PREPARED IN COOPERATION WITH THE
KANSAS GEOLOGICAL SURVEY
AND THE
MISSOURI DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGY AND LAND SURVEY

FOLIO NOTE

This map is part of a folio of the Joplin 1° × 2° quadrangle, Kansas and Missouri, prepared under the Conterminous United States Mineral Assessment Program (CUSMAP). Other publications in this folio to date include U.S. Geological Survey Miscellaneous Field Studies Maps MF–2125–A through –E (Erickson and others, 1990; Grisafe and Rueff, 1991; Blair and others, 1992; McCafferty and Cordell, 1992; and Pratt and others, 1992). Additional maps showing various other geologic aspects of the Joplin quadrangle will be published as U.S. Geological Survey maps bearing the same series number with different letter suffixes (for example, MF–2125–F and MF–2125–G).

INTRODUCTION

Coal resources in the Joplin 1° × 2° quadrangle are all of Pennsylvanian age, and most of the economically recoverable coal is contained in the Cherokee Group. Although accurate production records for the entire quadrangle do not exist, coal production to date is estimated to be in excess of 300 million short tons. The Weir-Pittsburg coal bed, mined by both underground and surface-mining methods, accounts for most of the production, especially in Kansas. The Mineral coal bed, extensively strip mined where present, was economically important to both Missouri and Kansas. Five mines in the Joplin quadrangle, three in Kansas, and two in Missouri, produced 0.59 million short tons in 1991. The coal is used mainly for power generation, but a large amount is also used to fire kilns for the manufacture of cement.

STRATIGRAPHY

Stratigraphic nomenclature differs between Kansas and Missouri, but there is general agreement on coal-bed correlations. The stratigraphy of the coal-bearing succession in Kansas was described by Pierce and Courtier (1937), Howe (1956), Harris (1984), and Staton (1987); the succession in Missouri was described by Searight (1955, 1959) and Searight and Howe (1961). Searight and others (1953) described the section in both states in an effort to resolve stratigraphic correlation problems. Because the Cherokee Group, as defined in Kansas, and the Cherokee Group including the Riverton Formation, as defined in Missouri, contain over 95 percent of the quadrangle's coal resources, emphasis was placed on these coal-bearing units. However, strippable-coal resources also include the Mulberry coal bed in the Marmaton Group and the Thayer coal bed in the Kansas City Group. Figure 1 shows a generalized stratigraphic columnar section of Kansas stratigraphy that extends from the top of the Mississippian rocks to the top of the Cherokee Group. Figure 2 shows the same columnar section of Missouri stratigraphy, but includes the Marmaton Group in southwestern Missouri.

Deep-coal resources (defined as coal beds that are 14 in. or more thick and are covered by 100 ft or more of overburden in Kansas, and 90 ft or more of overburden in Missouri) include the Thayer coal bed, an informally named coal bed (Dawson) in the Pleasanton Group, the Mulberry coal bed and two other Marmaton Group coal beds in the Labette Shale, and 20 coal beds with three coal splits in the Cherokee Group of Kansas and the Cherokee Group and Riverton Formation in Missouri. Figures 3 and 4 are stratigraphic columnar sections showing distribution of important Cherokee Group and Riverton Formation coal beds in the quadrangle. Figure 3 includes gamma-ray logs for holes 1–5; neutron logs for holes 1, 2, and 4; and density logs for holes 3 and 5; only the logs for holes 3 and 5 were calibrated to API standards.

STRIPPABLE-COAL RESOURCES

Strippable-coal resources in the Joplin quadrangle total more than 5 billion short tons (table 1). In tables 2 and 3, individual coal-bed resources are divided into reliability categories. Because different methods were used to calculate coal resources, individual tables were made for each state. Strippable-coal resources, determined for Kansas by county and coal bed in an earlier study (Brady and others, 1976), were modified for this study. Strippable-coal resources for Missouri were determined by Robertson (1971 and 1973) and Robertson and Smith (1981). For this study, resource data were recalculated because of changes in the coal-resource calculation format called for by the two coal-resource-classification systems of the U.S. Geological Survey (Wood and others, 1983). General reliability classification of coal resources is shown on map A.

Tables 2 and 3 show that the Mineral, Weir-Pittsburg, Rowe, Riverton #4 bed (in Missouri), and Croweburg coal beds are important strippable-coal beds. Sixteen other coal beds contain resources in the quadrangle. Coal thicknesses were tabulated for the 8–14-in. category in Missouri and the 12–14-in. category in Kansas because both states have a history of mining coal beds of these thicknesses, especially where other coal beds were also mined. Strip-mined areas and outcrop lines of strippable-coal beds are shown on map A.

Data used for resource calculations include the following: outcrop measurements; borehole logs made by private companies during exploration for coal, oil and gas, and metallic minerals; and logs of boreholes drilled by the geological surveys of both states for various commodity or stratigraphic studies.

DEEP-COAL RESOURCES

In the central and western parts of the quadrangle, preservation of Pennsylvanian units overlying most of the coal beds resulted in a thicker Pennsylvanian section, placing much of the quadrangle's coal resources in the deep-coal category. In Missouri, deep-coal beds 14 in. or more thick are present locally in areas associated with the strippable resources. Deep-coal resources in the Missouri part of the quadrangle total almost 900 million short tons. In addition to data used in determining strippable-coal resources, deep-coal resource data include data obtained from underground coal-mine maps and wireline geophysical logs run for oil and gas tests. Gamma-ray-neutron and gamma-ray-density geophysical logs were especially useful.

Methods used for determining thickness of coal beds from these logs are discussed in Hoffman and others (1982) and Wood and others (1983). However, during the course of this investigation, it was determined that, for the Kansas geophysical logs, these methods attribute artificially greater thicknesses to very thin coal beds than are actually present. Consequently, for coal beds thinner than 30 in., the thickness was determined by using a point halfway between the inflection point and the maximum deflection of neutron line or density line. For coal beds 30 in. or thicker, there is little difference in using either the inflection point (Wood and others, 1983) or a point determined in the method used for very thin coal beds.

The gamma-ray logs were very useful in clearly delineating carbonaceous black-shale beds that contain anomalous concentrations of uranium. These shale units have long been recognized as useful stratigraphic markers (Howe, 1956; Ebanks and others, 1977; Heckel, 1977; Wells, 1979; Livingston and Brady, 1981; Harris, 1984; Harris and others, 1985; Staton, 1987; and Staton and others, 1987; Brenner, 1989). Black-shale marker beds useful in stratigraphic correlations in the Cherokee Group are shown in figures 1 and 6. Figure 6 illustrates the high gamma-ray readings of black-shale marker beds and the low density response of coal beds.

Total deep-coal resources in the quadrangle exceed 22.7 billion short tons. This amount is estimated for coal beds present within three miles of a known data point (fig. 5), as defined by Wood and others (1983). Twenty-five different coal beds thicker than 14 in. were identified in the stratigraphic succession of the study area. The beds that contain the largest quantities of coal include the Riverton, Bevier, Mineral, Weir-Pittsburg, and Croweburg coal beds. Table 4 shows deep-coal resources tabulated by reliability categories. Figure 7 shows the distribution of the four most extensive deep-coal beds—the Bevier, Mineral, Weir-Pittsburg, and Riverton coal beds. Figure 8 shows the distribution of coal beds that are 42 in. or more thick—the Dawson, Bevier, Weir-Pittsburg, and Riverton coal beds. Thick-coal resources for the areas shown in figure 8 are about 800 million short tons.

Some coal beds in the Joplin quadrangle were extensively mined by underground room-and-pillar methods. The underground workings are almost all located in the Weir-Pittsburg coal bed (map B).

COAL QUALITY

Most of the coals in the quadrangle are high-volatile A or B bituminous (HvAb; HvBb) in apparent rank. Analyses of samples collected primarily from the eastern half of the quadrangle (fig. 9), where most of the coal has been mined, show that the coals are mainly high-volatile A in apparent rank, although a few samples are of high-volatile B apparent rank. Most of the coal beds are high in sulfur content (2.7–7.6 percent), although an unnamed coal unit at the top of the Riverton Formation near Sylvania (Dade County), Missouri, is classified as a low- to medium-sulfur coal ranging from 0.82 to 2.43 percent sulfur (Nuelle, 1985; Nuelle and others, 1985).

The coal-quality data presented in table 5 are based on records at the Missouri Division of Geology and Land Survey, the Kansas Geological Survey, and the U.S. Geological Survey, and on published reports by Swanson and others (1976) and Wedge and Hatch (1980).

COAL USE

Coal extracted from beds in the quadrangle has been used to produce coke and as a fuel source for industrial manufacturing, power generation, railroad locomotives, kilns for cement or brick manufacture, and home heating. Present use is almost exclusively for power generation and cement manufacture. However, small amounts of coal are still consumed for industrial use and home heating.

The high sulfur content of this coal limits its use in power generation and industrial plants. Regulation of SO_2 in smokestack emissions has resulted in a demand for low-sulfur coals for use in newer plants. Some power plants equipped with scrubber systems (systems that remove most of the sulfur-bearing gases from smokestack emissions) use coal mined in the quadrangle, but stricter SO_2-emissions regulations are forcing some of these plants to consider blending these high-sulfur coals with low-sulfur coals (mainly from Wyoming) or to convert entirely to low-sulfur coal to comply with upgraded air-quality standards.

Recently developed technology includes the use of fluidized-bed boilers that burn coal on a bed of limestone kept in steady motion by forcing hot air through the bed. The sulfur from the coal binds with oxygen derived from the limestone to form gypsum. If it is of sufficiently high quality, the gypsum produced might become a marketable byproduct of plants using fluidized-bed boilers. This technology is currently limited to small- to medium-sized power plants (generating capacity of as much as 150 megawatts), but it can use almost any type of coal because the undesirable gases are captured in the limestone bed; and the technology is potentially important for small industrial plants. In the near future, use of this type of boiler may become more widespread and thus provide a viable market for the high-sulfur coal present in the quadrangle.

Except in a few selected areas, future mining of deep coal in the Joplin quadrangle by conventional methods probably will not be economically feasible because most of the coal beds are thin and probably have high sulfur content.

Extraction of coalbed methane is a new development in the use of deep coal. Methane is the economically important gas present in natural gas that is transported by pipeline companies to their users. Significant quantities of methane are present in coals of certain rank found in the Joplin quadrangle. Medium-volatile bituminous coal offers the greatest potential for recovery of large quantities of methane. High-volatile A bituminous coal, such as that present in the quadrangle, is slightly lower in rank but still has some potential for significant methane production. Recent drilling of nearly a hundred wells for coalbed methane in Montgomery, Wilson, and Labette counties in Kansas indicates the importance of this energy source. Coal beds that are deeper than 500 ft probably contain more methane than shallower coal beds. Drilling and artificial fracturing of coal at these depths could produce significant amounts of methane. Based on measurements of the methane content of deep-coal samples, Stoeckinger (1989) indicates that a large amount of methane is present in deep coal beds. One core sample of Weir-Pittsburg coal collected in Montgomery County, Kansas, yielded 220 cubic feet of gas per short ton of coal. Although it is too early to determine the full potential of coalbed methane in the Joplin quadrangle, economic development of this resource seems promising.

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Table 1. *Summary of strippable-coal resources* in the Joplin 1° × 2° quadrangle*

	Missouri	Kansas	Total
Measured	403.40	236.97	640.37
Indicated	1,909.28	361.52	2,270.80
Inferred	1,363.28	815.31	2,178.59
Total	3,675.96	1,413.80	5,089.76

*In millions of short tons. In Missouri, coal is in beds 8 in. or more thick, lying under 90 ft or less of overburden. In Kansas, coal is in beds 12 in. or more thick, under 100 ft or less of overburden.

Table 2. Summary of strippable-coal resources classified by bed and reliability category in the Kansas part of the Joplin 1° × 2° quadrangle

[Quantities of coal are listed in millions of short tons; leaders (–) indicate no identified resources in this category]

Bed name, thickness (inches)	0–60 ft overburden			60–90 ft overburden			0–90 ft overburden		
	Measured	Indicated	Inferred	Measured	Indicated	Inferred	Measured	Indicated	Inferred
Thayer coal bed									
12"–14"	0.28	1.09	4.47	0.01	0.05	0.09	0.29	1.14	4.56
15"–28"	0.31	1.06	–	–	–	0.52	0.31	1.06	0.52
Mulberry coal bed									
15"–28"	–	–	16.15	–	–	0.37	–	–	16.52
Mulky coal bed									
12"–14"	3.11	5.58	31.16	0.17	1.18	12.01	3.28	6.76	43.17
14"–28"	2.51	5.77	37.65	0.15	0.98	16.94	2.66	6.75	54.59
Bevier coal bed									
12"–14"	10.47	21.53	15.63	3.86	14.86	16.46	14.33	36.39	32.09
15"–28"	25.55	42.37	49.43	8.93	39.92	32.06	34.48	82.29	81.49
Croweburg coal bed									
12"–14"	2.93	10.26	20.62	0.15	3.10	0.90	3.08	13.36	21.52
15"–28"	6.34	19.89	40.03	0.02	2.42	9.19	6.36	22.31	49.22
Fleming coal bed									
12"–14"	7.70	8.30	7.16	0.28	2.41	1.57	7.98	10.71	8.73
15"–28"	6.72	10.82	10.47	0.17	7.42	0.42	6.89	18.24	10.89
Mineral coal bed									
12"–14"	15.51	2.13	1.53	5.21	3.94	13.01	20.72	6.07	14.54
15"–28"	51.57	18.00	99.17	39.84	58.66	174.47	91.41	76.66	273.64
29"–42"	6.41	4.19	31.66	2.05	2.17	–	8.46	6.36	31.66
Weir-Pittsburg coal bed									
12"–14"	0.21	0.11	–	1.17	1.23	0.71	1.38	1.34	0.71
15"–28"	0.23	1.57	–	3.86	3.00	0.71	4.09	4.57	0.71
29"–42"	5.58	20.11	5.21	6.23	5.83	8.10	11.81	25.94	13.31
42"<	4.21	17.62	14.31	10.07	0.87	34.59	14.28	18.49	48.90
Dry Wood coal bed									
12"–14"	0.48	2.41	23.74	–	–	1.28	0.48	2.41	25.02
15"–28"	0.85	4.47	–	–	–	–	0.85	4.47	–
Rowe coal bed									
12"–14"	1.27	5.62	54.88	–	–	3.02	1.27	5.62	57.90
15"–28"	2.56	10.58	25.62	–	–	–	2.56	10.58	25.62
Total	154.80	213.48	488.89	82.17	148.04	326.42	236.97	361.52	815.31

Table 3. Summary of strippable-coal resources classified by bed and reliability category in the Missouri part of the Joplin 1° × 2° quadrangle

[Quantities of coal are listed in millions of short tons; *, not determined owing to inadequate data for geologic conditions; –, no identified resources in this category]

Bed name, thickness (inches)	0–60 ft overburden			60–90 ft overburden			0–90 ft overburden		
	Measured	Indicated	Inferred	Measured	Indicated	Inferred	Measured	Indicated	Inferred
Mulky coal bed									
12"–14"	1.51	5.80	*	–	0.50	*	1.51	6.30	*
15"–28"	2.45	4.59	*	1.53	3.35	*	3.98	7.94	*
Wheeler coal bed									
8"–14"	3.38	10.20	*	1.08	6.49	*	4.46	16.69	*
Croweburg coal bed									
8"–14"	2.18	22.78	5.38	0.43	2.86	2.11	2.61	25.64	7.49
15"–28"	20.49	70.23	141.07	–	4.32	9.75	20.49	74.55	150.82
Fleming coal bed									
8"–14"	2.60	8.36	*	–	–	*	2.60	8.36	*
15"–28"	3.51	17.09	*	–	–	*	3.51	17.09	*
Mineral coal bed									
8"–14"	5.32	7.38	25.07	4.32	17.28	6.62	9.64	24.66	31.69
15"–28"	22.69	35.36	183.95	2.43	8.91	22.78	25.12	44.27	206.73
Tebo coal bed									
8"–14"	9.30	17.09	*	0.18	3.02	*	9.48	20.11	*
15"–28"	1.94	40.42	*	0.97	6.80	*	2.91	47.22	*
Weir-Pittsburg coal bed									
8"–14"	6.23	18.21	6.30	–	6.66	*	6.23	24.87	6.30
15"–28"	11.30	24.14	112.70	–	–	*	11.30	24.14	112.70
29"–42"	9.69	64.84	164.40	–	–	*	9.69	64.84	164.40
Upper unnamed coal bed in Weir Fm.									
8"–14"	0.60	2.17		–	–	*	0.60	2.17	*
15"–28"	–	0.92	*	–	7.04	*	–	7.96	*
Lower unnamed coal bed in Weir Fm.									
8"–14"	2.30	19.30	*	2.27	8.07	*	4.57	27.37	*
Bluejacket coal bed									
8"–14"	0.16	18.58	*	–	2.16	*	0.16	20.74	*
15"–28"	2.27	16.84	*	–	–	*	2.27	16.85	*
Drywood coal bed									
8"–14"	13.44	108.80	129.22	3.34	22.56	–	16.78	131.36	129.22
15"–28"	4.03	2.09	35.66	–	4.03	–	4.03	6.12	35.66
Unnamed coal bed in Drywood Fm.									
8"–14"	15.42	70.84	65.79	4.02	27.66	95.86	19.44	98.50	161.65
15"–28"	7.50	49.53	44.92	–	0.86	2.02	7.50	50.39	46.94
Rowe coal bed									
8"–14"	17.27	81.15	–	7.03	23.45	*	24.30	104.60	*
15"–28"	31.61	115.12	309.68	2.08	38.64	*	33.69	153.76	309.68
Warner coal bed									
8"–14"	1.78	8.70	*	2.87	16.23	*	4.65	24.93	*
Riverton #5 coal bed									
8"–14"	1.01	1.38	*	2.65	23.26	*	3.66	24.64	*
15"–28"	14.69	26.63	*	–	–	*	14.69	26.63	*
29"–42"	4.32	11.34	*	–	–	*	4.32	11.34	*
Riverton #4 coal bed									
8"–14"	50.31	171.11	*	12.38	102.32	*	62.69	273.43	*
15"–28"	16.74	82.53	*	0.72	16.97	*	17.46	99.50	*
Riverton #3 & 4 coal beds together									
15"–28"	0.80	65.42	*	2.38	17.03	*	23.18	82.45	*
Riverton #3 coal bed									
8"–14"	10.77	68.87	*	12.88	95.29	*	23.65	164.16	*
15"–28"	3.51	20.52	*	3.67	11.01	*	7.18	31.53	*
Riverton #2c[1]									
8"–14"	–	–	*	–	10.69	*	–	10.69	*
Riverton #1 & 2 coal beds together									
8"–14"	–	0.32	*	–	7.45	*	–	7.77	*
Riverton #2 coal bed									
8"–14"	3.09	49.57	*	7.50	33.84	*	10.59	83.41	*
Riverton #1 coal bed									
8"–14"	2.05	25.34	*	2.41	14.80	*	4.46	40.14	*
15"–28"	–	–	*	–	2.16	*	–	2.16	*
Total	326.26	1,363.57	1,224.14	77.14	545.71	139.14	403.40	1,909.28	1,363.28

*Not determined.
[1] Small area of extra coal bed.

Table 4. Summary of deep-coal resources categorized by coal bed and reliability for the Joplin 1° × 2° quadrangle

[thicknesses in million short tons]

Coal bed	Measured	Indicated	Inferred	Total
Thayer	1	5	76	82
Dawson	2	13	125	140
Mulberry	2	21	298	321
Labette B	1	8	118	127
Labette C	2	12	202	216
Mulky	2	16	138	156
Iron Post	11	64	515	590
Bevier (Kans.); Wheeler (Mo.)	60	351	2,921	3,332
Croweburg	17	113	1,188	1,318
Fleming	9	50	357	416
Mineral	53	315	2,400	2,768
Scammon	6	54	652	712
Tebo	7	50	1,274	1,331
Weir-Pittsburg	67	323	2,010	2,400
Abj	13	64	648	725
Bbj	3	16	185	204
Dry Wood (Kans.); Drywood (Mo.)	2	18	236	256
Rowe	13	99	823	935
Neutral	–	–	7	7
Aw (Kans.); Riverton #5 (Mo.)	24	137	1,139	1,300
Bw (Kans.); Riverton #4 (Mo.)	12	71	439	522
Cw (Kans.); Riverton #3 (Mo.)	17	116	352	485
Dw (Kans.); Riverton #2 (Mo.)	29	165	225	419
Unnamed bed	–	3	50	53
Riverton (Kans.); Riverton #1 (Mo.)	98	605	2,998	3,701
Unnamed bed	1	15	187	203
Total	452	2,704	19,563	22,719

Table 5. Mean values of proximate energy and sulfur values for individual coal beds in the Joplin 1° × 2° quadrangle

[n, number of channel samples collected from coal beds; data from Wedge and Hatch (1980) and unpub. data of Kansas Geological Survey]

Coal bed	n*	Moist %	Volatile matter %	Fixed carbon %	Ash %	BTU	Sulfur %	Sulfate %	Pyritic %	Organic %
Thayer	2	6.8	33.7	41.3	18.3	10,675	3.9	0.53	2.29	1.08
Mulky	5	3.0	38.3	47.4	11.4	12,695	4.6	0.23	2.10	2.28
Bevier (KS)	2	3.9	36.1	48.6	11.5	12,250	2.7	0.34	1.22	1.15
Croweburg	7	3.4	35.4	44.2	17.2	11,677	4.5	0.35	3.21	0.91
Mineral	8	4.3	35.6	45.6	14.5	12,083	4.8	0.49	2.94	1.25
Drywood (Dry Wood)	5	2.6	32.0	46.1	19.3	11,518	7.3	0.45	5.59	1.27
Rowe	8	2.8	33.8	46.1	17.4	11,757	7.6	0.41	5.99	1.20
Aw	1	3.3	31.2	50.4	15.1	12,060	4.1	0.36	3.17	0.57

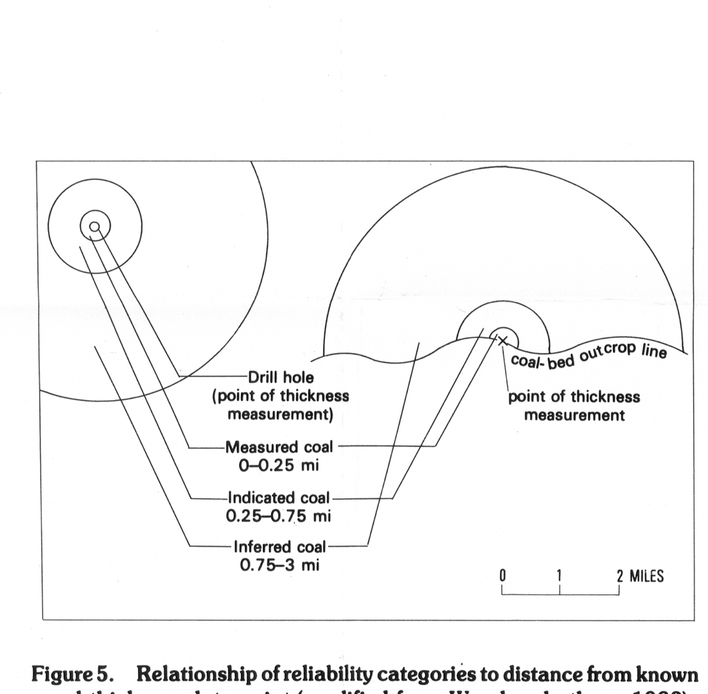

Figure 5. Relationship of reliability categories to distance from known coal-thickness data point (modified from Wood and others, 1983).

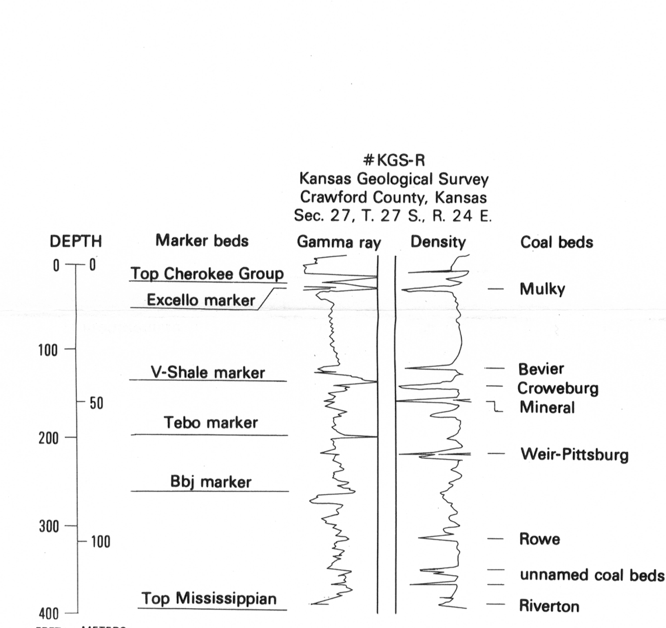

Figure 6. Unscaled gamma ray and density logs from bore-hole KGS-R, Crawford County, Kansas.

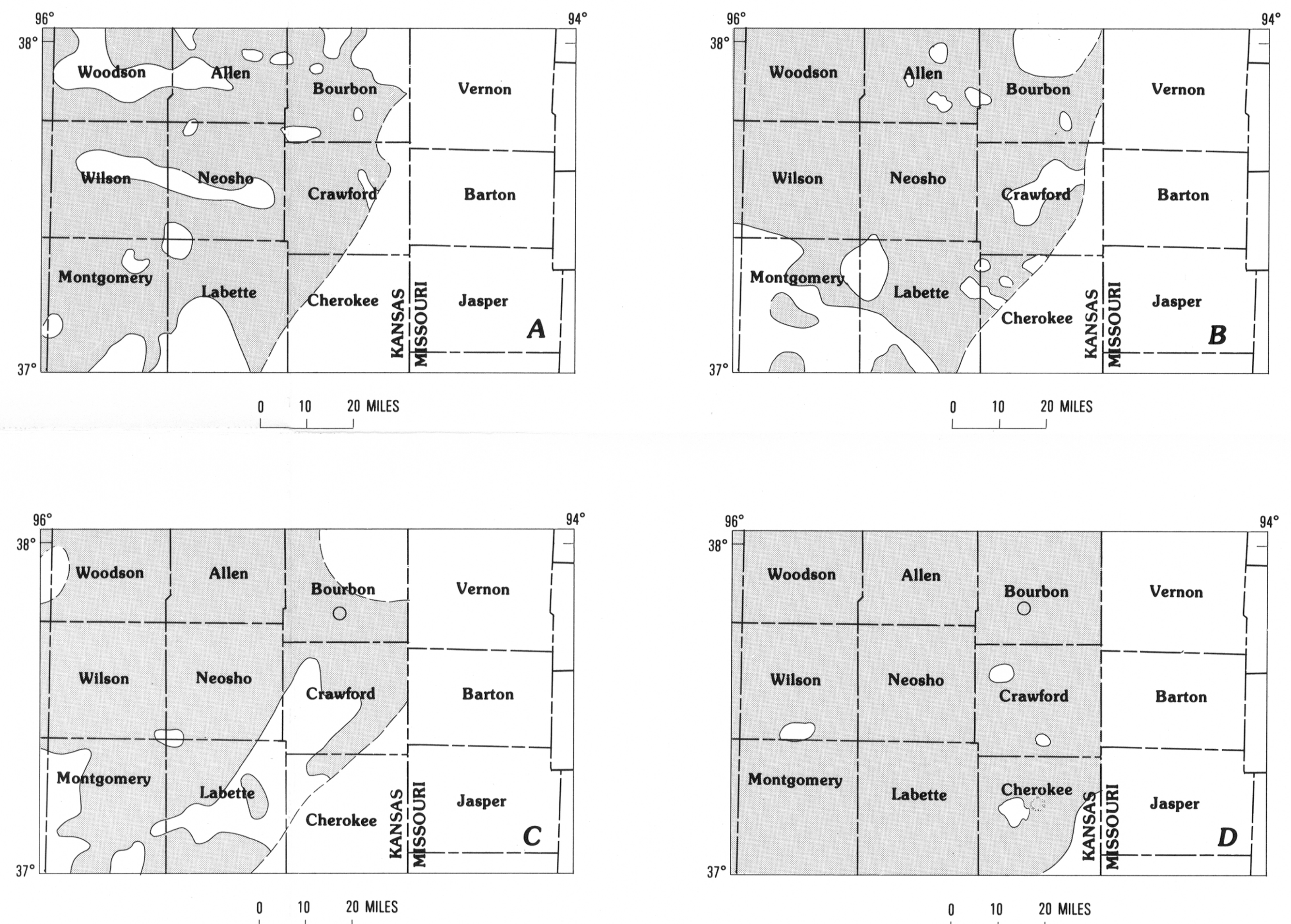

Figure 7. Distribution of coal beds in the Kansas part of the Joplin 1° × 2° quadrangle that have thicknesses of 14 in. or more and are greater than 100 ft in depth: (A) Bevier coal bed, (B) Mineral coal bed, (C) Weir-Pittsburg coal bed, and (D) Riverton coal bed.

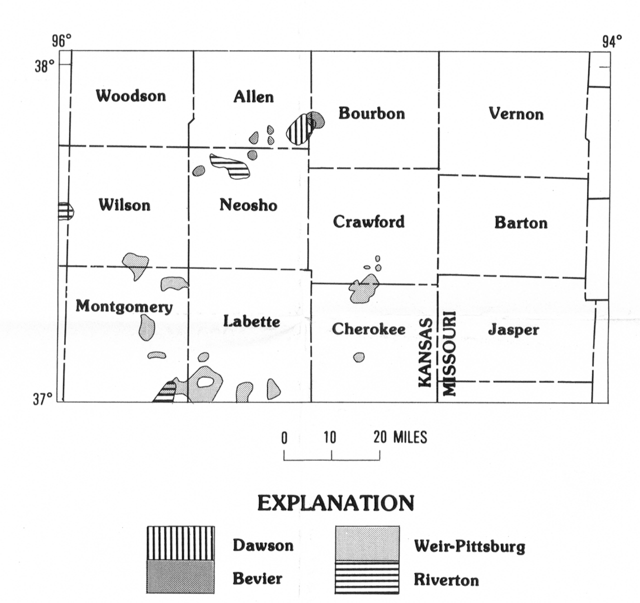

Figure 8. Distribution of deep coal beds that have thicknesses of 42 in. or more in the Kansas part of the Joplin 1° × 2° quadrangle.

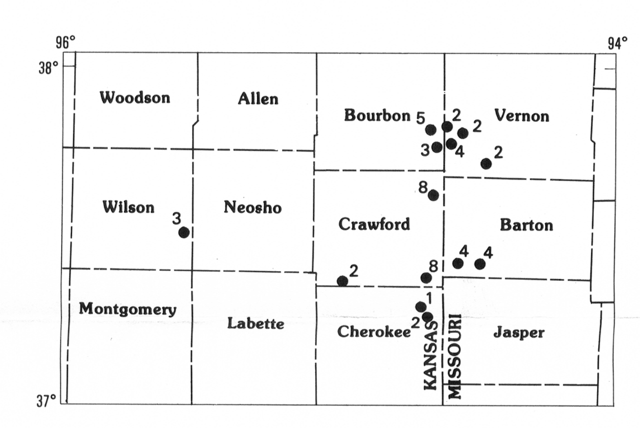

Figure 9. Localities of coal samples collected for chemical analyses listed in table 5. Number indicates quantity of samples collected.

CONVERSION FACTORS

Multiply	By	To obtain
inches (in)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

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COAL RESOURCES OF THE JOPLIN 1° × 2° QUADRANGLE, KANSAS AND MISSOURI

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