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COAL GEOLOGY OF CRAIG COUNTY AND EASTERN NOWATA COUNTY, OKLAHOMA

LEROY A. HEMISH

View of active strip mine in the SE¼ sec. 10, T25N, R18E, Craig County, Oklahoma. The Croweburg coal bed, 13 in. thick at this location, was mined by Ranchers Coal, Inc., in the spring of 1984.

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Cover Illustration

Marion 10-yd^3-bucket dragline, owned by Leon's Coal Co., stripping overburden from the Mineral coal bed, sec. 3, T28N, R20E.

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COAL GEOLOGY OF CRAIG COUNTY AND EASTERN NOWATA COUNTY, OKLAHOMA

LEROY A. HEMISH[1]

Abstract—Craig and Nowata Counties are situated in the northern part of the coal belt of eastern Oklahoma. The coal-bearing strata underlie ~890 mi^2 in parts of these two counties. In this area, estimated original resources are 699,564,000 tons (all tonnage figures are in short tons), estimated remaining resources are 669,737,000 tons, estimated reserves are 47,674,000 tons, and 29,827,000 tons has been mined or lost in mining. Seven coal beds have commercial importance in the study area: Rowe coal, with reserves of ~359,000 tons; Drywood coal, 2,980,000 tons; Weir-Pittsburg coal, 18,730,000 tons; Mineral coal, 6,919,000 tons; Fleming coal, 803,000 tons; Croweburg coal, 9,153,000 tons; and Iron Post coal, 8,730,000 tons. The methods used to calculate the resources and reserves are basically those adapted from the USGS by the OGS, as described by Friedman (1974) in the final report to the Ozarks Regional Commission. Estimated tonnage figures for resources and reserves increase significantly as additional mapping and exploratory work are done and new data are introduced.

The commercially important coal beds occur in rocks of Desmoinesian age, particularly the Krebs and Cabaniss Groups. Formations composing these groups consist of a series of shales, sandstones, and limestones of varied thickness that become thinner to the north. These strata dip northward and northwestward at 15–50 ft/mi.

Data from 218 analytical reports indicate that coals of Craig and Nowata Counties are generally low in moisture, high in sulfur (averaging >3%, except the Croweburg coal, which averages ~0.5% sulfur), and high in calorific value (averaging >14,000 Btu/lb on a moist, mineral-matter-free basis). All tested coals are bituminous, mostly in the high-volatile A group.

All coal produced during 1978 in Craig and Nowata Counties was mined by surface methods. The leading producer in the area (and the State) was Peabody Coal Co., which mined well over 1,000,000 tons. The estimated total value of all coal produced by the 15 operators in the area during 1978 is $33,253,000.

INTRODUCTION

This report is the first in a series of county studies by the Oklahoma Geological Survey evaluating the coal resources and reserves of Oklahoma. Figure 1 shows the area covered by the report. The area, comprising ~890 mi^2 in northeastern Oklahoma, includes Craig County and the part of Nowata County underlain by coals of commercial importance within the coalfield of eastern Oklahoma. The purpose of the study was to determine the location, amounts, and chemical character of the coal deposits, as well as the geologic character of the coal beds and associated strata.

Four maps (Pls. 1–4) show the locations of datum points, outcrop boundaries of coal beds, thickness of coal beds. mined-out areas, and thickness of overburden. These maps incorporate information on each of the seven coal beds for which resources and reserves are tabulated. A structure-contour map (Pl. 5) was prepared for the Croweburg and Weir-Pittsburg coals. Coal beds too thin to have commercial importance in the area are discussed briefly, but were not mapped. Seven cross sections (Pls. 6–8) show the succession of coals and associated strata. These cross sections form a crisscrossing network throughout the study area and establish correlation with the coal-bearing strata of southeastern Kansas.

Summary information on resources and reserves is presented in Table 1 according to township and coal thickness; and in Table 2 according to county and coal bed.

Detailed data on estimated original, mined, and remaining coal resources and reserves are tabulated by township for each county according to coal

[1]Oklahoma Geological Survey.

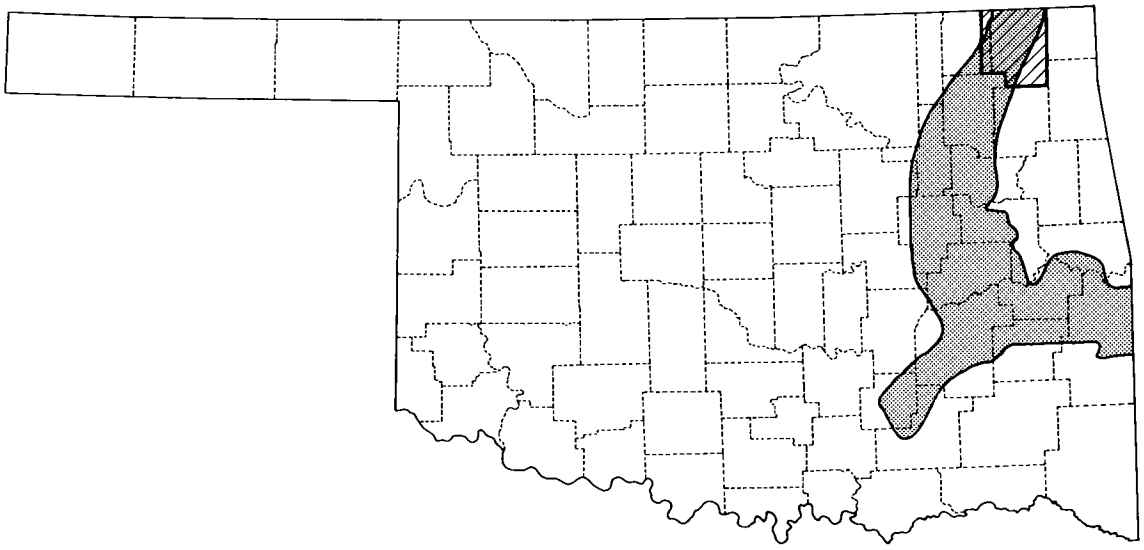


Figure 1. Index map of Oklahoma, showing the eastern Oklahoma coalfield (shaded) and area of this report (ruled).

thickness, overburden thickness, and reliability category in Appendix 1. Coal resources are considered to be economically strippable if the coal is not more than 100 ft deep and the ratio of overburden thickness to coal thickness is not more than 20:1 (for all coals except the Croweburg, for which the stripping ratio is set at 30:1, owing to its superior qualities). If both limitations are exceeded, the coal is considered recoverable only by underground mining.

All tonnage figures in this report represent short tons.

Previous Investigations

An excellent summary of geologic work in the area was presented by Branson and others (1965, p. 10–11) in their report on the geology, oil, and gas of Craig County. Studies dealing more specifically with coal geology include a palynological study of the Mineral coal (Urban, 1962); the palynology and stratigraphy of the Drywood coal (Bordeau, 1963); a study of the Iron Post coal (Gibson, 1961); and an investigation of the coal reserves in the Ozarks section of Oklahoma (Friedman, 1974).

Trumbull (1957, table 8, p. 373) estimated total remaining reserves (resources) of 175,550,000 short tons for Craig County. Results of the present study show estimated remaining resources of 640,092,000 short tons for Craig County (Table 2). However, Trumbull did not include tonnage estimates for coal beds <14 in. thick, whereas in the present study tonnage estimates were made for coal beds >10 in. thick. Trumbull did not include estimates for coal beds in Nowata County. Friedman (1974, table 42, p. 94–95) estimated total remaining resources of 121,052,000 short tons for Craig County, using thickness parameters identical to those used in the present study; Friedman further estimated (table 50, p. 102–103) total remaining resources of 279,000 short tons for Nowata County. Results of the present study show estimated total remaining resources of 29,645,000 short tons for Nowata County (Table 2). The present study shows an increase in estimated remaining resources for Craig and Nowata Counties of 494,187,000 short tons over Trumbull's estimates, and 548,406,000 short tons over Friedman's estimates.

Additional information concerning coal in Craig and Nowata Counties is included in reports by the U.S. Bureau of Mines (1928), Trumbull (1957), Doerr (1961), Johnson (1974), and Friedman (1976).

Acknowledgments

The writer is indebted to the mining companies operating in the study area. Without their cooperation, a detailed report such as this could not have been completed. The mining companies provided drill and core logs and permitted collection of coal samples in many active strip pits. These companies are Bill's Coal Co.; Carbonex Coal Co.; Custom Coal Co.; Design Service; ELCO, Inc.; Fuel Dynamics, Inc.; Jess Hefner and Son; Kerr-McGee Corp.; M. J. Lee Construction Co.; Leon's Coal Co.; Peabody Coal Co.; Russell Creek Coal Co.; Solar Excavating, Inc.; Tri-Con, Ltd.; and URCO Energy, Inc. Special acknowledgments

TABLE 1.—COAL RESOURCES AND RESERVES IN CRAIG AND NOWATA COUNTIES ACCORDING TO TOWNSHIP AND COAL THICKNESS*

(thousands of short tons)

Township, range, county	Remaining resources										Mined or lost in mining		Original resources		Reserves	
	0.8–1.2 ft		1.2–2.4 ft		2.4–3.5 ft		>3.5 ft		Total remaining resources							
	Acres	Tons	Acres	Tons	Acres	Tons	Acres	Tons	Acres	Tons	Acres	Tons	Acres	Tons	Acres	Tons
T24N, R19E, Craig	228	342							228	342			228	342	16	22
T24N, R17E, Nowata	8,664	16,676	3,690	8,597					12,354	25,273	2,105	4,659	14,459	29,932	2,844	4,841
T25N, R18E, Craig	4,617	8,749	3,840	8,925					8,457	17,674	1,169	2,679	9,626	20,353	3,055	5,315
T25N, R19E, Craig	5,222	10,003	2,945	6,716					8,167	16,719	275	670	8,442	17,389	1,360	2,257
T26N, R17E, Nowata	1,649	3,627							1,649	3,627	1,322	2,800	2,971	6,427	148	220
T26N, R18E, Craig	9,279	17,147	8,760	23,925					18,039	41,072	4,662	9,419	22,701	50,491	1,348	2,214
T26N, R19E, Craig	1,592	2,708	9,170	32,428	106	497			10,868	35,633	529	1,334	11,397	36,967	2,325	6,296
T26N, R20E, Craig			7	20					7	20	4	5	11	25	7	16
T26N, R21E, Craig	29	42							29	42			29	42	28	33
T27N, R18E, Craig	794	1,419	10,251	28,607	2,905	14,615			13,950	44,641			13,950	44,641		
T27N, R19E, Craig	11,380	20,675	11,234	35,399	4,149	22,371			26,763	78,445	1,175	2,320	27,938	80,765	3,349	6,737
T27N, R20E, Craig	922	1,733	3,679	12,253	772	3,595			5,373	17,581	125	264	5,498	17,845	2,909	7,724
T27N, R21E, Craig	97	156	7	27					104	183	2	2	106	185	64	93
T28N, R17E, Nowata			26	61					26	61			26	61		
T28N, R18E, Craig			5,241	18,110	6,274	32,498	1,346	9,416	12,861	60,024			12,861	60,024		
T28N, R19E, Craig	6,238	11,457	9,937	27,908	4,268	22,461	689	4,742	21,132	66,568	225	362	21,357	66,930	543	840
T28N, R20E, Craig	8,697	16,052	13,594	35,012	115	528			22,406	51,592	1,914	4,103	24,320	55,695	3,490	6,263
T28N, R21E, Craig	817	1,244	77	176					894	1,420	22	25	916	1,445	289	415
T29N, R17E, Nowata			304	684					304	684			304	684		
T29N, R18E, Craig			7,325	18,800	1,691	9,601	11,728	105,714	20,744	134,115			20,744	134,115		
T29N, R19E, Craig	1,957	3,164	10,398	27,708	145	668			12,500	31,540	38	59	12,538	31,599	94	121
T29N, R20E, Craig	10,309	16,734	10,226	23,712					20,535	40,446	636	1,117	21,171	41,563	2,712	4,121
T29N, R21E, Craig	1,201	2,033	1	2					1,202	2,035	11	9	1,213	2,044	107	146
TOTAL	73,692	133,961	110,712	309,070	20,425	106,834	13,763	119,872	218,592	669,737	14,214	29,827	232,806	699,564	24,688	47,674

*See Appendix 1 for details.

TABLE 2.—COAL RESOURCES AND RESERVES IN CRAIG AND NOWATA COUNTIES ACCORDING TO COUNTY AND COAL BED*
(thousands of short tons)

Coal	Total remaining resources		Mined or lost in mining		Original resources		Reserves	
	Acres	Tons	Acres	Tons	Acres	Tons	Acres	Tons
Craig County:								
Iron Post	33,751	68,426	6,457	13,027	40,208	81,453	3,437	5,545
Croweburg	27,476	53,136	1,846	3,528	29,322	56,664	4,694	7,530
Fleming	4,108	8,128	177	343	4,285	8,471	513	803
Mineral	36,276	81,663	1,368	3,075	37,644	84,738	3,974	6,666
Weir-Pittsburg	95,956	415,326	883	2,194	96,839	417,520	7,404	18,730
Drywood	6,231	12,626	51	195	6,282	12,821	1,404	2,980
Rowe	461	787	5	6	466	793	270	359
Total	204,259	640,092	10,787	22,368	215,046	662,460	21,696	42,613
Nowata County:								
Iron Post	6,524	13,536	2,885	6,142	9,409	19,678	1,976	3,185
Croweburg	7,365	15,081	542	1,317	7,907	16,398	888	1,623
Mineral	444	1,028			444	1,028	128	253
Total	14,333	29,645	3,427	7,459	17,760	37,104	2,992	5,061
Grand Total	218,592	669,737	14,214	29,827	232,806	699,564	24,688	47,674

*See Appendix 1 for details.

go to the Russell Creek Coal Co. for providing several hundred drill and core logs, as well as nearly 150 chemical analyses of coal samples. Special thanks go also to Leon's Coal Co. for the wealth of information supplied—especially to Maynard Walker of that company, whose knowledge of the coal geology of Craig County contributed greatly to the accuracy of interpretations in this report.

S. A. Friedman, senior coal geologist at the Oklahoma Geological Survey, gave invaluable assistance throughout the study. He provided many confidential drill logs that he had collected over the years, as well as much other information secured through his liaison work with mine operators and other people in the coal industry.

METHODS OF INVESTIGATION

Sources of Information

Data for compilation of the maps and coal resource and reserve estimates were obtained principally from about 1,000 drill and core logs provided by coal companies. Additional data came from geophysical logs derived from exploration drilling by the Oklahoma Geological Survey for "heavy" oil in Craig County.

Ninety-seven sections (Appendix 2), measured by the author in active and abandoned strip pits and on outcrops, supplemented the information from exploration logs. Other measured sections from previous studies were also used (Branson and others, 1965, appendix; Howe, 1956, appendix).

Mapping Techniques

Investigation of the coalfield in Craig and Nowata Counties began in January 1978 with a stereoscopic study of U.S. Department of Agriculture Agricultural Stabilization and Conservation Service (ASCS) aerial photographs supplied by the Oklahoma Geological Survey (scale approximately 1:40,000; made in 1972). Identification of stratigraphic markers (resistant limestones and sandstones) and delineation of mined-out areas were accomplished through this study. Examination of 7.5′-quadrangle topographic maps and a geologic map of Craig County (Branson and others, 1965, pl. 1) permitted further tentative identification of the outcrop boundaries of several coals in the area. Information was plotted on 7.5′-quadrangle topographic maps for the entire study area.

Outcrop boundaries of the various coals were field checked during the spring and summer of 1978. The general practice was to traverse all roads and trails by vehicle and then to traverse on foot all areas inaccessible by vehicle. Exposures of coal beds were difficult to find, owing to conceal-

ment by unconsolidated surficial materials and dense vegetation over most of the area. Slumping and ponded water (Fig. 2) have largely obliterated exposures of coal beds in abandoned strip mines; therefore, the best data were gathered from active strip mines.

The term *outcrop* is used broadly herein to describe the areal border of a coal bed, whether it is exposed at the surface or concealed beneath unconsolidated surficial materials. The accuracy of coal-boundary mapping varies with amount of surface cover, nature of topography, and number and distribution of exposures and drill holes. Structural features, erosional gaps, and areas in which the coal is lenticular or lacks persistence also impeded the mapping. Additional drill information will modify the outcrop boundaries shown on the maps for some areas. However, these boundary lines do show where strippable coal may be found. The closest control is in areas of active strip mines, where abandoned mines occur near the outcrop, and where data points are close to the projected line of outcrop.

Mined Areas

Areas mined by surface methods were mapped through use of ASCS aerial photographs and more-recent large-scale aerial photographs provided by coal companies. In places it was necessary to visually estimate the extent of mined-out areas that were not visible on the photographs, or that had been mined after the photographs were made. Field work for this project was completed in the summer of 1978. Maps of mined-out areas were updated in June 1984. However, calculations of mined acreages and tonnages reflect only the situation at the close of the 1978 field season.

No records were available for calculating tonnage of coal mined from old, abandoned underground mines. Extent of these mines is unknown. Many of the entrances to these old mines were plotted on the coal maps (Pls. 1–4).

Thickness of Coals

Isopach lines on the maps (Pls. 1-4) indicate thicknesses of the several coal beds. The isopach interval was set at 0.2 ft in this study. This small interval permits relatively accurate tonnage calculations in areas such as Craig and Nowata Counties, where average coal-bed thickness is <2 ft.

Overburden Categories

The term *overburden* includes all material that overlies useful geologic deposits such as coal; it is used in association with deposits that can be mined from the surface by open cuts. Thickness of overburden is shown on the coal maps (Pls. 1–4) by isopach lines which divide the overburden into four categories: ≤20 ft, >20 to ≤40 ft, >40 to ≤100 ft, and >100 ft. One hundred feet represents the maximum depth at which coal reserves are considered strippable in this area. Future economic and technological factors may change this limitation, but such predictions are beyond the scope of this report.

Figure 2. Ponded water in abandoned strip pit where the Weir-Pittsburg coal was mined during the 1950s in the SE¼SE¼SW¼SE¼ sec. 31, T26N, R19E, Craig County.

Procedures for Calculating Resources and Reserves

Polygons delineating the various categories of coal resources were constructed by superposing coal-thickness lines on a work map (scale 1:24,000) for each coal. Included on the map were lines of outcrop, mined-out areas, and overburden-thickness lines, all color-coded. Circles were drawn around each datum point, defining categories of reliability. (A circle whose radius is 0.25 mi defines an area of measured resources; a circle whose radius segment extends from 0.25 to 0.75 mi defines an area of indicated resources; and a circle whose radius segment extends from 0.75 to 2 mi defines an area of inferred resources.) Areas for each category of reliability were also color-coded. The end product was a map color-coded so that polygons to be measured for each category were readily distinguishable. The acreage in each polygon was measured with a planimeter, and these areas were compiled for each category. Coal tonnage was then calculated by multiplying the number of acres by the average thickness of the coal (to the nearest tenth of a foot) and the factor 1,800 tons/acre-ft (assumed for bituminous coal in the ground; Friedman, 1974, p. 17). Totals were rounded to the nearest 1,000 tons. Original work maps, charts, tables, and records of calculations are on file at the Oklahoma Geological Survey and are available for public examination.

Definition of Coal Resources and Reserves

Coal resources comprise maximum estimates of original and remaining coal resources that are

identified, or presumed to exist, within a coalfield on the basis of interpretation of geologic data and geologic judgment (Friedman, 1974, p. 13). No depth limits for coal resources were set for this study; however, no reliable data were available for depths much greater than 600 ft, so that became the limiting factor. Resources were not determined for coal beds <10 in. thick, regardless of depth. No resource figures were calculated for coal beds <14 in. thick lying at depths >100 ft.

The following definitions concerning coal resources and reserves are paraphrased and quoted from Friedman (1974, p. 13–14):

Original coal resources. Coal resources determined from coal datum points, including coal resources (based on data from all categories of reliability) that are present in beds now and that were present before mining. New coal data can be used in updating original-resources estimates.

Remaining coal resources. Coal resources (based on data from all categories of reliability) that are now present in beds, but excluding coal that has been mined or lost in mining. These estimates require periodic updating owing to coal production and new coal data. In areas with no mining, original resources equal remaining resources. Remaining resources are updated by subtracting coal production and coal lost in mining from the original-resources estimate.

Reserves. Reserves are calculated from estimates of maximum recoverable resources, using a 50% recovery for underground mining and an 80% recovery for surface mining. (In this report, reserves include only the portion of remaining resources that can be economically extracted at the time of determination.) Reserves and recoverable reserves are used in the same sense. Estimates of remaining resources may change because of new coal data or new additional coal production; thus, the recoverable reserves may change. Both remaining-resources figures and recoverable-reserves figures require periodic updating.

Quality of Coals

The quality of coals described in this report is summarized in Appendix 3 (Tables A3-1, A3-2). Average values for the various analytical properties of each coal are listed with data from 214 analytical reports. Fifteen of the 214 analyses reported in Table A3-1 for Craig and Nowata Counties are from the literature; 134 analyses are from private companies as donations of work done by commercial analytical laboratories; 11 previously unpublished analyses are from the U.S. Bureau of Mines; and 54 previously unpublished analyses are from the laboratory of the Oklahoma Geological Survey.

Forty-five channel samples of coal were collected by the writer in Craig and Nowata Counties in accordance with procedures outlined by Friedman (1978). These samples were collected mainly at active coal mines (Fig. 3). Analyses were done by chemists at the Oklahoma Geological Survey (Table A3-2).

Data reported in Appendix 3 indicate that the coal resources of Craig and Nowata Counties are generally very low in moisture content, averaging ~3%. Fixed carbon on a dry, mineral-matter-free basis was reported for all coals at <69%. Ash content is varied. In particular, analyses of the Weir-Pittsburg coal show ash contents ranging from ~3% to almost 27%. Analyses of the Drywood, Fleming, and Mineral coals show an average ash content >13%. Other economically important coals, such as the Croweburg and Iron Post, generally show ash contents in the range 6–8%. A few sample results have been reported from noncommercial coals (Tebo, Bevier, and others), and these coals are generally characterized by high ash contents. Sulfur content of the coals of Craig and Nowata Counties is generally high, averaging >3%. An exception is the Croweburg coal, which averages ~0.5% sulfur in all but the northern two tiers of townships in Craig County. Table A3-1 shows changes in sulfur content to the north; samples from T28N, R19E, and T28N, R20E, have sulfur contents averaging almost 2%. In T29N, R20E, the sulfur content of the Croweburg coal averages >3%.

The economic value of the coals of Craig and Nowata Counties lies chiefly in their comparatively high calorific value. On a moist, mineral-matter-free basis, the average is reported at well over 14,000 Btu/lb.

Rank of Coals

Coals of Craig and Nowata Counties have been ranked (Appendix 3) in accordance with standard American Society for Testing and Materials methods (ASTM, 1979). All analytical reports indicate that the tested coals are in the bituminous class, in the high-volatile A, B, or (rarely) C groups. As recommended by ASTM Standard D 388-77, only suitable analyses such as those published by the U.S. Bureau of Mines, the U.S. Geological Survey, and the Oklahoma Geological Survey, or results reported from laboratories of these organizations, were used in ranking. Outcrop samples and samples that showed indications of weathering were not used in determining rank.

With few exceptions, the calorific value of all coals in Craig and Nowata Counties tested on a moist, mineral-matter-free basis is >14,000 Btu/lb. Because the fixed-carbon percentage is <69% on a dry, mineral-matter-free basis, these coals are ranked as high-volatile A bituminous. Coals with Btu/lb values >13,000 but <14,000 are ranked as high-volatile B bituminous. Only one sample (from the Iron Post coal bed in Nowata County), with a value of <13,000 Btu/lb, is ranked as high-volatile bituminous C.

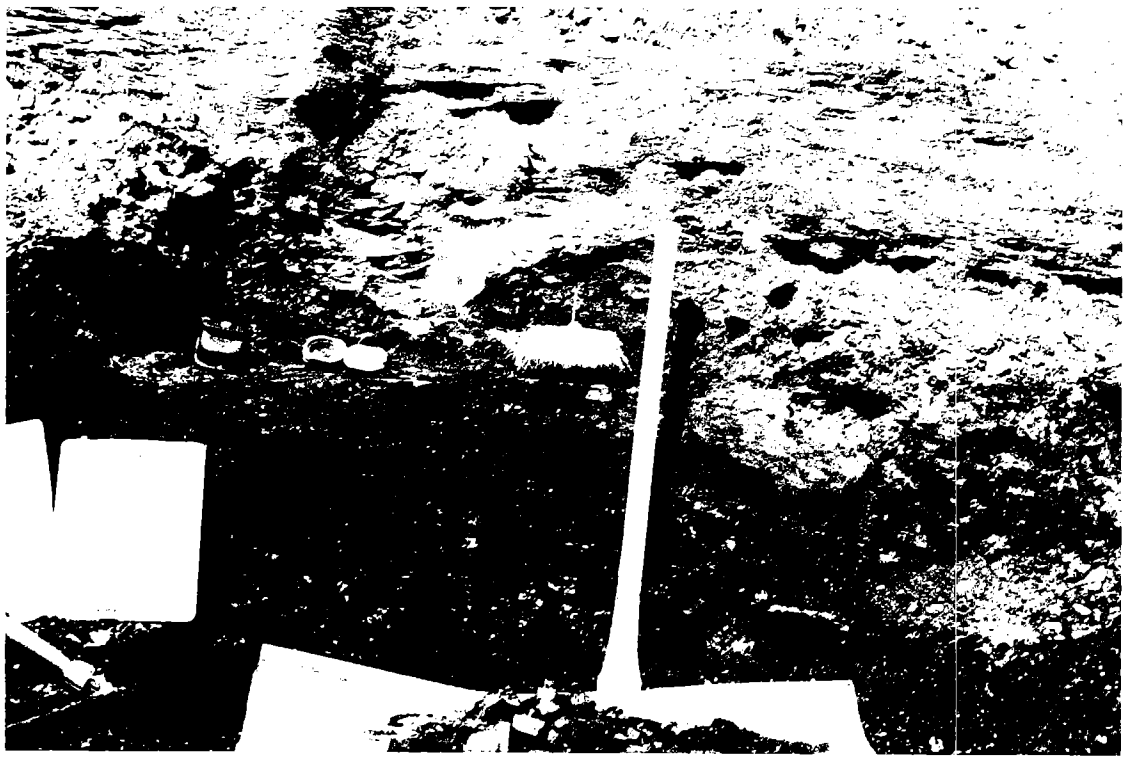


Figure 3. View of the Weir-Pittsburg coal (23 in. thick) and equipment used to collect coal channel samples. Direction of the butt cleat is N. 44° E. (approximately parallel to the highwall), and direction of the face cleat is N. 51° W. (extending obliquely into the highwall face and approximately paralleling joints in the overlying strata). Photograph taken in active strip mine in the SE¼ sec. 4, T25N, R19E, Craig County.

COAL GEOLOGY

General Statement

The coal beds of Craig and Nowata Counties occur in Pennsylvanian strata. These sediments were deposited on an uneven surface developed by earlier erosion and deformation of underlying Mississippian and older strata.

Upper Devonian and Mississippian rocks are exposed in southeastern Craig County (Branson and others, 1965, pl. 1), and coal beds are absent in that part of the study area. The most important coal beds are present in the Krebs and Cabaniss Groups of Desmoinesian age (Fig. 4). Formations composing these groups consist of a series of shales, sandstones, and limestones of varied thickness that become thinner to the north. Marine and nonmarine fossils in these rocks indicate that they were laid down under cyclical conditions. According to Dott and Batten (1971, p. 311–315), vegetation which subsequently formed coal grew in coastal swamps near epeiric seas that covered part of northeastern Oklahoma at that time. Fluctuations of sea level caused oscillatory transgressions and regressions of the sea over the area. Channel sandstones, black shales, and interchannel coals here represent environments associated with deltas. Just as the shoreline oscillated back and forth, so did the delta environment. This accounts for the distribution, geometry, and relationships of the various rock units preserved across the area. Burial of these sediments resulted in alteration of vegetal material to coal. Differential compaction of coals, shales, and sandstones accounts for much of the pinch-out and minor structures in the area.

Structure

The study area includes the northwest edge of the southwest part of the Ozark uplift (Fig. 5). Upper Mississippian and Pennsylvanian strata dip very gently westward and northwestward (Pl. 5) at 15–50 ft/mi, forming the Prairie Plains homocline (Huffman, 1958, p. 89).

According to Huffman (1958, p. 89), structural development in northeastern Oklahoma was closely associated with the development of the Ozark geanticline. Southward tilting occurred in Devonian time and again in Mississippian time. Huffman believed that major deformation oc-

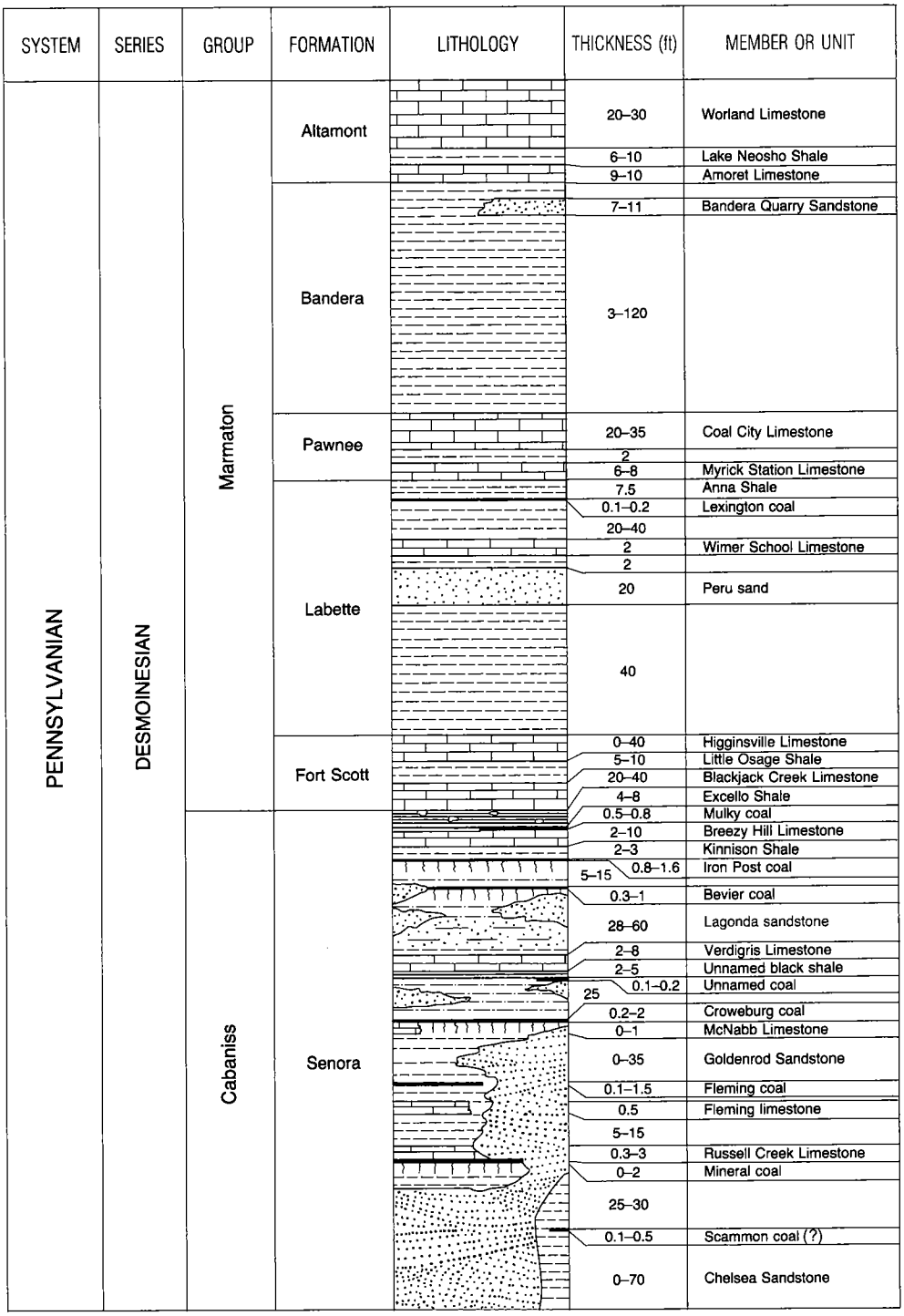
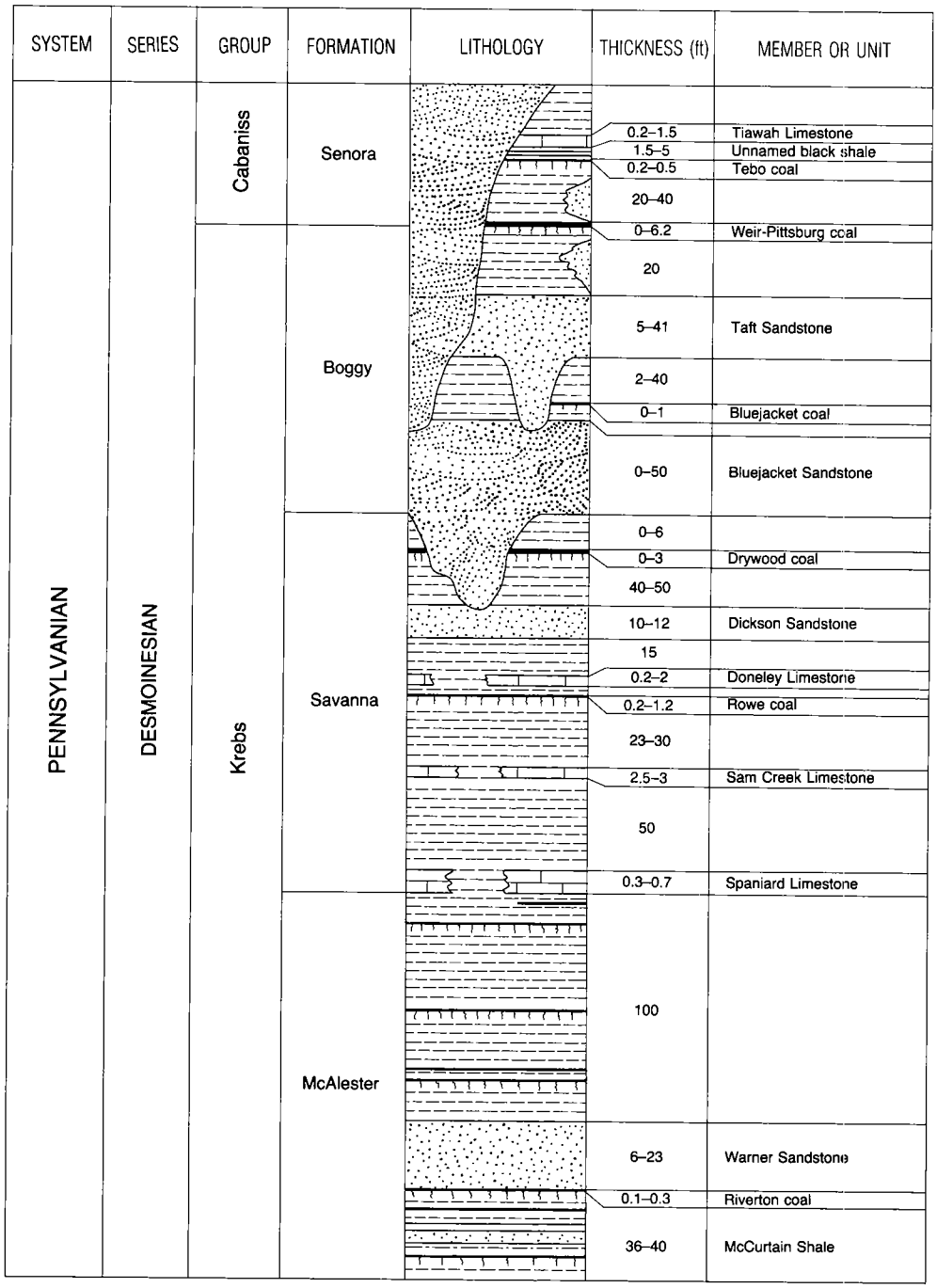


Figure 4. Generalized columnar section of Craig County and eastern Nowata County, Oklahoma (modified from Branson and others, 1965, pl. 2). For simplicity, the term *Member* is omitted here and elsewhere in this report. The formal status of members is indicated by capitalization of the lithologic term (e.g., Chelsea Sandstone); lowercase lithologic terms are used for informal units (e.g., Fleming limestone).


SYSTEM
SERIES
GROUP
FORMATION
LITHOLOGY
THICKNESS (ft)
MEMBER OR UNIT
PENNSYLVANIAN
DESMOINESIAN
Cabaniss
Krebs
Senora
Boggy
Savanna
McAlester
0.2–1.5
Tiawah Limestone
1.5–5
Unnamed black shale
0.2–0.5
Tebo coal
20–40
0–6.2
Weir-Pittsburg coal
20
5–41
Taft Sandstone
2–40
0–1
Bluejacket coal
0–50
Bluejacket Sandstone
0–6
0–3
Drywood coal
40–50
10–12
Dickson Sandstone
15
0.2–2
Doneley Limestone
0.2–1.2
Rowe coal
23–30
2.5–3
Sam Creek Limestone
50
0.3–0.7
Spaniard Limestone
100
6–23
Warner Sandstone
0.1–0.3
Riverton coal
36–40
McCurtain Shale

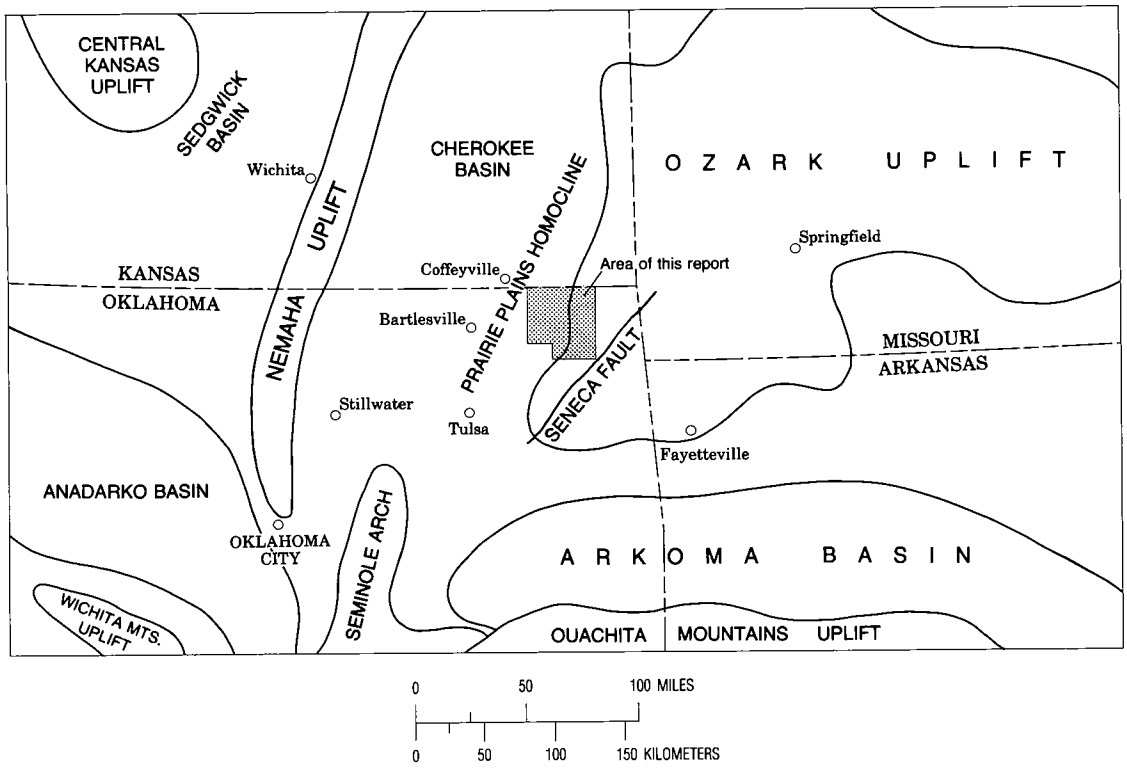


Figure 5. Tectonic map showing the relation of the report area to regional structural features. (Modified from Oetking and others, 1966.)

curred during Middle Pennsylvanian time, and that the folds and faults are of early Desmoinesian age. He hypothesized that the deformation was tensional and due to stretching of the rock layers across the end of the Ozark dome during loading of the Arkoma basin in Middle Pennsylvanian time. Evidence of continued deformation throughout Desmoinesian time is present in the study area in the form of minor faults (observed in coal mines) and small- and intermediate-scale anticlines and synclines (Pl. 5).

Major structures in the area include the Welch fault in northeastern Craig County (Pl. 5), which extends 7.5 mi in a northeasterly direction, from sec. 22, T27N, R20E, to sec. 18, T28N, R20E. Vertical displacement is 25–50 ft, the northwest side being downthrown (Branson and others, 1965, p. 48–49). Other major faults include the Dupree fault, extending 5.5 mi through central Craig County, and the Booker School fault in southwestern Craig County (Pl. 5). Several minor faults are also present (see Branson and others 1965, p. 47–48). No coal deposits of economic importance occur in the vicinity of these faults.

Bedrock strata generally appear to be flat-lying, because the regional dip is <1°. Beds with greater dip, or even flat-lying beds, may be present owing to intermediate- or small-scale folding.

The structure map drawn on the Croweburg and Weir-Pittsburg coals (Pl. 5) shows that numerous intermediate-scale synclines and anticlines are superimposed on the regional structure. Some of these folds reverse the regional dip. The structures generally occupy an area of 1–3 mi^2; closure on the anticlines is about 30–40 ft. Many of these features can be identified by close examination of the 7.5′-quadrangle topographic maps and aerial photographs, but others can be recognized only from subsurface data. A still smaller order of folding is manifested by the undulatory nature of the various coal beds (Fig. 6). Closure on these small-scale folds is about 1–3 ft.

Rose diagrams (Fig. 7) were constructed from 37 Brunton-compass measurements of cleat directions in the Craig and Nowata Counties coalfield (Appendix 4). *Cleat* is defined as a vertical joint or system of joints along which coal naturally fractures (McCulloch and others, 1974, p. 2). *Face cleat* is the major, well-defined joint in a coal bed, and *butt cleat* is the poorly defined joint, usually at right angles to the face cleat. According to McCulloch and others (1974, p. 1), "face cleats were formed as extension fractures during structural deformation, and butt cleats, as release fractures during erosion and uplift." Their studies indicate (p. 1) that "face cleat maintains a perpendicular

orientation to the shifting axial trend of local structures."

In general, the face cleat strikes NW and the butt cleat NE (Fig. 7). These trends suggest that the cleat structure was produced by tectonic forces related to doming of the Ozark uplift, which has a NE-trending axis.

Stratigraphy

Rocks of Devonian, Mississippian, and Pennsylvanian age in Craig and Nowata Counties are classified into groups and formations on the basis of variations in their gross lithologic character. The principal geologic features of the coal beds and associated strata in each group are discussed below, with emphasis on the nomenclature and correlation of the coals. The generalized columnar section (Fig. 4) shows the sequence of strata.

Upper Devonian and Mississippian Rocks

Rocks of Late Devonian and Mississippian age are exposed at the surface in southeastern Craig County. Because coal is not present in these strata, they are not discussed in this paper; information on these units can be obtained from Branson and others (1965).

Pennsylvanian Rocks

Krebs Group.—The oldest coal-bearing strata in the study area occur in the Krebs Group. According to Branson and others (1965, p. 22), the Krebs Group "includes all rocks between the top of the Atoka Formation, below, and the top of the Boggy Formation, above." According to Robert O. Fay (personal communication, 1979), the Atoka Formation is not present in Craig County. According to Fay, paleontologic evidence indicates that the McCurtain Shale Member of the McAlester Formation is the lowermost unit recognizable in the Pennsylvanian System in Craig County (Fig. 4).

The McAlester Formation is the oldest stratigraphic unit in the Krebs Group. Coal beds in the McAlester Formation have little or no economic importance in the study area; none is named except for the Riverton coal, at the base of the Warner Sandstone. The coal beds are no more than a few inches thick and are identified only from subsurface data (Pls. 7,8).

The Savanna Formation contains two coal beds that have been mined: the Rowe coal, underlying the Doneley Limestone, and the Drywood coal, in the upper part of the formation just below the Bluejacket Sandstone.

The Rowe coal was named by Pierce and Courtier (1937, p. 65) for the Rowe School in sec. 34, T30S, R25E, in Kansas, about 35 mi northeast from the northeast corner of Craig County. In the study area, the Rowe coal crops out approximately along a diagonal line extending from the southwestern part to the northeastern part of Craig County (Pl. 3). It averages <6 in. in thickness and

Figure 6. View of undulating surface on Croweburg coal that has been cleaned prior to stripping. The Croweburg is only 10 in. thick at this location in the NW¼ sec. 21, T29N, R20E, Craig County.

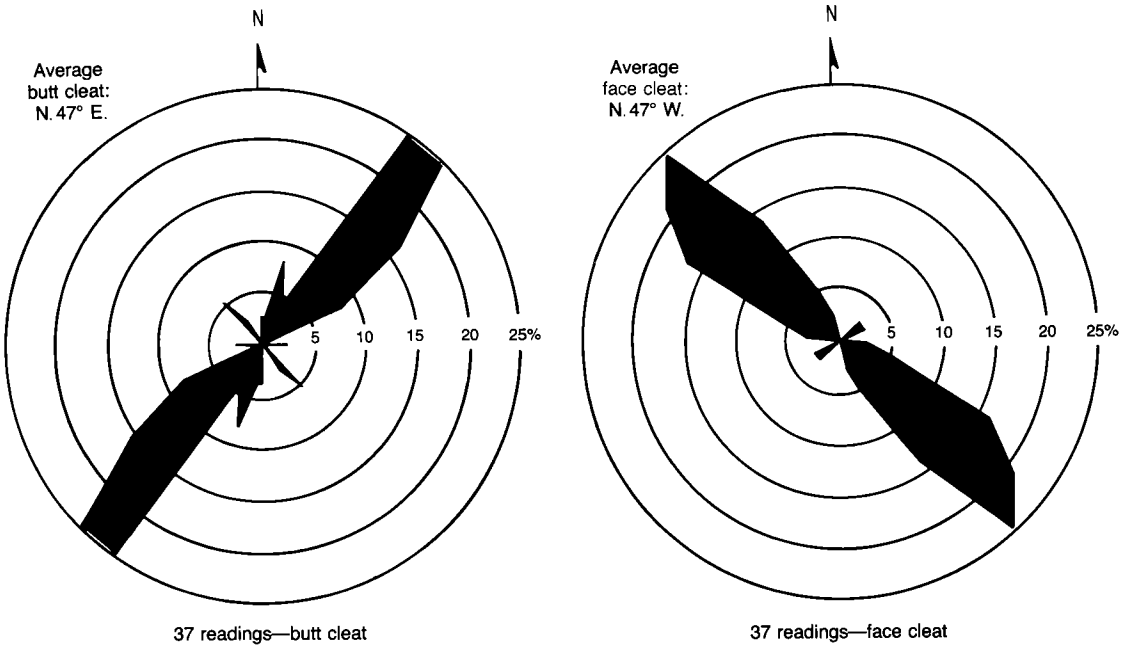


Figure 7. Rose diagrams of cleat orientations in the coal beds.

has economic importance only in small, isolated areas. The Rowe coal thickens to 10 in. in the SE¼SW¼ sec. 31, T27N, R21E (Appendix 2, measured section 76), and company drill information indicates that the coal is >1 ft thick in sec. 25, T28N, R21E. Opportunity for discovery of profitable deposits is good in both areas (Pl. 3).

The Rowe coal occurs at the base of the Savanna Formation in northern Craig County and about midway in the Savanna in southern Craig County (Pls. 7,8). The Rowe is associated with two good marker beds, the Doneley Limestone and the Dickson Sandstone. The Doneley is a 2-ft-thick, purple to black, fossiliferous limestone (in places, reddish-brown, noncalcareous clay-ironstone), separated from the underlying Rowe coal by a bed of dark-gray shale ~2 ft thick. The Doneley Limestone is present in about half of the mapped area; thus, it is sufficiently persistent to serve as a mapping guide. The other marker bed, the Dickson Sandstone, has an average thickness of ~12 ft; it can be traced almost continuously from T25N, R20E, to the northeast corner of Craig County in sec. 16, T29N, R21E. The Dickson Sandstone is separated from the Doneley Limestone by ~15 ft of dark-gray to gray, silty and sandy shale (Branson and others, 1965, p. 27).

Laboratory analyses of Rowe coal samples from Craig County (Appendix 3) show that it is a high-volatile bituminous coal with a sulfur content averaging >5%. These results are similar to the results from several samples of Rowe coal collected in Rogers County (directly south of the study area) by Gregg (1976, appendix B).

Howe (1956, p. 37) stated that the Rowe coal is equivalent to the Columbus coal, and in part equivalent to the Bellamy coal, both of which were named in Kansas.

The Drywood coal was named by Searight and others (1953, p. 2747); the type section is in sec. 4, T32N, R33W, in Missouri, about 48 mi northeast from the northeast corner of Craig County. According to Howe (1956, p. 39), the Drywood coal is equivalent in part to the Bellamy coal of western Missouri. In Kansas and Missouri "Dry Wood" has been spelled as two words (Searight and others, 1953; Howe, 1956; Brady and others, 1976), but in Oklahoma it is spelled as a single word (Reed and others, 1955; Trumbull, 1957; Branson and others, 1965; Friedman, 1974; Gregg, 1976).

Lack of drill information and the absence of coal in outcrops precluded mapping of the Drywood coal continuously across Craig County (Pl. 2). Where mapped, the coal varies in thickness from a feather edge to 3 ft within a distance of a few feet. In the area from White Oak south to the county line, average thickness of the Drywood coal is only ~2 in.; from Bluejacket and Welch northeastward to the county line, the average thickness is <6 in.; and in much of central Craig County the Drywood has negligible thickness. The Drywood locally thickens to nearly 3 ft in the Timber Hill area, southeast of Pyramid Corners. A 3-ft thickness also has been measured in an active strip mine in

sec. 13, T26N, R19E (Appendix 2, measured section 51; Pls. 2,8).

The Drywood coal is identified by its stratigraphic position at or near the base of the Bluejacket Sandstone, a well-known and prominent member of the Boggy Formation. The Bluejacket Sandstone is 0–50 ft thick; it is yellowish brown, cross-bedded, and medium-grained, and locally at the base it includes conglomerate containing abundant clay-ironstone pebbles. The Bluejacket rests unconformably on older beds, and in some places cuts into or completely through the underlying Drywood coal. This partly explains variations in thickness of the Drywood coal, and its absence in some areas.

Analyses of Drywood coal show that it is high-volatile bituminous in rank. It has a high ash content (averaging almost 15%), a high sulfur content (averaging ~6%), and a heat value averaging more than 12,000 Btu/lb (Appendix 3).

In addition to the Drywood and Rowe coals, thin, lenticular coal stringers of little significance occur in the Savanna Formation. In southern Craig County, the base of the Savanna Formation is marked by the Spaniard Limestone; however, owing to the discontinuous nature of the Spaniard, in northern Craig County the base of the Savanna is mapped at the base of the Rowe coal (Branson and others, 1965, p. 26). The top of the Savanna Formation is marked by the base of the Bluejacket Sandstone.

The Boggy Formation extends upward from the base of the Bluejacket Sandstone to the base of the Weir-Pittsburg coal, or, in the absence of the Weir-Pittsburg, to the top of the Taft Sandstone (Branson and others, 1965, p. 31). The Bluejacket coal is the only named coal within this interval. It was identified in only one place in Craig County (Timber Hill, secs. 25 and 26, T27N, R20E), where it reaches a maximum thickness of 12 in. and occurs ~20 ft below the base of the Weir-Pittsburg coal, at an elevation of ~890 ft above sea level. The Bluejacket coal is not considered to be of economic importance, owing to its limited areal extent, its lenticular nature, and the thickness of overburden.

The top of the Krebs Group is drawn at the top of the Boggy Formation, which is overlain by the Senora Formation. The Senora Formation is the sole representative of the Cabaniss Group in Craig and Nowata Counties (Branson and others, 1965, p. 34).

Cabaniss Group.—The Cabaniss Group extends upward from the base of the Weir-Pittsburg coal to the base of the Fort Scott Formation. Nine named coals are included, of which five are, or have been, important sources of coal production, making this interval one of the most important economically. In ascending order, the nine coals are the Weir-Pittsburg, Tebo, Scammon(?), Mineral, Fleming, Croweburg, Bevier, Iron Post, and Mulky. Of this group, the Tebo, Scammon(?), Bevier, and Mulky coals have no commercial value, owing generally to thinness of the beds.

The Weir-Pittsburg coal was discussed first by Haworth and Crane (1898, p. 26), who described it as the "heaviest vein of coal in Kansas" and stated that it was extensively mined near Weir City, Pittsburg (about 32 mi northeast of Craig County, in Kansas), and other prominent mining towns. It was commonly known as the "Weir-Pittsburg Lower coal"; its average thickness was given as 40 in. Howe (1956, p. 46-48) further discussed the Weir-Pittsburg coal and explained how the term was modified to its present form.

The Weir-Pittsburg coal is widely distributed in Craig County (Pl. 4). It has been extensively mined in the vicinity of Estella, where large areas of "orphan" mined land (Fig. 8) remain; it has also been strip-mined west and north of Welch, and more recently in sec. 2, T26N, R19E. The coal crops out in an isolated area along the Craig–Rogers county line (Appendix 2, measured section 1; Pl. 4).

Like the Drywood, the Weir-Pittsburg coal varies considerably in thickness over short distances. It is, however, the thickest coal in the study area, reaching a maximum thickness of 6.2 ft at a depth of >400 ft in northwestern Craig County (Pl. 4); whether the Weir-Pittsburg could be profitably mined in this area of maximum thickness is uncertain, because the interval was described in the company drill log as "coal and sulfur streaks."

The Weir-Pittsburg coal occurs at the base of the Senora Formation. In southern Craig County, the coal lies a few feet above the Taft Sandstone. The Taft previously had not been mapped north of sec. 21, T25N, R19E, but in this study it was traced into sec. 5, T25N, R19E, where it crosses the road in the southwest corner of the section. A yellowish-brown, micaceous, fine-grained sandstone crops out along State Highway 25 in sec. 25, T27N, R20E, stratigraphically above the Bluejacket Sandstone and below a coal at the base of the Chelsea Sandstone (Appendix 2, measured section 70; Pl. 8). The same yellowish-brown, micaceous sandstone crops out in an area north of Welch, at the top of the Boggy Formation (Appendix 2, measured section 94). This unnamed sandstone has been tentatively correlated with the Taft Sandstone of southern Craig County; the significance of this interpretation is discussed below.

The Tiawah Limestone, a marker bed valuable for identifying the Weir-Pittsburg coal, occurs about 22.5–41 ft above the top of the coal (Branson and others, 1965, p. 34).

The Chelsea Sandstone is another marker useful for identifying the Weir-Pittsburg coal, provided that the stratigraphy of the lower part of the Senora Formation is clearly understood. Interpretations concerning this section (from field observations and new drill data) are as follows: In

Figure 8. "Orphan" mined land 1 mi west of Estella, where the Weir-Pittsburg coal was stripped during the 1950s in sec. 5, T25N, R19E.

southwestern Craig County, near Rogers County, in T25N, R18E, the Chelsea Sandstone is a single, thick unit. However, northwest of White Oak, the Chelsea is split into an upper and a lower unit by a thick shale section (Pl. 8). The Weir-Pittsburg coal lies at the base of the lower unit. In places, pre-Chelsea channels have cut completely through the coal and may extend down to the Bluejacket Sandstone (Fig. 4). This lower unit of the Chelsea can be traced northeastward across Craig County to sec. 5, T27N, R20E, where it apparently pinches out after it crosses the east–west road in the southwest part of the section. The Chelsea Sandstone mapped by Branson and others (1965, pl. 1) on Timber Hill, in sec. 26, T27N, R20E, is the lower unit.

Branson and others (1965, pl. 1) traced the upper split of the Chelsea Sandstone from the White Oak area northeastward to sec. 33, T27N, R19E. Field observations made during the present study show that the unit crops out discontinuously until it joins a lithologically identical sandstone in sec. 31, T28N, R20E, which has been named the Goldenrod (Branson and others, 1965 p. 38). These two units are equivalent. A mapping error by Branson and others (1965, pl. 1) occurred when the upper unit of the Chelsea (Goldenrod) was misidentified as the Lagonda Sandstone in secs. 1 and 12, T27N, R19E, and sec. 6, T27N, R20E. Recently acquired subsurface data show that an anticline there brings the Chelsea (Goldenrod) to the surface, where it crops out at an anomalously high elevation. In this same general area the problem was compounded when Branson and others (1965, pl. 1) confused the Fleming limestone with the Verdigris Limestone. The limestone in the creek bank along the east–west road in the SW¼ Sec. 1, T27N, R19E, is in reality the Fleming limestone. Owing to misidentification of these above-named beds, the coal beds in the same area also were misidentified by Branson and others (1965, pl. 1).

As a result of these new interpretations, the following conclusions have been drawn (Pls. 7,8):

1) The coal mined in the Estella area (Pl. 4) is the Weir-Pittsburg, not the Bluejacket as identified by Branson and others (1965, p. 53). The coal bed cannot be the Bluejacket coal, because it is stratigraphically above the Taft Sandstone. As further proof, the Tiawah Limestone and Tebo coal crop out in the highwall of the abandoned strip pit about 1 mi west of Estella (Appendix 2, measured section 58; Pl. 8). (The Tebo coal generally cannot be seen in highwalls of strip pits in the area, because it has been removed by pre-Chelsea erosion.)

2) The coal along Pawpaw Creek in secs. 27 and 28, T26N, R19E, and the coal mined in that vicinity is the Weir-Pittsburg. Cross sections drawn from logs of >200 closely spaced drill holes definitely connect the coal that was mined 1 mi west of Estella with the coal in secs. 27 and 28, T26N, R19E. Therefore, the sandstone mapped as Bluejacket in that area by Branson and others (1965, pl. 1, fig. 18, p. 32) must be the lower unit of the Chelsea Sandstone. (The Weir-Pittsburg coal cannot be stratigraphically below the Bluejacket Sandstone.)

3) The coal recently strip-mined in sec. 2, T26N, R19E, is the Weir-Pittsburg. Stratigraphic sections measured along the northeast edge of sec. 2 (Appendix 2, measured sections 49–50; Pl. 8) show that the Tiawah Limestone and Tebo coal crop out stratigraphically higher than the coal being mined, and stratigraphically lower than a sandstone that is believed to be the lower unit of the Chelsea. This sandstone can be traced southwestward across sec. 3, T26N, R19E, to an area where Branson and others (1965, pl. 1) tentatively mapped it as Bluejacket Sandstone. This was a stratigraphic error in mapping. The Bluejacket Sandstone cannot occur above the Tiawah Limestone. The interpretation of this paper is that in secs. 14 and 23, T26N, R19E, the lower unit of the Chelsea has filled channels cut down to the top of the Bluejacket Sandstone, and that they combine to form a composite sandstone. A drill hole in sec. 15, T26N, R19E (Pl. 8) shows that the sandstones are split there, and that a thin streak of Weir-Pittsburg coal has been preserved at the base of the lower unit of the Chelsea. Proceeding north and east from this drill site to sec. 2, T26N, R19E, the sandstone tentatively mapped as Bluejacket by Branson and others (1965, pl. 1) is the lower unit of the Chelsea.

4) The coal that underlies the lower unit of the Chelsea Sandstone on Timber Hill is the Weir-Pittsburg coal, not the Bluejacket coal as Branson and others believed (1965, p. 33). This new interpretation is based on the similarity between the succession of beds in the Timber Hill area and that in the Estella area; in descending order, the succession is: conglomeratic sandstone (Chelsea lower unit) filling channels cut down to coal (Weir-Pittsburg); underclay; yellowish-brown,

micaceous sandstone (Taft); a shale section in the upper part of the Boggy Formation; and conglomeratic sandstone (Bluejacket). This succession can be observed in measured section 70 (Appendix 2; Pl. 8) and along the road east from Pyramid Corners on State Highway 25 (secs. 23 and 26, T27N, R20E). Drill holes and measured section 71 (Appendix 2; Pl. 8), in sec. 25, T27N, R20E, show that the Bluejacket coal is also present locally on Timber Hill; it is separated from the Weir-Pittsburg coal above by ~20 ft of shale and sandy shale, and from the Drywood coal below by ~40 ft of sandstone and shale.

The Weir-Pittsburg coal is high-volatile bituminous in rank. One of its detrimental qualities is that locally it contains clay partings, and inclusions resulting from plastic flow of underclays (Appendix 2, measured section 43). The impurity of the coal also causes skepticism concerning the reliability of coal thicknesses as recorded on some company drill logs. Several logs were omitted in compilation of resource figures because they seemed to contain unrealistic data. It is possible that black shale and clay interbedded with streaks of coal were misidentified as pure coal in places above the Weir- Pittsburg bed. Average thickness of the Weir-Pittsburg bed in operating mines is ~2 ft (Fig. 9). Sulfur content averages ~6% (Appendix 3).

Other names applied to the Weir-Pittsburg coal include "Pawpaw" in Rogers and Mayes Counties (Lohman, 1952, p. 32); and "Weir-Pittsburg lower," "Cherokee," "4-foot," and "Big Lower" in Kansas (Howe, 1956, p. 48).

The Tebo coal occurs about 20–40 ft above the Weir-Pittsburg coal. It was named in Henry County, Missouri (Marbut, 1898, p. 123), about 125 mi northeast of Craig County, where it is of minable thickness. In the area of this report, drill logs and exposures (Appendix 2, measured sections 26,30,37,49,58,67,84,85) indicate that the average thickness of the Tebo is about 5–6 in. The Tebo is not of minable thickness in the report area, but its association with the Tiawah Limestone and a fissile black shale that directly overlies the coal makes it a valuable stratigraphic marker. Failure to recognize this succession has led to misidentification of the Weir-Pittsburg coal bed by previous investigators (such as Branson and others, 1965, p. 33,53) in T25–26N, R19E, in the vicinity of Estella.

The Scammon coal previously has not been identified in Oklahoma; however, several drill logs indicate a 2- to 6-in. coal bed ~30 ft above the Tebo and about 25–30 ft below the Mineral, the next-higher coal (Pl. 8). All logs showing this succession are from test holes drilled in T27N, R19E. Owing to its stratigraphic position between the Tebo and Mineral coals, this coal bed is tentatively correlated here with the Scammon coal of Kansas (Howe, 1956, p. 52). The Scammon coal was named

Figure 9. Weir-Pittsburg coal, 26 in. thick, overlain by gray shale, in active strip mine (SW¼NE¼ sec. 9, T25N, R19E) operated by Jess Hefner and Son. Face-cleat direction is N. 49° W. Tape banded at 1-ft intervals.

for exposures along Cherry Creek, northwest of Scammon, Cherokee County, Kansas, about 25 mi northeast of Craig County (Abernathy, 1936, p. 83–84; 1938, p. 195). In Craig County the Scammon coal is known only in the subsurface, where it is too thin to be mined.

The Mineral coal was named by Pierce and Courtier (1937, p. 69–70) from exposures near the town of Mineral, Kansas, about 25 miles northeast of Craig County. It is the next minable coal above the Weir-Pittsburg in the study area. The Mineral coal reaches its maximum thickness (27 in.) in T28N, R20E; the coal has been and is surface-mined there and along the outcrop to the southwest and northeast in T27N, R19E, and T29N, R20E (Pl. 3). The Mineral coal in northern Craig County is typically about 14–18 in. thick. In central Craig County the bed thins to <6 in. and appears to pinch out in T26N, R19E. It reappears in T26N, R18E, where it has recently been strip-mined. It is present also just north of Rogers County (T25N, R17–18E), where its maximum thickness is 16 in.

The Mineral coal lies about 80–90 ft above the Weir-Pittsburg coal and ~30 ft above the Tebo coal in northern Craig County, where it can be readily identified by its association with the Russell Creek Limestone, a dense, black, impure limestone directly overlying the coal. The Russell Creek ranges from a few inches to 3 ft thick; although it is discontinuous, it creates problems for miners, because during shooting of the overburden the limestone breaks into massive, rectangular blocks weighing several tons (Fig. 10), which must be removed in order to extract the coal. The Russell Creek Limestone pinches out in central Craig County, in the area where the Mineral coal becomes too thin to mine. The southernmost exposure of the Russell Creek Limestone occurs on a knoll along the east–west road in the NE¼ sec. 24, T27N, R19E.

Locally, in the area northwest of Welch, the Goldenrod Sandstone fills channels that are cut down to the top of the Mineral coal (Appendix 2, measured section 93; Pl. 6). The Russell Creek Limestone is missing in these areas. A similar relationship was observed in the highwall of a strip mine in southwestern Craig County, where the upper unit of the Chelsea Sandstone fills channels cut down to the Mineral coal (Appendix 2, measured section 28). The similarity of these sections is additional evidence for the equivalence of the Goldenrod Sandstone and the upper unit of the Chelsea Sandstone.

Analyses of the Mineral coal (Appendix 3) show that it is high-volatile bituminous in rank, that it is a high-sulfur coal (averaging just below 5%), and that its heat value averages >12,600 Btu/lb.

The Mineral coal has been referred to in Kansas as the "Weir-Pittsburg upper," "Lightning Creek," "Baxter," "22-inch vein," and "upper seam" (Pierce and Courtier, 1937, p. 70). Friedman (1974, fig. 4, p. 9) has tentatively correlated the Mineral coal with the Morris coal of Okmulgee County, Oklahoma.

The Fleming coal was named from exposures in strip pits north of the village of Fleming, Crawford County, Kansas, about 30 mi northeast of the northeast corner of Craig County (Pierce and Courtier, 1937, p. 73). It is present in Oklahoma only in northern Craig County (Pl. 1). The Fleming coal is extremely variable in thickness; it locally attains thicknesses of 18 in. but tends to thin abruptly over short distances. Its stratigraphic position is approximately midway between the Mineral coal below and the Croweburg coal above; therefore, the Fleming coal is sometimes mined with one or the other, or with both (Fig. 11).

The Fleming coal is differentiated from other coal beds by its stratigraphic position between the Mineral and Croweburg coals. The interval between the Croweburg and Mineral coals remains fairly regular (Pls. 7,8); however, the Fleming tends to undulate within this interval. It is in places closer to the Mineral and in other places closer to the Croweburg. A discontinuous limestone is present about 5–15 ft above the Russell Creek Limestone; it has been called "Fleming cap rock" (Branson and others, 1965, p. 38). It is apparent that the term "cap rock" should be abandoned, because the limestone lies below the Fleming coal in northern Craig county, except at one known locality. It will be referred to informally as the "Fleming limestone" in this report (Fig. 4; Pl. 7).

Figure 10. Slabs of Russell Creek Limestone in spoil piles, sec. 14, T27N, R19E, Craig County. Thickness of the limestone is 0.5–3 ft. The Mineral coal was mined at this location in 1978.

The Fleming coal is locally cut out by channels filled by the overlying Goldenrod Sandstone near the Kansas–Oklahoma border in T29N, R20E (Appendix 2, measured section 93; Pl. 6).

The Fleming coal is high-volatile bituminous in rank; it has a high sulfur content (averaging almost 6%) and a heat value averaging ~12,500 Btu/lb (Appendix 3).

Pierce and Courtier (1937, p. 74) correlated the Fleming coal with the "Middle coal", or "Two-foot coal," of Vernon County, Missouri. Other names, from Kansas, are the "Bastard bed" and the "Mineral rider" (Howe, 1956, p. 68).

The Croweburg coal was named from exposures in strip pits about 1 mi east of Croweburg, Kansas (Pierce and Courtier, 1937, p. 74), about 45 mi northeast of Craig County. It is a highly persistent coal, occurring continuously throughout the coal belt in Craig and Nowata Counties. Its outcrop line extends northeastward across the study area (Pl. 2); coal has been extensively surface-mined all along the outcrop. The Croweburg typically is 14–18 in. thick across much of the area, but it thins to the north and averages only 10–12 in. northwest of Welch.

The Croweburg coal is readily identified in the field by the succession of overlying beds. It is directly overlain by light-gray, silty shale that varies in thickness from as much as 50 ft in Nowata County to ~10 ft in north-central Craig County

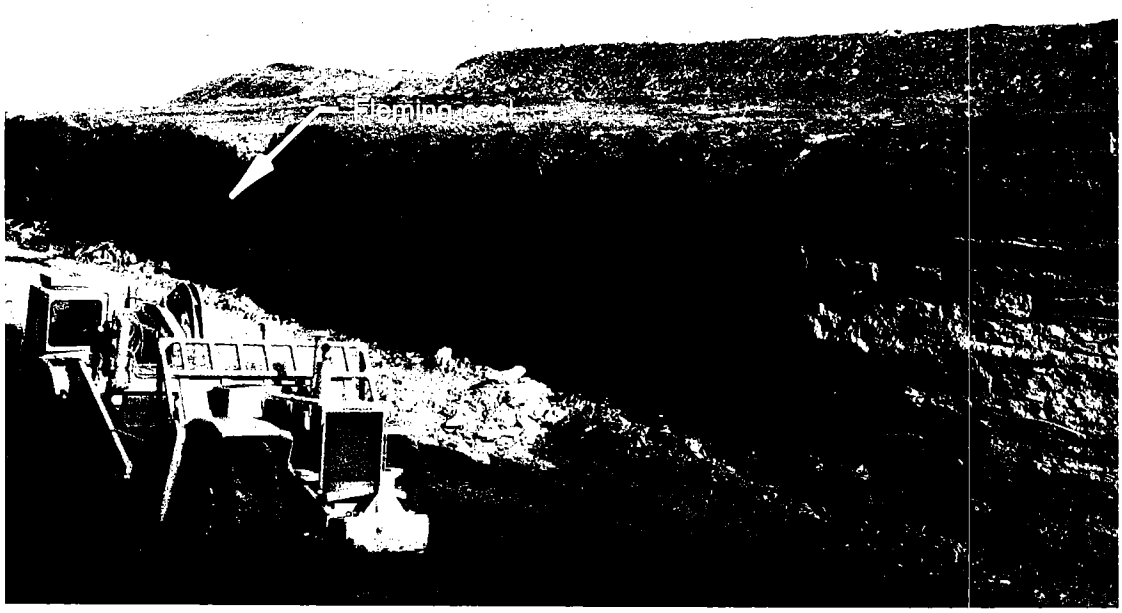


Figure 11. Multiple-seam mining in sec. 1, T28N, R20E, Craig County. The Croweburg coal was mined at the top of the hill, Fleming coal midway down, and Mineral coal at the bottom.

(Appendix 2, measured sections 16,22,78; Pl. 6). The light-gray shale is overlain by fissile black shale containing phosphatic nodules. The black shale is overlain in turn by a persistent, dark-gray, fossiliferous limestone, about 2–8 ft thick, that weathers yellow-brown. The name "Verdigris" was formally adopted for this fossiliferous limestone by the geological surveys of Nebraska, Kansas, Missouri, and Oklahoma (Branson, 1954, p. 2).

An unnamed 1- to 2-in. coal seam occurs locally in association with the black phosphatic shale that underlies the Verdigris Limestone. Austin (1946, appendix, p. 35) misidentified this coal as the "Broken Arrow" (Croweburg) in sec. 24, T26N, R18E, where it lies 2 ft below the Verdigris Limestone. The interval between the Croweburg coal and Verdigris Limestone is ~40 ft in that area.

Analyses of numerous samples of Croweburg coal (Appendix 3) show that it is high-volatile bituminous in rank. It is characterized in the study area by low sulfur content (average <1%) and a high calorific value (average >13,000 Btu/lb).

The Croweburg coal is also known in Oklahoma as the "Broken Arrow coal," "Henryetta coal," "Sequoyah coal," and "Speckled Bird coal" (a miners' term). Branson (1954, p. 2) formally adopted the name "Croweburg" for the "Broken Arrow coal" of Oklahoma, but Oakes (1944, p. 11–12) was the first to correlate the "Broken Arrow" with the Croweburg coal of Kansas. According to Howe (1956, p. 71–72), popular informal names applied to the Croweburg coal in Kansas include "Fireclay," "One-foot," "Ten-inch," "Moundville," and "Soapstone."

The Bevier coal occurs in the interval between the Verdigris Limestone and the Iron Post coal, commonly about 8–15 ft below the Iron Post (Pl. 7; Appendix 2, measured section 64). According to Howe (1956, p. 78), "The name 'Bevier' was originally applied by McGee (1888, p. 328–336) to coal mined extensively at Bevier, Macon County, Missouri, after which town it takes its name, and in other places in north-central Missouri."

The Bevier coal was identified in exposures and drill logs in northwestern Craig County, but it was not identified in Nowata County. The southernmost exposure of the Bevier was described by Lohman (1952, p. 88–89) in sec. 36, T26N, R18E, where it is 1 ft thick. Although Brady and others (1976, p. 22) characterized the Bevier as one of the five most important coal beds in Kansas, it is not commercially important in Oklahoma. In Craig County, the Bevier averages 8–10 in. in thickness and is of poor quality (Appendix 3).

The Iron Post coal was named by Howe (1951, p. 2092) for a rural school of that name in the southwest corner of sec. 31, T29N, R20W, in Craig County, Oklahoma. Plate 1 shows that the Iron

Post has been strip-mined extensively in the southwest part of the study area, where the topography allows for large-scale mining on the dip slope. The Iron Post coal crops out along a northeasterly line in the northwest third of Craig County. The line of outcrop is well marked by nearly continuous abandoned strip pits (Fig. 12; Pl. 1).

Isopach contours (Pl. 1) show that the Iron Post coal has little commercial value in the northern part of Craig County, where its average thickness is <10 in. Its average thickness is ~14 in. in the southwest part of the study area.

According to Howe (1956, p. 84), the Iron Post coal is absent in areas north of Oklahoma. However, Branson (1952, p. 191) wrote that the "Breezy Hill Limestone and the Iron Post coal have been traced from near Fort Scott, Kansas, to a point near Broken Arrow, Oklahoma."

Recent work by the Kansas Geological Survey has helped to resolve the problem of the Iron Post coal in Kansas. N. D. Livingston (personal communication, 1980) has examined approximately 50 drill logs from southern Labette County, Kansas, and has shown that the Bevier coal is the only coal in the interval between the Verdigris Limestone and the Breezy Hill Limestone in the eastern part of the area. The coal occurs near the base of the Lagonda Sandstone, a few feet above the Verdigris Limestone. He has also shown that the Bevier coal splits into two beds in the central and western parts of southern Labette County. The upper split of the Bevier coal is correlative with the Iron Post coal of Oklahoma, and the lower split is correlative with the Bevier coal of Oklahoma (Fig. 13).

The Iron Post coal is easily identified in the field by its stratigraphic position; it lies ~30 ft above the Verdigris Limestone and is overlain by a few feet of black and gray shale (Kinnison Shale) which contains phosphatic nodules. The shale in turn is overlain by an impure, dense, fossiliferous, brown-weathering limestone, 2–10 ft thick, known as the Breezy Hill. Another phosphatic black shale (Excello Shale), 4–8 ft thick, separates the Breezy Hill Limestone from the overlying Fort Scott Formation (Appendix 2, measured sections 11–15,17,18,21,24); Pl. 6; Fig. 12).

In Oklahoma, the Iron Post coal is known informally as the "Fort Scott coal" and the "Red coal," whereas in Kansas these names have been applied to a coal that lies a few feet below the base of the Fort Scott Formation and above the Breezy Hill Limestone (Pierce and Courtier, 1937, p. 78). The coal in Kansas is the Mulky coal; the Mulky is not correlative with the Iron Post coal of Oklahoma, which occurs below the Breezy Hill Limestone (Fig. 13).

The Iron Post coal is high-volatile bituminous in rank. Its sulfur content averages ~3.6%, and its heat value averages >13,000 Btu/lb (Appendix 3).

Figure 12. Abandoned strip pit where the Iron Post coal was mined in the NW¼SW¼NW¼ sec. 6, T27N, R20E. Stratigraphic sequence includes the Kinnison Shale (above water), Breezy Hill Limestone, and Excello Shale at the surface.

The uppermost coal bed in the Senora Formation is the Mulky coal. Previously it has not been recognized in Oklahoma, but subsurface information from three drill holes in secs. 13 and 22, T28N, R19E, indicates that a coal bed with a maximum thickness of 10 in. occurs near the top of the Senora in that area. The coal lies immediately above the Breezy Hill Limestone, and at the base of the Excello Shale. This newly discovered coal is correlative with the Mulky coal of Kansas, described by Brady and others (1976, p. 22–23). Although the Mulky coal has been mined in Kansas (where it has been referred to as the "Fort Scott coal"), it has no economic importance in Oklahoma, owing to extensive overburden. Drill logs show an average overburden of ~60 ft, of which ~44 ft is limestone of the Fort Scott Formation.

Marmaton Group.—The Marmaton Group comprises all strata between the base of the Fort Scott Formation and the disconformity at the base of the overlying Missourian Series (Branson and others, 1965, p. 42). In the study area, only the Fort Scott, Labette, Pawnee, Bandera, and Altamont Formations are present. Near the top of the Labette Formation is a thin, soft, earthy coal known as the Lexington (Fig. 4). It was observed only in northwestern Craig County, in T28–29N, R18E, where its maximum thickness is only ~2 in. No other coals are found in the Marmaton Group.

COAL ECONOMICS

Production

In 1978, Craig County ranked first in coal production among the coal-producing counties of Oklahoma. Statistics from the Oklahoma Depart-

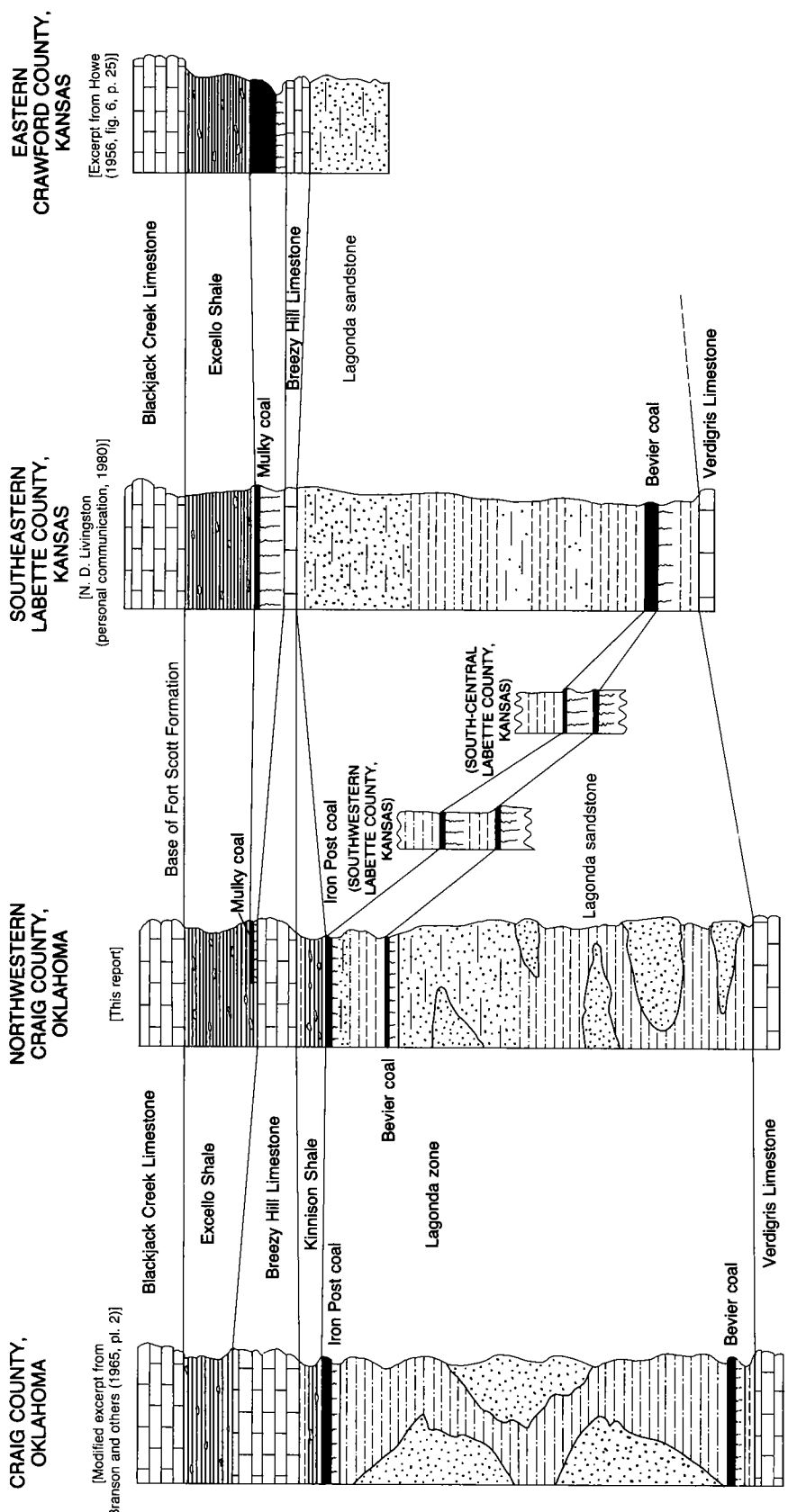


Figure 13. Stratigraphic positions of the Bevier coal, the Iron Post coal, and the Mulky coal, and correlation of beds in northwestern Craig County, Oklahoma, southern Labette County, Kansas, and eastern Crawford County, Kansas. The stratigraphic interpretation of Branson and others (1965) contrasts with the interpretation of this report. Thickness of units approximate.

ment of Mines show that total production was 1,924,131 tons. Additionally, 31,912 tons was produced in Nowata County in 1978, for a grand total of 1,956,043 tons annual production for the area covered in this report. Total coal production for Oklahoma in 1978 was 5,428,678 tons (Oklahoma Department of Mines, 1979, p. 22). Therefore, 36% of the State's coal production came from the coalfield of Craig and Nowata Counties.

The leading producer in the area (and the State) in 1978 was Peabody Coal Co., which mined well over 1,000,000 tons. All of this production was from the Iron Post coal bed. The second-leading producer, in both the study area and the State, was Leon's Coal Co., which mined just under 400,000 tons. Most of this production was from the Croweburg, Mineral, and Drywood coal beds.

Fifteen operators were producing coal from a total of 39 strip mines (some were multiple-seam operations) in the study area at various times during 1978 (Pls. 1–4). According to statistics provided by coal companies, the average value of the coal produced is estimated at $17/ton. The total value of all coal produced from the seven commercial coal beds is estimated at $33,253,000.

Friedman (1974, p. 43–51) summarized the history of coal production in Oklahoma. Figures 14 and 15 show the reported production of coal in Craig and Nowata Counties from 1917 to 1978. Production peaked in Nowata County in 1972, when 476,000 tons was mined, and in Craig County in 1977, when 2,546,583 tons was mined. Total production was down in 1978, owing to a miners' strike. An unknown tonnage of coal was mined on a small scale for local use before production records were kept. Campbell and Vinita (1969, p. 161), in their report on the history of the Craig County area, wrote about recollections of early settlers from the late 1800s:

> For cooking fuel we had the finest of wood along the creek. For heating we used coal. That country was underlaid with coal. When water was low in the creek in summer one could scrape off a few inches of dirt and there was coal. A man for one dollar threw up on the bank all the coal we needed for winter.

Appendix 1 contains tablulated coal data including original resources, remaining resources, coal mined or lost in mining, and reserves. These data are arranged by township and pertain to each of the seven coals in the study area that have economic importance: Rowe, Drywood, Weir-Pittsburg, Mineral, Fleming, Croweburg, and Iron Post. Table 1 shows a combined grand total of 699,564,000 tons as the original resources of the study area; 669,737,000 tons as the remaining resources; 29,827,000 tons as mined or lost in mining; and 47,674,000 tons as the reserves. These figures combine the statistics for all seven commercial coals in Craig and Nowata Counties.

Table 2 incorporates the statistics by coal bed for each of the two counties. The Weir-Pittsburg coal has the greatest remaining resources in Craig County (415,326,000 tons). The Weir-Pittsburg leads also in reserves (18,730,000 tons). In Nowata County, the Croweburg coal has the greatest remaining resources (15,081,000 tons). In the reserves category, the Iron Post coal leads (3,185,000 tons).

Coal from the study area is used primarily in steam electric generating plants, most of which are in Missouri. The coal is transported mainly by truck and rail (Fig. 16).

Most of Oklahoma's coal is shipped for use out of the State, owing to the State's existing air-quality standards. According to the Oklahoma State Air Quality Service, as much as 1.2 lb of SO_2 emissions per million British thermal units of fuel is allowed. This is equivalent to about 0.7–0.8% sulfur in coal that has heat values of 12,000–14,000 Btu/lb (Arndt and others, 1978, p. 9). The weighted average sulfur content of coal produced in the study area exceeds 2%; therefore, electric-power companies in Oklahoma do not plan to use the local coal.

Mining Methods

At the time this study was made, all coal produced in Craig and Nowata Counties was mined by surface methods. Underground mining is not practiced in the area at present, owing to the gentle dip of coal beds in the northeastern Oklahoma shelf area and the comparative ease with which the coal can be strip-mined.

Several methods of overburden removal are used in the area. Bill's Coal Co., Leon's Coal Co., Peabody Coal Co., and Russell Creek Coal Co. use draglines (Fig. 17). This system allows for comparatively low costs when it is used in conjunction with bulldozers and scrapers for reclamation and topsoil handling. Peabody Coal Co. also uses stripping shovels, which are most efficient for handling the limestone overburden associated with the Iron Post coal.

Many of the smaller companies operate only with crawler tractors, dirt scrapers, and front-end loaders for removal of overburden and reclamation work. Overburden is generally blasted before removal, but, if the overburden is shale, only ripping with large bulldozers may be needed. After the coal beds are exposed, the surface of the coal is cleaned thoroughly, then ripped. Front-end loaders pile the ripped coal and later load it onto trucks for removal to a preparation plant. In many operations the coal is crushed into fragments ranging from 0.25 in. to 1.5 in. diameter before shipment.

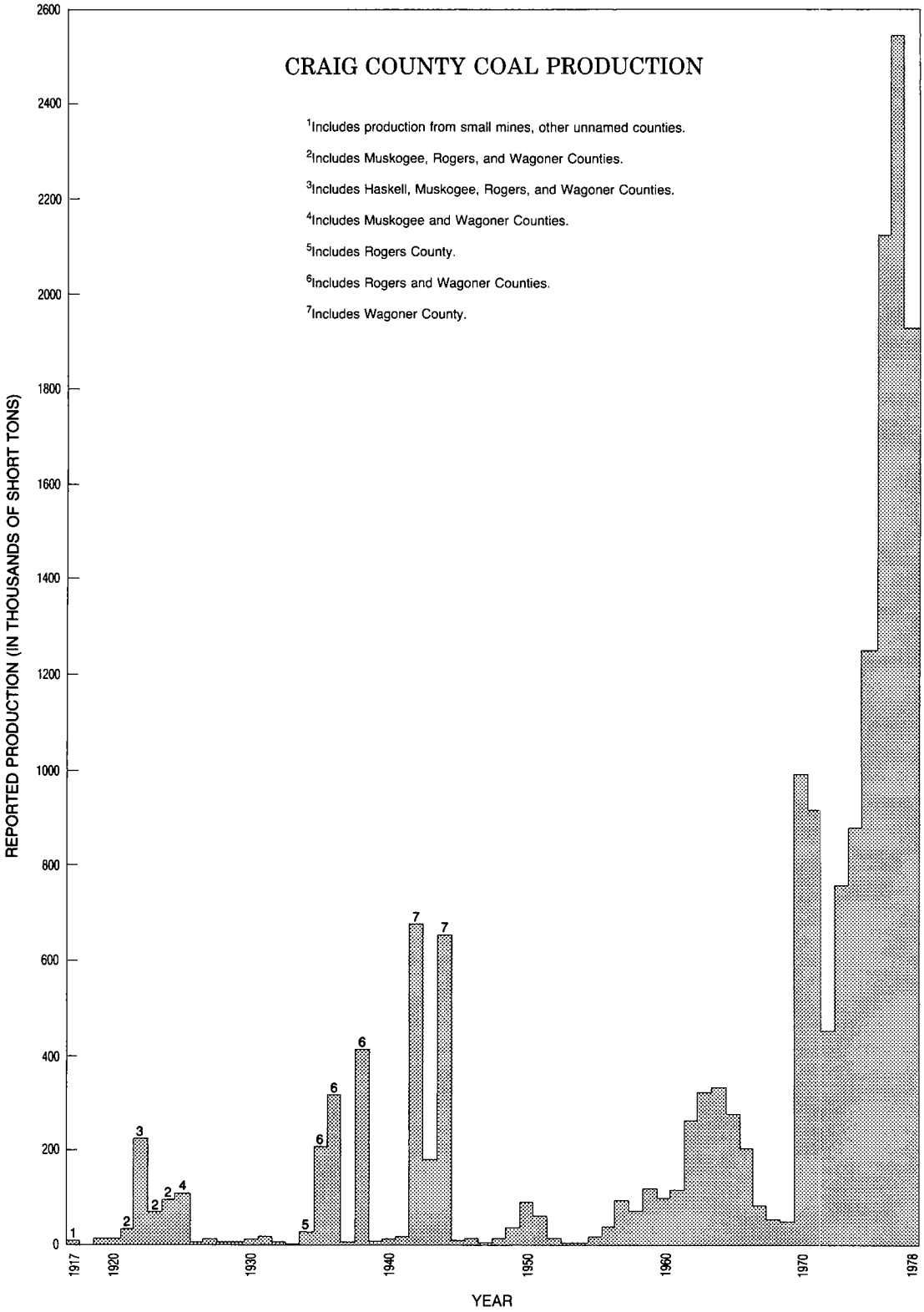


Figure 14. Histogram illustrating reported production of coal in Craig County, 1917–78. (Data for 1917–33 from USGS, *Mineral Resources of the United States*; data for 1933–52 from USBM; data for 1953–78 from *Annual Report of the Chief Mine Inspector, Oklahoma Department of Mines*.)

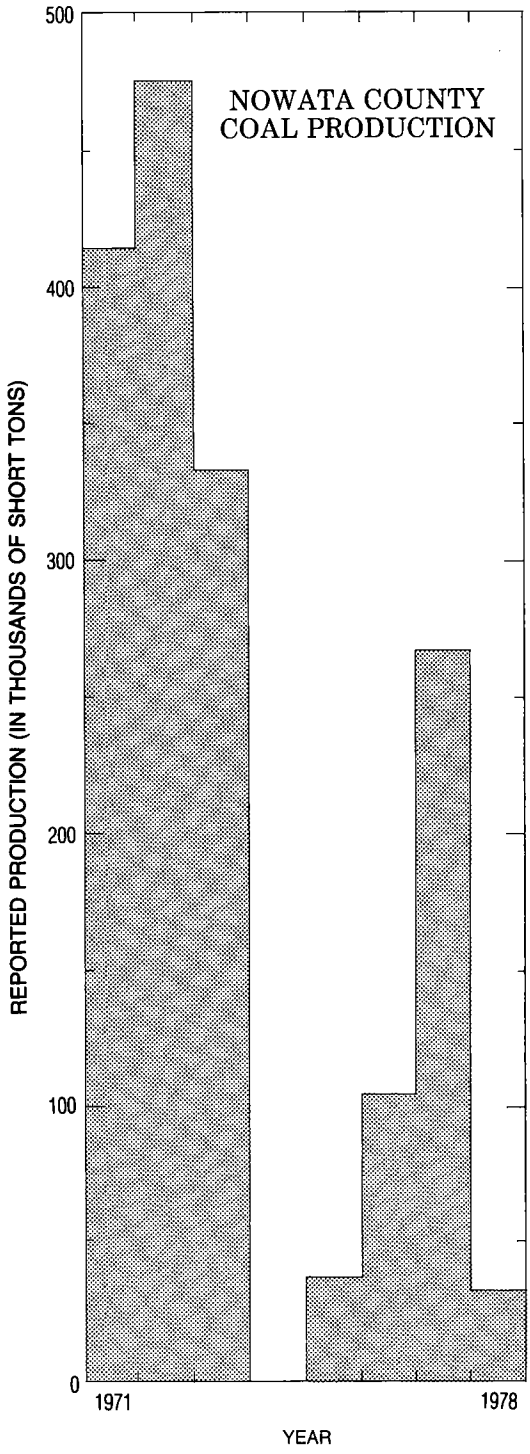


Figure 15. Histogram illustrating reported production of coal in Nowata County, 1971–78. (Data from *Annual Report of the Chief Mine Inspector, Oklahoma Department of Mines*.)

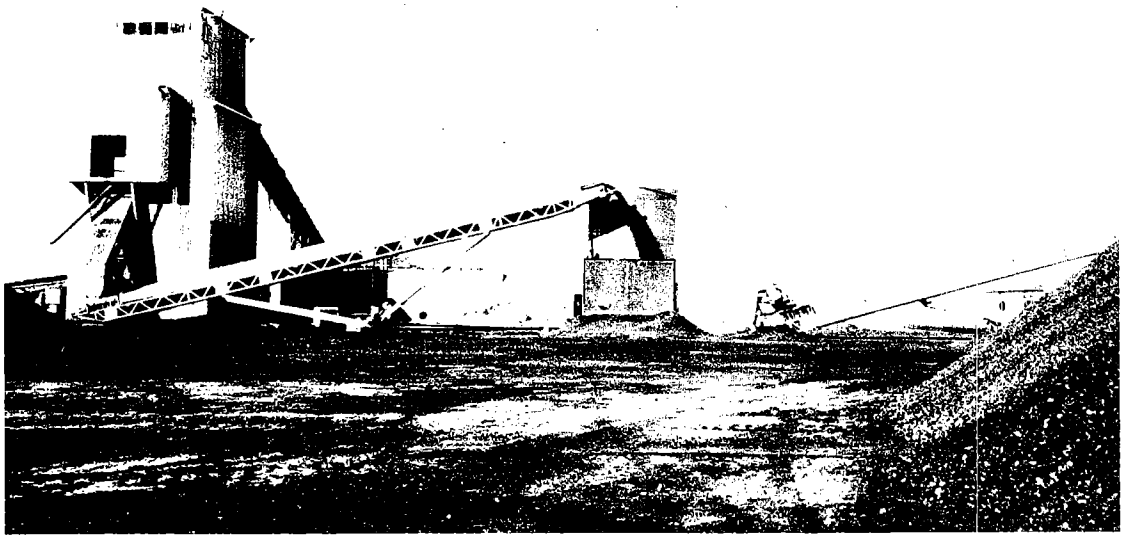


Figure 16. Russell Creek Coal Co. preparation plant and loading dock north of Welch, on the Missouri-Kansas-Texas Railroad, in sec. 6, T29N, R21E.

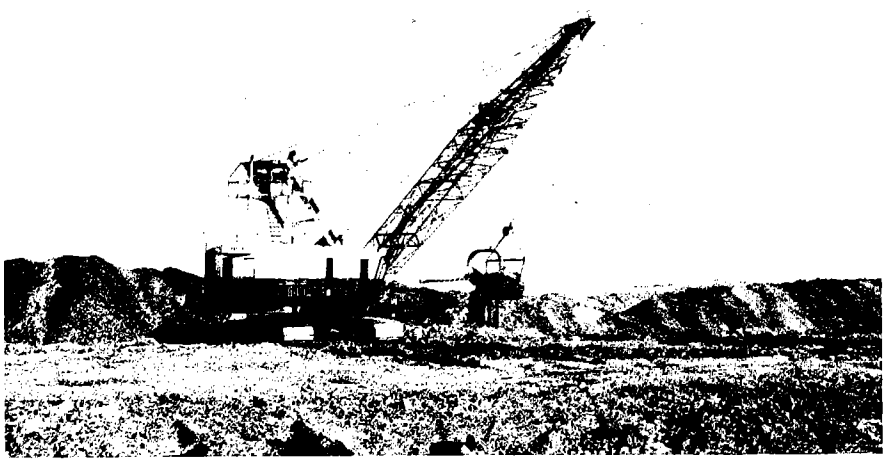


Figure 17. Marion 10-yd^3-bucket dragline, owned by Leon's Coal Co., stripping overburden from the Mineral coal bed, sec. 3, T28N, R20E.

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Appendixes

APPENDIX 1: Coal Resources and Reserves by Township and Range and by Coal Bed

(thousands of short tons)

Coal	Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
T24N, R19E, CRAIG COUNTY																		
WEIR-PITTSBURG	Measured	0-20	8	12							8	12			8	12	8	10
		20-40	20	35							20	35			20	35		
		40-100	46	67							46	67			46	67		
		>100																
		Total	74	114							74	114			74	114	8	10
	Indicated	0-20	8	15							8	15			8	15	8	12
		20-40	11	16							11	16			11	16		
		40-100	118	172							118	172			118	172		
		>100																
		Total	137	203							137	203			137	203	8	12
	Inferred	0-20																
		20-40																
		40-100	17	25							17	25			17	25		
		>100																
		Total	17	25							17	25			17	25		
	Grand Total		228	342							228	342			228	342	16	22
T25N, R17E, NOWATA COUNTY																		
IRON POST	Measured	0-20	451	862	289	682					740	1,544	1,563	3,342	2,303	4,886	740	1,235
		20-40	259	505	240	552					499	1,057			499	1,057		
		40-100																
		>100																
		Total	710	1,367	529	1,234					1,239	2,601			2,802	5,943	740	1,235
	Indicated	0-20	374	694	354	655					728	1,349			728	1,349	728	1,079
		20-40	561	1,130	684	1,553					1,245	2,683			1,245	2,683		
		40-100																
		>100																
		Total	935	1,824	1,038	2,208					1,973	4,032			1,973	4,032	728	1,079

CROWEBURG	Inferred	0-20	114	220	246	594		360	814			360	814	360	651
		20-40	933	1,636	18	41		951	1,677			951	1,677		
		40-100	22	40				22	40			22	40		
		>100													
		Total	1,069	1,896	264	635		1,333	2,531			1,333	2,531	360	651
	Grand Total		2,714	5,087	1,831	4,077		4,545	9,164	1,563	3,342	6,108	12,506	1,828	2,965
	Measured	0-20	109	218	230	583		339	801	542	1,317	881	2,118	339	641
		20-40	125	250	192	481		317	731			317	731	192	385
		40-100	982	2,069	645	1,594		1,627	3,663			1,627	3,663		
		>100													
		Total	1,216	2,537	1,067	2,658		2,283	5,195			2,825	6,512	531	1,026
	Indicated	0-20	169	326	66	157		235	483			235	483	235	386
		20-40	206	390	105	232		311	622			311	622	105	186
		40-100	1,479	2,988	210	514		1,689	3,502			1,689	3,502		
		>100			70	152		70	152			70	152		
		Total	1,854	3,704	451	1,055		2,305	4,759			2,305	4,759	340	572
	Inferred	0-20	17	31				17	31			17	31	17	25
		20-40	67	121				67	121			67	121		
		40-100	2,652	4,886				2,652	4,886			2,652	4,886		
		>100			41	89		41	89			41	89		
		Total	2,736	5,038	41	89		2,777	5,127			2,777	5,127	17	25
	Grand Total		5,806	11,279	1,559	3,802		7,365	15,081	542	1,317	7,907	16,398	888	1,623
MINERAL	Measured	0-20			57	142		57	142			57	142	57	114
		20-40			157	371		157	371			157	371	38	73
		40-100	102	223				102	223			102	223		
		>100													
		Total	102	223	214	513		316	736			316	736	95	187
	Indicated	0-20			16	40		16	40			16	40	16	32
		20-40			62	144		62	144			62	144	17	34
		40-100	42	87				42	87			42	87		
		>100			8	21		8	21			8	21		
		Total	42	87	86	205		128	292			128	292	33	66

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal Category of Reliability	Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
Inferred	0-20																
	20-40																
	40-100																
	>100																
	Total																
Grand Total		144	310	300	718					444	1,028			444	1,028	128	253
Combined Grand Totals		8,664	16,676	3,690	8,597					12,354	25,273	2,105	4,659	14,459	29,932	2,844	4,841
							T25N, R18E, CRAIG COUNTY										
IRON POST																	
Measured	0-20	117	210	63	151					180	361	819	1,931	999	2,292	180	289
	20-40			8	20					8	20			8	20		
	40-100																
	>100																
	Total	117	210	71	171					188	381			1,007	2,312	180	289
Indicated	0-20			104	249					104	249			104	249	104	199
	20-40			15	35					15	35			15	35		
	40-100																
	>100																
	Total			119	284					119	284			119	284	104	199
Inferred	0-20			277	679					277	679			277	679	277	543
	20-40																
	40-100																
	>100																
	Total			277	679					277	679			277	679	277	543
Grand Total		117	210	467	1,134					584	1,344	819	1,931	1,403	3,275	561	1,031

CROWEBURG	Measured	0-20	72	140	152	361	224	501	320	684	544	1,185	224	401
		20-40	73	144	160	381	233	525			233	525	160	305
		40-100	122	238	529	1,227	651	1,465			651	1,465		
		>100			27	69	27	69			27	69		
		Total	267	522	868	2,038	1,135	2,560			1,455	3,244	384	706
	Indicated	0-20	440	879	248	584	688	1,463			688	1,463	688	1,170
		20-40	169	313	475	1,111	644	1,424			644	1,424	475	889
		40-100	730	1,456	1,171	2,693	1,901	4,149			1,901	4,149		
		>100												
		Total	1,339	2,648	1,894	4,388	3,233	7,036			3,233	7,036	1,163	2,059
	Inferred	0-20	149	282	51	118	200	400			200	400	200	320
		20-40	116	217	26	60	142	277			142	277	16	30
		40-100	142	271	49	113	191	384			191	384		
		>100												
		Total	407	770	126	291	533	1,061			533	1,061	216	350
	Grand Total		2,013	3,940	2,888	6,717	4,901	10,657	320	684	5,221	11,341	1,763	3,115
MINERAL	Measured	0-20	79	152	146	328	225	480	30	64	255	544	225	384
		20-40	57	118	85	191	142	309			142	309		
		40-100	112	221			112	221			112	221		
		>100												
		Total	248	491	231	519	479	1,010			509	1,074	225	384
	Indicated	0-20	159	286	239	523	398	809			398	809	398	647
		20-40	294	566	15	32	309	598			309	598		
		40-100	764	1,440			764	1,440			764	1,440		
		>100												
		Total	1,217	2,292	254	555	1,471	2,847			1,471	2,847	398	647
	Inferred	0-20	108	173			108	173			108	173	108	138
		20-40	206	349			206	349			206	349		
		40-100	708	1,294			708	1,294			708	1,294		
		>100												
		Total	1,022	1,816			1,022	1,816			1,022	1,816	108	138

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
Grand Total		2,487	4,599	485	1,074					2,972	5,673	30	64	3,002	5,737	731	1,169
Combined Grand Totals		4,617	8,749	3,840	8,925					8,457	17,674	1,169	2,679	9,626	20,353	3,055	5,315
							T25N, R19E, CRAIG COUNTY										
WEIR-PITTSBURG																	
Measured	0-20	124	246	166	393					290	639	275	670	565	1,309	290	511
	20-40	68	134	185	534					253	668			253	668	74	210
	40-100	39	72	317	1,077					356	1,149			356	1,149		
	>100																
	Total	231	452	668	2,004					899	2,456			1,174	3,126	364	721
Indicated	0-20	196	390							196	390			196	390	196	312
	20-40	247	481	8	18					255	499			255	499		
	40-100	212	416	12	8					224	424			224	424		
	>100			7	15					7	15			7	15		
	Total	655	1,287	27	41					682	1,328			682	1,328	196	312
Inferred	0-20	238	477							238	477			238	477	238	382
	20-40	299	583							299	583			299	583		
	40-100	979	2,004							979	2,004			979	2,004		
	>100			2,120	4,386					2,120	4,386			2,120	4,386		
	Total	1,516	3,064	2,120	4,386					3,636	7,450			3,636	7,450	238	382
Grand Total		2,402	4,803	2,815	6,431					5,217	11,234	275	670	5,492	11,904	798	1,415

DRYWOOD	Measured	0-20	230	427	3	6		233	433		233	433	233	346
		20-40	67	127	23	54		90	181		90	181		
		40-100	589	1,089	50	99		639	1,188		639	1,188		
		>100												
		Total	886	1,643	76	159		962	1,802		962	1,802	233	346
	Indicated	0-20	295	566	2	4		297	570		297	570	297	456
		20-40	318	609	20	48		338	657		338	657		
		40-100	1,173	2,138	32	74		1,205	2,212		1,205	2,212		
		>100												
		Total	1,786	3,313	54	126		1,840	3,439		1,840	3,439	297	456
	Inferred	0-20	18	28				18	28		18	28	18	22
		20-40	46	76				46	76		46	76		
		40-100	69	115				69	115		69	115		
		>100												
		Total	133	219				133	219		133	219	18	22
	Grand Total		2,805	5,175	130	285		2,935	5,460		2,935	5,460	548	824
ROWE	Measured	0-20	14	23				14	23		14	23	14	18
		20-40	1	2				1	2		1	2		
		40-100												
		>100												
		Total	15	25				15	25		15	25	14	18
	Indicated	0-20												
		20-40												
		40-100												
		>100												
		Total												
	Inferred	0-20												
		20-40												
		40-100												
		>100												
		Total												

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal Category of Reliability	Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
							T26N, R17E, NOWATA COUNTY										
	Grand Total	15	25							15	25			15	25	14	18
	Combined Grand Totals	5,222	10,003	2,945	6,716					8,167	16,719	275	670	8,442	17,389	1,360	2,257
IRON POST Measured	0-20											1,322	2,800	1,322	2,800		
	20-40																
	40-100																
	>100																
	Total													1,322	2,800		
Indicated	0-20																
	20-40																
	40-100	111	180							111	180			111	180		
	>100																
	Total	111	180							111	180			111	180		
Inferred	0-20	148	275							148	275			148	275	148	220
	20-40	786	2,196							786	2,196			786	2,196		
	40-100	604	976							604	976			604	976		
	>100																
	Total	1,538	3,447							1,538	3,447			1,538	3,447	148	220
	Grand Total	1,649	3,627							1,649	3,627	1,322	2,800	2,971	6,427	148	220

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

T26N, R18E, CRAIG COUNTY

IRON POST	Measured	0-20	40	76	70	160	110	236	4,528	9,155	4,638	9,391	110	188
		20-40	256	481	122	263	378	744			378	744		
		40-100	154	262			154	262			154	262		
		>100												
		Total	450	819	192	423	642	1,242			5,170	10,397	110	188
	Indicated	0-20	325	616	243	549	568	1,165			568	1,165	568	932
		20-40	1,128	2,241	924	2,081	2,052	4,322			2,052	4,322		
		40-100	606	972			606	972			606	972		
		>100												
		Total	2,059	3,829	1,167	2,630	3,226	6,459			3,226	6,459	568	932
	Inferred	0-20	127	241	129	300	256	541			256	541	256	433
		20-40	1,305	2,329	1,031	2,229	2,336	4,558			2,336	4,558		
		40-100	2,646	4,869	1,336	2,887	3,982	7,756			3,982	7,756		
		>100												
		Total	4,078	7,439	2,496	5,416	6,574	12,855			6,574	12,855	256	433
	Grand Total		6,587	12,087	3,855	8,469	10,442	20,556	4,528	9,155	14,970	29,711	934	1,553
CROWEBURG	Measured	0-20	66	128			66	128	134	264	200	392	66	102
		20-40	78	146	14	30	92	176			92	176	14	24
		40-100	267	496	21	52	288	548			288	548		
		>100			34	93	34	93			34	93		
		Total	411	770	69	175	480	945			614	1,209	80	126
	Indicated	0-20	115	213	27	62	142	275			142	275	142	220
		20-40	124	238	25	58	149	296			149	296	25	46
		40-100	970	1,841	301	707	1,271	2,548			1,271	2,548		
		>100			30	71	30	71			30	71		
		Total	1,209	2,292	383	898	1,592	3,190			1,592	3,190	167	266
	Inferred	0-20	138	266	13	31	151	297			151	297	151	238
		20-40	127	247	16	39	143	286			143	286	16	31
		40-100	807	1,485	187	441	994	1,926			994	1,926		
		>100												
		Total	1,072	1,998	216	511	1,288	2,509			1,288	2,509	167	269
	Grand Total		2,692	5,060	668	1,584	3,360	6,644	134	264	3,494	6,908	414	661

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
WEIR-PITTSBURG	Measured	0-20																
		20-40																
		40-100																
		>100																
		Total																
	Indicated	0-20																
		20-40																
		40-100			37	141					37	141			37	141		
		>100			154	634					154	634			154	634		
		Total			191	775					191	775			191	775		
	Inferred	0-20																
		20-40																
		40-100			36	88					36	88			36	88		
		>100			4,010	13,009					4,010	13,009			4,010	13,009		
		Total			4,046	13,097					4,046	13,097			4,046	13,097		
	Grand Total				4,237	13,872					4,237	13,872			4,237	13,872		
Combined Grand Totals			9,279	17,147	8,760	23,925					18,039	41,072	4,662	9,419	22,701	50,491	1,348	2,214
		T26N, R19E, CRAIG COUNTY																
	Measured	0-20	13	22							13	22	25	36	38	58	13	23
		20-40	30	43							30	43			30	43		
		40-100																
		>100																
		Total	43	65							43	65			68	101	13	23

IRON POST	Indicated	0-20	10	16		10	16			10	16	10	13
		20-40											
		40-100											
		>100											
		Total	10	16		10	16			10	16	10	13
	Inferred	0-20											
		20-40											
		40-100											
		>100											
		Total											
	Grand Total		53	81		53	81	25	36	78	117	23	36
CROWEBURG	Measured	0-20	41	72		41	72	145	208	186	280	41	58
		20-40	53	100		53	100			53	100		
		40-100	164	267		164	267			164	267		
		>100											
		Total	258	439		258	439			403	647	41	58
	Indicated	0-20	35	61		35	61			35	61	35	49
		20-40	12	18		12	18			12	18		
		40-100	209	322		209	322			209	322		
		>100											
		Total	256	401		256	401			256	401	35	49
	Inferred	0-20											
		20-40											
		40-100	52	81		52	81			52	81		
		>100											
		Total	52	81		52	81			52	81		
	Grand Total		566	921		566	921	145	208	711	1,129	76	107
	Measured	0-20											
		20-40											
		40-100											
		>100											
		Total											

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal Category of Reliability		Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
MINERAL	Indicated	0-20																
		20-40	17	27							17	27			17	27		
		40-100	6	10							6	10			6	10		
		>100																
		Total	23	37							23	37			23	37		
	Inferred	0-20	261	422							261	422			261	422	261	338
		20-40	38	61							38	61			38	61		
		40-100																
		>100																
		Total	299	483							299	483			299	483	261	338
	Grand Total		322	520							322	520			322	520	261	338
WEIR-PITTSBURG	Measured	0-20	8	14	215	666	25	119			248	799	310	898	558	1,697	248	639
		20-40	80	144	687	2,194	15	71			782	2,409			782	2,409	420	1,233
		40-100	80	143	1,376	4,809					1,456	4,952			1,456	4,952	142	484
		>100																
		Total	168	301	2,278	7,669	40	190			2,486	8,160			2,796	9,058	810	2,356
	Indicated	0-20	11	22	235	853					246	875			246	875	246	700
		20-40	52	111	312	1,052					364	1,163			364	1,163	210	662
		40-100			2,042	6,678	66	307			2,108	6,985			2,108	6,985	158	509
		>100			57	177					57	177			57	177		
		Total	63	133	2,646	8,760	66	307			2,775	9,200			2,775	9,200	614	1,871
	Inferred	0-20			106	396					106	396			106	396	106	317
		20-40			240	944					240	944			240	944	236	747
		40-100	7	12	1,444	5,590					1,451	5,602			1,451	5,602	121	384
		>100			2,329	8,672					2,329	8,672			2,329	8,672		
		Total	7	12	4,119	15,602					4,126	15,614			4,126	15,614	463	1,448
	Grand Total		238	446	9,043	32,031	106	497			9,387	32,974	310	898	9,697	33,872	1,887	5,675

DRYWOOD	Measured	0-20	49	83	27	90			76	173	49	192	125	365	76	138
		20-40	88	147	90	275			178	422			178	422		
		40-100	105	172	10	32			115	204			115	204		
		>100														
		Total	242	402	127	397			369	799			418	991	76	138
	Indicated	0-20	2	3					2	3			2	3	2	2
		20-40	25	50					25	50			25	50		
		40-100	144	285					144	285			144	285		
		>100														
		Total	171	338					171	338			171	338	2	2
	Inferred	0-20														
		20-40														
		40-100														
		>100														
		Total														
	Grand Total		413	740	127	397			540	1,137	49	192	589	1,329	78	140
	Combined Grand Totals		1,592	2,708	9,170	32,428	106	497	10,868	35,633	529	1,334	11,397	36,967	2,325	6,296
								T26N, R20E, CRAIG COUNTY								
DRYWOOD	Measured	0-20			7	20			7	20			7	20	7	16
		20-40														
		40-100														
		>100														
		Total			7	20			7	20			7	20	7	16
	Indicated	0-20														
		20-40														
		40-100														
		>100														
		Total														

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

ROWE

Coal Category of Reliability	Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
Inferred	0-20																
	20-40																
	40-100																
	>100																
	Total																
Grand Total				7	20					7	20			7	20	7	16
Measured	0-20											4	5	4	5		
	20-40																
	40-100																
	>100																
	Total													4	5		
Indicated	0-20																
	20-40																
	40-100																
	>100																
	Total																
Inferred	0-20																
	20-40																
	40-100																
	>100																
	Total																
Grand Total												4	5	4	5		
Combined Grand Totals				7	20					7	20	4	5	11	25	7	16

T26N, R21E, CRAIG COUNTY

ROWE	Measured	0-20	1	1			1	1	1	1	1	1
		20-40										
		40-100										
		>100										
		Total	1	1			1	1	1	1	1	1
	Indicated	0-20	27	40			27	40	27	40	27	32
		20-40	1	1			1	1	1	1		
		40-100										
		>100										
		Total	28	41			28	41	28	41	27	32
	Inferred	0-20										
		20-40										
		40-100										
		>100										
		Total										
	Grand Total		29	42			29	42	29	42	28	33

T27N, R18E, CRAIG COUNTY

IRON POST	Measured	0-20									
		20-40									
		40-100	8	11			8	11	8	11		
		>100			69	162	69	162	69	162		
		Total	8	11	69	162	77	173	77	173		
	Indicated	0-20										
		20-40										
		40-100	5	7			5	7	5	7		
		>100			475	1,112	475	1,112	475	1,112		
		Total	5	7	475	1,112	480	1,119	480	1,119		
	Inferred	0-20										
		20-40										
		40-100	781	1,401	455	1,065	1,236	2,466	1,236	2,466		
		>100			3,421	8,005	3,421	8,005	3,421	8,005		
		Total	781	1,401	3,876	9,070	4,657	10,471	4,657	10,471		

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
WEIR-PITTSBURG	Grand Total		794	1,419	4,420	10,344					5,214	11,763			5,214	11,763		
	Measured	0-20																
		20-40																
		40-100																
		>100			142	442					142	442			142	442		
		Total			142	442					142	442			142	442		
	Indicated	0-20																
		20-40																
		40-100																
		>100			972	3,100	77	362			1,049	3,462			1,049	3,462		
		Total			972	3,100	77	362			1,049	3,462			1,049	3,462		
	Inferred	0-20																
		20-40																
		40-100																
		>100			4,717	14,721	2,828	14,253			7,545	28,974			7,545	28,974		
		Total			4,717	14,721	2,828	14,253			7,545	28,974			7,545	28,974		
	Grand Total				5,831	18,263	2,905	14,615			8,736	32,878			8,736	32,878		
	Combined Grand Total		794	1,419	10,251	28,607	2,905	14,615			13,950	44,641			13,950	44,641		
		T27N, R19E, CRAIG COUNTY																
	Measured	0-20	214	399	25	56					239	455	391	731	630	1,186	239	364
		20-40	607	1,035	6	14					613	1,049			613	1,049		
		40-100	327	540	2	5					329	545			329	545		
		>100																
		Total	1,148	1,974	33	75					1,181	2,049			1,572	2,780	239	364

IRON POST	Indicated	0-20	243	439	98	212		341	651			341	651	341	521
		20-40	1,136	2,029				1,136	2,029			1,136	2,029		
		40-100	740	1,202				740	1,202			740	1,202		
		>100													
		Total	2,119	3,670	98	212		2,217	3,882			2,217	3,882	341	521
	Inferred	0-20	173	454	29	64		202	518			202	518	202	414
		20-40	634	1,064				634	1,064			634	1,064		
		40-100	47	72				47	72			47	72		
		>100													
		Total	854	1,590	29	64		883	1,654			883	1,654	202	414
	Grand Total		4,121	7,234	160	351		4,281	7,585	391	731	4,672	8,316	782	1,299
CROWEBURG	Measured	0-20	103	193	18	45		121	238	765	1,551	886	1,789	121	190
		20-40	138	266	17	41		155	307			155	307	118	210
		40-100	953	1,815	13	31		966	1,846			966	1,846		
		>100			42	91		42	91			42	91		
		Total	1,194	2,274	90	208		1,284	2,482			2,049	4,033	239	400
	Indicated	0-20	217	444				217	444			217	444	217	355
		20-40	181	391				181	391			181	391	116	200
		40-100	1,679	3,155				1,679	3,155			1,679	3,155		
		>100			536	1,168		536	1,168			536	1,168		
		Total	2,077	3,990	536	1,168		2,613	5,158			2,613	5,158	333	555
	Inferred	0-20	68	148				68	148			68	148	68	118
		20-40	48	104				48	104			48	104	48	83
		40-100	634	1,250				634	1,250			634	1,250		
		>100			1,801	3,922		1,801	3,922			1,801	3,922		
		Total	750	1,502	1,801	3,922		2,551	5,424			2,551	5,424	116	201
	Grand Total		4,021	7,766	2,427	5,298		6,448	13,064	765	1,551	7,213	14,615	688	1,156

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
MINERAL	Measured	0-20	147	268	24	60					171	328	18	33	189	361	171	262
		20-40	569	1,060	46	116					615	1,176			615	1,176		
		40-100	734	1,304	141	309					875	1,613			875	1,613		
		>100			17	37					17	37			17	37		
		Total	1,450	2,632	228	522					1,678	3,154			1,696	3,187	171	262
	Indicated	0-20	320	560							320	560			320	560	320	448
		20-40	256	440							256	440			256	440		
		40-100	724	1,186	24	60					748	1,246			748	1,246		
		>100			44	95					44	95			44	95		
		Total	1,300	2,186	68	155					1,368	2,341			1,368	2,341	320	448
	Inferred	0-20	45	70							45	70			45	70	45	56
		20-40	59	80							59	80			59	80		
		40-100	66	95							66	95			66	95		
		>100																
		Total	170	245							170	245			170	245	45	56
	Grand Total		2,920	5,063	296	677					3,216	5,740	18	33	3,234	5,773	536	766
WEIR-PITTSBURG	Measured	0-20			54	179	2	10			56	189	1	5	57	194	56	151
		20-40			134	403	39	185			173	588			173	588	173	470
		40-100			94	308	50	233			144	541			144	541	92	323
		>100			55	218	278	1,600			333	1,818			333	1,818		
		Total			337	1,108	369	2,028			706	3,136			707	3,141	321	944
	Indicated	0-20	99	196	167	470					266	666			266	666	266	533
		20-40	23	47	251	775	20	98			294	920			294	920	272	698
		40-100			362	1,334	139	699			501	2,033			501	2,033	136	511
		>100			650	2,185	1,051	5,549			1,701	7,734			1,701	7,734		
		Total	122	243	1,430	4,764	1,210	6,346			2,762	11,353			2,762	11,353	674	1,742
	Inferred	0-20	154	291	45	108					199	399			199	399	199	319
		20-40	42	78	175	492	19	90			236	660			236	660	90	275
		40-100			1,080	4,181	1,274	7,110			2,354	11,291			2,354	11,291	59	236
		>100			5,284	18,420	1,277	6,797			6,561	25,217			6,561	25,217		
		Total	196	369	6,584	23,201	2,570	13,997			9,350	37,567			9,350	37,567	348	830

Grand Total		318	612	8,351	29,073	4,149	22,371	12,818	52,056	1	5	12,819	52,061	1,343	3,516
Combined Grand Totals		11,380	20,675	11,234	35,399	4,149	22,371	26,763	78,445	1,175	2,320	27,938	80,765	3,349	6,737
							T27N, R20E, CRAIG COUNTY								
IRON POST	Measured	0-20								42	91	42	91		
		20-40													
		40-100													
		>100													
		Total										42	91		
	Indicated	0-20	1	2	26	61		27	63			27	63	27	50
		20-40													
		40-100													
		>100													
		Total	1	2	26	61		27	63			27	63	27	50
	Inferred	0-20			84	198		84	198			84	198	84	158
		20-40													
		40-100													
		>100													
		Total			84	198		84	198			84	198	84	158
Grand Total			1	2	110	259		111	261	42	91	153	352	111	208
CROWEBURG	Measured	0-20								13	28	13	28		
		20-40	1	2				1	2			1	2		
		40-100			48	112		48	112			48	112		
		>100			3	7		3	7			3	7		
		Total	1	2	51	119		52	121			65	149		
	Indicated	0-20	12	27				12	27			12	27	12	22
		20-40	20	44				20	44			20	44	20	35
		40-100	137	297				137	297			137	297		
		>100			39	92		39	92			39	92		
		Total	169	368	39	92		208	460			208	460	32	57

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

MINERAL	Coal Category of Reliability	Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
	Inferred	0-20	7	15							7	15			7	15	7	12
		20-40	11	25							11	25			11	25	11	20
		40-100	14	30							14	30			14	30		
		>100																
		Total	32	70							32	70			32	70	18	32
	Grand Total		202	440	90	211					292	651	13	28	305	679	50	89
	Measured	0-20											52	102	52	102		
		20-40																
		40-100																
		>100																
		Total													52	102		
	Indicated	0-20	15	23							15	23			15	23	15	18
		20-40	24	40							24	40			24	40		
		40-100	82	135							82	136			82	136		
		>100																
		Total	121	199							121	199			121	199	15	18
	Inferred	0-20	44	87							44	87			44	87	44	70
		20-40	25	49							25	49			25	49		
		40-100	64	125							64	125			64	125		
		>100																
		Total	133	261							133	261			133	261	44	70
	Grand Total		254	460							254	460	52	102	306	562	59	88
	Measured	0-20	31	51	147	391	76	341			254	783	17	41	271	824	254	626
		20-40	23	38	53	151	68	304			144	493			144	493	121	387
		40-100	4	9			27	123			31	132			31	132	27	98
		>100																
		Total	58	98	200	542	171	768			429	1,408			446	1,449	402	1,111

WEIR-PITTSBURG																
	Indicated	0-20	91	147	235	713	122	540	448	1,400			448	1,400	448	1,120
		20-40			202	626	59	269	261	895			261	895	211	346
		40-100			20	80	126	601	146	681			146	681	146	543
		>100														
		Total	91	147	457	1,419	307	1,410	855	2,976			855	2,976	805	2,009
	Inferred	0-20	5	9	286	1,075			291	1,084			291	1,084	291	867
		20-40			317	1,163	5	22	322	1,185			322	1,185	318	941
		40-100			864	3,137	192	953	1,056	4,090			1,056	4,090	137	469
		>100			503	1,831			503	1,831			503	1,831		
		Total	5	9	1,970	7,206	197	975	2,172	8,190			2,172	8,190	746	2,277
	Grand Total		154	254	2,627	9,167	675	3,153	3,456	12,574	17	41	3,473	12,615	1,953	5,397
DRYWOOD																
	Measured	0-20	66	119	145	471	23	109	234	699	1	2	235	701	234	559
		20-40	16	30	74	217	35	157	125	404			125	404	50	169
		40-100	48	93	42	143	32	147	122	383			122	383	32	118
		>100			5	10			5	10			5	10		
		Total	130	242	266	841	90	413	486	1,496			487	1,498	316	846
	Indicated	0-20	29	51	281	996			310	1,047			310	1,047	310	838
		20-40	41	76	203	540	5	21	249	637			249	637	58	154
		40-100	68	132	29	88	2	8	99	228			99	228	8	26
		>100														
		Total	138	259	513	1,624	7	29	658	1,912			658	1,912	376	1,018
	Inferred	0-20	20	35	24	63			44	98			44	98	44	78
		20-40	23	41	49	88			72	129			72	129		
		40-100														
		>100														
		Total	43	76	73	151			116	227			116	227	44	78
	Grand Total		311	577	852	2,616	97	442	1,260	3,635	1	2	1,261	3,637	736	1,942
	Combined Grand Totals		922	1,733	3,679	12,253	772	3,595	5,373	17,581	125	264	5,498	17,845	2,909	7,724

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
							T27N, R21E, CRAIG COUNTY											
DRYWOOD	Measured	0-20	16	28	7	27					23	55	1	1	24	56	23	44
		20-40	22	39							22	39			22	39		
		40-100																
		>100																
		Total	38	67	7	27					45	94			46	95	23	44
	Indicated	0-20	5	7							5	7			5	7	5	6
		20-40	1	2							1	2			1	2		
		40-100																
		>100																
		Total	6	9							6	9			6	9	5	6
	Inferred	0-20																
		20-40																
		40-100																
		>100																
		Total																
	Grand Total		44	76	7	27					51	103	1	1	52	104	28	50
ROWE	Measured	0-20	6	9							6	9	1	1	7	10	6	7
		20-40	7	11							7	11			7	11		
		40-100																
		>100																
		Total	13	20							13	20			14	21	6	7
	Indicated	0-20	30	45							30	45			30	45	30	36
		20-40	10	15							10	15			10	15		
		40-100																
		>100																
		Total	40	60							40	60			40	60	30	36

IRON POST

Inferred	0-20														
	20-40														
	40-100														
	>100														
	Total														
Grand Total		53	80					53	80	1	1	54	81	36	43
Combined Grand Totals		97	156	7	27			104	183	2	2	106	185	64	93
						T28N, R17E, NOWATA COUNTY									
Measured	0-20														
	20-40														
	40-100														
	>100														
	Total														
Indicated	0-20														
	20-40														
	40-100														
	>100														
	Total														
Inferred	0-20														
	20-40														
	40-100														
	>100			26	61			26	61			26	61		
	Total			26	61			26	61			26	61		
Grand Total				26	61			26	61			26	61		

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
			T28N, R18E, CRAIG COUNTY															
IRON POST	Measured	0-20																
		20-40																
		40-100																
		>100																
		Total																
	Indicated	0-20																
		20-40																
		40-100																
		>100																
		Total																
	Inferred	0-20																
		20-40																
		40-100																
		>100			59	128					59	128			59	128		
		Total			59	128					59	128			59	128		
	Grand Total				59	128					59	128			59	128		
WEIR-PITTSBURG	Measured	0-20																
		20-40																
		40-100																
		>100			37	154	145	708			182	862			182	862		
		Total			37	154	145	708			182	862			182	862		
	Indicated	0-20																
		20-40																
		40-100																
		>100			484	1,532	930	4,726	58	377	1,472	6,635			1,472	6,635		
		Total			484	1,532	930	4,726	58	377	1,472	6,635			1,472	6,635		

Inferred	0-20															
	20-40															
	40-100															
	>100			4,661	16,296	5,199	27,064	1,288	9,039	11,148	52,399			11,148	52,399	
	Total			4,661	16,296	5,199	27,064	1,288	9,039	11,148	52,399			11,148	52,399	
	Grand Total			5,182	17,982	6,274	32,498	1,346	9,416	12,802	59,896			12,802	59,896	
	Combined Grand Totals			5,241	18,110	6,274	32,498	1,346	9,416	12,861	60,024			12,861	60,024	
	T28N, R19E, CRAIG COUNTY															
Measured	0-20	81	141	6	15					87	156	225	362	312	518	87	125
	20-40	375	653	30	71					405	724			405	724		
	40-100	709	1,238	110	257					819	1,495			819	1,495		
	>100																
	Total	1,165	2,032	146	343					1,311	2,375			1,536	2,737	87	125
Indicated	0-20	54	105	13	30					67	135			67	135	67	108
	20-40	407	742	186	506					593	1,248			593	1,248		
	40-100	919	1,597	295	690					1,214	2,287			1,214	2,287		
	>100																
	Total	1,380	2,444	494	1,226					1,874	3,670			1,874	3,670	67	108
Inferred	0-20	76	147							76	147			76	147	76	118
	20-40	167	326							167	326			167	326		
	40-100	930	1,803							930	1,803			930	1,803		
	>100																
	Total	1,173	2,276							1,173	2,276			1,173	2,276	76	118
	Grand Total	3,718	6,752	640	1,569					4,358	8,321	225	362	4,583	8,683	230	351
Measured	0-20	10	19							10	19			10	19	10	15
	20-40	34	68							34	68			34	68	14	24
	40-100	289	576	75	185					364	761			364	761		
	>100			56	123					56	123			56	123		
	Total	333	663	131	308					464	971			464	971	24	39

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
CROWEBURG	Indicated	0-20	106	206							106	206			106	206	106	165
		20-40	135	271							135	271			135	271	24	42
		40-100	841	1,652	54	131					895	1,783			895	1,783		
		>100			1,592	3,468					1,592	3,468			1,592	3,468		
		Total	1,082	2,129	1,646	3,599					2,728	5,728			2,728	5,728	130	207
	Inferred	0-20	126	234							126	234			126	234	126	187
		20-40	104	193							104	193			104	193	33	56
		40-100	326	608							326	608			326	608		
		>100			1,005	2,189					1,005	2,189			1,005	2,189		
		Total	556	1,035	1,005	2,189					1,561	3,224			1,561	3,224	159	243
	Grand Total		1,971	3,827	2,782	6,096					4,753	9,923			4,753	9,923	313	489
FLEMING	Measured	0-20																
		20-40	4	6							4	6			4	6		
		40-100	38	55							38	55			38	55		
		>100																
		Total	42	61							42	61			42	61		
	Indicated	0-20																
		20-40	1	2							1	2			1	2		
		40-100	61	87							61	87			61	87		
		>100																
		Total	62	89							62	89			62	89		
	Inferred	0-20																
		20-40																
		40-100	32	47							32	47			32	47		
		>100																
		Total	32	47							32	47			32	47		

Grand Total		136	197							136	197	136	197
MINERAL	Measured	0-20											
		20-40											
		40-100	8	13						8	13	8	13
		>100											
		Total	8	13						8	13	8	13
	Indicated	0-20											
		20-40											
		40-100	290	479	46	108				336	587	336	587
		>100			38	85				38	85	38	85
		Total	290	479	84	193				374	672	374	672
	Inferred	0-20											
		20-40											
		40-100	115	189	120	281				235	470	235	470
		>100			314	735				314	735	314	735
		Total	115	189	434	1,016				549	1,205	549	1,205
Grand Total		413	681	518	1,209					931	1,890	931	1,890
WEIR-PITTSBURG	Measured	0-20											
		20-40											
		40-100											
		>100			369	1,250	721	3,795	271	1,986	1,361	7,031	1,361	7,031
		Total			369	1,250	721	3,795	271	1,986	1,361	7,031	1,361	7,031
	Indicated	0-20											
		20-40											
		40-100											
		>100			2,302	7,645	2,641	13,939	397	2,621	5,340	24,205	5,340	24,205
		Total			2,302	7,645	2,641	13,939	397	2,621	5,340	24,205	5,340	24,205
	Inferred	0-20											
		20-40											
		40-100											
		>100			3,326	10,139	906	4,727	21	135	4,253	15,001	4,253	15,001
		Total			3,326	10,139	906	4,727	21	135	4,253	15,001	4,253	15,001

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
Grand Total				5,997	19,034	4,268	22,461	689	4,742	10,954	46,237			10,954	46,237		
Combined Grand Total		6,238	11,457	9,937	27,908	4,268	22,461	689	4,742	21,132	66,568	225	362	21,357	66,930	543	840
							T28N, R20E, CRAIG COUNTY										
IRON POST																	
Measured	0-20	27	52	28	66					55	118	223	406	278	524	55	94
	20-40	15	30							15	30			15	30		
	40-100																
	>100																
	Total	42	82	28	66					70	148			293	554	55	94
Indicated	0-20	97	157	6	14					103	171			103	171	103	137
	20-40	124	201							124	201			124	201		
	40-100	53	85							53	85			53	85		
	>100																
	Total	274	443	6	14					280	457			280	457	103	137
Inferred	0-20	53	99							53	99			53	99	53	79
	20-40	73	133							73	133			73	133		
	40-100	14	23							14	23			14	23		
	>100																
	Total	140	255							140	255			140	255	53	79
Grand Total		456	780	34	80					490	860	223	406	713	1,266	211	310
Measured	0-20	86	175							86	175	251	452	337	627	86	140
	20-40	174	259	2	6					176	265			176	265	72	125
	40-100	246	475							246	475			246	475		
	>100																
	Total	506	909	2	6					508	915			759	1,367	158	265

CROWEBURG															
	Indicated	0-20	328	590			328	590			328	590	328	472
		20-40	456	778	21	49	477	827			477	827	87	153
		40-100	760	1,332			760	1,332			760	1,332		
		>100			6	13	6	13			6	13		
		Total	1,544	2,700	27	62	1,571	2,762			1,571	2,762	415	625
	Inferred	0-20	179	325			179	325			179	325	179	260
		20-40	207	376			207	376			207	376	30	53
		40-100	318	496			318	496			318	496		
		>100												
		Total	704	1,197			704	1,197			704	1,197	209	313
	Grand Total		2,754	4,806	29	68	2,783	4,874	251	452	3,034	5,326	782	1,203
FLEMING															
	Measured	0-20	38	69	70	173	108	242	98	182	206	424	108	194
		20-40	94	181	111	273	205	454			205	454	42	83
		40-100	74	133	103	253	177	386			177	386		
		>100			50	127	50	127			50	127		
		Total	206	383	334	826	540	1,209			638	1,391	150	277
	Indicated	0-20	88	157			88	157			88	157	88	126
		20-40	141	254	22	54	163	308			163	308	1	2
		40-100	400	764	324	792	724	1,556			724	1,556		
		>100			352	876	352	876			352	876		
		Total	629	1,175	698	1,722	1,327	2,897			1,327	2,897	89	128
	Inferred	0-20	22	31			22	31			22	31	22	25
		20-40	48	71			48	71			48	71		
		40-100	100	161			100	161			100	161		
		>100			47	118	47	118			47	118		
		Total	170	263	47	118	217	381			217	381	22	25
	Grand Total		1,005	1,821	1,079	2,666	2,084	4,487	98	182	2,182	4,669	261	430
	Measured	0-20	247	495	302	728	549	1,223	1,089	2,509	1,638	3,732	459	978
		20-40	434	938	537	1,299	971	2,237			971	2,237	58	148
		40-100	281	574	672	1,774	953	2,348			953	2,348		
		>100			87	188	87	188			87	188		
		Total	962	2,007	1,598	3,989	2,560	5,996			3,649	8,505	607	1,126

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
MINERAL	Indicated	0-20	60	128	397	916					457	1,044			457	1,044	457	835
		20-40	403	747	406	948					809	1,695			809	1,695		
		40-100	1,407	2,780	1,439	3,791					2,846	6,571			2,846	6,571		
		>100			1,024	2,556					1,024	2,556			1,024	2,556		
		Total	1,870	3,655	3,266	8,211					5,136	11,866			5,136	11,866	457	835
	Inferred	0-20	15	32	96	208					111	240			111	240	111	192
		20-40	5	9	38	89					43	98			43	98		
		40-100	252	454	60	159					312	613			312	613		
		>100			84	204					84	204			84	204		
		Total	272	495	278	660					550	1,155			550	1,155	111	192
	Grand Total		3,104	6,157	5,142	12,860					8,246	19,017	1,089	2,509	9,335	21,526	1,175	2,153
WEIR-PITTSBURG	Measured	0-20	15	26	23	57					38	83	253	554	291	637	38	66
		20-40	48	90	10	22					58	112			58	112		
		40-100	249	413	24	54					273	467			273	467		
		>100																
		Total	312	529	57	133					369	662			622	1,216	38	66
	Indicated	0-20	45	79	172	446					217	525			217	525	217	420
		20-40	216	378	70	171					286	549			286	549	30	59
		40-100	686	1,281	627	1,254					1,313	2,535			1,313	2,535		
		>100			203	879	15	69			218	948			218	948		
		Total	947	1,738	1,072	2,750	15	69			2,034	4,557			2,034	4,557	247	479
	Inferred	0-20			365	954					365	954			365	954	365	763
		20-40			826	2,162					826	2,162			826	2,162	411	859
		40-100	119	221	1,600	3,970					1,719	4,191			1,719	4,191		
		>100			3,390	9,369	100	459			3,490	9,828			3,490	9,828		
		Total	119	221	6,181	16,455	100	459			6,400	17,135			6,400	17,135	776	1,622
	Grand Total		1,378	2,488	7,310	19,338	115	528			8,803	22,354	253	554	9,056	22,908	1,061	2,167
	Combined Grand Total		8,697	16,052	13,594	35,012	115	528			22,406	51,592	1,914	4,103	24,320	55,695	3,490	6,263

T28N, R21E, CRAIG COUNTY

MINERAL															
Measured	0-20	64	117	12	28			76	145	9	13	85	158	76	116
	20-40	20	39	17	38			37	77			37	77		
	40-100														
	>100														
	Total	84	156	29	66			113	222			122	235	76	116
Indicated	0-20			14	32			14	32			14	32	14	26
	20-40			10	22			10	22			10	22		
	40-100														
	>100														
	Total			24	54			24	54			24	54	14	26
Inferred	0-20														
	20-40														
	40-100														
	>100														
	Total														
Grand Total		84	156	53	120			137	276	9	13	146	289	90	142
WEIR-PITTSBURG															
Measured	0-20									13	12	13	12		
	20-40														
	40-100														
	>100														
	Total											13	12		
Indicated	0-20														
	20-40														
	40-100														
	>100														
	Total														
Inferred	0-20														
	20-40														
	40-100														
	>100														
	Total														
Grand Total										13	12	13	12		

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
DRYWOOD	Measured	0-20																
		20-40																
		40-100																
		>100																
		Total																
	Indicated	0-20	2	3							2	3			2	3	2	2
		20-40	32	54							32	54			32	54		
		40-100	25	46							25	46			25	46		
		>100																
		Total	59	103							59	103			59	103	2	2
	Inferred	0-20	5	7							5	7			5	7	5	6
		20-40	40	67							40	67			40	67		
		40-100	289	327							289	327			289	327		
		>100																
		Total	334	401							334	401			334	401	5	6
	Grand Total		393	504							393	504			393	504	7	8
ROWE	Measured	0-20	94	168	7	17					101	185			101	185	101	148
		20-40	62	112	15	35					77	147			77	147		
		40-100	25	47	2	4					27	51			27	51		
		>100																
		Total	181	327	24	56					205	383			205	383	101	148
	Indicated	0-20	91	146							91	146			91	146	91	117
		20-40	54	88							54	88			54	88		
		40-100	14	23							14	23			14	23		
		>100																
		Total	159	257							159	257			159	257	91	117
	Inferred	0-20																
		20-40																
		40-100																
		>100																
		Total																

Grand Total	340	584	24	56			364	640			364	640	192	265
Combined Grand Totals	817	1,244	77	176			894	1,420	22	25	916	1,445	289	415
T29N, R17E, NOWATA COUNTY														
IRON POST — Measured — 0-20														
20-40														
40-100														
>100														
Total														
IRON POST — Indicated — 0-20														
20-40														
40-100														
>100														
Total														
IRON POST — Inferred — 0-20														
20-40														
40-100														
>100			304	684			304	684			304	684		
Total			304	684			304	684			304	684		
Grand Total			304	684			304	684			304	684		
T29N, R18E, CRAIG COUNTY														
IRON POST — Measured — 0-20														
20-40														
40-100														
>100			388	961			388	961			388	961		
Total			388	961			388	961			388	961		
IRON POST — Indicated — 0-20														
20-40														
40-100														
>100			1,456	3,653			1,456	3,653			1,456	3,653		
Total			1,456	3,653			1,456	3,653			1,456	3,653		

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

MINERAL

Coal Category of Reliability	Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
Inferred	0-20																
	20-40																
	40-100																
	>100			2,592	6,884					2,592	6,884			2,592	6,884		
	Total			2,592	6,884					2,592	6,884			2,592	6,884		
Grand Total				4,436	11,498					4,436	11,498			4,436	11,498		
Measured	0-20																
	20-40																
	40-100																
	>100			183	448					183	448			183	448		
	Total			183	448					183	448			183	448		
Indicated	0-20																
	20-40																
	40-100																
	>100			801	2,009					801	2,009			801	2,009		
	Total			801	2,009					801	2,009			801	2,009		
Inferred	0-20																
	20-40																
	40-100																
	>100			1,893	4,794					1,893	4,794			1,893	4,794		
	Total			1,893	4,794					1,893	4,794			1,893	4,794		
Grand Total				2,877	7,251					2,877	7,251			2,877	7,251		
Measured	0-20																
	20-40																
	40-100																
	>100							662	6,331	662	6,331			662	6,331		
	Total							662	6,331	662	6,331			662	6,331		

WEIR-PITTSBURG																
	Indicated	0-20														
		20-40														
		40-100														
		>100				180	1,044	2,923	27,620	3,103	28,664			3,103	28,664	
		Total				180	1,044	2,923	27,620	3,103	28,664			3,103	28,664	
	Inferred	0-20														
		20-40														
		40-100														
		>100			12	51	1,511	8,557	8,143	71,763	9,666	80,371			9,666	80,371
		Total			12	51	1,511	8,557	8,143	71,763	9,666	80,371			9,666	80,371
	Grand Total				12	51	1,691	9,601	11,728	105,714	13,431	115,366			13,431	115,366
	Combined Grand Totals				7,325	18,800	1,691	9,601	11,728	105,714	20,744	134,115			20,744	134,115
								T29N, R19E, CRAIG COUNTY								
IRON POST	Measured	0-20	11	18							11	18	38	59	49	77	11	14
		20-40	10	15							10	15			10	15		
		40-100	1	1							1	1			1	1		
		>100																
		Total	22	34							22	34			60	93	11	14
	Indicated	0-20	10	17							10	17			10	17	10	14
		20-40	18	29							18	29			18	29		
		40-100	14	22							14	22			14	22		
		>100																
		Total	42	68							42	68			42	68	10	14
	Inferred	0-20	64	103							64	103			64	103	64	82
		20-40	212	344							212	344			212	344		
		40-100	1,512	2,449							1,512	2,449			1,512	2,449		
		>100																
		Total	1,788	2,896							1,788	2,896			1,788	2,896	64	82
	Grand Total		1,852	2,998							1,852	2,998	38	59	1,890	3,057	85	110

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
CROWEBURG	Measured	0-20																
		20-40																
		40-100																
		>100																
		Total																
	Indicated	0-20																
		20-40																
		40-100																
		>100																
		Total																
	Inferred	0-20	9	14							9	14			9	14	9	11
		20-40	32	51							32	51			32	51		
		40-100	64	101							64	101			64	101		
		>100																
		Total	105	166							105	166			105	166	9	11
	Grand Total		105	166							105	166			105	166	9	11
FLEMING	Measured	0-20																
		20-40																
		40-100																
		>100																
		Total																
	Indicated	0-20																
		20-40																
		40-100																
		>100																
		Total																
	Inferred	0-20																
		20-40																
		40-100																
		>100			97	231					97	231			97	231		
		Total			97	231					97	231			97	231		

	Grand Total	97	231			97	231	97	231	
MINERAL	Measured									
	0-20									
	20-40									
	40-100									
	>100	143	489			143	489	143	489	
	Total	143	489			143	489	143	489	
	Indicated									
	0-20									
	20-40									
	40-100									
	>100	890	2,634			890	2,634	890	2,634	
	Total	890	2,634			890	2,634	890	2,634	
	Inferred									
	0-20									
	20-40									
	40-100	149	349			149	349	149	349	
	>100	6,376	15,728			6,376	15,728	6,376	15,728	
	Total	6,525	16,077			6,525	16,077	6,525	16,077	
	Grand Total	7,558	19,200			7,558	19,200	7,558	19,200	
WEIR-PITTSBURG	Measured									
	0-20									
	20-40									
	40-100									
	>100									
	Total									
	Indicated									
	0-20									
	20-40									
	40-100									
	>100	232	610	14	61	246	671	246	671	
	Total	232	610	14	61	246	671	246	671	
	Inferred									
	0-20									
	20-40									
	40-100									
	>100	2,511	7,667	131	607	2,642	8,274	2,642	8,274	
	Total	2,511	7,667	131	607	2,642	8,274	2,642	8,274	

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
		Grand Total			2,743	8,277	145	668			2,888	8,945			2,888	8,945		
		Combined Grand Totals	1,957	3,164	10,398	27,708	145	668			12,500	31,540	38	59	12,538	31,599	94	121
								T29N, R20E, CRAIG COUNTY										
IRON POST	Measured	0-20	17	28							17	28	166	256	183	284	17	22
		20-40	27	45							27	45			27	45		
		40-100																
		>100																
		Total	44	73							44	73			210	329	17	22
	Indicated	0-20	141	227							141	227			141	227	141	182
		20-40	447	725							447	725			447	725		
		40-100	42	68							42	68			42	68		
		>100																
		Total	630	1,020							630	1,020			630	1,020	141	182
	Inferred	0-20	342	554							342	554			342	554	342	443
		20-40	657	1,063							657	1,063			657	1,063		
		40-100	198	321							198	321			198	321		
		>100																
		Total	1,197	1,938							1,197	1,938			1,197	1,938	342	443
		Grand Total	1,871	3,031							1,871	3,031	166	256	2,037	3,287	500	647
	Measured	0-20	156	225	5	12					161	237	218	341	379	578	161	190
		20-40	294	455	5	12					299	467			299	467	5	10
		40-100	296	453							296	453			296	453		
		>100																
		Total	746	1,133	10	24					756	1,157			974	1,498	166	200

CROWEBURG															
	Indicated	0-20	356	512			356	512			356	512	356	410
		20-40	377	544			377	544			377	544		
		40-100	1,234	1,777			1,234	1,777			1,234	1,777		
		>100												
		Total	1,967	2,833			1,967	2,833			1,967	2,833	356	410
	Inferred	0-20	77	111			77	111			77	111	77	89
		20-40	267	393			267	393			267	393		
		40-100	1,201	1,742			1,201	1,742			1,201	1,742		
		>100												
		Total	1,545	2,246			1,545	2,246			1,545	2,246	77	89
	Grand Total		4,258	6,212	10	24	4,268	6,236	218	341	4,486	6,577	599	699
FLEMING															
	Measured	0-20	112	195	36	86	148	281	79	161	227	442	148	225
		20-40	374	675	12	28	386	703			386	703		
		40-100	523	893			523	893			523	893		
		>100												
		Total	1,009	1,763	48	114	1,057	1,877			1,136	2,038	148	225
	Indicated	0-20	98	174	4	9	102	183			102	183	102	146
		20-40	106	191			106	191			106	191		
		40-100	387	631			387	631			387	631		
		>100			106	254	106	254			106	254		
		Total	591	996	110	263	701	1,259			701	1,259	102	146
	Inferred	0-20	2	3			2	3			2	3	2	2
		20-40	1	1			1	1			1	1		
		40-100												
		>100			30	73	30	73			30	73		
		Total	3	4	30	73	33	77			33	77	2	2
	Grand Total		1,603	2,763	188	450	1,791	3,213	79	161	1,870	3,374	252	373

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal	Category of Reliability	Depth (ft)	Remaining Resources 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
MINERAL	Measured	0-20	353	659	266	729					619	1,388	170	354	789	1,742	619	1,110
		20-40	131	238	418	915					549	1,153			549	1,153		
		40-100	201	386	460	1,096					661	1,482			661	1,482		
		>100			39	94					39	94			39	94		
		Total	685	1,283	1,183	2,834					1,868	4,117			2,038	4,471	619	1,110
	Indicated	0-20	176	327	202	527					378	854			378	854	378	683
		20-40	610	1,125	282	608					892	1,733			892	1,733		
		40-100	136	268	1,503	3,306					1,639	3,574			1,639	3,574		
		>100			927	2,000					927	2,000			927	2,000		
		Total	922	1,720	2,914	6,441					3,836	8,161			3,836	8,161	378	683
	Inferred	0-20			125	271					125	271			125	271	125	217
		20-40			187	405					187	405			187	405		
		40-100			1,584	3,707					1,584	3,707			1,584	3,707		
		>100			2,163	4,975					2,163	4,975			2,163	4,975		
		Total			4,059	9,358					4,059	9,358			4,059	9,358	125	217
	Grand Total		1,607	3,003	8,156	18,633					9,763	21,636	170	354	9,933	21,990	1,122	2,010
WEIR-PITTSBURG	Measured	0-20	70	115	2	4					72	119	3	5	75	124	72	95
		20-40	111	186	163	311					274	497			274	497	46	78
		40-100	13	25	105	285					118	310			118	310		
		>100																
		Total	194	326	270	600					464	926			467	931	118	173
	Indicated	0-20	33	61	30	71					63	132			63	132	63	106
		20-40	190	337	88	220					278	557			278	557	58	113
		40-100	264	487	305	737					569	1,224			569	1,224		
		>100																
		Total	487	885	423	1,028					910	1,913			910	1,913	121	219

Inferred	0-20														
	20-40														
	40-100	289	514	873	2,196		1,162	2,710			1,162	2,710			
	>100			306	781		306	781			306	781			
	Total	289	514	1,179	2,977		1,468	3,491			1,468	3,491			
Grand Total		970	1,725	1,872	4,605		2,842	6,330	3	5	2,845	6,335	239	392	
Combined Grand Totals		10,309	16,734	10,226	23,712		20,535	40,446	636	1,117	21,171	41,563	2,712	4,121	
						T29N, R21E, CRAIG COUNTY									
Measured	0-20	8	12				8	12	11	9	19	21	8	10	
	20-40	22	35				22	35			22	35			
	40-100	1	2				1	2			1	2			
	>100														
	Total	31	49				31	49			42	58	8	10	
Indicated	0-20	80	139	1	2		81	141			81	141	81	113	
	20-40	22	41				22	41			22	41			
	40-100														
	>100														
	Total	102	180	1	2		103	182			103	182	81	113	
Inferred	0-20	18	29				18	29			18	29	18	23	
	20-40	5	8				5	8			5	8			
	40-100														
	>100														
	Total	23	37				23	37			23	37	18	23	
Grand Total		156	266	1	2		157	268	11	9	168	277	107	146	
Measured	0-20														
	20-40	27	47				27	47			27	47			
	40-100	133	223				133	223			133	223			
	>100														
	Total	160	270				160	270			160	270			

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

Coal Category of Reliability	Depth (ft)	Remaining Resources: 0.8-1.2 ft Acres	0.8-1.2 ft Tons	1.2-2.4 ft Acres	1.2-2.4 ft Tons	2.4-3.5 ft Acres	2.4-3.5 ft Tons	>3.5 ft Acres	>3.5 ft Tons	Total Remaining Resources Acres	Total Remaining Resources Tons	Mined or Lost in Mining* Acres	Mined or Lost in Mining* Tons	Original Resources Acres	Original Resources Tons	Reserves Acres	Reserves Tons
DRYWOOD																	
Indicated	0-20																
	20-40	128	222							128	222			128	222		
	40-100	315	542							315	542			315	542		
	>100																
	Total	443	764							443	764			443	764		
Inferred	0-20																
	20-40																
	40-100	442	733							442	733			442	733		
	>100																
	Total	442	733							442	733			442	733		
Grand Total		1,045	1,767							1,045	1,767			1,045	1,767		
Combined Grand Totals		1,201	2,033	1	2					1,202	2,035	11	9	1,213	2,044	107	146

*Coal mined or lost in mining is not categorized by depth, thickness, or category of reliability.

APPENDIX 2: Measured Sections

Measured Section 1

SE¼SE¼NE¼ sec. 25, T24N, R18E, Rogers County. Measured in road cut on west side of gravel road, from 0.5 mi south of northeast corner of section north to valley bottom, by LeRoy A. Hemish. Field notebook designation CN-94-78-H. (Estimated elevation at top of section, 843 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Sandstone, reddish-brown, ferruginous, fine-grained, noncalcareous, crossbedded; laminated in lower 1 ft, with black streaks of very fine-grained coaly material included; a 1- to 2-in. band of ironstone concretions occurs at the base of the unit	38.0
Shale, very dark-gray; light-gray, weathered flakes abundant on the outcrop	3.0
Shale, brownish-gray, highly silty	4.5
Coal, black, soft, smutty; appears to be quite local in extent (Weir-Pittsburg)	0.1
KREBS GROUP	
Boggy Formation:	
Clay-ironstone, dark-reddish-brown to orange to dark-gray, brecciated; includes spheroidal and boxlike structures enclosing unindurated, fine-grained, brown sand	1.2
Sandstone, red to brown, medium- to fine-grained; locally conglomeratic with black coal fragments included; thin- to medium-bedded; in the basal 2 to 6 in., includes a black layer of fine-grained, reworked coal fragments interlaminated with buff sandstone	5.0
Coal, black (Bluejacket?)	0.7
Underclay, light-gray with orange staining	1.2
Shale, gray-brown with some orange staining	10.0
Covered interval	11.0
Sandstone, light-brown with numerous dark-brown flecks, ferruginous, fine- to medium-grained, well-rounded, noncalcareous, medium-bedded (only upper part of unit exposed)	2.0
Total	76.7

2

Measured Section 2

NE¼NE¼SE¼SE¼ sec. 4, T24N, R19E, Craig County. Measured in road ditch on west side of gravel road, just southwest of farm site on top of hill, by LeRoy A. Hemish. Field notebook designation CN-56-78-H. (Estimated elevation at top of section, 805 ft.)

	Thickness (ft)
KREBS GROUP	
Boggy Formation:	
Sandstone, brown, fine- to medium-grained, massively crossbedded; includes some silty shale layers; channels into underlying strata . . .	5.0
Savanna Formation:	
Coal, black with reddish-brown iron-oxide staining, weathered (Drywood) .	0.2
Shale, light-gray with orange iron-oxide staining; becomes dark-gray downward; includes abundant carbonized plant fragments	7.0
Total	12.2

Measured Section 3

SE¼SE¼SE¼SW¼ sec. 4, T24N, R19E, Craig County. Measured in road cut near top of hill on north side of gravel road, just northeast of farm site, by LeRoy A. Hemish. Field notebook designation CN-58-78-H. (Estimated elevation at top of section, 848 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, reddish-brown, contains humus (regolith)	2.5
KREBS GROUP	
Boggy Formation:	
Sandstone, reddish-brown, ferruginous, fine- to medium-grained, massively crossbedded	4.0
Savanna Formation:	
Coal, black, soft, weathered (Drywood)	0.1
Shale, tan and orange to light-gray where unoxidized, clayey	1.4
Shale, medium-greenish-gray, silty, hard	1.0
Shale, dark-gray with purple-brown iron-oxide staining on stratification surfaces	2.8
Total	11.8

Measured Section 4

SE¼NE¼NE¼SE¼ sec. 9, T24N, R19E, Craig County. Measured in gully in road ditch, west side of bend in gravel road, just south of creek, by LeRoy A. Hemish. Field notebook designation CN-57-78-H. (Estimated elevation at top of section, 772 ft.)

	Thickness (ft)
KREBS GROUP	
Savanna Formation:	
Shale, medium- to dark-gray; includes brown clay-ironstone concretions about 4 in. in diameter	17.0
Coal, black (Rowe)	0.5
Shale, light-gray	5.5
Total	23.0

Measured Section 5

SW¼SE¼SE¼SE¼ sec. 20, T24N, R19E, Craig County. Measured in road cut on north side of gravel road, by LeRoy A. Hemish. Field notebook designation CN-61-78-H. (Estimated elevation at top of section, 793 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, brown, contains humus, unconsolidated (regolith)	1.5
KREBS GROUP	
Boggy Formation:	
Siltstone, light-gray-brown, shaly, laminated	1.5
Savanna Formation:	
Coal, black (Drywood)	0.2
Shale, dark-gray with orange iron-oxide staining; weathers light-gray-brown	4.8
Total	8.0

Measured Section 6

NW¼NE¼NW¼NW¼ sec. 22, T24N, R19E, Craig County. Measured in wall of entrance to abandoned drift mine, just south of gravel road, near top of escarpment, by LeRoy A. Hemish. Field notebook designation CN-59-78-H. (Estimated elevation at top of section, 804 ft.)

	Thickness (ft)
KREBS GROUP	
Boggy Formation:	
Sandstsone, buff, fine-grained, micaceous, medium-bedded	2.5
Sandstone, light-brown, very fine-grained, shaly, micaceous, carbonaceous, laminated	0.5
Sandstone, buff, fine-grained, micaceous, massive	0.5

Siltstone, brownish-gray, sandy, micaceous; interlaminated with gray shale; carbonaceous film abundant on stratification surfaces. . . .	2.0

Savanna Formation:

Coal, black with red iron-oxide staining on cleat surfaces (Drywood) . . .	0.2
Shale, light-gray with orange iron-oxide staining; includes bands of brown clay-ironstone concretions about 3 in. thick	6.3
Total	12.0

Measured Section 7

NE¼NE¼NW¼ sec. 28, T24N, R19E, Craig County. Measured along north side of gravel road, where road bends to the southwest, by Leroy A. Hemish. Field notebook designation CN-60-78-H. (Estimated elevation at top of section, 770 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown, with shale pebbles (regolith)	3.0
KREBS GROUP	
Savanna Formation:	
Shale, dark-gray; weathers orange-brown	2.0
Coal, black, partly weathered (Rowe)	0.7
Shale, light-gray with reddish-orange staining	4.3
Total	10.0

Measured Section 8

SW¼SW¼SW¼NW¼ sec. 28, T24N, R19E, Craig County. Measured along east side of gravel road, from top of sandstone ledge downslope to bridge, by LeRoy A. Hemish. Field notebook designation CN-72-78-H. (Estimated elevation at top of section, 806 ft.)

	Thickness (ft)
KREBS GROUP	
Boggy Formation:	
Sandstone, brown to reddish-brown, fine-grained, micaceous, ferruginous, noncalcareous, medium-bedded	6.0
Savanna Formation:	
Coal, black, soft, weathered (Drywood)	0.2
Underclay, light-gray with orange streaks; includes carbonized plant fragments	1.8
Shale, gray, poorly exposed	27.0
Total	35.0

Measured Section 9

NE¼NE¼SE¼SE¼ sec. 29, T24N, R19E, Craig County. Measured in ditch where trail curves to the northwest, by LeRoy A. Hemish. Field notebook designation CN-71-78-H. (Estimated elevation at top of section, 900 ft.)

	Thickness (ft)
KREBS GROUP	
Boggy Formation:	
Sandstone, buff, micaceous, fine-grained (poorly exposed)	40.0
Covered interval (probably shale)	10.0
Sandstone, brown, ferruginous, micaceous, fine-grained, noncalcareous, thin- to medium-bedded	5.0
Sandstone, light-gray with orange iron-oxide staining, silty, micaceous, very fine-grained, noncalcareous, weakly indurated	1.2
Sandstone, brown, ferruginous, micaceous, fine-grained, noncalcareous, thick-bedded; includes some hard, dark-reddish-brown, banded iron-oxide-cemented concretions	30.5
Savanna Formation:	
Coal, black, soft, weathered (Drywood)	0.2
Underclay, light-gray with orange staining; includes abundant fossil-plant fragments	2.4
Shale, medium- to dark-gray; reddish-brown iron-oxide staining and crust on bedding surfaces; includes black and reddish-brown ironstone layer about 13 ft from top of unit; (poorly exposed near base of unit)	26.0
Total	115.3

Measured Section 10

SE¼SE¼SE¼SW¼ sec. 32, T24N, R19E, Craig County. Measured in road cut on north side of gravel road along Craig-Mayes County line, by LeRoy A. Hemish. Field notebook designation CN-70-78-H. (Estimated elevation at top of section, 809 ft.)

	Thickness (ft)
KREBS GROUP	
Boggy Formation:	
Sandstone, buff, micaceous, very fine- to fine-grained, noncalcareous, medium-bedded	4.0
Savanna Formation:	
Coal, black, weathered (Drywood)	0.2
Underclay, light-gray with orange iron-oxide streaks; includes abundant, black carbonized plant fragments	1.5
Shale, light-gray with orange iron-oxide staining, silty	3.5
Total	9.2

Measured Section 11

NW¼NE¼SE¼SE¼ sec. 2, T25N, R17E, Nowata County. Measured due west of abandoned farm site, in escarpment above flood plain of Madden Creek, by LeRoy A. Hemish. Field notebook designation CN-45-78-H. (Estimated elevation at top of section, 700 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Limestone, light-yellow-gray, silty, fossiliferous; weathered into large, flat boulders 3 to 6 in. thick separated by dark-brown, clayey soil	2.0
Shale, gray	4.0
Coal, black with reddish-brown staining on cleat surfaces (Iron Post)	1.0
Underclay, gray; base not exposed	0.8
Total	7.8

Measured Section 12

SE¼SW¼NE¼NW¼ sec. 11, T25N, R17E, Nowata County. Measured in bank of small stream flowing through small, abandoned strip mine, just west of electric power line, by LeRoy A. Hemish. Field notebook designation CN-46-78-H. (Estimated elevation at top of section, 690 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, orange-brown; includes abundant limestone clasts (regolith)	2.0
CABANISS GROUP	
Senora Formation:	
Coal, black, soft, weathered (Iron Post)	1.1
Underclay, very dark-gray	0.1
Sandstone, reddish-brown, shaly, fine-grained, thin-bedded; base covered by water in stream	2.8
Total	6.0

Measured Section 13

NE¼NW¼SE¼SW¼ sec. 14, T25N, R17E, Nowata County. Measured in highwall of Strip Pit 69-72 operated by Peabody Coal Company, by LeRoy A. Hemish. Field notebook designation CN-64-78-H. (Estimated elevation at top of section, 750 ft.)

Undifferentiated:

Clay, silty, orange-brown to brown, contains humus in upper part (regolith)	4.0

CABANISS GROUP

Senora Formation:

Limestone, gray, silty, fossiliferous, hard	4.0
Shale, black, hard; contains pyritized brachiopod shells	12.0
Shale, gray; includes some small brachiopod fossils	10.0
Coal, black; minor amount of calcite and pyrite on cleat surfaces (Iron Post)	1.1
Sandstone, dark-gray, silty, calcareous, very fine-grained	0.9
Total	32.0

Measured Section 14

NW¼SW¼NE¼ sec. 21, T25N, R17E, Nowata County. Measured in highwall of strip pit (Osage Mine No. 1) operated by M. J. Lee Construction Co., by Leroy A. Hemish. Field notebook designation CN-87-78-H. (Estimated elevation at top of section, 680 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Limestone, light-gray, weathers buff, silty, fossiliferous, dense, hard	12.0
Shale, brown to gray-brown, clayey, highly weathered	0.8
Shale, black, slaty; includes small brachiopod shells	2.2
Coal, black, shiny; some reddish-brown iron-oxide staining on cleat surfaces; also includes some coatings of white calcite and pyrite (Iron Post)	1.2
Sandstone, black, silty, micaceous; includes carbonized plant fragments	0.8
Total	17.0

Measured Section 15

NW¼NW¼NW¼NW¼ sec. 22, T25N, R17E, Nowata County. Measured in road cut on east side of State Highway 28, by LeRoy A. Hemish. Field notebook designation CN-52-78-H. (Estimated elevation at top of section, 700 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Limestone, buff to yellow-gray, impure, sandy, fossiliferous, thick-bedded; forms ledge	7.0

Shale, black to dark-gray, poorly exposed	2.5
Coal, black with reddish-brown iron-oxide staining on cleat surfaces (Iron Post)	1.2
Sandstone, light-gray with brown iron-oxide streaks, very fine-grained, clayey; base not exposed	1.3
Total	12.0

Measured Section 16

SW¼SW¼SE¼ sec. 26, T25N, R17E, Nowata County. Measured in highwall of strip pit operated by Fuel Dynamics, Inc., by LeRoy A. Hemish. Field notebook designation CN-50-78-H. (Estimated elevation at top of section, 780 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown, oxidized (regolith)	1.0
CABANISS GROUP	
Senora Formation:	
Limestone, yellow-buff, hard, massive fossiliferous	4.0
Shale, black; contains abundant, black phosphatic nodules	2.5
Shale, light-gray; uniform in character	47.5
Coal, black, shiny, hard (Croweburg)	1.1
Underclay, gray	0.4
Total	56.5

Measured Section 17

NW¼SW¼SW¼SW¼ sec. 27, T25N, R17E, Nowata County. Measured in road ditch just northeast of Alluwe along State Highway 28, by LeRoy A. Hemish. Field notebook designation CN-51-78-H. (Estimated elevation at top of section, 741 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown, oxidized (regolith)	0.5
CABANISS GROUP	
Senora Formation:	
Limestone, buff, silty, fossiliferous	0.5
Shale, medium-gray; contains black, carbonized plant fragments	3.0
Coal, black with reddish-brown iron-oxide staining on cleat surfaces (Iron Post)	1.1
Underclay, light-gray streaked with yellow, plastic; base not exposed	0.8
Total	5.9

Measured Section 18

NW¼SE¼SW¼ sec. 33, T25N, R17E, Nowata County. Measured in highwall of strip pit operated by Carbonex Coal Company, by LeRoy A. Hemish. Field notebook designation CN-42-78-H. (Estimated elevation at top of section, 735 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown; weathered limestone boulders included (regolith)	2.0
MARMATON GROUP	
Fort Scott Limestone:	
Limestone, yellow-buff, silty, fossiliferous, weathered	1.0
CABANISS GROUP	
Senora Formation:	
Shale, yellow-gray, partly weathered	2.6
Shale, black, hard, slaty; contains phosphatic nodules; rectangularly-jointed, with reddish-brown staining on joint surfaces	2.9
Limestone, grayish-tan, dense, massive, fossiliferous	8.0
Shale, black, hard; bottom 1 ft includes the following: fossil tracks, trails, and burrows; a 6-in. zone of impure, shaly limestone containing brachiopod shells; black phosphatic nodules; and pyritized brachiopods and wood fragments	3.0
Coal, black with reddish-orange iron-oxide staining on cleat surfaces (Iron Post)	1.1
Shale, gray	0.3
Total	20.9

Measured Section 19

SE¼NW¼NE¼NW¼ sec. 34, T25N, R17E, Nowata County. Measured in creek bank abut 50 yd east of junction of two small tributary streams of Panther Creek, by LeRoy A. Hemish. Field notebook designation CN-85-78-H. (Estimated elevation at top of section, 710 ft.)

	Thickness (ft)
Undifferentiated:	
Covered interval (includes topsoil, regolith, weathered shale fragments, and ironstone and limestone pebbles).	15.0
Clay, light-brown-gray, silty, pebbly (appears to be colluvium derived from highly weathered shale)	2.0

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Coal, black, soft, weathered (Croweburg)	1.1
Underclay, light-yellow-gray with orange mottling	1.0
Limestone, gray with purple blotches and reddish-brown weathered surfaces, fossiliferous, hard; well exposed in stream bed	0.3
Shale, light-gray with orange streaks, weathered	2.6
Total	22.0

Measured Section 20

SE¼NW¼SE¼NE¼ sec. 34, T25N, R17E, Nowata County. Measured in bank of small intermittent stream about 250 yd south of farm building site, by LeRoy A. Hemish. Field notebook designation CN-86-78-H. (Estimated elevation at top of section, 730 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown to yellow-brown, contains humus (regolith)	2.0
CABANISS GROUP	
Senora Formation:	
Shale, tan; includes small clay-ironstone concretions	2.0
Coal, black (Croweburg)	1.5
Underclay, yellow-gray; includes abundant fossil-leaf compressions and other plant fragments	1.2
Sandstone, gray with maroon blotches on weathered surfaces, fine-grained, hard, thin- to medium-bedded, highly calcareous	2.3
Siltstone, light-brown, shaly, laminated	2.0
Total	11.0

Measured Section 21

SW¼SE¼SW¼NE¼ sec. 35, T25N, R17E, Nowata County. Measured in highwall of strip pit operated by Carbonex Coal Co., by LeRoy A. Hemish. Field notebook designation CN-43-78-H. (Estimated elevation at top of section, 818 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown to reddish-brown, silty (regolith)	3.0

CABANISS GROUP

Senora Formation:

Limestone, yellow-buff, fossiliferous, weathered	7.0
Shale, dark-gray with reddish-brown iron-oxide staining on fracture surfaces	2.5
Coal, black, stained reddish-brown on cleat faces (Iron Post)	1.0
Shale, gray, silty	0.4
Total	13.9

Note: Coal seam is highly undulated, varying as much as 4 ft in elevation within 50 yd.

Measured Section 22

SE¼NW¼SE¼NW¼ sec. 35, T25N, R17E, Nowata County. Measured in highwall of strip pit operated by Carbonex Coal Co., by LeRoy A. Hemish. Field notebook designation CN-44-78-H. (Estimated elevation at top of section, 796 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, orange-brown (regolith)	10.0
CABANISS GROUP	
Senora Formation:	
Limestone, buff	5.0
Shale, black; contains black phosphatic nodules	3.0
Shale, light-gray, silty; includes lenses of reddish-orange clay-ironstone concretions	13.0
Sandstone, tan to orange-brown	1.8
Shale, light-gray; includes numerous tan-gray, 1- to 2-in. bands of clay-ironstone	34.2
Coal, black, shiny; contains some very thin, impure, shaly layers (Croweburg)	1.1
Underclay, gray	0.4
Total	68.5

Measured Section 23

NE¼NW¼SW¼SE¼ sec. 36, T25N, R17E, Nowata County. Measured in highwall of strip pit operated by Fuel Dynamics, Inc., by LeRoy A. Hemish. Field notebook designation CN-49-78-H. (Estimated elevation at top of section, 815 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown, silty, highly oxidized; shale pebbles abundant in lower 4 ft (regolith)	8.0

CABANISS GROUP

Senora Formation:

Shale, yellow-gray, oxidized; includes numerous reddish-brown clay-ironstone concretions about 3 to 4 in. in diameter and ¾-in. thick	2.0
Coal, black; shiny and hard in lower 10 in.; somewhat soft and weathered in upper 12 in. (Croweburg)	1.8
Underclay, light-tan-gray, kaolinitic, plastic	0.2
Total	12.0

Measured Section 24

NE¼NE¼NE¼SE¼ sec. 10, T25N, R18E, Craig County. Measured in highwall of strip pit operated by ELCO Coal Co., by LeRoy A. Hemish. Field notebook designation CN-54-78-H. (Estimated elevation at top of section, 920 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Shale, black with reddish-brown iron-oxide staining on joint surfaces; contains black, phosphatic nodules	4.0
Limestone, light-brown-gray, silty, fossiliferous, thick-bedded	10.0
Shale, black, fossiliferous; tiny (1/16-in. diameter) corals very abundant	2. 7
Coal, black, hard; calcite on cleat surfaces (Iron Post)	1.3
Shale, medium-gray, highly silty, micaceous	0.5
Total	18.5

Measured Section 25

SE¼SW¼SW¼ sec. 11, T25N, R18E, Craig County. Measured in highwall of strip pit operated by ELCO Coal Co., by LeRoy A. Hemish. Field notebook designation CN-55-78-H. (Estimated elevation at top of section, 878 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown, silty (regolith)	2.0
CABANISS GROUP	
Senora Formation:	
Shale, yellow-gray, partly oxidized	5.0
Shale, light-gray with reddish-brown iron-oxide staining on fracture surfaces	17.0
Coal, black, shiny, hard (Croweburg)	1.3
Underclay, gray	0.2
Total	25.5

Measured Section 26

SW¼SW¼SE¼NE¼ sec. 12, T25N, R18E, Craig County. Measured in bank of White Creek and up steep slope to the north, by LeRoy A. Hemish. Field notebook designation CN-62-78-H. (Estimated elevation at top of section, 845 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Covered interval (grassy slope)	10.0
Sandstone, reddish-brown, ferruginous, medium-grained, medium-bedded, well-indurated, jointed; contains Stigmaria	20.0
Shale, yellow-brown, weathered	0.5
Covered interval (probably shale)	30.5
Shale, dark gray; includes orange-brown clay-ironstone concretions	4.0
Clay-ironstone, reddish-brown to purple, weathers orange, brecciated; angular blocks about 1.5 in. by 1.5 in. by 2.0 in. form mosaics cemented with white calcite that fills fractures up to 0.5-in. thick. Unit is very hard and resistant; occurs as a discontinuous layer of pods and irregularly shaped masses (Tiawah Limestone)	0.3
Shale, black, hard	1.7
Total	67.0

Note: Tebo coal bed not exposed; however, Lohman (1952) measured 0.3 ft of Tebo coal, 15.1 ft below the Tiawah Limestone in the creek bank in the same general vicinity in the early 1950s.

Measured Section 27

NW¼NW¼SW¼SW¼ sec. 12, T25N, R18E, Craig County. Measured in road cut where erosion has deepened ditch, by LeRoy A. Hemish. Field notebook designation CN-47-78-H. (Estimated elevation at top of section, 840 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, brown, contains humus (regolith)	2.0
CABANISS GROUP	
Senora Formation:	
Sandstone, reddish-brown, ferruginous, micaceous, fine- to medium-grained, thin-bedded; crescentic marks on stratification surfaces	2.0
Coal, black, weathered (Mineral)	1.0
Shale, black, highly carbonaceous, grading to impure coal	0.3
Underclay, light-gray with reddish-brown iron-oxide staining, bleached, plastic; includes carbonized plant compressions; base not exposed	0.8
Total	6.1

Measured Section 28

NE¼NW¼SE¼ sec. 14, T25N, R18E, Craig County. Measured in highwall of strip pit operated by G & P Mining, Inc., by LeRoy A. Hemish. Field notebook designation CN-48-78-H. (Estimated elevation at top of section, 882 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, dark-brown, contains humus (regolith)	1.0
CABANISS GROUP	
Senora Formation:	
Sandstone, reddish-brown to light-brown, ferruginous, micaceous, fine- to medium-grained, noncalcareous, massively crossbedded, weakly indurated	19.0
Sandstone, greenish-gray to brownish-gray, fine-grained, laminated; includes very abundant carbonized plant fragments on stratification surfaces; some black coal laminae; locally includes lenses of conglomerate consisting of coal pebbles and gray clay pebbles in a matrix of brown, ferruginous, fine-grained sandstone	2.0
Coal, black with reddish-brown iron-oxide staining on cleat surfaces in upper 10 in.; soft and impure, with flattened pyrite nodules up to 6 in. in diameter near base of seam (Mineral)	1.3
Underclay, light-brown-gray	0.6
Total	23.9

Measured Section 29

SW¼NE¼NE¼NW¼ sec. 30, T25N, R18E, Craig County. Measured in highwall of strip pit operated by Solar Excavating, Inc., by LeRoy A. Hemish. Field notebook designation CN-53-78-H. (Estimated elevation at top of section, 813 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, dark-gray-brown, silty (regolith)	2.0
Clay, orange-brown; contains weathered shale fragments (regolith)	4.0
CABANISS GROUP	
Senora Formation:	
Shale, yellow-gray, partly oxidized	5.0
Shale, light-gray; includes scattered, oblate, gray clay-ironstone concretions about 6 to 8 in. in diameter	22.0
Coal, black, hard (Croweburg)	1.2
Shale, gray; includes abundant, black carbonized plant fragments; base not exposed	0.6
Total	34.8

Measured Section 30

SW¼SW¼NW¼NW¼ sec. 36, T25N, R18E, Craig County. Measured in bank of small stream about 100 yd east of bridge, by LeRoy A. Hemish. Field notebook designation CN-83-78-H. (Estimated elevation at top of section, 820 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Shale, light-gray, weathers to light-tan; flakes of weathered shale litter slope	9.0
Shale, very dark-gray with reddish-brown and purple brown staining on stratification planes and joint surfaces; grades downward to black shale	1.0
Limestone, brown and black with reddish-brown ironstone rind, very hard, fossiliferous	0.2
Shale, very dark-gray to black	0.7
Shale, black; contains black phosphatic nodules about ½ in. in diameter; hard, slaty, joint pattern nearly rectangular	1.1
Coal, black (Tebo)	0.2
Underclay, dark-gray; fossil-plant fragments abundant	0.6
Total	12.8

Measured Section 31

SW¼SW¼SW¼SE¼ sec. 4, T25N, R19E, Craig County. Measured in highwall of strip pit operated by Jess Hefner & Son, by LeRoy A. Hemish. Field notebook designation CN-63-78-H. (Estimated elevation at top of section, 806 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, dark-brown, contains humus, unconsolidated (regolith)	0.5
Sand, brown, weathered; contains hard remnants of sandstone of assorted sizes, orange-brown in color (regolith)	2.5
CABANISS GROUP	
Senora Formation:	
Sandstone, buff to orange-brown, micaceous, fine- to medium-grained, crossbedded	9.5
Sandstone, gray-brown, micaceous, crossbedded; contains laminae of black and brown carbonaceous material	8.0
Shale, dark-olive-gray, fissile, hard	4.5
Coal, black; pyrite nodules and veins in bottom 0.5 ft (Weir-Pittsburg)	1.9

KREBS GROUP

Boggy Formation:

Underclay, light-gray with yellow and orange mottling; black carbonaceous plant fragments abundant	0.6
Total	27.5

Measured Section 32

NW¼NE¼NE¼NW¼ sec. 5, T25N, R19E, Craig County. Measured in highwall of abandoned strip pit on south side of road through middle of mine (west-facing wall of final cut), by LeRoy A. Hemish. Field notebook designation CN-24-78-H. (Estimated elevation at top of section, 775 ft.)

	Thickness (ft)
Undifferentiated	
Clay, reddish-brown, overlain by dark-brown soil (regolith)	1.5
CABANISS GROUP	
Senora Formation:	
Sandstone, orange-brown, fine-grained, thin-bedded, noncalcareous, weakly indurated; interbedded with silt	3.5
Sandstone, reddish-brown, ferruginous, massive to thick-bedded; includes several 1- to 2-in., very fine-grained, thin-bedded, silty sand beds near base of unit (channels into underlying strata) . .	8.0
Shale, light-gray, weathers tan, micacaeous, very sandy and silty; interbedded with zones of very fine-grained, thin-bedded, ripple-marked, micaceous, light-gray sandstone containing abundant black, carbonaceous flecks	9.3
Sandstone, gray-brown, conglomeratic; includes gray clay pebbles and dark reddish-black clasts derived from ironstone concretions . . .	0.2
Sandstone, light-gray-tan; weathers reddish-brown to very dark-brown; very fine-grained, highly calcareous, well-indurated	0.4
Conglomerate, gray with reddish-brown mottling, sandy, calcareous; includes angular fragments of gray shale, black shale, and ironstone .	0.8
Limestone, dark-gray, dense, hard; occurs in a lens that pinches out laterally and grades into overlying and underlying strata	0.3
Conglomerate, gray-brown, highly calcareous; contains abundant angular, brecciated fragments of black shale as much as 12 in. long and 6 in. thick; includes reddish-purple clasts as much as 3 in. in diameter derived from clay-ironstone concretions; pinches out in a short distance laterally; channels into underlying strata	1.0
Shale, medium-gray	1.0
Covered to water in bottom of pit by slump, but laterally along the highwall, a buff, micaceous, fine-grained, white-weathering sandstone channels into shale at a similar elevation. Locally, the sandstone is highly contorted and contains angular chunks of	

brecciated coal, as well as displaced portions of coal seams 3 to 4 ft long and 6 in. thick	6.0
Total	32.0

Note: Weir-Pittsburg coal mined here; seam now concealed by water in bottom of pit.

Measured Section 33

SW¼SW¼SW¼NW¼ sec. 8, T25N, R19E, Craig County. Measured in roadcut southeast of bridge where junction of section-line road and U.S. Route 60 forms an acute angle, by LeRoy A. Hemish. Field notebook designation CN-34-78-H. (Estimated elevation at top of section, 770 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Shale, yellow-gray; poorly exposed	5.0
Coal, black (Weir-Pittsburg)	1.3
KREBS GROUP	
Boggy Formation:	
Underclay, reddish-brown to orange, highly ferruginous, hard, laminated, conglomeratic; contains black coal fragments; soft, and bright orange in bottom 6 in.	0.7
Shale, gray-brown, clayey; grades downward into light-gray shale	4.0
Total	11.0

Measured Section 34

SE¼NW¼SW¼SW¼ sec. 8, T25N, R19E, Craig County. Measured in old, abandoned, small strip pit and eastward downhill to sandstone ledge, by LeRoy A. Hemish. Field notebook designation CN-33-78-H. (Estimated elevation at top of section, 790 ft.)

	Thickness (ft)
Spoils from old mine (predominantly light-brown shale fragments and dark-brown clay-ironstone pebbles and cobbles)	9.0
CABANISS GROUP	
Senora Formation:	
Shale, brown, weathered	1.0
Coal, black, weathered (Weir-Pittsburg)	1.0

Boggy Formation:

Covered interval (grassed-over slope)	9.0
Sandstone, buff, very fine-grained, thin-bedded, noncalcareous, micaceous; dark-brown to orange-brown staining on weathered surfaces	7.0
Total	27.0

Measured Section 35

NW¼SW¼NE¼ sec. 9, T25N, R19E, Craig County. Measured in highwall of strip pit operated by Jess Hefner & Son, by LeRoy A. Hemish. Field notebook designation CN-29-78-H. (Estimated elevation at top of section, 820 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, tan, unconsolidated; includes organic material and broken sandstone fragments (regolith)	1.0
CABANISS GROUP	
Senora Formation:	
Sandstone, light-brown to reddish-brown, ferruginous, fine- to medium-grained, thin-bedded, micaceous; includes carbonized streaks of plant matter on stratification surfaces	3.5
Conglomerate, dark-reddish-brown, ferruginous, hard; contains ironstone pebbles and coal streaks; grades into overlying unit; basal contact highly irregular	1.5
Shale, medium-gray with reddish-brown staining on fracture surfaces	11.0
Coal, black; includes some pyrite nodules (Weir-Pittsburg)	2.1
KREBS GROUP	
Boggy Formation:	
Fire clay, light-gray, hard; base not exposed	0.4
Total	19.5

Measured Section 36

NW¼NE¼SE¼NW¼ sec. 9, T25N, R19E, Craig County. Measured in highwall of strip pit operated by Jess Hefner & Son, by LeRoy A. Hemish. Field notebook designation CN-36-78-H. (Estimated elevation at top of section, 833 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, brown, unconsolidated (regolith)	4.0
CABANISS GROUP	
Senora Formation:	

Sandstone, brown to reddish-brown to dark-brown, ferruginous, coarse-grained, massive, crossbedded, micaceous	6.0
Sandstone, light-tan to gray-brown, fine-grained, micaceous, laminated; black, carbonaceous film on stratification surfaces; locally includes black, spherical phosphatic nodules; contact with underlying unit sharply defined	3.0
Siltstsone, gray, sandy in part, shaly in part, conglomeratic in part; locally includes blocks of coal 6 in. thick and 3 ft long, as well as smaller pieces. This unit is highly disturbed and contorted, giving the appearance of a fault zone	1.5
Sandstone, dark-reddish-brown, fine-grained, massive; very irregular in thickness; channels into underlying unit	1.1
Conglomerate, reddish-brown, ferruginous, very coarse and poorly sorted; includes a zone of black ironstone concretions at the top. Unit is composed of black phosphatic nodules, angular blocks of hard, black shale, ironstone pebbles, fragments of red sandstone, coal streaks (faulted), angular fragments of soft light-gray and orange clay--all in a coarse sand matrix	1.2
Shale, medium-gray, uniform in character	17.2
Coal, black (Weir-Pittsburg)	2.1
Total	36.1

Measured Section 37

NW¼NW¼SE¼NW¼ sec. 9, T25N, R19E, Craig County. Measured in highwall of strip pit operated by Jess Hefner & Son, by LeRoy A. Hemish. Field notebook designation CN-35-78-H. (Estimated elevation at top of section, 845 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, brown, contains humus (regolith)	1.0

CABANISS GROUP

Senora Formation:

Sandstone, brown, medium- to coarse-grained, crossbedded; interbedded with coal streaks and seams about 1 in. thick; near the base of the unit, black coal laminae, gray coarse sand, and brown coarse sand are interlaminated	6.0
Sandstone, yellow-gray, coarse, interbedded with 1-in. coal seams; beds are highly contorted and faulted	1.0
Coal, black, hard, discontinuous laterally (Tebo?)	0.2
Sandstone, brown, coarse; contains clay pebbles and coal flecks; basal contact highly irregular	0.3
Sandstone, hematite-red, coarse, well-indurated; finely conglomeratic in part; contains black coal flecks	4.5

Shale, light-gray, hard	2.0
Siltstone, very light-gray, micaceous, hard; grades into underlying unit	6.0
Shale, medium-gray, hard, uniform in character	25.2
Coal, black (Weir-Pittsburg)	2.0
Total	48.2

Measured Section 38

SE¼NE¼NW¼NE¼ sec. 10, T25N, R19E, Craig County. Measured in steep bank of Pawpaw Creek southeast of farm site, where stream bends sharply to the south, by LeRoy A. Hemish. Field notebook designation CN-40-78-H. (Estimated elevation at top of section, 702 ft.)

	Thickness (ft)
Undifferentiated:	
Silt, light-brown, sandy, gravelly; pebbles imbricated (alluvium associated with Pawpaw Creek)	6.0
KREBS GROUP	
Savanna Formation:	
Shale, dark-gray; includes layers of brown clay-ironstone about 1 to 1½ in. thick, spaced 8 in. to 1 ft apart vertically; shale is is black and highly carbonaceous in bottom 6 in.; grades into underlying unit	4.0
Coal, black, weathered (Rowe)	0.3
Underclay, brown-gray	0.7
Covered by slump to water level in creek	2.0
Total	13.0

Measured Section 39

NW¼NE¼SW¼ sec. 10, T25N, R19E, Craig County. Measured in creek bank just south of junction of two intermittent streams, by Leroy A. Hemish. Field notebook designation CN-81-78-H. (Estimated elevation at top of section, 728 ft.)

	Thickness (ft)
Undifferentiated	
Silt, dark-brown, contains humus (regolith)	1.0
KREBS GROUP	
Savanna Formation:	
Shale, light-yellow-brown, weathered	6.0
Shale, dark-gray-brown, silty, very highly carbonaceous; weathers to elongated chocolate-brown flakes	1.8
Coal, black with reddish-brown iron-oxide coating on cleat surfaces, weathered (Drywood)	0.7

Shale, dark-brown, highly carbonaceous; includes very thin coal stringers	0.2
Underclay, gray and reddish-orange; black, carbonized fossil-plant fragments abundant	1.3
Shale, light-gray, highly silty, stained reddish-brown on weathered surfaces	2.0
Total	13.0

Measured Section 40

SW¼SE¼SE¼NW¼ sec. 10, T25N, R19E, Craig County. Measured in creek bank due northwest of farm stock pond, by Leroy A. Hemish. Field notebook designation CN-82-78-H. (Estimated elevation at top of section, 705 ft.)

	Thickness (ft)
Undifferentiated:	
Silt, brown, sandy, pebbly (alluvium)	1.5
KREBS GROUP	
Savanna Formation:	
Limestone, dark-gray, well-indurated, fossiliferous, thin-bedded; weathers reddish-orange	0.2
Shale, dark-gray, highly carbonaceous, flaky; grades into underlying unit	1.1
Coal, black with red and yellow coating on weathered surfaces; impure and shaly in bottom 6 in. (Rowe)	1.3
Underclay, dark-gray	1.0
Total	5.1

Measured Section 41

NE¼SE¼SE¼NW¼ sec. 10, T25N, R19E, Craig County. Measured east of creek, from knoll south of farm site, downhill through gully to dry creek bed, by LeRoy A. Hemish. Field notebook designation CN-83-78-H. (Estimated elevation at top of section, 718 ft.)

	Thickness (ft)
KREBS GROUP	
Savanna Formation:	
Sandstone, reddish-brown, ferruginous, fine-grained, well-sorted (poorly exposed)	12.0
Shale, gray; contains reddish-orange ironstone layers in bottom 2 ft	3.0
Limestone, purple-brown, hard, fossiliferous	0.4
Shale, black; includes small phosphatic nodules	0.4

Coal, black (Rowe)	0.3
Underclay, light-gray with orange bands	0.8
Shale, gray, highly silty; includes abundant iron-oxide-cemented nodules; base not exposed	3.1
Total	20.0

Measured Section 42

SE¼SW¼SE¼SW¼ sec. 11. T25N, R19E, Craig County. Measured in bank of small creek on north side of bridge, where stream bends sharply to the east, by LeRoy A. Hemish. Field notebook designation CN-39-78-H. (Estimated elevation at top of section, 703 ft.)

	Thickness (ft)
Undifferentiated:	
Silt and clay, dark-gray to brown-gray (alluvium)	2.0
KREBS GROUP	
Savanna Formation:	
Shale, gray; includes a thin (½- to 1-in.) layer of brown clay-ironstone concretions about 2 ft above base of unit	5.0
Limestone, reddish-purple, very highly fossiliferous	0.2
Shale, medium-gray; includes black, carbonized plant fragments	0.6
Coal, black, weathered (Rowe)	0.3
Underclay, yellow-gray, plastic; surface stained orange to water level in creek	0.9
Total	9.0

Measured Section 43

SE¼NE¼NE¼NE¼ sec. 14, T25N, R19E, Craig County. Measured in bank of Pawpaw Creek, just west of road, by LeRoy A. Hemish. Field notebook designation CN-84-78-H. (Estimated elevation at top of section, 698 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown, silty (topsoil and slumped regolith)	4.0
KREBS GROUP	
Savanna Formation:	
Shale, very dark-gray; weathers to brittle, sharp-edged, elongated flakes; includes a discontinuous 2-in. layer of reddish-brown clay-ironstone concretions about 4 ft above base of unit	9.0
Coal, black with reddish-brown staining on cleat surfaces (Rowe)	0.5
Underclay, dark-gray; includes black, carbonized fossil-plant fragments	0.8

Shale, gray, clayey; includes spherical and dumbbell-shaped ironstone concretions about 1 to 4 in. in diameter; weathers to very small, thin flakes on exposed surfaces	2.7
Coal, black with reddish-orange iron-oxide staining (unnamed)	0.1
Shale, light-gray; base covered	0.9
Total	18.0

Note: About 100 yd westward along the creek bank the Rowe thins and wedges out. It has been cut off by a body of dark-gray shale (unit 2, above) that fills a shallow channel approximately 25 yd wide. The coal seam reappears going westward from the channel with about the same thickness as previously measured.

Measured Section 44

NW¼NE¼SW¼NW¼ sec. 17, T25N, R19E, Craig County. Measured in bank of north-flowing tributary of White Creek, where stream is cutting into small abandoned strip pit, by LeRoy A. Hemish. Field notebook designation CN-32-78-H. (Elevation at top of section, 795 ft.)

	Thickness (ft)
Spoils from abandoned strip pit	6.0
CABANISS GROUP	
Senora Formation:	
Conglomerate, hematite-red; contains much brecciated material, including angular shale fragments, coal fragments, and clasts derived from clay-ironstone concretions; porous. (Ten ft north this unit thickens to 3 ft, and cuts down into underlying coal bed, which is 6 in. thick; 5 ft farther north, the conglomerate cuts completely through the coal, and only a few displaced tabular coal masses are present	0.5
Coal, black (Weir-Pittsburg). Adjacent to the measured section a dikelike finger of underclay extends upward into the coal seam where it has been fractured and pulled apart by tension	1.5
KREBS GROUP	
Boggy Formation:	
Underclay, yellow-gray; base covered by water in creek	0.5
Total	8.5

Measured Section 45

NW¼NW¼SW¼NW¼ sec. 20, T26N, R18E, Craig County. Measured in highwall of Strip Pit 7507 operated by Peabody Coal Co., by LeRoy A. Hemish. Field notebook designation CN-67-78-H. (Estimated elevation at top of section, 793 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, orange-brown; contains humus at the surface; includes assorted sizes of weathered limestone fragments (regolith)	2.0
MARMATON GROUP	
Fort Scott Limestone:	
Limestone, gray, weathers yellow-brown, fossiliferous, hard	8.5
CABANISS GROUP	
Senora Formation:	
Shale, black, hard, slaty; contains spherical black phosphatic nodules as much as 1 in. in diameter	4.0
Limestone, gray, silty, highly fossiliferous, hard	10.7
Shale, black; includes a few small brachiopod fossils	1.8
Coal, black (Iron Post)	1.1
Sandstone, very dark-gray, silty, calcareous, well-indurated, very fine-grained	0.8
Total	28.9

Measured Section 46

NW¼SW¼SE¼SE¼ sec. 22, T26N, R18E, Craig County. Measured in highwall of Strip Pit 291 operated by Peabody Coal Co., by LeRoy A. Hemish. Field notebook designation CN-65-78-H. (Estimated elevation at top of section, 883 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, dark-brown and silty with humus near the surface; orange-brown at base; includes angular limestone fragments (regolith)	3.5
MARMATON GROUP	
Fort Scott Limestone:	
Limestone, gray to gray-brown, fossiliferous, dense	3.0

CABANISS GROUP

Senora Formation:

Shale, black, weathers gray-brown; includes black phosphatic nodules about 0.5 to 1.0 in. in diameter	9.5
Limestone, gray, silty, fossiliferous, massive, hard	7.0
Shale, black, fossiliferous	4.2
Coal, black; minor amount of calcite and pyrite on cleat surfaces (Iron Post)	1.3
Sandstone, dark-gray, silty, calcareous, very fine-grained	0.5
Total	29.0

Measured Section 47

SW¼NE¼SE¼NW¼ sec. 24, T26N, R18E, Craig County. Measured north of stock pond in area of small abandoned strip pits near head of north-south ravine, by LeRoy A. Hemish. Field notebook designation CN-23-78-H. (Estimated elevation at top of section, 890 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown; contains humus (regolith)	1.0
CABANISS GROUP	
Senora Formation:	
Shale, light-gray with orange streaks, weathered	0.5
Coal, black with red iron-oxide stains on cleat surfaces (Iron Post)	1.2
Underclay, brownish-gray	0.3
Total	3.0

Measured Section 48

NW¼NW¼NE¼NE¼ sec. 35, T26N, R18E, Craig County. Measured in highwall of Strip Pit 1050 operated by Peabody Coal Co., by LeRoy A. Hemish. Field notebook designation CN-66-78-H. (Estimated elevation at top of section, 915 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, orange-brown; very dark-gray, silty, contains humus near the surface (regolith)	4.0

CABANISS GROUP

Senora Formation:

Limestone, light-gray, weathers light-orange-brown, dense, massive, hard	7.0
Shale, black; contains abundant small fossils, some pyritized	2.2
Coal, black; calcite on cleat surfaces (Iron Post)	1.1
Sandstone, very dark-gray, silty, calcareous, very fine-grained, weakly indurated	0.7
Total	15.0

Measured Section 49

NE¼NE¼NW¼NW¼ sec. 2, T26N, R19E, Craig County. Measured in road cut, south side of gravel road, by LeRoy A. Hemish. Field notebook designation CN-92-78-H. (Estimated elevation at top of section, 764 ft.)

	Thickness (ft)
Undifferentiated:	
Silt and clay, brown to reddish-brown, organic; includes orange ironstone pebbles (regolith)	2.8
CABANISS GROUP	
Senora Formation:	
Ironstone, orange, fossiliferous (altered limestone)	0.5
Shale, black, slaty	2.0
Shale, gray; weathers yellow-brown with reddish-brown iron-oxide staining	2.2
Coal, black; stained reddish-brown on cleat surfaces; weathered (Tebo)	0.6
Underclay, medium-gray with orange streaks, plastic	1.4
Total	9.5

Measured Section 50

NW¼NW¼NW¼ sec. 2, T26N, R19E, Craig County. Measured in road cut on south side of gravel road and in ditch on north side of road, by LeRoy A. Hemish. Field notebook designation CN-80-78-H. (Estimated elevation at top of section, 775 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown, silty, sandy, organic; contains numerous weathered chunks of sandstone (regolith)	1.0

CABANISS GROUP

Senora Formation:

Sandstone, light-brown with reddish-brown specks, ferruginous, fine-grained, highly weathered	1.5
Shale, light-gray to orange-brown, weathered	1.0
Clay-ironstone, reddish-brown with concentric orange bands, hard, rectangularly jointed	0.5
Shale, light-gray	5.0
Shale, black	0.8
Limestone, dark-brown to black, hard, fossiliferous; weathers to purple and reddish-brown clay-ironstone	0.3
Shale, black, brittle, highly carbonaceous	1.4
Shale, medium-gray with yellow and orange bands; base not exposed	1.9
Total	13.4

Note: Tebo coal crops out in road ditch about 100 yd east of this location.

Measured Section 51

NW¼SW¼NW¼SW¼ sec. 13, T26N, R19E, Craig County. Measured in highwall of strip pit operated by Leon's Coal Co., by LeRoy A. Hemish. Field notebook designation CN-37-78-H. (Estimated elevation at top of section, 776 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, silt, and clay; brown, oxidized; includes fragments of fine-grained sandstone (regolith)	4.0
KREBS GROUP	
Boggy Formation:	
Sandstone, light-brown, shaly, micaceous, very thin-bedded; dark-brown iron-oxide staining on stratification surfaces	2.0
Shale, light-gray-brown, silty	4.0
Sandstone, rust-brown, fine-grained, massive; forms podlike lenses	2.2
Shale, medium-gray, silty, interlaminated with very fine-grained, light-gray, micaceous sandstone; black, carbonized plant compressions on stratification surfaces	6.8
Sandstone, light-gray, medium-grained, micaceous; locally includes shale stringers; bottom 4 ft of unit includes numerous coal seams from ½ in. to 4 in. thick that are contorted, faulted, and discontinuous; clay pebbles, coal fragments, and ironstone pebbles in a sandstone matrix form a conglomerate in the basal 2 to 3 ft	6.0

Savanna Formation:

Shale, dark-gray	1.0
Coal, black; white calcite on cleat surfaces; locally includes pyrite lenses (Drywood)	3.0
Shale, black, papery, highly carbonaceous; grades into light-gray underclay	0.4
Total	29.4

Measured Section 52

SW¼SW¼SE¼SE¼ sec. 21, T26N, R19E, Craig County. Measured in west bank of Pawpaw Creek where bank steepens abruptly, by LeRoy A. Hemish. Field notebook designation CN-31-78-H. (Estimated elevation at top of section, 744 ft.)

	Thickness (ft)
Undifferentiated:	
Slump; poorly exposed; includes some slabs of buff, thin- to medium-bedded sandstone	8.0
CABANISS GROUP	
Senora Formation:	
Siltstone, gray-brown, thin-bedded, micaceous; carbonized plant fragments very abundant on stratification surfaces	1.0
Sandstone, orange-brown, ferruginous, fine-grained, well-indurated	0.1
Coal, black with orange iron-oxide staining on surface (Weir-Pittsburg)	2.3
KREBS GROUP	
Boggy Formation:	
Shale, gray with reddish-brown iron-oxide staining on surface; includes about 1 in. of black, highly carbonaceous shale at top of unit	4.6
Total	16.0

Measured Section 53

NW¼NE¼SW¼SE¼ sec. 21, T26N, R19E, Craig County. Measured in north bank of Pawpaw Creek just west of juncture with small, south-flowing tributary stream, by LeRoy A. Hemish. Field notebook designation CN-30-78-H. (Estimated elevation at top of section, 742 ft.)

	Thickness (ft)
Undifferentiated:	
Gravel, brown-gray, silty, sandy, poorly sorted; contains abundant sandstone fragments (alluvium associated with Pawpaw Creek)	5.0

CABANISS GROUP

Senora Formation:

Sandstone, buff with some reddish-brown staining, fine-grained, micaceous, thin-bedded, ripple-marked	1.0
Siltstone, gray with reddish-brown staining, shaly, micaceous; carbonized plant fragments very abundant on stratification surfaces	1.0
Coal, black; base covered by water in Pawpaw Creek; total thickness unknown (Weir-Pittsburg)	1.5
Total	8.5

Measured Section 54

SW¼NW¼NW¼SW¼ sec. 27, T26N, R19E, Craig County. Measured in highwall of abandoned strip pit near north-south fence line, by LeRoy A. Hemish. Field notebook designation CN-25-78-H. (Estimated elevation at top of section, 755 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown, overlain by dark-brown topsoil (regolith)	6.5
CABANISS GROUP	
Senora Formation:	
Sandstone, buff, fine-grained, micaceous, thin-bedded, noncalcareous, ripple-marked; includes thin shale and siltstone laminae	6.0
Sandstone, tan-gray, fine-grained, micaceous, thin- to medium-bedded calcareous, well-indurated; forms ledge above underlying strata	2.0
Shale, light- to medium-gray, noncalcareous	1.5
Shale, gray; interbedded with fine-grained, thin-bedded sandstone (poorly exposed owing to slumping)	2.0
Sandstone, gray-brown; weathers to reddish-brown; fine-grained, micaceous, noncalcareous, well-indurated; unbedded in bottom 3 in.	0.5
Coal, black (Weir-Pittsburg)	2.0
KREBS GROUP	
Boggy Formation:	
Underclay, black to dark-gray; includes coalified plant fragments	0.5
Shale, light-gray with reddish-brown spots and streaks	2.0
Total	23.0

Measured Section 55

NE¼NE¼SW¼NE¼ sec. 28, T26N, R19E, Craig County. Measured in southeast bank of Pawpaw Creek near old, abandoned, small strip pit, by LeRoy A. Hemish. Field notebook designation CN-26-78-H. (Estimated elevation at top of section, 735 ft.)

	Thickness (ft)
Undifferentiated:	
Silt, brown, clayey, sandy (alluvium associated with Pawpaw Creek) . . .	2.0
CABANISS GROUP	
Senora Formation:	
Shale, black, highly carbonaceous	0.5
Conglomerate, reddish-brown, ferruginous, sandy; includes carbonized plant fragments and ironstone concretion pebbles	0.5
Coal, black (Weir-Pittsburg)	2.6
KREBS GROUP	
Boggy Formation:	
Underclay, black to purple-brown	0.4
Shale, gray with purple-orange staining on weathered surfaces; some indurated siltstone stringers near top of interval; base not exposed . .	7.0
Total	13.0

Measured Section 56

NW¼SW¼NE¼SE¼ sec. 28, T26N, R19E, Craig County. Measured just east of juncture of Pawpaw Creek and unnamed tributary stream, in extreme southwest corner of large, abandoned strip mine, by LeRoy A. Hemish. Field notebook designation CN-28-78-H. (Estimated elevation at top of section, 743 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Conglomerate, reddish-brown to purple-black, ferruginous, massive; contains abundant pebbles and cobbles derived from clay-ironstone concretions	3.0
Sandstone, reddish-brown, ferruginous, medium-grained, medium-bedded, micaceous	1.5
Conglomerate, same as conglomerate above, but rudely stratified	2.0
Coal, black (Weir-Pittsburg)	2.0
KREBS GROUP	

Boggy Formation:

Underclay, gray	0.5
Total	9.0

Note: Large blocks of indurated overburden in adjacent spoil piles include boulders derived from ironstone concretions measuring 16 in. in diameter and 12 in. thick; angular fragments of purple-red, medium- to coarse-grained sandstone, 4 in. by 6 in.; cobbles of purple conglomerate, 3 in. in diameter; black phosphatic nodules about ½ in. in diameter--all bound in a matrix of buff sandstone.

Measured Section 57

NE¼SW¼NW¼SE¼ sec. 28, T26N, R19E, Craig County. Measured in bank of small stream flowing through very old, abandoned, small strip pit, by LeRoy A. Hemish. Field notebook designation CN-27-78-H. (Estimated elevation at top of section, 742 ft.)

	Thickness (ft)
Spoils from abandoned strip pit	1.0
CABANISS GROUP	
Senora Formation:	
Conglomerate, reddish-brown and orange, ferruginous; rudely stratified; contains abundant pebbles derived from clay-ironstone concretions . .	3.0
Sandstone, buff to light-brown, fine-grained, massive	1.0
Conglomerate, reddish-brown, ferruginous; includes pebbles and cobbles derived from clay-ironstone concretions; also includes several 1- to 2-in. coal seams, one being faulted in several places with each section of about 1 ft in length thrust over the next in en enchelon arrangement; bedding is highly contorted throughout the unit	1.5
Coal, black (Weir-Pittsburg)	2.0
Total	8.5

Measured Section 58

SE¼SE¼SW¼SE¼ sec. 31, T26N, R19E, Craig County. Measured in west highwall of abandoned strip pit, north side of gravel road, by LeRoy A. Hemish. Field notebook designation CN-69-78-H. (Estimated elevation at top of section, 785 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Shale, gray; weathers brown with orange spots and streaks; partly oxidized	5.0

Shale, light-gray	2.5
Ironstone, purple-brown, very hard, fossiliferous	0.3
Shale, black; includes abundant flattened and rounded phosphatic nodules as much as 2 in. in diameter	1.4
Shale, light-gray with yellow streaks; includes about 0.1 ft of reddish-brown, highly oxidized, carbonaceous shale at the base	0.4
Coal, black (Tebo)	0.3
Underclay, orange with gray streaks; includes bright-reddish-orange fossil-plant fragments	0.4
Underclay, light-gray with yellow streaks, plastic; includes abundant, black carbonaceous plant fragments	1.7
Shale, gray; includes hard gypsiferous ironstone concretions as much as 2 ft in diameter and 0.5 ft thick. (Base not exposed, water in bottom of pit)	7.0
Total	19.0

Note: Weir-Pittsburg coal was mined here. Thickness of seam not known.

Measured Section 59

SE¼SE¼NW¼SE¼ sec. 1, T26N, R20E, Craig County. Measured in hillside and cut for spillway, south side of stock pond, by LeRoy A. Hemish. Field notebook designation CN-93-78-H. (Estimated elevation at top of section, 830 ft.)

	Thickness (ft)
KREBS GROUP	
Savanna Formation:	
Sandstone, reddish-brown, ferruginous, micaceous, fine-grained	5.0
Covered interval	9.0
Shale, gray-brown, weathered; includes abundant reddish-brown ironstone concretions (fragments litter slope)	5.0
Limestone, dark-gray, highly fossiliferous; weathers reddish-brown	0.5
Shale, gray-brown, weathered	3.5
Coal, black, soft (Rowe)	0.6
Underclay, light-gray, mottled orange; contains black coalified plant fragments.	1.4
Shale, gray-brown, weathered, poorly exposed	4.0
Total	29.0

Measured Section 60

NW¼SW¼NW¼NW¼ sec. 34, T26N, R20E, Craig County. Measured in south bank of small tributary of Elm Creek, a few yd east of road, by LeRoy A. Hemish. Field notebook designation CN-38-78-H. (Estimated elevation at top of section, 713 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, buff, gravelly, ironstone concretion fragments abundant (alluvium associated with Elm Creek)	2.0

KREBS GROUP

Savanna Formation:

Shale, gray-tan, weathered	0.8
Limestone, purple-brown, nodular	0.2
Coal, black, soft, weathered (Rowe)	0.2
Shale, black, very highly carbonaceous, rectangular joints	1.0
Shale, light-gray, clayey; base covered by water in creek	2.6
Total	6.8

Note: About 100 yd north, the black, rectangularly jointed shale is exposed in the bed of Elm Creek. It is overlain by purple-brown, resistant, nodular limestone about 2 to 3 in. thick; this is overlain by medium-gray shale (14 in.) and a persistent zone of reddish-brown clay-ironstone that weathers into rectangular blocks about 5 in. by 7 in., and slightly more than 1 in. thick. This unit is overlain by 2 ft of medium-gray shale and 4 ft of brown weathered shale and alluvium.

Measured Section 61

NE¼NW¼NW¼NE¼ sec. 2, T27N, R19E, Craig County. Measured in highwall of strip pit (Danita Mine 1) operated by Design Service, by LeRoy A. Hemish. Field notebook designation CN-89-78-H. (Estimated elevation at top of section, 870 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown, silty, organic (regolith)	1.0
CABANISS GROUP	
Senora Formation:	
Limestone, gray, buff to brown on weathered surfaces, massive, dense, hard, fossiliferous	2.8
Shale, gray with minute white veins, calcareous, partly weathered	4.0
Shale, black, carbonaceous	0.5
Shale, light-gray; includes a few light-gray, oblate limestone concretions about 0.5 to 2.0 ft in diameter	42.0
Coal, black, shiny, hard (Croweburg)	1.2
Shale, gray, hard	1.0
Total	52.5

Measured Section 62

SW¼NE¼NE¼SE¼ sec. 2, T27N, R19E, Craig County. Measured in highwall of strip pit operated by Russell Creek Coal Co., by LeRoy A. Hemish. Field notebook designation CN-90-78-H. (Estimated elevation at top of section, 857 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown (regolith)	3.0
CABANISS GROUP	
Senora Formation:	
Shale, brown to yellow-brown, weathered	14.0
Shale, light-gray; includes a few oblate limestone concretions as much as 2 ft in diameter	10.0
Coal, black, shiny, hard; some white calcite on cleat surfaces (Croweburg)	1.3
Underclay, dark-gray; abundant black carbonized plant fragments included	0.7
Total	29.0

Measured Section 63

NE¼NW¼SW¼SW¼ sec. 10, T27N, R19E, Craig County. Measured a short distance southwest of large stockpond retention dam, in side of cut eroded by overflowing water, by LeRoy A. Hemish. Field notebook designation CN-22-78-H. (Estimated elevation at top of section, 882 ft.)

	Thickness (ft)
Spoils from nearby abandoned strip pit	1.9
CABANISS GROUP	
Senora Formation:	
Limestone, dark-gray-brown with yellow-brown weathered areas; impure, shaly, highly fossiliferous; includes small coal fragments	0.1
Coal, black with reddish-orange, iron-oxide-stained cleat surfaces (Iron Post)	1.0
Sandstone, light-buff with black and dark-reddish-brown streaks, very fine- to fine-grained; bedding is contorted and irregular; carbonized plant fragments abundant, including root casts as much as 2 in. in diameter	1.0
Limestone, gray, very sandy; highly fossiliferous, with brachiopods and pelecypods predominant; occurs as irregular, discontinuous masses and slabs from 1 in. to 18 in. thick, protruding into both the overlying and underlying strata	1.4
Sandstone, brown, fine-grained, thin-bedded, highly calcareous, micaceous; calcite-cemented concretions from ½ in. to 2 in. in diameter, and brachiopod casts, abundant	1.0

Shale, light-gray, with dark-reddish-brown iron-oxide staining on bedding planes and joint surfaces. Thin (½ to 1 in.), light-gray, fine-grained, micaceous sandstone stringers occur about 1 in. from top of unit	2.6
Total	9.0

Measured Section 64

SW¼SW¼NW¼SW¼ sec. 11, T27N, R19E, Craig County. Measured in highwall of strip pit operated by Russell Creek Coal Co., by LeRoy A. Hemish. Field notebook designation CN-91-78-H. (Estimated elevation at top of section, 920 ft.)

	Thickness (ft)
Undifferentiated:	
Clay and broken limestone, orange-brown (regolith)	6.0
CABANISS GROUP	
Senora Formation:	
Limestone, gray-brown, weathers yellow, highly fossiliferous, dense, silty	8.0
Shale, gray-brown, weathered; poorly exposed	4.0
Coal, black, stained reddish-brown, soft, weathered (Iron Post)	1.1
Sandstone, orange-brown, micaceous, fine-grained, massive to thin-bedded and shaly near base of unit	2.6
Siltstone, light-yellow-gray, shaly, micaceous, laminated, weathered	2.5
Shale, yellow-gray with purple-black manganese staining on fracture surfaces, silty, micaceous; interlaminated with silt stringers	2.8
Coal, black with reddish-brown and orange iron-oxide staining on cleat surfaces (Bevier)	0.8
Underclay, light-gray with orange mottling	0.2
Sandstone, light-gray and dark-gray, laminated, highly micaceous; much macerated carbonized plant material on stratification planes; very fine-grained, silty	15.0
Shale, dark-gray, silty; includes abundant small, brownish-gray, oblate limestone concretions	5.0
Limestone, gray-brown, fossiliferous, dense, hard, massive	3.0
Shale, gray, calcareous	0.7
Shale, black, slaty, highly carbonaceous	0.8
Siltstone, light-gray, shaly, laminated; grades into underlying unit	2.5
Shale, light-gray; contains a few zones of light-gray, oblate limestone concretions locally	20.0
Total	75.0

Note: Croweburg coal mined here approximately 10 ft below base of last described unit, but not exposed at time section was measured; however, data from nearby test hole indicate a coal thickness of 1.2 to 1.3 ft.

Measured Section 65

NE¼SE¼NW¼NE¼ sec. 14, T27N, R19E, Craig County. Measured in highwall of strip pit operated by Tri-Con Ltd., by LeRoy A. Hemish. Field notebook designation CN-21-78-H. (Estimated elevation at top of section, 795 ft.)

	Thickness (ft)
Undifferentiated:	
Silt, brown, clayey, sandy (alluvium associated with Middle Fork, Big Cabin Creek)	5.0
CABANISS GROUP	
Senora Formation:	
Limestone, dark-gray, dense, hard, fossiliferous	1.5
Coal, black with reddish-brown iron-oxide staining on cleat surfaces; somewhat weathered (Mineral)	0.9
Underclay, gray; base not exposed	0.5
Total	7.9

Measured Section 66

SW¼NW¼NE¼ sec. 21, T27N, R19E, Craig County. Measured in highwall of strip pit operated by URCO ENERGY, Inc., by LeRoy A. Hemish. Field notebook designation CN-12-78-H. (Estimated elevation at top of section, 868 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, orange-brown, oxidized (regolith)	4.0
CABANISS GROUP	
Senora Formation:	
Limestone, yellow-brown, weathered, hard, fossiliferous	2.8
Shale, black, highly carbonaceous; contains abundant, small, black phosphatic nodules	3.2
Shale, silty, tannish-gray, blocky fracture	5.0
Shale, light-gray; locally includes orange-tan limestone concretions and large lenses of limestone several feet in length	12.4
Siltstone, light-gray, cross-laminated	5.6
Shale, light-gray; includes hard limestone concretionary zones about 2 in. thick near top of unit	12.0
Coal, black, hard, shiny (Croweburg)	1.3
Underclay, dark-brown	0.6
Total	46.9

Measured Section 67

NW¼NW¼NW¼NW¼ sec. 25, T27N, R19E, Craig County. Measured in road cut and along east bank of Big Cabin Creek, south of bridge, by LeRoy A. Hemish. Field notebook designation CN-13-78-H. (Estimated elevation at top of section, 776 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Sandstone, dark-red-brown, ferruginous, fine-grained, thin- to medium-bedded, well-indurated	3.5
Shale, yellow-gray, silty	1.0
Covered, slumped material	11.0
Shale, grayish-tan	6.0
Shale, black, fissile	2.0
Limestone, dark-gray to black, weathers hematite red, highly fossiliferous, quite dense; hard and black in upper 2 in. where not weathered; pyritic in places	0.3
Clay, ironstone, black, very hard, dense, unbedded	0.3
Shale, black, carbonaceous, fissile; fractures into rectangular blocks	2.0
Coal, black (Tebo)	0.5
Underclay, gray	1.3
Total	27.9

Measured Section 68

SW¼SE¼NE¼ sec. 29, T27N, R19E, Craig County. Measured in highwall of strip pit operated by Tri-Con Ltd., by LeRoy A. Hemish. Field notebook designation CN-20-78-H. (Estimated elevation at top of section, 830 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown, overlain by dark-gray soil (regolith)	3.0
CABANISS GROUP	
Senora Formation:	
Shale, brown to brown-gray with reddish-brown staining along joint surfaces	6.0
Shale, light-gray; highly silty and laminated in bottom 8 ft; includes some light-brown-gray bands of clay-ironstone concretions about 2 in. thick near bottom of interval	21.0
Coal, black, bright; calcite on cleat surfaces (Croweburg)	1.0
Underclay, dark-gray; contains coal streaks and black coalified plant fragments; disseminated pyrite included.	0.2
Total	31.2

Measured Section 69

NE¼SE¼NE¼SE¼ sec. 15, T27N, R20E, Craig County. Measured in north creek bank, west side of road in pasture, by LeRoy A. Hemish. Field notebook designation CN-68-78-H. (Estimated elevation at top of section, 762 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown, silty; mottled with iron-oxide spots; brown and humus-bearing at the surface (regolith)	2.5
KREBS GROUP	
Savanna Formation:	
Shale, light-gray, weathered; mottled with reddish-brown iron-oxide spots.	2.0
Shale, black; partly weathered; stained with iron-oxide	1.0
Coal, black, soft, weathered (Rowe).	0.2
Underclay, light-gray; contains black carbonized plant fragments	1.3
Shale, gray; locally includes a 0.2-ft stringer of very fine-grained sandstone.	4.0
Total	11.0

Measured Section 70

NE¼NW¼NW¼ sec. 25, T27N, R20E, Craig County. Measured near top of hill in road cut on south side of State Highway 25, by LeRoy A. Hemish. Field notebook designation CN-1-78-H. (Estimated elevation at top of section, 905 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Covered to top of hill	5.0
Conglomerate, reddish-brown, iron-oxide cemented; contains coal fragments, pebbles derived from clay-ironstone concretions, and angular and rounded chert and shale pebbles, mixed	2.0
Coal, black, weathered (Weir-Pittsburg)	0.9
KREBS GROUP	
Boggy Formation:	
Underclay, light-orange-tan; abundant plant fragments included	0.6
Underclay, light-gray, plastic; black plant fragments included	2.0
Sandstone, buff, micaceous, very fine-grained, silty	4.0
Sandstone, buff, micaceous, very fine-grained, base not exposed	2.5
Total	17.0

Measured Section 71

NE¼SW¼SW¼ sec. 25, T27N, R20E, Craig County. Measured in wall of abandoned strip pit, by LeRoy A. Hemish. Field notebook designation CN-2-78-H. (Estimated elevation at top of section, 925 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, silty and clayey, reddish-brown, unconsolidated (regolith)	2.0
CABANISS GROUP	
Senora Formation:	
Sandstone, buff with reddish iron-oxide staining, medium-grained; interbedded with light-gray, laminated silt and shale	4.0
Shale, silty, light-tannish-gray with some light-reddish-brown and black staining; interlaminated with fine-grained sandstone	1.0
Sandstone, pinkish-tan, medium-grained, massive; contains scattered oblate iron-oxide concretions about ½ to 1 in. in diameter and ¼ in. thick	0.7
Shale and fine-grained sandstone, interbedded, light-gray to orange-tan; contains abundant iron-oxide concretions and some coaly streaks and fragments; in places, shell-shaped, white-weathering inclusions occur, leaving rounded cavities where missing. These features, and limonite concretions, give the unit a conglomeratic appearance	0.8
Coal, black; stained orange and red on weathered fracture planes (Weir-Pittsburg)	0.7
KREBS GROUP	
Boggy Formation:	
Underclay, light-gray with reddish staining on fracture planes; carbonized plant fragments included	0.8
Shale, silty; light-gray with red-orange staining	17.0
Total	27.0

Note: Bluejacket coal mined here; base of shale unit described above and coal seam now concealed by water in bottom of pit.

Measured Section 72

SE¼NW¼NW¼SW¼ sec. 26, T27N, R20E, Craig County. Measured in adit of small, abandoned drift mine on southwest side of stream flowing northwest from Timber Hill area, by LeRoy A. Hemish. Field notebook designation CN-19-78-H. (Estimated elevation at top of section, 845 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, brown, organic material included; boulder-size clasts of sandstone litter the surface (regolith)	4.0

KREBS GROUP

Boggy Formation:

Sandstone, brown to orange-brown; reddish-brown iron-oxide concretions included; fine- to medium-grained, noncalcareous, thick- to thin-bedded in bottom 4 in.	3.0

Savanna Formation:

Coal, black, weathered (Drywood)	2.8
Underclay, brown-gray	0.2
Total	10.0

Measured Section 73

SE¼NW¼SE¼SE¼ sec. 27, T27N, R20E, Craig County. Measured in slope of hill on east side of State Highway 2 where road curves northeast around Timber Hill, by LeRoy A. Hemish. Field notebook designation CN-3-78-H. (Estimated elevation at top of section, 845 ft.)

KREBS GROUP

Boggy Formation:

	Thickness (ft)
Sandstone, reddish-brown, medium-grained, mostly massive; some black carbonaceous streaks and thin coal laminae included locally.	2.0

Savanna Formation:

Silt, sandy, and clayey, light-gray to orange-gray, unconsolidated and powdery; thin coal laminae and some iron-oxide concretions and layers included	0.2
Coal, black, contains closely spaced fractures (Drywood)	1.3
Underclay, light-gray with orange iron-oxide staining, very silty; abundant plant fragments included; base not exposed	0.7
Total	4.2

Measured Section 74

SW¼NE¼SE¼ & NE¼SW¼SE¼ sec. 14, T27N, R21E, Craig County. Measured from top of hill downslope to the southwest through small, abandoned strip pit, by LeRoy A. Hemish. Field notebook designation CN-77-78-H. (Estimated elevation at top of section, 890 ft.)

KREBS GROUP

Boggy Formation:

	Thickness (ft)
Sandstone, reddish- to light-brown, ferruginous, micaceous, fine-grained; poorly exposed	1.0

Covered interval, grassy slope; probably sandstone and shaly sandstone	37.0
Sandstone, buff to reddish-orange, ferruginous, highly micaceous, fine-grained, thin-bedded; cemented in part by iron-oxide	1.0

Savanna Formation:

Shale, light-gray with orange streaks and spots, weathered	1.8
Coal, black with reddish-brown staining, weathered (Drywood)	0.7
Underclay, light-gray with orange mottling; contains abundant, black carbonized fossil roots	1.5
Shale, light-gray and orange, weathered	6.0
Shale, black	2.5
Covered interval	1.5
Sandstone, reddish-brown, ferruginous, fine-grained, well-sorted, medium-bedded	10.0
Total	63.0

Measured Section 75

NW¼NW¼NW¼NE¼ sec. 30, T27N, R21E, Craig County. Measured in road cut, south side of Highway 25, by LeRoy A. Hemish. Field notebook designation CN-76-78-H. (Estimated elevation at top of section, 827 ft.)

	Thickness (ft)
Undifferentiated:	
Silt, brown, organic (regolith)	1.0
KREBS GROUP	
Savanna Formation:	
Sandstone, buff, micaceous, very fine-grained, well-sorted, thin- to thick-bedded; red to reddish-brown and ferruginous in part	2.5
Shale, brown to gray-brown, very silty, micaceous; interlaminated in part with very fine-grained sandstone; abundant, black carbonized plant fragments on stratification surfaces	6.0
Shale, dark-gray	2.5
Shale, black	3.0
Limestone, very dark-gray to black, dense, hard, fossiliferous; weathers to reddish-brown and orange clay-ironstone	0.9
Shale, olive-brown, clayey; includes abundant brachiopod fossils	1.0
Shale, black and reddish-orange, banded, brittle; carbonaceous in part	0.5
Coal, black with reddish-orange iron-oxide staining on cleat surfaces (Rowe)	0.3
Underclay, light-gray with orange staining; includes small, hard, irregularly-shaped masses of iron-oxide	1.3
Shale, gray with much reddish-orange iron-oxide staining; base not exposed	5.0
Total	24.0

Measured Section 76

SE¼SE¼SW¼ sec. 31, T27N, R21E, Craig County. Measured from sandstone outcrop east of small stream, to exposure in pasture about 100 yd southwest of stock pond, by LeRoy A. Hemish. Field notebook designation CN-95-78-H. (Estimated elevation at top of section, 810 ft.)

	Thickness (ft)
KREBS GROUP	
Savanna Formation:	
Sandstone, buff with reddish-brown iron-oxide staining, very fine-grained, micaceous, thin-bedded, well-indurated	2.0
Shale, gray-brown (poorly exposed)	8.0
Coal, black, weathered (Rowe)	0.8
Underclay, light-gray with orange staining	0.7
Total	11.5

Measured Section 77

NW¼NE¼SW¼SE¼ sec. 1, T28N, R20E, Craig County. Measured in highwall of strip pit operated by Russell Creek Coal Co., by LeRoy A. Hemish. Field notebook designation CN-88-78-H. (Estimated elevation at top of section, 886 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown, silty, organic (regolith)	3.0
CABANISS GROUP	
Senora Formation:	
Shale, purple-gray with reddish-brown vertical streaks along joint surfaces; very highly weathered	11.0
Shale, light-gray with orange banding, partly weathered; includes a few scattered, small, ironstone concretions	7.5
Limestone, dark-purplish-gray, massive, dense, very hard	2.1
Coal, black, hard; calcite and pyrite coating on cleat surfaces (Mineral)	1.2
Underclay, medium-gray, silty and sandy; black carbonized plant fragments abundant	0.2
Total	25.0

Measured Section 78

SE¼SW¼SW¼NE¼ sec. 1, T28N, R20E, Craig County. Measured in highwall of strip pit operated by Russell Creek Coal Co., by LeRoy A. Hemish. Field notebook designation CN-96-78-H. (Estimated elevation at top of section, 890 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, silty, brown, organic (regolith)	2.5

CABANISS GROUP

Senora Formation:

Shale, purple-gray with reddish-brown vertical streaks along joint surfaces; highly weathered	13.0
Shale, light-gray with orange banding, partly weathered; includes a few small, reddish-brown ironstone concretions	9.5
Limestone, dark-purplish-gray, massive, dense, very hard	1.9
Coal, black, hard; calcite and pyrite on cleat surfaces (Mineral)	1.2
Underclay, medium-gray, silty and sandy; black carbonized plant fragments abundant	0.2
Total	28.3

Measured Section 79

SE¼NE¼NW¼ sec. 1, T28N, R20E, Craig County. Measured in highwall of strip pit operated by Russell Creek Coal Co., by LeRoy A. Hemish. Field notebook designation CN-4-78-H. (Estimated elevation at top of section, 930 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, silty, orange-brown (regolith)	2.0

CABANISS GROUP

Senora Formation:

Limestone, medium-gray, weathering brown; hard, dense, fossiliferous	2.5
Shale, light-gray to reddish-brown, fissile, clayey, fossiliferous, weathered.	2.5
Shale, black; stained reddish-brown on stratification planes and joints; includes abundant, small black phosphatic nodules as much as 2 in. in diameter.	2.0
Shale, light-gray with some reddish-brown iron-oxide staining, fissile	8.5
Coal, black (Croweburg)	1.1
Underclay, gray	1.4
Total	20.0

Note: Fleming coal was mined here, about 10 ft below the Croweburg coal, but was not exposed at time section was measured; Russell Creek Coal Co. reported a thickness of 1.5 ft for the Fleming coal.

Measured Section 80

NW¼SW¼NE¼NW¼ sec. 1, T28N, R20E, Craig County. Measured in highwall of strip pit operated by Russell Creek Coal Co., about 300 yd northwest and downslope from measured section 79, by LeRoy A. Hemish. Field notebook designation CN-5-78-H. (Estimated elevation at top of section, 911 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, silty, orange-brown (regolith; unknown thickness of overlying soil, removed prior to mining)	1.0
CABANISS GROUP	
Senora Formation:	
Shale, medium-gray, fissile; partially weathered to reddish-brown and orange; includes numerous clay-ironstone concretions and concretionary bands about 1 ft apart vertically	8.0
Shale, black, fissile; includes reddish-brown clay-ironstone concretions and bands (as above), but about 1.5 ft apart vertically	4.5
Limestone, black, occurs in rounded lenses, 10 to 18 in. thick, surrounded by black shale	3.5
Shale, medium-gray with light-tan-gray bands	4.0
Coal, black, very hard; contains scattered pyrite veins and nodules, and white calcite on cleat surfaces (Fleming)	1.3
Shale, light-gray; stained brown to reddish-brown	20.7
Limestone, dark-gray, hard, dense, fossiliferous	3.0
Coal, black, hard (Mineral)	1.3
Underclay, light-gray	0.7
Total	48.0

Measured Section 81

NE¼NW¼NE¼NW¼ sec. 3, T28N, R20E, Craig County. Measured in highwall of strip pit operated by Leon's Coal Co., by LeRoy A. Hemish. Field notebook designation CN-16-78-H. (Estimated elevation at top of section, 878 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown, highly oxidized (regolith)	4.0
CABANISS GROUP	
Senora Formation:	
Shale, brown, weathered; includes a 6-in. zone of reddish-brown, hard, rounded pods of clay-ironstone	8.0
Shale, black, hard, jointed. Within 50 ft laterally, a 2.5-ft, very dark-gray, dense, massive, fossiliferous limestone occurs at the base of this unit, directly above the underlying coal seam	8.1
Coal, black, hard (Mineral)	1.4
Underclay, dark gray; includes coalified plant fragments	0.6
Total	22.1

Measured Section 82

NW¼NW¼SE¼SW¼ sec. 12, T28N, R20E, Craig County. Measured in highwall of strip pit operated by Leon's Coal Co., by LeRoy A. Hemish. Field notebook designation CN-15-78-H. (Estimated elevation at top of section, 870 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown (regolith)	2.0
CABANISS GROUP	
Senora Formation:	
Shale, light-tannish-gray with orange bands	3.0
Coal, black, weathered (Fleming)	1.7
Shale, light-gray with streaks of orange iron-oxide staining	6.3
Shale, medium- to dark-gray, hard. At the contact with the underlying coal seam, a thin (about 1 in.) layer of hard, carbonaceous, black shale is present which contains numerous white flecks of calcite. Coal fragments are included in this layer in places. Within 200 yd laterally, a 2.5-ft black, fossiliferous limestone occurs at the base of this unit, directly above the underlying coal seam	12.0
Coal, black, hard (Mineral)	1.5
Underclay, light-gray	0.4
Total	26.9

Measured Section 83

SE¼SE¼SW¼SW¼ sec. 12, T28N, R20E, Craig County. Measured in highwall of strip pit operated by Leon's Coal Co., by LeRoy A. Hemish. Field notebook designation CN-14-78-H. (Estimated elevation at top of section, 874 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown (regolith)	3.0
CABANISS GROUP	
Senora Formation:	
Shale, yellow-gray-brown with some orange banding; weathered	6.0
Coal, black, weathered (Fleming)	1.1
Shale, black, highly carbonaceous, fissile	0.9
Shale, gray; base not exposed	4.5
Total	15.5

Measured Section 84

SE¼SW¼SW¼NW¼ sec. 15, T28N, R20E, Craig County. Measured in bank of Wolfe Creek, due east of the west quarter corner of the section, by LeRoy A. Hemish. Field notebook designation CN-74-78-H. (Estimated elevation at top of section, 804 ft.)

	Thickness (ft)
Undifferentiated:	
Silt, dark-gray-brown (alluvium associated with Wolfe Creek)	3.0
CABANISS GROUP	
Senora Formation:	
Shale, gray and brown, weathered	4.0
Limestone, purple-black with reddish-brown ironstone rind, fossiliferous, hard	0.3
Shale, black, brittle; contains black phosphatic nodules	1.2
Coal, black with reddish-brown iron-oxide staining on cleat surfaces, weathered (Tebo).	0.6
Total	9.1

Measured Section 85

NW¼SE¼NE¼SE¼ sec. 16, T28N, R20E, Craig County. Measured in bank of Wolfe Creek, about 100 yd west of road, by LeRoy A. Hemish. Field notebook designation CN-75-78-H. (Estimated elevation at top of section, 800 ft.)

	Thickness (ft)
Undifferentiated:	
Silt, dark-gray (alluvium associated with Wolfe Creek)	3.0
CABANISS GROUP	
Senora Formation:	
Shale, light-brown to gray, weathered	2.5
Limestone, purple-black, fossiliferous, hard; ironstone in part	0.2
Shale, black, brittle; contains black phosphatic nodules	1.5
Coal, black, weathered; reddish-brown iron-oxide staining on cleat surfaces (Tebo)	0.7
Underclay, dark-gray with orange mottling; contains black carbonized fossil-plant fragments	1.1
Siltstone, light-gray, well-indurated, noncalcareous; cut by dikes of laminated, silty, dark-gray shale with vertical stratification that form a crisscross pattern (exposed in dry stream bed)	1.0
Shale, medium-gray; base not exposed	0.1
Total	10.1

Measured Section 86

NW¼NW¼SE¼NE¼ sec. 17, T28N, R20E, Craig County. Measured in highwall of strip pit operated by Bill's Coal Co., by LeRoy A. Hemish. Field notebook designation CN-41-78-H. (Estimated elevation at top of section, 820 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Shale, orange-brown, oxidized	8.0
Shale, medium-gray	12.0
Coal, black; calcite on cleat surfaces (Mineral)	1.5
Underclay, gray-brown	0.4
Total	21.9

Measured Section 87

SE¼SE¼SE¼SE¼ sec. 20, T28N, R20E, Craig County. Measured in highwall of abandoned strip pit, by LeRoy A. Hemish. Field notebook designation CN-97-78-H. (Estimated elevation at top of section, 885 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Limestone, yellow-brown, weathered, hard, fossiliferous	2.8
Shale, yellow-gray-brown, banded, weathered	1.0
Shale, black	0.7
Shale, light-gray; base not exposed	20.0
Total	24.5

Note: Croweburg coal mined here; coal seam now concealed by water in bottom of pit.

Measured Section 88

SE¼NW¼NE¼NW¼ sec. 31, T28N, R20E, Craig County. Measured in highwall of pit recently operated by Bill's Coal Co., by LeRoy A. Hemish. Field notebook designation CN-17-78-H. (Estimated elevation at top of section, 865 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown, weathered (regolith)	6.0

CABANISS GROUP

Senora Formation:

Shale, light-gray and orange-brown, banded	3.0
Limestone, purple-brown with yellow laminae; includes a 5-in. band of algal limestone and black, shaly limestone midway through the unit; abundant fossil tracks, trails, and burrows occur on the underside of slabs	1.0
Shale, light-brown-gray	3.0
Shale, black	0.8
Limestone, reddish-brown, algal	0.7
Shale, black, highly carbonaceous	0.3
Limestone, purple, fossiliferous	0.6
Shale, black, hard, fissile; base not exposed	5.5
Total	20.9

Note: Mineral coal was mined here; coal seam now concealed by slope wash, slump, and water in bottom of pit.

Measured Section 89

SE¼NW¼NW¼NW¼ sec. 31, T28N, R20E, Craig County. Measured in highwall of strip pit recently operated by Bill's Coal Co., by LeRoy A. Hemish. Field notebook designation CN-18-78-H. (Estimated elevation at top of section, 927 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown; overlain by dark-brown topsoil (regolith)	1.5
CABANISS GROUP	
Senora Formation:	
Shale, brown, oxidized	3.5
Shale, light-gray; 1-in. bands of clay-ironstone concretions occur about 1 ft apart vertically in bottom 10 ft of unit	22.0
Coal, black, bright (Croweburg)	1.3
Underclay, light-gray with purple tinge	0.6
Total	28.9

Note: Verdigris Limestone is present at top of highwall about 300 yd north of measured section, where exposed section is thicker.

Measured Section 90

NW¼NW¼SW¼ sec. 13, T29N, R20E, Craig County. Measured in small gully south of tributary of Russell Creek, near seepage spring, by LeRoy A. Hemish. Field notebook designation CN-79-78-H. (Estimated elevation at top of section, 814 ft.)

	Thickness (ft)
Disturbed ground, includes shale fragments as well as chunks of hard, fossiliferous, dark-gray limestone; probably spoils from old, abandoned, nearby strip pit	4.0

CABANISS GROUP

Senora Formation:

Coal, black, weathered (Mineral)	1.1
Shale, dark-gray and light-gray, laminated, silty	1.0
Shale, light-gray, silty	3.0
Total	9.1

Note: A few yards east of this exposure at a similar elevation, buff to reddish-brown, micaceous, very fine-grained sandstone crops out, and the coal is missing.

Measured Section 91

SW¼NW¼NW¼ sec. 20, T29N, R20E, Craig County. Measured from top of hill into shale pit, and downslope into abandoned coal strip pit, by LeRoy A. Hemish. Field notebook designation CN-10-78-H. (Estimated elevation at top of section, 895 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, orange-brown; surface littered with weathered slabs of limestone (regolith)	1.0
MARMATON GROUP	
Fort Scott Limestone:	
Limestone, light-yellowish-gray-brown, orange to tan on weathered surfaces, hard, dense, finely crystalline, highly fossiliferous; corals, brachiopods, and sections of crinoid columnals abundant (standing out on weather-etched surfaces)	2.0
CABANISS GROUP	
Senora Formation:	
Shale, black, fissile, hard and slaty; contains small, black, spherical and ovate phosphatic nodules; base not exposes	4.0
Covered interval, grassy slope, few trees	9.0
Limestone, light-gray, hard, dense, finely crystalline, highly fossiliferous; weathers to light-yellow-tan	1.0
Limestone, dark-gray to black, impure, shaly, fossiliferous, thin-bedded; splits easily into thin flagstones	0.8
Shale, clayey, light-gray-brown, fissile; soft when wet	6.2
Covered to water in bottom of pit	1.0
Total	25.0

Note: Iron Post coal mined here; seam concealed by water and slumped material.

Measured Section 92

SW¼SW¼NE¼NW¼ sec. 21, T29N, R20E, Craig County. Measured in highwall of strip pit operated by Custom Coal Company, by LeRoy A. Hemish. Field notebook designation CN-11-78-H. (Estimated elevation at top of section, 845 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, reddish-brown to orange-brown with light-gray streaks; root casts included (regolith)	2.0
CABANISS GROUP	
Senora Formation:	
Shale, black, fissile, highly carbonaceous; oxidized reddish-brown on bedding planes and fracture surfaces; includes abundant, small black phosphatic nodules	2.5
Shale, light- to medium-gray	6.0
Coal, black, shiny; includes rare pyrite nodules (surface of coal seam undulates by as much as 2 to 3 ft in area cleaned for mining) (Croweburg)	0.9
Underclay, light-gray	0.8
Total	12.2

Measured Section 93

SW¼NW¼NE¼NE¼ sec. 23. T29N, R20E, Craig County. Measured near top of bluff south of Russell Creek where ledge is formed by outcrops of Goldenrod Sandstone, by LeRoy A. Hemish. Field notebook designation CN-8-78-H. (Estimated elevation at top of section, 836 ft.)

	Thickness (ft)
CABANISS GROUP	
Senora Formation:	
Covered to top of hill	3.0
Sandstone, buff with some brown iron-oxide staining, fine- to medium-grained, massive	6.0
Sandstone, buff with orange iron-oxide bands and black coal laminae, thin-bedded, fine-grained (laterally along the outcrop this sandstone is conglomeratic and contains a coal seam 3 to 4 in. thick)	2.0
Coal, black (Mineral)	1.0
Underclay, gray	0.1
Total	12.1

Measured Section 94

NE¼NW¼SE¼SW¼ sec. 24, T29N, R20E, Craig County. Measured in north bank of Elm Creek to meander loop, due north of junkyard, by LeRoy A. Hemish. Field notebook designation CN-9-78-H. (Estimated elevation at top of section, 800 ft.)

CABANISS GROUP

Senora Formation:

Clay and shale, reddish-brown, weathered; contains some black, highly weathered coal streaks	2.0
Shale, silty, tan. Oblate silty and shaly concretions occur in lower 1½ ft, ranging in size from 2 in. to as much as 2 ft in diameter, and about 2 to 4 in. thick; interiors are light gray	3.0
Coal, black; seam undulates (Weir-Pittsburg)	0.3

KREBS GROUP

Boggy Formation:

Underclay, gray with golden-brown to rouge-red banding	1.7
Shale, clayey gray	4.0
Sandstone, buff, very fine-grained, micaceous, thin-bedded (to water level in creek)	1.0
Total	12.0

Note: About 300 yd downstream the sandstone is light-tan and at least 6 ft thick where exposed in the creek bank and stream bottom.

Measured Section 95

SW¼SW¼NE¼ sec. 34, T29N, R20E, Craig County. Measured in highwall of strip pit operated by Russell Creek Coal Co., by LeRoy A. Hemish. Field notebook designation CN-6-78-H. (Estimated elevation at top of section, 880 ft.)

	Thickness (ft)
Undifferentiated:	
Clay, brown, weathered (regolith)	2.0
CABANISS GROUP	
Senora Formation:	
Shale, tan to reddish-brown, weathered	18.0
Shale, black, fissile	6.0
Limestone, black, hard, dense, fossiliferous	1.5
Coal, black (Mineral)	1.1
Underclay, gray	0.5
Total	29.1

Measured Section 96

NE¼NE¼SW¼ sec. 34, T29N, R20E, Craig County. Measured in highwall of strip pit operated by Russell Creek Coal Co., by LeRoy A. Hemish. Field notebook designation CN-7-78-H. (Estimated elevation at top of section, 910 ft.)

	Thickness (ft)
Undifferentiated:	
Sand, silty and clayey, brown, unconsolidated (regolith)	2.0
CABANISS GROUP	
Senora Formation:	
Sandstone, orange-brown to purple-brown, medium-grained, highly oxidized, laminated, crossbedded	2.0
Sandstone, light-tan-gray; heavily mottled with light-reddish-brown iron-oxide specks; medium- to coarse-grained; crossbedded and laminated with thin coal streaks; black, coalified plant fragments abundant; conglomeratic in part, with coal pebbles and fragments derived from clay-ironstone concretions	2.0
Shale, black, blocky fracture; banded with orange iron-oxide staining; black phosphatic nodules common	2.5
Shale, light-gray	10.5
Coal, black, shiny (Croweburg)	1.0
Underclay, gray, with abundant, black plant fragments	0.5
Total	20.5

Measured Section 97

SW¼SE¼SW¼NW¼ sec. 19, T29N, R21E, Craig County. Measured in cutbank of Elm Creek, just northeast of abandoned farm site, by LeRoy A. Hemish. Field notebook designation CN-78-78-H. (Estimated elevation at top of section, 810 ft.)

	Thickness (ft)
Undifferentiated:	
Silt, light-brown, clayey (regolith)	2.5
CABANISS GROUP	
Senora Formation:	
Sandstone, light-gray to buff, micaceous, very fine-grained; occurs as discontinuous lenses	0.4
Shale, tan, silty, micaceous, weathered; locally includes 1- to 2-in. stringers of buff, very fine-grained sandstone	3.1
Shale, black, carbonaceous, flaky	0.4
Coal, black; thins to a 1-in. seam within a few ft laterally and pinches out locally (Weir-Pittsburg)	0.2

KREBS GROUP

Boggy Formation:

Shale, black with purple staining in places, carbonaceous; grades into underlying unit	1.4
Shale, light-gray with orange iron-oxide staining	1.8
Siltstone, light-gray, micaceous, shaly; base not exposed	1.2
Total	11.0

APPENDIX 3: Analyses of Coals

In Table A3-1, the analyses are grouped first by township and range, progressing from south to north and west to east, respectively. Within each township block, coal analyses are listed according to the age of the data report, from oldest to youngest. Coal beds are arranged alphabetically by name within the age group. Averages of the data from two or more analyses were computed only if (1) analyses were reported under identical conditions, such as "as-received basis" or "moisture-free basis"; and (2) analyses were done in the same laboratory.

Table A3-2 contains data from individual samples of coal collected and analyzed by OGS personnel. Listing of analyses is alphabetical, by names of coal beds. Location of sample sites can be obtained by referring to the map numbers (see footnote *a*, table 27). Analyses in Table A3-2 are included in averages in Table A3-1.

TABLE A3-1--AVERAGE ANALYSES OF COALS IN CRAIG AND NOWATA COUNTIES, OKLAHOMA

Township/Range	Coal bed and rank[a]	Sample condition[b]	Proximate analysis (%) Moisture[c]	Volatile matter	Fixed carbon	Ash	Sulfur (%)	Btu/lb	Free swelling index	Number of analyses (whole seam)	Data source[d]	Year reported
T25N, R17E	Iron Post	1	7.4	33.7	53.1	5.8	2.2	12,482	8.0	2	Company	1972
	--	2	N/A	36.4	57.3	6.3	2.4	13,480				
		3	N/A	38.8	61.2	N/A		14,386				
	Iron Post	1	9.7	35.9	49.9	4.5	1.9	11,946		2	OGS	1974
	hvCb	2	N/A	39.7	55.2	5.1	2.1	13,213				
		3	N/A	41.8	58.2	N/A		13,914				
	Croweburg	1	5.7	33.4	56.1	4.8	0.6	13,481	6.0	1	USBM	1977
	hvAb	2	N/A	35.4	59.5	5.1	0.6	14,302				
		3	N/A	37.3	62.7	N/A		15,064				
	Iron Post	1	2.8	42.4	49.5	5.3	3.3	13,800	9.0	2	USBM	1977
	hvAb	2	N/A	43.7	50.8	5.5	3.4	14,188				
		3	N/A	46.3	53.7	N/A		15,012				
	Iron Post	1	1.1	42.9	47.1	8.9	3.8	13,424	7.5	2	OGS	1977
	hvAb	2	N/A	43.4	47.6	9.0	3.9	13,576				
		3	N/A	47.7	52.3	N/A		14,926				
	Croweburg	1	2.9	35.0	57.1	5.0	0.5	13,593	2.0	2	OGS	1979
	hvAb	2	N/A	36.1	58.8	5.1	0.6	14,000				
		3	N/A	38.0	62.0	N/A		14,750				
	Iron Post	1	1.6	43.4	49.1	5.9	3.7	13,605	7.0	4	OGS	1979
	hvAb	2	N/A	44.1	49.9	6.0	3.8	13,825				
		3	N/A	46.9	53.1	N/A		14,703				
T25N, R18E	Iron Post	1	2.9	43.2	47.4	6.5	3.2	13,598	7.5	1	USBM	1977
	hvAb	2	N/A	44.5	48.8	6.7	3.3	14,002				
		3	N/A	47.7	52.3	N/A		15,006				
	Croweburg	1	4.0	34.5	56.7	4.8	0.7	13,489	2.0	3	OGS	1979
	hvAb	2	N/A	36.0	59.0	5.0	0.8	14,042				
		3	N/A	37.8	62.2	N/A		14,781				
	Iron Post	1	2.0	43.7	46.8	7.5	4.0	13,184	7.5	1	OGS	1979
	hvAb	2	N/A	44.6	47.8	7.6	4.1	13,448				
		3	N/A	48.3	51.7	N/A		14,556				
	Mineral	1	5.0	38.0	42.2	14.8	3.3	11,376	5.5	1	OGS	1979
	hvBb	2	N/A	40.0	44.4	15.6	3.5	11,979				
		3	N/A	47.4	52.6	N/A		14,195				
	Tebo	1	5.0	35.5	53.3	6.2	1.3	12,350	1.0	1	OGS	1979
	--	2	N/A	37.3	56.2	6.5	1.4	13,000				
		3	N/A	39.9	60.1	N/A		13,907				
T25N, R19E	Drywood	1	2.3	30.5	32.7	34.5	5.8	9,228		2	Company	1977
	--	2	N/A	31.2	33.4	35.3	5.9	9,445				
		3	N/A	48.3	51.7	N/A		14,788				
	Rowe	1	1.7	37.4	50.5	10.4	2.0	12,987	2	1	OGS	1979
	--	2	N/A	38.1	51.3	10.6	2.0	13,209				
		3	N/A	42.6	57.4	N/A		14,768				
	Weir-Pittsburg	1	1.8	39.6	48.7	9.9	6.2	12,736	6.5	2	OGS	1979
		2	N/A	40.3	49.7	10.0	6.3	12,973				
	hvAb	3	N/A	44.8	55.2	N/A		14,406				

Township/Range	Coal bed and rank[a]	Sample condition[b]	Proximate analysis (%) Moisture[c]	Volatile matter	Fixed carbon	Ash	Sulfur (%)	Btu/lb	Free swelling index	Number of analyses (whole seam)	Data source[d]	Year reported
T26N, R18E	Iron Post hvAb	1	4.4	44.3	46.0	5.3	3.5	13,416		2	OGS	1975
		2	N/A	46.3	48.1	5.6	3.7	14,056				
		3	N/A	49.0	51.0	N/A		14,882				
	Iron Post hvAb	1	3.1	43.6	47.5	5.8	3.8	13,663	8.0	2	USBM	1977
		2	N/A	45.0	49.1	5.9	3.9	14,101				
		3	N/A	47.9	52.1	N/A		14,986				
	Iron Post hvBb	1	3.5	40.5	47.1	8.9	2.9	12,700	5.0	3	OGS	1979
		2	N/A	41.8	48.8	9.4	3.0	13,142				
		3	N/A	46.0	54.0	N/A		14,479				
T26N, R19E	Drywood hvAb	1	3.7	38.4	47.2	10.7	6.9	12,615		2	Moose and Searle (1929, p. 18)	1929
		2	N/A	39.8	49.1	11.1	7.2	13,095				
		3	N/A	44.8	55.2	N/A		14,737				
	Weir-Pittsburg --	1	3.2	41.5	51.6	3.7	2.8	14,029	8	1	Company	1975
		2	N/A	42.8	53.3	3.9	2.9	14,488				
		3	N/A	44.5	55.5	N/A		15,068				
	Bevier --	1	2.3							2	Company	1977
		2	N/A	36.8	47.7	15.5	5.8	12,457				
	Croweburg --	1	5.7							3	Company	1977
		2	N/A	36.5	52.1	11.4	0.5	12,456				
	Drywood --	1	3.6							4	Company	1977
		2	N/A	39.0	49.6	11.4	5.0	13,326				
	Iron Post --	1	2.0						7	2	Company	1977
		2	N/A	44.3	45.8	9.9	3.8	13,428				
	Mineral --	1	2.0							3	Company	1977
		2	N/A	34.5	40.1	25.4	5.9	10,814				
	Weir-Pittsburg --	1	2.0						6.5	1	Company	1977
		2	N/A	32.4	46.2	21.4	6.0	11,596				
	Drywood hvAb	1	1.5	40.4	46.5	11.6	6.4	12,611		1	OGS	1979
		2	N/A	41.0	47.2	11.8	6.5	12,799				
		3	N/A	46.5	53.5	N/A		14,475				
	Tebo --	1	1.4	33.3	39.9	25.4	9.8	10,105	1.5	1	OGS	1979
		2	N/A	33.8	40.5	25.7	9.9	10,252				
		3	N/A	45.5	54.5	N/A		13,806				
	Weir-Pittsburg hvAb	1	1.7	37.9	47.9	12.5	4.1	12,597	7.0	2	OGS	1979
		2	N/A	38.6	48.7	12.7	4.2	12,810				
		3	N/A	44.2	55.8	N/A		14,592				
T26N, R20E	Drywood --	1	1.4						6.0	1	Company	1977
		2	N/A	35.5	46.2	18.3	10.4	12,010				
	Rowe --	1	2.0						7.0	2	Company	1977
		2	N/A	37.5	49.2	13.3	7.1	12,957				
T27N, R18E	Iron Post --	1	2.4							1	Company	1977
		2	N/A	40.0	50.3	9.7	5.3	13,265				
T27N, R19E	Croweburg --	1	5.3	30.7	57.8	6.2	0.5	13,295		2	Company	1977
	Iron Post --	1	4.3	38.2	48.4	9.1	2.7	12,712		3	Company	1977
	Mineral --	1	2.4	36.8	48.0	12.8	4.6	12,686		3	Company	1977
	Tebo --	1	1.8	36.9	49.0	12.3	4.2	13,018		1	Company	1977
	Weir-Pittsburg --	1	1.6	33.5	43.8	21.1	11.6	11,334		1	Company	1977
	Bevier --	1	1.7						6.5	15	Company	1977
		2	N/A	36.1	45.4	18.5	8.1	11,930				

Township/Range	Coal bed and rank[a]	Sample condition[b]	Proximate analysis (%) Moisture[c]	Volatile matter	Fixed carbon	Ash	Sulfur (%)	Btu/lb	Free swelling index	Number of analyses (whole seam)	Data source[d]	Year reported
	Croweburg	1	4.4						8.0	8	Company	1977
	--	2	N/A	32.5	60.6	6.9	0.6	13,786.				
	Fleming	1	2.3						9.0	4	Company	1977
	--	2	N/A	37.8	47.5	14.7	5.9	12,604				
	Iron Post	1	2.0						8.0	22	Company	1977
	--	2	N/A	41.5	47.5	11.0	3.8	13,266				
	Mineral	1	2.6						8.5	10	Company	1977
	--	2	N/A	37.4	52.0	10.6	3.9	13,373				
	Scammon	1	1.9						7.5	3	Company	1977
	--	2	N/A	34.8	42.9	22.3	5.1	11,433				
	Weir-Pittsburg	1	2.0						8.0	1	Company	1977
	--	2	N/A	39.0	50.0	11.0	4.7	13,283				
	Bevier	1	3.6	37.3	47.5	11.6	1.7	11,831	1.0	1	OGS	1979
	hvBb	2	N/A	38.7	49.2	12.1	1.8	12,278				
		3	N/A	44.0	56.0	N/A		13,962				
	Croweburg	1	3.6	32.4	56.8	7.2	0.5	13,025	2.0	6	OGS	1979
	hvAb	2	N/A	33.6	58.9	7.5	0.5	13,509				
		3	N/A	36.3	63.7	N/A		14,598				
	Mineral	1	3.2	34.6	53.1	9.1	1.2	12,496	1	1	OGS	1979
	hvBb	2	N/A	35.8	54.8	9.4	1.3	12,908				
		3	N/A	39.5	60.5	N/A		14,247				
T27N, R20E	Drywood	1	4.2	37.8	47.9	10.1	5.2	12,830		2	Moose and Searle (1929, p. 17)	1929
	hvAb	2	N/A	39.4	50.1	10.5	5.4	13,392				
		3	N/A	44.0	56.0	N/A		14,971				
	Bluejacket	1	2.6							1	Company	1977
	--	2	N/A	33.4	49.8	16.8	8.9	12,629				
	Weir-Pittsburg	1	2.7							1	Company	1977
	--	2	N/A	30.1	43.3	26.6	12.2	10,243				
	Unnamed coal in McAlester Fm.	1	3.5							1	Company	1977
	--	2	N/A	30.9	47.1	22.0	9.3	10,982				
	Weir-Pittsburg	1	3.2	35.2	45.3	16.3	6.9	11,728	8.0	1	Company	1978
	--	2	N/A	36.3	46.8	16.8	7.1	12,122				
		3	N/A	43.7	56.3	N/A		14,580				
T27N, R21E	Rowe	1	1.6	41.8	47.4	9.2	4.6	13,119	8.0	1	OGS	1979
	--	2	N/A	42.6	48.1	9.3	4.7	13,336				
		3	N/A	47.0	53.0	N/A		14,707				
T28N, R19E	Croweburg	1	4.6	31.7	54.2	9.5	0.4	12,556		1	OGS	1976
	hvBb	2	N/A	33.2	56.9	9.9	0.4	13,162				
		3	N/A	36.8	63.2	N/A		14,616				
						N/A		13,874				
	Bevier	1	1.8						5.5	8	Company	1977
	--	2	N/A	38.6	44.4	17.0	6.7	12,320				
	Croweburg	1	3.8						6.5	3	Company	1977
	--	2	N/A	34.3	54.5	11.2	1.9	13,072				
	Fleming	1	3.0						8.5	1	Company	1977
	--	2	N/A	35.0	48.5	16.5	8.0	12,216				
	Iron Post	1	2.2						7.5	12	Company	1977
	--	2	N/A	41.9	46.8	11.3	4.1	13,256				
	Mineral	1	2.4						8.5	2	Company	1977
	--	2	N/A	37.1	51.9	11.0	4.8	13,197				

Township/Range	Coal bed and rank[a]	Sample condition[b]	Proximate analysis (%) Moisture[c]	Volatile matter	Fixed carbon	Ash	Sulfur (%)	Btu/lb	Free swelling index	Number of analyses (whole seam)	Data source[d]	Year reported
T28N, R20E	Weir-Pittsburg hvBb	1	5.7	34.2	51.3	8.8	4.3	12,730		1	Moose anc Searle (1929, p. 18)	1929
		2	N/A	36.3	54.4	9.3	4.6	13,510				
		3	N/A	40.0	60.0	N/A		14,889				
	Mineral hvAb	1	3.9	36.6	46.5	13.0	4.7	12,396		3	OGS	1974
		2	N/A	38.3	48.4	13.5	4.9	12,899				
		3	N/A	44.2	55.8	N/A		14,916				
	Mineral hvBb	1	5.5	34.5	43.8	16.2	5.3	11,518		2	OGS	1975
		2	N/A	36.5	46.4	17.1	5.6	12,196				
		3	N/A	44.0	56.0	N/A		14,702				
	Fleming hvAb	1	1.6	39.7	46.9	11.8	3.4	12,958	8	1	OGS	1976
		2	N/A	40.4	47.6	12.0	3.4	13,169				
		3	N/A	45.9	54.1	N/A		14,965				
	Croweburg hvAb	1	2.9	37.1	51.6	8.4	3.2	13,383	7.0	1	USBM	1977
		2	N/A	38.2	53.1	8.7	3.3	13,786				
		3	N/A	41.9	58.1	N/A		15,093				
	Mineral hvAb	1	2.7	34.8	47.9	14.6	5.0	12,320	8.5	4	USBM	1977
		2	N/A	35.8	49.2	15.0	5.1	12,662				
		3	N/A	42.1	57.9	N/A		14,897				
	Croweburg hvAb	1	3.4	33.6	53.1	9.9	2.0	12,742	4.0	2	OGS	1979
		2	N/A	34.8	55.0	10.2	2.1	13,190				
		3	N/A	38.8	61.2	N/A		14,697				
	Fleming hvAb	1	1.6	40.2	48.5	9.7	5.2	13,091	7.5	1	OGS	1979
		2	N/A	40.9	49.2	9.9	5.3	13,300				
		3	N/A	45.4	54.6	N/A		14,760				
						N/A		14,497				
	Mineral hvAb	1	1.6	36.4	47.8	14.2	5.7	12,210	8.0	5	OGS	1979
		2	N/A	37.0	48.6	14.4	5.8	12,409				
		3	N/A	43.2	56.8	N/A		14,501				
T28N, R21E	Mineral --	1	2.2						8.0	1	Company	1977
		2	N/A	37.2	46.1	16.7	10.9	12,151				
T29N, R20E	Croweburg --	1	2.2							1	Company	1977
		2	N/A	39.4	50.4	110.2	3.4	13,546				
	Fleming --	1	1.8							1	Company	1977
		2	N/A	38.7	41.8	19.5	6.7	11,941				
	Mineral --	1	1.7						8.5	2	Company	1977
		2	N/A	40.8	45.5	13.7	6.2	12,905				
	Tebo --	1	2.3							1	Company	1977
		2	N/A	36.0	48.1	15.9	5.3	12,452				
	Croweburg hvAb	1	1.8	37.4	49.0	11.8	3.1	12,734	8	2	OGS	1979
		2	N/A	38.0	50.0	12.0	3.2	12,967				
		3	N/A	43.3	56.7	N/A		14,738				
Unknown	Undifferentiated --	1	4.6	37.5	47.7	10.2	5.6	12,750		7	Trumbull, J.V.A. (1957, p. 343)	Pre-1953
Unknown	Iron Post --	1	3.5	43.4	46.2	6.9	3.5	12,950		1	Janus, J.B. and Shirley, B.S. (1972, p. 8)	1972
Unknown	Mineral --	1	3.6							2	Janus, J.B. and Shirley, B.S. (1972, p. 8)	1972
		2	N/A	39.4	49.6	11.0	3.6	12,272				
Unknown	Croweburg --	1	5.8	29.3	61.7	3.2	0.5	13,695		1	Company	1977

(See footnotes on following page.)

Appendix 3

[a]hvAb, high-volatile A bituminous; hvBb, high-volatile B bituminous; hvCb, high-volatile C bituminous; --, not classified.

[b]1 = as received; 2 = moisture-free; 3 = moisture- and ash-free.

[c]N/A, not applicable.

[d]Company, coal company or other industry-related source; OGS, Oklahoma Geological Survey; USBM, United States Bureau of Mines; USGS, United States Geological Survey.

TABLE A3-2--ANALYSES OF COALS IN CRAIG AND NOWATA COUNTIES, OKLAHOMA
(Samples collected by Hemish and tested by Oklahoma Geological Survey Chemistry Laboratory.)

Sample number	Map number[a] (Pls. 1-4)	Coal bed and rank[b]	Sample condition[c]	Proximate analysis (%) Moisture	Volatile matter	Fixed carbon	Ash	Sulfur (%)	Btu/lb	Free swelling index	Year sampled	Type of sample site[d]
78C45H	64, Pl. 1	Bevier hvBb	1	3.6	37.3	47.5	11.6	1.7	11,831	1	1978	AcSM
			2	N/A	38.7	49.2	12.1	1.8	12,278			
			3	N/A	44.0	56.0	N/A		13,962			
78C3H	96, Pl. 2	Croweburg hvAb	1	2.5	36.9	50.1	10.5	3.2	12,813	7.5	1978	AcSM
			2	N/A	37.8	51.4	10.8	3.3	13,136			
			3	N/A	42.4	57.6	N/A		14,726			
78C4H	92, Pl. 2	Croweburg hvAb	1	1.1	38.0	47.9	13.0	3.0	12,655	8	1978	AcSM
			2	N/A	38.4	48.5	13.1	3.1	12,796			
			3	N/A	44.2	55.8	N/A		14,728			
78C5H	66, Pl. 2	Croweburg hvBb	1	4.1	32.5	56.6	6.8	0.5	13,010	2.5	1978	AcSM
			2	N/A	33.9	59.0	7.1	0.5	13,572			
			3	N/A	36.5	63.5	N/A		14,603			
78C8H	89, Pl. 2	Croweburg hvBb	1	4.9	31.3	58.5	5.3	0.6	13,222	1	1978	AcSM
			2	N/A	32.9	61.5	5.6	0.6	13,906			
			3	N/A	34.9	65.1	N/A		14,726			
78C9H	68, Pl. 2	Croweburg hvAb	1	3.3	32.7	55.2	8.8	0.5	12,781	1.5	1978	AcSM
			2	N/A	33.8	57.1	9.1	0.5	13,217			
			3	N/A	37.2	62.8	N/A		14,535			
78C20H	(no measured section)	Croweburg hvBb	1	3.2	32.1	57.7	7.0	0.58	12,849		1978	SP
			2	N/A	33.2	59.6	7.2	0.60	13,277			
			3	N/A	35.8	64.2	N/A		14,307			
78C23H	22, Pl. 2	Croweburg hvAb	1	2.7	34.1	57.8	5.4	0.50	13,590		1978	AcSM
			2	N/A	35.1	59.4	5.5	0.51	13,968			
			3	N/A	37.1	62.9	N/A		14,781			
78C27H	16, Pl. 2	Croweburg hvAb	1	3.1	36.0	56.4	4.5	0.6	13,597	2	1978	AcSM
			2	N/A	37.1	58.2	4.7	0.6	14,032			
			3	N/A	38.9	61.1	N/A		14,719			
78C28H	29, Pl. 2	Croweburg hvAb	1	3.1	34.3	58.1	4.5	0.5	13,709	2	1978	AcSM
			2	N/A	35.3	60.0	4.7	0.5	14,143			
			3	N/A	37.0	63.0	N/A		14,834			
78C30H	25, Pl. 2	Croweburg hvBb	1	4.2	35.8	54.4	5.6	0.9	13,200	2.5	1978	AcSM
			2	N/A	37.3	56.8	5.9	1.0	13,777			
			3	N/A	39.6	60.4	N/A		14,639			
78C43H	61, Pl. 2	Croweburg hvBb	1	3.4	32.7	56.8	7.1	0.5	12,988	1.5	1978	AcSM
			2	N/A	33.9	58.7	7.4	0.5	13,451			
			3	N/A	36.6	63.4	N/A		14,526			
78C44H	62, Pl. 2	Croweburg hvAb	1	4.3	31.1	56.3	8.3	0.6	12,902	1.5	1978	AcSM
			2	n/a	32.5	58.8	8.7	0.6	13,478			
			3	N/A	35.6	64.4	N/A		14,756			
78C16H Top 12 in. of 36-in. bed	51, Pl. 2	Drywood hvBb	1	1.5	37.8	41.7	19.0	11.4	10,879		1978	AcSM
			2	N/A	38.4	42.3	19.3	11.6	11,045			
		3	N/A	47.6	52.4	N/A	13,690					

Sample number	Map number[a] (Pls. 1-4)	Coal bed and rank[b]	Sample condition[c]	Proximate analysis (%) Moisture	Volatile matter	Fixed carbon	Ash	Sulfur (%)	Btu/lb	Free swelling index	Year sampled	Type of sample site[d]
78C17H	51, Pl. 2	Drywood	1	1.5	42.8	51.0	4.7	2.8	14,040		1978	AcSM
Middle		hvAb	2	N/A	43.5	51.7	4.8	2.8	14,255			
12 in. of			3	N/A	45.7	54.3	N/A		14,970			
36-in. bed												
78C18H	51, Pl. 2	Drywood	1	1.4	40.5	46.9	11.2	4.9	12,915		1978	AcSM
Bottom		hvAb	2	N/A	41.1	47.6	11.3	5.0	13,097			
12 in. of			3	N/A	46.3	53.7	N/A		14,766			
36-in. bed												
78C1H	80, Pl. 1	Fleming	1	1.6	40.2	48.5	9.7	5.2	13,091	7.5	1978	AcSM
		hvAb	2	N/A	40.9	49.2	9.9	5.3	13,300			
			3	N/A	45.4	54.6	N/A		14,760			
78C21H	18, Pl. 1	Iron Post	1	1.1	44.4	48.8	5.7	4.2	13,620		1978	AcSM
		hvAb	2	N/A	44.9	49.3	5.8	4.2	13,765			
			3	N/A	47.7	52.3	N/A		14,606			
78C22H	21, Pl. 1	Iron Post	1	1.9	43.4	50.2	4.5	3.8	13,671		1978	AcSM
		hvAb	2	N/A	44.2	51.2	4.6	3.9	13,934			
			3	N/A	46.3	53.7	N/A		14,606			
78C29H	24, Pl. 1	Iron Post	1	2.0	43.7	46.8	7.5	4.0	13,184	7.5	1978	AcSM
		hvAb	2	N/A	44.6	47.8	7.6	4.1	13,448			
			3	N/A	48.3	51.7	N/A		14,556			
78C33H	13, Pl. 1	Iron Post	1	1.5	42.3	49.5	6.7	3.2	13,593	7	1978	AcSM
		hvAb	2	N/A	42.9	50.3	6.8	3.3	13,796			
			3	N/A	46.0	54.0	N/A		14,795			
78C34H	46, Pl. 1	Iron Post	1	2.0	44.0	47.3	6.7	4.3	13,486	7.5	1978	AcSM
		hvAb	2	N/A	44.9	48.3	6.8	4.4	13,756			
			3	N/A	48.2	51.8	N/A		14,761			
78C35H	48, Pl. 1	Iron Post	1	1.9	45.4	46.8	5.9	3.7	13,571	6.5	1978	AcSM
		hvAb	2	N/A	46.3	47.7	6.0	3.8	13,836			
			3	N/A	49.3	50.7	N/A		14,724			
78C36H	45, Pl. 1	Iron Post	1	6.7	32.1	47.1	14.1	0.8	11,044	1	1978	AcSM
		hvCb	2	N/A	34.3	50.5	15.2	0.9	11,834			
			3	N/A	40.4	59.6	N/A		13,952			
78C41H	14, Pl. 1	Iron Post	1	1.9	43.7	47.8	6.6	3.5	13,537	7.5	1978	AcSM
		hvAb	2	N/A	44.5	48.7	6.8	3.6	13,805			
			3	N/A	47.7	52.3	N/A		14,806			
78C2H	80, Pl. 3	Mineral	1	1.4	36.9	49.4	12.3	7.0	12,438	8	1978	AcSM
		hvAb	2	N/A	37.4	50.1	12.5	7.1	12,608			
			3	N/A	42.7	57.3	N/A		14,414			
78C6H	82, Pl. 3	Mineral	1	1.9	35.9	47.7	14.5	6.1	12,054	7.5	1978	AcSM
		hvAb	2	N/A	36.6	48.6	14.8	6.2	12,282			
			3	N/A	43.0	57.0	N/A		14,414			
78C7H	81, Pl. 3	Mineral	1	1.4	35.9	49.2	13.5	4.4	12,587	8	1978	AcSM
		hvAb	2	N/A	36.5	49.8	13.7	4.5	12,770			
			3	N/A	42.3	57.7	N/A		14,801			
78C10H	65, Pl. 3	Mineral	1	3.2	34.6	53.1	9.1	1.2	12,496	1	1978	AcSM
		hvBb	2	N/A	35.8	54.8	9.4	1.3	12,908			
			3	N/A	39.5	60.5	N/A		14,247			
78C19H	86, PL. 3	Mineral	1	1.4	37.8	46.3	14.5	5.7	12,012		1978	AcSM
		hvAb	2	N/A	38.3	46.9	14.7	5.8	12,184			
			3	N/A	45.0	55.0	N/A		14,290			
78C24H	28, Pl. 3	Mineral	1	5.0	38.0	42.2	14.8	3.3	11,376	5.5	1978	AcSM
		hvBb	2	N/A	40.0	44.4	15.6	3.5	11,979			
			3	N/A	47.4	52.6	N/A		14,195			
78C42H	77, Pl. 3	Mineral	1	1.8	35.7	46.2	16.3	5.4	11,961	8	1978	AcSM
		hvAb	2	N/A	36.4	47.0	16.6	5.5	12,183			
			3	N/A	43.6	56.4	N/A		14,608			

Appendix 3

Sample number	Map number[a] (Pls. 1-4)	Coal bed and rank[b]	Sample condition[c]	Proximate analysis (%) Moisture	Volatile matter	Fixed carbon	Ash	Sulfur (%)	Btu/lb	Free swelling index	Year sampled	Type of sample site[d]
78C39H	75, Pl. 3	Rowe	1	1.6	41.8	47.4	9.2	4.6	13,119	8	1978	RC
		hvAb	2	N/A	42.6	48.1	9.3	4.7	13,336			
			3	N/A	47.0	53.0	N/A		14,707			
78C40H	43, Pl. 3	Rowe	1	1.7	37.4	50.5	10.4	2.0	12,987	2	1978	CB
		hvAb	2	N/A	38.1	51.3	10.6	2.0	13,209			
			3	N/A	42.6	57.4	N/A		14,768			
78C37H	58, Pl. 4	Tebo	1	1.4	33.3	39.9	25.4	9.8	10,105	1.5	1978	AbSM
		hvBb	2	N/A	33.8	40.5	25.7	9.9	10,252			
			3	N/A	45.5	54.5	N/A		13,806			
78C38H	30, Pl. 4	Tebo	1	5.0	35.5	53.3	6.2	1.3	12,350	1	1978	CB
		hvBb	2	N/A	37.3	56.2	6.5	1.4	13,000			
			3	N/A	39.9	60.1	N/A		13,907			
78C11H	(no measured section)	Weir-Pittsburg	1	1.2	35.5	45.7	17.6	5.3	11,880	6.5	1978	SP
			2	N/A	35.9	46.3	17.8	5.4	12,027			
		hvAb	3	N/A	43.7	56.3	N/A		14,639			
78C12H Upper 12 in. of 24-in. bed	54, Pl. 4	Weir-Pittsburg	1	2.2	42.7	51.0	4.1	2.3	13,936	7.5	1978	AbSM
			2	N/A	43.7	52.2	4.1	2.4	14,247			
		hvAb	3	N/A	45.6	54.4	N/A		14,565			
78C13H Lower 12 in. of 24-in. bed	54, Pl. 4	Weir-Pittsburg	1	2.0	38.0	49.3	10.7	3.3	12,690	7	1978	AbSM
			2	N/A	38.8	50.3	10.9	3.4	12,942			
		hvAb	3	N/A	43.5	56.5	N/A		14,525			
78C14H Upper 13 in. of 26-in. bed	35, Pl. 4	Weir-Pittsburg	1	2.3	37.7	48.5	11.5	6.3	12,263	6.5	1978	AcSM
			2	N/A	38.6	49.8	11.6	6.5	12,552			
		hvAb	3	N/A	43.7	56.3	N/A		14,204			
78C15H Lower 13 in. of 26-in. bed	35, Pl. 4	Weir-Pittsburg	1	1.8	37.8	48.1	12.3	8.0	12,156	7	1978	AcSM
			2	N/A	38.5	49.0	12.5	8.2	12,381			
		hvBb	3	N/A	44.0	56.0	N/A		14,151			
78C32H	31, Pl. 4	Weir-Pittsburg	1	1.6	41.5	49.1	7.8	5.1	13,261	6.5	1978	AcSM
			2	N/A	42.2	49.9	7.9	5.2	13,479			
		hvAb	3	N/A	45.8	54.2	N/A		14,635			

[a]Data point number on map corresponds to measured section number, Appendix 2, this report.

[b]hvAb, high-volatile A bituminous; hvBb, high-volatile B bituminous; hvCb, high-volatile C bituminous.

[c]1 = as received; 2 = moisture-free; 3 = moisture- and ash-free.

[d]AbSM, abandoned strip mine; AcSM, active strip mine; CB, cutbank of stream; RC, road cut; SP, stockpile.

APPENDIX 4: Cleat Orientations in Coals Sampled in Craig and Nowata Counties

Coal	Face Cleat	Butt Cleat	Degrees of Separation*	Location
Bevier	N. 55° W.	N. 35° E.	90	SW¼NW¼SW¼ sec. 11, T27N, R19E
	N. 65° W.	N. 6° E.	71	NW¼SW¼SE¼ sec. 36, T25N, R17E
	N. 62° W.	N. 38° E.	100	SW¼SW¼SE¼ sec. 26, T25N, R17E
	N. 75° W.	N. 16° E.	91	NW¼SE¼NW¼ sec. 35, T25N, R17E
	N. 82° W.	N. 4° E.	86	SE¼SW¼SW¼ sec. 11, T25N, R18E
	N. 42° W.	N. 41° E.	83	NE¼NE¼NW¼ sec. 30, T25N, R18E
Croweburg	N. 55° E.	N. 34° W.	89	SW¼NW¼NE¼ sec. 21, T27N, R19E
	N. 60° W.	N. 53° E.	113	SW¼SE¼NE¼ sec. 29, T27N, R19E
	N. 19° W.	N. 62° E.	81	NW¼NW¼NE¼ sec. 2, T27N, R19E
	N. 70° E.	N. 45° W.	115	NE¼NE¼SE¼ sec. 2, T27N, R19E
	N. 54° W.	N. 22° E.	76	SW¼NE¼NW¼ sec. 21, T29N, R20E
	N. 66° W.	N. 37° E.	103	NE¼NE¼SW¼ sec. 34, T29N, R20E
Drywood	N. 30° W.	N. 59° E.	89	SW¼NW¼SW¼ sec. 13, T26N, R19E
Fleming	N. 40° W.	N. 70° E.	110	SW¼NE¼NW¼ sec. 1, T28N, R20E
	N. 35° W.	N. 50° E.	85	NW¼SE¼SW¼ sec. 14, T25N, R17E
	N. 32° W.	N. 60° E.	92	NW¼SW¼NE¼ sec. 21, T25N, R17E
	N. 37° W.	N. 67° E.	104	NW¼SE¼SW¼ sec. 33, T25N, R17E
Iron Post	N. 58° W.	N. 52° E.	110	SE¼SW¼NE¼ sec. 35, T25N, R17E
	N. 25° W.	N. 66° E.	91	NE¼NE¼SE¼ sec. 10, T25N, R18E
	N. 45° W.	N. 40° E.	85	NW¼SW¼NW¼ sec. 20, T26N, R18E
	N. 50° W.	N. 38° E.	88	SW¼SE¼SE¼ sec. 22, T26N, R18E
	N. 40° W.	N. 46° E.	86	NW¼NE¼NE¼ sec. 35, T26N, R18E
	N. 32° W.	N. 56° E.	88	NE¼NW¼SE¼ sec. 14, T25N, R18E
	N. 62° W.	N. 50° E.	112	SE¼NW¼NE¼ sec. 14, T27N, R19E
	N. 52° W.	N. 60° E.	112	SW¼NW¼NE¼ sec. 1, T28N, R20E
Mineral	N. 40° W.	N. 44° E.	84	NE¼SW¼SE¼ sec. 1, T28N, R20E
	N. 46° W.	N. 51° E.	97	NW¼NE¼NW¼ sec. 3, T28N, R20E
	N. 46° E.	N. 40° W.	86	NW¼SE¼SW¼ sec. 12, T28N, R20E
	N. 43° W.	N. 50° E.	93	NW¼SE¼NE¼ sec. 17, T28N, R20E
	N. 43° W.	N. 31° E.	74	NE¼NW¼NW¼ sec. 28, T24N, R19E
Rowe	N. 51° W.	N. 46° E.	97	NE¼NE¼NE¼ sec. 14, T25N, R19E
	N. 13° W.	N. 85° E.	98	NW¼NW¼NE¼ sec. 30, T27N, R21E
Tebo	N. 44° W.	N. 38° E.	82	SW¼NW¼NW¼ sec. 36, T25N, R18E
	N. 30° W.	N. 58° E.	88	SE¼SW¼SE¼ sec. 31, T26N, R19E
	N. 59° W.	N. 20° E.	79	NW¼NW¼SW¼ sec. 27, T26N, R19E
Weir-Pittsburg	N. 51° W.	N. 44° E.	95	SW¼SW¼SE¼ sec. 4, T25N, R19E
	N. 49° W.	N. 52° E.	101	NW¼SW¼NE¼ sec. 9, T25N, R19E

*Separation is defined as the angular difference between the average face-cleat and butt-cleat directions. Ideal separation is 90°.

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Heads in 10- and 9-pt. Century Schoolbook
Figure captions in 8-pt. Helvetica, with 1-pt. leading
Plate descriptions in 8-pt. Century Schoolbook
Running heads in 9-pt. Century Schoolbook bold

Presswork: Miller 38-in. 2-color; covers on 23 by 29 Harris

Binding: Smyth sewn

Paper: Text on 70-lb. Patina
Covers: Softbound on 65-lb. Hammermill gray, antique finish