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Chancellor of the University, and ex officio Director of the Survey

RAYMOND C. MOORE, Ph.D., Sc.D.,
*State Geologist and
Director of Research*

JOHN C. FRYE, Ph.D.,
Executive Director

BULLETIN 63

COAL RESOURCES OF THE WABAUNSEE
GROUP IN EASTERN KANSAS

By WALTER H. SCHOEWE



*Printed by Authority of the State of Kansas
Distributed from Lawrence*

UNIVERSITY OF KANSAS PUBLICATIONS
DECEMBER, 1946

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COAL RESOURCES OF THE WABAUNSEE GROUP IN EASTERN KANSAS

BY WALTER H. SCHOEWE

ABSTRACT

The Wabaunsee coal-bearing rocks constitute the youngest or uppermost group of Peensylvanian strata in Kansas. The rocks crop out in a northeast-southwest belt, approximately 3,100 square miles in area, in the eastern part of the State, extending from Doniphan, Brown, and Nemaha Counties on the north to the Kansas-Oklahoma state line in Chautauqua and Cowley Counties on the south. At least 6 of the 12 coal beds in the Wabaunsee group have been mined at one time or another within the last 75 years. Nodaway, the lowermost coal, is by far the most important of the coals mined, and it is the only one of commercial importance at the present time. Including the 1944-45 coal-mining season, a minimum cumulative total of 11,783,464 tons of Nodaway coal had been mined, of which 97.2 percent came from Osage County. The Elmo coal, of which more than 200,000 tons has been produced, is the second most important of the Wabaunsee coals. The cumulative tonnage of all coals of the Wabaunsee group mined is 12,017,737 tons, which is 4.8 percent of the total coal production in Kansas. There are 186,680,000 tons of proved Wabaunsee reserve coal, of which 128,050,000 tons is Nodaway, 47,560,000 tons Elmo, and 11,070,000 tons other miscellaneous coals. The greatest Nodaway proved coal reserve, 77,670,000 tons, is found in Osage County; the greatest Elmo proved coal reserve, in Brown County, amounts to 23,160,000 tons. The proved Wabaunsee coal reserves are sufficient to last about 50 years if mined at the average annual rate of production for the 5-year period 1940-44. The potential Wabaunsee coal reserves are calculated at 3,685,780,000 tons, an amount sufficient to last approximately 250 years at the average rate of production for the last 5 years. Of the potential coal reserve, 1,285,960,000 tons or 34.8 percent is Nodaway coal, 1,515,850,000 tons or 41.1 percent is Elmo coal, and 883,970,000 tons or 24.1 percent is miscellaneous coals.

This report includes a description of the geographic distribution, stratigraphic position, thicknesses, contact rocks, and physical and chemical characters of the Wabaunsee group coals. It also contains information on the history of Wabaunsee coal mining, mining methods, production and coal reserve data, and a short account of the origin of the coal. Each of the mined Wabaunsee group coals is treated separately under each of the 16 counties in which the coal occurs.

INTRODUCTION

Coal is the Nation's leading mineral resource. In 1944 the value of all coal produced in the United States was \$2,174,335,884 as compared with \$2,030,500,000, the value of petroleum, the Nation's second leading mineral product (Clark and Meyer, 1945, p. 4). In Kansas, coal production ranks fourth among minerals produced. In 1944 Kansas produced 3,610,000 tons of coal, valued at approximately \$9,350,000 (Clark and Meyer, 1945, p. 28). From 1869 to the end of 1944 a total of 251,596,368 tons of coal, valued at approximately \$488,171,198 has been mined in Kansas. This cumulative production is, however, only 21.7 percent of the State's known original minable coal of 1,157,909,543 tons. If all this coal, not considering the rock waste, had been mined from a single square mile, a hole 262 feet deep would have resulted. The State's proved coal reserves are calculated to be 906,300,000 tons. At the average rate of production for the 5-year period 1940-44, these reserves are sufficient to last approximately 250 years. Of the State's total proved coal reserves more than 20 percent or 186,680,000 tons are Wabaunsee coals which are sufficient to last about 50 years at the present rate of output. The Wabaunsee potential coal reserves exceed the Wabaunsee proved reserves by more than 19 times.

Coal was undoubtedly the first mineral resource looked for by the early pioneers who settled Kansas. Blessed with good soil, a healthful climate, and an abundance of luscious prairie grass, eastern Kansas offered every advantage for settlement that a new region could offer. Her greatest lack was obviously one of fuel. Except along the major drainage courses, where fuel wood was in fair abundance, the open prairie offered very little in fuel supplies; therefore, the early explorers passing through Kansas were continually on the lookout for coal. In 1828 Isaac McCoy, a missionary sent by the Federal Government into the territory of Kansas to study the Indians, recorded in his diary the finding of coal on the Neosho River at the Osage agency (McDermott, 1945, pp. 421, 449). This coal, he said, burned well and was comparable to that mined at Pittsburgh, Pennsylvania. Hale (1854, p. 127) in his book "Kanzas and Nebraska," one of the first two books written about Kansas, frequently mentions coal in his descriptions of the land and on his map, drawn from original surveys, the word *coal* appears between the Kansas and Marais des Cygnes Rivers

east of the 95th meridian. On page 87 Hale says, "The great coal-field of Missouri, south of the Missouri, extends thirty or forty miles in to Kansas," and on page 127 he refers to one of the coal beds cropping out at the surface near the State line south of the mouth of the Kansas River. The importance of coal in the selection of town sites is indicated in his description of the selection of the Lawrence town site by the pioneer body of the Emigrant Aid Company. In writing of this, Hale says (pp. 238-239): "They have here a good landing, wood and stone in abundance for building, the neighborhood of coal, and a good commercial position."

Although the earliest records of coal mining in Kansas go back to the year 1869, coal was mined much earlier. According to Brown (1896, p. 12) probably the first coal mined in Kansas by white men was dug out of a hillside about 3 miles northwest of Fort Leavenworth shortly after its establishment in 1827. This coal was hauled to Weston and other points on the Missouri side of the Missouri River in 1855-56 where it was sold at 35 to 40 cents a bushel. From talking to old settlers and from early reports it is known that coal mining in Kansas was contemporaneous with the establishment of the first towns in the late 1850's. The Indians, however, mined coal before the coming of the white man. Before 1854, according to Hale (1854, p. 127), the Shawnee Indians mined coal 40 miles west of the Missouri state line at the Wah-karusi (Wakarusa; undoubtedly at Blue Mound, 6 miles southeast of Lawrence) and carried it as far east as Westport, Missouri. Commercial coal mining in Kansas may be said to have started in the late 1860's.

Purpose of study.—This report is the third of a series on Kansas coal started by the State Geological Survey of Kansas in 1942. The chief purpose of the coal investigations is to make a detailed study of the occurrence, distribution, and commercial reserves of Kansas coal deposits. Although the studies were initiated during World War II and were designed to help forestall a threatening fuel shortage in the State, such inventories are also of post-war value in that they furnish a basis for special studies on the utilization of Kansas coal. Furthermore, they serve as a guide to new mining operations because they cover not only coal already mined extensively but also coal beds containing sizable reserves that are not now being utilized.

This report describes the coal resources of the Wabaunsee

group of rocks. The two earlier reports of this series on Kansas coal resources have been published by the State Geological Survey. The coal resources of the Douglas group in east-central Kansas were studied by Bowsher and Jewett (1943) and the coal resources of the Kansas City group, Thayer bed, in eastern Kansas were studied by Schoewe (1944). A report on mined areas of the Weir-Pittsburg coal bed was prepared by Abernathy (1944). Earlier publications dealing solely with coal include reports on the coal resources of Kansas, post-Cherokee deposits (Whitla, 1940); the geology and coal resources of the southeastern Kansas coal field in Crawford, Cherokee, and Labette Counties (Pierce and Courtier, 1937); and a special report on coals by Haworth and Crane (1898). Mention should also be made of reports by Young and Allen on Kansas coal published in 1925. Other references on Kansas coals are listed in Schoewe's report (1944, pp. 133-136).

Previous work.—The need for suitable fuel prompted the pioneer settler of Kansas to search early for coal. References to the Wabaunsee coals, primarily the Nodaway or "Osage" coal as it was formerly called, may be found in early reports dealing with the geology and mineral resources of the State. By 1866, only 5 years after Kansas had joined the Union, the Wabaunsee coals had been recognized. Mudge (1866, pp. 18-19), the first State Geologist of Kansas, was one of the first to note the occurrence of the Wabaunsee coals in Atchison, Jefferson, Nemaha, Osage, Shawnee, and Wabaunsee Counties. Although his report does not contain detailed descriptions of the coals, he cites locations and thicknesses of the coal and says that the coal was mined. Swallow (1866, p. 56), the second State Geologist of Kansas, likewise reports the occurrences of the Wabaunsee coals and adds Brown, Coffey, Doniphan, Greenwood, and Jackson to Mudge's list of counties. Hawn, (in Swallow, 1866, pp. 102, 113, 120) presents a more detailed account of the Wabaunsee coals. He recognized three distinct beds of coal in Brown County and correlated the uppermost one with the Burlingame coal bed of Osage County. Hawn believed that his middle coal, which cropped out on Wolf River near Robinson, was 50 to 100 feet lower stratigraphically than his uppermost coal bed. His lowermost coal, which he calculated to be 200 feet below his Wolf River coal, was correlated with the Topeka coal bed. From my field investigations in Brown County, it is now known that the coal along Wolf

River near Robinson is the Elmo coal and is the same bed that Hawn identified as his uppermost coal in the northeastern part of the county. However, Hawn, as well as other investigators as late as 1895 (Haworth, 1896a, fn., p. 161; Brown, 1896, p. 209), was in error in believing that the coal mined in the Osage City-Burlingame district was the Elmo coal and that the coal mined at Topeka, which they called the Topeka coal, was stratigraphically lower. The Topeka coal and the coal mined in the Osage City-Burlingame district are the Nodaway coal. St. John in 1881 (Beede, 1898, p. 28) was probably the first one to correctly correlate the Topeka and Burlingame coals. Another early account of the Wabaunsee coal is given by Hutchinson (1871, pp. 74-76) in a private publication "designed to anticipate and answer many of the questions which would be asked by persons contemplating a removal from some other region to Kansas." Hutchinson refers briefly to the coals and coal-mining activities of Osage County and the entire eastern part of the state.

One of the first analyses of the Wabaunsee coal is given by Saunders (1873, p. 390; 1896, p. 33), who was of the opinion that there was no true bituminous coal west of the Missouri River. Saunders refers briefly to the coal district in Osage County and presents a table of coal analyses. In this table, which includes analyses of Kansas, Colorado, and Missouri coals, is an analysis of the Nodaway coal sampled at one of the mines at Carbondale in Osage County. He reports (p. 31) that the Fort Scott coal of Bourbon County was also called the "Osage" vein. In 1887, Kelly (p. 45) published a paper on the coal measures of Lyon County in which he discusses the search for coal particularly in the vicinity of Emporia, where in 1874 several thin layers of coal had been found in borings. According to Kelly's report, workable coal had not been located in Lyon County until about 1883 or 1884. Reference to the first coal mines in the county near Neosho Rapids is made in the report of the State Board of Agriculture for 1885. In 1886 coal had been found at a number of places in the northern part of the county and near the new town of Admire, where a shaft 28 feet deep had been sunk to a 17-inch vein of coal. In the same year, at least four tunnels to coal were driven about 3 miles northwest of Emporia. Nowhere was the coal less than 11 inches thick, and in some places it was as much as 17 inches thick. In 1889 two short but important papers dealing with Kansas coals

appeared, one by Bailey (1889, pp. 46-49) and the other by Blake (1889, pp. 42-46). Bailey's paper discussed the composition of Kansas coals and Blake's paper was concerned with the evaporative power of these coals. Both papers contain analyses of 11 Wabaunsee coals from Osage County.

Detailed stratigraphic studies of Kansas rocks were begun in 1895 by the University Geological Survey of Kansas under the direction of Erasmus Haworth. In 1895, Haworth (p. 278), presented a description of rocks now classified as the Wabaunsee group in which he recognized two coal horizons. He called the lower coal the Topeka coal, and the upper one, a little more than 100 feet higher stratigraphically, he designed the Osage coal. It is evident from his description that his Topeka coal, which he said was mined just west of Topeka, is the Nodaway coal. His Osage coal, which he believed to be the same coal as that mined at Osage City, Burlingame, Scranton, and Carbondale, is the Elmo coal, not the coal mined in Osage County. As previously indicated, St. John (1883) correctly correlated in 1881 the coal mined at Topeka with that mined in the Osage City-Burlingame district. In Haworth's second paper (1895a, pp. 303-304) on the coal fields of Kansas this error in correlation is repeated, as well as the mis-correlation of the Silver Lake coal with the Osage City coal; the coal mined in Coffey and Lyon Counties is correctly correlated with the coal mined at Osage City but incorrectly correlated stratigraphically. The data presented by Haworth in these two papers are repeated in his preliminary report on the coal fields of Kansas (Haworth, 1896, pp. 226-227). Data taken from Haworth's 1895 papers are also incorporated in Brown's (1896, p. 209) report of the state inspector of coal mines for 1895. A short paper by Hay (1896, p. 258) refers to a thin coal seam at Arrington in Atchison County but adds nothing of importance to the knowledge of the Wabaunsee coals.

In 1898 Beede (pp. 28-29) described the stratigraphy of Shawnee County and, like St. John, correctly correlates the coal mined at Topeka with that mined in the Osage City-Burlingame district, with the vein of coal occurring north of Kansas River in Shawnee County, and with that occurring near Meriden and Valley Falls in Jefferson County. His report also refers to the Silver Lake coal (Elmo), which he says is the highest stratum of coal found in paying quantity in the State. A report by Haworth and Crane

published in 1898 is the most comprehensive contribution to the knowledge of Kansas coals. The stratigraphy of the coal-bearing rocks and the economic, statistical, and historical aspects of the coal are discussed. Much of the material in this report is from Haworth's earlier papers and those by Bailey (1889) and Blake (1889). Although much progress in the correlation of the mined coal beds had been made, confusion still prevailed and all the coals were included in the Osage shales.

Between 1898 and 1925 no new data in regard to the Wabaunsee coals were published. Two short papers published in 1901 (Grimsley, 1901, p. 201; Mead, 1901, p. 208) refer to the coals in Osage County and in the Flint Hills. Adams, Girty, and White (1903, pp. 49-51) in their important stratigraphic report give a brief description of the Severy shale, Howard limestone, and Burlingame shales and the included coals. In 1925 Young and Allen published reports which brought up to date much of the material presented by Haworth and Crane in 1898 and which include proximate and ultimate analyses of some Wabaunsee coals. A general description of the Wabaunsee coal district was given by Moore in 1929.

An important, though generalized, contribution to reports on Wabaunsee coals is a report by Whitla (1940) in which he discusses briefly the history of mining in Atchison County and in the Osage City coal district; presents generalized descriptions of the Nodaway, Elmo, and Nyman coals; and discusses the coals in Atchison, Brown, Chautauqua, Coffey, Elk, Jackson, Jefferson, Lyon, Osage, Shawnee, and Wabaunsee Counties. The most recent paper referring to the Wabaunsee coals is one by Jewett and Schoewe (1942, pp. 83-84), which briefly discusses the history of the east-central Kansas coal field, its products, and coal resources. The Wabaunsee coals are also included in several general reports, (Moore and Landes, 1927; Moore, 1936; Landes, 1937; and Moore, Frye, and Jewett, 1944).

Statistical information on the Wabaunsee coals is given in the various reports of the Kansas coal and metal mine inspectors; U.S. Geological Survey, Mineral Resources of the United States, 1882 to 1923; U.S. Bureau of Mines, Minerals Yearbook, 1924 to 1943; Kansas State Board of Agriculture, Annual Reports 1 to 5 (1872-1876) and Biennial Reports 1 to 9 (1878-1895); and the

University Geological Survey of Kansas annual bulletins on mineral resources of Kansas for 1897 to 1903.

Field and laboratory investigations.—Field work that forms the basis for this report was carried on from August 15 to October 28, 1944, and from August 17 to October 30, 1945. The Wabaunsee coals were traced throughout their geographical extent from the Kansas-Nebraska to the Kansas-Oklahoma state lines. The stratigraphic position, occurrence, physical nature, and thicknesses of the coals, the character of contact rocks, and the nature and thickness of overburden were studied in the field. All active and abandoned 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. Coal samples from six shaft, one drift, and two strip mines were collected. These samples were analyzed by August Fleming in the laboratory of the State Geological Survey.

Acknowledgements.—John M. Jewett of the Survey staff made several trips with me in the field and aided in the stratigraphic aspects of the investigation, and Norman Plummer, also of the Survey staff, spent one day in the field with me. Many residents of the coal-mining districts supplied names and locations of present mines and former mining operations. Appreciation is especially expressed to the following mine owners, operators, and superintendents who gave their time and supplied valuable data and samples of coal for analyses: William Isaacs, Bell mine No. 4, Burlingame; Clarence Elliott, Elliott coal mine, Burlingame; James Curley, J. C. mine, Burlingame; Neal Hotchkiss, Central mines Nos. 2 and 3, Burlingame; James Parre, Didier and Parre Coal Company, No. 1, Osage City; Ira Rogers, strip mine northeast of Osage City; Perry Jones and R. A. Linville, Carbon-hill strip pit; and H. A. Rogers, strip mine south of Arvonia. The following persons assisted materially: LeRoy Johnson, Osage City; L. D. Pierce, Lyndon; Ben Lowes, Scranton; C. Evans, Lebo; W. J. Hestland, D. H. Acker, and C. T. Whartenby, Cowley County; Will Neigh, Elk County; J. C. Bell, Eskridge; Joseph M. Piazzek, Valley Falls; Bryan Bowles, Muscotah; Bud Wilson, Huron; Wilbur Peck and Milton Hitchcock, Brown County; Merle L. Sowell, formerly of Admire; and Carl Jauken, Bern.

HISTORY OF MINING OF WABAUNSEE COALS

It is impossible to determine accurately the exact date of the first mining of any of the Wabaunsee coals, but it is certain that the coal was known to pioneers at the time of the first settlements in the area for it was mined for local consumption. Mudge (1866, pp. 18-19), Swallow (1866, p. 56), and Hawn (Swallow, 1866, pp. 102, 120) as early as 1866 reported the mining of these coals in Atchison, Brown, Jefferson, Nemaha, Osage, Shawnee, and Wabaunsee Counties and their outcropping in Coffey, Doniphan, Greenwood, and Jackson Counties. Not only was the coal known to crop out and to have been mined, but Hawn (Swallow, 1866, p. 102) recognized more than one coal horizon in the Wabaunsee group of rocks in Brown County at this early date. Mead (1901, p. 208) stated that a Wabaunsee coal was mined in 1866 for neighborhood use on Coal Creek, 10 miles southwest of Emporia in Lyon County. Coal was first mined in Lyon County near Neosho Rapids in 1874 (Gray, 1875, p. 322), at Admire in 1886, and in the Neosho River bluffs 3 to 4 miles northwest of Emporia in 1886. According to interviewed residents of Chautauqua, Coffey, Cowley, Elk, and Greenwood Counties, local mining in these counties was coincident with the first settlements near coal-bearing rocks and outcrops. In Osage County coal was mined before 1867 and in 1869 mining was begun on a commercial scale. By 1890 the Osage County coal-mining district, centered chiefly around Osage City, Burlingame, Scranton, and Carbondale, had become the most important coal-mining district in Kansas. As many as 75 mines were in operation in 1891 and approximately 3,000 persons were employed. Since 1893, however, the Osage district has steadily declined in importance, and in 1944 less than 200 men were working in the 8 active mines. More detailed information on the history of mining of the Wabaunsee coals is given under the various county discussions.

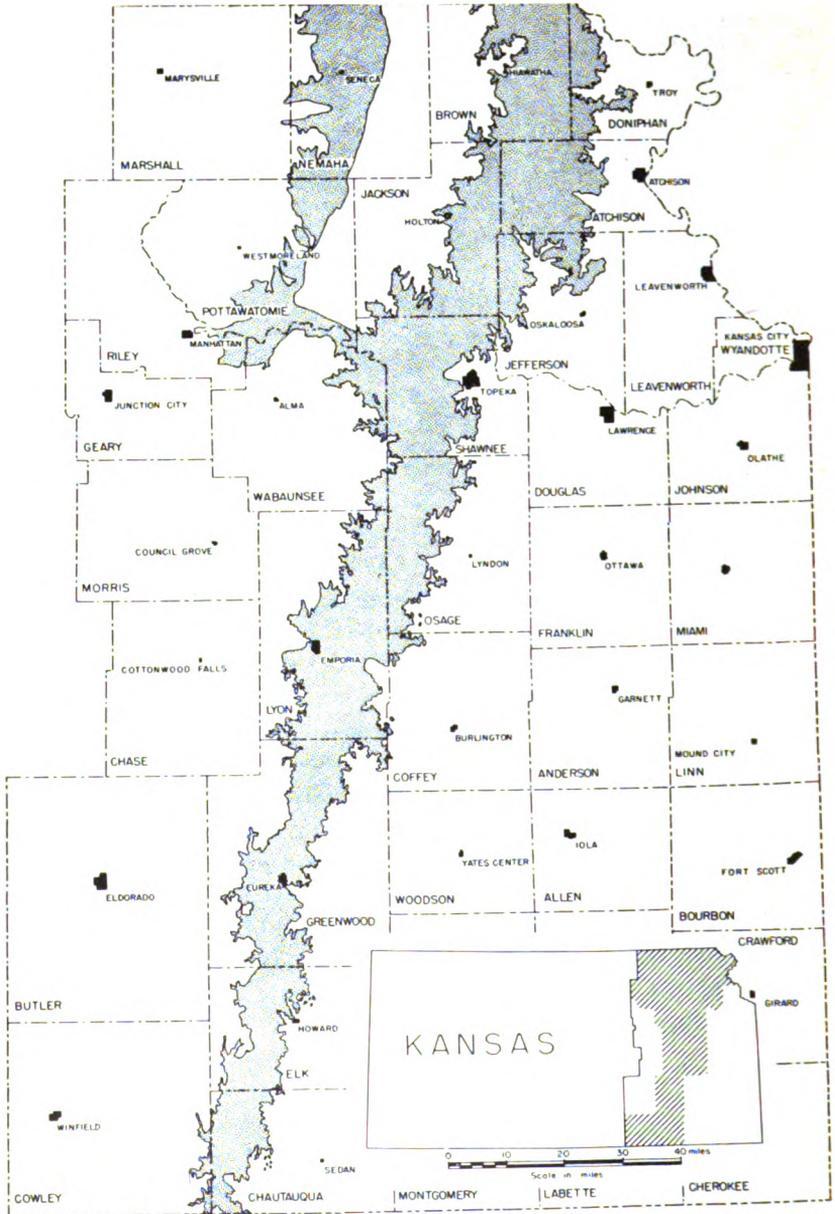


FIG. 1. Map of eastern Kansas showing outcrop area of the Wabaunsee group of rocks.

GEOGRAPHY OF THE WABAUNSEE COAL-BEARING AREA

The Wabaunsee group of rocks crops out in a northeast-southwest belt in eastern Kansas. It extends from Doniphan, Brown, and Nemaha Counties on the north to the Kansas-Oklahoma state line in Chautauqua and Cowley Counties on the south (Fig. 1). Counties included in this area, which contains approximately 3,100 square miles, are Atchison, Brown, Chautauqua, Coffey, Cowley, Doniphan, Elk, Greenwood, Jackson, Jefferson, Lyon, Nemaha, Osage, Pottawatomie, Shawnee, and Wabaunsee. Physiographically, the Wabaunsee coal-bearing rocks are in the Central Lowlands Province of the Interior Plains. The part lying north of Kansas River Valley is known as the Dissected Till Plains, whereas the part lying south of this river is called the Osage Plains. The topography consists of a series of northeast-southwest terraces or *cuestas*, which are gently tilted westward. The eastern slope of the steplike surfaces is characteristically steep. The height of the escarpment varies with the thickness of the soft non-resistant rocks intervening between harder resistant limestone formations. Each escarpment marks the beginning of a new step or *cuesta*. Because of erosion, most of the escarpments are highly dissected and of crenulated pattern. In the Dissected Till Plains, the *cuesta*-like topography is generally obscured by a thick covering of glacial drift. Local relief varies considerably, reaching as much as several hundred feet in Chautauqua and Cowley Counties. Streams cross the Wabaunsee rocks from west to east, except in Chautauqua County and north of Kansas River, where the main drainage courses parallel the escarpments.

The most important towns in the Wabaunsee coal-bearing area are Hiawatha and Horton, Brown County; Sabetha and Seneca, Nemaha County; Valley Falls, Jefferson County; Topeka, Shawnee County; Burlingame and Osage City, Osage County; Emporia, Lyon County; Madison and Eureka, Greenwood County; Howard, Elk County; and Cedar Vale, Chautauqua County. The cities and towns are well served by Federal and State highways, and the entire area is well traversed by railroads. Because of the good road system and the proximity of the Osage City-Burlingame coal district to the Kansas City industrial area, much of the Nodaway

coal is hauled westward to distant places in Kansas and eastern Colorado by cattle trucks returning from Kansas City.

COALS OF THE WABAUNSEE GROUP

STRATIGRAPHY

The Wabaunsee group of coal-bearing rocks constitutes the youngest or uppermost group of Pennsylvanian strata in Kansas. As classified by the State Geological Survey of Kansas (Moore, Frye, and Jewett, 1944, pp. 170-176), it belongs to the Virgilian series and includes 14 limestone and 14 shale formations (Fig. 2). The limits of the group are defined at the base by the Severy shale overlying the Topeka limestone formation of the Shawnee group and above by the Brownville limestone which lies immediately below the disconformity that separates Permian and Pennsylvanian rocks in Kansas. The Wabaunsee group is about 500 feet thick except in places where the overlying unconformity eliminates some of the uppermost Wabaunsee formations, as, for example, in Pottawatomie County where beds as low as the Auburn shale formation have been cut out by the Indian Cave sandstone of Permian age (Harned and Chelikowsky, 1945).

There are at least 12 coal beds in the Wabaunsee group of rocks, of which the lowermost or Nodaway coal is at present the only one of commercial importance. At least six coals, the Nodaway, Elmo, Cedar Creek in the Willard shale, an unnamed coal in the Wamego shale, the Nyman, and Lorton coals, are definitely known to have been mined at one time or another 40 to 60 years ago. The other coals are thin and unminable. The Wabaunsee coals and the formations in which they occur, in ascending order (Fig. 2), are: Nodaway in the Howard limestone; Elmo in the Cedar Vale shale; unnamed coals in the Silver Lake, Soldier Creek, Auburn, and Harveyville shale formations; Cedar Creek in the Willard shale; Nyman in the Langdon (formerly called Table Creek) shale; unnamed coals in the Dry and Friedrich shale formations; Lorton in the French Creek shale; and an unnamed coal in the Pony Creek shale. No attempt will be made in this report to describe all Wabaunsee coals. Only those coals which have been mined or are sufficiently thick to be mined will be discussed.

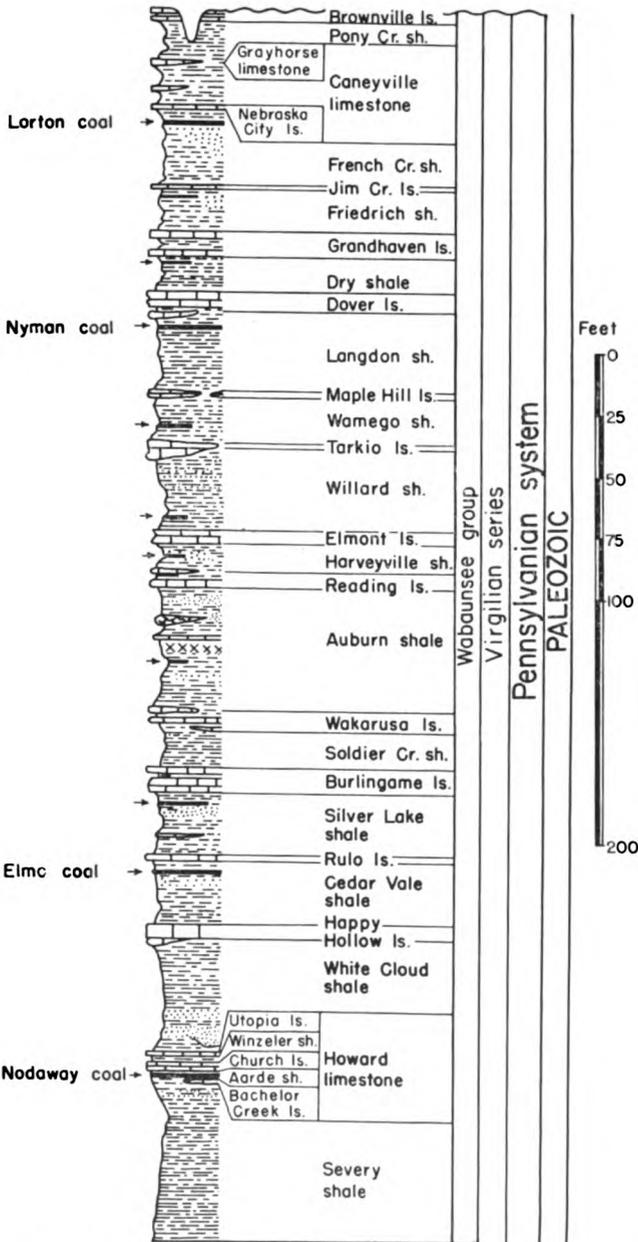


FIG. 2. Generalized section of the Wabaunsee group of rocks in Kansas.

NODAWAY COAL

Geographic distribution.—Nodaway coal, as tracing shows, occurs almost continuously across the entire north-south width of Kansas along the strike of the Howard limestone formation from Doniphan and Nemaha Counties to the Kansas-Oklahoma state line in Chautauqua County (Fig. 1). It has been mined in Atchison, Doniphan, Nemaha, Jefferson, Shawnee, Osage, Coffey, Elk, and Greenwood Counties. At present this coal is mined in Osage County and to a limited extent in Jefferson County. All the places where the Nodaway coal has been observed by me or is known to occur are listed by counties in Tables 12, 22, 25, 28, 30, 31, and 35 and shown on Figures 9, 17, 20-23, 25-29 and Plate 1.

Stratigraphic position.—The Nodaway coal occurs in the basal part of the Howard limestone formation. As classified by the State Geological Survey (Moore, 1936, pp. 204-208) the Howard limestone formation, where fully developed, is made up of the Bachelor Creek limestone, Aarde shale, Church limestone, Winzeler shale, and Utopia limestone. The Nodaway coal occurs below the Church limestone in the Aarde shale. The Bachelor Creek limestone is missing north of Scranton in Osage County. Where the Bachelor Creek limestone is absent, Moore (1936, p. 206) classed the Nodaway coal and other beds that are stratigraphically equivalent to the Aarde shale as belonging at the top of the Severy shale, for it was thought impractical to draw a boundary between two shale bodies. Because the Nodaway coal, as well as the shale between it and the overlying Church limestone, can be identified and traced without break along the strike of the Howard limestone throughout its extent, the boundary line between the Severy shale and Howard limestone formations is here placed at the base of the Nodaway coal, thus avoiding classification of the coal as part of the Severy shale in the northern half of eastern Kansas and as a unit of the Howard limestone in the southern half. Throughout the territory where the Nodaway coal is defined as the lowermost subdivision of the Howard limestone, the shaly beds lying between the Nodaway and the base of the Church limestone are called Shunganunga shale, in accordance with nomenclature introduced by Beede (1898, p. 29) from southern Shawnee County, Kansas. Studies by Moore and other Survey members subsequent to 1936 have demonstrated the presence in

south-central Greenwood County and localities farther south of a dense limestone and black fissile shale in the upper part of the Aarde shale as previously defined, between the Nodaway coal and Church limestone.

Additional observations made in preparing this report follow.

(1) The Bachelor Creek limestone can be traced northward into Osage County approximately as far as Scranton, and at several places north of Osage County, as at the abandoned coal mines in Shawnee County along Muddy Creek in sec. 10, T. 10 S., R. 16 E. about 2 miles west of Meriden in Jefferson County, the Bachelor Creek limestone may be represented by the occurrence of dense limestone nodules 20 inches below the coal. (2) The Utopia limestone locally contains abundant fusulinids in the upper part. (3) The Utopia limestone in Osage County and as far north as Jefferson and Atchison Counties is divisible into several limestone beds, lithologically and texturally unlike, separated by shales, some of which are black, fissile, and full of ostracodes. (4) The Utopia limestone is absent at places in Atchison County where it has seemingly been cut out by a channel sandstone and conglomerate. (5) The black fissile shale in the Aarde shale member is persistent northward from south-central Greenwood County into Nebraska, Missouri, and Iowa (Moore, personal communication).

The Aarde shale is from 3 to 15 feet thick, averaging 8 feet in Chautauqua County, 3.6 feet in Elk County, 5.5 feet in Greenwood County, and 13 feet in Osage County. The true thickness of the Aarde shale north of Osage County is indeterminate because the basal Bachelor Creek limestone member is missing. The Aarde shale is typically gray to bluish gray and yellowish gray and clayey to sandy. In Osage County and southward a thin dense fine-grained bluish limestone is commonly present between the Nodaway coal and the base of the Church limestone (Pl. 4A). This limestone ranges from 2 to 22 inches in thickness and is from 9 inches to 3 feet 4 inches below the Church limestone. At places this dense limestone lies immediately above the coal, as at the outcrop in the NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 11, T. 29 S., R. 10 E., Elk County, and in sec. 17, T. 32 S., R. 10 E., Chautauqua County. At most other outcrops, however, a grayish shale separates it from the coal. The greatest interval between the limestone and the coal is in Osage County where as much as 9 feet (sec. 34, T. 17 S., R. 14 E.) of shale intervenes. The black fissile shale, which is persistent

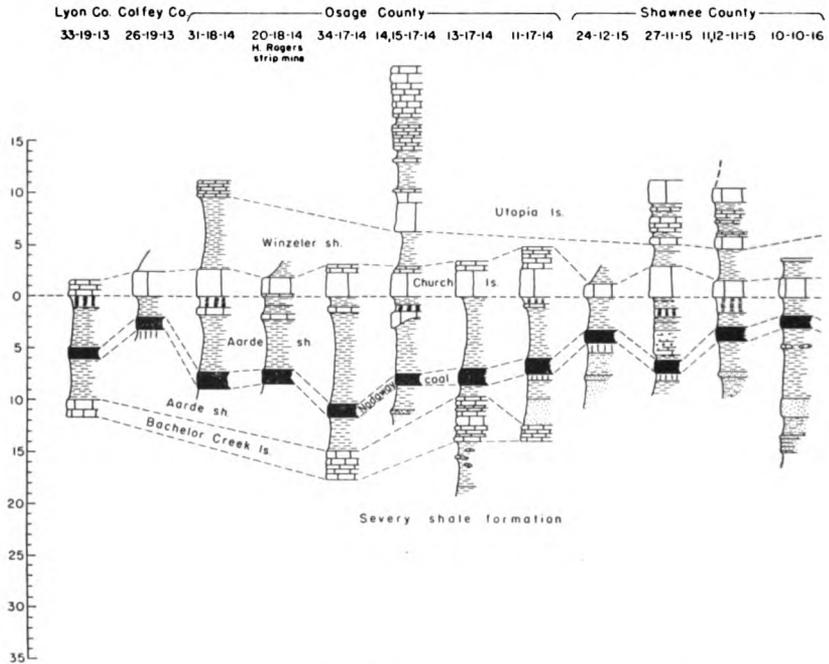
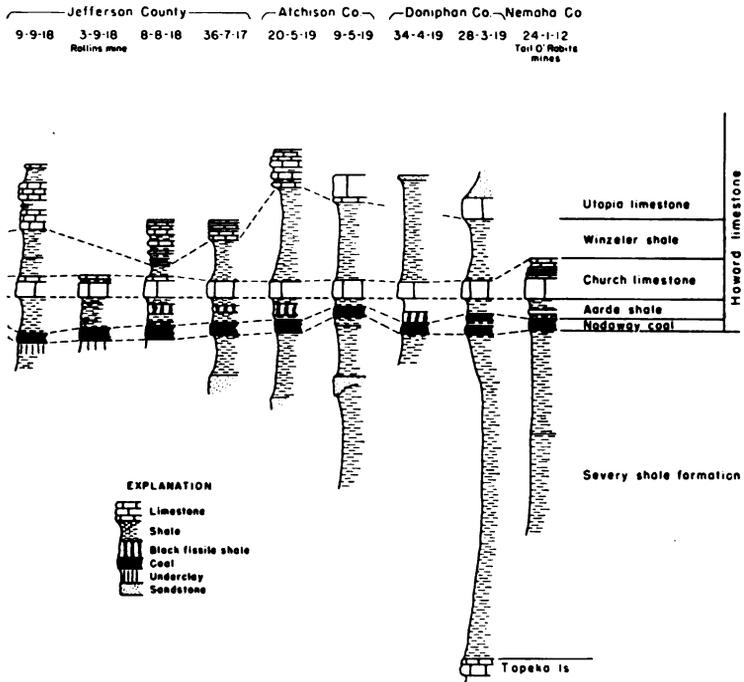


FIG. 3. Stratigraphic sections showing position and thickness

in the upper part of the Aarde shale even though the thin dense limestone previously discussed is absent, is from 3 to 18 inches thick. A structureless sticky ash-colored underclay, averaging 1 foot in thickness, lies immediately beneath the coal.

The Church limestone, because of its massive, well-jointed character, serves as an excellent horizon marker in searching for Nodaway coal (Pl. 1) but the position of the coal varies from 2 to 126 inches below the limestone. The coal lies closest to the Church limestone in Greenwood County and farthest away in Osage County. The interval between the coal and the Bachelor Creek limestone ranges from 6 to 60 inches. The coal lies closest to the Bachelor Creek limestone in Elk County. The position of the coal relative to the Church and Bachelor Creek limestones in the various counties is presented in Table 1 and is shown graphically by Figures 3 and 4.



of Nodaway coal and its relation to adjacent rocks in Kansas.

TABLE 1.—Thickness, in inches, of beds between Nodaway coal and Church and Bachelor Creek limestones

County	From base of Church limestone to top of Nodaway coal		From base of Nodaway coal to top of Bachelor Creek limestone	
	Range	Average	Range	Average
Nemaha	21- 30	25.5		
Doniphan	14- 30	23.2		
Atchison	8- 23.5	15.4		
Jefferson	15- 37	26.3		
Shawnee	20- 82	48.6		
Osage	54-126	74.2	12-60	40.5
Coffey	24			
Lyon	60		48	48
Greenwood	2- 30	10.9	7-54	18.6
Elk	24- 36	33	6-24	12
Chautauqua	24- 60	50.4	15-48	30.3

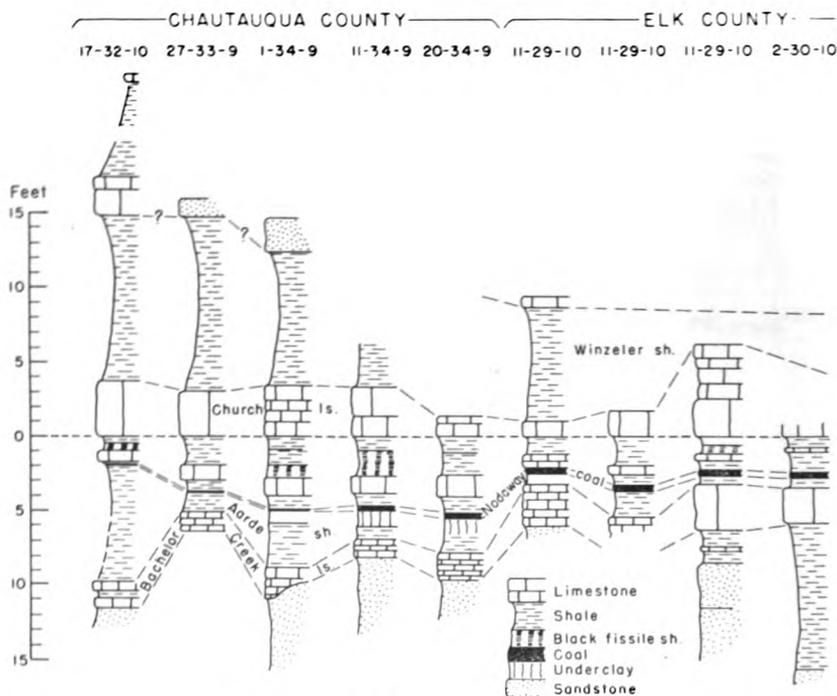
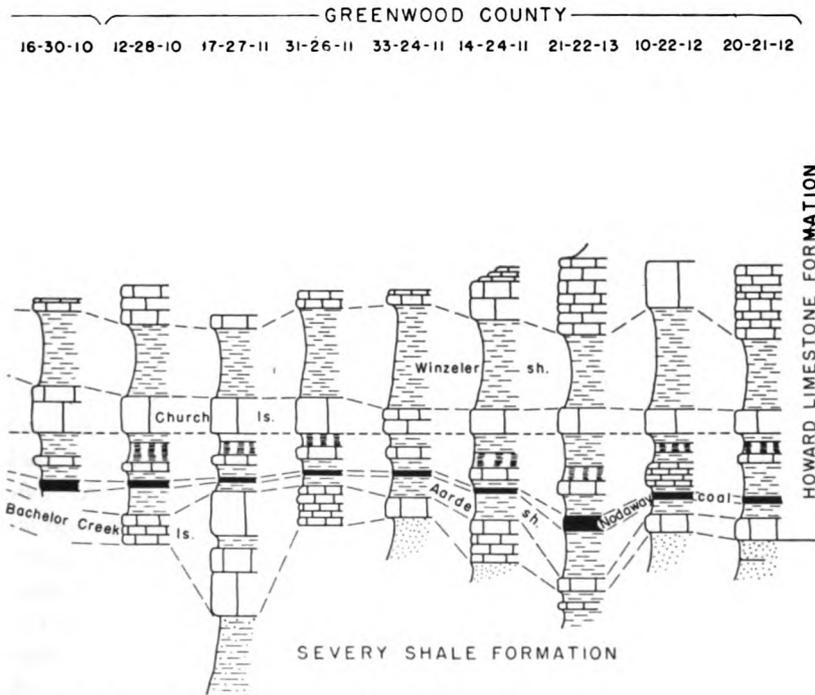


FIG. 4. Stratigraphic sections showing position and thickness of

Thickness.—Where seen in outcrops Nodaway coal ranges in thickness from a streak to 18 inches. Greater thicknesses, however, have been reported by various state coal mine inspectors and by operators and mine superintendents. In the active mines at Burlingame and Osage City, Osage County, the coal ranges from 16 to 20 inches in thickness and averages 18 inches, according to the mine operators and superintendents. These men report local thicknesses of as much as 36 inches. The coal is thinnest in Chautauqua, Greenwood, and Elk Counties and thickest in Osage County. The minimum thickness, one-fourth to 1 inch, was observed in a road ditch on the south side of the road, 0.25 mile west of the school on the Chautauqua-Elk County line, in sec. 4, T. 32 S., R. 10 E. A similar thickness of coal occurs in a road cut on highway US 166, 0.1 mile west of the SE cor. sec. 1, T. 34 S., R. 9 E. The coal at this locality is an outlier of the Howard lime-



Nodaway coal and its relation to adjacent rocks in Kansas.

stone and is 0.9 mile east of Wauneta. In most places in Greenwood County the coal is not more than 3 inches thick. A maximum thickness of 18 inches was measured in Osage County in the SE cor. sec. 12, T. 16 S., R. 14 E., in the Ira Rogers strip mine northeast of Osage City in the NW¼ sec. 17, T. 16 S., R. 15 E. and in the recently opened Bell mine No. 4 in the SW cor. NW¼ sec. 23, T. 15 S., R. 14 E., about 1½ miles south of the junction of highways US 50N and K 31 in Burlingame. The Nodaway coal at this mine is 120 feet beneath the surface. The Nodaway coal occurs as a single bed with one exception—in sec. 28, T. 3 S., R. 19 E., 1½ miles south and 1 mile east of Leona in Doniphan County where the coal consists of a 2-inch vein separated from a lower 4-inch bed by 6 inches of shale. The thicknesses of the coal are summarized by counties in Table 2.

TABLE 2.—Summary of thicknesses of Nodaway coal, in inches

County	At outcrops		In underground mines	
	Range	Average	Range	Average
Nemaha	10-12			
Doniphan	5-12	8.1		
Atchison	9-14	11.5		
Jefferson	9-15	11.1	12-17	
Shawnee	3-13	10.4	10-16	12
Osage	11-18	15.1	12-36	18
Coffey	12			
Lyon	12			
Greenwood	2- 7	3.1		
Elk	2- 7	5		
Chautauqua	.025- 2	1		

Contact rock.—With very few exceptions, the contact rock above and below the coal is gray to dark-gray shale. An ash-colored to light-bluish structureless and very sticky underclay which averages less than 1 foot in thickness immediately underlies the coal at numerous places. Typical laminated shale is present beneath the underclay. In the NW¼ NE¼ sec. 11, T. 29 S., R. 10 E., Elk County, and in sec. 17, T. 32 S., R. 10 E., Chautauqua County, a thin hard bluish limestone forms the upper contact rock, whereas in sec. 4, T. 5 S., R. 19 E., Atchison County, the Church limestone rests on the coal.

Physical and chemical characteristics.—Nodaway coal is classified as bituminous coal. It occurs practically everywhere as a single bed without any clay seams or partings. Where mined, it commonly splits in the middle of the bed into two distinct units, although no visible dirt or impure matter is present along the parting planes. The coal separates readily from the contact rock above and below with a clean-cut parting. Although the coal splits readily into two distinct layers, close examination reveals that it is composed of many thin layers from one-sixteenth to one-half inch thick which give the coal a laminated appearance. The uppermost one-quarter inch or less contains extremely matted highly carbonized coaly material showing the impression and structure of the woody material from which the coal was derived. On mining, the coal breaks into more or less rectangular slabs measuring approximately 30 by 36 by 8 inches and weighing between 300 and 400 pounds each. These large slabs remain fairly

well intact even when slid down the steeply inclined loading chute and dumped and bumped vigorously on the bed and sides of trucks or against other slabs of coal. The coal also rides well without breaking while being hauled. Because of its slablike shape, the coal can be packed nicely in trucks and later stacked well in cellars or elsewhere. Even though the coal has a tendency to remain in large slabs, it can be broken up easily with little pulverization into smaller lumps.

Normally the coal is bright, shiny, black, brittle, and moderately hard. Where exposed to weathering processes, the coal is duller in appearance and has a reddish to brownish cast, especially along the joint cracks and smaller fractures. Such coal is commonly termed "red coal" by the miners. The coal is generally free of clay, shale, or dirt impurities. In general, it is also free of visible pyrite grains, although pyrite may be seen in scattered clumps of small crystals along joint or fracture surfaces in some of the coal. Calcite in the form of white to semitransparent film-like sheets or veins commonly occurs along the joint and fracture surfaces.

The Nodaway coal is fairly uniform in thickness in any given area. Localized thickening of the coal, however, is reported by the miners. Where the coal is abnormally thick it is also much harder than usual. These thicker and harder coals are termed "rolls" by the miners who do not like to mine them. In places, small faults have caused several inches of displacement in the coal beds. The faults, however, are of no special significance to the miner. The coal dips gently toward the west and northwest.

The Nodaway coal is exposed at numerous places along the steep face of the Howard limestone escarpment and in the beds of streams (Pl. 2A) that cut into the escarpment face. In these places the coal is usually mined by strip mining methods (Pl. 2B). Away from the escarpment edge, however, the coal is progressively farther beneath the surface as one travels westward. In the shaft mines, now mainly abandoned, the depth to the coal ranges from 27 feet nearest the escarpment edge to 120 feet 2 or 3 miles distant in the direction of dip.

Samples of Nodaway coal were collected at the eight mines operating in the fall of 1944. All of these except sample No. 12, which was collected in a recently opened small slope mine in the NW $\frac{1}{4}$ sec. 10, T. 9 S., R. 18 E., Jefferson County, were taken

from mines in Osage County. Samples 1 to 5 are strip mine coals, and the other samples were obtained from shaft mines. Samples 4 and 5 are from the same strip mine, operated by Ira Rogers northeast of Osage City in the NW $\frac{1}{4}$ sec. 17, T. 16 S., R. 15 E. Samples 1 and 2 are from a strip mine in the SW $\frac{1}{4}$ sec. 20, T. 18 S., R. 14 E., operated by H. Rogers. Samples 1 and 5 were collected along the coal face early in the fall of 1944 before mining activities were started. This coal had been exposed to weathering for approximately a year and represents what the miners call "red coal" rather than true or fresh coal. Samples 2 and 4 were secured after the "red coal" had been removed and the coal face had been extended to a point where the overburden was sufficiently thick to protect the coal from the ordinary processes of weathering. Sample 9 was taken in the newly opened Bell No. 4 shaft mine operated by William Isaacs in the NW $\frac{1}{4}$ sec. 23, T. 17 S., R. 14 E., 1 mile south of Burlingame. The coal was secured approximately 35 feet east of the shaft opening at a depth of 120 feet. All other deep mine samples were taken from the coal bed at distances of several hundred feet from the shaft openings. The Jefferson County slope mine sample was collected at the farthest extremity of the slope, which at the time of collection was about 25 feet from the portal of the mine. All samples represent the entire thickness of the coal bed. They were obtained either in unbroken pieces or in two or more pieces which were then arranged in proper sequence so as to restore the total thickness of the coal. In the laboratories of the State Geological Survey all coal samples were channeled and analyzed by August Fleming. In addition, samples 2, 4, 5, 6, and 7 were zoned vertically into 2-inch bands, each of which was then analyzed separately from top to bottom. The proximate analyses of the Nodaway coal samples are given in Tables 3 and 4.

The analyses show that Nodaway coal has a high moisture and sulfur content as compared with other Kansas coals (Table 5). The ash content, on the other hand, is not unusually high. The B.T.U. value per pound compares favorably with the Bevier coal of Leavenworth County. Chemically, the coal is not uniform from top to bottom, as the zonal analyses of samples 2, 4, 5, 6, and 7 (Table 4) show, but seemingly there is no definite order in which the chemical variation occurs.



PLATE 2. *A*, Nodaway coal forming creek bed in the SW $\frac{1}{4}$ sec. 20, T. 18 S., R. 14 E., Osage County. *B*, Nodaway coal face in the H. Rogers & Sons strip mine in the SW $\frac{1}{4}$ sec. 20, T. 18 S., R. 14 E., Osage County, immediately west of view shown in *A*. Cap rock is the Church limestone. *C*, Superior Coal Co. strip mine in NW $\frac{1}{4}$ sec. 17, T. 16 S., R. 14 E., Osage County, showing coal face in fall of 1944, equipment used in removing overburden, and method of mining and loading coal.

TABLE 3.—Proximate analyses, sulfur content, and heating value of the Nodaway coal of eastern Kansas
Analyses by August Fleming in the State Geological Survey laboratories

Sample No.	County	Mine	Location	B. T. U. per pound									
				Moisture (percent)	Volatile matter (percent)	Fixed carbon (percent)	Ash (percent)	Sulfur (percent)	As Received	Moisture free	Moisture and ash free		
1	Osage	H. Rogers strip	SW $\frac{1}{4}$ 20-18-14	9.21	27.41	47.69	15.69	9.90	10,671	11,753	14,209		
2	do	do	do	9.75	36.98	43.15	10.13	7.96	11,150	12,689	13,914		
3	do	Box car strip	NE $\frac{1}{4}$ 34-17-14	15.34	39.35	33.78	11.52	5.09	8,728	10,309	11,935		
4	do	Ira Rogers strip	NW $\frac{1}{4}$ 17-16-15	8.77	31.50	46.09	7.47	8.10	11,603	12,726	13,845		
5	do	do	do	9.00	36.86	45.29	8.85	7.26	11,363	12,493	13,827		
6	do	Didier & Parre No. 1	NE $\frac{1}{4}$ 22-16-14	9.68	35.89	44.04	10.32	7.70	11,054	12,527	13,904		
7	do	Central Fuel Co. No. 2	SE $\frac{1}{4}$ 22-15-14	10.24	37.43	44.04	8.29	8.90	12,170	13,558	14,938		
8	do	Central Fuel Co. No. 3	SW $\frac{1}{4}$ 23-15-14	12.26	35.90	43.93	7.88	7.80	11,335	12,928	14,196		
9	do	Bell No. 4	NW $\frac{1}{4}$ 23-17-14	8.16	39.09	46.00	6.74	6.30	11,953	13,015	14,047		
10	do	J. C.	NE $\frac{1}{4}$ 14-15-14	7.37	39.82	43.95	8.87	8.00	11,778	12,715	14,060		
11	do	Elliott Coal	NW $\frac{1}{4}$ 13-15-14	11.31	37.02	44.61	7.00	7.00	11,479	12,943	14,052		
12	Jefferson	Gaston Rolins	NW $\frac{1}{4}$ 10-9-18	11.52	31.72	39.18	17.57	6.80	9,826	11,105	13,590		
Average				10.22	35.74	43.48	10.03	7.57	11,093	12,230	13,843		

TABLE 4.—Proximate analyses, sulfur content, and heating value of zoned Nodaway coal samples, Osage County, Kansas. (Table 3 mine and location) Analyses by August Fleming in the State Geological Survey laboratories

Sample No.	Zone	Thickness, inches	Moisture (percent)	Volatile matter (percent)	Fixed carbon (percent)	Ash (percent)	Sulfur (percent)	B. T. U. per pound		
								As Received	Moisture free	Moisture and ash free
2	a	2.5	8.67	32.60	41.76	16.97	14.0	10,230	11,201	13,757
	b	1.25	7.77	39.67	42.67	9.89	10.9	11,657	12,639	14,157
	c	2	9.69	39.41	44.60	6.29	6.4	11,781	13,045	14,023
	d	2.25	10.38	38.10	42.71	8.91	6.0	11,357	12,672	14,053
	e	2.5	11.11	35.37	43.49	10.08	6.1	11,241	12,646	14,271
	f	2	10.88	36.74	43.69	8.67	4.4	10,634	11,932	13,221
Average			9.75	36.98	43.15	10.13	7.96	11,150	12,689	13,914
4	a	2	9.37	40.07	46.20	4.36	7.1	12,055	13,301	13,973
	b	2	9.73	39.05	46.50	4.73	7.1	12,203	13,518	14,264
	c	1.75	9.42	39.18	46.05	5.35	7.1	12,019	13,268	14,102
	d	1.75	8.50	37.00	44.24	10.26	7.6	11,102	12,133	13,666
	e	2.5	7.83	34.55	46.27	11.35	10.8	10,859	11,781	13,436
	f	2	7.74	36.19	47.29	8.78	6.9	11,379	12,333	13,631
Average			8.77	31.50	46.09	7.47	7.75	11,603	12,726	13,845
5	a	2	8.34	32.67	42.05	16.94	7.6	10,035	10,948	13,430
	b	2	7.63	37.52	46.30	8.53	6.2	11,643	12,605	13,890
	c	2	8.39	34.58	45.30	11.73	6.45	10,999	13,006	13,769
	d	2	9.82	38.92	45.42	5.84	8.6	12,802	14,196	15,179
	e	1.5	9.44	39.88	45.76	4.92	7.7	10,940	12,080	12,774
	f	1.5	10.38	37.57	46.90	5.15	6.5	11,758	13,120	13,919
Average			9.00	36.86	45.29	3.85	7.26	11,363	12,493	13,827
6	a	1.75	6.30	34.50	43.45	15.74	6.6	10,885	11,617	13,964
	b	2	8.92	37.61	46.08	7.39	7.1	11,193	13,805	13,374
	c	2	10.11	36.83	43.97	9.15	6.6	11,489	12,781	14,220
	d	2	11.22	35.67	43.42	9.69	5.5	10,999	12,389	13,907
	e	2	10.64	36.09	44.66	8.61	6.5	11,312	12,659	14,009
	f	2.50	11.01	36.54	44.98	7.52	7.8	11,522	12,948	14,134
	g	3.25	9.57	33.98	41.61	14.73	14.1	10,376	11,487	13,722
Average			9.68	35.89	44.04	10.32	7.70	11,054	12,527	13,904
7	a	2	8.76	31.07	45.34	14.81	12.0	10,626	11,646	13,906
	b	2	11.79	34.56	42.83	10.89	7.4	10,937	12,399	14,141
	c	2	15.35	36.07	42.52	6.05	6.75	11,470	13,550	14,594
	d	2	12.27	36.58	45.02	5.84	6.9	11,721	13,406	14,363
	e	2	13.13	38.57	44.25	4.05	6.8	11,314	13,024	13,661
	f	2	12.43	39.72	43.84	3.90	4.8	11,809	13,485	14,122
	g	2	11.60	38.38	44.59	5.42	6.3	11,699	13,234	14,100
	h	2	12.42	32.30	43.34	12.04	12.4	11,104	12,679	14,680
Average			12.26	35.90	43.98	7.88	7.80	11,335	12,928	14,196

TABLE 5.—Average proximate analyses, sulfur content, and heating value of Kansas coals
(Schoewe, 1944, Tables 4 and 5)

County	No. of analyses	Name of coal	B. T. U. per pound							
			Moisture (percent)	Volatile matter (percent)	Fixed carbon (percent)	Ash (percent)	Sulfur (percent)	As received	Moisture free	Moisture and ash free
Crawford	3	Fort Scott ¹	2.80	40.3	47.4	9.3	3.9	13,286	13,670	15,130
Crawford and Labette	6	Bevier ¹	3.80	37.8	48.6	9.8	2.6	13,026	13,545	15,077
Cherokee	1	Fleming ¹	2.80	39.3	47.3	10.6	2.3	13,090	13,470	15,120
Cherokee and Crawford	9	Mineral ¹	4.30	34.3	48.7	12.6	3.8	12,488	13,048	15,029
Barton (Mo.), Crawford, and Cherokee	21	Weir-Pittsburg ¹	6.10	33.3	50.7	9.9	3.7	12,622	13,367	15,007
Cherokee	3	"Local" ¹	5.0	30.7	48.1	16.1	6.8	11,576	12,193	14,696
Cherokee	6	Weir-Pittsburg ²	5.05	33.98	52.33	8.63	3.8	13,045	13,738	
Crawford		do	5.95	33.0	51.1	8.3	4.2	12,590	13,385	14,965
Leavenworth	12	Bevier ²	11.85	35.35	39.9	12.9	4.1	11,145	12,335	14,433
Linn	11	Mulberry ²	9.26	31.66	45.44	13.43	2.94	11,386	12,552	14,733
Linn-Miami	3	Thayer ³	4.27	36.27	44.81	14.66	2.39	12,341	12,863	15,064
Neosho	3	do	5.94	33.33	53.15	7.56	0.97	12,878	13,676	14,796
Montgomery	5	do	7.08	34.62	45.50	11.20	1.74	11,967	12,820	14,456
Wilson	2	do	2.96	32.50	51.10	13.45	2.02	12,789	13,187	15,269

¹From Pierce and Courtier (1937, p. 81).

²Average computed from U.S. Bureau of Mines analyses (1929, Table 7).

³Averages computed from Table 4, Schoewe, 1944.

Mining methods.—Nodaway coal is at present mined by strip-ping and deep shaft mining methods, and at one place, in the SW $\frac{1}{4}$ sec. 3, T. 9 S., R. 18 E. in Jefferson County, by drifting or slope mining methods. In former years, drift or slope mining was prevalent along the line of coal outcrops throughout the entire Wabaunsee coal-mining area. Some coal was, and undoubtedly still is, mined directly from the face of the outcrop. Such outcrop mines are commonly in the beds of creeks or along their banks. They are of extremely local extent and yield only a small amount of coal.

Strip mines.—Much of the coal has been mined by the strip-ping method, especially around Carbondale, Scranton, Osage City, and Arvonnia in Osage County, at Lebo in Coffey County, and a short distance east of Neosho Rapids near the Lyons-Coffey County line. In the fall of 1944 only two strip mines were in operation, both in Osage County. One of the mines is northeast of Osage City in the NW $\frac{1}{4}$ sec. 17, T. 16 S., R. 15 E., and is operated by Ira Rogers (Pl. 2C). The other mine is operated by H. Rogers and Sons and is in the SW $\frac{1}{4}$ sec. 20, T. 18 S., R. 14 E., about 1 mile south and 1 mile west of Arvonnia (Pl. 2B). On August 7, 1945, Perry Jones and R. A. Linville of Carbondale began preparations for stripping about 5 acres of coal land in the NE $\frac{1}{4}$ sec. 19, T. 14 S., R. 16 E., about 1 mile east of Carbondale. Coal had been stripped here last in 1942. Stripping of coal is usually done during the fall and winter months. During the other months both Ira and H. Rogers build dams and farm ponds. The overburden at the mines, which ranges from 9 to 20 feet, is removed by huge bulldozers, and the coal, which is 13 to 20 inches thick, is broken into large slabs along the coal face with wedges and crowbars (Pl. 2C). The coal sells for \$4.25 a ton at the mine. According to Ira Rogers, operator of the strip mine northeast of Osage City, the coal is trucked from his mine to Burlington, Council Grove, Dunlap, Emporia, Eureka, Harveyville, Lawrence, McLouth, Melvern, Osage City, Ottawa, Overbrook, Pomona, Quenemo, Reading, Richmond, Soldier, Topeka, Vermillion, and Waverly (Fig. 5). In the strip mine country the royalty paid to the lessor is 1 to 3.5 cents per bushel or 25 to 75 cents per ton of coal mined. Stripping of coal was formerly much more extensive than now. Old strip pits are numerous in the vicinity of Carbondale, east and south of Scranton, northeast and southeast of Osage City, and in a more

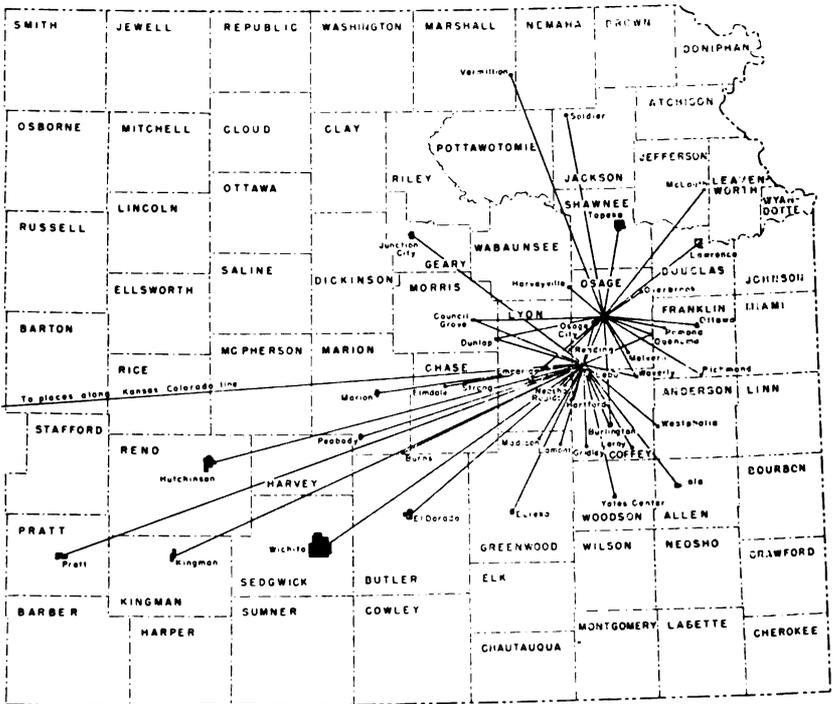


FIG. 5. Map showing the distribution of coal from the Nodaway coal strip mines of Osage County, Kansas.

or less continuous strip along the Howard limestone escarpment between Arvonja (Osage County) and Lebo (Coffey County) (Fig. 17). Other Nodaway coal strip pits are the Capital mines in the SW $\frac{1}{4}$ sec. 13, T. 12 S., R. 15 E., about 2 miles south of Topeka, the strip pits near the Coffeyville-Lyon County line in secs. 23, 24, and 26, T. 13 S., R. 19 E., and the strip mines in Nemaha County in the NW $\frac{1}{4}$ sec. 12 and SW $\frac{1}{4}$ sec. 24, T. 1 S., R. 12 E.

Shaft mines.—All the commercial mines producing Nodaway coal, except the three strip mines just referred to, are shaft mines. In the fall of 1944 only six shaft mines were in operation in the Wabaunsee coal-bearing area. Two of the mines are east and three are south of Burlingame; the sixth mine is northwest of Osage City. The mines are 109 to 120 feet deep. The coal is mined by the longwall method (Fig. 6; for description of method see

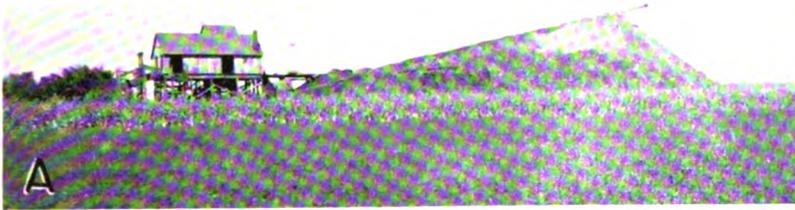


PLATE 3. A, Surface view of the active shaft mine in the Osage coal field operated by Central Fuel Coal Company in the SW $\frac{1}{4}$ sec. 23, T. 15 S., R. 14 E. about 1 $\frac{1}{2}$ miles south of Burlingame, Osage County. B, Typical coal mine dump of abandoned shaft mine adjacent to railroad right of way, south line sec. 22, T. 16 S., R. 14 E. immediately west of west limits of Osage City. C, Newest shaft mine in the Osage coal field, the Bell No. 4 mine, started in March 1944. Mine about 1 mile south of Burlingame in SW cor. NW $\frac{1}{4}$ sec. 23, T. 15 S., R. 14 E.

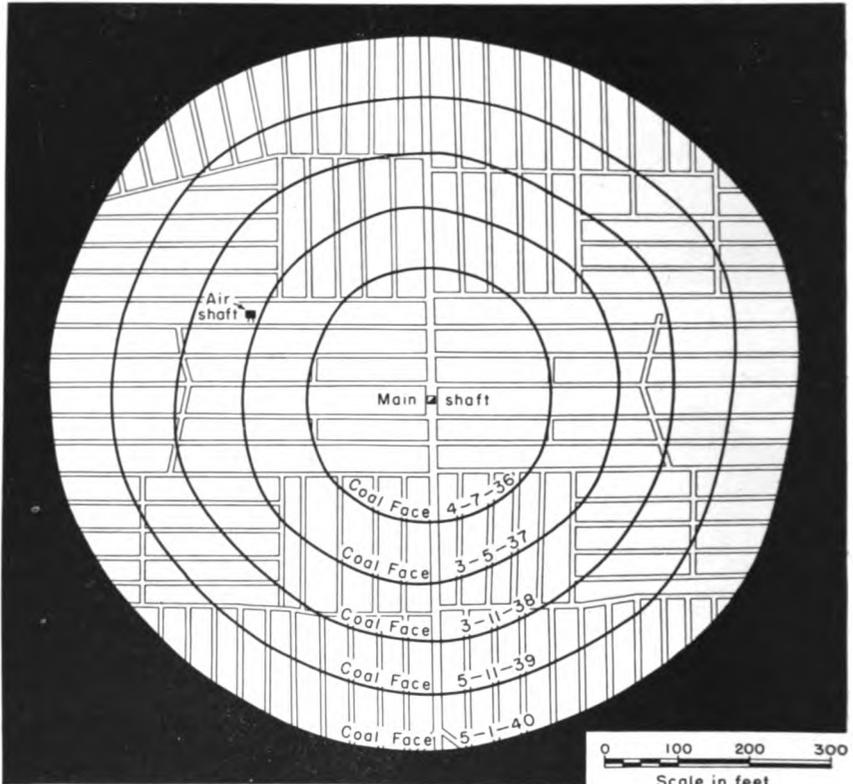


FIG. 6. Plat of an Osage County shaft mine showing the longwall method of mining.

Bowsher and Jewett, 1943, pp. 24-26) and is hoisted to the surface electrically after being cut by machine. The shafts are of standard size, 12 by 6 feet. All the coal mined is trucked away as none of the mines have railroad connections. The selling price of the coal at the mines is \$5.00 per ton. A royalty of 8 cents per ton of mined coal is paid the lessor.

Because of the manpower shortage the mines are not operating with as large a force as normal. Before the war 30 to 40 men per mine were employed, but in the 1944-45 coal season less than half this number were employed. Before the war most of the miners were young to middle aged men, whereas at the time of my visit to the mines practically all the miners were men in their late sixties or early seventies who had returned to the mines from retire-

ment in order to do their share in the war effort. During the years of greatest development, Osage County had 70 or more mines employing about 2,000 men operating at one time. Today only six shaft mines are being operated (Pl. 3A). In the vicinity of Osage City and Burlingame, however, several shaft buildings and tipples are still standing (Pl. 5A) at the mines, but at most places the buildings have been removed, the only evidence of the old mines being the dump piles (Pl. 3B). Between Scranton and Burlingame, a distance of only 5 miles, traces of at least 50 mines may be found and a like number occur within a 1-mile radius from the center of Osage City. At some places the tell-tale dump piles of former mines have been removed and information regarding the former existence of mines must be obtained from coal operators and local citizens.

Drift mines.—In the past, drift or slope mines were common along the entire edge of the Howard limestone escarpment. All such mines are now caved in, cannot be entered, and many cannot be located without detailed descriptions. Only one drift or slope mine was in operation in 1944 (Pl. 4B). Late in 1943 Gaston Rolins opened a drift mine in the SW $\frac{1}{4}$ sec. 3, T. 9 S., R. 18 E., Jefferson County. On September 26, 1945, the tunnel had been extended 25 feet into the hill. The tunnel opening was 7 feet high and 10 feet wide. The coal, 14 inches thick, lies 3 feet beneath the Church limestone. By September 1945, 15 tons of coal had been taken from the drift. A proximate analysis of the coal is found in Table 3.

Number of Nodaway coal mines.—The number of Nodaway coal mines in the Wabaunsee coal-mining area is surprisingly large. I have located and plotted on maps a total of 408 Nodaway coal mines, of which 302 are in Osage County. This is the minimum number of mines once worked as undoubtedly there are some mines whose physical traces are entirely absent and knowledge of which is entirely forgotten. Furthermore, it is practically impossible to know how many mines there are in any given strip mining area. All strip mining areas are counted in this report as representing a single mine unless it is definitely known that contiguous acreage has been mined by independent operators. A tabulation of the number of each type of mine operated in the 10 counties in which the Nodaway coal occurs is presented in Table 6.

TABLE 6.—Mines in the Nodaway coal classified by county and type

County	Number of mines			Total
	Shaft	Strip	Drift	
Atchison	1		3	4
Coffey	3	26	x	29
Doniphan			1	1
Elk		5	1	6
Greenwood		x		x
Jefferson	2		26	28
Lyon			1	1
Nemaha	1	2	9	12
Osage	174	128	x	302
Shawnee	5	3	17	25
Total	186	164	58	408

x Mines reported but number and location unknown.

Production.—Complete statistics on Nodaway coal production are not available, primarily because much of the coal mined, especially in the earlier years, did not enter into regular commercial channels. Much of the coal, particularly in the counties north of the Osage City-Burlingame coal district, was removed and used by local individuals, chiefly farmers, who mined the coal as needed and were not concerned with keeping records of production. Although some early reports give data on the total amount of coal produced in some of the counties, no differentiation is made as to what horizon the coal came from. As far as is known, coal mining started with the coming of the first settlers and the establishment of the first towns. Commercial coal mining may be said to have had its inception in 1869. According to all available published data, a cumulative minimum of 11,783,464 tons of Nodaway coal of which 11,448,861 tons was produced in Osage County, had been mined at the close of the 1944-45 coal mining season. This total includes coal mined in Coffey, Jefferson, Nemaha, Osage, and Shawnee Counties (Table 11) but does not represent the entire cumulative Nodaway production for the records do not show how much of the coal mined in Atchison, Doniphan, Elk, Greenwood, Jackson, and Lyon Counties came from the Nodaway coal bed.

Noncommercial coal mined.—In addition to the commercial coal mined, some Nodaway coal has been mined from earliest times on by farmers and others for their own use. The tonnage of

coal mined in this manner is not included in published statistical data on the State's coal production. During the course of field studies numerous individuals on whose farms coal occurs were contacted for production and other mine data, and all former but now abandoned mines that could be located were visited. Such mines, mainly drift or slope mines, are especially numerous in Atchison and Jefferson Counties.

Present production.—Production of Nodaway coal at the present time is far below that of former years. Annual production ranged from 372,000 to 452,751 tons between 1885 and 1892 and from 120,000 to 296,000 tons in the next 16 years; however, annual production has been less than 90,000 tons in subsequent years except 1940. In that year Osage County, the only commercial producer since about 1900, mined 103,885 tons of Nodaway coal. Production dropped to 79,161 tons in 1941, 85,180 tons in 1942, 51,239 tons in 1943, and 48,861 tons in 1944. In 1931 only 45,984 tons of Nodaway coal were mined. In 1943, nine shaft and five strip mines, employing a total of 195 men, were in operation. During the first six months of 1944, 136 men worked in the eight shaft and four strip mines that were active. In the fall of 1944 coal was mined in only six shaft and two strip mines by about 100 men. In the summer of 1945 considerable acreage was being leased and core drilled for possible future stripping development.

Reserves.—Practically all the coal that has been mined was removed either along the face of the Howard escarpment or from a narrow belt within 2 miles of the escarpment edge. This latter belt is in the shaft mining district between Scranton and Burlingame and between Burlingame and Osage City. Here most of the shaft mines either follow the tracks of the Santa Fe Railroad or line both sides of highway US 50N. The Osage County map (Pl. 1) showing the location of the coal mines, proved reserve lands, and potential coal yielding areas shows that the coal has been mined from a very limited area. Thus far only the most accessible and convenient coal has been exploited. According to Young (1925, p. 36), there is still a large amount of coal to be mined but the best portions of the Nodaway coal have already been mined. Many of the miners, however, are of the opinion that most of the Nodaway coal is still unmined. In the new Bell No. 4 mine in sec. 23, T. 15 S., R. 14 E. about 1 mile south of Burlingame, for example, there is no diminishing in the thickness of the coal

down the dip or in a westerly direction. It is the miners' opinion that the present distribution of the shaft mines was determined mainly by the location of the railroad and the main highway, and that in the future shafts will be sunk at places farther and farther away from the highway.

Bases for computing reserves.—In determining coal reserves, both proved and potential reserves are considered. Proved coal reserves are those coals which can be mined with profit under existing economic conditions. All proved coal reserves are limited to active mining districts or places where definite thicknesses of the coal are known from outcrops, drill records, or actual mined coal seams. Potential coal reserve lands are the areas believed to be underlain by coal of given thicknesses. As no procedure for calculating coal reserves has been generally accepted by the various operating companies and scientific agencies, a definite procedure for determining both proved and potential coal reserves of the state was established in 1946 by Abernathy, Jewett, and Schoewe of the State Geological Survey in connection with their studies of the coal reserves of the state. As used by the Survey the proved coal reserve refers to coal that lies within arbitrary limits of thickness and distance from a known occurrence. These limits are based on past experience of the industry and geological observations in Kansas. The potential reserve is arrived at by regional stratigraphic projection. The following methods of computing the coal reserves in the state are taken from the report by Abernathy, Jewett, and Schoewe (1947).

a. Minimum thickness of coal bed considered for strippable coal and all potential coal is 10 inches.

b. Reserve coal is considered to amount to 125 tons per acre-inch of coal.

c. Preparation and mining losses were not considered; the calculated reserves are tons of coal in place.

d. Maximum depth of coal included in these calculations is 60 feet or the ratio of overburden to be stripped to the coal is not more than 35 cubic yards to 1 ton of coal.

e. Minimum thickness of reserve coal considered minable at various depths by underground methods are shown in Table 7 (Abernathy, Jewett, and Schoewe, 1947, Table 1).

TABLE 7.—Maximum depth to coal per minimum thickness of coal beds considered minable by underground methods in Kansas.

(Abernathy, Jewett, and Schoewe, 1947, Table 1)

Maximum depth to coal, feet	Minimum thickness of coal, inches
100	16
150	18
200	22
600	32
1,200	36

f. The method of computing an area of proved coal reserves is based on the following. A known thickness of coal at an outcrop, a drill hole, deep well, or in a mine is regarded as proving the presence of coal having the same thickness under 1 square mile (Fig. 7A). Two or more known occurrences of the same coal bed 4 miles or less apart and lying in the general direction of the strike are regarded as proving the coal to be continuous between these points (Fig. 7B and C). In the calculation of potential reserves a known thickness of coal at an outcrop, a drill hole, or in a mine is regarded as indicating the presence of coal of the same thickness under 400 square miles (Fig. 7E). The areas of both proved and potential coal calculated by these methods were in most cases greatly reduced from their maximum size by the location of drill holes or outcrops which indicated poor coal, thin coal, or no coal; by areas where the coal has been removed by erosion (Fig. 7C and D); or areas that extend across the state line.

All reserve figures cited in this report are stated to the nearest ten thousand tons.

Total Nodaway coal reserves.—The total proved Nodaway coal reserves are calculated at 128,050,000 tons and the potential reserves at 1,285,960,000 tons. A summary of the Nodaway coal reserves by counties is presented in Table 11. Detailed discussion of coal reserve lands and tonnage for each county is presented on subsequent pages.

ELMO COAL

Geographic distribution.—The Elmo coal, like the Nodaway, is a persistent coal that can be traced from northeastern Brown

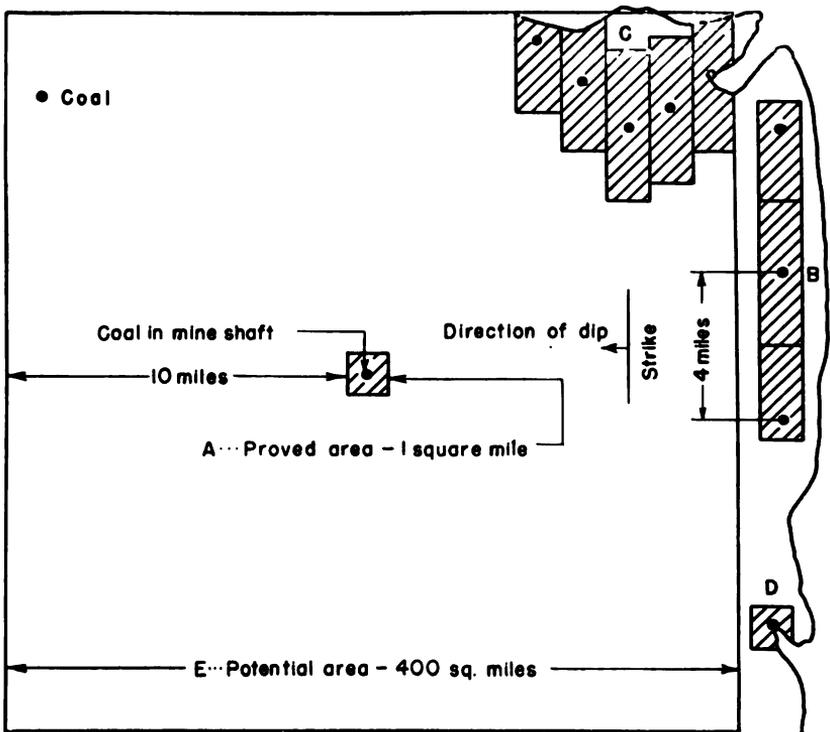


FIG. 7. Diagram showing method of determining proved and potential coal reserves.

County to the Kansas-Oklahoma state boundary in Chautauqua County (Fig. 1). The coal occurs in the upper part of the Cedar Vale shale which underlies the Burlingame limestone so that it can be traced in outcrops close to and following the escarpment of the Burlingame limestone.

Stratigraphic position.—The Elmo coal occurs in the uppermost part of the Cedar Vale shale, whose thickness ranges from about 17 feet in Brown County to about 56 feet in Greenwood County. The formation has an average thickness of 25 feet. The Cedar Vale shale comprises bluish to yellowish-brown clayey and sandy shale and sandstone, which is overlain by the Rulo limestone and underlain by the Happy Hollow limestone. The Rulo limestone is an impure bluish-gray rock, commonly massive, well-jointed, and consisting either of a single bed or of two beds. The rock weathers shelly and breaks into large rectangular

blocks. Not uncommonly the limestone is more shaly than calcareous and loses its identity as a distinct bed. The Rulo limestone is highly fossiliferous, containing abundant crinoid fragments, brachiopods, bryozoans, and, locally, mollusks and algae. Observed thicknesses range from 4 inches to 3.5 feet, averaging about 2 feet. The Happy Hollow limestone at the base of the Cedar Vale shale consists generally of a single massive bed or of two to three beds of pinkish-brown limestone containing large fusulines. The limestone becomes yellowish-brown and crumbly on weathering. In secs. 19 and 30, T. 22 S., R. 12 E., Greenwood County, the Happy Hollow limestone consists of a 9-inch whitish crumbly limestone separated from a 13-inch massive single bed by a 7-inch shale containing calcareous nodules. Beneath the massive limestone is 11 inches of thin-bedded fusuline-bearing limestone. The Happy Hollow limestone is 9 inches to 8 feet thick. At several localities, especially in Brown County, the Elmo coal underlies the Rulo limestone without any intervening shale, whereas at other places, as at the outcrop northwest of Kiro in Shawnee County in sec. 1, T. 11 S., R. 14 E., at least 15 feet of shale separates the coal from the limestone. The intervening shale is 8 feet thick $1\frac{1}{2}$ miles south of Madison in Greenwood County. In Atchison and Brown Counties the Rulo limestone is not everywhere present. This fact may be explained on the basis that either the Rulo limestone has become so shaly that its identity as a resistant calcareous rock has been lost or it was eroded before the deposition of the overlying Silver Lake shale. In the latter case a disconformable contact between the Cedar Vale and Silver Lake shale formations exists. The Rulo limestone is missing on the east side of a road cut, 1 mile north of Larkinburg in sec. 31, T. 6 S., R. 17 E., Atchison County; on the north side of a road cut 0.8 mile east of Arrington in sec. 4, T. 7 S., R. 17 E., Atchison County; and in an abandoned quarry 1.75 miles east and 1.5 miles south of Robinson in sec. 15, T. 3 S., R. 18 E., Brown County.

Locally at least, as at the outcrop in Chautauqua County in the SE $\frac{1}{4}$ sec. 26, T. 32 S., R. 9 E., a coal occurs a short distance below the Burlingame limestone in the Silver Lake shale. Where the Rulo limestone is absent and the Silver Lake and Cedar Vale shales are in contact, and the coal occurs at some distance below the Burlingame limestone, it is believed to be Elmo. Stratigraphic relationships of the Elmo coal are shown graphically in Figure 8.

Geological Survey of Kansas

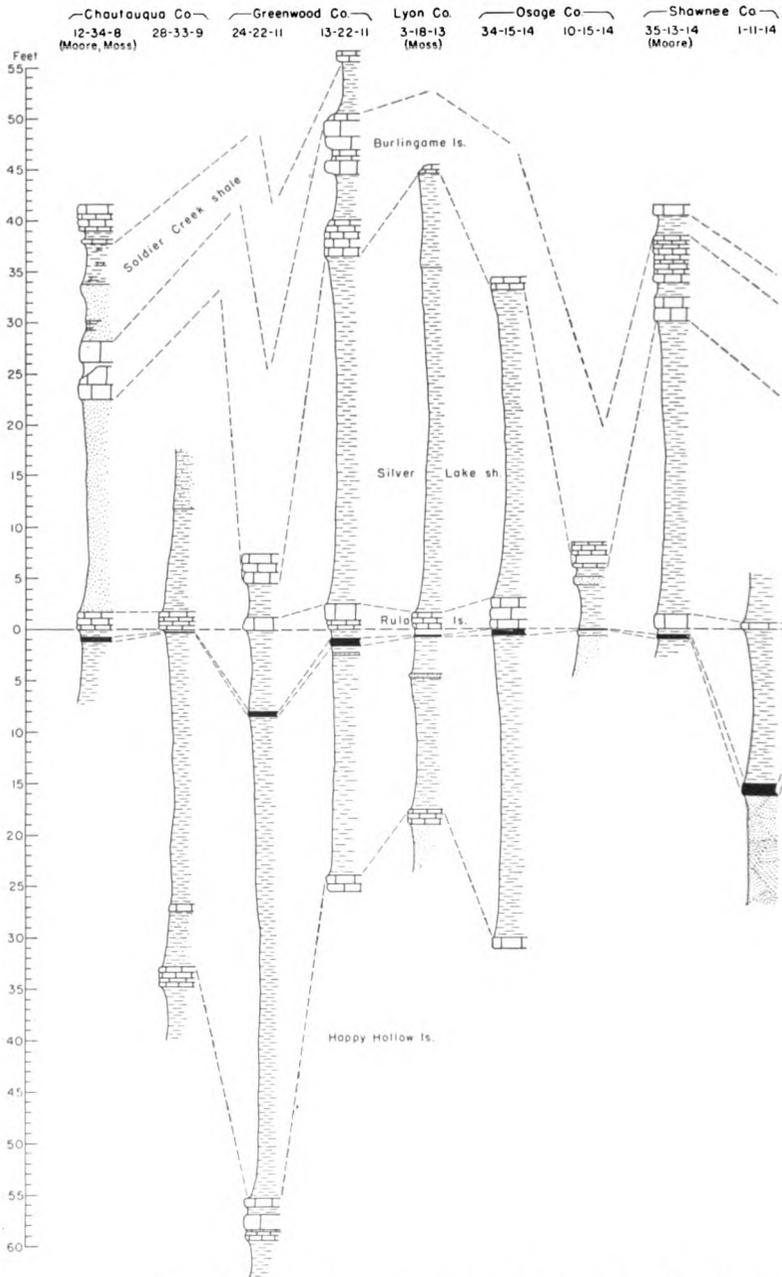
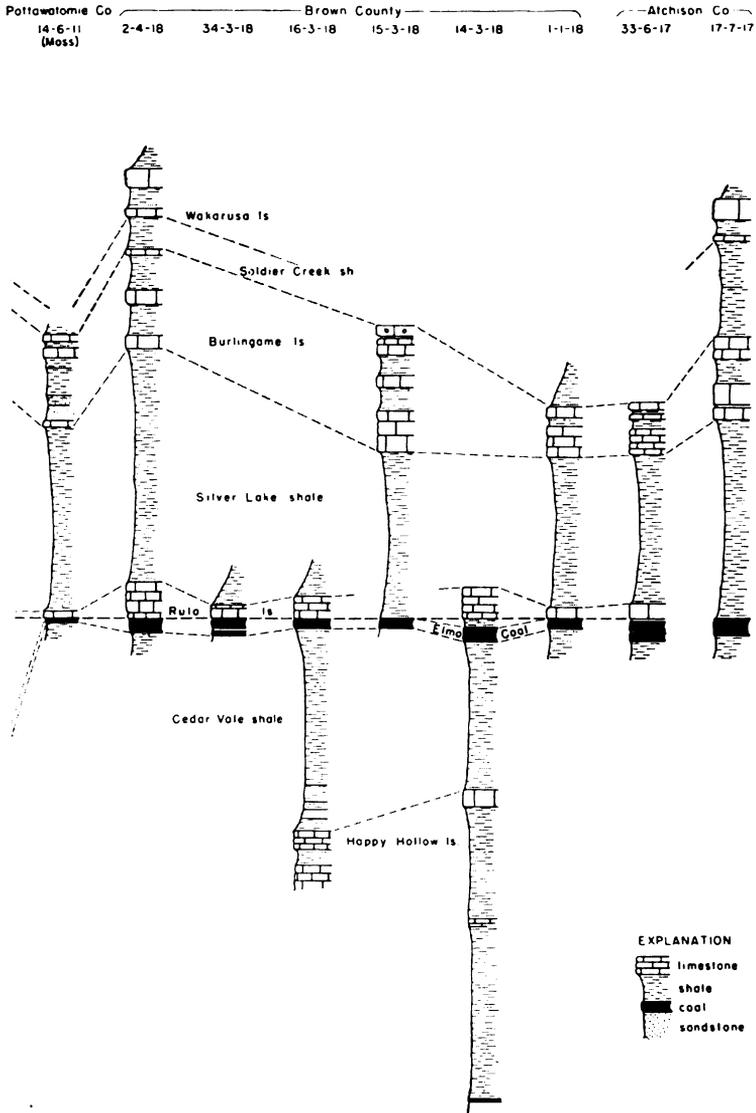


FIG. 8. Stratigraphic sections showing position and thickness



of Elmo coal and its relation to adjacent rocks in Kansas.

Thickness.—Elmo coal where observed ranges from less than 1 inch to 16 inches in thickness. The maximum thickness was observed in Brown County, where the coal was mined extensively for local consumption 20 to 40 years ago. The great thickness of Elmo coal reported to me is 19 to 21 inches where it was mined by drifting about 2 miles south of Arrington in the NE cor. sec. 20, T. 7 S., R. 17 E., Atchison County. Nowhere south of Shawnee County have I seen Elmo coal thicker than 5 inches. Coal has been mined in the vicinity of the former town of Leeds in Chautauqua County. Whitla (1940, pp. 32-33) considered the coal to be Nodaway, from 16 to 18 inches thick. Field studies, however, show that the coal is Elmo and that the cap rock interpreted by Whitla to be Church limestone in reality is Rulo limestone, 50 feet below the base of the Burlingame limestone. The coal is not exposed in the vicinity of Leeds. Further detailed discussion of this coal is found under Chautauqua County. Unlike Nodaway coal, Elmo coal at some outcrops in Atchison and Brown Counties is divided into two beds by a clay or shale parting 1 to 2½ inches thick. Along the road 1 mile north of Larkinburg, in sec. 31, T. 6 S., R. 17 E., Atchison County, there are three seams of coal: coal 8 inches, clay 1 inch, coal 4 inches, black shale 4 inches, and coal 1 inch. Table 8 gives the observed thickness of Elmo coal.

Contact rock.—The contact rock of the Elmo coal is either limestone or shale. Where the Rulo limestone is present, the coal lies either directly beneath the limestone or is separated from it by a shale 1½ inches to 15 feet thick. Where the Rulo limestone

TABLE 8.—Summary of thicknesses of Elmo coal, in inches

County	At outcrops		In underground mines	
	Range	Average	Range	Average
Atchison	7-16	15	17-21	17
Brown	12-18		12-30	16
Pottawatomie		3		
Shawnee	3.6-16	3.6		16
Osage	0.5- 2	1		
Lyon	2.4- 4.8	3		
Greenwood	2- 4	2		
Chautauqua	1.2- 1.5	1.2	16-18	18

is missing, the upper contact rock is shale. The lower contact rock is everywhere shale or underclay. The bluish to ash-white sticky structureless underclay which is found at many outcrops beneath the Nodaway coal is missing beneath the Elmo coal except at two outcrops, in sec. 10, T. 15 S., R. 14 E., Osage County, and in sec. 34, T. 3 S., R. 18 E., Brown County. At the Osage County exposure the underclay is 6 inches thick; in Brown County it is 12 inches thick.

Physical and chemical characteristics.—The Elmo coal is a bituminous coal. It does not everywhere occur as a single vein, but in all other respects it is similar to the Nodaway coal.

Mining methods.—Elmo coal, as far as could be learned, has been mined only in Atchison, Brown, Chautauqua, Elk, and Shawnee Counties. Strip, drift, shaft, and outcrop mining have been employed, but slope (or drift) mining has been the predominant method.

Elmo coal has been extracted from at least 81 mines, of which 61 may be classified as drift or slope mines, 9 as shaft mines, 9 as strip mines, and 2 as outcrop mines. Brown County, with 30 mines, leads in the number of Elmo coal mines followed by Atchison County with 26 mines (Table 9).

The most recently operated Elmo coal mine is on the Clyde Royer farm 1 mile north and 0.5 mile east of Arrington in the SE¼ sec. 33, T. 6 S., R. 17 E., Atchison County. The mine was operated in 1942 and the coal, at least 14 inches thick, was obtained by the stripping method. The coal also was stripped at

TABLE 9.—Mines in the Elmo coal classified by county and type

County	Number of mines				
	Shaft	Strip	Drift	Outcrop	Total
Atchison	2	2	22		26
Brown	3	2	23	2	30
Chautauqua			5		5
Elk	1	4			5
Jackson			3		3
Shawnee	3	1	8		12
Total	9	9	61	2	81

other places, all of which are discussed under the counties in which the mines occur. The drift or slope mines have long been abandoned so that their entries or portals are now caved in. In most places the only evidence of their former existence is the grass and tree-covered dump heaps and traces of trenches leading to the former mine openings. Such mines can be located only with the help of detailed descriptions supplied by the older residents, followed by diligent search and by scratching suspected mounds for coal chips. Coal has been mined along the face of the outcrop in the SE $\frac{1}{4}$ sec. 35, T. 3 S., R. 18 E., Brown County, on the south bank of a small east-flowing stream. The coal here consists of an upper 10-inch bed separated from a 2-inch lower coal by a 2-inch underclay. A short distance upstream the coal crops out in the stream bed. Here also some of the coal has been mined by striping. At present the Elmo coal is not being mined.

Production.—Because much of the Elmo coal was mined for local consumption, production figures were not reported to the state coal mine inspectors and thus are incomplete. At a number of mines, as those near Leeds in Chautauqua County and along Roys Creek and the south fork of Wolf Creek in Brown County, much coal was extracted and sold for neighborhood use. From available information it is estimated that a cumulative minimum of 206,273 tons of Elmo coal have been mined. Of this total, 100,000 tons were mined in Brown County, 46,000 tons in Atchison County, 35,273 tons in Chautauqua County, 15,000 tons in Shawnee County, and 10,000 tons in Elk County (Table 11). More detailed information on production in specific counties is presented in the county sections.

Reserves.—The proved Elmo coal reserves total 47,560,000 tons. Of this amount 23,160,000 tons or 48 percent are in Brown County. Atchison County has 9,910,000 tons or 20.8 percent of the proved coal reserve. Other counties containing proved Elmo coal reserves are Chautauqua with 5,720,000 tons; Shawnee, 3,950,000 tons; Jackson, 2,800,000 tons; and Elk, 2,020,000 tons. The potential Elmo coal reserves constitute the largest reserves of the entire Wabaunsee coals. It is calculated at 1,515,850,000 tons. Further discussion of proved and potential Elmo coal reserves is found on subsequent pages under the respective counties in which the coal occurs and tonnages of reserves are summarized in Table 11.

OTHER WABAUNSEE COALS

Mined coals.—The Nodaway and Elmo coals are the most important commercial coals of the Wabaunsee group. Several other Wabaunsee coals, however, have been mined in the past. These coals, mined principally for local use, include the Cowley County coal in the Willard shale; Blacksmith Creek coal in the Wamego shale, Shawnee County; Nyman coal in the Langdon shale in Lyon County; and Lorton coal in the French Creek shale in Lyon, Greenwood, Pottawatomie, and Wabaunsee Counties. All the coals mentioned are of relatively minor importance commercially and each, with the exception of the Lorton coal, has been mined in no more than one county. They are therefore discussed under the county in which the coal has been mined. Table 10 shows the number of each type of mine at which these miscellaneous Wabaunsee coals have been mined.

Unmined coals.—In addition to the mined Wabaunsee coals, noncommercial coals, for the most part less than 6 inches thick, occur in each of the 14 Wabaunsee shale formations except the White Cloud shale. These coals, because of their noncommercial nature, are not discussed.

SUMMARY OF WABAUNSEE COAL PRODUCTION
AND RESERVES

According to information available (Table 11), 12,017,737 tons of Wabaunsee coal were mined in the Wabaunsee coal-bearing area from 1869 to December 31, 1944. This amount is 4.7 per-

TABLE 10.—*Mines in coal beds of the Wabaunsee group, other than Nodaway and Elmo, classified by county and type*

County	Number of mines				Total
	Shaft	Strip	Drift	Outcrop	
Cowley	1	2	3		6
Greenwood			1		1
Lyon	5	4	6		15
Pottawatomie				1	1
Shawnee		1			1
Wabaunsee				1	1
Total	6	7	10	2	25

TABLE 11.—Summary of Wabunsee coal production and coal reserves in eastern Kansas, by counties, in tons

County	Production				Proved reserves				Potential reserves			
	Nodaway	Elmo and others*	Total	Total	Nodaway	Elmo	Others	Total	Nodaway	Elmo	Others	Total
Atchison		46,000	46,090	1,410,000	9,910,000			11,329,000	115,210,000	137,210,000		252,929,000
Brown		100,000	100,000		23,160,000	280,000	23,440,000		455,900,000		224,000,000	679,900,000
Chautauqua		35,273	35,273		5,720,000		5,720,000		216,020,000			216,020,000
Coffey	199,603		199,603	11,320,000			11,320,000		15,220,000		191,990,000	15,220,000
Cowley		10,000	10,000			6,790,000	6,790,000					191,990,000
Doniphan				3,980,000			3,980,000		47,280,000			47,280,000
Elk		10,000	10,000	1,220,000	2,020,000		3,240,000		72,020,000	259,220,000		331,240,000
Greenwood											61,600,000	61,600,000
Jackson					2,800,000		2,800,000			191,500,000		191,500,000
Jefferson	40,000		40,000	13,600,000			13,600,000		132,000,000			132,000,000
Lyon		18,000	18,000	2,800,000		2,720,000	5,520,000		120,800,000		182,380,000	303,180,000
Nemaha		30,000	30,000	5,760,000			5,760,000		268,800,000			268,800,000
Osage		11,448,861	11,448,861	77,670,000			77,670,000		269,830,000			269,830,000
Pottawatomie											160,000,000	160,000,000
Shawnee	65,000	15,000	80,000	10,290,000	3,950,000	1,280,000	15,520,000		244,800,000	256,000,000	64,000,000	564,800,000
Total	11,783,464	234,273	12,017,737	128,050,000	47,560,000	11,070,000	86,680,000	1,285,960,000	1,515,850,000	883,970,000	3,685,780,000	

*All Elmo coal except figures for Cowley and Lyon Counties.

cent of all coal mined in Kansas. Of the 12,017,737 tons of Wabaunsee coal mined, 98 percent was Nodaway coal and the remaining 2 percent was Elmo and miscellaneous coals (Table 11). The greatest tonnage of Wabaunsee coals, 11,448,861 tons or 95.2 percent, came from mines in Osage County, with Coffey and Brown Counties ranking next (Table 11).

More Wabaunsee coal remains in the ground than has been extracted from it. The proved reserves are calculated at 186,680,000 tons or an amount 15.5 times more than has thus far been produced. The Wabaunsee coal reserves are sufficient to last about 50 years at the average rate of production for the last 5 years. Of these proved reserve coals 128,050,000 tons or 68.5 percent is Nodaway coal, 47,560,000 tons or 25.4 percent is Elmo coal, and the remaining 11,070,000 tons or 6.1 percent is other miscellaneous coals. Osage County leads in the amount of proved reserve of Wabaunsee coals with 77,670,000 tons.

The potential Wabaunsee coal reserves exceed the proved reserves by 19.7 times. The total potential reserve is 3,685,780,000 tons of which 1,285,960,000 tons or 34.8 percent is Nodaway coal, 1,515,850,000 tons or 41.1 percent is Elmo coal, and 883,970,000 tons or 24.1 percent is miscellaneous coals. The potential Wabaunsee coal reserves are sufficient to last about 250 years if the coal is mined at the average rate of production for the 5-year period 1940-44.

ORIGIN OF WABAUNSEE COALS

Coals are accumulations of organic matter, mainly of vegetable origin. The vegetation consists of many kinds—trees, ferns, grasses, sedges, mosses, algae and micro-organisms such as trunks, leaves, stems, branches, seeds, and spores. All these, together with animal remains and inorganic sediments such as silts, sands, and muds, were deposited in a body of water. The coals are believed to consist of the most resistant components of the plants, particularly resins, resin waxes, and higher fats, or the derivatives of compounds comprising them. It is commonly agreed that coal originated from vegetation which grew in swampy or marshy places or was washed into them. The vegetation was usually covered by water, although not to any great depth. As the vegetation died, it underwent a partial decay and was buried beneath succes-

sive layers of matter like itself or of earthy sediments. As the accumulations increased the vegetable matter was subjected to a gradual increase in pressure and an increase in temperature, all of which were factors in the formation of the coal of today. Some of the coal-forming vegetation grew directly in the swamp in which the coal eventually formed, whereas in other cases the vegetable matter drifted in. It is generally believed that coal was formed in fresh water swamps rather than in marine waters and that coal therefore is a terrestrial or continental type of deposit.

The origin of the Wabaunsee coals was not especially considered in this investigation, but factors that suggest clues to the environment or site of deposition of the coal have been observed. Some of the Wabaunsee coals, especially the Nodaway, Elmo, Nyman, and Lorton, extend without interruption across the entire north-south width of the state, a distance of more than 200 miles. Furthermore, they are also known to occur in Oklahoma, Missouri, Nebraska, and Iowa. This widespread distribution strongly suggests that the swamp in which the vegetation grew or in which it was deposited was not a local isolated inland swamp but rather a coastal swamp bordering the continental shore line for hundreds of miles, very much like the marginal swamps of today along the Atlantic seaboard. Whether the swamp waters were entirely fresh or partly brackish is not known. The presence of an underclay immediately beneath the coal suggests that the vegetation, which later was converted into coal, grew in the swamp environment rather than drifting in from elsewhere. In many places the coal is immediately overlain by fossiliferous marine limestone or separated from it by a few inches of marine fossil-bearing shale, which indicates that the coal was formed in coastal swamps close to sea level. The juxtaposition of the marine strata to the seemingly nonmarine coal suggests that a very slight change in sea level could easily flood a fresh to brackish marginal or coastal swamp with marine waters, sever or destroy the barrier between the swamp and the open sea, and thus convert the swamp into open ocean again. The fact that highly fossiliferous marine limestone overlies the coal also indicates that the land adjacent to the swamp must have been low at the time of coal formation. The great predominance of crinoid stems among the fossils suggests that the waters were clear and that relatively little sediment was being washed in from the shore, conditions which again indicate

low-lying shore lines. The general absence of clay partings and other visible impurities in the coal strengthens this hypothesis.

CORE DRILLING

Although it is reasonably certain that the coal beneath the surface of the coal reserve lands forms a continuous deposit and that within limits the thickness of the coal is fairly uniform and predictable, it is nevertheless recommended that sufficient tests by core drilling or other methods be made to establish definitely the actual thickness of the coal as well as its quality in areas thought worthy of exploitation. Such tests could be made with relative ease, speed, and low cost as the overburden, usually soft shales or sandstones, is commonly less than 150 feet thick and in many places less than 50 feet.

WABAUNSEE COAL-BEARING COUNTIES

ATCHISON COUNTY

Nodaway and Elmo coals crop out in Atchison County (Fig. 9). The Nodaway coal outcrops are limited to T. 5 S., R. 19 E., north of Lancaster and east of Huron. Because of the glacial drift, outcrops of the Nodaway coal and the overlying Howard limestone formation are not numerous. The Elmo coal, on the other hand, has a wider distribution. Although it is concealed at numerous places by glacial drift, it can be traced from the northern part of the county southwest of Huron southwestward to the Atchison-Jefferson County line south of Arrington.

Nodaway coal.—The Nodaway coal where seen in Atchison County ranges from 7 to 14 inches in thickness. It crops out only in T. 5 S., R. 19 E.; elsewhere it is concealed beneath a covering of glacial drift. The 14-inch coal occurs in the NW $\frac{1}{4}$ sec. 21 in the bank of a small north-flowing creek (Pl. 5B). The same coal is 10 to 12 inches thick in the stream bank of an east-flowing stream in the NE $\frac{1}{4}$ sec. 20, and it measures 7 inches in the NW cor. SW $\frac{1}{4}$ sec. 16. In sec. 9 the coal is 9 to 11 inches thick. The Nodaway coal underlies the Church limestone and is separated from it by gray to black shale which ranges from a featheredge to 23 inches in thickness. The Church limestone, which serves as an

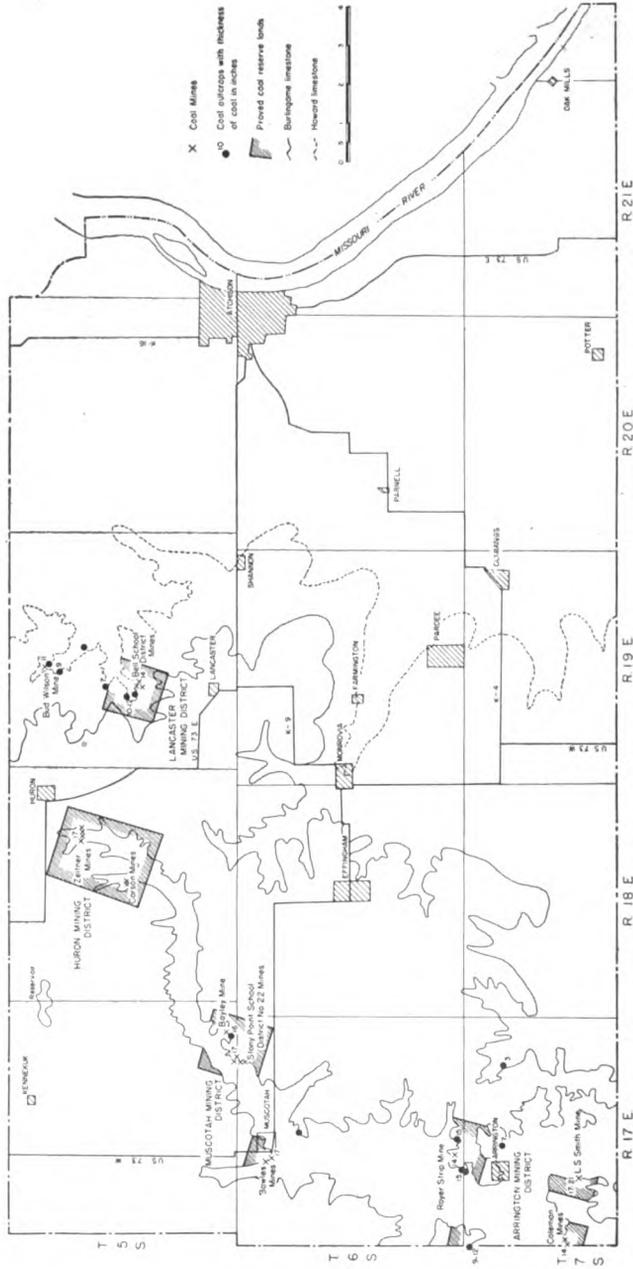


FIG. 9. Map of Atchison County, Kansas, showing Wabaunsee group coal mining districts, location of coal mines and outcrops, proved coal reserve lands, and traces of the Howard and Burlingame limestones.

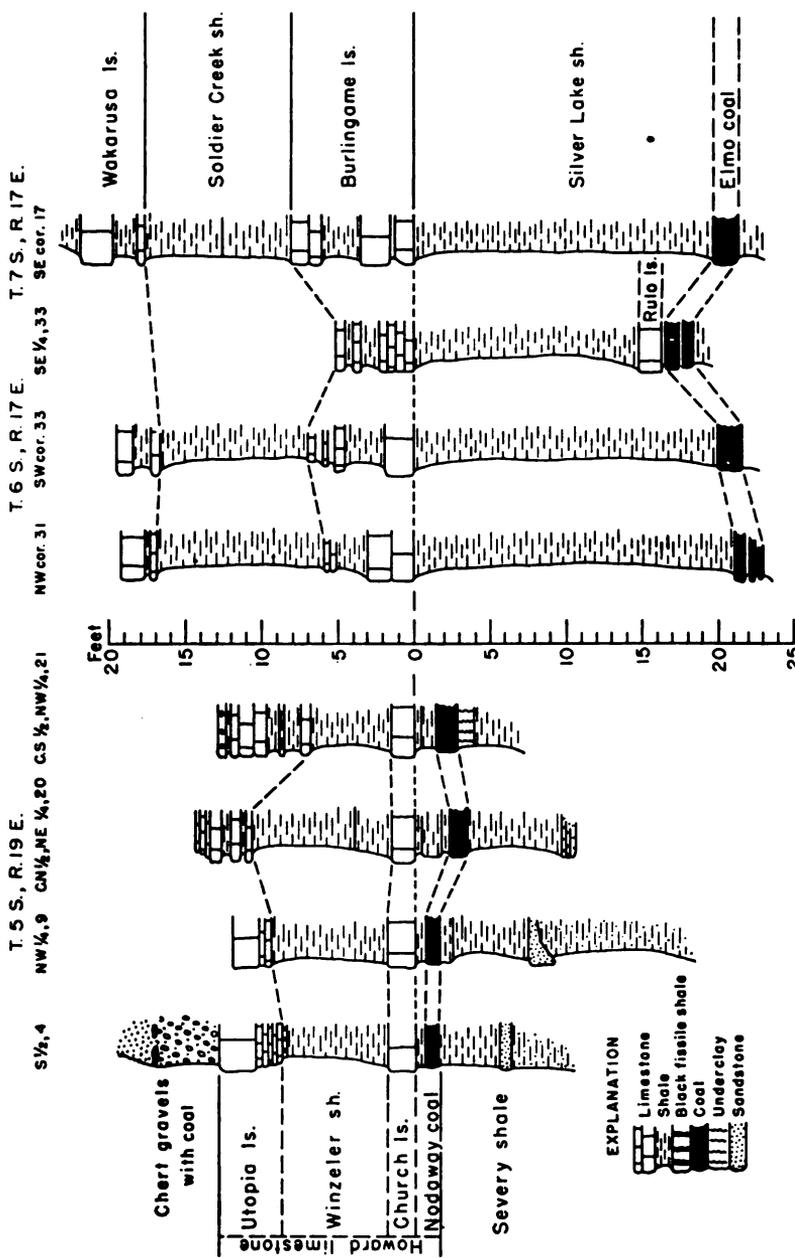


Fig. 10. Stratigraphic sections showing Nodaway and Elmo coals and their relation to adjacent rocks in Atchison County, Kansas.

excellent horizon marker in searching for the coal, is a massive dark-bluish rock that weathers to a rusty brown. The rock is very hard and dense and is cut by vertical joints which cause it to break into large rectangular blocks when weathered. Its average thickness is 18 inches. The Church limestone is fossiliferous and contains especially abundant crinoid stems. Toward its top bryozoans are common. In Atchison County and as far south as Osage County the basal Bachelor Creek limestone is absent and the Nodaway coal marks the base of the Howard limestone formation. The underlying shale, 4 to 6 feet thick, is bluish and argillaceous, and the strata beneath it consist of sandy shales and sandstones. In the NW $\frac{1}{4}$ sec. 21, T. 5 S., R. 19 E., the coal is underlain by an ash-colored sticky structureless underclay 1 foot thick. The Nodaway coal is 42 feet above the top of the Coal Creek limestone, the uppermost member of the Topeka limestone formation, in the SW cor. sec. 10, T. 5 S., R. 19 E.

In Atchison County and as far south as southern Osage County the Utopia limestone is divisible into several units consisting of limestones and dark-gray to black ostracode-bearing shales. The uppermost limestone is full of robust fusulinids. Evidence of a disconformity is indicated by the presence of a brecciated to conglomeratic sandstone which overlies the Utopia limestone or rests directly on the Winzeler shale where the Utopia limestone is missing. In approximately the Cen. SW $\frac{1}{4}$ sec. 4, T. 5 S., R. 19 E., the conglomeratic bed, 4 feet thick and highly dipping, rests on the Utopia limestone. At the top of the conglomerate is a discontinuous coal seam, 3 to 5 inches thick, which is overlain by sandstone containing numerous fine coal streaks. At the mine in the southern part of the NW $\frac{1}{4}$ sec. 21, T. 5 S., R. 19 E., about 2 miles north of Lancaster, the conglomerate bed also rests on the Utopia limestone, whereas about 1,000 feet farther north the Utopia limestone is missing and the conglomerate lies directly on part of the Winzeler shale.

Stratigraphic sections showing the Nodaway coal in relation to overlying and underlying strata are presented in Figure 10.

The Nodaway coal has been and still is being mined by farmers on whose land the coal crops out. It crops out in stream banks and can be mined without much difficulty along the face of the outcrop. As far as I could ascertain, the Wabaunsee coal was formerly mined at one place in the county by shaft mining and at

Clyde Royer strip mine in the SE $\frac{1}{4}$ sec. 33, T. 6 S., R. 17 E., 1 mile north and one-half mile east of Arrington, the coal is practically in contact with the limestone, being separated from it by no more than 3 inches of coaly shale. About one-half mile west of the strip mine along the section-line road a good exposure of rocks from the Wakarusa limestone to the coal reveals no Rulo limestone. The shale between the coal and the base of the white sugarylike basal Burlingame limestone is gray to bluish and is 20 feet thick. One mile north of Larkinburg in the NW cor. sec. 31, T. 6 S., R. 17 E., a similar relationship exists. At this locality the shale between the coal and the basal Burlingame bed is 21.5 feet thick, clayey, and blue to black in color. In a road cut on the Arrington-Cummings highway, about 0.5 mile east of Arrington in sec. 4, T. 7 S., R. 17 E., the coal, 7 inches thick, is overlain and underlain by shale with no Rulo limestone present. Less than 0.25 mile farther west on the same highway the total thickness of the coal is 15 inches. Unlike the Nodaway coal, the Elmo coal at places is split into two or three units. In the outcrop 0.25 mile south and east of the Royer strip mine in sec. 33, T. 6 S., R. 17 E., north and east of Arrington, a 1-inch clay seam divides the coal into two units of 3 and 6.5 inches respectively, and in the road cut 1 mile north of Larkinburg in the NW cor. sec. 31, T. 6 S., R. 17 E., the coal consists of three units, 8, 4, and 1 inch thick separated by clay seams 1 and 4 inches thick. Similarly, 0.2 mile east of the east edge of Arrington on the Arrington-Cummings road in sec. 4, T. 6 S., R. 17 E., the coal is split into three 5-inch units separated by 1- and 2-inch clay seams.

Elmo coal has been mined on the Clarence Zeltner farm (former Hugh Kelley place) in the southern part of sec. 11, T. 5 S., R. 18 E., about 1 mile west and 1 mile south of Huron. According to Mr. Zeltner the coal was 17 inches thick. Only four coal dump piles may still be seen on the Zeltner place, but according to Bud Wilson of Huron, coal was mined from two shaft mines and at least five drift mines which on the average were 300 feet long. Mining started in about 1883 and ceased in 1910. The coal is not exposed on the Zeltner place. According to Wilson, the coal consisted of two seams, the upper of which was 12 to 14 inches thick and the lower, separated from the upper by 1.5 to 3 inches of shale, measured 3 inches in thickness. Elmo coal was also mined by stripping and drifting on the Carson farm in the NW $\frac{1}{4}$ sec. 22,

T. 5 S., R. 18 E. From 40 to 50 years ago Elmo coal was mined by drifting in the Stony Point school district about 2 to 3 miles east and 1.25 miles north of Muscotah. About 0.2 mile north and 0.15 mile east of the school, in the SW cor. SE $\frac{1}{4}$ sec. 35, T. 5 S., R. 17 E., coal dump piles and trenches reveal the former existence of three drift or slope mines. Likewise along the escarpment face in sec. 2, T. 6 S., R. 17 E., less than 0.2 mile west and no more than 0.25 mile south of the school, remnants of other mines abandoned long ago are faintly in evidence. According to Norman Plummer of the Geological Survey staff, who as a youth lived in the Stony Point school district, coal was mined last in this locality about 40 years ago. As far as could be determined the coal lies approximately 20 feet below the base of the Burlingame limestone. No coal outcrops are visible at the present time around the school. In the Bayley pasture about 0.65 mile east of the school and 0.15 mile north, in the SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 36, T. 5 S., R. 17 E., the Elmo coal crops out in a stream bank close to water level. The coal is 16 inches thick and is 39 feet below the first visible overlying limestone. A second outcrop occurs in the stream bed of a small tributary coming from the east about 0.25 mile north and 0.2 mile east of the 16-inch coal outcrop. Coal was also mined in this section close to the junction of the two creeks in whose banks the coal outcrops just mentioned occur. Elmo coal was also mined on the Bryan Bowles place at the west edge of Muscotah in the SW $\frac{1}{4}$ sec. 4, T. 6 S., R. 17 E. Several drift mines indicated by traces of trenches and coal dump piles are still to be seen in the bluffs of Grasshopper or Delaware Creek just west and north of the barn northwest of the Bowles residence. The most recent mine is a strip mine on the Clyde Royer place in the SE $\frac{1}{4}$ sec. 33, T. 6 S., R. 17 E. This mine was operated as late as 1942. Coal was stripped from 2 to 3 acres. A clean bank on the strip pit at the time of my visit showed the coal to be 14 inches thick. On the basis of this thickness, about 5,000 tons of coal were mined at this place. A drift mine was operated in about 1900 in the SE cor. sec. 17, T. 7 S., R. 17 E. Part of the coal vein is still visible close to the mine entrance. The coal is reported to have had a thickness of 17 to 21 inches. Several other drift or slope mines are located in the river bluff approximately 2 miles west and 0.3 mile north of the mine in sec. 17. These mines are on the Coleman place in the SW $\frac{1}{4}$ sec. 18, T. 7 S., R. 17 E., a little more than

1.5 miles south of Larkinburg on the Atchison-Jackson County line. The coal, 14 inches thick, crops out west of the mine in a road cut on the Atchison County side of the road in the SW $\frac{1}{4}$ sec. 18.

Production.—Coal has been mined in Atchison County from at least 30 Wabaunsee coal mines (Table 12), of which 3 were shaft mines, 25 drift mines, and 2 strip pits. Four of the mines produced Nodaway coal, whereas 26 derived their coal from the Elmo coal bed. Except for the period previous to 1877 (Wilson, 1898, p. 113) when practically all the coal used in Atchison County came from the Elmo coal vein and such towns as Effingham secured their entire coal supply from this source, the Wabaunsee coals of the county may be considered essentially non-commercial. All the mines have been operated primarily by local residents or local coal companies to supply fuel for domestic purposes in the immediate vicinity of the mines. For those reasons coal production data have not been recorded with the state coal mine inspectors and consequently are not found in the official reports of the State or Federal governments. Production figures, therefore, must be estimates. If it is assumed that each of the 25 drift mines was operated an average of 5 years, that the minimum

TABLE 12.—Location and classification by type of mine of coal mines in the Wabaunsee group in Atchison County, Kansas

	Location		Number of mines			Coal bed
			Shaft	Drift or slope	Strip	
SW $\frac{1}{4}$	4-5-19E	Eud Wilson mine		1		Nodaway
NW $\frac{1}{4}$	21-5-19E	Bell School district	1	2		do
SW $\frac{1}{4}$	11-5-18E	Zeltner farm	2	5		Elmo
SE $\frac{1}{4}$	15-5-18E			1		do
NW $\frac{1}{4}$	22-5-18E	Carson farm		1	1	do
SE $\frac{1}{4}$	35-5-17E	Stony Point school, District 22		3		do
NE $\frac{1}{4}$	2-6-17E	do		2		do
SW $\frac{1}{4}$	36-5-17E	Bayley pasture		1		do
SW $\frac{1}{4}$	4-6-17E	Bowles place		4		do
SW $\frac{1}{4}$	33-6-17E	Clyde Royer farm			1	do
SW $\frac{1}{4}$	18-7-17E	Coleman farm		4		do
SE cor.	17-7-17E	L. S. Smith farm		1		do
Total			3	25	2	30

thickness of the coal is 12 inches, and that no more than one acre of coal has been extracted from each mine, the estimated production of the drift mines is approximately 39,000 tons. To this amount should be added the estimated 5,000 tons of coal stripped north of Arrington and that mined in the three shaft mines. In addition some coal has been mined by individuals from the face of the outcrops. A reasonable estimate of the cumulative production of Wabaunsee coal mined in Atchison County is 46,000 tons. It should be noted, however, that this does not represent the total amount of coal mined in the county, for in the vicinity of Atchison much coal has been mined in the past from veins stratigraphically lower than the Wabaunsee group.

Proved reserves.—Of the Wabaunsee coal mines in Atchison County, all but four are drift mines along the edge of the escarpments. Therefore, little of the coal has been mined thus far and considerable reserve coal exists. In secs. 20 and 21, T. 5 S., R. 19 E., 1.5 to 2 miles north of Lancaster, there are 940 acres underlain by Nodaway coal averaging 12 inches in thickness. Approximately 1,410,000 tons of minable Nodaway coal underlie these proved reserve lands. Practically all this coal lies less than 35 feet beneath the surface; it is therefore available by stripping methods.

In the Zeltner-Carson district southwest of Huron the Elmo reserve coal lands include all or parts of secs. 9, 10, 11, 14, 15, 16, 21, 22, and 23, T. 5 S., R. 18 E., and total 2,240 acres. The coal underlying this area averages 17 inches in thickness and is all within the depth limit for shafting. Approximately half of it could be mined by stripping. The proved coal reserve of these lands amounts to 4,760,000 tons of Elmo coal. In the Stony Point School district northeast of Muscotah 1,950,000 tons of 16-inch Elmo coal underlies the 973 acres of proved coal reserve lands. The proved area comprises parts of secs. 35 and 36, T. 5 S., R. 17 E., and secs. 1 and 2, T. 6 S., R. 17 E. At Muscotah 269 acres are underlain by 17-inch Elmo coal, or 570,000 tons. North of Arrington in the southern part of sec. 33, T. 6 S., R. 17 E., and in the northern part of sec. 4, T. 7 S., R. 17 E., the proved Elmo coal is 14 to 15.5 inches thick and underlies 544 acres. On the basis of an average of 15 inches for the thickness of the coal, the 544 proved reserve coal acres contain 1,020,000 tons of minable coal. Most of this coal can be mined by stripping as has been done on the Royer property in

TABLE 13.—Proved and potential Wabauusee group coal reserve lands and tonnage by mining districts in Atchison County, Kansas

Coal bed	Mining district or coal reserve area	Mine	Location	Proved reserves			Potential reserves		
				Average thickness of coal, inches	Acres	Tons	Average thickness of coal, inches	Sq. miles	Tons
Nodaway	Lancaster	Bell School Bud Wilson	20, 21-5-19E 4-5-19E	12	940	1,410,000	12	120	115,210,000
Elmo	Huron	Zeltner- Carson	9, 10, 11, 14, 15, 16, 21, 22, 23-5-18E	17	2,240	4,760,000			
	Muscotah	Stony Point school	35-5-17E 1, 2-6-17E	16	972	1,950,000			
do		Bayley	36-5-17E	16					
		Bowles	4-6-17E	17	269	570,000			
	Arrington	Royer	33, 34-6-17E 4, 5-7-17E	15 14	544	1,020,000			
		Coleman	18, 19-7-17E	14	269	470,000			
do		L. S. Smith	17, 20-7-17E	17	352	750,000			
		Larkinburg	31-6-17E 6-7-17E	12	260	390,000			
Total					5,847	11,320,000		263	252,420,000

sec. 33. In the southwest corner of the county in secs. 17, 18, 19, and 20, T. 7 S., R. 17 E., the proved coal reserve lands are estimated at 617 acres. Of these, 269 acres are underlain by 14-inch Elmo coal and 352 acres by 17-inch coal. The proved tonnage of the 14-inch coal which is exposed near the Coleman mines in sec. 18 amounts to 470,000 tons whereas 750,000 tons underlie the L. C. Smith mine and vicinity in secs. 17 and 20. North of Larkinsburg, the Elmo coal is 12 inches thick. The 260 acres of proved coal reserve lands should yield approximately 390,000 tons of Elmo coal.

In summary, the proved reserve coal lands of the Wabaunsee group in Atchison County total 5,847 acres, of which 940 acres are underlain by the Nodaway coal and 4,907 acres contain Elmo coal. Quantitatively there are 11,320,000 tons of proved reserve coals composed of 1,410,000 tons of Nodaway coal and 9,910,000 tons of Elmo coal. Reserve coal acreage and tonnage by mining districts is presented in Table 13.

Potential reserves.—On the basis of the adopted method of computing potential coal reserve lands and tonnage, all of Atchison County west of the trace of the Burlingame limestone (Fig. 9) is underlain by Elmo coal. This area comprises 143 square miles. On the assumption that the average thickness of the coal is 15 inches, 171,600,000 tons of coal lie beneath its surface. The more conservative figure of 137,210,000 tons, given in Table 13, is based on an estimated 12-inch average thickness of coal. The potential reserve Nodaway coal lands comprise 120 square miles and contain 115,210,000 tons of 12-inch coal. Thus there are calculated to be 263 square miles of potential reserve coal lands in Atchison County containing 252,420,000 tons of 12-inch Wabaunsee group coals (Table 13).

Noncommercial coal.—In addition to the proved and potential coal reserves there is much coal that can be recovered in a non-commercial manner by farmers and others at places where the coal averages less than 10 inches in thickness and where it is easily accessible. A favorable locality for such outcrop mining is in secs. 4 and 9, T. 5 S., R. 19 E., about 3 miles east of the east edge of Huron. Years ago Bud Wilson of Huron operated a drift mine in sec. 4. The coal measures 11 inches close to the mine, but is only 9 inches thick less than 0.25 mile distant in a north-south direction from the now-abandoned drift mine.

BROWN COUNTY

All the eastern half of Brown County and parts of Ts. 1, 2, 3, and 4, R. 16 E. are underlain by rocks of Wabaunsee age with all formations but two present (Fig. 11). Four coals crop out in the county. Of these, only the Elmo coal has been mined; one other, the Lorton coal, is minable. The coal in the Wamego shale below the Maple Hill limestone and the Nyman coal in the Langdon shale beneath the Dover limestone are less than 6 inches thick and unminable.

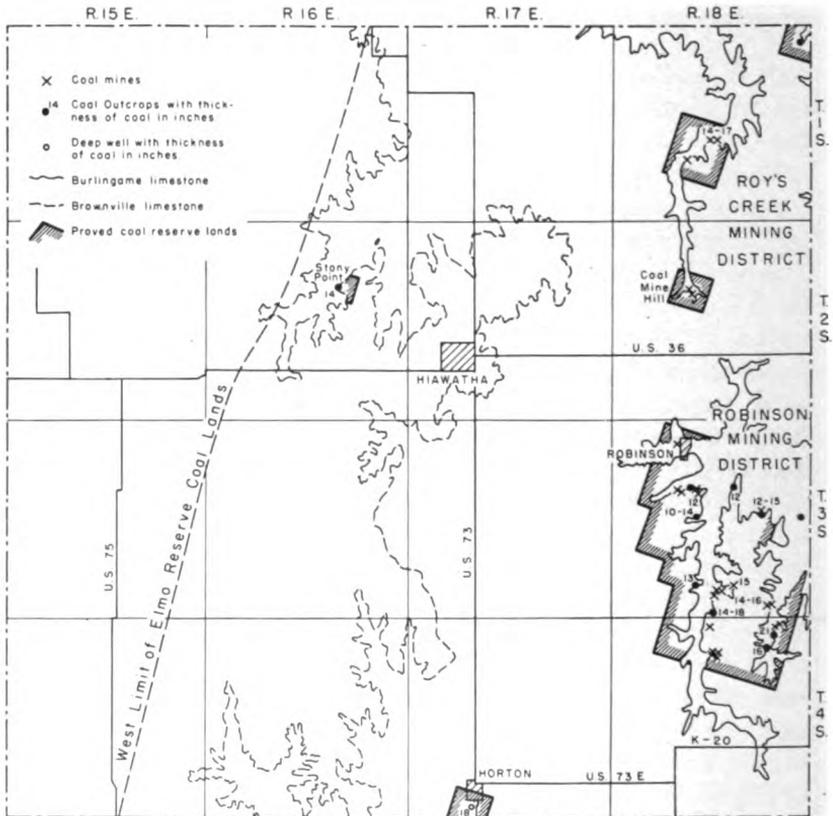


FIG. 11. Map of Brown County, Kansas, showing coal mining districts, location of coal mines and outcrops, proved coal reserve lands, and traces of the Burlingame and Brownville limestones.

Elmo coal.—The most important coal in Brown County is the Elmo coal. It crops out principally in the eastern part of the county in the four townships of R. 18 E. in Brown County (Fig. 11). The coal ranges in thickness from 12 to 18 inches and at most places is directly overlain by the Rulo limestone, which in Brown County is 1 to 3 feet thick. The coal lies 10 to 26 feet below the base of the Burlingame limestone. Beneath the coal is the Cedar Vale shale which is 17 to 23 feet thick. At the abandoned strip mine in the NE cor. sec. 34, T. 3 S., R. 18 E., the coal consists of two seams separated by an underclay 2½ inches thick. The upper seam is 12 inches thick and the lower one 3 inches. Beneath the lower seam are 12 inches of ash-colored underclay. The coal is also exposed in a ditch at the north end of the now inactive limestone quarry in sec. 15, T. 3 S., R. 18 E., approximately 1.5 miles east and 0.75 mile south of the southeast corner of Robinson. The coal is 12 inches thick and occurs 16 feet 6 inches below the base of the Burlingame limestone formation, the strata of which show slight disturbance. No Rulo limestone is present at this locality.

The presence of Elmo coal in Brown County was known about the time of the first settlements in 1854 and 1855. As early as 1866, Mudge (1866, p. 18), Swallow (1866, p. 56), and Hawn (Swallow, 1866, p. 102) noted the occurrence of several coal horizons in the county. Mudge (1866, p. 18) states that the coal was mined at various points in Brown and Doniphan Counties and that it was seldom more than 12 inches thick. Hawn (Swallow, 1866, p. 102), on the other hand, described the Elmo coal as being 14 to 30 inches thick and of good quality. According to Hawn, much coal was mined on Roys Creek at the crossing of the upper road from White Cloud in Doniphan County to Hiawatha. The coal is reported to have been 30 inches thick and was mined by shafting. The coal also has been worked on the west fork of Nemaha Creek where the seam is thought to have a great lateral extent. Hawn correlated the Brown County coal with the Burlingame or Nodaway coal of Osage County. He also referred to the coal cropping out and mined on Wolf Creek near Robinson. This coal, reported at one place to be 36 inches thick, Hawn believed to be from 50 to 100 feet stratigraphically below the coal mined along Roys Creek. It is now known that the coal at the two places is from the same zone and is the Elmo coal. Stripping of coal in 1875 is also reported by Mudge (1875). Coal was mined

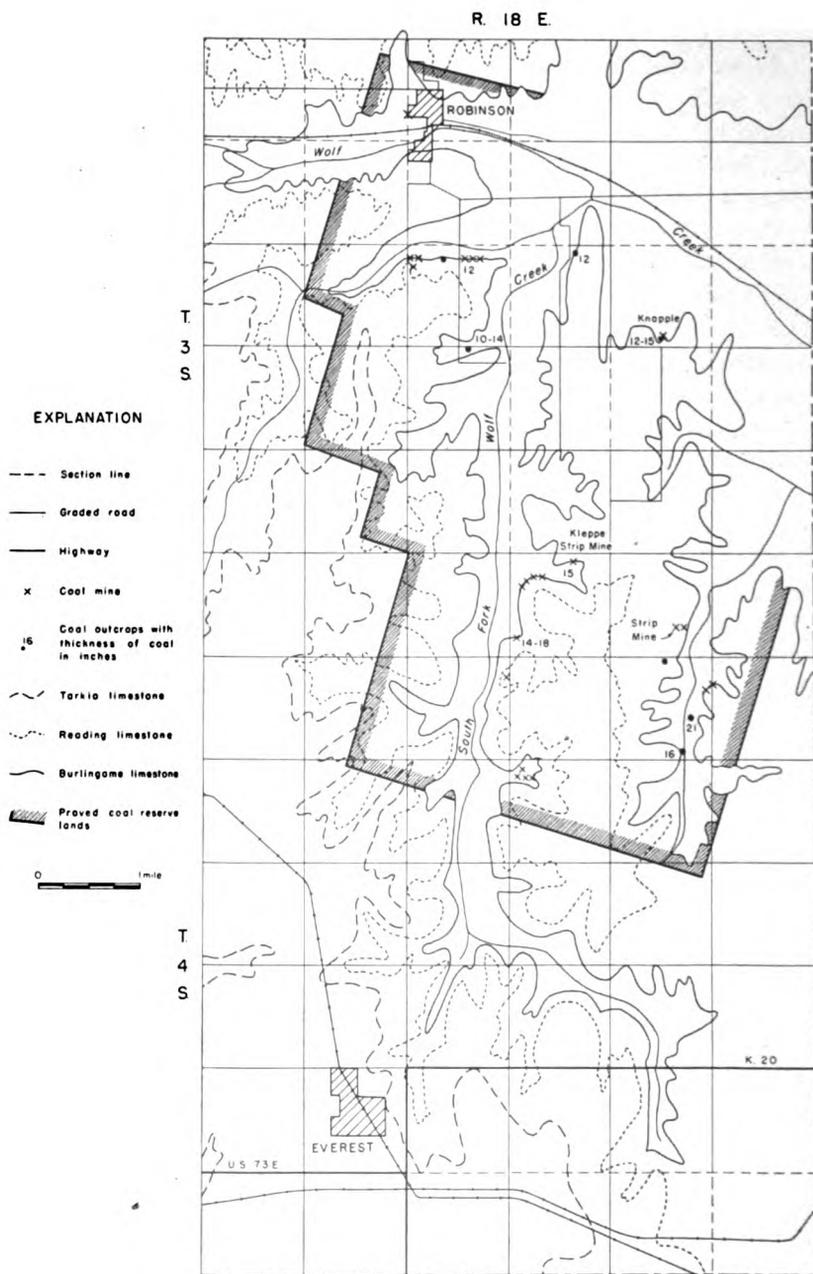


Fig. 12. Map of the Robinson coal mining district, Brown County, Kansas, showing location of mines and coal outcrops, proved coal reserve lands, and traces of the Burlingame, Reading, and Tarkio limestones.

southeast of Robinson as late as 1934 and is worked locally at the present time by farmers who use the coal for their own fuel supplies.

Elmo coal has been worked in Brown County in 30 mines, most of which are located along the bluffs of the South Fork of Wolf Creek south of Robinson (Fig. 12). The coal was worked by drifting at most mines, by stripping at two mines, by shafting at three mines, and by taking the coal from the face of the outcrop in two places. Details on the location of the mines are presented in Table 14.

Lorton coal.—In the extreme NE cor. sec. 15, T. 2 S., R. 16 E., 1.5 miles east and 2 miles south of Hamlin at a place known locally as Stony Point is a 14-inch coal. The coal crops out near the base of a road bank but, on account of the steepness of the bank and nonresistant nature of the rocks, the coal is commonly buried beneath an accumulation of weathered rock waste and thus hidden from view. This is the Lorton coal. It occurs in the French Creek shale formation 8 feet 2 inches below the Nebraska City limestone member of the Caneyville limestone formation (Fig. 13). The coal lies 22 feet below the base of the Brownville

TABLE 14.—Location and classification by type of mine of Elmo coal mines in Brown County, Kansas

Location	Number of mines				Total
	Shaft	Drift or slope	Strip	Outcrop	
NW cor. SW $\frac{1}{4}$ 22-1-18E	1	2			3
NW $\frac{1}{4}$ 28-1-18E		1			1
NE cor. NW $\frac{1}{4}$ 16-2-18E		2			2
SW $\frac{1}{4}$ 4-3-18E	1				1
SE cor. SW $\frac{1}{4}$ 14-3-18E				1	1
NW cor. 16-3-18E		3			3
NE $\frac{1}{4}$ 16-3-18E		3			3
NE $\frac{1}{4}$ 34-3-18E			1		1
NW $\frac{1}{4}$ 34-3-18E		4			4
SW $\frac{1}{4}$ 34-3-18E		1			1
SE $\frac{1}{4}$ 35-3-18E		1	1	1	3
NE $\frac{1}{4}$ 2-4-18E		2			2
NE $\frac{1}{4}$ 4-4-18E		1			1
NW $\frac{1}{4}$ 10-4-18E	1	3			4
Total	3	23	2	2	30

limestone, which marks the contact between the Pennsylvanian and Permian rocks in Kansas. The complete stratigraphic section at the Stony Point outcrop is given below.

Measured section at Stony Point, NE cor. sec. 15, T. 2 S., R. 16 E., east road bank, west-facing slope of hill

	Thickness	
	Feet	Inches
PERMIAN-Wolfcampian		
Falls City limestone		
10. Limestone, large rectangular slabs; contains fossils		
9. Shale, light bluish green	12	
Hawxby shale		
8. Limestone, weathers white; thickness not determinable, probably thin		
7. Shale, more or less covered	26	
PENNSYLVANIAN-Virgilian		
Brownville limestone		
6. Limestone, poorly exposed		
Pony Creek shale		
5. Shale, sandy	11	4
Caneyville limestone		
4. Limestone (Nebraska City member), impure, silty, weathers crumbly, ashy gray	2	6
French Creek shale		
3. Shale, gray brown; contains thin sandy limestones about 1 inch thick distributed throughout the shale	8	2
2. Coal, Lorton	1	2
1. Shale, gray		

The Lorton coal crops out about 0.5 mile north and 0.25 mile east of the Stony Point outcrop in the NW $\frac{1}{4}$ sec. 11, T. 2 S., R. 16 E., and at water level of Walnut Creek in the SE $\frac{1}{4}$ sec. 21, T. 2 S., R. 16 E. At the latter locality the coal is 6 inches thick and lies 10 feet beneath the Nebraska City limestone member of the Caneyville formation. The Lorton coal occurs at other places in the county but is too thin to be mined.

Other Wabaunsee coals.—Coals of two other Wabaunsee zones are present in Brown County. Both coals, however, are less than 6 inches thick and thus are unminable; therefore, they are not considered important for purposes of this report. In the upper part of the Wamego shale close to the Maple Hill limestone is an unnamed thin coal which crops out at the southeast end of the dam at Mission Lake at Horton and in the surrounding vicinity. The other coal, the Nyman, underlies the Dover limestone. It is

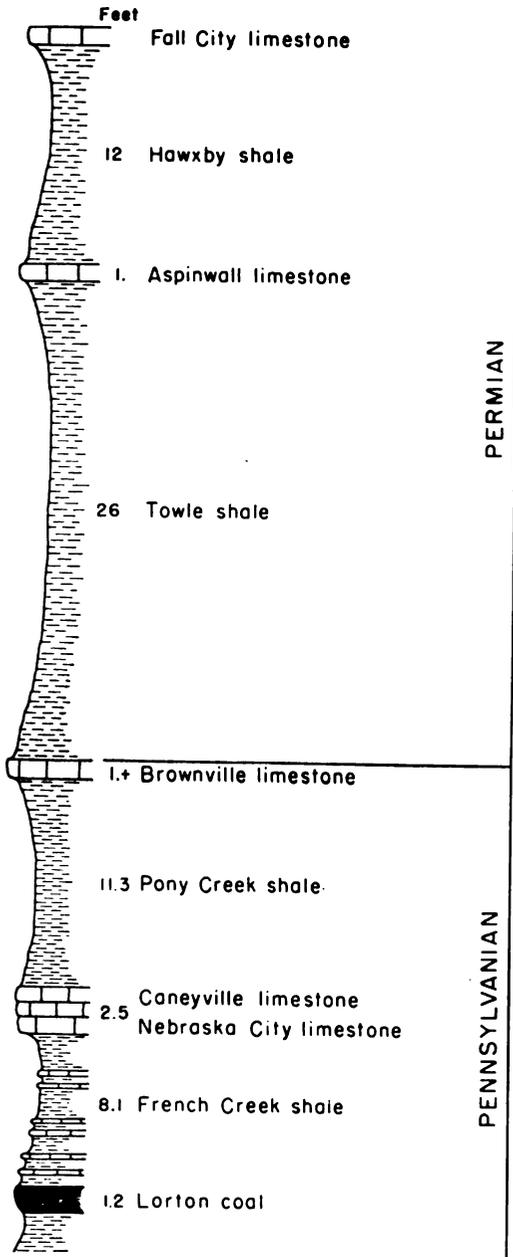


FIG. 13. Stratigraphic section at Stony Point, Brown County, Kansas, showing Lorton coal and its relation to adjacent rocks.

TABLE 15.—Published coal production data for Brown County, Kansas

Year	Tons mined	Year	Tons mined
1878	2,000	1896	3,000
1894	2,000	1897	2,300
1895	3,400		
		Total	12,700

in the upper part of the Langdon shale and crops out at a number of places between Horton and Mercier.

Production.—Coal production figures for Brown County are very incomplete. The only ones published in official reports are those given in Table 15. Without doubt, coal has been mined in the county since 1854, when the first settlements were established in the coal-bearing area. Production records, however, are available for only 5 of the 43 years from 1854 to 1897. The average production for those years is 2,540 tons per year. Assuming an average yearly production of 2,000 tons for the unrecorded 38 years, an additional 76,000 tons should be added to the 12,700 tons listed in Table 15, a total of 88,700 tons. Coal production, however, did not cease with 1897, for it is known that coal was mined south-east of Robinson as late as 1934. It is not unlikely that 100,000 tons of coal have been mined in Brown County.

Proved reserves.—The proved coal reserve lands of Brown County comprise 19.6 square miles underlain by Elmo coal and 160 acres underlain by Lorton coal. There are 23,160,000 tons of proved Elmo coal reserves and 280,000 tons of Lorton coal, a total of 23,440,000 tons of reserve coal. Of the proved Elmo reserve coal, 1,440,000 tons are calculated on the basis of a diamond drill record at Horton where an 18-inch coal lies 131 feet beneath the surface at a depth favorable for shaft mining. Data concerning the proved coal reserves by mining districts are presented in Table 16.

Potential reserves.—Essentially the eastern three-fourths or about 380 square miles of Brown County is underlain by potential Elmo coal reserves. The coal ranges in thickness from 12 to 18 inches with the 16- to 18-inch thickness predominating. Assuming that 15 inches is the average thickness of the Elmo coal for the entire potential area, there are 456,000,000 tons of potential reserve coals less the 100,000 tons already mined, or a net total of

TABLE 16.—*Proved and potential Wabauensee group coal reserve lands and tonnage by mining districts in Brown County, Kansas*

Coal bed	Mining district or coal reserve area	Location	Proved reserves			Potential reserves		
			Average thickness of coal, inches	Square miles	Tons	Average thickness of coal, inches	Square miles	Tons
Elmo	White Cloud	1-1-18E	12	0.75	720,000			
	Roy's Creek	22, 28-1-18E	16	1.96	3,510,000			
	Coal Mine Hill	16-2-18E	16	0.90	1,110,000			
	Robinson	4, 5, 8, 14, 15, 16, 17, 20, 21, 23, 24-3-18E	12	7.38	7,080,000	15	380	456,000,000
	do	26, 27, 35						
	do	36-3-18E	16	5.40	7,110,000			
	do	1, 2, 3, 9, 10, 11, 12-4-18E						
	do	2, 8, 29, 32, 33-3-18E	13	2.2	2,290,000			
	do	4, 5, 8, 9-4-18E	18	1	1,440,000	14	200	224,000,000
	Horton	32-4-17E	14	0.25	280,000			
	Stony Point	15-2-16E						
	Totals			19.84	23,540,000	580		680,000,000
	Production				100,000			100,000
Net reserves				23,440,000			679,900,000	

455,900,000. The Lorton potential coal reserve lands comprise 200 square miles and contain 224,000,000 tons of 14-inch coal. The total potential coal reserves of Brown County amount to 679,900,000 tons (Table 16).

CHAUTAUQUA COUNTY

Rocks of Wabaunsee age crop out in the western one-third of Chautauqua County, chiefly in Ts. 8 and 9, Rs. 32, 33, 34, and 35 E. (Fig. 14). Except for Leeds and its immediate vicinity, in secs. 25, 26, and 36, T. 32 S., R. 9 E., the coal is everywhere too thin to be mined. No coal more than 6 inches thick was observed and at most places it ranged in thickness from a featheredge to 2 inches.

Elmo coal.—The only coal mined commercially in Chautauqua County is the Elmo coal. Five abandoned drift or slope mines are located in the vicinity of the former town of Leeds. The mines were operated from 1890 to 1903 and occasionally since that time. The entrance to a mine in the Cen. SE $\frac{1}{4}$ sec. 26 is still visible. According to Whitla (1940, p. 32) this mine was operated as recently as 1939. The coal in the mines is the Elmo coal and occurs 41 feet 4 inches below the base of the Burlingame limestone (Fig. 15). Whitla (1940, pp. 32-33) believed that the coal, which he says was 18 inches thick, was the Nodaway coal and that the limestone partly exposed at the mine entrance was the Church limestone member of the Howard limestone formation. A study of the geology of the mine area (Figs. 15 and 16), however, reveals that the mine entrance is located between the outcrop of the Burlingame and Happy Hollow limestones and that its entrance or portal is approximately 30 feet below the base of the Burlingame limestone. The outcrop of the basal Howard limestone is 0.5 mile east of the mine. The 4-foot limestone partly exposed at the mine entrance and 7 feet above the coal is the Rulo limestone, not the Church limestone as Whitla believed. The Leeds coal was mined by the room and pillar method. It was used chiefly in the former town of Leeds, although some of the coal was trucked to Cedar Vale, Arkansas City, and Winfield. Two of the mines are located in the SE $\frac{1}{4}$ sec. 25, one in the SW $\frac{1}{4}$ sec. 26, and at least two in the NW $\frac{1}{4}$ sec. 36, T. 12 S., R. 9 E. Whitla (1940, p. 33) also states in his report that a mine is reported to

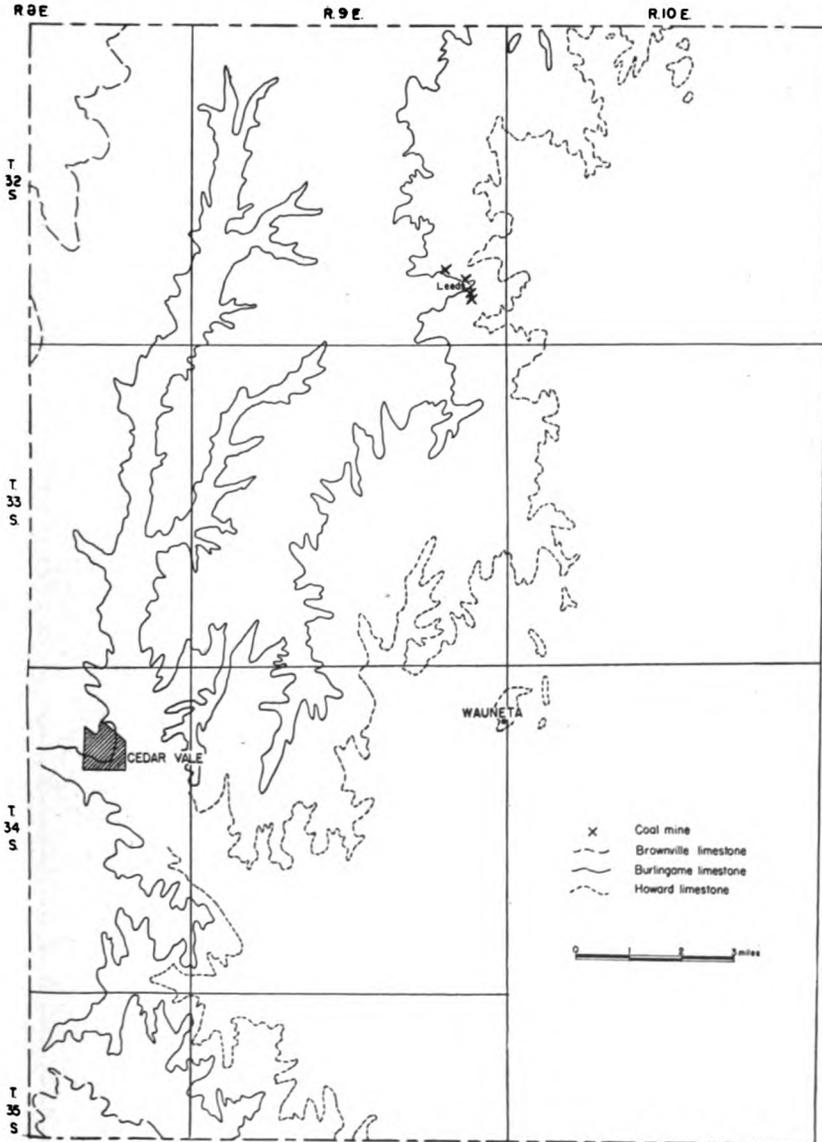


FIG. 14. Map of Chautauqua County, Kansas, showing location of coal mines and traces of the Howard, Burlingame, and Brownville limestones.

Geological Survey of Kansas

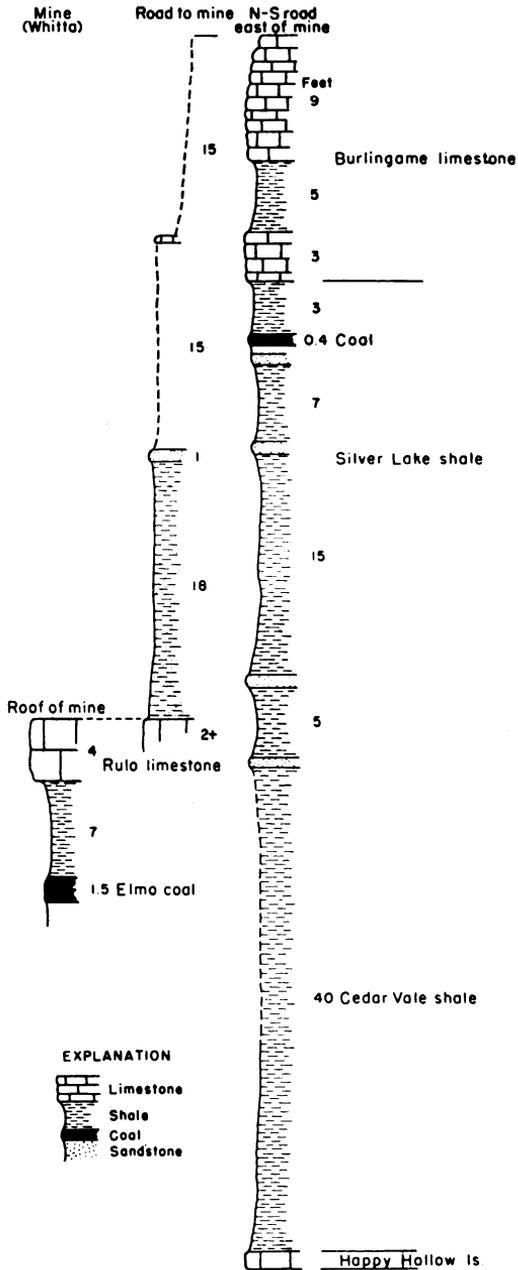


FIG. 15. Stratigraphic section in the Leeds coal mining district, Chautauqua County, Kansas, showing the position of the coal.

have been worked near Cedar Vale in 1938. Several abandoned slope mines are located several miles southwest of Cedar Vale in adjoining Cowley County, but none were seen near this town by me or are known to exist by local residents in Chautauqua County.

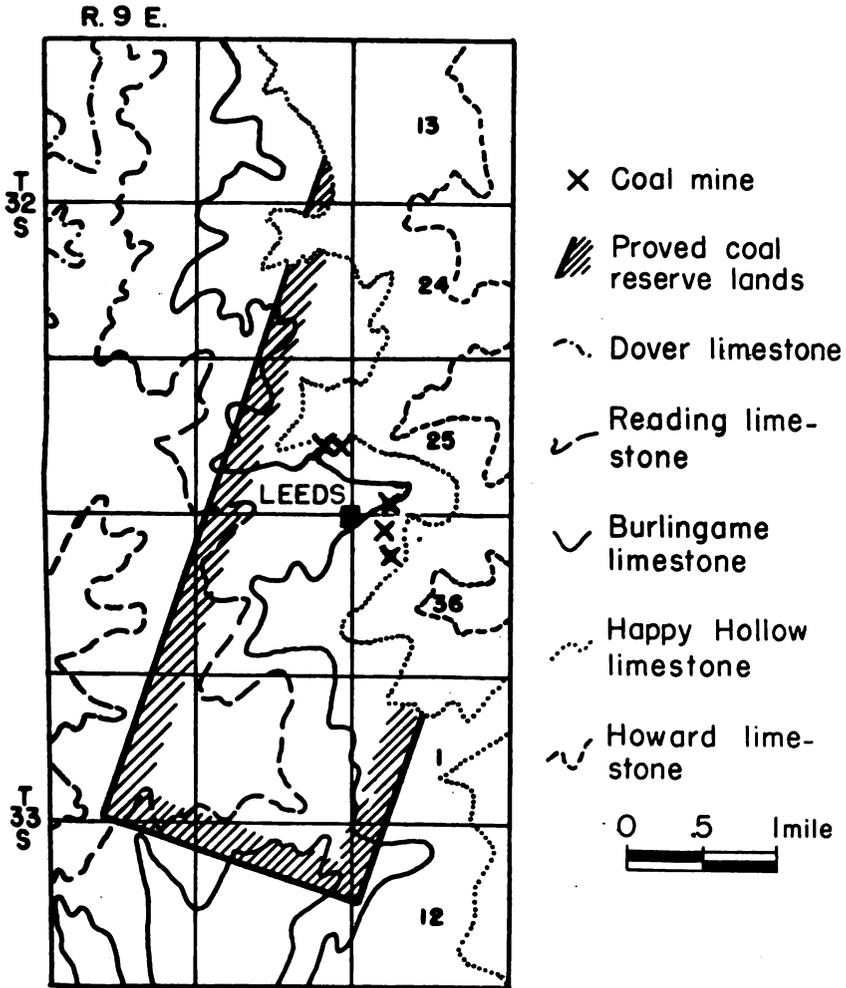


FIG. 16. Map of the Leeds coal mining district, Chautauqua County, Kansas, showing the location of coal mines, proved Elmo coal reserve lands, and traces of the Wabaunsee group limestones.

TABLE 17.—Published coal production data for Chautauqua County, Kansas

YEAR	TONS	YEAR	TONS
1880	400	1897	1,200
1890	1,480	1899	600
1891	1,528	1900	1,100
1893	1,760	1901	1,400
1894	1,520	1902	800
1895	3,000	1903	185
1896	5,000		
		Total	20,273

Production.—Chautauqua County has produced a cumulative minimum of 20,273 tons of coal (Table 17), according to published records. An estimated 15,000 tons might reasonably be added to this amount to allow for almost 40 years for which no data are available. The total coal production for the county, therefore, is approximately 35,273 tons.

Reserves.—In Chautauqua County there are 4 square miles of proved reserve coal lands underlain by 18-inch coal containing about 5,720,000 tons of Elmo coal (Table 11). The potential Elmo coal reserve lands in the county comprise 150 square miles and contain 216,020,000 tons of coal.

COFFEY COUNTY

Wabaunsee coal-bearing rocks are present in only about 20 of the 656 square-mile area of Coffey County. Of the 20 square miles, 16 are in the Lebo district in the northwest corner of the county (Fig. 17). The Howard limestone escarpment along which the coal has been stripped extends in an irregular pattern across this corner of the county. The Howard limestone also crops out at four places in the westernmost tier of sections in Ts. 21 and 22, R. 13 E., but because of the general flatness of the county no coal outcrops were seen.

Nodaway coal.—Nodaway coal is the only coal of the Wabaunsee group present in Coffey County. A stratigraphically lower coal in the Lawrence shale of the Douglas group, however, crops out in the southeastern part of the county. There have been extensive strip and drift or slope mining along the edge of the Howard limestone escarpment at and northwest of Lebo (Fig. 17).

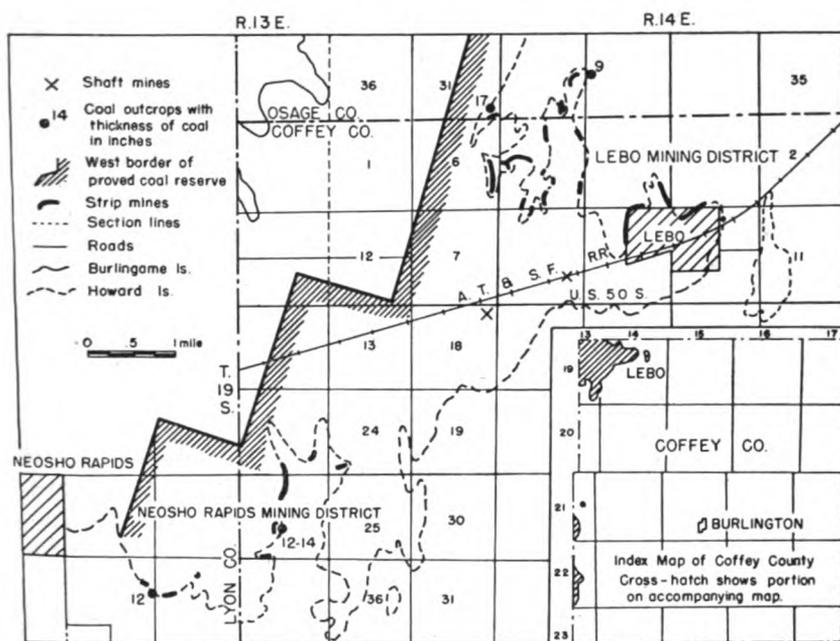


FIG. 17. Map of parts of Coffey, Osage, and Lyon Counties, Kansas, showing Nodaway coal mining district, location of coal mines and outcrops, proved coal reserve lands, and traces of the Howard and Burlingame limestones.

This mining area is a southern extension of the Arvonnia mining district of Osage County. A second strip mining district is in secs. 23, 24, and 26, R. 19 S., R. 13 E., southwest of Lebo and 2 to 3 miles east of Neosho Rapids in Lyon County. According to Keegan (1900, p. 69) a shaft mine was operated by G. H. Slead 2.25 miles east of Neosho Rapids in 1899. The mine was 14 feet deep and the shaft opening was 5 by 9 feet. The coal averages 12 inches in thickness, was mined by the longwall system, and sold for \$2.50 per ton. In 1899 there were 21 mines producing coal in the county.

Although no coal outcrops were seen in Coffey County, the Nodaway coal, 17 inches thick, is exposed in an abandoned strip pit about 300 feet north of the Coffey-Osage County line in the SE cor. sec. 31, T. 18 S., R. 14 E. According to reports of the Kansas coal mine inspectors and local residents, the coal in Coffey County ranges in thickness from 13 to 15 inches. The actual number of mines in the county is difficult to ascertain as most of them are strip mines, many of which are contiguous. There are approxi-

TABLE 18.—Published coal production data for Coffey County, Kansas

YEAR	TONS	YEAR	TONS
1887	6,680	1899	39,740
1889	18,272	1902	15,000
1890	17,200	1933	1,684
1891	17,382	1934	2,200
1893	15,000	1935	2,450
1894	3,500	1936	1,245
1895	3,600	1937	150
1896	4,000		
1897	10,000	Total	154,603

mately 20 mines in the Lebo district and 6 in the Neosho Rapids mining district. In addition there are at least 3 shaft mines and several drift mines. The total number of Nodaway coal mines in the county is between 30 and 35.

Production.—No Nodaway coal is mined commercially in Coffey County at the present time*; the last reported production was for the year 1937 (O'Donnell, 1938, p. 11). It is not known when commercial coal mining first started in the county. However, in 1875 coal was shipped on the Missouri, Kansas, and Texas Railroad, and on the county map for 1875 which accompanied the Fourth Annual Report of the State Board of Agriculture (pp. 232-233), a coal mine is shown in secs. 5 and 8, T. 19 S., R. 14 E., about 1 mile west of the present site of Lebo.

Commercial coal mining in the county has not been continuous. The first and longest period ended in 1902. According to published records, coal mining on a smaller scale was resumed in 1933 and continued until 1937. During those 5 years 7,729 tons of coal were produced, 2,409 tons by shafting and 5,320 tons by stripping. In the early 1890's, the production of coal exceeded 17,000 tons annually. The greatest production was in 1899 when 39,740 tons of coal valued at \$99,250 were produced (Keegan, 1900, p. 69). During that year 21 mines were in operation and 266 men and 56 teams were employed. T. R. and D. O. Jones alone mined 25,000 tons of coal during that year. According to published records, the cumulative total amount of Nodaway coal mined in

*When this report went to press (November 1946) a new strip mine was being opened by Alton Thorne at the north limits of Lebo in the SE¹/₄ sec. 4, T. 19 S., R. 14 E.

the county is 154,603 tons (Table 18). A possible 45,000 tons might be added to this amount to represent the 19 years before 1887 and the 36 years between 1903 and 1943 when some coal undoubtedly was mined although there are no production records. The cumulative production of Nodaway coal in Coffey County may thus be estimated at 199,603 tons.

Proved reserves.—All coal mining activity in Coffey County has been concentrated along the edge of the Howard limestone escarpment in the north, east, and south extremities of the escarpment. In the Lebo district the coal ranges from 11 to 16 inches in thickness; most of the coal has a thickness of 13 or 14 inches. In the Neosho Rapids mining district southwest of Lebo the average thickness of the coal is 12 inches. The proved reserve coal area includes 12 square miles and, on the basis of an average 12-inch coal, contains 11,520,000 tons of coal. The estimated cumulative coal production is 199,600 tons, which leaves a net reserve coal tonnage of approximately 11,320,000 tons.

Potential reserves.—The potential and proved coal reserve areas of Coffey County practically coincide, the former exceeding the latter by 4 square miles. The potential reserve coal tonnage of the 16 square mile area amounts to 15,220,000 tons.

COWLEY COUNTY

In Cowley County the Wabaunsee group of rocks, including formations from the Burlingame to the Brownville limestone, is restricted to Ts. 32, 33, 34, and 35 S., R. 8 E., and along Rock Creek in sec. 12, T. 35 S., R. 7 E. (Fig. 18). Coal is said to have been found in the southeastern part of the county as early as 1875 (Gray, 1875, p. 237). A map of Cowley County for 1875 (Gray, 1875, p. 236) shows the location of coal in sec. 5, T. 35 S., R. 8 E., south of Rock Creek. According to Gray (1878) and Hudson (1881) no coal was mined between 1878 and 1880 but some coal was mined during 1881 and 1882 (Sims, 1883, p. 188). No mention of coal in Cowley County is made in subsequent reports of the State Board of Agriculture and no statistics on coal production for the county are published in any of the reports of the state coal mine inspectors.

Cedar Creek coal.—Coal has been mined in Cowley County at three localities. There are three drift mines in the west-facing

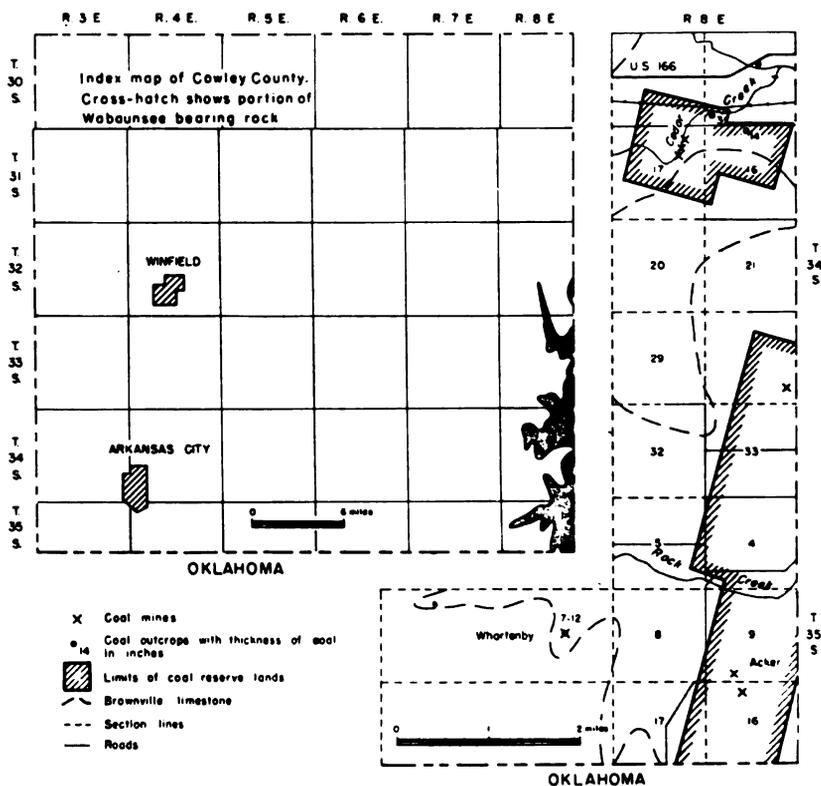


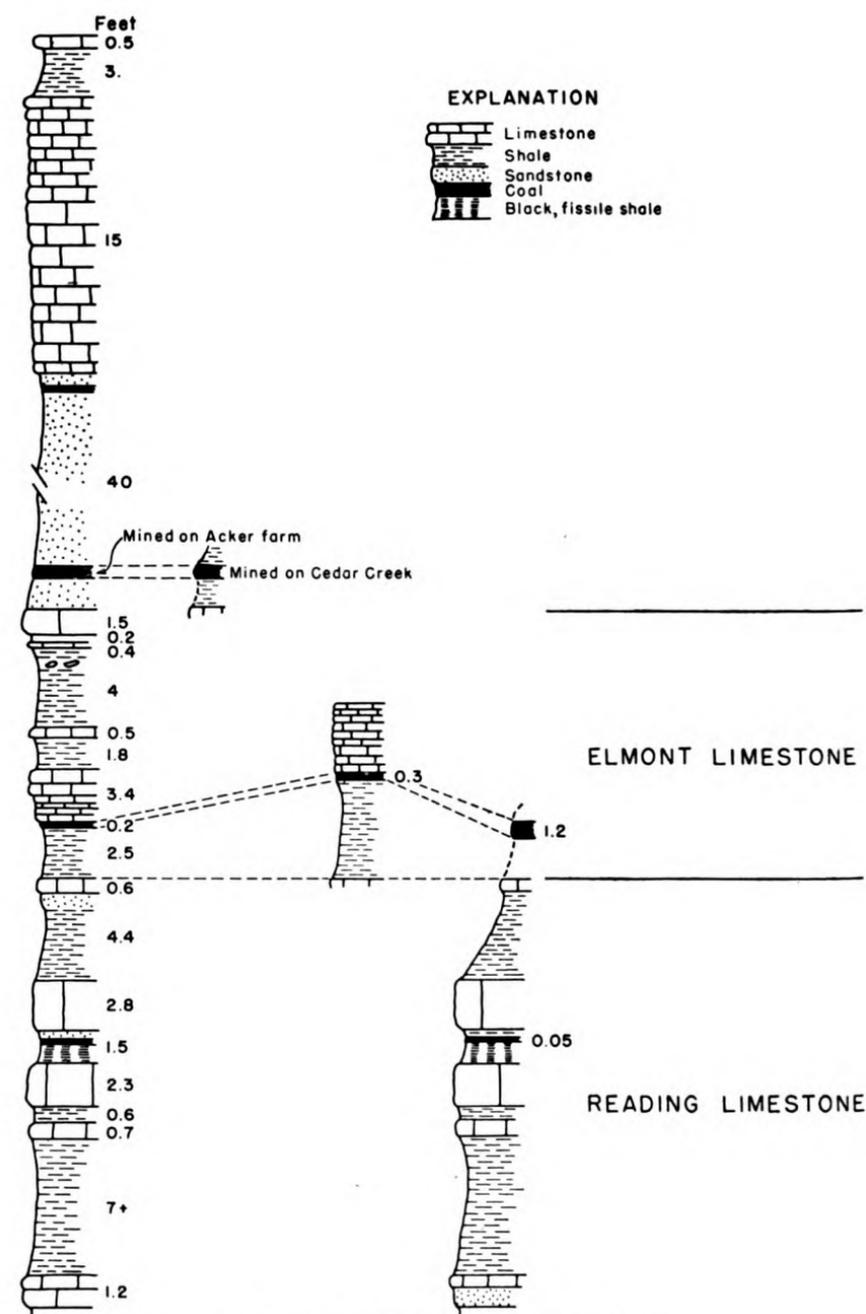
FIG. 18. Map of Cowley County, Kansas, showing location of coal mines and outcrops, proved coal reserve lands, and trace of the Brownville limestone.

bluffs of Cedar Creek in the NE $\frac{1}{4}$ sec. 17, T. 34 S., R. 8 E., about 2.25 miles west and 0.25 to 0.5 mile south of Cedar Vale and 0.25 mile south of the east-west section line road. According to W. J. Hestland, who lives in the SE cor. sec. 8, approximately 0.25 mile east of the mines, the coal is 18 inches thick and was mined as recently as 1937 or 1938. Mining started at this locality between 40 and 50 years ago. The coal at that time was hauled to Arkansas City and Cedar Vale. The same coal was mined in the extreme southeast corner of the county within a mile of the Kansas-Oklahoma state line where it was stripped along a small north-flowing stream on the D. H. Acker farm in the SW $\frac{1}{4}$ sec. 9, T. 35 S., R. 8 E., and on the farm adjoining on the south in sec. 16. According to Mr. Acker the coal was 14 to 16 inches thick and was

overlain by 8 feet of shale and soil. The coal was mined 50 or more years ago and hauled to Cedar Vale, High Prairie, Dexter, and Otto. The coal occurs in the basal part of the Willard shale a few feet above the upper Elmont limestone bed (Figs. 2, 19). In the SE cor. sec. 28, T. 34 S., R. 8 E., along the Cowley-Chautauqua County line, a low dump heap containing fragments of coal marks the location of a former shaft mine. The coal lies about 20 feet beneath the surface and is believed to be the equivalent of the coal stripped on the Acker farm 3 miles south.

The coal under consideration has not previously been discussed and stratigraphically defined. A comparative study by J. M. Jewett and me of the stratigraphy along Cedar Creek and at the Acker locality has demonstrated that the coal at the two localities is the same and that it occurs a few feet above the top of the Elmont limestone in the basal part of the Willard shale formation. The name "Cedar Creek coal" is assigned to it for purposes of discussion.

Unnamed coal.—In the SW cor. sec. 9, T. 34 S., R. 8 E., about 0.3 mile east and 0.3 mile north of the three Cedar Creek drift mines in sec. 17 previously discussed, a 2- to 3-inch coal crops out in the north bank of Cedar Creek. The coal also crops out at the terrace along the north section line road of sec. 16 about 0.6 mile east where it is 14 inches thick. Because of the proximity of this coal to the Cedar Creek drift mines, it was thought that the coals at the two localities were the same. Study of the stratigraphic sequence of the rocks in the Acker locality 6 to 7 miles farther south and comparison with the rock section along Cedar Creek, however, disclosed that the coal exposed along Cedar Creek in sec. 9 and along the road in sec. 16 is stratigraphically below the coal mined at the three drift mines in sec. 17, T. 34 S., R. 8 E., and at the Acker strip mines in secs. 9 and 16, T. 35 S., R. 8 E. The coal occurs in the Harveyville shale between the Elmont and Reading limestone formations and is approximately 13 feet below the Cedar Creek coal in the Willard shale formation (Fig. 19). This coal, like the Cedar Creek coal, has not been discussed previously nor named. Coal 7 to 12 inches thick is also reported by C. T. Whartenby (personal communication) to have been mined on his ranch in the east part of sec. 7, T. 35 S., R. 8 E. Search for the coal and mines, however, was unsuccessful.



9,16-35-9E NE $\frac{1}{4}$, 17-34-8E SW cor. 9-34-8E NE $\frac{1}{4}$ & SW $\frac{1}{4}$, 9-34-8E

FIG. 19. Stratigraphic section of strata in the southeastern corner of Cowley County, Kansas, showing coal beds and their relation to adjacent rocks.

TABLE 19.—Location and classification by type of mine of coal mines in Cowley County, Kansas

Location	Number of mines			
	Shaft	Drift	Strip	Total
NE $\frac{1}{4}$ sec. 17-34-8E		3		3
SE cor. sec. 28-34-8E	1			1
SW $\frac{1}{4}$ sec. 9-35-8E			1	1
NW $\frac{1}{4}$ sec. 16-35-8E			1	1
Total	1	3	2	6

Production and reserves.—Although local residents report that much coal has been mined at the Cedar Creek drift mines and in the southeast corner of the county, no production has been recorded with the state coal mine inspectors; hence no definite tonnage can be given. It is doubtful whether more than 10,000 tons of coal, 5,000 tons at each one of the two mining localities, have been mined in the six coal mines (Table 19) in southeastern Cowley County. The proved Cedar Creek coal reserve lands include 1 square mile in secs. 16 and 17, T. 34 S., R. 8 E., which is underlain by 18-inch coal, and 4 square miles in secs. 28 and 33, T. 34 S., R. 8 E. and secs. 4, 8, 9, 16, and 17, T. 35 S., R. 8 E., underlain by 15-inch coal. Of the unnamed 14-inch coal in sec. 16, T. 34 S., R. 8 E., there is a proved reserve of 0.5 square mile and 560,000 tons of coal. The total proved reserve coal is approximately 6,790,000 tons. The potential reserve lands and tonnage of the Cedar Creek coal are 150 square miles and 191,990,000 tons of coal. Because of the rapid thinning of the unnamed coal from 14 to 2 inches within half a mile, no potential coal reserve area and tonnage of this coal are presented (Table 20).

DONIPHAN COUNTY

The only coal in the Wabaunsee group that crops out in Doniphan County is the Nodaway. The Wabaunsee rocks, from the Howard to the Reading formations, inclusive, are essentially confined to the westernmost tier of R. 19 E. with an extension into R. 20 E. in Ts. 3 and 4 S. (Fig. 20).

Nodaway coal.—Outcrops of the Nodaway coal and of the overlying Howard limestone formation are scarce, largely because

TABLE 20.—*Proved and potential Wabaunsee coal reserve lands and tonnage in Cowley County, Kansas*

Coal bed	Location	Proved reserves			Potential reserves		
		Average thickness of coal, inches	Square miles	Tons	Average thickness of coal, inches	Square miles	Tons
Cedar Creek	16, 17-34-8E	18	1	1,435,000			
	28, 33-34-8E 4, 8, 9, 16, 17-35-8E	15	4	4,795,000	16	150	191,990,000
Unnamed	16-34-8E	14	0.5	560,000			
Total				6,790,000			191,990,000

of the heavy glacial drift covering this part of the state. The Bachelor Creek limestone member of the Howard limestone formation is absent; thus the coal is overlain and underlain by shale, which aids in concealing the coal. Where the coal can be seen it lies 1 foot 2 inches to 2 feet 6 inches below the Church limestone, which consists of a single massive bed 17 to 20 inches thick. The coal was observed at five places. In the NW cor. SW $\frac{1}{4}$ sec. 28, T. 3 S., R. 19 E., $1\frac{1}{2}$ miles south and 1 mile east of Leona, the coal is split into two units by a 6-inch shale; the upper unit is 2 inches thick and the lower 4 inches. At the other four localities the coal consists of a single bed 5 to 12 inches thick. At the Van Roussen farm, in the NW cor. sec. 34, T. 4 S., R. 19 E., $2\frac{1}{2}$ miles east and 1 mile south of Purcell, the Utopia or uppermost member of the Howard limestone formation is missing. Beneath the coal, which is 12 inches thick, is a gray shale. In the NW cor. SW $\frac{1}{4}$ sec. 34, T. 4 S., R. 19 E., the coal which is 9 inches thick, is underlain by a 9-inch ash-colored underclay and overlain by glacial till. The present exposure is due to recent undermining of the supports of a small county road bridge which when repaired will again conceal the coal. The 9-inch thickness of the coal does not necessarily represent the entire thickness as is suggested by the 12-inch seam 0.5 mile farther north.

The occurrence of the Nodaway coal in Doniphan County had been noted by Swallow (1866, p. 105) before 1866. Mudge, who had also seen the coal, reported (1866, p. 18) that the coal had been mined at various places in Doniphan and Brown Counties. Mudge (1875, p. 125) also states that the coal, at that time not

recognized as the same vein that was mined near Osage City in Osage County, had been worked by stripping in various counties including Doniphan. Condra (1927, p. 103) reports the presence of an abandoned coal mine at the railroad level about 0.4 mile west of White Cloud. Search for this mine in the SW $\frac{1}{4}$ sec. 9, T. 1 S., R. 19 E., was unsuccessful largely because of the great amount of slumping that has taken place and the change in the road level since the abandonment of the railroad some years ago. If coal was mined at this locality, it probably was not less than 12 inches thick.

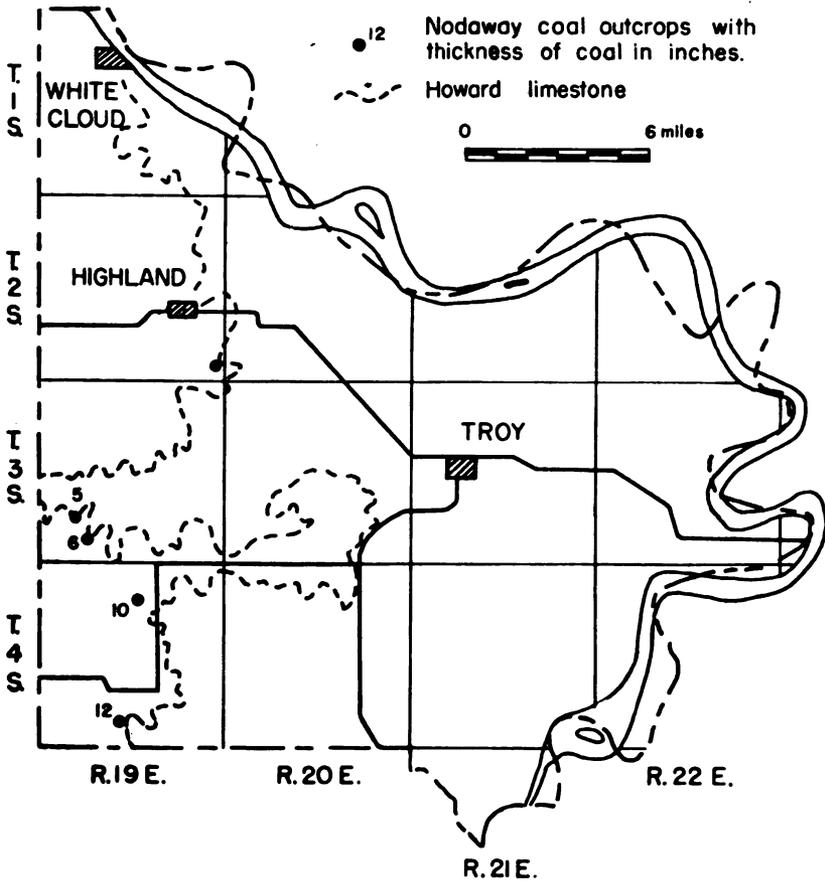


FIG. 20. Map of Doniphan County, Kansas, showing outcrops of the Nodaway coal and trace of the Howard limestone.

TABLE 21.—*Proved and potential Nodaway coal reserve lands and tonnage in Doniphan County, Kansas*

Location	Proved reserves			Potential reserves		
	Average thickness of coal, inches	Square miles	Tons	Average thickness of coal, inches	Square miles	Tons
Secs. 21, 22, 27, 28, 33, 34-4-19E	12	1.9	1,820,000	11	21	18,480,000
Secs. 3, 10, 11, 15, 16, 22-4-19E	10	2.7	2,160,000			
Secs. 8, 9, 16-1-19E				12	30	28,800,000
Total		4.6	3,980,000		51	47,280,000

Production and reserves.—It is not known how much coal was mined just west of White Cloud or anywhere else in Doniphan County, but the tonnage probably is insignificant. On the basis of coal outcrops, it is calculated that there are 1.9 square miles of proved coal reserve lands in secs. 21, 22, 27, 28, 33, and 34, T. 4 S., R. 19 E., underlain by 1,820,000 tons of 12-inch coal (Table 21). In addition there are 2.7 square miles of 10-inch proved reserve lands south of Denton capable of yielding 2,160,000 tons of coal. The total proved reserve coal tonnage for Doniphan County is 3,980,000 tons. Although coal has been mined just west of White Cloud (Condra, 1927, p. 103), no proved coal reserves are listed for this locality. The coal is at least 100 feet beneath the surface, which is too deep for economical stripping or shaft mining of a 12-inch seam. Limited drift mining, however, could be carried on. Potentially there are 47,280,000 tons of coal reserves underlying 51 square miles in Doniphan County.

ELK COUNTY

The Wabaunsee group of rocks crops out in the western half of Elk County (Fig. 21). Coal occurs at several horizons, but as far as known only the Nodaway and Elmo coals have been mined. As early as 1877 coal from this county was used for local domestic purposes (Gray, 1878, p. 201). Production in the county, however, has not been great.

Nodaway coal.—Nodaway coal crops out at a number of places along the edges of the Howard limestone escarpment, but nowhere has the thickness of the coal been more than 7 inches. North of Howard, in sec. 11, T. 29 S., R. 10 E., the coal is 4 to 5 inches thick; 1 mile west of the city, in sec. 2, T. 30 S., R. 10 E., it is only 4 inches thick; and in sec. 16, T. 30 S., R. 10 E., about 2.5 miles west and 1.5 miles south of Howard, it is again 7 inches thick. In the SE¼ sec. 21, T. 30 S., R. 10 E., the coal was found close to creek level but because of high water and slump its thickness could not be measured. As far as I could determine from the general descriptions given in the reports of the state coal mine inspectors and by Whitla (1940, p. 36), coal was formerly mined at this locality. According to Whitla (1940, p. 36) the coal is 18 inches thick. The mine, a slope mine, was abandoned in 1899 after a cave-in killed a man. South of Moline, in the NE cor. sec. 21 and at the SW cor. NW¼ sec. 33, T. 31 S., R. 10 E., the Nodaway coal is only 1 inch thick. Even though the coal is less than

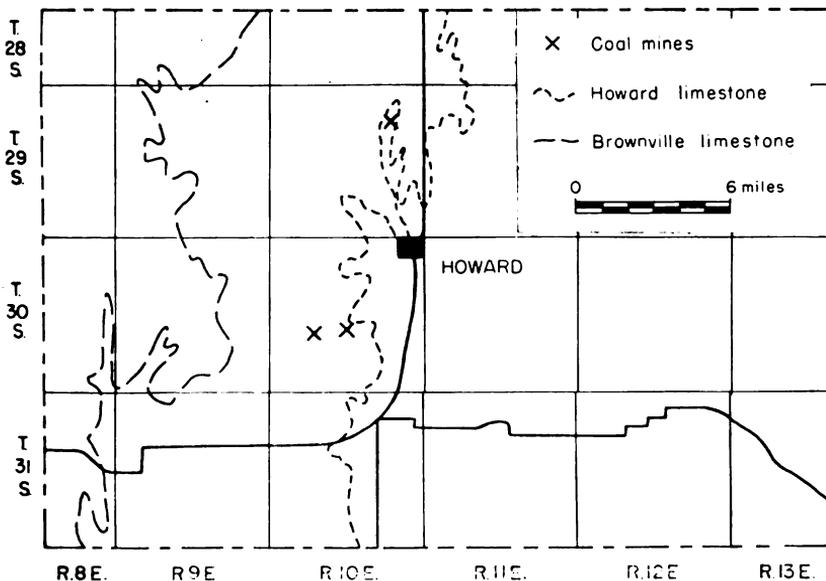


FIG. 21. Map of Elk County, Kansas, showing the Wabaunsee coal-bearing strata, coal mines, and traces of the Howard and Brownville limestones.

12 inches thick attempts to mine it are evident. In secs. 11 and 12, T. 29 S., R. 10 E., 4.5 miles north of Howard there are several shallow pits from which coal has been taken. Less than 100 to 500 feet from these pits the coal is exposed in the bed of a small creek and is only 4 inches thick. The Nodaway coal occurs between the

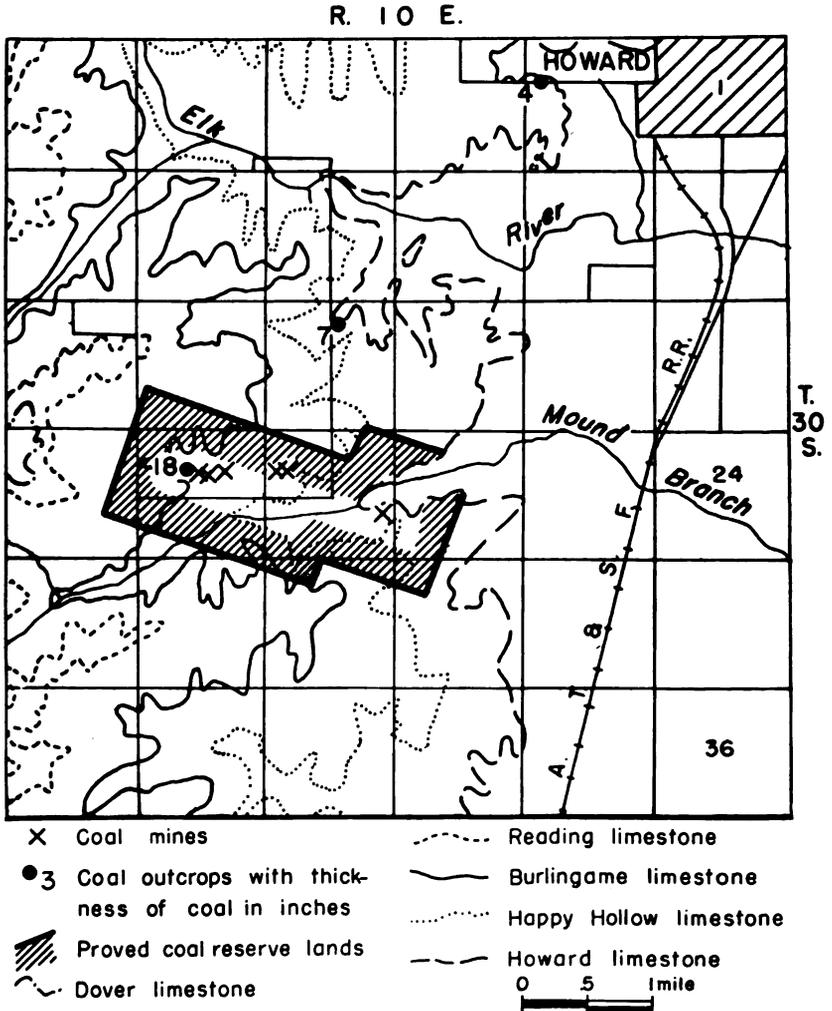


FIG. 22. Map of the Howard coal mining district, Elk County, Kansas, showing location of Nodaway and Elmo coal mines, proved coal reserve lands, and traces of the Howard, Happy Hollow, Burlingame, Reading, and Dover limestones.

Bachelor Creek limestone and a thin limestone bed 4 to 5 inches thick underlying the typical massive well-jointed Church limestone, from which it is separated by about 1 foot of black fissile and gray shale. The five stratigraphic sections on Figure 4 show the typical sequence and variations of the Howard limestone members and associated Nodaway coal in Elk County.

Elmo Coal.—In the NW¼ sec. 21 and N½ sec. 20, T. 30 S., R. 10 E., southwest of Howard, are the remnants of long-abandoned strip mines. The main mines are on the Will Neigh farm (formerly occupied by Jenks and Jaggards) in the N½ sec. 20. Coal was last mined from two strip pits and one shaft mine at this locality in 1922. By a little digging I was able to find the coal, which ranges from 16 to 18 inches in thickness. A grayish-blue shale overlies the coal. Mr. Neigh reported that beneath the coal is 4 feet of underclay. The coal is the Elmo coal, not the Nodaway coal as previously reported by Whitla (1940, pp. 36-37). The Nodaway coal occurs at least 1 mile east or downstream from the nearest strip mine (Fig. 22).

Production.—There are at least six coal mines in Elk County in addition to the small pits from which coal was taken north of Howard in secs. 11 and 12, T. 29 S., R. 10 E. (Table 22). The first recorded production of coal in Elk County is for 1894 when 800 tons were reported. For the following year Elk County is credited with 1,560 tons, which is probably in error if the location of the mine cited by the state coal mine inspector is correct. According to his report (Brown, 1896, p. 65) the mine was 13 miles southeast of Grenola. Since Grenola is only 3 miles north of the Elk-Chautauqua County line, the mine undoubtedly is in Chautauqua

TABLE 22.—Location and classification by type of mine of coal mines in Elk County, Kansas

Location	Number of mines			Total
	Shaft	Drift	S'lope	
NE cor. SE¼ sec. 11-29-10E			2	2
SW cor. SW¼ sec. 12-29-10E			3	3
SE¼ sec. 21-30-10E		1		1
NW¼ sec. 21-30-10E			2	2
N½ sec. 20-30-10E	1		2	3
Totals	1	1	9	11

TABLE 23.—Published coal production data for Elk County, Kansas

YEAR	TONS	YEAR	TONS
1894	800	1898	75
1896	1,500	1899	120
1897	320	1901-02	800
		Total	3,615

County and probably in the Leeds mining district. According to published data, the cumulative coal production for Elk County totals 3,615 tons not counting the 1895 tonnage (Table 23). As elsewhere, more coal has been mined than the published records show and it is not unlikely that the total cumulative production is close to 10,000 tons.

Reserves.—Elk County contains approximately 544 acres or 0.85 square mile of proved Nodaway reserve coal lands underlain by an 18-inch coal. This acreage contains 1,220,000 tons of proved coal reserve. The potential Nodaway coal reserve area consists of 50 square miles containing 72,020,000 tons of coal. The proved reserve coal lands underlain by Elmo coal 18 inches thick include 986 acres or 1.4 square miles and contain 2,020,000 tons of coal. The potential Elmo reserve coal area and tonnage amount to 180 square miles and 259,220,000 tons. Elk County has a total proved coal reserve of 3,240 tons and a potential reserve of 331,240,000 tons (Table 24).

TABLE 24.—Proved and potential Wabaunsee group reserve coal lands and tonnage in Elk County, Kansas

Coal bed	Location	Proved reserves			Potential reserves		
		Average thickness of coal, inches	Square miles	Tons	Average thickness of coal, inches	Square miles	Tons
Nodaway	Secs. 21, 22-30-10E	18	0.85	1,220,000	18	50	72,020,000
Elmo	Secs. 16, 17, 20, 21-30-10E	18	1.4	2,020,000	18	180	259,220,000
	Total			3,240,000			331,240,000

GREENWOOD COUNTY

Greenwood County is traversed centrally from north to south by a strip of Wabaunsee coal-bearing rocks averaging 9 miles in width (Fig. 23). Nodaway, Elmo, and Lorton coals are known to crop out in the county. The occurrence of coal in Greenwood

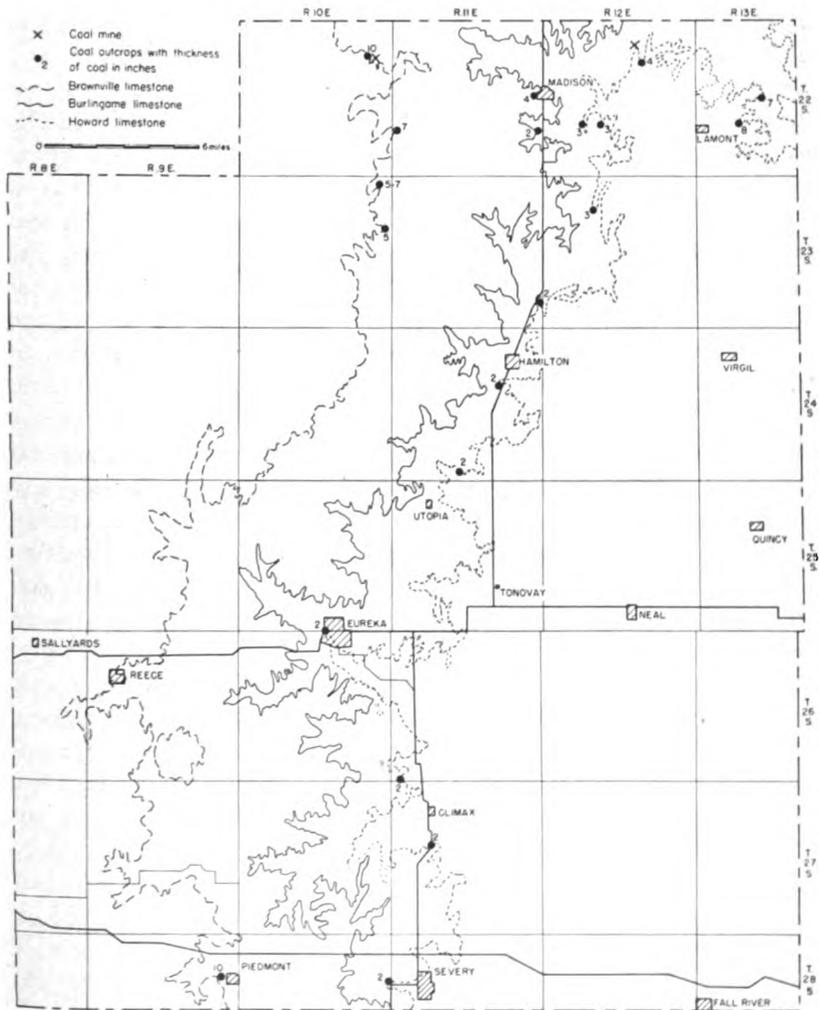


FIG. 23. Map of Greenwood County, Kansas, showing location of coal mines and outcrops and traces of the Howard, Burlingame, and Brownville limestones.

County was noted by Swallow in 1866 (p. 56). Likewise Hawn (Swallow, 1866, p. 113) refers to the outcropping of several beds of coal in the Verdigris Valley, especially on Wilhites Creek in sec. 18, T. 24 S., R. 13 E. near Verdigris Falls and at the mouth of Rock Creek near the northern boundary of the county. The coal at the former locality does not belong in the Wabaunsee group as the rocks in that part of the Verdigris Valley are stratigraphically lower than the Severy shale which marks the base of the Wabaunsee group. In 1875 and before, some coal found at a depth of 4 to 8 feet was used for blacksmithing, as fuel for steam mills, and to a limited extent for domestic purposes (Gray, 1875, p. 279). In 1890 (Mohler, 1891, p. 98) preparations were being made in the northwestern part of the county to work a vein of coal which was reported to be 37 inches thick and to lie 26 feet below the surface. Subsequent reports carry no references to the actual mining of this coal; it is inferred, therefore, that the venture was unsuccessful and that most likely the thickness of the coal was grossly exaggerated. That coal was actually mined to a limited extent is indicated by Crane (1898, pp. 128-129) who states: "There is a line of strip pits on the eastern side of the Santa Fe Railway extending both to the northeast and southwest of Eureka, reaching Elk County on the south and Lyon County and Coffey County on the north." It is probably these same mines that Adams, Girty, and White (1903, p. 51) had in mind in referring to some small mines in Greenwood County in which the coal, they thought, probably came from the same horizon as that mined in the vicinity of Silver Lake, west of Topeka, in Shawnee County.

Nodaway coal.—From field observations and in the absence of any published data on coal production it seems certain that there has been no commercial coal mining of any significance in Greenwood County. The Nodaway coal crops out at numerous places along the edge of the Howard limestone escarpment but it is not of minable thickness at any place where seen. The common thicknesses of the coal observed in the field are 2, 3, 4, 7, and 8 inches. The line of strip pits referred to by Crane (1898, pp. 128-129) on the east side of the Santa Fe Railway extending northeast of Eureka to Lyon County must be in Nodaway coal territory. No evidence of them can be found now, undoubtedly because the strip pits were extremely local, small, and scattered owing to the thinness of the coal. Only one mine worked for local use was reported

to me. This mine is in approximately the Cen. sec. 3, T. 22 S., R. 12 E. The coal near by is only 4 inches thick.

Lorton coal.—Lorton coal crops out in the NW cor. sec. 12, T. 22 S., R. 10 E., 1 mile south of the Greenwood-Lyon County line in the northwest township of the county. The coal, 11 inches thick, contains a clay parting 1 inch thick 1 inch above the base of the coal. According to an old resident living about 1 mile north of the coal outcrop, coal was mined here 50 or 60 years ago by drifting. The drift extended about 100 feet into the hillside. This mine may possibly be the one referred to by Mohler in 1891 in which the coal was supposed to have had a thickness of 37 inches.

Production and reserves.—Production of coal in Greenwood County is negligible. There are no proved reserve coal lands in the county and only 70 square miles of potential reserve coal lands containing Lorton coal. The potential reserve area contains 61,600,000 tons of 10-inch coal. Some of the Lorton coal in the NW cor. sec. 12, T. 22 S., R. 10 E. could be mined by drifting at the present time.

JACKSON COUNTY

Wabaunsee coal-bearing rocks crop out in the eastern part of Jackson County east of a north-south line drawn through Holton and in parts of Ts. 8 and 9 S., Rs. 13 and 14 E. (Fig. 24).

Elmo coal.—Very little coal has been mined in Jackson County. Only 3 drift mines were located. They are in the NE $\frac{1}{4}$ near the Cen. sec. 12, T. 7 S., R. 16 E., about 1.5 miles south and 0.5 mile west of Larkinburg. This coal, the Elmo, is 14 inches thick and crops out in the same north-facing bluff into which the mines have been drifted. The Coleman mines in Atchison County (p. 59) are approximately 0.5 mile to the east. Crane (1898, p. 129) reported the occurrence of mines in the extreme southeastern part of the county along Muddy and Cedar Creeks, but these mines were of little importance. I did not see these mines.

Reserves.—No production figures for the three drift mines near Larkinburg are available. There are 2.5 square miles of proved reserve coal lands in Jackson County, underlain by 14-inch coal. These lands contain 2,800,000 tons of Elmo coal. The potential reserve coal area is 200 square miles containing approximately 191,500,000 tons of coal which averages 12 inches in thickness (Table 11).

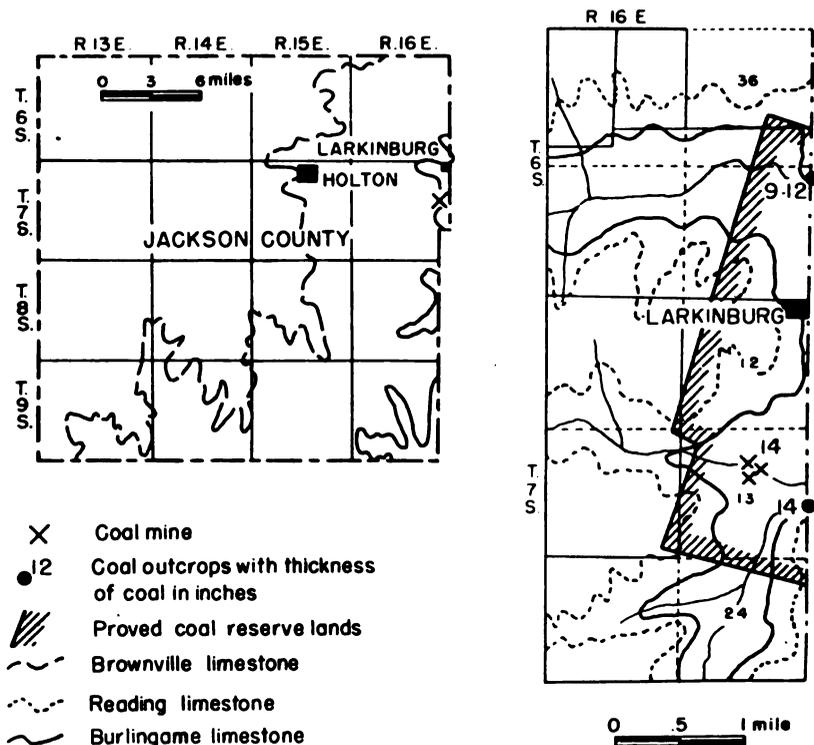


FIG. 24. Maps of Jackson County, Kansas, and the Larkinburg mining district, showing location of coal mines and outcrops, proved coal reserve lands, and traces of the Burlingame, Reading, and Brownville limestones.

JEFFERSON COUNTY

Rocks of the Wabaunsee group crop out in the northern and western tier of townships covering almost half the area of Jefferson County (Fig. 25). Two coals, Nodaway and Elmo, are present, but only the Nodaway has been mined.

Nodaway coal.—All the outcrops and mines of the Nodaway coal follow closely the outcrop of the Church limestone of the Howard limestone formation. Throughout the area of outcrop the coal maintains a fairly uniform thickness, ranging from 9 to 14 inches with much of the coal 1 foot thick. The coal occurs as a single bed and lies close to the overlying Church limestone from which it is separated by a light to dark partly fissile shale. The

shale is 1 foot 3 inches to 3 feet 4 inches thick, averaging 2 feet 4 inches at most outcrops. The Church limestone, the stratigraphic marker for the coal, at most places occurs as a single massive well-jointed bed of blue to bluish-gray fossiliferous rocks, which on weathering turn yellowish to deep rich brown. At a number of places the massive bed is overlain by a 4- to 7-inch

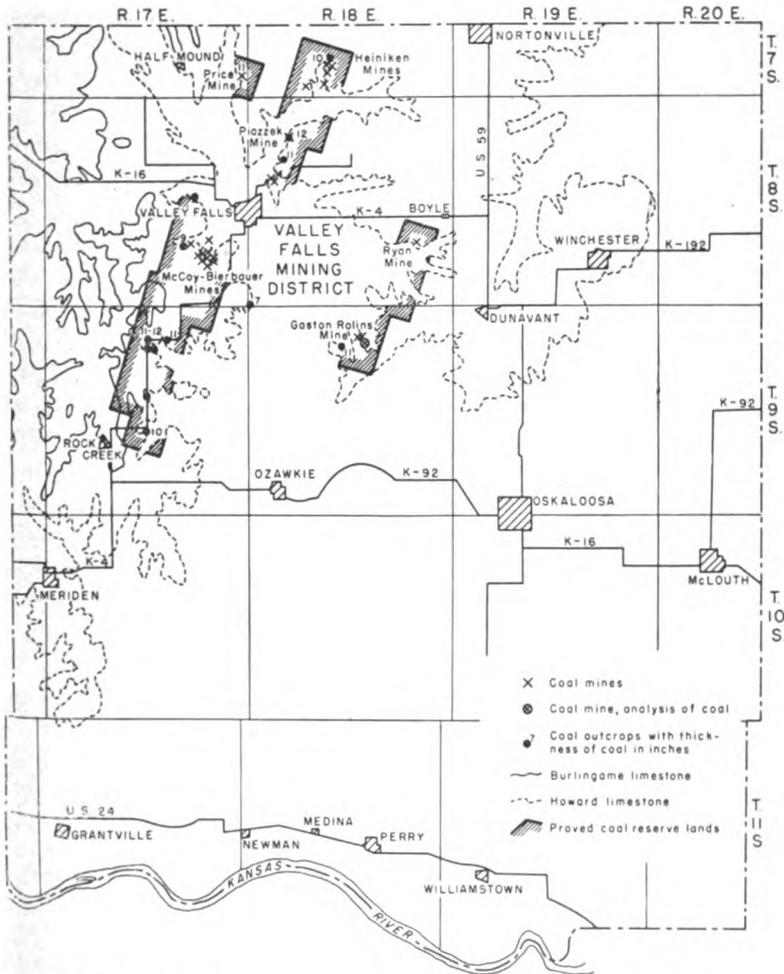


FIG. 25. Map of Jefferson County, Kansas, showing location of coal mines and outcrops, proved coal reserve lands, and traces of the Howard and Burlingame limestones.

TABLE 25.—Location and classification by type of mine of Nodaway coal mines in Jefferson County, Kansas

Location		Number of mines		
		Shaft	Drift	Total
Cen. 36-7-17E	Price farm		1	1
SE $\frac{1}{4}$ 14-8-17E			1	1
SE $\frac{1}{4}$ 32-7-18E			1	1
NW $\frac{1}{4}$ 33-7-18E	Heiniken farm		3	3
SW $\frac{1}{4}$ 33-7-18E			1	1
NE $\frac{1}{4}$ 18-8-18E		1	4	5
SW $\frac{1}{4}$ 18-8-18E			2	2
NW $\frac{1}{4}$ 26-8-17E			1	1
NE $\frac{1}{4}$ 26-8-17E			1	1
SE $\frac{1}{4}$ 26-8-17E	McCoy-Bierbauer		8	8
NE $\frac{1}{4}$ 26-8-18E	Ryan farm	1		1
SW $\frac{1}{4}$ 3-9-18E	Rolins farm		2	2
NW $\frac{1}{4}$ 10-9-18E	Rolins farm		1	1
Totals		2	26	28

limestone, and in the road bank outcrop on Kansas Highway 4, at the SW cor. SE $\frac{1}{4}$ sec. 3, T. 9 S., R. 17 E., four 3-inch beds are present above the massive bed. In Jefferson County the Church limestone ranges from 1 foot 6 inches to 2 feet 5 inches in thickness, the average being about 2 feet. Immediately underlying the coal is a sticky structureless ash-gray to bluish clay averaging 1 foot in thickness. Beneath this underclay is a bluish-gray shale which at places is sandy. The Bachelor Creek limestone, lowermost member of the Howard limestone formation, is missing in Jefferson County. Shale and the Utopia limestone overlie the Church limestone. The Utopia limestone is composed of several units of limestone and interbedded dark shales similar to those in Osage County. Sections showing stratigraphic relations of the coal to overlying and underlying rocks are presented in Figure 3. Proximate analyses of the coal are given in Table 3.

Twenty-eight Nodaway coal mines (Table 25) have been in operation at one time or another in Jefferson County. All were drift or slope mines with the exception of two shaft mines. It is also reported that a strip mine formerly existed along Grasshopper or Delaware Creek in sec. 34, T. 7 S., R. 17 E., 0.5 mile south of Half Mound. The mines, now abandoned and for the most part

caved in, follow the edge of the Howard limestone escarpment. According to one resident, coal mining in the county started in 1856 and practically ceased following the depression years of World War I. It is definitely known that coal was mined by stripping in 1875 (Mudge, 1875, p. 125). According to Whitla (1940, p. 41) the mining of Nodaway coal in an area 1 mile south of Valley Falls started in 1924, and in 1939 one mine was still being operated to supply fuel for the owner. A drift mine was opened late in the fall of 1943 on the Gaston Rolins farm in the NW $\frac{1}{4}$ sec. 10, T. 9 S., R. 18 E., 3.5 miles west and 0.75 mile south of Dunavant. At the time of my visit on September 26, 1944, the tunnel had been extended 25 feet into the hill and was 7 feet high and 10 feet wide. The coal, 14 inches thick, lies 3 feet beneath the Church limestone. Beneath the coal is an underclay. The overburden is approximately 25 to 30 feet, so that considerable coal could be mined here by the stripping method. A proximate analysis of this coal, which compares favorably with other Nodaway coals, is presented in Table 3. Perhaps the largest mine, now abandoned, in Jefferson County is less than 0.25 mile north and 0.25 mile west of the Gaston Rolins drift mine just described. This mine, formerly operated by Rolins, is in a small ravine in the SW $\frac{1}{4}$ sec. 3, T. 9 S., R. 18 E. Much coal must have been removed from this mine judging from the size of the dump heap, trackage, and coal cars scattered about. Coal was also mined in the SW cor. NE $\frac{1}{4}$ sec. 36, T. 7 S., R. 17 E. Several abandoned drift mines are found along the west-facing bluff of a small stream on the Heiniken farm, in the NW $\frac{1}{4}$ sec. 33, T. 7 S., R. 18 E., and farther south in the SW $\frac{1}{4}$ of the same section.

Several drift mines and a shaft mine were formerly operated about 1 mile northeast of Valley Falls in the E $\frac{1}{2}$ sec. 18, T. 8 S., R. 18 E. An exposure in the road cut just south of the mines shows that the coal is 13 inches thick. Some coal was mined south of Valley Falls on the McCoy farm in the NE cor. SE $\frac{1}{4}$ sec. 26, T. 8 S., R. 18 E., and also 0.5 mile north in the NE cor. NE $\frac{1}{4}$ of the same section. According to Whitla (1940, p. 41), the haulage way of the mine at the latter locality is 4 feet wide and reaches from a layer 15 to 18 inches below the coal to the limestone 29 inches above it. The room in which the miners worked was 24 feet wide. The coal was 8 to 9 inches thick and contained clay

seams and pyrite. The mine was worked last in 1939. At the McCoy mine near the barn the coal is 9 to 11 inches thick and is 25 inches below the Church limestone. Several coal cars were seen on the dump heap. The mines were operated by Mr. Bierbauer who lives close to them. According to him the 8 mines on the place were operated from 1923 to 1941. The coal averaged 10.5 inches in thickness and sold at first for \$6.50 per ton; 12 to 15 miners were employed. The room and pillar method of mining was used, and the rooms measured 20 by 100 feet. The longest tunnel extended 500 to 600 feet from the mine portal. At no place was the mine more than 25 feet below the surface. Coal was also mined in the NW cor. NE $\frac{1}{4}$ NW $\frac{1}{4}$ of the same section. On the Stephan Ryan farm 4.5 miles east and 0.75 mile south of Boyle Station, in the NE $\frac{1}{4}$ sec. 26, T. 8 S., R. 18 E., is an abandoned shaft mine. This mine is reported to have had a 12-inch coal seam and to have furnished coal for local trade. It was in operation in 1902 (Casselman, 1903, p. 20).

Production.—Published statistical data on the amount of Nodaway coal mined in Jefferson County are very scarce. Although it is known that coal was dug as early as 1856, the earliest production record is for 1875 (Gray, p. 294) when 2,000 tons, sold at \$4.00 per ton, were produced. According to Mudge (1875, p. 125), the coal was mined by stripping. According to published records a cumulative total of 6,110 tons of coal has been mined in Jefferson County (Table 26). A reasonable estimate of the amount of coal produced from the 28 known mines or that taken during the 78 years for which no published records are available probably would not exceed 40,000 tons. In addition, coal was undoubtedly taken directly from the face of outcrops by farmers on whose land the coal crops out. The amount thus taken is quantitatively unimportant and not subject to estimation.

TABLE 26.—Published coal production data for Jefferson County, Kansas

YEAR	TONS	YEAR	TONS
1875	2,000	1930	500
1878	280	1931	250
1928	1,120	1934	460
1929	1,500		
		Total	6,110

Reserves.—The Nodaway coal in Jefferson County is fairly uniform in thickness throughout the county wherever observed. Considering 11 inches as the average thickness of the coal there are in the 15.5 square miles of proved coal reserve lands in the county (Table 27) 13,600,000 tons of proved coal reserve. The potential Nodaway coal reserve area includes 150 square miles containing 132,000,000 tons of 11-inch coal.

LYON COUNTY

Approximately half of Lyon County or the area east of a diagonal line drawn from the northeast to the southwest corners of the county is underlain by rocks belonging to the Wabaunsee group (Fig. 26). At least six coals crop out in this territory, of which the Nodaway, Nyman, and Lorton are definitely known to have been mined in the past.

The presence of coal in Lyon County was known to the earliest settlers. Its occurrence is recorded by Swallow in 1866 (p. 56),

TABLE 27.—*Proved and potential Nodaway coal reserve lands and tonnage in Jefferson County, Kansas**

Location	Proved reserves		Potential reserves			
	Square miles	Tons	Square miles	Tons		
secs. 25, 36 sec. 31	7-17E 7-18E	Price farm	0.7	620,000		
secs. 28, 29, 32, 33 sec. 5	7-18E 8-18E	Heiniken farm	1.8	1,580,000		
secs. 4, 5, 8, 9, 17, 18	8-18E	NE Valley Falls	0.8	700,000		
secs. 14, 22, 23, 25, 26, 27, 34, 35, 36	8-17E	McCoy-Bierbauer	9.6	8,450,000	150	132,000,000
secs. 2, 3, 4, 9, 10, 15, 16, 21, 22, 27, 28	9-17E	Rock Creek				
secs. 23, 24, 25, 26, 34, 35, 36	8-18E	Ryan farm	2.6	2,290,000		
secs. 2, 3, 4, 9, 10	9-18E	Rolins farm				
Total			15.5	13,640,000	150	132,000,000
Production				40,000		
Reserves			15.5	13,600,000	150	132,000,000

* Average thickness of coal, 11 inches.

and its mining for neighborhood use on Coal Creek, 10 miles southwest of Emporia, in the same year is noted by Mead (1901). As early as 1874 (Gray, 1875, p. 322) coal was mined in the vicinity of Neosho Rapids and south of Emporia on the banks of Eagle Creek, southwest of Hartford. Kelly (1887) refers to the finding of workable coal within the county as early as 1874 and the discovery of coal at several places in the northern part of the county, especially northeast and northwest of Emporia and near the town of Admire where a 17-inch seam of coal was found at a depth of 28 feet.

Nodaway coal.—Nodaway coal crops out from Neosho Rapids south to the county line in R. 13 E. The coal is 12 inches thick near the SE cor. NE $\frac{1}{4}$ sec. 33, T. 19 S., R. 13 E., 1 mile south and 0.5 mile east of the southeast corner of Neosho Rapids, and 10 inches thick along the banks of Eagle Creek southwest of Hartford in the SE $\frac{1}{4}$ sec. 31, T. 30 S., R. 13 E. At the latter place the coal lies 24 inches below a 5-inch impure limestone, which is overlain by 24 inches of black shale and an 18-inch bed of Church limestone. The coal was mined at this locality along the face of the outcrop and by drifting as late as 1924. This coal was first mined in 1874 when it was known as the Eagle Creek coal. In the SW $\frac{1}{4}$ sec. 6, T. 21 S., R. 13 E., the Nodaway coal is only 4 inches thick; however, it thickens again to 9 inches in the NE cor. NW $\frac{1}{4}$ sec. 16.

Nyman coal.—According to Smith (1903, p. 100), who identified four coal horizons in Lyon County, a 9-inch coal was stripped for local consumption on Coal Creek south of Emporia. The only possible locality where the coal could have been mined is at the N. line NW $\frac{1}{4}$ sec. 14, T. 20 S., R. 11 E. The coal, 5 to 7 inches thick, is overlain and underlain by shale and is 3.5 feet above creek level. The shale above the coal contains numerous pelecypods and crinoid stem fragments. This coal lies between the Reading and Dover limestones and is probably the Nyman coal in the upper part of the Wamego shale formation.

Lorton coal.—Coal was formerly mined near the NE cor. SW $\frac{1}{4}$ sec. 30, T. 18 S., R. 11 E., several miles northwest of Emporia; in the NE cor. NW $\frac{1}{4}$ sec. 4, T. 18 S., R. 12 E., 9.5 miles northeast of the center of Emporia; and near the Cen. E. line sec. 21, T. 16 S., R. 12 E., 1 mile east of Admire. The coal at all three localities is a short distance below the Brownville limestone and is the Lorton coal. It is 6 inches thick in the NE cor. NW $\frac{1}{4}$ sec. 3, T. 16 S.,

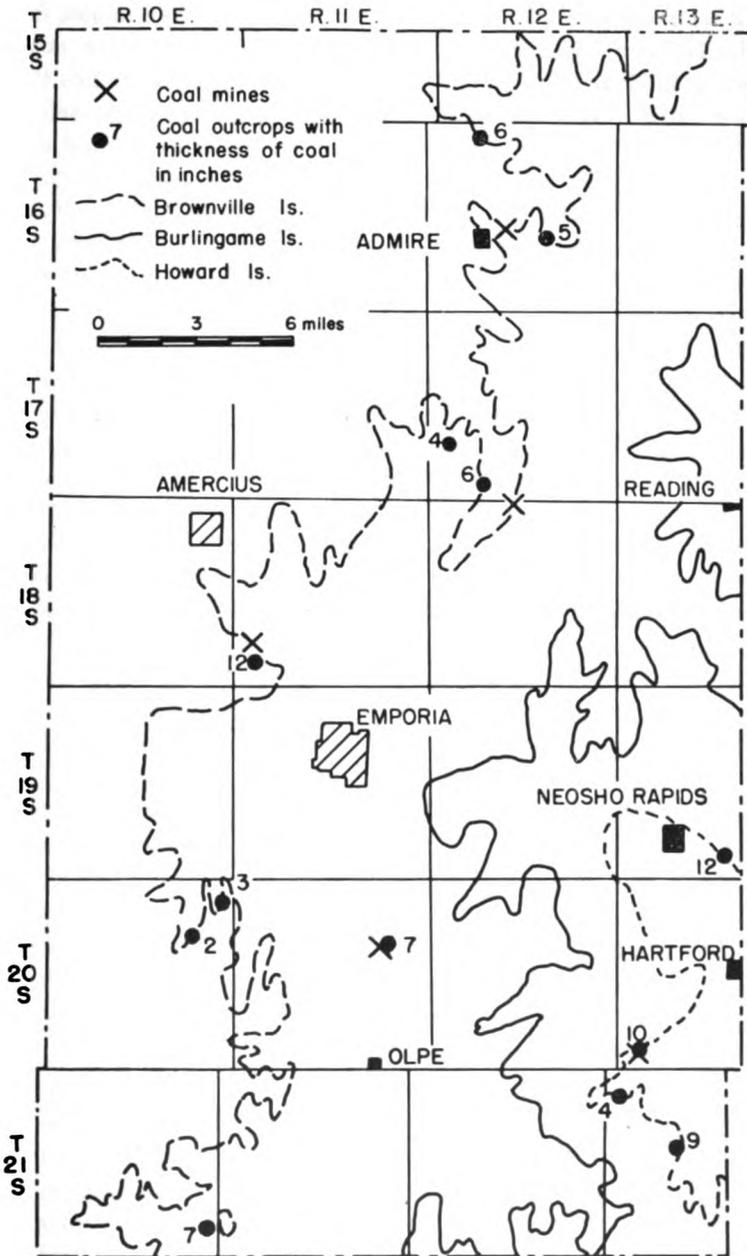


FIG. 26. Map of Lyon County, Kansas, showing location of coal mines and outcrops and traces of the Howard, Burlingame, and Brownville limestones.

R. 12 E., about 4 miles northeast of Admire, and 5 to 6 inches thick in the NE cor. SE $\frac{1}{4}$ sec. 32, T. 17 S., R. 12 E. The same coal is 9 inches thick near the Cen. NE $\frac{1}{4}$ sec. 9 and 9 to 12 inches thick 3 to 4 miles northwest of Emporia in the NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 30, T. 18 S., R. 11 E., where it has been mined by stripping and drifting. Kelly (1887) reported the presence of four drift mines, the largest one of which was 175 feet long, near the Cen. sec. 30, and stated that the coal ranged in thickness from 11 to 17 inches. The mines were started in 1886. Coal was also mined by stripping at this locality.

The most important Lyon County mining district is that at Admire. According to Merle L. Sowell, formerly of Admire, the first coal mined in the Admire vicinity was stripped from the bed of 142 Mile Creek, 1 mile east and 0.25 mile north of the town. Between 1885 and 1890 three shallow shaft mines were operated east of this strip mine. Mr. Sowell estimated that about 4 to 5 acres of 16- to 20-inch coal were taken out by the early miners. In 1930 Sowell and his father sank a 25-foot shaft in the old workings of the No. 2 mine east of the creek. After mining about 500 tons of coal, the mines were flooded out and abandoned due to a spring flood which entered the old workings from a ravine above the mines. In 1931 the Sowells drove a slope drift into the coal vein 0.75 mile east and 0.5 mile north of Admire in the NE $\frac{1}{4}$ sec. 21, T. 16 S., R. 12 E. A fall flood this time caused the mine, about 25 feet deep, to cave in. Later in the fall, a new 40-foot shaft was sunk on somewhat higher ground east of the drift mine. A good thickness of coal, together with a good top or roof, was found. By spring the mine was in fair working condition again. It was operated for two years and 4,000 tons of coal were produced. The coal was blocky and easily mined. It compared favorably in quality with the Nodaway coal of Osage County, and was mined by the longwall system.

Lorton coal was also mined near Miller on old highway US 50N where the coal measured 10 inches in thickness and was mined by drifting from 1 or 2 acres. According to Sowell much coal was formerly stripped farther upstream from Miller on Elm Creek where the coal cropped out. Kelly (1887) reported the discovery of the Admire coal in 1886, stating that the coal was struck at a depth of 28 feet and was 17 inches thick.

TABLE 28.—Location and classification by type of mine of coal mines in the Wabaunsee group in Lyon County, Kansas

Coal bed	Location	Number of mines			
		Shaft	Drift	Strip	Total
Nodaway	SE¼ sec. 31-20-13E		1		1
Lorton	E½ 21-16-12E	5	1	1	7
	NE cor. NW¼ 4-18-12E		1		1
	S½ 30-18-11E		4	2	6
Nyman	NE cor. NW¼ 14-20-11E			1	1
	Total	5	7	4	16

Production.—The only published accounts of coal production in Lyon County are for the years 1874 (Gray, 1875, p. 322) and 1894, when 455 and 360 tons, respectively, were mined in the vicinity of Neosho Rapids and south of Emporia in T. 20 S., R. 11 E. The coal sold for \$2.00 to \$2.50 per ton and was the Nodaway coal. Sowell estimates that approximately 15,500 tons of Lorton coal have been mined in the Admire mining district. A reasonably fair estimate of all coal produced from the 16 coal mines known to have been in operation (Table 28) in Lyon County would probably not exceed 18,000 tons.

Reserves.—There are approximately 5,520,000 tons of proved coal reserves and 303,180,000 tons of potential coal reserves in the Wabaunsee group in Lyon County. Of the proved reserves, 2,800,000 tons is Nodaway coal and the remainder is Lorton coal. The largest Nodaway coal reserve area is 2.5 square miles in extent and is in the general vicinity of Neosho Rapids in secs. 21, 22, 27, 28, 33, and 34, T. 19 S., R. 13 E. A smaller area of 0.5 square mile is southwest of Hartford in secs. 31 and 32, T. 20 S., R. 13 E. The Lorton coal reserves occur in three areas: one is east of Admire, another west of Reading, and a third northwest of Emporia, the largest area centering about Admire. Detailed data on the coal reserves are presented in Table 29.

NEMAHA COUNTY

Rocks of the Wabaunsee group, from the Severy shale to the Brownville limestone, crop out in the western half of Nemaha County (Fig. 27). The presence of coal in these rocks has been known since at least 1866 (Mudge, p. 18; Swallow, p. 56) and it

TABLE 29.—*Proved and potential Wabaunsee group coal reserve lands and tonnage by mining districts in Lyon County, Kansas*

Coal bed	Mining district	Location	Proved reserves			Potential reserves		
			Average thickness of coal, inches	Square miles	Tons	Average thickness of coal, inches	Square miles	Tons
Nodaway	Neosho Rapids	Secs. 21, 22, 27, 28, 33, 34-19-13E	12	2.5	2,400,000	12	80	76,800,000
	Hartford	Secs. 31, 32-20-13E	10	0.5	400,000	10	55	44,000,000
Lorton	Admire	Secs. 15, 16, 21, 22-16-12E	18	1.0	1,440,000	18	50	72,000,000
	Reading	Sec. 33-17-12E Sec. 4-18-12E	12	0.5	500,000	12	115	110,400,000
	Emporia	Sec. 30, 31, 32- 18-11E	10	1.0	800,000			
Total					5,540,000	303,200,000		
Production					18,000	18,000		
Approximate reserves					5,520,000	303,180,000		

was used for domestic fuel as early as 1875 (Gray, p. 352). In 1879 or 1880 (Hudson, 1881, p. 246) two shafts were worked to a limited extent in Illinois township (T. 4 S., R. 12 E.). Although these mines have not been located, the coal most likely was either the Nyman or the Lorton (Fig. 3). It was about this same time that the Nodaway coal cropping out in the bluffs of Nemaha River west of Bern was first reported. Sims (1883, p. 357) mentions limited coal mining in Illinois township (T. 4 S., R. 12 E.) and near Sabetha (12 miles northwest of Sabetha in the Bern vicinity) where the coal is reported to have ranged from 18 to 24 inches in thickness. According to Stewart (1892, p. 38), 2,208 tons of coal was mined from two shafts in the Bern area in 1890 and 2,280 tons was produced in 1891. The existence of these mines and their production seemingly were known to relatively few persons, even among those living near the coal mines. Gallagher (1894, p. 66), reported that he visited Bern with the intention of inspecting the mines reported by Stewart to center around that town but that he could not find them and that public officials of Bern and of the county had no knowledge concerning them. With

the aid of information received from a farmer living 4.5 miles east and 1 mile north of the southeast corner of Bern and from Mr. Carl Jauken, a farmer residing 3.5 miles west of Bern, I located the mines as well as several others operated more recently.

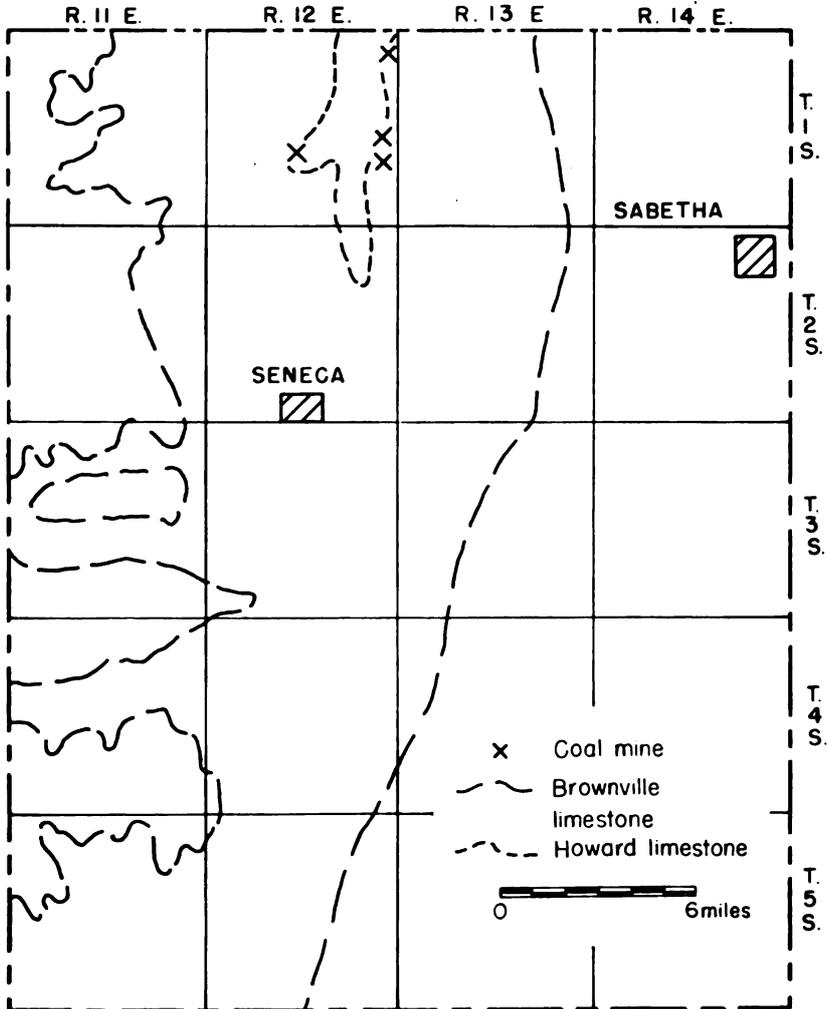


FIG. 27. Map of Nemaha County, Kansas, showing location of coal mines and traces of the Howard and Brownville limestones.

Nodaway coal.—At least 12 coal mines have been operated in Nemaha County in the past (Table 30). Greatest mining activity centered in the SW¼ sec. 24, T. 1 S., R. 12 E., at a place known locally as Tail O'Rabbits (Fig. 28). According to Jauken, coal was first mined here 70 to 75 years ago. In the early years of mining, the industry at Tail O'Rabbits had developed to the extent that a village with a hotel and school grew up around the mines. So far as I could ascertain all the mines were drift or slope mines. A similar situation and history is reported for a place called Coal

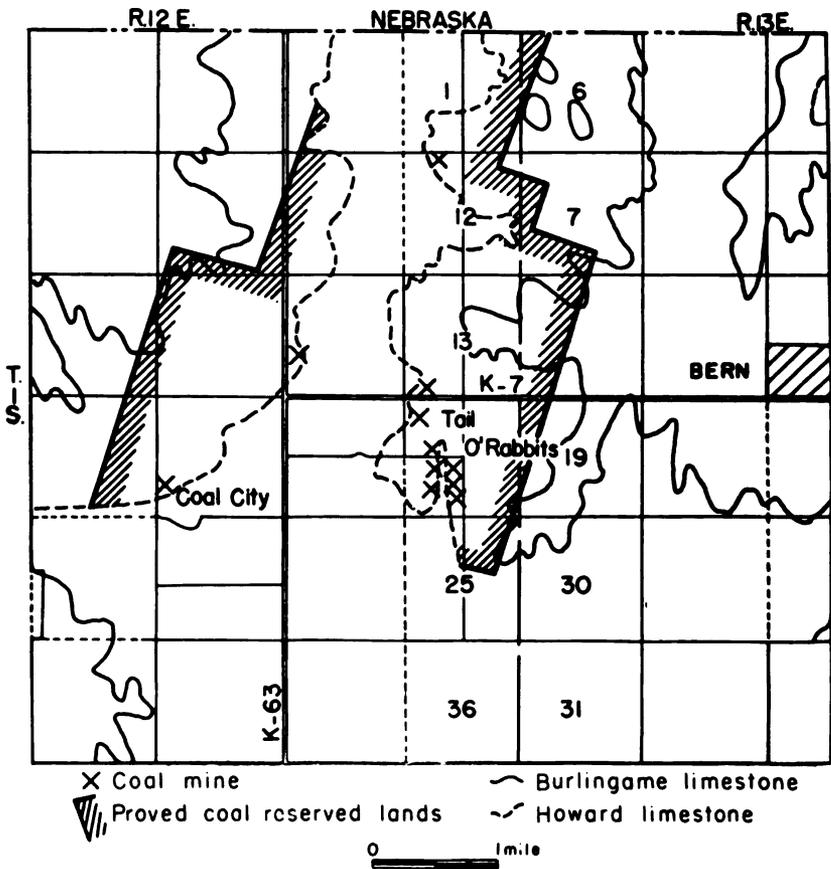


FIG. 28. Map of the Bern coal mining district, Nemaha County, Kansas, showing location of coal mines, proved coal reserve lands, and traces of the Howard and Burlingame limestones.

TABLE 30.—Location and classification by type of mine of Nodaway coal mines in Nemaha County, Kansas

Location	Number of mines			
	Shaft	Drift or slope	Strip	Total
NW¼ 12-1-12E Korber place			1	1
SW cor. 13-1-12E		1		1
SW¼ 14-1-12E		1		1
SW¼ 22-1-12E Coal City	1	*		1
NW cor. 24-1-12E Tail O'Rabbits		1		1
S line NW¼ 24-1-12E do		1	1	2
SW¼ 24-1-12E do		5		5
Total	1	9	2	12

*Number not known.

City in the SW¼ sec. 22, T. 1 S., R. 12 E., about 2.5 miles east of the Tail O'Rabbits mining district. The only evidence of coal mining activity seen at Coal City was a large coal dump and a former hotel now serving as a barn. According to Jauken, the coal was mined by shafting. Due to high water in the creek the drift mines were not seen. Other drift mines are located in the NW cor. sec. 24, in the SW cor. sec. 13, and in the SW¼ sec. 14, T. 1 S., R. 12 E. As recently as 1940 coal was mined by stripping in the Tail O'Rabbits district in the NW¼ sec. 24 and on the Korber place 1 mile south of the Kansas-Nebraska line in the NW¼ NW¼ sec. 12, T. 1 S., R. 12 E. Coal was taken from 1 to 2 acres at each strip mine.

According to Stewart (1892, p. 38), the coal in the Bern area ranges from 16 to 28 inches in thickness and averages 22 inches. The only outcrop of coal seen was in the Tail O'Rabbits district along the creek bluff in the east part of the SW¼ sec. 24, T. 1 S., R. 12 E. The coal is 10 to 12 inches thick, which I believe represents more nearly the average thickness of the coal than the 22 inches reported earlier. I am certain that if average thickness of the coal had been 22 inches, stripping operations at the two strip mines and also at several places in Nebraska south of Du Bois, Nebraska, would not have ceased after the stripping of 1 or 2 acres, especially when the overburden was thin. The coal mined

in the Nemaha Valley west, north, and south of Bern is the Nodaway coal. This is probably the coal that was referred to as the Nyman coal (Moore and Landes, 1927, p. 49) and was mined in the county before rail transportation made other fuel readily available. The following stratigraphic sections show the relationship of the coal to the overlying and underlying strata.

Measured section in the SW¼ sec. 24, T. 1 S., R. 12 E., along the east side of a creek bluff at Tail O'Rabbits

	Thickness	
	Feet	Inches
PENNSYLVANIAN-Virgilian		
Howard limestone—Church limestone member		
8. Limestone, slabby, upper surface weathers into small chips	1	11
7. Limestone, massive, well-jointed, weathers into large slabs; contains abundant fossils, crinoid stems, algal growths, brachiopods, and cephalopods.	1	11
Aarde shale member		
6. Shale, gray	1	0
5. Shale, black, fissile	0	3
4. Shale, gray	0	6
3. Coal (Nodaway)		10-12
Severy shale		
2. Shale, sandy, gray	10	
1. Shale, clayey, dark gray, exposed to creek level	10	

Measured section in the Kober strip mine, NW¼ sec. 12, T. 1 S., R. 12 E.

	Thickness	
	Feet	Inches
PENNSYLVANIAN-Virgilian		
7. Sandstone, micaceous		
Howard limestone—Church limestone member		
6. Limestone, slabby	0	6
5. Limestone, massive, jointed	1	6
4. Limestone, massive, jointed	4	0
Aarde shale member		
3. Shale, gray	0	6
2. Shale, black, fissile	1	0
1. Shale, gray, exposed to pit level	1	

Production.—The only recorded production of coal in Nemaha County is for 1890 and 1891 when 2,208 and 2,280 tons were mined. It is estimated that the two strip mines produced 3,000 tons of coal in 1940. As it is known that coal was mined in the county

as early as 1875 and that the industry in the Tail O'Rabbits and Coal City mining districts had developed to the extent of a small village with school and hotel, it is not unreasonable to estimate the total past coal production for the county at about 30,000 tons.

Reserves.—There are approximately 6 square miles, including all or parts of secs. 1, 2, 10 to 16, and 21 to 25, T. 1 S., R. 12 E., and secs. 7, 18, 19, and 30, T. 1 S., R. 13 E. (Fig. 28), in the Nemaha-Bern area underlain by Nodaway coal 12 or more inches thick. These proved coal reserve lands contain 5,760,000 tons of coal. The potential Nodaway coal reserve lands total 280 square miles and contain approximately 268,800,000 tons of 12-inch Nodaway coal.

OSAGE COUNTY

All of Osage County west of a line drawn through Carbondale, Scranton, Osage City, and Arvonía is underlain by rocks of the Wabaunsee group. All formations of the group are present (Pl. 1). Of all Kansas counties, Osage County is the largest producer of coals of the Wabaunsee group. The coal mined is the Nodaway coal, which crops out or is indicated by the presence of mines or dump heaps from Carbondale to Arvonía. The Elmo coal is known to occur at several places, but nowhere is it thick enough to be mined. The Upper Williamsburg coal (Bowsher and Jewett, 1943, pp. 62-64) in the Lawrence shale of the Douglas group was formerly mined in the Quenemo mining district in T. 17 S., R. 17 E., near the Osage-Franklin County line.

Nodaway coal.—The Nodaway coal in Osage County ranges in thickness from 11 to 18 inches at the outcrop and from 12 to 36 inches underground in the shaft mines at Burlingame and Osage City. The average reported thickness of the deep mine coal is 18 inches. The coal at the outcrop is thickest between Peterton, 2 miles north of Osage City, and points 3 miles south of Osage City. The coal in this part of the county is 13 to 18 inches thick. It occurs as a single massive bed and is bright, shiny, black, brittle, and free from clay seams or impurities. On mining it breaks into large rectangular blocks, which commonly split in the middle into two distinct units. On close examination, the coal seems to be made up of thin layers $1/16$ to $1/2$ -inch thick, giving the coal a laminated appearance. Highly carbonized coaly material showing the impression and structure of the woody material from which

the coal was derived is commonly present in the uppermost half inch of the coal. The coal occurs 4.5 to 9 feet below the Church limestone and 1 to 6 feet above the Bachelor Creek limestone, which in Osage County and southward constitutes the base of the Howard limestone formation (Fig. 4). Nodaway coal crops out at the surface in Osage County along the edge of the Howard limestone escarpment where it has been extensively mined by striping. Westward from the escarpment the coal is gradually buried deeper. The deepest coal mined at the present time, 120 feet beneath the surface, is in the Bell No. 4 mine about 1 mile south of Burlingame in the SW cor. NW¼ sec. 23, T. 15 S., R. 14 E. (Pl. 3C). Since there are active mines, good coal samples could be collected. The samples were analyzed by August Fleming in the laboratories of the State Geological Survey and are presented in Tables 3 and 4. A comparison of proximate analyses of Osage County coals with those of other Kansas coals (Table 5) shows that the Nodaway coal compares favorably with other coals mined commercially in Kansas.

Mines and mining methods.—In the fall of 1945, there were 10 mines (Table 31) in operation in Osage County as compared with 90 mines in 1891. The 302 Nodaway coal mines in the county that were active at one time or another have been located and plotted on a map (Pl. 1). Most of these mines are now represented only by dump heaps, a few by abandoned shafts and buildings, some by strip pit scars and caved-in drift mine openings, 6 by active operating shafts, and 4 by active strip pits. The mines follow closely the edge of the Howard limestone escarpment, the tracks of the Santa Fe Railroad, and both sides of highway US 50 N. The greatest concentration of mines is between Scranton and Burlingame, at Osage City and surrounding territory, and at Arvonnia.

Strip mines.—In the fall of 1944 three strip mines were in operation. A fourth strip mine in the NE¼ sec. 19, T. 14 S., R. 16 E. was being prepared for mining by Perry Jones and R. A. Linville of Carbondale at the time of my visit on August 7, 1945 (Table 35). This mine was operated from 1939 to 1942. The coal averages 20 inches in thickness, underlies 4 to 5 acres, and has an overburden ranging from 9 to 20 feet. At the time of my visit scattered debris was being removed by means of a large Diesel

TABLE 31.—Location and mining data on Nodaway coal mines active in Osage County, Kansas, in 1944 and 1945*

Location	Name of mine	Operator	Type of mine	Depth of mine, feet	Thickness of coal, inches	Distance mined from shaft, feet	No. men employed	Prox. analysis No.
NW¼ 13-15-14E	Elliott	Clarence Elliott	Shaft	109	18	500	22-25	11
NE cor. 14-15-14E	J. C.	James Curley	do	113	17-18	500		10
NW¼ 23-15-14E	Bell No. 4	William Isaacs	do	120	16-20	35	3-4	9
NE cor.	Central							
SE¼ 22-15-14E	Fuel No. 2	Neal Hotchkiss	do	116	18	600		7
SW¼ 23-15-14E	Central							
	Fuel No. 3	do	do	116	18	600	12-15	8
NW cor.	Didier &							
NE¼ 22-16-14E	Parre No. 1	James Parre	do	116	13-18	700		6
NW¼ 17-16-15E		Ira Rogers	Strip	8-9	16-18		5-6	4.5
SE¼ 17-18-14E		Ellis Graham	do	10	13		4	
SW¼ 20-18-14E		H. A. Rogers & Sons	do	8	13-16		4	1.2
NE¼ 19-14-16E		Perry Jones and R. A. Linville	do	9-20	20		2	

*Since this report went to press (November 1946) two new strip mines are being opened. One of these mines is on the farm of C. Muykendall in the SW cor. sec. 18, T. 17 S., R. 15 E., about 4 miles east of Barclay. The other, operated by Ellis Graham, is at the west edge of Arvonía in the SW¼ SW¼ sec. 16, T. 18 S., R. 14 E.

catpillar. The mine is approximately 1 mile west of highway US 75 at Carbondale. The Ira Rogers strip mine is in the NW¼ sec. 17, T. 16 S., R. 15 E., about 2.5 miles east and 1.5 miles north of the Santa Fe Railroad depot in Osage City. The coal is 16 to 18 inches thick and is overlain by 2 feet of bluish-gray shale, which in turn is overlain by a 6- to 8-inch dense limestone. Above the limestone is 1 foot of black fissile shale and 2 feet of gray shale on which 3 feet of Church limestone rests. The overburden, often the massive Church limestone, is removed by a bulldozer after being shot. The coal is then wedged or pried loose along the face of the coal and loaded by hand into waiting trucks (Pl. 2C) which haul the coal to near-by and distant towns (Fig. 5). At the H. A. Rogers strip mine southwest of Arvonía, in the SW¼ sec. 20, T. 18 S., R. 14 E., the coal crops out in the bed of a stream. It is 13 to 16 inches thick. The overburden, which is composed of shale and the Church limestone, is 8 feet thick. Mining conditions are

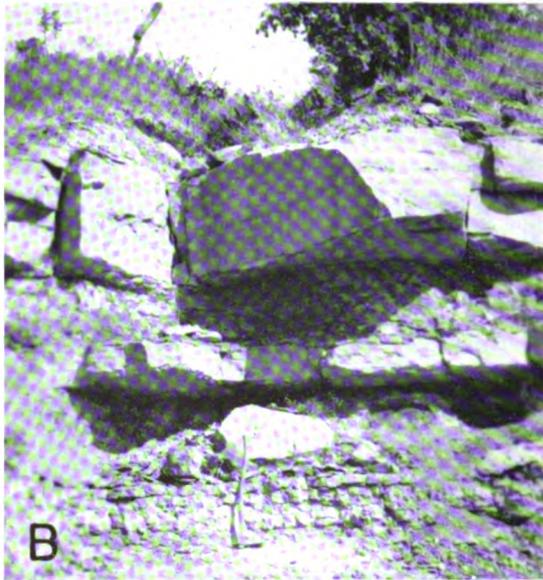


PLATE 4. *A*, Only active drift mine in the Osage coal field, started in the fall of 1943 by Gaston Rolins in the NE $\frac{1}{4}$ sec. 10, T. 9 S., R. 18 E., Jefferson County, Church limestone, 23 inches thick, forms roof of mine. Nodaway coal, 14 inches thick, exposed on the right hand wall just below middle of mine opening. *B*, Outcrop of lower half of the Howard limestone formation. Massive uppermost bed is typical Church limestone. The Nodaway coal, here represented by only a streak is immediately beneath the thin dense limestone which is persistent from Osage County southward. The adz marks the position of the Bachelor Creek or basal limestone member of the formation. Cut along U.S. 166 in the SE cor .SW $\frac{1}{4}$ sec. 3, T. 34 S., R. 9 E., Chautauqua County.

practically the same as at the Ira Rogers strip mine northeast of Osage City. According to H. A. Rogers, who with his sons operates the mine, the coal is trucked as far west as the Kansas-Colorado line including such towns as Burlington, Burns, Council Grove, El Dorado, Elmdale, Emporia, Eureka, Gridley, Hartford, Hutchinson, Iola, Junction City, Kingman, Lamont, Lebo, LeRoy, Madison, Marion, Neosho Rapids, Olpe, Osage City, Peabody, Pratt, Quenemo, Reading, Strong City, Waverly, Westphalia, Wichita, and Yates Center (Fig. 5). The third strip mine is operated by Ellis Graham and is located west of Arvonía in the SE $\frac{1}{4}$ sec. 17, T. 18 S., R. 14 E. The coal is 13 inches thick and lies 10 feet beneath the surface.

All the strip mines are along the edge of the Howard limestone escarpment, the greatest concentration being in the Carbondale and Arvonía mining districts. The largest single stripped mine area is east and south of Carbondale in secs. 17, 19, 20, 29, and 30, T. 14 S., R. 16 E. (Pl. 1). With the exception of the pit recently re-opened by Jones and Linville in sec. 19, the mines are abandoned, although unmined areas exist between the various strip pits. Coal formerly was also mined by the stripping method east and south of Scranton in secs. 2, 11, and 14, T. 15 S., R. 15 E. In secs. 12 and 13, T. 17 S., R. 14 E., and secs. 17, 19, and 20, T. 17 S., R. 15 E., 3 to 6 miles east of Barclay, coal has been mined by stripping at about 12 localities. South and east of Barclay, in the NE $\frac{1}{4}$ sec. 34, T. 17 S., R. 14 E., is a strip pit covering several acres, and in the NW $\frac{1}{4}$ and SW $\frac{1}{4}$ sec. 4, T. 18 S., R. 14 E., are two other strip mines. There are at least 20 strip pits at Arvonía and in secs. 7, 17, 18, 20, 21, 22, 28, 29, 31, and 32, T. 18 S., R. 14 E. (Pl. 1). The H. A. Rogers strip mine is in the Arvonía mining district.

Deep mines.—Of the 302 Wabaunsee coal mines in Osage County, 174 are shaft mines. In the early years of mining, however, slope or drift mines along the edge of the Howard limestone escarpment were common.

A glance at the coal mining map of Osage County (Pl. 1) shows that the shaft mines follow closely the tracks of the Santa Fe Railroad or dot both sides of highway US 50N. Very few shaft mines are found any distance away from these two main transportation arteries. The greatest concentration of deep mines is between Scranton and Burlingame and in the Osage City area.

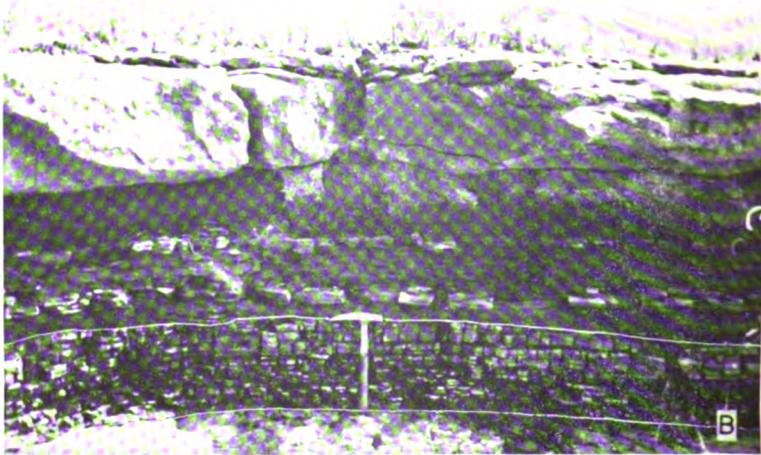


PLATE 5. *A*, Typical shaft mine in the Osage coal field. The mine, Didier and Parre No. 1 about 1 mile northwest of Osage City in the NE $\frac{1}{4}$ sec. 22, T. 16 S., R. 14 E., is now abandoned. *B*, Outcrop of 14-inch Nodaway coal bed beneath the Church limestone, 1 $\frac{1}{2}$ miles north of Lancaster in the NW $\frac{1}{4}$ sec. 21, T. 5 S., R. 19 E., Atchison County. Photographs by R. E. Whitla.

A large number of mines were formerly located within the city limits of Scranton and Osage City (Fig. 29) so that today these cities are more or less honeycombed with underground passageways, one of which is illustrated in Figure 30.

Only six shaft mines produced coal during the mining season of 1944 and 1945 (Table 31). These mines reach depths of 109 to 120 feet. The coal in all of them is cut by machine, hoisted electrically, and mined by the longwall system. The coal is undercut by machines which cut a swath 27 to 28 inches wide and 6 inches thick in the underclay beneath the coal. After the coal has been undercut for several hours, the weight of the overburden causes the coal to break down without wedging or shooting. The coal is then placed by hand on small cars and pushed to the shaft opening. From there it is hoisted electrically to the top of the tippie room, where it is weighed and finally chuted down to receiving trucks, the only means by which the coal is hauled away. No present coal mine has railroad connections. Shaft mine openings range from 4.5 by 9 to 6 by 13 feet. The depth of the shaft mines varies with the distance of the mines westward in the direction of dip of the strata from the face or outcrop of the coal along the escarpment border. Miscellaneous mining data pertaining to these mines are presented in Table 29.

Only one of the active mines, the Didier and Parre No. 2 in the NW cor. NE $\frac{1}{4}$ sec. 22, T. 16 S., R. 14 E., produced coal in the Osage City mining district. It is 116 feet deep. The coal ranges in thickness from 13 to 18 inches and has been mined 700 feet distant from the shaft opening. The remaining five active shaft mines are in the Burlingame mining district, south and east of Burlingame in secs. 13, 14, 22, and 23, T. 15 S., R. 14 E (Pl. 3A). One of these mines, the Bell No. 4 in the NW $\frac{1}{4}$ sec. 23 was opened in March 1944 (Pl. 3C). At the time of my visit on August 17, 1944, the coal, which is 18 inches thick, was being mined at a distance of 35 feet from the shaft opening. The mine is 120 feet deep and is the deepest one in the district.

History of mining.—According to Ben Lowes (personal communication), a former miner now farming southeast of Scranton, coal was first discovered in Osage County in the early 1850's in the creek bed of 110 Creek a short distance north of the Santa Fe bridge southwest of Scranton. Coal was mined before 1867 when

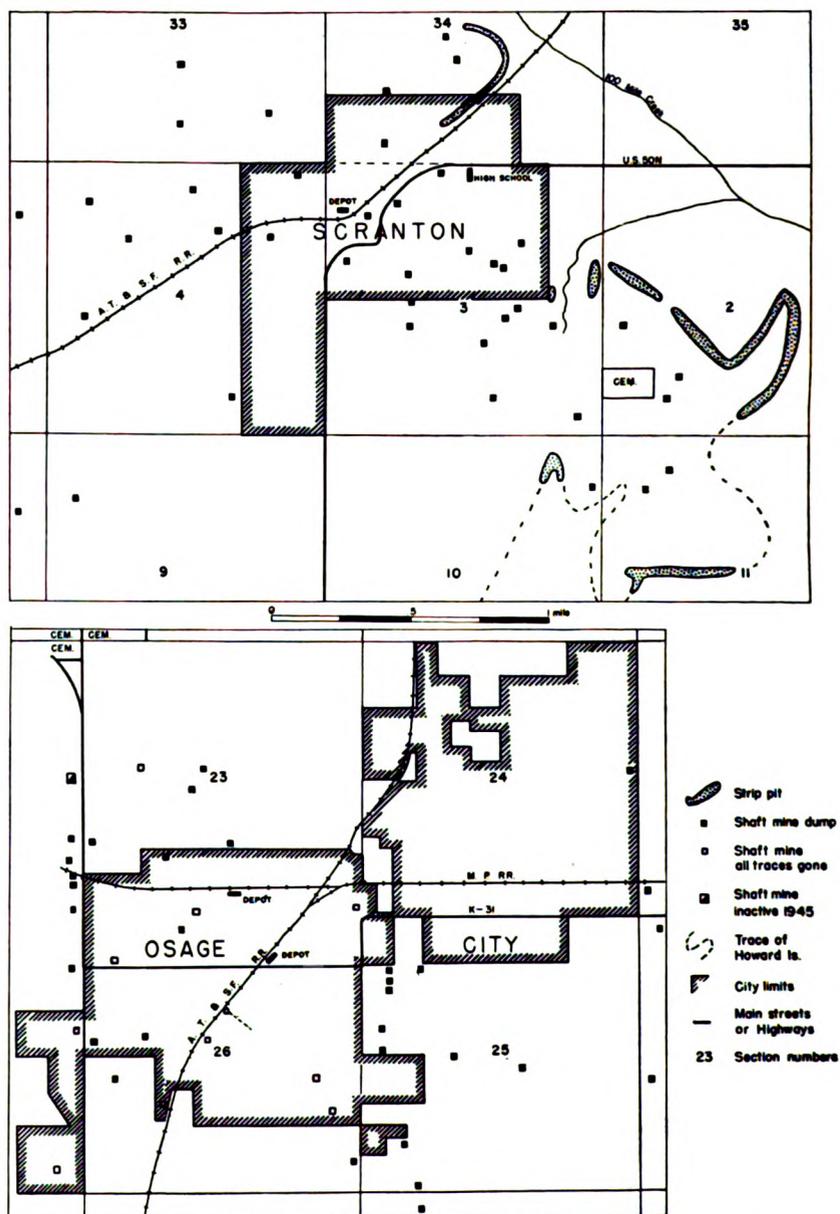


FIG. 29. Maps showing location and distribution of coal mines in and near Scranton and Osage City, Osage County, Kansas.

Ira Philbrick opened a strip mine, a little more than 1 mile east of Scranton in sec. 2, T. 15 S., R. 15 E. In the spring of 1869 (Crane, 1898, pp. 189-190) John F. Dodds, living at Carbon Hill east of Carbondale in Osage County, accidentally encountered the Nodaway coal while digging a well on top of a hill. This find, according to some, resulted in the opening of the Osage City coal-mining district, although, as just mentioned, coal was mined east of Scranton by stripping before 1867. Mines were opened at Osage City by Godfrey and Price of Hannibal, Missouri, in the fall of 1869. Interest in the mines operated under the name of the Carbon Coal and Mining Company of Missouri was bought a year or two later by T. J. Peter, who substituted the word Kansas for Missouri in the name (Young, 1925, p. 48). It seems, however,

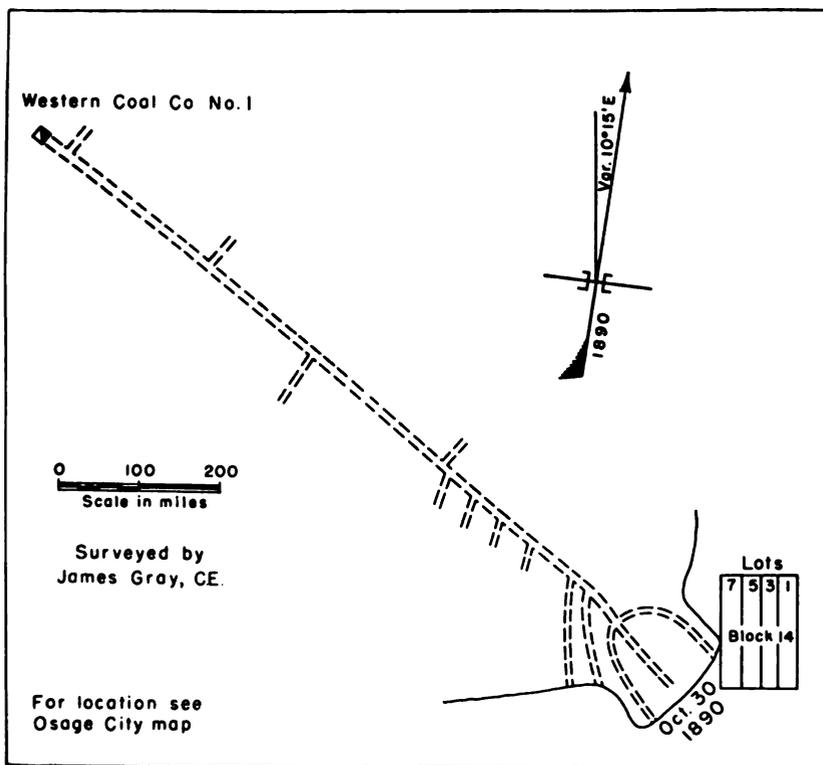


FIG. 30. Plat showing tunnels of Western Coal No. 1 mine just north of the Cen. sec. 26 on October 30, 1890, under part of Osage City, Osage County, Kansas. (See Fig. 29).

that early mining operations were not very successful (Brown, 1896, p. 17) and that up to 1871 the industry was practically a failure, both in regard to the quantity of coal mined and the cost of production. According to Brown (1896, p. 17), the poor showing of the mines was due primarily to the application of wrong mining methods for coals having thicknesses of only 12 to 16 inches. In 1871 under the direction of Robert Craig, a highly capable mining engineer, the longwall plan of mining was inaugurated and horsepower plants to hoist the coal out of the shafts were erected. Under Craig's management the coal mines became profitable, new shafts were sunk, and many practical miners from eastern states were brought to work in the mines. The coal-mining industry in Osage County flourished, and for a number of years it became the leading county in Kansas in the production of coal and in the number of men employed in mining west of the Mississippi River.

At Scranton and vicinity mining started before the opening of the Ira Philbrick strip mine in 1867 in sec. 2, T. 15 S., R. 15 E. (Lowes, personal communication). In 1871 O. H. Sheldon and Elix Thomas, co-founders of Scranton, opened a slope mine east of Scranton, and in 1872 they sank the first shaft mine at Scranton in the NE cor. NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 3. In 1873 several shafts were sunk, including the Osage Carbon Company No. 1 mine in the north part of Scranton in the SE cor. SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34. This mine is reported to have been the first one in the district served by a railroad spur. According to Crane (1898, p. 190), coal mining at Scranton did not start until 1874. In 1874 the first shaft mine was sunk at Peterton, a small community 2 miles north of Osage City. Although coal was mined along the coal outcrop near Burlingame as early as 1866 (Swallow, 1866, p. 120), seemingly no shaft mining was done in this part of Osage County until 1878 or 1879.

Up to 1880 the T. J. Peter Company was the principal coal-mining company in the Osage County district. In that year the Atchison, Santa Fe, and Pacific Railroad bought a half interest in the Peter company and a year or two later became the sole owner and operator of the company. Because of the importance of coal to the railroad, the Santa Fe system soon acquired mining rights to about 30,000 acres of land and became the principal coal-mining

operator in Osage County. The Santa Fe mines in Osage County practically supplied the whole Santa Fe system with coal for all points east of Colorado from 1880 until its mines were opened in Crawford County. The coal of the Santa Fe mines furnished power for the trains of the Santa Fe system, and much of the coal was shipped into the general market. By 1898 the Santa Fe Railroad had reduced its Osage County land holdings by one-half, and in that year it leased its entire coal-mining property in Kansas to the Mount Carmel Coal Mining Company. In 1898, 31 mining companies were operating in the Osage district; however, the Mount Carmel Company did more than 45 percent of the coal business. The Osage County coal-mining district, at one time the most important district in Kansas, has steadily declined in coal production since 1893. In 1889, 118 mines were in operation, employing about 2,000 men. Maximum production was reached in 1890 when the 73 mines in operation produced 452,751 tons of coal. In 1944, less than 200 men working in 8 mines (6 shaft and 2 strip mines) were producing Nodaway coal in Osage County. Figure 31 and Table 33 show for the various years the annual coal production, number of mines in operation, and the number of persons employed.

TABLE 32.—Trend of coal mining and production in Osage County, Kansas, 1935-44

Year	Shaft mines			Strip mines			Totals		
	No. of mines	Men employed	Tons	No. of mines	Men employed	Tons	No. of mines	Men employed	Tons
1935			75,734			13,393	48	521	89,127
1936	37		77,065	12		11,530		612	88,595
1937	28		82,184	10		8,268	38		90,452
1938	22		62,368	6		5,670	28		68,038
1939	24		65,276	8		8,055	32		73,331
1940	22		95,515	8		8,370	30	377	103,885
1941	23		74,813	7		4,348	30		79,161
1942	16		81,797	6		3,383	22		85,180
1943	9	177	45,687	4	18	5,552	13	195	51,239
1944*	10		16,715	4		3,626	14	173	20,342
1944‡	6		24,492	3		4,027	9		28,519

*First half.

‡Second half.

TABLE 33.—Annual coal production, number of mines, and number employed in the Nodaway coal mines of Osage County, Kansas, 1874 to 1944 (See Figure 31)

Year	Tons	Number of mines	Number of persons employed
1874	73,400		
1875	123,400		
1884	208,735	15	1,000
1885	425,834	45	1,936
1886			
1887	417,607	54	2,044
1888			
1889	396,784	118	2,271
1890	452,751	73	
1891	447,920	75	2,917
1892	372,806		
1893	280,213	54	1,558
1894	296,011	55	1,887
1895	263,036	48	1,604
1896	195,652	30	1,544
1897	181,857	40	1,463
1898	179,070	32	1,201
1899	253,668	66	1,396
1900	193,529	53	1,369
1901	171,753	36	1,015
1902	180,211	45	994
1903	173,451	43	961
1904	60,786	37	788
1905	148,106	41	1,000
1906	136,443	35	998
1907	133,990	38	788
1908	120,496	38	745
1909	64,929	17	530
1910	60,847	17	531
1911			
1912	71,421	15	520
1913	101,151	24	588
1914	115,554	24	623
1915	102,006	21	553
1916	124,926	25	640
1917			
1918			
1919			
1920	90,879	20	416
1921	70,612	26	545
1922	92,787	24	504
1923	74,047	17	386

1924	88,614	25	430
1925	95,227	27	374
1926	91,671	21	458
1927	86,768	22	415
1928	73,408	22	406
1929	72,801	21	380
1930	62,040	26	398
1931	45,984	24	376
1932	46,885	25	383
1933	46,932	37	387
1934	67,879	47	478
1935	89,127	48	521
1936	88,595	44	612
1937	90,452	38	521
1938	68,038	28	385
1939	73,331	32	317
1940	103,885	30	376
1941	79,161	30	354
1942	85,180	22	285
1943	51,239	13	195
1944	48,861	11	173

Present production.—The trend of coal mining in Osage County in the last decade is presented in Table 32. The general decrease in number of mines and production since 1940 is due largely to the shortage of manpower caused by the war. In 1940, 30 operating coal mines employed 377 men who produced 103,885 tons of coal. By 1943 the number of mines had decreased to 13, the number of men employed had dropped to 195, and production of coal had dropped to 51,239 tons. In the first half of 1944, 10 shaft and 4 strip mines employed 173 men who produced 20,342 tons of coal. During the second half of 1944 the number of mines decreased to 6 shaft and 3 strip but production amounted to 28,519 tons.

Cumulative production.—The cumulative coal production of Osage County from 1869 to 1944 is 11,448,861 tons. The peak of production was reached in 1890 when 452,751 tons of coal were produced. The period from 1885 to 1892 marks the greatest development of the Osage County mining industry. Seventy-five mines employing 2,917 men were operated in 1891. The annual production from 1874 to 1944 is tabulated in Table 33 and shown graphically in Figure 31.

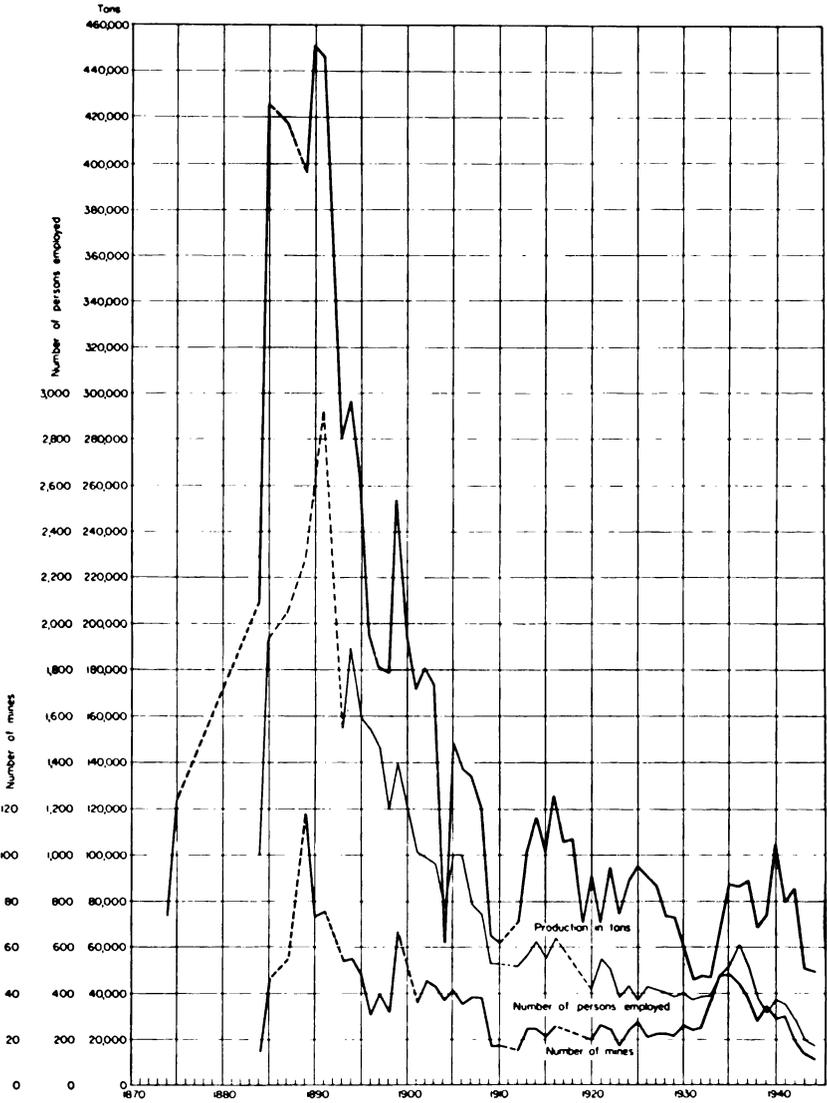


FIG. 31. Graph showing annual production of Nodaway coal, number of persons employed, and number of mines in operation in Osage County, Kansas, from 1874 to 1944.

A study of the spacing of the strip mines and the distribution of shaft mines near the border of the Howard limestone escarpment indicates that all land in a strip 0.5 mile wide from the south county line to the north edge of Scranton and skirting the Howard limestone escarpment should be considered proved coal reserve land suitable for stripping. This area totals approximately 30 square miles, to which 2 square miles should be added for proved coal reserve lands in the Carbondale mining district. Presuming that the coal averages 14 inches in thickness, the 32 square miles proved coal reserve lands suitable for stripping contain 35,840,000 tons of coal less the amount of coal thus far removed. The proved reserve area also includes 37 square miles in which the coal lies too deep to be stripped but is suitable for shaft mining. This area is underlain by coal averaging 18 inches in thickness and contains 53,280,000 tons of coal less the amount already produced. The total proved coal reserve area consists of 69 square miles containing approximately 77,670,000 tons of proved coal reserve. Proved and potential coal reserve areas and tonnage by mining districts are presented in Table 34.

Potential reserves.—Practically all lands in Osage County underlain by Wabaunsee rocks contain potential coal reserves. The Scranton-Burlingame potential coal reserve consists of 122 square miles underlain by 18-inch coal and contains 175,680,000 tons of coal. The Arvonja and Carbondale areas embrace 50 and 60 square miles, respectively. On the basis of a 12-inch coal, these areas contain 105,600,000 tons. The total potential reserve tonnage, therefore, is 281,280,000 less 11,448,861 tons of coal already mined, or approximately 269,830,000 tons (Table 34).

POTTAWATOMIE COUNTY

Rocks of the Wabaunsee group from the Burlingame to the Brownville limestone formations crop out to a limited extent in Pottawatomie County. The Wabaunsee rocks are found primarily in a triangular area bounded by Duluth on the west, Havensville on the east, Onaga toward the south, and by the valley of Vermillion River and its tributaries on the west toward Louisville. From Louisville the rocks are exposed westward on both sides of Pleasant Run Creek. The strata also crop out in

TABLE 34.—Proved and potential Nodaway coal reserve lands and tonnage by mining districts in Osage County, Kansas

Mining District	Location	Proved reserves				Potential reserves			
		Sq. miles		Tons		Thickness of coal, inches	Sq. mi.	Thickness of coal, inches	Tons
		Strip mines	Deep mines	Strip mines	Deep mines				
Carbondale	Secs. 24, 25, 36-14-15E 19, 29, 30-14-16E	14	2	2,240,000		12	60	57,600,000	
Scranton-	Secs. 1, 2, 10 to 16, 21 to 28- 14-16E								
Burlingame	Secs. 26 to 29, 31 to 34-14-15E	14	6	6,720,000					
	Secs. 1 to 11, 14 to 20, 29, 30- 15-15E	18	19		27,360,000	18	122	175,680,000	
Osage City	Secs. 27, 28, 33 to 36-15-14E 31-15-15E								
	1, 2, 3, 10 to 15, 21 to 28, 32 to 35-16-14E	14	9	10,080,000					
	6, 7, 17 to 19, 30-16-15E 1, 2, 3-17-14E	16	18	25,920,000					
Barclay	Secs. 10 to 16, 21 to 28, 33 to 35-17-14E								
	7, 18 to 20-17-15E 3 to 6, 9, 10-18-14E	14	9	10,080,000					
Arvonia	Secs. 13, 24-18-13E 16 to 22, 28 to 32-18-14E	14	6	6,720,000		12	50	48,000,000	
Total		32	37	35,840,000	53,280,000		232	281,280,000	
Cumulative production				11,448,861				11,448,861	
Approximate reserves				77,670,000				269,830,000	

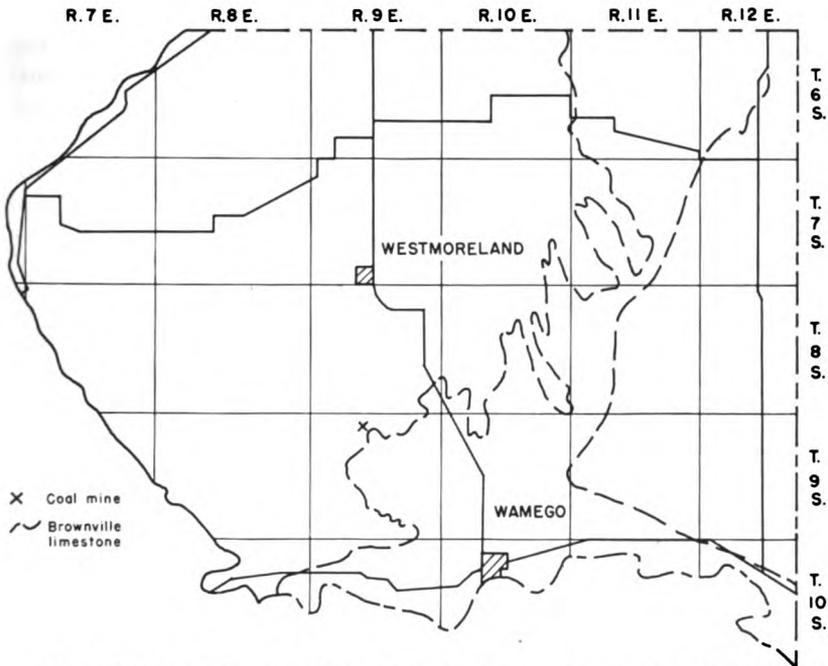


FIG. 32. Map of Pottawatomie County, Kansas, showing location of coal mines and outcrops of the Wabaunsee group of rocks.

Kansas River Valley near Wamego and in Big Blue River Valley east of Manhattan (Fig. 32).

Lorton coal.—The Elmo coal is known to occur at several places in the above-defined area, but is too thin to be minable. The only coal reported mined in Pottawatomie County, Lorton coal in the French Creek shale formation, is found a short distance northwest of the Cen. SE $\frac{1}{4}$ sec. 4, T. 9 S., R. 9 E., along Rock Creek about 1.5 miles due east of Flush. The coal is 10 inches thick and occurs 3 feet above water level of Rock Creek at the base of a steep bluff 50 or more feet high (Fig. 33). It is hard, bright, and shiny, and is reported to burn well. The coal underlies the Nebraska City limestone member of the Caneyville limestone formation, from which it is separated by 8 inches of black jack or coaly silty clay. The Nebraska City limestone is a dark-gray, well-jointed, highly fossiliferous impure limestone 1.5 feet thick. The upper foot is massive whereas the lower part weathers into

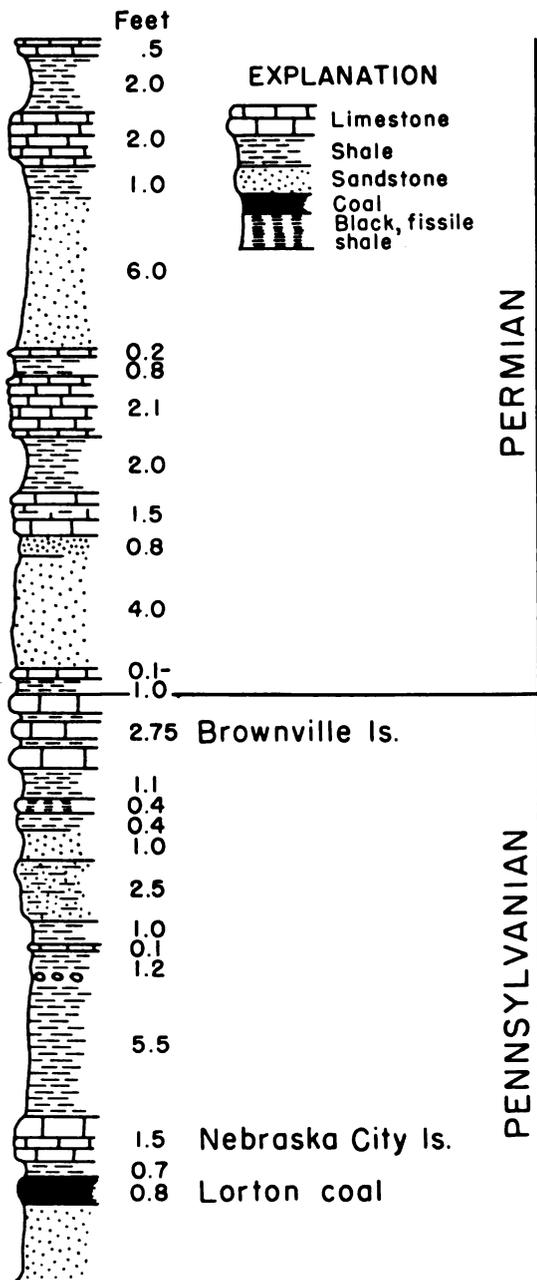


FIG. 33. Stratigraphic section of strata exposed in Rock Creek in the SE $\frac{1}{4}$ sec. 4, T. 9 S., R. 9 E., Pottawatomie County, Kansas, showing position of Lorton coal and adjacent rocks.

small chips. Light-bluish siltstone or fine-grained sandstone underlies the coal. The Nebraska City limestone at this locality is 13 feet below the base of the Brownville limestone, the top of the Pennsylvanian rocks in Kansas. The coal was taken along the outcrop, but because of difficulty in getting to it very little has been mined. The coal is too close to creek level for drifting and too much rock overlies it for stripping. Much coal can be taken from the face of the outcrop, however.

Production and reserves.—Coal has been mined in Pottawatomie County solely for local use and there are no production figures available. It is doubtful whether more than 100 tons of coal have been mined. Because of the nearness of the coal to present normal water level and because of the excessive overburden the coal is deemed commercially unminable and thus constitutes no proved coal reserve. Potentially, 200 square miles are underlain by the 10-inch coal seam, thus affording a potential coal reserve of 160,000,000 tons of Lorton coal.

SHAWNEE COUNTY

With the exception of all territory south of Kansas River and east of a north-south line extending south from the east limits of Topeka, all of Shawnee County is underlain by strata belonging to the Wabaunsee group (Fig. 34). All formations of the group from the Severy shale to and including the Brownville limestone are present in the county. Three coals, the Nodaway, Elmo, and an unnamed coal in the Wamego shale, have been mined from 38 known mines (Table 35) in the county.

Nodaway coal.—The Nodaway coal crops out at a number of places from north to south across the county close to the subdued escarpment of the Howard limestone. The coal ranges from 2 to 17 inches in thickness. It is 2 to 3 inches thick along the half section line road in secs. 23 and 26, T. 10 S., R. 16 E., just north of Kilmer. On both sides of State highway K 4 along Muddy Creek in the NE $\frac{1}{4}$ and SE $\frac{1}{4}$ sec. 10, T. 10 S., R. 16 E., about 2 miles west of Meriden in Jefferson County, the coal is 10 to 12 inches thick. Several drift mines are located at this locality. The coal is 13 inches thick 2.25 miles east and 1.75 miles north of Menoken in the NE cor. sec. 11 and the NW cor. sec. 12, T. 11 S., R. 15 E. Here also the coal was formerly mined by stripping and by drifting. At

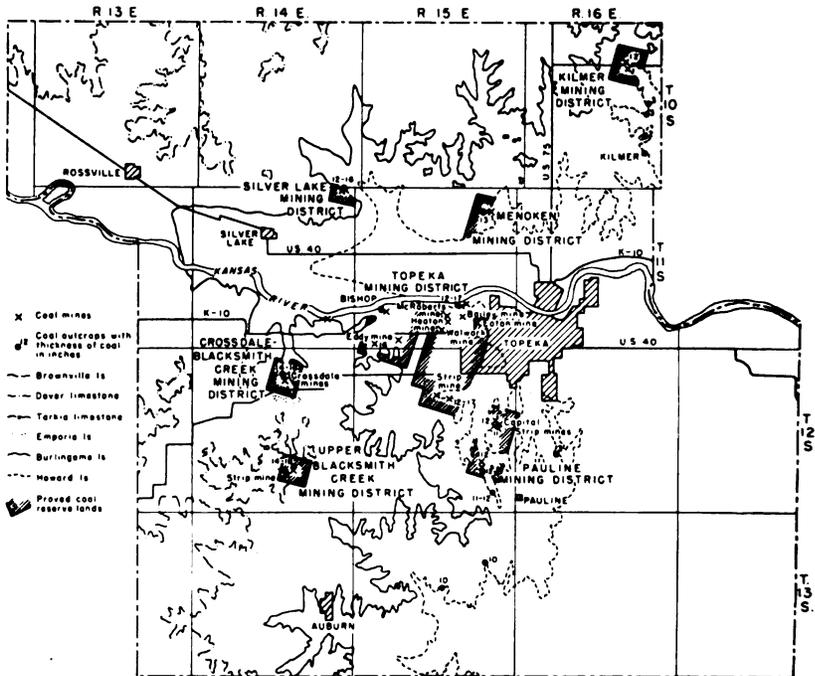


FIG. 34. Map of Shawnee County, Kansas, showing location of coal mines and outcrops, proved coal reserve lands, and traces of the Howard, Burlingame, Reading, Tarkio, Dover, and Brownville limestones.

the abandoned quarry and brick plant at the west edge of Topeka north of Gage Park the coal is 12 inches thick, and 0.25 mile farther north and a short distance west along the Kansas River bluffs skirting the tracks of the Rock Island and Pacific Railroad the coal ranges from 12 to 17 inches in thickness. Coal 12 to 17 inches thick was also observed in a north-facing bluff of Shungunga Creek in the SE $\frac{1}{4}$ sec. 10, T. 12 S., R. 15 E., about 1 mile south and a little west of the southwest corner of Topeka. At the old Capital strip pits in the SW $\frac{1}{4}$ sec. 13, T. 12 S., R. 15 E., and in the NE $\frac{1}{4}$ sec. 26 and the NW $\frac{1}{4}$ sec. 36, T. 12 S., R. 15 E., the Nodaway coal is 11 to 12 inches thick. In the SE cor. sec. 11, T. 13 S., R. 15 E., a 15-inch black shaly coal containing a clay parting 1 inch thick crops out 25 inches below the Church limestone. A little less than 1 mile south and 1.5 miles west, in the SW $\frac{1}{4}$ sec. 15, the coal is 10 inches thick. The coal is only 3 inches thick

at the escarpment edge in the SW cor. SE $\frac{1}{4}$ sec. 20, T. 12 S., R. 16 E., 1.5 miles north and 1.5 miles east of Pauline.

The Bachelor Creek limestone is missing in Shawnee County; hence the coal is overlain and underlain by shale. The overlying shale is partly grayish and partly black, has a tendency to be papery to fissile, and ranges in thickness from 1 foot 8 inches to 6 feet 10 inches. The overlying Church limestone consists of a single massive hard dense rock normally 1 foot 3 inches to 2 feet 9 inches thick. In the SW $\frac{1}{4}$ sec. 15, T. 13 S., R. 15 E., the Church limestone either is abnormally thick, measuring 4 to 5 feet, or is overlain directly by the Utopia limestone. Above the Church limestone is the Winzeler shale which commonly is dark gray and ranges from 2 feet to 6 feet 8 inches in thickness. Above the Winzeler shale is the Utopia limestone which consists of several limestone beds interspersed with shale, some of which is black, fissile, and contains abundant white ostracodes. The uppermost limestone bed of the Utopia is filled with numerous robust fusulinids. The entire Utopia limestone member is present and well exposed at the following localities: (1) Kansas River bluffs along the tracks of the Rock Island and Pacific Railroad north of Gage Park, Topeka, in sec. 27, T. 11 S., R. 15 E., and (2) in a road cut and stream bluff north of Topeka in secs. 11 and 12, T. 11 S., R. 15 E. At these two localities the Utopia limestone is respectively 5 feet 8 inches and 4 feet 9 inches thick. Stratigraphic sections showing the Nodaway coal and associated rocks are presented in Figure 4.

Of the 38 known coal mines in Shawnee County 25 derived their coal from the Nodaway seam. Of these 3 were strip, 5 were shaft, and 17 were drift mines (Table 35). The Nodaway coal was formerly mined in what is now the west part of Topeka in the Gage Park neighborhood; in the northeast corner of the county along Muddy Creek in the E $\frac{1}{2}$ sec. 10, T. 10 S., R. 16 E.; northeast of Menoken at the junction of secs. 2 and 12, T. 11 S., R. 15 E.; along Shunganunga Creek in sec. 10, T. 12 S., R. 15 E.; in the SW $\frac{1}{4}$ sec. 13, T. 12 S., R. 15 E. on the east side of the Topeka-Burlingame road about 1.5 miles south of the city limits of Topeka; and in the NE $\frac{1}{4}$ sec. 26, T. 12 S., R. 15 E.

The presence of the coal at Topeka was known to the early pioneers who settled and founded the city in the middle of the

TABLE 35.—Location and classification by type of mine of coal mines in Shawnee County, Kansas.

Location	Name of mine	Coal bed	Average thickness of coal, inches	Number of mines			
				Shaft	Drift	Strip	Total
E½ 10-10-16E		Nodaway	10-12		4		4
NW cor. NE¼ 1-11-14E		Elmo	12-16	2	3		5
SE cor. 2-11-15E		Nodaway	13			1	1
NW cor. 12-11-15E		do	13		3		3
36-11-14E		Elmo	12		1		1
NW¼ 26-11-15E		Nodaway	12-17		4		4
SW¼ 26-11-15E	Bailey	do		1			1
27-11-15E	McRoberts	do		1			1
SW¼ 29-11-15E	Sugar works or Bishop	Elmo	16	1			1
SE¼ 31-11-15E	Eddy	do	16		1	1	2
SE¼ 32-11-15E		Nodaway		1			1
34-11-15E	Heaton	do		1			1
cen. 34-11-15E	Walwork	do		1			1
NW cor. NE¼ 35-11-15E	Eaton	do			1		1
NW¼ 10-12-14E	Crossdale	Elmo	14-18		1		1
NE¼ 10-12-14E	do	do	14-18		2		2
NE¼ 27-12-14E		Unnamed	14-18			1	1
SW¼ 10-12-15E		Nodaway				1	1
SE¼ 10-12-15E		do	12-17		2		2
SW¼ 13-12-15E	Capital	do	11-12		1	1	2
NE¼ 26-12-15E	Coffman	do	13		2		2
Summary		Nodaway		5	17	3	25
		Elmo		3	8	1	12
		Unnamed		—	—	1	1
		Total		8	25	5	38

19th century. Both Mudge (1866, p. 19) and Swallow (1866, p. 56) mention the coal at Topeka, and Mudge (1866, p. 19) reports that coal was obtained in numerous places by stripping 1 to 3 feet of overlying soil from coal 12 to 16 inches thick. The coal at Topeka is reported by Gray (1875, p. 408) to be 14 to 20 inches thick and to occur 15 to 20 feet below the surface. He also states that the coal was used to quite a large extent for local, domestic,

and manufacturing purposes. St. John (1883, p. 585) correctly correlated the coal mined at Topeka with that mined in Osage County. For some unexplained reason, however, St. John's correlation was overlooked, for as late as 1896 Haworth (1896b, p. 304; Bennett, 1896, p. 209) asserted that the coal at Topeka "is not the geologic equivalent of any other coal known in the state, unless possibly the coal claimed to have been discovered recently in Jefferson County should be correlated with it." Haworth and others believed that the coal mined near Dover and Silver Lake in the western part of the county was the equivalent of the Osage County coal. In 1896 Beede, in studying the stratigraphy of Shawnee County (Haworth, 1896a, p. 161 fn.; Beede, 1898, p. 29), confirmed St. John's correlation and also established the fact that the coal discovered at Valley Falls in Jefferson County was the same as that mined at Topeka. Most of the coal at Topeka and vicinity was mined by drifting into the hillsides. Extensive stripping, however, was done at the Capital mines located east of the Topeka-Burlingame highway in the SW $\frac{1}{4}$ sec. 13, T. 12 S., R. 15 E. According to reports, the coal was also stripped along Shungununga Creek in the SW $\frac{1}{4}$ sec. 10, T. 12 S., R. 15 E., and in the SE cor. sec. 2, T. 11 S., R. 15 E.

The shaft mines, of which there were at least five, were especially the bane of the state coal mine inspectors. These mines caused them more anxiety, worry, and disgust than any other mines operated in the State. Brown (1896, pp. 98-99) writes thus of the Topeka mines: "Any person who is interested in seeing the art of mining coal practiced in all its pristine beauty and simplicity should drive three miles west of Topeka and spend one-half day looking around. Here we have coal shafts from 20 to 50 feet in depth, a single opening about 5 x 5 and a large-sized stovepipe or old smoke-stack placed in one corner of it to serve as a ventilator and escapement shaft. Horse power is used exclusively for hoisting the coal. How men can be tempted to risk their lives in such a trap is beyond my comprehension, unless it is man's inordinate desire for personal freedom and liberty, and the right to come and go just as it suits his own sweet will."

Elmo coal.—The Elmo coal, formerly known in Shawnee County as the Dover and Silver Lake coals, crops out at a number of places from the northeast corner of the county to Silver Lake

and southeastward to within a mile of Pauline from which it can be traced southwestward again to Auburn. The Elmo coal was formerly thought to be the equivalent of the Nodaway or Osage County coal (Bennett, 1896, p. 119). In 1896, Beede (1898, p. 30) traced the Topeka coal bed (Nodaway) to the coal-mining area of Carbondale, Scranton, Burlingame, and Osage City, thus definitely establishing the fact that the coal mined at Topeka and in Osage County were equivalents and that the coal mined from 6 to 10 miles west of Topeka was a stratigraphically higher coal (Elmo). Beede's work also confirmed St. John's correlation (1883) that the Topeka and the Osage County coals were the same.

The Elmo coal ranges from 4 to 16 inches in thickness. The coal was mined 2.5 miles north and 0.5 mile west of Kiro in the NW cor. NE $\frac{1}{4}$ sec. 1, T. 11 S., R. 14 E. At this locality the coal crops out in a steep bank next to the tracks of the Union Pacific Railroad. The coal is 12 inches thick and is overlain by shale estimated to be 15 feet thick. Beneath the coal to the level of the railroad tracks, a distance of 11 feet, is a channel sandstone, yellow to tan, micaceous, laminated, wavy, and cross-bedded, that contains small faults. The mines are located on the hill to the south and east of the outcrops along the railroad tracks. There is evidence of at least two shaft openings and two drift mines, which are separated vertically by approximately 50 feet. The mines were operated last in 1927 when excessive water caused them to be abandoned. Considerable coal was also taken out of three drift mines on the Crossdale place along Blacksmith Creek in the N $\frac{1}{2}$ sec. 10, T. 12 S., R. 14 E., 6.5 miles due west of the southwest edge of Topeka. Other Elmo coal mines were operated 2 to 5 miles west of Topeka, especially on the J. A. Eddy farm in the SE $\frac{1}{4}$ sec. 31, T. 11 S., R. 15 E., where coal was formerly mined by stripping and drifting.

Unnamed coal.—Toward the head of Blacksmith Creek near the S. line NE $\frac{1}{4}$ sec. 27, T. 12 S., R. 14 E., about 3.5 miles south of the Crossdale mines, an unnamed coal several feet stratigraphically above the Tarkio limestone (Fig. 34) was mined from an acre or so by stripping. According to I. Price, a local farmer, the coal was last mined in 1920 and ranged from 14 to 18 inches in thickness. The coal is associated with massive sandstone lying

above the Tarkio limestone and occurs in the Wamego shale where elsewhere a coal associated with the Maple Hill limestone member is present.

Nyman coal.—According to an early state coal mine inspector (Gallagher, 1894, pp. 81-82) coal was mined at Dover in 1893. As the description given does not adequately locate the mine or mines, it is not known whether the coal was mined at Dover at the western border of Shawnee County or in the general vicinity of the town. The Dover limestone crops out in the immediate vicinity of Dover and the Nyman coal is known to occur beneath it. However, no Nyman coal mines were found. Crane (1898, p. 137) and Whitla (1940, p. 61) report the mining of coal a few miles west of Dover in Wabaunsee County. This coal occurs beneath the Nebraska City limestone member of the Caneyville limestone formation and is the Lorton coal, erroneously correlated by Whitla as the Nyman coal underlying the Dover limestone.

Production.—Except for extremely local consumption, no coal has been mined in Shawnee County since 1927 and for the most part not since 1908. The highest production, so far as published records indicate, was 9,547 tons in 1889. On the basis of published records Shawnee County has produced since 1882 a minimum of 71,683 tons of coal. Since it is known that coal was mined in the county before 1866 and that by 1874 it was mined to a great extent for local, domestic, and manufacturing purposes (Gray, 1875, p. 200) and that mining did not cease in 1908 but continued certainly to 1927, the total amount of coal produced may be in excess of 80,000 tons. The records for the most part are not clear as to how much of each coal has been mined; therefore it is not possible to give production figures for individual coals. It is true, however, that most of the 80,000 tons came from the Nodaway bed. Available published coal production data for Shawnee County are presented in Table 36.

Proved reserves.—There are 11 square miles of proved Nodaway reserve coal lands in Shawnee County, most of which are underlain by a 12-inch coal. This area contains 10,340,000 tons of coal. Assuming that 65,000 tons of all coal produced in Shawnee County was Nodaway coal, the proved Nodaway reserve coal tonnage is approximately 10,290,000 tons. Calculated proved reserves, area, and tonnage for the various mining districts are

TABLE 36.—Published coal production data for Shawnee County, Kansas

Year	Tons	Number of mines	Number of Employees
1882	1,500	4	20
1884	3,781	7	48
1885	3,824		
1887	4,280		42
1889	9,547		
1890	8,185		
1891	8,200	7	58
1893	7,634	6	
1894	6,000	6	45
1895	4,500	7	51
1896	5,000		40
1897	804	3	20
1898	600	1	19
1899	728	1	15
1901	53	1	2
1902	287	1	3
1904	134	1	7
1906	517	1	1
1908	100	1	1
	71,683		

presented in Table 37. Elmo proved reserves comprise 3.3 square miles, containing 3,950,000 tons of coal. At the head of Blacksmith Creek there is also a proved reserve area of 1 square mile of a 16-inch unnamed coal containing 1,280,000 tons of coal. The proved reserve area of all coals totals 15.3 square miles and 15,520,000 tons of coal (Table 37).

Potential reserves.—Practically the entire area of Shawnee County underlain by the Wabaunsee group of rocks may be considered potential coal reserve lands. Two hundred fifty-five square miles contain Nodaway coal averaging 12 inches in thickness. The potential reserve tonnage of the Nodaway coal totals 244,800,000 tons. The Elmo potential reserve area contains 200 square miles and 256,000,000 tons of coal. The potential area and tonnage of the unnamed coal are 50 square miles and 64,000,000 tons respectively. Shawnee County contains potentially 564,800,000 tons of Wabaunsee coal.

TABLE 37.—Proved and potential Wabaunsee group coal reserve lands and tonnage by mining districts in Shawnee County, Kansas

Coal bed	Mining district	Location	Proved reserves					Potential reserves					
			Thickness of coal, inches	Square miles	Tons	Total tons	Cumulative production	Aprox. proved reserve, tons	Thickness of coal, inches	Square miles	Tons		
Nodaway	Kilmer	Secs. 3, 10, 11, 14, 15, 10-16E	12	1.35	1,000,000								
do	Menoken	Secs. 1, 2, 11, 12-11-15E	13	1.0	1,040,000								
do	Topeka	Secs. 26, 27, 31, 32, 33, 34, 34-11-15E									12	255	244,800,000
		2, 3, 9, 10, 11, 15, 16- 12-15E	12	7.0	6,720,000								
do	Pauline	Secs. 13, 23, 24, 25, 26-12- 15E	12	1.65	1,580,000	10,340,000	65,000	10,290,000					
Elmo	Silver Lake	Secs. 36-10-14E; 1-11-14E	16	0.5	640,000								
do	Crossdale- Blacksmith Creek	Secs. 2, 3, 9, 10-12-14E	16	0.8	770,000						16	200	256,000,000
do	Topeka	Secs. 29, 30, 31, 32-11-15E	16	2.0	2,560,000	3,970,000	15,000	3,950,000					
Unnamed	Upper Blacksmith Creek	Secs. 26, 27-12-14E	16	1.0	1,280,000	1,280,000		1,280,000			16	50	64,000,000
Approximate reserves												15,520,000	564,800,000

WAUBAUNSEE COUNTY

Rocks of the Wabaunsee group in Wabaunsee County are essentially limited to the easternmost tier of townships in Rs. 12 and 13 E. and constitute a relatively small percentage of the entire area of the county (Fig. 35). Strata include formations from the Tarkio to the Brownville limestones. Two coals, the Lorton beneath the Nebraska City limestone member of the Caneyville limestone formation and the Nyman coal beneath the Dover limestone, occur in the county.

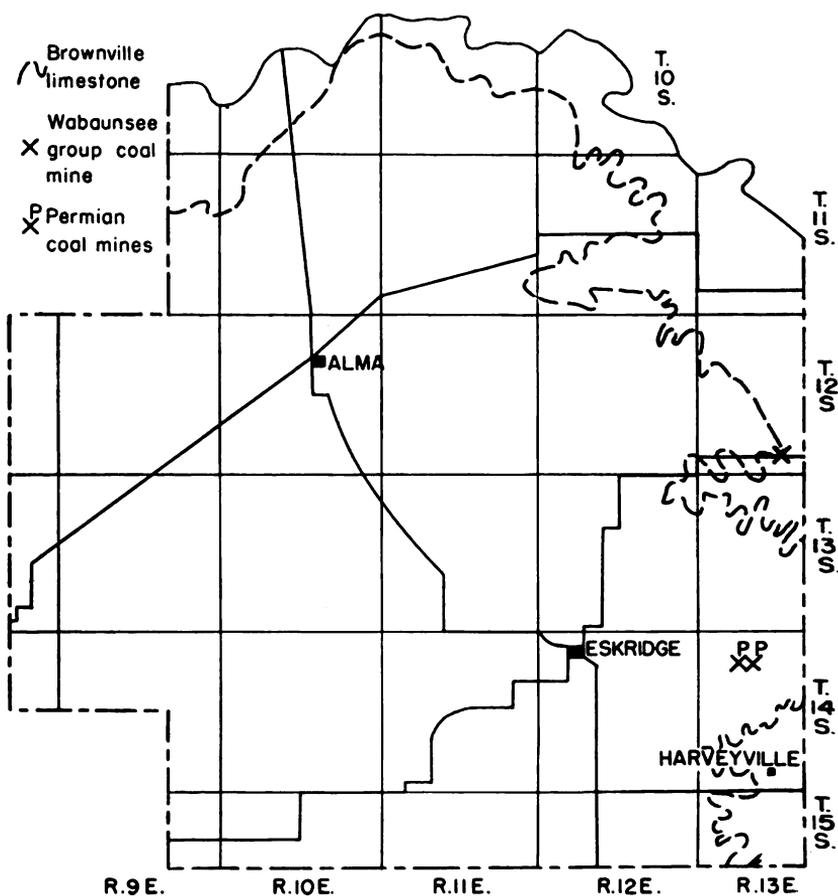


FIG. 35. Map of Wabaunsee County, Kansas, showing location of coal mines and trace of the Brownville limestone.

Lorton coal.—According to Crane (1898, p. 137), a small amount of coal was produced along the ravines of the tributaries of Mission Creek, about halfway between Keene and Dover in Shawnee County. The coal ranges from 6 to 12 inches in thickness and was correlated by Crane as the same coal as the upper stratum of coal occurring 5 to 6 miles west of Topeka in the vicinity of Sugar Works or Bishop. Whitla (1940, p. 61) describes a dull black coal about 8 inches thick occurring in Wabaunsee County several miles west of Dover, which is just east of the county line in Shawnee County. According to him the coal is the Nyman coal. It is certain, however, that the coal mined as recently as 1939 by farmers on whose land it occurs is the Lorton coal between the Dover and Brownville limestones. The coal, seen in a stream bank 2.5 miles west and 0.6 mile north of Dover in the SW $\frac{1}{4}$ sec. 28, T. 12 S., R. 13 E. at the place probably referred to by Whitla, is 2 to 9 inches thick and lies immediately under an impure shelly fossiliferous limestone about 1 foot thick or is separated from it by 4 to 6 inches of clay. The coal occurs either as a single seam or is split into four or five units separated by clay seams. The coal and intervening clay seams have a combined thickness of 2 feet 2 inches and are underlain by light-gray shale.

Production and reserves.—There has been no commercial coal mining of the Wabaunsee group coals in Wabaunsee County. The quantity mined by local residents is negligible. As far as could be observed, there is no Wabaunsee group coal worthy of being mined in the county; hence no proved and potential coals of this group are available.

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MAP OF OSAGE COUNTY, KANSAS

Showing location of active and abandoned Nodaway coal mines, coal outcrops, mining districts, proved coal reserve lands and traces of the Howard and Burlingame limestones

State Geological Survey
of Kansas

by Walter H. Schoewe
1946

Bulletin 63
Plate 1

R.13 E.

R.14 E.

R.15 E.

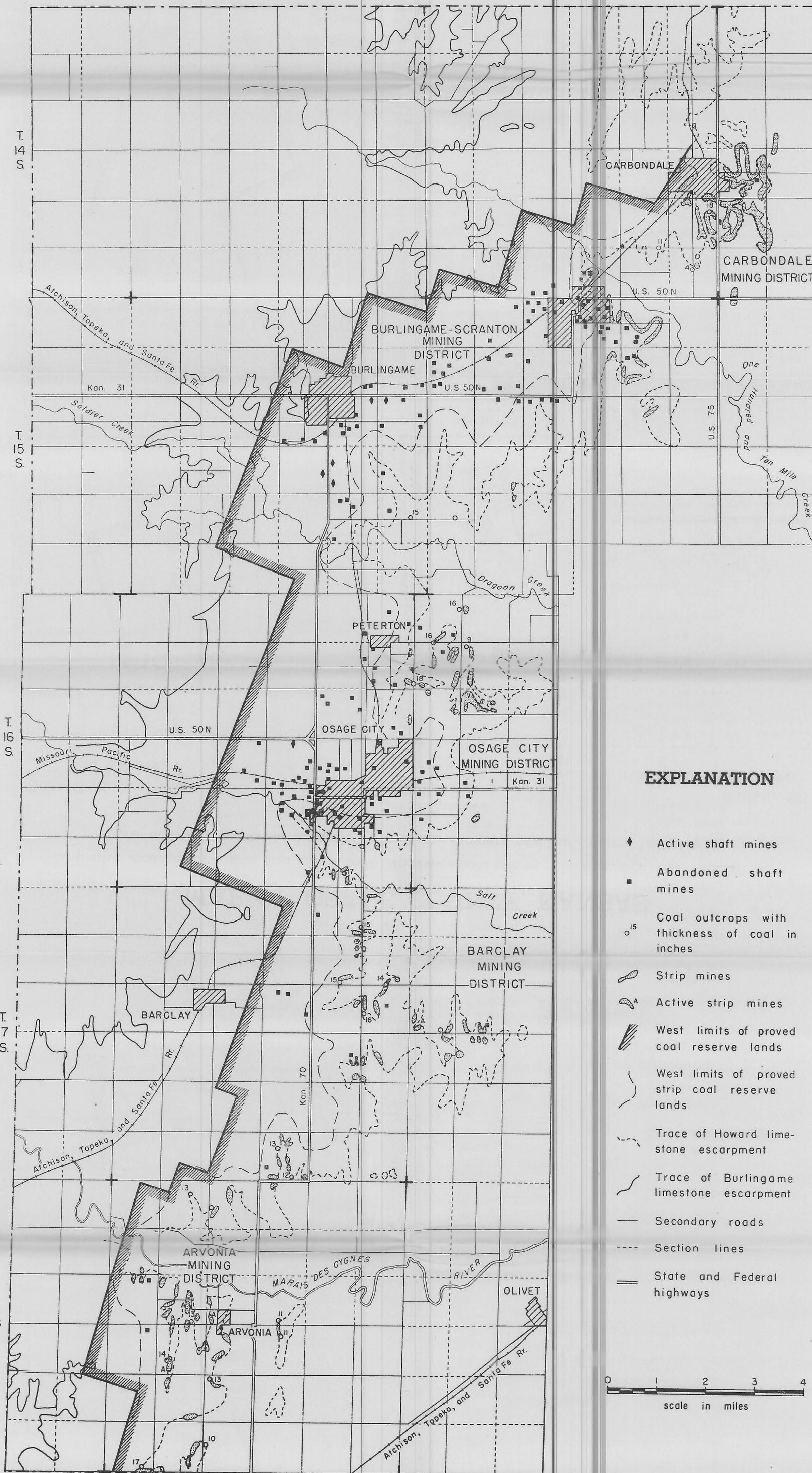
T. 14 S.

T. 15 S.

T. 16 S.

T. 17 S.

T. 18 S.



EXPLANATION

- ◆ Active shaft mines
- Abandoned shaft mines
- ¹⁵ Coal outcrops with thickness of coal in inches
- ⌒ Strip mines
- ⌒^A Active strip mines
- ▨ West limits of proved coal reserve lands
- ⋯ West limits of proved strip coal reserve lands
- - - Trace of Howard limestone escarpment
- - - Trace of Burlingame limestone escarpment
- Secondary roads
- - - Section lines
- == State and Federal highways

