

STATE OF ARKANSAS
Arkansas Geological and Conservation Commission
Norman F. Williams, Geologist-Director

INFORMATION CIRCULAR No. 20-B

GEOLOGY OF PARIS QUADRANGLE, LOGAN COUNTY, ARKANSAS

By
Boyd R. Haley
U. S. Geological Survey



Prepared by the U. S. Geological Survey in cooperation with the
Arkansas Geological and Conservation Commission

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GEOLOGY OF PARIS QUADRANGLE, LOGAN COUNTY, ARKANSAS

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ABSTRACT

The Paris quadrangle, Logan County, Arkansas, covers an area of approximately 61 square miles between 35°15'00" and 35°22'30" north latitudes and 93°37'30" and 93°45'00" west longitudes.

Sedimentary rocks of Pennsylvanian and Quaternary ages are exposed at the surface, and sedimentary rock of Devonian, Mississippian, and Pennsylvanian ages have been penetrated by wells drilled in or near the Paris quadrangle.

In the northern part of the quadrangle the structure of the rocks is characterized by broad east-west trending gently dipping folds interrupted in places by generally parallel high-angle normal faults. The fault planes trend east-west and dip northward or southward. In the southern part of the quadrangle the structure consists of a large asymmetrical east-west trending anticline that is overturned and broken by a thrust fault along the axis of folding near the west edge of the mapped area.

Coal beds are present in the Atoka, Hartshorne, McAlester, and Savanna formations of Pennsylvanian age but only the Paris coal bed in the upper part of the Savanna formation has been mined. All the coal mined in the Paris quadrangle is of low-volatile bituminous rank, but the coal in the extreme eastern part of the quadrangle is assumed to be semianthracite. Coal produced from, and lost in mining of, the Paris coal bed in the Paris quadrangle amounts to an estimated 5,649,000 short tons. Approximately 2,606,000 short tons of coal remain in the unmined part of the Paris coal bed in the Paris quadrangle.

A commercial quantity of natural gas was discovered by a well in the northwestern part of the quadrangle. The gas was found in the basal sandstone unit of the Atoka formation. Additional natural gas is probably present in the northwestern part of the quadrangle, and may be present along anticlines in the east-central and southern parts.

Building stone can be obtained from the Atoka and Hartshorne formations, road metal from the Atoka, Hartshorne, McAlester, and Savanna formations and from the more gravelly part of the river terraces, and gravel, sand, and clay can be obtained from the river alluvium.

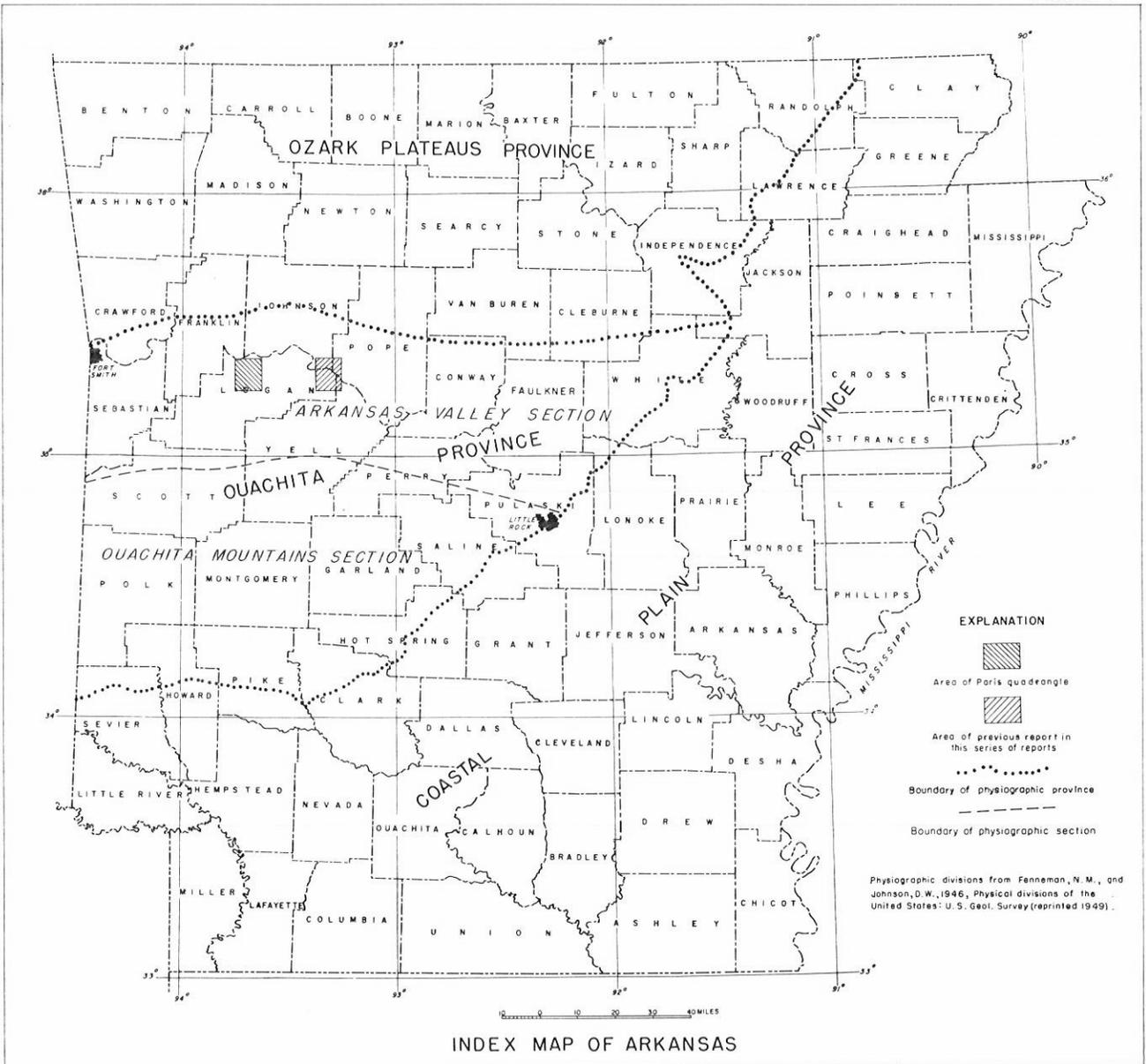
INTRODUCTION

This report on the geology of the Paris quadrangle, Arkansas, is one in a series of reports being prepared by the U. S. Geological Survey in cooperation with the Arkansas Geological and Conservation Commission. It has been prepared to: (1) provide a geologic map of a quadrangle, (2) show extent, thickness, and quality of coal beds in the quadrangle, and evaluate the reserves of coal, (3) provide surface and subsurface

geologic data and interpretations relevant to the location of deposits of petroleum and natural gas, and (4) provide information pertaining to building stone, sand, gravel, and clay.

The Paris quadrangle, Logan County, Arkansas, is between 35°15'00" and 35°22'30" north latitudes and 93°37'30" and 93°45'00" west longitudes, and it covers an area of approximately 61 square miles (fig. 1).

FIGURE 1



INDEX MAP OF ARKANSAS

FIGURE 1—INDEX MAP OF ARK.

Paris, in the southwestern part of the quadrangle, is the county seat of Logan County and has a population of about 3,800. Subiaco is in the southeastern part of the quadrangle, and it has a population of about 200. Arkansas State Highway 22 crosses the quadrangle through Paris and Subiaco, State Highway 109 enters Paris from the southwest, and Magazine Mountain Highway enters Paris from the southeast. U. S. Forest Service, county, and private roads branching from these highways permit easy access to most parts of the quadrangle. The Missouri-Pacific Railroad has a line into Paris from the west.

Soil creep is particularly active in parts of the Paris quadrangle. The downhill movement of the soil on the north side of the Pine Ridge anticline has altered the position and attitude of the outcropping sandstone units in the Atoka formation to such an extent that the bedrock cannot be mapped. The effect of soil creep on bedrock can be observed in exposures along the south side of State Highway 109 northwest of the horseshoe bend in the SW $\frac{1}{4}$ sec. 13, T. 7 N., R. 26 W.

Elevations in the quadrangle range from about 340 feet above sea level in the east-central part along the Arkansas River to about 1,300 feet above sea level in the southeastern part.

Geologic features in the quadrangle were mapped on aerial photographs at a scale of approximately 1:20,000. Contact lines, strike and dip symbols, and other geologic annotations were placed on the photographs by inspection

and later were transferred from the aerial photographs to a previously prepared planimetric base (scale 1:20,000) by means of a radial planimetric plotter and a reflecting projector. The base map was made from the aerial photographs using radial plotting methods. Control for the map is provided by U. S. Coast and Geodetic Survey triangulation stations Tanyard, Carroll, Subiaco, and Pine Hill.

Several earlier geologic reports relate to the area of the Paris quadrangle. Collier (1907) and Croneis (1930) discussed the regional geology, and information given in their reports helped guide the present investigations. Hendricks, Dane, and Knetchel (1936) and Hendricks (1937) established the stratigraphic nomenclature of rocks of Atoka and younger age in Arkansas. Hendricks and Parks (1950) mapped in detail these rocks in the Fort Smith district, Arkansas. The Paris quadrangle includes about 12 square miles of the eastern part of the Fort Smith district, and the rock units as mapped in the Paris quadrangle are the same as or equivalent to the rock units mapped by Hendricks and Parks (1950, pl. 13).

E. A. Merewether, U. S. Geological Survey, assisted in the field work during 1958. N. F. Williams, Arkansas Geological and Conservation Commission, reviewed this report. B. W. Miller, Gulf Oil Corp., and C. W. Couser, Carter Oil Co., provided rock samples and electrical logs from the two wells studied in the vicinity of the Paris quadrangle. The writer thanks these men for their help.

STRATIGRAPHY

Rocks of Pennsylvanian and Quaternary ages are exposed at the surface (pl. 1), and rocks of Devonian, Mississippian, and Pennsylvanian ages have been penetrated by wells drilled in or near the area of the Paris quadrangle. These rocks, except those of Quaternary age, are described in detail in the appendix of this report and are shown graphically on plate 2.

The Quaternary rocks are stream and river terrace deposits of Pleistocene age (Hendricks and Parks, 1950, p. 78) and alluvium of Recent age.

The rock units known or thought to be present in or near the Paris quadrangle, their geologic age, and their stratigraphic relations are shown graphically in the table on plate 2.

Stratigraphic terminology used in this report for the Pennsylvanian rocks in the Paris quad-

rangle is the terminology used by Merewether and Haley (1960) in their report, "Geology of Delaware quadrangle, Logan County and vicinity, Arkansas." The pre-Pennsylvanian stratigraphic terminology corresponds to that of Frezon and Glick (1959), Henbest (1953), Croneis (1930), or Miser (1920).

Rocks present in the subsurface in and near the Paris quadrangle were studied by examining and logging the rock cuttings from two wells, the Gulf Oil Corp. No. 1 Raymond Hembree well in the northwestern part of the quadrangle in sec. 13, T. 8 N., R. 26 W., and the Carter Oil Co. (T. H. Barton) No. 1 H. B. McVay well 6 miles west of the quadrangle in sec. 22, T. 7 N., R. 27 W.

Rock units penetrated by the Gulf Oil Corp. No. 1 Hembree well below a depth of 7,812 feet were logged without the information afforded

by an electrical log. The well was drilled by rotary methods with a circulating mud fluid and hence the samples were contaminated with fragments of younger rock. Depths of rock samples as recorded by the driller were about 20 feet too great in the interval 7,595 feet to 7,812 feet because of the time taken for samples to reach the surface. The same discrepancy in recorded depth is assumed for the interval 7,812 to 8,078 feet (total depth) and depths of rock units logged below the 7,812 feet are corrected accordingly.

A normal fault is known to be present in the Hembree well and, according to the writer's interpretation of the sample data, it is in the interval above the highest samples recognizable as from the Chattanooga shale (7,962 feet) and below the lowest samples recognizable as from the Cane Hill member of the Hale formation (7,915 feet). Abundant fragments of slickensided shale come from the interval 7,920 to 7,930 feet and these fragments probably represent the shear zone of the fault at a depth of 7,925 feet (pls. 2 and 3). It is possible that the fault is deeper in the well than 7,925 feet; however, the fault cannot be deeper than the top of the Penters chert at a depth of 8,028 feet.

DEVONIAN SYSTEM

Penters Chert

The Penters chert was named by Miser (1920, p. 98). According to Croneis (1930, p. 36 and 37) and Frezon and Glick (1959, p. 178), the Penters chert in northern Arkansas unconformably overlies formations ranging in age from Middle Ordovician to Silurian, and is unconformably overlain by the Chattanooga shale of Devonian and Mississippian age or by the Boone formation of Mississippian age. The Penters chert was found only in the Hembree well in the Paris quadrangle (pl. 3), and the Hembree well penetrated only 30 feet into the formation; therefore the thickness and lithology of underlying rocks in the quadrangle could not be determined. Rocks of Silurian age underlie the Penters chert to the north in Franklin, Johnson, and Pope Counties (Sheldon, 1954, p. 64, 82, 99, 102, 131, and 138). The Penters chert, in the area of the Hembree well, is overlain by rocks interpreted by the writer as the Sylamore sandstone member of the Chattanooga shale.

That part of the Penters chert penetrated by the Hembree well (see Appendix) consists of very light gray to dark-gray dense to granular translucent chert that is slightly limy to limy in part, pyritic in part, and slightly dolomitic in

part; it contains widely scattered fine euhedral crystals of clear quartz and well-rounded fine- to medium-grained quartz sand. Frezon and Glick (1959, pl. 24) estimate a thickness of at least 150 feet for the Penters chert in the vicinity of the Hembree well.

DEVONIAN AND MISSISSIPPIAN SYSTEMS

Chattanooga Shale

Frezon and Glick (1959, p. 178) describe the Chattanooga shale of northern Arkansas as "the sequence of black carbonaceous fissile shale and thin basal sandstone that occupies the stratigraphic interval between the Penters chert and Boone formation and includes rocks of both Devonian and Mississippian age." The Chattanooga shale in the area of the Hembree well overlies the Penters chert with a contact that presumably is unconformable, and underlies a limestone called the undifferentiated Boone and Moorefield formations in this report. The exact nature of the upper contact of the Chattanooga shale is unknown in the area of this report, but elsewhere in Arkansas it is unconformable in some areas (Frezon and Glick, 1959, p. 178).

The rocks identified as the Chattanooga shale, where penetrated by the Hembree well, consist of grayish-black pyritic shale, with a bed of silty limy very fine to fine-grained sandstone at the base tentatively identified as the Sylamore sandstone member. The Chattanooga shale is 66 feet thick in the Hembree well.

MISSISSIPPIAN SYSTEM

Boone and Moorefield Formations Undifferentiated

Overlying the Chattanooga shale in the Hembree well is a unit 37 feet thick of grayish-black to black shale, dark-gray limy siltstone, medium- to dark-gray silty oolitic limestone, and dark-gray very silty limestone. The lithology of this unit suggests two possibilities. (1) The unit is the Moorefield formation, and the Boone formation, which in other areas underlies the Moorefield, is absent because of nondeposition or pre-Moorefield erosion. The lithology in many ways is similar to that of the Moorefield formation (Sheldon, 1954, p. 64, 82, 99, 102, 131, and 138). Frezon and Glick (1959, pl. 27) show a southward thinning of the Boone formation. (2) The unit is the Boone formation; the lithology has changed from limestone and chert in the Ozark region to shale, siltstone, and limestone in the area of the Paris quadrangle. Frezon and Glick (1959, pl. 27) show a southward increase in the

secs. 14, 15, 16, and 17, T. 7 N., R. 25 W.), and (7) breached anticline (along Pine Ridge anticline, secs. 14 and 15, T. 7 N., R. 26 W.).

The larger streams in the Paris quadrangle may be classified as a combination of the following stream types: superposed—a stream that has maintained a previous existing course through one or more periods of uplift and erosion; subsequent—a stream that has a course determined by the relative softness of the bedrock and by the structure of the bedrock; and obsequent—a stream that extends its course headward against the dip of the rock.

The Arkansas River (now flowing north of the quadrangle) is a combined superposed and subsequent stream. Gum Creek (secs. 20 and 21, T. 7 N., R. 25 W.) is an obsequent stream in its lower part that has captured a west-flowing subsequent stream in sec. 21, T. 7 N., R. 25 W., so that it is now a combined obsequent and subsequent stream. Short Mountain Creek has some of the characteristics of a superposed stream in that it flows across structure in secs. 2, 11, and 14, T. 7 N., R. 26 W., and in secs. 19 and 20, T. 7 N., R. 25 W. However, an abandoned channel in sec. 19, T. 7 N., R. 25 W., (one-half mile west of present channel), the westward flow in sec. 18, T. 7 N., R. 25 W., and sec. 13, T. 7 N., R. 26 W., and the northwestward flow in sec. 34, T. 8 N., R. 26 W., are evidence that the course of Short Mountain Creek locally has been affected by the structure of the rocks and hence the stream at these places is a subsequent stream.

The Arkansas River has cut across the northwest part of the quadrangle at two different

levels as shown by the river terrace deposit in sec. 25, T. 8 N., R. 26 W., and sec. 30, T. 8 N., R. 25 W., and by the river alluvial deposits in the present flood plain.

The two arcuate areas of alluvium in the west-central and central part of the quadrangle may represent abandoned alluviated valleys of lower Short Mountain Creek. Probably Short Mountain Creek was an overloaded stream during late Pleistocene and early Recent time and therefore alluviated its valley and tributary valleys to the extent that some, if not all, of the water left the original channel and cut the now abandoned ones. Regional uplift, lowering of base level of the Arkansas River, and less water or smaller load in Short Mountain Creek are possible factors that led to the return of Short Mountain Creek to its original channel. It is possible but it seems less likely that these widespread deposits of alluvium are the result of aggradation of the local streams brought about by a rise in the level of the Arkansas River.

Changes in the drainage pattern of upper Short Mountain Creek are shown by the extent of terrace and alluvial deposits in the southern part of the area. A large alluvial fan, now eroded into two parts, was deposited by Short Mountain Creek in secs. 17, 18, 19, 20, and 21, T. 7 N., R. 26 W. This alluvial fan acted as a natural dam to the streams draining the area east of Short Mountain Creek. These streams, and perhaps part of the water in Short Mountain Creek, flowed eastward and deposited the alluvium that now extends across the drainage divided in secs. 14 and 15, T. 7 N., R. 25 W. The water later resumed its westward flow through a breach in the deposit in sec. 17, T. 7 N., R. 25 W.

ECONOMIC GEOLOGY

COAL

Coal beds are present in the Atoka, Hartshorne, McAlester, and Savanna formations, but only the Paris coal bed in the upper part of the Savanna formation has been mined. The outcrops of all known coal beds are shown on plate 1 and the outcrops and location and thickness of all known exposures of coal are shown on plate 4.

The coal in the western part of the Paris quadrangle is of low-volatile bituminous rank and the coal in the extreme eastern part of the quadrangle is assumed to be semianthracite (Haley, 1960) based on the percentage of dry, mineral-matter-free fixed carbon in the coal as specified by the American Society for Testing Materials (1954). The approximate dividing

line between the area of low-volatile bituminous coal and the area of semianthracite (Haley, 1960, pl. 62) is shown on plate 4. Analyses of coal samples located in or near the area of the Paris quadrangle are given in table 1.

Coal Beds in the Atoka Formation

Coal beds in the Atoka formation are thin, generally high in ash content, and of small extent. Coal beds two feet, one foot, and one foot thick were penetrated by the Hembree well at depths of 1,860 feet, 2,305 feet, and 2,977 feet, respectively. The coal bed at a depth of 1,860 feet may be equivalent to a coal bed seven inches thick exposed in a ditch northwest of the junction of State Highway 190 and old State High-

Table 1.—Analyses of coal samples of the Paris coal bed in or near Paris quadrangle, Logan County, Arkansas

[Form of analyses: 1, as-received; 2, moisture-free; 3, moisture- and ash-free. Source of data: 1—Fieldner, A. C., Cooper, H. M., and Osgood, J. N., 1928, U. S. Bureau of Mines Technical Paper 416, p. 10, table 4; 2—U. S. Bureau of Mines coal-analysis reports]

Approximate location	Sample locality (pl. 4)	Type of sample	Bureau of Mines Laboratory no.	Form of analyses	Moisture	Proximate analysis			Ultimate analysis			Heating value (Btu)	Ash softening temperature (°F)	Source of data			
						Volatiles	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen				
						matter											
Center north line SE $\frac{1}{4}$ sec. J	J	Mine	18750	1	2.5	17.1	70.6	9.8	3.3	—	—	—	—	13,500	2,130	1	
			18751	1	2.4	17.3	70.4	9.9	3.1	—	—	—	—	—	13,570	2,140	1
			18752	1	2.5	17.1	70.5	9.9	3.2	—	—	—	—	—	13,570	2,160	1
2. T. 7 N., R. 26 W.	J	Composite of above samples	18753	1	2.4	17.2	70.4	10.0	3.2	4.2	78.0	1.5	3.1	13,520	—	1	
				2	—	17.7	72.0	10.3	3.3	4.0	79.9	1.6	.9	13,860	—	1	
				3	—	19.7	80.3	—	—	3.7	4.5	89.0	1.7	1.1	15,440	—	1
Center north line SE $\frac{1}{4}$ sec. 27, T. 8 N., R. 26 W.	K	Tipple	56395	1	1.5	18.0	73.5	7.0	1.4	—	—	—	—	14,180	2,500	2	
				2	—	18.3	74.6	7.1	1.4	—	—	—	—	—	14,390	—	2
				3	—	19.7	80.3	—	—	1.5	—	—	—	—	15,500	—	2
SW corner SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 9, T. 7 N., R. 26 W	do	do	56359	1	1.8	18.0	71.4	8.8	2.4	—	—	—	—	13,890	2,410	2	
				2	—	18.3	72.7	9.0	2.5	—	—	—	—	—	14,140	—	2
				3	—	20.1	79.9	—	—	2.7	—	—	—	—	15,530	—	2
Center east line SW $\frac{1}{4}$ sec. 29, T. 8 N., R. 26 W.	do	do	57792	1	2.1	17.1	72.7	8.1	2.0	—	—	—	—	14,000	2,350	2	
				2	—	17.5	74.2	8.3	2.0	—	—	—	—	—	14,310	—	2
				3	—	19.0	81.0	—	—	2.2	—	—	—	—	15,600	—	2

way 109 in sec. 22, T. 7 N., R. 26 W. A coal bed one foot thick was penetrated by the McVay well at a depth of 2,713 feet.

Coal Beds in the Hartshorne Sandstone

A coal zone 2 feet thick at the base of the Hartshorne sandstone is exposed in a road cut along Magazine Mountain highway in sec. 21, T. 7 N., R. 25 W. The coal zone interfingers with the basal sandstone unit of the Hartshorne sandstone. A coal bed 10 inches thick is at the base of the Hartshorne along Short Mountain Creek in sec. 29, T. 7 N., R. 25 W.

Coal Beds in the McAlester Formation

Coal beds in the McAlester formation are not exposed in the Paris quadrangle. The Lower Hartshorne coal bed, which is near the base of the McAlester formation elsewhere in Arkansas, is presumed to be present in the quadrangle, although coal was not found in the rock samples from the Hembree well. Haley (1960, pl. 59) shows the Lower Hartshorne coal bed to be less than 14 inches thick in the area of the Paris quadrangle.

Coal Beds in the Savanna Formation

At least six coal beds are present in the Savanna formation. Most of these are thin and have not been mined. A coal bed 2 inches thick exposed at the Paris city dump in sec. 12, T. 7 N., R. 26 W., is thought to be the Charleston coal bed as mapped by Hendricks and Parks (1950, pl. 13). A coal zone mapped in secs. 14, 15, 16, and 21, T. 8 N., R. 25 W., consists of two coal beds about 20 feet apart. The upper coal bed is less than 4 inches and the lower coal bed is less than 1 foot 3 inches thick. One or both of these coal beds may be equivalent to the Charleston coal bed.

The Paris coal bed is the thickest and most extensive coal bed in the Savanna formation. In the Paris quadrangle it ranges in thickness from 19 to 32 inches, and is covered by less than 250 feet of overburden. It underlies an area of 2,540 acres in the Paris quadrangle and, prior to the start of mining before 1860 (Owen, 1860, p. 85), contained an estimated reserve of 8,255,000 short tons of coal. Mining has been done in an area of 1,690 acres and an estimated 5,649,000 short tons of coal has been mined or lost in mining. Probably less than 20 percent of the remaining 2,606,000 short tons of coal can be recovered because of inaccessibility of the coal or because the coal is in barrier pillars between mines. The thickness of the coal bed, the amount of overburden, and the mined areas are shown on plate 4.

OIL AND GAS

Oil has not been discovered in or near the area of the Paris quadrangle; however, the more likely reservoir rocks, particularly those of Ordovician age, have not been tested. Natural gas has been discovered in rocks of Atoka and Morrow ages and these rocks are the principal targets of those drilling for oil and gas in the Arkansas Valley.

A show of natural gas was encountered in the Hembree well at a depth of 2,079 feet and a commercial quantity was discovered at a depth of 7,274 to 7,288 feet in the basal sandstone of the Atoka formation, a source of much of the gas produced elsewhere in Arkansas. Rocks of Morrow age do not contain gas in the Hembree well. The rocks of Morrow age and the basal sandstone of the Atoka are the major sources of the gas produced from the Aetna gas field, on the Aetna anticline 7 miles west of the Hembree well. The Hembree well is located on what appears to be an eastward extension of the Aetna anticline, but producing capacity is much less than the producing capacity of the wells in the Aetna gas field. Twelve wells in the Aetna gas field have producing capacities ranging from 3.0 million cubic feet per day to 21.5 million cubic feet per day and averaging 10.0 million cubic feet per day. The Hembree well has a production capacity of 0.8 million cubic feet per day. This relatively small producing capacity may be attributed to either of the following factors: (1) the lithology, initial porosity and permeability of the reservoir rocks may differ; or (2) the initial porosity and permeability of the reservoir rock has been altered by the fault in the Hembree well.

If large reserves of gas are present in the northern part of the Paris quadrangle, their location and size are controlled to a great extent by faulting. The location, extent, and trend of the faults and their effect upon the structure of the rocks, in or near the northern part of the Paris quadrangle, should be determined by a shallow-hole drilling program or by a seismic survey prior to drilling wells for gas.

Commercial reserves of natural gas may be present along Pine Ridge anticline in the southern part of the Paris quadrangle. A small show of gas was encountered in the Carter Oil Co. (Barton) No. 1 H. B. McVay well (sec. 22, T. 7 N., R. 27 W.) on the Pine Ridge anticline about 6 miles west of the quadrangle. On the same anticline about 20 miles east of the quadrangle the Shell Oil Co. No. 1 T. V. Jones well (sec. 19, T. 7 N., R. 21 W.) encountered 333,000 cubic feet of gas per day. Wells drilled for gas along the Pine

Ridge anticline should be located south of the surface trace of the anticlinal axis inasmuch as the axial plane probably dips southward because of the asymmetry of the anticline.

Gas may be present along the Prairie View anticline in the Paris quadrangle. Gas was produced at a rate of 88,000 cubic feet per day from the Western Natural Gas Co. No. 1 R. Gray well (sec. 25, T. 8 N., R. 24 W.) on this anticline about 8 miles east of the quadrangle. The Prairie View fault may have affected the location and quantity of gas present along the Prairie View anticline, however, by providing a means of escape for the gas and by altering the porosity and permeability of the reservoir rocks near the fault zone.

In the area of this report, most of the reservoir rocks and lateral changes in porosity and permeability within these reservoir rocks are important factors in controlling the accumulation of gas. Therefore, a dry hole on a structure is not proof that the structure does not contain gas nearby. Gas might be found at a structural low position on the flank of the structure.

BUILDING STONE

Slabs and blocks of weathered sandstone from the Atoka formation are used as flagstones and as exterior finish on some buildings in and near

the quadrangle. Most of this stone is float debris from the sandstone outcrops. Some stone was quarried in sec. 28, T. 7 N., R. 26 W.

The Hartshorne sandstone, a source of excellent quality building stone elsewhere in Arkansas, is not quarried in the Paris quadrangle. Good quality building stone in the Hartshorne is exposed in sec. 10, T. 7 N., R. 25 W., and sec. 14, T. 7 N., R. 26 W.; however, the steep dip of the Hartshorne sandstone in these areas prohibits large-scale quarrying.

ROAD METAL

Stone suitable for road metal has been quarried and crushed from sandstone units in the Atoka formation and could be obtained from sandstone units in the Hartshorne, McAlester, and Savanna formations. Shale from the Atoka and McAlester formations has been used as road metal. The more gravelly part of the river terrace in sec. 25, T. 8 N., R. 26 W., has been used as a base in some unpaved roads.

GRAVEL, SAND, AND CLAY

Abundant deposits of sand and gravel are present in the river alluvium and in the river terrace. Deposits of clay are also present in the river alluvium.

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APPENDIX

The surface and subsurface stratigraphic sections described below are shown graphically on plate 2 and their locations (except the McVay well) are shown on plate 1. The surface sections are keyed to the plates by letters and the subsurface section (Hembree well) by an arabic numeral. The surface sections were described from outcrops. The subsurface sections were described by examining drill cuttings with a binocular microscope and by comparing the descriptions with the electrical log of each well.

The colors given in the descriptions below are the colors shown on the Rock Color Chart issued by the National Research Council. The grain sizes accord with the Wentworth grade scale. Each stratigraphic section is arranged so that the youngest or stratigraphically highest rock unit is described first.

The technique used in examining and logging drill cuttings and describing rock units is given by Maher (1959).

SURFACE STRATIGRAPHIC SECTIONS

SECTION A			19.8	92.0-111.8	Shale, dark-gray, very finely micaceous, beds as much as ¼ in. thick; 2 in. thick bed of dark-gray siltstone 15 ft. from base
Old Highway 109 section			1.1	111.8-112.9	
Sec. 17, T. 7 N., R. 26 W., Logan County, Arkansas			12.9	112.9-125.8	Siltstone, medium-gray, irregularly bedded, beds as much as 1½ in. thick; and ⅛ in. thick beds of dark-gray, very finely micaceous shale in uppermost 1 ft. 9 in.
Thickness in feet	Interval in feet	Description Pennsylvanian system			
28.1	0- 28.1	Shale, dark-gray, silty; siltstone, dark-gray; and sandstone, dark-gray, very fine grained, very silty, 7 in. thick, 13 ft. 6 in. from base			
14.7	28.1- 42.8	Sandstone, dark-gray, very fine grained, very silty, well-cemented, irregularly bedded, beds as much as 6 in. thick; and siltstone, dark-gray, irregularly bedded, beds as much as ¼ in. thick	16.8	125.8-142.6	Shale, dark-gray; and siltstone, dark-gray; ironstone concretions as much as 2 in. in diameter in upper 2 ft. 5 in.
26.7	42.8- 69.5	Shale, dark-gray, silty, beds as much as ¼ in. thick; and siltstone, dark-gray, irregularly bedded, beds as much as ¼ in. thick	11.7	142.6-154.3	Shale, dark-gray, very finely micaceous; beds as much as ¼ in. thick
9.4	69.5- 78.9	Siltstone, dark-gray, finely micaceous; shale, dark-gray, silty, finely micaceous; and sandstone, dark-gray, very fine grained, silty, finely micaceous, well-cemented	156.2	154.3-310.5	Shale, dark-gray, very finely micaceous
0.3	78.9- 79.2	Sandstone, dark-gray, very fine grained, silty, finely micaceous, well-cemented	0.6	310.5-311.1	Coal
0.4	79.2- 79.6	Shale, dark-gray, silty, beds as much as ⅛ in. thick	0.8	311.1-311.9	Underclay, light-gray; ironstained red where weathered
0.7	79.6- 80.3	Sandstone, dark-gray, very fine grained, very silty, well-cemented, irregularly bedded	7.9	311.9-319.8	Shale, dark-gray, very finely sandy in part, beds as much as 1 in. thick
10.3	80.3- 90.6	Shale, dark-gray, very finely micaceous	21.7	319.8-341.5	Sandstone, light-gray, fine-grained, finely micaceous, irregularly bedded, ripple-marked, beds as much as 8 in. thick
1.4	90.6- 92.0	Siltstone, dark-gray, very finely micaceous, irregularly bedded, beds as much as 2 in. thick	5.6	341.5-347.1	Shale, dark-gray
			0.5	347.1-347.6	Sandstone, medium-gray, fine-grained, finely micaceous, ripple-marked
			1.2	347.6-348.8	Shale, dark-gray, white to very light gray where weathered
			10.7	348.8-359.5	Sandstone, medium-gray, fine-grained, silty, medium micaceous, irregularly bedded, beds as much as 6 in. thick

Thick- ness in feet	Interval in feet	Description Pennsylvanian system			
16.6	359.5-376.1	Shale, dark-gray, silty, finely mica- ceous, beds as much as ½ in. thick; siltstone, dark-gray, beds as much as 2 in. thick; and sandstone, dark- gray, very fine grained, very silty, beds as much as 2 in. thick	4.0	1065.6-1069.6	Shale, dark-gray, silty, finely micaceous, beds as much as 1½ in. thick
15.7	376.1-391.8	Shale, dark-gray, silty, finely mica- ceous, beds as much as ½ in. thick in units as much as 3 in. thick; and sandstone, medium- gray, fine-grained, scattered medi- um sand grains, irregularly bedded, beds as much as 3 in. thick	3.8	1069.6-1073.4	Shale, dark-gray, finely micaceous, beds as much as ¼ in. thick in units 2 in. thick; and sandstone, medium-gray, very fine to medi- um-grained, very silty, beds as much as 2 in. thick
6.8	391.8-398.6	Shale, dark-gray, silty, finely mica- ceous	69.9	1073.4-1143.3	Sandstone, light-gray, very fine grained, very silty, medium mica- ceous, ironstone concretions as much as 1½ in. in diameter in upper 7 ft., beds as much as 6 in. thick
12.2	398.6-410.8	Siltstone, light-gray, very finely sandy, finely micaceous	6.0	1143.3-1149.3	Sandstone, very light gray, very fine to fine-grained, medium mica- ceous, beds as much as 2 ft. thick
88.0	410.8-498.8	Sandstone, light-gray, very fine grained, very silty, finely mica- ceous, irregularly bedded, beds as much as 4 in. thick	15.0	1149.3-1164.3	Sandstone, light-gray, very fine grained, very silty, finely mica- ceous, irregularly bedded, beds as much as 10 in. thick
116.0	498.8-614.8	Covered interval	23.2	1164.3-1187.5	Sandstone, light-gray, very fine to fine-grained, medium micaceous, irregularly bedded, beds as much as 6 in. thick
9.0	614.8-623.8	Sandstone, light-gray, very fine grained, very silty, finely mica- ceous, irregularly bedded, beds as much as 10 in. thick	12.8	1187.5-1200.3	Sandstone, light-gray, very fine grained, very silty, medium mica- ceous, crossbedded, beds as much as 4 in. thick
61.3	623.8-685.1	Sandstone, light-gray, very fine grained, very silty, irregularly bedded, beds as much as 8 in. thick; and shale, dark-gray, silty, finely micaceous, beds as much as ¼ in. thick in units as much as 6 in. thick	34.0	1200.3-1234.3	Sandstone, medium - gray, very fine grained, very silty, medium micaceous, abundant macerated plant fragments, irregularly bed- ded, beds as much as 8 in. thick
20.6	685.1-705.7	Sandstone, light-gray, very fine grained, silty, finely micaceous, irregularly bedded, beds as much as 10 in. thick	22.0	1234.3-1256.3	Sandstone, medium - gray, very fine grained, very silty, finely to medium micaceous, abundant macerated plant fragments, ir- regularly bedded, beds as much as 6 in. thick; and siltstone, medi- um-gray, very finely sandy, finely micaceous, beds as much as 2 in. thick
2.2	705.7-707.9	Shale, dark-gray, silty, white to very light gray where weathered	10.3	1256.3-1266.6	Sandstone, light- to medium-gray, very fine grained, finely to medi- um, micaceous, irregularly bedded, beds as much as 8 in. thick; silt- stone, medium-gray, finely mica- ceous, irregularly bedded, beds as much as 2 in. thick; and shale, dark-gray, silty, beds as much as ½ in. thick
70.6	707.9-778.5	Sandstone, light-gray very fine grained, very silty, finely mica- ceous, irregularly bedded	8.9	1266.6-1275.5	Shale, dark-gray, silty, very fine- ly micaceous, beds as much as ¼ in. thick; and siltstone, medium- gray, very finely micaceous, in lenses as much as ½ in thick
216.0	778.5-994.5	Covered interval	21.3	1275.5-1296.8	Siltstone, medium- to dark-gray, very finely micaceous, beds as much as 2 in. thick; and shale, dark-gray, silty, very finely mica- ceous, beds as much as ½ in. thick in units as much as 2 in. thick
36.8	994.5-1031.3	Sandstone, light-gray, very fine to fine-grained, medium mica- ceous, ironstone concretions as much as 2 in. in diameter, irreg- ularly bedded, beds as much as 10 in. thick			
9.1	1031.3-1040.4	Sandstone, medium - gray, very fine grained, very silty, medium micaceous, beds as much as 4 in. thick			
1.3	1040.4-1041.7	Sandstone, light-gray, very fine to fine-grained, abundant ironstone concretions as much as 2 in. in diameter, irregularly bedded			
23.9	1041.7-1065.6	Sandstone, light-gray, fine-grain- ed, very silty, finely micaceous, irregularly bedded, beds as much as 2 in. thick; siltstone, medium- gray, irregularly bedded, beds as much as 2 in. thick; and shale,			

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
21.6	1296.8-1318.4	Shale, dark-gray, silty, very finely micaceous; and siltstone, medium-gray, very finely micaceous, in lenses as much as 2 in. thick
5.4	1318.4-1323.8	Shale, dark-gray, silty, very finely micaceous, beds as much as ½ in. thick
10.8	1323.8-1334.6	Shale, dark - gray, very finely micaceous, beds as much as ¼ in. thick
7.8	1334.6-1342.4	Shale, dark-gray, silty, very finely micaceous; and siltstone, dark-gray, in lenses as much as ½ in. thick
17.5	1342.4-1359.9	Shale, dark - gray, very finely micaceous, beds as much as ¼ in. thick
26.2	1359.9-1386.1	Shale, dark-gray, silty, very finely micaceous, beds as much as ¼ in. thick
16.5	1386.1-1402.6	Shale, dark - gray, very finely micaceous, beds as much as ¼ in. thick
SECTION B		
Short Mountain Creek section		
Sec. 14, T. 7 N., R. 26 W., Logan County, Arkansas		
Lower part of McAlester formation, and Hartshorne sandstone		
Lower part of McAlester formation		
64.2	0- 64.2	Sandstone, light- to medium-gray fine-grained, silty in upper 15 ft., finely to medium micaceous, widely scattered ironstone concretions as much as ½ in. in diameter, irregularly bedded, convolute bedded, crossbedded, beds from 2 to 10 in. thick
104.5	64.2- 168.7	Sandstone, medium-gray, very fine grained, silty, finely micaceous, irregularly bedded, cross-bedded, beds from 2 in. to 1 ft. 8 in. thick
308.0	168.7- 476.7	Covered interval; base of unit is base of McAlester formation
Hartshorne Sandstone		
88.9	476.7- 565.6	Sandstone, very light gray to white, very fine grained, finely to medium micaceous, well-cemented, irregularly bedded, convolute bedded in upper 15 ft., bedding from 1 in. to 1 ft. 8 in. thick
6.2	565.6- 571.8	Sandstone, light-gray, very fine grained, silty, finely to medium micaceous, crossbedded, beds from 1 in. to 1 ft. thick, upper 2 ft. is convolute bedded and contains beds as much as 1 in. thick of dark-gray shale and dark-gray silty shale
0.3	571.8- 572.1	Shale, dark-gray to grayish-black, beds from ⅙ to ¼ in. thick
0.6	572.1- 572.7	Sandstone, medium-gray, very fine grained, silty, finely micaceous, irregularly bedded, ripple-marked, beds from ⅙ to ½ in. thick
1.8	572.7- 574.5	Sandstone, light-gray, very fine grained, dark-gray shale pebbles as much as ¼ in. thick and 1 in. wide, ironstone concretions as much as ½ in. in diameter, one bed, crossbedded
2.6	574.5- 577.1	Shale, dark-gray; and sandstone, light- to medium-gray, very fine grained, in lenses from ½ to 1 in. thick
1.0	577.1- 578.1	Sandstone, light-gray, very fine to fine-grained, unit ranges from 4 in. to 1 ft. 4 in. in thickness, has a channel type contact with underlying shale
1.6	578.1- 579.7	Shale, dark-gray, beds from ⅙ to ¼ in. thick; and medium-gray siltstone and light-gray fine-grained sandstone, in lenses as much as 1 in. thick
6.3	579.7- 586.0	Sandstone, light-gray, very fine grained, slightly silty, finely micaceous, irregularly bedded, beds from 4 in. to 2 ft. 6 in. thick
21.9	586.0- 607.9	Sandstone, white to very light gray, fine-grained, scattered medium sand grains, finely micaceous, irregularly bedded, crossbedded, beds from 2 to 10 in. thick; base of unit is base of Hartshorne sandstone
SECTION C		
Paris Lake East Section		
Sec. 17, T. 7 N., R. 25 W., Logan County, Arkansas		
Lower part of McAlester formation, Hartshorne sandstone, and upper part of Atoka formation		
Lower part of McAlester formation		
20.0	0- 20.0	Sandstone, light-gray, very fine to fine-grained
146.0	20.0- 166.0	Covered interval; probably shale, dark-gray
59.9	166.0- 225.9	Shale, dark-gray, very finely micaceous; base of unit is base of McAlester formation
Hartshorne sandstone		
3.3	225.9- 229.2	Siltstone, medium-gray, very finely sandy, irregularly bedded, beds as much as 1 in. thick
1.7	229.2- 230.9	Sandstone, medium-gray, very fine grained, very silty, well-cemented, regularly bedded, beds as much as 8 in. thick
2.2	230.0- 233.1	Siltstone, medium-gray, very finely sandy, finely micaceous, ironstone concretions as much as ½ in. in diameter, irregularly bedded, beds as much as 1 in. thick

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
2.0	233.1- 235.1	Sandstone, medium-gray, very fine grained, very silty, finely micaceous, well-cemented, irregularly bedded, beds as much as 6 in. thick
3.0	235.1- 238.1	Shale, dark-gray, silty, finely micaceous, beds as much as ½ in. thick
11.8	238.1- 249.9	Sandstone, medium-gray, very fine grained, very silty, finely micaceous, dark-gray shale pebbles ¼ in. thick and 1½ in. wide, abundant macerated plant fragments, irregularly bedded, beds ¼ to 6 in. thick
38.0	249.9- 287.9	Sandstone, light- to medium-gray, very fine grained, very silty, crossbedded, beds as much as 6 ft. thick
2.2	287.9- 290.1	Shale, dark-gray, beds as much as ⅛ in. thick
5.8	290.1- 295.9	Sandstone, medium-gray, very fine grained, silty, finely micaceous, crossbedded; and shale, dark-gray, in lenses as much as 1 ft. 9 in. thick
20.8	295.9- 316.7	Shale, dark-gray, beds as much as ⅛ in. thick in units as much as 1 ft. 8 in. thick; and sandstone, medium-gray, very fine grained, silty, regularly to irregularly bedded, beds from 3 in. to 1 ft. thick; some sandstone beds overlie the shale beds with a channel-type contact
7.9	316.7- 324.6	Sandstone, light- to medium-gray, very fine grained, very silty, crossbedded, beds as much as 2 ft. thick
0.6	324.6- 325.2	Shale, dark-gray, very finely micaceous, beds as much as ⅛ in. thick
5.2	325.2- 330.4	Sandstone light-gray, very fine grained, silty, finely micaceous, crossbedded, beds as much as 1 ft. 6 in. thick
1.4	330.4- 331.8	Shale, dark-gray, slightly silty, very finely micaceous, beds as much as ¼ in. thick
16.4	331.8- 348.2	Sandstone, light-gray, very fine grained, silty, dark-gray shale pebbles ¼ in. thick and ½ in. wide, crossbedded, beds as much as 4 ft. thick
4.7	348.2- 352.9	Shale, dark-gray, silty; beds as much as ¼ in. thick in units as much as 10 in. thick; and sandstone, medium-gray, very fine grained, very silty, very finely micaceous, irregularly and lenticular bedded, ripple-marked, beds as much as 4 in. thick
6.5	352.9- 359.4	Sandstone, light- to medium-gray, very fine grained, silty, crossbedded, beds as much as 3 ft. thick
0.7	359.4- 360.1	Shale, dark-gray, very finely micaceous
0.3	360.1- 360.4	Siltstone, medium-gray, very finely sandy, irregularly bedded, beds as much as ¼ in. thick
3.0	360.4- 363.4	Sandstone, medium-gray, very fine grained, very silty, well-cemented, beds as much as 1 ft. 3 in. thick
7.1	363.4- 370.5	Shale, dark-gray, silty, beds as much as ¼ in. thick in units as much as 1 ft. 1 in. thick; and sandstone, medium-gray, very fine grained, very silty, very finely micaceous, ripple-marked, beds as much as 1 ft. 2 in. thick
7.9	370.5- 378.4	Sandstone, light-gray, very fine grained, crossbedded, beds as much as 3 ft. thick; and shale, dark-gray silty, very finely micaceous, in lenses as much as 3 in. thick
36.0	378.4- 414.4	Sandstone, light-gray, very fine grained, shale pebbles as much as ½ in. in diameter, plant impressions, convolute bedded, crossbedded, beds as much as 4 ft. thick
1.0	414.4- 415.4	Sandstone, light-gray, very fine grained, very silty, irregularly bedded, lenticular bedded, crossbedded overlies shale with channel-type contact; base of unit is base of Hartshorne sandstone
Upper part of Atoka formation		
3.0	415.4- 418.4	Shale, dark-gray, very finely micaceous, beds as much as ¼ in. thick
2.2	418.4- 420.6	Siltstone, medium-gray, very finely sandy, irregularly bedded, beds as much as 1 in. thick
20.0	420.6- 440.6	Shale, dark-gray, silty; and sandstone, very fine grained, medium-gray, very silty, in lense as much as 5 ft. thick near top of unit
4.4	440.6- 445.0	Sandstone, medium-gray, very fine grained, silty, even-bedded, beds as much as 10 in. thick
4.3	445.0- 449.3	Sandstone, light- to medium-gray, very fine grained, silty, abundant ironstone concretions in lower 1 ft 8 in., irregularly bedded, beds as much as 1 ft. 8 in. thick
280.0	449.3- 729.3	Covered interval
10.1	729.3- 739.4	Sandstone, medium-gray, very fine grained, very silty, finely micaceous, regularly bedded, beds as much as 8 in. thick
1.8	739.4- 741.2	Shale, dark-gray, silty, very finely micaceous
134.3	741.2- 875.5	Covered interval
31.2	875.5- 906.7	Shale, dark-gray, very finely micaceous

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
16.3	906.7- 923.0	Shale, dark-gray, finely micaceous, beds as much as 1/8 in. thick, and siltstone, medium-gray, finely micaceous, irregularly bedded, beds as much as 1 in. thick
3.6	923.0- 926.6	Sandstone, dark-gray, very fine grained, very finely micaceous, well-cemented, regularly bedded, beds as much as 6 in. thick
5.8	926.6- 932.4	Siltstone, medium-gray, very finely micaceous, irregularly bedded, beds as much as 1 in. thick
3.0	932.4- 935.4	Sandstone, medium-gray, very fine grained, silty, finely micaceous, irregularly bedded, beds as much as 10 in. thick
6.4	935.4- 941.8	Siltstone, medium- to dark-gray, irregularly bedded, beds as much as 2 in. thick
10.0	941.8- 951.8	Shale, dark-gray, very finely micaceous
0.6	951.8- 952.4	Sandstone, dark-gray, very fine grained, very silty, well-cemented
0.2	952.4- 952.6	Shale, dark-gray, very finely micaceous
0.4	952.6- 953.0	Sandstone, as above
10.8	953.0- 963.8	Shale, as above
0.3	963.8- 964.1	Sandstone, as above
27.2	964.1- 991.3	Shale, as above
3.7	991.3- 995.0	Shale, dark-gray, silty; and sandstone, medium-gray, very fine grained, very silty, very finely micaceous
14.0	995.0-1009.0	Sandstone, light-gray, very fine grained, very silty, abundant macerated plant fragments, beds 10 in. to 6 ft. thick; and shale, dark-gray, silty, in scattered lenses as much as 4 in. thick
2.4	1009.0-1011.4	Shale, dark-gray, silty, very finely micaceous; and siltstone, dark-gray, very finely micaceous; both rock types in beds as much as 1 in. thick
5.9	1011.4-1017.3	Sandstone, medium-gray, very fine grained, very silty, finely micaceous, abundant macerated plant fragments, beds as much as 2 ft. thick
4.7	1017.3-1022.0	Shale and siltstone, as above
2.9	1022.0-1024.0	Sandstone, light-gray, very fine grained, finely micaceous, irregularly bedded, beds as much as 1 ft. thick
0.8	1024.0-1024.8	Shale, dark-gray, silty, very finely micaceous
11.1	1024.8-1035.9	Sandstone, as above
6.5	1035.9-1042.4	Sandstone, medium-gray, very fine grained, very silty, very finely micaceous, irregularly bedded, crossbedded, beds as much as 1 ft. thick

5.7	1042.4-1048.1	Siltstone, medium-gray, very finely micaceous; and sandstone, medium-gray, very fine grained, very silty, very finely micaceous; both rock types are irregularly bedded and have beds as much as 2 in. thick
12.3	1048.1-1060.4	Shale, dark-gray, very finely micaceous; siltstone, medium-gray, very finely micaceous; and sandstone, medium-gray, very fine grained, very silty; siltstone and sandstone irregularly bedded, ripple-marked, and in beds as much as 3 in. thick
6.4	1060.4-1066.8	Sandstone, light-gray, very fine grained, silty, finely micaceous, pebbles of dark-gray shale as much as 1/4 in. thick, irregularly bedded, beds as much as 1 ft. thick
14.2	1066.8-1081.0	Sandstone, light- to medium-gray, very fine grained, silty, irregularly bedded, beds as much as 10 in. thick

SECTION D

Gum Creek section

Sec. 21, T. 7 N., R. 25 W., Logan County, Arkansas Upper part of Atoka formation

3.3	0- 3.3	Sandstone, light- to medium-gray, very fine grained, slightly silty, finely micaceous, crossbedded, beds as much as 8 in. thick
15.7	3.3- 19.0	Sandstone, medium-gray, very fine grained, well-cemented, convolute bedded
3.6	19.0- 22.6	Sandstone, medium-gray, very fine grained, finely micaceous, regularly bedded, beds 2 in. to 1 ft. 2 in. thick
13.6	22.6- 36.2	Sandstone, light- to medium-gray, very fine grained, silty, finely micaceous, irregularly bedded, beds 1 in. to 1 ft. 2 in. thick
40.7	36.2- 76.9	Sandstone, light- to medium-gray, very fine grained, silty, irregularly bedded, cross-bedded, beds 1 to 8 in. thick
7.8	76.9- 84.7	Sandstone, medium-gray, very fine grained, silty, finely micaceous, regularly bedded, ripple-marked, beds 2 to 10 in. thick
4.1	84.7- 88.8	Sandstone, medium-gray, very fine grained, very silty, finely micaceous, irregularly bedded, beds as much as 2 in. thick
10.0	88.8- 98.8	Sandstone, medium-gray, very fine grained, silty, finely micaceous; limonite pebbles as much as 1 1/2 in. in diameter, crossbedded, beds as much as 1 ft. 2 in. thick
0.8	98.8- 99.6	Shale, dark-gray, very finely micaceous, beds as much as 1/8 in. thick

Thick- ness in feet	Interval in feet	Description	
		Pennsylvanian system	
7.8	99.6- 107.4	Sandstone, medium-gray, very fine grained, silty, finely micaceous, crossbedded in part, beds as much as 6 in. thick	11.5 19.2- 30.7
1.2	107.4- 108.6	Shale, dark-gray, silty, finely micaceous, irregularly bedded, beds as much as 1/8 in. thick	
0.3	108.6- 108.9	Sandstone, medium-gray, very fine grained, silty, irregularly bedded	28.8 30.7- 59.5
0.8	108.9- 109.7	Shale, dark-gray, silty, beds as much as 1/4 in. thick	
3.6	109.7- 113.3	Sandstone, medium-gray, very fine grained, silty, finely micaceous, irregularly bedded, ripple-marked, beds as much as 10 in. thick	28.8 59.5- 88.3 28.8 88.3- 117.1
6.2	113.3- 119.5	Sandstone, medium-gray, very fine grained, silty, finely micaceous, crossbedded, beds as much as 2 ft. thick; shale, medium- to dark-gray, silty, in lenses as much as 6 in. thick	149.5 117.1- 266.6 23.0 266.6- 289.6
4.5	119.5- 124.0	Sandstone, medium-gray, very fine grained, silty, finely micaceous	23.0 289.6- 312.6 5.8 312.6- 318.4
9.2	124.0- 133.2	Sandstone, medium-gray, very fine grained, crossbedded, weathered surface has honeycomb appearance; shale, dark-gray, silty, in lenses; limonite nodules as much as 1 in. thick, in lenses and layers as much as 10 in. thick	11.6 318.4- 330.0
3.7	133.2- 136.9	Sandstone, medium-gray, very fine grained, silty, finely micaceous, beds as much as 3 ft. thick	
11.5	136.9- 148.4	Covered interval	
109.2	148.4- 257.6	Shale, dark-gray, very finely micaceous, beds as much as 1/4 in. thick	
83.2	257.6- 340.8	Covered interval	20.0 0- 20.0
18.8	340.8- 359.6	Sandstone, medium-gray, very fine grained, very silty, finely micaceous, irregularly bedded, beds 2 in. to 1 ft. 6 in. thick	

ly micaceous; siltstone, medium- to dark-gray, very finely micaceous; and shale, dark-gray, very finely micaceous; all beds are irregularly bedded

Siltstone, medium- to dark-gray, very finely micaceous, irregularly bedded, beds as much as 1 in. thick; shale, dark-gray, very finely micaceous, in stringers as much as 1/4 in. thick

Shale, dark-gray, very finely micaceous; and siltstone, medium- to dark-gray, very finely micaceous, irregularly bedded, beds as much as 1/4 in. thick

Covered interval

Shale, dark-gray, silty, very finely micaceous, irregularly bedded, beds as much as 1/2 in. thick

Shale, dark-gray, very finely micaceous

Shale, dark-gray, very finely micaceous, abundant ironstone concretions as much as 1 1/2 in. in diameter

Shale, dark-gray, very finely micaceous

Covered interval

Shale, dark-gray, very finely micaceous, beds as much as 1/8 in. thick, ironstone bands as much as 1/4 in. thick

SECTION F

Subiaco Lake Section

Sec. 10, T. 7 N., R. 25 W., Logan County, Arkansas
Lower part of Savanna formation, McAlester formation,
Hartshorne sandstone, and upper part of Atoka
formation

Lower part of Savanna formation

20.0 0- 20.0 Sandstone, white to very light gray, very fine grained, very silty, irregularly bedded, beds 1/2 to 10 in. thick; base of unit is base of Savanna formation

McAlester formation

372.6 20.0- 392.6 Covered interval
72.0 392.6- 464.6 Shale, dark-gray, weathers to a dark greenish gray, beds as much as 1/2 in. thick

100.0 464.6- 564.6 Covered interval; probably shale, dark-gray

14.0 564.6- 578.6 Sandstone, light-gray, very fine grained, almost silt size (less than 0.062 mm in diameter), quartzose, irregularly bedded, beds 2 to 10 in. thick

15.4 578.6- 594.0 Sandstone, light-gray, very fine to fine-grained, slightly silty, very finely micaceous, irregularly bedded, beds 2 in. to 2 ft. thick

SECTION E

Red Bench section

Sec. 15, T. 7 N., R. 25 W., Logan County, Arkansas
Upper part of Atoka formation

8.0 0- 8.0 Sandstone, medium-gray, very fine grained, very silty, finely micaceous, regularly bedded, beds as much as 1 ft. 6 in. thick

1.9 8.0- 9.9 Sandstone, medium-gray, very fine grained, very silty, very finely micaceous, irregularly bedded, beds as much as 3 in. thick

9.3 9.9- 19.2 Sandstone, medium-gray, very fine grained, very silty, very fine-

Thick- ness in feet	Interval in feet	Description Pennsylvanian system			
114.2	594.0- 708.2	Sandstone, medium-gray, very fine grained, very silty, very finely micaceous, irregularly to regularly bedded, beds 1 in. to 1 ft. thick	14.2	1210.5-1224.7	bedded, crossbedded, beds as much as 6 in. thick Sandstone, light yellowish gray to light-gray, very fine grained, very silty, regularly bedded, beds ½ to 3 in. thick
340.0	708.2-1048.2	Covered interval; base of unit is base of McAlester formation	13.0	1224.7-1237.7	Sandstone, very light gray to light-gray, very fine to fine-grained, finely to medium micaceous, crossbedded, beds as much as 10 in. thick
Hartshorne sandstone					
23.2	1048.2-1071.4	Sandstone, light-gray, very fine grained, silty, finely micaceous, irregularly bedded, convolute bedded, beds 2 in. to 2 ft. 6 in. thick	15.0	1237.7-1252.7	Sandstone, white to very light gray, very fine grained, finely to medium micaceous, irregularly bedded, beds 6 in. to 2 ft. 6 in. thick
41.9	1071.4-1113.3	Sandstone, medium-gray, very fine grained, finely micaceous, abundant carbonaceous streaks (probably plant fragments), irregularly bedded, beds 6 in. to 2 ft. 6 in. thick	5.0	1252.7-1257.7	Sandstone, light-gray, very fine grained, irregularly bedded, beds 2 to 10 in. thick, ironstone in lenses ⅛ in. thick and 2 in. long
6.0	1113.3-1119.3	Shale, medium-gray, silty, irregularly bedded, beds ⅛ to 1 in. thick; sandstone, medium-gray, very fine grained, in a lense 1 ft. 2 in. thick and 7 ft. long	7.0	1257.7-1264.7	Sandstone, light-gray, irregularly bedded, beds as much as 1 ft. thick, abundant ironstone nodules as much as 2 in. in diameter
0.4	1119.3-1119.7	Sandstone, medium-gray, well-cemented, ripple-marked	5.0	1264.7-1269.7	Sandstone, light-gray, very fine grained, irregularly bedded, beds 1 to 8 in. thick
0.8	1119.7-1120.5	Shale, grayish-black, beds as much as ¼ in. thick	8.0	1269.7-1277.7	Sandstone, light-gray, very fine to fine-grained, scattered medium sand grains, medium micaceous, crossbedded, beds 2 in. to 2 ft. thick
0.8	1120.5-1121.3	Siltstone, medium-gray, finely micaceous, irregularly bedded, beds ⅛ to ¼ in. thick	9.2	1277.7-1286.9	Sandstone, light-gray, very fine to fine-grained, silty, irregularly bedded, beds ¼ to 1 in. thick, ironstone concretions as much as ½ in. in diameter in a zone 1 in. from top of unit
0.8	1121.3-1122.1	Sandstone, medium-gray, very fine grained, silty, finely micaceous, ripple-marked	2.2	1286.9-1289.1	Sandstone, medium-gray, very fine grained, very silty, one bed; base of unit is base of Hartshorne sandstone
0.8	1122.1-1122.9	Shale, dark-gray to grayish-black, beds as much as ⅛ in. thick	Upper part of Atoka formation		
2.6	1122.9-1125.5	Siltstone, medium-gray, finely micaceous, irregularly bedded, beds as much as 1 in. thick	10.0	1289.1-1299.1	Siltstone, yellowish-brown, weathered, irregularly bedded, as much as ½ in. thick
1.0	1125.5-1126.5	Sandstone, dark-gray, very fine grained, very silty, well-cemented	SECTION G		
6.0	1126.5-1132.5	Shale, dark-gray to grayish-black, beds as much as ¼ in. thick	Pine Hill section		
15.4	1132.5-1147.9	Shale, dark-gray, beds as much as ¼ in. thick; and siltstone, medium- to dark-gray, lenticular bedded, ripple-marked, beds as much as 2 ft. thick	Secs. 10 and 16, T. 8 N., R. 25 W., Logan County, Arkansas		
1.1	1147.9-1149.0	Sandstone, light-gray, very fine grained, very silty, finely micaceous	Lower part of Savanna formation and upper part of McAlester formation		
1.8	1149.0-1150.8	Shale, dark-gray, beds as much as ¼ in. thick	Lower part of Savanna formation		
1.0	1150.8-1151.8	Sandstone, light-gray, very fine grained, finely micaceous	15.0	0- 15.0	Sandstone, white to very light gray, fine-grained, scattered medium sand grains, irregularly bedded, beds 6 in. to 4 ft. thick
2.7	1151.8-1154.5	Shale, dark-gray to grayish-black, beds as much as ¼ in. thick	132.2	15.0- 147.2	Shale, dark-gray, beds as much as ¼ in. thick, silty zone 1 ft. thick 29 ft. above base of unit, scattered ironstone concretions as much as ½ in. in diameter in lower 6 ft.
5.8	1154.5-1160.3	Sandstone, light-gray, very fine grained, one bed			
40.0	1160.3-1200.3	Covered interval			
10.2	1200.3-1210.5	Sandstone, white to very light gray, fine-grained, irregularly			

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
5.8	147.2- 153.0	Sandstone, white to very light gray, fine-grained, porous, irregularly bedded, beds 2 to 8 in. thick
26.0	153.0- 179.0	Siltstone, medium- to dark-gray, very slightly sandy, irregularly bedded, beds ½ to 3 in. thick
57.5	179.0- 236.5	Shale, dark-gray, beds as much as ¼ in. thick, silty bands as much as ½ in. thick, ironstone bands and concretions as much as ½ in. thick
0.3	236.5- 236.8	Coal
3.2	236.8- 240.0	Shale, dark-gray, beds as much as ½ in. thick, abundant ironstone concretions as much as ½ in. in diameter
6.9	240.0- 246.9	Siltstone, medium-gray, beds as much as ¼ in. thick; and shale, dark-gray, beds as much as ¼ in. thick
5.4	246.9- 252.3	Shale, dark-gray, beds as much as ½ in. thick
1.0	252.3- 253.3	Coal
3.8	253.3- 257.1	Shale, dark-gray, beds as much as ¼ in. thick
4.3	257.1- 261.4	Shale, dark-gray, beds as much as ⅛ in. thick; and siltstone, dark-gray, irregularly bedded, beds as much as 1 in. thick
9.7	261.4- 271.1	Siltstone, light-gray, irregularly bedded, beds as much as 1 in. thick
50.8	271.1- 321.9	Shale, dark-gray, beds as much as ½ in. thick, widely scattered ironstone concretions as much as 3 in. in diameter; and claystone, dark-gray, in scattered beds as much as 4 in. thick
5.4	321.9- 327.3	Siltstone, medium-gray, slightly very finely sandy, irregularly bedded, beds as much as 4 in. thick
5.4	327.3- 332.7	Shale, dark-gray to grayish-black, beds as much as ⅛ in. thick in units as much as 8 in. thick; and siltstone, dark-gray, irregularly bedded, beds as much as 1 in. thick in zones as much as 6 in. thick
6.0	332.7- 338.7	Siltstone, medium-gray, irregularly bedded, ripple-marked, beds ¼ to 1 in. thick
5.8	338.7- 344.5	Sandstone, light- to medium-gray, fine-grained, becomes very fine grained at top of unit, silty, cross-bedded, ripple-marked, beds 2 to 8 in. thick
11.5	344.5- 356.0	Siltstone, medium-gray, very finely sandy in lower 3 in.; ironstone concretions as much as 3 in. in diameter in lower 1 ft.; unit rests on underlying shale with a channel-type contact; base of unit is base of Savanna formation
Upper part of McAlester formation		
82.5	356.0- 438.5	Shale, dark-gray to grayish-black, beds as much as ⅛ in. thick

SUBSURFACE STRATIGRAPHIC SECTIONS

SECTION 1

Carter Oil Company (T. H. Barton) No. 1 H. B. McVay
 Sec. 22, T. 7 N., R. 27 W., Logan County, Arkansas
 (Drilled approximately 6 miles west of Paris
 quadrangle, Arkansas)

Elevation: 747 ft.; total depth: 8,770 ft.

Rock samples examined and logged by **Boyd R. Haley**
 Atoka formation, Bloyd shale and Hale formation
 (undifferentiated), and upper part of Pitkin limestone

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
		Atoka formation
10	0- 10	(No sample)
6	10- 16	Sandstone, medium-gray, very fine grained, silty, very finely micaceous
4	16- 20	Shale, dark-gray, silty, very finely micaceous
5	20- 25	Sandstone, as above
5	25- 30	Shale, as above
13	30- 43	Sandstone, as above
9	43- 52	Shale, as above
6	52- 58	Sandstone, as above
4	58- 62	Shale, as above
10	62- 82	Sandstone, light- to medium-gray, very fine grained, silty, medium micaceous
11	82- 93	Shale, dark-gray, silty, very finely micaceous
10	93- 103	Sandstone, medium-gray, very fine grained, silty, very finely micaceous
6	103- 109	Shale, as above
16	109- 125	Siltstone, medium- to dark-gray, very finely sandy, finely micaceous
50	125- 175	Shale, dark-gray, silty, finely micaceous
5	175- 180	Siltstone, dark-gray, very finely sandy, finely micaceous
5	180- 185	Sandstone, medium-gray, very fine grained, very silty, finely micaceous
5	185- 190	Shale, dark-gray, silty, finely micaceous
15	190- 205	Siltstone, medium- to dark-gray, very finely sandy, finely micaceous
65	205- 270	Siltstone, dark-gray, finely micaceous
21	270- 291	Shale, dark-gray, silty, finely micaceous
14	291- 305	Siltstone, medium- to dark-gray, finely micaceous
23	305- 328	Shale, dark-gray to grayish-black, finely micaceous
14	328- 342	Sandstone, medium-gray, very fine grained, very silty, finely micaceous
2	342- 344	Shale, as above
12	344- 356	Sandstone, as above
2	356- 358	Shale, as above; scattered slickensided fragments
16	358- 374	Sandstone, as above
6	374- 380	Shale, dark-gray to grayish-black, finely micaceous
20	380- 400	Siltstone, medium- to dark-gray, very finely sandy, finely micaceous
5	400- 405	Siltstone, medium- to dark-gray, finely micaceous
30	405- 435	Siltstone, medium- to dark-gray, very finely sandy, finely micaceous
10	435- 445	Siltstone, medium- to dark-gray, slightly very finely sandy, finely micaceous
5	445- 450	Sandstone, light-gray, very fine grained, finely micaceous
30	450- 480	Siltstone, dark-gray, very finely sandy, finely micaceous
10	480- 490	Sandstone, light-gray, very fine to fine-grained, slightly silty, finely micaceous
10	490- 500	Sandstone, very light gray, very fine to fine-grained
15	500- 515	Sandstone, very light-gray, fine-grained, scattered subangular to subrounded medium sand grains
30	515- 545	Sandstone, light-gray, very fine grained, silty, finely micaceous
5	545- 550	Sandstone, very light gray, very fine grained, finely micaceous
20	550- 570	Sandstone, medium-gray, very fine grained, silty, finely micaceous
25	570- 595	Sandstone, light-gray, very fine grained, silty
20	595- 615	Siltstone, dark-gray, very finely sandy, finely micaceous
15	615- 630	Sandstone, very light gray, very fine to fine-grained, slightly silty, finely micaceous
5	630- 635	Siltstone, medium-gray, well-cemented
5	635- 640	Sandstone, very light gray, very fine to fine-grained, finely micaceous
30	640- 670	Siltstone, medium-gray, very finely micaceous
54	670- 724	Sandstone, light-gray, very fine grained, silty, finely micaceous
26	724- 750	Shale, dark-gray, very silty, finely micaceous
70	750- 820	(No sample)
10	820- 830	Shale, grayish-black, very finely micaceous, crystals of pyrite
30	830- 860	(No sample)
50	860- 910	Siltstone, medium-gray, very finely sandy, finely micaceous
60	910- 970	(No sample)
10	970- 980	Shale, dark-gray, very silty, very finely micaceous

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
20	980-1,000	Shale, dark-gray, very finely mica- ceous
50	1,000-1,050	(No sample)
11	1,050-1,061	Shale, grayish-black, very finely mi- caceous
9	1,061-1,070	Siltstone, medium-gray, slightly very finely sandy, finely micaceous
30	1,070-1,100	(No sample)
10	1,100-1,110	Sandstone, light-gray, very fine to fine-grained, slightly silty
10	1,110-1,120	Sandstone, light- to medium-gray, very fine grained, silty
1440	1,120-2,560	(No sample)
9	2,560-2,569	Shale, dark-gray, very finely mica- ceous
21	2,569-2,590	Siltstone, medium-gray, very finely sandy, finely micaceous
40	2,590-2,630	Siltstone, dark-gray, very finely micaceous
12	2,630-2,642	Sandstone, light-gray, very fine grained, very silty, very finely mica- ceous, well-cemented
25	2,642-2,667	Siltstone, light- to medium-gray, very finely micaceous
13	2,667-2,680	Sandstone, light-gray, very fine grained, very silty, very finely mi- caceous
20	2,680-2,700	Siltstone, medium- to dark-gray, very finely micaceous
13	2,700-2,713	Shale, grayish-black
1	2,713-2,714	Coal
12	2,714-2,726	Shale, as above
14	2,726-2,740	Sandstone, white to very light gray, very fine grained
15	2,740-2,755	Sandstone, light-gray, very fine grained, very silty, well-cemented
25	2,755-2,780	Sandstone, grayish-white, very fine grained
20	2,780-2,800	(No sample)
15	2,800-2,815	Siltstone, medium-gray, slightly very finely sandy, very finely micaceous
9	2,815-2,824	Siltstone, light-gray, well-cemented
7	2,824-2,831	Shale, dark-gray, very silty
10	2,831-2,841	Siltstone, light- to medium-gray
12	2,841-2,853	Sandstone, light-gray, very fine grained, very silty
4	2,853-2,857	Siltstone, as above
38	2,857-2,895	Sandstone, light- to medium-gray, very fine grained, silty, finely mi- caceous
25	2,895-2,920	Sandstone, medium-gray, very fine grained, very silty, very finely mi- caceous
10	2,920-2,930	Sandstone, light- to medium-gray, very fine grained, silty
15	2,930-2,945	Sandstone, medium-gray, very fine grained, very silty
13	2,945-2,958	Shale, grayish-black, very finely mi- caceous
8	2,958-2,966	Siltstone, white to very light gray, very fine grained, silty
12	2,966-2,978	Siltstone, medium-gray, very finely sandy, very finely micaceous
59	2,978-3,037	Shale, grayish-black, very finely micaceous
8	3,037-3,045	Siltstone, medium-gray, very finely sandy, very finely micaceous
5	3,045-3,050	Siltstone, medium-gray, very finely micaceous
6	3,050-3,056	Siltstone, medium-gray, very finely sandy, very finely micaceous
16	3,056-3,072	Shale, grayish-black
30	3,072-3,102	Siltstone, light- to medium-gray, very finely sandy, finely micaceous
50	3,102-3,152	Shale, grayish-black, very finely micaceous
24	3,152-3,176	Siltstone, light- to medium-gray, very finely micaceous
84	3,176-3,260	Shale, dark-gray, very finely mica- ceous
20	3,260-3,280	Siltstone, medium-gray, very finely micaceous
20	3,280-3,300	Siltstone, dark-gray, very finely micaceous
5	3,300-3,305	Shale, dark-gray, very finely mica- ceous
25	3,305-3,330	Siltstone, dark-gray, argillaceous, very finely micaceous
30	3,330-3,360	Shale, medium - gray, very finely micaceous
30	3,360-3,390	Siltstone, dark - gray, very finely micaceous
105	3,390-3,495	Shale, dark-gray, very silty, very finely micaceous
160	3,495-3,655	Shale, grayish-black, very finely micaceous; crystals of pyrite in 3,640 to 3,655
13	3,655-3,668	Siltstone, medium-gray, very finely sandy, very finely micaceous
22	3,668-3,690	Sandstone, very light gray, very fine grained, slightly silty, finely micaceous
10	3,690-3,700	Sandstone, light- to medium-gray, very fine grained, very silty, well- cemented
20	3,700-3,720	Siltstone, medium-gray, very finely sandy, very finely micaceous
42	3,720-3,762	Siltstone, medium - gray, slightly very finely sandy, very finely mica- ceous
64	3,762-3,826	Siltstone, medium- to dark-gray, very finely micaceous
29	3,826-3,855	Siltstone, light-gray, silt is almost very fine sand size (more than 0.062 mm in diameter), finely mica- ceous
5	3,855-3,860	Siltstone, light - gray, very finely sandy, finely micaceous
20	3,860-3,880	(No sample)
55	3,880-3,935	Siltstone, dark - gray, very finely micaceous
15	3,935-3,950	Siltstone, medium-gray, very finely micaceous

Thick- ness in feet	Interval in feet	Description	
			Pennsylvanian system
18	3,950-3,968	Siltstone, dark - gray, very finely micaceous	
37	3,968-4,005	Shale, grayish - black, very finely micaceous	
21	4,005-4,026	Siltstone, dark-gray, very finely micaceous	
2	4,026-4,028	Shale, as above	
17	4,028-4,045	Siltstone, medium-gray, very finely micaceous	
13	4,045-4,058	Shale, dark-gray, silty, very finely micaceous	
34	4,058-4,092	Shale, grayish-black, very finely micaceous	
16	4,092-4,108	Shale, dark-gray, slightly silty, very finely micaceous	
137	4,108-4,245	Shale, grayish - black, very finely micaceous	
22	4,245-4,267	Shale, dark-gray, silty, very finely micaceous	
50	4,267-4,317	Siltstone, dark - gray, very finely micaceous	
49	4,317-4,356	Sandstone, light- to medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty, finely micaceous	
6	4,356-4,362	Shale, grayish-black, very finely micaceous	
58	4,362-4,420	Shale, dark-gray, silty, very finely micaceous	
8	4,420-4,428	Shale, grayish-black, very finely micaceous	
10	4,428-4,438	Shale, dark-gray, silty, very finely micaceous	
4	4,438-4,442	Shale, grayish - black, silty, very finely micaceous	
63	4,442-4,505	Siltstone, medium-gray, silt is almost very fine sand size (more than 0.062 mm in diameter), very finely sandy, very finely micaceous	
25	4,505-4,530	Siltstone, dark-gray, very finely micaceous	
50	4,530-4,570	Shale, dark-gray, silty, very finely micaceous	
55	4,570-4,625	Siltstone, medium- to dark-gray, very finely micaceous	
40	4,625-4,665	Siltstone, medium- to dark-gray, very finely sandy, very finely micaceous	
25	4,665-4,680	Siltstone, medium- to dark-gray, very finely micaceous	
15	4,680-4,695	Siltstone, medium- to dark-gray, slightly very finely sandy, very finely micaceous	
70	4,695-4,765	Siltstone, medium- to dark-gray, very finely micaceous	
15	4,765-4,780	Siltstone, medium- to dark-gray, slightly very finely sandy, very finely micaceous	
13	4,780-4,793	Siltstone, medium- to dark-gray, very finely sandy, very finely micaceous	
3	4,793-4,796	Shale, grayish-black, very finely micaceous	
32	4,796-4,828	Shale, dark-gray, silty, very finely micaceous	
37	4,838-4,865	Siltstone, medium-gray, very finely sandy, very finely micaceous	
35	4,865-4,900	Siltstone, medium-gray, slightly very finely sandy, very finely micaceous	
10	4,900-4,910	Siltstone, medium-gray, very finely micaceous	
20	4,910-4,930	Siltstone, medium-gray, very finely sandy, very finely micaceous	
10	4,930-4,940	Siltstone, medium-gray, very finely micaceous	
5	4,940-4,945	Siltstone, medium-gray, slightly very finely sandy, very finely micaceous	
41	4,945-4,986	Siltstone, medium-gray, very finely micaceous	
55	4,986-5,041	Shale, dark-gray, silty, very finely micaceous	
23	5,041-5,064	Siltstone, medium-gray, very finely sandy, finely micaceous	
15	5,064-5,079	Shale, grayish-black, very finely micaceous	
23	5,079-5,102	Shale, dark-gray, silty, finely micaceous	
60	5,102-5,162	Shale, dark-gray to grayish-black, very finely micaceous, crystals of pyrite in 5,150 to 5,162	
14	5,162-5,176	Shale, dark-gray, very finely micaceous; crystals of pyrite; ironstone concretion	
20	5,176-5,196	Shale, grayish-black, very finely micaceous	
15	5,196-5,211	Siltstone, medium-gray, silt is almost very fine sand size (more than 0.062 mm in diameter), very finely sandy, finely micaceous	
15	5,211-5,226	Siltstone, dark - gray, very finely micaceous	
5	5,226-5,231	Sandstone, medium-gray, very fine grained, silty	
2	5,231-5,233	Siltstone, as above	
7	5,233-5,240	Sandstone, very light gray, very fine grained, very silty, finely micaceous	
20	5,240-5,260	Sandstone, light - gray, very fine grained, very silty	
14	5,260-5,274	Sandstone, light - gray, very fine grained, very silty, well-cemented	
2	5,274-5,276	Shale, dark-gray, very finely micaceous	
9	5,276-5,285	Sandstone, light - gray, very fine grained, silty; plant fragments	
20	5,285-5,305	Sandstone, light-gray, very fine grained, very silty, well-cemented	
15	5,305-5,320	Siltstone, dark-gray, very finely micaceous	
12	5,320-5,332	Siltstone, medium-gray, very finely sandy, very finely micaceous	
40	5,332-5,372	Siltstone, dark-gray, very finely micaceous	
33	5,372-5,405	Shale, dark-gray, very silty, finely micaceous	

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
27	5,405-5,432	Shale, dark-gray, very finely mica- ceous
2	5,432-5,434	Siltstone, dark-gray, very finely micaceous
10	5,434-5,444	Shale, dark-gray, very finely mica- ceous
2	5,444-5,446	Siltstone, as above
12	5,446-5,458	Shale, as above
2	5,458-5,460	Sandstone, light-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty
65	5,460-5,525	Siltstone, dark-gray, very finely micaceous
5	5,525-5,530	Sandstone, light-gray, very fine grained, very silty, very finely mica- ceous, well-cemented
35	5,530-5,665	Siltstone, as above; crystals of pyrite in 5,580 to 5,600
35	5,665-5,700	Shale, dark-gray, silty, very finely micaceous; crystals of pyrite in 5,680 to 5,700
21	5,700-5,721	Siltstone, dark-gray, very finely micaceous
30	5,721-5,751	Siltstone, medium- to dark-gray, slightly very finely sandy, very fine- ly micaceous
9	5,751-5,760	Sandstone, white to very light gray, very fine grained, silty, finely mica- ceous
35	5,760-5,795	Siltstone, medium-gray, finely mica- ceous
5	5,795-5,800	Sandstone, light - gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), finely micaceous
7	5,800-5,807	Siltstone, as above
5	5,807-5,812	Sandstone, as above
8	5,812-5,820	Siltstone, as above
16	5,820-5,836	Sandstone, as above
109	5,836-5,945	Siltstone, medium- to dark-gray, very finely micaceous; crystals of pyrite in 5,880 to 5,890
60	5,945-6,005	Siltstone, dark-gray, very finely micaceous
64	6,005-6,069	Shale, dark-gray, silty, very finely micaceous
21	6,069-6,090	Shale, grayish-black, very finely micaceous
10	6,090-6,100	Siltstone, dark-gray, very finely micaceous
50	6,100-6,150	(No sample)
25	6,150-6,175	Shale, grayish-black, very finely micaceous
15	6,175-6,190	(No sample)
25	6,190-6,215	Shale, dark-gray, silty, very finely micaceous
11	6,215-6,226	Shale, grayish-black, very finely micaceous
67	6,226-6,293	Shale, dark-gray, very finely mica- ceous
17	6,293-6,310	Shale, grayish-black
55	6,310-6,365	Sandstone, medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty, very finely micaceous
16	6,365-6,381	Shale, dark-gray, very silty, very finely micaceous
8	6,381-6,389	Shale, grayish-black, very finely micaceous
11	6,389-6,400	Shale, dark-gray, very silty, very finely micaceous
3	6,400-6,403	Shale, grayish-black, very finely micaceous
7	6,403-6,410	Shale, dark-gray, very silty, very finely micaceous
9	6,410-6,419	Shale, grayish-black, very finely micaceous
29	6,419-6,448	Sandstone, medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty, finely micaceous
10	6,448-6,458	Shale, dark-gray, very finely mica- ceous
52	6,458-6,510	Siltstone, medium- to dark-gray, very finely micaceous
11	6,510-6,521	Shale, as above
11	6,521-6,532	Siltstone, medium-gray, very finely micaceous
100	6,532-6,632	Shale, grayish-black, very finely micaceous; crystals of pyrite in 6,560 to 6,570
6	6,632-6,638	Shale, dark-gray, slightly silty, finely micaceous
34	6,638-6,672	Shale, grayish-black; drill cuttings are flaky
4	6,672-6,676	Siltstone, dark-gray
29	6,676-6,705	Shale, as above
17	6,705-6,722	Siltstone, dark-gray, argillaceous, very finely micaceous
3	6,722-6,725	Shale, grayish-black
7	6,725-6,732	Siltstone, very dark gray
8	6,732-6,740	Sandstone, medium- to dark-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diam- eter), very silty, very finely mica- ceous
12	6,740-6,752	Siltstone, dark-gray, argillaceous, finely micaceous, very slightly limy
6	6,752-6,758	Siltstone, medium-gray, finely mica- ceous, slightly limy, well-cemented
14	6,758-6,772	Siltstone, dark-gray, argillaceous, very finely micaceous
13	6,772-6,785	Siltstone, dark-gray, very finely micaceous, slightly limy
18	6,785-6,803	Siltstone, dark-gray, argillaceous, very finely micaceous
6	6,803-6,809	Siltstone, dark-gray, very finely micaceous, slightly limy
11	6,809-6,820	Siltstone, dark-gray, very finely micaceous
2	6,820-6,822	Shale, grayish-black
3	6,822-6,825	Siltstone, dark-gray, very finely micaceous

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
2	7,856-7,858	Siltstone, medium- to dark-gray, scattered subrounded fine to medium sand grains, finely micaceous
9	7,858-7,867	Shale, dark-gray, very finely micaceous
8	7,867-7,875	Siltstone, medium-gray, very finely to finely sandy, scattered subround medium to coarse sand grains
9	7,875-7,884	Sandstone, medium-gray, fine-grained, abundant subrounded medium to coarse sand grains; base of unit is base of Atoka formation
Boyd shale and Hale formation (undifferentiated)		
5	7,884-7,889	Shale, dark-gray
3	7,889-7,892	Siltstone, medium-gray, finely micaceous
8	7,892-7,900	Shale, as above
10	7,900-7,910	(No sample)
10	7,910-7,920	Shale, dark-gray to grayish-black; abundant slickensided fragments
6	7,920-7,926	Siltstone, medium-gray, very finely sandy
7	7,926-7,933	Shale, dark-gray
7	7,933-7,940	Sandstone, light-gray, very fine grained, very silty, slightly limy
4	7,940-7,944	Shale, as above
3	7,944-7,947	Siltstone, medium-gray
4	7,947-7,951	Shale, as above
4	7,951-7,955	Siltstone, as above
15	7,955-7,970	Shale, as above
2	7,970-7,972	Siltstone, as above
16	7,972-7,988	Shale, as above
70	7,988-8,058	Shale, dark-gray to grayish-black
12	8,058-8,070	Limestone, medium-gray, granular, slightly very finely sandy; crinoid fragments
3	8,070-8,073	Shale, dark-gray
5	8,073-8,078	Siltstone, medium-gray, finely micaceous
36	8,078-8,114	Shale, dark-gray, very finely micaceous
84	8,114-8,198	Shale, grayish-black; crystals of pyrite in 8,160 to 8,170
4	8,198-8,202	Sandstone, light-gray, medium-grained, limy; crinoid fragments; drills free
11	8,202-8,213	Sandstone, light-gray, fine- to medium-grained, slightly limy
10	8,213-8,223	Sandstone, light- to medium-gray, very fine grained, very silty
6	8,223-8,229	Shale, grayish-black
5	8,229-8,234	Siltstone, medium-gray, very finely sandy
6	8,234-8,240	Shale, dark-gray
2	8,240-8,242	Siltstone, medium-gray
5	8,242-8,247	Shale, as above
5	8,247-8,252	Sandstone, medium-gray, very fine grained, very silty
38	8,252-8,290	Shale, as above
3	8,290-8,293	Siltstone, medium-gray, very finely sandy
4	8,293-8,297	Shale, as above
4	8,297-8,301	Siltstone, as above
18	8,301-8,319	Shale, dark-gray, pyritic
2	8,319-8,321	Siltstone, as above
9	8,321-8,330	Shale, as above
3	8,330-8,333	Siltstone, as above
13	8,333-8,346	Shale, as above
7	8,346-8,353	Sandstone, light-gray, very fine to fine-grained, slightly limy; drills free
3	8,353-8,356	Shale, dark-gray, finely micaceous
4	8,356-8,360	Sandstone, as above
1	8,360-8,361	Shale, as above
5	8,361-8,366	Sandstone, as above
1	8,366-8,367	Shale, as above
1	8,367-8,368	Sandstone, as above
12	8,368-8,380	Shale, as above
6	8,380-8,386	Siltstone, medium-gray, very finely to finely sandy
2	8,386-8,388	Shale, dark-gray
3	8,388-8,391	Siltstone, as above
13	8,391-8,404	Shale, as above
9	8,404-8,413	Siltstone, medium-gray, very finely sandy; pyritic
2	8,413-8,415	Shale, as above
2	8,415-8,417	Siltstone, as above
1	8,417-8,418	Shale, as above
3	8,418-8,421	Siltstone, as above
10	8,421-8,431	Shale, dark-gray, pyritic
19	8,431-8,450	Sandstone, light-gray, fine-grained, scattered rounded medium sand grains, silty, limy; crinoid fragments
22	8,450-8,472	Shale, dark-gray to grayish-black; crystals of pyrite
8	8,472-8,480	Shale, dark-gray, very silty
30	8,480-8,510	Shale, grayish-black; crystals of pyrite in 8,490 to 8,510
8	8,510-8,518	Sandstone, white to very light gray, very fine grained, slightly limy, well-cemented
4	8,518-8,522	Shale, dark-gray
4	8,522-8,526	Sandstone, as above
2	8,526-8,528	Shale, as above
4	8,528-8,532	Sandstone, white to very light gray, very fine grained, well-cemented
2	8,532-8,534	Shale, as above
6	8,534-8,540	Sandstone, as above
2	8,540-8,542	Shale, as above
3	8,542-8,545	Sandstone, as above
95	8,545-8,640	Shale, dark-gray to grayish-black; crystals of pyrite in 8,560 to 8,590 and 8,600 to 8,640
6	8,640-8,646	Siltstone, medium-gray, very finely sandy; base of unit is base of undifferentiated Boyd shale and Hale formation

Thick- ness in feet	Interval in feet	Description Mississippian system
Upper part of Pitkin limestone		
24	8,646-8,670	Shale, grayish-black; crystals of pyrite
7	8,670-8,677	Limestone, dark-gray, dense to granular, slightly very finely sandy, pyritic
2	8,677-8,679	Shale, as above
5	8,679-8,684	Limestone, as above
6	8,684-8,690	Shale, as above
7	8,690-8,697	Limestone, dark-gray, dense to granular, pyritic
5	8,697-8,702	Shale as above
3	8,702-8,705	Limestone, dark-gray, dense to granular
6	8,705-8,711	Shale, as above
2	8,711-8,713	Limestone, as above
6	8,713-8,719	Shale, as above
2	8,719-8,721	Limestone, as above
4	8,721-8,725	Shale, as above
3	8,725-8,728	Limestone, medium- to dark-gray, dense, pyritic
4	8,728-8,732	Shale, dark-gray
4	8,732-8,736	Limestone, medium-gray, dense; crinoid fragments
1	8,736-8,737	Shale, as above
7	8,737-8,744	Limestone, as above
1	8,744-8,745	Shale, as above
25	8,745-8,770	Limestone, medium-gray, pyritic; samples are comprised mostly of crinoid fragments
	8,770	Total depth

SECTION 2

Gulf Oil Corp. No. 1 R. Hembree

Sec. 13, T. 8 N., R. 26 W., Logan County, Arkansas
Elevation: 367 ft.; total depth: 8,075 ft.

Rock samples examined and logged by Boyd R. Haley

Lower part of McAlester formation, Hartshorne sandstone, Atoka formation, Bloyd shale, Hale formation (Prairie Grove member and upper part of Cane Hill member), Boone and Moorefield formations, undifferentiated, Chattanooga shale (Sylamore sandstone member), and upper part of Penters chert

Pennsylvanian system

Lower part of McAlester formation

50	0- 80	(No sample)
90	80- 170	Shale, grayish-black, very finely micaceous; crystals of pyrite in 150 to 160
28	170- 198	Shale, medium- to dark-gray, slightly silty, very finely micaceous; crystals of pyrite in 170 to 180
32	198- 230	Shale, dark-gray, very finely micaceous
20	230- 250	Shale, grayish-black, very finely micaceous
22	250- 272	Shale, dark-gray to grayish-black, very finely micaceous

7	272- 285	Siltstone, medium-gray, finely micaceous
35	285- 320	Shale, grayish-black, very finely micaceous
26	320- 346	Shale, dark-gray to grayish-black, very finely micaceous; base of unit is base of McAlester formation

Hartshorne sandstone

5	346- 351	Sandstone, dark-gray, fine-grained, finely to medium micaceous, argillaceous
2	351- 353	Shale, grayish-black
7	353- 360	Sandstone, white to very light-gray, fine-grained, slightly limy
10	360- 370	Sandstone, white to very light gray, fine-grained
10	370- 380	Sandstone, medium- to dark-gray, fine-grained, very silty, medium micaceous
12	380- 392	Sandstone, medium-gray, fine- to medium-grained, silty, medium micaceous, slightly limy
5	392- 397	Shale, dark-gray, finely micaceous
10	397- 407	Sandstone, medium- to dark-gray, very fine to fine-grained, very silty; abundant plant fragments
2	407- 409	Shale, as above
16	409- 425	Sandstone, medium- to dark-gray, very fine grained, very silty, very finely micaceous
14	425- 439	Sandstone, white to very light gray, fine-grained, medium to coarsely micaceous
2	439- 441	Shale, as above
5	441- 446	Sandstone, medium-gray, very fine grained, very silty, medium micaceous
7	446- 453	Sandstone, white to very light gray, very fine grained, silty, medium micaceous, slightly limy; carbonaceous streaks
5	453- 458	Shale, as above
24	458- 482	Sandstone, white to very light gray, fine-grained, medium micaceous; carbonaceous streaks
3	482- 485	Shale, as above
7	485- 492	Sandstone, very light gray to light-gray, fine-grained, slightly silty, medium micaceous
2	492- 494	Shale, as above
7	494- 501	Sandstone, as above
3	501- 504	Shale, as above
4	504- 508	Sandstone, as above
5	508- 513	Shale, as above
23	513- 536	Sandstone, white to very light gray, fine-grained, medium micaceous
10	536- 546	Sandstone, light-gray, very fine to fine-grained, silty, medium micaceous
2	546- 548	Shale, grayish-black
3	548- 551	Sandstone, as above; base of unit is base of Hartshorne sandstone

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
		Atoka formation
46	551- 597	Shale, as above
33	597- 630	Siltstone, dark-gray, very finely sandy, very finely micaceous
40	630- 670	Shale, dark-gray, silty, very finely micaceous
18	670- 688	Shale, grayish-black, very finely micaceous
6	688- 694	Sandstone, medium-gray, fine-grained, silty, medium micaceous
4	694- 698	Shale, as above
7	698- 705	Sandstone, as above
2	705- 707	Shale, as above
11	707- 718	Sandstone, dark-gray, very fine grained, silty, limy
86	718- 804	Shale, dark-gray, slightly silty, finely micaceous
26	804- 830	Shale, grayish-black, very finely micaceous; crystals of pyrite in 810 to 820
57	830- 887	Shale, dark-gray, slightly silty, finely micaceous
8	887- 895	Sandstone, light- to medium-gray, very fine to fine-grained, silty, medium micaceous, slightly limy; carbonaceous streaks
5	895-1,000	Shale, dark-gray to grayish-black, very finely micaceous
8	1,000-1,008	Siltstone, dark-gray, finely micaceous
2	1,008-1,010	Shale, grayish-black
13	1,010-1,023	Sandstone, light- to medium-gray, very fine grained, silty
2	1,023-1,025	Shale, as above
9	1,025-1,034	Sandstone, as above
2	1,034-1,036	Shale, as above
7	1,036-1,043	Sandstone, as above
30	1,043-1,073	Shale, dark-gray, finely micaceous
21	1,073-1,094	Sandstone, medium-gray, very fine grained, very silty, very finely micaceous
14	1,094-1,108	Siltstone, medium-gray, very finely micaceous
46	1,108-1,154	Shale, dark-gray to grayish-black, very finely micaceous
91	1,154-1,245	Shale, dark-gray, silty, finely micaceous; crystals of pyrite in 1,230 to 1,240
35	1,245-1,280	Shale, dark-gray to grayish-black, very finely micaceous
10	1,280-1,290	Siltstone, dark-gray, very finely sandy, finely micaceous
30	1,290-1,320	Shale, dark-gray slightly silty, finely micaceous; crystals of pyrite in 1,290 to 1,300
16	1,320-1,336	Shale, grayish-black, very finely micaceous
19	1,336-1,355	Sandstone, medium- to dark-gray, very fine grained, very silty, finely micaceous, well-cemented
7	1,355-1,362	Siltstone, dark-gray, finely micaceous
8	1,362-1,370	Shale, dark-gray, very finely micaceous
25	1,370-1,395	Sandstone, medium-gray, very fine grained, very silty, finely micaceous
10	1,395-1,405	Shale, black; coaly; layers 1/8 in. thick of coal
10	1,405-1,415	Sandstone, light-gray, very fine grained, silty, medium to coarsely micaceous
8	1,415-1,423	Sandstone, light-gray, very fine grained, medium to coarsely micaceous
2	1,423-1,425	Shale, dark-gray, finely micaceous
10	1,425-1,435	Sandstone, light-gray, very fine grained, silty, medium to coarsely micaceous
8	1,435-1,443	Sandstone, light-gray, very fine grained, medium to coarsely micaceous
3	1,443-1,446	Shale, as above
13	1,446-1,459	Sandstone, light-gray, very fine grained, silty, medium to coarsely micaceous
3	1,459-1,462	Shale, as above
18	1,462-1,480	Sandstone, light-gray, very fine to fine-grained, medium micaceous; drills free
2	1,480-1,482	Shale, as above
7	1,482-1,489	Sandstone, as above
1	1,489-1,490	Shale, as above
15	1,490-1,505	Sandstone, light-gray, very fine grained; drills free
5	1,505-1,510	Sandstone, light-gray, very fine grained, silty; drills free
15	1,510-1,525	Sandstone, light-gray, very fine grained; drills free
30	1,525-1,555	Sandstone, light-gray, very fine grained, slightly silty; drills free
16	1,555-1,571	Sandstone, medium-gray, very fine grained, silty, medium micaceous, well-cemented
7	1,571-1,578	Siltstone, dark-gray, finely micaceous
7	1,578-1,585	Sandstone, light- to medium-gray, very fine grained, silty
7	1,585-1,662	Shale, grayish-black, very finely micaceous
4	1,662-1,666	Siltstone, dark-gray, finely micaceous
4	1,666-1,670	Shale, as above
8	1,670-1,678	Siltstone, dark-gray, very finely sandy, finely micaceous
2	1,678-1,680	Shale, as above
6	1,680-1,686	Sandstone, medium-gray, very fine grained, very silty, finely micaceous
26	1,686-1,712	Shale, dark-gray to grayish-black, finely micaceous
48	1,712-1,760	Shale, dark-gray, silty, finely micaceous
79	1,760-1,839	Shale, grayish-black, finely micaceous

Thick- ness in feet	Interval in feet	Description	
		Pennsylvanian system	
7	1,839-1,846	Sandstone, very light gray, fine- to medium-grained	6 2,132-2,138 Shale, dark-gray, silty, finely mica- ceous; crystals of pyrite
4	1,846-1,850	Shale, as above	12 2,138-2,150 Shale, dark-gray to grayish-black, finely micaceous
6	1,850-1,856	Sandstone, light-gray, fine-grained	10 2,150-2,160 Shale, dark-gray, silty, finely mica- ceous; crystals of pyrite
4	1,856-1,860	Shale, grayish-black	6 2,160-2,166 Shale, dark-gray to grayish-black, finely micaceous; crystals of pyrite
2	1,860-1,862	Coal	4 2,166-2,170 Shale, dark-gray, silty, finely mica- ceous
3	1,862-1,865	Shale, as above	30 2,170-2,200 Shale, dark-gray to grayish-black
31	1,865-1,896	Sandstone, light-gray, very fine to fine-grained, slightly silty, finely micaceous	6 2,200-2,206 Shale, dark-gray, silty, very finely micaceous
12	1,896-1,908	Shale, dark-gray, slightly silty, finely micaceous	9 2,206-2,215 Siltstone, dark-gray, very finely sandy, finely micaceous
12	1,908-1,920	Sandstone, medium-gray, very fine grained, silty, finely micaceous, well-cemented	3 2,215-2,218 Shale, as above
2	1,920-1,922	Shale, grayish-black	9 2,218-2,227 Sandstone, light- to medium-gray, very fine to fine-grained, scattered rounded medium sand grains, slight- ly silty
16	1,922-1,938	Sandstone, as above	2 2,227-2,229 Shale, as above
4	1,938-1,942	Shale, as above	16 2,229-2,245 Sandstone, light-gray, fine-grained, slightly limy
5	1,942-1,947	Sandstone, light-gray, very fine grained, very silty	10 2,245-2,255 Sandstone, light-gray, very fine to fine-grained, slightly silty, finely micaceous; drills free
4	1,947-1,951	Shale, as above	15 2,255-2,270 Sandstone, light-gray, fine-grained, scattered rounded medium sand grains; some iron stained sand grains; drills free
7	1,951-1,958	Sandstone, medium-gray, very fine grained, very silty, finely micaceous, well-cemented	20 2,270-2,290 Sandstone, light reddish brown, fine- grained, scattered rounded medium sand grains; some iron stained sand grains; drills free
3	1,958-1,961	Shale, as above	10 2,290-2,300 Sandstone, white to very light gray, medium-grained, slightly limy, por- ous
19	1,961-1,980	Sandstone, as above	5 2,300-2,305 Sandstone, light-gray, very fine to fine-grained, silty, finely micaceous, slightly limy
8	1,980-1,988	Shale, dark-gray, silty, finely mica- ceous	1 2,305-2,306 Coal
12	1,988-2,000	Sandstone, as above	14 2,306-2,320 Sandstone, light-gray, very fine to fine-grained, silty, medium mica- ceous
2	2,000-2,002	Shale, as above	2 2,320-2,322 Shale, grayish-black, finely mica- ceous
6	2,002-2,008	Sandstone, as above	3 2,322-2,325 Sandstone, as above
2	2,008-2,010	Shale, as above	15 2,325-2,340 Shale, as above
4	2,010-2,014	Sandstone, as above	5 2,340-2,345 Siltstone, dark-gray, very finely sandy, very finely micaceous
3	2,014-2,017	Shale, as above	2 2,345-2,347 Shale, moderate-red, finely mica- ceous
3	2,017-2,020	Sandstone, as above	7 2,347-2,354 Sandstone, brownish-gray, very fine grained
2	2,020-2,022	Shale, as above	6 2,354-2,360 Siltstone, brownish-gray, very finely sandy
5	2,022-2,027	Sandstone, as above	2 2,360-2,362 Siltstone, dark-gray
6	2,027-2,033	Shale, as above	6 2,362-2,368 Sandstone, reddish-brown to dark- gray, silty
7	2,033-2,040	Sandstone, light-gray, fine-grained, finely micaceous, limy	2 2,368-2,370 Shale, reddish-brown, finely mica- ceous
15	2,040-2,055	Sandstone, light-gray, fine-grained, scattered subrounded, medium sand grains, finely micaceous, limy; drills free	6 2,370-2,376 Sandstone, as above
15	2,055-2,070	Sandstone, light-gray, very fine grained, silty; drills free	2 2,376-2,378 Shale, as above
32	2,070-2,102	Sandstone, light-gray, very fine to fine grained, silty, finely micaceous	
2	2,102-2,104	Shale, dark-gray to grayish-black, finely micaceous	
8	2,104-2,112	Shale, dark-gray, silty, finely mica- ceous	
3	2,112-2,115	Shale, dark-gray to grayish-black, finely micaceous	
5	2,115-2,120	Shale, dark-gray, silty, finely mica- ceous	
12	2,120-2,132	Shale, dark-gray to grayish-black, finely micaceous; crystals of pyrite	

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
4	2,378-2,382	Sandstone, dark-gray, very fine grained, silty, finely micaceous
7	2,382-2,389	Siltstone, dark-gray, very finely sandy, finely micaceous
36	2,389-2,425	Shale, dark-gray to grayish-black, finely micaceous
25	2,425-2,450	Siltstone, as above
8	2,450-2,458	Shale, as above
4	2,458-2,462	Siltstone, as above
15	2,462-2,477	Shale, as above
23	2,477-2,500	Sandstone, medium-gray, very fine grained, very silty, slightly limy, well-cemented
10	2,500-2,510	Shale, as above
41	2,510-2,551	Shale, dark-gray, slightly silty, finely micaceous
39	2,551-2,590	Shale, dark-gray to grayish-black, finely micaceous
15	2,590-2,605	Shale, grayish-black
25	2,605-2,630	Sandstone, light-gray, very silty, very finely micaceous, well-cemented; carbonaceous streaks
5	2,630-2,635	Sandstone, white to very light gray, very fine grained, silty, well-cemented
5	2,635-2,640	Sandstone, light-gray, fine- to medium-grained, slightly argillaceous, limy; crinoids, brachiopods, and bryozoa
5	2,640-2,645	Sandstone, light-gray, very fine grained, silty, very finely micaceous, well-cemented
3	2,645-2,648	Shale, grayish-black
15	2,648-2,663	Sandstone, light- to medium-gray, very fine grained, silty, finely micaceous, well-cemented; carbonaceous streaks
7	2,663-2,670	Sandstone, white to very light gray, very fine grained, slightly limy
16	2,670-2,686	Shale, grayish-black, very finely micaceous
4	2,686-2,690	Siltstone, medium- to dark-gray, very finely sandy, finely micaceous
35	2,690-2,725	Shale, as above; crystals of pyrite in 2,710 to 2,720
5	2,725-2,730	Siltstone, as above
15	2,730-2,745	Shale, dark-gray to grayish-black, finely micaceous; crystals of pyrite
40	2,745-2,785	Shale, grayish-black, very finely micaceous; crystals of pyrite in 2,750 to 2,760
7	2,785-2,792	Siltstone, medium- to dark-gray, finely micaceous
8	2,792-2,800	Sandstone, light brownish gray, very fine grained, silty, well-cemented
10	2,800-2,810	Siltstone, brownish-gray
20	2,810-2,830	Shale, dark-gray to grayish-black, very finely micaceous
4	2,830-2,834	Siltstone, dark-gray, finely micaceous
6	2,834-2,840	Shale, grayish-black, finely micaceous
6	2,840-2,846	Siltstone, as above
4	2,846-2,850	Shale, as above
8	2,850-2,858	Siltstone, brownish-gray, finely micaceous
10	2,858-2,868	Shale, as above
8	2,868-2,876	Siltstone, dark-gray, finely micaceous
2	2,876-2,878	Shale, as above
10	2,878-2,888	Siltstone, as above
1	2,888-2,889	Shale, as above
6	2,889-2,895	Sandstone, white to very light gray, finely micaceous
4	2,895-2,899	Shale, as above
11	2,899-2,910	Sandstone, light-gray, fine-grained, finely micaceous, slightly limy
10	2,910-2,920	Sandstone, light-gray, very fine to fine-grained, finely micaceous, crystals of glauconite, slightly limy
25	2,920-2,945	Sandstone, light-gray, fine-grained, slightly silty, slightly limy
10	2,945-2,955	Sandstone, dark-gray, very fine grained, some fine to medium sand grains, slightly limy; fine to very coarse angular to rounded white clay pellets; carbonized plant fragments
15	2,955-2,970	Sandstone, white to very light gray, fine- to medium-grained, slightly limy
7	2,970-2,977	Shale, grayish - black; scattered slickensided fragments
1	2,977-2,978	Coal
1	2,978-2,979	Shale, grayish-black
10	2,979-2,989	Sandstone, light-gray, very fine grained, silty, finely micaceous
12	2,989-3,001	Shale, grayish-black, very finely micaceous
15	3,001-3,016	Shale, dark-gray, silty, finely micaceous
4	3,016-3,020	Shale, grayish-black
20	3,020-3,040	(No sample)
4	3,040-3,044	Sandstone, medium-gray, very fine grained, very silty, finely micaceous
2	3,044-3,046	Shale, dark-gray to grayish-black, very finely micaceous
4	3,046-3,050	Sandstone, as above
6	3,050-3,056	Shale, as above
5	3,056-3,061	Sandstone, as above
9	3,061-3,070	Shale, as above
3	3,070-3,073	Sandstone, as above
2	3,073-3,075	Shale, as above
5	3,075-3,080	Sandstone, as above
6	3,080-3,086	Siltstone, dark-gray, very finely micaceous
2	3,086-3,088	Shale, grayish-black, very finely micaceous
4	3,088-3,092	Siltstone, as above
2	3,092-3,094	Shale, as above
3	3,094-3,097	Siltstone, as above
2	3,097-3,099	Shale, as above

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
3	3,099-3,102	Siltstone, as above
2	3,102-3,104	Shale, as above
9	3,104-3,113	Siltstone, as above
1	3,113-3,114	Shale, as above
6	3,114-3,120	Siltstone, as above
10	3,120-3,130	Shale, as above
7	3,130-3,137	Siltstone, as above
5	3,137-3,142	Shale, as above
6	3,142-3,148	Siltstone, as above
12	3,148-3,160	Shale, as above
8	3,160-3,168	Siltstone, as above
2	3,168-3,170	Shale, as above
6	3,170-3,176	Siltstone, as above
3	3,176-3,179	Shale, as above
7	3,179-3,186	Siltstone, as above
2	3,186-3,188	Shale, as above
3	3,188-3,191	Siltstone, as above
30	3,191-3,221	Shale, grayish-black
7	3,221-3,228	Sandstone, medium- to dark-gray, very fine grained, very silty, well-cemented (glassy)
1	3,228-3,229	Shale, as above
11	3,229-3,240	Sandstone, medium- to dark-gray, very fine grained, silty, well-cemented (glassy)
10	3,240-3,250	Sandstone, white to very light gray, very fine grained, well-cemented
2	3,250-3,252	Shale, as above
6	3,252-3,258	Sandstone, as above
2	3,258-3,260	Shale, as above
2	3,260-3,262	Sandstone, light- to medium-gray, very fine grained, well-cemented (glassy)
2	3,262-3,264	Shale, as above
6	3,264-3,270	Sandstone, as above
2	3,270-3,272	Shale, as above
10	3,272-3,282	Sandstone, as above
2	3,282-3,284	Shale, as above
6	3,284-3,290	Sandstone, light-gray, very fine grained, well-cemented (glassy)
2	3,290-3,292	Shale, as above
8	3,292-3,304	Sandstone, as above
2	3,304-3,306	Shale, as above
16	3,306-3,322	Sandstone, light- to medium-gray, very fine grained, silty, well-cemented (glassy)
1	3,322-3,323	Shale, as above
5	3,323-3,328	Siltstone, medium- to dark-gray, very finely sandy, well-cemented (glassy)
2	3,328-3,330	Shale, as above
12	3,330-3,342	Siltstone, as above
1	3,342-3,343	Shale, as above
25	3,343-3,368	Siltstone, medium- to dark-gray, very finely micaceous
4	3,368-3,372	Sandstone, medium-gray, very fine grained, silty, finely micaceous
83	3,372-3,455	Shale, dark-gray to grayish-black, very finely micaceous
28	3,455-3,483	Shale, grayish-black
8	3,483-3,491	Siltstone, grayish-brown, very finely sandy, argillaceous
27	3,491-3,518	Shale, as above
12	3,518-3,530	Siltstone, dark-gray, argillaceous
5	3,530-3,535	Shale, as above
7	3,535-3,542	Siltstone, dark-gray, abundant crystals of pyrite, well-cemented
5	3,542-3,547	Shale, as above
6	3,547-3,553	Siltstone, dark-gray
4	3,553-3,557	Shale, as above
7	3,557-3,564	Siltstone, brownish-gray, very finely sandy, well-cemented
4	3,564-3,570	Shale, brownish-gray, silty, very finely micaceous
10	3,570-3,580	(No sample)
34	3,580-3,614	Sandstone, medium-gray, brownish tinge from 3,600 to 3,614, very fine grained, very silty, very finely micaceous
3	3,614-3,617	Shale, grayish-black
6	3,617-3,623	Sandstone, medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty
7	3,623-3,630	Sandstone, light- to medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter)
10	3,630-3,640	Sandstone, medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty
10	3,640-3,650	Sandstone, white to very light gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty
2	3,650-3,652	Sandstone, light- to medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty; carbonaceous streaks
18	3,652-3,670	Siltstone, dark-gray, very finely sandy
20	3,670-3,690	(No sample)
20	3,690-3,710	Shale, dark-gray to grayish-black, very finely micaceous
15	3,710-3,725	Siltstone, grayish-brown, very finely sandy, finely micaceous
15	3,725-3,740	Siltstone, dark-gray, very finely sandy, finely micaceous
6	3,740-3,746	Shale, grayish-black
11	3,746-3,757	Siltstone, dark grayish-brown, very finely sandy
5	3,757-3,762	Shale, as above
8	3,762-3,770	Siltstone, as above
18	3,770-3,788	Shale, grayish-black; drills splintery
40	3,788-3,828	Siltstone, dark-gray, silt is almost very fine sand size (more than 0.062 mm in diameter), very finely sandy, very finely micaceous

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
12	3,828-3,840	Shale, grayish-black, very finely micaceous
6	3,840-3,846	Sandstone, light-gray, very fine to fine-grained, very silty
11	3,846-3,857	Siltstone, dark-gray, very finely sandy, very finely micaceous
1	3,857-3,858	Shale, as above
5	3,858-3,863	Siltstone, as above
2	3,863-3,865	Shale, as above
5	3,865-3,870	Siltstone, as above
14	3,870-3,884	Siltstone, dark-gray, very finely micaceous
21	3,884-3,905	Sandstone, light- to medium-gray, very fine grained, very silty
25	3,905-3,930	Sandstone, medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty, very finely micaceous
10	3,930-3,940	Shale, dark-gray, silty, very finely micaceous
10	3,940-3,950	Siltstone, medium- to dark-gray, very finely sandy, very finely micaceous
10	3,950-3,960	Sandstone, medium-gray, very fine grained, very silty
20	3,960-3,980	(No sample)
10	3,980-3,990	Sandstone, light- to medium-gray, very fine grained, silty, finely micaceous
150	3,990-4,140	(No sample)
20	4,140-4,160	Siltstone, dark-gray, very finely sandy, very finely micaceous
25	4,160-4,185	Shale, dark-gray, silty, very finely micaceous
5	4,185-4,190	Siltstone, medium-gray
15	4,190-4,205	Shale, as above
45	4,205-4,250	Siltstone, dark-gray, slightly very finely sandy, very finely micaceous
10	4,250-4,260	Shale, as above
40	4,260-4,300	(No sample)
10	4,300-4,310	Sandstone, light-gray, very fine grained, slightly silty
1	4,310-4,311	Shale, grayish-black
6	4,311-4,317	Sandstone, as above
3	4,317-4,320	Shale, as above
10	4,320-4,330	Sandstone, as above
2	4,330-4,332	Shale, as above
8	4,332-4,340	Sandstone, medium-gray, very fine grained, silty
10	4,340-4,350	(No sample)
4	4,350-4,354	Sandstone, as above
26	4,354-4,380	Siltstone, medium-gray, very finely sandy, very finely micaceous
33	4,380-4,413	Siltstone, medium- to dark-gray
45	4,413-4,458	Shale, dark-gray, very finely micaceous
24	4,458-4,482	Sandstone, medium-gray, very fine grained, very silty, very finely micaceous
8	4,482-4,490	Shale, as above
25	4,490-4,515	Sandstone, medium-gray, very fine grained; drills free
25	4,515-4,540	Sandstone, light-gray, very fine to fine-grained, slightly silty, finely micaceous; drills free
8	4,540-4,548	Shale, as above
27	4,548-4,575	Sandstone, light-gray, very fine to fine-grained, silty; drills free
2	4,575-4,577	Shale, as above
10	4,577-4,587	Sandstone, light- to medium-gray, very fine grained, very silty; drills free
1	4,587-4,588	Shale, as above
14	4,588-4,602	Sandstone, as above
2	4,602-4,604	Shale, as above
8	4,604-4,612	Sandstone, as above
8	4,612-4,620	Shale, as above
15	4,620-4,635	Sandstone, light-gray, very fine to fine-grained, silty, finely micaceous; drills free
10	4,635-4,645	Sandstone, light-gray, fine-grained, scattered subrounded medium sand grains, silty; drills free
25	4,645-4,670	Sandstone, very light gray, very fine to fine-grained; drills free
8	4,670-4,678	Sandstone, light- to medium-gray, very fine grained, very silty
1	4,678-4,679	Shale, as above
5	4,679-4,684	Sandstone, as above
1	4,684-4,685	Shale, as above
7	4,685-4,692	Sandstone, as above
32	4,692-4,724	Shale, dark-gray, silty, very finely micaceous
24	4,724-4,748	Sandstone, medium-gray, very fine grained, very silty, finely micaceous
7	4,748-4,755	Shale, dark-gray, very finely micaceous
12	4,755-4,767	Sandstone, light-gray, very fine to fine-grained, widely scattered rounded medium sand grains; drills free
1	4,767-4,768	Shale, as above
24	4,768-4,792	Sandstone, light- to medium-gray, very fine to fine-grained, silty
3	4,792-4,795	Shale, as above
14	4,795-4,809	Sandstone, light-gray, very fine to fine-grained; drills free
11	4,809-4,820	Sandstone, very light gray, very fine grained; drills free
2	4,820-4,822	Shale, as above
10	4,822-4,832	Sandstone, light- to medium-gray, very fine grained
2	4,832-4,834	Shale, as above
5	4,834-4,839	Sandstone, as above
6	4,839-4,845	Shale, as above
5	4,845-4,850	Sandstone, as above
6	4,850-4,856	Shale, as above
5	4,856-4,861	Siltstone, light-gray, very finely sandy
2	4,861-4,863	Shale, as above
5	4,863-4,868	Siltstone, as above

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
3	4,868-4,871	Shale, as above
9	4,871-4,880	Siltstone, as above
3	4,880-4,883	Shale, as above
3	4,883-4,886	Siltstone, as above
3	4,886-4,889	Shale, as above
1	4,889-4,890	Siltstone, as above
10	4,890-4,900	Shale, as above
30	4,900-4,930	(No sample)
20	4,930-4,950	Shale, dark-gray, silty, very finely micaceous
8	4,950-4,958	Shale, dark-gray
14	4,958-4,972	Siltstone, medium-gray, finely micaceous
8	4,972-4,980	Sandstone, light-gray, very fine to fine-grained, scattered rounded medium sand grains
15	4,980-4,995	Siltstone, light- to medium-gray
12	4,995-5,007	Shale, dark-gray, very finely micaceous
15	5,007-5,022	Siltstone, medium-gray
12	5,022-5,034	Shale, as above
4	5,034-5,038	Siltstone, as above
2	5,038-5,040	Shale, as above
8	5,040-5,048	Siltstone, as above
3	5,048-5,051	Shale, as above
8	5,051-5,059	Siltstone, as above
3	5,059-5,062	Shale, as above
8	5,062-5,070	Siltstone, as above
10	5,070-5,080	Shale, as above
90	5,080-5,170	Shale, grayish-black, very finely micaceous
20	5,170-5,190	(No sample)
2	5,190-5,192	Shale, dark-gray, very finely micaceous
9	5,192-5,201	Sandstone, medium-gray, very fine to fine-grained, silty
12	5,201-5,213	Shale, as above
10	5,213-5,223	Sandstone, light gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty
5	5,223-5,228	Shale, as above
10	5,228-5,238	Sandstone, as above
4	5,238-5,242	Shale, as above
8	5,242-5,250	Sandstone, as above
6	5,250-5,256	Shale, as above
4	5,256-5,260	Sandstone, as above
1	5,260-5,261	Shale, as above
12	5,261-5,273	Sandstone, as above
6	5,273-5,279	Shale, as above
4	5,279-5,283	Sandstone, as above
5	5,283-5,288	Shale, as above
5	5,288-5,293	Sandstone, as above
2	5,293-5,295	Shale, as above
7	5,295-5,302	Sandstone, as above
7	5,302-5,309	Shale, as above
9	5,309-5,138	Sandstone, light- to medium-gray, very fine grained, very silty, well-cemented
1	5,318-5,319	Shale, as above
4	5,319-5,323	Sandstone, as above
4	5,323-5,327	Shale, as above
15	5,327-5,342	Sandstone, as above
6	5,342-5,348	Shale, as above
11	5,348-5,359	Sandstone, as above
22	5,359-5,381	Shale, grayish-black, very finely micaceous
7	5,381-5,388	Sandstone, as above
7	5,388-5,395	Shale, grayish-black
81	5,395-5,476	Sandstone, light- to medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty
4	5,476-5,480	Shale, dark-gray, very finely micaceous
50	5,480-5,530	Sandstone, as above
6	5,530-5,536	Shale, as above
11	5,536-5,547	Sandstone, as above
2	5,547-5,549	Shale, as above
3	5,549-5,552	Sandstone, as above
4	5,552-5,556	Shale, as above
22	5,556-5,578	Sandstone, as above
13	5,578-5,591	Shale, dark-gray, silty, very finely micaceous
9	5,591-5,600	Sandstone, light-gray, very fine grained, very silty
30	5,600-5,630	(No sample)
10	5,630-5,640	Sandstone, as above
60	5,640-5,700	(No sample)
6	5,700-5,706	Shale, as above
4	5,706-5,710	Sandstone, as above
40	5,710-5,750	(No sample)
5	5,750-5,755	Sandstone, as above
15	5,755-5,770	Sandstone, light-gray, very fine grained, silty
2	5,770-5,772	Shale, dark-gray, very finely micaceous
9	5,772-5,781	Sandstone, light-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty
2	5,781-5,783	Shale, as above
4	5,783-5,787	Sandstone, as above
3	5,787-5,790	Shale, as above
11	5,790-5,801	Sandstone, as above
5	5,801-5,806	Shale, as above
6	5,806-5,812	Sandstone, as above
15	5,812-5,827	Shale, grayish-black
26	5,827-5,853	Sandstone, as above
5	5,853-5,858	Shale, as above
12	5,858-5,870	Siltstone, light- to medium-gray, very finely sandy, well-cemented
14	5,870-5,884	Siltstone, light- to medium-gray, well-cemented
6	5,884-5,890	Shale, as above
30	5,890-5,920	(No sample)

Thick- ness in feet	Interval in feet	Description Pennsylvanian system
10	5,920-5,930	Sandstone, light-gray, very fine grained, very silty
14	5,930-5,944	Siltstone, dark-gray, well-cemented
3	5,944-5,947	Shale, as above
6	5,947-5,953	Siltstone, as above
5	5,953-5,958	Shale, as above
2	5,958-5,960	Siltstone, as above
10	5,960-5,970	Shale, as above
20	5,970-5,990	Sandstone, light-gray, very fine grained; drills free
140	5,990-6,130	(No sample)
17	6,130-6,147	Sandstone, light-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty
18	6,147-6,165	Siltstone, medium-gray
14	6,165-6,179	Shale, grayish-black
3	6,179-6,182	Siltstone, light- to medium-gray
47	6,182-6,229	Shale, as above
6	6,229-6,235	Siltstone, dark-gray
2	6,235-6,237	Shale, as above
3	6,237-6,240	Siltstone, as above
4	6,240-6,244	Shale, as above
4	6,244-6,248	Siltstone, as above
1	6,248-6,249	Shale, as above
4	6,249-6,253	Siltstone, as above
2	6,253-6,255	Shale, as above
6	6,255-6,261	Siltstone, as above
19	6,261-6,280	Shale, as above
49	6,280-6,329	Siltstone, medium- to dark-gray, finely micaceous
36	6,329-6,365	Shale, dark-gray, silty; crystals of pyrite in 6,340 to 6,350
67	6,365-6,432	Shale, grayish-black
8	6,432-6,440	Siltstone, medium- to dark-gray, limy
4	6,440-6,444	Shale, as above
15	6,444-6,459	Sandstone, light-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty, very limy
7	6,459-6,466	Shale, as above
41	6,466-6,507	Siltstone, light- to medium-gray, silt is almost very fine sand size (more than 0.062 mm in diameter), very finely sandy, slightly limy to limy
30	6,507-6,537	Siltstone, medium- to dark-gray, slightly limy, well-cemented
3	6,537-6,540	Shale, as above
5	6,540-6,545	Siltstone, as above
1	6,545-6,546	Shale, as above
4	6,546-6,550	Siltstone, as above
23	6,550-6,573	Shale, as above
13	6,573-6,590	Siltstone, medium to dark-gray, slightly limy
10	6,590-6,600	(No sample)
13	6,600-6,613	Sandstone, light- to medium-gray, very fine grained, very silty
18	6,613-6,631	Shale, grayish-black; drills splintery
12	6,631-6,643	Sandstone, light- to medium-gray, very fine grained, sand is almost silt size (less than 0.062 mm in diameter), very silty
2	6,643-6,645	Shale, grayish-black
5	6,645-6,650	Siltstone, dark-gray
2	6,650-6,652	Shale, as above
5	6,652-6,657	Siltstone, as above
2	6,657-6,659	Shale, as above
4	6,659-6,663	Siltstone, as above
3	6,663-6,666	Shale, as above
4	6,666-6,670	Siltstone, as above
3	6,670-6,673	Shale, as above
7	6,673-6,680	Siltstone, as above
1	6,680-6,681	Shale, as above
2	6,681-6,683	Siltstone, as above
3	6,683-6,686	Shale, as above
14	6,686-6,700	Siltstone, as above
27	6,700-6,727	Shale, as above; slickensided fragments in 6,700 to 6,710
18	6,727-6,745	Sandstone, very light gray to light-gray, very fine grained, silty, well-cemented
33	6,745-6,778	Sandstone, light- to medium-gray, very fine grained, very silty, well-cemented
10	6,778-6,788	Shale, as above
7	6,788-6,795	Sandstone, medium- to dark-gray, fine-grained, widely scattered sub-rounded medium sand grains, silty, well-cemented
61	6,795-6,856	Shale, grayish-black; drills splintery
14	6,856-6,870	Sandstone, light- to medium-gray, very fine grained, very silty, well-cemented
5	6,870-6,875	Sandstone, very light gray, fine- to medium-grained, slightly silty
13	6,875-6,888	Sandstone, very light to light-gray, very fine grained, very silty, well-cemented
17	6,888-6,905	Siltstone, medium-gray, very finely micaceous
15	6,905-6,920	Siltstone, dark-gray, very finely micaceous
8	6,920-6,928	Shale, grayish-black
5	6,928-6,933	Sandstone, medium-gray, very fine to fine-grained, very silty
5	6,933-6,938	Shale, as above
3	6,938-6,941	Sandstone, as above
10	6,941-6,951	Siltstone, dark-gray, very finely micaceous
15	6,951-6,965	Shale, grayish-black; drills splintery
6	6,965-6,971	Siltstone, dark-gray
7	6,971-6,978	Shale, grayish-black
4	6,978-6,982	Sandstone, medium- to dark-gray, very fine grained, very silty, well-cemented
6	6,982-6,988	Shale, as above
14	6,988-7,002	Sandstone, as above

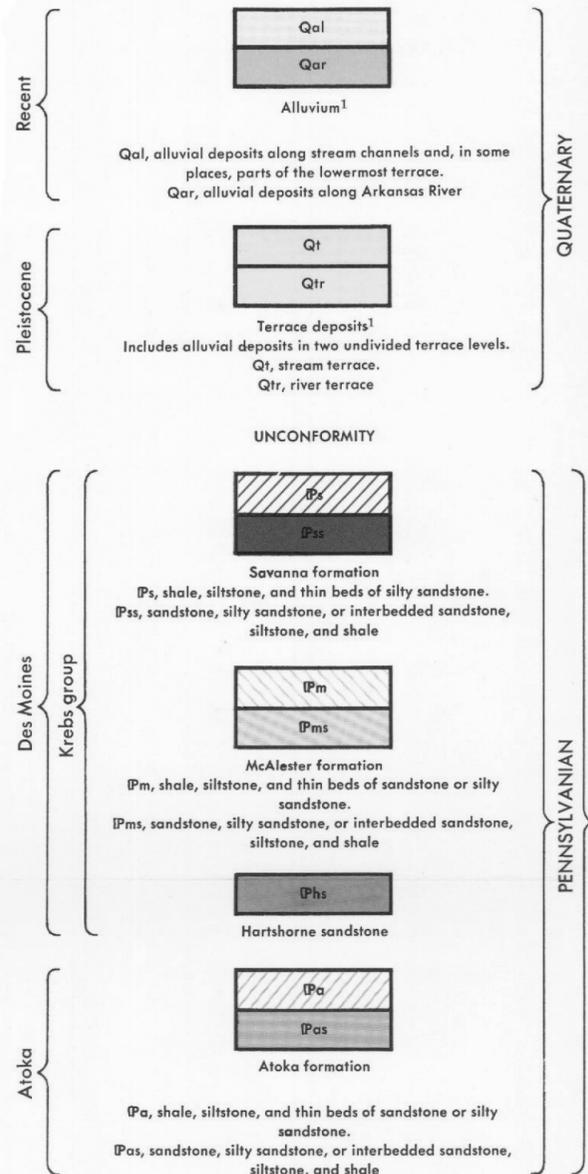
Thick- ness in feet	Interval in feet	Description Pennsylvanian system
4	7,002-7,006	Shale, as above
5	7,006-7,011	Siltstone, dark-gray, very finely mica- ceous
7	7,011-7,018	Shale, as above
2	7,018-7,020	Siltstone, as above
3	7,020-7,023	Shale, as above
6	7,023-7,029	Siltstone, very light to medium-gray, very finely sandy, very finely mica- ceous
3	7,029-7,032	Siltstone, medium-gray, very finely micaceous
43	7,032-7,080	Shale, dark-gray to grayish-black
53	7,080-7,133	Shale, grayish-black
12	7,133-7,145	Siltstone, medium- to dark-gray, very finely sandy, very finely micaceous
20	7,145-7,165	Shale, dark-gray to grayish-black
3	7,165-7,168	Shale, light olive gray, flaky texture, waxy appearance
2	7,168-7,170	Shale, dark brownish gray, silty, slightly limy
23	7,170-7,193	Sandstone, medium-gray, very fine grained, very silty; medium quartz crystals (fracture filling?)
31	7,193-7,224	Shale, dark-gray to grayish-black; drills splintery
15	7,224-7,229	Shale, light- to light yellowish-grey, waxy appearance, silty, slightly very finely sandy, slightly limy
2	7,229-7,231	Shale, very light to light-gray, waxy appearance, slightly limy
7	7,231-7,238	Siltstone, very light gray, argillace- ous, very finely sandy
5	7,238-7,243	Sandstone, very light gray, very fine to fine-grained, porous
6	7,243-7,249	Shale, grayish-black; abundant slick- ensided fragments
4	7,249-7,253	Siltstone, light- to medium-gray, very finely sandy, very finely micaceous, widely scattered rounded medium sand grains
9	7,253-7,262	Shale, grayish-black; slickensided fragments
9	7,262-7,271	Sandstone, light-gray, very fine grained, very finely micaceous, well- cemented
5	7,271-7,276	Shale, grayish-black
4	7,276-7,280	Sandstone, medium-gray, very fine grained, very silty, slightly limy
11	7,280-7,291	Sandstone, very light gray, very fine grained, very limy
3	7,291-7,294	Shale, grayish-black
13	7,294-7,307	Sandstone, light-gray, very fine grained, very limy
11	7,307-7,318	Sandstone, light-gray, very fine grained, silty, limy
13	7,318-7,331	Siltstone, light brownish gray, very finally micaceous, very finely sandy, well-cemented; base of unit is base of Atoka formation
Bloyd shale		
6	7,331-7,337	Shale, grayish-black
3	7,337-7,340	Sandstone, light-gray, very fine grained, very silty, very finely mica- ceous, well-cemented
8	7,340-7,348	Shale, grayish-black; slickensided fragments
2	7,348-7,350	Siltstone, very light gray, very finely sandy, very finely micaceous
8	7,350-7,358	Shale, grayish-black
5	7,358-7,363	Siltstone, dark-gray, very finely mi- ceous
4	7,363-7,367	Shale, grayish-black
3	7,367-7,370	Limestone, dark-gray, silty, very finely sandy
5	7,370-7,375	Siltstone, dark-gray, very finely mi- ceous, slightly limy
17	7,375-7,392	Siltstone, dark-gray, very finely mi- ceous; dark brownish gray streaks
3	7,392-7,395	Sandstone, dark-gray, very fine to fine-grained, silty, well-cemented
5	7,395-7,400	Siltstone, dark-gray, very finely mi- ceous
8	7,400-7,408	Sandstone, light- to medium-gray, very fine grained, silty, limy
9	7,408-7,417	Siltstone, medium-gray, very finely micaceous, very limy
13	7,417-7,430	Sandstone, medium-gray, very fine grained, very limy
13	7,430-7,443	Limestone, light- to medium-gray, finely sandy; black coating (phos- phate) on some sand grains; cri- noids; bryozoans
7	7,443-7,450	Limestone, light- to medium-gray, finely to medium sandy; black coat- ing (phosphate) on fine to medium sand grains; black ovoid medium oolites; crinoids; bryozoans
8	7,450-7,458	Limestone, medium-gray, very finely to finely sandy, widely scattered medium rounded sand grains; brown- ish-gray ovoid medium oolites; cri- noids; bryozoans
7	7,458-7,495	Shale, grayish-black
4	7,495-7,499	Siltstone, medium- to dark-gray, slightly limy
2	7,499-7,501	Shale, as above
3	7,501-7,504	Siltstone, as above
3	7,504-7,507	Shale, as above
3	7,507-7,510	Siltstone, medium- to dark-gray, slightly limy, very finely to finely sandy
2	7,510-7,512	Shale, as above
4	7,512-7,516	Limestone, medium-gray, silty, slightly very finely sandy
1	7,516-7,517	Shale, as above
5	7,517-7,522	Limestone, as above
5	7,522-7,527	Shale, as above
2	7,527-7,529	Siltstone, medium-gray, silty
2	7,529-7,531	Shale, as above
4	7,531-7,535	Siltstone, as above
8	7,535-7,543	Shale, as above
5	7,543-7,548	Limestone, medium-gray, silty; dark- gray ovoid fine to medium oolites
49	7,548-7,597	Shale, dark-gray; drills splintery; base of unit is base of Bloyd shale

Thickness in feet	Interval in feet	Description Pennsylvanian system
Hale formation		
Prairie Grove member		
9	7,597-7,606	Sandstone, medium-gray, very fine to fine-grained, silty, limy
3	7,606-7,609	Shale, dark-gray
35	7,609-7,644	Sandstone, medium-gray, very fine to fine-grained, slightly silty, very limy; black coating (phosphate) on some sand grains; coarse crystals of calcite (fracture filling)
6	7,644-7,650	Limestone, light- to medium-gray, very finely sandy; abundant black round fine oolites; black coating (phosphate) on some sand grains
1	7,650-7,651	Shale, grayish-black
10	7,651-7,661	Sandstone, medium-gray, very fine to fine-grained, limy
2	7,661-7,663	Shale, as above
2	7,663-7,665	Limestone, light- to medium-gray, granular, argillaceous; crinoids
8	7,665-7,673	Shale, grayish-black; drills splintery
7	7,673-7,680	Limestone, medium-gray, granular, widely scattered fine sand
5	7,680-7,685	Limestone, medium-gray, granular, silty; crinoids
5	7,685-7,690	Limestone, medium-gray, granular, argillaceous, widely scattered fine sand; large fragments of bryozoans filled with clear quartz
8	7,690-7,698	Limestone, dark-gray, dense to granular, widely scattered dark-gray to grayish-black ovoid fine oolites
2	7,698-7,700	Shale, grayish-black
5	7,700-7,705	Limestone, as above
10	7,705-7,715	Limestone, as above, with widely scattered fine sand; crinoids
13	7,715-7,728	Siltstone, dark-gray, limy
5	7,728-7,733	Shale, dark-gray to grayish-black; drills splintery
4	7,733-7,737	Siltstone, as above
5	7,737-7,742	Limestone, medium- to dark-gray, silty; crinoids
10	7,742-7,752	Siltstone, dark-gray, very finely sandy, limy
3	7,752-7,755	Shale, grayish-black
5	7,755-7,760	Limestone, medium-gray, very finely sandy, silty; crinoids
5	7,760-7,765	Limestone, medium-gray, very finely to finely sandy; crinoids
3	7,765-7,768	Sandstone, light- to medium-gray, fine grained, very limy; black coating on some sand grains
2	7,768-7,770	Limestone, medium-gray, finely sandy
8	7,770-7,778	Sandstone, as above
2	7,778-7,780	Limestone, as above
2	7,780-7,782	Sandstone, as above
4	7,782-7,786	Limestone, medium- to dark-gray, silty
3	7,786-7,789	Sandstone, medium- to dark-gray, very fine grained, limy
2	7,789-7,791	Limestone, as above
3	7,791-7,794	Sandstone, as above
13	7,794-7,807	Sandstone, very light gray, very fine grained, well-cemented; base of unit is base of Prairie Grove member
Upper part of Cane Hill member		
8	7,807-7,815	Siltstone, medium- to dark-gray, very finely sandy, slightly limy
7	7,815-7,822	Shale, dark-gray to grayish-black
25	7,822-7,847	Siltstone, medium- to dark-gray, slightly very finely sandy, limy
8	7,847-7,855	Shale, as above
11	7,855-7,866	Siltstone, dark-gray, slightly very finely sandy, slightly limy
4	7,866-7,870	Shale, brownish-gray to dark brownish gray
6	7,870-7,876	Sandstone, light- to medium-gray, very fine to fine-grained, silty, limy
5	7,876-7,881	Limestone, medium-gray, silty, slightly very finely sandy; crinoids; pyrite
9	7,881-7,890	Siltstone, medium- to dark-gray, very finely sandy, limy
10	7,890-7,900	Shale, dark-gray; many slickensided fragments; pyrite
3	7,900-7,903	Limestone, medium- to dark-gray, very silty; crinoids
7	7,903-7,910	Siltstone, medium-gray, very finely sandy, limy
4	7,910-7,914	Siltstone, medium-gray, well-cemented
11	7,914-7,925	Shale, grayish-black; abundant slickensided fragments; base of unit is in fault contact with rocks of Boone and Moorefield formations undifferentiated
Mississippian system		
Boone and Moorefield formations undifferentiated		
8	7,925-7,933	Shale, grayish-black; abundant slickensided fragments
4	7,933-7,937	Siltstone, dark-gray, limy
3	7,937-7,940	Limestone, medium- to dark-gray, very silty
3	7,940-7,943	Siltstone, as above
7	7,943-7,950	Limestone, as above
5	7,950-7,955	Shale, grayish-black
3	7,955-7,958	Siltstone, medium- to dark-gray, very limy
4	7,958-7,962	Limestone, medium-gray, silty; abundant black ovoid fine to medium oolites; base of unit is base of Boone and Moorefield formations undifferentiated

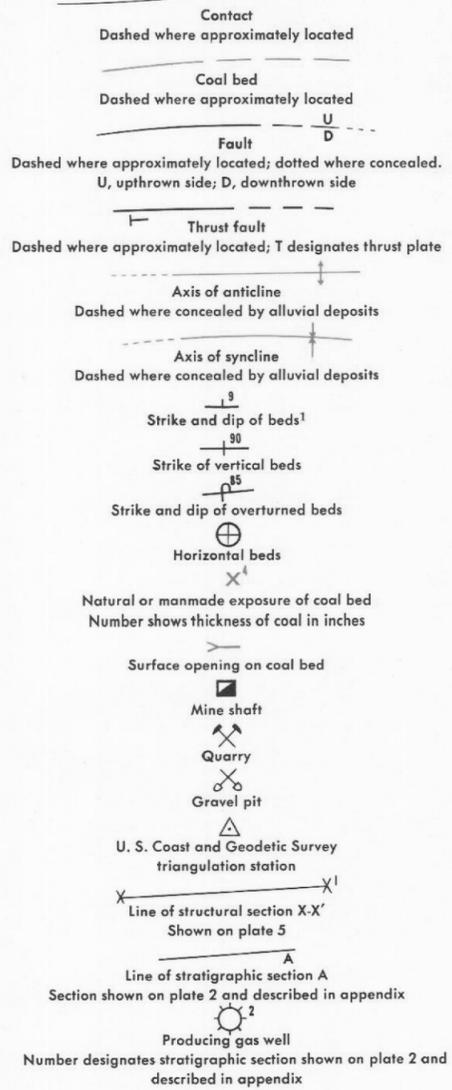
Thick- ness in feet	Interval in feet	Mississippian and Devonian systems Description			
		Chattanooga shale			
18	7,962-7-980	Shale, grayish-black; very abundant very fine crystals of pyrite	5	8,035-8,040	Chert, medium- to dark-gray, translucent to opaque, slight show of lime, very widely scattered crystals of dolomite; quartz crystals along fractures
44	7,980-8,024	Shale, grayish-black; fragment of grayish-black dense concretion in 7,985 to 7,990; very fine crystals of pyrite in 7,990 to 8,000; dark-gray pyritic concretion in 8,000 to 8,005	5	8,040-8,045	Chert, grayish-white to white, translucent; scattered layers of very fine to medium sand; scattered quartz crystals; some very fine to fine sand grains are loci for concentric layers of grayish white silica
		Sylamore sandstone member			
4	8,024-8,028	Sandstone, light- to medium-gray, very fine to fine-grained, silty, limy; widely scattered dark-gray fine oolites; black phosphate coating on some sand grains; base of unit is base of Chattanooga shale	5	8,045-8,050	Chert, light-gray, translucent, very finely sandy in part, slightly limy; widely scattered very fine crystals of pyrite; very fine quartz crystals along fractures
		Devonian system			
		Upper part of Penters chert			
7	8,028-8,035	Chert, very light gray, translucent, to dark-gray, opaque; quartz crystals along fractures; limy along fractures	8	8,050-8,058	Chert, very light gray, translucent, very slightly limy; widely scattered crystals of dolomite; crinoids; bryozoans
			20	8,058-8,078	(No sample), assumed 20-ft. lag
				8,078	Total depth

PLATE I

EXPLANATION

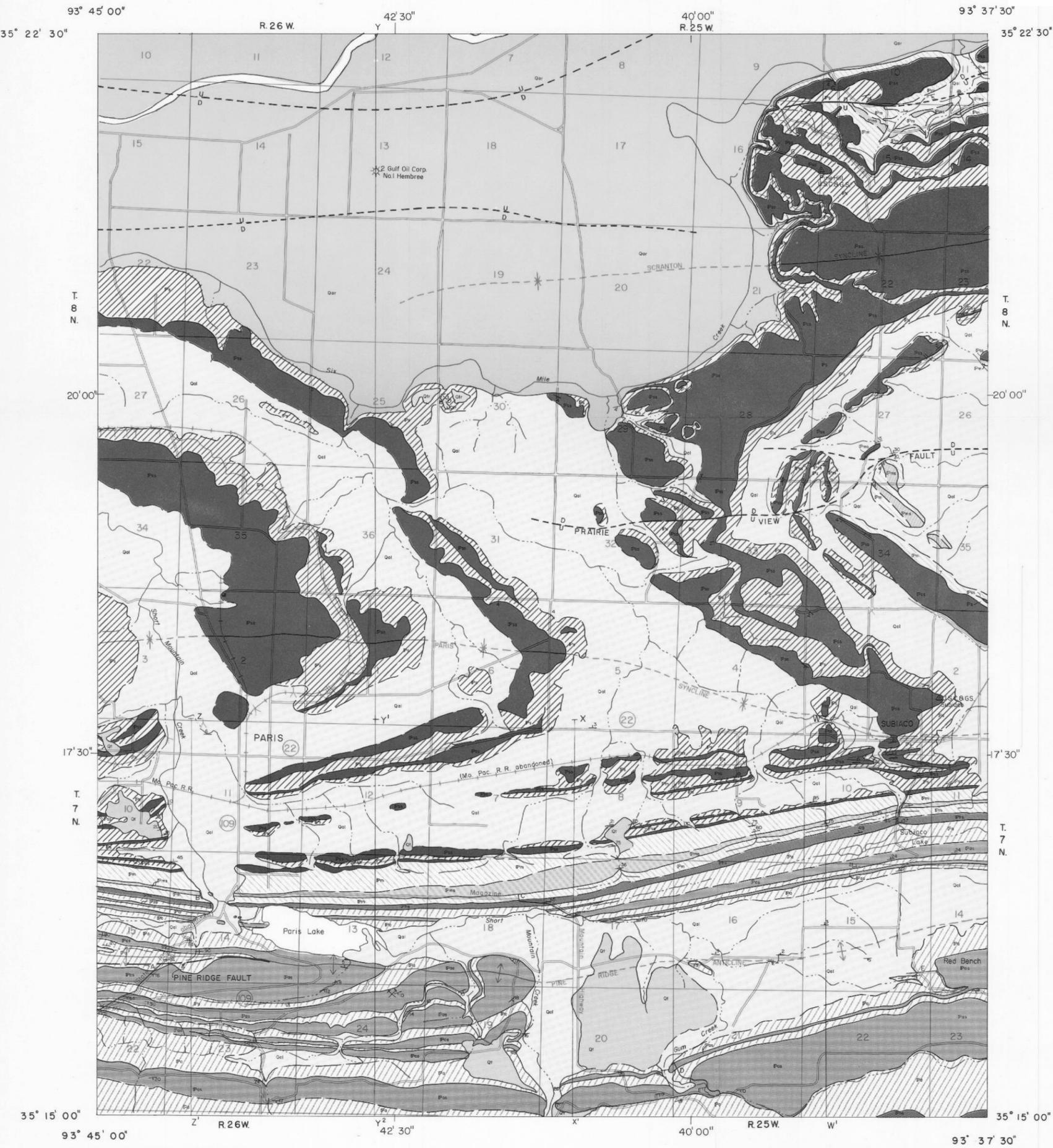


QUATERNARY
PENNSYLVANIAN
CARBONIFEROUS



¹ Strike and dip symbols shown in areas of alluvial deposits were measured on bedrock through windows in the deposits. The windows range in width from 2 to 10 feet and in length from 4 to 60 feet; therefore, they cannot be shown on this map without gross exaggeration.

Section lines, township lines, and county lines are indicated for general orientation and identification but are not authenticated for legal purposes.



GEOLOGICAL MAP OF PARIS QUADRANGLE, LOGAN COUNTY AND VICINITY, ARKANSAS

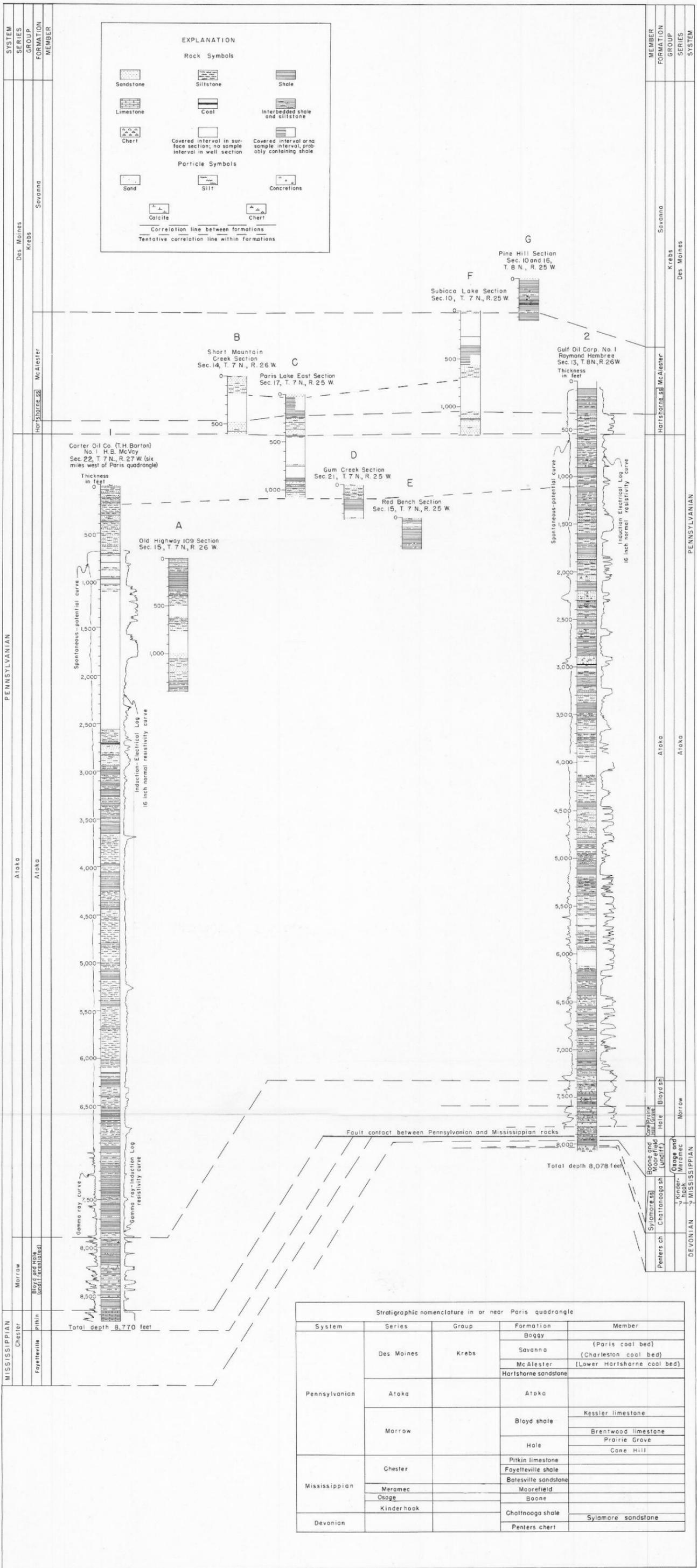
by
Boyd R. Haley
U. S. Geological Survey
1960

Scale: 0 to 1 mile

APPROXIMATE MEAN DECLINATION, 1960

Planimetric base compiled by Boyd R. Haley

Geology mapped in 1958



EXPLANATION

Rock Symbols

- Sandstone
- Limestone
- Chert
- Siltstone
- Coal
- Interbedded shale and siltstone
- Shale
- Covered interval in surface section; no sample interval in well section
- Covered interval and sample interval, probably containing shale

Particle Symbols

- Sand
- Silt
- Concretions
- Calcite
- Chert

Correlation line between formations
Tentative correlation line within formations

Stratigraphic nomenclature in or near Paris quadrangle

System	Series	Group	Formation	Member	
Mississippian	Chester	Krebs	Boggy	(Paris coal bed)	
			Savanna	(Charleston coal bed)	
			McAlester	(Lower Hartshorne coal bed)	
			Hartshorne sandstone		
Pennsylvanian	Atoka		Atoka		
			Morrow	Bloyd shale	Kessler limestone
				Hole	Brentwood limestone Prairie Grove Cane Hill
Mississippian	Chester		Pitkin limestone		
			Fayetteville shale		
			Batesville sandstone		
			Moorefield		
			Osage	Boone	
Devonian	Kinderhook		Chattanooga shale		
			Peneters chert	Sylamore sandstone	

STRATIGRAPHIC SECTIONS IN PARIS QUADRANGLE, LOGAN COUNTY, ARKANSAS

by
Boyd R. Haley
U.S. Geological Survey
1960

percentage of shale in the Boone formation. A grayish-black shale 8 feet thick in the upper part of the unit is arbitrarily considered a part of the undifferentiated Boone and Moorefield formations in this report; however, it may be a part of the Fayetteville shale, which overlies the Moorefield formation elsewhere in Arkansas.

Fayetteville Shale

The Fayetteville shale probably is not present in the Hembree well because of a fault (pls. 2 and 3) unless it is an 8-foot thick grayish-black shale assigned tentatively to the Boone and Moorefield formations, undifferentiated. However, it is assumed to be present throughout most of the area of the Paris quadrangle. The Fayetteville shale, elsewhere in Arkansas, is a dark-gray to grayish-black shale containing some medium- to dark-gray siltstone, medium-gray very fine sandstone, and dark-gray dense limestone. The Fayetteville shale may be as much as 300 feet thick in the Paris quadrangle.

Pitkin Limestone

The Pitkin limestone is not present in the Hembree well because of a fault (pls. 2 and 3), but 124 feet of the Pitkin was penetrated by the Carter Oil Co. No. 1 H. B. McVay well about 6 miles west of the Paris quadrangle (pl. 2). The part of the Pitkin limestone penetrated by the McVay well consists of grayish-black shale and dark-gray dense limestone that is pyritic in part, very finely sandy in the upper part, and has abundant crinoid fragments in the lower 25 feet. The total thickness of the Pitkin limestone in the Paris quadrangle is unknown but it may be more than 400 feet.

PENNSYLVANIAN SYSTEM

Morrow Series

The Morrow series in other parts of Arkansas consists of the Hale formation, which unconformably overlies the Pitkin limestone, and the younger Bloyd shale, which is unconformably overlain by the Atoka formation. The character of the upper and lower contacts of the Morrow in the Paris quadrangle cannot be determined from available information. The Morrow series is at least 594 feet thick in the Hembree well and it is 762 feet thick in the McVay well.

The Morrow series in the Hembree well consists of shale, siltstone, limy siltstone, limy sandstone, sandy limestone, and limestone, and can be divided into the Cane Hill and Prairie Grove members of the Hale formation, and the Bloyd shale. The Morrow series in the McVay

well consists of units of shale, siltstone, sandy siltstone, silty sandstone, slightly limy sandstone, and one bed of limestone. These units cannot be correlated with certainty with named units elsewhere, and therefore are called Bloyd shale and Hale formation (undifferentiated) on plate 2 and in the Appendix of this report.

Hale Formation

The Hale formation was defined by Henbest (1953, p. 1938). It unconformably overlies the Pitkin limestone and is overlain conformably by the Bloyd shale. The formation consists of the Cane Hill and overlying Prairie Grove members. The part of the Hale formation in the Hembree well is 328 feet thick.

Cane Hill Member

The Cane Hill member of the Hale formation in the Hembree well overlies the undifferentiated Boone and Moorefield formations with a fault contact. The top of the Cane Hill member cannot be identified in the McVay well, but its base (base of undifferentiated Bloyd and Hale formations) can be identified.

The part of the Cane Hill member in the Hembree well is 118 feet thick and consists mostly of dark-gray slightly limy to limy siltstone and medium- to dark-gray limy very finely sandy siltstone, with minor amounts of grayish-black shale, light- to medium-gray silty slightly limy very fine grained sandstone, light- to medium-gray limy very fine to fine-grained sandstone, dark-gray silty very finely sandy granular limestone, and medium- to dark-gray very silty limestone.

Prairie Grove Member

The nature of the contact between the Cane Hill and overlying Prairie Grove members in the area of this report is unknown, but Frezon and Glick (1959, p. 182) consider the members unconformable in other parts of Arkansas. Presumably the Prairie Grove member is overlain conformably by the Bloyd shale. The Prairie Grove member in the Hembree well is 210 feet thick and consists mostly of medium-gray silty limy very fine to fine-grained sandstone and medium-gray limy to very limy very fine grained sandstone, with a smaller amount of medium-gray very finely to finely sandy limestone and medium- to dark-gray granular to very finely crystalline limestone, and a minor amount of grayish-black shale and dark-gray limy and very finely sandy siltstone.

Bloyd Shale

The Bloyd shale was named by Purdue (1907, p. 3). Its relations to the underlying and over-

lying rock units in the Paris quadrangle are unknown, but elsewhere in Arkansas it rests conformably on the Prairie Grove member of the Hale formation and is overlain unconformably by the Atoka formation. The Bloyd shale in the Hembree well is 266 feet thick and consists of dark-gray to grayish-black shale, with subordinate amounts of medium- to dark-gray slightly limy to limy siltstone, dark-gray finely micaceous very finely sandy siltstone, medium- to dark-gray silty limy very fine to fine-grained sandstone, medium-gray very limy fine-grained sandstone, medium-gray very finely to coarsely sandy limestone, medium- to dark-gray silty granular to very finely crystalline limestone, and medium-gray granular to finely crystalline limestone. The Bloyd shale could not be separated from the underlying Hale formation in the McVay well.

Atoka Series

In Arkansas the Atoka series comprises the Atoka formation. The formation was named for Atoka, Oklahoma, by Taff and Adams (1900, p. 273). In 1901 Taff described the Atoka formation in Oklahoma as overlying the Wapanucka limestone of Morrow age and underlying the Hartshorne sandstone. The Atoka formation in northwestern Arkansas unconformably overlies the Bloyd shale of Morrow age (Henbest, 1953, p. 1947) and in the Arkansas Valley is unconformably overlain by the Hartshorne sandstone (Hendricks and Parks, 1950, p. 73; Merewether and Haley, 1960, p. 6). The contact relations are probably the same in the area of this report.

The Atoka formation in the Hembree well consists of shale and sandstone with a subordinate amount of siltstone. The shale ranges in color from dark gray to grayish black and is micaceous and silty in part. The sandstone ranges in color from very light gray to dark gray, is mostly very fine to fine grained and is silty and limy in part. The siltstone ranges in color from very light gray to dark gray and is sandy and limy in part. Generally, all the above rock types are micaceous. Some of the shale, siltstone, and sandstone in the interval 2,300 to 3,800 feet is brownish gray to dark brownish gray. In the upper part of the Atoka are at least three coal beds. The lithology of the Atoka formation is different in the Hembree well than in the McVay well. In the McVay well the sandstone is, in general, finer grained, more silty, less limy, and comprises a smaller percentage of the total thickness. Siltstone and shale comprise a larger percentage of the total thickness. The Atoka formation thickens from 6,781 feet in the Hembree well to about 8,330 feet in the McVay well.

The decrease in amount of sandstone and the thickening of the formation southward in the area of this report suggest that sediments deposited during Atoka time had a source to the north and were deposited in a downwarping basin. Merewether and Haley (1960, p. 6) reported that southward thickening of the Atoka formation in the Delaware quadrangle occurs mostly in the middle of the formation. It is not known if this is true of the formation in the Paris quadrangle.

A sequence of beds approximately 2,700 feet thick in the upper part of the Atoka formation is exposed in the Pine Ridge anticline in the Paris quadrangle. The sandstone beds are lenticular, regular to irregular or very thin to massive. Locally the sandstone is crossbedded in zones as much as 10 feet thick and, in some places, zones of sandstone as much as 3 feet thick are convolute bedded. The bedding features are especially well displayed along Gum Creek in the center of the SW $\frac{1}{4}$ sec. 21, T. 7 N., R. 25 W.

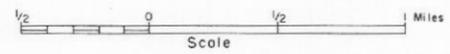
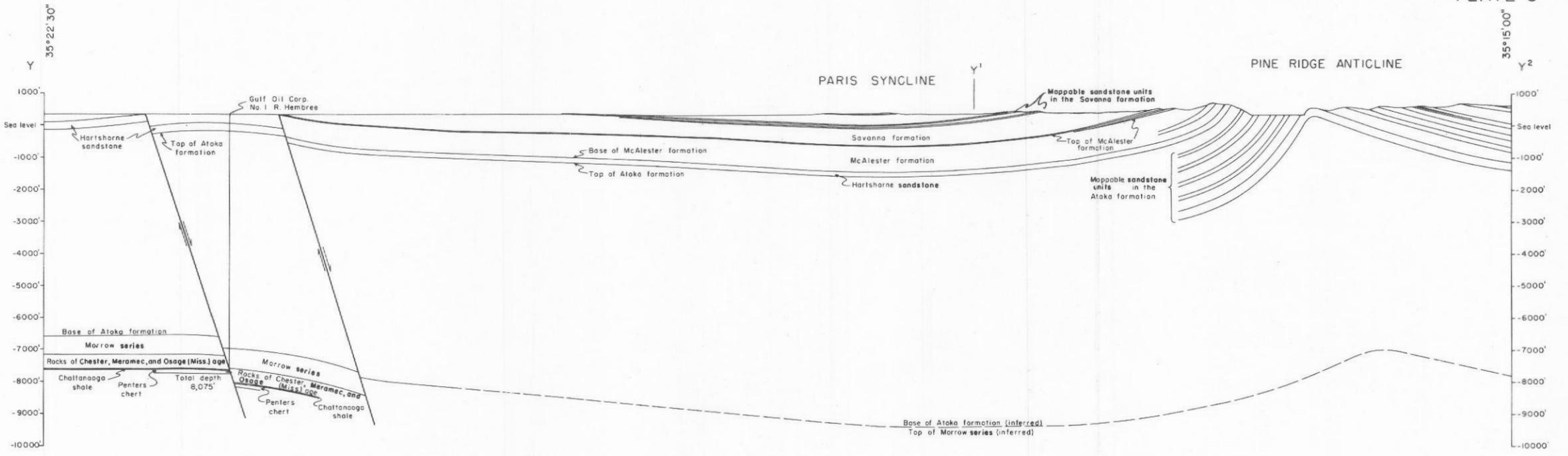
Some of the sandstone units in the Atoka formation (pl. 1) have been mapped along their outcrop for a distance of more than 40 miles. The lithology of the sandstone units changes rather rapidly so that a correlation based only on lithologic similarities generally is impossible over distances greater than a few miles. Some of the sandstone units are well exposed along Gum Creek in the SW $\frac{1}{4}$ sec. 21, T. 7 N., R. 25 W., along old State Highway 109 in secs. 15 and 22, T. 7 N., R. 26 W., along new State Highway 109 in secs. 13 and 14, T. 7 N., R. 26 W., and below the spillway of Paris Lake in sec. 14, T. 7 N., R. 26 W.

The exposed shale in the Atoka formation is fissile to thin bedded. Locally it contains thin beds of siltstone or very fine grained sandstone, and in some places it contains ironstone concretions. The shale is well exposed along Gum Creek in the NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 20, T. 7 N., R. 25 W., west of Red Bench in the SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 15, T. 7 N., R. 25 W., and at the spillway of Paris Lake in the center of sec. 14, T. 7 N., R. 26 W.

Des Moines Series

Krebs Group

The Krebs group, from oldest to youngest, is composed of the Hartshorne sandstone and the McAlester, Savanna, and Boggy formations. This nomenclature was established by Oakes (1953) in northeastern Oklahoma and adopted by Miser (1954). The Hartshorne sandstone, the McAlester formation, and most of the Savanna formation are present in the Paris quadrangle.



by
Boyd R. Haley
U.S. Geological Survey
1960

**PLATE 3.—STRUCTURAL CROSS SECTION Y-Y² OF PARIS QUADRANGLE,
LOGAN COUNTY, ARKANSAS.**

Hartshorne Sandstone

The Hartshorne sandstone of this report is equivalent to the unit called the Hartshorne sandstone by Hendricks and Parks (1950, p. 73) and by Merewether and Haley 1960, p. 7). It is the first continuous sandstone underlying the Lower Hartshorne coal bed. The Hartshorne sandstone of Hendricks and Parks is equivalent to the lower sandstone member of the Hartshorne sandstone in the type area near Hartshorne, Oklahoma. A minor unconformity between the Hartshorne sandstone and the underlying Atoka formation is present in the mapped area. The contact between the two formations is well exposed along Magazine Mountain Highway at the center of the south line of sec. 21, T. 7 N., R. 25 W., and at the spillway of Subiaco Lake in sec. 10, T. 7 N., R. 25 W. The Hartshorne sandstone is conformably overlain by the McAlester formation in the Paris quadrangle.

The Hartshorne sandstone in the Paris quadrangle ranges in thickness from 122 feet to 251 feet, and consists mostly of light- to medium-gray very silty very fine grained sandstone and very light- to light-gray very fine to fine-grained sandstone. In some areas it has a thin coal bed at the base. Bedding in the sandstone is regular, irregular, or lenticular. The sandstone is cross-bedded at many places and convolute bedded in a few places. The contacts between beds of sandstone are even to undulating; locally sandstone beds are separated by thin zones of very silty sandstone or siltstone. Some of the sandstone beds contain lenses of grayish-black shale. Pebbles of dark-gray shale or siltstone are found near the base of some sandstone beds.

The Hartshorne sandstone is one of the most persistent sandstone units in Arkansas, and it has lithologic characteristics that tend to set it apart from sandstone units in the Atoka, McAlester, or Savanna formations. In general, it is lighter colored, coarser grained, less silty or clayey, and thicker bedded. However, in Arkansas sandstone units in the Atoka formation and in the McAlester formation locally may be lithologically similar to the Hartshorne sandstone. The sandstone unit in the McAlester formation that crops out along the north side of the Pine Ridge anticline is very similar to typical Hartshorne in lithology.

McAlester Formation

The McAlester formation in the western part of the Paris quadrangle is stratigraphically equivalent to the McAlester shale as described by Hendricks and Parks (1950, p. 74), but in the eastern part of the quadrangle the top of the

McAlester formation is about 90 feet higher stratigraphically than the top of the McAlester shale of Hendricks and Parks. The formation conformably overlies the Hartshorne sandstone and is unconformably overlain by the Savanna formation in the western part of the quadrangle. The upper part of the McAlester formation interfingers with the lower part of the Savanna formation in the eastern part of the quadrangle. The contact between the McAlester formation and overlying Savanna formation as mapped in this report is well exposed in secs. 9, 10, and 16, T. 8 N., R. 25 W.

The McAlester formation ranges in thickness from about 800 feet in the northeastern part of the quadrangle to about 1,000 feet in the south-central part. It consists predominantly of dark-gray to grayish-black shale and silty shale, and medium- to dark-gray siltstone that is slightly limy in part and very finely sandy in part. It includes minor amounts of light- to medium-gray slightly silty to very silty very finely micaceous very fine grained sandstone and very light to light-gray very fine to fine-grained sandstone. A sandstone unit that crops out along the north side of the Pine Ridge anticline is about 170 feet thick in sec. 10, T. 7 N., R. 25 W. This unit thins to the east, and it thins rapidly and becomes finer grained and more silty to the north.

The Lower Hartshorne coal bed, which is near the base of the McAlester formation elsewhere in Arkansas, was not seen in the Paris quadrangle, and evidence of the coal bed was not found in the Hembree well. However, the coal bed is exposed to the east of the quadrangle and is reported to be present in the quadrangle.

Savanna Formation

The Savanna formation in the Paris quadrangle is believed to be stratigraphically equivalent to the Savanna formation in Oklahoma (Miser, 1954). It includes a shale unit that Hendricks and Parks (1950, pl. 13) mapped as part of the Boggy formation in the Fort Smith district. The formation overlies the McAlester formation in the Paris quadrangle and is overlain by the Boggy formation beyond the west limit of the Paris quadrangle.

The map relations show that the lower part of the Savanna formation interfingers with the upper part of the McAlester formation in the eastern part of the quadrangle. The lower contact of the formation is at the base of a sandstone unit in sec. 14, T. 7 N., R. 26 W. This sandstone unit lenses into a shale unit in sec. 18, T. 7 N., R. 25 W.; at this locality the contact between the McAlester and Savanna formations was mapped at the base of the next younger

sandstone unit. This sandstone unit lenses into a shale unit to the east and north in sec. 35, T. 8 N., R. 25 W., and the contact between the two formations was raised again to the base of the next younger sandstone unit. A similar change was made in mapping the contact in sec. 15, T. 8 N., R. 25 W.

Hendricks and Parks (1950, p. 77) determined the position of the contact between the Savanna and Boggy formations in the Fort Smith district by a stratigraphic and lithologic comparison of equivalent rocks in Oklahoma. The contact between the Savanna and Boggy formations chosen by Hendricks and Parks in the Fort Smith district is difficult to identify in the Paris quadrangle because a shale unit that they included in the Boggy formation contains lenses of siltstone and sandstone in its lower part that are lithologically similar to lenses of siltstone and sandstone in the underlying part of the Savanna formation. Only the lower part, 200 feet thick, of this shale unit is present in the Paris quadrangle; the upper part, 400 feet thick, is present in Short and Little Short Mountains, 1 and 4 miles west of Paris, respectively. In the present report the contact between the two formations is the top of the shale. In moving the contact between the two formations stratigraphically upward, the writer follows the recent practice of Miser (1954) in Oklahoma. Miser expanded the Savanna formation to include a shale unit that Hendricks, Knechtel, Dane, Rothrock, and Williams (1939) had mapped as part of the Boggy formation.

The Savanna formation is about 2,200 feet thick. It consists, predominantly, of dark-gray shale and silty shale. It contains minor amounts of light- to medium-gray siltstone and very finely sandy siltstone, and light- to medium-gray very fine to fine-grained sandstone. The sandstone is silty in some places, and contains medium- to coarse-grained rounded quartz sand in some places. At least six coal beds are present in the formation.

Both the siltstone and the sandstone are ripple marked, micaceous, and in many places contain abundant macerated plant fragments. Bedding is thin to massive, and irregular, regular, or lenticular.

The lithology and thickness of the sandstone changes rapidly along the outcrop. In general, the sandstone is more massively bedded, coarser grained, and less silty or clayey in the areas where the sandstone is thickest.

A sandstone-filled channel in shale is present near the center of the east line of the SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 16, T. 8 N., R. 25 W., and a sandstone-filled

channel in sandstone is present near the center of the SE $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 10, T. 7 N., R. 26 W. The two mesas in the SW $\frac{1}{4}$ sec. 3, T. 7 N., R. 25 W., are capped by erosional remnants of sandstone that filled a channel in shale and siltstone.

Marine fossils including pelecypods, brachiopods, gastropods, and crinoids are found in a limy sandstone in the lower part of the Savanna on the north side of a section-line road about 800 feet east of the NW. corner of sec. 34, T. 8 N., R. 25 W.

Plant fossils including ferns, calamites, lepodendrons, sigillaria, and stigmara are found in a carbonaceous shale in the lower part of the Savanna on top of the hill in the center of the SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 10, T. 8 N., R. 25 W.

Boggy Formation

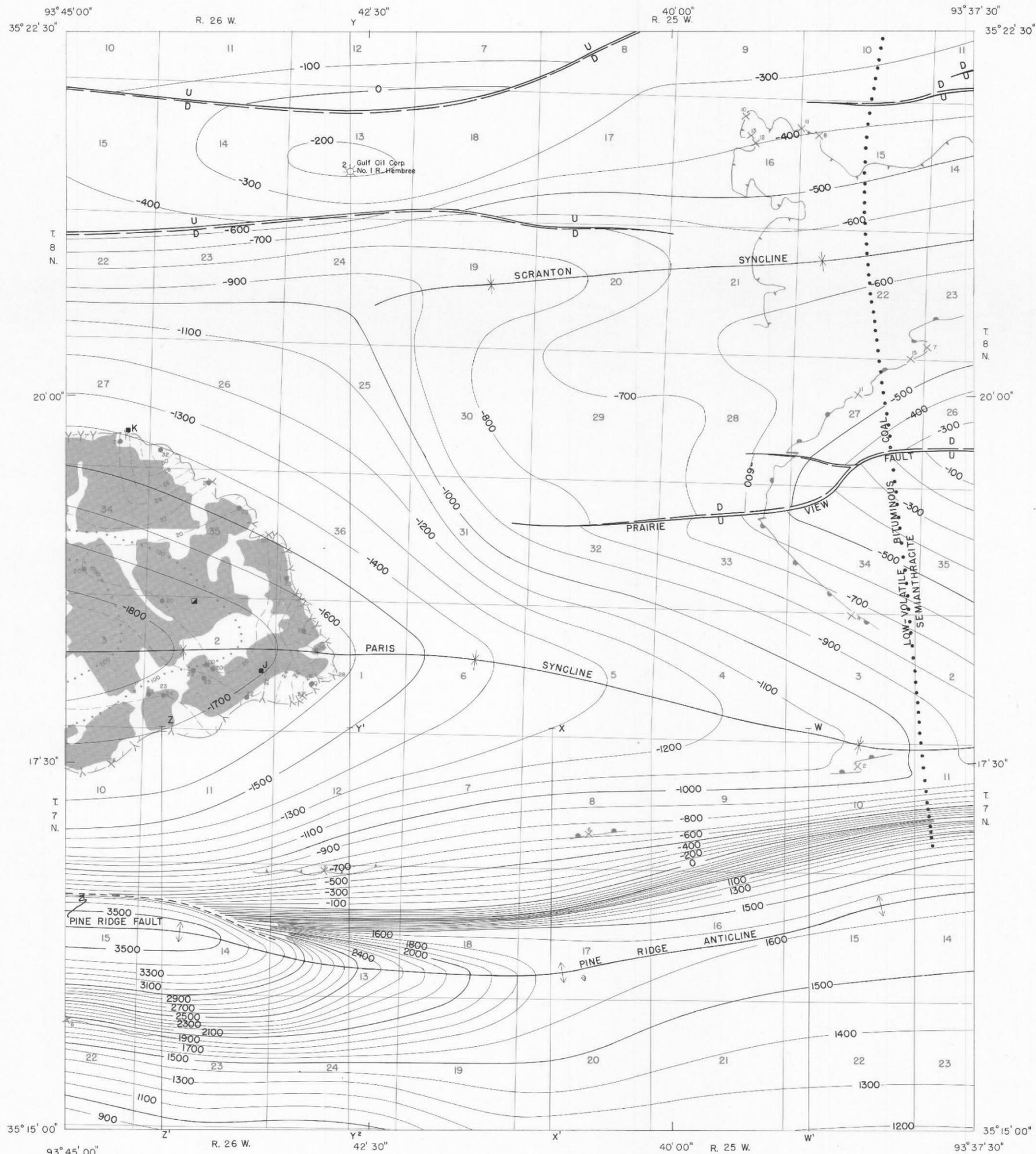
The Boggy formation is not present in the Paris quadrangle; however, part of the basal sandstone unit of the Boggy formation caps Short Mountain and Little Short Mountain a few miles farther west. At these places the basal sandstone unit fills channels cut into the Savanna formation. The sandstone is very light to light gray, very fine to medium grained, silty in part, finely to medium micaceous, cross-bedded, irregularly bedded, ripple marked, and contains thin beds and lenses of light- to medium-gray siltstone and medium- to dark-gray shale.

QUATERNARY SYSTEM

Terrace Deposits

Quaternary deposits of alluvial material are present at one terrace level along the Arkansas River and at two or more terrace levels along several of the major tributary streams. The terrace surface along the Arkansas River is about 50 feet above the present river level. Terrace deposits formed by the Arkansas River are present in sec. 30, T. 8 N., R. 25 W., and sec. 25, T. 8 N., R. 26 W., where they consist of clay, silt, and sand, some of which is probably of local origin, pebbles and cobbles of sandstone and shale of local origin, and pebbles and cobbles of quartz, quartzite, and chert that have been transported from a distant source.

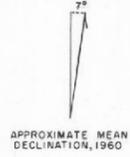
The upper of the two terrace levels along the major tributary streams in the Paris quadrangle is about 50 feet above the present stream level and the lower terrace level is about 30 feet above the present stream level. Deposits on the two terrace levels along the major streams have been grouped together, but are differentiated from the terrace deposits along the Arkansas River, on plate 1. The terrace deposits formed by the



- EXPLANATION**
- Structure contours drawn on base of Hartshorne sandstone
Projected above the surface in some areas.
Contour interval 100 feet; datum is mean sea level
 - Trace of normal fault
Solid where located on upthrown block; dashed where located on downthrown block. U, upthrown side; D, downthrown side
 - Trace of thrust fault projected above surface
Position on thrust plate shown on this map; \blacktriangle designates thrust plate
 - Trace of synclinal axis
 - Trace of anticlinal axis
 - Line of structural section
Shown on plate 5
 - COAL BEDS**
 - Paris coal bed
 - Unnamed coal bed in Savanna formation
 - Charleston coal bed or beds
 - Unnamed coal bed in Atoka formation
 - Mined area
 - Exposure of coal
Number indicates thickness of coal in inches
 - Surface opening on coal bed
Number indicates thickness of coal in inches
 - Drill hole or mine locality of coal
Number indicates thickness of coal in inches
 - Mine shaft
 - Coal thickness line
Number indicates thickness of coal in inches
 - Overburden thickness line
Number indicates thickness in feet
 - Locality of coal sample listed in table 1
 - Producing gas well
Number designates stratigraphic section shown on plate 2 and described in appendix
- Section lines and township lines are indicated for general orientation and identification but are not authenticated for legal purposes.

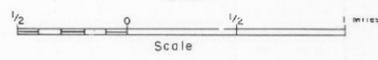
93° 45' 00" R. 26 W. Y² 42' 30" 40' 00" R. 25 W. W' 93° 37' 30"

Planimetric base compiled by Boyd R. Haley



STRUCTURE CONTOUR AND COAL BED MAP, PARIS QUADRANGLE, LOGAN COUNTY AND VICINITY, ARKANSAS

by
Boyd R. Haley
U. S. Geological Survey
1960



major streams consist of clay, silt, sand, and pebbles, cobbles, and boulders of siltstone and sandstone, all of local origin.

The terrace deposits are equivalent to the terrace deposits that Hendricks and Parks (1950, p. 78 and 91) correlated with the Gerty sand of Oklahoma, which is believed to be Pleistocene in age (Miser, 1954).

Alluvium

Alluvium has been deposited along the Arkansas River and along most of its tributary streams and covers much of the Paris quadrangle.

Alluvium along the Arkansas River consists mainly of clay, silt, and sand, with pebbles, cobbles, and widely scattered boulders near the base.

The thickness of the river alluvium ranges from a feather edge to about 40 feet, where penetrated by wells drilled for water. The generally flat surface of the river alluvium is broken by the channels of tributary streams and by shallow marshy depressions that may represent former ox-bow lakes.

Alluvium along the tributary streams consists of clay, silt, sand, and pebbles of shale, siltstone, and sandstone and, locally, cobbles and boulders of siltstone and sandstone. The surface of the alluvium generally has a very slight slope towards the stream channel. Alluvial material in the valleys east and northeast of Paris (pl. 1) could be classed as stream terrace deposits, at least in part, but the deposits have been mapped as stream alluvium by the writer.

STRUCTURE

The Paris quadrangle is located approximately in the west-central part of the Arkansas Valley section of the Ouachita province (fig. 1). The structure of the rocks in the northern part of the quadrangle consists of broad, gently dipping, slightly asymmetrical folds interrupted in places by normal faults. In the southern part of the quadrangle the dominant structure is a large asymmetrical anticline that has been ruptured in part by a thrust fault along the axis of folding near the west edge of the Paris quadrangle (pls. 4 and 5).

Folds

Anticlines in the Paris quadrangle include an unnamed anticline extending into the northern part of the quadrangle from the west, the Prairie View anticline extending into the central part of the quadrangle from the east, and the Pine Ridge anticline extending across the southern part of the quadrangle. The unnamed anticline and the Prairie View anticline have been faulted and the south limb of each seems to be steeper than the north limb. The north limb is the steeper one of the Pine Ridge anticline and at some places it is overturned.

Synclines in the Paris quadrangle are the Scranton syncline, which extends into the northeast part of the quadrangle from the east, and the Paris syncline, which extends across the central part of the quadrangle. The north limb of the Scranton syncline seems to be the steeper limb, and the south limb of the Paris syncline is the steeper limb.

The amplitude of the folds in the Paris quad-

range probably diminishes with depth. The rate at which they diminish depends on the regional thickening of the rock units, amount of faulting, and location of the faults, and degree of parallelism in the folding. An interpretation of the structure at depth across the folds and faults of the Paris quadrangle is shown in the cross sections on plates 3 and 5.

Faults

High-angle normal faults and thrust faults are mapped and described as though the movement along the fault occurred in a single plane. It is possible that movement along some of the faults occurred in a zone of several planes.

Normal Faults

Two normal faults, each downthrown to the south, can be located in the area west of the quadrangle. These faults are believed to continue into the northwestern part of the quadrangle under cover of alluvium, and the projection of the trace of each is shown on plate 1.

The projected trace of the northernmost fault is believed to lie north of the Gulf Oil Corp. No. 1 Hembree well and to cut the strata in the well. If the fault trace continues as shown on the map (pl. 1), the depth at which it cuts the strata in that well indicates a south dip of about 70°. The displacement of the fault must be at least 300 feet in order to account for the rocks of Chester and Meremec (Mississippian) ages missing in the No. 1 Hembree well. The trace is curved northward east of the well in the direction of the

Big Danger fault zone north of the quadrangle to which it is believed to be related.

The second fault lies about a mile farther south to the west of the quadrangle. Where it has been observed it is similar to but somewhat less prominent than the fault to the north. From this it is assumed that its dip is southward at about the same degree and the displacement somewhat less, possibly about 200 feet.

Two unnamed normal faults, downthrown on the north side, extend into the northeast corner of the quadrangle. The fault planes dip north at an angle between 60° and 75°. The maximum amount of displacement along these faults in the Paris quadrangle is less than 100 feet. The fault planes are not exposed but the surface trace of the southern one can be located within a north-south distance of 150 feet in the SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 10, T. 8 N., R. 25 W.

The Prairie View fault extends from the east into the east-central part of the quadrangle where it cuts back in the Krebs group and Atoka formation. This fault is downthrown on the north side, the fault plane dips about 65° northward, and the maximum displacement in the Paris quadrangle is about 170 feet. The fault is exposed in the SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 27, T. 8 N., R. 25 W., where movement along the fault occurred in a zone of fault planes.

A branch of the Prairie View fault extends from the main fault in sec. 27, T. 8 N., R. 25 W., to the central part of sec. 28, T. 8 N., R. 25 W., and is downthrown on the south side. The dip of the fault plane is assumed to be southward. The faulted Prairie View anticline is similar to faulted anticlines discussed by Hendricks and Parks (1950, p. 87). It is their opinion that the faulted anticlines in the Fort Smith district were faulted then folded or contemporaneously faulted and folded.

Thrust Faults

A thrust fault, here named the Pine Ridge fault, extends into the southwestern part of the

quadrangle in the Atoka formation along the crest of the Pine Ridge anticline. Movement along the fault occurred in a zone approximately 150 feet wide. This zone, where exposed, occurs in shale so sheared and macerated that the dip of the fault plane cannot be determined. The fault plane at the surface probably dips southward at an angle of about 45° (cross section Z-Z', pl. 5). The maximum amount of displacement along the fault in the Paris quadrangle cannot be determined. Movement along the Pine Ridge fault probably occurred after the Pine Ridge anticline had been folded to nearly its present asymmetrical shape.

A small thrust fault is exposed in a roadcut on the west side of old State Highway 109 (NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 15, T. 7 N., R. 26 W.). The relative movement of the thrust plate is southward along a fault plane that dips about 30° northward. The southward movement along this fault represents adjustment of younger strata to the acute folding along the crest of the Pine Ridge anticline.

Several thrust faults and zones of sheared and macerated shale are exposed in vertical beds of sandstone and shale at the base of the Paris Lake spillway in sec. 14, T. 7 N., R. 26 W. The movement of the upper plates was northward, with the maximum amount of movement along any single fault less than 35 feet. One fault plane is horizontal at its southern exposures, dips eastward or southeastward from 5° to 15° along its middle part, and dips southward from 45° to 65° at its northern exposures. The movement of the thrust plate is northward along the southern and middle parts of the exposed fault plane and northward or northeastward along the northern part. The faults and the zones of sheared and macerated shale probably originated during the late stages of the folding of the Pine Ridge anticline and represent a partial relief of horizontal pressures that caused the asymmetry of the anticline.

GEOMORPHOLOGY

The landscape in the Paris quadrangle is the result of differential erosion of flat-lying and folded sedimentary rocks. Examples of particular land forms in the quadrangle are as follows (pl. 1): (1) mesa (Pine Hill, sec. 16, T. 8 N., R. 25 W.), (2) cuesta (ridge of sandstone of the Atoka formation, secs. 21, 22, and 23, T. 7 N., R. 25 W.), (3) hogback (ridge of Hartshorne

sandstone west of Short Mountain Creek, secs. 14 and 15, T. 7 N., R. 26 W.), (4) anticlinal ridge (ridge of sandstone of the Atoka formation south of Paris Lake, sec. 13, T. 7 N., R. 26 W.), (5) synclinal mountain (ridge of sandstone of the Savanna formation along Scranton syncline, secs. 14, 15, 22, and 23, T. 8 N., R. 25 W.), (6) anticlinal valley (along Pine Ridge anticline,

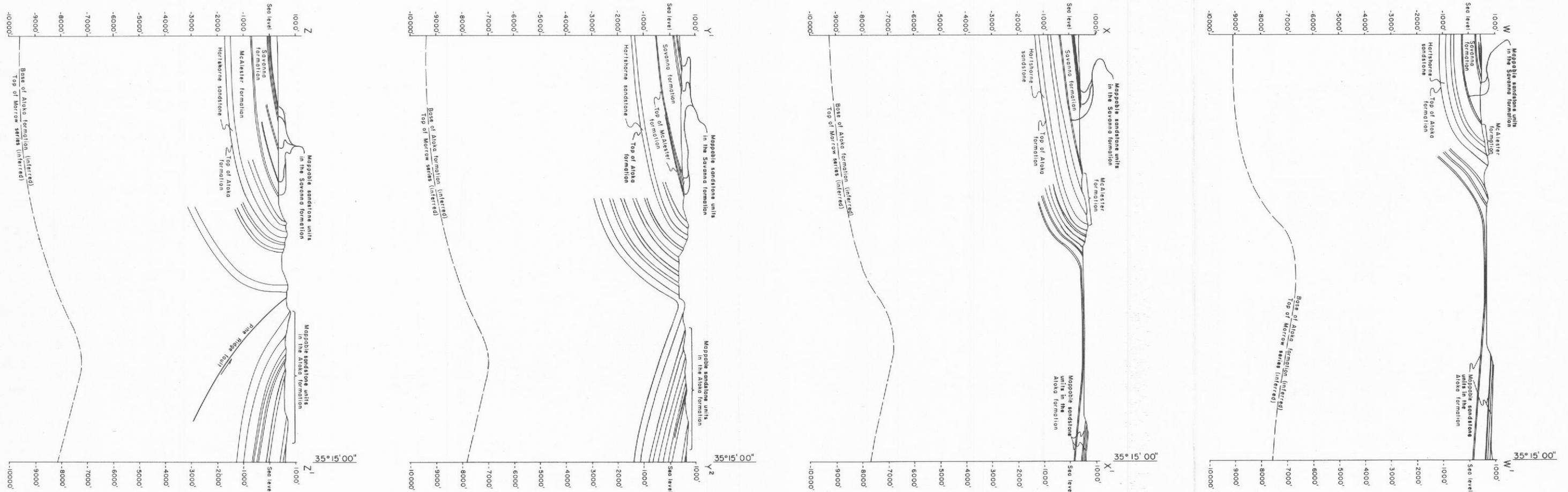


PLATE 5.—STRUCTURAL CROSS SECTIONS ACROSS PINE RIDGE ANTICLINE,
PARIS QUADRANGLE, LOGAN COUNTY, ARKANSAS.