29th Forum of the Coal Geologists of the Western Interior Coal Region

Field Trip

May 25, 2005

Phoenix Coal Co. Garland Mine, Bourbon Co., KS
and
Coalbed Methane Operations of
Dart Cherokee Basin Operating Co., LLC
Montgomery Co., KS

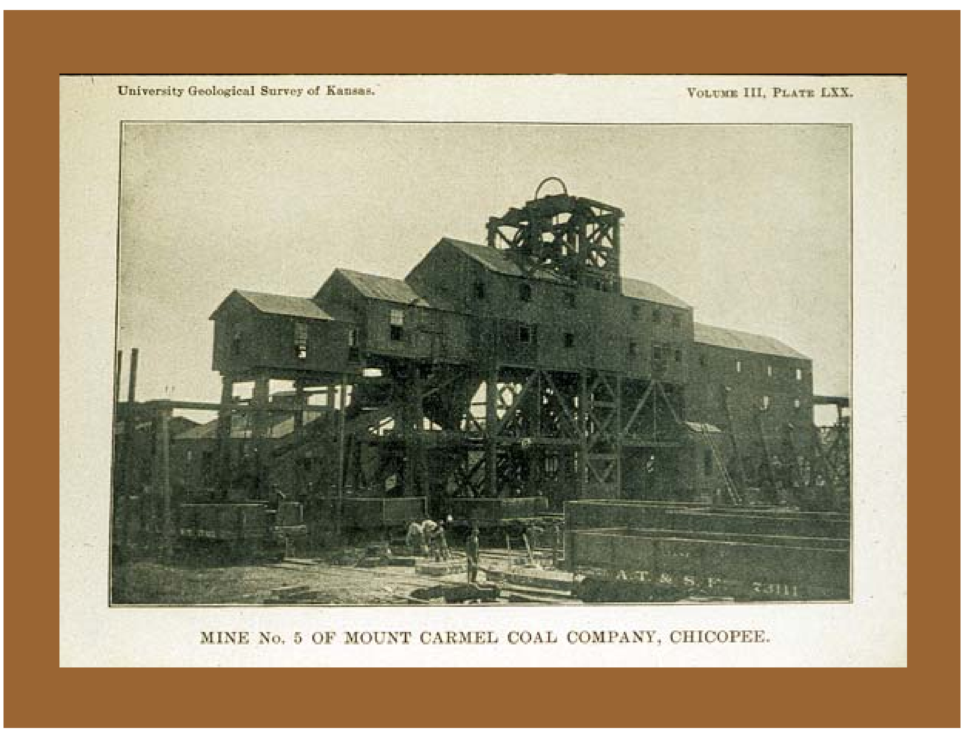
Leaders

Lawrence L. Brady and K. David Newell—Kansas Geological Survey

With assistance from

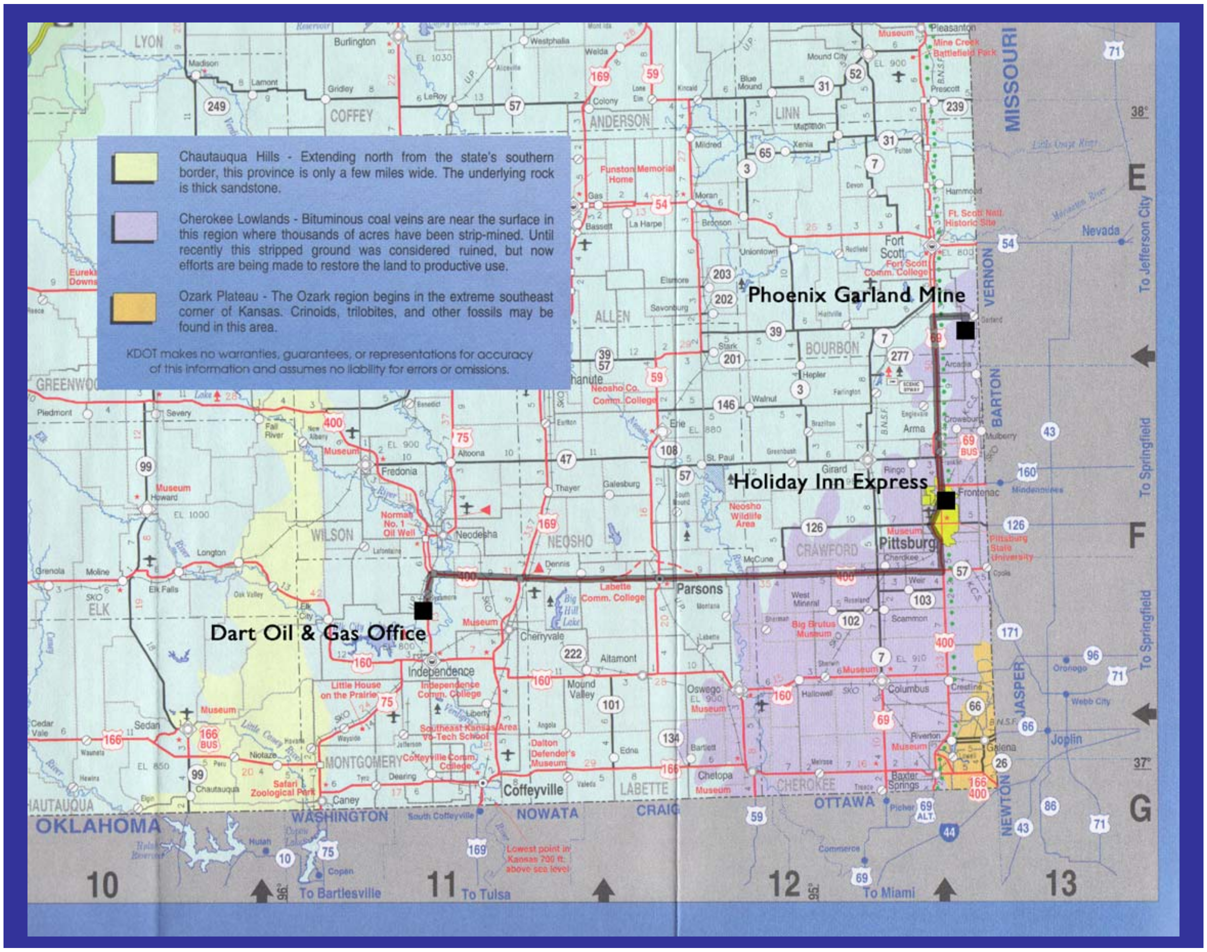
Ron Chaney (Mine Supt.)—Phoenix Coal Co., Garland Mine

Michael Murphy (District Mgr.)—Dart Cherokee Basin Operating Co.



MINE No. 5 OF MOUNT CARMEL COAL COMPANY, CHICOPEE.

Kansas Geological Survey Open-File Report 2005-31



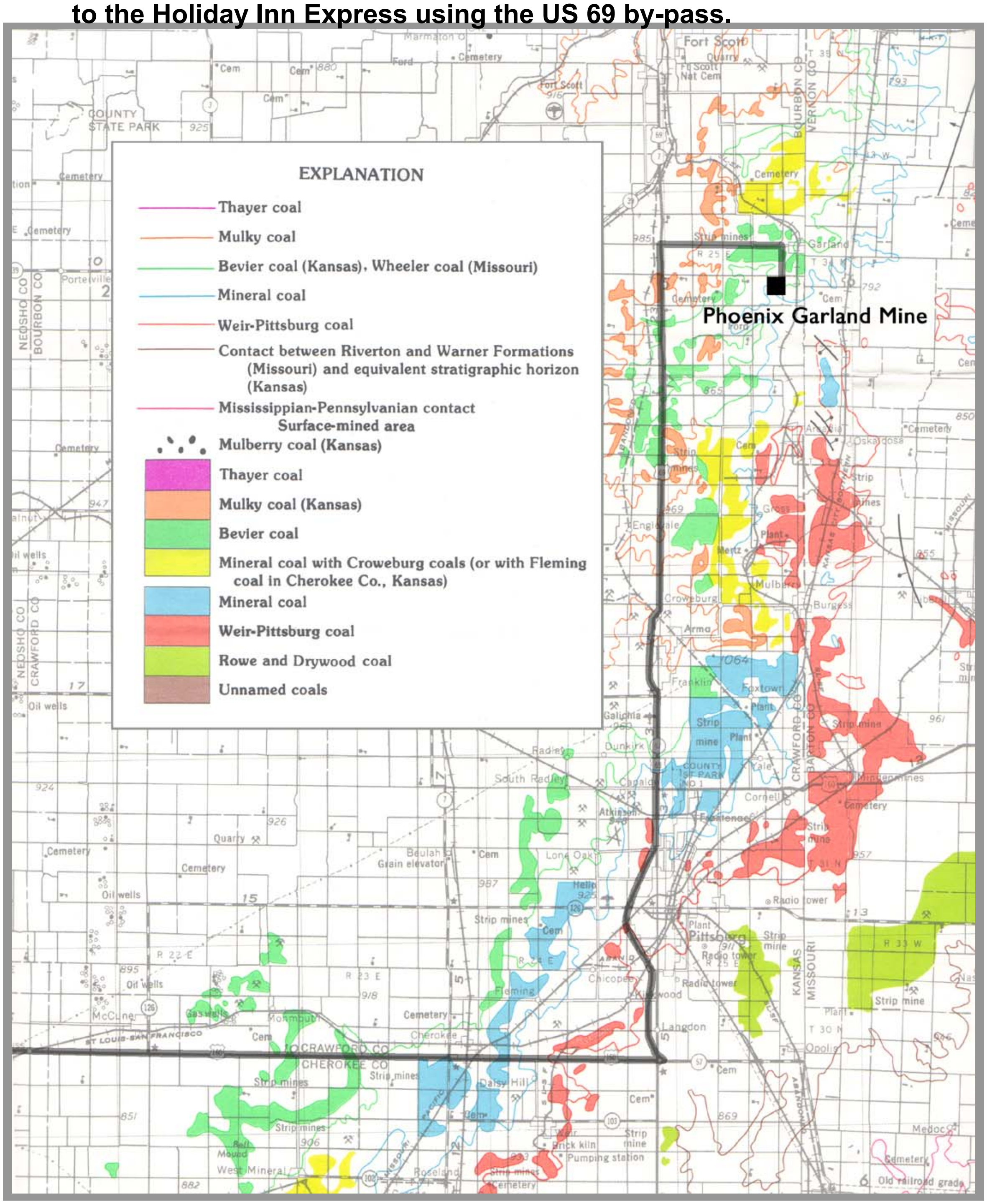
Route of the Coal Forum Field Trip—May 25, 2005

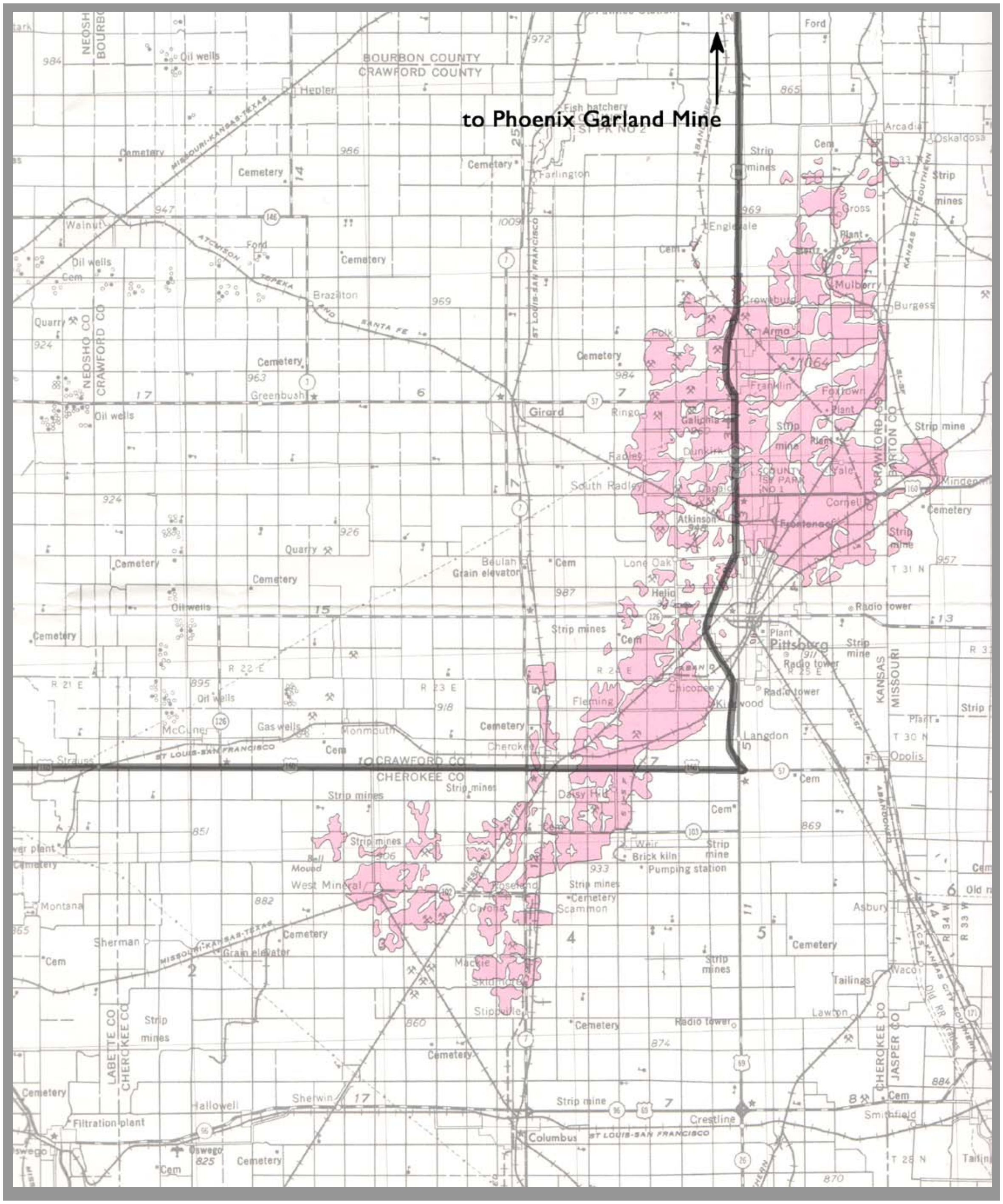
Directions to—
Phoenix Coal Company—Garland Mine
and
Dart Cherokee Basin Operating Company

- **From Holiday Inn Express travel north on US 69 for 20 miles. A small sign indicating Garland is on the left side of the road.**
- **Turn right (east) at the sign on the blacktop road. Go east 4 miles.**
- **Turn right (south). Travel for 1.2 miles to coal stockpiles of Phoenix Coal.**
- **We will meet Ron Chaney, Mine Superintendent, who will lead us into the mine and will be available to answer questions.**

- **Return toward Pittsburg using the same roads.**
- **In Pittsburg—just south of the Holiday Inn Express, take US 69 by-pass—turn right a short distance then the road bends back south—continue south for approximately 8 miles to US 400.**
- **Turn right (west) on US 400 and travel west for approximately 55 miles until we meet US 75 (N-S road).**
- **Turn left (south) on US 75—go south 2 miles to Sycamore.**
- **At Sycamore Dave Newell will lead us to the Dart office.**
- **Michael Murphy, District Manager for Dart Cherokee Basin Operating Co., will discuss the Dart operations in Kansas then lead us to some of the field facilities to observe wells, compressors, and possibly some drilling operations.**
- **Return to Pittsburg by reversing travel using the same roads. We can stop for lunch in Parsons—approximately 23 miles east from the US 75 and US 400 intersection. For lunch in Parsons, instead of taking the bypass north of Parsons we will continue straight east through Parsons.**
- **Following lunch, continue east on the same road until we again join US 400. Continue east to US 69.**

- **Turn left (north) on US 69 and continue approximately 8 miles back to the Holiday Inn Express using the US 69 by-pass.**





to Phoenix Garland Mine
BOURBON COUNTY
CRAWFORD COUNTY
Oil wells
Hepler
Fish hatchery
Farlington
Cemetery
Walnut
Brazilton
SANTA FE
Englevale
Crowburg
Arma
Mulberry
Burgess
Franklin
Foxtown
Girard
Ringo
Strip mines
Strip mine
Radley
South Radley
Dunkirk
Yale
Cornell
Atkinson
Frontenac
Beulah
Grain elevator
Lone Oak
Helio
Pittsburg
Radio tower
Chicopee
Kirkwood
Fleming
Langdon
McCune
Gas wells
Monmouth
Cherokee
ST LOUIS-SAN FRANCISCO
CRAWFORD CO
CHEROKEE CO
Opolis
Daisy Hill
Weir
Brick kiln
Pumping station
West Mineral
Scammon
Montana
Sherman
Grain elevator
MISSOURI-KANSAS-TEXAS
Asbury
Tailings
Lawton
Waco
Stippville
LABETTE CO
CHEROKEE CO
Hallowell
Sherwin
Filtration plant
Oswego
Columbus
Crestline
Smithfield
KANSAS
MISSOURI
CHEROKEE CO
JASPER CO
Quarry
Greenbush
Arcadia
Oskaloosa
Gross

General distribution of underground mines, by room and pillar mining, of the Weir-Pittsburg coal in Crawford and Cherokee counties, Kansas. Modified from Map B, U.S. Geological Survey I-2426-A, by Brady and others. Original map from Abernathy, 1944, plate 1.

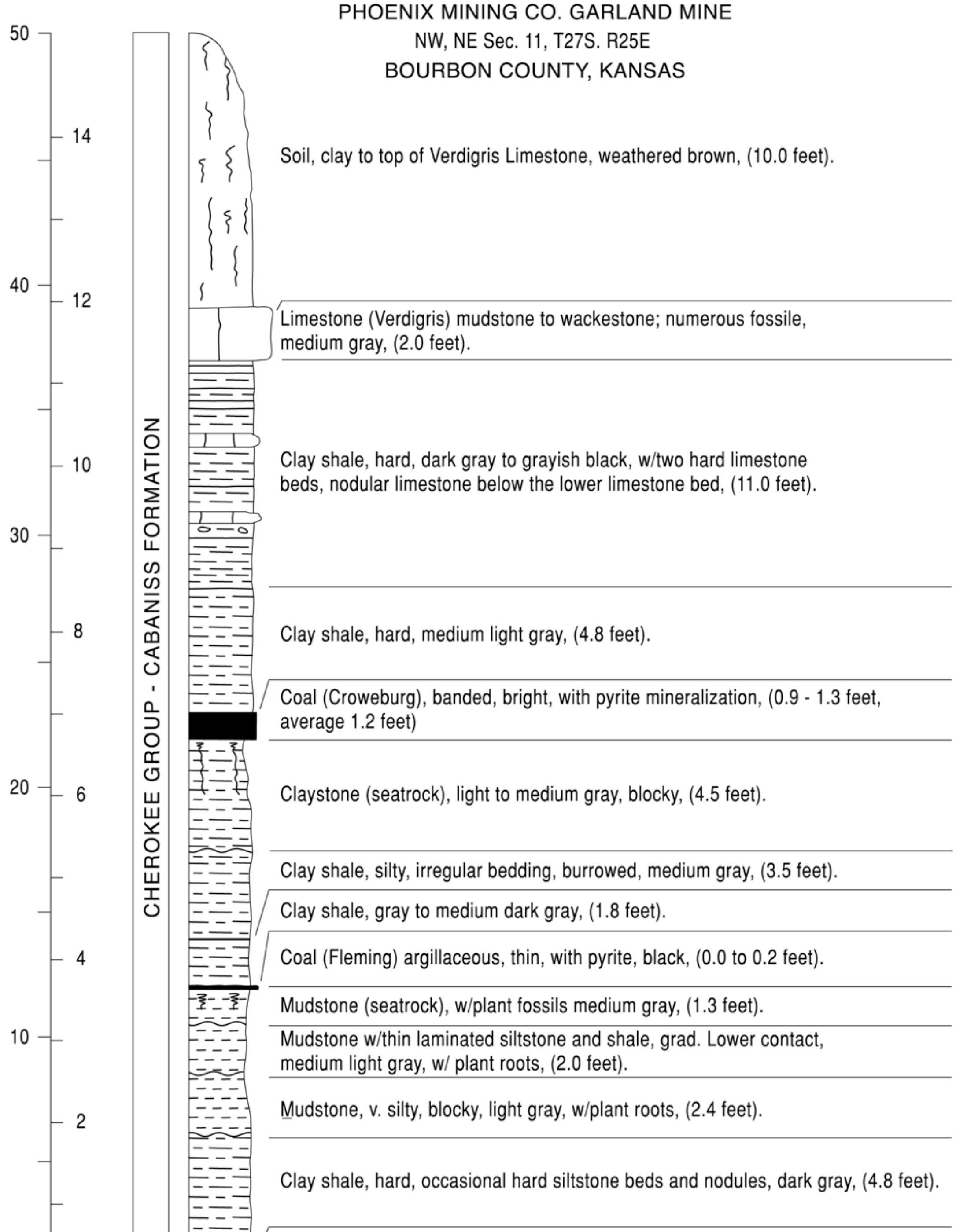
PHOENIX COAL COMPANY—GARLAND MINE
NE 11 & NW 12, T27S, R25E, Bourbon Co., KS

During the first year of mining operations in Kansas (2004), the Phoenix Coal Company produced 72,331 tons of coal at their Garland Mine in southeast Bourbon County, KS. This loader-bulldozer strip-mining operation produced the coal from the Mineral and Croweburg coals in the Cherokee Group of Middle Pennsylvanian age. The coal is trucked to the Asbury Power Plant, near Asbury, MO, and the Riverton Power Plant at Riverton, KS. Both plants are owned by the Empire District Electric Co. The coal is blended with Wyoming Powder River Basin coal at both plants. At the Asbury plant (210 mw), the blend is about 9:1 (90.3 % western coal and 9.7% local coal), while at the Riverton plant, the blend is 75% western coal, and 25% local coal for the 92 mw unit #7.

Company President is Bob Hartley, Vinita, OK.

Garland Mine Superintendent is Ron Chaney

PHOENIX MINING CO. GARLAND MINE
NW, NE Sec. 11, T27S. R25E
BOURBON COUNTY, KANSAS



KANSAS ACTIVE COAL MINES

(May 2005)

Phoenix Coal Company (Pres. Bob Hartley)	P.O. Box 498 Vinita, OK 74301	918-256-7873
Garland Mine (Supt. Ron Chaney)	NE 11 & NW 12, T27S, R25E Bourbon County	620-223-9852 (Mineral & Croweburg coals)

Note: Phoenix Coal Company started mining coal in Kansas in early 2004, and has been mining in Section 11. As they mine eastward, they anticipate possibly having some mineable Bevier coal.

Mulberry Limestone Co.	***Route 1, Box 187*** ***Mulberry, KS 66756***	***620-764-3337***

In 2004, the Mulberry Limestone Company produced 3,833 tons of coal (reported) at their Mulberry Limestone Quarry located in Section 2, T.29S, R.25.E, Crawford Co. The coal is the Mulky coal that was produced as interburden between limestone beds (assume to be Breezy Hill Ls. and Fort Scott Ls.).

Watco, Inc.

Reclaiming coal from the old washings of coal at the Pittsburg and Midway Coal Mining wash plant area north of Hallowell (west-central Cherokee Co.) The coal in the washings is mainly from the Mineral and Fleming coals, with minor amounts of Bevier and Croweburg coals.

Continental Coal, Inc. (Pres. Bill Moore)	10801 Mastin, Suite 920 Overland Park, KS 66210	913-491-1717
Lost Creek Mine	Sec. 18, T23 S, R24E Linn County	 (Mulberry coal)

Note: <u>Production of the Mulberry coal at the Lost Creek Mine ended in late 2003</u>, with the mined area still under reclamation. A new mining permit by Continental Coal is presently under review by Kansas Surface Mining Section, KDHE. This new mine (if approved) will open east of Pleasanton near the Kansas-Missouri line (in Sec. 35-36, T.21S., R.25E., Linn County) and will be named the Lucky Strike Mine. Mulberry coal will be mined to supply the LaCygne Power Plant #1 unit for blending with the Wyoming Powder River coal. It is anticipated to start mining in the Fall 2005.

Coal Mine Regulatory Office

Surface Mining Section Kansas Department of Health & Environment (Murray Balk, Chief)	4033 Parkview Drive Frontenac, KS 66763 (on west side of US69)	620-231-8540

KANSAS COAL RESOURCES, PRODUCTION, AND POTENTIAL USE IN THE NEAR FUTURE*

by
Lawrence L. Brady
Kansas Geological Survey
Lawrence, Kansas 66047

ABSTRACT

The important coals of Kansas are primarily Middle Pennsylvanian in age, with the cumulative production and deep and strippable coal resources of the state represented mainly by the coal beds in the Cherokee Group. Deep coal resources are present primarily in the eastern one-fourth of Kansas, with a preliminary total of nearly 53 billion tons (48 billion mt). Coal beds with the largest resource totals include the Bevier, Mineral, an unnamed coal bed called the "Aw", Riverton, and Weir-Pittsburg coals.

Resources of strippable coal total nearly 1.3 billion tons (1.2 billion mt) for coal having a stripping ratio of 30:1 or less. Beds with the largest resources of strippable coal include the Mineral, Bevier, Mulberry, and Nodaway coals.

Production of coal in Kansas has totaled nearly 300 million tons (270 million mt) over the past 140 years. Nearly two-thirds of the production was by underground methods. However, all coal production is now by area strip-mining methods.

Nearly 90 percent of the coal mined in Kansas was high-volatile A bituminous coal. Most of the other coals mined were either high-volatile B or C bituminous, with nearly all of Pennsylvanian age. A small amount (300,000 tons; 270,000 mt) of lignite was mined from the Cretaceous Dakota Formation, and about 10,000 tons (9,000 mt) of bituminous coal was mined from Lower Permian rocks.

Present uses of Kansas coal are almost totally for electric power generation and cement manufacture. However, high sulfur content of most Kansas coals is causing concern in meeting air quality standards resulting in a demand for low-sulfur coals at the power-generating plants. Blends of low-sulfur coals with Kansas coals are now common at eastern Kansas and western Missouri power plants. Further development of fluidized bed combustion and the construction of these plants in Kansas appears to be the best answer for future direct uses of Kansas coal. Methane derived from coal beds at depths greater than 500 feet (150 m) in eastern Kansas also shows good potential for further development in Kansas.

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*Modified from Brady, L. L., 1990, Kansas coal resources and their potential for utilization in the near future; in Coal Geology of the Interior Coal Region—Western Region: Guidebook for the 1990 Geological Society of America Coal Geology Division Field Trip, Oct. 26-28, 1990, p. 107-127

INTRODUCTION

Coal deposits in Kansas have been exploited for nearly 140 years with a total production of approximately 300 million tons (270 million mt). There were two major peaks of production availability and use of natural gas and petroleum in Kansas and the extraction of most of the important Weir-Pittsburg coal reserves were the important factors in the decline of Kansas coal production. The peak production year was 1918 with over 7.3 million short tons (6.6 million mt) produced. Production of coal in 1989 was 0.85 million tons (.77 million mt) and as recent as 1987 production was 2.0 million tons (1.8 million mt). In the past 20 years 19 different coal mines operated in Kansas. All but one of the mines operated in either Crawford, Cherokee, Bourbon, Linn, or Labette counties in southeast Kansas. In early 1990 only three coal mines were in operation in Kansas, all in eastern Crawford County.

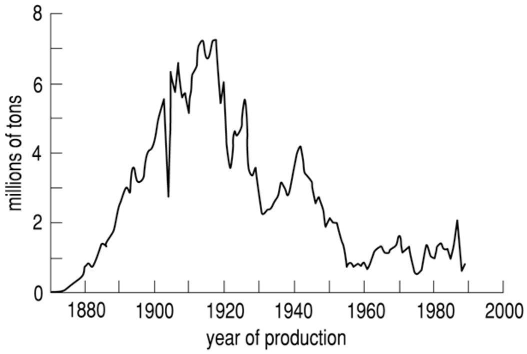


Figure 1. Historic production of coal by year in Kansas.

Bituminous coal resources of Pennsylvanian age are widespread in eastern Kansas and represent nearly all the coal resources in Kansas. There is a small amount of coal in Lower Permian rocks and a limited amount of lignite in Lower Cretaceous rocks in central Kansas. Deep coal resources were determined for 32 coal beds, and strippable coal resources were determined for 17 coal beds. Five of the strippable coal beds are not represented in the deep coal resource study because preliminary evaluation of coals above the Cherokee Group has not been completed. Emphasis of the deep coal resources is on coals of the Cherokee Group. Study of Pennsylvanian rocks above the Cherokee Group should provide higher deep coal resource estimates. At the present time, six coal beds stratigraphically higher than the Cherokee Group are included in the preliminary deep coal resource total.

STRATIGRAPHIC POSITION OF COAL

Coal beds having resource potential are present almost entirely in rocks of Pennsylvanian age. Past production, however, included coals from Permian and Cretaceous age rocks in Kansas; but coal won from Pennsylvanian age rocks represents 99.9 percent of the total recorded coal production in Kansas. The remaining 0.1 percent represents a small production of 300,000 tons (270 thousand mt) of lignite from the Dakota Formation of Lower Cretaceous age (Schoewe, 1952, p. 99) and about 10,000 tons (9,000 mt) from Permian rocks (Schoewe, 1951, p. 57). Shown in Table 1 is the stratigraphic position of the coal beds with past commercial mining history in the state. A stratigraphic column of Pennsylvanian rocks showing stratigraphic position of coal beds with strippable coal resources is shown in Figure 2. Nearly 90 percent of all coal mined in Kansas is from the Cherokee Group and these coals also dominate the resources in the state. Two important exceptions are the Nodaway coal of the Wabaunsee Group and the Mulberry coal of the Marmaton Group. The Mulberry coal was

Table 1. Stratigraphic distribution of commercial coal beds mined in Kansas

Period	Group	Formation[1]	Coal Bed[2]
Cretaceous	-	Dakota Fm.	Lignite in Janssen Member (several beds)
Permian	Council Grove	Blue Rapids Sh.	Unnamed
Pennsylvanian	Wabaunsee	Root Sh.	Unnamed "Lorton"
	"	Pillsbury Sh.	Unnamed "Nyman"
	"	Cedar Vale Sh.	Elmo
	"	Aarde Sh.	Nodaway (*) (u)
"	Douglas	Lawrence Fm.	Williamsburg
	"	Stranger Fm.	Upper Sibley
	"	"	Unnamed "Ottawa"
	"	"	Unnamed "Blue Mound"
"	Kansas City	Chanute Sh.	Thayer
"	Marmaton	Bandara Sh	Mulberry (*) (c)
"	Cherokee	Cabaniss	Mulky (*)
	"	"	Unnamed "Stice"
	"	"	Bevier (*) (u) (c)
	"	"	Croweburg (*) (c)
	"	"	Fleming (*)
	"	"	Mineral (*) (c)
	"	"	Weir-Pittsburg (*) (u) (c)
	"	Krebs	Dry Wood (*)
	"	"	Rowe (*)
	"	"	Unnamed
	"	"	Riverton

(*) Important Production.
[1] Formation and informal coal bed names based on Zeller (1968).
[2] If the unnamed coal has a local name, it is shown in quotes.
(c) Coal beds mined commercially in 1989.
(u) >500,000 tons underground production.

recently mined by the Pittsburg and Midway Coal Mining Company at their Midway mine in eastern Linn County. This coal bed was the leading coal bed produced in Kansas during the late 1980's. Prior to the recent extensive mining of the Mulberry coal in these years, the Cherokee Group coals were the main coal beds mined, especially the Weir-Pittsburg coal. Mining of this one coal bed (Weir-Pittsburg) represents nearly half of the total historic coal production in Kansas. Most of the original shallow-depth coal resources of this important coal bed were either stripped or mined by room and pillar methods. Present mining of the Weir-Pittsburg coal bed is by stripping of small areas that remain after the larger mining operations have been completed. Other Cherokee coal beds presently mined include the Mineral, Bevier, and Croweburg coals. Other coal beds mined within the past twenty years include the Mulky, Fleming, Dry Wood, Rowe, and two unnamed coal beds. One of the two unnamed coal beds is

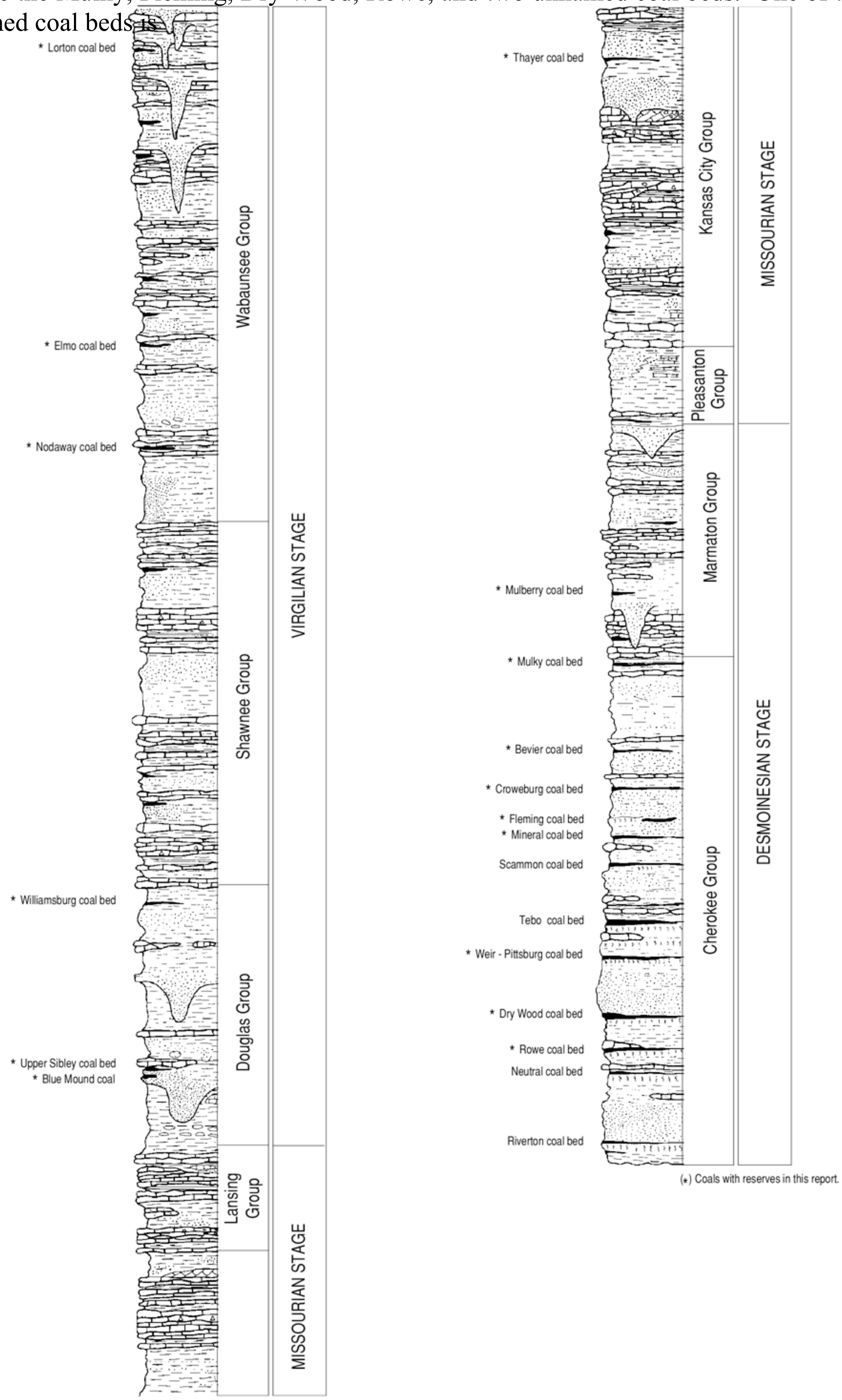
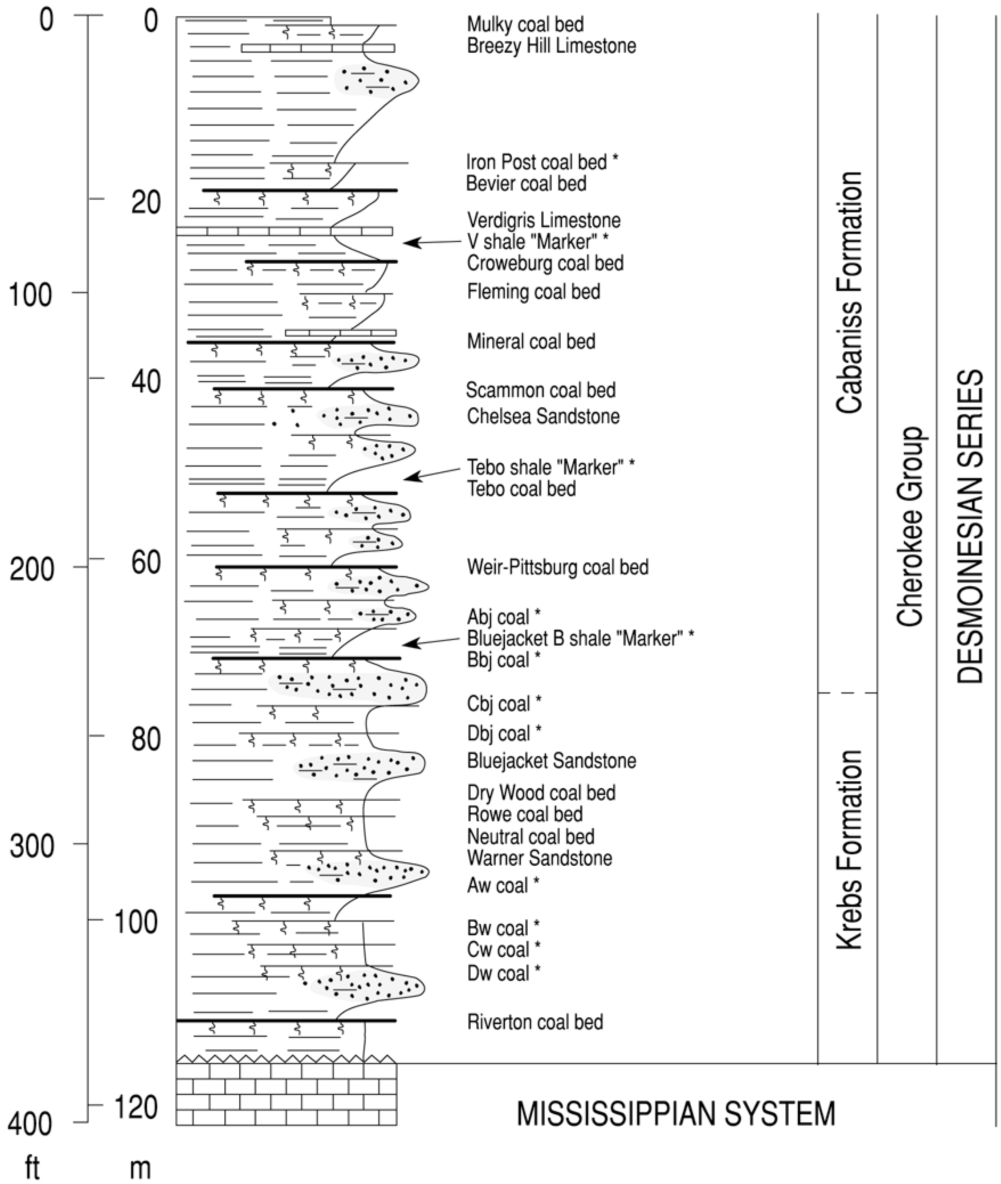


Figure 2. Stratigraphic distribution of coal beds having strippable coal resources in Kansas (modified from Brady and others, 1976, p. 9; and Zeller, 1968).

present above the Bevier coal and the second bed is present below the Neutral coal bed (the "Aw" coal as shown on Figure 3).

When evaluating the strippable coal beds for resource potential, existing recognized coal bed names were used (Zeller, 1968). However, several coal names used were informal local names. When evaluating the deeper coal resources, informal names were used for those coals not recognized in Zeller (1968). These terms have evolved during usage in coal and stratigraphic studies at the Kansas Geological Survey as shown in Figure 3. However, those terms not listed in Zeller (1968) are still strictly informal and eventually more formal terminology will be assigned the important units.



* Coal bed names that are used for correlation purposes, but are not formal or informal names recognized in Kansas.

Figure 3. Stratigraphic column of the Cherokee Group showing formal and working names of coal beds and marker beds in the Kansas part of the Cherokee Group used in this report.

Geologic Group	Coal Bed	Tonnages (million short tons) by Reliability Category					
		0-100 ft Overburden			30:1 Stripping Ratio		
		Measured	Indicated	Inferre	Measured	Indicated	Inferred
Wabaunsee	Lorton	0.1	1.3	6.1	0.1	1.3	2.8
	Elmo	5.9	22.4	222.5	3.6	14.0	44.7
	Nodaway	20.3	87.3	389.6	15.0	58.8	87.9
Douglas	U. Williamsburg	14.7	26.6	40.4	7.7	19.4	8.8
	L. Williamsburg	0.8	3.6	49.2	0.6	2.1	16.2
	Sibley	4.7	12.5	63.6	3.4	8.8	21.3
	Blue Mound	0.9	2.7	3.9	0.5	0.8	1.8
Kansas City	Thayer	1.8	9.1	53.6	1.5	6.1	16.0
Marmaton	Mulberry	59.4	137.4	217.8	30.6	67.1	162.0
Cherokee	Mulky	4.9	12.5	86.6	4.2	10.2	38.4
	Bevier	48.7	118.7	113.6	31.6	54.4	59.6
	Croweburg	9.4	35.6	70.7	6.6	19.2	54.2
	Fleming	14.9	26.8	19.6	3.0	2.7	18.9
	Mineral	120.6	88.5	307.2	53.5	25.7	131.7
	Weir-Pittsburg	29.5	47.6	62.9	10.9	36.0	43.4
	Dry Wood	1.3	6.9	25.0	1.4	6.3	19.9
	Rowe	3.8	16.2	82.9	3.8	15.5	67.7
Total		341.7	655.7	1,815.2	178.0	348.4	794.7

[1] Data modified from Brady and others (1976).

Strippable Resources

Strippable coal resources in Kansas that are present under less than 100 ft (30 m) of overburden total nearly 2.8 billion tons (2.6 billion mt) as is summarized in Table 2. Details of individual coal-bed resources and their reliability category (Figure 4) amounts are also listed in Table 2. A general analysis of the strippable coals, having a stripping ratio (overburden/coal) of 30:1 or less, indicates a total of over 1.3 billion tons (1.2 billion mt) of coal. Minimum thickness of the coals evaluated by Brady and others (1976) was 12 inches (30 cm). Evaluation of the strippable coals in the Brady and others (1976) study shows the importance of the Cherokee Group coals, with the Mulberry and Nodaway coals being the important coal beds higher stratigraphically than the Cherokee Group. Strippable coal resources were determined for 17 different coal beds in 25 counties in eastern Kansas. General areal distribution of the coal resources by stratigraphic group is shown in Figure 5.

Deep Coal Resources

Included in the deep coal resources in this paper are those coals deeper than 100 ft (>30 m). Because of on-going studies of deep coal in Kansas, all figures shown here are considered preliminary. Information used for determining the deeper coal resources for individual coal

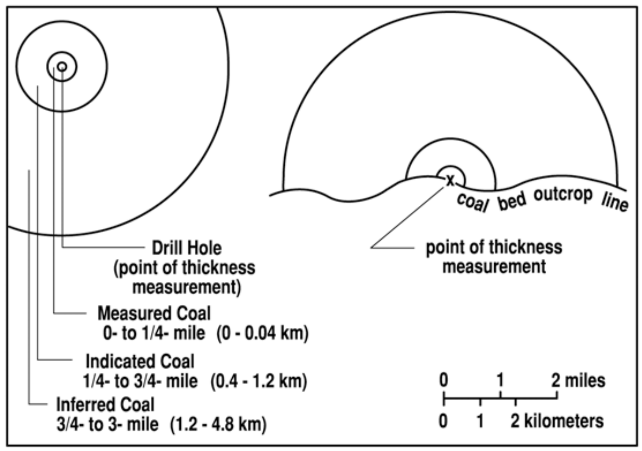
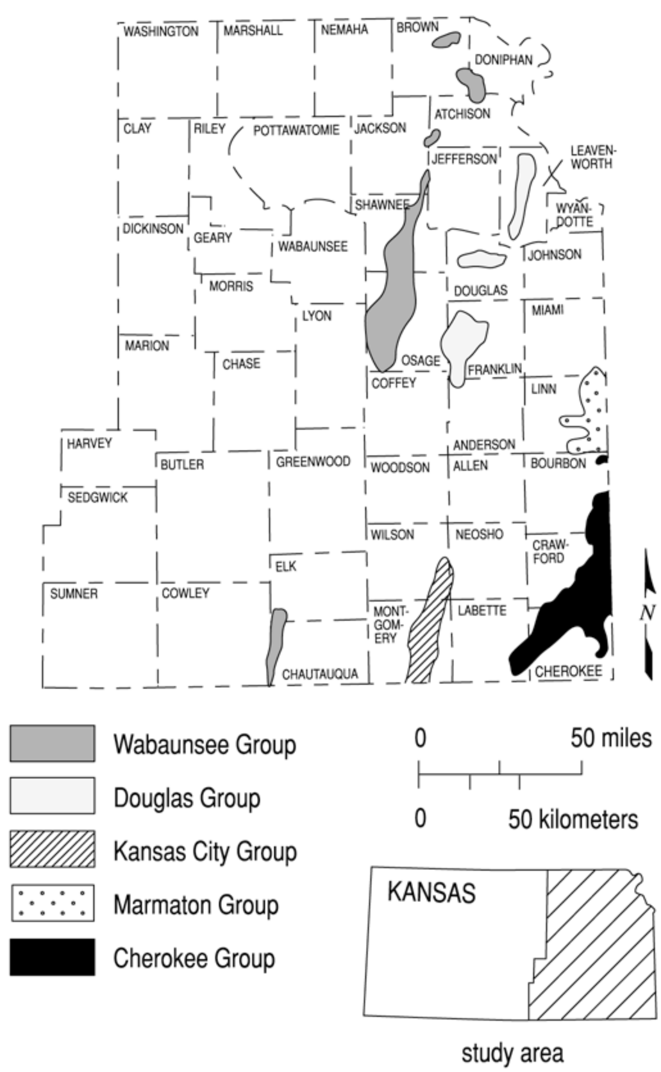


Figure 4. Radius of influence of reliability categories used in coal-resource studies (Modified from Wood and others, 1983, p. 11.)



beds are based, in part, on studies of the stratigraphy in the strip-mining areas of southeast Kansas. This information, using mine and outcrop studies and earlier studies, especially those of Abernathy (1937), Pierce and Courtier (1937), Howe (1956), and Harris (1984), established the stratigraphy of near outcrop and shallow subsurface deposits. This stratigraphy was then extended into the subsurface using studies by Ebanks and others (1977); Livingston and Brady (1981); and later studies by Harris (1984); Harris and others (1985); Killen (1986), Staton (1987), Staton and others (1987) and Brenner (1989).

Deep coal resources were determined from old underground coal mine maps, from deep coal tests by mining companies, and especially from wireline geophysical logs run for oil and gas tests. Gamma ray-density and gamma ray-neutron logs were the logs used for most of the resource estimates.

Methods used for determining coal thickness from the geophysical logs are discussed in Wood and others (1983) and Hoffman and others (1982, p. 125-140). However, it was determined that very thin coals tend to show a greater thickness than the actual coal bed if the inflection point is used for coal-thickness determination. For coal thickness less than 30 inches (0.7 m or less), a coal thickness was determined for coal beds at a point half way between the inflection point and the maximum deflection of the neutron or density line. For coal-bed thickness 30 inches or greater (0.7 m or greater) there is little difference in picking these two points. The inflection point is the usual place for picking the coal thickness as suggested in Wood and others (1983, p. 55-65).

Coal beds can be determined from the geophysical logs by their low density, low neutron count, and for most coals (at least those in Kansas and surrounding areas) low natural gamma ray reading. Indication of coal-bed presence, as shown by gamma ray-density logs illustrated in Figure 6. The left geophysical log shows the low natural gamma radiation of the coal and the log on the right shows the low-density reading of coal.

The highly radioactive shales that give a high reading on the gamma-ray logs are important in the correlation of the different coal beds. These radioactive shales were used as stratigraphic markers and were found to have widespread occurrences (Livingston and Brady 1981; Harris, 1984; Harris and others, 1984; Killen, 1986; Staton, 1987; Staton and others, 1987; and Brenner, 1989, who was an advisor to several students working on these shales at the University of Iowa in the middle and late 1980's). Key marker beds used for stratigraphic correlation are listed on Figure 3, and a profile showing the lateral extent of the major marker beds is shown in Figure 7.

The coal resource quantity for deep coals in eastern Kansas is determined to be about 53 billion tons (48 billion mt) of coal (table 3) measured from 32 different coal beds. These preliminary resource quantities are subject to additional review of data. Emphasis of the deep coal study was on coal beds of the Cherokee Group because of the recognized importance of coal in this geologic group in Kansas. However, six coal beds stratigraphically higher than the Cherokee coals are included in the deep resource total. Considerable undetected coal in the higher coal beds will be further evaluated in later studies.

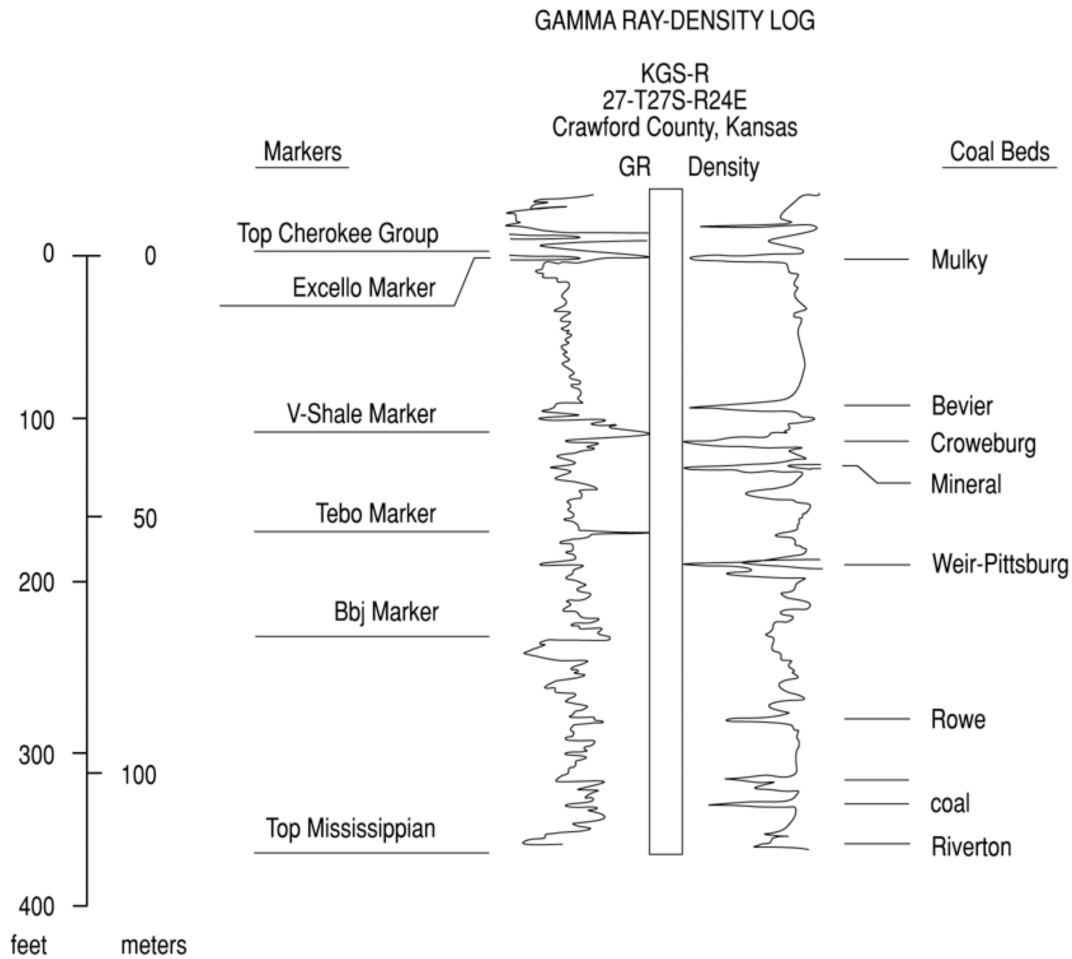


Figure 6. Gamma ray-density log showing response of the main marker beds and coals.

Coal resource quantities are determined to be present within three miles of a known data point (Figure 4) if the coal is considered to be present as defined and described by Wood and others (1983, p. 11). For deep coals, a thickness of 14 inches (>35 cm) or greater is considered in the resource quantity.

Coal beds having the largest resources in Kansas include the Bevier, Riverton, Mineral, "Aw" (unnamed coal bed), and Weir-Pittsburg coals. The distribution of these five coal beds in Kansas are shown in Figures 8A-D and 9. The Weir-Pittsburg coal in Figure 9 was the most important coal produced in the state, with nearly 200 million tons (180 million mt) total. Total coal distribution of those deep coal resources that are 42 inches or thicker (>105 cm) is summarized in Table 4 and their general distribution is shown in Figure 10. Total resource amounts in these thicker coal areas are two billion tons (1.8 billion mt).

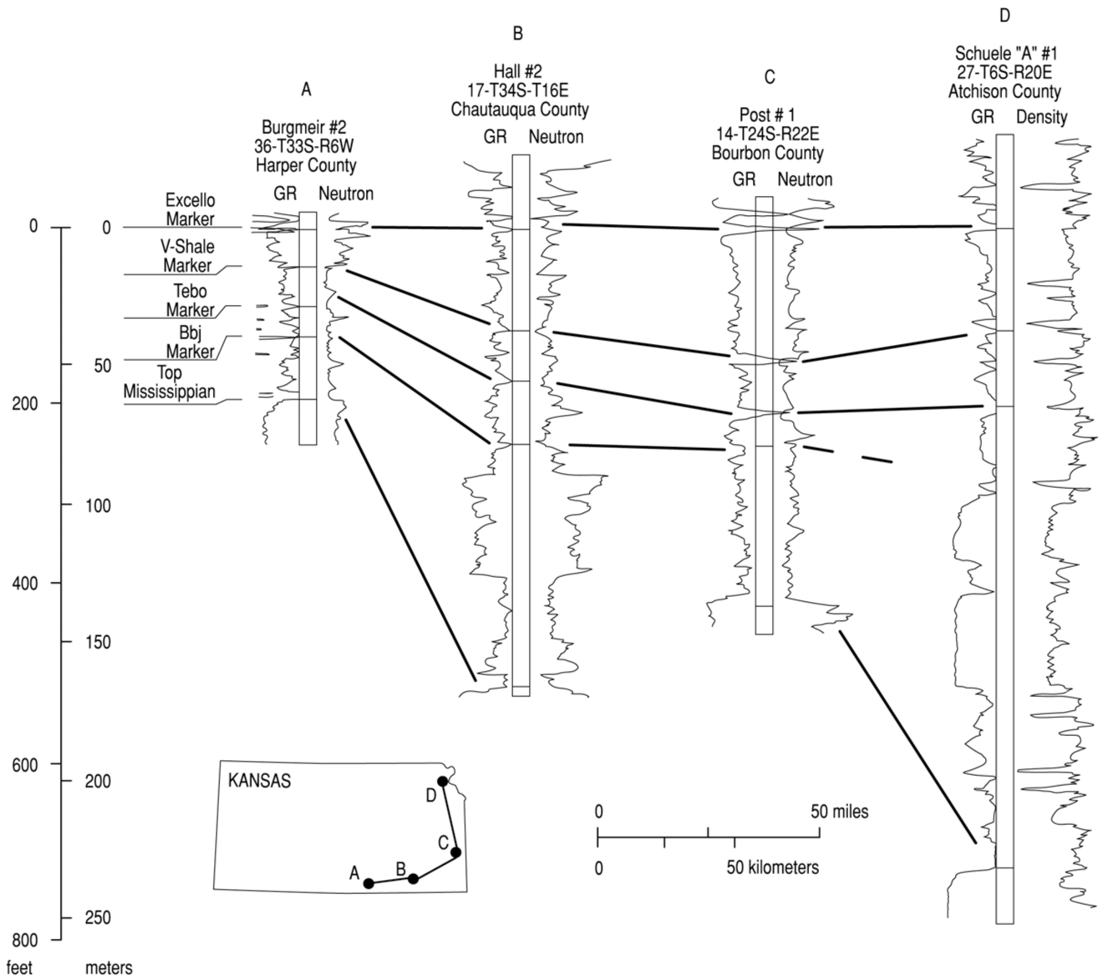


Figure 7. Profile showing distribution of important marker beds in eastern Kansas.

COAL QUALITY

Kansas coal of Pennsylvanian age is all high-volatile bituminous and varies in rank from HvAb to HvCb. Nearly 90 percent of the coal produced in the past was HvAb with most of this coal produced in the southeast Kansas area. Large amounts of high-volatile B and C rank bituminous coal (HvBb, HvCb) were produced mainly from Leavenworth County (Bevier coal produced from deep mines), and Osage County (Nodaway coal produced from strip and deep mines).

Proximate and ultimate analyses of Kansas coals are listed in numerous sources including: Allen (1925), Fieldner and others (1929, p. 30-37), Pierce and Courtier (1938), and Schowe (1946). Recent work that includes proximate and ultimate analyses and also elemental analyses include: Swanson and others (1976), Finkleman and Tewalt (1990), Tewalt and Finkleman (1990), and Brady and Hatch (1990). Studies of Kansas coal, specifically for germanium, was conducted by Schleicher and Hambleton (1954), and Schleicher (1959).

Mineral matter in Kansas coals was discussed as part of a larger study by Hambleton (1953, p. 50-61) on the petrography of the Mineral, Croweburg, and Bevier coals. Detrital minerals determined in the study include quartz, clay minerals, and apatite, with authigenic minerals consisting of calcite, aragonite, pyrite, marcasite, and minor amounts of sphalerite. Hatch and others (1976) and Cobb (1981) discuss the presence of sphalerite in the Mulky, Croweburg, Mineral, and Dry Wood coals. Observations have also been made of sphalerite in the Mulberry coal in east-central Kansas.

A general summary of the chemical quality of strippable coals of southeast Kansas and adjacent areas of southwest Missouri is shown in Table 5. The samples used in this summary were channel samples collected from fresh exposures in coal mines.

Table 3. Preliminary summary of deep coal resources and reliability category in Kansas.

Geologic Group	Coal Bed	Tonnages (million short tons) by Reliability Category			
		Measured	Indicated	Inferred	Total
Douglas	Williamsburg	1	6	109	116
Kansas City	Thayer	3	20	282	305
Pleasanton	"Dawson"	4	33	473	510
Marmaton	Mulberry	11	83	1,158	1,252
"	"Labette B"	19	120	1,381	1,520
"	"Labette C"	2	17	249	268
Cherokee	Mulky	5	31	413	449
"	"Iron Post"	13	82	771	866
"	Unnamed	6	42	433	481
"	Bevier	90	561	5,477	6,128
"	Croweburg	20	141	1,613	1774
"	Fleming13	74	615	702	
"	Mineral	87	540	4,975	5,602
"	Scammon	20	148	1,752	1,920
"	Scammon B"	2	18	158	178
"	Tebo	16	117	1,576	1,709
"	"Tebo B"	1	6	99	106
"	Weir-Pittsburg	73	364	2,616	3,053
"	"Weir-Pittsburg"	5	44	719	768
"	"Abj"	13	91	1,170	1,274
"	"Bbj"	3	23	298	324
"	Dry Wood	4	31	413	448
"	Rowe	35	258	3,135	3,428

"	Neutral	3	26	420	449
"	"Neutral B"	0	2	23	25
"	"Aw"	49	381	4,579	5,009
"	"Bw"	15	109	1,330	1,454
"	"Cw"	29	228	2,862	3,119
"	"Dw"	15	114	1,446	1,575
"	Unnamed	2	17	175	194
"	Riverton88	654	7,225	7,967	
"	Unnamed	5	40	516	561
TOTAL		652	4,421	48,461	53,534

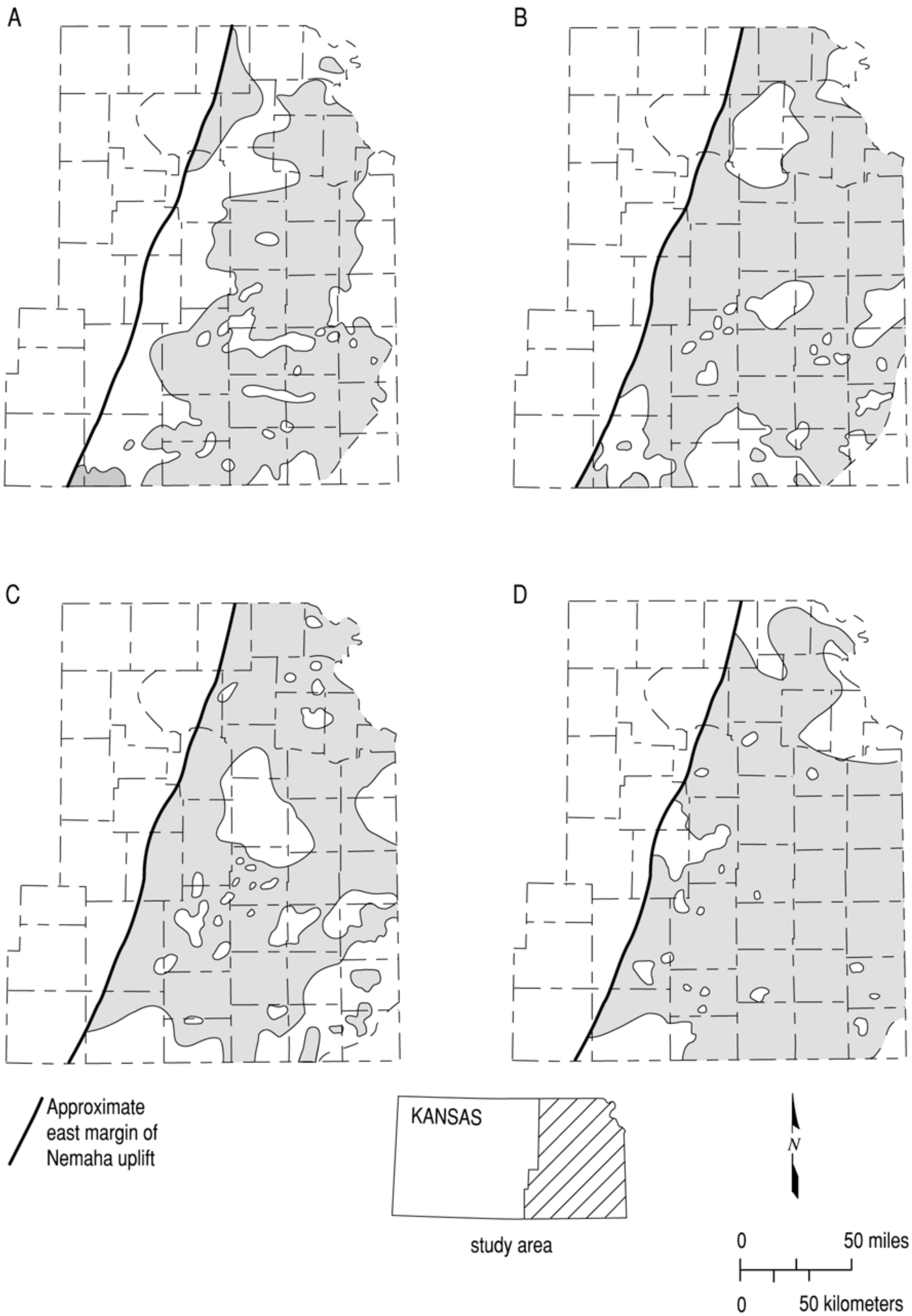


Figure 8. General distribution of four important deep coal beds—Bevier (A), Mineral (B), “Aw” (unnamed coal) (C), and Riverton (D) in eastern Kansas with thickness of 14 inches (35 cm) or greater that are under 100 feet (30 m) or more of overburden.

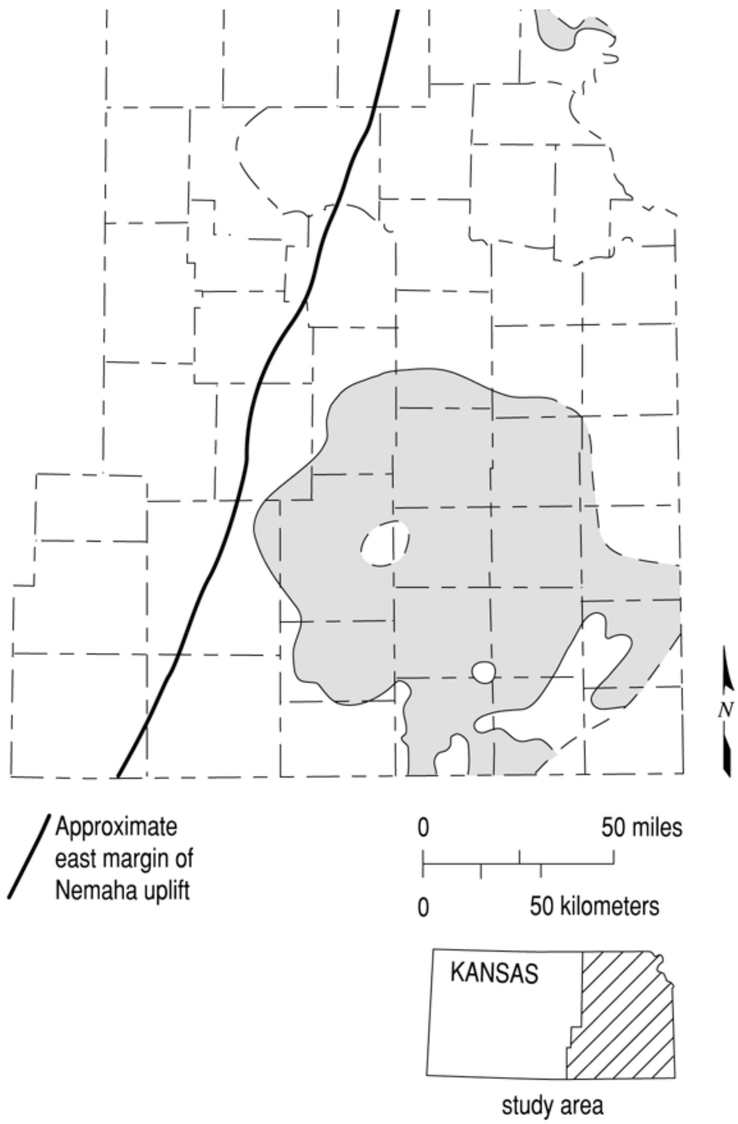


Figure 9. General distribution of the Weir-Pittsburg coal bed in eastern Kansas having a thickness of 14 inches (35 cm) or greater that underlies 100 feet (30 m) or more of overburden. The Weir-Pittsburg coal was the most important coal bed mined in Kansas.

POTENTIAL USES

Coals mined in Kansas have had many uses in the past. Early coal was used for steam generation in railroad locomotives, heat for smelters, cement manufacture, and home and industrial heating. Other uses included coke production, brick and tile manufacturing, and other types of industrial manufacturing.

TABLE 4. Preliminary estimate of deep coal resources (≥100 ft) in eastern Kansas of beds ≥42 inches by county and reliability category

Coal	County	Resource total (million short tons)			
		Measured	Indicated	Inferred	Total
Dawson	Allen	2	12	88	102
	Coffey	2	17	285	304
Mulberry	Osage	1	7	86	94
Bevier	Allen	2	11	16	29
	Bourbon	-	1	34	35
	Neosho	2	13	11	26
Weir-Pittsburg	Cherokee	1	9	61	71
	Crawford	1	8	36	45
	Elk	1	9	139	149
	Greenwood	1	7	102	110
	Labette	12	40	84	136
	Montgomery	6	39	259	304
	Wilson	-	-	59	59
Rowe	Atchison	1	5	39	45
"Aw"	Atchison	1	5	59	65
	Doniphan	2	13	38	53
Riverton	Elk	2	15	149	166
	Montgomery	-	1	26	27
	Neosho	2	16	161	179
	Wilson	-	-	1	1
TOTAL		39	228	1733	2000

Present use of Kansas coal is almost exclusively power generation and cement manufacture (Table 6). However, small amounts of coal are still used for other industrial purposes such as lightweight aggregate manufacture and for home heating.

At the present time, power generation is the dominant end-use of coal in Kansas, with nearly 15 million tons (13.6 million mt) used for that purpose (Table 6). Concern by state and federal regulatory authorities over the SO_2 and NO_x content of gases emitted from the power plants has resulted in a demand for low-sulfur coals for use in new power-generating plants. This low-sulfur demand has been met by use of Wyoming coal. Some power plants equipped with scrubber systems are using local Kansas or Missouri coals. However, tighter controls on the SO_2 emissions is now forcing some of these plants to consider blending with lower sulfur coals to meet these new standards. With the Kansas coals having a medium-to-high sulfur content and also the thin-bedded coal beds (12-36"; 30-91 cm) of Kansas resulting in a high mining cost, the present Kansas coal market is shrinking rapidly.

What potential exists for use of Kansas coals in the near future? Perhaps the biggest hope lies in the use of fluidized bed combustion for power generation in smaller power-generation plants or industrial plants. This new technology should provide some direct benefits to the Kansas coal industry. A second possibility, and perhaps of a more immediate use, is the production of methane gas from deep coal beds.

Fluidized Bed Combustion

Interest has greatly increased in recent years in the use of fluidized bed combustion technology. The important factors of these systems are high combustion efficiency, sulfur

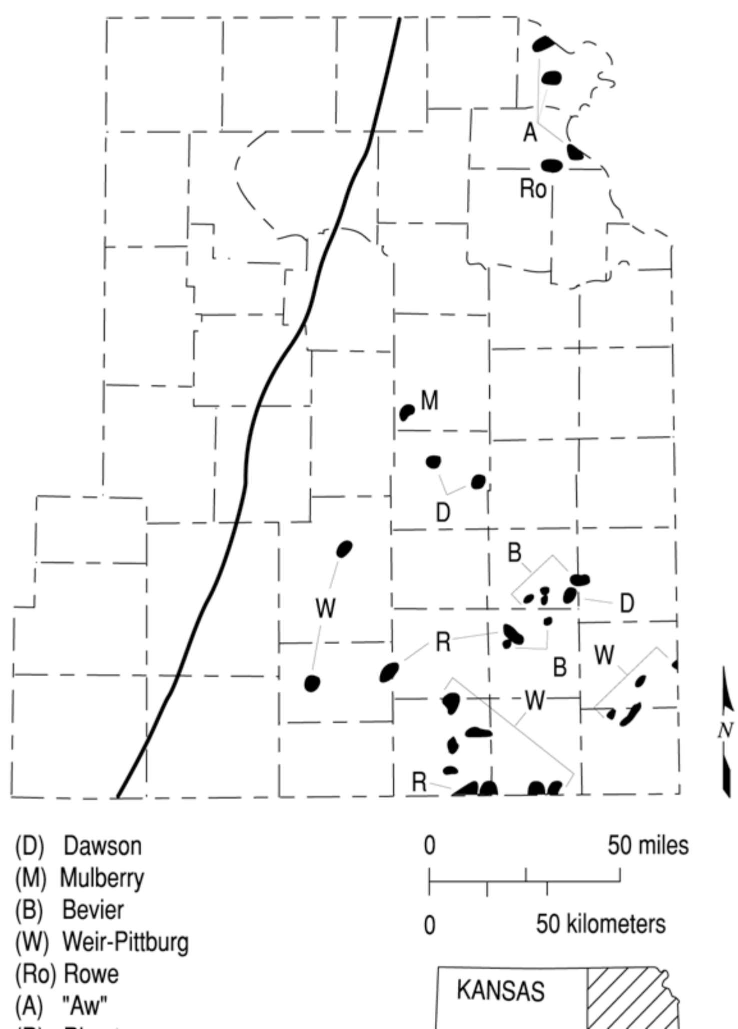


Table 5. Mean values of proximate energy and sulfur values for individual coal beds in southeast Kansas and southwest Missouri

Coal	n	Moisture %	Volatile Matter %	Fixed Carbon %	Ash	BTU %	kcal/kg	Sulfur %	Sulfur: Sulfate %	Sulfur: Pyritic %	Sulfur: Organic %
Thayer	2	6.8	33.7	41.3	18.3	10,675	5,930	3.9	.53	2.29	1.08
Mulberry	3	6.8	32.3	39.4	21.4	10,310	5,730	4.5	.45	2.35	1.73
Mulky	5	3.0	38.3	47.4	11.4	12,695	7,050	4.6	.23	2.10	2.28
Bevier	2	3.9	36.1	48.6	11.5	12,250	6,810	2.7	.34	1.22	1.15
Croweburg	7	3.4	35.4	44.2	17.2	11,677	6,490	4.5	.35	3.21	.91
Fleming	3	4.6	36.4	43.0	16.0	11,857	6,590	4.9	.60	2.97	1.29
Mineral	5	4.1	35.1	47.1	13.6	12,219	6,790	4.7	.42	2.92	1.22
Dry Wood	5	2.6	32.0	46.1	19.3	11,518	6,400	7.3	.45	5.59	1.27
Rowe	8	2.8	33.8	46.1	17.4	11,757	6,530	7.6	.41	5.99	1.20
"Aw"	1	3.3	31.2	50.4	15.1	12,060	6,700	4.1	.36	3.17	.57

Data from Wedge and Hatch (1980), Swanson and others (1976, p. 279-287), and Brady and Hatch (1990).

emission control, and the flexibility to use a wide range of fuels (Nechvatal, 1988, p. iii). The primary advantage of using fluidized bed boilers for Kansas coals would be the large reduction of sulfur oxides and nitrogen oxide emissions during combustion as compared with conventional coal-fired boilers in power plants.

A typical design has a bed of limestone and coal within the boiler that is supported by a bar grate through which air is blown. The coal and limestone are lifted and suspended by the air allowing the bed to act like a fluid. The high velocity of the air results in bubbles passing through the bed. These air bubbles evenly mix the bed resulting in rapid heat distribution. At any given time, the bed contains less than 5 percent coal. The sulfur oxides are captured by the limestone in the bed with the optimum sulfur oxide absorbtion by the limestone between 850°-900°C (Valk, 1986, p. 7).

The fluidized bed combustion boiler can use high-sulfur coal as well as other fuels. The sulfur dioxide is captured by the limestone bed and the combustion temperatures are below the ash melting point so that solids accumulation and boiler tube erosion and corrosion are minimized. Flue gas clean-up requires only particulate removal (Office of Fossil Energy, 1987, Appendix A, p. A-18-21).

This type of power plant, although still in smaller size designs (up to approx. 150 MW), will be important in the use of high-sulfur coals because of its pollution-abatement potential. Cost rather than air-pollution concern would be the primary factor governing fuel use. Kansas coal should then be able to compete favorably with fuels from other states for the eastern Kansas markets where the fluidized bed combustion boilers are anticipated to be installed.

Methane from Coal

Methane is present in large amounts in certain ranks of coal. For years this fact has been considered a major problem in deep coal mines because of the potential for explosions. In recent years, utilization of the methane from coal has become important as a commercial gas source. In areas of the San Juan basin in New Mexico and Colorado and parts of the Warrior basin in Alabama, large amounts of methane are presently being developed.

Medium-volatile bituminous coal is the ideal rank for methane to be present in large quantities. High-volatile A bituminous coal that is present in southeast Kansas and adjacent areas is slightly lower in rank, but still has potential to release large quantities of methane. If sufficient overburden is present over the coal and a seal, such as a thick shale, overlies the coal bed to prevent loss of the methane, then methane of possible economic quantities could be present.

In areas where the coal is deeper than 500 feet (150 m), the coals probably retain a large amount of methane. Drilling and artificial fracturing of the thicker coal beds or multiple coal beds could produce significant amounts of the gas. Stoeckinger (1989) has measured and reported a gas content of 220 cubic feet per ton (6900 liters per mt) from a core sample of the Weir-Pittsburg coal bed in Montgomery County (Table 7). Other coal beds reported by Stoeckinger (1989) have also given good indication of large methane content. Recent developments in Kansas at recovering coalbed methane, as reported by the Oil and Gas Journal (1990, p. 70), shows good promise for this new gas source. Future study and testing of this possible methane resource could result in a new industry for the state and additional benefits for the Kansas coal resource.

Table 6. Coal received in Kansas for 1987, 1988.

	1987		1988
Coal received (million short tons)	15.4	14.3	
Use			

Electric Utilities	98.4%	99.0%
Industrial Plants	1.6	1.0
Residential and Commercial	<0.01	<0.01
Coal Source		
Wyoming	84%	91%
Kansas (est.)*	10 4	
Illinois	3 4	
Missouri (est.)*	2 <1	
Oklahoma (est.)*	1 1	

Information Source—
Coal Distribution, Energy Information Administration (1988), p. 56.
Coal Distribution, Energy Information Administration (1989), p. 88.

* Estimate based on other sources because the Energy Information Administration combines portions of these three states into one coal district.

Table 7. Volume of desorbed gas (mainly methane) determined in test canisters from selected wells in southeast Kansas.*

Location	Depth ft	Coal	Thick ft	Volume Desorbed Gas cf/ton	Remarks
3-T27S-R15E Wilson Co.	865	Mulky	1.5	174-197	Drilled chips
3-T27S-R15E Wilson Co.	1200	Riverton	3.0	186	Clean core
7-T31S-R16E Montgomery Co.	970	Weir-Pittsburg	5.0	220	Good gas flow when drilled

- Data from Stoeckinger (1989).

ACKNOWLEDGMENTS

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COALBED METHANE OPERATIONS OF
DART CHEROKEE BASIN OPERATING COMPANY, LLC

Sycamore, Kansas

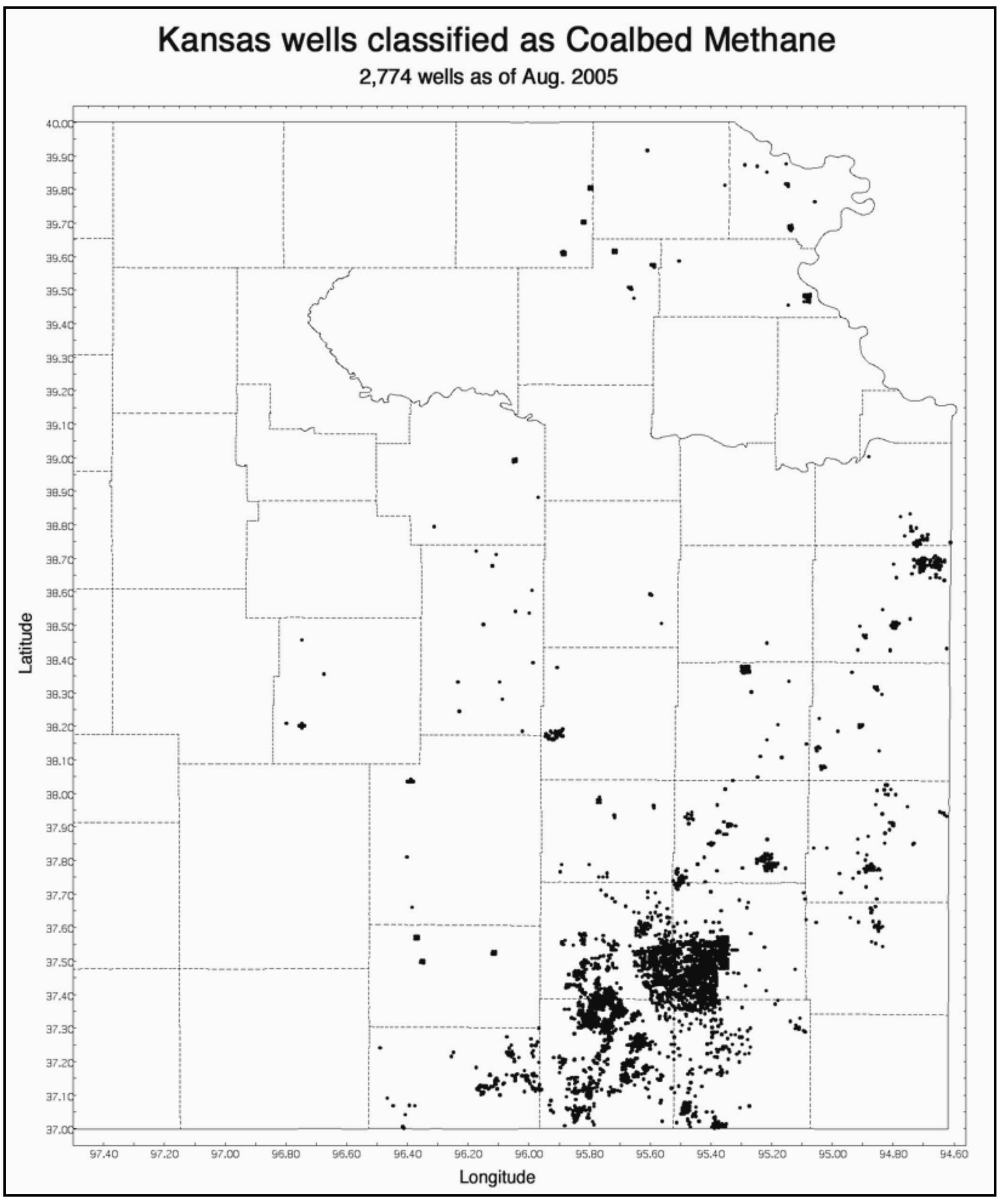
Michael Murphy—District Manager

Mr. Murphy will provide an overall review of their Kansas operations and go over their system map. We will observe some of their coalbed methane wells, possibly some of their drilling operations, and their N. Williams Compressor Facility.

In their operations, the main coals are the Riverton, Weir-Pittsburg, Rowe, and where developed the Mulky coals. In addition, they also develop other coals where economical in the Cherokee Group including the Croweburg, Mineral, and Tebo.

Figure 1. A Dart Cherokee Basin Operating Co. coal gas well located east of company field office near Sycamore (Montgomery Co.), Kansas.

Figure 3. Dehydrator tower used by Dart Cherokee Basin Operating Co. to remove moisture, and minor impurities from the coal gas prior to passing through the Tallman Compressor Station. The tower is adjacent to the Tallman compressor.



Kansas wells classified as Coalbed Methane
2,774 wells as of Aug. 2005
Latitude
Longitude
40.00
39.90
39.80
39.70
39.60
39.50
39.40
39.30
39.20
39.10
39.00
38.90
38.80
38.70
38.60
38.50
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37.00
97.40
97.20
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95.40
95.20
95.00
94.80
94.60

D. Adkins-Heljeson

KANSAS COAL AND COALBED METHANE—AN OVERVIEW*

Lawrence L. Brady and K. David Newell
Kansas Geological Survey
Lawrence, Kansas

INTRODUCTION

Bituminous coal resources of Middle and Upper Pennsylvanian age are widespread in eastern Kansas and represent nearly all the coal resources in the state. These coal beds have been exploited for over 160 years with a total recorded production of approximately 300 million tons. Peak production for Kansas coal was during World War I (1918) with 7.3 million tons.

Exploration and development of natural gas from coal beds in areas such as the Warrior basin in Alabama, San Juan basin in Colorado and New Mexico, Raton basin in Colorado, and the Powder River basin in Wyoming and Montana have increased interest in other coal areas, especially in eastern Kansas following the success of coalbed methane development in northeastern Oklahoma. Earlier developments of coalbed methane in southeast Kansas in the late 1980's and early 1990's—mainly in Montgomery, Wilson, and Labette counties, has shown the potential for developments in other portions of eastern Kansas This resulted in the review of existing data and information by many companies and consultants resulting in extensive leasing in both the Cherokee basin of southeast Kansas and the Forest City basin in east-central and northeast Kansas.

Deep coal resources are recognized for 32 coal beds, and strippable coal resources have been determined for 17 coal beds. At the present time, six coals stratigraphically higher than the Cherokee Group also are included in the deep coal resource total. However, the deep bituminous coal resources—primarily of the Cherokee Group appear to provide the best potential for present and future development of coalbed methane in Kansas. Important to the early coalbed methane development in southeast Kansas in the late 1980's and early 1990's was the Section 29 federal tax credits for development of this unconventional gas source. The recent interest has developed due to the increase in price of natural gas, a recognized Kansas petroleum industry infrastructure including major pipelines through eastern Kansas, primarily fee lands, and a coal resource that suggests potential development of that resource at an economic cost.

Gas content for coal cores obtained from a well from Montgomery County, in the middle of the developing coalbed methane area in southeastern Kansas, is shown in Figure 6 (from Newell and others, 2004). Deeper coals in the Cherokee Group, specifically the Weir-Pittsburg and Riverton coals, have gas contents (as received, not including residual gas) ranging from 150-250 scf/ton. Shallower coals generally have lesser gas content. To date, the maximum gas content recorded in southeastern Kansas from 250 desorption tests ran by the Kansas Geological Survey is 346 scf/ton for a Rowe coal at 1400 ft depth.

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*Modified from Brady, L. L., and Newell, K. D., 2004, Kansas coal and coalbed methane—an overview, in Overview of coal and coalbed methane in the Cherokee basin, northeast Oklahoma: Fieldtrip guidebook for the First Coalbed Methane Symposium, Tulsa, Oklahoma, November, 9, 2004, Oklahoma Geological Survey and Kansas Geological Survey, p. 97-116. (Available as Kansas Geological Survey Open-file report 2004-49).

DEEP COAL RESOURCES AND STRATIGRAPHIC POSITION OF COAL BEDS

When evaluating the deeper coal resources, informal terms and names were used to identify unnamed coals and certain key marker beds, especially in the Cherokee Group. Many of these coal names are formally recognized in Zeller (1968), and Baars and Maples (1998), but several of the coals and most of the "black shale" marker beds in the Cherokee Group are not listed. These terms have evolved during usage in coal and stratigraphic studies at the Kansas Geological Survey as shown in Figure 1. Informal names used in Kansas for some coals do not correspond with the stratigraphic nomenclature of adjacent states, but most of the important coal beds do correlate and maintain the same coal names used in western Missouri and northeast Oklahoma.

Stratigraphy of the deep coal beds, especially of the Cherokee Group, was determined and developed from mine and outcrop studies, especially those of Abernathy (1937), Pierce and Courtier, (1938), Howe (1956), and Harris (1984), all of whom helped established the Kansas stratigraphy of the Cherokee Group in outcrop and shallow subsurface studies. These stratigraphic units and their relations were extended into the subsurface by various workers including Ebanks and others (1977), Livingston and Brady (1981), Harris (1984), Killen (1986), Staton (1987), Brady and Livingston (1989), Brenner (1989), Huffman (1991), and Walton (1996). Recent major studies of coal distribution and thickness in the deeper subsurface are by Lange (2003) and Johnson (2004).

Deep coal resources in eastern Kansas determined in earlier studies (Brady and Livingston, 1989; Brady, 1990, 1997) using USGS coal resources criteria (Wood and others, 1983) amount to a conservative total of 53 billion tons of coal (Table 1) measured from 32 different coal beds using information from 600+ geophysical logs, numerous drillers logs from coal exploration wells, and continuous cores. Of this total, an estimated 45 billion tons of resources are from coals in the 14 to 28 inch thickness range; 6 billion tons in the 28-42 inch range; 1.9 billion tons in the 42-56 inch range; and 0.14 billion tons for coal resources exceeding 56 inches in thickness. Nearly all of these resources were determined for coal at depths less than 2500 feet, but based on recent drilling coals are known to be present in deeper parts of the eastern Kansas basins to depths of at least 3000 feet. Emphasis of the deep coal resources was on coal beds of the

Cherokee Group because of the stratigraphic importance of the coal in this group in Kansas. However, six coal beds stratigraphically higher than the Cherokee Group are included in the deep coal resource total.

Most of the data points for the resource study are located in the Kansas portion of the Cherokee basin in southeast Kansas and the area of the Bourbon arch (a low divide between the Forest City and Cherokee basins). A coal resource of 37 billions tons that was determined for this generalized Cherokee basin area and the resource is represented by 31 coal beds. Of these coals, 25 are in the Cherokee Group. A coal resource of 16 billion tons was determined for the Kansas portion of the Forest City basin. In the Forest City area, 27 coals are represented in the resource figure, and of these coals, 23 coals are part of the Cherokee Group or older Middle Pennsylvanian rocks. Due to the 3-mile limit on resource determination and the limited amount of geophysical logs used in eastern Kansas for the coal resource analysis, a much larger coal quantity probably exists than is listed in the resource totals. Coal beds having the largest deep resources in Kansas include the Bevier, Riverton, Mineral, "Aw" (unnamed coal bed), and the Weir-Pittsburg coals. Recent studies by Lange (2003) and Johnson (2004), and on-going work at the Kansas Geological Survey, suggests that much larger coal resource totals probably exist in eastern Kansas. This is based mainly on new drilling in areas lacking drill data which has shown general continuity of the principal coal beds.

Many of the highly radioactive “black shales” that commonly are present a few feet above a coal bed in a typical Kansas cycle give a high γ reading on the gamma-ray logs. The distinctive characteristics of these shales are important in the correlation of the different coal beds. These radioactive shales are used as stratigraphic markers and were found to have widespread occurrences (e.g. Ebanks and others, 1977; Livingston and Brady, 1981; Harris, 1984; Killen, 1986; Staton, 1987; and Huffman, 1991). Important marker beds with widespread readily identifiable signatures are the Anna Shale and Little Osage Shale in the Marmaton Group (overlies the Cherokee Group), and the Excello Shale, “V-shale marker”, “Tebo marker”, and the “Bjb marker”. Other more local shales such as the “Mineral marker”, “Scammon marker”, and “Weir-Pittsburg marker” are important in limited areas—primarily in the Cherokee basin and southern Forest City basin.

COAL QUALITY

Kansas coal of Pennsylvanian age is all of apparent high-volatile bituminous rank. Nearly 90 percent of the coal mined in the past was of apparent high-volatile A bituminous rank, with most of this coal produced in southeastern Kansas in Crawford, Cherokee, and southern Bourbon counties. Large amounts of high-volatile B bituminous coal were produced in Leavenworth County (Bevier coal of the Cherokee Group produced from deep mines at depths of 700-750 feet). Proximate and ultimate analyses of Kansas coals are listed in numerous sources including: Young and Allen (1925) and Fieldner and others (1929, p. 30-37). Recent work that includes proximate and ultimate analyses and elemental analyses include: Swanson and others (1976), Tewalt and Finkelman (1990), Finkelman and others (1990), Bostic and others (1993), and Brady and Hatch (1997).

Vitrinite reflectance values for coals in eastern Kansas is presented along with other maturity indexes by Newell (1997, p. 23) in his paper on thermal history in Kansas. However, care must be taken in considering coal rank from the vitrinite measurements in

Kansas because apparent coal rank determined from proximate and Btu values for the coals indicates a higher rank than is suggested by the vitrinite reflectance values. This suggests possible suppression of the vitrinite reflectance values.

Gas content data for eastern Kansas is sparse, but preliminary information indicates that the gas content (scf/ton) for most coals varies over short distances and even with separate samples for the same coal in a given well. Nevertheless, generally there is a decrease in gas content northward toward the Bourbon arch and eastward toward the outcrop. The northward increase is likely due to an overall northward decreasing maturation in eastern Kansas, which is reflected in maturation measurements made on shale samples from oil and gas wells (see Newell, 1997; Hatch and Newell, 1999; Newell and others, 2002, 2004). The eastward decrease is likely due to lower confining pressure due to shallower overburden and possibly lesser maturity.

METHANE FROM COAL

Drilling and fracturing of the thicker coal beds or multiple coal beds at depth does produce large amounts of the gas from multiple coal beds in southeast Kansas, and also east-central parts of the state. By August 2004, there were nearly 1800 wells drilled for coalbed methane in eastern Kansas (Adkins-Heljeson, and others, 2004), with an estimated 1000 coalbed methane producing wells in the state (generalized in Figure 2). (By May 2005, about 2500 wells were drilled for coalbed methane.) Most of these wells in eastern Kansas have been drilled since 2000, with the number of wells per year continuing at a rapid pace (Figure 3; from Newell and others, 2004). Production is largely concentrated in a five-county area in southeastern Kansas, including Montgomery, Neosho, Wilson, Labette and Chautauqua counties. Concomitant with this drilling effort, coalbed gas production in southeastern Kansas has markedly increased in the last decade, and is now approaching 10 bcf/year (Figure 4; from Newell and others, 2004). The production rise is expected to continue for the next few years. Southeastern Kansas coalbed gas wells hit their peak gas production from 12 to 36 months after their initial production (Figure 5, from Newell and others, 2002, 2004). A long and gradual decline follows.

Several coalbed gas pilot projects have been initiated farther north in eastern Kansas on the Bourbon arch and Forest City basin, but the economic viability of these pilot projects has yet to be determined. Similarly, westward expansion of production westward to the axis of the Cherokee and Forest City basins has yet to happen. Coal thickness, gas content, and dewatering behavior of the wells is largely unknown for this region. One outpost of commercial development, by Osborn Energy, is present just south of the Kansas City metropolitan area in southern Johnson/northern Miami counties. This area is on the broad, shallow southeastern flank of the Forest City basin.

Gas content for coal cores obtained from a well from Montgomery County, in the middle the developing coalbed methane area in southeastern Kansas, is shown in Figure 6 (from Newell and others, 2004). Deeper coals in the Cherokee Group, specifically the Weir-Pittsburg and Riverton coals, have gas contents (as received, not including residual gas) ranging from 150-250 scf/ton. Shallower coals generally have lesser gas content. To date, the maximum gas content recorded in southeastern Kansas from 250 desorption tests run by the Kansas Geological Survey is 346 scf/ton for a Rowe coal at 1400 ft depth.

Farther north on the flanks of the Forest City basin in Miami County, gas content for a well in Miami County is less than for the same coals buried almost as deep as they are in Montgomery County (Figure 7). Gas content data from Johnson (2004) shows that coals on the Bourbon arch and southeastern Forest City basin have gas contents (as received, not including residual gas) not exceeding 143 scf/ton.

The coals in the well in Montgomery County are buried less deeply in Labette County (the county immediately east), for Labette County is higher on the flank of the Cherokee basin and closer to the outcrop (Figure 8; from Newell and others, 2004). Some of these coals have only half the gas content they have in Montgomery County 15 miles to the west. The gas contents in Labette County, based on this one well, are considerably less than the Montgomery County coals. However, the Iron Post coal at 382 ft (116 m) depth in the Labette County well has an unexpectedly high gas content (144 scf/ton), exceeding that of the deeper coals in the same well.

A microbial or mixed thermogenic-microbial origin for this Iron Post gas is suggested (Newell and others, 2004). Pennsylvanian coal-bearing units crop out at the surface in Cherokee County (the county immediately east of Labette County). Downdip movement of fresh water from the outcrop may augment biogenic production of coalbed gas in shallow coals along the eastern flank of the Cherokee and Forest City basins. A possible consequence to this model is that separate thermogenic and biogenic production fairways in the same coal may be present. The thermogenic fairway would be deeper in the basin where there is sufficient burial and confining pressure. The biogenic fairway would be updip and closer (and likely parallel) to the outcrop where basinal brines would be diluted by meteoric waters carried downdip from the outcrop. Coals with unusually high gas content for their relatively shallow depth in eastern Kansas could constitute tantalizing economic targets, but considerably more testing needs to be done to identify these types of production fairways.

SOUTHEAST KANSAS COAL AND ITS RELATIONS TO COAL AT FIELD TRIP STOPS

Coal beds observed on the Oklahoma field trip (Cardott and others, 2004) at the Phoenix Coal Company Alluwe Mine (Sec. 33, T.25N., R.17E., Nowata Co., OK--Iron Post coal) and their Kelley Mine (Sec. 19, T.25N., R.25N. R.18E., Craig Co., OK--Croweburg coal) continue northward into Kansas. The Mulky coal (not observed at either mine) is commonly located just below the "black" Excello Shale (also observed at the Alluwe Mine) and also continues northward into Kansas. Distribution and thickness of these three coals in southeast Kansas are shown in Figures 9, 10, and 11, as mapped by Lange (2003).

Gas from coals produced at the Amvest Osage Inc. #32 well (Sec 26, T.20N., R.11E., Osage Co., OK) include the Rowe, Bluejacket, Weir-Pittsburg, Tebo, and Mineral coals. Lange (2003) mapped the distribution and thickness of the Weir-Pittsburg, Tebo, and Mineral coals as shown in Figures 12 through 14. Of those five coals in the Amvest well, the Weir-Pittsburg is the most important coal in Kansas and represents a significant portion of the southeast Kansas coalbed methane production. Also shown is the Riverton coal (Fig. 15) mapped by Lange (2003)—which is another important widespread coal for coalbed gas production throughout southeastern Kansas and other areas of the state.

SUMMARY

Kansas has a coal resource base that exceeds 50 billion tons that is widespread in the eastern one-fourth of the state. That resource base is determined primarily from evaluation of 600+ geophysical wells, and also driller's logs for coal exploration, and limited continuous cores. Therefore, a large amount of coal present is not included in those resource figures. New isopach mapping of key coal beds is presently underway at the Kansas Geological Survey. Most of the coal resource lies at a depth of less than 2500 feet.

Estimated coalbed in-place gas resource of the Bourbon arch region in east-central Kansas is 2.1 tcf (Johnson, 2004). Coals in the Cherokee basin in southeastern Kansas, in general, are thicker, more extensive, and have higher gas content. An assessment of the Cherokee basin coalbed gas resource by Lange (2003) places this resource base at 6.6 tcf.

Based on coal chemistry, the rank of the coals is high volatile bituminous, with the coal ranging generally from high-volatile A bituminous in southeastern Kansas to high-volatile B and C bituminous in the central and northern areas of eastern Kansas. Because of the cyclic nature of coals and associated rock units in the Pennsylvanian rock column, especially in the Cherokee Group, multiple coal beds (up to 14 coals) could be encountered in a given well drilled through the Pennsylvanian section. The main problem to solve is locating coals with sufficient thickness to provide the quantities of gas needed for economical development. Most of the individual Kansas coal beds making up the resource are less than 28 inches thick, but in some places coal beds exceed five feet in thickness. Early desorption in southeastern Kansas shows some coals having values up to 343 cubic feet of gas/ton of coal. Many gas pipeline networks are in place, and Kansas has recognized disposal zones for the formation waters. With all of the given factors considered, Kansas represents an important area for present and future coalbed methane exploration and development.

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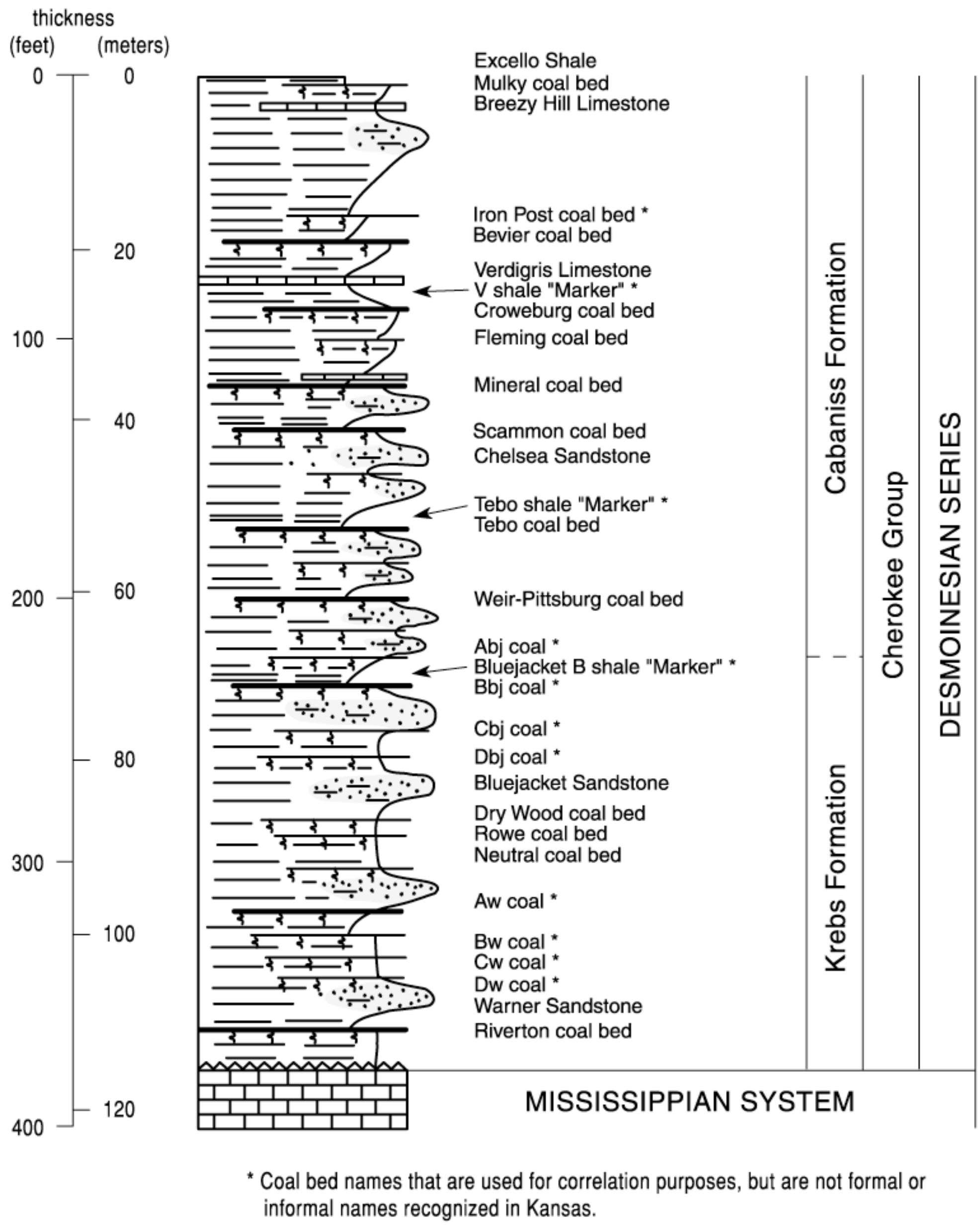

Figure 1. Composite section of the Cherokee Group in southeastern Kansas showing relations of marker beds and coal beds. Modified from Harris, 1984, p. 30.

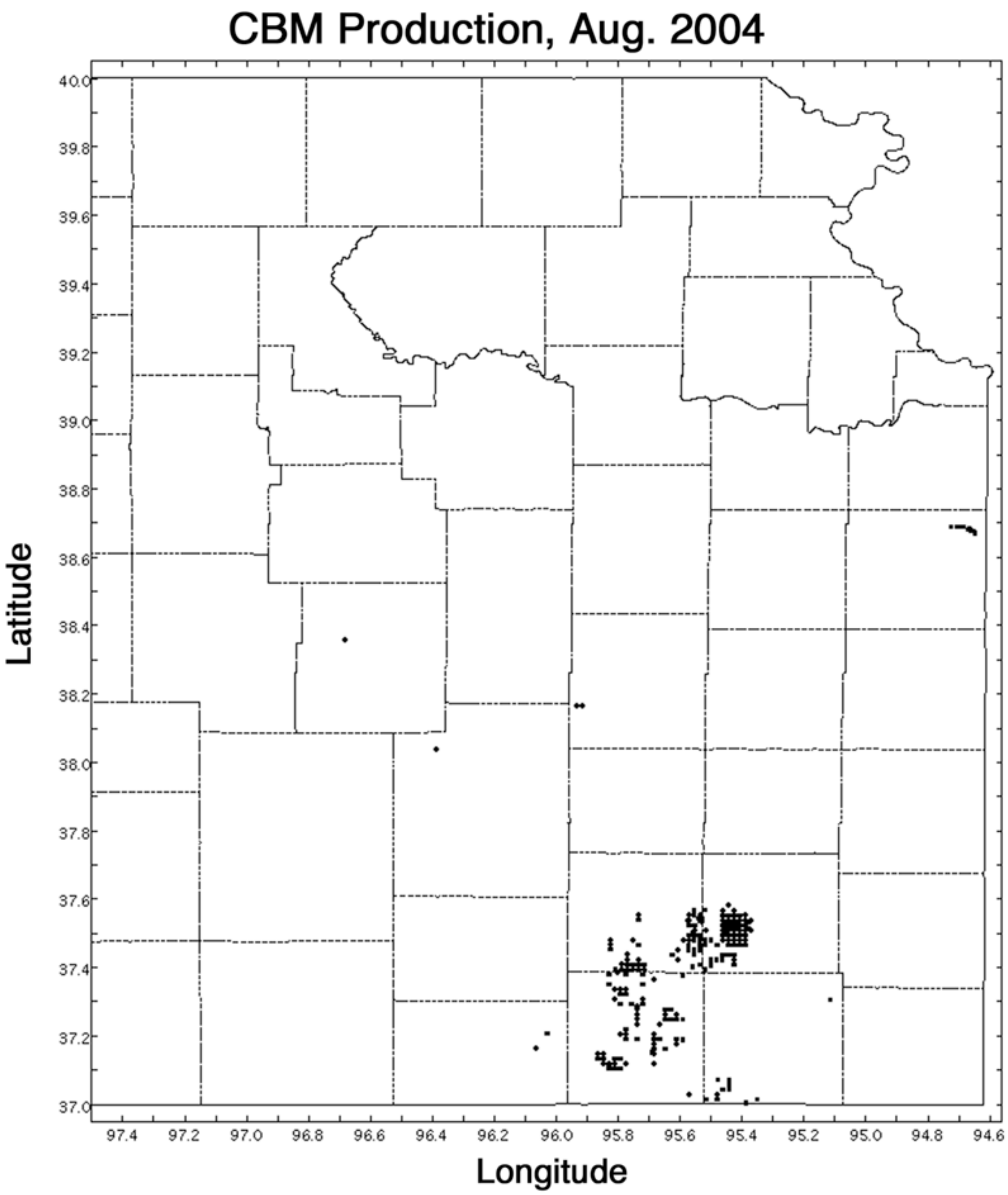

Figure 2. General location of coalbed methane production leases in eastern Kansas. A total of total of 847 leases are entered in the database through July 31, 2004. Modified from Adkins-Heljeson (2004).

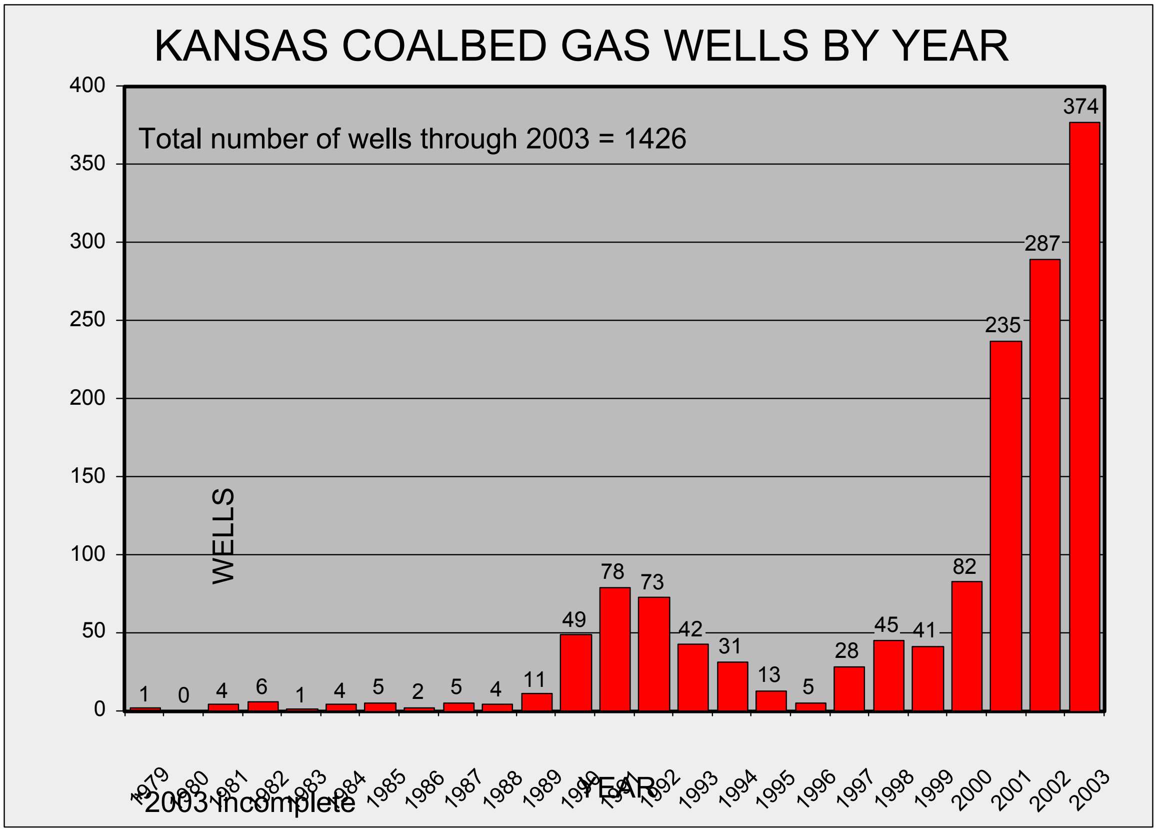

Figure 3. Annual tally of coalbed gas wells drilled in Kansas. The small surge in drilling in the 1990s is due to the influence of temporary federal tax credits for unconventional gas wells. The latest surge in drilling is largely price driven, in combination with available excess capacity in pipelines crossing the state.

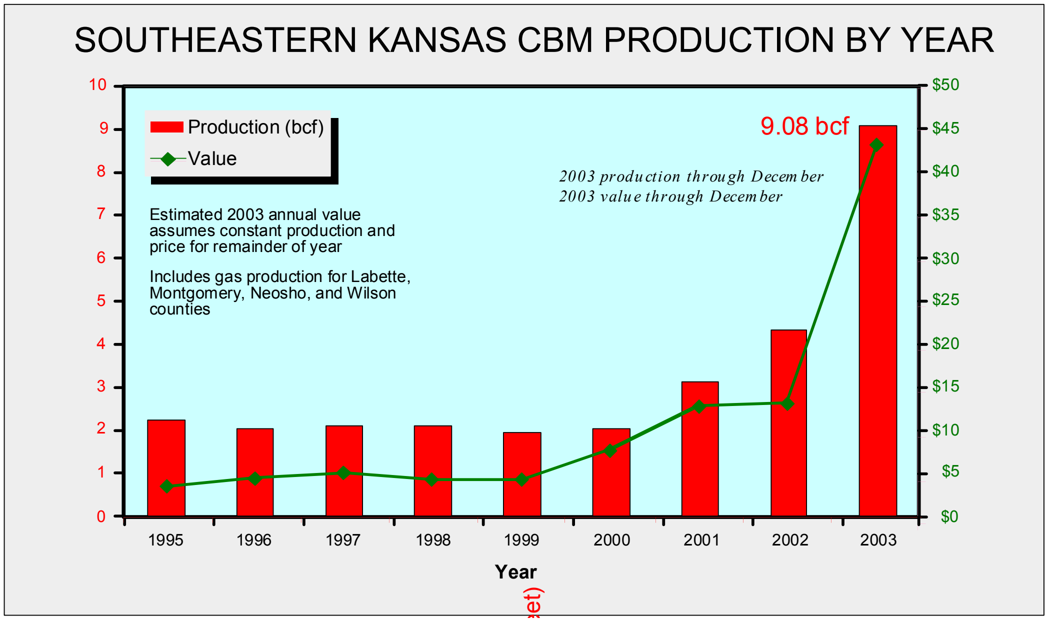

Figure 4. The surge in drilling for coalbed gas wells has been quickly followed by an increase in gas production in southeastern Kansas. Most of this new production is from Labette, Montgomery, Neosho, and Wilson counties.

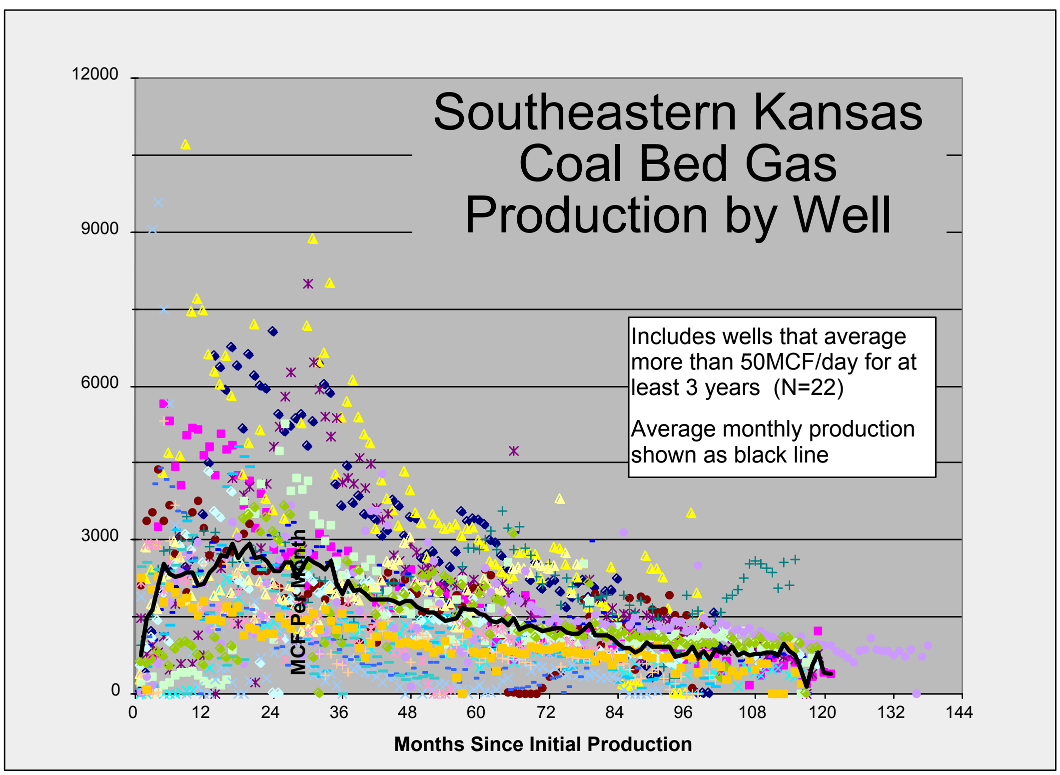

Figure 5. Production is reported in Kansas by lease name, customarily with the monthly production and number of wells producing from the lease. In order to gain an understanding of individual coalbed-well production characteristics, only single-well leases were used for this diagram. Production appears to peak about two years after initial production is reported, then a long period of decline follows (from Newell and others, 2002).

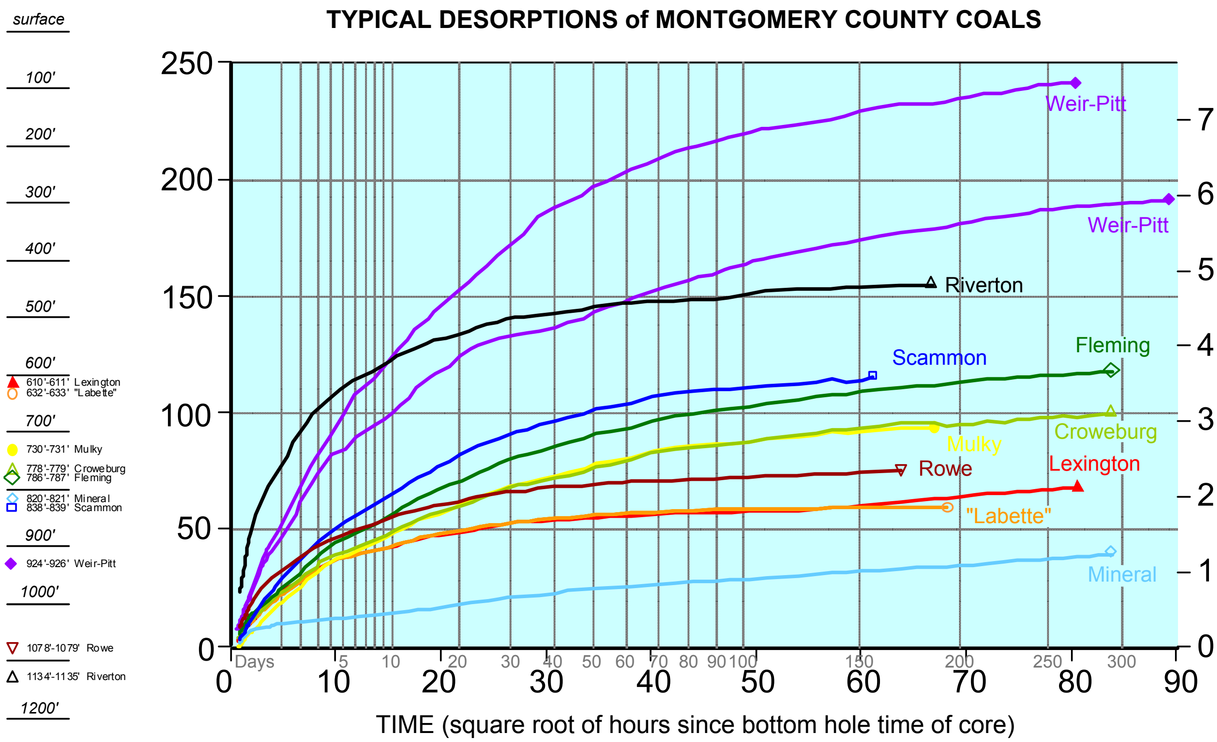

Figure 6. Desorption diagram for coals from a well in central Montgomery County, KS. Deeper coals (Weir-Pittsburg, Riverton) have the greatest gas content. Gas content is on an as-received basis, and does not include residual gas.

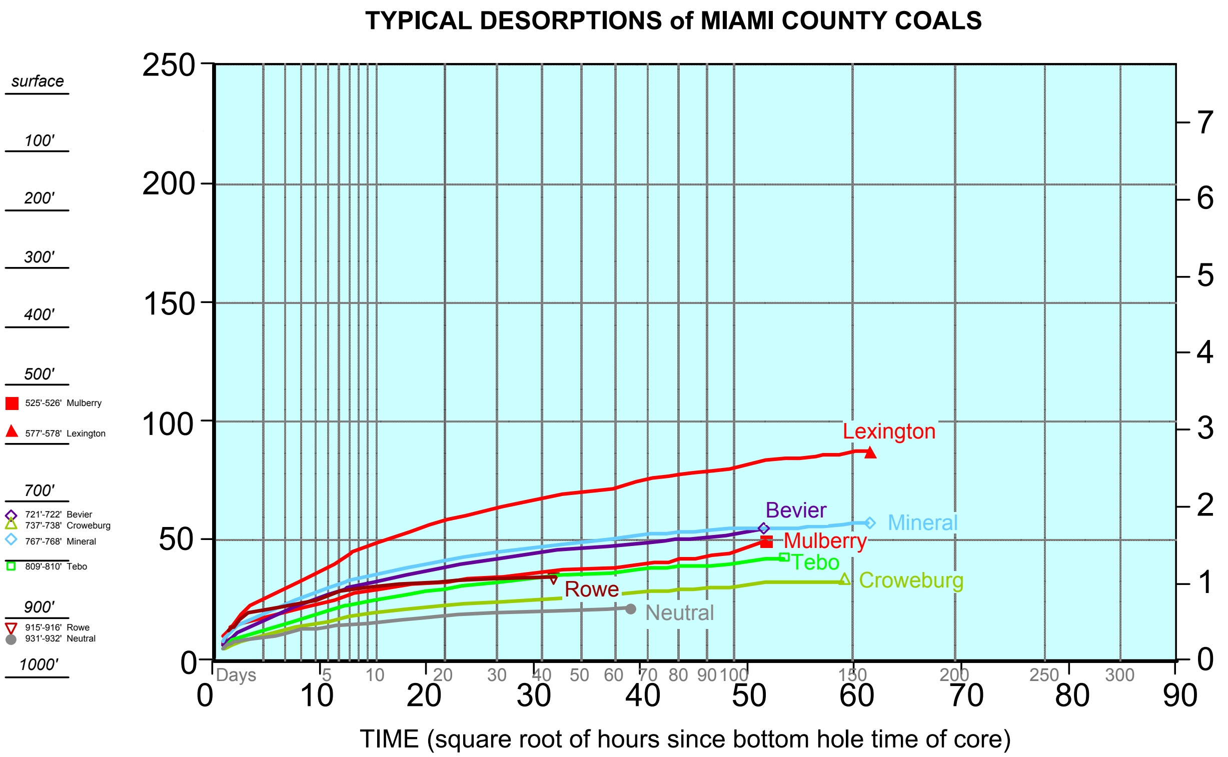

Figure 7. Desorption diagram for coals from a well in northern Miami County, KS. Less gas content is recorded for this locality (on the southeastern flank of the Bourbon arch) than farther south in the Cherokee basin. Gas content is on an as-received basis, and does not include residual gas.

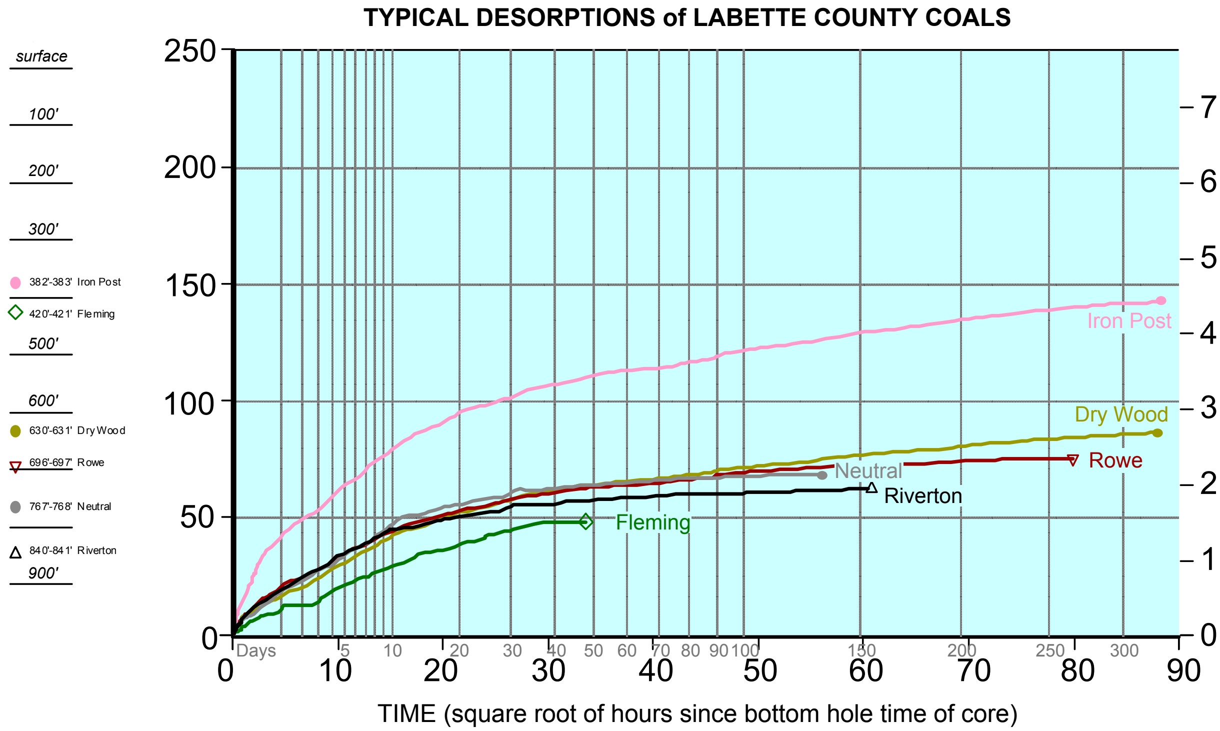

Figure 8. Desorption diagram for coals from a well in southern Labette County, KS. Shallower burial probably decreases the gas content of the coals at this locality (just 15 miles [25 km] southeast of the Montgomery County well). Nevertheless, the Iron Post coal at 380-ft depth has substantial gas content compared to deeper coals. Gas content is on an as-received basis, and does not include residual gas.

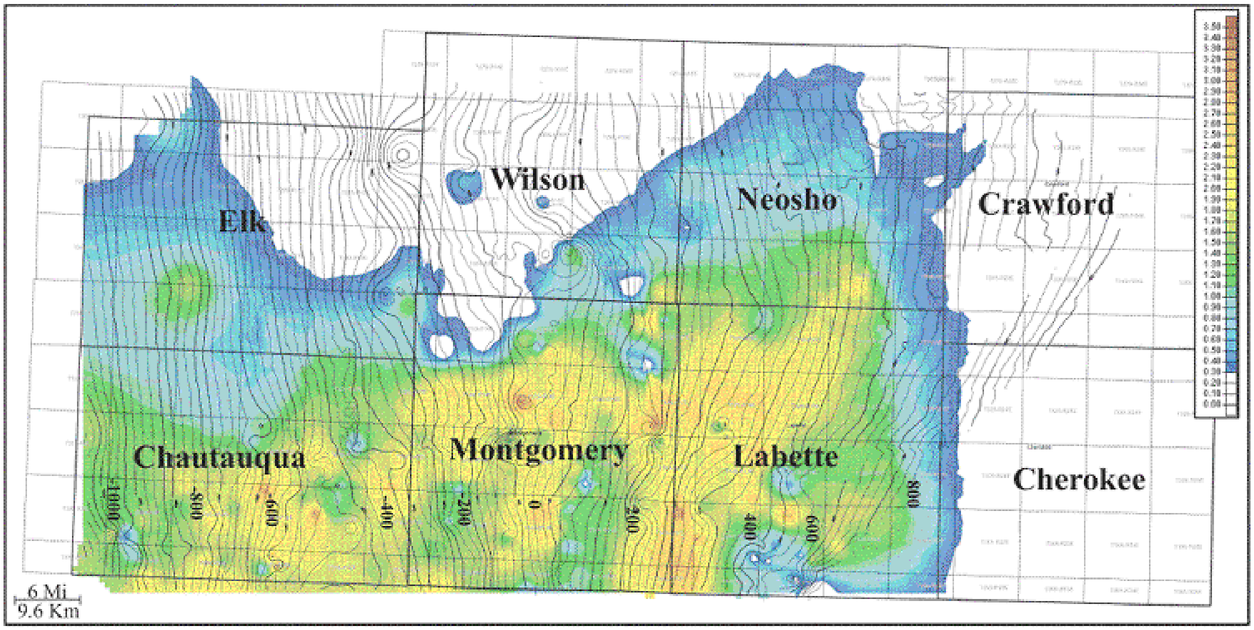

Figure 9. Isopach of Iron Post coal overlain with contours of the top of the Iron Post coal structure (isopach-color interval: 0.1 ft; structure CI: 25 ft). Modified from Lange, 2003, p. 104.

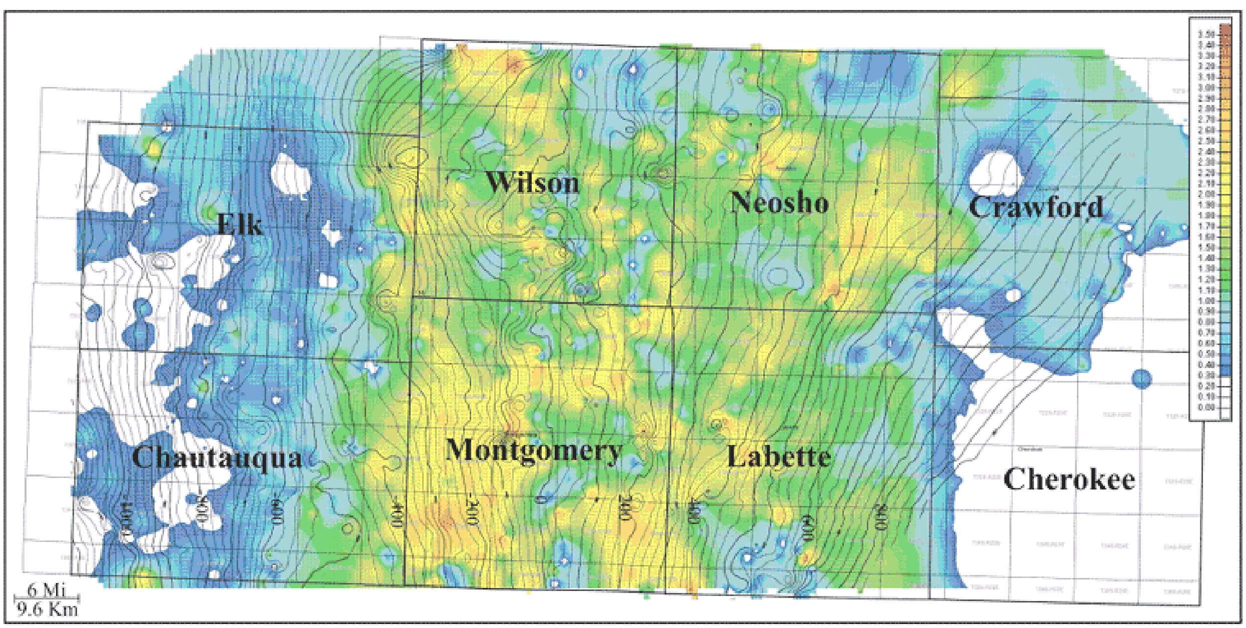

Figure 10. Isopach of Croweburg coal overlain with contours of the bottom of the Croweburg coal structure (isopach-color interval: 0.1 ft; structure CI: 25 ft). Modified from Lange, 2003, p. 97.

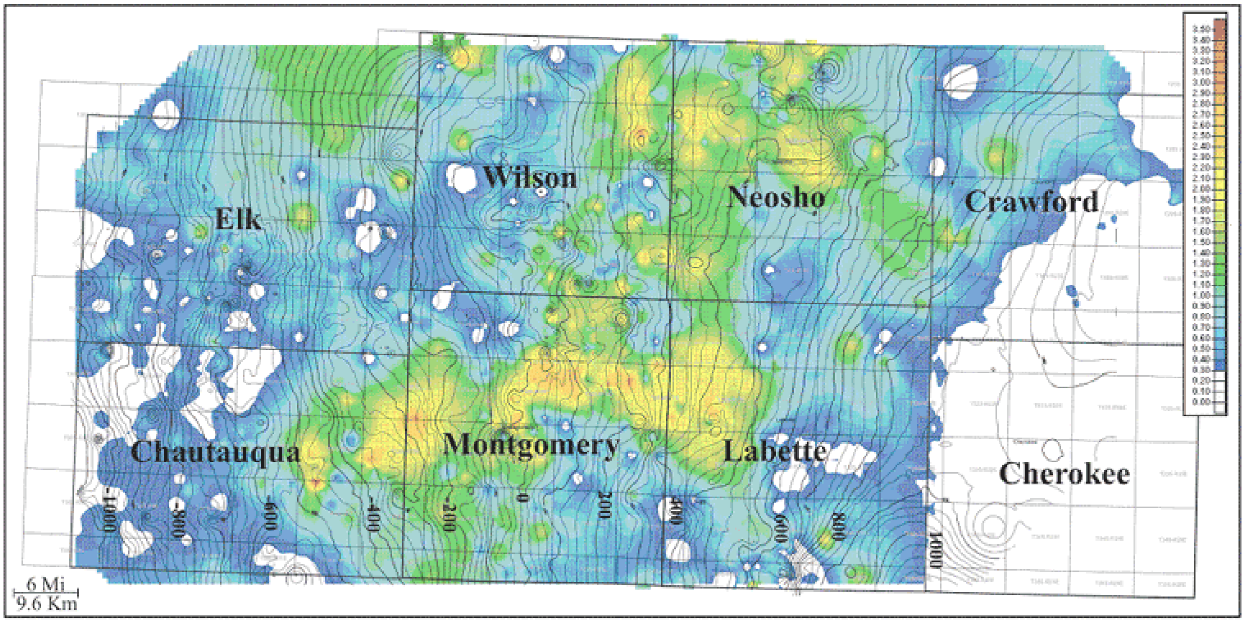

Figure 11. Isopach of Mulky coal overlain with contours of the top of the Breezy Hill Limestone structure (isopach-color interval: 0.1 ft; structure CI: 25 ft). Modified from Lange, 2003, p. 106.

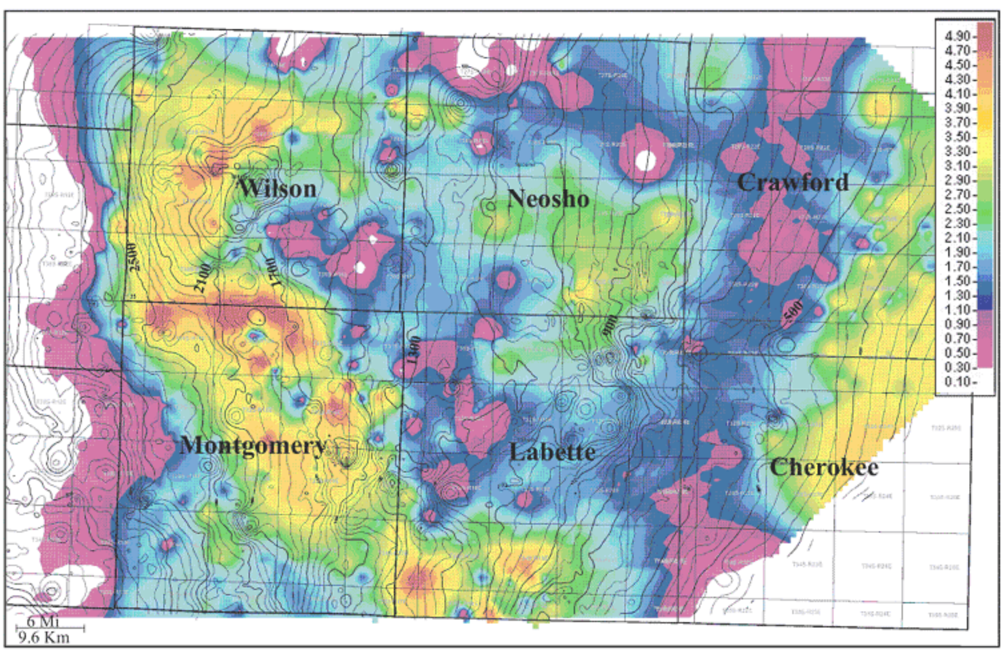

Figure 12. Isopach of Weir-Pittsburg coal overlain with contours of the top of the Mississippi limestone structure (isopach-color interval: 0.1 ft; structure CI: 25 ft). Modified from Lange, 2003, p. 82.

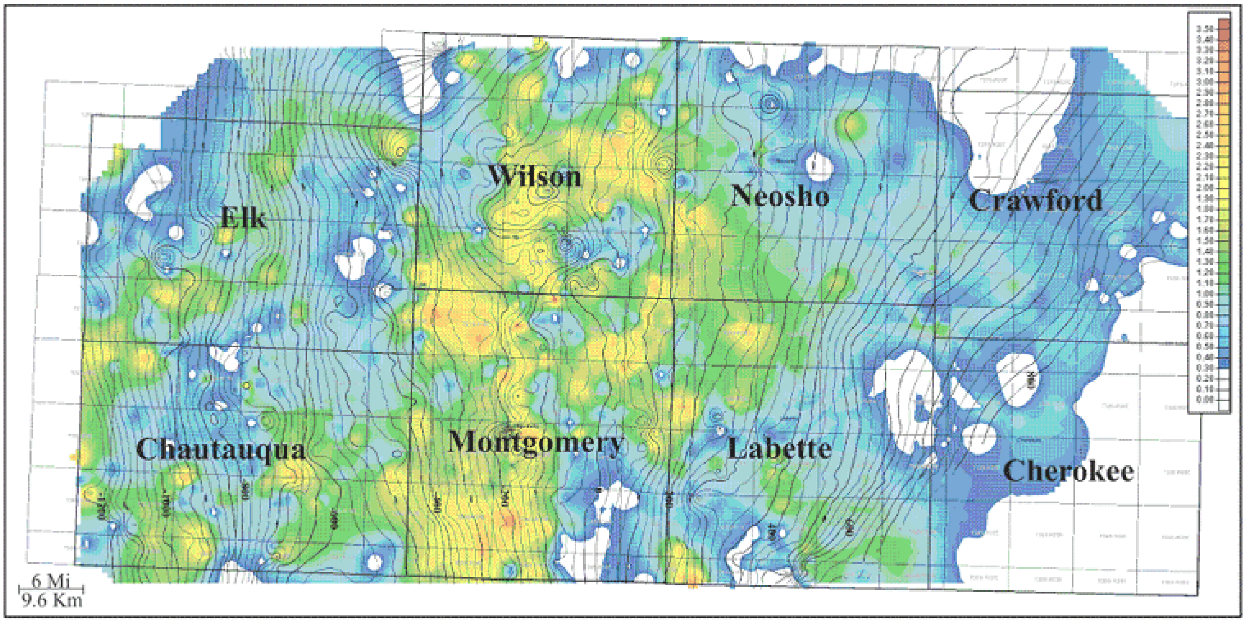

Figure 13. Isopach of Tebo coal overlain with contours of the bottom of the Tebo coal structure (isopach-color interval: 0.1 ft; structure CI: 25 ft). Modified from Lange, 2003, p. 86.

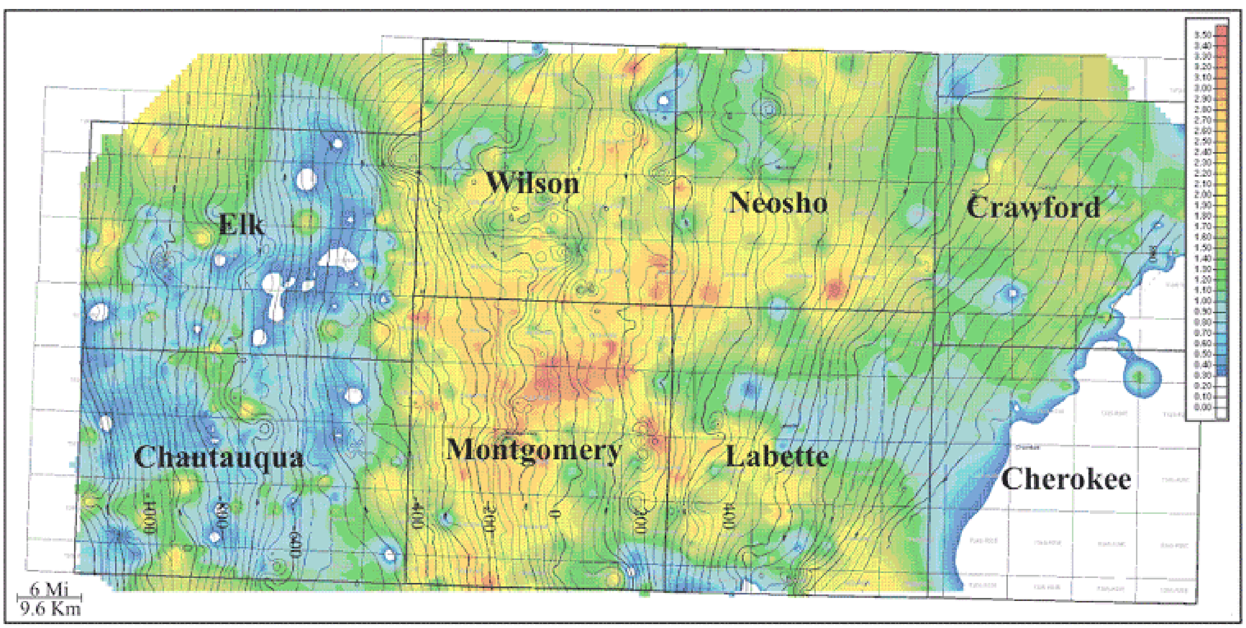

Figure 14. Isopach of Mineral coal overlain with contours of the top of the Mississippian limestone structure (isopach-color interval: 0.1 ft; structure CI: 25 ft). Modified from Lange, 2003, p. 92

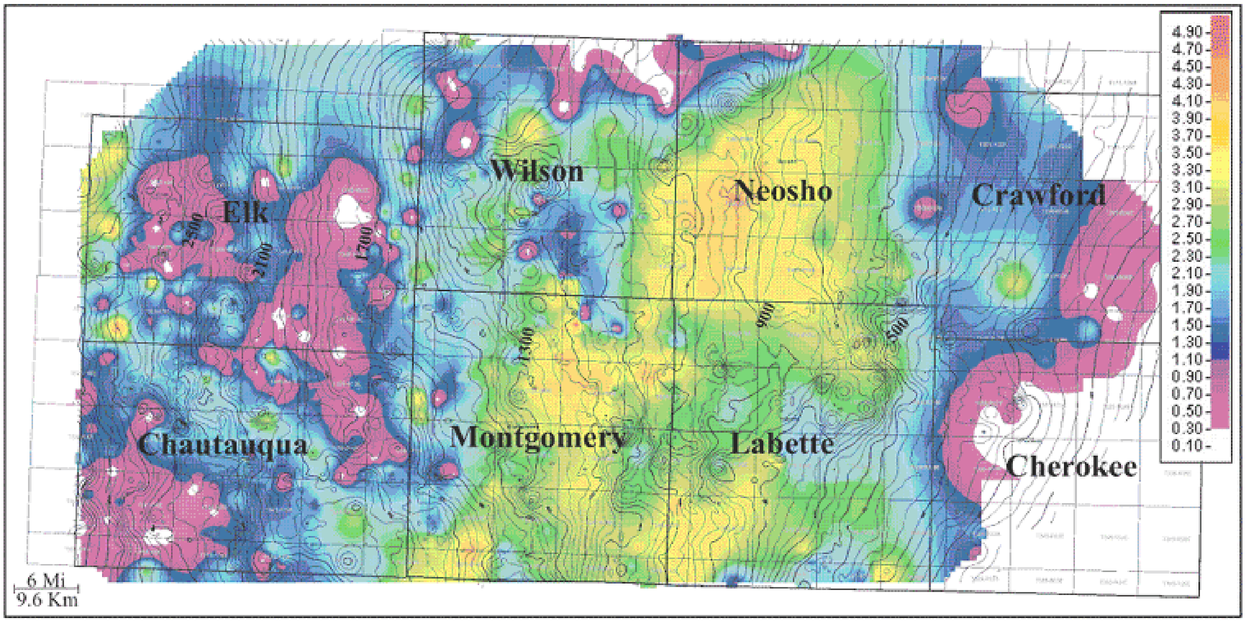

Figure 15. Isopach of Riverton coal overlain with contours of the top of the Mississippian limestone structure (isopach-color interval: 0.1 ft; structure CI: 25 ft). Modified from Lange, 2003, p. 76.

Table 1. Preliminary summary of deep coal resources and reliability category in Kansas **

Geologic Group	Coal Bed	Tonnages (million short tons) by Reliability Category Measured	Indicated	Inferred	Total	Total (MT)
Douglas	Williamsburg	1	6	109	116	(105)
Kansas City	Thayer	3	20	282	305	277
Pleasanton	* “Dawson”	4	33	473	510	463
Marmaton	Mulberry	11	83	1,158	1,252	1,136
“	* “Labette B”	19	120	1,381	1,520	1,379
“	* “Labette C”	2	17	249	268	243
Cherokee	Mulky	5	31	413	449	407
“	* “Iron Post”	13	82	771	866	786
“	* Unnamed	6	42	433	481	436
“	Bevier	90	561	5,477	6,12	5,559
“	Croweburg	20	141	1,613	1,774	1,609
“	Fleming	13	74	615	702	637
“	Mineral	87	540	4,975	5,602	5,082
“	Scammon	20	148	1,752	1,920	1,742
“	* “Scammon B”	2	18	158	178	161
“	Tebo	16	117	1,576	1,709	1,550
“	* “Tebo B”	1	6	99	106	96
“	Weir-Pittsburg	73	364	2,616	3,053	2,770
“	* “Weir-Pittsburg B”	5	44	719	768	697
“	* “Abj”	13	91	1,170	1,274	1,156
“	* “Bbj”	3	23	298	324	294
“	Dry Wood	4	31	413	448	406
“	Rowe	35	258	3,135	3,428	3,110
“	Neutral	3	26	420	449	407
“	* “Neutral B”	0	2	23	25	23
“	* “Aw”	49	381	4,579	5,009	4,544
“	* “Bw”	15	109	1,330	1,454	1,319
“	* “Cw”	29	228	2,862	3,119	2,830
“	* “Dw”	15	114	1,446	1,575	1,429
“	* Unnamed	2	17	175	194	176
“	Riverton	88	654	7,225	7,967	7,228
“	*Unnamed	5	40	516	561	509
Totals	(short tons)	652	4,421	48,461	53,534	
	(metric tons)	(591)	(4,011)	(43,964)	(48,566)	

* Coal bed names that are used for correlation purposes, but are not formal or informal names recognized in Zeller (1968).

** Modified from Brady, 1990, p.120.

Table 1. Preliminary summary of deep coal resources and reliability category in Kansas**