

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

INFORMATION CIRCULAR 20-A

**GEOLOGY OF DELAWARE QUADRANGLE, LOGAN COUNTY,
AND VICINITY, ARKANSAS**

By
E. A. Merewether and Boyd R. Haley
U. S. Geological Survey



Prepared by the U. S. Geological Survey in cooperation with the
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Little Rock
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**GEOLOGY OF DELAWARE QUADRANGLE, LOGAN COUNTY,
AND VICINITY, ARKANSAS**

By

E. A. Merewether and Boyd R. Haley

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ABSTRACT

The Delaware quadrangle comprises an area of approximately 61 square miles in parts of Johnson, Logan, Pope, and Yell Counties, in west-central Arkansas. Most of the area is in Logan County.

In the Delaware quadrangle, rocks of the Morrow series, the Atoka series and the Krebs group of the Des Moines series, all of Pennsylvanian age, are folded into east-west trending anticlines and synclines and broken by high-angle normal faults that strike generally east-west. Rocks of the Atoka series and of the Krebs group of Pennsylvanian age and alluvial deposits of Quaternary age are exposed in the quadrangle.

Rocks of the Morrow series are not exposed, but are penetrated by a well drilled for gas in sec. 2, T. 8 N., R. 22 W. They consist of shale, siltstone, sandstone, and limestone. That part of the Morrow (635 feet) penetrated by this well cannot be divided, with certainty, into the established Hale and Bloyd formations. However, it is the authors' opinion that the bottom of the well is in the upper part of the Cane Hill member of the Hale formation and that the Prairie Grove member of the Hale formation and the overlying Bloyd shale are also present.

The Atoka series in the Delaware quadrangle is made up of the Atoka formation, which is predominantly shale and siltstone but contains sandstone and some coal. Its thickness increases from 6,750 feet near the north edge of the quadrangle in the Tackett well to about 7,880 feet in the central part of the quadrangle in the Roberts well, a distance of approximately 5 miles.

The Krebs group in the Delaware quadrangle is comprised of the Hartshorne sandstone and the McAlester and Savanna formations. The Hartshorne sandstone is mostly sandstone but includes thin beds of shale and siltstone, and ranges in thickness from 80 to 150 feet. The McAlester formation is predominantly shale and siltstone, but includes sandstone and a few thin beds of coal, and is about 780 feet thick. Only the basal sandstone of the Savanna formation is present in the quadrangle.

The Quaternary system in the area of this report is represented by terrace deposits and alluvium. Terrace deposits of clay, silt, sand, and pebbles are present at two levels along the Arkansas River and many of the other major streams. The terrace deposits are believed to be of Pleistocene age. Alluvium, consisting of clay, silt, sand, and gravel, has been deposited along the Arkansas River and along most of the tributary streams. The alluvium is assumed to be of Recent age.

The Delaware quadrangle, centrally located in the Arkansas Valley section of the Ouachita province, contains several broad gently dipping asymmetrical folds and three high-angle normal faults. From north to south the folds are: the south limb of the Knoxville anticline; a small unnamed anticline; the Piney syncline; the London anticline; the Scranton (Ouita) syncline; the Prairie View anticline; the Paris syncline; and the

north limb of the Pine Ridge anticline. The London fault, trending slightly south of west, extends into the northeastern part of the quadrangle for a distance of about 5 miles. It is a high-angle normal fault with the downthrown block on the south side. About one mile south of the London fault along the eastern boundary of the quadrangle is the western part of an unnamed fault that trends west and northwest for about 1½ miles and probably joins the London fault. It is probably a high-angle normal fault with the downthrown block on the north side. The Prairie View fault extends about 2 miles into the quadrangle from the west. It is a high-angle normal fault with the downthrown block on the north side.

Coal, natural gas, building stone, road metal, and gravel, sand, and clay are present in economic quantities in the Delaware quadrangle. Coal in the Atoka and McAlester formations is exposed and a coal bed in the Atoka formation was penetrated by the Tackett well. The coal is of poor quality and the coal beds are too thin to warrant an estimation of reserves or for large-scale mining. A commercial quantity of gas was discovered in the Tackett well on the Knoxville anticline and a show of gas was found in the Roberts well on the Prairie View anticline. In both wells the gas was found in sandstone units in the upper half of the Atoka formation.

Rock suitable for construction purposes can be found in all of the formations exposed in the quadrangle; however, the Hartshorne sandstone is the best source for building and decorative stone. Road metal has been obtained from sandstone units in the Atoka and Hartshorne formations and from the gravelly part of some of the terrace deposits. Many of the terrace deposits contain sand and gravel that can be utilized in the construction industry. Clay, a common constituent of the terrace deposits, may be useful as source material for the brick, pottery, and tile industries or, when bloated (heated to the melting point), as a lightweight aggregate.

INTRODUCTION

This report on the geology of the Delaware quadrangle, Ark., is one of 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 the 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 information relevant to the location and character of deposits of petroleum and natural gas, and (4) provide information pertaining to building stone, gravel, sand, and clay.

The Delaware quadrangle includes parts of Johnson, Logan, Pope, and Yell Counties in west-central Arkansas (fig. 1). It is bounded by 35° 15' N. and 35° 22'30" N. longitudes, by 93° 15'00" W. and 93° 22'30" W. latitudes, has an area of approximately 61 square miles, and is crossed by the Arkansas River.

Delaware, London, and Piney are small communities within the quadrangle. Arkansas Highway 22 crosses the quadrangle south of the Arkansas River and U. S. Highway 64 crosses the northeast part of the quadrangle north of the river. County and private roads branching from these highways permit easy access to most areas in the quadrangle. The Missouri-Pacific Railroad crosses the northeast part of the quadrangle north of the Arkansas River.

The land forms of the Delaware quadrangle are the characteristic result of the differential erosion of gently folded strata. The largest and perhaps the most unusual land form in the quadrangle is the anticlinal ridge, best represented by the surface expression of the Prairie View anticline northwest of Delaware, and less perfectly by the London anticline northwest of London. Flanking the anticlinal ridges are cuestas alternating with valleys, which are best developed in the southernmost quarter of the quadrangle. Along the axes of the synclines are the remnants of synclinal ridges, a butte 1¼ miles south of London and a dissected mesa 2 miles west-southwest of Delaware. The inliers of shale of the Atoka formation, near the crest of the Prairie View anticline, seem to be a very early stage in the

development of an anticlinal valley. Synclinal valleys occur north of the Arkansas River along the Piney syncline and south of the Arkansas River along lower Delaware Creek. Both the anticlinal ridges and the synclinal valleys are probably resequent (land forms similar to those originating from the erosion of an initial surface but developed during a later period of erosion) and result, at least in part, from the unusual resistance to erosion of the Harthshorne sandstone in this area. The scarp along part of the London fault is probably a resequent fault-line scarp.

Both trellis and dendritic drainage patterns occur in the Delaware quadrangle. Most of the creeks are either resequent or longitudinal subsequent streams. Big Piney Creek in the Delaware quadrangle, however, is a superposed stream (a stream whose course has been determined by a previously existing geologic terrane, and that has cut down into rock structures of very different nature), crossing the Piney syncline and the London anticline almost perpendicular to the axes of these folds. The Arkansas River channel follows the Prairie View fault from the western boundary of the quadrangle almost to the mouth of Big Piney Creek, then follows the axis of the Scranton (Ouita) syncline, crosses the axis of the Prairie View anticline, and follows the axis of the Paris syncline. The Arkansas River in the Delaware quadrangle appears to be a resequent stream but additional observations east and west of the quadrangle indicate that the Arkansas River may be in part a superposed stream.

Elevation above sea level ranges from 1,000 feet in the southwestern corner of the quadrangle to about 320 feet in the east-central part of the quadrangle along the Arkansas River.

The geology of the quadrangle was mapped on aerial photographs at a scale of approximately 1:20,000. During field mapping, contact lines, strike and dip symbols, and other geologic notations were placed in their proper positions on the photos by inspection. The geologic annotations and the topographic and cultural features were transferred from the aerial photographs to a planimetric base map

FIGURE 1

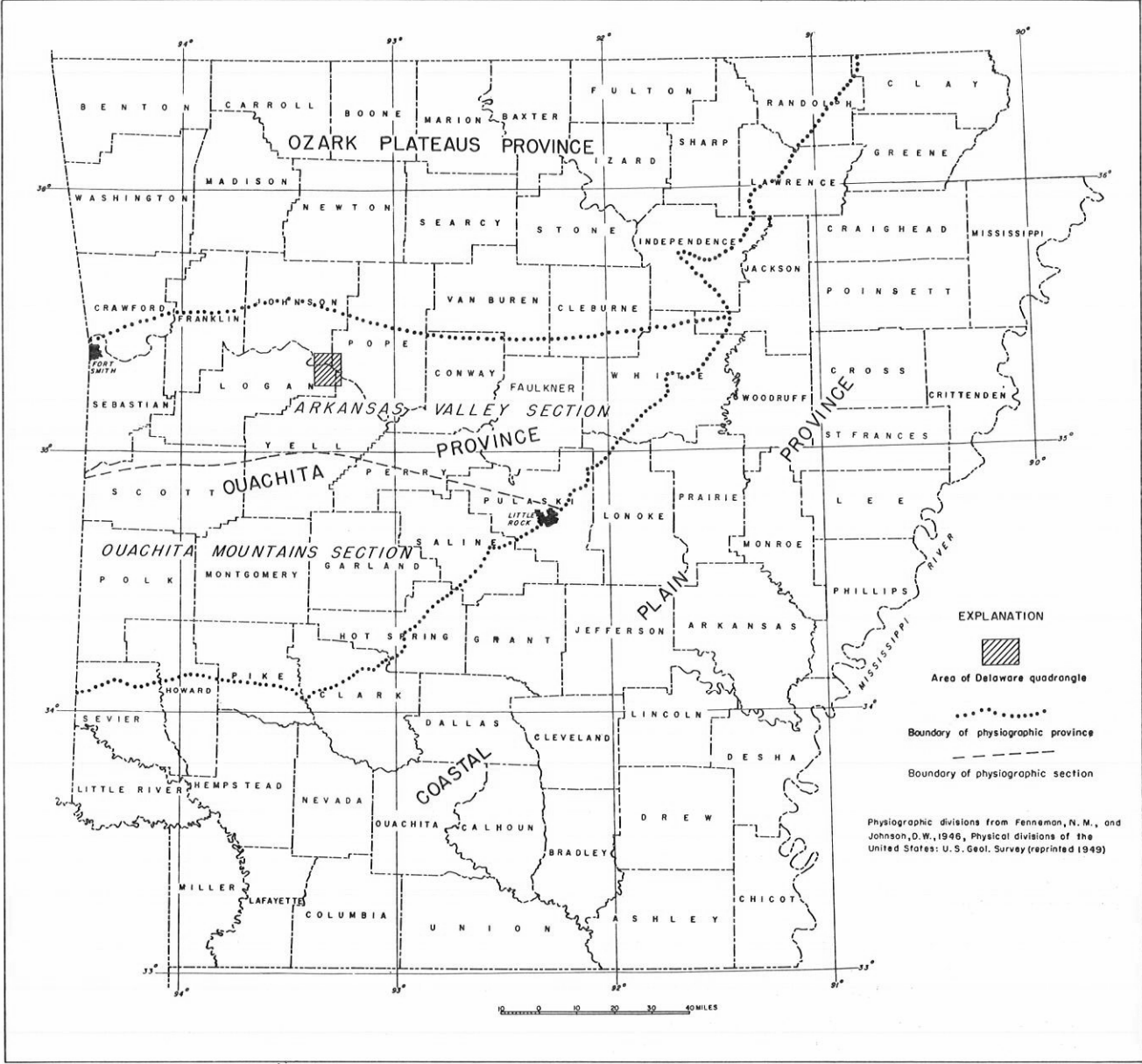


FIGURE 1—INDEX MAP OF ARK.

(scale 1:20,000) by means of a radial planimetric plotter and a reflecting projector. The horizontal scale of the aerial photographs was adjusted to that of the base map by use of U. S. Coast and Geodetic Survey triangulation stations located both on the photographs and on the quadrangle base map. The aerial photographs were oriented to the planimetric base by point controlled radial triangulation nets.

Several earlier geologic reports relating to the area of the Delaware quadrangle, including regional studies and more detailed papers, were used in the preparation of this report. Those published in 1907 (A. J. Collier), in 1929 (Arkansas Geological Survey), and in 1930 (Carey Croneis) provided regional information and were useful guides to the necessary geologic investigations. Reports by T. A. Hendricks, C. H. Dane, and M. M. Knetchel in 1936, and T. A. Hendricks in 1937, established the stratigraphic nomenclature of rocks of Atoka and younger age in Arkansas. A report by T. A. Hendricks and Bryan Parks (1950) includes a detailed map of these formations and mappable rock units within these formations in the Fort Smith district, Ark. B. R. Haley has traced the major rock units, excepting the Savanna formation, on the surface from the Fort Smith district to the area of this report.

STRATIGRAPHY

Rocks of the Pennsylvanian and Quaternary systems are exposed or have been penetrated by wells drilled for gas in the mapped area. The Pennsylvanian rocks are, from oldest to youngest, the Morrow series (subsurface only in this quadrangle), the Atoka series, and the

Krebs group. Detailed descriptions of the Pennsylvanian rocks that crop out or were penetrated by wells are included in the appendix of this report. These rocks are shown graphically on plate 1.

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

The rock units of Pennsylvanian and Mississippian age exposed in or near the Delaware quadrangle and pertinent to this report are given, with ages and stratigraphic relations, in table 1.

The stratigraphic terminology used in this report is that used by Oakes (1953) and Miser (1954) for equivalent rocks in Oklahoma. The formations used in this report with the exception of the Hartshorne sandstone are stratigraphically equivalent to the formations in the type areas in Oklahoma. The Hartshorne sandstone in the Delaware quadrangle is equivalent to the lowermost sandstone in the Hartshorne sandstone in Oklahoma. Hendricks and Parks (1950, p. 69) state "Hendricks traced the formation boundaries eastward from their type localities in Oklahoma to the Arkansas-Oklahoma State line, and from there into Arkansas." The boundaries were traced from the Fort Smith district, Ark. (Hendricks and Parks, 1950), eastward to the Delaware quadrangle by B. R. Haley.

PENNSYLVANIAN SYSTEM

Morrow Series

The Morrow series, which consists of the Hale formation and the overlying Bloyd shale,

Table 1.—Selected stratigraphic units in and near the Delaware quadrangle, Ark.

	System	Series	Group	Formation	Member
CARBONIFEROUS	Pennsylvanian	Des Moines	Krebs	Boggy formation	
				Savanna formation	
				McAlester formation	
				Hartshorne sandstone	
		Atoka		Atoka formation	
		Morrow		Bloyd shale	
				Hale formation	Prairie Grove member Cane Hill member
	Mississippian	Chester		Pitkin limestone	
				Fayetteville shale	

was originally named the Morrow formation (Adams and Ulrich, 1904). The Hale formation was originally named the Hale member of the Morrow formation (Taff, 1905). Purdue (1907) named the Bloyd shale. Henbest (1953) subdivided the Hale formation into the Cane Hill member and the overlying Prairie Grove member. The type areas of all the Morrow series units are in Washington County, Ark. In the type area, the Morrow unconformably overlies the Pitkin limestone of Mississippian age and is unconformably overlain by the Atoka formation. Where the Pitkin limestone has been removed by erosion, the Morrow overlies the Fayetteville shale of Mississippian age. In the Delaware area the relations of the Morrow series to the underlying and overlying rocks cannot be determined with the limited information available.

Rocks of the Morrow series have been penetrated by the Gulf Oil Corp. No. 1 W. H. Tackett well drilled for gas 1,000 feet north of the area of the Delaware quadrangle (pl. 2) in sec. 2, T. 8 N., R. 22 W. It is the writers' opinion that little, if any, lithologic change occurs between the rocks penetrated by the Tackett well and equivalent rocks in the northern part of the Delaware quadrangle.

Rocks of the Morrow series penetrated by the Tackett well cannot be divided, with certainty, into the Bloyd shale and underlying Hale formation. However, these rocks can be divided into two lithologic units. The upper unit, undifferentiated Bloyd shale and Prairie Grove member of the Hale formation, is 506 feet thick and consists of shale, slightly silty to silty shale, siltstone, very fine to coarse-grained sandstone and limy sandstone, and very fine to medium-grained sandy fossiliferous limestone. These rocks differ from the rocks in the Atoka formation as follows: the shale is, generally, a darker shade of gray and is less silty; the sandstone is coarser grained, more limy, more fossiliferous, and less silty; and the limestone is more prevalent. The lower unit, the Cane Hill member of the Hale formation, was penetrated 129 feet by the Tackett well. That part of the unit consists of shale, very finely sandy siltstone, and well-cemented very silty very fine grained sandstone.

The rocks of Morrow age penetrated by the Tackett well are shown graphically on plate 1, and described in detail in the appendix.

Atoka Series

In the area of this report and throughout Arkansas the Atoka series is comprised of the Atoka formation (table 1). The Atoka for-

mation was named by Taff and Adams (1900, p. 273) from the town of Atoka, Okla. In 1901, Taff described the Atoka formation as overlying the Wapanucka limestone of Morrow age and underlying the Hartshorne sandstone. The Atoka formation described by the authors of this report overlies the Morrow series and underlies the Hartshorne sandstone, thereby corresponding to the Atoka formation as mapped elsewhere in Arkansas and presumably corresponding to that described by Taff.

Henbest (1953) described the contact between the Atoka formation and the Morrow series and named the basal sandstone of the Atoka the Greenland sandstone member of the Atoka formation. According to Henbest, the Greenland sandstone member consists of silty, ripple-marked, flaggy sandstone with shaly partings, and, locally, interfingering marine quartz-gravel conglomerate.

This unit of sandstone or a lithologically similar unit is at the base of the Atoka formation throughout most of northwestern Arkansas. In the Ozark region the contact between the Atoka formation and the Morrow series, where exposed, is easily identified. In the Arkansas Valley region the contact between the Atoka formation and the Morrow is not exposed but has been penetrated by wells drilled for gas or oil. In preparing a stratigraphic log of the rock cuttings from any one of these wells, the contact is placed at the base of the first sandstone unit overlying a unit of rocks similar to those of the Morrow (shale and limy sandstone, sandy limestone, and limestone). The sandstone unit contains thin beds of shale and siltstone. The sandstone is, in part, silty, limy, fossiliferous, and is fine to medium grained; it generally contains coarse to very coarse grains of quartz, and, occasionally, granules and pebbles of quartz and dark-gray shale. The lithologic character of this basal sandstone unit of the Atoka formation, as identified from the well cuttings in the Arkansas Valley region and in the Delaware quadrangle, are similar to those of the Greenland sandstone member as described by Henbest. However, the regional decrease in amount of carbonate and increase in amount of sand in the rocks of the upper part of the Morrow series make them increasingly similar to the rocks in the lower part of the Atoka formation south and east of Washington County, and thus the two not easily separated, south, southeast and east of the Delaware quadrangle.

The unconformable relation of the Atoka formation to the underlying Morrow series

observed in other areas (Henbest, 1953) cannot be studied in the Delaware quadrangle.

Hendricks and Parks (1950, p. 73) reported a minor unconformity between the Atoka formation and the overlying Hartshorne sandstone. The contact between the Atoka formation and the Hartshorne sandstone is clearly exposed in the Delaware quadrangle in only one locality (sec. 27, T. 8 N., R. 22 W.); however, it is well exposed in localities near the quadrangle. In each of these exposures the basal sandstone bed of the Hartshorne sandstone overlies the uppermost bed (generally dark-gray shale or silty shale) of the Atoka formation with a channel-type relationship which Hendricks and Parks (1950) and the authors of this report have interpreted as a minor unconformity. The stratigraphic sections (pl. 1) show a convergence of the base of the Hartshorne sandstone and the top of the youngest sandstone of the Atoka from the southern to the northern part of the quadrangle. It is the authors' opinion that the minor unconformity of Hendricks and Parks is present in the Delaware quadrangle.

The Atoka formation consists of dark-gray to grayish-black shale, dark-gray slightly silty to very silty shale, medium- to dark-gray siltstone, light- to dark-gray very fine grained sandy siltstone, light- to medium-gray slightly silty to very silty very fine to fine-grained sandstone, some light- to medium-gray slightly limy to limy fine- to medium-grained sandstone, and, in the upper part, a few coal beds and one zone containing thin beds of very silty limestone.

The Atoka formation ranges in thickness from 6,750 feet near the Tackett well to about 7,880 feet near the J. D. Roberts well (Gulf Oil Corp., sec. 33, T. 8 N., R. 22 W.). About 1,700 feet of the upper part of the Atoka formation is exposed in the southern part of the mapped area (pl. 2).

The bedding in the exposed sandstones in the Atoka formation is extremely variable. It may be lenticular, irregular, or regular, and very thin to massive. The sandstone is cross-bedded, foreset bedded, or in some cases, convolute bedded. Most of the above bedding characteristics are exposed along the South Fork of Stinette Creek (NW cor. NE $\frac{1}{4}$, SE $\frac{1}{4}$, sec. 13, T. 7 N., R. 21 W.). The character of the bedding in one exposure of sandstone is not duplicated at another exposure of the same sandstone unit. Some of the beds in the sandstone units shown on plate 2 may be traced

on the surface for several miles; and a few of the sandstone units have been traced for more than 40 miles.

The exposed shale in the Atoka formation is fissile to thin bedded, may contain thin beds of siltstone or very fine grained sandstone, and in some places contains ironstone concretions.

Where the Atoka formation is exposed, individual clastic units can be traced from place to place, making possible a surface correlation within the formation. This surface correlation can be extended, with limitations, to the rocks penetrated by nearby wells drilled for oil or gas. The validity of the surface to subsurface correlation depends upon the amount of change in lithology and thickness of the individual clastic units; the less the amount of change the more valid the surface to subsurface correlation. The change in lithology and thickness is too great to permit positive identification of all equivalent clastic units in many of the surface to subsurface correlations and in most of the subsurface to subsurface correlations. However, individual clastic units can be combined to form clastic zones that can be identified in many of the correlations.

The tentative correlations within the Atoka formation shown on plate 1 are based on identifiable clastic units and clastic zones. If these correlations within the Atoka formation are valid, most of the thickening from the Tackett well to the Roberts well occurs in the middle of the formation with the remainder occurring at the top of the formation.

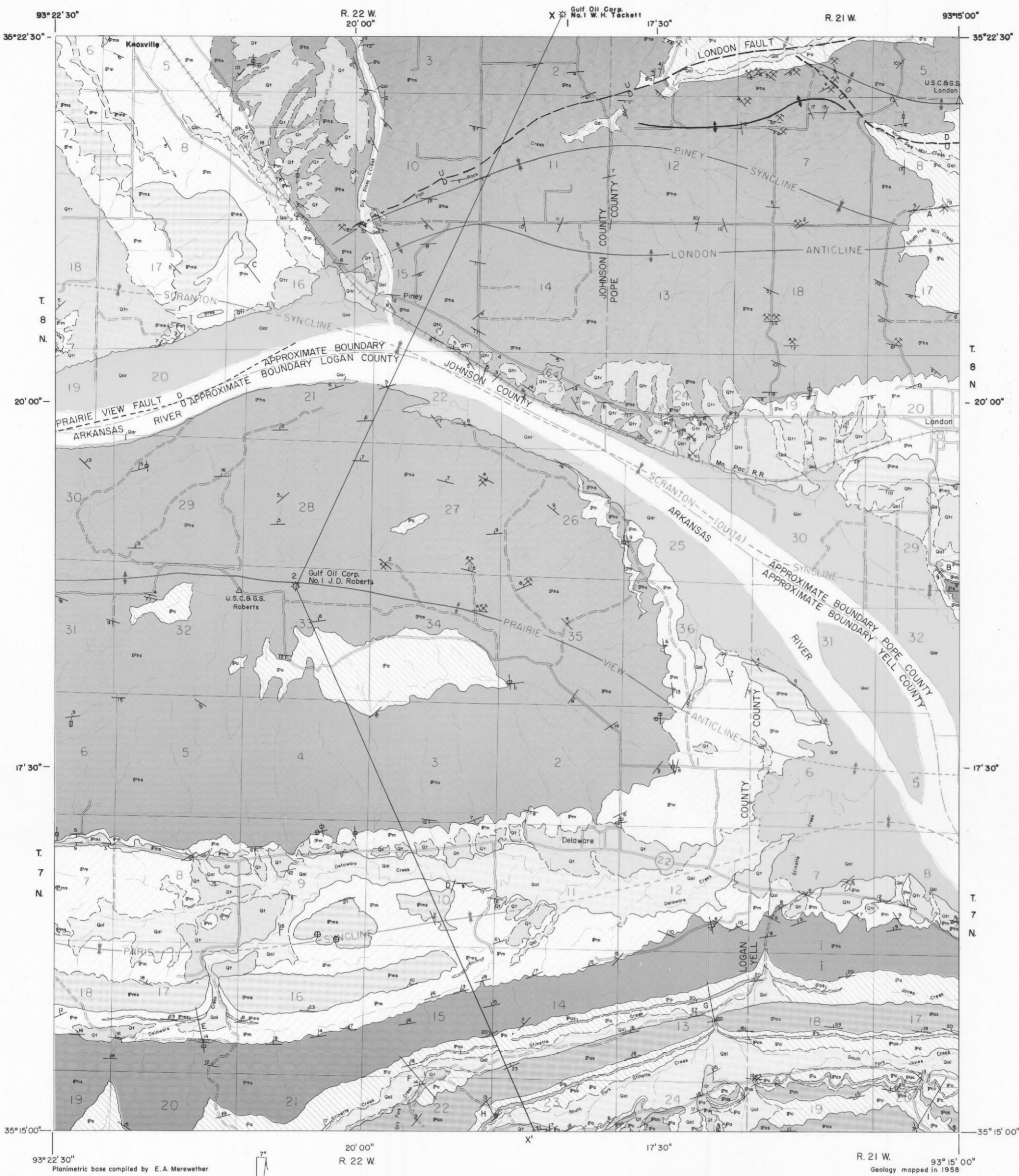
Des Moines Series

Krebs Group

The Krebs group comprises, from oldest to youngest, the Hartshorne sandstone and the McAlester, Savanna, and Boggy formations (table 1). Only the Hartshorne sandstone, the McAlester formation, and the basal part of the Savanna formation are present in the mapped area.

Hartshorne Sandstone

The Hartshorne sandstone of this report is equivalent to the Hartshorne sandstone of Hendricks and Parks (1950, p. 73), that is, "the first continuous sandstone underlying the lower Hartshorne coal bed." The Hartshorne sandstone of Hendricks and Parks is equivalent to the lowermost sandstone in the Hartshorne sandstone in the type area near Hartshorne, Okla. The minor unconformity between the Hartshorne sandstone and the



GEOLOGIC MAP OF DELAWARE QUADRANGLE, LOGAN COUNTY AND VICINITY, ARKANSAS

APPROXIMATE MEAN DECLINATION, 1960

by
E. A. Merewether and Boyd R. Haley
U. S. Geological Survey
1960

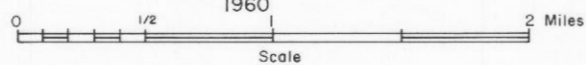


PLATE 2

Recent
Pleistocene
Des Moines
Krebs group
Atoka

EXPLANATION

Recent

Qar / Qal
Alluvium*

Qal, alluvial deposits along stream channels and, in some places, parts of the lowermost terrace
Qar, alluvial deposits along Arkansas River

Pleistocene

Qt / Qtr
Terrace deposits*

Includes alluvial deposits in two undivided terrace levels
Qt, stream terrace
Qtr, river terrace

UNCONFORMITY

Des Moines

Krebs group

Ps
Savanna formation

Pm / Pms
McAlester formation

Pm, shale, siltstone, and thin beds of sandstone or silty sandstone
Pms, sandstone, silty sandstone, or interbedded sandstone, siltstone and shale

Ph / Phs
Hartshorne sandstone

Ph, shale, siltstone, and thin beds of sandstone or silty sandstone
Phs, sandstone, silty sandstone, or interbedded sandstone, siltstone and shale

Atoka

Pa / Pas
Atoka formation

Pa, shale, siltstone, and thin beds of sandstone or silty sandstone
Pas, sandstone, silty sandstone, or interbedded sandstone, siltstone and shale

--- Contact

--- Long dashes where approximately located; short dashes where indefinitely located

--- Coal outcrop

--- Dashes where approximately located

--- Fault

--- Dashes where approximately located; dotted where indefinitely located and concealed by alluvial deposits; U, upthrown side; D, downthrown side; arrow indicates dip of fault plane

--- Axis of anticline

--- Dotted where concealed by alluvial deposits

--- Axis of syncline

--- Dotted where concealed by alluvial deposits

--- Strike and dip of beds*

--- Horizontal beds

--- Strike of vertical joint

--- Strikes of multiple vertical joints

--- Natural or man-made exposure of coal bed

--- Number shows thickness of coal in inches

--- Line of structural cross section X-X' shown on plate 4

--- Line of stratigraphic section A

Section shown on plate 1 and described in appendix

WELL SYMBOLS

Company name and lease name shown

1
Producing gas well

Number designates stratigraphic section shown on plate 1 and described in appendix

2
Dry well with show of gas

Number designates stratigraphic section shown on plate 1 and described in appendix

Quarry

Gravel pit

U. S. Coast and Geodetic Survey triangulation station

QUATERNARY
PENNSYLVANIAN
CARBONIFEROUS

* 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 feet to 10 feet and in length from 4 feet 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.

Atoka formation, as reported by Hendricks and Parks (1950, p. 73), is considered to be present in the mapped area. The Hartshorne sandstone is conformably overlain by the McAlester formation.

The structure contour lines shown on plate 3 of this report are drawn on the base of the Hartshorne sandstone.

The Hartshorne sandstone in the area of this report consists of grayish-white to light-gray very fine to medium-grained sandstone containing thin beds and lenses of dark-gray shale, silty shale, and siltstone. The formation ranges in thickness from 80 feet to 150 feet. Individual beds of sandstone in the Hartshorne sandstone may be regular, irregular, or lenticular. They may be crossbedded, foreset bedded, or in some places, convolute bedded. The contact between two beds of sandstone ranges from even to undulating and may be marked by a very thin zone of very silty sandstone or siltstone. Pebbles of shale and siltstone are present near the base of some sandstone beds.

The Hartshorne sandstone is one of the most persistent sandstone units in Arkansas. As a sandstone unit, it has several lithologic characteristics which tend to set it apart from most of the sandstone units in the overlying McAlester formation or in the underlying Atoka formation. In general, the Hartshorne sandstone is lighter in color (grayish-white to light-gray), coarser in grain size (very fine to medium), less silty or clayey, and more widespread. A sandstone unit in the McAlester formation (secs. 15, 16, 17, and 18, T. 7 N., R. 22 W.) has been identified as Hartshorne sandstone on the basis of lithologic characteristics. In many parts of Arkansas, sandstone units in the McAlester formation and in the Atoka formation can be mistaken for Hartshorne sandstone because of lithologic similarity. Positive identification of the Hartshorne sandstone is possible only by tracing the Hartshorne sandstone from an area where it is known.

Fossilized plants, usually pieces of the roots, trunks, or branches of sigillaria and lepidodendron types, are commonly found in many rock units of Pennsylvanian age in Arkansas but in the Delaware quadrangle they appear to be most numerous in the upper part of the Hartshorne sandstone.

McAlester Formation

The McAlester formation of this report is equivalent to the McAlester formation

described by Hendricks and Parks (1950). It overlies the Hartshorne sandstone conformably, and according to Hendricks and Parks, is overlain by the Savanna formation in an unconformable relationship, perhaps minor; the authors could not find evidence of an unconformity in the area of this report. The gradational contact between the McAlester and Savanna formations is well exposed on the south and west sides of the flat-topped hill in sec. 29, T. 8 N., R. 21 W.

The McAlester formation in the Delaware quadrangle consists of shale, silty shale, siltstone, silty very fine grained sandstone, and three or more coal beds, and is about 800 feet thick. The beds of sandstone are lenticular, irregularly to regularly bedded, and generally rest on shale with a channel-type relationship. The shale is fissile to thin bedded and locally contains ironstone concretions.

Poorly preserved marine fossils (brachiopods, trilobites, and crinoids), in the lower part of the McAlester formation, are exposed in an iron-rich limy sandstone on the top of a hill along U. S. Highway 64 one-half mile west of London (SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 20, T. 8 N., R. 21 W.).

Savanna Formation

Only the basal sandstone member of the Savanna formation is present in the Delaware quadrangle. This member is thought to be equivalent to the basal sandstone member of the Savanna formation mapped by Hendricks and Parks (1950).

That part of the Savanna formation present in the area of this report consists of siltstone and silty to very silty very fine grained sandstone, and is 18 feet thick. The beds of siltstone and sandstone are regular to irregular bedded, lenticular, and ripple marked. The sandstone of the Savanna differs slightly from sandstone of the McAlester units in tending to be finer grained, more silty and better cemented.

QUATERNARY SYSTEM

Terraces

Deposits of alluvial material are present on at least two terrace levels along the Arkansas River and on corresponding terrace levels along some of the major streams. The upper terrace surface is about 50 feet above the present river level and the lower terrace surface is about 40 feet above the present river level. The two levels have not been differentiated on plate 2.

The terrace deposits formed by the Arkansas River consist of clay, silt, and sand, some of which is probably of local origin, some pebbles and cobbles of sandstone of local origin, and pebbles and cobbles of quartz, quartzite, granite, and chert which have been transported from a distant source. The terrace deposits formed by major tributary streams consist of clay, silt, and sand, and pebbles, cobbles, and boulders of siltstone and sandstone. Probably all of the material in the terrace deposits of tributary streams is of local origin. The terraces formed by the Arkansas River have been differentiated on plate 2 from the terraces formed by the tributary streams.

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

Alluvium

Alluvium has been deposited along the Arkansas River and along many of the tributary streams.

The alluvium along the Arkansas River consists of clay, silt, sand, and gravel. The flat surface of the Arkansas River alluvium is broken by the channels of tributary streams and by shallow marshy depressions which may represent former ox-bow lakes. The total thickness of the Arkansas River alluvium is unknown, but a thickness of 20 feet is exposed in some places. The alluvium along the Arkansas River has been differentiated on plate 2 from the alluvium along the smaller streams.

The alluvial material along the tributary streams is clay, silt, sand, and pebbles of siltstone and sandstone. The surface of the stream alluvium is generally flat but may slope gently towards the stream channel. The areas of stream alluvium as mapped on plate 2 include smaller areas of terrace deposits in places where the present streams flow on or in the lowermost terrace deposit, generally near the headwaters of the stream where alluvium and terrace deposits converge.

STRUCTURE

The Delaware quadrangle is located approximately in the central part of the Arkansas Valley section of the Ouachita province (fig. 1). The structure of the rocks in the quadrangle is characterized by broad gently dipping asymmetrical folds and high-angle normal faults (pls. 3 and 4).

FOLDS

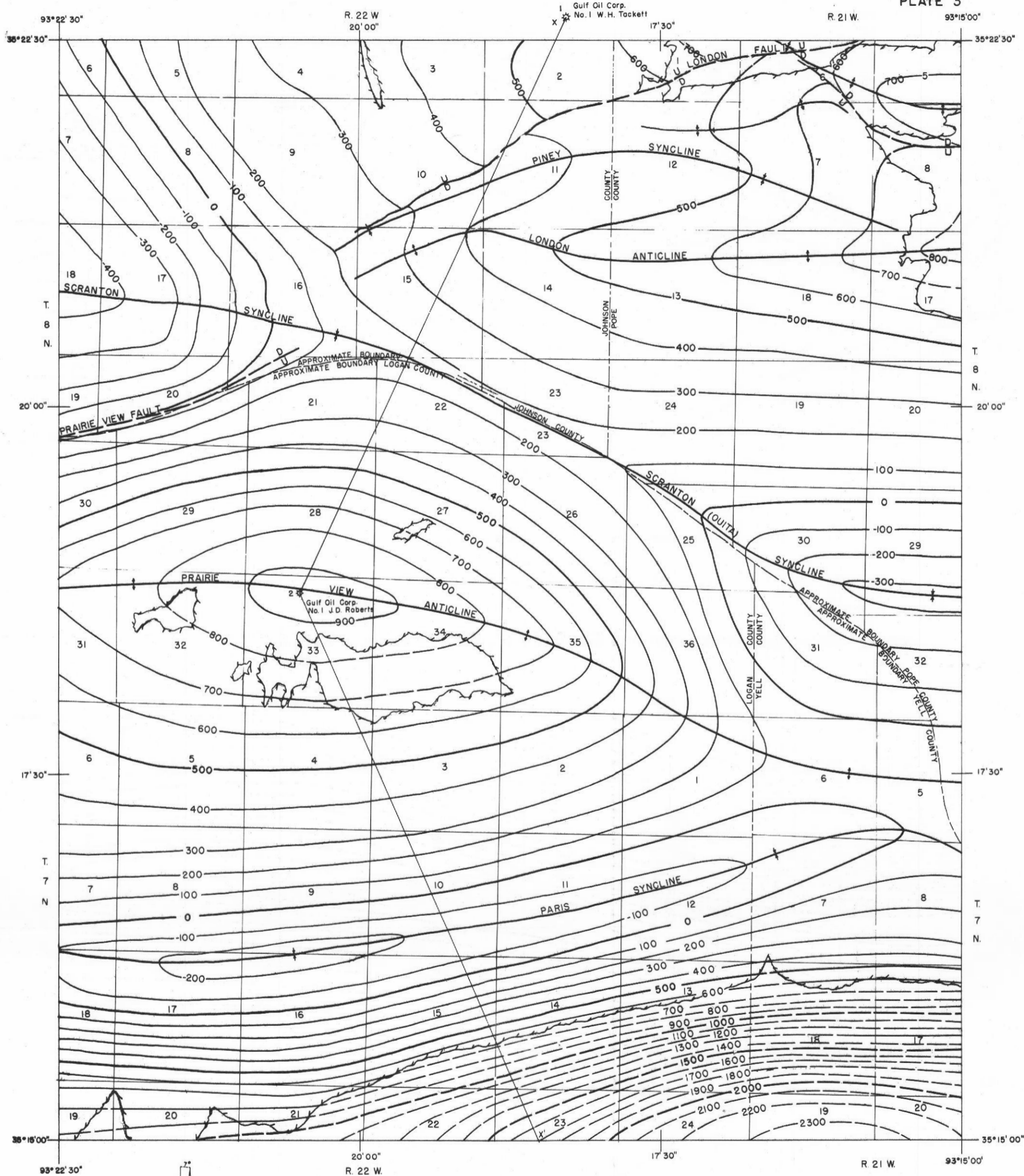
Anticlines (from north to south) in the Delaware quadrangle are as follows (pl. 3): part of the south limb of the Knoxville anticline, the axis of which is north of the quadrangle; a small unnamed anticline that may represent drag along the London fault; the London anticline; the Prairie View anticline; and part of the north limb of the Pine Ridge anticline, the axis of which is south of the quadrangle. The north limbs of the Pine Ridge and of the Prairie View anticlines are steeper than the south limbs although the south limb of the Pine Ridge anticline lies outside the area of this report. The south limb of the London anticline is steeper than the north limb.

The sequence of synclines from north to south in the Delaware quadrangle is as follows: the Piney syncline, which may be a bifurcation of the Scranton syncline; the Scranton (Ouita) syncline—the name Scranton has priority over the name Ouita; and the Paris syncline. The south limbs of the Paris syncline and of the western part of the Scranton syncline are steeper than the north limbs; however, the north limb of the eastern portion of the Scranton syncline is steeper than the south limb.

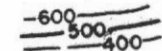
FAULTS

The Prairie View fault, the outcrop of which is concealed by alluvium in the Delaware quadrangle, has been extended into the mapped area from the west. Where exposed (west of the Delaware quadrangle), the Prairie View fault is a high-angle north-dipping normal fault with the downthrown block on the north side.

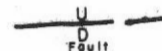
The London fault extends into the Delaware quadrangle from the east and probably ends a few hundred yards west of Big Piney Creek. The fault is a high-angle south-dipping normal fault with the downthrown block on the south side. The fault plane is best exposed on the west side of Big Piney Creek in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 15, T. 8 N., R. 22 W. At this locality, the fault plane dips 58° south and the fault has an apparent displacement of about 20 feet. The fault is exposed along Flat Rock Creek to the east and in a drainage ditch along the county road between secs. 10 and 11, T. 8 N., R. 22 W. East of the county road, the fault is not exposed but it can be located within a north-south distance of 150 feet (secs. 1 and 2, T. 8 N., R. 22 W.).



EXPLANATION

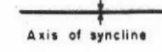


Structure contours on base of Hartshorne sandstone, dashed where projected above surface; contour interval 100 feet; datum is mean sea level



Dashed where approximately located, U, upthrown side; D, downthrown side

Surface trace of the contact between the Hartshorne sandstone and the underlying Atoka formation



Axis of syncline
Axis of anticline



Line of structural cross section shown on plate 4

WELL SYMBOLS

Company name and lease name shown

Producing gas well; number designates stratigraphic section shown on plate 1 and described in appendix

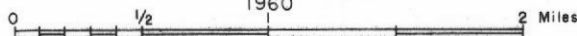
Dry hole with show of gas; number designates stratigraphic section shown on plate 1 and described in appendix

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

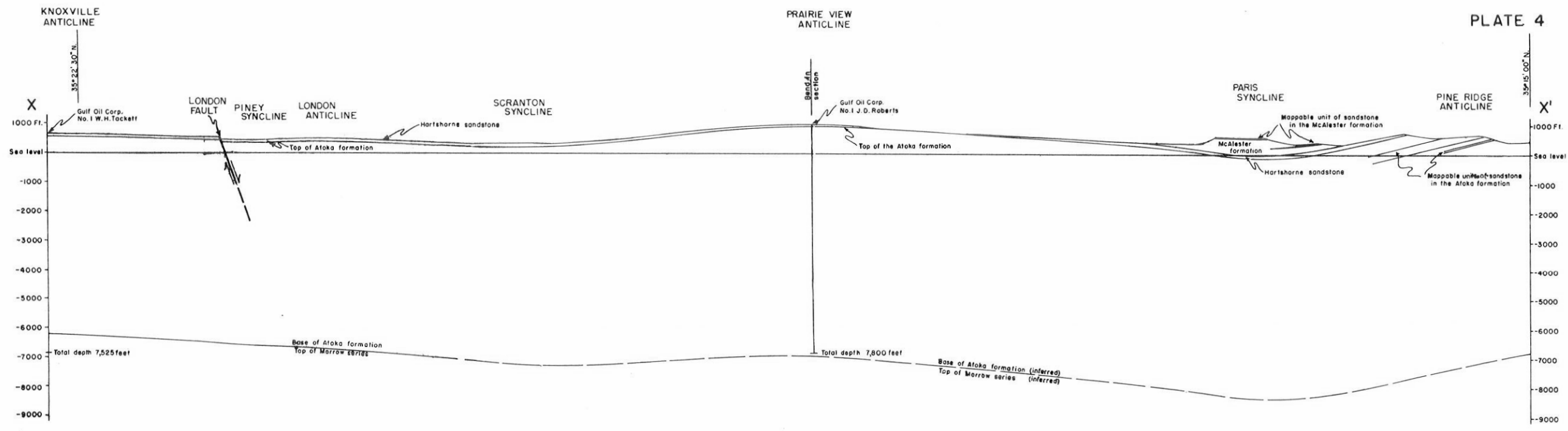
STRUCTURAL CONTOUR MAP OF DELAWARE QUADRANGLE, LOGAN COUNTY AND VICINITY, ARKANSAS

by
E. A. Merewether and Boyd R. Haley

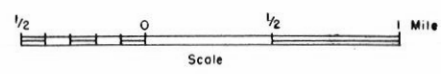
U. S. Geological Survey
1960



APPROXIMATE MEAN DECLINATION, 1980



STRUCTURAL CROSS SECTION OF DELAWARE QUADRANGLE, LOGAN COUNTY AND VICINITY, ARKANSAS



By
 E. A. Merewether and Boyd R. Haley
 U. S. Geological Survey
 1960

An east-west trending unnamed fault lies about one mile south of the London fault along the eastern boundary of the quadrangle. About $\frac{1}{2}$ mile west of the quadrangle boundary the trend of the fault changes from west-east to northwest-southeast and the unnamed fault may join the London fault near the northern boundary of the quadrangle. The fault plane is not exposed in the Delaware quadrangle but the displacement of the Hartshorne sandstone at the western end of the valley formed by the north fork of Mill Creek suggests that the fault plane dips north at a high angle, and that the north block is downthrown.

ECONOMIC GEOLOGY

COAL

Coal beds are present in the Atoka and the McAlester formations. The known coal beds in the quadrangle are thin and the coal is of poor quality. The location and the thickness of the known exposures of coal are shown on plate 2. The coal beds are too thin (less than 14 inches) to warrant an estimation of the reserves of coal in the Delaware quadrangle.

The coal in the Delaware quadrangle has not been sampled and analyzed for rank determination. Haley (1960) assumed the coal to be semianthracite. His assumption was based on the percentage of dry, mineral-matter-free fixed carbon in coal samples from coal beds near the Delaware quadrangle.

Coal Beds in Atoka Formation

A thin coal bed exposed in sec. 8, T. 8 N., R. 21 W., may grade laterally into or be equivalent to a carbonaceous zone exposed in sec. 15, T. 7 N., R. 22 W.

Coal beds were penetrated by the Tackett well at depths from 1,310 to 1,325 feet. These coal beds, although not found in the Roberts well, may be equivalent to a coal bed that is reported to crop out in the valley formed by the south fork of Jones Creek in secs. 19, 20, and 21, T. 7 N., R. 21 W. An exposure of this coal bed could not be found, but the coal is reported to be about 8 inches thick.

A coaly zone is exposed in a road cut a few feet north of the northern boundary of the Delaware quadrangle, about $\frac{1}{2}$ mile east of the Johnson-Pope County line (NW $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 1, T. 8 N., R. 22 W.), and may extend into the Delaware quadrangle. The coaly zone occurs in the shale of the upper part of the Atoka formation about 20 feet below the base

of the Hartshorne sandstone and consists of, from top to bottom, a lens of coal from a fraction of an inch to 8 inches in thickness, a few feet of shale, an ironstone unit about 2 inches thick, a 2-inch thick coal bed, approximately 18 inches of shale, another ironstone bed about 2 inches thick, and another 2-inch thick coal bed.

Coal Beds in McAlester Formation

The lower Hartshorne coal bed, which is near the base of the McAlester formation elsewhere in Arkansas, is presumed to be present in the Delaware quadrangle but only one exposure has been found. In a road cut along U. S. Highway 64 (center sec. 24, T. 8 N., R. 22 W.) about 2 miles west of London, a coal bed about 1 inch thick occurs in an outlier of shale of the McAlester a few feet above the Hartshorne sandstone. The coal bed is not exposed but local residents report it to be about 12 inches thick near the junction of Big Piney Creek and the Arkansas River. The Lower Hartshorne coal bed is 25 inches thick and has been mined in an area 5 miles east of London. The same coal bed is 11 inches to 14 inches thick in an area about 9 miles west of Delaware and 7 inches to 13 inches thick in an area 4 miles north of Knoxville. The position of the outcrop of the Lower Hartshorne coal bed is not shown on plate 2. Exploration for the outcrop should start from the contact between the Hartshorne and McAlester formations and proceed up section until the coal bed is discovered.

Several coal beds in the McAlester formation are exposed in sec. 29, T. 8 N., R. 21 W. The coal beds are 2 inches to 9 inches thick and the coal is of poor quality.

OIL AND GAS

Crude oil has not been discovered in the Delaware quadrangle, but the more likely reservoir rocks, those of pre-Pennsylvanian age, have not been tested. At present, gas deposits in rocks of Pennsylvanian age are much more attractive drilling targets.

A commercial quantity of gas was discovered in the Tackett well and a show of gas was found in the Roberts well. The gas in the Tackett well is from a sandstone near the middle of the Atoka formation, and the gas in the Roberts well is from one of the sandstone units in the upper half of the Atoka formation. Gas was not discovered in the basal sandstone of the Atoka or that part of the Morrow series

penetrated by the Tackett well, nor in that part of the basal sandstone of the Atoka penetrated by the Roberts well. However, these tests do not condemn the basal part of the Atoka formation or the Morrow series, which are the source of much of the gas elsewhere in the Arkansas Valley province.

The Tackett well is located near the crest of the Knoxville anticline, which has an apparent closure of 400 feet at the surface, and the Roberts well is located near the crest of the Prairie View anticline, which has an apparent closure of about 800 feet at the surface. Stratigraphic correlation between the two wells is not certain, but the sandstone at a depth of 3,308 to 3,376 feet (producing zone) in the Tackett well is probably equivalent to the sandstone at a depth of 4,308 to 4,477 feet in the Roberts well (pl. 1). If this correlation is valid, this sandy zone has about 400 feet of effective closure on the Prairie View anticline.

The most promising locations for future drilling are along the crests of the Knoxville and London anticlines, north and east of the Delaware quadrangle, and along the crest of the Pine Ridge anticline south of the Delaware quadrangle. However, before wells are drilled, it would be advisable to make a study of the structural differences between the producing or target horizon and a horizon higher in the stratigraphic section. For example, the closure of some of the folds in the Delaware quadrangle, as determined from a structural contour map of the base of the Hartshorne sandstone (pl. 3), is larger than the closure of the same fold as determined from a structural map of the basal sand of the Atoka formation. This difference in the closure of the same folds with depth is a result of regional thickening of the Atoka formation.

The extent of individual gas reservoirs in the Atoka formation is not well defined in this area or elsewhere in the Arkansas Valley. Even though the crests of anticlines generally are favored for drilling sites, changes in porosity and permeability probably limit certain reservoirs to the flanks of anticlines, or even to the synclines.

BUILDING STONE

Most of the rock from the Delaware quadrangle used as building and decorative stone is quarried from the Hartshorne sandstone. The sized stone, usually ranging from 1 to 5 inches in thickness, from 3 to 4 inches in width, and from 12 to 36 inches in length, is used extensively as interior and exterior finish in the same way brick is used. Exploration for this type of building stone and for top-grade flagstone should be in the areas where the Hartshorne sandstone is exposed at the surface (pl. 2). In general, the better quality stone is found high on the ridges formed by the Hartshorne sandstone.

Stone suitable for use as building stone or flagstone also is present in the Atoka and McAlester formations. In general, the quality of this building stone is inferior to that of the Hartshorne.

ROAD METAL

Stone suitable for road metal has been quarried from sandstone units in the Atoka formation and Hartshorne sandstone and dug from some of the river terraces. The sandstone is crushed and used as an aggregate and as a base in paved and in some unpaved roads. The more gravelly part of the terrace deposits is used as a base for unpaved roads. Shale from the Atoka and the McAlester formations has been used as road metal on some of the unpaved roads.

GRAVEL, SAND, AND CLAY

Large amounts of gravel and sand can be obtained from the river terraces and river alluvium. Relatively pure deposits of clay are also present in some of the river terraces and in some places in the river alluvium.

The sand and gravel are useful in many phases of the construction industry. The deposits of clay may be source material for brick, pottery, and tile, and, when bloated (heated to the melting point), may be used as a light-weight aggregate for cement and cement block.

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APPENDIX

The surface and subsurface stratigraphic sections described below are shown on plates 1 and 2. The surface sections are keyed to the two plates by letters, and the well sections are keyed by arabic numerals. The lithologic descriptions of the surface sections were obtained by field observation. The lithologic descriptions of the well sections resulted from a concurrent examination of the rock samples under a binocular microscope and a study of

the electrical logs from each well.

The colors given in the descriptions below correspond to the colors of the Rock Color Chart issued by the National Research Council. The grain sizes are described in accordance with the Wentworth grade scale. Each stratigraphic section is arranged so that the youngest or uppermost rock unit is described first and the oldest or lowermost rock unit is described last.

Surface Stratigraphic Sections

SECTION A

Upper Mill Creek section
Sec. 8, T. 8 N., R. 21 W., Pope County, Arkansas
Measured and described by B. R. Haley, logged by E. A. Merewether

Lower part of Hartshorne sandstone and upper part of Atoka formation

<i>Thickness in feet</i>	<i>Interval in feet</i>	DESCRIPTION
Hartshorne sandstone		
28.8	0 - 28.8	Sandstone, poorly exposed, light-gray, fine-grained scattered medium sand grains; beds as much as 2 feet thick
23.0	28.8- 51.8	Covered interval; contains contact between Hartshorne sandstone and underlying Atoka formation
Atoka formation		
20.1	51.8- 71.9	Shale, dark-gray, silty, very finely micaceous; beds as much as ½ inch thick
5.7	71.9- 77.6	Shale, dark-gray, silty, very finely micaceous, and medium-gray very finely micaceous siltstone; irregularly bedded; shale, siltstone, and ironstone beds as much as ¼ inch thick
4.1	77.6- 81.7	Siltstone, medium- to dark-gray, very finely micaceous; irregularly bedded; beds as much as ½ inch thick
7.9	81.7- 89.6	Shale, dark-gray, slightly silty, very finely micaceous, and dark-gray very finely micaceous siltstone; irregularly bedded; beds as much as ¼ inch thick
4.8	89.6- 94.4	Shale, dark-gray, very finely micaceous; beds as much as ¼ inch thick
28.7	94.4-123.1	Shale, dark-gray, very finely micaceous; beds as much as ¼ inch thick; ironstone concretions as much as 1½ inches in diameter
28.8	123.1-151.9	Shale, poorly exposed, dark-gray
5.7	151.9-157.6	Shale, dark-gray, very finely micaceous

17.3	157.6-174.9	Covered interval
31.0	174.9-205.9	Shale, grayish-black, very finely micaceous
0.1	205.9-206.0	Shale, grayish - black; abundant plant fragments
0.3	206.0-206.3	Coal; bands as much as ½ inch thick; approximately 90 percent vitrain
0.2	206.3-206.5	Underclay, dark-gray
86.3	206.5-292.8	Shale, dark-gray, very finely micaceous; beds as much as ¼ inch thick
0.4	292.8-293.2	Sandstone, medium-gray, very fine grained, finely micaceous; one bed
97.7	293.2-390.9	Shale, dark-gray, slightly silty in part, very finely micaceous; beds as much as ¼ inch thick
29.7	390.0-419.7	Covered interval
17.2	419.7-436.9	Sandstone, light - gray, very fine grained, very silty, finely to medium micaceous; irregularly bedded; beds as much as 4 inches thick

SECTION B

London section
Sec. 29, T. 8 N., R. 21 W., Pope County, Arkansas
Measured and described by B. R. Haley, logged by E. A. Merewether

Lower part of Savanna formation and upper part of McAlester formation

<i>Thickness in feet</i>	<i>Interval in feet</i>	DESCRIPTION
Lower part of Savanna formation		
4.0	0 - 4.0	Sandstone, light-gray, very fine grained, silty, finely micaceous; regularly bedded; beds as much as ½ inch thick
2.4	4.0- 6.4	Sandstone, light-gray, very fine grained, silty, finely micaceous; beds as much as 2 inches thick; ripple-marked
1.1	6.4- 7.5	Siltstone, light-gray, slightly very finely sandy, very finely micaceous; regularly bedded; beds as much as 1 inch thick

1.9	7.5- 9.4	Sandstone, light - gray, very fine grained, very silty, very finely micaceous; one bed 16 inches thick and one bed 6 inches thick
2.7	9.4- 12.1	Siltstone, medium-gray, finely micaceous; irregularly bedded; beds as much as 3 inches thick
5.7	12.1- 17.8	Sandstone, medium-gray, very fine grained, silty, finely micaceous; beds as much as 4 inches thick; bottom of unit is base of Savanna formation
Upper part of McAlester formation		
1.5	17.8- 19.3	Siltstone, medium-gray, finely micaceous; irregularly bedded; beds as much as 1 inch thick; beds of dark-gray silty shale as much as ¼ inch thick
1.6	19.3- 20.9	Shale, dark-gray, silty, finely micaceous; beds as much as ¼ inch thick
0.7	20.9- 21.6	Siltstone, medium-gray, finely micaceous; irregularly bedded; beds as much as ½ inch thick; and dark-gray finely micaceous shale beds as much as ¼ inch thick
0.3	21.6- 21.9	Siltstone, medium-gray, finely micaceous; irregularly bedded; beds as much as ¼ inch thick
2.6	21.9- 24.5	Shale, dark-gray; ironstone concretions as much as 3 inches thick and 8 inches in diameter; ironstone bands as much as ¼ inch thick
10.6	24.5- 35.1	Covered interval; probably dark-gray shale
34.5	35.1- 69.6	Shale, dark-gray; beds as much as ¼ inch thick; ironstone bands as much as ¾ inch thick
0.2	69.6- 69.8	Coal; two beds each ½ inch thick, separated by a 2-inch bed of black shale
3.5	69.8- 73.3	Shale, dark-gray, very finely micaceous; beds as much as ¼ inch thick; scattered ironstone concretions as much as 1 inch in diameter
0.8	73.3- 74.1	Coal; vitrain bands as much as ¼ inch thick, fusain bands as much as ⅛ inch thick; approximately 50 percent vitrain
0.5	74.1- 74.6	Shale, dark-gray; scattered plant fragments
5.7	74.6- 80.3	Shale, dark-gray, very finely micaceous; abundant irregularly shaped ironstone concretions as much as 2 inches in diameter
46.0	80.3-126.3	Shale, dark-gray, finely micaceous; beds as much as ½ inch thick
34.5	126.3-160.8	Shale, dark-gray, slightly silty, finely micaceous; beds as much as ½ inch thick

SECTION C

Knoxville section
 Sec. 16, T. 8 N., R. 22 W., Johnson County, Arkansas
 Measured and described by B. R. Haley, logged by E. A. Merewether
 Middle part of McAlester formation

<i>Thickness in feet</i>	<i>Interval in feet</i>	DESCRIPTION
		Middle part of McAlester formation
6.0	0 - 6.0	Sandstone, light - gray, very fine grained, very silty, finely micaceous; beds as much as 4 inches thick
3.0	6.0- 9.0	Covered interval
11.5	9.0- 20.5	Sandstone, light-gray, very fine grained, very silty, finely micaceous; beds as much as 4 inches thick
28.7	20.5- 49.2	Covered interval
51.8	49.2-101.0	Shale, dark-gray, very finely micaceous; beds as much as ¼ inch thick; some very silty dark-gray shale in beds as much as ¼ inch thick; ironstone concretions as much as 2 inches thick
40.2	101.0-141.2	Shale, poorly exposed, dark-gray, very finely micaceous

SECTION D

Delaware Creek section
 Sec. 10, T. 7 N., R. 22 W., Logan County, Arkansas
 Measured and described by B. R. Haley, logged by E. A. Merewether

<i>Thickness in feet</i>	<i>Interval in feet</i>	DESCRIPTION
		Middle part of McAlester formation
8.0	0 - 8.0	Sandstone, light-gray, very fine grained, silty, very finely micaceous; beds as much as 30 inches thick
50.0	8.0- 58.0	Shale, dark-gray; beds as much as ¼ inch thick
108.1	58.0-166.1	Covered interval; probably dark-gray shale
5.0	166.1-171.1	Shale, dark greenish gray; beds as much as ¼ inch thick; beds of dark greenish gray siltstone as much as ⅛ inch thick
86.3	171.1-257.4	Shale, dark-gray, finely micaceous; beds as much as 1 inch thick

SECTION E

Upper Delaware Creek section
 Sec. 17, T. 7 N., R. 22 W., Logan County, Arkansas
 Measured and described by B. R. Haley, logged by E. A. Merewether

<i>Thickness in feet</i>	<i>Interval in feet</i>	DESCRIPTION
		Lower part of McAlester formation
5.8	0 - 5.8	Covered interval; probably sandstone
11.4	5.8- 17.2	Sandstone, grayish - white, very fine grained; abundant coaly plant fragments; dark - gray shale pebbles as much as ½ inch in diameter
203.0	17.2-220.2	Covered interval
17.8	220.2-238.0	Sandstone, light- to medium-gray, very fine grained, very silty, very finely micaceous; irregularly bedded; beds ¼ to 2 inches thick; appears to have been slightly limy

7.7	238.0-245.7	Siltstone, badly weathered, olive-gray, slightly very finely sandy; ironstone concretions as much as 4 inches in diameter; upper 2 feet has beds of silty very fine grained sandstone as much as ½ inch thick
225.5	245.7-471.2	Covered interval; base of covered interval is base of McAlester formation Upper part of Hartshorne sandstone
19.2	471.2-490.4	Sandstone, light-gray, very fine to fine-grained
49.6	490.4-540.0	Covered interval; probably sandstone

SECTION F

Upper Stinette Creek section
 Sec. 15, T. 7 N., R. 22 W., Logan County, Arkansas
 Measured and described by B. R. Haley, logged by E. A. Merewether
 Lower part of Hartshorne sandstone and upper part of Atoka formation

Thickness in feet	Interval in feet	DESCRIPTION
Lower part of Hartshorne sandstone		
30.0	0 - 30.0	Sandstone, light - gray, very fine to fine-grained; beds as much as 48 inches thick
2.0	30.0- 32.0	Sandstone, light-gray, very fine to fine-grained; well-cemented
8.3	32.0- 40.3	Sandstone, light - gray, fine-grained; one bed; weathers friable
12.2	40.3- 52.5	Sandstone, light - gray, fine-grained; beds as much as 48 inches thick
7.1	52.5- 59.6	Sandstone, light-gray, very fine to fine-grained, slightly silty; crossbedded; beds as much as 24 inches thick
149.0	59.6-208.6	Covered interval; contact between Hartshorne sandstone and underlying Atoka formation is in upper part of this interval Upper part of Atoka formation
17.2	208.6-225.8	Shale, dark-gray; beds as much as ¼ inch thick
48.9	225.8-274.7	Shale, dark-gray, finely micaceous; beds as much as ½ inch thick; and beds of dark - gray siltstone as much as ¼ inch thick
5.8	274.7-280.5	Covered interval; probably dark-gray shale
17.0	280.5-297.5	Shale, dark-gray, finely micaceous
10.3	297.5-307.8	Shale, black; coaly plant fragments; calamites leaf impressions; ironstone concretions as much as ½ inch thick
1.5	307.8-309.3	Shale, dark-gray, silty, finely micaceous
11.5	309.3-320.8	Shale, dark-gray, finely micaceous; beds as much as ¼ inch thick; and dark-gray finely micaceous siltstone beds as much as 6 inches thick
3.5	320.8-324.3	Siltstone, medium-gray, finely micaceous; irregularly bedded; beds as much as 2 inches thick

4.9	324.3-329.2	Shale, dark-gray, finely micaceous; beds as much as ¼ inch thick; and dark-gray finely micaceous siltstone beds as much as ½ inch thick
3.5	329.2-332.7	Siltstone, dark-gray, very finely sandy, finely micaceous; irregularly bedded; beds as much as 3 inches thick
5.3	332.7-338.0	Siltstone, dark-gray, finely micaceous; irregularly bedded; beds as much as 2 inches thick; a few beds of dark-gray shale as much as ¼ inch thick
4.6	338.0-342.6	Shale, dark-gray, very finely micaceous; and dark-gray finely micaceous siltstone
187.7	342.6-530.3	Covered interval
7.0	530.3-537.3	Shale, dark-gray, finely micaceous; beds as much as ¼ inch thick
184.0	537.3-721.3	Covered interval
3.7	721.3-725.0	Sandstone, poorly exposed

SECTION G

Lower Stinette Creek section
 Sec. 13, T. 7 N., R. 22 W., Logan County, Arkansas
 Measured and described by B. R. Haley, logged by E. A. Merewether
 Lower part of Hartshorne sandstone and upper part of Atoka formation

Thickness in feet	Interval in feet	DESCRIPTION
Lower part of Hartshorne sandstone		
8.1	0 - 8.1	Sandstone, very light gray, very fine to fine - grained, scattered medium sand grains; one bed with undulating bedding plane at top
6.7	8.1- 14.8	Sandstone, very light gray, very fine to fine-grained, slightly clayey; one bed
8.3	14.8- 23.1	Sandstone, very light gray, fine-grained, scattered medium sand grains, finely micaceous; abundant plant fragments and tree trunk impressions; irregularly bedded; beds grade laterally into one bed
18.7	23.1- 41.8	Sandstone, light - gray, fine-grained, scattered medium sand grains; grades into underlying unit
3.4	41.8- 45.2	Sandstone, light-gray, very fine to fine-grained, slightly silty; widely scattered grains of weathered glauconite
23.0	45.2- 68.2	Covered interval; probably shale, also contains base of above sandstone, which is base of Hartshorne sandstone Upper part of Atoka formation
10.9	68.2- 79.1	Sandstone, light - gray, very fine grained, silty, finely micaceous; beds 6 to 48 inches thick
281.7	79.1-360.8	Covered interval
31.8	360.8-392.6	Sandstone, light - gray, very fine grained, finely micaceous; irregularly bedded; beds 2 to 24 inches thick
15.4	392.6-408.0	Covered interval

34.5	408.0-442.5	Shale, dark-gray, very finely micaceous; beds as much as ½ inch thick; beds of dark-gray siltstone as much as ¼ inch thick
6.8	442.5-449.3	Shale, poorly exposed, dark-gray
215.7	449.3-665.0	Covered interval
20.0	665.0-685.0	Sandstone, poorly exposed
12.2	685.0-697.2	Sandstone, medium-gray, very fine grained, very silty, finely micaceous; foreset-bedded in part, irregularly bedded in part; beds ½ to 8 inches thick
0.3	697.2-697.5	Shale, medium- to dark-gray, slightly silty, finely micaceous
11.6	697.5-709.1	Sandstone, light- to medium-gray, very fine grained, very silty; irregularly bedded in part, foreset-bedded in part; beds as much as 6 inches thick
3.0	709.1-712.1	Sandstone, light-gray, very fine grained, very silty; even-bedded; beds as much as 8 inches thick
2.7	712.1-714.8	Sandstone, light - gray, very fine grained; beds of siltstone as much as ¼ inch thick; irregularly bedded in part, foreset-bedded in part
5.4	714.8-720.2	Sandstone, light - gray, very fine grained, silty, very finely micaceous; well-cemented; even-bedded; beds 2 to 8 inches thick
5.4	720.2-725.6	Sandstone, light- to medium-gray, very fine grained, very silty, very finely micaceous; irregularly bedded in part, crossbedded in part; beds as much as 5 inches thick
3.0	725.6-728.6	Sandstone, light- to medium-gray, very fine grained, silty; pebbles of shale as much as ½ inch in diameter; irregularly bedded in part, crossbedded in part; beds ½ to 8 inches thick; a few beds of dark-gray shale as much as ¼ inch thick
4.1	728.6-732.7	Sandstone, light- to medium-gray, very fine grained, very silty, very finely micaceous; beds as much as 8 inches thick
8.3	732.7-741.0	Sandstone, light- to medium-gray, very fine grained, silty; irregularly bedded; beds as much as 6 inches thick
3.5	741.0-744.5	Sandstone, light - gray, very fine grained, slightly silty, finely micaceous; beds as much as 4 inches thick
4.3	744.5-748.8	Sandstone, light- to medium-gray, very fine grained, finely micaceous; crossbedded in part, foreset-bedded in part; beds as much as 10 inches thick
6.0	748.8-754.8	Sandstone, medium-gray, very fine grained, silty, finely micaceous; well-cemented; beds as much as 6 inches thick
4.0	754.8-758.8	Covered interval
3.0	758.8-761.8	Shale, medium- to dark-gray, silty, very finely micaceous; plant fragments

4.3	761.8-766.1	Sandstone, light-gray, very fine grained, silty, finely micaceous; well-cemented; plant fragments; scattered fine sand grains in upper part; crossbedded in part; beds as much as 5 inches thick
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SECTION H

South Fork Stinette Creek section
 Sec. 22, T. 7 N., R. 22 W., Logan County, Arkansas
 Measured and described by B. R. Haley, logged by E. A. Merewether

Upper part of Atoka formation		DESCRIPTION
Thickness in feet	Interval in feet	
Upper part of Atoka formation		
11.5	0 - 11.5	Sandstone, light - gray, very fine grained, silty; crossbedded; beds as much as 12 inches thick
17.3	11.5- 28.8	Sandstone, light-gray, very fine to fine-grained, slightly silty, finely micaceous; regularly bedded; beds as much as 8 inches thick
221.3	28.8-250.1	Covered interval
23.0	250.1-273.1	Shale, siltstone, and sandstone, poorly exposed
6.1	273.1-279.2	Sandstone, medium-gray, very fine grained, very silty, finely micaceous; beds as much as 10 inches thick; and medium - gray finely micaceous siltstone beds as much as ¼ inch thick
0.6	279.2-279.8	Shale, dark-gray; beds as much as ¼ inch thick; and medium-gray siltstone beds as much as ¼ inch thick
0.5	279.8-280.3	Sandstone, medium-gray, very fine grained, very silty, finely micaceous; beds as much as 3 inches thick
0.7	280.3-281.0	Shale, dark-gray; beds as much as ¼ inch thick; and medium-gray siltstone beds as much as ¼ inch thick
1.3	281.0-282.3	Sandstone, medium-gray, very fine grained, very silty, finely micaceous; beds as much as 3 inches thick
8.0	282.3-290.3	Siltstone, medium-gray, very finely sandy, finely to medium micaceous; beds as much as ½ inch thick; medium-gray finely micaceous siltstone beds ¼ to ½ inch thick; and dark-gray silty very finely micaceous shale beds as much as ¼ inch thick; unit is irregularly bedded

SECTION I

South Fork Jones Creek section
 Sec. 17, T. 7 N., R. 21 W., Yell County, Arkansas
 Measured and described by B. R. Haley, logged by E. A. Merewether

Upper part of Atoka formation		DESCRIPTION
Thickness in feet	Interval in feet	
Upper part of Atoka formation		
46.0	0 - 46.0	Covered interval; probably contains sandstone
34.5	46.0- 80.5	Sandstone, poorly exposed, light-gray, very fine grained
46.0	80.5-126.5	Shale, dark-gray, finely micaceous
149.5	126.5-276.0	Covered interval

6	667-	673	Sandstone, as above	15	1,383-1,398	Shale, as above
7	673-	680	Siltstone, dark - gray, very finely sandy, finely micaceous	3	1,398-1,401	Sandstone, lightgray, very fine to fine-grained, scattered rounded medium sand grains, finely micaceous
15	680-	695	Sandstone, medium-gray, very fine to fine-grained, silty, finely micaceous	13	1,401-1,414	Shale, as above
45	695-	740	(No sample)	4	1,414-1,418	Sandstone, medium-gray, very fine to fine-grained, silty; well cemented
65	740-	805	Sandstone, light - gray, very fine grained, silty, finely micaceous	22	1,418-1,440	Shale, as above
15	805-	820	Shale, dark-gray, finely micaceous	10	1,440-1,450	(No sample)
60	820-	880	(No sample)	49	1,450-1,499	Shale, as above
20	880-	900	Shale, as above	5	1,499-1,504	Sandstone, light - gray, very fine grained, very silty, finely micaceous
24	900-	924	(No sample)	11	1,504-1,515	Shale, as above
21	924-	945	Siltstone, medium- to dark - gray very finely sandy, finely micaceous	8	1,515-1,523	Sandstone, light- to medium-gray, very fine to fine-grained, silty; well-cemented
15	945-	960	Shale, dark-gray, silty, finely micaceous	10	1,523-1,533	Shale, dark-gray, silty, finely micaceous
10	960-	970	(No sample)	5	1,533-1,538	Sandstone, as above
15	970-	985	Shale, dark-gray, very finely micaceous	4	1,538-1,542	Shale, as above
9	985-	994	Siltstone, medium-gray, very finely sandy, finely micaceous	5	1,542-1,547	Sandstone, as above
2	994-	996	Shale, as above	2	1,547-1,549	Shale, as above
6	996-	1,002	Siltstone, as above	2	1,549-1,551	Sandstone, as above
6	1,002-	1,008	Shale, as above	7	1,551-1,558	Shale as above
4	1,008-	1,012	Siltstone, medium-gray, finely micaceous	7	1,558-1,565	Sandstone, light - gray, medium-grained, well - rounded grains, abundant rounded coarse sand grains
18	1,012-	1,030	Shale, as above	15	1,565-1,580	Sandstone, light- to medium-gray, very fine grained, very silty, very finely micaceous
4	1,030-	1,034	Siltstone, as above	10	1,580-1,590	(No sample)
46	1,034-	1,080	Shale, dark - gray, slightly silty, very finely to finely micaceous	10	1,590-1,600	Shale, dark - gray, slightly silty, finely micaceous
10	1,080-	1,090	Shale, grayish-black	6	1,600-1,606	Sandstone, as above
8	1,090-	1,098	Siltstone, as above	104	1,606-1,710	Shale, dark-gray to grayish-black, very finely micaceous; abundant crystals of pyrite
11	1,098-	1,109	Sandstone, medium-gray, very fine grained, very silty, finely micaceous	10	1,710-1,720	(No sample)
17	1,109-	1,126	Shale, dark-gray, silty, finely micaceous	7	1,720-1,727	Sandstone, light- to medium-gray, very fine to fine-grained, abundant rounded medium sand grains, silty, finely to medium micaceous
4	1,126-	1,130	Siltstone, as above	2	1,727-1,729	Shale, dark-gray
5	1,130-	1,135	Sandstone, as above	9	1,729-1,738	Sandstone, as above
15	1,135-	1,150	Shale, dark - gray, slightly silty, very finely micaceous	4	1,738-1,742	Shale, as above
8	1,150-	1,158	Sandstone, light - gray, very fine grained, silty, finely micaceous	8	1,742-1,750	Sandstone, light-gray, fine- to medium-grained, slightly silty, finely micaceous
7	1,158-	1,165	Shale, as above	11	1,750-1,761	Shale, dark-gray, silty, finely micaceous
35	1,165-	1,200	Shale, dark-gray, very finely micaceous	8	1,761-1,769	Sandstone, light- to medium-gray, fine-grained, abundant rounded medium sand grains, silty, finely micaceous
8	1,200-	1,208	Siltstone, as above	3	1,769-1,772	Shale, as above
4	1,208-	1,212	Shale, as above	6	1,772-1,778	Sandstone, as above
6	1,212-	1,218	Siltstone, as above	3	1,778-1,781	Shale, as above
11	1,218-	1,229	Shale, as above	7	1,781-1,788	Sandstone, as above
16	1,229-	1,245	Siltstone, as above	7	1,788-1,795	Sandstone, light- to medium-gray, very fine to fine-grained, very silty, finely micaceous
29	1,245-	1,274	Shale, dark-gray, finely micaceous	55	1,795-1,850	Shale, dark-gray to grayish-black, finely micaceous
6	1,274-	1,280	Siltstone, light- to medium-gray, finely micaceous	24	1,850-1,874	Shale, dark - gray, slightly silty, very finey micaceous
30	1,280-	1,310	(No sample)	24	1,874-1,898	Shale, dark-gray to grayish-black, very finely micaceous
10	1,310-	1,320	Siltstone, dark - gray, very finely micaceous			
2	1,320-	1,322	Coal			
7	1,322-	1,329	Shale, dark-gray; crystals of pyrite			
3	1,329-	1,332	Coal			
16	1,332-	1,348	Shale, dark-gray, very finely micaceous			
14	1,348-	1,362	Sandstone, light - gray, very fine grained, silty			
7	1,362-	1,369	Siltstone, medium-gray, very finely sandy			
14	1,369-	1,383	Sandstone, light-gray, fine-grained, finely micaceous, very slightly limy			

2	1,898-1,900	Limestone, dark-gray, very silty; crinoids	6	3,295-3,301	Sandstone, light - gray, very fine grained, silty
5	1,900-1,905	Shale, as above	5	3,301-3,306	Shale, as above
2	1,905-1,907	Limestone, as above	4	3,306-3,310	Sandstone, light - gray, very fine to fine-grained, silty, finely micaceous; well-cemented
3	1,907-1,910	Shale, as above	67	3,310-3,377	(No sample)
1	1,910-1,911	Limestone, as above	3	3,377-3,380	Shale, dark-gray, silty, finely micaceous
36	1,911-1,947	Shale, as above; except crystals of pyrite in sample 1,920-1,930	24	3,380-3,404	Shale, dark-gray to grayish-black, very finely micaceous
33	1,947-1,980	Shale, dark-gray, very finely micaceous	26	3,404-3,430	Siltstone, medium-gray, very finely sandy, finely micaceous
20	1,980-2,000	(No sample)	22	3,430-3,452	Shale, dark-gray, silty, very finely micaceous
28	2,000-2,028	Shale, as above	8	3,452-3,460	Sandstone, light- to medium-gray, very fine grained, very silty, finely micaceous
20	2,028-2,048	Shale, grayish - black, very finely micaceous; abundant crystals of pyrite	2	3,460-3,462	Shale, as above
7	2,048-2,055	Sandstone, very light gray, very fine to fine-grained, slightly silty; well-cemented	19	3,462-3,481	Sandstone, medium-gray, very fine grained, very silty, finely micaceous
6	2,055-2,061	Shale, dark-gray, very finely micaceous	2	3,481-3,483	Shale, dark-gray, very finely micaceous
9	2,061-2,070	Sandstone, light - gray, very fine grained, slightly silty	7	3,483-3,490	Siltstone, medium-gray, very finely sandy, finely micaceous
10	2,070-2,080	(No sample)	2	3,490-3,492	Shale, as above
9	2,080-2,089	Sandstone, as above	8	3,492-3,500	Siltstone, as above
9	2,089-2,098	Shale, as above	24	3,500-3,524	Shale, as above
4	2,098-2,102	Sandstone, very light gray, very fine to fine - grained, slightly silty, finely micaceous	12	3,524-3,536	Siltstone, medium-gray, very finely sandy, finely micaceous; silt is almost very fine sand grain size (more than 0.062 mm in diameter)
84	2,102-2,186	Shale, dark-gray to grayish-black, very finely micaceous; crystals of pyrite in samples 2,130-2,170	9	3,536-3,545	Shale, dark-gray, silty, very finely micaceous
3	2,186-2,189	Sandstone, medium-gray, very fine grained, very silty, very finely micaceous	35	3,545-3,580	Siltstone, medium-gray, very finely sandy, finely micaceous
31	2,189-2,220	Shale, dark-gray to grayish-black, very finely micaceous	15	3,580-3,595	Shale, dark-gray, silty, finely micaceous
20	2,220-2,240	(No sample)	35	3,595-3,630	Shale, dark-gray, very finely micaceous
90	2,240-2,330	Shale, as above; except crystals of pyrite in sample 2,300-2,310	100	3,630-3,730	Shale, dark-gray to grayish-black, very finely micaceous
8	2,330-2,338	Sandstone, light-gray, very fine to fine-grained, slightly silty, finely micaceous	65	3,730-3,795	Shale, grayish-black; crystals of pyrite in samples 3,740-3,760
12	2,338-2,350	Shale, dark-gray, silty, finely micaceous	7	3,795-3,802	Sandstone, medium-gray, very fine grained, very silty, very finely micaceous
6	2,350-2,356	Sandstone, light - gray, fine-grained, scattered rounded medium sand grains, silty	5	3,802-3,807	Shale, dark-gray, very finely micaceous
8	2,356-2,364	Shale, dark-gray, very finely micaceous	10	3,807-3,817	Sandstone, as above
7	2,364-2,371	Sandstone, light-gray, fine-grained, abundant rounded medium sand grains, scattered rounded coarse sand grains, slightly silty	8	3,817-3,825	Shale, as above
2	2,371-2,373	Shale, as above	13	3,825-3,838	Sandstone, light - gray, fine-grained; drills free
5	2,373-2,378	Sandstone, light-gray, very fine to fine-grained, finely micaceous	12	3,838-3,850	Sandstone, light-gray, very fine to fine-grained; drills free
2	2,378-2,380	Shale, as above	12	3,850-3,862	Sandstone, light - gray, very fine grained
5	2,380-2,385	Sandstone, as above	3	3,862-3,865	Shale, as above
15	2,385-2,400	Shale, as above	5	3,865-3,870	Siltstone, medium-gray, very finely sandy, finely micaceous
820	2,400-3,220	(No sample)	3	3,870-3,873	Shale, as above
10	3,220-3,230	Shale, dark-gray, silty, finely micaceous	7	3,873-3,880	Siltstone, as above
40	3,230-3,270	(No sample)	4	3,880-3,884	Shale, as above
10	3,270-3,280	Sandstone, light - gray, very fine grained, slightly silty, finely micaceous; sand is almost silt size (less than 0.062 mm in diameter)	9	3,884-3,893	Sandstone, medium-gray, very fine grained, very silty, finely micaceous; well-cemented
10	3,280-3,290	(No sample)	2	3,893-3,895	Shale, as above
5	3,290-3,295	Shale, dark-gray, very finely micaceous	5	3,895-3,900	Sandstone, as above
			6	3,900-3,906	Shale, as above
			12	3,906-3,918	Sandstone, as above

2	3,918-3,920	Shale, as above	2	4,391-4,393	Shale, dark-gray, silty, very finely micaceous
5	3,920-3,925	Sandstone, as above	3	4,393-4,396	Siltstone, as above
3	3,925-3,928	Shale, as above	2	4,396-4,398	Shale, as above
7	3,928-3,935	Sandstone, as above	8	4,398-4,406	Siltstone, as above
2	3,935-3,937	Shale, as above	2	4,406-4,408	Shale, as above
10	3,937-3,947	Sandstone, medium-gray, very fine grained, very silty, finely micaceous; well - cemented; sand is almost silt size (less than 0.062 mm in diameter)	3	4,408-4,411	Siltstone, as above
4	3,947-3,951	Shale, as above	24	4,411-4,435	Shale, as above
23	3,951-3,974	Sandstone, as above	11	4,435-4,446	Siltstone, as above
6	3,974-3,980	Shale, as above	4	4,446-4,450	Shale, as above
5	3,980-3,985	Sandstone, as above	5	4,450-4,455	Siltstone, as above
9	3,985-3,994	Shale, as above	4	4,455-4,459	Shale, as above
6	3,994-4,000	Sandstone, as above	6	4,459-4,465	Siltstone, as above
8	4,000-4,008	Shale, as above	2	4,465-4,467	Shale, as above
4	4,008-4,012	Sandstone, as above	5	4,467-4,472	Siltstone, as above
6	4,012-4,018	Shale, as above	3	4,472-4,475	Shale, as above
2	4,018-4,020	Siltstone, medium-gray, very finely micaceous	5	4,475-4,480	Siltstone, as above
2	4,020-4,022	Shale, as above	21	4,480-4,501	Shale, as above
4	4,022-4,026	Siltstone, as above	119	4,501-4,620	Shale, dark-gray to grayish-black, very finely micaceous
12	4,026-4,038	Shale, as above	4	4,620-4,624	Siltstone, as above
8	4,038-4,046	Sandstone, light- to medium-gray, fine-grained, scattered rounded medium sand grains, slightly silty, finely micaceous	47	4,624-4,671	Shale, as above
6	4,046-4,052	Siltstone, as above	25	4,671-4,696	Siltstone, medium-gray, very finely micaceous; silt is almost very fine sand size (more than 0.062 mm in diameter)
43	4,052-4,095	Shale, as above	10	4,696-4,706	Shale, dark-gray, very finely micaceous
65	4,095-4,160	Siltstone, light- to medium-gray, very finely sandy, very finely micaceous	3	4,706-4,709	Siltstone, as above
4	4,160-4,164	Shale, as above	1	4,709-4,710	Shale, dark-gray to grayish-black, very finely micaceous
12	4,164-4,176	Sandstone, light-gray, very fine to fine - grained, finely micaceous; drills free	4	4,710-4,714	Siltstone, as above
2	4,176-4,178	Shale, as above	2	4,714-4,716	Shale, as above
6	4,178-4,184	Sandstone, light- to medium-gray, very fine grained, very silty, very finely micaceous; sand is almost silt size (less than 0.062 mm in diameter)	6	4,716-4,722	Siltstone, as above
2	4,184-4,186	Shale, as above	6	4,722-4,728	Shale, as above
4	4,186-4,190	Sandstone, as above	2	4,728-4,730	Siltstone, as above
2	4,190-4,192	Shale, as above	1	4,730-4,731	Shale, as above
8	4,192-4,200	Sandstone, as above	6	4,731-4,737	Siltstone, as above
4	4,200-4,204	Shale, as above	3	4,737-4,740	Shale, as above
5	4,204-4,209	Sandstone, as above	5	4,740-4,745	Siltstone, as above
2	4,209-4,211	Shale, as above	2	4,745-4,747	Shale, as above
7	4,211-4,218	Sandstone, as above	5	4,747-4,752	Siltstone, as above
62	4,218-4,280	Shale, dark-gray, very finely micaceous; in beds 2 to 3 feet thick; and light- to medium-gray very fine grained very silty very finely micaceous sandstone; sand is almost silt size (less than 0.062 mm in diameter); in beds 3 to 6 feet thick	5	4,752-4,757	Shale, as above
10	4,280-4,290	Sandstone, light- to medium-gray, very fine grained, very silty, very finely micaceous; sand is almost silt size (less than 0.062 mm in diameter)	4	4,757-4,761	Siltstone, as above
20	4,290-4,310	Siltstone, medium-gray, very finely micaceous	6	4,761-4,767	Sandstone, light- to medium-gray, very fine grained, silty
56	4,310-4,366	Siltstone, medium-gray, very finely sandy, very finely micaceous	19	4,767-4,786	Sandstone, medium-gray, very fine grained, very silty; well-cemented; sand is almost silt size (less than 0.062 mm in diameter)
14	4,366-4,380	Shale, dark-gray, very silty, very finely micaceous	11	4,786-4,797	Shale, dark-gray, silty, very finely micaceous
11	4,380-4,391	Siltstone, medium-gray, very finely micaceous	15	4,797-4,812	Sandstone, as above
			11	4,812-4,823	Siltstone, dark-gray, very finely micaceous
			46	4,823-4,869	Shale, dark-gray to grayish-black, very finely micaceous
			13	4,869-4,882	Siltstone, light-gray; well-cemented; silt is almost very fine sand size (more than 0.062 mm in diameter)
			23	4,882-4,905	Sandstone, light - gray, very fine grained, very silty; well-cemented; sand is almost silt size (less than 0.062 mm in diameter)
			10	4,905-4,915	Shale, dark - gray, slightly silty, very finely micaceous
			59	4,915-4,974	Siltstone, light- to medium-gray, very finely sandy, very finely micaceous
			3	4,974-4,977	Shale, grayish-black, very finely micaceous

6	4,977-4,983	Siltstone, medium-gray, very finely micaceous	3	5,358-5,361	Siltstone, medium-gray, very finely micaceous
36	4,983-5,019	Shale, dark-gray to grayish-black	8	5,361-5,369	Shale, grayish-black
10	5,019-5,029	Siltstone, medium-gray, very finely micaceous; well-cemented	17	5,369-5,386	Sandstone, light - gray, very fine grained, very silty, very finely micaceous
3	5,029-5,032	Shale, as above	6	5,386-5,392	Shale, as above
6	5,032-5,038	Siltstone, as above	8	5,392-5,400	Siltstone, medium-gray, very finely micaceous; silt is almost very fine sand size (more than 0.062 mm in diameter)
2	5,038-5,040	Shale, as above	3	5,400-5,403	Shale, as above
7	5,040-5,047	Siltstone, as above	9	5,403-5,412	Siltstone, dark - gray, very finely micaceous; crystals of pyrite
9	5,047-5,056	Shale, as above	8	5,412-5,420	Shale, as above
8	5,056-5,064	Siltstone, as above	4	5,420-5,424	Siltstone, as above
2	5,064-5,066	Shale, as above	6	5,424-5,430	Shale, as above
3	5,066-5,069	Siltstone, as above	15	5,430-5,445	Siltstone, medium-gray, very finely sandy, very finely micaceous; silt is almost very fine sand size (more than 0.062 mm in diameter)
1	5,069-5,070	Shale, as above	3	5,445-5,448	Shale, as above
7	5,070-5,077	Siltstone, as above	5	5,448-5,453	Siltstone, as above
6	5,077-5,083	Shale, as above	3	5,453-5,456	Shale, as above
10	5,083-5,093	Siltstone, as above	4	5,456-5,460	Siltstone, as above
1	5,093-5,094	Shale, as above	9	5,460-5,469	Shale, grayish - black, very finely micaceous
10	5,094-5,104	Siltstone, as above	3	5,469-5,472	Siltstone, medium-gray, very finely micaceous
4	5,104-5,108	Shale, as above	18	5,472-5,490	Shale, as above
7	5,108-5,115	Siltstone, as above	3	5,490-5,493	Siltstone, as above
4	5,115-5,119	Shale, as above	17	5,493-5,510	Shale, as above
7	5,119-5,126	Sandstone, light- to medium-gray, very fine grained, very silty; well-cemented; sand is almost silt size (less than 0.062 mm in diameter)	10	5,510-5,520	Siltstone, medium- to dark-gray, very finely micaceous
1	5,126-5,127	Shale, as above	2	5,520-5,522	Shale, dark-gray, silty, very finely micaceous
9	5,127-5,136	Sandstone, as above	6	5,522-5,528	Siltstone, as above
2	5,136-5,138	Shale, as above	1	5,528-5,529	Shale, as above
10	5,138-5,148	Sandstone, as above	7	5,529-5,536	Siltstone, as above
2	5,148-5,150	Shale, as above	1	5,536-5,537	Shale, as above
20	5,150-5,170	(No sample)	5	5,537-5,542	Siltstone, as above
5	5,170-5,175	Shale, dark-gray to grayish-black, very finely micaceous	16	5,542-5,558	Shale, as above
10	5,175-5,185	Siltstone, medium-gray, very finely micaceous	10	5,558-5,568	Siltstone, as above
3	5,185-5,188	Shale, as above	4	5,568-5,572	Shale, as above
9	5,188-5,197	Siltstone, as above	7	5,572-5,579	Siltstone, as above
2	5,197-5,199	Shale, as above	84	5,579-5,663	Shale, grayish-black
7	5,199-5,206	Siltstone, as above	6	5,663-5,669	Siltstone, as above
4	5,206-5,210	Shale, as above	2	5,669-5,671	Shale, dark-gray to grayish-black
11	5,210-5,221	Sandstone, light- to medium-gray, very fine grained, very silty, very finely micaceous	9	5,671-5,680	Siltstone, as above
5	5,221-5,226	Shale, dark-gray, very finely micaceous	10	5,680-5,690	Shale, as above
4	5,226-5,230	Sandstone, as above	70	5,690-5,760	Shale, grayish-black
2	5,230-5,232	Shale, as above	20	5,760-5,780	(No sample)
3	5,232-5,235	Sandstone, as above	8	5,780-5,788	Shale, as above
3	5,235-5,238	Shale, as above	2	5,788-5,790	Shale, light-gray; flaky; abundant fine crystals of dolomite
3	5,238-5,241	Sandstone, as above	13	5,790-5,803	Siltstone, light- to medium - gray, very finely micaceous
16	5,241-5,257	Siltstone, medium- to dark - gray, very finely micaceous	17	5,803-5,820	Shale, dark-gray, silty, very finely micaceous; crystals of pyrite
23	5,257-5,280	Shale, dark-gray, silty, very finely micaceous	10	5,820-5,830	Shale, dark-gray, very finely micaceous
6	5,280-5,286	Siltstone, as above	20	5,830-5,850	(No sample)
3	5,286-5,289	Shale, dark-gray, very finely micaceous	3	5,850-5,853	Shale, grayish-black
16	5,289-5,305	Siltstone, as above	8	5,853-5,861	Sandstone, light- to medium-gray, medium-grained, abundant sub-angular to subrounded coarse sand grains
7	5,305-5,312	Shale, as above	2	5,861-5,863	Shale, as above
9	5,312-5,321	Siltstone, as above	9	5,863-5,872	Sandstone, light- to medium-gray, very fine to fine-grained, silty; well-cemented
2	5,321-5,323	Shale, as above			
8	5,323-5,331	Siltstone, as above			
2	5,331-5,333	Shale, as above			
6	5,333-5,339	Siltstone, as above			
3	5,339-5,342	Shale, as above			
13	5,342-5,355	Sandstone, light - gray, very fine grained, silty, very finely micaceous			
3	5,355-5,358	Shale, as above			

6	5,872-5,878	Shale, as above	24	6,363-6,387	Shale, dark-gray, silty, very finely micaceous; crystals of pyrite in sample 6,370-6,380
24	5,878-5,902	Sandstone, light-to medium-gray, very fine grained, very silty; well-cemented	25	6,387-6,412	Shale, dark-gray, very silty, very finely micaceous
2	5,902-5,904	Shale, as above	43	6,412-6,455	Shale, grayish - black, very finely micaceous
6	5,904-5,910	Sandstone, light-gray, very fine to fine-grained, silty	6	6,455-6,461	Siltstone, light-gray; well-cemented
4	5,910-5,914	Shale, as above	12	6,461-6,473	Shale, dark-gray, silty, very finely micaceous
6	5,914-5,920	Sandstone, light - gray, fine-grained, abundant rounded medium sand grains, limy; crinoids	8	6,473-6,481	Siltstone, light - gray, very finely micaceous
10	5,920-5,930	Sandstone, light - gray, very fine grained; well-cemented	9	6,481-6,490	Shale, as above
14	5,930-5,944	Sandstone, light - gray, very fine grained, silty; well-cemented	37	6,490-6,527	Shale, grayish-black
5	5,944-5,949	Shale, dark-gray	10	6,527-6,537	Siltstone, light- to medium-gray, finely micaceous
5	5,949-5,954	Siltstone, light - gray, very finely sandy, slightly limy	1	6,537-6,538	Shale, as above
28	5,954-5,982	Sandstone, light- to medium-gray, very fine grained, slightly silty, very slightly limy; well-cemented	4	6,538-6,542	Siltstone, as above
10	5,982-5,992	Siltstone, medium-gray, very finely sandy, very finely micaceous	1	6,542-6,543	Shale, as above
8	5,992-6,000	Sandstone, light- to medium-gray, very fine grained, silty	5	6,543-6,548	Siltstone, as above
10	6,000-6,010	(No sample)	7	6,548-6,555	Shale, dark-gray to grayish-black, very finely micaceous
8	6,010-6,018	Siltstone, dark-gray, finely micaceous	8	6,555-6,563	Siltstone, medium- to dark-gray, very finely micaceous
4	6,018-6,022	Shale, grayish-black	3	6,563-6,566	Shale, as above
6	6,022-6,028	Siltstone, as above	6	6,566-6,572	Siltstone, as above
21	6,028-6,049	Shale, as above	3	6,572-6,575	Shale, as above
12	6,049-6,061	Sandstone, light- to medium-gray, very fine grained, very silty; well-cemented	6	6,575-6,581	Siltstone, as above
14	6,061-6,075	Shale, dark-gray to grayish-black	3	6,581-6,584	Shale, as above
20	6,075-6,095	Siltstone, medium- to dark-gray, very finely micaceous	6	6,584-6,590	Siltstone, as above
55	6,095-6,150	Shale, grayish-black	10	6,590-6,600	Shale, as above
10	6,150-6,160	Sandstone, light-gray, very fine to fine-grained; drills free	7	6,600-6,607	Siltstone, as above
8	6,160-6,168	Sandstone, light - gray, very fine grained; drills free	38	6,607-6,645	Shale, grayish-black
2	6,168-6,170	Shale, as above	7	6,645-6,652	Siltstone, light- to medium-gray, finely micaceous
5	6,170-6,175	Sandstone, as above	2	6,652-6,654	Shale, as above
1	6,175-6,176	Shale, as above	2	6,654-6,656	Siltstone, as above
5	6,176-6,181	Sandstone, medium- to dark-gray, very fine grained, very silty; well-cemented; crystals of pyrite	2	6,656-6,658	Shale, as above
2	6,181-6,183	Shale, as above	4	6,658-6,662	Siltstone, as above
4	6,183-6,187	Sandstone, as above	2	6,662-6,664	Shale, as above
38	6,187-6,225	Shale, grayish - black; crystals of pyrite	7	6,664-6,671	Sandstone, light-gray, fine-grained, abundant subrounded medium sand grains; drills free
17	6,225-6,242	Siltstone, dark - gray, very finely micaceous, clayey	7	6,671-6,678	Shale, grayish-black
18	6,242-6,260	Shale, as above	7	6,678-6,685	Sandstone, light- to medium-gray, fine-grained, scattered rounded medium sand grains, finely micaceous
10	6,260-6,270	(No sample)	56	6,685-6,741	Shale, as above
2	6,270-6,272	Shale, as above	1	6,741-6,742	Shale, very light gray, slightly very finely sandy; crystals of dolomite; flaky
6	6,272-6,278	Sandstone, light - gray, very fine grained, silty; well-cemented	8	6,742-6,750	Sandstone, light-gray, fine-grained, scattered rounded medium sand grains; porous
2	6,278-6,280	Shale, as above	30	6,750-6,780	Sandstone, very light to light-gray, very fine to fine-grained, slightly limy; porous
20	6,280-6,300	(No sample)	26	6,780-6,806	Shale, grayish-black
6	6,300-6,306	Siltstone, light- to medium-gray, finely micaceous	14	6,806-6,820	Sandstone, light-gray, fine-grained, abundant rounded medium sand grains, scattered subrounded coarse sand grains, limy; porous; crystals of pyrite
3	6,306-6,309	Shale, dark-gray, silty, very finely micaceous	5	6,820-6,825	Sandstone, medium-to dark-gray, fine- to medium-grained, abundant subrounded coarse to very coarse sand grains, silty, limy; crinoids
7	6,309-6,316	Siltstone, as above			
9	6,316-6,325	Shale, as above			
6	6,325-6,331	Siltstone, as above			
10	6,331-6,341	Shale, as above			
22	6,341-6,363	Siltstone, medium- to dark-gray, finely micaceous			

5	6,825-6,830	Sandstone, grayish-white, fine- to medium - grained, abundant coarse to very coarse sand grains, slightly limy	16	6,965-6,981	Shale, dark - gray, slightly silty, very finely micaceous; crinoids
10	6,830-6,840	Sandstone, grayish-white, medium- to coarse-grained, abundant subrounded very coarse sand grains; very porous	6	6,981-6,987	Shale, dark-gray, very finely micaceous; fragments of very finely micaceous dark brownish-gray shale
3	6,840-6,843	Sandstone, grayish - white, medium-grained, abundant subrounded coarse sand grains	32	6,987-7,019	Shale, dark-gray, silty, very finely micaceous
3	6,843-6,846	Shale, as above	2	7,019-7,021	Shale, dark-gray, very finely micaceous; fragments of very finely micaceous dark brownish - gray shale
4	6,846-6,850	Sandstone, very light gray, medium - grained, abundant subrounded coarse sand grains	24	7,021-7,045	Shale, dark-gray, very finely micaceous
7	6,850-6,857	Sandstone, grayish-white, fine- to medium-grained; porous	5	7,045-7,050	Limestone, medium - gray, granular, very finely to finely sandy
3	6,857-6,860	Sandstone, grayish - white, medium- to coarse-grained, abundant subrounded coarse to very coarse sand grains, slightly limy; porous	2	7,050-7,052	Shale, grayish-black
15	6,860-6,875	Sandstone, grayish-white, fine- to medium-grained, scattered subrounded coarse to very coarse sand grains; porous	8	7,052-7,060	Sandstone, light-gray, very fine to fine-grained, silty, slightly limy; porous
2	6,875-6,877	Shale, as above	15	7,060-7,075	Shale, as above
6	6,877-6,883	Sandstone, grayish-white, fine- to medium-grained; porous	5	7,075-7,080	Sandstone, light- to medium-gray, fine-grained, very limy; crinoids
2	6,883-6,885	Shale, as above	15	7,080-7,095	Sandstone, grayish-white to very light gray, fine-grained, slightly limy; porous
5	6,885-6,890	Sandstone, as above; base of unit is base of Atoka formation Boyd shale and Prairie Grove member of Hale formation, undifferentiated	15	7,095-7,110	Sandstone, light-gray, fine- to medium-grained, scattered rounded coarse sand grains; porous
21	6,890-6,911	Shale, grayish-black; drills splintery	10	7,110-7,120	Sandstone, brownish - gray, very fine to fine - grained, scattered rounded medium sand grains, finely micaceous; well-cemented
5	6,911-6,916	Sandstone, light-gray, fine- to medium-grained, very limy	10	7,120-7,130	Sandstone, light- to medium-gray, fine-grained, scattered rounded medium sand grains; well - cemented
9	6,916-6,925	Limestone, medium - gray, granular, finely to medium sandy; crystals of pyrite; crinoids	34	7,130-7,164	Sandstone, light- to medium-gray, very fine to fine-grained, scattered rounded medium sand grains, slightly silty, finely to medium micaceous; well-cemented
5	6,925-6,930	Limestone, light- to medium-gray, granular, very finely to finely sandy; scattered rounded medium sand grains; crystals of pyrite; crinoids, bryozoans, brachiopods	6	7,164-7,170	Sandstone, brownish - gray, very fine to fine - grained, scattered rounded medium sand grains, slightly silty; well-cemented
9	6,930-6,939	Limestone, medium - gray, granular, finely to medium sandy, scattered rounded very coarse sand grains; ovoid fine to medium grayish - black ooliteoids; crystals of pyrite; crinoids, bryozoans, brachiopods, spines	5	7,170-7,175	Sandstone, very light to light-gray, very fine to fine-grained, scattered rounded medium sand grains; well-cemented
3	6,939-6,942	Shale, grayish-black	4	7,175-7,179	Sandstone, light- to medium-gray, very fine to fine-grained, silty, very coarsely micaceous; well-cemented
8	6,942-6,950	Sandstone, light- to medium-gray, fine- to medium - grained, very limy; crinoids, bryozoans, brachiopods	5	7,179-7,184	Siltstone, dark - gray, very finely micaceous; well-cemented
4	6,950-6,954	Sandstone, brownish - gray, fine- to medium - grained, scattered rounded very coarse sand grains, limy; crinoids	48	7,184-7,232	Shale, as above
5	6,954-6,959	Shale, dark-gray, very finely micaceous; fragments of very finely micaceous slightly silty dark brownish-gray shale	20	7,232-7,252	Sandstone, light- to medium-gray, very fine grained, very silty, very slightly limy
6	6,959-6,965	Sandstone, light- to medium-gray, fine- to medium-grained, limy; crystals of pyrite; crinoids, brachiopods	2	7,252-7,254	Shale, as above
			8	7,254-7,262	Sandstone, brownish - gray, very fine grained, very silty, very slightly limy
			3	7,262-7,265	Shale, as above
			15	7,265-7,280	Sandstone, very light to light-gray, very fine grained, silty, slightly limy
			8	7,280-7,288	Sandstone, light - gray, very fine grained, slightly silty; well-cemented

2	7,288-7,290	Shale, as above	10	130- 140	Shale, dark-gray, silty, finely micaceous; crystals of pyrite
10	7,290-7,300	Sandstone, light-gray, very fine grained; well-cemented	10	140- 150	Shale, dark-gray, silty, finely micaceous
31	7,300-7,331	Shale, grayish-black; drills splintery	40	150- 190	Shale, dark-gray, very finely micaceous
10	7,331-7,341	Limestone, medium - gray, granular, finely to medium sandy; crinoids	20	190- 210	Sandstone, dark - gray, very fine grained, silty, very finely micaceous, slightly limy
9	7,341-7,350	Sandstone, light- to medium-gray, fine- to medium-grained, scattered rounded coarse sand grains, very limy	25	210- 235	Shale, dark - gray, slightly silty, very finely micaceous
4	7,350-7,354	Shale, grayish-black	7	235- 242	Sandstone, medium- to dark-gray, very fine grained, silty, very finely micaceous, slightly limy
7	7,354-7,361	Sandstone, medium-gray, medium-grained, abundant rounded coarse to very coarse sand grains, limy; crystals of pyrite; crinoids	5	242- 247	Shale, as above
3	7,361-7,364	Shale, as above	13	247- 260	Sandstone, as above
6	7,364-7,370	Sandstone, light-gray, fine- to medium-grained; well-cemented	30	260- 290	Shale, dark - gray, slightly silty, finely micaceous
10	7,370-7,380	Sandstone, light- to medium-gray, very fine to fine-grained, silty; well-cemented	52	290- 342	Shale, dark-gray, very finely micaceous
10	7,380-7,390	Shale, as above	8	342- 350	Siltstone, dark - gray, very finely sandy, finely micaceous
6	7,390-7,396	Sandstone, very light to light-gray, very fine grained, silty; base of unit is base of Bloyd shale and Prairie Grove member of Hale formation, undifferentiated	80	350- 430	Shale, as above
			10	430- 440	Sandstone, medium-gray, very fine grained, very silty, finely micaceous
			15	440- 455	Siltstone, as above
			9	455- 464	Sandstone, medium-gray, very fine to fine-grained, silty; well - cemented
			1	464- 465	Siltstone, medium- to dark-gray, very finely micaceous
			7	465- 472	Sandstone, as above
			2	472- 474	Siltstone, as above
			8	474- 482	Sandstone, as above
			3	482- 485	Siltstone, as above
			7	485- 492	Sandstone, as above
			28	492- 520	Siltstone, medium-gray, very finely sandy, finely micaceous
			10	520- 530	Sandstone, medium - gray, very fine grained, very silty, finely micaceous
			3	530- 533	Siltstone, as above
			7	533- 540	Sandstone, as above
			2	540- 542	Siltstone, as above
			5	542- 547	Sandstone, as above
			3	547- 550	Siltstone, as above
			5	550- 555	Sandstone, as above
			2	555- 557	Siltstone, as above
			33	557- 590	Sandstone, as above
			10	590- 600	(No sample)
			10	600- 610	Sandstone, light-gray, very fine to fine-grained, silty, finely micaceous
			25	610- 635	Sandstone, light-gray, very fine to fine-grained, very finely micaceous; drills free
			15	635- 650	Sandstone, light-gray, fine-grained, scattered subrounded medium sand grains, finely micaceous
			7	650- 657	Sandstone, light-gray, fine-grained, scattered subrounded medium sand grains, widely scattered rounded coarse sand grains, finely micaceous
			28	657- 685	Shale, as above
			15	685- 700	Shale, dark-gray, silty, very finely micaceous
			16	700- 716	Siltstone, as above

Cane Hill member of Hale formation

SECTION 2

Gulf Oil Corp. No. 1 J. D. Roberts well
 Sec. 33, T. 8 N., R. 22 W., Logan County, Arkansas
 Elevation: 968 ft.; total depth: 7,800 ft.

Rock samples examined and logged by B. R. Haley
 Hartshorne sandstone and Atoka formation

Thickness in feet	Interval in feet	DESCRIPTION
		Hartshorne sandstone
10	0- 10	(No sample)
20	10- 30	Sandstone, grayish-white, fine- to medium-grained, scattered subrounded coarse sand grains; base of this unit is base of the Hartshorne sandstone
		Atoka formation
60	30- 90	Shale, dark-gray, very finely micaceous
10	90- 100	Shale, dark-gray, very finely micaceous; crystals of pyrite
10	100- 110	Shale, dark-gray, silty, finely micaceous; crystals of pyrite
20	110- 130	Shale, dark-gray, silty, finely micaceous

14	716- 730	Sandstone, medium-gray, very fine grained, very silty, finely micaceous, very slightly limy	20	1,700-1,720	Sandstone, light-gray, fine-grained, scattered subrounded medium and coarse sand grains, silty
10	730- 740	Sandstone, medium-gray, very fine grained, very silty, finely micaceous, slightly limy	14	1,720-1,734	Sandstone, light-gray, fine- to medium-grained, scattered rounded coarse sand grains, slightly silty, limy
40	740- 780	Shale, dark-gray, silty, very finely micaceous	6	1,734-1,740	Sandstone, light - gray, medium-grained, silty
10	780- 790	Shale, dark-gray, silty, very finely micaceous; crystals of pyrite	9	1,740-1,749	Shale, medium- to dark-gray, very silty, very finely micaceous
10	790- 800	Shale, dark-gray, silty, very finely micaceous	4	1,749-1,753	Siltstone, light - gray, very finely sandy
30	800- 830	(No sample)	14	1,753-1,767	Shale, dark-gray, very finely micaceous
20	830- 850	Shale, dark - gray, slightly silty, very finely micaceous	6	1,767-1,773	Siltstone, light- to medium-gray, very finely sandy
20	850- 870	Shale, dark - gray, slightly silty, very finely micaceous; crystals of pyrite	54	1,773-1,827	Shale, dark-gray, silty, very finely micaceous
60	870- 930	Shale, dark - gray, slightly silty, very finely micaceous	109	1,827-1,936	Shale, dark-gray, very finely micaceous
30	930- 960	Shale, dark-gray, silty, finely micaceous	6	1,936-1,942	Siltstone, light- to medium-gray, finely micaceous
30	960- 990	Shale, dark - gray, slightly silty, very finely micaceous	8	1,942-1,950	Shale, as above
3	990- 993	Siltstone, dark - gray, very finely sandy, finely micaceous	5	1,950-1,955	Siltstone, as above
17	993-1,010	(No sample)	2	1,955-1,957	Shale, as above
80	1,010-1,090	Shale, dark-gray, silty, very finely micaceous	11	1,957-1,968	Siltstone, light- to medium-gray, very finely sandy, finely micaceous
78	1,090-1,168	Shale, dark-gray, very finely micaceous	2	1,968-1,970	Shale, as above
4	1,168-1,172	Siltstone, medium- to dark-gray, finely micaceous	10	1,970-1,980	Siltstone, as above
7	1,172-1,179	Shale, as above	2	1,980-1,982	Shale, as above
5	1,179-1,184	Siltstone, medium-gray, very finely micaceous	14	1,982-1,996	Siltstone, light- to medium-gray, finely micaceous
229	1,184-1,413	Shale, dark-gray to grayish-black, very finely micaceous	1	1,996-1,997	Shale, as above
27	1,413-1,440	Siltstone, light- to medium-gray, very finely sandy in part, very finely micaceous	9	1,997-2,006	Siltstone, as above
2	1,440-1,442	Shale, dark-gray, very finely micaceous	1	2,006-2,007	Shale, as above
5	1,442-1,447	Siltstone, as above	24	2,007-2,031	Siltstone, light- to medium-gray, very finely sandy, finely micaceous
1	1,447-1,448	Shale, as above	14	2,031-2,045	Shale, dark-gray, silty, very finely micaceous
9	1,448-1,457	Siltstone, as above	95	2,045-2,140	Shale, dark-gray, very finely micaceous
1	1,457-1,458	Shale, as above	30	2,140-2,170	(No sample)
11	1,458-1,469	Siltstone, as above	10	2,170-2,180	Shale, as above
1	1,469-1,470	Shale, as above	10	2,180-2,190	Shale, dark-gray, very finely micaceous; crystals of pyrite
14	1,470-1,484	Siltstone, as above	10	2,190-2,200	Shale, dark-gray, very finely micaceous
1	1,484-1,485	Shale, as above	4	2,200-2,204	Siltstone, medium- to dark-gray, very finely micaceous, slightly limy
7	1,485-1,492	Siltstone, as above	16	2,204-2,220	Siltstone, medium- to dark-gray, very finely micaceous
8	1,492-1,500	Sandstone, light - gray, very fine grained, very silty, finely micaceous	20	2,220-2,240	Siltstone, medium-gray, very finely sandy, very finely micaceous
3	1,500-1,503	Shale, as above	8	2,240-2,248	Siltstone, medium - gray, slightly very finely sandy, scattered rounded medium to coarse sand grains, very finely micaceous
5	1,503-1,508	Sandstone, as above	17	2,248-2,265	Siltstone, medium-gray, very finely micaceous
2	1,508-1,510	Shale, as above	24	2,265-2,289	Shale, as above
5	1,510-1,515	Sandstone, as above	4	2,289-2,293	Sandstone, light- to medium-gray, fine- to medium-grained, scattered subrounded coarse to very coarse sand grains, silty
1	1,515-1,516	Shale, as above	16	2,293-2,309	Shale, as above
10	1,516-1,526	Sandstone, as above			
10	1,526-1,536	Shale, dark - gray, slightly silty, very finely micaceous			
12	1,536-1,548	Sandstone, as above			
132	1,548-1,680	Shale, dark-gray to grayish-black, very finely micaceous			
14	1,680-1,694	Sandstone, light-gray, fine-grained, abundant subrounded medium sand grains, slightly silty			
6	1,694-1,700	Sandstone, light-gray, very fine to fine-grained, very silty			

25	2,309-2,334	Sandstone, light-gray, very fine to fine-grained, abundant rounded medium sand grains, silty	8	2,962-2,970	Shale, dark - gray, slightly silty, very finely micaceous; crystals of pyrite
16	2,334-2,350	Shale, dark - gray, slightly silty, very finely micaceous	5	2,970-2,975	Shale, dark - gray, slightly silty, very finely micaceous
4	2,350-2,354	Sandstone, medium-gray, very fine grained, very silty, very finely micaceous	87	2,975-3,062	Shale, dark-gray to grayish-black, very finely micaceous
109	2,354-2,463	Shale, dark-gray to grayish-black	8	3,062-3,070	Sandstone, light - gray, very fine grained, very silty
7	2,463-2,470	Shale, grayish-black, very finely micaceous; crystals of pyrite	2	3,070-3,072	Shale, dark - gray, slightly silty, very finely micaceous
10	2,470-2,480	Shale, grayish - black, very finely micaceous	7	3,072-3,079	Sandstone, as above
10	2,480-2,490	Shale, grayish - black, very finely micaceous; crystals of pyrite	17	3,079-3,096	Shale, as above
10	2,490-2,500	Shale, grayish - black, very finely micaceous	19	3,096-3,115	Siltstone, light - gray, very finely sandy, very finely micaceous, slightly limy in part
5	2,500-2,505	Shale, grayish - black, very finely micaceous; crystals of pyrite	25	3,115-3,140	Sandstone, light - gray, very fine to fine - grained, slightly silty, finely micaceous
5	2,505-2,510	Shale, grayish - black, very finely micaceous	1	3,140-3,141	Shale, dark-gray, very finely micaceous
8	2,510-2,518	Shale, grayish - black, very finely micaceous; crystals of pyrite	15	3,141-3,156	Sandstone, light-gray, very fine to fine-grained, slightly silty, finely micaceous; crystals of pyrite
162	2,518-2,680	Shale, grayish - black, very finely micaceous	36	3,156-3,192	Shale, as above
13	2,680-2,693	Sandstone, grayish - white, very fine grained; drills free	11	3,192-3,203	Sandstone, light- to medium-gray, very fine to fine-grained, scattered rounded medium sand grains, very silty
10	2,693-2,703	Siltstone, as above	14	3,203-3,217	Siltstone, medium-gray, very finely micaceous
17	2,703-2,720	Shale, dark-gray, very finely micaceous	21	3,217-3,238	Shale, as above
10	2,720-2,730	Sandstone, light-gray, very fine to fine-grained, scattered rounded medium sand grains, silty	15	3,238-3,253	Siltstone, as above
17	2,730-2,747	Sandstone, light-gray, very fine to fine-grained, silty	6	3,253-3,259	Sandstone, medium-gray, very fine to fine-grained, scattered rounded medium sand grains, silty
3	2,747-2,750	Shale, as above	39	3,259-3,298	Shale, dark-gray, silty, very finely micaceous
12	2,750-2,762	Siltstone, medium- to dark-gray, very finely sandy, finely micaceous	7	3,298-3,305	Siltstone, as above
6	2,762-2,768	Shale, dark-gray, very finely micaceous; some maroon and yellowish-brown shale and siltstone fragments	77	3,305-3,382	Shale, dark - gray, slightly silty, very finely micaceous
5	2,768-2,773	Siltstone, medium-gray, very finely micaceous	3	3,382-3,385	Siltstone, as above
1	2,773-2,774	Shale, dark-gray, very finely micaceous; crystals of pyrite	7	3,385-3,392	Shale, as above
6	2,774-2,780	Siltstone, as above	16	3,392-3,408	Siltstone, as above
3	2,780-2,783	Shale, dark-gray, very finely micaceous	58	3,408-3,466	Shale, dark-gray, very finely micaceous
7	2,783-2,790	Siltstone, as above	112	3,466-3,578	Siltstone, as above
20	2,790-2,810	Shale, as above	62	3,578-3,640	Shale, as above
20	2,810-2,830	Shale, dark-gray, very finely micaceous; crystals of pyrite	7	3,640-3,647	Siltstone, as above
24	2,830-2,854	Shale, dark-gray, very finely micaceous	8	3,647-3,655	Shale, dark-gray, silty, very finely micaceous
10	2,854-2,864	Siltstone, as above	155	3,655-3,810	Shale, dark-gray, very finely micaceous
26	2,864-2,890	Shale, dark-gray to grayish-black, very finely micaceous	30	3,810-3,840	(No sample)
10	2,890-2,900	Shale, dark-gray to grayish-black, very finely micaceous; crystals of pyrite	20	3,840-3,860	Shale, as above
32	2,900-2,932	Shale, dark-gray to grayish-black, very finely micaceous	20	3,860-3,880	Shale, dark-gray, very finely micaceous; crystals of pyrite
8	2,932-2,940	Shale, dark-gray to grayish-black, very finely micaceous; crystals of pyrite	15	3,880-3,895	Shale, dark-gray, very finely micaceous
10	2,940-2,950	Shale, dark-gray to grayish-black, very finely micaceous	3	3,895-3,898	Siltstone, medium-gray, very finely micaceous
12	2,950-2,962	Shale, dark - gray, slightly silty, very finely micaceous	15	3,898-3,913	Shale, dark-gray, very finely micaceous; crystals of pyrite
			4	3,913-3,917	Siltstone, as above
			29	3,917-3,946	Shale, dark-gray to grayish-black, very finely micaceous
			54	3,946-4,000	Shale, dark-gray, silty, very finely micaceous
			16	4,000-4,116	Shale, dark-gray, very finely micaceous
			114	4,116-4,230	Shale, dark-gray to grayish-black, very finely micaceous

22	4,230-4,252	Siltstone, medium-gray, very finely sandy, very finely micaceous	8	5,132-5,140	Shale, grayish-black; crystals of pyrite
23	4,252-4,275	Siltstone, dark - gray, very finely micaceous	5	5,140-5,145	Shale, grayish-black
33	4,275-4,308	Shale, dark-gray, very finely micaceous	6	5,145-5,151	Siltstone, grayish-white, very finely sandy
12	4,308-4,320	Sandstone, medium-gray, very fine to fine-grained, silty	6	5,151-5,157	Shale, as above
28	4,320-4,348	Sandstone, light-gray, fine-grained, scattered subrounded medium sand grains, slightly silty	3	5,157-5,160	Siltstone, as above
			30	5,160-5,190	(No sample)
			16	5,190-5,206	Siltstone, light- to medium-gray, very finely micaceous
2	4,348-4,350	Shale, dark-gray, very finely micaceous	16	5,206-5,222	Shale, grayish-black
15	4,350-4,365	Sandstone, light- to medium-gray, fine- to medium-grained, slightly silty	6	5,222-5,228	Siltstone, medium-gray, very finely micaceous
			5	5,228-5,233	Shale, dark-gray, silty, very finely micaceous
21	4,365-4,386	Sandstone, light- to medium-gray, fine- to medium-grained, abundant rounded coarse sand grains, slightly silty	12	5,233-5,245	Siltstone, as above
			3	5,245-5,248	Shale, as above
4	4,386-4,390	Shale, dark-gray, very finely micaceous	5	5,248-5,253	Siltstone, as above
25	4,390-4,415	Sandstone, light- to medium-gray, fine- to medium-grained, silty	5	5,253-5,258	Shale, as above
3	4,415-4,418	Shale, as above	9	5,258-5,267	Siltstone, as above
18	4,418-4,436	Sandstone, medium - gray, fine-grained, abundant rounded medium sand grains, silty	6	5,267-5,273	Shale, as above
			8	5,273-5,281	Siltstone, as above
1	4,436-4,437	Shale, as above	80	5,281-5,361	Shale, dark-gray, silty, very finely micaceous
6	4,437-4,443	Sandstone, light-gray, fine- to medium-grained, abundant rounded coarse sand grains	15	5,361-5,376	Siltstone, light, to medium-gray
			62	5,376-5,438	Siltstone, medium-gray, very finely micaceous
3	4,443-4,446	Shale, as above	15	5,438-5,453	Siltstone, medium- to dark-gray very finely micaceous
7	4,446-4,453	Sandstone, light-gray, fine-grained	42	5,453-5,495	Shale, dark-gray, very finely micaceous
14	4,453-4,467	Sandstone, light- to medium-gray, very fine to fine-grained, abundant rounded medium to coarse sand grains, very silty	23	5,495-5,518	Shale, dark-gray, very silty, very finely micaceous
51	4,467-4,518	Shale, dark-gray, silty, very finely micaceous	134	5,518-5,652	Shale, grayish-black
106	4,518-4,624	Shale, dark-gray, very finely micaceous	5	5,652-5,657	Siltstone, medium-gray; well - cemented
16	4,624-4,640	Sandstone, light-gray, very fine to fine-grained	60	5,657-5,717	Shale, as above
96	4,640-4,736	Shale, dark-gray to grayish-black, very finely micaceous	93	5,717-5,810	(No sample)
3	4,736-4,739	Siltstone, medium-gray, very finely micaceous	30	5,810-5,840	Shale, as above
41	4,739-4,780	Shale, as above	4	5,840-5,844	Siltstone, light- to medium-gray, very finely micaceous
8	4,780-4,788	Shale, dark-gray to grayish-black, very finely micaceous; crystals of pyrite	3	5,844-5,847	Shale, as above
63	4,788-4,851	Shale, dark-gray to grayish-black, very finely micaceous	50	5,847-5,897	Siltstone, as above
13	4,851-4,864	Shale, dark-gray, silty, very finely micaceous	53	5,897-5,950	Shale, dark-gray to grayish-black, very finely micaceous
6	4,864-4,870	Sandstone, medium-gray, very fine grained, very silty	9	5,950-5,959	Siltstone, medium-gray, very finely micaceous
40	4,870-4,910	Shale, as above	4	5,959-5,963	Shale, dark-gray, very finely micaceous
110	4,910-5,020	Siltstone, light - gray, very finely micaceous	12	5,963-5,975	Siltstone, light- to medium-gray, very finely sandy
			8	5,975-5,983	Shale, as above
40	5,020-5,060	(No sample)	12	5,983-5,995	Siltstone, as above
35	5,060-5,095	Siltstone, as above	7	5,995-6,002	Shale, as above
6	5,095-5,101	Shale, grayish-black	6	6,002-6,008	Siltstone, light- to medium-gray, slightly very finely sandy
4	5,101-5,105	Siltstone, as above	2	6,008-6,010	Shale, as above
5	5,105-5,110	Shale, as above	15	6,010-6,025	Siltstone, as above
5	5,110-5,115	Shale, grayish-black; crystals of pyrite	9	6,025-6,034	Shale, as above
17	5,115-5,132	Shale, grayish-black	7	6,034-6,041	Shale, dark-gray, very finely micaceous; crystals of pyrite
			6	6,041-6,047	Shale, dark-gray, very finely micaceous
			33	6,047-6,080	Sandstone, light- to medium-gray, very fine grained, very silty; well-cemented
			7	6,080-6,087	Siltstone, light- to medium-gray, very finely micaceous; well - cemented
			3	6,087-6,090	Shale, dark-gray, very silty, very finely micaceous
			12	6,090-6,102	Siltstone, as above

3	6,102-6,105	Shale, as above	10	6,480-6,490	Siltstone, medium-gray, very finely sandy, very finely micaceous; well-cemented
5	6,105-6,110	Siltstone, as above			
2	6,110-6,112	Shale, as above	4	6,490-6,494	Siltstone, medium-gray, very finely micaceous; well-cemented
6	6,112-6,118	Siltstone, as above	5	6,494-6,499	Shale, dark-gray, silty, very finely micaceous
3	6,118-6,121	Shale, as above	8	6,499-6,507	Siltstone, medium-gray, very finely sandy, very finely micaceous; well-cemented
20	6,121-6,141	Siltstone, as above	5	6,507-6,512	Shale, as above
1	6,141-6,142	Shale, as above	3	6,512-6,515	Siltstone, medium - gray, slightly very sandy, very finely micaceous; well-cemented
8	6,142-6,150	Siltstone, as above	4	6,515-6,519	Shale, as above
5	6,150-6,155	Shale, as above	5	6,519-6,524	Siltstone, as above
10	6,155-6,165	Siltstone, as above	36	6,524-6,560	Shale, as above
2	6,165-6,167	Shale, as above	10	6,560-6,570	Shale, dark-gray, silty, very finely micaceous; crystals of pyrite
3	6,167-6,170	Siltstone, as above	10	6,570-6,580	Shale, dark-gray, silty, very finely micaceous
21	6,170-6,191	Shale, dark-gray to grayish-black, very finely micaceous; crystals of pyrite	10	6,580-6,590	Shale, dark-gray, silty, very finely micaceous; crystals of pyrite
11	6,191-6,202	Sandstone, light - gray, very fine grained, scattered fine sand grains, silty; well-cemented	4	6,590-6,594	Shale, dark-gray, silty, very finely micaceous
16	6,202-6,218	Siltstone, medium-gray, very finely micaceous	6	6,594-6,600	Siltstone, medium-gray, very finely micaceous
13	6,218-6,231	Siltstone, dark-gray, very finely micaceous	17	6,600-6,617	Shale, dark-gray, very finely micaceous
16	6,231-6,247	Sandstone, light- to medium-gray, very fine grained, silty; well-cemented	5	6,617-6,622	Siltstone, as above
11	6,247-6,258	Siltstone, light- to medium-gray, very finely sandy, very finely micaceous; well-cemented	59	6,622-6,681	Shale, dark-gray to grayish-black, very finely micaceous
6	6,258-6,264	Shale, dark-gray, very finely micaceous	4	6,681-6,685	Siltstone, medium-gray; well - cemented
10	6,264-6,274	Siltstone, as above	121	6,685-6,806	Shale, grayish-black
9	6,274-6,283	Shale, as above	4	6,806-6,810	Siltstone, light - gray, very finely micaceous
10	6,283-6,293	Siltstone, as above	5	6,810-6,815	Shale, dark-gray, very finely micaceous
2	6,293-6,295	Shale, as above	5	6,815-6,820	Siltstone, light-gray, very finely sandy
4	6,295-6,299	Siltstone, light- to medium-gray, very finely micaceous; well - cemented	3	6,820-6,823	Shale, light - gray, silty; flaky; crystals of dolomite
7	6,299-6,306	Shale, as above	10	6,823-6,833	Shale, dark-gray, very finely micaceous
7	6,306-6,313	Siltstone, light- to medium-gray, slightly very finely sandy, very finely micaceous; well-cemented	6	6,833-6,839	Siltstone, light - gray, very finely sandy
12	6,313-6,325	Shale, as above	13	6,839-6,852	Shale, dark-gray, very finely micaceous
9	6,325-6,334	Siltstone, light- to medium-gray, very finely micaceous; well - cemented	21	6,852-6,873	Sandstone, medium-gray, fine-grained, abundant subrounded medium to coarse sand grains, silty; well-cemented
1	6,334-6,335	Shale, as above	57	6,873-6,930	Shale, dark-gray to grayish-black
17	6,335-6,352	Siltstone, light- to medium-gray, slightly very finely sandy, very finely micaceous; well-cemented	15	6,930-6,945	Sandstone, light-gray, very fine to fine-grained
6	6,352-6,358	Shale, as above	14	6,945-6,959	Shale, dark-gray
6	6,358-6,364	Siltstone, light- to medium-gray, very finely micaceous; well - cemented	8	6,959-6,967	Sandstone, light- to medium-gray, very fine to fine-grained, silty; well-cemented
6	6,364-6,370	Shale, as above	17	6,967-6,984	Shale, grayish-black
12	6,370-6,382	Siltstone, light- to medium-gray, very finely sandy, very finely micaceous; well-cemented	9	6,984-6,993	Sandstone, light- to medium-gray, very fine grained, very silty; well-cemented.
7	6,382-6,389	Shale, as above	6	6,993-6,999	Shale, dark-gray
6	6,389-6,395	Siltstone, as above	4	6,999-7,003	Sandstone, as above
9	6,395-6,404	Shale, as above	7	7,003-7,010	Shale, as above
3	6,404-6,407	Siltstone, medium- to dark-gray, very finely micaceous	5	7,010-7,015	Siltstone, light- to medium-gray, very finely sandy
6	6,407-6,413	Shale, as above	9	7,015-7,024	Siltstone, light- to medium-gray, slightly very finely sandy
3	6,413-6,416	Siltstone, as above	9	7,024-7,033	Shale, dark-gray
8	6,416-6,424	Shale, as above			
9	6,424-6,433	Siltstone, as above			
30	6,433-6,463	Shale, grayish-black			
7	6,463-6,470	Siltstone, medium-gray, very finely sandy, very finely micaceous; well-cemented			
10	6,470-6,480	Siltstone, medium-gray, very finely micaceous; well-cemented			

20	7,033-7,053	Sandstone, light - gray, very fine grained, very silty, very finely micaceous	9	7,518-7,527	Sandstone, light-gray, very fine grained, very silty; well-cemented
20	7,053-7,073	Shale, dark-gray, very silty, very finely micaceous	3	7,527-7,530	Shale, as above
31	7,073-7,104	Shale, dark-gray, very finely micaceous	5	7,530-7,535	Siltstone, medium-gray; well - cemented
10	7,104-7,114	Siltstone, light- to medium-gray, very finely micaceous	4	7,535-7,539	Shale, as above
4	7,114-7,118	Shale, dark-gray to grayish-black	4	7,539-7,543	Siltstone, as above
5	7,118-7,123	Siltstone, as above	3	7,543-7,546	Shale, as above
32	7,123-7,155	Shale, as above	4	7,546-7,550	Siltstone, as above
38	7,155-7,193	Siltstone, medium- to dark-gray; well-cemented	2	7,550-7,552	Shale, as above
64	7,193-7,257	Shale, as above	4	7,552-7,556	Siltstone, as above
14	7,257-7,271	Siltstone, light- to medium-gray	5	7,556-7,561	Shale, as above
9	7,271-7,280	Siltstone, light - gray, very finely sandy	6	7,561-7,567	Siltstone, as above
11	7,280-7,291	Sandstone, light - gray, very fine grained, very silty	3	7,567-7,570	Shale, as above
20	7,291-7,311	Shale, as above	2	7,570-7,572	Siltstone, as above
19	7,311-7,330	Shale, dark-gray to grayish-black; crystals of pyrite	42	7,572-7,614	Shale, as above
52	7,330-7,382	Shale, dark-gray to grayish-black	63	7,614-7,677	Shale, dark-gray to grayish-black
8	7,382-7,390	Siltstone, light-gray; well-cemented	38	7,677-7,715	Shale, dark - gray, slightly silty, very finely micaceous
3	7,390-7,393	Shale, dark-gray, very finely micaceous	5	7,715-7,720	Shale, grayish-black
7	7,393-7,400	Siltstone, as above	8	7,720-7,728	Shale, grayish - black; crystals of pyrite
4	7,400-7,404	Shale, as above	3	7,728-7,731	Shale, grayish-black
6	7,404-7,410	Siltstone, as above	7	7,731-7,738	Shale, grayish - black; crystals of pyrite
12	7,410-7,422	Shale, as above	9	7,738-7,747	Shale, grayish-black
7	7,422-7,429	Siltstone, as above	4	7,747-7,751	Shale, grayish-white, silty; flaky; crystals of dolomite
35	7,429-7,464	Shale, as above	9	7,751-7,760	Sandstone, light-gray, very fine to fine-grained
5	7,464-7,469	Siltstone, medium-gray; well - cemented	8	7,760-7,768	Shale, dark - gray, slightly silty, very finely micaceous
11	7,469-7,480	Shale, as above	12	7,768-7,780	Sandstone, light - gray, very fine grained, abundant fine sand grains, silty; well-cemented
2	7,480-7,482	Siltstone, as above	10	7,780-7,790	Sandstone, light- to medium-gray, very fine to fine-grained, silty
16	7,482-7,498	Shale, as above	10	7,790-7,800	Sandstone, light- to medium-gray, fine-grained, scattered rounded medium sand grains, slightly silty, limy
4	7,498-7,502	Siltstone, as above		7,800	Total depth
12	7,502-7,514	Sandstone, light - gray, very fine grained, very silty			
4	7,514-7,518	Shale, as above			