University of Kentucky
College of Arts and Sciences

KENTUCKY GEOLOGICAL SURVEY
Lexington

In Cooperation With
AGRICULTURAL AND INDUSTRIAL
DEVELOPMENT BOARD OF KENTUCKY
Frankfort

SERIES IX

BULLETIN — NO. 13

Geology and Mineral Resources of the Paintsville Quadrangle, Kentucky

By
Robert E. Hauser

Printed by the Authority of the State of Kentucky

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AGRICULTURAL AND INDUSTRIAL
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INTRODUCTION

The geological investigation described in this report was initiated by the Kentucky Geological Survey on September 20, 1949. It has been carried out in conjunction with a U. S. Geological Survey ground water study of the same area. It is a part of a statewide mineral resource program conducted in cooperation with the Agricultural and Industrial Development Board of Kentucky.

The data for the report have been collected from field observations, from private company and public office files, and from published reports. It is hoped that the information will be of value in the development of industries in Eastern Kentucky requiring mineral resource data, by showing location of various mineral deposits for possible exploitation, and indicating reserves, where this is possible.

Geologic mapping of the Paintsville southeast quarter was done in the fall and winter of 1949-50 by the author and John A. Baker, Ground Water Branch, U. S. Geological Survey. The areal geologic map and the structure map on the Van Lear coal are based on this work compiled by Baker and the author.

The field work for the other three quarters was done subsequently by the author, with the assistance of George R. Thomas from March 1950 through December 1951. Thomas was also responsible for compilation of much of the data regarding oil and gas production.

The writer wishes to acknowledge the excellent cooperation of several of the mineral operators and business men who have furnished much valuable information. Specific acknowledgment should be made to the following persons and organizations: G. G. Auxier, Manila; the late E. J. Evans, Paintsville; Oscar Evans, Paintsville; Elkhorn Coal Co., Wayland; Frank Fisher, Ashland Oil and Refining Co., Ashland; Coleman Hunter, E. O. Ray, W. G. Smith, Kentucky West Virginia Gas Co., Ashland and Prestonsburg; Harry LaViers, president and general manager, Southeast Coal Co., Paintsville; Crate Rice, Paintsville; Joe Slagel, Cumberland Petroleum Co., Oil Springs; R. N. Thomas, Inland Gas Corp., Ashland; W. M. Wallen, Paintsville; Les Watson, Farwest Coal Co., Van Lear; Hansel Wiley, engineer formerly with the Northeast Coal Co., Thealka; D. M. Young, formerly with Kentucky West Virginia Gas Co., Prestonsburg.

Location

The area included in this report comprises the U. S. Geological Survey Paintsville 15-minute quadrangle. It is presently being re-

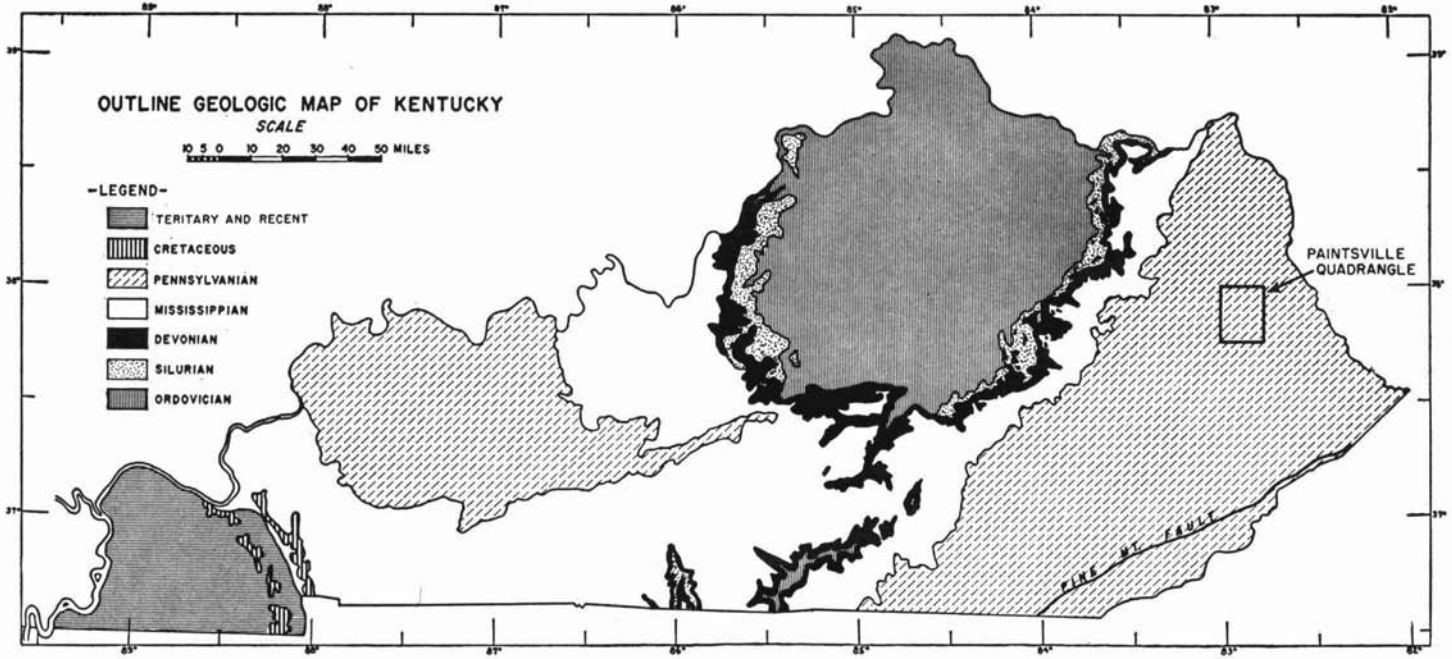

Fig. 1. Generalized geological map of Kentucky showing the location and regional setting of the Paintsville quadrangle.

mapped on a scale of 1 to 24,000 and will be published as four 7½-minute quadrangles.

The map area lies between 82° 45′ and 83° 00′ W. longitude, and 37° 45′ and 38° 00′ N. latitude (see figure 1) and includes most of Johnson County, a small portion of Floyd County, and parts of Morgan, Magoffin, and Lawrence Counties.

Paintsville (pop. 4,290) is in the approximate center of the southeast quarter and is the seat of Johnson County. Through highways enter Paintsville from the north, south, east, and west, and it is also located on the Chesapeake and Ohio Railroad Company line.

Geography and Physiography

The southwest corner of the quadrangle is drained by small tributaries of Licking River. The rest of the area is drained by Levisa Fork of the Big Sandy River and its tributaries, of which the most important are Toms Creek, Paint Creek, Jenny Creek, Hood Creek, Georges Creek, Upper Laurel Creek, and Lower Laurel Creek.

Levisa Fork, the lowest point in the quadrangle, has an altitude of slightly less than 600 feet above sea level, and the highest surrounding hilltops are about 1450 feet above sea level; thus there is more than 850 feet of relief in the quadrangle. Local relief in the Paintsville area is about 700 feet.

The region is a portion of the highly dissected Cumberland Plateau. Narrow valley bottoms and sharp stream divides characterize most of the region. In a small area surrounding Flat Gap the valleys are not so narrow nor the hills so steep. This is due to the strong resistance to erosion of the Lee formation, which is essentially at drainage here. In contrast to this type of topography the Lee formation elsewhere, where cut and exposed by streams, produces sheer cliffs and picturesque scenery.

Note: Portion below Big Six from L. B. Freeman (1953)

Fig. 2.

GENERALIZED STRATIGRAPHIC SECTION FOR PAINTSVILLE QUADRANGLE

DESCRIPTIVE GEOLOGY

Surface Stratigraphy

Introduction

The bedrock formations outcropping in the Paintsville quadrangle are all sedimentary and of Pennsylvanian age. These include formations of the Pottsville and possibly lowermost Allegheny groups.

The lowest unit of the Pottsville group is exposed in the north-central, central, and west-central portions of the area. This is the Lee formation, which is a massive, conglomeratic, cliff-forming sandstone containing two or three major shale breaks. Its average thickness is about 450 feet.

Overlying the Lee formation is the Breathitt formation, a series of sandstones, shales, siltstones, coals, and thin limestones, 600 to 700 feet thick.

Capping the hills in the eastern portion of the quadrangle is a massive sandstone which may be the Homewood sandstone (Phalen, 1912, p. 4) of the uppermost Pottsville group. This sandstone can be traced along U. S. Highway 23 from Louisa, where it is just above drainage, into the eastern portion of the Paintsville quadrangle.

Below drainage, rocks of Lower Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, and possibly Cambrian ages are known to be present through drilling tests for oil and gas (see figure 2).

Lee Formation

The Lee formation in southeastern Kentucky has two conglomeratic members, the Corbin and Rockcastle conglomerates, but in the Paintsville area the writer has not been able to distinguish these members.

The Lee crops out over all of the northwest quarter of the quadrangle except in the extreme northwest corner. It is also the surface rock in several less extensive areas of the quadrangle (see plate 1).

The Lee ranges in thickness from about 400 to 500 feet. The maximum thickness exposed is in the west-central area on the Mine Fork Dome, where about 200 feet is above drainage. The formation here rests uncomformably on beds of Mississippian age.

The upper portion of the Lee is a medium- to coarse-grained, massive, cliff-forming conglomerate and a white, clean, medium-grained

Fig. 3. "Bee rock" weathering in the Lee formation on Kentucky Route 172. This type of weathering, caused by variation in solubility of cementing material, is commonly found in the Lee formation.

quartz sandstone. The conglomerate contains rounded quartz pebbles, ranging from ½ to 1 inch in diameter, concentrated in sheetlike zones parallel to the bedding planes. Both are very prominently cross-bedded. Weathering produces a honeycomb-type structure commonly referred to as "bee rock" (see figure 3). Lower in the formation colors vary from white to shades of pink and brown.

Conifers, rhododendron, and holly are largely restricted to soils developed from the Lee, and thus these plants in abundance can usually be relied upon to delineate areas of Lee outcrop.

Along Mine Fork in the west-central portion of the quadrangle a thin coal is being mined locally for home use. The coal is 93 feet below the top of the Lee. It is underlain by a black shale and is referred to in an earlier report (Browning, 1919, p. 27) as the Mine Fork coal.

Breathitt Formation

The Breathitt formation consists of a series of sandstones, shales, siltstones, coals, and thin limestones. Some of these units are recognizable in widely separated sections, even though the intervening beds as traced laterally are highly variable. These distinctive units will be discussed in stratigraphic order from bottom to top. The unit names used are those of Wanless (1939). Figure 2, the generalized stratigraphic section, shows the relationships of these units.

Stray coals.—Opposite Gullett Branch on Paint Creek at the northern edge of the southwest quarter of the quadrangle, two thin coals are present just above the Lee formation. A 7-inch coal bloom occurs 3 feet above the Lee and a 5-inch coal bloom is present 18 feet above the top of the formation. These coals have not been observed elsewhere in the Paintsville area and are believed by the writer to be only of local extent.

Quakertown shale.—The Quakertown shale occurs from 6 feet to 18 feet above the top of the Lee formation and is a hard, black, fissile shale, 3 to 6 inches thick. In the western part of the area a thin coal has been noted in the position of the Quakertown, and it is believed by the writer that there is a lateral change from east to west of shale to coal.

In the central part of the area the shale is overlain by a thin sandstone and a thin limestone which contain numerous fossils. Charles Summerson of the Department of Geology, Ohio State University, has identified the following forms from a collection sent to him by the writer: *Lingula, Orbiculoidea, Chonetes, Worthenia, Punctospirifer, Neospirifer, Marginifera,* and *Aviculopecten.* The horizon also carries numerous trilobite and crinoid fragments, as well as ostracods. Outcrops of the shale are infrequent, affording the possibility that the shale is entirely absent at various places. The shale, when found, is a valuable marker for tracing the top of the Lee formation.

Immediately above the Quakertown shale is an unnamed shale 25 to 30 feet thick. It is blue-black at the base and gets progressively lighter toward the top, where it is brown. It contains small scattered ironstone nodules and sparse streaks of fine-grained sandstone. The shale upon exposure crumbles and breaks up rather easily, but it is quite hard and brittle on fresh surfaces. Clay sample number 2, discussed later in the report, was taken from this shale.

Howard (?) coal.—This coal is tentatively correlated with Wanless' (1939, p. 87) Howard coal of Magoffin County. It is a thin coal approximately 12 inches thick and is found 25 to 35 feet above the Quakertown shale, or 40 to 55 feet above the top of the Lee. It is mined only locally for home use. In places a highly crossbedded sandstone is found on top of the coal (see figure 4). The sandstone is usually about 5 to 7 feet thick and in places grades laterally into shale.

Field mapping indicates that the Howard coal is not continuous throughout the area, but where present it helps to determine the position of the top of the Lee formation.

Campbell Creek limestone.—Thirty to forty feet above the Howard coal is a zone of doorknob-shaped, dense, very hard, blue limestone

Fig. 4. Howard coal (middle of picture), 12 inches thick, overlain by a cross-bedded sandstone.

concretions (see figure 5). Individual concretions average 18 inches in thickness and 4½ feet in diameter. The zone occupies a position near the middle of a 35-foot brown, shaly siltstone, which locally contains lenses of sandstone.

Fig. 5. Limestone concretion in the Campbell Creek limestone horizon. (Hammer may be seen below the concretion.)

Campbell Creek coal.—The Campbell Creek coal is a thin coal from 20 to 45 feet below the Van Lear coal and about 20 feet above the Campbell Creek limestone. Because of insufficient thickness it is only mined for home use. Examination of some sections shows the coal to be discontinuous in its occurrence and in some places to be split into two or three seams.

Van Lear coal.—Also known as the Millers Creek coal, this is the most important coal in the Paintsville area (see figure 6). It ranges in thickness from 10 to 60 inches and occupies a position 145 to 200 feet above the top of the Lee formation, with an average interval of 155 feet between it and the Lee.

Although most of the easily accessible Van Lear coal has been mined out, there are many small truck mines obtaining coal from this bed.

The Van Lear dips below drainage in the northeast and southwest corners and in the extreme southeast corner of the area. From these points it rises gradually toward the west and north-central area, where it is high on many hillsides and even eroded from some of the higher country.

Most of the surface structure maps were made using the Van Lear coal as the key bed. This coal is very difficult to identify when only the coal is exposed. However, when the Elkins Fork shale above

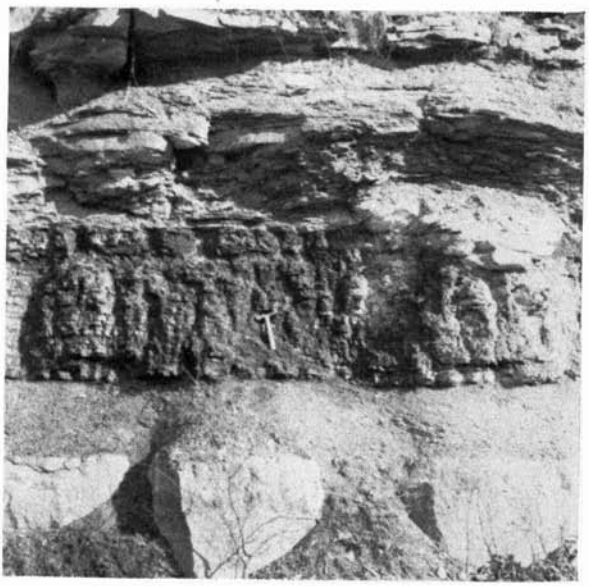

Fig. 6. Van Lear coal, 45 inches thick, near headwaters of Muddy Branch.

the coal and the Campbell Creek coal and Campbell Creek limestone below the coal are exposed, the Van Lear coal is readily identified.

Elkins Fork shale.—The Elkins Fork shale occupies a position from 10 to 30 feet above the Van Lear coal. Like the Campbell Creek limestone, it is a concretionary zone with individual concretions 3 to 4 feet in diameter and 1½ to 2 feet thick. The concretions are dense, hard, blue, and sandy and occur in a clayey, blue-gray siltstone along with numerous ironstone nodules. Some of the nodules are inclusions in the limestone concretions.

Amburgey coal.—The Amburgey coal, with a thickness of 6 to 12 inches, has been found in an interval from 25 to 60 feet above the Van Lear coal. It appears to be absent in many localities.

Kendrick shale.—The Kendrick shale lies directly on top of the Amburgey coal. It is a brown to black shale and siltstone and contains *Lingula* and *Orbiculoidea.* It ranges in thickness from 4 to 12 feet and in places contains doorknob-shaped concretions as much as 1½ feet thick and 3 feet in diameter. The type locality of the Kendrick shale is on Cow Creek in Floyd County, approximately 15 miles southeast of Paintsville (Morse, 1931, pp. 298-301). At the type locality it is about 50 feet thick and contains numerous marine fossils.

Whitesburg coal.—The Whitesburg coal, from 46 to 73 feet above the Kendrick shale, is usually about 12 inches thick. In the southwest corner of the area there are several caved mine openings where this coal has been produced commercially. The thickness of the coal seam in these mines is reported to be 36 inches.

Little Fire Clay coal.—This is an unimportant coal which attains thicknesses as much as 18 inches. It may be easily mistaken for the Fire Clay coal because of the presence of a hard, brown, flinty, clay parting found anywhere from the middle down to the bottom of the coal. This parting somewhat resembles the characteristic parting found in the Fire Clay coal above.

Stratigraphically, the Little Fire Clay coal is 17 to 26 feet above the Whitesburg coal and from 8 to 29 feet below the Fire Clay coal.

Fire Clay coal.—The Fire Clay coal is a multiple-bedded coal containing a characteristic flint clay parting 3 to 6 inches thick. The parting, which occurs anywhere from the middle down to the bottom of the coal, is brownish-gray, hard, and usually very brittle, breaking with a conchoidal fracture. This characteristic parting is present over widespread areas in Eastern Kentucky. Unfortunately, within the Paintsville area there are marked variations in composition, physical properties, and thickness of the parting from place to place, so that it does not materially aid in identification of the coal.

In places the Fire Clay coal contains streaks of bone and is can-

neloid in the top 12 inches. Though thin over most of the area, the Fire Clay coal attains thicknesses as much as 46 inches. It is being mined in only a few places, most of the mines being located on the waters of Toms Creek in the central portion of the area. Here the coal is known locally as the "Springville" coal.

Stratigraphically, the Fire Clay coal lies at an average of 137 feet above the Van Lear coal and from 32 to 60 feet below the Magoffin limestone.

Fire Clay Rider coal.—This is an unimportant thin coal with thicknesses as much as 22 inches. At places it has a clay parting near the middle. The coal occurs from 9 to 29 feet above the Fire Clay coal. It should be noted here that in other areas Wanless (1939, pp. 52-55, and p. 85) describes two coals, the Fire Clay Rider and the Hamlin, between the Fire Clay coal and the Magoffin limestone. In this area there is only one coal present between the Fire Clay coal and the Magoffin limestone and it is believed, by the writer, to be the Fire Clay Rider coal. About 50 miles west of Paintsville the Hamlin coal is found immediately under the Magoffin limestone. Within the Paintsville quadrangle no coal has been seen in this position; thus, the writer assumes that the Hamlin coal is absent.

Magoffin limestone.—The Magoffin limestone is from 22 to 29 feet feet above the Fire Clay Rider coal. In most places it is a dense, blue, septarian, concretionary limestone containing numerous to scattered fossils and ranging in thickness from 12 to 18 inches. Near Van Lear, at Richmond Gap, the Magoffin zone consists of 4 feet 11 inches of black shale at the base, followed by a 3½-inch ironstone bed, which in turn is overlain by a 13-inch black shale zone. Marine fossils are present throughout the zone.

Lateral variations make the Magoffin limestone difficult to identify on physical appearances alone, and in most cases its position in the section must be used in order to properly identify it.

Haddix coal.—This coal occupies a position from 13 to 20 feet above the Magoffin limestone. It is being mined at only a few places, because it generally occupies positions high on the hills and has little areal extent. However, it is rather persistent in thickness, averaging about 32 inches.

Measured Sections

Since there are numerous repeated lithologies and considerable lateral variations between key beds within the exposed Pennsylvanian strata, it was found necessary to compile detailed sections wherever outcrops permitted. Fifteen of these detailed sections appear on the following pages. The location of each section appears by number on plate 2.

SECTION No. 1.—*Baker Branch Section. Road cut from creek level to gap at head of Baker Branch and to top of hill above gap. Measured by J. A. Baker and R. E. Hauser.*

	FEET	INCHES
Concealed interval, top of hill	35	
Sandstone, white, massive, fine- to medium-grained, micaceous, cliff-forming	91	
Concealed interval	15	
Coal bloom, poorly exposed		6
Concealed interval	8	
Sandstone, top concealed	1	
Coal	2	
Concealed interval	25	
Clay, plastic, tenaceous		6
Coal		8
Underclay, gray, plastic	1	
Sandstone, fine-grained, probably continuous through concealed interval below	3	6
Concealed interval	17	
Sandstone, fine- to medium-grained, contains streaks of carbonaceous material	6	
Coal, canneloid		3
Coal	1	1
Shale, contains streaks of bituminous material		2
Clay parting, brownish-gray, slightly laminated, nonplastic	1	3
Coal, bottom concealed, *Fire Clay*	1	11
Siltstone, brownish-gray, poorly exposed	11	
Sandstone, very fine-grained, thinly bedded, crossbedded, contains streaks of ironstone concretions	11	3
Coal, *Little Fire Clay*		9
Underclay, brownish-gray, flinty		1
Shale, black, bituminous		3
Underclay, gray	2	
Siltstone, brown to grayish, very thinly bedded, micaceous, top 3″ contains ironstone nodules	11	8
Concealed interval	13	9
Siltstone, brown to grayish, very thinly bedded	22	5
Sandstone, white on fresh surface and brown on weathered surface, contains mica, iron-stained	9	8
Shale, brown to black, clayey, contains fossils, *Kendrick*	4	
Coal bloom, very poorly exposed, *Amburgey*		1
Underclay, grayish-green, contains plant fossils		2
Clay, gray on weathered outcrop and olive gray on fresh surface, may be weathered shale outcrop	5	6
Shale, light-brown, silty, contains ironstone concretions	9	1
Sandstone, fine-grained, medium-bedded at base and very thinly bedded at top, crossbedded	8	8
Concealed interval	12	10
Shale, sandy, contains small ironstone nodules 1″ thick and 2″ in diameter and limestone concretions 18″ thick and 3″ in diameter	4	
Concealed interval	17	
Sandstone, 1′ exposed, top part concealed	1	
Siltstone, laminated and clayey	3	
Coal, *Van Lear*	3	
Shale, black		6

SECTION No. 2.—*Richmond Gap Section. From top of hill about ¼ mile southeast of Richmond Gap to Richmond and along Dewey Dam road on north side of ridge. Measured by J. A. Baker and R. E. Hauser.*

	FEET	INCHES
Sandstone, massive, capping ridge	87	
Concealed interval	40	

Coal, poorly exposed, and probably not in position because of slumping		6
Concealed interval	95	
Coal bloom, poorly exposed in prospect ditch, thickness unknown		
Concealed interval	19	8
Sandstone, top concealed	29	
Coal	1	6
Underclay, gray	3	
Concealed interval	4	7
Sandstone, massive, top concealed	8	
Coal, *Haddix*	2	8
Underclay, gray	1	
Concealed partially, shaly	1	6
Sandstone, fine-grained, massive, bench-forming, contains bands of ironstone	2	6
Shale, silty		10
Sandstone, very fine grained		9
Shale, silty, platy, grades downward into black, thinly bedded shale	5	8
Ironstone band		3
Shale, black, silty, fossiliferous	1	1
Magoffin 1s.		
Ironstone, silty, fossiliferous, contains *Spirifer*		3½
Shale, black, thinly bedded, platy, fossiliferous; *Lingula* and *Chonetes* seen	4	11
Sandstone, massive, grades downward into thinly bedded sandstone, exposed in gap between Millers Creek and Johns Creek (Richmond Gap)	24	1
Shale, black, silty, thinly bedded	5	
Underclay, brownish-gray, soft, and somewhat shaly		2
Fire Clay Rider		
Coal		11
Clay, gray to brownish, soft, nonplastic		2
Coal		11
Underclay, light brownish-gray, silty, contains abundant plant stems, grades downward into sandstone, fine-grained	5	6
Clay, light-gray, silty, laminated	1	
Clay, dark-brown to black, hard, nonplastic		1
Coal bloom		1
Underclay, dark, hard, nonplastic, bituminous		5½
Underclay, light-gray, silty, nonplastic, with root traces		5½
Sandstone, medium-grained, massive, micaceous, lower 6′ thinly bedded and containing streaks of bituminous shale	20	1
Shale, black, thin-layered, carbonaceous	1	7
Underclay, light-gray, silty, nonplastic, contains root traces	5	6
Sandstone, gray, very fine-grained, platy	1	6
Sandstone, light-gray, fine- to medium-grained	21	5½

Fire Clay (elevation 870′)

Coal	1′	3″
Parting, gray		1½″
Coal		3″
Shale, black and gray clay alternating	1′	6″
Underclay, gray		8″
Shale, black, thin, carbonaceous		1″
Clay, light gray		5½″
Coal		5½″
Underclay, dark-gray to black, rather hard		3½″
Coal		9″

Above describtion taken on Johns Creek side of Richmond Gap and is probably the same coal (*Fire Clay*) seen in old road cut east of gap, which has the following description:

Fire Clay

Coal, cannel	1′	2″
Clay parting, black, medium to hard		4″
Coal, with parting	2′	

Coal bloom, probably same as 3′ 6″ coal seen in old road cut east of gap (*Fire Clay?*)		1
Underclay, very light gray, silty, nonplastic		11
Siltstone, light-brown and gray mottled, banded iron stains	2	4
Sandstone, greenish, fine-grained	1	2
Shale, black, sandy, with fine-grained sandstone lenses	5	
Shale, black, thinly bedded, micaceous, apparently barren of fossils, but possibly *Kendrick*	12	10
Sandstone, massive	6	
Concealed interval	6	
Sandstone, thinly bedded, containing thin streaks of coal and fossil tree impressions	3	
Coal, badly weathered, soft and rotten, poorly exposed		9½
Sandstone, light gray and brown mottled, very fine grained, clayey, with root traces	1	6
Siltstone, reddish-brown, ferruginous	1	6
Sandstone, greenish, fine-grained, well indurated, thinly and unevenly bedded	11	7
Concealed interval	6	
Sandstone, massive, medium-grained, cliff-former	23	3
Coal		1½-2
Siltstone and clay, thinly bedded, well indurated	14	5
Sandstone, medium-grained	4	
Concealed interval	13	5
Clay, grading downward into silt and clay, very fine grained sandstone, and fine-grained sandstone	6	4
Concealed interval	1	6
Silt and clay, well indurated	3	
Concealed interval	1	6
Sandstone, fine-grained	8	7
Ironstone		6
Clay	1	6
Sandstone, very fine grained, and hard siltstone intercalated	2	
Shale, greenish-gray, clayey	1	
Concealed interval	5	6
Sandstone, massive	3	
Shale, greenish-gray to black, clayey	2	
Coal, *Van Lear*	2	10

SECTION NO. 3.—*Whippoorwill Branch Section. From top of hill on north side of gap between Whippoorwill Branch and Muddy Branch down along road to creek level on Whippoorwill Branch side of gap. Measured by R. E. Hauser.*

	FEET	INCHES
Sandstone, light-gray, massive, capping ridge		
Bench, concealed, may be shale interval	28	6
Sandstone, massive, pink-colored near top, ironstone nodules, plant fossils	51	4
Partially concealed interval, may contain coal; underclay bloom seen, but position undeterminable	51	4
Limestone, concretionlike, evidently from septarian concretions, slightly fossiliferous, fractured and mineralized along minute veins; probably the *Magoffin* marine zone; poorly exposed above gap	1	

Concealed interval	21	9
Coal		6
Clay parting, plastic		3
Coal		5
Sandstone, fine-grained, silty, grades downward into sandy siltstone	8	8
Coal, top 6″ canneloid, hard, dark, clay base, probably *Fire Clay*	1	1
Underclay, brownish-gray to black	1	5
Sandstone, gray, shaly, micaceous	2	9
Sandstone, massive to thinly bedded, fine-grained, micaceous	2	10
Siltstone, shaly, carbonaceous, "pencil fractured"	2	10
Coal, black to brownish-gray clay at base, may be *Little Fire Clay*	1	6
Underclay, light-gray to white, nonplastic	2	4
Sandstone, brown to gray, massive, fine-grained, crossbedded, micaceous, contains coaly streaks	23	8
Coal, probably *Whitesburg*		11
Underclay, gray, sandy, root traces	1	10
Shale, gray, silty, harder and more sandy at top, contains ironstone nodules, fossils found	39	4
Sandstone, very fine grained, micaceous, iron-stained		4
Siltstone, very fine grained, "pencil fractured"	4	8
Sandstone, brown to grayish-white, massive, fine- to medium-grained, micaceous	22	5
Concealed interval	6	
Shale, gray to brownish, silty, top portion poorly exposed but yields fossils, may be *Kendrick*	11	
Coal, thin, poorly exposed, *Amburgey*		6
Underclay, gray, semiplastic when wet, hard when dry, contains carbonaceous material		7
Sandstone, gray, very fine grained, clayey, micaceous, contains carbonaceous streaks	3	2
Sandstone, gray to brownish, fine-grained, micaceous		6
Sandstone, black, fine-grained, micaceous, carbonaceous		6
Sandstone, contains ironstone nodules		6
Sandstone, fine-grained, iron-stained	2	6
Concealed interval	22	5
Sandstone, gray, massive, medium-grained, iron-stained, contains coal streaks	3	
Siltstone, gray		2
Coal, *Van Lear*	2	6
Sandstone, gray, fine-grained, carbonaceous streaks	3	9
Sandstone, gray, fine-grained, micaceous, plant traces		6
Shale, black to brownish, contains thin bands of ironstone; bottom concealed, base of section concealed in ditch		

SECTION NO. 4.—*Stave Branch Section. About 1 mile from mouth of Stave Branch beginning at a strip mine near top of hill and going down road to creek level. Measured by J. A. Baker.*

	FEET	INCHES
Siltstone, blue-gray, clayey, contains ironstone nodules; not measured, estimated	10	
Limestone concretions, blue, sandy, contain ironstone nodules 1-2″ in diameter. Limestone concretions about 4′ in diameter and about 18″ to 24″ thick	1½-2	
Siltstone, same as above concretions	10	
Coal, *Van Lear*	3	
Underclay, gray, bottom concealed	3	
Concealed interval	11	3
Shale, light- to pale-olive, poorly exposed, badly weathered	6	
Sandstone, very fine grained, well indurated, contains fossil tree impressions		2

Shale, top portion greenish-gray clay, contains ironstone nodules; bottom portion shale, variegated, pale-olive, yellow-green; poorly exposed and badly weathered	39	3
Coal bloom, poorly exposed in ditch		2-3
Underclay, light greenish-gray	2	
Shale, pale to olive, slightly sandy and contains thin, hard, sandstone stringers, grades upward into soft, very fine grained shaly sandstone	19	10
Concealed interval	5	7
Shale, pale-olive, becomes increasingly micaceous toward top, poorly exposed, top covered by weathered debris	6	
Coal bloom, poorly exposed	2	6
Underclay, light greenish-gray	2	6
Shale, variegated; top pale olive, nodules of ironstone in top half; bottom 2′ grayish-green to black; poorly exposed in bottom half	33	5
Sandstone, hard, forms small ledges in ditch; bottom portion shale, grayish-green, iron-stained, streaks of carbonaceous material	10	7
Sandstone, grayish-green, fine-grained, micaceous		8
Shale, light greenish-gray, clayey, sticky when wet, top 7″ grayish-black and shows "pencil fracture"	5	7
Sandstone, light greenish-gray, fine- to medium-grained, iron-stained, slightly micaceous, tight	26	
Shale, pale-green	1	
Sandstone, light greenish-gray, medium- to coarse-grained, micaceous, not well indurated, grades upward into shaly sandstone, bottom concealed. (This sandstone or the one above it may be the top of the *Lee formation*, although the *Quakertown shale* was not found here.)	6	7

SECTION NO. 5.—*Paintsville Section. Road cut along U. S. Highway 23 about 1 mile west of Paintsville. Measured by J. A. Baker and R. E. Hauser.*

	FEET	INCHES
Sandstone, massive, not measured, estimated	2	
Coal, not measured, estimated, *Howard*	1	
Sandstone, not measured, estimated	10	
Shale, blue-black, clayey; not measured, estimated; bottom 6″ fossiliferous, *Lingula* and *Orbiculoidea* seen, *Quakertown*	16	
Interval from fossil zone to coal	25	9

SECTION NO. 6.—*Slate Branch Section. Road cut on Ky. Route 172 about 100 yards south of the mouth of Slate Branch. Measured by J. A. Baker and R. E. Hauser.*

	FEET	INCHES
Sandstone, crossbedded, at top of cut and not accessible for measurement, thickness estimated	8	
Coal, inaccessible, estimated, *Howard*		10
Shale, blue-black, clayey, platy, sparse ironstone nodules, 6″ lens of sandstone about 15′ from top, top 6′ alternating thin sandstone and shale	25	
Sandstone	2	
Shale, black		6
Sandstone	2	
Shale, black, clayey, medium-hard		10
Shale, black, hard, fissile		5
Clay, black, very silty, fossiliferous, *Quakertown shale* horizon		5
Shale, gray to black, clayey, bottom concealed		6

Sample No. 2 is one of the best clay shales sampled. It will satisfactorily make common brick, drain tile, and hollow block, as well as high-grade face brick, roofing and quarry tile. It was taken from an unnamed shale about 12 feet above the top of the Lee formation and was sampled just south of Volga, Kentucky, in almost the exact center of the Paintsville quadrangle. About 20 feet of this shale is exposed in the road cut at the point of sampling (see figure 11). The shale is dark-blue at the bottom and becomes progressively lighter toward the top, where it is a light-brown. Both the top and bottom of the shale are covered, and thus the full thickness of the shale is not known.

The shale occurs above drainage just west of Paintsville and outcrops in most of the area from Paintsville northwestward. However, it is below drainage in each of the immediate corners of the quadrangle.

An extensive outcrop of the shale may be seen along U. S. Highway 460 from the west edge of Paintsville to the junction of routes 460 and U. S. 23 at the mouth of Turner Branch. As seen in this road cut it is a blue-gray, crumbling shale.

Sample No. 3 is a good clay recommended for use in production of vitrified clay products such as sewer pipe and also should be suitable for brick and tile or other structural clay products. The sample of this clay was taken approximately 10 miles northwest of Paintsville on an improved gravel road along Cantrill Branch 1½ miles southwest of Ky. Route 172. At the point of sampling this shale is 7 feet thick and is capped by 8 inches of sandstone and underlain by 5 inches of ironstone, followed by 18 inches of black fissile shale and 10 inches of coal. The shale is blue-gray, darker at the bottom than at the top, and contains small scattered ironstone nodules. This shale has about the same areal extent as (sample) No. 2, because it is only a few feet higher stratigraphically.

Sample No. 4 is a fairly good clay shale and might be suitable for vitrified heavy clay products, as well as for brick and tile. The sample was taken in a road cut ½ mile east of Flat Gap on an improved gravel road. The following section is exposed:

1′	coal bloom (top)
17′	siltstone, light-brown, thinly bedded
15′	shale, blue-gray, lighter at the top, darker at the bottom; sample taken from this portion of section
9′	shale, blue-gray, silty
1′	coal bloom

This shale lies 17 feet below the Van Lear coal, and therefore its areal extent is essentially shown by the outcrop position of the Van Lear coal (plates 1a, b, c, and d).

Sandstone, massive, medium-grained	35	
Coal bloom, *Whitesburg*		8
Underclay, light-gray	1	6
Shale, brown, slightly silty	6	
Sandstone, clayey	1	6
Shale, pinkish-brown, clayey	1	6
Coal bloom		6
Underclay, brown to pinkish	2	
Siltstone, thinly bedded	7	
Shale, grayish-black, clayey	1	
Siltstone, thinly bedded	18	
Sandstone, massive	9	
Siltstone, brown, clayey	3	
Shale, blue, clayey	4	
Concealed interval	2	
Coal bloom, *Amburgey*	1	
Siltstone, grades downward into clay shale	17	
Shale, blue, clayey, silty in spots	24	
Coal bloom, *Van Lear*	1	
Underclay, light-gray	2	
Siltstone, thinly bedded	6	6
Coal bloom (split in *Van Lear*)		10
Shale, blue, silty toward top	14	
Coal bloom		6
Siltstone and sandstone intercalated, mostly siltstone	35	

SECTION NO. 10.—*Hood Creek Section. Road cut between Hood Creek and Rockhouse Fork. Top of section at gap, base of section 1 mile north of Sip, Ky. Measured by R. E. Hauser.*

	FEET	INCHES
Coal bloom		6
Concealed interval	4	
Coal bloom		6
Concealed interval	8	
Coal bloom, *Fire Clay*	1	6
Underclay, grayish-black, rather hard, similar to *Fire Clay* flint parting		5
Concealed interval	10	
Coal bloom		5
Clay parting, brown, hard		1
Coal		4
Underclay, light-gray		8
Concealed interval	7	
Coal bloom, *Whitesburg*		6
Underclay, light-gray		6
Concealed interval	10	
Sandstone, massive	23	
Concealed interval	8	
Coal bloom, *Amburgey*	1	6
Underclay	1	8
Concealed interval	6	
Siltstone	5	6
Shale, clayey	16	
Siltstone, thinly bedded	6	
Concealed interval	3	
Shale, black, fissile		4
Concealed interval	13	
Shale, black, fissile		2
Coal bloom, *Van Lear*	1	
Underclay, light-gray	2	
Concealed interval	9	
Shale, light-gray, clayey	3	
Siltstone, brown	12	

Shale, black, fissile		2
Underclay		2
Sandstone, brown, medium-grained	3	
Siltstone, shaly	10	
Limestone concretions, *Campbell Creek*		8
Siltstone	13	

SECTION NO. 11.—*Wilbur Section. East side of gap in road cut leading from Left Fork of Brushy Creek to Right Fork of Little Blaine Creek. Measured by R. E. Hauser.*

	FEET	INCHES
Concealed interval to gap	110	
Underclay in road bed	1	
Concealed interval	11	6
Sandstone, fine-grained, thinly bedded	6	
Limestone concretions, sandy, *Magoffin*	2	
Sandstone, massive	9	
Concealed interval	5	
Coal bloom, *Fire Clay*		6
Underclay		3
Shale, black, fissile		6
Clay, brownish-black, conchoidal fracture, resembles *Fire Clay* parting		4
Underclay, sandy at base	1	6
Sandstone with coal streaks	25	
Shale, gray, sandy	5	
Coal, *Whitesburg*	1	8
Underclay, sandy	2	
Shale, buff-colored	6	
Shale, black, bituminous, fissile	2	
Underclay, gray	1	6
Sandstone, thinly bedded	5	
Concealed interval, base of section	17	

SECTION NO. 12.—*Upper Laurel-Mudlick divide Section. Road cut 1½ miles southeast of Redbush on Ky. Route 172. Measured by R. E. Hauser*

	FEET	INCHES
Siltstone, thinly bedded	3	
Coal bloom, *Fire Clay* (elevation 998′)		5
Underclay, light-gray		6
Siltstone, brown	2	
Sandstone, fine-grained	1	6
Siltstone, blue-gray	4	
Limestone concretion	1	
Siltstone, blue-gray	5	
Concealed interval	6	
Coal bloom, *Whitesburg*		4
Underclay, bottom 3′ very sandy and white	4	
Siltstone, thinly bedded	4	
Sandstone, thinly bedded	7	
Shale, clayey, bottom silty	16	
Siltstone, top portion shaly	5	
Siltstone, contains ironstone nodules		4
Siltstone, blue-gray		6
Sandstone, red and gray, contains brachiopods and streaks of iron, *Kendrick shale* horizon	2	2
Shale, black, bituminous		10
Coal bloom, *Amburgey*		7
Underclay, light-gray	1	
Siltstone	13	
Sandstone, medium-bedded	1	6
Siltstone, blue-gray, shaly	5	

Limestone concretions, sandy	1	6
Sandstone, fine-grained, thinly bedded	3	
Siltstone, brown, shaly	14	
Shale, blue	6	
Concealed interval	5	
Coal bloom, *Van Lear*	1	8
Underclay, dark-gray	1	
Concealed interval	2	
Sandstone, massive	4	
Siltstone, thinly bedded	5	

SECTION NO. 13.—*Redbush Section. Cut of abandoned road ½ mile east of Redbush. Measured by R. E. Hauser.*

	FEET	INCHES
Concealed interval to top of hill	29	
Coal bloom, *Fire Clay*	1	8
Clay, brownish-black, flinty, resembles *Fire Clay* parting		3
Underclay, medium-gray		3
Concealed interval	5	
Coal bloom		5
Underclay, light-gray		4
Concealed interval	65	
Coal bloom, *Whitesburg* (?)		8
Underclay, light-gray		6
Concealed interval	11	
Limestone concretions, sandy, 6′ in diameter, *Elkins Fork shale*	1	6
Sandstone, thinly bedded	1	
Shale and siltstone intercalated, partially concealed	16	
Concealed interval	21	
Coal bloom, *Van Lear*		7
Underclay, dark-gray		4
Concealed interval	6	
Sandstone	1	6
Siltstone, badly weathered	19	
Partially concealed, mostly shale exposed	17	
Shale, black, possibly badly weathered coal, *Howard* (?)		10
Shale, gray, clayey	1	3
Shale, black, bituminous	2	
Underclay, dark-gray		1
Partially concealed, alternating shale and sandstone seen as float	34	
Sandstone, massive, crossbedded, top of *Lee*	30	

SECTION NO. 14.—*Gullett Branch Section. Road cut opposite mouth of Gullett Branch of Paint Creek. Measured by R. E. Hauser.*

	FEET	INCHES
Sandstone, medium-bedded	1	3
Shale, black, fissile, bituminous, *Quakertown*		4
Sandstone, fine-grained, black streaks		1
Underclay, light-gray, sandy	4	
Sandstone, brownish-gray		10
Shale, gray, clayey	3	
Coal bloom		5
Underclay, dark-gray	2	
Shale, with ironstone	1	
Sandstone, contains numerous tree and plant fossils	9	
Shale, black, fissile	3	
Coal bloom		7
Underclay, light- to medium-gray, sandy at bottom	2	
Sandstone, massive, crossbedded, top of *Lee*	40	

SECTION NO. 15.—*Win Section. About 1 mile south of Win, Ky., in cut of road leading from head of Hargis Creek to head of Pigeon Creek. Base of section on Pigeon Creek side. Measured by R. E. Hauser.*

	FEET	INCHES
Sandstone, massive, fine-grained	15	
Concealed interval	27	
Sandstone, dark-gray, fine-grained	7	
Siltstone, shaly	3	
Limestone concretions, reddish-blue, sandy, *Magoffin*	2	
Sandstone, medium-bedded	22	
Siltstone, thinly bedded, shaly	5	
Coal bloom, *Fire Clay*		4
Underclay, light-gray		6
Sandstone, massive, medium-grained	20	
Siltstone, thinly bedded	6	
Coal bloom	1	2
Underclay, dark-gray	1	
Shale and siltstone intercalated	6	
Coal bloom		6
Underclay, dark-gray		6
Sandstone, massive, medium-grained	11	
Concealed interval	12	
Sandstone, fine-grained	5	
Shale and siltstone intercalated	6	
Coal bloom		8
Shale, gray, silty	5	
Coal bloom		6
Siltstone, shaly	15	
Coal bloom, *Van Lear*		3
Concealed interval	22	
Sandstone, brown to gray, medium-bedded	2	
Siltstone, brown, shaly	12	
Coal bloom, *Campbell Creek*		6
Underclay, light-gray	1	
Siltstone, thinly bedded	22	

Subsurface Stratigraphy

Gas and oil test drilling has penetrated beds ranging in age from Ordovician to Pennsylvanian. These will be discussed in order from youngest to oldest. All wells discussed in this report carry the author's numbers, unless otherwise indicated.

Pennsylvanian System

Inasmuch as only the upper 200 feet of the Lee formation is exposed at the surface, a short description of the full formation follows.

The Lee formation, or Salt Sand as it is best known to drillers, has an average thickness of about 450 feet in this area. Usually 2 or 3 shale breaks ranging from 5 to 80 feet thick are found in drilling through the sandstone, and these breaks divide the sandstone into the First, Second, and Third Salt Sands. The name Salt, according to Thomas (1949, pp. 166-179), was given to the sandstone because salt water is almost always encountered in drilling through the Lee formation. The Lee rests unconformably upon beds of Mississippian age.

Mississippian System

Pennington formation

The Pennington formation is the uppermost of the Mississippian system in this area. A sandstone member of the formation, known to drillers as the Maxon (Maxton) sand, is similar to the Salt Sand, and at times it is difficult to differentiate between the two. The name Maxon (Maxton) has been applied to subsurface sands of different ages in West Virginia, Ohio, and Eastern Kentucky, ranging from Lower Pennsylvanian to Upper Mississippian. In this area it refers to a sandstone member within the Pennington formation. In places red shale 0 to 30 feet thick lies between the Salt Sand and the Maxon sand. This zone probably represents the shale portion of the Pennington formation. When present the shale is used as a marker for the top of the Mississippian system.

Little Lime

The limestone occupying the interval between the Maxon sandstone and a shale parting known to drillers as the "Pencil Cave" (Golconda) is called the Little Lime. A member of the Mauch Chunk series (Lafferty, 1949, p. 218), the Little Lime is locally cut out by post-Mississippian erosion. Where present it attains thicknesses as much as 44 feet, with an average of 20 feet. It is sometimes called the "Black lime" by drillers because of its dark color.

Cuttings from well No. 56 in the southeast quarter of the quadrangle show the Little Lime here to be medium to dark brownish-gray mottled limestone. It ranges in texture from coarse- to medium-crystalline.

Big Lime

The next lower formation, the Big Lime, includes Renault-Paint Creek limestones (Gasper) of lower Chester age, and Ste. Genevieve limestone (Meramec). It is in general a massive, multicolored limestone with a large range in thickness (see plate 3 a, b, and c) and variation in lithology (Young, 1950). The most prominent lithologies are oolitic limestone and vaughanite ranging in color from white to gray to brown and containing coarse grains of quartz sand. Other lithologies are crystalline and dolomitic limestones containing chert and quartz sand.

The Big Lime in well No. 56 is 137 feet thick. The upper portion is predominantly brown to tan limestone containing numerous rounded limestone pellets. A zone of oolitic limestone, 25 feet thick and with numerous crinoid stem fragments, occupies the interval from 17 feet to 34 feet above the base of the formation.

Upper Waverly

A series of shales with thin sandstone zones occupy the interval between the base of the Big Lime and the Sunbury shale. The average thickness of this zone is approximately 350 feet. The top of the interval is fine-grained sandstone to siltstone with a thickness of ±40 feet. It is called the Big Injun by producers and drillers.

One hundred seventy-five to two hundred feet below the Big Injun is a second sandy zone, the Weir sand. The Weir is a fine- to medium-grained sandstone which shows a rapid lateral gradation to shale. The sand zone may be split into as many as three individual beds with dark shales occupying the intervals between. The average thickness of this oil and gas producing zone is 60 feet.

Lower Waverly

Lower Waverly is represented by the Sunbury shale and the Berea sandstone. The Sunbury is a brown carbonaceous shale ranging in thickness from 12 to 25 feet. It is a persistent bed and frequently used as a key bed in subsurface mapping.

The Berea, sometimes known as the Berea "grit," is more a siltstone than a sandstone. It is a quartz sand cemented by limonite or calcite. It is easily identified by its position, separating the Sunbury shale above and the Ohio shale below. The U. S. Geological Survey Oil and Gas Investigations Preliminary Map 69 (Pepper, and others, 1946) indicates the Berea ranges in thickness, within the quadrangle, from approximately 60 feet to a little more than 100 feet. Well logs checked by the writer indicated a maximum thickness of 111 feet. It is quite possible that some of the material logged as Berea is siltstone of the Bedford formation.

Devonian System

Ohio (Brown) shale

The upper Devonian is represented by shales varying in color from brown to black to greenish-gray. The thickness is somewhat variable over the area but averages ±450 feet. It is generally called the Brown shale by the drillers, but its position between the Bedford-Berea silts and the Olentangy shale conforms to the original usage of the name Ohio shale (Andrews, 1870, p. 62).

For years this shale has been a source of controversy as to age, Mississippian or Devonian. According to Freeman (1951, pp. 26, 27) it is a time-trangressing unit with deposition beginning in late middle Devonian and continuing in some areas into the Mississippian.

Huntersville, Oriskany, and *Helderberg*

Devonian and Silurian beds below the Olentangy shale and above the Big Six sandstone of Clinton (Silurian) age have long been referred to by the drillers and operators of eastern Kentucky as the "Corniferous." In recent years it has been found possible to split the Devonian portion of these beds locally into the Huntersville, Oriskany, and Helderberg. The three formations have a total thickness which ranges from 100 to 165 feet. The Huntersville at the top of this sequence is predominantly a gray to brown dolomitic limestone with considerable chert. The Oriskany consists of calcareous sandstone and crystalline limestone with scattered quartz grains. Well No. 1073, which is located in the southwest quarter of the quadrangle, shows a thickness of 36 feet of Oriskany, the lower 20 feet being calcareous sandstone. The Helderberg is a limestone sequence, tan to gray in color, with some chert and argillaceous layers.

Silurian System

Salina

The Salina marks the top of the Silurian system. It is limestone and dolomite with several zones of anhydrite and gypsum. Its thickness is ±300 feet.

Lockport

The Lockport is a massive-bedded, medium-crystalline dolomite with thin argillaceous partings. Locally, the formation has an average thickness of approximately 100 feet.

Big Six sand (Keefer)

Below the Lockport is a sandstone zone approximately 50 feet thick which has proven to be an important gas producing horizon. McFarlan (1943, p. 291) has designated this horizon as uppermost Clinton. Lafferty and Thomas (1942) have also stated that the Big Six marks the base of the "Corniferous" and is considered the top member of the Clinton. Freeman (1951) has placed the Big Six within the basal Lockport.

Clinton and Older Silurian

Little is known of the startigraphic details of the beds beneath the Big Six, because all but two of the wells within the quadrangle are bottomed within or a few feet below it. Well No. 1158 in the southwest quarter of the quadrangle has a total thickness of 265 feet of Clinton beds beneath the Big Six sandstone. They are predominantly red, maroon, and green shales with hematitic oolites near the base. This well also has 78 feet of Albion shales above the Richmond

(Ordovician) beds. The second deep test (No. 2338), in the northwest quarter of the quadrangle near Redbush, has a Clinton section 287 feet thick and 45 feet of Brassfield at the base of the Silurian (Freeman, 1953, pp. 188-194).

Ordovician System

Ordovician beds have been penetrated in the two deep tests previously mentioned. Well No. 1158 passed through 2482 feet of Ordovician and well No. 2338 more than 3000 feet. Freeman (1951, pp. 42-43) has subdivided these beds into Richmond, Maysville, Eden, Cynthiana, Lexington, Chazy-Black River, and Knox. Sample decriptions from both wells have been made by Freeman (1951, p. 42, and 1953, pp. 188-194). Following is a description by Freeman (1953, pp. 188-194) of well No. 2338. It should be noted that certain samples were missing, causing gaps in the log.

WELL No. 107 (1446).—*Ashland Oil and Refining Company No. 8 Wallace Williams, section 19-R-79, Johnson County.*

PENNSYLVANIAN	
18-151	Sandstone, poorly sorted to coarse-grained, some quartz pebbles; oil-stained at 86-100.
151-83	Sandstone, poorly sorted, to conglomerate, with occasional sideritic pebbles.
183-218	Shale, silty, sideritic, black to gray; some hard, brown clay.
218-57	Sandstone, poorly sorted to coarse-grained, chloritic.
257-80	Sandstone, very clean, white, friable.
MISSISSIPPIAN	
"Glen Dean"	
280-86	Limestone, argillaceous, fine-grained, brown; rare crinoid fragments.
286-90	Limestone, as above; some fine-grained gray clay.
"Maxon"	
290-300	Sandstone, fine-grained, well sorted for size, poorly sorted for minerals, tightly cemented.
300-12	Sandstone, as above; much grayish-red to greenish-gray shale.
Greenbrier ("Big Lime")	
312-34	Limestone, argillaceous, dark grayish-brown, occasional crinoid fragments; some limestone detrital.
334-45	Limestone, brown, fine-grained, some gray mottled, some pellet.
345-57	Limestone, light-brown, some finely dolomitic.
357-82	Limestone, fine-grained, tan to brown, slightly fossiliferous.
382-407	Limestone, brown, lithographic, ostracodal.
407-33	Limestone, creamy-gray, finely detrital, pellets and imperfect oolites, fossil fragments and rounded fragments of darker limestone; numerous pellets having rounded sand centers.
433-42	Limestone, slightly dolomitic, earthy; trace of coarse silt grains enclosed.
442-50	Limestone, very dolomitic, slightly silty, light grayish-brown.
Lower Mississippian	
450-70	Sandstone to very coarse siltstone, well-sorted for size; many heavy minerals and yellow, oxidized spots from glauconite or siderite; tightly cemented.

470-600	Siltstone, very coarse grained, as above, slightly argillaceous, more gray than above; increasingly argillaceous and micaceous with depth.
600-54	Siltstone, more argillaceous than above, gray, with some brownish-red, micaceous.
654-62	Shale, slightly silty, dark-gray, interbedded with siltstone, as above.
662-75	Siltstone, light-gray, tightly cemented, coarse-grained; some shale, as above.
675-95	Siltstone, very coarse grained, poor mineral sorting, light-gray.
695-722	Shale, silty, dark-gray, some rusty-brown; some interbedded siltstone.
722-60	Shale, slightly silty, very dark gray; some very slightly brownish-gray.
760-64	Shale, nonsilty, dark-gray.

New Albany

(Sunbury)

764-85	Shale, black, carbonaceous, and fine-grained.

(Berea-Bedford)

785-97	Siltstone, coarse-grained, well-cemented, pyritic, light-gray.
797-805	Siltstone, medium-grained, light-gray, very tightly cemented, pyritic.
805-65	Siltstone, fine-grained, well-cemented, micaceous and pyritic, light-gray.
865-72	Shale, fine-grained, medium-gray.
872-95	Shale, as above, interbedded with fine-grained, tightly cemented siltstone.

(Ohio)

895-980	Shale, coarse-grained, black, carbonaceous.
980-1000	Shale, dark-gray, less carbonaceous than above, finer grained.
1000-61	Shale, dark-gray, fine-grained, with some reddish-brown shale.
1061-1139	Shale, carbonaceous, coarse-grained, black, with some spores.
1139-81	Shale, black, as above, without spores.
1181-1256	Shale, very dark gray, interbedded with black, carbonaceous.
1256-1307	Shale, black, carbonaceous, coarse-grained; many spores.
1307-95	Shale, very finely silty, slightly greenish-gray, pyritic; interbedded with some black shale.
1395-1412	Shale, very dark gray, pyritic.

DEVONIAN

Huntersville

1412-32	Dolomite, medium-crystalline, dense, brown; chert, 30%, brownish-gray, translucent, with tiny fossiliferous inclusions; some chalky, light-tan, dolomoldic, with rare spores.
1432-37	Dolomite, as above; more chert than above.
1437-48	Dolomite, as above; some limestone, fine-grained, brown; chert, gray, mottled, pyritic; some chalky, as above.
1448-60	Limestone, tan, densely crystalline; chert, microspecked, brown to tan, some pyritic.

Oriskany

1460-68	Limestone, cream, crystalline, enclosing poorly sorted sand grains.
1468-74	Sandstone, very poorly sorted to medium-grained, rounded and frosted, slightly calcite-cemented.

SILURIAN-DEVONIAN

Salina

1500-21	Limestone, very fine-grained, sublithographic, brown.
1521-31	Limestone, very dolomitic, finely crystalline, dense.
1531-63	Dolomite, very fine grained, sublithographic; trace of gypsum.
1563-69	Dolomite, as above, with trace slightly gray, argillaceous.
1569-77	Dolomite, very fine grained, sublithographic, slightly anhydritic.
1577-85	Dolomite, finely crystalline to sucrose, brown.
1585-95	Dolomite, very fine grained, with finely disseminated anhydrite.
1605-17	Dolomite, very slightly argillaceous, light-gray; little selenite.

1617-53	Dolomite, finely crystalline to dense, slightly argillaceous; much anhydrite.
1653-1717	Dolomite, so fine-grained that it looks like lithographic limestone, brown; much anhydrite.
1750-57	Dolomite, fine, as above; much anhydrite.
1770-80	Dolomite, brown, medium-crystalline, vugular and porous.
1790-1820	Dolomite, some very fine grained, some fine- to medium-crystalline, brown.
1820-50	Dolomite, as above, with some anhydrite; trace of dark shale.

SILURIAN

Lockport

1850-65	Dolomite, gray and brown, crystalline, fine-grained; trace of black shale.
1865-80	Dolomite, more argillaceous and gray than above; some enclosing fine rounded sand; trace of green shale.
1880-85	Dolomite, brown, medium-crystalline, dense; trace of greenish-gray, finely crystalline dolomite.
1885-1900	Dolomite, finely crystalline, gray to slightly brown; much very dark gray argillaceous dolomite.
1900-04	Dolomite, very fine grained, gray, earthy, some mottled with dark-gray; rare fine sand grains enclosed.
1904-19	Dolomite, finely crystalline to medium-grained, grayish-brown, mottled.
1919-24	Dolomite, as above; some gray limestone enclosing dolomite rhombs.
1924-29	Dolomite, brown and gray mottled, densely crystalline to slightly vugular.
1929-34	Dolomite, as above; some with very small oolites (tiny rounded vugs filled with dolomite crystals).
1934-44	Dolomite, pale-gray, medium-crystalline, dense to vugular; some finely crystalline, tan.
1944-55	Dolomite, more densely crystalline, gray, mottled, and fossiliferous.
1955-72	Dolomite, silty and argillaceous, dark-gray; crystals silt-size, so that silt is not apparent except in residue.
1972-84	Dolomite, gray and brown mottled, medium-crystalline; rare sand grains enclosed.
1984-89	Dolomite, pale-gray, with some dark mottling, medium to coarsely crystalline, enclosing a little poorly sorted stand, medium-grained.
("Big Six")	
1989-2017	Sandstone, well-sorted for size, poorly sorted for minerals, fine-grained, with some dolomite cement.
2017-28	Sandstone; more dolomite than above, some gray and argillaceous.

Clinton

2028-38	Shale, very dark gray to red, coarse-grained, very slightly silty.
2038-82	Shale, very dark red, coarse-grained.
2082-90	Shale, as above, some greenish-gray; rare fragments of quartzite.
2090-2155	Shale, very dark red, coarse-grained.
2155-82	Shale, mainly grayish-green, fine-grained; some red, as above.
2182-87	Shale, as above; trace of glauconitic quartzite.
2187-2200	Shale, very dark gray to red; some green, with much glauconite.
2200-06	Dolomite, gray to brown, densely crystalline, pyritic.
2206-12	Shale, red, coarse-grained; trace of dolomite with glauconite.
2212-17	Green shale, fine-grained, fissile, with much glauconite; some red shale.
2217-22	Shale, red, coarse-grained.
2222-40	Shale, some red, as above; some green, fissile, and fine-grained.
2240-50	Shale, red and coarse, as above; some oolitic hematite.
2250-74	Shale, as above; trace of densely crystalline dolomite.
2274-98	Shale, as above; dolomite, yellow and gray, crystalline, dense, some slightly argillaceous; much oolitic hematite and some chamosite.
2298-2305	Mainly oolitic hematite; little shale as above.
2305-10	Shale, green, fissile.
2310-15	Mainly oolitic hematite.

Brassfield

2315-30	Dolomite, gray, densely crystalline, fossiliferous, some interbedded shale; much oolitic hematite.
2330-41	Dolomite, gray, densely crystalline to argillaceous, with some greenish-gray shale.
2341-60	Dolomite, as above; more shale; occasional fragments of very fine brown quartzite.

ORDOVICIAN

Richmond

2360-80	Dolomite, cream, densely crystalline, medium-grained, some pyritic; red and green shale.
2380-90	Shale, green, fissile; trace of dolomite.
2390-2400	Dolomite, coarsely crystalline, dense, gray, with much glauconite; trace of fine sand enclosed.
2400-24	Dolomite, gray, medium-crystalline, fossiliferous, slightly phosphatic; much glauconite.
2424-43	Shale, red, richly hematitic, very slightly calcareous.

Maysville

2443-91	Shale, calcareous, dark-gray; some very fossiliferous limestone interbedded, phosphatic, with trace of very fine silt.
2491-2508	Shale, as above, with trace red.
2508-83	Shale, slightly calcareous, coarse-grained, almost silty in residue; interbedded with rare, very fossiliferous and phosphatic limestone.
2583-98	Limestone, gray, very phosphatic and fossiliferous; little interbedded calcareous and fossiliferous shale.
2598-2607	Limestone, fine-grained, argillaceous, with some calcareous, fossiliferous shale.
2607-83	Limestone, very argillaceous, gray, very fossiliferous, with many bryozoans and ostracods.
2683-2770	Limestone, very dense, fine-grained, gray, fossiliferous, slightly argillaceous, some interbedded shale; leaves residue of very finely disseminated silt.
2770-88	Limestone, some as above, some more crystalline, fossiliferous and phosphatic, gray.
2788-96	Limestone, brownish-gray, crystalline, fossiliferous and phosphatic; some shale; much siltstone.
2796-2822	Limestone, crystalline, fossiliferous and phosphatic; little shale and siltstone.
2822-79	Limestone, fossiliferous, phosphatic, as above; more interbedded siltstone and shale.

Garrard

2879-2969	Siltstone, slightly calcareous and argillaceous; much gray shale; some interbedded fossiliferous limestone.

Cynthiana-Million

2969-90	Limestone, brown, crystalline, fossiliferous, with some interbedded siltstone, as above.
2990-3010	Shale, dark-gray, calcareous, coarse-grained, slightly silty.
3010-93	Limestone, brown, crystalline, fossiliferous, finer grained than above; residue still very finely silty shale.
3093-3109	Limestone, slightly brownish-gray, fossiliferous, slightly phosphatic, with some interbedded finely silty shale.
3109-48	Limestone, as above; much calcareous, very finely silty shale.
3148-90	Limestone, as above, less shale.
3190-3234	Limestone, argillaceous, grayish-brown, densely crystalline, fossiliferous, ostracodal.
3234-85	Limestone, gray, crystalline and phosphatic; much calcareous shale; trace of bentonite at 3265.

Lexington

3285-3351	Limestone, grayish-brown, fine-grained to fossiliferous; trace of phosphate and calcareous shale.

3351-3421	Limestone, fine-grained, sublithographic, fossiliferous, brown; little shale.
3421-58	Limestone, finely phosphatic, grayer than above.
3458-3530	Limestone, gray, finely argillaceous, fossiliferous, with some calcareous shale, finely phosphatic.
3530-44	Limestone, gray, fossiliferous and phosphatic; some interbedded gray calcareous shale.
3544-62	Limestone, gray, crystalline, very fossiliferous and phosphatic; some translucent gray chert; trace of bentonite.
3562-80	Limestone, as above; less shale; trace of biotitic bentonite in base.
3580-86	Limestone, grayish-brown, crystalline to dense, fossiliferous, slightly phosphatic.

Chazy-Black River

3586-94	Limestone, brown, lithographic; much dense chert and bentonite.
3594-99	Limestone, very fine, lithographic, light-tan, clean.
3599-3607	Limestone, fine, lithographic, some bentonitic and gray.
3607-18	Limestone, fine-grained, brown; much free bentonite.
3618-40	Limestone, lithographic to subcrystalline, brown, clean.
3640-43	Limestone, as above; much bentonite.
3643-85	Limestone, fine-grained, slightly bentonitic, grayish-brown.
3685-95	Limestone, light-tan, lithographic.
3695-3710	Limestone, as above; some grayish-green, argillaceous.
3710-21	Limestone, fine-grained, brown; rare dolomite.
3721-65	Limestone, brown, lithographic.
3765-90	Limestone, brown, as above; much brown granular dolomite.
3790-3806	Limestone, brown, lithographic; rare dolomite.
3806-27	Limestone, very dark brown, lithographic; trace of black argillaceous limestone.
3827-67	Limestone, argillaceous, dark-gray to greenish-gray.
3867-3910	Limestone, brown, lithographic; rare fragments slightly argillaceous.
3910-60	Limestone, very fine, lithographic, brown.
3960-4160	Limestone, brown, lithographic to subcrystalline, slightly fossiliferous; rare fragments of dark argillaceous limestone.
4160-88	Limestone, lithographic, cream.
4188-4235	Limestone, clear brown, lithographic; rare fragments slightly argillaceous and dolomitic.
4235-48	Limestone, brown, lithographic; some well-developed pellet limestone.
4248-96	Limestone, very dark brown, lithographic.
4296-4390	Limestone, darker brown than above, slightly argillaceous, very fine grained.
4390-4417	Limestone, very dark brown, slightly argillaceous, as above; interbedded with some slightly dolomitic limestone.
4417-23	Limestone, very dolomitic, fine-grained, light-brown.
4423-31	Limestone, dolomitic, as above; some darker and argillaceous.
4431-56	Limestone, argillaceous, very dark brown to black, fine-grained.
4456-73	Limestone, very dark, argillaceous, as above; some interbedded brown, detrital, dolomitic limestone.
4473-96	Limestone, very dark, argillaceous, fine-grained; much fine-grained detrital dolomite, enclosing fine quartz silt.
4496-4509	Limestone, argillaceous, black, fine-grained.
4509-23	Limestone, very dolomitic, slightly silty, detrital, greenish-gray.
4523-47	Limestone, argillaceous, black; little brown, lithographic.
4547-66	Limestone, very dolomitic, finely silty and argillaceous, dark-gray; residue is very fine silt to shale.
4566-75	Limestone, very dark brown to black, less dolomitic than above, more argillaceous.
4575-80	Limestone, as above; some light-brown, fine-grained.
4580-4600	Limestone, very argillaceous, lithographic, dark-brown to black.
4600-15	Limestone, as above, some grayish-brown dolomitic limestone.
4615-32	Dolomite, calcareous, detrital, including some fine silt, argillaceous.
4632-42	Little dolomite, as above; mainly brown, lithographic limestone.
4642-65	Limestone, argillaceous, dark-brown to black, fine-grained.

4665-73	Limestone, finely dolomitic, argillaceous, earthy texture, grayish-brown.
4673-85	Limestone, argillaceous, dark-brown to black, fine-grained.
4685-4710	Limestone, as above, interbedded with some limestone, finely dolomitic, grayish-brown.
4710-20	Dolomite, detrital, grayish-brown, fine-grained; some limestone.
4720-40	Dolomite, finely detrital, with enclosed silt and pyrite; trace of bentonitic shale.
4740-60	Dolomite, argillaceous, greenish-gray, trace red, silty.
4760-67	Dolomite, argillaceous and detrital, as above.
4767-74	Dolomite, as above, interbedded with dark-green dolomitic shale.
4774-87	Dolomite, detrital, as above, very argillaceous, greenish-gray, with traces of red.
4787-95	Shale, dolomitic, greenish-gray, detrital, trace red.
4795-4809	As above, but much more red.
4809-14	Shale, calcareous and dolomitic, fine-grained, dark-red.
4814-20	Shale, as above, interbedded with green shale and light-gray, medium-crystalline dolomite.
4820-46 (St. Peter)	Limestone, very argillaceous, dark-red, trace green, fine-grained.
4846-52	Sandstone to siltstone, very fine grained, dolomite-cemented, white to light-gray; dolomite, silty.
4852-60	Limestone, very argillaceous, dark-red, fine-grained.
4860-70	Shale, very finely silty, dolomitic, greasy-textured, greenish-gray; much pyrite.
4870-73	Shale, as above; some sandstone, very fine grained, dolomite-cemented; gray dolomite, studded with fine sand grains; trace of gray translucent chert.
4873-80	Dolomite, enclosing much poorly sorted, fine-grained sand, gray; trace of dense chert.
4880-85	Dolomite, sandy and slightly argillaceous, fine-grained.

CAMBRIAN (Steel Line Measurement shows 4892 = 4876. Thus, top of Knox is at 4870 feet.)

Elvins

4885-92	(Should be 4869-76) Dolomite, medium-crystalline, grayish-tan, dense to vugular; trace of dolomoldic white chert.
4876-83	Dolomite, some as above, some more finely crystalline, grayish-tan.
4883-90	Dolomite, medium-crystalline, light-brown, sucrose; trace of fine silt enclosed.
4890-96	Dolomite, slightly finer than above; much finely disseminated pyrite; some dark solution clay.
4896-4903	Dolomite, medium-crystalline, sucrose, light-gray to tan; rare silt and rounded and frosted sand grains.
4903-37	Dolomite, as above, with no sand; some coarse, white, vein dolomite at 4903-12.
4937-45	Dolomite, some brown, medium-crystalline; much light greenish-gray, finely crystalline, argillaceous,, with very finely disseminated silt and pyrite.
4945-53	Dolomite, as above; some sandstone, poorly sorted to medium-grained, rounded and frosted, dolomite-cemented.
4953-68	Dolomite, very finely crystalline, white to pale-gray, dense; trace of dolomite, enclosing very fine sand and broken with green shale.
4968-73	Dolomite, fine- to medium-crystalline, grayish-brown; much rounded and frosted sand, some as centers for chert oolites, some in chert matrix, and some dolomite-cemented.
4973-78	Dolomite, medium-crystalline, brown; little gray to brown mottled chert, slightly oolitic, rare large oolites.
4978-87	Dolomite, finely crystalline, brown, dense; sandstone, poorly sorted to medium-grained, dolomite-cemented; chert, brown, oolitic.
4987-93	Dolomite, finely crystalline, very finely silty, dense; rare chert, white, translucent, oolitic.

4993-5001	Dolomite, finely crystalline, dense, enclosing poorly sorted sand grains to medium size; some dolomite, fine-medium crystalline, light-brown, dense.
5001-10	Sandstone, very poorly sorted to medium size, rounded and frosted, with some secondary crystal growth, friable.
5010-14	Sandstone, as above, some quartz- and chert-cemented.
5014-24	Dolomite, finely crystalline, pale-gray to cream, dense.
5024-33	Dolomite, medium-crystalline, brown, sucrose and vugular; rare fine sand in residue.
5033-39	Dolomite, as above, with some sandstone, very poorly sorted to coarse-grained, with white dolomite cement.
5039-47	Dolomite, sandy, white, as above, with very poorly sorted sand; some pale-gray, medium-crystalline dolomite; chert, white and very oolitic.
5047-55	Dolomite, very finely crystalline, dense, pale-gray, very slightly argillaceous and silty, with trace of silt-size glauconite; pyrite.
5055-58	Mainly chert, very oolitic, gray to white, matrix very translucent chert to crystalline quartz.
5058-65	Some chert, as above; dolomite, brown, medium-crystalline, sucrose.
5065-76	Dolomite, brown, as above; some more dense and lighter brown; rare sand grains enclosed.
5076-87	Dolomite, tan, medium-crystalline, and some pale-gray, coarsely crystalline, vugular.
5087-97	Dolomite, fine-grained, finely pyritic and glauconitic; some sandstone, poorly sorted, slightly dolomite-cemented.
5097-5106	Sandstone, poorly sorted, fine to very coarse, subangular to rounded and frosted, friable.
5106-19	Sandstone, as above; some pale-gray, finely crystalline, dolomite cement. Increase in dolomite with depth.
5119-25	Dolomite, some slightly sandy, mainly medium-crystalline, pale-gray; much coarse, white, vein dolomite.
5125-30	Dolomite, brown, medium-crystalline, vugular; trace of enclosed sand.
5130-40	Sandstone, slightly dolomitic, white, poorly sorted, glauconitic.
5140-53	Sandstone, as above; dolomite, finely crystalline, pale-gray.
5153-81	Dolomite, fine-medium crystalline, grayish-tan, dense, with some finely disseminated silica.
5181-92	Sandstone, slightly dolomitic, white to cream, poorly sorted.
5192-5209	Dolomite, pale-gray, medium-crystalline, enclosing much poorly sorted sand.
5209-18	Sandstone, poorly sorted, fine-grained, friable.
Bonneterre	
5218-29	Dolomite, slightly argillaceous, dark grayish-brown, fine-grained.
5229-39	Dolomite, light-gray, fine-medium crystalline, dense, streaked with darker gray, slightly argillaceous dolomite.
5239-49	Dolomite, brown, medium-crystalline, dense, some slightly argillaceous and darker, some with pellets of dolomite; trace of chert, dense, gray, with numerous small irregular oolites.
5249-70	Dolomite, finer than above, more gray; little argillaceous dolomite.
5270-5300	Dolomite, densely crystalline, dark-brown, some slightly argillaceous.
5300-04	Dolomite, medium-crystalline, pale-gray, dense.
5304-27	Dolomite, dark-brown, medium-crystalline to slightly argillaceous; trace of dense, pale-gray chert.
5327-33	Dolomite, brown, medium-crystalline, dense, some oolitic; trace of dark-brown, dense, pellet chert.
5333-38	Dolomite, more oolitic than above; some sand enclosed.
5338-44	Dolomite, pale-gray, finely crystalline, dense, enclosing some sand; trace of green shale.
5344-65	Dolomite, pale-gray to brown, finely crystalline, dense; rare streaks argillaceous.
5365-87	Dolomite, cream to brown, finely crystalline, dense; trace of very oolitic chert.