Preliminary Evaluation of the Coalbed Methane Resources of the Gulf Coastal Plain

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Figure 1. Title page.

INTRODUCTION - OUTLINE

Review of the coal geology of the Gulf Coastal Plain

Review of coalbed methane prospect areas and data

1. Oak Hill prospect of Alabama and Mississippi (includes salt domes)
2. North-Central Louisiana deep-basin prospect
3. West Sabine Uplift prospect of Northwest Louisiana and Northeast Texas
4. East-Central Texas deep-basin prospect
5. South Texas prospect/play

Preliminary calculation of the coalbed methane gas in place for the Gulf Coastal Plain

Conclusions and recommendations

Figure 2. Introduction and outline.

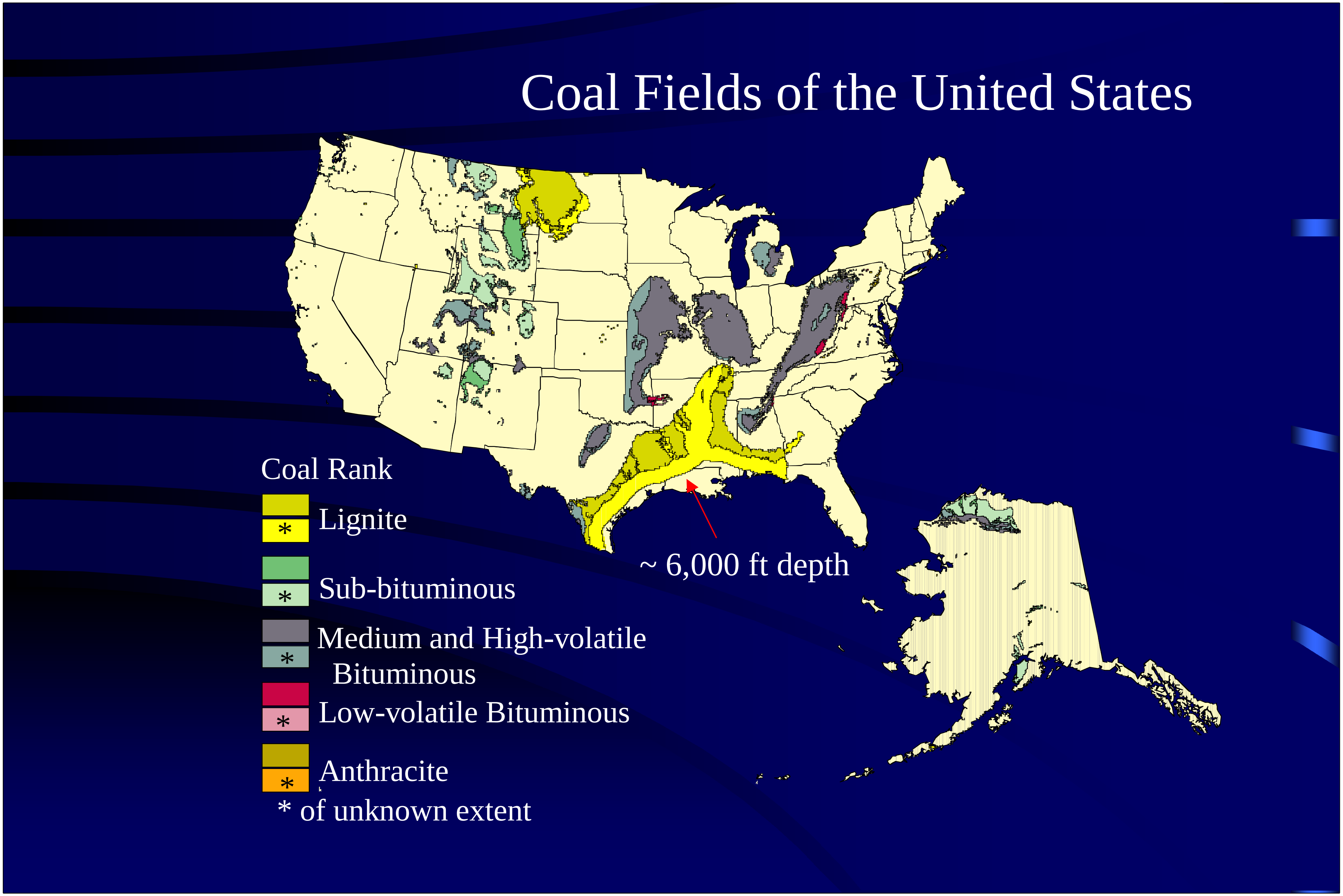

Figure 3. Coal field map of the United States. Note the relative size of the Gulf Coast coal region compared to other coal-bearing regions of the country. Also note that the Gulf coal-bearing strata dip southward into the Gulf of Mexico basin to where the coal-bearing formations are at depths greater than 10,000 ft. An estimated 6,000 ft depth to the top of coal-bearing formations is shown.

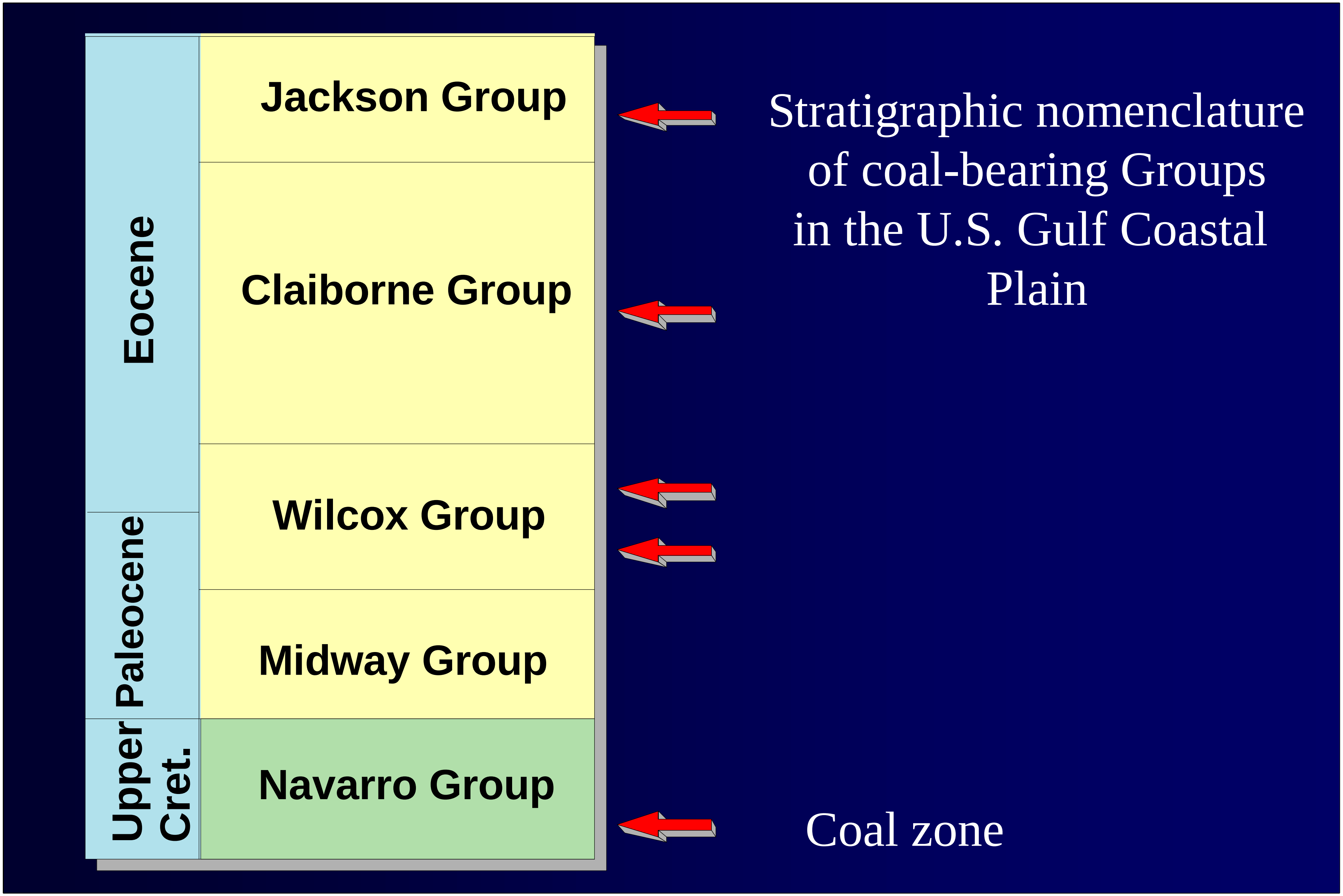

Figure 4. Stratigraphic nomenclature of coal-bearing Groups in the U.S. Gulf Coastal Plain. Arrows indicate position of major coal zones. Most coal mine production is from the Wilcox Group.

Series	N. American stage	Group	Formation
Eocene	Jacksonian	Jackson Group	Whitsett Manning Wellborn Caddell Moodys Branch
Eocene	Claibornian	Claiborne Group	Yegua Cook Mountain Sparta Weches Queen City Reklaw Carrizo
Eocene / Paleocene	Sabinian	Wilcox Group	Calvert Bluff Simsboro Hooper
Paleocene	Midwayan	Midway Group	Wills Point Kincaid

Coal-bearing formations in Central Texas

Figure 5. Detailed stratigraphic nomenclature for the lower Tertiary coal-bearing units in the East-central Texas area. The major coal-bearing formations are shown in red. Formation names change across the Gulf region.

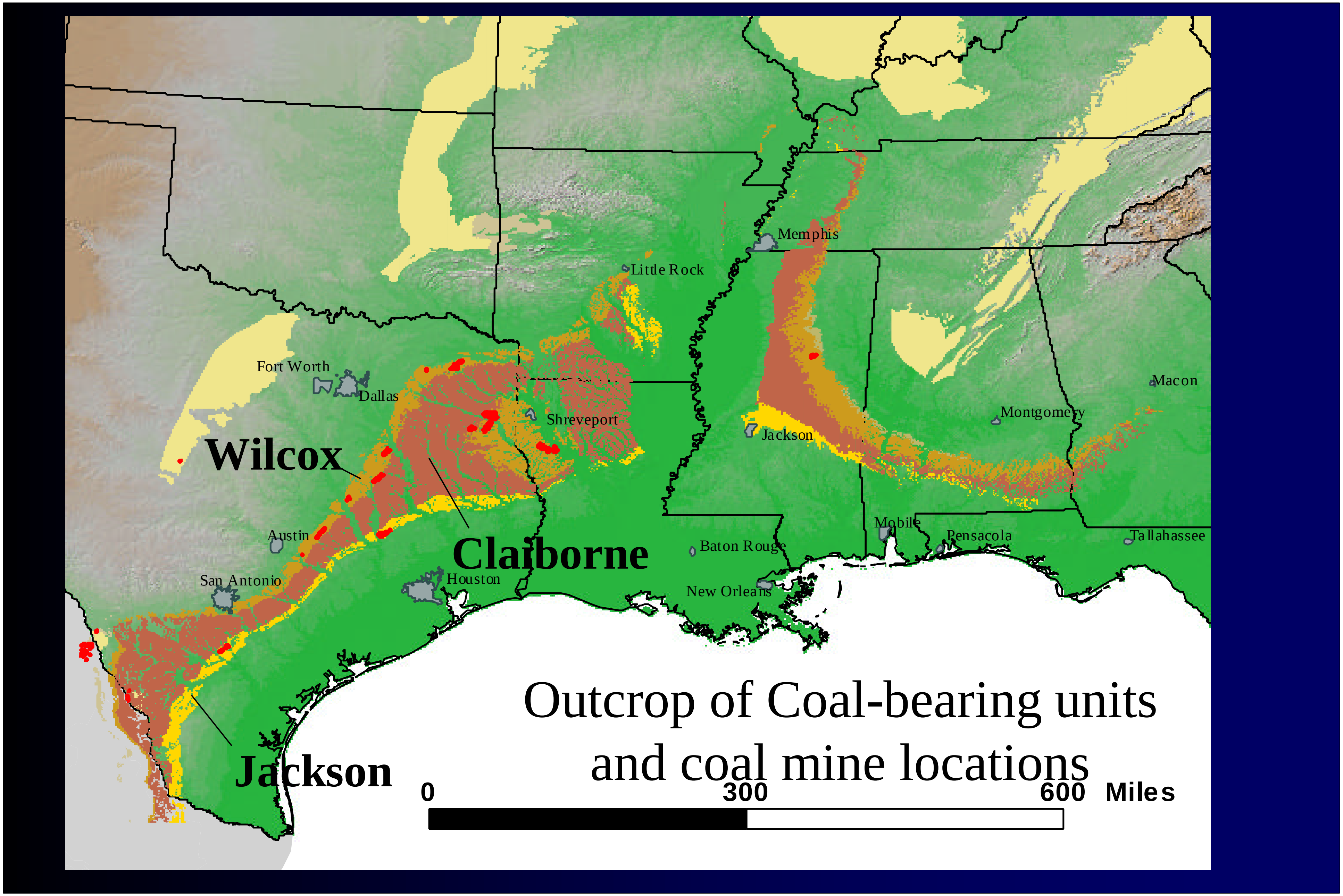

Figure 6. Generalized outcrop map of the Cretaceous - Eocene coal-bearing units and coal mine locations (shown in red) in the Gulf Region. Older coal basins are shown in yellow. From Tully (1996) and Warwick and others (1997).

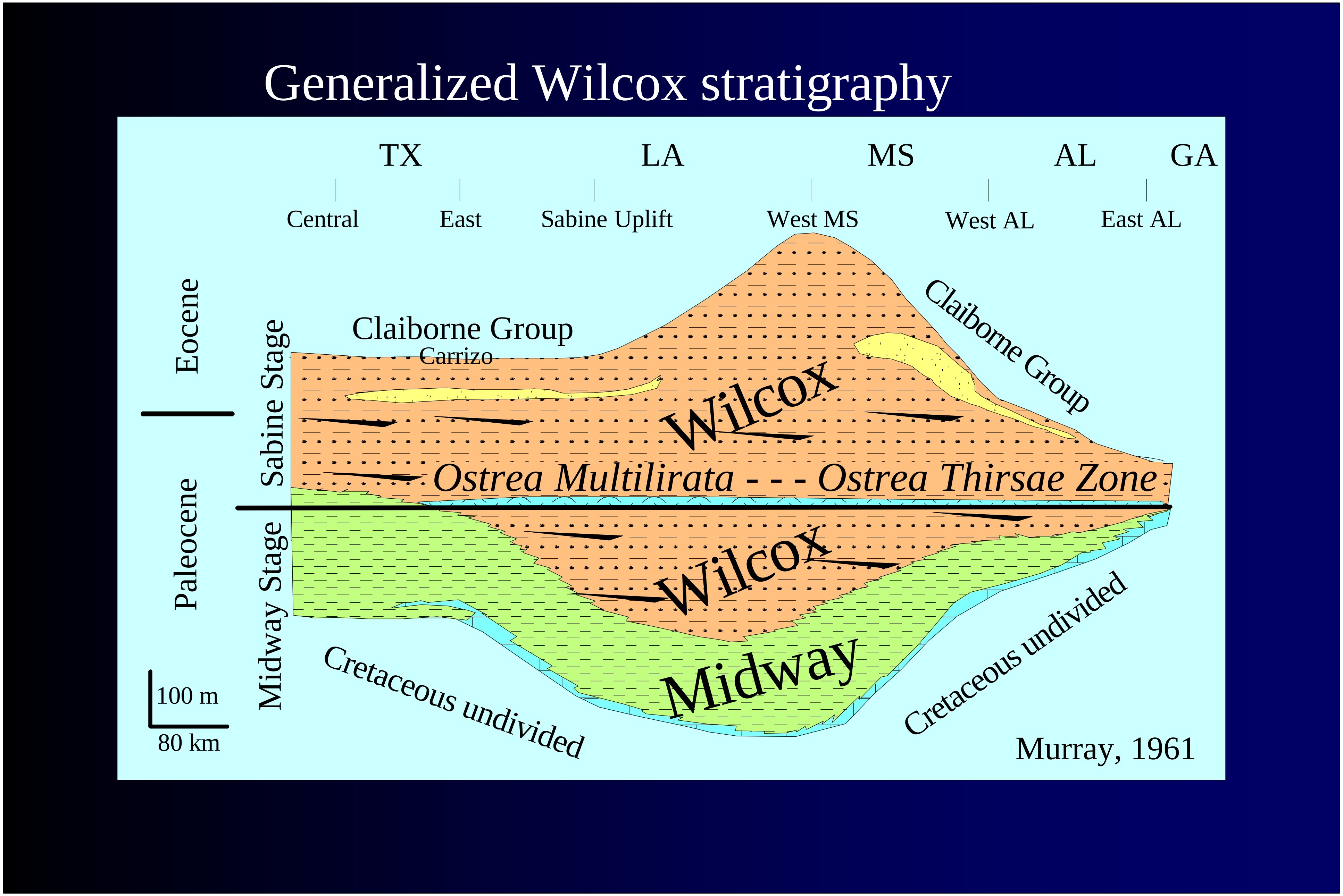

Figure 7. Cross section of the lower Tertiary coal-bearing units by (Murray, 1961). The cross section extends from Georgia to Central Texas.

Lower Wilcox Depositional Systems

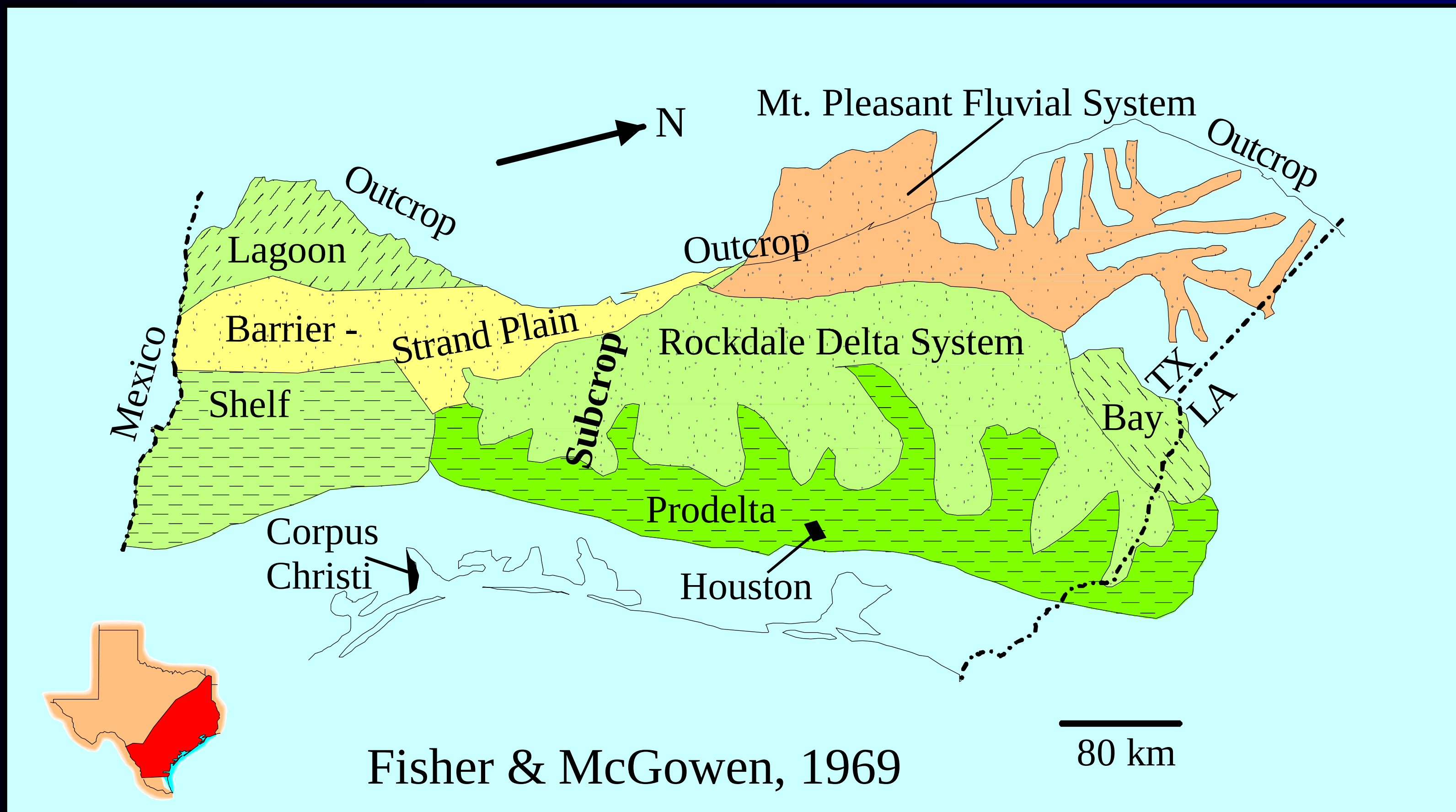

Figure 8. Fluvio – deltaic depositional model for East Texas Lower Wilcox sediments (Fisher and McGowen, 1969). Note that the model is for the Wilcox .

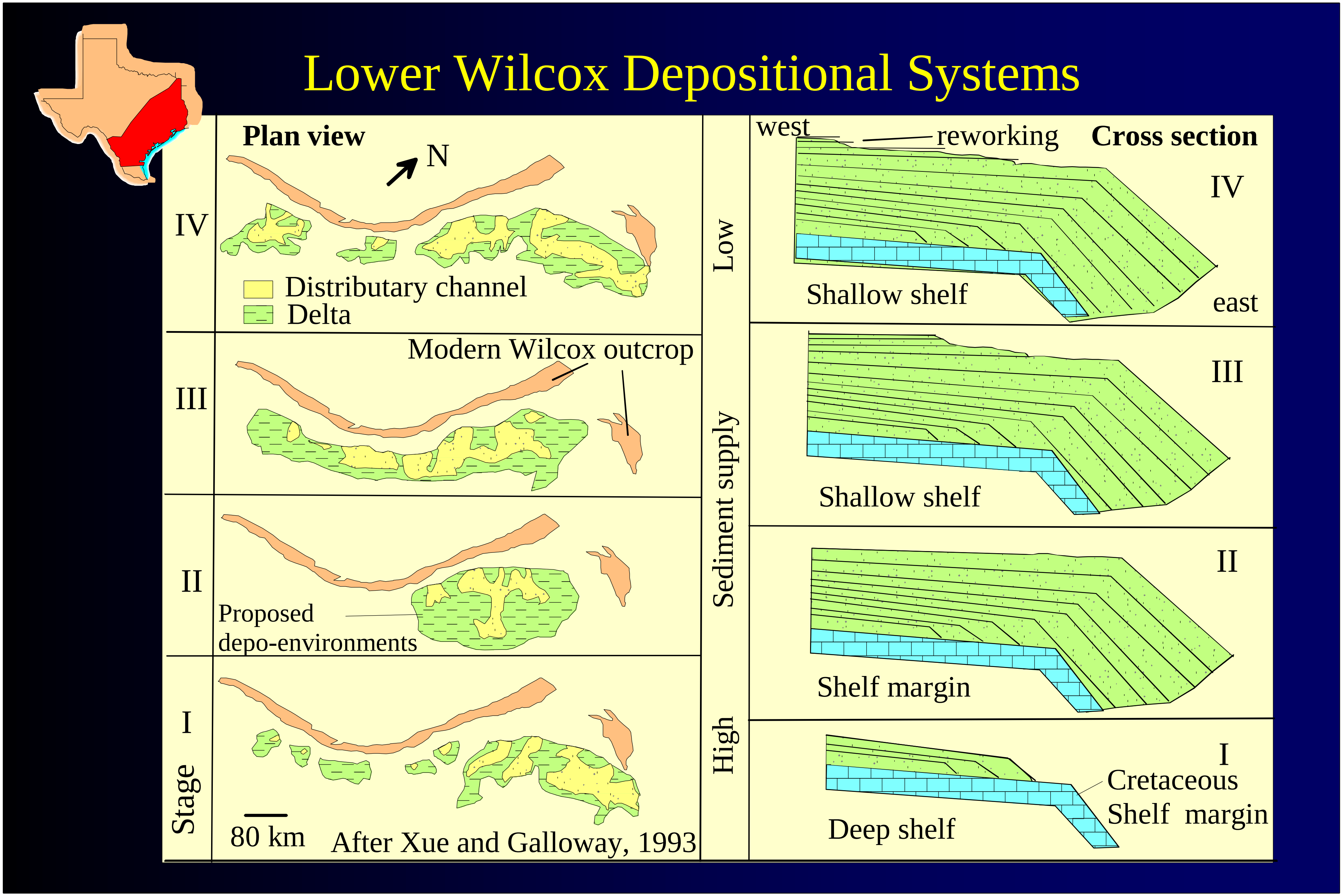

Figure 9. Four progressive stages, (I to IV) of Lower Wilcox deposition in plan view and corresponding generalized east to west cross section for East Texas (Xue and Galloway, 1993). Note the position of the Cretaceous shelf margin and that the outcrop belt extends from the Texas - Louisiana border (north) to the South Texas area (shown on inset map). Xue and Galloway (1993) suggest sediment supply varied during lower Wilcox deposition.

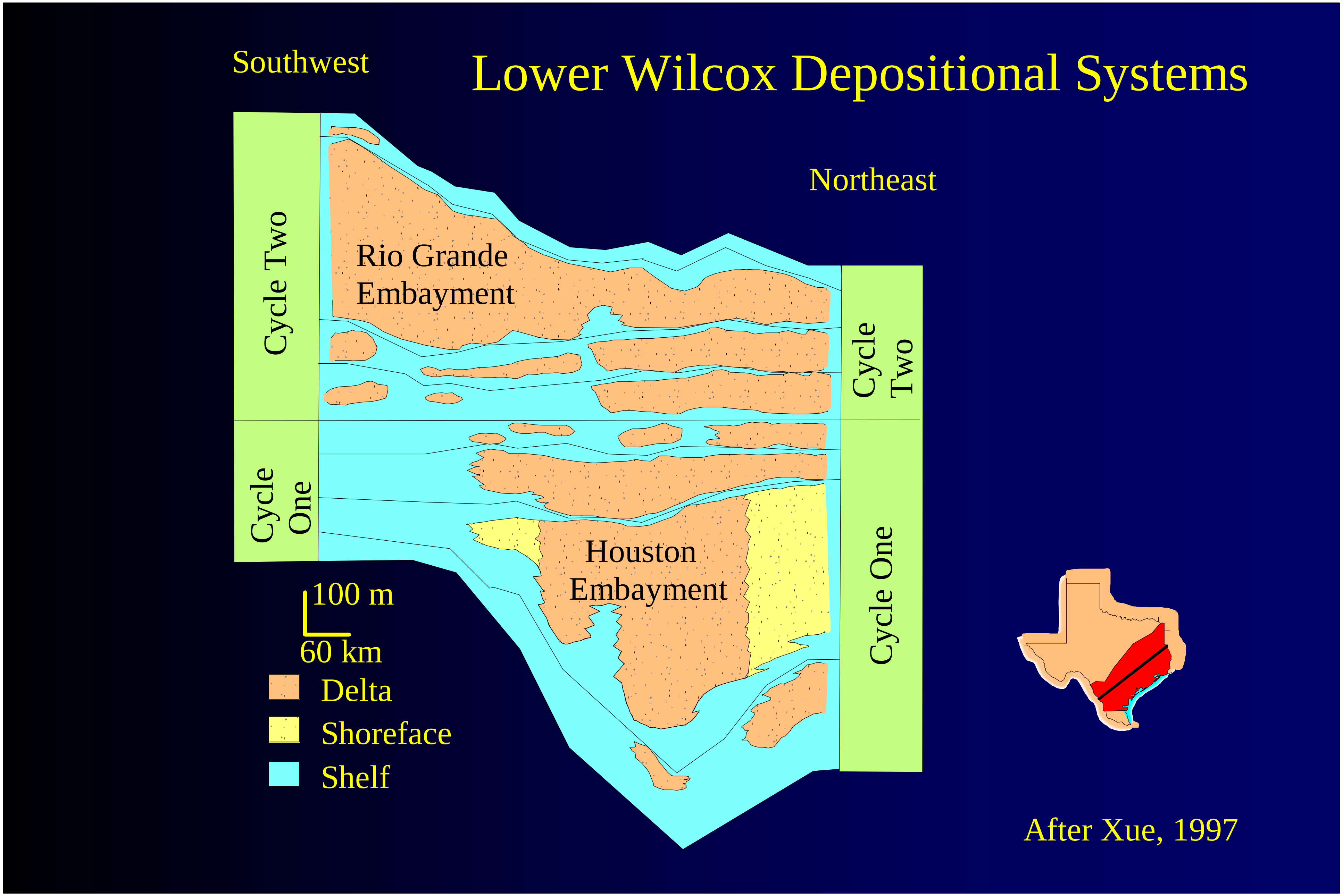

Figure 10. Xue (1997) proposed that the lower Wilcox sediments can be divided into two major depositional cycles that generally filled the Houston Embayment in the north and subsequently the Rio Grande Embayment in South Texas. The location of the section is shown on the inset map.

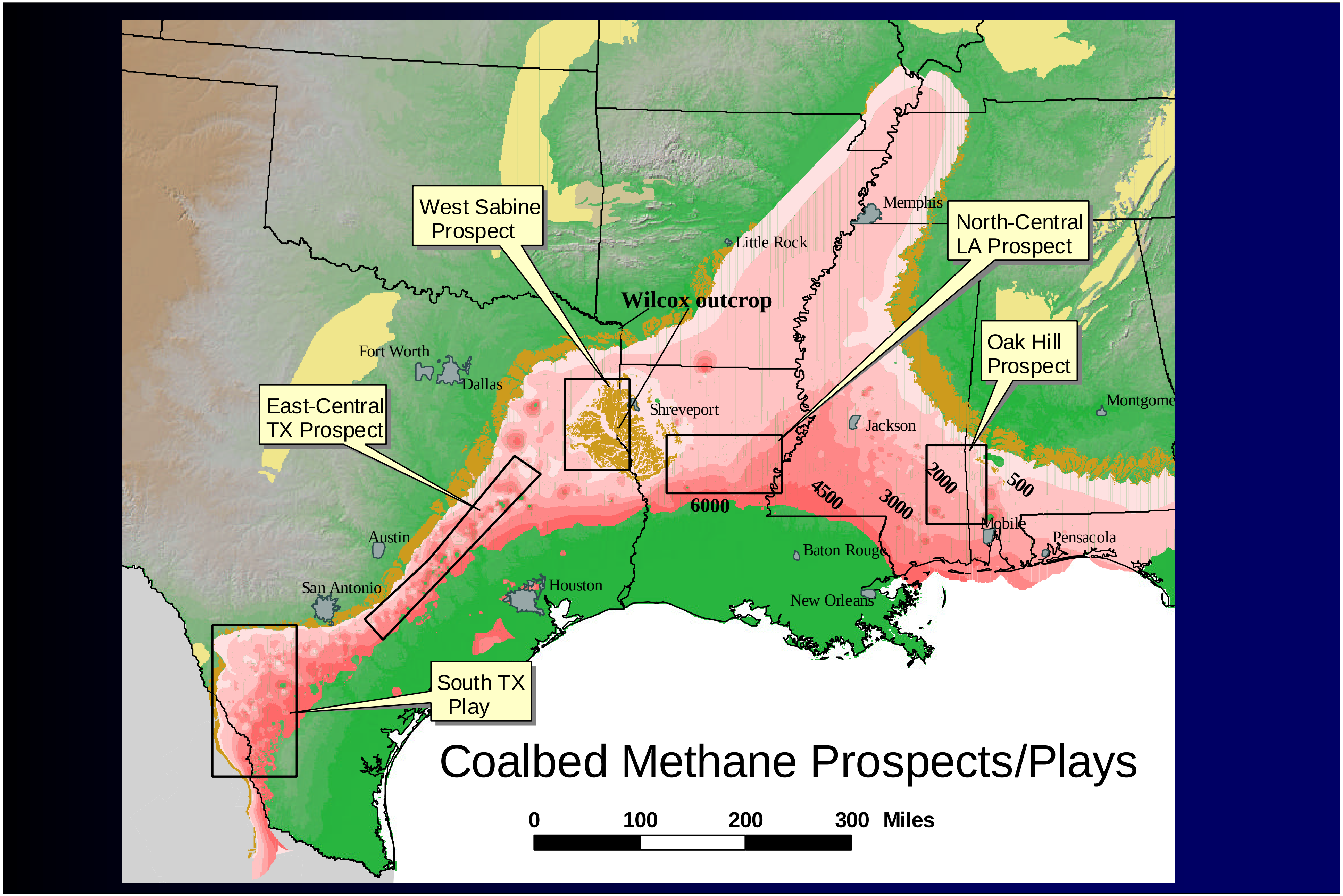

Figure 11. The location of five coalbed methane prospects and plays that are discussed in this presentation. The shaded red area indicates depth to the top of the Wilcox Group in 500, 1000, and 1500 ft contours and indicates the area underlain by Wilcox coal-bearing formations. Note that the concentric darker red areas indicate the location of a possible salt dome. The lower cut-off for the area shaded red is at a depth of 6,000 ft. The brown color is Wilcox outcrop and the yellow is older coal basins.

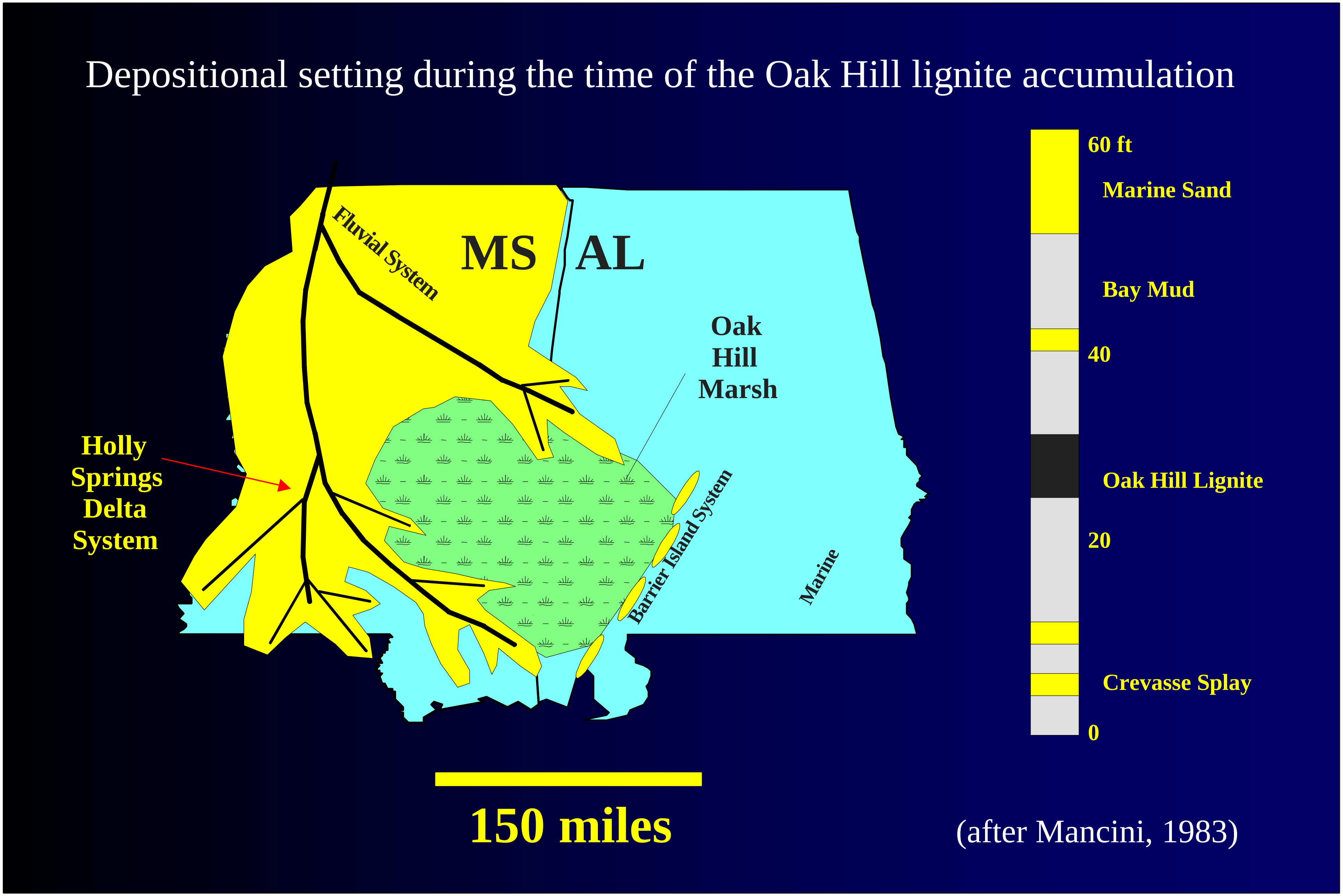

Figure 12. Depositional setting in southeast Mississippi and southwest Alabama during the time of the Oak Hill lignite accumulation (after Mancini, 1983). Initial desorption data from coal cuttings obtained from a depth of about 2000 ft indicate that the average methane gas content is about 19 SCF/ton in the Oak Hill deposit. Gas desorption results from cuttings usually under-estimate the gas content, which suggest that the gas content in the Oak Hill coal may be greater than 19 SCF/ton. The location of the generalized stratigraphic section is from the center of the deposit.

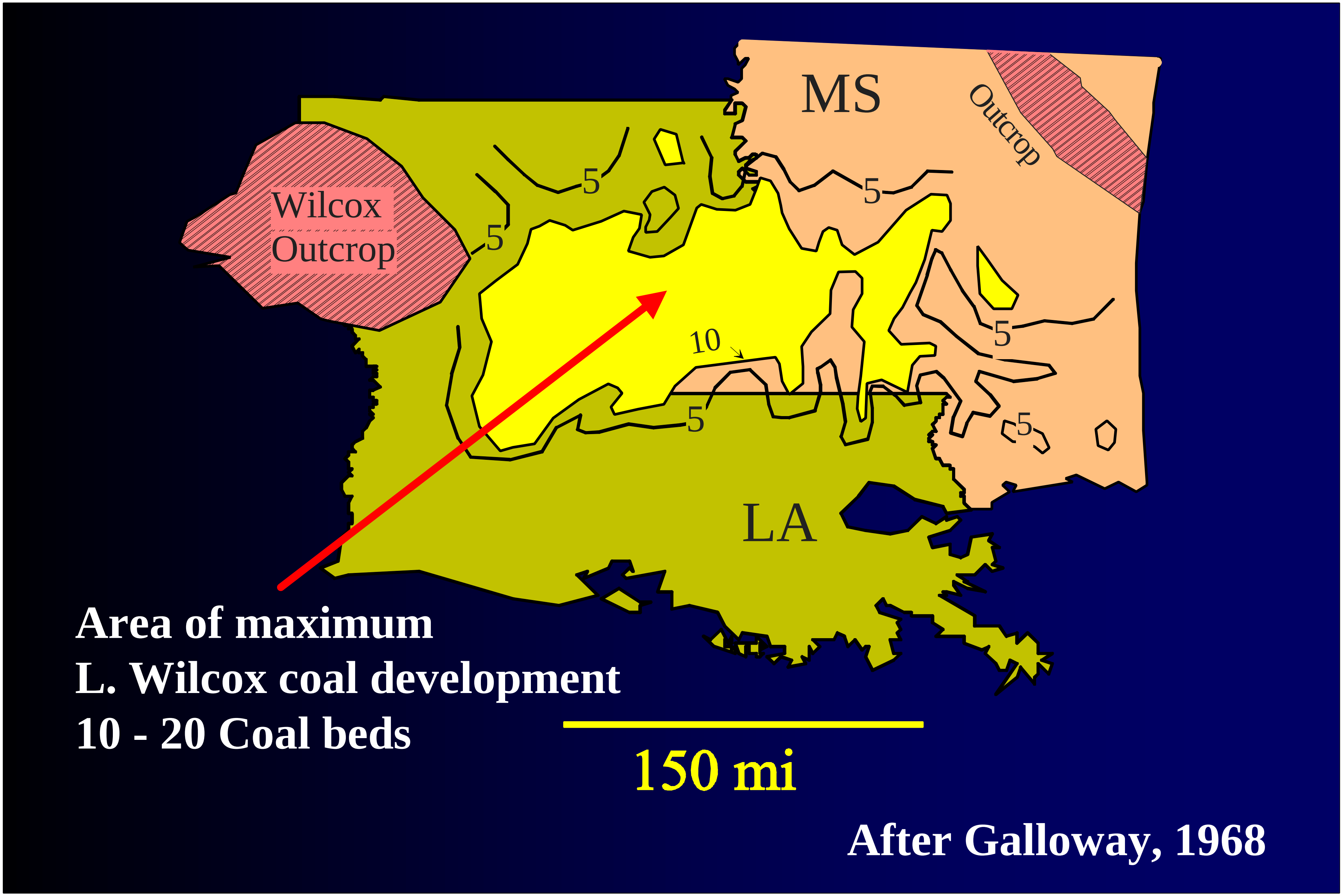

Figure 13. This is a map that shows the number of Lower Wilcox coalbeds in north-central Louisana and adjacent Mississippi that were reported by Galloway (1968). Contours indicate number of coal beds.

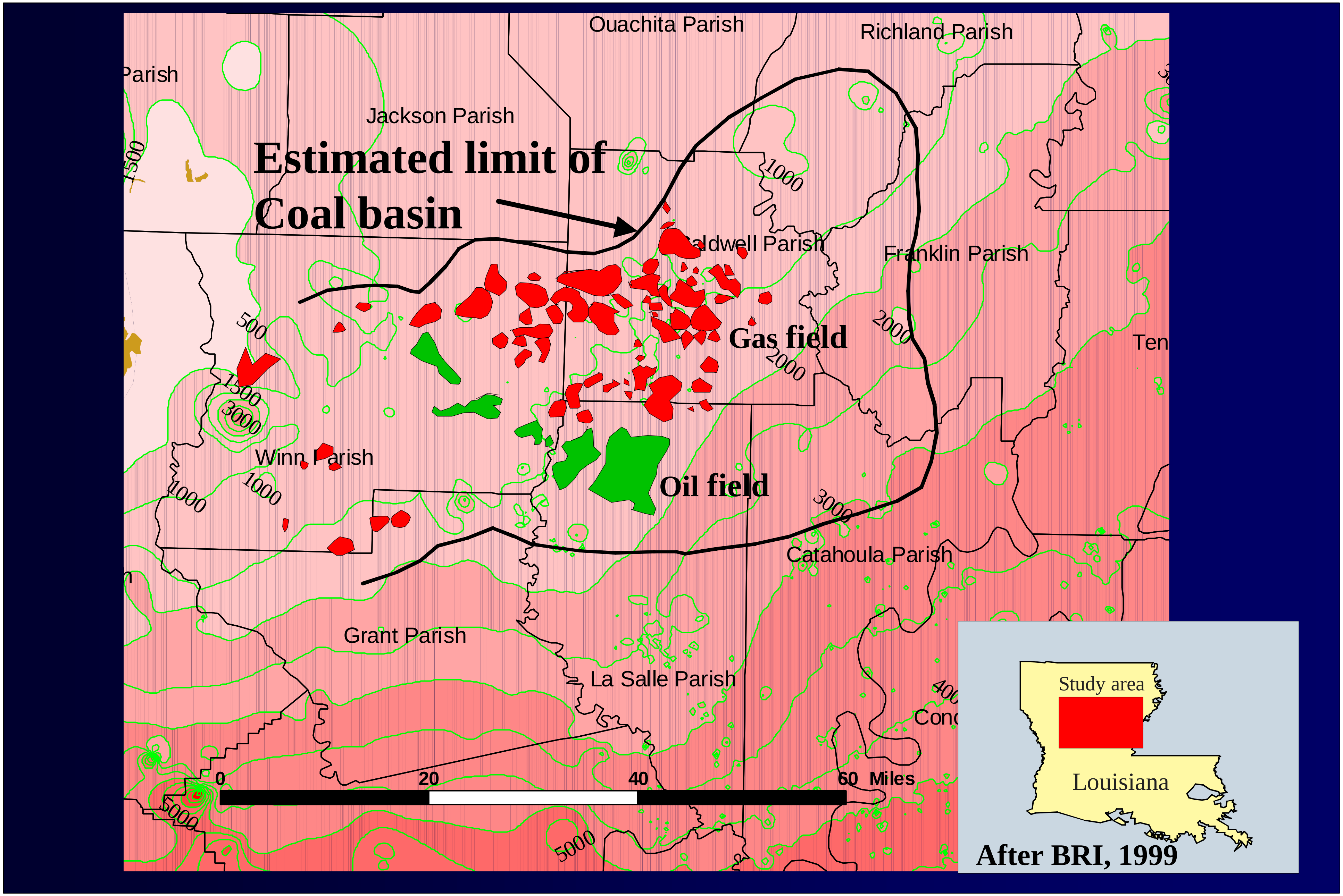

Figure 14. Estimated limit of the coalbed methane basin in north-central Louisiana. (After Basin Research Institute, 1999). Note that current gas production is from sandstone that is in the coal-bearing interval. Cumulative coal thickness for at least 6,000 acres is reported to be >150 ft, with some individual coal beds thicker than 50 ft. The Wilcox coal-bearing interval is approximately 1,500 ft thick. Green contours on the map show depth (in ft) to the top of the Wilcox Group.

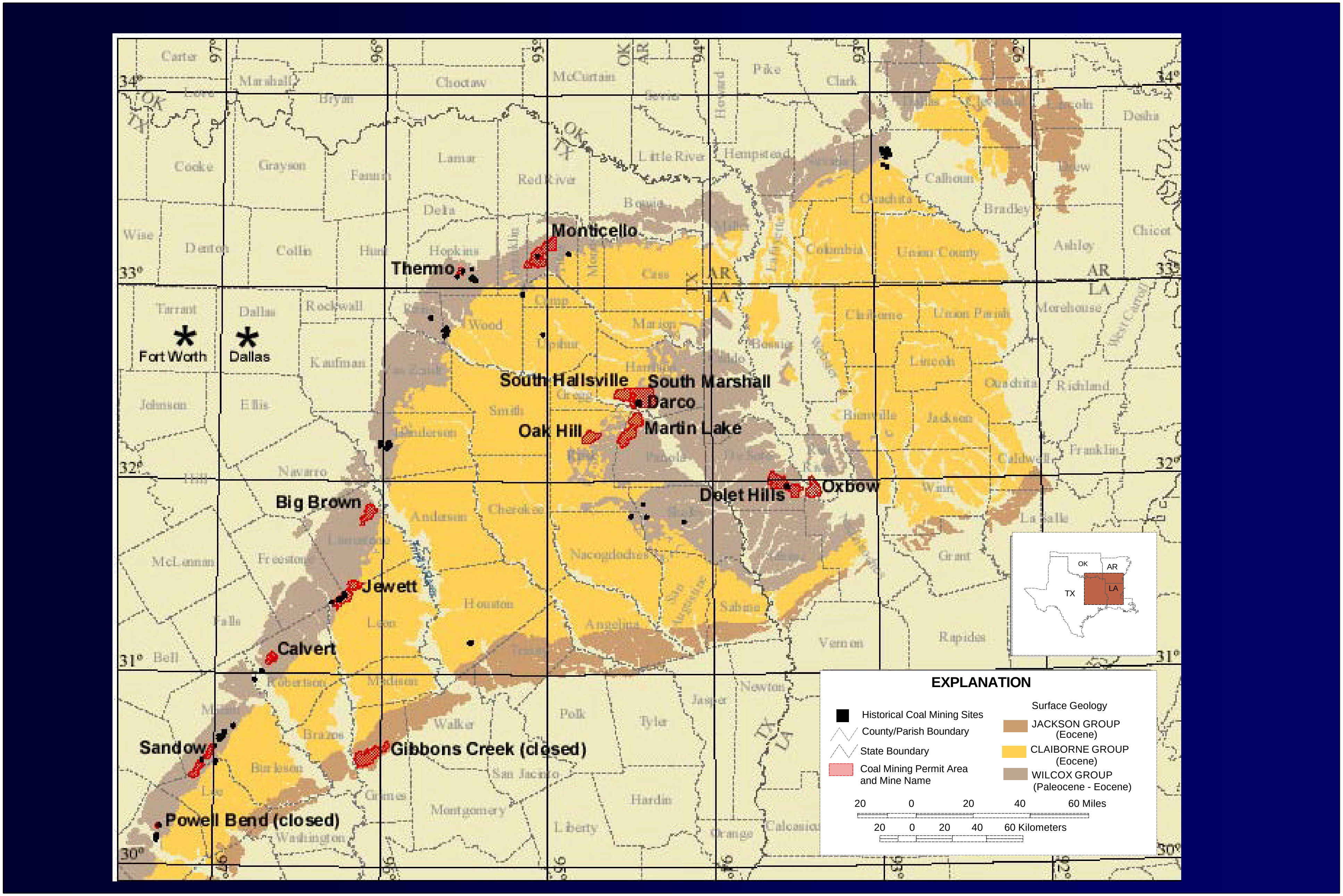

Figure 15. Generalized outcrop of coal-bearing units and location of current and historic coal mines in the Sabine Uplift area of Northeast Texas and Northwestern Louisiana. Coalbeds cored from shallow drill holes (<150 ft or 46 m deep), near the Calvert and Jewett mines, showed no gas content when tested.

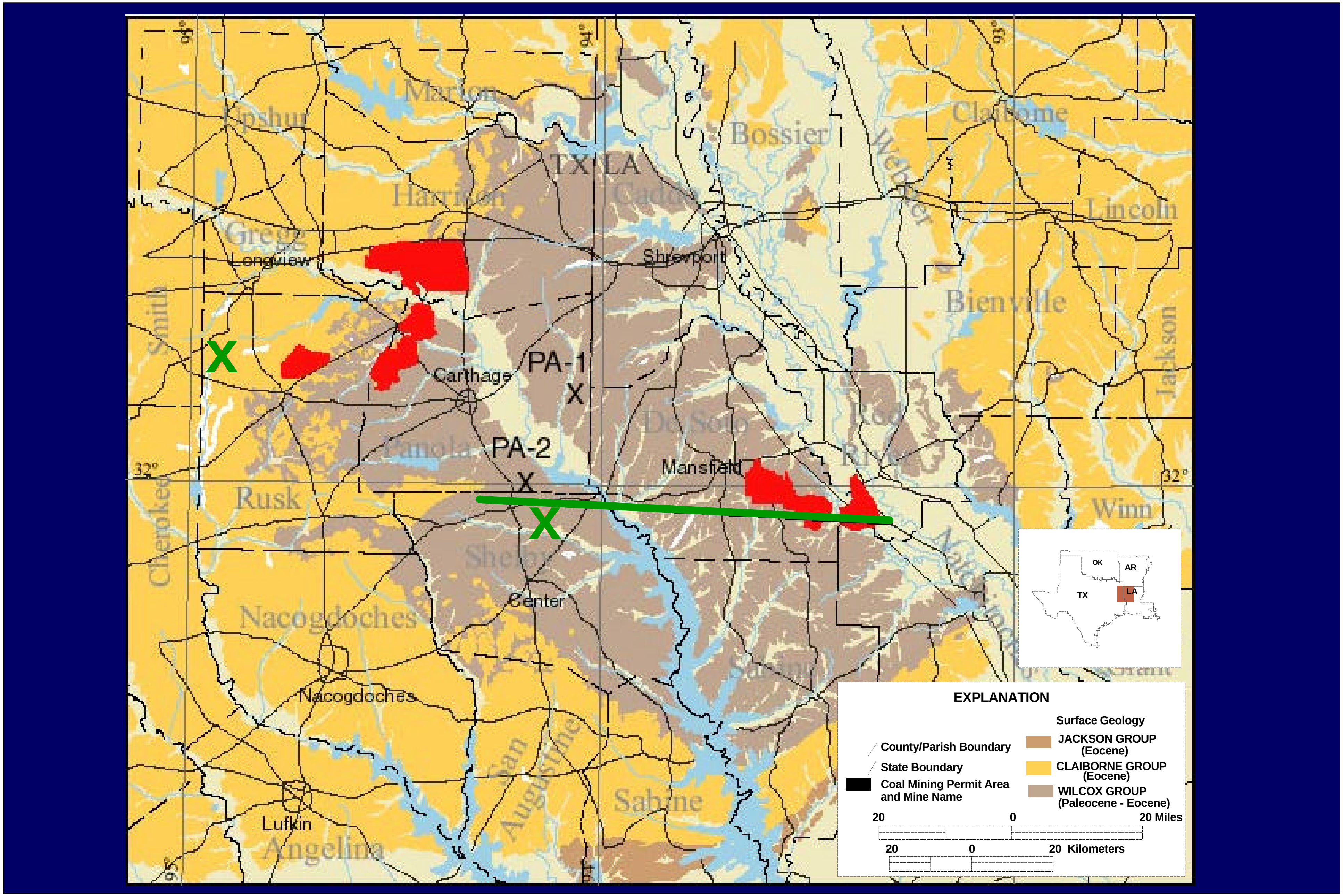

Figure 16. Close-up map of the Sabine Uplift area. Green "X" indicates location of stratigraphic control from drill holes. Green line is approximate line of section for a cross section from Luppens (1987). In June, 1999, the U.S. Geological Survey (USGS) and Texas A&M University drilled two coalbed methane test holes in Panola County, Texas. The following diagrams provide some preliminary results from drilling and samples collected. The first hole (USGS-PA-1) contained no measurable gas. The second hole (USGS-PA-2), contained some coal gas. Black "X" indicates location of 1999 USGS coal-bed methane test holes. Areas colored red are surface coal mine permits.

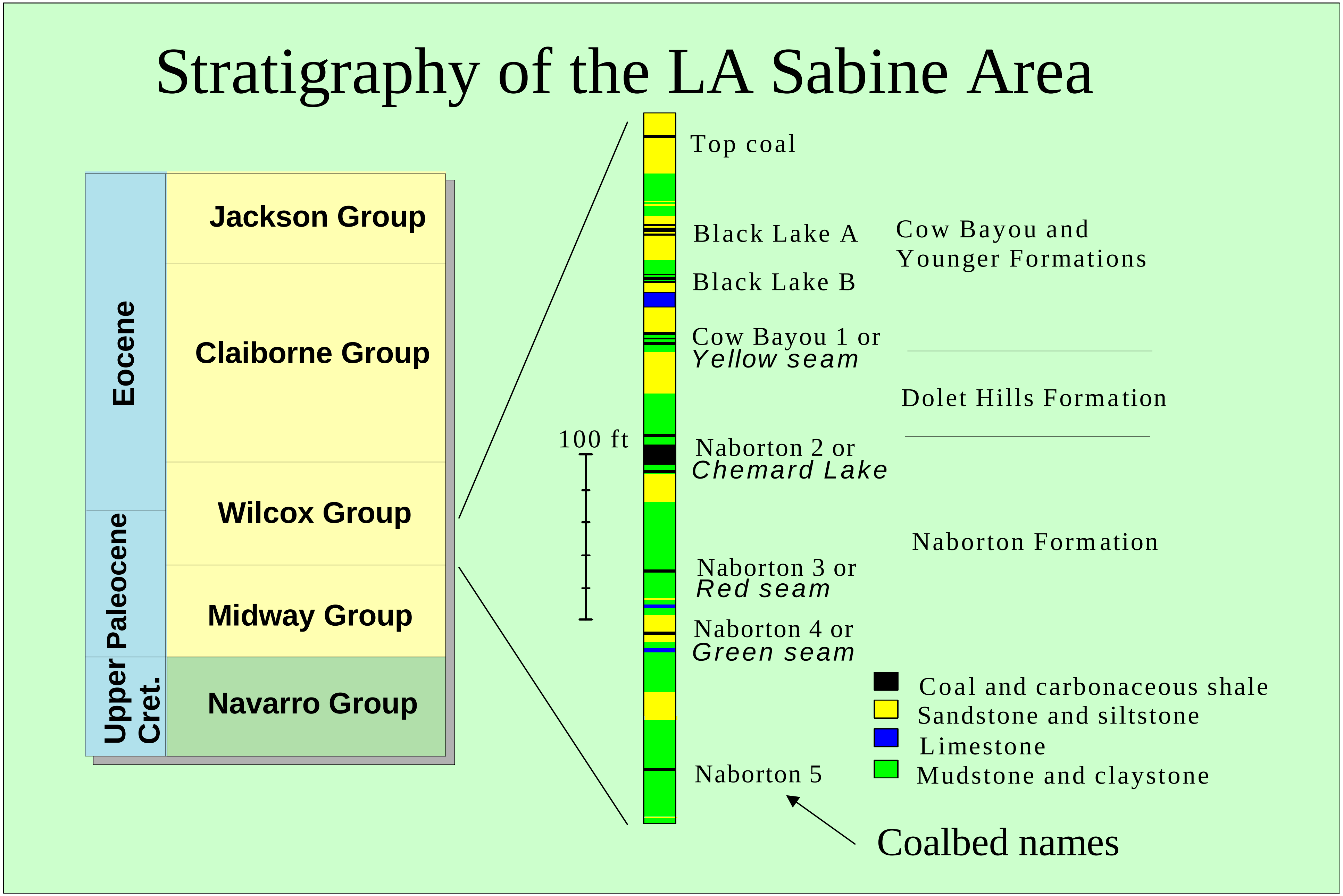

Figure 17. Detailed stratigraphy of the coal-bearing part of the Louisiana Sabine Uplift. Italicized coalbed names are from Williamson (1986).

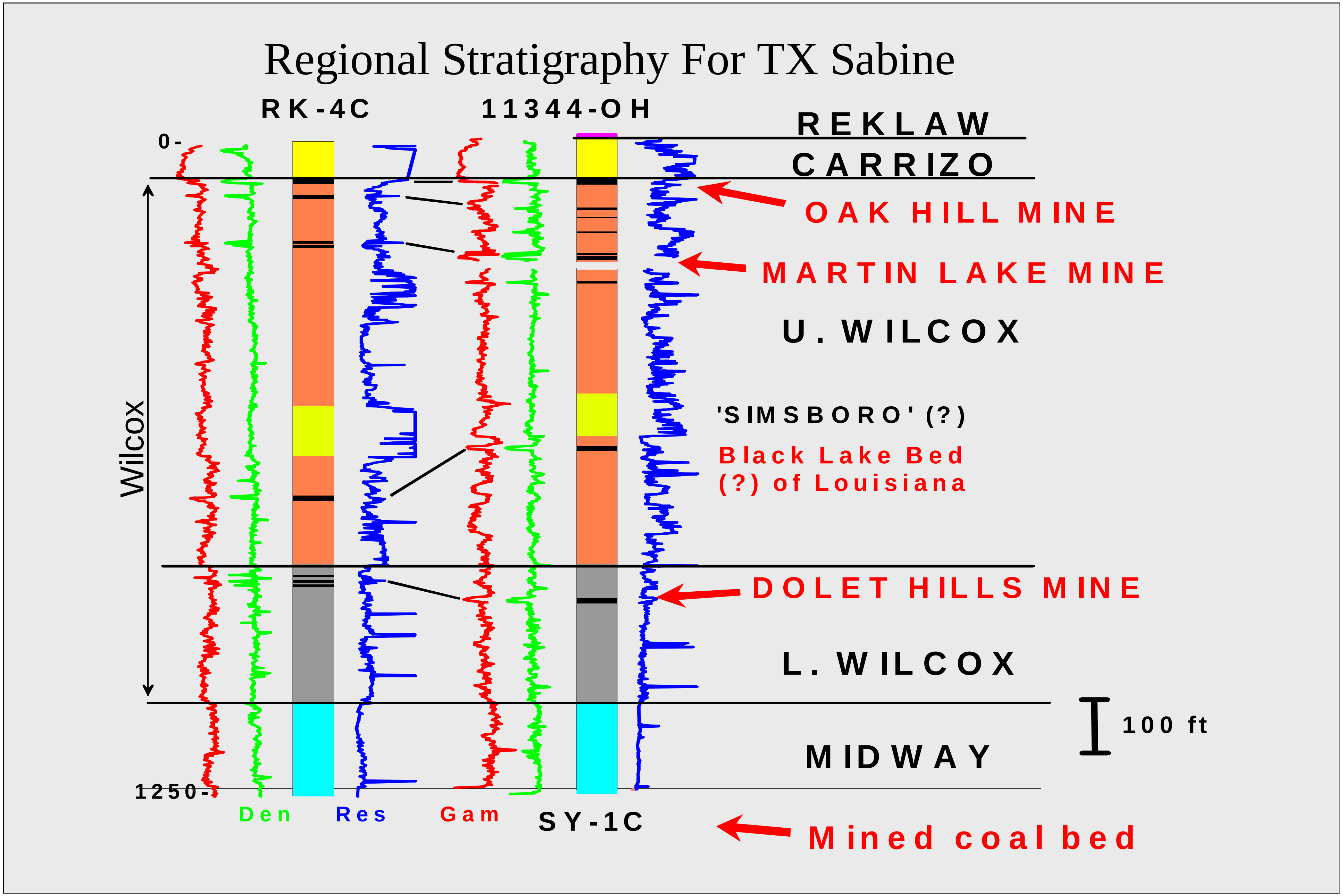

Figure 18. Boreholes showing regional correlation of the Wilcox Group in the Texas part of the Sabine Uplift. Boreholes 11344-OH and SY-1C form a composite section. Data modified from Oak Hill mine permits (1134-OH) and Kaiser (1990). Red arrows indicate stratigraphic position of coal beds mined at surface mines shown on figure 15.

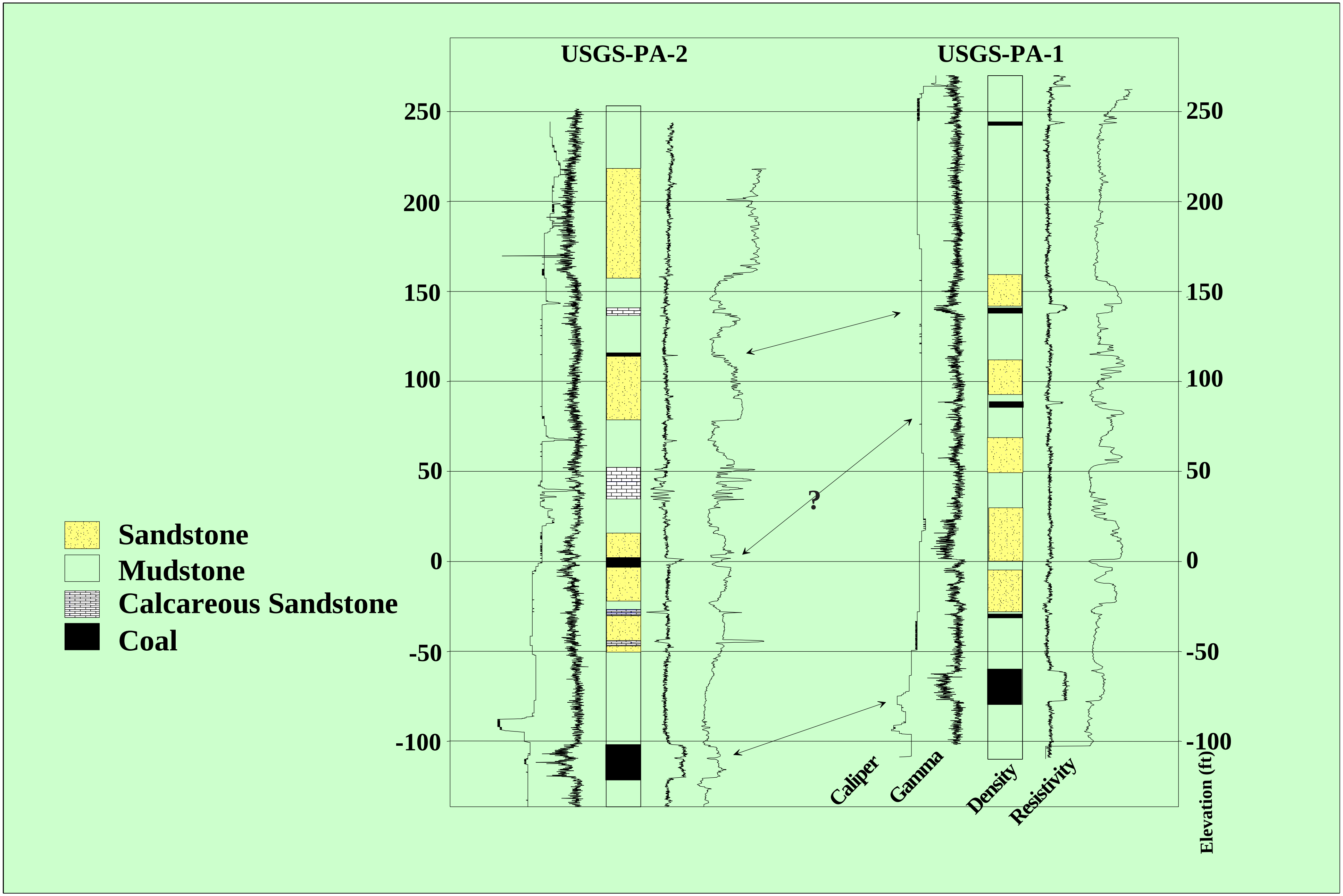

Figure 19. Generalized stratgraphic column and geophysical logs from USGS core holes in Panola County, Texas. Locations are shown on figure 16. Only the coal at the base of USGS-PA-2 contained coalbed gas.

Figure 20. Coal core being measured and described prior to insertion into the desorption canisters at USGS-PA-1. Note clay parting in coal core on the left end of the core. The clay parting occurs at depth 331.2 – 331.35 ft (USGS-PA-1) or about 0.2 ft from the top of the coal bed in both USGS-PA-1 and PA-2. The parting is a volcanic ash layer or tonstein, and occurs in the Dolet Hills mine in Louisiana (Ruppert and Warwick, 1994).

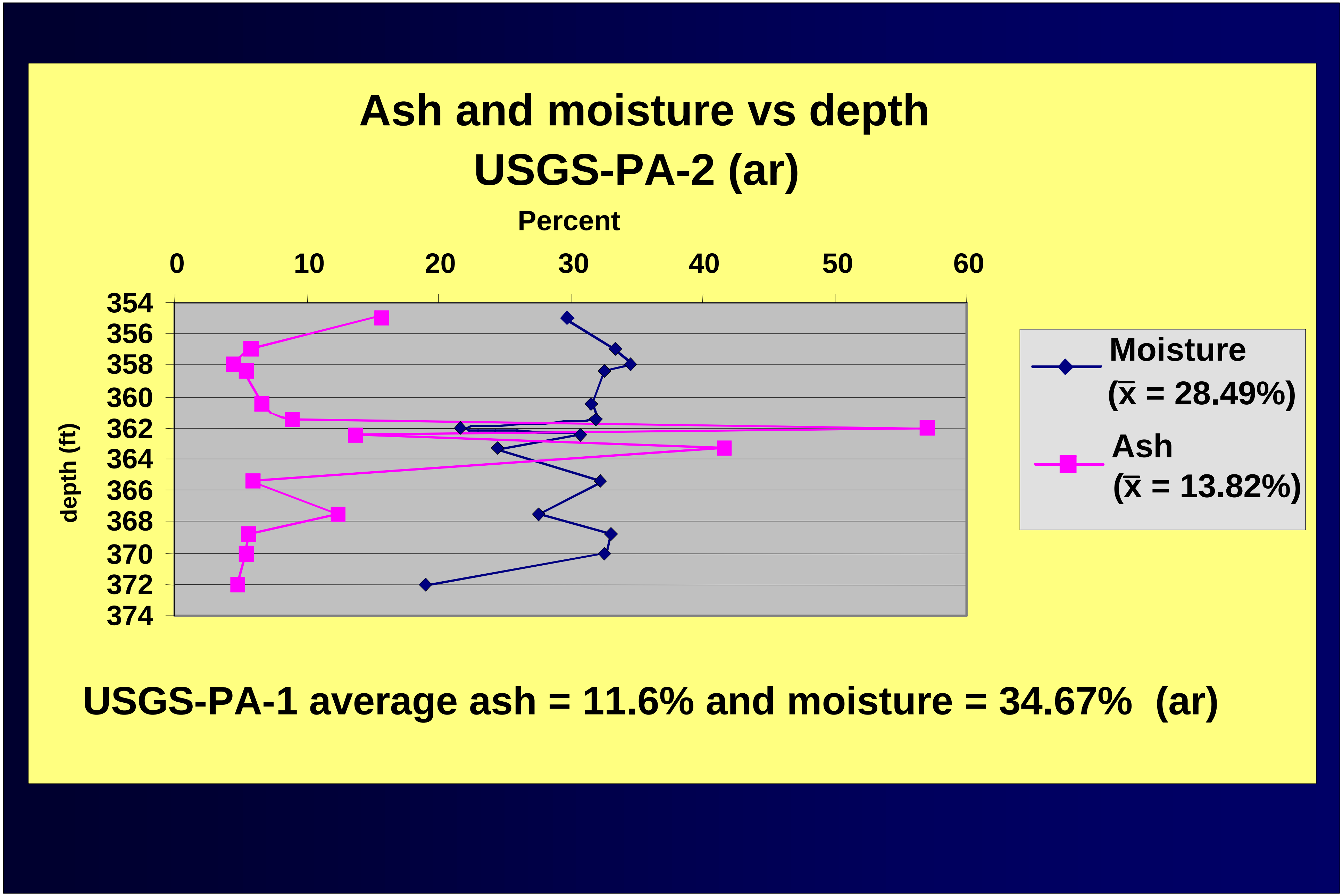

Figure 21. Plot of ash yield and moisture (as received basis, ar) for gas-bearing coal samples from USGA-PA-2. Note that the high ash yield from the middle of the bed indicates that a 3 ft zone of high-ash coal occurs in this interval. The tonstein shown on figure 20 is included in the coal sample plotted at 355 ft depth. Average ash and moisture values for the coal samples from both boreholes are given at the bottom and right side of the illustration.

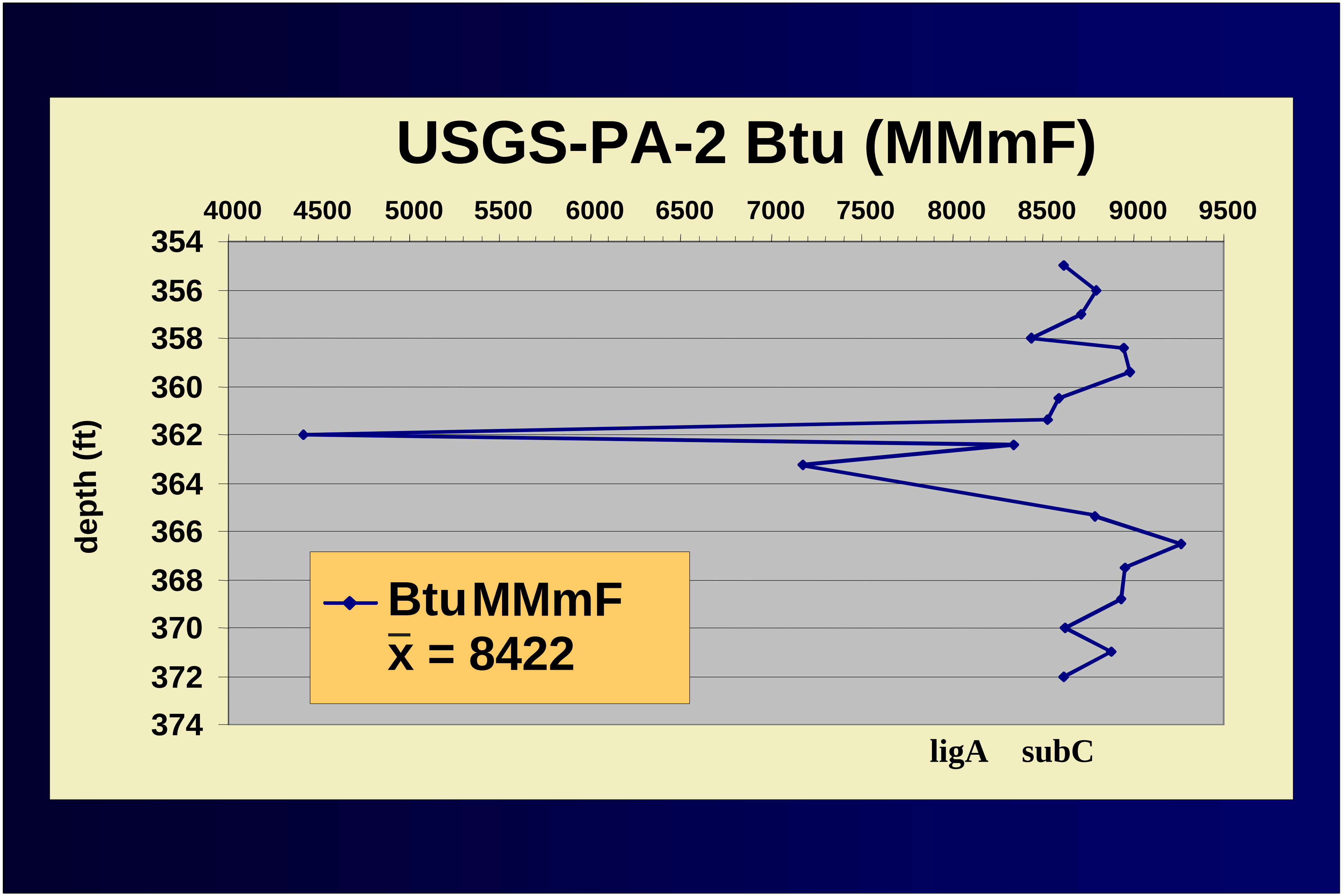

Figure 22. Plot of calorific values (Btu/lb on a moist, mineral matter free basis, MMmf, using equilibrium moisture) for gas-bearing coal samples from USGS-PA-2. Note most samples plot above 8300 Btu/lb, the boundary between lignite and sub-bituminous. Average Btu value is 8422.

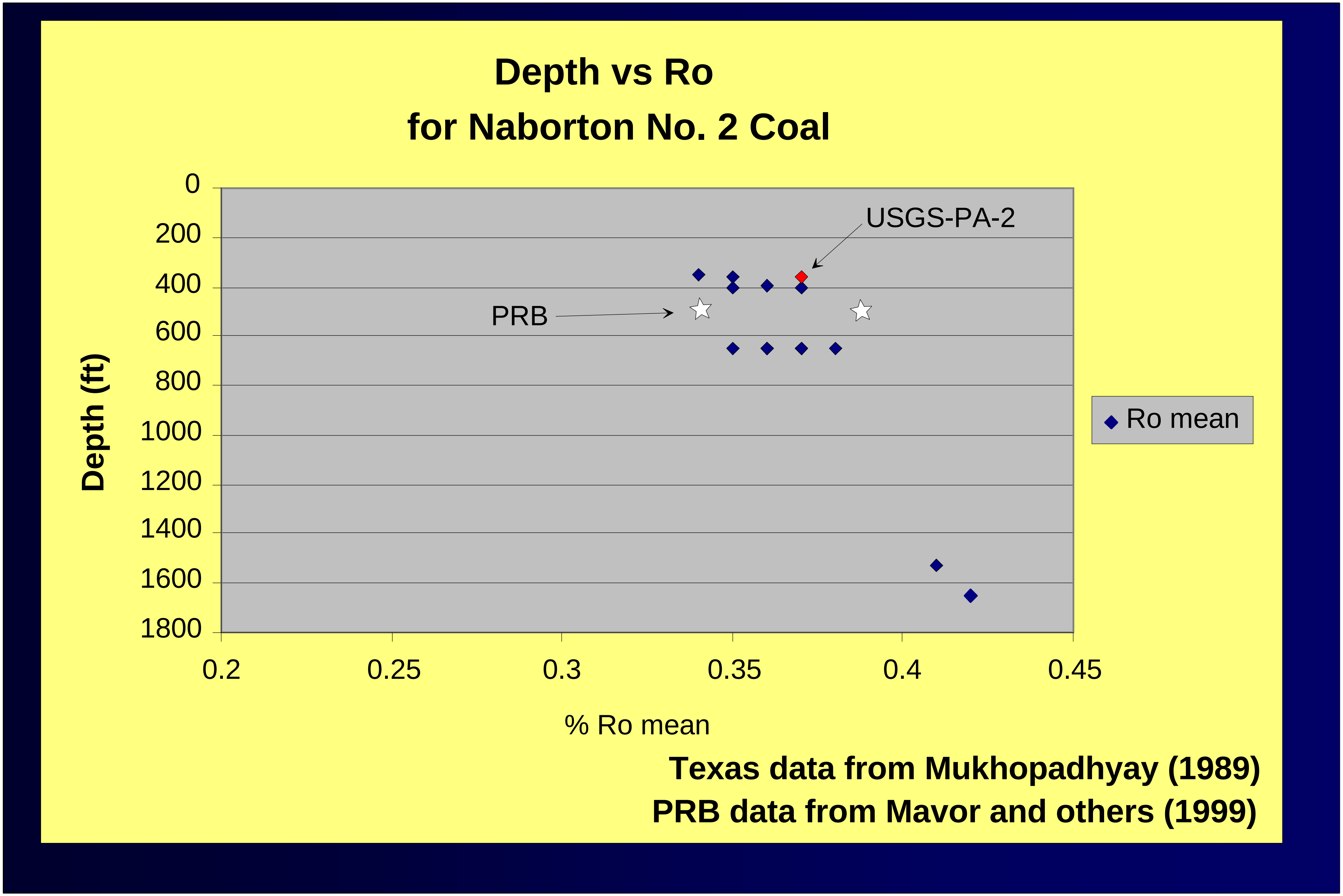

Figure 23. Plot of vitrinite reflectance data for the Naborton No. 2 (Chemard Lake) coal in Texas. Blue points from Mukhopadhy (1989). Red point is from USGS-PA-2. White stars are from Powder River basin (PRB) data (Mavor and others, 1999). The deep samples (>1400 ft) with high (>0.4%) Ro values indicate coal rank increase with depth.

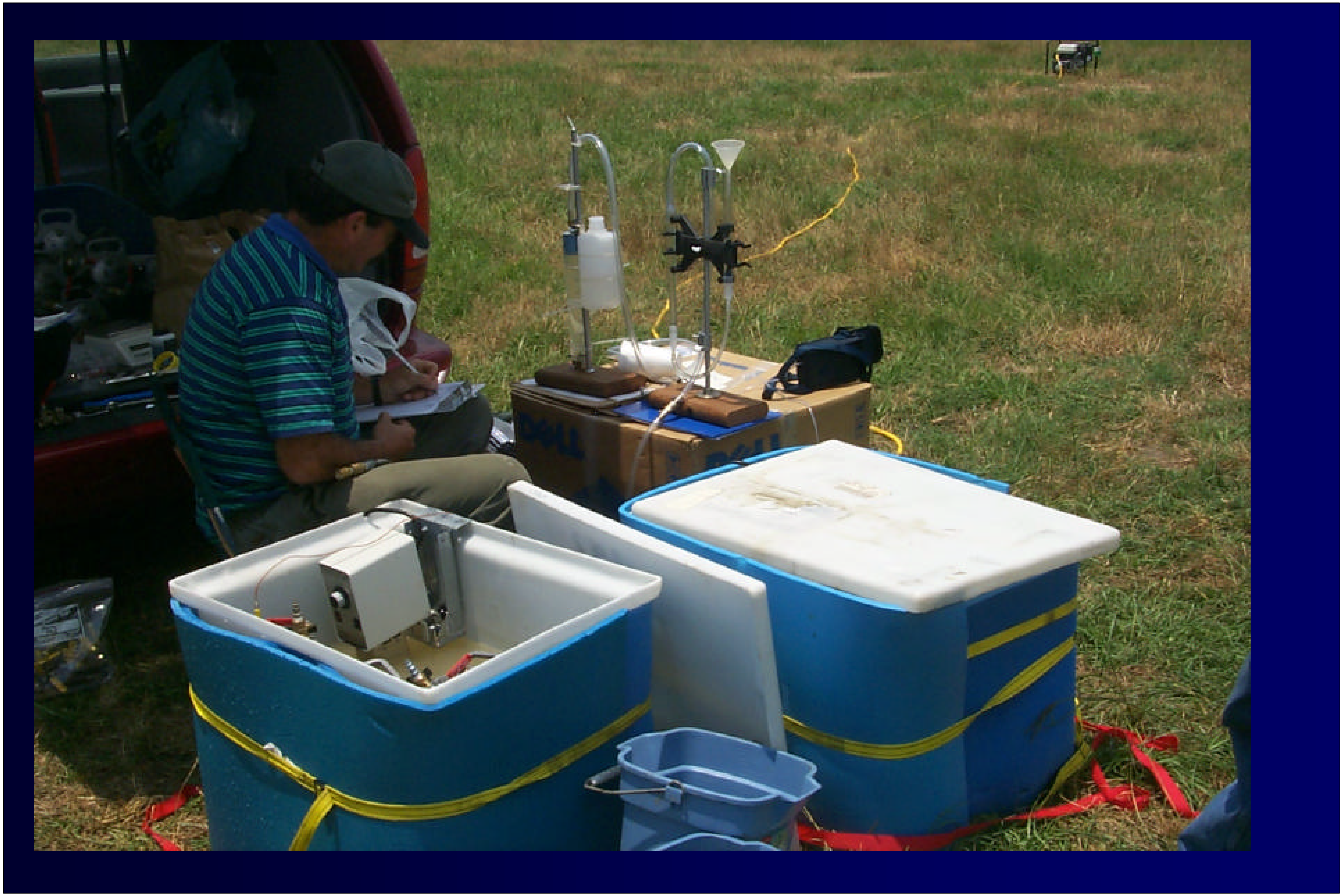

Figure 24. Photograph showing constant temperature water baths used with the coal desorption canisters.

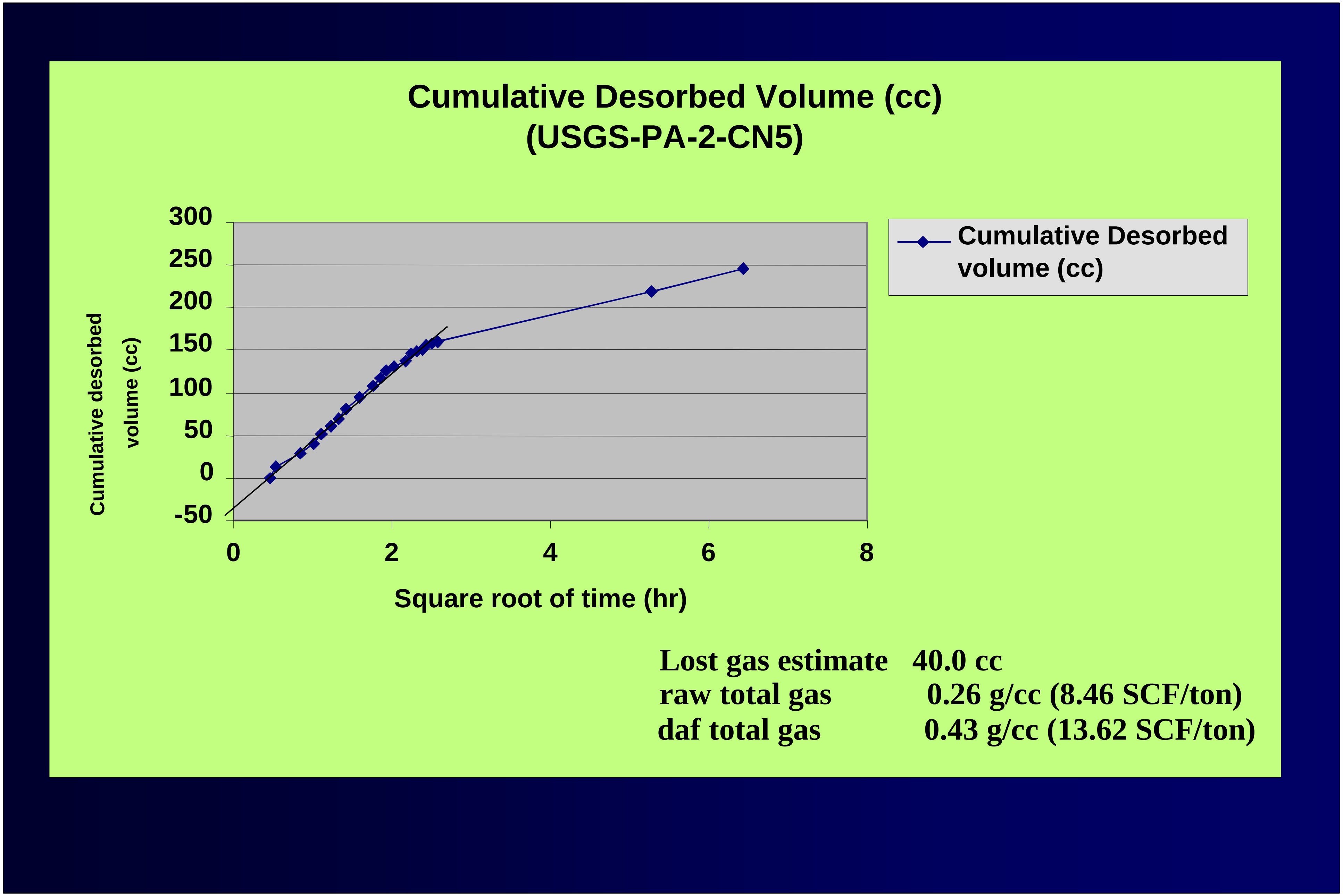

Figure 25. Example of one of the desorption plots from USGS-PA-2 (canister no. 5, which contains about 1ft of coal is about 5 ft from the top of the coal bed; daf = dry, ash free basis).

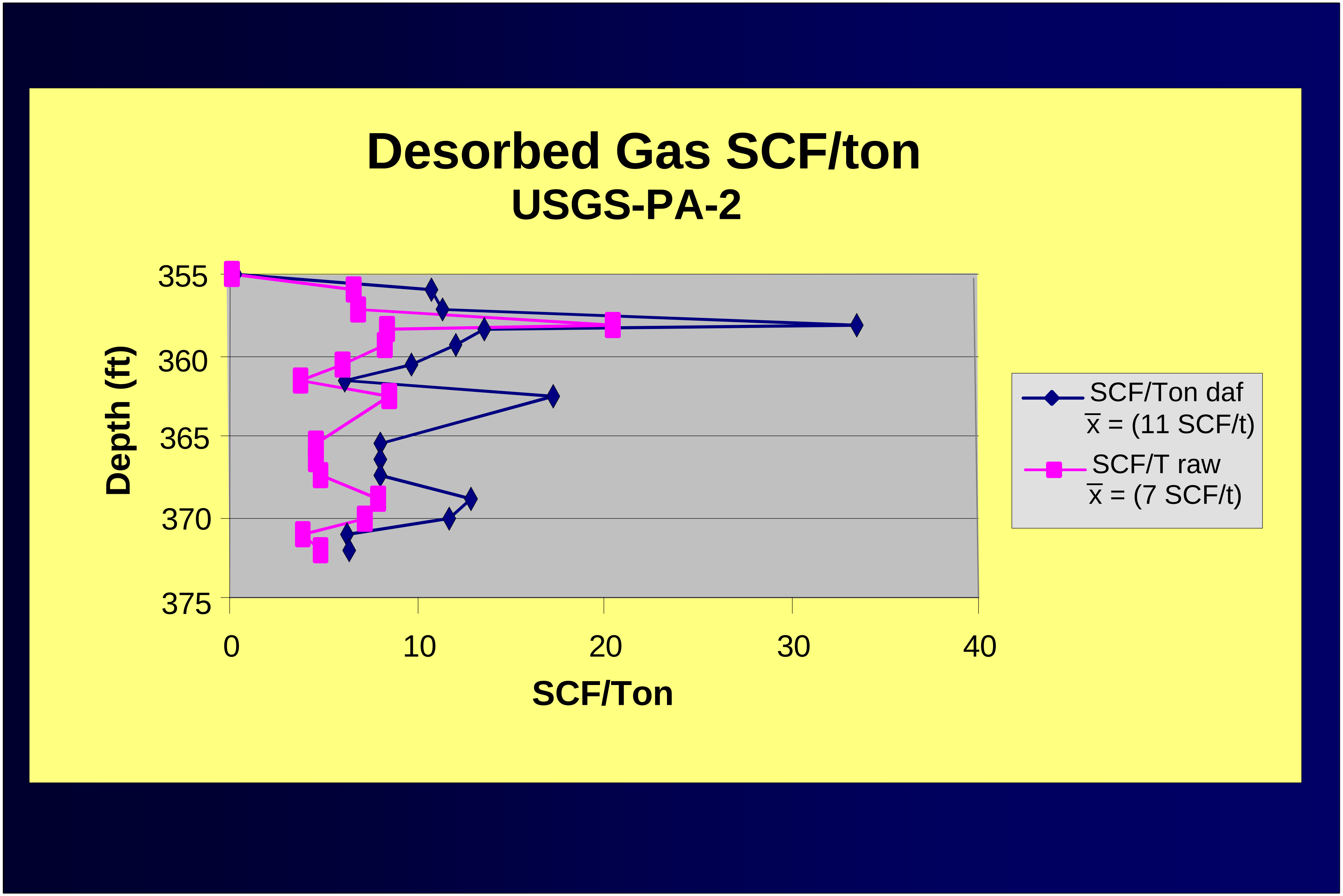

Figure 26. Results of all desorption tests on coal from USGS-PA-2. Note the higher gas content in the upper part of the coal bed. daf = dry, ash free basis.

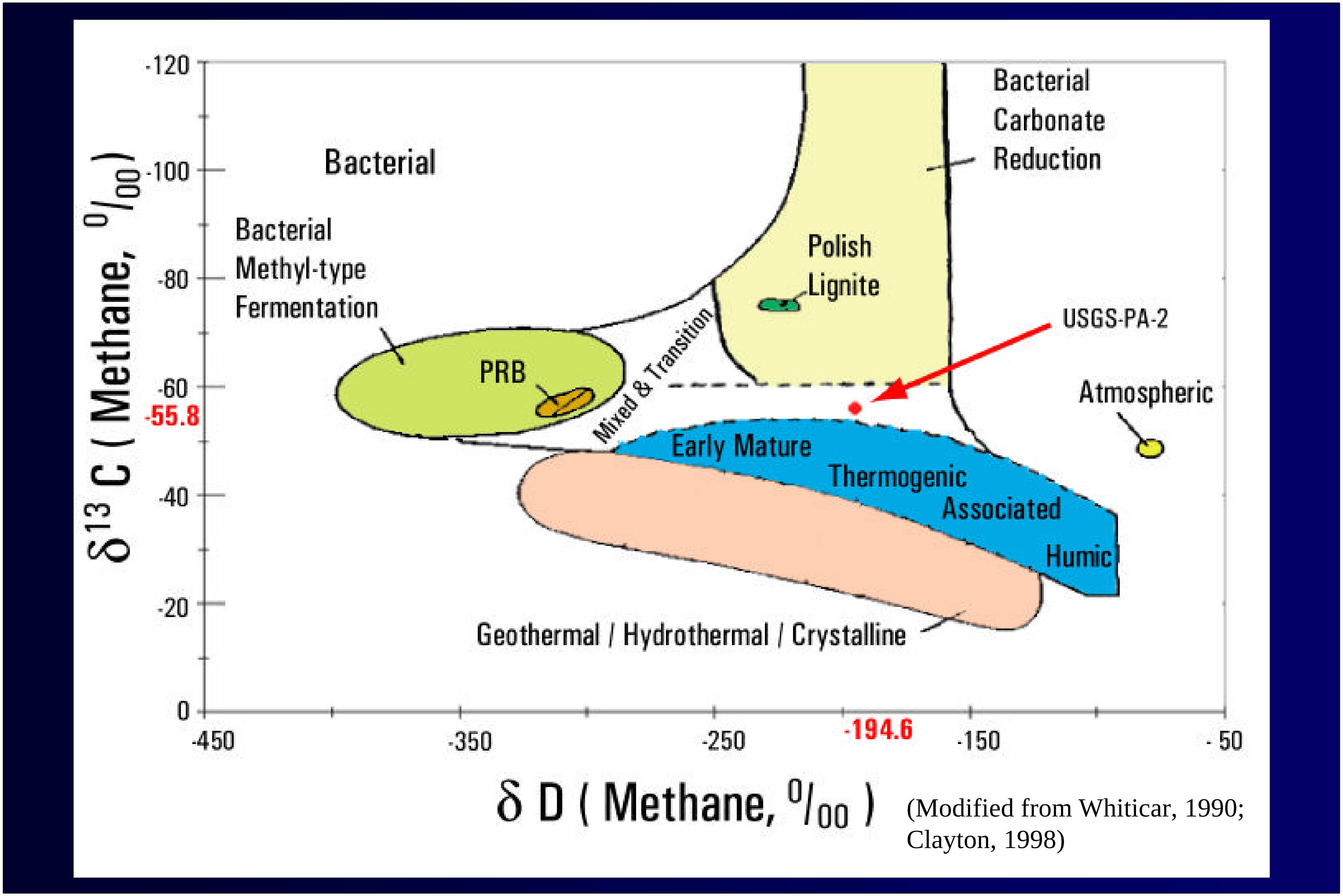

Figure 27. Isotopic composition of carbon (y axis) and hydrogen (x axis) for methane from a gas sample collected from one USGS-PA-2 coal sample. The values obtained from the sample are shown along the axes in red. Note that the gas sample plots in the mixed or transition zone between gases of biogenic and thermogenic origin and is different from Powder River basin (PRB) gases. Diagram after Clayton (1998).

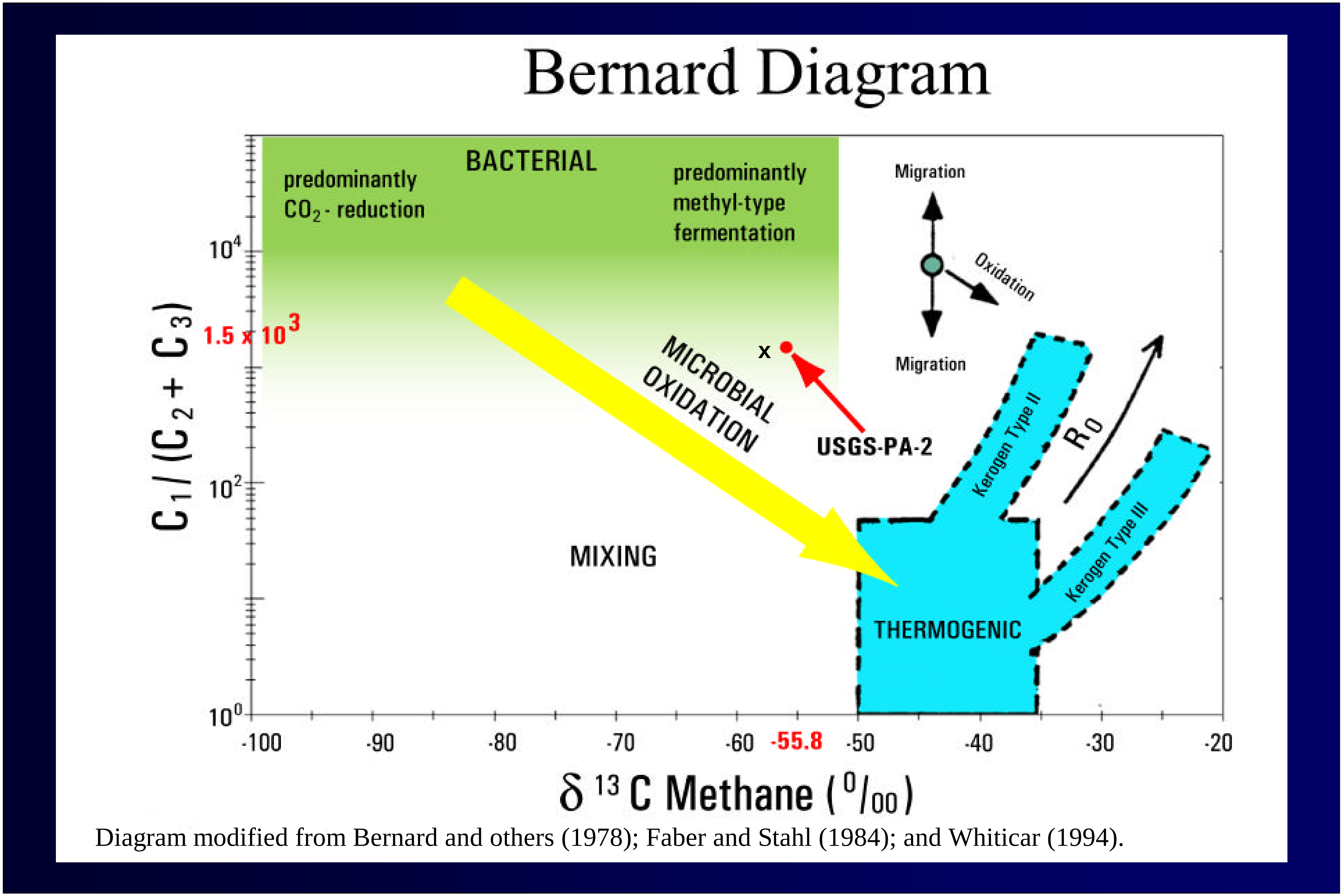

Figure 28. Bernard diagram for a gas sample collected from one USGS-PA-2 coal sample. The plot shows the molecular ratio of C_1, C_2 and C_3 (methane, ethane, and propane) and carbon isotopic composition in methane. The values obtained from the USGS-PA-2 sample are plotted along the axes in red. Note that the gas plots in the transition region of the diagram. The dryness of the gas indicates it falls outside the domain of the thermal region. The "X" near the red dot for USGS-PA-2 indicates the approximate plot position on the Benard Diagram for gas samples collected from sandstone reservoirs in the north-central Louisiana coalbed prospect (figure 14) (data from J.B. Echols, Basin Research Institute, Louisiana State University, written communication, 1996). Diagram modified from Bernard and others (1978); Faber and Stahl (1984); and Whiticar (1994).

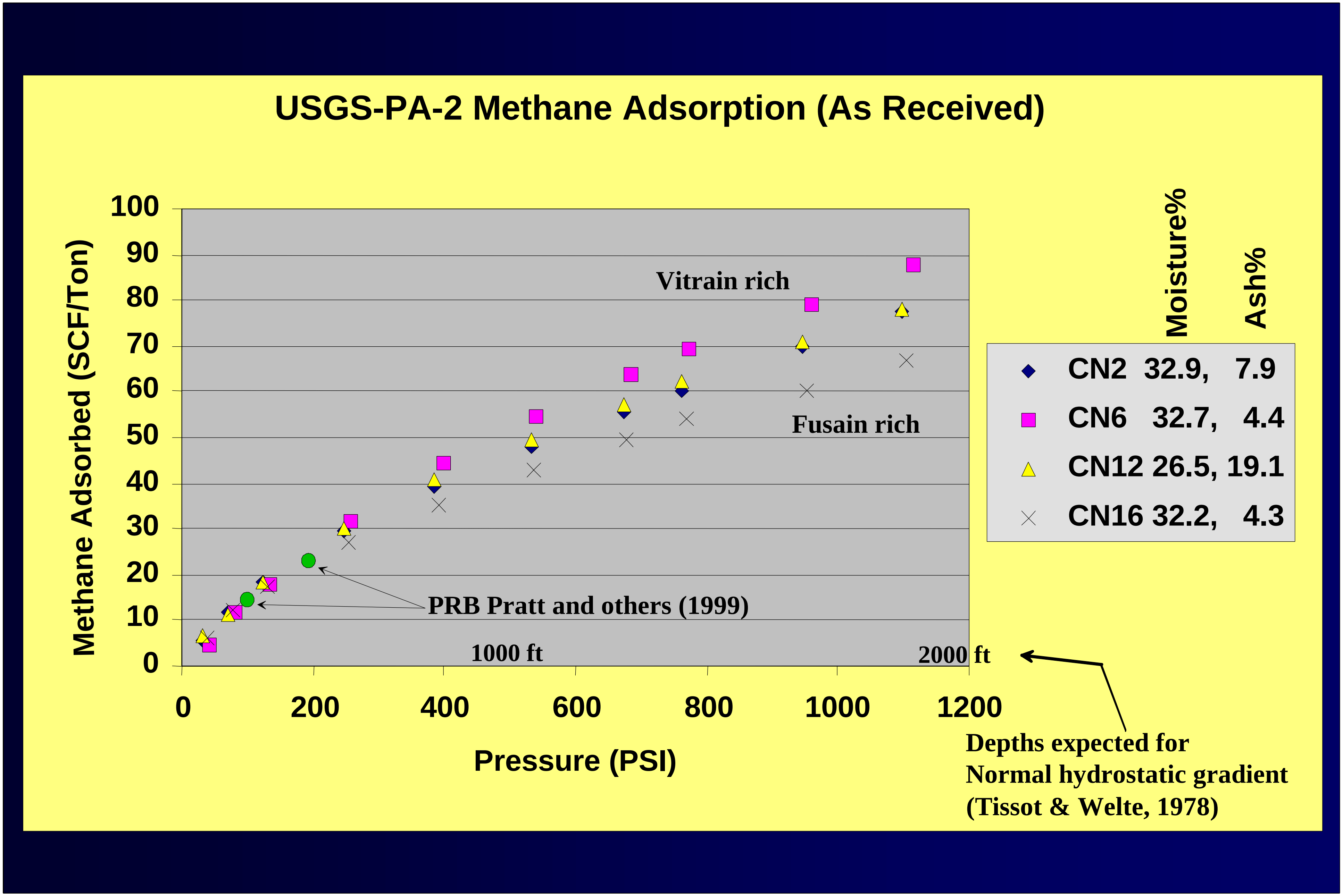

Figure 29. Plot of methane adsorption potential (as-received basis) for four samples from USGS-PA-2. The difference in adsorption potential may be associated with the organic composition of the sample. Examination of sample CN16 in hand specimen indicates it is fusain rich, and sample CN6 is vitrain rich. Expected depths are plotted above the corresponding pressures as derived from a normal hydrostatic gradient (from Tissot and Welte, 1978). Published adsorption values for Powder River basin (PRB) coals are plotted for comparison (green dots, data from Pratt and others, 1999). Sample number approximately indicates the depth in feet from the top of the coal.

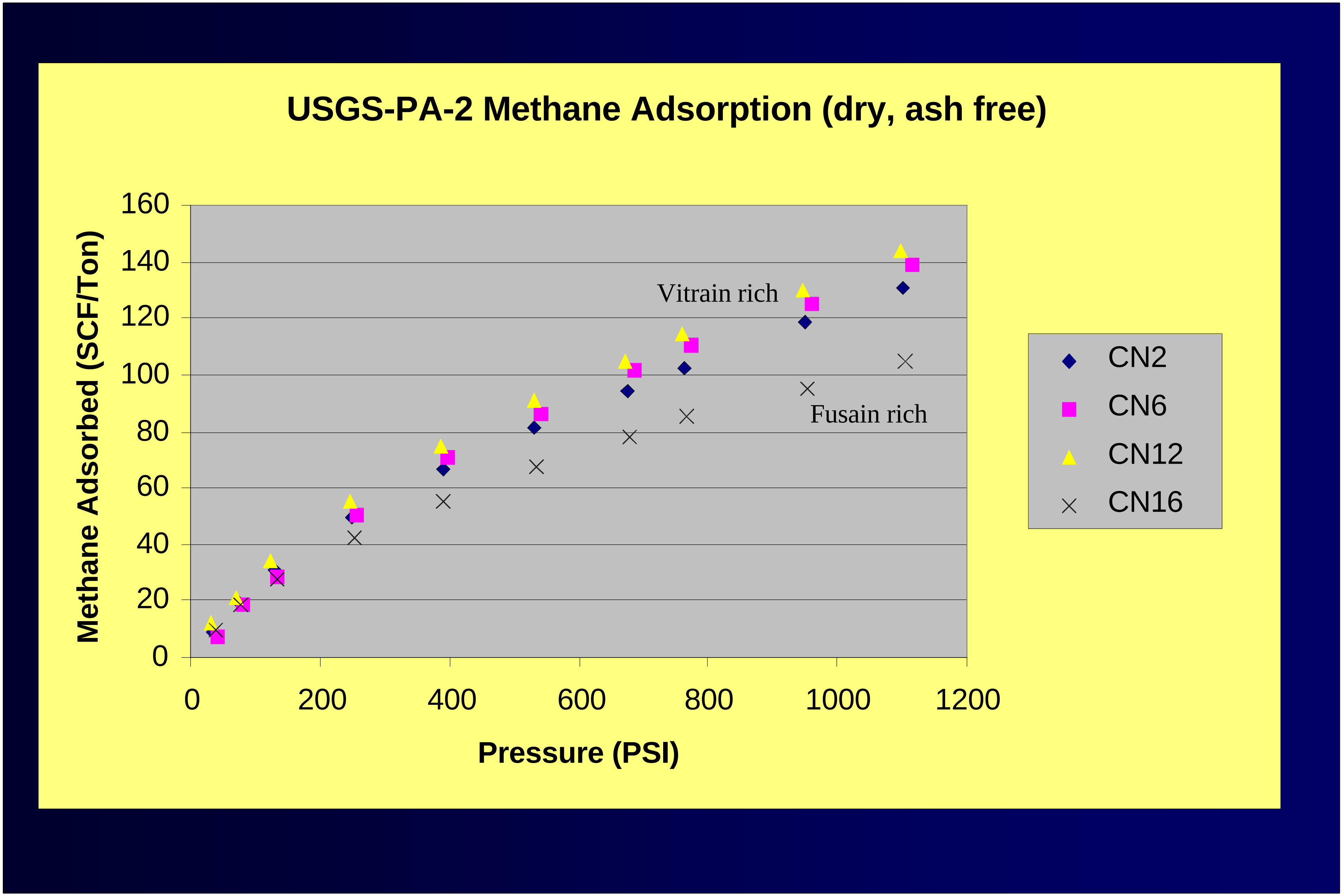

Figure 30. Plot of methane adsorption potential (dry, ash free basis) for four samples from USGS-PA-2 (same samples as shown on figure 29). Note that on a dry basis CN16 (fusain rich) and CN6 (vitrain rich) still diverge. The grouping of samples CN2, CN6, and CN12 may indicate that these samples have similar organic compositions.

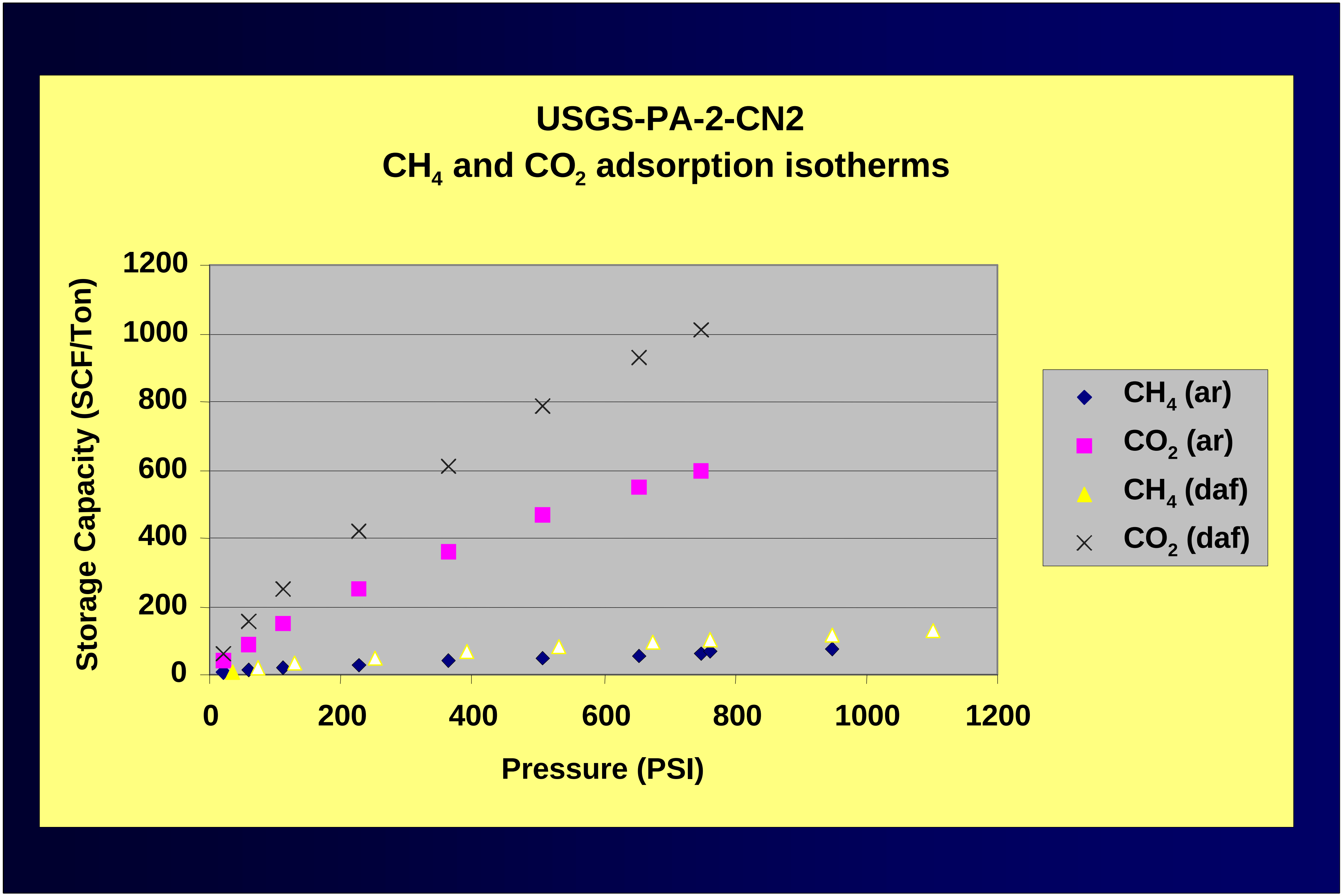

Figure 31. Comparison of methane and CO_2 adsorption isotherms on as-received (ar) and dry, ash-free (daf) basis for sample CN2. CO_2 adsorption characteristics are important for determining the CO_2 storage capacity for the coal.

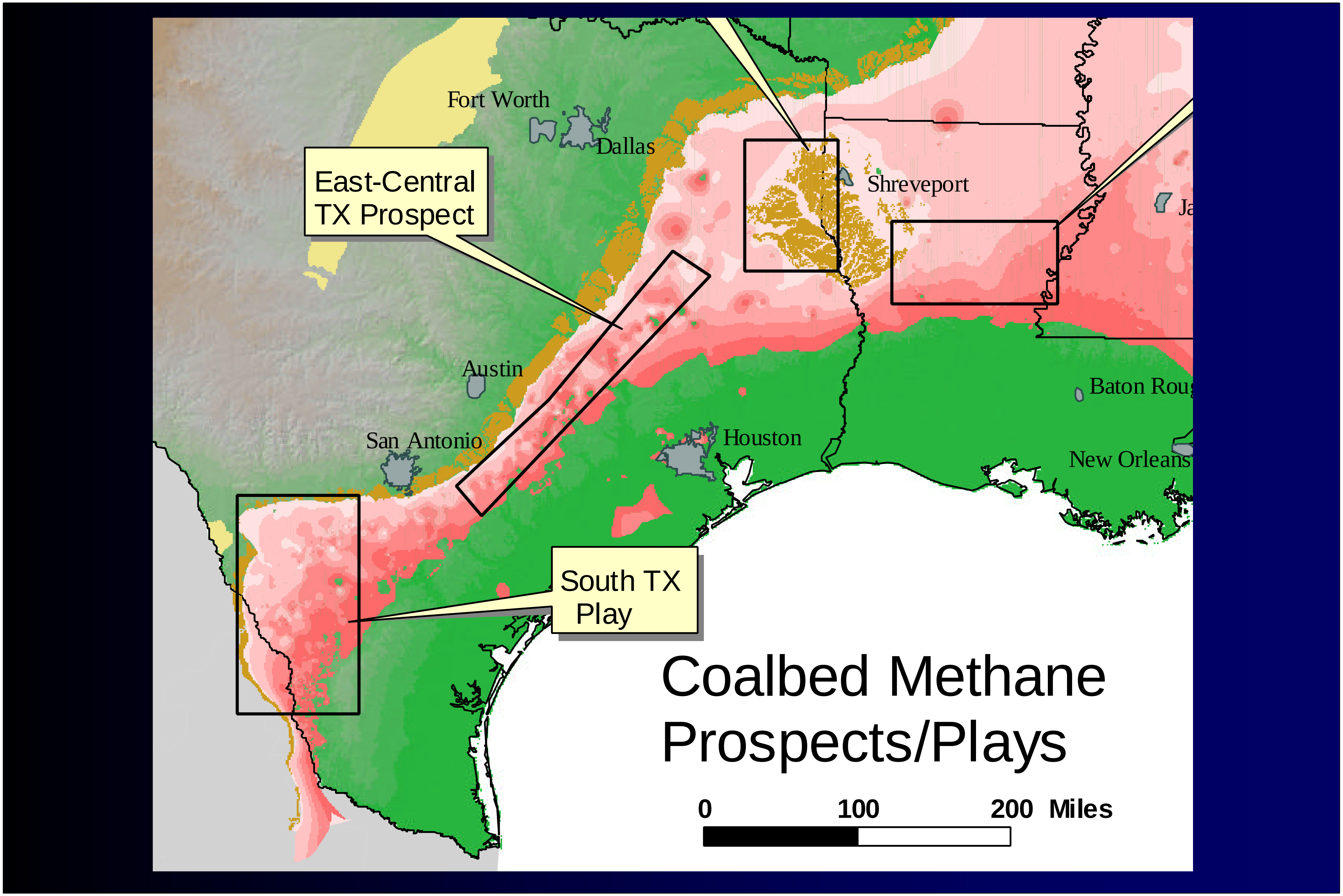

Figure 32. Location of Central and South Texas coalbed methane prospects and plays. Preliminary data from Griffiths and Pilcher (2000) indicate that coalbed gas contents in the East-central Texas prospect area ranges from 100 to 470 SCF/ton, coal rank is subbituminous to high-volatile A bituminous, cumulative coal thickness is 10 to 110 ft, and depths to coal range from 2500 to 6000 ft. The following figures focus on the south Texas area.

Geology & Rank map of South Texas

(SanFilipo, 1999)

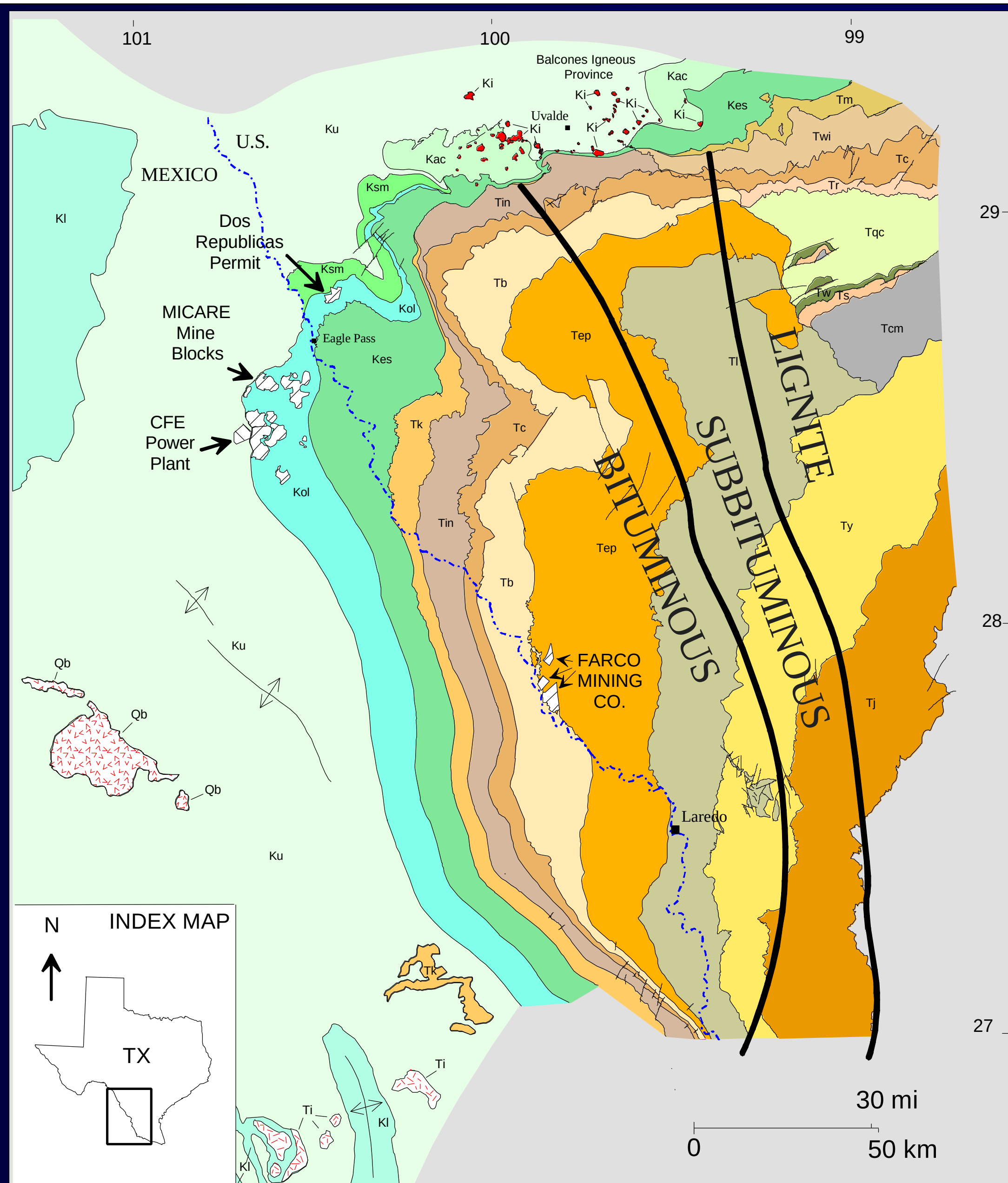

Figure 33. Geologic map of lower Tertiary and Upper Cretaceous rocks in South Texas showing generalized rank boundaries. For explanation of map units see SanFilipo (1999). This area is currently undergoing exploration for coalbed gas. Note the steep increase in rank toward the southwest.

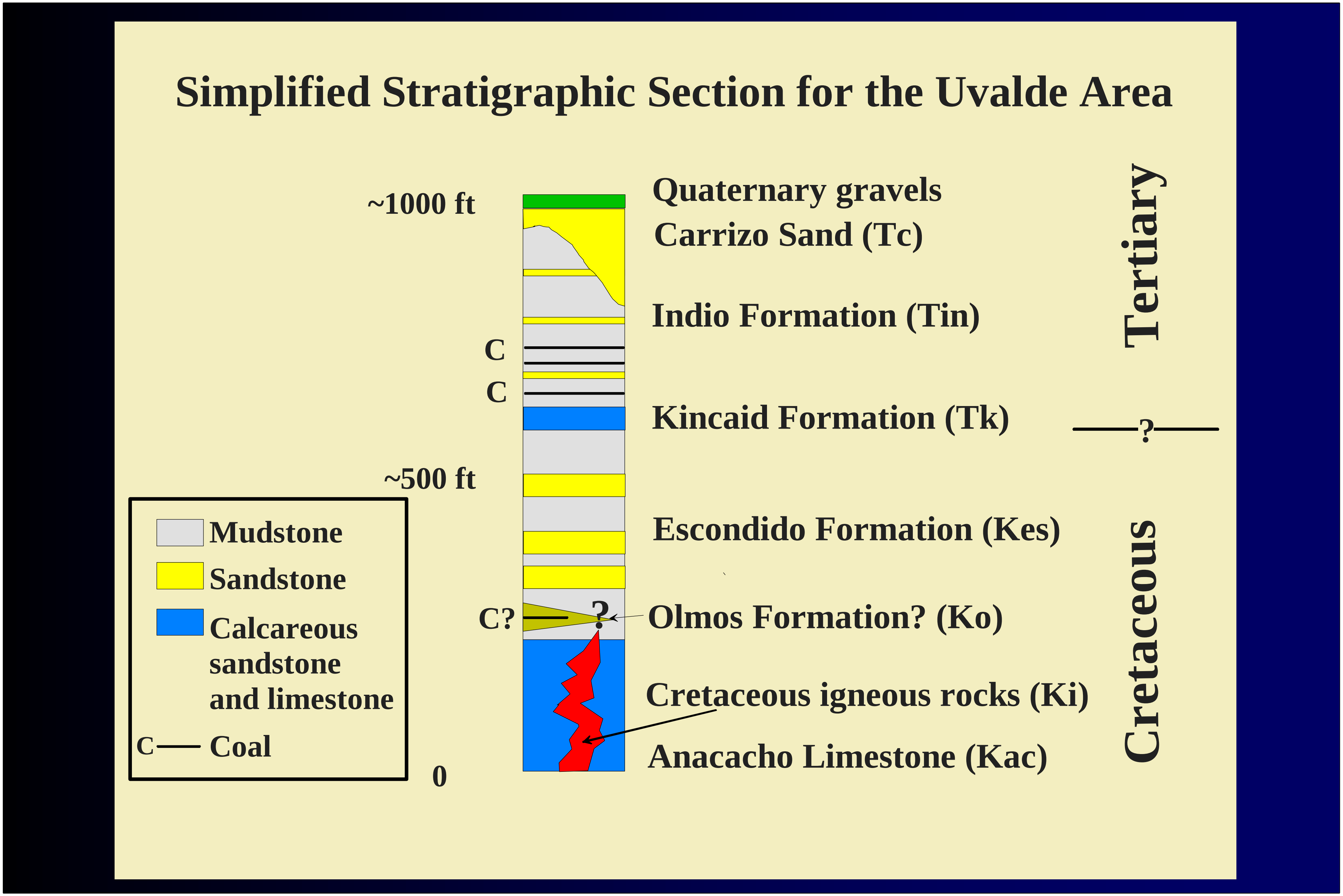

Figure 34. Simplified stratigraphic section for the Uvalde area (northern part of the map on figure 33) (stratigraphy after Barnes, 1974; and Breyer, 1997). Current coalbed methane exploration in South Texas is focused on Indio and Olmos Formation coals.

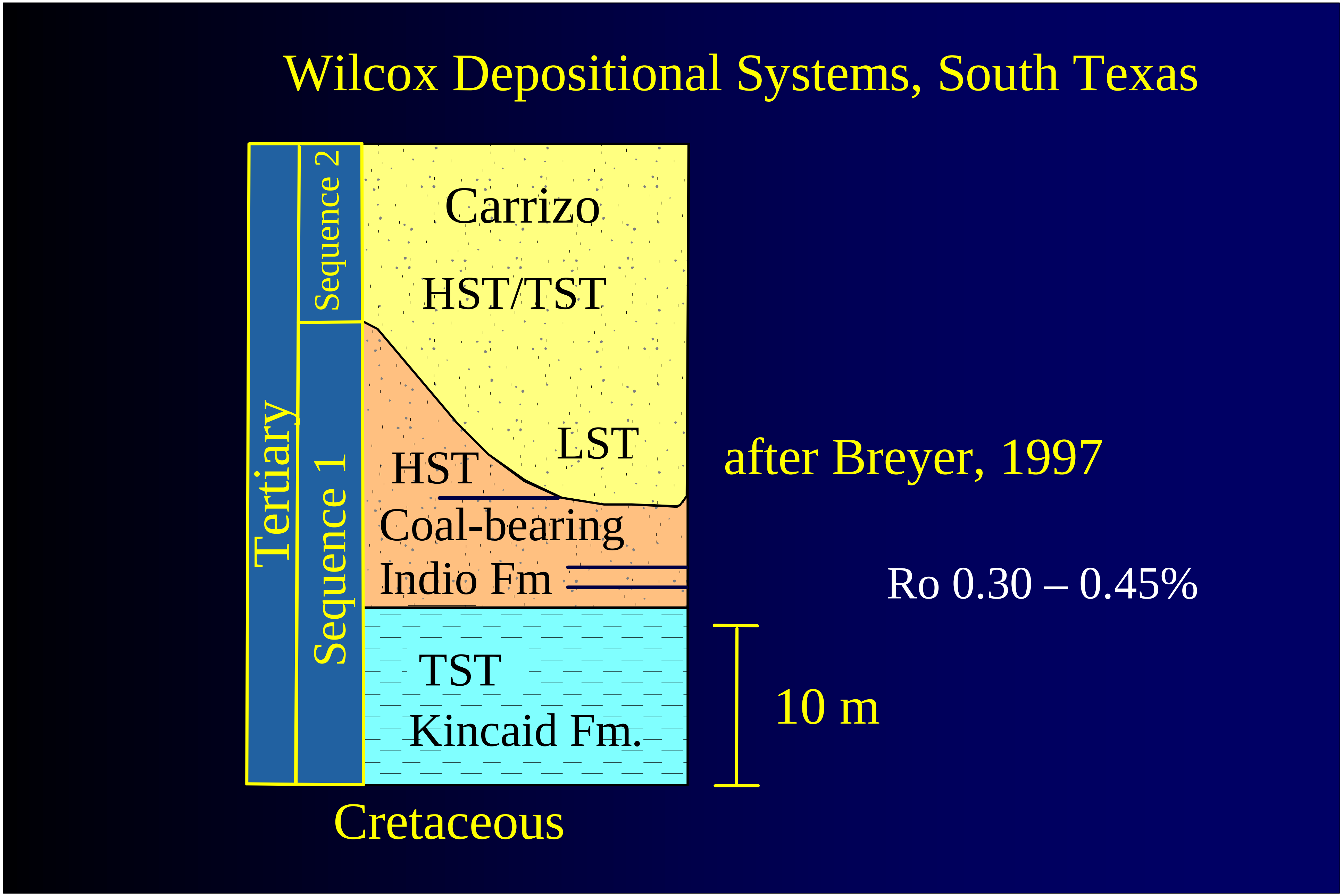

Figure 35. Stratigraphic section in the Uvalde area showing sequence stratigraphic systems tracts for the lower Tertiary units (Breyer, 1997). Breyer and McCabe (1986) reported that reflectance for the Wilcox coals in south Texas ranges from 0.30 to 0.45% Ro.

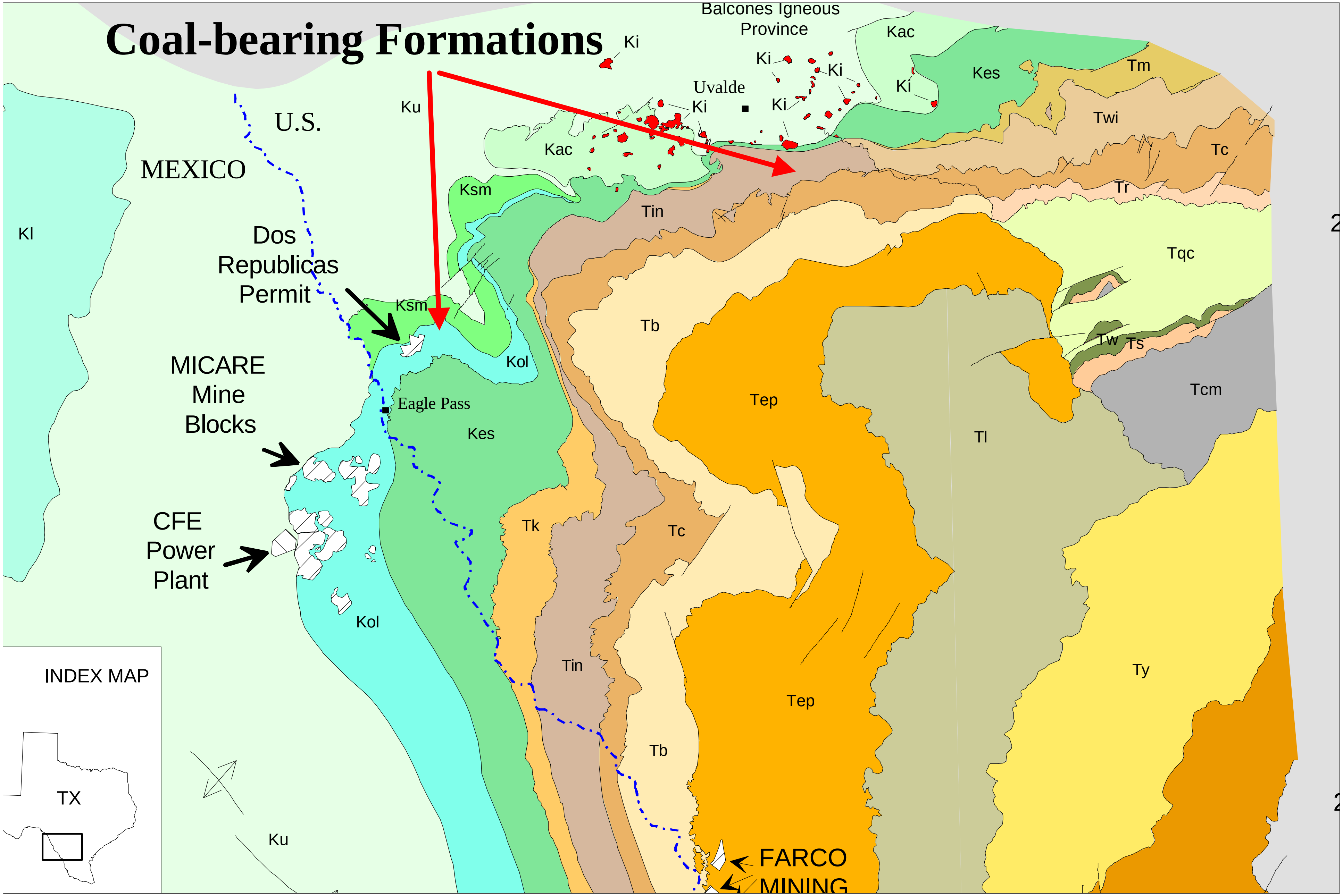

Figure 36. Expanded view of South Texas geology (SanFilipo, 1999) with coal-bearing formations indicated. Tin = Indio Formation and Kol = Olmos Formation.

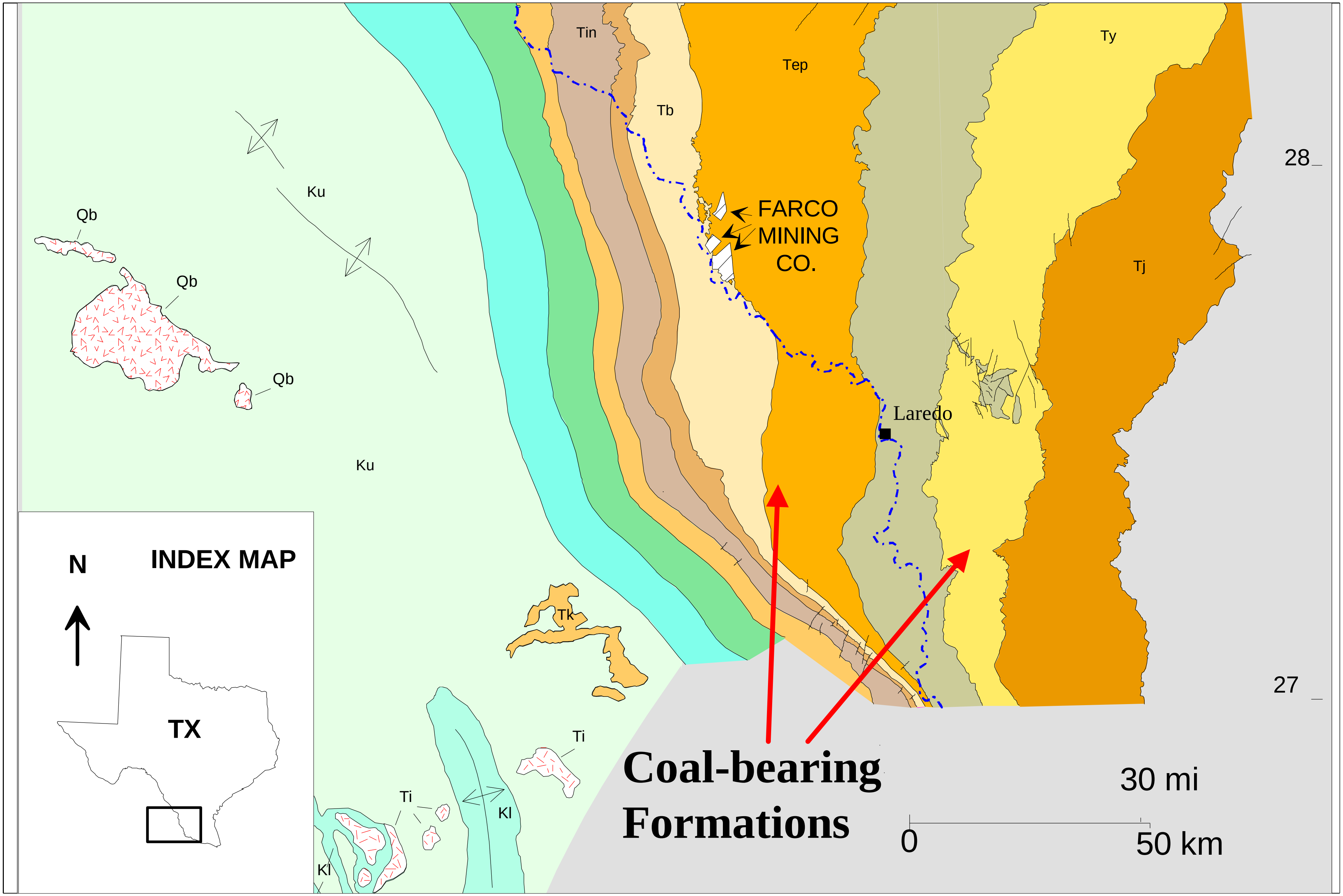

Figure 37. Expanded view of South Texas geology (SanFilipo, 1999) with coal-bearing formations marked. North of Laredo are the Claiborne coals (El Pico – Tep, and the Bigford – Tb Formations) described by Warwick and Hook (1995), and coals are reported to occur in the Jackson Group, Yegua Formation (Ty) south of Laredo. These areas are within the bituminous rank area defined by SanFilipo (1999).

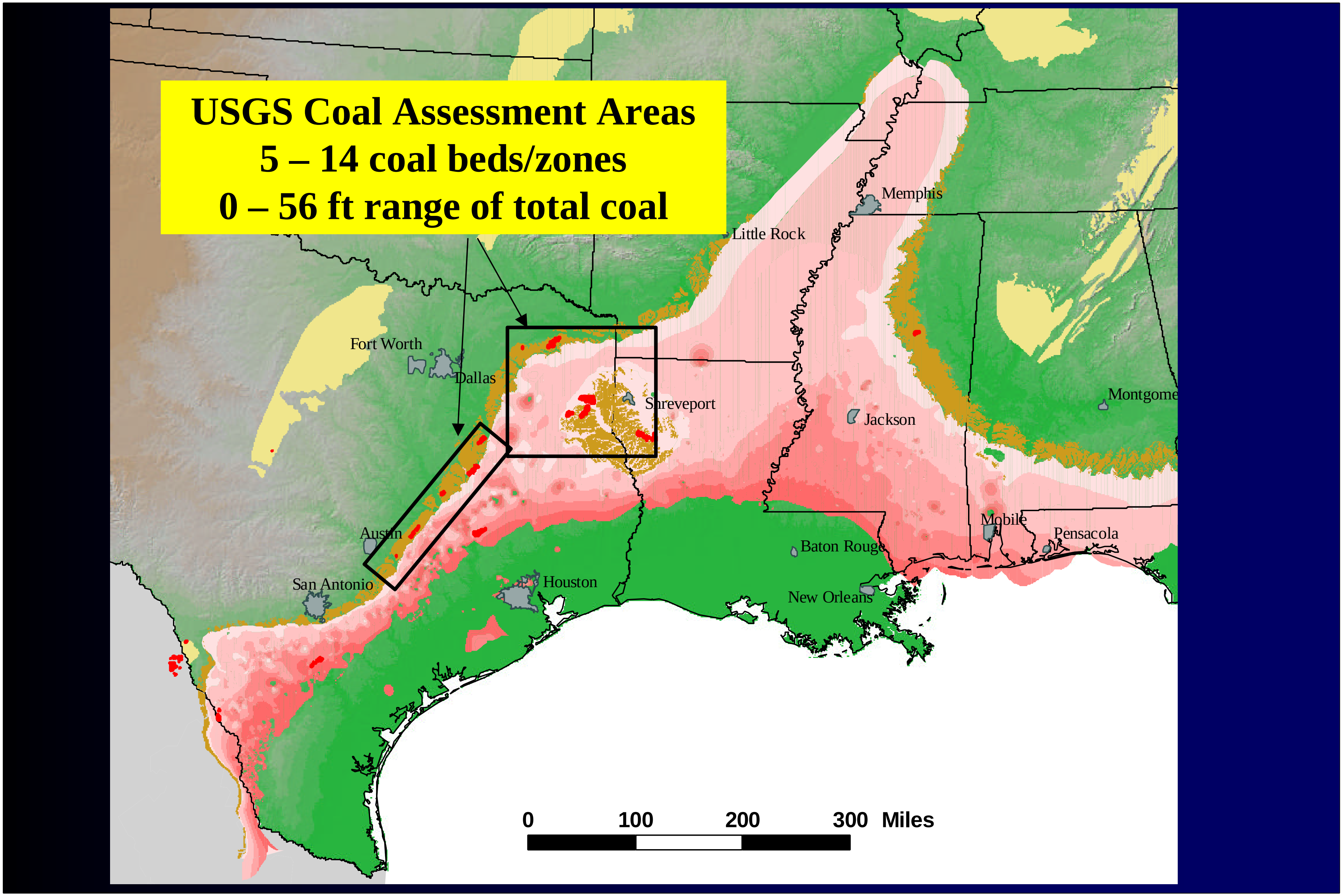

Figure 38. The U.S. Geological Survey is working on coal resource estimates for near-surface (<300 ft) Wilcox coal-bearing areas along the outcrop belt in northeast Texas and northwestern Louisiana. Using the coal assessment data, one could propose that there might be as much as 400 billion tons of coal in the Gulf Coast basin at depths less than 6,000 ft. For explanation of base map see figure 11.

Preliminary Calculation of Coalbed Gas In Place for Gulf Coastal Plain

Assumption: ~ 400 billion short tons of coal in basin (<6,000 ft)

Assumption: average coalbed gas content ranges from 10 to 20 SCF/ton

Total in-situ Coalbed gas for Gulf Coastal Plain = 4 to 8 TCF (gas in place)

Recoverable ???

Note: Potential Gas Committee (1993) reported 3.4 TCF for GCP
(Includes possible, probable and speculative potentially producible supply)

Figure 39. Preliminary calculation of in-place coalbed gas resources for the Gulf Coastal Plain (GCP). If one assumes that there are 400 billion short tons of coal at depths less that 6,000 ft and that coalbed gas content ranges from 10 to 20 SCF/ton, then the total gas in place would range from 4 to 8 TCF. The amount of gas that is economically producible is unknown. This gas in place calculation is a minimum. As new coalbed methane data become available, the estimated total gas in place for the Gulf Coastal Plain will undoubtedly increase. If the gas content data presented by Griffiths and Pilcher (2000) are representative for deep-basin coals, the total gas in place calculations given above could increase by an order of magnitude. Note that the Potential Gas Committee (1993) estimated a total producible coalbed gas resource for the Gulf Coastal Plain at 3.4 TCF.

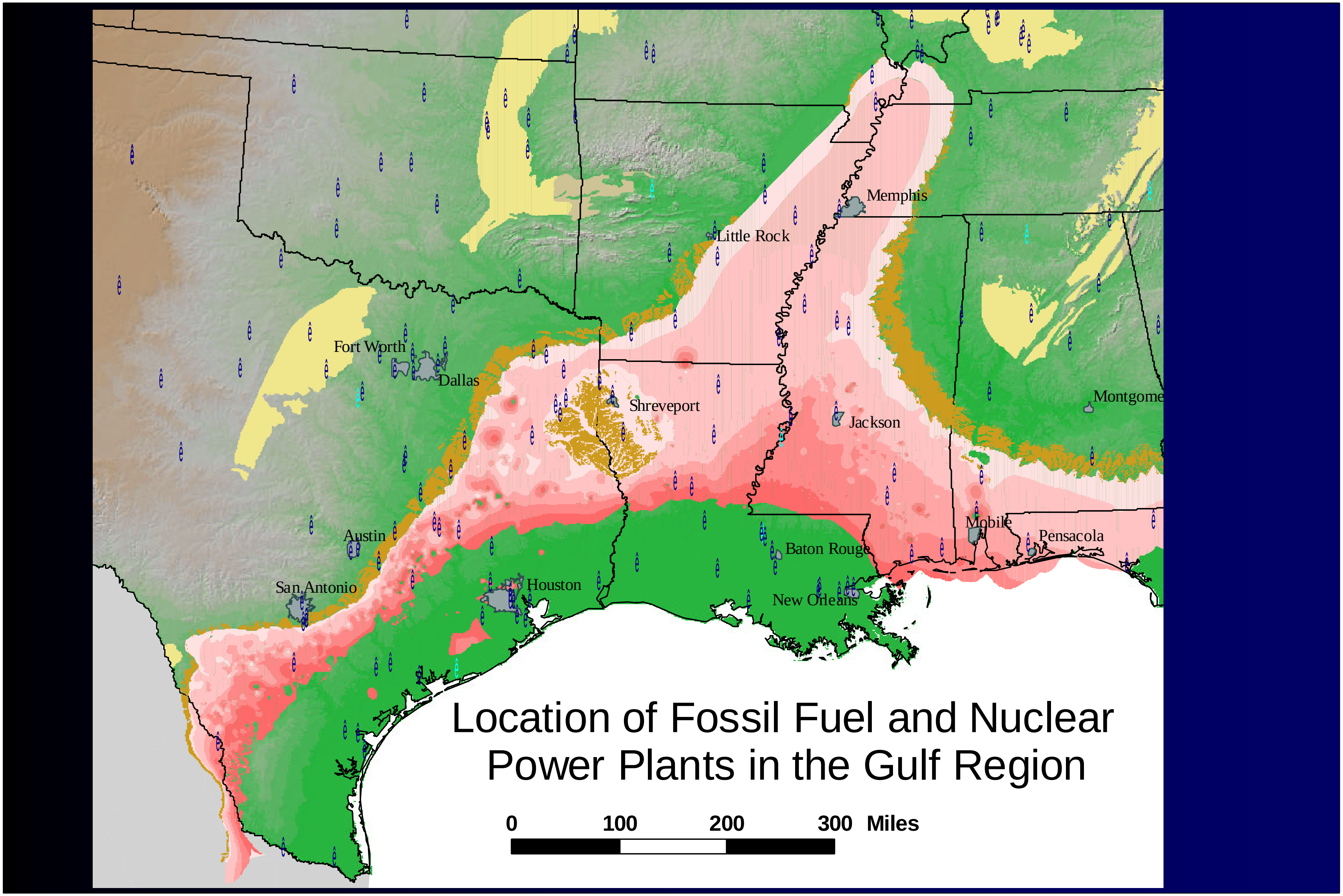

Figure 40. Location of fossil-fuel (dark blue) and nuclear (light blue) electric power plants in the Gulf Coastal Plain. The fossil-fuel power plants are producers of CO_2 and are sources for CO_2 that could be sequestered in deep coalbeds. Injection of CO_2 could enhance coalbed methane production. For explanation of base map see figure 11.

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Conclusions

- In the northern part of the basin, average Wilcox/Midway average coal gas content ranges from 11 to 19 SCF/ton, South Texas coalbed gas content is unknown, but apparently greater than other parts of the basin
- Isotopic signatures indicate the gas was generated in the transition zone between biogenic and thermogenic realms consistent with the approximate subbituminous rank of the coal
- Detailed coring and desorption/adsorption studies are needed to characterize the CBM production and CO_2 storage potential for the Gulf Coastal Plain Province
- An initial calculation of the total in-situ coalbed gas for the Gulf Coastal Plain ranges from 4 to 8 TCF (gas in place)
- Our data suggest that deeper Gulf Coastal Plain Wilcox and Upper Cretaceous coal beds warrant testing for commercial CBM accumulations

http://energy.er.usgs.gov

Figure 41. Conclusions.

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Figure 43. References continued.