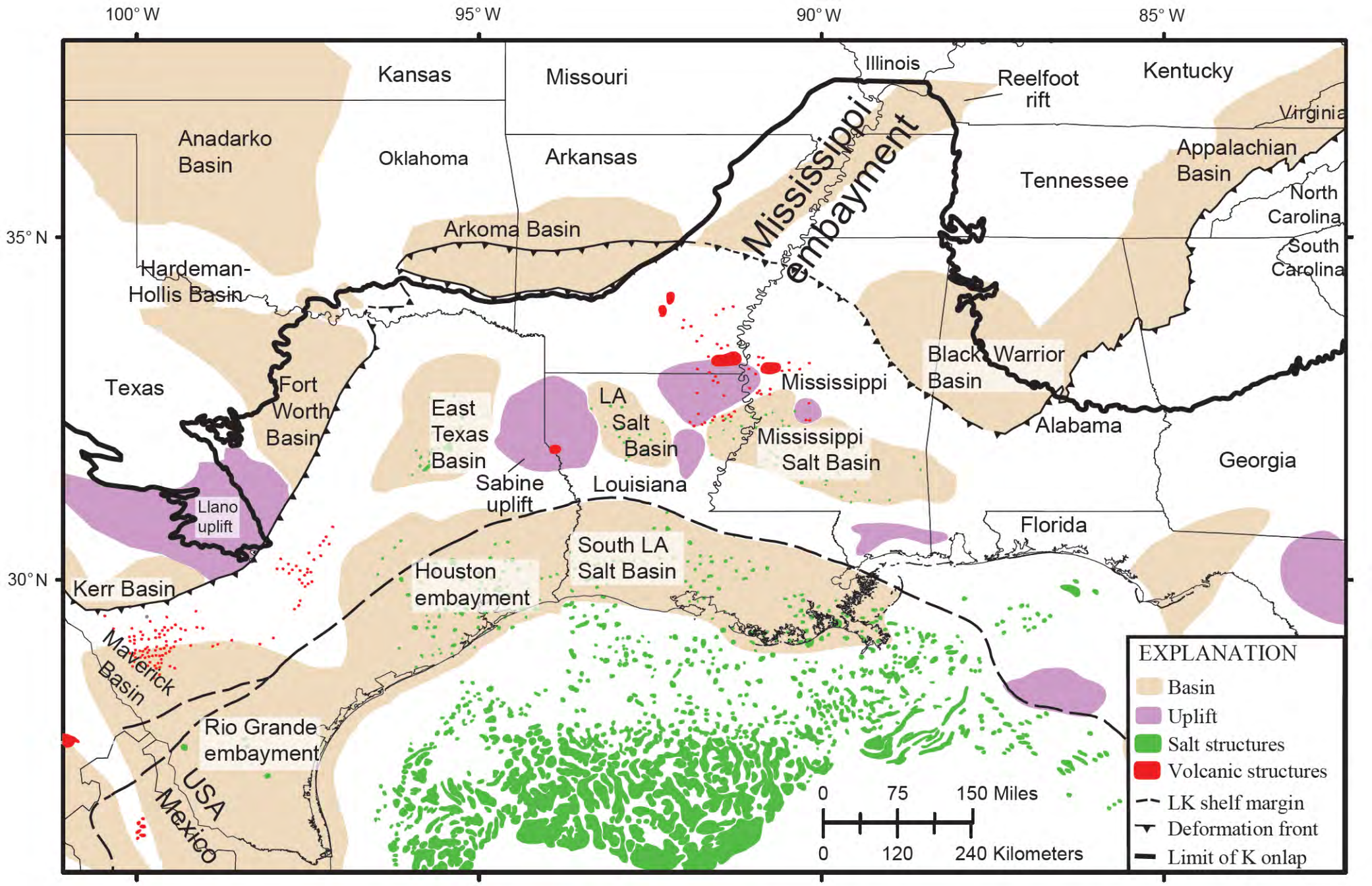
Outline for Presentation

- Geologic setting of Gulf of Mexico Coastal Plain
- Coal-bearing stratigraphy
- Depositional environments
- Coal deposits by geologic age (focus on volcanic ash layers or tonsteins)
- Coal resource estimates
- General coal quality
- Coalbed gas resources
- Summary

Major coal-bearing regions of conterminous United States and the 2000 U.S. Geological Survey (USGS) National Coal Resource Assessment project areas

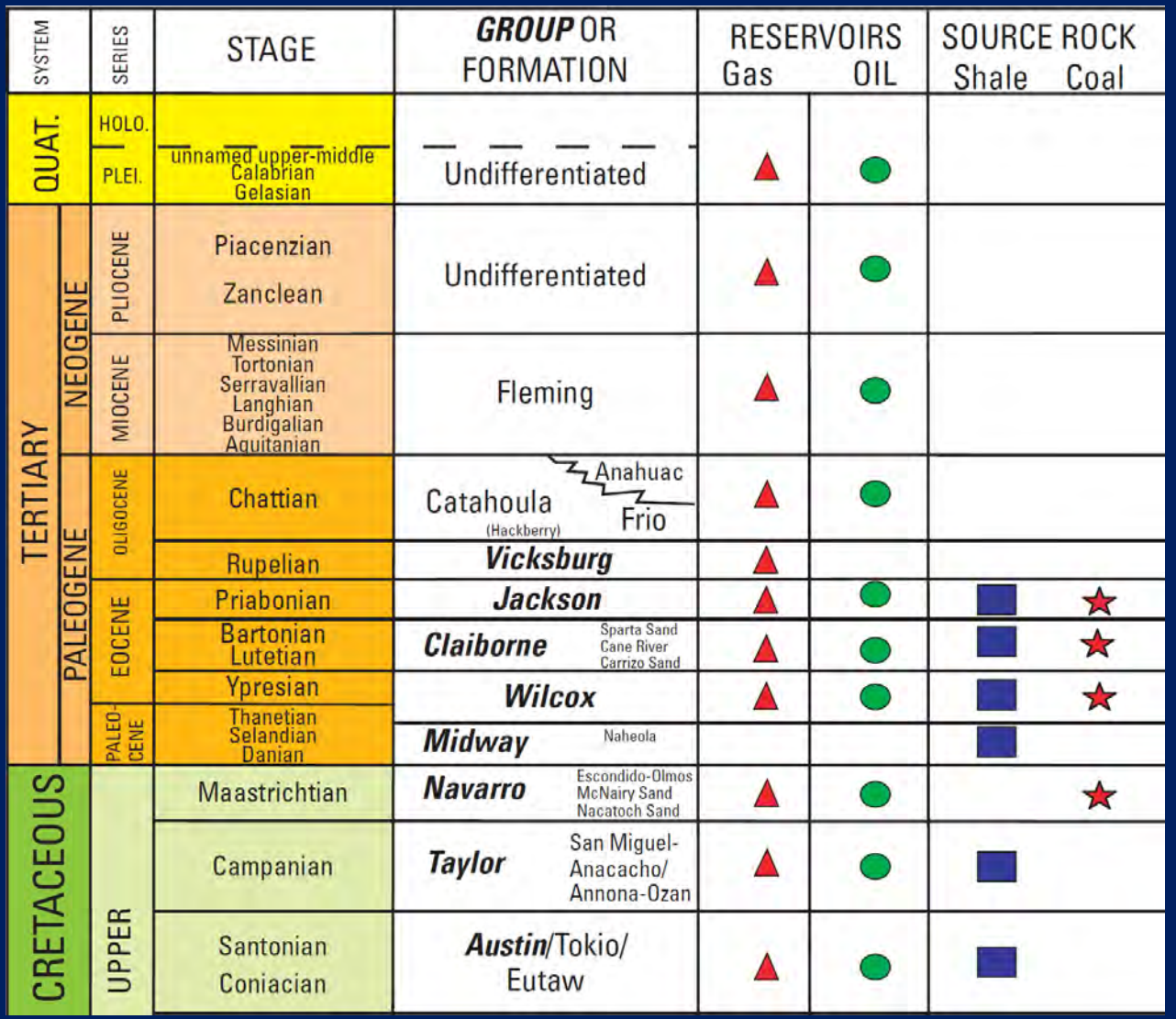


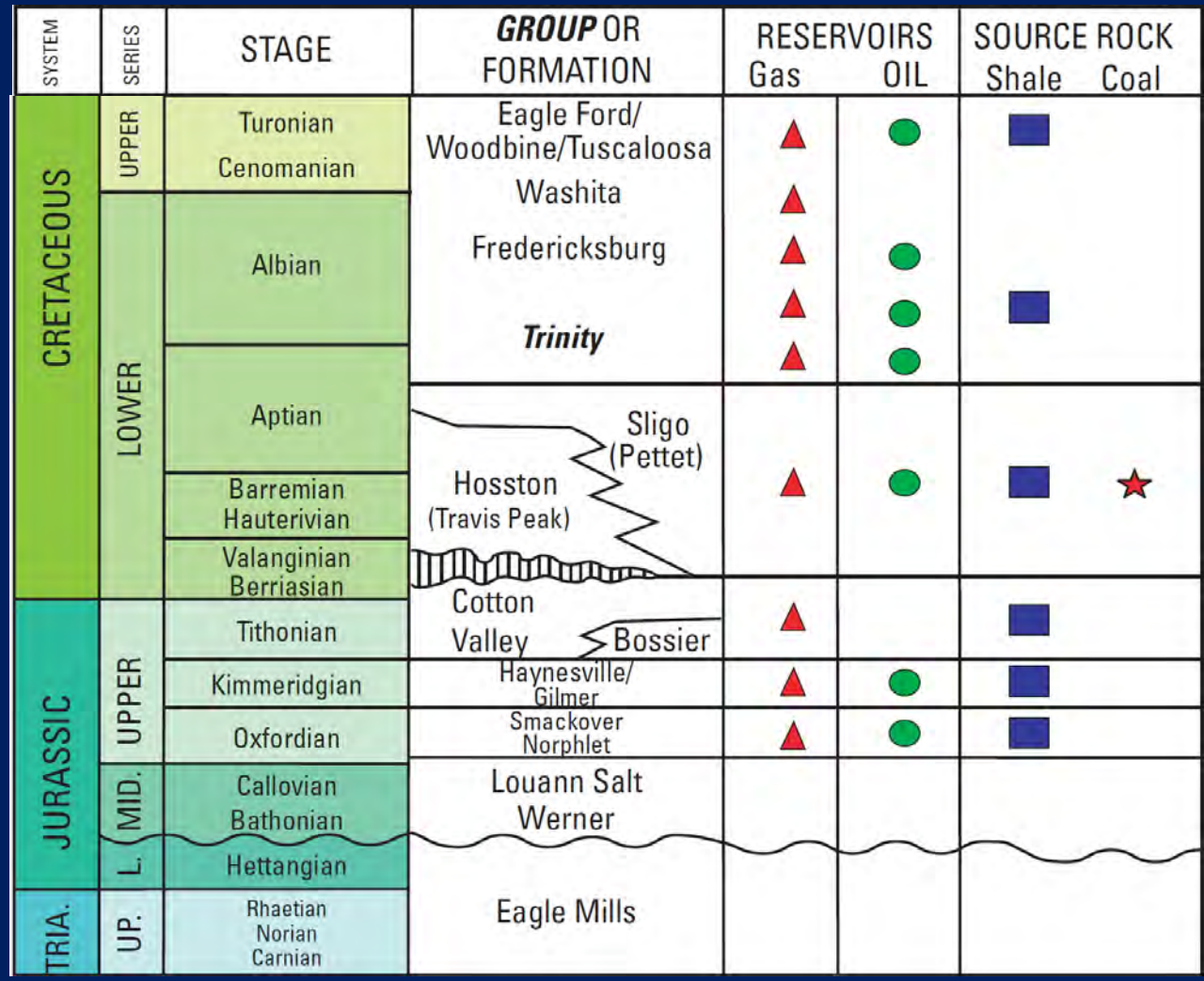


LK = Lower Cretaceous; K = Cretaceous

Warwick (2017)

Generalized stratigraphic section of the northern Gulf of Mexico Coastal Plain



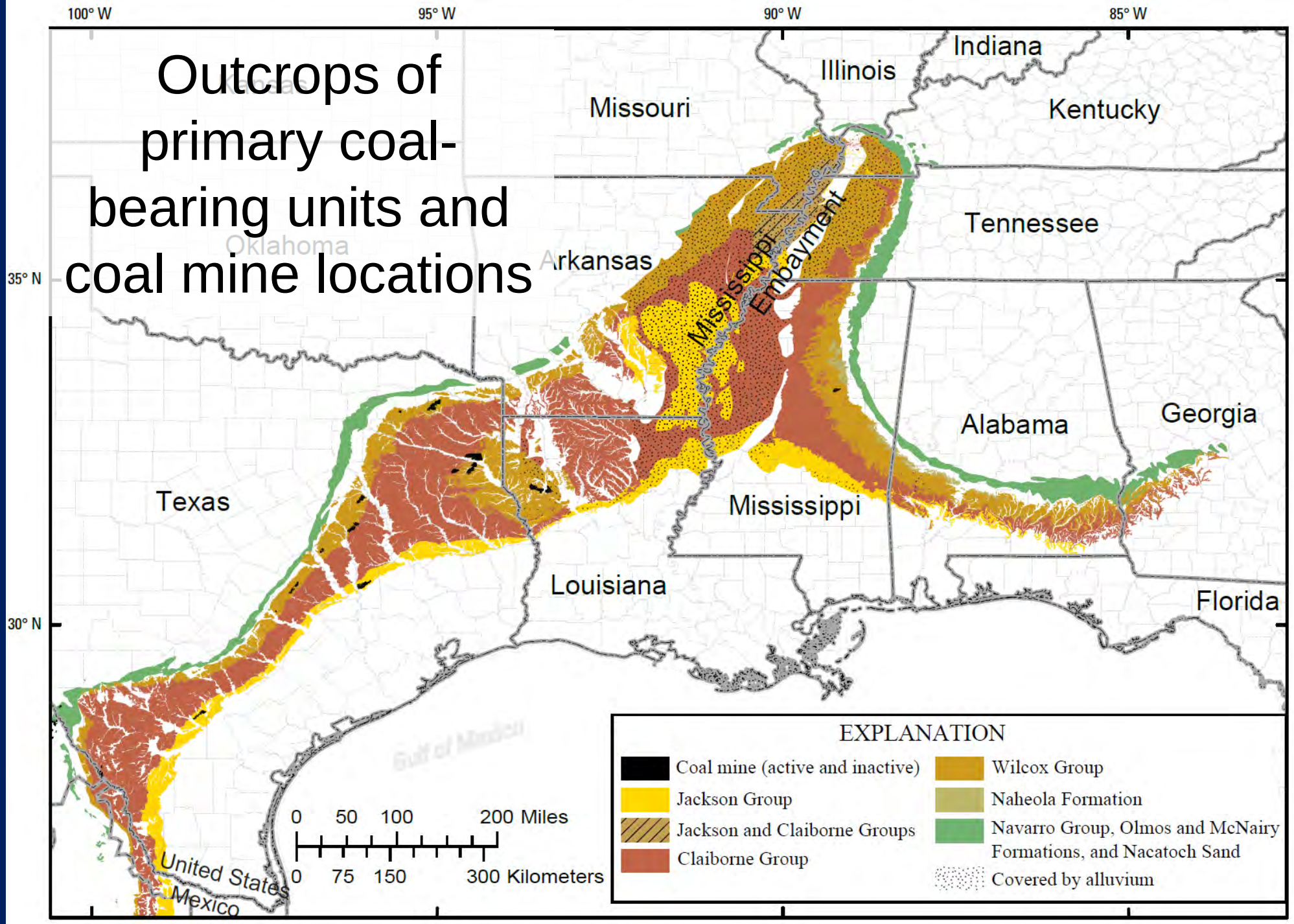


Abbreviations: L., Lower; Mid., Middle; Up., Upper; Tria., Triassic; Plei., Pleistocene; Holo., Holocene; Quat., Quaternary; evenly spaced vertical lines, unconformity; wavy line, disconformity; jagged line, interfingering; dashed line, uncertain

Warwick (2017)

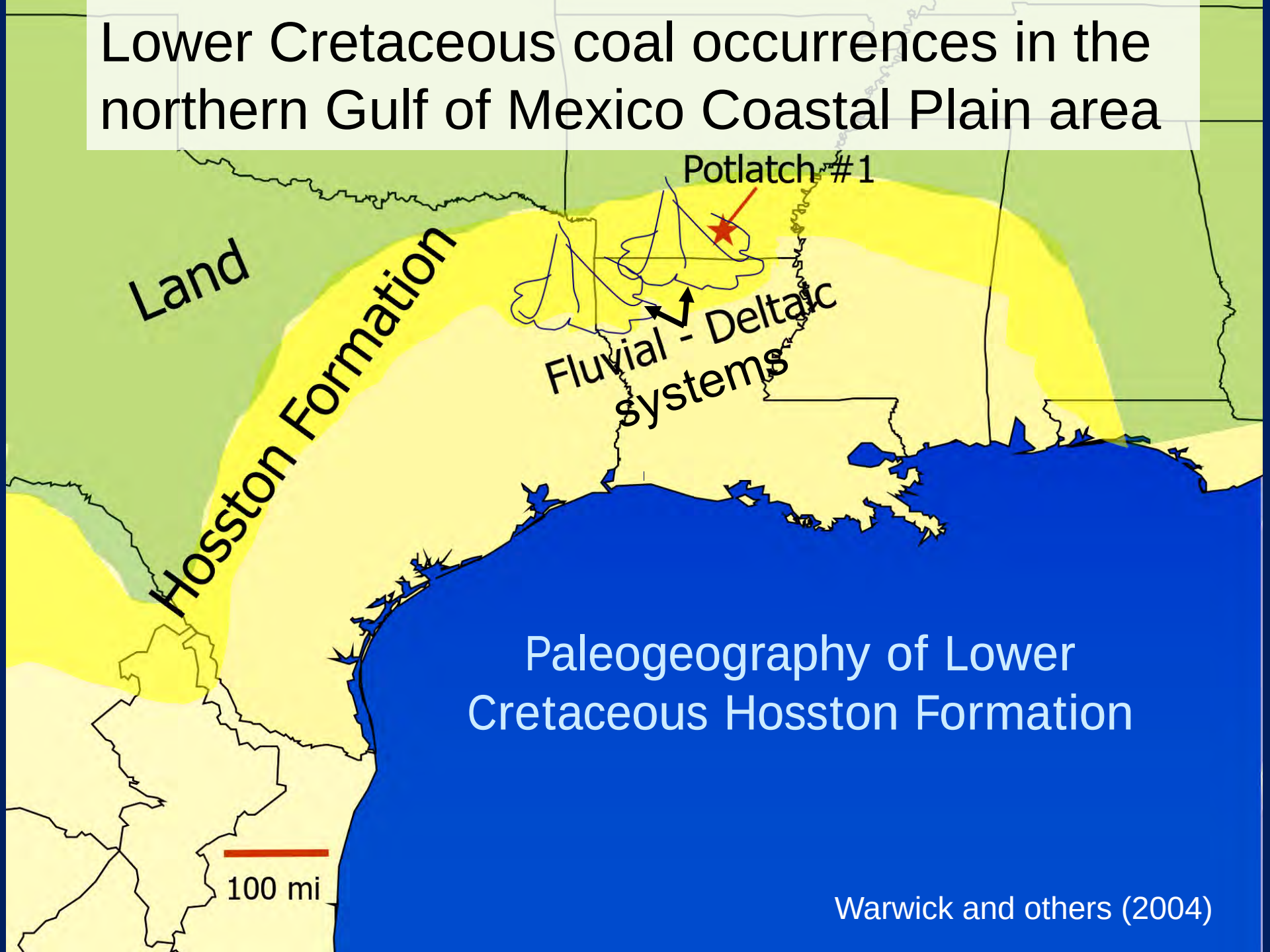
USGS

Outcrops of primary coal-bearing units and coal mine locations



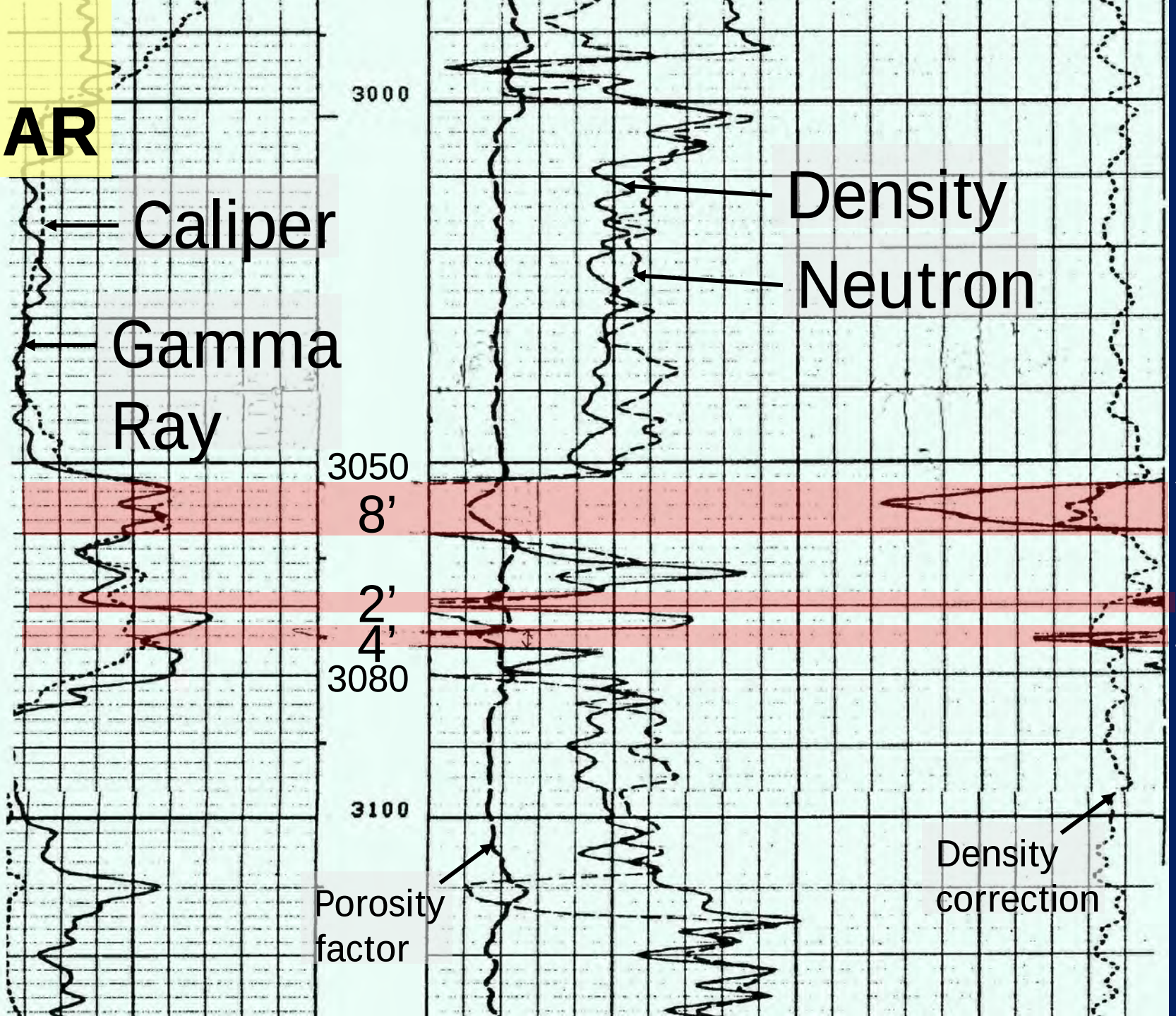
Warwick (in prep.)

Lower Cretaceous coal occurrences in the northern Gulf of Mexico Coastal Plain area



Warwick and others (2004)

Potlatch #1
Bradley CO, AR



Warwick and others (2004)

USGS

Lower Cretaceous coal occurrences in the northern Gulf of Mexico Coastal Plain area

- Three coal zones recognized in the Trinity - Hosston Formation (Travis Peak) in Bradley County, AR
  - Depths range from 3,050 – 3,500 ft
  - About 20 ft cumulative coal with individual beds up to 8 ft thick
  - Vitrinite reflectance at 3,050-3,080 ft is 0.53 % (high-volatile C bituminous)
- Lower Cretaceous coal zones extend into northeastern TX and northern LA (Imlay, 1945; Scherer, 1980; Mitchell-Tapping, 1997)

USGS

Warwick and others (2004)

Upper Cretaceous coal occurrences in the northern Gulf of Mexico Coastal Plain area

- Lignite beds occur in the Upper Cretaceous McNairy Sand
  - Beds are highly discontinuous and thin (<1.5 ft thick) (Olive, 1980)
  - Present in the subsurface in western Kentucky (Hower and others, 1990)
- Analysis of a carbonaceous shale sample from an outcrop in western Kentucky
  - 11.16 % (as-determined) moisture content and a 52.96 % (dry basis) ash yield
  - Huminite reflectance value of 0.28 % (Hower and others, 1990)
- Reports of Upper Cretaceous coals in MS and AL (Brown, 1907; Monroe and others, 1946)

USGS

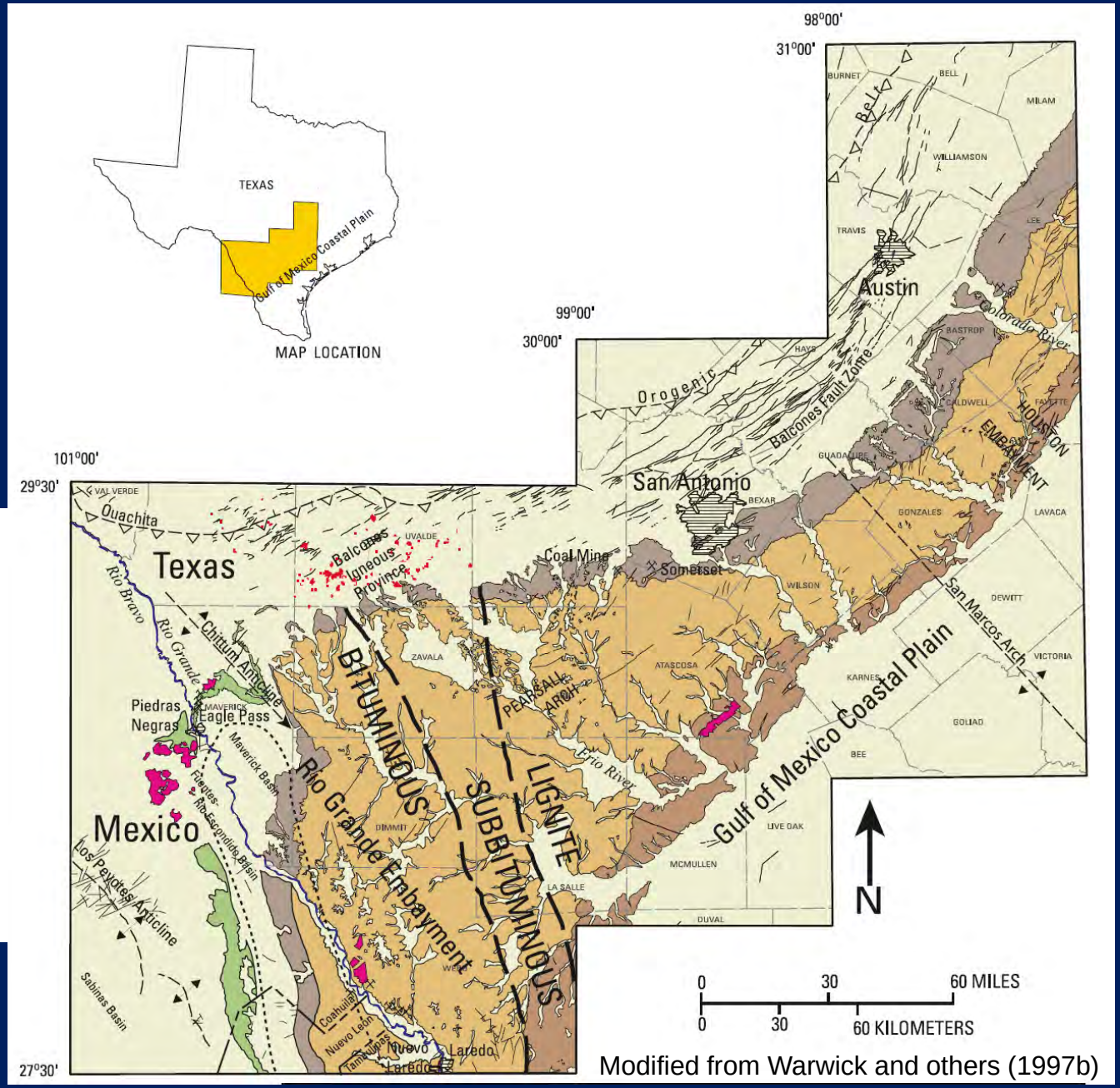
Warwick (in prep.)

Upper Cretaceous Olmos coals of south Texas and Mexico

EXPLANATION

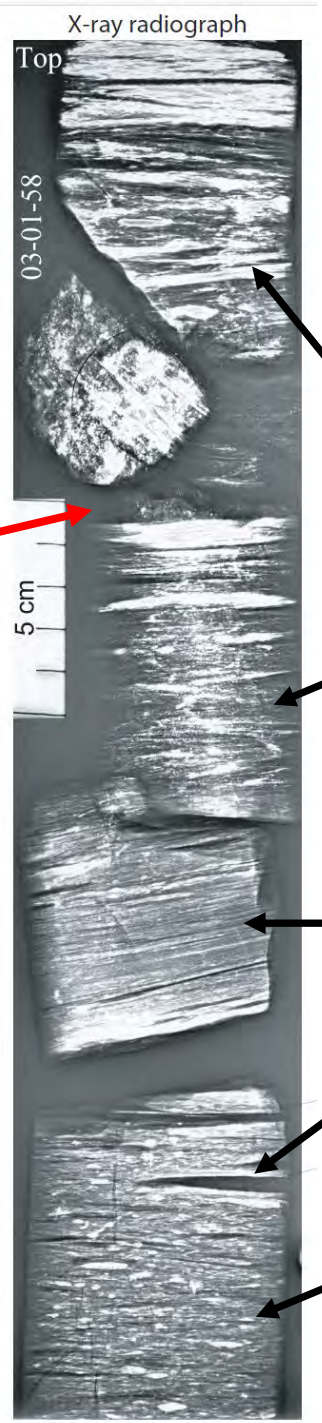
Coal-bearing Strata

- Jackson Group (Eocene)
- Claiborne Group (Eocene)
- Wilcox Group (Paleocene - Eocene)
- Olmos Formation (Upper Cretaceous)
- Cretaceous and post-Eocene non coal-bearing strata
- Igneous intrusives of Balcones Igneous Province (Upper Cretaceous - Paleocene?)
- Inferred Olmos coal-gas region
- Inferred coal rank boundary
- Antiform axis, approximately located
- Major fault
- Front of orogenic activity
- Coal mine or permit area
- Historic coal mine site
- Major city
- International boundary
- State boundary (Mexico)
- County boundary (Texas)



Modified from Warwick and others (1997b)

Hook and others (2011a)



Well: Comanche 1-117CR
Sample: 03-01-58
Depth:1189.80 - 1190.80 ft
As-received ash: 16.37%

Coal with shale lenses

Coal with horizontal and vertical burrows

Coal, laminated with horizontal burrows

Woody lenses - compressed root? cross-sections

Coal with horizontal burrows and vertical cleat development

Karlsen and others (2002)

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Olmos Formation coal resource characteristics

- Deltaic depositional setting (Tyler and Ambrose, 1986; Ewing, 2003)
- Coals are thin (less than 6 ft), laterally discontinuous, and host to numerous volcanic and siliciclastic partings
- Coal rank: high-volatile C bituminous (due to increased depth of coal burial and subsequent uplift)
- Mapel (1967) estimated that there are 525 million short tons of coal greater than 14 in thick and at depths less than 3,000 ft

Mean concentrations (in weight percent) of selected coal-quality parameters

	Volatile Matter	Fixed Carbon	Ash Yield	Sulfur
As Received Basis	33.47	44.11	16.96	1.40
Number of Analyses	15	15	15	12
Dry Basis	35.57	45.29	19.17	1.46
Number of Analyses	13	13	13	12

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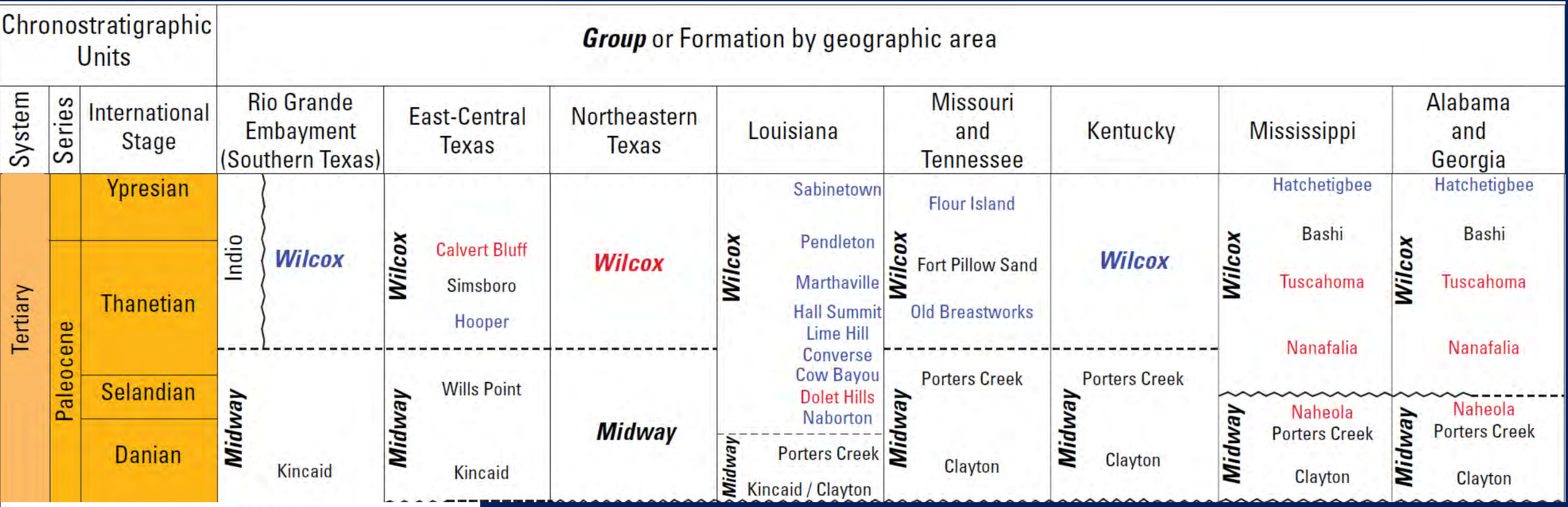
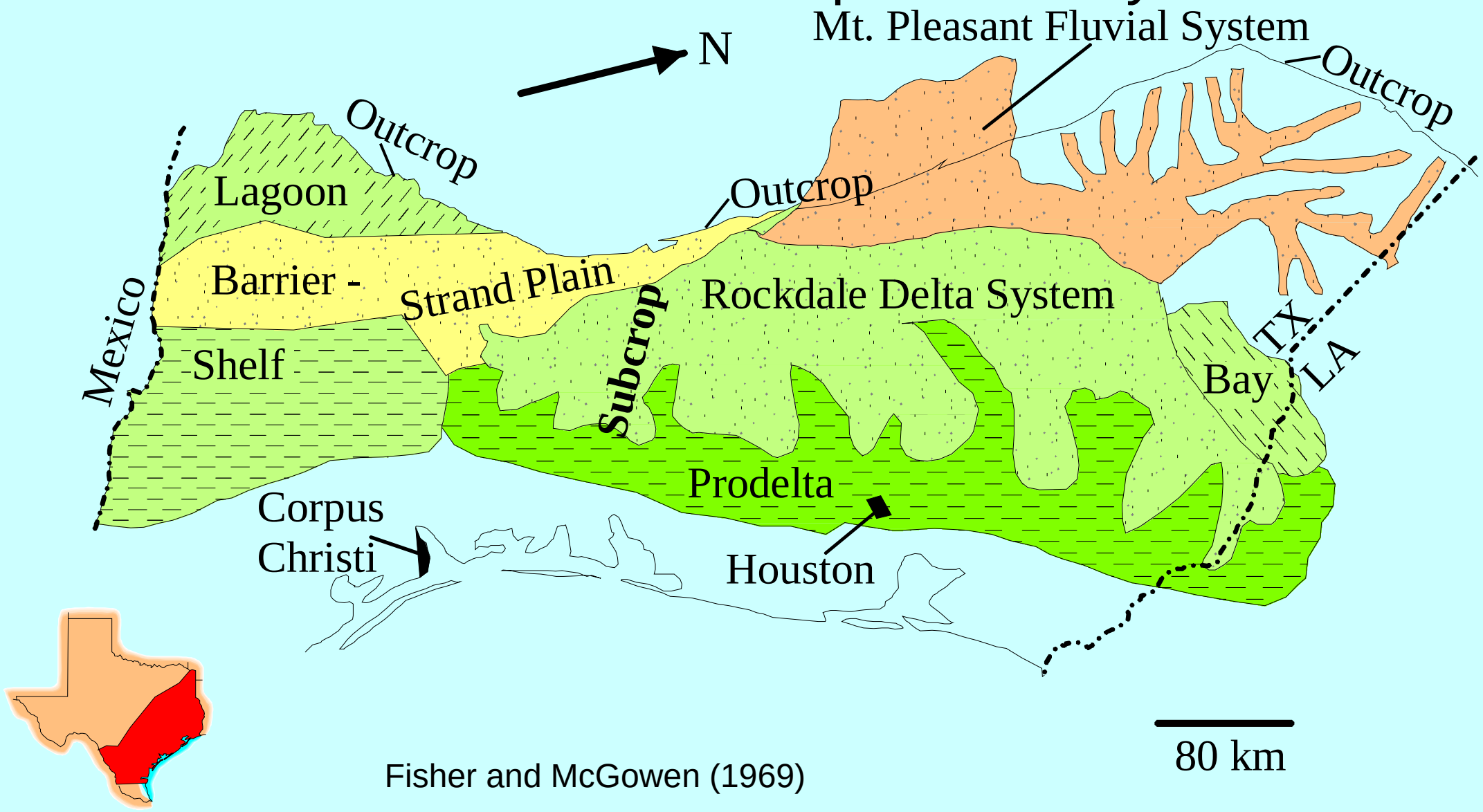
Hook and others (2011a)

Wilcox coals of the Gulf of Mexico Coastal Plain



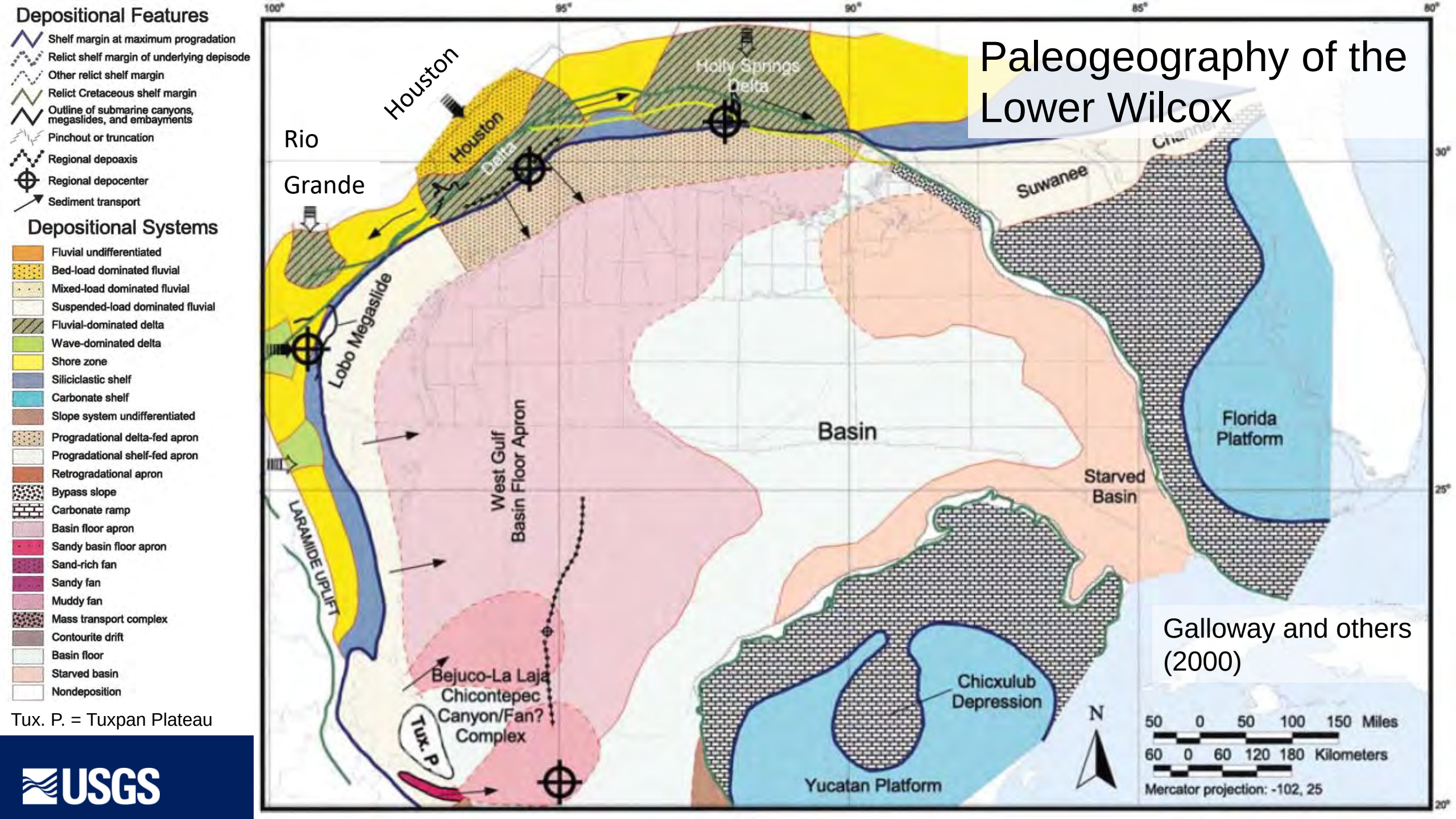
Warwick and others (1997); Valentine and Dennen (2012); Warwick (in prep.)

Lower Wilcox depositional systems



Fisher and McGowen (1969)

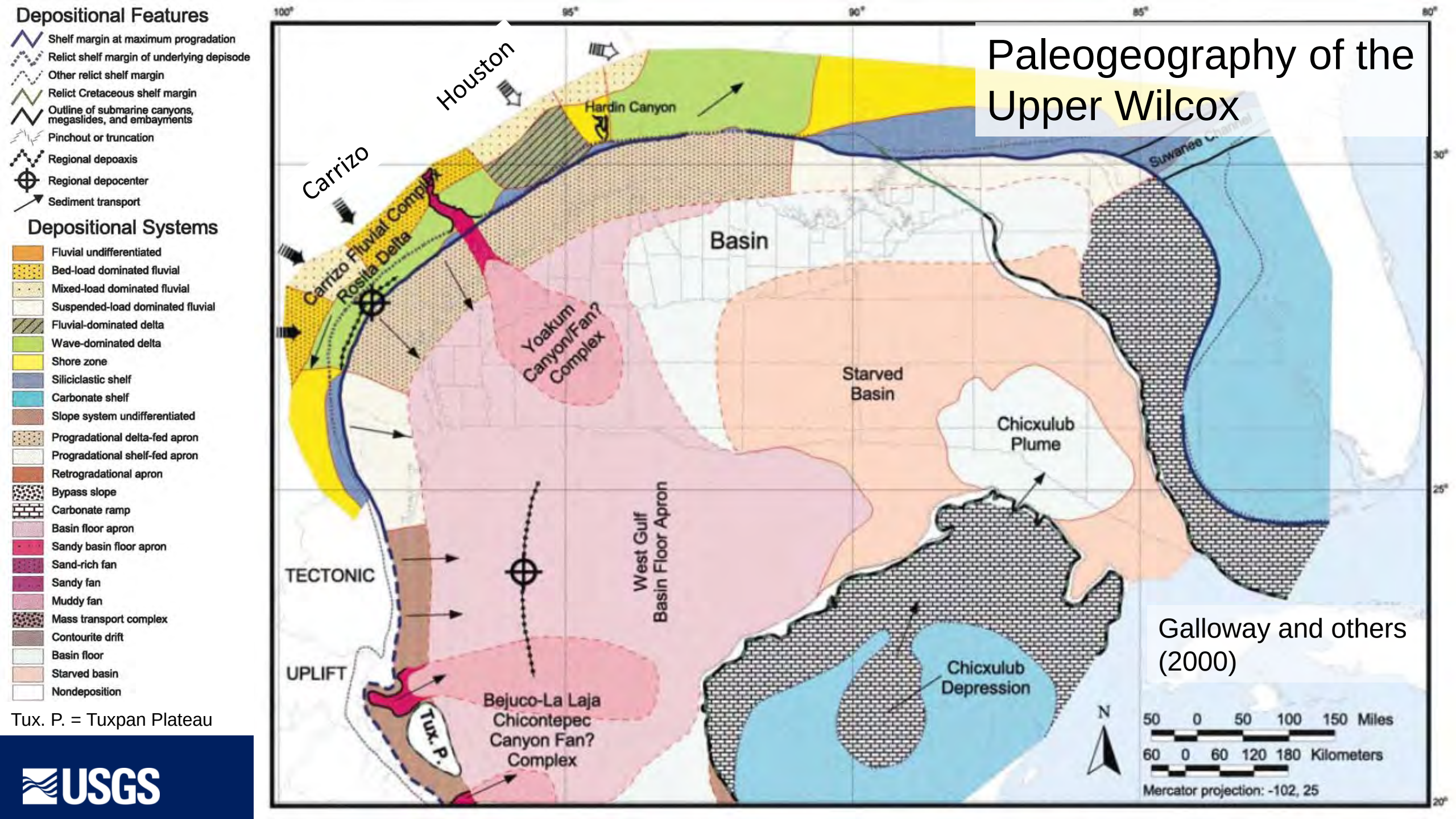
Paleogeography of the Lower Wilcox



Galloway and others (2000)

USGS

Paleogeography of the Upper Wilcox



Depositional Features

- Shelf margin at maximum progradation
- Relict shelf margin of underlying depisode
- Other relict shelf margin
- Relict Cretaceous shelf margin
- Outline of submarine canyons, megaslides, and embayments
- Pinchout or truncation
- Regional depoaxis
- Regional depocenter
- Sediment transport

Depositional Systems

- Fluvial undifferentiated
- Bed-load dominated fluvial
- Mixed-load dominated fluvial
- Suspended-load dominated fluvial
- Fluvial-dominated delta
- Wave-dominated delta
- Shore zone
- Siliciclastic shelf
- Carbonate shelf
- Slope system undifferentiated
- Progradational delta-fed apron
- Progradational shelf-fed apron
- Retrogradational apron
- Bypass slope
- Carbonate ramp
- Basin floor apron
- Sandy basin floor apron
- Sand-rich fan
- Sandy fan
- Muddy fan
- Mass transport complex
- Contourite drift
- Basin floor
- Starved basin
- Nondeposition

Tux. P. = Tuxpan Plateau

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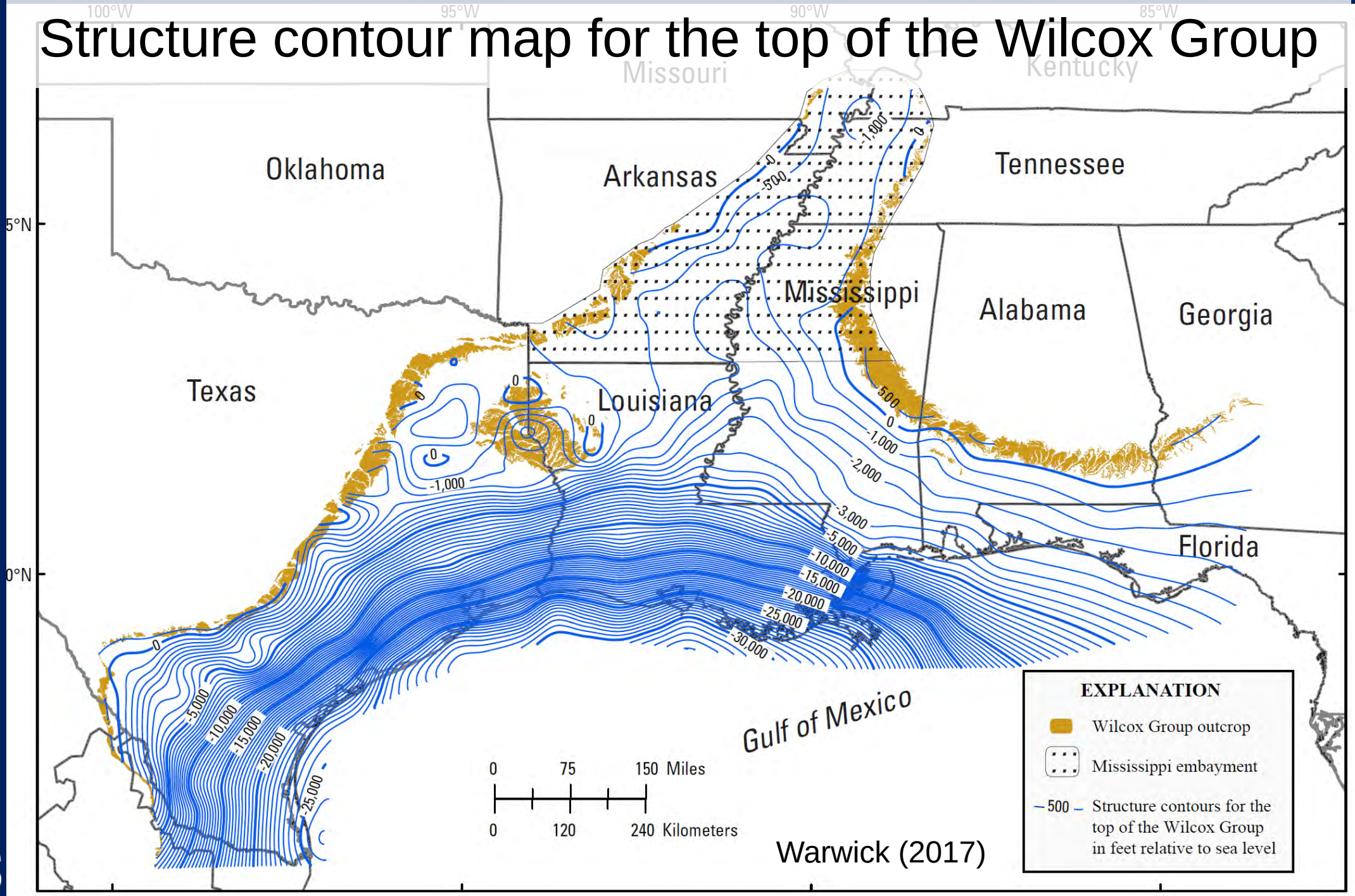
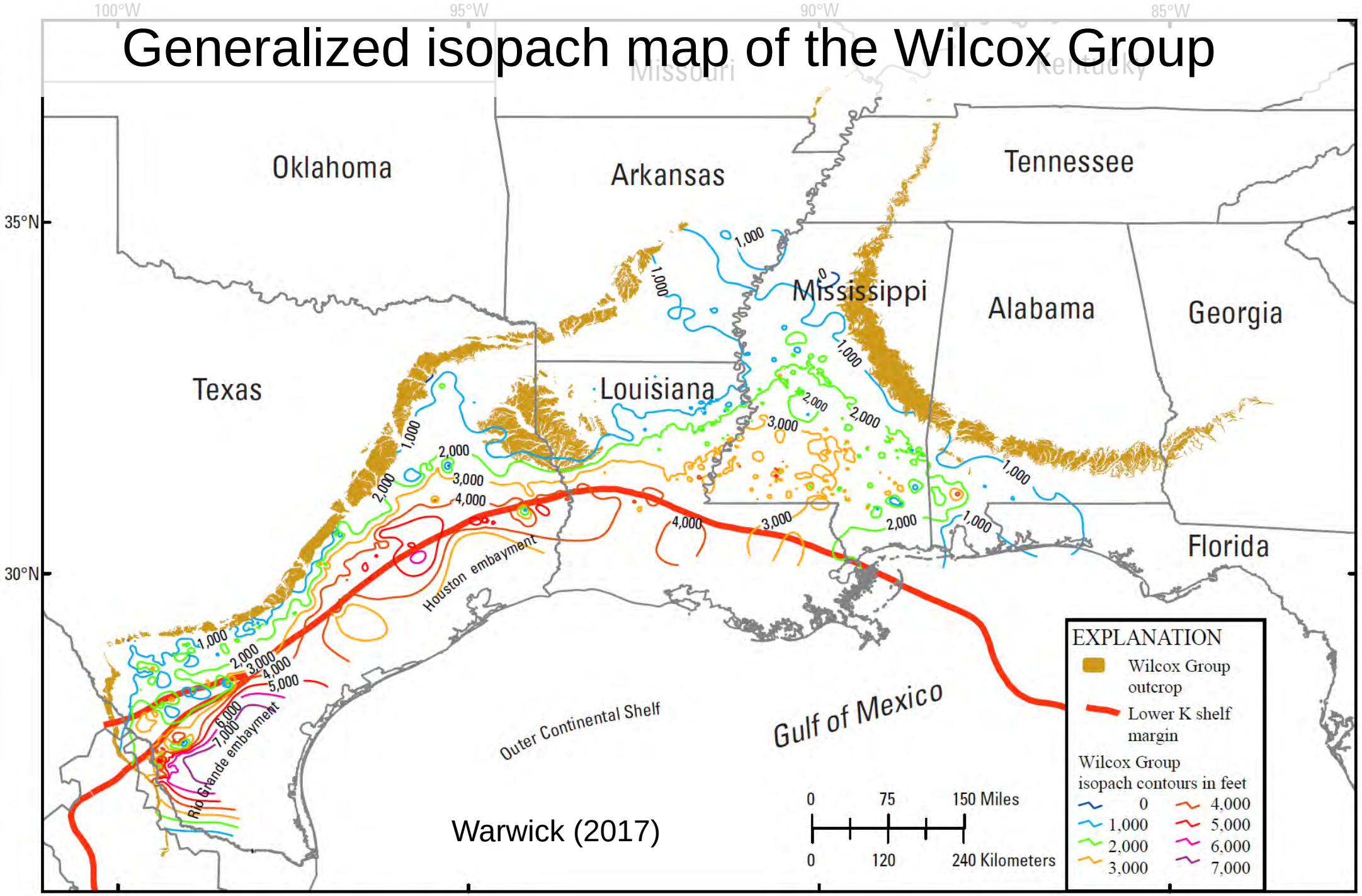
Structure contour map for the top of the Wilcox Group



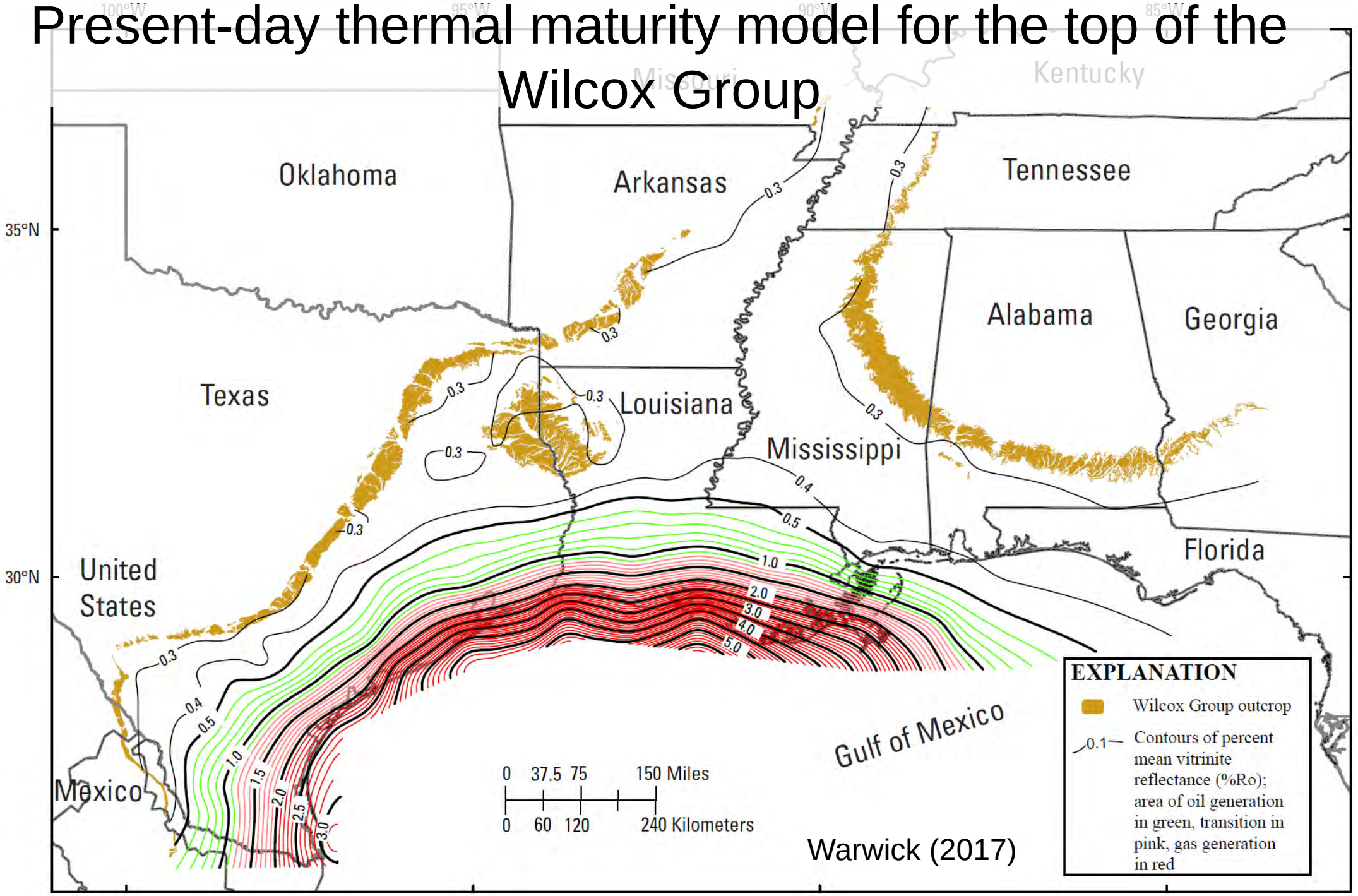
Warwick (2017)

Generalized isopach map of the Wilcox Group



Warwick (2017)

Present-day thermal maturity model for the top of the Wilcox Group



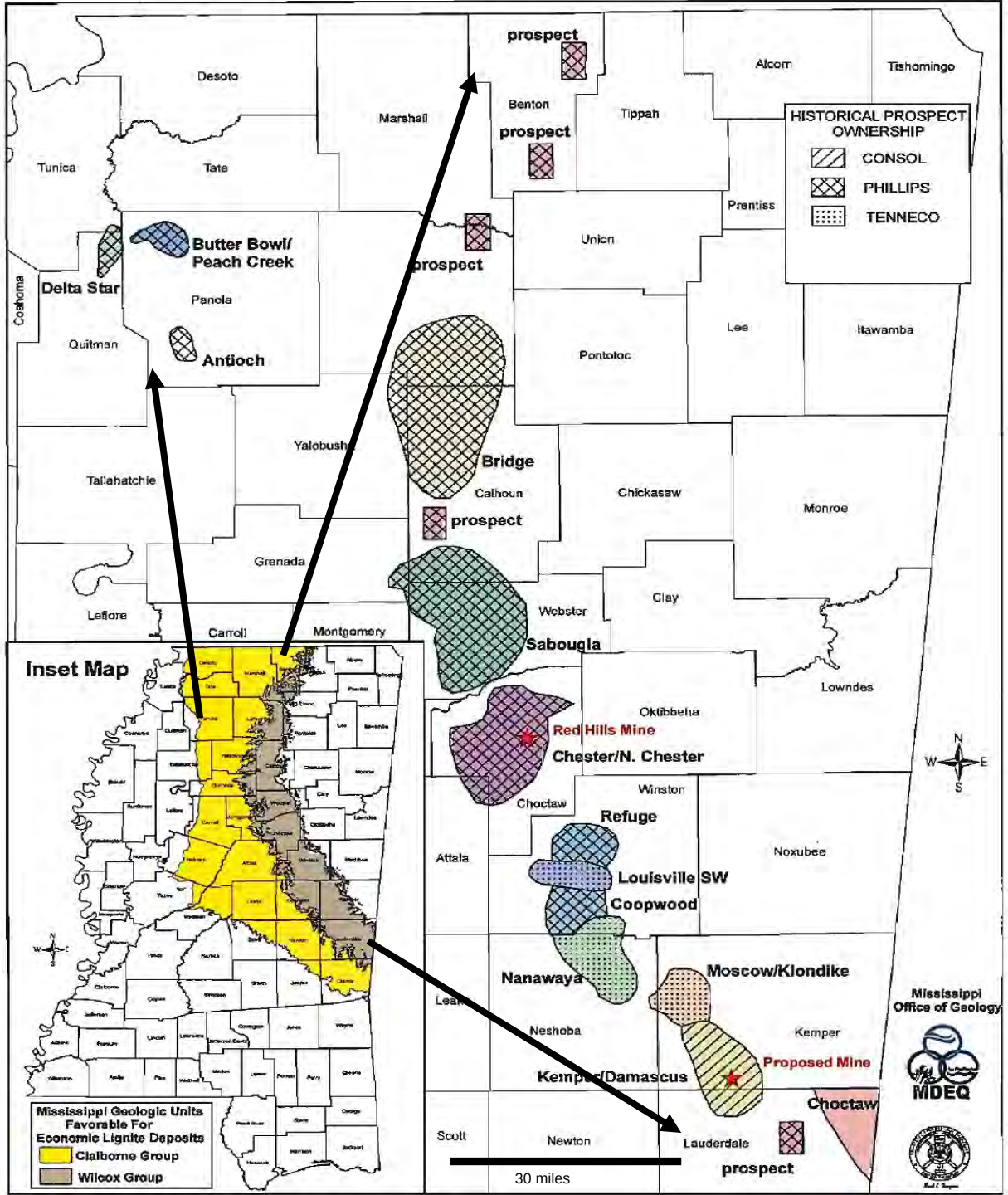
Warwick (2017)

Mississippi lignite resources

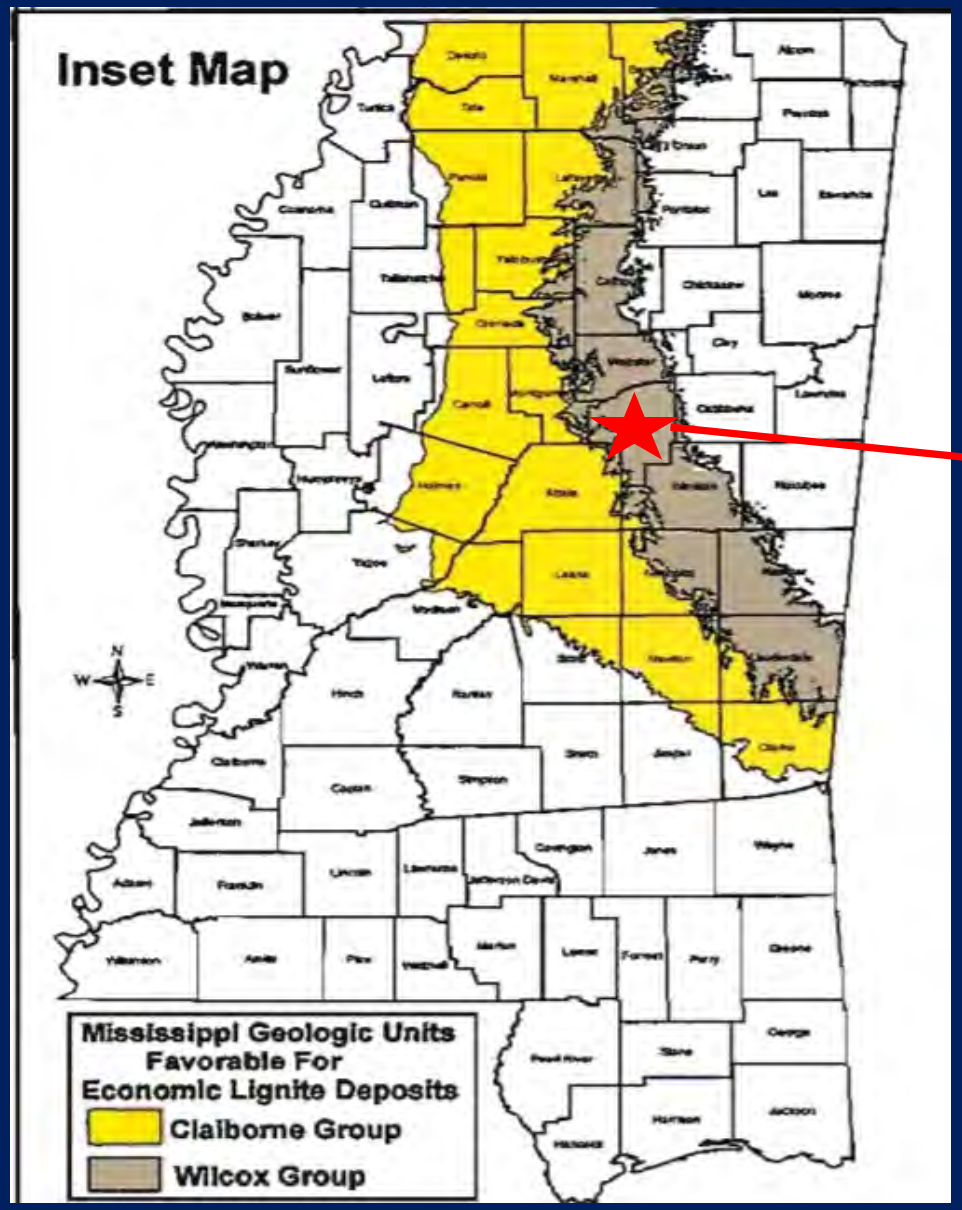
Prospect	BTU/lb. (In place)	Recoverable Tonnage Estimates (Millions)	Overburden Ratio
Delta Star	5575+	500	7.8 to 1
Chester-N. Chester	5100	1,450	9 to 1
Butter Bowl-Peach Creek-Antioch	5400-5600	340	15 to 1
Refuge-Coopwood	5100	667	—
Bridge	4700	336	—
Sabougla	5000	610	—
Louisville South	4700	220	9 to 1
Moscow/Klondike	4870	240	10 to 1
Nanawaya	4990	210	11 to 1
Kemper	4950	413	14 to 1

Total = 4,986 million short tons

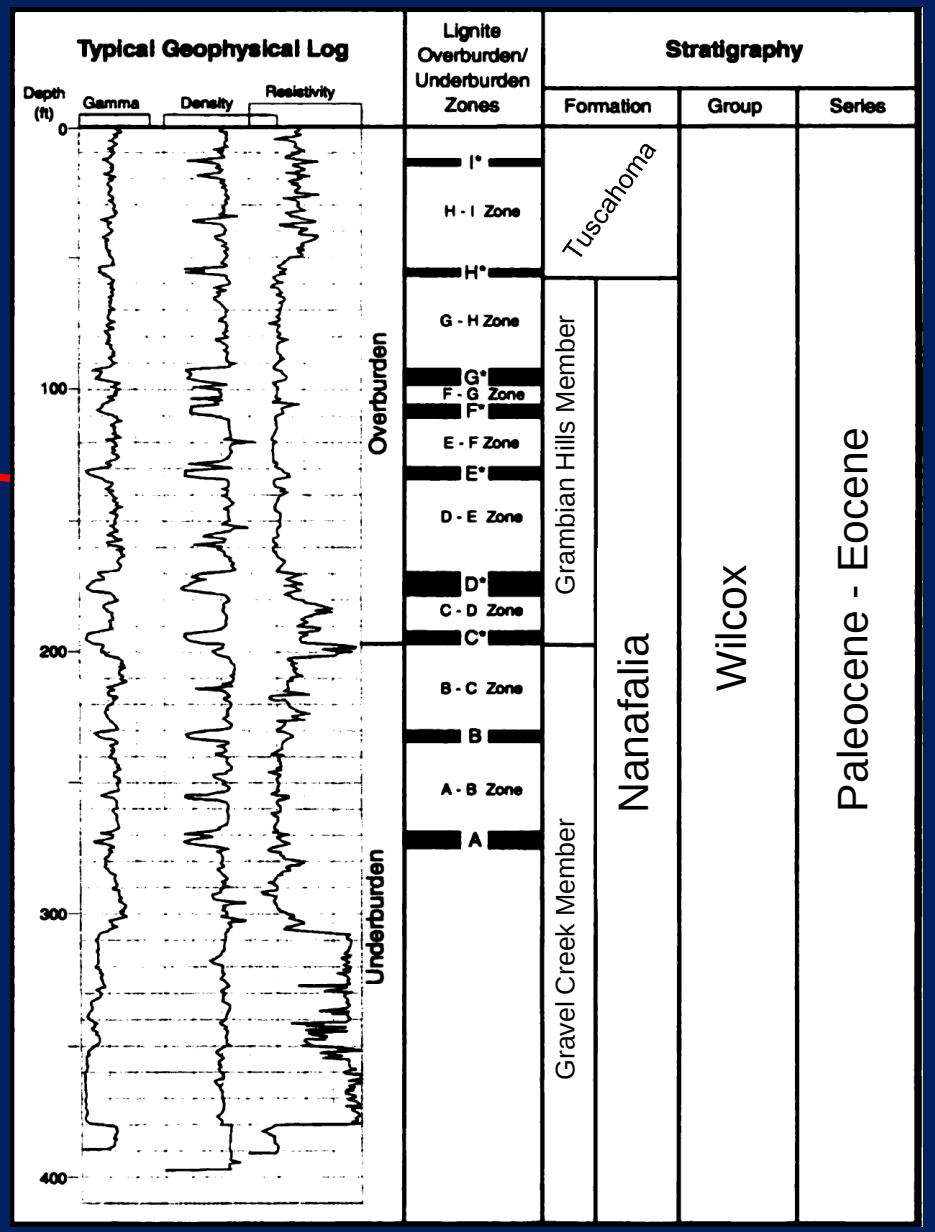
Thieling and others (2009)



Stratigraphy at Red Hills Mine, MS

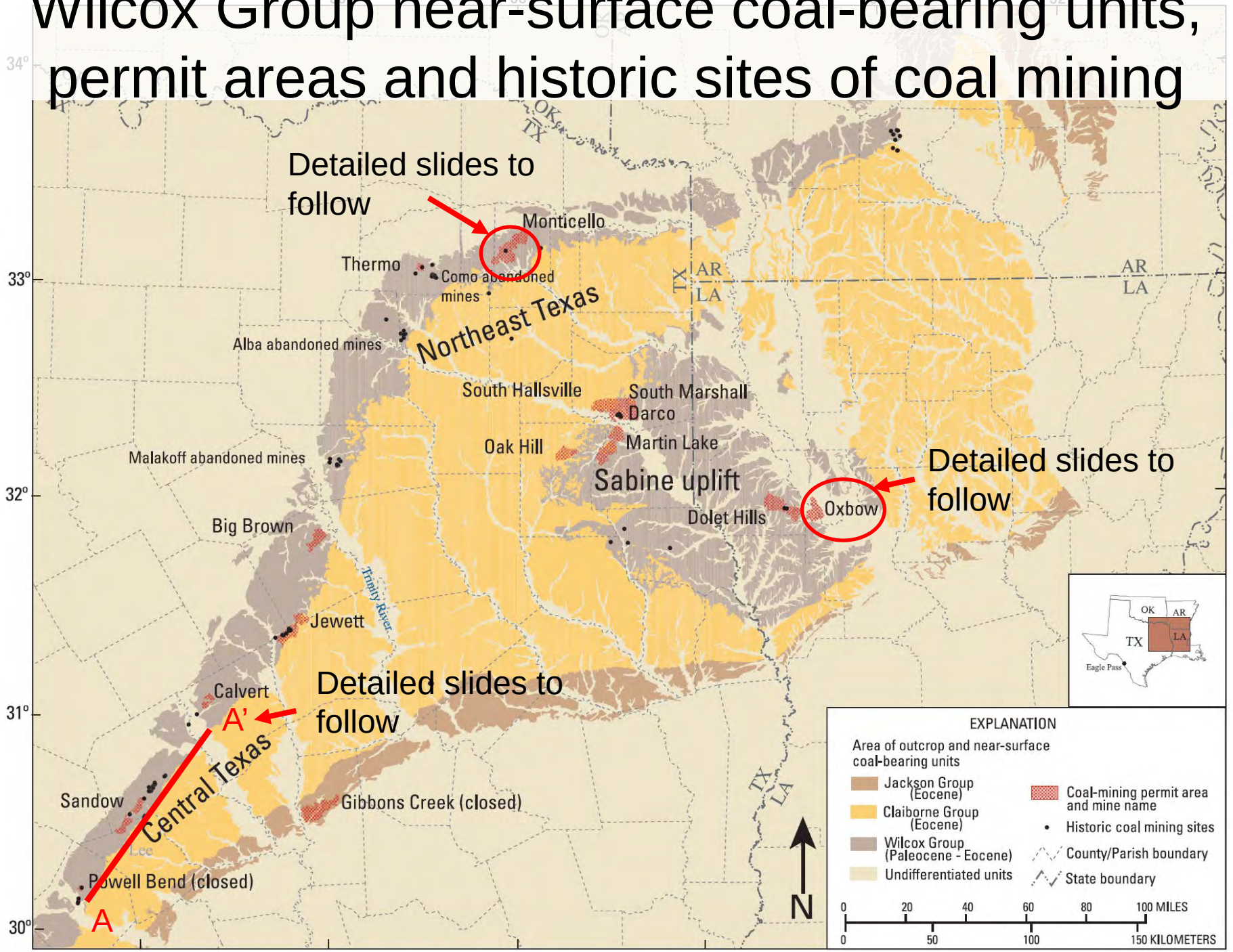


Thieling and others (2009)



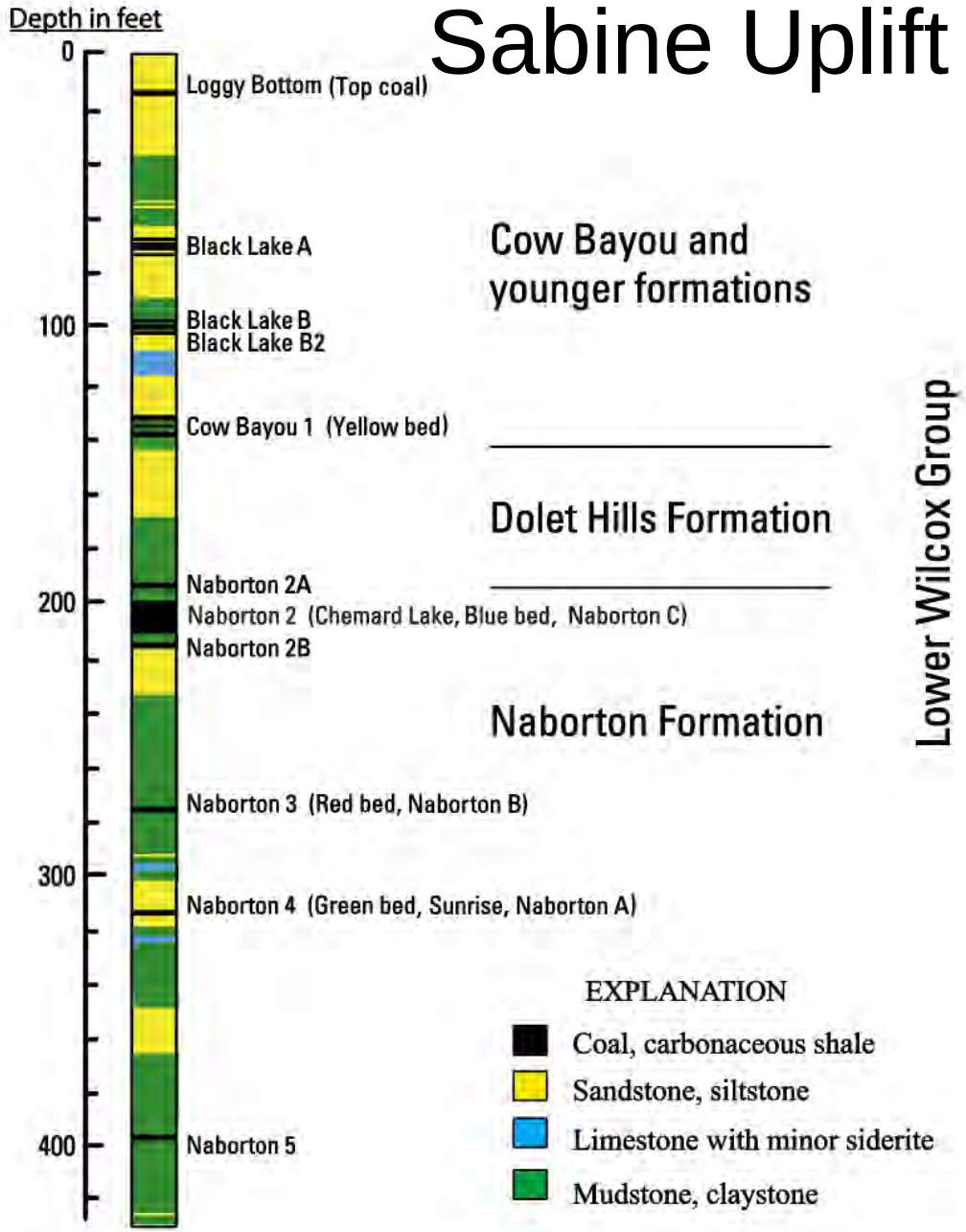
Tennessee Valley Authority (1998)

Wilcox Group near-surface coal-bearing units, permit areas and historic sites of coal mining



Warwick and others (2011a)

Sabine Uplift



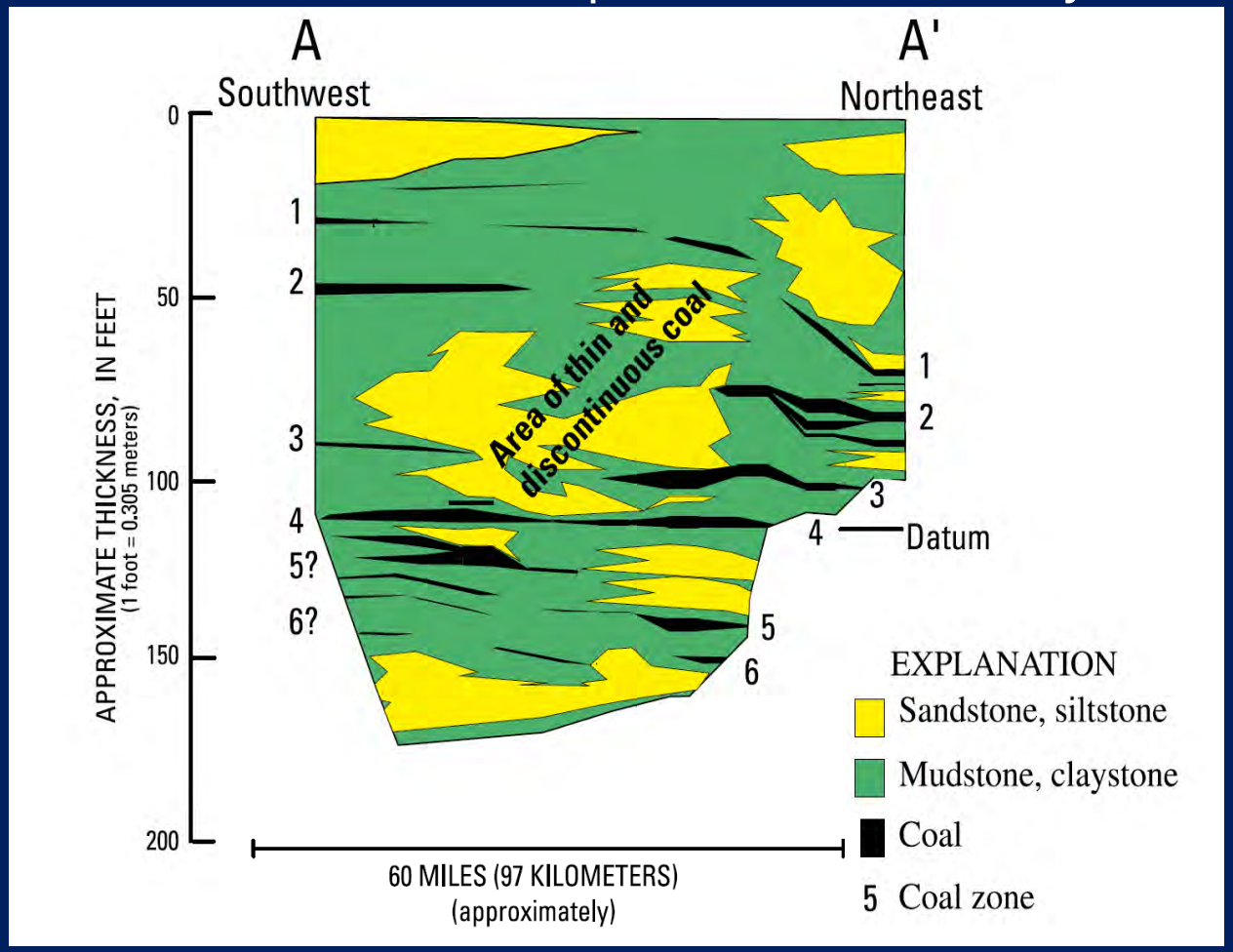
Chemard Lake lignite

Many of the minerals in the parting (arrow) are derived from a volcanic ashfall; possibly reworked by fluvial processes (Ruppert and Warwick, 1994)

Warwick and others (2011b)

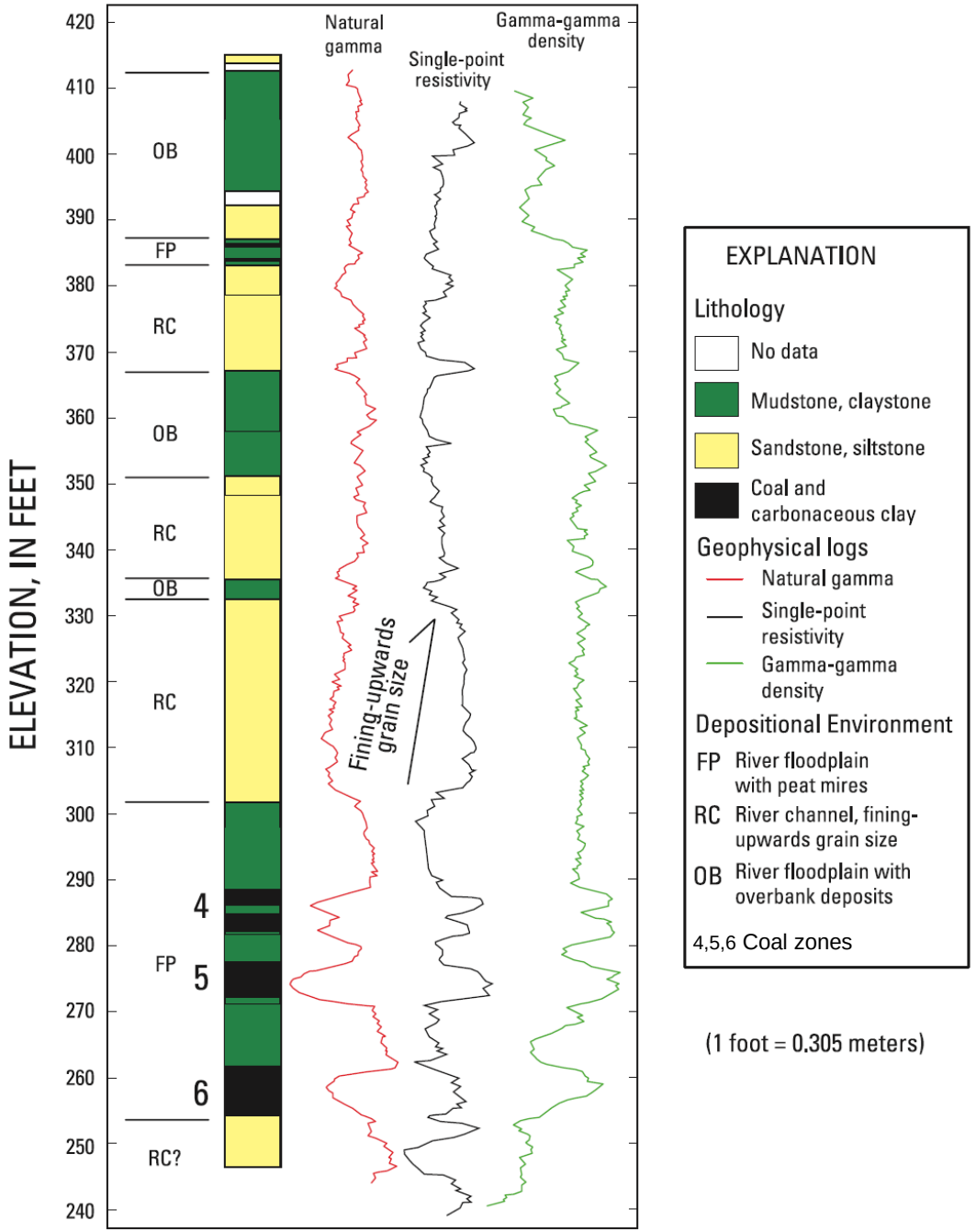
Northeast Texas

Typical mined zones, depositional environments, and geophysical logs from the southern part of the Monticello mine permit in Titus County, Texas



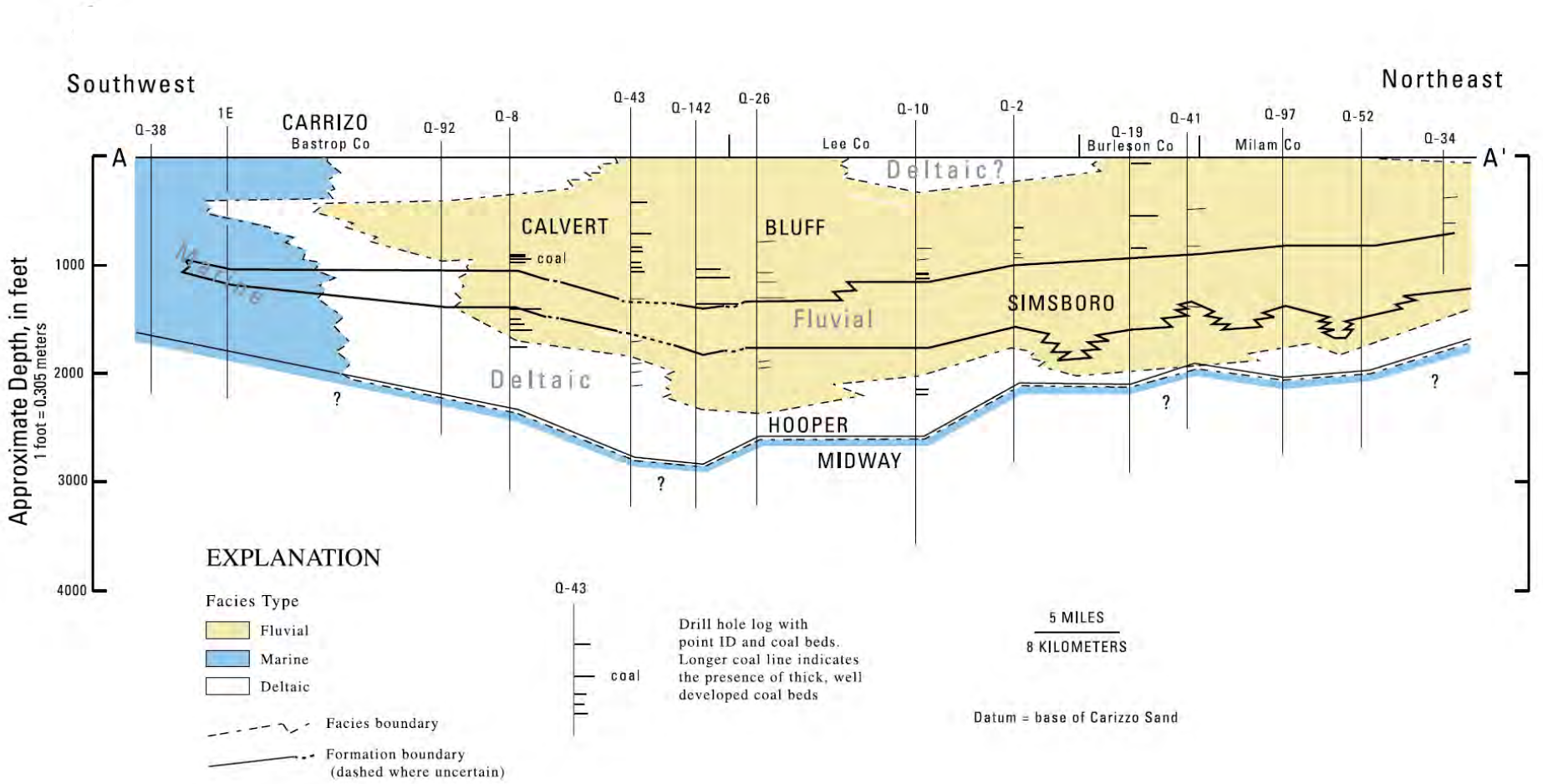
Generalized regional stratigraphic cross section of the Wilcox Group in northeast Texas

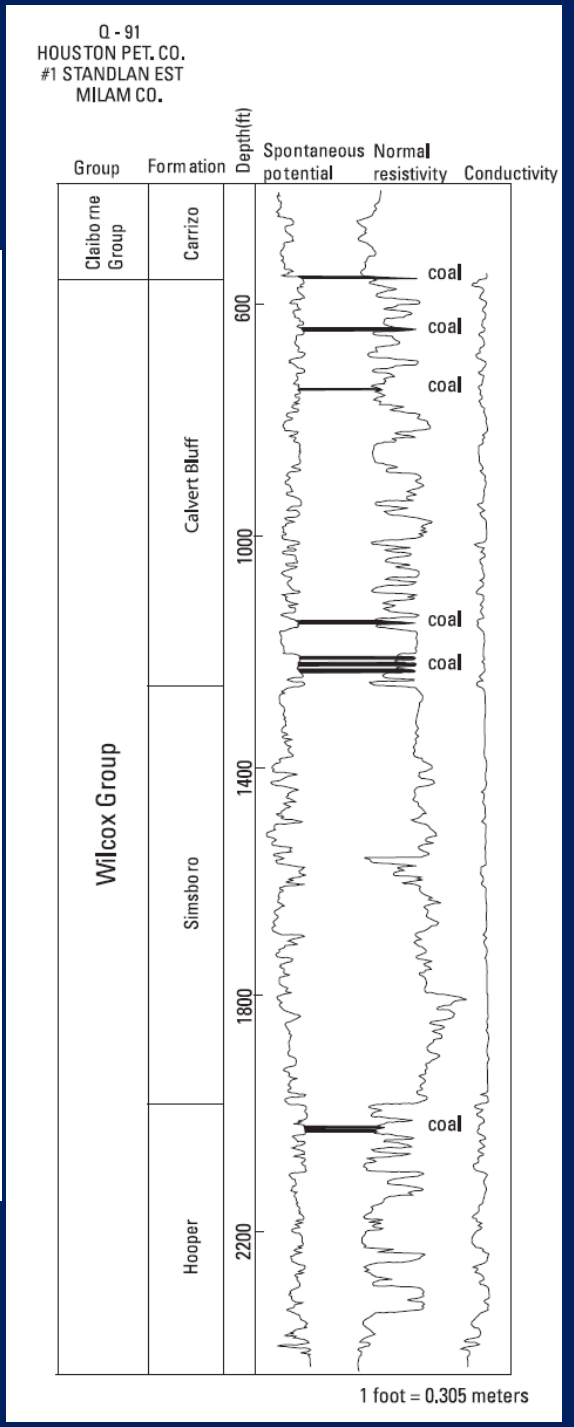
Hook and others (2011b)



Central Texas

Typical geophysical log of the Wilcox Group, Milam County, Texas

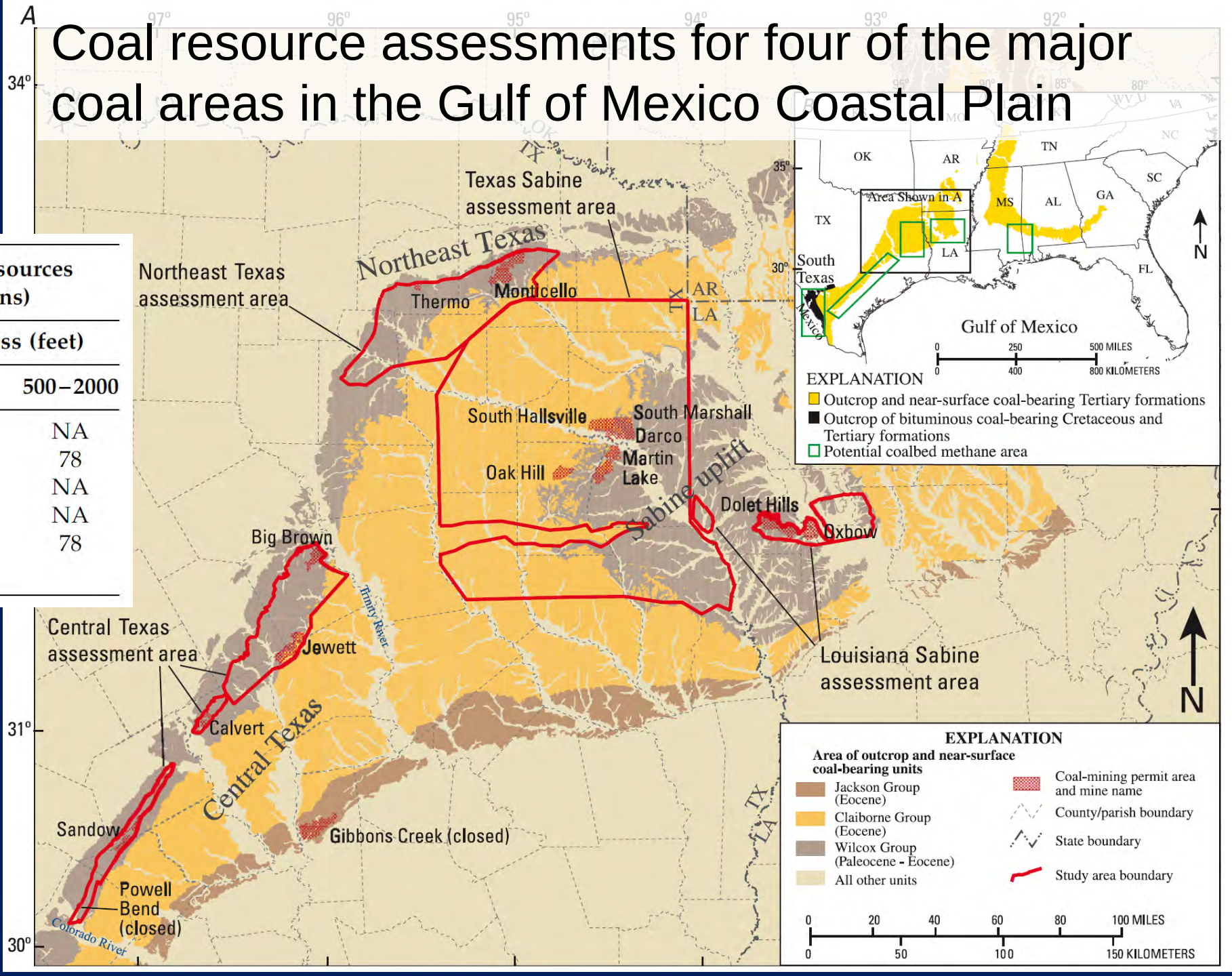




Hook and others (2011c)

Coal resource assessments for four of the major coal areas in the Gulf of Mexico Coastal Plain

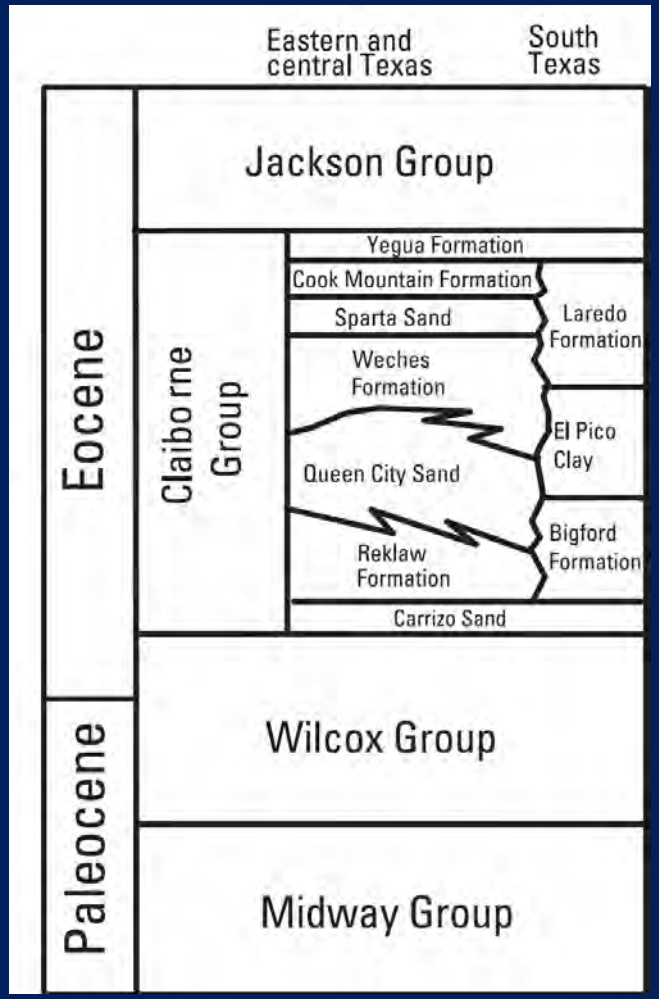
Assessment Area	Remaining Coal Resources (billion short tons)	
	Overburden Thickness (feet)	
	Less than 500	500–2000
Louisiana Sabine	1.1	NA
Texas Sabine	72	78
Northeast Texas	16	NA
Central Texas	7.7	NA
TOTAL	97	78
Grand Total	175 billion short tons	



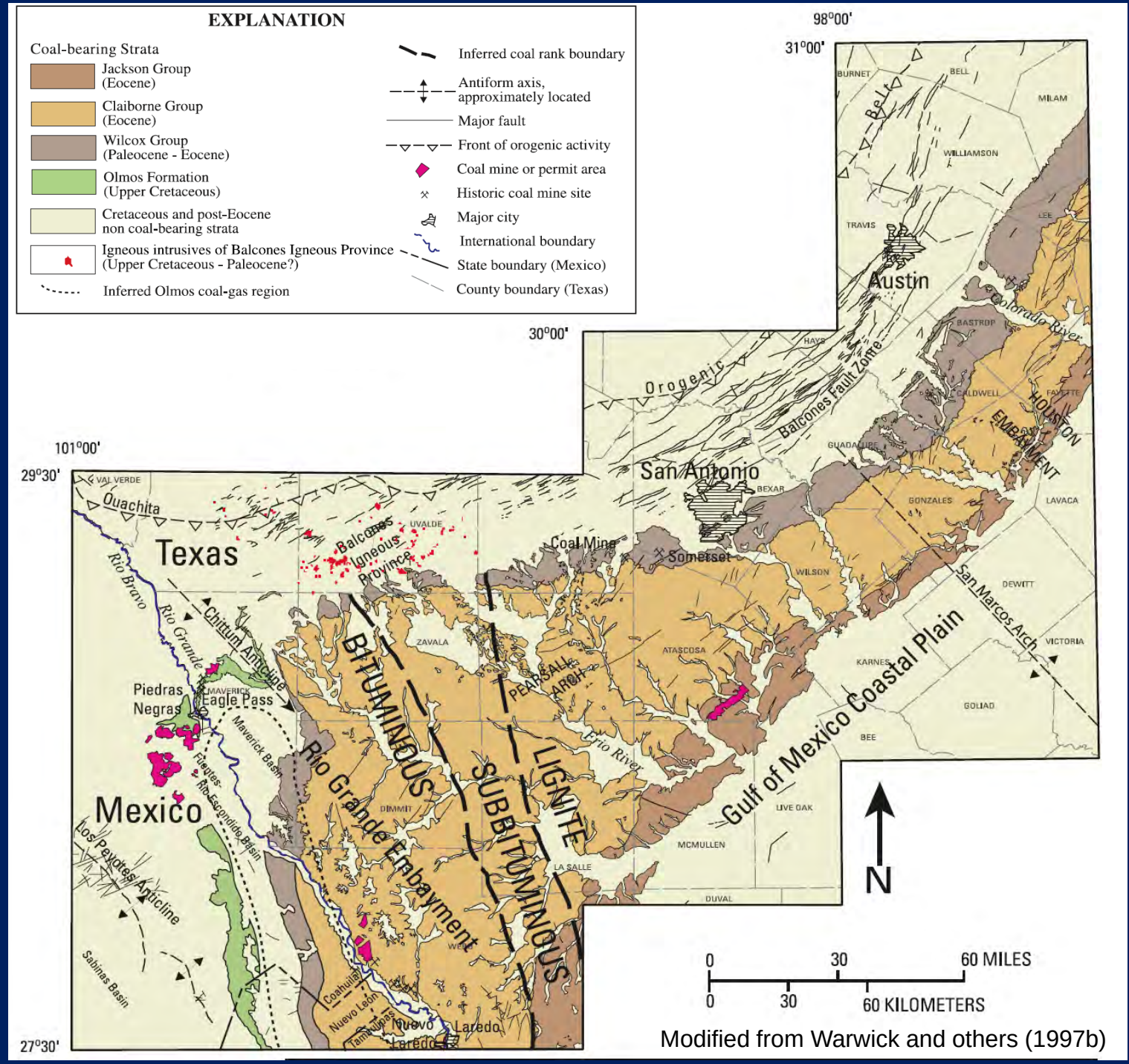
Warwick and others (2011a)

USGS

Claiborne Group (Eocene) Bituminous Coal Deposits Webb County, Texas

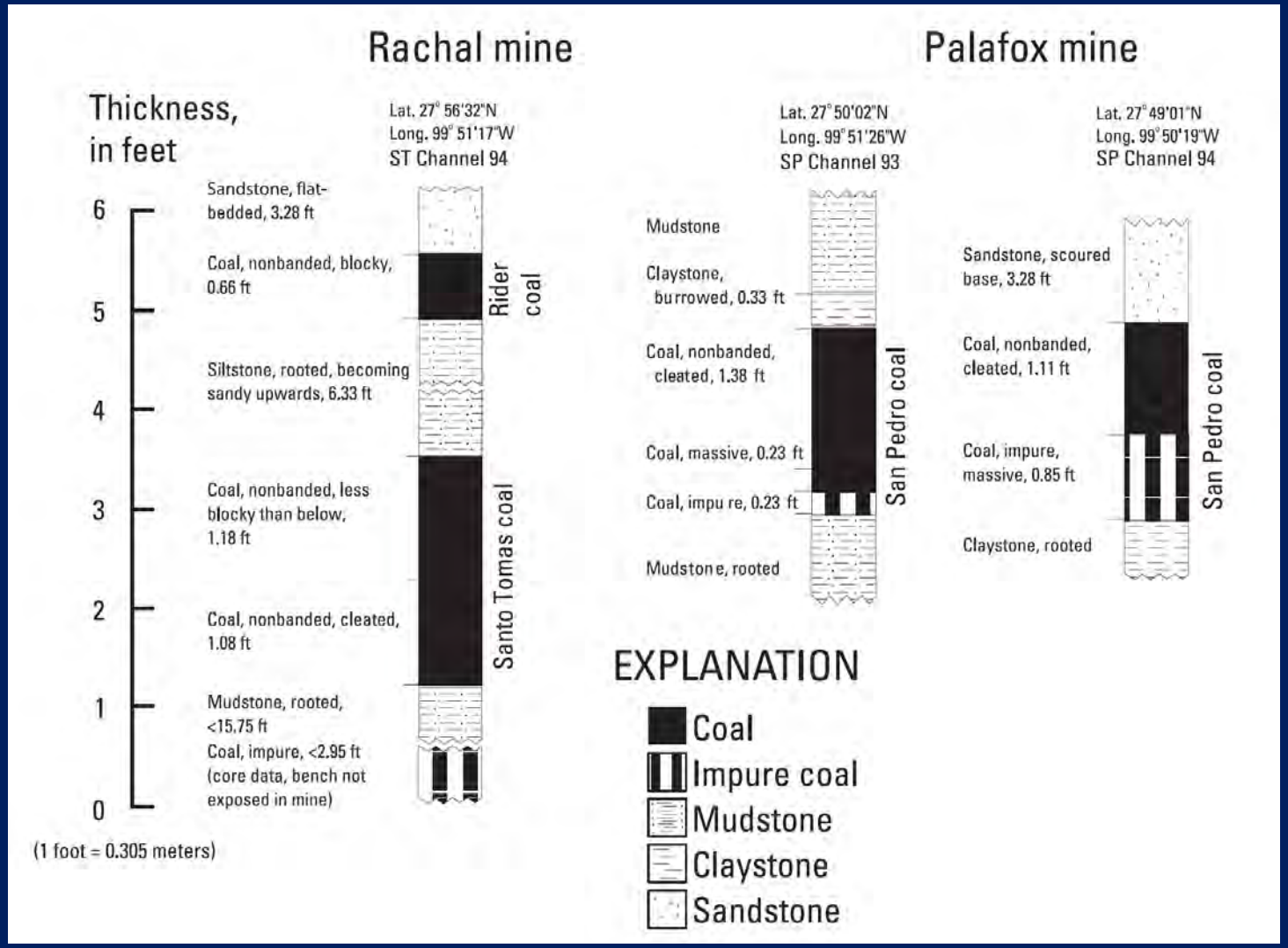


Hook and Warwick (2011)

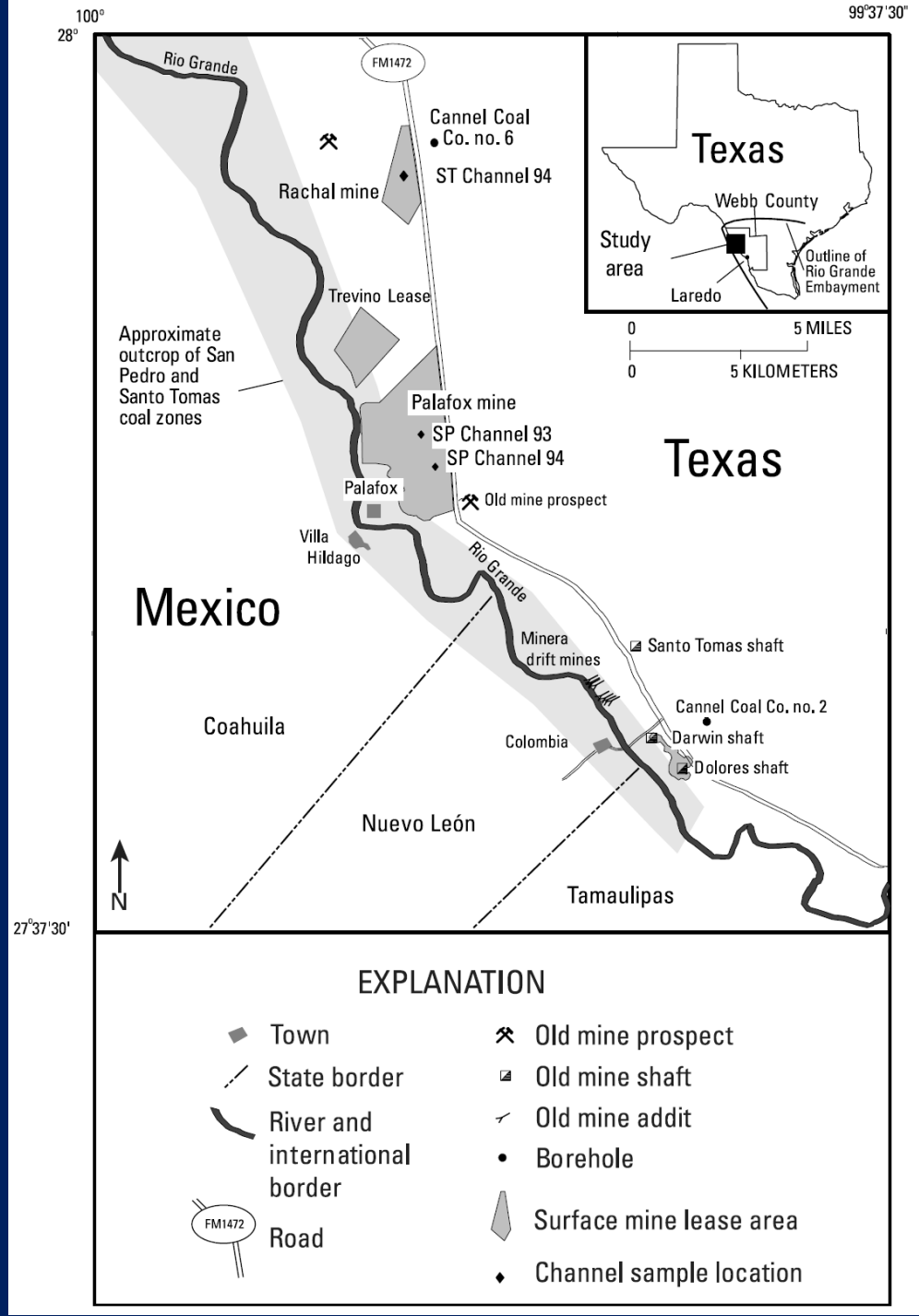


Modified from Warwick and others (1997b)

Claiborne Group (Eocene) Bituminous Coal Deposits Webb County, Texas



Mapel (1967) estimated 115 million short tons of coal



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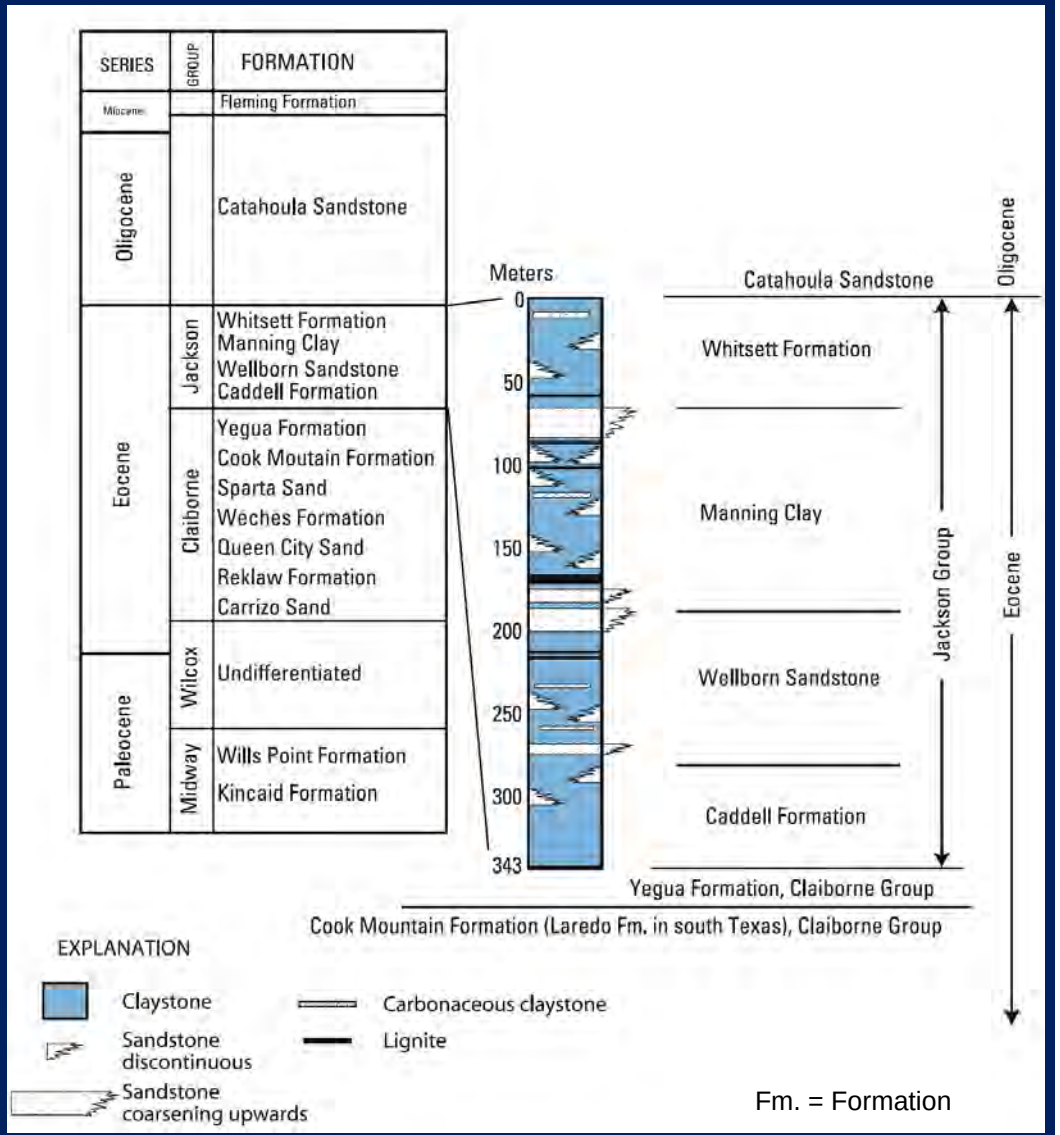
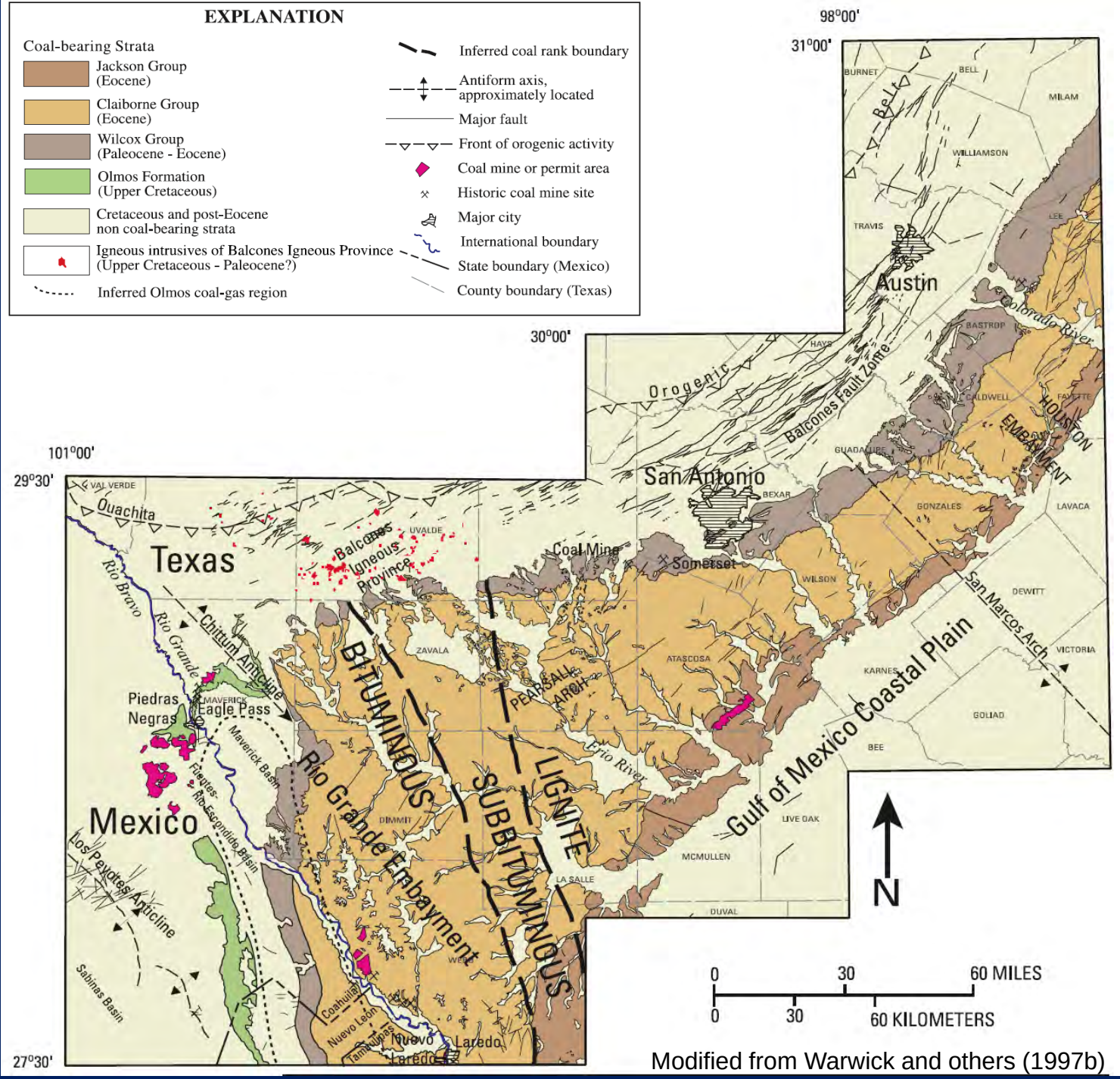
Warwick and Hook (1995); Hook and Warwick (2011)

Jackson Group coals





Modified from Warwick and others (1997b)

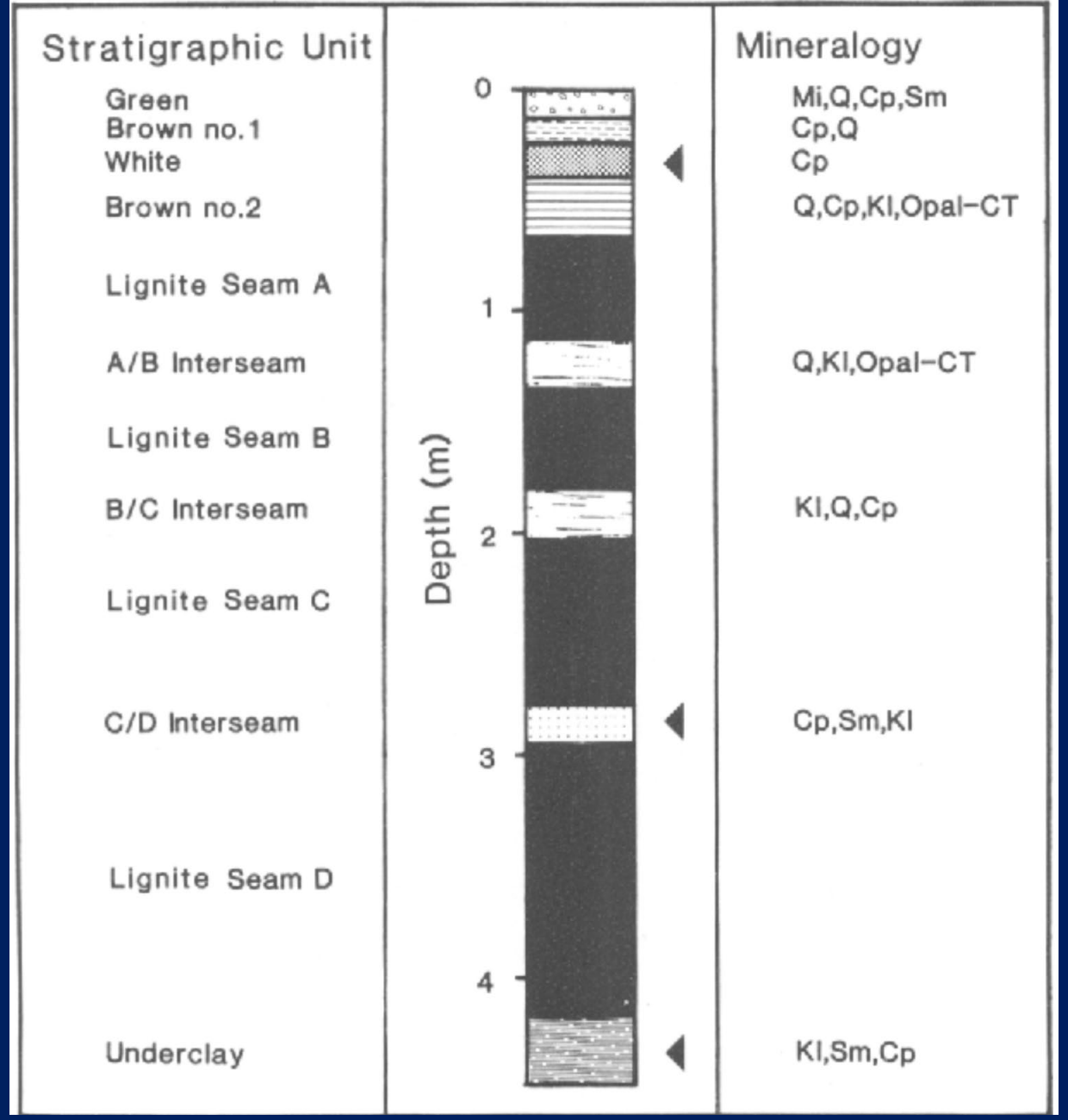
USGS

Hook and others (2011d)

Easi-Miner extracting lower Jackson Group lignite at the San Miguel mine, Atascosa County

Estimated 18,408 million short tons of coal in the Yegua-Jackson trend

Hook and others (2011d)

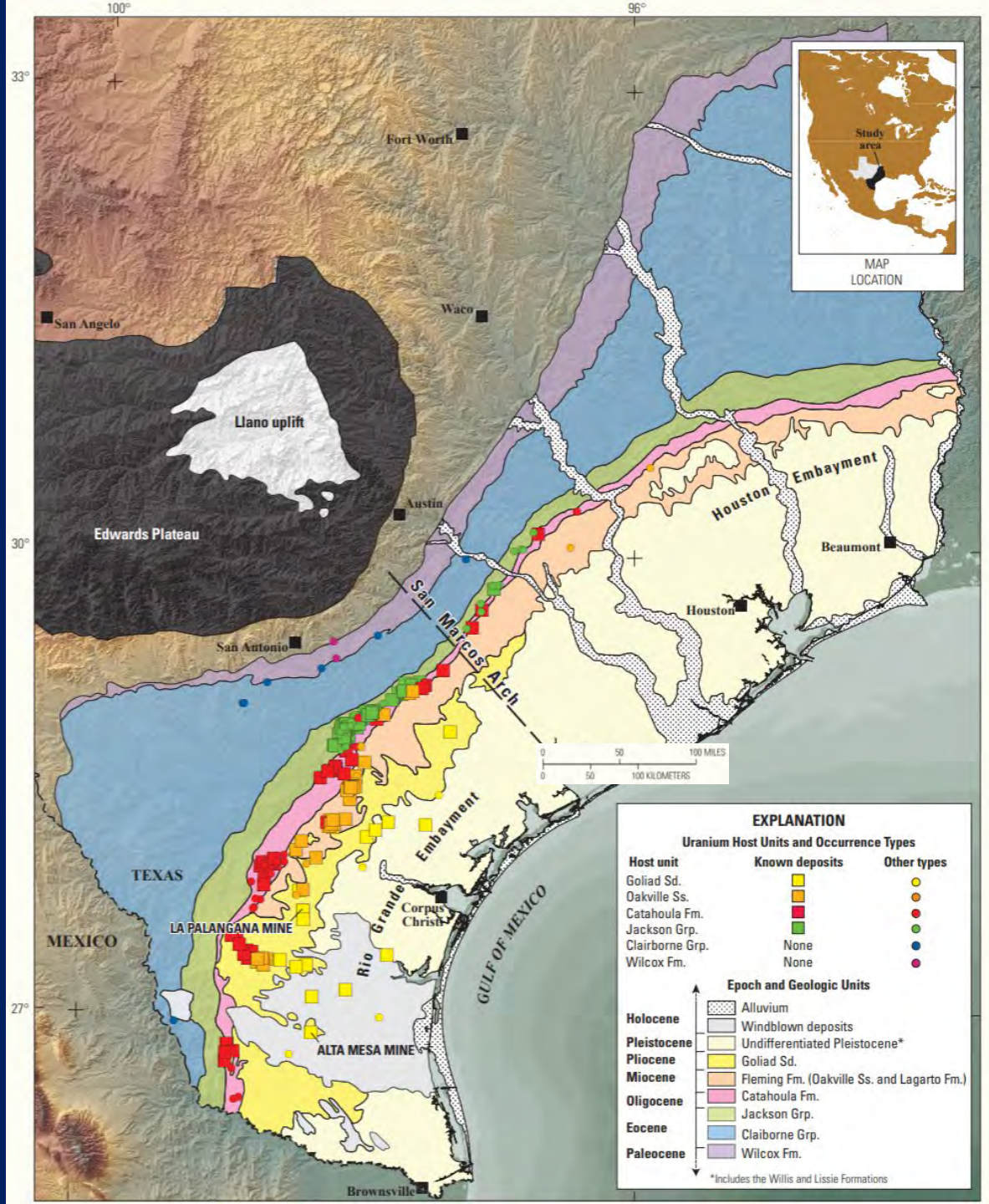


Mineralogy from X-ray powder diffraction peak intensities. Mi = mica, Q = quartz, Cp = clinoptilolite, Sm = smectite, K1 = kaolinite (Senkayi and others (1987)

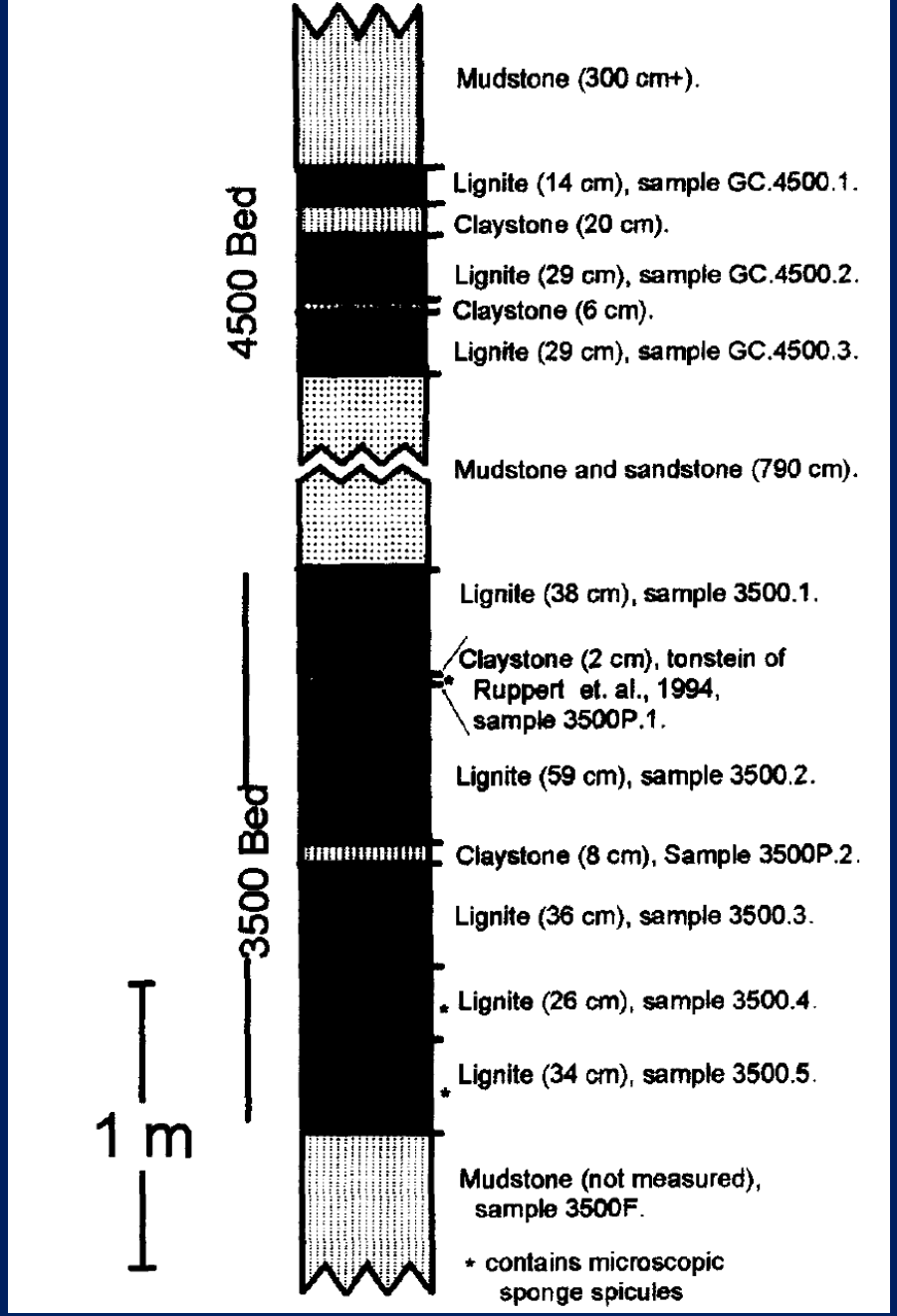
Sandstone-Hosted Uranium Resources in the Texas Coastal Plain

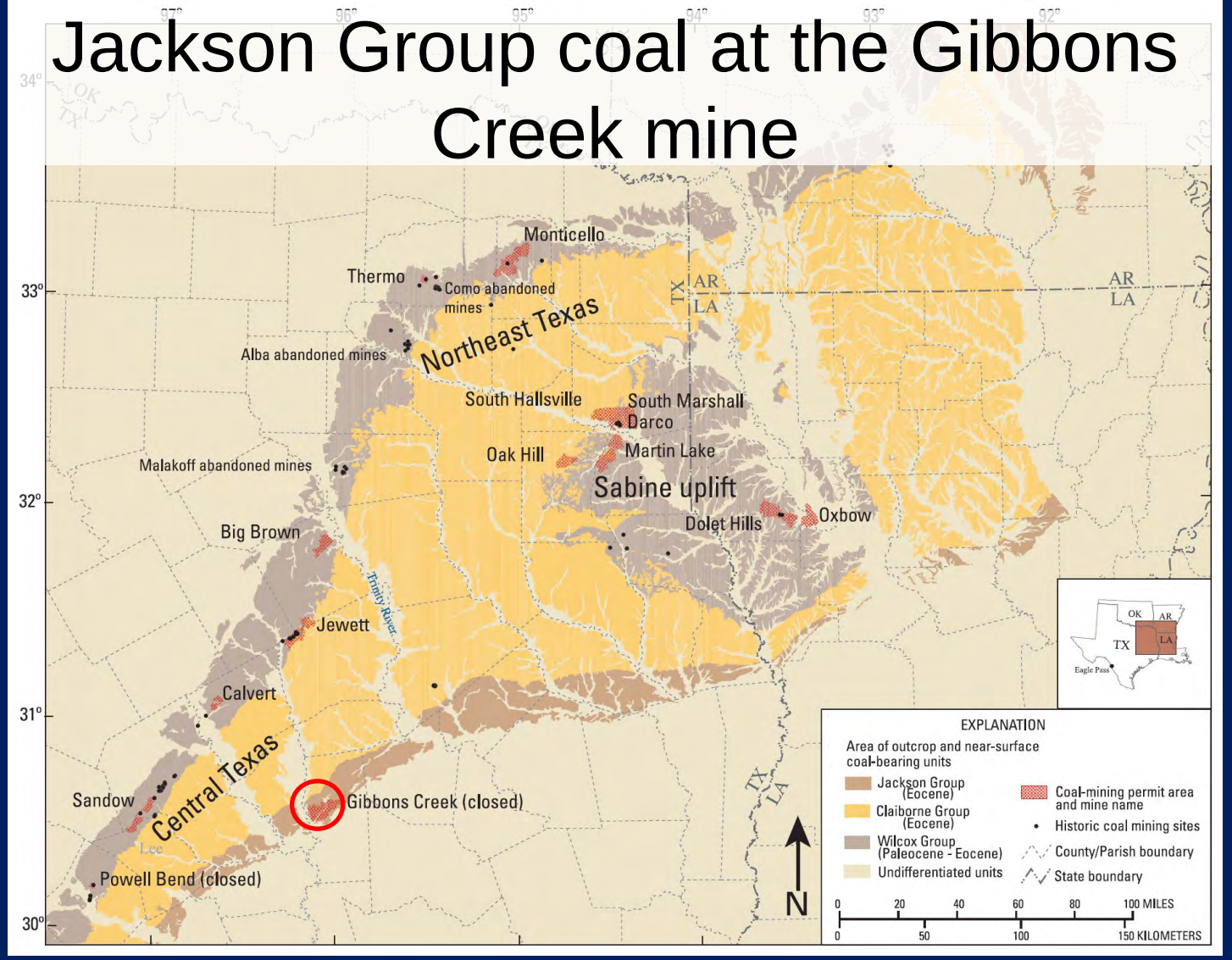
- Third largest domestic U.S. sandstone-hosted uranium resource
- The source is thought to be tuffs interbedded with host sandstones derived from Tertiary volcanic centers in NE Mexico and volcanic rock fragments within sedimentary rocks sourced from southwest highland areas (Adams and Smith 1981; Eargle and others, 1975; Hall, 2013)

U.S. Geological Survey Assessment Team (2015)



Jackson Group coal at the Gibbons Creek mine





Warwick and others (1997a)

"Eocene lignite of the Manning Formation at the Gibbons Creek mine area contain abundant subhedral to euhedral feldspar and minor amounts of euhedral to subhedral zircon, REE-rich phosphates, and quartz." (Ruppert and others, 1994)

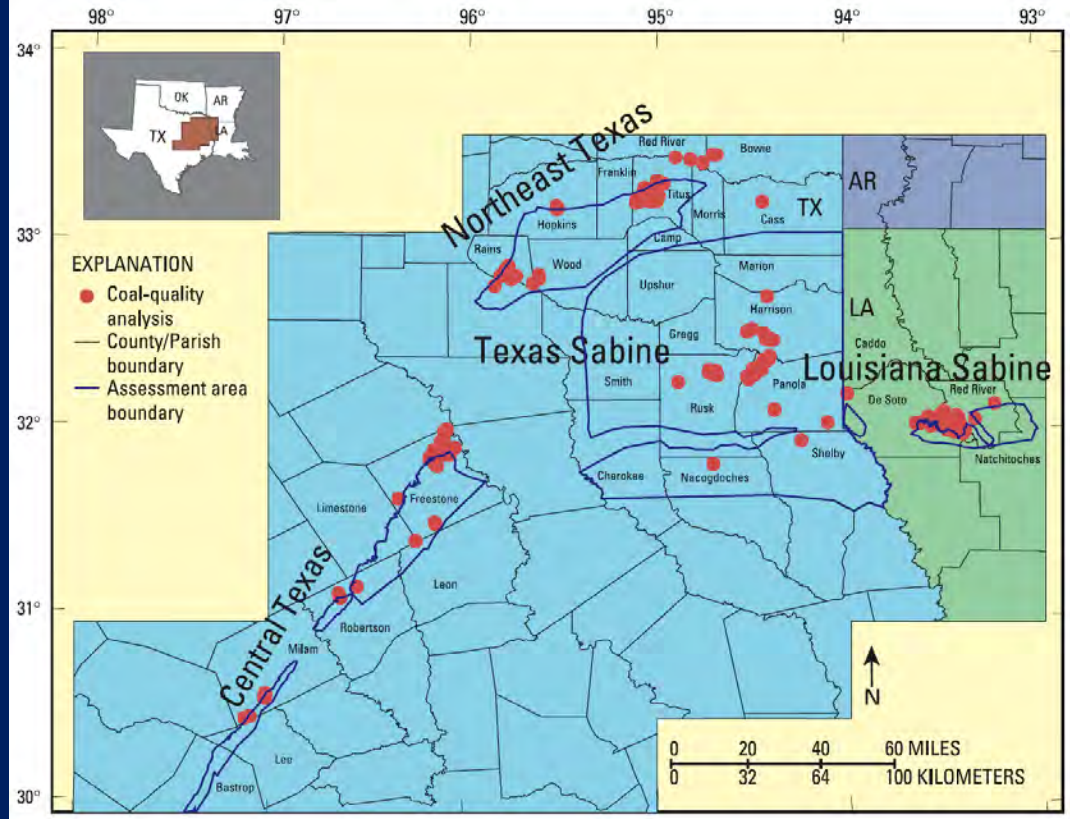
Estimated Coal Resources of the U.S. Gulf of Mexico Coastal Plain

Area	Reported resources	Billion short tons	Reference
Alabama	4.7 billion short tons	4.7	Self and others (1978)
Arkansas	9 billion short tons	9	Prior and others (1985)
Louisiana	1.1 billion short tons	1.1	Warwick and others (2011a)
Mississippi	5 billion short tons	5	Thieling and others (2009)
Kentucky (western)	50,000 short tons	0.00005	Olive (1971)
Tennessee (western)	1 billion short tons	1	Luppens (1979)
Texas Sabine	150 billion short tons	150	Warwick (2011)
Northeast Texas	16 billion short tons	16	Warwick (2011)
Central Texas	7.7 billion short tons	7.7	Warwick (2011)
Yegua Formation and Jackson Group	18,408 million short tons	0.018	Kaiser (1996)
Paleogene, south Texas	80 to 1078 million short tons	1.078	Hook and others (2011e)
Claiborne Group, Webb County	115 million short tons	0.115	Mapel (1967)
Cretaceous Olmos , south Texas	525 million short tons	0.525	Mapel (1967)
	Total	196.236	

USGS assessed 1,600 billion short tons of coal for the nation (Ruppert and others, 2002)

Distribution of public coal quality data for the four assessed areas of the Gulf Coast

Location of 177 coal-quality analyses are shown on the map

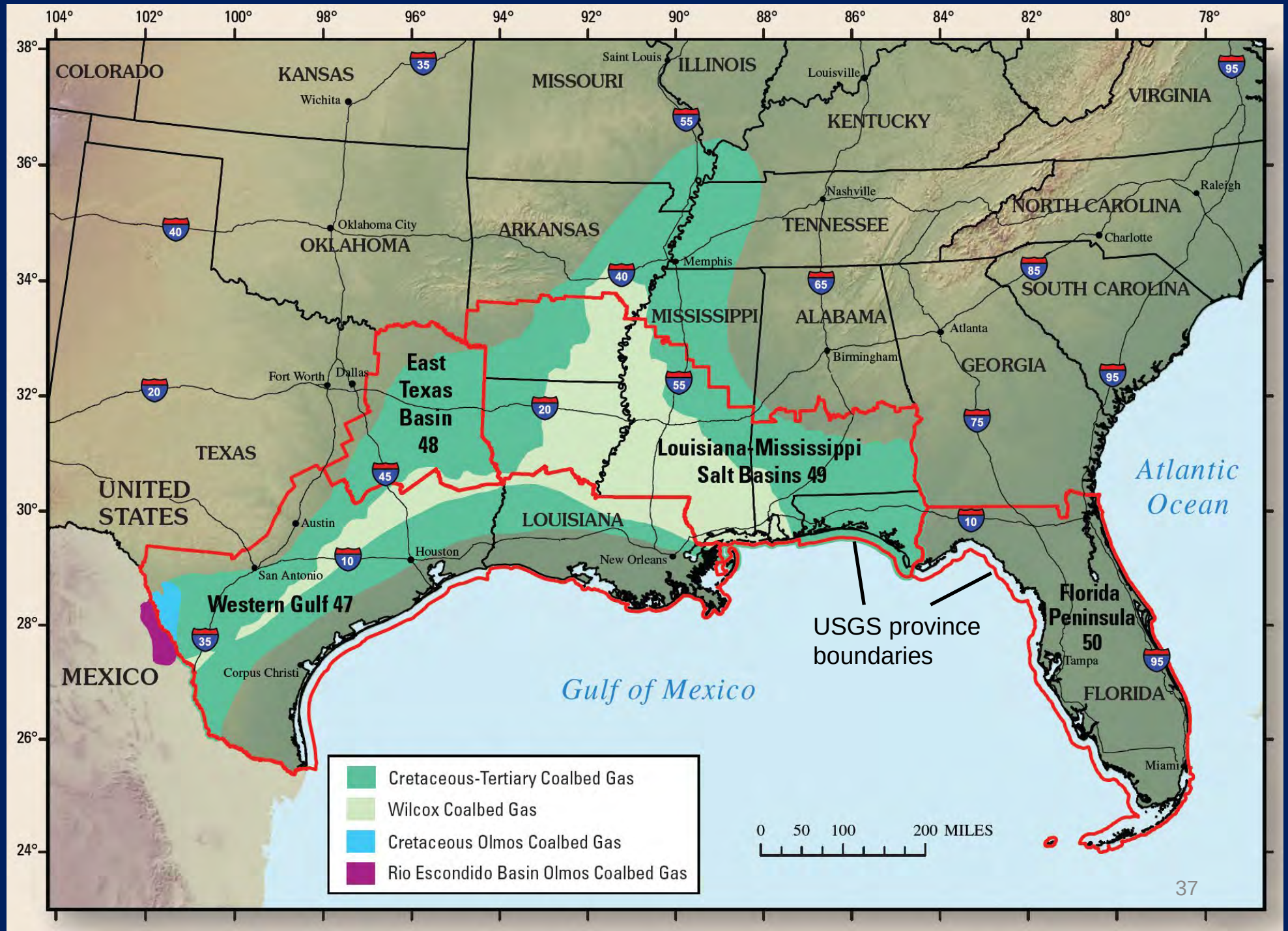


Assessment Area	Total Number of Analyses	Moisture (weight percent)	Ash Yield (weight percent)	Total Sulfur (weight percent)	Calorific Value (Btu/Pound)	Pounds SO_2/MMBtu	Arsenic (ppm)	Mercury (ppm)	Selenium (ppm)
Louisiana Sabine	134	32.10*	10.77	0.62	7244	1.74	3.2	0.12	3.6
Texas Sabine	64	34.97	9.84	1.04	6678	3.24	3.9	0.20	8.8
Northeast Texas	277	34.17	16.39	0.51	6075	1.75	3.2	0.23	5.2
Central Texas	103	33.00	13.35	1.03	6753	3.13	3.6	0.21	5.7
All assessment areas	578	33.58	13.86	0.67	6521	2.09	3.5	0.21	6.1
Texas Wilcox coals		32.00	15.00	1.00	6460	3.10**	3.4	0.17	7.3
		(n = 684)	(n = 684)	(n = 638)	(n = 644)		(n = 188)	(n = 164)	(n = 203)

*Includes both as-received total moisture (32 values) and equilibrium moisture (101 values).
**Not calculated from individual samples; calculated from average total sulfur and calorific values given in Tewalt (1986).

Pierce and others (2011)

Coalbed gas resource assessments areas in the Gulf of Mexico Coastal Plain



Warwick and others (2007)

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Coalbed gas resource assessments areas in the Gulf of Mexico Coastal Plain

Continuous Oil and Gas Resources

Total Petroleum Systems (TPS) and Assessment Units (AU)	Field Type	Total Undiscovered Resources											
		Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
		F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Olmos Coalbed Gas TPS (504702)													
Cretaceous Olmos Coalbed Gas AU (50470281)	*CBG*					37	70	133	75	0	0	1	0
Rio Escondido Basin Olmos Coalbed Gas AU (53000281)	*CBG*					60	114	215	123	0	0	1	0
Wilcox Coalbed Gas TPS (504703)													
Wilcox Coalbed Gas AU (50470381)	*CBG*					1,565	3,442	7,570	3,861	0	0	0	0
Cretaceous-Tertiary Coalbed Gas TPS (504704)													
Cretaceous-Tertiary Coalbed Gas AU (50470481)	*CBG*	Not quantitatively assessed											
Total Continuous Resources						**1,662**	**3,626**	**7,918**	**4,059**	**0**	**0**	**2**	**0**

MMBO, million barrels of oil; BCFG, billion cubic feet of gas; MMBNGL, million barrels of natural gas liquids

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Summary

- Gulf of Mexico Coastal Plain coal occurs in Cretaceous to lower Cenozoic intervals
- Fluvial to deltaic depositional environments
- Coal beds are generally are less than 15 ft thick and most coal mines produce from several beds
- Coal resource estimates could be up to 196 billion short tons
- Coalbed gas resources estimated to be about 4 billion cubic feet

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