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THE ARKANSAS COAL FIELD

By ARTHUR J. COLLIER

WITH

REPORTS ON THE PALEONTOLOGY

By DAVID WHITE and G. H. GIRTY

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THE ARKANSAS COAL FIELD.

By ARTHUR J. COLLIER.

INTRODUCTION.

Need of investigation.—Both the Carboniferous and the Tertiary rocks of Arkansas contain extensive deposits of coal, but only those of the older system in a field situated within the valley of Arkansas River and adjacent to the western boundary of the State have been exploited and are known to the trade. These coals have always borne a high reputation, but the demand for them has greatly increased in recent years. They grade from bituminous to semi-anthracite, and comparative experiments at the Geological Survey's fuel-testing plant have shown that coals of as good quality are not found elsewhere in the United States west of West Virginia.[a] New uses for them have been found which indicate their importance in the commercial development of the Middle West. At the same time mining operations within the field have demonstrated that its structure is more complex and the known areas of workable coal more limited than the results of earlier surveys would indicate.

For these reasons a number of operators and dealers in Arkansas coal called on the United States Geological Survey for more definite information regarding the extent and geologic structure of these coal beds, and in compliance with this demand a detailed reconnaissance investigation of the field was made from March 1 to August 1, 1906, the results of which are embodied in this report.

Personnel.—In both the field and the office the writer was efficiently assisted by Mr. Carl D. Smith, who was already familiar with the problems involved, through his previous connection with the survey of adjacent coal fields in Indian Territory, and who was identified with this investigation throughout both the field and the office work; by Mr. Sidney Paige, who participated in the field work during the first two months of the season, before his departure for Alaska, and after his return assisted in preparing some of the maps; and by Mr. R. D. Mesler, who brought to this work an

[a] Campbell, M. R., Classification of coals, in Report on the operations of the coal-testing plant, 1904: Prof. Paper U. S. Geol. Survey No. 48, 1906, pp. 156–173.

experience gained in adjacent regions north and west, and remained with the party through two months of the field season. Much of the accuracy of this report is due to the faithful work of these geologists.

Mr. M. R. Campbell, geologist in charge of economic geology of fuels, spent two weeks with the party in the field, making many valuable suggestions and directing the course of the work. Prof. A. H. Purdue, of the University of Arkansas, author of the Winslow folio, also visited the party while in the northwestern part of the field and contributed valuable information regarding the details of the structure there, as indicated by his interpretation of the geology of the Winslow quadrangle.[a]

Itinerary.—The field party began work early in March, 1906, at Midland, Ark., and, after carrying the investigation eastward along the southern boundary of the coal field to its eastern extremity near Dardanelle, turned westward along the northern boundary and completed the greater part of the field work by the last of June. Mr. Smith, however, with a smaller outfit, remained in the field until the last of July, reviewing many doubtful points regarding which the interpretation had not been fully settled during the first examination. Although the underground workings of many of the mines were examined and the coal from them was sampled, investigations of that character were prevented during the latter part of the season by a general strike among the miners. All the mines were shut down, and the fans and often the pumps were stopped, making the workings inaccessible.

Acknowledgments.—In the course of this investigation full use has been made of the maps and reports concerning the region that have previously been issued by various geological organizations. The most complete report on this field was made by the Geological Survey of Arkansas, under the direction of Dr. J. C. Branner, and published in 1888.[b] This report contains a brief summary of the information obtained by the Arkansas Survey, and was published in advance of a more complete description of the field. Further information regarding the structure and geology of this part of Arkansas was subsequently published by Winslow.[c] Unfortunately, the final report of the Arkansas Survey on the coal field has never been published, and the manuscripts were not available. A very large and important part of the work of the State Survey in this region consisted in the preparation of detailed topographic maps on a scale of 1 mile to the inch, with contour intervals of 20 feet, but like the final coal report these maps were never issued to the public, though the plates were

[a] Purdue, A. H., Description of the Winslow quadrangle: Geologic Atlas U. S., folio —, U. S. Geol. Survey, 1907.

[b] Winslow, Arthur, Ann. Rept. Geol. Survey Arkansas, vol. 2, 1888.

[c] Winslow, Arthur, The geotectonic and physiographic geology of western Arkansas: Bull. Geol. Soc. America, vol. 2, 1891, pp. 275-287, pl. 8.

partially engraved by the United States Geological Survey. A small edition was printed from the partially engraved plates and used during the season of 1906 as a basis for field mapping, and, although often inaccurate in topographic detail and generally deficient in culture, they are, nevertheless, the most useful maps of this field yet prepared and were of great assistance in the geologic work.

The results obtained and the conclusions reached in this paper have to a considerable extent been made possible by the careful detailed work which has been done by members of the United States Geological Survey in areas north and west of that under discussion. Acknowledgments for suggestions and information contained in published reports and for advice in the conduct of the field work are due to Mr. Joseph A. Taff,[a] who has for many years been identified with the work of the Survey in the adjacent coal fields of Indian Territory, and also to Prof. A. H. Purdue,[b] whose detailed and accurate geologic map of the Winslow quadrangle includes a portion of the northern part of this field.

Since the disorganization of the State Survey developments within the coal field have been very extensive. Many new openings on the coal have been made and much prospecting by drilling and other means has been done to determine the extent of the coal beds. The greater part of the information thus obtained was available and has been used in the preparation of this report. In the course of the field work many suggestions relative to the work were received from coal operators and prospectors, to whose cooperation much of the value of this report is due.

The various companies and individuals to whom the writer is more especially indebted for such information and assistance are as follows: The Western Coal and Mining Company of St. Louis, Mo., operating in the Jenny Lind and Denning districts, supplied the records of over 100 drill holes in various parts of the field. The Cherokee Construction Company of Fort Smith, Ark., operating mines near Midland and Hartford, a company that has done much intelligent prospecting in the western part of the field, permitted the examination of all their well records and mine maps. The Central Coal and Coke Company, operating at Bonanza and Huntington, who have accumulated much information regarding various parts of the field, supplied copies of their more important records. Mr. H. H. Jackman, man-

[a] Taff, Joseph A., and Adams, George I., Geology of the eastern Choctaw coal field: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 259-311.

Taff, Joseph A., Description of the Coalgate quadrangle: Geologic Atlas U. S., folio 74, 1901; also Description of the Atoka quadrangle, folio 79, 1902, U. S. Geol. Survey; The Southwestern coal field: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 361-413; maps of segregated coal lands in Indian Territory; U. S. Department of the Interior Circulars Nos. 1, 2, 3, 4, 5, and 6, 1904; Description of the Tahlequah quadrangle, folio 122, U. S. Geol. Survey, 1905. (Also Sallisaw and Windingstair folios, in preparation.)

[b] Purdue, A. H., Description of the Winslow quadrangle: Geologic Atlas U. S., folio —, U. S. Geol. Survey, 1907.

ager of the Spadra Creek Coal Company of Spadra, furnished records of a number of characteristic well sections in various parts of the field. Mr. Harry Kelly, president of the Mansfield Gas Company of Fort Smith, who has supervised the drilling of many deep wells in the rocks below the coal measures, kindly permitted an examination of the records of 13 typical wells, each over 1,000 feet deep, near Mansfield and Fort Smith, and supplied data obtained from many years of intelligent study of local geology. Messrs. Martin Rafter, State mine inspector, of Coal Hill; Henry Strother, real estate agent, of Fort Smith; Fremont Stokes, of Clarksville, and many others contributed material aid in assembling information regarding the facts herewith presented, and mine operators in general throughout the field very courteously granted access to mine maps and provided every facility possible for the examination of the underground workings.

General conclusions.—It will be shown in the following pages that the areas known to contain workable coal are more limited than is generally supposed, but that several promising districts of considerable extent have not yet been prospected. The complexity of the geologic structure along the northern edge of the field is here indicated for the first time, and it is believed that considerable unnecessary expense in searching for coal in unfavorable localities may be avoided, or if such work is undertaken the chances of success or failure may be better understood by use of the information here presented.

GEOGRAPHY.

Position and extent of the coal field.—The coal field herein described is situated in the western part of the State of Arkansas, adjoining the Indian Territory line, from which it extends eastward for 75 miles. Its general geographic position is shown in fig. 1, and its outline and extent are shown in fig. 2. It is about 50 miles wide at its western end, but the belt containing workable coal contracts sharply 12 miles from the boundary, beyond which its average width is not more than 20 miles. The areas of workable coal are more or less irregularly distributed over the district above described and some of them are in detached basins not known to be connected with one another. This irregularity and subdivision of the field is due in part to a complex geologic structure and in part to the peculiarities and local variations in the coal beds themselves, making them unfit for mining in some parts of the field, although their presence there is well known. The productive areas of the east end of the field are north of and those of the west end are south of Arkansas River.

Since nearly all the workable coal beds occur in or above the horizon of the Hartshorne coal of Indian Territory, the limits of the coal field have been determined by the presence or absence of rocks

overlying this horizon. (See fig. 2.) Coal beds that have been prospected at only a few localities also occur in some of the lower rocks, and their outcrops are found at considerable distances beyond the limits of the field as defined above. Most of these are probably not of commercial value but some of them may prove valuable locally, so that the extent of the coal fields will probably be increased by future discoveries.

Maps of the coal field.—This region was surveyed and subdivided into townships and sections of conventional size more than fifty years ago, but the maps made at that time show very few of the

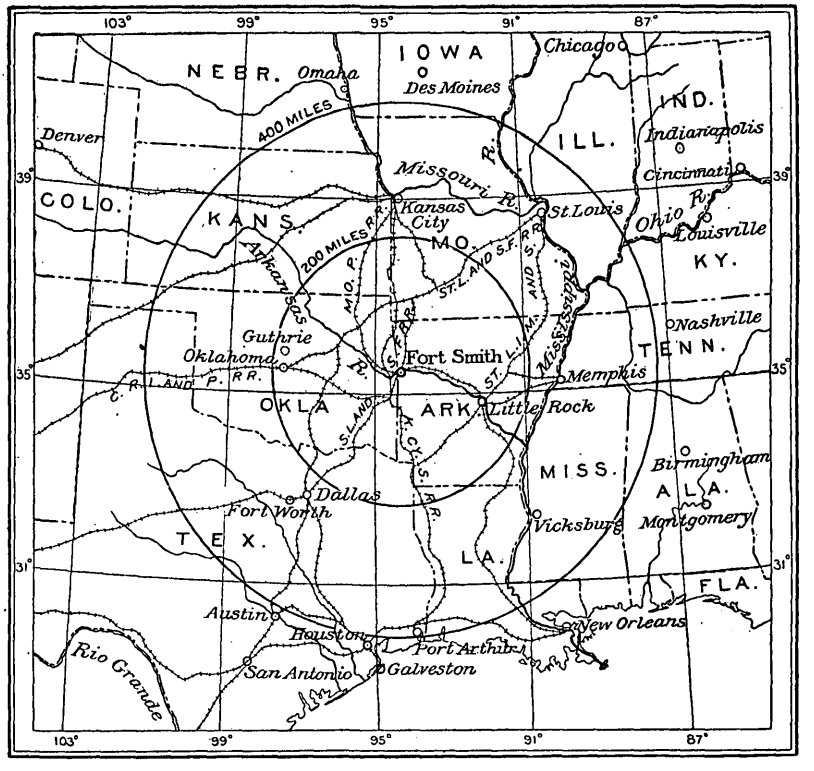


FIG. 1.—Map showing geographic position and railroad connection of the Arkansas coal field.

improvements now existing. The section and township corners established by these surveys were marked by the customary wooden posts and witness trees, but the original monuments have long ago rotted away or have been replaced by later ones established by local surveyors. At many places old fences and roads, placed on the lines when they were new, are the only evidences remaining to indicate their positions. These surveys were made with the needle compass, and the lines thus established often varied several degrees from true meridians and parallels. Nearly all the published maps

of Arkansas, however, are based on them and are sufficiently accurate for ordinary purposes.

The topographers of the United States Geological Survey made a reconnaissance of the field in 1888, the result of their work being topographic sheets of several thirty-minute quadrangles on a scale of one-half inch to the mile. Unfortunately, these maps were deficient both in topographic detail and in culture, a most notable defect being the omission of township and section lines, which are of the utmost economic value in any map to be used by the residents of the district. When the Arkansas Geological Survey undertook to interpret the geology of the coal field the existing maps were found to be inadequate, and they therefore conducted a topographic sur-

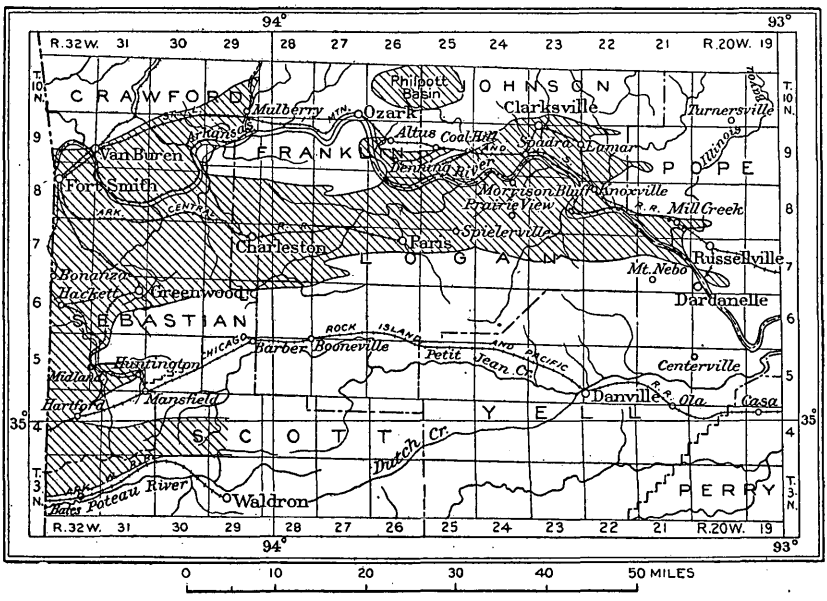


FIG. 2.—Outline map of Arkansas coal field, showing mining centers, railroads, settlements, etc.

vey in connection with their geologic work, using the base presented by the Land Office maps for control. The topography was sketched by a number of assistants, who retraced the section lines and determined elevations by aneroid barometers. This work resulted in the preparation of a detailed topographic map on a scale of 1 inch to the mile, covering the whole of the coal field. Unfortunately, the State survey was discontinued before this map was completed and and it has never been published, though the engraving of the plates by the United States Geological Survey was nearly completed. In many respects it is the most complete map of the Arkansas coal field that has been prepared, and a small edition was printed and used in the field work on which this report is based. The map (Pl. VI)

herewith presented, however, is based on the United States Geological Survey sheets of the region with the addition of the township and section lines, the topography being omitted in order to insure more speedy publication. Although a contour map would be more desirable from a scientific point of view, it is thought that the map as prepared will be of nearly equal value to those who are interested in the development of the field. The geologic structure is complex, but the scale, one-half inch to the mile, is sufficiently large to show all that is known or can be learned at present, except in some small areas where there have been more extensive developments, the details of which are presented in various text figures.

Commercial relations.—Fort Smith, the center of the coal-mining industry, is the principal town in western Arkansas. Its population in 1900, as determined by the Twelfth Census, was 11,587; its present population is about 20,000. It is approximately 250 miles from Kansas City, 350 miles from St. Louis, and 400 miles from the Gulf of Mexico, with which it is connected by the lines of the St. Louis and San Francisco, the St. Louis, Iron Mountain and Southern, and the Kansas City Southern railway systems (see fig. 1, p. 5). Branch lines and independent railroads of less importance, which radiate from Fort Smith and afford transportation to the various coal-mining districts are as follows:

The Little Rock and Fort Smith branch of the Iron Mountain Railway extends through the whole length of the field, north of the river, with spurs and branch roads to the mines near Denning, Coal Hill, Spadra, and Russellville. South of the river the Arkansas Central Railroad extends from Fort Smith to Paris; a branch of the Iron Mountain Railway leads to Greenwood, with a spur to the mines at Jenny Lind; the Mansfield branch of the St. Louis and San Francisco system affords transportation to the mines at Bonanza, Hackett, Montreal, and Huntington and connects with the Choctaw (Chicago, Rock Island and Pacific) line from Memphis; the Midland Valley Railroad follows the outcrop of the coal from Hackett east to Greenwood and thence south past Montreal and Midland to Hartford, affording transportation to a large number of small mines; and the extreme southern part of the field is reached by the Waldron branch of the Kansas City Southern Railway.

With the development of the mining industry new railroads have been projected, and during the last season surveys were in progress for a line connecting Fort Smith with the undeveloped district near Prairie View, 10 miles east of Paris, in Logan County. A railroad is also in course of construction from Dardanelle southward across a district that lies outside of the coal field as at present recognized but contains prospects of coal, some of which will probably be developed into mines.

The coal field is well supplied with wagon roads, very few of which are in good condition in either winter or summer, though in many places, where they are located along the outcrops of ridge-making sandstones, the road bed is firm but rough. Nearly all the roads for a few miles out of Fort Smith are macadamized and dressed with crushed chert from the northern part of the State. They are in good good condition the year round and effectually demonstrate the practicability and value of such improvements. The cost of such roads is so great, however, that it will doubtless be many years before they are extended over the whole of this field.

Towns and villages.—Outside of Fort Smith the important towns are the county seats and the villages around the mines. The county seats are supported mainly by agricultural trade and most of them present a thrifty and attractive appearance. They are: Van Buren, Crawford County, population 2,573; Greenwood, Sebastian County, population 491; Ozark, Franklin County, population 848; Paris, Logan County, population 836; Clarksville, Johnson County, population, 1,086; Russellville, Pope County, population 1,832; and Dardanelle, Yell County, population 1,602.[a]

The more important coal-mining towns are Bonanza, population 906; Jenny Lind, population 425; Huntington, population 1,298; Hartford, population 460; Coal Hill, population 1,341; Denning, population 700; and Spadra, population 260.

Drainage.—The coal field is drained by Arkansas River and its tributaries. Arkansas River is the main waterway and extends through the whole length of the field. It rises in the Rocky Mountains about 400 miles northwest of this region and joins the Mississippi at the eastern boundary of the State, where it carries a large volume of water. Before the building of railroads it was the principal method of transportation in this part of the State, but it is very little used at present, no steamers having been seen on the river during the last field season. It flows over a wide bed filled with many sandbars and was probably never navigable during extremely low stages. The river bed is generally from 50 to 100 feet below the general lowland level of the region. Its banks are bordered by flood plains, at some places several miles wide, that are overflowed every few years, back of which there is in many localities a low escarpment rising to the general lowland plain.

Most of the tributaries of the Arkansas that enter the main stream from the south rise within the coal-bearing district and are always heavily charged with very fine sediment. Poteau River, one of the largest of these, is the source of water supply for Fort Smith, and although the water is said to be wholesome it is never clear. This

[a] The population stated is that given by the Twelfth Census. Since 1900 the population of many of these towns has increased rapidly and that of some of them has probably more than doubled.

river rises south of Poteau Mountain but within a short distance crosses the State line into Indian Territory, in which the major part of its course is located. It again reaches the State line near its mouth, which is in Arkansas. The other notable streams south of the river are Vache Grasse, Sixmile, Hurricane, and Shoal creeks, all of which are sluggish and muddy, like Poteau River.

Nearly all the streams that enter Arkansas River from the north rise within the Boston Mountain area and are clear except at times of freshet. They carry larger volumes of water than the streams entering the river from the south. The more important northern tributaries of the Arkansas within the coal district are Lee Creek, Frog Bayou, Mulberry River, Horsehead, Spadra, and Piney creeks, and Illinois Bayou. None of these tributaries, except possibly a part of Poteau River, can be regarded as navigable.

Topographic provinces.—In this region three topographic provinces, the Boston Mountains, the Arkansas Valley, and the Ouachita Mountains, extending from Arkansas westward into Indian Territory, are recognized by geologists.

The Boston Mountains, which comprise the southern part of the Ozark Mountain region, consist of broad, flat-topped hills forming a dissected plateau whose highest point is about 2,000 feet above the sea.[a] In this region the strata are approximately horizontal; the flat-topped hills are capped by beds of hard sandstone, and the valleys, which are regarded as of comparatively recent origin, are deep and narrow. The southern edge of this mountain district in Arkansas is marked in many places by rather abrupt escarpments that rise from the lowlands of the valley to the lower plateau levels.

The Arkansas Valley province, comprising a belt about 50 miles wide, in which the coal fields are situated, lies south of the Boston Mountains, and is characterized by elevations averaging not more than 500 feet above the sea. Its more definite features are a base-level plain comprising a network of broad alluvial valleys surmounted by many ridges and flat-topped hills, most of whose summits blend in an even sky line about 650 to 700 feet above the sea. Where the strata are moderately inclined the topography is marked by many long, persistent, even-topped ridges, whose summits are from 50 to 100 feet above the base-level plain. A few of the hills take the form of low, broad domes mantled with hard sandstone, and at some places where the rocks are nearly horizontal there are buttes whose summits reach from 1,000 to 3,000 feet above tide, and from 400 to 2,000 feet above the general lowland. Notable among elevations of this character are Sugarloaf and Poteau mountains, near the western end of the coal field, and Magazine, Short, and Nebo moun-

[a] Purdue, A. H., Physiography of the Boston Mountains, Arkansas: Jour. Geol., vol. 9, 1901, pp. 694-701. Hershey, O. H., Peneplain of the Ozark highland: Am. Geologist, vol. 27, 1901, pp. 25-41.

tains, near its eastern end. Magazine Mountain, with an elevation of 3,000 feet, is the highest eminence in Arkansas. Potato Hill, a cone-shaped butte of this type, is shown in Pl. II, *A*. All of these features are direct resultants of the erosion of diverse bed-rock structures, the long, narrow ridges indicating moderately inclined rocks, while the buttes (Pl. II, *A*) indicate horizontal rocks in synclinal basins, and the domes are short anticlines. As a general rule the ridges are more pronounced in the southern part of the field, while the topography of the northern part partakes more of the nature of that found in the Boston Mountains.

The Ouachita Mountain province, which lies south of Arkansas Valley, is characterized by many sharp ridges, produced by the erosion of steeply dipping beds striking approximately east and west.[a] These ridges rise to a nearly uniform height, suggesting an old base-level erosion plain which has been so unequally elevated that while it is over 2,000 feet above the sea at the Arkansas-Indian Territory boundary it declines to only about 500 feet at its eastern end near Hot Springs.[b] From this description it will be seen that Arkansas Valley, in which these coal fields lie, is situated between two mountain masses of very distinct types, and that its topography is to a considerable extent intermediate in character between the two.

GENERAL GEOLOGY.

STRATIGRAPHY.

GENERAL DESCRIPTION AND CORRELATION.

The Arkansas field comprises the eastern end of a large area of coal land which has its greatest extent in Indian Territory. The stratigraphic relations of the rocks of that part of the field which lies in Indian Territory have already been studied in detail and mapped by geologists of the Survey.[c] A part of the northern edge of the coal field in Arkansas has also been mapped, and the results of investigations made there have been submitted for publication.[d] The formations comprising the stratigraphic column in Arkansas are directly comparable to those of Indian Territory, and there is also a marked similarity in the general type of geologic structure in the two districts. The various rock formations as defined and named

[a] Griswold, L. S., Ann. Rept. Geol. Survey Arkansas for 1890, vol. 3, 1892, pp. 195–202.

[b] Ashley, G. H., Geology of the Paleozoic area of Arkansas south of the novaculite region: Proc. Am. Philos. Soc., vol. 36, 1897, pp. 217–318.

[c] Taff, Joseph A., and Adams, George I., Geology of the eastern Choctaw coal field: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 259–311.

Taff, Joseph A., Coalgate folio (No. 74), 1901, and Atoka folio (No. 79), 1902, U. S. Geol. Survey; The Southwestern coal field, Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 361–413; Maps of segregated coal lands in Indian Territory, U. S. Department of the Interior Circulars Nos. 1, 2, 3, 4, 5, and 6, 1904; Tahlequah folio (No. 122), U. S. Geol. Survey, 1905. (Also Sallisaw and Windingstair folios, in preparation.)

[d] Purdue, A. H., Winslow folio (No. —), U. S. Geol. Survey, 1907.

in Indian Territory will therefore be described as they occur in Arkansas.

All the rocks herein described belong to the middle Carboniferous or Pennsylvanian series. They present a rather monotonous sequence of sandstones and shales with little contrast between individual beds. Except for the coal beds themselves there are no members that can be identified with certainty by lithologic characters. Limestone beds, which are interspersed through the series in other fields and aid the geologist by serving as horizon markers, are here almost totally wanting. Moreover, there is much local variation in the character of the rocks, and especially in the sandstone lenses, and correlations from one part of the field to another that are based on lithologic similarity alone are of little value.

In the region north of the coal field, near Fayetteville, lower Carboniferous (Mississippian) shales, sandstones, and limestones are exposed, and farther south these are overlapped by about 1,500 feet of shales and sandstones called the Winslow formation. The Winslow extends to the edge of the coal field, and the upper bed of this formation, as described by Purdue, apparently forms the base of the coal-bearing rocks of Arkansas. In Indian Territory the basal bed of the coal-bearing strata is a thick, often massive, sandstone, named for the town of Hartshorne. This sandstone overlies several thousand feet of shale, with only occasional sandstone beds interspersed, which has been called the Atoka shale in the southern part of the coal field, but occupies a position equivalent to that of the Winslow formation in the northern part. It is therefore evident that the Pennsylvanian rocks below the coal-bearing beds rapidly increase in thickness toward the south.

The coal-bearing rocks in Indian Territory comprise several thousand feet of sandstone and shale, which has been divided as follows:

Coal-bearing rocks in Indian Territory.

	Feet.
Boggy shale	2,000
Savanna sandstone	1,000
McAlester shale	2,000
Hartshorne sandstone	200

The Hartshorne sandstone, at the base of the series, is a thin but very persistent formation, which has been traced for 150 miles across the southern edge of the Indian Territory field, but has not heretofore been identified at its northern edge. The McAlester shale, which overlies the Hartshorne sandstone, contains the Hartshorne and McAlester coals. A group of massive sandstones and interbedded shales, including the Witteville coal bed, make up the Savanna formation, which is overlain by the Boggy shale, also including one or two coal beds.

The coal-bearing rocks of Arkansas were separated by the Geological Survey of Arkansas into three divisions, as follows:[a]

Coal-bearing rocks in Arkansas, according to the Geological Survey of Arkansas.

	Feet.
Western and upper division, including Huntington and other coal beds..	3,000±
Intermediate barren division, a succession of shale and sandstone beds which, though variable in magnitude, have an aggregate thickness not less than.	500
Eastern and lower division, including the coal beds in Coal Hill, Spadra, Ouita, and Shinn basins.....	250±

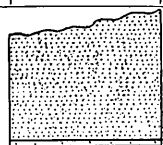
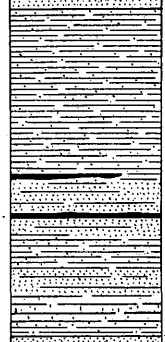
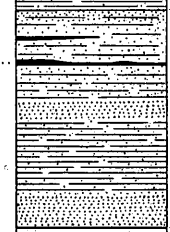
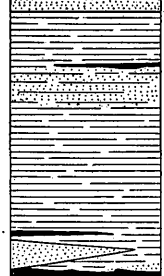
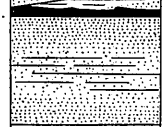
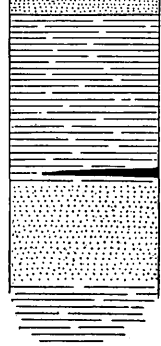
These divisions were not clearly defined, and the rocks below the coal-bearing formations were not discussed. The correlation of these groups into which the coal measures of Arkansas and Indian Territory have been subdivided by various surveys is set forth in the following table:

Stratigraphic relations in the Arkansas-Indian Territory coal field as exhibited in reports already published and in the present report.

Arkansas Survey preliminary report.	Indian Territory-southwestern Arkansas coal fields, J. A. Taff.[b]	Winslow folio, U. S. Geol. Survey, A. H. Purdue.	Arkansas coal field Collier and others (this report).
Upper or western coal-bearing division, 3,000 feet.	Boggy shale, 3,000 feet.		
	Savanna sandstone, 1,200–1,500 feet.		Savanna formation.
	McAlester shale, 2,000–2,500 feet.		Paris shale, 700 feet.
			Fort Smith formation, 400 feet.
			Spadra shale, 350–500 feet.
Intermediate barren division, 500± feet.	Hartshorne sandstone, 100–200 feet	Winslow formation, 1,500 feet.	Hartshorne sandstone, 100–300 feet.
Lower or eastern coal-bearing division, 250+ feet.	Atoka shale, 2,000–7,000 feet.		Atoka formation, 1,500–5,000 feet.
		Lower Carboniferous or Mississippian rocks.	

In the course of the present investigation the formations mapped in the Indian Territory coal field were traced from the Arkansas-Indian Territory boundary eastward into Arkansas with a considerable degree of success. The Hartshorne sandstone had already been located on the boundary line at three localities, Bonanza, Hackett, and the south slope of Poteau Mountain,[c] from which points its outcrop was traced without a single break in continuity eastward along the southern margin for 75 miles to the eastern end of the field. Its

[a] Ann. Rept. Geol. Survey Arkansas for 1888, vol. 3, pp. 10–11.
[b] Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 257–329.
[c] Taff, J. A., op. cit., Pl. XXXVII.

Names of coal beds.	Section.	Formation and thickness in feet.	General character of formations.
		Savanna. 100-1,000.	In Indian Territory this formation comprises three sandstone members with interbedded shales; only the lower part is present in Arkansas.
Paris.....		Paris. 600-700.	Sandy shale with thin beds of shaly sandstone. Paris coal bed about 400 feet from top.
Charleston		Fort Smith. 375-425.	Sandstone interbedded with shale. Formation yields building stones, flagstones, and brick shale. Coal beds are usually too thin for mining.
Upper Hartshorne .		Spadra. 400-500.	Shale with lenses of sandstone. Hartshorne coal at base is most important bed in Arkansas.
Hartshorne.....		Hartshorne. 100-300.	Typically massive sandstone, but varying to sandy shale in some places.
		Atoka. 1,500-5,000+.	Mainly shale, but sandstone lenses comprise from one-tenth to one-third of the section. Coal beds in the eastern part of the field may be thick enough in some places for mining.

GENERALIZED COLUMNAR SECTION OF THE COAL-BEARING ROCKS OF ARKANSAS.

continuity along the north side of the field is broken at a number of places and its recognition here depended on stratigraphic evidences other than continuous exposures. Nevertheless, the formation has been identified with a considerable degree of certainty in several disconnected areas within the field, along its northern border, and its character over the whole field is fairly well known.

The McAlester shale formation extends from Indian Territory into Arkansas, where it comprises the whole of the coal-bearing series. Some of the lower beds of the Savanna formation are probably also present in Arkansas, though it has not been possible to identify them with certainty at any point.

The McAlester formation as represented in Arkansas contains a group of sandstone beds near its middle portion. These were traced over a large part of the field and their stratigraphic position determined. On the geologic map herewith presented this group of sandstones is differentiated from the more shaly parts of the McAlester formation, subdividing it into three members called Spadra shale, Fort Smith formation, and Paris shale, which can be recognized throughout the field. The economic value of such a subdivision will not fail to be appreciated, since the boundaries of the formations mapped will serve as contour lines indicating approximately the depth of the Hartshorne coal horizon.

The rocks that underlie the Hartshorne formation in Arkansas have received little attention. They comprise a succession of shale and sandstone known to exceed 5,000 feet in thickness near the southern edge, but they are probably not more than 2,000 feet thick near the northern boundary of the field. In the southern part this group consists mainly of shale, but along the northern boundary the sandstone beds are much more important, making up possibly one-third of the section.

The subdivisions of the coal-bearing rocks of Arkansas, as differentiated and described in this report, are briefly tabulated as follows:

Coal-bearing rocks of Arkansas.

	Feet.
Savanna formation	200+
McAlester group:	
Paris shale	600
Fort Smith formation	400–500
Spadra shale	400–500
Hartshorne sandstone	50–400
Atoka formation	1,500–5,000

The general relations and lithologic features of these subdivisions are set forth in Pl. I.

ATOKA FORMATION.

The rocks belonging to this formation outcrop in the surrounding regions both north and south of the coal field and also occur in a number of limited areas included in it, the best known of which is

that in the Backbone Ridge between Hackett and Bonanza. They have also been penetrated at a number of places by deep drill holes through the overlying rocks. South of the coal field the rocks of the Atoka formation are tilted at high angles, and extensive sections of them can be measured, but on the north their attitude is more commonly horizontal and only the upper members are exposed. In the latter region these rocks correspond in stratigraphic position with the Winslow formation as mapped by Purdue in the Winslow quadrangle.

In general the Atoka formation consists of shales with occasional sandstone beds, which in the northern part make up possibly as much as one-third of the section, while farther south the proportion of sandstone is very much less. The thickness of these rocks north

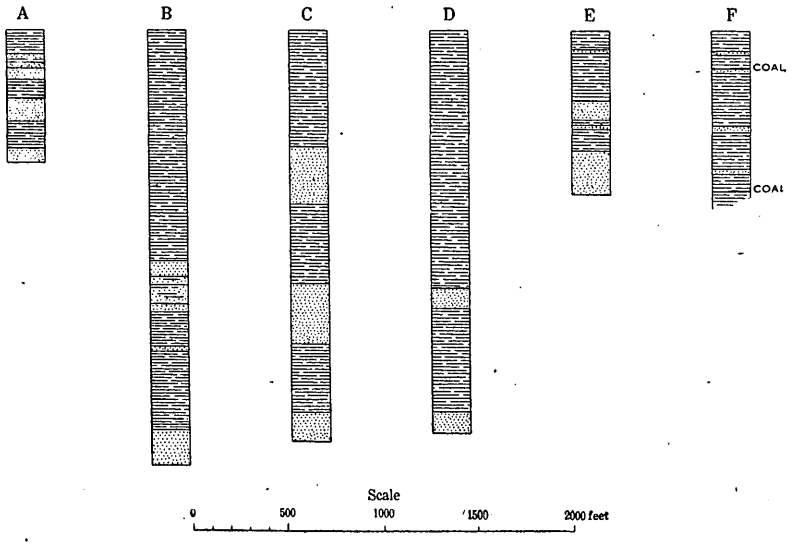


FIG. 3.—Graphic sections of the upper part of the Atoka formation. A, north of Van Buren; B, Massard Prairie; C, Jenny Lind; D, south of Huntington; E, Denning; F, Dardanelle.

of the coal field has been estimated to be approximately 1,500 feet, but near Mansfield, in the southern part, over 3,000 feet are exposed and 2,000 more have been pierced by deep drilling. The shales vary from fine-grained, black or blue clay stones to gray argillaceous sandstones. Generally the more sandy beds are harder, and where they outcrop form ridges and other prominent topographic features. Although the rocks of this formation have not been investigated in close detail, the observations made and the records of deep wells drilled through them show that the sandstone members are lenticular bodies, having no general distribution over the field. In many places where they have been examined the sandstones are very irregularly bedded, and in some places finger out into shale beds. A characteristic exposure of one of these beds is shown in Pl. IV, *A*.

The variation in the succession of sandstones and shales making up the Atoka formation is graphically shown in the sections presented in fig. 3. Lentils of coal, most of which are too thin to be of value, occur at rather infrequent intervals. Such coals seem to be more common in the eastern part of the field than in the western, a condition which may be partly due to the better exposures in the eastern portion. Some of these beds have been mined locally, and attempts to exploit them at various places are still in progress, though nearly all the old openings are deserted.

Though fossil plants have been found associated with the coal beds at several points, no satisfactory collections of them have been made. Several collections of marine invertebrates, which are described under the heading "Paleontology" (pp. 31–35), were obtained from some of the upper beds near Van Buren.

These rocks have been prospected successfully at a number of places in the search for oil and gas. The natural gas used at Fort Smith is obtained from sandstone lenses 1,000 to 2,000 feet below the top of the formation, while that at Mansfield and Huntington comes from sands 4,000 feet stratigraphically below the top of the formation.

HARTSHORNE SANDSTONE.

The Hartshorne sandstone is economically the most important formation, outside of the coal beds themselves, to be described in the district, since its outcrop indicates the position of the most important coal horizon. It had been identified at Bonanza and Hackett, on the Arkansas-Indian Territory boundary, previous to the beginning of this investigation. From these points its outcrop has been traced eastward around the end of the Backbone Ridge anticline, and its identity with the sandstone of Devils Backbone Ridge, which underlies the coal bed at Montreal and Burma, is established by drill holes at short intervals across the Greenwood syncline. From the latter localities it has been traced by continuous exposure eastward through the whole length of the coal field. The outcrop of this sandstone marks the northern boundary of the coal field through most of its length, and the rock also occurs in a number of isolated areas within the coal district, as is shown on the accompanying geologic map.

This formation is essentially sandstone, but does not differ materially from many of the heavier sandstone beds contained in the underlying rocks, except for its more general distribution over the field. Usually it can be identified by the presence of one or more coal beds in the rocks immediately above it. In its typical exposures it consists of massive, irregularly bedded rock, at most places more than 100 feet thick, and where the dips are moderately high it almost

invariably makes a prominent ridge. Locally, however, the sandstone becomes shaly and in places it may consist of two comparatively thin sandstone members with sandy shale between, or it may thin out to a single sandstone less than 20 feet thick. For example, at Burma the Hartshorne is a heavy sandstone over 50 feet thick, above which there is a coal bed overlain by another sandstone of nearly equal thickness, the two beds together forming the Devils Backbone Ridge. On the north side of the Huntington basin, a few miles east of Burma, the Hartshorne formation contains only 15 feet of hard rock, and the sandstone which overlies it at Burma is absent. Though the rocks stand at a comparatively high angle, the northern rim of the basin is not marked by any noticeable ridge. A similar variation in the Hartshorne sandstone occurs near Russellville, on the north side of Shinn basin, where it consists only of sandy shales, which do not appear in the topography, although they dip at a rather high angle. South of Shinn basin, only half a mile away, the Hartshorne formation is represented by a 75-foot bed of hard sandstone,

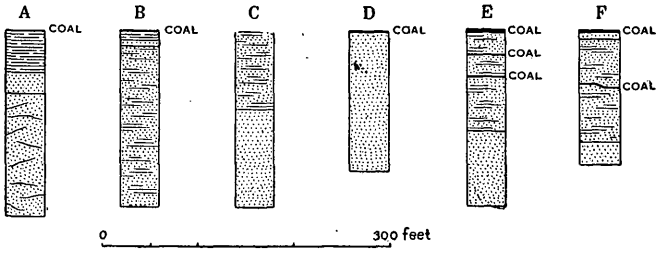
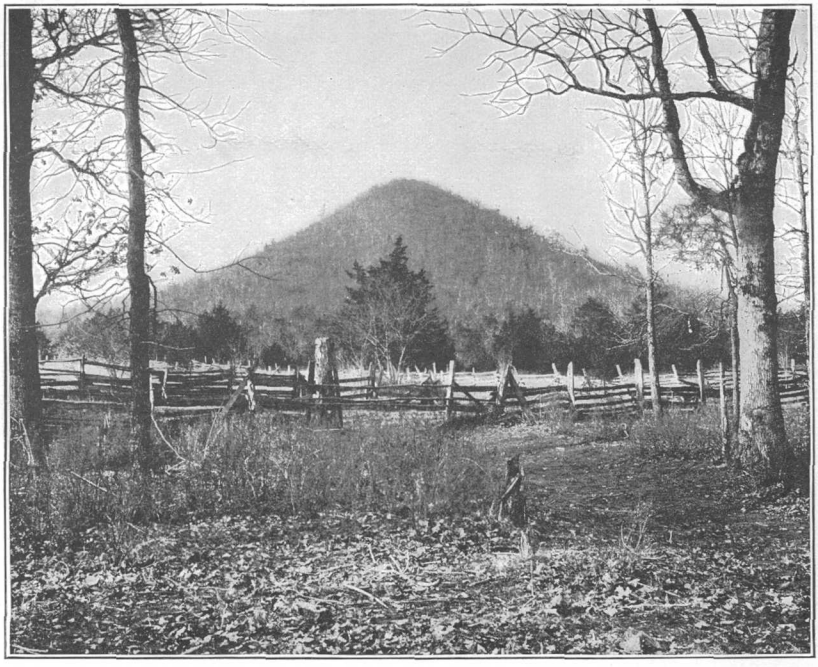


FIG. 4.—Graphic sections of the Hartshorne formation. A, Jenny Lind; B, Hackett; C, Chismville; D, Denning; E, Shinn basin; F, Ouita basin.

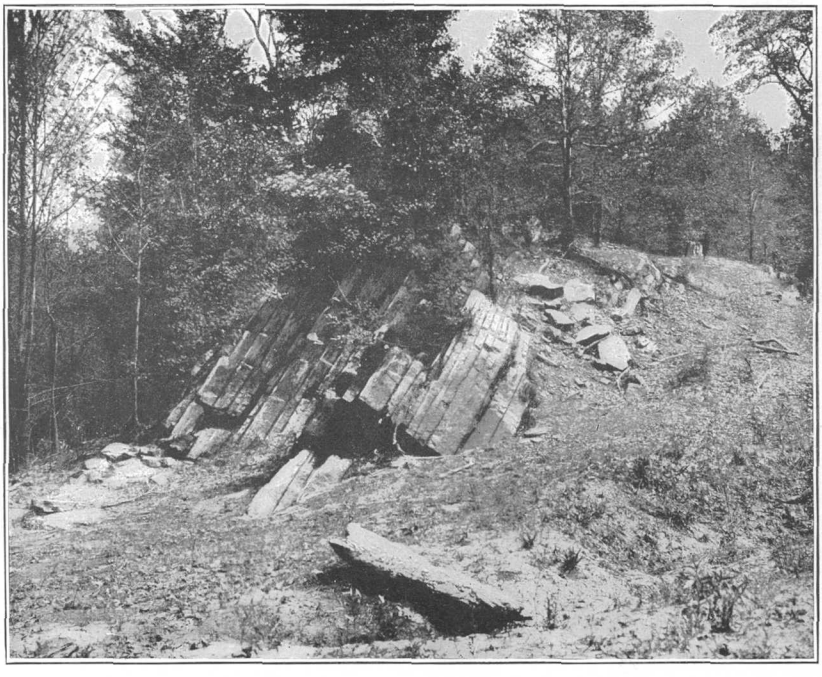
which makes a prominent ridge. Where exposed on Massard Prairie, near Fort Smith, the Hartshorne sandstone is only 10 to 12 feet thick, while farther northeast it is still thinner, and near Arkansas River it consists only of disconnected lenses of hard sandstone in a black shale. These variations in the sandstone and some detail as to its composition are shown in fig. 4. The peculiarities of bedding are illustrated in Pl. II, *B*, and Pl. III, *A* and *B*.

The coal bed which occurs in the rocks immediately above the sandstone and is called the Hartshorne coal has been traced westward into Indian Territory for 150 miles and to the eastern limits of the field in Arkansas. It is not probable that any one coal bed is continuous through this whole distance, but that there are several beds within a few feet of one another vertically, some one of which is nearly always present. In a large part of the Indian Territory field there are two coal beds, called the lower and upper Hartshorne coals, with an interval of 50 to 100 feet between them. The same two coal beds



A. VIEW OF POTATO HILL.

A cone-shaped butte formed by the erosion of horizontally bedded shales in a synclinal basin.



B. EXPOSURE OF HARTSHORNE SANDSTONE SOUTH OF SHINN BASIN.

Showing one of many phases of the Hartshorne sandstone.

are present in the southwestern part of the Arkansas field, near Montreal and Burma, but in other parts of the field only one of them, probably the lower, has been found.

This formation is barren of fossil remains, neither plants nor invertebrates having been found in it, with the exception, possibly, of a few fragments of *Stigmaria*. At many places, however, lumps of mud are included in the sand, which on weathering out leave cavities resembling those left by fossil invertebrates. This sandstone is not known to have yielded natural gas or oil, though it has yielded good flows of artesian water at several places, where drill holes have penetrated it.

SPADRA[a] SHALE.

The Spadra shale, named from the town of Spadra, in Johnson County, stands next in economic importance to the Hartshorne sandstone, which it overlies, since at its base it contains the most important coal beds. It is well known to coal operators and miners in Arkansas, being represented at nearly all of the mining towns. This formation is distributed over the whole of the workable coal field and its outcrop is eroded in many places to form broad valleys, many of which were indicated on the older maps of the region, where they are described as prairies. The residual soil it produces seems to be comparatively poor and the vegetation on it is relatively scant. In general this formation consists of fine-grained blue, black, or gray clay shales, but locally it contains sandy beds and in some places thin sandstone lenses, none of which extend for very great distances. The most prominent sandstone lens observed is one near Burma, in Sebastian County, which forms the parting between the upper and lower Hartshorne coals. This sandstone which has a maximum thickness of 60 feet, is irregularly cross-bedded, contains mud lumps, and resembles the Hartshorne sandstone in hardness, but it thins out and disappears within a few miles in each direction from its thickest part. At many other places sandstones having a thickness as great as 20 feet occur, but these are of irregular distribution and of no great extent. The thickness of the formation, which is well known not only from surface observations but from many drill holes that have penetrated it, varies from 350 to 500 feet. These differences may be due to either one of two causes—either the shale beds themselves vary in thickness in different parts of the field, or, as seems more likely, some of the sandy members at the base of the overlying formation thin out locally and disappear. The formation appears to be abnormally thin where it outcrops along the southern edge of the central part of the field, in some sections not exceeding 200 feet in thickness.

[a] The name Spadra stage, applied to the time this formation was deposited, was published by John J. Stevenson in 1895. Trans. New York Acad. Sci., vol. 15, 1896, p. 51.

This condition is attributed tentatively to the rather intense local folding of the beds, it being inferred that the softer shale has been either squeezed or sheared. A number of characteristic sections of the Spadra shale taken from various parts of the field are shown in fig. 5.

Fossil plants and occasionally invertebrate animal remains occur in the shale overlying the Hartshorne coal bed and representative collections were made from it at several localities. These collections have been examined by David White and G. H. Girty, whose reports on them are given in full on pages 24–35 of this paper. Although the Spadra shale has a flora that is to a certain extent characteristic of it, many of the species represented have also been collected from beds much higher in the stratigraphic column and therefore

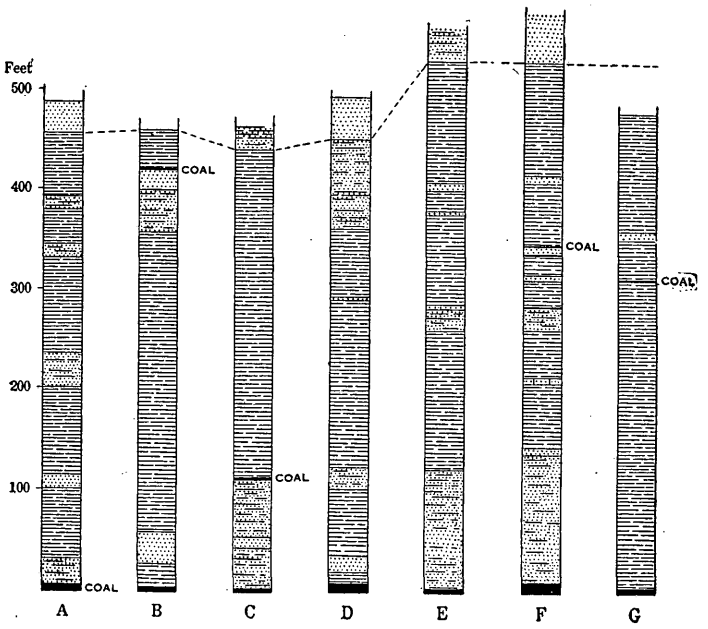


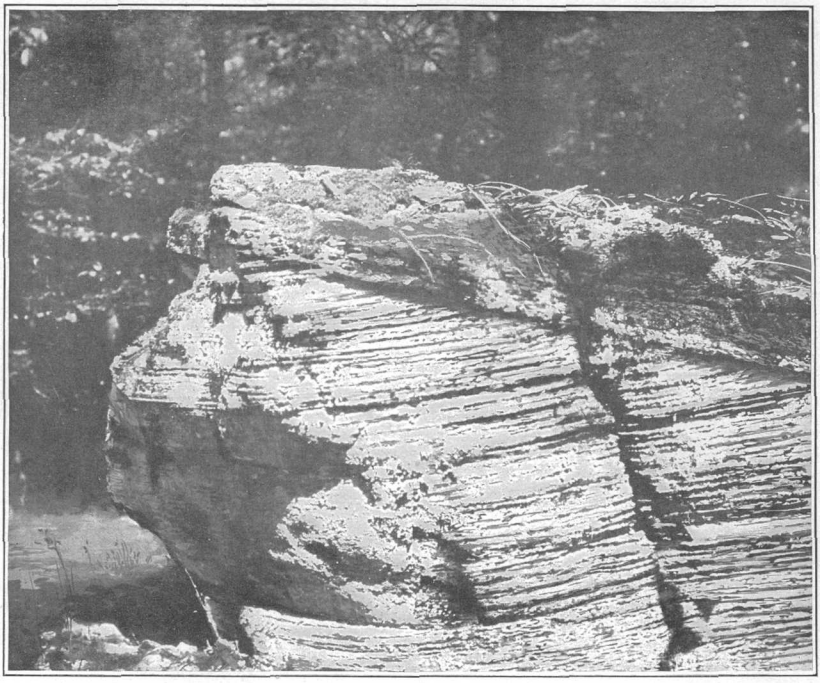
FIG. 5.—Graphic sections of Spadra shale. A, north of Jenny Lind; B, northwest of Midland; C, southwest of Hartford; D, east of Greenwood; E, north of Prairie View; F, east of Spadra; G, Shinn basin.

such collections of fossils are of little value in correlating formations in different parts of the field. The various fossils collected from these coal measures indicate that they were deposited very rapidly as compared with those of eastern coal fields.

These shales have been used to a limited extent near Fort Smith for brickmaking, but otherwise they have no economic value except for the coal beds.

FORT SMITH FORMATION.

The outcrops of the Fort Smith formation are more widely distributed than those of any other formation within the coal field, as



A. EXPOSURE OF THE HARTSHORNE SANDSTONE NEAR PINEY CREEK EAST OF KNOXVILLE.

Showing the false bedding characteristic of this formation in some places.

B. APPARENT UNCONFORMITY IN HARTSHORNE SANDSTONE, DUE TO FALSE BEDDING.

Illustrating another phase of irregularity in the bedding.

is shown by the geologic map. The formation consists of a group of thin and to some extent variable sandstone beds, with interbedded shale members, and is named from the city of Fort Smith, in Sebastian County. In general the sandstones are ripple-marked, the markings presenting considerable variety in both size and form, and many of the individual beds are characterized by a wavy cleavage approximately parallel to the minor undulations of the bedding planes. False bedding or cross-bedding, which is a common feature of the Hartshorne sandstone, is unusual in the Fort Smith formation, though it is not entirely absent. The shales are nearly everywhere more or less arenaceous and the resulting soils are reddish or yellowish and sandy. At Fort Smith the lower sandstone member is extensively quarried and has yielded most of the flagstones with which the city is paved. The formation here consists of a lower member, 20 to 50 feet thick, of hard, flaggy, ripple-marked sandstone, above which there are 40 to 60 feet of shale overlain by hard sandstone and shaly sandstone nearly 100 feet thick. Near the upper part of the formation there is a coal bed which was formerly mined and which appears on the map prepared by the Geological Survey of Arkansas as the Hermann and Wilson pits.

One of the best exposures of the formation is found in the region east of Greenwood. Here the lower sandstone member, which is probably identical with that at Fort Smith, forms a prominent ridge constituting the rim of a synclinal basin in which the town of Bloomer is situated. Above this sandstone is nearly 200 feet of shale, which is overlain by a series of hard, shaly sandstones forming Grand and Coal ridges, aggregating about 200 feet in thickness. There are two coal beds in the upper part of the formation here, the lower one of which has been opened in a number of pits and varies in thickness from 18 inches to 3 feet. The lower sandstone member of the formation is also typically exposed in Tennessee Ridge, which forms the northern wall of Long Prairie at Jenny Lind, and from this occurrence it has been locally called the "Tennessee sandstone."

The individual beds comprising this formation in the eastern end of the field have not been definitely correlated with those in the western part. In the vicinity of Spadra it is probable that the lower sandstone member corresponding to the sandstone of Tennessee Ridge is either absent or so shaly that it can not be identified, while a bed a little higher stratigraphically has taken its place as the first distinct sandstone above the Spadra shale. This sandstone forms the escarpment at the front of Big Danger Hill south of Clarksville and is about 60 feet thick.

The upper part of the Fort Smith formation is probably not represented in this part of the field. In general the formation here is much more sandy than the Spadra shale. It contains several small, unim-

portant coal beds, which have not been examined in detail nor correlated with those in the western part of the field.

The average thickness of the Fort Smith formation is estimated at 400 feet. Detailed sections exposed at various localities are shown in fig. 6.

Fossil plants occur in association with some of the coal beds, and several collections made from them have been examined by David White, who refers to them as the Coal Ridge flora. This flora seems to differ only slightly from that of the Hartshorne horizon, though it can be distinguished.

The sandstones of this formation have been quarried for paving and building stones at several places. At Fort Smith the lower sandstone member has been extensively worked, yielding flagstones from which most of the city's sidewalks are made. These flags are from 3 to 6 inches thick and, though hard and durable, their surfaces are invariably ripple-marked and rough.

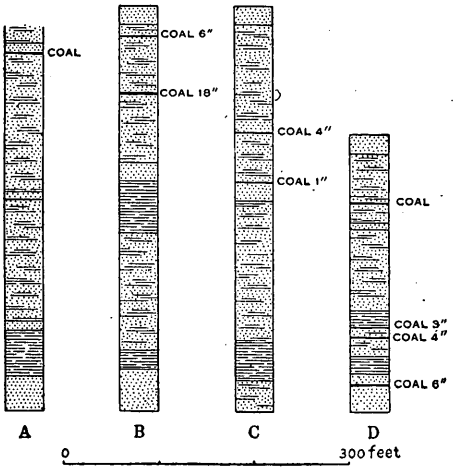


FIG. 6.—Graphic sections of the Fort Smith formation. A, section at Fort Smith; B, section north of Auburn; C, section north of Prairie View; D, section northeast of Lamar.

At Cabin Creek station (Lamar post-office), in the eastern part of the field, a more massive bed, somewhat higher in the formation, is quarried, yielding a good stone, which is shipped to more distant markets, some of it going as far as New Orleans. A view of this quarry showing the characteristic bedding and joint planes of the rock is shown in Pl. IV, *A*.

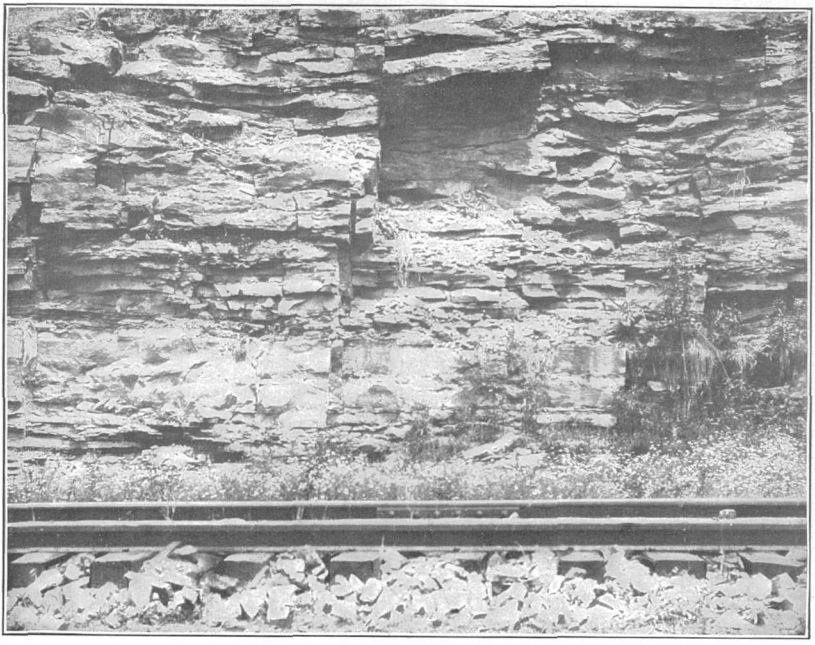
The rock quarried at Spielerville and used in the construction of the Subiaco College buildings is probably taken from a sandstone bed in this formation, and most of the brick factories near Fort Smith have obtained their material from shale beds that are included in it.

PARIS SHALE.

The Paris shale, which takes its name from the town of Paris in Logan County, covers two large areas, essentially broad synclinal basins, in the central part of the field. One syncline near Paris is surmounted by Short and Little Short mountains. The other, south of Charleston, surrounds the base of Potato Hill. It also occurs in smaller areas in Sugarloaf, Poteau, and Magazine mountains. The base of the formation is believed to be nowhere less than 800 feet above the horizon of the Hartshorne coal. This formation resembles

A. QUARRY AT CABIN CREEK.

Illustrating the system of jointing which prevails over the Arkansas coal field.



B. SANDSTONE OF ATOKA OR WINSLOW FORMATION, ONE-HALF MILE WEST OF OZARK.

Illustrating a type of irregular bedding characteristic of certain sandstones below the coal-bearing rocks.

the Spadra shale, but is almost invariably more sandy and contains a greater number of sandstone lenses, whose distribution has not been determined in close detail. The sandstone lenses, however, are generally softer than those included in the Spadra formation and do not contrast so strongly in topographic expression with the including shales.

The total thickness is estimated from the dips of the outcrops to be between 600 and 700 feet. Its upper limit is marked in the Paris basin by the base of the heavy sandstone which caps Short and Little Short mountains. Detailed sections of the formation as exposed at Short Mountain and Potato Hill are given in fig. 7.

The Paris coal bed occurs from 200 to 300 feet above the base of the Paris formation and about 400 feet below its upper limit. A large collection of fossil plants and invertebrate animal remains from the sandy shale in the roof of this bed was submitted to David White and G. H. Girty, whose reports are given on pages 24–35.

The flora resembles that from the Coal Ridge horizon but is provisionally correlated with that from above the McAlester coal bed of Indian Territory, which occupies a similar relation to the Hartshorne coal horizon. Except for its coal this formation yields no minerals of economic value. Its sandstones are usually too soft for building purposes and its shales have not been utilized in brick-making.

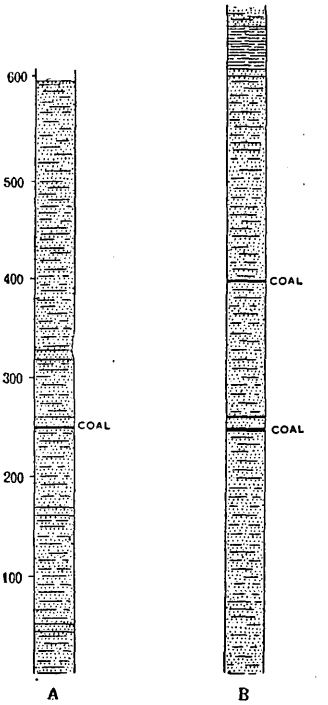


FIG. 7.—Graphic sections of Paris shale. A, Potato Hill; B, Short Mountain.

SAVANNA FORMATION.

The Savanna sandstone occurs in only a few small areas in Arkansas, where it caps several isolated mountains and buttes. This formation as represented in Indian Territory is described as a group of three more or less massive and thick sandstone beds with intervening shaly members, the total thickness being approximately 1,000 feet. In Arkansas only the lower part of this formation is present. Short and Little Short mountains near Paris are regarded as type localities. At Short Mountain the Savanna is represented by a massive sandstone nearly 100 feet thick, which lies as a flat cap forming a mesa on the summit. The conditions are similar at Little Short Mountain, which is capped by the same bed. The sandstone beds at the top of Magazine Mountain, which are provisionally correlated with the Savanna, have a total thickness of several hundred feet and contain some conglomeratic beds with quartz and chert pebbles as large as one-eighth

of an inch in diameter. This formation is also represented in Sugarloaf and Poteau mountains, where the detail of its beds is so obscured by talus that it has not been mapped closely.

In general the Savanna formation has little economic value in Arkansas. No coal beds have yet been discovered in it, though such beds may be present in Poteau and Sugarloaf mountains. The sandstone beds in Short Mountain are massive and could probably be used for building stones where large blocks are required.

SURFICIAL DEPOSITS.

Many of the lowland areas within the coal field are mantled over with deposits of silt, sand, or gravel that were laid down on surfaces formed by the erosion of the coal-bearing rocks. As noted above, there are remnants of several old plain surfaces representing different stages of erosional development in Arkansas Valley. The most recent stage is represented by the flood plains of Arkansas River and its tributary streams. A somewhat earlier stage is indicated by the general lowland area above the flood-plain level, while a much earlier stage is represented by the level-topped ridges and hills surmounting this lowland. The difference in elevation between the highest and lowest plain is about 400 feet. Deposits of gravel and sand are of wide distribution on the surfaces representing the two later stages, where they have received casual attention. These deposits are evidently distinct in age, though it is often hard to differentiate them in the field. On the accompanying geologic map, Pl. VI, they are indicated only in those areas where they are so thick as to conceal effectually the underlying strata and render it impossible to discover the geologic relations of the coal-bearing rocks. The recent deposits are not differentiated from the earlier ones.

The recent deposits, which are most extensively represented in the flood plains of Arkansas River, are composed generally of rather fine silt and sand, gravels and coarse pebbles being of rare occurrence. Their surfaces are marked by oxbow lakes and other ordinary flood-plain features. They comprise much of the richest agricultural land in this district, though they are subject to overflow at long intervals.

The earlier of these deposits, where identified, usually consist of sand and moderately fine gravel containing many pebbles of chert. Generally they are indicated by waterworn pebbles strewn over the surface, but in good exposures, such as banks of streams and road cuts, they are stratified and are often 20 feet or more in thickness. Such deposits are invariably more or less eroded and show none of the original surface features of flood-plain deposits.

Flat surfaces of this lowland plain of the earlier period are in many places marked by scattered low mounds[a] averaging 2½ feet in height

[a] Campbell, M. R., Natural mounds: Jour. Geol., vol. 14, No. 8, November-December, 1906. This paper is one of the latest and most comprehensive discussions of this subject and contains a bibliography of the literature relating to it.

by 50 feet in diameter, whose origin has been the subject of much speculation.

The mounds generally occur in localities of poor drainage, and in Arkansas are especially common over clay soils formed by the disintegration of the shale beds, though not confined to them exclusively. The general distribution of the mounds, not only here but in other States, disproves the theory very common in Arkansas that they are formed by escaping gases and are therefore good indications of gas, oil, or coal. Of the other hypotheses regarding them the one that they were built by burrowing animals of some kind now extinct seems to the writer most probable. At any rate they were produced under conditions not now existing in Arkansas Valley, and they can safely be taken as an infallible diagnostic feature of the older erosion levels and surficial deposits.

PALEONTOLOGY.

CONCLUSIONS DRAWN FROM STUDIES OF THE FOSSILS.

Fossils representing the plant and animal life of the coal period are not generally distributed through the Arkansas coal measures, though they are abundant in certain beds at a few horizons where a number of fairly representative collections have been made. The fossil plants collected for the Arkansas Geological Survey were examined and reported on in a paper by H. L. Fairchild and David White which, like several other reports of that organization, has unfortunately never been published. Several collections of invertebrate fossils from the coal field were identified, described, and illustrated by Prof. J. P. Smith,[a] formerly of the Arkansas Survey, and the correlation of the coal measures with Carboniferous rocks of other regions was adequately discussed by him in several papers published by private organizations, which are available for reference in any good geological library.

Since the discontinuance of the Arkansas Geological Survey, many collections, of both plants and marine invertebrates, from corresponding rocks in Indian Territory, have been examined by David White[b] and G. H. Girty,[c] and are described in the publications of the United States Geological Survey.

The collections made in the course of the present investigations in Arkansas have been examined by Messrs. White and Girty, whose reports on them are presented on pages 24–35. In general these

[a] Smith, James Perrin, The Arkansas coal measures in their relation to the Pacific Carboniferous province: Jour. Geol., vol. 2, 1894, pp. 187–203; Marine fossils from the coal measures of Arkansas: Proc. Am. Philos. Soc., vol. 35, 1896, pp. 214–285, Pls. XVI–XXIV.

[b] White, David, Report on fossil plants from the McAlester coal field, Indian Territory, collected by Messrs. Taff and Richardson in 1897: Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1899, pp. 457–534, Pls. LXVII–LXXVIII.

[c] Girty, G. H., Preliminary report on Paleozoic invertebrate fossils from the region of the McAlester coal field, Indian Territory: Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1899, pp. 539–593, Pls. LXIX–LXXII.

fossils afford little ground for the stratigraphic correlation of individual beds and horizons, though they determine in a general way the age or time relations of the coals of Arkansas as compared with those of other States. Two conclusions of general interest may be drawn from a study of the fossils:

1. The Arkansas coal measures correspond to a lower part of the Pennsylvanian series of the Carboniferous. They are somewhat older than the coals of Kansas and younger than those of Alabama.

2. The great thickness of coal-bearing sediments of Arkansas was deposited in a relatively short time as compared with that required for the deposition of the corresponding rocks in Pennsylvania and West Virginia. The rapid sedimentation may account for the great stratigraphic intervals between the several coal beds and for much of the irregularity in the bedding.

REPORT ON FOSSIL PLANTS FROM THE COAL MEASURES OF ARKANSAS.

By David White.

EXTENT AND CHARACTER OF THE COLLECTIONS.

The fossil plants collected by Mr. Arthur J. Collier and assistants from the Arkansas coal fields have been examined very closely, and the identifications listed below are, for the most part, final, though a portion are subject to revision and must be regarded as preliminary.

A fact that becomes at once apparent on inspecting the plants collected by Mr. Collier is the remarkable lack of strong or characteristic differences between the ferns of the upper and lower horizons represented in the collections. The entire period covered by the approximately 1,200 feet represented therein is not greater than that embraced in less than 200 feet of a corresponding portion of the Allegheny formation in the Appalachian trough. The Coal Hill coal appears paleobotanically at the level of the Brookville coal in the Allegheny formation. The Coal Ridge flora, on the other hand, is perhaps not younger than the lower Kittanning coal of the Allegheny formation, while the Paris coal furnishes no evidence of a date later than upper Kittanning. The entire interval falls within the limits of the Cherokee formation in Kansas; and of the basal coal measures in Henry County, Mo., including beds probably not over 150 feet above the Mississippian surface.

In view of this great dilation of the basal Allegheny and consequent extraordinarily rapid sedimentation it is not surprising that very little distinct change is to be observed from one point to another, or that the horizons can with difficulty be detected paleobotanically without elaborate collections. Some of the lots contain but few species, many of which have considerable vertical range. It is impossible, therefore, to foresee what similarities between certain lots would

appear if the collections were more complete. On the contrary, where the collections are from very different horizons it is safe to infer that larger collections would show greater paleontological differences.

In listing and discussing the collections I shall treat them in several natural groups, which are assumed to represent as many horizons or phases of the floras. A small number of lots will be omitted on account of the absolute insufficiency of the material.

FLORA OF THE COAL HILL COAL.

The collections which I regard as probably belonging to this horizon represent a basal Alleghenian flora in which a few traces of Pottsville development are still to be seen, as illustrated particularly in *Mariopteris* and *Neuropteris*.

Fossil plants (lot D) from NE. ¼ SE. ¼ sec. 29, T. 9 N., R. 25 W., below Coal Hill coal.

- Annularia sphenophylloides.
- Sphenophyllum emarginatum.
- Sphenophyllum suspectum.
- Pseudopecopteris macilenta.
- Cheilanthites trifoliolatus.
- Cheilanthites squamosus.
- Mariopteris occidentalis.
- Mariopteris nervosa.
- Pecopteris vestita.
- Pecopteris (Scolecopteris) cf. miltoni.
- Alethopteris serlii (lax).
- Neuropteris capitata.
- Neuropteris missouriensis.
- Neuropteris scheuchzeri.
- Neuropteris rogersii.
- Linopteris squarrosa?.
- Dolerophyllum angularis.
- Cardiocarpon bicuspidatum?.
- Rhabdocarpos sulcatus.

Fossil plants (lot E) from NE. ¼ sec. 24, T. 9 N., R. 26 W., west of Coal Hill.

- Annularia sphenophylloides.
- Sphenophyllum emarginatum var. minor.
- Sphenophyllum suspectum.
- Cheilanthites squamosus.
- Mariopteris occidentalis.
- Mariopteris nervosa.
- Pecopteris plumosa.
- Pecopteris vestita?.
- Pecopteris sp., indet. fragment.
- Alethopteris serlii.
- Neuropteris scheuchzeri.
- Wing of cockroach.

Fossil plants (lot B) from Southern Anthracite Coal Company's shaft No. 1, at Russellville, Ark., in sec. 16, T. 7 N., R. 21 W.

- Annularia sphenophylloides.
- Calamostachys sp.
- Sphenophyllum fasciculatum.
- Cheilanthites squamosus.
- Mariopteris occidentalis.
- Pecopteris vestita?.
- Alethopteris serlii.
- Aphlebia cf. hirsuta.
- Neuropteris missouriensis.
- Neuropteris capitata.
- Neuropteris scheuchzeri.
- Sigillariostrobus quadrangularis.
- Wing of cockroach.

Fossil plants (lot C) from Humphrey's shaft, north of Russellville, Ark., in sec. 28, T. 8 N., R. 21 W.

- Annularia radiata.
- Annularia sphenophylloides.
- Sphenophyllum emarginatum var. minor.
- Mariopteris latifolia?.
- Neuropteris cf. tenuifolia.
- Neuropteris harrisii?.
- Neuropteris missouriensis.
- Neuropteris scheuchzeri.
- Wing of cockroach.

Fossil plants (lot M) from Woodson's strip pit, one-fourth mile north of Burma station on the Frisco Railway, in sec. 19, T. 5 N., R. 31 W.

Annularia sphenophylloides.
Sphenophyllum emarginatum.
Alethopteris serlii.
Neuropteris harrisii.
Neuropteris missouriensis.
Neuropteris ovata.
Neuropteris cf. tenuifolia.

Fossil plants (lot C) from old No. 1 mine at Denning, Ark., in SE. ¼ sec. 22, T. 9 N., R. 26 W.

Annularia stellata.
Annularia sphenophylloides.
Phyllotheca? sp.
Sphenophyllum emarginatum.
Sphenophyllum majus.
Sphenophyllum suspectum.
Cheilanthites squamosus.
Mariopteris incompleta.
Mariopteris muricata.
Mariopteris occidentalis.
Mariopteris nervosa.
Sphenopteris sp.
Pecopteris emarginata.
Pecopteris cf. robusta.
Pecopteris vestita.
Pecopteris clintoni?.
Alethopteris serlii (lax).
Neuropteris capitata.
Neuropteris missouriensis.
Neuropteris scheuchzeri.
Lepidophloios scoticus?.
Sigillariostrobus quadrangularis.

The four lots first listed above appear to represent an identical flora. The plants in lot C show so close a relation to the flora of the Hartshorne coal of Indian Territory as in my judgment to justify the belief that it belongs to the same horizon—a conclusion sustained also by lot M.

Fossil plants (lot I) from NE. ¼ SW. ¼ sec. 29, T. 9 N., R. 25 W., southwest of Coal Hill.

Sphenophyllum emarginatum.
Mariopteris occidentalis.
Mariopteris nervosa.
Alethopteris serlii.
Neuropteris missouriensis?.
Rhabdocarpos sulcatus.
Rhabdocarpos ? sp.

The very small collection listed above is placed here on account only of its lack of difference from the preceding. In itself it is insufficient for paleontological correlation.

Fossil plants (lot K) from mine No. 4 Western Coal Company, in NW. ¼ SE. ¼, sec. 19, T. 9 N., R. 25 W., west of Coal Hill.

Neuropteris missouriensis.
Neuropteris scheuchzeri.
Lepidophyllum missouriense.
Asolanus camptotænia.
Cardiocarpon cf. circulare

This very meager collection differs from the other floras by the addition of two lepidophytes and by the relatively small number of ferns. Its inclusion with the Coal Hill flora is based purely on the stratigraphic data furnished by Mr. Collier.

FLORA OF THE SPADRA COAL.

The two collections next listed come from below the Spadra coal.

Fossil plants (lot H) from shale 4 feet below Spadra coal in old Allen slope, in NE. ¼ sec 13, T. 9 N., R. 25 W., northwest of Hartman, Ark.

Annularia sphenophylloides.
Eremopteris cf. lincolniana.
Pseudopecopteris macilenta.
Mariopteris sp. cf. sphenopteroides?
indet. fragment.
Sphenopteris cf. cristata.
Pecopteris vestita.
Alethopteris serlii.
Neuropteris ovata.
Neuropteris capitata?.
Neuropteris jenneyi.
Linopteris cf. squarrosa; small fragment.

Fossil plants (lot G) from SE. ¼ sec. 24, T. 10 N., R. 25 W., 4 miles north of Hartman, Ark.

Annularia sphenophylloides.
Eremopteris cf. lincolniana.
Pseudopecopteris macilenta.
Sphenopteris (Hawlea) cf. cristata?.
Small fragment.
Pecopteris vestita?.
Aphlebia hirsuta.
Alethopteris serlii.
Neuropteris scheuchzeri.
Neuropteris jenneyi.
Linopteris cf. squarrosa.
Sigillariostrobus quadrangularis.

While apparently as old as the Coal Hill flora these two lots are not so far identical with the latter as might be expected. The two lots are very nearly identical in composition and it is possible that their difference from the flora of the Coal Hill coal may be due only to the fact that the fossils come from below the coal rather than from the roof shale.

The interesting feature connected with the Spadra flora is the occurrence of *Pseudopecopteris macilenta, Neuropteris jenneyi,* and *Linopteris squarrosa,* three species originally described from the small outlying basin in the zinc region of southwestern Missouri.

FLORA OF THE COAL RIDGE OR CHARLESTON COAL.

Fossil plants (lot L) from Carter's coal mine, in sec. 17, T. 7 N., R. 28 W., southeast of Charleston, Ark.

Annularia sphenophylloides.
Sphenophyllum emarginatum var. minor.
Sphenophyllum fasciculatum.
Sphenopteris sp. indet. fragment.
Aloiopteris winslovii.
Pecopteris vestita.
Pecopteris miltoni?.
Callipteridium membranaceum.
Neuropteris missouriensis.
Neuropteris scheuchzeri.
Lepidophyllum lanceolatum.
Cordaites (communis?).

Fossil plants (lot Q) from point 50 paces south of iron bridge, one-half mile east of Caulksville, Ark., in sec. 3, T. 7 N., R. 17 W.

Annularia sp.
Sphenophyllum emarginatum.
Sphenophyllum majus.
Eremopteris spinosa.
Neuropteris cf. rarinervis.
Neuropteris cf. missouriensis?.
Neuropteris scheuchzeri.
Linopteris münsteri.
Lepidocystis vesicularis.

Fossil plants (lot N) from sec. 3; south center, south of bridge east of Caulksville, Ark., in sec. 3, T. 7 N., R. 27 W.

Annularia sphenophylloides.
Sphenopteris cf. illinoisensis.
Renaultia sp. indet.
Pecopteris villosa?.
Pecopteris oreopteridia.
Pecopteris candolliana.
Neuropteris missouriensis.
Linopteris münsteri.
Lepidophyllum ovatifolium?.

Fossil plants (lot P) from shale over Coal Ridge or Charleston coal in northeast corner sec. 6, T. 7 N., R. 28 W., north of Charleston, Ark.

Asterophyllites equisetiformis.
Sphenopteris ? sp. indet.
Pecopteris vestita.
Neuropteris scheuchzeri.
Linopteris münsteri.

The plants contained in lots L, Q, and N belong to a flora which, though very closely allied to that of the Coal Hill coal, appears, nevertheless, to differ from the latter by the absence of some of the earlier forms related to *Cheilanthites*, *Mariopteris*, and *Neuropteris*. The flora is fairly homogeneous, though not rich. It is characterized by the presence of a considerable number of species which were not collected from the Coal Hill coal and which point to an approximate contemporaneity with the lower coal in Henry County, Mo. It is doubtful whether the flora here represented is younger than the Lower or Middle Kittanning, though it is possible that more complete collections will prove it to be young as the Upper Kittanning. Strictly speaking, this flora is perhaps as high as any that is represented in the collections. The five species of lot P are tentatively placed in the same group with L and Q, on account of the identity of the *Linopteris münsteri*. The flora of lot P itself is too small for correlative value.

THE PARIS FLORA.

Fossil plants (lot O) from coal seams of the Paris Coal Company, in sec. 10, T. 7 N., R. 26 W., one-half mile west of Paris, Ark.

Calamites suckowii.
Cheilanthites trifoliolatus.
Linopteris münsteri (abundant).
Lepidophyllum lanceolatum.
Lepidostrobus sp. (small).
Sigillaria discophora.
Androstachys? sp. indet.

This flora, which is possibly the youngest represented in the collections, appears to be closely joined to the preceding by the very abundant *Linopteris münsteri*. The remaining species are, however, largely unrepresented in the other collections, but their general stratigraphical significance is not such as to permit of regarding the Paris coal as very much later in date than the Coal Ridge coal. I do not regard it as younger than Upper Kittanning.

LOTS OF DOUBTFUL AGE.

Hereunder I list the collections in lots V, W, U, and X, all of which are probably from the same horizon. It would seem that these lots can not be younger than the Coal Ridge flora, while, on the other hand, the number of species which they hold in common with the Coal Hill flora would at first make them seem susceptible of reference to the latter horizon. At the same time each lot contains so large a

proportion of forms not represented in the collections from Coal Hill coal as to leave some doubt as to the correctness of such a reference. The general indications of some of these extraneous species would seem to preclude considering the material as later, at furthest, than Coal Ridge flora. This is particularly true of lot V, whose connection with the Coal Hill flora is less evident than appears in the case of lot U. I am, on the whole, slightly more disposed to regard them as representing the Coal Hill coal. At the same time the presence of the species whose general status would seem to point to a higher horizon must leave doubt as to whether collections U and V are not, perhaps, as young as the Coal Ridge coal. Lots X and W are listed in connection with lots U and V for the reason only that they are too limited in species to present any differences from the other lots.

Fossil plants (lot V) from NW. ¼ NE. ¼ sec. 23, T. 9 N., R. 27 W., 5 miles west of Altus, Ark.

Calamites sp. indet.
Annularia sphenophylloides.
Sphenophyllum emarginatum.
Sphenophyllum fasciculatum.
Mariopteris sphenopteroides.
Mariopteris nervosa.
Sphenopteris cf. pinnatifida.
Crossotheca ophioglossoides.
Pachypteris gracillima.
Pecopteris vestita.
Neuropteris rarinervis.
Neuropteris missouriensis.
Neuropteris clarksoni?.
Neuropteris ovata.
Neuropteris scheuchzeri.
Odontopteris bradleyi?.
Lepidodendron sp., indet. twig.
Lepidophyllum oblongifolium.

Fossil plants (lot W) from SW. ¼ sec. 17, T. 9 R. 26 W., N. 2, miles west of Altus, Ark.

Calamites ramosus.
Annularia sphenophylloides.
Mariopteris nervosa.
Pecopteris villosa?. Fragments.
Wing of cockroach.

Fossil plants (lot U) from near Central Coal and Coke Company's mine at Hartford, in sec. 15, T. 4 N., R. 32 W.

Annularia sphenophylloides.
Sphenophyllum emarginatum var. minor.
Sphenophyllum cf. majus.
Cheilanthites squamosus.
Mariopteris occidentalis.
Mariopteris incompleta.
Mariopteris sphenopteroides.
Aloiopteris winslovii.
Pecopteris vestita.
Pecopteris candolliana.
Pecopteris dentata.
Pecopteris jenneyi?.
Alethopteris serlii var missouriensis.
Neuropteris ovata.
Neuropteris scheuchzeri.

Fossil plants (lot X) from sec. 21, T. 10 N., R. 29 W., 2 miles west of Pleasant Hill, on old wire road.

Sphenopteris sp.
Alethopteris serlii.
Neuropteris ovata.
Neuropteris scheuchzeri.

THE VAN BUREN FLORA.

Fossil plants (lot T) from E. ½ SE. ¼ sec. 9, T. 9 N., R. 31 W.

Asterophyllites equisetiformis.
Annularia radiata.
Annularia sphenophylloides.
Sphenophyllum emarginatum.
Sphenophyllum fasciculatum?.
Cheilanthites pluckenetii.
Mariopteris sphenopteroides.
Mariopteris occidentalis.
Mariopteris nervosa.
Crossotheca ophioglossoides.
Sphenopteris cf. mixta.
Pecopteris vestita?.
Pecopteris villosa.
Pecopteris robusta?.
Pecopteris dentata.
Aphlebia hirsuta.
Alethopteris serlii.
Callipteridium inæquale?.
Callipteridium sullivantii.
Neuropteris ovata.
Neuropteris fimbriata.
Neuropteris missouriensis.
Neuropteris scheuchzeri.
Neuropteris clarksoni?.
Cordaites cf. principalis.
Cordaianthus sp.
Cardiocarpon fluitans.
Rhabdocarpus sp.

The review of the species listed above shows at once that the Van Buren flora is most intimately associated with that represented by lots U and V. Its species are identical with the former, but they are, by the generally recognized range of the forms, shown to be of approximately the same age. The Van Buren flora (lot T) is therefore, I believe, to be considered as not younger than the Coal Ridge flora. If it can be shown that lots V and W are as old as Coal Hill it will then be possible to refer lot T to nearly as low an horizon. In this connection it may be of interest to compare lots U and V, as well as T, with two collections made by Mr. Taff from the Poteau and Sallisaw quadrangles of Indian Territory. I am not informed as to the stratigraphical position of the Indian Territory floras, though it is probable that Mr. Taff can readily supply the data; but it is desirable to call attention to the strong evidence of approximate contemporaneity which would appear to exist between these localities and those of the lots last discussed.

Fossil plants (lot 2180) from lower coal at Witteville, Ind. T. (Poteau quadrangle), in NE. ¼ sec. 15, T. 7 N., R. 25 E.

Sphenophyllum emarginatum.
Cheilanthites squamosus.
Mariopteris sphenopteroides.
Mariopteris nervosa.
Mariopteris incompleta.
Mariopteris occidentalis.
Pecopteris vestita.
Neuropteris ovata.
Neuropteris rarinervis.
Neuropteris scheuchzeri.
Odontopteris bradleyi.

Fossil plants (lot 2737) from center of sec. 13, T. 11 N., R. 23 E., Sallisaw (Ind. T.) quadrangle.

Annuluria stellata.
Annularia sphenophylloides.
Sphenophyllum emarginatum.
Sphenophyllum fasciculatum.
Sphenophyllum cf. thoni.
Mariopteris sphenopteroides.
Mariopteris occidentalis.
Mariopteris incompleta.
Sphenopteris pinnatifida.
Sphenopteris mixta.
Sphenopteris cf. cristata?.
Pecopteris vestita?.
Pecopteris robusta?.
Alethopteris ambigua.
Callipteridium sullivantii.
Neuropteris missouriensis.
Neuropteris scheuchzeri.
Linopteris cf. münsteri.
Cordaianthus ovatus.

OTHER COLLECTIONS.

The following localities are represented by collections too small and of too little value to deserve formal consideration from a correlative standpoint, especially in a case like the present, where the expansion of the formations is so great as to show but little floral change in an interval of hundreds of feet.

The first of these lots, from shale just above the quarry at the Catholic church, may belong to the Coal Ridge or Van Buren stage.

Fossil plants (lot S) from sec. 2, T. 7 N., R. 25 W.

Pecopteris vestita.
Pecopteris oreopteridia.
Cardiocarpon branneri.
Cardiocarpon cf. circulare.

Fossil plants (lot J) from sec. 31, T. 7 N., R. 28 W.

Neuropteris missouriensis.

Fossil plants (lot R) from Caulk's pit, east of Caulksville.

Alethopteris serlii.
Linopteris sp.

Fossil plants (lot A) from sec. 16, T. 9 N., R. 22 W.

Neuropteris missouriensis.
Mariopteris occidentalis.
Mariopteris sp.

REPORT ON MARINE CARBONIFEROUS FOSSILS FROM THE COAL FIELDS OF ARKANSAS.

By GEORGE H. GIRTY.

From Sixmile Creek, south of bridge east of Caulksville.

Aviculipecten whitei.

From No. 1 mine of Consolidated Anthracite Coal Company, Spadra, Ark., in sec. 24, T. 9 N., R. 24 W.

Pleurophorus subcostatus?.

No label.

Pleurophorus subcostatus.
Aviculipecten whitei.

From shale on Little Piney Creek above junction with Big Piney.

Euomphalus catilloides?.

From southeast corner sec. 30, T. 7 N., R. 29 W., in sandstone over coal.

Sedgwickia aff. topekensis.

From Sixmile P. O., in sec. 25, T. 8 N., R. 28 W.

Marginifera muricata.
Composita subtilita.
Edmondia aff. E. subtruncata.
Edmondia? sp.
Leda aff. L. nasuta.
Schizodus? sp.
Astartella varica?
Deltopecten aff. D. occidentalis.
Yoldia aff. Y. carbonaria.
Pleurophorus angulatus.
Euphemus nodicarinatus.
Platyceras aff. P. nebraskense.
Nautilus sp.
Orthoceras sp.
Various small undet. gasteropods.

From south side of Spadra Hill, in sec. 29, T. 9 N., R. 24 W.

Crania? sp.
Aviculipecten whitei.
Aviculipecten sp.
Leda? sp.
Pleurophorus oblongus.
Naticopsis nana.
Naticopsis sp.
Pleurotomaria? sp.
Murchisonia? sp.
Ostracoda.

From southwest corner NW. ¼ NE. ¼ sec. 15, T. 9 N., R. 32 W.

Lophophyllum profundum.
Derbya sp. (not crassa).
Productus sp.
Squamularia perplexa.
Spirifer rockymontanus.
Composita subtilita.
Hustedia mormoni.
Aviculipecten sp.
Myalina perniformis.
Astartella vera.
Nucula ventricosa.
Edmondia aff. E. nebraskensis.
Pleurophorus angulatus.
Macrodon obsoletus.
Patellostium? sp.
Orthoceras sp.

From NW. ¼ sec. 15, T. 9 N., R. 32 W., 3 miles northwest of Van Buren.

Crinoidal.
Lophophyllum profundum.
Composita subtilita.
Pleurophorus angulatus.
Soleniscus klipparti.
Pleurotomaria sp.

From road 50 paces south of railroad, in sec. 9, T. 9 N., R. 31 W. (C. D. S).

Crinoidal.
Prismopora sp.
Rhombopora sp.
Derbya sp. (not crassa).
Marginifera muricata.
Composita subtilita.
Dielasma? sp.
Spirifer rockymontanus.
Hustedia mormoni.
Macrodon obsoletus.
Deltopecten occidentalis.
Schizodus sp.
Pleurophorus immaturus?
Naticopsis sp.
Pleurotomaria sp.

From vicinity of Plymouth, Ark., on road 100 paces north of town, in NW. ¼ sec. 35 T. 11 N., R. 29 W.

Michelinia sp.
Polypora ? sp.
Fistulipora ? sp.
Derbya sp. (not crassa).
Marginifera ingrata?.
Spirifer rockymontanus.
Composita subtilita.
Hustedia mormoni.
Macrodon obsoletus?.
Leda aff. L. nasuta.
Astartella concentrica Conrad.
Euomphalus catilloides.
Euphemus nodicarinatus.
Nautilus sp.

From W. ½ sec. 35, T. 9 N., R. 28 W., just south of hill.

Marginifera muricata.
Hustedia mormoni
Derbya crassa?.
Composita subtilita.
Avicula acosta?.
Lima retifera?.
Aviculipecten sp. *a.*
Nucula ventricosa.
Leda sp.
Astartella ? sp.
Pteria ohioensis?
Astartella concentrica Conrad.
Pleurotomaria aff. brazoensis.

From one-fourth mile north of Burma station, on Frisco Railroad, Woodson's strip pit, sec. 19, T. 5 N., R. 31 W.

Naiadites elongatus.
Allerisma ? sp.

From near southwest corner of sec. 15, T. 9 N., R. 32 W.

Monilipora sp.
Crinoidal.
Lophophyllum profundum.
Rhombopora sp.
Spirifer sp.
Spirifer rockymontanus.
Spirifer cameratus.
Spiriferina kentuckyensis?.
Composita subtilita.
Dielasma sp.
Deltopecten occidentalis.
Deltopecten aff. D. texanum.
Aviculipecten sp. *a.*
Nucula ventricosa?.
Astartella varica.
Schizodus sp.
Modiola aff. M. subelliptica.
Euomphalus catilloides.
Bellerophon sp.
Loxonema ? sp.
Griffithides sp. *a.*

From mine of Union Coal Company, west of Paris, Ark.

Aviculipecten whitei.
Pleurophorus subcostatus.

From point 3 miles northeast of Fort Smith, Ark., on Wilson farm, in sec. 1, T. 8 N., R. 32 W.

Marginifera ? sp.
Spirifer rockymontanus.
Spiriferina kentuckyensis.
Composita subtilita.

From west end of Poteau Mountain, Indian Territory, 2½ miles northwest of Coaldale, Ark.

Lophophyllum profundum.
Crinoidal fragments.
Stenopora ? sp.
Fistulipora sp.
Rhombopora lepidodendroides.
Septopora biserialis.
Lingulidiscina aff. L. convexa.
Derbya crassa.
Productus cora.
Productus cf. P. nebraskensis.
Marginifera ingrata.
Spirifer rockymontanus.
Spirifer cameratus.
Spiriferina kentuckyensis.
Composita subtilita.
Hustedia mormoni.
Pugnax osagensis.
Dielasma bovidens?.
Aviculipecten aff. A. coxanus.
Aviculipecten germanus.
Lima retifera?.
Pteria ohioensis?.
Pseudomonotis ? sp.
Leda bellistriata.
Myalina aff. M. perniformis.
Solenomya sp.
Schizodus affinis?.
Allerisma terminale?.
Parallelodon tenuistriatus.
Cypricardinia carbonaria.
Astartella concentrica?.
Astartella varica.
Edmondia mortonana?.
Pleurophorus immaturus?.
Pleurophorus tropidophorus.
Euconospira n. sp.
Pleurotomaria aff. P. tenuicincta.
Pleurotomaria aff. P. subconstricta.
Pleurotomaria aff. P. giffordi.
Patellostium marcouanum.
Bellerophon harrodi?.
Aclis stevensana.
Sphærodoma sp.
Orthoceras cribrosum?.
Nautilus sp.
Phillipsia cliftonensis?.

From west end of Poteau Mountain, Indian Territory, 2½ miles northwest of Coaldale, Ark., at point 150 feet above shale fossils.

Deltopecten occidentalis?.
Myalina perattenuata.
Myalina aviculoides.
Aviculipinna americana.
Allerisma terminale.
Schizodus compressus.
Pleurophorus sp.

All these fossils are of Pennsylvanian age, and all show closely related faunal facies. I regard them as rather low in the Pennsylvanian. Very little discrimination can be made between these collections on the strength of their invertebrate faunas. Those from the black shale associated with coal beds have to a certain extent an individual aspect, owing to their limited variety, a fact which I ascribe to impure or brackish water conditions, but even these are related to the more varied and more obviously marine assemblages of species.

The lot collected near Sixmile post-office, in sec. 25, T. 8 N., R. 28 W., which represents, I believe, the highest horizon in the collection from Arkansas, has to a limited extent peculiarities that differentiate it from some of the other collections coming from lower beds. One fact in point is the relatively restricted representation of brachiopods, which group is more abundant in some of the other lots. The pelecypods are largely the same. It is very doubtful, however, whether this difference (the brachiopod representation) should be given any stratigraphic significance. It may be local or accidental. Other

collections from the same horizon at somewhat separated points would be necessary to determine this fact.

Lithologically the collections from shale on the west end of Poteau Mountain in Indian Territory are distinct from the others; and though a good many species are common to both series of collections, I believe the Poteau Mountain material to represent a younger horizon. This is perhaps especially true of the collection obtained from 150 feet above the shale fauna. The latter can possibly be correlated with the Flint Ridge horizon of Ohio.

STRUCTURE.

GENERAL FEATURES.

The coal field of Arkansas lies in a long, comparatively narrow synclinal trough extending eastward along Arkansas River valley from the Indian Territory line. North and south of the field the coal-bearing strata have been eroded, leaving only barren rocks of the Atoka and Winslow formations exposed. This trough lies between the Boston Mountains on the north and the Ouachita Mountains on the south, two elevated land masses which have very different geologic structures. The Ouachita region is characterized by long, sharp ridges formed by the erosion of alternating hard and soft beds dipping at high angles. They are in fact strike ridges of upturned rocks. The various strata comprising this mass have been subjected to violent strains and compressed in a north-south direction, throwing them into folds whose axes extend approximately east and west. Subsequent to this crumpling the upper parts of the folds have been eroded, leaving the edges of the harder beds projecting in ridges as we now find them. In the process of folding the strata were here and there broken and in many places the beds slipped out of position so that their outcrops are not now continuous for very great distances. Such fractures are called faults by geologists. As a general rule, the faults of the Ouachita Mountain province are of the kind that is produced by compression. In such faults the fracture plane is, as a rule, inclined, and the beds on the upper side have slipped over those on the lower side—in fact, are thrust over them—and for this reason such displacements are called thrust faults. In general the faults of the Ouachita Mountain region extend approximately east and west parallel with the trend of the ridges.[a]

The rocks of the Boston Mountain province[b] are not so intensely folded as those of the Ouachita province, but are, as a rule, only slightly distorted from their original horizontal positions. They are

[a] For a description of the geologic structure of the Ouachita Mountains, see Taff, Joseph A., Atoka folio (No. 79), pp. 6 and 7; Coalgate folio (No. 74), p. 5; and manuscripts of McAlester, Windingstair, and Tuskahoma folios, not yet published.

[b] Purdue, A. H., Winslow folio. (In preparation.)

characterized by low dips, seldom exceeding 4° or 5°. This mass appears to have been raised up like a great block of the earth's crust, allowing the lowlands of Arkansas Valley to break away from it. Where one part of the earth's crust is raised up higher than an adjoining part, the beds at the two levels must either bend or break. A flexure produced in this way is described as a monocline or monoclinal fold. Fractures or faults thus produced differ in type from those found in the Ouachita Mountains in that they occur in beds not crumpled by lateral pressure and otherwise little disturbed from their original positions. Usually in such faults the plane of fracture does not stand exactly vertical, and the beds on the upper or hanging-wall side slip down, while those on the lower or foot-wall side rise. Faults of this kind are described as normal, drop, or tension faults. They are characteristic of the geologic structure of the Boston Mountains, and a series of them, extending approximately east and west, occurs along the north side of Arkansas Valley, and in many places separates the Boston Mountain province from the coal field.

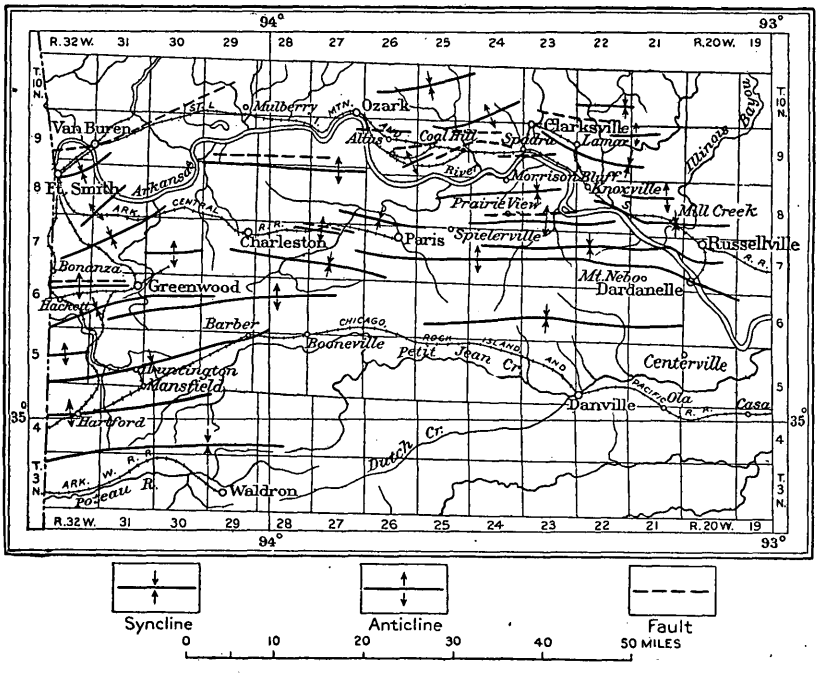


FIG. 8.—Map showing structural features of Arkansas coal field.

It will be seen from this description that the Arkansas Valley syncline, which contains the coal field, is peculiar in that on its south side the underlying rocks rise by pronounced folds and thrust faults, while on the north side the underlying rocks are brought to the surface by a simple monoclinal uplift, accompanied at some places by normal faulting.

The structures within the coal field partake of the nature of both these types, since the rocks are definitely folded at many places along the southern edge of the field, while near the northern edge the dips are gentle, the beds lie nearly flat, and normal faults are of frequent occurrence. The principal structural features of the field are shown in fig. 8.

ANTICLINES.

Although the coal field in general has been described as a synclinal trough, it is folded into a number of minor synclines and anticlines. The determination of these features is of great importance to the miner and coal prospector, since without a knowledge of this structure it is impossible to determine the best methods of prospecting and working the coal. Generally the largest areas of coal land are in the synclines, and where the structure is of this type the bed is at its greatest depth in the axis of the fold. The coal bed is most easily prospected around the margins of such basins, but in mining it is usually most economical to locate the main shaft at the deepest place, so that the loaded cars can be moved to it by gravity. Where the coal beds lie deep, however, the value to the prospector of recognizing the anticlinal structure is of almost equal importance, for it is in the anticlines that he must expect to find the coal for which he is searching nearest to the surface. In general the minor anticlines and synclines of the Arkansas coal field have approximately east and west axes only a few miles in length.

Backbone anticline.—Probably the best known anticline in the whole district is that in Backbone Ridge, between Bonanza and Hackett, which extends from the State line eastward for about 7 miles. The coal-bearing beds that outcrop on the north and south sides of this ridge are tilted at high angles, and in its axis rocks lying far below the coal horizons are exposed. (See fig. 9.) This anticline is an unsymmetrical fold resembling the Ouachita Mountain type, and represents a thrust of the rocks from the south over those on the north side of the ridge. The strata are broken along its axis and a well-marked thrust fault, which at the Indian Territory boundary has a displacement of over 2,000 feet, has been traced nearly to Greenwood, 7 miles to the east. The area of marked folding also ends here.

Biswell Hill anticline.—Biswell Hill, an elliptical domelike eminence northeast of Greenwood, which is mantled over by the Hartshorne sandstone, is the topographic expression of a broad anticline whose axis is parallel with and a short distance northeast of the east end of the Backbone Ridge anticline. The fold is slightly unsymmetrical in that the dips to the north are higher than those to the south. Like the Backbone Ridge anticline, it marks a barren

area surrounded by the outcrops of the Hartshorne coal, which dips away from it to the north and south. The structure, however, is apparently favorable for the accummulation of natural gas.

Massard Prairie anticline.—Another anticline, which is of considerable economic importance, since it has been successfully exploited for natural gas, is that at Massard Prairie, 5 miles southeast of Fort Smith. The surface indications here suggest a broad elliptical uplift with low dips to both the north and the south. The many drill holes in the axis of this fold indicate a barren area surrounded by the outcrop of the Hartshorne coal.

Montreal anticline.—Another anticline of some importance in coal mining is one which extends west from Montreal, in the southern part of Sebastian County, to the State line. This is a very broad fold, but it serves to bring the Hartshorne coal horizon nearer the surface than it is in the region north and south of it.

Hartford anticline.—The Hartford anticline, a broad fold whose axis extends for several miles in a northeast-southwest direction, is of great economic importance, since it brings the coal horizon within easy reach from the surface. At Coops Prairie, northeast of Hartford, this fold assumes a domelike structure almost ideal for the accumulation of natural gas. The wells located here supply the gas used at Huntington and at the Mansfield brick factories.

Mill Creek Ridge anticline.—East of Greenwood the coal field narrows down to a width not exceeding 15 miles, and in this strip there is at many places only one simple syncline from the south side of the coal field to the north. It comprises, however, a few minor anticlines which are worthy of mention. One of these is the Mill Creek Ridge, which extends from Arbuckle Island, in Sebastian County, to Roseville, in Franklin County. This ridge belongs rather to the northern edge of the coal field, from which it is not wholly disconnected. It is a broad, open fold characterized by low-dipping rocks. Since the rock which mantles this fold is for the most part Hartshorne sandstone, it can not be regarded as coal land, though its southern boundary marks the edge of the coal fields.

Game Hill anticline.—There is also a small, short, elliptical anticline in Logan County, extending westward from Caulksville to Branch, which is worthy of examination, since it brings the Hartshorne horizon within a few hundred feet of the surface. There is also some evidence here of a fault, which will be described later.

Prairie View anticline.—The Prairie View anticline, about 10 miles east of Paris, appears to be a broad, open fold, but of sufficient magnitude to bring up the Hartshorne sandstone and Atoka shale, leaving a barren area in the center. The folding here is rather pronounced, and there is an east and west fault along the axis. It is not known whether it is of the thrust or normal type, though its

association with the fold and the fact that the downthrow is on the north side suggests that it is a thrust fault.

Coal Hill anticline.—The Coal Hill anticline is a broad fold with east and west axis and low dips to both the north and the south. (See fig. 22.) It is of considerable economic importance, since it forms a barren area in the heart of the Coal Hill-Denning field, and will be described further in connection with the coal beds.

Russellville anticline.—The Russellville anticline is a very broad, dome-shaped uplift, with indefinite axis, between the Ouita and Shinn coal basins. It is surrounded by the outcrop of the Hartshorne sandstone.

SYNCLINES.

The synclines of the Arkansas coal field, especially near the southern edge of the field, are apt to be unsymmetrical, the beds on the south side having a higher dip than those on the north. Many of the synclines which occur near the north side of the coal field are faulted, so that only a part of the original fold is left. In general the more valuable coal deposits occur where the structure is synclinal.

Fort Smith syncline.—In the heart of the syncline beneath Fort Smith the Hartshorne coal horizon lies at a depth of 700 to 800 feet. This is a very broad fold, with rather indefinite axis. The strata dip northward from Massard Prairie at a low angle to the northern limit of the city, beyond which the dips are to the south.

Central syncline.—Another syncline of greater importance extends from the town of Central, in Sebastian County, southwestward to the State boundary. This also is a very broad and shallow trough, in the deepest part of which the Hartshorne horizon is probably not more than 800 feet below the surface.

Greenwood syncline.—South of Greenwood there is a more extensive trough of this kind, which extends from the boundary line at Hackett northeastward past Greenwood for about 30 miles. At its deepest point in this trough, south of Hackett, the coal horizon does not exceed 800 feet below the surface. At Greenwood the depth of the coal is not beyond 600 feet, while at Potato Hill, a prominent butte a few miles east of Auburn, the coal horizon is at a depth not less than 1,400 feet.

Sugarloaf syncline.—The next important syncline south of the Greenwood syncline may be described as the Sugarloaf syncline, since it includes the two peaks of Sugarloaf Mountain. It is an important coal basin, containing large areas where the coal is within easy reach from the surface, though the depth of the coal horizon below the top of the eastern peak of Sugarloaf Mountain is about 2,000 feet. East of Huntington this syncline has no economic importance, since the rocks exposed are below the coal horizon.

Poteau syncline.—Poteau and Whiteoak mountains mark the axis of a syncline in the center of which the coal horizon must be at great

depth, since the rocks exposed on the surface all have comparatively high dips.

Paris syncline.—In the central part of the field there is a broad and very deep syncline underlying the town of Paris, at which place the depth of the Hartshorne coal horizon is about 1,200 feet. This basin is unsymmetrical in that the rocks at the southern edge stand vertical and are sometimes slightly overturned, while those at the northern edge have only very gentle dips. East of Paris the syncline is constricted to a comparatively narrow trough, which extends eastward for several miles south of the Prairie View anticline.

Prairie View syncline.—The Prairie View syncline is a broad basin, with east-west axis, including the Prairie View coal field. Its structure is shown in fig. 24, and it will be further described in connection with the coal beds.

Cabin Creek syncline.—The Cabin Creek syncline is a very broad basin, whose longer axis extends from Clarksville southeastward nearly to Knoxville. The dips, both north and south, are low and practically symmetrical. In its axis the Hartshorne coal horizon is from 600 to 700 feet below the surface.

London basin.—Near its east end the coal field narrows down to a single broad synclinal basin with rather indefinite axis, which may be described as the London basin. This syncline lies between the ends of the Prairie View and Russellville anticlines, and its structure is not well known, for the surface is largely covered with alluvial deposits. The Hartshorne coal horizon is probably 600 to 800 feet below the surface in its deepest part.

Ouita and Shinn basins.—The London basin apparently divides at its west end, one limb passing north of the Russellville anticline, where it is known as the Ouita basin, the other, which passes south of Russellville, being the Shinn basin.

The Ouita basin is a shallow flexure from which the coal-bearing rocks extend westward in depth and are continuous with those of the London basin.

The Shinn basin is a comparatively sharp fold carrying the coal horizon to a depth of 600 feet. The coal-bearing rocks, however, are not connected with those of the London basin, an area of barren rocks intervening.

FAULTS.

General types.—The term fault, in the geologic sense, is applied only to a break or fracture of the earth's crust along which there has been some displacement of the rocks. It is often used by coal miners and operators in Arkansas to signify original defects in the coal, marked by unusually thin places, places showing many partings, or other conditions due to causes that prevailed at the time of its deposition.

It has already been shown that the Arkansas coal field exhibits both normal and thrust faults, whereby the rocks making up the coal-bearing series and comprising a part of the earth's crust have been broken and displaced. (See figs. 9 and 10.) Where a fault is encountered in the mines the coal bed is usually cut off abruptly, and it often requires much labor and great expense to find it again. Indeed, many mines have been abandoned for this cause, and the economic importance to the mine operator of a thorough understanding of the nature of the faults in his particular field is very great. Within this coal field eleven faults of large proportions and a number of smaller unimportant ones are known to occur, and it is probable that there are other faults which were not recognized in this rather rapid reconnaissance. It is not believed, however, that any faults affecting the more important parts of the district have been overlooked. The recognition of features of this kind in a region like the Arkansas coal field, where all the rocks are similar, is very difficult,

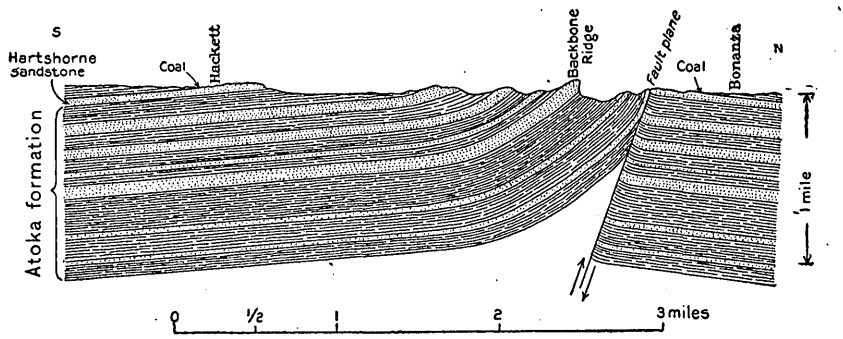


FIG. 9.—Diagram of Backbone Ridge fault.

and it has often been practically impossible to locate them with the accuracy desired. Therefore the position of many of the faults shown on the map must be regarded as only approximate.

Backbone Ridge fault.—The best known fault in the district is that along the axis of Backbone Ridge. (See fig. 9.) This displacement was recognized by the geologists of the Arkansas Survey and is represented on the geologic map published in the preliminary report on the coal field.[a] Its western end in Indian Territory has been located by J. A. Taff.[b]

The fault extends from the boundary eastward for about 8 miles to a point a mile northwest of Greenwood. Measurements during the past season indicate that the displacement is approximately 5,000 feet near the Indian Territory line. The fault occurs in barren rocks and does not affect the economic development of the field.

[a] Ann. Rept. Geol. Survey Arkansas for 1888, vol. 3, map of coal field (in pocket), Little Rock Press Printing Co., 1888. Winslow, Arthur, Geology of western Arkansas: Bull. Geol. Soc. America, vol. 2, 1891, fig. 4, p. 229.

[b] Taff, Jos. A., geology of the eastern Choctaw coal field: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 285.

Devils Backbone Ridge and Pine Ridge faults.[a]—Faults of similar character probably also occur in some places along the southern boundary of the coal field, in what is known as the Devils Backbone Ridge at Chismville and as Pine Ridge farther east. For several miles along this ridge, which is composed of the Hartshorne sandstone, the beds are slightly overturned and the rocks on the south side are very much crumpled and at places broken. Although the evidence has not been worked out in the same detail for this area as for Backbone Ridge, there seems little doubt that thrust faulting has occurred, producing a certain amount of displacement.

Caulksville fault.—There is probably also a small fault, with a downthrow of 50 or 60 feet on the north side, extending from a point near Caulksville to Branch. This fault would run through the prairie between Game Hill and Rocky Hill. It is probably of very little economic importance, and would not interfere seriously with mining operations.

Prairie View fault.—The Prairie View fault, which has already been mentioned in connection with the Prairie View anticline, extends from sec. 25, T. 8 N., R. 25 W., eastward for about 7 miles to Arkansas River. The downthrow is to the north and the displacement is not less than 500 feet. This fault cuts off and defines the southern limit of what is called the Prairie View coal field. The evidences of disturbance here shown by drill records and surface geology are very conclusive, but there is nothing to show the character of the fault, though its association with moderate folds and its proximity to Pine Ridge, which marks a well-developed fold, would suggest that it is due to overthrust.

Faults which occur along the northern edge of the coal field are much more difficult to discover; the evidence regarding their existence is obscure, and they are very troublesome to the geologist who attempts to interpret the structure of the coal field. They are, however, much more troublesome and have been a source of great expense to those who have attempted to operate coal mines in this region. These faults are all of normal type; they are not accompanied by folds, and most of them extend in an approximately east-west direction. At their extremities the displacement gradually grows less and disappears, so that the beds can be traced continuously around the ends. In some of these faults, however, sandstone beds are brought against other sandstones, shales against shales, so that it is only by the most careful study that the displacement can be recognized or its nature determined.

Clarksville fault.—One of the first of these faults discovered during the work here reported extends from a point a few miles south of

[a] Winslow, Arthur, op. cit., fig. 3, p. 228.

Lutherville westward for about 15 miles, and probably dies out a mile or so northwest of Clarksville. Through this distance the exact line of the fault could not be located with certainty in the time available. A few miles east of Clarksville sandstone belonging to the Fort Smith formation is dropped down and brought into contact with the Hartshorne sandstone, showing that the displacement is not less than 500 feet. (See fig. 10.) At the contact the two sandstone beds are not easily distinguishable, and in making a circuit northeastward from Clarksville across this fault, thence west for a few miles, and then south, the geologist is bewildered by finding that the sandstone which he must believe is still in the Fort Smith formation dips under the Spadra shale.

North of this fault the rocks below the coal horizon are raised and the coal-bearing rocks washed away except in small local basins. The economic importance of the fault, therefore, is very great.

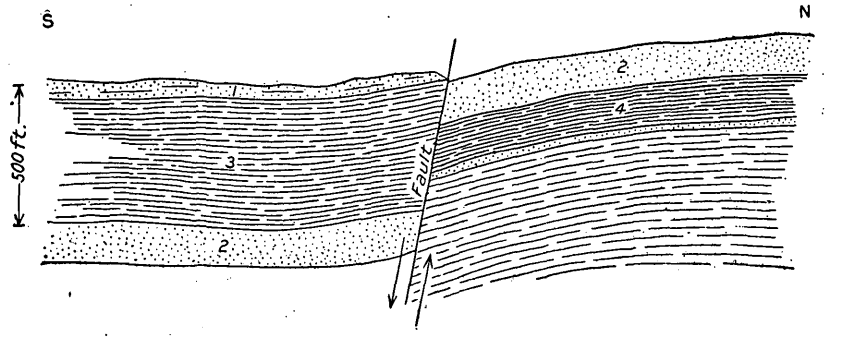


FIG. 10.—Diagram of Clarksville fault at a point 2½ miles east of Clarksville, illustrating type of faulting common in the northern part of the coal field. 1, Fort Smith formation; 2, Hartshorne sandstone; 3, Spadra shale; 4, Atoka formation.

Big Danger fault.—Another fault which lies south of Clarksville and affects the value of the Spadra coal field will be called the Big Danger fault from the fact that the best surficial evidence of the existence of a fault is found at the south base of Big Danger Hill, in sec. 23, T. 9 N., R. 23 W. From that point the fault extends westward for a total distance of 10 miles. From Spadra west it is parallel with and about a quarter of a mile south of the line of the Iron Mountain Railway. It is a normal fault, with the downthrow on the south side. The amount of displacement is indicated by a drill hole to be about 270 feet opposite the mouth of Spadra Creek and about 300 feet at the east end of Spadra Hill. West of that point the displacement probably decreases gradually and dies out near the west end of Spadra Hill. The economic importance of this fault is very great, since south of it the Spadra coal bed has been dropped down so far that it has not yet been mined.

Spadra fault.—The name Spadra is applied to a fault which was first encountered in one of the mines in the Spadra field. It was afterwards located by a series of drill holes at a point a mile or two farther west, and its presence a short distance east of Hartman is indicated by the results of drilling. Its extension from Hartman in a southwesterly direction is based wholly on a study of the outcrops. The evidence is as follows: A pronounced escarpment extending southwestward from Hartman for a distance of about 4 miles marks the boundary of the river bottom lands. Bed-rock exposures along this scarp are favorable for study, and since a branch of the Iron Mountain Railway follows its base, indications of disturbance are to be seen at many places. The occurrence of the coal bed, as well as the surface distribution of the various other formations as far as they are known, can hardly be accounted for on any other hypothesis than that the Spadra fault follows the line of this escarpment after passing Hartman. This is a normal fault with downthrow to the south, the coal bed being raised on the north side. At its eastern end, where the fault was first encountered in one of the mines, the displacement is only a few feet, and, although it is reported to have caused great consternation at first, the coal was soon located again on the other side, and there was very little loss. It has not been encountered elsewhere in the mines, for the reason that none of them have extended their workings so as to cross the supposed line of the fault. About 2 miles east of Hartman the displacement, as indicated by a reported drill hole, is not less than 200 feet.

The recognition of this fault is of the utmost importance in the economic development of the Spadra field, since it indicates the possibility of coal in a large area south of Hartman, heretofore regarded as barren.

Hartman fault.—A fault extends from a point in sec. 14, T. 9 N., R. 25 W., about 1 mile north of Hartman, in an east-northeast direction through sec. 10, T. 9 N., R. 24 W., for a distance of 4 miles. It differs from the two faults just described in that the downthrow is on the north side. The fault was first encountered in the workings of the old Allen[a] slope about 1½ miles northeast of Hartman. It is reported that at this place the coal was followed down a slope to the south until the bed ended abruptly against a wall of sandstone. Although the mine has been abandoned for many years, the surface indications verify this report. The fault is traceable from the old mine westward across Horsehead Creek to a point north of Hartman, where a sandstone, presumably the Hartshorne, has been followed continuously around its western end. East of the old Allen mine the exact position of the fault could not be located nor its extent determined from the surface geology. The amount of displacement at

[a] Ann. Rept. Geol. Survey Arkansas, vol. 3, 1888, p. 23.

the point of original discovery is about 200 feet. The effect of this fault is to raise a part of the Hartshorne sandstone and Atoka shale south of the Allen mine and to produce a tongue of barren ground which extends from Hartman northeastward into the heart of the Spadra field.

Coal Hill fault.—The Coal Hill fault extends westward from a point 1½ miles east of the town of Coal Hill to a point about midway between the towns of Altus and Denning. It is of the same type as the Spadra fault; the downthrow is on the south side and the maximum amount of displacement is not less than 200 feet. The effect of the fault is to bring the shale which underlies the Hartshorne sandstone in contact with the Spadra shale. Anyone examining this field casually would be justified in the opinion that the coal bed mined between Coal Hill and Denning extends northward and passes under the Pond Creek Hills. The existence of this fault is indicated by the evident displacement of sandstone beds which are found to be identical at its ends. It is also proved by numerous drill holes within the coal field. A rather remarkable and significant condition in this field is that the workings of the various mines between Coal Hill and Denning all lie south of a rather definite east and west line, although there is no topographic or other evidence of the discontinuance of the coal bed to be seen on the surface. It is generally reported that the coal bed is divided by a thick shale parting near the fault, so that the workings are usually abandoned before the actual break is reached. In a few of the mines, however, the fault has been actually observed, though at present none of the workings which approach it are accessible. In one or two instances where the fault plane was reached the coal bed is reported to be dragged upward slightly, indicating the direction of the movement.

Altus fault.—A fault believed to pass through the town of Altus also extends in an east and west direction. Its existence is inferred from the distribution of geologic formations on the surface, although its exact location was not determined at any point on the ground. The Hartshorne sandstone, which mantles the hill south of Altus at an elevation of about 600 feet, is raised by this fault so that it also caps Catholic Hill, north of the town, at an elevation of 900 feet. This fault is of the same type as the Coal Hill fault, with which it is parallel, and it probably takes up the displacement where the latter dies out.

Mill Creek fault.—The Mill Creek fault apparently extends from Arkansas River at Arbuckle Island eastward to sec. 24, T. 9 N., R. 28 W. Mill Creek, which flows nearly due west from the latter point, follows a valley whose position is determined by the fault. The downthrow of this fault is to the north, and in this respect it differs from most of the faults of the northern part of the coal field.

The total amount of displacement, which can be easily measured, since the Hartshorne sandstone caps the hills on both sides of Mill Creek valley, probably does not exceed 200 feet at any point. This fault has little economic significance, since it is not believed that any coal beds large enough to work are affected by it.

Massard fault.—There is evidence of a fault near the mouth of Massard Creek about 7 miles southeast of Fort Smith. Its direction and linear extent could not be determined on account of imperfect geologic exposures, though at the point mentioned a lower bed of the Fort Smith formation is dropped down and brought in contact with the Hartshorne sandstone, thus indicating a displacement of at least 400 feet. In this case the downthrow is on the south side, like most of the northern faults. The course of the fault seems to be approximately northeast and southwest. Although the fault could not be located for more than a quarter of a mile there are some indications of disturbance in Massard Prairie southeast of the gas wells in sec. 1, T. 7 N., R. 32 W., and at the Indian Territory boundary 1 mile southwest of Cavanaugh. These conditions would be explained by the continuance of this fault from the mouth of Massard Creek southwestward through Massard Prairie and thence westward to the Indian Territory line. The evidence at hand for such a fault, however, can not be regarded as in any way conclusive, and the proximity of the gas wells on Massard Prairie seems to be prima facie evidence against the existence of a fault in the position mentioned. The position of the Massard fault can be proved only by systematic drilling, and therefore it has not been indicated on the geologic map except for a short distance at the mouth of Massard Creek.

Mulberry fault.—One of the most extensive faults or systems of faults recognized in the coal field extends from a point a few miles north of the town of Mulberry[a] southwestward past the town of Van Buren and for a distance of about 15 miles into Indian Territory.[b] The east end of this fault near Mulberry has already been mapped by Purdue, since it extends into the area covered by the Winslow quadrangle. At this point the evidence regarding the existence of a fault seems to be conclusive. Its course westward is marked through a considerable part of the distance by a prominent escarpment. For several miles between Alma and Van Buren the evidence of the existence of a fault is not conclusive, and it is possible that the movement is taken up in a monoclinal fold. The possible position of the fault is indicated by dotted lines. At the town of Van Buren the amount of the displacement can not be less than 300 feet, while it may be as great as 1,000 feet. At this place the soft shaly sand-

[a] Purdue, A. H., Winslow folio, No. —, U. S. Geol. Survey. (In preparation.)
[b] Taff, Joseph A., Sallisaw folio, U. S. Geol. Survey. (In preparation.)

stone and shale of the coal-bearing rocks are brought in contact with some of the lower shale of the Winslow formation, and on superficial examination the conclusion would be justified that the coal-bearing rocks continue northward, passing under the Van Buren Hills.

This fault has a number of economic bearings. First, it limits the area of the coal-bearing rocks on the north. Although it is not known that the rocks of this group here carry any coal beds of commercial value, it is possible that valuable coal beds may be found in them. Second, the people of Fort Smith and Van Buren have been accustomed to regard those towns as lying in the center of a synclinal trough, and to believe that the Winslow sandstone dips under them from the Boston Mountains. If penetrated by deep wells these rocks could therefore be expected to yield a flow of good artesian water in place of the present unsatisfactory supply. The existence of a fault here is an unfortunate thing for this hope, since it is hardly conceivable that artesian water would pass across it. A number of deep wells which have been drilled near Fort Smith have failed to produce artesian water, and this failure may well be accounted for by the presence of the fault.

MINOR STRUCTURAL FEATURES.

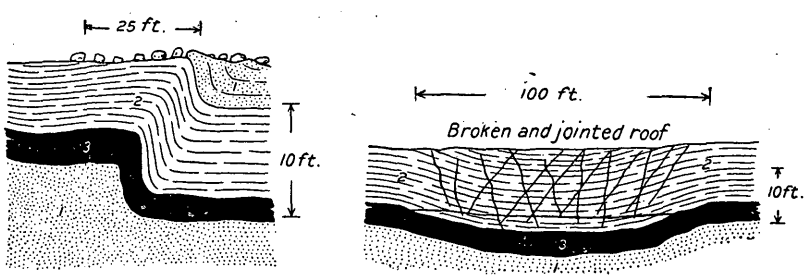
Joints.—Nearly all the harder rocks, especially the thin beds of hard sandstone included in the shale, show on weathering a system of jointing characteristic of this field. The prevailing joints, which are developed with great regularity, are nearly vertical and invariably strike a few degrees west of north, regardless of other more dominant structures. Secondary irregular joints extend at right angles to these, and the two sets often give thin flat-lying sandstone beds the appearance of artificially laid paving stones. The intervals between the joints of the prevailing system vary from 2 or 3 inches to several feet, and advantage is taken of the joints in quarrying the rock, as shown in Pl. IV, *B*. This jointing is best developed in thin, regularly bedded sandstones and harder shales. It is somewhat irregular and obscure in the more massive cross-bedded sandstones, and can not be recognized at all in the softer shales. The coal beds generally do not show it, even though it may be very well developed in sandstone beds a short distance above or below. In some places where coal beds have sandstone roofs or floors the regular joints are confined to these rocks where they are well developed and do not extend into the coal. Nearly all the coal beds have a somewhat irregular vertical cleavage.

The average strike of the prevailing joints in the west end of the coal field is 15° west of north, while in the east end it is 5° west of north, and in other parts it is intermediate between these two direc-

tions. In any given locality the variations in direction are so small as to be difficult of detection even with a pocket compass, and, indeed, the joints are nearly as reliable for giving direction as such an instrument. In one instance which came under the writer's observation they were used in place of a sun dial for giving the time of day and were described as the "eleven o'clock marks." In geologic investigations when there is doubt as to whether certain rocks are outcrops or detached bowlders the direction of the prevailing joints will often be sufficient evidence to settle the question.

Miniature folds.—Another structural feature of minor importance very often seen in the coal field consists of small local folds or buckles in some of the beds, especially in the weathered zone near the surface. Such small folds are usually anticlinal in form, and where encountered in mines and strip pits are sometimes called rolls. In a few instances such folds are accompanied by apparent faults, though such occurrences are relatively rare.[a] Usually the zone of disturbance is only a few feet wide, and beyond it the beds affected continue with perfect regularity. In general, it is not believed that the flexures extend far in depth, since they are very common in such exposures as stream banks and road cuts, and are rarely, if ever, met with in deeper mine workings.

M. R. Campbell, while with the U. S. Geological Survey party in the Arkansas field, examined a number of these rolls, and in a recent paper describing them attributes their formation to expansion of the surface rocks due to weathering.[b]



A. B.

FIG. 11.—Minor structural features of coal beds. A, Miniature monocline in coal bed at Woodson's strip pit; B, miniature syncline in mine of Fidelity Fuel Company. 1, Sandstone; 2, shale; 3, coal.

Two such folds affecting coal beds are shown in fig. 11. The fold exposed at Woodson's strip pit (fig. 11, A), near Burma, partakes of the nature of a fault, since the coal bed is noticeably displaced by it. It is in apparent alignment with a small fault exposed in the Branner mine about half a mile away, and may possibly be due to the same cause. The trough in the Fidelity mine (fig. 11, B) is unusual in that the flexure is synclinal.

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[a] Purdue, A. H., Illustrated note on a miniature overthrust fault and anticline: Jour. Geol., vol. 9, 1901, pp. 341-342.

[b] Campbell, M. R., Rock folds due to weathering: Jour. Geol., vol. 14, No. 8, 1906, pp. 718-721.

In general, the coal-bearing rocks are subject to great local variation in dip, so that, while they are thrown into broad anticlines and synclines that are easily recognized, the limbs of these folds carry minor anticlines and synclines which it is difficult to locate from surface exposures. Where encountered in the mines, such features are often also called rolls, but they are to be distinguished from the more local phenomena described above, since they are due to the same stresses that produced the more dominant structures, and presumably will extend in depth. The best examples of structure of this type, one of which is given in fig. 15 (p. 53), were found in the Bonanza and Jenny Lind district, though they are probably as common in some of the other districts, where opportunities for investigation are not so good.

ECONOMIC GEOLOGY.

THE COAL BEDS.

DISTRIBUTION.

Coal is by far the most important mineral product of this part of Arkansas, though natural gas, shale, and building stone are also utilized. Prospecting has thus far failed to demonstrate the presence of valuable oil-bearing sands.

Coal beds large enough to be worked occur at three horizons or stratigraphic positions in the coal-bearing rocks of Arkansas. These rocks were deposited as sediments on the bottom of a shallow sea or lake, and each layer of sand or shale represents a part of the deposit made at the same time. The coal beds were formed from vegetable matter at times when the water became so shallow as to permit the growth of vegetation over its surface, shutting out the ordinary sediments. Each coal bed, then, may be regarded as representing a part of the actual surface of the earth at some particular time, and coal beds that were formed at the same time, although they may never have been actually connected with each other, are said to belong to the same horizon.

For convenience in discussion the coal beds now to be described will be grouped according to the geologic horizons at or near which they occur, namely, the horizon of the Hartshorne coal, which takes its name from Hartshorne, Ind. T.; that of the Charleston coal, mined for local use near Charleston, Ark., and not known to be represented in Indian Territory; and that of the Paris coal, which in all probability corresponds approximately to the McAlester coal of Indian Territory.

The stratigraphic positions of these horizons are shown in Pl. I. Nearly all the various coals mined in Arkansas can be correlated with

one or another of these horizons. There is, however, still some doubt regarding the exact correlation of the Pickartz and Philpott coal beds, which lie north of the main body of the coal field as outlined, and it is possible that one of them may not be represented elsewhere in Arkansas. Small coal beds, some of which have been mined for neighborhood use, are also known to occur locally at many places in rocks which lie below the Hartshorne sandstone, and it is possible that future development will establish the fact that there are small areas of valuable coal at other horizons than those noted.

COALS OF THE HARTSHORNE HORIZON.

CHARACTER AND DISTRIBUTION.

The coal beds which occur at or near the horizon of the Hartshorne coal are economically the most important in both Indian Territory and Arkansas. This horizon is at the contact of the Hartshorne sandstone with the Spadra shale, and in general the coal bed is taken as the line of demarcation between these formations. As actually observed, however, there is from a few inches to 20 or 30 feet of shale or fire clay between the coal bed and the sandstone, a condition due to local variations either in the character of the upper part of the sandstone formation or in the exact position of the coal itself. In many places in its lower part the Spadra shale is somewhat sandy, and contains lenses of hard sandstone, which lie immediately above the coal bed. For this reason the exact contact of the Hartshorne with the Spadra formation is at some places difficult to determine, and it is probable that in some localities where the outcrop of the coal bed could not be found there have been minor errors in mapping. The Hartshorne sandstone, which is usually called "bed rock" in Arkansas, also varies greatly in character and thickness in different parts of the field. While typically a hard rock over 100 feet thick, described in drill sections as granite, in places it contains less than 10 feet of hard rock and in some localities is represented only by sandy shale or by irregular thin lenses of hard sandstone distributed through 15 or 20 feet of sandy shale, making it difficult to recognize except by its stratigraphic position. It has not been identified at all in the northern part of the Indian Territory field.

The extent and distribution of the Hartshorne coal horizon, as represented in the rocks of Arkansas, is seen in the outline map, fig. 12, which shows approximately the extent of the Arkansas coal field. The coal bed is subject to great local variation in thickness and character. Partings come and go without reference to any known rule,

and in some parts of the field the coal is entirely absent. Those areas in which there is reason to believe that the coal is sufficiently thick for mining are indicated in fig. 12. The local conditions and variations of this bed are best described under the headings of the various districts in which it is mined.

The area north of Backbone Ridge, in the western end of the field, will be described as one district, since the coal bed throughout this area exhibits a general similarity in character. The region south of Backbone Ridge is best described under several headings on

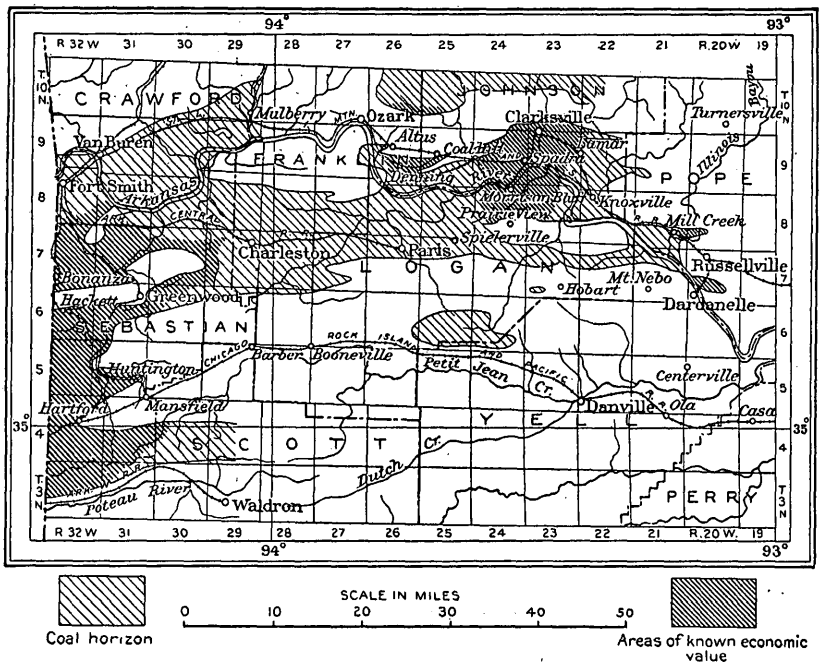

FIG. 12.—Distribution of Hartshorne coal horizon and areas in which the coal is known to be of economic value.

account of the local variations in the coal bed, though the mine workings are almost continuous. The various districts where coal is mined in the eastern end of the field are isolated from one another.

BONANZA AND JENNY LIND DISTRICT.

The district north of Backbone Ridge, in Sebastian County, includes several important mines, which are located along the southern outcrop of the coal bed near the towns of Bonanza and Jenny Lind. The position of the outcrop here is indicated by the Hartshorne sandstone, which is easily traced along the north side of Back-

bone Ridge and Biswell Hill to Oak Valley, where it turns southward and connects with the sandstone that underlies the coal at Greenwood and Hackett. From its southern outcrop at Jenny Lind the coal dips northward at an average angle of approximately $2\frac{1}{2}°$ for about 3 miles, where it is from 600 to 900 feet below the surface. It then rises with a still more gentle slope and outcrops at several points on Massard Prairie, from which it dips northward again and

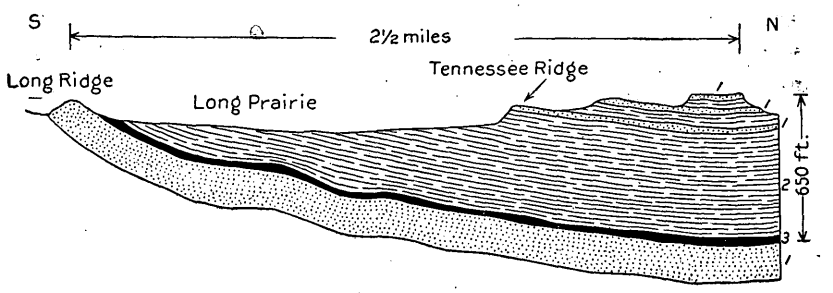

FIG. 13.—Diagram showing relation of topography to geologic structure at Long Prairie near Jenny Lind. 1, Sandstone; 2, shale; 3, coal.

passes under Fort Smith. The areas in which the coal is near the surface in this district are indicated by the extent of Long and Massard prairies. Long Prairie at Jenny Lind is a broad lowland, bounded on the south side by Long Ridge and on the north by Tennessee Ridge, the former being the topographic expression of the Hartshorne sandstone, which underlies the coal, the latter that of the

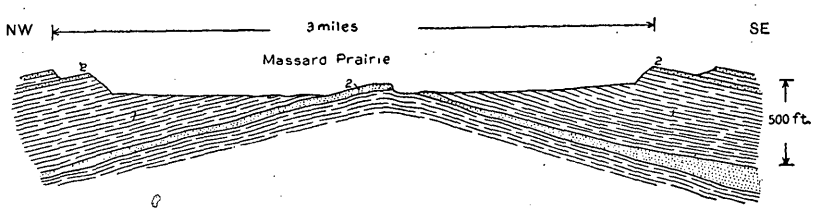

FIG. 14.—Diagram showing relation of topography to geologic structure at Massard Prairie. Section along road from Fort Smith to Greenwood. The gas wells are located in the center. 1, Shale; 2, sandstone.

lower member of the Fort Smith formation. The relation of this prairie to the bed-rock structure is shown in the sketch, fig. 13.

Massard Prairie is surrounded by the outcrops of a sandstone bed correlated with that of Tennessee Ridge, the relations of topography to bed-rock structure being shown in fig. 14. The coal bed which outcrops in the center of this prairie is probably the same as that at Jenny Lind and Bonanza, though the Hartshorne sandstone is represented by a bed not over 15 feet thick.

In the basin north of Jenny Lind the greatest depth to coal probably does not exceed 800 feet, while in a large part of the district it is within 500 feet of the surface. At Central, a small town about 6 miles northeast of Jenny Lind, coal has been mined from a smaller bed, estimated to lie about 850 feet above the Hartshorne coal, which will be described later in connection with the Charleston horizon. The nature of the coal bed is best shown in this district along the outcrop between Bonanza and Jenny Lind, where it has been mined for about 2½ miles northward from the outcrop. It is thick enough for mining along this crop line for about 10 miles, nearly all the way from Bonanza to Oak Valley post-office, beyond which point it is reported to be too thin for mining and to be divided by partings. In general the bed consists of two benches of coal, with a shale parting near the center. Some of its local variations are shown by the sections presented in fig. 16. At the most eastern

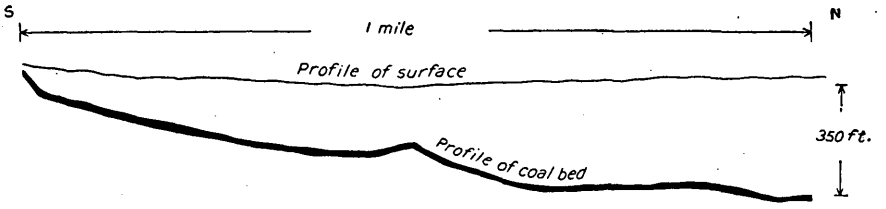

FIG. 15.—Profile of coal bed at Jenny Lind, showing variations in dip.

point at which the coal has been measured it has a thickness of 2 feet, with a small parting at the center.

At Bonanza the Central Coal and Coke Company of Kansas City has two mines, and near Jenny Lind there are two active mines operated by the Western Coal and Mining Company. East of Jenny Lind several strip pits and banks have been mined for local use, the Bostick bank, in sec. 13, T. 8 N., R. 31 W., being the most eastern point.

In the underground workings of the mines there is considerable irregularity in the dip of the coal north of the crop line. In some places along its outcrop the coal dips northward at angles as high as 15°, but after reaching a certain depth the dip flattens rather abruptly, and in some places is locally reversed before it again dips to the north. This condition in mine No. 17 at Jenny Lind is shown graphically in fig. 15.

The relative thickness and the variations of the coal benches and partings in the mines along the outcrop in this district are

shown in the sections presented in fig. 16. The coal is thickest in a mine about one-half mile northwest of the town of Jenny Lind. From this mine it gradually thins both eastward and westward, though its thickness varies locally. In these mines the only parting actually rejected in mining is the one that appears in the center of the bed in all the sections measured. This parting varies from less than an inch to over 6 inches in thickness. Although usually shaly, it is variable in character, in some places being described as a soft muck or a hard sulphur band. As a general rule the coal is said to be of better grade where the bed is thin and to contain more impurities in the thicker part. For example, in mine No. 17, at Jenny Lind, where it has the greatest thickness, there is a somewhat irregular band of bony coal, usually not above 1 inch thick, near the center of the upper bench. This is referred to by the miners as the "gray band," but it is not thrown out in mining. In the same mine there is often a sulphur band near the middle of the lower bench. This band is irregular in its occurrence, but is not of sufficient importance to cause any part of the coal to be rejected.

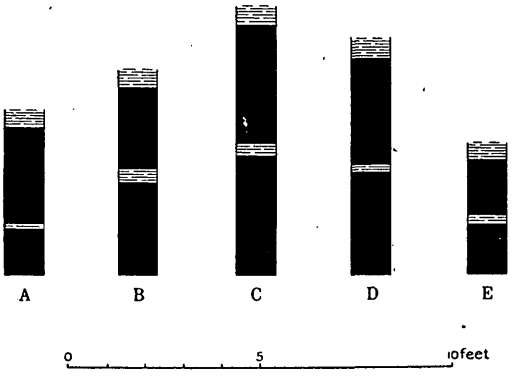

FIG. 16.—Graphic sections of coal along the line of outcrop from Bonanza east to Oak Grove. A, Mine No. 12 at Bonanza, sec. 3, T. 6 N., R. 32 W.; B, mine No. 18, sec. 36, T. 7 N., R. 32 W.; C, mine No. 17, Jenny Lind, sec. 32, T. 7 N., R. 31 W.; D, outcrop on sec. 34, T. 7 N., R. 31 W.; E, Bostick bank, sec. 13, T. 7 N., R. 31 W.

The coal in the upper bench in these mines has a somewhat brighter luster than that in the lower. It is not very distinctly jointed, and although face and butt slips, as they are called, can be found on close inspection, advantage is not taken of them in mining. In some localities a definite system of joints, which do not affect the coal, is apparent in the harder parts of the roof. The roof and floor generally consist of hard, more or less sandy shale; usually the floor is a little harder than the roof. Neither roof nor floor has any features that are especially unfavorable to mining, though in one of the mines, No. 18, near Jenny Lind, parts of the roof are likely to fall out on account of the joints.

The only knowledge we have of the coal beyond the northern limit of present mining development for a distance of several miles is that obtained by drilling. Over a comparatively large area here that is believed to be coal land drill holes have been put down to the coal at rather too long intervals to demonstrate fully the value of the land.

About 6 miles north of the Jenny Lind outcrop, however, this coal bed outcrops again on Massard Prairie, in the center of which there is probably a barren area, surrounded by outcrops of the coal. Coal has been mined from strip pits here for an almost continuous distance of about 3 miles, within which it was possible to measure the coal bed and to study its general appearance and physical character. The variations in the coal bed in its extent northward from the Jenny Lind outcrop to the center of Massard Prairie are shown by the group of graphic sections presented in fig. 17. Throughout this whole distance the bed is characterized by two benches with a varying shale parting between. The coal bed may possibly become progressively thinner northward from the Jenny Lind outcrop, but the field has not been sufficiently tested to demonstrate whether this is true or not. Three of the sections presented in fig. 17 were measured at the outcrop of the coal on Massard Prairie, where it is

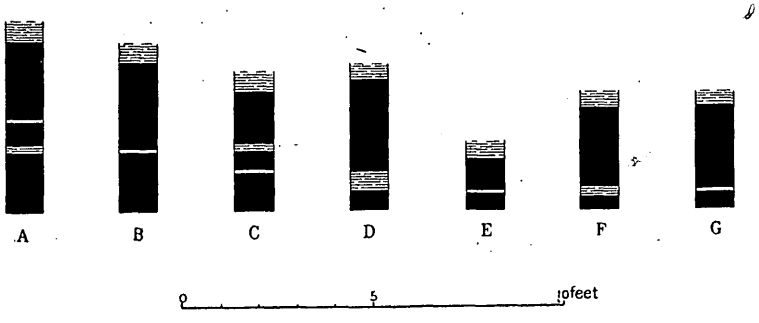

FIG. 17.—Graphic sections of the coal bed from the Jenny Lind outcrop northward to Massard Prairie. A, NW. ¼ sec. 21, T. 7 N., R. 31 W.; B, NE. ¼ sec. 19, T. 7 N., R. 31 W.; C, NE. ¼ sec. 14, T. 7 N., R. 32 W.; D, SE. ¼ sec. 9, T. 7 N., R. 32 W.; E, NE. ¼ sec. 2, T. 7 N., R. 32 W.; F, NE. ¼ sec. 36, T. 8 N., R. 32 W.; G, SW. ¼ sec. 30, T. 8 N., R. 31 W.

rather too thin to permit development on a large scale. It is operated, however, in a small way, to supply local demand at Fort Smith. The coal has a luster like that at Jenny Lind. That from the upper bench is brighter but much softer than that of the lower, and is also of a much better quality. The lower bench coal is high in sulphur and ash and after exposure to the air is coated with a white efflorescence. A chemical analysis of coal from Massard Prairie indicates that it may be of a somewhat higher grade chemically than that at Jenny Lind. (See table of analyses, p. 98.)

From Massard Prairie the coal dips northward at an angle of from 1° to 2° and passes under the town of Fort Smith, where a coal bed approximately 2 feet thick, which is probably identical with this one, has been reported at a depth of 500 feet in a well drilled for gas and oil.

GREENWOOD AND HUNTINGTON DISTRICT.

Location and extent.—The Hartshorne coal bed is continuous over an extensive region south of Backbone Ridge in Sebastian County, where a large number of mines are located along its outcrop. Although the same bed is believed to extend over this whole region, the character of the coal and peculiarities of the bed vary so much locally as to make a number of minor divisions necessary in describing it. In general the whole region could be divided into two parts by a line running south-southwest from Greenwood—a western part in which the coal bed is without partings and free from excessive ash, and an eastern part in which the coal bed is thick but divided and relatively impure. The local character can be more conveniently described, however, under headings which indicate the several centers of mining activity.

Beginning near the Indian Territory line at Hackett the coal outcrop south of Backbone Ridge has been traced eastward for several miles beyond Greenwood, where it turns northward and connects with the outcrop of the coal mined at Bonanza and Jenny Lind. From this line of outcrop the bed dips southward into the Greenwood syncline, south of which it rises and crops out along the flank of a ridge known as Devils Backbone. This ridge, which stretches for miles nearly east and west in an almost straight line and marks the southern boundary of the coal field, turns abruptly southward a few miles southwest of Greenwood and carries the coal outcrop southward to sec. 13, T. 5 N., R. 32 W., which is in the heart of a minor anticline between Midland and Montreal. The outcrop line then turns eastward, the coal dipping southward, and extends in that direction for several miles to Huntington. This town is situated in a syncline, around the end of which the outcrop again turns westward, the coal dipping to the north, and extends in a nearly straight line to Hartford, where it again turns to the east, swinging around the Hartford anticline. The coal bed east of Hartford was followed for only about 10 miles, to a point where the investigation was given up because the bed, although still of considerable size, was found to be so divided by partings as to be of no value. The coal dips to the south from the Hartford anticline and passes under Poteau Mountain, on the south flank of which it again comes to the surface and outcrops for several miles.

Character and thickness of the coal.—From the above description it will be seen that the Greenwood-Huntington district covers a large and roughly rectangular area, including several townships of land on which the almost continuous line of outcrop indicates that the coal

bed exists in sufficient size to make it of economic value. In a part of the district, notably that immediately east of the towns of Montreal and Midland, there is an upper coal bed from 40 to 60 feet above the Hartshorne coal, which probably corresponds with the upper Hartshorne coal reported from many points in Indian Territory. Where noted in Arkansas the upper Hartshorne coal is invariably an impure, dirty bed, broken by many shale partings, and is probably nowhere of economic value. The lower coal bed varies in thickness from a minimum of about 2 feet to a maximum of not less than 7 feet. Its floor is usually only a short distance above the hard beds of the Hartshorne sandstone, but its roof is variable. Although it generally consists of shale, a heavy lens of hard, often cross-bedded, sandstone, having a maximum thickness of 60 feet, overlies the coal bed for several miles at Montreal and Burma. In the northwestern part of the district the bed is without partings and is from 2 to 3½ feet thick. In the southeastern part it increases in size, at places, to 6 or 7 feet, and is divided by one or more partings of shale. As a general rule chemical analyses show that the coal is of better quality in the western than in the eastern part of the district.

The coal bed has been opened in a number of mines, small slopes, and strip pits along the whole line of outcrop described, and in some localities the workings have extended back for as much as 1½ miles. Beyond the data obtained by these workings, however, the only information as to the character of the coal is that derived from a few scattering drill holes. While it can not be said that the whole district has been prospected sufficiently to prove that it is all underlain by valuable deposits of coal, the evidence at hand seems to indicate that the greater part is valuable coal land. The maximum depths of the coal below the surface will be found beneath Sugarloaf and Poteau mountains, where the depth is from 1,400 to 2,500 feet. On the lower lands surrounding Sugarloaf Mountain the coal probably does not lie at a greater depth than 900 feet at any point, while its average depth probably does not exceed 600 feet, as indicated by the distribution of formations shown on the geologic map (Pl. VI). The various mines and openings at which the coal has been examined may be best described in order following the lines of outcrop.

Hackett region.—On the outcrop lines south of Backbone Ridge coal has been mined at many small openings between Hackett and Greenwood and from several larger mines east of Greenwood. The Midland Valley Railroad was located and built as near as possible to this line of outcrop in order to facilitate the marketing of the coal. The thickness of bed, partings, and benches, together with their

variations, are shown in the series of graphic sections, fig. 18, from which it will be seen that the coal bed at the State line consists of one bench of good coal without partings, having a thickness of 3½ feet. This general condition of the bed holds to within a mile of the town of Greenwood, east of which the bed thickens rapidly and is divided into two or more benches by shale partings.

Samples and analyses of the coal mined in the vicinity of Hackett and Excelsior indicate that for about 8 miles along this outcrop line the coal is unusually free from ash and other impurities and that its efficiency must be comparatively very high. In this respect it resembles the coals mined near Montreal and Midland, described later. From Hackett to Excelsior the bed is without partings, and varies in thickness from 2 to 3½ feet.

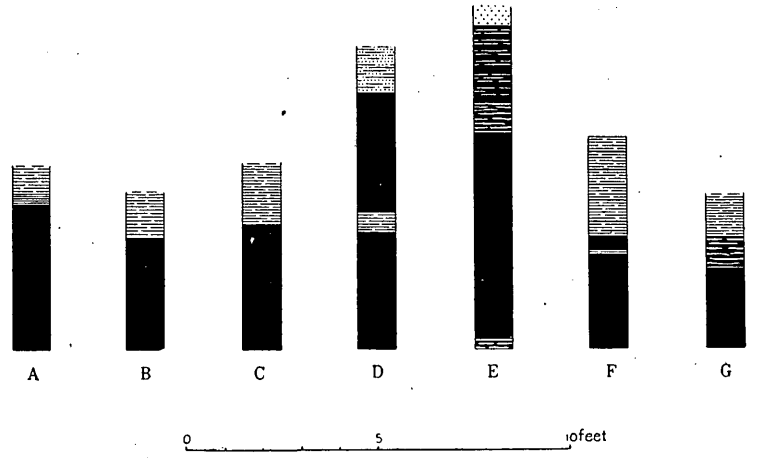

FIG. 18.—Graphic sections of coal showing variations along outcrop from Hackett east through Greenwood and Fidelity. A, Hackett City Smokeless Coal Company mine, sec. 21, T. 6 N., R. 32 W.; B, Bates and McWilliams mine, sec. 23, T. 6 N., R. 31 W.; C, Skinner mine, sec. 17, T. 6 N., R. 31 W.; D, Greenwood Coal and Lumber Company mine, sec. 12, T. 6 N., R. 31 W.; E, Banner mine, Fidelity Coal Company, sec. 6, T. 6 N., R. 30 W.; F, section at old McConnell pit, sec. 32, T. 7 N., R. 30 W., as given in Ann. Rept. Geol. Survey Arkansas, 1888, vol. 3, p. 16; G, drill hole, sec. 14, T. 7 N., R. 30 W.

The floor is a sandy shale with a hard sandstone a short distance below. The roof generally is a hard shale, which stands well, but in some of the mines there is a varying amount of draw slate above the coal.

Although indistinct joints that form face and butt slips in the coal can be recognized in nearly every mine, advantage is not taken of them in mining. The coal generally has a bright, live luster and a somewhat granular fracture. Coal was at one time extensively mined near the town of Hackett by the Central Coal and Coke Company, but the works there are said to have been abandoned on account of bad roof. The Smokeless Coal Company, of Hackett, recently opened a new mine about half a mile west of the town, and though

it is reported that 6 or 8 inches of draw slate occurs above the bed no difficulty is experienced with the roof. There are also two or three small mines in operation near Excelsior, and several old slopes and strip pits at other points. Many of these mines are small and are worked by undercutting with the pick.

Greenwood region.—In several mines east of Greenwood the character of the coal bed differs from that seen in mines near Hackett, the bed being very much thicker but divided by shale partings, as shown in fig. 18. Analyses of the coal show a much higher percentage of ash than that contained in the coal of the smaller bed at Hackett. In the mine of the Greenwood Coal and Lumber Company, in sec. 12, T. 6 N., R. 31 W., the coal has a maximum thickness of 7 feet, with a parting of shale near the center which varies in thickness from a fraction of an inch to 6 inches. Two miles farther east, at the Fidelity Fuel Company's mine, the bed is nearly 6 feet thick with a large shale parting in the upper half.

East of the mine of the Fidelity Fuel Company no operations are now in progress on this bed. It was formerly worked about 1 mile farther east, at an opening known as McConnell's, which is at present abandoned. The section measured here by the geologists of the Arkansas Survey gives only 33 inches of coal, with a shale parting near the top. Beyond this no measurements have been made on the outcrop of the coal, though it has been occasionally seen in wells and other accidental exposures. Near Auburn it is reported to have a thickness of 18 inches. A diamond-drill hole in sec. 14, T. 7 N., R. 30 W., 3 miles north of Auburn, showed that this coal bed was there 33 inches thick, 9 inches of which was reported as bone. East of this point the coal is not exposed for many miles, and no measurements have been made.

In all of the mines and openings noted the floor of the coal is only a few inches above a bed of hard sandstone, the upper member of the Hartshorne formation. The roof is invariably sandy shale.

On the outcrop line which follows Devils Backbone Ridge, southeast of Greenwood, small exposures have been found at points several miles east of Greenwood, the positions of which are shown on the geologic map. No coal has been produced at any of these points, nor have the coal beds been opened sufficiently to permit accurate measurements. The inclosing rocks here are tilted at a high angle, in some places are slightly overturned and probably sheared, so that the coal bed is probably more or less crushed. Small amounts of coal have been obtained from a strip pit in sec. 18, T. 6 N., R. 30 W., at a point where Vache Grasse Creek cuts across Backbone Ridge, but the workings have all been abandoned, and it was impossible to learn the exact thickness of the coal or the detail of its section.

Montreal, Burma, and Midland regions.—Along the outcrop line running southwest from Greenwood to Montreal and Midland the coal bed, as far as known, is without partings, and the quality of the coal resembles that at Hackett. Most of the development is to be found near Midland, about 10 miles southwest of Greenwood, though the general character of the bed and quality of the coal through a large area seem to be practically uniform, as shown by the graphic sections presented in fig. 19 and by the table of analyses.

About 2 miles southwest of the town of Greenwood coal has been mined recently from a small slope on sec. 21, T. 6 N., R. 31 W. At this point the coal dips northward at an angle of about 15° and has a thickness of 24 to 30 inches, without partings. The same bed of coal is opened again at the Moran mine, a slope on sec. 8, T. 5 N., R. 31 W., where it has a thickness of 40 inches without partings. South of this point there are many openings, both new and old, and it is

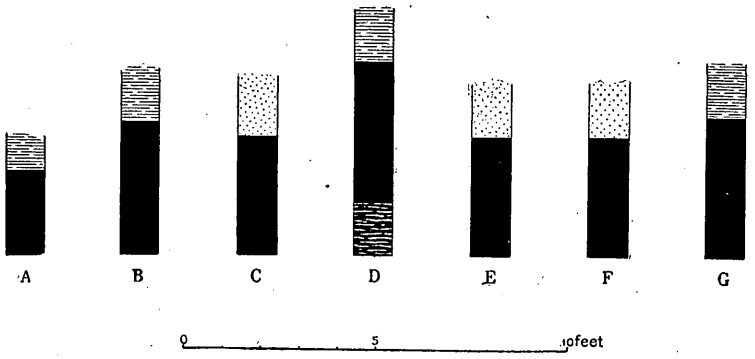

FIG. 19.—Graphic sections showing variations of coal bed and roof along outcrop in Montreal, Burma, and Midland regions. A, Slope on sec. 21, T. 6 N., R. 31 W.; B, Moran mine, sec. 8, T. 5 N., R. 31 W.; C, Irby mine, sec 7., T. 5 N., R. 31 W.; D, Banner Coal Company, sec. 19, T. 5 N., R. 31 W.; E, Denman Coal Company, sec. 19, T. 5 N., R. 31 W.; F, Turnipseed mine, sec. 20, T. 5 N., R. 31 W.; G, strip pit on sec. 21, T. 5 N., R. 31 W.

usually not difficult to trace the line of outcrop, although it is obscured by an overlying lens of sandstone that resembles in all respects the Hartshorne sandstone and has a maximum thickness of 60 feet. In general the exposures show from 2 to 4 feet of coal without partings. The coal bed dips at angles varying from 1° to 15°, but it seems to be invariably true that where the dip is high at the outcrop it rapidly decreases and the coal bed flattens out in depth.

A rather unexpected variation, locally described as a fault, occurs near the center of sec. 20, T. 5 N., R. 31 W., in the entry to a small slope mine where the coal, which in the mine has a thickness of over 3 feet, very suddenly changes in character and beds of shale abruptly take its place, the shale fingering in with lenses of coal. East of this place for a distance of about 1 mile the bed, as exposed by prospecting along the outcrop, consists for the most part of shale and bone,

but contains very little good coal. The coal is of good quality again in a strip pit near the south line of sec. 21, T. 5 N., R. 31 W., from which point it has been traced eastward to Huntington. In this distance the bed changes rapidly, becoming very much thicker and being divided by several partings.

In the vicinity of Midland and Burma an upper bed of coal, corresponding to the upper Hartshorne coal of Indian Territory, is indicated by drill records. This bed averages 60 feet above the lower one. It has a maximum thickness of approximately 5 feet, but is generally shaly or bony, and is described as a "dirty vein." It is not mined anywhere in Arkansas, though it may be found to be of some importance toward the Indian Territory line.

Huntington region.—The coal bed in the Huntington basin resembles that at Greenwood. Although characterized by great thickness it is divided by shale partings, and chemical analyses of the merchantable coal show that it contains a rather high percentage of ash. This character of the bed continues southwest along the outcrop nearly to Hartford, where the bed is not divided. East of Hartford, on the outcrop that lies south of the Hartford anticline, the bed becomes so much divided by partings as to be of little value.

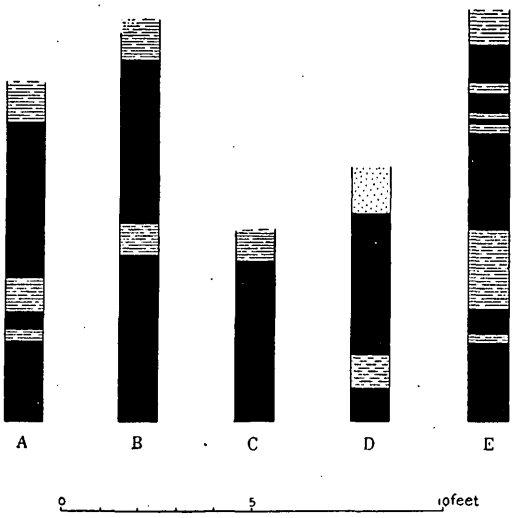

FIG. 20.—Graphic sections of coal bed along outcrop from Huntington through Hartford to the Chasteen slope. A, Mine No. 2, Central Coal and Coke Co., sec. 26, T. 5 N., R. 31 W.; B, Mammoth vein mine, sec. 1, T. 4 N., R. 32 E.; C, Bolen and Darnall mine, sec. 10, T. 5 N., R. 32 E.; D, Patterson Coal Company mine No. 1, sec. 14, T. 4 N., R. 32 W.; E, Chasteen pit, sec. 18, T. 4 N., R. 31 W.

The variations in the bed along the outcrop from Huntington to Hartford and then eastward along the southern outcrop are shown graphically in fig. 20. From the center of sec. 22, T. 5 N., R. 31 W., the coal has been stripped almost continuously along the outcrop for 2½ miles to the town of Huntington, where the outcrop and accompanying strip pit swing around a half circle to the south and then extend southeastward toward Hartford. There are two large mines operated from shafts as well as these strip pits in the synclinal basin near Huntington. The coal is in three benches separated by thin shale partings.

For several miles southeast of Huntington the coal is not mined, though the position of the outcrop has been determined by prospecting. It is mined again, however, in sec. 32, T. 5 N., R. 31 W., where the

bed known as the Mammoth vein is over 8 feet thick, including a parting of several inches of shale near its center. At the town of Hartford, in sec. 10, T. 4 N., R. 32 W., the coal is worked in a number of small slopes and in two large ones. It consists here of a single bench of coal about 3½ feet thick. From this point the coal outcrop swings eastward around the western end of the Hartford anticline, and the coal is again mined in secs. 13 and 14, T. 4 N., R. 32 W. The coal bed here resembles the Huntington coal in that it consists of several benches of coal with partings between. East of this point there are no active mines. Although the coal has been prospected here, it is common report that the bed is separated into many benches. At the Chasteen mine, in sec. 18, T. 4 N., R. 31 W., it is very much divided and contains no bench over 2½ feet thick, though the total thickness of the bed is near 8 feet. East of this point no measurements have been made, though the outcrop of the coal has been traced for a number of miles.

Depths to the coal.—The coal dips westward at a low angle from the line of outcrop from Greenwood to Burma, but probably does not reach a depth of more than 800 feet below the surface at any point. The synclinal trough in which the town of Huntington is situated extends westward to the State line and includes Sugarloaf Mountains. For several miles west from Huntington the coal lies within 400 feet of the surface. It reaches its greatest depth in Sugarloaf Mountains, where it can probably all be reached by tunnels or slopes and should not be regarded as inaccessible. The anticline on which the town of Hartford is situated also extends southwestward to the Arkansas–Indian Territory boundary and along it the coal is all near the surface. Drill holes which have been sunk near the boundary line indicate that the greatest depth on this anticline at the boundary will not exceed 800 feet. South of the Hartford anticline the coal dips at a rather high angle and passes under Poteau Mountain. Some of the coal here is probably scarcely fit for mining on account of the divided condition of the coal bed, but further prospecting will no doubt develop a large area of coal land worthy of attention in this region also. The variations in the quality of the coal from the different mines of this district is indicated by the analyses in the table on pages 96–97.

BATES AND COALDALE DISTRICT.

The coal bed which dips southward from Hartford and passes under Poteau and Whiteoak mountains comes to the surface again in a line of outcrop parallel with the south flank of Poteau Mountain, where it has been traced from the Indian Territory line eastward for a distance of about 20 miles. It is continuous with the outcrop of coal beds mined in Indian Territory. Two analyses from samples taken at the Seymour mine near Bates indicate that the coal is distinctly bituminous in character and lower in the scale of classification than the other

coals of the Arkansas field. The workings at Coaldale near the State line were not examined, but section A of the bed given in fig. 21 was reported by the operator. The bed here consists of over 7 feet of coal divided by a parting of shale. Three miles east of the State line, in sec. 21, T. 3 N., R. 32 W., the coal bed is divided into three benches and contains an aggregate of 8 feet of coal. Mining is done only in the largest bench, which is 4 feet thick. Nine miles farther east the coal bed still has a thickness of 5 or 6 feet, but is divided into many small benches, the largest of which is only 12 inches thick, and it is not probable that the coal can be successfully mined in this locality, though it is possible that the lower part of the bed was not all exposed. Croppings of this bed have been observed for about 2 miles farther east, but it has nowhere been opened so that a section could be measured, nor have any reports indicating a workable coal bed been received. These variations are shown by the graphic sections presented in fig. 21. The portion of the coal field that extends eastward from Lookout Gap and underlies Whiteoak Mountain was not examined, owing to the short time available for field work. Although the Hartshorne horizon is known to extend over a considerable area here, the facts presented indicate that the coal bed is probably divided and of little value. Both north and south of Poteau Mountain the coal dips at a high angle and the rocks maintain this dip well toward the center of the basin, indicating that the coal there is very deep. It is probable, however, that all of the coal can be mined from slopes entering the basin from the north and south sides.

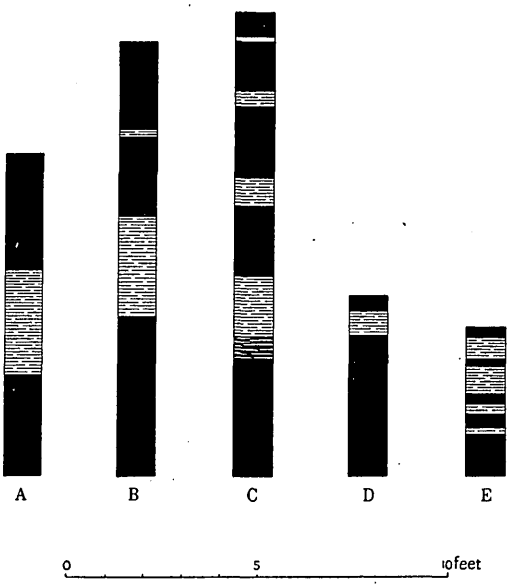

FIG. 21.—Characteristic sections of coal bed on outcrop south of Poteau Mountain. A, Witte Coal Company mine, sec. 19, T. 3 N., R. 32 W.; B, Seymour mine, sec. 21, T. 3 N., R. 32 W.; C, prospect hole in sec. 21, T. 3 N., R. 32 W.; D, Davidson slope, sec. 16, T. 3 N., R. 32 W., upper part of bed probably omitted; E, prospect hole in sec. 1, T. 3 N., R. 31 W.

CHARLESTON AND PARIS DISTRICT.

The Hartshorne coal has not been opened nor has the thickness of the bed been measured on the outcrop east of Auburn for a distance of about 35 miles, to what will be described as the Prairie View district. This unexplored region includes the towns of Charleston and Paris, near which coals of higher horizons are mined. The horizon

of the Hartshorne coal outcrops through the whole length of this region along the north base of Devils Backbone Ridge and its eastern extension, Pine Ridge. It also outcrops near the southern base of Mill Creek Ridge, on Grand Prairie, which extends from the Arkansas River at the mouth of Vache Grasse Creek eastward to Roseville. Along the southern outcrop line the presence of the bed is occasionally indicated by coal smut, but it is nowhere so exposed that its thickness can be measured, and the natural conclusion to be drawn is that along this line the bed is thin and of no economic value.

Along the northern outcrop, on Grand Prairie, no exposures of coal were seen by members of our party. There are some indications of a fault along the north side of this prairie, and it is possible that the coal horizon does not reach the surface, though it can not be at a very great depth. In the preliminary report of the Arkansas State Survey it is noted that coal occurs near the town of Vesta, probably at the Hartshorne horizon. This coal has been found in several wells near that place, but present information regarding it is no more advanced than that given by the State Survey. So far as known this coal bed has never been opened or accurately measured. Coal has been reported in a few shallow wells that penetrate the sandstone mantling Mill Creek Ridge near the town of Sub Rosa. If these reports are true this may possibly be the Hartshorne bed, though the stratigraphic evidence seems to locate it in the Hartshorne sandstone at a short distance below the general coal horizon.

The Hartshorne coal has been penetrated by diamond drills 3 miles northwest of Charleston, where it is approximately 2 feet thick and has a shale parting. East of this point the coal bed would be found at a depth usually exceeding 400 feet. At the base of Potato Hill and also at Paris its depth is estimated to be approximately 1,000 feet, while at Charleston it can probably be reached at from 800 to 900 feet. Between the towns of Branch and Caulksville there is an anticlinal flexure which probably brings the Hartshorne coal horizon within 300 or 400 feet of the surface. Although a certain amount of drilling has been done near Charleston and also near Paris, it is probable that none of the wells have reached a sufficient depth to find the Hartshorne coal.

South of Prairie View the Hartshorne sandstone is brought to the surface in an anticlinal flexure, along the axis of which there is a profound fault, as has been shown. A coal bed, presumably the Hartshorne, outcrops north of this anticline, and its extent has been partly determined by a number of drill holes, though the western boundary of the workable coal area can not be regarded as determined. South of the Prairie View anticline the Hartshorne horizon is present in a narrow syncline between it and Pine Ridge. No outcrop of the coal has been discovered here, though the bed has been penetrated by drill holes which indicate a thickness less than 18

inches. A coal bed about 400 feet below the Hartshorne sandstone outcrops at a number of places south of Pine Ridge and has in some localities been mistaken for the Hartshorne coal. It has been worked in strip pits in sec. 20, T. 7 N., R. 24 W., south of Ellsworth, but prospecting has not shown that the coal is of commercial value.

Coal of the Hartshorne horizon is also mined in the Denning and Coal Hill district, from which the coal bed dips southward at a rather low angle toward the Paris syncline. Drill records here indicate that the coal bed thins rapidly south of Denning, although its southern limit was not reached.

From the above facts it will be seen that the Hartshorne coal underlies a large area, about 15 miles wide, extending from Auburn eastward to Prairie View, in which the thickness and value of the coal has not been determined. The outcrops along the north and south sides of this area reveal no coal of commercial importance, but in view of the great local variation that may be expected in the Hartshorne coal further prospecting by deep drilling is fully warranted. The coal horizon can certainly be reached by a series of drill holes less than 400 feet deep on Grand Prairie along the northern edge of the basin and also in the center of the Caulksville anticline. The beds are so highly tilted and the structure so broken along the southern edge of the basin that the coal there would probably be of little value if found.

VAN BUREN AND ALMA DISTRICT.

Much that has been said in regard to the Charleston and Paris district can well be repeated in regard to the region north of the river in the vicinity of Van Buren and Alma. It is a district that has not been thoroughly prospected, though stratigraphic investigations show that it is underlain by the Hartshorne coal.

The coal outcrops at several places in the vicinity of Mulberry, where there is a small coal bed at a horizon very close to if not identical with that of the Hartshorne coal, which is usually overlain by 20 or 30 feet of sandstone and sandy shale that lies near the base of the Spadra formation. West of Mulberry the coal horizon is at a greater depth and does not outcrop, since at the northern edge of the field it is cut off by a fault north of which the Winslow sandstone is exposed. The depth of the Hartshorne horizon could not be estimated closely on account of the very obscure stratigraphic evidence, much of the surface being covered with deposits of gravel and sand.

A small coal bed found near Alma and Van Buren is provisionally correlated with the Charleston coal, which is about 800 feet above the Hartshorne horizon. What is probably the Hartshorne bed has been reached in a drill hole near Almá at a depth of 700 feet. It is reported to be 9 inches thick and overlies a sandstone 150 feet thick, provisionally correlated with the Hartshorne. A small coal bed which may also

correspond with the Hartshorne coal was formerly mined at the Hendricks pit, in sec. 16, T. 9 N., R. 31 W., 2 miles northeast of Van Buren.[a] This coal bed is said to be 2 feet thick. It overlies a hard, massive sandstone which is possibly equivalent to the Hartshorne. A coal bed is also reported in a number of wells in Van Buren which can not be definitely correlated with that south of the river from the stratigraphic evidence available, but probably corresponds very nearly with the Charleston coal. If this interpretation of the stratigraphy is correct, it necessitates the presence of a fault with a displacement of about 800 feet between the coal 2 miles northeast of Van Buren and that just mentioned. None of these coal beds have been found to be of sufficient size to warrant systematic development.

COAL HILL AND DENNING DISTRICT.

The Coal Hill and Denning district lies north of the Arkansas, between the river and the main line of the Iron Mountain Railway, about 40 miles east of the Indian Territory line. Its general outline and structure are shown in fig. 22. Along its north side the coal is cut off by a fault extending from Denning to a point a few miles east of Coal Hill, north of which the underlying rocks are raised. Half a mile south of this fault there is an anticlinal axis extending east and west through the district, in the center of which the underlying barren rocks are exposed south of Coal Hill. Near Denning the anticline pitches below the surface and the coal bed is continuous across it. South of Altus, at the west end of the Coal Hill fault, the coal bed approaches the surface, as indicated by drill records, and the Hartshorne sandstone rises and mantles Altus Hill.

A few miles west of Altus there is a smaller basin of coal land, including possibly 1 square mile, resting on this sandstone. The southern limb of the Coal Hill anticline, about 2 miles south of Coal Hill, is thrown down by the Spadra fault, so that the coal does not reach the surface.

Coal has been mined almost continuously from Coal Hill to Denning and southeastward from Denning around the southern limb of the anticline for several miles. The coal ranges in thickness from 1 to 5 feet, and the bed is usually characterized by a parting of shale or clay near the center, which varies greatly within short distances, being so thick in a number of places as to render the bed of no value.

Generally the parting thickens along the northern edge of the field, so that the underground workings have been stopped before they reach the fault. One of the first shafts sunk here for mining purposes found the parting over 4 feet in thickness and was abandoned for mining purposes, though it is still used as a pump shaft to drain one

[a] Ann. Rept. Geol. Survey Arkansas, 1888, vol. 3, p. 21.

of the mines farther south. South of the anticline coal has been mined near the outcrop, but beyond half a mile from the outcrop it is known only by rather meager drill records. These indicate that the bed becomes thin and of little value before the river is reached. Very little prospecting for this coal has been done at any distance south of the Coal Hill anticline, though its presence at a considerable depth

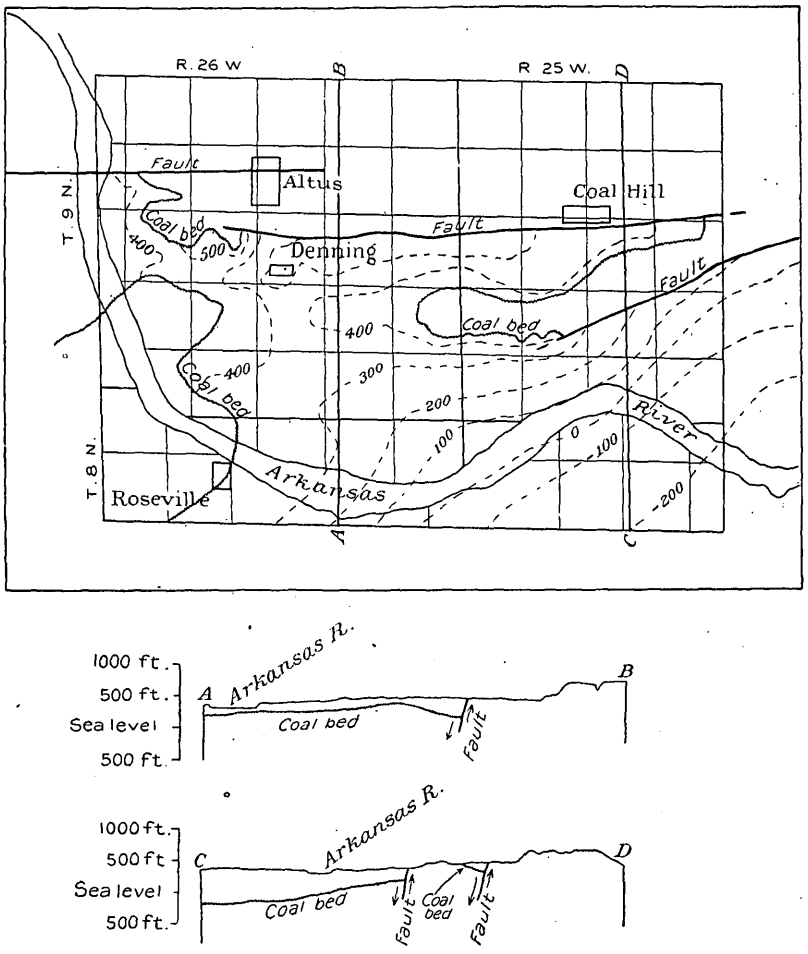

FIG. 22.—Map showing structure of Coal Hill-Denning district. Underground contour interval 100 feet. Diagrammatic profiles of land surface and coal bed along lines *A–B* and *C–D*; horizontal scale, 1 inch=3 miles; vertical scale, 1 inch=3,000 feet.

has been demonstrated by drilling, and it is reported that the parting is so thick as to preclude the possibility of successful mining. This coal bed probably extends eastward south of Hartman and is identical with that mined at Spadra, but for several miles the prospecting has not been sufficient to determine its quality and it does not outcrop at the surface. It will be found at a depth of several hundred feet and will doubtless present a number of difficulties for mining,

since it is below the flood plain of Arkansas River and the hard rocks are overlain by thick alluvial deposits.

Variations in the thickness of the coal and its partings in the Coal Hill district are shown graphically in fig. 23. The coal is semi-bituminous, as is shown by chemical analyses. It has a bright luster and is somewhat harder than that mined at the west end of the field.

Coal is mined for local trade from a number of small slopes in the small outlying basin west of Altus, in sec. 17, T. 9 N., R. 26 W. Here there are two coal beds, the lower averaging 2 feet and the upper 10 inches thick, with 18 feet of sandy shale between them. These two beds are regarded as equivalent to the two benches of the Denning coal bed with an excessive thickness for the parting. The coal resembles that of the Denning bed, though, being shallow, it

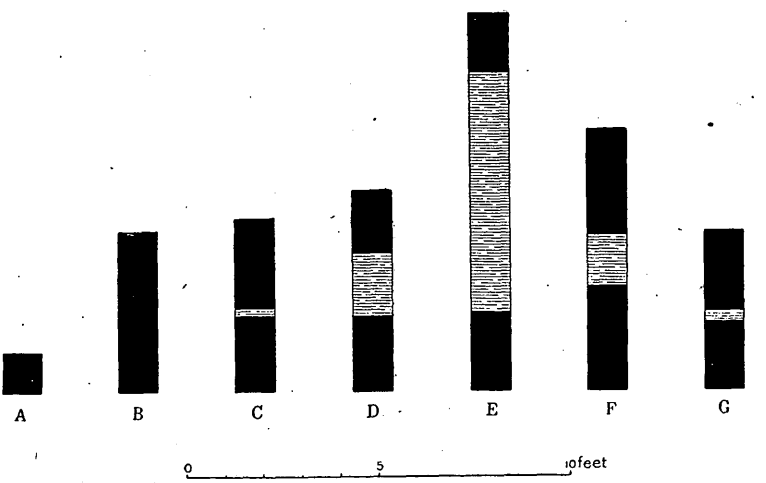

FIG. 23.—Graphic sections of coal at Denning, showing variations of the parting as revealed by drill records and other openings. A, Drill hole in NW. ¼ sec. 34, T. 9 N., R. 26 W.; B, drill hole in SW. ¼ sec. 27, T. 9 N., R. 26 W.; C, drill hole in NW. ¼ sec. 27 (average section of the bed as reported by Western Coal and Mining Co.); D, drill hole in NW. ¼ sec. 26, T. 9 N., R. 26 W.; E, drill hole near pump shaft in SW. ¼ sec. 23, T. 9 N., R. 26 W.; F, drill hole in SE. ¼ sec. 23, T. 9 N., R. 26 W.; G, drill hole near old Stiewell slope, sec. 20, T. 9 N., R. 25 W.

is affected by weathering and the joints are iron stained. Chemically it has a much lower percentage of sulphur.

A similar coal bed, with a parting more than 12 feet thick, is indicated by outcrops of coal smut on the south side of the river about 2 miles west of this basin in sec. 23 of the same township. No coal has been mined here. The outcrop probably indicates a small shallow basin of coal of the Hartshorne horizon resting on the Hartshorne sandstone.

SPADRA DISTRICT.

This district is also north of Arkansas River and its center is about 10 miles east of Coal Hill. It takes its name from the town of Spadra,

near which the coal bed outcrops and where the first developments were made. The coal differs slightly from that at Denning, in that it is considerably harder and of higher grade chemically. It is mined almost exclusively for domestic use and sold as semianthracite or Arkansas anthracite coal. The coal is somewhat thinner than at Coal Hill and Denning, though it is regarded as a continuation of the same bed, and it presents similar irregularities.

The structure of the Spadra field (fig. 24) is complicated, and its interpretation is made difficult by extensive deposits of sand and

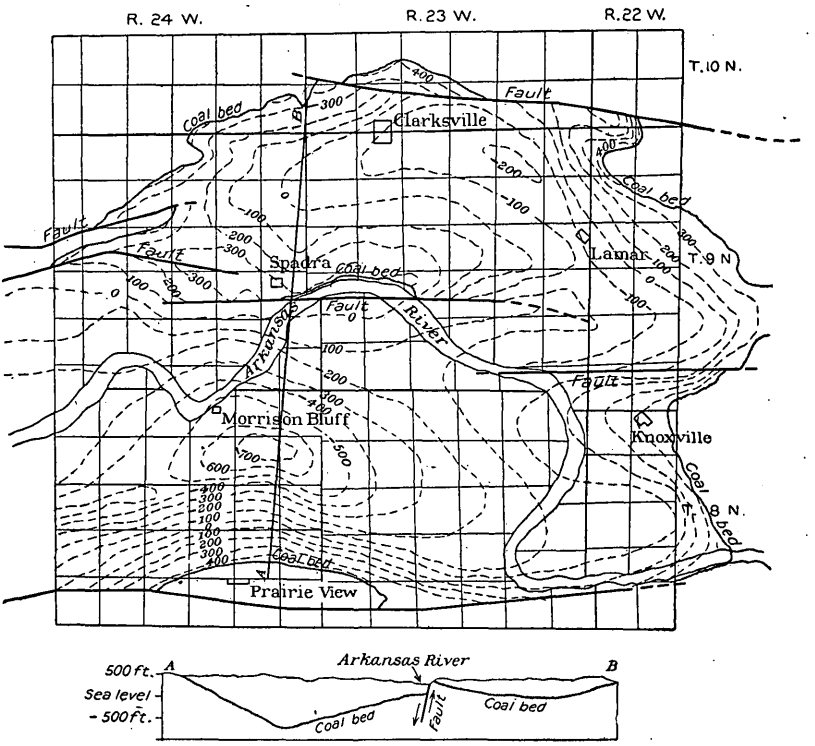

FIG. 24.—Map of Spadra and Prairie View coal fields, showing the nature of the deformation and faulting of the coal bed. Underground contour interval, 100 feet. Profiles of land surface and coal bed along line *A–B*. Vertical scale, 1 inch=4,000 feet. Horizontal scale, 1 inch=4 miles. Elevation of river at average stages, 300 to 320 feet.

gravel, which conceal a large part of the surface. It has been prospected by many companies and individuals, and though numerous drill holes have penetrated the coal horizon it has been impossible to assemble all of the information that has been obtained, since some of the records have been lost and others probably withheld. The available information, however, is sufficient to show that the continuity of the coal bed is broken by several faults of normal type that strike approximately east and west with downthrows generally to the south. Only one of these has been encountered in the mine workings, and its

extension conclusively demonstrated by drill holes. The others are indicated by stratigraphic evidence. The best known of these faults was first encountered 2 miles northwest of Spadra in one of the mines of the Eureka Coal Company, from which point it extends west-northwest nearly to the town of Hartman, where it turns a little south of west and continues to the center of the Coal Hill field.

Another fault, trending nearly east and west, marks approximately the southern limit of present mining operations. It is parallel with and a short distance north of Spadra Hill, a long ridge capped by flat-lying sandstone south of Spadra, and its east end is a few hundred yards north of the branch railroad at the south base of Big Danger Hill, in sec. 23, T. 9 N., R. 23 W., where its position is indicated by conclusive stratigraphic evidence. The displacement at the mouth of Spadra Creek is at least 200 feet. A small fault, which differs from those described in that the downthrow is to the north, lies north of the western part of the Spadra field, bringing in a small area of Spadra coal at the old Allen slope in sec. 18, T. 9 N., R. 24 W.

Another fault, which marks the northern boundary of the coal field northwest of Clarksville, occurs 3 miles north of Cabin Creek. The west end of this fault is probably north of Clarksville, from which point it extends eastward for about 15 miles. North of this fault the barren rocks below the coal horizon are exposed.

From Spadra the coal bed extends northward for about 5 miles. It underlies the town of Clarksville at a depth of from 400 to 500 feet, and outcrops 1½ miles northwest of Clarksville at a point noted by the Geological Survey of Arkansas as the Harkreader well,[a] from which point the outcrop can not be traced eastward with certainty. Coal again occurs and has been mined at a point 2 miles northeast of Clarksville, in what is known as the Mason drift, sec. 27, T. 10 N., R. 23 W. While it is probable that this coal is in the Hartshorne horizon, its characteristics are quite different from those of the Spadra bed, as will be shown later. The Spadra bed is known to extend from Spadra and Clarksville eastward, where it underlies Big Danger Hill and the massive sandstone of which it is composed. It has been penetrated by drill holes west of Cabin Creek (Lamar) at a depth of 550 feet, and the same bed probably outcrops on sections 6 and 7, T. 9 N., R. 23 W., 2 miles north of Cabin Creek.

The rather complicated structure of the coal field, as interpreted, is presented in the sketch map forming fig. 24, from which it will be seen that at the western limit of prospecting the coal bed is at a depth of 400 feet and that its depth probably increases westward.

On account of the miners' strike it was impossible to obtain measurements of the coal at the extreme west end of the district, though the coal bed had been reached in one of the shafts. A number of

[a] Ann. Rept. Geol. Survey Arkansas, 1888, vol. 3, p. 24.

drill holes have been made in this part of the field, but the owners would furnish no information regarding the coal except its distance below the surface. The coal bed is exposed by outcrop at the old Allen slope, in sec. 18, T. 9 N., R. 24 W., and also in an unnamed slope on section 17 of the same township, both of which have been abandoned for many years. The Allen slope, however, was open at the time the field was examined by the geologists of the Arkansas Survey, who report that the coal bed measures 4 feet, including a thin parting near the center. Old residents say that the coal is 3 feet thick at the slope in section 17, and the impression gained by conversation with mine owners and operators interested in the western part of the Spadra field is that approximately this thickness prevails over the entire west end of the field.

Coal mines are located at very short intervals from a point a short distance west of Montana post-office eastward along the railroad

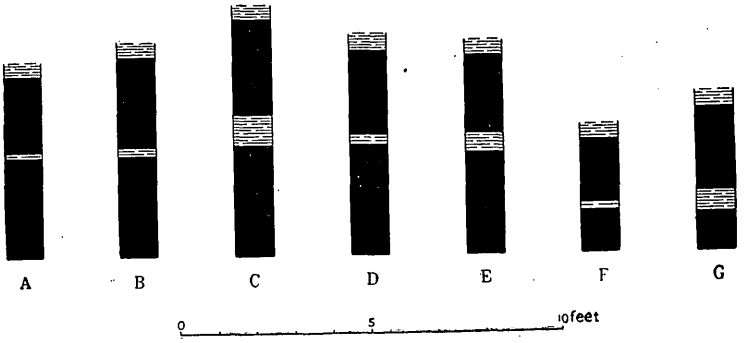

FIG. 25.—Sections showing thickness of the coal bed in the Spadra district and in the undeveloped field north of Lamar. A, Scranton Anthracite Co. mine, sec. 22, T. 9 N., R. 24 W.; B, Central Anthracite Co., sec. 22, T. 9 N., R. 24 W.; C, Eureka Anthracite Co., sec. 23, T. 9 N., R. 24 W.; D, Spadra Creek Coal Co., Needmore mine, sec. 23, T. 9 N., R. 24 W.; E, Consolidated Anthracite Coal Co., mine No. 1, sec. 24, T. 9 N., R. 23 W.; F, Brooks mine, Western Anthracite Coal Co., sec. 17, T. 9 N., R. 23 W.; G, prospect on sec. 7, T. 9 N., R. 22 W., north of Lamar.

for a distance of 6 or 7 miles. Nearly all of the openings are made by shafts that reach the coal at a depth of 200 feet or less. The average thickness of the coal is 2½ feet, including a small parting near the center of the bed. In general the coal dips to the north or northwest at a low angle, usually less than 3 per cent. The variations in the thickness of the coal bed and the position and size of the parting are shown in fig. 25.

The underground workings of the mines near Spadra extend for a maximum distance of 1 mile north from the main line of the Iron Mountain Railway, and two new mines have recently been opened near the southwest face of Big Danger Hill, about 2 miles northeast of Spadra. Although the records of much of the drilling that has been done north of these mines were not available, it is common report that in that direction the parting increases rapidly and makes much

of the coal unfit for mining. A shaft about 1½ miles northwest of Clarksville, near the old Harkreader well, was sunk in 1906, but had not reached the coal at the time of our examination. The coal bed, however, outcrops a short distance to the southwest, where it shows a thickness of 18 to 24 inches without parting.

At all of the mines and openings described thus far the coal bed is overlain directly by shale. The coal bed at the old Mason slope, which has been correlated provisionally with the Spadra coal, is different, however, in that it is overlain by several feet of hard sandstone. Coal has been mined from a strip pit 1½ miles southeast of the Mason drift, probably from a somewhat higher bed, though the exact location of the old pit is obliterated, and it was impossible to determine its stratigraphic position. In view of the tendency of the coal bed at Denning to divide in areas farther north, it seems at least possible that the same tendency may appear in the Spadra field—that the parting increases rapidly northward, separating the Spadra coal into two beds. The Mason coal may therefore represent the lower bench of the Spadra bed. The coal at the Mason slope is protected from erosion by the thin bed of sandstone which overlies it, and remnants of the coal bed have been found mantling the hill to the north at a number of places. Presumably it is the same bed that outcrops in a thickness of 15 inches on Dicks Branch, in sec. 10, T. 10 N., R. 23 W., 2 miles north of the Mason opening. It has been noted that the Spadra coal is believed to outcrop again northeast of Cabin Creek, where it has been opened at two points and seems to be sufficiently thick to warrant development. The section measured there is over 2 feet thick and is shown in fig. 25. From these openings the coal bed has been traced eastward and is correlated with two outcrops which are shown on the map near Piney Creek. At this point, however, the coal is of no value. It consists of 7 inches of coal overlying 2 feet of bony coal.

PRAIRIE VIEW DISTRICT.

This coal field lies on the south side of Arkansas River immediately south of the Spadra district. The presence of coal near the village of Prairie View has been known for many years and was noted in the report of the State Survey.[a] Attempts to prospect the field and determine the extent of the coal land have been made only within the last few years, and large areas of land have been purchased or optioned by a company known as the Arkansas Anthracite Company, whose headquarters are at Little Rock.

In the examination of the field preparatory to the purchase of coal lands 37 drill holes were sunk to various depths, 13 of which reached the Hartshorne horizon and found workable coal. A number

[a] Ann. Rept. Geol. Survey Arkansas, 1888, vol. 3, p. 25.

of the holes were evidently not carried to depths sufficient to reach the horizon sought, while others showed that there are parts of the field in which the coal is too thin for exploitation. The greatest thickness of the Hartshorne coal reported is 5 feet and the least about 1 foot.

This field lies in a broad syncline having a general east-west axis. Its southern edge is along the Prairie View fault, and its northern edge, which is contiguous to the southern edge of the Spadra field, is along the Big Danger fault, both of which have been described. A large part of the land surface is covered with heavy deposits of sand and gravel, so that inferences drawn from bed-rock exposures are not of very great value. The structure of the field, as indicated by drill records and observations of outcrops, is shown in fig. 24.

Three analyses of coal from diamond-drill cores, obtained at different points in the field, published in the prospectus of the Arkansas Anthracite Company, are given in the table on page 88. The samples

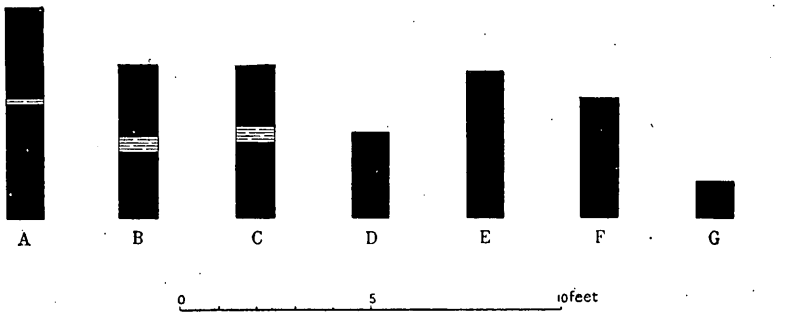

FIG. 26.—Graphic sections showing approximate thickness of coal at various points in the Prairie View field. A, B, and C from northern part of field; D, E, F, G from southern part. A, SW. ¼ SE. ¼ sec. 5, T. 8 N., R. 24 W.; B, SW. ¼ NW. ¼ sec. 2, T. 8 N., R. 24 W.; C, NE. ¼ SW. ¼ sec. 31, T. 9 N., R. 23 W.; D, SE. ¼ SE. ¼ sec. 17, T. 8 N., R. 24 W.; E, SE. ¼ SW. ¼ sec. 15, T. 8 N., R. 24 W.; F, NE. ¼ sec. 23, T. 8 N., R. 24 W.; G, SW. ¼ NE. ¼ sec. 24, T. 8 N., R. 24 W.

appear to be fully representative of the beds, and the analyses, which seem to be reliable, indicate that the coal in the northern part of the field is semianthracite, like that of the Spadra district, while that of the southern part is semibituminous, like that at Coal Hill. This is a condition to be expected from the facts learned in other parts of the Arkansas field. In the northern part of this district the bed is divided into two benches, resembling in this respect the Spadra coal, but in the southern half no parting is reported. Several graphic sections of the bed, as reported by engineers of the coal company, are given in fig. 26.

The east and west limits of workable coal in the Prairie View field can not be regarded as determined by the prospecting which has been done. Along the southern edge of the field, however, the drill holes show a thickness of 14 inches in sec. 24, T. 8 N., R. 24 W., east of which no workable coal was found. That the bed pinches out

altogether farther east is indicated by prospecting near Knoxville in T. 8 N., R. 23 W., where several drill holes have passed through the Hartshorne horizon without finding any coal. In the western part of the district very few drill holes have been sunk to the coal horizon, and the inference made by the coal company that workable coal does not extend in that direction does not seem fully justified.

This district is undeveloped except for these drill holes, and no coal has been mined except for local use. The field is not accessible from any of the existing railroads, but could be reached by an extension of the Arkansas Central road, which now terminates at Paris. The distance would be not more than 15 miles.

RUSSELLVILLE DISTRICT.

The Russellville district lies at the extreme eastern end of the coal field as at present recognized, and includes two small basins of coal land, known as the Ouita basin, a few miles north of Russellville, and the Shinn basin, a few miles south of that place. Between Knoxville and Russellville the Hartshorne sandstone comes to the surface and crosses Arkansas River in a slight anticlinal flexure, so that these basins are not connected with the Spadra and Prairie View basins, although the coal is in the same horizon. A few miles west of Russellville, in the vicinity of London, there is an area of land containing something over one and one-half townships which is underlain by Spadra shale and Hartshorne sandstone, and, as will be seen from the geologic map, the Ouita basin is a northeastern extension of this larger basin. The Shinn basin is not connected with the London basin, a belt of Hartshorne sandstone intervening between them.

Ouita basin.—The coal lands in the Ouita basin, which are partially worked out, are estimated to have covered an area of approximately 2 square miles. Although the formation that carries the coal extends westward over the larger area of the London basin, coal has not been mined in that basin except in the area noted, and prospect wells a few miles farther west, near London, have revealed no coal. On the south side of the river opposite London, as much as 18 inches of coal have been found in a drill hole penetrating the Hartshorne horizon. The coal beds of Shinn and Ouita basins are evidently small remnants of a more extensive sheet of coal, which have been protected in synclinal folds, while the greater part has been eroded. This coal bed probably thins rapidly toward the northwest and pinches out entirely in a few miles, though it probably was once continuous along the south side of the river. The northern, eastern, and southern boundaries of the Ouita basin are determined by the outcrops of the Hartshorne sandstone, which dips under the coal land from all these directions. The coal in this field does not at any

point lie very deep and has been mined from many small slopes, strip pits, and shafts which have now been abandoned and have caved in. Owing to the careless methods of mining probably much of the coal has been left in the ground and will be lost. Moreover, Illinois Bayou, a strong stream which heads in the Ozark Mountains, flows across the basin and has no doubt eroded a great deal of the shallow coal, so that much of the area included in the basin is not coal land.

The field includes one active mine as well as a number of small slopes and shafts that are occasionally worked for local supply. When it was examined all of the mines were shut down owing to the strike, and most of them were full of water, so that the coal bed was absolutely inaccessible. Although it was impossible to make measurements of the thickness of this coal bed, reports concerning it, believed to be reliable, indicate that the bed is without parting and has an average thickness of 28 inches. The roof and floor are shale. As reported by the Geological Survey of Arkansas the coal is about 26 inches thick and is overlain by 4 inches of bony or "wild" coal.[a]

Shinn basin.—The Shinn basin lies about 2 miles south of Russellville and includes approximately 2 square miles of coal land. Like the Ouita basin, this is bounded on all sides by outcrops of Hartshorne sandstone. On the south side of the basin this bed rock dips at a very high angle and is in some places slightly overturned, indicating that the basin has considerable depth. Shafts sunk for mining purposes show that its maximum depth from the surface probably exceeds 600 feet. Coal has been mined along the northern side of the basin for a great many years, where there are several abandoned slopes, but owing to the high pitch of the coal and its greater depth only a comparatively small amount of the area has been mined. The coal here is somewhat thicker than in the Ouita basin, ranging between 40 and 46 inches, with an 8 to 10 inch parting. Two thin coal beds, which are not worked, are reported several feet below, and a bed of coal a foot thick, lying above the main bed, has been passed through by some of the shafts. There are only three active mines in the basin, one of which has a shaft 480 feet deep and is the deepest coal mine in Arkansas.

The coals from both of these basins are classed as semianthracite. They command a somewhat higher price than the Spadra and other coals farther west, and are used almost exclusively for domestic purposes.

PHILPOTT DISTRICT.

The Philpott district lies in an isolated synclinal trough extending east and west through T. 10 N., Rs. 24, 25, and 26 W., north of the Coal Hill and Spadra fields. It includes a number of prospects and

[a] Ann. Rept. Geol. Survey Arkansas, 1888, vol. 3, p. 34.

small mines which were operated before the larger mines along the railroad were opened. The coal produced was softer than the Spadra coal, and for local use formerly commanded a better price, since it ignites and burns more freely. Analyses show that it is semibituminous and of about the same grade as that at Coal Hill and Denning. (See table, p. 98.)

Two beds of coal, separated by from 600 to 800 feet of shale and shaly sandstone, occur here. The lower of these, known as the Pickartz bed, from the old Pickartz mine, is correlated on stratigraphic evidence with the Hartshorne bed. The shale and sandstone above it represent the Spadra and a part of the Fort Smith formation, and the upper coal bed, known as the Philpott coal, is near the Charleston coal horizon.

The Pickartz mine is situated in sec. 24, T. 10 N., R. 26 W., and the horizon of the coal has been traced eastward for a distance of nearly 18 miles, connecting with the coal which outcrops on Dicks Branch, sec. 10, T. 10 N., R. 23 W., and Minnow Creek, sec. 20, T. 10 N., R. 22 W. The position of this outcrop is shown on the geologic map, and from it the coal land extends northward in a synclinal trough 5 or 6 miles wide. The coal evidently passes under Mulberry Mountain, where the northern outcrop has not been determined. No mining has been done along this outcrop for many years.

The geologists of the Arkansas Survey reported the following section at the Pickartz mine:

Section of coal bed at Pickartz mine.

	Inches.
Coal	20 to 22
Shale	½ to 2
Coal	1 to 4

The coal exposed at Dicks Branch measures 15 inches and at Minnow Creek 14 inches. So far as known there has been very little prospecting by deep drills to determine the amount of coal contained in this basin, though such an investigation would seem to be warranted by the showings already made. The upper bed, on which the old Moomaw and Philpott mines were located, is described in connection with the coal of the Charleston horizon.

OTHER LOCALITIES.

The most extensive and the best known areas in which the Hartshorne coal horizon occurs have now been described, but this horizon has been noted at a few other localities, where the coal is probably not present in minable quantity. One of the largest of these areas underlies Magazine Mountain, in T. 6 N., Rs. 24 and 25 W. Another smaller area lies about 10 miles northeast of Magazine Mountain. Nebo and Spring mountains, probably also Petit Jean Mountain,

southeast of Russellville, and comparatively large areas north and east of Russellville, are capped with Hartshorne sandstone, but in all these the overlying rocks in which the coal is contained have probably been eroded away. In the region north of the district investigated there may be areas covered by Hartshorne sandstone and some of the overlying rocks, in which some Hartshorne coal may be found, but they are not known at present.

COALS OF THE COAL RIDGE OR CHARLESTON HORIZON.

The Fort Smith formation near its upper part contains one or more coal beds which have been mined for local supply at many places in the Arkansas field. These coals lie from 800 to 900 feet stratigraphically above the Hartshorne horizon and are nowhere more than 3 feet thick, generally being too thin for mining except from strip pits. Owing to the erosion of intervening areas it has been impossible to correlate these upper beds in different districts by continuous exposures, and though no individual coal bed at this

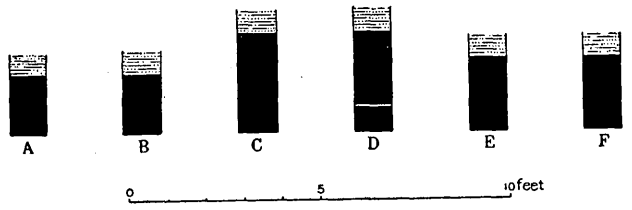

FIG. 27.—Characteristic sections of coal bed at Charleston horizon. A, Strip pit at Central, sec. 1, T. 7 N., R. 29 W.; B, slope under Coal Ridge, sec. 20, T. 7 N., R. 29 W.; C, Carters slope near Charleston, sec. 17, T. 7 N., R. 28 W.; D, prospect in bank of Big Creek, sec. 19, T. 7 N., R. 27 W.; E, Moomaw shaft near Ozark, sec. 22, T. 10 N., R. 26 W.; F, Philpott shaft, sec. 20, T. 10 N., R. 25 W.

horizon was probably ever continuous over the whole Arkansas coal field, it is believed that they are all within 100 feet of the same horizon. Coals at this horizon have been mined locally near Fort Smith, Central, Charleston, Caulksville, Alma, and in the Philpott basin. Their outcrops have been seen in many other places. The area covered by rocks of this horizon is indicated on the geologic map, Pl. VI. In general, the coal is of good quality and, as compared with Hartshorne coal, relatively free from ash, though on weathering it is often coated with white efflorescence. Graphic sections of coal beds of this horizon are shown in fig. 27.

CHARLESTON DISTRICT.

These coals are best exposed in the vicinity of Charleston, Franklin County, where the bed has been worked by stripping at many places indicated on the geologic map. In general, they have sandstone or sandy shale roofs and floors. The rocks overlying the coals contain at some places an abundance of fossil plants, which have already been described. (See report on paleobotany, pp. 24–31.) The coals are

best exposed and were first examined in the west end of Coal Ridge, in sec. 15, T. 7 N., R. 30 W., 2 miles north of Auburn, where they occur in a group of thin sandstones with intervening sandy shale. The outcrops of the inclosing rocks form two ridges, known as Grand Ridge and Coal Ridge. The sandstone of Grand Ridge is estimated to be about 800 feet above the Hartshorne sandstone and 150 feet below the sandstone forming Coal Ridge, which is the upper bed of the Fort Smith formation. Coal has been mined here from a succession of small slopes on a bed about 100 feet below the sandstone forming Coal Ridge. It has a thickness of 18 inches without partings. An analysis of a sample (U. S. G. S. No. 13) taken at this horizon is given in the table (p. 98). About 60 feet above the bed mined there is a smaller bed, which is of no importance here but is probably of greater thickness elsewhere, and it is probably true that some of the many outcrops near Charleston represent this small upper bed, while others represent the lower.

In sec. 27, T. 6 N., R. 30 W., about 1 mile south of Auburn, an old strip pit, which was full of water at the time of examination, probably represents the upper one of these two beds. The coal here shows a tendency to break into cubical blocks and is coated with a white efflorescence. Its thickness was not measured, but the coal has been mined for local purposes for many years, and the opening is mentioned in the report of the Arkansas State Survey under the name Bean pit. Coal has also been obtained in the bed of Big Creek from an opening called the Langston pit, 1 mile south of the Bean pit, but the locality was not examined. The bed worked here probably corresponds with that mined at Coal Ridge north of Auburn.

East and north of Charleston there are many openings on one or the other of these beds, which will not require description in detail, their positions being shown on the geologic map. It is probable that there are still some large areas of land which can be mined by stripping in the region, but the topographic maps at hand and the time available for the work were not sufficient to define them. Two miles east of Charleston, on the Carter place, there is a new slope from which more or less coal is taken every year. It was full of water when examined, but the coal is reported to be 3 feet thick.

The same coal is probably represented in an old pit on sec. 3, T. 7 N., R. 27 W., 1 mile east of the town of Caulksville, where it is reported to be only 13 or 14 inches thick.

BONANZA AND JENNY LIND DISTRICT.

Coal of the same horizon outcrops at a number of places between Charleston and Fort Smith, the best known of which is on sec. 1, T. 7 N., R. 31 W., near Central, where there are several strip pits, small shafts, and slopes. The bed has a thickness of about 20 inches

without parting. The coal has a cubical fracture, and after mining becomes coated with a white efflorescence. The same coal has been penetrated by wells at a number of points in the region southwest of Central, and has been mined from strip pits at Little Vache Grasse Creek and probably at other points.

The coal at the old Herman mine, in sec. 1, T. 8 N., R. 22 W., near Fort Smith, is probably also at this horizon. It is said to have been worked before and during the civil war and is noted in the Arkansas Survey reports. When the old workings were examined only one exposure, revealing 10 inches of good coal overlain by 1 foot of "bony" coal, was found. The bed is contained in sandy shale resembling that near Charleston.

VAN BUREN AND ALMA DISTRICT.

Coal of probably the same horizon outcrops at several points on the north side of the river near Alma, the thickness of the bed nowhere exceeding 18 inches and averaging 9 or 10 inches. At the Sullivant pit, in sec. 13, T. 9 N., R. 31 W., the coal measures 13 inches, and at the Graves pit in sec. 33, T. 9 N., R. 30 W., it measures 18 inches. Analyses of samples from these pits made by the Geological Survey of Arkansas (11 and 16 in table, p. 88) show that the coal is semibituminous. The same bed, perhaps, outcrops on Arkansas River at Moores Rock, in T. 8 N., R. 30 W., and it has probably also been found in wells at Van Buren. None of these openings expose a coal of workable thickness.

HUNTINGTON DISTRICT.

The same coal bed is probably exposed in Sugarloaf and Poteau mountains. It outcrops at the base of the Sugarloaf Mountains near the gap, where old excavations show that it has been opened, though no reports as to its thickness were obtained. The accidental exposures seen do not indicate that it is sufficiently thick to be of commercial value. A bed which may correspond with this is exposed at the Noblet pit, in sec. 31, T. 4 N., R. 32 W., on Poteau Mountain, where it is reported to consist of four thin benches aggregating 31 inches.[a]

PARIS DISTRICT.

At Paris this horizon is from 200 to 400 feet below the surface, and its outcrops north and south of the Paris basin have not been seen. In the Prairie View region, however, a coal bed 9 or 10 inches thick at about the proper distance above the horizon of the Hartshorne coal has been examined at a number of localities, which are noted on the geologic map. In no place has it been found to be of sufficient thickness to give it economic value under present conditions.

[a] Ann. Rept. Geol. Survey Arkansas, vol. 3, 1888, p. 19.

SPADRA DISTRICT.

A number of small coal beds, none of which are of economic importance and which correspond closely in stratigraphic position with the Charleston horizon, outcrop in the vicinity of Cabin Creek east of Clarksville. Although the detail of the stratigraphic succession of these beds has not been closely determined, they are regarded as corresponding approximately with the group of beds represented at Charleston.

PHILPOTT DISTRICT.

The bed mined at the old Philpott and Moomaw openings, in T. 10 N., R. 26 W., also seems to correspond approximately in stratigraphic position with the Charleston bed, though the interval between it and the Hartshorne may be as small as 600 feet. This coal lies in a synclinal basin about 4 miles long by 2 miles wide in which the rocks dip at low angles, and the coal is nowhere very deep. At the Philpott slope, sec. 20, T. 10 N., R. 25 W., the bed is from 18 to 22 inches thick, without partings, and a similar thickness is reported from other openings in the basin. The coal is semibituminous. Analyses of samples taken by the Arkansas Geological Survey indicate that it is comparatively low in ash and that it is chemically of a somewhat higher grade than the coal from the Pickartz bed.[a] Most of the product of one or two small mines is sold for domestic use at Ozark, to which place it is hauled by wagons. The eastern boundary of this basin has not been definitely determined, though the stratigraphy indicates that it can not extend far beyond the limit stated above.

Although the bed is comparatively thin, it seems to be well adapted to "long wall" mining, which has not yet been attempted, and all the coal contained will doubtless ultimately be available.

A similar small basin containing this coal doubtless underlies Mulberry Mountain, a few miles farther north, where no coal has been mined and no investigations were made by the United States Geological Survey party.

COALS OF THE PARIS HORIZON.

The horizon of the Paris coal is from 1,000 to 1,200 feet above the Hartshorne horizon. Stratigraphically it is about midway between the top and the bottom of the Paris formation. At the type locality near Paris the coal bed is overlain by shaly sandstone and underlain by sandy shale. A few inches of draw slate generally lies above the coal and at places some fire clay lies between it and the sandy shale floor. The bed varies in thickness from 2 to nearly 3 feet where it is worked. Near Paris the outcrop of the bed has been traced around the margin of the basin in which Short Mountain and Little Short Mountain are situated, as is shown by the geologic map.

[a] Ann. Rept. Geol. Survey Arkansas, 1888, vol. 3, p. 43.

The whole area underlain by this coal does not exceed 8 square miles, and in its western part the bed is probably too thin for mining. The coal has a bright luster and a rather indefinite cubical fracture. Chemically it is semibituminous and somewhat higher in hydrocarbon than the average Hartshorne coals in the same region. (See fig. 28, p. 85, and table of analyses, p. 98.) It is sold principally for domestic use. All the coal mined is hand picked or forked, the slack being left in the gob.

Outside of the Paris district this coal horizon is represented only in the vicinity of Potato Hill, where a coal bed provisionally correlated with it has been mined by stripping at several localities, though its thickness is not great enough at any opening to be of commercial importance. West of Potato Hill, in sec. 23, T. 6 N., R. 27 W., the coal is exposed in a strip pit which has been worked for local supply within the last year. The pit was full of water when examined, so that the coal could not be measured, but its thickness is reported to be about 14 inches. The same coal outcrops in several localities near Pine Hill, but it is not mined to any extent, and its thickness is not great enough to warrant development.

Except in these two areas the coal of this horizon has not been examined in Arkansas. It should outcrop in Sugarloaf, Poteau, and Magazine mountains, and it has probably been seen by prospectors and others in each of the two former localities, though it has not been reported from the latter. On stratigraphic and paleobotanic evidence it is provisionally correlated with the McAlester coal of Indian Territory. (See report on fossil plants, pp. 24–31.)

COALS IN THE ATOKA FORMATION.

Coal beds have been reported from many localities in the series of shales and sandstones underlying the Hartshorne, to which the name Atoka formation is applied. These lower coal beds are not continuous for any great distance and are thin, except in small areas. The investigation of the rocks below the Hartshorne horizon has been too limited and too unsystematic to enable the correlation of such coal beds with one another, and they will be described by localities without reference to horizons. In the western part of the field such coal has been reported at only one locality, in the center of the Backbone anticline, about 2 miles northeast of Hackett. The coal bed here lies between 500 and 1,000 feet below the Hartshorne sandstone and is not believed to be more than a few inches thick. Coal is also reported by the Geological Survey[a] of Arkansas in the neighborhood of Booneville, on Fletcher Creek, the locality being known as the Carlan drift. Although not examined, this coal is believed to be several hundred feet below the Hartshorne sandstone.

[a] Ann. Rept. Geol. Survey Arkansas, 1888, vol. 3, pp. 23, 59, and 80.

A small bed of coal which has been mined from strip pits for local use also outcrops on a bench on the north side of Rich Mountain 4 miles southwest of Ellsworth, in T. 7 N., R. 24 W. It was impossible to make an examination of this coal bed, as the pit has not been worked for several years and had caved in. The coal here is estimated to be about 300 to 400 feet below the Hartshorne sandstone. What is believed to be the same bed of coal has been penetrated by two drill holes in the vicinity of Shoal Creek, in T. 7 N., R. 23 W. It is 400 feet below the Hartshorne coal horizon, and one of the wells shows that it is nearly 4 feet thick, but is divided by shale partings. Where penetrated by the other well this bed is somewhat thinner.

Coal beds of horizons below the Hartshorne outcrop at several localities south of Shinn basin, in the Russellville district. The rocks here strike approximately east and west and dip northward under Shinn basin at high angles. There is some evidence of a fault here, making it difficult to estimate the interval between these coals and the Hartshorne horizon. It is probable that two beds are represented here, one about 400, the other from 800 to 1,000 feet below the Hartshorne. Prospecting with diamond drills was in progress here during the summer of 1906, though at the time the region was visited no coal thick enough to work had been discovered.

In the region south and southeast of Dardanelle the same beds have been mined occasionally since the civil war. Some old excavations in sec. 35, T. 6 N., R. 21 W., north of Centerville, expose from 18 to 20 inches of coal at the outcrop. Several drill holes which have been sunk on this bed indicate that it has a maximum thickness of a little less than 3 feet. The structure here indicates that this bed should dip north into an extensive synclinal basin, and should crop out again a few miles south of Dardanelle. Its northern outcrop, however, has not been recognized. Near the center of this syncline a higher bed of coal has been discovered in one or two wells and is reported to have a thickness of 14 to 15 inches. These beds are estimated to be about 400 feet and 800 feet, respectively, below the Hartshorne. What is probably the equivalent of the lower of these beds has been mined near Chickalah, south of Mount Nebo, and its occurrence west of Spring Mountain has been noted in the report of the Geological Survey of Arkansas, neither of which localities were examined. A thin coal that must also belong to one of the lower horizons has been reported near Atkins in T. 7 N., R. 18 W., and also near Galla Rock in T. 6 N., R. 20 W.

A coal bed 1 foot thick in one of these lower horizons outcrops and has been mined in the NE. ¼ sec. 24, T. 9 N., R. 26 W., in the Coal Hill district just north of the Coal Hill fault. This bed has been estimated to be about 100 feet below the base of the Hartshorne sandstone. Another similar bed 500 feet below the Hartshorne coal horizon has been penetrated by a drill hole in sec. 20, T. 9 N., R. 26 W., northwest

of Denning, where it is reported to be 5 feet thick. Between Altus and Ozark there are several outcrops of a coal bed less than 1 foot thick, which is probably near the same horizon.

A bed that is possibly slightly lower outcrops and has been prospected at the base of the sandstone on which the town of Ozark is built, and a similar coal outcrops south of Arkansas River opposite Ozark. The geologic work around Ozark has not been sufficient to demonstrate whether or not these various outcrops of coal can be correlated with one another. The beds vary greatly in thickness at different points, but are characterized by great irregularity and impurity, more than half of the bed usually being bone or black shale. A dirty coal bed somewhat resembling these, but more than 2 feet thick, has been reported from drill holes near the river several miles above Ozark. This bed, if present as reported, must necessarily be below the Hartshorne sandstone, and the results of prospecting thus far indicate that it has no economic value.

Drill holes that have been sunk to great depths in the neighborhood of Alma and Van Buren disclose no coal beds below the Hartshorne horizon. The same may be said of the drill holes in the vicinity of Fort Smith. Small coal beds of no economic value, which have not been correlated with each other nor with the beds herein described, are reported at several places in the large area underlain by Winslow sandstone north of the western part of the coal field, which has been examined in detail for the Winslow folio. All the evidence now available regarding coal below the Hartshorne horizon indicates that these coals are of greater thickness in the eastern part of the field than in the western, where they are practically absent.

From present indications further investigation of such beds in the vicinity of Russellville and Dardanelle is certainly justified and will probably result in extending the boundaries of the coal field as at present defined.

CHARACTER OF THE COAL.

PHYSICAL CHARACTERISTICS.

Most of the coals of Arkansas have a bright luster when freshly mined, though parts of some of the beds at a few places are described as dull. They generally present little evidence of stratification and seldom any cleavage parallel to the bedding, but the vertical cleavage or "cleat" is complex and somewhat indefinite. Except at one or two mines, the cleat is an unimportant factor in mining, entries and rooms being driven without respect to any inherent structure, though the many cleavage planes affect the value of the coal by making it fragile.

All of the coals are more or less brittle and friable and as mined yield from 10 to 40 per cent of fine slack, the percentage of which is probably an index to the relative hardness of the coal in different

parts of the field. For example, mine-run coal in the Jenny Lind, Greenwood, and Huntington districts, at the west end of the field, contains from 20 to 35 per cent slack, while that at Russellville, in the east end of the field, contains not more than 10 per cent. This difference, however, is due in part to the method of mining. Where the coal is mined by blasting or shooting off the solid, the percentage of slack is higher than that produced by hand or pick mining. The coals at Spadra and at Russellville seem to be of nearly equal hardness, but a much higher per cent of slack is produced in the former district owing to the use of powder in mining, the coal in the latter district being won by pick mining.

All of these coals are of comparatively high specific gravity, ranging from 1.29 to 1.49 and averaging about 1.35, which is equal to the average of Pennsylvania bituminous coals of better grade. Although hardness and specific gravity are not indicated by the results of chemical analysis, they are of the utmost importance in determining the uses to which any particular coal is best adapted. For example, the hard coals, even though they may produce a less amount of heat, are better adapted to domestic use than the soft ones. Coals of high specific gravity, other things being equal, are better adapted to use under locomotive and marine boilers than light ones, since a greater amount of fuel can be stored in the same space, and the heavier coals also give better results under forced draft. The relative hardness and specific gravity of different coals are doubtless due to a number of causes, the two more important probably being the degree of alteration of the original woody material of which it is composed and the amount of impurity contained in the coal as ash. One of the chief advantages of the Arkansas coals is that in burning they produce relatively little smoke.

CLASSIFICATION OF THE COAL.

The classification of coal into the various grades recognized in trade, based primarily on their physical properties and their adaptability to particular uses, coincides approximately with a classification based on the degree of alteration from their original woody character, coal of the lowest grade being lignite, while the most highly metamorphosed coal is anthracite. This classification is indicated by proximate chemical analyses showing the proportions of fixed carbon, volatile matter, water, and ash, which they contain. The method of analysis is as follows:

A small amount of coal is crushed and reduced to fine powder, weighed, and then dried at a temperature somewhat above the boiling point, which drives off the greater part of the moisture. It is again weighed and the difference in the two weights is taken as that of the water contained in the coal. The sample is then placed in a tightly

covered crucible and heated in a Bunsen flame until all the gases are driven off and burned around the edges of the cover. It is then cooled and again weighed, the loss in weight being taken as the amount of volatile matter. The residue in the crucible now consists only of fixed carbon and ash. In the coking coals this residue will be fused into a solid mass, but in others it remains as an incoherent powder. It is then heated over the flame in an uncovered crucible until all of the carbon is burned and only ash remains, when it is again weighed and the difference between this weight and the preceding is taken as the fixed carbon and the weight of the residue as ash.

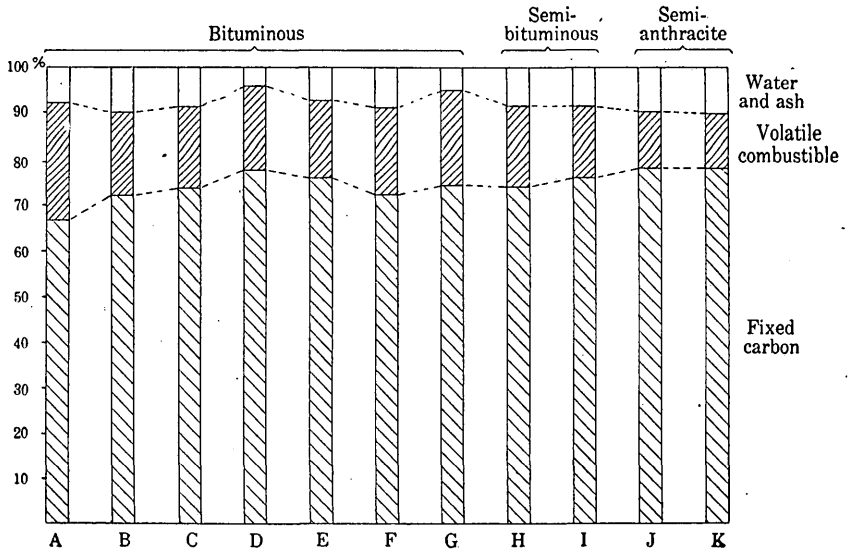

FIG. 28.—Diagram showing the composition of coals from different parts of the Arkansas field. A, coal from Bates district; B, Huntington coal; C, Bonanza and Jenny Lind coal; D, Hackett coal; E, Montreal, Midland, and Burma coal; F, Greenwood coal; G, Charleston coal; H, Paris coal; I, Coal Hill and Denning coal; J, Spadra coal; K, Russellville coal.

Such analyses are easily and quickly made and are usually sufficient for classification purposes when taken in connection with the obvious physical properties of the coal. Coals of higher grades are well differentiated by the relation between the percentages of fixed carbon and of volatile matter they contain. This relation is called the fuel ratio.

In the original Pennsylvania classification proposed by Persifor Frazer, jr.,[a] anthracite coals have fuel ratios above 12, semianthracite coals from 12 to 8, semibituminous coals from 8 to 5, and bituminous coals from 5 to 1. Generally, however, the limits of the various groups as understood in the trade are somewhat lower.[b] Arkansas anthracite or semianthracite coals have fuel ratios from 8½ to 6½ and

[a] Trans. Am. Inst. Min. Eng., vol. 6, p. 430; also Rept. MM, Second Geol. Survey Pennsylvania, 1879.

[b] Report on the coals of Maryland: Maryland Geol. Survey, vol. 5, 1905, p. 239. Campbell, M. R., Character of Yampa coals: Bull. U. S. Geol. Survey No. 297, 1906, p. 87.

the semibituminous coals from $6\frac{1}{2}$ to $4\frac{1}{2}$. As graded by this standard the Arkansas coals range from bituminous to semianthracite; those in the district south of Poteau Mountain are bituminous, their fuel ratios averaging about 3. The coals north of Poteau Mountain also, in the western part of the field, are near the dividing line between bituminous and semibituminous, and may perhaps be regarded as semibituminous, their fuel ratios averaging nearly 5; those in the Coal Hill–Denning and Paris districts are also semibituminous and of somewhat higher grade, while the coals in the Spadra and Russellville districts are semianthracite, their fuel ratios averaging above 7. The relative grades of the coals in the various districts are shown graphically in the group of diagrams forming fig. 28, those of the highest grade, from the eastern part of the field, being at the right, and those of lower grades, from the southwestern part, at the left of the figure.

A somewhat more satisfactory determination of the character of the coal is obtained from ultimate analyses, in which, by more elaborate chemical methods, the exact amounts of carbon, hydrogen, oxygen, sulphur, and other elements are determined.

EFFICIENCY OF THE COAL.

The relative efficiencies of various coals are determined in the laboratories by burning them in an apparatus called a calorimeter, in which the amount of heat developed by the total combustion of a given weight of the coal is accurately measured, and the results of such determinations are stated both in pound calories and in British thermal units, the former being the number of pounds of water, at maximum density, whose temperature can be raised 1 degree centigrade by the combustion of 1 pound of coal, the latter representing the number of pounds of water which will be raised 1° F. and being equal to nine-fifths of the former.

Calorific values of coal can be calculated very closely from ultimate analyses by Dulong's formula:

Heat value per pound, B. t. u. $= 146\ C + 620\ (H - \frac{O}{8})$, in which C, H, and O are, respectively, the percentages of carbon, hydrogen, and oxygen.

Proximate analyses give only the roughest approximations to the heat value of coals, owing to the very indefinite composition of the so-called volatile matter. Proximate analyses of coals within any given district or field, however, vary but slightly from one another, and it may be expected that the volatile combustible matter will have about the same relative value, so that if a few calorific determinations have been made the heat values of the others can be roughly estimated from proximate analyses. The efficiency of the coal from various parts of the field will depend mainly on its freedom from impurities in the form of ash.

Calorific determinations which have been made of Arkansas coals give an average value of 207 B. t. u. for each per cent of volatile matter and 146 B. t. u. for each per cent of fixed carbon. The heat value, in B. t. u., can therefore be roughly estimated from the proximate analyses as equal to 146 times the percentage of fixed carbon plus 207 times the percentage of volatile matter. The relative heat-producing values of the coals in the various parts of the field under discussion are shown graphically in fig. 29, from which it will be seen that the semianthracites of the eastern districts are slightly lower in efficiency than the semibituminous coals to the west.

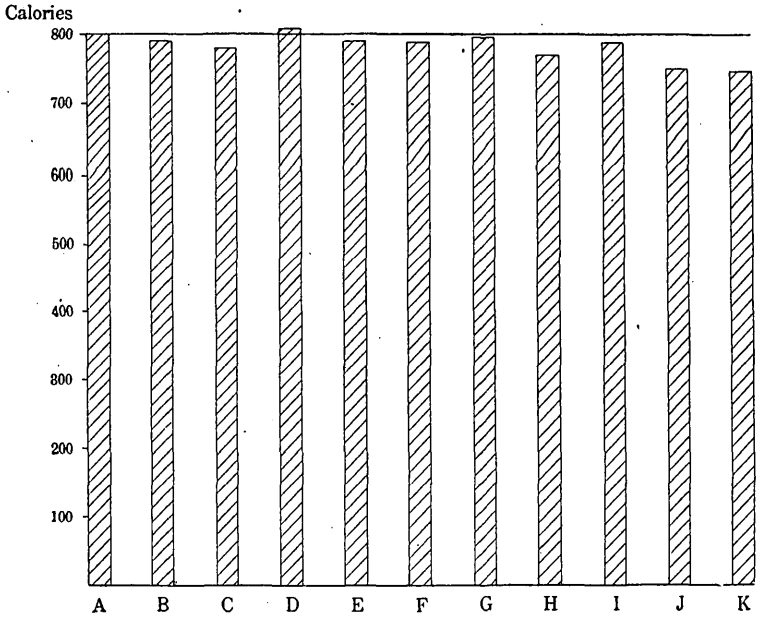

FIG. 29.—Diagram showing relative calorific values of coals from different parts of the Arkansas field. A, coal from Bates district; B, Huntington coal; C, Bonanza and Jenny Lind coal; D, Hackett coal; E, Montreal, Midland, and Burma coal; F, Greenwood coal; G, Charleston coal; H, Paris coal; I, Coal Hill and Denning coal; J, Spadra coal; K, Russellville coal.

SPECIAL TESTS AND ANALYSES.

ANALYSES MADE BY ARKANSAS GEOLOGICAL SURVEY.

Samples of coal from twenty-seven localities were collected by the Geological Survey of Arkansas, and proximate analyses, including specific-gravity determinations made by the chemists of the Survey, were published in their preliminary report.[a] No uniform method was followed in collecting these samples, some being taken from working faces of mines, while others were from carloads or from piles of coal left on the dumps. They can hardly be regarded, therefore, as strictly representative of the coal beds sampled. Moreover, the method of analyses is not stated in the report.

[a] Ann. Rept. Geol. Survey Arkansas, 1888, vol. 3, p. 43.

Proximate analyses of Arkansas coals made by the Geological Survey of Arkansas.

[Analyses by Dr. R. N. Brackett, assisted by Mr. J. P. Smith.[a]]

Sample No.	Name of pit or mine.	Nearest town.	Location.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio:
1	Carnall's drift	Oak Valley	S. 18, T. 7 N., R. 30 W.	5.26	17.66	61.98	13.62	1.49	3.51
2	Page's pit	Greenwood	S. 19, T. 6 N., R. 30 W.	.85	16.39	78.22	3.30	1.24	4.77
3	Baxley's pit	Paris	S. 35, T. 8 N., R. 26 W.	1.23	15.75	75.34	5.28	2.40	4.79
4	Hackett Cy. shaft.	Hackett	S. 22, T. 6 N., R. 32 W.	.85	14.916	73.87	9.04	1.32	4.95
5	Pickartz drift	Ozark	S. 26, T. 10 N., R. 26 W.	.70	15.88	79.00	3.56	.86	4.97
6	Huntington slope.	Huntington	S. 24, T. 5 N., R. 31 W.	.93	15.55	77.54	4.85	1.43	4.99
7	Claiborne's pit	Hartford	S. 17, T. 4 N., R. 31 W.	.94	15.54	78.36	4.01	1.15	5.04
8	Lewis's pit	Alston	S. 4, T. 9 N., R. 28 W.	.88	15.23	77.20	4.24	2.45	5.07
9	McConnel's shaft.	Greenwood	S. 32, T. 7 N., R. 30 W.	.600	15.38	78.30	4.58	1.14	5.09
10	Greenwood shaft	do	S. 12, T. 6 N., R. 31 W.	.82	14.87	75.82	5.97	2.52	5.10
11	Sullivant	Alma	S. 13, T. 9 N., R. 31 W.	.76	12.95	67.13	14.20	4.96	5.19
12	Bocquin	Jenny Lind	S. 31, T. 7 N., R. 31 W.	.75	14.98	77.87	5.00	1.40	5.20
13	Gwyn's drift	Hartford	S. 14, T. 4 N., R. 32 W.	.89	14.58	77.09	6.25	1.19	5.29
14	Carlan's slope	Booneville	S. 22, T. 5 N., R. 28 W.	.85	14.67	78.40	4.71	1.37	5.34
15	Moomaw's pit	Ozark	S. 22, T. 10 N., R. 26 W.	.66	14.89	79.81	3.27	1.37	5.36
16	Graves drift	Alma	S. 33, T. 9 N., R. 30 W.	.57	13.90	75.07	7.61	2.85	5.40
17	Petty's slope	Jenny Lind	S. 32, T. 7 N., R. 31 W.	1.78	13.33	76.23	7.05	1.62	5.72
18	Philpott shaft	Coal Hill	S. 20, T. 10 N., R. 25 W.	.87	14.13	80.92	3.09	.99	5.73
19	Watt's slope	Central	S. 13, T. 7 N., R. 31 W.	.74	12.62	72.61	9.97	4.07	5.75
20	Felker slope	Coal Hill	S. 24, T. 9 N., R. 26 W.	1.13	13.21	81.28	3.22	1.16	6.15
21	Ouita slope	Russellville	S. 30, T. 8 N., R. 20 W.	.98	12.20	76.82	8.17	1.83	6.29
22	Eureka shaft	Spadra	S. 23, T. 9 N., R. 24 W.	1.10	11.28	72.84	12.04	2.75	6.46
23	Coal Hill shaft	Coal Hill	S. 20, T. 9 N., R. 25 W.	1.02	10.84	76.12	8.35	3.67	7.02
24	Allister slope	do	S. 24, T. 9 N., R. 26 W.	1.18	10.48	76.49	8.32	3.53	7.30
25	Mason drift	Clarksville	S. 27, T. 10 N., R. 23 W.	1.12	11.01	80.86	5.86	1.16	7.34
26	Harkreader's well	do	S. 34, T. 10 N., R. 24 W.	1.56	10.35	78.91	6.31	2.87	7.62
27	Shinn slope	Russellville	S. 21, T. 7 N., R. 20 W.	1.06	8.41	75.43	11.75	3.35	8.96

Proximate analyses of Arkansas coals furnished by mining companies.

W. C. & M. Co.[b]	Jenny Lind		0.49	13.64	76.73	7.12		5.63
P. C. C. Co.[c]	Huntington		1.33	14.03	77.83	5.63	1.33	5.55
W. C. & M. Co.[b]	Denning		1.07	11.21	78.01	8.13		6.96
A. A. Co.[d]	Prairie View.	S. 23, T. 8 N., R. 24 W.	1.1	14.6	73.2	9.7	1.4	5.01
Do	do	S. 31, T. 9 N., R. 23 W.	.6	10.7	77.5	10.1	1.1	7.24
Do	do	S. 12, T. 8 N., R. 24 W.	.6	10.1	75.4	11	2.9	7.46

[a] Ann. Rept. Geol. Survey Arkansas, 1888, vol. 3, p. 43.
[b] Western Coal and Mining Co., St. Louis Sampling and Testing Works, analyst, 1897. Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 398.
[c] Prairie Creek Coal Co., analyses by Bureau of Equipment, Navy Department, Washington, D. C.
[d] Arkansas Anthracite Co., Little Rock. Prospectus.

Many analyses of Arkansas coal from various localities have also been made by commercial assayers working for private parties, some of which have been reported to members of the Geological Survey. Like those made by the State Survey, the private analyses are not uniform in either the method of sampling or the method of analysis; but since many of the localities represented were not duplicated by the present survey, it seems advisable to republish them. All such analyses at hand, including those made by the State Survey and by private assayers, are presented in the above table.

FUEL-TESTING PLANT SAMPLES.

The agents of the United States Geological Survey fuel-testing plant, at the Louisiana Purchase Exposition, in 1904 and 1905, collected four sets of samples representing the Arkansas coal field. Each set included two samples cut from working faces in the mine and a carload lot representing the commercial product. They also

collected mine samples from four other mines and obtained several carloads of slack from various localities for experimental work.

In taking mine samples the following method was invariably observed:[a]

> After the face of the coal was cleaned of any weathered coal or powder smoke a cut was made across the face of the coal from roof to floor, including all of the benches of coal mined and such impurities as were not removed in ordinary work. This cut was about 3 inches wide and 1 inch deep. The coal obtained from it, amounting to 25 or 30 pounds, was caught upon an oilcloth blanket spread upon the floor of the mine, so as to protect the sample from water and from including any shale or clay fragments.
>
> The coal composing the sample was then pulverized and quartered down according to the generally accepted rules for preparing samples until a quart sample was obtained, with the particles of coal reduced to a size not much greater than one-fourth inch in diameter. The sample was placed in an air-tight galvanized-iron can having a screw top, and the can was hermetically sealed by screwing the top down tight and covering the joint with tire tape. The can containing the sample was then mailed to the testing plant, and in almost all cases it reached its destination within two or three days of the date of sampling in the mine.

The four complete sets of samples from this field are described in the report of the fuel-testing plant as Arkansas Nos. 1, 2, 3, and 5, and they will be so designated in this report.

Arkansas No. 1, collected by M. R. Campbell and John W. Groves, represents the coal locally known as the Huntington coal. It is in the horizon of the Hartshorne coal of Indian Territory and is probably continuous with the Hartshorne bed. Sample A, laboratory No. 1046, was taken at a point where the coal bed has a thickness of 7 feet 7 inches, with two partings, one of black shale 5 inches, the other of shale and coal 10 inches thick. Sample B, laboratory No. 1045, represents the coal where the bed is 6 feet 6 inches thick, with two partings, one of black shale 5 inches, the other of shale and coal 1 foot thick. Sample C, laboratory No. 1114, represents as nearly as possible a carload containing 44 short tons of engine coal which was shipped to St. Louis to be tested.

Arkansas No. 2, sampled by M. R. Campbell and John W. Groves, represents the coal bed that is known locally as the "Jenny Lind vein." This bed is in the Hartshorne horizon, and is equivalent to if not identical with, the bed mined at Huntington, Ark., and Hartshorne, Ind. T. Sample A, laboratory No. 1053, represents the coal where the bed is 3 feet 8½ inches thick, with a shale parting 1½ inches thick near the center. Sample B, laboratory No. 1049, represents the bed where it is 3 feet 8 inches thick, with a similar parting 2½ inches thick. Sample C, laboratory No. 1160, represents, as near as possible, a carload shipped to St. Louis for testing.

Arkansas No. 3, sampled by John W. Groves, represents the coal mined at Jenny Lind. At the point where sample A, laboratory

[a] Campbell, M. R., Field work, in Preliminary report on the operations of the coal-testing plant of the United States Geological Survey: Bull. U. S. Geol. Survey No. 261, 1905, pp. 19-20.

No. 1115, was taken the bed has a thickness of 4 feet 8 inches, with a 3½-inch shale parting near the center. Sample B, laboratory No. 1118, represents the same bed where its thickness is 3 feet 9 inches, with a 3-inch parting. Sample C, laboratory No. 1296, represents a carload sent to St. Louis for testing.

Arkansas No. 4 was a carload sample of slack for briquetting tests, representing four mines near Denning.

Arkansas No. 5, collected by John W. Groves, 1½ miles west of Coal Hill, is from a bed locally known as the Denning bed. The coal bed is in the Hartshorne horizon, and is probably identical with the Hartshorne bed of Indian Territory. Sample A, laboratory No. 1130, was cut where the coal is 3 feet 9 inches thick, with a 5½-inch parting of shale and coal near the center. Sample B, laboratory No. 1131, was cut where the bed is 3 feet 9 inches and the shale parting 7 inches thick. Sample C, laboratory No. 1331, represents a carload consisting of about 20 short tons of lump coal over a 1.8-inch bar screen and about 20 tons of slack or coal that passed through this screen.

Arkansas No. 6, laboratory No. 1542, was a car sample of slack mined at Jenny Lind and was shipped to the fuel-testing plant by the operator for special tests in briquetting and coking.

Eight special samples taken for chemical tests from mines not represented by carload lots are as follows:

Laboratory numbers 1030 and 1031 represent a mine in sec. 36, T. 9 N., R. 31 W., near Jenny Lind. They were collected by John W. Groves. The same mine is represented by sample No. 9, collected by the Geological Survey party.

Laboratory Nos. 1040 and 1042 represent a mine in sec. 22, T. 9 N., R. 26 W., near Denning. The bed is the same as that represented by the samples under Arkansas No. 5, and the coal measures 3 feet 7 inches and 4 feet 5 inches, respectively, at the two points where samples were cut.

Laboratory Nos. 1052 and 1054 represent a mine in sec. 13, T. 5 N., R. 32 W., near Midland. They were collected by J. Shober Burrows. The coal is without partings and measures, respectively, 2 feet 10 inches and 2 feet 9 inches at the points where the samples were cut.

Laboratory Nos. 1066 and 1068 represent a mine in sec. 1, T. 4 N., R. 32 W., south of Midland. The bed is in the Hartshorne horizon and is a western extension of that mined at Huntington. It measures 8 feet 7 inches and 8 feet 5 inches, respectively, at the two points sampled, but is divided by a parting into two benches, both of which are mined.

Twenty-six samples from various mines were taken by the United States Geological Survey party in the summer of 1906. The method of sampling was identical with that followed by the agents of the fuel-testing plant, except that usually only one sample was taken from

each mine. These samples were numbered consecutively in the order in which they were collected and are as follows:

Sample No. 1, laboratory No. 3155, represents the coal at a strip pit near Burma in sec. 19, T. 5 N., R. 31 W. The bed mined is in the Hartshorne horizon and is regarded as equivalent to that mined at Hartshorne, Ind. T. The bed here is 3 feet 7 inches thick without partings. Sampled by C. D. Smith.

Sample No. 2, laboratory No. 3154, represents one of the working faces of a mine at Burma station in sec. 20, T. 5 N., R. 31 W. The bed is the same as that at the pit, represented by sample No. 1, laboratory No. 3155. It is 36 inches thick, has a hard sandstone roof and sandy shale floor, and is worked from a shaft about 60 feet deep. Sampled by C. D. Smith and A. J. Collier.

Sample No. 3, laboratory No. 3158, is from a mine near Burma station, in sec. 19, T. 5 N., R. 31 W. The coal bed has an average thickness of 36 inches and is the same as that of sample No. 2. It is overlain by a thick bed of hard sandstone, but in the western part of the workings shale of varying thickness intervenes between the coal and the sandstone. Sampled by C. D. Smith.

Sample No. 4, laboratory No. 3150, represents a mine in sec. 19, T. 5 N., R. 31 W., a short distance southeast of Montreal station on the St. Louis and San Francisco Railroad. The bed mined is the same as that at the Denman and Red Rock mines and is in the Hartshorne horizon, though the roof is shale. The sandstone lens, which constitutes the roof in the mines just mentioned, thins out and disappears before reaching this mine. The coal averages about 42 inches thick without partings. Sampled by C. D. Smith.

Sample No. 5, laboratory No. 3152, is from a mine located near Montreal station in sec. 13, T. 5 N., R. 32 W. The bed, which is the same as that just described, has an average thickness of 3 feet 4 inches. The sample was taken by C. D. Smith from one of the lowest entries in the slope.

Sample No. 6, laboratory No. 3156, is from a slope in sec. 19, T. 5 N., R. 31 W., near the line of the St. Louis and San Francisco Railroad. At this place the coal has been mined by stripping for half a mile or more along the outcrop and sample No. 1 was taken from a face exposed in the pits. Where the pitch of the coal has carried it to such a depth as to make strip mining impracticable, short slopes have been driven from the face as exposed. This sample was collected by C. D. Smith from the face in one of these slopes for comparison with sample No. 1, to determine the effect of weathering. The analyses of the two samples, 1 and 6, however, are nearly identical, and indicate that the coal is stable and only slightly affected by weathering.

Sample No. 7, laboratory No. 3148, is from a partially developed mine located about three-eighths of a mile northeast of Burma

station. The coal is reached by a shaft about 25 feet deep, which pierces the hard sandstone lens that forms the roof of the Red Rock and Denman mines. The bed is not quite so thick as that in the Red Rock mine, and about 4 inches near the top is thrown out in mining. The coal which is hand-picked and sacked, is used for blacksmithing purposes and brings a somewhat higher price than the other coals of the district. Sampled by C. D. Smith.

Sample No. 8, laboratory No. 3157, represents the coal at a mine in sec. 18, T. 6 N., R. 31 W., about 2 miles east of Hackett. The bed is 32 inches thick without partings. It is reached by a shaft 60 feet deep. The sample was taken by Sidney Paige from a clean dry working face. This coal is in the eastern extension of the bed mined at Hackett, Ark., and at Panama, Ind. T., and is almost identical in character. At Greenwood, a few miles farther east, it is very much thicker, but is divided by partings.

Sample No. 9, laboratory No. 3153, represents the coal from a mine at Jenny Lind. The bed averages about 6 feet. The sample was taken by C. D. Smith from a working face near the end of one of the west entries. The mine was rather damp with surface water, though the face of the coal was not wet.

Sample No. 10, laboratory No. 3151, represents the coal in a mine 1 mile west of Jenny Lind. It is the same mine as is represented by the sample Arkansas No. 3, previously collected for the fuel-testing plant. The bed where the sample was collected contains 38 inches of coal separated into two benches by a parting of hard shale 14 inches from the floor. It was sampled by Sidney Paige.

Sample No. 11, laboratory No. 3173, represents a mine in sec. 12, T. 6 N., R. 30 W., near Greenwood. The bed varies in thickness from 4 feet to 7 feet and is separated into two benches by a parting of soft shale near the center, which varies from a fraction of an inch to 6 inches. The sample was taken by C. D. Smith from a working face in the lower part of the mine as far as possible from the outcrop.

Sample No. 12, laboratory No. 3175, represents the coal in a mine a few miles east of Greenwood. The total thickness of the bed is about 8 feet, 5 feet of which in one bench is mined. The sample was collected by C. D. Smith and represents the part mined.

Sample No. 13, laboratory No. 3218, represents a bed that has supplied coal for neighborhood use from a number of strip pits and other openings near Charleston. The bed is stratigraphically from 800 to 900 feet above the Hartshorne horizon and is provisionally correlated with that formerly worked near Caulksville, Central, Fort Smith, and other places. It is believed to be at about the same horizon as the Philpott bed north of Coal Hill, though the exact correlation of the latter is regarded as doubtful. It is described in this report as the Charleston bed, but is variously known locally as

the Sky vein, Coal Ridge vein, etc. The sample, which is the only representative of the coal at this horizon, was taken by Sidney Paige from a small drift worked occasionally at the west end of Coal Ridge in sec. 20, T. 7 N., R. 29 W., a few miles north of Auburn. The face from which it was cut had probably been exposed to the air for several months. The bed has a thickness of 18 inches without partings.

Sample No. 14, laboratory No. 3174, is from a mine at Paris, Ark. The mine is located in sec. 10, T. 6 N., R. 26 W., and the coal bed is known and described in this report as the Paris coal. It is from 1,000 to 1,400 feet vertically above the Hartshorne coal and probably from 400 to 600 feet above the Charleston coal. The sample was taken from one of the working faces in the deepest part of the mine and represents a thickness of 26 inches without partings. The bed has a firm sandstone roof from which it is separated by half a foot or more of draw slate. It is underlain by a thin seam of fire clay and mining is done by undercutting.

Sample No. 15, laboratory No. 3177, represents a mine in the Shinn basin, south of Russellville, and was collected by C. D. Smith from a working face in the deepest part of the mine. The coal is reached by a shaft 70 feet deep, located in sec. 22, T. 7 N., R. 20 W. It varies in thickness from 30 to 36 inches. The bed is in the Hartshorne horizon and may be identical with that mined in the western part of the field at Huntington, Jenny Lind, and Greenwood.

Sample No. 16, laboratory No. 3176, from a mine in Shinn basin, south of Russellville, represents the same bed as sample No. 15. This is the deepest mine in Arkansas, the coal being reached by a 480-foot shaft. It is situated in sec. 21, T. 7 N., R. 20 W. The sample was collected by C. D. Smith from one of the working faces of the mine.

Sample No. 17, laboratory No. 3368, from a mine near Spadra, Ark., in the SW. ¼ sec. 14, T. 9 N., R. 24 W. The bed is 44 inches thick, with a parting of 3 inches or more near the middle. It is mined from a shaft 140 feet deep. The sample was cut by R. D. Mesler from one of the working faces of the mine.

Sample No. 18, laboratory No. 3369, is from the Brooks mine about 2 miles south of Clarksville in sec. 17, T. 9 N., R. 23 W. The coal bed is known as the Spadra bed and has a thickness of 34 inches with a 2-inch shale parting near the center. It is mined from a shaft 240 feet deep. The sample was taken by R. D. Mesler from one of the working faces of the mine.

Sample No. 19, laboratory No. 3370, is from a mine 2½ miles southwest of Coal Hill. The bed mined here is the same as that represented by the sample Arkansas No. 5, of the fuel-testing plant which was taken from a mine about 1½ miles to the west. Both of these are

in the Hartshorne horizon and are probably identical with the bed mined at Bonanza and Huntington. This mine is a small one and was not shut down during the strike. The sample was taken from one of the working faces, where the bed is 3½ feet thick with a half-inch parting near the center.

Sample No. 20, laboratory No. 3371, is from a small mine at Center Cross about 2 miles west of Altus. The coal bed is in the Hartshorne horizon and is regarded as equivalent to the Coal Hill and Denning bed from which sample No. 19 was collected. It consists, however, of two beds of coal, each about 2 feet thick with 18 feet of sandy shale between them, which is probably equivalent to the parting found in the Coal Hill and Denning beds. In the Denning field the parting is known to increase locally to a thickness of 6 or 7 feet. Only the lower bench, about 25 inches thick, is mined, and it alone is represented in this sample, which is cut from a working face. The mine, however, is shallow, and the total cover over the coal where sampled does not exceed 25 feet. Sampled by R. D. Mesler and A. J. Collier.

Sample No. 21, laboratory No. 3372, is from a mine in sec. 30, T. 8 N., R. 31 W., on Massard Prairie about 5 miles from Fort Smith. The coal bed which is regarded as equivalent to the bed mined at Jenny Lind and Bonanza, is from 27 to 30 inches thick, with a shale parting less than 1½ inches thick. Its upper bench is said to be softer and freer from impurities than the lower. The sample was collected by C. D. Smith from the working face under a cover of about 30 feet.

Sample No. 22, laboratory No. 3407, represents the coal from a mine in sec. 23, T. 9 N., R. 24 W., near Spadra. The coal is mined from a shaft 100 feet deep, and is known locally as the Spadra bed. It is in the Hartshorne horizon and is equivalent to the coal mined at Jenny Lind and Huntington, Ark., and at Hartshorne, Ind. T. The sample was taken by R. D. Mesler from one of the working faces, where the coal is 3 feet 5 inches thick with a 2-inch shale parting near the center.

Sample No. 23, laboratory No. 3503, represents the upper part of the coal bed at a mine in sec. 21, T. 3 N., R. 32 W., south of Poteau Mountain. This bed is divided into four benches, the upper three each about 2 feet thick, separated by 2-inch shale partings. The lower bench is about 4 feet thick and is separated from the upper ones by 30 inches of shale and bone. Only the lower bench is mined. This sample represents the three upper benches of the mine, including the partings, and was obtained by boring a hole upward from the roof of the lower bench through the upper three benches, the cuttings from the auger being taken as a sample. The sample was collected by C. D. Smith.

Sample No. 24, laboratory No. 3505, represents the coal produced at a mine in sec. 21, T. 3 N., R. 32 W., near Bates. This is a new mine opened by a slope from which no entries have been turned. Only the lower bench, 4 feet thick, is mined. The sample was taken by C. D. Smith from the working face and represents unweathered coal.

Sample No. 25, laboratory No. 3500, represents the coal at a mine in sec. 14, T. 4 N., R. 32 W., about 2 miles east of Hartford. The coal bed is 52 inches thick, with a 10-inch clay parting near the bottom, and the lower bench is not mined. Only the upper bench, 3 feet 6 inches thick, is represented by the sample, which was collected by C. D. Smith from one of the working faces.

Sample No. 26, laboratory No. 3497, represents the coal mined in sec. 21, T. 6 N., R. 32 W. The mine is a new one and has been in operation for only a few months. It is opened by a slope with an incline of about 15° from the outcrop. The bed is 3 feet 8 inches thick and is without parting. It has a sandstone floor and about 4 inches of draw slate between the coal and the solid shale roof. The sample was collected by C. D. Smith from one of the working faces.

CHEMICAL ANALYSES.

Analyses and other tests of the samples described above were made under uniform conditions at the fuel-testing plant. All of the samples were tested by proximate analyses. After they had been pulverized most of the samples were exposed to dry air at ordinary temperatures until their weight became stable and their basis of moisture on air drying was carefully determined. In this way the samples were brought to a nearly uniform condition as regards moisture before analysis. In the following tables the analyses of the samples as received and after air drying are given. Owing to the provisions of the law authorizing the work done at the fuel-testing plant, the names of the operators from whose mines the samples were obtained can not be printed.

For comparison of coals from the various districts the analyses of the air-dried samples are preferable. It will be seen from these analyses that the moisture retained in the Arkansas coals after air-drying is nearly constant, the limits of variation being from 0.51 to 1.28 per cent. All the samples, except five, noted in the table, were mine samples.

Analyses of coal samples from Arkansas.

[U. S. Geol. Survey fuel-testing plant, analyst.]

District	Bates-Coaldale.		Greenwood-Huntington.					
Nearest town	Bates.		Hartford.			Huntington.		
Name of sample	U. S. G. S. No. 23.	U. S. G. S. No. 24.	U. S. G. S. No. 25.	Special.	Special.	Ark. No. 1 A.	Ark. No. 1 B.	Ark. No. 1 C.[a]
Laboratory number	3503.	3505.	3500.	1066.	1068.	1046.	1045.	1114.
Analysis of sample as received:								
Prox. Moisture	6.85	3.39	4.12	.80	.90	.75	1.02	3.24
Prox. Volatile matter	25.75	24.44	18.15	17.80	18.35	18.50	17.88	17.46
Prox. Fixed carbon	43.40	66.40	69.97	72.71	71.65	73.77	73.61	66.69
Prox. Ash	24.00	5.79	7.76	8.69	9.10	6.98	7.49	12.61
Ult. Sulphur	2.32	.87	.98	1.95	1.74	1.15	1.10	1.24
Ult. Hydrogen								4.15
Ult. Carbon								74.09
Ult. Nitrogen								1.44
Ult. Oxygen								6.47
Calorific value determined:								
Calories				7,934			8,019	7,294
British thermal units				14,282			14,434	13,129
Loss of moisture on air drying	5.90	2.50	3.40					2.10
Analysis of air-dried sample:								
Prox. Moisture	1.02	.89	.75					1.17
Prox. Volatile matter	27.38	25.07	18.79					17.83
Prox. Fixed carbon	46.12	68.10	72.43					68.12
Prox. Ash	25.51	5.94	8.03					12.88
Ult. Sulphur	2.46	.89	1.01					1.27
Ult. Hydrogen								4.00
Ult. Carbon								75.68
Ult. Nitrogen								1.47
Ult. Oxygen								4.70
Calorific value determined:								
Calories								7,450
British thermal units								13,410
Fuel ratio	1.69	2.72	3.86	4.08	3.91	3.99	4.12	3.82

District	Greenwood-Huntington—Continued.						
Nearest town	Burma.					Midland.	
Name of sample	U. S. G. S. No. 2.	U. S. G. S. No. 7.	U. S. G. S. No. 3.	U. S. G. S. No. 1.	U. S. G. S. No. 6.	Special.	Special.
Laboratory number	3154.	3148.	3158.	3155.	3156.	1052.	1054.
Analysis of sample as received:							
Prox. Moisture	2.44	4.53	2.65	3.54	2.80	.79	1.00
Prox. Volatile matter	16.85	16.52	15.70	14.89	15.93	19.68	16.90
Prox. Fixed carbon	74.97	74.03	74.52	74.88	74.06	69.62	71.80
Prox. Ash	5.73	4.92	7.13	6.69	7.21	9.73	10.30
Ult. Sulphur	2.57	1.76	2.86	1.21	.73	1.11	.60
Ult. Hydrogen							
Ult. Carbon							
Ult. Nitrogen							
Ult. Oxygen							
Calorific value determined:							
Calories						7,790	
British thermal units						14,022	
Loss of moisture on air drying	1.60	3.70	1.90	2.70	2.00		
Analysis of air-dried sample:							
Prox. Moisture	.85	.86	.76	.86	.82		
Prox. Volatile matter	17.12	17.16	16.01	15.30	16.28		
Prox. Fixed carbon	76.11	76.87	75.95	76.93	75.57		
Prox. Ash	5.82	5.10	7.26	6.88	7.36		
Ult. Sulphur	2.61	1.82	2.92	1.24	.74		
Ult. Hydrogen							
Ult. Carbon							
Ult. Nitrogen							
Ult. Oxygen							
Fuel ratio	4.45	4.48	4.75	5.05	4.67	3.53	4.24

[a] Car sample.

Analyses of coal samples from Arkansas—Continued.

District	Greenwood-Huntington—Continued.					
Nearest town	Montreal.		Hackett.		Greenwood.	
Name of sample	U. S. G. S. No. 5.	U. S. G. S. No. 4.	U. S. G. S. No. 26.	U. S. G. S. No. 8.	U. S. G. S. No. 11.	U. S. G. S. No. 12.
Laboratory number	3152.	3150.	3497.	3157.	3173.	3175.
Analysis of sample as received:						
Prox. Moisture	2.57	3.01	3.55	3.64	2.31	2.26
Prox. Volatile matter	15.48	15.75	17.16	16.57	14.48	15.79
Prox. Fixed carbon	76.17	75.93	75.46	76.00	72.66	71.91
Prox. Ash	5.78	5.31	3.83	3.79	9.29	10.04
Ult. Sulphur	2.05	.93	.96	.83	3.12	1.20
Ult. Hydrogen	.....	.....	.....	.....	3.75	.....
Ult. Carbon	.....	.....	.....	.....	78.37	.....
Ult. Nitrogen	.....	.....	.....	.....	1.52	.....
Ult. Oxygen	.....	.....	.....	.....	3.95	.....
Calorific value determined:						
Calories	.....	.....	.....	.....	7,549	.....
British thermal units	.....	.....	.....	.....	13,588	.....
Loss of moisture on air drying	1.80	2.20	2.80	3.00	2.40	1.60
Analysis of air-dried sample:						
Prox. Moisture	.78	.83	.77	.66	.77	.67
Prox. Volatile matter	15.76	16.21	17.65	17.03	15.21	16.05
Prox. Fixed carbon	77.33	78.36	77.63	78.35	74.45	73.07
Prox. Ash	5.88	5.43	3.94	3.96	9.52	10.20
Ult. Sulphur	2.09	.95	.99	.85	3.20	1.22
Ult. Hydrogen	.....	.....	.....	.....	3.84	.....
Ult. Carbon	.....	.....	.....	.....	80.30	.....
Ult. Nitrogen	.....	.....	.....	.....	1.56	.....
Ult. Oxygen	.....	.....	.....	.....	4.05	.....
Calorific value determined:						
Calories	.....	.....	.....	.....	7,735	.....
British thermal units	.....	.....	.....	.....	13,923	.....
Fuel ratio	4.92	4.78	4.40	4.54	4.90	4.55

District	Bonanza-Jenny Lind.							
Nearest town	Bonanza.			Jenny Lind.				
Name of sample	Ark. No. 2 A.	Ark. No. 2 B.	Ark. No. 2 C.[a]	Ark. No. 3 A.	Ark. No. 3 B.	Ark. No. 3 C.[a]	U. S. G. S. No. 10.	Ark. No. 6.[b]
Laboratory number	1053.	1049.	1160.	1115.	1118.	1296.	3151.	1542.
Analysis of sample as received:								
Prox. Moisture	.78	.95	2.23	1.60	1.63	2.19	1.95	3.80
Prox. Volatile matter	16.60	18.70	16.03	17.40	16.86	19.47	15.55	13.89
Prox. Fixed carbon	73.53	73.38	72.55	73.09	69.03	66.71	73.27	68.50
Prox. Ash	9.09	6.97	9.20	7.91	12.66	11.63	9.23	13.81
Ult. Sulphur	2.50	2.12	1.78	1.42	1.46	1.28	1.23	1.26
Ult. Hydrogen	.....	.....	4.24	.....	.....	4.17	.....	.....
Ult. Carbon	.....	.....	78.83	.....	.....	75.31	.....	.....
Ult. Nitrogen	.....	.....	1.38	.....	.....	1.53	.....	.....
Ult. Oxygen	.....	.....	4.48	.....	.....	6.08	.....	.....
Calorific value determined:								
Calories	.....	7,993	7,639	7,868	.....	7,480	.....	.....
British thermal units	.....	14,387	13,750	14,162	.....	13,464	.....	.....
Loss of moisture on air drying	.....	.....	1.50	.80	.80	1.40	1.20	3.00
Analysis of air-dried sample:								
Prox. Moisture	.....	.....	.74	.81	.84	.80	.76	.82
Prox. Volatile matter	.....	.....	16.26	11.54	16.81	14.75	15.74	14.32
Prox. Fixed carbon	.....	.....	73.66	73.68	69.59	67.65	74.16	70.62
Prox. Ash	.....	.....	9.39	7.97	12.76	11.80	9.34	14.24
Ult. Sulphur	.....	.....	1.90	1.51	1.47	1.30	1.25	1.30
Ult. Hydrogen	.....	.....	4.13	.....	.....	4.07	.....	.....
Ult. Carbon	.....	.....	80.03	.....	.....	76.37	.....	.....
Ult. Nitrogen	.....	.....	1.40	.....	.....	1.55	.....	.....
Ult. Oxygen	.....	.....	3.20	.....	.....	4.91	.....	.....
Calorific value determined:								
Calories	.....	.....	7,756	7,931	.....	7,586	.....	.....
British thermal units	.....	.....	13,961	14,275	.....	13,655	.....	.....
Fuel ratio	4.43	3.92	4.52	4.20	4.10	3.43	4.71	4.93

[a] Car sample. [b] Slack car sample.

Analyses of coal samples from Arkansas—Continued.

District	Bonanza-Jenny Lind—Continued.				Charleston.	Paris.
Nearest town	Jenny Lind.			Fort Smith.	Auburn.	Paris.
Name of sample	Special.	Special.	U. S. G. S. No. 9.	U. S. G. S. No. 21.	U. S. G. S. No. 13.	U. S. G. S. No. 14.
Laboratory number	1030.	1031.	3153.	3372.	3218.	3174.
Analysis of sample as received:						
Prox. Moisture	.95	.80	3.18	2.19	3.80	2.77
Prox. Volatile matter	17.91	17.20	14.64	14.00	15.96	14.69
Prox. Fixed carbon	71.52	74.35	76.06	72.15	75.86	73.47
Prox. Ash	9.62	7.65	6.12	11.66	4.38	9.07
Ult. Sulphur	2.07	1.64	1.51	2.06	2.21	2.79
Ult. Hydrogen						4.02
Ult. Carbon						78.71
Ult. Nitrogen						1.46
Ult. Oxygen						3.95
Calorific value determined:						
Calories	7,831					7,652
British thermal units	14,096					13,774
Loss of moisture on air drying			2.40	1.40	2.60	2.20
Analysis of air-dried sample:						
Prox. Moisture			.79	.80	1.23	.58
Prox. Volatile matter			15.00	14.20	16.39	15.02
Prox. Fixed carbon			77.93	73.18	77.88	75.12
Prox. Ash			6.27	11.83	4.49	9.27
Ult. Sulphur			1.58	3.09	2.27	3.04
Ult. Hydrogen						3.87
Ult. Carbon						80.48
Ult. Nitrogen						1.49
Ult. Oxygen						2.04
Calorific value determined:						
Calories						7,824
British thermal units						14,084
Fuel ratio	3.98	4.32	5.20	5.15	4.75	5.00

District	Denning-Coal Hill.						
Nearest town	Denning.		Altus.	Coal Hill.			
Name of sample	Special.	Special.	U. S. G. S. No. 20.	U. S. G. S. No. 19.	Ark. No. 5 A.	Ark. No. 5 B.	Ark. No. 5 C.[a]
Laboratory number	1040.	1042.	3371.	3370.	1130.	1131.	1331.
Analysis of sample as received:							
Prox. Moisture	.85	.84	3.77	3.41	1.38	1.80	2.36
Prox. Volatile matter	14.45	16.46	13.96	12.09	14.76	15.00	12.68
Prox. Fixed carbon	76.41	75.32	79.35	78.42	76.91	75.94	72.88
Prox. Ash	8.29	7.38	2.92	6.08	6.95	7.26	12.08
Ult. Sulphur	2.05	1.91	.74	4.05	1.52	1.94	1.99
Ult. Hydrogen							3.82
Ult. Carbon							76.44
Ult. Nitrogen							1.37
Ult. Oxygen							4.30
Calorific value determined:							
Calories		8,136			7,961		7,366
British thermal units		14,645			14,330		13,259
Loss of moisture on air drying			2.80	2.40	.70	1.30	1.10
Analysis of air-dried sample:							
Prox. Moisture			1.00	1.03	.68	.51	1.28
Prox. Volatile matter			14.36	12.39	14.87	15.19	12.82
Prox. Fixed carbon			81.64	80.35	77.45	76.94	73.69
Prox. Ash			3.00	6.23	7.00	7.36	12.21
Ult. Sulphur			.76	4.15	1.53	1.97	2.01
Ult. Hydrogen							3.74
Ult. Carbon							77.29
Ult. Nitrogen							1.39
Ult. Oxygen							3.36
Calorific value determined:							
Calories					8,017		7,448
British thermal units					14,431		13,406
Fuel ratio	5.29	4.58	5.68	6.48	5.21	5.06	5.74

[a] Car sample.

Analyses of coal samples from Arkansas—Continued.

District	Spadra.			Russellville.	
Nearest town	Spadra.		Clarksville.	Russellville.	
Name of sample	U. S. G. S. No. 17.	U. S. G. S. No. 22.	U. S. G. S. No. 18.	U. S. G. S. No. 15.	U. S. G. S. No. 16.
Laboratory number	3368.	3407.	3369.	3177.	3176.
Analysis of sample as received:					
Prox. Moisture	2.11	2.15	1.72	2.33	2.07
Prox. Volatile matter	11.42	10.82	10.46	10.60	9.81
Prox. Fixed carbon	77.83	76.87	79.50	77.67	78.82
Prox. Ash	8.64	10.16	8.32	9.40	9.30
Ult. Sulphur	1.99	2.30	2.49	1.81	1.74
Ult. Hydrogen	.....	.....	.....	.....	3.62
Ult. Carbon	.....	.....	.....	.....	80.28
Ult. Nitrogen	.....	.....	.....	.....	1.47
Ult. Oxygen	.....	.....	.....	.....	3.59
Calorific value determined:					
Calories	7,619	.....	7,704	.....	7,612
British thermal units	13,714	.....	13,867	.....	13,703
Loss of moisture on air drying	1.00	1.40	.70	1.60	1.40
Analysis of air-dried sample:					
Prox. Moisture	1.12	.76	1.03	.74	.68
Prox. Volatile matter	11.54	10.97	10.53	10.77	9.93
Prox. Fixed carbon	78.62	77.96	80.06	78.93	79.94
Prox. Ash	8.73	10.30	8.38	9.55	9.43
Ult. Sulphur	2.01	2.33	2.51	1.84	1.76
Ult. Hydrogen	.....	.....	.....	.....	3.67
Ult. Carbon	.....	.....	.....	.....	81.42
Ult. Nitrogen	.....	.....	.....	.....	1.49
Ult. Oxygen	.....	.....	.....	.....	3.64
Calorific value determined:					
Calories	7,693	.....	7,758	.....	7,720
British thermal uuits	13,853	.....	13,965	.....	13,896
Fuel ratio	6.82	7.11	7.59	7.33	8.04

COKING TESTS.

Although some of the Arkansas coals, especially those from the western part of the field, seem to coke in laboratory experiments, none of them have yet been successfully coked on a commercial scale. Laboratory tests made at St. Louis indicated that the samples called Arkansas Nos. 1 and 2, representing the mines at Huntington and Bonanza, respectively, are coking coals.[a] Parts of each of the five representative carload samples sent to the fuel-testing plant were tried in a beehive coking oven and all gave negative results.[b]

In order to determine whether or not the Arkansas coals could be made to produce coke by mixing them with small amounts of more highly bituminous coal from other sources, or by adding pitch to act as a binder, a test was made of lump and slack coal from mine No. 18 at Jenny Lind. A charge consisting of a small amount of briquets, containing 6 per cent of hard pitch, was placed in an oven with a coking coal and produced a dense coke high in ash.

Equal parts of unwashed slack mixed with 8 per cent of hard pitch and briquets made of the same material gave a very dark coke with large cells. This charge contained 640 pounds of pitch and weighed

[a] Prof. Paper U. S. Geol. Survey No. 48, pt. 1, 1904, p. 300. [b] Idem, pt. 3, pp. 1328-1332.

8,000 pounds. It burned 42 hours and yielded 4,056 pounds of coke and 539 pounds of breeze and ash.

Slack mixed with 8 per cent of pitch, without briquetting, gave a dark-gray coke that was high in ash and had no metallic ring, which can be used where high ash and sulphur are not important considerations. These tests are valuable, since they show that although most of the Arkansas coals are naturally noncoking they may be made so by the addition of pitch.

BRIQUETTING TESTS.

The friable nature of the coal and the high percentage of slack resulting from it are notable drawbacks connected with the coal-mining industry in Arkansas. The slack has a high fuel value and is not notably impure as regards ash, but is difficult to burn economically, since it requires special grates and is not worth more than one-third as much as the lump coal. For this reason any method of utilizing the slack and increasing its value is of considerable importance, and the possibility of making it into briquets has therefore been considered. The fuel-testing plant at St. Louis was equipped with two briquetting machines, one of English make, producing a rectangular briquet 6 by 5 by 4 inches, the other of American design, producing eggettes weighing 0.3 pound. Slacks from nearly every part of the Arkansas field were tested, but all attempts to produce briquets from the coal alone were unsuccessful. It was found, however, that by adding to the slack from 6 to 10 per cent of pitch, obtained from the by-products of various gas plants, good briquets, that have a somewhat higher heat- and steam-producing value than the original coal, can be made. A full description of the various briquetting tests made at St. Louis is contained in the report of the fuel-testing plant, pp. 1389 to 1472, from which the following more salient results have been abstracted.[a]

Slack from the mines at Huntington was tested with a hard pitch, 6 tons being mixed with 9.25 per cent of pitch and made into briquets in the English machine. The briquets were compact and well pressed, but were too friable for handling, showing that they contained insufficient pitch. They were also brownish in color and very dirty. Coal from Jenny Lind was also tested with hard pitch, briquets being made in the English machine. Six tons of crushed lump coal were run through the machine, which was set to give approximately 11 per cent of pitch, but the briquets were pitchy and wrinkled, and probably contained nearer 15 than 11 per cent. Although these were not commercial briquets, a boiler test made

[a] Report of the operations of the coal-testing plant, 1904; Prof. Paper U. S. Geol. Survey No. 48, pt. 3, 1906, pp. 1389–1472.

with them showed that they were well adapted to produce steam. The pitch used for both these lots of briquets was too hard to give the best results.

Seventeen tons of coal from the Denning field were briquetted in the English machine with 6 per cent of comparatively soft pitch, for the purpose of making locomotive tests on the Missouri Pacific Railway. Excellent briquets were obtained, which were readily handled while warm, stood a good deal of handling when cold, and did not break so readily as the original lumps of coal. They were tested for locomotive use in comparison with Illinois coal. Three trips were made from St. Louis to Washington, Mo., and return, making a total of 324 miles for each fuel. The comparative results of the test are best stated in terms of the number of miles run per ton of coal, which for the Arkansas briquets averaged 21 miles per ton, while with the coal from Illinois only 19 miles per ton was made by the same train. The results showed that the Arkansas briquets have greater efficiency than the Illinois coal and indicate that by briquetting the slack it is possible to obtain a high-grade fuel. The briquets were said to be too large for locomotive use and had to be broken before the engine could steam well.

BOILER TESTS.

Seventy boiler tests of car samples representing coals from many different localities and fields in the United States were made under uniform conditions at the fuel-testing plant in St. Louis, and the tabulated results obtained have been published in part 2 of the report of the coal-testing plant for the year 1904.[a] Eight of these tests were of coals from the Arkansas field, including both natural coal and briquets made by combining slack or crushed coal with a certain amount of pitch. Four of the tests were of natural coal.

The boiler plant was equipped with two 210-horsepower Heine water-tube boilers. The same boilers were used for all the tests, and an effort was made to have the coals nearly uniform in size, the usual size being small lump and egg mixed with varying amounts of slack. Full details regarding these tests are available for further examination in the professional paper cited, from which a few of the more obvious and important results have been abstracted in the accompanying table to show the relative efficiencies of various Arkansas coals. From these figures it will be seen that while the coal (Arkansas No. 5) from the Denning district is higher in the scale of classification than the other coals tested, its efficiency in heat and steam production is some-

[a] Prof. Paper U. S. Geol. Survey No. 48, 1906.

what lower. The results selected from the report cited for purposes of comparison are—

1. The number of pounds of water at the boiling point which can be converted into steam at the same temperature by the combustion of 1 pound of dry coal.

2. The amount of heat absorbed by the boiler, stated in British thermal units. This is equal to the number of pounds of water evaporated at 212° multiplied by 965.7 the number of British thermal units required to convert 1 pound of water into steam. This result is given for comparison with the next to indicate the proportion of the total heat value of the coal available for the production of steam. It is a factor which depends to a considerable extent on the appliances for burning the coal, and with engines better adapted to any particular coal would probably be larger than the figures given.

3. The calorific value of the dry coal stated in British thermal units as determined by the oxygen calorimeter. This factor gives the total heat value of the coal.

4. The number of pounds of coal per hour required to produce one indicated horsepower. This figure is calculated theoretically from the determinations given in the first column, together with other factors, it being estimated that 34½ pounds of water evaporated per hour into dry steam from and at 212° F. equal 1 horsepower.

5. The last column gives the number of pounds of dry coal consumed per hour per electric horsepower, which may be regarded as the actual measured horsepower produced. It will be seen that as far as these tests go the coals from Bonanza and Jenny Lind, Arkansas Nos. 2 and 3, are more efficient than those from Denning and Huntington, Arkansas Nos. 5 and 1, respectively. In order to compare the efficiency of the Arkansas coals in general with the coals from other parts of the United States with which they come in competition, a second table is given in which the average results from 4 Arkansas coals are combined with similar results from 12 coals from West Virginia, 6 from Illinois, 4 from Indian Territory, 8 from Kansas, and 8 from Missouri. It will be readily seen from this table that average Arkansas coals are nearly, though probably not quite, as efficient as those from West Virginia, and that they are better than coals from Indian Territory and Kansas, and very much better than those from Illinois and Missouri.

Although these results and the comparisons based on them would undoubtedly be modified if they were obtained from boilers and grates especially adapted to the coal burned, it is believed that they show fairly well the relative efficiency of the Arkansas coal as compared with other coals with which it comes into competition.

Determinations of efficiency of four Arkansas coals by boiler tests, and averages of coals from various other States for comparison.

Designation.	Water at 212° F. evaporated per pound of coal.	British thermal units absorbed by boiler.	Calorific value in B.t.u. determined by oxygen calorimeter.	Pounds of coal per hour per indicated horsepower.	Pounds of coal used per electric horsepower hour
	Pounds.				
Arkansas No. 1, Huntington	8.86	8,556	13,572	3.12	3.86
Arkansas No. 2, Bonanza	9.72	9,387	14,244	2.91	3.59
Arkansas No. 3, Jenny Lind	9.50	9,174	14,151	2.98	3.68
Arkansas No. 5, Coal Hill	8.04	7,764	13,617	3.52	4.34
4 Arkansas coals	9.03	8,720	13,893	3.13	3.87
12 West Virginia coals	9.72	9,388	14,466	2.92	3.61
6 Illinois coals	7.55	7,292	12,292	3.75	4.64
4 Indian Territory coals	8.19	7,909	12,820	3.46	4.28
8 Kansas coals	8.23	7,948	12,983	3.20	4.26
8 Missouri coals	7.60	7,239	12,169	3.77	4.66
2 Alabama coals	8.17	7,894	12,746	3.33	4.11

CONDITIONS OF MINING AND DEVELOPMENT.

PRODUCTION.

The statistics of coal mining in Arkansas for the last sixty-five years show a production of 220 tons in the year 1840 and 200 tons in 1860.[a] During those years the coal was used almost exclusively for blacksmithing, and was obtained from strip pits, which were worked only occasionally. The development of the coal industry on a commercial scale was started about 1870, when a steam plant was put in operation at the mouth of Spadra Creek. Coals from the Ouita basin and the Coal Hill mines were brought to market about 1873, after the extension of the Little Rock and Fort Smith Railroad.

By the year 1880 the production had reached 14,778 tons, and from that time it steadily increased until 1903, when it attained a maximum of 2,229,172 tons. The decline in production since 1903 is attributed to the competition of fuel oil, of which there was overproduction in Texas. Present conditions, however, indicate that the demand for Arkansas coal is again increasing, and were it not for the scarcity of labor and a general strike from April to June, inclusive, the production in 1906 would probably have nearly equaled that of 1903.

The four tables following, abstracted from Mineral Resources of the United States for 1905,[b] show the progressive increase of the coal production since 1840, the amounts produced in the various counties since 1901, and the production, value, average price per ton, and number of men employed in the various counties in 1904 and 1905.

From the third table it will be seen that the greatest output is from Sebastian County, though the coals of the eastern end of the district—namely, from Shinn and Ouita basins—command the highest

[a] Ann. Rept. Geol. Survey Arkansas for 1888, vol. 3, p. 27.

[b] Mineral Resources U. S. for 1905, U. S. Geol. Survey, 1906, pp. 550-552.

price, while those from the Paris basin are second in price and those from the Spadra and Coal Hill fields third. A fourth table showing the average price per ton of the coals of neighboring States which come in competition with the Arkansas coals is given for comparison.[a]

Average production of coal in Arkansas, 1840–1905.

[Short tons.]

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840	220	1888	276,871	1898	1,205,479
1860	200	1889	279,584	1899	843,554
1880	14,778	1890	399,888	1900	1,447,945
1881	20,000	1891	542,379	1901	1,816,136
1882	25,000	1892	535,558	1902	1,943,932
1883	50,000	1893	574,763	1903	2,229,172
1884	75,000	1894	512,626	1904	2,009,451
1885	100,000	1895	598,322	1905	1,934,673
1886	125,000	1896	675,374		
1887	129,600	1897	856,190		

Coal production of Arkansas, 1901–1905, by counties.

[Short tons.]

County.	1901.	1902.	1903.	1904.	1905.	Increase (+) or decrease (−), 1905.
Franklin	504,946	338,013	394,884	408,494	420,384	+ 11,890
Johnson		193,258	198,999	217,667	214,234	− 3,433
Logan		21,751	27,286	35,300	26,090	− 9,210
Pope		34,966	48,836	51,488	39,685	− 11,803
Sebastian	1,305,190	1,325,181	1,528,888	1,234,794	1,189,455	− 45,339
Other counties and small mines	6,600	30,763	[a]30,279	61,708	44,825	− 16,883
Total	1,816,136	1,943,932	2,229,172	2,009,451	1,934,673	− 74,778
Total value	$2,068,613	$2,539,214	$3,360,831	$3,102,660	$2,880,738	−$221,922

[a] Includes also production of Perry County.

Coal production of Arkansas, in 1904 and 1905, by counties, uses, etc.

1904.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*				
Franklin	400,994	2,000	5,500	408,494	$582,703	$1.43	168	695
Johnson	210,062	2,050	5,555	217,667	392,445	1.80	175	652
Logan	30,700	3,770	830	35,300	77,461	2.19	194	115
Pope	44,053	460	6,975	51,488	168,245	3.27	189	229
Sebastian	1,174,630	24,544	35,620	1,234,794	1,780,203	1.44	158	2,820
Scott and Washington	59,720	1,068	920	61,708	101,603	1.65	194	69
Total	1,920,159	33,892	55,400	2,009,451	3,102,660	1.54	165	4,580

1905.

Franklin	413,384	1,000	6,000	420,384	$585,419	$1.39	202	750
Johnson	204,091	1,771	8,372	214,234	364,390	1.70	164	730
Logan	24,390	800	900	26,090	58,388	2.24	191	104
Pope	33,952	813	4,920	39,685	140,030	3.53	217	140
Sebastian	1,150,856	7,667	30,932	1,189,455	1,668,597	1.40	168	2,389
Scott and Washington	42,500	1,245	1,080	44,825	63,914	1.43	216	79
Total	1,869,173	13,296	52,204	1,934,673	2,880,738	1.49	177	4,192

[a] Op. cit., p. 504.

Average prices for coal at the mines in Arkansas and neighboring regions, 1901–1905.

[Per short ton.]

State or Territory.	1901.	1902.	1903.	1904.	1905.
Alabama	$1.10	$1.20	$1.22	$1.20	$1.21
Arkansas	1.14	1.31	1.51	1.54	1.49
Illinois	1.03	1.03	1.17	1.10	1.06
Indiana	1.01	1.10	1.23	1.11	1.05
Indian Territory	1.62	1.51	1.82	1.82	1.76
Iowa	1.39	1.47	1.65	1.61	1.56
Kansas	1.22	1.30	1.52	1.52	1.46
Kentucky	.95	.99	1.06	1.04	.99
Missouri	1.24	1.38	1.61	1.63	1.58

METHODS OF MINING.

The methods of mining practiced in Arkansas are well adapted to the local conditions. The following general statements regarding these methods are given for the information of readers who are not familiar with those conditions.

System of working coal.—Coal was first mined in Arkansas by stripping, and in some pits this method of mining is still followed, but most of the coal now mined is from deeper workings, which are reached either by slopes or shafts, the deepest mine in the State being a 480-foot shaft in Shinn basin in the eastern part of the field. In regard to mining by stripping little need be said, since the workings operated in this way are of rather small extent, and much of the coal accessible by this method has already been mined. As a rule, the overlying soil and shale are removed either by hand or by horsepower to a maximum depth of about 10 feet. The quality of the coal obtained is not greatly affected by weathering, and some coal beds that are only 18 inches thick can be profitably worked.

Most of the deeper mines are still comparatively shallow, the average depth being less than 200 feet. In such mines, whether opened by shaft or slope, the room-and-pillar system of mining prevails, with local modifications, throughout the whole field. The pillars are not drawn after the rooms are exhausted. The entries are usually double in the larger mines, but in many small mines single entries are used. Some of the beds, especially those in which the coal is thin but of high grade, could probably be worked more economically by the "long wall" system, though it is not known that this has been employed anywhere up to the present time.

Mining.—The actual mining of the coal is generally done by shooting or blasting it off the solid face of the bed. Owing to the friable nature of the coal, this practice results in the formation of a large percentage of slack, but it seems to be the most effective method possible in many of the mines, where the floor is hard and not well adapted to undercutting. In some of the smaller mines, where the coal is of high grade and commands a good price, undercutting by hand is the method used, and in a few mines where the bed is divided by a parting

of soft shale or clay this is mined out by hand and the upper bench wedged down, after which the lower one is either wedged up or shot off the solid. Where the coal is hand-mined the percentage of slack is generally lower regardless of other characters of the coal.

No mining machines of any kind are used in Arkansas, and such machines are not likely to be used in the immediate future, since the beds generally are comparatively thin, and the percentage of slack from the cuttings of machines would probably be nearly as great as that made by shooting from the solid.

Haulage, ventilation, and drainage.—In most of the larger mines haulage from the rooms to the main heading is by mules and in the main gangway by rope or cable, or, as in one of the mines at Bonanza, by electric motors. In many of the mines mules are used throughout and in a few instances the cars are moved wholly by hand. Ventilation is accomplished in the larger mines by fans and in the smaller ones by fire boxes. The mines are comparatively free from gas, and accidents from this cause are relatively rare. During the year ending June 30, 1906, 8 men were killed and 34 injured, among over 4,000 employed in the mines, and most of these accidents were due to other causes than gas. Open lamps are used throughout practically all the workings. Since most of the entries are below drainage levels, pumping is almost invariably necessary. In most of the mines steam pumps are used, but some of the small mines are bailed with buckets.

Minimum limit of thickness.—The minimum thickness of coal mined for shipment is found in the Ouita basin, where the bed averages less than 2½ feet. That mined at Paris is between 2 and 2½ feet, and the coal mined for local supply in the Philpott basin is between 18 and 20 inches thick. Special agreements are made with the miners in working these thin coals. In general a uniform rate per ton applies throughout the Arkansas field for mining all coals in beds more than 2 feet 10 inches thick. Mining in thinner beds is considered "deficient work," for which special rates are made. Under favorable conditions it is probable that beds only 18 inches thick will ultimately be worked at a profit.

PREPARATION OF THE COAL FOR MARKET.

The coal is sold either in the form it comes from the mines, as "mine-run," which includes both lump and slack, or, more commonly, is prepared for sale by passing it over screens which separate the slack from the lump. In general, bar screens not more than 6 feet wide and 16 feet long, with 1⅛ inch spaces between the bars, are used. At some of the mines lump coal to be used for domestic purposes is graded into various sizes, such as pea, nut, and egg. In the Paris basin all of the lump coal is separated from the slack by hand with a fork, and the slack left in the gob. The same method prevails in the Ouita basin and at many of the small mines which supply local mar-

BREAKER AT SCRANTON ANTHRACITE COAL COMPANY'S MINE, SPADRA DISTRICT.

Showing a new and modern equipment for hoisting, screening, and sorting the Arkansas anthracite coal.

kets within the coal field. The slack from all of the larger mines is marketed, the prices being usually less than one-third the price of lump coal. Slack from the bituminous coals of the west end of the field is sold in Kansas City and St. Louis, where it is used for producing steam in stationary engines. The semianthracite slack from the Spadra field is used in lead and zinc smelters at Joplin, Mo. One of the most complete plants for screening and sorting coal in Arkansas is shown in Pl. V.

Within the last two years the Central Coal and Coke Company has established a plant near Hackett for washing slack produced at their mines. Many of the impurities are thus removed from the slack, together with the finer coal dust, and the remainder, about 80 per cent of the original quantity, is raised in value almost to that of the lump coal. Washing plants have not yet been established in other parts of the field, though it is probable that similar results can be obtained elsewhere.

LABOR.

Except in a few very small mines all of the labor of extracting the coal is performed under contract by piecework at a definite rate per ton. The operator, therefore, has little to do in directing the miners except to decide what parts of the land shall be first developed. The rates for mining coal are established by definite agreements between the operators and the labor union. There are practically no miners in the field except union men. The conditions of mining as affected by the labor element, therefore, are best set forth by the contract between the operators and the labor union, which is given below.

During 1904 and 1905 the coal-mining industry in Arkansas was not interrupted by the labor strikes which prevailed in other States, but in 1906 all of the principal mines were shut down from the 1st of April to the 1st of July. Only a few small mines and strip pits worked by nonunion miners or by union men under special agreements continued in operation, and their output was unimportant. For two months preceding the strike all of the mines were unusually active, the coal obtained being hoarded in anticipation of the trouble. The amount of coal produced during these months was limited only by the capacity of the mines and the number of the men available.

PORTION OF MINERS' CONTRACT FOR DISTRICT 21, U. M. W. A.[a]

PRICES FOR MINING IN ARKANSAS.

All coal in Arkansas, at the option of the operator, to be mined and paid for on a sliding scale in proportion to the percentage, or weight, of lump coal contained in the whole, based on the present prices and size of screens where such are established.

That the question of establishing a scale of prices for mining mine-run coal in all the anthracite mines of Arkansas be referred to Commissioner Brown, on the part of the

[a] Joint Interstate Agreement and Contracts for Districts 14, 21, and 25 of Operators and Miners, adopted at Kansas City, Mo., June 16, 1906, for period ending March 31, 1908, pp. 39–51.

operators, and District President Hanraty, of District 21, on the part of the miners, for adjustment.

The price for mine-run coal per ton shall be 62 cents.

For screened coal, per ton, 90 cents.

The operators are to have the option of paying on a screened-coal or mine-run basis. When the coal is mined on a screened-coal basis, the screens used shall be not more than 6 feet wide, have bars not more than 16 feet long, and a 1¼-inch space between the bars.

OUITA.

For hand-picked coal, free from slack, slate, sulphur, bony, and black jack, the price shall be as follows:

From the 1st of September to the 1st of March	$1.22
From the first of March to the 31st of August	1.07

SPADRA.

For screened coal per ton, from the 1st of September to the 1st of March	$1.02
From the 1st of March to the 31st of August	.92

For all coal under 3 feet in height, for each 3 inches less of coal, there shall be 5 cents per ton additional to above prices.

The price for narrow work shall be as follows:

20 feet gob entries or air courses	per yard	$1.12
18 feet gob entries or air courses	do	1.25
16 feet gob entries or air courses	do	1.50
12 feet gob entries or air courses	do	1.75
8 feet entries or air courses	do	2.00
All brushing, 16 inches	do	1.12

And all over 16 inches, 7 cents for each inch extra.

The company shall have the right to do all brushing by shift work at $2.56 per day when desired.

All cross-cuts in rooms shall be	per yard	$1.12
All room turning shall be	do	1.12

RUSSELLVILLE.

Ten cents per ton less than the price paid at Ouita.

ENTRY YARDAGE, ETC.

Entry, yardage, and deficient work will be 1903 rate. The same rules and customs defining deficient work in district 21 shall be in force during the life of this agreement.

For mining hand-picked or forked coal free from slate, slack, and other impurities, $1.05 per ton shall be paid.

Where draw slate or rock comes with coal the following prices shall be adopted:

For all over 1 inch and under 5 inches, 5 cents per ton extra; over 5 inches and less than 10 inches, 9 cents per ton extra; over 10 inches and less than 15 inches, 14 cents per ton extra; over 15 inches and less than 20 inches, 19 cents per ton extra.

LOCAL CONDITIONS.

The brushing price at Bonanza, Jenny Lind, Coal Hill, and Denning shall be $1.40 for 18 inches of brushing. Where the company requires more than 18 inches to be brushed, they agree to pay 8 cents per inch for each additional inch over the 18 inches.

Draw slate in air courses will be paid as follows:

For 3 inches or over	$0.25
For 6 inches or over	.50
For 9 inches or over	.75
For 12 inches or over	1.00

All coal in Arkansas 2 feet 10 inches and less in height shall be considered deficient work, except where special price has been made.

Scale of prices to be paid for draw slate and rock at Bache & Denman's mines at Burma and Montreal No. 2:

Over 4 inches and up to 8 inches, 56 cents per yard; over 8 inches and up to 12 inches, 84 cents per yard; over 12 inches, to be settled locally. Brushing entries to be $1.41 per yard.

Where bottom is taken up in rooms and room necks it shall be paid 56 cents per yard. This applies to Bache & Denman's mines at Burma only.

All break-throughs in Arkansas, when required to cut through, to be paid at the 1903 rate.

Brushing bottom in entries, at Dallas mine, Burma, Ark.; width of brushing to be 4 feet, height 4 feet 6 inches on top of rail. All over and above this height and width to be paid at the rate of 7 cents per inch.

Air courses and rooms, 4 cents per inch for bottom brushing, width or roadway 3 feet.

Where miners at Coal Hill, No. 18 Jenny Lind, and Denning, Ark., have been pushing cars both ways the company shall assist the miner one way when necessary; and all miners in the Indian Territory who have been pushing their cars both ways shall receive for all coal pushed over 200 feet 5 cents per ton extra. The conditions that prevail at Lehigh apply to all mines on the Atoka track in regard to lowering cars down to the switch.

That the loading rate of the McCurtain machine scale be extended over those mines in Arkansas which now carry 62 cents per ton mine-run tonnage rate. Where punching machines are installed, in Arkansas, the McCurtain cutting rate to be adopted. Where chain machines are installed, in Arkansas, the rate for runners and helpers shall be established by the commissioner and district president, and in case of their failure to agree, the matter will be taken up in the manner provided for other controversies.

Inside day wage scale.

Track layers	per day	$2.56
Track layers' helpers	do	2.36
Trappers	do	1.13
Bottom cagers	do	2.56
Drivers	do	2.56
Trip riders	do	2.56
Pushers	do	2.56
Water haulers and machine haulers	do	2.56
All other inside day labor	do	2.36
Spragging, coupling, and greasing, when done by boys	do	1.75
Shot firers under normal conditions	do	3.00

The fire boss shall receive $3.04 per day and shall be subject to discharge by the management of the mine without appeal; if competent, shall be given other work.

The fire runner shall receive not less than $2.56 where such is employed.

Electric hoist operators:

For boys[a]	per day	$2.00
Electric slope engineers	do	2.56
Motormen	do	2.56
Pump men (inside)	do	2.56
Head machinist	do	3.10
Machinists	do	2.75
Day wages for digging coal	do	2.81
Machine runners	do	3.00
Machine helpers	do	2.75
Shaft sinkers	do	3.04

[a] "Boys" means those of maximum age of 19 years.

Outside day wage scale.

First blacksmiths	per day..	$3.00
Second blacksmiths	do....	2.75
Blacksmiths' helpers	do....	2.36
Carpenters[a]	do....	2.43
All other outside day labor[b]	do....	2.02½

Scale for engineers.

Engineers:		
First class, 500 tons and over	per month..	$79.00
Second class, 300 to 500 tons	do....	73.00
Third class, 300 tons or less	do....	65.00

Tail rope and slope engineers, 5.9 per cent above present wages.

The minimum rate for tail rope and slope engineers shall be $2.38 per day, or $62 per month; provided, further, that the maximum rate for tail rope and slope engineers shall be $2.70 per day or $70 per month, twenty-six days to constitute a month's work and nine hours to constitute a day's work. All overtime in excess of nine hours to be paid for at a proportionate rate per hour.

The mining prices inside and outside day-wages scale (except engineers) provided for in this contract is based upon an eight-hour work day.

GENERAL CONDITIONS.

There shall be two pay days a month and the operators shall issue to each employee a statement of his account, which the employee may retain. The dates of pay days shall be arranged between the respective companies and their employees.

Where air courses are driven in chute or platform work—that is, where the coal is in a greater pitch than 20°—the work shall be considered as air-course work and shall be paid for at the regular district price, provided such air course or brake-through is cut or sheared before being shot.

The company shall put in all batteries, wing boards, and platforms in all chute work in district No. 21.

The miners shall load their own coal in pitching veins in this district at the regular scale price.

No person employed underground shall use an inferior grade of lard oil, and the use of any other except lard oil is prohibited. Rope riders in mine slopes are excepted.

The taking up of bottom for stub switches for chute rooms will be done by the miner and payment for same is referred to local union and mine officials for adjustment. In the event of their failure to agree, general resolutions to govern.

Where coal is screened before being weighed it shall be dumped on flat sheets and passed over the screen specified in the Pittsburg agreement, and there shall be no obstruction on said screen.

When an employee leaves the employment of a company he shall receive all money due him within three days from the date of notice. Settlement must be asked for between the hours of 8 a. m. and 6 p. m. on day settlement is due.

All company men shall receive an equal share of all work when competent to do such work.

The gas man shall place marks at last inside break-through, showing clearly whether there is any standing gas in working place. Should there be standing gas, he shall place gas mark at room neck in addition to mark at inside break-through; but should working place be clear, he shall place marks so indicating this at coal face. No miner shall be permitted to brush out gas.

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[a] *Provided,* That all carpenters now receiving more than $2.30 shall be advanced 5.9 per cent.

[b] *Provided,* That any class of outside day labor now receiving $1.91 or more per day shall be advanced 5.9 per cent. This provision only applies to outside labor not otherwise enumerated.

Miners shall have the right to send out their dull tools on top of loaded cars and the company shall deliver same to blacksmith shop for sharpening, and no man be allowed to carry tools up or down shaft. In slopes the company shall deliver the same to parting or bottom. The company shall not be responsible for tools.

Any underground employee not on hand to go down to work at the hour for commencing work shall not be entitled to go below except at the convenience of the company.

When an employee is sick or injured he shall be given a cage at once. When a cage load of men come to the bottom of the shaft who have been prevented from working by reason of falls or other things over which they have no control, they shall be given a cage at once. For the accommodation of individual employees less than a cage load who have been prevented from working as above cage will be run mid-forenoon, noon, and mid-afternoon to each working day: *Provided, however*, That the foregoing shall not be permitted to enable men to leave their work for other than the reasons stated above.

The sinking of slopes and driving narrow work through faults shall be left to local union and mine management for adjustment.

All double-shift places to be paid 28 cents per yard extra.

All wet entries, rooms, slopes, slope air courses, and all other work connected with the slopes shall be left to local union and superintendent or manager for agreement of price.

Frozen or seamy coal, stuck top or bottom, shall be deficient work, and shall be paid for extra, the same to be determined by mine committee and pit boss. If they fail to agree the miner shall be given an average place in the mine.

There shall be no deduction for school purposes except authorized by the individuals.

For the health and safety of the miners' lives, air courses shall be kept up with the entries as near as possible, and crosscuts shall be driven every 40 feet; where gas exists, they shall be driven every 30 feet. No room shall be turned inside the last crosscut.

Scale price for blacksmithing miners' tools and machine mine tools.

Three-fourths of 1 per cent on gross earnings for blacksmithing of miners' tools, and three-eighths of 1 per cent on gross earnings for machine coal loaders' tools.

All sharpening and repairing of tools shall be done as promptly as possible.

The present conditions in regard to double and single work shall prevail.

Any employee absenting himself from work two days and not reporting for work on the morning of the third day shall forfeit his right to his working place, unless excused by mine foreman, but shall be given another place on turn; provided, however, this shall not apply in case of sickness.

Where a fall occurs in any working place the company shall make preparations to clean up same within four hours from time of notice; failing to do so the miner or miners affected shall clean up same, company paying at the rate of $2.56 per shift.

Price for moving all draw slate and rock exceeding 2 inches in thickness, 2½ cents per inch per running yard for each 5 feet in width, and all over and above to be paid accordingly. This applies to all mines except where there is a special contract.

Where rooms are driven up narrow on account of bad top, the yardage shall be same as that in air courses, measurements to be made from the entry; and when room is widened out one-half room turning shall be paid. Where bottom is taken up entry yardage shall be paid. This does not apply in rooms that have been widened out, then narrowed up and renecked, but in these cases the prices shall be the 1903 rate.

When a car leaves working place it is in charge of the company and average weight shall be paid for broken cars. Such cars shall be reported by the man that dumps the coal. The company shall keep all cars in good repair.

All coal 4 feet and over where it comes down to under a thickness of 3 feet 4 inches shall be declared deficient work. This applies to Arkansas and the Indian Territory.

Where cars are delivered at working face all timber and rails shall be delivered there.

Where powder is taken into the mine in kegs it shall be delivered to the working place; otherwise it shall be handled according to the methods in vogue at the various mines.

When any employee shall be requested to fill the place of another employee, as specified herein, he shall receive the wages of the employee whose place he takes, plus 28 cents; provided further, that it is not compulsory on any man who may not wish to take such place.

All questions that have been left to the president of the United Mine Workers of America, District 21, and commissioner of the Operators' Association, or to arbitration shall become a part of this contract and be binding upon both parties when the same have both been decided and agreed upon by the said president and commissioner, or by arbitration; and the operators shall furnish the district secretary of the United Mine Workers of America and also post at the mines the prices to be paid on and after June 16, 1906, based hereon.

Color shall be no bar to employment.

In behalf of the Southwestern Interstate Coal Operators' Association.

W. C. PERRY,
President.
S. J. TONKIN,
Secretary.

In behalf of the miners.

PETE HANRATY,
President District No. 21.
S. F. BRACKNEY,
Secretary District No. 21.

MINES, OPENINGS, AND EXPOSURES OF COAL.

The following table presents in condensed form data of interest in regard to the mines, openings, and exposures of coal in the Arkansas field.

Table of mines, openings, and exposures of coal.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
9	32	13, SW. ¼ NE. ¼.		Prospect.	Coal, 6 in.	Hartshorne.	U. S. Geol. Survey.	
8	32	2, SE. ¼ SW. ¼.	Herman.	Old strip.	Shale roof. Bone, 12 in. Coal 10 in. Shale floor.	Fort Smith.	U. S. Geol. Survey.	
		9, SW. ¼.		Gas well, 500 ft.	Coal, 2 ft.	Hartshorne.	H. E. Kelly.	
		25, SE. ¼.		Old shaft.	No record.	Hartshorne.	U. S. Geol. Survey.	
		25, SE. ¼ SW. ¼.		Old shaft.	No record.	Hartshorne.	U. S. Geol. Survey.	
		35, SE. ¼.		Old strip.	Shale roof. Coal, 9 in. Shale, 1 in. Coal, 5 in.	Hartshorne.	U. S. Geol. Survey.	
		36, NW. ¼ NE. ¼.	Angelo Birt.	Strip.	Shale roof. Coal, 2 ft. Shale, 3 in. Coal, 4 in.	Hartshorne.	U. S. Geol. Survey.	
7	32	1, NE. ¼.		Old strip.	Coal, 1 ft. 8 in.	Hartshorne.	Citizen.	
		10, SW. ¼ SW. ¼.		Drill hole, 190 ft.	Coal, 2 ft. 4 in. Shale, 6 in. Coal, 6 in.	Hartshorne.	Citizen.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
7	32	14, SE. ¼ NE. ¼.		Drill hole, 192 ft.	Shale roof. Coal, 1 ft. 4 in. Shale, 2 in. Coal, 6 in. Gray band, 1 in. Coal, 11 in.	Hartshorne.	Central Coal and Coke Co.	12 ft. below this is a 4-ft. bed of shaly coal.
		33, SE. ¼ SW. ¼.		Drill hole, 276 ft.	Shale roof. Coal, 1 ft. Clay, 3 in. Coal, 2 ft. 3 in.	Hartshorne.	Central Coal and Coke Co.	
		34, NE. ¼.		Drill hole, 347 ft.	Shale roof. Coal, 2 ft. 2 in. Shale, 1 in. Coal, 11 in. Shale floor.	Hartshorne.	Central Coal and Coke Co.	
		34, NE. ¼ SW. ¼.	No. 26, Central Coal and Coke Co.	Shaft, 350 ft.	Shale roof. Coal, 3 ft. Shale floor.	Hartshorne.	Central Coal and Coke Co.	
		36, SE. ¼ NW. ¼.	No. 18, Western Coal and Mining Co.	Shaft, 260 ft.	Shale roof. Coal, 3 ft. 2 in. Shale, 2 in. Coal, 1 ft. 2 in. Shale floor.	Hartshorne.	Western Coal and Mining Co.	Coal has live luster, is hard, varies from 3 ft. 2 in. to 6 ft. in thickness.
		4, lot 4.	No. 20, Central Coal and Coke Co.	Shaft.	Shale roof. Coal, 2 ft. 5 in. Shale, 1 in. Coal, 1 ft. 2 in.	Hartshorne.	Central Coal and Coke Co.	Coal and parting vary in thickness.

		5, S. ½.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	
6	32	21, SW. ¼ NW. ¼.	Hackett City Smokeless Coal Co.	Slope.	Shale roof. Coal, 3 ft. 8 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	
		22, SW. ¼.		Old shaft.	Coal, 3 ft.	Hartshorne.	Arkansas Geol. Survey.	
		24.		Drill hole.	Shale roof. Coal, 1 ft. 2 in. Sandstone floor.	Hartshorne.	Cherokee Construction Co.	
		11, SW. ¼ SE. ¼.		Drill hole, 240 ft.	Shale roof. Coal, 2 ft. 8 in.	Hartshorne.	Cherokee Construction Co.	51 ft. above this is a 6-ft. bed of coal and bone.
		12, SE. ¼ SW. ¼.		Drill hole, 187 ft.	Shale roof. Coal, 3 ft. 1 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	45 ft. above this is a 5 ft. 6 in. bed of coal and bone.
		12, SW. ¼ SW. ¼.		Drill hole, 186 ft.	Shale roof. Coal, 2 ft. 7 in. Bone, 11 in.	Hartshorne.	Cherokee Construction Co.	39 ft. above this is a 5 ft. 6 in. bed of coal and bone.
5	32	13, SW. ¼.		Old shaft, 170 ft.	Shale roof. Coal, 3 ft. 4 in.	Hartshorne.	Dallas Coal Co.	55 ft. above this is another bed of coal.
		14, NE. ¼ NE. ¼.		Drill hole, 163 ft.	Shale roof. Coal, 2 ft. 9 in. Bone, 8 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	45 ft. above this is a 5 ft. 6 in. bed of bone, coal, and shale.
		14, SE. ¼ SE. ¼.		Drill hole, 203 ft.	Shale roof. Coal, 2 ft. 7 in. Bone, 8 in.	Hartshorne.	Cherokee Construction Co.	48 ft. above this is a 4 ft. 6 in. bed of dirty coal.

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
5	32	14, SW. ¼ NE. ¼.		Drill hole, 177 ft.	Shale roof. Coal, 3 ft. 3 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	45 ft. above this is a 3 ft. 4 in. bed of coal, bone, and shale.
		14, NW. ¼ NE. ¼.		Drill hole, 183 ft.	Shale roof. Coal, 2 ft. 9 in. Bone, 8 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	41 ft. above this is a 6 ft. 10 in. bed of coal, shale, and bone.
		14, SW. ¼ NW. ¼.		Drill hole, 239 ft.	Shale roof. Coal, 2 ft. 11 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	40 ft. above this is a 3 ft. 3 in. bed of dirty coal.
		22, NE. ¼ NE. ¼.		Drill hole, 456 ft.	Shale roof. Coal, 3 ft. 3 in. Sandstone floor.	Hartshorne.	Cherokee Construction Co.	50 ft. above this is a 4 ft. 2 in. bed of coal and bone.
		1, lot 4 or 5.	No. 4, Cherokee Construction Co.	Shaft, 170 ft.	Sandstone roof. Coal, 4 ft. 3 in. Shale, 8 in. Coal, 3 ft. 6 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	
		1, lot 8.		Old slope.	No record.	Hartshorne.	U. S. Geol. Survey.	
		1, lot 12.		Old slope.	No record.	Hartshorne.	U. S. Geol. Survey.	
		2, NE. ¼.		Old slope.	No record.	Hartshorne.	U. S. Geol. Survey.	
		2, SE. ¼ NW. ¼.		Old slope.	No record.	Hartshorne.	U. S. Geol. Survey.	

		2, W. ½ SW. ¼.		Old slope.	No record.	Hartshorne.	U. S. Geol. Survey.	
		6, lot 13.		Crop.		Charleston.	U. S. Geol. Survey.	Blossom.
		10, SE. ¼ NW. ¼.	No. 4, Bolen-Darnall Coal Co.	Slope.	Shale roof. Coal, 4 ft.	Hartshorne.	U. S. Geol. Survey.	
4	32	10, SW. ¼ SW. ¼.	No. 2, Bolen-Darnall Coal Co.	Slope.	Shale roof. Coal, 4 ft.	Hartshorne.	U. S. Geol. Survey.	
		13, NW. ¼ SE. ¼.	Arkansas Smokeless Coal Co.	Slope	Sandstone roof. Coal, 3 ft. 8 in. Shale, 1 ft. 4 in. Coal, 8 in. Shale floor.	Hartshorne.	U. S. Geol. Survey.	2 in. bone in top bench. Lower bench not mined.
		14, NE. ¼ SE. ¼.	Patterson Coal and Mining Co.	Slope.	Sandstone roof. Coal, 3 ft. 6 in. Clay, 10 in. Coal, 10 in. Shale floor.	Hartshorne.	U. S. Geol. Survey.	3 ft. or more of "black jack" lies below the coal.
		15, N. ½ NW. ¼.	No. 4, Central Coal and Coke Co.	Slope.	Shale roof. Coal, 4 ft.	Hartshorne.	U. S. Geol. Survey.	
		17, SW. ¼ NW. ¼.		Drill hole.	Sandstone roof. Coal, 4 ft. 3 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	110 ft. above this is a 5-ft. bed of coal and bone.
		22, NW. ¼ NW. ¼.	Central Coal and Coke Co.	Drill hole.	Shale roof. Coal, 3 ft. 6 in. Shale, 3 in. Coal, 2 in. Shale, 7 in. Coal, 11 in. Bone, 1 ft. 8 in.	Hartshorne.	Cherokee Construction Co.	52 ft. above this is a 5 ft. 9 in. bed of bone and coal. 100 ft. above is a 5-ft. bed of shale and coal.

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
3	32	19, SW. ¼.	Witte Coal Co.	Slope.	Shale roof. Coal, 5 ft. Shale, 7 in. Coal, 2 ft. 6 in. Shale floor.	Hartshorne.	D. Lytle.	Only the upper bench is mined.
		21, NE. ¼ NE. ¼.	Davidson.	Slope.	Shale roof. Coal, 4 ft. Shale, 8 in. Coal, 3 ft. 4 in. Shale floor.	Hartshorne.	U. S. Geol. Survey.	Partings contain more or less coal.
		21, NW. ¼ NE. ¼.		Slope.	Shale roof. Coal, 7 in. Shale, 1 in. Coal, 1 ft. 3 in. Shale, 4 in. Coal, 1 ft. 9 in. Shale, 8 in. Coal, 1 ft. 9 in. Shale, 1 ft. 6 in. Bone, 6 in. Coal, 3 in. Shale floor.	Hartshorne.	U. S. Geol. Survey.	Partings contain thin seams of coal. Coal beds contain shale bands.
		21, NE. ¼ NW. ¼.	Seymour Coal Co.	Slope.	Shale roof. Coal, 2 ft. Shale, 3 in. Coal, 2 ft. Shale, 2 ft. Coal, 2 ft. Shale, 2 ft. 6 in. Coal, 4 ft.	Hartshorne.	U. S. Geol. Survey.	Only the lowest bench is worked.

		3, NE. ¼.		Crop.	Sandstone roof. Coal, 4 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	Exposed in railroad cut.
9	31	13, NE. ¼.	Sullivant.	Crop.	Shale roof. Coal, 1 ft.	Fort Smith.	U. S. Geol. Survey.	
		16, NW. ¼.	Hendricks.	Old slope.	Coal, 2 ft.	Fort Smith.	Arkansas Geol. Survey.	Possibly another bed 5 ft. below.
		28, SW. ¼.		Slope.	Shale roof. Coal, 1 ft. 11 in.	Hartshorne.	U. S. Geol. Survey.	
		30, NW. ¼.		Shaft, 85 ft.	Shale roof. Coal, 1 ft. 10 in. Shale, 4 in. Coal, 1 ft.	Hartshorne.	U. S. Geol. Survey.	
8	31	30, SW. ¼.		Shaft, 42 ft.	Same as next above.	Hartshorne.	Citizen.	
		30, SW. ¼.	Montgomery and Jones.	Slope.	Shale roof. Coal, 1 ft. 10 in. Shale, 1½ in. Coal, 8 in.	Hartshorne.	U. S. Geol. Survey.	Parting varies up to 1½ in.
		1, N. ½.		Old slopes.	Shale roof. Coal, 1 ft. 8 in.	Charleston.	U. S. Geol. Survey.	Coal varies from 14 in. to 20 in.
7	31	3, NE. ¼ SW. ¼.		Prospect.	Shale roof. Coal, 1 ft. 6 in.	Charleston.	U. S. Geol. Survey.	
		13, SW. ¼.	Bostick.	Old slope.	Coal, 2 ft. 10 in. Parting.	Hartshorne.	U. S. Geol. Survey.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
		17, NE. ¼ NW. ¼.		Drill hole, 792 ft.	Coal, 1 ft. 3 in. Shale, ½ in. Coal, 1 ft. Shale, 4½ in. Coal, 1 ft. 7 in.	Hartshorne.	Cherokee Construction Co.	
		19, SW. ¼ NE. ¼.		Drill hole, 660 ft.	Shale roof. Coal, 2 ft. 2 in. Shale, 1 in. Coal, 1 ft. 6 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	
		21, NE. ¼ NW. ¼.		Drill hole, 689 ft.	Coal, 3 ft. 9 in. Parting, 2½ in.	Hartshorne.	Western Coal and Mining Co.	
		22, SW. ¼ SW. ¼.		Drill hole, 89 ft.	Coal, 3 ft. 9 in. Parting, 1 in.	Hartshorne.	Western Coal and Mining Co.	
		22, SE. ¼ NE. ¼.		Drill hole, 25 ft.	Coal, 3 ft. 7 in. Parting, 3 in.	Hartshorne.	Western Coal and Mining Co.	
7	31	22.		Drill hole, 305 ft.	Coal, 6 ft.	Hartshorne.	Western Coal and Mining Co.	Location in section not known.
		28, NE. ¼ SW. ¼.		Drill hole, 198 ft.	Coal, 4 ft. 5 in.	Hartshorne.	Western Coal and Mining Co.	
		31, SW. ¼ NW. ¼.		Drill hole, 271 ft.	Coal, 4 ft. 5 in. Parting, 8 in.	Hartshorne.	Western Coal and Mining Co.	
		31, NW. ¼ SW. ¼.		Drill hole, 129 ft.	Coal, 4 ft. 7 in. Parting, 5 in.	Hartshorne.	Western Coal and Mining Co.	

		32, NE. ¼ NE. ¼.		Drill hole, 204 ft.	Coal, 4 ft.	Hartshorne.	Western Coal and Mining Co.	
		32, SE. ¼ NE. ¼.		Drill hole, 60 ft.	Coal, 5 ft. Parting, 1 in.	Hartshorne.	Western Coal and Mining Co.	
		32, SW. ¼ NE. ¼.		Drill hole, 77 ft.	Coal, 5 ft. 4 in. Parting, 1½ in.	Hartshorne.	Western Coal and Mining Co.	
		32, SW. ¼ SW. ¼.	Western Coal and Mining Co., No. 17.	Shaft, 212 ft.	Shale roof. Coal, 3 ft. Shale, 4 in. Coal, 3 ft.	Hartshorne.	U. S. Geol. Survey.	Some sulphur and gray bands in coal.
6	31	12 NW. ¼ NE. ¼.	Greenwood Coal and Lumber Co., No. 1.	Slope.	Shale roof. Coal, 3 ft. Parting, up to 6 in. Coal, 3 ft. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	Coal varies in thickness from 4 ft. to 7 ft.
		12, SE. ¼ SW. ¼.		Drill hole, 13 ft.	Coal, 3 ft. 1 in. Parting, 2 in.	Hartshorne.	Western Coal and Mining Co.	
		12, SW. ¼ SE. ¼.		Drill hole, 138 ft.	Coal, 3 ft. 5 in.	Hartshorne.	Western Coal and Mining Co.	Bony coal; contains sulphur.
		12, NW. ¼ SE. ¼.		Drill hole, 75 ft.	Coal, 3 ft.	Hartshorne.	Western Coal and Mining Co.	
		12, NW. ¼ SE. ¼.		Drill hole, 112 ft.	Coal, 6 ft. 7 in. Parting, 1 in.	Hartshorne.	Western Coal and Mining Co.	
		12, SE. ¼ SW. ¼.		Drill hole, 16 ft.	Coal, 2 ft. 2 in.	Hartshorne.	Western Coal and Mining Co.	
		12, SE. ¼ SW. ¼.		Drill hole, 11 ft.	Coal, 3 ft.	Hartshorne.	Western Coal and Mining Co.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
		12, NE. ¼ SE. ¼.		Drill hole, 215 ft.	Coal, 7 ft. 7 in. Partings, 5 in.	Hartshorne.	Western Coal and Mining Co.	One 4 in. and one 1 in. parting.
		12, NW. ¼ NW. ¼		Drill hole, 15 ft.	Coal, 2 ft. 11 in. Shale floor.	Hartshorne.	Western Coal and Mining Co.	
		12, NW. ¼ SE. ¼.		Drill hole, 80 ft.	Shale roof. Coal, 3 ft. Shale floor.	Hartshorne.	Cherokee Construction Co.	
		12, SE. ¼ NE. ¼.		Drill hole, 125 ft.	Shale roof. Coal, 3 ft. 3 in. Parting, 1 in. Coal, 3 ft. 4 in.	Hartshorne.	Cherokee Construction Co.	
		12, SE. ¼ SW. ¼.		Drill hole, 10 ft.	Coal, 2 ft. 5 in. Shale, 2 in. Coal, 8 in.	Hartshorne.	Cherokee Construction Co.	
		12, SW. ¼ SE. ¼.		Drill hole, 150 ft.	Shale roof. Coal, 3 ft. 5 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	Coal is bony and contains sulphur.
6	31	13, NE. ¼ NE. ¼.		Drill hole, 39 ft.	Coal, 2 ft. 7 in.	Hartshorne.	Western Coal and Mining Co.	
		13, NE. ¼ NW. ¼.		Drill hole, 40 ft.	Shale roof. Coal, 2 ft. 7 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	

		17, S. ½ NW. ¼	Skinner and Knott.	Slope.	Shale roof. Coal, 3 ft. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	Coal varies between 2 ft. 5 in. and 4 ft.
		18, NE. ¼ SW. ¼	Swofford.	Slope.	Shale roof. Coal, 2 ft. 8 in.	Hartshorne.	U. S. Geol. Survey.	Coal varies between 2 ft. 8 in. and 2 ft. 10 in.
		18, SW. ¼.	Bates and McWilliams	Shaft, 70 ft.	Shale roof. Coal, 2 ft. 10 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	Coal varies between 2 ft. 8 in. and 3 ft.
		21, NE. ¼.		Slope.	Shale roof. Coal, 2 ft. 6 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	A bed of bony coal lies 50 ft. below this.
		21, N. ½ SW. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		29, SW. ¼.		Old workings.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		5, SE. ¼.		Prospect.	Coal.	Hartshorne.	U. S. Geol. Survey.	
		7, SE. ¼ SE. ¼.	Irby Coal Co.	Slope.	Sandstone roof. Coal, 3 ft. Shale floor.	Hartshorne.	U. S. Geol. Survey.	
5	31	8, NE. ¼ NE. ¼.	Moran Coal Co.	Slope.	Shale roof. Coal, 3 ft. 4 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	
		18, SW. ¼.	Cherokee Construction Co.	Slope No. 5.	Coal, 3 ft. 4 in.	Hartshorne.	Cherokee Construction Co.	Coal variable in thickness.
		19, NW. ¼ NW. ¼.	Branner Coal Co.	Shaft, 60 ft.	Shale roof. Coal, 3 ft. 6 in.	Hartshorne.	U. S. Geol. Survey.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
		19, NE. ¼ NW. ¼.	C. C. Woodson.	Strip.	Shale roof. Coal, 3 ft. 7 in. Shale floor.	Hartshorne.	U. S. Geol. Survey.	
		19, NE. ¼ NE. ¼.		Strip.	Shale roof. Coal, 3 ft. Shale floor.	Hartshorne.	U. S. Geol. Survey.	
		19, E. ½ SE. ¼.	Denman Coal Co.	Shaft 50 ft.	Shale roof. Coal, 3 ft. Shale floor.	Hartshorne.	U. S. Geol. Survey.	
		19, SW. ¼.		Drill hole, 253 ft.	Shale roof. Coal, 3 ft. 5 in. Sandstone floor.	Hartshorne.	Cherokee Construction Co.	58 ft. above this is another bed of coal.
		19, SE. ¼ SW. ¼.		Drill hole, 270 ft.	Shale roof. Coal, 3 ft.	Hartshorne.	Cherokee Construction Co.	55 ft. above is another bed.
		20, NW. ¼ SW. ¼.	Dallas Coal Co.	Shaft, 60 ft.	Sandstone roof. Coal, 3 ft. Shale floor.	Hartshorne.	U. S. Geol. Survey.	
		20, NE. ¼ SW. ¼.	C. C. Turnipseed.	Slope.	Sandstone roof. Coal, 3 ft.	Hartshorne.	U. S. Geol. Survey.	
5	31	20, S. ½ NW. ¼.	Dallas Coal Co.	Shaft, 24 ft.	Sandstone roof. Coal, 3 ft.	Hartshorne.	U. S. Geol. Survey.	Blacksmithing coal.
		21, SE. ¼.		Strip.	Shale roof. Coal, 3 ft. 6 in.	Hartshorne.	U. S. Geol. Survey.	

		21, SE. ¼ NE. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		22, SW. ¼.	G. W. Crabtree.	Slope.	Sandstone roof. Coal, 4 ft. 6 in. Parting, 1 ft. Coal, 6 in. Parting, 2 in. Coal, 1 ft. 10 in.	Hartshorne.	U. S. Geol. Survey.	Coal is exposed in several places near here.
		26, NW. ¼ NE. ¼.	Central Coal and Coke Co., No. 2.	Shaft, 49 ft.	Shale roof. Coal, 4 ft. Parting, 9 in. Coal, 6 in. Parting, 3 in. Coal, 2 ft. 6 in. Shale floor.	Hartshorne.	Central Coal and Coke Co.	Benches are variable in thickness.
		27, NW. ¼ SW. ¼.	Central Coal and Coke Co., No. 3.	Shaft, 23 ft.	Shale roof. Coal, 4 ft. Parting, 9 in. Coal, 6 in. Parting, 3 in. Coal, 2 ft. 6 in. Shale floor.	Hartshorne.	Central Coal and Coke Co.	Coal has sandstone roof on west side of shaft.
		12, SW. ¼.	Bethel.	Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		15, NW. ¼.		Old workings.	No record.	Hartshorne.	U. S. Geol. Survey.	
		16, SW. ¼.		Old slope.	No record.	Hartshorne.	U. S. Geol. Survey.	
4	31	17, NE. ¼ SW. ¼.	Claborn.	Prospect.	Coal, 10 in. Shale, 4 in. Shaly coal, 8 in. Coal, 1 ft. 7 in. Shale, 2 ft. 6 in. Coal, 2 ft. 4 in. Shale, 2 ft. Coal, 4 in. to 1 ft. Shale, 8 ft. Coal, 3 in.	Hartshorne.	Arkansas Geological Survey.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
4	31	18 E. ½ SE. ¼.	Chasteen.	Prospect.	Coal, 1 ft. Parting, 3 in. Coal, 6 in. Parting, 1 in. Coal, 2 in. Parting, 2 in. Coal, 2 ft. 6 in. Parting, 1 ft. 11 in. Coal, 8 in. Parting, 4 in. Coal, 2 ft.	Hartshorne.	U. S. Geol. Survey.	All of the lowest bench of coal was not seen, though it is probably 2 ft., as reported.
3	31	1, SE. ¼ NE. ¼.		Prospect.	Shale roof. Coal, 3 in. Parting, 7 in. Coal, 2 in. Parting, 8 in. Coal, 3 in. Parting. 3 in. Coal, 4 in. Parting, 2 in. Coal, 1 ft. Shale floor.	Hartshorne.	U. S. Geol. Survey.	All of the bed is not exposed.
		8, NE. ¼ SW. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		9, NW. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		10, NW. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		17, NW. ¼.		Drill hole, 391 ft.	Shaly coal, 1 ft. 7 in.	Hartshorne.	Central Coal and Coke Co.	

9	30	17, NW. ¼.			Coal, 9 in.	300 ft. above Hartshorne.	Central Coal and Coke Co.	Same drill hole as one next above.
		19.	Gross.	Drill hole.	Coal, 10 in.	Hartshorne.	G. P. Gross.	
		33, SE. ¼ NE. ¼.	Graves.	Prospect.	Coal, 1 ft. 6 in.	Fort Smith.	U. S. Geol. Survey.	
8	30	22, NE. ¼.		Crop.	Coal.	Fort Smith.	U. S. Geol. Survey.	Blossom.
7	30	7.		Drill hole, 698 ft.	Bone coal, 4 ft. Coal, 4 ft.	Hartshorne.	Cherokee Construction Co.	On the Edenborn farm.
		14, NW. ¼ SW. ¼.		Drill hole, 268 ft.	Shale roof. Bone coal, 9 in. Coal, 2 ft. Shale floor.	Hartshorne.	Cherokee Construction Co.	
		24, S. ½ NE. ¼.		Old working.	Coal, 1 ft. 6 in.	Hartshorne.	Citizen.	
		25, NW. ¼.		Old working.	Coal, 1 ft. 4 in.	Hartshorne.	Citizen.	
		32, SE. ¼ SE. ¼.	McConnel.	Old working.	Shale roof. Coal, 4 in. Shale, 1 in. Coal, 2 ft. 5 in.	Hartshorne.	Arkansas Geol. Survey.	
6	30	5, lot 5.		Drill hole, 100 ft.	Shale roof. Coal, 6 ft. 10 in. Shale floor.	Hartshorne.	Western Coal and Mining Co.	Bands of coal in roof and floor.
		5, lot 5.		Drill hole, 36 ft.	Shale roof. Coal, 1 ft. 9 in. Shale floor.	Hartshorne.	Western Coal and Mining Co.	
		5, lot 5.		Drill hole, 50 ft.	Shale roof. Coal, 2 ft. 3 in. Shale floor.	Hartshorne.	Western Coal and Mining Co.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
		5.		Drill hole, 345 ft.	Shale roof. Coal, 2 ft. 9 in. Bone coal, 3½ in. Coal, 2 ft. 6 in. Shale, 2½ in. Coal, 3½ in. Shale, 1 ft. Coal, 4½ in. Bone coal, 2 in. Coal, 1 in. Parting, 1 in. Coal, 1½ in. Bone coal, 3 in. Coal, 1 ft. 7½ in.	Hartshorne.	Western Coal and Mining Co.	Diamond drill hole on the McCord farm.
		6, lot 13.		Drill hole, 25 ft.	Shale roof. Coal. Shale floor.	Hartshorne.	Cherokee Construction Co.	
6	30	6, SW. ¼ SW. ¼.		Drill hole, 20 ft.	Coal, 5 ft. 6 in. Shale floor.	Hartshorne.	Cherokee Construction Co.	
		6, lot 8.		Drill hole, 38 ft.	Shale roof. Coal, 1 ft. 6 in. Shale, 2 in. Coal, 2 ft. 7½ in.	Hartshorne.	Cherokee Construction Co.	½-inch sulphur band in lower bench.
		6, SE. ¼ NE. ¼.	Fidelity Fuel Co., Banner mine.	Slope.	Shale roof. Coal, 5 ft. 3 in. Bone coal, 3 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	

		7, lot 4.		Drill hole, 315 ft.	Sandstone roof. Coal, 3 ft. Shale, 1 ft. 5 in. Coal, 4 ft. 1½ in. Shale floor.	Hartshorne.	Cherokee Construction Co.	
		19, N. ½.		Old working.	Coal.	Hartshorne.	U. S. Geol. Survey.	No record.
4	30	8, S. ½.	Lewis Pogue.	Old working.	Coal.	Hartshorne.	Citizen.	In two benches.
		9, SW. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		13, NE. ¼ SW. ¼.		Drill hole, 320 ft.	Coal, 6 in. Fire-clay floor.	Fort Smith.	Cherokee Construction Co.	
3	30	3, NW. ¼.		Prospect.	Coal.	Hartshorne.	U. S. Geol. Survey.	
		4, NW. ¼.	Holloway.	Well.	Coal.	Hartshorne.	Citizen.	Coal struck in well.
		5, NE. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		6, W. ¼.		Prospect.	Coal.	Hartshorne.	U. S. Geol. Survey.	
10	29	10, N. ½ SE. ¼.		Crop.	Coal, 5 in.	Hartshorne.	U. S. Geol. Survey.	
		21, SW. ¼.		Old strip.	Coal, 1 ft.	Hartshorne.	U. S. Geol. Survey.	
		36, N. ½.		Crop.	Clay roof. Coal, 1 ft. 1 in. Bone coal, 5 in.	Hartshorne.	U. S. Geol. Survey.	Exposed in road.
		36, E. ½.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Exposed in road.
8	29	11, SE. ¼	Vesta.	Old working.	Coal.	Hartshorne.	Citizen.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
7	29	13, NW. ¼ NW. ¼.		Prospect, 16 feet deep.	Coal.	Charleston.	Citizen.	
		16, NE. ¼ NE. ¼.		Old workings.	Coal; no record.	Charleston.	U. S. Geol. Survey.	
		16, W. ½.		Old workings.	Coal; No record.	Charleston.	U. S. Geol. Survey.	
		20, NW. ¼.	Coal Ridge.	Old slope.	Shale roof. Coal, 1 ft. 6 in. Shale floor.	Charleston.	U. S. Geol. Survey.	
		25, SW. ¼.		Crop.	Coal.	Paris.	U. S. Geol. Survey.	Blossom.
		27, NW. ¼.		Strip.	Coal, 1 ft. 2 in.	Paris.	Citizen.	
		31 SW. ¼.	Bean.	Strip.	Coal, 1 ft. 8 in.	Charleston.	Arkansas Geol. Survey.	
6	29	5, SW. ¼ NE. ¼.	McClellan.	Drill hole, 28 ft.	Coal, 1 ft. 7½ in.	Hartshorne.	McClellan.	Coal crops out near.
		6, S. ½.	Langston.	Strip.	Coal, 1 ft. 6 in.	Fort Smith.	Arkansas Geol. Survey.	
4	29	7, SE. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom in road.
9	28	4, W. ½.	Lewis.	Old working.	Coal, 1 ft. 2 in.	Hartshorne.	Arkansas Geol. Survey.	
		6, SW. ¼ NW. ¼.	Anderson.	Prospect.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	

8	28	8, SE. ¼ SE. ¼.	Logan.	Prospect.	Coal.	Hartshorne.	Logan.	
		11, NW. ¼.		Well.	Coal, 1 ft. 6 in.	Hartshorne.	Citizen.	Reported as struck in a well.
		17, E. ½.		Crop.	Coal.	Spadra.	Citizen.	
		28, SW. ¼.	Minden.	Strip.	Coal, 1 ft. 8 in.	Charleston.	U. S. Geol. Survey.	
		29, SW. ¼.		Crop.	Coal, 1 ft. 5 in.	Charleston.	U. S. Geol. Survey.	
		31, NW. ¼ NW. ¼.		Old strip.	Coal, 1 ft. 5 in.	Charleston.	U. S. Geol. Survey.	
		32, SW. ¼.		Crop.	Coal, 10 in.	Charleston.	U. S. Geol. Survey.	
		32, NW. ¼ SE. ¼.	Fealy.	Strip.	Coal, 1 ft. 8 in.	Charleston.	U. S. Geol. Survey.	
		34, SE. ¼.	Cotton.	Crop.	Coal, 1 ft. 8 in.	Charleston.	U. S. Geol. Survey.	
7	28	2, NE. ¼.		Crop.	Coal, 1 ft. 4 in.	Charleston.	U. S. Geol. Survey.	
		3, SE. ¼ NE. ¼.		Crop.	Coal.	Charleston.	U. S. Geol. Survey.	
		13, SW. ¼.		Crop.	Coal, 1 ft. 6 in.	Charleston.	U. S. Geol. Survey.	
		16, SW. ¼.		Old working.	Coal, 1 ft. 6 in.	Charleston.	U. S. Geol. Survey.	
		17, SE. ¼ NE. ¼.	Carter.	Slope.	Coal, 2 ft. 6 in.	Charleston.	C. C. Carter.	Reported to vary between 30 in. and 36 in.
		22, NW. ¼.		Prospect.	Coal.	Charleston.	U. S. Geol. Survey.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T. N.	R. W.	Section.						
7	28	22, SW. ¼ NE. ¼.		Prospect.	Coal.	Charleston.	U. S. Geol. Survey.	
		23, N. ½.		Prospect.	Coal, 1 ft. 8 in.	Charleston.	U. S. Geol. Survey.	
		24, NW. ¼.		Strip.	Coal, 1 ft. 6 in.	Charleston.	U. S. Geol. Survey.	
		24, NE. ¼.			Coal, 9 in.	Charleston.	U. S. Geol. Survey.	
		30, SE. ¼.		Slope.	Coal, 1 ft. 6 in.	Charleston.	U. S. Geol. Survey.	
		32, NW. ¼.		Prospect.	Coal, 1 ft. 10 in.	Charleston.	U. S. Geol. Survey.	
		33, NW. ¼.		Prospect.	Coal, 1 ft. 8 in.	Charleston.	U. S. Geol. Survey.	
		33, NE. ¼.		Prospect.	Coal.	Charleston.	U. S. Geol. Survey.	
10	27	3, SW. ¼.		Prospect.	Coal, 10 in.	Below Hartshorne.	U. S. Geol. Survey.	
		8, SE. ¼ NW. ¼.		Prospect.	Coal, 10 in.	Below Hartshorne.	U. S. Geol. Survey.	
		10, SW. ¼.		Prospect.	Coal.	Below Hartshorne.	U. S. Geol. Survey.	
		34, SE. ¼.		Crop.	Coal.	Below Hartshorne.	U. S. Geol. Survey.	

		36, NE. ¼.	Adams.	Crop.	Coal.	Below Hartshorne.	U. S. Geol. Survey.	
9	27	9, SE. ¼.		Drill hole, 258 ft.	Shaly coal, 2 in. Coal, 11 in. Shaly coal, 1 in. Coal, 11 in. Shale, 2 in. Coal, 10 in.	Below Hartshorne.	Central Coal and Coke Co.	
		11, NW. ¼.		Prospect.	Coal, 5 in.	Below Hartshorne.	U. S. Geol. Survey.	
		23, NE. ¼.		Prospect.	Coal.	Hartshorne.	U. S. Geol. Survey.	In two benches.
8	27	22, SE. ¼.		Prospect.	Coal, 1 ft. 2 in.	Charleston.	U. S. Geol. Survey.	
		30, NW. ¼.	Carpenter.	Prospect.	Coal, 1 ft. 10 in.	Charleston.	U. S. Geol. Survey.	
		35, SW. ¼.	Ockenfels.	Crop.	Coal, 6 in.	Paris.	U. S. Geol. Survey.	
		35, NE. ¼.			Coal, 10 in.	Paris.	Citizen.	
7	27	3, SW. ¼.		Strip.	Coal, 1 ft. 11 in.	Charleston.	Citizen.	
		10, NE. ¼.	Caulk's.	Prospect.	Coal, 1 ft. 1 in.	Charleston.	U. S. Geol. Survey.	Base of coal not seen.
		13, N. ½.		Prospect.	Coal.	Spadra.	U. S. Geol. Survey.	Blossom.
		14, NE. ¼.		Prospect.	Coal.	Hartshorne.	U. S. Geol. Survey.	Crops in road east of creek.
		18, SW. ¼.			Coal.	Charleston.	U. S. Geol. Survey.	
		19, W. ½.			Coal, 2 ft. 6 in.	Charleston.	U. S. Geol. Survey.	
		33, W. ½.		Prospect.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T.N.	R.W.	Section.						
10	26	12, SW. ¼.		Old working.	Coal.	Charleston.	U. S. Geol. Survey.	
		13, NE. ¼ NW. ¼.		Well, 27 ft.	Coal; no record.	Charleston.	N. G. Greer.	
		22.	Old Moomaw openings.	Slopes.	Coal, 1 ft. 10 in.	Charleston.	U. S. Geol. Survey.	Five or six openings.
		23, NW. ¼ SW. ¼.		Slope.	Coal, 1 ft. 10 in.	Charleston.	Adams.	
		23, SW. ¼ NW. ¼.		Slope.	Coal, 1 ft. 10 in.	Charleston.	Adams.	
		27, NW. ¼ NW. ¼.		Prospect.	Coal, 2 ft. 2 in.	Hartshorne.	Adams.	
		6, SE. ¼ SE. ¼.		Crop.	Coal, 6 in.	Below Hartshorne.	U. S. Geol. Survey.	Crops in railroad cut.
		7, SE. ¼.		Crop.	Coal.	Below Hartshorne.	U. S. Geol. Survey.	
		17, SW. ¼.	Garritz.	Slope.	Coal, 2 ft. 1 in.	Hartshorne.	U. S. Geol. Survey.	18 ft. above this is a 22-in. bed.
		20, NE. ¼ NW. ¼.		Drill hole, 457 ft.	Coal, 5 feet.	Below Hartshorne.	Western Coal and Mining Co.	
		21, SE. ¼ NW. ¼		Drill hole, 24 ft.	Coal, 6 in. Shale, 1 ft. 2 in. Coal, 2 ft.	Hartshorne.	Western Coal and Mining Co.	

9	26	21, SW. ¼ SW. ¼.		Drill hole, 66 ft.	Coal, 2 ft. 6 in. Shale, 4 in. Coal, 2 ft. 3 in.	Hartshorne.	Western Coal and Mining Co.	
		22, NE. ¼ SW. ¼.		Drill hole, 258 ft.	Coal, 2 ft. Shale, 8 in. Coal, 2 ft. 2 in.	Hartshorne.	Western Coal and Mining Co.	
		22, NW. ¼ SW. ¼.	No. 2, Western Coal and Mining Co.	Shaft, 185 ft.	Coal, 2 ft. 3 in. Shale, 3 in. Coal, 2 ft.	Hartshorne.	Western Coal and Mining Co.	Benches and partings variable.
		23, NW. ¼ SE. ¼.		Drill hole.	Coal, 2 ft. 5 in. Shale, 1 ft. Coal, 2 ft.	Hartshorne.	Western Coal and Mining Co.	
		23, SE. ¼ SE. ¼.	No. 3, Western Coal and Mining Co.	Shaft, 160 ft.	Coal, 2 ft. 8 in. Shale, 1 ft. 2 in. Coal, 2 ft. 7 in.	Hartshorne.	Western Coal and Mining Co.	Benches and partings variable.
		24, NW. ¼ SW. ¼.		Drill hole. 116 ft.	Coal, 1 ft. 7 in. Shale, 3 ft. Coal, 1 ft. 11 in.	Hartshorne.	Western Coal and Mining Co.	
		24, SW. ¼ SE. ¼.		Drill hole, 27 ft.	Coal, 4 ft. 6 in.	Hartshorne.	Western Coal and Mining Co.	
		24 NE. ¼.		Old slope.	Coal, 1 ft.	Below Hartshorne.	U. S. Geol. Survey.	
		25, SE. ¼.		Shaft.	Coal.	Hartshorne.	U. S. Geol. Survey.	
		25, SW. ¼.	No. 5, Western Coal and Mining Co.	Shaft.	Coal.	Hartshorne.	U. S. Geol. Survey.	
		26, SW. ¼ NE. ¼.		Drill hole, 36 ft.	Coal, 4 ft. 2 in.	Hartshorne.	Western Coal and Mining Co.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T.N.	R.W.	Section.						
9	26	27, NE. ¼ NE. ¼.		Drill hole, 121 ft.	Coal, 2 ft. Shale, 2 in. Coal, 2 ft. 7 in.	Hartshorne.	Western Coal and Mining Co.	
		27, SE. ¼.		Drill hole, 106 ft.	Coal, 4 ft. 3 in.	Hartshorne.	Western Coal and Mining Co.	
		28 NE. ¼ NE. ¼.		Drill hole, 142 ft.	Coal, 2 ft. 3 in. Shale, 3 in. Coal, 2 ft.	Hartshorne.	Western Coal and M ining Co.	
		28, NE. ¼ SE. ¼.		Drill hole, 137 ft.	Coal, 4 ft.	Hartshorne.	Western Coal and Mining Co.	
		34, S. ½ NW. ¼.		Drill hole, 108 ft.	Coal, 1 ft.	Hartshorne.	Western Coal and Mining Co.	
8	26	26, SW. ¼ SW. ¼.		Crop.	Coal.	Paris.	U. S. Geol. Survey.	Blossom.
		28, SE. ¼.		Crop.	Coal.	Paris.	U. S. Geol. Survey.	Blossom.
		28, SW. ¼.		Crop.	Coal, 2 ft. 6 in.	Paris.	U. S. Geol. Survey.	
		29, SE. ¼.		Crop.	Coal.	Paris.	U. S. Geol. Survey.	Blossom.
		29, SW. ¼ SW. ¼.	Goldsworthy.	Old working.	Shale roof. Coal, 2 ft. 4 in.	Paris.	U. S. Geol. Survey.	
		31, NE. ¼.		Crop.	Coal.	Above Paris.	U. S. Geol. Survey.	Blossom in road.

		35, NW. ¼ NE. ¼.	Blue Ribbon.	Slope.	Coal.	Paris.	U. S. Geol. Survey.	
		35, E. ½.	Baxley.	Slope.	Coal.	Paris.	U. S. Geol. Survey.	
7	26	1, SW. ¼.	Domestic Coal Co.	Slope.	Shale roof. Coal, 2 ft. 6 in.	Paris.	U. S. Geol. Survey.	
		1, SE. ¼ NW. ¼.	Enterprise Mining Co.	Slope.	Shale roof. Coal, 2 ft. 2 in.	Paris.	U. S. Geol. Survey.	
		2, SE. ¼.	Spot Cash.	Shaft.	Coal.	Paris.	U. S. Geol. Survey.	
		3, SE. ¼.		Drill hole, 182 ft.	Coal, 2 ft. 8 in.	Paris.	Citizen.	
		6, SE. ¼.		Strip.	Coal.	Paris.	U. S. Geol. Survey.	
		10, SW. ¼ NW. ¼.	Union Coal Co.	Shaft.	Coal.	Paris.	U. S. Geol. Survey.	
		10, SE. ¼ NE. ¼.	Paris Coal Co.	Slope.	Coal, 2 ft. 2 in. Fire-clay floor.	Paris.	U. S. Geol. Survey.	
		15, NE. ¼.		Prospect.	Coal; no record.	Spadra.	U. S. Geol. Survey.	
10	25	18, W. ½.	Pete Close.	Slope.	Shale roof. Coal, 1 ft. 6 in.	Charleston.	U. S. Geol. Survey.	Reported to vary between 18 in. and 26 in.
		20, NE. ¼.	Philpott.	Slope.	Shale roof. Coal, 1 ft. 10 in.	Charleston.	U. S. Geol. Survey.	
		26, SE. ¼ SE. ¼.		Prospect.	Coal, 1 ft. 8 in.	Below Hartshorne.	U. S. Geol. Survey.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—.	Remarks.
T.N.	R.W.	Section.						
10	25	31, SE. ¼.		Crop.	Coal, 1 ft.	Below Hartshorne.	U. S. Geol. Survey.	
		35, SE. ¼.		Crop.	Coal, 8 in.	Below Hartshorne.	U. S. Geol. Survey.	
		3, N. ½.		Crop.	Coal, 8 in.	Below Hartshorne.	U. S. Geol. Survey.	
		13, NW. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Exposed in road.
		19, NW. ¼ SE. ¼.	No. 4, Western Coal and Mining Co.	Shaft, 160 ft.	Shale roof. Coal, 3 ft. 5 in. Parting, 4 in.	Hartshorne.	Western Coal and Mining Co.	Parting varies between 4 in. and 10 in.
		19, NW. ¼ SW. ¼.		Old working.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		19, SE. ¼ SE. ¼.		Drill hole, 36 ft.	Coal, 1 ft. 4 in. Shale, 2 in. Coal, 2 ft. 2 in.	Hartshorne.	Western Coal and Mining Co.	
		19, SW. ¼ SW. ¼.		Old slope.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		20, SE. ¼ NE. ¼.		Shaft.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	Not working.
		20, NW. ¼ NE. ¼.	Stiewell.	Old shaft.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	

9	25	20, SE. ¼ SW. ¼.		Drill hole, 27 ft.	Coal, 1 ft. 9 in. Shale, 6 in. Coal, 2 ft.	Hartshorne.	Western Coal and Mining Co.	
		21 NE. ¼ NE. ¼.		Drill hole, 72 ft.	Coal, 2 ft. 6 in. Shale, 4 in. Coal, 8 in.	Hartshorne.	Jollin.	In the N. ½ of sec. 21 are 12 drill holes showing coal.
		21, SE. ¼ NE. ¼.		Drill hole, 29 ft.	Coal, 2 ft. 9 in.			
		29, NW. ¼.		3 shafts.	Coal, 3 ft. 10 in.	Hartshorne.	Citizen.	Small parting near center.
		29, SW. ¼.		Old slopes.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	Coal is in two benches.
		30, NE. ¼.		Shaft.	Coal, 3 ft. 10 in.	Hartshorne.	Citizen.	
		30, SW. ¼.	Black Diamond.	Shaft, 28 ft.	Shale roof. Coal, 2 ft. Parting. Coal, 2 ft. Shale floor.	Hartshorne.	U. S. Geol. Survey.	Coal varies between 3 ft. 6 in. and 4 ft. Parting not always present.
		30, SW. ¼.	Henry West.	Shaft.	Coal.	Hartshorne.	Citizen.	Same as next above.
8	25	12, SE. ¼ SE. ¼.		Drill hole, 567 ft.	Coal, 10 in. Parting, 10 ft. Shaly coal, 2 ft.	Hartshorne.	Arkansas Anthracite Coal Co.	
		9, SE. ¼ SE. ¼.		Drill hole, 502 ft.	Shaly coal, 6 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		7, SE. ¼ SW. ¼.		Drill hole, 481 ft.	Coal, 10 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		22, SE. ¼.		Crop.	Coal.	Charleston.	U. S. Geol. Survey.	Blossom in road.

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T.N.	R.W.	Section.						
7	25	8, S. ½.		Crop.	Coal.	Charleston.	U. S. Geol. Survey.	Blossom in road.
		12, NE. ¼ NE. ¼.		Crop.	Coal, 1 ft. 3 in.	Charleston.	U. S. Geol. Survey.	
10	24	9, NE. ¼.		Crop.	Coal, 1 ft. 5 in.	Charleston.	U. S. Geol. Survey.	
		36, E. ½.	McConnell.	Slope.	Coal, 1 ft. 8 in.	Hartshorne.	U. S. Geol. Survey.	Shaft is being sunk near.
		1, NW. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom in road.
		3, NE. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom in road.
		5, NW. ¼.		Old working.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		6, NE. ¼.		Old working.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		7, SE. ¼.		Old working.	Coal, 1 ft. 10 in.	Hartshorne.	U. S. Geol. Survey.	
		8, W. ½.		Old slope.	Coal, 1 ft. 9 in.	Hartshorne.	U. S. Geol. Survey.	
		10, N. ½.		Drill hole, 226 ft.	Coal, 3 ft. 8 in. Parting, 6 in.	Hartshorne.	Citizen.	

		14, SW. ¼.	Pigg and Collier, Eureka Anthracite Coal Co.	Shaft, 140 ft.	Shale roof. Coal, 1 ft. 4 in. Parting, 6 in. Coal, 1 ft. 10 in.	Hartshorne.	U. S. Geol. Survey.	
		17, SW. ¼ NW. ¼.		Old slope.	Coal, 3 ft.	Hartshorne.	U. S. Geol. Survey.	
		18, NW. ¼.		Old working.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
9	24	19.		Drill hole, 443 ft.	Coal; no record.	Hartshorne.	Citizen.	
		20, N. ½.	Southwestern Coal Co.	Shaft, 315 ft.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		20, S. ½.		Drill hole, 483 ft.	Coal; no record.	Hartshorne.	Citizen.	
		21, SW. ¼.		Drill hole, 448 ft.	Coal; no record.	Hartshorne.	Citizen.	
		21, E. ½.		Drill hole, 268 ft.	Coal, no record.	Hartshorne.	Citizen.	
		22, W. ½.	Scranton Anthracite Coal Co.	Shaft, 200 ft.	Coal, 1 ft. 8 in. Parting, 2 in. Coal, 1 ft. 8 in.	Hartshorne.	U. S. Geol. Survey.	
		22, NE. ¼.	Central Anthracite Coal Co.	Shaft, 200 ft.	Coal, 1 ft. 8 in. Parting, 2 ft. Coal, 1 ft. 8 in.	Hartshorne.	U. S. Geol. Survey.	
		23, SE. ¼.	Duck's Nest.	Shaft, 42 ft.	Coal, 2 ft. 10 in. Parting?.	Hartshorne.	Martin Rafter.	
		23, NW. ¼ NW. ¼.	Needmore Mine, Spadra Creek Coal Co.	Shaft, 100 ft.	Shale roof. Coal, 1 ft. 5 in. Parting, 2 in. Coal, 1 ft. 10 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T.N.	R.W.	Section.						
9	24	23, NW. ¼ NW. ¼.	McWilliams, Ward & Co.	Shaft, 85 ft.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		23, NE. ¼ NE. ¼.	No. 5, Consolidated Anthracite Coal Co.	Slope.	Shale roof. Coal, 1 ft. 4 in. Parting, 4 in. Coal, 1 ft. 8 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	
		24, NW. ¼ NW. ¼.	Clark and McWilliams.	Shaft, 100 ft.	Coal, 3 ft. 3 in. Parting ?.	Hartshorne.	Martin Rafter.	
		24, NW. ¼ NE. ¼.	No. 1, Consolidated Anthracite Coal Co.	Shaft, 87 ft.	Shale roof. Coal, 1 ft. 4 in. Parting, 4 in. Coal, 1 ft. 8 in.	Hartshorne.	U. S. Geol. Survey.	
		24, NE. ¼ NW. ¼.	No. 3, Consolidated Anthracite Coal Co.	Shaft, 91½ ft.	Shale roof. Coal, 1 ft. 4 in. Parting, 4 in. Coal, 1 ft. 8 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	
		2, SW. ¼ NW. ¼.		Drill hole, 848 ft.	Coal, 3 ft. 6 in. Parting, 4 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		5, SW. ¼ SE. ¼.		Drill hole.	Coal, 5 ft. 4 in. Parting, 1 in.	Hartshorne.		Thickness of coal includes parting.
		12, NW. ¼ NW. ¼.		Drill hole, 1,137 ft.	Coal, 1 ft. 2 in. Parting, 3½ in. Coal, 1 ft. 8 in.	Hartshorne.	Arkansas Anthracite Coal Co.	

		15, SE. ¼ SW. ¼.		Drill hole, 433 ft.	Coal, 3 ft. 8 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		17, SE. ¼ SE. ¼.		Drill hole, 670 ft.	Coal, 2 ft. 2 in. Shaly coal, 3 ft. 2 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		17, NE. ¼ NE. ¼.		Drill hole, 924 ft.	Coal, 1 ft. 4 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		20, NW. ¼ SE. ¼.		Drill hole, 413 ft.	Coal, 2 ft. 2 in. Shaly coal, 3 ft.	Hartshorne.	Arkansas Anthracite Coal Co.	Coal is shaly at the base.
8	24	21, SW. ¼ SE. ¼.		Drill hole, 86 ft.	Coal, 3 ft.	Hartshorne.	Arkansas Anthracite Coal Co.	
		21, SE. ¼ SE. ¼.		Drill hole, 42 ft.	Coal, 3 ft.	Hartshorne.	Arkansas Anthracite Coal Co.	
		22, NE. ¼ SW. ¼.		Drill hole, 80 ft.	Coal, 3 ft. 4 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		22, SW. ¼ NE. ¼.		Drill hole, 215 ft.	Coal, 1 ft. 6 in. Shaly coal, 1 ft. 9 in.	Hartshorne.	Arkansas Anthracite Coal Co.	125 ft. below is another bed.
		23, near center.		Shaft, 54 ft.	Coal, 3 ft. 2 in.	Hartshorne.	Citizen.	
		23, NE. ¼.		Drill hole, 278 ft.	Coal, 3 ft.	Hartshorne.	C., R. I. & P. Railroad.	
		24, SE. ¼ NW. ¼.		Drill hole, 65 ft.	Coal, 1 ft. 2 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		24, SW. ¼ NE. ¼.		Drill hole, 88 ft.	Coal, 11 in.	Hartshorne.		
		24, NE. ¼ NE. ¼.		Drill hole, 403 ft.	Coal.	Hartshorne.	Arkansas Anthracite Coal Co.	"Thin bed."

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T.N.	R.W.	Section.						
8	24	28, NW. ¼ NW. ¼.		Drill hole, 168 ft.	Coal, 2 ft. 10 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
10	23	9, SW. ¼.		Crop.	Coal.	Hartshorne.	Arkansas Anthracite Coal Co.	Blossom.
		10, SW. ¼.		Crop.	Coal, 1 ft. 2 in.	Hartshorne.	Citizen.	
		17, N. ½.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		20, NW. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		21, SE. ¼.		Crop.	Coal, 1 ft. 3 in.	Hartshorne.	U. S. Geol. Survey.	
		27, SW. ¼ SW. ¼.	Mason.	Slope.	Sandstone roof. Coal, 1 ft. 9 in. Shale floor.	Hartshorne.	E. L. Mason.	
		34, NE. ¼.		Old strip.	Coal, 1 ft. 3 in.	Hartshorne.	Citizen.	
		6, N. ½.		Drill hole.	Coal.	Hartshorne.	Citizen.	Reported at 300 ft. and at 500 ft.
		11, NE. ¼.		Drill hole, 646 ft.	Coal.	Hartshorne.	Garner.	
		11, SW. ¼.		Crop.	Coal, 8 in.	600 ft. above Hartshorne.	U. S. Geol. Survey.	
		14, NW. ¼.		Crop.	Coal, 8 in.		U. S. Geol. Survey.	

		16, SW. ¼.	Union Anthracite Coal Co.	Shaft, 150 ft.	Shale roof. Coal, 3 ft. Parting, 3 in.	Hartshorne.	Higgins.	
9	23	17.	Brooks Mine, Western Anthracite Coal Co.	Shaft, 240 ft.	Shale roof. Coal, 1 ft. 7 in. Shale, 2 in. Coal, 1 ft. 1 in.	Hartshorne.	U. S. Geol. Survey.	
		17.	Clarksville Anthracite Coal Co.	Shaft, 112 ft.	Coal, 3 ft. 6 in. Parting ?.	Hartshorne.	Rafter.	
		18, SE. ¼.		Old workings.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		28, SW. ¼ SW. ¼.		Drill hole, 437 ft.	Coal, 3 ft. 10 in. Parting, 4 in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		30, NE. ¼ NE. ¼.		Drill hole, 270 ft.	Coal, 3 ft. 4 in. Parting, 2 in.	Hartshorne.		
		31, NE. ¼ SW. ¼.		Drill hole, 518 ft.	Coal, 1 ft. 7 in. Parting, 4½ in. Coal, 1 ft. 11½ in.	Hartshorne.	Arkansas Anthracite Coal Co.	
		20, NW. ¼ NW. ¼.		Drill hole, 533 ft.	Coal.	Hartshorne.	Arkansas Anthracite Coal Co.	Thin coals at 488 ft. and at 533 ft.
8	23	21, NE. ¼ SE. ¼.		Drill hole, 525 ft.	Coal.	Hartshorne.	Arkansas Anthracite Coal Co.	Thin coal at 525 ft.
		28, SE. ¼ NW. ¼.		Drill hole, 114 ft.	Coal.	Hartshorne.	Arkansas Anthracite Coal Co.	Thin coal at 114 ft.

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T.N.	R.W.	Section.						
7	23	4, W. ½.		Drill hole, 470 ft.	Shaly coal, 1 ft.	Hartshorne.	H. H. Jackman.	Coal at 35 ft.
		4, W. ½.		Drill hole, 470 ft.	Shaly coal, 3 ft.	435 ft. below Hartshorne.	H. H. Jackman.	Coal at 470 ft.; same hole as above.
		6, W. ½.		Drill hole, 584 ft.	Shaly coal, 1 ft.	Hartshorne.	H. H. Jackman.	Coal at 71 ft.
		6, W. ½.		Drill hole, 584 ft.	Coal, 1 ft. Shaly coal, 7 in. Coal, 1 ft. 6 in.	451 ft. below Hartshorne.	H. H. Jackman.	Coal at 522 ft.; same hole as above.
10	22	29, NW. ¼ NW. ¼.	Mose Pearson.	Old working.	Sandstone roof. Coal, 1 ft. 2 in. to 1 ft. 6 in.	Hartshorne.	U. S. Geol. Survey.	
		1, NW. ¼.		Crop.	Coal, 6 in.	Hartshorne sandstone.	U. S. Geol. Survey.	
		5, NW. ¼.		Old working.	Coal, 1 ft. 6 in. to 1 ft. 8 in.	Hartshorne.	Citizen.	
		6, SW. ¼.	Madison mine.	Shaft, 21 ft.	Coal, 1 ft. 8 in. Parting, 7 in. Coal, 8 in.	Hartshorne.	Madison.	
		7, NW. ¼.	Garner.	Shaft.	Coal, 2 ft. 1 in. Parting. Coal, 1 ft.	Hartshorne.	Garner.	

9	22	8, E. ½.		Crop.	Coal, 9 in. Shale, 5 in. Coal, 7 in.	Hartshorne.	U. S. Geol. Survey.	
		9, SW. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		16, NW. ¼.		Prospect.	Coal, 5 in. Bony coal, 2 ft. 1 in. Sandstone, 5 in. Bone, 1 ft.	Hartshorne.	U. S. Geol. Survey.	
		20, SE. ¼ NE. ¼.		Prospect.	Coal; no record.	Charleston.	U. S. Geol. Survey.	
		25, W. ½.		Prospect.	Coal; no record.	Charleston.	Citizen.	
		30, NE. ¼.		Crop.	Coal, 10 in.	Charleston.	U. S. Geol. Survey.	
8	22	36, S. ½.		Well.	Coal; no record.	Hartshorne.	Citizen.	
9	21	22, SW. ¼.		Crop.	Coal.	About 1,000 ft. below Hartshorne.	U. S. Geol. Survey.	Blossom.
8	21	SE. part of township.			Coal.		Citizen.	Reported on Joe Loss's place.
6	21	15, SW. ¼.		Well.	Coal; no record.	About 1,000 ft. below Hartshorne.	Citizen.	
		27, NW. ¼.		Well.	Coal; no record.	About 1,000 ft. below Hartshorne.	Citizen.	
		33, SE. ¼.		Well.	Coal; no record.	About 1,000 ft. below Hartshorne.	Citizen.	

Table of mines, openings, and exposures of coal—Continued.

Location.			Name of opening.	Kind of exposure.	Section of coal bed.	Stratigraphic horizon.	Examined or reported by—	Remarks.
T.N.	R.W.	Section.						
6	21	34, E. ½.		Crop.	Coal, 1 ft. 6 in. to 1 ft. 8 in.	About 1,000 ft. below Hartshorne.	U. S. Geol. Survey.	
		35, NW. ¼ NW. ¼.		Drill hole, 300 ft.	Coal, 8 in. Shale, 2 in. Coal, 1 ft. 8 in.	About 1,000 ft. below Hartshorne.	Citizen.	
		35, W. ½.		Drill hole, 80 ft.	Coal, 8 in. Shale, 2 in. Coal, 1 ft. 8 in.	About 1,000 ft. below Hartshorne.	Citizen.	
8	20	20 SW. ¼.		Old drift.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		28, NW. ¼.	Humphrey-Smith Coal Co.	Shaft, 38 ft.	Shale roof. Coal, 2 ft. 4 in.	Hartshorne.	Humphrey.	
		29 NW. ¼.		Prospect.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		30.		15 or 20 openings.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	Coal is shallow.
		30 SW. ¼.	Ouita Coal Co.	Shaft.	Coal, 2 ft. 2 in.	Hartshorne.	U. S. Geol. Survey.	
		17, SW. ¼.		Old shaft, 60 ft.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	
		18, SE. ¼.		Old slope.	Coal; no record.	Hartshorne.	U. S. Geol. Survey.	

		21, N. ½.	Southern Anthracite Coal Co.	Slope.	Shale roof. Coal, 8 in. to 10 in. Parting, 6 in. to 10 in. Coal, 1 ft. 10 in. to 2 ft. 2 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	
		21, SW. ¼ NE. ¼.	Southern Anthracite Coal Co.	Shaft, 480 ft.	Section same as next above.	Hartshorne.	U. S. Geol. Survey.	
7	20	22, NW. ¼.	Russellville Anthracite Coal Co.	Shaft, 70 ft.	Shale roof. Coal, 8 in. to 10 in. Parting, 6 in. to 10 in. Coal, 1 ft. 10 in. to 2 ft. 2 in. Sandstone floor.	Hartshorne.	U. S. Geol. Survey.	
		22, E. ½.	Russellville Anthracite Coal Co.	Slope.	Same section as next above.	Hartshorne.		
		25, SE. ¼.		Old shaft.	Coal; no record.	Below Hartshorne.	Citizen.	
		27, SW. ¼.		Crop.	Coal.		Citizen.	Blossom.
		28, NE. ¼.		Crop.	Coal.	Hartshorne.	U. S. Geol. Survey.	Blossom.
		29, SE. ¼.		Crop.	Coal.	Below Hartshorne.	Citizen.	Blossom.
		35, SW. ¼.		Crop.	Coal.		Citizen.	Blossom.
		36, SW. ¼.		Prospect.	Coal, 1 ft.	Below Hartshorne.	U. S. Geol. Survey.	

INDEX.

CLASSIFICATION OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 326.]

The publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists can be had on application.

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