

COAL RESOURCES OF THE CRETACEOUS SYSTEM (DAKOTA FORMATION) IN CENTRAL KANSAS

By

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ABSTRACT

The Cretaceous lignite-bearing strata (in the Dakota formation) crop out in the north-central part of the State, chiefly in Clay, Cloud, Ellsworth, Hodgeman, Lincoln, Ottawa, Republic, Rice, Saline, and Washington Counties. Between 1875 and 1940 more than 300,000 tons of lignite valued at approximately \$1,000,000 were mined in Clay, Cloud, Ellsworth, Jewell, Lincoln, Mitchell, Republic, and Russell Counties. The lignite where mined ranged from 12 to 36 inches in thickness and occurred within the uppermost 25 feet of the Janssen clay, upper member of the Dakota formation. It is estimated that there are approximately 55,000,000 tons of lignite from 12 to 36 inches thick remaining in the ground and 198,000,000 tons if all types of reserves—marginal, measured, and alleged—are considered.

This report includes a description of the geographic distribution, stratigraphic position, thickness, contact rocks, and physical and chemical characters of the Dakota formation coals. It also contains information on the history of Cretaceous coal mining, mining methods, production, and coal reserve data. The report consists of two parts. The first part deals with the lignite in general, whereas the second discusses in detail the occurrence, mining, mining districts, production, and reserves in each of the 10 counties in which the lignite has been mined as well as its occurrence in several other counties.

The demonstrated value of lignite as a possible future source of synthetic gasoline and other liquid fuels places the Kansas lignite deposits as a potential coal reserve.

INTRODUCTION

Purpose of the investigation.—This report is the fifth in a series on Kansas coals started by the State Geological Survey in 1942 for the purpose of evaluating the occurrence, distribution, and commercial reserves of Kansas coal deposits. The possibility of using the State's coal to furnish petroleum and other hydrocarbon compounds as well as modern advances, experimental and actual, in coal technology, especially in the gasification of coal underground, make a knowledge of all our coal resources more than of passing interest. Recent experiments (Fieldner, Storch, and Hirst, 1944) indicate that lignites are especially amenable to liquefaction and hydrogenation; hence the Kansas lignite reserves may eventually prove to be a source of gasoline and other liquid fuels.

This report describes the coal resources of the Cretaceous rocks of central Kansas. Unlike the coal of eastern Kansas which is of bituminous rank and of Pennsylvanian age, the coal of central Kansas is lignite or brown coal and is Cretaceous in age.

The four earlier reports of this series on Kansas coal resources that have been published by the Geological Survey deal respectively with the coals of the Douglas (Bowsher and Jewett, 1943), Kansas City (Schoewe, 1944), and Wabaunsee (Schoewe, 1946) groups and with the Permian System (Schoewe, 1951). Two short reports on coals of the Cherokee group in southeastern Kansas were issued (Abernathy, 1944, 1946). A report dealing solely with the Kansas coal reserves (Abernathy, Jewett, and Schoewe, 1947) has also been published. Other reports dealing with Kansas coals are listed in the comprehensive bibliography by Schoewe (1944, pp. 133-136).

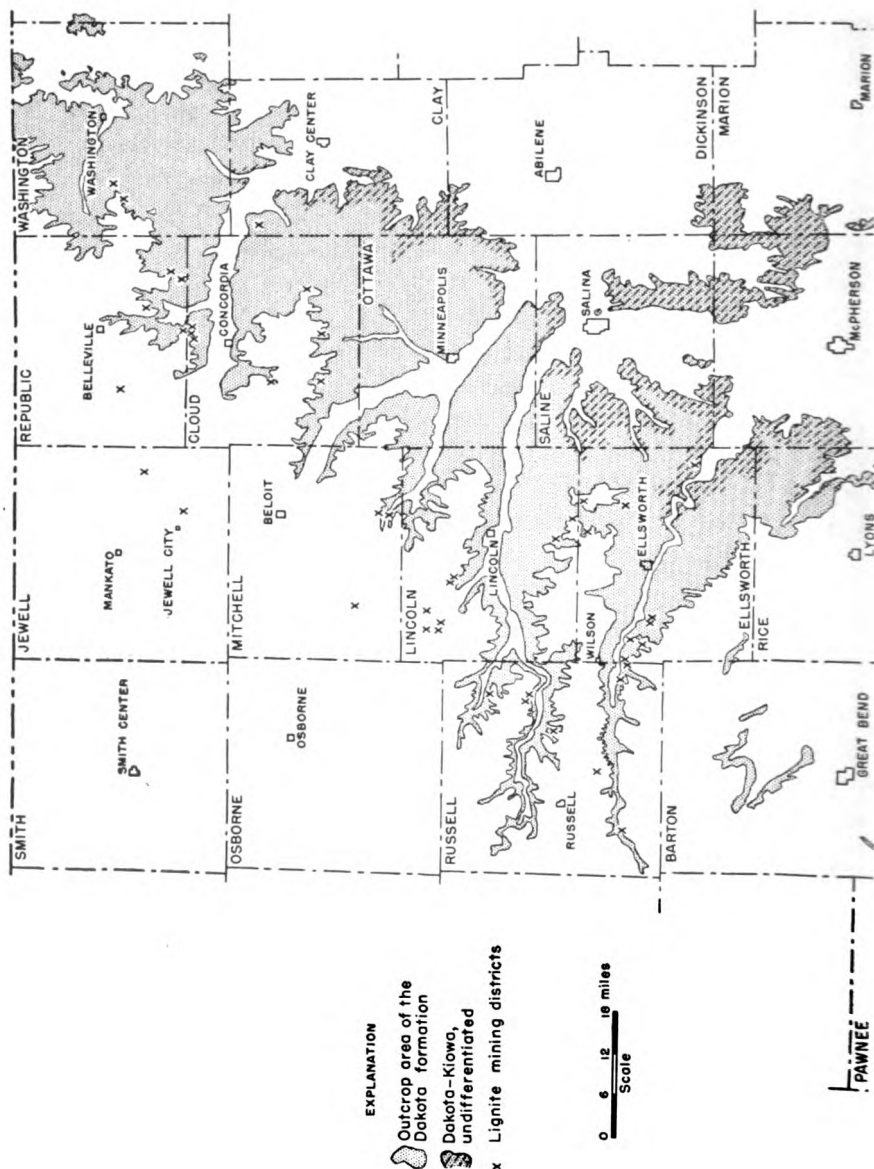
Previous work.—Relatively little detailed information has been published on the lignite deposits of Kansas. The reports are of a general nature and consist primarily of brief descriptions of thicknesses, depth below the surface, and general stratigraphic position, geographic distribution, physical character, location of mines, and production. Mudge (1866, p. 17) noted the occurrence of lignite in Republic County in 1864 and was perhaps the first to publish a short account of its thickness and general location in the county. Lignite was mined along Wilson Creek in Ellsworth County before 1870 (Saunders, 1896, p. 32; Anonymous, 1951, p. 209). By 1875 (Mudge, 1875, pp. 124-125) lignite was reported to occur in Barton, Cloud, Ellsworth, Lincoln, McPherson, Mitchell, Ottawa, Republic, Rice, Russell, Saline, and Washington Counties. Jewell County was added to the lignite counties in 1887 (Findley, 1888, p. 8; Hay, 1889, p. 6) and Barber County in the same year (Hay, 1889, p. 7; 1890, p. 27). According to Hay (1889, p. 6), black lignitic shale occurs in the upper part of the Dakota formation in Hodgeman and Hamilton Counties. In 1929 Moore (p. 4) reported the presence of lignite in Ford and Osborne Counties. The first published analysis of Kansas lignite appeared in 1873 and was made by Saunders (1873, pp. 387-389; 1896, pp. 32-33) from a mine sample obtained on Wilson Creek in Ellsworth County. Bailey (1889, p. 48) and Blake (1889, p. 46) made analyses of lignite from Cloud County in 1889.

The stratigraphic position of the lignite seams was first definitely established by Hay in 1887 (1889, pp. 6, 7) who placed the lignite horizon in the highest part or near the top of the Dakota although Mudge (Hay, 1885, p. 111) and St. John (1887, p. 143) had earlier suggested that the seams of lignite of the various

localities constituted one horizon. In 1897 Logan (pp. 208-209) described the Cretaceous deposits of Kansas and placed the lignite horizon immediately above the sandstones of his lower group and below the saliferous shale or upper group. Crane (1898, pp. 142-143) briefly describes the occurrences of lignite in Cloud, Ellsworth, Lincoln, Mitchell, Republic, and Russell Counties and cites Logan in regard to the stratigraphic position of the lignite horizon. The same account was republished by Crane in 1903. Others who have briefly commented on the lignite include Gould (1901, pp. 151-152), Charles (1901), Rubey and Bass (1925, p. 56), Wing (1930, pp. 43-44), and Landes (1930, pp. 53-54). The most recent general description of the Kansas lignite deposits is given by Whitla (1940) who briefly discusses the history of mining in the Cretaceous coal area (pp. 14-15), gives a general description of the Cretaceous coal (pp. 25-26), and presents data concerning the lignite deposits in Cloud (pp. 33-34), Ellsworth (pp. 37-39), Jewell (pp. 42-43), Lincoln (pp. 45-46), Mitchell (p. 52), Republic (p. 57), and Russell (pp. 57-58) Counties. Other references to the lignite deposits of lesser importance are those of Young and Allen (1925, pp. 37-38, 134), Moore and Landes (1927, p. 49), Twenhofel (1924, p. 34), Landes (1937, pp. 19, 63, 77), Plummer and Romary (1942, p. 328), Jewett and Schoewe (1942, p. 85), Moore, Frye, and Jewett (1944, p. 153), and Moore and others (1951, p. 25).

Statistical information on the Cretaceous lignites is given in the various reports of the Kansas coal and metal mine inspectors; Kansas State Board of Agriculture, Annual Reports 1 to 5 (1872-1876) and Biennial Reports 1 to 5 (1878-1886); U.S. Geological Survey, Mineral Resources of the United States, 1882 to 1923; U.S. Bureau of Mines, Minerals Yearbook, 1924 to 1940; and the University Geological Survey of Kansas annual bulletins on mineral resources of Kansas for 1897 to 1903.

Field and laboratory investigations.—The field work for this investigation was done chiefly during the summer months of 1947 to 1949. Effort was made to locate all outcrops of the lignite as well as the sites where the coal was mined. The stratigraphic position, occurrence, physical nature, and thickness of the lignite, the character of contact rocks, and the nature and thickness of overburden were studied in the field. All active and abandoned



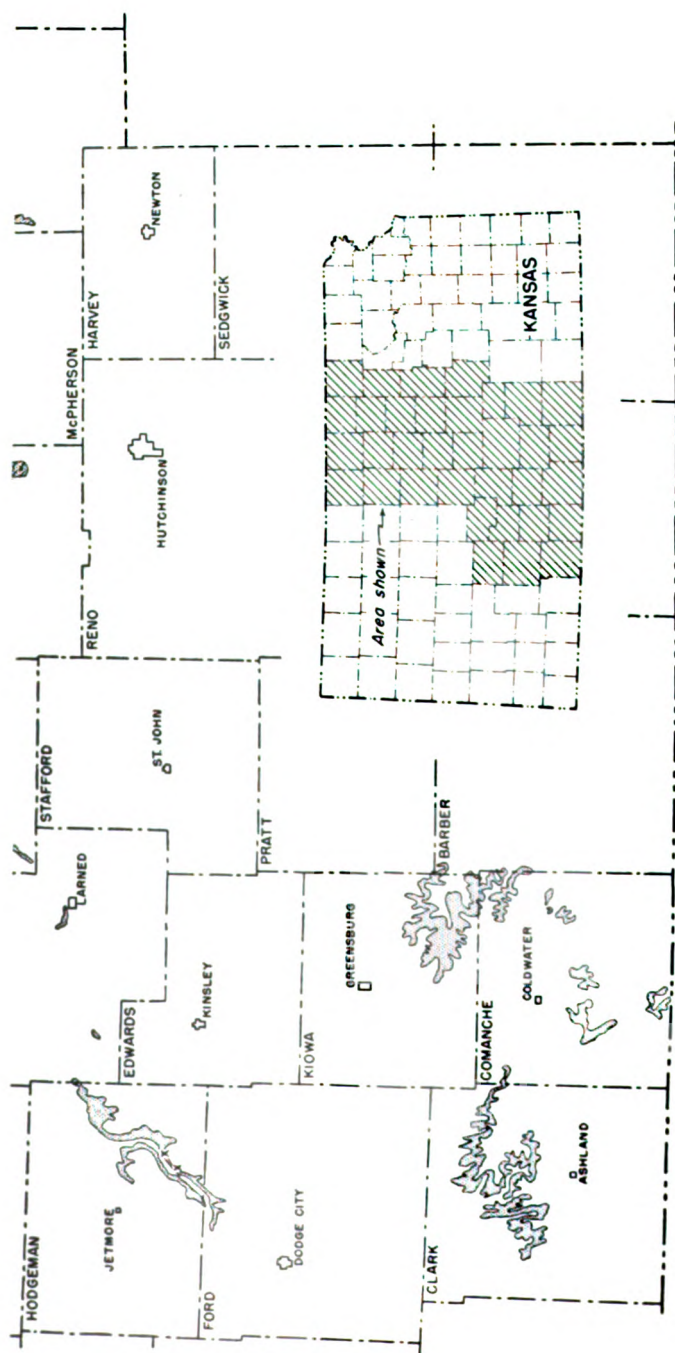
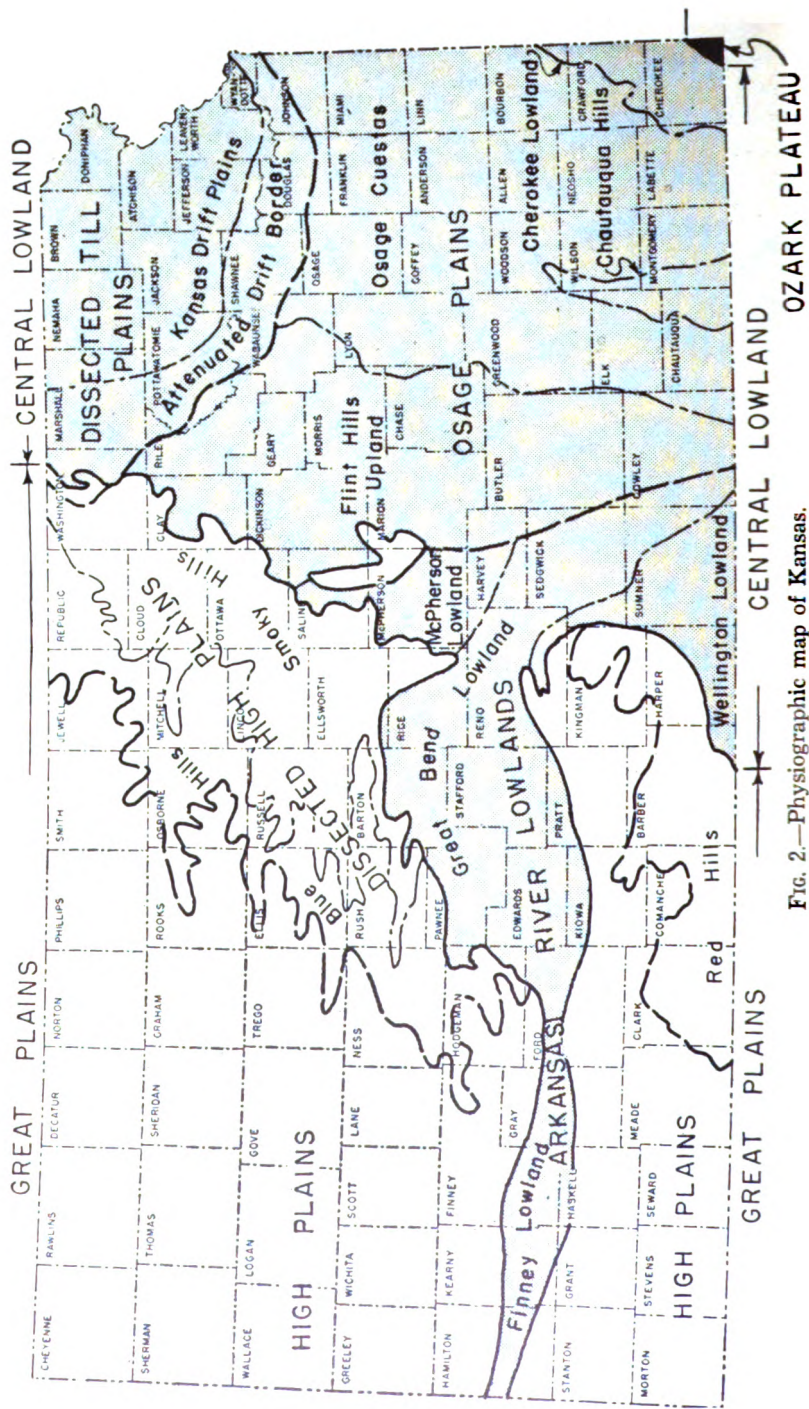


FIG. 1.—Map of central Kansas showing outcrop area of the Dakota formation and location of lignite mining districts.



mines were located on maps. Data concerning production, mines, mining methods, and history of mining were obtained from old settlers and miners living in the mining districts and from various State and Federal publications. Sixteen lignite samples were collected in the field. These samples were analyzed in the chemical laboratories of the State Geological Survey.

Acknowledgments.—In the course of the field work, many residents of the lignite-bearing counties supplied information concerning the locations of lignite mines, thicknesses of the coal, former mining operations, and other pertinent data relative to the lignite. I wish to express my appreciation to all these individuals who so graciously cooperated and rendered invaluable assistance. In this connection I am especially indebted to Dick Curtis of Concordia, Will Callahan of Aurora, Mr. La Barge of Aurora, Dave Walter of Dorrance, Emmet Cooper of Wilson, George Wade of Jetmore, Robert Spaulding of Lucas, J. D. Hayden of Ash Grove, Robert Boal of Clyde, W. W. Shoemaker of Bunker Hill, Henry Briand of Ellsworth, John McFarland of Hays, E. Palmer of Jewell, L. L. Burchinal of Formosa, and Mrs. Tom Shedden of Formosa. Albert Walker assisted in collecting the lignite samples; Norman Plummer, ceramist for the State Geological Survey, aided in matters pertaining to the stratigraphy of the Dakota formation, and Russell T. Runnels, chemist for the Survey, ran the proximate analyses of the lignite samples collected.

GEOGRAPHY OF THE CRETACEOUS LIGNITE-BEARING AREA

The Cretaceous lignite-bearing strata, the Dakota formation, crop out mainly in the north-central part of the State (Fig. 1). Physiographically the outcrop area of the coal-bearing formation constitutes the Smoky Hills of the dissected High Plains section of the Great Plains physiographic province (Fig. 2; Schoewe, 1949, fig. 22). The Dakota topography is in general that of a gently rolling to undulating dissected plain dotted with numerous outlying mounds or buttes; part of it, however, is characterized by flat-topped hills with steep slopes (Pl. 1). Terrace deposits, loess, glacial outwash, and till modify the Dakota topography at places and elsewhere, especially near Minneapolis in Ottawa



PLATE 1. Dakota formation topography. **A**, Typical flat-top hills capped by resistant upper siltstone of the Janssen clay member, Ellsworth County (Photo by Norman Plummer). **B**, Gently rolling topography near Miltonvale, Cloud County. **C**, Topography typical of the Dakota outcrop area in Hell Creek Valley area in Lincoln and Russell Counties (Photo by Norman Plummer). **D**, Dakota buttes at Terra Cotta, Ellsworth County.

County and near Carneiro in Ellsworth County, the surface is strewn with numerous sandstone concretions, some of which are of very large size (Schoewe, 1949, pp. 309, 314-315). In elevation the Smoky Hills range from 1,500 to 2,000 feet above sea level. The local relief varies greatly from place to place, reaching as much as 200 to 300 feet. In general, however, the relief is much less.

The Smoky Hills are traversed from west to east by Republican, Solomon, Saline, and Smoky Hill Rivers. Ellsworth, Minneapolis, and Wilson lie within the topographic unit. Belleville, Beloit, Concordia, Russell, and Lincoln are cities located along or near its western margin, whereas Washington, Clay Center, and Salina mark its eastern border. The Smoky Hills are served by four major railroad systems with the Atchison, Topeka, and Santa Fe Railway extending in a general north-south direction and the Union Pacific, Rock Island, and Missouri Pacific Railroads traversing the area generally in an east-west direction. Three major U.S. highways (24, 36, and 40) traverse the area in an east-west direction and U.S. 81 extends from north to south.

Outside the Smoky Hills physiographic unit no lignite crops out at any place where the Dakota formation is exposed.

STRATIGRAPHY OF THE CRETACEOUS LIGNITE-BEARING STRATA

Stratigraphically the Kansas lignites are of Cretaceous age and occur for the most part in the upper member of the Dakota formation (Figs. 3 and 4).

DAKOTA FORMATION

The Dakota formation consists essentially of variegated clays (Pl. 2A) with minor amounts of thin siltstones and sandstone and numerous thick lenticular channel sandstones (Pl. 2B). The channel sandstones, which because of their resistance to erosion and their capping many of the hills, appear to the casual observer as the dominant and characteristic feature of the formation. These sandstones are in reality but a minor component of the formation and according to Plummer and Romary (1942, p. 327; 1947, p. 41) comprises only about one-fourth of the total thickness of the formation. Detailed studies by these men (1942, p. 327) show

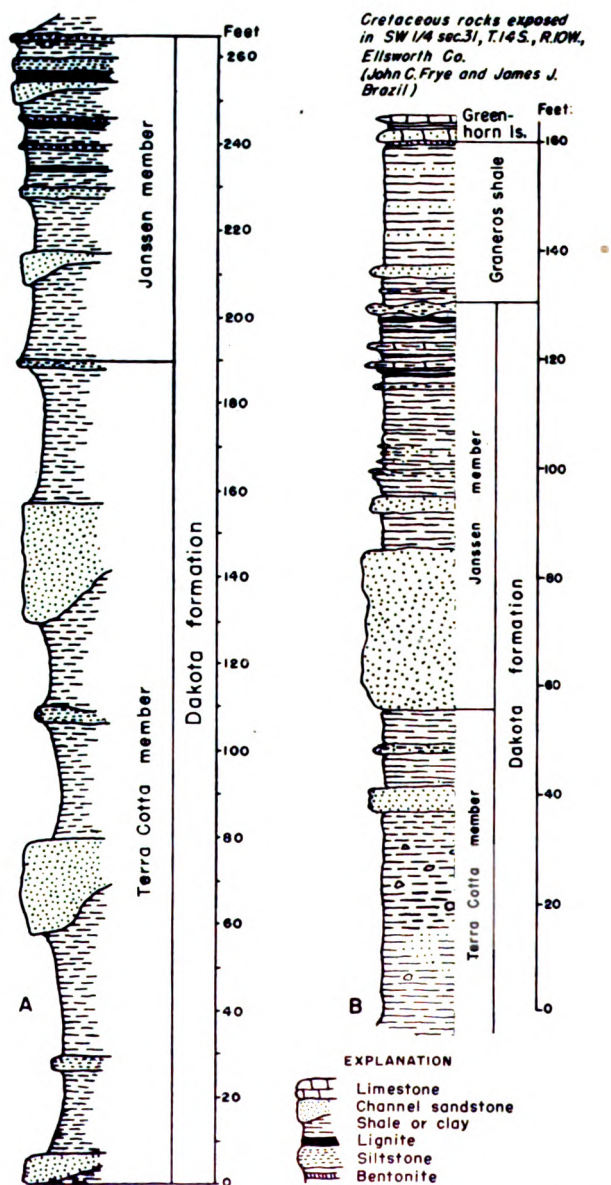


FIG. 3.—Dakota formation sections. **A**, Generalized; **B**, detailed section measured by Frye and Brazil in sec. 31, T. 14 S., R. 10 W., Ellsworth County, Kansas.

that the channel sandstones are not confined to any definite stratigraphic horizon within the formation but may occur anywhere within it. The Dakota formation is from 100 to 300 feet thick. As classified by the State Geological Survey (Plummer and Romary, 1942, p. 319) the Dakota formation in Kansas is made up of the Terra Cotta and Janssen clay members (Fig. 3).

Terra Cotta clay member.—The Terra Cotta clay or lower member consists of interbedded red, gray, brown, tan, and mottled clay, shale, and sandstone. The clay is commonly massive, mottled gray, red, and yellow, and is of the fire-clay type. Some of the clay is silty. Pellets of granular hematite, limonite, and siderite are common. The sandstones are coarse to fine-grained, lenticular, contain abundant hematitic and limonitic concretions and near the top are quartzitic. The member ranges from 70 to 220 feet in thickness, averaging about 160 feet. Lignitic material is sparsely present in the member.

Janssen clay member.—Most of the lignite seams are in the Janssen clay or upper member of the formation which is from 30 to 80 feet thick. Its average thickness is 55 feet. This member consists of gray to dark-gray clay, siltstone, and fissile shale containing interbedded sandstone, lignite, and lignitic clay. Concretions of hematite, limonite, and beds of "ironstone" are common. The uppermost bed of fine-grained sandstone or siltstone, commonly gray to light gray in color, is characterized by the presence of numerous vertical channels, some of which may be worm borings and others molds of stems or roots. The lignite occurs beneath this siltstone.

The Dakota formation is overlain by the Graneros shale and underlain by the Kiowa shale and Cheyenne sandstone formations. These formations, with the possible exception of the Dickinson, Republic, Clay, and Barton County lignite localities to be described later, do not contain lignite deposits and hence are not discussed in this report.

Figure 3A is a generalized section of the Dakota formation and is intended primarily to show the lithologic character of the formation and its subdivision into two members. The positions, thicknesses, and number of channel sandstones and lignite seams are not necessarily exact as, according to Plummer (personal communication), the channel sandstones may occur anywhere within the section and within short distances may disappear en-

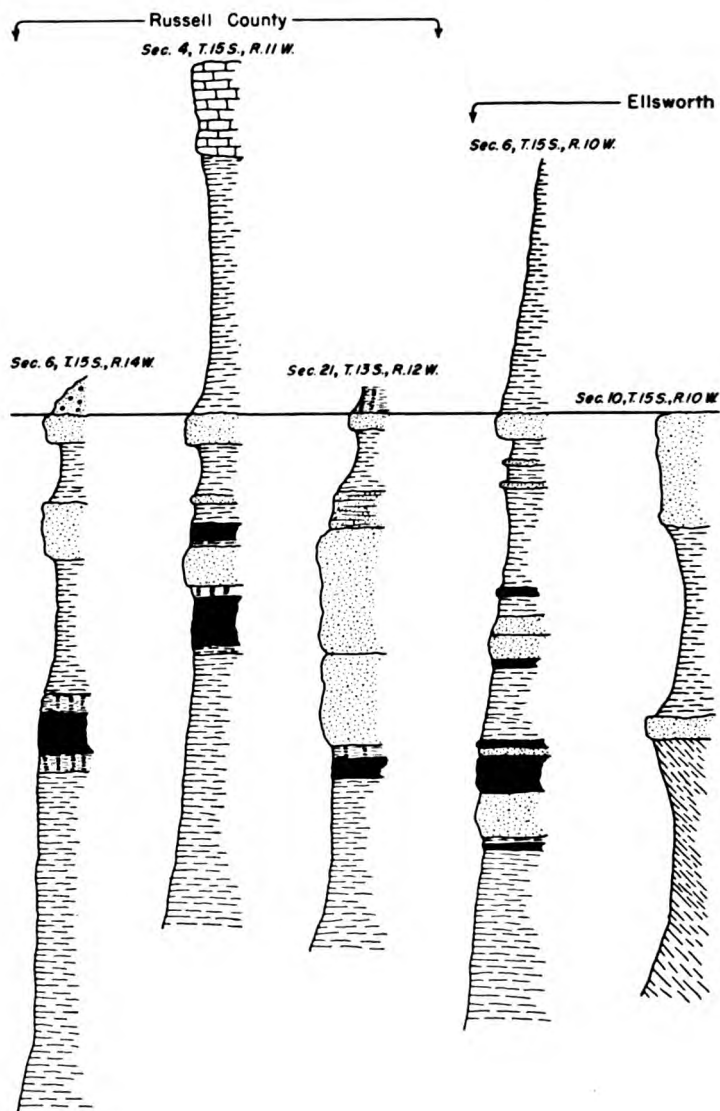
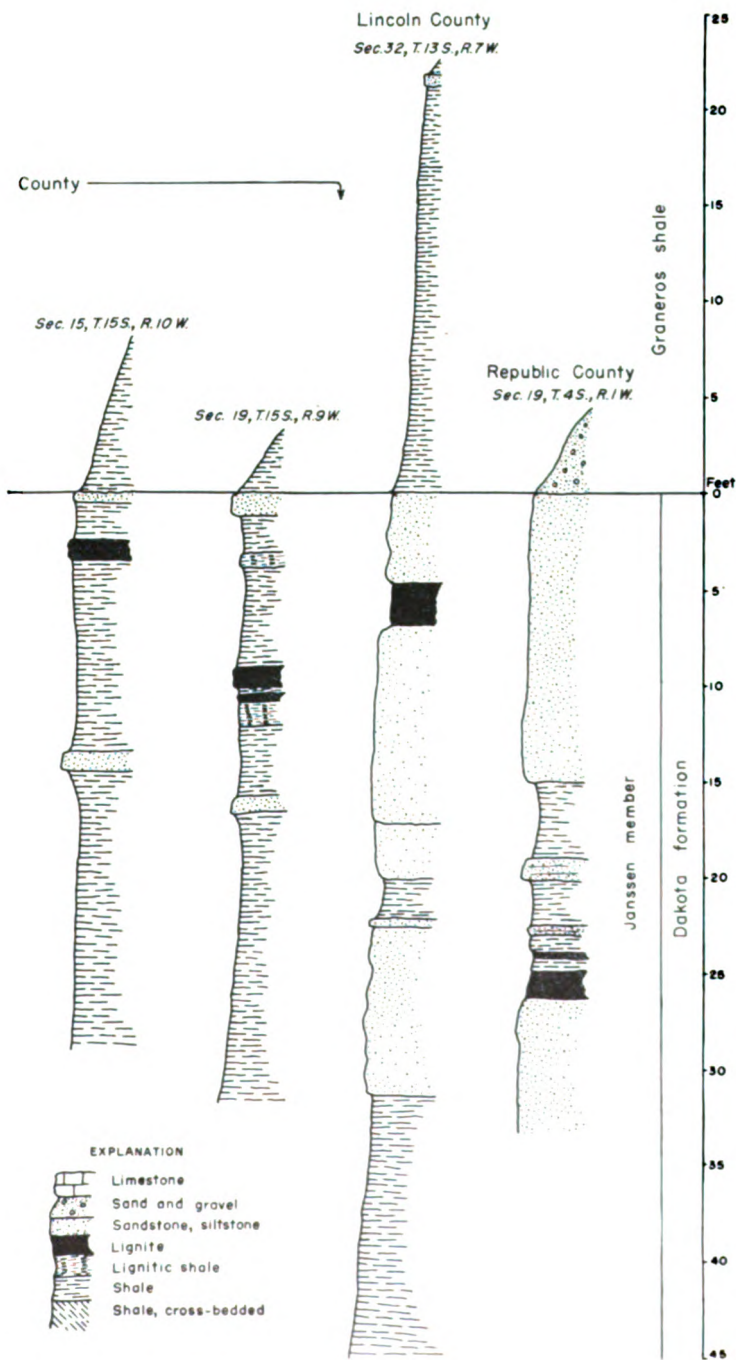


FIG. 4.—Stratigraphic sections showing position and thickness of the lignite and its relation to adjacent rocks in Kansas.



tirely. Lithologically, the Dakota formation is unpredictable. A detailed section measured by Frye and Brazil (1943, pp. 22-23; Moore and others, 1951, p. 26) in sec. 31, T. 14 S., R. 10 W., in Ellsworth County showing practically a complete section of the Dakota formation is given in Figure 3B. Other detailed measured sections of the Dakota formation are shown in Figures 4, 9, and 13.

THE CRETACEOUS LIGNITE

General description of lignite.—Lignite is coal of the lowest rank. As used by the U.S. Geological Survey (Campbell, 1917, p. 7) lignite is "restricted to those coals that are distinctly brown and either markedly woody or claylike in appearance." Lignites grade into subbituminous coals or "black lignite" from which they are not always differentiated. Lignites are very high in moisture content, ranging from 30 to 40 percent, high in ash content, and when exposed to weathering slack or crumble very readily, a factor unfavorable for storing purposes and for long distance haulage. Lignite if not stored properly will take fire spontaneously. The heating value of lignite when compared to other grades of coal is low and does not exceed 8,300 B.t.u. Its weight or specific gravity is 1.28. In calculating coal reserves lignite is assigned a value of 1,750 tons per acre-foot (Averitt and Berryhill, 1950, p. 11).

Geographic distribution of Kansas lignite.—Outcrops of lignite in Kansas are scarce. According to Mudge (1875, p. 125) lignite in the early years of mining was extracted chiefly by the stripping method suggesting that the coal was very shallow and that it probably was exposed at more numerous places than it is to day. Evidences of strip-mining are very scarce. At practically all places where there is evidence of past mining, the mines, now mainly represented by dump heaps, were either of the shaft or slope type. Many of the mines had their portals stratigraphically much higher than the coal horizon in the Graneros shale or basal member of the Greenhorn limestone formation. Inquiry relative to their location reveals the fact that the lignite in many cases was discovered accidentally in drilling wells for domestic water supplies.

Outcrops of lignite were observed in Cloud, Dickinson, Ellsworth, Lincoln, Mitchell, Republic, Russell, and Washington

Counties. In addition, lignite has also been reported to have cropped out in Hodgeman County although search for the coal at the described localities proved fruitless. At the two places where the lignite was said to have cropped out and where it was reported to have been mined, alluviation had buried the lignite outcrops under a fill of river sediment to an estimated depth of 10 to 15 feet. Test holes for oil in the vicinity, however, reveal the presence of lignite at a number of places in Hodgeman and Ford Counties. Lignite has also been mined in Clay, Jewell, and Mitchell Counties and reported to occur in Barber, Barton, Ford, McPherson, Osborne, Ottawa, Rice, and Saline Counties. It is evident from field studies that the lignite is not continuous over wide areas as is the bituminous Pennsylvanian coal of eastern Kansas. The geographic distribution of the lignite outcrop areas, location of mines, and reported occurrences are shown on Figure 1.

Stratigraphic position and contact rock.—Most of the lignite occurs in the upper part of the Dakota formation, a fact established first by Hay in 1887 (1889, pp. 6, 7). Earlier Mudge (Hay, 1885, p. 111) and St. John (1887, p. 143) had suggested that the various seams of lignite then recognized at the then known localities constituted a single stratigraphic horizon or zone. Field evidence indicates that most of the lignite occurs within the uppermost 25 feet of the formation. South of Wilson in Ellsworth County in the W $\frac{1}{2}$ sec. 6, T. 15 S., R. 10 W., six lignite seams occur in the uppermost 17 feet of the Dakota formation, whereas on the Boal farm in the SE $\frac{1}{4}$ sec. 19, T. 4 S., R. 1 W., Republic County, the lignite is found 25 feet 3 inches below the top of the formation. In the NW cor. sec. 15, T. 15 S., R. 10 W. in Ellsworth County only 2 $\frac{1}{2}$ feet of black shale and ironstone separate the 12-inch lignite seam from the Graneros shale. It is now known that not all the lignite seams are confined to the uppermost part of the Dakota formation. In the SE $\frac{1}{4}$ sec. 24 and the NE $\frac{1}{4}$ sec. 25, T. 16 S., R. 1 E. in Dickinson County, 3 miles south and 1 to 1 $\frac{1}{2}$ miles west of Elmo, a 22-inch seam of lignite is either in the Terra Cotta clay member of the Dakota formation or in the uppermost part of the Kiowa shale. Immediately below the lignite is a dark-gray to black clay shale containing numerous large and well-developed selenite crystals as well as some fragments of pyritized logs. Overlying the lignite is a cream to yellowish silty shale or thin-bedded siltstone which on weath-

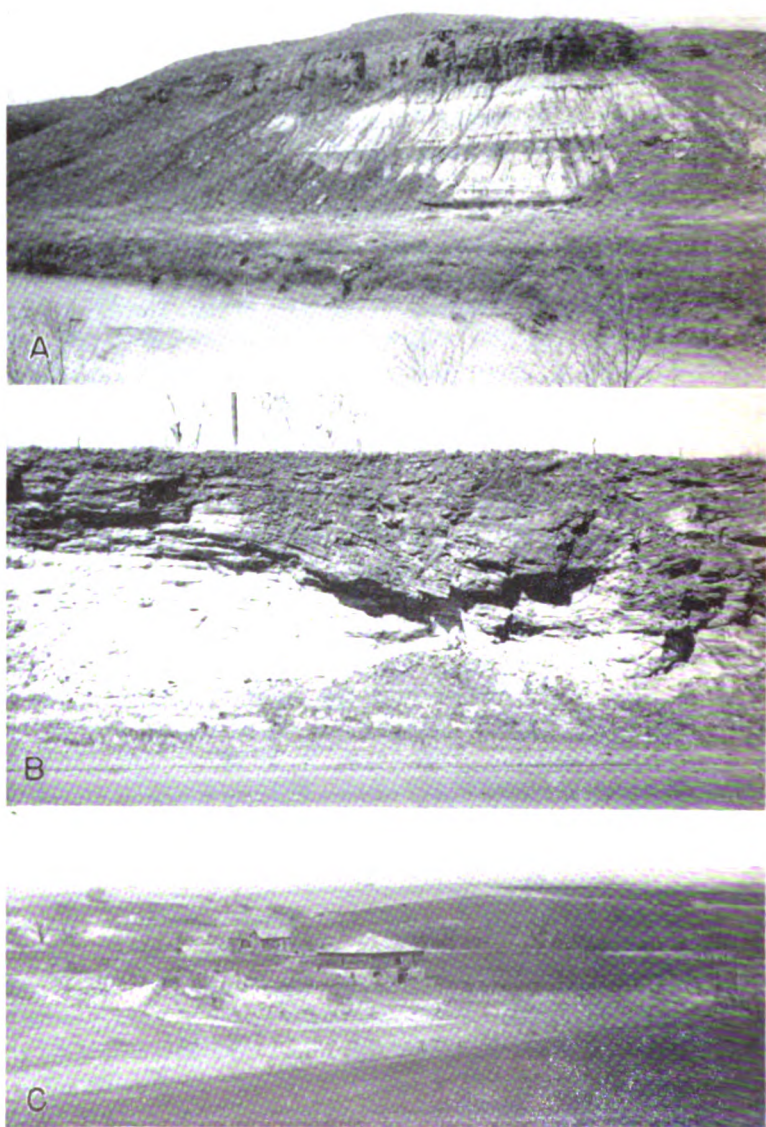


PLATE 2. Lithologic character of the Dakota formation. **A**, Variegated clays and shales overlain by massive sandstone in bluffs along Saline River north of Russell, Russell County, along U.S. 281. **B**, Channel sandstone along U.S. 24 west of Miltonvale, Cloud County. **C**, Former site of Minersville northeast of Concordia, foreground Cloud County, background Republic County. View shows at least six mine dumps, typical Dakota formation topography, and remnants of former Minersville buildings.

ering breaks up into small chip stones. This unit, which is 30 inches thick, is overlain by an 18-inch thin-bedded siltstone. Since the top of the Kiowa shale is not always readily distinguishable from the basal part or clay of the Dakota formation except by ceramic or other tests that show the mineralogical characteristics of the two (Plummer and Romary, 1942, pp. 331-332), it cannot be stated with certainty whether the Dickinson County lignite is in the Dakota or in the Kiowa shale. It can be stated, however, that the lignite does not occupy its normal position in the upper part of the Dakota formation as observed at most other localities. About a mile east of the lignite outcrop Permian strata crop out at the surface. Plummer and Romary (1942, p. 329) in presenting a generalized section of the Dakota formation in north-central Kansas describe a lignite zone near the base of the Terra Cotta clay member as follows:

"2 Clay with silt, gray to dark gray, or fine sandstone bands, lignite and fossil leaves common. In some sections portions of this bed are shale or thin-bedded clay. A highly lignitic, darker band commonly occurs toward the bottom, and pyrite, also. This bed is mostly a refractory fireclay; and, unless yellow stain is marked, samples fire to ivory or cream colors, [thickness] 5.0 to 30.0 feet."

Underlying their zone 2 is a siltstone and fine sandstone up to 20 feet thick. Zone 1, however, is missing in places. At such places zone 2 rests directly on Kiowa shale from which it, in some cases, is indistinguishable from the Dakota clay or shale except by ceramic or other tests that show the mineralogical characteristics of the two. Selenite crystals which are typical of the Kiowa shale are not mentioned as being present in zone 2 described by Plummer and Romary. The occurrence of lignite in the basal part of the Terra Cotta member is indicated in a section measured by Plummer in Ellsworth County (Moore and others, 1951, p. 26; Fig. 9). It may be, therefore, that the Dickinson County lignite corresponds to Plummer and Romary's zone 2 and hence is in the basal part of the Terra Cotta clay member of the Dakota formation. For purposes of this report the lignite is assigned to the lower Dakota formation. Other possible occurrences of lower Dakota lignite may be found in Barton, Clay, Republic, and Stafford Counties.

At the outcrop the lignite occurs within shale, between layers of sandstone or siltstone, or is overlain by siltstone and underlain by shale. Where observed most of the lignite is overlain by siltstone. Along the bluffs of Smoky Hill River in the NE $\frac{1}{4}$ sec. 6, T. 15 S., R. 14 W., Russell County, the coal is entirely within the shale.

Thickness.—Where seen, the lignite is nowhere greater than 25 inches in thickness. At most places it is much thinner. On the basis of published data seams of lignite as much as 40 inches thick have been mined. Since no lignite has been mined commercially since about 1940 no deep or mined lignite was seen. Lignite from 3 to 12 feet thick has been reported to me to underlie southern Hodgeman and northern Ford Counties. Field evidence seems to indicate that the thickness of the lignite seams varies greatly from place to place and in short distances and that the coal is, for the most part, spotty and discontinuous. The thicknesses of the lignite are summarized by counties in Table 1.

Number of seams.—The lignite occurs in more than one seam. South of Wilson in Ellsworth County in the bluffs along Saline River in both Ellsworth and adjoining Russell Counties there are as many as six coal seams varying from 2 to 12 inches in thickness, all within a vertical distance of 17 feet. Elsewhere, it is not unusual for a single seam to be separated by a 2 to 4 inch silt or clay parting.

Physical and chemical characteristics.—Most of the lignite seen in the field is composed of extremely matted highly carbon-

TABLE 1.—Summary of thickness of lignite and depth to coal where mined

County	Thickness range at outcrops, inches	Thickness in mines, inches	Reported thickness, inches	Depth to coal where mined, feet
Barton	.....	.....	12	.....
Clay	.....	18	.....	.....
Cloud	2-25	24	.....	surface-110
Dickinson	3-22	.....	.....	.....
Ellsworth	2-20	12-36	.....	20-75
Ford	.....	.....	48-96	.....
Hodgeman	.....	36	36-144	15-25
Jewell	.....	30-36	.....	150-160
Lincoln	24	15-26	.....	50-60
Mitchell	3	14	.....	25
Ottawa	.....	.....	6	.....
Republic	16-48	25	.....	surface-75
Russell	9-24	11-40	.....	surface-75
Washington	4-14	14-18	.....	surface-30

ized coal material imbedded or intermingled with a large amount of silt and dark clay. Within the woody material are found streaks of shiny jet-black dense brittle amorphous coal. The lignite also contains pyrite in the form of small crystals, nodules, and pyritized woody fragments. According to reports of those having used the lignite for fuel, the lignite yields a large quantity of white ash when burned and emits considerable sulfurous odors. The coal emits no soot and gives off a fair degree of heat. Because of the high moisture content the coal or lignite slacks readily when exposed to the atmosphere. On weathering the lignite assumes a brownish color and a more or less foliated or papery appearance. At a few places, especially along the east bluff of Smoky Hill River in the NE $\frac{1}{4}$ sec. 6, T. 15 S., R. 14 W. south and west of Russell, the lignite is jet black instead of brownish and has the appearance of true coal. The seam here also is essentially free from impurities of clay and silt except for small streaks of pyrite crystals. This coal seam is from 15 to 24 inches thick and is over and underlain by dark-gray to black lignitic shale. A sample of coal received and reported to have come from one of the test holes sunk in Hodgeman County is essentially similar to the Smoky Hill coal of Russell County. Because of the scarcity of outcrop, the thinness of the lignite seams, the highly weathered nature, and the impure character of the coal where seen, no good description of bedding and other structural features can be given. At most of the outcrops the lignite seems foliated and when pried off breaks into irregular masses suggesting poor bedding and jointing. The Smoky Hill deposit south and west of Russell when sampled broke off into small more or less rectangular shaped pieces. That some of the mined coal, especially where it measured several feet in thickness, may have had good bedding is suggested by a report in the Jewell County Republican, a weekly newspaper, in 1904 that a block of coal measuring 36 by 36 by 36 inches and weighing 900 pounds had been taken from the 160-foot deep mine in the NW $\frac{1}{4}$ sec. 34, T. 4 S., R. 7 W. about 3.25 miles east of Jewell. In the Black Wolf area in sec. 19, T. 15 S., R. 9 W., in sec. 24, T. 15 S., R. 10 W. in Ellsworth County, and in the Dickinson County area south and west of Elmo in sec. 24, T. 16 S., R. 1 E. the lignite is seen to dip considerably (Pl. 5A). As previously indicated the lignite is thin and as far as could be ascertained from field observations the seams vary considerably

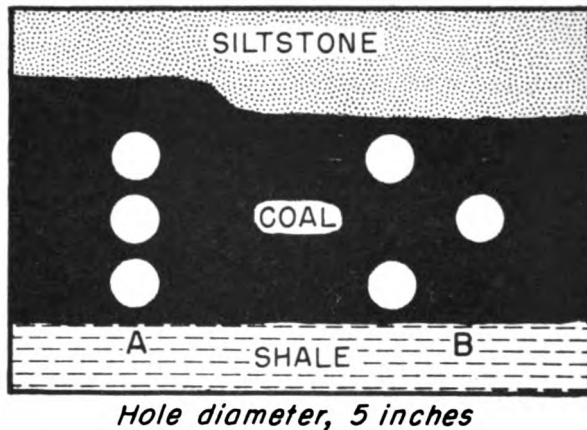


FIG. 5.—Diagram showing arrangement of sample holes where lignite samples were obtained by augering horizontally into the coal seam.

in thickness in short distances and seem to be spotty and discontinuous. However, outcrops of the lignite are very scarce undoubtedly owing to the thinness of the seams and also to the fact that the containing strata are easily weathered and eroded accompanied by excessive slumping. Where formerly mined, outcrops of the lignite are conspicuously lacking. Many of the shafts have their portals in strata stratigraphically much higher than the Dakota formation, probably because most of the coal was discovered accidentally while drilling for water supplies. Table 1 shows the depth to the coal where formerly mined.

Proximate analyses.—Sixteen samples of the lignite were collected from seven localities. Because of the character of the overburden, sampling was done by using a 5-inch auger and boring into the coal seam from a horizontal position. Before augering from 2 to 3 feet of the face of the coal was removed, thereby removing most, if not all, of the weathered lignite. Holes then were bored horizontally into the newly exposed coal to a depth of 7 to 35 inches, the material collected in quart jars, and immediately sealed. Where the coal was sufficiently thick the holes were vertically one above the other (Fig. 5A) with the top of the uppermost hole from 3 to 5 inches below the top of the coal seam. In some cases the holes were arranged as shown in Figure 5B. The samples were analyzed in the chemical laboratories of the State Geological Survey under the direction of Russell T.

TABLE 2.—*Proximate analyses, sulfur content, and heating value of the Cretaceous lignite coals of central Kansas (Analyses by Russell T. Runnels in the State Geological Survey laboratories)*

County	Location	Sample no.	Form*	Moisture, percent	Ash, percent	Volatile, percent	Fixed carbon, percent	Sulfur, percent	B.t.u.
Ellsworth	6-15-10W	1, 2, 3	A	13.08	35.19	27.17	24.56	1.00	3,968
			B	.....	40.48	31.25	28.25	1.15	4,565
			C	.....	.....	52.52	47.47	1.93	7,671
Russell	4-15-11W	5, 6, 7	A	10.18	56.19	20.29	13.34	0.48	2,156
			B	.....	62.55	22.59	14.85	0.53	2,400
			C	.....	.....	60.35	39.67	1.42	6,114
Russell	21-13-12W	8, 9	A	14.07	14.80	36.85	34.28	1.97	6,706
			B	.....	17.22	42.88	39.89	2.29	7,803
			C	.....	.....	51.80	48.19	2.77	9,428
Russell	6-15-14W	10, 11, 12	A	10.68	19.23	32.60	37.49	6.28	7,290
			B	.....	21.52	36.49	41.97	7.03	8,162
			C	.....	.....	46.51	53.48	8.95	10,401
Lincoln	32-13-7W	13, 14	A	12.18	39.82	24.87	23.13	1.02	3,600
			B	.....	45.34	28.31	26.33	1.16	4,939
			C	.....	.....	51.81	48.19	2.12	7,500
Republic	24-4-3W	15	A	13.90	38.91	24.91	22.28	1.01	3,469
			B	.....	45.19	28.93	25.87	1.17	4,029
			C	.....	.....	52.78	47.21	2.14	7,351
Dickinson	24-16-1E	16	A	6.03	70.74	12.33	10.87	4.45	1,105
			B	.....	75.30	13.12	11.57	4.73	1,176
			C	.....	.....	17.43	15.36	6.29	4,763

* A, Air dry basis; B, moisture free basis; C, moisture and ash free basis.

Runnels. Proximate analyses of the lignite samples are given in Table 2. As compared to the heating value of the bituminous coals of eastern Kansas (Schoewe, 1946, pp. 30-32) the Kansas Cretaceous lignites are decidedly inferior. The analyses presented in Table 2 probably do not represent the average proximate analyses and heating value of the coals that formerly were mined which are believed to have had a higher B.t.u. value. None of the mines are in a condition to enter; thus no underground samples of lignite were obtained. All samples of lignite collected were secured from surface outcrops and although as much of the weathered material was removed before sampling as possible, it is questionable whether the lignite obtained was entirely unaltered. Several analyses of lignite were made many years ago. Since, however, the methods employed in making these early analyses are not known, it is not safe to compare them with the more recent analyses presented herewith. They are included, however, for historical purposes. In 1872 Saunders (1873, p. 390) made an analysis of lignite obtained from the Kansas Pacific Railroad (Union Pacific Railroad) along Wilson Creek in Ells-

TABLE 3.—*Analysis of lignite from Wilson's Creek, Ellsworth County, Kansas (Saunders, 1873, p. 390)*

Constituent	Percent
Water	7.50
Combustible gases, cubic feet per pound	2.33
Illuminating power	low
Amount of tar	small
Sulphur	1.63
Coke	68.75
Ash	9.50
Rate of combustion in open air	fast
Volatile matter	31.25
Fixed carbon	59.25
Ash	9.50

worth County (Table 3). Bailey (1889, p. 49) made an analysis of lignite obtained from Minersville north of Concordia in Cloud County in 1888 (Table 4). Blake (1889, p. 46), using the same sample analyzed by Bailey, determined the evaporative power of the lignite (Table 5).

Uses.—Even though of inferior quality as compared to the coals of the eastern part of the State, the lignite served a useful purpose to the people of central Kansas before 1900 in the days when better types of fuel such as natural gas, oil, commercial fuels as butane etc., and shipped-in better grades of bituminous coal were available to them. A good illustration of how the mining of the lignite affected the economy of central Kansas is shown by the fact that in Lincoln County farmers and others in the early 1890's had to haul coal from shipping points as much as 10 to 20 miles distant and pay from \$7.00 to \$12.00 a ton for the coal. When the lignite was put on the market, shorter distances for hauling the fuel were involved and the price per ton of coal at the railroad yards dropped immediately to \$5.00. The lignite sold at \$3.25 per ton (Brown, 1896, p. 77). Another instance of the value of the lignite is reported by Young (Young and Allen, 1925, p. 39) as follows: "During the shortage of coal caused by a pro-

TABLE 4.—*Analysis of lignite from Minersville, Cloud County, Kansas (Bailey, 1889, p. 49)*

Constituent	Percent
Water	13.70
Volatile	46.14
Fixed carbon	28.52
Ash	11.64
Sulphur	not tested for

TABLE 5.—*Evaporative power of Minersville lignite, Cloud County, Kansas (Blake, 1889, p. 46)*

Pounds per Correction on 10 percent	water evaporated pound of coal apparatus 30 percent	Duration of burning, seconds	Calories, gram-degrees centigrade	
			10 percent	Correction 30 percent
9.90	11.68	135	5,316	6,273

tracted strike in 1919 in the operating districts from which coal is commonly obtained, some coal was mined from the Cretaceous deposits and served a very useful purpose of ameliorating the condition caused by a fuel shortage in a cold season." Not only was the lignite used as a domestic fuel but it was also employed by the railroads of the lignite-bearing country to fire their locomotives (Malin, personal communication; Hutchinson, 1871, p. 63; Kansas Daily Tribune, Lawrence, Aug. 1, 1868). The fact that more than 300,000 tons of lignite valued at approximately \$1,000,000 was mined in Kansas testifies to its economic importance to central Kansas. While it is true that the lignite deposits of Kansas at the present time are not to be considered commercially minable, nevertheless they should not be considered valueless. Fuel shortages due to protracted strikes in the bituminous coal areas, transportation breakdowns, depletion of oil and gas reserves, labor difficulties in the manufacture of synthetic fuels, and unusually high prices of natural fuels are not impossible in the future. Should such happen the mining of lignite in central Kansas may again be revived. Of much greater importance, however, is the fact that experiments on the liquefaction and hydrogenation of coals show that lignites are especially amenable to those processes and that the lignites are a potential source of future gasoline and other liquid fuels. It is on this basis that the Kansas lignites may be considered as marginal reserves.

MINING HISTORY AND MINING METHODS

Without doubt lignite was used for fuel just as soon as it was discovered by the settlers in the coal-bearing counties of central Kansas. According to Wing (1930, p. 43) lignite was mined at Minersville in Cloud and Republic Counties as early as 1855. The first lignite mined was obtained by stripping methods. This was especially true in the early 1870's (Mudge, 1875, pp. 124-125).

Apparently mining by stripping did not persist very long as most published reports list the lignite mines as drift or shaft mines. The last lignite mined in Kansas and officially reported was for the year 1940 (Delplace, 1941, pp. 54-55).

The mines at their best were crude affairs when compared to modern coal mines. Coal mine inspectors complained of the unsatisfactory conditions prevailing in the mines of the western counties. In Cloud County (Gallagher, 1894, p. 19) where much of the mining was done, shaft mines had no second openings, the ventilation in the mines was poor, places to land the cages on top were lacking as well as gates at the landings. Horse power was used to lift the cages which were held in place by the gin horses while the cars were being pulled off the cages. Ordinary precautions for the safety of the men were disregarded or not considered at all. Since most of the mines were operated only in fall and during the winter months, water collected in the mines during the idle months. If later the mine was to be used again and found not to be in good shape, another hole in the ground near by was sunk and the new mine opened, using the old shaft for an air shaft. A small scale and a dugout comprised the improvements on top at the mine (McGrath, 1898, pp. 67-68). Since all the work in the mines was done by man power, entries in many instances were less than 3 feet high. Many of the shafts were no larger than 4 by 4 feet.

Each one of the mining districts was small and limited to a few mines each. The mines too were small affairs employing in each no more than 10 to 15 men of whom 8 to 12 were classified as miners. As far as known there were only two mining districts in central Kansas where mining of the lignite was a major operation. About 6 miles northeast of Concordia in Cloud County was Minersville, a small town consisting of several houses, a store or two, a post office, and a hotel. Its inhabitants were primarily associated with the mining industry. Minersville was located chiefly in the NE $\frac{1}{4}$ sec. 2, T. 5 S., R. 3 W. in Cloud County and extended across the county line into sec. 35, T. 4 S., R. 3 W., Republic County. A second mining community was formerly located in Russell County, 5 to 6 miles south and 2 $\frac{1}{2}$ miles east of Dorrance or 4 miles south and 3 $\frac{1}{2}$ miles west of Wilson in Ellsworth County. The exact location of this mining community is in secs. 3 and 4, T. 15 S., R. 11 W., Russell County.

None of the lignite mines had railroad connections. The coal was hauled away in wagons to distances as much as 75 miles from the mines. The last lignite mine was opened in 1930 by a Mr. Curtis in the now abandoned Minersville district in the NE $\frac{1}{4}$ sec. 2, T. 5 S., R. 3 W. (Wing, 1930, p. 44). This mine was being cleaned and made ready for operation at the time of Whitla's visit in August 1939 (Whitla, 1940, p. 34) and during the following mining season produced 50 tons of coal, the last to be reported officially from any of the lignite mines in central Kansas.

PRODUCTION

Production statistics of lignite are incomplete. The earliest production figures found for lignite are for the year 1875 when both Cloud and Russell Counties reported an output of 500 tons each or a total of 1,000 tons. The peak of production was reached in 1890 and 1891 when 26,192 and 28,352 tons of lignite were produced respectively. In 1890 production was reported from seven counties, Cloud, Ellsworth, Lincoln, Russell, Republic, Jewell, and Mitchell. Most of the lignite mined came from Cloud County whose cumulative production amounted to 130,753 tons. Russell County produced 44,808 tons, Ellsworth County 41,229 tons, Lincoln County 39,493 tons, Republic County 30,790 tons, Jewell County 9,963 tons, and Mitchell County 3,148 tons. As far as the reports of the State Coal Mine Inspectors are concerned no lignite was mined between the years 1907 and 1935. Last production reported is for Cloud County in 1940 when 50 tons were produced. As no records were kept in former years as to the amount of coal produced by the miners for their own use (Brown, 1896, p. 65) and since it is questionable whether all the smaller mines reported their production the 300,184 tons of lignite reported represent the minimum production of lignite. Published production statistics of the lignite-producing counties of central Kansas are summarized in Table 6. Annual production statistics of lignite for each county are presented on subsequent pages.

RESERVES

Because of the variable nature of the Kansas lignite in regard to thickness, the scarcity of outcrop, and the general lack of information relative to the coal, it is extremely difficult to estimate

the quantity of lignite unmined. On the basis of the standard used by the U.S. Geological Survey Fuels Branch in calculating lignite reserves, Kansas is essentially without lignite reserves. Except for local pockets, practically all the lignite mined in the State was 30 inches or less in thickness, the minimum thickness considered by the Fuels Branch as lignite reserve coal.

Marginal lignite reserves.—The unmined Kansas lignites, although too thin to be classified as true measured reserves, are here considered marginal lignite reserves (1) because of their shallow depth and therefore ease to which they may be subject to processes converting them into possible liquid fuels and gasoline and (2) the lignites may again under adverse economic conditions be resorted to, as in former years, as an emergency fuel. All reserves in this report are considered as original lignite reserves and are to be compared to the proved original reserves (measures of the U.S. Geological Survey) of eastern Kansas. No attempt is made to estimate or consider potential reserves. The standard and methods adopted by the State Geological Survey of Kansas in estimating the bituminous coal reserves of the eastern part of the State (Abernathy, Jewett, and Schoewe, 1947, pp. 13-14; Schoewe, 1946, pp. 40-41) are not entirely satisfactory or applicable to the study of the lignite reserves of central Kansas. For the purpose of estimating the lignite reserves of Kansas the following guide based primarily on methods employed by the Fuels Branch of the U.S. Geological Survey in calculating original reserves has been selected (mimeographed suggested rules for calculating and reporting coal reserves, U.S. Geological Survey, Fuels Branch, pp. 3-4).

1. All lignite is computed on the basis of original coal reserves prior to mining.
2. Isolated outcrops, mine workings, drill holes, etc., are considered to determine an area of coal extending for a radius of one-half mile around the outcrop, mine working, drill hole, etc.
3. A circular area of 1 mile diameter or one-half mile radius comprises 502.66 acres of land containing 72,886 tons per inch of coal or 879,655 tons per foot of coal.
4. There are 1,750 short tons of coal per acre foot or 145 tons per acre inch.
5. The coal lies within 1,000 feet of the surface.
6. The unit for reporting the amount of lignite remaining in the ground as of June 1, 1950, is the county. This unit had to be adopted even though the original reserves of lignite are computed for each local

mining district. Production figures are on the county basis thus affording no accurate way to estimate how much coal had been mined at any one specified place.

All reserve estimates are stated to three significant figures or less.

The original lignite coal reserves of coals less than 3 feet thick prior to mining operations of the central Kansas counties considered in this report total 55,000,000 tons (Table 6).

Alleged lignite reserves.—In addition to the known thin seams of 30 inches or less in thickness, several areas in the State are reported to be underlain by lignite more than 30 inches thick. The lignite of such areas which are not associated with any mining activity but whose presence or occurrence is based on non-technical reports and suggested by broad geologic field relationships are here designated as alleged lignite reserves. Alleged reserves of lignite are thought to underlie parts of Hodgeman, Ford, Russell, and Republic Counties. Such alleged reserves total about 121,000,000 tons to which slightly more than 22,000,000 tons should be added for similar coals in Jewell County less than 30 inches thick, making thus a total of approximately 143,000,000 tons alleged lignite reserves (Table 6).

The grand total of all original lignite reserves amounts to 198,000,000 tons, an amount reduced by mining by only 300,000

TABLE 6.—Summary of cumulative Kansas Cretaceous lignite production from 1875 to 1940 and original reserves, by counties, in tons*

County	Production officially reported	Original reserves			Total
		Marginal (measured)	Alleged		
			Less than 3 feet thick	More than 3 feet thick		Less than 3 feet thick
Clay		400,000			400,000
Cloud	130,753	5,300,000			5,300,000
Dickinson		500,000			500,000
Ellsworth	41,229	8,800,000			8,800,000
Hodgeman and Ford			105,000,000		105,000,000
Jewell	9,963	7,400,000		22,400,000	29,800,000
Lincoln	39,493	10,500,000			10,500,000
Mitchell	3,148	500,000			500,000
Republic	30,790	8,200,000	7,900,000		16,100,000
Russell	44,808	12,700,000	7,900,000		20,600,000
Washington		700,000			700,000
Total	300,184	55,000,000	121,000,000	22,400,000	198,000,000

* Reserve estimates are stated to three significant figures or less.

tons. Table 6 summarizes the lignite reserves of central Kansas. Detailed data concerning the reserves are to be found under the various county discussions.

Recoverable coal.—All the lignite reserves given are original reserves or coals that are underground and are not to be considered as coals all of which are recoverable. At the present time it is not known precisely how much coal can be extracted or recovered from any mine or mining district in the United States. What may be recoverable coal in one locality is not necessarily recoverable coal in another mining district. As an illustration of this it may be cited that the bituminous coal mined in the Burlingame-Osage City area is sold as mine-run coal. The coal coming from the mines is not washed or treated in any way. All coal mined is sold and therefore is recoverable coal. A little farther to the southeast in the Cherokee coal country of southeastern Kansas the coal before being sold is washed, graded, and treated, thus reducing the actual mineral tonnage by about 25 percent. Hence only 75 percent of the coal mined is recoverable. Furthermore the amount of coal that can be recovered will depend upon the type of mining that is employed—the longwall system versus the room-and-pillar method and the stripping method as against underground mining. Other factors such as the structure of the coal beds also affect the percentage of the total coal that may be recovered in mining. Averitt and Berryhill (1950, p. 8) of the Fuels Branch of the U.S. Geological Survey in estimating the recoverable coal in the United States assume a recovery of 50 percent of the coal in the ground and are of the opinion that this rate will be maintained in the future. On the assumption that 50 percent of the lignite estimated to be underground is recoverable, Kansas then has approximately 27,000,000 tons of recoverable marginal lignite reserves 30 inches or less in thickness and an additional 72,000,000 tons if the alleged reserves are considered, making a grand total of about 99,000,000 tons of recoverable lignite reserves of all kinds. It should be stated in this connection that the State Geological Survey of Kansas is interested primarily in the estimates of original coal reserves—that is, coal underground—and that it is for the coal industry to decide or determine how much of that coal is recoverable under present-day conditions. Obviously recoverable coal estimates must vary from time to time depending upon economic conditions and new

advances in coal technology, two factors which we cannot foresee or predict for the future.

CRETACEOUS LIGNITE-BEARING COUNTIES

CLAY COUNTY

The Dakota formation forms the bedrock of a triangular-shaped area of approximately 6 to 7 townships in the western part of the county (Fig. 6). No outcrops of lignite were seen in the field nor are there any published references to Clay County lignite outcrops in the geologic literature. Lignite, however, was formerly mined 50 or more years ago at one locality in the county. The mine, a drift mine, now represented by a dump heap (Pl. 3A) is located on the south bank of a small stream approximately in the NE cor. NW $\frac{1}{4}$ sec. 28, T. 6 S., R. 1 E. about 4 $\frac{1}{2}$ miles due east of St. Joseph in Cloud County. Two hundred feet south of the dump heap and 25 to 30 feet higher is a circular depression now mostly filled which may have been the site of a shaft. The lignite is reported to have been 18 inches thick and has been encountered in a number of near-by water wells. Judged by the character of the materials composing the mine dump, the coal or lignite occurred in a shale. Massive reddish-colored Dakota sandstone crops out approximately at the same elevation as the partially filled circular depression referred to above and continues to crop out on the slopes still higher. No data are at hand as to the amount of coal mined, by whom, depth to the coal, or the exact time of mining. The mine is not included in any of the published reports of the State Coal Mine Inspector.

Reserves.—On the basis of an 18-inch seam of lignite there were about 400,000 tons of coal originally under the 160 acres considered here as marginal reserve coal land. It is believed that the amount mined was not great and would not change materially the reserve tonnage of this coal as estimated. It is therefore listed as this figure in this report.

CLOUD COUNTY

More than 40 percent of all lignite mined in central Kansas was produced in Cloud County. The Dakota formation forms the surface rocks of approximately 11 of the 20 townships that comprise the county. The coal-bearing strata are found chiefly in the

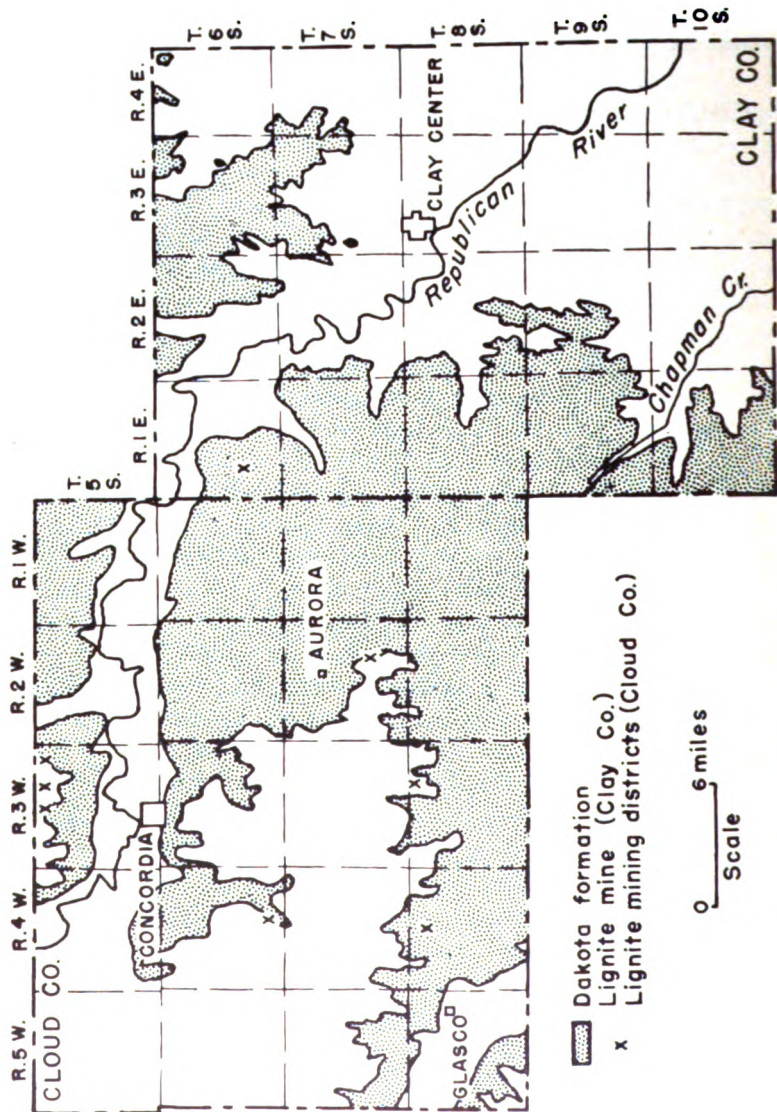


FIG. 6.—Map of Clay and Cloud Counties, Kansas, showing distribution of the Dakota formation and the location of lignite mines.

eastern two tiers of ranges and the easternmost tier of townships (Fig. 6). The occurrence and mining of lignite in Cloud County were known as early as 1855 (Wing, 1930, p. 43). Coal is reported last mined in 1940 (Delplace, 1941, p. 10).

Minersville mining district.—Of the five localities in the county where lignite is reported to have been mined, the most important one is the Minersville coal mining district from 5 to 6 miles north and $1\frac{1}{2}$ to 3 miles east of Concordia, primarily in secs. 1 and 2, T. 5 S., R. 3 W. The mining district extended northward into sec. 35, T. 4 S., R. 3 W. in Republic County. Minersville, now entirely abandoned, was a mining community of several houses, a hotel, stores, and a U.S. post office (Pl. 2C).

As reported to me by Mr. D. Curtis the coal seam is 22 to 24 inches thick and is divided into an upper 6 to 8-inch coal which is separated from a lower 12-inch seam by 3 to 4 inches of impure coal or "blackjack." The average thickness of the lignite reported by the various coal mine inspectors is 22 inches. Outcrops of the lignite are essentially absent in the area where the mines are located. The only good outcrop of the coal seen in the Minersville mining district is in Republic County in the NW cor. SW $\frac{1}{4}$ sec. 26, T. 4 S., R. 3 W. about $1\frac{1}{4}$ miles north of the northernmost mine of the area. The lignite at the outcrop measures 25 inches in thickness. The coal in the Minersville district occurs 12 feet below the sandstone forming the top of the Dakota formation (Whitla, 1940, p. 33) and 102 feet below the Jetmore limestone of the Greenhorn formation (Wing, 1930, p. 44). The coal is over and underlain by shale. The lignite was mined in shaft and slope mines and chiefly by the longwall system. On the lower ground some of the lignite was obtained by stripping methods. The coal lay at various depths below the surface. In 1875 the shafts were 25 feet deep, in 1890 the mines averaged 55 feet in depth, in 1899 they averaged 75 feet, and the last mines opened were in the neighborhood of 100 feet. None of the mines had railroad connections. All the coal was sold as mine-run coal and hauled away by the wagon load to points as much as 20 to 30 miles distant. The mines were small affairs and employed from 4 to 14 men each. The miners were paid from \$1.25 to \$2.50 a ton for mining the coal which was sold at prices from \$2.25 to \$4.00 per ton at the mines. Most of the mines operated for six months or less during the year; others, however, were active

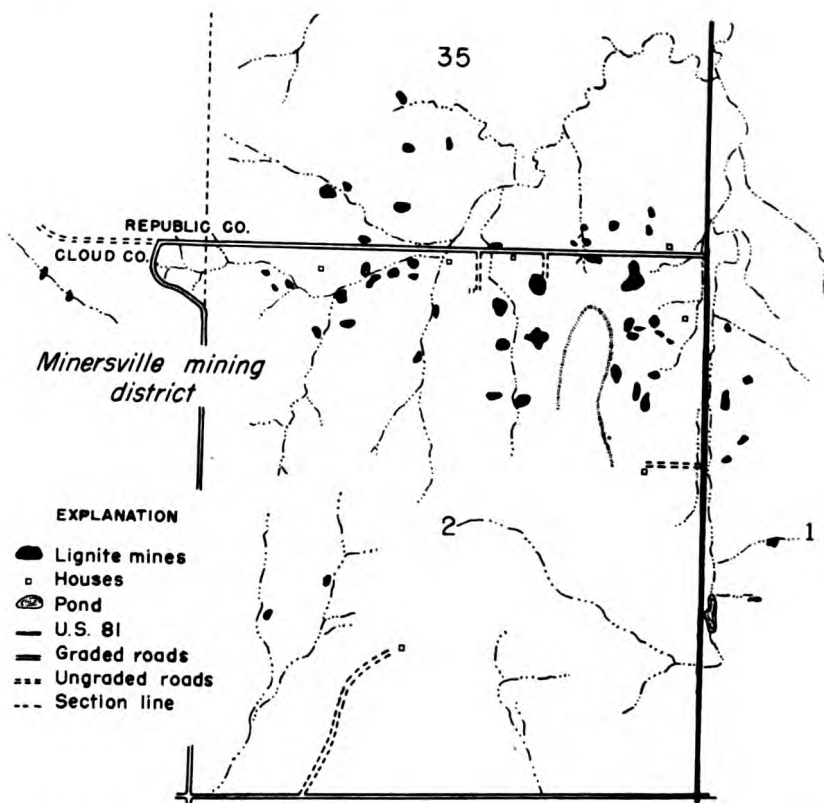


FIG. 7.—Map of the Minersville lignite mining district, Cloud and Republic Counties, Kansas.

during the entire year as is suggested by the fact that the price paid to the miners during the summer months was slightly less than the pay they received per ton for mining the coal during the winter months.

The presence of lignitic coal is also recorded in the logs of test holes put down on the flood plain of Republican River north of Concordia (Fishel, 1948, pp. 177-180). The lignite is encountered at a depth of 78 to 97.5 feet beneath the valley floor surface and in the test hole put down in the SE cor. sec. 19, T. 5 S., R. 3 W. the lignite is 2 feet thick. It is apparent from the geologic relationship that the lignite in this test hole found at a depth of 80 feet below the Republican River flood plain is not at the same

stratigraphic horizon at which the coal was mined 3 to 4 miles farther north in the Minersville mining district. The test hole lignites are presumably to be correlated with the lignite cropping out in the basal part of the Dakota formation south of Elmo in Dickinson County.

Concordia mining district.—According to a Cloud County map (Sims, 1883, p. 32) published in 1883, coal occurred in sec. 16, T. 6 S., R. 3 W., from 2 to 3 miles south of Concordia. A search for this coal mine proved futile as did the location of another mine shown on the map in sec. 26, T. 6 S., R. 4 W., near the former town of Graves. Evidence of a mine, however, reported by a local resident to have existed about 1 mile west of the Graves mine was found in a pasture in the Cen. NE $\frac{1}{4}$ sec. 34, T. 6 S., R. 4 W. on the Wilcox farm. This mine is represented by a circular shaft depression about 12 feet in diameter and now 5 feet deep. No other information was obtained relative to the mine.

Glasco mining district.—Coal is also shown on the Sims' (1883) map in sec. 4, T. 8 S., R. 4 W. about 4 miles east and 1 to 2 miles north of Glasco. All field traces of any mining activity that may have existed are gone and if any coal was mined as reported the mine must have been very small. Inquiry at Glasco and in the general area where the coal was reported to have been led to the discovery of a place in the NW $\frac{1}{4}$ sec. 10, T. 8 S., R. 4 W., a mile farther south and about one-half mile east where coal was formerly taken from the bank of a small stream. At the time of my visit to the place alluviation had so filled up the valley floor that only the capping sandstone of the Dakota formation was exposed.

Aurora mining district.—Sims' (1883) map of Cloud County also shows coal to be present in Aurora Township, secs. 18 and 26, T. 7 S., R. 2 W. The locality in sec. 18, about 3 miles west of Aurora, is in the Carlile shale and Graneros limestone formations. Search for the mines in this section and inquiry concerning them at Aurora and vicinity yielded no results. South of Aurora about 2 miles, coal was seen in the SW cor. sec. 23 where it also was mined and in the NW $\frac{1}{4}$ sc. 26. Half a mile farther south in the same section the lignite was reported to have been mined. All the lignite seen was very thin, from 2 to 8 inches thick, and cropped out no more than 2 feet above creek level and from 50 to 60 feet below the lowest limestone in the Greenhorn limestone

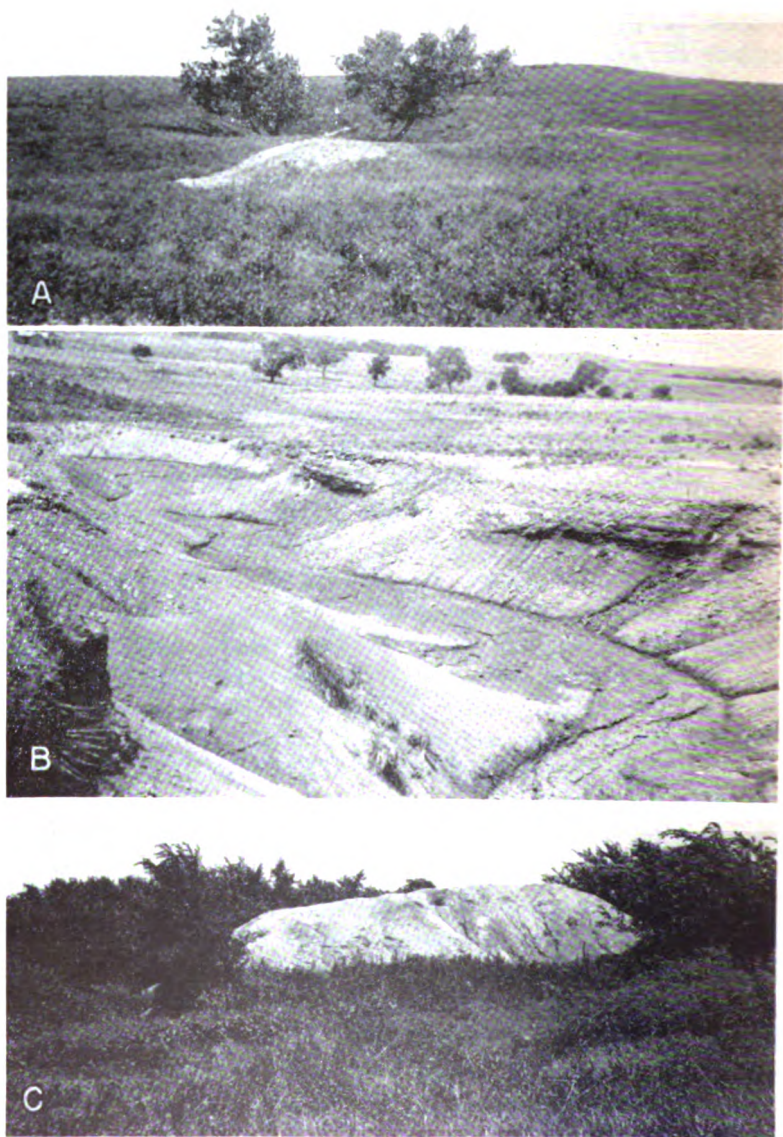


PLATE 3. Lignite mines and outcrop. **A**, Mine dump of only known lignite mine in Clay County. Portal of mine in depression flanked by trees. Channel Dakota sandstone marks horizon. **B**, Lignite outcrop (dark band) in ravine southwest of Elmo in sec. 24, T. 16 S., R. 1 E., Dickinson County. **C**, Mine dump 3 miles east of Jewell in sec. 34, T. 4 S., R. 7 W., Jewell County. The mine is 160 feet deep and the lignite from 30 to 36 inches thick.

formation. Without doubt the lignite seen was not the seam that was mined formerly. Mr. La Barge, an old resident of Aurora, reported to me that coal was mined south of Aurora more than 60 years ago and that he as a youngster helped his father haul some of the mined coal away in partial payment for certain moneys which the owner of the mine owed Mr. La Barge's father. Because of the gentle slopes that prevail in this part of Cloud County and the excessive slumping found almost everywhere where erosion has caused gullies, outcrops of lignite are extremely difficult to find in the Aurora area.

West Pipe Creek mining district.—A coal mine was also reported to me by Mr. Will Callahan who lives on a farm in the NW $\frac{1}{4}$ sec. 12, T. 8 S., R. 3 W. This mine is about 1 $\frac{1}{4}$ miles west and 1 mile north of Callahan's house and is 0.35 mile west and 0.15 mile south of the NE cor. sec. 3, T. 8 S., R. 3 W. When seen the remains of the mine, a spot of mine debris worn down to the level of the surrounding surface, was in the midst of an oats field and never would have been found except for the help of a nearby farmer and a knowledge of the exact location. No information was obtained regarding the mine except that the coal was last mined more than 50 years ago and that much water was encountered in the mine.

Production.—The coal at Minersville was probably the first lignite mined in central Kansas. As reported by Wing (1930, p. 43) mining probably started in 1855. Mr. D. Curtis, now living where Minersville formerly was located and whose father settled there in 1872, related to me that mining at Minersville was in full progress by 1872. Data on coal production are incomplete. The first coal officially reported mined was for 1875 when 500 tons of lignite were produced. Three years later production had reached 10,000 tons and in 1884, 16,000 tons of coal were mined (if the

TABLE 7.—Published lignite production data for Cloud County, Kansas

Year	Tons	Year	Tons	Year	Tons
1875—	500	1891—	7,040	1901—	8,876
1878—	4,000	1893—	3,588	1902—	5,561
1880—	1,000	1894—	3,700	1936—	670
1883—	1,333	1895—	5,000	1937—	50
1884—	16,000	1896—	5,500	1938—	50
1885—	4,118	1897—	2,800	1939—	50
1887—	8,000	1898—	400	1940—	50
1889—	7,313	1899—	6,146		
1890—	6,800	1900—	7,208	Total	130,753

TABLE 8.—*Marginal lignite reserve lands and tonnage in Cloud County, Kansas*

Mining district	Location	Thickness, inches	Reserves, tons*
Minersville	1, 2, 3-5-3W	12	1,700,000
Concordia	34-6-4W	12	900,000
Glasco	10-8-4W	12	900,000
Aurora	23, 26-7-2W	12	900,000
West Pipe Creek	12-8-3W	12	900,000
Total			5,300,000
Production			130,753
Reserves			5,200,000

* Reserves estimates are stated to three significant figures or less.

coal sold at \$2.50 a ton, the prevailing price at that time and the published value \$40,000 is correct). Production data are given in Table 7 for the years beginning with 1875. It will be noted that no tonnage is listed for 1936 to 1940. It is not to be presumed that no coal was mined in Cloud County during that period or in the other years for which no data are available. On the basis of published data Cloud County produced a minimum of 130,753 tons of lignite (Table 7).

Reserves.—Since all the lignite mined and known to occur in the county is less than 3 feet thick all reserve lignites of Cloud County are classified as marginal coal reserves. Furthermore, a thickness of 1 foot was considered as the average thickness of the original coal reserves since lignite of a lesser thickness would hardly have been mined by shafting or drifting methods. It is estimated that prior to mining there was in Cloud County approximately a minimum of 5,300,000 tons of coal of 1 foot thickness and that the reserves as of June 1, 1950, amount to 5,200,000 tons. Coal reserves for the various mining districts in Cloud County are recorded in Table 8.

DICKINSON COUNTY

Elmo area.—No coal or lignite has been reported to occur or to have been mined in Dickinson County. However, 3 miles south and from 1½ to 5 miles west of Elmo (Fig. 8) lignite is exposed in several ravines. The best outcrop is in the SW cor. SE¼ sec. 24, T. 16 S., R. 1 E. where the lignite, 22 inches thick, is exposed in the sides of a short ravine just north of the east-west section-line road (Pl. 3B). Beneath the lignite is a dark-

gray to blackish clay shale that contains numerous and large well-developed selenite crystals and pieces of pyritized logs. Small gypsum veins cut the upper part of the shale, of which 7 to 10 feet is exposed. Overlying the lignite is 48 inches of silty shale or light-cream to yellowish siltstone, the lower 30 inches of which is thin-bedded and the upper 18 inches made up of layers 1 to 2 inches thick. The entire unit tends to weather down into small fragments or chipstones. The lignite dips westward. The coal is to be seen again south of the east-west section-line road in sec. 25 where it ranges in thickness from a featheredge to 30 inches. A mile east and about 0.2 mile south of this road, in sec. 8, T. 16 S., R. 2 E., the lignite seam is 8 inches thick. At this outcrop the coal is overlain by 3 to 4 feet of gray shale which is capped by a 3-inch sandstone. A fourth exposure of the coal is in

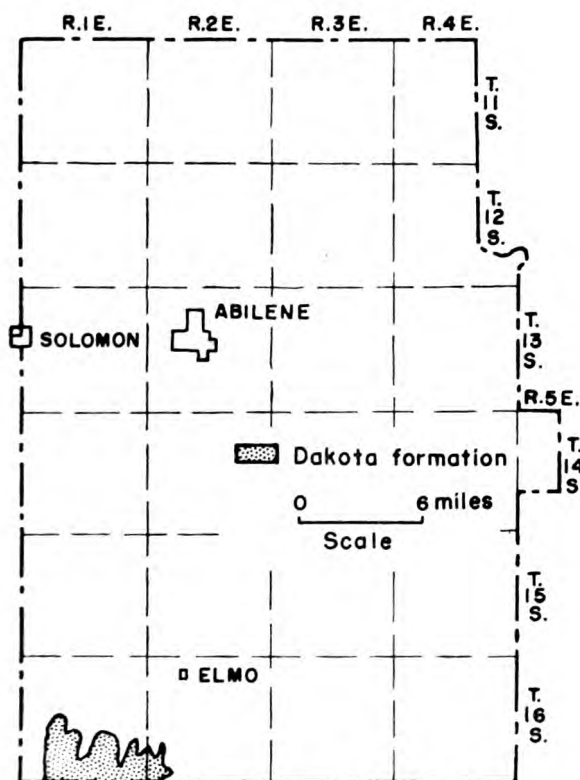


FIG. 8.—Map of Dickinson County, Kansas, showing distribution of the Dakota formation.

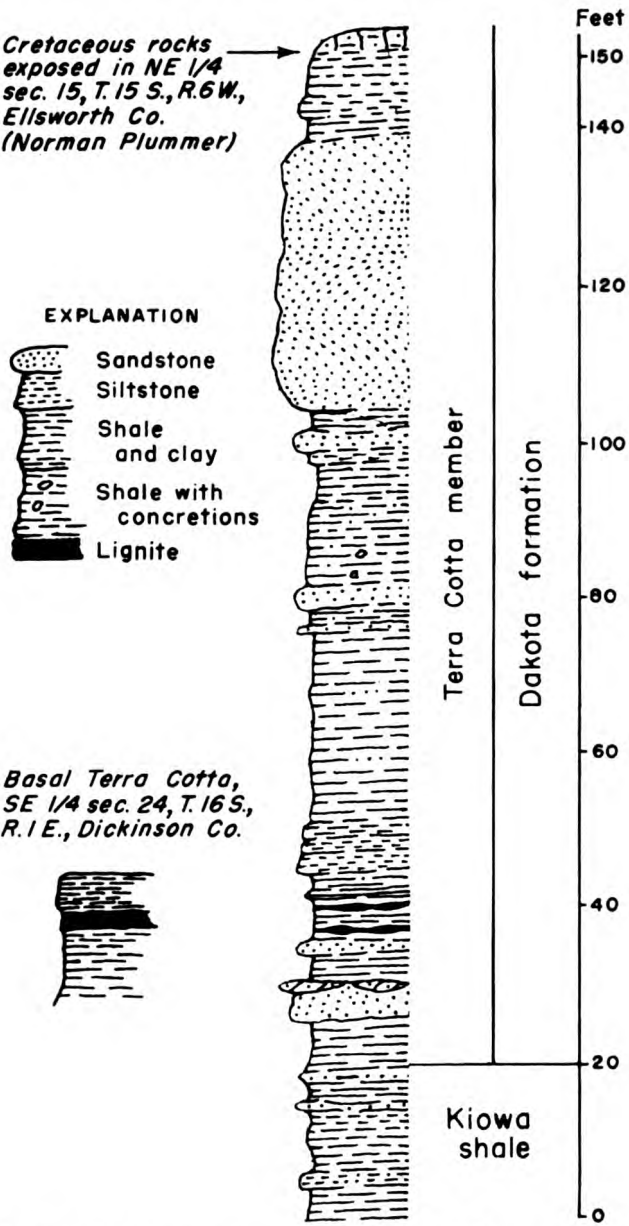


FIG. 9.—Stratigraphic sections measured in Dickinson and Ellsworth Counties, Kansas, showing the position of the lignite in the Terra Cotta member of the Dakota formation.

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the NW cor. NE $\frac{1}{4}$ sec. 27, T. 16 S., R. 1 E., approximately 2 $\frac{1}{4}$ miles west of the first outcrop. At this easternmost outcrop the coal is associated with black shale 18 to 24 inches thick. The lignite zone rests on 5 feet of gray shale which lies on top of a thin-bedded limy siltstone that weathers to chipstones and small sheet or platelike fragments. The overlying rock is soft white to iron-stained sandstone 5 or more feet thick (Fig. 9).

Stratigraphic position of the lignite.—The Dickinson County lignite differs from that in the other counties described in this report in that it does not occur in the upper part of the Dakota formation. The lignite is either in the basal part (Terra Cotta member) of the Dakota formation or is in the upper part of the Kiowa shale. It is not always possible in the field to distinguish with certainty the base of the Terra Cotta clay member of the Dakota formation from the upper part of the Kiowa shale. According to Plummer and Romary (1942, pp. 331-332) differentiation between the two stratigraphic units can be made only by ceramic and other tests that show the mineralogic characteristics of the two rock units. Permian strata crop out no more than 1 mile east of the coal exposures and typical Dakota channel sandstones cap the much higher surrounding hills to the west of the coal localities. Plummer (personal communication) is of the opinion that the coal horizon is in the Terra Cotta member of the Dakota formation (so classified here). Similar lower Dakota formation lignite has been encountered in test holes drilled on the flood plain of Republican River several miles north of Concordia in Cloud County. Plummer (Moore and others, 1951, p. 26) also measured a section in Ellsworth County in which lignite occurs in the lower part of the Terra Cotta member (Fig. 9).

Proximate analysis.—A sample of the coal collected in sec. 24, T. 16 S., R. 1 E. was analyzed. Table 2 shows that the Dickinson County sample has by far the highest ash content and the lowest B.t.u. value of all the samples analyzed. It should be noted that the coal has been exposed for a very long time and even though much of the face of the coal was removed before taking the sample, no real typical or good sample could be obtained.

Reserves.—No more than 160 acres of land can be classified as reserve coal land in secs. 24 and 25. On the basis of the coal averaging 20 inches in thickness it is estimated that the 160 acres contain approximately 500,000 tons of marginal lignite reserves.

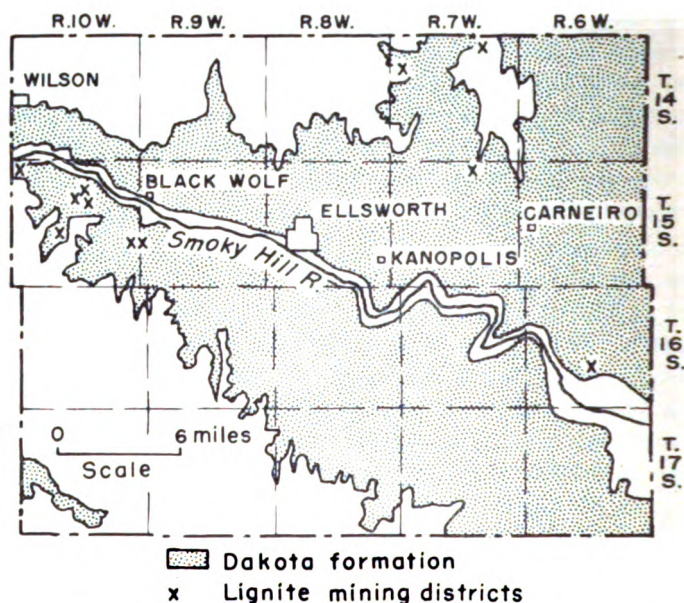


FIG. 10.—Map of Ellsworth County, Kansas, showing distribution of the Dakota formation and the location of lignite mining districts.

As far as is known no lignite has been produced in Dickinson County.

ELLSWORTH COUNTY

The Dakota formation is the dominant bedrock in Ellsworth County and is found in each of the county's 20 townships (Fig. 10). As reported by Saunders (1873, pp. 389-390) who probably made the first chemical analysis of the Kansas Cretaceous lignite, lignite was mined along Wilson Creek, a south-flowing tributary to Smoky Hill River, just east of Wilson a few years before 1872. The coal in Ellsworth County where mined ranged in thickness from 12 to 36 inches and was in all respects similar to the lignite mined elsewhere in the other Cretaceous coal-bearing counties of central Kansas. The mines were chiefly of the shaft and drift or slope type although some stripping was done. The underground mines were worked on the longwall system. Several seams of coal, at some places five or six, occur in the upper part of the Dakota formation. In 1895 two coal seams were reported being mined (Brown, 1896, p. 65) 3 miles south of Wilson.

All the mines, most of which were worked only during the winter months, were small and employed no more than three to a dozen or so men. The prevailing selling price of the coal was \$3 to \$3.25 a ton. No coal has been reported mined in Ellsworth County since 1902. The coal was used primarily for heating houses but some was used to burn lime (Gray, 1874, p. 142) and some to fire railroad locomotives (Hutchinson, 1871, p. 63; Anonymous, 1951, p. 209; Malin, personal communication). The lignite was mined in at least five localities within the county and is known to occur at several other places (Fig. 10).

Coal Creek-Smoky Hill River mining district.—One of the important, if not the most important, of the mining districts in the county was along Smoky Hill River and its north-flowing tributaries about 3 miles due south of Wilson in the northwestern part of the county. This mining district extended westward into adjacent Russell County (Fig. 11) where it continued along Coal Creek (see Russell County). The coal south of Wilson is found in the SW cor. sec. 31, T. 14 S., R. 10 W. and in the NW $\frac{1}{4}$ sec. 6, T. 15 S., R. 10 W. The coal crops out and the mine dumps follow the steep slopes of a short unnamed north-south gulch headed into Smoky Hill River Valley (Plate 4B). Most of the mines were on the west- or east-facing slope of the rock spur whose west and also west-facing slopes are in Russell County. Some of the mines in later years extended entirely across the rock spur, a distance of approximately 1,000 feet, and had their portals in one county and their exits in the other county. Evidences of six mines were noted in the two Ellsworth County sections. In 1890 the I. H. Baldrige mine was a double drift mine consisting of 2 mines running parallel to each other and 40 feet apart. One of the mines was used as an inlet and the other as the outlet. The coal was mined on the longwall system and rooms branched to the right of one mine and to the left of the other so that the ventilation in the mines was very good (Stewart, 1891, pp. 27-29).

The lignite crops out at a number of places in the two sections. A section measured (Fig. 4) in the gulch in sec. 6 shows the coal to be 20 inches thick and lying between two siltstones, the upper one of which is 8 inches thick and the lower one 24 inches thick. At this locality four other coal seams from 2 to 5 inches thick occur within a zone of shales and siltstones 12 feet thick (Pl. 4A). According to the reports of the coal mine inspectors the mined

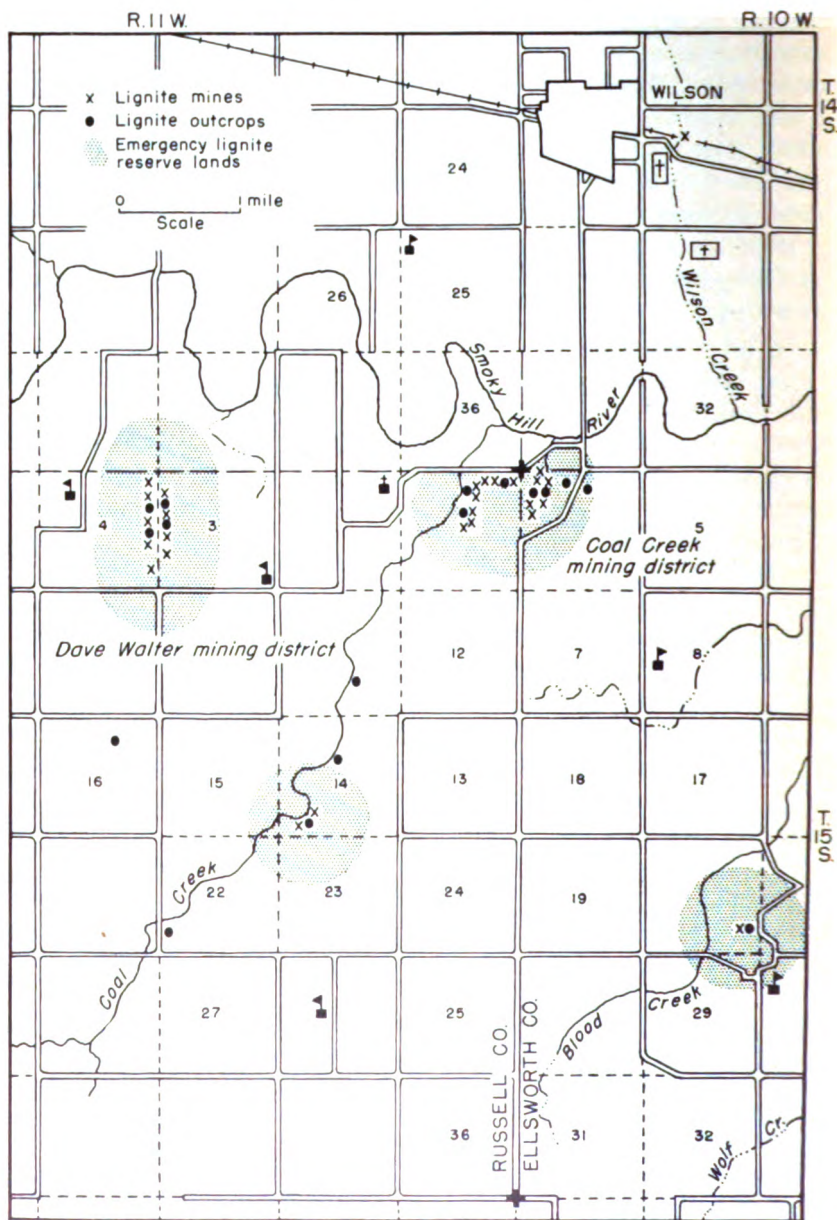


FIG. 11.—Map of the Coal Creek-Smoky Hill River lignite mining district, Ellsworth and Russell Counties, Kansas, showing location of mines and marginal lignite reserve areas. On map read "marginal" in place of "emergency" lignite reserve lands.

coal ranged in thickness from about 8 to 20 inches. About $1\frac{1}{2}$ miles south of these mines was another mine, the Vandine (Brown, 1896, p. 65) which according to the report was in operation in 1895, employed five men, and produced 600 tons of coal. A search for this mine was unsuccessful and no one in the neighborhood knew of its existence. Another mine not seen by me is along Wilson Creek just east of Wilson on what was then the Kansas Pacific Railroad (now the Union Pacific Railroad). It was from this mine that the first lignite coal was sampled and analyzed (Saunders, 1873, pp. 389-390; 1896, pp. 32-33). A special search for this mine was made on April 26, 1951, without discovering its location. Nowhere within a radius of one-half mile from where the Union Pacific Railroad crosses Wilson Creek is there any indication of a former mine or any trace of the Dakota formation. All material seen is sand and silt which presumably conceals the former mine site if the mine really existed. It may be that the Wilson Creek mine along the Kansas Pacific Railroad may actually have been several miles south of the railroad for in a business directory entitled St. Louis to Denver, for 1870 and published (presumably in 1870) by N. W. Josselyn and Co. of St. Louis is found the following excerpt (Anonymous, 1951, p. 209):

"Wilsons Station. A 'wood and water' station, 239 miles from State line. . . Coal is found about 5 miles south of here and is being worked but it is not of a very good quality."

Apparently a better grade of coal must have been mined in the Wilson area if a statement made in connection with the town of Ellsworth has any merit. According to the agent who recorded his candid impressions in the business directory just cited "A vein of anthracite coal is being mined near the western boundary line of the county [Ellsworth], and is delivered at the railroad for \$8 per ton."

Coal samples 1, 2, and 3 were collected in sec. 6, T. 15 S., R. 10 W. Proximate analyses of these samples are presented in Table 2.

Blood Creek mining district.—Lignite coal occurs in secs. 10, 15, 16, and 20, T. 15 S., R. 10 W. between 5 and 7 miles southeast of Wilson. In the SE $\frac{1}{4}$ sec. 20 a 12-inch lignite seam showed evidence of having been mined by stripping the coal from a small bench or shoulder at a point 15 feet above creek level and about 0.2 of a mile west of the north-south section-line road. The coal

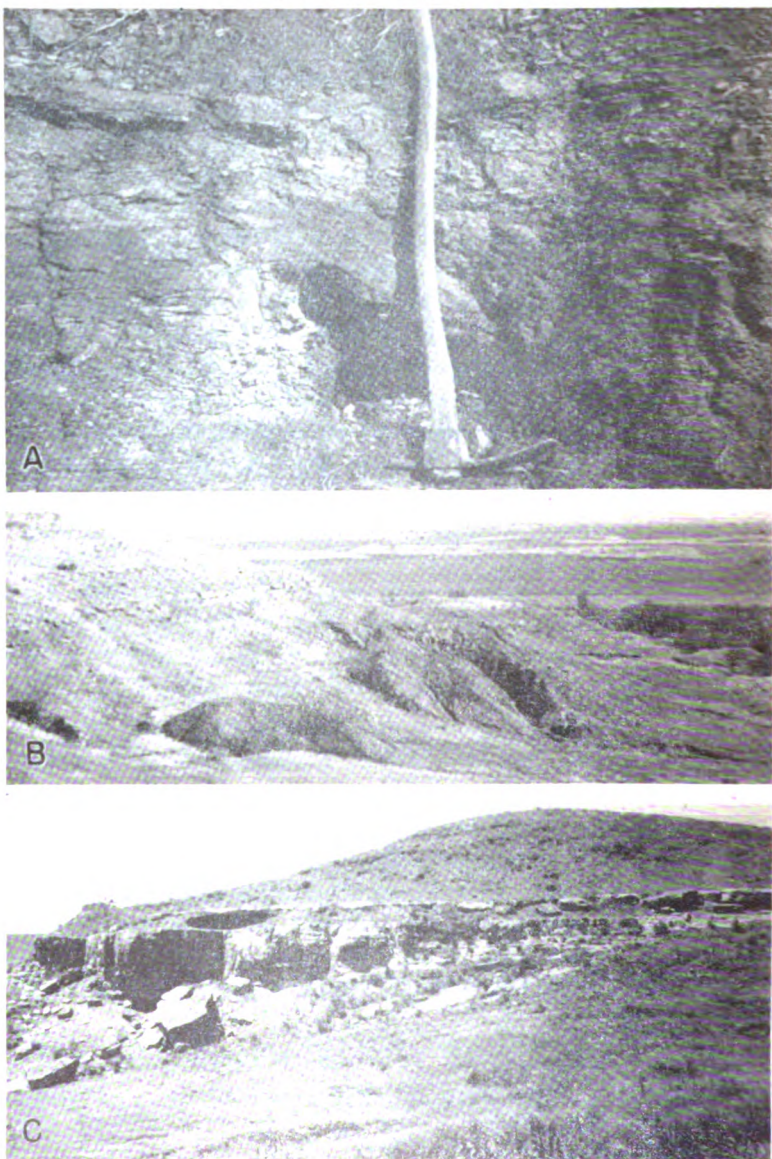


PLATE 4. Smoky Hill River-Coal Creek mining district, Ellsworth County, and mine in Lincoln County. **A.** Outcrop of lignite, sec. 6, T. 15 S., R. 10 W. Adz at base of lignite, top of seam at top of dark band above horizontal sample drill hole. Lignite 17 inches thick overlain by $7\frac{1}{2}$ inches of laminated lignitic clay shale. **B.** Mine dumps just north of outcrop shown in **A.** Smoky Hill Valley in upper background. **C.** Mine portal between two massive silt-stones, the lower one of which is 10 feet thick. The mine is in the East Elkhorn Creek mining district in sec. 32, T. 13 S., R. 7 W., Lincoln County.

is overlain by a soft white sandstone 1 to several feet thick and is underlain by white and yellowish clay. In the NW cor. sec. 15, 12 inches of lignite crops out 2 feet below the top of the Dakota formation which here is represented by 6 inches of iron-stained sandstone. Above the sandstone is typical Graneros black fissile shale containing many well-developed selenite crystals. Between the sandstone and the coal is 2 feet of black fissile shale much like the Graneros shale. The measured section (Fig. 4) also shows 10 feet of black fissile shale beneath the coal, 9 to 12 inches of dirty-gray ripple-marked siltstone, and about 15 feet of white and yellow-brown clay. This same seam crops out in the bluffs in the SW cor. sec. 10 and NE cor. sec. 16. Approximately 1 mile to the east in the SE cor. sec. 10 and NW cor. sec. 15 the coal contains a large amount of clay and is as much as 30 inches thick. It underlies a 6-foot siltstone, the lower part of which is white and in the form of a single bed, whereas the remaining upper 5 feet is thin-bedded. Above the siltstone is at least 12 feet of soft white siltstone which has a tendency to weather into chipstones. Some lignite was mined here by stripping along the outcrop. The coal horizon is also exposed in the bluffs on the west side of the gulch several hundred feet wide and opposite the coal outcrop. The stratigraphic relationships are somewhat different on the west side of the gulch from that seen on its east side. The coal zone is much more shaly and silty, shows cross-bedding at a high angle, and has a thickness of 10 feet. The overlying siltstone is only 10 to 12 inches thick and is overlain by 10 feet of dark-gray clay shale above which is sandstone 5 to 6 feet thick. In the SW cor. sec. 10 the coal is essentially pure lignite and is 12 inches thick.

Black Wolf area.—Lignite also is found in sec. 19, T. 15 S., R. 9 W., and in sec. 24, T. 15 S., R. 10 W., from 1½ to 2 miles southwest of Black Wolf. The lignite occurs within a dark-gray to black fissile shale. Rapid changes in the character of the lignite and adjacent rocks are common and the entire sequence of strata shows a pronounced dip (Pl. 5A). At about the SE cor. SW¼ NW¼ sec. 19, T. 15 S., R. 9 W., the lignite zone (Pl. 5B) consists of a top layer of lignite 12 inches thick below which is a 3-inch pure white clay or kaolin resting on a 3-inch layer of black powdery material overlying a lignitic silt to clay 17 inches thick. A gray siltstone (the uppermost part of the Dakota formation here)

15 inches thick is found 7 feet 7 inches above the lignite. Below the lignitic zone is clay containing an interbedded siltstone. The detailed measured section is shown in Figure 4. According to Whitla (1940, p. 37) the lignite ranges from 13 to 18 inches of pure lignite to a zone of alternating bands of lignite and white sand to a carbonaceous clay. Plummer (Whitla, 1940, p. 38) reports 5 feet of clayey lignite, 3 feet of which probably would burn, in the same area. No record of lignite having been mined in the Black Wolf area is known.

Ellsworth area.—A lignitic clay 3 to 4 inches thick was observed in a road cut south of Oxide Creek in the SW cor. SE $\frac{1}{4}$ sec. 33, T. 15 S., R. 8 W., about 2 $\frac{1}{2}$ miles southeast of Ellsworth. The impure coal is 37 feet below a massive cross-bedded sandstone which marks the top of the Dakota formation. A coal 3 feet thick was reported to me to have been penetrated at a depth of about 100 feet in a test well drilled for water at the municipal airport in the SE $\frac{1}{4}$ sec. 16, T. 15 S., R. 8 W. This coal, however, upon further investigation proved to be but a few inches thick and according to the geology of the area is in the basal part of the Dakota formation. No coal has been produced in the immediate Ellsworth area.

Venango or Kanopolis Dam mining district.—A 26-inch lignite seam is reported to have been mined at or near the former town of Venango in the early 1880's (Sims, 1883, p. 233). Venango was located in the southern part of Ellsworth County in the NW $\frac{1}{4}$ sec. 27, T. 16 S., R. 6 W., just east of the north end of the Kanopolis Dam. Search for the mine was without success. A man operating a large earth-removing shovel near the dam informed me at the time of my visit on July 16, 1947, that he plowed up lignite near the present spillway of the dam (about 1 $\frac{1}{2}$ miles south of the former townsite). According to this individual there were two seams of lignite, one of which was 2 inches thick and the other 12 inches. The lignite reported mined in 1880 apparently is related to the 12-inch seam. No production figures are available for the Venango mining district.

Carneiro mining district.—Lignite was mined about 3 miles north and 2 to 2 $\frac{1}{2}$ miles west of Carneiro in the NW $\frac{1}{4}$ sec. 2, T. 15 S., R. 7 W. Evidences of 12 mines, mainly drift mines and one or two strip mines, are still to be seen on both sides of a small north-flowing stream. The coal, according to Mr. W. W.

Shoemaker, a resident of the area and one who helped mine the coal 60 to 65 years ago, was from 12 to 16 inches thick and lay at an average depth of 20 feet. According to him 25 to 30 men were engaged in getting the coal. Entries extended into the hillsides for several hundred feet. Apparently some of the coal was mined by stripping (Whitla, 1940, p. 38). It is impossible in the field to tell the exact stratigraphic horizon at which the lignite seam occurred. A dark iron-stained sandstone crops out 15 to 20 feet above the coal dump heap and forms the surface rock in this vicinity. The coal sold for \$4.00 a ton and was hauled as far as Wilson, 25 miles distant. Lignite 1.5 feet thick crops out in the SW $\frac{1}{4}$ sec. 23, T. 14 S., R. 7 W., about 2 miles due north of the mines just referred to. This lignite occurs 5 feet below the top of the Dakota formation. Four miles still farther north in the SE $\frac{1}{4}$ sec. 2, T. 14 S., R. 7 W., a very short distance south of the Ellsworth-Lincoln County line, are the Crossgrove and Whitehead drift mines. Mr. Shoemaker also helped mine the coal here which according to him measured 12 inches in thickness, although pockets of 3-foot coal were encountered and mined.

East Elkhorn Creek mining district.—Coal was obtained from several drift mines in secs. 7 and 8, T. 14 S., R. 7 W., about 1 $\frac{1}{2}$ miles south of the Ellsworth-Lincoln County line. Mr. Henry Briand who lives in sec. 8 stated to me that the coal was mined 65 years ago and as late as about 1917. The coal ranged from 16 to 24 inches in thickness and was found at a depth of 75 feet. The coal was obtained by drifting into the hillsides and was mined by 12 to 15 men during the fall and winter months. The coal sold for \$3.00 a ton and was hauled by the wagonload to Lincoln and Ellsworth, towns 12 and 15 miles distant, respectively. A royalty of 25 cents per ton was paid to the Union Pacific Railroad, owner of the mineral rights.

Buff-Cow Creeks area.—Coal was reported to have been mined in T. 14 S., R. 9 W., east of Wilson and northwest of Ellsworth before but not after 1875 (Gray, 1875, p. 269) in veins from 7 to 24 inches thick and at a depth of 45 feet. No evidence of the mines was seen nor did people of the community know of their existence. A thin lignite seam 2 to 6 inches thick was observed in the south bank of a small stream in the SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 23, T. 14 S., R. 9 W.

TABLE 9.—Published lignite production data for Ellsworth County, Kansas

Year	Tons	Year	Tons	Year	Tons
1883	3,450	1890	5,000	1897	1,427
1884	3,450	1891	6,048	1898	96
1885	3,308	1892	.....	1899	195
1886	.....	1893	2,400	1900	2,510
1887	3,000	1894	2,100	1901	2,730
1888	.....	1895	2,000	1902	20
1889	5,035	1896	2,000	Total	41,229

Production.—The first year for which lignite production is officially listed is 1883 when 3,450 tons of coal was reported mined. It is clear that coal was mined much earlier but apparently only in small amounts. The last year for which production is listed is 1902 when only 20 tons of lignite was reported mined. A minimum total of 41,229 tons of lignite is recorded for Ellsworth County (Table 9).

Reserves.—There are no known lignite deposits in the county having a thickness of 3 feet. All reserves listed here therefore are considered marginal coal reserves. Before mining Ellsworth County had an original reserve of approximately 8,800,000 tons of coal. Of this amount a minimum of 41,229 tons is recorded as having been mined, leaving thus in the ground as of June 1950, a total of about 8,800,000 tons of lignite coal. Table 10 gives data relative to the reserve coals of Ellsworth County by mining districts.

HODGEMAN AND FORD COUNTIES

Point of Rocks mining district.—A narrow strip (1 to 4 miles wide) of the Dakota formation crops out along Buckner and Sawlog Creeks in the southeastern part of Hodgeman County and to a small extent in adjoining Ford County (Fig. 12). Lignite has been reported mined at two localities in Hodgeman County. The southernmost mine was on the west bank of a north-flowing creek tributary to Sawlog Creek in the NW¼ sec. 18, T. 24 S., R. 22 W. The coal underlies a thick massive sandstone which at this locality forms the caprock of the Dakota formation. The coal is supposed to have been 3 feet thick, was mined 50 years or so ago, and burned with such an intense heat that the grates of the stoves usually were burned through in a short time. All evidence of the mine, a drift mine, is obliterated as the creek has completely buried the mine portal and mining debris under at

TABLE 10.—Marginal lignite reserve lands and tonnage in Ellsworth County, Kansas

Mining district	Location	Acres	Thickness, inches	Reserves, tons*
Coal Creek-Smoky Hill River	6-15-10W	502.66	20	1,500,000
Blood Creek	10, 15, 16, 20-15-10W	1,507.98	12	2,600,000
Black Wolf	19-15-9W	502.66	12	900,000
	24-15-10W			
Carneiro	2-15-7W	502.66	12	900,000
	23-14-7W			900,000
East Elkhorn Creek	7, 8-14-7W	502.66	20	1,500,000
Venago-Kanopolis Dam	27-16-6W			500,000
Total				8,800,000
Production				41,229
Reserves				8,800,000

* Reserves estimates are stated to three significant figures or less.

least 15 feet of sand, silt, and mud, a condition repeated at the more northerly mine on the south bank of Sawlog Creek, $2\frac{1}{2}$ miles farther north and 2 miles east in the SW $\frac{1}{4}$ sec. 33, T. 23 S., R. 22 W. Although search was made for outcrops of lignite in Hodgeman County, no coal was seen. About 1 mile east of Hanston, also known as Olney, in the SW $\frac{1}{4}$ sec. 24 and the NW $\frac{1}{4}$ sec. 25, T. 22 S., R. 22 W., the upper part of the Dakota formation is well exposed. Plummer (personal communication) reported the presence of thin lignite at this locality but at the time of my visit in July 1948 I found only two horizons of black fatty clay where normally elsewhere the lignite is known to occur.

Alleged lignite area.—Between Sawlog and Whitewoman Creeks south of a promontory known locally as Point of Rocks and extending a short distance into Ford County is an area reported to be underlain by lignite. The presence of the lignite is reported from numerous drill and seismic holes penetrating to depths of 63 to more than 100 feet in the search for oil and gas in Hodgeman and Ford Counties. The coal is asserted to range in thickness from 3 to 12 feet. A sample of the coal given me and reported to have come from one of the test holes is a black, brittle, shiny pure coal which may be classified as a high-grade black lignite. According to the information at hand no coal is reported to occur west of Sawlog Creek, a fact apparently corroborated by field evidence and the stratigraphic section measured by me in the SE $\frac{1}{4}$ sec. 13, T. 24 S., R. 23 W. (Fig. 13). The

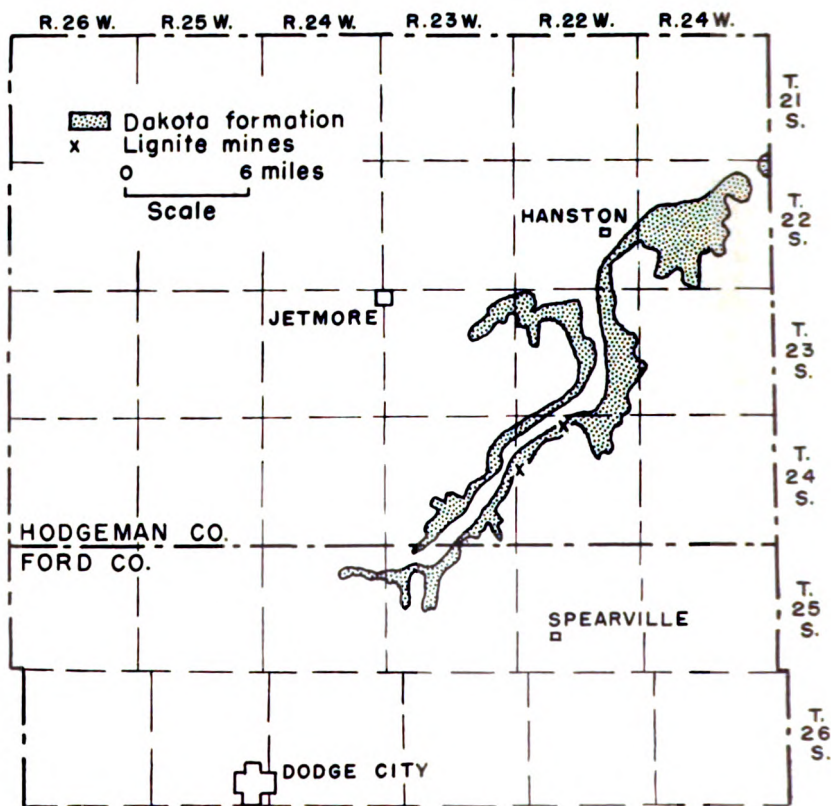


FIG. 12.—Map of Hodgeman and northern Ford Counties, Kansas, showing distribution of the Dakota formation and the location of the two lignite mines in Hodgeman County.

coal on the basis of the test holes thus far drilled is thought to underlie a northeast-southwest trending area approximately 2 miles wide and 7 miles long or a total of 14 square miles. The maximum thickness of coal reported is 12 feet with most of the coal along the margins of the field as outlined by the test holes measuring 3 feet. The exact limits of the alleged field which extends southward into Ford County is not known. A coal sample submitted to the State Geological Survey and the samples of coal given to me subsequently at the time of my visit to the area are similar to the black lignite cropping out along the bluffs of Smoky Hill River in the NE $\frac{1}{4}$ sec. 6, T. 15 S., R. 14 W. about 7 miles south and 3 miles west of Russell in Russell County.

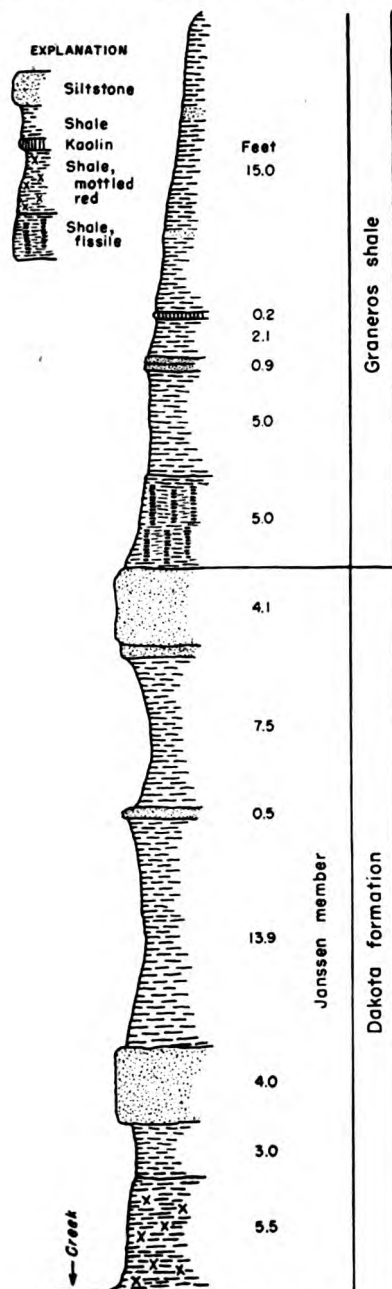


FIG. 13.—Stratigraphic section of the Dakota formation measured in sec. 13, T. 24 S., R. 22 W., Hodgeman County, Kansas.

Alleged lignite reserves.—No outcrops of the lignite were seen in the field and knowledge of the coal, its thickness, and distribution are known only from reported information based upon drilled test holes. The presence of the coal is accepted and is based on the veracity of the reports and suggested by broad geologic field relationships. The coal reserves are therefore classified as alleged lignite reserves in contradistinction to marginal, potential, or inferred reserves, all of which are supported by more data. Computation of the alleged coal reserves, based on an isopachous map drawn from data furnished me and giving the thicknesses of the lignite in the various test holes, indicates that the alleged Hodgeman-Ford County coal reserve lands contain approximately 105,000,000 tons of lignite.

JEWELL COUNTY

Jewell County is entirely underlain by Cretaceous strata but nowhere, with the exception of a very small area along Buffalo Creek in sec. 13, T. 5 S., R. 6 W., is the Dakota or lignite-bearing formation exposed (Fig. 14). Mudge (Gray, 1875, p. 298) as early as 1874 reported surface coal from 15 to 20 inches thick was being used locally in the southeastern corner of the county and in the same year T. B. Carpenter, Secretary of the Jewell County Agricultural Society, also stated that coal existed but not in paying quantity.

Omio mining district.—There are two and possibly three places in Jewell County where lignite was formerly mined. The first of these is in the SE $\frac{1}{4}$ sec. 35, T. 3 S., R. 6 W., at a place where formerly the town of Omio was located. With the coming of the railroad in 1887 the town of Omio was moved 3 miles to the north to become the town of Formosa. The Omio coal was discovered accidentally by G. W. Wade in drilling a water well to a depth of about 150 feet (Findley, 1888, p. 8). The coal encountered measured 3 or more feet thick, a figure both published and given to me by a number of people of the Omio neighborhood. According to Mrs. Tom Shedden, who came to Omio in 1882, talk of mining was then in progress and shortly after that a local mining company was organized. By 1886 or earlier coal was being mined. Eight shaft mines supposedly operated in this district. The main mine was on the south bank of a creek about 100 feet west of the present north-south road to Formosa. A

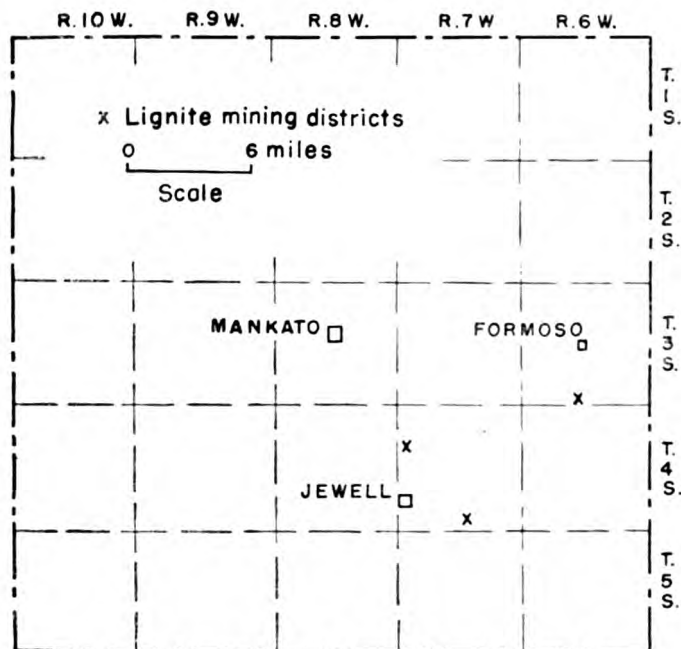


FIG. 14.—Map of Jewell County, Kansas, showing location of lignite mining districts.

second mine was located north of the creek about 300 feet north of the bridge and 200 feet west of the Formosa road. This shaft mine is evidenced today by a circular depression, now almost completely filled, 10 feet in diameter. Evidences of other near-by mines are to be seen by the presence of mining debris now leveled down to ground level and scattered among the cultivated fields. The mines encountered a large amount of water which was so salty that when pumped out and drained into the pools of the surrounding marsh killed all the fish in the ponds and streams. Mrs. Shedden informed me that in the early years of mining the mines were operated day and night and that a large amount of lignite which sold for about \$3.00 a ton was produced. Mining in the Omio district came to an end about 1900.

Jewell mining district.—The other Jewell County coal mines now represented by large dump piles and an old shaft (Pl. 3C) are in the NW $\frac{1}{4}$ sec. 34, T. 4 S., R. 7 W., about 5 $\frac{1}{2}$ miles south and a like distance west of the Omio mines. Jewell is practically 3 miles due west of the mines. Like the Omio mines, the lignite

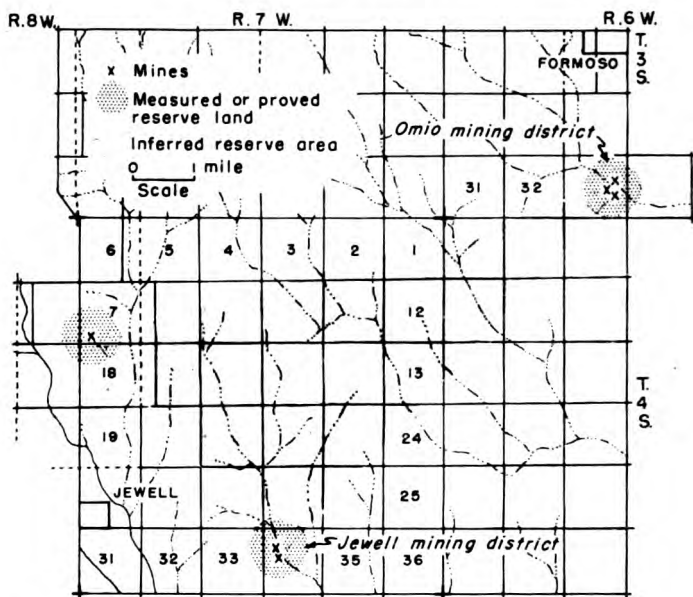


FIG. 15.—Map of part of Jewell County, Kansas, showing lignite mining districts, proved or measured lignite reserve lands, and inferred or potential lignite reserve area.

was discovered while drilling for water. The coal lay at a depth of 160 feet and was from 30 to 36 inches thick. According to published reports a thick hard sandstone overlies the coal. The first of the two mines found in this district was sunk in about 1901. According to the Jewell City Republican in an issue of 1904 a block of coal $36 \times 36 \times 36$ inches and weighing 900 pounds was taken out of the mine by Mr. Smithmeyer, superintendent of the mine. Sometime in April of 1904 a new shaft was started and by September it was connected with the tunnels of the old mine in order to drain mine waters into the old mine. The Jewell mines, known as the Basye and Wallace mines, experienced considerable water trouble and many delays due primarily because of strikes. Advertisements in the Jewell City Republican for 1904 and 1905 were to the effect that the coal was being sold at from \$3.00 to \$4.00 a ton. The mines operated last in about 1907. Mining was done by the longwall method. The mines were without railroad connections although the Missouri Pacific Railroad tracks were only half a mile farther south.

TABLE 11.—Published lignite production data for Jewell County, Kansas

Year	Tons	Year	Tons
1885	800	1902	1,000
1889	800	1905	2,833
1890	400	1906	4,070
		Total	9,963

It is not clear whether coal was mined or encountered at a third locality north of Jewell. According to Casselman (1903, p. 25) the Waconda Oil and Mining Company in 1901 sank a shaft 3 miles north of Jewell to a depth of 165 feet where they found a 32-inch seam of good-quality lignite. Much trouble was encountered in the sinking of this shaft as a vein of quicksand was penetrated that yielded a large amount of salt water. In May 1902 the superintendent of the mine, Mr. Edward Keegan, was accidentally killed by falling 60 feet to the bottom of the shaft. In the same report (Casselman, 1903, p. 20) is a description of the Waconda Coal and Mining Company's No. 1 mine. This mine, however, is 3 miles east of Jewell. The coal reported in mine No. 1 was 34 inches thick. Whether the two reported mines are separate mines, one north and the other east of Jewell or whether the two mentioned mines are really one and the same mine, the one east of Jewell, is not clear. According to Casselman the north mine is reported to have been closed down after the fatal accident in May 1902. The east mine produced about 1,000 tons of coal in 1902 and was last reported as an active mine in 1907. On the basis of thickness of coal, location of mines, production data, and slight differences in the names of the mining companies it is reasonable to assume that there was a mine located north of Jewell and another east of the town.

Production.—Published coal production figures (Table 11) for Jewell County total 9,963 tons. Of this amount 2,000 tons came from the Omio mines and 7,963 tons was produced in the mines east of Jewell which began mining in 1902 at the time when the Omio mines were no longer operating.

Proved or measured reserves.—According to the criteria used by the Fuels Branch of the U.S. Geological Survey an isolated drill hole, mine, or outcrop may be considered to determine an original area of coal extending for a radius of half a mile around the hole, mine, or outcrop. On this basis the original lignite reserves of Jewell County are approximately 7,400,000 tons, a

TABLE 12.—Lignite reserve lands and tonnage in Jewell County, Kansas

Mining district	Location	Thickness, inches	Acres	Original reserve, tons*	Production, tons	Measured reserve, tons*
Omio	35-3-6W	36	502.66	2,600,000	2,000	2,600,000
Jewell East	34-4-7W	30-36	502.66	2,500,000	7,963	2,500,000
Jewell North	7-4-7W	32	502.66	2,300,000	.....	2,300,000
Totals				7,400,000	9,963	7,400,000

* Reserve estimates are stated to three significant figures or less.

figure which might also be used for the reserves of the measured lignite as of June 1, 1950, since the total production is less than 10,000 tons. The estimated reserves are shown by districts in Table 12.

Inferred or potential reserves.—The presence of lignite at approximately the same depth and reported thickness at three separate localities, the statement that the coal is supposed to have been of good quality, and the belief by practically everyone between Omio and Jewell that the coal underlies the area between the two places suggest that the entire 5 by 8 mile triangular area defined by the three occurrences of coal (Fig. 15) is underlain by lignite having an average thickness of at least 16 inches (one-half the reported average thickness at the three tested localities). On this basis Jewell County has a reserve of inferred or potential lignite coal to the extent of about 22,400,000 tons or a grand total of 29,800,000 tons of lignite of all classifications (Table 6).

LINCOLN COUNTY

Of the lignite-bearing counties in Kansas, Lincoln County ranks fourth in production. All the county, with the exception of the alluvium in the major river valleys, is underlain by rocks of Cretaceous age. The Dakota or lignite-bearing formation is the most widespread formation in the county, covering approximately 11 of its 20 townships (Fig. 16). Lignite coal occurs and has been mined in T. 10 S., Rs. 9 and 10 W.; T. 11 S., R. 9 W.; and T. 13 S., Rs. 7 and 8 W. The coal is from 16 to 24 inches thick and where seen in sec. 33, T. 13 S., R. 7 W., lies between two massive sandstones (Pl. 4C).

East Elkhorn Creek mining district.—The best exposure of lignite is in the SW cor. NW¼ sec. 33, and approximately in the Cen. SE¼ sec. 32, T. 13 S., R. 7 W. Both places are about half a mile north of the Lincoln-Ellsworth County line. The coal ob-

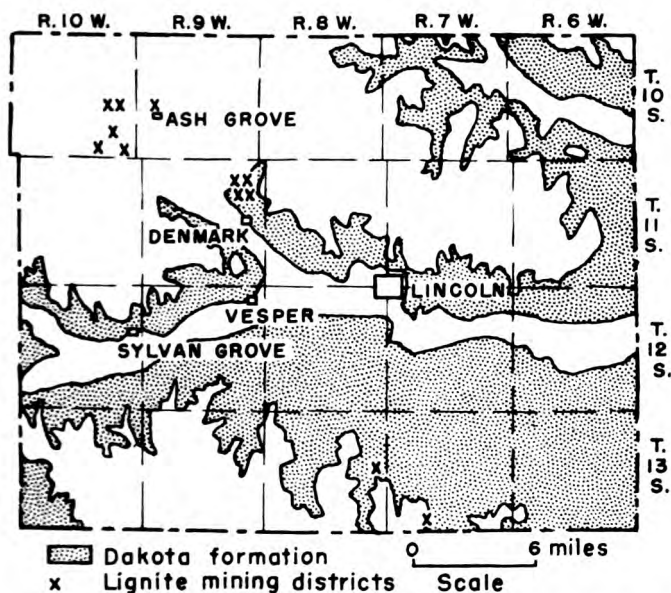


FIG. 16.—Map of Lincoln County, Kansas, showing distribution of the Dakota formation and location of the lignite mining districts.

served in a short deep ravine in the SW cor. NW $\frac{1}{4}$ sec. 33 is 2 feet thick. It is over and underlain by massive siltstone. The lower siltstone is 10 feet thick and is separated from the coal by a 3-inch layer of silty lignitic shale or clay. The overlying siltstone is soft, irregularly bedded, iron-stained, and 6 feet thick. Beneath the underlying siltstone is about 30 feet of gray shale containing siltstones and thin layers of iron-stained sandstone. On top of the 6-foot overlying soft siltstone is a 5-foot dark-gray shale, 12 feet of gray shale with sandstone layers, 4 feet of dark-gray shale containing selenite crystals capped by about 1 foot of brownish ironstone. Immediately above the ironstone is 15 feet of typical Graneros gray shale filled with well-developed selenite crystals. About one-fourth mile farther west and a short distance south in the SE $\frac{1}{4}$ sec. 32 are two abandoned drift mines (Pl. 4C). As reported by Whitla (1940, pp. 45-46) the coal zone between the two massive siltstones is 42 inches thick. The upper siltstone measures 4 feet thick whereas the lower one is 10 feet in thickness. The coal at the entrance to one of the drift mines is 24 inches thick and forms the lower part of the coal horizon; the upper 18 inches is lignitic clay. According to Whitla (1940,

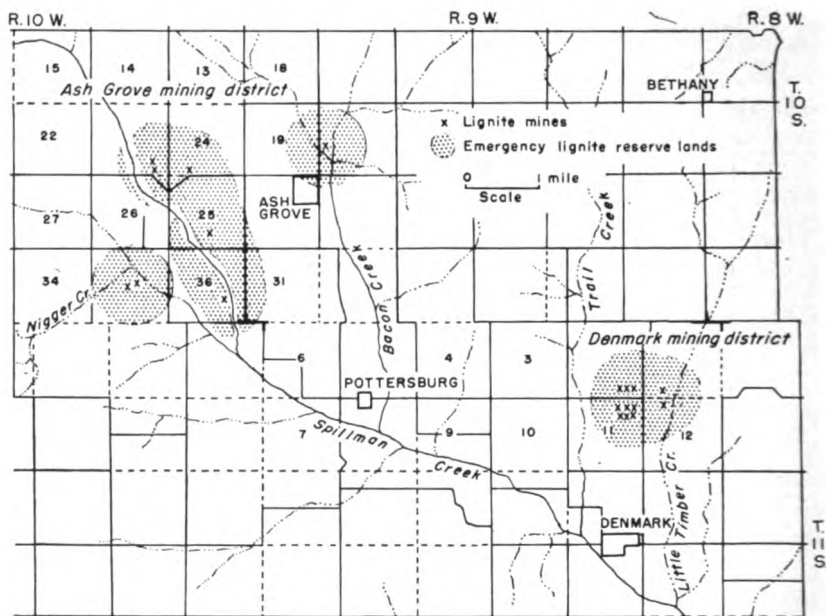


FIG. 17.—Map of the northwestern part of Lincoln County, Kansas, showing the location of lignite mines, mining districts, and marginal lignite reserve lands. On map read “marginal” instead of “emergency” lignite reserve lands.

p. 46), “Ten feet back from the entrance the entire thickness of beds between the two sandstones is lignite.” Proximate analyses of lignite sampled in sec. 33 (No. 13 and 14) are given in Table 2.

West Elkhorn Creek mining district.—About 3 miles northwest of the East Elkhorn Creek mines in the NE¼ sec. 24, T. 13 S., R. 8 W. are the J. Gettes and McDonald mines. These mines are close to West Elkhorn Creek. The mines are drift mines and extend into the hillside slopes just beneath a sandstone or siltstone of variable thickness. No outcrops of lignite were seen anywhere in the vicinity of the mines. Outcrops of rocks of any kind are exceedingly few in the entire section of land in which the mines occur (Pl. 5C). Data on thickness of coal, when, and how much mined are not available.

Ash Grove mining district.—Most of the Lincoln County coal mines are in the northwest part of the county in the area several miles north of Denmark and at Ash Grove and vicinity between

Bacon Creek and South Branch of Spillman Creek (Fig. 17). A shaft mine 55 feet deep was located about one-fourth mile north and one-fourth mile east of the school house and church at the northeast corner of Ash Grove or about at the NE cor. SW $\frac{1}{4}$ sec. 20, T. 10 S., R. 9 W. The coal, according to Mr. J. D. Hayden, a blacksmith at Ash Grove and one of the early coal miners in that community, averaged 15 inches in thickness and was mined chiefly from 1881 to 1896. Ten to 15 men were normally employed at the mine. The mine today is represented by a dump heap 150 to 200 feet in diameter and a filled-in shaft depression about 10 feet in diameter. The coal mined was reported in 1893 as being at Allamead (Gallagher, 1894, p. 59), a town formerly located 2 miles east and half a mile north of Ash Grove. Inquiry and field evidence indicate that no mine ever existed at Allamead and that the only mine known close by was the one just northeast of Ash Grove. The coal mine shaft was located on the N. B. Alley farm and according to Brown (1896, p. 77) 210 tons of coal were mined in 1895 by six men. The shaft opening is situated on a rock terrace which stratigraphically is in the upper part of the Graneros shale. The coal was discovered accidentally in the process of putting down a water well. The coal horizon apparently is in the upper part of the Dakota formation.

Coal 18 to 20 inches thick was mined 2 miles due west of Ash Grove in the SW $\frac{1}{4}$ sec. 24 and in the SE $\frac{1}{4}$ sec. 23, T. 10 S., R. 10 W. The mine in sec. 24 was a shaft mine 60 feet deep whereas the two mines in sec. 23 now represented by dump heaps were drift or slope mines. Another shaft mine was in the SE $\frac{1}{4}$ sec. 25 where the coal was reported to have been 14 to 18 inches thick. Along the north branch of Spillman Creek in the SE $\frac{1}{4}$ sec. 36, T. 10 S., R. 10 W. is evidence of a slope mine close to the creek and about 50 feet below the general upland level. This mine is approximately 1 $\frac{1}{4}$ miles north and 1 $\frac{1}{2}$ miles west of the former townsite of Pottersburgh. Other shaft mines operated about 1895 and before were located in the Cen. sec. 35, T. 10 S., R. 10 W. along South Branch Spillman Creek.

Denmark mining district.—Coal was mined in the SW $\frac{1}{4}$ sec. 1; SE $\frac{1}{4}$ sec. 2; NE $\frac{1}{4}$ sec. 11; NW $\frac{1}{4}$ sec. 12, T. 12 S., R. 9 W., about 2 miles north of Denmark. The coal mined was from 18 to 24 inches thick and was separated into two seams by a thin parting or band of blackjack or lignitic clay. The mines in the Denmark

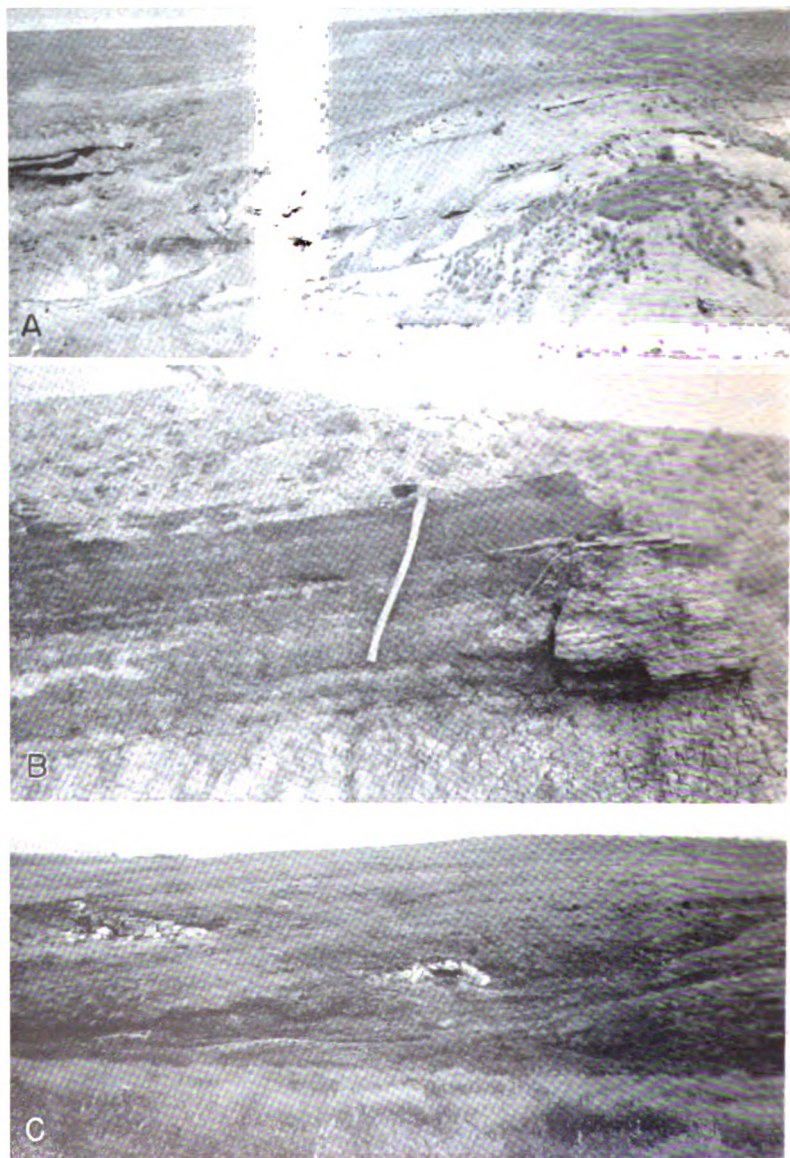


PLATE 5. Wolf Creek area, Ellsworth County, and the Gettes-McDonald mine, Lincoln County. **A**, View showing the dipping nature of the strata exposed in sec. 19, T. 15 S., R. 9 W., southwest of Wolf Creek, Ellsworth County. The lower strata constitute the Dakota formation, the upper rocks belong to the Graneros shale and Greenhorn limestone formations. **B**, Close-up of lignitic zone showing thickness and dip. Upper 12 inches lig-

district were all shaft mines and were from 50 to 60 feet deep. There were at least three mines in sec. 2, six in sec. 11, and one each in secs. 1 and 12.

Other reported mining districts.—Coal was also reported to occur and to have been mined in Madison Township, the southeasternmost township in the county. No mines or evidences of mines or lignite outcrops were seen in this part of the county or are known by residents of the township. A shaft mine 45 feet deep and having a coal seam 22 inches thick was reported (Gallagher, 1894, p. 60) to have been sunk in 1893 at a locality 2 miles north and $1\frac{1}{2}$ miles west of Vesper. Vesper is approximately 7 miles due west of Lincoln. This mine, known as the Andrew Nelson mine, must have been either in the southern part of sec. 26 or in the northern part of sec. 35, T. 11 S., R. 9 W. Since either place is remote from any known coal mines in the county it is more likely that the mine was 2 miles north and half a mile west of Denmark where several coal mines had been worked. L. B. Nelson in 1898 (McGrath, 1899, p. 9) operated a coal mine in the SW $\frac{1}{4}$ sec. 1, T. 11 S., R. 9 W., about 2 miles north of Denmark and along Little Timber Creek.

Production.—Coal from 10 to 20 inches thick was discovered cropping out along the banks of some of the streams in Lincoln County especially in T. 11 S., R. 9 W. north and northwest of Denmark as early as 1875 (Gray 1875, p. 316; Mudge, 1875, p. 125). Although some coal north of Denmark had been mined to a limited extent (Hudson, 1881, p. 242) as early as 1879 no official coal production for Lincoln County was reported until 1884 when 1,100 tons was mined. The last year for which production is reported is 1902. Lincoln County produced a minimum total of 39,493 tons of coal insofar as published records reveal. Without doubt more coal was mined than reported. Data published relative to lignite production in Lincoln County are presented in Table 13.

Marginal reserves.—Since all the mined lignite was less than 3 feet in thickness with the possible exception of some that may

nite, lower 2 feet black lignitic silt to clay. Lignite interbedded in shale and clay. Same locality as in A. C. Portal to Gettes-McDonald drift mine in sec. 24, T. 13 S., R. 8 W., Lincoln County. The mine opening is immediately below a massive sandstone seen better to the left of the mine. The general absence of outcrops and the difficulty of finding the mine located in the middle of the section are well illustrated in this view.

TABLE 13.—Published lignite production data for Lincoln County, Kansas

Year	Tons	Year	Tons	Year	Tons
1883	1,100	1890	6,600	1897	750
1884	1,100	1891	6,768	1898	350
1885	2,775	1892	.....	1899	400
1886	.....	1893	2,400	1900	400
1887	2,920	1894	2,400	1901	714
1888	.....	1895	2,000	1902	437
1889	6,499	1896	1,800		
Total					39,493

have been mined in the East Elkhorn Creek mines, all the reserves in Lincoln County are classified here as marginal reserve coals. Original reserves previous to mining total slightly more than 10,500,000 tons in Lincoln County. Of this amount 39,493 tons have been mined, leaving thus about 10,500,000 tons of lignite still in the ground. Table 14 presents data by districts on lignite reserves in Lincoln County.

MITCHELL COUNTY

Very little of the Dakota or lignite-bearing formation crops out in Mitchell County (Fig. 18). In the Solomon River Valley between Simpson and Beloit the upper part of the formation forms the bluffs on both sides of the valley as it does along Salt Creek in T. 9 S., R. 7 W. The sandstone is reddish, cross-bedded, and sufficiently resistant to form a fairly distinct bench.

TABLE 14.—Marginal lignite reserve lands and tonnage in Lincoln County, Kansas

Mining district	Location	Thickness, inches	Reserves, tons*
East Elkhorn Creek	32, 33-13-7W	24	1,000,000
West Elkhorn Creek	24-13-8W	12	900,000
Denmark	1, 12-10-9W	20	1,500,000
	2, 11-10-9W	20	1,500,000
Ash Grove	20-10-9W	14	1,000,000
North Branch Spillman Creek	25-10-10W	16	1,200,000
	23, 24-10-10W	19	1,400,000
South Branch Spillman Creek	36-10-10W	14	1,000,000
	35-10-10W	14	1,000,000
Total			10,500,000
Production			39,493
Reserves			10,500,000

* Reserves estimates are stated to three significant figures or less.

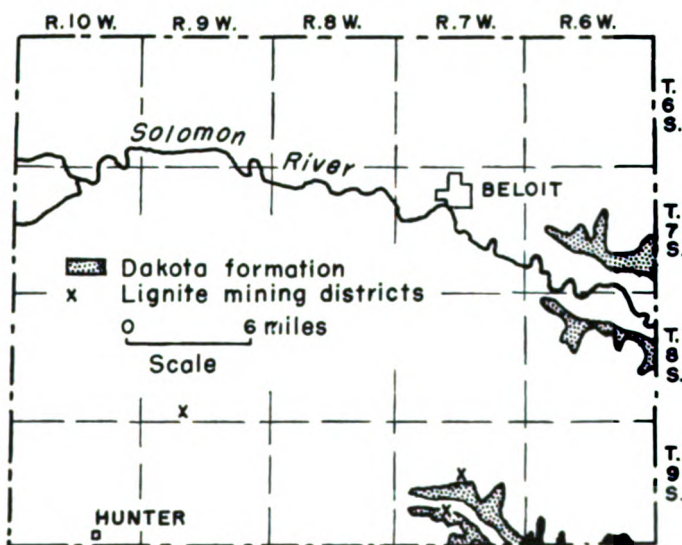


FIG. 18.—Map of Mitchell County, Kansas, showing distribution of the Dakota formation and the location of the lignite mining districts.

Salt Creek mining district.—Thin lignite seams were seen in the south bluffs of Salt Creek in the NE cor. sec. 28, T. 9 S., R. 7 W., where also in former years the coal was mined. Evidence of an old drift mine was still seen in spite of the tremendous amount of slumping or small scale landsliding that had taken place and which made it impossible to get good data on the coal. The lignite is reported to have had an average thickness of 14 inches (Stewart 1892, p. 37) and was mined by drifting. The mines of this area were crude and in constant need of attention and were worked primarily and during the winter months by farmers and their families. The coal was sold locally. Saltville, no longer existent, in the SE $\frac{1}{4}$ sec. 9, T. 9 S., R. 7 W., was the center of the Mitchell County coal mining district. According to Stewart (1891, pp. 44-45) two drift mines were in operation at Saltville in 1890. About 20 men were employed mining the coal. According to Whitla (1940, p. 52) coal 14 inches thick was drift-mined in sec. 21, T. 9 S., R. 7 W. during the years before 1900. These mines may well have been the same as those referred to above in sec. 28 on the south side of Salt Creek. Local residents knew of no mines in sec. 21.

Landes (1930, p. 54) states that a coal mine was reported to him to be in the NW cor. sec. 22, T. 9 S., R. 8 W., along Rock Creek. A search for this mine, however, proved futile and no one in that vicinity knew or ever heard of it. A more likely place for this mine would have been 6 miles due east in the NW cor. sec. 22, T. 9 S., R. 7 W., along Fifth Creek and about $1\frac{1}{4}$ miles south of Saltville which served as the center of the Salt Creek mining district and where coal might logically be expected to be present. The country rock at the location cited by Landes is Carlile shale, Greenhorn limestone, and the top of the Graneros shale. The nearest Dakota outcrop is 3 miles east of the supposed location of the mine.

Solomon River Valley mining district.—Lignite mines were also reported (Logan, 1897, p. 209; Crane, 1898, p. 143) to have been present in the Solomon River Valley. These mines although searched for were not seen or located by me.

Hunter mining district.—A mine supposedly was operated years ago (Landes, 1930, p. 54) in the SE $\frac{1}{4}$ sec. 32, T. 8 S., R. 9 W., about 5 miles north and $2\frac{1}{2}$ miles east of Hunter. No information is available on this mine except that it was along the banks of a small north-flowing tributary of Walnut Creek and that its portal was in the Blue Hill shale, the uppermost member of the Carlile shale formation. The top of the Blue Hill shale in Mitchell County lies approximately 400 feet above the top of the Dakota formation. It is therefore reasonable to assume that any coal that may have been mined at this locality was not the Dakota lignite. No positive proof of the mine or any mining dump material was to be seen at the time of my visit to the place where I was told the mine was located. However, a farmer who lives on the quarter section of land where the mine was, informed me that the deed to his farm specifies that his ownership of the land does not include the mining rights for that quarter section of land.

TABLE 15.—Published lignite production data for Mitchell County, Kansas

Year	Tons	Year	Tons
1879	80	1890	948
1880	120	1891	1,040
1889	960		
		Total	3,148

Production.—The Mitchell County lignite was known and mined to a limited extent as early as 1875 (Gray, 1875, p. 34) from seams reported to have been from 15 to 30 inches thick although later reports gave the coal a thickness of 12 to 14 inches. The coal sold for \$2.00 a ton and was used locally. Production figures for Mitchell County are very incomplete (Table 15) and none are reported by the State Coal Mine Inspector after 1891. It seems that following that year the State coal mine inspectors were unable to locate the mines and on inquiry at Saltville were told that no mines were known to exist near by (Gallagher, 1894, pp. 65, 66). As far as official published reports are concerned Mitchell County produced a total of 3,148 tons of lignite.

Marginal reserves.—The original coal reserves of Mitchell County are estimated at 500,000 tons.

REPUBLIC COUNTY

The coal-bearing Dakota formation is found chiefly in the southern part of the county in T. 4, Rs. 1, 2 and the eastern one-half of R. 3 (Fig. 19). Several sections in the vicinity of Haworth, sec. 36, T. 2 S., R. 1 W., are also underlain by the Dakota forma-

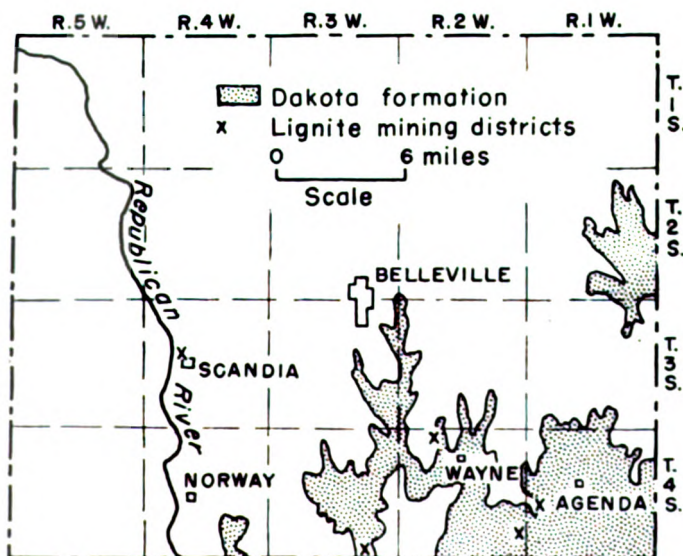


FIG. 19.—Map of Republic County, Kansas, showing distribution of the Dakota formation and the location of lignite mining districts.

tion. Coal has been mined at several localities in the county and since at least 1875 (Gray, 1875, pp. 385-386) and probably as early as 1855 (Wing, 1930, p. 43).

Scandia mining district.—Coal from 16 to 20 inches thick is reported as having been mined at Scandia between 1891 and 1893 when the shaft was abandoned and later caved in (Gallagher, 1894, p. 80). According to old settlers and a retired well driller at Scandia, lignite 3 to 4 feet thick was struck in drilling a water well 3 miles north and 3 miles west of Scandia in the NW cor. sec. 36, T. 29 S., R. 5 W. Attempts to mine the coal were made and after obtaining some of it water trouble soon put a stop to mining activities here. A similar thick lignite seam was encountered in a well $1\frac{3}{4}$ miles north of Scandia in the NE $\frac{1}{4}$ sec. 5, T. 3 S., R. 4 W. A man fatally injured at this well stopped all further operations for securing the coal. No definite information could be learned relative to the depth of the encountered coal nor to its quality. Scandia and surrounding areas are not in the area of the Dakota formation which crops out at the nearest place about 9 miles southeast of Scandia. The Greenhorn limestone and Carlile shale constitute the bedrock of the Scandia area. Whether the Scandia coal or lignite is Dakota lignite or a stratigraphically higher coal similar to that north of Hunter in Mitchell County is not known.

Norway area.—Three and one-half miles east of Norway in the NE cor. sec. 24, T. 4 S., R. 4 W., coal or lignite 3 feet thick was penetrated in drilling a well 120 feet deep. The surface rock at this locality is the Carlile shale formation. On the basis of the thickness of the Cretaceous rocks occurring in Republic County given by Wing (1930, pp. 21-35) the coal seam encountered in the 120-foot well could well have been the Dakota lignite.

North extension, Minersville mining district.—The Minersville mining district of Cloud County extends northward into Republic County in sec. 35, T. 4 S., R. 3 W. (Fig. 7, Pls. 2C, 6A). There are eight mines in the SE $\frac{1}{4}$ and seven mines in the SW $\frac{1}{4}$ of the section. The coal is 20 to 22 inches thick and is in all respects similar to that mined in Cloud County. The only good outcrop of lignite seen in the vicinity of the mines is in the NW cor. SW $\frac{1}{4}$ sec. 26, approximately 1 mile north of the northernmost mine in sec. 35. The lignite crops out in ravines and is contained in shales. The seam 25 inches thick consists of an upper

3-inch lignite separated from the lower 12-inch coal by 10 inches of impure coal. Sample 15 was collected at this outcrop and analyzed in the chemical laboratories of the State Survey (Table 2).

Wayne mining district.—Lignite was formerly mined from 1 to 2 miles north of Wayne which is in sec. 9, T. 4 S., R. 2 W. Two abandoned drift mines are along the west bank of a stream in the SE $\frac{1}{4}$ sec. 5, T. 4 S., R. 2 W. The entries to the mines are about 15 feet above creek level and are capped by a 10-foot bed of soft massive Dakota sandstone. Another mine was formerly located along the same stream about one-half mile farther north in the NE $\frac{1}{4}$ sec. 2. The presence of coal is also reported in a water well about half a mile east of the mines (Cen. W $\frac{1}{2}$ sec. 4, T. 4 S., R. 2 W.). No other information regarding the mines was learned.

Agenda mining district.—Lignite is exposed and was mined 60 years ago by drifting on the Boal farm in the NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 19, T. 4 S., R. 1 W. The mine is 2 miles south and 1 $\frac{1}{2}$ miles west of Agenda. The lignite varies in thickness and quality in very short distances. Where measured (Fig. 4) the lignite constitutes the lower 17 inches of a 40-inch lignitic zone. Above the lignite is 10 inches of black lignitic clay which in turn is overlain by 4 inches of black sooty lignite. Beneath the lignite is 7 feet 2 inches of ashy white nonbedded siltstone. The lignitic zone is overlain by 9 feet 2 inches of clay and siltstone above which is 15 feet of dark-brown and bright-red sandstone and siltstone. The amount of coal removed is not known but according to Mr. Boal a considerable amount has been mined. Plummer also re-

TABLE 16.—Published lignite production data for Republic County, Kansas

Year	Tons	Year	Tons	Year	Tons
1883	2,700	1891	1,056	1899	1,696
1884	2,700	1892	.....	1900	501
1885	2,431	1893	1,605	1901	525
1886	.....	1894	2,575	1902	1,700
1887	.....	1895	1,724	1903	.....
1888	.....	1896	2,000	1904	.....
1889	998	1897	1,300	1905	6,902
1890	400	1898	.....	1906	547
				Total	30,790

TABLE 17.—Lignite reserve lands and tonnage in Republic County, Kansas

Mining district	Location	Thickness, inches	Reserves, tons*
N. extension, Minersville	35, 27, 26-4-3W	20	1,900,000
Wayne	4, 5-4-2W	20	2,100,000
Agenda	19, 25-4-2W	20	3,700,000
Scandia area	16, 17-3-4W	20	500,000
Northwest and north of Scandia	5, 3-4W } 36-2-5W }	36	7,900,000**
Norway	24-4-4W }		
Total			16,100,000
Production			30,790
Reserves			16,100,000

* Reserves estimates are stated to three significant figures or less.

** This is the only lignite in Republic County considered by the U.S. Geological Survey as actual reserves. Others listed are marginal reserves.

ported an outcrop of lignite in a road cut at the southeast corner of the same section. This lignite was not exposed at the time of my visit to the place. Another mine was also reported to me to be in the SE cor. NE¼ sec. 25, three-fourths of a mile south and 1 mile west of the Boal lignite. Because of stream alluviation the exact spot locating the mine could not be ascertained with certainty. Proximate analysis of lignite sample 15, collected on the Boal farm, is given in Table 2.

Production.—According to published records, Republic County produced a total of 30,790 tons of lignite (Table 16).

Reserves.—According to reports there is 3-foot lignite in Republic County at NE cor. sec. 6, T. 3 S., R. 4 W., northwest of Scandia; NW cor. sec. 36, T. 2 S., R. 5 W., north of Scandia; and NE cor. sec. 24, T. 4 S., R. 4 W. east of Norway. The estimated reserves at these three localities (considered here as inferred coal reserves) totals 7,900,000 tons. Reserve lignite lands in which the coal is less than 3 feet thick and classified as marginal coal reserve lands comprise 1 square mile in the north extension of the Minersville mining district, 1½ square miles in the Wayne area, and 2 square miles in the Agenda area, a total of 4½ square miles containing about 7,700,000 tons of 20-inch coal. An additional 500,000 tons of reserve coal are to be found at Scandia. The total original coal reserves of Republic County amount to approximately 16,100,000 tons and are summarized in Table 17.

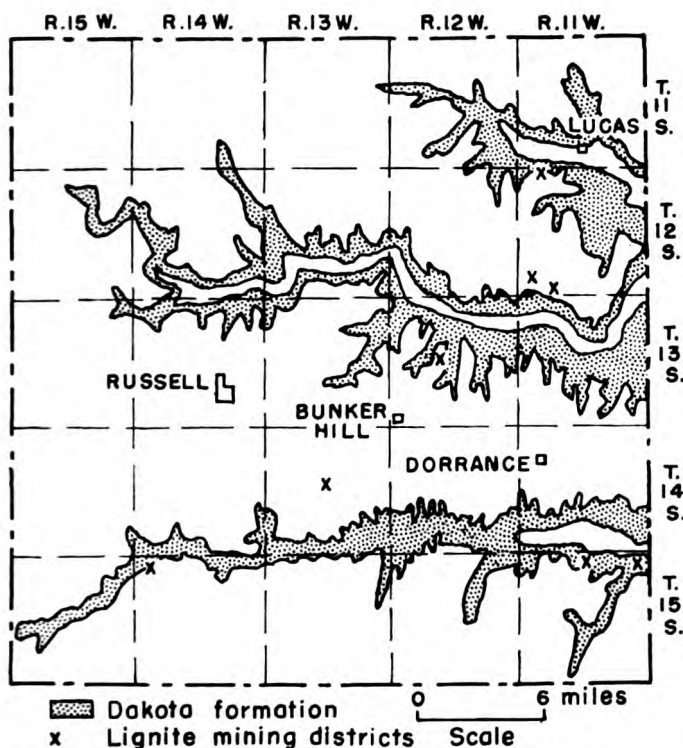


FIG. 20.—Map of Russell County, Kansas, showing distribution of the Dakota formation and the location of lignite mining districts.

RUSSELL COUNTY

In Russell County the Cretaceous coal-bearing strata follow in the main the valleys of Smoky Hill and Saline Rivers, together with their tributaries (Fig. 20). Lignite was known to occur in the county by at least 1875 (Mudge, 1875, pp. 124-125) for in that year according to Gray (1875, p. 399) considerable coal had been developed. This coal, reported from 30 to 40 inches thick, sold at the mines for \$2.00 a ton. Production for 1875 amounted to 500 tons. By 1881 (Hudson, 1881, p. 252; Sims, 1883, p. 437) lignite was reported to be found in nearly all parts of the county and 11 mines were in operation. Of these 11 mines, 2 were in Fairview Township in the northeast part of the county, 3 in Plymouth Township southeast of Dorrance or southwest of Wilson in Ellsworth County, 4 in Center Township northeast

of Bunker Hill, and 2 in Russell Township in which Russell is located. These mines, between February 28, 1881, and March 1, 1882, yielded a total of 6,175 tons of lignite valued at \$24,000. The capital invested in the mines is reported to have been \$6,075. The principal mines by 1897 were located on Wolf Creek and Coal Canyon (Logan, 1897, p. 209). The Wolf Creek mines were southwest of Lucas whereas the Coal Canyon mines were in the southeastern part of the county. There are at least seven areas in Russell County, possibly nine (Hudson, 1881, p. 252) where lignite was mined (Fig. 20). Coal is supposed to have been mined in Russell and Winterset Townships, although the mines were not located by me.

Lincoln Township mining district.—Although no mines were located by me in Winterset Township, lignite crops out along Smoky Hill River in the NW $\frac{1}{4}$ sec. 6, T. 15 S., R. 14 W., less than 1 mile east of sec. 1, T. 15 S., R. 15 W., in the northeast corner of Winterset Township. The lignite occurs in shale exposed in the west-facing bluffs of Smoky Hill River. The coal is jet black, shiny, very hard, and where sampled 15 inches thick. The coal cropping out here is by far the best lignite seen in central Kansas and is very similar to the coal sample reported to have come from one of the test holes drilled in Hodgeman County. Immediately above the coal is 1 foot of black lignite shale which is overlain by 7 feet of gray shale, the upper part of which is dark-gray to black. The shale is overlain by 3 feet of red crinkled sandstone above which is 3 feet of grayish shale topped by 1½ feet of red to brownish sandstone. Sand and gravel of variable thickness overlie the sandstone. Beneath the coal is a 6-inch black clay shale containing lignite fragments and 15 feet of well-bedded grayish shale. Figure 4 shows the stratigraphic section measured at this place. A proximate analyses of the coal is given in Table 2 (samples 10, 11, and 12). A comparison with the other samples analyzed shows clearly that this coal is by far superior to the lignites collected elsewhere in the area covered by this report. Evidence of stripping the coal was seen along the outcrop immediately to the west of the place where the coal was sampled. If, as reported in 1881 (Hudson, 1881, p. 252), coal had been mined in Winterset Township immediately to the west of this outcrop in Lincoln Township, then it is evident that the coal must have been mined either in the NW cor. sec. 12 or in

sec. 1, T. 15 S., R. 15 W., as farther to the west the Graneros shale crops out at the level of Smoky Hill River.

South Bunker Hill mining district.—Lignite averaging 12 inches in thickness was formerly mined in secs. 14, 15, and 22, T. 14 S., R. 13 W., about 2½ to 4 miles southwest of Bunker Hill. The mines in secs. 15 and 22 were close to stream level above which cropped out black Graneros shale. Evidence of four mines was seen in sec. 22 and two mines to the north in sec. 15. A shaft mine was also reported in the NW¼ sec. 14, T. 14 S., R. 13 W., approximately 1 mile east and three-quarter mile north of the mines in secs. 15 and 22. These mines were in operation in 1893 (Gallagher, 1894, p. 81). The shaft mine reported in the NW¼ sec. 14 was known as the Menzes mine. Very little information is known concerning the mines south of Bunker Hill. In 1895 Mr. James Menzes reported (Brown, 1896, p. 98) that the lignite was very extensive in Russell County but was not opened or developed very much and that there was supposed to be a second vein on an average 110 feet lower. The price paid for mining was \$2.00 a ton.

Northeast Bunker Hill mining district.—A large amount of lignite was mined from 3 to 4 miles northeast of Bunker Hill in Center Township in sec. 21, T. 13 S., R. 12 W. Ten entries of slope mines were observed in the bluffs of a small north-flowing tributary of Saline River about 200 feet east of the Bunker Hill-Anspaugh road in the center of the section. In addition a quarter of a mile farther north and the same distance east of the road are evidences of two other slope mines. A section (Fig. 4) measured at the mines shows the coal to be 12 inches thick which according to various reports appears to be the average thickness of the lignite in this part of Russell County. The coal is underlain by shale

Measured section in sec. 21, T. 13 S., R. 12 W. northeast of Bunker Hill, Russell County, Kansas

	Feet	Inches
Shale, black fissile	1	2
Sandstone, crinkly	1	0
Shale, gray, well-bedded	3	0
Sandstone, crinkly, iron-stained, weathering into rusty chips	2	0
Sandstone, massive	6	8
Sandstone, pyrite nodules	4	10
Shale, black, fissile	0	8
Lignite	1	0
Shale, gray	1	6
Shale, dark-gray, exposed to creek level	7	6



PLATE 6. Republic County mine dump and Dave Walter mining district, Russell County. **A.** Large mine dump in Minersville mining district, Republic County. Material now being sold and used for road mettle and other purposes. In time the evidence for and location of many mines will thus be obliterated as is the case now. **B.** General view of Dave Walter mining district, secs. 3 and 4, T. 15 S., R. 11 W., Russell County; view looking north.

and overlain by 11 feet 6 inches of massive sandstone which marks the approximate upper part of the Dakota formation. The following stratigraphic section shows the relationship of the lignite to the overlying and underlying strata. Four coal mines were producing here in 1881 (Sims, 1881, p. 437). In 1899 two mines were in operation. The mines were worked on the long-wall system. In 1897 the coal sold for \$3.00 a ton. A proximate analysis of the lignite sampled in sec. 21 is presented in Table 2 (samples 8 and 9).

Coal Creek-Smoky Hill River mining district.—By far the greatest number of mines in Russell County were located in Plymouth Township south of Smoky Hill River (Fig. 11). Coal was known to occur and mined in the bluffs of Coal Creek by 1879 (Hudson, 1881, p. 252). The lignite crops out at numerous places in the ravines or gulches that are tributary to Smoky Hill River and especially along Coal Creek in secs. 1, 14, and 22, T. 15 S., R. 11 W. Most of the mines are located in sec. 1 about 3 miles south and 1 mile west of Wilson in Ellsworth County. The mines in sec. 1 are the western extensions of the Coal Creek-Smoky Hill River mining district of Ellsworth County. The lignite occurs in six seams within the upper 15 to 17 feet consisting of dark-gray shale and thin siltstones of the upper part of the Dakota formation. The coal or lignite seams range in thickness from 2 to 20 inches and for the most part are overlain by dirty-gray siltstones. The underlying rock is dark-gray shale. According to reports the mined coal was from 12 to 20 inches thick. Entries and mine dumps of eight drift or slope mines are still seen in the west-facing bluffs of Coal Creek in sec. 1 and eight in the gulch no more than one-fourth mile east in the W½ sec. 6, T. 15 S., R. 10 W. in Ellsworth County. Some of the mines extended into Ellsworth County where they connected with the Ellsworth County mines. The coal was mined by the longwall system and sold for \$2.00 to \$3.00 per ton. The coal also crops out along Coal Creek at a number of places for a distance of 4 miles southwest of the mines in sec. 1. According to Whitla (1940, p. 58) the lignite is from 24 to 28 inches thick along

The inner terrace of the gulch is penetrated by numerous drift mines for a distance of about 1 mile. Formerly a coal-mining town was located here. C. Exposure of lignite 30 inches thick on west side of gulch approximately at the center of the east section line of sec. 4. The lower lignite seam shown is part of the upper seam which has been broken off.

Coal Creek in sec. 14, T. 15 S., R. 11 W. Of this thickness the upper 10 to 12 inches of the seam is free from impurities. The lignite is overlain by at least 4 feet of gray sandstone or siltstone above which is shale. Beneath the coal is a white clay shale or fire clay. Whitla reports that this seam has not been mined but according to Mr. David Walter and a number of other local residents the 12- to 14-inch lignite seam has been mined in the SW $\frac{1}{4}$ of the section. The lignite is also found in the bluffs of sec. 22 where only 6 inches of coal was observed. Lignite was also reported by Mr. David Walter to outcrop at the foot of a terrace in the NW cor. NE $\frac{1}{4}$ sec. 16, T. 15 S., R. 11 W., not quite 2 miles northwest of the coal outcrop in sec. 14. The coal was found as reported but no measurements of thickness could be made due to its position at the foot of the terrace and the heavy grass cover. Pieces of coal were seen, however, by digging into the ground.

Dave Walter mining district.—Along the bluffs of a valley or canyon of a north-flowing tributary of Smoky Hill River approximately along the section line between secs. 3 and 4, T. 15 S., R. 11 W., and 2½ to 3 miles due west of the coal mines in sec. 1 are the traces of at least a dozen mines (Pl. 6B). Mr. David Walter, who lives in the SE cor. sec. 4, informed me that formerly a small coal town was located here and that a large amount of coal was mined. Coal was mined last at this locality according to Mr. Walter in 1907. Part of the coal was mined by stripping along the outcrop but most of the mines were drift mines. The coal is on the average about 2 feet thick (Pl. 6C), is overlain by a massive siltstone that varies in thickness in short distances and is characterized by vertical joints and holes which Plummer (Plummer and Romary, 1942, pp. 339) has interpreted to be worm borings, and is underlain by white to brown clay shale. Between the coal and siltstone is 6 to 7 inches of black lignitic shale and immediately beneath the lignite is 6 inches of dark shale. Above the capping sandstone are 3 inches of gray shale, a 10-inch lignite seam, and several thin (2- to 3-inch) siltstones imbedded in a more or less bedded shaly siltstone totaling about 5 feet. The uppermost layer of siltstone which marks the top of the Dakota formation here is brownish and from 10 to 16 inches thick. Fifteen feet of black fissile selenite-bearing Graneros shale overlies the Dakota siltstone. The black fissile shale

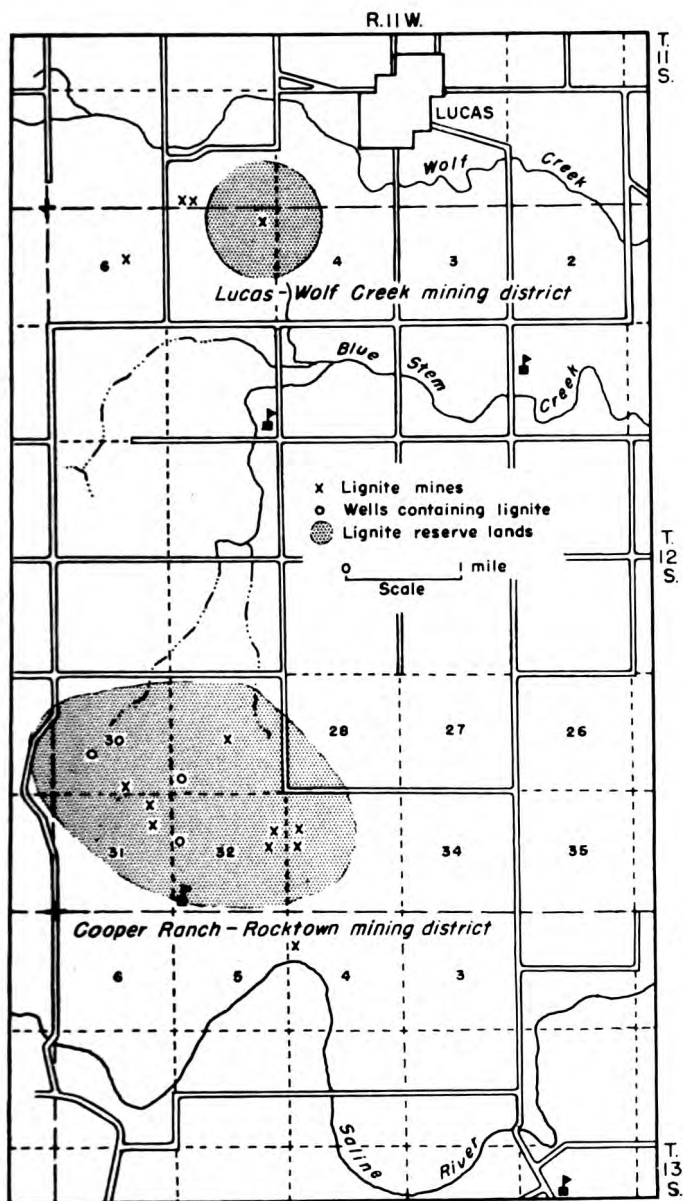


FIG. 21.—Map of the northeastern part of Russell County, Kansas, showing the location of lignite mines, the Cooper Ranch-Rocktown and Lucas-Wolf Creek mining districts, and the reserve lignite areas.

is overlain by about 5 feet of brown sandy limestone that weathers into small chipstones and that constitutes at this locality the upper surface of a rock bench or terrace. At the time of last mining the coal sold for \$4.00 a ton, the owner receiving a royalty of 25 cents for each ton of lignite mined. Samples 5, 6, and 7 (Table 2), probably not too representative of the coal actually mined, were taken along the outcrop in the NE cor. SE $\frac{1}{4}$ sec. 4, T. 15 S., R. 11 W., about one-fourth mile north of Mr. Walter's house. The proximate analysis is given in Table 2.

Lucas-Wolf Creek mining district.—Coal was being mined along Wolf Creek near Lucas in Fairview Township as early as 1881 (Sims, 1883, p. 437) and in 1897 Logan (p. 209) reported that the principal coal mines in Russell County were located on Wolf Creek and Coal Canyon. Mr. Robert Spaulding of Lucas reported that coal, 11 to 12 inches thick, had been mined in the NE cor. sec. 5, T. 12 S., R. 11 W., as early as 1880. The mine was operated by Mr. John Hole as a drift mine and was located in a small draw tributary to Wolf Creek approximately 1 mile south and slightly more than 1 mile west of Lucas. Considerable coal was supposed to have been produced. The entry to the mine was above a massive poorly exposed sandstone which presumably marked the top of the Dakota formation at this place. Prospect holes, not seen by me however, according to Mr. Spaulding are present in the W $\frac{1}{2}$ sec. 5 and in the eastern part of sec. 32, T. 11 S., R. 11 W. The coal of the Lucas area is supposed to have contained much sulfur and on burning to have left a large amount of ash. The coal was used extensively in Lucas and vicinity.

Cooper Ranch-Rocktown mining district.—Lignite is known to occur in secs. 29, 30, 31, 32, and 33, T. 12 S., R. 11 W., in the southwest part of Fairview Township, and to have been mined

TABLE 18.—Published lignite production data for Russell County, Kansas

Year	Tons	Year	Tons	Year	Tons
1875—	500	1887—	120	1896—	1,000
1878—	500	1888—	.....	1897—	181
1880—	9,400	1889—	6,005	1898—	35
1881—	.....	1890—	6,044	1899—	28
1882—	6,175	1891—	6,044	1900—	11
1883—	967	1892—	.....	1901—	....
1884—	967	1893—	2,100	1902—	27
1885—	140	1894—	900	1903—	2,718
1886—	.....	1895—	600		
				Total	30,790

TABLE 19.—Lignite reserve lands and tonnage in Russell County, Kansas

Mining district	Location	Thickness, inches	Reserves, tons*
Cooper Ranch-Rocktown	29, 30, 31-12-11W	36	7,900,000**
	32, 33-12-11W	12	2,600,000
Lucas-Wolf Creek	5-12-11W	12	900,000
Bunker Hill Northeast	21-13-12W	12	900,000
Bunker Hill Southwest	14, 15, 22-14-13W	12	800,000
Coal Creek	1-15-11W	15	500,000
	14-15-11W	12	900,000
Dave Walter	3, 4, 9, 10-15-11W	24	4,000,000
	33, 34-14-11W		
Lincoln Township	6-15-14W	15	1,100,000
Total			20,600,000
Production			44,808
Reserves			20,600,000

* Reserves estimates are stated to three significant figures or less.

** This is the only lignite in Russell County considered by the U.S. Geological Survey as actual reserves. Others listed are marginal reserves.

most extensively on the Cooper ranch in sec. 32 (Fig. 21). In reference to the Cooper ranch mining district Mr. Emmet Cooper of Wilson, in a letter to me dated July 5, 1947, states: "There is a strip, at least six miles long east and west, in which there is definite proof of coal deposits—in some cases three different veins at different levels . . . and that hundreds of tons of coal were mined from 1880 to 1890." The mines were located chiefly in the E½ sec. 32, and in sec. 33, T. 12 S., R. 11 W., a place also known as Rocktown. Coal was also mined at the cen. sec. 29, near the S. line sec. 30, and several mines were reported in the NE¼ sec. 31. In addition to the mines lignite as much as 3 feet thick was also reported encountered in several wells in secs. 29, 30, and 32. The coal, which ranged from 12 to 18 inches in thickness, was obtained by drifting for distances of 250 to 300 feet into the north valley walls of Saline River. A second seam of coal also 12 inches thick was exposed in some of the numerous canyons but was not mined. A third seam, 3 feet thick, is reported to have been encountered in several wells, particularly in the SW¼ sec. 29, SW¼ sec. 30, and NW¼ sec. 32. This coal lay from 40 to 50 feet below the middle seam or 65 to 80 feet beneath the upper or mined seam. This lower seam may correspond stratigraphically to the position of the lignite exposed south and west of Elmo in Dickinson County and which has been assigned to the lower Dakota formation. A 3-foot seam of lignite was also reported to me to have cropped out in 1874 at

the bottom of a canyon somewhere close to the line between secs. 21 and 28, T. 12 S., R. 12 W., about 5 to 6 miles northwest of the Cooper Ranch. This coal can no longer be seen. The Cooper Ranch coal was discovered by the grandfather of Mr. Emmet Cooper either in the fall of 1879 or spring of 1880 while getting a drink from a spring. Mining ceased in 1890. According to Mr. Cooper hundreds of tons were mined and hauled away by the wagonload to places as much as 70 or more miles distant. The coal was trucked to Smith Center, Lebanon, Beloit, Osborne, Cawker City, and other places in western Kansas. Much of the coal was sold at \$3.00 per ton.

Production.—On the basis of published reports Russell County produced from 1875 to 1904 a total of 44,808 tons of lignite. More coal was produced than the published records show as coal was mined as late as 1907 in the Dave Walter mining district and some coal was mined in the Cooper-Rocktown area during the winter of 1938-1939 and sold on the market even though not recorded (Whitla, 1940, p. 58). Production data are given in Table 18.

Reserves.—The minimum original reserve lignites of Russell County may be estimated at 20,600,000 tons. Of this amount 7,900,000 tons is 3-foot coal, the remainder consisting of lignites from 12 to 24 inches thick and is the coal which was formerly mined to the extent of 44,808 tons. There remains approximately 20,600,000 tons of unmined coal in Russell County of which 12,700,000 tons is classified as marginal lignite reserves and 7,900,000 tons as proved or measured reserves. Reserve lignite data for Russell County are summarized by districts in Table 19.

WASHINGTON COUNTY

Lignite was known to occur in Washington County as early as 1875 (Mudge, 1875, pp. 124-125). Most of Washington County is underlain by the Dakota formation (Fig. 22) but since most of the lignite occurs in the upper part of the formation outcrops of the coal are necessarily confined to the northwest and west-central parts of the county. Outcrops of lignite are extremely few. The nonresistant character of the Dakota formation together with the thinness of the lignite seams and the excessive slumping on the hillsides are responsible for the concealment

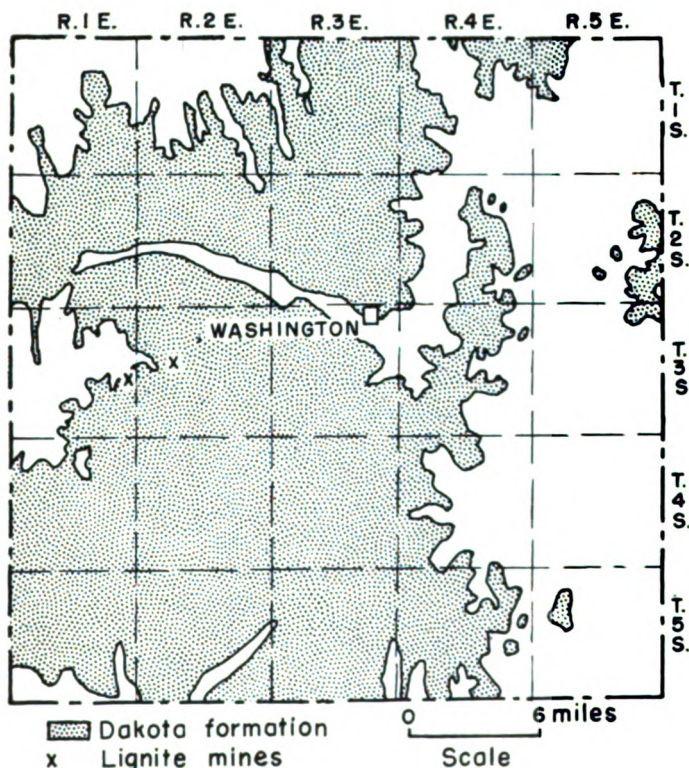


FIG. 22.—Map of Washington County, Kansas, showing distribution of the Dakota formation and location of lignite mines.

of the coal at most places. A 2- to 3-inch seam of lignite was observed in a roadside ditch in the SW cor. NW¼ sec. 35, T. 1 S., R. 1 E., about 4½ miles north of the east edge of Haddam.

Clara-Throop mining district.—Coal was mined 50 or more years ago on the Cupp farm now owned by Earl Pascal in the NE cor. SW¼ sec. 17, T. 3 S., R. 2 E. The Cupp location is about 3 miles north and half a mile west of Throop. The coal as reported by Plummer (personal communication) was 18 inches thick although at the time of my visit to the place on July 29, 1947, only 4 to 6 inches of the coal was seen. Whether the coal seen was the seam mined or whether a second and thicker seam is present could not be ascertained as the coal observed was practically at creek level and the slopes above the coal were excessively slumped and soggy from springs. The coal is over-

lain by a sandstone and occurs in a dark-gray shale. Associated with the lignite were many pyrite nodules. A small amount of lignite was mined by stripping in the cen. NE $\frac{1}{4}$ sec. 20, T. 3 S., R. 1 E., along the bank of a small creek. This strip location is about 2 miles west and half a mile south of the Cupp mine or 3 miles north and half a mile east of Clara. The seam seen at this place measures 14 inches in thickness and occurs in a dark-gray shale. The same seam of lignite, also 14 inches thick, crops out in the creek bed in the NW cor. NE $\frac{1}{4}$ of the section. The overburden at both places is from 20 to 30 feet thick.

Production and reserves.—No data were obtained in regard to how much lignite was mined in Washington County. It is reasonably certain, however, that production did not amount to much. All lignite reserves in Washington County consist of coals less than 30 inches in thickness, and therefore are classified here as marginal reserves. It is reasonably certain that 300,000 tons of lignite is available in sec. 24 and 400,000 tons in sec. 17, a total of 700,000 tons in the Clara-Throop area.

OTHER COUNTIES

Ottawa County.—Coal about 6 inches thick was discovered by a Mr. Gladden who lived on the headwaters of Hard Crossing Creek in about 1864 or 1865 (Scheffer, 1934, p. 234). Gladden took a sample of the coal to Junction City for the purpose of organizing a coal-prospecting company. Failing in his efforts to organize a coal company and endeavoring to keep the matter of coal before the public, Gladden was able to have the name of Hard Crossing Creek changed to Coal Creek, the name it still bears. Just where the coal was found is not certain. Coal Creek post office was established on October 3, 1866. Its location, however, is uncertain as on the Ottawa County map for 1875 (Gray, 1875, p. 367) Coal Creek post office is located in the SE $\frac{1}{4}$ sec. 23, T. 12 S., R. 2 W., whereas on the map for 1880 (Hudson, 1881, p. 60) Coal Creek post office is in the SE $\frac{1}{4}$ sec. 18, T. 12 S., R. 1 W. By 1887 Coal Creek post office no longer appeared on the Ottawa County map published by the Kansas State Board of Agriculture. The Ottawa County coal seam was not seen but judging from the geologic map of Kansas the coal must occur in the basal part of the Dakota formation which forms the bedrock for most of the county (Fig. 23). Mudge (1875, p. 125) also

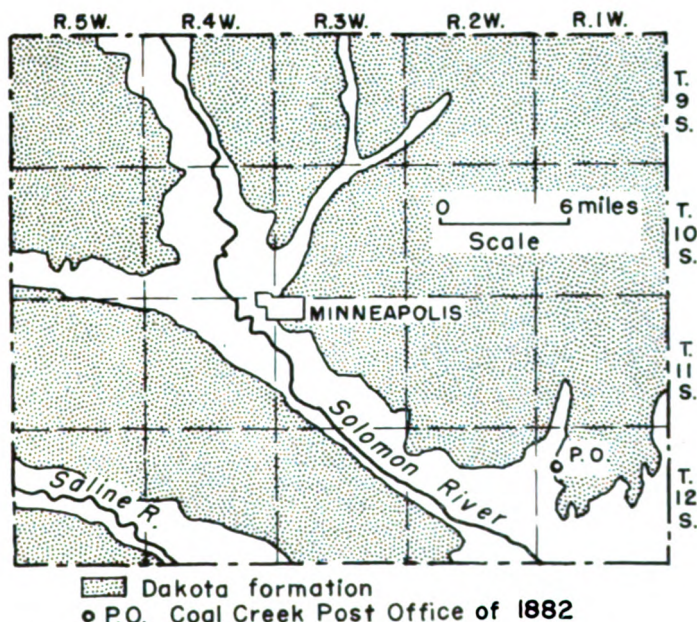


FIG. 23.—Map of Ottawa County, Kansas, showing distribution of the Dakota formation and the location of the Coal Creek post office of 1882.

included Ottawa County among the Cretaceous lignite-bearing counties of central Kansas at an early date.

Other counties containing lignite.—Lignite has been reported also from Barton, McPherson, Rice, and Saline Counties by Mudge as early as 1875 (p. 125) and from Barber County in 1887 by Hay (1889, p. 7) and is likewise reported to be present in Ford and Osborne Counties (Moore, 1929, p. 4). Latta (1950, pp. 179-180) reports a 1-foot brown to black lignite in a test hole drilled in 1945 at a depth of 98 feet below the surface and 61 feet below the top of the Dakota formation and thin beds of coal at a depth from 145 to 148 feet at the base of the Dakota formation in Barton County. The test hole is in the Cheyenne Bottoms (Schoewe, 1949, pp. 294-296) at the NE cor. sec. 9, T. 18 S., R. 13 W., less than a mile southeast of Hoisington. No coal was seen in any of the counties listed and with the possible exception of the northern part of Ford County (see discussion under Hodgeman County) no minable coal is believed to exist in those counties.

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