UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

Bulletin 874

GEOLOGY AND FUEL RESOURCES

OF THE

SOUTHERN PART OF THE OKLAHOMA COAL FIELD

BY

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UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1939

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Bulletin 874—A

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PART 1. THE McALESTER DISTRICT

PITTSBURG, ATOKA, AND LATIMER COUNTIES

BY
THOMAS A. HENDRICKS

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1937

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - Price 65 cents

NOTE

The Geological Survey, in 1930, 1931, 1933, and 1934, conducted an investigation of the geology and coal resources of the portion of the southeastern Oklahoma coal field extending northeastward from Coalgate to McAlester and thence eastward through Wilburton and Howe to the Oklahoma-Arkansas State line. The geologists have prepared separate reports on the areas for which they were responsible. However, as these areas are adjacent and form a real unit both geographically and geologically, the four reports are issued as parts of a single bulletin covering this portion of the southeastern Oklahoma coal field. No edition of the consolidated volume will be published, but the four parts can be bound together if desired.

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GEOLOGY AND FUEL RESOURCES OF THE SOUTHERN PART OF THE OKLAHOMA COAL FIELD

PART 1. THE McALESTER DISTRICT, PITTSBURG, ATOKA, AND LATIMER COUNTIES

By Thomas A. Hendricks

ABSTRACT

The McAlester district is an area of about 477 square miles in Pittsburg, Atoka, and Latimer Counties, Okla. It lies entirely within the Arkansas Valley geomorphic province except for the extreme northwest corner, which is crossed by the easternmost cuesta of the Osage Plains province.

The stratified rocks of the district belong to the Atoka, Hartshorne, McAlester, Savanna, Boggy, and Thurman formations, of Pennsylvanian age, and consist of alternating beds of shale and sandstone with some associated coal and lenticular limestone beds. The total thickness of these formations is between 8,500 and 9,000 feet. No pronounced unconformity could be found in the section, but it is probable that the Savanna sandstone rests unconformably on the McAlester shale. Overlying these beds in parts of the district are unconsolidated sand, gravel, and clay, the great part of which belong in the Gerty (†Guertie [1]) sand, a deposit in an abandoned Quaternary (?) river channel that flowed eastward across this part of Oklahoma. The other unconsolidated deposits consist of gravel on former stream terraces, some local deposits of sand, and recent alluvium.

The district is traversed by three large, closely folded anticlines that trend northeastward in the western part of the district and eastward in the eastern part or roughly parallel to the northern front of the Ouachita Mountains. Broad, shallow synclines lie adjacent to the anticlines. Two of the anticlines are broken by thrust faults that extend approximately along the crests of the folds. Several smaller folds and faults are present, particularly in the southern part of the district, adjacent to the Ouachita Mountains.

The coal deposits of the district are by far the most valuable of the mineral resources. The McAlester district has been a large coal-producing area for about 50 years, and it is estimated that about 38,000,000 tons was produced in the period from 1872 to 1927. The coal is bituminous and is a good steam and domestic fuel. Prior to 1910 considerable coke was made from the coal of the McAlester district, but in 1910 the manufacture of coke was abandoned. In 1930, 26 commercial mines were operating in the district. Most of the mining has been confined to two coal beds, the Lower Hartshorne and the McAlester. Smaller operations have been conducted in five other coal beds—the Upper Hartshorne,

[1] A dagger (†) preceding a geologic name indicates that the name has been abandoned or rejected for use in classification in publications of the U. S. Geological Survey. Quotation marks, formerly used to indicate abandoned or rejected names, are now used only in the ordinary sense.

the Cavanal (?), an unnamed bed in the Savanna sandstone, the Lower Witteville (?), and the Secor. A considerable amount of coal is still available in the district.

Neither petroleum nor natural gas has been found in commercial quantities in the district, but adequate tests for their presence have not been made. Natural gas may be found where there are suitable reservoirs, but the high carbon ratio of the coal suggests that only small amounts of high-gravity petroleum may be present. The suitability of the anticlines for the trapping of natural gas is questionable, because two of the larger anticlines are broken by faults and a smaller one may have been flushed out by circulating waters. The Savanna anticline, however, might prove to be a satisfactory reservoir, and small noses and terraces on the McAlester and Burning Springs anticlines may have trapped small amounts of gas. Unless it has been flushed out by circulating waters, the Craig anticline may be a suitable gas reservoir.

Sand and gravel, stone suitable for structural purposes, and shale suitable for the manufacture of brick are present in the district.

INTRODUCTION

LOCATION AND AREA

The McAlester district lies almost entirely within the McAlester quadrangle in southeastern Oklahoma. (See fig. 1.) Prior to 1907, when Oklahoma Territory and the Indian reservations east of it were united to form the State of Oklahoma, the McAlester district lay within the reservation set aside by the Government for the Choctaw Nation, one of the five civilized tribes of Oklahoma Indians. The largest city is McAlester, which has a population of about 12,000 and is in the north-central part of the district. Numerous other towns and cities have sprung up as a result of the progressive development of the natural resources. The area of the McAlester district is about 477 square miles, of which about 446 square miles is in Pittsburg County, 20 square miles in Atoka County, and 11 square miles in Latimer County.

PREVIOUS PUBLICATIONS

In 1890 was published a report by H. M. Chance [2] on a part of the coal measures between McAlester and Cavanal, which is about 50 miles east of the McAlester district. The report contained a map that showed the lines of outcrop of the principal coal beds in a general way. No attempt was made to show the areas of outcrop of the various beds of rock, but fairly accurate vertical sections of the beds present, structural sections showing the altitudes of the beds along several lines, and general descriptions of the types of rocks were given.

In 1897 the results of several months' study by Drake [3] of the coal fields of the Indian Territory were published. Accompanying this report was a geologic map of the coal fields on which the rocks present

[2] Chance, H. M., Geology of the Choctaw coal field: Am. Inst. Min. Eng. Trans., vol. 18, pp. 653-661, 1890.

[3] Drake, N. F., A geological reconnaissance of the coal fields of the Indian Territory: Am. Philos. Soc. Proc., vol. 36, pp. 226-419, 1897.

in the McAlester district were divided into three groups, although no detailed sections of these groups were given for the district. Many of the structural features of the district were shown on the map in a general way, and the text included some description and interpretation of the structural features.

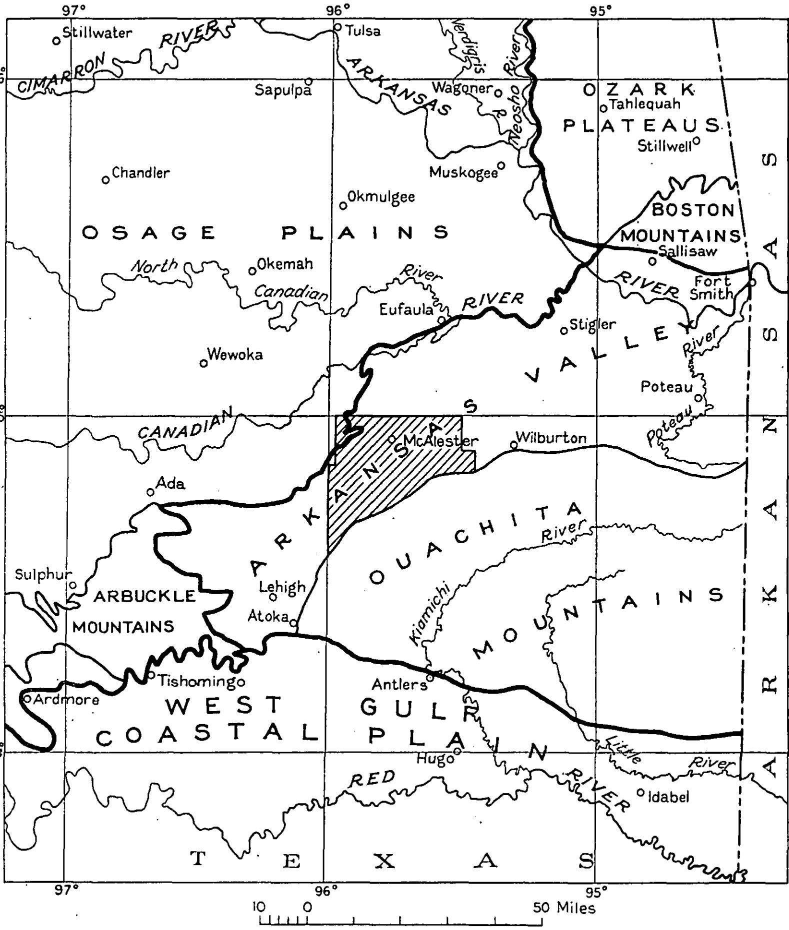

FIGURE 1.—Outline map of southeastern Oklahoma showing the geomorphic divisions and the location of the McAlester district (shaded area).

An abstract of a paper by David White [4] on the age of the McAlester coal group appeared in 1898. In this paper the age of the Hartshorne coal was given as lower Allegheny, and it was stated that all plant fossils studied from the McAlester district were of Pennsylvanian age.

In a report by Taff [5] on the McAlester and Lehigh coal fields published in 1899, all the formations of the southeastern Oklahoma coal

[4] White, David, The probable age of the McAlester coal group: Science, new ser., vol. 7, p. 612, 1898.

[5] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, pp. 423–600, 1899.

fields except the Atoka formation were named. A geologic map showing the location of formational boundaries, with the 30-minute topographic map of the McAlester quadrangle as a base, accompanied the report. This map was of much value to the writer in field work, for it helped to establish the boundaries of the formations as mapped by Taff and gave a clear and accurate regional picture of the geology that was of great aid for detailed mapping. In a detailed description of the topography of the area Taff called attention to the concordance of the summit levels of the higher hills, to uniform levels of the crests of lower ridges, and to the dissected sand plain marking the former course of the Canadian River. Taff named and described rather fully the principal structural features of the area, as well as the chief coal beds. Much information relative to the coals was given, particularly regarding the possibility of mining the coal at various places. A small-scale map showing the main structural axes and the lines of outcrop of the Hartshorne and McAlester coal beds accompanied the report.

Included in this report were discussions of the fossil plants and invertebrates collected by Taff and his assistants from the McAlester and Lehigh districts and studied by David White and G. H. Girty, respectively. From his studies of the fossil plants White concluded that the Hartshorne coal was of Allegheny age and that the plants from the higher horizons (as much as 3,300 feet above the Hartshorne) were of Pennsylvanian age and showed no similarity to known Permian flora. Girty considered the invertebrate fossils representative of the †Upper Coal Measures but did not think it advisable to attempt any subdivision of the beds on the basis of the invertebrate evidence.

In 1905 Taff [6] reported on the progress of coal work in the Indian Territory, including the McAlester district. Very little was added to his earlier discussion of this district, but a small-scale map showing the areal geology and the outcrops of all the eastern Oklahoma coal fields made clear the general relation of the geology of the McAlester district to that of the other districts.

In 1910 a Senate document [7] on the Oklahoma coal lands was published. It contained coal outcrop maps on a scale of 2 inches to the mile and much information on production, extent, quality, and value of coals in the McAlester district, together with several other districts in Oklahoma. This was a compilation of material collected for the purpose of determining the extent and value of coal under the segregated coal lands of the Choctaw and Chickasaw Nations.

In 1917 the Oklahoma Geological Survey [8] published a comprehensive bulletin on oil and gas in Oklahoma, which contained a dis-

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[6] Taff, J. A., Progress of coal work in Indian Territory: U. S. Geol. Survey Bull. 260, pp. 382–401, 1905.

[7] U. S. Dept. Interior, Coal lands in Oklahoma: 61st Cong., 2d sess., S. Doc. 390, 374 pp., 1910.

[8] Shannon, C. W., and others, Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 19, pt. 2, pp. 423–448, 1917.

cussion of the geology and oil and gas resources and possibilities of Pittsburg County. The discussions of the various formations exposed in the McAlester district followed the earlier discussions by Taff. The map showing structural axes was essentially the same as the one given by Taff, and the discussions of the structure of the McAlester district were largely taken from Taff's reports. However, the conclusion that the McAlester district lies in a possible gas territory and is an area in which prospecting for gas might be profitably undertaken was an addition to former published geologic data on the district.

A report on coal in Oklahoma published in 1926[9] contained short discussions of the rock formations and geologic structure, together with many data regarding the thickness, quality, chemical composition, and development of the coals in the McAlester district and the other coal districts of the State. This report was accompanied by several maps, one of which, a geologic map of the McAlester district printed on a scale of 2 miles to an inch, showed the lines of outcrop of the Lower Hartshorne, McAlester, and Secor coal beds.

In 1928 was published a report by Clawson[10] on the oil and gas geology of Coal and Pittsburg Counties, Okla., which include all but 11 square miles of the McAlester district. The discussion of the geology of the McAlester district was very brief and added little to earlier published data except the fact that the Savanna sandstone thickens considerably in the southwestern part of the district. In the "Conclusions regarding age of folding" Clawson placed the age of the major folding as middle or late Boggy time on the basis of four different lines of evidence. This conclusion is not supported by my observations, however.

In 1928 the Bureau of Mines[11] published a compilation of the information in its files and in its earlier bulletins on the coals of Oklahoma. This technical paper contained many data regarding the thickness, chemical composition, and heating value of the coals of the McAlester district, as well as some data on mining practices in the district. Similar data were given for the other districts of the State.

A report by Moose and Searle[12] published in 1929 contained data on Oklahoma coals studied by the Oklahoma Geological Survey in 1928. This report gave much additional information as to the thickness, chemical composition, and heating value of the coals of the McAlester and other districts, together with some additional notes on mining practices.

[9] Shannon, C. W., and others, Coal in Oklahoma: Oklahoma Geol. Survey Bull. 4, 1926.

[10] Clawson, W. W., Jr., Oil and gas geology of Coal and Pittsburg Counties: Oklahoma Geol. Survey Bull. 40-JJ, 1928.

[11] Fieldner, A. C., and others, Analyses of Oklahoma coals: U. S. Bur. Mines Tech. Paper 411, 62 pp., 1928.

[12] Moose, J. E., and Searle, V. C., A chemical study of Oklahoma coals: Oklahoma Geol. Survey Bull. 51, 112 pp., 1929.

NATURE AND PURPOSE OF THE REPORT

The field work on which this report is based was undertaken primarily to obtain detailed information on the coal resources of the McAlester district with which to expand and bring up to date Taff's report of 1899. Although Taff mapped and discussed the coals in detail, the mining and prospecting that have been done since his field work was completed have yielded many additional data regarding lines of outcrop, thickness of rock units, and character of the coal beds, which make possible a much more detailed report on the coal resources. In addition to its economic resources the district has special geologic interest because a part of one of the thickest known sections of Pennsylvanian rocks is exposed here and because the type localities of the formational units of the southeastern Oklahoma coal fields lie in or near this district. Taff's geologic map showed the boundaries of these formations but did not show any subdivisions within the formations, and his discussions of the character of the formations were generalized. In the present work all possible subdivisions of the various formations were mapped, and much information on which to base detailed descriptions of the formations was obtained. The new data have made necessary some changes of Taff's discussion of the geologic structure of the rocks, as well as additions.

FIELD WORK

The field work extended over a period of 4½ months in the summer and fall of 1930, and additional work was done for about 3 weeks in 1931. By means of plane table and stadia traverses run on a scale of 2 inches to a mile the outcrops of the sandstone and coal beds in the several formations, all other geologic features that were found, and all mining developments were mapped in detail. About 25 square miles in the northern part of the area was mapped on airplane photographs taken by the Air Corps of the Army on a scale of about 5 inches to a mile. C. W. Wilson, Jr., mapped about 147 square miles; C. B. Read, who replaced Mr. Wilson in the later part of the season, mapped about 100 square miles; and the remainder of the area was mapped by me. C. R. Williams, T. L. Metcalf, B. M. Choate, and T. D. Mundorf each served ably as instrumentman for part of the season.

ACKNOWLEDGMENTS

Mr. W. W. Fleming, of the Geological Survey office in McAlester, kindly placed all information in his files at my disposal and rendered other assistance that long acquaintance with the area made possible. The analyses and measured sections of the coals and some details of mining methods were for the most part compiled from publications of the Bureau of Mines and the Oklahoma Geological Survey. I also

wish to thank the Cities Service Gas Co. for permission to use the well logs and laboratory descriptions of cuttings from two wells drilled on the Burning Springs anticline.

GEOGRAPHY

POPULATION AND ACCESSIBILITY

The rural population of the McAlester district is evenly distributed over the entire area, but most of the towns are in the northeastern part of the district, where the greater part of the coal mining has been done. McAlester, in the north-central part of the district, is the largest city, having a population of about 12,000. It is supplied with natural gas and electricity, and most of its streets are paved. Many of the coal companies operating in southeastern Oklahoma and Arkansas have their offices in McAlester, which has become the main business center of the coal trade in Oklahoma. The Bureau of Mines maintains a mine rescue station there, and the office of the Geological Survey engineer in charge of leasing, sale, and supervision of coal rights on the segregated Indian coal lands is in the Mine Rescue Building. Two United States highways, several State and county highways, and two trunk railroad lines roughly paralleling the United States highways pass through McAlester. The Missouri-Kansas-Texas Railroad, with stations in McAlester and Kiowa, connects the district with cities to the north and south. The Chicago, Rock Island & Pacific Railway, with stations at Haileyville and McAlester, connects the district with cities to the east and west. A branch line of the Missouri-Kansas-Texas Railroad runs from McAlester to Wilburton, which lies about 10 miles east of the McAlester district. An electric railway runs from McAlester to Hartshorne and Haileyville, modern twin cities in the southeastern part of the district. From Haileyville a branch line of the Chicago, Rock Island & Pacific Railway runs southwestward to Ardmore, which lies about 75 miles southwest of the McAlester district. All the towns and villages in the area are accessible by rail except Arpelar and Celestine, and these can be easily reached by highway.

RELIEF

The relief of the McAlester district is only about 550 feet, the altitude of the surface ranging between 475 and 1,025 feet above sea level, but the entire area is much dissected and is hilly. In the northwest corner of the district there is a curving eastward-facing scarp about 250 feet high, broken by several reentrants where streams such as Caney Creek have cut through it. West of this scarp the land slopes gently westward. Southwest of Kiowa, north of Blanco, and north of Adamson are three more or less flat-topped elliptical hills several miles long that rise 200 to 300 feet above the tops of the surrounding ridges. Most of the remainder of the district is characterized by long, narrow ridges generally only a few hundred feet wide and 50 to 250 feet high. These ridges trend northeastward except in the northeastern part of the district, where they trend nearly due east. They are separated by valleys two or three times as wide as the ridges themselves, and each ridge is broken at several places by streams that have cut their valleys at right angles to the ridge. North of Kiowa is a practically level plain covering about 10 square miles that stands at an altitude of about 720 feet. The larger streams of the district, such as Gaines, Peaceable, Brushy, and Coal Creeks, flow in narrow channels about 20 feet deep, cut into nearly level flood plains that are more than a mile wide in some places and in general decrease in width toward the heads of the streams. A much dissected plain of low relief, locally as much as 4 miles wide and about 50 feet above the level of the main streams, extends across the district from the west side to a point about 1 mile west of Haileyville, where it turns sharply and continues northward to the boundary of the district. This plain branches at several places, the longest branch continuing as a separate though smaller plain for 14 miles.

DRAINAGE

The McAlester district is well drained. Most of the larger streams, such as Gaines, Brushy, Peaceable, Wildhorse, Coal, and Deer Creeks, follow meandering northward courses toward the Canadian River, into which their waters flow. Wards Creek and North Boggy Creek, the two largest streams in the southwest corner of the district, pursue meandering courses southward toward the Red River, into whose tributaries their waters are emptied. These larger streams flow in all seasons, frequently overflowing their banks in wet seasons and generally having only a slight flow in the dry summer. The smaller streams have more or less straight courses parallel to the ridges and generally flow only in wet seasons, although a few that are fed by springs flow at all times. The larger artificial lakes in the district, such as Talawanda, Krebs, Dow, and Penitentiary Lakes, have been made for the purpose of supplying water for the larger communities. The Fin and Feather Lake, in the extreme northern part of the district, was made for the use of a hunting and fishing club. A few small ponds northwest of McAlester are used as fish hatcheries, and many ponds or tanks have been built by farmers to trap water for livestock. The smaller communities and some of the mines use shallow wells for water supply.

CLIMATE AND VEGETATION

The McAlester district is agreeable for residence and is exceptionally favorable for agricultural pursuits, so far as its climatic features are concerned. The winters are short, and extremely cold weather is seldom experienced. The summers are long, with occasional periods of very high day temperatures, but these are almost invariably coincident with a dry atmosphere, so that the heat is rarely oppressive. The mean annual temperature is 62.6° F., and the mean temperatures of January, April, July, and October are 41°, 61.6°, 82.7°, and 64.3°, respectively. The average annual rainfall from 1891 to 1920 was 42.45 inches. The rains are general and abundant in the growing season of the spring and early summer, are generally local during July and August, and become general again in the fall and winter, though not so abundant as in the spring.

The McAlester district is for the most part covered with timber, although there are a few small areas of natural prairie, and much of the natural cover has been removed in the lowlands to supply the demand for tillable ground. Large areas of upland are covered by forests in which red and white oaks, blackjack, hickory, elm, and hackberry are most prominent. On some of the higher hills in the eastern part of the district pines are also present. The rocky slopes have a scrubby growth of persimmon and sumac. In the parts of the valleys that have not been cleared there are thick stands of water and willow oaks, hickory, wild plum, willow, and cottonwood, often heavily burdened with masses of clambering vines.

STRATIGRAPHY

GENERAL FEATURES

The rocks of the McAlester district are chiefly of Pennsylvanian age, with some that are tentatively classified as Quaternary (?). The Pennsylvanian rocks contain valuable coal beds and have been subdivided into the following formations, listed in order of age, with the oldest first: Atoka formation, Hartshorne sandstone, McAlester shale, Savanna sandstone, Boggy shale, and Thurman sandstone. Each of these formations consists of alternating sandstone and shale, and all except the Atoka and Thurman include beds of coal. The shales and sandstones at some horizons are of continental origin, and those at others are marine. Some continental beds grade laterally into marine beds. No marked unconformity in the Pennsylvanian rocks can be recognized at any one horizon over the entire district, but locally between the Savanna and McAlester formations there is an unconformity that probably extends over the entire area without being recognizable at all places. Minor breaks within the formations are indicated by considerable irregularity in the bedding of the rocks.

The rocks that are tentatively classified as Quaternary (?) include the Gerty (†Guertie) sand and a few areas of terrace gravel. The reference of these rocks to the Quaternary is made on the basis of vertebrate animal remains found in the Gerty sand in a nearby area, and the probable contemporaneity of the other above-mentioned areas of gravel with the Gerty.

Alluvium of recent age floors the valleys of the larger streams.

The general character, range in thickness, position of the important coal beds, age, and topographic expression of the Pennsylvanian formations exposed in the McAlester district are summarized in plate 1, and their areal distribution is shown on plate 2 (in pocket).

CARBONIFEROUS SYSTEM

PENNSYLVANIAN SERIES

ATOKA FORMATION

The Atoka formation was named by Taff and Adams [13] in 1900 from the town of Atoka, about 16 miles southwest of the McAlester district. It is the oldest formation exposed in the district. It crops out in three belts—one just northwest of McAlester, another just south of Adamson, and a third between Kiowa and Savanna—all of which are on the crests of anticlines, and there is a fourth and more extensive exposure along the southern margin of the district, adjacent to the Choctaw fault.

The formation consists chiefly of shale, with lesser amounts of sandstone. The shale in a few outcrops is light gray or light pink, is highly fissile, and weathers into a plastic clay. In other outcrops, notably southeast of Adamson on the south side of the Hartshorne sandstone ridge, in the S½ sec. 9, T. 5 N., R. 17 E., the shale is dark gray, very sandy, and micaceous and contains much fragmental plant material. The sandstone in some exposures is brown, fine-grained, and highly micaceous, contains fragments of fern leaves, and shows considerable crinkling of bedding laminae. In other places, as in sec. 30, T. 4 N., R. 15 E., sandstone in the formation is coarse-grained, white, and pure. In the exposure just mentioned the sandstone contains fragments of plant stems and is bedded in layers 3 inches to 2 feet thick that show ripple marks on many of the bedding planes. The character of the portion of the formation present in the district but not exposed is inferred from outcrops in adjoining areas to be much the same as that of the exposed portion. A section of the upper part of the Atoka formation as revealed by the log of the Featherstone No. 1 well of the Cities Service Gas Co. is given on page 86.

No coal is known to occur in the Atoka formation in the McAlester district.

The part of the formation that crops out in the McAlester district is probably more than 2,000 feet thick.

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[13] Taff, J. A., and Adams, G. I., Geology of the eastern Choctaw coal field, Indian Territory: U. S. Geol. Survey 21st Ann. Rept., pt. 2, p. 273, 1900.

HARTSHORNE SANDSTONE

The Hartshorne sandstone was named by Taff [14] from the city of Hartshorne, in the southeastern part of the McAlester district. It crops out in four narrow bands. One of these is a northward-facing arc just northwest of McAlester, and another is an elongated elliptical band around the area of the Atoka formation between Savanna and Kiowa. Both of these outcrops lie near the crests of anticlines. A third band extends northeastward from the southwest corner of the district through Pittsburg to a point about 1 mile east of Blanco, where it is terminated by a fault. The fourth band begins about half a mile southwest of Blanco, on the opposite side of the same fault, forms a small loop to the west, and follows a curving trend northeastward to Haileyville. From Haileyville it forms a loop to the east, passing through Gowen and returning northwestward for about 12 miles, then curves north and east to Carbon, where it is offset a few hundred feet by a fault. From Carbon it extends eastward to the boundary of the district.

The Hartshorne sandstone overlies the Atoka formation and grades downward into it. The character of the Hartshorne varies greatly in the different parts of the district. At Hartshorne the formation consists of about 100 feet of sandstone at the base, overlain by 50 feet of shale containing the Lower Hartshorne coal and this, in turn, overlain by a sandstone about 75 feet thick. Fossil plants are abundant in the shale immediately above the Lower Hartshorne coal. The lower sandstone of the formation ranges from massive, medium-grained, and pure in some parts of the area to thin-bedded, shaly, ripple-marked, and fine-grained at other places. However, this sandstone retains a characteristic ash-gray color on fresh surfaces in practically all exposures. The middle shale interval is present throughout the district but varies somewhat in thickness. The upper sandstone is the most variable part of the formation. At Hartshorne and on the south and east sides of the band of outcrop extending from Hartshorne to Gowen it is a massive coarse-grained pure-white, poorly cemented sandstone that weathers white and ranges from 50 to 100 feet in thickness. In other parts of the district this sandstone ranges from 10 to 50 feet in thickness and has much the same character as the lower sandstone. Locally, particularly in the southwestern part of the district, the upper sandstone of the Hartshorne grades laterally into sandy shale. Where this upper sandstone is thick the Lower Hartshorne coal crops out either between two prominent ridges formed by the upper and lower sandstones or on a terrace between the two. Where the upper sandstone is thin, how-

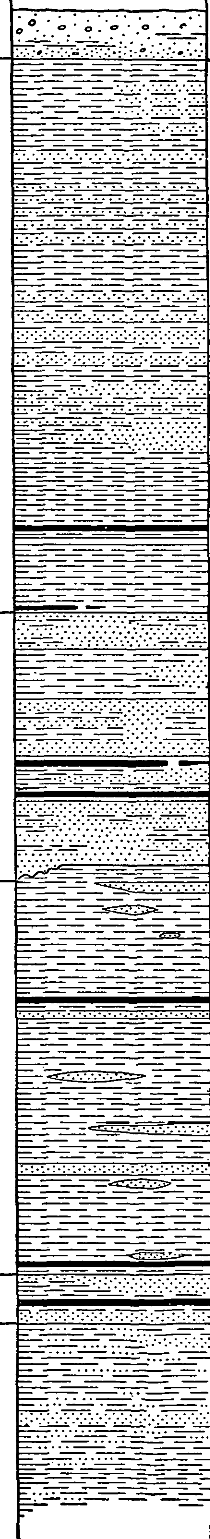
[14] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, p. 441, 1899.

ever, the coal bed crops out at the base of the dip slope of the lower sandstone.

The thickness of the Hartshorne sandstone ranges from 168 feet in the J. R. Hughes No. 1 well of the Cities Service Gas Co., in the northeast corner of the McAlester district, to about 300 feet in exposures southwest of Carbon. This unusually great thickness may be due in part to some duplication by faulting, but no evidence of faulting could be found. Throughout the greater part of the district the formation is 200 to 250 feet thick. Sections of the Hartshorne in the J. R. Hughes No. 1 and Featherstone No. 1 wells of the Cities Service Gas Co. are given on pages 85–86, and measured sections of exposures of the formation are given below.

Measured section of Hartshorne sandstone exposed on the east line of sec. 7, T. 5 N., R. 17 E.

	Ft.	in.
McAlester shale (lower part of formation only):		
Weathered coal (Upper Hartshorne)	1	0
Underclay	1	6
Gray sandy shale	10	0
Total	12	6
Hartshorne sandstone:		
Sandstone and sandy shale. The sandstone is present in beds 1 to 2 inches thick with two beds 6 inches thick. The shale is present as partings	25	0
Covered interval (shale)	50	0
Lower Hartshorne coal	4±	
Covered interval (shale)	2	0
Sandy shale and shaly sandstone. The shale is gray and micaceous. The sandstone is thin-bedded, white when fresh, and weathers brown	4	0
Light-gray nonfissile sandy shale. Sandstone masses about 3 feet thick cut the top of the shale irregularly, much like minor channel fillings	13	0
Shaly sandstone with sandy-shale partings. The sandstone is ripple-marked, white when fresh, and weathers light brown	6	0
Sandstone in beds mostly between 1 and 2 feet thick. The sandstone is ripple-marked, white when fresh, weathers light brown, and grades downward into sandy shale which is mostly covered	5	0
Covered interval (shale)	25	0
Thick-bedded coarse-grained sandstone (exposed 600 feet west of section)	20	0
Covered interval in which massive to thick-bedded white coarse-grained sandstone is present about half a mile to the west	70	0
Total	224	0
Top of Atoka formation.		



Feet	Formation	Symbol	Section	Thickness in feet	Coal beds	Character of rocks	Topographic expression
7,000	Thurman sandstone.	Ct		200+		Sandstone with some shale and some beds of grit and conglomerate.	Caps prominent scarps.
6,000 5,000 4,000	Boggy shale.	Cb		2,850	Secor. Lower Witteville(?).	Alternating shale and sandstone with local beds of blocky red clay in western part of area. Dark-blue blocky shale is predominant. Marine fossils and plant remains present in both shales and sandstones. Lower Witteville(?) coal near base and Secor coal about 400 feet higher.	Sandstone generally forms ridges but in central portions of large synclines forms high irregular hills.
3,000	Savanna sandstone.	Cs		1,120-2,500	Unnamed bed. Cavanal(?).	Alternating sandstone and shale, each made up of marine and continental beds. Sandstones are highly variable in thickness and character but in general fall into three or four groups. A thin coal bed occurs about 300 feet above base, and the Cavanal coal somewhat higher.	Sandstone forms prominent ridges separated by valleys that occupy areas of shale. Natural prairie common.
	Unconformity.						
2,000 1,000	McAlester shale.	Cma		1,904-2,420	McAlester. Thin local coal. Upper Hartshorne.	Mostly blue marine shale. Two to five sandstones near the middle. Upper Hartshorne coal near the base and McAlester coal about 700 feet below top.	Forms wide valleys between the Hartshorne and Savanna ridges. Sandstones near the middle of the shale form low ridges in all except the southwestern part of the area, where the sandstone outcrops are eroded to the level of the surrounding country.
	Hartshorne sandstone.	Ch		200-500	Lower Hartshorne.	Sandstone, massive to thin-bedded. Near the middle is a persistent shale unit containing the Lower Hartshorne coal. Upper part of the sandstone is shaly at many places.	Forms a prominent ridge except in the southwestern part of the area, where the ridge is low.
0	Atoka formation.	Ca		2,000+		Mostly shale, sandy to clayey. Occasional beds of sandstone and sandstone members up to 300 feet thick. Only about upper 1,000 feet well exposed.	Generally crops out in broad valleys broken by ridges formed by the thicker sandstone members.

GENERALIZED SECTION OF THE PENNSYLVANIAN ROCKS EXPOSED IN THE McALESTER DISTRICT, OKLA.

Measured section through part of the Hartshorne sandstone on east line of sec. 13, T. 3 N., R. 14 E., 500 feet south of northeast corner

	Ft.	in.
Top covered.		
Dark-gray shale containing much fragmental plant material	5	0
Black carbonaceous shale, fissile; contains streaks of coal	1	0
Weathered coal (Lower Hartshorne)	3	6
Light-gray shale with underclay at top		11
Massive fine- to medium-grained sandstone that weathers light brown	6	0
Sandstone, shaly and thin-bedded	40	0
Sandy shale	24	0
Thin-bedded sandstone with some thicker massive beds; contains many worm tubes	48	0
Total	128	5
Base covered.		

Collections of plants from the roof of the Lower Hartshorne coal in the McAlester district by Taff in 1897–98 and by C. B. Read and me in 1930 have been studied by Mr. Read. These plants indicate that the Hartshorne is of about the same age as the lower part of the Allegheny of Pennsylvania. The flora of the Coal Hill coal in Arkansas indicates that it is at about the same horizon as the Hartshorne coal, and the Cherokee flora of Henry County, Mo., is only slightly younger.

Several individuals of *Lingula carbonaria* were the only invertebrate fossils found in the Hartshorne sandstone.

McALESTER SHALE

The McAlester shale was named by Taff [15] from the city of McAlester. This formation overlies the Hartshorne sandstone throughout the McAlester district, and at all places in the district where the contact between the two formations is exposed it appears to be gradational and conformable.

The McAlester shale crops out in two broad irregular bands. One is an elongated ellipse surrounding the outcrop of the Hartshorne sandstone between Kiowa and Savanna. The other extends from the southwest corner of the district to Gowen, near the east side of the district, turns westward and extends about 6 miles west of McAlester, where it turns abruptly to the north and back to the east and passes through the north side of McAlester, Carbon, and Adamson to the east side of the district.

The formation is divisible into three parts—upper, middle, and lower. The lower part consists mostly of shale, which measures about 500 to 640 feet in thickness. It contains the Upper Hartshorne coal

[15] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, p. 441, 1899.

bed 1 to 50 feet above the base and local thin beds of sandstone and coal in the lower 350 feet. The shale is uniformly dark, firm, and platy and contains numerous clay-ironstone concretions. No plant or invertebrate fossils were found in it. The shale is easily eroded and at most places forms a wide valley in which exposures are poor.

The middle part of the McAlester consists of shale in which there are at places two and at other places as many as five sandstone members. It ranges in thickness from 595 to 1,030 feet, and the sandstone members range from a few feet to 140 feet. The belts of outcrop are marked by low ridges of sandstone and by valleys developed on the shale. In most places three sandstone members are distinguishable, but locally the shale interval between the two lower ones thins so much that it is impossible to distinguish the two sandstones. Similarly, shale beds within each sandstone thicken locally and split it into two or more distinguishable beds. Locally in the southwestern part of the district no sandstone outcrops could be found, but I believe that at least two thin sandstones are present beneath the soil cover. The sandstones are easily distinguishable from those of the other formations: they are buff, fine-grained, thinly and regularly bedded, and ripple-marked, but in a few exposures they are made up of irregular masses of sandstone separated by shale. In the southeastern part of the district the lower two sandstone members are more massive, coarser-grained, and thicker than elsewhere. The upper sandstone is thickest near Krebs and Carbon, but no marked change in character accompanies this thickening. Thickening and thinning of the shale in the middle McAlester appears to be irregular except in the extreme northeast corner of the district, where this shale unit appears to thin progressively northward and where drilling has revealed a thickness of only 595 feet. The shale in the middle part of the McAlester ranges from light gray and sandy to dark and carbonaceous. In general it is more sandy and lighter in color than the shale in the upper and lower parts of the McAlester.

Several thin coal beds are present in the middle part of the McAlester, the most persistent one just above the second of the three main sandstones. No fossils were found in the sandstone beds, but plant fossils were found at the horizon of the coal bed just mentioned.

The upper portion of the formation is made up of shale that includes several lenticular sandstones, some coal, and two thin beds of very argillaceous limestone. The thickness of this upper portion of the formation ranges from about 300 to about 925 feet. The thickest section of this upper portion is exposed near McAlester. Northeastward from McAlester it thins gradually to about 560 feet in the extreme northeast corner of the district. Southward from McAlester it thins gradually to about 640 feet near Pittsburg. About 8 miles southwest of Pittsburg the apparent thickness is only about 300 feet. This abrupt decrease in thickness is probably due in part to the unconformity at the base of the Savanna sandstone in that part of the district and in part to squeezing out of the soft shales by horizontal pressure. The base of this portion of the McAlester has been placed at the top of the first sandstone below the McAlester coal. The McAlester coal lies only a few feet above this sandstone in the southern part of the district, but near McAlester the interval between the two is as much as 100 feet. Numerous thin coal beds are present a short distance above the McAlester coal, and some of these beds are present over considerable areas. (See pl. 3.) Four lenticular sandstone beds similar to those found in the middle part of the McAlester and two local impure limestone beds were noted in this member. The shale and limestone beds are for the most part fossiliferous. Immediately above the McAlester coal and in a zone near the top of the formation abundant plant fossils were found, but throughout the intervening beds invertebrate marine and brackish-water fossils such as those listed below in collections 2 and 3 are common. The invertebrate fossils listed in collection 3 came from the zone immediately above the McAlester coal, in which plant fossils are abundant. The shale is dark and carbonaceous in general, but locally beds of lighter-gray sandy shale were noted. The upper portion of the McAlester crops out in a valley between the sandstone ridges of the middle part of the formation and the larger ridge formed by the lower part of the Savanna sandstone.

The McAlester formation ranges from 1,904 to 2,420 feet in thickness, but at several places, as just southeast of Savanna, the apparent thickness varies greatly. At that locality in exposures about a mile apart the apparent thickness ranges from 1,500 to 2,800 feet, owing to squeezing of the soft shale by compressive forces. Sections of the McAlester shales penetrated in three wells in the district are given on pages 84–86.

Fossil plants collected from the roof of the McAlester coal in the McAlester district by Taff in 1897–98 and by C. B. Read and me in 1930 were studied by Mr. Read, who concludes that they are of Allegheny age. Three collections of invertebrate fossils from the shales and limestones above the McAlester coal were studied by G. H. Girty and P. V. Roundy. Regarding these fossils Mr. Girty says:

The McAlester coal has likewise yielded a small fauna of nonmarine type. The two other collections from the McAlester shale present a more varied fauna. * * * These two faunas have little in common, but they may be essentially contemporaneous.

The following invertebrate fossils were collected from the upper part of the McAlester:

Collection 1 (NE¼NE¼NW¼ sec. 17, T. 3 N., R. 13 E., in bed of creek 100 feet south of old road):

Chonetes mesolobus?	Pleurophorus, 2 sp.
Marginifera muricata var.	Euphemus carbonarius?
Allerisma? sp.	Phanerotrema grayvillense?
Nucula sp.	Trepospira depressa.
Leda sp.	Sphaerodoma sp.
Schizodus sp.	Gastrioceras sp.
Aviculipecten aff. A. pellucidus.	Gnathodus, 2 sp.

Collection 2 (SE¼NE¼NW¼ sec. 17, T. 3 N., R. 13 E., in bed of creek about 400 yards south of old road):

Hydreionocrinus mucrospina.	Lima retifera.
Hydreionocrinus acanthrophorus?	Pteria ohioensis.
Enchostoma sp.	Prothyris carinata?
Fenestella sp.	Pleurophorus occidentalis?
Polypora sp.	Patellostium n. sp.?
Allerisma terminale?	Euphemus carbonarius.
Edmondia ovata.	Pleurotomaria? sp.
Edmondia gibbosa?	Sphaerodoma sp.
Nucula? sp.	Nautilus sp.
Leda bellistriata?	Healdia limacoides.
Yoldia sp.	Healdia formosa?
Schizodus? sp.	Healdia n. sp.
Deltopecten occidentalis?	Paraparchites sp.
Deltopecten occidentalis var.	Glaphyra n. gen., n. sp.

Collection 3 (SE¼SE¼SW¼ sec. 3, T. 5 N., R. 16 E., mine dump north of road):

Spirorbis sp.	Ostracoda indet.
Aviculipecten aff. A. whitei.	

SAVANNA SANDSTONE

The Savanna sandstone, which was named by Taff [16] from the town of Savanna, located on the outcrop of the formation in the west-central part of the district, rests upon the McAlester shale with an irregular contact. Although all exposures observed in the McAlester district show only minor erosion of the McAlester shale prior to the deposition of the Savanna sandstone, and no single horizon near the top of the McAlester shale can be traced far enough to establish any variation in its relation to the base of the Savanna sandstone, I believe that the Savanna rests unconformably on the McAlester shale, for the following reasons: (1) About 4½ miles west of the McAlester district, at the center of sec. 6, T. 1 N., R. 12 E., a good exposure of the McAlester-Savanna contact shows the base of the Savanna sandstone cutting downward about 20 feet into the McAlester shale in a distance of about 100 feet; (2) the upper part of the McAlester

[16] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, p. 438, 1899.

is variable in thickness within the district; (3) the Savanna sandstone increases greatly in thickness in the southwestern part of the district, where the upper part of the McAlester shale appears to thin.

The Savanna sandstone crops out in two large bands and in several smaller isolated areas in the district. The larger band of outcrop extends from a point near the southwest corner of the district northeastward to Dow, where it turns westward. About 8 miles west of Dow it turns northward for about 4 miles, and then curves westward again. This produces a roughly Z-shaped band of outcrop westward from Dow that passes south of Alderson, through the west side of Krebs, and through McAlester to a point about 7 miles farther west. From that point the outcrop bends sharply northward and back to the east and follows a curving eastward trend to the east side of the district, passing just north of McAlester, Carbon, and Alderson. The second large area of outcrop enters the district due west of Kiowa and in a little over a mile divides into two bands separated by an area of McAlester shale. Both of these bands continue northeastward to a point just northeast of Savanna, where they join around the end of the area of McAlester shale. About 1 mile farther northeast the outcrop of the Savanna is covered by a belt of Gerty sand through which rise several small isolated areas of the Savanna. The largest of the isolated outcrops of the Savanna, however, is in the northeast corner of the district. There is an isolated outcrop just southwest of Haileyville, and also one on the west side of the district about 3½ miles north of the southwest corner.

The Savanna sandstone is extremely variable in character throughout the district. It consists of 5 to 13 distinguishable sandstone beds separated by shale. In most parts of the district it was impossible to trace each individual sandstone bed, and for convenience in mapping several sandstones separated by thin shale beds were mapped together as sandstone groups. Over most of the district four such groups were traceable. Locally the interbedded shales die out and a sandstone group becomes a single unbroken bed of sandstone, and at other places the interbedded shales thicken and two or more individual beds within a sandstone group can be mapped separately. The individual sandstone beds can also be mapped separately where they dip at low angles, as the interbedded shales form narrow valleys between the more resistant sandstone beds at those places and, consequently, can be recognized. At some places it is impossible to separate the three lower sandstone groups, which were mapped together around the west end of the loop of outcrop that lies west of McAlester. In two parts of the district—one a small zone north of Adamson and the other the entire south half of the district—the two upper groups of sandstone beds were mapped separately, but the two lower groups could not be separated and were mapped together.

Thus it is apparent that the units shown on the geologic map represent individual sandstone beds where they could be recognized and groups made up of sandstone beds separated by shale where the shale is either too thin or too poorly exposed to be recognized in the outcrops. This means that at many places on the map sandstone beds or groups are shown as joining, with the intervening shale dying out, although as a matter of fact the intervening shale continues but could not be recognized.

Marine invertebrates and plant fossils have been found at several horizons in the sandstones and interbedded shales of the Savanna, and as nearly as could be determined, marine invertebrates and continental plant fossils are present at the same horizon in different parts of the district. Collections 1 and 4 (pp. 20–21) came from the basal portion of the Savanna, collection 2 from the upper portion, and collection 3 from the middle portion. Locally some of the sandstone beds cut downward along a rude arc into the underlying beds of shale. (See pl. 5, *A*.) Such sandstones probably were deposited in stream channels that had cut downward into the previously deposited shale. At many places in the district extreme variability in the nature of the bedding of sandstones and abrupt increases in thickness and in the size of the sand grains suggest that locally the sandstones of the Savanna were deposited in stream channels, although the actual outlines of the channels cannot be seen. Throughout most of the district the sandstones in the Savanna are even bedded and fine- to medium-grained. (See pl. 4, *B*.) However, southwest of Blanco, in the southern part of the district, several local beds of conglomerate 1 to 12 inches thick were noted in sandstone beds near the middle part of the formation. These consist of pebbles of quartz and chert in a matrix of coarse sand. The chert pebbles are angular to subangular and are as much as a quarter of an inch in length, whereas the quartz pebbles are generally well rounded and somewhat smaller.

Interbedded with the sandstone is a considerable amount of clay shale and sandy micaceous shale. Locally this shale contains spheroidal masses of sandstone a few inches to about 2 feet in diameter that appear to have been formed by the rolling of sandy mud lumps in the process of deposition of the beds. (See pl. 4, *A*.) These masses of sandstone are made up of concentric sheets, and plant debris and flakes of mica follow the curving surfaces of many of these sheets. This indicates that the plant fragments and mica flakes were picked up by the sandy mud lump as it was rolled along the depositional surface, much as debris is gathered by a snowball.

Blocky red and green clay in lenticular beds as much as 10 feet thick was found at several horizons in the Savanna throughout the western part of the McAlester district but was not found east of a north-south line passing through Kiowa. This clay is conglomeratic. Two samples were washed and sorted in order to ascertain whether fossils were present in it or not. No fossils were found, but the clay was found to consist of a clay matrix containing spheroidal pellets of manganiferous clay as much as one-tenth of an inch in length, angular fragments of coal and sandstone as much as one-fifth of an inch in length, and flat plates of shale one-tenth of an inch in length. These beds increase in number and size in the area west of the McAlester district, and it is hoped that additional work in that area will bring to light the explanation of their origin.

Numerous local coal beds were noted in the Savanna sandstone, but only two of these beds are known to be thick enough to be mined. The older of these two beds lies about at the horizon of the Cavanal coal, which is mined near Poteau, about 50 miles east of the McAlester district. This coal bed lies just above the lowest sandstone group of the Savanna and has been mined in and near North McAlester, where it is reported to be about 4 feet thick. The bed cannot be traced westward from North McAlester, but it was traced eastward and in about 5 miles was found to have decreased in thickness to about 1 foot. The younger coal bed is exposed just west of Krebs on the road to McAlester, where it lies about 20 feet below a sandstone bed near the middle of the formation. It can be traced eastward and southward from that point to sec. 18, T. 4 N., R. 16 E., where it has been worked at a small mine that is now abandoned. Both of these coal beds may be present throughout the district, but they were not found in outcrop except in the localities mentioned above.

The Savanna sandstone ranges from 1,120 to 1,325 feet in thickness in measured sections. About 3½ miles northwest of McAlester on the highway to Oklahoma City the shale in the formation has been squeezed and crumpled so badly that the apparent thickness of the formation is only about 500 feet. About 4 miles southwest of Pittsburg the apparent thickness of the Savanna sandstone is about 2,500 feet, but it is impossible to determine how much of this thickness is due to the squeezing in of shales and how much is due to depositional thickening of the formation. Part or all of this thickening is depositional, as the formation has a thickness of over 1,700 feet in the area immediately to the west.[17]

Fossil plants collected from the Savanna sandstone in the McAlester district by Taff in 1897–98 and by C. B. Read and me in 1930 have been studied by Mr. Read, who states that they are of Allegheny age. Invertebrate fossils collected from the formation in the area in 1930

[17] Clawson, W. W., Jr., Oil and gas geology of Coal and Pittsburg Counties: Oklahoma Geol. Survey Bull. 40-JJ, p. 8, 1928.

were studied by G. H. Girty, who says of the fauna that "Some features suggest an age early in the Pennsylvanian though post-Pottsville."

Invertebrate fossils collected from the Savanna sandstone are listed below:

Collection 1 (NE¼SW¼ sec. 3, T. 3 N., R. 13 E.):

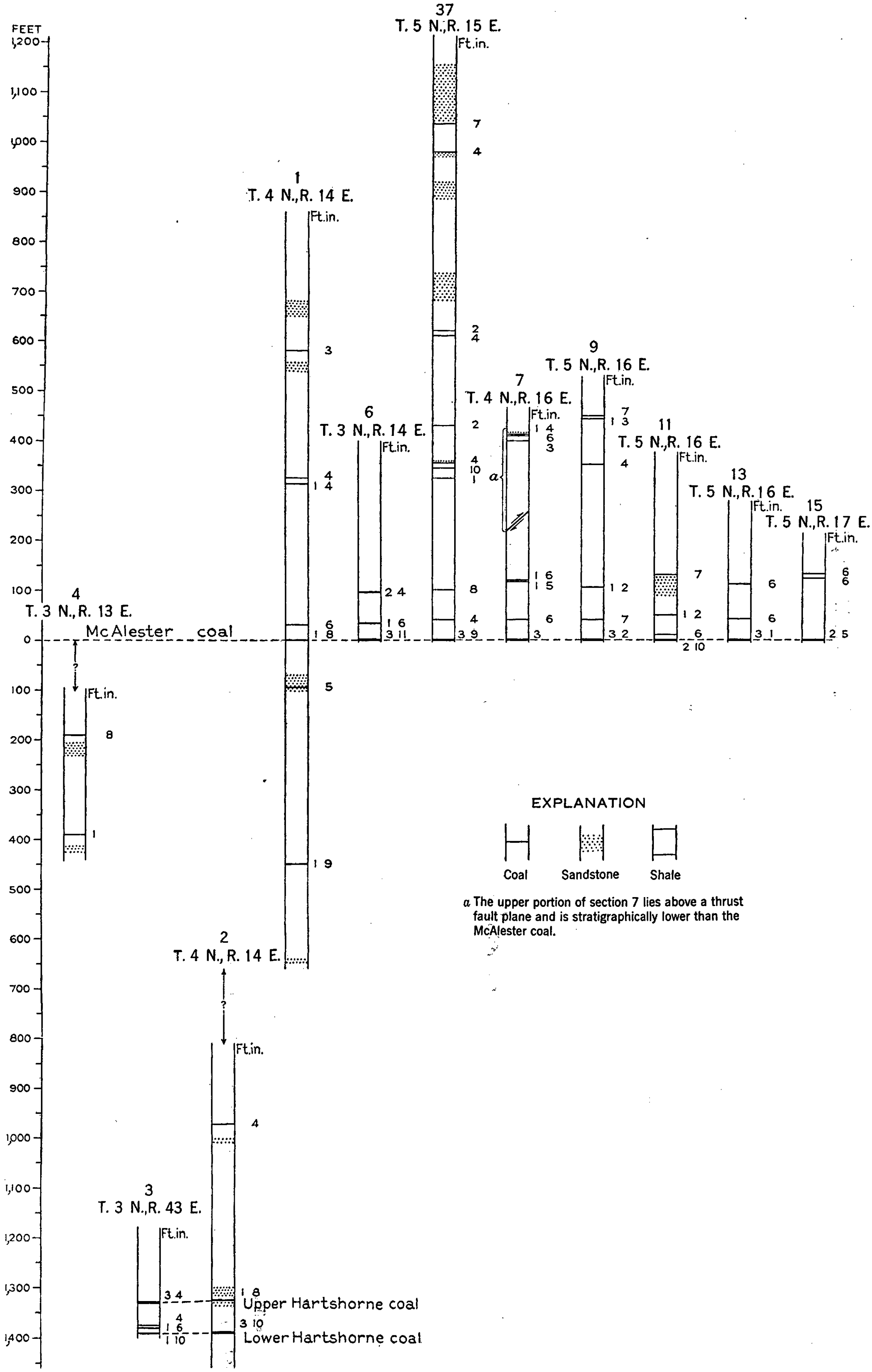
Chonetes mesolobus var. decipens?
Productus cora.
Edmondia sp.
Schizodus sp.
Deltopecten occidentalis.
Pinna peracuta.
Pleurophorus n. sp.?
Pleurophorus angulatus?
Astartella concentrica.

Collection 2 (SE¼NE¼ sec. 4, T. 2 N., R. 13 E.):

Lophophyllum profundum.
Stenopora aff. S. carbonaria.
Orbiculoidea meekana?
Chonetes mesolobus var. decipens.
Productus cora.
Marginifera muricata.
Pustula nebraskensis.
Dielasma bovidens.
Spirifer cameratus.
Spirifer opimus?
Squamularia perplexa.
Cleiothyridina pecosi.
Hustedia mormoni.
Chaenomya n. sp.
Allerisma? sp.
Nucula anodontoides.
Nucula wewokana.
Leda bellistriata var.
Yoldia glabra.
Anthraconeilo taffiana?
Schizodus affinis.
Deltopecten occidentalis.
Limatulina n. sp.
Astartella concentrica.
Bellerophon crassus var. wewokanus?
Pharkidonotus percarinatus.
Bucanopsis meekana.
Euphemus carbonarius.
Euphemus nodicarinatus?
Worthenia tabulata.
Phanerotrema grayvillense var.
Orestes nodosus.
Meekospira peracuta var. choctawensis.
Sphaerodoma brevis?
Sphaerodoma sp.
Orthoceras sp.
Coloceras? sp.
Metacoceras cornutum var. carinatum?
Metacoceras, 2 sp.
Goniatites aff. G. lunatus.
Goniatites sp.
Healdia simplex.
Cytherella missouriensis.
Sansabella n. sp.
Hollinella bassleri?

Collection 3 (NE¼NW¼ sec. 3, T. 2 N., R. 13 E.):

Lophophyllum profundum.
Lindstroemella patula.
Chonetes sp.
Productus cora.
Pustula nebraskensis.
Pugnax rockymontana.
Ambocoelia planiconvexa.
Nucula wewokana?
Nuculopsis ventricosa.
Yoldia glabra.
Anthraconeilo taffiana.
Leda bellistriata?
Astartella concentricia.
Bellerophon crassus var. wewokanus.
Trepospira depressa.
Phanerotrema grayvillense.
Worthenia tabulata.
Meekospira peracuta var. choctawensis.
Orthoceras sp.
Coloceras liratum.
Metacoceras cornutum var. sinuosum.
Metacoceras cornutum var. multituberculatum.
Nautilus sp.
Gastrioceras listeri.
Gastrioceras sp.

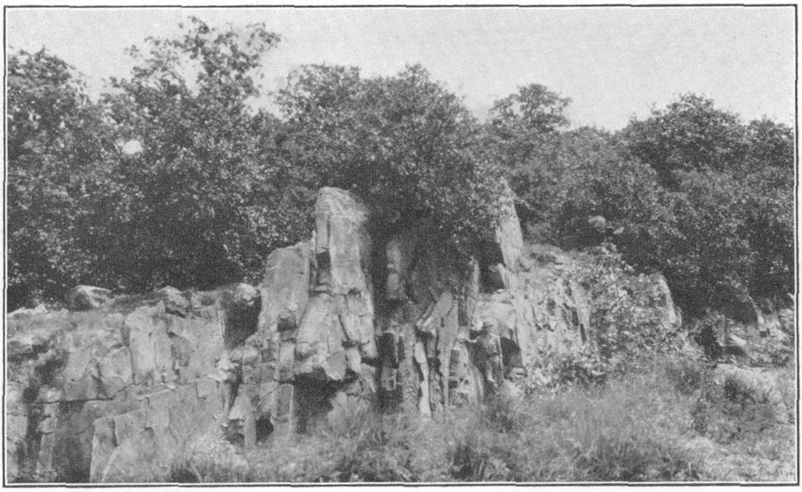


SECTIONS OF GOVERNMENT DRILL HOLES IN THE McALESTER DISTRICT, SHOWING COAL BEDS ENCOUNTERED.

Numbers correspond to those given on coal map (pl. 7) and in 61st Cong. 2d sess., S. Doc. 390, 1910.

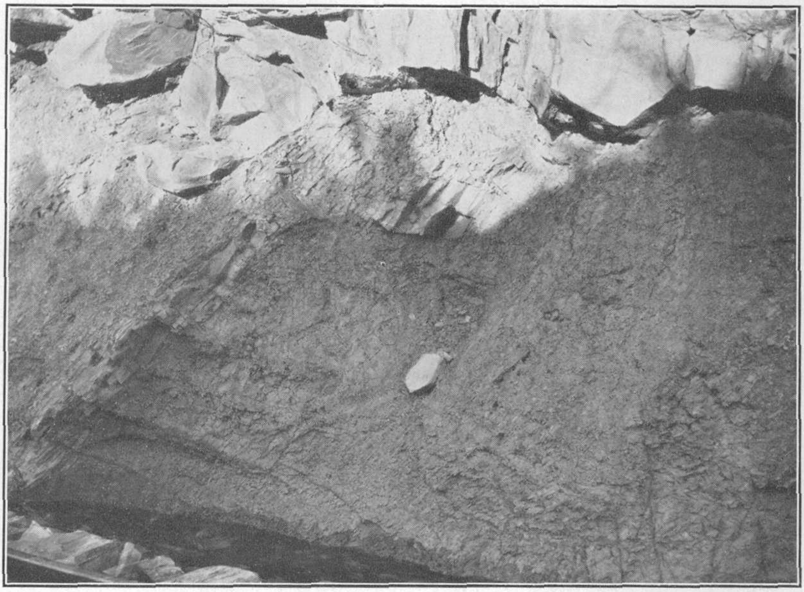
A. ROLLED SANDSTONE MASS FROM THE SAVANNA SANDSTONE.

Showing concentric banding and in upper right fragments of plant material lying parallel to curving surface of banding.



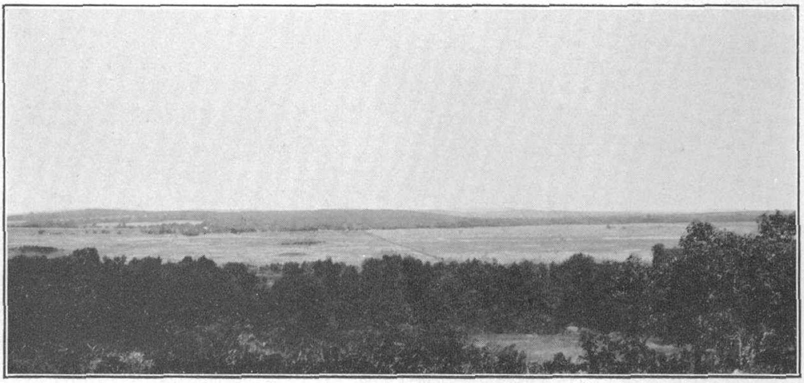
B. EVEN-BEDDED SAVANNA SANDSTONE ON NORTH SIDE OF GROUNDS OF OKLAHOMA STATE PENITENTIARY.

Beds stand vertical.



A. BASE OF GENTLY DIPPING SANDSTONE BED IN THE SAVANNA SANDSTONE IN RAILROAD CUT JUST SOUTH OF KREBS, OKLA.

Showing irregular contact between the sandstone and the underlying shale. Photograph by J. A. Taff.



B. VIEW OF GERTY SAND PLAIN, LOOKING ABOUT N. 15° E. FROM MIDDLE OF SOUTH SIDE OF SEC. 3, T. 4 N., R. 13 E.

The plain is nearly 2 miles wide in the eastern part of the area shown.

Collection 4 (NE¼SE¼ sec. 23, T. 5 N., R. 15 E.):

Lophophyllum profundum.
Agassizocrinus carbonarius.
Agassizocrinus sp.
Crinoid stems.
Orbiculoidea sp.
Pugnax rockymontana.
Ambocoelia planiconvexa.
Hustedia mormoni.
Sedgwickia? sp.
Anthraconeilo taffiana?
Nucula anodontoides?
Nuculopsis ventricosa.
Leda bellistriata.
Schizodus? sp.
Pleurophorus aff. P. subcostatus.
Pleurophorus n. sp.
Bellerophon crassus var. wewokanus.
Patellostium montfortianum.
Patellostium n. sp.
Euphemus carbonarius.
Trepospira depressa.
Phanerotrema grayvillense?
Pseudorthoceras knoxense?
Nautilus, 2 sp.
Ostracoda.

Section through the Savanna sandstone on the east side of sec. 5, T. 5 N., R. 16 E., and sec. 32, T. 6 N., R. 16 E.

	Feet
Sandstone, coarse-grained, white or buff when fresh; weathers brown; much false bedding (top bed of Savanna)	140
Shale, blue to gray, fissile; contains many plates and oval masses of sandstone. The sandstone is in ovals made up of thin concentric bands of sandstone on whose curving surface fern leaves have been found, thus indicating that the oval form was original and probably was formed by the rolling of sand and mud lumps, and slabs that are marked by worm trails, irregular ridges, and hummocky surfaces	358
Sandstone, buff, massive to irregularly bedded, fine-grained, soft, and friable	25
Covered interval. Shale	30
Sandstone, buff, fine-grained, thick-bedded, and cross-laminated	23
Covered interval. Shale	37
Sandstone, poorly exposed	8
Covered interval. Shale	20
Sandstone, dark brown, irregularly bedded	13
Covered interval. Shale	36
Sandstone, poorly exposed, buff, fine-grained; weathers to angular fragments	10
Covered interval. Shale	60
Sandstone, poorly exposed	10
Covered interval. Shale	25
Sandstone, medium-grained, buff, soft. The bedding planes are about 1½ inches apart and are remarkably smooth. The beds become as much as 4 inches thick toward the top	20
Covered interval. Shale	14
Sandstone, fine- to medium-grained, light brown; weathers dark brown. Lower part thin-bedded and weathers to small angular fragments. Upper part massive to irregularly bedded. Locally it weathers into spheroidal masses that were deposited as rolled lumps. (See description of the sandstone present in the highest shale bed in this section.) *Sigillaria*, *Calamites*, fern fragments, and worm trails are common	58

Section through the Savanna sandstone on the east side of sec. 5, T. 5 N., R. 16 E., and sec. 32, T. 6 N., R. 16 E.—Continued

	Feet
Covered interval. Shale	58
Sandstone bed; appears only as float	15
Covered interval. Shale	72
Sandstone, fine-grained, brown, thick to irregularly bedded	73
Covered interval. Shale	22
Sandstone, greenish gray, fine-grained to shaly, with a 5-foot bed of gray sandy shale near the middle	58
Shale; upper 3 feet is gray, grading downward into bluish-gray clay shale containing numerous limonitic concretions	50
Sandstone, greenish gray; contains many limonite bands and concretions. About the middle is a 6-inch zone of black fissile shale that contains poorly preserved *Pecten* and *Chonetes*	40
Sandstone, fine-grained, white; weathers light gray; shows many fine rippled laminae	5
Shale, light gray, sandy and micaceous	4
Shale, greenish gray, platy, clay shale with many clay-ironstone concretions. The upper part contains plant material; the lower part contains invertebrate remains	80
Sandstone; appears only as float (bottom bed of Savanna)	5
Total	1, 369

Section through the base of the Savanna sandstone on the west side of sec. 3, T. 3 N., R. 13 E.

	Feet
Savana sandstone (lower part only):	
Sandstone, medium-grained, massive, friable, light brown; weathers dark brown and to a gnarled surface	75
Shale, gray and clayey	30
Sandstone, massive	12
Shale, gray, with thin coal and underclay	12
Sandstone, massive	12
Shale, gray, with thin coal and underclay	18
Sandstone, massive	14
Shale, gray	15
Sandstone, massive	3
Gray shale with red and green clay	40
Sandstone, massive	12
McAlester shale: Shale, blue to gray; contains one 3- to 4-inch coal underlain by clay	60

All the shale in the above section contains considerable plant material.

BOGGY SHALE

The Boggy shale, named by Taff [18] from its exposure over wide areas on the branches of Boggy Creek immediately southwest of the McAlester district, overlies the Savanna sandstone with apparent conformity.

[18] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, p. 438, 1899.

The Boggy shale crops out in two wide belts in the McAlester district. One of these belts extends southwestward from a point about 2 miles west of Dow through Kiowa to the west side of the district. About 5 miles southwest of Kiowa this belt is joined from the south by a narrow belt of Boggy shale that enters the district near the southwest corner. The second wide belt of Boggy shale enters the district northwest of Kiowa, extends to McAlester, swings westward for about 6 miles, curves northward and eastward, and extends along the north side of the district to the east side near the northeast corner.

In the McAlester district the Boggy shale consists of thin sandstone beds alternating with thick shale beds. As many as 18 sandstone beds are present in the formation, but over the greater part of the district their aggregate thickness is only about 7½ percent of that of the entire formation. Some of the sandstone beds are too thin to be mapped, and some were grouped for convenience in mapping. In the northeastern part of the district the lower sandstone beds thicken and probably constitute 15 percent or more of the total thickness of the formation. The sandstone beds of the Boggy shale are locally variable in thickness and character. They range from fine-grained, thin-bedded, platy, and ripple-marked to coarse-grained and massive. Some of the sandstones show extreme false bedding locally. Worm trails, fucoid markings, and fragments of *Sigillaria*, *Lepidodendron*, and *Calamites* are common in the sandstone beds. In the northwest corner of T. 3 N., R. 13 E., a thin sandstone bed near the base of the formation contains invertebrate marine fossils, and the invertebrate fossils listed in collections 1, 3, and 2 were found in shale 500, 700, and 1,000 feet above the base of the formation, respectively.

The shale beds of the formation are generally dark, platy to blocky, and carbonaceous and at most places contain invertebrate remains. Locally, especially in the north half of the district, plant remains were found near the base and near the top of the formation. At some places in the western part of the district beds as much as 40 feet thick of conglomeratic blocky red clay similar to those found in the Savanna sandstone are present in the shale. These clay beds are made up of spheroidal pellets of clay one-tenth of an inch or less in diameter in a matrix of similar material. Larger fragments of coal, shale, and sandstone and calcareous nodules containing small black pellets are present in the clay.

A coal bed about 20 feet above the base of the formation has been mined in the NW¼ sec. 3, T. 4 N., R. 14 E. This bed is believed by me to be at or near the horizon of the Lower Witteville coal, which is found near Poteau, Okla., about 70 miles to the east. About 50 feet above the lowest sandstone of the Boggy shale is the Secor coal bed, which has been mined in several parts of the district. It is probably the equivalent of the Upper Witteville coal of the Poteau district.

Several other thin coal beds are present in the formation, but none of them, so far as known, are thick enough to be mined.

The Boggy shale is about 2,850 feet thick in the southeast quarter of T. 4 N., R. 13 E., where a complete continuous section of the formation is exposed. Exposures are so poor in the other parts of the district where the entire formation is present that exact determination of the thickness is impossible.

Fossil plants collected in the McAlester district by Taff in 1897–98 and by C. B. Read and me in 1930 were studied by Mr. Read, who considers them to be of Allegheny age in the lower part of the formation and very late Allegheny in the upper part. G. H. Girty, who studied the invertebrate fossils collected from the formation in the McAlester district, believes them all to be somewhat lower in the Allegheny than is indicated by the fossil plants. Lists of the invertebrate fossils are given below:

Collection 1 (SW¼SW¼ sec. 5, T. 4 N., R. 15 E.):

Orbiculoidea sp.	Marginifera muricata.
Chonetes mesolobus var. decipiens.	Euphemus carbonarious.

Collection 2 (1,000 feet west of northwest corner of sec. 12, T. 4 N., R. 15 E.):

Orbiculoidea missouriensis?	Squamularia perplexa.
Chonetes mesolobus var. decipiens.	Yoldia glabra.
Productus cora.	Orthoceras sp.
Marginifera muricata.	Coloceras? sp.
Spirifer triplicatus.	Metacoceras sp.
Spirifer opimus.	

Collection 3 (SW¼SE¼ sec. 5, T. 4 N., R. 15 E.):

Orbiculoidea missouriensis?	Aviculipecten sp.
Chonetes mesolobus var. decipiens?	Euphemus carbonarius.
Marginifera muricata var.	Planerotrema? sp.
Ambocoelia planiconvexa.	Sphaerodoma sp.
Edmondia sp.	Goniatites sp.
Streblopteria sp.	

Section through the Boggy shale in secs. 27, 26, and 35, T. 4 N., R. 13 E.

	Feet
Thurman sandstone:	
1. Sandstone, light brown; weathers dark brown; gritty and contains pebbles of quartz and chert as much as half an inch long, though most of the pebbles are smaller	10
Boggy shale:	
2. Shale, greenish gray to bluish gray, nonfissile; breaks into splintery or concentric fragments; contains a few invertebrate fossils, chiefly *Chonetes*	100
3. Sandstone	5
4. Shale interval, mostly covered. Dark-blue clay shale, locally fissile but mostly blocky. Contains some red blocky clay and invertebrate fossils	415

Section through the Boggy shale in secs. 27, 26, and 35, T. 4 N., R. 13 E.—Contd.

	Feet
Boggy shale—Continued.	
5. Sandstone, massive to irregularly bedded	15
6. Covered interval. Probably shale	105
7. Sandstone, massive and banded with limonite parallel to joints	10
8. Covered interval. Shale	75
9. Sandstone, massive to irregularly bedded	8
10. Covered interval. Shale	38
11. Sandstone in beds about 1 foot thick	4
12. Covered interval. Shale	80
13. Sandstone; appears as float	5
14. Covered interval. Shale	40
15. Sandstone, massive	5
16. Covered interval. Shale	10
17. Sandstone, massive	5
18. Covered interval. Shale	295
19. Sandstone, massive to irregularly bedded	15
20. Covered interval. Shale	80
21. Sandstone, medium-bedded; breaks into slabs	15
22. Covered interval. Shale	70
23. Sandstone, irregularly bedded, coarse-grained; weathers dark brown into deeply grooved and reticulated surfaces. Two ledges, each 13 feet thick, separated by sandy shale or shaly sandstone	40
24. Shale, bluish green, nonfissile; breaks concentrically and contains many clay-ironstone concretions	95
25. Sandstone, in two massive to irregularly bedded ledges about 5 feet thick, separated by 30 feet of thin-bedded sandstone. The massive beds are buff when fresh, weather dark brown, and show crinkled banding on weathered surfaces	40
26. Covered interval. Shale	175
27. Sandstone in beds about 8 inches thick	8
28. Covered interval. Shale	62
29. Sandstone, ripple-marked, in beds 4 to 6 inches thick	10
30. Covered interval. Shale	40
31. Sandstone, much ripple-marked, in beds 4 inches to 2 feet thick	8
32. Covered interval. Shale	35
33. Sandstone in beds about 8 inches thick	8
34. Covered interval. Shale	332
35. Sandstone; appears as float	4
36. Covered interval. Shale; contains Secor coal horizon near base	246
37. Sandstone in beds 1 to 2 feet thick on an average, with a 4-foot bed at base	12
38. Covered interval. Shale. Has a workable coal near base about 10 miles northeast of section (base of formation)	330
Total	2, 850

THURMAN SANDSTONE

The Thurman sandstone, named by Taff[19] from the town of Thurman, about 10 miles west of the McAlester district, rests conformably on the Boggy shale in this district.

A large area of the Thurman sandstone caps a prominent eastward-facing scarp in the northwest corner of the district, near the village of Arpelar. Six outliers of the Thurman of varying size lie east and southeast of this scarp. Two of these outliers cap hills just north of Lower Lake Talawanda, in the north-central part of the district. Three others cap small hills in the extreme west-central part of the district. A few miles southwest of these hills the Thurman caps a rudely circular outward-facing scarp that is broken only on the west side, where the Thurman is covered by the Gerty sand, of Quaternary (?) age.

The change from the Boggy shale to Thurman sandstone is gradational in the McAlester district. The lower 50 feet of the sandstone is thick-bedded and coarse-grained to conglomeratic. Parts of this sandstone contain subangular to rounded fragments of chert and quartz as much as half an inch long, and in most places it is a coarse-grained sandstone or grit made up of fragments of chert and quartz. Above the massive lower part of the formation the beds consist of alternating shale and brown coarse-grained sandstone.

The upper part of the formation is so poorly exposed in the McAlester district that it was impossible to measure a complete section. The thickness was estimated at about 200 feet. No fossil remains were found in the formation.

QUATERNARY (?) SYSTEM

GERTY SAND[20]

The Gerty sand was named by Taff[21] from the town of Gerty, in Hughes County, Okla., about 15 miles west of the McAlester district. It forms the surface of a highly dissected and discontinuous eastward-sloping plain about 90 miles long and locally as much as 4 miles wide and extends from Byars, Okla., about 60 miles to the west, to and across the McAlester district. (See pl. 5, *B*, and fig. 2.) Several small areas of high-level sand just north of the Canadian River in the Muskogee-Porum district, Oklahoma, have been mapped by C. W. Wilson, Jr.,[22] and correlated with the Gerty sand, but no other deposits of the Gerty have been recorded north or east of the McAlester

[19] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, p. 439, 1899.

[20] The name of this formation as spelled by all previous writers has been "Guertie sand," but the spelling is here changed because the original name of the type locality ("Guertie") has been changed to "Gerty" by the United States Geographic Board.

[21] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, p. 439, 1899.

[22] Wilson, C. W., Jr., Geology of the Muskogee-Porum district, Oklahoma (manuscript report).

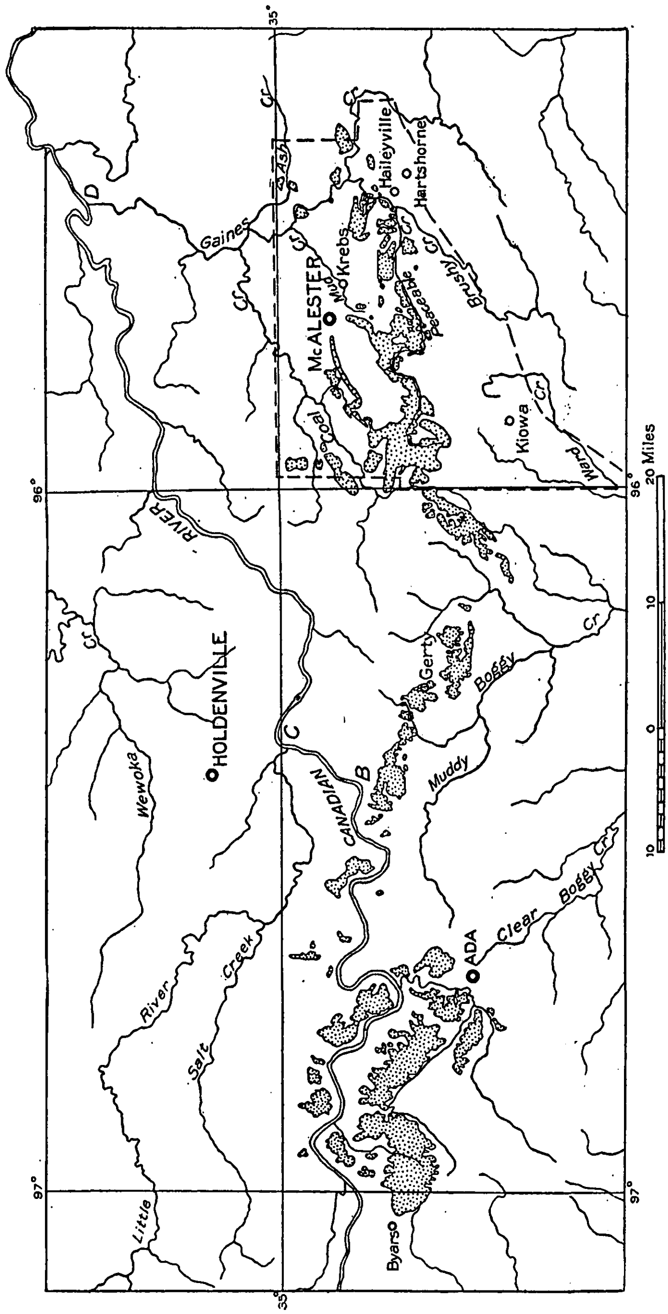


FIGURE 2.—Known areas of Gerty sand in Oklahoma (stippled areas). See text (pp. 32-33) for explanation of letters *B*, *C*, and *D*. Dashed line indicates boundary of McAlester district.

district. Throughout its extent the maximum thickness of the Gerty sand is estimated at 50 feet.

The Gerty sand is widely distributed over the north half of the McAlester district (see fig. 3), chiefly in a nearly continuous belt that extends from the west side of the district due east nearly to Haileyville. Northward from Haileyville scattered remnants of the sand are found in the Brushy, Gaines, and Ash Creek Valleys. Several isolated areas of Gerty sand, the largest of which covers about 5 square miles, occur north of the main belt in the McAlester district, and there are three small areas short distances to the south of the main belt. One large area branches off to the south of the main belt near the west side of the district, and two long, narrow belts branch off to the north of the main belt southwest and south of McAlester.

The Gerty sand consists of unconsolidated sand, gravel, and clay of which Taff[23] says:

> These gravels and sands are not cemented into hard rocks; instead, they are incoherent deposits and resemble recent lake or river plains.

The sand and gravel of the Gerty are almost entirely siliceous, the main constituents being quartz, quartzite, chert, flint, jasper, and silicified wood. H. D. Miser[24] has found one pebble of schist. The silicified wood has been examined by C. B. Read, who believes much or all of it to be of Cretaceous age. The nearest sources for these materials are the Cretaceous and older rocks of the Rocky Mountains or the Tertiary deposits of the High Plains, which contain pebbles and cobbles derived from rocks cropping out in and near the Rocky Mountains.

This narrow eastward-sloping plain appears to have been formed by deposition from a large stream that flowed eastward from the High Plains or the Rocky Mountains. The Canadian River is large enough to have deposited the sand, and its headwaters are in the Rocky Mountains. As the Canadian River flows between deposits of Gerty sand in the western part of the area of occurrence of the Gerty (fig. 2) and flows north of the areas of Gerty farther east, it is assumed that this river deposited the Gerty sand and has since been diverted northward in the eastern part of the area where the Gerty is found.

Prior to the deposition of the Gerty sand the Canadian River probably flowed eastward across a broad, nearly level plain that stood about at the level of the tops of the highest hills in the McAlester district. The Canadian River at that time was not cutting downward but was migrating laterally and forming a wide alluvial plain. The leveling of the region by stream erosion had proceeded so far that differences in the hardness of the underlying beds of rock had but little effect on

[23] Taff, J. A., op. cit., pp. 439–440.

[24] Oral communication.

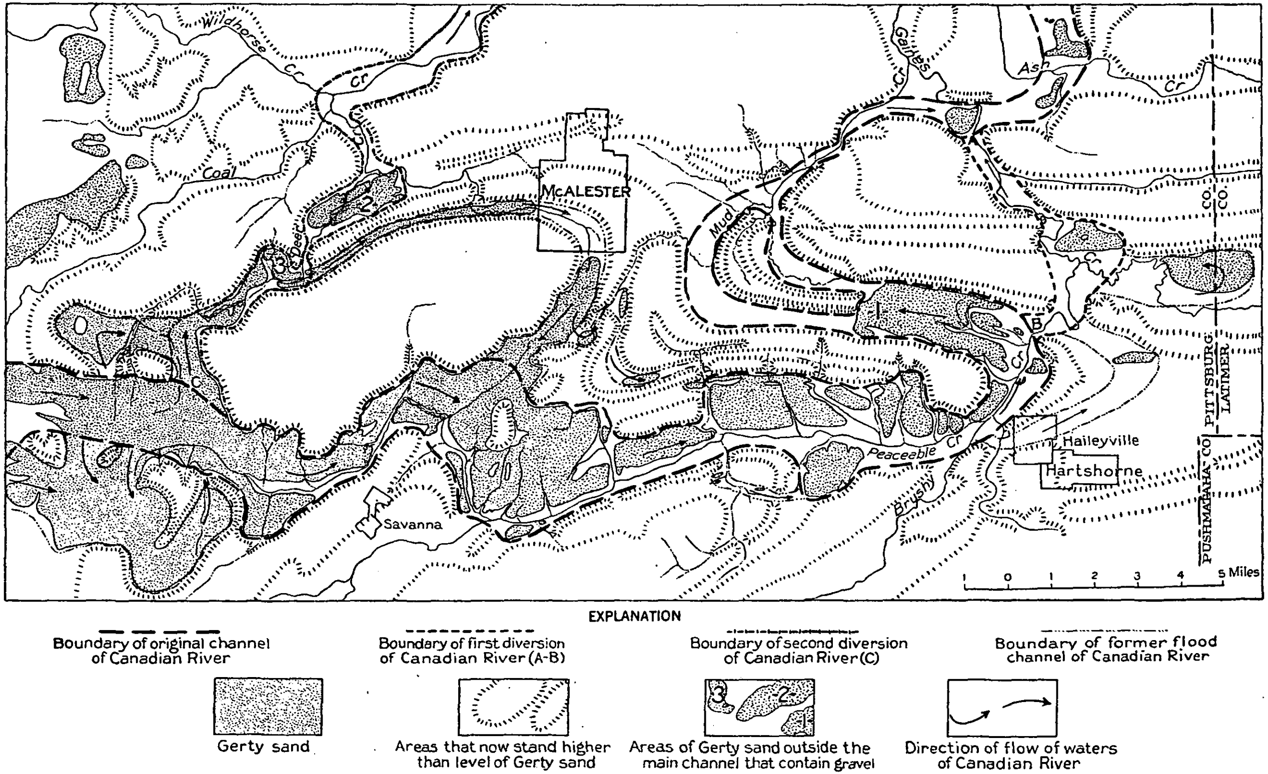


FIGURE 3.—Map showing areas of Gerty sand in the McAlester district and the various watercourses in which the sand was deposited. See text (pp. 31–32) for explanation.

the course of the stream, which cut across hard and soft beds without any apparent relation to their structure.

Later, the Canadian River started cutting downward through its alluvium and into the Pennsylvanian rocks below. This downward cutting of the stream may have been due to any one of several causes. The area may have been tilted toward the east, producing a higher gradient and greater erosive power for the stream. The entire area between the mouth of the Canadian River and the Rocky Mountains may have risen as a block, resulting in downward cutting starting at the mouth of the river and progressing headward. A change to a more humid climate may have occurred, increasing the volume of water carried by the Canadian River and consequently increasing the erosive power of the stream. Whatever the cause for this increased erosive power, in the McAlester district the down-cutting continued until the river was flowing about 200 feet below the former level, but at that level the stream became graded and was depositing as much material as it was eroding away. Unable to cut downward further, the stream migrated laterally, building up a wide flood plain underlain by gravel, sand, and clay. This flood-plain deposit is the Gerty sand.

There is considerable evidence that the Canadian River flowed about at the level of the Gerty sand for a rather long time. Several remnants of stream terraces that lie at about the same level as the Gerty sand are present in the valley of Brushy Creek, which joined the former course of the Canadian River near Haileyville. As the level of this tributary was controlled by the level of the Canadian River, it is apparent that the Canadian stood about at the level of the Gerty sand for a sufficient period of time for Brushy Creek to cut distinct terraces. The Poteau River and its tributaries, which lie to the east of the McAlester district, built wide terraces at about the same level as the Gerty sand. As both the Poteau and Canadian Rivers were and are tributary to the Arkansas River, these terraces must have been developed while the Canadian stood at the level of the Gerty sand.

During the time that the Canadian River stood at the level of the Gerty sand it built up deposits of gravel, sand, and clay by the deposition of the materials transported from areas far to the west. A study of these deposits tells us something of the history of the stream during that time.

Gravel is confined to the main channel and three areas not directly connected with the main channel of the former stream. Only sand and clay are found in the remaining areas.

It is probable that gravel could have been transported by the river only in the central part of the channel, where the carrying power of the water was greatest. Sand and clay particles could have been carried in all portions of the stream and by branches of the stream occupying separate channels during times of flood. It is my opinion that the areas of sand and clay that contain no gravel and are partly or entirely separated from the main channel were deposited by flood waters that overflowed the banks of the main channel and continued as smaller independent channels that returned to the main stream in a few miles. (See fig. 3.)

The presence of gravel in three deposits of sand not directly connected with the main channel (deposits 1, 2, and 3, fig. 3) indicates that the course of the main stream was shifted several times, so that it occupied a channel that flowed over each of the gravel-bearing deposits at some time in its life. The altitudes of the several gravel-bearing deposits give some suggestion as to the sequence of events in the changing of the location of the main channel of the stream.

Deposit 1 (fig. 3), northwest of Haileyville, contains gravel, and the top of the sand toward the west side of that deposit stands at an altitude of about 755 feet, whereas the gravel-bearing deposits in the Brushy Creek and Gaines Creek Valleys stand at slightly less than 700 feet. It is probable that the original course of the Canadian River at the time of the deposition of the Gerty sand was down Peaceable and Brushy Creeks to the east side of deposit 1, where it turned westward to the valley of Mud Creek, went down Mud Creek to Gaines Creek, and then crossed the present courses of Gaines and Ash Creeks to the north side of the district. A tributary of Gaines Creek probably started cutting headward from point A, figure 3. As the distance from the east side of deposit 1 to point A was about twice as great by way of the Mud Creek Valley as by way of this tributary and Gaines Creek, the tributary probably had a higher gradient than the Canadian River then flowing in the Mud Creek Valley. By virtue of the higher gradient the tributary cut downward and headward while the Canadian River maintained the same level. Finally the tributary cut into the channel of the Canadian River at the east side of deposit 1 (point B), and the waters of the river were diverted into the shorter and steeper course of the tributary and Gaines Creek. The increased gradient of the Canadian River in its new course from the east side of deposit 1 to point A increased the erosive and transporting power of the river. This resulted in erosion headward from point A, which continued until the gradient was lowered so much that the velocity of the stream was again too low to permit further erosion of the channel. When that condition was reached the stream began migrating laterally and forming new deposits of sand, gravel, and clay, but these deposits were formed at a lower level than those in deposit 1 in the former course of the river. Thus we now find Gerty sand at the altitude of 755 feet in deposit 1 and at less than 700 feet in the Brushy Creek Valley, a short distance to the east.

A second area in which gravel is present (deposit 2, fig. 3) lies west of McAlester in the Deer Creek Valley, at an altitude of about 660 feet.

Some parts of the main channel about 5 miles to the south stand as high as 822 feet, but in the central part of the main channel the altitude of the sand is only about 720 feet. The discussion in the following paragraphs explains the apparent discrepancy between the two altitudes.

After the diversion of the Canadian River near Haileyville, described above, the river flowed in the main channel from the west side of the district to Haileyville, where it turned northward and pursued a relatively straight course to the north side of the district. North of the McAlester district the stream must have followed the present course of Gaines Creek rather closely, as any other course would have crossed a divide higher than the level of the Gerty sand at the north side of the McAlester district.

Coal Creek, which joins Gaines Creek from the west a few miles north of the McAlester district, was at that time a tributary to the Canadian River. The distance from point C, figure 3, to the junction of Coal Creek with the Canadian River was about 15 miles shorter by way of Deer Creek and Coal Creek than by way of the course of the Canadian River described above. Thus Coal Creek had a higher gradient and more cutting power than the Canadian River. It cut headward and lowered its channel, and its tributary, Deer Creek, did likewise. Deer Creek finally cut headward into the Canadian River channel at point C. Because of the higher gradient of Deer and Coal Creeks, the Canadian River abandoned its old course and flowed in the shorter course to the junction of Coal and Gaines Creeks. This shortening of the course and steepening of the gradient caused the Canadian to flow more rapidly and to erode its channel. This erosion continued until the gradient was reduced to the point where deposition and erosion were equal. The stream then migrated laterally, building up a thick flood-plain deposit of sand, gravel, and clay that stood at a much lower level than the sand that had been deposited prior to the diversion of the stream. Therefore, deposit 2 was formed at an altitude of only about 660 feet, and contemporaneous deposits upstream were formed at an altitude of about 720 feet in close proximity to other deposits standing as much as 100 feet higher.

After the diversion of the Canadian River into the Coal Creek channel, the Little River, a tributary that joined the Canadian River at point D, figure 2, flowed in the present course of the Canadian from C to D. The distance from B to D is about 20 miles shorter by way of C and the valley then occupied by the Little River than by way of the Gerty sand deposits and the Coal Creek channel then occupied by the Canadian River. Consequently the Little River at point C soon cut lower than the Canadian River could cut at point B. A tributary to the Little River worked headward along a belt of soft shale (Wewoka formation) from C to B and diverted the Canadian

River into the channel of the Little River in the same way that the Canadian had been diverted on a smaller scale by Coal Creek and the tributary to Gaines Creek. With its higher gradient the Canadian River started cutting downward in its new course until now it lies about 150 feet below the level of the top of the Gerty sand at point B. The Canadian River has now cut its channel down so far that with the present gradient about the same amount of material is being deposited as is being eroded away by the river.

Owing to the sequence of events above set forth the Gerty sand is now found at several levels in the McAlester district, and the Canadian River has been diverted so that it does not now flow across the district.

All springs or seeps that were noted in the McAlester district are at or near the base of the Gerty sand. This sand is a good water-bearing bed, and where clay is present in its base or shale is present below the sand, rain water enters the sand on the surface of the level plain and moves downward through the porous sand and gravel to the top of the dense shale or clay, through which it cannot pass. The water then moves horizontally through the sand just above the impervious beds and reappears in springs or seeps at points where recent erosion has cut through the sand and underlying beds. The presence of water in the Gerty sand makes the land underlain by the Gerty extremely good for truck farming.

Morgan [25] reports that A. E. Brainerd discovered an elephant tusk in the Gerty sand in the Stonewall quadrangle, and on that evidence Morgan suggests a Pleistocene age for the Gerty sand. No evidence bearing on the age of the sand was found in the McAlester district.

TERRACE DEPOSITS

In the southern part of the McAlester district nine areas of cobbles and gravel were found. Six of these lie in the Brushy Creek Valley between Blanco and Haileyville, and three in the Wards Creek Valley about 7 miles south of Kiowa. These deposits are at levels about 50 feet above the present streams. They form a veneer, nowhere more than a few feet thick, over the underlying beds and probably are remnants of extensive deposits that were formed at the same time that the Gerty sand was laid down. The deposits are made up of rounded to angular fragments of chert, sandstone, and novaculite, and according to H. D. Miser [26] most of the constituent materials are identical with rocks exposed in the Ouachita Mountains, to the south.

From west to east the six deposits in the Brushy Creek Valley approach nearer and nearer the outcrop of the Gerty sand, the easternmost deposit being about 3 miles from the nearest area of the Gerty.

[25] Morgan, G. D., Geology of the Stonewall quadrangle, Oklahoma: Oklahoma Bur. Geology Bull. 2, pp. 144-145, 1924.

[26] Oral communication.

Likewise, the altitude of these deposits decreases eastward, the easternmost standing only about 15 feet above the level of the nearest area of the Gerty. It is likely that these deposits were formed by a stream flowing down from the Ouachita Mountains and pursuing a northeasterly course to a point about a mile west of Haileyville, where it joined the Canadian River, which was then depositing the Gerty sand.

The three terrace deposits in the Wards Creek Valley decrease in altitude southwestward and probably were formed by a southwestward flowing stream at the same time that the Gerty sand and the other terrace deposits were being laid down.

All these terrace deposits are equivalent in age to the Gerty sand, but the source of the materials, the distance they were transported, and the relative size of the deposits are widely different.

QUATERNARY SYSTEM

RECENT ALLUVIUM

The valleys of the larger streams of the area range from half a mile to a mile in width and are underlain by alluvium. In most places this material is an ash-gray silt that ranges in thickness from a few inches on the edges of the flood plains to as much as 25 feet in the banks of the streams. Locally the thickness may be more than 25 feet, as the streams have not cut through the alluvium to bedrock at all points.

STRUCTURE

Structurally, the McAlester district is characterized by long, tightly folded anticlines separated by broad, flat synclines. (See pl. 6.) About half of these folds are broken by tear faults or thrust faults of small displacement. The folds are roughly divided into two groups of different trends. Those in the southern and western four-fifths of the district trend northeastward, and those in the northeastern part of the district trend eastward. In the zone where the trend changes the western group of folds dies out and the eastern group of folds begins. The axes of the folds in these two groups are not alined but instead are offset. The folding is rather gentle in the extreme northern part of the district but increases in intensity southward. In the central part of the district the anticlines are broken on the crest by thrust faults or on the flanks by tear faults, all of which are at or near the point of most intense folding on each anticline. Near the south boundary of the district are several small, rather tightly folded anticlines and synclines, most of which are terminated by thrust faults. Immediately south of this group of folds is the Choctaw fault, a southward-dipping thrust fault that separates the McAlester district from the Ouachita Mountains, to the south. The rocks of the Ouachita Mountains are broken by numerous southward-dipping thrust faults whose trends are roughly parallel to the structural trends throughout the McAlester district.

These structural relations suggest that the folds and faults in the McAlester district are due to horizontal compressive forces directed northwestward. These forces were greatest in the Ouachita Mountains, where much thrust faulting occurred, and decreased in magnitude northwestward into and across the McAlester district, where they produced folds and faults roughly parallel to the north side of the Ouachita Mountains and of decreasing intensity northwestward away from the mountains. This folding and faulting was completed at some time after the deposition of the Thurman sandstone, in middle Allegheny time, as beds in the Thurman are involved in the folding.

The topography of the McAlester district is for the most part directly related to the structure of the underlying rocks. The most characteristic surface features are low parallel ridges that mark the outcrops of steeply dipping sandstone beds and are separated by broad valleys cut in intervening beds of shale. These ridges trend roughly parallel to the axes of the anticlines and synclines except that where the axes are plunging the ridges form crescents across the axes. The height of each ridge depends on the thickness of the individual sandstone bed that holds it up, the thicker sandstones forming the higher ridges. The width of each intervening valley depends on the thickness and dip of the shale unit on which it is developed, the thicker shales with the lower dips underlying the wider valleys.

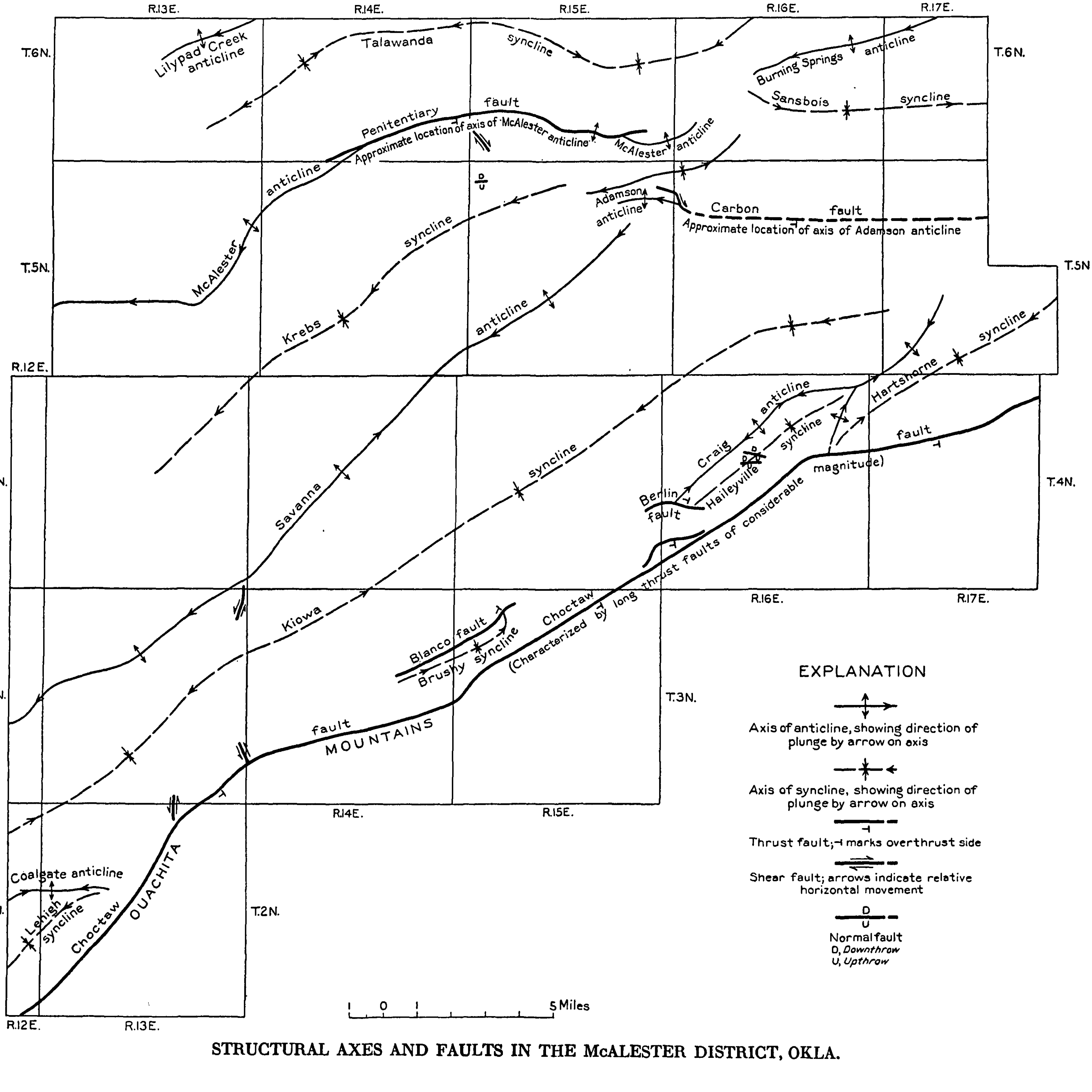
The crests of two of the largest anticlines are marked by long canoe-shaped valleys. In four of the synclines gently dipping beds of sandstone and shale stand in large elliptical hills 200 to 300 feet above the surrounding country. Consequently, when the area is viewed from a distance the synclinal hills appear as the dominant features of the topography and give a false impression that the area is a dissected plateau. Several small buttes are present, such as Belle Starr Mountain, northeast of Hartshorne. These are located in synclines and are capped by horizontal or gently dipping beds of sandstone that have withstood erosion because of their structurally low position in the synclines and their fortuitous location in regard to streams.

Descriptions of the major structural features are given below.

Choctaw fault.—The Choctaw fault is a southward-dipping thrust fault that forms the south boundary of the McAlester district. It begins about 70 miles east of the McAlester district in Arkansas and continues westward to and southwestward beyond the McAlester district for about 15 miles, to the north side of the Coastal Plain, where it passes beneath rocks of Cretaceous age. This fault brings beds in the Atoka formation of the McAlester district into contact with the top of the Caney shale of the Ouachita Mountains, which is separated from the Atoka formation above by the Wapanucka limestone. The beds dip away from the outcrop of the fault on each side at high angles. The high dips of the beds on the south side of the fault indicate that the dip of the fault plane is also high near the surface. The northward-dipping beds on the north side of the fault may represent the north limb of an anticline which has been broken on the crest by the Choctaw fault and whose south limb has been concealed by the overriding beds on the south side of the fault. Owing to poor exposures of the rocks near the fault it is impossible to determine whether the fault, which is completely concealed, has a single continuous plane along which movement has occurred or whether it is made up of several faults within a general continuous zone, with no single plane persisting for the entire length of the zone.

Hartshorne syncline.—The Hartshorne syncline starts about a mile south of Haileyville and extends eastward through Hartshorne and Gowen to the east side of the district. In the central part of the syncline the beds of rock lie horizontal or have only a slight dip. The dips increase northward away from the axis to about 10° in 2 miles and southward to 22° to 25° in about a mile. The axis of the syncline rises toward both ends, and on these rising ends the dips are 10° or less. The beds exposed in this syncline are the Hartshorne sandstone, which crops out on the ends and high on the flanks, and the McAlester shale, which is exposed in the central portion. The soft McAlester shale has been deeply eroded throughout much of the length of this syncline, forming the Hartshorne topographic basin, which is surrounded on all sides except the northwest by dip slopes of the Hartshorne sandstone. On the northwest side of the basin beds of sandstone in the McAlester shale close around the end of the Kiowa syncline and form the rim of the basin. Along the axis of the syncline three outliers of the lowest sandstone in the McAlester have been protected from erosion and cap buttes about 200 feet high that are called "Belle Starr Mountain."

Craig anticline.—The Craig anticline, named from the village of Craig, begins about 3 miles west of Gowen and follows a curving southwestward trend through Haileyville to a point about 5 miles beyond, where it ends against the Berlin fault. The total length of this anticline is about 9 miles. The portion of the anticline between the Berlin fault and Haileyville is strongly folded and asymmetric, with dips of 21° to 80° on the south side and a rather uniform dip of about 20° on the north side. As Haileyville is approached from the southwest the dips decrease to about 18° and are about the same on both flanks of the fold. Northeast of Haileyville exact dip readings could not be taken, but the dips are probably not greater than 5° at any point, and the anticline is symmetrical. Along the crest of the anticline there are four structurally high portions separated by three



STRUCTURAL AXES AND FAULTS IN THE McALESTER DISTRICT, OKLA.

saddles. Two of the structurally high points are at the two ends of the anticline. Another is the dome just south of Craig, which has a closure of about 50 feet and covers an area of about one-third of a square mile. The fourth structural high is in Haileyville, where the Craig anticline is joined from the south by a north-northeastward-plunging anticline that probably terminates on the south against the Choctaw fault. The junction of these two anticlines has produced a peculiar areal distribution of the Hartshorne sandstone, which has been mentioned by several authors and can be seen on the geologic map (pl. 2, in pocket). The rocks exposed in the Craig anticline are the McAlester shale, which crops out in most of the length of the fold, and the Hartshorne sandstone, which crops out in the structural high in Haileyville and at the northeast end of the anticline.

Haileyville syncline.—The Haileyville syncline, named from the city of Haileyville, lies southeast of the Craig anticline and extends from Haileyville southwestward for about 5 miles to the Berlin fault, where it ends. The syncline plunges toward the center from each end. It is strongly asymmetric and tightly folded, with dips of 80° to 90° on the southeast side and 21° to 45° on the north side, except where very local steep dips are present. Two small westward-trending normal faults, with the downthrow to the north, break the beds in the central part of the syncline. The Savanna sandstone is exposed throughout the central part of the syncline; at the southwest the fold ends in the McAlester shale, and at the northeast end it dies out in the underlying Hartshorne sandstone.

Berlin fault.—The Berlin fault, named from the abandoned Berlin mine, about 5 miles southwest of Haileyville, lies in the south-central part of the McAlester district. It extends for about 1½ miles from sec. 20, T. 4 N., R. 16 E., into sec. 24, T. 4 N., R. 15 E. It has an east-west trend and is a northward-dipping thrust fault. The northward dip of the fault plane was determined from the log of a drill hole (see fig. 4) that was started at the surface north of the outcrop of the fault plane and below the horizon of the McAlester coal. At a depth of 444 feet, however, the McAlester coal was encountered beneath 120 feet of beds typical of the section just above the coal in other parts of the district. The McAlester coal crops out with a northward dip just south of the outcrop of the plane of the Berlin fault. In order to be encountered in the drill hole, the coal bed must continue beneath the fault plane, which must also dip northward. This is in sharp contrast to other thrust faults in the district and in adjacent areas, as most of the other thrusts are either known or supposed to dip southward. The beds broken by the Berlin fault all lie in the McAlester shale. The maximum stratigraphic displacement of the fault is about 300 feet.

Unnamed fault south of Berlin fault.—The outcrop of a fault was observed in the east bank of Brushy Creek in sec. 36, T. 4 N., R. 15 E., but the fault could not be traced either eastward or westward from that point, as it runs under a broad area of alluvium. At the outcrop, shale in the Atoka formation is so badly crushed, contorted, and slickensided that no single plane of movement could be determined. About 900 feet south of the outcrop is a ridge on which is exposed about 300 feet of hard sandstone of the Atoka. Such a resistant bed should form a ridge wherever it is present, but it can be traced for only about a quarter of a mile west of the outcrop of the fault, terminating against alluvium, and for only about a mile to the east. In this eastern portion it is partly covered by alluvium, but

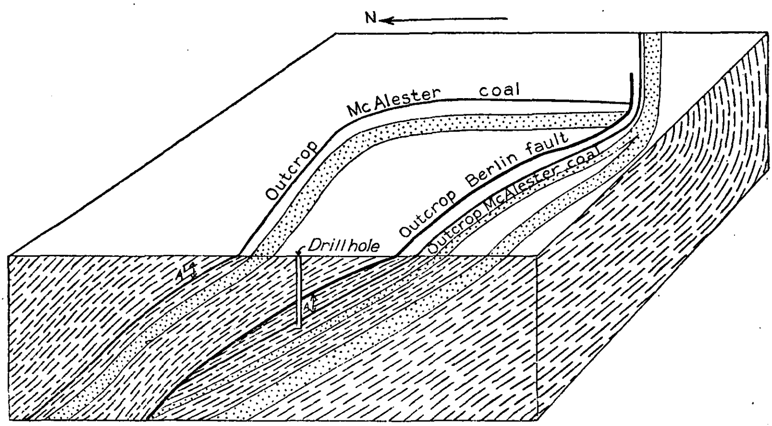


FIGURE 4.—Diagram illustrating evidence of northward dip of the Berlin fault. A and A′ represent the same stratigraphic horizon.

the sandstone is exposed at several points. At the east end the reason for the termination of the belt of this sandstone bed is not apparent. It seems probable that the fault mentioned above cuts across the belt of this sandstone at each end, and that the fault is a minor slice of the nearby Choctaw fault zone.

Brushy syncline.—The Brushy syncline, named from Brushy Creek, begins about 1½ miles east of Blanco, in the south-central part of the district, and extends southwestward for about 4 miles. The beds on the southeast flank stand at or near the vertical, but on the northwest flank all resistant beds have been cut out by the Blanco fault, and the dip could not be determined. The axis of the syncline plunges eastward throughout its length, and from west to east the Atoka formation, the Hartshorne sandstone, and the McAlester shale are exposed in succession in the syncline. A small fault with the downthrow to the south breaks the Hartshorne sandstone south of the axis of the syncline and trends parallel to that axis. To the southwest the Brushy syncline dies out into a zone of northward-dipping beds, and to the northeast it terminates against the Blanco fault.

Blanco fault.—The Blanco fault, named from the town of Blanco, starts about 2 miles northeast of that town and continues for at least 3 miles and possibly 4 miles to the southwest. It cuts beds of the Atoka, Hartshorne, and McAlester formations and appears to die out along the bedding of the Atoka formation to the southwest and along the bedding of the McAlester shale to the northeast. The Blanco fault has completely concealed the crest of an anticline that lay between the Brushy syncline and the Kiowa syncline, to the north. The fault may dip either north or south at a rather high angle. Several features suggest that the fault dips northward, but the evidence is not conclusive. In the first place, the fault is very similar to the Berlin fault, only about 5 miles away, and the Berlin fault has a northward dip. In addition, the Blanco fault appears to die out at each end parallel to the bedding of northward-dipping rocks.

Lehigh syncline.—The Lehigh syncline was named by Taff [27] from the town of Lehigh, which lies about 15 miles southwest of the McAlester district. The syncline enters the McAlester district from the west near the southwest corner and extends northeastward for about 2 miles. It then turns eastward for about half a mile and dies out against beds that deep steeply to the northwest. The axis of this syncline plunges southwestward throughout its length in the McAlester district. Beds of the Savanna sandstone crop out at the northeast end of the syncline, and progressively younger beds in the Boggy shale are exposed to the southwest. The syncline is narrow and somewhat asymmetric, with dips of about 20° on the southeast flank and about 14° on the northwest flank.

Coalgate anticline.—The Coalgate anticline was named by Taff [28] from the town of Coalgate, about 12 miles southwest of the McAlester district. Part of it lies in the southwest corner of the McAlester district, immediately north of the Lehigh syncline. The axis of this part of the anticline trends almost due east from the west boundary of the district for about 2½ miles, to a point where the anticline dies out against beds that dip steeply northwest. The axis of the anticline plunges westward at the east end, but this plunge is reversed in about a mile, and the axis rises westward from that point to the west boundary of the district. Rocks in the Savanna sandstone are exposed at the east and west ends of this portion of the Coalgate anticline and are separated by a belt about 1½ miles wide in which rocks in the Boggy shale are exposed. The anticline is narrow and

[27] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, p. 447, 1899.

[28] Idem, p. 447.

symmetrical, and no dips of more than 14° were observed on it in the McAlester district.

Kiowa syncline.—The Kiowa syncline, named by Taff [29] from the town of Kiowa, has a total length of about 30 miles in the district. It enters the west side of the district southwest of Kiowa and trends northeastward through Kiowa and Dow to a point about 1½ miles north of Hartshorne, where it dies out. The syncline contains two structurally low portions along its axis, separated by a structurally higher zone whose greatest altitude is reached about 2 miles northeast of Kiowa. Rocks in the Boggy shale are exposed in the syncline throughout most of its length, but near the northeast end the Savanna sandstone and the upper part of the McAlester shale crop out. Sandstone beds in the Boggy shale lying in the center of the two low portions or troughs of the syncline have withstood erosion and rise as hills about 200 feet above the surrounding country. Toward the ends of the troughs and in the structurally high zone between them the more resistant sandstones of the Boggy shale have been removed by erosion because of their greater altitude, and continued erosion has worn the softer beds below down to the level of the surrounding country. In the structurally high portion of this syncline and at its northeast end the outcrops of sandstone beds in the various formations form horseshoe-shaped ridges that cross the axis of the syncline, with the open end of the horseshoe pointing in the direction of plunge of the axis. Near the centers of the troughs, however, the syncline is broad and flat, with a width of 3 to 6 miles and dips of about 2° to 3° within half a mile of the axis. These dips are so low that outcrop lines follow the contour of the land and are extremely irregular.

Savanna anticline.—The Savanna anticline was named by Taff [30] from the town of Savanna, which is just northwest of the anticline, in the west-central part of the McAlester district. The Savanna anticline lies northwest of and roughly parallel to the Kiowa syncline. It enters the McAlester district due west of Kiowa and trends northeastward for about 22 miles, to a point about three-quarters of a mile north of Alderson, where it dies out. The greatest structural closure on the anticline is in the central portion, where beds in the Atoka formation are exposed. From this structurally high portion the axis of the anticline plunges southwestward at an angle of about 7°, and beds in the Hartshorne, McAlester, and Savanna formations close successively around the end of the anticline as the west side of the district is approached. The axis plunges about 20° northeastward from the central portion to the northeast corner of T. 4 N., R. 14 E., where the degree of plunge decreases. Beds in the Harts-

[29] Taff, J. A., op. cit., p. 443.
[30] Idem, p. 444.

horne, McAlester, and Savanna formations likewise close around this plunging part of the anticline. In the southeast corner of T. 5 N., R. 14 E., the plunge is reversed, and the axis rises northeastward to the point where the anticline ends against southwestward-dipping beds of the McAlester shale on the flank of the Adamson anticline. Progressively older beds of the Savanna sandstone and the McAlester shale cross this northeastward-rising axis but do not close around the anticline.

The trend of the axis of the Savanna anticline is about N. 60° E. in its southwestern portion but changes to N. 45° E. in sec. 36, T. 4 N., R. 13 E., and varies only slightly from that throughout the northeastern portion of the fold. About half a mile south of the point where the trend changes is a small fault that breaks several beds on the south flank of the anticline. This fault strikes N. 15° E. at the south end and N. 2° E. at the north end. The beds are offset northward on the east side of this fault, and the dips of the beds are steeper on the west side of the fault. This suggests that the principal movement along the fault was horizontal and was produced by the same forces and at the same time as the Savanna anticline.

The Savanna anticline is symmetrical throughout most of its length. The dips along its flanks range from only a few degrees near the northeast end to nearly 90° in the central part. About 4 miles east of the west side of the district, however, the dips on the southeast side are about 20° higher than those on the northwest. As the anticline is traced westward from that point for about 2 miles, the dips on the southeast side decrease to about 10°, while those on the northwest side increase to 90° and are locally overturned. Near the west boundary of the district the dips on the northwest side have decreased to about 20°, and the dips on the southwest side are even lower. About 1½ miles west of the McAlester district the anticline dies out. The portion of the anticline where the dips are greater to the south shows asymmetry only in the outcrops of the McAlester shale, as dips on a bed in the Savanna sandstone are about 85° on both flanks of the fold. This suggests that the soft McAlester shale on and near the crest of the anticline was squeezed by the pressure which produced the folding and that the amount of shale squeezed out on the southeast flank was somewhat greater than that on the northwest. Thus dips in the McAlester shale would be greater on the southeast flank than on the northwest flank, but it is probable that the Hartshorne sandstone was not affected by such squeezing and that the asymmetry of the fold disappears with depth before the Hartshorne sandstone is reached.

Adamson anticline.—The Adamson anticline is named from the town of Adamson, on the north flank of the fold in the northeastern part of the McAlester district. It is an asymmetric fold that begins about a mile east of Krebs and extends almost due east for 10½ miles to the east boundary of the district and continues eastward for about 8½ miles farther. Beds in the Atoka formation crop out in the central and eastern parts of this anticline except where they are covered by Gerty sand or alluvium. Toward the west end the anticline plunges westward, and the Hartshorne sandstone and the lower beds of the McAlester shale close around that plunging end. The anticline has gentle dips on the south flank and steep dips on the north flank. The dips on the south flank range from 10° to 26°, but those on the north flank are much more variable. At the east side of the district they are about 37°, but they increase westward to the west side of sec. 9, T. 5 N., R. 16 E., where beds near the axis are vertical. Moreover, within a few hundred feet to the west the beds are overturned, the observed dips ranging from 75° to 56° S. The overturned beds continue westward to the middle of the south line of sec. 1, T. 5 N., R. 15 E., where the beds are about vertical. About a quarter of a mile farther west the outcrop of the Hartshorne sandstone turns southward abruptly, and the dips on it drop to less than 10° in a distance of about 100 feet, but the beds in the lower part of the McAlester shale close more smoothly around the end of the fold as it dies out westward. The north flank of the Adamson anticline is broken by the Carbon fault just south of Carbon, where the outcrop of the Hartshorne sandstone is offset about 1,000 feet northward on the west side.

The Hartshorne sandstone, which crops out on both flanks and closes around the west end of the anticline, forms a ridge that encloses a beautifully developed anticlinal valley cut into the soft shale of the Atoka formation, which crops out on the axis of the anticline throughout most of its length.

Carbon fault.—The Carbon thrust fault is named from the village of Carbon, which is about 5 miles east of McAlester. It breaks the outcrops of the Hartshorne sandstone and also sandstones near the base of the McAlester shale on the north flank of the Adamson anticline just southwest of Carbon. This fault continues for about three-quarters of a mile west of Carbon and dies out in the soft beds of the McAlester shale that occur above the lower sandstones in that formation. The Hartshorne sandstone has been moved northward about 1,000 feet on the west side of this fault. The fault cannot be followed eastward into the Atoka formation beyond the point where it breaks the Hartshorne sandstone, but this is due to the poor exposure of the shales in the Atoka. The strong asymmetry of the Adamson anticline, with very steeply dipping and even overturned beds on the north limb, indicates that the fault may continue near the axis of the anticline. This is further suggested by the location of a thrust fault in that position on the Adamson anticline at two points in the Wilburton district, 4 and 7 miles east of the McAlester district. For these reasons the Carbon fault has been mapped as continuing eastward as a hypothetical fault.

McAlester anticline.—The McAlester anticline was named by Taff [31] from the city of McAlester. It pursues a curving eastward and northeastward course for about 21 miles from the west side of the district through Haywood, along the north side of McAlester, and about half a mile north of Carbon to the south side of sec. 30, T. 6 N., R. 16 E., where it dies out. Throughout the central part the McAlester anticline is broken on the crest by the Penitentiary fault. Beds in the Atoka formation are exposed in the central part of the anticline. South of the Atoka outcrop lies an arc of Hartshorne sandstone terminated by the fault. Beds in the upper part of the McAlester shale and the lower part of the Savanna sandstone close around the plunging east end of the fold, and all the beds of the Savanna sandstone and all except the uppermost beds of the Boggy shale close around the west end. Where well developed the McAlester anticline is strongly asymmetric, the dips on the south limb being only about one-half to one-third as steep as those on the north limb, on which the beds are commonly vertical and locally overturned. The anticline plunges steeply at each end, and on the southwest end several poorly defined noses are present south of the main axis, but these also plunge out in short distances.

In the northern part of McAlester a small fault on the south flank of the McAlester anticline breaks beds in the middle part of the McAlester shale. The fault strikes N. 40° W., and the beds on its southwest side have been offset northward in respect to those on the northeast side and dip at a lower angle.

Penitentiary fault.—A fault that appears to be overthrust from the south extends for about 11 miles along the crest of the McAlester anticline from a point about 4 miles west of McAlester to a point about 2 miles northeast of Krebs. This fault appears to be the Cherryvale fault described by Taff,[32] but its location and extent do not coincide with those given by Taff. As this fault is exposed in the brick yard at the Oklahoma State Penitentiary, the name "Penitentiary fault" is applied to it. The beds broken by the fault are in the Atoka, Hartshorne, and McAlester formations. The greatest stratigraphic displacement of the fault is between secs. 34 and 25, T. 6 N., R. 14 E., and is about 4,000 feet, bringing beds more than 1,000 feet below the top of the Atoka into contact with the uppermost beds of the McAlester shale. In secs. 34 and 35, T. 6 N., R. 15 E., the fault

[31] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann Rept., pt. 3, p. 443, 1899.
[32] Idem, p. 446.

cuts across the axis of the McAlester anticline at three places. Eastward from that locality the fault continues along the north flank of the anticline for about a mile, to a point where it dies out parallel to the strike of the McAlester shale. The line of the Penitentiary fault is roughly parallel with the outcrop of the Savanna sandstone on its north side, but on the south side beds of the Atoka, Hartshorne, and lower part of the McAlester formations terminate against it at both ends.

Krebs syncline.—The Krebs syncline extends southwestward from Krebs through McAlester and for about 11 miles beyond, its total length being about 14 miles. The syncline is a broad structural depression lying between the McAlester and Savanna anticlines. The synclinal axis plunges 4° to 10° southwestward throughout its length, and beds at the top of the McAlester shale and in the Savanna sandstone, Boggy shale, and Thurman sandstone close around the syncline in succession from northeast to southwest. Erosion of these beds has produced a series of horseshoe-shaped ridges that are held up by sandstone beds in the various formations and lie with the open end of the horseshoe pointing in the direction of plunge. Four of the sandstones near the top of the Boggy shale die out on the east side of T. 4 N., R. 13 E., and in that township the syncline becomes a topographic basin broken only by the scarp of the Thurman sandstone, which closes around the basin and forms a smaller basin within the large one. On the northwest side of the syncline the dips decrease as the syncline is followed toward the southwest, but on the southeast side the dips increase toward the southwest.

Saddle between the McAlester and Adamson anticlines.—A small syncline begins in Krebs, about a mile east of the Krebs syncline, and continues eastward through the saddle between the McAlester and Adamson anticlines. Northeastward from that point it plunges out in about 3½ miles. The total length of the syncline is about 5 miles, and it is poorly defined except in the saddle mentioned above.

Sansbois syncline.—The Sansbois syncline was named by Taff [33] from the Sansbois Mountains, about 30 miles east of the McAlester district. This syncline lies north of Adamson, in the northeastern part of the McAlester district. It begins in sec. 28, T. 6 N., R. 16 E., in the saddle between the McAlester and Burning Springs anticlines, and continues eastward beyond the east side of the McAlester district. The total length in this district is about 7 miles. The syncline is asymmetric, with steep dips on the south flank as the Adamson anticline is approached and dips of 12° or less on the north flank as the Burning Springs anticline is approached. The syncline plunges eastward at a very low angle, the dips of the beds on the axis being so

[33] Taff, J. A., Geology of the eastern Choctaw coal field, Indian Territory: U. S. Geol. Survey 21st Ann. Rept., pt. 2, p. 283, 1900.

low that accurate dip readings could not be taken. The Boggy shale crops out along the axis of the syncline throughout its length in the district, and the Savanna sandstone crops out on both flanks.

Burning Springs anticline.—The Burning Springs anticline is named from Burning Springs, a few miles northeast of the McAlester district. This anticline enters the northeast corner of the district near the middle of the north side of sec. 17, T. 6 N., R. 17 E., and trends slightly south of west for about 5½ miles to the SW¼ sec. 21, T. 6 N., R. 16 E., where it ends. It plunges westward at a low angle throughout this distance, and the Savanna sandstone and the lower part of the Boggy shale close around its west end. The anticline is rather wide and flat, the dips on the flanks not exceeding 12°. North of the anticline and toward the west end some irregularity in the direction of dip of the beds suggests that one or more small noses are present. Only one of these lies within the McAlester district, in secs. 15 and 16, T. 6 N., R. 16 E.

Talawanda syncline.—The Talawanda syncline is named from Lake Talawanda, in the north-central part of the McAlester district. The syncline is broad, with low dips on each flank, and its axis has a curving trend that averages slightly south of west across the north side of the district. The portion of the syncline that lies within the district is about 17 miles long and is divided into two structural troughs separated by a small structurally higher zone. One trough makes up the eastern portion of the syncline, and the other is in the central portion near Lake Talawanda. West of the latter trough, near Wildhorse Creek, is a small structural high in the syncline, west of which the syncline plunges out in about 2½ miles. The Boggy shale crops out in the eastern portion of the syncline, and the Boggy shale and Thurman sandstone are folded into the central and western portions. This is significant, as it indicates that the folding of the rocks of the McAlester district was not completed until some time after the Thurman sandstone was deposited.

Lilypad Creek anticline.—The Lilypad Creek anticline is named from Lilypad Creek, which is on the anticline a short distance north of the McAlester district. Only the southwest end of the anticline enters the district, however, and this is located near Wildhorse Creek, in the northwestern part of the district. This part of the anticline is rather broad, with dips of only 5° or less on each flank, and plunges out southwestward in about 3 miles. Only the upper part of the Boggy shale crops out in this anticline in the McAlester district.

Structural thinning and thickening of beds.—Structural thinning of shale units on the flanks of folds and thickening of the same units on the axes of folds were found at several places in the district. One of

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the best examples is on the southeast side of the Haileyville syncline, near Haileyville, where the outcrop of the McAlester shale crosses the axis of the syncline near its east end and continues southwestward on the south limb of the syncline nearly parallel to the axis. Three sandstone beds are present in the McAlester shale where it crosses the axis of the syncline. Along the axis the thickness of the shale between the upper and middle sandstones, computed from dip readings and the width of the outcrop, is about 255 feet, and the thickness of the shale between the middle and lower sandstones is about 175 feet. However, about 2½ miles to the west, on the south flank of the syncline, these beds are nearly vertical, and it is impossible to separate the three sandstone beds. The two shale units are certainly no more than one-tenth as thick as where they crop out on the axis of the syncline, and it is my opinion that if exposures were sufficiently good to permit accurate measurement of the shale units where they are thinned they would be found to be considerably less than one-tenth as thick.

Just southeast of Savanna the McAlester shale crosses the northeastward-plunging axis of the Savanna anticline. There the computed thickness of the shale between the thin sandstone near the base of the formation and the sandstone just below the McAlester coal is about 1,400 feet, but less than 2 miles to the south, on the southeast flank of the anticline, the computed thickness of the same shale unit is less than 100 feet.

In general throughout the district the computed thickness of any shale unit on the flank of a tight fold is appreciably less than that computed from outcrops on the plunging axis of the fold. However, there is no known quantitative relation between the thickness of a shale unit and either its position on a fold or its degree of dip. For example, the thinning of the shale unit on the Savanna anticline mentioned above is about 1,300 feet from the axis, where it is 1,400 feet thick, to a point about 1½ miles away on the southeast flank of the anticline, where it is less than 100 feet thick. The thinning from the axis to a point similarly located on the northwest flank of the anticline, where the shale is 1,000 feet thick, however, is not more than 400 feet, or less than one-third as much.

In the northeastern part of T. 2 N., R. 13 E., in the southwest corner of the McAlester district, the part of the McAlester shale below the McAlester coal varies greatly in thickness. This variation appears to have resulted from the squeezing out of the shale with attendant movement along the strike from places of thinning in one zone to places of thickening in the same zone.

The more competent formations, such as the Savanna sandstone, locally show thinning of the incompetent shale members along the flanks of the folds. For example, on the north flank of the McAlester anticline about 5 miles west of McAlester the Savanna sandstone is only about 500 feet thick, although the normal thickness of the formation is about 1,300 feet. Where the shales of the Savanna sandstone have been squeezed out, however, the massive sandstone beds show considerable fracturing and slickensiding.

From the evidence given above it is apparent that the forces that folded and faulted the rock strata in the McAlester district also squeezed the soft, incompetent strata out at some places and into other places. In general the thinning of the soft beds took place on the flanks of the folds, and the thickening on the axes of the folds.

MINERAL RESOURCES

COAL

Coal was first mined on a commercial scale in this district in 1872 near McAlester and has been the chief commercial product of the district up to the present time. The coals of the district are all of bituminous rank, ranging from about 35.4 to 37.8 percent in content of volatile matter and from about 1.4 to 1.5 in fuel ratio (averaged analyses for each bed).

Seven coals have been mined in the McAlester district. These are, from oldest to youngest, the Lower Hartshorne, Upper Hartshorne, McAlester, Cavanal (?), an unnamed bed in the Savanna sandstone, Lower Witteville (?), and Secor (pl. 1). About half of the coal produced in the district has come from the McAlester bed, and about 40 percent has come from the Lower Hartshorne bed. Most of the remaining 10 percent has come from the Upper Hartshorne and Secor beds, as only a few small mines have been worked in the other beds. In addition to these beds there are numerous thin coal beds, chiefly in the McAlester shale and the Savanna sandstone. Several of these beds locally reach thicknesses of 15 to 22 inches, but in most places they are less than 12 inches thick.

The location of the outcrops of these coal beds is shown on plate 7 (in pocket).

LOWER AND UPPER HARTSHORNE COALS

The Lower Hartshorne coal lies in the Hartshorne sandstone. The thickness and character of the parts of the formation above and below the coal are variable, but in general the coal occurs in the upper part of the formation and above the more massive sandstone beds. From the southwest corner of the McAlester district to a point about 4 miles southwest of Haileyville the Hartshorne coal crops out near the crest of the ridge held up by the Hartshorne sandstone. This ridge pursues a gently curving course that is interrupted at one point near Blanco, where it is offset about 2 miles by the Blanco fault. From the point 4 miles southwest of Haileyville to the NW¼ sec. 7,

T. 4 N., R. 17 E., the coal crops out near the base of the dip slope of the massive lower sandstones of the Hartshorne, which pursues a sharply curving course northward to the west side of Haileyville, eastward through both Haileyville and Hartshorne, and southward to sec. 7, T. 4 N., R. 17 E. From the point last mentioned eastward to the northeast end of the Hartshorne Basin, just north of Gowen, the coal crops out either on a terrace or in a saddle between massive upper and lower sandstones in the Hartshorne formation that pursue a smoothly curving course throughout that distance. Westward from Gowen to the northwest corner of sec. 18, T. 5 N., R. 16 E., the coal bed crops out near the base of the gently curving dip slope of the lower sandstone of the Hartshorne formation. Northwestward from the point last mentioned the coal crops out for about a mile in a smoothly curving saddle between the massive upper and lower sandstones of the Hartshorne formation. Thence to the east side of the district the outcrop of the coal extends nearly due eastward and is located on a terrace near the crest of a ridge that passes just south of Carbon and Adamson. Near Carbon this ridge is broken by the Carbon fault and is offset southward about 1,000 feet on the east side of the fault.

Just northwest of McAlester the Lower Hartshorne coal crops out on a terrace on the south side of the crest of a ridge held up by the Hartshorne sandstone. This ridge is a northward-facing arc about 4 miles long that passes through North McAlester and the grounds of the Oklahoma State Penitentiary and is terminated at each end by the Penitentiary fault.

A third belt of outcrop of the Lower Hartshorne coal lies between Kiowa and Savanna, in the west-central part of the district. The coal crops out at or near the crest of a low ridge that forms a northeastward-trending oval about 8 miles long and half a mile wide.

The Lower Hartshorne coal as shown by the available records of measured sections ranges in thickness from 2 feet 5½ inches to 6 feet. The thickest section was measured in the Adamson No. 4 mine, in the center of the W½ sec. 7, T. 5 N., R. 17 E.; the thinnest section was measured in the Pocahontas No. 2 mine, in the SW¼SW¼ sec. 13, T. 5 N., R. 16 E. The average thickness of the coal where it has been mined is about 4 feet, and it is probable that in the areas not mined the thickness is about the same or only slightly less.

In most parts of the district the dip of the coal bed has been the most important factor in the mining of the Lower Hartshorne coal. Near Haileyville, in the Hartshorne Basin, and westward from the Hartshorne Basin to the north side of sec. 12, T. 5 N., R. 15 E., the dip of the coal bed is between 11° and 50° at the outcrop but decreases away from the crop line, and in the Hartshorne Basin about 10 square miles of surface is underlain by Lower Hartshorne coal that dips less than 10°. In these areas of low dips the coal has been mined extensively, but in the other parts of the district, where the dips are steeper, only a few small mines have been opened in this coal.

In most places partings are either absent in the Lower Hartshorne coal or range from one to three in number and from one thirty-second to one-fourth inch in thickness. As many as four partings have been recorded locally. The partings are made up chiefly of pyrite and mineral charcoal. In several mines in the Hartshorne Basin local bands of cannel coal as much as 6 inches thick are present. The roof of the coal is generally firm shale or "slate", although as much as 1 foot 1 inch of bone and bony coal and as much as 1 foot 8 inches of draw slate have been recorded. The floor is generally firm shale, but in the Rock Island Improvement Co.'s mine 8, in the NE¼SW¼ sec. 36, T. 5 N., R. 16 E., underclay is recorded in all available sections. Thus neither the roof material nor floor material is likely to give much trouble in mining.

Sections of the Lower Hartshorne coal are given in plate 8, and analyses are given on pages 65–77.

The Upper Hartshorne coal lies in the McAlester shale near the base, from a few feet to about 50 feet stratigraphically above the top of the Hartshorne sandstone. Where the vertical interval between the Upper Hartshorne coal and the Hartshorne sandstone is small, the coal crops out very close to the base of the dip slope formed on the top of the sandstone, but where the vertical interval is about 50 feet the horizontal distance from the base of the dip slope to the outcrop of the coal is about 200 feet. The Upper Hartshorne coal is present in the same parts of the area as the Lower Hartshorne coal. (See pp. 47–48.) Its outcrop nearly parallels and lies about 200 to 500 feet in the direction of the dip from the outcrop of the Lower Hartshorne except in secs. 25 and 26, T. 5 N., R. 17 E., where the distance between the outcrops of the two beds is as much as half a mile, and in sec. 12, T. 5 N., R. 15 E., where it is as much as 1,300 feet.

The Upper Hartshorne coal, as shown by the available measured sections, ranges in thickness from 1 foot 8 inches to 5 feet 7 inches and averages about 3 feet. Relatively little mining of this bed has been done, largely because the dip of the bed is more than 45° at most places and because the Lower Hartshorne bed is thicker and has been mined in preference to it where the dips are low enough to permit mining. However, five mines of considerable size, southwest of Carbon, southwest of Haileyville, and near Blanco, have worked in this bed, and numerous small mines were located on its outcrop.

Available measured sections of the Upper Hartshorne coal are too few to give much general information as to the amount of impurities in this bed. In the Hailey-Ola No. 7 mine, near Haileyville, 2 inches of cannel coal was noted in this bed.

Sections of the Upper Hartshorne coal are given in plate 8, and analyses on pages 67–70.

Descriptions of both the Upper and Lower Hartshorne coals by townships are given below.

T. 2 N., R. 13 E.—The Lower Hartshorne coal crops out in T. 2 N., R. 13 E., at a few places near the crest of a low northeastward-trending ridge about half a mile from the southeast boundary of the district. The coal bed stands vertical or nearly vertical along its entire outcrop in this area. Consequently mining difficulties are too great to permit working under present conditions, although some coal has been removed from three small pits in sec. 3. The coal is 1 foot 3 inches thick in an exposure in the center of the W½ sec. 10.

The horizon of the Upper Hartshorne coal in this township parallels that of the Lower Hartshorne coal and lies about 200 feet to the northwest. The coal bed is 2 feet 1 inch thick in an exposure in the center of the W½ sec. 10 and dips too steeply throughout the township to be worked under present conditions.

T. 3 N., R. 13 E.—The Lower Hartshorne coal is not exposed in the southeast corner of T. 3 N., R. 13 E., but beds at the horizon of the coal appear near the crest of a low ridge running northeastward across that corner of the township. These beds stand vertical or nearly vertical. In sec. 25 they are offset about 100 feet northward on the east side of a fault that strikes about N. 27° W. The thickness of the coal is not known. The steep dips would make it impracticable to work the coal under present conditions.

The Lower Hartshorne coal crops out in two belts that run northeastward across secs. 1, 2, 3, 10, and 11. These belts are on the northwest and southeast flanks of the Savanna anticline and join in sec. 10, where they cross the axis of the anticline. The coal dips between 70° and 80° except in sec. 10, where the two bands of outcrop join and the dip decreases to 7° SW. Some shallow prospecting has been done at several places in this part of the township, and in the SW¼ sec. 10 an abandoned mine was located that was reported to be of considerable size. In 1930 a slope mine was working out about 2 acres of coal in the NW¼NE¼ sec. 10. The coal was reported to be 3 feet thick in this mine and 4 feet thick in the abandoned mine just mentioned. A drill record in the SW¼NW¼ sec. 10 shows coal 1 foot 6 inches, bony coal 5 feet, and coal 1 foot 10 inches. The coal might be worked by shafts in secs. 9, 16, 17, 18, 19, and 20 of this township and secs. 24 and 25, T. 3 N., R. 12 E., provided the bed retains a thickness of 3 to 4 feet westward from its outcrop in sec. 10. The steep dips along the two belts of outcrop to the northeast would make mining difficult there.

The Upper Hartshorne coal, like the Lower Hartshorne, does not crop out in the southeast corner of the township. Beds at the horizon of the coal are exposed on the northwest side of the low ridge that crosses secs. 35, 36, and 25, but the thickness of the coal is not known, and the beds stand at or near the vertical. Therefore, mining would be impracticable in this part of the township under present conditions.

The Upper Hartshorne crops out in two bands in secs. 1, 2, 3, 10, and 11, on the northwest and southeast flanks of the Savanna anticline, where they lie about 200 feet farther from the axis than the corresponding outcrops of the Lower Hartshorne. In these two belts the dips are about 70° to 80°. The two bands join in sec. 10, where they cross the axis of the anticline. Here the Upper Hartshorne lies from 300 to 500 feet west of the Lower Hartshorne, and the dip decreases to 7° W. A small abandoned mine was located on this bed in the NE¼ sec. 10. A drill cutting of the Upper Hartshorne coal in the SW¼NW¼ sec. 10 shows 3 feet 4 inches of coal. This coal could be worked by slope mines in sec. 10 or by shaft in secs. 9, 16, and 17, and possibly in secs. 18 and 19 of this township and sec. 24, T. 3 N., R. 12 E., provided the coal does not thin out in that direction.

T. 3 N., R. 14 E.—Beds at the horizon of the Lower Hartshorne coal crop out near the crest of a low ridge that trends east-northeastward across T. 3 N., R. 14 E., passing through Pittsburg and leaving the township just south of Blanco. The coal itself is not exposed except in the SE¼ sec. 12 and the NE¼ sec. 13, about 1 mile south of Blanco, where it crops out on a ridge that forms an arc around the end of a basin that lies to the northeast. The coal in this arc is offset about 800 feet by a fault near the center of sec. 13 and is terminated by the Blanco fault in sec. 12. In secs. 12 and 13 the dips of the coal bed range from vertical down to about 11°, but elsewhere the beds at its horizon are vertical or nearly vertical. The Lower Hartshorne coal has not been mined in this township, and its thickness is not known, although weathered outcrops of 3 to 4 feet of the coal were noted in road cuts on the east and west sides of sec. 13. The dips are too steep to permit mining under present conditions except in secs. 12 and 13, from which mining could be carried eastward into T. 3 N., R. 15 E.

The Upper Hartshorne coal crops out 100 to 200 feet northwest of the beds at the horizon of the Lower Hartshorne coal, on the north side of the low ridge that trends east-northeastward across the township. In secs. 12 and 13 the Upper Hartshorne crops out on an arc that lies within and 150 to 500 feet away from that formed by the outcrop of the Lower Hartshorne. In sec. 13 the fault that breaks the Lower Hartshorne also offsets the Upper Hartshorne about 800 feet. The coal dips more than 45° along its entire outcrop in this township except toward the west and north sides of the outcrop in secs. 12 and 13, where the dips decrease to 11°. The Upper Hartshorne coal has been worked in the Blanco No. 1 mine, in sec. 14, where the workings were all near the outcrop. A prospect pit has been dug in this coal about 300 feet east of the west township line. No measurements of the thickness of this coal in the township are available, but in the mine of the Thomas Coal Co., about 400 feet east of the township line, in sec. 7, T. 3 N., R. 15 E., it has a thickness of 3 feet 5½ inches (section 83, pl. 8). The dips are too great for extensive mining except in secs. 12 and 13, where the bed might be worked profitably. Shallow mining might be done in the area of steep dips.

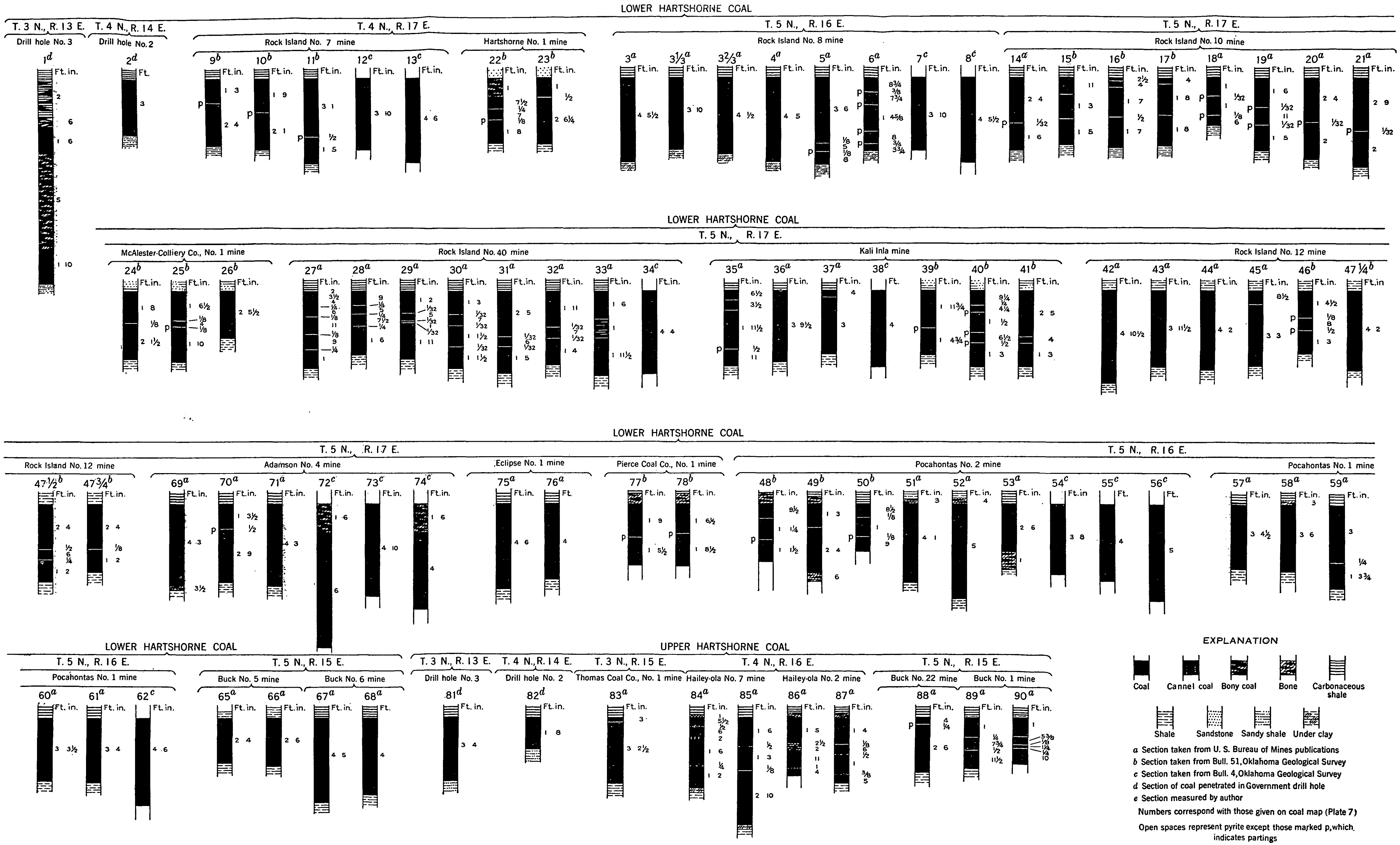
T. 3 N., R. 15 E.—Beds at the horizon of the Lower Hartshorne coal crop out near the crest of a low ridge that extends from the township line just south of Blanco into the W½ sec. 5, T. 3 N., R. 15 E., where it is terminated by the Blanco fault. There is a weathered exposure of the coal on the west side of sec. 18, about 1 mile south of Blanco, and another exposure about half a mile to the northeast. Both outcrops lie on the northwest side of a low ridge that trends east-northeast. The coal is probably present on the northwest side of the ridge where that feature is present across the remainder of the township. Where the ridge is absent the coal bed is concealed beneath alluvium. No mining has been done in this coal in this township. On the east side of sec. 5 and in sec. 4 the dip of the coal is about 40°, and it is possible that the coal could be worked by slope mines. Throughout the remainder of the township the coal dips too steeply at the surface to permit slope mining to any great depth, as the beds stand at or near the vertical in all exposures. North of the belt of coal extending from sec. 18 into sec. 5 the dips of the beds decrease rapidly away from the outcrop, and it is possible that coal in much of this area south of the Blanco fault could be mined by shaft. However, it would be advisable to drill a sufficient number of holes to determine the depth, dip, and thickness of the coal before attempting any mining.

The Upper Hartshorne coal crops out along two lines parallel to the lines of outcrop of the Lower Hartshorne and 100 to 200 feet farther northwest. The dips are essentially the same as those of the Lower Hartshorne coal. Three mines have operated in this coal, one in sec. 18 and two in sec. 7. In the Thomas mine, in sec. 7, the coal is 3 feet 5½ inches thick (section 83, pl. 8). Some shallow mining might be done in this coal in secs. 4, 5, and 6 and the N½ sec. 7. It is probable that the dip of the Upper Hartshorne coal decreases rapidly northward from its outcrop in the S½ sec. 7 and in sec. 18, and shaft mining might be practicable there. However, drilling to determine the depth, dip, and thickness of the coal bed should be done before mining is attempted.

T. 4 N., R. 15 E.—The Upper and Lower Hartshorne coals crop out at only one place in T. 4 N., R. 15 E., but their horizons are present about 150 to 200 feet apart on the northwest side of a ridge that crosses the township with a curving trend from the SE¼ sec. 33 to the SE¼ sec. 24. This ridge lies from a quarter to half a mile southeast of the branch line of the Chicago, Rock Island & Pacific Railway. No mining has been done in either bed in this township, and the only exposures of the coal beds noted were weathered outcrops along a freshly graded highway that crosses the two beds near the east side of sec. 26. The outcrops were too deeply weathered for the thickness of the coal beds to be determined. The coal beds dip about 50° to 55° N. across the entire township, but in secs. 33, 34, and 35 and the western part of sec. 26 the dip probably decreases beneath the surface. Shallow mining might be done in either bed in that part of the township, but farther east the dip of at least 50° probably remains constant or increases to a considerable depth on the coal bed and would make even shallow mining difficult.

T. 4 N., R. 16 E.—The Lower Hartshorne coal crops out north of the crest of a ridge that enters T. 4 N., R. 16 E., in the southwest corner of sec. 19, about half a mile south of the branch line of the Chicago, Rock Island & Pacific Railway. This ridge trends eastward across sec. 19 to the center of sec. 20, where the trend changes to about N. 50° E., which continues to the NE¼ sec. 11. Thence to the NE¼ sec. 12 the outcrop of the Lower Hartshorne coal trends first northward, then eastward, and finally southward through Haileyville and Hartshorne in the rough form of three-quarters of a circle. In the NE¼ sec. 12 the outcrop curves eastward and leaves the township. The outcrop of the Upper Hartshorne coal lies at the north base of the ridge mentioned above that extends from sec. 19 to sec. 11. From the NE¼ sec. 11 to the NE¼ sec. 12 the outcrop of the Upper Hartshorne describes a rude three-quarters of a circle that lies 300 to 750 feet outside that formed by the outcrop of the Lower Hartshorne. In the NE¼ sec. 12 the Upper Hartshorne also curves eastward and leaves the township.

One small abandoned mine on the Upper Hartshorne and numerous prospect pits indicate the presence of both coals along the entire lines of outcrop in the western part of the township. Several small mines, now abandoned, on each coal and two long strip pits on the Lower Hartshorne bed were located in the northeastern part of the township. Both coal beds dip 80° or more from the west side of the township to sec. 11. From the west side of sec. 11 eastward the dip decreases progressively and is less than 20° throughout secs. 2, 1, and 12. No sections of the Lower Hartshorne coal are available for this township, but measured sections of the coal in the adjacent townships to the north and east indicate that the coal is 3½ to 4 feet thick, at least in the northeastern part of the township. Measured sections of the Upper Hartshorne coal in the Hailey-Ola No. 2 and No. 7 mines range from 3 feet 4 inches to 5 feet 7 inches in thickness



MEASURED SECTIONS OF THE UPPER AND LOWER HARTSHORNE COALS.

and contain as much as 6½ inches of bone or bony coal (sections 84, 85, 86, and 87, pl. 8). In the part of the township west of sec. 11 the dips are too steep to permit extensive mining. Throughout the eastern part of the township abandoned workings in either coal bed probably would make slope mining difficult in both beds. Some mining might be done in either bed in western parts of secs. 11 and 2, well to the west of the abandoned workings of the earlier mines.

T. 4 N., R. 17 E.—The outcrop of the Lower Hartshorne coal enters T. 4 N., R. 17 E., in the NW¼ sec. 7, in the city of Hartshorne, where it trends S. 60° E. Near the center of sec. 7 the trend changes to N. 70° E., which continues to the north side of sec. 2. Along this line the outcrop of the Lower Hartshorne coal is on a terrace on the north side of a prominent ridge and is marked by a strip pit that extends westward into the adjoining township and 12 slope mines, 10 of which are now abandoned. The Upper Hartshorne coal, if present, is about 200 to 600 feet N. 20° W. of the Lower Hartshorne, at the north base of the prominent ridge mentioned above. This coal has not been worked at any point in the township. The two slope mines operating in the Lower Hartshorne coal in 1930 were the mine of the Hartshorne Coal Co., near the center of sec. 3, where outcrops of the coal cross the Chicago, Rock Island & Pacific Railway, and a wagon mine in the NE¼ sec. 2. A shaft mine, the Rock Island Improvement Co.'s No. 7, was working the Lower Hartshorne coal in the NE¼ sec. 5 in 1930. Both the Upper and Lower Hartshorne coal beds dip between 14° and 25° along their outcrops throughout the township, and the dips decrease northward away from the outcrop. Seven sections of the Lower Hartshorne coal measured in this township average about 3 feet 9 inches in thickness (sections 9, 10, 11, 12, 13, 22, and 23, pl. 8). The whole area north of the outcrop of the coal bed in this township could be mined where the coal has not already been removed. No measured sections of the Upper Hartshorne coal in this township were available. If the Upper Hartshorne retains the thickness of 3 feet 4 inches to 5 feet 7 inches that it has in the township to the west, it might be worked along its entire outcrop in this township. However, the absence of workings along the outcrop suggests that the thickness is appreciably less than that of the Lower Hartshorne, which has been mined in preference to the upper bed. It is likely that mining in the Upper Hartshorne bed above the workings of the mines in the Lower Hartshorne would be difficult.

T. 5 N., R. 17 E.—Both the Upper and Lower Hartshorne coals crop out in two separate bands in T. 5 N., R. 17 E. One band of outcrop is located in the south half of the township, most of which is underlain by both beds. The outcrop of the Lower Hartshorne coal enters the southern part of the township in the SW¼ sec. 35 and extends northeastward to the SE¼ sec. 24, where it turns westward, passing just north of Gowen, and continues westward to the NW¼ sec. 19, where it leaves the township. From the south boundary of the township to Gowen the coal crops out on a terrace or in a saddle between massive sandstone beds. Westward from Gowen the coal crops out at the south base of a ridge held up by the lower part of the Hartshorne sandstone. The outcrop of the Upper Hartshorne coal enters the southern part of the township in the SW¼ sec. 35 and trends northeastward to the SW¼ sec. 25, where it curves northwestward through Gowen. The outcrop trends roughly westward from Gowen to the west side of sec. 19, where it leaves the township. Throughout its outcrop the Upper Hartshorne lies near the base of a ridge held up by the Hartshorne sandstones. The dips of the two coal beds along their outcrops in the southern part of the township range from 9° to 14°. The Upper Hartshorne coal has not been mined in this township, but it is reported to be less than 3 feet thick where it was encountered in sinking shafts nos. 10 and 12 of the Rock Island Improvement Co. to the Lower Hartshorne bed. These mines are in secs. 29

and 33 and were operating in the Lower Hartshorne bed in 1930. One other abandoned shaft has worked the Lower Hartshorne at Gowen, in sec. 26. In addition, seven slope mines and one abandoned strip pit were located on the Lower Hartshorne coal in this township. Two of the slope mines—the Kali Inla mine, in sec. 22, and the McAlester Colliery Co.'s mine, in sec. 24—were operating in 1930. The Lower Hartshorne coal averages about 4 feet in thickness in measured sections throughout the southern part of the township (sections 14–21, 24–46, 47¼, 47½, 47¾, pl. 8). Within the area of its outcrop in the southern part of the township the maximum cover above the Lower Hartshorne coal is about 900 feet, and the entire area could be worked by slope mines near the outcrop and by shaft elsewhere. The Upper Hartshorne coal could be worked by slope or shaft in those parts of the township where the lower bed has not been mined, but as the interval between the two is reported to be only about 90 feet in this township, it is probable that old workings in the lower bed would cause trouble in mining the Upper Hartshorne.

In the northern part of the township the Lower Hartshorne coal crops out on a terrace on the north side of a ridge that trends eastward through secs. 7, 8, and 9, and the Upper Hartshorne coal crops out at the north base of the same ridge. Both coal beds are exposed in a road cut on the east line of sec. 7. The Lower Hartshorne coal dips 30°–37° N. along its entire line of outcrop, and the Upper Hartshorne dips 5° to 20° less. A mine, now abandoned, was located on the upper bed in sec. 8, but no measured sections are available from that mine. Ten abandoned slope mines and one slope mine that was operating in 1930 have worked the Lower Hartshorne coal back about 1,000 feet from its outcrop everywhere except in the E½ sec. 8. In these mines the coal is about 4 feet 3 inches thick (sections 69–78, pl. 8). The Lower Hartshorne coal probably could be worked farther back from its outcrop by slope mines or combined shaft and slope mines throughout this part of the township. The abandoned workings in the lower bed would probably interfere with mining in the Upper Hartshorne bed.

T. 5 N., Rs. 15 and 16 E.—The Upper and Lower Hartshorne coals crop out in a narrow loop that enters the NE¼ sec. 24, T. 5 N., R. 16 E., and extends slightly north of west to sec. 13, T. 5 N., R. 15 E., where it curves northward across sec. 12. On the north side of sec. 12 the band turns sharply eastward and extends into the NW¼ sec. 7, T. 5 N., R. 16 E., near Carbon, where it is offset about 1,000 feet southward by the Carbon fault. From the Carbon fault the band continues almost due eastward to the east side of sec. 12, where it leaves the township. The Lower Hartshorne coal crops out at the south base of the prominent ridge held up by the lower sandstone of the Hartshorne formation along the line that extends from sec. 24 to sec. 18, T. 5 N., R. 16 E. In T. 5 N., R. 15 E., the Lower Hartshorne coal crops out in a saddle between two prominent ridges formed by the upper and lower parts of the Hartshorne sandstone. In the belt of outcrop extending from sec. 7 to sec. 12, T. 5 N., R. 16 E., the coal crops out on a terrace on the north side of the Hartshorne sandstone ridge. The Upper Hartshorne coal crops out near the south base of the prominent ridge that extends from sec. 24, T. 5 N., R. 16 E., to the north side of sec. 12, T. 5 N., R. 15 E. Eastward from that point to sec. 12, T. 5 N., R. 16 E., the Upper Hartshorne crops out at the north base of the ridge held up by the Hartshorne sandstone. From sec. 24 of the eastern township to sec. 12 of the western township both coal beds dip between 9° and 26° S., with the average dip closer to the lower figure. Eastward from sec. 1, T. 5 N., R. 15 E., across the township to the east, the dips of both coal beds are 35° or more at all points along the outcrop and are greater than 60° except in parts of secs. 10 and 11, T. 5 N., R. 16 E. Five mines, now abandoned, were located on the Lower Hartshorne in the last-mentioned, or northern belt, and none were noted on the Upper Hartshorne. No unweathered outcrops were noted, and no measured sections were available. Weathered outcrops of both coal beds were noted on the west bank of Gaines Creek in sec. 12, T. 5 N., R. 16 E. The very steep dips of both coal beds in this northern belt of outcrop would make mining impracticable. In sec. 12, T. 5 N., R. 15 E., and sec. 18, T. 5 N., R. 16 E., five slope mines, now abandoned, have worked the Upper Hartshorne coal. Measured sections of the coal in these mines show it to be 2 feet 4⅝ inches to 2 feet 10 inches thick (sections 88–90, pl. 8). Between sec. 1, T. 5 N., R. 15 E., and sec. 24, T. 5 N., R. 16 E., 10 slope mines, now abandoned, and 2 slope mines that were operating in 1930 have worked the Lower Hartshorne coal. The two operating mines are the Richards-Thompson mine, in sec. 18, and the Pocahontas No. 2 mine, in sec. 13, T. 5 N., R. 16 E. The Lower Hartshorne bed has also been worked in two shaft mines, now abandoned, in secs. 11 and 12, T. 5 N., R. 15 E. Measured sections of the Lower Hartshorne coal in this group of operating and abandoned mines indicate that the bed is extremely variable in thickness, ranging from 2 feet 5 inches to 5 feet and averaging about 3 feet 9 inches (sections 3–8, 48–61, and 65–68, pl. 8). The Lower Hartshorne coal could be worked by slope or shaft mines throughout secs. 14 and 13, T. 5 N., R. 16 E., and secs. 18, 17, 16, 15, 14, 22, 23, 24, 25, 26, 35, and 36 and the northern parts of secs. 19, 20, and 21, T. 5 N., R. 15 E. Shallow mining could be carried on in the Upper Hartshorne bed near its outcrop, but the lower bed, being thicker, would probably be mined in preference, and deep mining of the upper bed would probably not be attempted, as it might cause trouble in working the lower coal.

T. 6 N., Rs. 14 and 15 E.—The Upper and Lower Hartshorne coals crop out about 300 feet apart in a belt that extends from the SE¼ sec. 33, T. 6 N., R. 14 E., to the SE¼ sec. 30, T. 6 N., R. 15 E. This belt is a northward-facing arc that passes through North McAlester and the grounds of the Oklahoma State Penitentiary and is terminated at each end by the Penitentiary fault. The two coal beds may be present in a small area in the N½ sec. 34, T. 6 N., R. 15 E., where the Hartshorne sandstone is exposed on the south side of the Penitentiary fault. In the belt of outcrop mentioned first the Lower Hartshorne coal is present on a terrace on the south side of a low ridge. The Upper Hartshorne bed crops out at the south base of the same ridge. The lower bed has been prospected at several points in the two townships but has not been mined, and no measurements of thickness are available. The upper bed has been worked in 13 slope mines and a strip pit, all of which are now abandoned. No measurements of this coal bed could be obtained. Along this line of outcrop the dips range from about 40° to nearly 90° and are between 50° and 75° at most places. The steepness of these dips would make mining difficult except in very shallow workings.

South of the Penitentiary fault and east of the area of outcrop of the Hartshorne coals the two beds are probably present beneath the surface at depths of less than 1,600 feet in secs. 36, 35, 34, 33, the N½ secs. 32 and 31, and the S½ secs. 28, 29, and 30, T. 6 N., R. 15 E. The dips of the beds exposed at the surface are less than 20° at most points in those sections, and either of the two coals might be mined by shafts if found to be thick enough to warrant the expense of working at that depth.

T. 4 N., Rs. 13 and 14 E.—The outcrop of the Lower Hartshorne coal forms a hairpin-shaped loop about 5 miles long and half a mile wide that extends northeastward from the SW¼ sec. 36, T. 4 N., R. 13 E., to sec. 16, T. 4 N., R. 14 E., where it turns sharply and trends southwestward back to the SE¼ sec. 36, T. 4 N., R. 13 E. The northeast point of this loop lies about 1 mile south of Savanna. The Upper Hartshorne coal crops out in a similar loop roughly parallel to and 100 to 500 feet outside that of the Lower Hartshorne. In sec. 16 of the eastern township the coal beds dip 20° to 24° at the surface, but southwest from that section the dips increase to 70° to 90° in a short distance and remain thus throughout the remainder of the two townships. The Lower Hartshorne has been worked in a small mine in sec. 31, T. 4 N., R. 14 E., and the Upper Hartshorne in a small mine in sec. 20 of the same township, but both mines are now abandoned. A small mine was being opened in the Lower Hartshorne bed in the SE¼ sec. 36, T. 4 N., R. 13 E., in 1930. In a drill hole in the SE¼ sec. 16, T. 4 N., R. 14 E., the lower bed was found to be 3 feet thick (section 2, pl. 8) and the upper bed 1 foot 8 inches thick (section 82, pl. 8).

The Lower Hartshorne could be minded by slope or shaft in secs. 16 and 15 and the southern part of sec. 10, T. 4 N., R. 14 E., where the dips are rather low and the coal is under less than 2,000 feet of cover. The Upper Hartshorne bed is so thin that the lower bed would be mined in preference, and the presence of mine workings in the lower bed would probably prevent mining of the upper bed.

McALESTER COAL

The McAlester coal crops out along three separate lines in the McAlester district. The longest line of outcrop extends from a point near the southwest corner to a point near Haileyville, where it turns westward to pursue a curving course westward through Alderson, Krebs, and McAlester to a point about 5 miles west of McAlester. There it curves back sharply to the north and then northeast for about 1½ miles and ends against the Penitentiary fault. The second line of outcrop begins about 2 miles northwest of Carbon, on the south side of the Penitentiary fault, and has a Z-shaped course that trends eastward, southwestward, and eastward again to Carbon. East of Carbon the outcrop of the coal continues nearly due east to the boundary of the district, passing just north of Adamson. The third line of outcrop forms an elongated oval about 10 miles long and 1 mile wide that extends southwestward from a point about 1 mile east of Savanna to a point about 3 miles west-northwest of Kiowa.

The McAlester coal lies 1,400 to 1,600 feet above the base of the McAlester shale and 300 to 1,000 feet below the top of the formation. The coal bed lies between 2 and 100 feet above the top of the highest bed of the sandstone group near the middle of the McAlester shale and crops out on a line roughly parallel to the outcrop of that sandstone. The distance between the outcrops of the coal bed and the top of the sandstone bed ranges from a few feet to 900 feet but at most places is about 50 feet. In the zone parallel to the south boundary of the district in T. 3 N., R. 13 E., and the west half of T. 3 N., R. 14 E., the underlying sandstone is either absent or so soft that it does not crop out. The same is true along the outcrop between Kiowa and Savanna in T. 4 N., Rs. 13 and 14 E. In those parts of the district there is no traceable outcrop associated with the coal bed, and its position is inferred from the dips and the locations of the top and base of the formation, except where mines or prospect pits give the exact location of the bed.

The McAlester coal ranges from 1 foot 8 inches to 4 feet 2 inches in thickness in measured sections. The average thickness of the bed where it has been mined is about 3½ feet, but prospecting has shown that the coal thins down to less than 2½ feet beneath much of the area that has not been mined.

The dip of the McAlester coal has been the most important factor in its development. The dips are consistently lower than those of the Hartshorne coals, and where they are 45° or less the coal has been mined. In the places where the dips are less than 20° and the bed is 3 feet or more thick it has been mined extensively. Where the dip is more than 45° few attempts have been made to mine the coal, and the largest mines at such places have removed only the coal within 1,000 feet of the outcrop.

The McAlester coal bed contains more partings and bands of impurities than the Lower and Upper Hartshorne beds, as many as seven partings having been recorded in a single section. Most of the partings are very thin bands of pyrite, however, and can be removed from the coal easily. The roof of the coal is firm shale or "slate." The floor is either firm shale or underclay. Where the clay is present it causes some trouble by swelling, thus making the mine floor uneven.

Sections of the McAlester coal are given in plates 9 and 10, analyses are given on pages 66–77, and descriptions of the coal by townships are given below.

T. 2 N., Rs. 12 and 13 E.—Although the McAlester coal does not crop out in T. 2 N., R. 13 E., and the east tier of sections in T. 2 N., R. 12 E., the beds at its horizon come to the surface along a line roughly parallel to and about half a mile from the south boundary of the McAlester district. The coal is not exposed along this line, and the thickness is not known. The dips of the beds near the horizon of the coal range from about 75° to 90°. No mining has been done in either township, and the steep dip would make mining difficult near the outcrops. In secs. 7, 18, and 19, T. 2 N., R. 13 E., and secs. 12, 13, 24, and 25, T. 2 N., R. 12 E., the surface rocks dip 30° or less and the horizon of the McAlester coal is about 2,500 feet below the surface. If the coal is sufficiently thick it might be worked by shaft in those sections at some time in the future, but the depth to the coal is too great for mining under present conditions.

T. 3 N., R. 13 E.—The McAlester coal is present in the southeast corner of T. 3 N., R. 13 E., and beds at the horizon of the coal come to the surface in the northern part of the township. The outcrop of the coal crosses secs. 34, 35, 36, and 25 on a line that lies about half a mile northwest of the boundary of the district. In sec. 25, about 1 mile southwest of Pittsburg, the coal is broken by a small fault. West of that fault the dips of beds near the horizon of the coal are 50° or more, but east of the fault the dip decreases rapidly to about 40° at the east side of the township. The coal has been worked by the McAlester-Edwards No. 1 mine, now abandoned, in this area of lower dips, but to the west steep dips would make mining difficult. The coal averages 3 feet 10 inches in thickness in the mine mentioned (sections 99–103, pl. 9). Beds at the horizon of the McAlester coal are exposed in a hairpin-shaped loop that extends from the northeast corner of the township west-southwestward to sec. 17, where it curves northward and returns east-northeastward to the north side of sec. 2. Attempts have been made to locate the coal along this line by prospecting but are reported to have been unsuccessful. The dips of the beds near the horizon of the coal are 45° to 80° except in sec. 17, where they decrease to only 8°. If the coal bed is present and is thick enough mining might be carried on in secs. 17 and 18, but throughout the remainder of the northern part of the township the steep dips would make mining difficult.

T. 3 N., R. 14 E.—The horizon of the McAlester coal is represented in T. 3 N., R. 14 E., on two separate lines. One just barely cuts across the extreme northwest corner of the township. The coal is not exposed there, and the dips of the beds near its horizon are so steep (about 80°) that mining would be difficult. The second line of outcrop crosses the southern part of the township in an east-northeasterly direction from the NW¼ sec. 30 to the NE¼ sec. 12, passing through Pittsburg and following closely the branch line of the Chicago, Rock Island & Pacific Railway, which it crosses twice. The McAlester coal dips about 45° in the east half of the township and less than 45° in the west half. Four operating slope mines were located on this line of outcrop in 1930. From three of these mines, the McAlester-Edwards Nos. 2, 3, and 4, the coal has been mined back an average distance of about 2,000 feet from the outcrop in secs. 16, 17, 19, and 20. In the mine of the Blanco Coal Co., in sec. 11, the coal has been mined back about 900 feet from the outcrop for a distance of about three-quarters of a mile. In these mines and one drill hole measured sections of the coal range from 2 feet 11 inches to 3 feet 7 inches in thickness (sections 104–116, pl. 9). Under present conditions the McAlester coal could be mined along its entire outcrop in the southern part of the township, and it is possible that with an increased demand in the future mining could be carried on in most of the township north of the outcrop, as the coal is nowhere more than 3,500 feet beneath the surface.

T. 3 N., R. 15 E.—The outcrop of the McAlester coal enters T. 3 N., R. 15 E., at Blanco, in the NW¼ sec. 7, and trends about N. 60° E. to the NW¼ sec. 4, where it leaves the township. The dip is about 46° N. along that entire outcrop. No mining has been done on the McAlester coal in this township, but in one outcrop the coal is 2 feet 3 inches thick (section 117, pl. 9). This thickness is less than has been considered essential for mining in the McAlester district, but in time the whole of the township northwest of the outcrop of the coal may be mined, as the dips decrease northwestward and the coal is nowhere more than 2,000 feet below the surface.

T. 4 N., R. 15 E.—The McAlester coal does not crop out in T. 4 N., R. 15 E., but beds at its horizon come to the surface on a line that enters the township in the SW¼ sec. 33 and trends about N. 56° E. across the township to a point near the east quarter corner of sec. 24. The dip is about 46° in sec. 33 and increases eastward to about 68° in sec. 24. The coal has not been mined in this township, and no measured sections of it are available. However, the section measured in the township to the south and the fact that the coal has been mined just east of this township indicate that the coal is between 2 and 3 feet thick here. If the bed is as thick as is supposed, increased demand for coal might permit it to be worked for a distance of about 4,000 feet northwest of the outcrop, where it is about 2,500 feet below the surface.

T. 4 N., R. 16 E.—There are two lines of outcrop of the McAlester coal in T. 4 N., R. 16 E. One line enters the township in the NW¼ sec. 19, trends east-northeast into the NE¼, then turns southward and ends against the Berlin fault. The abandoned Berlin mine and the operating Craig No. 1 mine of the Messina Coal Co. are on this line of outcrop. The coal bed dips about 10° E. in the E½ sec. 19, but the dip increases to about 45° at the west side of the section. The coal could be mined back a considerable distance from its outcrop in the eastern part of the section, and a large area extending northeastward as well as northward could be mined by the Craig No. 1 mine.

The second line of outcrop of the McAlester coal begins on the south side of the Berlin fault, in the SW¼ sec. 19, extends eastward about 1 mile, then follows a northeasterly course to a point within a mile of Haileyville, curves westward for a mile and southwestward for a mile, curves sharply northward, then northeastward, and follows that trend through the deserted village of Craig to the NE¼ sec. 3, where it leaves the township. In the W½ sec. 19 the coal bed dips about 23°, but the dip increases eastward, and from the east side of the section to the west side of sec. 11 the dips are 75° or more. Near the west side of sec. 11 the dips decrease rapidly and throughout secs. 2 and 3 and most of sec. 11 are between 20° and 27°. In secs. 9 and 10 the dips are even lower. Two mines were working the McAlester coal in the SE¼ sec. 3 in 1930, and 10 mines, now abandoned, were located on the coal in secs. 3, 9, 10, and 11. In those mines measured sections of the coal show a thickness of 2 feet 8 inches to 3 feet 6 inches (sections 119–123, pl. 9). One abandoned slope mine was located on the McAlester coal in the S½ sec. 19, and in a drill hole just north of the mine the coal was 3 feet thick.

The coal probably could be mined by slope north of its outcrop in sec. 19, as the record of the drill hole mentioned above indicates that the coal is not cut off by the Berlin fault for at least 900 feet to the north. Considerable mining either by slope or shaft could be done in secs. 3, 9, 10, and 11. In sec. 17 the coal lies within 500 feet of the surface along a line extending from the northeast to the southwest corner of the section. The depth in the NW¼ and SE¼ sec. 17 is greater than 500 feet, but the coal probably could be mined by shaft in all of that section.

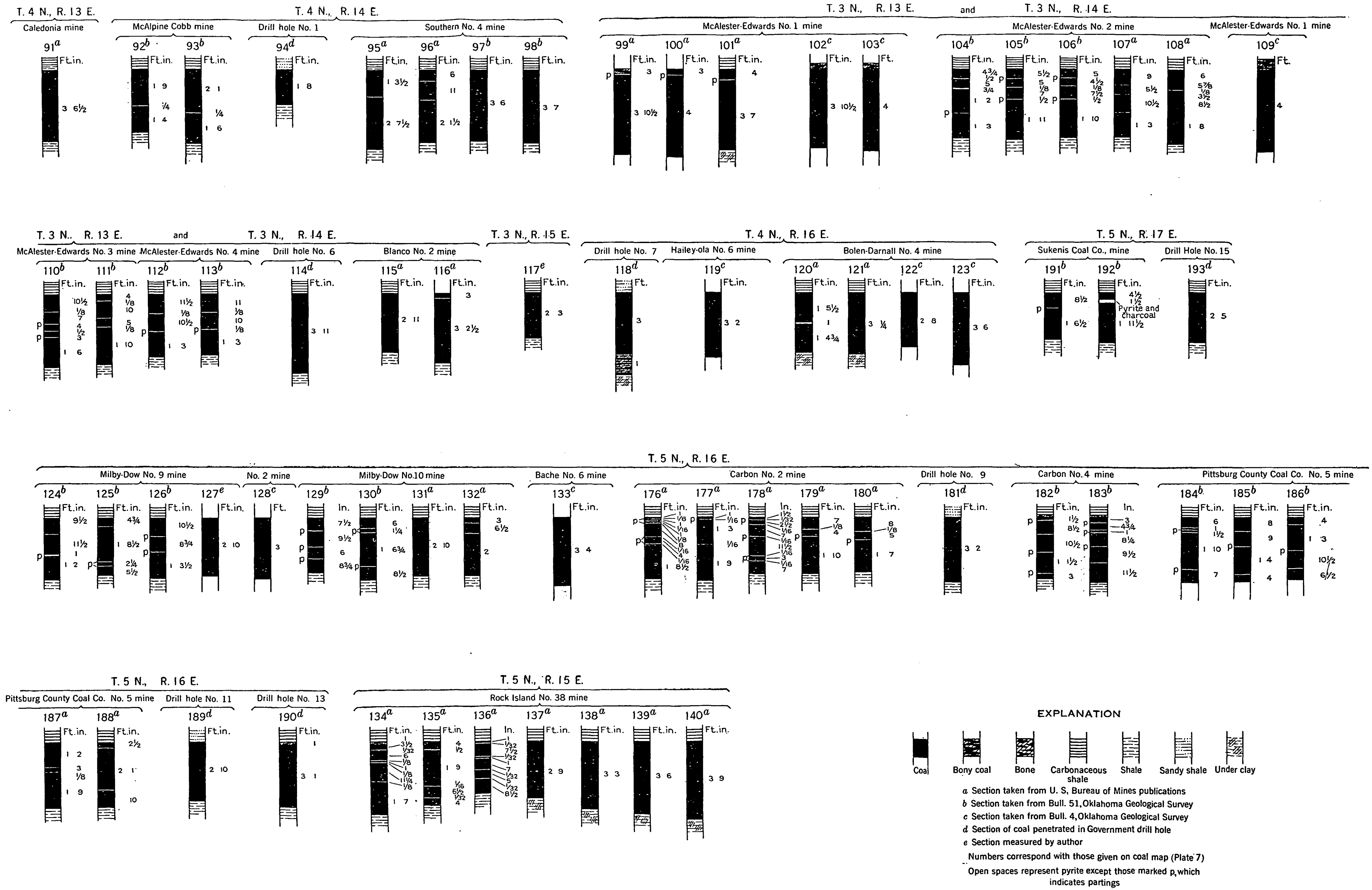
T. 5 N., R. 17 E.—The McAlester coal enters the part of T. 5 N., R. 17 E., that lies in the McAlester district in the SE¼ sec. 4, where it trends about S. 85° W. Westward from that point the trend changes gradually to due west, which continues to the SW¼ sec. 6, where the outcrop leaves the township. The dip is 25°–30° N. along the entire outcrop within the township. The coal has been worked by two mines that were operating in 1930 in secs. 4 and 6, where it is 2 feet 3 inches to 2 feet 5 inches thick (sections 191–193, pl. 9). Dips decrease northward from the outcrop, and the McAlester coal could be mined for more than 1 mile north from its outcrop, provided it does not become too thin.

T. 5 N., R. 16 E.—Crossing T. 5 N., R. 16 E., are two lines of outcrop of McAlester coal—one that enters from the south and curves northwestward and one that enters the township in the SE¼ sec. 1 and trends almost due west across the entire township. The dips along the northern line of outcrop are 23° to 37° but are generally nearer the lower figure. The coal has been worked in eight slope mines and two strip pits, now abandoned, in secs. 4, 5, and 6. Two slope mines were operating in sec. 4 in 1930. In this entire strip the coal is 2 feet 8 inches to 3 feet 2 inches thick (sections 176–190, pl. 9). The McAlester coal could be mined for at least 1 mile north of its outcrop in secs. 1, 2, and 3 and for at least 1¾ miles north of its outcrop in secs. 4, 5, and 6. The outcrop of the McAlester coal enters the southern part of the township in the southeast corner of sec. 34, where its trend is about N. 40° E. The outcrop curves northward to the NW¼ sec. 26, where it swings to a trend of about N. 70° W., which continues to the NW¼ sec. 20. Thence the outcrop passes north of Bache and trends nearly due west to the NW¼ sec. 19, where it leaves the township. The dips are about 10° in secs. 34, 35, and 26 and increase westward to about 24° in sec. 19. The coal has been mined extensively in secs. 19, 21, 22, 26, 27, 34, where it is 2 feet 7¾ inches to 3 feet 4 inches thick (sections 124–133, pl. 9), but it has not been mined in the remaining sections. It could be mined for 2 miles west and south of its outcrop in the southern part of the township.

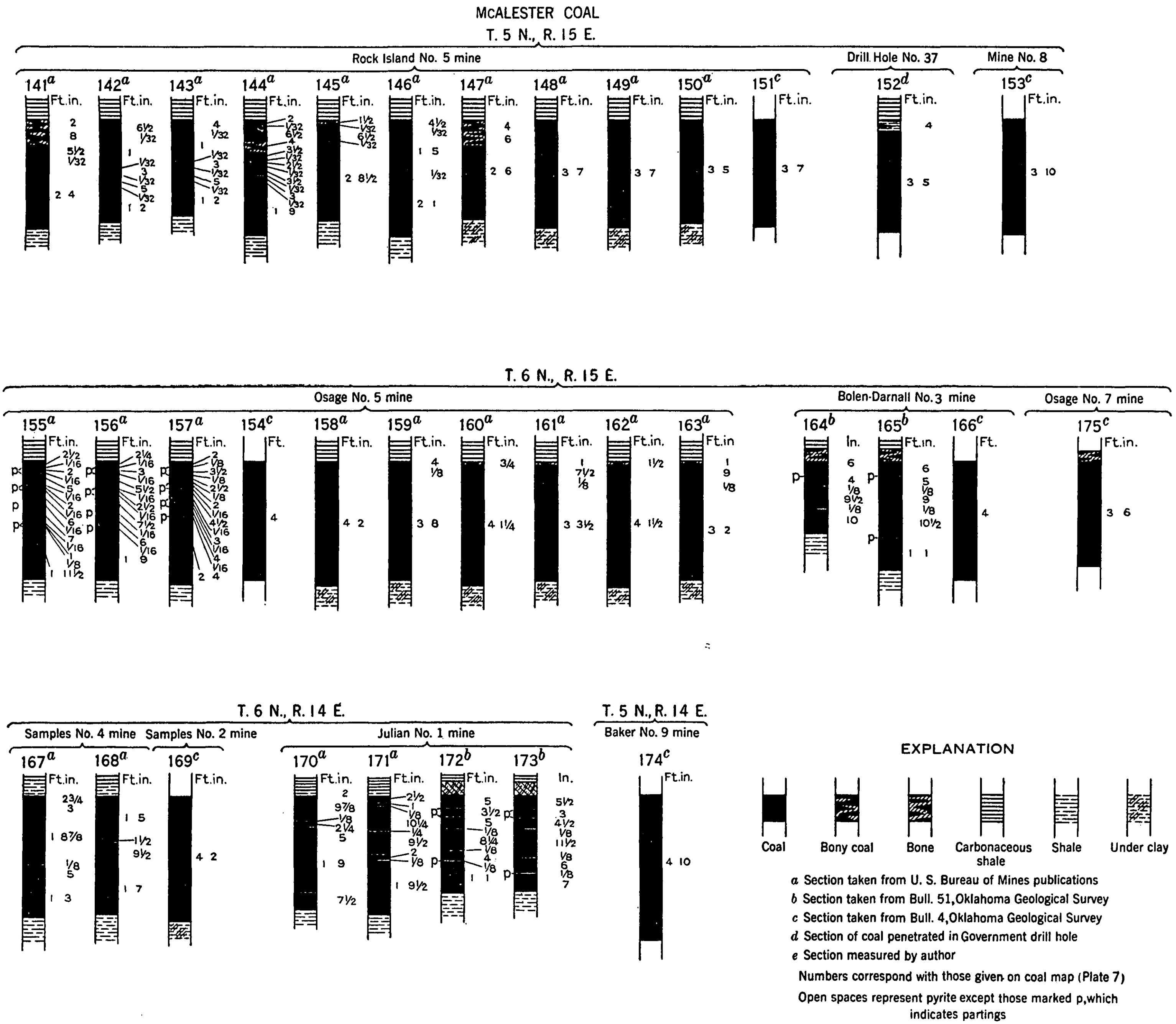
T. 5 N., R. 15 E.—Two lines of outcrop of the McAlester coal cross T. 5 N., R. 15 E. The northern outcrop enters sec. 1 in the SE¼, follows a curving line to the center of the section, then swings northward and leaves the township in the NE¼ sec. 1. The coal bed dips about 6° in all parts of sec. 1 except the southeast quarter, where the dips increase to about 20°. The coal is about 3 feet thick and has been mined in the eastern part of the section and in several small slope mines and one strip mine farther west, but all the mines are now abandoned. Near the center of the SE¼ sec. 1 the coal is reported to be broken by small faults. The part of this section not mined out might be worked, if the coal is not broken by small faults that do not appear at the surface. The second line of outcrop enters the township in the NE¼ sec. 24 and trends about N. 80° W. to the west side of sec. 14, where it curves northward across secs. 15 and 10 into the SE¼ sec. 3. There it bends northwestward and trends about N. 60° W. to the NE¼ sec. 4, where it leaves the township. This line of outcrop passes through Alderson and Krebs. In secs. 24, 13, and 14 the coal bed dips about 27°. In sec. 15 the dip decreases rapidly to about 13° and then more gradually to about 10° in sec. 10 and about 7° in secs. 3 and 4. Along the whole of this outcrop line the coal has been mined 1,000 to 6,700 feet back from the outcrop. In these mines the coal is 2 feet 6 inches to 3 feet 10½ inches thick (sections 134–153, pls. 9 and 10). With an increase in demand for coal the McAlester bed could be mined for at least 3 miles from the outcrop except in the southeast corner of the township, where the steeper dips carry it below 2,500 feet of cover in about 2 miles. The coal could be mined in secs. 7, 6, 5, 8, 17, 19, and 30, in parts of secs. 31, 32, 27, 26, and 25, and in all of the area between those sections and the outcrop of the coal bed.

T. 6 N., Rs. 15 and 16 E.—Two lines of outcrop of the McAlester coal are present in T. 6 N., Rs. 15 and 16 E. The northern outcrop enters T. 6 N., R. 15 E., in the SE¼ sec. 36 and trends about N. 35° E. into the extreme western part of sec. 31, T. 6 N., R. 16 E., where it curves northward and westward back into sec. 36 of the first township. It crosses sec. 36 with a trend of about S. 85° W. into the NE¼ sec. 35, where the outcrop of the coal ends against the Penitentiary fault. In the SE¼ sec. 36, T. 6 N., R. 15 E., the coal bed dips about 5°, but in the northern part of sec. 36 the dip increases to nearly 90° in a distance of about 500 feet and remains the same to the end of the outcrop against the Penitentiary fault. The coal has been mined in sec. 31, T. 6 N., R. 15 E., and is about 3½ feet thick there (section 175, pl. 10). A strip mine about half a mile long is located in the SE¼ sec. 36, T. 6 N., R. 15 E. The coal could be mined from this quarter section into the southern part of sec. 31, T. 6 N., R. 16 E., and in sec. 32 and the S½ sec. 33 of the same township. The maximum cover in that area is about 2,000 feet. However, it is reported that drill records show the coal to be thin there. The second line of outcrop enters T. 6 N., R. 15 E., in the SE¼ sec. 33 and follows the railroad track very closely to the NE¼ sec. 32, where it curves westward and runs through McAlester to the west side of the township. In the W½ sec. 31 the outcrop is offset about 400 feet by a small fault that strikes N. 50° W. The coal bed dips 18°–25° along the entire outcrop. Practically all of the area underlain by the McAlester coal in this part of the township has been mined out. The coal is 2 feet 5½ inches to 4 feet 2 inches thick in these mines (sections 154–166, pl. 10).

Tps. 5 and 6 N., R. 14 E.—The McAlester coal enters T. 6 N., R. 14 E., in the NE¼ sec. 36 and has a trend of about S. 75° W., which continues to the SE¼ sec. 5, T. 5 N., R. 14 E. Beyond that point the McAlester coal is covered by Gerty sand, and its position cannot be determined. However, it probably



MEASURED SECTIONS OF THE McALESTER COAL.



MEASURED SECTIONS OF THE McALESTER COAL.

curves northward across the axis of the McAlester anticline about 1,200 feet southwest of the center of sec. 5, and then turns northeastward and continues to some point near the southeast corner of sec. 32, T. 6 N., R. 14 E., where it is cut off by the Penitentiary fault. The dip is 20°–59° along the known outcrop of the coal bed in these two townships. In general the dip increases westward across T. 6 N., R. 14 E., and decreases westward in T. 5 N., R. 14 E. The McAlester coal has been mined in secs. 34, 35, and 36, T. 6 N., R. 14 E., and in secs. 1, 2, 3, 4, and 5, T. 5 N., R. 16 E. In that area the coal is 3 feet 1½ inches to 3 feet 11½ inches thick (sections 167–174, pl. 10). The McAlester coal could be mined for about a mile back from its outcrop in these two townships, as the dip decreases southward. In sec. 7 and the SE¼ sec. 6, T. 5 N., R. 14 E., and the E½ secs. 12 and 13, T. 5 N., R. 13 E., the McAlester coal could be mined by shaft if it retains the thickness that it has in the nearest exposures to the east. In that area the coal dips only 7°–10° and is under 2,000 feet or less of cover.

T. 4 N., Rs. 13 and 14 E.—The McAlester coal crops out in a hairpin-shaped loop that extends southeastward from a point about 1 mile east of Savanna. The outcrop enters T. 4 N., R. 13 E., in the SE¼ sec. 35 and trends northeastward to the south side of sec. 9, T. 4 N., R. 14 E., where it bends eastward across sec. 9. In secs. 10 and 15 the outcrop curves southward to the center of sec. 15. There the trend changes to southwest, which continues to the southwest corner of sec. 31, T. 4 N., R. 14 E., where the outcrop leaves the township. The coal bed dips 60° to 80° in all parts of these two townships except secs. 16, 9, 10, and 15, T. 4 N., R. 14 E., where the dips are 19° to 60°. The coal has been mined in sec. 25, T. 4 N., R. 13 E., and in secs. 9, 10, 16, 17, 19, 20, 21, 28, 29, and 32, T. 4 N., R. 14 E., but only one of these mines has worked more than 1,000 feet from the outcrop, and all the mines are now abandoned. The coal bed is 3 feet 3 inches to 3 feet 11 inches thick in these mines (sections 91–93 and 95–98, pl. 9). The dips are steep for mining in the two belts where the trend is northeast, but as the dips decrease away from the outcrop the coal might be worked for about half a mile from its outcrop in the belt to the northwest and about 1 mile from its outcrop in the belt to the southeast. In the area of low dips mentioned above and in secs. 1, 2, 3, 10, and 11 and the northwestern part of sec. 12, T. 4 N., R. 14 E., the coal might be mined by shaft, as it is less than 2,000 feet beneath the surface in that area. However, a drill record in sec. 11 shows only 1 foot 8 inches of coal in the bed (section 94, pl. 9). This may be a locally thin section or may be representative of the bed.

CAVANAL (?) COAL

A coal bed that lies just above the lowest of the sandstone groups of the Savanna sandstone has been tentatively correlated with the Cavanal coal, which has been mined about 50 miles farther east. This coal has been mined in and near North McAlester in secs. 28, 29, and 30, T. 6 N., R. 15 E., where it is reported to be 4 feet thick. This coal bed thins rapidly eastward and is only 1 foot thick in an exposure on the north line of sec. 36 of the same township. The thickness of the bed elsewhere in the McAlester district is not known. Where it has been mined the coal stands vertical or nearly vertical and could not be mined extensively under present conditions. This coal bed was correlated erroneously with the McAlester coal by Taff.[34]

[34] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, p. 452, 1899.

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COAL ABOVE THE CAVANAL (?) IN THE SAVANNA SANDSTONE

A coal bed reported to be about 2 feet thick has been mined west of Krebs in sec. 9 and south of Krebs in secs. 27 and 28, T. 5 N., R. 15 E. A bed at about the same horizon, presumably the same bed, has been mined in sec. 18, T. 4 N., R. 16 E. Plant fossils, as well as the position in the Savanna sandstone, indicate that this bed is younger than the Cavanal (?) coal. The approximate location of the horizon of this coal appears on the coal outcrop map. The coal is not commercially important at present but may have some value in the future.

COAL NEAR THE BASE OF THE BOGGY SHALE

A coal bed in the Boggy shale and about 50 feet above the top of the Savanna sandstone has been mined north of Savanna in sec. 3, T. 4 N., R. 14 E. No measured section of the coal is available. This bed is tentatively correlated with the Lower Witteville coal of the Poteau district.

SECOR COAL

The Secor coal lies just above the lowest sandstone in the Boggy shale and about 450 feet above the base of the formation. This coal bed has been mined in three parts of the McAlester district. No analyses of the Secor coal are available. Sections of the Secor coal are given in figure 5, and the three areas in which the coal has been mined are described below:

T. 5 N., R. 14 E.—The Secor coal crops out on a line that trends N. 50° E. from the SW¼ sec. 34 to the northwest corner of sec. 25, T. 5 N., R. 14 E., where the trend changes and the outcrop passes through the southwest corner of McAlester. West of McAlester the outcrop takes a trend of about S. 85° W. across secs. 11 and 10 into sec. 9, beyond which the position of the bed could not be determined. The dips are 10°–15° along the entire outcrop. Two abandoned mines were located on this coal bed in secs. 26 and 34, and there is a small abandoned strip pit on the outcrop in the NW¼ sec. 12. The coal bed is reported to be about 3 feet thick and to have few partings. This area underlain by Secor coal has low dips and is located near the town of McAlester and the lines of the Missouri-Kansas-Texas Railroad and the Chicago, Rock Island & Pacific Railway. If the reported thickness of 3 feet is uniform throughout the area underlain by the bed and the coal is of good quality, it could be worked for 1 to 2 miles from its outcrop.

Tps. 4 and 5 N., Rs. 15 and 16 E.—The Secor coal crops out in a line that trends about N. 70° E. from the SE¼ sec. 32, T. 5 N., R. 15 E., to a point near the northeast corner of sec. 35, whence it swings about due east to the NE¼ sec. 36. In T. 5 N., R. 16 E., the coal bed crops out in an arc that averages about S. 45° E. across sec. 31, then enters T. 4 N., R. 16 E., in the NW¼ sec. 5, crosses that section with a curving trend that averages about S. 10° W., swings southwest, and crosses secs. 8, 7, and 18, T. 4 N., R. 16 E., and sec. 13, T. 4 N., R. 15 E. The coal has been worked by mines, now abandoned, in sec. 13, T. 4 N., R. 15 E.; sec. 7, T. 4 N., R. 16 E.; and sec. 36, T. 5 N., R. 15 E. An abandoned strip mine on this coal bed crosses sec. 33, T. 5 N., R. 15 E. The coal bed dips about 9° in T. 5 N., Rs. 15 and 16 E., but in T. 4 N. the dip increases southward to about 22°

in sec. 13, T. 4 N., R. 15 E. The thickness of the bed is reported to be about 3 feet in T. 5 N. and less than that in T. 4 N. If the coal is uniformly 3 feet thick in the area underlain by it, the entire area could be mined by slope and shaft mines.

T. 6 N., Rs. 15 and 16 E.—The Secor coal crops out at many places in T. 6 N., Rs. 15 and 16 E., but at only two places was it found to be thick enough to be commercially important. On the west end of the ridge in the SE¼ sec. 21, T. 6 N., R. 16 E., 2 feet 8½ inches of coal is exposed at the entrance to a small abandoned mine (section 195, fig. 5). The coal bed crops out around that hill, which extends eastward into sec. 22. The bed is horizontal. If the coal bed retains a thickness of nearly 3 feet in the area under which it lies, it could be mined. At the middle of the west side of sec. 25, T. 6 N., R. 15 E., the Secor coal is 1 foot 6 inches thick in an outcrop on the old road along the township line. It is reported that a farmer mines a small amount of coal from this bed 1 to 1½ miles farther west. The bed dips about 17° in this part of the township. Under present conditions of market, mining, and local supply this coal could not be worked commercially, but according to the land classification system of the Geological Survey its potential future value classes it as minable coal.

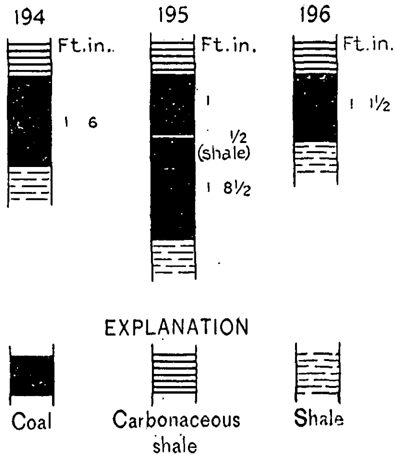

FIGURE 5.—Measured sections of the Secor coal. Sections measured by author.

LOCAL COAL BEDS IN THE McALESTER SHALE

Several coal beds more than 1 foot 2 inches thick have been penetrated in drill holes in the McAlester shale, but such thicknesses are probably local, and the coal cannot be classed as of commercial value without more complete knowledge.

PHYSICAL AND CHEMICAL CHARACTERISTICS

The coal of the McAlester district is a bituminous coal of good quality. It is made up chiefly of alternating bands of bright and dull coal, with some bands of cannel coal and partings of mineral charcoal (or mother coal), pyrite, clay, and "bone." The coal is tough and blocky, so that only a small percentage of "fines" is produced by the necessary handling. Practically all the coal can be burned to a coherent coke, but the amount of sulphur and phosphorus in the coke is generally rather high. (See analyses, p. 81.)

Numerous methods of representing the quality of coals by formulas have been used. The one most commonly used is based on the proximate analysis, in which the percentages of volatile matter (combustible gases), fixed carbon (combustible solid matter), moisture, and ash (noncombustible materials) are determined. In addition, the heating value is given in calories or, more commonly, British thermal units. From the proximate analysis the "fuel ratio" of the coal is determined by dividing the fixed carbon by the volatile matter.

This figure has been used more than any other to establish the quality of coal samples.

The ultimate analysis of coal shows the percentages of sulphur, hydrogen, carbon, nitrogen, and oxygen in the sample and is somewhat supplementary to the proximate analysis. Ultimate analyses are given for three conditions—as received, moisture free, and moisture and ash free. Proximate analyses and heating values are given for two conditions—as received and moisture free.

In addition to the analyses of the coal the softening temperature of the ash is frequently determined. This is the temperature at which the ash produced in burning the coal begins to melt and forms a slag.

Analyses of coals from the McAlester district are given in the following tables:

Chemical analyses of mine samples of coal from the McAlester district

[From U. S. Bur. Mines Tech. Paper 411]

Locality, bed, mine, etc.	Sample: Laboratory no.	Sample: Kind [1]	Sample: Condition [2]	Proximate: Moisture	Proximate: Volatile matter	Proximate: Fixed carbon	Proximate: Ash	Ultimate: Sulphur	Ultimate: Hydrogen	Ultimate: Carbon	Ultimate: Nitrogen	Ultimate: Oxygen	Air-drying loss	Calorific value: Calories	Calorific value: British thermal units	Softening temperature (°C.)	Reference [3]
LATIMER COUNTY																	
Gowen, 1 mile west of; Rock Island No. 40 mine, Lower Hartshorne bed (face of 5 room, 9 west entry, 41 slope entry).	30270	A	1	3.8	37.3	52.4	6.5	1.4					2.3	7,456	13,420	2,010	193
Same (face of 15 room, 7 west entry, 41 slope entry).	30271	A	1	3.5	39.2	50.4	6.9	.9					2.0	7,389	13,300	2,030	193
Same (face of 8 east entry, 41 slope entry)	30272	A	1	4.4	36.8	51.4	7.4	1.3					2.8	7,317	13,170	1,960	193
Same (face of 50 room, 6 west entry, 40 slope entry).	30273	A	1	4.1	38.8	51.3	5.8	1.9					2.6	7,489	13,480	1,990	193
Same (face of 5 east air course, 41 slope entry)	30274	A	1	3.9	38.4	52.4	5.3	1.1					2.3	7,528	13,550	2,070	193
Same (face of 6 east entry, 41 slope entry)	30275	A	1	4.1	38.6	50.8	6.5	2.2					2.4	7,450	13,410	2,050	193
Same (face of 5 west entry, 41 slope entry)	30276	A	1	4.0	37.7	50.6	7.7	1.0					2.5	7,311	13,160	1,910	193
Same (composite of samples 30270 to 30276, inclusive).	30277	A	1	3.9	38.1	51.4	6.6	1.4	5.4	74.3	1.9	10.4	2.4	7,422	13,360		193
			2		39.7	53.5	6.8	1.5	5.2	77.3	2.0	7.2		7,722	13,900		
			3		42.6	57.4		1.6	5.5	82.9	2.1	7.9		8,289	14,920		
PITTSBURG COUNTY																	
Adamson, ¼ mile south of; Adamson No. 4 mine, Lower Hartshorne bed (face of 9 east entry, 1,200 feet northeast of mine mouth).	19855	A	1	3.7	35.7	54.0	6.6	.9					2.2	7,533	13,560		123
Same (face of 10 east entry, 1,250 feet northeast of mine mouth).	19856	A	1	3.9	35.0	55.4	5.7	.6					2.4	7,650	13,770		123
Same (face of 10 west entry, 1,300 feet northwest of mine mouth).	19857	A	1	5.5	35.6	52.7	6.2	.9					4.1	7,450	13,410		123
Same (composite of samples 19855 to 19857, inclusive).	19858	A	1	4.3	35.5	54.1	6.1	.8	5.5	75.8	1.9	9.9	2.9	7,539	13,570		123
			2		37.1	56.5	6.4	.9	5.2	79.2	1.9	6.4		7,884	14,190		
			3		39.7	60.3		.9	5.6	84.7	2.1	6.7		8,422	15,160		
1½ miles east of; Eclipse No. 1 mine, Lower Hartshorne bed (face of 3 east entry, 600 feet northeast of mine mouth).	16143	A	1	5.2	35.6	55.2	4.0	1.1					3.8			2,030	85
Same (face of 3 west entry, 600 feet northwest of mine mouth).	16144	A	1	4.4	36.3	55.4	3.9	1.6					3.0			2,060	85
Same (composite of samples 16143 and 16144)	16145	A	1	4.8	35.8	55.5	3.9	1.3	5.6	77.1	2.0	10.1	3.4	7,683	13,830		
			2		37.6	58.3	4.1	1.4	5.3	81.0	2.1	6.1		8,072	14,530		
			3		39.2	60.8		1.5	5.5	84.4	2.2	6.4		8,417	15,150		

[1] A, U. S. Bureau of Mines sample; B, U. S. Geological Survey sample.
[2] 1, As received; 2, moisture free; 3, moisture and ash free.
[3] References to U. S. Bureau of Mines bulletins.

Chemical analyses of mine samples of coal from the McAlester district—Continued

Locality, bed, mine, etc.	Sample: Laboratory no.	Sample: Kind	Sample: Condition	Proximate: Moisture	Proximate: Volatile matter	Proximate: Fixed carbon	Proximate: Ash	Ultimate: Sulphur	Ultimate: Hydrogen	Ultimate: Carbon	Ultimate: Nitrogen	Ultimate: Oxygen	Air-drying loss	Calorific value: Calories	Calorific value: British thermal units	Softening temperature (°C.)	Reference
PITTSBURG COUNTY—continued																	
Alderson, ¼ mile southwest of; Rock Island No. 5 mine, McAlester bed (face of 5 east entry, main west slope entry).	30660	A	1	2.9	37.5	54.4	5.2	0.5	------	------	------	------	0.9	7,644	13,760	2,220	193
Same (face of 5 west entry, main west slope entry).	30661	A	1	2.6	38.3	54.6	4.5	.8	------	------	------	------	.9	7,744	13,940	2,230	193
Same (face of 7 east entry, main west slope entry).	30662	A	1	2.9	37.4	52.7	7.0	.6	------	------	------	------	1.1	7,478	13,460	2,030	193
Same (face of 3 west entry, main west slope entry).	30663	A	1	2.7	39.5	53.5	4.3	.9	------	------	------	------	1.0	7,756	13,960	2,220	193
Same (face of 9 west entry, main west slope entry).	30664	A	1	2.8	39.8	53.1	4.3	.7	------	------	------	------	1.0	7,761	13,970	2,210	193
Same (face of 4 west entry, 1 east slope entry)	30665	A	1	2.7	38.9	54.2	4.2	.6	------	------	------	------	.8	7,778	14,000	2,200	193
Same (face of 5 east entry, 1 east slope entry)	30666	A	1	2.9	37.8	54.4	4.9	.9	------	------	------	------	1.0	7,711	13,880	2,050	193
Same (composite of samples 30660 to 30666, inclusive).	30667	A	1	2.7	38.2	54.2	4.9	.7	5.4	77.4	1.9	9.7	1.0	7,706	13,870	------	193
			2	------	39.3	55.6	5.1	.7	5.2	79.5	2.0	7.5	------	7,922	14,260	------	------
			3	------	41.4	58.6	------	.8	5.5	83.8	2.1	7.8	------	8,344	15,020	------	------
½ mile east of; Rock Island No. 38 mine, McAlester bed (face of 9 west entry, main slope entry).	30656	A	1	2.9	37.2	54.6	5.3	.6	------	------	------	------	1.0	7,661	13,790	2,140	193
Same (face of 6 east entry, main slope entry)	30657	A	1	3.3	37.5	55.0	4.2	.5	------	------	------	------	1.3	7,705	13,870	2,100	193
Same (face of main east entry, main slope entry).	30658	A	1	2.6	38.3	54.6	4.5	.5	------	------	------	------	.6	7,733	13,920	1,950	193
Same (composite of samples 30656 to 30658, inclusive).	30659	A	1	2.8	37.8	54.6	4.8	.5	5.3	77.4	1.9	10.1	1.0	7,689	13,840	------	193
			2	------	38.9	56.1	5.0	.5	5.1	79.6	1.9	7.9	------	7,911	14,240	------	------
			3	------	40.9	59.1	------	.6	5.4	83.8	2.0	8.2	------	8,322	14,980	------	------
1½ miles southwest of; Alderson No. 5 mine, McAlester bed (face of 1 room, 4 west back entry, west slope, 2,200 feet west of shaft).	11915	A	1	2.8	36.4	56.3	4.5	.8	------	------	------	------	1.1	------	------	2,250	85
Same (face of 7 room, 7 west entry, west slope, 2,800 feet northwest of shaft).	11916	A	1	3.2	35.3	57.3	4.2	.6	------	------	------	------	1.3	------	------	2,230	85
Same (face of 66 room, 11 east entry, east slope, 4,000 feet east of shaft).	11917	A	1	3.3	34.6	57.5	4.6	.6	------	------	------	------	1.3	------	------	2,290	85
Same (face of 2 west entry, east slope, 2,000 feet southeast of shaft).	11918	A	1	3.0	35.8	56.8	4.4	.6	------	------	------	------	1.2	------	------	------	85
Same (composite of samples 11915 to 11918, inclusive).	11919	A	1	3.1	35.3	57.2	4.4	.6	5.5	78.3	1.7	9.5	1.2	7,761	13,970	------	85
			2	------	36.4	59.1	4.5	.6	5.3	80.8	1.8	7.0	------	8,006	14,410	------	------
			3	------	38.1	61.9	------	.7	5.5	84.6	1.8	7.4	------	8,389	15,100	------	------
2 miles east of; Alderson No. 38 mine, McAlester bed (face of 1 room, 7 west entry, 2,200 feet down main slope).	11592	A	1	3.2	32.7	57.1	7.0	.5	5.2	75.6	1.6	10.1	1.7	7,489	13,480	1,990	85
			2	------	33.8	58.9	7.3	.5	5.0	78.1	1.7	7.4	------	7,734	13,920	------	------
			3	------	36.4	63.6	------	.6	5.4	84.2	1.8	8.0	------	8,339	15,010	------	------

Same (face of 4 room, 5 east entry, 2,300 feet down main slope).	11594	A	1	3.6	33.4	58.0	5.0	.5	5.3	77.4	1.7	10.1	2.0	7,633	13,740	2,140	85
			2		34.6	60.2	5.2	.5	5.1	80.2	1.7	7.3		7,917	14,250		
			3		36.5	63.5		.5	5.4	84.6	1.8	7.7		8,350	15,030		
Same (face of 26 room, 4 east entry, 1,900 feet down main slope).	11670	A	1	3.2	34.8	57.3	4.7	.5	5.3	78.2	1.7	9.6	1.3	7,706	13,870	2,140	85
			2		36.0	59.1	4.9	.5	5.1	80.8	1.8	6.9		7,967	14,340		
			3		37.9	62.1		.5	5.3	84.9	1.9	7.4		8,372	15,070		
Same (face of 6 east entry)	15188	A	1	2.8	35.7	56.0	5.5	.6	5.4	77.7	1.9	8.9	1.2	7,656	13,780	2,090	85
			2		36.8	57.5	5.7	.6	5.2	80.0	2.0	6.5		7,878	14,180		
			3		39.0	61.0		.7	5.5	84.8	2.1	6.9		8,350	15,030		
Same (face of 7 west air course)	15189	A	1	3.2	36.7	56.5	4.6	.7	5.3	77.4	1.9	10.1	1.5	7,695	13,850	2,160	85
			2		36.8	58.4	4.8	.7	5.1	80.0	1.9	7.5		7,950	14,310		
			3		38.7	61.3		.7	5.3	84.0	2.0	8.0		8,350	15,030		
Blanco, ½ mile south of; Thomas mine, Upper Hartshorne bed (20 feet from face on left rib of 5 west entry, 2,000 feet from surface).	A21465	B	1	3.7	37.4	49.8	9.1	1.2	5.1	71.5	1.9	11.2	1.4	7,039	12,670	2,190	411
			2		38.8	51.8	9.4	1.3	4.8	74.2	2.0	8.3		7,036	13,150		
			3		42.9	57.1		1.4	5.3	81.9	2.2	9.2		8,067	14,520		
1½ miles west of; Blanco No. 2 mine, McAlester bed (right rib, 25 room, 5 west entry, 1,600 feet from surface).	A21463	B	1	4.2	40.0	50.3	5.5	.9	5.6	73.0	1.9	13.1	1.6	7,289	13,120	2,300	411
			2		41.7	52.5	5.8	1.0	5.3	76.2	2.0	9.7		7,606	13,690		
			3		44.3	55.7		1.0	5.6	80.8	2.2	10.4		8,072	14,530		
Buck; Buck No. 6 mine, Lower Hartshorne bed (16 room, main north level, 600 feet north of shaft).	2,645	A	1	3.6	34.0	54.8	7.6	1.2					2.4	7,544	13,580		22
			2		35.3	56.9	7.8	1.3						7,822	14,080		
Same (in 2 room, 1 south plane, 400 feet south of shaft).	2646	A	1	3.5	34.9	55.4	6.2	1.2					2.4				22
			2		36.1	57.5	6.4	1.2									
1 mile east of; Buck No. 22 mine, Upper Hartshorne bed (face of 1 east bottom entry, 6 feet from face of slope).	26150	A	1	5.3	32.9	57.3	4.5	1.6					3.6	7,550	13,590	2,200	193
			2		34.8	60.4	4.8	1.7						7,972	14,350		
Carbon; sec. 6, T. 5 N., R. 16 E.; Central mine, Lower Hartshorne bed.	1735	B	1	3.2	33.3	58.9	4.6	0.5					1.0				22
			2		36.1	63.2	4.7	.5									
1 mile east of; Carbon No. 2 mine, McAlester bed (face of 5 west entry, main slope entry).	W69527	A	1	3.1	32.6	56.6	7.7	.4						7,295	13,130		193
			2		33.6	58.5	7.9	.4						7,522	13,540		
Same (face of 7 east entry, main slope entry)	W69535	A	1	2.8	34.7	57.3	5.2	.4						7,600	13,680		193
			2		35.7	59.0	5.3	.4						7,822	14,080		
Same (face of 6 west entry, main slope entry)	W69546	A	1	2.9	34.1	57.5	5.5	.5						7,572	13,630		193
			2		35.1	59.2	5.7	.5						7,795	14,030		
2½ miles east of; boring no. 9, McAlester bed, at depth of 551⅔ feet, 2-inch core.	6225	B	1	2.1	27.6	50.2	20.1	5.7	4.5	63.7	1.3	4.7	1.0	6,500	11,700		22
			2		28.3	51.3	20.5	5.9	4.3	65.0	1.4	2.9		6,639	11,950		
			3		35.5	64.5		7.4	5.4	81.8	1.7	3.7		8,350	15,030		
Chambers; Chambers mine, McAlester bed	1743	B	1	3.5	40.1	47.0	9.4	3.5					1.2				22
			2		41.5	48.8	9.7	3.7									
Coleman; sec. 9, T. 4 N., R. 16 E.; Bolen Darnall mine, McAlester bed.	1757	B	1	3.6	35.6	57.4	3.4	.8					1.0				22
			2		36.9	59.5	3.6	.8									
Craig; Bolen Darnall No. 4 mine, McAlester bed (face of 8 west entry, 3,000 feet northwest of mine mouth).	15104	A	1	3.5	36.2	55.1	5.2	.8					1.7	7,533	13,560	2,290	85
			2		37.6	57.0	5.4	.9						7,806	14,050		
Same (face of 8 east entry, 3,000 feet from mine mouth).	15105	A	1	3.6	36.1	55.1	5.2	.9					1.7	7,539	13,570	2,200	85
			2		37.4	57.2	5.4	.9						7,817	14,070		
3 miles east of; boring no. 7, McAlester bed, at depth of 441½ feet, 2-inch core.	6224	B	1	3.1	32.1	59.3	5.5	.9	5.1	73.5	1.9	13.1	1.1	7,500	13,500		22
			2		33.1	61.2	5.7	.9	4.9	75.9	2.0	10.6		7,739	13,930		
			3		35.1	64.9		1.0	5.2	80.4	2.1	11.3		8,200	14,760		
3 miles south of; NE. of SW. cor. sec. 11, tract 53, T. 3 N., R. 14 E.; boring no. 6, through McAlester bed.	6118	B	1	3.7	32.0	59.4	4.9	.7	5.2	74.8	1.7	12.7		7,400	13,220		22
			2		33.2	61.7	5.1	.8	5.0	77.7	1.7	9.7		7,683	13,830		
			3		35.0	65.0		.8	5.3	81.9	1.8	10.2		8,100	14,580		

Chemical analyses of mine samples of coal from the McAlester district—Continued

Locality, bed, mine, etc.	Sample			Proximate				Ultimate					Air-drying loss	Calorific value		Softening temperature (°C.)	Reference
	Laboratory no.	Kind	Condition	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen		Calories	British thermal units		
PITTSBURG COUNTY—continued																	
Dow; sec. 26, T. 5 N., R. 16 E.; Milby & Dow mine, McAlester bed.	1716	B	1	4.1	36.1	55.9	3.9	0.5					1.8	7,539	13,570		22
			2		37.6	58.3	4.1	.5						7,861	14,150		
1½ miles west of; Dow No. 10 mine, McAlester bed (25 feet from face on left rib, 7 east entry, 3,000 feet from mine mouth).	A21280	B	1	2.9	37.6	55.3	4.2	.6					1.0	7,717	13,890	2,240	411
Same (20 feet from face, right rib, 8 west entry, 3,100 feet from mine mouth).	A21281	B	1	2.8	36.9	55.7	4.6	.6					.9	7,639	13,750	2,340	411
Same (250 feet from face, on left rib, main slope entry, 3,500 feet from mine mouth).	A21282	B	1	2.7	36.2	55.3	5.8	.5					.8	7,589	13,660	2,210	411
Same (composite of samples A21280, A21281, and A21282).	A21283	B	1	2.9	36.5	55.7	4.9	.6	5.4	77.7	1.8	9.6	.9	7,661	13,790		411
			2		37.6	57.4	5.0	.6	5.2	80.0	1.9	7.3		7,889	14,200		
			3		39.6	60.4		.6	5.5	84.2	2.0	7.7		8,306	14,950		
Edwards; No. 1 mine, McAlester bed (2 east air course).	1079	A	1	3.0	40.4	48.2	8.4	3.1									22
			2		41.7	49.7	8.6	3.1									
Same (2 west air course)	1080	A	1	2.9	39.0	27.8	10.3	3.7						6,995	12,590		22
			2		40.2	49.2	10.6	3.8						7,205	12,970		
Featherston, 2 miles southwest of; McHoma Coal Co. mine, Crowder (?) bed (500 feet from pit mouth).	A23795	B	1	2.7	38.6	46.6	12.1	4.3	5.4	69.0	1.4	7.8	.9	7,133	12,840	2,210	411
			2		39.7	47.8	12.5	4.5	5.2	70.9	1.5	5.4		7,333	13,200		
			3		45.3	54.7		5.1	6.0	81.0	1.7	6.2		8,378	15,080		
Haileyville, 1 mile south of; Hailey-Ola No. 2 mine, Upper Hartshorne bed (face of 1 south entry, main slope entry).	30398	A	1	5.0	36.3	51.6	7.1	1.7					2.4	7,172	12,910	2,130	193
Same (face of 1 north entry, main slope entry)	30399	A	1	5.0	35.4	50.6	9.0	1.9					2.6	7,044	12,680	2,090	193
Same (composite of samples 30398 and 30399)	30400	A	1	4.9	36.1	50.9	8.1	1.8	5.3	71.7	1.9	11.2	2.5	7,122	12,820		193
			2		37.9	53.6	8.5	1.8	5.0	75.5	2.0	7.2		7,494	13,490		
			3		41.4	58.6		2.0	5.4	82.4	2.2	8.0		8,183	14,730		
1½ miles south of; Blue Creek No. 7 mine, Lower Hartshorne bed (face of 1 south entry, main slope entry).	30401	A	1	4.9	36.2	52.7	6.2	2.0					2.3	7,383	13,290	2,000	193
Same (face of 1 north entry, main slope entry)	30402	A	1	5.3	37.1	52.3	5.3	2.4					2.8	7,372	13,270	2,060	193
Same (composite of samples 30401 and 30402)	30403	A	1	5.1	36.7	52.5	5.7	2.2	5.4	73.5	1.9	11.3	2.6	7,372	13,270		193
			2		38.6	55.4	6.0	2.3	5.1	77.5	2.0	7.1		7,761	13,970		
			3		41.1	58.9		2.5	5.4	82.4	2.2	7.5		8,256	14,860		

6 miles north of; Pocahontas No. 2 mine, Lower Hartshorne bed (50 feet from face on left rib, 6 east entry, 2,300 feet from mine mouth.)	A21122	B		1	2.7	38.7	50.7	7.9	1.8	------	------	------	------	1.2	7,539	13,570	2,040	411
Same (20 feet from face on right rib, 4 west entry, 2,300 feet from mine mouth).	A21124	B		1	2.7	39.3	50.7	7.3	2.1	------	------	------	------	1.2	7,553	13,560	2,220	411
Same (20 feet from face, left rib, main slope entry, 2,400 feet from mine mouth).	A21125	B		1	2.8	38.3	51.6	7.3	1.0	------	------	------	------	1.2	7,550	13,590	2,060	411
Same (composite of samples A21122, A21124, and A21125).	A21126	B		1	2.9	38.8	50.9	7.4	1.6	5.4	75.7	1.9	8.0	1.2	7,539	13,570	------	411
				2	------	39.9	53.5	7.6	1.7	5.2	78.0	2.0	5.5	------	7,761	13,970	------	------
				3	------	43.2	56.8	------	1.8	5.6	84.4	2.2	6.0	------	8,400	15,120	------	------
Hartshorne, 1 mile northwest of; Rock Island No. 8 mine, Lower Hartshorne bed (face of 14 room, 7 main east entry).	1073	A		1	1.3	38.9	52.1	7.7	1.6	------	------	------	------	------	------	------	------	22
				2	------	39.4	52.8	7.8	1.6	------	------	------	------	------	------	------	------	------
Same (face of 16 room, 7 west entry)	1071	A		1	1.5	39.0	53.1	6.4	1.4	------	------	------	------	------	7,800	14,040	------	22
				2	------	39.6	53.9	6.5	1.4	------	------	------	------	------	7,917	14,250	------	------
Same (east air course, 4,100 feet west of shaft)	10053	A		1	3.5	36.3	55.3	4.9	1.5	5.7	76.5	1.9	9.5	1.8	7,717	13,890	1,990	22
				2	------	37.7	57.2	5.1	1.6	5.5	79.3	2.0	6.5	------	7,994	14,390	------	------
				3	------	39.7	60.3	------	1.7	5.8	83.5	2.1	6.9	------	8,428	15,170	------	------
Same (1,800 feet northwest of shaft)	19703	A		1	5.1	37.6	51.2	6.1	2.0	------	------	------	------	3.6	7,400	13,320	2,030	123
				2	------	39.6	54.0	6.4	2.1	------	------	------	------	------	7,800	14,040	------	------
Same (2,000 feet northeast of shaft)	19707	A		1	3.7	38.0	50.9	7.4	2.6	------	------	------	------	2.0	7,389	13,300	------	123
				2	------	39.5	52.8	7.7	2.7	------	------	------	------	------	7,667	13,800	------	------
Same (2,300 feet northeast of shaft)	19708	A		1	3.9	37.8	53.1	6.2	1.7	------	------	------	------	2.1	7,500	13,500	------	123
				2	------	39.4	54.1	6.5	1.7	------	------	------	------	------	7,800	14,040	------	------
2½ miles northeast of; Rock Island No. 12 mine, Lower Hartshorne bed (face of 7 east entry, off slope, 3,400 feet from shaft bottom).	A21469	B		1	2.4	38.3	52.0	7.3	2.2	------	------	------	------	1.0	7,483	13,470	2,040	411
Same (face of 7 west entry. slope entry, 3,500 feet from shaft bottom).	A21470	B		1	2.6	38.4	50.8	8.2	1.8	------	------	------	------	1.0	7,444	13,400	2,040	411
Same (face of 8 west entry, plane entry, 2,600 feet from shaft bottom).	A21471	B		1	3.8	37.2	52.4	6.6	1.3	------	------	------	------	1.7	7,406	13,330	2,150	411
Same (face of 8 east entry, plane entry, 2,600 feet from shaft bottom).	A21472	B		1	3.3	37.7	52.1	6.9	2.6	------	------	------	------	1.3	7,378	13,280	2,240	411
Same (composite of samples A21469 to A21472, inclusive).	A21473	B		1	3.0	37.9	51.8	7.3	1.9	5.4	75.0	1.8	8.6	1.3	7,467	13,440	------	411
				2	------	39.1	53.3	7.6	2.0	5.2	77.3	1.9	6.0	------	7,700	13,860	------	------
				3	------	42.3	57.7	------	2.2	5.6	83.7	2.1	6.4	------	6,328	14,990	------	------
5 miles east of; Kali Inla mine, Lower Hartshorne bed (20 feet from face, right rib, 18 west entry, 6,200 feet from mine mouth).	A21478	B		1	3.2	39.3	51.2	6.3	2.1	------	------	------	------	1.4	7,567	13,620	2,130	411
Same (500 feet from face on right rib, main slope entry, 5,600 feet from mine mouth).	A21479	B		1	2.5	38.0	52.8	6.7	1.4	------	------	------	------	1.7	7,533	13,560	2,000	411
Same (15 feet from face on left rib, 18 east entry, 6,100 feet from mine mouth).	A21480	B		1	3.1	38.8	51.5	6.6	1.5	------	------	------	------	1.3	7,517	13,530	2,060	411
Same (composite of samples A21478 to A21480, inclusive).	A21481	B		1	2.8	38.4	52.3	6.5	1.7	5.5	75.7	1.9	8.7	1.2	7,539	13,570	------	411
				2	------	39.6	53.8	6.6	1.7	5.3	77.9	1.9	6.5	------	7,766	13,960	------	------
				3	------	42.4	57.6	------	1.8	5.7	83.4	2.0	7.1	------	8,306	14,950	------	------
Krebs, 1¼ miles northwest of; Osage No. 5 mine, McAlester bed (face of 8 west entry, east slope entry).	W69549	A		1	2.6	35.5	56.2	5.7	.5	------	------	------	------	------	7,589	13,660	------	193
				2	------	36.4	57.8	5.8	.6	------	------	------	------	------	7,789	14,020	------	------
Same (face of 2 west entry, west slope entry)	W69550	A		1	3.4	35.0	55.0	6.6	.5	------	------	------	------	------	7,395	13,310	------	193
				2	------	36.2	57.0	6.8	.6	------	------	------	------	------	7,650	13,770	------	------
Same (face of 6 east entry, east slope entry)	W69556	A		1	2.8	35.7	56.0	5.5	.4	------	------	------	------	------	7,550	13,590	------	193
				2	------	36.7	57.6	5.7	.5	------	------	------	------	------	7,767	13,980	------	------

Chemical analyses of mine samples of coal from the McAlester district—Continued

Locality, bed, mine, etc.	Sample: Laboratory no.	Sample: Kind	Sample: Condition	Proximate: Moisture	Proximate: Volatile matter	Proximate: Fixed carbon	Proximate: Ash	Ultimate: Sulphur	Ultimate: Hydrogen	Ultimate: Carbon	Ultimate: Nitrogen	Ultimate: Oxygen	Air-drying loss	Calorific value: Calories	Calorific value: British thermal units	Softening temperature (°C.)	Reference
PITTSBURG COUNTY—continued																	
McAlester; McAlester No. 3 mine	1736	B	1	3.4	34.4	57.3	4.9	0.8					1.0	7,639	13,750		22
			2		35.6	59.3	5.1	.9						7,905	14,230		
Valley mine, No. 2 slope, Lower Hartshorne bed	1737	B	1	4.6	32.4	58.2	4.8	1.2					2.1				22
			2		34.0	61.0	5.0	1.3									
2 miles east of; Busby No. 5 mine, McAlester bed (11 room, 3 west entry, east slope, 1,600 feet from shaft).	11569	A	1	3.3	33.8	57.7	5.2	.5	5.2	78.0	1.7	9.4	1.9	7,578	13,640	2,240	85
			2		34.9	59.7	5.4	.6	5.0	80.6	1.8	6.6		7,833	14,100		
			3		36.9	63.1		.6	5.3	85.2	1.9	7.0		8,278	14,900		
Same (face of 2 west entry, west slope, 300 feet beyond 26 room).	11586	A	1	4.0	31.0	59.5	5.5	.6					2.4			2,190	85
Same (face of 3 east entry, east slope, 120 feet beyond 22 room).	11587	A	1	3.6	32.9	57.9	5.6	.6					2.1			2,220	85
Same (face of 4 east entry, west slope)	11588	A	1	3.3	32.9	58.6	5.2	.6					1.8			2,230	85
Same (face of 5 east entry, east slope)	11589	A	1	3.1	32.5	59.7	4.7	.5					1.8			2,270	85
Same (face of 3 east entry, west slope, 200 feet beyond 8 room).	11590	A	1	3.2	32.3	59.4	5.1	.6					1.7			2,250	85
Same (composite of samples 11586 to 11590, inclusive).	11591	A	1	3.6	32.1	59.0	5.3	.6	5.3	77.1	1.6	10.1	2.0	7,567	13,620		85
			2		33.3	61.2	5.5	.6	5.1	80.0	1.7	7.1		7,844	14,120		
			3		35.2	64.8		.6	5.4	84.6	1.8	7.6		8,300	14,940		
2 miles from; Samples No. 4 mine, McAlester bed (50 feet from face on right rib, 11 west entry, 3,100 feet from mine mouth).	A21128	B	1	2.8	37.0	54.4	5.8	.9					.9	7,644	13,760	2,240	411
Same (10 feet from face on left rib, 12 east entry, 3,000 feet from slope mouth).	A21129	B	1	3.0	36.9	54.9	5.2	.9					1.0	7,667	13,800	2,260	411
Same (composite of samples A21128 and A21129).	A21130	B	1	3.0	36.6	55.0	5.4	.9	5.3	77.4	1.9	9.1	.9	7,639	13,750		411
			2		37.8	56.7	5.5	.9	5.1	79.8	2.0	6.7		7,872	14,170		
			3		40.0	60.0		.9	5.4	84.5	2.1	7.1		8,339	15,010		
8 miles east of; Buck No. 1 mine, Upper Hartshorne bed (30 feet from face on right rib, 4 west entry, 1,400 feet from mine mouth).	A21268	B	1	3.7	35.1	55.0	6.2	1.5					1.7	7,506	13,510	2,180	411
Same (20 feet from face on left rib, 4 east entry, 1,400 feet from mine mouth).	A21269	B	1	4.3	35.2	57.6	2.9	1.2					2.1	7,772	13,990	2,180	411
Same (composite of samples A21268 and A21269).	A21270	B	1	4.1	34.9	56.5	4.5	1.3	5.3	77.2	2.1	9.6	1.9	7,656	13,780		411
			2		36.3	59.0	4.7	1.4	5.0	80.4	2.2	6.3		7,978	14,360		
			3		38.1	61.9		1.5	5.3	84.4	2.3	6.5		8,372	15,070		
11 miles east of; Pittsburg County No. 5 mine, McAlester bed (25 feet from face on left rib, 5 west entry, 900 feet from mine mouth).	A21136	B	1	2.9	35.6	55.1	6.4	.5					1.2	7,583	13,650	2,22	411
Same (50 feet from face on right rib, 4 east entry, 1,150 feet from mine mouth).	A21137	B	1	2.9	35.9	55.1	6.1	.6					1.1	7,600	13,680	2,240	411

Same (composite of samples A21136 and A21137).	A21138	B	1	3.1	38.0	52.6	6.3	.6	5.1	76.8	1.9	9.3	1.2	7,583	13,650	------	411
			2	------	39.2	54.3	6.5	.6	4.9	79.3	2.0	6.7	------	7,828	14,090	------	------
			3	------	41.9	58.1	------	.6	5.3	84.9	2.1	7.1	------	8,372	15,070	------	------
12 miles south of; Southern No. 4 mine, McAlester bed (35 feet from face on left rib, 11 south entry, 2,800 feet from mine mouth).	A21272	B	1	3.9	38.5	51.2	6.4	1.5	------	------	------	------	1.4	7,317	13,170	2,210	411
Same (10 feet outby 19 room, on right rib, 10 north entry, 2,100 feet from mine mouth).	A21273	B	1	4.0	36.4	53.0	6.6	1.5	------	------	------	------	1.1	7,211	12,980	2,220	411
Same (composite of samples A21272 and A21273).	A21274	B	1	3.8	37.4	52.4	6.4	1.4	5.2	73.6	1.9	11.5	1.2	7,294	13,130	------	411
			2	------	38.9	54.4	6.7	1.5	4.9	76.5	2.0	8.4	------	7,583	13,650	------	------
			3	------	41.7	58.3	------	1.6	5.3	81.9	2.1	9.1	------	8,122	14,620	------	------
North McAlester, 4 miles west of; Julian mine, McAlester bed (20 feet from face on left rib, 6 east entry, 1,000 feet from mine mouth).	A21131	B	1	3.4	39.9	53.3	6.4	0.9	------	------	------	------	1.1	7,472	13,450	2,260	411
Same (30 feet from face on right rib, 5 west entry, 1,100 feet from mine mouth).	A21133	B	1	3.7	36.4	52.9	7.0	.8	------	------	------	------	1.5	7,339	13,210	2,340	411
Same (composite of samples A21131 and A21133).	A21134	B	1	3.5	36.4	53.3	6.8	.9	5.2	75.8	1.9	9.4	1.3	7,422	13,360	------	411
			2	------	37.7	55.3	7.0	.9	5.0	78.5	2.0	6.6	------	7,694	13,850	------	------
			3	------	40.5	59.5	------	1.0	5.4	84.5	2.2	6.9	------	8,272	14,890	------	------
8 miles east of; Buck No. 5 mine, Lower Hartshorne bed (25 feet from face on left rib, 3 east entry, 600 feet from mine mouth).	A21118	B	1	3.6	37.7	52.1	6.6	.5	------	------	------	------	2.2	7,522	13,540	2,280	411
Same (face of 3 west entry, 400 feet from mine mouth).	A21120	B	1	4.2	35.1	54.6	6.1	.5	------	------	------	------	2.4	7,511	13,520	2,150	411
Same (composite of samples A21118 and A21120).	A21121	B	1	3.9	36.9	52.8	6.4	.5	5.4	76.0	2.0	9.7	2.3	7,528	13,550	------	411
			2	------	38.5	54.8	6.7	.5	5.1	79.2	2.0	6.5	------	7,839	14,110	------	------
			3	------	41.2	58.8	------	.6	5.5	84.9	2.2	6.8	------	8,400	15,120	------	------
Pittsburg; McAlester-Edwards No. 1 mine, McAlester bed (face of 5 left entry, east entry, 1,300 feet north and 13° east of mine mouth).	10060	A	1	4.5	37.5	49.4	8.6	3.2	4.9	70.1	1.6	11.6	1.9	7,061	12,710	2,180	22
			2	------	39.3	51.7	9.0	3.4	4.6	73.4	1.7	7.9	------	7,400	13,320	------	------
			3	------	43.2	56.8	------	3.7	5.1	80.7	1.9	8.6	------	8,128	14,630	------	------
½ mile north of; McAlester-Edwards No. 2 mine, McAlester bed (10 feet from face on left rib, 11 west entry, 2,700 feet from mine mouth).	A21276	B	1	3.9	38.0	52.1	6.0	1.1	------	------	------	------	1.0	7,361	13,250	2,240	411
Same (35 feet from face on right rib, 10 east entry).	A21277	B	1	4.2	36.6	54.0	5.5	1.0	------	------	------	------	1.1	7,378	13,280	2,240	411
Same (composite of samples A21276 and A21277).	A21278	B	1	4.0	37.0	53.3	5.7	1.1	5.3	75.2	1.7	11.0	1.1	7,361	13,250	------	411
			2	------	38.5	55.5	6.0	1.1	5.0	78.3	1.8	7.8	------	7,667	13,800	------	------
			3	------	41.0	59.0	------	1.2	5.3	83.2	1.9	8.4	------	8,156	14,680	------	------
Pocahontas; Pocahontas No. 1 mine, Lower Hartshorne bed (face of 8 west entry, 1,650 feet southwest of mine mouth).	19727	A	1	3.7	37.6	53.7	5.0	.7	------	------	------	------	2.1	7,672	13,810	------	123
Same (face of 6 room, 7 east entry, 1,350 feet southwest of mine mouth).	19728	A	1	3.7	37.8	53.6	4.9	.8	------	------	------	------	2.0	7,678	13,820	2,030	123
Same (face of 12 room, 8 east entry, 1,850 feet southeast of mine mouth).	19729	A	1	3.4	38.8	51.9	5.9	.8	------	------	------	------	1.8	7,606	13,690	------	123
Same (face of 10 room, 7 east entry, 1,700 feet southeast of mine mouth).	19730	A	1	3.1	38.4	48.4	10.1	2.1	------	------	------	------	1.6	7,217	12,990	------	123
Same (face of main slope, 1,800 feet south of mine mouth).	19731	A	1	3.5	37.9	52.2	6.4	1.7	------	------	------	------	2.0	7,578	13,640	------	123
Same (composite of samples 19727 to 19731, inclusive).	19732	A	1	3.5	38.2	51.8	6.5	1.2	5.4	75.7	2.0	9.2	1.9	7,534	13,560	------	123
			2	------	39.6	53.6	6.8	1.3	5.2	78.5	2.1	6.1	------	7,811	14,060	------	------
			3	------	42.5	57.5	------	1.4	5.6	84.2	2.3	6.5	------	8,378	15,080	------	------

Chemical analyses of mine samples of coal from the McAlester district—Continued

Locality, bed, mine, etc.	Sample			Proximate				Ultimate					Air-drying loss	Calorific value		Softening temperature (°C.)	Reference
	Laboratory no.	Kind	Condition	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen		Calories	British thermal units		
PITTSBURG COUNTY—continued																	
Ridgway, ½ mile east of; Rock Island No. 10 mine, Lower Hartshorne bed (face of main east entry).	30222	A	1	3.1	37.5	50.3	9.1	1.6					1.7	7,239	13,030	1,980	193
Same (face of main west entry)	30223	A	1	3.4	37.3	50.7	8.6	1.8					1.8	7,339	13,210	2,040	193
Same (face of 27 room, main west entry)	30224	A	1	2.6	39.7	50.0	7.5	1.7					1.4	7,467	13,440	2,050	193
Same (face of east air course, main north entry)	30225	A	1	5.8	36.8	51.4	6.0	1.6					4.2	7,311	13,160	2,040	193
Same (face of 6 east entry, main south entry)	30226	A	1	2.9	38.9	51.9	6.3	1.5					1.3	7,544	13,580	2,120	193
Same (composite of samples 30222 to 30226, inclusive).	30227	A	1	3.8	38.0	50.6	7.6	1.7	5.4	73.8	1.9	9.6	2.1	7,378	13,280		193
			2		39.5	52.6	7.9	1.8	5.1	76.7	1.9	6.6		7,667	13,800		
			3		42.9	57.1		1.9	5.6	83.3	2.1	7.1		8,328	14,990		
Savanna; No. 1 mine, McAlester bed	1745	B	1	4.9	35.6	54.4	5.1	1.5					1.6				22
			2		37.4	57.2	5.4	1.6									
Savanna No. 1 slope, bed unnamed	1744	B	1	5.1	34.0	55.3	5.6	1.2					2.2	7,233	13,020		22
			2		35.9	58.2	5.9	1.3						7,628	13,730		
1 mile southeast of; in tract 69, NE ¼ SE ¼ sec. 16, T. 4 N., R. 14 E.; borehole No. 2, Lower Hartshorne bed, 2-inch core.	5921	B	1	2.6	33.5	54.5	9.4	1.3	4.7	72.6	1.6	10.3	.7	7,211	12,980		22
			2		34.4	56.0	9.6	1.4	4.6	74.5	1.6	8.3		7,406	13,330		
			3		38.0	62.0		1.5	5.0	82.5	1.8	9.2		8,195	14,750		
4 miles south of: Caledonia mine, McAlester bed (face of 4 south entry, 1,600 feet from mine mouth).	A21467	B	1	5.2	33.3	52.6	8.9	1.7	5.1	70.4	1.9	12.0	1.7	6,944	12,500	2,060	411
			2		35.1	55.6	9.3	1.8	4.8	74.3	2.0	7.8		7,328	13,190		
			3		38.8	61.2		1.9	5.3	82.0	2.2	8.6		8,083	14,550		
South McAlester; Great Western mine, bed unnamed.	1738	B	1	3.8	37.4	53.8	5.0	2.2					1.1	7,661	13,780		22
			2		38.9	55.9	5.2	2.3						7,961	14,330		

Chemical analyses of composite mine samples from the McAlester district

[From Oklahoma Geol. Survey Bull. 51]

Town, distance from mine, bed, and place in mine	Sample		Proximate analysis				Sulphur	Air-drying loss	Calorific value		
	Laboratory no.	Condition [1]	Moisture	Volatile matter	Fixed carbon	Ash			Calories	British thermal units	"Unit" British thermal units [2]
LATIMER COUNTY											
Gowen, ¾ mile east of; McAlester Colliery No. 1 mine, Lower Hartshorne bed, composite of samples from face of room 15 off 12 east entry, 3,000 feet from mouth of slope; face of room 4 off 15 east entry, 2,740 feet from mouth of slope; and face of 7 east air course, 3,010 feet from mouth of slope.	215	1	6.1	37.1	52.3	4.5	2.1	3.7	7,344	13,220	14,940
		2	--------	39.5	55.7	4.8	2.2	--------	7,822	14,080	--------
Hartshorne, 3 miles southeast of; Hartshorne Coal Co. No. 1 mine, Lower Hartshorne bed, composite of samples from face of 5 east entry, 1,200 feet from mouth of slope, and face of 4 west entry, 900 feet from mouth of slope.	216	1	6.4	35.6	48.6	9.4	3.4	4.0	6,885	12,400	15,000
		2	--------	38.0	52.0	10.0	3.6	--------	7,365	13,260	--------
6 miles northeast of; Kali-Inla No. 1 mine, Lower Hartshorne bed, composite of samples from face of 18 west entry, 7,200 feet from mouth of slope; face of room 1 off 20 west entry, 5,400 feet from mouth of slope; and face of long wall off 15 west entry, 6,200 feet from mouth of slope.	214	1	3.7	37.1	52.2	6.7	1.8	1.6	7,415	13,340	15,040
		2	--------	38.5	54.5	7.0	1.9	--------	7,695	18,850	--------
PITTSBURG COUNTY											
Adamson, 2 miles east of; Pierce No. 1 mine, Lower Hartshorne bed, composite of samples from face of room 36 off 8 west entry, 2,325 feet from mouth of slope, and face of room 32 off 10 east entry, 2,520 feet from mouth of slope.	196	1	4.4	35.5	56.1	4.0	1.7	2.5	7,715	13,880	15,280
		2	--------	37.1	58.7	4.2	1.8	--------	8,070	14,520	--------
5 miles west of; Pittsburg County Coal Co. No. 5, McAlester bed, composite	194	1	3.6	33.5	56.9	6.0	.6	1.3	7,580	13,640	15,200
		2	--------	34.7	59.1	6.2	.6	--------	7,865	14,160	--------
½ mile northeast of; Adamson No. 7 mine, McAlester bed, composite of samples from face of room 14 off 5 west entry, 1,320 feet from mouth of slope, and face of room 14 off 5 east entry, 1,340 feet from mouth of slope.	193	1	3.9	33.6	57.0	5.5	.8	1.3	7,540	13,570	15,100
		2	--------	35.0	59.3	5.7	.8	--------	7,850	14,130	--------
Bache, 2½ miles northwest of; Richards-Thompson No. 5 mine, McAlester bed, composite of samples from face of 5 east entry, 1,200 feet from mouth of slope, and face of room 17 off 4 east entry, 1,510 feet from mouth of slope.	198	1	4.6	35.0	56.3	4.1	.6	2.6	7,700	13,850	15,250
		2	--------	36.7	59.0	4.3	.6	--------	8,065	14,510	--------
Blanco, 2 miles southwest of; Blanco Coal Co. No. 2 mine, McAlester bed, composite of samples from face of 6 west entry, 1,650 feet from mouth of slope, and face of room 77 off 3 west entry, 2,750 feet from mouth of slope.	191	1	6.1	35.4	52.6	5.9	.9	1.8	7,065	12,710	14,550
		2	--------	37.7	56.0	6.3	1.0	--------	7,515	13,530	--------

[1] 1, As received; 2, moisture free.

[2] "Unit" British thermal units $= \dfrac{\text{B. t. u. as received}-(50\ \text{sulphur})}{\dfrac{100-(\text{moisture}+1.08\ \text{ash}+0.55\ \text{sulphur})}{100}}$. This is a calculated value supposed to represent the heating value of 1 pound of coal free from all noncombustible ingredients.

Chemical analyses of composite mine samples from the McAlester district—Continued

Town, distance from mine, bed, and place in mine	Sample		Proximate analysis				Sulphur	Air-drying loss	Calorific value		
	Laboratory no.	Condition	Moisture	Volatile matter	Fixed carbon	Ash			Calories	British thermal units	"Unit" British thermal units
PITTSBURG COUNTY—continued											
Dow, 2 miles northwest of; Milby-Dow No. 10 mine, McAlester bed, composite of samples from face of room 13 off 10 east entry, 2,840 feet from mouth of slope, and face of room 9 off 10 east entry, 2,720 feet from mouth of slope.	200	1	4.1	34.7	56.1	5.1	0.8	1.6	7,540	13,560	15,040
		2		36.2	58.5	5.3	.8		7,850	14,140	
¼ mile west of; Milby-Dow No. 9 mine, McAlester bed, composite of samples from face of 3 south entry, 3,200 feet from mouth of slope; face of room 10 off 2 north entry, 4,150 feet from mouth of slope; and face of room 107 off main south, 5,876 feet from mouth of slope.	199	1	4.2	34.6	56.4	4.8	.6	1.7	7,485	13,470	14,910
		2		36.1	57.9	5.0	.6		7,810	14,060	
Haileyville, 3 miles northeast of; Messina Coal Co. No. 2 mine, Lower Hartshorne bed, composite of samples from face of room 17 off 7 east entry, 3,900 feet from mouth of slope; face of 7 west entry, 3,400 feet from mouth of slope; and face of crosscut at bottom of slope, 3,200 feet from mouth.	197	1	3.6	37.2	52.1	7.1	1.9	1.6	7,470	13,440	15,210
		2		38.6	54.0	7.4	2.0		7,745	13,940	
Hartshorne, 4 miles northeast of; Rock Island No. 12 mine, Lower Hartshorne bed:											
Face of 9 east slope, 3,900 feet from shaft	206	1	3.8	37.2	52.1	6.9	1.3	1.7	7,400	13,310	15,050
		2		38.7	54.1	7.2	1.4		7,685	13,840	
Face of 3 east off main west plane, 3,700 feet from shaft	207	1	4.1	35.6	52.8	7.5	2.0	1.9	7,360	31,240	15,160
		2		37.1	55.1	7.8	2.1		7,700	13,810	
Face of main west slope, 4,100 feet from shaft	208	1	4.4	37.4	52.2	8.7	2.2	1.9	7,150	12,860	15,020
		2		36.3	54.6	9.1	2.3		7,475	13,450	
Face of 11 main east plane, 4,600 feet from shaft	209	1	4.8	35.2	54.9	5.1	1.1	2.7	7,480	13,480	15,080
		2		37.0	57.6	5.4	1.2		7,865	14,160	
Composite of 206, 207, 208, and 209 (averaged)		1	4.3	36.3	52.5	7.0	1.7	2.0	7,348	13,222	15,078
		2		37.3	55.3	7.4	1.8		7,681	13,815	
Composite of 206, 207, 208, and 209 (mixed sample)	210	1	4.1	36.0	52.8	7.1	1.9	2.0	7,350	13,230	15,050
		2		37.5	55.1	7.4	2.0		7,665	13,800	
3 miles east of; Rock Island No. 10 mine, Lower Hartshorne bed:											
Face of room 38 off 4 east off main south, 3,000 feet from mouth of shaft	201	1	3.3	38.8	49.3	8.6	2.7	1.4	7,400	13,320	15,200
	202	1	3.5	36.9	51.9	7.7	2.6	1.2	7,400	13,320	15,080
Face of room 19 off 5 east, 2,200 feet from bottom of shaft	202	1	3.5	36.9	51.9	7.7	2.6	1.2	7,400	13,320	15,080
		2		38.2	53.8	8.0	2.7		7,665	13,800	
Face of room 4 off 8 east, 3,200 feet from bottom of shaft	203	1	3.1	38.3	48.6	10.0	2.2	1.1	7,270	13,090	15,270
		2		39.5	50.2	10.3	2.3		7,500	13,500	
Composite of 201, 202, and 203 (averaged)		1	3.3	38.0	49.9	8.8	2.8	1.2	7,357	13,243	15,183
		2		39.2	51.7	9.1	2.6		7,608	13,693	
Composite of 201, 202, and 203 (mixed sample)	204	1	3.2	38.5	49.7	8.6	2.7	1.2	7,340	13,210	15,160
		2		39.8	51.3	8.9	2.8		7,580	13,650	

1 mile east of; Rock Island No. 7 mine, Lower Hartshorne bed, composite of samples from face of air course off 10 west entry, 4,400 feet from shaft; face of main north entry, 4,250 feet from shaft; and face of 4 south entry, 4,270 feet from shaft.	205	1	4.4	36.7	50.9	8.0	2.0	2.5	7,310	13,160	15,200
		2	--------	38.4	53.2	8.4	2.1	--------	7,645	13,770	--------
North McAlester, ¼ mile west of; Old Town Coal Co. mine, McAlester bed, composite of samples from face of 7 west entry, 5,000 feet from mouth of slope, and face of 7 east entry, 100 feet off slope and 5,050 feet from mouth of slope.	187	1	3.4	35.7	56.0	4.9	0.8	1.3	7,605	13,700	15,040
		2	--------	37.0	57.9	5.1	0.8	--------	7,875	14,180	--------
Manning, ¾ mile north of; Manning No. 4 mine, McAlester bed, composite of samples from face of 3 west entry, 510 feet from mouth of slope, and face of room 9 off 2 east entry, 540 feet from mouth of slope.	195	1	4.3	37.7	56.3	5.7	0.9	1.5	7,485	13,470	15,070
		2	--------	35.2	58.8	6.0	0.9	--------	7,820	14,080	--------
McAlester, 6 miles east of; Carbon No. 4 mine, McAlester bed, composite of samples from face of room 12 off 1 west entry, 700 feet from mouth of slope, and face of 3 west, 900 feet from mouth of slope.	211	1	4.2	33.0	57.8	5.0	0.5	1.8	7,515	13,510	14,950
		2	--------	34.4	60.4	5.2	0.5	--------	7,830	14,100	--------
3 miles west of; Julian No. 1 mine, McAlester bed, composite of samples from face at 120 feet west main slope, 1,000 feet from mouth, and face at 6 west entry, 400 feet from main slope.	186	1	5.3	36.0	53.3	5.4	0.8	2.5	7,335	13,200	14,850
		2	--------	38.0	56.3	5.7	0.8	--------	7,745	13,940	--------
Pittsburg, 1½ miles west of; McAlester-Edwards No. 4 mine, McAlester bed, composite of samples from face of crosscut off main slope, 700 feet from mouth of slope, and face of room 9 off 3 east entry, 400 feet from main slope.	190	1	5.7	35.0	51.1	6.2	1.2	1.6	7,135	12,840	14,700
		2	--------	37.1	54.2	6.6	1.3	--------	7,565	13,620	--------
½ mile north of; McAlester-Edwards No. 2 mine, McAlester bed, composite of samples from face of room 49 off 11 west entry, 4,700 feet from mouth of slope, and face of room 35 off 11 east entry, 3,750 feet from mouth of slope.	189	1	4.9	35.7	52.1	7.3	2.4	1.5	7,165	12,900	14,880
		2	--------	37.6	54.7	7.7	2.5	--------	7,535	13,570	--------
3 miles west of; McAlester-Edwards No. 3 mine, McAlester bed, composite of samples from face of room 29 off 7 east entry, 2,650 feet from mouth of slope, and face of room 57 off 5 east entry, 2,600 feet from mouth of slope.	188	1	6.0	34.6	52.9	6.5	1.5	2.0	7,075	12,760	14,710
		2	--------	36.8	56.3	6.9	1.6	--------	7,540	13,580	--------
Savanna, 2 miles south of; Pfeiffer Coal Co. No. 1 mine, McAlester bed, composite of samples from face of room 2 off 3 north entry, 580 feet from mouth of slope, and face of 3 north entry, 610 feet from mouth of slope.	192	1	5.9	36.0	53.0	5.1	1.6	3.1	7,255	13,060	14,810
		2	--------	38.2	56.4	5.4	1.7	--------	7,715	13,890	--------
4 miles southeast of; Southern No. 4 mine, McAlester bed, composite of samples from face of 13 north entry, 2,175 feet from mouth of slope, and face of 13 south entry, 2,200 feet from mouth of slope.	185	1	4.5	35.7	52.5	6.3	1.7	1.5	7,305	13,160	14,880
		2	--------	37.4	56.0	6.6	1.8	--------	7,655	13,780	--------

Analyses of coals from McAlester district

[From Oklahoma Geol. Survey Bull. 4]

Location and description	Sample no.	Authority[1]	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Phosphorus	British thermal units
McAlester bed, mine 3, northwest McAlester; from 12th east entry	19	a	2.52	35.24	54.25	6.08	1.61		13,693
McAlester bed, mine 4, Craig; from carload of nut coal after delivery	20	a	2.44	37.73	50.91	7.91	.38		13,529
McAlester bed, mine 9, Baker, northwest McAlester; from a working face, room 4, 5th east entry	28	a	3.56	36.22	51.44	6.81	1.97		13,053
Lower Hartshorne bed, mine 29, Haileyville; from mine, represents full thickness of coal	29	a	2.60	37.36	52.86	6.46	.70		13,707
Lower Hartshorne bed, mine 1, Haileyville; from block of coal on exhibit at Mineral Building, State Fair Grounds, Oklahoma City	30	a	1.68	38.05	54.44	4.62	1.21		14,547
Lower Hartshorne bed, mine 2, southwest of Haileyville; from mine, represents full thickness of coal	31	a	3.42	37.41	56.47	1.90	.80		14,441
Lower Hartshorne bed, mine 2, Haileyville	32	a[1]	3.32	37.20	53.96	4.05	1.47		13,932
Lower Hartshorne bed, mine 3, near Haileyville	33	a[1]	3.21	40.28	50.87	4.41	1.23		13,989
McAlester bed, mine 6, southwest of Haileyville; from carload of lump coal, ready for shipment	34	a	3.55	35.85	56.43	3.07	1.10		13,788
McAlester bed, mine 6, southwest of Haileyville; from working face of mine, represents full thickness of coal	35	a	3.88	38.20	52.36	4.35	1.21		13,656
McAlester bed, mine 1, Pittsburg; from a working face in third west entry	39	a	5.03	34.18	53.88	5.39	1.52		13,032
McAlester bed, mine 1, Pittsburg; represents carload shipment of well-screened coal	40	a	4.80	33.91	57.47	2.42	1.40		13,169
McAlester bed, mine 1, Pittsburg; from car of mine-run coal	41	a	4.95	35.01	50.24	8.38	1.42		12,648
McAlester bed, mine 1, Pittsburg; selected sample, lump coal	42	a	2.56	37.69	48.86	8.11	2.78		13,077
McAlester bed, mine 1, Pittsburg; from carload; small coal, 50 percent; slack, 50 percent	43	a	4.79	37.30	47.58	10.33	3.93		13,005
McAlester bed, mine 1, Pittsburg	44	a	2.12	39.37	50.47	6.95	1.09		13,781
McAlester bed, mine 1, Pittsburg	45	b	4.54	37.50	49.40	8.56			12,710
McAlester bed, mine 1, Pittsburg; 2d west air course	46	b	2.97	40.43	48.22	8.38	3.05		12,591
McAlester bed, mine 1, Pittsburg; 5th east air course	47	b	2.93	39.02	47.75	10.30	3.73		
McAlester bed, mine 1, Pittsburg; car sample of mine-run coal	48	b	3.45	37.45	47.82	11.28	3.67		12,258
McAlester bed, mine 1, Pittsburg; a, coal as shipped; b, washed coal	49a	b	3.00	37.10	50.03	9.87	3.20		
	49b	b	3.61	38.99	49.73	7.67	3.27		
McAlester bed, mine 2, Pittsburg; from fresh face, 2d east entry	50	a	5.46	34.69	51.84	6.37	1.64		13,162
McAlester bed, mine 2, Pittsburg; selected sample, lump coal	51	a	2.19	40.35	48.23	5.96	3.27		13,529
McAlester bed, mine 2, Pittsburg	52	a	2.01	37.91	49.22	8.54	2.32		13,361
McAlester bed, mines 1 and 2, Pittsburg; from sack of washed slack from washer at mine 2	53	a	2.93	40.95	49.68	6.44			14,000
McAlester bed, mines 2 and 3, Dow; from a car being loaded from trips from both mines	54	a	2.99	35.72	56.12	3.80	1.37		13,915
McAlester bed, mine 5, Dow; 1st south off north plane	55	a	2.64	36.02	54.72	5.42	1.20		13,807
McAlester bed, mine 8, south of Krebs; from face at end of mine slope, 4,500 feet from mouth	56	a	2.50	35.82	53.50	6.79	1.39		13,687
McAlester bed, mines 2, 5, and 9, McAlester area; from carload of washed nut coal, as shipped from washer at Krebs	57	a	1.91	36.40	54.63	6.11	.95		14,043
McAlester bed, mines 2, 5, 9, McAlester area; from carload of washed nut coal, as shipped from washer at Krebs	58	a	1.98	36.06	55.37	5.52	1.07		14,173
McAlester bed, mines 2, 5, and 9, McAlester area; from refuse of coal from washer at Krebs	59	a	7.05	14.50	39.25	42.43	5.77		
McAlester bed, mine 10, Krebs; from coal at mine, ready for shipment	60	b	1.74	37.00	56.86	4.40	.65	0.014	
McAlester bed, Homer slope (?) north of Krebs; from working face, represents full thickness of coal	61	a	3.55	34.92	55.53	4.75	1.25		13,865
McAlester bed, north of North McAlester; from pile of coal just removed from mine	62	a	3.23	35.86	56.66	3.04	1.21		14,343
Hartshorne bed, mine 1, Hartshorne; from coal ready for shipment	63	b	1.68	41.00	51.91	5.41	2.72	.012	
Lower Hartshorne bed, mine 3, Gowen	64	a[1]	4.32	38.57	48.42	7.30	1.39		13,353

McAlester bed, mine 5, Alderson; from fresh working face in room 28, 2d east entry	65	a	2.17	37.95	54.88	3.98	1.02	--------	14,691
McAlester bed, mine 5, Alderson; from block of coal on exhibit at Mineral Building, State Fair Grounds, Oklahoma City	66	a	1.71	37.46	55.47	4.48	.88	--------	14,310
Lower Hartshorne bed, mine 7, 1 mile east of Hartshorne; from working face in 1st north, 3d east entry	67	a	3.10	37.91	50.79	6.56	1.64	--------	13,690
Lower Hartshorne bed, mine 7, 1 mile east of Hartshorne; from carload of lump coal at tipple	68	a	2.42	40.06	48.02	6.36	3.14	--------	13,764
Lower Hartshorne bed, mine 7, 1 mile east of Hartshorne; represents carload of slack coal	69	a	2.95	35.85	44.46	14.14	2.60	--------	12,049
Lower Hartshorne bed, mine 7, 1 mile east of Hartshorne; from block of coal on exhibit at Mineral Building, State Fair Grounds, Oklahoma City	70	a	1.85	39.01	46.43	9.53	3.18	--------	13,094
Lower Hartshorne bed, mine 7, Hartshorne	71	a1	4.04	39.44	47.44	5.88	3.20	--------	13.350
Lower Hartshorne bed, mine 8; a, room 14, off east entry; b, room 16, off 7th west entry	72a	b	1.46	39.04	53.10	6.40	1.38	--------	14,040
	72b	b	1.30	38.90	52.15	7.65	1.58	--------	--------
Lower Hartshorne bed, mine 8, Hartshorne; mine-run coal; a, car sample: b, from quantity to be used for coking tests	73a	b	1.70	37.19	49.79	11.32	1.56	--------	12,874
	73b	b	1.66	38.29	49.84	10.21	1.50	--------	--------
Hartshorne bed, mine 8, Hartshorne; from carload of nut and slack	74	b	3.71	36.21	50.31	9.77	1.39	--------	13,414
Lower Hartshorne bed, mine 8, Hartshorne	75	a1	2.59	40.25	49.85	5.17	2.14	--------	13,833
Lower Hartshorne bed, mine 40, Gowen; from working face in 1st west entry	76	a	3.00	39.34	50.86	5.66	1.14	--------	13,701
Lower Hartshorne bed, mine 2, Pocahontas; from working face in 6th east entry	77	a	2.45	37.92	52.82	5.91	.90	--------	13,932
Lower Hartshorne bed, mine 2, Pocahontas; represents carload of lump coal as loaded at tipple	78	a	2.25	38.01	47.39	10.08	2.27	--------	13,112
Lower Hartshorne bed, mine 2, Pocahontas; sample from carload of lump coal	79	a	2.07	39.74	47.42	8.56	2.21	--------	13,263
McAlester bed, mine 1, 1 mile west of North McAlester; from car ready for shipment	80	b	2.08	37.52	56.02	4.38	.80	.016	--------
McAlester bed, mine 2, west of North McAlester; represents carload lot of mine-run coal	81	a	3.72	34.86	51.57	8.89	.96	--------	13.244
McAlester bed, mine 2, west of North McAlester; from mine car just loaded from 6th west entry	82	a	3.33	34.47	52.87	8.45	.83	--------	13,297
McAlester bed, mine at Alderson	111	c	2.35	32.42	58.47	4.32	2.42	--------	--------
Hartshorne bed, Hughes, 2 miles east of Krebs; from product of mine ready for shipment	113	b	1.04	37.96	55.84	5.16	2.00	.012	--------
McAlester bed, Carbon (Cherryvale)	114	c	2.54	30.90	62.37	3.56	.60	--------	--------
Lower Hartshorne bed, mine 7, Hartshorne; from block of coal on exhibit at Mineral Building, State Fair Grounds, Oklahoma City	115	a	1.85	39.01	46.53	9.53	3.08	--------	13,145
McAlester bed, mine 5, northeast of McAlester; from face of slope, represents full thickness of coal	138	a	2.83	34.14	55.40	6.93	.70	--------	13,770

[1] a, Oklahoma Geological Survey; a_1, Oklahoma Geological Survey and coal company; b, U. S. Geological Survey; c, N. F. Drake.

PRODUCTION

Coal mining on a commercial scale in the Indian Territory began near McAlester in 1872, immediately after the construction of the Missouri, Kansas & Texas Railroad. About 9 years later mining operations began at Savanna, about 8 miles southwest of McAlester and on the same railroad. Later, the Choctaw, Oklahoma & Gulf Railroad (now Chicago, Rock Island & Pacific) from McAlester eastward began mining operations in the eastern part of the district. Since that time branch lines of the two railroads have been built parallel to the main lines of outcrop of the commercially important coal beds, and at present no outcrop of such coal beds within the McAlester district is more than 4 miles from a railroad. Good connections can be made from these railroads to others that lead to all parts of the country.

No records of the coal produced in the Indian Territory before 1880 are available, but to judge from the production of 120,947 short tons in 1880 and the increases in output in succeeding years, it seems probable that there was a progressive increase in production from a small tonnage in 1872 and a total production of about 500,000 tons by 1880. Between 1880 and 1907, 37,327,369 short tons of coal was produced in the Indian Territory. It is estimated that about two-fifths of this came from the McAlester district, for mining was done there for some years before it was begun in the other fields and furthermore the McAlester district has produced about one-third of the total output since 1908. In 1907, when the Indian Territory became a portion of the State of Oklahoma, records were begun of the production from the several counties. As Pittsburg County includes practically all of the McAlester district and very little of any other mining district, the record for Pittsburg County may be regarded as representing the McAlester district with but slight error. From 1908 to 1927 Pittsburg County produced 23,264,950 short tons. I estimate that a total of about 38,000,000 short tons was produced in the McAlester district between 1872 and 1927.

Coal produced in Indian Territory, 1880–1907, in short tons

[Compiled from Mineral Resources of the United States]

Year	Production	Year	Production	Year	Production
1880	120,947	1890	869,229	1900	1,922,298
1881	150,000	1891	1,091,032	1901	2,421,781
1882	200,000	1892	1,156,603	1902	2,820,606
1883	350,000	1893	1,197,468	1903	3,517,388
1884	425,000	1894	969,606	1904	3,046,539
1885	500,882	1895	1,211,185	1905	2,924,427
1886	534,550	1896	1,366,646	1906	2,860,200
1887	685,911	1897	1,336,380	1907	3,642,658
1888	761,986	1898	1,381,466		
1889	752,832	1899	1,537,427		37,327,369

Coal produced in Pittsburg County and in Oklahoma, 1908–27, in short tons

[Compiled from Mineral Resources of the United States]

Year	Pittsburg County	Oklahoma	Year	Pittsburg County	Oklahoma
1908	1,294,936	2,948,116	1918	1,364,207	4,813,447
1909	1,271,109	3,119,377	1919	1,170,061	3,802,113
1910	1,083,243	2,646,226	1920	1,404,170	4,830,288
1911	1,018,742	3,074,242	1921	1,283,551	3,362,623
1912	1,234,334	3,675,418	1922	1,022,179	2,802,511
1913	1,429,350	4,165,770	1923	1,241,943	2,885,038
1914	1,373,771	3,988,613	1924	717,794	2,329,615
1915	1,132,272	3,693,580	1925	774,100	2,325,840
1916	977,043	3,608,011	1926	965,784	2,842,673
1917	1,279,063	4,386,844	1927	1,227,298	3,818,054
				23,264,950	69,118,399

Labor troubles have had but slight effect on coal production in the McAlester district. In 1894, 1910, and 1919 prolonged strikes caused decreases of 227,862, 187,866, and 194,146 short tons, respectively, or of 19.0, 14.8, and 14.2 percent from the preceding year. The high production in 1913 resulted from labor troubles in Colorado, which temporarily opened new markets for Oklahoma coal.

The first competition from fuel oil and natural gas came in 1905, but in about 3 years the price of oil rose so high that it could not compete with coal. However, some fuel oil and natural gas replaced coal in each successive year, and by 1920 the Midcontinent output of petroleum and natural gas had become so great and the price of the products so low that several large railroads installed oil-burning locomotives and many towns piped in natural gas for home and factory use. This has resulted in a pronounced decrease in coal production. The sharp increase in production in 1927 was due to increased demand resulting from a general strike in union coal fields, particularly those fields east of the Mississippi River.

Twenty-six commercial mines and several wagon mines were operating in the McAlester district in 1930. A list of the commercial mines is given below:

Operating commercial coal mines in the McAlester district, 1930

	Mine
Julian Coal & Mining Co., McAlester, Okla	No. 1.
Old Town Coal Co., Dow, Okla	Old Town.
Samples Coal & Mining Co., McAlester, Okla	No. 4.
Osage Coal Co., McAlester, Okla	No. 5.
Do	Henry Maione.
Homer Bros. Coal Co., Krebs, Okla	Homer's slope.
Rock Island Improvement Co., Hartshorne, Okla	No. 7.
Messina Coal Co., Haileyville, Okla	No. 2.
Milby & Dow Coal & Mining Co., Dow, Okla	No. 10.
Do	No. 9.
Carbon Coal Co., McAlester, Okla	No. 4.
Pittsburg County Coal Co., McAlester, Okla	No. 5.

Operating commercial coal mines in the McAlester district, 1930—Continued

	Mine
Richard-Thompson Coal Co., McAlester, Okla	No. 5.
Adamson Coal Co., Henryetta, Okla	No. 7.
Pierce Coal Co., McAlester, Okla	No. 1.
A. L. Sukenis, Adamson, Okla	No. 4.
Rock Island Improvement Co., Hartshorne, Okla	No. 12.
Do	No. 10.
Kali Inla Coal Co., Hartshorne, Okla	No. 1.
Messina Coal Co., Haileyville, Okla	Craig No. 1.
McAlester Edwards Coal Co., McAlester, Okla	No. 1.
Pittsburg McAlester Coal Co., Pittsburg, Okla	No. 4.
Blanco Coal Co., Dow, Okla	Nos. 1 and 2.
Palmer & Hubble, Haileyville, Okla	Slope Panels Nos. 1 and 2.
McAlester Colliery Co., McAlester, Okla	No. 1.
Hartshorne Coal Co., Hartshorne, Okla	No. 1.

MINING METHODS

Coal has been mined in the McAlester district both by surface stripping and by underground mining by slope and shaft. The underground mining has been by far the more prevalent, and slope mining has been done somewhat more extensively than shaft mining.

In the slope mines the entries are driven down the dip of the coal beds, and cross entries are driven along the strike. In the larger slope mines the double-entry room and pillar method of mining is used; in smaller mines the single-entry room and pillar method is generally used. In shaft mines the shaft is sunk to the coal, and cross headings are driven from the foot of the shaft.

At the time when the samples for the analyses on pages 65–77 were taken the coal was undercut in most mines by hand and shot down with black powder. In some other mines the coal was undercut by machine and shot down with "permissible" explosives,[35] and in others the coal was shot off the solid face with black powder. In recent years the use of undercutting machines and permissible explosives has increased, however. Roof material is shot down in most mines with 40 percent dynamite and permissible explosives.

All strip mines in the district are abandoned. In one of these the overburden was removed by drag-line scoop operated by a steam winch. So far as could be determined, in all other strip mines the overburden was removed by steam shovel. The coal was then removed by the same method as the overburden or by prying free with wedges. The strip pits have a total length of 8¾ miles and range from 25 to 35 feet in depth and 100 to 200 feet in width, the size depending on the dip of the coal bed. With modern equipment

[35] Any device that has passed standard tests and is officially approved by the U. S. Bureau of Mines is termed "permissible."

stripping could be carried on profitably to a greater depth than was possible when that method of mining was used in the McAlester district.

Coal is shipped from the McAlester district both as run-of-mine and size-graded coal. Most of the coal is graded into four sizes—lump, nut, pea, and slack—although at some mines the last two are combined as "screenings." Shaker screens are generally used for separating the coal into the commercial sizes. Rock is removed from the coal by hand picking, and the coal is not washed.

Mine explosions have been common in the McAlester district from the earliest days of the field until the present time. These are largely due to the amounts of explosive gases present in the mines and can be avoided or greatly reduced in number by observance of strict precautionary measures.

USE AND MARKETS

Steam and domestic coal.—Coal from the McAlester district has been used chiefly as steam coal and domestic fuel. It is a good quality steam coal and has been used in great quantities in railroad locomotives, but that use has decreased with the introduction of oil-burning engines. It has been used throughout Oklahoma, Texas, and parts of Louisiana, Arkansas, Missouri, Kansas, Colorado, and New Mexico as a domestic fuel, but the introduction of natural gas into the cities and many of the smaller towns has curtailed that use considerably in recent years.

Coke.—From 1880 to 1908 considerable coke was produced in the McAlester district. Washed slack coal and beehive ovens were used almost entirely. A few attempts were made to use unwashed slack coal and crushed and washed run-of-mine coal, but these proved unsatisfactory. Coal from the McAlester and Lower Hartshorne beds was used. Analyses of coke from the McAlester district are given below. The amount of coal used in coking and the amount of coke produced for the years 1880–1908 are given in the second table.

Analyses of coke from McAlester district

	1 (washed)	2 (washed)	3	
			Unwashed	Washed
Carbon	82.50	90.680	75.68	85.330
Volatile matter	4.53	1.340	1.74	2.590
Ash	11.60	4.570	14.45	11.120
Phosphorus	.01	.024	.05	.043
Sulphur	1.06	1.840	1.50	1.750

1. U. S. Geol. Survey Mineral Resources, 1887, p. 400, 1888.
2. U. S. Geol. Survey 19th Ann. Rept., pt. 6, p. 596, 1898.
3. U. S. Geol. Survey Prof. Paper 48, pt. 3, p. 1338, 1906.

Coke produced in McAlester district, 1880–1908

Year	Coal used (short tons)	Coke produced (short tons)	Year	Coal used (short tons)	Coke produced (short tons)
1880	2,494	1,546	1895	11,825	5,175
1881	2,852	1,768	1896	53,028	21,021
1882	3,266	2,025	1897	68,495	30,364
1883	4,150	2,573	1898	73,330	34,110
1884	3,084	1,912	1899	59,255	24,339
1885	5,781	3,584	1900 [1]	79,534	38,141
1886	10,242	6,351	1901 [1]	74,746	37,374
1887	20,121	10,060	1902 [1]	110,934	49,441
1888	13,126	7,502	1903 [1]	110,088	49,818
1889	13,227	6,639	1904 [1]	98,847	44,808
1890	13,278	6,639	1905	123,389	54,781
1891	20,551	9,464	1906	95,296	49,782
1892	7,138	3,569	1907	38,615	19,089
1893	15,118	7,135	1908	(2)	2,944
1894	7,274	3,051			

[1] Product of 100 beehive ovens at Howe, in the Wilburton-Poteau district, is included.
[2] Not reported.

PETROLEUM AND NATURAL GAS

The McAlester district lies south and east of areas of commercial production of petroleum and natural gas but has not yet been adequately tested for such resources. So far as I have been able to ascertain only five holes have been drilled in the district to test petroleum possibilities. Only two of these holes were located on well-defined anticlines. A show of gas was encountered in the Hartshorne sandstone in one hole, but no potentially productive stratum was reached in the other.

Reservoir beds or "sands" are known to underlie the anticlines in the McAlester district, but the folding and fracturing of the beds is thought to have been so intense that most of the petroleum has either been destroyed or allowed to escape. The average percentage of fixed carbon in the coals of the McAlester district is about 60, calculated on a pure-coal basis. According to the theory of carbon ratios[36] this is so high that probably little petroleum may be present in the area, and that is likely to be of very high gravity. However, natural gas may be present in suitable reservoirs. The petroleum and natural gas possibilities of the parts of the area structrally suited for the accumulation of oil or gas are discussed below. The location and extent of the structural features discussed herein are shown on the geologic map (pl. 2, in pocket).

Craig anticline.—There is a closure of about 60 feet on the Craig anticline in secs. 3, 9, and 10, T. 4 N., R. 16 E., the structure thus being suitable for the accumulation of natural gas. However, the Hartshorne sandstone, which is the potential shallow gas sand, may have been flushed out by circulating waters, as it crops out about 1 mile from the area of closure. Deeper sands in the Atoka formation might yield natural gas. A well drilled on this anticline in 1932 by the Ruby-

[36] White, David, Some relations in origin between coal and petroleum: Washington Acad. Sci. Jour., vol. 5, pp. 189–212, 1915.

Ann Oil & Gas Corporation yielded only a show of gas from the Hartshorne sandstone, but as it was outside the area of structural closure it cannot be considered an adequate test.

Savanna anticline.—On the Savanna anticline between its west end and the northeast corner of T. 4 N., R. 14 E., there is a closure of several thousand feet. However, it is likely that the intense folding that produced the anticline has thickened the Atoka shale exposed at the crest so much that the reservoir rocks below the Atoka are too deep to be reached by drilling. Some sands in the Atoka might bear natural gas.

McAlester anticline.—A fault is present on the crest of the McAlester anticline. It is possible that the fault may have supplied a vent for the drainage of any natural gas accumulated on that part of the anticline, or it may have sealed some gas-bearing sand and produced a reservoir. There are very small local noses or terraces on the west end of the McAlester anticline that might permit the accumulation of small amounts of natural gas.

Coalgate anticline.—The Coalgate anticline enters the district in sec. 13, T. 2 N., R. 12 E., and plunges eastward. In the E½ sec. 13 a cross fold reverses the plunge of the anticline, and the axis rises eastward to the east side of sec. 17, T. 2 N., R. 13 E., where the anticline dies out against the regional dips of the zone parallel to the Choctaw fault. The well drilled by C. E. Douglass in 1916 and 1917 to a depth of 2,840 feet on the south flank of the anticline in the SE¼ sec. 13, T. 2 N., R. 12 E., was a dry hole.

Adamson anticline.—No closure is known to exist on the Adamson anticline within this district, but the Atoka formation, which lies close to the crest, is poorly exposed, and some closure may be present. The Carbon fault is probably continuous approximately along the axis of this fold. The fault may have sealed some bed that bears petroleum or natural gas, but it might equally well have served as an avenue of escape for either. A few miles east of the McAlester district, approximately on the line of the Carbon fault, is a gas seep known as Burning Springs.

Burning Springs anticline.—There is no closure on the Burning Springs anticline within the McAlester district, but the beds are reported to close northeast of the district. A show of gas was encountered in the Hartshorne sandstone in the well drilled in 1930 by the Cities Service Gas Co. in sec. 16, T. 6 N., R. 17 E., and it is possible that adequate testing of the anticline would develop a small gas field. In secs. 15 and 16, T. 6 N., R. 16 E., there is a small nose on the north side of the anticline. This might be a favorable place for drilling.

Other anticlines.—No closures were observed on other anticlines within the McAlester district. Several anticlines that plunge out to the south just after crossing the north boundary of the district may have closures outside the district that would be favorable for drilling.

Drilling operations.—Five wells have been drilled to considerable depth in the McAlester district, and drilling has been proposed or started but not carried to adequate depth at several other places. One well has been drilled about three-eighths of a mile north of the district, near the northeast corner. The logs of four of these wells are given below.

In 1916 and 1917 C. E. Douglass drilled a well to a depth of 2,480 feet a short distance south of the axis of the Coalgate anticline, in the SE¼ sec. 13, T. 2 N., R. 12 E. The well was a dry hole but was not drilled to sufficient depth to reach any sand known to be productive in adjoining areas and cannot be considered a good test of the anticline for petroleum or natural gas.

In 1917 the Wagner Oil Co. began drilling a well in the SW¼SW¼ sec. 7, T. 1 N., R. 13 E. This well was abandoned in 1920 at a depth of 1,600 feet. It was started near the top of the Boggy shale and reached no sand known to be productive in adjoining areas. The Boggy shale is concealed beneath Gerty sand at this locality, but so far as I was able to determine the rocks dip only about 1° SE., toward the axis of the Krebs syncline.

In the NE¼ sec. 3, T. 2 N., R. 13 E., a hole drilled for water encountered oil at a depth of 125 feet.[37]

In 1932 a well was drilled to a depth of 1,282 feet on the Craig anticline in sec. 3, T. 4 N., R. 16 E., by the Ruby-Ann Oil & Gas Corporation. The well was started in the McAlester shale outside the area of structural closure on the anticline and was drilled through the Hartshorne sandstone, which rises to the surface about 1 mile east of the well. Although located in an unfavorable position structurally, the well yielded a show of gas, about 50,000 cubic feet a day, from the Hartshorne sandstone.

Log of J. H. George well of Ruby-Ann Oil & Gas Corporation (sec. 3, T. 4 N., R. 16 E.)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	2	2	McAlester shale—Contd.		
McAlester shale:			Sandy shale	20	900
Blue shale	178	180	Shale	120	1,020
Black shale	12	192	Hard sand	40	1,060
Blue shale	33	225	Coal and sand (coal about 18 inches; Upper Hartshorne)	4	1,064
Sand	22	247	Hartshorne sandstone:		
Brown shale	68	315	Sand	21	1,085
Blue shale	60	375	Shale	23	1,108
Sand	11	386	Coal (Lower Hartshorne)	4	1,112
Shale	3	389	Shale	4	1,116
Sand	3	392	Sand, hard	87	1,203
Shale	3	395	Sand; show of gas, about 50,000 cubic feet a day	27	1,230
Coal and sand	2	397	Sand, hard	25	1,255
Shale	1	398	Shale	3	1,258
Sand; show of oil	7	405	Sand and last few feet shale (base of Hartshorne sandstone)	24	1,282
Shale	18	423			
Sand	14	437			
Shale	27	464			
Blue shale	62	526			
Black shale	149	675			
Brown shale	205	880			

[37] Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 19, pt. 2, pp. 39–40, 1917.

In 1922–24 Ward A. Smith drilled to a depth of 2,102 feet in the center of the S½SE¼SE¼ sec. 22, T. 3 N., R. 13 E., about half a mile southeast of the axis of the Kiowa syncline. This was a dry hole.

Log of Ward A. Smith well (sec. 22, T. 3 N., R. 13 E.)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Boggy shale (near middle): [1]			Savanna sandstone—Contd.		
Soil	5	5	Blue mud	17	1,740
Sandstone	10	15	Dark shale	47	1,787
Blue shale	55	70	Light lime shell (probably calcareous sandstone [1])	20	1,807
White shells	20	90	Dark shale	31	1,838
Red shale	170	260	Sandy lime	7	1,845
White sandstone	5	265	Dark shale	10	1,855
Blue shale	40	305	Light lime	3	1,858
Shale	55	360	Dark shale	35	1,893
Red shale	70	430	Light lime (probably sandstone [1])	7	[illegible]
Blue shale	45	475	Dark shale	45	1,945
Gray lime (probably sandstone [1])	25	500	Dark lime (probably sandstone [1])	5	1,950
Red mud	150	650	Dark shale	35	1,985
Gray shale	310	960	Light lime	10	1,995
Red mud	42	1,002	Light shale	46	2,041
Gray shale	160	1,162	Dark lime (probably sandstone [1])	3	2,044
White sand	18	1,180	Blue shale	24	2,068
Gray shale	225	1,405	Sandy lime shell (probably calcareous sandstone [1])	24	2,092
Sand	6	1,411	White sand	8	2,100
Gray sandy shale	179	1,590	White shale	2	2,102
Red mud	15	1,605			
Light shale	88	1,693			
Savanna sandstone: [1]					
White lime (probably sandstone [1])	20	1,713			
Gray lime (probably sandstone [1])	10	1,723			

[1] Interpretation added by writer from study of nearby outcrops.

In 1930 the Cities Service Gas Co. drilled a well to a depth of 2,285 feet in the NW¼NW¼ sec. 16, T. 6 N., R. 17 E., a short distance south of the axis of the Burning Springs anticline. Shows of gas were noted from the Hartshorne sandstone at depths of 2,105, 2,145, and 2,205 feet.

Log of J. R. Hughes well of Cities Service Gas Co. (NW¼NW¼ sec. 16, T. 6 N., R. 17 E.)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Savanna sandstone (near base):			McAlester shale—Contd.		
Soil	10	10	Black shale	0	1,393
Soft sandstone	5	15	Shale; show of gas at 1,475-1,480 feet	482	1,875
McAlester shale:			Black shale	65	1,940
Yellow clay	8	23	Shale	25	1,965
Soft gray shale	207	230	Sand	13	1,978
Hard gray shale	30	260	Shale	24	2,002
Soft shale; show of gas at 665 feet	490	750	Coal (Upper Hartshorne)	2	2,004
Lime	5	755	Hartshorne sandstone:		
Shale	65	820	Shale	21	2,025
Black shale	170	990	Shale, very soft and black	38	2,063
Shale	106	1,096	Coal (Lower Hartshorne)	3	2,066
Hard sand; show of gas	9	1,105	Sand, broken	29	2,095
Sand	35	1,140	Hard sand	10	2,105
Shale	88	1,228	Sand, broken; show of gas	40	2,145
Hard sand	7	1,235	Shale	10	2,155
Hard shale	5	1,240	Sand	50	2,205
Sand and shells, broken	50	1,290	Sand, broken; show of gas	20	2,225
Hard gray sand	28	1,318	Atoka formation:		
Shale	47	1,365	Shale	15	2,240
Sand and shells, broken	20	1,385	Sand and shale	45	2,285

In 1930 the Cities Service Gas Co. drilled a well to a depth of 3,004 feet on the Burning Springs anticline three-eighths of a mile north of the McAlester district, in the center of the NW¼SE¼ sec. 9, T. 6 N., R. 17 E. This was a dry hole.

Log of Featherstone No. 1 well of Cities Service Gas Co. (NW¼SE¼ sec. 9, T. 6 N., R. 17 E.)

[NW¼SE¼ sec. 9, T. 6 N., R. 17 E.]

	Thickness (feet)	Depth (feet)
Savanna sandstone (near base):		
Hard rock	14	14
McAlester shale:		
Blue clay	6	20
Blue shale	45	65
Sand	45	110
Blue shale	570	680
Coal (McAlester bed)	3	683
Blue shale	47	730
Sand	50	780
Blue shale	320	1,100
McAlester shale—Continued.		
Gray sand	95	1,195
Blue shale	65	1,260
Gray sand (broken)	78	1,338
Blue shale	47	1,385
Broken sand	20	1,405
Blue shale	586	1,991
Hartshorne sandstone	189	2,180
Atoka formation:		
Black shale	160	2,340
Broken sandy shale	664	3,004

CLAY AND SHALE FOR BRICK

Bricks have been manufactured in two plants in the McAlester district. One of these, at the Oklahoma State Penitentiary, was operating in 1930 and was using clay shale from the Atoka formation. The second plant was on the east side of the city of McAlester but had been abandoned before 1930. This plant used shale from the upper part of the Savanna sandstone. Both of these shales are dark clay shales essentially free from grit, and both yielded a red brick of good quality.

The Atoka formation, McAlester shale, Savanna sandstone, and Boggy shale each contains a great amount of shale. Some of this shale probably contains too much calcareous material (lime carbonate) to be suitable for making bricks, but much of the shale in those formations would be satisfactory for that use.

Locally, thin underclays are present beneath the Lower Hartshorne and McAlester coal beds in the McAlester district. (See pls. 8–10.) These underclays would be suitable for making bricks, and some of them might yield refractory bricks.

The suitability of any one bed of shale or underclay for brickmaking should be tested before attempting to use it for that purpose on a commercial scale.

BUILDING STONE

Sandstone from several horizons has been used locally for building stone and has proved satisfactory for that purpose. The Hartshorne sandstone, particularly between Carbon and Adamson, contains beds of fine-grained hard ash-gray sandstone about 3 inches to 1 foot thick that weather light brown. This sandstone would be satisfactory for building stone but is too thin-bedded to be useful for structural stone. Locally some of the sandstone in the McAlester shale is hard, fine-grained, and evenly thin-bedded. This stone is light gray when fresh, weathers to a very light brown, and would make a durable and attractive building stone. The sandstone in the other formations is for the most part buff or light tan when fresh and weathers to a deep, rich brown. It is not so well cemented as the sandstone in the Hartshorne and McAlester formations and softens on weathering. Such sandstone would be unsuited for use as a building stone, but locally any one sandstone might be pure enough and hard enough for that use.

ROAD METAL

Most of the mine dumps in the McAlester district have burned spontaneously and have formed considerable amounts of clinker, a hard, angular porcelain-like material of light-red color. This clinker has been used without any binder for surfacing many of the roads in the district and has proved very satisfactory for that purpose. If used with some binder such as macadam or asphaltum, the sharpness of the edges and hardness of the clinker might result in the cutting of rubber tires, unless an asphaltum or macadam surface were placed over the clinker, which would then serve purely as a foundation filler.

SAND AND GRAVEL

The Gerty sand is made up largely of sand with lesser amounts of gravel and clay. The sand could be used as a filler in concrete work and in other structural work. It is almost entirely a silica sand, but it would probably not be useful as a glass sand, as much of it is yellow and red rather than the pure white desirable for glass making. The gravel in the Gerty sand could be used as a surfacing material for roads or as a filler in concrete work. Gravel is not found in the Gerty sand at all places but is present in rather local deposits that are largely concentrated in the belt that extends from the west side of the district nearly to Haileyville and in three areas whose locations are given in figure 3 (p. 29).

The upper part of the Hartshorne sandstone southeast of Gowen in the eastern part of the district is very coarse grained, friable, white, and pure. This sandstone might be satisfactory as a glass sand, but it should be tested thoroughly before any attempt is made to use it commercially. A large amount of this sand is easily available.

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