Pashin, J.C., 2004, Geologic heterogeneity and coalbed methane production - experience from the Black Warrior Basin, *in* Warwick, P.D., ed., Selected presentations on coal-bed gas in the eastern United States, U.S. Geological Survey Open-File Report 2004-1273, p. 61-92.

Geologic Heterogeneity and Coalbed Methane Production – Experience from the Black Warrior Basin[1]

By Jack C. Pashin[2]

Opening Points

- Numerous geologic factors, including stratigraphy, structure, coal quality, and hydrology influence coalbed methane production in the Black Warrior basin of Alabama.
- Producing coalbed methane requires a different paradigm that is used for conventional reservoirs.
- The Black Warrior basin is an operationally mature basin in which extreme geologic heterogeneity influences gas and water production from coal.

[1] Modified from unpublished short course notes from Short Course #4, Coalbed methane potential in the U.S. and Mexican Gulf Coast, Gulf Coast Association of Geological Societies/Gulf Coast Section SEPM – 52nd Annual Convention, Austin, TX, October 30, 2002.
[2] Geological Survey of Alabama, Tuscaloosa, AL

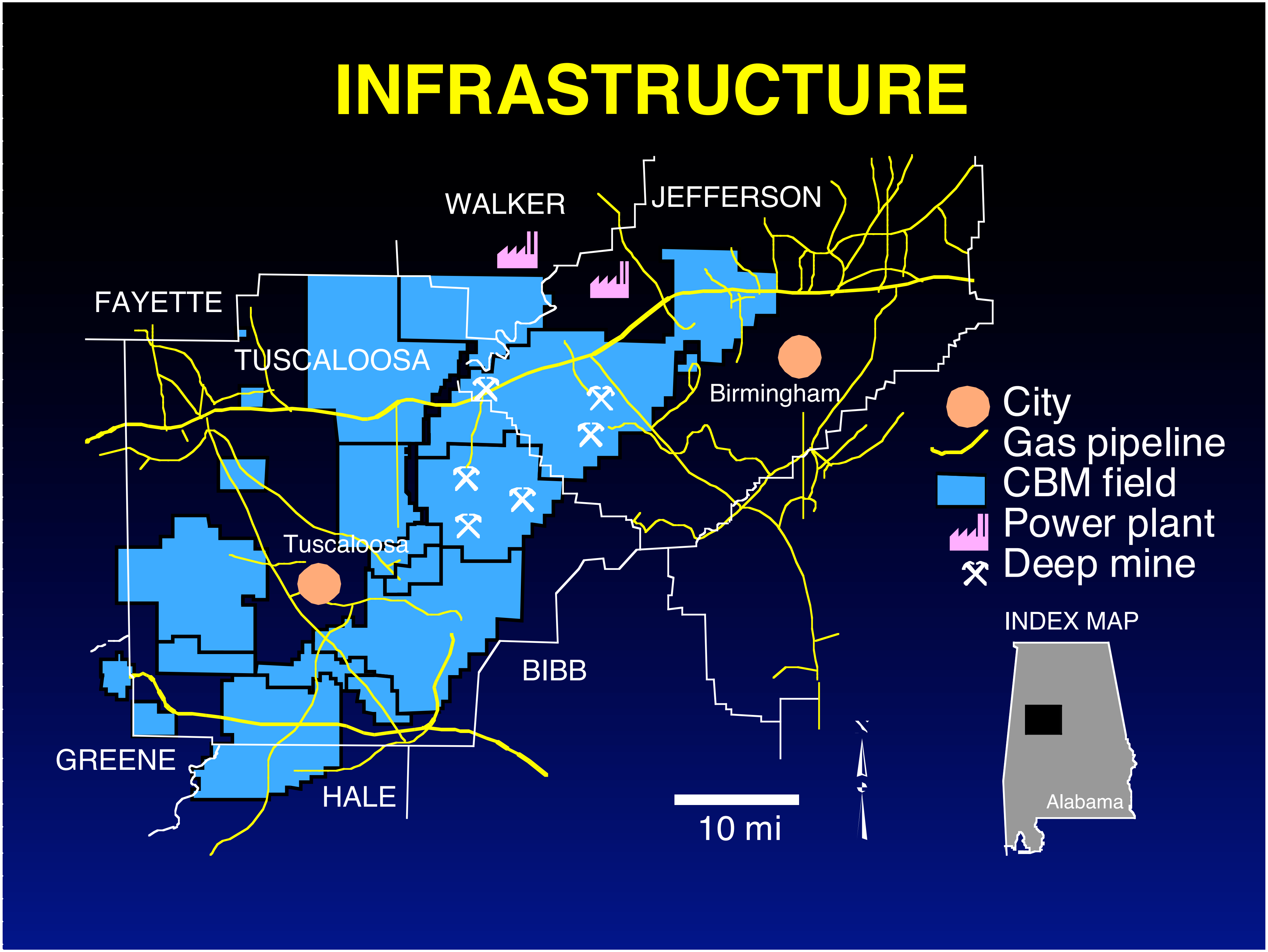


Figure 1. Infrastructure associated with coalbed methane fields in the Black Warrior basin of west-central Alabama.

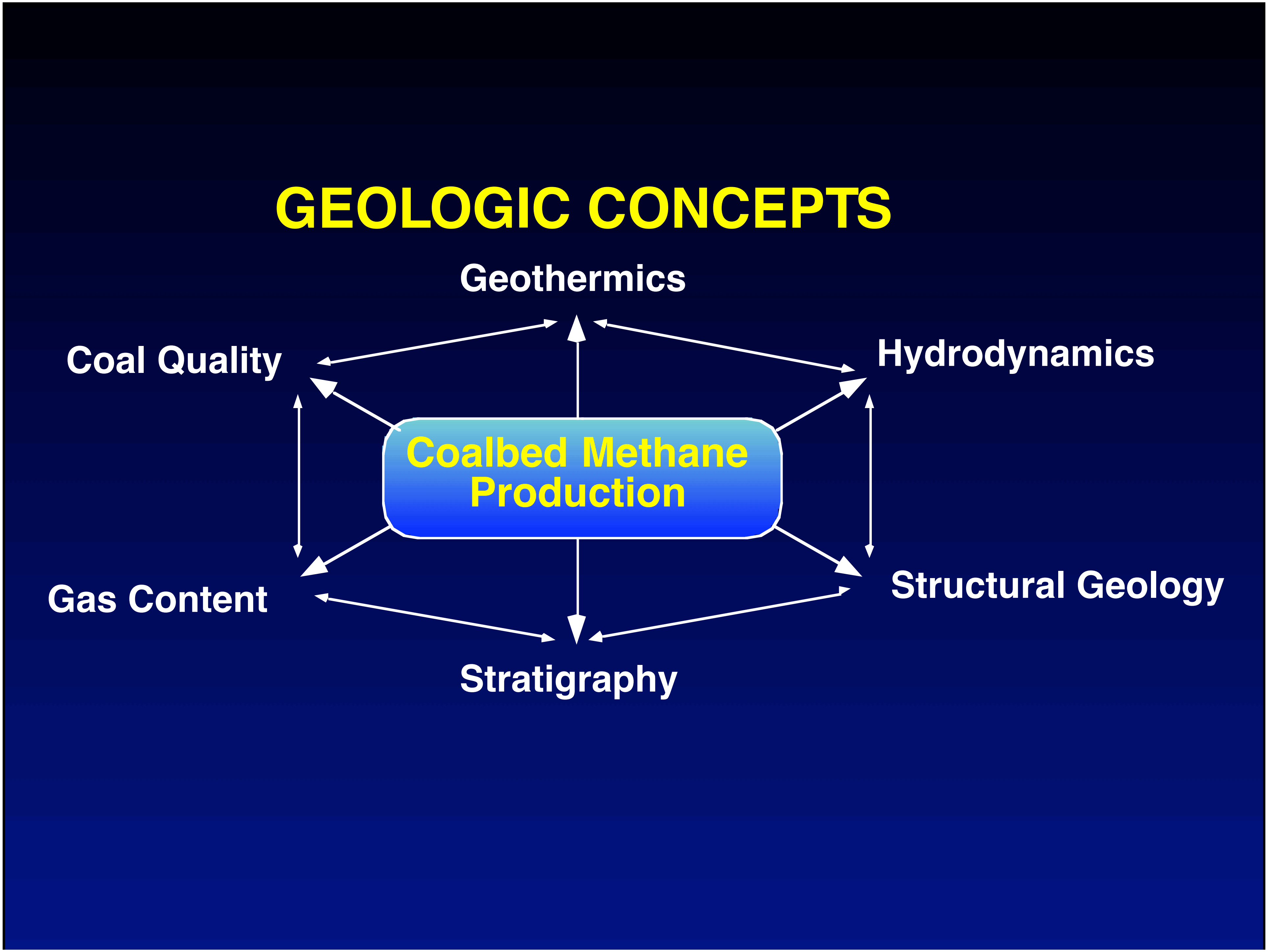


Figure 2. Major geologic concepts associated with coalbed methane production.

BLUE CREEK COAL BED

Medium volatile bituminous

Figure 3. The Blue Creek coal bed is the principal mining target in the Black Warrior basin and was the original focus of coalbed methane operations.

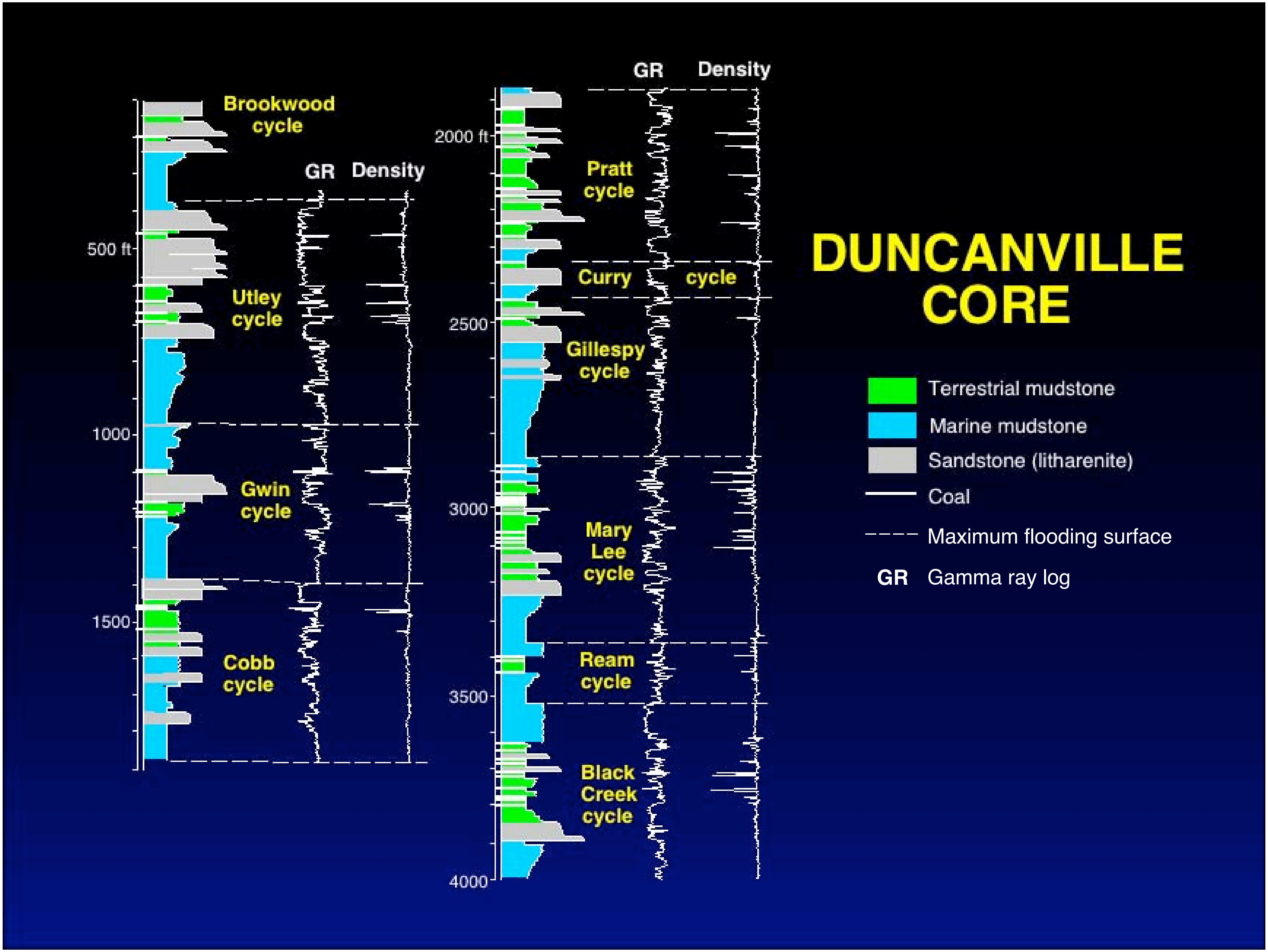


Figure 4. Graphic log of the Duncanville core showing upper Pottsville coal zones from which coalbed gas is produced.

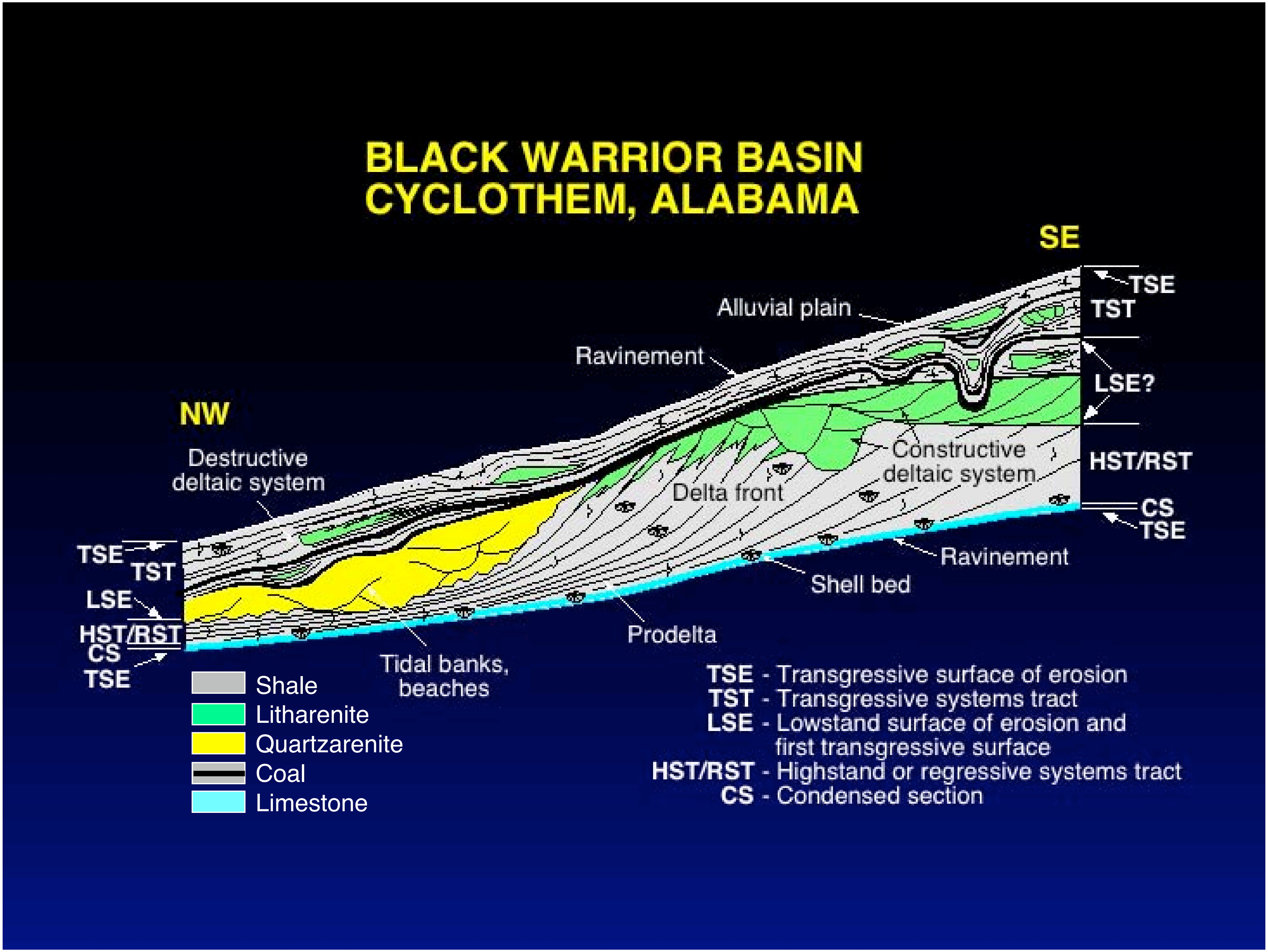


Figure 5. Stratigraphic model of an idealized Pottsville depositional cycle in the Black Warrior basin.

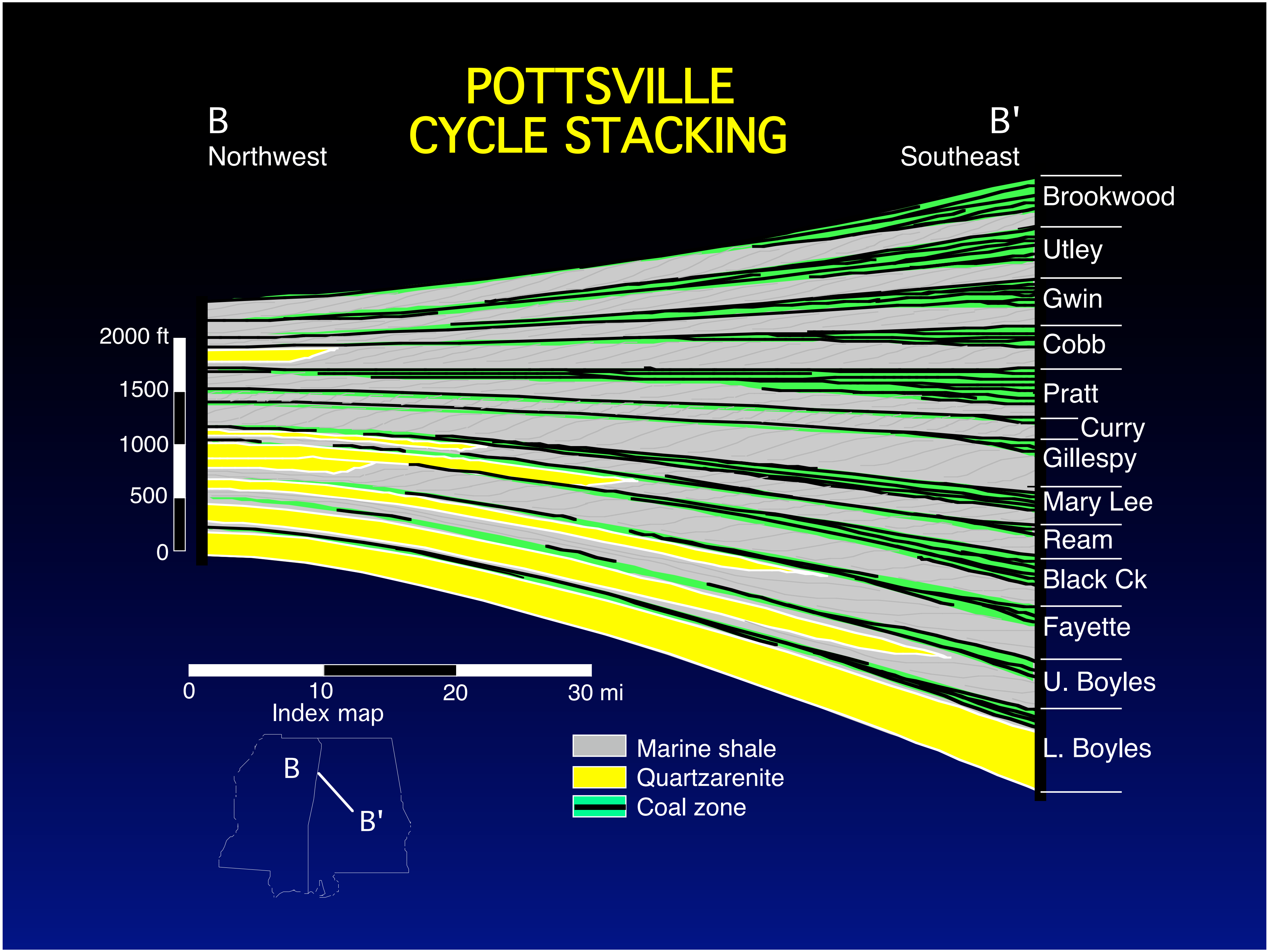


Figure 6. Cycle stacking patterns in the Pottsville Formation of the Black Warrior basin in Alabama.

FAULTING AND FRACTURING

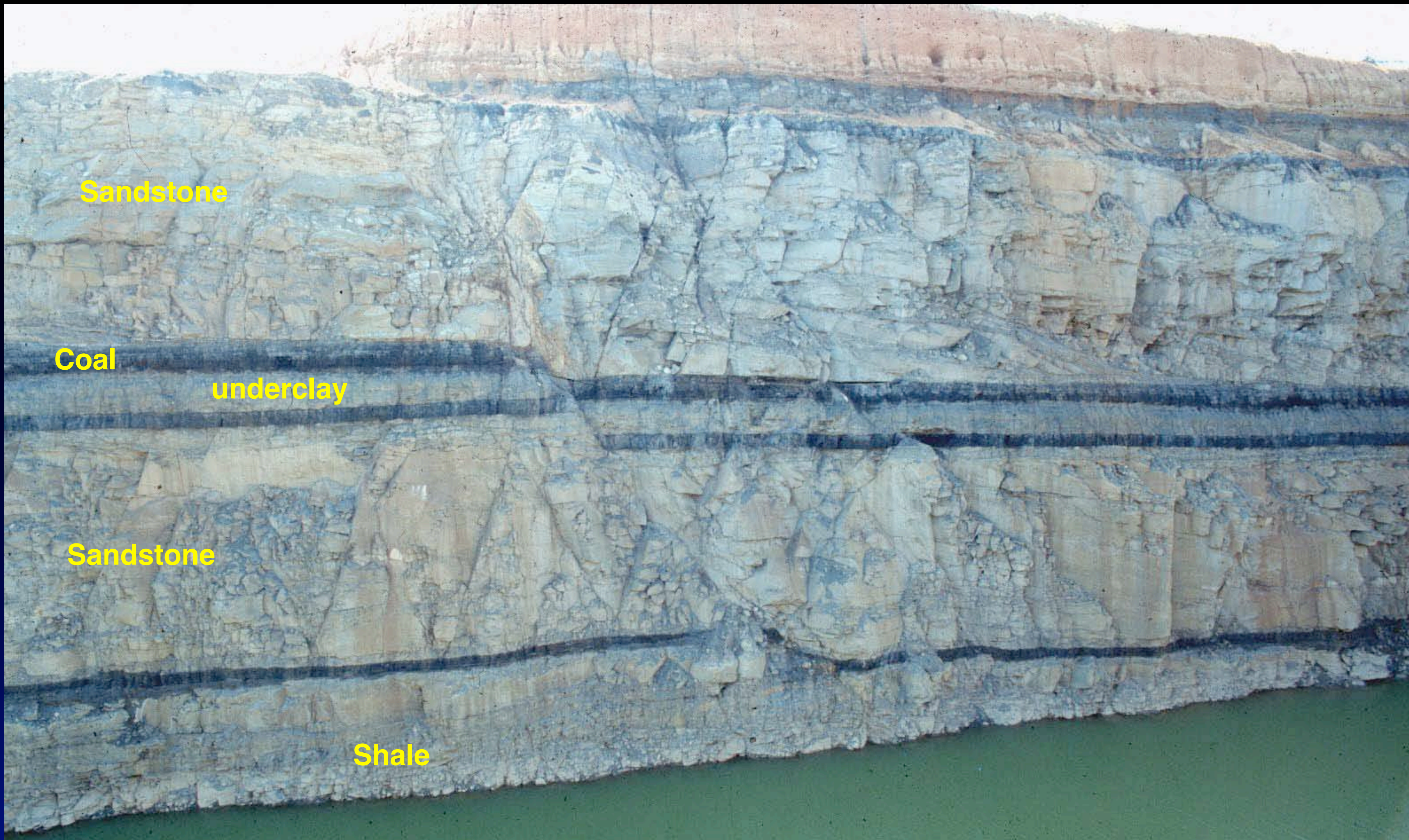


Figure 7. Flow of water in Pottsville coalbed methane reservoirs is exclusively through natural fractures, including cleats, joints, and shear fractures.

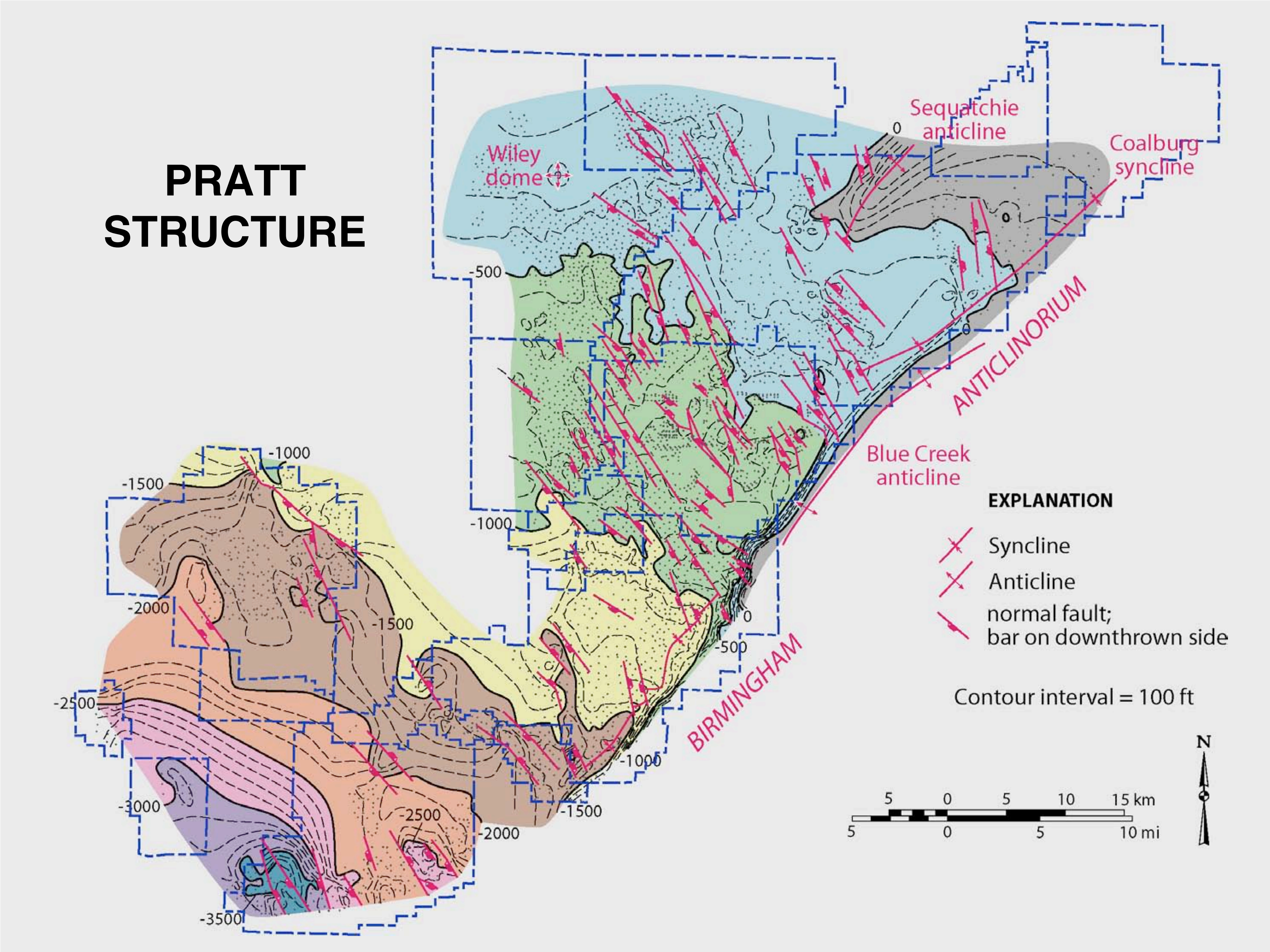


Figure 8. Structural contour map of the top of the Pratt coal zone in the Black Warrior coalbed methane fields. See Figure 3 for index map. Contours relative to mean sea level.

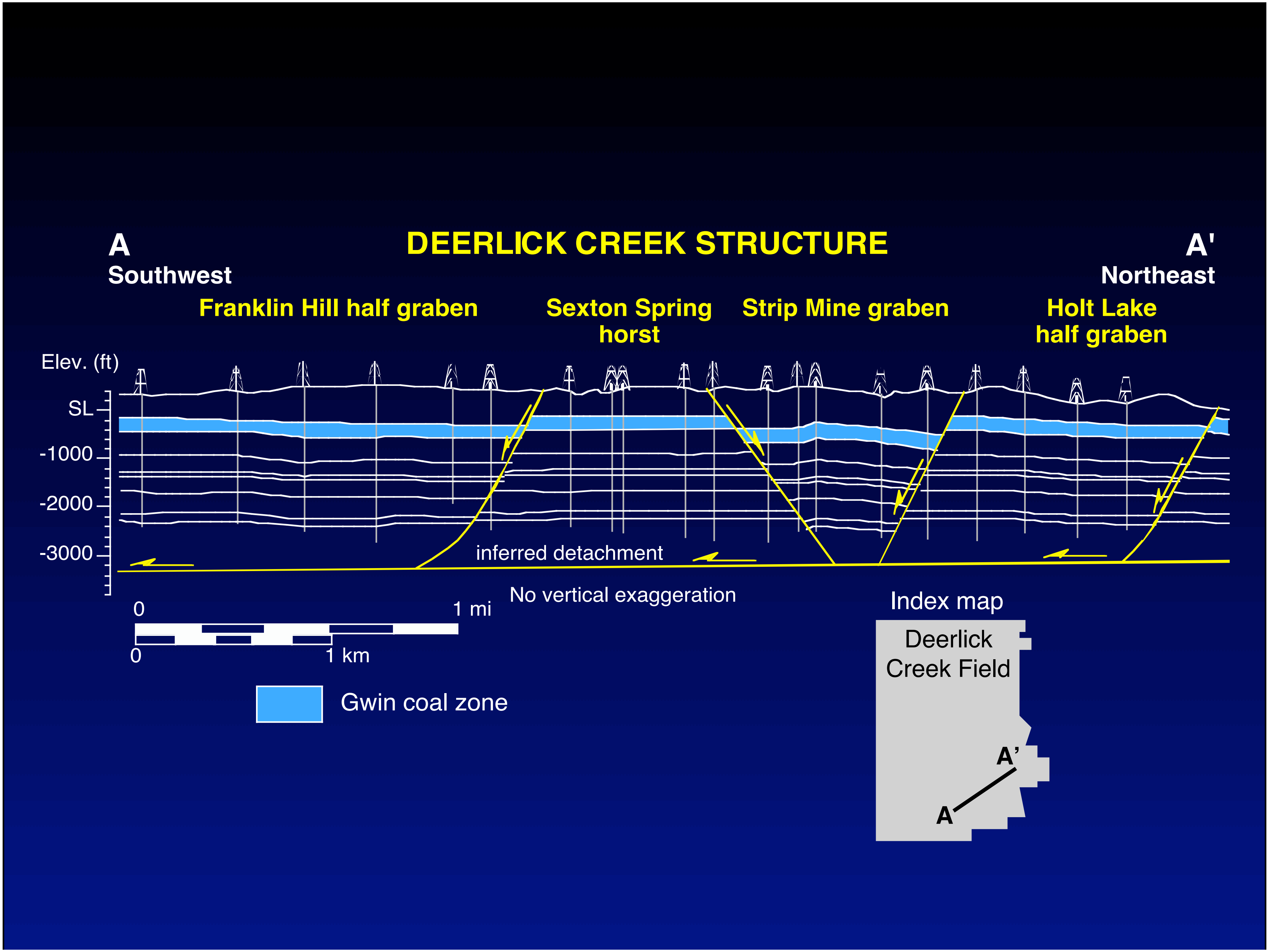


Figure 9. Structural cross section of thin-skinned horst-and-graben system in Deerlick Creek Field.

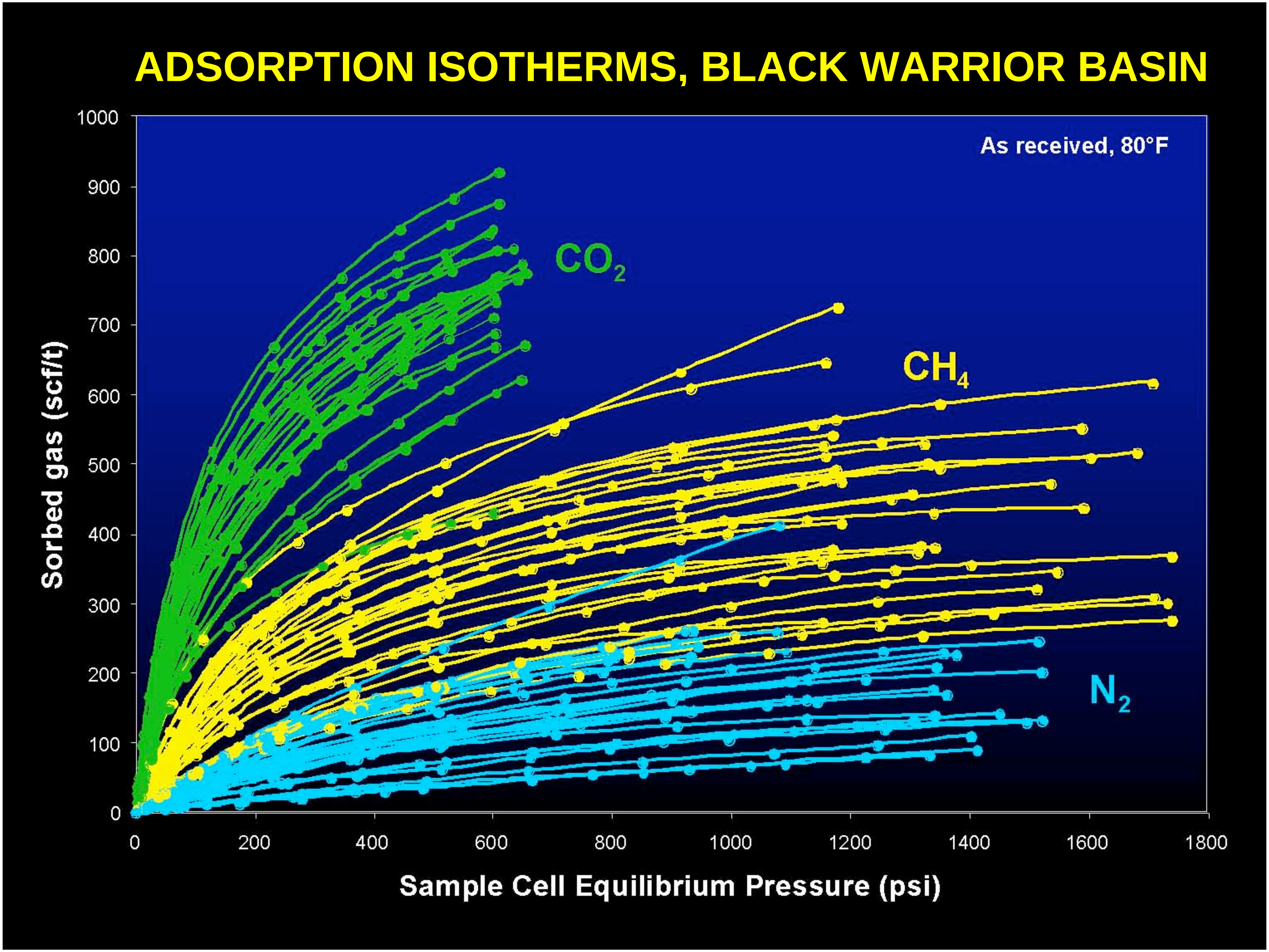


Figure 10. Isotherms showing variable sorption performance of Pottsville coal for three gases. Isotherms run by University of British Columbia.

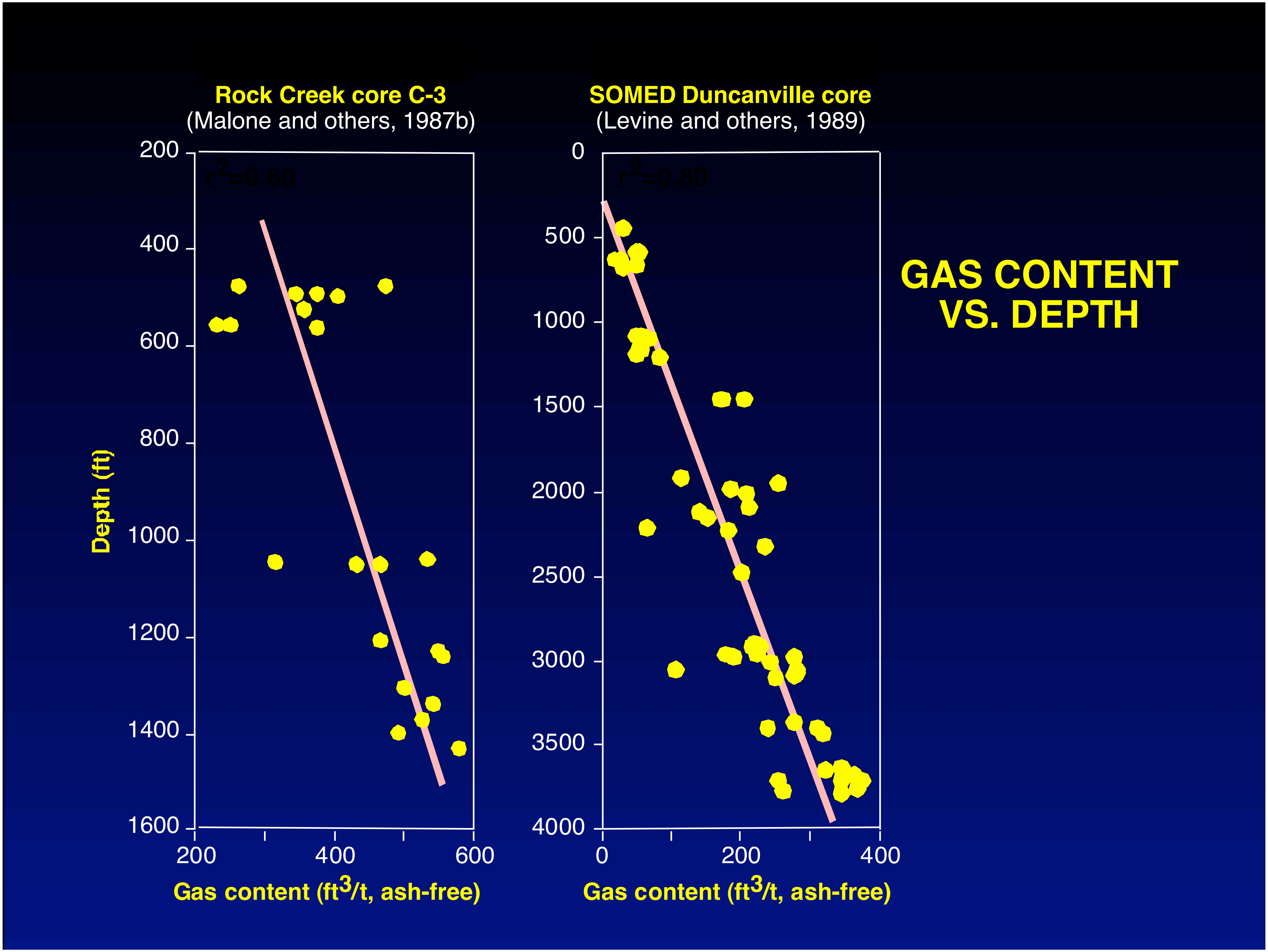
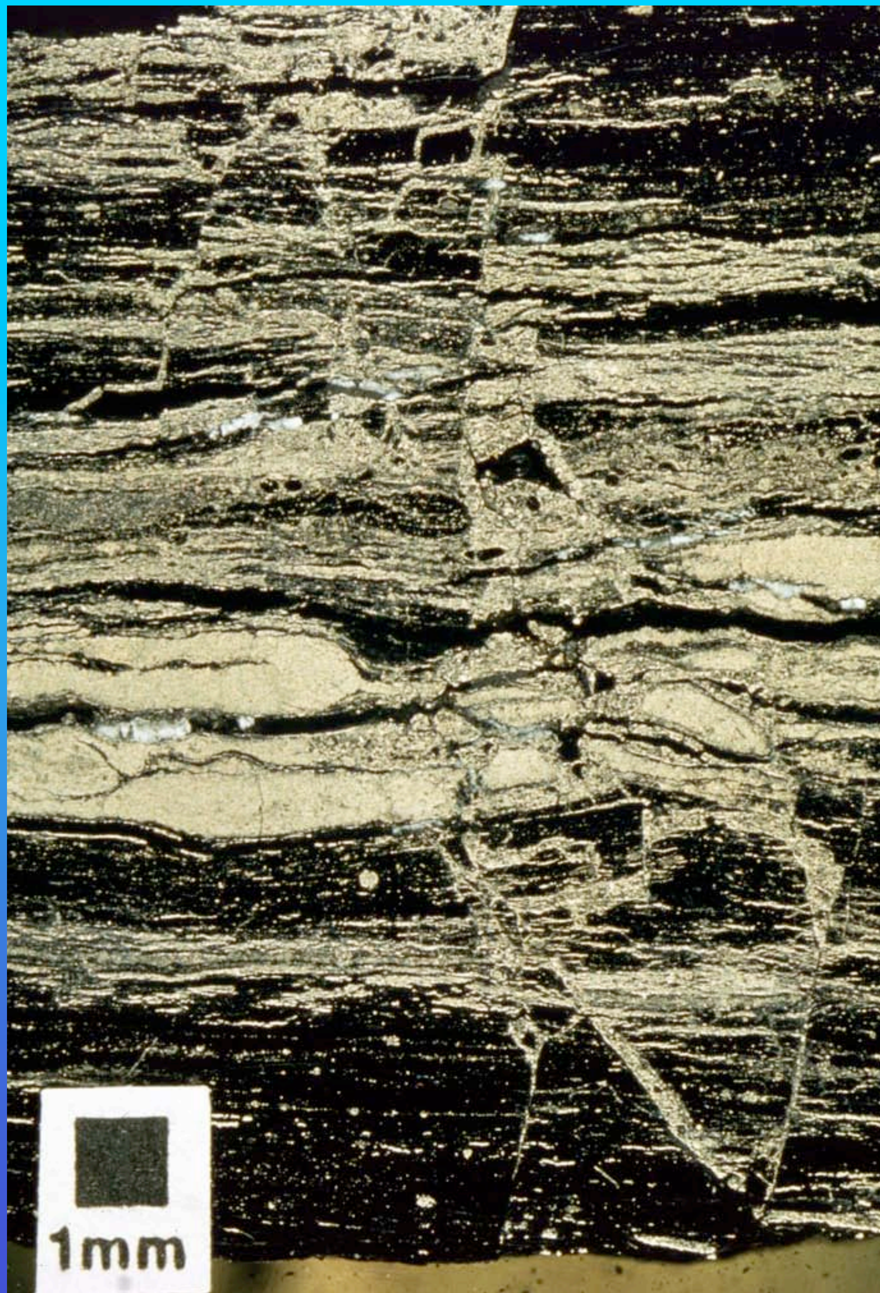


Figure 11. Plots of gas content versus depth showing heterogeneous distribution of coalbed gas in the Black Warrior basin.



COAL QUALITY

This may not be the world's best coalbed gas reservoir

Figure 12. Intensely pyritized coal with mineralized fractures suggests that coal quality affects reservoir properties.

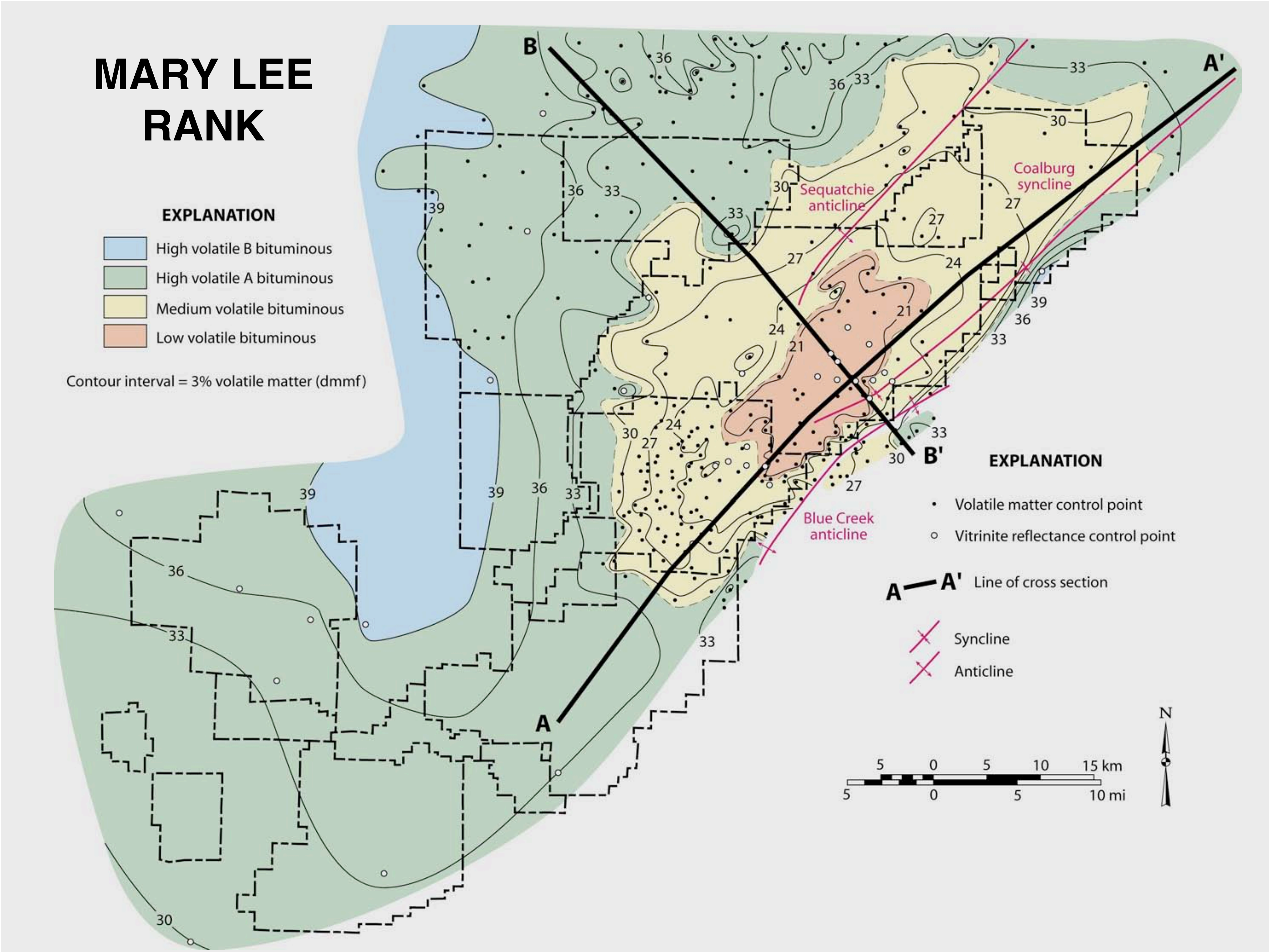


Figure 13. Map of coal rank in the Black Warrior coalbed methane fields.

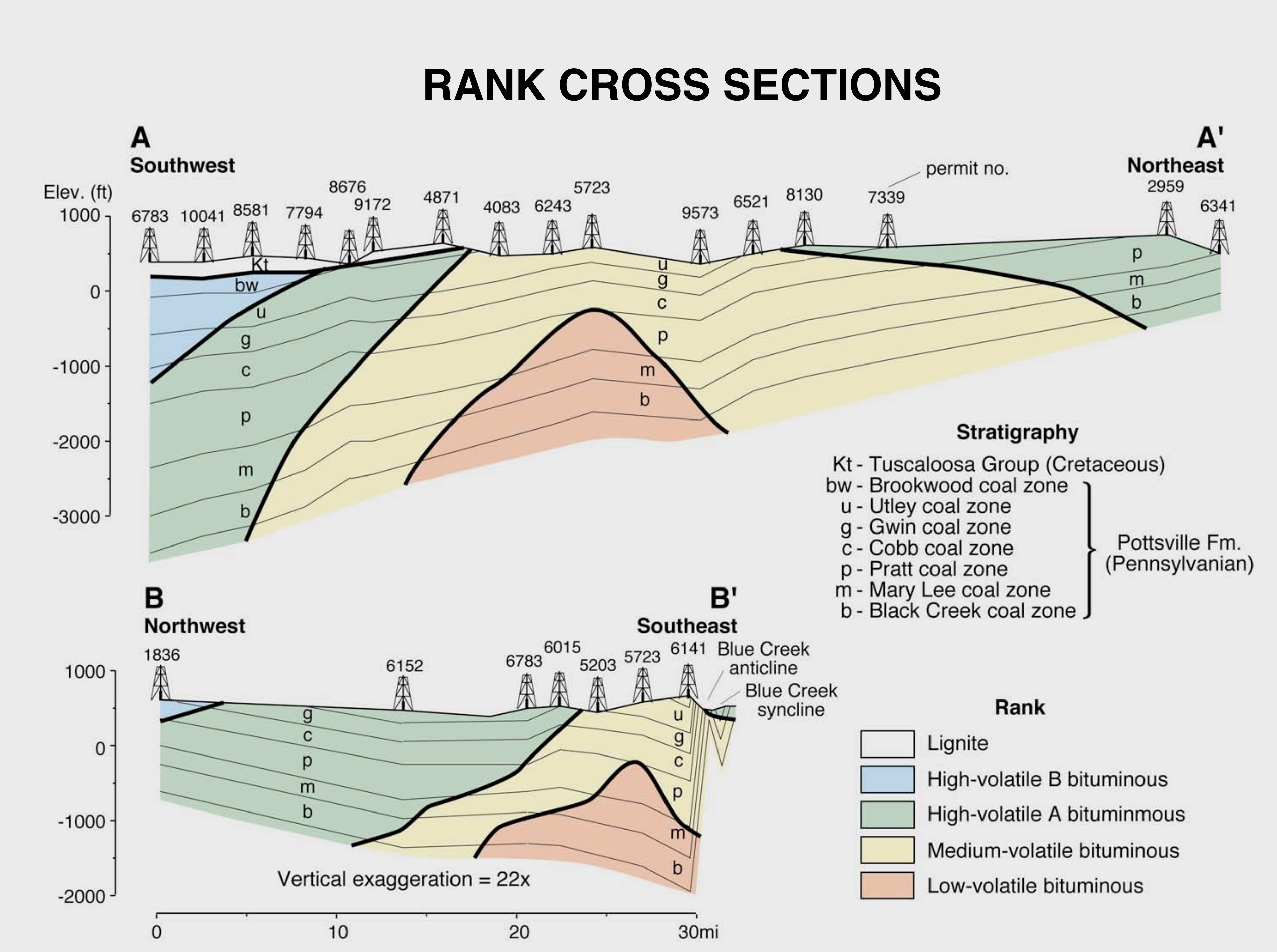


Figure 14. Cross sections showing coal rank in the Black Warrior basin. See Figure 15 for location.

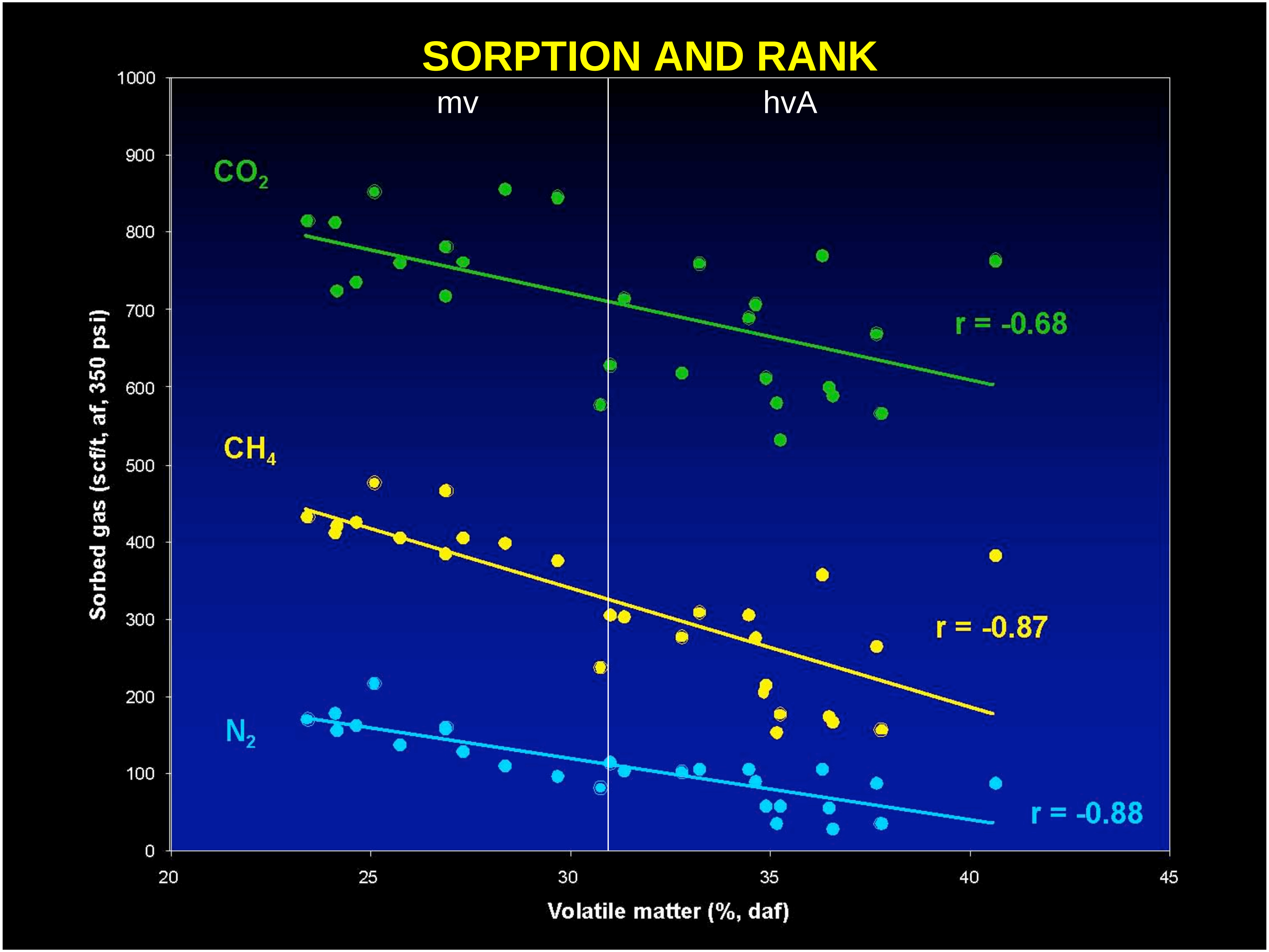


Figure 15. Relationship between coal rank and sorption capacity in the Black Warrior basin.

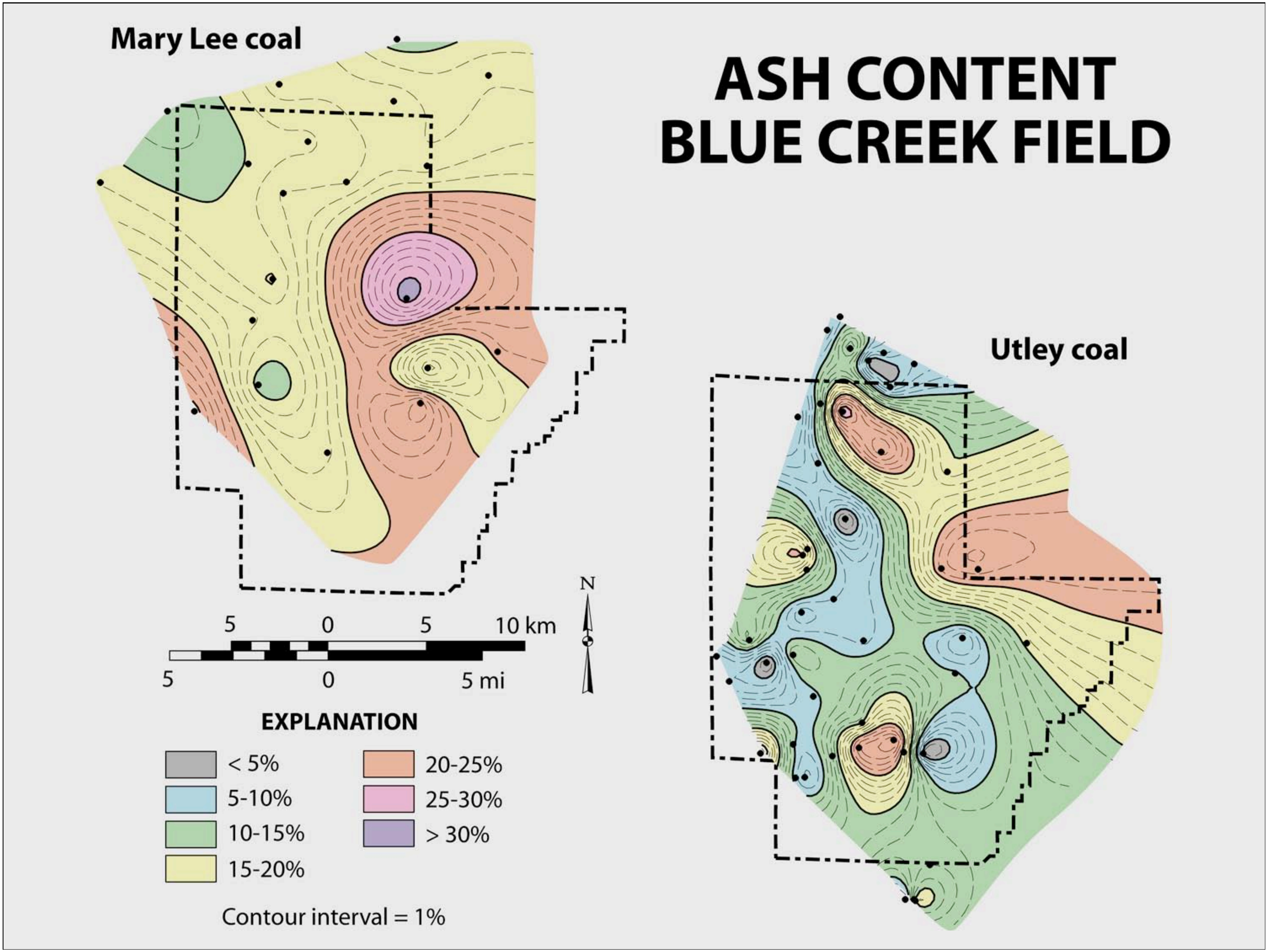


Figure 16. Maps of ash content contrasting the Mary Lee and Utley coal beds in Blue Creek Field.

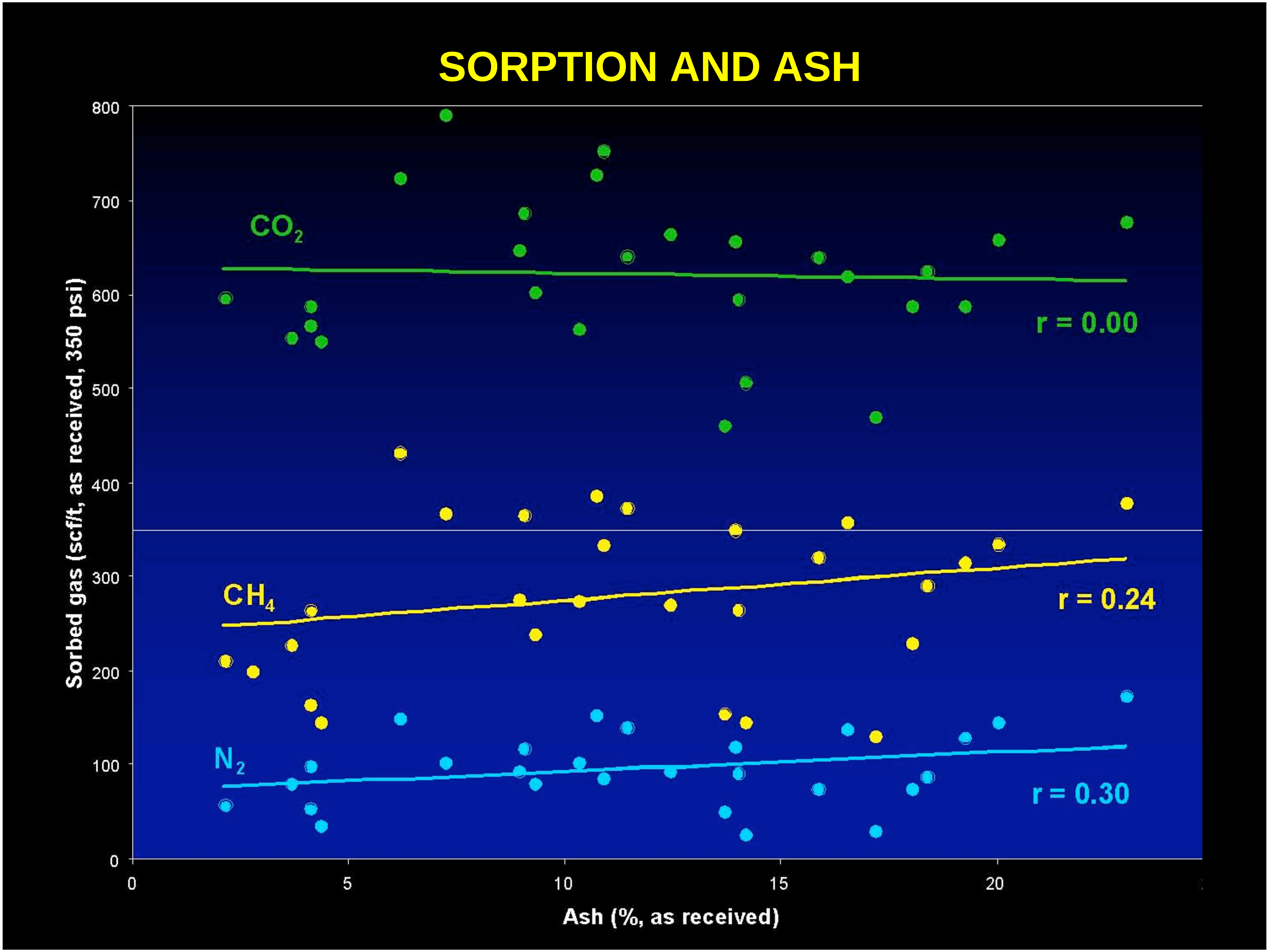


Figure 17. Relationship between sorption capacity and ash content and sorption capacity of coal in the Black Warrior basin.

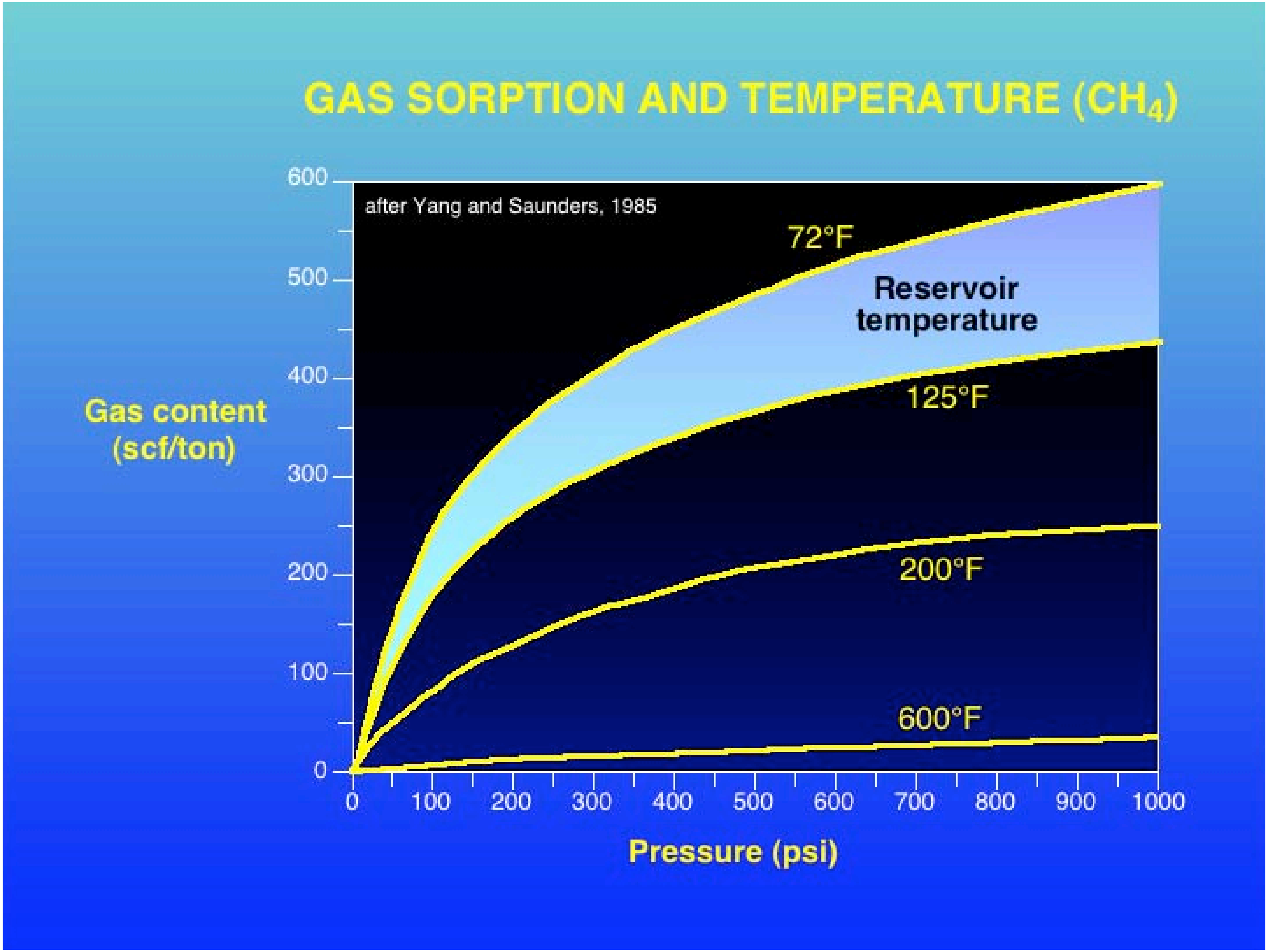


Figure 18. Relationship of methane sorption to temperature in a San Juan basin coal.

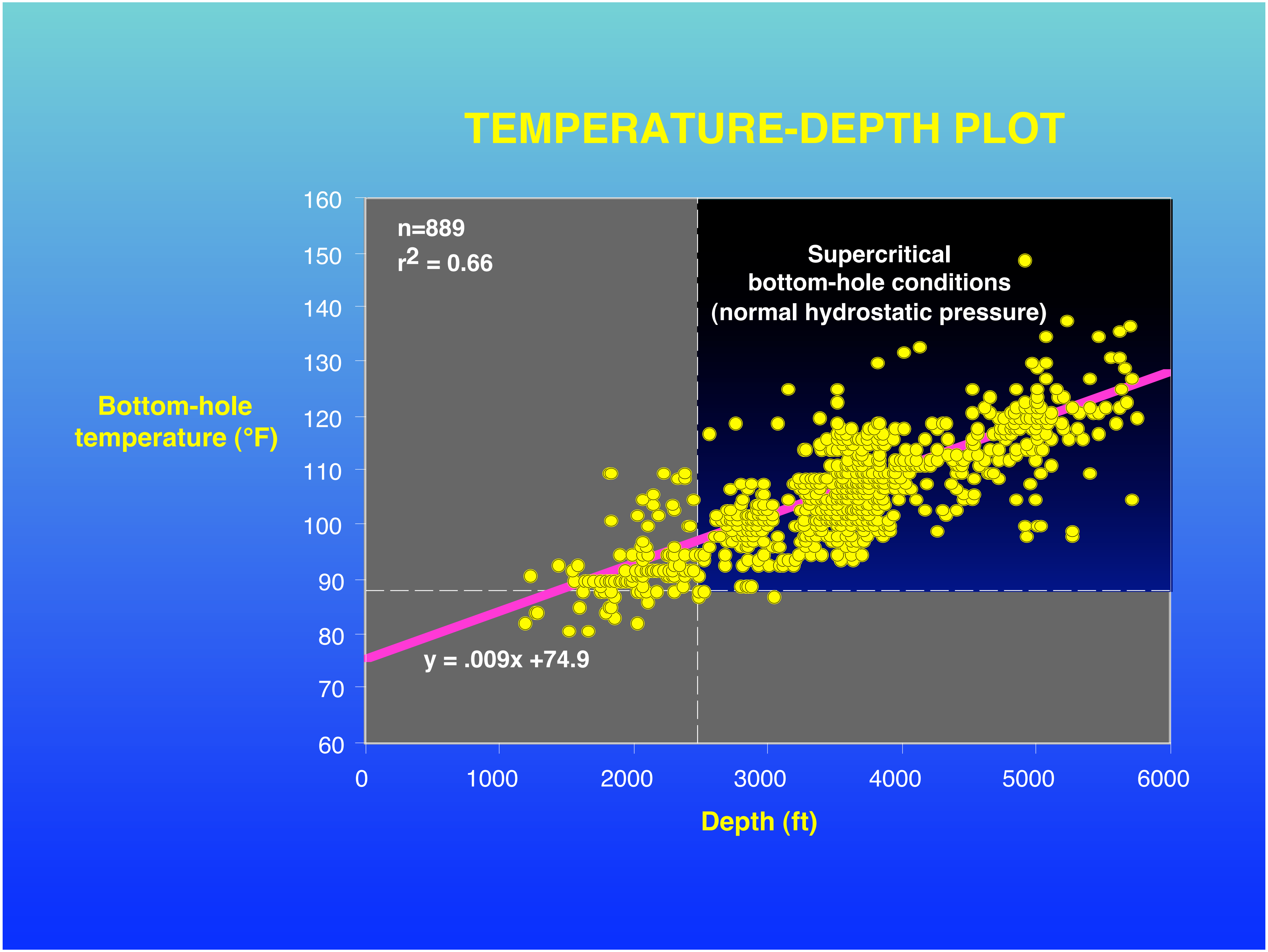


Figure 19. Temperature-depth plot for coalbed methane wells in the Black Warrior basin showing variation of geothermal gradient.

GEOTHERMAL GRADIENT

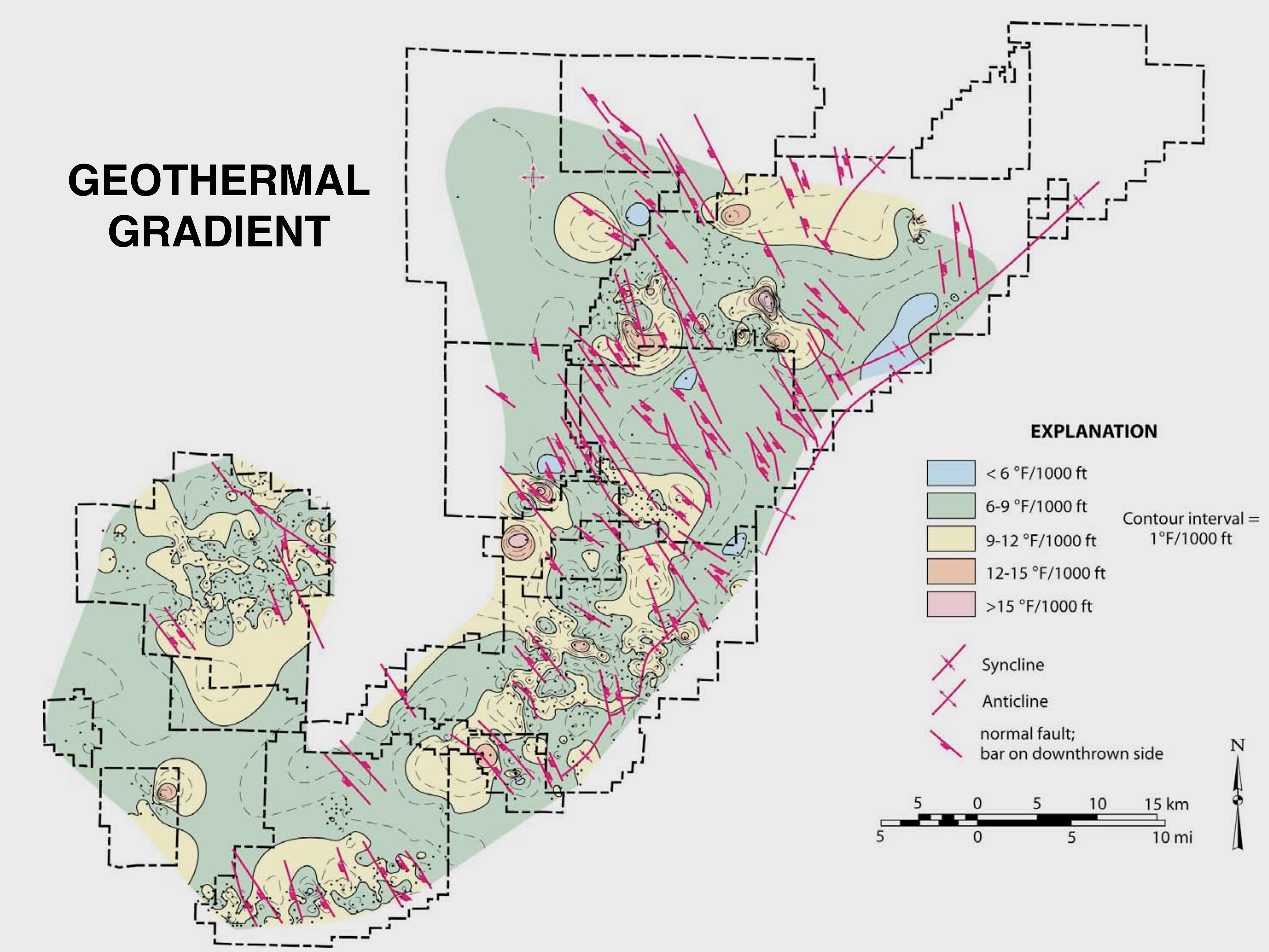


Figure 20. Map of geothermal gradient in the Black Warrior coalbed methane fields.

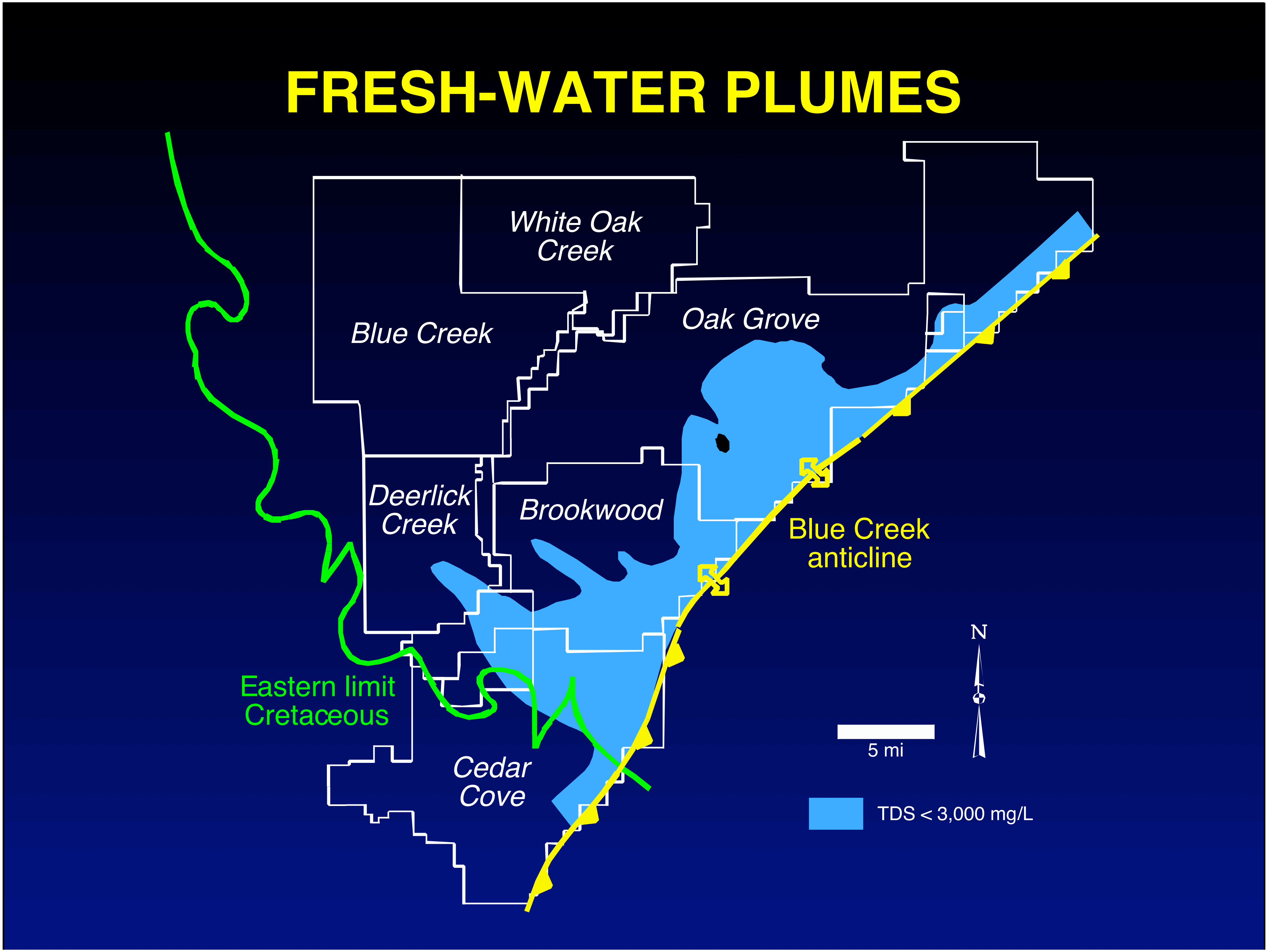


Figure 21. Location of fresh-water plumes in the Mary Lee coal zone, which are fed by recharge along the upturned southeast basin margin.

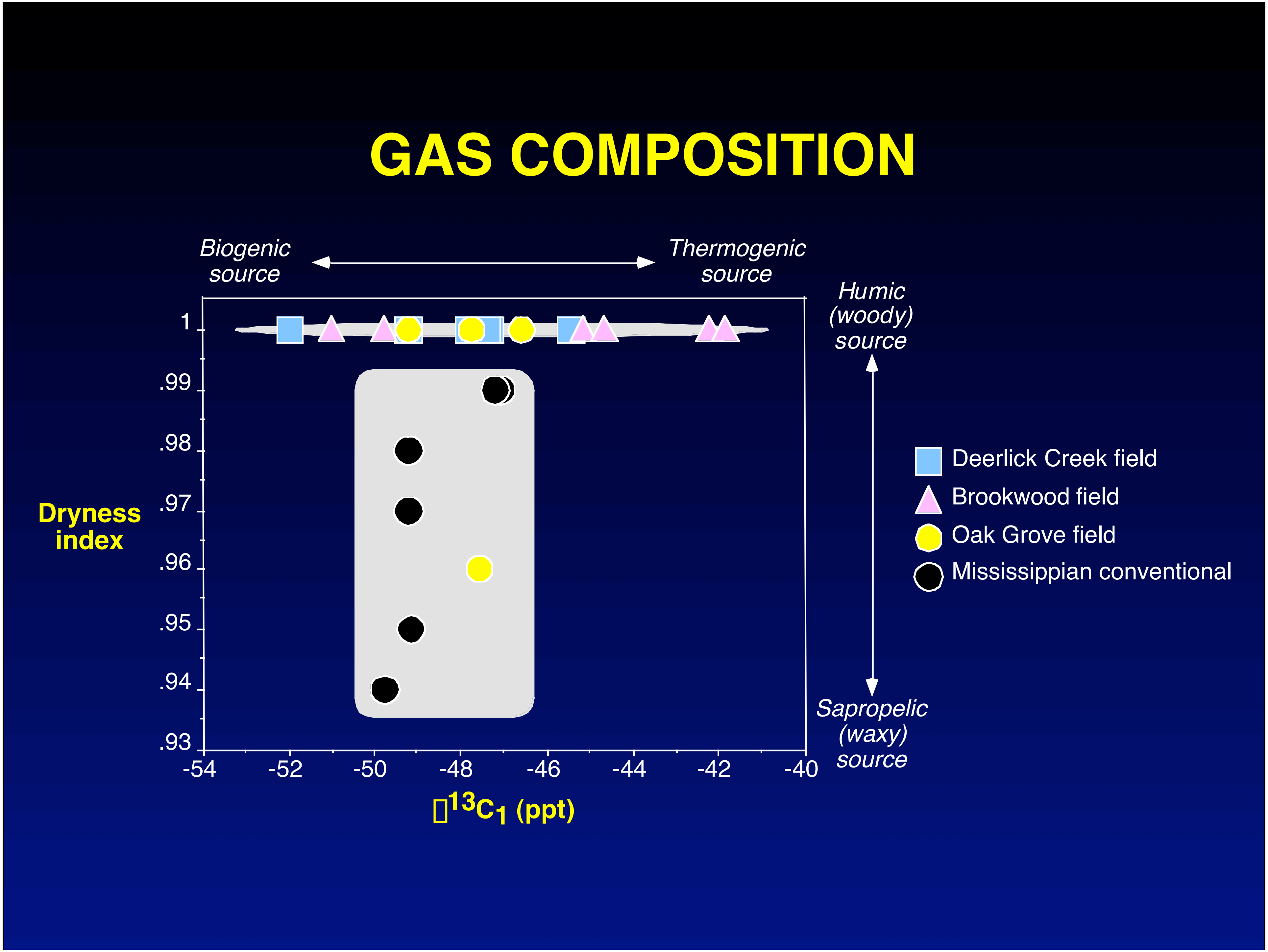


Figure 22. Comparison of composition of conventional and coalbed gas in the Black Warrior basin.

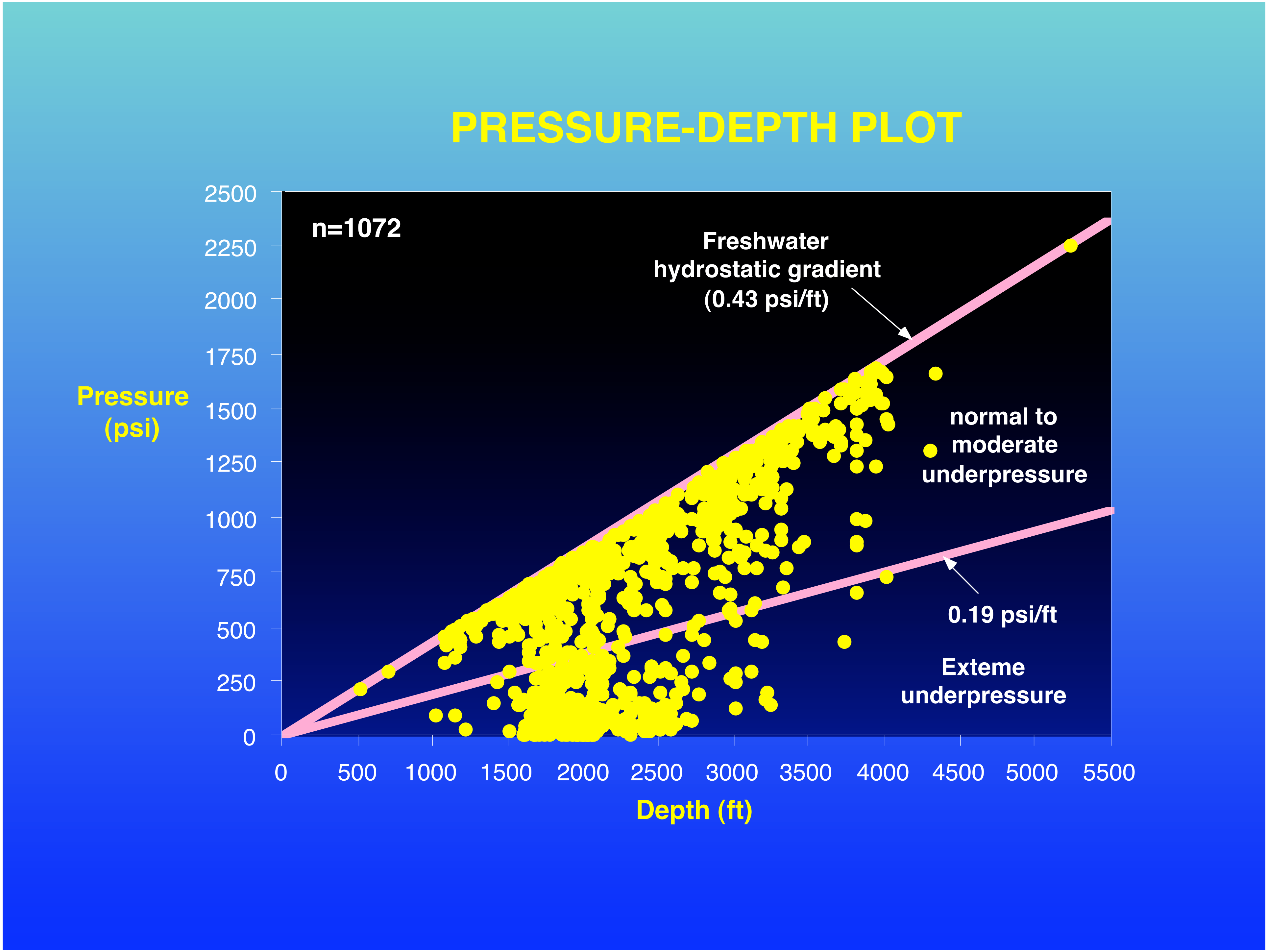


Figure 23. Pressure-depth plot showing bimodal pressure regime in the Black Warrior coalbed methane fields.

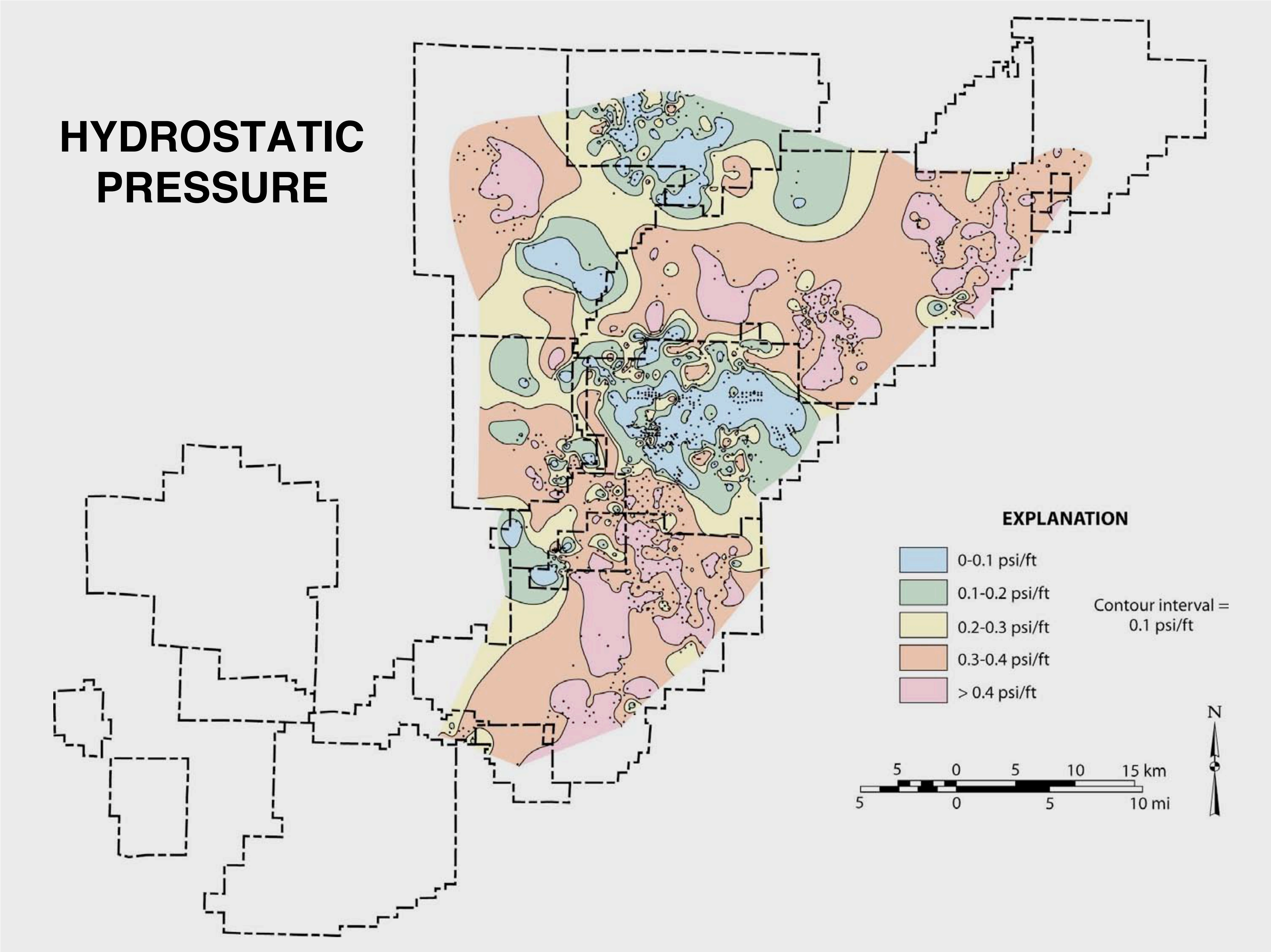


Figure 24. Map of hydrostatic pressure gradient determined from water levels in gas wells of the Black Warrior coalbed methane fields.

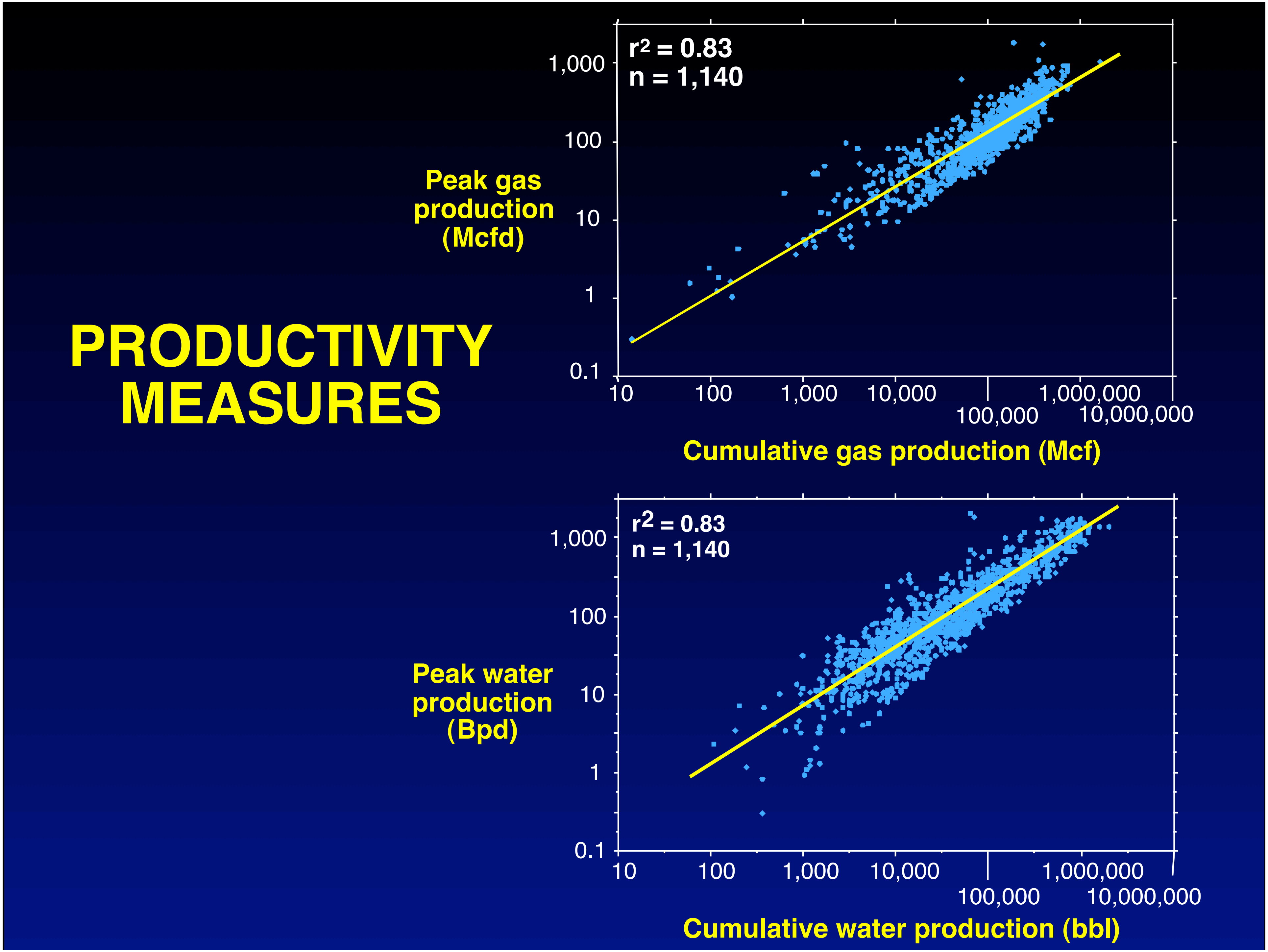


Figure 25. Relationship of peak and cumulative fluid production values in the Black Warrior coalbed methane fields.

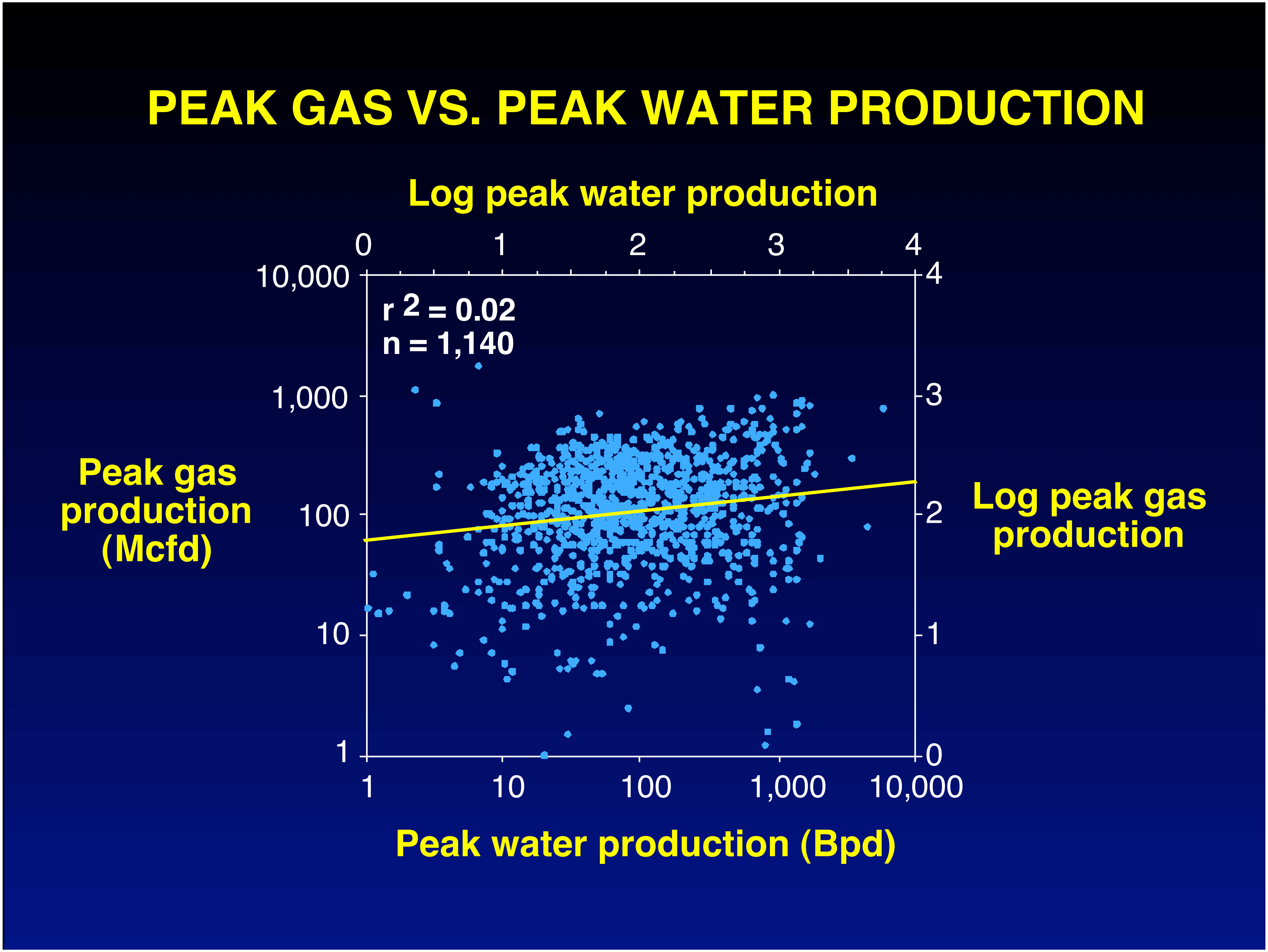


Figure 26. Scatterplot showing lack of correlation between peak and gas water production in the Black Warrior coalbed methane fields.

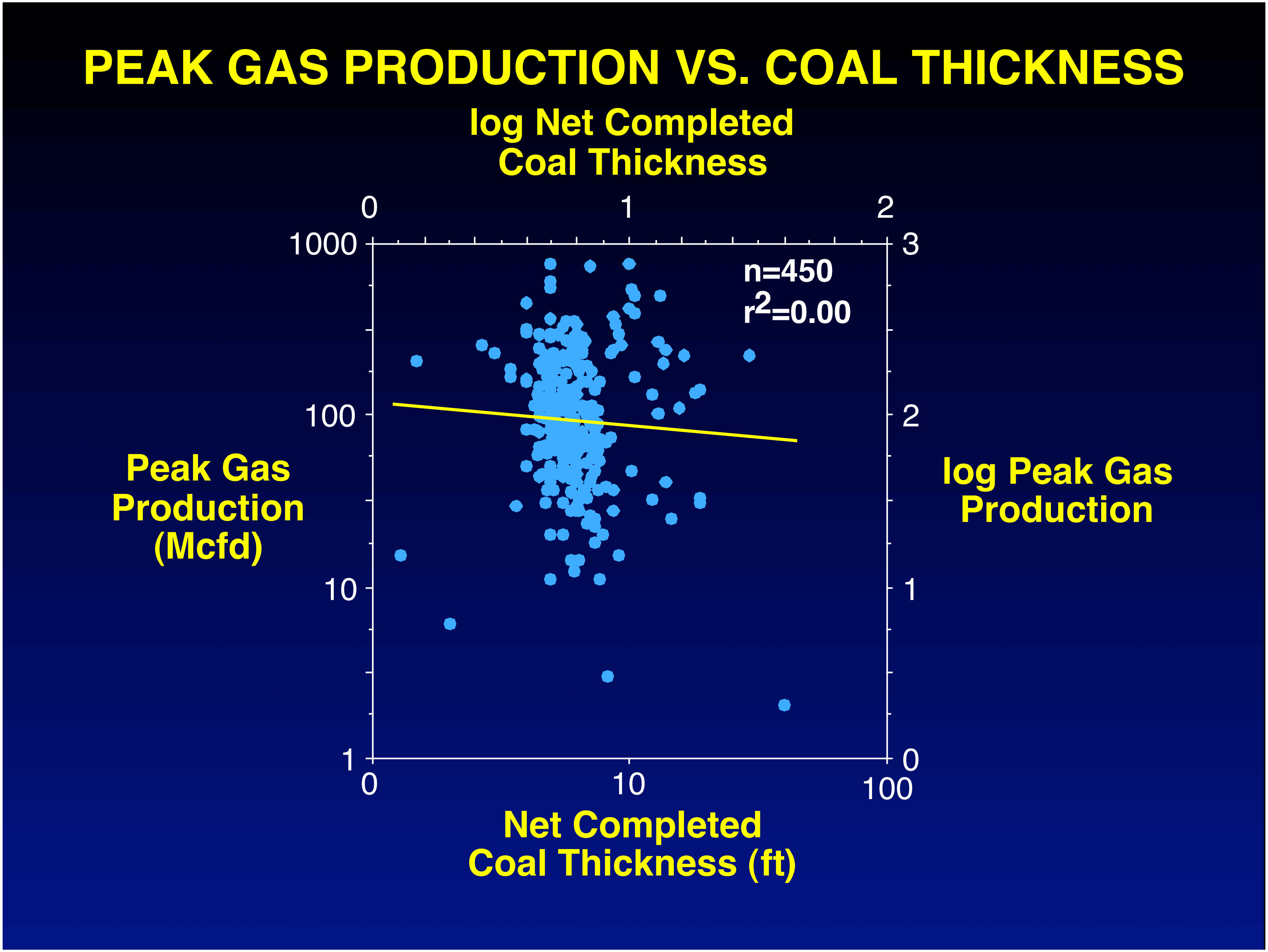


Figure 27. Scatterplot showing lack of correlation between peak gas production and net completed coal thickness in the Black Warrior basin.

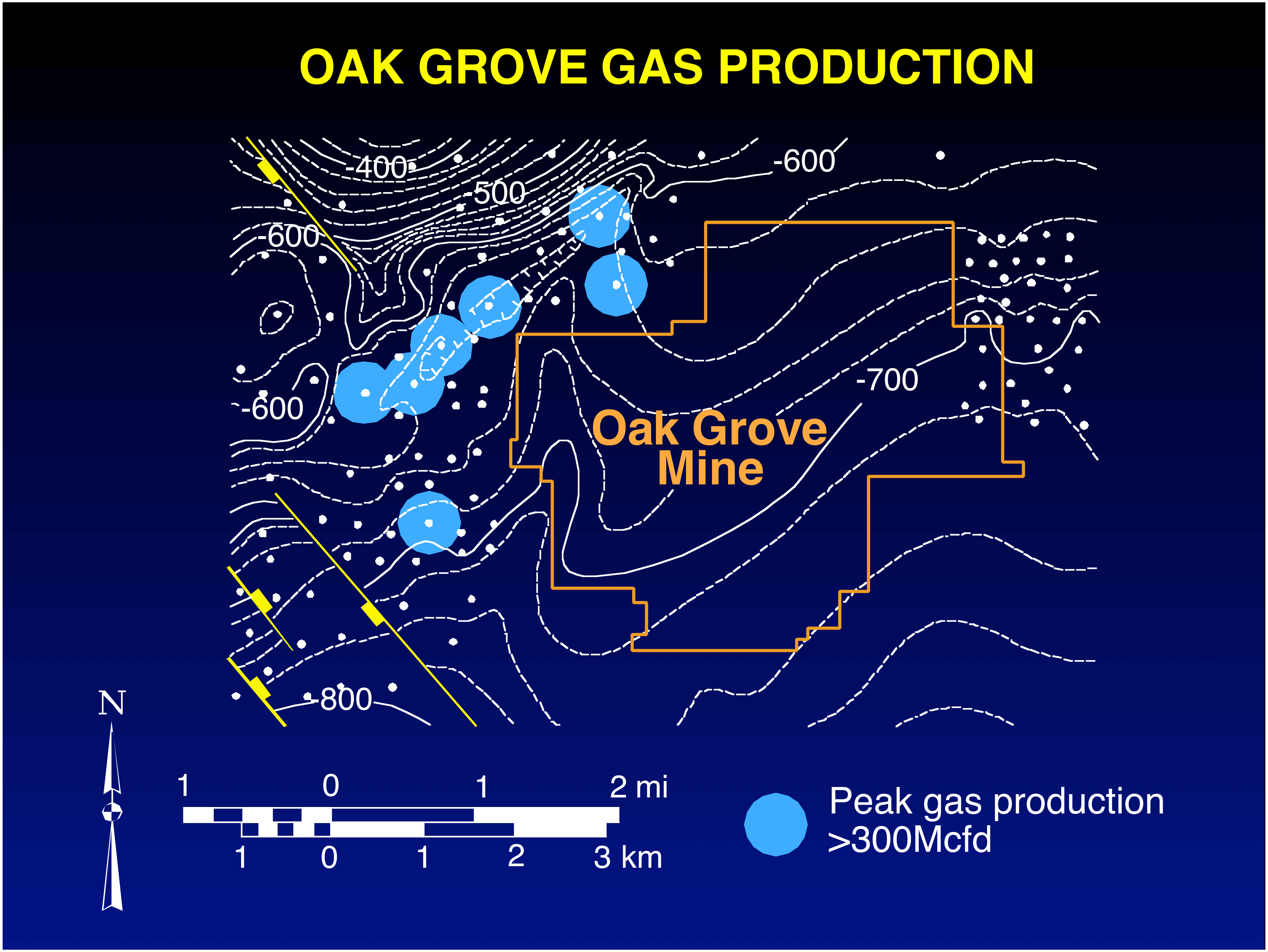


Figure 28. Map showing concentration of productive gas wells along a synclinal axis in Oak Grove Field. Structure contours (ft below sea level) on top of Mary Lee coal bed.

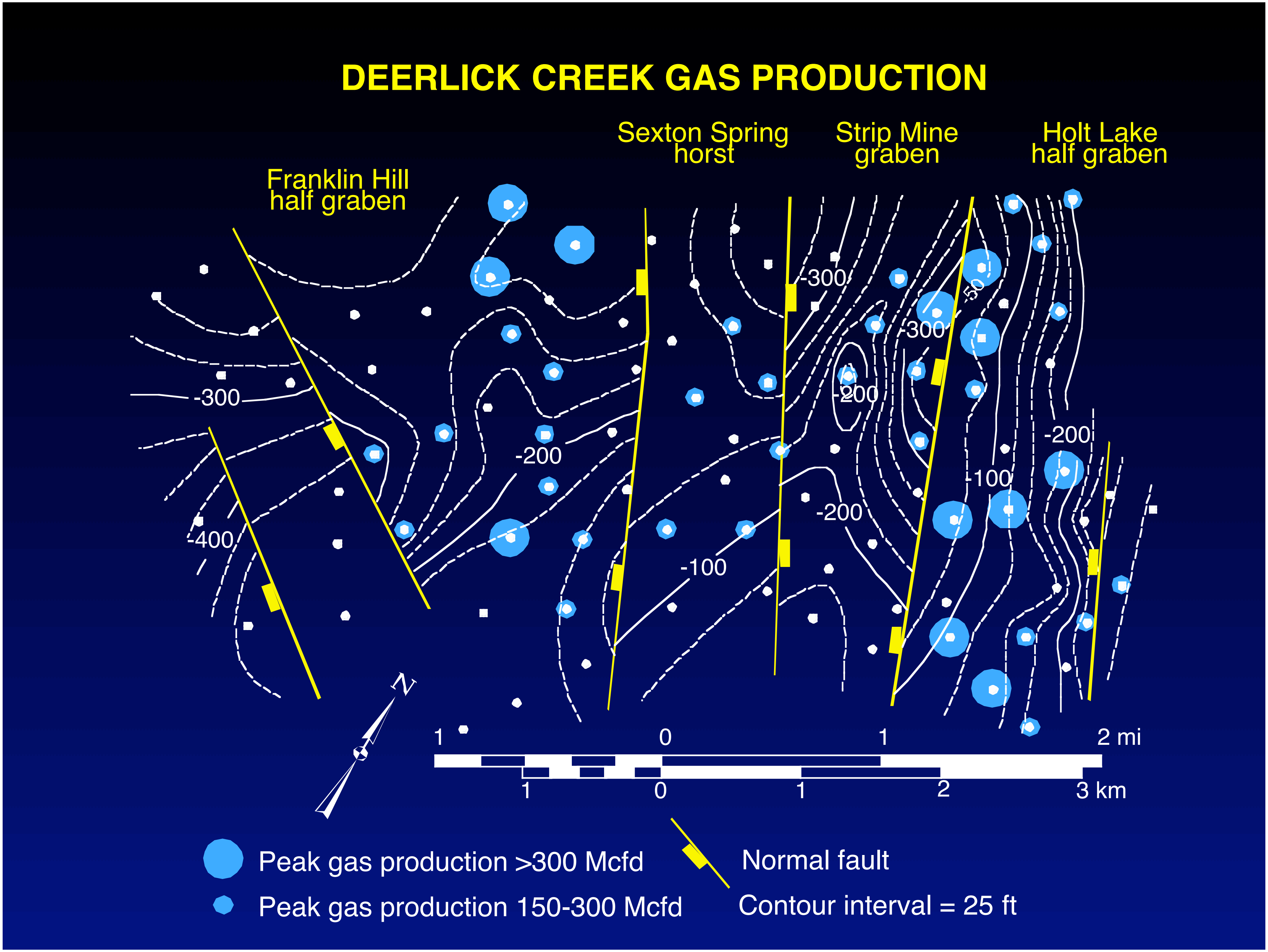


Figure 29. Map showing concentration of exceptional gas-producing wells in two half grabens in Deerlick Creek Field. Structure contours on top of Gwin coal zone.

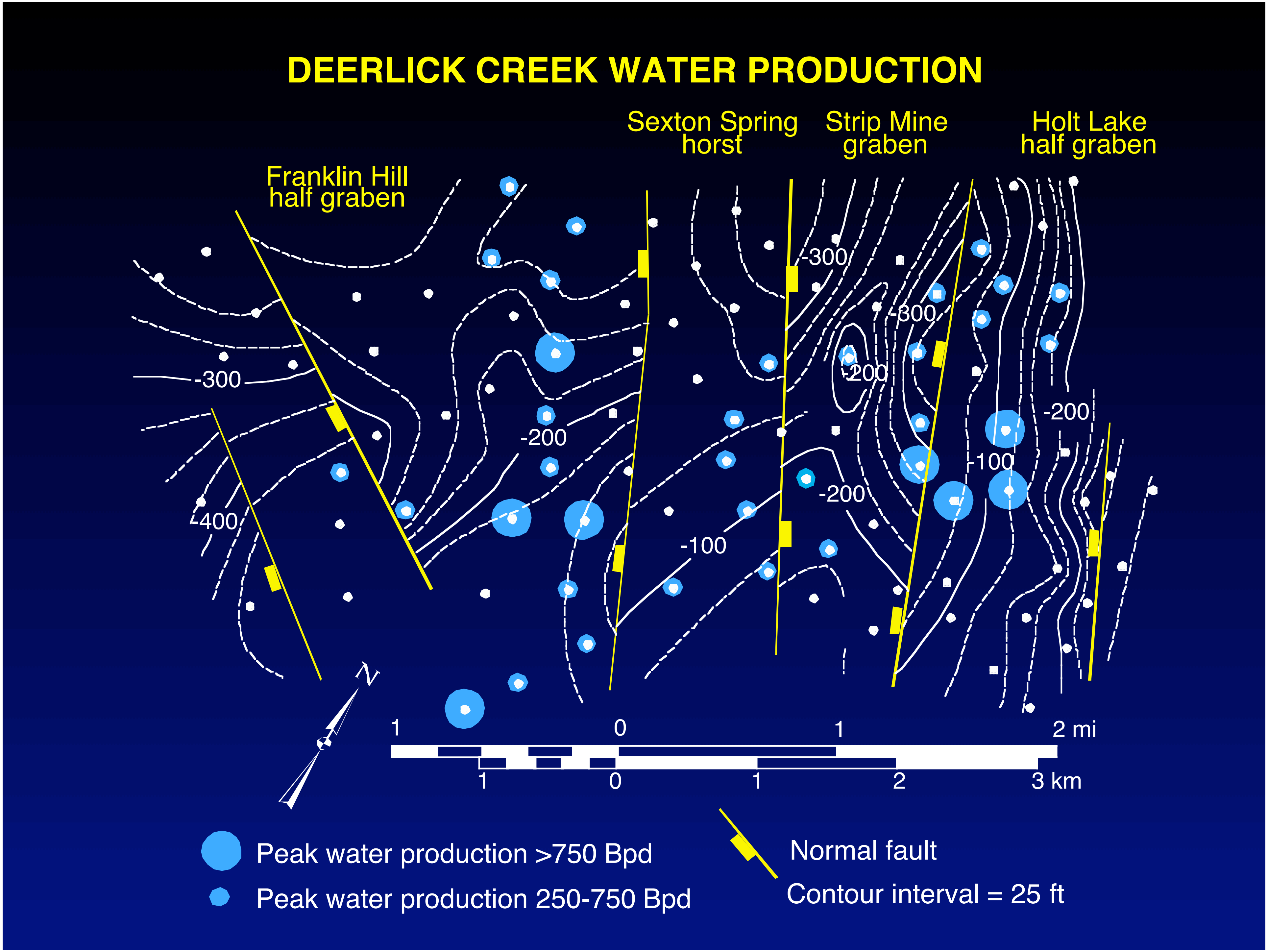


Figure 30. Map showing concentration of exceptional water-producing wells in two half grabens in Deerlick Creek Field. Structure contours on top of Gwin coal zone. Compare with Figure 29.

CONCLUDING THOUGHTS

CBM reservoirs in the Black Warrior basin are characterized by heterogeneous stratigraphy, structure, and coal quality.

This heterogeneity has a strong effect on sorption capacity, gas content, basin hydrology, and reservoir performance.

Similar factors affect CBM potential in other sedimentary basins, but differing geologic factors pose basin-specific challenges.

Figure 31. Concluding thoughts.