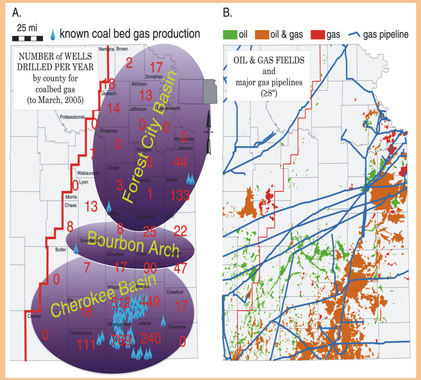
Abstract

The Forest City Basin of northeastern Kansas contains between 5 and 20 thin coal-beds (typically less than 1 m, but as thick as 1.2m) of variable depositional environments. These coals are interstratified within mixed siliclastic-carbonate cyclothem deposits of the Cherokee and Marmaton groups (Lower-Middle Pennsylvanian). These coals comprise a significant resource within the subsurface of Kansas and vary in rank from high volatile A to C bituminous. While not optimal for coal-bed methane production due to thinness and high volatile ranks, lateral persistence across a ten-county area in northeastern Kansas, coupled with sufficient overburden and competent seals make the Forest City basin an intriguing play for coal-bed methane exploration.

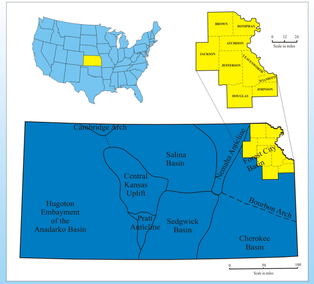
Continuous cores were described and linked to geophysical well-logs to construct structure and isopach maps and regional cross sections for a better understanding of depositional environments of major coals. Desorption tests of cores and cuttings of numerous coals show gas contents typically ranging from 10 to 60 scf/ton, although there have been measurements up to 160 scf/ton and methane and proximal coal analyses were performed to determine any variations in geochemical factors. A high-resolution sequence stratigraphic framework was developed for the Cherokee and Marmaton groups to develop depositional models and deduce potential relationships between depositional environment, coal quality, and gas content. A better understanding of spatial, geological and geochemical factors that influence the Cherokee and Marmaton coals is important to understanding coal-bed methane potential in northeastern Kansas.

Petroleum Significance - Active CBM Play

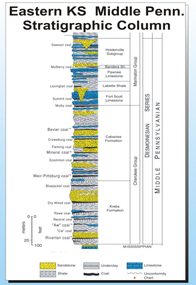


Conventional petroleum production in the Cherokee basin that began in the late 19th century continues to present, although in decline for the past fifty years. Since the mid-1980's and early 1990's unconventional shale and coal gas wells have reported cumulative production greater than 300 MMCF. Recent demands for natural gas, increasing prices, and new technologies have turned the Cherokee basin into an active energy play. Up to 14 relatively thin coals beds may be encountered in any one well. The key to a successful coalbed play is to identify numerous coals with higher gas contents located near pipeline infrastructure.

Coals in the Cherokee basin are less than 2,500 feet deep, so drilling costs are relatively low. Top reported completions intervals are in the Mulky coal and overlying Excello Shale, Weir-Pittsburg coal, and Riverton coal. Many producers are completing in coals that are less than 2 feet thick with promising results. The Mulky coal on average is much thinner than other coals, but the combination of a thick black shale with moderate absorbed gas capping the coal, provides an economic target.



Location map of Nemaha, Brown, Doniphan, Jackson, Jefferson, Leavenworth, Wyandotte, Douglas, and Johnson counties.



Stratigraphic column of Middle Pennsylvanian (Desmoinesian) strata in the study area.

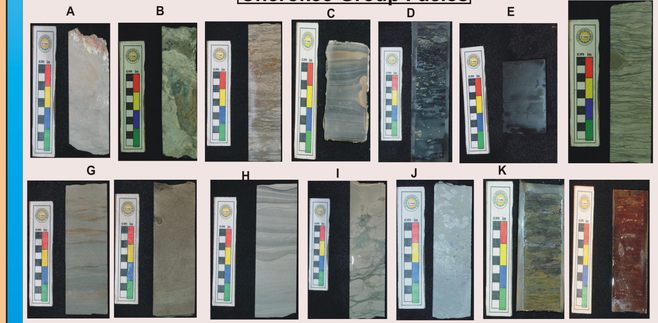
Geologic Background

The Forest City Basin is located in the central mid-continent (USA) occupying some 20,000 mi^2 (~52,000 km^2) in NE Kansas, NW Missouri, SW Iowa, and SE Nebraska. The basin is bound to the south by the Bourbon Arch, to the west by the Nemaha Uplift, to the east by the Ozark Dome and to the north by the Transcontinental Arch. Cherokee Group (Atokan - Desmoinesian, early to middle-Pennsylvanian) rocks, in which most of the coals are imbedded, gradually thicken to the north and west into the deeper basin. During the early to early-Desmoinesian the Forest City Basin was influenced by the orogenic activity of the convergent Ouachita system in present-day southeastern Oklahoma such that the Nemaha fault system was actively creating substantial topography on the karsted Mississippian surface (Ham and Wilson, 1967). Deposition of the Cherokee Group occurred while the area was part of a slowly subsiding, intracratonic basin (Staton, 1987). Early to middle Pennsylvanian strata disconformably overlie the Mississippian limestone surface throughout the mid-continent (Saueraker, 1966).

Depositional Environments

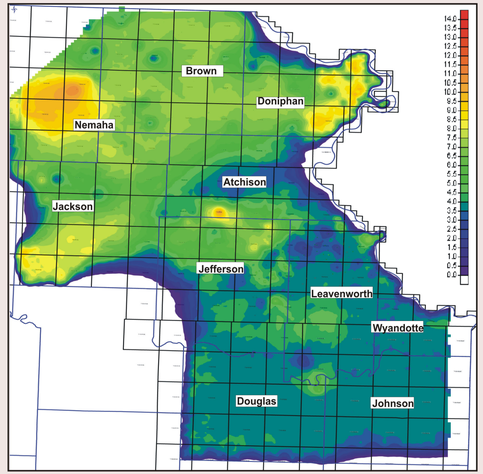
While depositional environments of many coals are not necessarily directly related to the environments of the overlying or underlying sediments (due to possible hiatus in deposition (McCabe, 1984)), depositional environments of overlying and underlying sediments must be identified in order to better understand variations in coal quality, thickness, and lateral extent within a sequence stratigraphic framework. Other factors, such as coal geometry, average thickness, aerial extent, orientation, ash content, and sulfur content also can give strong clues about coal depositional environment.

Cherokee Group Facies



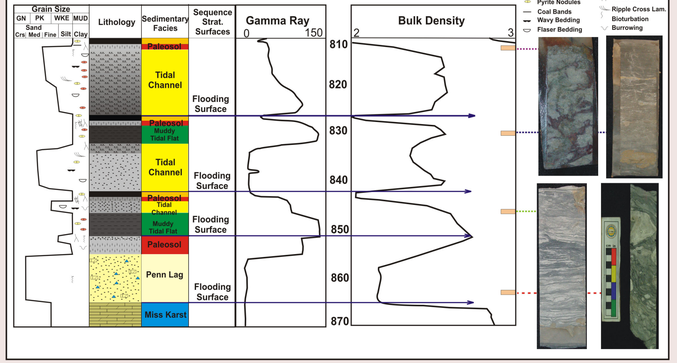
Core samples of Cherokee Group facies; (A) Mississipian Limestone; (B) Mississippian-Pennsylvanian Unconformity related facies (C) Sideritic gray shale; interpreted as shallow brackish water environment; (D) Pyritic gray shale; interpreted as shallow brackish water environment; (E) Phosphatic black shale, interpreted as "deep" water shelf shale associated with sediment starvation and maximum flood; (F) Ripple cross laminated heterolithic sandy shale, interpreted as tidal rythmites or tidal flats; (G) Sandstone interpreted as fluvial and deltaic environments, (H) Siltstone, interpreted as central estuarine low energy environment, (I), Bioclastic wackestone, interpreted as below wave base; (J)Bioclastic and Peloidal packstone and grainstone, interpreted as above wave base; (K)Pedogenically altered parent material, interpreted as paleosol indicating subaerial exposure

Riverton - Rowe Net Coal Isopach Map



Johnson County Riverton-Rowe Depositional Sequence

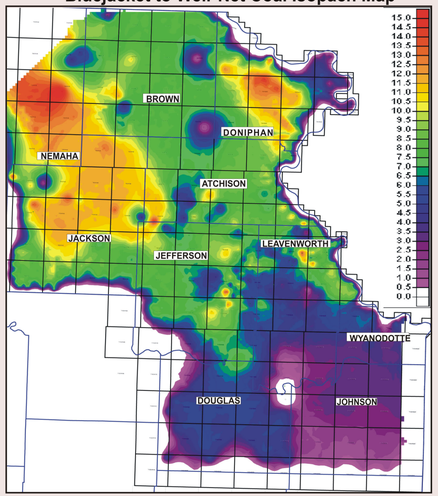
Core Interval: 810' - 870'



Riverton to Rowe Interval

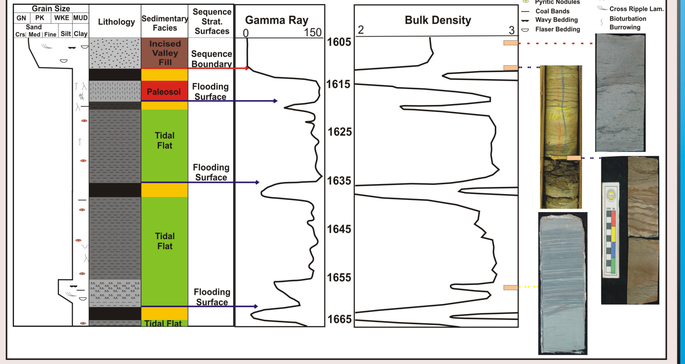
Isopachous map (in color scale) of net coal from the basal 4-7 coals of the Cherokee Group (Riverton, Aw, Bw, Cw, Neutral, and Rowe). The typical depositional sequence of the succession is based on cores and related log response. The net thickness of coal increases to the northwest associated with increased depth of the underlying Mississippian limestones. High sulfur and moderate ash values (pyritization and sideritization) indicate both marine influence (sulfur) and influx of other terrigenous or carbonate sediment (ash). No carbonates have been observed in this interval and thus coals with ash content likely are from clastic sources. Locally, peat growth in structural lows was negatively impacted by sediment influx making carbonaceous shales common lateral facies equivalents of coal, which developed on structural highs where mires protected it from marine influence.

Bluejacket to Weir Net Coal Isopach Map



Doniphan County BlueJacket - Weir-Pittsburg Depositional Sequence

Core Interval: 1605' - 1665'



Bluejacket to Weir-Pittsburg Interval

Isopachous map (in color scale) of net coal from the upper Krebs to lower Cabaniss Formations of the Cherokee Group (Dry Wood, BlueJacket series, and Weir-Pittsburg). The typical depositional sequence of the succession is based on cores and related log response. The net thickness of coal increases to the north and west due to greater accommodation. High sulfur and ash values (strongly pyritized coals) indicate both marine influence and influx of other sediment (either terrigenous or carbonate). Locally, peat growth in structural lows was negatively impacted by sediment influx making carbonaceous shales common lateral facies equivalents of coal that developed on structural highs where peat development was in mires protected from marine influence. Aerial extent, thickness and geometry of the Weir-Pittsburgh coal indicate a coastal depositional setting, yet thick and thin linear trends of coals of the BlueJacket series may indicate an alluvial origin, associated with incised valley fills.