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

PART 4. THE HOWE-WILBURTON DISTRICT LATIMER AND LE FLORE COUNTIES

BY

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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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PART 4. THE HOWE-WILBURTON DISTRICT, LATIMER AND LE FLORE COUNTIES

By Thomas A. Hendricks

ABSTRACT

The Howe-Wilburton district is a narrow area of about 540 square miles that extends westward from the Arkansas State line for about 60 miles across Latimer and Le Flore Counties, Okla. It lies in the southern part of the Arkansas Valley physiographic province and is a part of the large Arkansas-Oklahoma coal field.

The exposed stratified rocks of the district belong to the Atoka, Hartshorne, McAlester, Savanna, and Boggy formations, of Pennsylvanian age, and consist of alternating beds of shale and sandstone with some coal and lenticular limestone beds. The total thickness of the formations is about 13,000 feet. No pronounced unconformity could be found in the section, but minor unconformities are present at the base of the Savanna and Hartshorne sandstones. Overlying these beds at one place in the district is a small area of Gerty sand, a deposit of an abandoned Quaternary (?) river channel. The other unconsolidated deposits consist of sand and gravel on former stream terraces and recent alluvium.

The rocks of the district have been deformed by folding and faulting. The folding has produced a series of eastward-trending broad, gentle synclines and narrower, more sharply folded anticlines. The principal synclines are, from east to west, the Poteau Mountain, Sugarloaf, Cavanal, Sansbois, and Hartshorne synclines. The principal anticlines are, from east to west, the Hartford, Heavener, Brazil, Wilburton, and Adamson anticlines. All the folds are symmetrical except the Adamson anticline, on which the strata on the north flank are more steeply inclined than those on the south flank. The Adamson anticline differs from the other folds also in that the strata near the axis of the fold are broken by a thrust fault, the Carbon fault, along which the beds on the south side have been thrust upward and northward onto younger beds on the north side. On the flanks of the Wilburton, Adamson, and Heavener anticlines the strata commonly dip 40° or more, but in the other anticlines and all the synclines dips as great as 10° are rare. The Choctaw fault separates the strata of the coal basin from the more intensely deformed strata of the Ouachita Mountains, which lie to the south. Along that fault strata on the south side have been thrust northward over younger strata on the north side.

Coal and natural gas are the chief mineral resources of the district. The Howe-Wilburton district has been a large coal-producing area for about 45 years, and it is estimated that about 19,000,000 tons has been produced since mining began in 1890. The coal in the western part of the district is of medium-volatile bituminous rank, and that in the eastern part is of low-volatile bituminous rank.

All of the coal is of good quality and is good steam and domestic coal. Between 1900 and 1905 coke was produced at Howe, in the eastern part of the district, and all the coal would yield satisfactory coke if a market were available.

Most of the coal mining has been done in the Lower and Upper Hartshorne beds, although some has been done in the McAlester and Cavanal beds. Considerable reserves of coal in these four beds are present in the district, and some future mining may also be done in the Stigler (?) and Secor beds.

Natural gas has been produced at three places in the district—the Wilburton gas field, the Red Oak field, and the Poteau-Gilmore field. Most of the gas produced has been used locally, but most of the wells in the Red Oak field have been shut in and the field held as a gas reserve for future use. It is possible that gas might be encountered in wells drilled on the Adamson, Heavener, Summerfield, and Howe anticlines, as well as in a belt adjacent to the Choctaw fault.

The percentages of fixed carbon in the coals (moisture- and ash-free) in the Howe-Wilburton district increase progressively from less than 60 at the west side to more than 77.5 in the eastern part. According to the carbon-ratio theory it appears unlikely that any petroleum may be found east of the 65 isocarb, which runs northwestward through the central part of the district. Some petroleum may be present in suitable resservoirs in the extreme western part of the district, where the percentages of fixed carbon in the coals are less than 65.

Sand and gravel and shale suitable for the manufacture of brick are present in the district.

INTRODUCTION

LOCATION AND AREA

The Howe-Wilburton district lies on the southern margin of the Oklahoma coal field and immediately north of the Ouachita Mountains in east-central Oklahoma (fig. 12). Prior to 1907, when the Oklahoma Territory and the Indian Territory were united to form the State of Oklahoma, the Howe-Wilburton district lay within the reservation set aside by the Federal Government for the Choctaw Nation, one of the Five Civilized Tribes of Oklahoma Indians. The area extends westward from the Arkansas State line to the McAlester district, a distance of about 60 miles. The width of the district from north to south ranges from about 15 miles at the east side to as little as 5 miles, and the average width is about 9 miles. The towns of Wilburton and Howe, from which the district takes its name, are near the west end and east end of the area, respectively. The area of the district is about 540 square miles, of which about 342 square miles is in Le Flore County and 198 in Latimer County.

PREVIOUS PUBLICATIONS

In 1890 a report by Chance [1] on a part of the Coal Measures between Cavanal, which lies in the eastern part of the district, and McAlester, which lies west of the district, was published. This report contains a map that shows the lines of outcrop of the most important coal beds.

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

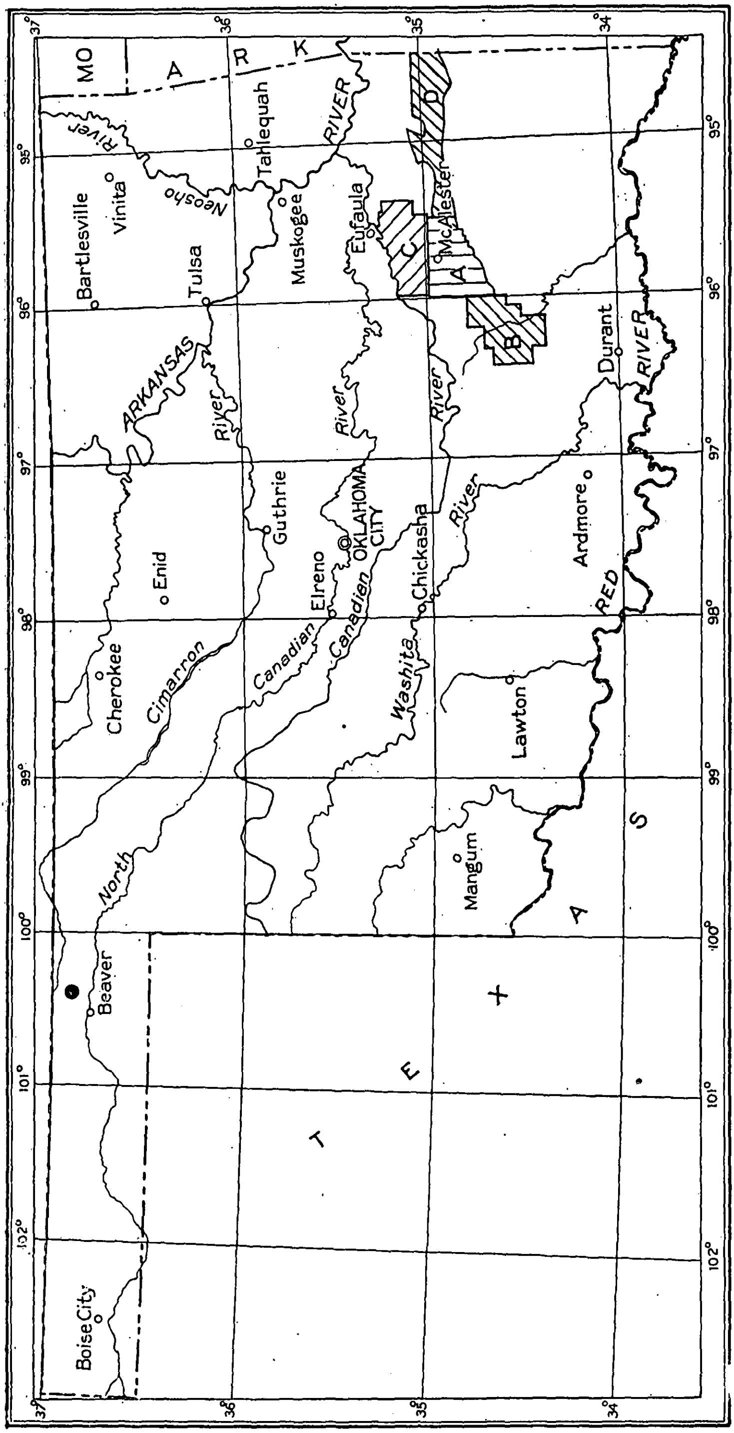

FIGURE 12.—Index map showing location of the Howe-Wilburton district and relation to other areas recently mapped by the Geological Survey in southeastern Oklahoma. A, McAlester district; B, Lehigh district; C, Quinton-Scipio district; D, Howe-Wilburton district.

It gives vertical sections of the beds present, structure sections showing the attitude of the beds along several lines, and general descriptions of the types of rocks present in the area.

The results of several months' study of the coal fields of the Indian Territory by Drake[2] were published in 1897. Accompanying his report is a geologic map of the coal fields of the territory, on which the rocks present in the Howe-Wilburton district are divided into three groups, although no detailed sections of these groups are given for the Howe-Wilburton district. Many of the structural features of the area are shown on the map, and the text describes and interprets the structural features.

In 1900 Taff and Adams[3] prepared for the Geological Survey of the United States Department of the Interior a report on the eastern Choctaw coal field, Indian Territory, which includes the Howe-Wilburton district. The extent and general character of the various rock formations and coal beds are given in that report. The major structural features and coals are described, and a geologic map on a scale of 2 miles to the inch accompanies the report and shows the locations of formational boundaries. A detailed description of the topography is also given.

A report by Taff[4] published in 1905 added very little to his earlier discussion of the Howe-Wilburton district, but a small-scale map showing the areal geology and the outcrops of the coal beds of all the eastern Oklahoma coal fields make clear the general relation of the geology of the Howe-Wilburton district to that of the other districts in the coal fields of eastern Oklahoma.

In 1907 the Federal Geological Survey published a report by Collier[5] on the Arkansas coal field, which lies adjacent to the Howe-Wilburton district on the east. Some of the rock formations and structural axes extend from that area into the Howe-Wilburton district.

In 1910 a Senate Document[6] on Oklahoma coal lands was published. It contains coal outcrop maps on a scale of 2 inches to a mile and much information on the production, extent, quality, and value of coals in the Howe-Wilburton district and several other districts in Oklahoma. This document represented 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 Oklahoma.

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[2] Drake, N. F., A geological reconnaissance of the coal fields of the Indian Territory: Am. Philos. Soc Proc., vol. 36, no. 36, pp. 326–419, 1897.

[3] 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, pp. 257–312, 1900.

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

[5] Collier, A. J., The Arkansas coal field: U. S. Geol. Survey Bull. 326, 1907.

[6] Coal lands in Oklahoma: 61st Cong., 2d sess., S. Doc. 390, 1910.

In 1914 the Oklahoma Geological Survey published a bulletin by Snider [7] on the geology of east-central Oklahoma, which includes the entire area of the Howe-Wilburton district. The features emphasized were the geologic structure and the oil and gas possibilities.

A bulletin by Smith [8] on the Fort Smith-Poteau gas field, Arkansas-Oklahoma, the southwestern part of which lies in the Howe-Wilburton district, was also published in 1914. This report contains a short discussion of the geologic formations present in the area and a detailed discussion of the geologic structure, particularly as related to the accumulation of natural gas. The report is accompanied by a small-scale geologic map.

In 1917 the Oklahoma Geological Survey [9] published a comprehensive bulletin on oil and gas in Oklahoma, which contained a discussion of the geology and oil and gas resources and possibilities of Latimer and Le Flore Counties. This bulletin contains data and discussions very nearly identical with those given in the earlier bulletin by Snider.

In 1926 Shannon and others [10] prepared for the Oklahoma Geological Survey a report that contains 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 Howe-Wilburton district and the other coal districts of the State. Maps of the Wilburton-Red Oak and of the Hughes-Howe-Poteau districts on a scale of 2 miles to the inch show the lines of outcrop of the various coal beds in the Howe-Wilburton district, as well as the locations of many mines, drill holes, and prospect pits.

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

The Oklahoma Geological Survey later published data on Oklahoma coals studied by Moose and Searle [12] in 1928. This report contains much additional information as to the thickness, chemical composition, and heating value of the coals of the Howe-Wilburton district and other districts in the State, together with some additional information on mining practices.

[7] Snider, L. C., Geology of east-central Oklahoma: Oklahoma Geol. Survey Bull. 17, 1914.

[8] Smith, C. D., Structure of the Fort Smith-Poteau gas field, Ark.-Okla.: U. S. Geol. Survey Bull. 541, pp. 23-33, 1914.

[9] Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 19, pt. 2, pp. 283-296, 1917.

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

[11] Analyses of Oklahoma coals: U. S. Bur. Mines Tech. Paper 411, 1928.

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

Stone and Cooper[13] prepared for the Oklahoma Geological Survey a report on the oil and gas possibilities and development in several counties in Oklahoma that was published in 1929. This report covers the entire area of the Howe-Wilburton district and gives much information on drilling and on natural-gas production, together with some rather generalized data on structure.

In 1935 the Federal Geological Survey published preliminary coal maps of the Howe district and the Wilburton district. The maps are on a scale of 2 inches to the mile and show all important features related to the distribution and past mining of coal in the two districts. The maps were published under the sponsorship of H. I. Smith, of the Geological Survey, chiefly for aid in the sale and leasing of segregated Indian coal lands, which are administered by the Mining Division of the Geological Survey.

NATURE AND PURPOSE OF THIS REPORT

The field work on which the present report is based was undertaken primarily to obtain detailed information on the coal resources of the Howe-Wilburton district. The area is of special geologic interest because it connects the McAlester district, in which the formations of the Oklahoma coal fields were defined,[14] with the Arkansas coal field, in which a somewhat different set of formations of the same age were defined by Collier.[15] By tracing the formations of the McAlester district eastward across the Howe-Wilburton district the correlation between formations of the Oklahoma and Arkansas coal fields has been determined.

In the present work all possible subdivisions of the formations were mapped, and much information on which to base detailed descriptions of the formations was obtained.

FIELD WORK

The field work for the present report extended over a period of 3 months in the summer of 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 were mapped in detail, together with all other geologic features and all mining developments. About one-fourth of the area was mapped on airplane photographs taken by the Air Corps of the United States Army on a scale of about 5 inches to a mile. C. B. Read, A. J. Eardley, and I did the geologic work, and T. L. Metcalf served ably as instrument man.

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[13] Stone, J. A., and Cooper, C. L., Oil and gas in Oklahoma, Haskell, Latimer, Le Flore and Sequoyah Counties: Oklahoma Geol. Survey Bull. 40-II. 1929.

[14] Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey 19th Ann. Rept., pt. 3, pp. 436-442, 1899.

[15] Collier, A. J., The Arkansas coal field: U. S. Geol. Survey Bull. 326, 1907.

ACKNOWLEDGMENTS

W. W. Fleming, of the Geological Survey office in McAlester, rendered much assistance that long acquaintance with the district made possible. The analyses and measured sections of the coals and details of mining methods were for the most part compiled from publications of the Bureau of Mines and the Oklahoma Geological Survey. H. I. Smith, of the Geological Survey, made available maps of the underground workings of the coal mines and the aerial photographs used as base maps for a part of the field work.

GEOGRAPHY

Population and accessibility.—The population of the Howe-Wilburton district is well distributed over the entire district. The principal towns are Heavener, Howe, and Wister, in the eastern part; Red Oak, in the central part; and Wilburton, in the western part. Heavener, with a population of about 2,300 (1930 census) is the largest town.

The area is served by three trunk railroad lines. The Chicago, Rock Island & Pacific Railway crosses it from west to east and passes through Wilburton, Red Oak, Fanshawe, Hughes, Wister, Howe, and Monroe. The Kansas City Southern Railway crosses the eastern part of the district from north to south and passes through Howe and Heavener. The St. Louis-San Francisco Railway crosses the eastern part of the district from northeast to southwest and passes through Wister and Le Flore. Two gravel-surfaced United States highways cross the area. United States Highway 270 follows the route of the Chicago, Rock Island & Pacific Railway, roughly, from the west side of the district to a point a few miles northeast of Wister, where it turns southward and follows the route of the Kansas City Southern Railway to the south side of the district. United States Highway 271 follows, roughly, the route of the St. Louis-San Francisco Railway across the area. In addition to these highways, numerous graded roads make all parts of the district easily accessible.

Topography.—The most prominent topographic features of the Howe-Wilburton district are Cavanal, Sansbois, Sugarloaf, and Poteau Mountains, which rise sharply above the surrounding country. The area between these mountains is characterized by a series of long eastward-trending ridges that stand 50 to 300 feet above the intervening valleys. The altitude of the valleys ranges from about 800 feet above sea level in the western part of the district to about 530 feet in the eastern part. The maximum relief is about 2,000 feet, the altitude ranging from about 530 feet where the Poteau River leaves the district at the north side to about 2,530 feet on the crest of Poteau Mountain. The larger streams of the area flow in narrow channels cut about 20 feet below nearly level flood plains that are locally several miles wide and decrease in width toward the heads of the streams. Scattered throughout the district are numerous remnants of terraces that stand 50 to 100 feet above the present streams.

Drainage.—The larger streams include Poteau River, Fourche Maline Creek, and Brazil Creek, which flow perennially. During wet seasons these streams frequently overflow their banks and spread their waters over the wide flood plains, but in the dryer summer they have only a slight flow. The smaller streams flow only in wet seasons, except where fed by springs. Numerous oxbow lakes are present in the Poteau River Valley. The large communities draw their water supply from the streams of the area, and the smaller communities depend on shallow wells for water.

Climate and vegetation.—The Howe-Wilburton district 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 and generally hot, 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 about 62.5° F., and the mean temperatures of January and July are 41° F. and 82.7° F., respectively. The average annual rainfall is about 41 inches. The rains are general and abundant in the growing season of the spring and early summer, are local during July and August, and become general again in the fall and winter, though not so abundant then as in the spring.

The Howe-Wilburton district is for the most part heavily timbered except in the valleys where the timber has been removed to supply the demand for tillable land. The upland areas are covered with forests in which red and white oaks, blackjacks, hickories, elms, and hackberries are most prominent. On the higher mountains and ridges pines are also present. In the parts of the valleys that have not been cleared are found thick stands of water and willow oaks, hickories, wild plums, willows, and cottonwoods, in many places heavily burdened with clambering vines.

STRATIGRAPHY

GENERAL FEATURES

The rocks of the Howe-Wilburton district are chiefly of Pennsylvanian age, with some that are tentatively classified as Quaternary (?) and some as Recent alluvium. The Pennsylvanian rocks contain valuable coal beds and have been subdivided into the following formations, listed in order of age, the oldest first: Atoka formation, Hartshorne sandstone, McAlester shale, Savanna sandstone, and Boggy shale. All these formations consist of alternating beds of sandstone and shale, and all except the Atoka contain beds of coal. Many of the beds of sandstone and shale appear to be of continental origin, but the presence of marine fossils at a few localities indicates that some of the beds are of marine origin. Unconformities are present at the base of the Hartshorne and Savanna sandstones, and minor breaks within the formations are present locally. The distribution of the formations is shown on the geologic map (pl. 27).

The rocks that are tentatively referred to the Quaternary (?) are deposits of sand and gravel that cover stream terraces at various places in the district, and one small area of Gerty sand in the extreme western part.

Alluvium of Recent age forms the floors of the larger valleys.

The general character, thickness, age, and topographic expression of the Pennsylvania formations are summarized in plate 28.

CARBONIFEROUS SYSTEM

PENNSYLVANIAN SERIES

ATOKA FORMATION

The Atoka formation was named by Taff and Adams [16] in 1900 from exposures near the town of Atoka, about 50 miles southwest of Wilburton. It is the oldest exposed formation and crops out in a continuous belt along the south side of the district. It has been penetrated to a depth of several thousand feet in wells about 4 miles southwest of Wilburton and in one well about 3 miles north of Red Oak.

The formation consists chiefly of shale with lesser amounts of sandstone. The shale is mostly black, sandy, and micaceous. Some of the shale is buff to brown, very sandy, and micaceous. Shale of this type is present either directly below or directly above beds of sandstone and is gradational from the sandstone to the black shale. The sandstone is highly variable in character, both from place to place in a single bed and from bed to bed. In most exposures it is brown, fine-grained, and irregularly bedded and contains considerable silt. Locally, however, it is coarse-grained, pure, and massive to thick-bedded. Most of the sandstone contains fragments of plant stems, and most of the shale contains abundant macerated plant leaves and stems. Poorly preserved marine invertebrate fossils are present locally in the shales, and Galloway and Ryniker [17] made a collection of well-preserved marine invertebrates from a thin bed of clay shale about 500 feet below the top of the Atoka formation at the middle of the north border of sec. 11, T. 5 N., R. 21 E., southwest of Red Oak. It is probable that if the Atoka shales were not generally cov-

[16] 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.

[17] Galloway, J. J., and Ryniker, Charles, Foraminifera from the Atoka formation of Oklahoma: Oklahoma Geol. Survey Circ. 21, 1930.

ered or badly weathered other beds containing marine fossils might be found in it.

Sections of the upper part of the Atoka formation as revealed by logs of wells drilled for gas in the southwestern, north-central, and northeastern parts of the area are given on pages 285 to 293. On the Heavener anticline, in the southeastern part of the area, about 7,750 feet of beds in the Atoka formation are exposed at the surface, and the depth to which the formation extends beneath the surface is not known. An isopach map (fig. 13) compiled from thicknesses of the Atoka formation in surrounding areas indicates that the formation is about 5,000 feet thick at the west side of the district and thickens eastward to more than 9,000 feet at the southeast corner of the district.

No coal is known to occur in the Atoka formation in the Howe-Wilburton district. Natural gas is being produced from sandstones in the Atoka on Limestone Prairie, about 4 miles southwest of Wilburton.

HARTSHORNE SANDSTONE

The Hartshorne sandstone was named by Taff [18] from the city of Hartshorne, about 10 miles west of Wilburton. It crops out in a single band that is continuous across the district from west to east, and it underlies the part of the district north of its outcrop.

In some exposures the Hartshorne sandstone appears to grade downward into the underlying shale of the Atoka formation, but in other exposures the contact is sharp and irregular, indicating that a minor unconformity separates the two formations, at least locally.

The Hartshorne sandstone is highly variable in thickness and character throughout the district. At many places it consists of thin-bedded, fine-grained sandstone interbeded with much sandy shale and is about 50 feet thick. At other places it is made up of two beds of massive, coarse-grained, pure sandstone separated by about 30 feet of sandy shale and reaching a total thickness of as much as 350 feet. Even in the places where it consists mostly of sandy shale with some interbedded sandstone the sandstone beds fall into two groups situated near the top and base of the formation and separated by a sandy shale unit in which lies the Lower Hartshorne coal. At all places the sandstone has an ashy-gray color in fresh exposures that distinguishes it from the sandstones of the overlying and underlying formations.

The Hartshorne sandstone yields gas in the Red Oak and Poteau-Gilmore gas fields.

The character of the formation in its more shaly facies is given in the following three sections, which were measured in railroad cuts

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

and water gaps. Where the formation is thick and made up mostly of sandstone, it forms the crests of high ridges on which exposures are too poor to permit the measuring of detailed sections. Additional sections of the Hartshorne sandstone are given in most of the well

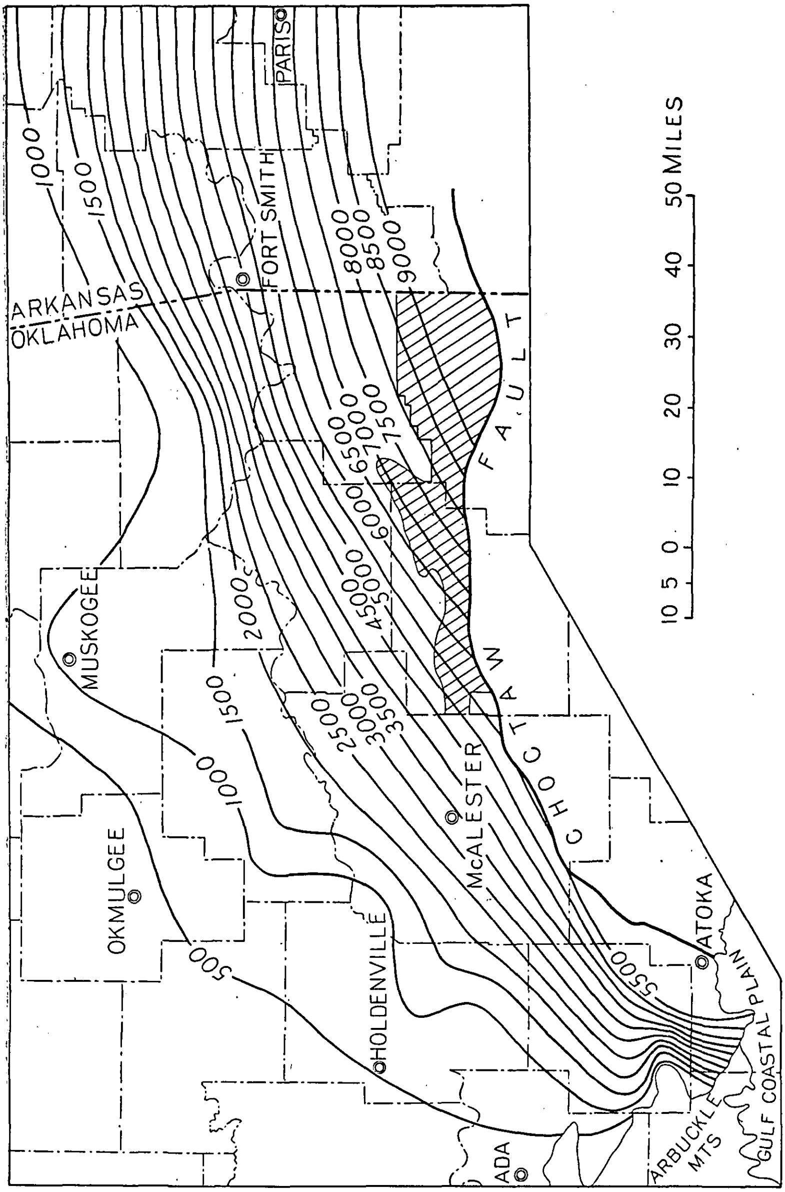


FIGURE 13.—Isopach map of the Atoka formation in portions of Oklahoma and Arkansas. Interval between isopach lines is 500 feet. Shaded area is the Howe-Wilburton district.

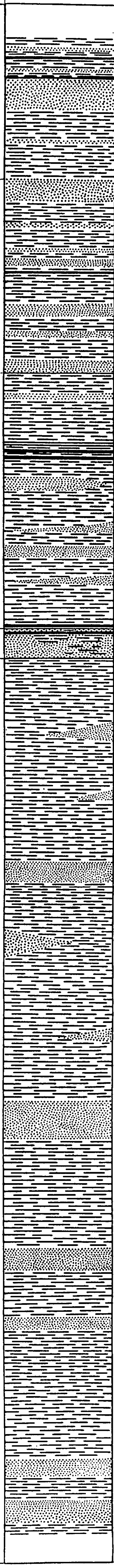
logs on pages 285 to 293. Locally the sandstone appears to have been deposited in a series of stream channels (pl. 29, *A*), and at some places the streams that deposited the sand in the upper part of the formation swept across forests growing in what is now the shale roof of the Lower Hartshorne coal, and buried hundreds of calamites and cordaites trunks, which now stand upright in the shale and overlying sandstone and even cross the contact between the two (pl. 29, *B*).

Section of Hartshorne sandstone and overlying beds along road at center of sec. 8, T. 5 N., R. 20 E.

	Ft.	in.
McAlester shale (basal part of formation only):		
Shale, bluish gray, clayey, with ferruginous concretions	20	
Shale, gray, sandy; grades upward into overlying shale	15	
Sandstone, fine-grained, beds one-eighth inch thick	3	
Shale, gray, sandy, with ferruginous concretions; grades upward into sandstone above	20	
Shale, black, carbonaceous and flaky	1	6
Coal, clean (Upper Hartshorne)	2	8
Shale, poorly exposed, brownish and sandy	15	
	77	2
Hartshorne sandstone:		
Sandstone, medium-grained, ashy white; weathers buff; beds about 2 feet thick	15	
Shale, poorly exposed, gray and sandy	150	
Coal (Lower Hartshorne)	3	
Shale, poorly exposed, buff and sandy	5	
Sandstone, medium-grained, ashy white; weathers rusty-colored; medium-bedded, with sandy shale partings	20	
	193	
Shale (Atoka), poorly exposed.		

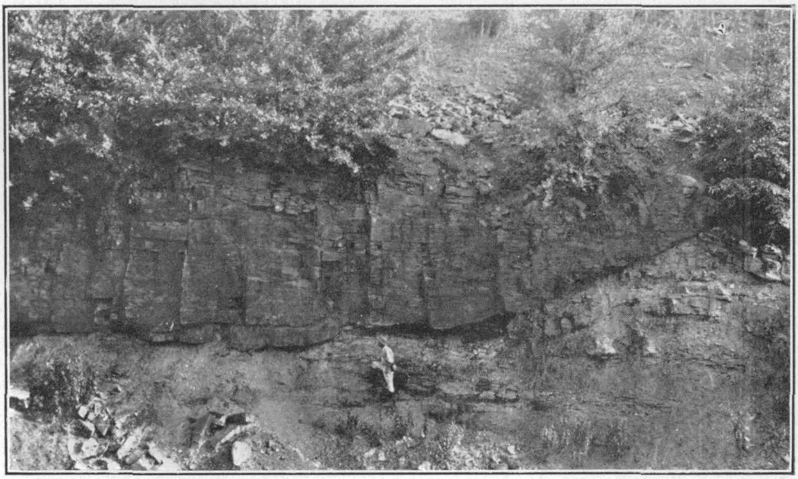
Section of Hartshorne sandstone and overlying beds exposed in railroad cut and small stream in the SE¼ sec. 35, T. 6 N., R. 23 E.

	Ft.	in.
McAlester shale (basal part of formation only):		
Shale, clayey, gray to brownish	10	
Coal (Upper Hartshorne)	2	4
Underclay, grading downward into clayey shale	5	
	17	4
Hartshorne sandstone:		
Sandstone, fine-grained to shaly, buff, beds one-third to one-half inch thick	8	
Shale, upper part fissile and weathers brown, lower part clayey and gray; contains ferruginous concretions throughout and grades upward into overlying sandstone	26	
Coal (Lower Hartshorne)	3	3
Shale, clayey, gray; contains ferruginous concretions	8	
Sandstone, buff, platy, with gray-shale partings	45	

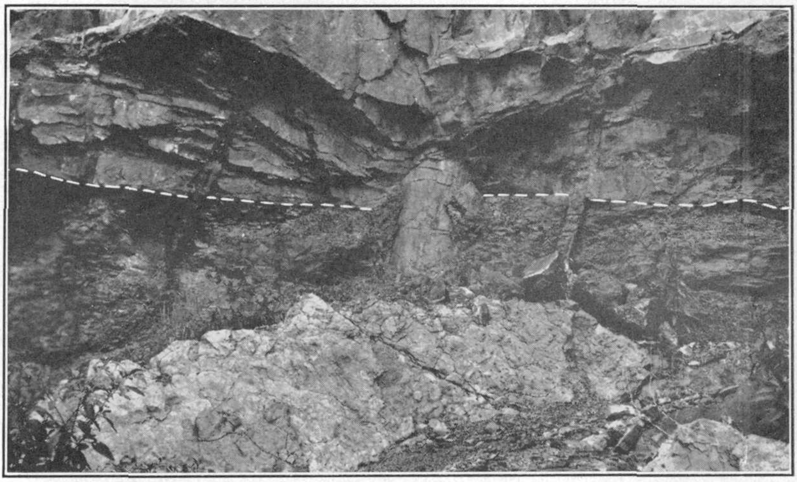
System	Series	Formation	Section	Thickness (feet)	Coal beds	Character of rocks	Topographic expression
Carboniferous.	Pennsylvanian.	Boggy shale.		1, 200+	Secor. Lower Witteville.	Alternating shale and sandstone with two coal beds near base. Dark shale with marine fossils or plant remains common.	Caps the higher mountains of the area.
		Savanna sandstone.		1, 750±	Cavanal.	Alternating sandstone and shale. The sandstones are highly variable in thickness and character but in general fall into four main groups. The shales are mostly gray and sandy, but some dark carbonaceous shale is present. Plant remains are common in both the sandstones and shales, and marine fossils were noted locally in shales near the base of the formation. Thin coaly zones are common.	The sandstone beds form high ridges generally separated by valleys developed on the shales.
		McAlester shale.		1, 240-2, 830	Thin coals. Stigler (?). Lower McAlester. Upper Hartshorne.	Mostly dark shale with one sandstone present near the top and four sandstones present in the lower part. The shales are sandy in the eastern part of the area and become progressively more clayey westward. Plant remains are present locally, but no marine fossils were found.	Forms a wide valley between the Savanna and Hartshorne ridges. The sandstones in the lower part of the formation form ridges that are high where the sandstones are thick and low where they are thin.
		Hartshorne sandstone.		50-350	Lower Hartshorne.	Sandstone, white, massive to thin-bedded, coarse- to fine-grained, with variable amounts of sandy shale. Plant remains and worm trails common.	Forms a prominent ridge over the entire area. This ridge is broken by streams where the sandstone is thin-bedded and shaly.
		Atoka formation.		7, 750+		Mostly black splintery shale with some lenticular sandstone beds and some continuous sandstone beds. Poorly preserved plant remains and marine fossils are preent at some horizons.	Generally forms a wide valley broken by a few ridges formed by the sandstone beds.

GENERALIZED SECTION OF THE PENNSYLVANIAN ROCKS EXPOSED IN THE HOWE-WILBURTON DISTRICT, LATIMER AND LE FLORE COUNTIES, OKLA.

Shows the names and positions of the coal beds in the rock formations. Scale, 1 inch=1,000 feet.



A. CHANNEL SANDSTONE IN THE UPPER PART OF THE HARTSHORNE SANDSTONE.



B. CONTACT BETWEEN THE SHALE IMMEDIATELY ABOVE THE LOWER HARTSHORNE COAL AND THE OVERLYING SANDSTONE OF THE HARTSHORNE SANDSTONE.

Shows fossil tree trunks standing upright and extending across the contact.

VIEWS IN PINE MOUNTAIN STRIP PIT, SEC. 26, T. 5 N., R. 25 E.

Section of Hartshorne sandstone and overlying beds exposed in railroad cut and small stream in the SE¼ sec. 35, T. 6 N., R. 23 E.

	Ft.	in.
Hartshorne sandstone—Continued.		
Sandstone, silty to fine-grained; beds less than 1 inch thick in upper part but gradually increase to as much as 3 feet near base; thicker beds are medium-grained and ashy white	125	
Sandstone, buff to brown, very irregularly bedded; contains plant stems and fragments of shale; at base sharp, irregular contact with black, sandy, and carbonaceous shale of Atoka formation	20	
	235	3

Section of Hartshorne sandstone at Petry's cut, in the NW¼ sec. 31, T. 5 N., R. 26 E.

	Ft.	in.
Hartshorne sandstone:		
Sandstone, buff and platy, with shale partings (top of Hartshorne sandstone)	4	
Shale, chocolate-colored and clayey at base, grading upward to buff and white, sandy, and limonitic	85	
Sandstone, thin-bedded, with shale partings	5	6
Shale, buff and sandy	1	7
Sandstone, massive, coarse-grained, ashy white	3	
Shale, fissile, black, carbonaceous, with sandy streaks	84	
Coal (Lower Hartshorne)	4	2
Shale, clayey and ferruginous	3	
Shale, carbonaceous, with coaly streaks	9	5
Underclay, sandy, mixed with carbonaceous and ferruginous shale	1	4
Sandstone, buff and massive	4	
Shale, sandy and buff	62	5
Sandstone, white; weathers buff; thin-bedded in upper part and irregularly bedded in lower part	22	
Shale, thinly laminated, sandy, dark; weathers into concentric spheroids 2 to 5 inches thick; contains plant stems	5	3
Shale, chocolate brown; weathers lighter-colored; numerous clay ironstone partings	6	
Shale, black and fissile		10
Coal		4
Shale, dark and carbonaceous, with some shaly coal	11	
Shale, clayey, brownish; contains numerous concretions and partings of clay ironstone	14	6
Coal		6
Underclay		6
Sandstone, shaly, grading downward into shale	1	6
	329	10

Atoka formation: Shale, black, carbonaceous, sandy, contains numerous limonite partings and concretions, 50 feet exposed.

74831—39——2

Plant fossils are abundant in the shale that overlies the Lower Hartshorne coal, and several large collections of the plants were obtained. These were studied by C. B. Read, who found them to be of about the same age as plants from the lower part of the Allegheny formation of Pennsylvania.

McALESTER SHALE

The McAlester shale was named by Taff [19] from exposures near the city of McAlester, which lies about 25 miles west of Wilburton. This formation overlies the Hartshorne sandstone, and at all places in the Howe-Wilburton district where the contact between the two formations is exposed it appears to be gradational and conformable.

The McAlester shale crops out in a broad band that extends eastward across the entire northern part of the district. Near Red Oak an elliptical area of outcrop of the shale extends northeastward from the eastward-trending band of outcrop for a distance of about 15 miles. In the extreme eastern part of the district the belt of McAlester shale splits into three parts separated by Poteau and Sugarloaf Mountains.

The McAlester shale consists mostly of shale but includes two to seven sandstone beds, several coal beds, and local lenses of impure limestone. The shale is uniformly dark, firm, and platy and contains numerous clay-ironstone concretions. In the western part of the district the shale is clayey, but eastward it becomes progressively more sandy, and in the extreme eastern part of the district it is characteristically a dark sandy shale. At most places it contains fragmental plant material, and at no place were well-preserved invertebrate fossils found, although such fossils are abundant in the upper 650 feet of the McAlester shale in the McAlester district, which adjoins the Howe-Wilburton district on the west.

There are at least two sandstone beds in the McAlester shale in all parts of the district, and locally as many as seven sandstone beds are present in the formation. Their thickness varies both from bed to bed and laterally within each bed. Each bed is only a few feet thick at some places, and locally some of the sandstone beds attain thicknesses of 200 feet. The thickness, extent, and position of the sandstone beds in the formation are shown in plate 30. At most places the sandstones are buff, fine-grained, regularly thin-bedded, and ripple-marked. Locally, particularly in the places where any one sandstone exceeds its normal thickness, the sandstone is coarse-grained, pure, massive, and almost white. Near the center of the N½ sec. 31, T. 7 N., R. 23 E., an exposure of sandstone in the upper part of the McAlester shale is made up of about 3 feet of thinly laminated fine-grained to silty sandstone in which stand the roots and base of the

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

trunk of a fossil tree about 2½ feet in diameter (pl. 31, *A*). Overlying this sandstone is about 4 feet of silty micaceous sandstone made up of smoothly rounded masses resting in irregular-shaped troughs in sandstone, as much as a foot long, 4 inches wide, and 2 inches deep (pl. 31, *B*). Some of the rounded masses are essentially flat on top, but most of them have both rounded tops and bottoms. I interpret the sequence of events in the formation of this bed to be as follows: (1)the formation of an irregular pattern of troughs and ridges by currents from two or more directions (interference ripple marks); (2) deposition of silt and sand on that irregular surface during a period when the water was not greatly agitated, thus producing a flat-topped bed whose base conformed to the underlying irregular surface; (3) partial cohesion of the material in the flat-topped bed; (4) greater agitation of the water, resulting in the disruption of the partly coherent flat-topped bed along the thin zones overlying the pre-existent ridges; (5) some rolling of the resulting masses, with resultant rounding; (6) decrease in agitation of the water, which caused the rounded masses to come to rest again in the troughs and to be covered by additional deposits; and (7) a repetition of this process several times in the period of deposition of the 4-foot bed of sandstone.

Lenticular beds of impure fossiliferous limestone were noted locally. The best exposure of such limestone is situated in the bed of Turkey Creek, about 500 feet north of the highway bridge in the center of sec. 33, T. 6 N., R. 22 E.

The Upper Hartshorne coal lies in the McAlester shale from 2 to 30 feet above its base. The McAlester coal lies in the upper part of the McAlester shale about 20 to 100 feet above the second persistent sandstone below the top of the formation. About 58 feet above the McAlester coal is a continuous coal bed that is probably the equivalent of the Stigler coal, which has been mined about 20 miles north of the Howe-Wilburton district. Four thin coals (1 foot or less in thickness) are present at least locally between the Stigler (?) coal and the top of the McAlester shale. The position of the various coal beds in the McAlester shale between the McAlester coal and the top of the formation as indicated by diamond-drill records is given in figure 14.

Southeast of Red Oak, in the central part of the district, the thickness of the McAlester shale is about 2,830 feet (calculated from distances and altitude determined by stadia shots and dips read with Brunton compass). The formation is about 1,240 feet thick on the south side of Poteau Mountain, where the thickness computed from surface exposures was almost exactly the same as the thickness encountered in a well drilled for gas in sec. 11, T. 5 N., R. 26 E. Throughout the greater part of the district, however, the McAlester shale is 2,000 to 2,400 feet thick. An isopach map of the McAlester shale in the Arkansas-Oklahoma coal field (fig. 15) shows that the zone of greatest thickness of the formation extends east-west across the Howe-Wilburton district.

Sections of the McAlester shale (pl. 30) show that the variation in thickness of the formation is for the most part due to variation in thickness of the individual units rather than to variable erosion prior to the deposition of the Savanna sandstone. Therefore, the deepest known portion of the basin of deposition of the McAlester shale is near Red Oak, in the Howe-Wilburton district (fig. 15).

Sections of parts or all of the McAlester shale are given in most of the well logs, pages 285–293.

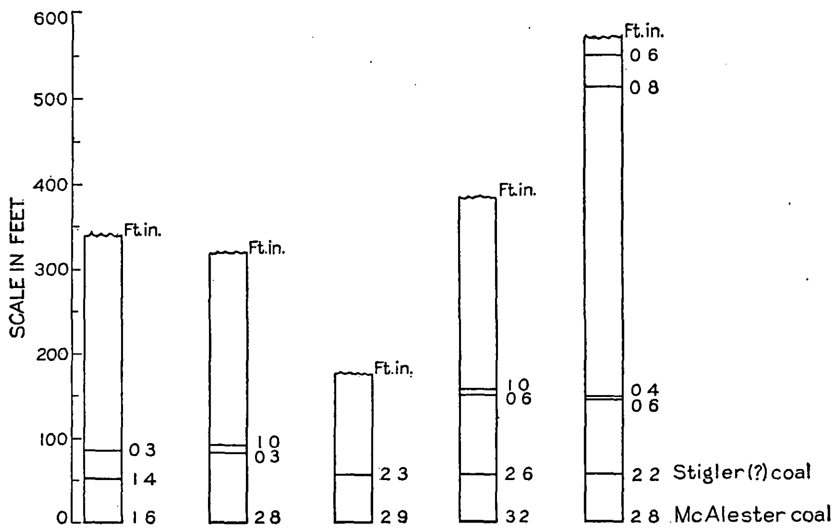


FIGURE 14.—Diagram showing position of coal beds encountered in diamond-drill holes penetrating the upper part of the McAlester shale. (From Coal Lands in Oklahoma: 61st Cong., 2d sess., S. Doc. 390, 1910.)

Plant fossils from the McAlester shale have been studied by C. B. Read, who considers them to be of Allegheny age.

SAVANNA SANDSTONE

The Savanna sandstone was named by Taff [20] from exposures near the town of Savanna, about 30 miles southwest of the Howe-Wilburton district. The basal portion of the Savanna sandstone crops out along the north border of the district west of the southwest corner of sec. 24, T. 6 N., R. 23 E. East of that point the entire Savanna sandstone and the lower part of the overlying Boggy shale are present along the north side of the district as far east as sec. 36, T. 7 N., R. 25 E., where that belt of outcrop leaves the district. In addition the Savanna sandstone crops out on the slopes of Sugarloaf and Poteau Mountains.

[20] 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 Savanna sandstone overlies the McAlester shale with an irregular contact, although at some places the transition from one formation to the other appears to be gradational. On the south side of Sugar-

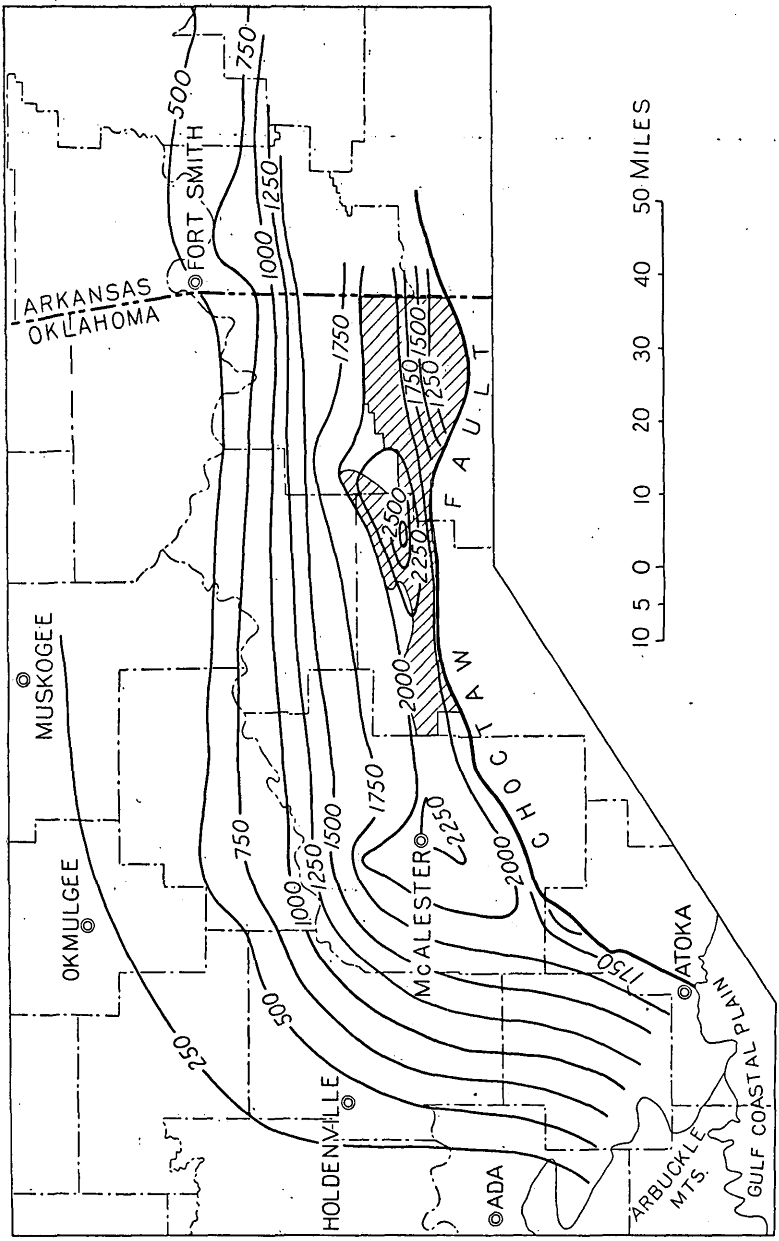


FIGURE 15.—Isopach map of the McAlester shale in portions of Oklahoma and Arkansas. Interval between isopach lines is 250 feet. Shaded area is the Howe-Wilburton district.

loaf Mountain the base of the Savanna sandstone truncates strata in the upper part of the McAlester shale and is clearly unconformable with the underlying strata.

The Savanna sandstone consists of alternating sandstone and shale. The Cavanal coal and several thin local coal beds are present in the shale of the formation. The sandstone is highly variable in character, both from bed to bed and from place to place in a single bed. It varies from buff, fine-grained, silty, and thin-bedded to almost white, coarse-grained, pure, and massive. At most places it is buff to brown, medium-grained, and irregularly bedded. Some of the thicker sandstones grade laterally into sandy shale. The shale in the formation is mostly gray sandy shale, although there are thin beds of black carbonaceous shale present. Most of the black shales contain well-preserved plant fossils, and locally marine invertebrates are present in the shales.

The thickness of the Savanna sandstone, as computed from plane-table traverses across the formation in T. 6 N., R. 25 E., is about 1,750 feet. In the McAlester district, about 50 miles farther west, the Savanna sandstone is 1,120 to 1,325 feet thick in measured sections,[21] and in Arkansas, east of the Howe-Wilburton district, the thickness of the formation is about the same as it is in the McAlester district.[22] The formation also thins northward from the Howe-Wilburton district. The available information on the thickness of the Savanna sandstone in the Arkansas-Oklahoma coal basin is shown on the isopach map (fig. 16). From these data, it seems that the deepest part of the basin of deposition of the Savanna sandstone extended through the Howe-Wilburton district. Plant fossils from the Savanna sandstone were studied by C. B. Read and indicate that the formation is of Allegheny age.

BOGGY SHALE

The Boggy shale, named by Taff,[23] crops out in three areas within the Howe-Wilburton district and overlies the Savanna sandstone conformably. One area of outcrop lies north of the town of Wister, and the other two are on the crests of Sugarloaf and Poteau Mountains.

Only the lower 1,200 feet of the Boggy shale is present in this district, although about 4,000 feet of beds in the Boggy shale occur on Cavanal Mountain just north of the district, in T. 7 N., R. 24 E., where the top of the formation is not present. That great thickness suggests that the southeastward increase in thickness of the Boggy shale shown on the isopach map (fig. 16), continued at least to the eastern part of the Howe-Wilburton district. The part of the formation present consists of dark shale in which are several sandstone beds and two beds of coal. The beds of the Boggy shale are not well

[21] Hendricks, T. A., Geology and fuel resources of the southern part of the Oklahoma coal field, pt. 1, The McAlester district, Pittsburg, Latimer, and Atoka Counties: U. S. Geol. Survey Bull. 874-A, p. 19, 1937.

[22] Hendricks, T. A., Geology and mineral resources of the western portion of the Arkansas coal field: U. S. Geol. Survey Bull. 847-E, p. 199, 1937.

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

exposed, but the detailed section given below of the part of the formation present in the NW¼ sec. 28, T. 7 N., R 25 E., shows their character.

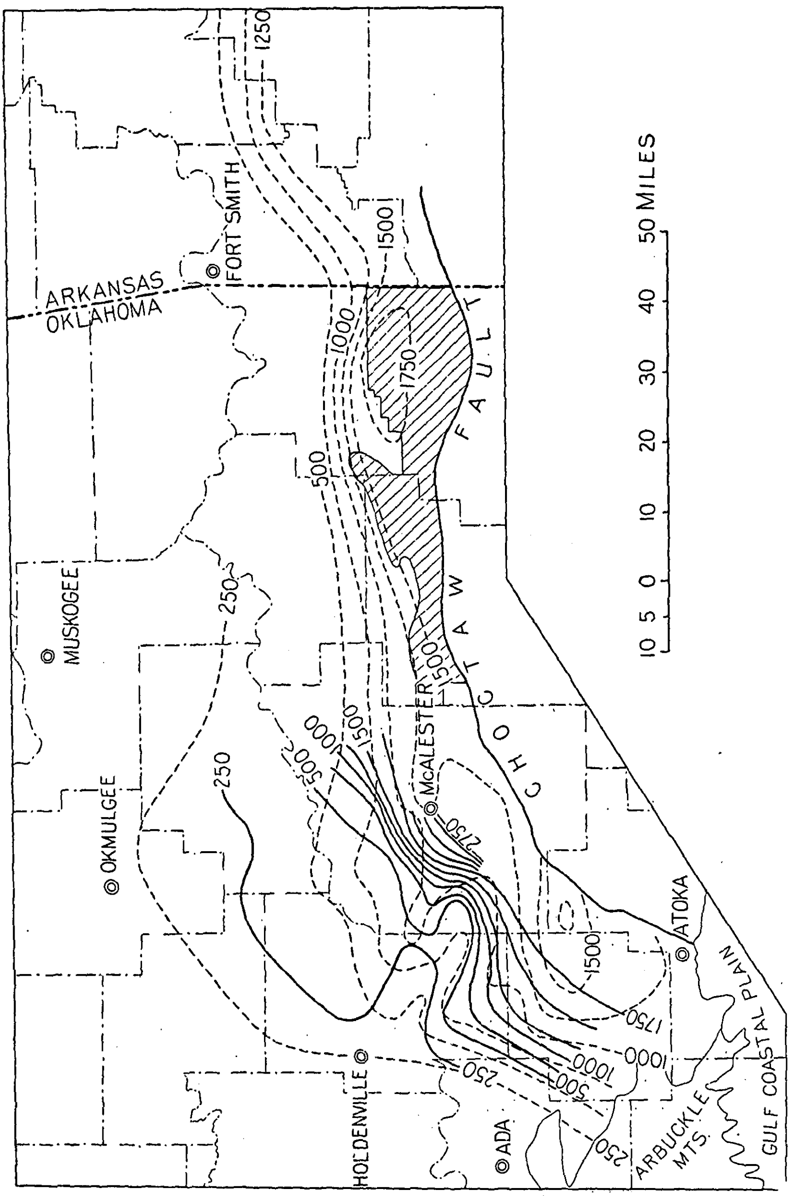


FIGURE 16.—Isopach map of the Savanna sandstone and Boggy shale in portions of Oklahoma and Arkansas. Isopach lines for the Boggy shale are solid; those for the Savanna sandstone are broken. Interval between isopach lines is 250 feet. Shaded area is the Howe-Wilburton district.

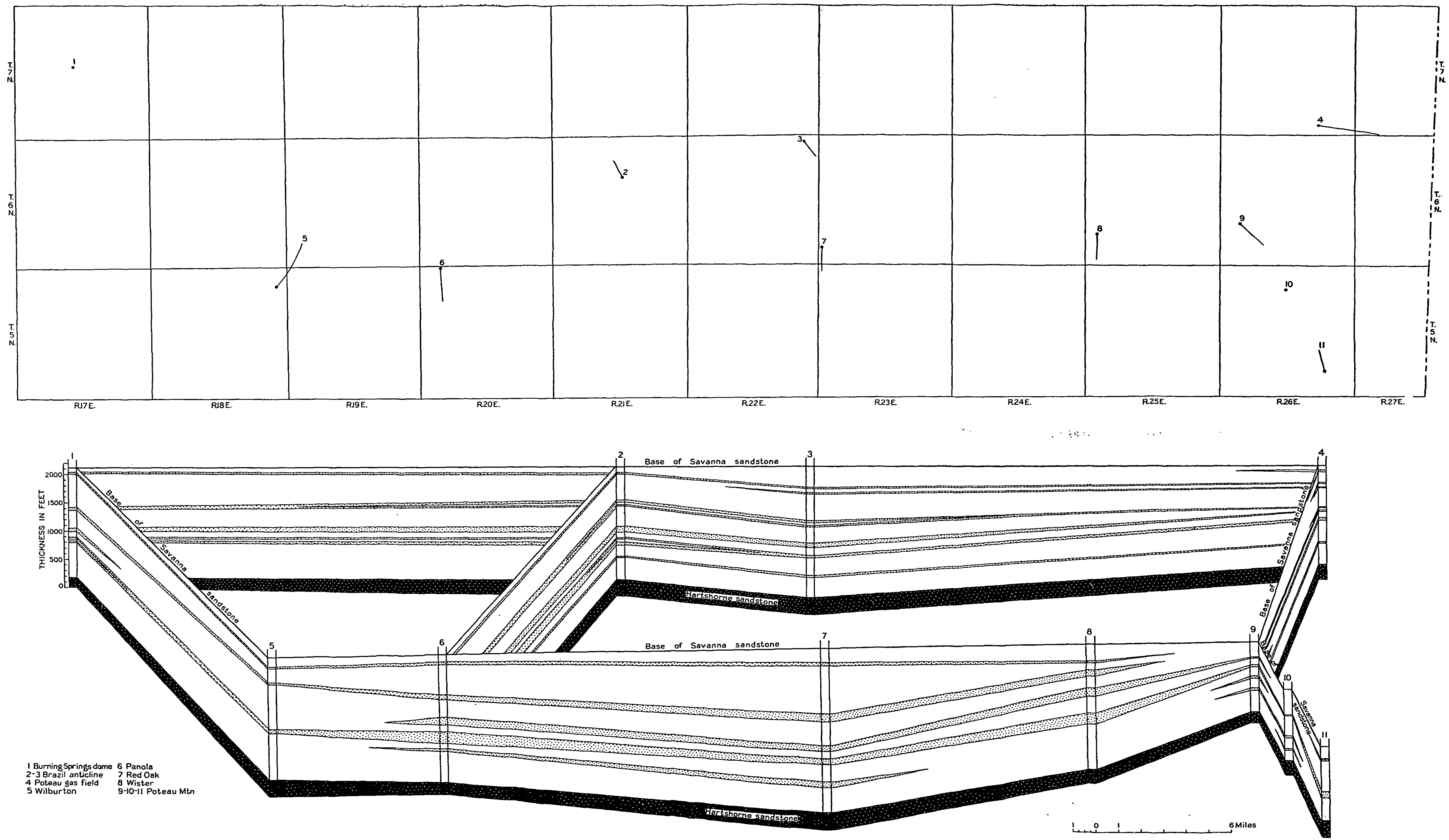
Plant fossils collected from the shale that underlies the Lower Witteville coal were studied by C. B. Read, who considers them to be of Allegheny age.

Section of lower part of Boggy shale in stream bed in the NW¼ sec. 28, T. 7 N., R. 25 E., north of Howe-Wilburton district

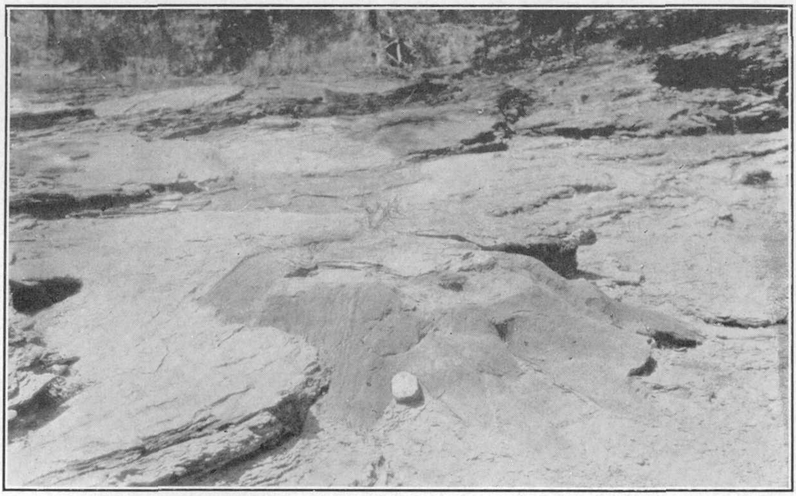
	Feet
Shale, dark, carbonaceous, and clayey	140
Sandstone, fine-grained, ripple-marked, gray to brown, thin-bedded; grades downward into underlying shale	25
Shale, dark bluish gray, fissile; contains marine invertebrates and numerous clay-ironstone concretions in bands and plates, and becomes platy toward top	52
Coal (Secor.)	4
Shale, dark bluish gray, fissile; contains some clay-ironstone concretions	75
Shale, gray to olive drab, sandy, and micaceous; contains a few clay ironstone concretions	10
Shale, poorly exposed, appears to be similar to the overlying shale	16
Sandstone, finely laminated, light and dark gray, fine-grained, micaceous, mud-surfaced bedding planes; beds toward top as much as 1 foot thick grade downward to beds less than 1 inch thick, which in turn grade downward into the underlying sandy shale	25
Shale, sandy and micaceous, poorly exposed	50
Coal (Lower Witteville)	1
Shale, brown, carbonaceous, clayey; contains abundant well-preserved plant fossils	4
Sandstone, gray to brown, fine-grained, ripple-marked, micaceous, medium-bedded; weathers to thin beds	26
Sandstone, buff to brown, fine-grained, micaceous, shaly-bedded	22
Sandstone, gray, fine-grained, micaceous, cross-bedded and channeled; weathers light-brown; base of this sandstone cuts across bedding of the underlying sandstone	70
Sandstone, dark gray at base, grading upward to light gray; weathers drab; fine-grained, micaceous; nearly all bedding planes are ripple- and rill-marked. The lower 13 feet is shaly-bedded, and the upper 30 feet is made up of beds 1 to 6 inches thick	43
Sandstone, greenish gray to brown; weathers drab; medium- to fine-grained, micaceous, ripple- and rill-marked; occurs in 6- to 8-inch beds that break down to ⅛- to ¼-inch plates on weathered surfaces; base of this sandstone cuts across bedding of the underlying sandstone	86
Sandstone, gray; weathers drab; ripple-marked, fine-grained, with mud-surfaced bedding planes, thin-bedded with local bedding irregularities that appear to be landslides that occurred during deposition (pl. 32, *A*). (Base of section lies about 525 feet above the base of the formation)	24
Total thickness	673

CORRELATION

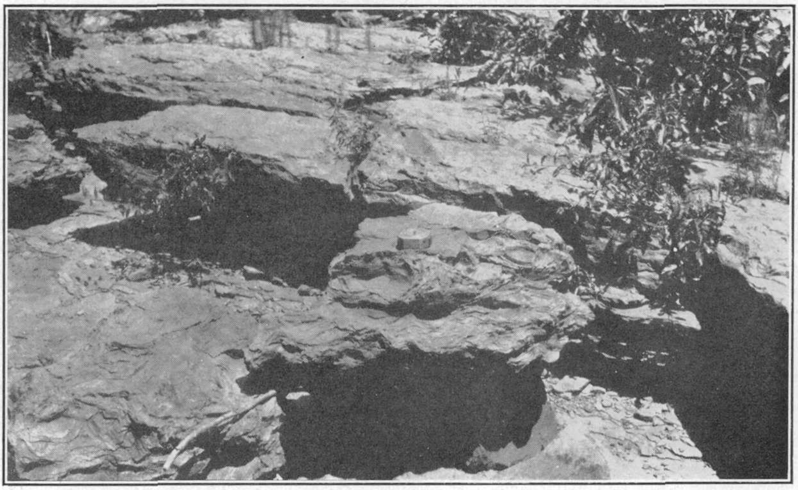
The correlation of the Pennsylvanian formations of the Howe-Wilburton district with those of the McAlester district to the west and those of the Arkansas coal field to the east is shown in plate 33



ISOMETRIC DIAGRAM SHOWING POSITION, THICKNESS, AND EXTENT OF SANDSTONE BEDS IN THE McALESTER SHALE.

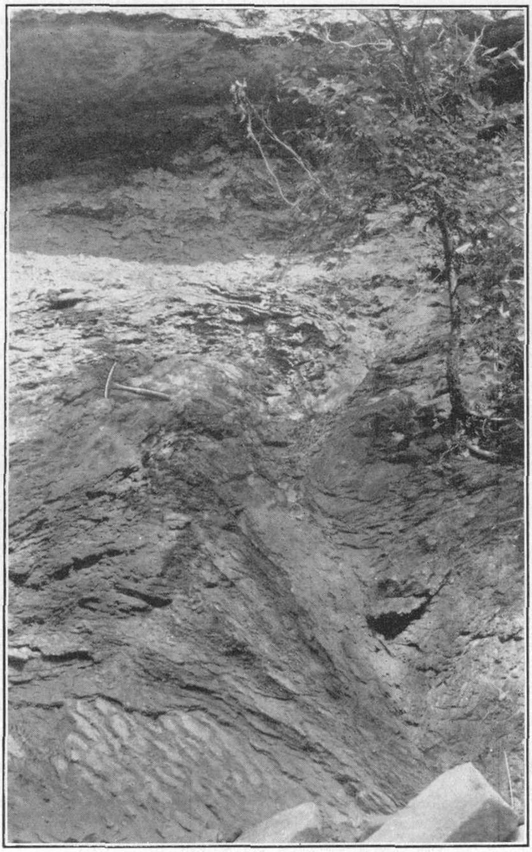


A. A FOSSIL STUMP PRESERVED IN A SANDSTONE BED.



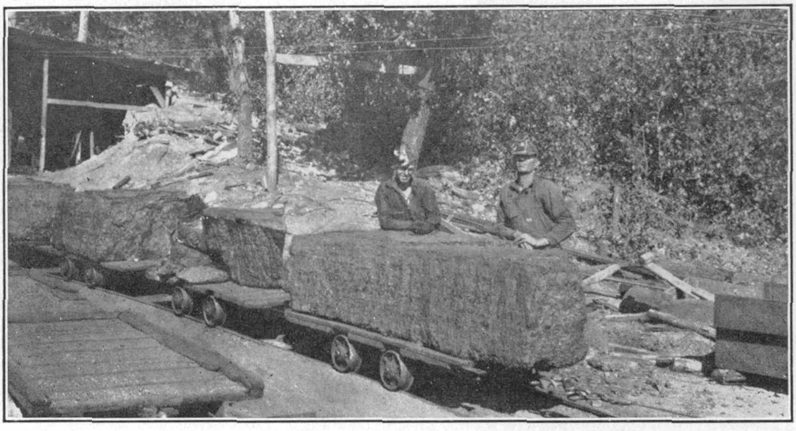
B. A SANDSTONE BED MADE UP IN PART OF ROUNDED MASSES OF SANDSTONE.

VIEWS OF McALESTER SHALE IN SEC. 31, T. 7 N., R. 23 E.



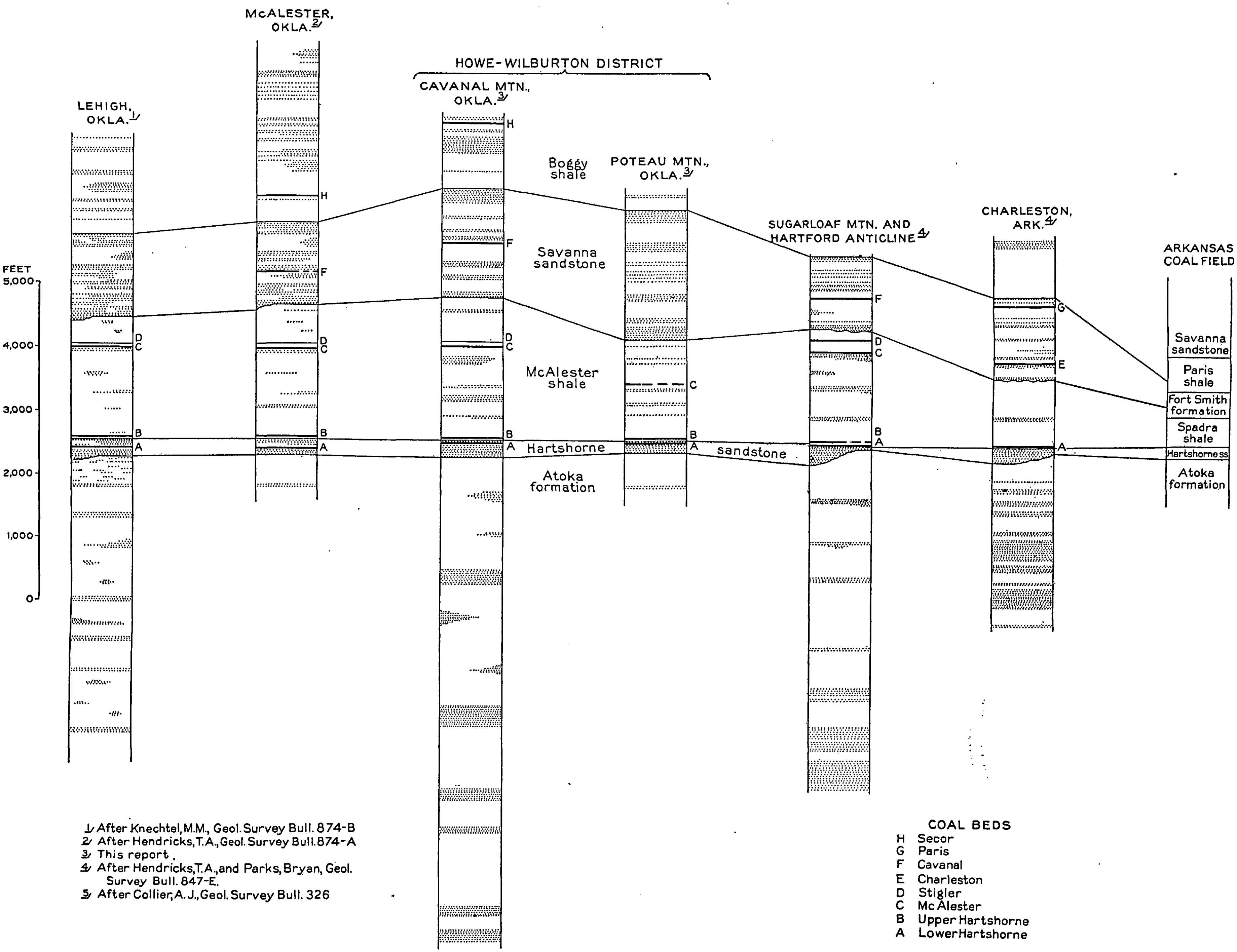
A. SANDSTONE IN THE LOWER PART OF THE BOGGY SHALE, SHOWING IRREGULAR BEDDING DUE TO SLUMPING BEFORE COMPLETE COMPACTION.

Sec. 28, T. 7 N., R. 25 E.



B. BLOCKS OF CAVANAL COAL ON MINE FLAT CARS.

Oakland Coal Co.'s Mine, sec. 4, T. 6 N., R. 25 E.



CORRELATION OF PENNSYLVANIAN FORMATIONS IN THE HOWE-WILBURTON DISTRICT WITH THOSE OF THE McALESTER AND LEHIGH DISTRICTS, OKLAHOMA, AND THE ARKANSAS COAL FIELD.

and has been discussed in previous reports.[24] The formations were traced from the McAlester district into the Howe-Wilburton district in the course of the field work on which this report is based; they are therefore direct equivalents in the two areas. The Atoka formation of the Howe-Wilburton district and the Arkansas coal field are identical. The Hartshorne sandstone of Arkansas, however, is equivalent to only the part of the Hartshorne of Oklahoma that lies below the Lower Hartshorne coal. The upper part of the Hartshorne of Oklahoma corresponds to a part of the †Spadra shale[25] in Arkansas as defined by Collier.[26] The †Spadra shale also includes beds equivalent to a part of the McAlester shale of Oklahoma. The †Fort Smith formation of Arkansas contains beds of the same age as the upper part of the McAlester shale and the lower part of the Savanna sandstone. The †Paris shale of Arkansas equals the upper part of the Savanna sandstone and the lower part of the Boggy shale. The beds that were mapped by Collier[26] as Savanna sandstone in Arkansas are of the same age as the Boggy shale of Oklahoma.

QUATERNARY (?) SYSTEM

GERTY SAND

A deposit of pure white quartz sand occupies an area of about half a square mile north of Gaines Creek, at the extreme west side of the district. This is an area of the Gerty sand, which is extensive farther west. This sand was deposited in Quaternary (?) time by the Canadian River, which then flowed in a channel many miles south of its present course. A full discussion of the character and deposition of the Gerty sand has been given in an earlier paper.[27]

Morgan[28] reports that A. E. Brainard discovered an elephant tusk in the Gerty sand in the Stonewall quadrangle, and on the basis of that evidence he suggests Pleistocene age for the formation. No evidence bearing on the age of the sand was found in the Howe-Wilburton district.

TERRACE DEPOSITS

Large areas of cobbles, gravel, sand, and silt form a veneer a few feet thick on the surfaces of terraces that stand about 50 feet above the beds of the streams thoughout the valleys of Fourche Maline

24 Hendricks, T. A., and Read, C. B., Correlations of Pennsylvanian strata in Arkansas and Oklahoma coal fields: Am. Assoc. Petroleum Geologists Bull., vol. 18, pp. 1050–1058, 1934. Hendricks, T. A., Dane, C. H., and Knechtel, M. M., Stratigraphy of Arkansas-Oklahoma coal basin: Am. Assoc. Petroleum Geologists Bull., vol. 20, pp. 1342–1356, 1936.

25 A dagger (†) preceding a geologic name indicates that the name has been abandoned or rejected for use in publications of the United States Geological Survey.

26 Collier, A. J., The Arkansas coal field: U. S. Geol. Survey Bull. 326, map in pocket, 1907.

27 Hendricks, T. A., Geology and coal resources of the southern part of the Oklahoma coal field, part 1, The McAlester district, Pittsburg, Atoka, and Latimer Counties: U. S. Geol. Survey Bull. 874–A, pp. 26–33, 1937.

28 Morgan, G. D., Geology of the Stonewall quadrangle, Okla.: Oklahoma Bur. Geology Bull. 2, pp. 144–145, 1924.

Creek and the Poteau River. The coarser material consists of subrounded to rounded fragments of sandstone, some of which are as much as 6 inches in diameter. The sand and silt constitute the bulk of the deposits and probably are disintegration products of sandstone and shale. As nearly as can be determined, the material present in the terraces is all of local origin, having come from the rocks that are exposed in or near the Howe-Wilburton district.

These terrace deposits stand at about the same level above the major streams as the Gerty sand, and base level for the stream that deposited the Gerty sand was controlled by the Arkansas River, which also controlled base level for the Poteau River and Fourche Maline Creek. For these reasons the Gerty sand and the terrace deposits of the Howe-Wilburton district are considered of the same age.

QUATERNARY SYSTEM

RECENT ALLUVIUM

The valleys of the larger streams of the area are narrow at some places and several miles wide at other places and are underlain by alluvium. At some places this material is an ash-gray silt, and at others, particularly in the valley of the Poteau River, it is a very dark-gray clayey silt. It ranges in thickness from a few inches on the edge of the flood plains to as much as 25 feet in the banks of the streams. Locally its thickness is probably greater than 25 feet, as the streams have not cut through the alluvium to bedrock at all points.

STRUCTURE

General features.—The strata of the Howe-Wilburton district have been deformed by folding and faulting. The Choctaw fault forms the south boundary of the district and separates the strata of the coal basin from the more intensely deformed strata of the Ouachita Mountains, which lie south of the coal basin. The Choctaw fault is probably a complex zone of faulting in which older strata on the south side have been thrust upward and northward onto the younger strata of the coal basin.

The strata of the Howe-Wilburton district dip generally northward away from the Choctaw fault. The northward dips are interrupted by eastward-trending anticlines and synclines in the extreme western, central, and extreme eastern parts of the district. The major anticlines are, from west to east, the Adamson, Wilburton, Brazil, Heavener, and Hartford anticlines. The major synclines are the Hartshorne, Cavanal, Poteau, and Sugarloaf synclines.

The synclines are broad, shallow folds, and in two of them the axes plunge toward the center from each end and form rude canoe-shaped troughs. However, the axis of the Hartshorne syncline is structurally high in the central part of the Howe-Wilburton district and plunges toward each end away from the high central part. A structurally high point is present on the Cavanal syncline just north of Red Oak, and the axis plunges both eastward and westward from that point. Both of these synclines continue for many miles beyond the district, and in the portion of each that lies outside the district the structure is of the shallow-basin type. The Poteau and Sugarloaf synclines continue eastward into Arkansas for many miles beyond the east boundary of the Howe-Wilburton district.

Only one fault can be traced for more than a few hundred feet in the district. It is the Carbon fault, which breaks beds in the Atoka formation approximately on the axis of the Adamson anticline. The fault plane probably dips southward, and the beds south of the fault have been pushed northward and upward, so that the rocks exposed at the surface on the south side of the fault are older than those on the north side. The Carbon fault probably extends westward from sec. 36, T. 6 N., R. 18 E., to and beyond the west side of the district, although it could be accurately located at only two places, one in sec. 5, T. 5 N., R. 18 E., and the other on the line between secs. 35 and 36, T. 6. N., R. 18 E. It is probable that Boiling Spring, a gas seep in sec. 6, T. 5 N., R. 18 E., is situated on the Carbon fault plane, which serves as an avenue of escape for gas present in beds beneath the surface at that locality.

Two small faults break beds in the Atoka formation about 6 miles southwest of Red Oak. It is possible that these faults are larger than they are shown to be on the geologic map (pl. 27) but that their full extent could not be recognized because of poor exposures of the rocks.

The topography of the Howe-Wilburton district is 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. The height of each ridge depends on the thickness of the sandstone bed that holds it up, the thicker sandstones forming the higher ridges. Each ridge also varies in height along its trend as the underlying sandstone varies in thickness. The widths of each of the intervening shale valleys depends on the thickness and dip of the shale units on which it is developed, the thicker shales with the lower dips underlying the wider valleys.

Large elliptical hills or mountains such as Sugarloaf and Poteau Mountains lie in the troughs of the synclines, and for the most part, valleys mark the axes of the anticlines. The Brazil anticline is occupied by a long canoe-shaped valley developed on the soft McAlester shale and surrounded by high hills held up by the Savanna sandstone in the adjoining synclines; it is the best example of an anticlinal valley in the district.

Descriptions of the anticlines in the district are given below.

Adamson anticline.—The Adamson anticline enters the Howe-Wilburton district from the west, north of Gaines Creek, in sec. 10, T. 5 N., R. 17 E., and extends slightly north of east for about 9 miles to sec. 36, T. 6 N., R. 18 E., northwest of Wilburton, where it dies out. The dips on the south flank of this anticline are low, although most of the surface outcrops are shale in which accurate dip determinations could not be made. The beds on the north flank, however, dip steeply (31° to 90°) northward. The Adamson anticline is broken along the crest by the Carbon fault (p. 277). The beds exposed on the south flank of the fold are shales and some thin sandstones of the Atoka formation, the oldest beds lying about 700 feet beneath the top of that formation. The beds exposed on the north flank are shales and sandstones of the upper part of the Atoka formation, the Hartshorne sandstone, and the McAlester shale. The Adamson anticline continues for about 10 miles west of the Howe-Wilburton district in the adjoining McAlester district.

Wilburton anticline.—The Wilburton anticline is a poorly defined fold about 5 miles long that begins in sec. 13, T. 5 N., R. 18 E., about 4 miles southwest of Wilburton, and extends southwestward to sec. 29 of the same township, where it passes beneath the Choctaw fault. At the east end a sandstone bed in the Atoka formation closes around the anticline, but in the central and western parts of the fold no horizon could be traced for more than a short distance. Both from the interruption of the surface exposures and from the lack of similarity of the logs of the wells drilled for gas on this anticline I believe the central and western parts of the anticline to be badly broken by faults, whose position and extent could not be determined. The rocks exposed in this anticline are all in the Atoka formation, and those exposed on the structurally highest part of the fold lie about 1,000 feet below the top of the Atoka.

Brazil anticline.—The Brazil anticline lies in the central part of the district. It begins in sec. 13, T. 6 N., R. 20 E., northwest of Red Oak, and extends northeastward to sec. 16, T. 7 N., R. 23 E., where it leaves the area. It is a gently folded anticline whose surface development is in the McAlester shale. The structure of this fold is shown on the geologic map (pl. 27) by structure contours drawn on the top of the Hartshorne sandstone, which lies about 2,000 feet beneath the surface in the highest part of the anticline. The Red Oak gas field, situated on the Brazil anticline, yields gas from the Hartshorne sandstone.

Heavener anticline.—The Heavener anticline lies in the southeastern part of the district. It begins in sec. 10, T. 5. N., R. 26 E., northeast of Heavener, and extends westward to sec. 11, T. 5 N., R. 24 E., where it passes beneath the alluvium of the Poteau River

Valley. The anticline cannot be recognized beyond that point, although it probably continues beneath the alluvium for several miles. It is tightly and symmetrically folded, with dips of 40° to 65° common on both the north and south flanks. Many of the beds exposed near the crest of the fold are broken and slickensided, and it is probable that much minor faulting has occurred near the axis and on the flanks of the fold. As the western part of the anticline is covered by alluvium, it is impossible to determine the amount of structural closure from surface outcrops. Sandstones and shales of the Atoka formation, more than 7,000 feet thick, constitute the surface rocks exposed in the central part of the anticline. The east end of the anticline continues across exposures of the Hartshorne sandstone, McAlester shale, and Savanna sandstone but is poorly defined in the McAlester and Savanna formations.

Hartford anticline.—The Hartford anticline lies in the extreme eastern part of the Howe-Wilburton district. It begins at Howe and extends about N. 75° E. to the east side of fractional sec. 15, T. 6 N., R. 27 E., where it leaves the district. East of that point it continues for about 20 miles into Arkansas. In the part of the anticline that lies in Oklahoma the beds have been gently and symmetrically folded. The surface rocks exposed in the anticline are sandstones and shales of the McAlester shale. The details of structure in the anticline are shown on the geologic map (pl. 27) by structure contours drawn on the top of the Harthshorne sandstone, which lies about 300 feet beneath the surface in the structurally highest part of the anticline.

Summerfield anticline.—A small anticline lies about 2 miles southeast of Summerfield in secs. 24 and 25, T. 5 N., R. 23 E. This anticline is marked at the surface by an elliptical outcrop of a sandstone in the Atoka formation, in which the dips are outward in all directions. It is possible that the anticline continues northwestward or southeastward, but the surface exposures are so poor that it cannot be identified if it is present.

MINERAL RESOURCES

COAL

PRODUCTION

Coal has been produced commercially in the Howe-Wilburton district since about 1890. The total production of coal in the district can only be estimated, because, prior to 1907, when Oklahoma became a State, production records of the Indian Territory were not kept by districts, and since that time available records have been prepared by counties. The production in the Howe-Wilburton district comes from Latimer and Le Flore Counties, and there is also some production in the parts of these two counties that lie outside the Howe-

Wilburton district. I estimate that about 19,000,000 tons of coal had been produced in the district before 1931.

Most of the mining has been done in the Upper and Lower Hartshorne beds near Wilburton, in the Lower Hartshorne bed near Red Oak and Howe, and in the Cavanal bed northeast of Wister. Several small strip pits and slope mines have also operated in the McAlester bed throughout the central part of the district near Red Oak, Fanshawe, and Hughes.

The Stigler(?) coal is of minable thickness at least locally east of Red Oak, and the Secor coal is of minable thickness north of Wister, but no attempt has been made to work those beds.

COAL RESERVES

Measured sections of the Lower Hartshorne, Upper Hartshorne, McAlester, Stigler (?), Cavanal, and Secor coals are given on plates 34 and 35 and show the thickness of and partings in the coals in the various parts of the district. So far as can be determined from available data the Lower and Upper Hartshorne beds are of minable thickness in all parts of the district north of their lines of outcrop (pl. 27). The McAlester bed contains between 1 foot 6 inches and 2 feet 9 inches of clean coal in all measured sections. The Stigler (?) coal varies between 1 foot 4 inches and 2 feet 6 inches in thickness, and the Cavanal coal between 1 foot 8 inches and 3 feet 2 inches. It is unlikely that much mining will be attempted in these beds in the near future, because much thicker coal in the Lower and Upper Hartshorne beds is available and probably will be mined first. However, the areas underlain by McAlester, Stigler (?), and Cavanal coals north of their lines of outcrop (pl. 27) in the Howe-Wilburton district constitute coal reserves that eventually will be in demand. The Secor coal is about 2 feet 6 inches thick in sec. 32, T. 7 N., R. 25 E., and thins westward. It generally contains one or more shale partings that reduce the value of the bed. It is possible that the Secor coal may be worked in the future.

The lines of outcrop of each of the coal beds, areas of mine workings, and location of measured sections are all given on the geologic map (pl. 27).

RANK, QUALITY, AND USES

The coal of the Howe-Wilburton district is all bituminous. West of Fanshawe it is of medium-volatile bituminous rank. All the coals that lie east of Wister are of low-volatile bituminous rank except possibly the Secor coal. Unfortunately, analyses of the Secor coal and the other coals in the part of the area where the transition from medium-volatile to low-volatile bituminous coal occurs (in Rs. 23 and 24 E.) are not available, and the exact location of the line of demarcation between the two ranks cannot be determined.

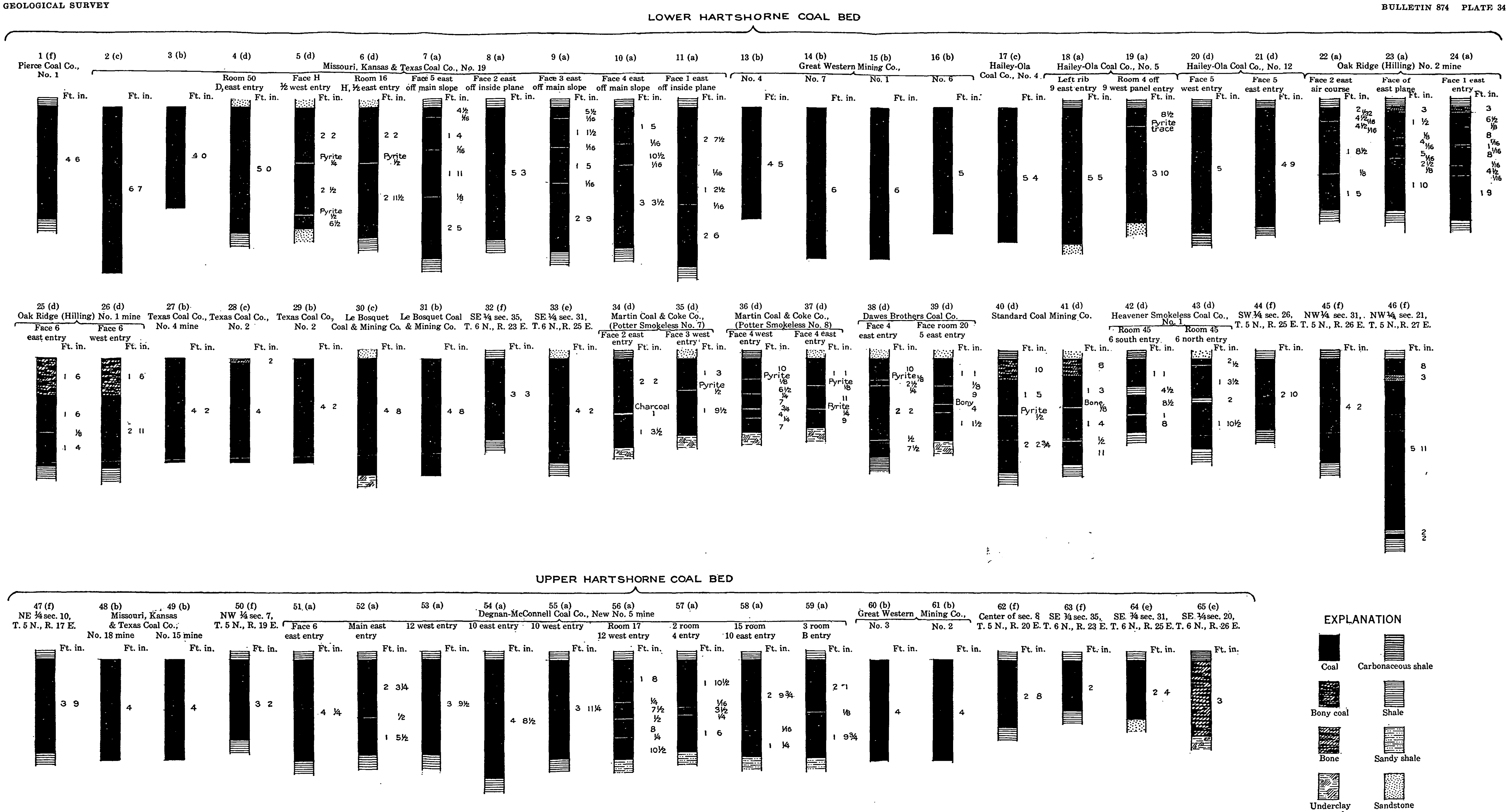
The coals of the district are of high quality and are excellent as steam coals and domestic fuel, the principal uses to which they have been put. Between 1900 and 1905 a battery of 40 coke ovens at Howe manufactured coke from the Lower Hartshorne coal. The coke is reported to have been of good quality, and the coking was abandoned chiefly because of the distance from an adequate market. In the event of increased demand for coke in areas that could be supplied from the Howe-Wilburton district any of the coals in the district could be considered coking coals. Before any commercial coking is attempted the coal at any one mine should be coked experimentally, in order to eliminate the possibility that some local peculiarity of composition of the coal might reduce its coking properties.

At the mine of the Lincoln Power Co., in sec. 31, T. 6 N., R. 25 E., briquets are made from slack coal of the Lower Hartshorne bed. These are firm and durable and make an excellent fuel.

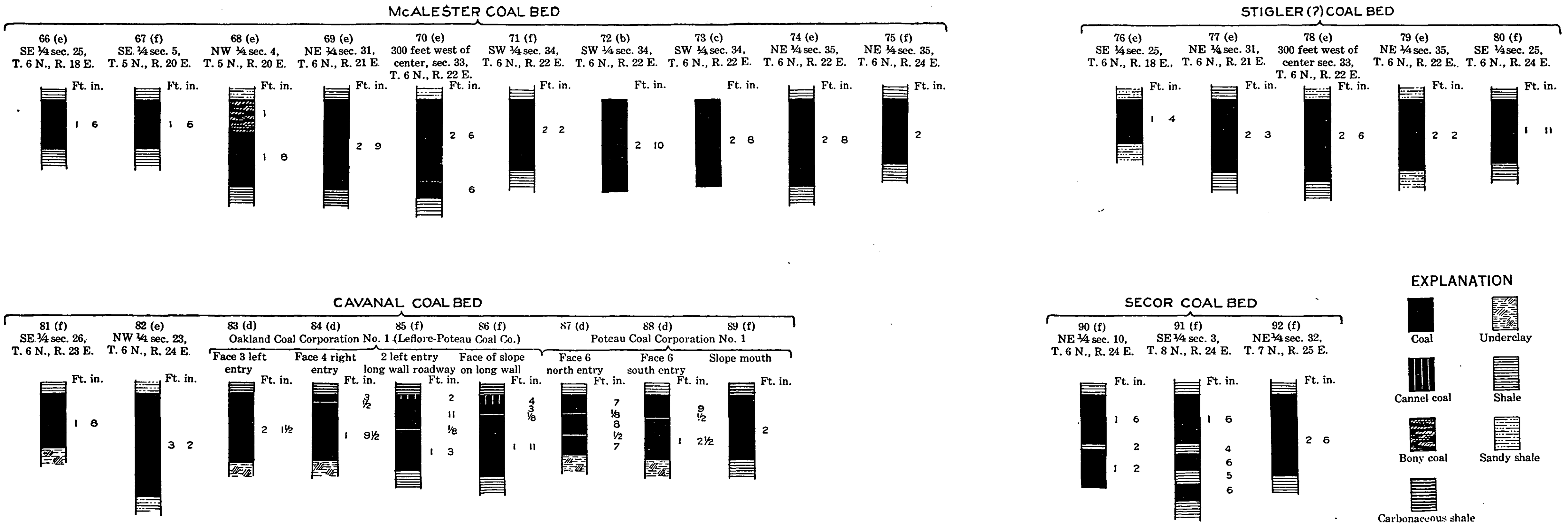
Analyses of coals of the Howe-Wilburton district that have been made by the United States Bureau of Mines are given in the following table:

TABLE 1.—*Chemical analyses of mine samples of coal from the Howe-Wilburton district*

Locality, bed, mine, etc.	Sample			Proximate				Ultimate					Air-drying loss	Calorific value		Softening temperature	Reference	
	Laboratory No.	Kind[1]	Condition[2]	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen		Calories	British thermal units		Bulletin no.[3]	Page[4]
LATIMER COUNTY																		
Adamson, 3 miles east of; Adamson No. 6 mine, Lower Hartshorne bed (face of 2 west entry, 460 feet northeast of mine mouth).	19852	A	1	12.1	33.0	52.1	2.8	1.1					10.3	7,184	12,930	1,920	123	
Same (face of 2 east entry, 400 feet northeast of mine mouth).	19853	A	1	8.5	33.9	54.7	2.9	1.4					6.4	7,433	13,380	1,990	123	
Same (composite of samples 19852 and 19853)	19854	A	1	10.2	34.0	52.9	2.9	1.3	6.0	73.6	1.8	14.4	8.4	7,328	13,190		123	
			2		37.8	59.0	3.2	1.4	5.5	81.9	2.0	6.0		8,161	14,690			
			3		39.1	60.9		1.5	5.6	84.7	2.1	6.1		8,433	15,180			
Degnan, ¾ mile west of; M. K. & T. No. 19 mine, Lower Hartshorne bed (face of 3 east entry, main slope entry).	W69530	A	1	11.2	33.5	46.6	3.7	1.8						6,660	11,970		193	
			2		37.7	52.5	9.8	2.0						7,483	13,470			
Same (face of 2 east entry, inside plane entry)	W69542	A	1	2.9	36.1	55.7	5.3	.8						7,689	13,840		193	
			2		37.2	57.3	5.5	.9						7,917	14,250			
Same (face of 4 east entry, main slope entry)	W69547	A	1	3.7	36.9	53.8	5.6	.9						7,572	13,630		193	
			2		38.3	55.9	5.8	.9						7,861	14,150			
Same (face of 5 east entry, main slope entry)	W69552	A	1	2.9	34.8	53.4	8.9	1.2						7,389	13,300		193	
			2		35.8	55.0	9.2	1.3						7,611	13,700			
Same (face of 1 east entry, inside plane entry)	W69560	A	1	4.2	36.9	53.4	5.5	.8						7,480	13,480		193	
			2		38.5	55.8	5.7	.9						7,817	14,070			
Hughes; SE. ¼ sec. 33, T. 6 N., R. 22 E.; Turkey Creek mine, McAlester bed.	1817	B	1	2.5	31.6	54.2	11.7	3.2					1.2				22	
			2		32.4	55.6	12.0	3.2										
Lutie; sec. 11, T. 5 N., R. 19 E.; Hailey-Ola mine, Lower Hartshorne bed.	1818	B	1	3.9	34.8	54.7	6.6	2.3					2.3				22	
			2		36.2	56.9	6.9	2.4										
1¼ miles east of; Hailey-Ola No. 5 mine, Lower Hartshorne bed (25 feet from face on left rib, 9 east entry, 2,200 feet from mine mouth).	A21474	B	1	2.4	37.9	54.6	5.1	1.5					1.1	7,789	14,020	2,220		32
Same (20 feet from face on left rib, 4 room, 9 west panel entry, 1,900 feet from mine mouth).	A21475	B	1	2.6	37.1	53.1	7.2	2.0					1.3	7,594	13,670	2,220		32
Same (composite of samples A21474 and A21475).	A21476	B	1	2.4	37.6	53.9	6.1	1.7	5.4	76.7	1.9	8.2	1.2	7,672	13,810			32
			2		38.6	55.2	6.2	1.8	5.2	78.6	2.0	6.2		7,861	14,150			
			3		41.1	58.9		1.9	5.6	83.8	2.1	6.6		8,383	15,090			
Red Oak, 3½ miles southeast of; Hilling No. 2 mine, Lower Hartshorne bed (face of 2 east air course, main slope entry).	W69613	A	1	6.0	31.0	58.7	4.3	1.1						7,600	13,680		193	
			2		33.0	62.4	4.6	1.2						8,083	14,550			
Same (face of east plane entry, main slope entry).	W69630	A	1	3.9	32.1	59.8	4.2	1.3						7,745	13,940		193	
			2		33.4	62.2	4.4	1.3						8,061	14,510			
Same (face of 1 east entry, main slope entry)	W69634	A	1	4.2	31.8	60.0	4.0	1.0						7,839	14,110		193	
			2		33.2	62.6	4.2	1.1						8,133	14,730			



MEASURED SECTIONS OF THE LOWER AND UPPER HARTSHORNE COAL BEDS.



MEASURED SECTIONS OF THE McALESTER, STIGLER (?), CAVANAL, AND SECOR COAL BEDS.

Wilburton, 1¼ miles northwest of; Degnan-McConnell New No. 5 mine, Upper Hartshorne bed (face of 12 west entry, where 17 room was to be turned, 1,200 feet west of main shaft).	27531	A	1	4.1	37.2	53.3	5.4	.9					2.8	7,528	13,550	2,340	193	
Same (face of 2 room, A entry, 600 feet northeast of main shaft).	27532	A	1	3.5	37.7	53.8	5.0	.9					2.1	7,633	13,740	2,250	193	
Same (face of 3 room, B entry, 200 feet north of main shaft).	27533	A	1	3.4	37.1	54.5	5.0	1.2					2.1	7,650	13,770	2,150	193	
Same (face of 15 room, 10 east entry, 1,100 feet southeast of main shaft).	27534	A	1	3.7	37.9	53.9	4.5	.9					2.3	7,639	13,750	2,020	193	
Same (composite of samples 27531 to 27534, inclusive).	27535	A	1	3.7	37.4	53.8	5.1	1.0	5.2	75.2	1.7	11.8	2.3	7,606	13,690		193	
			2		38.9	55.9	5.3	1.0	5.0	78.1	1.7	8.9		7,895	14,210			
			3		41.0	59.0		1.1	5.3	83.4	1.8	9.4		8,333	15,000			
Same (face of 6 east entry)	W69509	A	1	3.4	35.8	54.8	6.0	1.0						7,495	13,490		193	
			2		37.1	56.7	6.2	1.1						7,756	13,960			
Same (face main east entry)	W69510	A	1	3.6	38.0	52.7	5.7	.8						7,483	13,470		193	
			2		39.4	54.7	5.9	.9						7,761	13,970			
Same (face 12 west entry)	W69513	A	1	3.1	37.7	53.8	5.4	.8						7,533	13,560		193	
			2		38.9	55.5	5.6	.9						7,772	13,990			
Same (face 10 east entry)	W69516	A	1	3.9	36.9	52.8	6.4	1.2						7,383	13,290		193	
			2		38.4	54.9	6.7	1.2						7,678	13,820			
Same (face 10 west entry)	W69517	A	1	3.2	37.7	54.4	4.7	.9						7,561	13,610		193	
			2		38.9	56.3	4.8	.9						7,811	14,060			
1 mile west of; sec. 8, T. 5. N., R. 19 E., Wilburton No. 7 mine, Lower Hartshorne bed.	1771	B	1	3.4	37.8	53.4	5.4	1.8					1.5				22	
			2		39.2	55.2	5.6	1.9										
Wilburton No. 6 mine, Upper Hartshorne bed	1770	B	1	3.0	36.0	55.9	5.1	1.1					1.9	7,617	13,710		22	
			2		37.1	57.6	5.3	1.1						7,849	14,130			
Sec. 10, T. 5 N., R. 19 E., Wilburton No. 2 mine, Upper Hartshorne bed.	1769	B	1	2.8	36.5	55.5	5.2	.9					.7				22	
			2		37.6	57.0	5.4	.9										
LE FLORE COUNTY																		
Howe, 2 miles south of; Mexican Gulf mine, Lower Hartshorne bed.	1815	B	1	5.1	15.8	72.5	6.6	.7					4.4				22	
			2		16.6	76.4	7.0	.7										
3 miles southwest of; Howe-McCurtain No. 3 mine, Lower Hartshorne bed (face of 4 west entry, main slope entry).	W69464	A	1	3.5	18.5	70.0	8.0	.8						7,628	13,730		193	
			2		19.2	72.5	8.3	.8						7,906	14,230			
Same (face of 6 west entry)	W69465	A	1	3.8	18.7	70.2	7.3	.8						7,633	13,740		193	
			2		19.4	73.0	7.6	.9						7,933	14,280			
Same (face of 30 room, 5 entry, main slope entry).	W69482	A	1	2.5	19.1	71.7	6.7	.5						7,800	14,040		193	
			2		19.6	73.5	6.9	.6						8,000	14,400			
Hughes (Latimer County), 1 mile southwest of; No. 2 mine, Lower Hartshorne bed (face of 20 room, 4 west entry, northwest of slope mouth).	10065	B	1	3.1	31.7	58.9	6.3	.9	5.5	78.1	1.8	7.4	2.4	7,789	14,020	2,050	22	
			2		32.7	60.8	6.5	.9	5.3	80.6	1.9	4.8		8,044	14,480			
			3		35.0	65.0		1.0	5.7	86.2	2.0	5.1		8,600	15,480			
2 miles southwest of: E. ½ sec. 4, T. 5 N., R. 22 E.; prospect, Lower Hartshorne bed.	1816	B	1	4.0	29.0	63.4	3.6	1.1					3.0	7,950	14,310		22	
			2		30.2	66.1	3.7	1.1						8,282	14,910			

[1] A, Sample collected by engineer of the Bureau of Mines; B, sample collected by a geologist of the Geological Survey.
[2] 1, As received; 2, dried at 105° C.; 3, moisture-, and ash-free.
[3] Figures represent the Bureau of Mines bulletins in which can be found the description of the section of the bed from which the sample was taken.
[4] Figures represent the pages in Bureau of Mines Technical Paper 411 on which mine notes and face sections can be found.

MINING METHODS

Coal has been mined in the Howe-Wilburton district both in strip pits and in underground mines. Most of the underground mines are slopes, although a few shafts have also been operated in the district. The mining in the slopes and shafts has been done by the double-entry room and pillar method for the most part. In some of the mines operating on the room and pillar method the coal has been shot down from the solid face, in others it has been undercut by hand before shooting, and in the more modern mines it has been undercut by machine before shooting. The mines operating in the Cavanal bed have used the long-wall system of mining. In the mine of the Oakland Coal Corporation, sec. 4, T. 6 N., R. 25 E., operating in the Cavanal bed, the coal is undercut for a distance of about 3 feet from the face of the coal and along a 600-foot continuous face. A flat metal scow pan 16 feet long and 3½ feet wide that operates on an endless cable is slid beneath the undercut block of coal. The coal is wedged down in blocks 3 to 5 feet long onto the scow pan, which is then pulled to a roadway situated at one end of the 600-foot wall. At the roadway a cable is snubbed around each block of coal, which is then slid off the pan onto a mine flatcar running on tracks set below the level of the base of the coal bed. A trip of cars, each of which carries a single block of coal, is dragged to the tipple by cable (pl. 32, *B*). At the tipple any shale or bony cannel coal present on the top of the block is removed by use of a pick-bitted jackhammer and discarded. The remaining block of coal is then broken by the jackhammer into large-size lump coal and loaded directly into railroad cars. By this method of handling about 87½ percent of the coal produced is of lump size, an unusually high percentage for low-volatile bituminous coal, which is generally very friable and yields much slack in handling.

NATURAL GAS

Natural gas has been produced in commercial quantities at three places in the Howe-Wilburton district—the Wilburton, Red Oak, and Poteau-Gilmore gas fields. Wells have been drilled at various other places in the district but have failed to yield more than a show of gas. The production has been very low from the three fields, because the Wilburton field contains only a few small wells; most of the available gas in the Red Oak field has been shut in, and only a few small wells at the extreme southwest end of the Poteau-Gilmore field lie in this district. The total production from the Poteau-Gilmore field has been considerable, but by far the greater part of it has come from the part of the field that lies north of the Howe-Wilburton district.

The three producing fields in the district and the anticlines on which commercial production has not been encountered are discussed below.

WILBURTON GAS FIELD

The Wilburton gas field lies about 4 to 5 miles west-southwest of Wilburton in the central part of T. 5 N., R. 18 E. Four producing wells and two dry holes have been drilled in this field. The first producing well was completed in 1929, at a production of 2,000,000 cubic feet daily and a rock pressure of 250 pounds to the square inch. The largest producer is reported to have had an initial flow of 8,000,000 cubic feet a day. The field lies on the crest and flanks of the Wilburton anticline, a fold about 5 miles long, terminated at the southwest end by the Choctaw fault and poorly defined except at the east end. The gas comes from sandstones in the lower part of the Atoka formation. It is probable that additional gas might be encountered in wells drilled near the crest of the anticline between the previously drilled wells and the Choctaw fault, but the outcrops are so poor in that belt that the location of the axis of the anticline cannot be accurately determined from them.

The gas produced in the Wilburton field supplies the town of Wilburton, but so far as could be ascertained no production records of the field have been kept.

The log of the Nettie McCurray No. 1 well of the Limestone Oil & Gas Co., in sec. 15, T. 5 N., R. 18 E., in the Wilburton field is given below. The well yielded 2,000,000 cubic feet of gas daily at a depth of 2,518 to 2,548 feet, and under a rock pressure of 250 pounds to the square inch. The well starts about 1,000 feet below the top of the Atoka formation, and the bottom of the hole is in the same formation.

Log of Limestone Oil & Gas Co. Nettie McCurray No. 1 well, SW¼SW¼SW¼ sec. 15, T. 5 N., R. 18 E., Latimer County

	Feet	
Black sod and earth	0–	20
Gray sandstone	20–	35
Blue shale	35–	100
Black sand	100–	110
Blue slate	110–	140
Dark sand	140–	155
Blue slate	155–	160
Blue mud and gumbo	160–	185
Gray sandy shale	185–	230
Black slate	230–	315
Blue slate	315–	380
Brown slate	380–	435
Blue slate	435–	470
Blue shale	470–	530
Blue slate	530–	555

Log of Limestone Oil & Gas Co. Nettie McCurray No. 1 well, SW¼SW¼SW¼sec. 15, T. 5 N., R. 18 E., Latimer County—Continued

	Feet
Black sandy lime	555– 605
Blue shale	605– 660
White shale and lime shells	660– 700
Blue shale	700– 755
Gray sandy lime	755– 800
Black shale	800– 820
Blue shale	820– 860
White sandy lime and shells	860– 880
Blue slate	880– 895
Gray sandy limestone	895– 945
Blue slate	945– 965
Black slate	965–1, 010
Black sandy shale	1, 010–1, 030
Blue sandy shale	1, 030–1, 075
White sand; some gas	1, 075–1, 120
Blue shale	1, 120–1, 175
White slate	1, 175–1, 195
White sand; some gas	1, 195–1, 205
Brown shale	1, 205–1, 210
Dark sand; oil showing	1, 210–1, 250
Brown shale	1, 250–1, 265
Light lime, hard	1, 265–1, 280
Light slate	1, 280–1, 315
Black sandy shale	1, 315–1, 350
Light slate	1, 350–1, 370
Dark shale	1, 370–1, 390
Dark slate	1, 390–1, 400
Light sandy shale	1, 400–1, 415
Light slate	1, 415–1, 450
Dark slate	1, 450–1, 575
Black lime; shells, gas	1, 575–1, 600
Black slate	1, 600–1, 700
Light sand; oil showing	1, 700–1, 715
Dark slate	1, 715–1, 720
Light sandy lime	1, 720–1, 750
Dark sandy lime	1, 750–1, 830
Dark shale	1, 830–1, 840
Dark shale and slate	1, 840–1, 900
White lime	1, 900–1, 915
Gray slate	1, 915–1, 945
Blue shale	1, 945–1, 975
Brown shale	1, 975–2, 025
Brown sandy lime	2, 025–2, 040
Black shale	2, 040–2, 107
Gray shale	2, 107–2, 117
Gray sandy lime; oil showing	2, 117–2, 175
Gray shale	2, 175–2, 245
Gray sandy shale	2, 245–2, 255
Light lime shells	2, 255–2, 280
Brown slate	2, 280–2, 310

Log of Limestone Oil & Gas Co. Nettie McCurray No. 1 well, SW¼SW¼SW¼sec. 15, T. 5 N., R. 18 E., Latimer County—Continued

	Feet
Brown sandy lime; gas pocket	2, 310–2, 383
Black shale	2, 383–2, 518
Gray sand, producing gas	2, 518–2, 548
Gray sandy shale	2, 548–2, 568
Black slate	2, 568–2, 752
Light sandy lime	2, 752–2, 766
Black shale	2, 766–2, 927
Light sand; gas pocket	2, 927–2, 945
Black shale	2, 945–2, 980
Light sandy lime	2, 980–3, 052
Black shale	3, 052–3, 092
Black sandy shale	3, 092–3, 232
Gray sand; gas showing	3, 232–3, 242
Gray sandy shale	3, 242–3, 270
Sand and shale, broken; light oil showing	3, 270–3, 375
Blue slate	3, 375–3, 385
Black	3, 385–3, 475
Black sandy shale	3, 475–3, 530
Blue shale	3, 530–3, 667
Blue sandy shale	3, 667–3, 775
Black sandy	3, 775–3, 814
Blue shale	3, 814–3, 876
Sandy shale	3, 876–3, 917
Gray sandy lime	3, 917–3, 985
Light lime	3, 985–4, 038

RED OAK GAS FIELD

The Red Oak gas field lies on the Brazil anticline north and northeast of the town of Red Oak, in the north-central part of the district. The first production in this field was from the Gladys-Bell Oil & Gas Co.'s well drilled in sec. 10, T. 6 N., R. 21 E., in 1912. Available records show that 23 wells have been drilled in this field and that 18 wells have yielded gas in commercial quantities. The gas comes from the Hartshorne sandstone, about 1,500 to 2,000 feet beneath the surface, and extends over a belt 1½ miles wide and 9 miles long. The producing area has been fairly well outlined but probably could be extended slightly. The largest producer recorded is the McFerran No. R. O. 12, in the SE¼SW¼SE¼ sec. 2, T. 6 N., R. 22 E., which had an initial daily flow of 25,000,000 cubic feet at a rock pressure of 555 pounds to the square inch. No large pipe line has been laid into this field, and there has been only slight local consumption of the gas in the village of Red Oak.

The log of the Morrison R. O. No. 14 well of the Le Flore County Gas & Electric Co., in sec. 1, T. 6 N., R. 22 E., is given below. The section of rocks encountered in this well is fairly typical for the field.

Log of LeFlore County Gas & Electric Co. Morrison No. R. O. 14 well, in the NE¼SW¼SE¼ sec. 1, T. 6 N., R. 22 E., Latimer County

	Feet
McAlester shale:	
Shell rock	0–6
Shale	6–85
Sand	85–90
Shale	90–440
Coal (McAlester)	440–442
Shale	442–586
Sand	586–612
Shale	612–662
Sand	662–677
Shale	677–969
Sand	969–974
Sandy shale	974–989
Sand	989–1, 106
Shale	1, 106–1, 903
Hartshorne sandstone: Sand	1, 903–2, 196
Atoka formation: Shale	2, 196–2, 202

This well had an initial daily flow of 9,500,000 cubic feet of gas from the Hartshorne sandstone under a rock pressure of 550 pounds to the square inch.

The log of the S. J. Yancy No. 1 well, a dry hole drilled by the S. J. Cochran estate in sec. 10, T. 6 N., R. 21 E., is given below.

Log of S. J. Cochran estate S. J. Yancy No. 1 well, in the SW¼ SW¼ SW¼ sec. 10, T. 6 N., R. 21 E., Latimer County

	Feet
McAlester shale:	
Clay	4–8
Blue shale	8–45
Sandstone HFW, 15-inch casing	45–65
Black shale, 12-inch casing	65–490
White shale	490–501
Lime, hard	501–520
Brown sand	520–545
Broken sand	545–575
Lime, very hard	575–592
Black shale	592–601
Lime, very hard	601–615
Brown shale	615–695
Lime, hard	695–712
Broken sand	712–725
Lime, very hard	725–755
Black shale	755–770
Lime	770–800
Sandy shale	800–805
Lime, hard and blue	805–835
Black shale	835–1, 130
Broken sandy lime	1, 130–1, 145
Black shale	1, 145–1, 501
Lime	1, 501–1, 554

Log of S. J. Cochran estate S. J. Yancy No. 1 well, in the SW¼ SW¼ SW¼ sec. 10, T. 6 N., R. 21 E., Latimer County—Continued

	Feet
Hartshorne sandstone:	
Sandrock, very hard	1, 554–1, 593
Gas sand	1, 593–1, 601
Water sand	1, 601–1, 801
Atoka formation:	
Broken lime	1, 801–1, 855
Sand	1, 855–1, 930
Shale, 10-inch casing 2,010 feet	1, 930–3, 685
Dark lime, 8-inch casing 2,470 feet	3, 685–3, 695
Shale, 6-inch casing 3,672 feet	3, 695–3, 807
Sandy shale	3, 807–3, 815
Shale	3, 815–3, 870
Lime	3, 870–3, 872
Shale	3, 872–3, 879
Sand, gas sand	3, 879–3, 904
Shale	3, 904–3, 911
Sand	3, 911–3, 915
Hard white	3, 915–3, 921
White	3, 921–3, 924
Sandy shale; gas sand at 3,989 and 4,011 feet	3, 924–4, 006
Shale	4, 006–4, 250
Lime	4, 250–4, 252
Lime, shale	4, 252–4, 265
Sandy shale; pocket of gas	4, 265–4, 277
Hard sand shale	4, 277–4, 285
Sandy shale	4, 285–4, 375
Lime, sand, shale	4, 375–4, 415
Sandy shale	4, 415–4, 440
Lead	4, 440–4, 443
Sandy shale	4, 443–4, 465
Lime shale	4, 465–4, 490
Sand and lime	4, 490–4, 498
Gray sand	4, 498–4, 508
Sand and shale	4, 508–4, 525
Gray sand and lime	4, 525–4, 540
Sand and lime	4, 540–4, 598
Sandy shale	4, 598–4, 620
Gray sand	4, 620–4, 635
Sand lime	4, 635–4, 652
Black sand	4, 652–4, 692
Sand lime	4, 692–4, 707
Hard sandy shale, cave	4, 707–4, 775
Black sandy shale	4, 775–5, 145

It is probable that most of the "lime" recorded in the log is hard slightly sandy shale.

POTEAU-GILMORE GAS FIELD

Only the extreme south side of the Poteau-Gilmore gas field lies in the Howe-Wilburton district east of Poteau in secs. 33, 34, and 35,

T. 7 N., R. 26 E. The greater part of the field lies north of the district in secs. 20 to 29, T. 7 N., R. 26 E. (Poteau), and secs. 19 and 30, T. 7 N., R. 27 E. (Gilmore).

The first well in the Poteau field was completed in 1910 with an initial daily flow of 4,500,000 cubic feet of gas and a rock pressure of 365 pounds to the square inch. The initial daily production of wells in the Poteau field ranged from 250,000 to 8,000,000 cubic feet and the initial rock pressure from 118 to 365 pounds.

The first producing well in the Gilmore field was completed in 1924 at an initial daily flow of 2,071,000 cubic feet of gas and a rock pressure of 200 pounds to the square inch. The initial rock pressure in other wells ranges from 135 to 293 pounds.

In 1929 there were 59 producing wells in the Poteau-Gilmore gas field.

The main production comes from the Hartshorne sandstone, which lies 1,200 to 2,000 feet below the surface. Production is practically confined to the upper part of that sandstone in some wells and to the lower part in all others. Some short-lived production has been obtained from the upper part of the Atoka formation in a few wells. The producing wells are on the crest and flanks of the Poteau anticline, which lies north of the Howe-Wilburton district. The eight wells within the district lie on the south flank of the anticline. Four of those wells were dry holes, three were producers, and one a small producer.

The log of the Calloway No. 68 well of the Le Flore County Gas & Electric Co. in sec. 35, T. 7 N., R. 26 E., is given below.

Log of Le Flore County Gas & Electric Co. Calloway No. 68 well, in the SW¼NW¼ NE¼ sec. 35, T. 7 N., R. 26 E., Le Flore County

	Feet
McAlester shale:	
Soil and clay	0– 15
Sandy shale	15– 45
Shale	45– 363
Sand	363– 395
Shale	395– 928
Sand	928– 952
Shale	952–1, 269
Sand	1, 269–1, 274
Shale	1, 274–1, 293
Sand	1, 293–1, 311
Shale	1, 311–1, 355
Sand	1, 355–1, 360
Sandy shale	1, 360–1, 369
Hartshorne sandstone: Sand; gas at 1,400–1,446 feet and 1,508–1,540 feet	1, 369–1, 604
Atoka formation: Shale	1, 604–1, 607

ADAMSON ANTICLINE

The structure of the Adamson anticline is favorable for the accumulation of gas. It is closed at the east end, in secs. 34 and 35, T. 6 N., R. 18 E., and is open westward from sec. 10, T. 5 N., R. 17 E., where it crosses the west side of the district. However, it is closed about 9 miles farther west, in the McAlester district. The anticline is broken on the crest by the Carbon fault, and its axial plane is inclined southward. Because of these features it is difficult to predict the exact location of closure in any bed beneath the surface.

One well, the Hunt No. 1 of the P. & F. Petroleum Co., in sec. 7, T. 5 N., R. 18 E., has been drilled on this anticline. Shows of both oil and gas were encountered at several horizons in this well, which penetrated only beds in the Atoka formation. The log of the well is given below.

Log of P. & F. Petroleum Co. Hunt No. 1 well, SE¼SE¼NW¼ sec. 7, T. 5 N., R. 18 E., Latimer County

	Feet
Soil, blue	0–7
Shale	7–25
Shale, sandy, blue	25–30
Shale, blue	30–55
Shell lime	55–60
Shale, sandy	60–100
Shale, blue	100–190
Shale, sandy; showing gas	190–205
Shale, blue	205–215
Shale, sandy	215–225
Shale, gray	225–250
Shale, dark-blue	250–315
Shale, brown	315–325
Sand, brown; showing oil and gas	325–328
Shale, brown	328–380
Shale, blue	380–490
Shale, brown	490–500
Slate, black	500–545
Shale, dark blue	545–620
Shale, blue	620–630
Shell, hard	630–632
Shale, blue	632–650
Not logged	650–760
Shell, hard	760–763
Shale, blue	763–810
Shell, gray	810–812
Shale, blue	812–850
Shell, lime, gray	850–865
Shale, sandy, light blue	865–900
Shale, blue	900–943
Shell, gray	943–948
Sandy shale, blue	948–1, 160
Sand, showing oil and gas	1, 160–1, 178

Log of P. & F. Petroleum Co. Hunt No. 1 well, SE¼SE¼NW¼ sec. 7, T. 5 N., R. 18 E., Latimer County—Continued

	Feet
Sandy shale, blue	1, 178–1, 215
Shell, gray	1, 215–1, 239
Shale, blue	1, 239–1, 460
Lime, black, and sandy shale; showing oil and gas	1, 460–1, 515
Shale with shell intervals	1, 515–1, 850
Lime, black, hard	1, 850–1, 860
Shale, light, with sandstone intervals; pocket of gas; cleaned hole	1, 860–2, 128
Lime, some sand, hard	2, 128–2, 140
Shale, black, with lime shells	2, 140–2, 180
Shale, very light	2, 180–2, 270
Shell lime, very hard	2, 270–2, 280
Sandstone and dark shale	2, 280–2, 335
Shale, light, with sandstone and shell intervals showing gas	2, 335–2, 800
Lime, with streaks of sand, and shale intervals; showing oil and gas with a few bailers of salt water at 2,940 feet	2, 800–3, 300
Black carbonaceous shale	3, 300–3, 600

HEAVENER ANTICLINE

The Heavener anticline lies northwest of the town of Heavener. A sequence of rocks including the upper 7,000 feet of the Atoka formation, the Hartshorne sandstone, and the McAlester shale closes around the east end of the anticline. The west end passes beneath alluvium in the Poteau and Fourche Maline River Valleys, and no structural closure can be determined from surface outcrops. Two wells are reported to have been drilled to depths of about 2,000 feet on or near the axis of this anticline, but I have been unable to obtain a log of either well and could find the location of only one of them.

SUMMERFIELD ANTICLINE

The Summerfield anticline is a small upfold about 2 miles southeast of the town of Summerfield, in secs. 24 and 25, T. 5 N., R. 23 E. A sandstone bed can be traced along the north and south flanks of this anticline but cannot be traced around the east and west ends. A low ridge is present at each end, however, and I believe that the sandstone on the flanks holds up the ridges that complete the closure of the anticline. No wells have been drilled on this anticline.

HARTFORD ANTICLINE

The Hartford anticline extends from the town of Howe about N. 75° E. to the Arkansas State line. Beds in the McAlester shale crop out on the crest and flanks of the anticline throughout its extent in the Howe-Wilburton district. An area of structural closure on the anticline is present southeast of the town of Monroe. The closure is about 100 feet and covers about 2 square miles. The structure of the anticline is shown on the geologic map (pl. 27) by contours drawn on the top of the Hartshorne sandstone, which lies about 300 feet below the surface in the highest part of the anticline. The geologic structure is favorable for the accumulation of gas. One well, the Winterfeat, No. 6 of the American Indian Oil & Gas Co., located in sec. 19, T. 6 N., R. 27 E., has been drilled on this anticline. The well is near the axis of the anticline and about a mile west of the area of closure. It started in the McAlester shale and penetrated the Hartshorne sandstone, together with the upper 2,425 feet of the Atoka formation. A show of gas was encountered in a sandstone of the Atoka formation at a depth of 1,695 feet. The log of the well is given below.

Log of American Indian Oil & Gas Co. Winterfeat No. 6 well, NW¼NW¼SW¼ sec. 19, T. 6 N., R. 27 E., Le Flore County

	Feet
Rock	14-25
McAlester shale: Slate, soft, black	25–390
Hartshorne sandstone: Sand, hard	390–485
Atoka formation:	
Slate, black, soft	485–1, 100
Sand, white, hard	1, 100–1, 172
Slate, black, soft	1, 172–1, 685
Sand, hard	1, 685–1, 750
Show of gas	1, 695
Slate, black, soft	1, 750–2, 160
Lime, black, hard	2, 160–2, 225
Slate, brown, soft	2, 225–2, 440
Lime, shells, hard	2, 440–2, 575
Slate, black, soft	2, 575–2, 910
Reduced hole at	2, 575–[1] 6⅝
Bottom hole	2, 910 TD

[1] Inches.

The Hartford anticline continues eastward into Arkansas, and the Mansfield gas field is located on an area of closure about 12 miles east of the State line. The production of that field comes from sandstones in the Atoka formation, the uppermost of which lies about 4,075 feet below the top of the formation. If this sandstone continues westward and is present in the area of closure in Oklahoma it would lie about 4,560 feet beneath the surface and might contain gas. Other sands that are productive in the Mansfield gas field lie 4,300 and 5,050 feet below the top of the Atoka formation and may be present at depths of about 4,785 and 5,535 feet beneath the surface of the area of structural closure in Oklahoma.

BELT OF NORTHWARD-DIPPING STRATA ADJACENT TO THE CHOCTAW FAULT

Along most of the south side of the area beds in the Atoka formation dip northward away from the Choctaw fault. It is possible that at some places sandstone beds present beneath the surface are cut and sealed by the fault. If any of these beds are gas bearing some production may be encountered in wells drilled in that belt.

PETROLEUM POSSIBILITIES

Shows of oil have been found in each of the wells drilled in T. 5 N., R. 18 E., near the west end of the Howe-Wilburton district. Oil in commercial quantities has not been found, however, and no shows of oil have been recorded in wells drilled farther east.

No strata below the Atoka formation have been penetrated in drilling, and as most of the Atoka strata are of nonmarine origin it is unlikely that they would contain adequate source materials for commercial amounts of petroleum. Strata containing suitable source beds may be present beneath the Atoka formation, but the possibility that heat and pressure may have destroyed any petroleum that may have been generated in such strata must be considered. Some index to the possibility of such destruction of petroleum may be obtained by a study of the fixed carbon contents of the coals of the area, as the fixed carbon contents of the coals are at least in large part dependent upon the amounts of heat and pressure that have affected them.

An isocarb map based on analyses of the coals ranging in age from the Lower Hartshorne to the Henryetta and covering the Arkansas and Oklahoma coal fields is given in figure 17. Most of the figures for fixed carbon used in the preparation of the map represent an average of several analyses. (See table, p. 297.) The analyses used are with only eight exceptions standard United States Bureau of Mines analyses and are analyses with laboratory numbers higher than 16,000. Analyses numbered less than 16,000 were not used because they were run before the present standard method of analysis was adopted by the Bureau of Mines. In earlier analyses the amount of volatile matter in coal was determined by heating the sample for 7 minutes over a gas burner and determining the loss of weight, exclusive of moisture. It was found that variations in gas pressure and in composition of the gas used in heating produced variations of several percent in the amount of volatile matter driven off from duplicate samples in the 7-minute period. As fixed carbon is determined by subtracting the determined percentages of moisture, ash, and volatile matter from 100, this also produced a variation of several percent in fixed carbon. In order to eliminate that error, the Bureau adopted the electric furnace for heating the samples at a constant temperature. All analyses with laboratory numbers above 16,000 were run by this method and are considered comparable within small limits of error.

Several analyses with laboratory numbers above 16,000 were not used because the samples analyzed were high in ash. Such samples generally have abnormally low percentages of fixed carbon, and comparison of high-ash samples in the Arkansas-Oklahoma coal field with low-ash analyses from adjacent points showed the high-ash samples to be unreliable.

Seven analyses run by Moose and Searle[29] for the Oklahoma Geological Survey were used. Where they made analyses of coal from mines also represented by samples analyzed by the Bureau of Mines, the two sets of analyses checked very closely. It was assumed, therefore, that their analyses could be used for mines not sampled by the Bureau of Mines.

A single United States Bureau of Mines analysis numbered less than 16,000 was used for No. 59 on the isocarb map (fig. 17). This analysis was 5.7 to 7.1 percent lower than the analyses for adjacent points 58, 60, and 61. This difference is much greater than the probable error by the old method of analysis, and although the actual result for point 59 may be somewhat in error, it shows that the isocarbs diminish in value eastward from point 58 and southward from point 60.

In general there is an increase in fixed carbon in the coals from west to east across the Arkansas-Oklahoma coal field. The carbon ratios increase from 51.2 percent near Atoka, Okla., to 88.4 percent near Russellville, Ark.

In 1915 David White [30] pointed out that a direct relationship exists between the amount of metamorphism that coals have undergone, as expressed by their fixed carbon content, and the degree of possibility of occurrence of petroleum. In his last paper on that subject White [31] states:

> I have yet to learn of an authoritative occurrence of oil in commercial amounts within the extinction zone as originally defined by me, namely, 65 to 70 percent of fixed carbon. In fact, it is probable that little commercial oil will, in general, have been found where the reliably determined carbonization (fixed carbon content of the coals) exceeds 62.

Thus, on the basis of fixed-carbon content of the coals of the Howe-Wilburton district, it appears unlikely that petroleum will be found north or east of the 65 isocarb (fig. 17), which trends northwestward through Red Oak. From Wilburton west to the west side of the district the fixed carbon content is less than 60 (see fig. 17), which, together with the shows of oil obtained in wells drilled in the Atoka formation, suggests that petroleum may be present in strata beneath

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

[30] White, David, Some relations in origin between coal and petroleum, Washington Acad. Sci. Jour., vol. 5, no. 6, pp. 189-212, 1915.

[31] White, David, Metamorphism of organic sediments and derived oils; Amer. Assoc. Petroleum Geologists Bull., vol. 19, no. 5, p. 608, 1936.

any yet penetrated by drilling, provided adequate source beds and reservoir beds are present.

The nature of the strata that underlie the Atoka formation in the Howe-Wilburton district is not known, but around the north and west

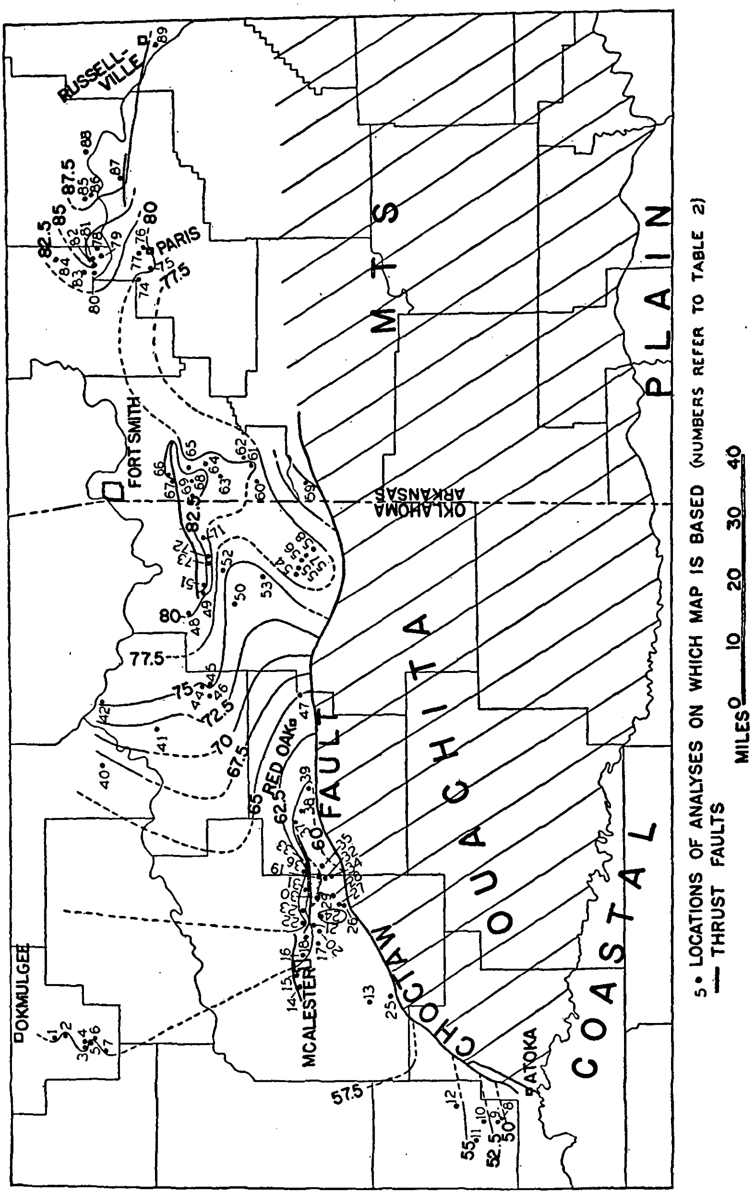


FIGURE 17—Isocarb map of the Arkansas-Oklahoma coal field.

margins of the Arkansas-Oklahoma coal basin, of which this district is a part, rocks of a facies characteristic of the Arbuckle Mountains underlie the Atoka formation. The rocks of that facies generally contain both adequate source beds for petroleum and suitable reservoir beds. It is possible, therefore, that deep drilling on structural features favorable for the accumulation of petroleum located west of Wilburton may yield petroleum in commercial quantities.

TABLE 2.—*Analyses on which isocarb map (fig. 17) is based*

Number on fig. 17	Authority[1]	Analyses	Coal bed	Mine	Average fixed carbon (moisture- and ash-free)
1	1	A21783 to A21786	Henryetta	B. & A. mine	60.1
2	1	A21768, A24770, A24771, A24772	do	Whitehead No. 2	
	3	A21767, A21769	do	do	59.8
3	1	A21771, A21772, A21773	do	Star mine	60.7
4	1	A21779, A21780, A21781	do	Atlas No. 2	60.8
5	1	A21763, A21764, A21765	do	Warden-Pullen No. 2	59.2
6	1	A21775, A21776, A21777	do	Pittsburgh & Midway No. 12.	60.9
7	3	A68381 to A68383	do	Wise-Buchanan	60.9
8	1	30713, 30714, 30715, 30716, 30717, 30718.	McAlester	Folsom-Morris No. 8	50.2
9	1	30708, 30709, 30710, 30711, 30712	do	Folsom-Morris No. 5	52.2
10	1	30719, 30720, 30721, 30722, 30723, 30724.	do	Folsom-Morris No. 6	53.7
11	2	229	do	Keystone No. 1	
	3	B-785	do	do	54.2
12	2	228	do	M. K. & T. No. 21	56.3
13	1	A21272, A21273, A21274	do	Southern No. 4	58.3
14	1	A21131, A21133, A21134	do	Julian mine	59.3
15	1	A21128, A21129, A21130	do	Samples No. 4	59.8
16	1	W69549, W69550, W69556	do	Osage No. 5	61.7
17	1	30660 to 30667	do	Rock Island No. 5	58.4
18	1	A21268, A21269, A21270	Upper Hartshorne.	Buck No. 1	61.7
19	1	A21478 to A21481	Lower Hartshorne.	Kali Inla	57.4
20	1	30656 to 30659	McAlester	Rock Island No. 38	59.5
21	1	A21118, A21120, A21121	Lower Hartshorne.	Buck No. 5	59.2
22	1	W69527, W69535, W69564	McAlester	Carbon No. 2	62.9
23	1	A21136, A21137, A21138	do	Pittsburg County No. 5	60.1
24	1	A21280 to A21283	do	Dow No. 10	60.1
25	1	A21276, A21277, A21278	do	McAlester-Edwards No. 2	58.9
26	1	30401, 30402, 30403	Lower Hartshorne.	Blue Creek No. 7	58.9
27	1	30398, 30399, 30400	Upper Hartshorne.	Hailey-Ola No. 2	58.7
28	1	19703, 19707, 19708	Lower Hartshorne.	Rock Island No. 8	57.6
29	1	19727 to 19732	do	Pocahontas No. 1	57.6
30	1	A21122, A21124, A21125, A21126	do	Pocahontas No. 2	56.7
31	1	19855 to 19858	do	Adamson No. 4	60.4
32	1	A21469 to A21473	do	Rock Island No. 12	57.8
33	1	19852, 19853, 19854	do	Adamson No. 6	61.3
34	2	201, 202, 203, 204, 205	do	Rock Island No. 10	59.0
35	1	30271 to 30277	do	Rock Island No. 40	59.4
36	1	16143, 16144, 16145	do	Eclipse No. 1	63.3
37	1	W69542, W69547, W69530, W69552, W69560.	do	M. K. & T. No. 19	59.6
38	1	27531 to 27535, (inclusive) W69509, W69510, W69513, W69516, W69517.	Upper Hartshorne.	Degnan-McConnell New No. 5.	59.1
39	1	A21474, A21475, A21476	Lower Hartshorne.	Hailey-Ola No. 5	59.6
40	1	A23791	Stigler	Trojan strip pit	
	2	171	do	do	66.3
41	1	17646, 26323, 30344	do	Turner Bros. strip pit	71.2
42	1	26324, 30706	do	Floyd Nunnally strip pit and slope mine.	75.2
44	1	W69353, W69354, W69355, W69356	Hartshorne	Blue Ridge No. 3	74.9
45	1	29839, 29842, 29844	do	Blue Ridge No. 5	75.4
46	1	29840, 29841, 29843	do	Blue Ridge No. 4	74.7
47	1	W69613, W69630, W69634	Lower Hartshorne.	Hilling No. 2	65.0
48	1	26801, 26802	Hartshorne	No. 3 slope (Bokoshe)	80.2
49	1	A22020, A22021, A22022	Upper Hartshorne.	Buck Creek	80.3

[1] 1, Analyses of Oklahoma coal: U. S. Bureau of Mines Technical Paper 411; 2, A chemical study of Oklahoma coals: Oklahoma Geological Survey Bulletin 51; 3, unpublished analyses of U. S. Bureau of Mines 4, Analyses of Arkansas coals: U. S. Bureau of Mines Technical Paper 416.

TABLE 2.—*Analyses on which isocarb map (fig. 17) is based*—Continued

Number on fig. 17	Authority	Analyses	Coal bed	Mine	Average fixed carbon (moisture- and ash-free)
50	1	W69461, W69468, W69470, W69473	Lower Witteville.	Central No. 8	74.0
51	1	A21923, A21924, A21925	Lower Hartshorne.	Hanraty mine	82.7
52	1	A24780, A24779	Cavanal	Leflore County Coal Co.	75.7
53	3	A87203, A87204, A87205	do	Leflore Poteau Coal Co.	74.4
54	1	W69464, W69465, W69482	Lower Hartshorne.	Mexican Gulf	69.0
55	2	230	do	Potter Smokeless No. 7	78.7
56	2	222	do	Potter Smokeless No. 8	78.4
57	2	221	do	Dawes Brothers No. 4	78.7
58	2	220	do	Standard No. 5	78.8
59	4	3505	do	Seymour mine	73.1
60	4	29835 to 29838 (inclusive), 81809 to 81812 (inclusive).	Hartshorne	Central No. 10	79.4
61	4	W69615, W69620, W69632, W69633	do	Central No. 11	80.2
62	4	27612 to 27617 (inclusive), W69329 to W69334 (inclusive).	do	Central No. 6	79.2
63	3	A99402 to A99405 (inclusive)	do	Majestic	81.4
64	3	A99414 to A99417 (inclusive)	do	Bianca	82.3
65	3	A3299, A3300, A3301	do	Sun Coal Co.	80.6
66	3	A99398 to A99401 (inclusive)	do	Western No. 18	83.4
67	4	W69378, W69379, W69397	do	Central No. 135	81.3
68	3	A99827, A99836, A99837, A99838	do	Excelsior Coal Co. Skinner mine.	82.6
69	3	A99418 to A99421 (inclusive)	do	Barr Coal Co.	83.0
71	1	19673 to 19678 (inclusive), W69409, W69410, W69411.	Lower Hartshorne.	Williams No. 1	81.5
72	1	A24785 to A24789 (inclusive)	do	Superior Smokeless No. 29	82.0
73	3	A55907, A55908, A55909, A55963	do	Covington Coal Co. No. 7	82.4
74	3	A99828, A99829, A99830, A99384	Paris	Superfuel	79.7
75	3	A99406 to A99409 (inclusive)	do	Eureka	80.3
76	4	18750 to 18753 (inclusive)	do	Grand No. 1	80.2
77	3	A99824, A99826, A99833	do	Jewel	81.3
78	4	W69641, W69643, W69644	Hartshorne	Dodson No. 2	84.1
79	3	A99378 to A99381 (inclusive)	do	Melton No. 1	84.5
80	4	18746 to 18749 (inclusive)	do	Denning No. 2	83.0
81	3	A99375, A99376, A99377	do	Western No. 2	84.0
82	3	A99371 to A99374 (inclusive)	do	Western No. 6	85.5
83	3	A99367 to A99370 (inclusive)	do	Quality Coal Co.	84.1
84	3	A99835, A99382, A99383, A99385	do	Merrill Coal Co.	83.0
85	3	A99390 to A99393 (inclusive)	do	Clark-McWilliams	88.0
86	3	A99394 to A99397 (inclusive)	do	Fernwood No. 2	87.9
87	3	A99825, A99831, A99832, A99834	do	New Deal Coal Co.	87.7
88	3	A99386 to A99389 (inclusive)	do	Sterling Anthracite	88.4
89	3	A99410 to A99413 (inclusive)	do	Bernice No. 3	87.3

SAND AND GRAVEL

Extensive deposits of sand and gravel are present in the stream terrace deposits scattered throughout the district. Much of this material would be satisfactory for use as structural sand and gravel, but the lack of an adequate market has prevented any development of these resources, and so far as could be determined they have not been used locally.

SHALE FOR BRICK

Shale in the Atoka, McAlester, and Savanna formations has been used successfully in manufacturing brick in areas adjoining the Howe-Wilburton district on the east, north, and west, but no attempt has been made to manufacture brick in the district. It is probable that much of the shale is suitable for brick manufacture.

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